# The Structural Design of an all Composite Motor-Glider Wing

## PhD Thesis

## By Jason Russell


## ABSTRACT


The relaxed certification requirements associated with amateur construction – "homebuilt" – aircraft, particularly in the USA, has led to a renaissance in the light aircraft industry. Europa Aircraft Ltd has addressed the current demand for a privately owned aircraft by producing a two seat, low wing aircraft of composite construction (fig 1). The aircraft is supplied in kit form and features detachable main wings to allow ease of storage. Critical structural components, such as the main wings, wing spars, and fuselage are fabricated by independent suppliers and inspected prior to being supplied to the customer. Final assembly of the fuselage and wing structure is performed by the customer.

The following thesis details two composite motor-glider wings whose structure was designed and engineered by the author to meet set airworthiness requirements. This was the first time a retro-fit glider wing had been designed for a light aircraft, and the first time the Advanced Composites Group (ACG) LTM 26 low-temperature curing pre-impregnated carbon laminate material system was combined with Airex R62.60 core material to form a reinforced sandwich skin material on a manned flight vehicle. This thesis was performed under scholarships from both Strathclyde University and Europa Aviation Ltd. Testing of the structure was partially funded by the Department of Trade and Industry (DTI) under a SMART program award.



Keywords: Composite material, experimental aircraft, wing structure, A and B Basis.

# DECLARATION OF AUTHOR'S RIGHTS



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Finally the author wishes to express special gratitude to the late Mr. Barry Mellers, Consulting Chief Aircraft Design Engineer. Through their many discussions, the author was able to avoid a number of ambiguities and improve his knowledge of aircraft structural design and composite materials.


*Fig 1: Europa Tri-Gear and Monowheel Aircraft*

The purpose of this thesis was to develop a reliable method of analysis and testing that could be used to ensure the structural integrity of a retro-fit glider wing structure. Initially work focused on the calculation methods used to derive flight and inertia loads, as highlighted within appendix B. These were then used to size a prototype glider wing structure. Consideration was then given to meeting or exceeding fully certified standards on material strength. From this approach a prototype glider wing was constructed and subsequently static load and flight tested.

This thesis also pulls on data that the author developed during the structural design of the Europa 'fast-build' light aircraft wing. Structural design of the 'fast-build' light aircraft wing was conducted in parallel by the author in addition to work on the prototype glider wing. The fast-build wing employs thin pre-moulded wing skins of pre-impregnated Glass Reinforced Plastic (GRP) sandwich construction. A detailed examination of wing skin buckling is presented for the fast-build light aircraft wing, together with a review of practical analytical and experimental techniques developed by the author used to assess this phenomenon. The main aim of the examination of skin buckling on the 'fast-build' light aircraft wing was to establish a practical and efficient technique that could be used to ensure stability of wing skin panels on a production variant of the motor-glider wing structure. The production fast-build motor-glider wing structure would be specifically engineered for low to medium volume construction.

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# 1 Introduction to a New Aircraft Type

## 1.1 Overview

To increase the product life of the existing Europa aircraft kit and to satisfy the general demand for a glider aircraft, Europa Aircraft Ltd aimed to address this demand by introducing a set of retro-fit glider wings for the existing Europa aircraft. These wings needed to be engineered to be a direct structural replacement for the existing light aircraft wings given the aerodynamic constraints of horizontal and directional stabilizer stability and control power, centre of gravity and trim range.

This thesis details the structural design, analysis and testing techniques developed by the author to ensure the structural integrity of a prototype and pre-moulded glider wing designed using these advanced composite materials. This thesis covers the first use of Advanced Composites Ltd LTM 26 pre-impregnated material combined with the first use of Airex Ltd R62-60 core materials in an all carbon-composite-sandwich primary aircraft-structure. These techniques that were developed for the prototype glider wing were subsequently modified and applied to the structural design of a glider wing for volume production. Both glider wing structures were designed to be a direct replacement for the standard wings employed by the Europa light aircraft. Structural configuration and plan-form configuration was defined by the author. The aerodynamic profile geometry was defined by Europa Aircrafts consulting aerodynamicist.

The following general design constraints were considered:

1. Minimum change to the existing Europa light aircraft
2. Commonality of airframe and wing coupling mechanism
3. Commonality of prototype construction techniques and materials
4. Retention of aerodynamic qualities over the span of the wing
5. For volume production, the glider wing structure should be capable of being assembled by unskilled personnel within a standard car garage
6. For volume production, the glider wing must be capable of being transported worldwide in component form within a standard twenty foot shipping container

Structural design and inspection of the glider wings was conducted in accordance with mandatory requirements specified by the Popular Flying Association. In the United Kingdom the Popular Flying Association is a body appointed by the UK Civil Aviation Authority to oversee the construction and certification of amateur built aircraft. Although no stringent structural design requirements exist specifically for 'home-built' aircraft sold in kit form, the Popular Flying Association recognize aircraft structures designed to meet the following standards.

- JAR-VLA The Joint Airworthiness Requirements for Very Light Aircraft
- JAR-22 The Joint Airworthiness Requirements for Sailplanes and Powered Sailplanes
- FAR-23 The Federal Aviation Authority Requirements for Light Aircraft
- BCAR The British Civil Airworthiness Requirements, Section K, Light Aircraft

These standards are detailed within the reference section of this thesis and are used to derive the flight loads presented within Appendix B through G

By using these requirements as a guide, analysis and testing methods could be developed to ensure integrity of both a prototype glider wing structure, and a glider wing structure designed specifically for volume production.

Initially work in this thesis focussed on developing calculation methods that could be used to derive loads experienced by the wing in flight. These loads are then used to size the prototype glider wing structure. From this approach a prototype glider wing was constructed and subsequently static load tested and test flown. Work then focuses on the structural design of the fast-build light aircraft wing. The structural design of the fast-build light aircraft wing incorporated composite processing methodologies, and the general structural arrangement that was used as background data necessary to benchmark analytical and testing philosophies that could be transferred to the design of a glider wing designed for volume production. Consideration is then given to meeting or exceeding certified standards on material strength. Work concludes with the final design of a glider wing structure for volume production using results from a combination of hand calculations, finite element analysis and static load testing.

## 1.2 Literature Review

To generate a viable analysis technique, aspects of wing aerodynamic and structural design were reviewed. Relevant literature covering the subject dates back to the 1930s. However information relating to orthotropic composite sandwich construction wing structures is thin on the ground due to their lack of use in primary flight vehicle structures. This data is generally restricted to the design manuals of larger aircraft companies with unlimited access to material coupon testing.

Structural and flight envelopes for the glider wing were defined after a review of standards JAR-22[4], JAR-VLA[5], BCAR-Section K[6], and FAR-23[7]. To define the wing chord-wise loading and flight envelope of the glider wing aircraft the appendices of FAR-23[7] and JAR-VLA[5] were reviewed. The author noted that these requirements and, moreover, their associated appendices, did not contain guidelines on main wing and tail-plane span-wise aerodynamic load grading. In addition, within JAR-VLA a number of ambiguities were noticed with respect to the graphical presentation of tail loading information.

In order to design the composite spar of the prototype glider wing structure, solutions for the wing aerodynamic loading were sought. Solutions for span-wise wing loading approximations were presented by Stinton[2], Raymer[1] and the Light Aircraft Design Handbook[3]. The wing loading methods described by Stinton, and the Light Aircraft Design Handbook, were useful in describing the Shrenk aerodynamic loading for a general wing planform, however this data had to be re-written and compiled into practical analysis spreadsheets by the author for the glider wing. Consideration was given to writing the core calculation code in 'BASIC' however, the flexibility afforded by Microsoft Excel was considered to be more straightforward to use given the numerous calculations that had to be conducted. The author noted that, of the conceptual aircraft design texts read during this study, Raymer treated the basic structural aspects of light aircraft design with the best descriptive detail.

Use of composite materials in primary aircraft structures necessitated a detailed review of JAR-VLA Acceptable Means of Compliance. This standard presents simplified 'knock-down' factors to account for degradation in composite material strength due to the effects of manufacturing variability, and the combined effects of moisture ingress and elevated temperature on the structure over the life of the aircraft. In addition, the JAR-VLA Acceptable Means of Compliance also provided detailed guidelines on designing metallic and non-metallic aerospace structures to resist fatigue.

Composite material design allowable strengths were derived for the Advanced Composites Group Ltd LTM 26 laminate materials and in sandwich form by coupon testing. These specific materials were chosen after a review of the material strength values derived from material specimen coupon test data from tests conducted on existing wet-lay up and pre-impregnated materials used on the classic light aircraft wing, and fast-build light aircraft wing[22]. The author noted the profound variation in material strength that can occur during coupon testing due to manufacturing technique alone.

1. Reduction of composite material coupon test data was presented within the Mil-Spec Handbook 17 [7], and DOT/FAA/AR-00/47[29]. The DOT/FAA/AR-00/47 document contains a comprehensive method for material qualification and equivalency for polymer matrix composite material systems. This qualification plan defines specific test matrices for laminae level composite materials for various modes of loading and environmental conditions for aircraft not exceeding 200 deg F. Although this plan covers the initial material characterization at the laminae level and does not include a procedure for laminate or subcomponent testing, the general methodology and statistical data reduction techniques can be used for sub component tests. Statistical methods of composite material coupon test data reduction were presented within this document and Mil-Spec Handbook 17. By dividing the 'B' – basis elevated temperature-wet strength of the laminae by the mean room temperature dry laminae strength gives a

'composite super factor' that can be applied to a component as an 'overload' during a room temperature test.

Due to the 'experimental' nature of the Europa aircraft, Europa Aircraft Ltd had no legacy test data to support the design of the aircraft. To ensure structural integrity during the design phase the author undertook coupon testing of the Advanced Composites Group Ltd LTM 26 carbon as both laminate materials and in sandwich form. The simplified data reduction technique, and statistical approach used to derive composite material strengths within JAR-VLA Acceptable Means of Compliance was chosen, over the methodologies provided in Mil handbook 17. This was primarily because the structure was small enough to static test at room temperature with a laminae-defined super-factor. The JAR-VLA method equates a coefficient of variance for a minimum of 6 coupon test results to a material knock-down or 'super factor'. Strength allowables were generated for glider spar and skin materials. All material test results are presented for clarity as raw data, and reduced using the statistical methods of the Acceptable Means of Compliance within appendix I of this thesis.

In order to establish an initial structural design for volume production of the glider wing, the structural design of the light aircraft 'fast-build' wing was reviewed in considerable detail. Particular attention was paid to the practical and efficient experimental approach used by the author to ensure integrity of the fast-build light aircraft wing. This wing was engineered and tested by the author using Advanced Composites Group Ltd LTM 26 glass cloth as laminate materials and in form orthotropic composite sandwich wing skins. This wing structure was sized using testing methods alone.

The inherent lack of ductility of composite sandwich panels render them incapable of redistributing internal loads once buckled. Instead their facing plies shatter or crimp the foam because of their brittle nature. This phenomenon was observed during the static strength tests conducted on the fast-build light aircraft wing[22]. Steps taken to prevent the premature onset of this behaviour are reviewed in detail. The final ultimate load test conducted on the fastbuild light aircraft wing is outlined within appendix J of this thesis for reference purposes. Extracts from the Boeing design manual[11] and the Fokker design manual[12] both outline approaches to the design of orthotropic composite sandwich panels for structural airframe elements. Both methods use the graphical interpretation of reduced test specimen data to derive effective stability curves for shear resistant orthotropic sandwich panels. Although this literature was reviewed in detail, it is limited to specific materials and processes adopted by these companies.

General information covering the stiffness-to-weight and strength-to weight capabilities of carbon reinforced plastic (CRP) and Glass Reinforced Plastic (GRP) composite materials was reviewed. This information was made available within Hollmans series of Modern Aircraft Design manuals[13]. And within the handbooks of various composite material suppliers[1].

To size the glider wing for volume production it was necessary to develop a reliable stress analysis and sizing procedure, based on derived flight loads. This procedure would then be verified by static load testing of a representative wing structure under simulated operating loads. The stress analysis and sizing procedure formulated within this thesis allowed the design of light weight sandwich skins for a glider wing designed for volume production which could cost effectively meet the combined compression, shear stability and weight requirements imposed upon them.

## 1.1 The Europa Classic Light Aircraft Wing, and the Europa 'fast-build' light aircraft wing, a structural comparison.

The Europa Classic Light Aircraft Wing

In order to commence the design of the prototype glider wing structure it was necessary to survey and become familiar with the methods of construction used for the 'classic' light aircraft wing structure. To maintain low development costs, the prototype glider wing would be constructed using similar methods.

The classic light aircraft wing structure was originally designed for home construction with the customer performing the majority of the main wing assembly using the foam core mouldless technique of composite construction developed independently in the United States by aircraft designers Rand[17] and Rutan[18] in the 1970s.

This technique involves using a hot wire to cut wing leading and trailing edges, and the wing control surfaces out of high-density acrylic Styrofoam blocks. These blocks are then used as inexpensive contact moulds. The blocks are reinforced with wet lay-up GRP ribs. Once the ribs cure, the blocks and ribs are bonded to a wing spar. The complete block and spar structure is then covered with wet lay-up GRP skins. The composite structure then cures in atmospheric conditions. Typical construction using this method was applied to the prototype glider wing structure as highlighted in figure 2.

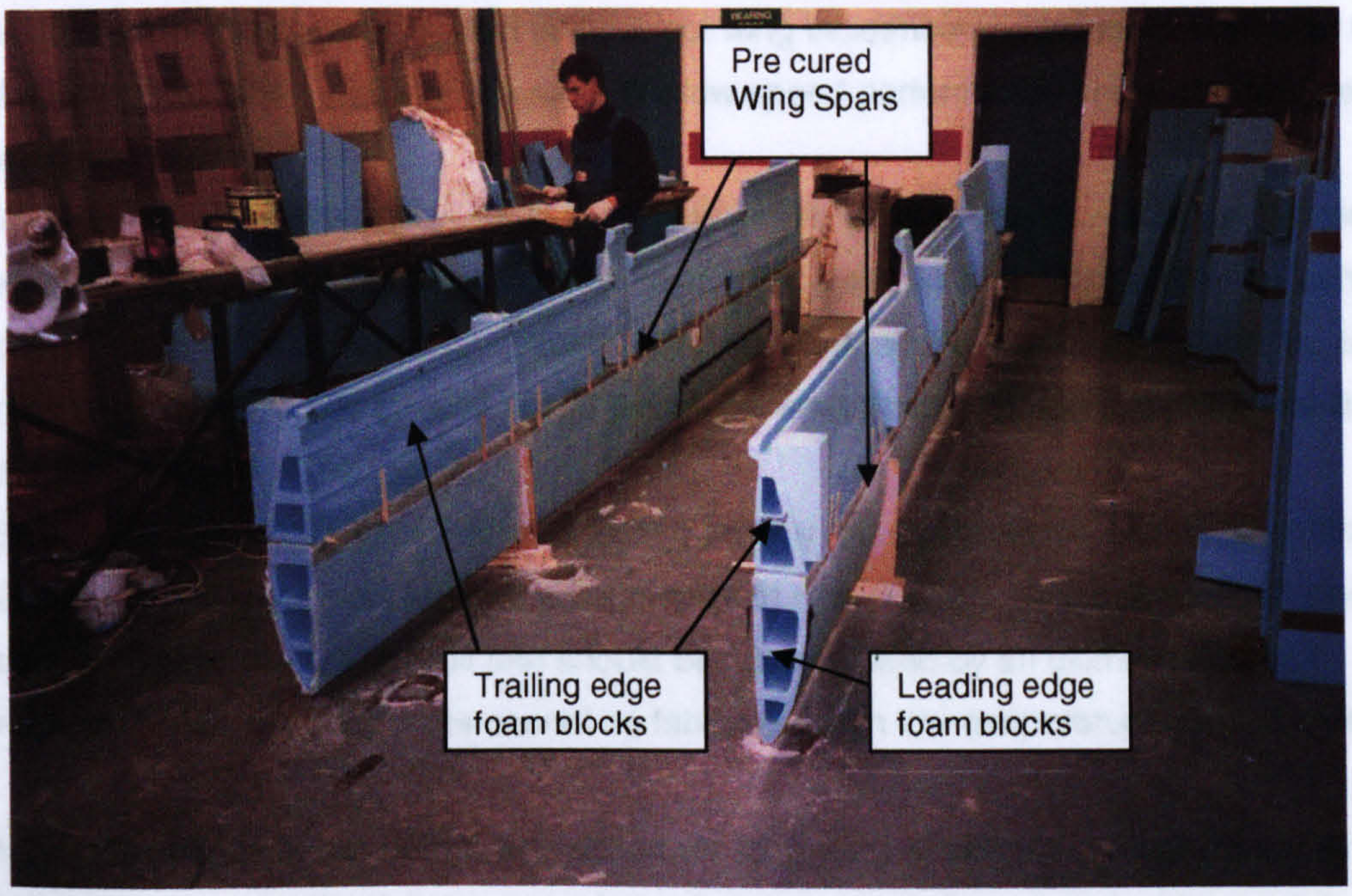



*Fig 2: Mouldless foam Core Construction of the Classic Europa light Aircraft and Prototype Glider Wing*

This technique offers a multitude of desirable properties for a small or start-up aircraft company, in that,

- It is relatively inexpensive
- Rapid prototyping of concepts can be achieved
- A minimum amount of additional tooling is required to complete structures
- Major modifications to wing structures, for example, increases or decreases in wing span or chord, can be conducted within a space of hours rather than weeks when compared with modifications conducted on an aluminium wing with an equivalent wing area.
- 3 dimensional curvature can be achieved without expensive tooling
- Areas of the structure that have been found under strength after testing, can be compensated for quickly and efficiently with additional plies of cloth
- Production tools can be taken from prototype structures
- For an aircraft company supplying structures in kit form, there is no tooling or labor costs involved with final wing assembly.

Interviews with technicians at Europa Aircraft Ltd and customers who have used this mouldless technique to construct prototype components and classic light aircraft wing structures, high-light some of the problems with this approach.

- Large structures require multiple leading and trailing edge blocks. It is difficult to achieve perfect block alignment with multiple block structures, visible in figure 2.

- Lack of block alignment can lead to incorrect wing incidence and incorrect twist over the length of the wing (washout) which will degrade the low speed performance and stall characteristics of the wing structure
- Wing surface finish is critical on laminar flow profile wing structures, such as the glider and light aircraft wings. The wing skins require filling with phenolic type filler which, on curing, requires considerable time-consuming sanding. Although composite female tools can be taken off the prototype structure, the quality of the prototype wing block alignment and surface finish dictates the performance of the tool.
- Structures can weigh more than anticipated as they are designed for 'worse-case' fabrication.
- Given the complexity of load paths and nature of construction, stress analysis of mouldless foam core structures can be difficult and should be substantiated by an ultimate load test.
- High temperature curing parts cannot be fabricated with low temperature contact molds

Although this technology is not particularly suited for long wing structures as highlighted by Strojnik[23] it was adopted as a cost effective means of producing a one-off prototype glider wing. For volume production of the glider wing an alternative construction method would be sought. The structural design of the Europa 'fast-build' light aircraft wing closely mirrors the construction and processing technology necessary for volume production of the glider wing.

Europa 'fast-build' Light Aircraft Wing

Customer feedback combined with the need for an additional weight increase of the Europa light aircraft to cope with customer installed automobile derived powerplants, led to the design of the Europa 'Fast-build' Light Aircraft Wing. Planform geometry of the wing was increased by 7% in wing area to maintain a 45 knot stalling speed at an increase in gross weight from 1300 lb (591 kg) to 1370 lb (623 kg). In addition, it was necessary to expand the existing flight envelope imposed by the UK PFA, allowing a 'Never Exceed Speed' increase from 150 kts to 165 kts.

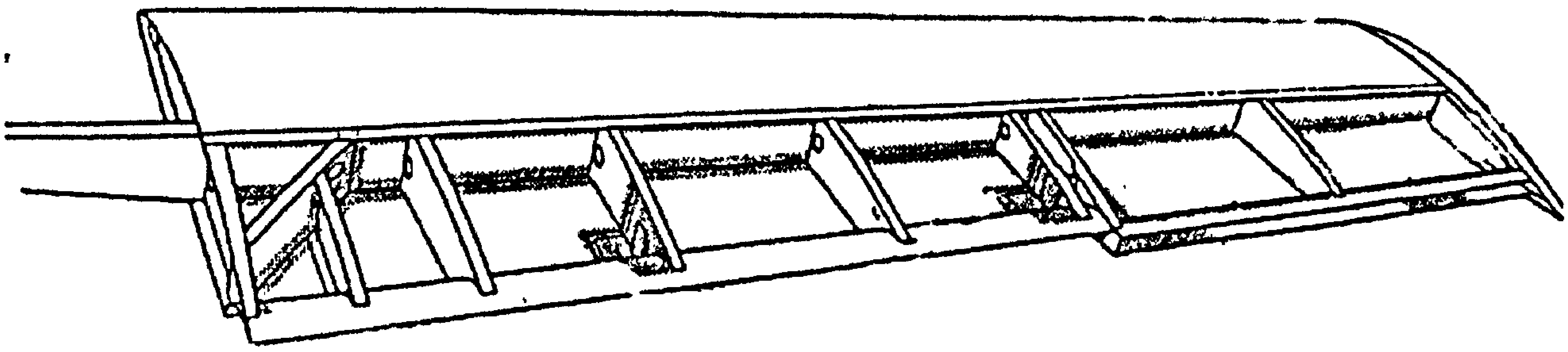


*Fig 3: Europa Fast-Build Light Aircraft Wing*

The structural design of the Europa 'fast-build' Light Aircraft Wing is highlighted within figure 3. The design criteria used for this wing was as follows:

- Commercially, the 'fast-build' wing should be cost-effective in terms of design and factory construction.
- The 'fast-build' wing should employ the same wet-lay up spar structure as the classic light aircraft wing, however with closer tolerances on manufacturing variability, and tighter quality control.
- The 'fast-build' wing should employ the same wet-lay up control surfaces as the classic light aircraft wing. It is anticipated that these will be superceded by pre-moulded surfaces at a later date.
- The 'fast-build' wing should be supplied pre-moulded with the customer performing very little in terms of final wing assembly.
- The aircraft flight envelope should be redefined to reflect the never-exceed speed increase from 150 to 165 knots.
- The aircraft limit and ultimate 'g' load should be revised to include a composite super-factor. The method specified within JAR-VLA would be used as an acceptable means of complying with this requirement.
- The 'fast-build' wing should have a wing skin sandwich structure that employs the latest material technology in terms of low temperature curing pre-impregnated cloths, and low density, high shear strength, damage tolerant foam cores.
- A minimum number of pre-cured ribs, hence rib tools, should be used to transmit aerodynamic loads from the wing skins to the wing spar
- The sandwich-construction wing-skin structure should be designed to meet specific stability criteria.

The complexity of the design of the 'fast-build' wing skin structure and wing skin load paths, combined with minimal material coupon testing and no access to a finite element analysis package capable of handling the design of composite sandwich panels effectively, led to a purely experimental approach of structural sizing. An attempt was made to reduce results from experimental tests by reverse engineering these results through empirical factoring to derive effective rigidity values for the wing skin panels. However initial results from this approach were ambiguous due to spurious strain gauge readings experienced during testing, and the limited performance of hand calculations beyond limit loading the non-linear range.

Chapter Summary

In this chapter the general structural design challenge of the Europa prototype glider wing has been presented. An overview of both light aircraft wing designs has been given together with the reasoning behind the use of fibre reinforced composite materials for this particular structural application. Two very different structural designs and composite construction methods have been presented, one suitable for rapid prototype construction, the other for low to medium volume production.

# 2 Structural Design of the Prototype Glider Wing

## 2.1 The V-N diagram

The greatest aerodynamic loads on any aircraft come from the generation of lift during high-g maneuvers. The aircraft load factor (n) expresses the maneuvering envelope of an aircraft as a multiple of the acceleration of gravity, where g = 32.2 ft/sec$^2$ (9.81m/sec$^2$) At lower airspeeds the highest load factor an aircraft will experience is limited by the maximum lift available from the main wing, which in turn is a function of wing area and profile shape. At higher airspeeds the maximum value of load factor is limited to a value based upon the expected use of the aircraft during normal operations. This load factor is defined as the limit load factor. For the Europa glider aircraft, the limit load factors for both the low and high speed cases are defined within a series of requirements[4][5][6][7]. A review of these requirements was undertaken to establish the lowest acceptable value of limit load that could be used to size the glider wing structure. A brief review of all load levels generated by each requirement is presented within appendix E. The lower the value of limit load, the lower the resulting spar stress levels are, consequently the lighter the wing spar, therefore, aircraft structure. JAR-VLA was chosen after a review of limit loads and composite material requirements. Initially the Europa glider prototype was sized to meet the utility category of the requirement JAR-22. This resulted in limit load factors of +5.3g and –2.65g for the low speed cases, with +4.0g and –1.5g being the limit load factors for the high speed case. Using JAR-VLA these values drop to acceptable values of limit load factors of +3.8g and –1.9g for both the low and high speed maneuver cases, with +4.54g and –2.54g derived for gust load cases. These values can be plotted on a chart known as the V-N diagram or flight envelope as indicated within figure 4.

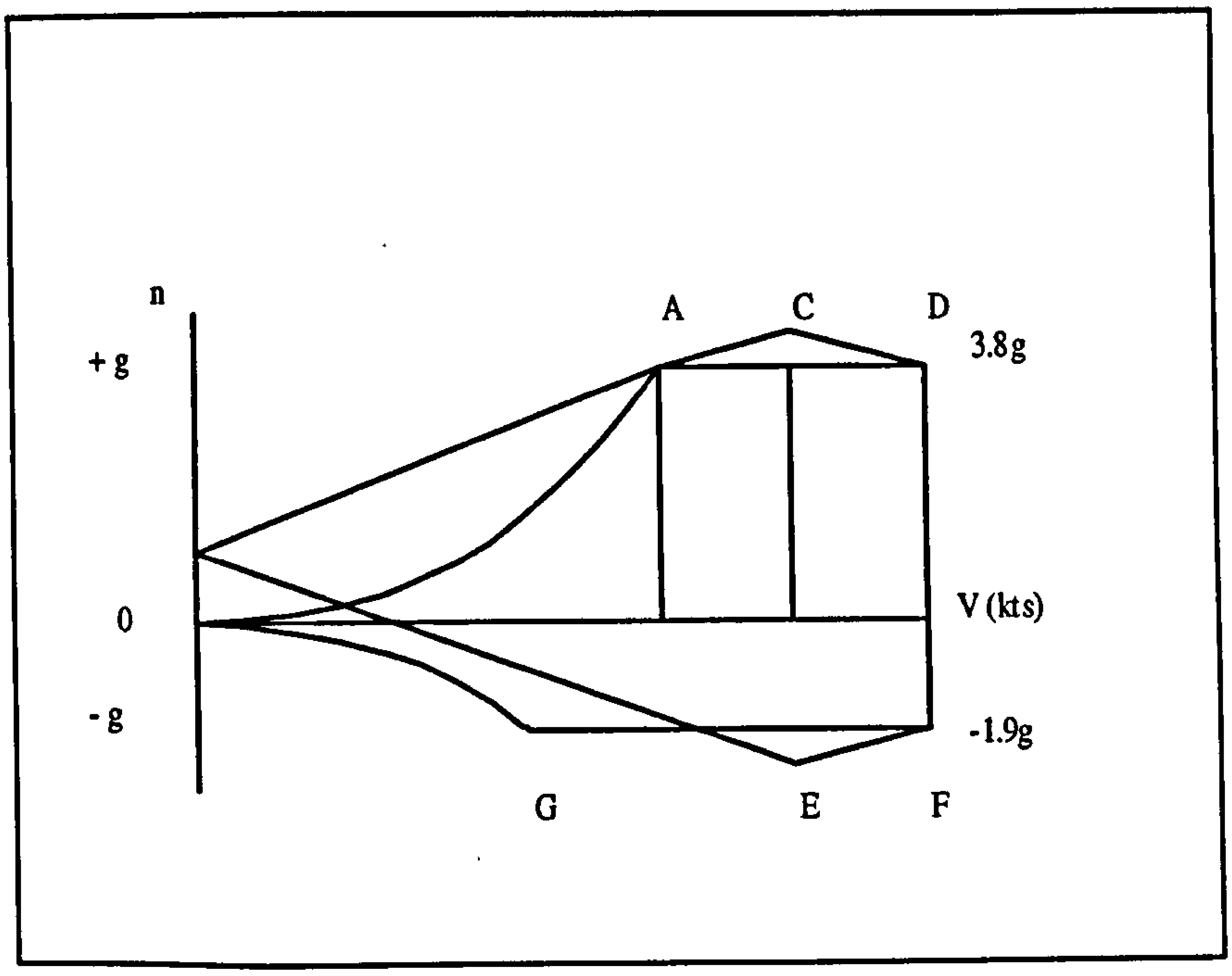



*Fig 4: Glider V-N diagram derived from JAR-VLA for an aircraft at 1370 lb (623 kg) AUW*

The V-N diagram depicts the aircraft limit load factor as a function of airspeed and defines the aircraft operational flight envelope. In order to determine the strength of any wing or flight vehicle structure, critical conditions on the flight envelope need to be defined. The first condition exists at $V_A$, at the aircraft maneuvering speed. This condition represents the slowest speed at which the maximum positive limit load factor can be reached without stalling the wing. This part of the flight envelope requires investigation because the load on the wing is approximately perpendicular to the flight direction, not as might be thought, perpendicular to the fuselage horizontal datum.

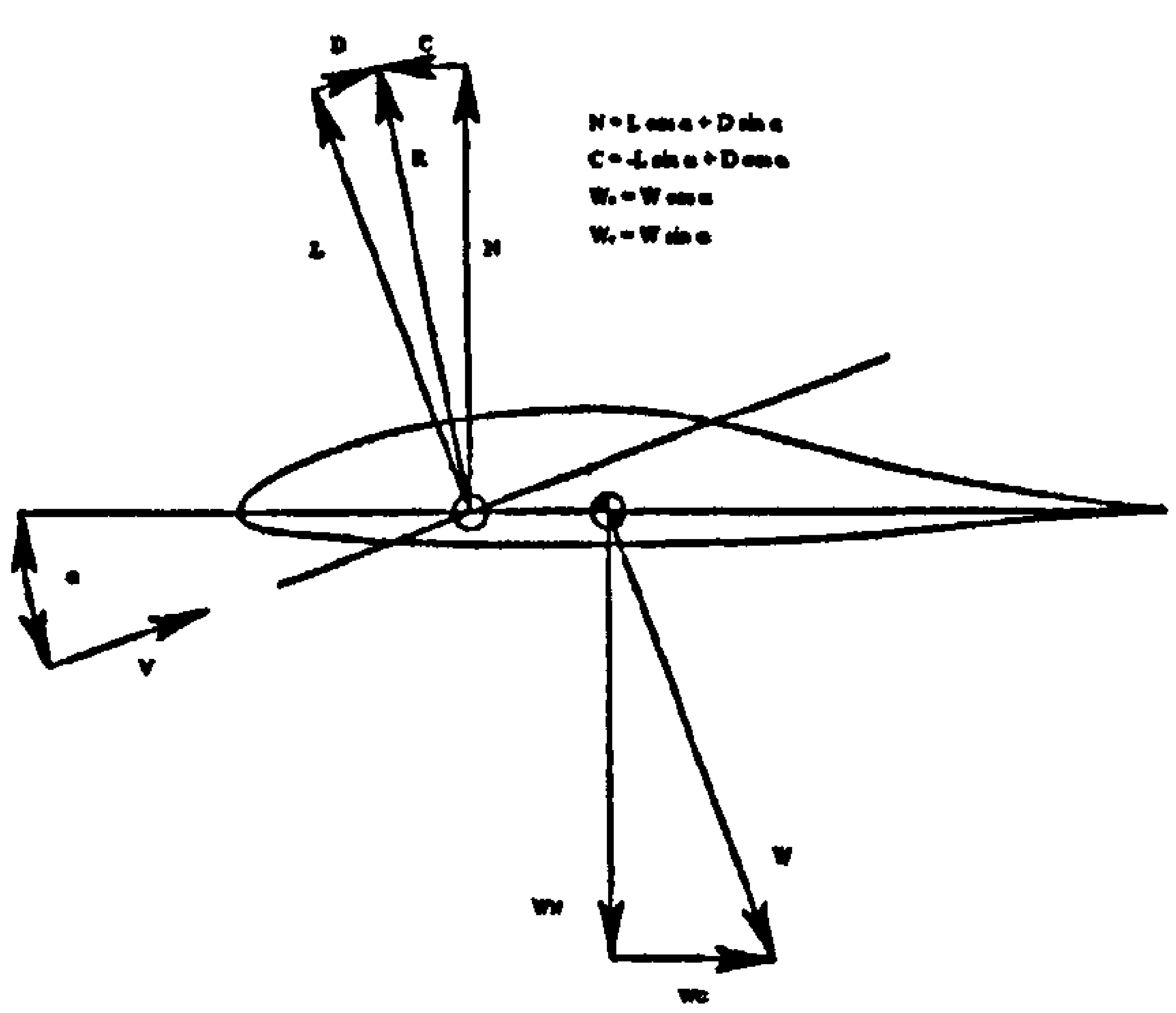


*Fig 5: Aircraft angles relative to Airflow*

At this condition, *Condition A*, the wing presents a very high angle of attack to the airflow. The load direction will be forward of the aircraft fuselage vertical datum, causing a forward load component on the wing structure. If the wing and wing carry through structure was not stressed to meet this condition, the wings could fail by shedding forward in flight. The combination of high angle of attack and load factor result in the wing skins experiencing high shear loads due to torsion. The resulting force vectors and summations are presented for clarity within figure 5.

The second critical condition requiring investigation occurs at $V_D$, the aircraft design dive speed. This condition, *Condition D*, at the extreme right hand side of the aircraft flight envelope, represents the point where maximum dynamic pressure and maximum limit load factor coincide. This condition is important for structural sizing of the wing spar. At Condition D the aircraft is traveling fast therefore, the wing is at a low angle of attack because of the high dynamic pressure. The wing load is approximately perpendicular to the fuselage horizontal datum. The combination of dynamic pressure and maximum load factor results in the wing spar experiencing high spanwise bending loads. The resulting force vectors and summations are again presented for clarity within figure 5.

Conditions A and D however ignore the effect of very strong gusts acting on the aircraft. Loads experienced when an aircraft encounters a strong gust can, in some cases, exceed the limit maneuvering loads evaluated at conditions A and D. All vertical gusts produce a momentary increase in wing lift. Violent gusts however appear instantaneously and can throw the aircraft up tens of feet in a couple of seconds. Gusts of fast rising air with a vertical rising airspeed of 50 ft/sec (15 m/sec) can be encountered in close proximity to clouds or above ridges, where gliding is common. Gusts increase the angle of attack of the wing therefore produces a substantial increase in lift. Wing lift can therefore be increased by a magnitude of 3 or 4. Slow aircraft or aircraft with small mass are able to adjust to the onset of a gust quicker than larger aircraft. Highly flexible wings, like those of a glider will absorb some of the impact of a strong gust. To establish the g load that results from strong gusts acting on the aircraft within its flight envelope, the requirements of JAR-VLA and FAR-23 were reviewed. These requirements use calculation methods that account for the action of gust alleviation by introducing a 'gust alleviation factor' in their calculation methods.

Both positive and negative vertical gusts loads have been derived for the Europa glider wing at a range of aircraft weights. Derivation of gust loads is presented within appendix A.

Fixing a V-N diagram for the prototype Europa glider wing, enables the airload distribution acting on the wing surface to be determined. Examination of the limit g loads derived from JAR-VLA for the Europa glider wing suggests that the critical case for structural sizing of this aircraft exists at *Condition C*, the gust case outlined on the aircraft flight envelope. The higher g load combined with high angle of attack produces the most unfavourable combination of span-wise bending and torsion on the wing structure, whereas for the fast-build light aircraft wing Conditions A and D were the critical cases. For the glider wing structure conditions, A,C,D,E,F and G on the aircraft flight envelope were investigated fully. The angle that the airflow makes with respect to the wing is presented for clarity in figure 6.

Conditions E and G represent the negative maneuver cases. Condition F represents the effect of down gusts or inverted flight with upgusts at high negative angle of attack.

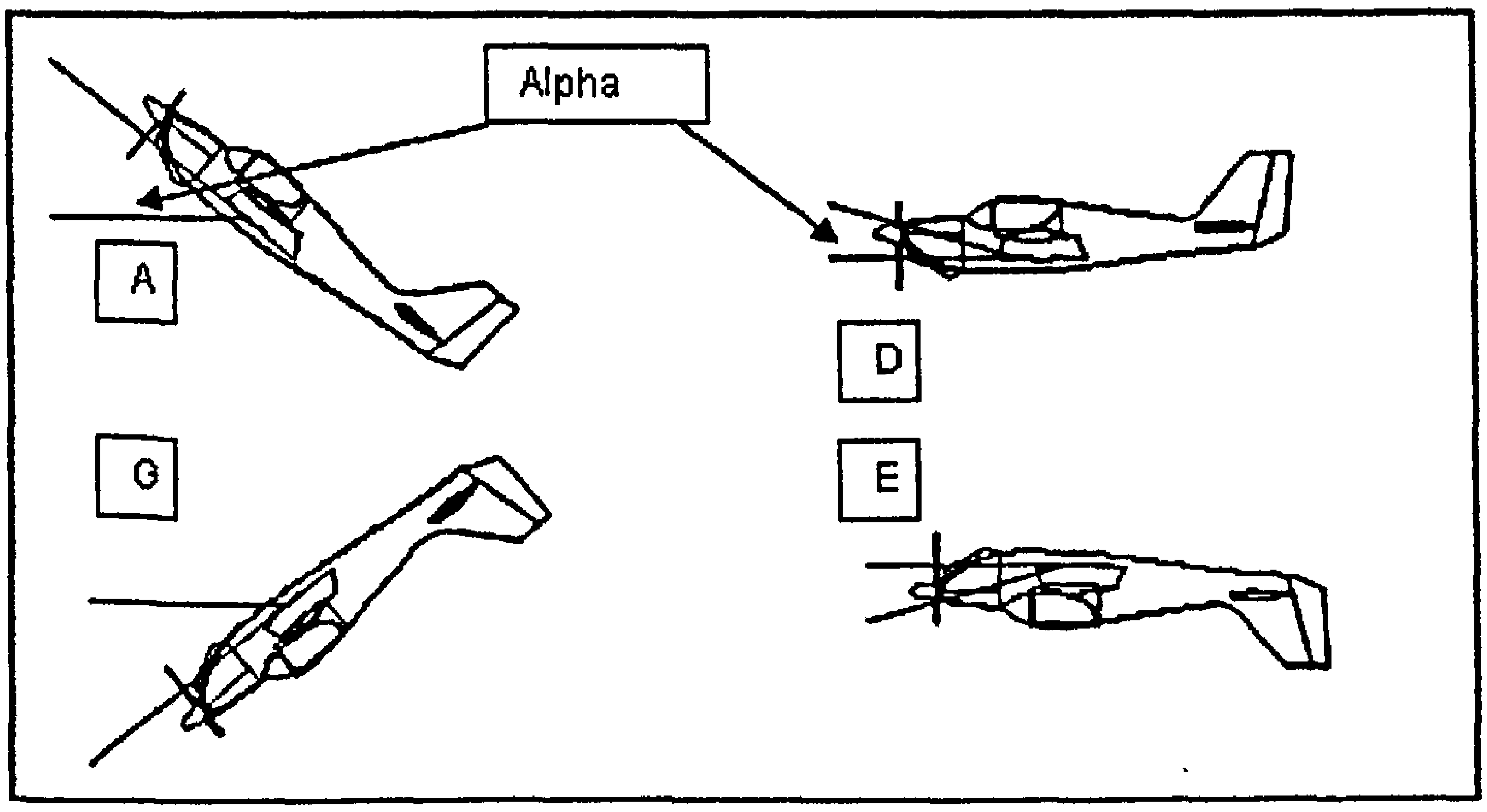



*Fig 6: Visualization of Positive and Negative Maneuver Cases*

Cases A through to G consider clean-symmetric positive and negative loads acting on the wing structure. In addition to the clean-symmetric cases, the effect of airbrakes and aileron deflection at these points must also be considered.

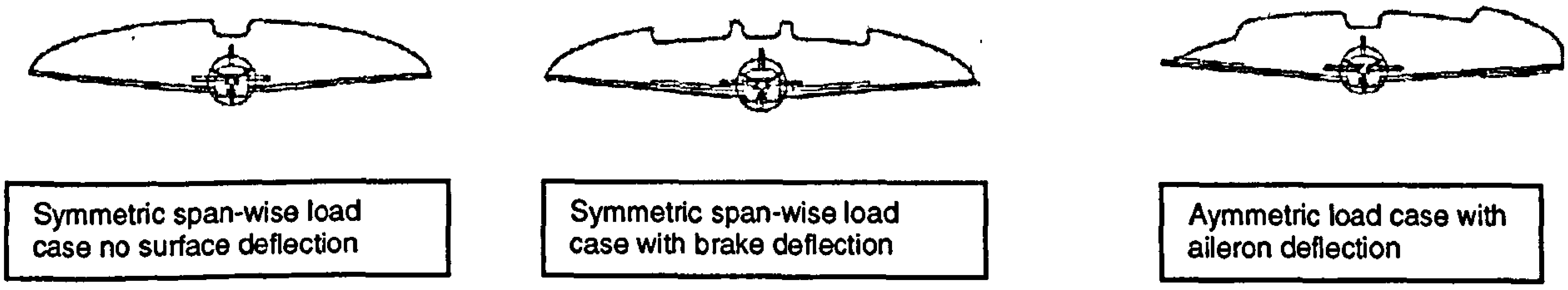



*Fig 7: Symmetric and Asymmetric Maneuver Loads resulting from Airbrake and Aileron Deflection*

Unlike the basic Europa light aircraft wing, the glider wing is fitted with very powerful trailing edge speed limiting airbrakes. These brakes are deflected symmetrically and produce a large aft chordwise bending moment on the wing structure. The effect of airbrake deflection, particularly when no lift is being generated by the wing to oppose the resultant chordwise drag component of load, is of particular interest when sizing the wing attachments and the wing spar carry through structure.

The local airflow is disturbed when these surfaces are operated. A schematic view of how the span-wise wing-lift load magnitude is affected by the deflection of these surfaces is presented within figure 7.

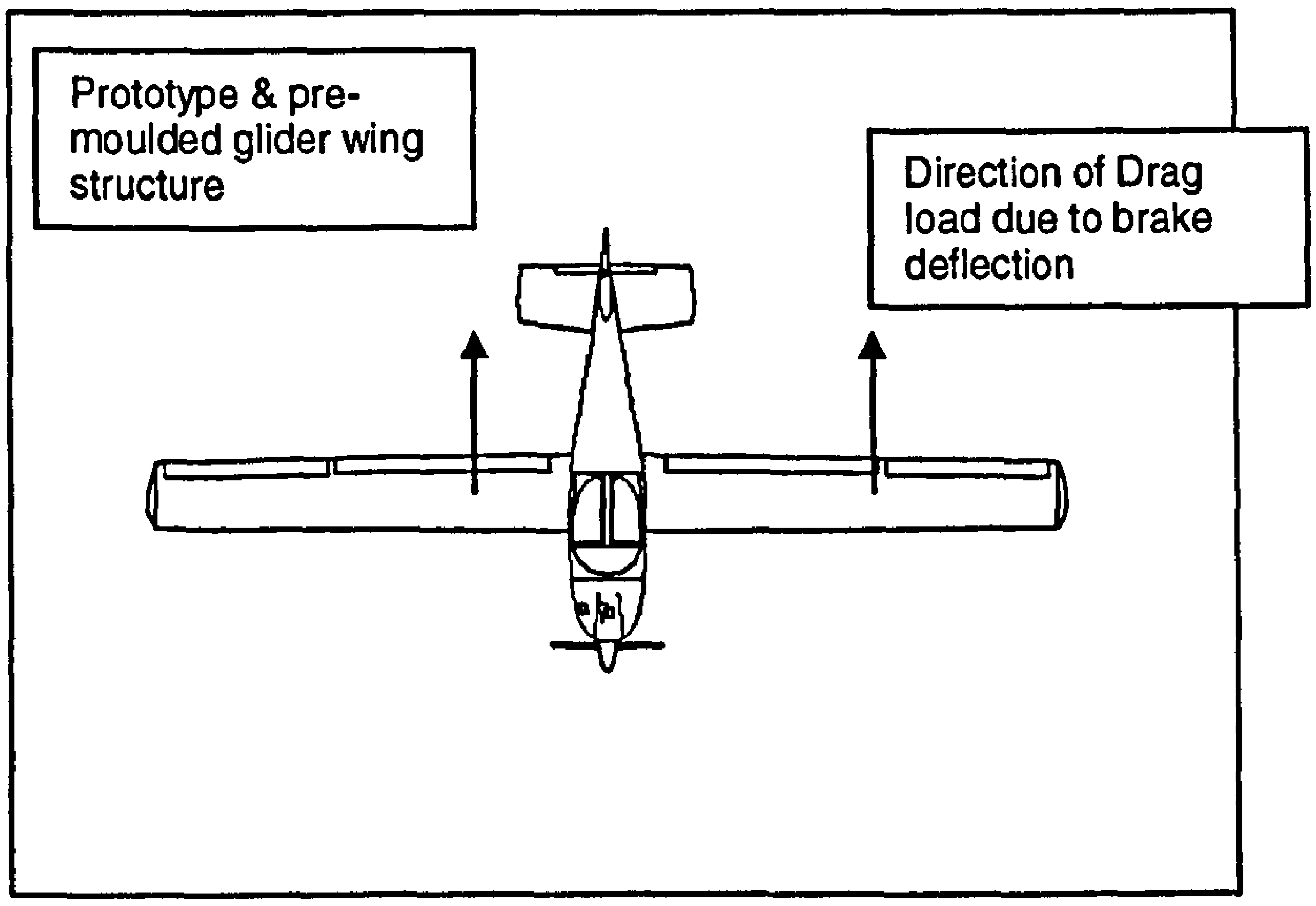



*Fig 8: Effect of Drag due to Airbrake Deflection*

In addition to symmetric loads, asymmetric loads generated from aileron deflection have also been investigated. Aileron deflection locally alters the pitching moment coefficient and the lift coefficient of the wing adjacent to the control surface. This can induce torques on the wing structure that is greater than those that occur from a clean wing. Aileron upward deflection reduces the camber of the wing surface, whereas downward deflection behaves like a small plain flap increasing the lifting ability of the wing over the span of the aileron. The force vectors that result from dive brake operation & drag induce large chordwise loads on the wing structure that the structure has to be engineered to resist. The force vectors that result from their deployment are presented for clarity within figure 8

Both upward and downward aileron deflection were investigated for the glider wing at all points on the aircraft flight envelope with 2/3 limit load. 2/3 limit load is the basic requirement for 'rolling pull-up' type maneuvers per the regulations investigated. The symmetric effect of airbrake deflection has also been examined in detail with 2/3 limit load applied. From a review of all symmetric and asymmetric flight combinations for the glider wing, the most unfavourable loads generated on the wing structure have been recorded within appendix E of this thesis. These loads have been used to size the glider wing structure, aileron and airbrake surfaces.

In order to commence structural analysis of the wing in detail using the most unfavourable combination of loads derived from the preceding review of the requirements, it was necessary to review aspects of general wing design[1][2]. An aircraft main wing is designed to meet requirements associated with, aircraft performance, and flying characteristics. The structural integrity of the wing must be maintained throughout all aspects of normal aircraft operations within the aircraft flight envelope. The wing sub-structure is constrained within the external aerodynamic surfaces. In the case of composite wings, like those of the prototype Europa glider wing, the aerodynamic surfaces can be considered to contribute wholly to the overall torsional strength and stiffness of the wing structure. The complete wing should satisfy demands regarding rigidity, weight, strength, and manufacturing costs. To quantify these demands, the shear, bending and torsional stresses must be evaluated.

Initially, stability and control calculations were conducted to determine the lift on the horizontal stabilizer necessary to balance the glider wing pitching moment at all points on the aircraft flight envelope. The stability calculations are approximated by summation of the wing and tailplane moments about the most forward flyable position of the aircraft centre of gravity. A simple conservative approximation within JAR-VLA is to assume that 5% of the lift produced by the main wing can be generated as a balance load by the horizontal tailplane. The horizontal tailplane load is then added to the main wing to give the *maximum balance lifting load* acting on the wing.

With the *maximum balance lifting load* known, the span-wise and chord-wise lift distributions can be determined. From classical wing theory, on an elliptical planform wing the span-wise lift distribution is of an elliptical shape. A semi-empirical method for determining the span-wise lift load is the Shrenk approximation. This method is similar to lifting line theory. This method Shrenk approximation considers that the load distribution on an un-twisted, non elliptical planform such as the glider wing has a shape that is the average of the actual planform shape and an elliptical shape of the same wing span and area. The total area under the Shrenk lift load curve must be equal to the *maximum balance lifting load.* With the spanwise load distribution defined, the main wing shear and bending stresses can be determined at Conditions A, C, D, E and G on the aircraft flight envelope. Loads are determined for the wing both clean and with aileron and airbrakes deflected. Shear force, bending moment and torsion results are presented for all symmetric and asymmetric conditions within appendices C & D of this thesis.

Wing spar bending and torsional stresses were determined by formulating a four step analysis procedure.

From this procedure, the geometry could be defined and the materials could be selected for the prototype glider wing spar and wing carry through structure.

This four step analysis can be summarised as follows:

1. Symmetric and asymmetric lifting loads and pitching moments were derived for the glider wing in aerodynamic equilibrium at conditions A, C, D, E, F and G on the aircraft flight envelope.
2. The wing span-wise lift distribution was then determined for all conditions
3. From the span-wise lift distribution and weight approximation, values of shear force, bending moment and torsion were determined for all conditions.
4. Wing structural analysis was then conducted using the most unfavourable conditions that produce peak values of shear force, bending moment and torsion. This analysis allowed materials to be selected for critical structural components of the prototype and production glider wing. Materials were selected after reviewing the geometry of the spar at various span-wise locations and magnitude of stress acting on the spar at these stations.

## 2.2 Aircraft balance, establishing aerodynamic equilibrium.

The four step analysis commences with an aircraft balance analysis. Aircraft balance analysis, involves placing the aircraft in aerodynamic equilibrium at the most unfavourable flyable centre of gravity location. An examination of aerodynamic derivatives results in the summation of forces and moments about the aircraft centre of gravity and the wing centre of pressure. The analysis establishes the magnitude of the '*total wing lift load*', $L_{wing}$. The total wing lift load is defined as the lift load from the main wing alone, $L$ added to the contribution of restoring lift load from the horizontal stabiliser $L_{tail}$. A schematic of the force balance arrangement is presented within figure 9.

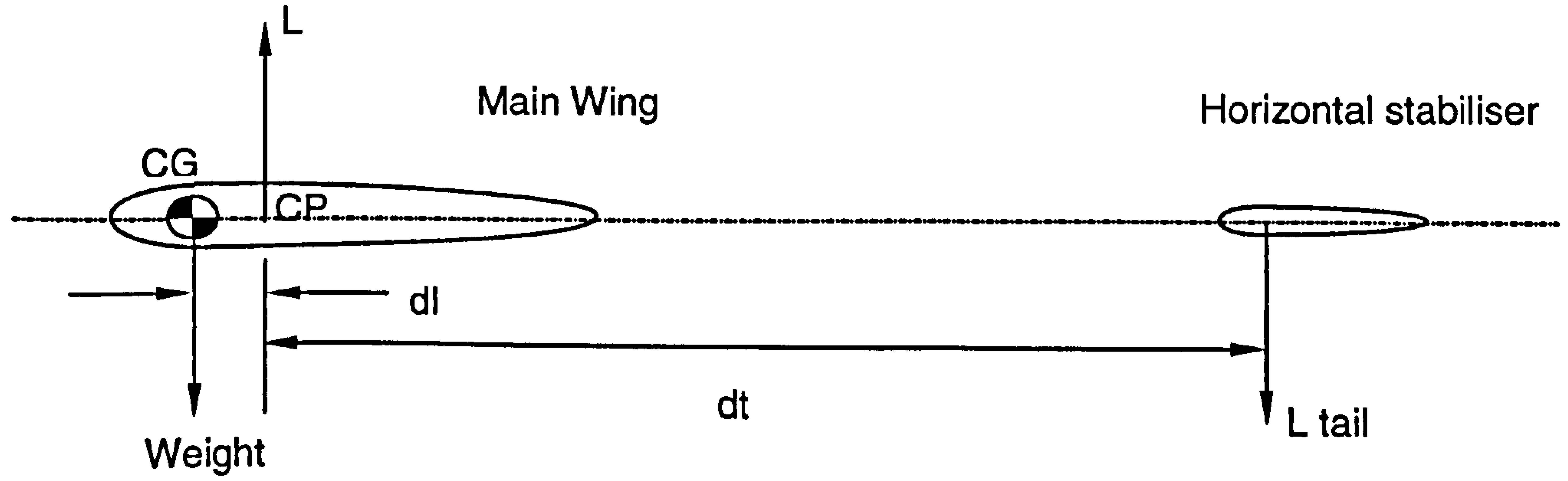


*Fig 9: Summary of Balance of Forces acting on Aerodynamic Surfaces.*

Resulting Load $L_{wing}$ is used to determine the total lift load acting on the main wing.

To obtain the maximum value of *total lift load, $L_{wing}$.* , the most extreme case of aircraft balance was considered. This occurs when;

- The aircraft is fully laden operating at its maximum all up weight (AUW)
- The aircraft centre of gravity is at its most forward flyable position
-

The aircraft can then be put into a state of aerodynamic equilibrium at each point in the aircraft flight envelope. Due to inaccuracies in weight distribution and limited flight test data, 5% of the lift generated by the glider wing was assumed to act at the horizontal stabiliser. As a result the total lift on the wing could be conservatively estimated as being equal to 1.05 multiplied by the aircraft all up weight. This approach is considered by JAR-VLA and FAR part 23 to be conservative.

## 2.3 Wing span-wise lift distribution

To determine the span-wise aerodynamic lift load produced by the glider wing, a *'first principles'* method of lift load derivation was sought.

The span-wise lift distribution arises from the average pressure difference between the upper and lower surfaces of the wing. In order to establish the magnitude of the span-wise lift distribution, the Shrenk method[1][2] was employed. The Shrenk method was used to develop the span-wise lifting load distribution that acts over the glider wing. The mathematical process used to derive the *'final factored span-wise lifting load'* distribution acting over the wing structure is summarised below.

1. A wing chord v wing semi-span curve was constructed
2. An elliptical lift distribution v wing semi-span curve was constructed
3. Superposition of these curves gives the mean 'Shrenk lift load' curve
4. The Shrenk lift load was simplified to a series of concentrated loads by trapezoidal rule method
5. The wing weight distribution was estimated, and simplified to a series of concentrated equivalent loads
6. Straight forward subtraction of the wing weight from the Shrenk span-wise lift load at equivalent span-wise stations, gave the *'span-wise lift load'* over the span of the glider wing.

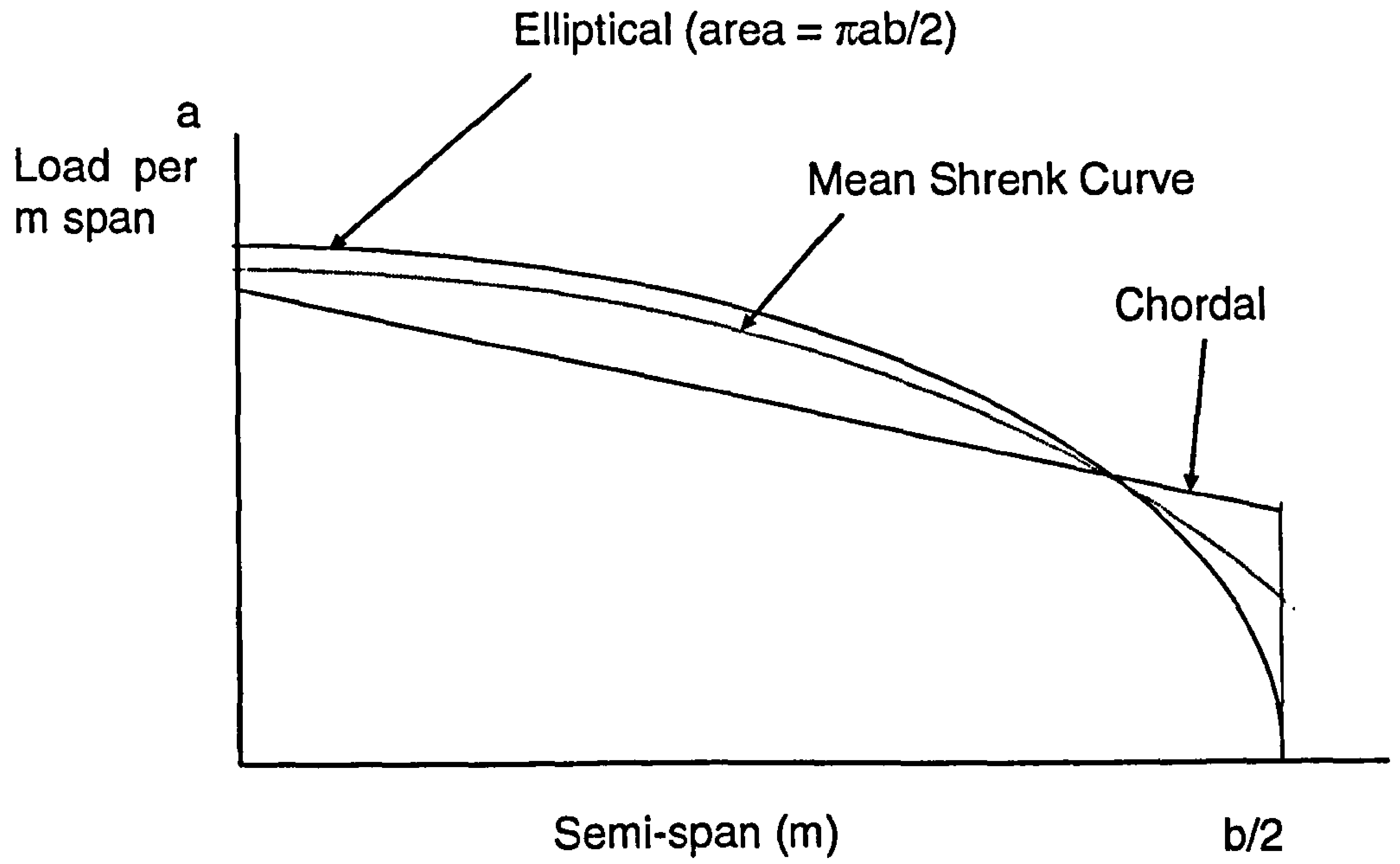



*Fig10: Schematic Representation of Shrenk 'mean' Loading Curve, from the Ai ft Centreline, (the y axis) to the Wing Tip, (b/2)*

To complete the derivation of lifting load, the Shrenk *'span-wise lift load'* was scaled to account for one wing semi-span. This involved scaling the Shrenk *'span-wise lift load'* for half the maximum *total wing lift load*, $L_{wing}$. This resulted in a span-wise loading defined as the *'scaled lift load'*. Figure 10 provides a schematic representation of the approach used.

### 2.4.1 Derivation of shear force, bending moment, and torsion distributions over the wing

Aerodynamic loading on any wing, creates stresses within the wing structure. The response of the structure to these loads produces internal forces and moment couples. The shear force and bending moment distributions were derived from the *'scaled lift load'*. Once the shear force and bending moment distributions were established for all conditions on the aircraft flight envelope, the complete state of stress of the wing could be defined. The method that was used to calculate values of shear force and bending moment from the *'scaled lift load'* distribution is presented below. It should be noted from the last chart presented in figure 10 that this method defines a finite level of lift at the wing tip. In reality this value is zero however, by having a finite load level at the wing tip, the Shrenk method forces the spanwise lift centre of pressure outboard such that conservative wing root bending moments can be obtained.

1. Graphical integration of the *'scaled lift load'* distribution curve gave the shear force distribution over the wing semi-span at 1g, *(Integration of Area A1, at span-wise position X, giving area A1, fig 11)*
2. Subsequent graphical integration of the shear force diagram gave the bending moment distribution over the wing semi-span at 1g, *(Integration of area A2 at Point A1, i.e. at span-wise position X, giving point A2, fig 11)*
3. Both the shear force and bending moment distributions were factored to account for the final *'limit'* manoeuvring 'g' load imposed on the wing structure.
4. An additional safety factor of 1.5 was used, to give the *'ultimate'* values of shear force and bending moment that the wing could sustain without structural failure.

*'Ultimate'* values of shear force and bending moment were plotted against wing semi-span. These charts are presented within appendix B of this thesis.

In more detail, the production of Lift (L) and Drag (D) are combined into a resultant aerodynamic force (R) acting on the wing. As has been shown, the wing lift minus the wing weight gives the incremental net load at span-wise stations along the wing. Summation of this net load gives the shear at span-wise stations on the wing. From Figure 5 the lift is always perpendicular to the local airflow and the direction of the drag is along the airflow. To size the wing spar, loads are required normal (N) and parallel (C) to the wing spar. Resolving the resultant force (R) into a pair of mutually perpendicular forces parallel and perpendicular to the wing spar, gives a normal force (N) and tangential or chord-wise force (C). Transformation of the aerodynamic forces was conducted using the following relationships.

1. $N = L \cos\alpha + D \sin\alpha$
2. $C = -L \sin\alpha + D \cos\alpha$
3. $W_N = W \cos\alpha$
4. $W_C = W \sin\alpha$

The normal force (N) is important for sizing the spar structure, whereas the chord-wise force (C) is important for sizing the spar attachment and wing carry through structure.

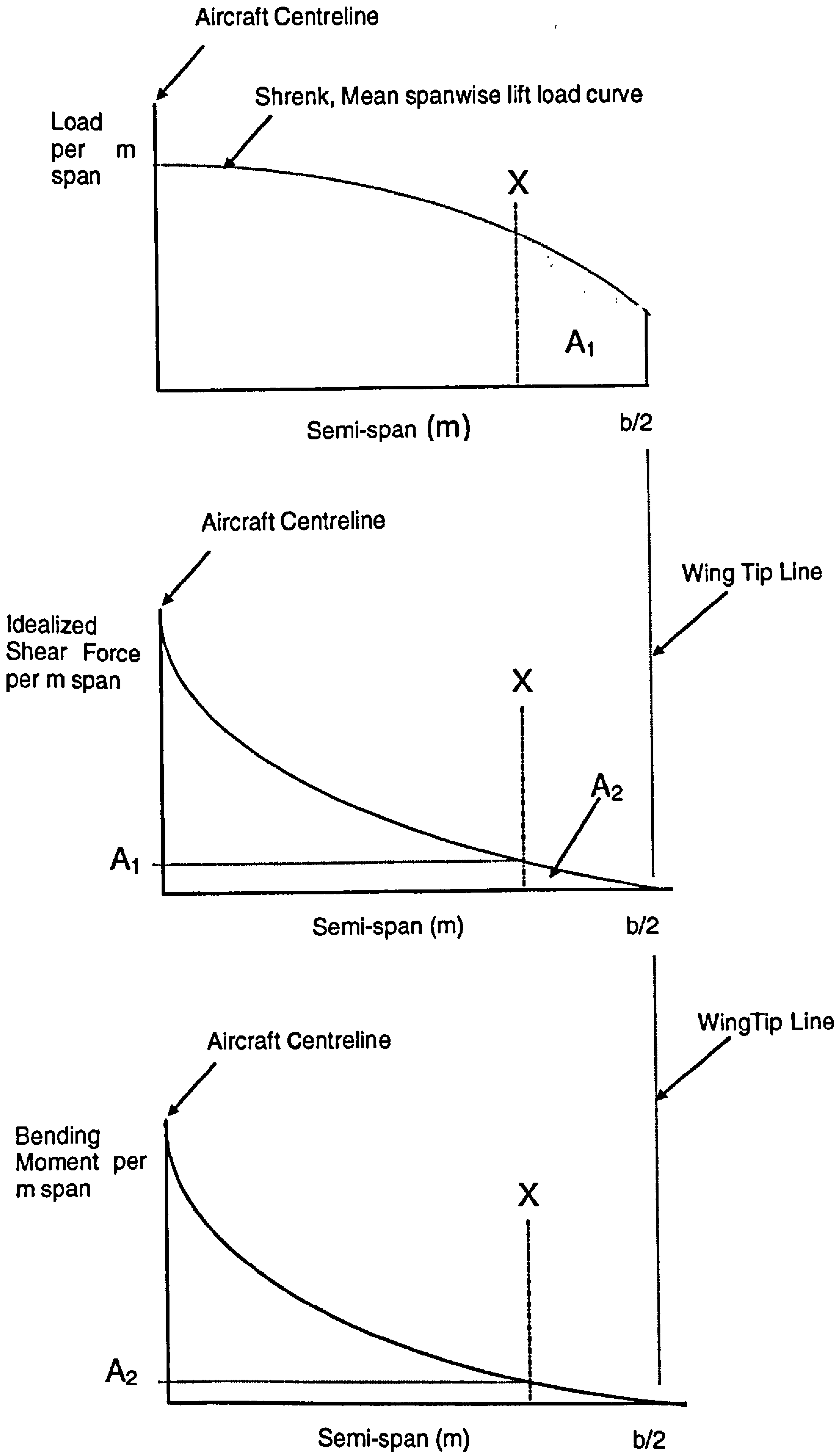

Aircraft Centreline
Shrenk, Mean spanwise lift load curve
Load per m span
X
A1
Semi-span (m)
b/2
Aircraft Centreline
Wing Tip Line
Idealized Shear Force per m span
X
A2
A1
Semi-span (m)
b/2
WingTip Line
Aircraft Centreline
Bending Moment per m span
X
A2
Semi-span (m)
b/2

*Fig 11: Schematic representation of Shear Force and bending Moment distribution, derived from the Shrenk approximation. The aircraft centreline corresponds to the y axis, with the wing tip at b/2.*

In addition to the effects of shear force and bending moment, the effect of torsion has also to be considered. An applied torque produces a twisting deformation that is proportional to the length of the wing semi-span. This is related directly to the magnitude of the chord-wise position of lift, and the distance from this position to the wing flexural centre as illustrated in figure 12.

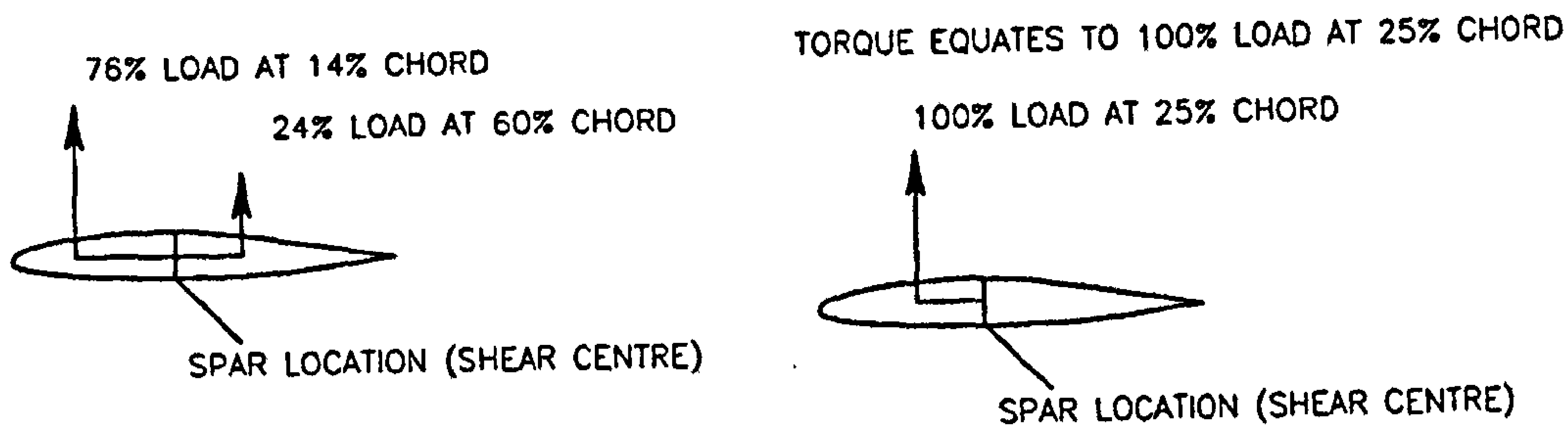



*Fig 12: Chord-wise Distribution of Load and resulting position of Lift relative to the Wing Flexural Centre*

## 2.5 Wing chord-wise lift distribution

The Europa motorglider wing profile shape was designed using an inverse mathematical technique[21]. Lift coefficients were known for the wing at critical points within the flight envelope. From this information, pressure distributions were then developed. These pressure distributions could then be mathematically manipulated to generate the two dimensional profile geometry for the wing. Although the mathematical technique used to develop the profile geometry of the glider wing is beyond the scope of this thesis, the resulting chord-wise pressure distributions from this technique are however relevant for the summation of load about the wing spar. Integration of chord-wise pressure plots give an indication of the aerodynamic load acting fore and aft of the wing spar. Moreover the wing root attachment and root rib structure can be strength checked to resist the most unfavourable torsional loads that act within the aircraft flight envelope. Figure 13 presents, as a schematic, the shapes of the 'load' distributions resulting from integration of chord-wise pressure plots, at both low and high angles of attack.

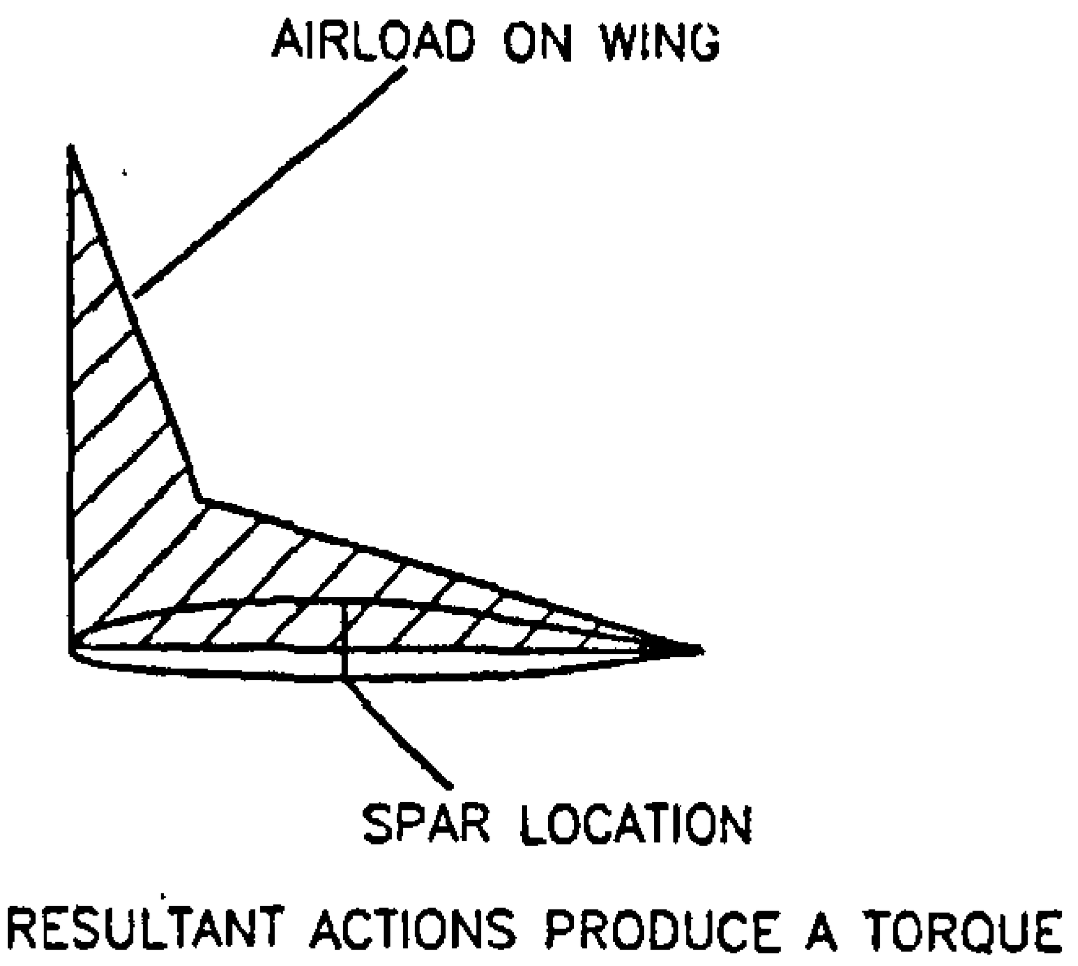



*Fig 13: Typical Chord-Wise Pressure distribution generated by the Glider Wing at one specific Angle of Attack*

To determine the wing torsional loads and stresses, in particular those that occur when the wing is at high angles of attack, the airfoil moment coefficient at zero lift $C_{Mo}$ is applied to span-wise strips along the wing and the total torsional moment is summed from the wing tip to the wing root. $C_{Mo}$ is an inherent characteristic of the wing profile shape 'cast' into the airfoil when it is located at a 'zero lift' incidence that is based on the camber of the surface. It acts at the aerodynamic centre and is independent of angle of attack and Cp position. The torsional stresses experienced by the wing then depend heavily on the chord-wise position of the wing centre of pressure relative to the chord-wise location of the wing flexural centre. On the glider wing structure, initially the wing flexural centre was approximated to the position of the wing spar location, at roughly 40% chord.

Summation of chord-wise torsional moments about the wing spar was conducted using the following 5 step process:

1. With the theoretical aerodynamic centre of the glider wing assumed to act at the quarter chord point (25%c), the chord-wise centre of pressure is dependent on wing lift coefficient $C_L$ and the inherent pitching moment coefficient of the airfoil profile $C_{Mo}$. The chord-wise centre of pressure can then be calculated for the glider wing at each point on the flight envelope using the relationship $X_{cp} = 0.24-(C_{Mo}/C_L)$ where the aerodynamic centre is considered to act at 24% wing chord
2. Wing lift was assumed to act at the chord-wise centre of pressure. An aerodynamic moment is then produced by the wing lift acting at the centre of pressure, about the wing flexural centre as

illustrated by figure 13. (The wing flexural centre is the chord-wise point on the wing structure where the wing will bend without twisting.)

3. The wing weight can also act at a distance from the wing flexural centre, also illustrated by figure 13. Combination of the moment couple that results from wing lift with the couple from wing weight, and adding this to the couple due to the inherent pitching moment coefficient of the wing profile $C_{Mo}$ fully defines the torque acting on the wing structure.
4. The chord-wise position of the wing centre of pressure obtained in 1 above can then be compared with that of chord-wise pressure distribution plots at each point on the aircraft flight envelope for correlation purposes. The chord-wise pressure distribution plots were generated analytically by Europas aerodynamicist and integrated by the author to provide accurate levels of load at each point on the aircraft flight envelope.
5. Agreement between the position of the wing centre of pressure from the chord-wise pressure distribution plots and the value obtained by formula 1 above was used as an independent check. Wing lift was then resolved into load increments forward and aft of the wing spar location.

The chord-wise position of the wing centre of pressure varies with wing angle of attack therefore necessitating the summation of torsional moments by the above method at conditions A, C, D, E, F and G on the aircraft flight envelope. High angle of attack conditions such as A,C,F and G result in forward biased chord-wise pressure distributions where the majority of the lifting load acts forward of the wing spar. In general these distributions results in a *nose up* type torque acting on the wing. Lower angles of attack such as conditions E and D result in 'flatter' more aft biased chord-wise pressure distribution, where, in the case of the Europa motorglider, the majority of the lifting load acts close to the main wing spar at 30% mean chord. In general these distributions result in a *nose up* type torque acting on the wing, with a lower magnitude to that of condition A and C.

The effect of airbrake and aileron deflection on the chord-wise position of the wing centre of pressure has also been considered at these points on the aircraft flight envelope. Aerodynamically the airbrake system has been designed to induce minimal change in the local pitching moment coefficient of the wing structure; however, local increases in drag result from airbrake deployment.

Aileron deflection on the other hand modifies the wing local lift coefficient and pitching moment coefficient. The result is a very aft chord-wise centre of pressure location (approximately 70% chord length) over the aileron portion of the wing during deflection Downward aileron deflection results in more negative values of local wing pitching moment coefficient combined with an increase in local wing lift, whereas upward aileron deflection results in a less negative value of pitching moment coefficient combined with a decrease in local wing lift. The effect of the aileron deflection on profile pitching moment is presented in figure 14.

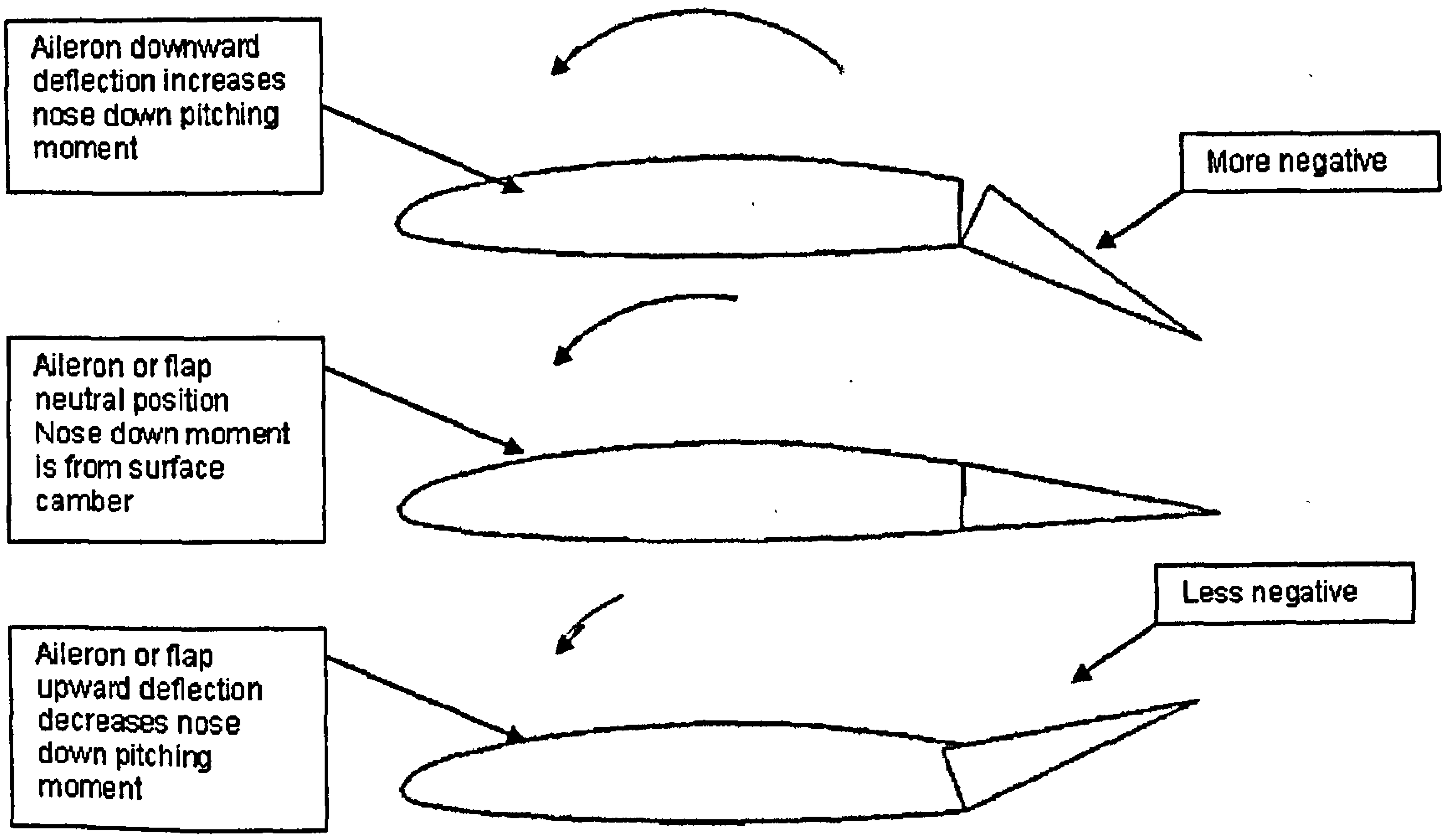



*Fig 14: Effect of Aileron Deflection on profile pitching moment*

## 2.6 Applied structural loads

It has been shown previously within this chapter that limit loads are defined within the airworthiness requirements to set categories that depend on the expected use of the aircraft, e.g., if the aircraft is aerobatic, the limit load would be considerably higher than if it were only used for carrying passengers. Limit loads are defined as the maximum loads that would be expected during flight. Application of these loads should produce no detrimental permanent deformation or elastic deflection of the structure that would impair the safe operation of the aircraft. A factor of safety must also be applied for both metallic and composite structures. This factor of safety is defined within the airworthiness requirements as 1.5. Traditionally aluminium has been used for aircraft primary structures. As a result aluminium wing structures are designed to meet ultimate loads and statically tested to meet limit load requirements prior to prototype first flight. It is necessary to demonstrate that during the limit load static test that all deflections of the wing structure are elastic. As the ultimate strength of aluminium is approximately 1.5 times the yield strength, it is assumed that the wing structure will not fail when loaded to ultimate loads. Ultimate load defined within airworthiness requirements is equal to 1.5 * Limit Load. This is a standard aerospace factor of safety. Aircraft structures should be capable of supporting ultimate load without failure for at least three seconds.

The use of composite materials for primary aircraft structures means additional factors of safety have to be considered to account for degradation in material strength due to the combined effects of moisture and temperature over the life of the aircraft. In addition another factor of safety used to account for manufacturing variability is also required. This factor is heavily dependent on the type of manufacturing process used. Early composite aircraft manufacturers adopted the approach of using an arbitrary 'plastics' factor of 1.5[13] to account for the effects of moisture, temperature, and manufacturing variability.

## 2.7 Metallic and Non-Metallic Material Properties

In order to size an aircraft structure accurately, particularly when assessing the capability of a structure to carry load without failing, knowledge of the mechanical properties of airframe materials is essential. The mechanical properties of metallic aerospace materials are well known. Their properties are available within the publications of the Engineering and Science Data Unit (ESDU) or within Mil-Handbook-5[16]. For composite materials however their mechanical properties are not well standardized due to the large number of variables associated with these materials. One typical publication Mil-Handbook 17[9] attempts to publish supplier's data. In practice however material properties for composite materials are best obtained from material coupon tests conducted on representative laminate structures.

Composite laminate qualification can be conducted by material coupon testing. Typical standard test methods can be used to characterize; tension (ASTM D3039), compression (ASTM D3410), in plane shear (SACMA8-17), short beam shear (ASTM D2344) and flexural properties (ATSM D790) of composite laminates. These test methods can be expanded to evaluate properties for orthotropic composite sandwich structures, and were used to characterize the composite laminates used in the construction of the glider wing.

Statistical manipulation of material coupon test results will give design allowables for these materials. Design allowables are material strength values less than the ultimate material strength values obtained from test results. These allowables depend upon what statistical method of reduction of the test data is made.

For metallic materials ESDU, Mil-handbook 5, and the Joint Airworthiness Requirements specify that: Where applied loads are eventually distributed through a single member within an assembly, the failure of which would result in the loss of the structural integrity of the component involved, the guaranteed minimum design mechanical properties ('A' values) should be met.

In addition, for redundant structures, in which the failure of the individual elements would result in applied loads being safely distributed to other load carrying members, the structure should be designed on the basis of 90% probability ('B 'values). An 'A' is a value above which at least 99% of the population of values is expected to fall within a confidence level of 95%. A 'B' value is a value above which at least 90% of the population of values is expected to fall within a confidence level of 95%. Statistical derivation of these values is presented within the Mil handbooks. Essentially, a 'B' basis material design allowables should be used for secondary structure, the failure of which would not be catastrophic to the aircraft. For primary and critical structures 'A' basis values should be used. Wing spar materials have 'A'-basis strengths, wing skin materials have 'B'-basis strengths.

## 2.8 Composite material factoring

Composite materials do not have a yield point therefore composite aircraft should be designed and tested to failure to establish margins of safety. Both aluminium and composite structures are designed with the standard factor of safety of 1.5. However additional composite factors are required to account for the following:

- Degradation of composite material strength due to manufacturing variability
- Degradation of composite material strength due to the effect of moisture ingress and elevated temperature over the life of the aircraft

Material coupon specimen testing is required to qualify the resulting composite 'super factor'. During the course of this work the author noted that the results of these tests depend heavily on the resin system of the material and manufacturing process used.

The author developed the following composite super-factor to design the glider wing structure. This factor is based on the results from the material coupon testing presented within Appendix I and can be broken down as follows,

| | |
|---|---|
| Factor accounting for manufacturing variability | $K_V$=1.20 |
| Factor accounting for thermal degradation | $K_T$=1.25 |
| Factor accounting for degradation of material due to moisture ingress (minimum value) agreed with PFA | $K_M$=1.0 |
| Super-factor (minimum value) | 1.2*1.25*1.0*= 1.5 |

This super-factor can vary heavily depending on the type (nature of processing, wet-lay-up, prepreg) of materials used.

Multiple coupon testing was also necessary to produce B value design allowables for the composite materials used on the Europa glider wing. The composite super-factor above was derived using the statistical data reduction methods specified within JAR-VLA, acceptable means of compliance number

619. This factor was then used in conjunction with the basic factor of safety of 1.5 to produce an ultimate test factor for the glider wing static load test. The glider wing static load test was conducted at room temperature conditions, therefore the additional load level is used to compensate for not having the structure fully moisture conditioned or tested at elevated temperature.

The resulting effect of combining these static strength load factors is highlighted in table 1.

| WING STRUCTURE | LIMIT LOAD Defined within airworthiness requirement | ULTIMATE LOAD | TEST FACTORED LIMIT LOAD | TEST FACTORED ULTIMATE LOAD |
|---|---|---|---|---|
| METALLIC | 3.8g | 3.8*1.5 =5.7g | - | - |
| COMPOSITE | 3.8g | - | 3.8*1.25*1.2*1.0 = 5.7g | 5.7*1.5 = 8.55g |

*Table 1: Derivation of Limit, Ultimate, Test Factored Limit and Test Factored Ultimate Load.*

By establishing the effect of temperature and moisture on the structure by material coupon testing, this allows the glider wing structure to be tested at room temperature without any moisture conditioning, although, as can be seen above, the metal components would be overstressed by a factor of 1.5 in the process.

Chapter Summary

This chapter has presented the importance of the aircraft flight envelope (V-N) diagram and its significance when deriving loads acting on a wing structure. In addition the process of aerodynamic load derivation at conditions A, C, D, E, F and G on the aircraft flight envelope have been presented. Actual loads derived from this analysis are made available within appendices B through G. The inextricable link between composite material selection, structural design, and limit load has been shown through composite material super-factoring

# 3 Prototype Glider Wing Detailed Design Constraints

## 3.1 Overview

In addition to loads derived for the glider wing structure within chapter 2, detailed design constraints such as geometry limitations, control circuit stiffness and flutter prevention had to be investigated. This chapter examines briefly these additional constraints and their impact on the retro-fit nature of the glider wing structure.

## 3.2 Geometrical Constraints

### 3.2.1 Fuselage wing spar housing

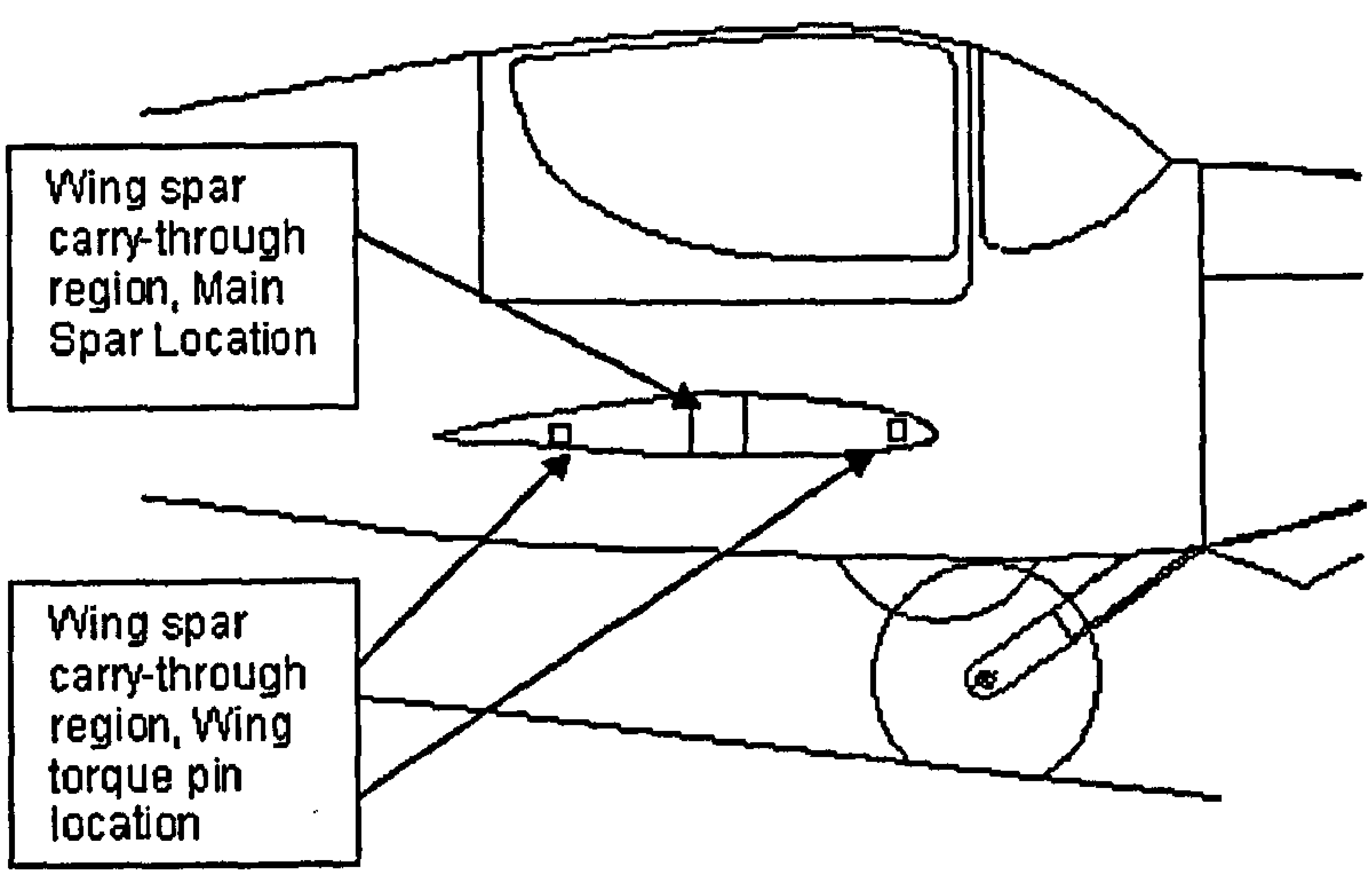



*Fig 15: Fuselage Wing Spar housing*

The wing spar housing as illustrated within figure 15 cross sectional geometry within the Europa fuselage dictates the maximum depth that can be used to house a wing spar and therefore, support wing spar bending stresses. The horizontal proximity of the seatback bulkhead in relation to the main fuel tank and the aileron coupling mechanism restricts spar width. The spar depth is restricted by the vertical slot location of the wing spar on the fuselage side and wing profile geometry. These constraints limit the effective depth of the spars at the outer most spar pin location, the point of maximum wing bending stress. Analysis of the bending stresses developed by the wing at points A, C, D, E, F and G on the aircraft flight envelope yield peak values of load at this point. The cross sectional area of the spar boom at this point drives spar material choice. The upper spar boom is particularly critical as it supports compressive loads due to spar bending. The shear stresses experienced by the spar shear web are also maximum at the outermost spar pin location. The intensity of shear and endload experienced by the spar varies from a maximum at the wing root to a minimum at the wing tip. The load gradient developed along the length of the wing spar can be matched by staggering the spar shear web plies and tapering the spar boom roving cross sectional area along the spar.

### 3.2.2 Wing spar coupling mechanism

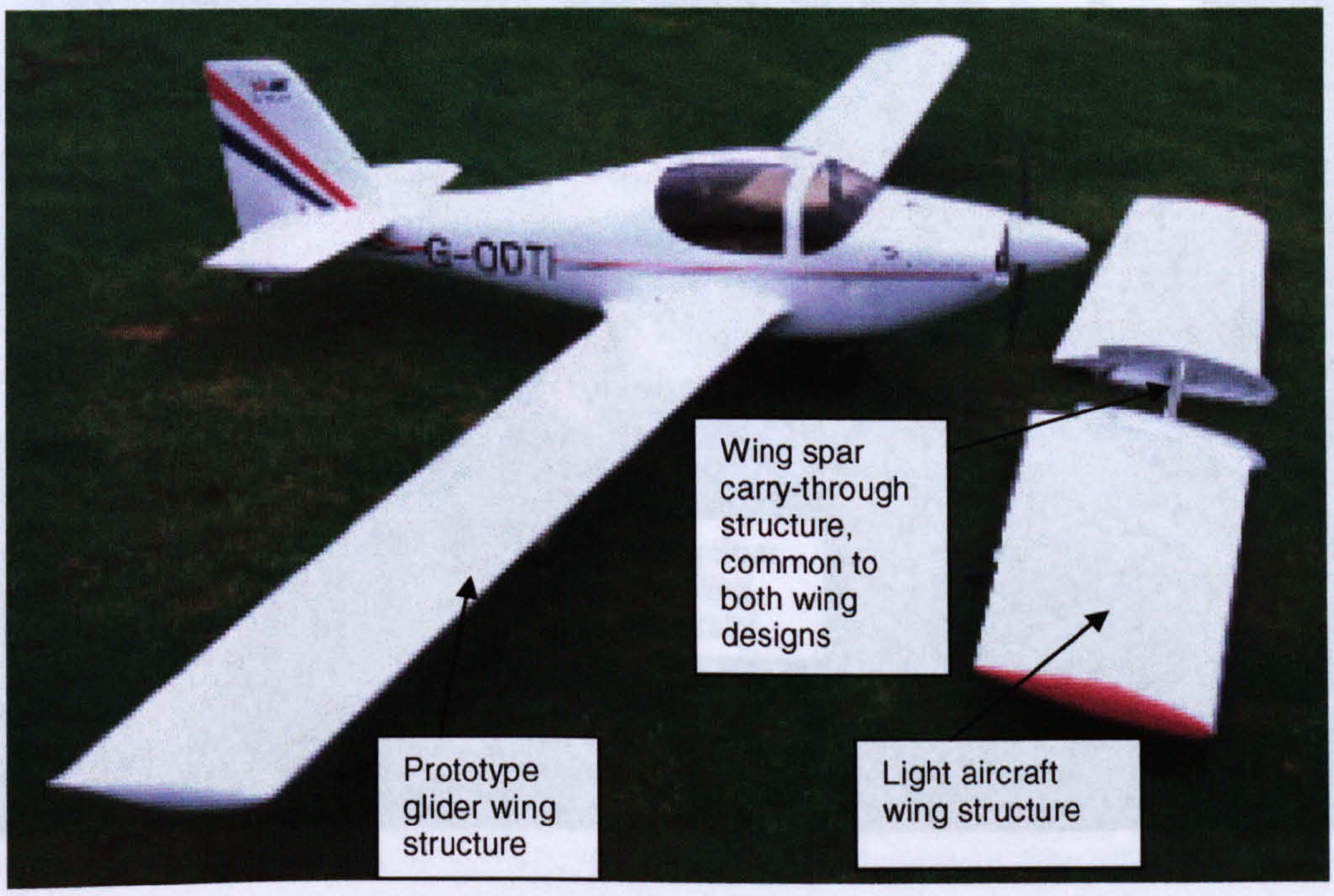



*Fig16: Retrofit visualization of wings showing spar coupling*

The retro-fit nature of the prototype glider wing and the light aircraft wing spars is highlighted in figure 16. The wing spar coupling mechanism is illustrated within figure 17. This system employs two 0.5 inch (12 mm) pins that locate within both wing spars through the cockpit seatback. Analysis of the wing spar coupling by hand calculation, in conjunction with results from previous static strength tests conducted on the 'Fast-build' light aircraft wings revealed that the failure mode of the wing spars is by spar buckling between the two spar pins. This mode of failure was aggravated by the single shear overlapping nature of the coupling mechanism. The spar pins were prevented from being put into double shear due to the close proximity of the seat back and fuel tank bulkheads. To prevent wing spar buckling, an alternative solution was sought. The solution employed a composite restraint that was attached to the forward wing spar which tied the spars together midway between the spar pins. Sufficient clearance between the restraint and the spar was left to allow vertical movement of the spar between the spar pins during normal bending of the wing. The wing spar buckling restraint is presented within figure 17.

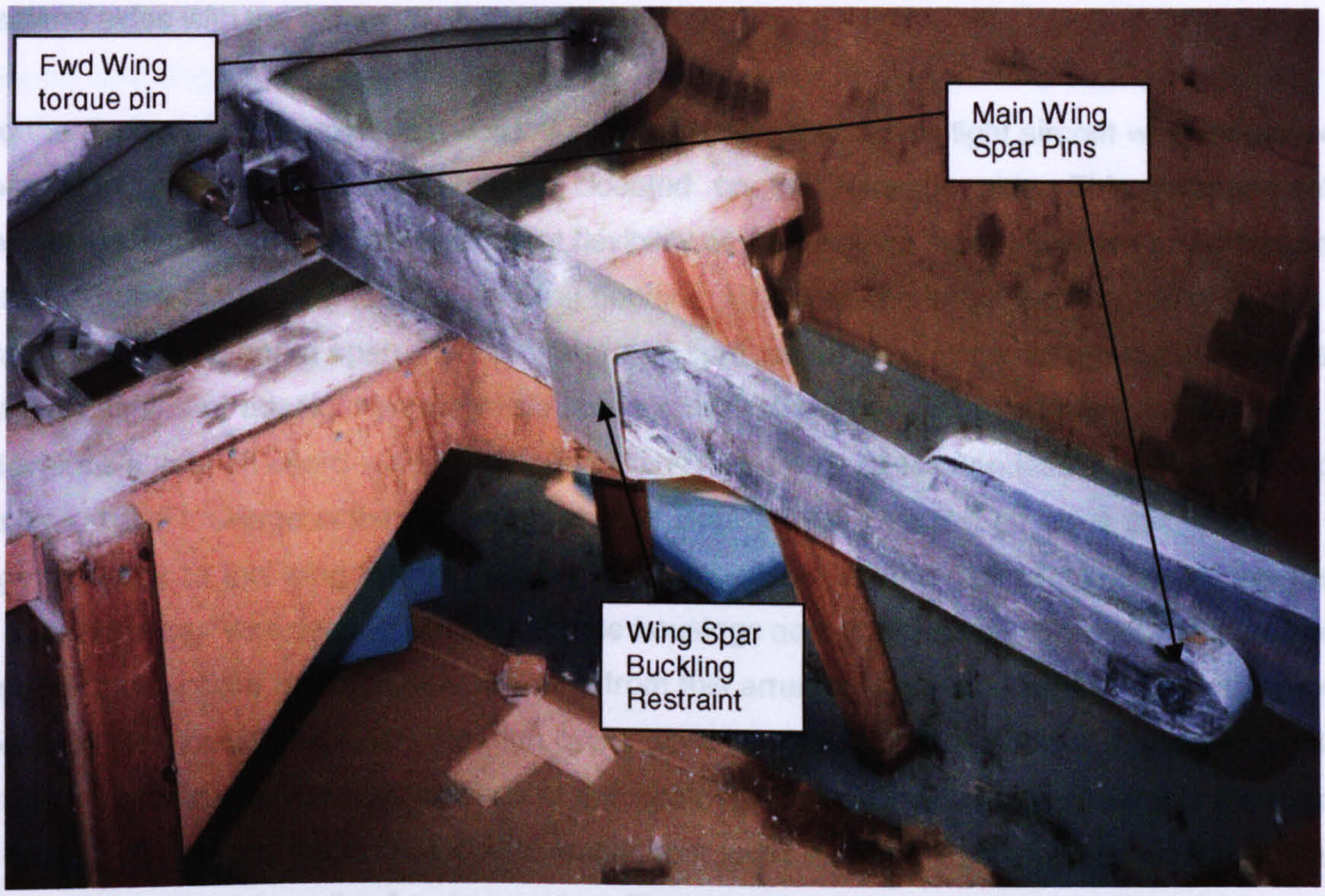



*Fig 17: Wing Spar Buckling restraint, showing wing pin detail*

### 3.2.3 Wing torque pin housing located on the fuselage sides

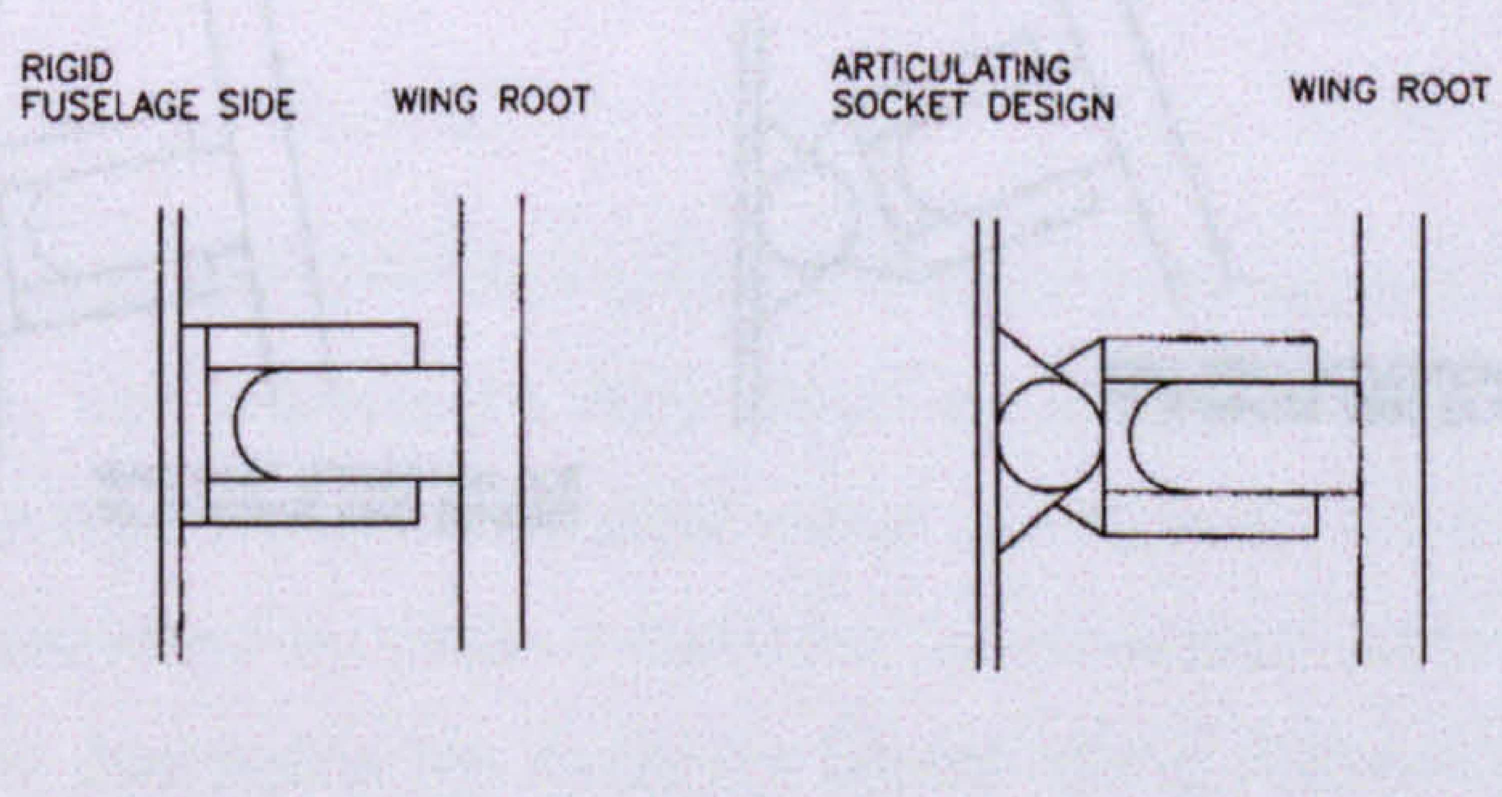



*Fig18: Wing Torque Housings located on the Fuselage sides*

To maintain commonality with the light aircraft wing, the housings located on the fuselage side, as illustrated within figure 18, are used to diffuse torsion from the main wing as shear into the fuselage, had to be the same. The glider wing torque pins were therefore designed to locate within these housings on the fuselage sides with the minimum of change.

Prior to the design of the Europa 'fast-build' light aircraft wing the classic light aircraft wing employed rigid stainless steel pins within a rigid housing located on the fuselage side. This arrangement was inexpensive. However it relied on the inherent flexibility of the fuselage sides to relieve any offset bending loads that occurred from wing torque and wing bending. However, the larger span of the prototype glider wing, with its more outboard span-wise centre of pressure, develops a larger forward span-wise bending load at high angles of attack, than the basic light aircraft. In addition, with airbrakes deployed the glider wing develops a very aft chord-wise bending load. These extreme cases can lead to the sandwich panels that make up the fuselage sides experiencing high Brazier type bending stresses in the region of the fuselage adjacent to the wing torque housing. To compensate for the lack of stiffness of the fuselage sides, a steel 'tie-bar' was used to join both torque housings across the inside of the aircraft fuselage. The increase in rigidity of the fuselage side resulting from this arrangement could lead to the rigid torque pins that locate in the housing experiencing high cyclic bending stresses. The mode of loading is highlighted within figure 19 for clarity. Analysis of loads at this point[22] indicated that a fatigue failure of the torque pin could occur. To prevent loads that could result from both extreme bending load cases, articulating sockets were employed on the fuselage sides. These sockets prevent the rigid torque pins and the adjacent wing root insert within the prototype glider wing experiencing any offset bending.

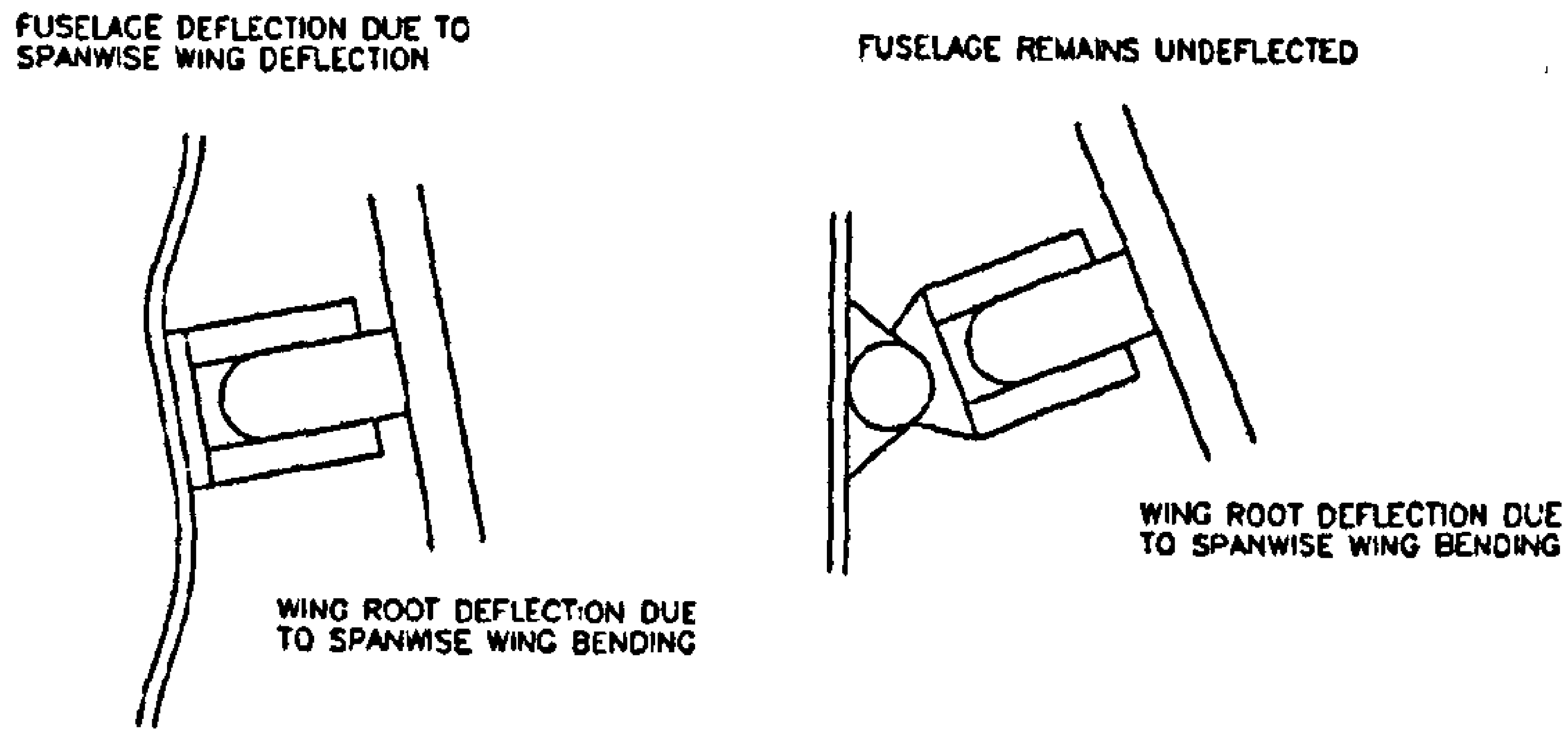



*Fig 19: Wing Torque Housing modification*

## 3.3 Control circuit stiffness

The vibratory response of a wing aileron surface, is not only a function of surface torsional stiffness, but also a function of the general stiffness of the aileron control circuit as a whole. To minimize the effect of control circuit flexibility, the Europa glider wing structure employs a conventional push-rod aileron control mechanism, with travel and gust limiting stops. The system was designed and tested to meet the control circuit stiffness requirements of JAR-22.

The aileron coupling mechanism is common with that of the light aircraft wing and uses the same self aligning and connecting 'flipper' plates as illustrated within figure 20.

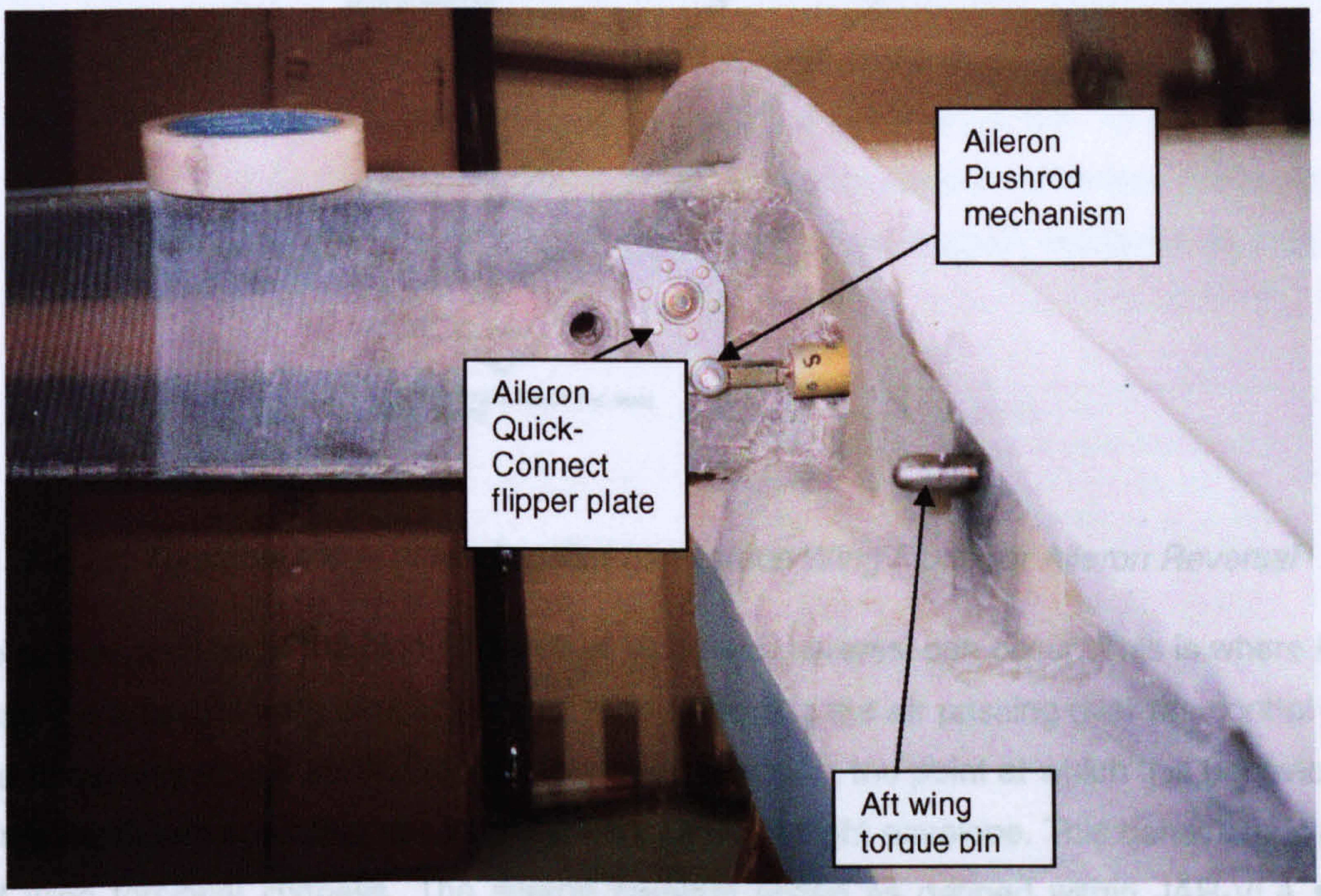



*Fig 20: Aileron Self-Aligning and Connecting 'flipper' plate*

## 3.4 Wing flutter

Unfortunately composites, specifically GRP and graphite sandwich laminates, similar to those selected for use on the glider wing skin, can experience high strain rates under load. Wing flexibility can initiate distortions that, in the case of high aspect ratio glider wings can have an adverse effect on lateral stability. A typical mode of loading generated by these instabilities is presented within figure 21. Wing twisting in response to aileron deflection decreases the available lateral rolling moment of the wing as a function of the dynamic pressure. Dynamic pressure is proportional to airspeed squared, because as speed doubles the loads on the wing quadruple.

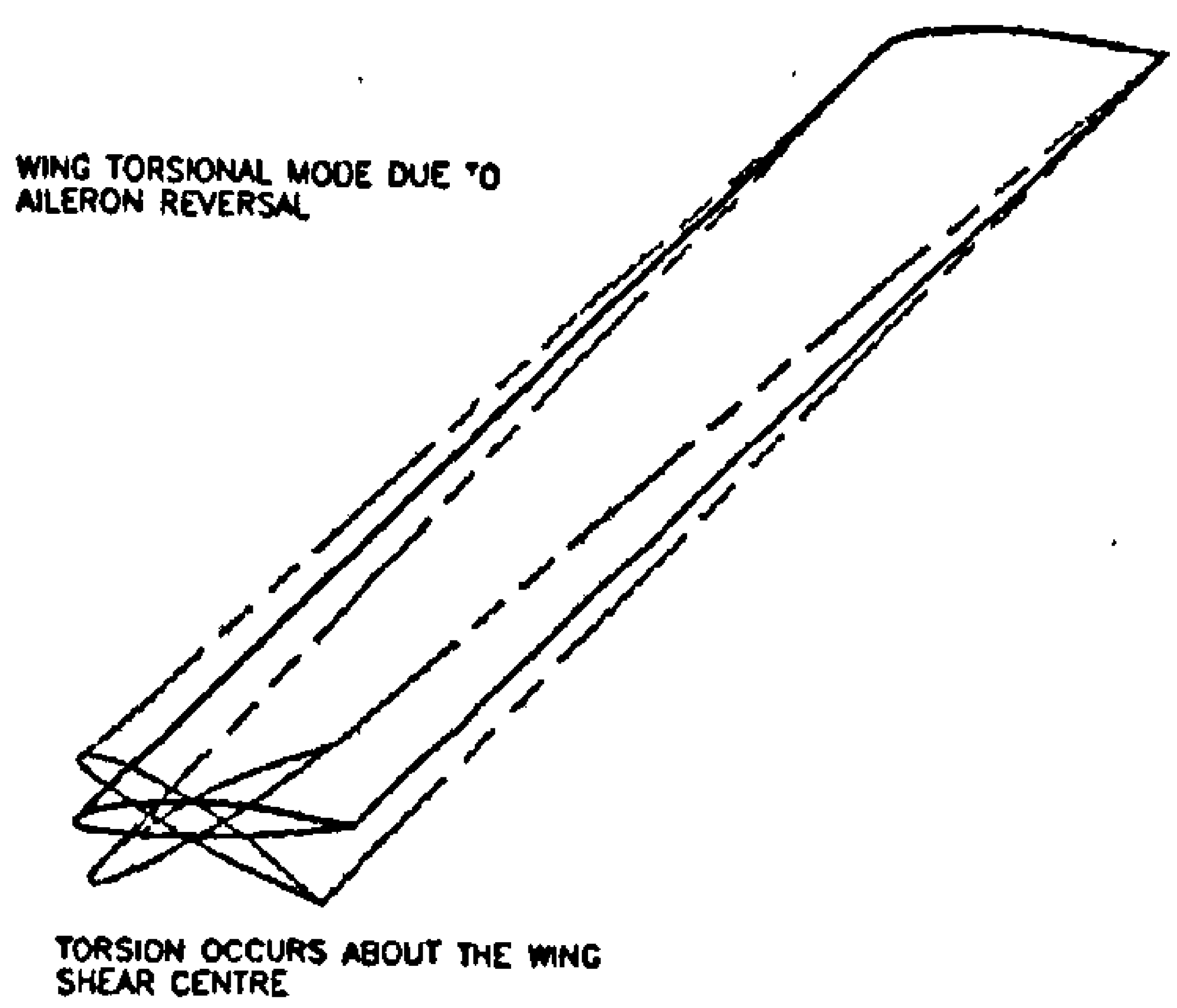



*Fig 21: Torsional Mode of loading that can induce Wing Flutter or Aileron Reversal*

In extreme cases, such as at the high airspeed of $V_D$ aileron reversal can occur. This is where the aileron load deflects the adjacent wing structure rather than deflecting the air passing over the control surface. It is therefore necessary to ensure that the aileron reversal speed, the point at which this behaviour occurs, is beyond the maximum operating speed of the glider aircraft flight envelope. This behaviour is primarily a function of wing torsional stiffness. The aileron reversal speed as defined within JAR-VLA should not occur at an airspeed 20% greater than the design dive speed $V_D$ at condition D on the aircraft flight envelope.

One benefit of both GRP and CRP composite materials is the ability to tailor wing skin thickness and fibre orientation to increase the torsional stiffness of the wing structure, correcting resonant flutter problems. The long span of the glider wing, in conjunction with its shorter chord makes the glider wing more susceptible to torsion instability. To prevent the possibility of unwanted, dangerous aeroelastic behaviour, solutions to the problem of Flutter and Divergence –aileron reversal- were sought. These were presented within the FAA engineering and Equipment Report No 45 [7] and within the appendices of BCAR section K[6]. These references provided basic stiffness criteria to which the stiffness of the glider wing was designed to meet in order to prevent this phenomenon occurring within the aircraft flight envelope.

Chapter Summary

This chapter has reviewed the additional design constraints that also needed to be satisfied so that the prototype glider wing could be a true retro-fit structure. Geometrical constraints associated with the fuselage and control circuit mechanism have been described in detail and addressed. In addition the importance of control circuit and wing skin stiffness has on wing flutter avoidance has been presented.

# 4 Prototype Glider Wing Structural Design

## 4.1 Main wing spar structural design

The primary structural component in any wing is the wing spar. The wing spar must transfer wing bending moments and shear loads along its length to the fuselage attachment and wing/fuselage carry through structure. In order to maintain commonality in manufacturing processes with its light aircraft counterpart, the glider wing spar consists of a wet lay up composite box beam structure. Its basic construction is presented within figure 22 for clarity. Both sides of the wing spar booms in the box beam structure are supported by the spar shear webs. The spar booms therefore have good resistance to crippling when subjected to compression loads.

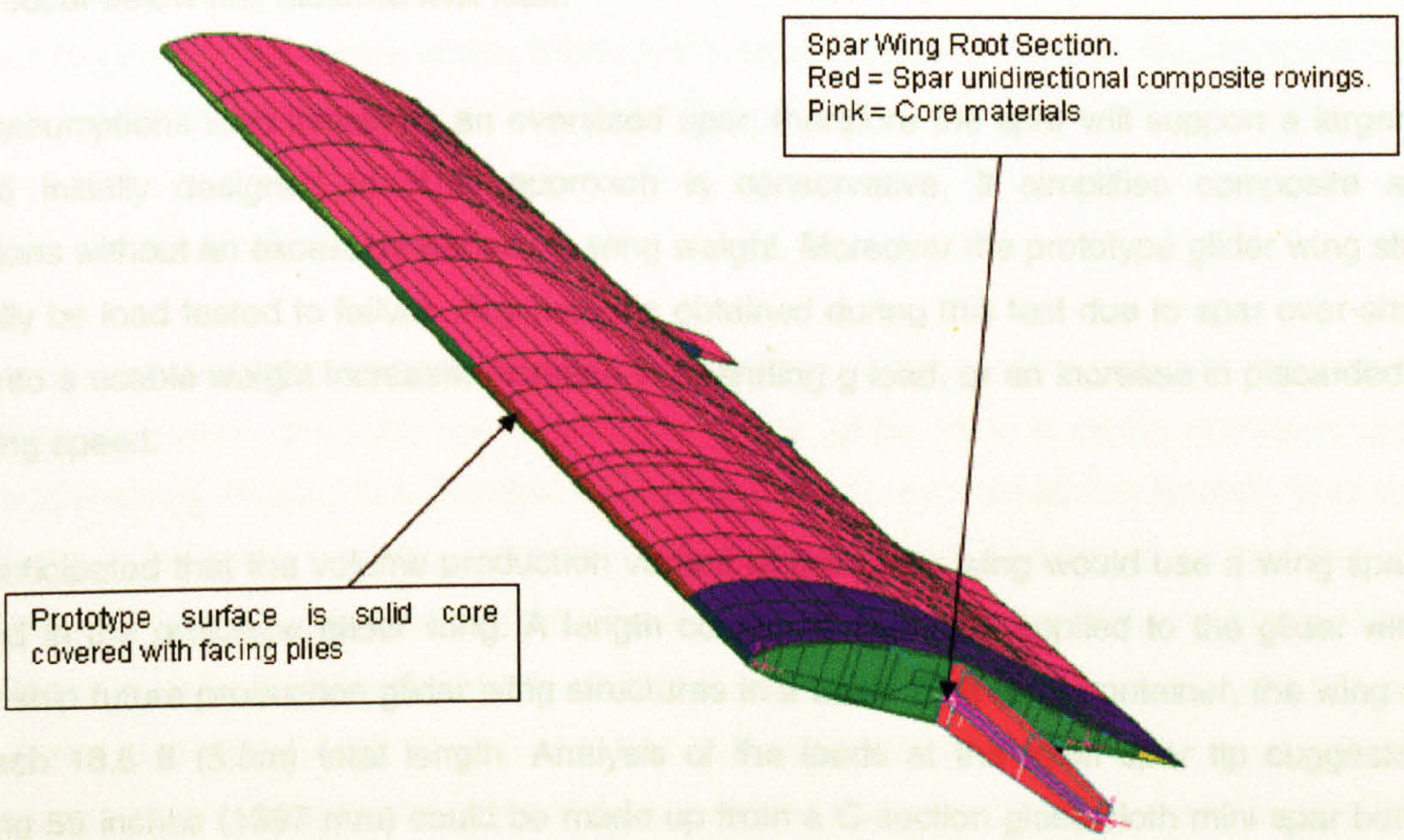



*Fig 22: Glider Wing Spar cross section at Wing Root*

Spar booms, particularly those of a fibrous composite nature, can cripple at very low stress levels if they are not supported normal to the boom plane.

By supporting the spar boom on all sides it is possible in some cases to achieve the full compressive strength of the spar boom material. The prototype glider wing spar is also symmetric, improving the stability of the spar structural design.

Simplified assumptions [1][2][3] taken during the structural sizing of the prototype Europa glider wing structure were that:

- The wing spar boom structure carries the longitudinal loads due to bending.
- The shear web was sized only to carry the wing shear loads. As shown within chapter 2, the shear loads, at any specific station, are the total air-loads outboard of that wing station minus the wing weight.
- The wing skin facing plies take only the shear loads due to torsion and wing span-wise deflection.
- Due to the mouldless foam core nature of prototype construction, elastic buckling of the wing skins need not be considered, however permanent deformation of the wing skins should not occur below test factored limit load.

These assumptions lead initially to an oversized spar, therefore the spar will support a larger load than the load initially designed to. This approach is conservative. It simplifies composite spar sizing calculations without an excessive penalty in wing weight. Moreover the prototype glider wing structure will eventually be load tested to failure. Any margins obtained during this test due to spar over-sizing can be turned into a usable weight increase, increase in operating g load, or an increase in placarded maneuver or cruising speed.

It was anticipated that the volume production variant of the glider wing would use a wing spar similar to that used in the prototype glider wing. A length constraint was also applied to the glider wing spar. In order to ship future production glider wing structures in a basic 20 ft (6m) container, the wing spar would only reach 18.5 ft (5.5m) total length. Analysis of the loads at the main spar tip suggested that the remaining 55 inches (1397 mm) could be made up from a C-section glass cloth mini spar bonded to the tip of the main wing spar. The size and thickness of the spar could be determined by hand calculations and spreadsheet analysis. The weight of the glider wing spar was also calculated and verified by weight test.

Analysis of the ultimate bending moment and shear force values acting on the wing, at all conditions of the aircraft flight envelope, in conjunction with extreme fibre geometry of wing spar, allowed shear stresses and longitudinal fibre stresses to be obtained at various points on the cross section of the spar. These calculations were repeated at various span-wise stations along the prototype glider wing structure. Spreadsheets were developed that enabled spar boom cross sectional areas and shear web plies to be variable factors along the length of the wing spar. These spreadsheets are presented within appendix F. This approach considers the second moment of area required to support the ultimate longitudinal stresses in the extreme outer fibres of a specific wing spar boom material to be varied until acceptable factors of safety (defined as Reserve Factors) on material ultimate strength and fatigue could be obtained. From this approach unidirectional carbon fibre rovings were selected for the wing spar boom material. Bi-directional glass fibre cloth was selected as the wing spar shear web material for the prototype glider wing.

Reserve Factors are defined within the appendices of this thesis as Allowable Load divided by the Applied Load. Within JAR-VLA[5], acceptable means of compliance number 572 a test factored limit stress level for CFRP unidirectional rovings of 58000 psi (400 mpa) is acceptable to ensure against fatigue, without additional testing. Consideration was given to designing the spar roving materials to meet this requirement. The A value ultimate tensile strength of the unidirectional rovings selected for the spar boom materials is 160000 psi. (1100 mpa) At limit load, the spar tensile stress levels are approximately 54553 psi (376 mpa) by analysis, very close to the level required by JAR-VLA. An ultimate load test was conducted to establish the actual stress levels in the spar. Formulae used for the structural design of the wing spars are listed within appendix F together with their relevant spreadsheet cell number.

## 4.2 Main spar detailed design

A section of the glider wing spar is presented for clarity in figure 23. One problem with both fibrous wet lay-up glass and carbon fibre spar boom structures is that, all the glass or carbon filaments cannot be laid down straight during construction therefore, a truly consistent resin content or ultimate fibre compressive strength cannot be achieved. As a result the laminates contain a lot of localized strength deficiencies. One solution to the problem is through the use of pultruded-post cured carbon fibre rods. The pultrusion process forms a carbon rod in a machine that then lays all filaments straight, parallel and under equal tension. Resin content is closely controlled during pultrusion; therefore the maximum performance can be obtained in every fibre resulting in tensile and compressive strengths far above basic wet lay-up yarn.

The problem with this type of pultruded fibre is that the outboard section of current spar structures requires a gradual decrease in spar boom cross sectional area, which is obtainable with basic wet, lay up rovings, but would require considerable redesign of the spar if pultruded-post cured fibre was used. In addition wet lay up yarn would be required to form the inboard curve of the current spar boom design. Joining basic wet lay-up yarn to pre-cured rovings would also require a costly material testing programme.

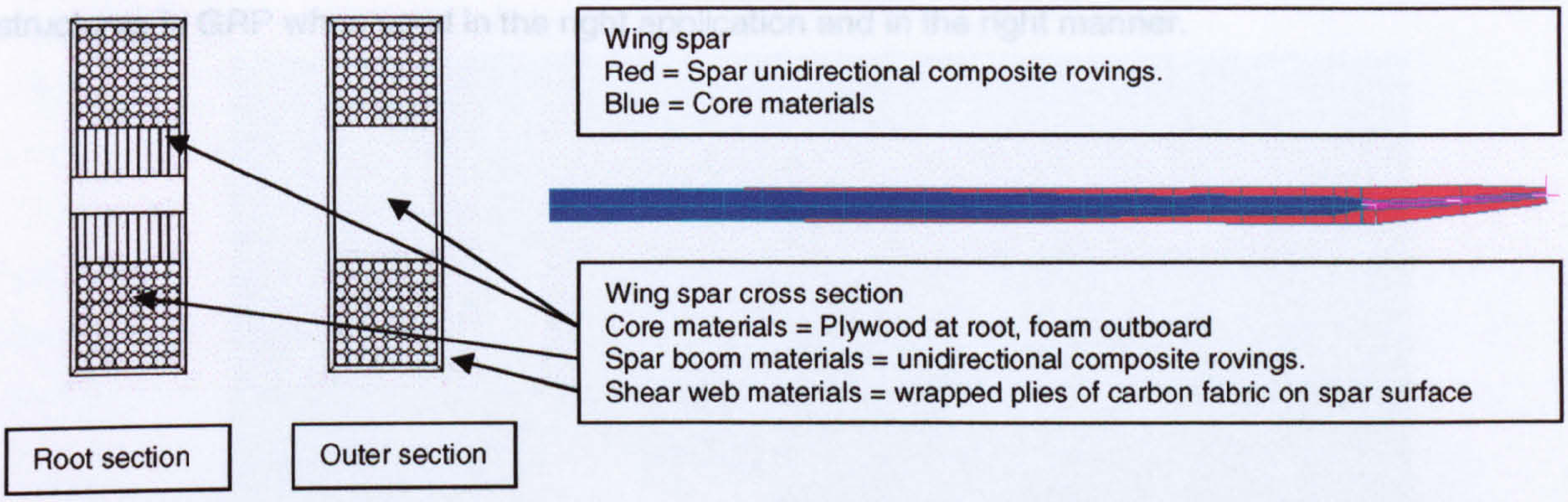



*Fig: 23 Spar Roving Geometry Variation along Span of wing (Rovings being red and core materials, blue)*

Although the benefits in weight and strength are apparent with pultruded-post cured carbon fibre, this solution would also cost approximately 1.5 times as much as the current wet lay-up spar design. As a cost effective compromise, additional quality assurance procedures were introduced to ensure wet lay-up glider wing spar strength. These included additional thermal condition monitoring during cure and post cure and more stringent visual inspection prior to shear web closure in order to reduce fibre waviness.

## 4.3 Prototype glider wing skin structural design

For the prototype glider wing skin structure, the mouldless foam core technique employed on the Europa classic light aircraft wing, was modified and applied to the glider wing as presented in figure 25. Bi-directional cloth was used as a rib material. These ribs were bonded to the terminating outboard length of each polystyrene foam block. The aerodynamic surfaces were hot-wire cut from polystyrene foam and bonded to the main spar structure.

*Fig 24: Construction of the Prototype Glider Wing Leading Edge structure*

This method of sandwich construction is an extremely effective way of producing stiff, light inexpensive structures in GRP when used in the right application and in the right manner.

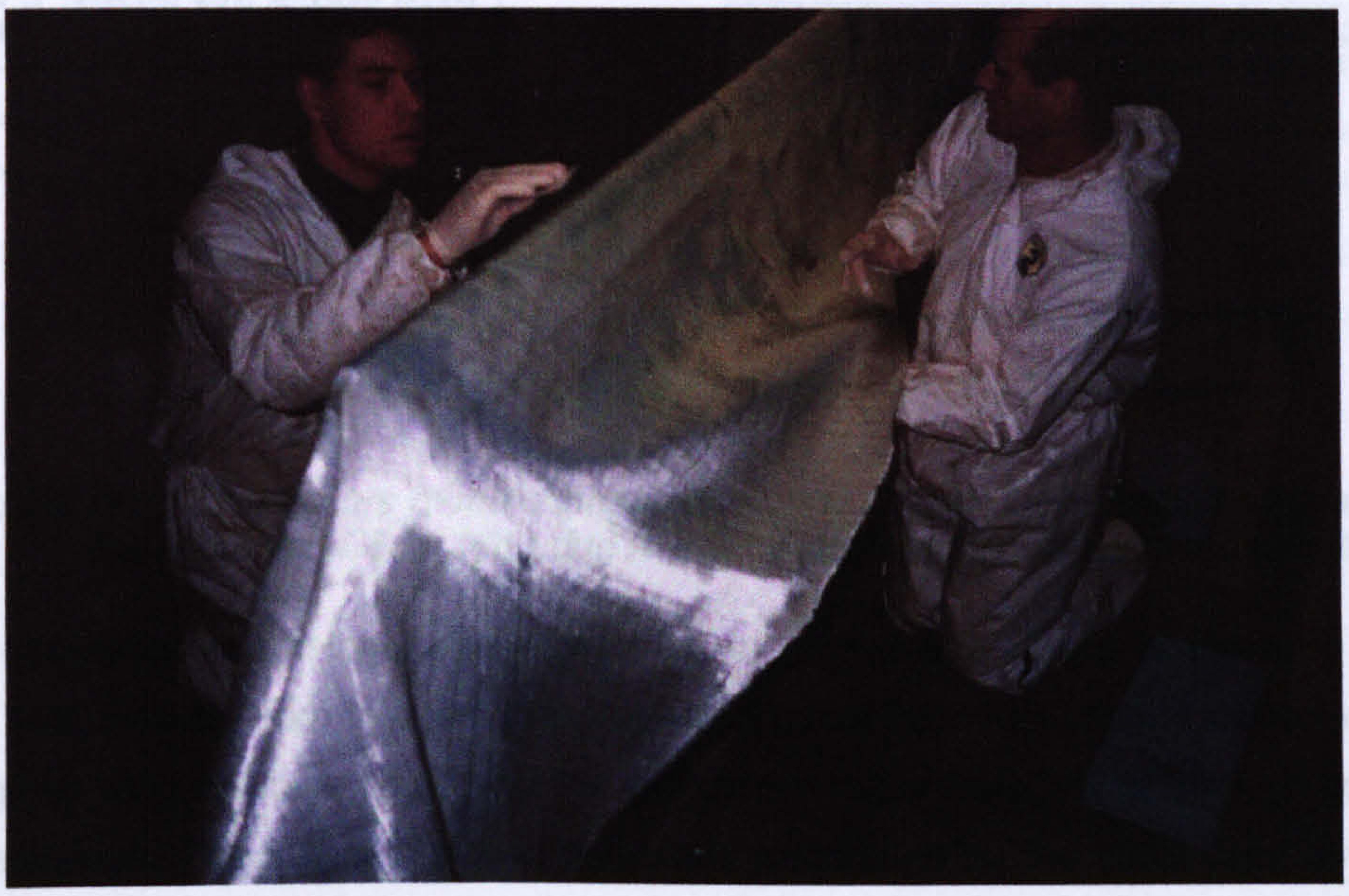


*Fig 25: Wing Skin construction*

The wing structure was then skinned with five layers of cloth. Initially two layers of bi-axial cloth oriented at $\pm$45 degrees were laid-up over the full semi-span of the wing.

Next one layer of uni-directional cloth orientated span-wise was used to reinforce the leading edge of the wing D-box structure and improve general torsional stiffness. Finally two local layers of bi-directional cloth were used to reinforce the walkway region of the wing structure. To close-out the wing skin trailing edge multiple layers of bi-directional cloth was used. This cloth has an 8 harness satin style weave with exceptional drapability. This feature was necessary to cope with the reverse curvature of the air-brake closeout structure. The final wing structure was then filled with a phenolic filler and sanded. Profile blocks located along the wing chord were used to maintain correct wing profile shape during sanding. Construction of the wing skin is presented in figure 25.

Wing skin cloth was sized purely on its ability to support torsional shear stresses. Results from this analysis are presented within appendix H(iv). Elastic buckling of these wing skins was not considered. Previous ultimate load tests conducted on classic light aircraft wing structures manufactured by similar construction methods had shown that the wing skin failed in compression at the junction between stepped cloth lay-ups due to an abrupt change in the skin second moment of area. This forced a permanent crease to develop on the upper surface of the wing structure that crimped the polystyrene foam core. The post buckling stiffness of the crimping interaction between the solid core and the skin did however prevent catastrophic failure of the wing structure. A similar failure mode was observed on the glider wing skin structure when tested beyond limit load.

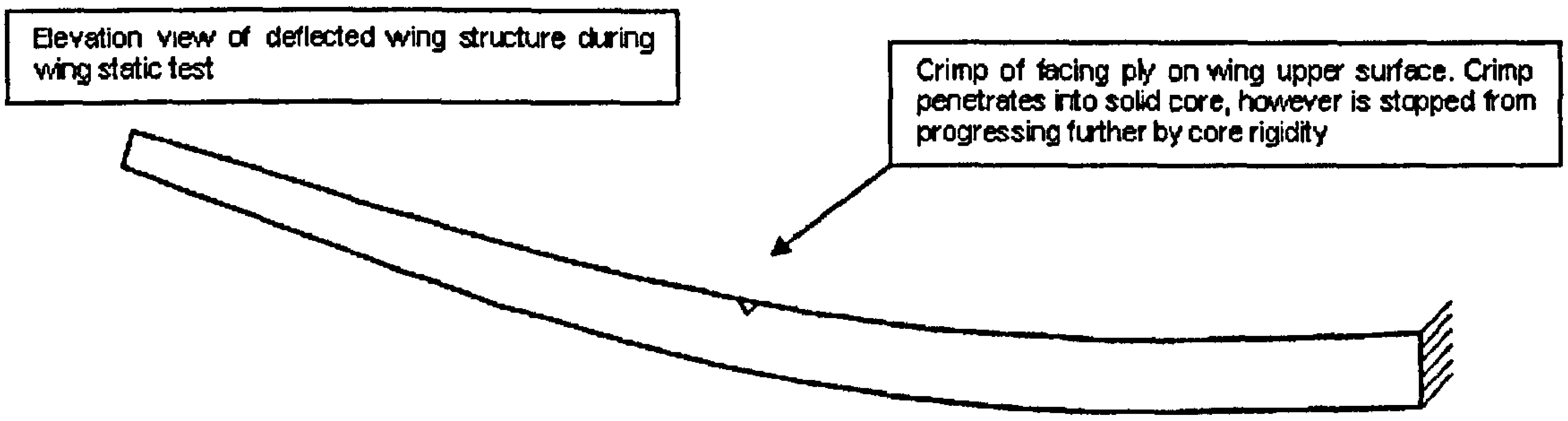



*Fig 26: Wing Skin Failure mode shared by both the Classic Light Aircraft wing and the Prototype Glider wing due to their Mouldless Construction technique*

In addition to calculation of torsional shear stresses, the torsional stiffness of the wing structure was determined by test. Results from this test are presented within appendix H(iv). This test concluded that the prototype glider wing structure could possibly experience flutter instability at the high speed end of its defined flight envelope. The author imposed numerous restrictions on the initial flight envelope for test flying purposes on the proof of concept glider aircraft to ensure that this phenomenon did not occur during flight. This included a weight restriction of 1200 lb (544 kg). Additional analysis was conducted to ensure that this phenomenon occurs beyond the production glider flight envelope.

Prior to first flight a static strength proof load test was also conducted on the glider wing structure. The proof load test report for the prototype glider wing is presented within appendix K for reference purposes only. This test was conducted in a manner so that realistic loads could be achieved in the wing spar and wing to fuselage attachment structure.

In addition to the main wing structure the wing aileron and airbrake surfaces were also fabricated using hot-wired styrofoam cores laminated with glass facing plies. The support from the polystyrene foam prevents the onset of elastic buckling of these surfaces. Again aileron and airbrake skins were sized on their ability to support bending stresses and torsional shear stresses that are developed during deflection.

Prior to first flight a static strength proof load test was also conducted on both the aileron and airbrake surfaces.

## 4.4 Flight testing of the prototype glider wing

First flight of the prototype glider wing was conducted on July 12th 1999. After numerous flight tests to assess the aerodynamic performance of the aircraft at the prescribed points on the flight envelope, the flight-test program concluded that the longitudinal and lateral stability characteristics of the aircraft lay within acceptable parameters without the necessity of increasing horizontal or vertical stabilizer size. The prototype configuration of the aircraft is presented within figure 27. The prototype wing formed the basis from which a low to medium volume pre-moulded wing structure could be developed.


*Fig 27: Prototype Glider Wing aircraft in flight*

The structural design study for a low to medium volume pre-moulded derivative of the glider wing was now conducted. This new wing structure was used to fully assess the aerodynamic performance of the glider wing at all design weights up to 1370 lb (623 kg). A wing weight target of 130 lb (59 kg) was also considered.

Chapter Summary

Reasons for the general structural design of the prototype glider wing have been presented in detail. The choice of materials for the prototype glider wing spar and wing skins has been presented.

# 5 Structural Design of the Pre-Moulded Glider Wing for Volume

# Production

## 5.1 Overview

In order to mass produce the glider wing structure and reduce wing structural weight for a given torsional rigidity, it was necessary to review the construction of the fast-build light aircraft wing. This wing used the existing classic light aircraft wing spar mated to orthotropic sandwich wing skins.

## 5.2 Sandwich wing skin construction

In any sandwich composite, like those of the fast-build light aircraft wing skins, the core bears the greatest portion of the shear loads of a panel in flexure. An example is presented for clarity in figure 28. The facing plies of sandwich composites are made from relatively low modulus fibres, which means that attention has to be paid to total panel stiffness. Bending stiffness is a function of core thickness, facing ply type and orientation. The whole sandwich composite should be designed to suit the physical loading requirement, in this case uniformly distributed air loads.

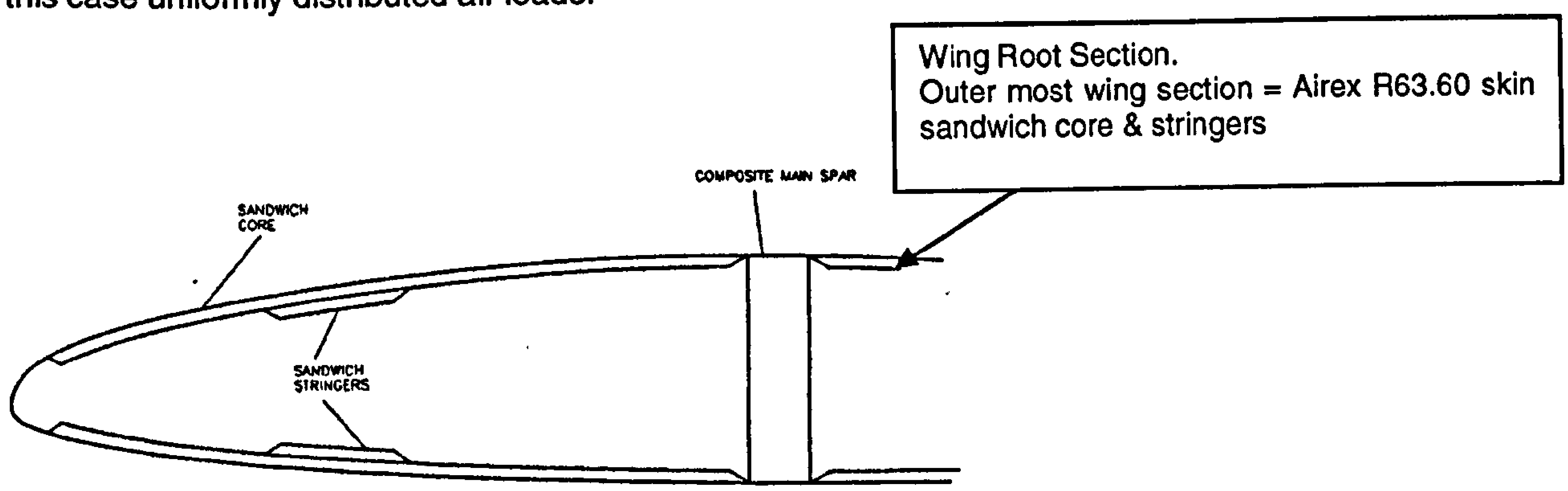



*Fig 28: Sandwich Wing Skin construction*

Sandwich properties vary considerably with skin reinforcement type, and the level of adhesion between the resin to the fibre and the resin to the core. Sandwich shear properties are in most cases, inversely proportional to core thickness.

In addition to basic static strength requirements, the loading frequency applied to the sandwich requires investigation. Repetitive stresses or deformations often cause damage or failure even if these are well below their allowable values for static strength. This phenomenon, called fatigue, occurs for example, in slamming of boat hulls, vibration of non-moving parts in vehicles and aircraft or any other type of repetitive loading of structures. Fatigue is generally said to cause the major part of all structural failures, but for sandwich structures this is not true: sandwich constructions have gained a reputation for being a very good concept in avoiding fatigue failures [16] [23]. One reason is that the faces fail in local instability at loads lower than the fatigue limit and the core is designed with a high margin of safety due to a lack of knowledge about its fatigue properties. The constituents in a sandwich are subjected to different kinds of loading: the faces exhibit almost entirely membrane tension/compression of the core in pure shear. The core on the other hand exhibits a more complex loading situation and fatigue data are almost non-existent. When subject to combined loads sandwich panels can fail in several ways, each failure mode giving one constraint on the load bearing capacity of the sandwich. Depending on the geometry of the sandwich and the loading, different failure modes become critical and set the limits for the performance of the structure. These failure modes have been highlighted for clarity within figure 29, 30 and 31.

### 5.2.1 Core shear failure

In a sandwich panel, the core material is mainly subjected to shear as it carries almost the entire transverse force. Direct stresses in the core can be of the same order of magnitude as the shear stresses. The direct stress is much lower than the shear stress reducing the maximum shear stress. This shear stress produces a tensile stress equal to compressions stress at a 45 deg angle from the x direction which causes cracks inclined 45 degrees (0.786 rads). Such cracks are typical for shear failure and are also called shear cracks. This failure mode can be used as a failure criterion. Core shear failure was considered as a criterion for the FE model developed for the production glider wing.


*Fig 29: Core Shear failure*

### 5.2.2 Buckling failure

From a series of experimental tests conducted on the Europa fast-build light aircraft wing by the author, it was deduced that the buckled sandwich usually retains its original state if unloaded, providing the facing plies have not failed, and therefore buckling has not damaged the structure. If however the buckling load equals the maximum load that can be applied, it means that the structure has actually failed. If the deformation is controlled, the load will drop after buckling, and if the loading continues the deformation will increase until failure. Final failure of a buckled sandwich panel can occur in several ways:

(1) The facing plies on the compressive side of the sandwich fail in compression
(2) The facing plies on the compressive side of the sandwich fail by wrinkling
(3) The foam core fails through shear fracture.

Point (3) tends to occur when the deformation increases so does the transverse force and eventually the transverse force grows to a level that will initiate core shear fracture. This kind of failure mode can appear as visible shear crimping.

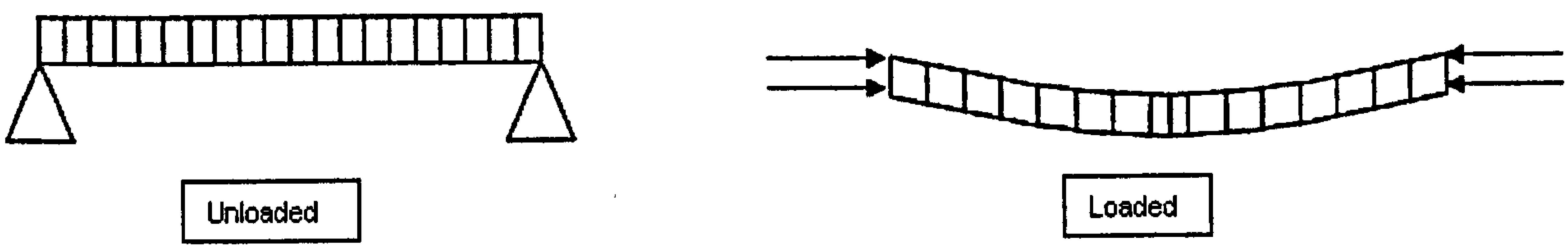



*Fig 30: Buckling failure*

Rigidity is a design sensitive characteristic. From testing of general panels by the author, there is no difficulty for a wing skin membrane to take tension. The problem lies with the skin taking compression without buckling. The nature of orthotropic sandwich structures allows the design of low deflection structures at minimum weight. A wing skin buckling and general design criterion had to be devised for the sandwich Europa fast-build light aircraft and production concept glider wing structure. Very little data were available to aid the structural design of the fast-build wing due to the materials and processes adopted for its construction. This resulted in a review of criteria adopted by traditional metallic aircraft wing structural designs. Historically, monolithic aluminum wing structures use a design criterion where initial wing skin buckling is acceptable at between 70 to 75% limiting g load, depending on the fatigue criterion and post buckling strength of the wing structure. The lower the buckling load the greater the chance that at higher loads the gross deformation of the skin panel during post buckling, will induce loads that will exceed the shear strength of the rivets or adhesive used to restrain the skin panel. Like aluminium wing skins buckling of composite orthotropic sandwich structure wing skins produces disbonding forces that are comprised of normal and moment type loads. Normal disbond loads are produced by longitudinal rib compression, in-plane shears, geometric kicks, and tension air loads. Disbond moments are produced between skin and ribs by foreshortening of the skin between ribs, due primarily to wing span-wise bending. This mode of loading is presented within figure 31.

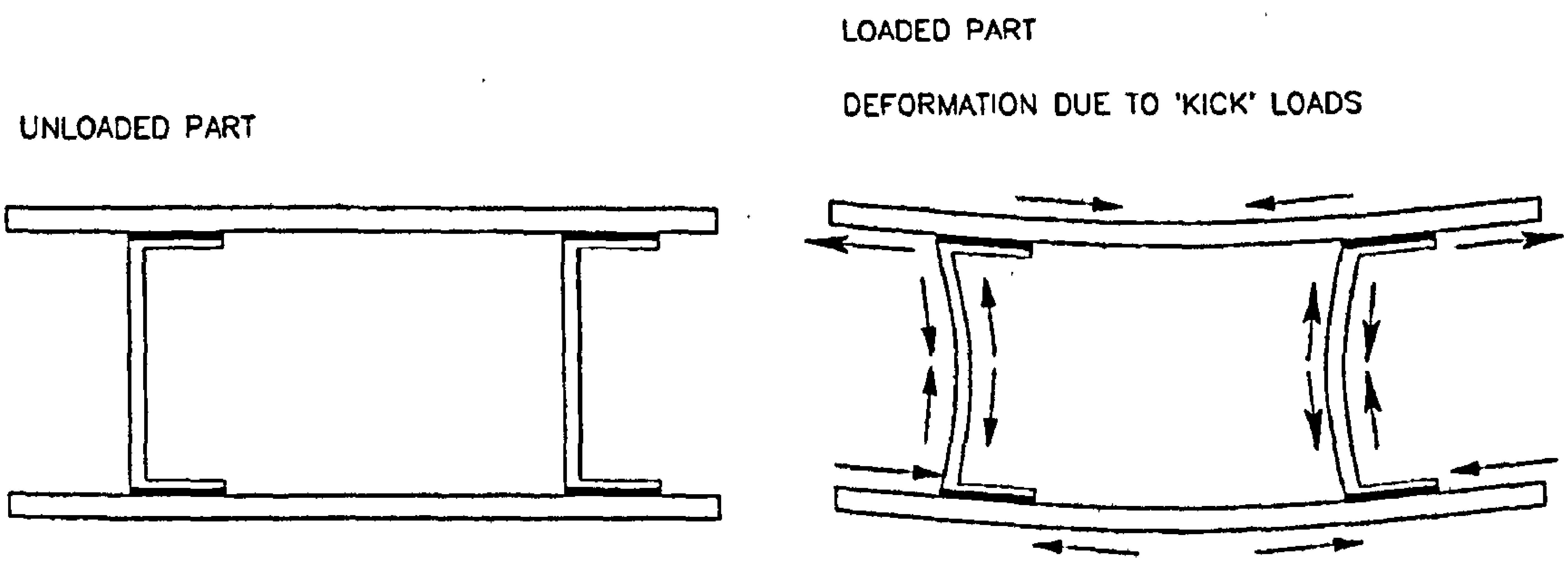



*Fig 31: Gross deformation of Wing Skin panels that induces Dis-Bonding Force*

The main production drivers behind the use of orthotropic sandwich skins on the glider wing were the importance of retaining the laminar aerodynamic qualities of the wing after assembly by unskilled personnel, and, to producing a low to medium volume composite component (approximately 60 pairs of wings) cost-effectively. In a similar vein to that of the fast-build light aircraft wing, it was anticipated that this structure would use the wet lay up glider wing spar of the prototype wing structure mated to thin sandwich construction wing skins. The aim was to supply the wing skins almost complete in kit form. The sandwich wing skins would be pre-moulded using low temperature pre-impregnated facing plies mated to a damage tolerant foam core. The majority of the wing would be supplied pre-fabricated with the customer completing assembly of the wing structure within a standard size car garage. The structural design of the pre-moulded glider wing aimed to use the limited data collected during testing of the Europa fast-build light aircraft wing.

## 5.3 Results from ultimate static strength testing of the Europa fast-build light aircraft wing structure.

The aim from this work was to develop a stress analysis procedure and design criteria that could be reverse engineered for the fast-build light aircraft sandwich construction wing skins and be modified and applied to the structural design of the pre-moulded, sandwich construction glider wing.

The ultimate load test conducted on the final production version of the Europa fast-build light aircraft wing is presented for clarity within appendix J. This report also includes the general structural arrangement necessary for the light aircraft to be produced in low to medium volumes. Prior to this ultimate load test, a series of static strength tests were conducted on a variety of structural concepts. Initially, a Europa fast-build light aircraft wing skin was designed using a very thin foam core (3mm thick) sandwich with a minimum number of wing ribs and no stringers. Ultimate load tests were conducted on this structure to assess the general performance of thin skin sandwich panels acting alone. After observing the failure mode of the wing skins, foam stringers were then added to the inner surface of the leading and trailing edges of the wing skins. Details of the test procedure, and test measurements mirror the methods used to check the strength of the glider wing structure.

Conclusions that were reached from these initial tests were as follows:

- The addition of foam stiffeners to the inner-upper surface of the basic sandwich wing skin delays the onset of initial elastic buckling of the wing skin. However the failure load of the skin structure remained roughly the same.
- Modifying the outer skins with stringers and re-testing the wing revealed that the skins buckled inward due to a neutral axis shift in the panel resulting from the presence of the foam stringers. In reality the presence of aerodynamic suction loads on the upper surface of the wing would slightly inhibit elastic skin buckling, but not significantly.
- For plain skin structures in metal or composite, a much higher post buckling ratio (skin failure load/elastic buckling load) would be expected prior to skin failure when compared with composite sandwich panels. This is due to the low section modulus of monolithic skins compared with that of sandwich skin panels. In addition lower bending stresses are experienced by plain skins for a given amplitude of buckle when compared with sandwich skins.
- By allowing the skins in the initial test to buckle at a low load level the orthotropic sandwich panels making up the wing skins tended to fail the skin facing plies in combined compression and shear by crimping. The shear crimping failure could be used as a limit of a general buckling mode considering thin faces. The failure itself looks as illustrated in fig 30 and is a shear instability failure. This kind of failure occurs as a result of large out-of plane deformations in a post buckled state when the transverse forces build up due to the deformation. The failure results where the transverse force is a maximum.
- Delaying the onset of skin buckling of this particular type of orthotropic panel would avoid catastrophic structural failure of the panel at higher load levels. This was achieved in the case of the fast-build light aircraft wing by using thicker sandwich cores, combined with the addition of wing skin stringers.
- Stringers added to the inner surface of the upper fore and aft wing skins after initial tests on the thin core (3mm) sandwich wing skin, delayed initial buckling and constrained buckling amplitude. The size of the stringers required was based not only on the requirement of forming a structural node line and delaying the onset of elastic buckling, but also to protect the panel from

catastrophic failure below ultimate load (multiplied by a composite material super-factor) when post-buckled. Skin panel buckling below ultimate load (multiplied by a composite material super-factor) would appear acceptable provided that the behaviour is elastic.

- One of the problems with this specific type of wing skin design is damage detection and repair. A considerable amount of damage to the wing skins facing plies occurred during testing of the wings both before and after the introduction of stringers. The full visible extent of this damage was hidden upon unloading of the wing after test. For example during testing one inner skin facing ply was noted to fail by crimping. Upon unloading the previously visible 'kink' disappeared giving no further indication of damage in that region of the wing skin.
- The exact calculation of physical stringer size is complicated by the basic sandwich panel design.

These results highlighted the implication of allowing thin orthotropic sandwich panel skins to buckle at relatively low load. They also demonstrate the relatively unpredictable nature of the sandwich skin buckling and post buckling characteristics.

A wing skin design criterion was developed by the author from these tests. This criterion was applied to the Europa fast-build light aircraft wing static strength test. Subsequently this criterion was generalized and applied to the Europa glider wing skin panels. This criterion was set out as follows:

- Orthotropic composite sandwich skin panels should remain unbuckled below limit load (multiplied by a composite super-factor) to account for the effects of material variability and moisture.
- The buckling ratio should be determined by the end-load and shear load resistance of the wing skin panels.
- From experimental testing conducted by the author, post-buckling of composite sandwich skin panels should occur between limit (multiplied by a composite super-factor) and ultimate load (multiplied by a composite super-factor).
- Gross catastrophic failure of the composite sandwich skin panels should not occur below ultimate load (multiplied by a composite super-factor).
- Rib webs should not catastrophically fail at ultimate load (multiplied by a composite super-factor).
- Final substantiation of this type of wing structure should be by conducting an ultimate load test to catastrophic failure.

Material coupon testing was conducted to characterize the wing skin materials at room and at elevated temperature for strength and stiffness in tension, compression shear and flexure. A statistical method of data reduction was used to characterize material strengths at elevated temperature. This procedure involved examining the resulting mean strengths of room temperature test results and selecting a super factor to account for the predicted change in material strength at elevated temperature. Although limited data were collected for laminated properties from tests, combined with other available sources of data these materials could be used in the design of the production glider wing. Mean strength values and standard deviations are listed within appendix I for glider wing spar and skin materials.

To further reduce the weight of the glider wing structure, consideration was given to conducting a series of tests to reduce the composite super factor. For thin composite sandwich structures, typical of those used on the Europa fast-build wing skin and those that are anticipated being used on the pre-moulded glider wing skin, the influence of temperature on panel buckling loads would however need to be established. One approach that could be used to establish the influence of temperature on panel buckling loads would be to determine initial buckling loads, and post buckling failure loads of moisture conditioned wing skin panels tested at both room and elevated temperature. These tests could then be compared with finite element models of similar panels. The results of these tests could then be used to derive design allowable strength values, and design curves for sandwich panels as a function of panel aspect ratio, and facing ply type.

However this experimental approach was considered costly. The results of these tests depend heavily on the type of composite materials used. In lieu of the results from these material coupon tests, the behaviour of moisture conditioned sandwich panels at elevated temperature could be accounted for by accepting the elevated temperature super factor set out within the requirements of JAR-VLA. This approach basically defines the point that no elastic wing skin deformation should occur at test factored limit load.

## 5.4 Wing skin detailed design

With the design criteria generated for the pre-moulded glider wing, the wing skin detailed design could commence.

The pre-disposition of the wing airbrake and aileron hinge locations lead to natural wing skin terminators (rib locations) as illustrated in figure 32. Ribs are used on the wing to transmit the aerodynamic load from the skins to the wing spar as shear. Ribs also reduce the aspect ratio (panel length divided by the panel width) of wing skin panels. They also to an extent improve the post buckling torsional rigidity of wing structures as a whole however Strojnik[23] noted that multiple rib structures with monolithic composite or aluminium skins tend to be heavier than equivalent structures with thicker wing skins or stringers.

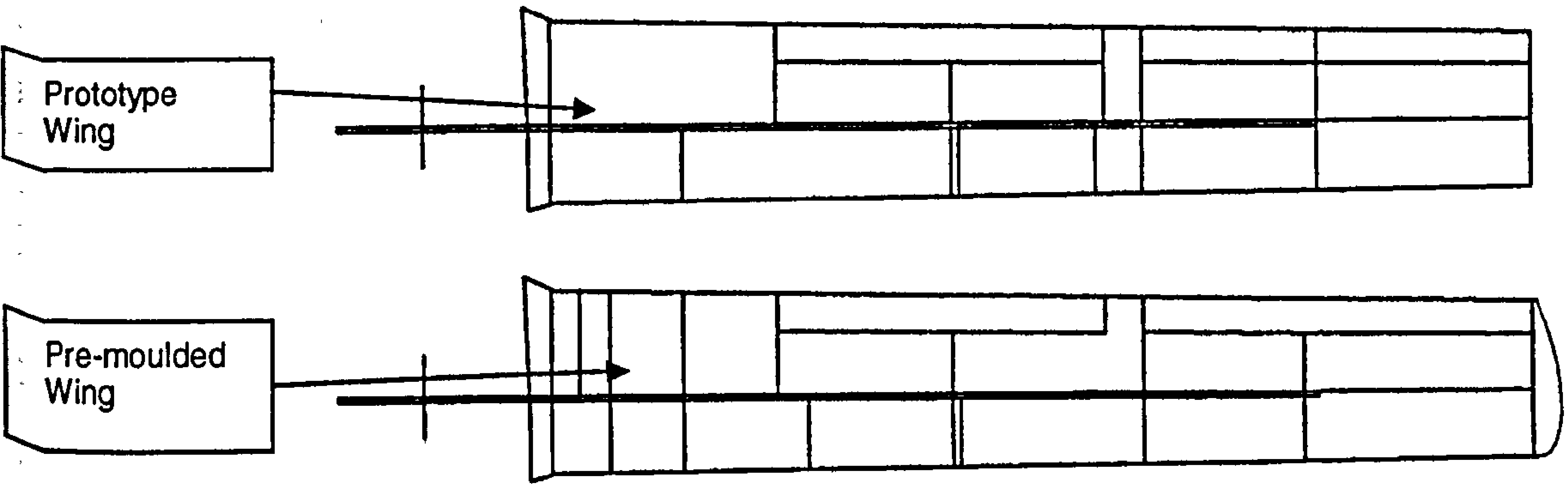



*Fig 32: Pre-disposition of wing ribs within the Wing Structure*

Closer examination of basic stability formulae for flat or curved monolithic aluminium panels show that increasing the skin thickness increases the effective skin bending stiffness of wing skin panels. This has a more pronounced effect on wing skin stability than reducing panel aspect ratio alone, as can be seen from figure 33.

$$\sigma_{cr} = \frac{\pi^2 k_c E}{12\,(1-\nu_e^2)} \left(\frac{t}{b}\right)^2$$

Where $k_c$ = buckling coefficient which depends on edge boundary conditions and sheet aspect ratio (a/b)

$E$ = modulus of elasticity

$\nu_e$ = elastic Poisson's ratio

$b$ = short dimension of plate or loaded edge

$t$ = sheet thickness

*Fig 33: Basic Stability formulae for Flat panels – This shows the Dominance of Skin Thickness in general Stability equations*

## Chapter Summary

By applying the lessons learned from the load testing conducted by the author on the thin skinned fast-build light aircraft wing, and by selecting a set core thickness, in combination with stringers produced the final fast-build light aircraft wing structure design. This design had the minimum number of ribs necessary to support the applied air-load. Theoretically, successive design iterations should lead to an optimum rib spacing for a given aircraft weight, limit load and wing span. This will result in the minimum number of ribs required to support the wing skins. Fewer ribs also implies fewer rib tools, therefore lower tooling fabrication costs.

However the reality of the situation is that loading of the skin and ribs is complex and detailed hand analysis is often unreliable. It is more reliable to produce a full size wing including skins and ribs and test this item to destruction to evaluate what load it will actually carry. The rib spacing can then be determined from actual tests. A more cost effective and easier method is to set up a finite element analysis of the wing structure.

# 6 Review of Composite Processing Technology developed for the Pre-Moulded Glider Wing Structure

## 6.1 Overview

The manufacturing process adopted by Europa Aircraft Ltd for the proposed construction of a production variant of the glider wing structure is inextricably linked to the design of the wing structure itself. This chapter reviews the processing technology required to cost effectively produce the pre-moulded glider wing structure along with the reasoning behind the selection of materials and this particular manufacturing technique.

## 6.2 Wing skin facing ply materials

Low temperature pre-impregnated materials were considered for the wing skin sandwich facing plies. These materials have a lower material cost and better material processing flexibility than higher temperature cure pre-pregs. Their low temperature cure results in low cost tooling that is suited to low to medium volume production. Low temperature curing pre-preg is an affordable and flexible material that is uniquely suited to application of the Europa pre-moulded glider wing skin. In order to reduce the number of the structural parts in the wing and consequently the number of joints, large sandwich skins were utilized. This design philosophy also minimizes the tooling cost and design time for a wing structure as noted during the construction of the Europa fast-build light aircraft wings. Moreover the processing flexibility of low temperature pre-pregs allows for larger structures to be cured in single steps in an oven, instead of requiring a costly autoclave or multiple joints.

Conventional epoxy pre-pregs fall into two broad processing bands, the first is where these materials cure at 120 deg C, and The second is where these materials cure at 175 deg C. For reactive epoxy systems the room temp out life can be as short as 2 days. Systems that will cure between room temp and below 80 deg C are generally regarded as low temp curing systems. Such a material that will cure at room temp will naturally have a limited out life (useable life outside the freezer).

In order to achieve the desired low structure cost, all design and manufacturing parameters needed to be considered, including raw material cost, tooling processing and assembly.

To select a wing skin material from a structural standpoint, multiple cross-plies of unidirectional carbon and glass cloth were considered. This cloth would be used to transmit torsional shear loads from the skin to the wing spar. The torsional shear loads were derived after a FE analysis using the most unfavourable loads that the wing would experience within the aircraft flight envelope. Carbon and glass cloth was considered acceptable to maintain torsional stiffness of the wing structure.

Advanced Composites LTM-26 low temperature pre-preg resin system was selected so that the wing skin lay up could be accomplished before the resin had reacted sufficiently to lose its tack and preclude good consolidation. For speed of manufacture a resin system that did not require a debulking process was also necessary. In addition since the wing skin structure is a reasonable size and includes complex contours, matching the skin and tool resin coefficients of thermal expansion was also necessary. The wing skin tooling was also constructed of similar materials, therefore tooling becomes lower in cost. As necessary the wing skin parts were selectively post cured to generate the required performance for their particular end use.

## 6.3 Wing skin core materials

The relatively recent development of high density and high quality cellular foams has had a major impact on the use of sandwich construction. Cellular foams do not offer the same high stiffness and strength to weight ratios as honeycombs but have other advantages.
Primarily cellular foams are less expensive than honeycombs, but more importantly, they are a solid on a macroscopic level making the manufacturing of sandwich elements much easier. In addition the foam surface is easy to bond to, surface preparation and shaping is simple and connections of core blocks is easily performed by adhesive bonding.

Airex R 63 was chosen as the core material for the wing skins on the Europa fast-build light aircraft and production glider wing structures. Airex R 63 is a resilient, closed cell, linear foam with extremely high damage tolerance. It is cold formable to simple 3-dimensional contours. Primarily it was selected as a core material due to its exceptional fatigue and shock absorbing qualities. This core material exhibits the following properties:

- It has a resilient non brittle failure mode
- It has excellent fatigue resistance
- It is easily cold shapeable to 3-dimensional contours
- It is rot-resistant in humid hanger type environments

It is not affected, even when subjected to high impact loads[16]. It is also able to recover after an impact without loosing its mechanical properties. Examination of manufacturer's data indicated that the failure of notched Airex is totally different to the behaviour of notched cross linked foam specimens. A crack in Airex remains local, the material fails finally in a non-catastrophic manner at high deflection. This is important when considering the operating environment of a wing skin.

The core material never becomes brittle, even at extremely high strain rates to cope with these special demands.

### 6.3.1 High Peel strength

When bonding Airex core to GRP skins, a mechanical bond between the two different materials is produced. The resin grips the partially open cells on the cut surface of the foam and after curing, bonds tenaciously under all service conditions, such as vibration, impact, overloading and fatigue. The closed cell nature of the core allows enough resin to flow allowing adhesion between the core and the facing plies, but does not dry the pre-preg enough that a resin-film is required between the core and the facing plies. In general the choice of a material for a particular sandwich core structure should be a compromise between stiffness, strength, energy absorption, and weight. The difference between thermoplastic PVC foam and common cross-linked foams makes Airex R 63 extremely suitable for the use of sandwich composites of dynamically loaded wing skin structures. It has outstanding properties like high shear and tensile elongation at break and the inability to under go brittle failure under fatigue loads.

## 6.4 The manufacture of Europa 'Fast-Build' Light Aircraft Wing

The manufacturing and processing technology that was developed for the Europa fast-build light aircraft wing closely mirrors the technology required to produce the production variant of the Europa glider wing structure. The Europa Fast-build wing is fabricated in the following steps:

1. Wing leading edge and trailing edge ribs are moulded using bi-directional glass cloth and cured at room temperature for eight hours. These wet lay-up ribs then post cure at 40 degrees for three hours. Aileron close-out, hinge boxes and wing tip sections are constructed in parallel with the wing ribs in a similar manner.
2. Low temperature pre-preg skin plies are moulded into a female mould. Foam is also added during this process. No debulking occurs. The skin structure including sandwich top hat stiffeners and local spar reinforcements is then vacuum bagged and cures for twelve hours at 60 degrees C. The skin tool was designed to incorporate wing wash-out. The skin has been designed to be moulded in two sections. The first section wrapping around the full chord of the wing. The second section being a close-out panel for the customer to install.
3. Once the ribs and skin have cured independently the wing leading edge ribs are bonded into the wing skin. A spar, constructed and cured independently, is then bonded in followed by the wing trailing edge ribs and the aileron trailing edge close out. This assembly then cures at room temp for 17 hours. A jig then holds the complete structure in place and applies pressure at the bond

lines. The structure is not post cured. The completed wings are then stored vertically.

4. To complete the wing structure the customer has to bond in the aileron mass balance boxes, bond in local lap joint reinforcements between the spar and the trailing edge skins, then bond in the flap hinge points, route controls, and the skin close-out panel.
5. The wing and control surfaces predominantly use bonded joints, by using the parts themselves as the tool surface, in contrast to secondary bonding which requires a near perfect fit, co-curing/bonding provides a controlled bond line without pre-stressing the structure. As a result secondary bonding is only used during the final close out of the wing when the planer surfaces are joined as illustrated in figure 34.

*Fig 34: Factory Fabrication of the Pre-Moulded Glider Wing*

Chapter Summary

The benefits of using sandwich composite structures for wing skin materials has been presented.

# 7 Finite Element Analysis of the Pre-Moulded Glider Wing Structure

## 7.1 FEA an overview

To size the glider wing structure that was designed using the Advanced Composites LTM system, it was necessary to develop a practical and reliable stress analysis and sizing procedure. The aim was to produce a procedure that could be verified by physical testing of a representative structure under simulated operating loads.

Finite Element Analysis (FEA) offers a cost effective analysis solution. However this route is not without its problems. The FEA package purchased by Europa Aircraft Ltd, 'Strand 7' by G & D computing, handles composite materials using plate/shell theory. Its laminated composites module has the following analysis capabilities for laminated composite materials:

- Calculation of in-plane, bending and coupling stiffness matrices
- Calculation of in-plane, bending and coupling compliance matrices
- Calculation of laminate engineering properties for the laminate including elastic modulus and Poison's ratio, laminate mid-plane stresses and strains, laminate bending moments and curvature
- Recovery of mid-plane stresses and strains for each ply of the laminate, reserve factors for each ply based on the five most common composite failure criteria.

Deflection results obtained from the ultimate static strength test conducted on the Europa fast-build light aircraft wing allowed the following stress analysis and sizing procedure to be developed. The procedure can be summarized as follows:

1. Loads acting on the fast-build light aircraft wing structure were derived using the appropriate standard (JAR-VLA in the case of the light aircraft).
2. Loads were then resolved into specific load increments at numerous points on the wing structure.
3. Load increment summations were checked to give the correct shear force, bending moment and torsion values at the wing root.
4. Material coupon tests were conducted to establish accurate material strength and stiffness properties.
5. Load increments were derived at 'g' loads, where –during static testing- visible structural phenomenon (such as the load level increment that induced skin elastic buckling, and the load level increment that induced crimping of the skin).

6. Loads at these specific 'g' levels combined with results from the material strength characterization coupon test results were applied to a representative finite element geometry model of the fast-build light aircraft wing.
7. Physical test deflection and strain measurements obtained during physical static strength testing could then be compared with FEA deflection and strain measurements.
8. FE model material stiffness values could then be correlated and/or modified by an empirical correction factor (ECF) to produce visible structural phenomenon at equivalent 'g' loads. This ECF could be used to on future FEA models using these materials to produce a more accurate indication of when this phenomenon would be likely to occur.

Through the use of a linear static, small displacement type, finite element model this approach could then be used to predict the 'g' load that produces the onset of elastic buckling of the sandwich wing skin panels composed of similar composite materials. This approach was used to predict the onset of elastic buckling of a pre-moulded 'fast-build' glider wing structure.

In order to assess the feasibility of this approach, FEA trials were conducted initially on the fast-build light aircraft wing spar alone. The same type of main spar supports both the classic and fast-build light aircraft wing structures. In general the wing spar is the main structural component of both these wings that resists bending stresses. Test reports[8] compiled for static strength tests conducted on both light aircraft structures yielded results that could be used to compare the performance of a FE composite material model with results from a physical test on a similar component. By reviewing the results from tests conducted by the author and results from the test data that had been accumulated previously at Europa Aircraft Ltd, could allow conclusions to be drawn quite quickly as to the feasibility of this analysis approach.

### 7.1.1 Model 1 Light Aircraft Spar Bending Analysis

As an initial simple case study to prove the performance of the above approach an FE model of the light aircraft wing spar was set up. The incremental loads that were applied during physical static strength tests were applied to a model of the light aircraft wing spar. The wing tip deflection and strain measurement results that had been obtained from the Europa fast-build wing static strength test programme were compared with those values obtained from the basic FE model of the light aircraft wing spar.

A geometrically accurate light aircraft wing spar with accurate composite ply geometry was considered. The spar boom, foam core, and marine ply were however modeled as isotropic brick elements (BRICK 8). This model provided an accurate physical representation of the light aircraft wing spar to which test loads could be applied.

This model could be summarized as follows:

1. Spar boom, foam core and marine ply were modeled by BRICK-8 elements using isotropic material properties.
2. The gradual span-wise sloping of the wing spar booms allowed the correct cross sectional area variation of the spar boom strength.
3. Correct gradual span-wise variation of the core materials (ply and foam) at the centre of the spar.
4. A physical connection between the spar boom and reinforcing ply material could be achieved. Spar shear web geometry was modeled as QUAD-4 plate elements.
5. The wing spar was fully restrained at the inner wing spar pin location, and allowed to rotate in plane about the outer wing spar pin. In addition the spar was allowed to rotate about the outer wing root pin position.
6. Fore and aft translation between the spar pins that occurs during spar bending and that promotes wing spar buckling was also restrained.
7. The wing spar pins were modeled as solid 0.5 inch (12 mm) beam elements.

The use of isotropic brick elements for the spar boom unidirectional spar boom rovings produces experimental error. In reality the unidirectional spar boom rovings are stiffer in the longitudinal span-wise direction than in the transverse, chord-wise direction. The isotropic assumption assumes that the stiffness of the spar boom is the same in all directions. This results in an inaccurate distribution of load across the spar booms and into the composite laminate shear webs.

Comparing the results from this model with those obtained during the ultimate static strength test conducted on the Europa fast-build light aircraft wing, suggested the following:

- Wing tip deflection, spar boom and shear web stress distributions were inaccurate.
- Accurate material characterization and property input data for all wing spar components (spar booms, spar shear webs, foam and ply core materials) was required.

### 7.1.2 Model 2 Light Aircraft Spar Bending

This model aimed to replicate the spar boom as a homogeneous brick element as in the previous FE model, but the stiffness of the spar boom brick elements were modified to give the tip deflection measurements obtained during the physical static strength test of the fast-build light aircraft wing to within an error of 5%. This model would not only provide a geometrically accurate representation of the wing spar, but would also produce correct spar curvature, inducing a brazier type load distribution in the wing skin panels due to span-wise fore shortening of these panels between wing ribs. These loads are the primary source of skin panel buckling.

Model 2 could be summarized as follows.

1. Spar boom, foam core and marine ply were modeled by BRICK-8 elements using modified isotropic material properties.
1 The gradual span-wise sloping of the wing spar booms allowed the correct cross sectional area variation of the spar boom strength.
2 Correct span-wise variation of the core materials (ply and foam) at the centre of the spar could be achieved. A physical connection between the spar boom and reinforcing ply material could also be achieved.
3 Spar shear web geometry was modeled as QUAD-4 plate elements. The wing spar was fully restrained at the inner wing spar pin location, and allowed to rotate in plane about the outer wing spar pin. In addition the spar was allowed to rotate about the outer wing root pin position.
4 Fore and aft translation between the spar pins that occurs during spar bending and that promotes wing spar buckling was once again restrained.
5 The wing spar pins were modeled as solid 0.5 inch (12 mm) beam elements.

This model allowed wing tip deflection to be calculated to within 5% of those experienced at test factored limit loads during static strength testing of the Europa fast-build light aircraft wing.

However as with the previous model, accurate material characterization and property data and accurate applied load input data for all wing spar components is required to confidently predict stress levels.

From the FE analysis conducted on the light aircraft wing spar alone, results indicated that this technique:

- Provided a reasonable means of predicting strength, strain and deflection values for laminated composite structures.
- Demonstrated the necessity for conducting accurate coupon testing to establish material property data.
- Demonstrated that, in order to accurately predict elastic buckling of sandwich composite components, structural testing is required to gain a true insight into the behaviour of composite components subjected to load.
- As FEA is based on stiffness matrix and deflection algorithms, good correlation with deflections could be obtained with deflection measurement results.

The next step in this programme of work was to fully assess the performance of this technique by comparing directly a full model of the Europa fast-build light aircraft wing structure with deflection and strain results obtained from physically testing this structure.

### 7.1.3 Model 3 Complete fast-build light aircraft wing

The initial analysis method developed for the light aircraft wing spar structure was used to evaluate a model of the complete fast-build light aircraft wing subject to HAA test factored limit loads. The FE model of the light aircraft wing structure could be used to verify the value of the ECF that could be attributed to modeling the spar boom as an anisotropic brick element opposed to modeling the spar boom as an orthotropic element.
Test factored limit loads applied during the HAA fast-build light aircraft wing static strength test were applied to the FE model of the fast-build wing structure.

Model 3 could be summarized as follows:

1. Spar boom, foam core and marine ply were modeled by BRICK-8 elements using modified isotropic material properties. The gradual span-wise sloping of the wing spar booms allowed the correct cross sectional area variation of the spar boom strength.
2. Correct span-wise variation of the core materials (ply and foam) at the centre of the spar was obtained. The physical connection between the spar boom and reinforcing ply material was achieved.
3. Spar shear web geometry was modeled as QUAD-4 plate elements. The wing spar was fully restrained at the inner wing spar pin location, and allowed to rotate in plane about the outer wing spar pin. In addition the spar was allowed to rotate about the outer wing root pin position.
4. Fore and aft translation between the spar pins that occurs during spar bending and that promotes wing spar buckling was once again restrained.
5. The wing spar pins were modeled as solid 0.5 inch (12 mm) beam elements.
1. The wing skin reinforcing plies were modeled as QUAD-4 composite plate elements.
2. The sandwich core was modeled as BRICK-8 elements with low shear modulus.

Sandwich core material can be included in the laminated plate definition. The core materials however are treated in the same way as the rest of the plies in the composite laminae, but the shear modulus of the core material is very low compared with that for the plies of the composite material. Consequently the shear deformation can be large and this can have a significant effect on the deflections and stress distribution in the sandwich. These shear deformations are not modeled by the Strand FE package. An alternative approach used was to model the core material as a low modulus brick element with plate element composite facing plies.

As illustrated in previous chapters, buckling is the primary mode of failure of the compressive facing plies in a sandwich. The Strand FE package does not consider this mode of failure in the calculation of reserve factors for laminated sandwich plate elements. The use of a brick element supporting laminated composite facing plies, it was thought, would allow buckling reserve factors to be determined. In addition, core materials invariably fail by both transverse shear and in-plane shear. Although this particular FE package does not include these shears in the determination of failure criteria for laminated sandwich plate elements, this failure mode could be checked separately by checking both transverse shear and in-plane shear stresses against the ultimate shear stress of the low modulus brick elements used to simulate the sandwich core.

The fast-build light aircraft wing structure static strength test results indicated that the onset of elastic buckling occurred at 6 g at condition A on the aircraft flight envelope, with initial visible ply failure at, approximately, 7 g. By using the analysis developed for the basic wing spar, and applying this to the complete fast-build light aircraft wing, the spar boom stiffness of FE model 3 was modified at test factored limit load to produce the wing tip deflection measurements obtained during the wing static strength test. By way of a check the wing tip deflection measurements at all load increments up to and including 5.7 g (test factored limit load (TFL)) were then checked.

This approach gave the correct brazier loads in the sandwich wing skins that would induce elastic wing skin buckling. From these results a more accurate value of ECF could be determined that directly relates wing deflection to sandwich panel buckling between physical test and FE model. However the accuracy of this approach relies heavily on accurate characterization of material strengths via coupon test data.

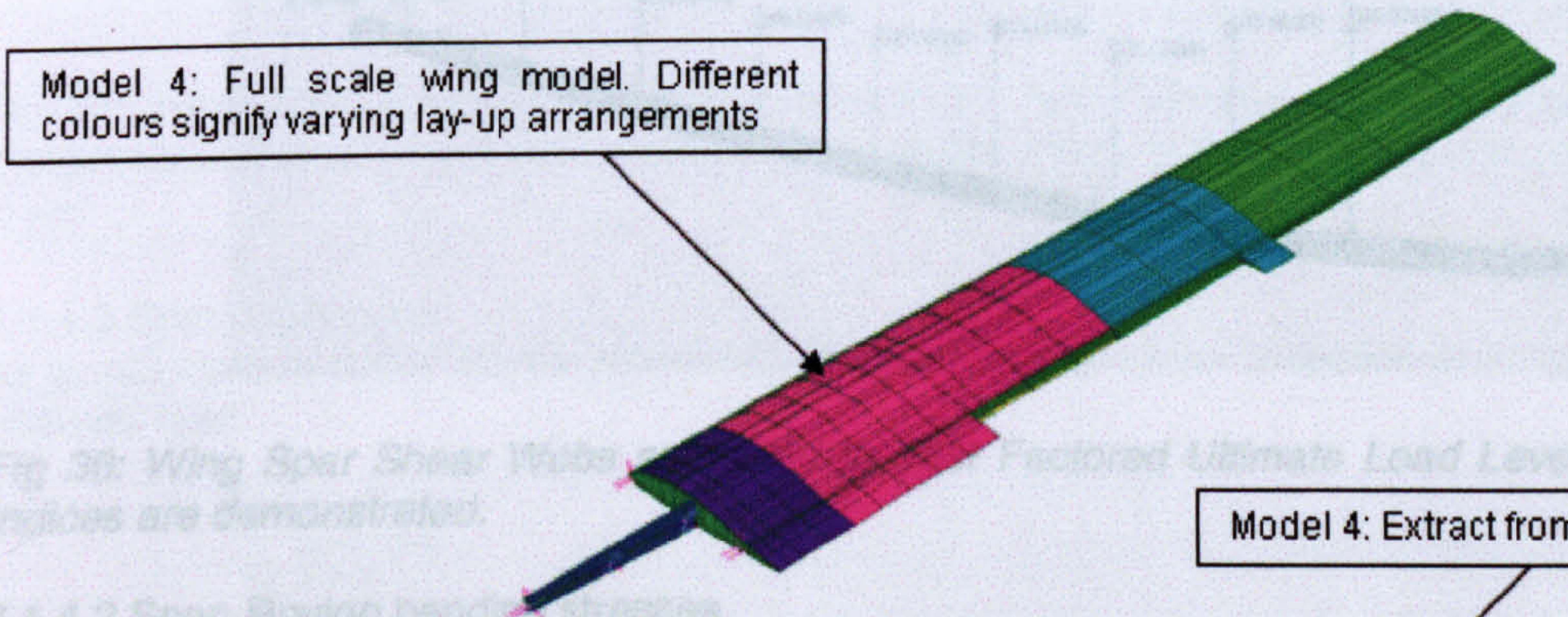
### 7.1.4 Model 4 Pre-moulded glider wing

The initial analysis method developed for the light aircraft wing spar and the complete fast-build light aircraft structure was used to evaluate a model of the complete pre-moulded glider wing subject to flight condition C test factored limit loads. The FE model of the glider wing structure was used with the ECF that could be attributed to modeling the spar boom as an isotropic brick element as opposed to modeling the spar boom as an orthotropic composite element.

Test factored limit loads at flight condition C were applied to the FE model of the pre-moulded wing structure. The structure is presented in figure 35, together with a typical ply lay-up schedule

Model 4 could be summarized as follows:

1. Spar boom, foam core and marine ply were modeled by BRICK-8 elements using modified isotropic material properties. The gradual span-wise sloping of the wing spar booms allowed the correct cross sectional area variation of the spar boom strength.
2. Correct gradual span-wise variation of the core materials (ply and foam) at the centre of the spar was obtained. The physical connection between the spar boom and reinforcing ply material was achieved.
3. Spar shear web geometry was modeled as QUAD-4 plate elements. The wing spar was fully restrained at the inner wing spar pin location, and allowed to rotate in plane about the outer wing spar pin. In addition the spar was allowed to rotate about the outer wing root pin position.
4. Fore and aft translation between the spar pins that occurs during spar bending and that promotes wing spar buckling was once again restrained.
5. The wing spar pins were modeled as solid 0.5 inch (12 mm) beam elements.
6. The wing skin reinforcing plies were modeled as QUAD-4 composite plate elements.
7. The sandwich core was modeled as BRICK-8 elements with low shear modulus.



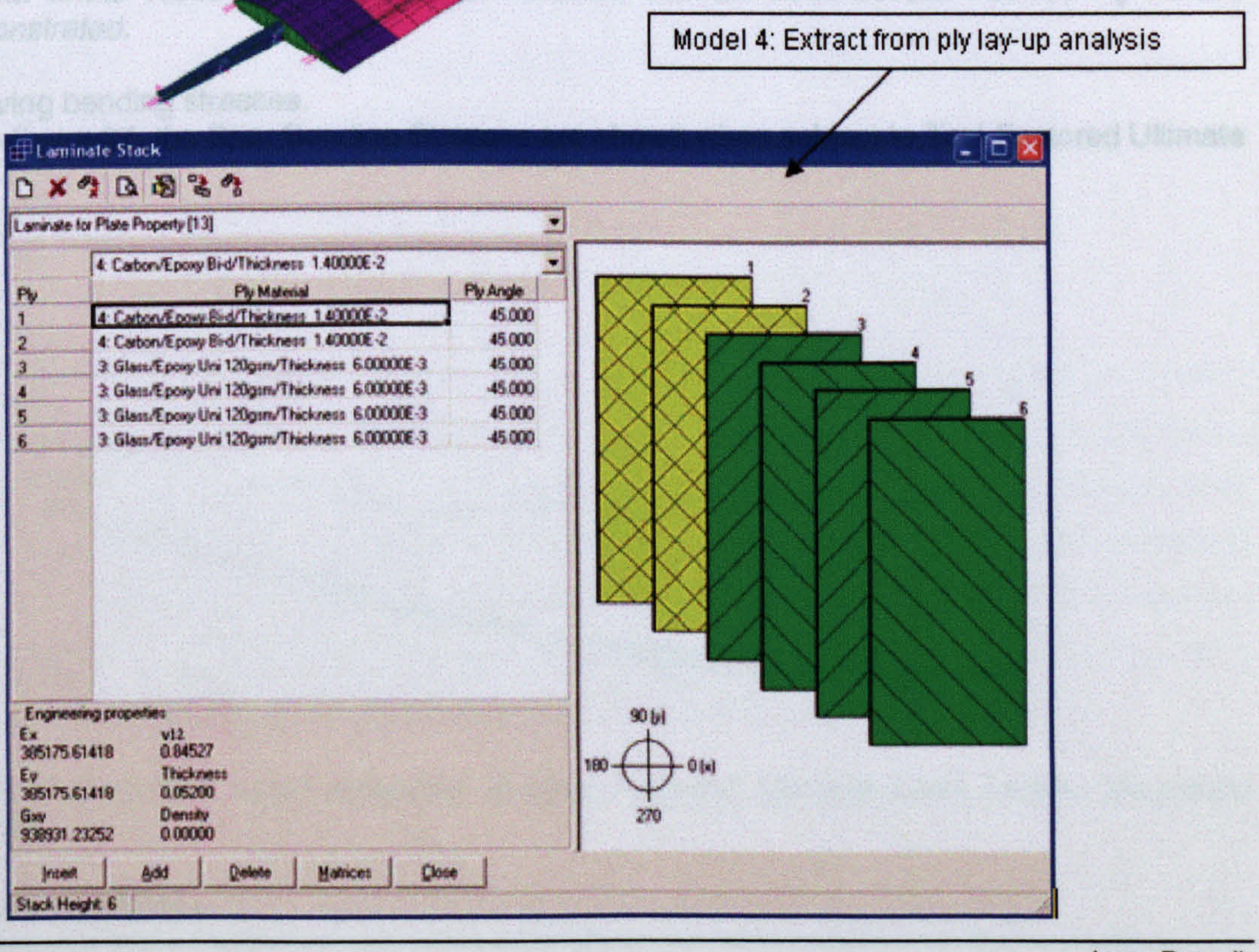



*Fig 35: Full Wing Model. Shading signifies different facing ply orientation and lay-up.*

The results from the Model 4 analysis are presented as follows:

7.1.4.1 Spar: Shear web ply failure Indices.
As is indicated in figure 36, the Spar Shear web stresses show positive ply (safe) indices when subject to Test Factored Ultimate load

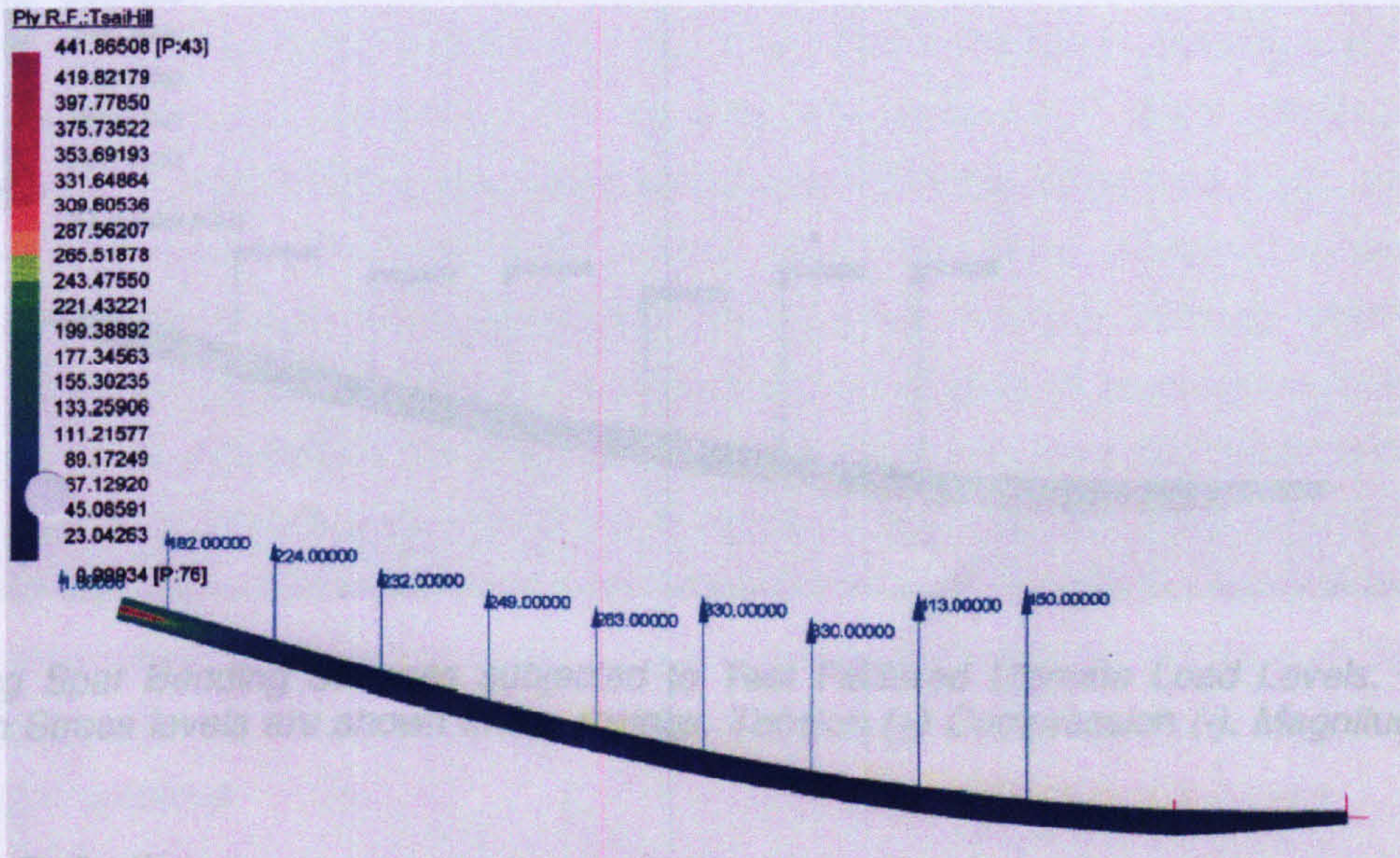



*Fig 36: Wing Spar Shear Webs subjected to Test Factored Ultimate Load Levels. Positive Ply Failure Indices are demonstrated.*

7.1.4.2 Spar: Roving bending stresses.
As is indicated in figure 37, the Spar Bending Stresses are shown when subject to Test Factored Ultimate load

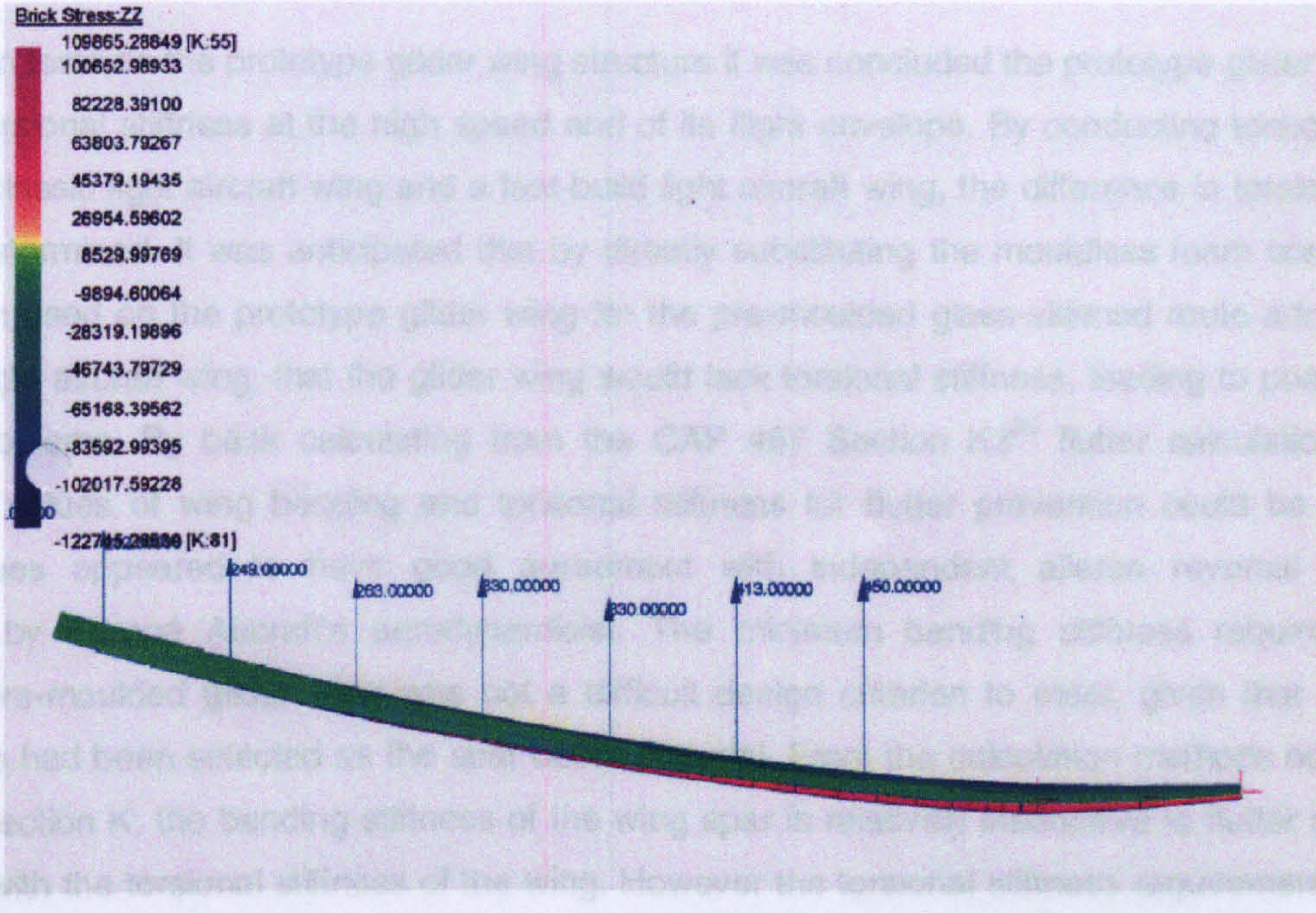



*Fig 37: Wing Spar Bending Stresses subjected to Test Factored Ultimate Load Levels. Tension and compression Stress levels are shown in the rovings. Tension (+) Compression (-). Magnitude presented in psi*

7.1.4.3 Spar: Deflection.

As is indicated in figure 38, the deflection of the wing spar alone is shown when subject to Test Factored Ultimate load

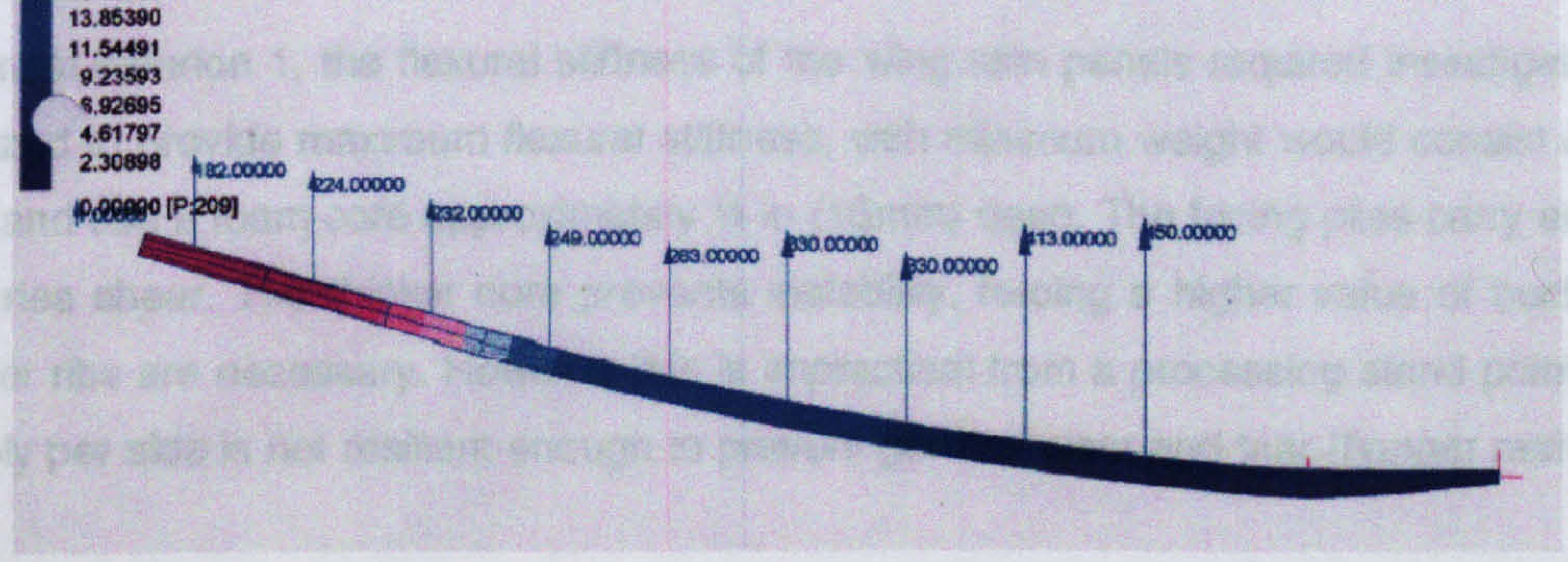



*Fig 38: Wing Spar Deflection when subjected to Test Factored Ultimate Load Levels. Magnitude presented in inches.*

7.2 Wing torsional stiffness

From torsion tests on the prototype glider wing structure it was concluded the prototype glider wing lacked sufficient torsional stiffness at the high speed end of its flight envelope. By conducting torsional stiffness tests on a classic light aircraft wing and a fast-build light aircraft wing, the difference in torsional stiffness could be determined. It was anticipated that by directly substituting the mouldless foam core method of construction used on the prototype glider wing for the pre-moulded glass-skinned route adopted for the fast-build light aircraft wing, that the glider wing would lack torsional stiffness, leading to possible aileron reversal problems. By back calculating from the CAP 467 Section K3[6] flutter calculation, minimum acceptable values of wing bending and torsional stiffness for flutter prevention could be determined. These values appeared to have good agreement with independent aileron reversal calculations conducted by Europa Aircraft's aerodynamicist. The minimum bending stiffness requirement for a proposed pre-moulded glider wing was not a difficult design criterion to meet, given that uni-direction carbon fibre had been selected as the spar boom material. From the calculation methods outlined within CAP 467 Section K, the bending stiffness of the wing spar is relatively insensitive to flutter speed, when compared with the torsional stiffness of the wing. However the torsional stiffness requirement became an additional design criterion to that of no elastic wing skin buckling at test factored limit load. To improve the general torsional stiffness of a pre-moulded glider wing structure a variety of structural design routes offered possible solutions.

Pre-moulded glider wing main design criteria

1. No elastic wing skin buckling at test factored limit load.
2. Torsional stiffness approximately equal to, or greater than 19000lbft/rad (25761NM/rad) required to prevent aileron-reversal related flutter problems.
3. No catastrophic failure of the wing structure at test factored ultimate load.
4. Extensive use of low temperature pre-preg technologies.
5. Wing panel weight no greater than 130 lb (63 kg) per side

In order to meet criterion 1, the flexural stiffness of the wing skin panels required investigation. An ideal panel optimized to provide maximum flexural stiffness, with minimum weight would consist of one facing ply per side and use a foam core approximately ¾ in (15mm) deep. The facing plies carry endload, while the core carries shear. The thicker core prevents instability, forcing a higher value of buckling load. In addition fewer ribs are necessary. However this is impractical from a processing stand point. In addition, one facing ply per side is not resilient enough to prevent general wear and tear (hanger rash) of the wing structure.

Results from the FE analysis used to predict the torsional rigidity of the pre-molded wing structure are presented within 7.2.1.1

7.2.1.1 Wing Deflection.

As is indicated in figures 39, 40 and 41 the deflection of the wing skin as a complete structure is shown when subject to an applied load of 10 lb (5kg). This approach was used to predict the performance of the structure under a torque load in order to meet the torsional stiffness criteria of CAP 467 section K3-9[6]

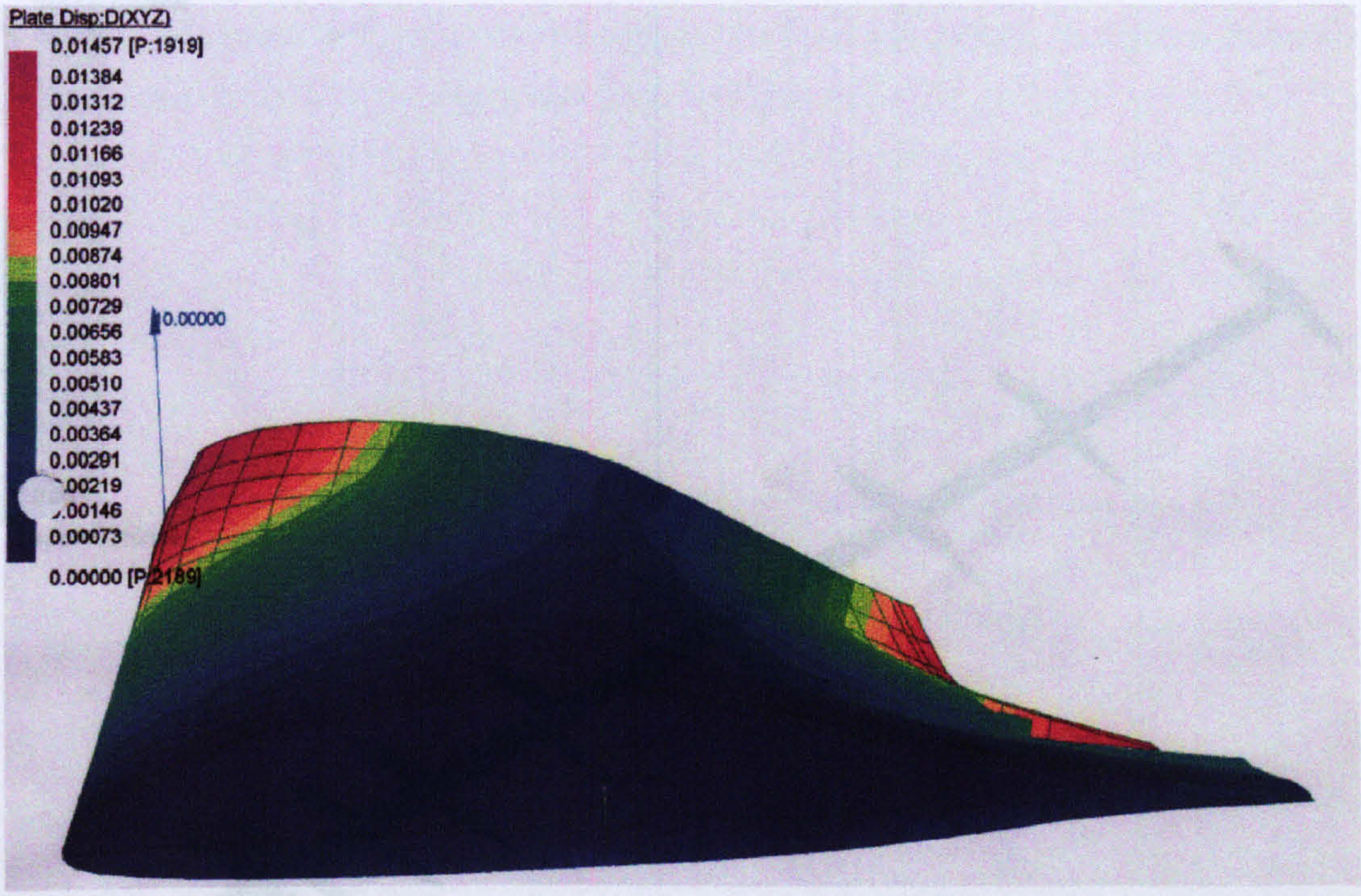



*Fig 39: Wing Deflection when subjected to 10 lb (5kg) torque load. Magnitude presented in inches*

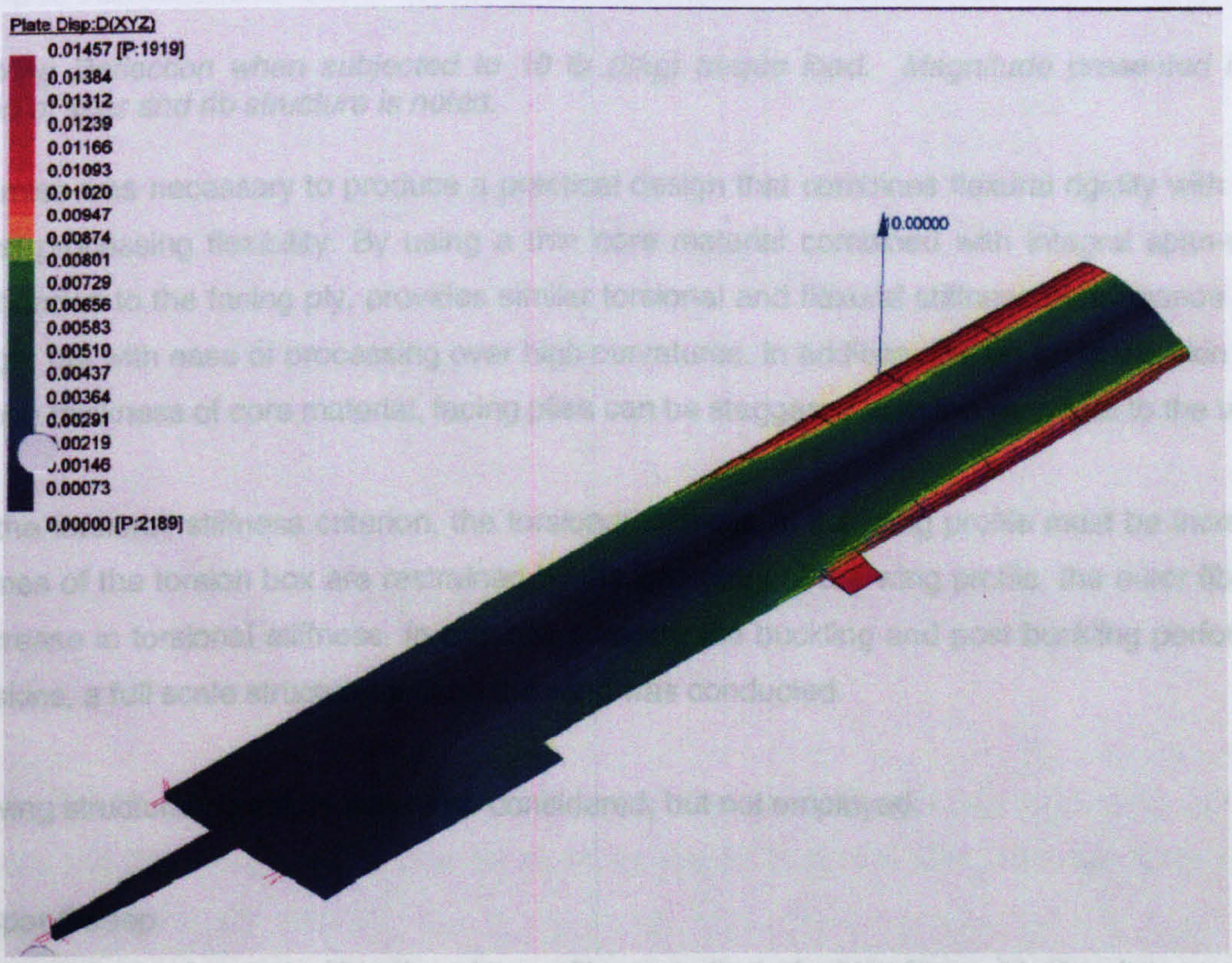



*Fig 40: Wing Deflection when subjected to 10 lb (5kg) torque load. Magnitude presented in inches*

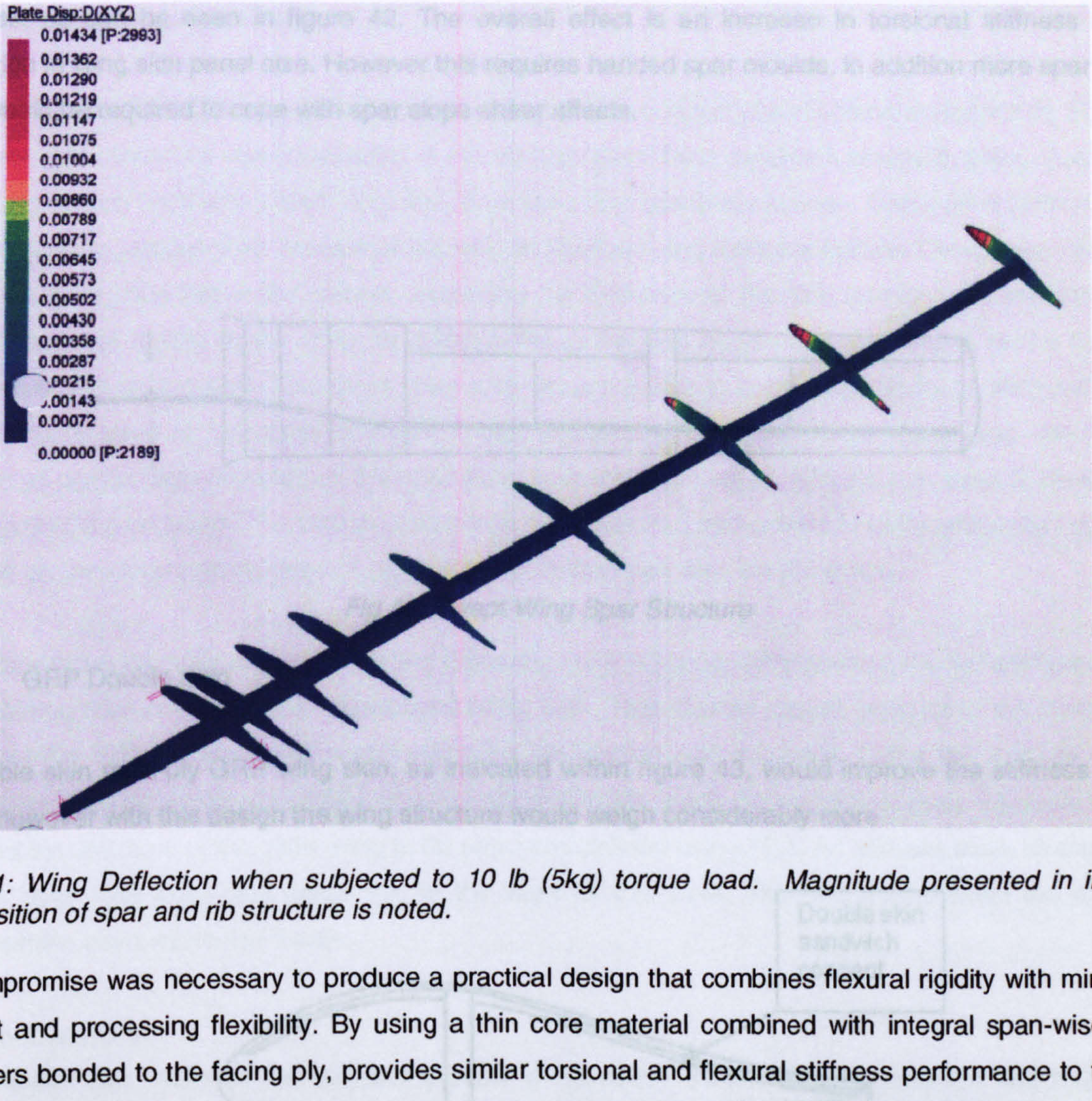



*Fig 41: Wing Deflection when subjected to 10 lb (5kg) torque load. Magnitude presented in inches. Disposition of spar and rib structure is noted.*

A compromise was necessary to produce a practical design that combines flexural rigidity with minimum weight and processing flexibility. By using a thin core material combined with integral span-wise core stringers bonded to the facing ply, provides similar torsional and flexural stiffness performance to thicker core design, but with ease of processing over high curvatures. In addition, the lay up of the skin core only requires one thickness of core material, facing plies can be staggered from the wing root to the wing tip.

To meet the torsional stiffness criterion, the torsional stiffness of the wing profile must be increased. As the extremes of the torsion box are restrained by the geometry of the wing profile, the outer fibres of the profile increase in torsional stiffness. In order to evaluate the buckling and post buckling performance of the wing skins, a full scale structural test on the wing was conducted.

The following structural concepts were also considered, but not employed.

### 7.2.1 Spar Sweep

By sweeping the spar forward within the wing profile, as indicated within figure 41, the shear centre of the wing moves forward, therefore the arm from the shear centre of the wing to the centre of pressure reduces, as can be seen in figure 42. The overall effect is an increase in torsional stiffness and a reduction in wing skin panel size. However this requires handed spar moulds, in addition more spar shear web would be required to cope with spar slope shear effects.

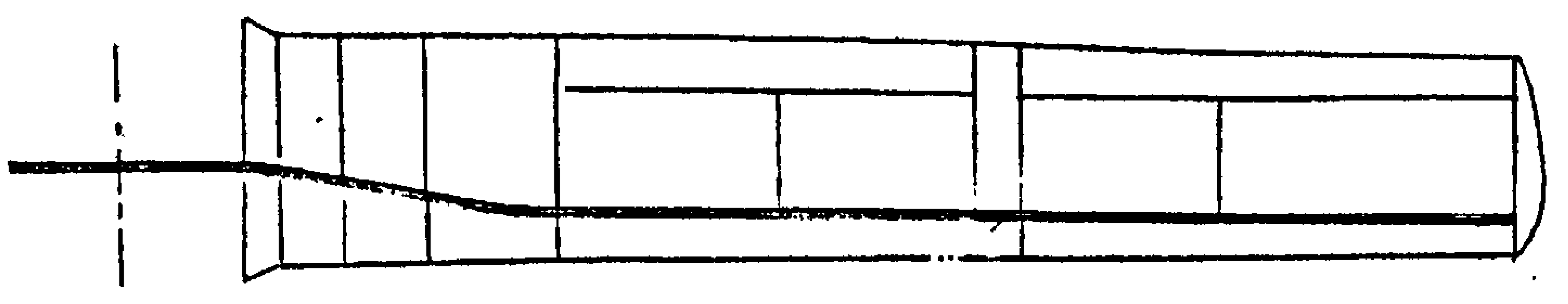


*Fig 42: Swept Wing Spar Structure*

### 7.2.2 GRP Double Skin

A double skin multi-ply GRP wing skin, as indicated within figure 43, would improve the stiffness of the wing, however with this design the wing structure would weigh considerably more.

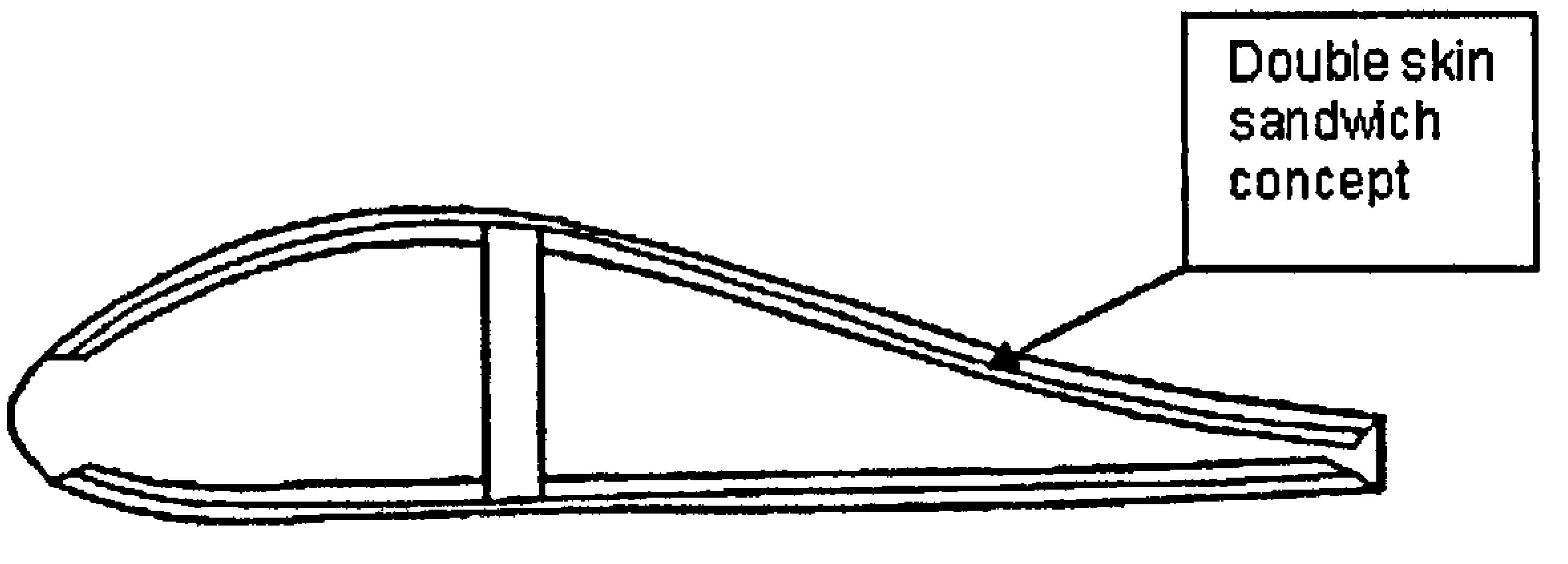



*Fig 43: GRP Double Skin Structure*

### 7.2.3 Graphite facing plies

A complete CFRP sandwich wing skin could meet the torsional stiffness and wing skin stability requirements but this design would cost as much as the GRP double skin, and due to its dark color, would be difficult to 'visually' inspect.

## 7.3 Structural compromise

Results from the FEA of the wing, and coupon material tests suggested a structural compromise, whereby a carbon/glass structure was considered. A thin carbon/glass/ foam sandwich structure, using cross-plied glass and carbon cloth with a foam core and foam stiffeners was finally chosen. Cross-plied carbon would be used on the inboard outer surface of the wing to improve wing torsional rigidity. The cross plied glass cloth would be plied below the carbon, increasing the thickness of the skin thereby also improving the overall torsional rigidity of the wing. In addition the cross-plied glass cloth also improves the bending stiffness of the skin panels. The glass plies also go some way to protecting the foam from splintered carbon facing plies at catastrophic failure. It was anticipated that this design would also use the bi-directional carbon cloth selected as the spar shear web material to cope with the curvature of the wing in the region of the walkway. The carbon cloth would be cross-plied and extend from the wing root out to the wing tip on the wing upper surface. A glass wing tip section was also incorporated

By initially fixing the span-wise location and orientation of this lay–up arrangement, the material properties of the facing plies could then be manipulated using FEA. This allowed quicker analysis of the component to obtain the optimum structural configuration for the applied load schemes. Using the material design allowables derived within appendix I in conjunction with the loads derived within appendices A and B, enabled the structure of the glider wing to be sized and defined using FEA. An ultimate static strength test of one wing semi span was conducted in the wake of this work. This test corroborates the analysis assumptions used within this thesis.

### Chapter Summary

This chapter has reviewed the detailed aspects of sandwich construction for both the fast build light aircraft wing and production glider wing structures. Structural failure modes have been reviewed together with the relevance to the design of the production glider wing structure. The problem of wing skin panel stability has been presented in detail together with the development of a the design criteria that the author used to assess buckling of thin skinned sandwich wing panels. The problems of designing with thin sandwich panels have been highlighted together with steps taken to solve these problems. A conceptual structural design of the production glider wing structure has been presented.

The use of FEA has been presented to address the structural design of a production variant of the glider wing structure. FE modeling can be used to assess the performance of composite structures. The approach outlined within this chapter could cost effectively simplify the conceptual design process of composite wing structures. Moreover this approach has recognized the importance of material coupon testing in order to obtain accurate material property data. This approach has also stressed the necessity and importance of physical structural tests to verify FE analysis

# 8 Results and Conclusions

8.1 Results from both the design of the prototype and pre-moulded glider wing structures, were as follows:

8.1.1 Results from both the design of the prototype glider wing:

- The prototype glider wing was designed by hand calculations and structurally proof tested using simplified test methods.
- The wing structure weighed 135 lb (61kg) per side when complete.
- The aerodynamic performance of the prototype glider wing was assessed at prescribed points on the flight envelope, and determined to meet prescribed aerodynamic requirements.
- The flight-test program on the prototype glider concluded that the longitudinal and lateral stability characteristics of the motor-glider aircraft lay within acceptable parameters without the necessity of increasing horizontal or vertical stabilizer size.
- The prototype wing construction method demonstrated that mould-less foam core techniques can be used to cost effectively produce medium size prototype primary aircraft structure.

8.1.2 Results from the design of the pre-moulded glider wing:

- By testing the fast-build light aircraft wing and evaluating the results from this test, the author designed a pre-moulded fast-build, pre-moulded glider wing using a practical combination of hand calculations, and Finite Element Analysis. The wing was structurally tested using simplified test methods. The resulting structure was tested and met the static strength test and torsional rigidity requirements imposed upon it.
- The wing structure weighed 125 lb (57kg) per side when complete.
- The use of LTM 26 pre-pregs combined with Airex R62.60 core materials allowed a pre-moulded wing skin to be made that met the shear and rigidity requirements imposed upon them.
- Material characterization testing produced a composite super factor of 1.5 for the LTM 26 materials.
- The aerodynamic performance of the pre-moulded glider wing was assessed at prescribed points on the flight envelope, and determined to meet prescribed aerodynamic requirements.
- The flight-test program concluded that the longitudinal and lateral stability characteristics of the motor-glider aircraft lay within acceptable parameters without the necessity of increasing horizontal or vertical stabilizer size.
- The pre-moulded wing construction method allowed the structure to meet all requirements imposed upon it. The pre-moulded construction method can produce medium size prototype primary aircraft structures, with better control of aerodynamic performance. The construction time is approximately half of that when compared with the methods used for the prototype glider wing.

8.2 Conclusions from both the design of the prototype and pre-moulded glider wing structures, were as follows:

- The design and examination of skin buckling on the 'fast-build' light aircraft wing was used to establish a practical and efficient analysis technique that employed a combination of FEA, hand calculations and testing that could be used to ensure stability of wing skin panels, and wing static strength.
- Although no specific standard or requirement exists for the derivation of loads for kit-built aircraft, the structural design and flight characteristics of these types of aircraft should be engineered to meet or exceed certified requirements. These aircraft are more prone to variability in component strength due to their nature of construction. Federal Aviation Requirements or Joint Airworthiness Requirements should be used for the derivation of structural loads and flight envelopes.
- Material coupon testing is fundamental in providing accurate values of material strength and stiffness, and absolutely necessary to determine material property design allowables. Coupon testing should be conducted to an approved aerospace method of testing, even on experimental 'homebuilt' aircraft structures. Composite material super-factoring is necessary to account for the effects of manufacturing variability and the degradation of the material strength due to the combined effects of elevated temperature and moisture over the projected life of the aircraft. Composite material super-factors that account for the effects of manufacturing variability, elevated temperature and the ingress of moisture should be determined using an accepted statistical method of data reduction. Material strength and stiffness properties must be derived from material coupon tests. Accurate derivation of these properties is required to obtain a reasonable degree of agreement between finite element models and real aircraft structure test results.
- Construction of thin skinned foam core sandwich wing structures for volume production can be cost effectively achieved using a combination of low temperature pre-impregnated composite cloths combined with durable fatigue resistant PVC foams.
- For small complex composite structures, a combination of basic hand calculations and physical ultimate static strength testing alone can achieve quicker, more accurate results than developing complex sub-component specimen testing to simulate part behaviour.
- Due to the complexity of wing structural load paths, ultimate static load testing is necessary to substantiate the static strength of composite wing and composite wing carry through structures.
- Combined composite and metallic structures, typically interfacial connections, should be ultimate load tested to establish the true distribution of stress between these dissimilar connections.
- Clearer guidance is required from both the Federal Aviation Requirements and the Joint Airworthiness Requirements regarding strength substantiation of 'combined' composite and metallic structures.

- Consistency within Airworthiness Requirements is necessary to produce sound structures. Today the FAA and JAA requirements for sailplanes and motorgliders (JAR-22), the requirements for very light aircraft (JAR-VLA) and the requirements for light aircraft under 6000 lb (2721 kg) in weight (JAR-23) do not address the static, fatigue and damage tolerance of primary composite structures in a consistent manner. These requirements need to be harmonized to assure both the static strength and fatigue strength requirements are similar for all manned flight vehicles.
- The pre-moulded glider wing structure designed by the author met the strength, stability and torsional rigidity criteria imposed upon it, whilst providing a cost effective, reproducible primary structure using Advanced Composites Group (ACG) LTM 26 low-temperature curing pre-impregnated composite material system was combined with Airex R62.60 core material to form a reinforced skin sandwich structure.

*Fig 44: Pre-Moulded Glider Wing and Europa tri-gear in flight*

# NOMENCLATURE

| | |
|---|---|
| a.c. | Aerodynamic centre |
| $a_1$ | Wing lift-curve slope |
| A | Aspect ratio = $b^2/S$ |
| b | Wing span |
| c | Chord (in) (mm) |
| $c_{AV}$ | Average chord of span-wise element (in) (mm) |
| $c_{bar}$ | Mean Aerodynamic Chord (MAC) (in) (mm) |
| $c_o$ | Wing chord at aircraft centre-line (in) (mm) |
| $c_r$ | Wing root chord (in) (mm) |
| $c_t$ | Wing tip chord (in) (mm) |
| CFRP | Carbon fiber reinforced plastic |
| $C_D$ | Elemental drag coefficient parallel to freestream |
| $C_{DX}$ | Drag coefficient parallel to wing chord |
| $C_{DZ}$ | Drag coefficient perpendicular to wing chord |
| $C_D$ | Total drag coefficient $C_D = C_{Do} + C_{Di}$ |
| $C_{Do}$ | Profile drag coefficient |
| $C_{Di}$ | Lift induced drag coefficient |
| $C_L$ | Lift coefficient normal to freestream |
| $C_{Lbar}$ | Overall lift coefficient for wing $L = qSC_{Lbar}$ |
| $C_{Lt}$ | Tail lift coefficient = $L_t/(q_tS_t)$ |
| $C_{LX}$ | Lift coefficient parallel to wing chord |
| $C_{LZ}$ | Lift coefficient perpendicular to wing chord |
| $C_{Mo}$ | Pitching moment coefficient about a.c. |
| D | Drag (lb) (N) |
| FRP | Fibre reinforced plastic |
| GRP | Glass reinforced plastic |
| alpha | Angle between chord line and aircraft horizontal datum (degrees) |
| L | Wing lift |
| LIFT | Wing lift * 1.05 |
| $L_t$ | Tail lift force |
| M | Bending Moment (lb in) |
| MAC | Mean Aerodynamic Chord |
| n | Maneuver load factor (g) |
| $n_1$ | Positive limit maneuvering load factor at $V_A$ |
| $n_2$ | Positive limit maneuvering load factor at $V_D$ |
| $n_3$ | Negative limit maneuvering load factor at $V_D$ |
| $n_4$ | Negative limit maneuvering load factor at $V_G$ |
| pre-preg | Beta phase resin pre-impregnated into glass or carbon cloth |
| q | Dynamic pressure $q = ½ \rho V^2$ |
| S | Shear force (lb) (N) |
| $S_W$ | Wing area (ft2) (m2) |
| $S_t$ | Horizontal tailplane area |
| T | Torque (lb in) (N M) |
| V | Aircraft airspeed (kts) (ft/sec) (m/sec) |
| $V_A$ | Design maneuvering speed, positive maneuver |
| $V_C$ | Design cruising speed, positive gust |
| $V_D$ | Design dive speed, positive maneuver |
| $V_G$ | Design maneuvering speed, negative maneuver |
| $V_S$ | Stalling speed at 1g, aircraft clean |
| W | Aircraft weight (lb) (N) |
| $\alpha$ | Wing angle of attack of wing |

| | |
|---|---|
| $\Delta S$ | Element of wing area |
| $\Delta y$ | Element of wing span |
| $\lambda$ | Taper ratio $\lambda = c_r / c_t$ |
| $\Theta$ | Wing angle of twist due to torsion (degrees) |
| $\tau$ | Shear stress |
| $\tau_t$ | Shear stress due to torsion |
| $\sigma_a$ | Stress due to end load |
| $\sigma_{allow}$ | Allowable stress |
| $\sigma_{applied}$ | Applied stress |
| $F_{TU}$ | Material ultimate tensile strength (psi) |
| $F_{CU}$ | Material ultimate compressive strength (psi) |
| $F_{SU}$ | Material ultimate shearing strength (psi) |
| RF | Reserve Factor $RF = \sigma_{allow} / \sigma_{applied}$ |
| $K_T$ | Test factor used to account for the degradation in material strength due to the effect of elevated temperature over the life-span of the component |
| $K_M$ | Test factor used to account for the degradation of material strength due to the effect of moisture ingress over the life-span of the component |
| $K_V$ | Test factor used to account for the degradation of material strength due to the manufacturing variability |
| G | Shear modulus (psi) |
| E | Youngs Modulus (psi) |
| $F_{crit}$ | Critical buckling load (psi) |
| 1 | Properties in the longitudinal direction |
| 2 | Properties in the transverse direction |
| 12 | Properties tested at 45 degrees to the longitudinal direction |

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# APPENDIX A: FLIGHT ENVELOPE EVALUATION

# EUROPA MOTORGLIDER WING
## FLIGHT ENVELOPE TO JAR-VLA

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Trial No | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | | |
| Gross weight | W = | 1150.00 | 1200.00 | 1250.00 | 1300.00 | 1350.00 | 1370.00 | 1400.00 | lb | |
| Wing area | S = | 135.00 | 135.00 | 135.00 | 135.00 | 135.00 | 135.00 | 135.00 | $ft^2$ | |
| Wing loading | W/S = | 8.52 | 8.89 | 9.26 | 9.63 | 10.00 | 10.15 | 10.37 | psf | |
| Gross weight | M = | 521.78 | 544.46 | 567.15 | 589.84 | 612.52 | 621.60 | 635.21 | kg | |
| Wing area | S = | 12.54 | 12.54 | 12.54 | 12.54 | 12.54 | 12.54 | 12.54 | $m^2$ | |
| | | | | | | | | | | |
| Calculated Design Stalling Speed | $V_{S\,calc}$ = | 38 | 39 | 40 | 41 | 42 | 42 | 42 | kts | from $L = 1/2\,\rho\,V^2 S\,CLmax$ |
| Calculated Design Manoeuvring Speed | $V_{A\,calc}$ = | 75 | 77 | 78 | 80 | 81 | 82 | 83 | kts | from $n_1 W = 1/2\,\rho\,V^2 S\,CLmax$ |
| | | | | | | | | | | |
| Design Manoeuvring Speed | $V_A$ = | 75 | 77 | 78 | 80 | 81 | 82 | 83 | kts | From VLA 335 |
| Design Cruising Speed | $V_C$ = | 95 | 97 | 99 | 101 | 103 | 104 | 105 | kts | From VLA 335 |
| Design Cruising Speed (need not exceed) | $V_C$ = | 117 | 117 | 117 | 117 | 117 | 117 | 117 | kts | |
| Design Diving Speed (may not be less than) | $V_D$ = | 119 | 121 | 124 | 126 | 129 | 130 | 131 | kts | |
| Design Diving Speed (may not be less than using $V_{C\,min}$) | $V_D$ = | 133 | 136 | 139 | 141 | 144 | 145 | 147 | kts | From VLA 335 |
| | | | | | | | | | | |
| Design weight | W = | 1150.00 | 1200.00 | 1250.00 | 1300.00 | 1350.00 | 1370.00 | 1400.00 | lb | From VLA 335 |
| Design wing area | S = | 135.00 | 135.00 | 135.00 | 135.00 | 135.00 | 135.00 | 135.00 | $ft^2$ | |
| Design wing loading | W/S = | 8.52 | 8.89 | 9.26 | 9.63 | 10.00 | 10.15 | 10.37 | psf | |
| $dC_L/d\alpha$ | a = | 5.24 | 5.24 | 5.24 | 5.24 | 5.24 | 5.24 | 5.24 | cl/rad | |
| Mean geometric chord | $C_{bar}$ = | 3.20 | 3.20 | 3.20 | 3.20 | 3.20 | 3.20 | 3.20 | ft | |
| Acceleration | g = | 32.20 | 32.20 | 32.20 | 32.20 | 32.20 | 32.20 | 32.20 | $ft/s^2$ | |
| Density of air at sea level | $\rho_o$ = | 0.002378 | 0.002378 | 0.002378 | 0.002378 | 0.002378 | 0.002378 | 0.002378 | $slugs/ft^3$ | |
| Aeroplane mass ratio | $\mu_g$ = | 13.27 | 13.85 | 14.42 | 15.00 | 15.58 | 15.81 | 16.15 | | |
| Gust alleviation factor | $K_g$ = | 0.63 | 0.64 | 0.64 | 0.65 | 0.66 | 0.66 | 0.66 | | |
| | | | | | | | | | | |
| Design weight | W = | 1150.00 | 1200.00 | 1250.00 | 1300.00 | 1350.00 | 1370.00 | 1400.00 | lb | |
| Minimum Design Cruising Speed | $V_{C\,min}$ = | 95 | 97 | 99 | 101 | 103 | 104 | 105 | kts | |
| Minimun Design Dive Speed | $V_{D\,min}$ = | 133 | 136 | 139 | 141 | 144 | 145 | 147 | kts | |
| | $V_{C\,min}$ = | 160 | 164 | 167 | 171 | 174 | 175 | 177 | ft/sec | |
| | $V_{D\,min}$ = | 225 | 229 | 234 | 239 | 243 | 245 | 248 | ft/sec | |
| | | | | | | | | | | |
| | $U_{de}$ | n | n | n | n | n | n | n | | |
| At $V_{C\,min}$ = | 50 | 4.69 | 4.65 | 4.62 | 4.59 | 4.55 | 4.54 | 4.52 | $n_{+gust}$ | g |
| | -50 | -2.69 | -2.65 | -2.62 | -2.59 | -2.55 | -2.54 | -2.52 | $n_{-gust}$ | g |
| At $V_{D\,min}$ = | 25 | 3.58 | 3.56 | 3.53 | 3.51 | 3.49 | 3.48 | 3.47 | $n_{+gust}$ | g |
| | -25 | -1.58 | -1.56 | -1.53 | -1.51 | -1.49 | -1.48 | -1.47 | $n_{-gust}$ | g |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Using Appendix A (Applicability? ) | | | | | | | | | | |
| | | | | | | | | | | |
| Minimum Design Manoeuvring Speed | $V_{A\,min}$ = | 85 | 87 | 89 | 91 | 93 | 93 | 94 | kts | From Appendix A3 |
| Minimum Design Manoeuvring Speed (need not exceed) | $V_{A\,min}$ = | 97 | 99 | 101 | 103 | 105 | 106 | 107 | kts | From Appendix A Table 3 |
| Minimum Design Cruising Speed | $V_{C\,min}$ = | 97 | 99 | 101 | 103 | 105 | 106 | 107 | kts | From Appendix A3 |
| Minimum Design Cruising Speed (need not exceed) | $V_{C\,min}$ = | 117 | 117 | 117 | 117 | 117 | 117 | 117 | kts | From Appendix A Table 3 |
| Minimum Design Diving Speed | $V_{D\,min}$ = | 137 | 139 | 142 | 145 | 148 | 149 | 151 | kts | From Appendix A3 |
| Minimum Design Diving Speed (need not exceed) | $V_{D\,min}$ = | 135 | 138 | 141 | 144 | 147 | 148 | 149 | kts | From Appendix A Table 3 |
| Minimum Design Flap Speed | $V_{F\,min}$ = | 63 | 64 | 65 | 67 | 68 | 68 | 69 | kts | From Appendix A3 |
| | | | | | | | | | | |
| Positive Manoeuvring Limit Load Factor | $n_1$ = | 3.80 | 3.80 | 3.80 | 3.80 | 3.80 | 3.80 | 3.80 | g | From Appendix A Table 1 Normal Category |
| Negative Manoeuvring Limit Load Factor | $n_2$ = | -1.90 | -1.90 | -1.90 | -1.90 | -1.90 | -1.90 | -1.90 | g | From Appendix A Table 1 Normal Category |
| Aeroplane Positive Gust Limit Load Factor at $V_C$ | $n_3$ = | 3.80 | 3.80 | 3.80 | 3.80 | 3.80 | 3.80 | 3.80 | g | From Appendix A Fig A1 |
| Aeroplane Negative Gust Limit Load Factor at $V_C$ | $n_4$ = | -1.90 | -1.90 | -1.90 | -1.90 | -1.90 | -1.90 | -1.90 | g | From Appendix A Fig A2 |
| | | | | | | | | | | |
| Envelope Summary (Not using appendix A values) | | | | | | | | | | |
| | | | | | | | | | | |
| Design weight | W = | 1150.00 | 1200.00 | 1250.00 | 1300.00 | 1350.00 | 1370.00 | 1400.00 | lb | |
| Stalling speed clean | $V_S$ = | 38 | 39 | 40 | 41 | 42 | 42 | 42 | kts | |
| Design manoeuvre speed | $V_A$ = | 75 | 77 | 78 | 80 | 81 | 82 | 83 | kts | |
| Design cruising speed | $V_C$ = | 95 | 97 | 99 | 101 | 103 | 104 | 105 | kts | |
| Design dive speed | $V_D$ = | 133 | 136 | 139 | 141 | 144 | 145 | 147 | kts | |
| Design never exceed speed | $V_{NE}$ = | 120 | 122 | 125 | 127 | 130 | 131 | 132 | kts | |
| Design minimum critical flutter speed | $V_{FLUT}$ = | 160 | 163 | 166 | 170 | 173 | 174 | 176 | kts | |
| | | | | | | | | | | |
| | | | | | | | | | | |
| Positive manoeuvre g load | $n_1$ = | 3.80 | 3.80 | 3.80 | 3.80 | 3.80 | 3.80 | 3.80 | At +g $V_A$ | |
| Negative manoeuvre g load | $n_2$ = | -1.90 | -1.90 | -1.90 | -1.90 | -1.90 | -1.90 | -1.90 | At -g $V_D$ | |
| Negative manoeuvre g load | $n_3$ = | -1.90 | -1.90 | -1.90 | -1.90 | -1.90 | -1.90 | -1.90 | At -g $V_C$ | |
| | | | | | | | | | | |
| Positive gust g load | $n_{C+}$ = | 4.69 | 4.65 | 4.62 | 4.59 | 4.55 | 4.54 | 4.52 | At +g $V_C$ | |
| Negative gust g load | $n_{C-}$ = | -2.69 | -2.65 | -2.62 | -2.59 | -2.55 | -2.54 | -2.52 | At -g $V_C$ | |
| Positive gust g load | $n_{D+}$ = | 3.58 | 3.56 | 3.53 | 3.51 | 3.49 | 3.48 | 3.47 | At +g $V_D$ | |
| Negative gust g load | $n_{D-}$ = | -1.58 | -1.56 | -1.53 | -1.51 | -1.49 | -1.48 | -1.47 | At -g $V_D$ | |

EUROPA MOTORGLIDER WING
QUICK CHECK STRESS

| | 1150 | 1200 | 1250 | 1300 | 1350 | 1370 | 1400 | XS | |
|---|---|---|---|---|---|---|---|---|---|
| Span b = | 516.00 | 516.00 | 516.00 | 516.00 | 516.00 | 516.00 | 516.00 | 323.00 | in |
| Semi-span b/2 = | 258.00 | 258.00 | 258.00 | 258.00 | 258.00 | 258.00 | 258.00 | 161.50 | in |
| Centreline root chord $c_r$ = | 41.90 | 41.90 | 41.90 | 41.90 | 41.90 | 41.90 | 41.90 | 51.78 | in |
| Tip chord $c_t$ = | 35.00 | 35.00 | 35.00 | 35.00 | 35.00 | 35.00 | 35.00 | 39.45 | in |
| $\lambda$ = | 0.84 | 0.84 | 0.84 | 0.84 | 0.84 | 0.84 | 0.84 | 0.76 | |
| S = | 137.78 | 137.78 | 137.78 | 137.78 | 137.78 | 137.78 | 137.78 | 102.32 | $ft^2$ |
| semi S = | 68.89 | 68.89 | 68.89 | 68.89 | 68.89 | 68.89 | 68.89 | 51.16 | $ft^2$ |
| AR = | 13.42 | 13.42 | 13.42 | 13.42 | 13.42 | 13.42 | 13.42 | 7.08 | |
| smc = | 38.45 | 38.45 | 38.45 | 38.45 | 38.45 | 38.45 | 38.45 | 45.62 | in |
| Dist centreline to smc = | 125.14 | 125.14 | 125.14 | 125.14 | 125.14 | 125.14 | 125.14 | 77.11 | in |
| Dist centreline to smc % b/2 = | 48.50 | 48.50 | 48.50 | 48.50 | 48.50 | 48.50 | 48.50 | 47.75 | % b/2 |
| check = | 48.50 | 48.50 | 48.50 | 48.50 | 48.50 | 48.50 | 48.50 | 47.75 | % b/2 |
| | | | | | | | | | |
| g load n = | 4.69 | 4.65 | 4.62 | 4.59 | 4.55 | 4.54 | 4.52 | 3.8 | g |
| Design wt = | 1150.00 | 1200.00 | 1250.00 | 1300.00 | 1350.00 | 1370.00 | 1400.00 | 1370.00 | lb |
| Wing wt = | 260.00 | 260.00 | 260.00 | 260.00 | 260.00 | 248.00 | 260.00 | 180.00 | lb |
| Design wt -Wing wt = | 890.00 | 940.00 | 990.00 | 1040.00 | 1090.00 | 1122.00 | 1140.00 | 1190.00 | lb |
| (Design wt -Wing wt)/2 = | 445.00 | 470.00 | 495.00 | 520.00 | 545.00 | 561.00 | 570.00 | 595.00 | lb at centreline |
| Limit shear = | 2086.32 | 2187.45 | 2287.10 | 2385.33 | 2482.20 | 2547.83 | 2577.76 | 2261.00 | lb at centreline |
| Ultimate shear = | 3129.48 | 3281.18 | 3430.65 | 3578.00 | 3723.30 | 3821.74 | 3866.64 | 3391.50 | lb at centreline |
| Test Factored Ultimate shear = | 4694.21 | 4921.76 | 5145.98 | 5367.00 | 5584.95 | 5732.61 | 5799.95 | 5087.25 | lb at centreline composite s factor |
| | | | | | | | | | |
| 1g Bend mom = | 55688.08 | 58816.62 | 61945.16 | 65073.71 | 68202.25 | 70204.52 | 71330.79 | 45881.72 | lb in at centreline |
| Limit mom = | 261085.33 | 273741.43 | 286212.06 | 298504.75 | 310626.77 | 318839.39 | 322585.01 | 174350.54 | lb in at centreline |
| Ultimate mom = | 391628.00 | 410612.15 | 429318.08 | 447757.13 | 465940.15 | 478259.08 | 483877.51 | 261525.80 | lb in at centreline |
| Test Factored Ultimate mom = | 587442.00 | 615918.23 | 643977.13 | 671635.69 | 698910.22 | 717388.62 | 725816.27 | 392288.70 | lb at centreline composite s factor |
| Test Factored Ultimate root mom = | 484169.31 | 507639.40 | 530765.53 | 553561.70 | 576041.35 | 591271.23 | 598217.30 | 280369.20 | lb in at root |
| Limit root fibre stress = | 55056.97 | 57725.85 | 60355.62 | 62947.87 | 65504.13 | 67235.99 | 68025.85 | 39051.42 | psi |
| Ultimate root fibre stress = | 82585.45 | 86588.78 | 90533.43 | 94421.81 | 98256.20 | 100853.98 | 102038.78 | 58577.14 | psi |
| $RF_{REQUIRED}$ = | 1.34 | 1.34 | 1.34 | 1.34 | 1.34 | 1.34 | 1.34 | 1.34 | |
| $F_{TU\ REQUIRED}$ = | 110665 | 116029 | 121315 | 126525 | 131663 | 135144 | 136732 | 78493 | psi |
| $F_{TU}/2$ = | 55332 | 58014 | 60657 | 63263 | 65832 | 67572 | 68366 | 39247 | psi |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| EUROPA MOTORGLIDER WING | | | | | | | | | | |
| FLIGHT ENVELOPE TO JAR-22 | | | | | | | | | | |
| | | | | | | | | | | |
| Trial No | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | | |
| Gross weight | W = | 1150.00 | 1200.00 | 1250.00 | 1300.00 | 1350.00 | 1370.00 | 1400.00 | lb | |
| Wing area | S = | 135.00 | 135.00 | 135.00 | 135.00 | 135.00 | 135.00 | 135.00 | $ft^2$ | |
| Wing loading | W/S = | 8.52 | 8.89 | 9.26 | 9.63 | 10.00 | 10.15 | 10.37 | psf | |
| Gross weight | M = | 521.78 | 544.46 | 567.15 | 589.84 | 612.52 | 621.60 | 635.21 | kg | |
| Wing area | S = | 12.54 | 12.54 | 12.54 | 12.54 | 12.54 | 12.54 | 12.54 | $m^2$ | |
| | | | | | | | | | | |
| Calculated Design Stalling Speed | $V_{S\ calc}$ = | 38 | 39 | 40 | 41 | 42 | 42 | 42 | kts | from $L = 1/2\ \rho\ V^2 S\ CLmax$ |
| Calculated Design Manoeuvring Speed | $V_{A\ calc}$ = | 88 | 90 | 92 | 94 | 96 | 97 | 98 | kts | from $n_1 W = 1/2\ \rho\ V^2 S\ CLmax$ |
| | | | | | | | | | | |
| Design Manoeuvring Speed | $V_A$ = | 88 | 90 | 92 | 94 | 96 | 97 | 98 | kts | From 22-335 |
| Design Gust Speed (not < $V_A$) | $V_B$ = | 88 | 90 | 92 | 94 | 96 | 97 | 98 | kts | From 22-335 |
| Design Diving Speed (may not be less than using eqn) | $V_D$ = | 225 | 228 | 231 | 234 | 237 | 238 | 240 | km/hr | |
| | $V_D$ = | | | | | | | | kts | |
| Design Diving Speed (may not be less than using $1.35*V_H$) | $V_D$ = | 176 | 176 | 176 | 176 | 176 | 176 | 176 | kts | |
| | | | | | | | | | | |
| | | | | | | | | | | |
| | | | | | | | | | | |
| Design weight | W = | 1150.00 | 1200.00 | 1250.00 | 1300.00 | 1350.00 | 1370.00 | 1400.00 | lb | |
| Design wing area | S = | 135.00 | 135.00 | 135.00 | 135.00 | 135.00 | 135.00 | 135.00 | $ft^2$ | |
| Design wing loading | W/S = | 8.52 | 8.89 | 9.26 | 9.63 | 10.00 | 10.15 | 10.37 | psf | |
| $dC_L/d\alpha$ | a = | 5.24 | 5.24 | 5.24 | 5.24 | 5.24 | 5.24 | 5.24 | cl/rad | |
| Mean geometric chord | $C_{bar}$ = | 3.20 | 3.20 | 3.20 | 3.20 | 3.20 | 3.20 | 3.20 | ft | |
| Acceleration | g = | 32.20 | 32.20 | 32.20 | 32.20 | 32.20 | 32.20 | 32.20 | $ft/s^2$ | |
| Density of air at sea level | $\rho_o$ = | 0.002378 | 0.002378 | 0.002378 | 0.002378 | 0.002378 | 0.002378 | 0.002378 | $slugs/ft^3$ | |
| Aeroplane mass ratio | $\mu_g$ = | 13.27 | 13.85 | 14.42 | 15.00 | 15.58 | 15.81 | 16.15 | | |
| Gust alleviation factor | $K_g$ = | 0.63 | 0.64 | 0.64 | 0.65 | 0.66 | 0.66 | 0.66 | | |
| | | | | | | | | | | |
| Design weight | W = | 1150.00 | 1200.00 | 1250.00 | 1300.00 | 1350.00 | 1370.00 | 1400.00 | lb | |
| Minimum Design Gust Speed | $V_B$ = | 88 | 90 | 92 | 94 | 96 | 97 | 98 | kts | |
| Minimun Design Dive Speed | $V_B$ = | 176 | 176 | 176 | 176 | 176 | 176 | 176 | kts | |
| | $V_D$ = | 149 | 153 | 156 | 159 | 162 | 163 | 165 | ft/sec | |
| | $V_D$ = | 296 | 296 | 296 | 296 | 296 | 296 | 296 | ft/sec | |
| | | | | | | | | | | |
| | | | | | | | | | | |
| | $U_{de}$ | n | n | n | n | n | n | n | | |
| At $V_B$ = | 50 | 4.44 | 4.40 | 4.37 | 4.34 | 4.31 | 4.30 | 4.28 | $n_{+gust}$ | g |
| | -50 | -2.44 | -2.40 | -2.37 | -2.34 | -2.31 | -2.30 | -2.28 | $n_{-gust}$ | g |
| At $V_D$ = | 25 | 4.41 | 4.31 | 4.21 | 4.12 | 4.03 | 4.00 | 3.95 | $n_{+gust}$ | g |
| | -25 | -2.41 | -2.31 | -2.21 | -2.12 | -2.03 | -2.00 | -1.95 | $n_{-gust}$ | g |

| Envelope Summary | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | |
| Design weight | W = | 1150.00 | 1200.00 | 1250.00 | 1300.00 | 1350.00 | 1370.00 | 1400.00 | lb |
| Stalling speed clean | $V_s$ = | 38 | 39 | 40 | 41 | 42 | 42 | 42 | kts |
| Design manoeuvre speed | $V_A$ = | 88 | 90 | 92 | 94 | 96 | 97 | 98 | kts |
| Design gust/cruising speed | $V_C$ = | 88 | 90 | 92 | 94 | 96 | 97 | 98 | kts |
| Design dive speed | $V_D$ = | 176 | 176 | 176 | 176 | 176 | 176 | 176 | kts |
| Design never exceed speed | $V_{NE}$ = | 158 | 158 | 158 | 158 | 158 | 158 | 158 | kts |
| Design minimum critical flutter speed | $V_{FLUT}$ = | 211 | 211 | 211 | 211 | 211 | 211 | 211 | kts |
| | | | | | | | | | |
| | | | | | | | | | |
| Positive manoeuvre g load | $n_1$ = | 5.30 | 5.30 | 5.30 | 5.30 | 5.30 | 5.30 | 5.30 | At +g $V_A$ |
| Positive manoeuvre g load | $n_2$ = | 4.00 | 4.00 | 4.00 | 4.00 | 4.00 | 4.00 | 4.00 | At +g $V_D$ |
| Negative manoeuvre g load | $n_3$ = | -1.50 | -1.50 | -1.50 | -1.50 | -1.50 | -1.50 | -1.50 | At -g $V_C$ |
| Negative manoeuvre g load | $n_4$ = | -2.65 | -2.65 | -2.65 | -2.65 | -2.65 | -2.65 | -2.65 | At -g $V_C$ |
| | | | | | | | | | |
| Positive gust g load | $n_{C+}$ = | 4.44 | 4.40 | 4.37 | 4.34 | 4.31 | 4.30 | 4.28 | At +g $V_C$ |
| Negative gust g load | $n_{C-}$ = | -2.44 | -2.40 | -2.37 | -2.34 | -2.31 | -2.30 | -2.28 | At -g $V_C$ |
| Positive gust g load | $n_{D+}$ = | 4.41 | 4.31 | 4.21 | 4.12 | 4.03 | 4.00 | 3.95 | At +g $V_D$ |
| Negative gust g load | $n_{D-}$ = | -2.41 | -2.31 | -2.21 | -2.12 | -2.03 | -2.00 | -1.95 | At -g $V_D$ |

EUROPA MOTORGLIDER WING

CHECK STRESS

| | 1150 | 1200 | 1250 | 1300 | 1350 | 1370 | 1400 | XS | |
|---|---|---|---|---|---|---|---|---|---|
| Span b = | 516.00 | 516.00 | 516.00 | 516.00 | 516.00 | 516.00 | 516.00 | 323.00 | in |
| Semi-span b/2 = | 258.00 | 258.00 | 258.00 | 258.00 | 258.00 | 258.00 | 258.00 | 161.50 | in |
| Centreline root chord $c_r$ = | 41.90 | 41.90 | 41.90 | 41.90 | 41.90 | 41.90 | 41.90 | 51.78 | in |
| Tip chord $c_t$ = | 35.00 | 35.00 | 35.00 | 35.00 | 35.00 | 35.00 | 35.00 | 39.45 | in |
| $\lambda$ = | 0.84 | 0.84 | 0.84 | 0.84 | 0.84 | 0.84 | 0.84 | 0.76 | |
| S = | 137.78 | 137.78 | 137.78 | 137.78 | 137.78 | 137.78 | 137.78 | 102.32 | $ft^2$ |
| semi S = | 68.89 | 68.89 | 68.89 | 68.89 | 68.89 | 68.89 | 68.89 | 51.16 | $ft^2$ |
| AR = | 13.42 | 13.42 | 13.42 | 13.42 | 13.42 | 13.42 | 13.42 | 7.08 | |
| smc = | 38.45 | 38.45 | 38.45 | 38.45 | 38.45 | 38.45 | 38.45 | 45.62 | in |
| Dist centreline to smc = | 125.14 | 125.14 | 125.14 | 125.14 | 125.14 | 125.14 | 125.14 | 77.11 | in |
| Dist centreline to smc % b/2 = | 48.50 | 48.50 | 48.50 | 48.50 | 48.50 | 48.50 | 48.50 | 47.75 | % b/2 |
| check = | 48.50 | 48.50 | 48.50 | 48.50 | 48.50 | 48.50 | 48.50 | 47.75 | % b/2 |
| | | | | | | | | | |
| g load n = | 5.30 | 5.30 | 5.30 | 5.30 | 5.30 | 5.30 | 5.30 | 3.8 | g |
| Design wt = | 1150.00 | 1200.00 | 1250.00 | 1300.00 | 1350.00 | 1370.00 | 1400.00 | 1370.00 | lb |
| Wing wt = | 260.00 | 260.00 | 260.00 | 260.00 | 260.00 | 260.00 | 260.00 | 180.00 | lb |
| Design wt - Wing wt = | 890.00 | 940.00 | 990.00 | 1040.00 | 1090.00 | 1110.00 | 1140.00 | 1190.00 | lb |
| (Design wt - Wing wt)/2 = | 445.00 | 470.00 | 495.00 | 520.00 | 545.00 | 555.00 | 570.00 | 595.00 | lb at centreline |
| Limit shear = | 2358.50 | 2491.00 | 2623.50 | 2756.00 | 2888.50 | 2941.50 | 3021.00 | 2261.00 | lb at centreline |
| Ultimate shear = | 3537.75 | 3736.50 | 3935.25 | 4134.00 | 4332.75 | 4412.25 | 4531.50 | 3391.50 | lb at centreline |
| Test Factored Ultimate shear = | 5306.63 | 5604.75 | 5902.88 | 6201.00 | 6499.13 | 6618.38 | 6797.25 | 5087.25 | lb at centreline composite s factor |
| | | | | | | | | | |
| 1g Bend mom = | 55688.08 | 58816.62 | 61945.16 | 65073.71 | 68202.25 | 69453.67 | 71330.79 | 45881.72 | lb in at centreline |
| Limit mom = | 295146.80 | 311728.08 | 328309.36 | 344890.64 | 361471.92 | 368104.44 | 378053.20 | 174350.54 | lb in at centreline |
| Ultimate mom = | 442720.20 | 467592.12 | 492464.04 | 517335.96 | 542207.88 | 552156.65 | 567079.81 | 261525.80 | lb in at centreline |
| Test Factored Ultimate moment = | 664080.30 | 701388.18 | 738696.06 | 776003.95 | 813311.83 | 828234.98 | 850619.71 | 392288.70 | lb at centreline composite s factor |
| Ultimate root mom = | 547334.55 | 578083.68 | 608832.81 | 639581.95 | 670331.08 | 682630.73 | 701080.21 | 280369.20 | lb in at root |
| Limit root fibre stress = | 62239.76 | 65736.37 | 69232.99 | 72729.60 | 76226.22 | 77624.87 | 79722.84 | 39051.42 | psi |
| Ultimate root fibre stress = | 93359.64 | 98604.56 | 103849.48 | 109094.41 | 114339.33 | 116437.30 | 119584.25 | 58577.14 | psi |
| $RF_{REQUIRED}$ = | 1.34 | 1.34 | 1.34 | 1.34 | 1.34 | 1.34 | 1.34 | 1.34 | |
| $F_{TU\,REQUIRED}$ = | 125102 | 132130 | 139158 | 146187 | 153215 | 156026 | 160243 | 78493 | psi |
| $F_{TU}/2$ = | 62551 | 66065 | 69579 | 73093 | 76607 | 78013 | 80121 | 39247 | psi |

EUROPA MOTORGLIDER WING

FLIGHT ENVELOPE TO FAR-23

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Trial No | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | | | |
| Gross weight | W = | 1150.00 | 1200.00 | 1250.00 | 1300.00 | 1350.00 | 1370.00 | 1400.00 | lb | | |
| Wing area | S = | 135.00 | 135.00 | 135.00 | 135.00 | 135.00 | 135.00 | 135.00 | $ft^2$ | | |
| Wing loading | W/S = | 8.52 | 8.89 | 9.26 | 9.63 | 10.00 | 10.15 | 10.37 | psf | | |
| Gross weight | M = | 521.78 | 544.46 | 567.15 | 589.84 | 612.52 | 621.60 | 635.21 | kg | | |
| Wing area | S = | 12.54 | 12.54 | 12.54 | 12.54 | 12.54 | 12.54 | 12.54 | $m^2$ | | |
| Calculated Design Stalling Speed | $V_{S\ calc}$ = | 38 | 39 | 40 | 41 | 42 | 42 | 42 | kts | from $L = 1/2\ \rho\ V^2 S\ CLmax$ | |
| Calculated Design Manoeuvring Speed | $V_{A\ calc}$ = | 75 | 77 | 78 | 80 | 81 | 82 | 83 | kts | from $n_1 W = 1/2\ \rho\ V^2 S\ CLmax$ | |
| Minimum Design Manoeuvring Speed | $V_A$ = | 75 | 77 | 78 | 80 | 81 | 82 | 83 | kts | From FAR 23 | |
| Minimum Design Cruising Speed | $V_C$ = | 96 | 98 | 100 | 102 | 104 | 105 | 106 | kts | From FAR 23 | |
| Design Cruising Speed need not be more than | $V_C$ = | 117 | 117 | 117 | 117 | 117 | 117 | 117 | kts | | |
| Minimum Design Diving Speed | $V_D$ = | 135 | 138 | 141 | 143 | 146 | 147 | 149 | kts | | |
| | | | | | | | | | | From FAR 23 | |
| Design weight | W = | 1150.00 | 1200.00 | 1250.00 | 1300.00 | 1350.00 | 1370.00 | 1400.00 | lb | From FAR 23 | |
| Design wing area | S = | 135.00 | 135.00 | 135.00 | 135.00 | 135.00 | 135.00 | 135.00 | $ft^2$ | | |
| Design wing loading | W/S = | 8.52 | 8.89 | 9.26 | 9.63 | 10.00 | 10.15 | 10.37 | psf | | |
| $dC_L/d\alpha$ | a = | 5.24 | 5.24 | 5.24 | 5.24 | 5.24 | 5.24 | 5.24 | cl/rad | | |
| Mean geometric chord | $C_{bar}$ = | 3.20 | 3.20 | 3.20 | 3.20 | 3.20 | 3.20 | 3.20 | ft | | |
| Acceleration | g = | 32.20 | 32.20 | 32.20 | 32.20 | 32.20 | 32.20 | 32.20 | $ft/s^2$ | | |
| Density of air at sea level | $\rho_o$ = | 0.002378 | 0.002378 | 0.002378 | 0.002378 | 0.002378 | 0.002378 | 0.002378 | $slugs/ft^3$ | | |
| Aeroplane mass ratio | $\mu_g$ = | 13.27 | 13.85 | 14.42 | 15.00 | 15.58 | 15.81 | 16.15 | | | |
| Gust alleviation factor | $K_g$ = | 0.63 | 0.64 | 0.64 | 0.65 | 0.66 | 0.66 | 0.66 | | | |
| Design weight | W = | 1150.00 | 1200.00 | 1250.00 | 1300.00 | 1350.00 | 1370.00 | 1400.00 | lb | | |
| Minimum Design Cruising Speed | $V_{C\ min}$ = | 96 | 98 | 100 | 102 | 104 | 105 | 106 | kts | | |
| Minimun Design Dive Speed | $V_{D\ min}$ = | 135 | 138 | 141 | 143 | 146 | 147 | 149 | kts | | |
| | $V_{C\ min}$ = | 163 | 166 | 170 | 173 | 176 | 178 | 180 | ft/sec | | |
| | $V_{D\ min}$ = | 228 | 233 | 237 | 242 | 247 | 249 | 251 | ft/sec | | |
| | $U_{de}$ | n | n | n | n | n | n | n | | | |
| At $V_{C\ min}$ = | 50 | 4.74 | 4.71 | 4.67 | 4.64 | 4.61 | 4.59 | 4.57 | $n_{+gust}$ | g | |
| | -50 | -2.74 | -2.71 | -2.67 | -2.64 | -2.61 | -2.59 | -2.57 | $n_{-gust}$ | g | |
| At $V_{D\ min}$ = | 25 | 3.62 | 3.59 | 3.57 | 3.55 | 3.52 | 3.51 | 3.50 | $n_{+gust}$ | g | |
| | -25 | -1.62 | -1.59 | -1.57 | -1.55 | -1.52 | -1.51 | -1.50 | $n_{-gust}$ | g | |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Using Appendix A (Applicability?) | | | | | | | | | | | |
| | | | | | | | | | | | |
| Minimum Design Manoeuvring Speed | $V_{A\,min}$ = | 97 | 99 | 101 | 103 | 105 | 106 | 107 | kts | From Appendix A23.3 | |
| Minimum Design Manoeuvring Speed (need not exceed) | $V_{A\,min}$ = | 85 | 87 | 89 | 91 | 92 | 93 | 94 | kts | From Appendix A23 Fig A3 | |
| Minimum Design Cruising Speed | $V_{C\,min}$ = | 111 | 113 | 116 | 118 | 120 | 121 | 122 | kts | From Appendix A23.3 | |
| Minimum Design Cruising Speed (need not exceed) | $V_{C\,min}$ = | 117 | 117 | 117 | 117 | 117 | 117 | 117 | kts | From Appendix A23 Fig A3 | |
| Minimum Design Diving Speed | $V_{D\,min}$ = | 155 | 159 | 162 | 165 | 168 | 170 | 171 | kts | From Appendix A23.3 | |
| Minimum Design Diving Speed (need not exceed) | $V_{D\,min}$ = | 164 | 164 | 164 | 164 | 164 | 164 | 164 | kts | From Appendix A23 Fig A3 | |
| Minimum Design Flap Speed | $V_{F\,min}$ = | 71 | 73 | 74 | 76 | 77 | 78 | 78 | kts | From Appendix A23.3 | |
| | | | | | | | | | | | |
| Positive Manoeuvring Limit Load Factor | $n_1$ = | 3.80 | 3.80 | 3.80 | 3.80 | 3.80 | 3.80 | 3.80 | g | From Appendix A Table 1 Normal Category | |
| Negative Manoeuvring Limit Load Factor | $n_2$ = | -1.90 | -1.90 | -1.90 | -1.90 | -1.90 | -1.90 | -1.90 | g | From Appendix A Table 1 Normal Category | |
| Aeroplane Positive Gust Limit Load Factor at $V_C$ | $n_3$ = | 3.80 | 3.80 | 3.80 | 3.80 | 3.80 | 3.80 | 3.80 | g | From Appendix A Fig A1 | |
| Aeroplane Negative Gust Limit Load Factor at $V_C$ | $n_4$ = | -1.90 | -1.90 | -1.90 | -1.90 | -1.90 | -1.90 | -1.90 | g | From Appendix A Fig A2 | |
| | | | | | | | | | | | |
| Envelope Summary (Not using appendix A values) | | | | | | | | | | | |
| | | | | | | | | | | | |
| Design weight | W = | 1150.00 | 1200.00 | 1250.00 | 1300.00 | 1350.00 | 1370.00 | 1400.00 | lb | | |
| Stalling speed clean | $V_S$ = | 38 | 39 | 40 | 41 | 42 | 42 | 42 | kts | | |
| Design manoeuvre speed | $V_A$ = | 75 | 77 | 78 | 80 | 81 | 82 | 83 | kts | | |
| Design cruising speed | $V_C$ = | 96 | 98 | 100 | 102 | 104 | 105 | 106 | kts | | |
| Design dive speed | $V_D$ = | 135 | 138 | 141 | 143 | 146 | 147 | 149 | kts | | |
| Design never exceed speed | $V_{NE}$ = | 121 | 124 | 127 | 129 | 131 | 132 | 134 | kts | | |
| Design minimum critical flutter speed | $V_{FLUT}$ = | 162 | 165 | 169 | 172 | 175 | 177 | 179 | kts | | |
| | | | | | | | | | | | |
| | | | | | | | | | | | |
| Positive manoeuvre g load | $n_1$ = | 3.80 | 3.80 | 3.80 | 3.80 | 3.80 | 3.80 | 3.80 | At +g $V_A$ | | |
| Negative manoeuvre g load | $n_2$ = | -1.90 | -1.90 | -1.90 | -1.90 | -1.90 | -1.90 | -1.90 | At -g $V_D$ | | |
| Negative manoeuvre g load | $n_3$ = | -1.90 | -1.90 | -1.90 | -1.90 | -1.90 | -1.90 | -1.90 | At -g $V_C$ | | |
| | | | | | | | | | | | |
| Positive gust g load | $n_{C+}$ = | 4.74 | 4.71 | 4.67 | 4.64 | 4.61 | 4.59 | 4.57 | At +g $V_C$ | | |
| Negative gust g load | $n_{C-}$ = | -2.74 | -2.71 | -2.67 | -2.64 | -2.61 | -2.59 | -2.57 | At -g $V_C$ | | |
| Positive gust g load | $n_{D+}$ = | 3.62 | 3.59 | 3.57 | 3.55 | 3.52 | 3.51 | 3.50 | At +g $V_D$ | | |
| Negative gust g load | $n_{D-}$ = | -1.62 | -1.59 | -1.57 | -1.55 | -1.52 | -1.51 | -1.50 | At -g $V_D$ | | |

EUROPA MOTORGLIDER WING

CHECK STRESS

| | 1150 | 1200 | 1250 | 1300 | 1350 | 1370 | 1400 | XS | |
|---|---|---|---|---|---|---|---|---|---|
| Span b = | 516.00 | 516.00 | 516.00 | 516.00 | 516.00 | 516.00 | 516.00 | 323.00 | in |
| Semi-span b/2 = | 258.00 | 258.00 | 258.00 | 258.00 | 258.00 | 258.00 | 258.00 | 161.50 | in |
| Centreline root chord $c_r$ = | 41.90 | 41.90 | 41.90 | 41.90 | 41.90 | 41.90 | 41.90 | 51.78 | in |
| Tip chord $c_t$ = | 35.00 | 35.00 | 35.00 | 35.00 | 35.00 | 35.00 | 35.00 | 39.45 | in |
| $\lambda$ = | 0.84 | 0.84 | 0.84 | 0.84 | 0.84 | 0.84 | 0.84 | 0.76 | |
| S = | 137.78 | 137.78 | 137.78 | 137.78 | 137.78 | 137.78 | 137.78 | 102.32 | $ft^2$ |
| semi S = | 68.89 | 68.89 | 68.89 | 68.89 | 68.89 | 68.89 | 68.89 | 51.16 | $ft^2$ |
| AR = | 13.42 | 13.42 | 13.42 | 13.42 | 13.42 | 13.42 | 13.42 | 7.08 | |
| smc = | 38.45 | 38.45 | 38.45 | 38.45 | 38.45 | 38.45 | 38.45 | 45.62 | in |
| Dist centreline to smc = | 125.14 | 125.14 | 125.14 | 125.14 | 125.14 | 125.14 | 125.14 | 77.11 | in |
| Dist centreline to smc % b/2 = | 48.50 | 48.50 | 48.50 | 48.50 | 48.50 | 48.50 | 48.50 | 47.75 | % b/2 |
| check = | 48.50 | 48.50 | 48.50 | 48.50 | 48.50 | 48.50 | 48.50 | 47.75 | % b/2 |
| | | | | | | | | | |
| g load n = | 4.74 | 4.70 | 4.67 | 4.64 | 4.60 | 4.59 | 4.57 | 3.8 | g |
| Design wt = | 1150.00 | 1200.00 | 1250.00 | 1300.00 | 1350.00 | 1370.00 | 1400.00 | 1370.00 | lb |
| Wing wt = | 260.00 | 260.00 | 260.00 | 260.00 | 260.00 | 260.00 | 260.00 | 180.00 | lb |
| Design wt -Wing wt = | 890.00 | 940.00 | 990.00 | 1040.00 | 1090.00 | 1110.00 | 1140.00 | 1190.00 | lb |
| (Design wt -Wing wt)/2 = | 445.00 | 470.00 | 495.00 | 520.00 | 545.00 | 555.00 | 570.00 | 595.00 | lb at centreline |
| Limit shear = | 2108.92 | 2211.10 | 2311.78 | 2411.02 | 2508.88 | 2547.65 | 2605.41 | 2261.00 | lb at centreline |
| Ultimate shear = | 3163.38 | 3316.65 | 3467.67 | 3616.53 | 3763.32 | 3821.47 | 3908.11 | 3391.50 | lb at centreline |
| Test Factored Ultimate shear = | 4745.07 | 4974.98 | 5201.51 | 5424.80 | 5644.97 | 5732.20 | 5862.17 | 5087.25 | lb at centreline composite s factor |
| | | | | | | | | | |
| 1g Bend mom = | 55688.08 | 58816.62 | 61945.16 | 65073.71 | 68202.25 | 69453.67 | 71330.79 | 45881.72 | lb in at centreline |
| Limit mom = | 263913.94 | 276701.25 | 289300.53 | 301719.43 | 313965.29 | 318816.77 | 326045.13 | 174350.54 | lb in at centreline |
| Ultimate mom = | 395870.91 | 415051.88 | 433950.79 | 452579.14 | 470947.94 | 478225.16 | 489067.70 | 261525.80 | lb in at centreline |
| Test Factored Ultimate moment = | 593806.37 | 622577.82 | 650926.19 | 678868.71 | 706421.91 | 717337.73 | 733601.55 | 392288.70 | lb at centreline composite s factor |
| Ultimate root mom = | 489414.82 | 513128.23 | 536492.94 | 559523.15 | 582232.48 | 591229.29 | 604633.92 | 280369.20 | lb in at root |
| Limit root fibre stress = | 55653.46 | 58350.01 | 61006.91 | 63625.78 | 66208.15 | 67231.22 | 68755.51 | 39051.42 | psi |
| Ultimate root fibre stress = | 83480.19 | 87525.02 | 91510.37 | 95438.66 | 99312.23 | 100846.82 | 103133.27 | 58577.14 | psi |
| $RF_{REQUIRED}$ = | 1.34 | 1.34 | 1.34 | 1.34 | 1.34 | 1.34 | 1.34 | 1.34 | |
| $F_{TU REQUIRED}$ = | 111863 | 117284 | 122624 | 127888 | 133078 | 135135 | 138199 | 78493 | psi |
| $F_{TU}/2$ = | 55932 | 58642 | 61312 | 63944 | 66539 | 67567 | 69099 | 39247 | psi |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| EUROPA PRODUCTION MOTORGLIDER WING | | | | | | | | | | |
| FLIGHT ENVELOPE TO BCAR K3-2 & K3-3 | | | | | | | | | | |
| Trial No | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | | |
| Gross weight | W = | 1150.00 | 1200.00 | 1250.00 | 1300.00 | 1350.00 | 1370.00 | 1400.00 | lb | |
| Wing area | S = | 135.00 | 135.00 | 135.00 | 135.00 | 135.00 | 135.00 | 135.00 | $ft^2$ | |
| Wing loading | W/S = | 8.52 | 8.89 | 9.26 | 9.63 | 10.00 | 10.15 | 10.37 | psf | |
| Calculated Design Stalling Speed | $V_{S\ calc}$ = | 38 | 39 | 40 | 41 | 42 | 42 | 42 | kts | from $L = 1/2\ \rho\ V^2 S\ CLmax$ |
| Calculated Design Manoeuvring Speed | $V_{A\ calc}$ = | 75 | 77 | 78 | 80 | 81 | 82 | 83 | kts | from $n_1\ W = 1/2\ \rho\ V^2 S\ CLmax$ |
| | | | | | | | | | | |
| From Section K Table K3-2 | | | | | | | | | | |
| Calculated Positive Manoeuvring Limit Load Factor at $V_A$ | $n_1$ = | 4.25 | 4.24 | 4.23 | 4.22 | 4.21 | 4.21 | 4.21 | g | |
| Choosing Lower Positive Manoeuvring Limit Load Factor at $V_A$ | $n_1$ = | 3.80 | 3.80 | 3.80 | 3.80 | 3.80 | 3.80 | 3.80 | g | |
| Calculated Negative Manoeuvring Limit Load Factor at $V_D$ | $n_2$ = | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | g | |
| Calculated Aeroplane Negative Gust Limit Load Factor at $V_C$ | $n_3$ = | -1.52 | -1.52 | -1.52 | -1.52 | -1.52 | -1.52 | -1.52 | g | |
| | | | | | | | | | | |
| Design Manoeuvring Speed | $V_{A\ des}$ = | 75 | 77 | 78 | 80 | 81 | 82 | 83 | kts | Section K3-2 para 2.7.1 |
| Design Cruising Speed | $V_{C\ des}$ = | 111 | 113 | 116 | 118 | 120 | 121 | 122 | mph | Section K3-2 para 2.7.2 |
| | $V_{C\ des}$ = | 96 | 98 | 100 | 102 | 104 | 105 | 106 | kts | |
| Minimum Design Cruising Speed need not be > than 0.9 $V_H$ | $V_{C\ min}$ = | 117 | 117 | 117 | 117 | 117 | 117 | 117 | kts | Section K3-2 para 2.7.2 |
| Minimum Design Cruising Speed Checking > 2*$V_{S\ calc}$ | $V_{C\ min}$ = | 77 | 79 | 80 | 82 | 83 | 84 | 85 | kts | Section K3-2 para 2.7.2 |
| Note $V_{NO} \leq V_{C\ min}$ | | | | | | | | | | |
| Design Dive Speed = 1.4 $V_C$ | $V_D$ = | 135 | 138 | 140 | 143 | 146 | 147 | 149 | kts | Section K3-2 para 2.7.3 |
| Design Dive Speed = $V_C$ + 40 kts | $V_D$ = | 136 | 138 | 140 | 142 | 144 | 145 | 146 | kts | Section K3-2 para 2.7.3 |
| | | | | | | | | | | |
| Gust Loads | | | | | | | | | | Section K3-3 para 3 |
| Design weight | W = | 1150.00 | 1200.00 | 1250.00 | 1300.00 | 1350.00 | 1370.00 | 1400.00 | lb | |
| Design wing area | S = | 135.00 | 135.00 | 135.00 | 135.00 | 135.00 | 135.00 | 135.00 | $ft^2$ | |
| Design wing loading | W/S = | 8.52 | 8.89 | 9.26 | 9.63 | 10.00 | 10.15 | 10.37 | psf | |
| $dC_L/d\alpha$ | a = | 5.24 | 5.24 | 5.24 | 5.24 | 5.24 | 5.24 | 5.24 | cl/rad | |
| Mean geometric chord | $C_{bar}$ = | 3.20 | 3.20 | 3.20 | 3.20 | 3.20 | 3.20 | 3.20 | ft | |
| Acceleration | g = | 32.20 | 32.20 | 32.20 | 32.20 | 32.20 | 32.20 | 32.20 | $ft/s^2$ | |
| Density of air at sea level | $\rho_o$ = | 0.002378 | 0.002378 | 0.002378 | 0.002378 | 0.002378 | 0.002378 | 0.002378 | $slugs/ft^3$ | |
| Aeroplane mass ratio | $\mu_g$ = | 13.27 | 13.85 | 14.42 | 15.00 | 15.58 | 15.81 | 16.15 | | |
| Gust alleviation factor | $K_g$ = | 0.63 | 0.64 | 0.64 | 0.65 | 0.66 | 0.66 | 0.66 | | |
| | | | | | | | | | | |
| Design weight | W = | 1150.00 | 1200.00 | 1250.00 | 1300.00 | 1350.00 | 1370.00 | 1400.00 | lb | |
| Minimum Design Cruising Speed | $V_{C\ min}$ = | 96 | 98 | 100 | 102 | 104 | 105 | 106 | kts | |
| Minimun Design Dive Speed | $V_{D\ min}$ = | 136 | 138 | 140 | 143 | 146 | 147 | 149 | kts | |
| | $V_{C\ min}$ = | 163 | 166 | 170 | 173 | 176 | 177 | 179 | ft/sec | |
| | $V_{D\ min}$ = | 230 | 234 | 237 | 242 | 247 | 248 | 251 | ft/sec | |
| | | | | | | | | | | |
| | $U_{de}$ | n | n | n | n | n | n | n | | |
| At $V_{C\ min}$ = | 50 | 4.74 | 4.70 | 4.67 | 4.64 | 4.60 | 4.59 | 4.57 | $n_{+gust}$ | g |
| | -50 | -2.74 | -2.70 | -2.67 | -2.64 | -2.60 | -2.59 | -2.57 | $n_{-gust}$ | g |
| At $V_{D\ min}$ = | 25 | 3.65 | 3.61 | 3.57 | 3.55 | 3.52 | 3.51 | 3.50 | $n_{+gust}$ | g |
| | -25 | -1.65 | -1.61 | -1.57 | -1.55 | -1.52 | -1.51 | -1.50 | $n_{-gust}$ | g |

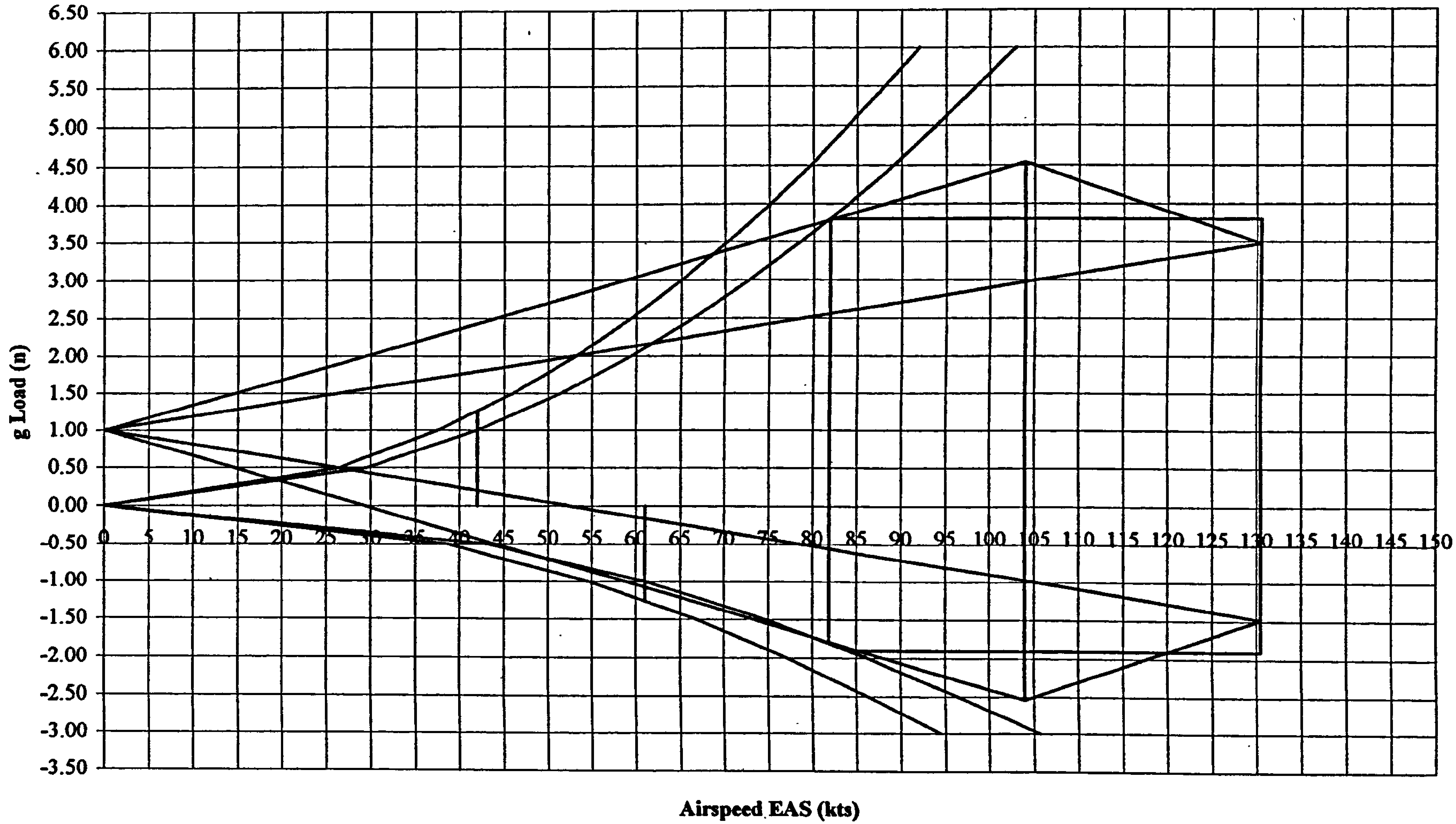
| Envelope Summary | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | |
| Design weight | W = | 1150.00 | 1200.00 | 1250.00 | 1300.00 | 1350.00 | 1370.00 | 1400.00 | lb | |
| Stalling speed clean | $V_S$ = | 38 | 39 | 40 | 41 | 42 | 42 | 42 | kts | |
| Design manoeuvre speed | $V_A$ = | 75 | 77 | 78 | 80 | 81 | 82 | 83 | kts | |
| Design cruising speed | $V_C$ = | 96 | 98 | 100 | 102 | 104 | 105 | 106 | kts | |
| Design dive speed | $V_D$ = | 136 | 138 | 140 | 143 | 146 | 147 | 149 | kts | |
| Design never exceed speed | $V_{NE}$ = | 123 | 124 | 126 | 129 | 131 | 132 | 134 | kts | |
| Design minimum critical flutter speed | $V_{FLUT}$ = | 170 | 173 | 175 | 179 | 183 | 184 | 186 | kts | |
| | $V_{FLUT\ VLA}$ = | 164 | 166 | 168 | 172 | 175 | 177 | 178 | kts | |
| | | | | | | | | | | |
| Positive manoeuvre g load | $n_1$ = | 3.80 | 3.80 | 3.80 | 3.80 | 3.80 | 3.80 | 3.80 | At +g $V_A$ | |
| Negative manoeuvre g load | $n_2$ = | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | At -g $V_D$ | |
| Negative manoeuvre g load | $n_3$ = | -1.52 | -1.52 | -1.52 | -1.52 | -1.52 | -1.52 | -1.52 | At -g $V_C$ | |
| | | | | | | | | | | |
| Positive gust g load | $n_{C+}$ = | 4.74 | 4.70 | 4.67 | 4.64 | 4.60 | 4.59 | 4.57 | At +g $V_C$ | |
| Negative gust g load | $n_{C-}$ = | -2.74 | -2.70 | -2.67 | -2.64 | -2.60 | -2.59 | -2.57 | At -g $V_C$ | |
| Positive gust g load | $n_{D+}$ = | 3.65 | 3.61 | 3.57 | 3.55 | 3.52 | 3.51 | 3.50 | At +g $V_D$ | |
| Negative gust g load | $n_{D-}$ = | -1.65 | -1.61 | -1.57 | -1.55 | -1.52 | -1.51 | -1.50 | At -g $V_D$ | |

EUROPA MOTORGLIDER WING

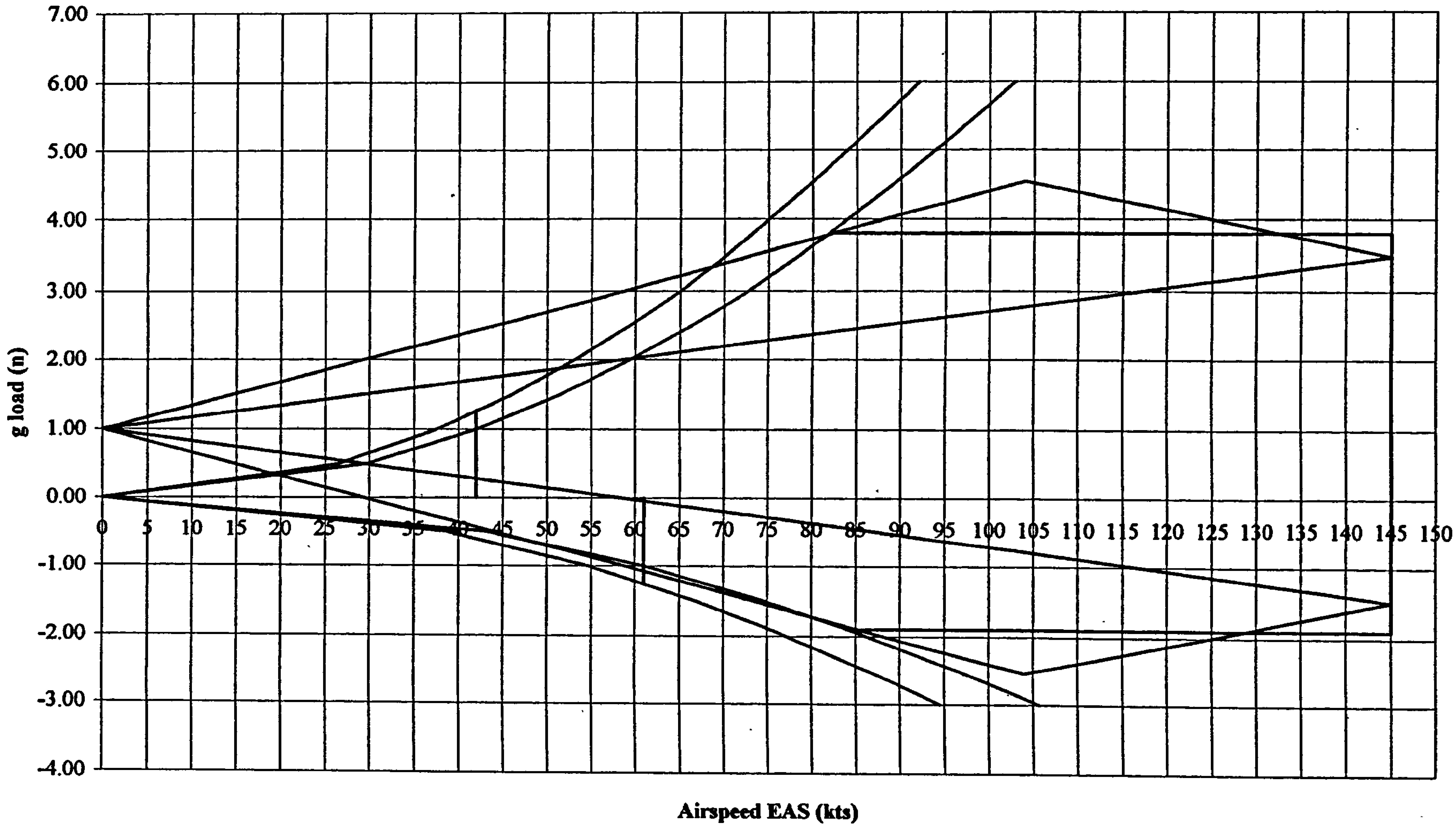
CHECK STRESS

| | 1150 | 1200 | 1250 | 1300 | 1350 | 1370 | 1400 | XS | |
|---|---|---|---|---|---|---|---|---|---|
| Span b = | 516.00 | 516.00 | 516.00 | 516.00 | 516.00 | 516.00 | 516.00 | 323.00 | in |
| Semi-span b/2 = | 258.00 | 258.00 | 258.00 | 258.00 | 258.00 | 258.00 | 258.00 | 161.50 | in |
| Centreline root chord $c_r$ = | 41.90 | 41.90 | 41.90 | 41.90 | 41.90 | 41.90 | 41.90 | 51.78 | in |
| Tip chord $c_t$ = | 35.00 | 35.00 | 35.00 | 35.00 | 35.00 | 35.00 | 35.00 | 39.45 | in |
| $\lambda$ = | 0.84 | 0.84 | 0.84 | 0.84 | 0.84 | 0.84 | 0.84 | 0.76 | |
| S = | 137.78 | 137.78 | 137.78 | 137.78 | 137.78 | 137.78 | 137.78 | 102.32 | $ft^2$ |
| semi S = | 68.89 | 68.89 | 68.89 | 68.89 | 68.89 | 68.89 | 68.89 | 51.16 | $ft^2$ |
| AR = | 13.42 | 13.42 | 13.42 | 13.42 | 13.42 | 13.42 | 13.42 | 7.08 | |
| smc = | 38.45 | 38.45 | 38.45 | 38.45 | 38.45 | 38.45 | 38.45 | 45.62 | in |
| Dist centreline to smc = | 125.14 | 125.14 | 125.14 | 125.14 | 125.14 | 125.14 | 125.14 | 77.11 | in |
| Dist centreline to smc % b/2 = | 48.50 | 48.50 | 48.50 | 48.50 | 48.50 | 48.50 | 48.50 | 47.75 | % b/2 |
| check = | 48.50 | 48.50 | 48.50 | 48.50 | 48.50 | 48.50 | 48.50 | 47.75 | % b/2 |
| | | | | | | | | | |
| g load n = | 4.74 | 4.71 | 4.67 | 4.64 | 4.61 | 4.59 | 4.57 | 3.8 | g |
| Design wt = | 1150.00 | 1200.00 | 1250.00 | 1300.00 | 1350.00 | 1370.00 | 1400.00 | 1370.00 | lb |
| Wing wt = | 260.00 | 260.00 | 260.00 | 260.00 | 260.00 | 260.00 | 260.00 | 180.00 | lb |
| Design wt - Wing wt = | 890.00 | 940.00 | 990.00 | 1040.00 | 1090.00 | 1110.00 | 1140.00 | 1190.00 | lb |
| (Design wt - Wing wt)/2 = | 445.00 | 470.00 | 495.00 | 520.00 | 545.00 | 555.00 | 570.00 | 595.00 | lb at centreline |
| Limit shear = | 2109.90 | 2212.13 | 2312.85 | 2412.13 | 2510.03 | 2548.82 | 2606.60 | 2261.00 | lb at centreline |
| Ultimate shear = | 3164.85 | 3318.19 | 3469.28 | 3618.20 | 3765.05 | 3823.22 | 3909.90 | 3391.50 | lb at centreline |
| Test Factored Ultimate shear = | 4747.27 | 4977.28 | 5203.91 | 5427.30 | 5647.57 | 5734.84 | 5864.86 | 5087.25 | lb at centreline composite s factor |
| | | | | | | | | | |
| 1g Bend mom = | 55688.08 | 58816.62 | 61945.16 | 65073.71 | 68202.25 | 69453.67 | 71330.79 | 45881.72 | lb in at centreline |
| Limit mom = | 264036.33 | 276829.32 | 289434.16 | 301858.52 | 314109.75 | 318963.34 | 326194.85 | 174350.54 | lb in at centreline |
| Ultimate mom = | 396054.50 | 415243.98 | 434151.24 | 452787.78 | 471164.62 | 478445.01 | 489292.27 | 261525.80 | lb in at centreline |
| Test Factored Ultimate moment = | 594081.74 | 622865.97 | 651226.86 | 679181.67 | 706746.93 | 717667.51 | 733938.41 | 392288.70 | lb at centreline composite s factor |
| Ultimate root mom = | 489641.79 | 513365.72 | 536740.75 | 559781.09 | 582500.36 | 591501.10 | 604911.56 | 280369.20 | lb in at root |
| Limit root fibre stress = | 55679.27 | 58377.02 | 61035.09 | 63655.11 | 66238.61 | 67262.12 | 68787.09 | 39051.42 | psi |
| Ultimate root fibre stress = | 83518.90 | 87565.52 | 91552.64 | 95482.66 | 99357.92 | 100893.19 | 103180.63 | 58577.14 | psi |
| $RF_{REQUIRED}$ = | 1.34 | 1.34 | 1.34 | 1.34 | 1.34 | 1.34 | 1.34 | 1.34 | |
| $F_{TU\,REQUIRED}$ = | 111915 | 117338 | 122681 | 127947 | 133140 | 135197 | 138262 | 78493 | psi |
| $F_{TU}/2$ = | 55958 | 58669 | 61340 | 63973 | 66570 | 67598 | 69131 | 39247 | psi |

**Production Glider Wing**
**JAR-VLA Flight Envelope**
**1370 lb AUW**



**Production Glider Wing**
**JAR-VLA Structural Flight Envelope**
**1370 lb AUW**



# APPENDIX B: SPANWISE LOADS DETERMINATION: SYMMETRIC & CLEAN CONDITIONS A THROUGH G

# Spanwise Loads

Legend for Spanwise Load Calculation Spreadsheets

Suffix "A" indicates condition on the aircraft flight envelope under investigation.

| Column Number | Description of Calculation |
|---|---|
| 1. | Trapezoidal Wing Measured from A/C $C_L$ (in) |
| 2. | Non Dimensional Wing Span |
| 3. | Distance Between Stations dy= $(STN_{(n+1)} - STN_{(n)})$ |
| 4. | Chord AT STN (in) |
| 5. | Chord AT STN (ft) |
| 6. | Average Chord = $\dfrac{5_{(n+1)} + 5_{(n)}}{2}$ |
| 7. | Average Area= 3 * 6 |
| 8. | Elliptical Spline= $\dfrac{4 * S}{\pi b((1-(\frac{2y}{b})^2)^{1/2})}$<br>S=Wing Area  b=Wing Span |
| 9. | Shrenk Spline= $\dfrac{5+8}{2}$ |
| 10. | Unit Lift= $\dfrac{9}{5}$ |
| 11. | Average Lift= $\dfrac{10_{(n+1)} + 10_n}{z}$ |
| 12. | dy $c^2$= 6 * 7 |
| 13. | [$C_L$ Calculated for Wing] *10 |
| 14. | $C_{LX}$= $C_{LWing}$ * Sinx = 13 * Sinx |
| 15. | $C_{LZ}$= $C_{LWing}$ * Cosx = 13 * Cosx |
| 16. | $C_D$= $C_D$ Wing<br>Note:$C_D$ Wing at Tip=1.2 * $C_D$ Wing Due to Tip Vortex<br>80% span – $C_D$ Wing Inboard = 0.95 * $C_D$ Wing<br>** I D |
| 17. | $C_{DX}$= 16 * Cosx |
| 18. | $C_{DZ}$= 16 * Sinx |
| 19. | 15 + 18 |
| 20. | 17 – 14 |

| | |
|---|---|
| 21. | Average of Column 19 $=\frac{19_{n+1} + 19_n}{2}$ |
| 22. | Average of Column 20 $=\frac{20_{n+1} + 20_n}{2}$ |
| 23. | Lift= qdyc ($C_{LZ} + C_{DZ}$)AV =3 * 6 * 21 * q |
| 24. | Drag= qdyc ($C_{DX}$-$C_{LX}$)AV =3 * 6 * 22 * q |
| 25. | =Limit Normal Shear =Σ Lift Column = Σ 23 |
| 26. | Limit Normal Moment =Av 25 * 3 + Prev STN Moment =Normal Moment |
| 27. | Limit Chordwise Shear = Σ Drag Column = Σ24 |
| 28. | Limit Chordwise Moment =Av 27 * 3 + Prev STN Moment= Chordwise Moment |
| 29. | Ultimate Normal Shear=1 1/2 * 25 |
| 30. | Ultimate Normal Moment= 1 1/2 * 26 |
| 31. | Ultimate Chordwise Shear= 1 1/2 * 27 |
| 32. | Ultimate Chordwise Moment= 1 1/2 * 28 |
| 33. | Wing Weight= nw A7 1g= 95 lb. |
| 34. | Element Shear Force $V_X$= -(33) Sinx |
| 35. | Element Shear Force $V_Z$= 33 Cosx |
| 36. | Limit Normal Shear $\Sigma V_Z$= Σ34 |
| 37. | Limit Normal Moment =Av36 * 3 + Prev STN Moment= Normal Movement |
| 38. | Limit Chordwise Shear $\Sigma_{VX}$=Σ35 |
| 39. | Limit Chordwise Moment= Av 38 * 3 + Prev STN Moment= Chordwise Moment |
| 40. | Ultimate Normal Shear= 11/2 * 36 |
| 41. | Ultimate Normal Moment= 11/2 * 37 |
| 42. | Ultimate Chordwise Shear= 11/2 * 38 |
| 43. | Ultimate Chordwise Moment= 11/2 * 39 |
| 44.Δ | Ultimate Normal Shear= 29 + 40 |
| 45.Δ | Ultimate Normal Moment= 30 + 41 |
| 46.Δ | Ultimate Chordwise Shear= 31 + 42 |
| 47.Δ | Ultimate Chordwise Moment= 32 + 43 |
| 50. | Clean Wing $C_L$= 13 |
| 51. | [$X_{CP}$ for Cond ACD, $0.24\text{-}^{CMO}/_{CL}=0.24\text{-}^{CMO}/_5$]<br>[$X_{CP}$ for Cond EFG, $0.24+^{CMO}/_{CL}=0.24+^{CMO}/_5$] ** ID |
| 52. | Aerodynamic Centre =$X_{CP}$ * Chord (in) =5 *12 * 51 |
| 53. | $X_{AC}$=52 |
| 54. | $X_{SC}$= 0.38 * Chord = Wing Shear Centre =0.41 * 5 *12 |
| 55. | Delta X= 54–53 |
| 56. | $Z_{AC}$=0 [Unused Analysis] |
| 57. | $Z_{SC}$= ½ of the SPAR Depth [Unused Within Analysis] |
| 58. | Delta Z= [Unused Within Analysis] |

| | |
|---|---|
| | Delta $X_{AV}$= $\frac{55_{n+1} - 55_n}{z}$ |
| | Delta $Z_{AV}$= $\frac{58_{n+1} - 58_n}{z}$ [Unused Within Analysis] |
| 23. | Span Element Lift= 23 |
| 24. | Span Element Drag=24 |
| 59. | Torque Due to $C_{MO}$= q * $S_{local}$ * $C_{mo}$ C =q * 3 * 6 * -.02 * 6 *12 |
| 60. | Torque Due to Lift = 23 * Delta $X_{AV}$ |
| 61. | Torque Due to Drag= [Unused in Analysis] |
| 62. | Element Limit Torque=59+60+61 |
| 63. | Total Limit Torque= Σ62 |
| 64. | Total Ultimate Torques= 11/2 * 63 |
| 65. | $X_{CG}$=0.40 * 12 * .5 |
| 54. | $X_{SC}$= 54 |
| 66. | Delta X=54-65 |
| 67. | $X_{AV}$= Average 66 |
| 33. | Element Load= 33 |
| 68. | Element Limit Torque= 33 * 76 |
| 69. | Total Limit Torque= Σ68 |
| 70. | Total Ultimate Torque=69 * 1 1/2 |
| 71. Δ | Aerodynamic + Internal Torque=72+79 |

**Notes:

ID=Raymer Aircraft Design & Conceptual Approach p.344

$R_S$=Resolved Shear= $\sqrt{(ChordwiseShear)^2 + (SpanwiseShear)^2}$

$R_M$=Resolved Moment= $\sqrt{(ChordwiseMoment)^2 + (SpanwiseMoment)^2}$

ID=$X_{CP}$ is local to the surface.

EUROPA GLIDER WING LOADING ANALYSIS

ANALYSIS TO JAR VLA

DESIGN SPANWISE AERODYNAMIC LOAD DISTRIBUTION

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| W = | 1370.00 | lb | | | | | | | | | | | |
| b = | 43.00 | ft | | | | | | | | | | | |
| S = | 135.00 | $ft^2$ | | | | | | | | | | | |
| AR = | 13.70 | | | | | | | | | | | | |
| e = | 0.80 | | | | | | | | | | | | |
| | | | GUST | GUST | | ZL | | | GUST | GUST | | | |
| | COND.A | COND.A | COND.C | COND.C | COND.D | COND.D | COND.E | COND.E | COND.F | COND.F | COND.G | COND.G | |
| | | BRAKES OUT | | BRAKES OUT | | BRAKES OUT | | BRAKES OUT | | BRAKES OUT | | BRAKES OUT | |
| $V_{SEL}$ = | 82 | 82 | 104 | 104 | 145 | 145 | 145 | 145 | 104 | 104 | 82 | 82 | kts |
| $V_{SEL}$ = | 139 | 139 | 176 | 176 | 245 | 245 | 245 | 245 | 176 | 176 | 139 | 139 | ft/sec |
| $V_{SEL}$ = | 94 | 94 | 120 | 120 | 167 | 167 | 167 | 167 | 120 | 120 | 94 | 94 | mph |
| n = | 3.80 | 3.80 | 4.54 | 4.54 | 3.80 | 0.00 | -1.90 | -1.90 | -2.54 | -2.54 | -1.90 | -1.90 | g |
| 2/3 n = | | 2.53 | | 3.03 | | 0.00 | | -1.27 | | -1.69 | | -1.27 | |
| nW = | 5206.00 | 5206.00 | 6219.80 | 6219.80 | 5206.00 | 0.00 | -2603.00 | -2603.00 | -3479.80 | -3479.80 | -2603.00 | -2603.00 | lb |
| $L_t$ = | -260.30 | -260.30 | -310.99 | -310.99 | -260.30 | 0.00 | 130.15 | 130.15 | 173.99 | 173.99 | 130.15 | 130.15 | lb USING 5% of nW |
| LIFT = | 5466.30 | 5466.30 | 6530.79 | 6530.79 | 5466.30 | 0.00 | -2733.15 | -2733.15 | -3653.79 | -3653.79 | -2733.15 | -2733.15 | lb |
| | | | | | | | | | | | | | |
| q = | 23.82 | 23.82 | 36.73 | 36.73 | 71.39 | 71.39 | 71.39 | 71.39 | 36.73 | 36.73 | 25.31 | 25.31 | psf |
| $C_L$ = | 1.70 | 1.70 | 1.32 | 1.32 | 0.57 | 0.00 | -0.28 | -0.28 | -0.74 | -0.74 | -0.80 | -0.80 | FROM JAR VLA |
| $C_{Do}$ = | 0.021 | 0.021 | 0.017 | 0.017 | 0.006 | 0.006 | 0.007 | 0.007 | 0.009 | 0.009 | 0.010 | 0.010 | USING NACA 241 |
| $C_D$ = | 0.105 | 0.105 | 0.067 | 0.067 | 0.015 | 0.006 | 0.009 | 0.009 | 0.025 | 0.025 | 0.028 | 0.028 | |
| alpha = | 14.50 | 14.50 | 10.51 | 10.51 | 2.70 | -3.21 | -6.16 | -6.16 | -10.88 | -10.88 | -11.54 | -11.54 | deg |
| $C_{Mo}$ = | -0.025 | -0.025 | -0.025 | -0.025 | -0.025 | -0.025 | -0.025 | -0.025 | -0.025 | -0.025 | -0.025 | -0.025 | |
| Xcp = | 0.25 | 0.25 | 0.26 | 0.26 | 0.28 | #DIV/0! | 0.15 | 0.15 | 0.21 | 0.21 | 0.21 | 0.21 | |

SHRENK APPROXIMATION

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| STATION | 2y/b | dy | CHORD | CHORD | c av | ELEM AREA | ELLIPSE | SHRENK | UNIT | | dy c av$^2$ |
| (in) | | (ft) | (in) | (ft) | (ft) | dy * c av | | Cla | Cla | av Cla | |
| | | | | | | (ft$^2$) | | | | | |
| 258 | 1.000 | - | 35.00 | 2.917 | - | - | 0.000 | 1.458 | 0.500 | - | - |
| 251.25 | 0.974 | 0.56 | 35.18 | 2.932 | 2.924 | 1.645 | 0.908 | 1.920 | 0.655 | 0.577 | 4.81 |
| 238 | 0.922 | 1.10 | 35.53 | 2.961 | 2.946 | 3.253 | 1.543 | 2.252 | 0.761 | 0.708 | 9.59 |
| 228 | 0.884 | 0.83 | 35.80 | 2.984 | 2.972 | 2.477 | 1.871 | 2.427 | 0.814 | 0.787 | 7.36 |
| 218 | 0.845 | 0.83 | 36.07 | 3.006 | 2.995 | 2.496 | 2.138 | 2.572 | 0.856 | 0.835 | 7.47 |
| 208 | 0.806 | 0.83 | 36.34 | 3.028 | 3.017 | 2.514 | 2.365 | 2.697 | 0.891 | 0.873 | 7.59 |
| 198 | 0.767 | 0.83 | 36.60 | 3.050 | 3.039 | 2.533 | 2.563 | 2.807 | 0.920 | 0.905 | 7.70 |
| 188 | 0.729 | 0.83 | 36.87 | 3.073 | 3.062 | 2.551 | 2.738 | 2.905 | 0.945 | 0.933 | 7.81 |
| 178 | 0.690 | 0.83 | 37.14 | 3.095 | 3.084 | 2.570 | 2.894 | 2.994 | 0.967 | 0.956 | 7.92 |
| 163.65 | 0.634 | 1.20 | 37.52 | 3.127 | 3.111 | 3.720 | 3.090 | 3.109 | 0.994 | 0.981 | 11.57 |
| 159 | 0.618 | 0.36 | 37.64 | 3.137 | 3.132 | 1.129 | 3.144 | 3.140 | 1.001 | 0.998 | 3.53 |
| 155.00 | 0.601 | 0.36 | 37.75 | 3.146 | 3.141 | 1.132 | 3.196 | 3.171 | 1.008 | 1.005 | 3.56 |
| 138 | 0.535 | 1.42 | 38.21 | 3.184 | 3.165 | 4.484 | 3.377 | 3.281 | 1.030 | 1.019 | 14.19 |
| 128 | 0.496 | 0.83 | 38.48 | 3.206 | 3.195 | 2.663 | 3.471 | 3.339 | 1.041 | 1.036 | 8.51 |
| 118 | 0.457 | 0.83 | 38.74 | 3.229 | 3.218 | 2.681 | 3.555 | 3.392 | 1.051 | 1.046 | 8.63 |
| 108 | 0.419 | 0.83 | 39.01 | 3.251 | 3.240 | 2.700 | 3.630 | 3.441 | 1.058 | 1.054 | 8.75 |
| 98 | 0.380 | 0.83 | 39.28 | 3.273 | 3.262 | 2.718 | 3.698 | 3.486 | 1.065 | 1.062 | 8.87 |
| 88 | 0.341 | 0.83 | 39.55 | 3.296 | 3.284 | 2.737 | 3.758 | 3.527 | 1.070 | 1.067 | 8.99 |
| 80.00 | 0.310 | 0.67 | 39.76 | 3.313 | 3.304 | 2.203 | 3.800 | 3.557 | 1.073 | 1.072 | 7.28 |
| 68 | 0.264 | 1.00 | 40.08 | 3.340 | 3.327 | 3.327 | 3.856 | 3.598 | 1.077 | 1.075 | 11.07 |
| 58 | 0.225 | 0.83 | 40.35 | 3.362 | 3.351 | 2.793 | 3.895 | 3.629 | 1.079 | 1.078 | 9.36 |
| 48 | 0.186 | 0.83 | 40.62 | 3.385 | 3.374 | 2.811 | 3.928 | 3.656 | 1.080 | 1.080 | 9.48 |
| 22 | 0.085 | 2.17 | 41.31 | 3.443 | 3.414 | 7.396 | 3.983 | 3.713 | 1.078 | 1.079 | 25.25 |
| 19 | 0.074 | 0.25 | 41.39 | 3.449 | 3.446 | 0.861 | 3.987 | 3.718 | 1.078 | 1.078 | 2.97 |
| 0 | 0.000 | 1.58 | 41.90 | 3.492 | 3.470 | 5.495 | 3.997 | 3.745 | 1.072 | 1.075 | 19.07 |
| | | | | | Σ= | 68.89 | | | | Σ= | 221.32 |
| | | | | | Area calc = | 137.78 | ft$^2$ | | MAC calc = | 3.21 | ft |
| | | | | | | | | | MAC calc = | 38.55 | in |

SPANWISE AERODYNAMIC LOAD DISTRIBUTION

CONDITION. A

| | | | | | |
|---|---|---|---|---|---|
| $V_{sel}$ = | 138.51 ft/s | $C_L$ = | 1.7 | alpha wrp = | 14.5000 |
| Lift = | 5466.30 lb | $C_{Do}$ = | 0.021 | sin alpha = | 0.2504 |
| q = | 23.82 psf | $C_D$ = | 0.105 | cos alpha = | 0.9681 |
| n = | 3.80 g | $C_{Mo}$ = | -0.025 | | |
| $q.C_L$ = | 40.49 $q.C_L$ =Lift/S | S = | 135.00 $ft^2$ | | |
| | | b = | 43.00 ft | | |

| 1 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| STATION (in) | $C_L$ | $C_{Lx}$ | $C_{Lz}$ | $C_D$ | $C_{Dx}$ | $C_{Dz}$ | $C_{Lz}+C_{Dx}$ | $C_{Dz}-C_{Lx}$ | $(C_{Lz}+C_{Dx})_{AV}$ | $(C_{Dz}-C_{Lx})_{AV}$ | SPAN ELEMENT LIFT (lb) | SPAN ELEMENT DRAG (lb) |
| 258 | 0.8500 | 0.2128 | 0.8229 | 0.1259 | 0.1219 | 0.0315 | 0.8545 | -0.0909 | - | - | 0.00 | 0.00 |
| 251.25 | 1.1134 | 0.2788 | 1.0779 | 0.1259 | 0.1219 | 0.0315 | 1.1094 | -0.1568 | 0.9820 | -0.1239 | 38.47 | -4.85 |
| 238 | 1.2930 | 0.3237 | 1.2518 | 0.1259 | 0.1219 | 0.0315 | 1.2833 | -0.2018 | 1.1964 | -0.1793 | 92.71 | -13.89 |
| 228 | 1.3830 | 0.3463 | 1.3389 | 0.1259 | 0.1219 | 0.0315 | 1.3705 | -0.2243 | 1.3269 | -0.2131 | 78.28 | -12.57 |
| 218 | 1.4546 | 0.3642 | 1.4082 | 0.1259 | 0.1219 | 0.0315 | 1.4398 | -0.2423 | 1.4051 | -0.2333 | 83.52 | -13.87 |
| 208 | 1.5139 | 0.3790 | 1.4656 | 0.0997 | 0.0965 | 0.0250 | 1.4906 | -0.2825 | 1.4652 | -0.2624 | 87.74 | -15.71 |
| 198 | 1.5641 | 0.3916 | 1.5143 | 0.0997 | 0.0965 | 0.0250 | 1.5393 | -0.2951 | 1.5149 | -0.2888 | 91.39 | -17.42 |
| 188 | 1.6073 | 0.4024 | 1.5561 | 0.0997 | 0.0965 | 0.0250 | 1.5811 | -0.3059 | 1.5602 | -0.3005 | 94.81 | -18.26 |
| 178 | 1.6447 | 0.4118 | 1.5923 | 0.0997 | 0.0965 | 0.0250 | 1.6173 | -0.3153 | 1.5992 | -0.3106 | 97.89 | -19.01 |
| 163.65 | 1.6900 | 0.4232 | 1.6362 | 0.0997 | 0.0965 | 0.0250 | 1.6612 | -0.3266 | 1.6392 | -0.3209 | 145.25 | -28.44 |
| 159 | 1.7020 | 0.4262 | 1.6478 | 0.0997 | 0.0965 | 0.0250 | 1.6728 | -0.3296 | 1.6670 | -0.3281 | 44.82 | -8.82 |
| 155.00 | 1.7133 | 0.4290 | 1.6588 | 0.0997 | 0.0965 | 0.0250 | 1.6837 | -0.3325 | 1.6783 | -0.3310 | 45.26 | -8.93 |
| 138 | 1.7516 | 0.4386 | 1.6958 | 0.0997 | 0.0965 | 0.0250 | 1.7208 | -0.3420 | 1.7023 | -0.3372 | 181.80 | -36.02 |
| 128 | 1.7701 | 0.4432 | 1.7137 | 0.0997 | 0.0965 | 0.0250 | 1.7387 | -0.3467 | 1.7297 | -0.3443 | 109.70 | -21.84 |
| 118 | 1.7859 | 0.4471 | 1.7290 | 0.0997 | 0.0965 | 0.0250 | 1.7539 | -0.3506 | 1.7463 | -0.3486 | 111.52 | -22.26 |
| 108 | 1.7992 | 0.4505 | 1.7419 | 0.0997 | 0.0965 | 0.0250 | 1.7668 | -0.3539 | 1.7604 | -0.3523 | 113.20 | -22.65 |
| 98 | 1.8102 | 0.4532 | 1.7526 | 0.0997 | 0.0965 | 0.0250 | 1.7775 | -0.3567 | 1.7722 | -0.3553 | 114.75 | -23.01 |
| 88 | 1.8192 | 0.4555 | 1.7612 | 0.0997 | 0.0965 | 0.0250 | 1.7862 | -0.3590 | 1.7819 | -0.3578 | 116.16 | -23.33 |
| 80.00 | 1.8249 | 0.4569 | 1.7668 | 0.0997 | 0.0965 | 0.0250 | 1.7918 | -0.3604 | 1.7890 | -0.3597 | 93.87 | -18.87 |
| 68 | 1.8313 | 0.4585 | 1.7730 | 0.0997 | 0.0965 | 0.0250 | 1.7979 | -0.3620 | 1.7948 | -0.3612 | 142.22 | -28.62 |
| 58 | 1.8347 | 0.4594 | 1.7762 | 0.0997 | 0.0965 | 0.0250 | 1.8012 | -0.3628 | 1.7996 | -0.3624 | 119.70 | -24.11 |
| 48 | 1.8363 | 0.4598 | 1.7778 | 0.0997 | 0.0965 | 0.0250 | 1.8028 | -0.3632 | 1.8020 | -0.3630 | 120.66 | -24.31 |
| 22 | 1.8334 | 0.4590 | 1.7750 | 0.0997 | 0.0965 | 0.0250 | 1.7999 | -0.3625 | 1.8014 | -0.3629 | 317.34 | -63.93 |
| 19 | 1.8324 | 0.4588 | 1.7740 | 0.0997 | 0.0965 | 0.0250 | 1.7990 | -0.3623 | 1.7995 | -0.3624 | 36.92 | -7.44 |
| 0 | 1.8231 | 0.4565 | 1.7650 | 0.0997 | 0.0965 | 0.0250 | 1.7900 | -0.3599 | 1.7945 | -0.3611 | 234.86 | -47.26 |
| | | | | | | | | | | Σ = | 2712.85 | -525.42 |
| | | | | | | | | | | LIFT calc = | 5425.70 | |
| | | | | | | | | | | Lift = | 5466.30 | |
| | | | | | | | | | | error = | 0.7 | % |

SPANWISE AERODYNAMIC LOAD DISTRIBUTION

CONDITION. A cont..

| 1 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 |
|---|---|---|---|---|---|---|---|---|
| STATION | LIMIT | LIMIT | LIMIT | LIMIT | ULT | ULT | ULT | ULT |
| (in) | NORMAL | NORMAL | CHORD | CHORD | NORMAL | NORMAL | CHORD | CHORD |
| | SHEAR | MOMENT | SHEAR | MOMENT | SHEAR | MOMENT | SHEAR | MOMENT |
| | (lb) | (lb in) | (lb) | (lb in) | (lb) | (lb in) | (lb) | (lb in) |
| 258 | 0.00 | 0.00 | 0.00 | 0.00 | 0 | 0 | 0 | 0 |
| 251.25 | 38.47 | 129.84 | -4.85 | -16.38 | 58 | 195 | -7 | -25 |
| 238 | 131.18 | 1253.76 | -18.75 | -172.73 | 197 | 1881 | -28 | -259 |
| 228 | 209.46 | 2956.96 | -31.32 | -423.05 | 314 | 4435 | -47 | -635 |
| 218 | 292.98 | 5469.18 | -45.18 | -805.57 | 439 | 8204 | -68 | -1208 |
| 208 | 380.72 | 8837.70 | -60.90 | -1335.98 | 571 | 13257 | -91 | -2004 |
| 198 | 472.11 | 13101.86 | -78.32 | -2032.06 | 708 | 19653 | -117 | -3048 |
| 188 | 566.92 | 18296.99 | -96.58 | -2906.55 | 850 | 27445 | -145 | -4360 |
| 178 | 664.80 | 24455.59 | -115.59 | -3967.40 | 997 | 36683 | -173 | -5951 |
| 163.65 | 810.05 | 35037.68 | -144.03 | -5830.17 | 1215 | 52557 | -216 | -8745 |
| 159 | 854.87 | 38638.07 | -152.85 | -6472.17 | 1282 | 57957 | -229 | -9708 |
| 155.00 | 900.13 | 42433.24 | -161.78 | -7152.55 | 1350 | 63650 | -243 | -10729 |
| 138 | 1081.93 | 59280.72 | -197.80 | -10208.92 | 1623 | 88921 | -297 | -15313 |
| 128 | 1191.63 | 70648.53 | -219.63 | -12296.07 | 1787 | 105973 | -329 | -18444 |
| 118 | 1303.16 | 83122.46 | -241.90 | -14603.74 | 1955 | 124684 | -363 | -21906 |
| 108 | 1416.36 | 96720.04 | -264.55 | -17136.00 | 2125 | 145080 | -397 | -25704 |
| 98 | 1531.11 | 111457.36 | -287.56 | -19896.56 | 2297 | 167186 | -431 | -29845 |
| 88 | 1647.27 | 127349.23 | -310.89 | -22888.80 | 2471 | 191024 | -466 | -34333 |
| 80.00 | 1741.14 | 140902.85 | -329.76 | -25451.39 | 2612 | 211354 | -495 | -38177 |
| 68 | 1883.36 | 162649.81 | -358.38 | -29580.23 | 2825 | 243975 | -538 | -44370 |
| 58 | 2003.06 | 182081.89 | -382.49 | -33284.56 | 3005 | 273123 | -574 | -49927 |
| 48 | 2123.72 | 202715.79 | -406.80 | -37230.97 | 3186 | 304074 | -610 | -55846 |
| 22 | 2441.06 | 262057.99 | -470.72 | -48638.70 | 3662 | 393087 | -706 | -72958 |
| 19 | 2477.99 | 269436.56 | -478.16 | -50062.02 | 3717 | 404155 | -717 | -75093 |
| 0 | 2712.85 | 318749.53 | -525.42 | -59596.00 | 4069 | 478124 | -788 | -89394 |
| | | | | | | | | |
| Centre of lift is | 117 | in from aircraft centreline | | | | | | |
| | 46 | % semispan | | | | | | |

SPANWISE INERTIAL LOAD DISTRIBUTION

CONDITION. A cont..

| 1 | 3 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 | 41 | 42 | 43 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| STATION | dy | WEIGHT | ELEMENT | ELEMENT | LIMIT | LIMIT | LIMIT | LIMIT | ULT | ULT | ULT | ULT |
| (in) | (in) | nW | SHEAR | SHEAR | NORMAL | NORMAL | CHORD | CHORD | NORMAL | NORMAL | CHORD | CHORD |
| | | (lb) | FORCE | FORCE | SHEAR | MOMENT | SHEAR | MOMENT | SHEAR | MOMENT | SHEAR | MOMENT |
| | | | $V_z$ | $V_x$ | (lb) | (lb in) | (lb) | (lb in) | (lb) | (lb in) | (lb) | (lb in) |
| | | | (lb) | (lb) | | | | | | | | |
| 258 | - | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0 | 0 | 0 | 0 |
| 251.25 | 6.75 | -1.49 | 0.37 | -1.44 | -1.44 | -4.85 | 0.37 | 1.26 | -2 | -7 | 1 | 2 |
| 238 | 13.25 | -3.95 | 0.99 | -3.83 | -5.26 | -49.26 | 1.36 | 12.74 | -8 | -74 | 2 | 19 |
| 228 | 10.00 | -6.84 | 1.71 | -6.62 | -11.89 | -135.01 | 3.07 | 34.92 | -18 | -203 | 5 | 52 |
| 218 | 10.00 | -9.58 | 2.40 | -9.27 | -21.16 | -300.23 | 5.47 | 77.64 | -32 | -450 | 8 | 116 |
| 208 | 10.00 | -11.74 | 2.94 | -11.37 | -32.53 | -568.64 | 8.41 | 147.06 | -49 | -853 | 13 | 221 |
| 198 | 10.00 | -13.79 | 3.45 | -13.35 | -45.88 | -960.67 | 11.87 | 248.45 | -69 | -1441 | 18 | 373 |
| 188 | 10.00 | -16.34 | 4.09 | -15.82 | -61.70 | -1498.57 | 15.96 | 387.56 | -93 | -2248 | 24 | 581 |
| 178 | 10.00 | -18.51 | 4.63 | -17.92 | -79.62 | -2205.15 | 20.59 | 570.29 | -119 | -3308 | 31 | 855 |
| 163.65 | 14.35 | -21.28 | 5.33 | -20.60 | -100.22 | -3495.46 | 25.92 | 903.99 | -150 | -5243 | 39 | 1356 |
| 159 | 4.33 | -21.96 | 5.50 | -21.26 | -121.48 | -3974.88 | 31.42 | 1027.97 | -182 | -5962 | 47 | 1542 |
| 155.00 | 4.32 | -22.88 | 5.73 | -22.15 | -143.63 | -4548.19 | 37.15 | 1176.24 | -215 | -6822 | 56 | 1764 |
| 138 | 17.00 | -24.02 | 6.01 | -23.25 | -166.88 | -7187.53 | 43.16 | 1858.82 | -250 | -10781 | 65 | 2788 |
| 128 | 10.00 | -24.40 | 6.11 | -23.62 | -190.50 | -8974.44 | 49.27 | 2320.95 | -286 | -13462 | 74 | 3481 |
| 118 | 10.00 | -25.08 | 6.28 | -24.28 | -214.78 | -11000.84 | 55.55 | 2845.01 | -322 | -16501 | 83 | 4268 |
| 108 | 10.00 | -25.42 | 6.37 | -24.61 | -239.39 | -13271.72 | 61.91 | 3432.30 | -359 | -19908 | 93 | 5148 |
| 98 | 10.00 | -25.84 | 6.47 | -25.02 | -264.41 | -15790.73 | 68.38 | 4083.76 | -397 | -23686 | 103 | 6126 |
| 88 | 10.00 | -26.87 | 6.73 | -26.01 | -290.42 | -18564.89 | 75.11 | 4801.20 | -436 | -27847 | 113 | 7202 |
| 80.00 | 8.00 | -27.44 | 6.87 | -26.56 | -316.98 | -20994.50 | 81.98 | 5429.54 | -475 | -31492 | 123 | 8144 |
| 68 | 12.00 | -28.46 | 7.13 | -27.56 | -344.54 | -24963.63 | 89.10 | 6456.03 | -517 | -37445 | 134 | 9684 |
| 58 | 10.00 | -29.18 | 7.31 | -28.25 | -372.79 | -28550.28 | 96.41 | 7383.60 | -559 | -42825 | 145 | 11075 |
| 48 | 10.00 | -30.32 | 7.59 | -29.36 | -402.15 | -32424.99 | 104.00 | 8385.67 | -603 | -48637 | 156 | 12578 |
| 22 | 26.00 | -32.49 | 8.13 | -31.46 | -433.61 | -43289.83 | 112.14 | 11195.50 | -650 | -64935 | 168 | 16793 |
| 19 | 3.00 | -16.36 | 4.10 | -15.84 | -449.45 | -44614.41 | 116.24 | 11538.06 | -674 | -66922 | 174 | 17307 |
| 0 | 19.00 | -10.91 | 2.73 | -10.56 | -460.01 | -53254.26 | 118.97 | 13772.48 | -690 | -79881 | 178 | 20659 |
| | Σ = | 125 | lb | | | | | | | | | |
| | | at 1 g | | | Centre of gravity is | 116 | in from aircraft centreline | | | | | |
| | | | | | | 45 | % semispan | | | | | |

COMBINED ULTIMATE LOADS ( AERODYNAMIC + INERTIAL )

CONDITION. A cont..

| 1 | 44 A | 45 A | 46 A | 47 A | 48 A | 49 A |
|---|---|---|---|---|---|---|
| | ULT | ULT | ULT | ULT | ULT | ULT |
| | NORMAL | NORMAL | CHORD | CHORD | RESOLVED | CHORD |
| STATION | SHEAR | BEND MOMENT | SHEAR | BEND MOMENT | ULT SHEAR | BEND MOMENT |
| (in) | COND. A | COND. A | COND. A | COND. A | COND. A | COND. A |
| | (lb) | (lb in) | (lb) | (lb in) | (lb) | (lb in) |
| 258 | 0 | 0 | 0 | 0 | 0 | 0 |
| 251.25 | 56 | 187 | -7 | -23 | 56 | 189 |
| 238 | 189 | 1807 | -26 | -240 | 191 | 1823 |
| 228 | 296 | 4233 | -42 | -582 | 299 | 4273 |
| 218 | 408 | 7753 | -60 | -1092 | 412 | 7830 |
| 208 | 522 | 12404 | -79 | -1783 | 528 | 12531 |
| 198 | 639 | 18212 | -100 | -2675 | 647 | 18407 |
| 188 | 758 | 25198 | -121 | -3778 | 767 | 25479 |
| 178 | 878 | 33376 | -143 | -5096 | 889 | 33762 |
| 163.65 | 1065 | 47313 | -177 | -7389 | 1079 | 47887 |
| 159 | 1100 | 51995 | -182 | -8166 | 1115 | 52632 |
| 155.00 | 1135 | 56828 | -187 | -8964 | 1150 | 57530 |
| 138 | 1373 | 78140 | -232 | -12525 | 1392 | 79137 |
| 128 | 1502 | 92511 | -256 | -14963 | 1523 | 93713 |
| 118 | 1633 | 108182 | -280 | -17638 | 1656 | 109611 |
| 108 | 1765 | 125172 | -304 | -20556 | 1791 | 126849 |
| 98 | 1900 | 143500 | -329 | -23719 | 1928 | 145447 |
| 88 | 2035 | 163177 | -354 | -27131 | 2066 | 165417 |
| 80.00 | 2136 | 179863 | -372 | -30033 | 2168 | 182353 |
| 68 | 2308 | 206529 | -404 | -34686 | 2343 | 209422 |
| 58 | 2445 | 230297 | -429 | -38851 | 2483 | 233552 |
| 48 | 2582 | 255436 | -454 | -43268 | 2622 | 259075 |
| 22 | 3011 | 328152 | -538 | -56165 | 3059 | 332924 |
| 19 | 3043 | 337233 | -543 | -57786 | 3091 | 342148 |
| 0 | 3379 | 398243 | -610 | -68735 | 3434 | 404131 |

AERODYNAMIC TORQUE AT SHEAR CENTRE

CONDITION. A cont..

| 1 | 50 | 51 | 52 | 53 | 54 | 55 | 56 | 57 | 58 |
|---|---|---|---|---|---|---|---|---|---|
| STATION | LOCAL | LOCAL | AERO | X AC | X SC | DELTA X | Z AC | Z SC | DELTA Z |
| | $C_L$ | $X_{CP}$ | CENTRE | (in) | (in) | (in) | (in) | (in) | (in) |
| (in) | | | (in) | | using 38% chord | | | | |
| 258 | - | - | 0.00 | 0.00 | 13.30 | 13.30 | 0.00 | 2.39 | -2.39 |
| 251.25 | 0.98 | 0.27 | 9.34 | 9.34 | 13.37 | 4.03 | 0.00 | 2.40 | -2.40 |
| 238 | 1.20 | 0.26 | 9.27 | 9.27 | 13.50 | 4.23 | 0.00 | 2.44 | -2.44 |
| 228 | 1.33 | 0.26 | 9.27 | 9.27 | 13.60 | 4.34 | 0.00 | 2.47 | -2.47 |
| 218 | 1.41 | 0.26 | 9.30 | 9.30 | 13.71 | 4.41 | 0.00 | 2.49 | -2.49 |
| 208 | 1.47 | 0.26 | 9.34 | 9.34 | 13.81 | 4.47 | 0.00 | 2.52 | -2.52 |
| 198 | 1.51 | 0.26 | 9.39 | 9.39 | 13.91 | 4.52 | 0.00 | 2.54 | -2.54 |
| 188 | 1.56 | 0.26 | 9.44 | 9.44 | 14.01 | 4.57 | 0.00 | 2.57 | -2.57 |
| 178 | 1.60 | 0.26 | 9.49 | 9.49 | 14.11 | 4.62 | 0.00 | 2.60 | -2.60 |
| 163.65 | 1.64 | 0.26 | 9.58 | 9.58 | 14.26 | 4.68 | 0.00 | 2.64 | -2.64 |
| 159 | 1.67 | 0.25 | 9.60 | 9.60 | 14.30 | 4.70 | 0.00 | 2.65 | -2.65 |
| 155.00 | 1.68 | 0.25 | 9.62 | 9.62 | 14.35 | 4.72 | 0.00 | 2.66 | -2.66 |
| 138 | 1.70 | 0.25 | 9.73 | 9.73 | 14.52 | 4.79 | 0.00 | 2.70 | -2.70 |
| 128 | 1.73 | 0.25 | 9.79 | 9.79 | 14.62 | 4.83 | 0.00 | 2.73 | -2.73 |
| 118 | 1.75 | 0.25 | 9.85 | 9.85 | 14.72 | 4.87 | 0.00 | 2.76 | -2.76 |
| 108 | 1.76 | 0.25 | 9.92 | 9.92 | 14.82 | 4.91 | 0.00 | 2.78 | -2.78 |
| 98 | 1.77 | 0.25 | 9.98 | 9.98 | 14.93 | 4.94 | 0.00 | 2.81 | -2.81 |
| 88 | 1.78 | 0.25 | 10.05 | 10.05 | 15.03 | 4.98 | 0.00 | 2.84 | -2.84 |
| 80.00 | 1.79 | 0.25 | 10.10 | 10.10 | 15.11 | 5.01 | 0.00 | 2.86 | -2.86 |
| 68 | 1.79 | 0.25 | 10.18 | 10.18 | 15.23 | 5.05 | 0.00 | 2.89 | -2.89 |
| 58 | 1.80 | 0.25 | 10.24 | 10.24 | 15.33 | 5.09 | 0.00 | 2.92 | -2.92 |
| 48 | 1.80 | 0.25 | 10.31 | 10.31 | 15.43 | 5.12 | 0.00 | 2.94 | -2.94 |
| 22 | 1.80 | 0.25 | 10.49 | 10.49 | 15.70 | 5.21 | 0.00 | 3.01 | -3.01 |
| 19 | 1.80 | 0.25 | 10.51 | 10.51 | 15.73 | 5.22 | 0.00 | 3.01 | -3.01 |
| 0 | 1.79 | 0.25 | 10.64 | 10.64 | 15.92 | 5.28 | 0.00 | 1.25 | -1.25 |
| $X_{CP}$ CHECK = | 0.25 | | | | | | | | |

AERODYNAMIC TORQUE AT SHEAR CENTRE

CONDITION. A cont..

| 1 | 55 | 56 | 23 | 24 | 59 | 60 | 61 | 62 | 63 | 64 |
|---|---|---|---|---|---|---|---|---|---|---|
| STATION | DELTA X av | DELTA Z av | SPAN ELEMENT LIFT | SPAN ELEMENT DRAG | ELEMENT TORQUE DUE TO $C_{Mo}$ | ELEMENT TORQUE DUE TO LIFT | ELEMENT TORQUE DUE TO DRAG | ELEMENT LIMIT TORQUE | TOTAL LIMIT TORQUE | TOTAL ULT TORQUE |
| (in) | (in) | (in) | (lb) | (lb) | (lb in) | (lb in) | (lb in) | (lb in) | (lb in) | (lb in) |
| 258 | - | - | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 251.25 | 8.66 | 0.00 | 38.47 | -4.85 | -34.37 | 333.34 | 0.00 | 298.97 | 298.97 | 448.46 |
| 238 | 4.13 | 0.00 | 92.71 | -13.89 | -68.50 | 382.97 | 0.00 | 314.47 | 613.45 | 920.17 |
| 228 | 4.29 | 0.00 | 78.28 | -12.57 | -52.61 | 335.45 | 0.00 | 282.84 | 896.29 | 1344.43 |
| 218 | 4.37 | 0.00 | 83.52 | -13.87 | -53.40 | 365.23 | 0.00 | 311.83 | 1208.11 | 1812.17 |
| 208 | 4.44 | 0.00 | 87.74 | -15.71 | -54.20 | 389.35 | 0.00 | 335.15 | 1543.26 | 2314.90 |
| 198 | 4.49 | 0.00 | 91.39 | -17.42 | -55.00 | 410.69 | 0.00 | 355.69 | 1898.95 | 2848.43 |
| 188 | 4.55 | 0.00 | 94.81 | -18.26 | -55.81 | 430.99 | 0.00 | 375.18 | 2274.13 | 3411.19 |
| 178 | 4.60 | 0.00 | 97.89 | -19.01 | -56.63 | 449.79 | 0.00 | 393.16 | 2667.29 | 4000.94 |
| 163.65 | 4.65 | 0.00 | 145.25 | -28.44 | -82.70 | 675.41 | 0.00 | 592.71 | 3260.00 | 4890.00 |
| 159 | 4.69 | 0.00 | 44.82 | -8.82 | -25.26 | 210.32 | 0.00 | 185.06 | 3445.06 | 5167.60 |
| 155.00 | 4.71 | 0.00 | 45.26 | -8.93 | -25.41 | 213.35 | 0.00 | 187.94 | 3633.00 | 5449.50 |
| 138 | 4.76 | 0.00 | 181.80 | -36.02 | -101.41 | 864.60 | 0.00 | 763.19 | 4396.19 | 6594.28 |
| 128 | 4.81 | 0.00 | 109.70 | -21.84 | -60.79 | 527.60 | 0.00 | 466.80 | 4862.99 | 7294.49 |
| 118 | 4.85 | 0.00 | 111.52 | -22.26 | -61.65 | 540.90 | 0.00 | 479.26 | 5342.25 | 8013.38 |
| 108 | 4.89 | 0.00 | 113.20 | -22.65 | -62.50 | 553.40 | 0.00 | 490.90 | 5833.15 | 8749.73 |
| 98 | 4.93 | 0.00 | 114.75 | -23.01 | -63.36 | 565.27 | 0.00 | 501.91 | 6335.06 | 9502.59 |
| 88 | 4.96 | 0.00 | 116.16 | -23.33 | -64.23 | 576.55 | 0.00 | 512.31 | 6847.37 | 10271.06 |
| 80.00 | 5.00 | 0.00 | 93.87 | -18.87 | -52.02 | 469.00 | 0.00 | 416.98 | 7264.36 | 10896.53 |
| 68 | 5.03 | 0.00 | 142.22 | -28.62 | -79.08 | 715.64 | 0.00 | 636.56 | 7900.92 | 11851.38 |
| 58 | 5.07 | 0.00 | 119.70 | -24.11 | -66.88 | 606.98 | 0.00 | 540.10 | 8441.02 | 12661.53 |
| 48 | 5.11 | 0.00 | 120.66 | -24.31 | -67.77 | 616.04 | 0.00 | 548.28 | 8989.29 | 13483.94 |
| 22 | 5.17 | 0.00 | 317.34 | -63.93 | -180.41 | 1639.56 | 0.00 | 1459.15 | 10448.45 | 15672.67 |
| 19 | 5.22 | 0.00 | 36.92 | -7.44 | -21.21 | 192.56 | 0.00 | 171.35 | 10619.79 | 15929.69 |
| 0 | 5.25 | 0.00 | 234.86 | -47.26 | -136.27 | 1233.28 | 0.00 | 1097.01 | 11716.81 | 17575.21 |

DEAD WEIGHT ANALYSIS FOR WING TORQUE
CONDITION. A cont..

| 1 | 65 | 54 | 66 | 67 | 33 | 68 | 69 | 70 |
|---|---|---|---|---|---|---|---|---|
| STATION | X CG | X SC | DELTA | DELTA | ELEMENT | ELEMENT | TOTAL | TOTAL |
| | (in) | (in) | X | X av | LOAD | LIMIT | LIMIT | ULT |
| (in) | | | (in) | (in) | (lb) | TORQUE | TORQUE | TORQUE |
| | using 40% chord | | | | | (lb in) | (lb in) | (lb in) |
| 258 | 14.00 | 13.30 | -0.70 | - | - | - | - | 0.00 |
| 251.25 | 14.07 | 13.37 | -0.70 | -0.70 | -1.49 | 1.04 | 1.04 | 1.56 |
| 238 | 14.21 | 13.50 | -0.71 | -0.71 | -3.95 | 2.79 | 3.84 | 5.76 |
| 228 | 14.32 | 13.60 | -0.72 | -0.71 | -6.84 | 4.88 | 8.72 | 13.07 |
| 218 | 14.43 | 13.71 | -0.72 | -0.72 | -9.58 | 6.88 | 15.60 | 23.40 |
| 208 | 14.53 | 13.81 | -0.73 | -0.72 | -11.74 | 8.50 | 24.10 | 36.15 |
| 198 | 14.64 | 13.91 | -0.73 | -0.73 | -13.79 | 10.06 | 34.16 | 51.24 |
| 188 | 14.75 | 14.01 | -0.74 | -0.73 | -16.34 | 12.01 | 46.17 | 69.25 |
| 178 | 14.86 | 14.11 | -0.74 | -0.74 | -18.51 | 13.70 | 59.87 | 89.80 |
| 163.65 | 15.01 | 14.26 | -0.75 | -0.75 | -21.28 | 15.89 | 75.75 | 113.63 |
| 159 | 15.06 | 14.30 | -0.75 | -0.75 | -21.96 | 16.51 | 92.26 | 138.39 |
| 155.00 | 15.10 | 14.35 | -0.76 | -0.75 | -22.88 | 17.25 | 109.51 | 164.26 |
| 138 | 15.28 | 14.52 | -0.76 | -0.76 | -24.02 | 18.24 | 127.75 | 191.63 |
| 128 | 15.39 | 14.62 | -0.77 | -0.77 | -24.40 | 18.71 | 146.46 | 219.69 |
| 118 | 15.50 | 14.72 | -0.77 | -0.77 | -25.08 | 19.37 | 165.83 | 248.74 |
| 108 | 15.60 | 14.82 | -0.78 | -0.78 | -25.42 | 19.77 | 185.60 | 278.39 |
| 98 | 15.71 | 14.93 | -0.79 | -0.78 | -25.84 | 20.23 | 205.83 | 308.74 |
| 88 | 15.82 | 15.03 | -0.79 | -0.79 | -26.87 | 21.18 | 227.00 | 340.50 |
| 80.00 | 15.90 | 15.11 | -0.80 | -0.79 | -27.44 | 21.76 | 248.76 | 373.14 |
| 68 | 16.03 | 15.23 | -0.80 | -0.80 | -28.46 | 22.72 | 271.49 | 407.23 |
| 58 | 16.14 | 15.33 | -0.81 | -0.80 | -29.18 | 23.47 | 294.96 | 442.44 |
| 48 | 16.25 | 15.43 | -0.81 | -0.81 | -30.32 | 24.55 | 319.51 | 479.27 |
| 22 | 16.52 | 15.70 | -0.83 | -0.82 | -32.49 | 26.62 | 346.13 | 519.19 |
| 19 | 16.56 | 15.73 | -0.83 | -0.83 | -16.36 | 13.53 | 359.66 | 539.49 |
| 0 | 16.76 | 15.92 | -0.84 | -0.83 | -10.91 | 9.09 | 368.75 | 553.12 |

| COMBINED ULTIMATE TORSION ( AERODYNAMIC + INERTIAL ) | | | |
|---|---|---|---|
| CONDITION. A cont.. | | | |
| | | | |
| 1 | 71 A | | |
| STATION | COND. A | | |
| (in) | (lb in) | | |
| 258 | 0 | | |
| 251.25 | 450 | | |
| 238 | 926 | | |
| 228 | 1358 | | |
| 218 | 1836 | | |
| 208 | 2351 | | |
| 198 | 2900 | | |
| 188 | 3480 | | |
| 178 | 4091 | | |
| 163.65 | 5004 | | |
| 159 | 5306 | | |
| 155.00 | 5614 | | |
| 138 | 6786 | | |
| 128 | 7514 | | |
| 118 | 8262 | | |
| 108 | 9028 | | |
| 98 | 9811 | | |
| 88 | 10612 | | |
| 80.00 | 11270 | | |
| 68 | 12259 | | |
| 58 | 13104 | | |
| 48 | 13963 | | |
| 22 | 16192 | | |
| 19 | 16469 | | |
| 0 | 18128 | | |

SPANWISE AERODYNAMIC LOAD DISTRIBUTION

CONDITION. C

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| $V_{sel}$ = | 175.68 | ft/s | $C_L$ = | 1.3 | | alpha wrp = | 10.5128 |
| Lift = | 6530.79 | lb | $C_{Do}$ = | 0.017 | | sin alpha = | 0.1825 |
| q = | 36.73 | psf | $C_D$ = | 0.067 | | cos alpha = | 0.9832 |
| n = | 4.54 | g | $C_{Mo}$ = | -0.025 | | | |
| $q.C_L$ = | 48.38 | $q.C_L$ =Lift/S | S = | 135.00 | $ft^2$ | | |
| | | | b = | 43.00 | ft | | |

| 1 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| STATION | $C_L$ | $C_{Lx}$ | $C_{Lz}$ | $C_D$ | $C_{Dx}$ | $C_{Dz}$ | $C_{Lz}+C_{Dz}$ | $C_{Dx}-C_{Lx}$ | $(C_{Lz}+C_{Dz})_{AV}$ | $(C_{Dx}-C_{Lx})_{AV}$ | SPAN ELEMENT LIFT | SPAN ELEMENT DRAG |
| (in) | | | | | | | | | | | (lb) | (lb) |
| 258 | 0.6586 | 0.1202 | 0.6476 | 0.0809 | 0.0795 | 0.0148 | 0.6623 | -0.0406 | - | - | 0.00 | 0.00 |
| 251.25 | 0.8627 | 0.1574 | 0.8482 | 0.0809 | 0.0795 | 0.0148 | 0.8630 | -0.0779 | 0.7626 | -0.0593 | 46.07 | -3.58 |
| 238 | 1.0018 | 0.1828 | 0.9850 | 0.0809 | 0.0795 | 0.0148 | 0.9998 | -0.1033 | 0.9314 | -0.0906 | 111.28 | -10.82 |
| 228 | 1.0716 | 0.1955 | 1.0536 | 0.0809 | 0.0795 | 0.0148 | 1.0684 | -0.1160 | 1.0341 | -0.1096 | 94.07 | -9.97 |
| 218 | 1.1271 | 0.2056 | 1.1081 | 0.0809 | 0.0795 | 0.0148 | 1.1229 | -0.1261 | 1.0956 | -0.1210 | 100.42 | -11.09 |
| 208 | 1.1730 | 0.2140 | 1.1533 | 0.0640 | 0.0630 | 0.0117 | 1.1650 | -0.1511 | 1.1440 | -0.1386 | 105.62 | -12.80 |
| 198 | 1.2120 | 0.2211 | 1.1916 | 0.0640 | 0.0630 | 0.0117 | 1.2033 | -0.1582 | 1.1841 | -0.1546 | 110.14 | -14.38 |
| 188 | 1.2454 | 0.2272 | 1.2245 | 0.0640 | 0.0630 | 0.0117 | 1.2362 | -0.1643 | 1.2197 | -0.1612 | 114.29 | -15.11 |
| 178 | 1.2744 | 0.2325 | 1.2530 | 0.0640 | 0.0630 | 0.0117 | 1.2647 | -0.1696 | 1.2504 | -0.1669 | 118.02 | -15.75 |
| 163.65 | 1.3095 | 0.2389 | 1.2875 | 0.0640 | 0.0630 | 0.0117 | 1.2992 | -0.1760 | 1.2819 | -0.1728 | 175.15 | -23.60 |
| 159 | 1.3188 | 0.2406 | 1.2967 | 0.0640 | 0.0630 | 0.0117 | 1.3084 | -0.1777 | 1.3038 | -0.1768 | 54.05 | -7.33 |
| 155.00 | 1.3276 | 0.2422 | 1.3053 | 0.0640 | 0.0630 | 0.0117 | 1.3170 | -0.1793 | 1.3127 | -0.1785 | 54.58 | -7.42 |
| 138 | 1.3572 | 0.2476 | 1.3344 | 0.0640 | 0.0630 | 0.0117 | 1.3461 | -0.1847 | 1.3315 | -0.1820 | 219.28 | -29.97 |
| 128 | 1.3715 | 0.2502 | 1.3485 | 0.0640 | 0.0630 | 0.0117 | 1.3602 | -0.1873 | 1.3532 | -0.1860 | 132.33 | -18.19 |
| 118 | 1.3838 | 0.2525 | 1.3605 | 0.0640 | 0.0630 | 0.0117 | 1.3722 | -0.1895 | 1.3662 | -0.1884 | 134.53 | -18.55 |
| 108 | 1.3941 | 0.2544 | 1.3707 | 0.0640 | 0.0630 | 0.0117 | 1.3824 | -0.1914 | 1.3773 | -0.1905 | 136.56 | -18.88 |
| 98 | 1.4026 | 0.2559 | 1.3791 | 0.0640 | 0.0630 | 0.0117 | 1.3908 | -0.1930 | 1.3866 | -0.1922 | 138.43 | -19.19 |
| 88 | 1.4096 | 0.2572 | 1.3859 | 0.0640 | 0.0630 | 0.0117 | 1.3976 | -0.1942 | 1.3942 | -0.1936 | 140.14 | -19.46 |
| 80.00 | 1.4140 | 0.2580 | 1.3903 | 0.0640 | 0.0630 | 0.0117 | 1.4020 | -0.1950 | 1.3998 | -0.1946 | 113.25 | -15.75 |
| 68 | 1.4190 | 0.2589 | 1.3951 | 0.0640 | 0.0630 | 0.0117 | 1.4068 | -0.1959 | 1.4044 | -0.1955 | 171.59 | -23.88 |
| 58 | 1.4216 | 0.2594 | 1.3977 | 0.0640 | 0.0630 | 0.0117 | 1.4094 | -0.1964 | 1.4081 | -0.1962 | 144.42 | -20.12 |
| 48 | 1.4229 | 0.2596 | 1.3990 | 0.0640 | 0.0630 | 0.0117 | 1.4107 | -0.1966 | 1.4100 | -0.1965 | 145.58 | -20.29 |
| 22 | 1.4206 | 0.2592 | 1.3967 | 0.0640 | 0.0630 | 0.0117 | 1.4084 | -0.1962 | 1.4095 | -0.1964 | 382.88 | -53.36 |
| 19 | 1.4198 | 0.2591 | 1.3960 | 0.0640 | 0.0630 | 0.0117 | 1.4077 | -0.1961 | 1.4080 | -0.1962 | 44.55 | -6.21 |
| 0 | 1.4126 | 0.2577 | 1.3889 | 0.0640 | 0.0630 | 0.0117 | 1.4006 | -0.1948 | 1.4041 | -0.1954 | 283.36 | -39.44 |
| | | | | | | | | | | Σ = | 3270.58 | -435.14 |
| | | | | | | | | | | LIFT calc = | 6541.17 | |
| | | | | | | | | | | Lift = | 6530.79 | |
| | | | | | | | | | | error = | -0.2 | % |

SPANWISE AERODYNAMIC LOAD DISTRIBUTION

CONDITION. C cont..

| 1 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 |
|---|---|---|---|---|---|---|---|---|
| STATION | LIMIT | LIMIT | LIMIT | LIMIT | ULT | ULT | ULT | ULT |
| (in) | NORMAL | NORMAL | CHORD | CHORD | NORMAL | NORMAL | CHORD | CHORD |
| | SHEAR | MOMENT | SHEAR | MOMENT | SHEAR | MOMENT | SHEAR | MOMENT |
| | (lb) | (lb in) | (lb) | (lb in) | (lb) | (lb in) | (lb) | (lb in) |
| 258 | 0.00 | 0.00 | 0.00 | 0.00 | 0 | 0 | 0 | 0 |
| 251.25 | 46.07 | 155.49 | -3.58 | -12.08 | 69 | 233 | -5 | -18 |
| 238 | 157.35 | 1503.17 | -14.40 | -131.20 | 236 | 2255 | -22 | -197 |
| 228 | 251.42 | 3547.04 | -24.37 | -325.07 | 377 | 5321 | -37 | -488 |
| 218 | 351.84 | 6563.34 | -35.47 | -624.28 | 528 | 9845 | -53 | -936 |
| 208 | 457.46 | 10609.85 | -48.26 | -1042.93 | 686 | 15915 | -72 | -1564 |
| 198 | 567.61 | 15735.20 | -62.65 | -1597.47 | 851 | 23603 | -94 | -2396 |
| 188 | 681.89 | 21982.71 | -77.75 | -2299.45 | 1023 | 32974 | -117 | -3449 |
| 178 | 799.91 | 29391.72 | -93.50 | -3155.73 | 1200 | 44088 | -140 | -4734 |
| 163.65 | 975.06 | 42127.11 | -117.11 | -4666.87 | 1463 | 63191 | -176 | -7000 |
| 159 | 1029.10 | 46461.11 | -124.44 | -5189.22 | 1544 | 69692 | -187 | -7784 |
| 155.00 | 1083.69 | 51030.02 | -131.86 | -5743.46 | 1626 | 76545 | -198 | -8615 |
| 138 | 1302.96 | 71316.53 | -161.82 | -8239.76 | 1954 | 106975 | -243 | -12360 |
| 128 | 1435.29 | 85007.77 | -180.01 | -9948.94 | 2153 | 127512 | -270 | -14923 |
| 118 | 1569.82 | 100033.31 | -198.56 | -11841.81 | 2355 | 150050 | -298 | -17763 |
| 108 | 1706.38 | 116414.33 | -217.45 | -13921.86 | 2560 | 174621 | -326 | -20883 |
| 98 | 1844.81 | 134170.31 | -236.63 | -16192.26 | 2767 | 201255 | -355 | -24288 |
| 88 | 1984.96 | 153319.16 | -256.09 | -18655.90 | 2977 | 229979 | -384 | -27984 |
| 80.00 | 2098.21 | 169651.81 | -271.84 | -20767.63 | 3147 | 254478 | -408 | -31151 |
| 68 | 2269.79 | 195859.81 | -295.72 | -24173.02 | 3405 | 293790 | -444 | -36260 |
| 58 | 2414.21 | 219279.85 | -315.84 | -27230.86 | 3621 | 328920 | -474 | -40846 |
| 48 | 2559.80 | 244149.91 | -336.14 | -30490.76 | 3840 | 366225 | -504 | -45736 |
| 22 | 2942.67 | 315682.02 | -389.50 | -39923.96 | 4414 | 473523 | -584 | -59886 |
| 19 | 2987.22 | 324576.86 | -395.70 | -41101.76 | 4481 | 486865 | -594 | -61653 |
| 0 | 3270.58 | 384026.02 | -435.14 | -48994.77 | 4906 | 576039 | -653 | -73492 |
| | | | | | | | | |
| Centre of lift is | 117 | in from aircraft centreline | | | | | | |
| | 46 | % semispan | | | | | | |

SPANWISE INERTIAL LOAD DISTRIBUTION

CONDITION. C cont..

| 1 | 3 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 | 41 | 42 | 43 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| STATION | dy | WEIGHT | ELEMENT | ELEMENT | LIMIT | LIMIT | LIMIT | LIMIT | ULT | ULT | ULT | ULT |
| (in) | (in) | nW | SHEAR | SHEAR | NORMAL | NORMAL | CHORD | CHORD | NORMAL | NORMAL | CHORD | CHORD |
| | | (lb) | FORCE | FORCE | SHEAR | MOMENT | SHEAR | MOMENT | SHEAR | MOMENT | SHEAR | MOMENT |
| | | | $V_x$ | $V_z$ | (lb) | (lb in) | (lb) | (lb in) | (lb) | (lb in) | (lb) | (lb in) |
| | | | (lb) | (lb) | | | | | | | | |
| 258 | - | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0 | 0 | 0 | 0 |
| 251.25 | 6.75 | -1.77 | 0.32 | -1.74 | -1.74 | -5.89 | 0.32 | 1.09 | -3 | -9 | 0 | 2 |
| 238 | 13.25 | -4.72 | 0.86 | -4.64 | -6.39 | -59.77 | 1.19 | 11.09 | -10 | -90 | 2 | 17 |
| 228 | 10.00 | -8.17 | 1.49 | -8.03 | -14.42 | -163.81 | 2.68 | 30.40 | -22 | -246 | 4 | 46 |
| 218 | 10.00 | -11.44 | 2.09 | -11.25 | -25.67 | -364.28 | 4.76 | 67.60 | -39 | -546 | 7 | 101 |
| 208 | 10.00 | -14.03 | 2.56 | -13.79 | -39.46 | -689.95 | 7.32 | 128.03 | -59 | -1035 | 11 | 192 |
| 198 | 10.00 | -16.48 | 3.01 | -16.20 | -55.67 | -1165.61 | 10.33 | 216.30 | -84 | -1748 | 15 | 324 |
| 188 | 10.00 | -19.52 | 3.56 | -19.19 | -74.86 | -1818.26 | 13.89 | 337.41 | -112 | -2727 | 21 | 506 |
| 178 | 10.00 | -22.11 | 4.03 | -21.74 | -96.60 | -2675.57 | 17.93 | 496.51 | -145 | -4013 | 27 | 745 |
| 163.65 | 14.35 | -25.42 | 4.64 | -25.00 | -121.60 | -4241.14 | 22.56 | 787.03 | -182 | -6362 | 34 | 1181 |
| 159 | 4.33 | -26.24 | 4.79 | -25.80 | -147.40 | -4822.84 | 27.35 | 894.98 | -221 | -7234 | 41 | 1342 |
| 155.00 | 4.32 | -27.33 | 4.99 | -26.87 | -174.27 | -5518.45 | 32.34 | 1024.06 | -261 | -8278 | 49 | 1536 |
| 138 | 17.00 | -28.69 | 5.24 | -28.21 | -202.48 | -8720.85 | 37.57 | 1618.33 | -304 | -13081 | 56 | 2427 |
| 128 | 10.00 | -29.15 | 5.32 | -28.66 | -231.14 | -10888.95 | 42.89 | 2020.67 | -347 | -16333 | 64 | 3031 |
| 118 | 10.00 | -29.96 | 5.47 | -29.46 | -260.60 | -13347.65 | 48.36 | 2476.93 | -391 | -20021 | 73 | 3715 |
| 108 | 10.00 | -30.37 | 5.54 | -29.86 | -290.46 | -16102.97 | 53.90 | 2988.23 | -436 | -24154 | 81 | 4482 |
| 98 | 10.00 | -30.87 | 5.63 | -30.35 | -320.82 | -19159.36 | 59.53 | 3555.41 | -481 | -28739 | 89 | 5333 |
| 88 | 10.00 | -32.10 | 5.86 | -31.56 | -352.38 | -22525.33 | 65.39 | 4180.03 | -529 | -33788 | 98 | 6270 |
| 80.00 | 8.00 | -32.78 | 5.98 | -32.23 | -384.60 | -25473.25 | 71.37 | 4727.08 | -577 | -38210 | 107 | 7091 |
| 68 | 12.00 | -34.00 | 6.20 | -33.43 | -418.04 | -30289.10 | 77.58 | 5620.76 | -627 | -45434 | 116 | 8431 |
| 58 | 10.00 | -34.87 | 6.36 | -34.28 | -452.32 | -34640.90 | 83.94 | 6428.32 | -678 | -51961 | 126 | 9642 |
| 48 | 10.00 | -36.23 | 6.61 | -35.62 | -487.94 | -39342.20 | 90.55 | 7300.74 | -732 | -59013 | 136 | 10951 |
| 22 | 26.00 | -38.82 | 7.08 | -38.17 | -526.11 | -52524.82 | 97.63 | 9747.05 | -789 | -78787 | 146 | 14621 |
| 19 | 3.00 | -19.55 | 3.57 | -19.22 | -545.33 | -54131.98 | 101.20 | 10045.28 | -818 | -81198 | 152 | 15068 |
| 0 | 19.00 | -13.03 | 2.38 | -12.81 | -558.14 | -64614.96 | 103.57 | 11990.62 | -837 | -96922 | 155 | 17986 |
| | Σ = | 125 | lb | | | | | | | | | |
| | | at 1 g | | | Centre of gravity is | 116 | in from aircraft centreline | | | | | |
| | | | | | | 45 | % semispan | | | | | |

COMBINED ULTIMATE LOADS ( AERODYNAMIC + INERTIAL )

CONDITION. C cont..

| 1 | 44 C | 45 C | 46 C | 47 C | 48 C | 49 C |
|---|---|---|---|---|---|---|
| | ULT | ULT | ULT | ULT | ULT | ULT |
| | NORMAL | NORMAL | CHORD | CHORD | RESOLVED | RESOLVED |
| STATION | SHEAR | BEND MOMENT | SHEAR | BEND MOMENT | SHEAR | BEND MOMENT |
| (in) | COND. C | COND. C | COND. C | COND. C | COND. C | COND. C |
| | (lb) | (lb in) | (lb) | (lb in) | (lb) | (lb in) |
| 258 | 0 | 0 | 0 | 0 | 0 | 0 |
| 251.25 | 66 | 224 | -5 | -16 | 67 | 225 |
| 238 | 226 | 2165 | -20 | -180 | 227 | 2173 |
| 228 | 355 | 5075 | -33 | -442 | 357 | 5094 |
| 218 | 489 | 9299 | -46 | -835 | 491 | 9336 |
| 208 | 627 | 14880 | -61 | -1372 | 630 | 14943 |
| 198 | 768 | 21854 | -78 | -2072 | 772 | 21952 |
| 188 | 911 | 30247 | -96 | -2943 | 916 | 30390 |
| 178 | 1055 | 40074 | -113 | -3989 | 1061 | 40272 |
| 163.65 | 1280 | 56829 | -142 | -5820 | 1288 | 57126 |
| 159 | 1323 | 62457 | -146 | -6441 | 1331 | 62789 |
| 155.00 | 1364 | 68267 | -149 | -7079 | 1372 | 68633 |
| 138 | 1651 | 93894 | -186 | -9932 | 1661 | 94417 |
| 128 | 1806 | 111178 | -206 | -11892 | 1818 | 111812 |
| 118 | 1964 | 130028 | -225 | -14047 | 1977 | 130785 |
| 108 | 2124 | 150467 | -245 | -16400 | 2138 | 151358 |
| 98 | 2286 | 172516 | -266 | -18955 | 2301 | 173555 |
| 88 | 2449 | 196191 | -286 | -21714 | 2466 | 197389 |
| 80.00 | 2570 | 216268 | -301 | -24061 | 2588 | 217602 |
| 68 | 2778 | 248356 | -327 | -27828 | 2797 | 249910 |
| 58 | 2943 | 276958 | -348 | -31204 | 2963 | 278711 |
| 48 | 3108 | 307212 | -368 | -34785 | 3130 | 309175 |
| 22 | 3625 | 394736 | -438 | -45265 | 3651 | 397323 |
| 19 | 3663 | 405667 | -442 | -46585 | 3689 | 408333 |
| 0 | 4069 | 479117 | -497 | -55506 | 4099 | 482321 |

| AERODYNAMIC TORQUE AT SHEAR CENTRE | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| CONDITION. C cont.. | | | | | | | | | |
| 1 | 50 | 51 | 52 | 53 | 54 | 55 | 56 | 57 | 58 |
| STATION | LOCAL | LOCAL | AERO | X AC | X SC | DELTA X | Z AC | Z SC | DELTA Z |
| | $C_L$ | $X_{CP}$ | CENTRE | (in) | (in) | (in) | (in) | (in) | (in) |
| (in) | | | (in) | | using 38% chord | | | | |
| 258 | - | - | 0.00 | 0.00 | 13.30 | 13.30 | 0.00 | 2.39 | -2.39 |
| 251.25 | 0.76 | 0.27 | 9.60 | 9.60 | 13.37 | 3.77 | 0.00 | 2.40 | -2.40 |
| 238 | 0.93 | 0.27 | 9.48 | 9.48 | 13.50 | 4.02 | 0.00 | 2.44 | -2.44 |
| 228 | 1.03 | 0.26 | 9.46 | 9.46 | 13.60 | 4.15 | 0.00 | 2.47 | -2.47 |
| 218 | 1.10 | 0.26 | 9.48 | 9.48 | 13.71 | 4.23 | 0.00 | 2.49 | -2.49 |
| 208 | 1.14 | 0.26 | 9.52 | 9.52 | 13.81 | 4.29 | 0.00 | 2.52 | -2.52 |
| 198 | 1.18 | 0.26 | 9.56 | 9.56 | 13.91 | 4.35 | 0.00 | 2.54 | -2.54 |
| 188 | 1.22 | 0.26 | 9.61 | 9.61 | 14.01 | 4.41 | 0.00 | 2.57 | -2.57 |
| 178 | 1.25 | 0.26 | 9.66 | 9.66 | 14.11 | 4.46 | 0.00 | 2.60 | -2.60 |
| 163.65 | 1.28 | 0.26 | 9.74 | 9.74 | 14.26 | 4.52 | 0.00 | 2.64 | -2.64 |
| 159 | 1.30 | 0.26 | 9.76 | 9.76 | 14.30 | 4.55 | 0.00 | 2.65 | -2.65 |
| 155.00 | 1.31 | 0.26 | 9.78 | 9.78 | 14.35 | 4.57 | 0.00 | 2.66 | -2.66 |
| 138 | 1.33 | 0.26 | 9.89 | 9.89 | 14.52 | 4.63 | 0.00 | 2.70 | -2.70 |
| 128 | 1.35 | 0.26 | 9.95 | 9.95 | 14.62 | 4.68 | 0.00 | 2.73 | -2.73 |
| 118 | 1.37 | 0.26 | 10.01 | 10.01 | 14.72 | 4.72 | 0.00 | 2.76 | -2.76 |
| 108 | 1.38 | 0.26 | 10.07 | 10.07 | 14.82 | 4.75 | 0.00 | 2.78 | -2.78 |
| 98 | 1.39 | 0.26 | 10.14 | 10.14 | 14.93 | 4.79 | 0.00 | 2.81 | -2.81 |
| 88 | 1.39 | 0.26 | 10.20 | 10.20 | 15.03 | 4.83 | 0.00 | 2.84 | -2.84 |
| 80.00 | 1.40 | 0.26 | 10.25 | 10.25 | 15.11 | 4.86 | 0.00 | 2.86 | -2.86 |
| 68 | 1.40 | 0.26 | 10.33 | 10.33 | 15.23 | 4.90 | 0.00 | 2.89 | -2.89 |
| 58 | 1.41 | 0.26 | 10.40 | 10.40 | 15.33 | 4.93 | 0.00 | 2.92 | -2.92 |
| 48 | 1.41 | 0.26 | 10.47 | 10.47 | 15.43 | 4.97 | 0.00 | 2.94 | -2.94 |
| 22 | 1.41 | 0.26 | 10.65 | 10.65 | 15.70 | 5.05 | 0.00 | 3.01 | -3.01 |
| 19 | 1.41 | 0.26 | 10.67 | 10.67 | 15.73 | 5.06 | 0.00 | 3.01 | -3.01 |
| 0 | 1.40 | 0.26 | 10.80 | 10.80 | 15.92 | 5.12 | 0.00 | 1.25 | -1.25 |
| $X_{CP\ CHECK}$ = | 0.26 | | | | | | | | |

AERODYNAMIC TORQUE AT SHEAR CENTRE

CONDITION. C cont..

| 1 STATION (in) | 55 DELTA X av (in) | 56 DELTA Z av (in) | 23 SPAN ELEMENT LIFT (lb) | 24 SPAN ELEMENT DRAG (lb) | 59 ELEMENT TORQUE DUE TO $C_{Mo}$ (lb in) | 60 ELEMENT TORQUE DUE TO LIFT (lb in) | 61 ELEMENT TORQUE DUE TO DRAG (lb in) | 62 ELEMENT LIMIT TORQUE (lb in) | 63 TOTAL LIMIT TORQUE (lb in) | 64 TOTAL ULT TORQUE (lb in) |
|---|---|---|---|---|---|---|---|---|---|---|
| 258 | - | - | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 251.25 | 8.54 | 0.00 | 46.07 | -3.58 | -52.99 | 393.25 | 0.00 | 340.26 | 340.26 | 510.39 |
| 238 | 3.90 | 0.00 | 111.28 | -10.82 | -105.62 | 433.62 | 0.00 | 328.00 | 668.26 | 1002.40 |
| 228 | 4.08 | 0.00 | 94.07 | -9.97 | -81.12 | 384.17 | 0.00 | 303.05 | 971.31 | 1456.97 |
| 218 | 4.19 | 0.00 | 100.42 | -11.09 | -82.34 | 420.42 | 0.00 | 338.08 | 1309.39 | 1964.09 |
| 208 | 4.26 | 0.00 | 105.62 | -12.80 | -83.57 | 449.95 | 0.00 | 366.38 | 1675.77 | 2513.66 |
| 198 | 4.32 | 0.00 | 110.14 | -14.38 | -84.81 | 476.09 | 0.00 | 391.28 | 2067.06 | 3100.59 |
| 188 | 4.38 | 0.00 | 114.29 | -15.11 | -86.06 | 500.47 | 0.00 | 414.42 | 2481.47 | 3722.21 |
| 178 | 4.43 | 0.00 | 118.02 | -15.75 | -87.31 | 523.01 | 0.00 | 435.69 | 2917.17 | 4375.75 |
| 163.65 | 4.49 | 0.00 | 175.15 | -23.60 | -127.51 | 786.28 | 0.00 | 658.77 | 3575.94 | 5363.91 |
| 159 | 4.53 | 0.00 | 54.05 | -7.33 | -38.95 | 245.08 | 0.00 | 206.13 | 3782.07 | 5673.11 |
| 155.00 | 4.56 | 0.00 | 54.58 | -7.42 | -39.19 | 248.74 | 0.00 | 209.55 | 3991.63 | 5987.44 |
| 138 | 4.60 | 0.00 | 219.28 | -29.97 | -156.37 | 1008.51 | 0.00 | 852.14 | 4843.76 | 7265.65 |
| 128 | 4.65 | 0.00 | 132.33 | -18.19 | -93.74 | 615.83 | 0.00 | 522.09 | 5365.85 | 8048.78 |
| 118 | 4.70 | 0.00 | 134.53 | -18.55 | -95.05 | 631.70 | 0.00 | 536.65 | 5902.50 | 8853.76 |
| 108 | 4.73 | 0.00 | 136.56 | -18.88 | -96.37 | 646.54 | 0.00 | 550.17 | 6452.67 | 9679.01 |
| 98 | 4.77 | 0.00 | 138.43 | -19.19 | -97.70 | 660.62 | 0.00 | 562.91 | 7015.58 | 10523.38 |
| 88 | 4.81 | 0.00 | 140.14 | -19.46 | -99.04 | 673.96 | 0.00 | 574.92 | 7590.50 | 11385.76 |
| 80.00 | 4.84 | 0.00 | 113.25 | -15.75 | -80.20 | 548.35 | 0.00 | 468.14 | 8058.65 | 12087.97 |
| 68 | 4.88 | 0.00 | 171.59 | -23.88 | -121.94 | 836.85 | 0.00 | 714.91 | 8773.56 | 13160.34 |
| 58 | 4.92 | 0.00 | 144.42 | -20.12 | -103.12 | 709.86 | 0.00 | 606.74 | 9380.30 | 14070.45 |
| 48 | 4.95 | 0.00 | 145.58 | -20.29 | -104.49 | 720.52 | 0.00 | 616.03 | 9996.33 | 14994.50 |
| 22 | 5.01 | 0.00 | 382.88 | -53.36 | -278.18 | 1917.66 | 0.00 | 1639.48 | 11635.81 | 17453.72 |
| 19 | 5.06 | 0.00 | 44.55 | -6.21 | -32.71 | 225.21 | 0.00 | 192.50 | 11828.32 | 17742.48 |
| 0 | 5.09 | 0.00 | 283.36 | -39.44 | -210.11 | 1442.29 | 0.00 | 1232.18 | 13060.50 | 19590.75 |

DEAD WEIGHT ANALYSIS FOR WING TORQUE

CONDITION. C cont..

| 1 | 65 | 54 | 66 | 67 | 33 | 68 | 69 | 70 |
|---|---|---|---|---|---|---|---|---|
| STATION | X CG | X SC | DELTA | DELTA | ELEMENT | ELEMENT | TOTAL | TOTAL |
| | (in) | (in) | X | X av | LOAD | LIMIT | LIMIT | ULT |
| (in) | | | (in) | (in) | (lb) | TORQUE | TORQUE | TORQUE |
| | using 40% chord | | | | | (lb in) | (lb in) | (lb in) |
| 258 | 14.00 | 13.30 | -0.70 | - | - | - | - | 0.00 |
| 251.25 | 14.07 | 13.37 | -0.70 | -0.70 | -1.77 | 1.25 | 1.25 | 1.87 |
| 238 | 14.21 | 13.50 | -0.71 | -0.71 | -4.72 | 3.34 | 4.58 | 6.88 |
| 228 | 14.32 | 13.60 | -0.72 | -0.71 | -8.17 | 5.83 | 10.41 | 15.62 |
| 218 | 14.43 | 13.71 | -0.72 | -0.72 | -11.44 | 8.22 | 18.64 | 27.96 |
| 208 | 14.53 | 13.81 | -0.73 | -0.72 | -14.03 | 10.16 | 28.79 | 43.19 |
| 198 | 14.64 | 13.91 | -0.73 | -0.73 | -16.48 | 12.02 | 40.82 | 61.22 |
| 188 | 14.75 | 14.01 | -0.74 | -0.73 | -19.52 | 14.34 | 55.16 | 82.74 |
| 178 | 14.86 | 14.11 | -0.74 | -0.74 | -22.11 | 16.36 | 71.52 | 107.29 |
| 163.65 | 15.01 | 14.26 | -0.75 | -0.75 | -25.42 | 18.98 | 90.51 | 135.76 |
| 159 | 15.06 | 14.30 | -0.75 | -0.75 | -26.24 | 19.72 | 110.23 | 165.34 |
| 155.00 | 15.10 | 14.35 | -0.76 | -0.75 | -27.33 | 20.61 | 130.83 | 196.25 |
| 138 | 15.28 | 14.52 | -0.76 | -0.76 | -28.69 | 21.80 | 152.63 | 228.95 |
| 128 | 15.39 | 14.62 | -0.77 | -0.77 | -29.15 | 22.35 | 174.98 | 262.47 |
| 118 | 15.50 | 14.72 | -0.77 | -0.77 | -29.96 | 23.14 | 198.12 | 297.18 |
| 108 | 15.60 | 14.82 | -0.78 | -0.78 | -30.37 | 23.62 | 221.74 | 332.61 |
| 98 | 15.71 | 14.93 | -0.79 | -0.78 | -30.87 | 24.17 | 245.91 | 368.86 |
| 88 | 15.82 | 15.03 | -0.79 | -0.79 | -32.10 | 25.30 | 271.21 | 406.81 |
| 80.00 | 15.90 | 15.11 | -0.80 | -0.79 | -32.78 | 26.00 | 297.20 | 445.81 |
| 68 | 16.03 | 15.23 | -0.80 | -0.80 | -34.00 | 27.15 | 324.35 | 486.53 |
| 58 | 16.14 | 15.33 | -0.81 | -0.80 | -34.87 | 28.04 | 352.40 | 528.60 |
| 48 | 16.25 | 15.43 | -0.81 | -0.81 | -36.23 | 29.33 | 381.73 | 572.60 |
| 22 | 16.52 | 15.70 | -0.83 | -0.82 | -38.82 | 31.80 | 413.53 | 620.30 |
| 19 | 16.56 | 15.73 | -0.83 | -0.83 | -19.55 | 16.17 | 429.70 | 644.55 |
| 0 | 16.76 | 15.92 | -0.84 | -0.83 | -13.03 | 10.86 | 440.56 | 660.84 |

COMBINED ULTIMATE TORSION ( AERODYNAMIC + INERTIAL )

CONDITION. C cont..

| | | | |
|---|---|---|---|
| 1 | 71 C | | |
| STATION | COND. C | | |
| (in) | (lb in) | | |
| 258 | 0 | | |
| 251.25 | 512 | | |
| 238 | 1009 | | |
| 228 | 1473 | | |
| 218 | 1992 | | |
| 208 | 2557 | | |
| 198 | 3162 | | |
| 188 | 3805 | | |
| 178 | 4483 | | |
| 163.65 | 5500 | | |
| 159 | 5838 | | |
| 155.00 | 6184 | | |
| 138 | 7495 | | |
| 128 | 8311 | | |
| 118 | 9151 | | |
| 108 | 10012 | | |
| 98 | 10892 | | |
| 88 | 11793 | | |
| 80.00 | 12534 | | |
| 68 | 13647 | | |
| 58 | 14599 | | |
| 48 | 15567 | | |
| 22 | 18074 | | |
| 19 | 18387 | | |
| 0 | 20252 | | |

| SPANWISE AERODYNAMIC LOAD DISTRIBUTION | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CONDITION. D | | | | | | | | | | | | |
| $V_{sal}$ = | 244.93 | ft/s | | | $C_L$ = | 0.6 | | alpha wrp = | 2.6998 | | | |
| Lift = | 5466.30 | lb | | | $C_{Do}$ = | 0.006 | - | sin alpha = | 0.0471 | | | |
| q = | 71.39 | psf | | | $C_D$ = | 0.015 | | cos alpha = | 0.9989 | | | |
| n = | 3.80 | g | | | $C_{Mo}$ = | -0.025 | | | | | | |
| | $q.C_L$ = | 40.49 | $q.C_L$ =Lift/S | | | S = | 135.00 | $ft^2$ | | | | |
| | | | | | | b = | 43.00 | ft | | | | |
| 1 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 |
| STATION | $C_L$ | $C_{Lz}$ | $C_{Lz}$ | $C_D$ | $C_{Dz}$ | $C_{Dz}$ | $C_{Lz}+C_{Dz}$ | $C_{Dz}-C_{Lz}$ | $(C_{Lz}+C_{Dz})_{AV}$ | $(C_{Dz}-C_{Lz})_{AV}$ | SPAN | SPAN |
| (in) | | | | | | | | | | | ELEMENT | ELEMENT |
| | | | | | | | | | | | LIFT | DRAG |
| | | | | | | | | | | | (lb) | (lb) |
| 258 | 0.2836 | 0.0134 | 0.2833 | 0.0184 | 0.0184 | 0.0009 | 0.2841 | 0.0050 | - | - | 0.00 | 0.00 |
| 251.25 | 0.3715 | 0.0175 | 0.3710 | 0.0184 | 0.0184 | 0.0009 | 0.3719 | 0.0009 | 0.3280 | 0.0030 | 38.52 | 0.35 |
| 238 | 0.4314 | 0.0203 | 0.4309 | 0.0184 | 0.0184 | 0.0009 | 0.4318 | -0.0019 | 0.4018 | -0.0005 | 93.33 | -0.12 |
| 228 | 0.4614 | 0.0217 | 0.4609 | 0.0184 | 0.0184 | 0.0009 | 0.4618 | -0.0033 | 0.4468 | -0.0026 | 79.00 | -0.47 |
| 218 | 0.4853 | 0.0229 | 0.4848 | 0.0184 | 0.0184 | 0.0009 | 0.4856 | -0.0045 | 0.4737 | -0.0039 | 84.39 | -0.70 |
| 208 | 0.5051 | 0.0238 | 0.5045 | 0.0146 | 0.0146 | 0.0007 | 0.5052 | -0.0092 | 0.4954 | -0.0068 | 88.92 | -1.23 |
| 198 | 0.5218 | 0.0246 | 0.5213 | 0.0146 | 0.0146 | 0.0007 | 0.5220 | -0.0100 | 0.5136 | -0.0096 | 92.86 | -1.74 |
| 188 | 0.5363 | 0.0253 | 0.5357 | 0.0146 | 0.0146 | 0.0007 | 0.5363 | -0.0107 | 0.5292 | -0.0104 | 96.38 | -1.89 |
| 178 | 0.5487 | 0.0258 | 0.5481 | 0.0146 | 0.0146 | 0.0007 | 0.5488 | -0.0113 | 0.5426 | -0.0110 | 99.54 | -2.02 |
| 163.65 | 0.5639 | 0.0266 | 0.5632 | 0.0146 | 0.0146 | 0.0007 | 0.5639 | -0.0120 | 0.5564 | -0.0116 | 147.76 | -3.09 |
| 159 | 0.5679 | 0.0267 | 0.5672 | 0.0146 | 0.0146 | 0.0007 | 0.5679 | -0.0122 | 0.5659 | -0.0121 | 45.60 | -0.97 |
| 155.00 | 0.5716 | 0.0269 | 0.5710 | 0.0146 | 0.0146 | 0.0007 | 0.5717 | -0.0124 | 0.5698 | -0.0123 | 46.06 | -0.99 |
| 138 | 0.5844 | 0.0275 | 0.5838 | 0.0146 | 0.0146 | 0.0007 | 0.5844 | -0.0130 | 0.5781 | -0.0127 | 185.04 | -4.05 |
| 128 | 0.5906 | 0.0278 | 0.5899 | 0.0146 | 0.0146 | 0.0007 | 0.5906 | -0.0133 | 0.5875 | -0.0131 | 111.68 | -2.49 |
| 118 | 0.5958 | 0.0281 | 0.5952 | 0.0146 | 0.0146 | 0.0007 | 0.5958 | -0.0135 | 0.5932 | -0.0134 | 113.55 | -2.56 |
| 108 | 0.6003 | 0.0283 | 0.5996 | 0.0146 | 0.0146 | 0.0007 | 0.6003 | -0.0137 | 0.5981 | -0.0136 | 115.27 | -2.62 |
| 98 | 0.6040 | 0.0284 | 0.6033 | 0.0146 | 0.0146 | 0.0007 | 0.6040 | -0.0139 | 0.6021 | -0.0138 | 116.86 | -2.68 |
| 88 | 0.6069 | 0.0286 | 0.6063 | 0.0146 | 0.0146 | 0.0007 | 0.6070 | -0.0140 | 0.6055 | -0.0140 | 118.31 | -2.73 |
| 80.00 | 0.6089 | 0.0287 | 0.6082 | 0.0146 | 0.0146 | 0.0007 | 0.6089 | -0.0141 | 0.6079 | -0.0141 | 95.61 | -2.21 |
| 68 | 0.6110 | 0.0288 | 0.6103 | 0.0146 | 0.0146 | 0.0007 | 0.6110 | -0.0142 | 0.6099 | -0.0142 | 144.86 | -3.36 |
| 58 | 0.6121 | 0.0288 | 0.6114 | 0.0146 | 0.0146 | 0.0007 | 0.6121 | -0.0143 | 0.6116 | -0.0142 | 121.93 | -2.84 |
| 48 | 0.6127 | 0.0289 | 0.6120 | 0.0146 | 0.0146 | 0.0007 | 0.6127 | -0.0143 | 0.6124 | -0.0143 | 122.91 | -2.87 |
| 22 | 0.6117 | 0.0288 | 0.6110 | 0.0146 | 0.0146 | 0.0007 | 0.6117 | -0.0142 | 0.6122 | -0.0143 | 323.24 | -7.54 |
| 19 | 0.6113 | 0.0288 | 0.6107 | 0.0146 | 0.0146 | 0.0007 | 0.6114 | -0.0142 | 0.6115 | -0.0142 | 37.61 | -0.88 |
| 0 | 0.6083 | 0.0287 | 0.6076 | 0.0146 | 0.0146 | 0.0007 | 0.6083 | -0.0141 | 0.6098 | -0.0142 | 239.22 | -5.56 |
| | | | | | | | | | | Σ = | 2758.45 | -55.25 |
| | | | | | | | | | | LIFT calc = | 5516.91 | |
| | | | | | | | | | | Lift = | 5466.30 | |
| | | | | | | | | | error = | -0.9 | % | |

SPANWISE AERODYNAMIC LOAD DISTRIBUTION

CONDITION. D cont..

| 1 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 |
|---|---|---|---|---|---|---|---|---|
| STATION | LIMIT | LIMIT | LIMIT | LIMIT | ULT | ULT | ULT | ULT |
| (in) | NORMAL | NORMAL | CHORD | CHORD | NORMAL | NORMAL | CHORD | CHORD |
| | SHEAR | MOMENT | SHEAR | MOMENT | SHEAR | MOMENT | SHEAR | MOMENT |
| | (lb) | (lb in) | (lb) | (lb in) | (lb) | (lb in) | (lb) | (lb in) |
| 258 | 0.00 | 0.00 | 0.00 | 0.00 | 0 | 0 | 0 | 0 |
| 251.25 | 38.52 | 130.00 | 0.35 | 1.18 | 58 | 195 | 1 | 2 |
| 238 | 131.85 | 1258.71 | 0.23 | 5.00 | 198 | 1888 | 0 | 8 |
| 228 | 210.85 | 2972.23 | -0.24 | 4.96 | 316 | 4458 | 0 | 7 |
| 218 | 295.25 | 5502.74 | -0.93 | -0.88 | 443 | 8254 | -1 | -1 |
| 208 | 384.17 | 8899.81 | -2.16 | -16.34 | 576 | 13350 | -3 | -25 |
| 198 | 477.03 | 13205.78 | -3.90 | -46.64 | 716 | 19809 | -6 | -70 |
| 188 | 573.41 | 18457.94 | -5.79 | -95.08 | 860 | 27687 | -9 | -143 |
| 178 | 672.95 | 24689.71 | -7.80 | -163.03 | 1009 | 37035 | -12 | -245 |
| 163.65 | 820.71 | 35406.70 | -10.90 | -297.20 | 1231 | 53110 | -16 | -446 |
| 159 | 866.31 | 39054.89 | -11.87 | -346.42 | 1299 | 58582 | -18 | -520 |
| 155.00 | 912.37 | 42901.28 | -12.86 | -399.90 | 1369 | 64352 | -19 | -600 |
| 138 | 1097.41 | 59984.42 | -16.92 | -653.01 | 1646 | 89977 | -25 | -980 |
| 128 | 1209.09 | 71516.96 | -19.41 | -834.63 | 1814 | 107275 | -29 | -1252 |
| 118 | 1322.65 | 84175.67 | -21.97 | -1041.51 | 1984 | 126264 | -33 | -1562 |
| 108 | 1437.92 | 97978.52 | -24.59 | -1274.31 | 2157 | 146968 | -37 | -1911 |
| 98 | 1554.78 | 112942.01 | -27.27 | -1533.61 | 2332 | 169413 | -41 | -2300 |
| 88 | 1673.08 | 129081.30 | -30.00 | -1819.94 | 2510 | 193622 | -45 | -2730 |
| 80.00 | 1768.69 | 142848.39 | -32.21 | -2068.76 | 2653 | 214273 | -48 | -3103 |
| 68 | 1913.55 | 164941.81 | -35.57 | -2475.47 | 2870 | 247413 | -53 | -3713 |
| 58 | 2035.47 | 184686.91 | -38.41 | -2845.41 | 3053 | 277030 | -58 | -4268 |
| 48 | 2158.38 | 205656.18 | -41.28 | -3243.88 | 3238 | 308484 | -62 | -4866 |
| 22 | 2481.62 | 265976.24 | -48.82 | -4415.14 | 3722 | 398964 | -73 | -6623 |
| 19 | 2519.23 | 273477.52 | -49.69 | -4562.91 | 3779 | 410216 | -75 | -6844 |
| 0 | 2758.45 | 323615.56 | -55.25 | -5559.84 | 4138 | 485423 | -83 | -8340 |
| | | | | | | | | |
| Centre of lift is | 117 | in from aircraft centreline | | | | | | |
| | 45 | % semispan | | | | | | |

SPANWISE INERTIAL LOAD DISTRIBUTION

CONDITION. D cont..

| 1 | 3 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 | 41 | 42 | 43 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| STATION | dy | WEIGHT | ELEMENT | ELEMENT | LIMIT | LIMIT | LIMIT | LIMIT | ULT | ULT | ULT | ULT |
| (in) | (in) | nW | SHEAR | SHEAR | NORMAL | NORMAL | CHORD | CHORD | NORMAL | NORMAL | CHORD | CHORD |
| | | (lb) | FORCE | FORCE | SHEAR | MOMENT | SHEAR | MOMENT | SHEAR | MOMENT | SHEAR | MOMENT |
| | | | $V_x$ | $V_z$ | (lb) | (lb in) | (lb) | (lb in) | (lb) | (lb in) | (lb) | (lb in) |
| | | | (lb) | (lb) | | | | | | | | |
| 258 | - | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0 | 0 | 0 | 0 |
| 251.25 | 6.75 | -1.49 | 0.07 | -1.48 | -1.48 | -5.01 | 0.07 | 0.24 | -2 | -8 | 0 | 0 |
| 238 | 13.25 | -3.95 | 0.19 | -3.95 | -5.43 | -50.82 | 0.26 | 2.40 | -8 | -76 | 0 | 4 |
| 228 | 10.00 | -6.84 | 0.32 | -6.83 | -12.26 | -139.30 | 0.58 | 6.57 | -18 | -209 | 1 | 10 |
| 218 | 10.00 | -9.58 | 0.45 | -9.57 | -21.83 | -309.76 | 1.03 | 14.61 | -33 | -465 | 2 | 22 |
| 208 | 10.00 | -11.74 | 0.55 | -11.73 | -33.56 | -586.70 | 1.58 | 27.67 | -50 | -880 | 2 | 41 |
| 198 | 10.00 | -13.79 | 0.65 | -13.78 | -47.34 | -991.17 | 2.23 | 46.74 | -71 | -1487 | 3 | 70 |
| 188 | 10.00 | -16.34 | 0.77 | -16.32 | -63.66 | -1546.15 | 3.00 | 72.91 | -95 | -2319 | 5 | 109 |
| 178 | 10.00 | -18.51 | 0.87 | -18.49 | -82.14 | -2275.17 | 3.87 | 107.29 | -123 | -3413 | 6 | 161 |
| 163.65 | 14.35 | -21.28 | 1.00 | -21.26 | -103.40 | -3606.45 | 4.88 | 170.06 | -155 | -5410 | 7 | 255 |
| 159 | 4.33 | -21.96 | 1.03 | -21.94 | -125.34 | -4101.10 | 5.91 | 193.39 | -188 | -6152 | 9 | 290 |
| 155.00 | 4.32 | -22.88 | 1.08 | -22.85 | -148.19 | -4692.61 | 6.99 | 221.28 | -222 | -7039 | 10 | 332 |
| 138 | 17.00 | -24.02 | 1.13 | -23.99 | -172.18 | -7415.77 | 8.12 | 349.69 | -258 | -11124 | 12 | 525 |
| 128 | 10.00 | -24.40 | 1.15 | -24.37 | -196.55 | -9259.41 | 9.27 | 436.63 | -295 | -13889 | 14 | 655 |
| 118 | 10.00 | -25.08 | 1.18 | -25.05 | -221.60 | -11350.16 | 10.45 | 535.22 | -332 | -17025 | 16 | 803 |
| 108 | 10.00 | -25.42 | 1.20 | -25.39 | -246.99 | -13693.14 | 11.65 | 645.70 | -370 | -20540 | 17 | 969 |
| 98 | 10.00 | -25.84 | 1.22 | -25.81 | -272.81 | -16292.15 | 12.86 | 768.26 | -409 | -24438 | 19 | 1152 |
| 88 | 10.00 | -26.87 | 1.27 | -26.84 | -299.64 | -19154.39 | 14.13 | 903.22 | -449 | -28732 | 21 | 1355 |
| 80.00 | 8.00 | -27.44 | 1.29 | -27.41 | -327.05 | -21661.16 | 15.42 | 1021.43 | -491 | -32492 | 23 | 1532 |
| 68 | 12.00 | -28.46 | 1.34 | -28.43 | -355.48 | -25756.32 | 16.76 | 1214.54 | -533 | -38634 | 25 | 1822 |
| 58 | 10.00 | -29.18 | 1.37 | -29.15 | -384.63 | -29456.86 | 18.14 | 1389.04 | -577 | -44185 | 27 | 2084 |
| 48 | 10.00 | -30.32 | 1.43 | -30.29 | -414.92 | -33454.61 | 19.57 | 1577.55 | -622 | -50182 | 29 | 2366 |
| 22 | 26.00 | -32.49 | 1.53 | -32.45 | -447.37 | -44664.44 | 21.10 | 2106.15 | -671 | -66997 | 32 | 3159 |
| 19 | 3.00 | -16.36 | 0.77 | -16.35 | -463.72 | -46031.08 | 21.87 | 2170.59 | -696 | -69047 | 33 | 3256 |
| 0 | 19.00 | -10.91 | 0.51 | -10.90 | -474.62 | -54945.28 | 22.38 | 2590.94 | -712 | -82418 | 34 | 3886 |
| | Σ = | 125 | lb | | | | | | | | | |
| | | at 1 g | | | Centre of gravity is | 116 | in from aircraft centreline | | | | | |
| | | | | | | 45 | % semispan | | | | | |

COMBINED ULTIMATE LOADS ( AERODYNAMIC + INERTIAL )

CONDITION. D cont..

| 1 | 44 D | 45 D | 46 D | 47 D | 48 D | 49 D |
|---|---|---|---|---|---|---|
| | ULT | ULT | ULT | ULT | ULT | ULT |
| | NORMAL | NORMAL | CHORD | CHORD | RESOLVED | RESOLVED |
| STATION | SHEAR | BEND MOMENT | SHEAR | BEND MOMENT | ULT SHEAR | ULT BEND MOM |
| (in) | COND. D | COND. D | COND. D | COND. D | COND. D | COND. D |
| | (lb) | (lb in) | (lb) | (lb in) | (lb) | (lb in) |
| | | | | | | |
| 258 | 0 | 0 | 0 | 0 | 0 | 0 |
| 251.25 | 56 | 187 | 1 | 2 | 56 | 188 |
| 238 | 190 | 1812 | 1 | 11 | 190 | 1812 |
| 228 | 298 | 4249 | 1 | 17 | 298 | 4249 |
| 218 | 410 | 7789 | 0 | 21 | 410 | 7789 |
| 208 | 526 | 12470 | -1 | 17 | 526 | 12470 |
| 198 | 645 | 18322 | -3 | 0 | 645 | 18322 |
| 188 | 765 | 25368 | -4 | -33 | 765 | 25368 |
| 178 | 886 | 33622 | -6 | -84 | 886 | 33622 |
| 163.65 | 1076 | 47700 | -9 | -191 | 1076 | 47701 |
| 159 | 1111 | 52431 | -9 | -230 | 1111 | 52431 |
| 155.00 | 1146 | 57313 | -9 | -268 | 1146 | 57314 |
| 138 | 1388 | 78853 | -13 | -455 | 1388 | 78854 |
| 128 | 1519 | 93386 | -15 | -597 | 1519 | 93388 |
| 118 | 1652 | 109238 | -17 | -759 | 1652 | 109241 |
| 108 | 1786 | 126428 | -19 | -943 | 1786 | 126432 |
| 98 | 1923 | 144975 | -22 | -1148 | 1923 | 144979 |
| 88 | 2060 | 164890 | -24 | -1375 | 2060 | 164896 |
| 80.00 | 2162 | 181781 | -25 | -1571 | 2163 | 181788 |
| 68 | 2337 | 208778 | -28 | -1891 | 2337 | 208787 |
| 58 | 2476 | 232845 | -30 | -2185 | 2476 | 232855 |
| 48 | 2615 | 258302 | -33 | -2499 | 2615 | 258314 |
| 22 | 3051 | 331968 | -42 | -3463 | 3052 | 331986 |
| 19 | 3083 | 341170 | -42 | -3588 | 3084 | 341189 |
| 0 | 3426 | 403005 | -49 | -4453 | 3426 | 403030 |

AERODYNAMIC TORQUE AT SHEAR CENTRE

CONDITION. D cont..

| 1 | 50 | 51 | 52 | 53 | 54 | 55 | 56 | 57 | 58 |
|---|---|---|---|---|---|---|---|---|---|
| STATION | LOCAL | LOCAL | AERO | X AC | X SC | DELTA X | Z AC | Z SC | DELTA Z |
| | $C_L$ | $X_{CP}$ | CENTRE | (in) | (in) | (in) | (in) | (in) | (in) |
| (in) | | | (in) | | using 38% chord | | | | |
| 258 | - | - | 0.00 | 0.00 | 13.30 | 13.30 | 0.00 | 2.39 | -2.39 |
| 251.25 | 0.33 | 0.32 | 11.12 | 11.12 | 13.37 | 2.24 | 0.00 | 2.40 | -2.40 |
| 238 | 0.40 | 0.30 | 10.74 | 10.74 | 13.50 | 2.76 | 0.00 | 2.44 | -2.44 |
| 228 | 0.45 | 0.30 | 10.60 | 10.60 | 13.60 | 3.01 | 0.00 | 2.47 | -2.47 |
| 218 | 0.47 | 0.29 | 10.56 | 10.56 | 13.71 | 3.15 | 0.00 | 2.49 | -2.49 |
| 208 | 0.50 | 0.29 | 10.55 | 10.55 | 13.81 | 3.25 | 0.00 | 2.52 | -2.52 |
| 198 | 0.51 | 0.29 | 10.57 | 10.57 | 13.91 | 3.34 | 0.00 | 2.54 | -2.54 |
| 188 | 0.53 | 0.29 | 10.59 | 10.59 | 14.01 | 3.42 | 0.00 | 2.57 | -2.57 |
| 178 | 0.54 | 0.29 | 10.62 | 10.62 | 14.11 | 3.49 | 0.00 | 2.60 | -2.60 |
| 163.65 | 0.56 | 0.28 | 10.69 | 10.69 | 14.26 | 3.57 | 0.00 | 2.64 | -2.64 |
| 159 | 0.57 | 0.28 | 10.70 | 10.70 | 14.30 | 3.61 | 0.00 | 2.65 | -2.65 |
| 155.00 | 0.57 | 0.28 | 10.72 | 10.72 | 14.35 | 3.63 | 0.00 | 2.66 | -2.66 |
| 138 | 0.58 | 0.28 | 10.82 | 10.82 | 14.52 | 3.70 | 0.00 | 2.70 | -2.70 |
| 128 | 0.59 | 0.28 | 10.87 | 10.87 | 14.62 | 3.75 | 0.00 | 2.73 | -2.73 |
| 118 | 0.59 | 0.28 | 10.93 | 10.93 | 14.72 | 3.79 | 0.00 | 2.76 | -2.76 |
| 108 | 0.60 | 0.28 | 10.99 | 10.99 | 14.82 | 3.83 | 0.00 | 2.78 | -2.78 |
| 98 | 0.60 | 0.28 | 11.06 | 11.06 | 14.93 | 3.87 | 0.00 | 2.81 | -2.81 |
| 88 | 0.61 | 0.28 | 11.12 | 11.12 | 15.03 | 3.90 | 0.00 | 2.84 | -2.84 |
| 80.00 | 0.61 | 0.28 | 11.18 | 11.18 | 15.11 | 3.93 | 0.00 | 2.86 | -2.86 |
| 68 | 0.61 | 0.28 | 11.26 | 11.26 | 15.23 | 3.97 | 0.00 | 2.89 | -2.89 |
| 58 | 0.61 | 0.28 | 11.33 | 11.33 | 15.33 | 4.00 | 0.00 | 2.92 | -2.92 |
| 48 | 0.61 | 0.28 | 11.41 | 11.41 | 15.43 | 4.03 | 0.00 | 2.94 | -2.94 |
| 22 | 0.61 | 0.28 | 11.60 | 11.60 | 15.70 | 4.10 | 0.00 | 3.01 | -3.01 |
| 19 | 0.61 | 0.28 | 11.63 | 11.63 | 15.73 | 4.10 | 0.00 | 3.01 | -3.01 |
| 0 | 0.61 | 0.28 | 11.77 | 11.77 | 15.92 | 4.15 | 0.00 | 1.25 | -1.25 |
| $X_{CP\ CHECK}$ = | 0.28 | | | | | | | | |

AERODYNAMIC TORQUE AT SHEAR CENTRE

CONDITION. D cont..

| 1 | 55 | 56 | 23 | 24 | 59 | 60 | 61 | 62 | 63 | 64 |
|---|---|---|---|---|---|---|---|---|---|---|
| STATION | DELTA X av | DELTA Z av | SPAN ELEMENT LIFT | SPAN ELEMENT DRAG | ELEMENT TORQUE DUE TO $C_{Mo}$ | ELEMENT TORQUE DUE TO LIFT | ELEMENT TORQUE DUE TO DRAG | ELEMENT LIMIT TORQUE | TOTAL LIMIT TORQUE | TOTAL ULT TORQUE |
| (in) | (in) | (in) | (lb) | (lb) | (lb in) | (lb in) | (lb in) | (lb in) | (lb in) | (lb in) |
| 258 | - | - | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 251.25 | 7.77 | 0.00 | 38.52 | 0.35 | -103.01 | 299.37 | 0.00 | 196.36 | 196.36 | 294.54 |
| 238 | 2.50 | 0.00 | 93.33 | -0.12 | -205.31 | 233.71 | 0.00 | 28.41 | 224.77 | 337.15 |
| 228 | 2.89 | 0.00 | 79.00 | -0.47 | -157.68 | 228.04 | 0.00 | 70.36 | 295.12 | 442.69 |
| 218 | 3.08 | 0.00 | 84.39 | -0.70 | -160.06 | 259.72 | 0.00 | 99.66 | 394.79 | 592.18 |
| 208 | 3.20 | 0.00 | 88.92 | -1.23 | -162.45 | 284.53 | 0.00 | 122.08 | 516.87 | 775.30 |
| 198 | 3.30 | 0.00 | 92.86 | -1.74 | -164.86 | 306.27 | 0.00 | 141.41 | 658.28 | 987.42 |
| 188 | 3.38 | 0.00 | 96.38 | -1.89 | -167.28 | 325.90 | 0.00 | 158.61 | 816.89 | 1225.33 |
| 178 | 3.45 | 0.00 | 99.54 | -2.02 | -169.73 | 343.84 | 0.00 | 174.11 | 991.00 | 1486.50 |
| 163.65 | 3.53 | 0.00 | 147.76 | -3.09 | -247.87 | 521.26 | 0.00 | 273.40 | 1264.39 | 1896.59 |
| 159 | 3.59 | 0.00 | 45.60 | -0.97 | -75.71 | 163.57 | 0.00 | 87.86 | 1352.26 | 2028.39 |
| 155.00 | 3.62 | 0.00 | 46.06 | -0.99 | -76.18 | 166.63 | 0.00 | 90.45 | 1442.71 | 2164.07 |
| 138 | 3.66 | 0.00 | 185.04 | -4.05 | -303.96 | 677.82 | 0.00 | 373.85 | 1816.57 | 2724.85 |
| 128 | 3.72 | 0.00 | 111.68 | -2.49 | -182.22 | 415.81 | 0.00 | 233.59 | 2050.16 | 3075.23 |
| 118 | 3.77 | 0.00 | 113.55 | -2.56 | -184.77 | 428.14 | 0.00 | 243.37 | 2293.53 | 3440.30 |
| 108 | 3.81 | 0.00 | 115.27 | -2.62 | -187.34 | 439.33 | 0.00 | 251.99 | 2545.52 | 3818.28 |
| 98 | 3.85 | 0.00 | 116.86 | -2.68 | -189.92 | 449.84 | 0.00 | 259.92 | 2805.44 | 4208.16 |
| 88 | 3.89 | 0.00 | 118.31 | -2.73 | -192.53 | 459.73 | 0.00 | 267.20 | 3072.64 | 4608.96 |
| 80.00 | 3.92 | 0.00 | 95.61 | -2.21 | -155.91 | 374.54 | 0.00 | 218.63 | 3291.27 | 4936.91 |
| 68 | 3.95 | 0.00 | 144.86 | -3.36 | -237.03 | 572.18 | 0.00 | 335.15 | 3626.42 | 5439.63 |
| 58 | 3.98 | 0.00 | 121.93 | -2.84 | -200.45 | 485.75 | 0.00 | 285.31 | 3911.73 | 5867.59 |
| 48 | 4.01 | 0.00 | 122.91 | -2.87 | -203.12 | 493.32 | 0.00 | 290.20 | 4201.93 | 6302.89 |
| 22 | 4.06 | 0.00 | 323.24 | -7.54 | -540.75 | 1313.14 | 0.00 | 772.39 | 4974.32 | 7461.47 |
| 19 | 4.10 | 0.00 | 37.61 | -0.88 | -63.58 | 154.19 | 0.00 | 90.61 | 5064.92 | 7597.38 |
| 0 | 4.13 | 0.00 | 239.22 | -5.56 | -408.43 | 986.89 | 0.00 | 578.47 | 5643.39 | 8465.08 |

DEAD WEIGHT ANALYSIS FOR WING TORQUE
CONDITION. D cont..

| 1 | 65 | 54 | 66 | 67 | 33 | 68 | 69 | 70 |
|---|---|---|---|---|---|---|---|---|
| STATION | X CG | X SC | DELTA | DELTA | ELEMENT | ELEMENT | TOTAL | TOTAL |
| | (in) | (in) | X | X av | LOAD | LIMIT | LIMIT | ULT |
| (in) | | | (in) | (in) | (lb) | TORQUE | TORQUE | TORQUE |
| | using 40% chord | | | | | (lb in) | (lb in) | (lb in) |
| 258 | 14.00 | 13.30 | -0.70 | - | - | - | - | 0.00 |
| 251.25 | 14.07 | 13.37 | -0.70 | -0.70 | -1.49 | 1.04 | 1.04 | 1.56 |
| 238 | 14.21 | 13.50 | -0.71 | -0.71 | -3.95 | 2.79 | 3.84 | 5.76 |
| 228 | 14.32 | 13.60 | -0.72 | -0.71 | -6.84 | 4.88 | 8.72 | 13.07 |
| 218 | 14.43 | 13.71 | -0.72 | -0.72 | -9.58 | 6.88 | 15.60 | 23.40 |
| 208 | 14.53 | 13.81 | -0.73 | -0.72 | -11.74 | 8.50 | 24.10 | 36.15 |
| 198 | 14.64 | 13.91 | -0.73 | -0.73 | -13.79 | 10.06 | 34.16 | 51.24 |
| 188 | 14.75 | 14.01 | -0.74 | -0.73 | -16.34 | 12.01 | 46.17 | 69.25 |
| 178 | 14.86 | 14.11 | -0.74 | -0.74 | -18.51 | 13.70 | 59.87 | 89.80 |
| 163.65 | 15.01 | 14.26 | -0.75 | -0.75 | -21.28 | 15.89 | 75.75 | 113.63 |
| 159 | 15.06 | 14.30 | -0.75 | -0.75 | -21.96 | 16.51 | 92.26 | 138.39 |
| 155.00 | 15.10 | 14.35 | -0.76 | -0.75 | -22.88 | 17.25 | 109.51 | 164.26 |
| 138 | 15.28 | 14.52 | -0.76 | -0.76 | -24.02 | 18.24 | 127.75 | 191.63 |
| 128 | 15.39 | 14.62 | -0.77 | -0.77 | -24.40 | 18.71 | 146.46 | 219.69 |
| 118 | 15.50 | 14.72 | -0.77 | -0.77 | -25.08 | 19.37 | 165.83 | 248.74 |
| 108 | 15.60 | 14.82 | -0.78 | -0.78 | -25.42 | 19.77 | 185.60 | 278.39 |
| 98 | 15.71 | 14.93 | -0.79 | -0.78 | -25.84 | 20.23 | 205.83 | 308.74 |
| 88 | 15.82 | 15.03 | -0.79 | -0.79 | -26.87 | 21.18 | 227.00 | 340.50 |
| 80.00 | 15.90 | 15.11 | -0.80 | -0.79 | -27.44 | 21.76 | 248.76 | 373.14 |
| 68 | 16.03 | 15.23 | -0.80 | -0.80 | -28.46 | 22.72 | 271.49 | 407.23 |
| 58 | 16.14 | 15.33 | -0.81 | -0.80 | -29.18 | 23.47 | 294.96 | 442.44 |
| 48 | 16.25 | 15.43 | -0.81 | -0.81 | -30.32 | 24.55 | 319.51 | 479.27 |
| 22 | 16.52 | 15.70 | -0.83 | -0.82 | -32.49 | 26.62 | 346.13 | 519.19 |
| 19 | 16.56 | 15.73 | -0.83 | -0.83 | -16.36 | 13.53 | 359.66 | 539.49 |
| 0 | 16.76 | 15.92 | -0.84 | -0.83 | -10.91 | 9.09 | 368.75 | 553.12 |

| COMBINED ULTIMATE TORSION ( AERODYNAMIC + INERTIAL ) | | | |
|---|---|---|---|
| CONDITION. D cont.. | | | |
| | | | |
| 1 | 71 D | | |
| STATION | COND. D | | |
| (in) | (lb in) | | |
| 258 | 0 | | |
| 251.25 | 296 | | |
| 238 | 343 | | |
| 228 | 456 | | |
| 218 | 616 | | |
| 208 | 811 | | |
| 198 | 1039 | | |
| 188 | 1295 | | |
| 178 | 1576 | | |
| 163.65 | 2010 | | |
| 159 | 2167 | | |
| 155.00 | 2328 | | |
| 138 | 2916 | | |
| 128 | 3295 | | |
| 118 | 3689 | | |
| 108 | 4097 | | |
| 98 | 4517 | | |
| 88 | 4949 | | |
| 80.00 | 5310 | | |
| 68 | 5847 | | |
| 58 | 6310 | | |
| 48 | 6782 | | |
| 22 | 7981 | | |
| 19 | 8137 | | |
| 0 | 9018 | | |

## SPANWISE AERODYNAMIC LOAD DISTRIBUTION

CONDITION. E

| | | | | | |
|---|---|---|---|---|---|
| $V_{sel}$ = | 244.93 ft/s | $C_L$ = | -0.3 | alpha wrp = | -6.1624 |
| Lift = | -2733.15 lb | $C_{Do}$ = | 0.007 | sin alpha = | -0.1073 |
| q = | 71.39 psf | $C_D$ = | 0.009 | cos alpha = | 0.9942 |
| n = | -1.90 g | $C_{Mo}$ = | -0.025 | | |
| $q.C_L$ = | -20.25 $q.C_L$ =Lift/S | S = | 135.00 ft$^2$ | | |
| | | b = | 43.00 ft | | |

| 1 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| STATION | $C_L$ | $C_{Lx}$ | $C_{Lx}$ | $C_D$ | $C_{Dx}$ | $C_{Dx}$ | $C_{Lx}+C_{Dx}$ | $C_{Dx}-C_{Lx}$ | $(C_{Lx}+C_{Dx})_{AV}$ | $(C_{Dx}-C_{Lx})_{AV}$ | SPAN ELEMENT LIFT | SPAN ELEMENT DRAG |
| (in) | | | | | | | | | | | (lb) | (lb) |
| 258 | -0.1418 | 0.0152 | -0.1410 | 0.0112 | 0.0111 | -0.0012 | -0.1422 | -0.0041 | - | - | 0.00 | 0.00 |
| 251.25 | -0.1857 | 0.0199 | -0.1847 | 0.0112 | 0.0111 | -0.0012 | -0.1859 | -0.0088 | -0.1640 | -0.0064 | -19.26 | -0.76 |
| 238 | -0.2157 | 0.0232 | -0.2144 | 0.0112 | 0.0111 | -0.0012 | -0.2156 | -0.0120 | -0.2008 | -0.0104 | -46.63 | -2.42 |
| 228 | -0.2307 | 0.0248 | -0.2294 | 0.0112 | 0.0111 | -0.0012 | -0.2306 | -0.0136 | -0.2231 | -0.0128 | -39.45 | -2.27 |
| 218 | -0.2426 | 0.0260 | -0.2412 | 0.0112 | 0.0111 | -0.0012 | -0.2424 | -0.0149 | -0.2365 | -0.0143 | -42.14 | -2.54 |
| 208 | -0.2525 | 0.0271 | -0.2511 | 0.0089 | 0.0088 | -0.0010 | -0.2520 | -0.0183 | -0.2472 | -0.0166 | -44.38 | -2.98 |
| 198 | -0.2609 | 0.0280 | -0.2594 | 0.0089 | 0.0088 | -0.0010 | -0.2604 | -0.0192 | -0.2562 | -0.0187 | -46.32 | -3.39 |
| 188 | -0.2681 | 0.0288 | -0.2666 | 0.0089 | 0.0088 | -0.0010 | -0.2675 | -0.0200 | -0.2639 | -0.0196 | -48.07 | -3.57 |
| 178 | -0.2744 | 0.0295 | -0.2728 | 0.0089 | 0.0088 | -0.0010 | -0.2737 | -0.0206 | -0.2706 | -0.0203 | -49.65 | -3.72 |
| 163.65 | -0.2819 | 0.0303 | -0.2803 | 0.0089 | 0.0088 | -0.0010 | -0.2813 | -0.0214 | -0.2775 | -0.0210 | -73.70 | -5.59 |
| 159 | -0.2839 | 0.0305 | -0.2823 | 0.0089 | 0.0088 | -0.0010 | -0.2832 | -0.0217 | -0.2822 | -0.0216 | -22.74 | -1.74 |
| 155.00 | -0.2858 | 0.0307 | -0.2842 | 0.0089 | 0.0088 | -0.0010 | -0.2851 | -0.0219 | -0.2842 | -0.0218 | -22.97 | -1.76 |
| 138 | -0.2922 | 0.0314 | -0.2905 | 0.0089 | 0.0088 | -0.0010 | -0.2915 | -0.0225 | -0.2883 | -0.0222 | -92.29 | -7.11 |
| 128 | -0.2953 | 0.0317 | -0.2936 | 0.0089 | 0.0088 | -0.0010 | -0.2945 | -0.0229 | -0.2930 | -0.0227 | -55.70 | -4.32 |
| 118 | -0.2979 | 0.0320 | -0.2962 | 0.0089 | 0.0088 | -0.0010 | -0.2971 | -0.0232 | -0.2958 | -0.0230 | -56.63 | -4.41 |
| 108 | -0.3001 | 0.0322 | -0.2984 | 0.0089 | 0.0088 | -0.0010 | -0.2994 | -0.0234 | -0.2982 | -0.0233 | -57.49 | -4.49 |
| 98 | -0.3020 | 0.0324 | -0.3002 | 0.0089 | 0.0088 | -0.0010 | -0.3012 | -0.0236 | -0.3003 | -0.0235 | -58.27 | -4.56 |
| 88 | -0.3035 | 0.0326 | -0.3017 | 0.0089 | 0.0088 | -0.0010 | -0.3027 | -0.0238 | -0.3019 | -0.0237 | -59.00 | -4.63 |
| 80.00 | -0.3044 | 0.0327 | -0.3027 | 0.0089 | 0.0088 | -0.0010 | -0.3036 | -0.0239 | -0.3031 | -0.0238 | -47.68 | -3.74 |
| 68 | -0.3055 | 0.0328 | -0.3037 | 0.0089 | 0.0088 | -0.0010 | -0.3047 | -0.0240 | -0.3042 | -0.0239 | -72.24 | -5.68 |
| 58 | -0.3061 | 0.0329 | -0.3043 | 0.0089 | 0.0088 | -0.0010 | -0.3052 | -0.0240 | -0.3050 | -0.0240 | -60.80 | -4.79 |
| 48 | -0.3063 | 0.0329 | -0.3046 | 0.0089 | 0.0088 | -0.0010 | -0.3055 | -0.0241 | -0.3054 | -0.0241 | -61.29 | -4.83 |
| 22 | -0.3058 | 0.0328 | -0.3041 | 0.0089 | 0.0088 | -0.0010 | -0.3050 | -0.0240 | -0.3053 | -0.0240 | -161.19 | -12.69 |
| 19 | -0.3057 | 0.0328 | -0.3039 | 0.0089 | 0.0088 | -0.0010 | -0.3049 | -0.0240 | -0.3049 | -0.0240 | -18.75 | -1.48 |
| 0 | -0.3041 | 0.0326 | -0.3024 | 0.0089 | 0.0088 | -0.0010 | -0.3033 | -0.0238 | -0.3041 | -0.0239 | -119.29 | -9.38 |
| | | | | | | | | | | Σ = | -1375.91 | -102.82 |
| | | | | | | | | | | LIFT calc = | -2751.82 | |
| | | | | | | | | | | Lift = | -2733.15 | |
| | | | | | | | | | | error = | -0.7 | % |

SPANWISE AERODYNAMIC LOAD DISTRIBUTION

CONDITION. E cont..

| 1 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 |
|---|---|---|---|---|---|---|---|---|
| STATION | LIMIT | LIMIT | LIMIT | LIMIT | ULT | ULT | ULT | ULT |
| (in) | NORMAL | NORMAL | CHORD | CHORD | NORMAL | NORMAL | CHORD | CHORD |
| | SHEAR | MOMENT | SHEAR | MOMENT | SHEAR | MOMENT | SHEAR | MOMENT |
| | (lb) | (lb in) | (lb) | (lb in) | (lb) | (lb in) | (lb) | (lb in) |
| 258 | 0.00 | 0.00 | 0.00 | 0.00 | 0 | 0 | 0 | 0 |
| 251.25 | -19.26 | -65.00 | -0.76 | -2.55 | -29 | -98 | -1 | -4 |
| 238 | -65.89 | -629.10 | -3.17 | -28.59 | -99 | -944 | -5 | -43 |
| 228 | -105.34 | -1485.24 | -5.44 | -71.65 | -158 | -2228 | -8 | -107 |
| 218 | -147.48 | -2749.33 | -7.98 | -138.77 | -221 | -4124 | -12 | -208 |
| 208 | -191.85 | -4445.98 | -10.96 | -233.49 | -288 | -6669 | -16 | -350 |
| 198 | -238.18 | -6596.12 | -14.35 | -360.05 | -357 | -9894 | -22 | -540 |
| 188 | -286.25 | -9218.26 | -17.92 | -521.38 | -429 | -13827 | -27 | -782 |
| 178 | -335.90 | -12329.03 | -21.64 | -719.16 | -504 | -18494 | -32 | -1079 |
| 163.65 | -409.60 | -17678.01 | -27.23 | -1069.79 | -614 | -26517 | -41 | -1605 |
| 159 | -432.34 | -19498.72 | -28.96 | -1191.31 | -649 | -29248 | -43 | -1787 |
| 155.00 | -455.31 | -21418.27 | -30.72 | -1320.39 | -683 | -32127 | -46 | -1981 |
| 138 | -547.60 | -29943.03 | -37.83 | -1903.12 | -821 | -44915 | -57 | -2855 |
| 128 | -603.29 | -35697.50 | -42.15 | -2303.03 | -905 | -53546 | -63 | -3455 |
| 118 | -659.92 | -42013.59 | -46.56 | -2746.56 | -990 | -63020 | -70 | -4120 |
| 108 | -717.41 | -48900.24 | -51.04 | -3234.56 | -1076 | -73350 | -77 | -4852 |
| 98 | -775.68 | -56365.68 | -55.60 | -3767.80 | -1164 | -84549 | -83 | -5652 |
| 88 | -834.68 | -64417.47 | -60.23 | -4346.97 | -1252 | -96626 | -90 | -6520 |
| 80.00 | -882.35 | -71285.59 | -63.98 | -4843.80 | -1324 | -106928 | -96 | -7266 |
| 68 | -954.59 | -82307.23 | -69.66 | -5645.59 | -1432 | -123461 | -104 | -8468 |
| 58 | -1015.39 | -92157.11 | -74.44 | -6366.07 | -1523 | -138236 | -112 | -9549 |
| 48 | -1076.68 | -102617.43 | -79.27 | -7134.63 | -1615 | -153926 | -119 | -10702 |
| 22 | -1237.87 | -132706.48 | -91.96 | -9360.63 | -1857 | -199060 | -138 | -14041 |
| 19 | -1256.62 | -136448.21 | -93.44 | -9638.73 | -1885 | -204672 | -140 | -14458 |
| 0 | -1375.91 | -161457.26 | -102.82 | -11503.17 | -2064 | -242186 | -154 | -17255 |
| | | | | | | | | |
| Centre of lift is | 117 | in from aircraft centreline | | | | | | |
| | 45 | % semispan | | | | | | |

SPANWISE INERTIAL LOAD DISTRIBUTION

CONDITION. E cont..

| 1 | 3 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 | 41 | 42 | 43 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| STATION (in) | dy (in) | WEIGHT nW (lb) | ELEMENT SHEAR FORCE $V_x$ (lb) | ELEMENT SHEAR FORCE $V_z$ (lb) | LIMIT NORMAL SHEAR (lb) | LIMIT NORMAL MOMENT (lb in) | LIMIT CHORD SHEAR (lb) | LIMIT CHORD MOMENT (lb in) | ULT NORMAL SHEAR (lb) | ULT NORMAL MOMENT (lb in) | ULT CHORD SHEAR (lb) | ULT CHORD MOMENT (lb in) |
| 258 | - | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0 | 0 | 0 | 0 |
| 251.25 | 6.75 | 0.74 | 0.08 | 0.74 | 0.74 | 2.49 | 0.08 | 0.27 | 1 | 4 | 0 | 0 |
| 238 | 13.25 | 1.98 | 0.21 | 1.96 | 2.70 | 25.29 | 0.29 | 2.73 | 4 | 38 | 0 | 4 |
| 228 | 10.00 | 3.42 | 0.37 | 3.40 | 6.10 | 69.32 | 0.66 | 7.48 | 9 | 104 | 1 | 11 |
| 218 | 10.00 | 4.79 | 0.51 | 4.76 | 10.86 | 154.16 | 1.17 | 16.64 | 16 | 231 | 2 | 25 |
| 208 | 10.00 | 5.87 | 0.63 | 5.84 | 16.70 | 291.98 | 1.80 | 31.53 | 25 | 438 | 3 | 47 |
| 198 | 10.00 | 6.90 | 0.74 | 6.86 | 23.56 | 493.27 | 2.54 | 53.26 | 35 | 740 | 4 | 80 |
| 188 | 10.00 | 8.17 | 0.88 | 8.12 | 31.68 | 769.46 | 3.42 | 83.08 | 48 | 1154 | 5 | 125 |
| 178 | 10.00 | 9.25 | 0.99 | 9.20 | 40.88 | 1132.27 | 4.41 | 122.25 | 61 | 1698 | 7 | 183 |
| 163.65 | 14.35 | 10.64 | 1.14 | 10.58 | 51.46 | 1794.80 | 5.56 | 193.79 | 77 | 2692 | 8 | 291 |
| 159 | 4.33 | 10.98 | 1.18 | 10.92 | 62.38 | 2040.97 | 6.73 | 220.36 | 94 | 3061 | 10 | 331 |
| 155.00 | 4.32 | 11.44 | 1.23 | 11.37 | 73.75 | 2335.34 | 7.96 | 252.15 | 111 | 3503 | 12 | 378 |
| 138 | 17.00 | 12.01 | 1.29 | 11.94 | 85.69 | 3690.55 | 9.25 | 398.47 | 129 | 5536 | 14 | 598 |
| 128 | 10.00 | 12.20 | 1.31 | 12.13 | 97.82 | 4608.07 | 10.56 | 497.54 | 147 | 6912 | 16 | 746 |
| 118 | 10.00 | 12.54 | 1.35 | 12.47 | 110.28 | 5648.56 | 11.91 | 609.88 | 165 | 8473 | 18 | 915 |
| 108 | 10.00 | 12.71 | 1.36 | 12.64 | 122.92 | 6814.57 | 13.27 | 735.77 | 184 | 10222 | 20 | 1104 |
| 98 | 10.00 | 12.92 | 1.39 | 12.85 | 135.77 | 8108.00 | 14.66 | 875.43 | 204 | 12162 | 22 | 1313 |
| 88 | 10.00 | 13.43 | 1.44 | 13.36 | 149.12 | 9532.44 | 16.10 | 1029.22 | 224 | 14299 | 24 | 1544 |
| 80.00 | 8.00 | 13.72 | 1.47 | 13.64 | 162.76 | 10779.96 | 17.57 | 1163.92 | 244 | 16170 | 26 | 1746 |
| 68 | 12.00 | 14.23 | 1.53 | 14.15 | 176.91 | 12817.97 | 19.10 | 1383.96 | 265 | 19227 | 29 | 2076 |
| 58 | 10.00 | 14.59 | 1.57 | 14.51 | 191.42 | 14659.59 | 20.67 | 1582.80 | 287 | 21989 | 31 | 2374 |
| 48 | 10.00 | 15.16 | 1.63 | 15.07 | 206.49 | 16649.13 | 22.29 | 1797.62 | 310 | 24974 | 33 | 2696 |
| 22 | 26.00 | 16.25 | 1.74 | 16.15 | 222.64 | 22227.85 | 24.04 | 2399.95 | 334 | 33342 | 36 | 3600 |
| 19 | 3.00 | 8.18 | 0.88 | 8.13 | 230.78 | 22907.98 | 24.92 | 2473.39 | 346 | 34362 | 37 | 3710 |
| 0 | 19.00 | 5.45 | 0.59 | 5.42 | 236.20 | 27344.24 | 25.50 | 2952.37 | 354 | 41016 | 38 | 4429 |
| | $\Sigma =$ | 125 | lb | | | | | | | | | |
| | | at 1 g | | | Centre of gravity is | 116 | in from aircraft centreline | | | | | |
| | | | | | | 45 | % semispan | | | | | |

COMBINED ULTIMATE LOADS ( AERODYNAMIC + INERTIAL )

CONDITION. E cont..

| 1 | 44 E | 45 E | 46 E | 47 E | 48 E | 49 E |
|---|---|---|---|---|---|---|
| | ULT | ULT | ULT | ULT | ULT | ULT |
| | NORMAL | NORMAL | CHORD | CHORD | RESOLVED | RESOLVED |
| STATION | SHEAR | BEND MOMENT | SHEAR | BEND MOMENT | ULT SHEAR | ULT BEND MOI |
| (in) | COND. E | COND. E | COND. E | COND. E | COND. E | COND. E |
| | (lb) | (lb in) | (lb) | (lb in) | (lb) | (lb in) |
| | | | | | | |
| 258 | 0 | 0 | 0 | 0 | 0 | 0 |
| 251.25 | -28 | -94 | -1 | -3 | 28 | 94 |
| 238 | -95 | -906 | -4 | -39 | 95 | 907 |
| 228 | -149 | -2124 | -7 | -96 | 149 | 2126 |
| 218 | -205 | -3893 | -10 | -183 | 205 | 3897 |
| 208 | -263 | -6231 | -14 | -303 | 263 | 6238 |
| 198 | -322 | -9154 | -18 | -460 | 322 | 9166 |
| 188 | -382 | -12673 | -22 | -657 | 382 | 12690 |
| 178 | -443 | -16795 | -26 | -895 | 443 | 16819 |
| 163.65 | -537 | -23825 | -33 | -1314 | 538 | 23861 |
| 159 | -555 | -26187 | -33 | -1456 | 556 | 26227 |
| 155.00 | -572 | -28624 | -34 | -1602 | 573 | 28669 |
| 138 | -693 | -39379 | -43 | -2257 | 694 | 39443 |
| 128 | -758 | -46634 | -47 | -2708 | 760 | 46713 |
| 118 | -824 | -54548 | -52 | -3205 | 826 | 54642 |
| 108 | -892 | -63128 | -57 | -3748 | 894 | 63240 |
| 98 | -960 | -72387 | -61 | -4339 | 962 | 72516 |
| 88 | -1028 | -82328 | -66 | -4977 | 1030 | 82478 |
| 80.00 | -1079 | -90758 | -70 | -5520 | 1082 | 90926 |
| 68 | -1167 | -104234 | -76 | -6392 | 1169 | 104430 |
| 58 | -1236 | -116246 | -81 | -7175 | 1239 | 116467 |
| 48 | -1305 | -128952 | -85 | -8006 | 1308 | 129201 |
| 22 | -1523 | -165718 | -102 | -10441 | 1526 | 166047 |
| 19 | -1539 | -170310 | -103 | -10748 | 1542 | 170649 |
| 0 | -1710 | -201170 | -116 | -12826 | 1713 | 201578 |

AERODYNAMIC TORQUE AT SHEAR CENTRE

CONDITION. E cont..

| 1 | 50 | 51 | 52 | 53 | 54 | 55 | 56 | 57 | 58 |
|---|---|---|---|---|---|---|---|---|---|
| STATION | LOCAL | LOCAL | AERO | X AC | X SC | DELTA X | Z AC | Z SC | DELTA Z |
| | $C_L$ | $X_{CP}$ | CENTRE | (in) | (in) | (in) | (in) | (in) | (in) |
| (in) | | | (in) | | using 38% chord | | | | |
| 258 | - | - | 0.00 | 0.00 | 13.30 | 13.30 | 0.00 | 2.39 | -2.39 |
| 251.25 | -0.16 | 0.09 | 3.08 | 3.08 | 13.37 | 10.29 | 0.00 | 2.40 | -2.40 |
| 238 | -0.20 | 0.12 | 4.10 | 4.10 | 13.50 | 9.40 | 0.00 | 2.44 | -2.44 |
| 228 | -0.22 | 0.13 | 4.58 | 4.58 | 13.60 | 9.02 | 0.00 | 2.47 | -2.47 |
| 218 | -0.24 | 0.13 | 4.84 | 4.84 | 13.71 | 8.86 | 0.00 | 2.49 | -2.49 |
| 208 | -0.25 | 0.14 | 5.05 | 5.05 | 13.81 | 8.76 | 0.00 | 2.52 | -2.52 |
| 198 | -0.26 | 0.14 | 5.21 | 5.21 | 13.91 | 8.70 | 0.00 | 2.54 | -2.54 |
| 188 | -0.26 | 0.15 | 5.36 | 5.36 | 14.01 | 8.65 | 0.00 | 2.57 | -2.57 |
| 178 | -0.27 | 0.15 | 5.48 | 5.48 | 14.11 | 8.63 | 0.00 | 2.60 | -2.60 |
| 163.65 | -0.28 | 0.15 | 5.63 | 5.63 | 14.26 | 8.63 | 0.00 | 2.64 | -2.64 |
| 159 | -0.28 | 0.15 | 5.70 | 5.70 | 14.30 | 8.60 | 0.00 | 2.65 | -2.65 |
| 155.00 | -0.28 | 0.15 | 5.74 | 5.74 | 14.35 | 8.61 | 0.00 | 2.66 | -2.66 |
| 138 | -0.29 | 0.15 | 5.86 | 5.86 | 14.52 | 8.66 | 0.00 | 2.70 | -2.70 |
| 128 | -0.29 | 0.15 | 5.95 | 5.95 | 14.62 | 8.67 | 0.00 | 2.73 | -2.73 |
| 118 | -0.30 | 0.16 | 6.02 | 6.02 | 14.72 | 8.70 | 0.00 | 2.76 | -2.76 |
| 108 | -0.30 | 0.16 | 6.09 | 6.09 | 14.82 | 8.73 | 0.00 | 2.78 | -2.78 |
| 98 | -0.30 | 0.16 | 6.16 | 6.16 | 14.93 | 8.77 | 0.00 | 2.81 | -2.81 |
| 88 | -0.30 | 0.16 | 6.22 | 6.22 | 15.03 | 8.81 | 0.00 | 2.84 | -2.84 |
| 80.00 | -0.30 | 0.16 | 6.26 | 6.26 | 15.11 | 8.85 | 0.00 | 2.86 | -2.86 |
| 68 | -0.30 | 0.16 | 6.33 | 6.33 | 15.23 | 8.91 | 0.00 | 2.89 | -2.89 |
| 58 | -0.30 | 0.16 | 6.38 | 6.38 | 15.33 | 8.96 | 0.00 | 2.92 | -2.92 |
| 48 | -0.31 | 0.16 | 6.42 | 6.42 | 15.43 | 9.01 | 0.00 | 2.94 | -2.94 |
| 22 | -0.31 | 0.16 | 6.53 | 6.53 | 15.70 | 9.17 | 0.00 | 3.01 | -3.01 |
| 19 | -0.30 | 0.16 | 6.54 | 6.54 | 15.73 | 9.19 | 0.00 | 3.01 | -3.01 |
| 0 | -0.30 | 0.16 | 6.61 | 6.61 | 15.92 | 9.31 | 0.00 | 1.25 | -1.25 |

AERODYNAMIC TORQUE AT SHEAR CENTRE

CONDITION. E cont..

| 1 | 55 | 56 | 23 | 24 | 59 | 60 | 61 | 62 | 63 | 64 |
|---|---|---|---|---|---|---|---|---|---|---|
| STATION | DELTA | DELTA | SPAN | SPAN | ELEMENT | ELEMENT | ELEMENT | ELEMENT | TOTAL | TOTAL |
| | X av | Z av | ELEMENT | ELEMENT | TORQUE | TORQUE | TORQUE | LIMIT | LIMIT | ULT |
| (in) | (in) | (in) | LIFT | DRAG | DUE TO | DUE TO | DUE TO | TORQUE | TORQUE | TORQUE |
| | | | (lb) | (lb) | $C_{Mo}$ | LIFT | DRAG | (lb in) | (lb in) | (lb in) |
| | | | | | (lb in) | (lb in) | (lb in) | | | |
| 258 | - | - | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 251.25 | 11.79 | 0.00 | -19.26 | -0.76 | -103.01 | -227.15 | 0.00 | -330.16 | -330.16 | -495.25 |
| 238 | 9.84 | 0.00 | -46.63 | -2.42 | -205.31 | -458.99 | 0.00 | -664.29 | -994.46 | -1491.68 |
| 228 | 9.21 | 0.00 | -39.45 | -2.27 | -157.68 | -363.45 | 0.00 | -521.13 | -1515.59 | -2273.38 |
| 218 | 8.94 | 0.00 | -42.14 | -2.54 | -160.06 | -376.84 | 0.00 | -536.90 | -2052.49 | -3078.73 |
| 208 | 8.81 | 0.00 | -44.38 | -2.98 | -162.45 | -391.04 | 0.00 | -553.49 | -2605.97 | -3908.96 |
| 198 | 8.73 | 0.00 | -46.32 | -3.39 | -164.86 | -404.36 | 0.00 | -569.22 | -3175.19 | -4762.79 |
| 188 | 8.68 | 0.00 | -48.07 | -3.57 | -167.28 | -417.07 | 0.00 | -584.36 | -3759.55 | -5639.32 |
| 178 | 8.64 | 0.00 | -49.65 | -3.72 | -169.73 | -429.10 | 0.00 | -598.83 | -4358.38 | -6537.57 |
| 163.65 | 8.63 | 0.00 | -73.70 | -5.59 | -247.87 | -636.17 | 0.00 | -884.03 | -5242.41 | -7863.62 |
| 159 | 8.62 | 0.00 | -22.74 | -1.74 | -75.71 | -196.02 | 0.00 | -271.73 | -5514.14 | -8271.21 |
| 155.00 | 8.61 | 0.00 | -22.97 | -1.76 | -76.18 | -197.66 | 0.00 | -273.83 | -5787.97 | -8681.96 |
| 138 | 8.63 | 0.00 | -92.29 | -7.11 | -303.96 | -796.87 | 0.00 | -1100.84 | -6888.81 | -10333.22 |
| 128 | 8.67 | 0.00 | -55.70 | -4.32 | -182.22 | -482.68 | 0.00 | -664.89 | -7553.71 | -11330.56 |
| 118 | 8.68 | 0.00 | -56.63 | -4.41 | -184.77 | -491.76 | 0.00 | -676.53 | -8230.23 | -12345.35 |
| 108 | 8.72 | 0.00 | -57.49 | -4.49 | -187.34 | -500.98 | 0.00 | -688.32 | -8918.56 | -13377.83 |
| 98 | 8.75 | 0.00 | -58.27 | -4.56 | -189.92 | -509.92 | 0.00 | -699.84 | -9618.40 | -14427.60 |
| 88 | 8.79 | 0.00 | -59.00 | -4.63 | -192.53 | -518.58 | 0.00 | -711.11 | -10329.51 | -15494.26 |
| 80.00 | 8.83 | 0.00 | -47.68 | -3.74 | -155.91 | -420.90 | 0.00 | -576.80 | -10906.31 | -16359.47 |
| 68 | 8.88 | 0.00 | -72.24 | -5.68 | -237.03 | -641.14 | 0.00 | -878.16 | -11784.48 | -17676.72 |
| 58 | 8.93 | 0.00 | -60.80 | -4.79 | -200.45 | -543.02 | 0.00 | -743.47 | -12527.94 | -18791.92 |
| 48 | 8.98 | 0.00 | -61.29 | -4.83 | -203.12 | -550.62 | 0.00 | -753.74 | -13281.68 | -19922.52 |
| 22 | 9.09 | 0.00 | -161.19 | -12.69 | -540.75 | -1465.07 | 0.00 | -2005.81 | -15287.49 | -22931.24 |
| 19 | 9.18 | 0.00 | -18.75 | -1.48 | -63.58 | -172.12 | 0.00 | -235.70 | -15523.20 | -23284.79 |
| 0 | 9.25 | 0.00 | -119.29 | -9.38 | -408 43 | -1103.38 | 0.00 | -1511.80 | -17035.00 | -25552 50 |

DEAD WEIGHT ANALYSIS FOR WING TORQUE
CONDITION. E cont..

| 1 | 65 | 54 | 66 | 67 | 68 | 69 | 70 | 71 |
|---|---|---|---|---|---|---|---|---|
| STATION | X CG | X SC | DELTA | DELTA | ELEMENT | ELEMENT | TOTAL | TOTAL |
| | (in) | (in) | X | X av | LOAD | LIMIT | LIMIT | ULT |
| (in) | | | (in) | (in) | (lb) | TORQUE | TORQUE | TORQUE |
| | using 40% chord | | | | | (lb in) | (lb in) | (lb in) |
| 258 | 14.00 | 13.30 | -0.70 | - | - | - | - | 0.00 |
| 251.25 | 14.07 | 13.37 | -0.70 | -0.70 | 0.74 | -0.52 | -0.52 | -0.78 |
| 238 | 14.21 | 13.50 | -0.71 | -0.71 | 1.98 | -1.40 | -1.92 | -2.88 |
| 228 | 14.32 | 13.60 | -0.72 | -0.71 | 3.42 | -2.44 | -4.36 | -6.54 |
| 218 | 14.43 | 13.71 | -0.72 | -0.72 | 4.79 | -3.44 | -7.80 | -11.70 |
| 208 | 14.53 | 13.81 | -0.73 | -0.72 | 5.87 | -4.25 | -12.05 | -18.08 |
| 198 | 14.64 | 13.91 | -0.73 | -0.73 | 6.90 | -5.03 | -17.08 | -25.62 |
| 188 | 14.75 | 14.01 | -0.74 | -0.73 | 8.17 | -6.00 | -23.08 | -34.63 |
| 178 | 14.86 | 14.11 | -0.74 | -0.74 | 9.25 | -6.85 | -29.93 | -44.90 |
| 163.65 | 15.01 | 14.26 | -0.75 | -0.75 | 10.64 | -7.94 | -37.88 | -56.82 |
| 159 | 15.06 | 14.30 | -0.75 | -0.75 | 10.98 | -8.25 | -46.13 | -69.20 |
| 155.00 | 15.10 | 14.35 | -0.76 | -0.75 | 11.44 | -8.62 | -54.75 | -82.13 |
| 138 | 15.28 | 14.52 | -0.76 | -0.76 | 12.01 | -9.12 | -63.88 | -95.81 |
| 128 | 15.39 | 14.62 | -0.77 | -0.77 | 12.20 | -9.35 | -73.23 | -109.85 |
| 118 | 15.50 | 14.72 | -0.77 | -0.77 | 12.54 | -9.68 | -82.91 | -124.37 |
| 108 | 15.60 | 14.82 | -0.78 | -0.78 | 12.71 | -9.88 | -92.80 | -139.20 |
| 98 | 15.71 | 14.93 | -0.79 | -0.78 | 12.92 | -10.12 | -102.91 | -154.37 |
| 88 | 15.82 | 15.03 | -0.79 | -0.79 | 13.43 | -10.59 | -113.50 | -170.25 |
| 80.00 | 15.90 | 15.11 | -0.80 | -0.79 | 13.72 | -10.88 | -124.38 | -186.57 |
| 68 | 16.03 | 15.23 | -0.80 | -0.80 | 14.23 | -11.36 | -135.74 | -203.61 |
| 58 | 16.14 | 15.33 | -0.81 | -0.80 | 14.59 | -11.74 | -147.48 | -221.22 |
| 48 | 16.25 | 15.43 | -0.81 | -0.81 | 15.16 | -12.28 | -159.76 | -239.63 |
| 22 | 16.52 | 15.70 | -0.83 | -0.82 | 16.25 | -13.31 | -173.06 | -259.60 |
| 19 | 16.56 | 15.73 | -0.83 | -0.83 | 8.18 | -6.77 | -179.83 | -269.75 |
| 0 | 16.76 | 15.92 | -0.84 | -0.83 | 5.45 | -4.54 | -184.37 | -276.56 |

| COMBINED ULTIMATE TORSION ( AERODYNAMIC + INER | | | |
|---|---|---|---|
| CONDITION. E cont.. | | | |
| | | | |
| 1 | 71 E | | |
| STATION | COND. E | | |
| (in) | (lb in) | | |
| 258 | 0 | | |
| 251.25 | -496 | | |
| 238 | -1495 | | |
| 228 | -2280 | | |
| 218 | -3090 | | |
| 208 | -3927 | | |
| 198 | -4788 | | |
| 188 | -5674 | | |
| 178 | -6582 | | |
| 163.65 | -7920 | | |
| 159 | -8340 | | |
| 155.00 | -8764 | | |
| 138 | -10429 | | |
| 128 | -11440 | | |
| 118 | -12470 | | |
| 108 | -13517 | | |
| 98 | -14582 | | |
| 88 | -15665 | | |
| 80.00 | -16546 | | |
| 68 | -17880 | | |
| 58 | -19013 | | |
| 48 | -20162 | | |
| 22 | -23191 | | |
| 19 | -23555 | | |
| 0 | -25829 | | |

| SPANWISE AERODYNAMIC LOAD DISTRIBUTION | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CONDITION. F | | | | | | | | | | | | |
| | | | | | | | | | | | | |
| $V_{sel}$ = | 175.68 | ft/s | | | $C_L$ = | -0.7 | | alpha wrp = | -10.8849 | | | |
| Lift = | -3653.79 | lb | | | $C_{Do}$ = | 0.009 | | sin alpha = | -0.1888 | | | |
| q = | 36.73 | psf | | | $C_D$ = | 0.025 | | cos alpha = | 0.9820 | | | |
| n = | -2.54 | g | | | $C_{Mo}$ = | -0.025 | | | | | | |
| $q.C_L$ = | -27.07 | $q.C_L$ = Lift/S | | | S = | 135.00 | $ft^2$ | | | | | |
| | | | | | b = | 43.00 | ft | | | | | |
| | | | | | | | | | | | | |
| 1 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 |
| STATION | $C_L$ | $C_{Lx}$ | $C_{Lz}$ | $C_D$ | $C_{Dx}$ | $C_{Dz}$ | $C_{Lz}+C_{Dz}$ | $C_{Dx}-C_{Lx}$ | $(C_{Lz}+C_{Dz})_{AV}$ | $(C_{Dx}-C_{Lx})_{AV}$ | SPAN | SPAN |
| (in) | | | | | | | | | | | ELEMENT | ELEMENT |
| | | | | | | | | | | | LIFT | DRAG |
| | | | | | | | | | | | (lb) | (lb) |
| 258 | -0.3685 | 0.0696 | -0.3618 | 0.0297 | 0.0292 | -0.0056 | -0.3675 | -0.0404 | - | - | 0.00 | 0.00 |
| 251.25 | -0.4826 | 0.0911 | -0.4740 | 0.0297 | 0.0292 | -0.0056 | -0.4796 | -0.0619 | -0.4235 | -0.0512 | -25.58 | -3.09 |
| 238 | -0.5605 | 0.1058 | -0.5504 | 0.0297 | 0.0292 | -0.0056 | -0.5560 | -0.0766 | -0.5178 | -0.0693 | -61.87 | -8.28 |
| 228 | -0.5995 | 0.1132 | -0.5887 | 0.0297 | 0.0292 | -0.0056 | -0.5944 | -0.0840 | -0.5752 | -0.0803 | -52.32 | -7.31 |
| 218 | -0.6306 | 0.1191 | -0.6192 | 0.0297 | 0.0292 | -0.0056 | -0.6248 | -0.0899 | -0.6096 | -0.0869 | -55.87 | -7.97 |
| 208 | -0.6563 | 0.1239 | -0.6445 | 0.0235 | 0.0231 | -0.0044 | -0.6489 | -0.1008 | -0.6369 | -0.0953 | -58.80 | -8.80 |
| 198 | -0.6781 | 0.1280 | -0.6659 | 0.0235 | 0.0231 | -0.0044 | -0.6703 | -0.1049 | -0.6596 | -0.1029 | -61.35 | -9.57 |
| 188 | -0.6968 | 0.1316 | -0.6842 | 0.0235 | 0.0231 | -0.0044 | -0.6887 | -0.1085 | -0.6795 | -0.1067 | -63.67 | -10.00 |
| 178 | -0.7130 | 0.1346 | -0.7002 | 0.0235 | 0.0231 | -0.0044 | -0.7046 | -0.1115 | -0.6966 | -0.1100 | -65.75 | -10.38 |
| 163.65 | -0.7326 | 0.1383 | -0.7195 | 0.0235 | 0.0231 | -0.0044 | -0.7239 | -0.1152 | -0.7143 | -0.1134 | -97.59 | -15.49 |
| 159 | -0.7378 | 0.1393 | -0.7246 | 0.0235 | 0.0231 | -0.0044 | -0.7290 | -0.1162 | -0.7265 | -0.1157 | -30.11 | -4.80 |
| 155.00 | -0.7427 | 0.1403 | -0.7294 | 0.0235 | 0.0231 | -0.0044 | -0.7338 | -0.1171 | -0.7314 | -0.1167 | -30.41 | -4.85 |
| 138 | -0.7593 | 0.1434 | -0.7457 | 0.0235 | 0.0231 | -0.0044 | -0.7501 | -0.1203 | -0.7420 | -0.1187 | -122.18 | -19.55 |
| 128 | -0.7673 | 0.1449 | -0.7535 | 0.0235 | 0.0231 | -0.0044 | -0.7580 | -0.1218 | -0.7540 | -0.1210 | -73.74 | -11.84 |
| 118 | -0.7742 | 0.1462 | -0.7602 | 0.0235 | 0.0231 | -0.0044 | -0.7647 | -0.1231 | -0.7613 | -0.1224 | -74.97 | -12.06 |
| 108 | -0.7799 | 0.1473 | -0.7659 | 0.0235 | 0.0231 | -0.0044 | -0.7704 | -0.1242 | -0.7675 | -0.1236 | -76.10 | -12.26 |
| 98 | -0.7847 | 0.1482 | -0.7706 | 0.0235 | 0.0231 | -0.0044 | -0.7751 | -0.1251 | -0.7727 | -0.1246 | -77.14 | -12.44 |
| 88 | -0.7886 | 0.1489 | -0.7744 | 0.0235 | 0.0231 | -0.0044 | -0.7789 | -0.1258 | -0.7770 | -0.1254 | -78.10 | -12.61 |
| 80.00 | -0.7911 | 0.1494 | -0.7769 | 0.0235 | 0.0231 | -0.0044 | -0.7813 | -0.1263 | -0.7801 | -0.1260 | -63.11 | -10.20 |
| 68 | -0.7939 | 0.1499 | -0.7796 | 0.0235 | 0.0231 | -0.0044 | -0.7840 | -0.1268 | -0.7827 | -0.1265 | -95.63 | -15.46 |
| 58 | -0.7953 | 0.1502 | -0.7810 | 0.0235 | 0.0231 | -0.0044 | -0.7855 | -0.1271 | -0.7847 | -0.1269 | -80.49 | -13.02 |
| 48 | -0.7961 | 0.1503 | -0.7817 | 0.0235 | 0.0231 | -0.0044 | -0.7862 | -0.1272 | -0.7858 | -0.1271 | -81.13 | -13.13 |
| 22 | -0.7948 | 0.1501 | -0.7805 | 0.0235 | 0.0231 | -0.0044 | -0.7849 | -0.1270 | -0.7855 | -0.1271 | -213.38 | -34.52 |
| 19 | -0.7943 | 0.1500 | -0.7800 | 0.0235 | 0.0231 | -0.0044 | -0.7845 | -0.1269 | -0.7847 | -0.1269 | -24.83 | -4.02 |
| 0 | -0.7903 | 0.1492 | -0.7761 | 0.0235 | 0.0231 | -0.0044 | -0.7805 | -0.1261 | -0.7825 | -0.1265 | -157.92 | -25.53 |
| | | | | | | | | | | Σ = | -1822.06 | -287.15 |
| | | | | | | | | | | LIFT calc = | -3644.12 | |
| | | | | | | | | | | Lift = | -3653.79 | |
| | | | | | | | | | | error = | 0.3 | % |

SPANWISE AERODYNAMIC LOAD DISTRIBUTION

CONDITION. F cont..

| 1 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 |
|---|---|---|---|---|---|---|---|---|
| STATION | LIMIT | LIMIT | LIMIT | LIMIT | ULT | ULT | ULT | ULT |
| (in) | NORMAL | NORMAL | CHORD | CHORD | NORMAL | NORMAL | CHORD | CHORD |
| | SHEAR | MOMENT | SHEAR | MOMENT | SHEAR | MOMENT | SHEAR | MOMENT |
| | (lb) | (lb in) | (lb) | (lb in) | (lb) | (lb in) | (lb) | (lb in) |
| 258 | 0.00 | 0.00 | 0.00 | 0.00 | 0 | 0 | 0 | 0 |
| 251.25 | -25.58 | -86.35 | -3.09 | -10.43 | -38 | -130 | -5 | -16 |
| 238 | -87.45 | -835.22 | -11.37 | -106.24 | -131 | -1253 | -17 | -159 |
| 228 | -139.78 | -1971.38 | -18.68 | -256.48 | -210 | -2957 | -28 | -385 |
| 218 | -195.65 | -3648.51 | -26.65 | -483.10 | -293 | -5473 | -40 | -725 |
| 208 | -254.45 | -5899.01 | -35.45 | -793.58 | -382 | -8849 | -53 | -1190 |
| 198 | -315.80 | -8750.29 | -45.02 | -1195.92 | -474 | -13125 | -68 | -1794 |
| 188 | -379.47 | -12226.67 | -55.02 | -1696.08 | -569 | -18340 | -83 | -2544 |
| 178 | -445.22 | -16350.13 | -65.40 | -2298.14 | -668 | -24525 | -98 | -3447 |
| 163.65 | -542.81 | -23439.21 | -80.89 | -3347.72 | -814 | -35159 | -121 | -5022 |
| 159 | -572.92 | -25851.96 | -85.68 | -3707.93 | -859 | -38778 | -129 | -5562 |
| 155.00 | -603.33 | -28395.61 | -90.54 | -4089.00 | -905 | -42593 | -136 | -6134 |
| 138 | -725.52 | -39690.84 | -110.08 | -5794.26 | -1088 | -59536 | -165 | -8691 |
| 128 | -799.26 | -47314.70 | -121.92 | -6954.28 | -1199 | -70972 | -183 | -10431 |
| 118 | -874.22 | -55682.10 | -133.98 | -8233.75 | -1311 | -83523 | -201 | -12351 |
| 108 | -950.33 | -64804.87 | -146.23 | -9634.80 | -1425 | -97207 | -219 | -14452 |
| 98 | -1027.47 | -74693.87 | -158.67 | -11159.34 | -1541 | -112041 | -238 | -16739 |
| 88 | -1105.57 | -85359.10 | -171.28 | -12809.13 | -1658 | -128039 | -257 | -19214 |
| 80.00 | -1168.69 | -94456.14 | -181.48 | -14220.19 | -1753 | -141684 | -272 | -21330 |
| 68 | -1264.31 | -109054.14 | -196.94 | -16490.72 | -1896 | -163581 | -295 | -24736 |
| 58 | -1344.80 | -122099.70 | -209.96 | -18525.22 | -2017 | -183150 | -315 | -27788 |
| 48 | -1425.93 | -135953.36 | -223.09 | -20690.45 | -2139 | -203930 | -335 | -31036 |
| 22 | -1639.31 | -175801.56 | -257.61 | -26939.49 | -2459 | -263702 | -386 | -40409 |
| 19 | -1664.14 | -180756.75 | -261.62 | -27718.33 | -2496 | -271135 | -392 | -41578 |
| 0 | -1822.06 | -213875.64 | -287.15 | -32931.72 | -2733 | -320813 | -431 | -49398 |
| | | | | | | | | |
| Centre of lift is | 117 | in from aircraft centreline | | | | | | |
| | 45 | % semispan | | | | | | |

SPANWISE INERTIAL LOAD DISTRIBUTION

CONDITION. F cont..

| 1 | 3 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 | 41 | 42 | 43 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| STATION (in) | dy (in) | WEIGHT nW (lb) | ELEMENT SHEAR FORCE $V_z$ (lb) | ELEMENT SHEAR FORCE $V_x$ (lb) | LIMIT NORMAL SHEAR (lb) | LIMIT NORMAL MOMENT (lb in) | LIMIT CHORD SHEAR (lb) | LIMIT CHORD MOMENT (lb in) | ULT NORMAL SHEAR (lb) | ULT NORMAL MOMENT (lb in) | ULT CHORD SHEAR (lb) | ULT CHORD MOMENT (lb in) |
| 258 | - | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0 | 0 | 0 | 0 |
| 251.25 | 6.75 | 0.99 | 0.19 | 0.98 | 0.98 | 3.29 | 0.19 | 0.63 | 1 | 5 | 0 | 1 |
| 238 | 13.25 | 2.64 | 0.50 | 2.59 | 3.57 | 33.40 | 0.69 | 6.42 | 5 | 50 | 1 | 10 |
| 228 | 10.00 | 4.57 | 0.86 | 4.49 | 8.06 | 91.54 | 1.55 | 17.60 | 12 | 137 | 2 | 26 |
| 218 | 10.00 | 6.40 | 1.21 | 6.29 | 14.34 | 203.55 | 2.76 | 39.14 | 22 | 305 | 4 | 59 |
| 208 | 10.00 | 7.85 | 1.48 | 7.71 | 22.05 | 385.53 | 4.24 | 74.14 | 33 | 578 | 6 | 111 |
| 198 | 10.00 | 9.22 | 1.74 | 9.05 | 31.11 | 651.33 | 5.98 | 125.25 | 47 | 977 | 9 | 188 |
| 188 | 10.00 | 10.92 | 2.06 | 10.73 | 41.83 | 1016.01 | 8.04 | 195.38 | 63 | 1524 | 12 | 293 |
| 178 | 10.00 | 12.37 | 2.34 | 12.15 | 53.98 | 1495.07 | 10.38 | 287.50 | 81 | 2243 | 16 | 431 |
| 163.65 | 14.35 | 14.22 | 2.69 | 13.97 | 67.95 | 2369.89 | 13.07 | 455.72 | 102 | 3555 | 20 | 684 |
| 159 | 4.33 | 14.68 | 2.77 | 14.42 | 82.36 | 2694.93 | 15.84 | 518.23 | 124 | 4042 | 24 | 777 |
| 155.00 | 4.32 | 15.29 | 2.89 | 15.02 | 97.38 | 3083.63 | 18.73 | 592.97 | 146 | 4625 | 28 | 889 |
| 138 | 17.00 | 16.05 | 3.03 | 15.76 | 113.14 | 4873.08 | 21.76 | 937.08 | 170 | 7310 | 33 | 1406 |
| 128 | 10.00 | 16.31 | 3.08 | 16.01 | 129.16 | 6084.59 | 24.84 | 1170.05 | 194 | 9127 | 37 | 1755 |
| 118 | 10.00 | 16.76 | 3.17 | 16.46 | 145.62 | 7458.47 | 28.00 | 1434.24 | 218 | 11188 | 42 | 2151 |
| 108 | 10.00 | 16.99 | 3.21 | 16.69 | 162.31 | 8998.10 | 31.21 | 1730.30 | 243 | 13497 | 47 | 2595 |
| 98 | 10.00 | 17.27 | 3.26 | 16.96 | 179.27 | 10705.97 | 34.47 | 2058.72 | 269 | 16059 | 52 | 3088 |
| 88 | 10.00 | 17.96 | 3.39 | 17.63 | 196.90 | 12586.82 | 37.86 | 2420.40 | 295 | 18880 | 57 | 3631 |
| 80.00 | 8.00 | 18.34 | 3.46 | 18.01 | 214.91 | 14234.08 | 41.33 | 2737.16 | 322 | 21351 | 62 | 4106 |
| 68 | 12.00 | 19.02 | 3.59 | 18.68 | 233.59 | 16925.11 | 44.92 | 3254.64 | 350 | 25388 | 67 | 4882 |
| 58 | 10.00 | 19.51 | 3.68 | 19.16 | 252.75 | 19356.82 | 48.60 | 3722.25 | 379 | 29035 | 73 | 5583 |
| 48 | 10.00 | 20.27 | 3.83 | 19.90 | 272.65 | 21983.84 | 52.43 | 4227.42 | 409 | 32976 | 79 | 6341 |
| 22 | 26.00 | 21.72 | 4.10 | 21.33 | 293.98 | 29350.10 | 56.53 | 5643.92 | 441 | 44025 | 85 | 8466 |
| 19 | 3.00 | 10.94 | 2.07 | 10.74 | 304.72 | 30248.15 | 58.60 | 5816.62 | 457 | 45372 | 88 | 8725 |
| 0 | 19.00 | 7.29 | 1.38 | 7.16 | 311.88 | 36105.89 | 59.97 | 6943.04 | 468 | 54159 | 90 | 10415 |
| | $\Sigma =$ | 125 | lb | | | | | | | | | |
| | | at 1 g | | | Centre of gravity is | 116 | in from aircraft centreline | | | | | |
| | | | | | | 45 | % semispan | | | | | |

COMBINED ULTIMATE LOADS ( AERODYNAMIC + INERTIAL )

CONDITION. F cont..

| 1 | 44 F | 45 F | 46 F | 47 F | 48 F | 49 F |
|---|---|---|---|---|---|---|
| | ULT | ULT | ULT | ULT | ULT | ULT |
| | NORMAL | NORMAL | CHORD | CHORD | RESOLVED | RESOLVED |
| STATION | SHEAR | BEND MOMENT | SHEAR | BEND MOMENT | ULT SHEAR | ULT BEND MON |
| (in) | COND. F | COND. F | COND. F | COND. F | COND. F | COND. F |
| | (lb) | (lb in) | (lb) | (lb in) | (lb) | (lb in) |
| 258 | 0 | 0 | 0 | 0 | 0 | 0 |
| 251.25 | -37 | -125 | -4 | -15 | 37 | 125 |
| 238 | -126 | -1203 | -16 | -150 | 127 | 1212 |
| 228 | -198 | -2820 | -26 | -358 | 199 | 2842 |
| 218 | -272 | -5167 | -36 | -666 | 274 | 5210 |
| 208 | -349 | -8270 | -47 | -1079 | 352 | 8340 |
| 198 | -427 | -12148 | -59 | -1606 | 431 | 12254 |
| 188 | -506 | -16816 | -70 | -2251 | 511 | 16966 |
| 178 | -587 | -22283 | -83 | -3016 | 593 | 22486 |
| 163.65 | -712 | -31604 | -102 | -4338 | 720 | 31900 |
| 159 | -736 | -34736 | -105 | -4785 | 743 | 35064 |
| 155.00 | -759 | -37968 | -108 | -5244 | 767 | 38328 |
| 138 | -919 | -52227 | -132 | -7286 | 928 | 52732 |
| 128 | -1005 | -61845 | -146 | -8676 | 1016 | 62451 |
| 118 | -1093 | -72335 | -159 | -10199 | 1104 | 73051 |
| 108 | -1182 | -83710 | -173 | -11857 | 1195 | 84546 |
| 98 | -1272 | -95982 | -186 | -13651 | 1286 | 96948 |
| 88 | -1363 | -109158 | -200 | -15583 | 1378 | 110265 |
| 80.00 | -1431 | -120333 | -210 | -17225 | 1446 | 121560 |
| 68 | -1546 | -138194 | -228 | -19854 | 1563 | 139612 |
| 58 | -1638 | -154114 | -242 | -22204 | 1656 | 155706 |
| 48 | -1730 | -170954 | -256 | -24695 | 1749 | 172729 |
| 22 | -2018 | -219677 | -302 | -31943 | 2040 | 221987 |
| 19 | -2039 | -225763 | -305 | -32853 | 2062 | 228141 |
| 0 | -2265 | -266655 | -341 | -38983 | 2291 | 269489 |

AERODYNAMIC TORQUE AT SHEAR CENTRE

CONDITION. F cont..

| 1 | 50 | 51 | 52 | 53 | 54 | 55 | 56 | 57 | 58 |
|---|---|---|---|---|---|---|---|---|---|
| STATION | LOCAL | LOCAL | AERO | X AC | X SC | DELTA X | Z AC | Z SC | DELTA Z |
| | $C_L$ | $X_{CP}$ | CENTRE | (in) | (in) | (in) | (in) | (in) | (in) |
| (in) | | | (in) | | using 38% chord | | | | |
| 258 | - | - | 0.00 | 0.00 | 13.30 | 13.30 | 0.00 | 2.39 | -2.39 |
| 251.25 | -0.42 | 0.18 | 6.37 | 6.37 | 13.37 | 7.00 | 0.00 | 2.40 | -2.40 |
| 238 | -0.52 | 0.19 | 6.81 | 6.81 | 13.50 | 6.69 | 0.00 | 2.44 | -2.44 |
| 228 | -0.58 | 0.20 | 7.04 | 7.04 | 13.60 | 6.57 | 0.00 | 2.47 | -2.47 |
| 218 | -0.61 | 0.20 | 7.18 | 7.18 | 13.71 | 6.53 | 0.00 | 2.49 | -2.49 |
| 208 | -0.64 | 0.20 | 7.29 | 7.29 | 13.81 | 6.51 | 0.00 | 2.52 | -2.52 |
| 198 | -0.66 | 0.20 | 7.40 | 7.40 | 13.91 | 6.51 | 0.00 | 2.54 | -2.54 |
| 188 | -0.68 | 0.20 | 7.49 | 7.49 | 14.01 | 6.52 | 0.00 | 2.57 | -2.57 |
| 178 | -0.70 | 0.20 | 7.58 | 7.58 | 14.11 | 6.53 | 0.00 | 2.60 | -2.60 |
| 163.65 | -0.71 | 0.20 | 7.69 | 7.69 | 14.26 | 6.57 | 0.00 | 2.64 | -2.64 |
| 159 | -0.73 | 0.21 | 7.74 | 7.74 | 14.30 | 6.56 | 0.00 | 2.65 | -2.65 |
| 155.00 | -0.73 | 0.21 | 7.77 | 7.77 | 14.35 | 6.58 | 0.00 | 2.66 | -2.66 |
| 138 | -0.74 | 0.21 | 7.88 | 7.88 | 14.52 | 6.64 | 0.00 | 2.70 | -2.70 |
| 128 | -0.75 | 0.21 | 7.96 | 7.96 | 14.62 | 6.66 | 0.00 | 2.73 | -2.73 |
| 118 | -0.76 | 0.21 | 8.03 | 8.03 | 14.72 | 6.70 | 0.00 | 2.76 | -2.76 |
| 108 | -0.77 | 0.21 | 8.09 | 8.09 | 14.82 | 6.73 | 0.00 | 2.78 | -2.78 |
| 98 | -0.77 | 0.21 | 8.16 | 8.16 | 14.93 | 6.77 | 0.00 | 2.81 | -2.81 |
| 88 | -0.78 | 0.21 | 8.22 | 8.22 | 15.03 | 6.81 | 0.00 | 2.84 | -2.84 |
| 80.00 | -0.78 | 0.21 | 8.27 | 8.27 | 15.11 | 6.84 | 0.00 | 2.86 | -2.86 |
| 68 | -0.78 | 0.21 | 8.34 | 8.34 | 15.23 | 6.89 | 0.00 | 2.89 | -2.89 |
| 58 | -0.78 | 0.21 | 8.40 | 8.40 | 15.33 | 6.93 | 0.00 | 2.92 | -2.92 |
| 48 | -0.79 | 0.21 | 8.46 | 8.46 | 15.43 | 6.98 | 0.00 | 2.94 | -2.94 |
| 22 | -0.79 | 0.21 | 8.60 | 8.60 | 15.70 | 7.10 | 0.00 | 3.01 | -3.01 |
| 19 | -0.78 | 0.21 | 8.62 | 8.62 | 15.73 | 7.11 | 0.00 | 3.01 | -3.01 |
| 0 | -0.78 | 0.21 | 8.72 | 8.72 | 15.92 | 7.20 | 0.00 | 1.25 | -1.25 |

AERODYNAMIC TORQUE AT SHEAR CENTRE

CONDITION. F cont..

| 1 STATION (in) | 55 DELTA X av (in) | 56 DELTA Z av (in) | 23 SPAN ELEMENT LIFT (lb) | 24 SPAN ELEMENT DRAG (lb) | 59 ELEMENT TORQUE DUE TO $C_{Mo}$ (lb in) | 60 ELEMENT TORQUE DUE TO LIFT (lb in) | 61 ELEMENT TORQUE DUE TO DRAG (lb in) | 62 ELEMENT LIMIT TORQUE (lb in) | 63 TOTAL LIMIT TORQUE (lb in) | 64 TOTAL ULT TORQUE (lb in) |
|---|---|---|---|---|---|---|---|---|---|---|
| 258 | - | - | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 251.25 | 10.15 | 0.00 | -25.58 | -3.09 | -52.99 | -259.71 | 0.00 | -312.70 | -312.70 | -469.05 |
| 238 | 6.85 | 0.00 | -61.87 | -8.28 | -105.62 | -423.57 | 0.00 | -529.19 | -841.89 | -1262.83 |
| 228 | 6.63 | 0.00 | -52.32 | -7.31 | -81.12 | -346.89 | 0.00 | -428.00 | -1269.89 | -1904.84 |
| 218 | 6.55 | 0.00 | -55.87 | -7.97 | -82.34 | -365.88 | 0.00 | -448.22 | -1718.11 | -2577.16 |
| 208 | 6.52 | 0.00 | -58.80 | -8.80 | -83.57 | -383.48 | 0.00 | -467.05 | -2185.15 | -3277.73 |
| 198 | 6.51 | 0.00 | -61.35 | -9.57 | -84.81 | -399.58 | 0.00 | -484.39 | -2669.55 | -4004.32 |
| 188 | 6.52 | 0.00 | -63.67 | -10.00 | -86.06 | -414.81 | 0.00 | -500.87 | -3170.41 | -4755.62 |
| 178 | 6.53 | 0.00 | -65.75 | -10.38 | -87.31 | -429.04 | 0.00 | -516.36 | -3686.77 | -5530.16 |
| 163.65 | 6.55 | 0.00 | -97.59 | -15.49 | -127.51 | -639.14 | 0.00 | -766.65 | -4453.42 | -6680.13 |
| 159 | 6.57 | 0.00 | -30.11 | -4.80 | -38.95 | -197.72 | 0.00 | -236.67 | -4690.09 | -7035.13 |
| 155.00 | 6.57 | 0.00 | -30.41 | -4.85 | -39.19 | -199.83 | 0.00 | -239.01 | -4929.10 | -7393.65 |
| 138 | 6.61 | 0.00 | -122.18 | -19.55 | -156.37 | -807.21 | 0.00 | -963.58 | -5892.68 | -8839.01 |
| 128 | 6.65 | 0.00 | -73.74 | -11.84 | -93.74 | -490.33 | 0.00 | -584.06 | -6476.74 | -9715.11 |
| 118 | 6.68 | 0.00 | -74.97 | -12.06 | -95.05 | -500.75 | 0.00 | -595.81 | -7072.55 | -10608.82 |
| 108 | 6.71 | 0.00 | -76.10 | -12.26 | -96.37 | -510.99 | 0.00 | -607.36 | -7679.90 | -11519.86 |
| 98 | 6.75 | 0.00 | -77.14 | -12.44 | -97.70 | -520.81 | 0.00 | -618.52 | -8298.42 | -12447.63 |
| 88 | 6.79 | 0.00 | -78.10 | -12.61 | -99.04 | -530.25 | 0.00 | -629.30 | -8927.72 | -13391.57 |
| 80.00 | 6.82 | 0.00 | -63.11 | -10.20 | -80.20 | -430.75 | 0.00 | -510.95 | -9438.67 | -14158.00 |
| 68 | 6.87 | 0.00 | -95.63 | -15.46 | -121.94 | -656.58 | 0.00 | -778.51 | -10217.18 | -15325.77 |
| 58 | 6.91 | 0.00 | -80.49 | -13.02 | -103.12 | -556.40 | 0.00 | -659.52 | -10876.70 | -16315.05 |
| 48 | 6.96 | 0.00 | -81.13 | -13.13 | -104.49 | -564.39 | 0.00 | -668.88 | -11545.58 | -17318.37 |
| 22 | 7.04 | 0.00 | -213.38 | -34.52 | -278.18 | -1501.86 | 0.00 | -1780.04 | -13325.62 | -19988.43 |
| 19 | 7.11 | 0.00 | -24.83 | -4.02 | -32.71 | -176.42 | 0.00 | -209.13 | -13534.75 | -20302.13 |
| 0 | 7.16 | 0.00 | -157.92 | -25.53 | -210.11 | -1130.54 | 0.00 | -1340.65 | -14875.41 | -22313.11 |

DEAD WEIGHT ANALYSIS FOR WING TORQUE

CONDITION. F cont..

| 1 | 65 | 54 | 66 | 67 | 33 | 68 | 69 | 70 |
|---|---|---|---|---|---|---|---|---|
| STATION | X CG | X SC | DELTA | DELTA | ELEMENT | ELEMENT | TOTAL | TOTAL |
| | (in) | (in) | X | X av | LOAD | LIMIT | LIMIT | ULT |
| (in) | | | (in) | (in) | (lb) | TORQUE | TORQUE | TORQUE |
| | using 40% chord | | | | | (lb in) | (lb in) | (lb in) |
| 258 | 14.00 | 13.30 | -0.70 | - | - | - | - | 0.00 |
| 251.25 | 14.07 | 13.37 | -0.70 | -0.70 | 0.99 | -0.70 | -0.70 | -1.05 |
| 238 | 14.21 | 13.50 | -0.71 | -0.71 | 2.64 | -1.87 | -2.56 | -3.85 |
| 228 | 14.32 | 13.60 | -0.72 | -0.71 | 4.57 | -3.26 | -5.83 | -8.74 |
| 218 | 14.43 | 13.71 | -0.72 | -0.72 | 6.40 | -4.60 | -10.43 | -15.64 |
| 208 | 14.53 | 13.81 | -0.73 | -0.72 | 7.85 | -5.68 | -16.11 | -24.16 |
| 198 | 14.64 | 13.91 | -0.73 | -0.73 | 9.22 | -6.73 | -22.84 | -34.25 |
| 188 | 14.75 | 14.01 | -0.74 | -0.73 | 10.92 | -8.03 | -30.86 | -46.29 |
| 178 | 14.86 | 14.11 | -0.74 | -0.74 | 12.37 | -9.16 | -40.02 | -60.02 |
| 163.65 | 15.01 | 14.26 | -0.75 | -0.75 | 14.22 | -10.62 | -50.64 | -75.95 |
| 159 | 15.06 | 14.30 | -0.75 | -0.75 | 14.68 | -11.03 | -61.67 | -92.51 |
| 155.00 | 15.10 | 14.35 | -0.76 | -0.75 | 15.29 | -11.53 | -73.20 | -109.80 |
| 138 | 15.28 | 14.52 | -0.76 | -0.76 | 16.05 | -12.19 | -85.39 | -128.09 |
| 128 | 15.39 | 14.62 | -0.77 | -0.77 | 16.31 | -12.51 | -97.90 | -146.85 |
| 118 | 15.50 | 14.72 | -0.77 | -0.77 | 16.76 | -12.95 | -110.84 | -166.26 |
| 108 | 15.60 | 14.82 | -0.78 | -0.78 | 16.99 | -13.21 | -124.06 | -186.08 |
| 98 | 15.71 | 14.93 | -0.79 | -0.78 | 17.27 | -13.52 | -137.58 | -206.37 |
| 88 | 15.82 | 15.03 | -0.79 | -0.79 | 17.96 | -14.16 | -151.73 | -227.60 |
| 80.00 | 15.90 | 15.11 | -0.80 | -0.79 | 18.34 | -14.54 | -166.28 | -249.42 |
| 68 | 16.03 | 15.23 | -0.80 | -0.80 | 19.02 | -15.19 | -181.47 | -272.20 |
| 58 | 16.14 | 15.33 | -0.81 | -0.80 | 19.51 | -15.69 | -197.16 | -295.74 |
| 48 | 16.25 | 15.43 | -0.81 | -0.81 | 20.27 | -16.41 | -213.57 | -320.35 |
| 22 | 16.52 | 15.70 | -0.83 | -0.82 | 21.72 | -17.79 | -231.36 | -347.04 |
| 19 | 16.56 | 15.73 | -0.83 | -0.83 | 10.94 | -9.05 | -240.41 | -360.61 |
| 0 | 16.76 | 15.92 | -0.84 | -0.83 | 7.29 | -6.07 | -246.48 | -369.72 |

COMBINED ULTIMATE TORSION ( AERODYNAMIC + INERTIAL )

CONDITION. F cont..

| | | | | |
|---|---|---|---|---|
| | | | | |
| 1 | 71 F | | | |
| STATION | COND. F | | | |
| (in) | (lb in) | | | |
| 258 | 0 | | | |
| 251.25 | -470 | | | |
| 238 | -1267 | | | |
| 228 | -1914 | | | |
| 218 | -2593 | | | |
| 208 | -3302 | | | |
| 198 | -4039 | | | |
| 188 | -4802 | | | |
| 178 | -5590 | | | |
| 163.65 | -6756 | | | |
| 159 | -7128 | | | |
| 155.00 | -7503 | | | |
| 138 | -8967 | | | |
| 128 | -9862 | | | |
| 118 | -10775 | | | |
| 108 | -11706 | | | |
| 98 | -12654 | | | |
| 88 | -13619 | | | |
| 80.00 | -14407 | | | |
| 68 | -15598 | | | |
| 58 | -16611 | | | |
| 48 | -17639 | | | |
| 22 | -20335 | | | |
| 19 | -20663 | | | |
| 0 | -22683 | | | |

SPANWISE AERODYNAMIC LOAD DISTRIBUTION

CONDITION. G

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| $V_{sel}$ = | 138.51 | ft/s | $C_L$ = | -0.8 | | alpha wrp = | -11.5417 |
| Lift = | -2733.15 | lb | $C_{Do}$ = | 0.010 | | sin alpha = | -0.2001 |
| q = | 25.31 | psf | $C_D$ = | 0.028 | | cos alpha = | 0.9798 |
| n = | -1.90 | g | $C_{Mo}$ = | -0.025 | | | |
| $q.C_L$ = | -20.25 | $q.C_L$ =Lift/S | S = | 135.00 | $ft^2$ | | |
| | | | b = | 43.00 | ft | | |

| 1 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| STATION (in) | $C_L$ | $C_{Lx}$ | $C_{Lz}$ | $C_D$ | $C_{Dx}$ | $C_{Dz}$ | $C_{Lz}+C_{Dz}$ | $C_{Dx}-C_{Lx}$ | $(C_{Lz}+C_{Dz})_{AV}$ | $(C_{Dx}-C_{Lx})_{AV}$ | SPAN ELEMENT LIFT (lb) | SPAN ELEMENT DRAG (lb) |
| 258 | -0.4000 | 0.0800 | -0.3919 | 0.0337 | 0.0330 | -0.0067 | -0.3987 | -0.0470 | - | - | 0.00 | 0.00 |
| 251.25 | -0.5239 | 0.1048 | -0.5133 | 0.0337 | 0.0330 | -0.0067 | -0.5201 | -0.0718 | -0.4594 | -0.0594 | -19.12 | -2.47 |
| 238 | -0.6084 | 0.1217 | -0.5961 | 0.0337 | 0.0330 | -0.0067 | -0.6029 | -0.0887 | -0.5615 | -0.0803 | -46.23 | -6.61 |
| 228 | -0.6508 | 0.1302 | -0.6377 | 0.0337 | 0.0330 | -0.0067 | -0.6444 | -0.0972 | -0.6236 | -0.0929 | -39.09 | -5.83 |
| 218 | -0.6845 | 0.1370 | -0.6707 | 0.0337 | 0.0330 | -0.0067 | -0.6774 | -0.1039 | -0.6609 | -0.1006 | -41.74 | -6.35 |
| 208 | -0.7124 | 0.1425 | -0.6980 | 0.0267 | 0.0261 | -0.0053 | -0.7033 | -0.1164 | -0.6904 | -0.1102 | -43.93 | -7.01 |
| 198 | -0.7361 | 0.1473 | -0.7212 | 0.0267 | 0.0261 | -0.0053 | -0.7265 | -0.1211 | -0.7149 | -0.1188 | -45.82 | -7.61 |
| 188 | -0.7564 | 0.1513 | -0.7411 | 0.0267 | 0.0261 | -0.0053 | -0.7464 | -0.1252 | -0.7365 | -0.1232 | -47.55 | -7.95 |
| 178 | -0.7740 | 0.1549 | -0.7583 | 0.0267 | 0.0261 | -0.0053 | -0.7637 | -0.1287 | -0.7550 | -0.1269 | -49.10 | -8.26 |
| 163.65 | -0.7953 | 0.1591 | -0.7792 | 0.0267 | 0.0261 | -0.0053 | -0.7846 | -0.1330 | -0.7741 | -0.1308 | -72.88 | -12.32 |
| 159 | -0.8010 | 0.1603 | -0.7848 | 0.0267 | 0.0261 | -0.0053 | -0.7901 | -0.1341 | -0.7873 | -0.1335 | -22.49 | -3.81 |
| 155.00 | -0.8063 | 0.1613 | -0.7900 | 0.0267 | 0.0261 | -0.0053 | -0.7953 | -0.1352 | -0.7927 | -0.1346 | -22.71 | -3.86 |
| 138 | -0.8243 | 0.1649 | -0.8076 | 0.0267 | 0.0261 | -0.0053 | -0.8130 | -0.1388 | -0.8041 | -0.1370 | -91.25 | -15.54 |
| 128 | -0.8330 | 0.1667 | -0.8161 | 0.0267 | 0.0261 | -0.0053 | -0.8215 | -0.1405 | -0.8172 | -0.1396 | -55.07 | -9.41 |
| 118 | -0.8404 | 0.1681 | -0.8234 | 0.0267 | 0.0261 | -0.0053 | -0.8287 | -0.1420 | -0.8251 | -0.1413 | -55.99 | -9.58 |
| 108 | -0.8467 | 0.1694 | -0.8296 | 0.0267 | 0.0261 | -0.0053 | -0.8349 | -0.1433 | -0.8318 | -0.1426 | -56.83 | -9.74 |
| 98 | -0.8519 | 0.1704 | -0.8347 | 0.0267 | 0.0261 | -0.0053 | -0.8400 | -0.1443 | -0.8374 | -0.1438 | -57.61 | -9.89 |
| 88 | -0.8561 | 0.1713 | -0.8388 | 0.0267 | 0.0261 | -0.0053 | -0.8441 | -0.1451 | -0.8421 | -0.1447 | -58.33 | -10.02 |
| 80.00 | -0.8588 | 0.1718 | -0.8414 | 0.0267 | 0.0261 | -0.0053 | -0.8468 | -0.1457 | -0.8454 | -0.1454 | -47.13 | -8.11 |
| 68 | -0.8618 | 0.1724 | -0.8444 | 0.0267 | 0.0261 | -0.0053 | -0.8497 | -0.1463 | -0.8482 | -0.1460 | -71.41 | -12.29 |
| 58 | -0.8634 | 0.1727 | -0.8459 | 0.0267 | 0.0261 | -0.0053 | -0.8512 | -0.1466 | -0.8505 | -0.1464 | -60.11 | -10.35 |
| 48 | -0.8642 | 0.1729 | -0.8467 | 0.0267 | 0.0261 | -0.0053 | -0.8520 | -0.1468 | -0.8516 | -0.1467 | -60.59 | -10.44 |
| 22 | -0.8628 | 0.1726 | -0.8453 | 0.0267 | 0.0261 | -0.0053 | -0.8507 | -0.1465 | -0.8513 | -0.1466 | -159.35 | -27.44 |
| 19 | -0.8623 | 0.1725 | -0.8449 | 0.0267 | 0.0261 | -0.0053 | -0.8502 | -0.1464 | -0.8504 | -0.1464 | -18.54 | -3.19 |
| 0 | -0.8579 | 0.1717 | -0.8406 | 0.0267 | 0.0261 | -0.0053 | -0.8459 | -0.1455 | -0.8481 | -0.1459 | -117.93 | -20.30 |
| | | | | | | | | | | Σ = | -1360.82 | -228.39 |
| | | | | | | | | | | LIFT calc = | -2721.64 | |
| | | | | | | | | | | Lift = | -2733.15 | |
| | | | | | | | | | | error = | 0.4 | % |

SPANWISE AERODYNAMIC LOAD DISTRIBUTION

CONDITION. G cont..

| 1 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 |
|---|---|---|---|---|---|---|---|---|
| STATION | LIMIT | LIMIT | LIMIT | LIMIT | ULT | ULT | ULT | ULT |
| (in) | NORMAL | NORMAL | CHORD | CHORD | NORMAL | NORMAL | CHORD | CHORD |
| | SHEAR | MOMENT | SHEAR | MOMENT | SHEAR | MOMENT | SHEAR | MOMENT |
| | (lb) | (lb in) | (lb) | (lb in) | (lb) | (lb in) | (lb) | (lb in) |
| 258 | 0.00 | 0.00 | 0.00 | 0.00 | 0 | 0 | 0 | 0 |
| 251.25 | -19.12 | -64.54 | -2.47 | -8.35 | -29 | -97 | -4 | -13 |
| 238 | -65.35 | -624.17 | -9.08 | -84.88 | -98 | -936 | -14 | -127 |
| 228 | -104.44 | -1473.16 | -14.91 | -204.82 | -157 | -2210 | -22 | -307 |
| 218 | -146.18 | -2726.30 | -21.26 | -385.64 | -219 | -4089 | -32 | -578 |
| 208 | -190.11 | -4407.77 | -28.27 | -633.26 | -285 | -6612 | -42 | -950 |
| 198 | -235.93 | -6537.99 | -35.88 | -953.98 | -354 | -9807 | -54 | -1431 |
| 188 | -283.48 | -9135.07 | -43.83 | -1352.52 | -425 | -13703 | -66 | -2029 |
| 178 | -332.59 | -12215.43 | -52.09 | -1832.10 | -499 | -18323 | -78 | -2748 |
| 163.65 | -405.47 | -17510.98 | -64.40 | -2667.91 | -608 | -26266 | -97 | -4002 |
| 159 | -427.96 | -19313.27 | -68.22 | -2954.71 | -642 | -28970 | -102 | -4432 |
| 155.00 | -450.67 | -21213.31 | -72.08 | -3258.10 | -676 | -31820 | -108 | -4887 |
| 138 | -541.92 | -29650.37 | -87.62 | -4615.52 | -813 | -44476 | -131 | -6923 |
| 128 | -596.99 | -35344.94 | -97.03 | -5538.78 | -895 | -53017 | -146 | -8308 |
| 118 | -652.98 | -41594.79 | -106.62 | -6557.00 | -979 | -62392 | -160 | -9836 |
| 108 | -709.81 | -48408.75 | -116.36 | -7671.88 | -1065 | -72613 | -175 | -11508 |
| 98 | -767.43 | -55794.94 | -126.25 | -8884.93 | -1151 | -83692 | -189 | -13327 |
| 88 | -825.75 | -63760 82 | -136.27 | -10197.56 | -1239 | -95641 | -204 | -15296 |
| 80.00 | -872.88 | -70555.36 | -144.38 | -11320.19 | -1309 | -105833 | -217 | -16980 |
| 68 | -944.30 | -81458.44 | -156.67 | -13126.51 | -1416 | -122188 | -235 | -19690 |
| 58 | -1004.40 | -91201.94 | -167.02 | -14744.97 | -1507 | -136803 | -251 | -22117 |
| 48 | -1064.99 | -101548.93 | -177.46 | -16467.35 | -1597 | -152323 | -266 | -24701 |
| 22 | -1224.35 | -131310.34 | -204.90 | -21437.96 | -1837 | -196966 | -307 | -32157 |
| 19 | -1242.89 | -135011.19 | -208.09 | -22057.45 | -1864 | -202517 | -312 | -33086 |
| 0 | -1360.82 | -159746.38 | -228.39 | -26203.98 | -2041 | -239620 | -343 | -39306 |
| | | | | | | | | |
| Centre of lift is | 117 | in from aircraft centreline | | | | | | |
| | 45 | % semispan | | | | | | |

SPANWISE INERTIAL LOAD DISTRIBUTION

CONDITION. G cont..

| 1 | 3 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 | 41 | 42 | 43 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| STATION (in) | dy (in) | WEIGHT nW (lb) | ELEMENT SHEAR FORCE $V_z$ (lb) | ELEMENT SHEAR FORCE $V_x$ (lb) | LIMIT NORMAL SHEAR (lb) | LIMIT NORMAL MOMENT (lb in) | LIMIT CHORD SHEAR (lb) | LIMIT CHORD MOMENT (lb in) | ULT NORMAL SHEAR (lb) | ULT NORMAL MOMENT (lb in) | ULT CHORD SHEAR (lb) | ULT CHORD MOMENT (lb in) |
| 258 | - | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0 | 0 | 0 | 0 |
| 251.25 | 6.75 | 0.74 | 0.15 | 0.73 | 0.73 | 2.46 | 0.15 | 0.50 | 1 | 4 | 0 | 1 |
| 238 | 13.25 | 1.98 | 0.40 | 1.94 | 2.66 | 24.92 | 0.54 | 5.09 | 4 | 37 | 1 | 8 |
| 228 | 10.00 | 3.42 | 0.68 | 3.35 | 6.01 | 68.32 | 1.23 | 13.95 | 9 | 102 | 2 | 21 |
| 218 | 10.00 | 4.79 | 0.96 | 4.69 | 10.71 | 151.92 | 2.19 | 31.02 | 16 | 228 | 3 | 47 |
| 208 | 10.00 | 5.87 | 1.17 | 5.75 | 16.46 | 287.74 | 3.36 | 58.76 | 25 | 432 | 5 | 88 |
| 198 | 10.00 | 6.90 | 1.38 | 6.76 | 23.22 | 486.11 | 4.74 | 99.27 | 35 | 729 | 7 | 149 |
| 188 | 10.00 | 8.17 | 1.63 | 8.00 | 31.22 | 758.29 | 6.38 | 154.85 | 47 | 1137 | 10 | 232 |
| 178 | 10.00 | 9.25 | 1.85 | 9.07 | 40.29 | 1115.82 | 8.23 | 227.86 | 60 | 1674 | 12 | 342 |
| 163.65 | 14.35 | 10.64 | 2.13 | 10.42 | 50.71 | 1768.73 | 10.36 | 361.19 | 76 | 2653 | 16 | 542 |
| 159 | 4.33 | 10.98 | 2.20 | 10.76 | 61.47 | 2011.32 | 12.55 | 410.73 | 92 | 3017 | 19 | 616 |
| 155.00 | 4.32 | 11.44 | 2.29 | 11.21 | 72.68 | 2301.42 | 14.84 | 469.97 | 109 | 3452 | 22 | 705 |
| 138 | 17.00 | 12.01 | 2.40 | 11.77 | 84.44 | 3636.94 | 17.24 | 742.70 | 127 | 5455 | 26 | 1114 |
| 128 | 10.00 | 12.20 | 2.44 | 11.95 | 96.39 | 4541.13 | 19.68 | 927.34 | 145 | 6812 | 30 | 1391 |
| 118 | 10.00 | 12.54 | 2.51 | 12.29 | 108.68 | 5566.51 | 22.19 | 1136.73 | 163 | 8350 | 33 | 1705 |
| 108 | 10.00 | 12.71 | 2.54 | 12.45 | 121.13 | 6715.58 | 24.74 | 1371.39 | 182 | 10073 | 37 | 2057 |
| 98 | 10.00 | 12.92 | 2.59 | 12.66 | 133.79 | 7990.23 | 27.32 | 1631.68 | 201 | 11985 | 41 | 2448 |
| 88 | 10.00 | 13.43 | 2.69 | 13.16 | 146.95 | 9393.97 | 30.01 | 1918.34 | 220 | 14091 | 45 | 2878 |
| 80.00 | 8.00 | 13.72 | 2.74 | 13.44 | 160.40 | 10623.37 | 32.75 | 2169.39 | 241 | 15935 | 49 | 3254 |
| 68 | 12.00 | 14.23 | 2.85 | 13.94 | 174.34 | 12631.78 | 35.60 | 2579.53 | 262 | 18948 | 53 | 3869 |
| 58 | 10.00 | 14.59 | 2.92 | 14.30 | 188.64 | 14446.65 | 38.52 | 2950.14 | 283 | 21670 | 58 | 4425 |
| 48 | 10.00 | 15.16 | 3.03 | 14.86 | 203.49 | 16407.28 | 41.55 | 3350.52 | 305 | 24611 | 62 | 5026 |
| 22 | 26.00 | 16.25 | 3.25 | 15.92 | 219.41 | 21904.97 | 44.81 | 4473.20 | 329 | 32857 | 67 | 6710 |
| 19 | 3.00 | 8.18 | 1.64 | 8.02 | 227.42 | 22575.21 | 46.44 | 4610.07 | 341 | 33863 | 70 | 6915 |
| 0 | 19.00 | 5.45 | 1.09 | 5.34 | 232.77 | 26947.04 | 47.53 | 5502.84 | 349 | 40421 | 71 | 8254 |
| | Σ = | 125 | lb | | | | | | | | | |
| | | at 1 g | | | Centre of gravity is | 116 | in from aircraft centreline | | | | | |
| | | | | | | 45 | % semispan | | | | | |

COMBINED ULTIMATE LOADS ( AERODYNAMIC + INERTIAL )

CONDITION. G cont..

| 1 | 44 G | 45 G | 46 G | 47 G | 48 G | 49 G |
|---|---|---|---|---|---|---|
| | ULT | ULT | ULT | ULT | ULT | ULT |
| | NORMAL | NORMAL | CHORD | CHORD | RESOLVED | RESOLVED |
| STATION | SHEAR | BEND MOMENT | SHEAR | BEND MOMENT | SHEAR | BEND MOMENT |
| (in) | COND. G | COND. G | COND. G | COND. G | COND. G | COND. G |
| | (lb) | (lb in) | (lb) | (lb in) | (lb) | (lb in) |
| 258 | 0 | 0 | 0 | 0 | 0 | 0 |
| 251.25 | -28 | -93 | -3 | -12 | 28 | 94 |
| 238 | -94 | -899 | -13 | -120 | 95 | 907 |
| 228 | -148 | -2107 | -21 | -286 | 149 | 2127 |
| 218 | -203 | -3862 | -29 | -532 | 205 | 3898 |
| 208 | -260 | -6180 | -37 | -862 | 263 | 6240 |
| 198 | -319 | -9078 | -47 | -1282 | 322 | 9168 |
| 188 | -378 | -12565 | -56 | -1797 | 383 | 12693 |
| 178 | -438 | -16649 | -66 | -2406 | 443 | 16822 |
| 163.65 | -532 | -23613 | -81 | -3460 | 538 | 23866 |
| 159 | -550 | -25953 | -83 | -3816 | 556 | 26232 |
| 155.00 | -567 | -28368 | -86 | -4182 | 573 | 28674 |
| 138 | -686 | -39020 | -106 | -5809 | 694 | 39450 |
| 128 | -751 | -46206 | -116 | -6917 | 760 | 46721 |
| 118 | -816 | -54042 | -127 | -8130 | 826 | 54651 |
| 108 | -883 | -62540 | -137 | -9451 | 894 | 63250 |
| 98 | -950 | -71707 | -148 | -10880 | 962 | 72528 |
| 88 | -1018 | -81550 | -159 | -12419 | 1031 | 82490 |
| 80.00 | -1069 | -89898 | -167 | -13726 | 1082 | 90940 |
| 68 | -1155 | -103240 | -182 | -15820 | 1169 | 104445 |
| 58 | -1224 | -115133 | -193 | -17692 | 1239 | 116484 |
| 48 | -1292 | -127712 | -204 | -19675 | 1308 | 129219 |
| 22 | -1507 | -164108 | -240 | -25447 | 1526 | 166069 |
| 19 | -1523 | -168654 | -242 | -26171 | 1542 | 170672 |
| 0 | -1692 | -199199 | -271 | -31052 | 1714 | 201605 |

AERODYNAMIC TORQUE AT SHEAR CENTRE

CONDITION. G cont..

| 1 | 50 | 51 | 52 | 53 | 54 | 55 | 56 | 57 | 58 |
|---|---|---|---|---|---|---|---|---|---|
| STATION | LOCAL | LOCAL | AERO | X AC | X SC | DELTA X | Z AC | Z SC | DELTA Z |
| | $C_L$ | $X_{CP}$ | CENTRE | (in) | (in) | (in) | (in) | (in) | (in) |
| (in) | | | (in) | | using 38% chord | | | | |
| 258 | - | - | 0.00 | 0.00 | 13.30 | 13.30 | 0.00 | 2.39 | -2.39 |
| 251.25 | -0.46 | 0.19 | 6.53 | 6.53 | 13.37 | 6.84 | 0.00 | 2.40 | -2.40 |
| 238 | -0.56 | 0.20 | 6.95 | 6.95 | 13.50 | 6.56 | 0.00 | 2.44 | -2.44 |
| 228 | -0.62 | 0.20 | 7.16 | 7.16 | 13.60 | 6.45 | 0.00 | 2.47 | -2.47 |
| 218 | -0.66 | 0.20 | 7.29 | 7.29 | 13.71 | 6.41 | 0.00 | 2.49 | -2.49 |
| 208 | -0.69 | 0.20 | 7.41 | 7.41 | 13.81 | 6.40 | 0.00 | 2.52 | -2.52 |
| 198 | -0.71 | 0.21 | 7.51 | 7.51 | 13.91 | 6.40 | 0.00 | 2.54 | -2.54 |
| 188 | -0.74 | 0.21 | 7.60 | 7.60 | 14.01 | 6.41 | 0.00 | 2.57 | -2.57 |
| 178 | -0.76 | 0.21 | 7.68 | 7.68 | 14.11 | 6.43 | 0.00 | 2.60 | -2.60 |
| 163.65 | -0.77 | 0.21 | 7.79 | 7.79 | 14.26 | 6.47 | 0.00 | 2.64 | -2.64 |
| 159 | -0.79 | 0.21 | 7.84 | 7.84 | 14.30 | 6.46 | 0.00 | 2.65 | -2.65 |
| 155.00 | -0.79 | 0.21 | 7.87 | 7.87 | 14.35 | 6.48 | 0.00 | 2.66 | -2.66 |
| 138 | -0.80 | 0.21 | 7.98 | 7.98 | 14.52 | 6.54 | 0.00 | 2.70 | -2.70 |
| 128 | -0.82 | 0.21 | 8.06 | 8.06 | 14.62 | 6.56 | 0.00 | 2.73 | -2.73 |
| 118 | -0.83 | 0.21 | 8.12 | 8.12 | 14.72 | 6.60 | 0.00 | 2.76 | -2.76 |
| 108 | -0.83 | 0.21 | 8.19 | 8.19 | 14.82 | 6.63 | 0.00 | 2.78 | -2.78 |
| 98 | -0.84 | 0.21 | 8.25 | 8.25 | 14.93 | 6.67 | 0.00 | 2.81 | -2.81 |
| 88 | -0.84 | 0.21 | 8.32 | 8.32 | 15.03 | 6.71 | 0.00 | 2.84 | -2.84 |
| 80.00 | -0.85 | 0.21 | 8.37 | 8.37 | 15.11 | 6.74 | 0.00 | 2.86 | -2.86 |
| 68 | -0.85 | 0.21 | 8.44 | 8.44 | 15.23 | 6.79 | 0.00 | 2.89 | -2.89 |
| 58 | -0.85 | 0.21 | 8.50 | 8.50 | 15.33 | 6.83 | 0.00 | 2.92 | -2.92 |
| 48 | -0.85 | 0.21 | 8.56 | 8.56 | 15.43 | 6.88 | 0.00 | 2.94 | -2.94 |
| 22 | -0.85 | 0.21 | 8.70 | 8.70 | 15.70 | 7.00 | 0.00 | 3.01 | -3.01 |
| 19 | -0.85 | 0.21 | 8.72 | 8.72 | 15.73 | 7.01 | 0.00 | 3.01 | -3.01 |
| 0 | -0.85 | 0.21 | 8.82 | 8.82 | 15.92 | 7.10 | 0.00 | 1.25 | -1.25 |

AERODYNAMIC TORQUE AT SHEAR CENTRE

CONDITION. G cont..

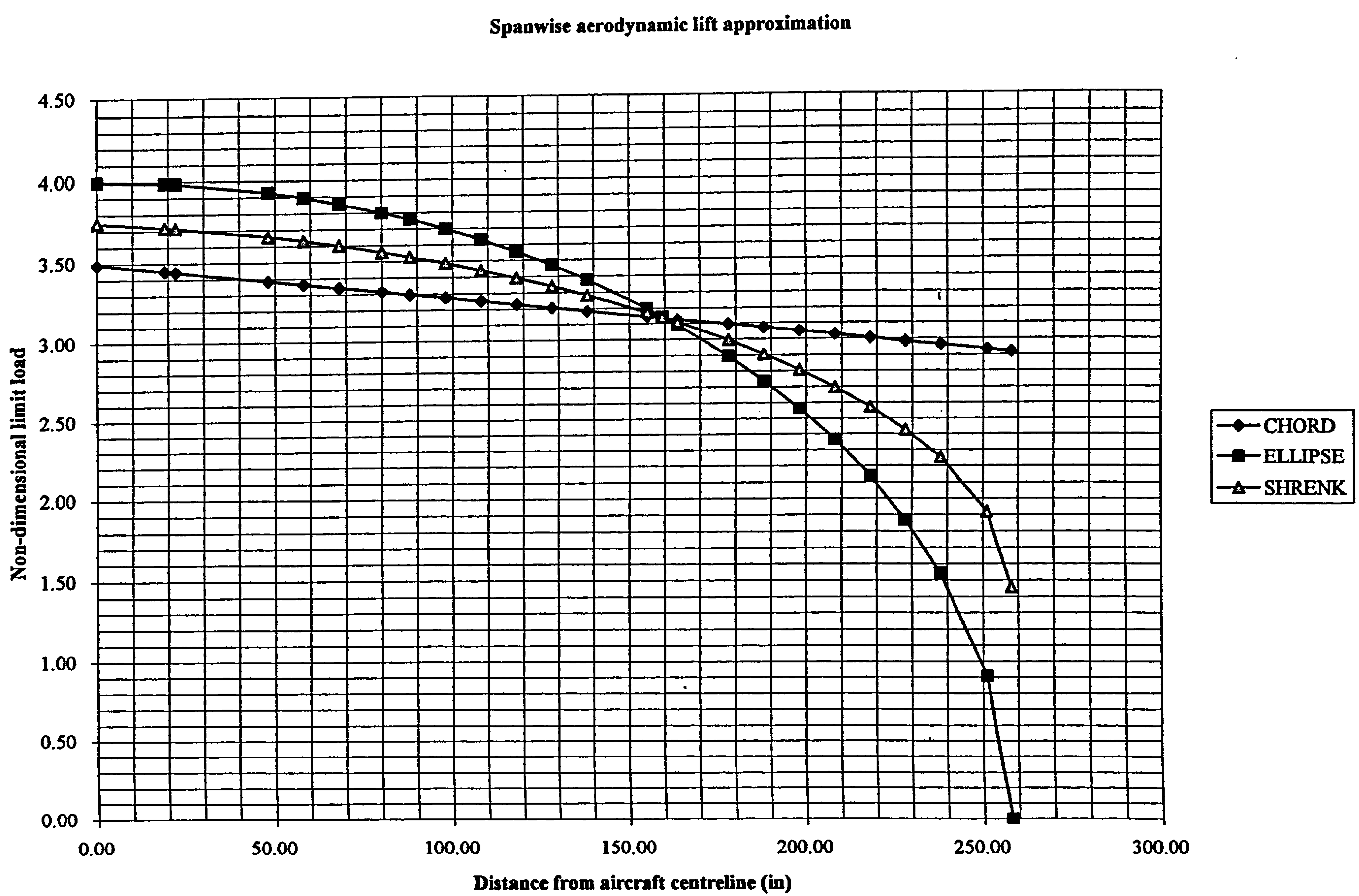
| 1 | 55 | 56 | 23 | 24 | 59 | 60 | 61 | 62 | 63 | 64 |
|---|---|---|---|---|---|---|---|---|---|---|
| STATION | DELTA | DELTA | SPAN | SPAN | ELEMENT | ELEMENT | ELEMENT | ELEMENT | TOTAL | TOTAL |
| | X av | Z av | ELEMENT | ELEMENT | TORQUE | TORQUE | TORQUE | LIMIT | LIMIT | ULT |
| (in) | (in) | (in) | LIFT | DRAG | DUE TO | DUE TO | DUE TO | TORQUE | TORQUE | TORQUE |
| | | | (lb) | (lb) | $C_{Mo}$ | LIFT | DRAG | (lb in) | (lb in) | (lb in) |
| | | | | | (lb in) | (lb in) | (lb in) | | | |
| 258 | - | - | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 251.25 | 10.07 | 0.00 | -19.12 | -2.47 | -36.52 | -192.56 | 0.00 | -229.07 | -229.07 | -343.61 |
| 238 | 6.70 | 0.00 | -46.23 | -6.61 | -72.78 | -309.67 | 0.00 | -382.44 | -611.52 | -917.28 |
| 228 | 6.50 | 0.00 | -39.09 | -5.83 | -55.90 | -254.20 | 0.00 | -310.09 | -921.61 | -1382.42 |
| 218 | 6.43 | 0.00 | -41.74 | -6.35 | -56.74 | -268.42 | 0.00 | -325.16 | -1246.77 | -1870.16 |
| 208 | 6.41 | 0.00 | -43.93 | -7.01 | -57.59 | -281.50 | 0.00 | -339.09 | -1585.86 | -2378.79 |
| 198 | 6.40 | 0.00 | -45.82 | -7.61 | -58.44 | -293.45 | 0.00 | -351.89 | -1937.74 | -2906.62 |
| 188 | 6.41 | 0.00 | -47.55 | -7.95 | -59.30 | -304.76 | 0.00 | -364.06 | -2301.80 | -3452.71 |
| 178 | 6.42 | 0.00 | -49.10 | -8.26 | -60.17 | -315.32 | 0.00 | -375.49 | -2677.30 | -4015.94 |
| 163.65 | 6.45 | 0.00 | -72.88 | -12.32 | -87.87 | -469.87 | 0.00 | -557.74 | -3235.03 | -4852.55 |
| 159 | 6.46 | 0.00 | -22.49 | -3.81 | -26.84 | -145.40 | 0.00 | -172.23 | -3407.27 | -5110.90 |
| 155.00 | 6.47 | 0.00 | -22.71 | -3.86 | -27.00 | -146.97 | 0.00 | -173.97 | -3581.24 | -5371.86 |
| 138 | 6.51 | 0.00 | -91.25 | -15.54 | -107.75 | -593.75 | 0.00 | -701.50 | -4282.73 | -6424.10 |
| 128 | 6.55 | 0.00 | -55.07 | -9.41 | -64.59 | -360.73 | 0.00 | -425.32 | -4708.05 | -7062.08 |
| 118 | 6.58 | 0.00 | -55.99 | -9.58 | -65.50 | -368.45 | 0.00 | -433.95 | -5142.00 | -7713.01 |
| 108 | 6.62 | 0.00 | -56.83 | -9.74 | -66.41 | -376.02 | 0.00 | -442.43 | -5584.43 | -8376.65 |
| 98 | 6.65 | 0.00 | -57.61 | -9.89 | -67.33 | -383.29 | 0.00 | -450.61 | -6035.04 | -9052.56 |
| 88 | 6.69 | 0.00 | -58.33 | -10.02 | -68.25 | -390.26 | 0.00 | -458.51 | -6493.55 | -9740.33 |
| 80.00 | 6.73 | 0.00 | -47.13 | -8.11 | -55.27 | -317.04 | 0.00 | -372.31 | -6865.86 | -10298.79 |
| 68 | 6.77 | 0.00 | -71.41 | -12.29 | -84.02 | -483.28 | 0.00 | -567.30 | -7433.17 | -11149.75 |
| 58 | 6.81 | 0.00 | -60.11 | -10.35 | -71.06 | -409.56 | 0.00 | -480.62 | -7913.78 | -11870.67 |
| 48 | 6.86 | 0.00 | -60.59 | -10.44 | -72.00 | -415.45 | 0.00 | -487.45 | -8401.23 | -12601.85 |
| 22 | 6.94 | 0.00 | -159.35 | -27.44 | -191.69 | -1105.53 | 0.00 | -1297.22 | -9698.45 | -14547.67 |
| 19 | 7.00 | 0.00 | -18.54 | -3.19 | -22.54 | -129.86 | 0.00 | -152.40 | -9850.85 | -14776.28 |
| 0 | 7.06 | 0.00 | -117.93 | -20.30 | -144.78 | -832.18 | 0.00 | -976.96 | -10827.81 | -16241.72 |

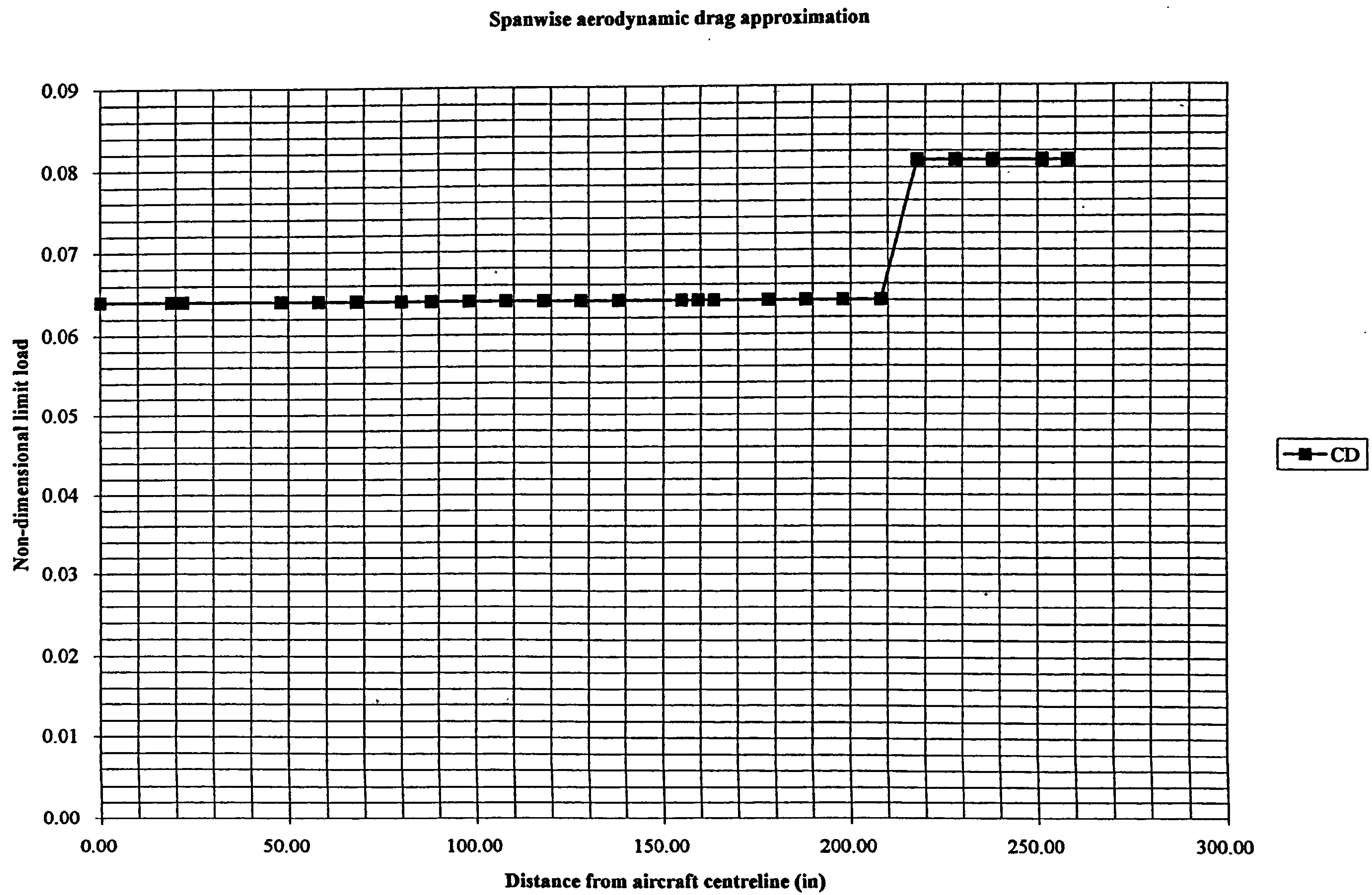
DEAD WEIGHT ANALYSIS FOR WING TORQUE

CONDITION. G cont..

| 1 | 65 | 54 | 66 | 67 | 33 | 68 | 69 | 70 |
|---|---|---|---|---|---|---|---|---|
| STATION | X CG | X SC | DELTA | DELTA | ELEMENT | ELEMENT | TOTAL | TOTAL |
| | (in) | (in) | X | X av | LOAD | LIMIT | LIMIT | ULT |
| (in) | | | (in) | (in) | (lb) | TORQUE | TORQUE | TORQUE |
| | using 40% chord | | | | | (lb in) | (lb in) | (lb in) |
| 258 | 14.00 | 13.30 | -0.70 | - | - | - | - | 0.00 |
| 251.25 | 14.07 | 13.37 | -0.70 | -0.70 | 0.74 | -0.52 | -0.52 | -0.78 |
| 238 | 14.21 | 13.50 | -0.71 | -0.71 | 1.98 | -1.40 | -1.92 | -2.88 |
| 228 | 14.32 | 13.60 | -0.72 | -0.71 | 3.42 | -2.44 | -4.36 | -6.54 |
| 218 | 14.43 | 13.71 | -0.72 | -0.72 | 4.79 | -3.44 | -7.80 | -11.70 |
| 208 | 14.53 | 13.81 | -0.73 | -0.72 | 5.87 | -4.25 | -12.05 | -18.08 |
| 198 | 14.64 | 13.91 | -0.73 | -0.73 | 6.90 | -5.03 | -17.08 | -25.62 |
| 188 | 14.75 | 14.01 | -0.74 | -0.73 | 8.17 | -6.00 | -23.08 | -34.63 |
| 178 | 14.86 | 14.11 | -0.74 | -0.74 | 9.25 | -6.85 | -29.93 | -44.90 |
| 163.65 | 15.01 | 14.26 | -0.75 | -0.75 | 10.64 | -7.94 | -37.88 | -56.82 |
| 159 | 15.06 | 14.30 | -0.75 | -0.75 | 10.98 | -8.25 | -46.13 | -69.20 |
| 155.00 | 15.10 | 14.35 | -0.76 | -0.75 | 11.44 | -8.62 | -54.75 | -82.13 |
| 138 | 15.28 | 14.52 | -0.76 | -0.76 | 12.01 | -9.12 | -63.88 | -95.81 |
| 128 | 15.39 | 14.62 | -0.77 | -0.77 | 12.20 | -9.35 | -73.23 | -109.85 |
| 118 | 15.50 | 14.72 | -0.77 | -0.77 | 12.54 | -9.68 | -82.91 | -124.37 |
| 108 | 15.60 | 14.82 | -0.78 | -0.78 | 12.71 | -9.88 | -92.80 | -139.20 |
| 98 | 15.71 | 14.93 | -0.79 | -0.78 | 12.92 | -10.12 | -102.91 | -154.37 |
| 88 | 15.82 | 15.03 | -0.79 | -0.79 | 13.43 | -10.59 | -113.50 | -170.25 |
| 80.00 | 15.90 | 15.11 | -0.80 | -0.79 | 13.72 | -10.88 | -124.38 | -186.57 |
| 68 | 16.03 | 15.23 | -0.80 | -0.80 | 14.23 | -11.36 | -135.74 | -203.61 |
| 58 | 16.14 | 15.33 | -0.81 | -0.80 | 14.59 | -11.74 | -147.48 | -221.22 |
| 48 | 16.25 | 15.43 | -0.81 | -0.81 | 15.16 | -12.28 | -159.76 | -239.63 |
| 22 | 16.52 | 15.70 | -0.83 | -0.82 | 16.25 | -13.31 | -173.06 | -259.60 |
| 19 | 16.56 | 15.73 | -0.83 | -0.83 | 8.18 | -6.77 | -179.83 | -269.75 |
| 0 | 16.76 | 15.92 | -0.84 | -0.83 | 5.45 | -4.54 | -184.37 | -276.56 |

| COMBINED ULTIMATE TORSION ( AERODYNAMIC + INER | | | |
|---|---|---|---|
| CONDITION. G cont.. | | | |
| | | | |
| 1 | 71 G | | |
| STATION | COND. G | | |
| (in) | (lb in) | | |
| 258 | 0 | | |
| 251.25 | -344 | | |
| 238 | -920 | | |
| 228 | -1389 | | |
| 218 | -1882 | | |
| 208 | -2397 | | |
| 198 | -2932 | | |
| 188 | -3487 | | |
| 178 | -4061 | | |
| 163.65 | -4909 | | |
| 159 | -5180 | | |
| 155.00 | -5454 | | |
| 138 | -6520 | | |
| 128 | -7172 | | |
| 118 | -7837 | | |
| 108 | -8516 | | |
| 98 | -9207 | | |
| 88 | -9911 | | |
| 80.00 | -10485 | | |
| 68 | -11353 | | |
| 58 | -12092 | | |
| 48 | -12841 | | |
| 22 | -14807 | | |
| 19 | -15046 | | |
| 0 | -16518 | | |


Spanwise aerodynamic lift approximation
Non-dimensional limit load
Distance from aircraft centreline (in)
CHORD
ELLIPSE
SHRENK
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
50.00
100.00
150.00
200.00
250.00
300.00


Spanwise aerodynamic drag approximation
Non-dimensional limit load
0.00
0.01
0.02
0.03
0.04
0.05
0.06
0.07
0.08
0.09
0.00
50.00
100.00
150.00
200.00
250.00
300.00
Distance from aircraft centreline (in)
CD

# APPENDIX C: SPANWISE LOADS DETERMINATION: SYMMETRIC WITH BRAKE DEFFLECTION CONDITIONS A THROUGH G

# APPENDIX C: SPANWISE LOADS DETERMINATION: SYMMETRIC WITH BRAKE DEFFLECTION CONDITIONS A THROUGH G

SPANWISE AERODYNAMIC LOAD DISTRIBUTION

CONDITION. A BRAKES OUT

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $V_{sel}$ = | 138.51 | ft/s | $C_L$ = | 1.2 | | alpha wrp = | 9.1179 | | | Brake angle = | 30.00 | deg |
| Lift = | 3644.20 | lb clean | $C_{Do}$ = | 0.010 | | sin alpha = | 0.1585 | | | Brake load = | 60.57 | lb at 1g (30 deg def) |
| q = | 22.81 | psf | $C_D$ = | 0.051 | | cos alpha = | 0.9874 | | | $\Delta C_L$ = | 0.00 | ECF = 0.21 |
| n = | 2.53 | g | $C_{Mo}$ = | -0.025 | | | | | | $\Delta C_D$ = | 0.58 | |
| $q.C_L$ = | 26.99 | $q.C_L$ =Lift/S | S = | 135.00 | $ft^2$ | | | | | $\Delta C_{Mo}$ = | 0.00 | |
| | | | b = | 43.00 | ft | | | | | S = | 4.60 | $ft^2$ |
| | | | | | | | | | | b = | 6.25 | ft |
| | | | | | | | | | | AR = | 8.49 | |

| 1 | 13 | 72 | 14 | 15 | 16 | 73 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| STATION | $C_L$ | FLAP | $C_{Lx}$ | $C_{Lz}$ | $C_D$ | FLAP | $C_{Dx}$ | $C_{Dz}$ | $C_{Lz}+C_{Dz}$ | $C_{Dx}-C_{Lx}$ | $(C_{Lz}+C_{Dz})_{AV}$ | $(C_{Dx}-C_{Lx})_{AV}$ | SPAN | SPAN |
| (in) | | $C_L$ | | | | $C_D$ | | | | | | | ELEMENT | ELEMENT |
| | | | | | | | | | | | | | LIFT | DRAG |
| | | | | | | | | | | | | | (lb) | (lb) |
| 258 | 0.5917 | 0.0000 | 0.0938 | 0.5842 | 0.0608 | 0.0000 | 0.0600 | 0.0096 | 0.5938 | -0.0337 | - | - | 0.00 | 0.00 |
| 251.25 | 0.7750 | 0.0000 | 0.1228 | 0.7652 | 0.0608 | 0.0000 | 0.0600 | 0.0096 | 0.7748 | -0.0628 | 0.6843 | -0.0482 | 25.68 | -1.81 |
| 238 | 0.9000 | 0.0000 | 0.1426 | 0.8886 | 0.0608 | 0.0000 | 0.0600 | 0.0096 | 0.8983 | -0.0826 | 0.8365 | -0.0727 | 62.09 | -5.39 |
| 228 | 0.9627 | 0.0000 | 0.1526 | 0.9505 | 0.0608 | 0.0000 | 0.0600 | 0.0096 | 0.9601 | -0.0925 | 0.9292 | -0.0875 | 52.50 | -4.95 |
| 218 | 1.0125 | 0.0000 | 0.1604 | 0.9997 | 0.0608 | 0.0000 | 0.0600 | 0.0096 | 1.0093 | -0.1004 | 0.9847 | -0.0965 | 56.06 | -5.49 |
| 208 | 1.0538 | 0.0000 | 0.1670 | 1.0404 | 0.0481 | 0.0000 | 0.0475 | 0.0076 | 1.0481 | -0.1194 | 1.0287 | -0.1099 | 59.00 | -6.30 |
| 198 | 1.0887 | 0.0000 | 0.1725 | 1.0750 | 0.0481 | 0.0000 | 0.0475 | 0.0076 | 1.0826 | -0.1250 | 1.0653 | -0.1222 | 61.55 | -7.06 |
| 188 | 1.1188 | 0.0000 | 0.1773 | 1.1047 | 0.0481 | 0.0000 | 0.0475 | 0.0076 | 1.1123 | -0.1298 | 1.0975 | -0.1274 | 63.87 | -7.41 |
| 178 | 1.1448 | 0.0000 | 0.1814 | 1.1304 | 0.0481 | 0.0000 | 0.0475 | 0.0076 | 1.1380 | -0.1339 | 1.1251 | -0.1318 | 65.96 | -7.73 |
| 163.65 | 1.1764 | 0.0000 | 0.1864 | 1.1615 | 0.0481 | 0.0000 | 0.0475 | 0.0076 | 1.1692 | -0.1389 | 1.1536 | -0.1364 | 97.90 | -11.57 |
| 159 | 1.1847 | 0.0000 | 0.1877 | 1.1698 | 0.0481 | 0.0000 | 0.0475 | 0.0076 | 1.1774 | -0.1402 | 1.1733 | -0.1395 | 30.21 | -3.59 |
| 155.00 | 1.1926 | 0.0000 | 0.1890 | 1.1775 | 0.0481 | 0.1211 | 0.1671 | 0.0268 | 1.2044 | -0.0218 | 1.1909 | -0.0810 | 30.76 | -2.09 |
| 138 | 1.2193 | 0.0000 | 0.1932 | 1.2038 | 0.0481 | 0.1211 | 0.1671 | 0.0268 | 1.2307 | -0.0261 | 1.2175 | -0.0240 | 124.54 | -2.45 |
| 128 | 1.2321 | 0.0000 | 0.1952 | 1.2165 | 0.0481 | 0.1211 | 0.1671 | 0.0268 | 1.2434 | -0.0281 | 1.2370 | -0.0271 | 75.14 | -1.65 |
| 118 | 1.2431 | 0.0000 | 0.1970 | 1.2274 | 0.0481 | 0.1211 | 0.1671 | 0.0268 | 1.2542 | -0.0298 | 1.2488 | -0.0290 | 76.38 | -1.77 |
| 108 | 1.2524 | 0.0000 | 0.1985 | 1.2365 | 0.0481 | 0.1211 | 0.1671 | 0.0268 | 1.2634 | -0.0313 | 1.2588 | -0.0306 | 77.53 | -1.88 |
| 98 | 1.2601 | 0.0000 | 0.1997 | 1.2441 | 0.0481 | 0.1211 | 0.1671 | 0.0268 | 1.2710 | -0.0325 | 1.2672 | -0.0319 | 78.58 | -1.98 |
| 88 | 1.2663 | 0.0000 | 0.2007 | 1.2503 | 0.0481 | 0.1211 | 0.1671 | 0.0268 | 1.2771 | -0.0335 | 1.2740 | -0.0330 | 79.55 | -2.06 |
| 80.00 | 1.2703 | 0.0000 | 0.2013 | 1.2542 | 0.0481 | 0.1211 | 0.1671 | 0.0268 | 1.2811 | -0.0342 | 1.2791 | -0.0338 | 64.28 | -1.70 |
| 68 | 1.2747 | 0.0000 | 0.2020 | 1.2586 | 0.0481 | 0.0000 | 0.0475 | 0.0076 | 1.2662 | -0.1545 | 1.2736 | -0.0943 | 96.66 | -7.16 |
| 58 | 1.2770 | 0.0000 | 0.2024 | 1.2609 | 0.0481 | 0.0000 | 0.0475 | 0.0076 | 1.2685 | -0.1548 | 1.2674 | -0.1546 | 80.74 | -9.85 |
| 48 | 1.2782 | 0.0000 | 0.2026 | 1.2621 | 0.0481 | 0.0000 | 0.0475 | 0.0076 | 1.2697 | -0.1550 | 1.2691 | -0.1549 | 81.39 | -9.94 |
| 22 | 1.2762 | 0.0000 | 0.2022 | 1.2600 | 0.0481 | 0.0000 | 0.0475 | 0.0076 | 1.2677 | -0.1547 | 1.2687 | -0.1549 | 214.06 | -26.13 |
| 19 | 1.2755 | 0.0000 | 0.2021 | 1.2594 | 0.0481 | 0.0000 | 0.0475 | 0.0076 | 1.2670 | -0.1546 | 1.2673 | -0.1546 | 24.91 | -3.04 |
| 0 | 1.2690 | 0.0000 | 0.2011 | 1.2530 | 0.0481 | 0.0000 | 0.0475 | 0.0076 | 1.2606 | -0.1536 | 1.2638 | -0.1541 | 158.42 | -19.31 |
| | | | | | | | | | | | | Σ = | 1837.75 | -152.32 |
| | | | | | | | | | | | | LIFT calc = | 3675.49 | |
| | | | | | | | | | | | | Lift = | 3644.20 | |

SPANWISE AERODYNAMIC LOAD DISTRIBUTION

CONDITION. A BRAKES OUT cont...

| 1 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 |
|---|---|---|---|---|---|---|---|---|
| STATION | LIMIT | LIMIT | LIMIT | LIMIT | ULT | ULT | ULT | ULT |
| (in) | NORMAL | NORMAL | CHORD | CHORD | NORMAL | NORMAL | CHORD | CHORD |
| | SHEAR | MOMENT | SHEAR | MOMENT | SHEAR | MOMENT | SHEAR | MOMENT |
| | (lb) | (lb in) | (lb) | (lb in) | (lb) | (lb in) | (lb) | (lb in) |
| 258 | 0.00 | 0.00 | 0.00 | 0.00 | 0 | 0 | 0 | 0 |
| 251.25 | 25.68 | 86.66 | -1.81 | -6.11 | 39 | 130 | -3 | -9 |
| 238 | 87.76 | 838.21 | -7.20 | -65.82 | 132 | 1257 | -11 | -99 |
| 228 | 140.27 | 1978.37 | -12.15 | -162.59 | 210 | 2968 | -18 | -244 |
| 218 | 196.33 | 3661.34 | -17.64 | -311.54 | 294 | 5492 | -26 | -467 |
| 208 | 255.33 | 5919.61 | -23.95 | -519.47 | 383 | 8879 | -36 | -779 |
| 198 | 316.88 | 8780.64 | -31.01 | -794.23 | 475 | 13171 | -47 | -1191 |
| 188 | 380.75 | 12268.78 | -38.42 | -1141.36 | 571 | 18403 | -58 | -1712 |
| 178 | 446.71 | 16406.08 | -46.15 | -1564.20 | 670 | 24609 | -69 | -2346 |
| 163.65 | 544.61 | 23518.81 | -57.72 | -2309.46 | 817 | 35278 | -87 | -3464 |
| 159 | 574.82 | 25939.57 | -61.31 | -2566.88 | 862 | 38909 | -92 | -3850 |
| 155.00 | 605.58 | 28492.18 | -63.41 | -2836.59 | 908 | 42738 | -95 | -4255 |
| 138 | 730.12 | 39845.59 | -65.86 | -3935.34 | 1095 | 59768 | -99 | -5903 |
| 128 | 805.26 | 47522.46 | -67.50 | -4602.15 | 1208 | 71284 | -101 | -6903 |
| 118 | 881.64 | 55956.93 | -69.27 | -5286.03 | 1322 | 83935 | -104 | -7929 |
| 108 | 959.17 | 65160.95 | -71.16 | -5988.19 | 1439 | 97741 | -107 | -8982 |
| 98 | 1037.75 | 75145.51 | -73.14 | -6709.67 | 1557 | 112718 | -110 | -10065 |
| 88 | 1117.29 | 85920.71 | -75.20 | -7451.35 | 1676 | 128881 | -113 | -11177 |
| 80.00 | 1181.57 | 95116.18 | -76.90 | -8059.74 | 1772 | 142674 | -115 | -12090 |
| 68 | 1278.23 | 109875.00 | -84.06 | -9025.48 | 1917 | 164812 | -126 | -13538 |
| 58 | 1358.97 | 123061.01 | -93.91 | -9915.30 | 2038 | 184592 | -141 | -14873 |
| 48 | 1440.36 | 137057.69 | -103.84 | -10904.07 | 2161 | 205587 | -156 | -16356 |
| 22 | 1654.42 | 177289.89 | -129.97 | -13943.69 | 2482 | 265935 | -195 | -20916 |
| 19 | 1679.33 | 182290.51 | -133.01 | -14338.16 | 2519 | 273436 | -200 | -21507 |
| 0 | 1837.75 | 215702.71 | -152.32 | -17048.86 | 2757 | 323554 | -228 | -25573 |

| | | |
|---|---|---|
| Centre of lift is | 117 | in from aircraft centreline |
| | 45 | % semispan |

SPANWISE INERTIAL LOAD DISTRIBUTION

CONDITION. A BRAKES OUT cont...

| 1 | 3 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 | 41 | 42 | 43 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| STATION | dy | WEIGHT | ELEMENT | ELEMENT | LIMIT | LIMIT | LIMIT | LIMIT | ULT | ULT | ULT | ULT |
| (in) | (in) | nW | SHEAR | SHEAR | NORMAL | NORMAL | CHORD | CHORD | NORMAL | NORMAL | CHORD | CHORD |
| | | (lb) | FORCE | FORCE | SHEAR | MOMENT | SHEAR | MOMENT | SHEAR | MOMENT | SHEAR | MOMENT |
| | | | $V_z$ | $V_x$ | (lb) | (lb in) | (lb) | (lb in) | (lb) | (lb in) | (lb) | (lb in) |
| | | | (lb) | (lb) | | | | | | | | |
| 258 | - | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0 | 0 | 0 | 0 |
| 251.25 | 6.75 | -0.99 | 0.16 | -0.98 | -0.98 | -3.30 | 0.16 | 0.53 | -1 | -5 | 0 | 1 |
| 238 | 13.25 | -2.63 | 0.42 | -2.60 | -3.58 | -33.49 | 0.57 | 5.37 | -5 | -50 | 1 | 8 |
| 228 | 10.00 | -4.56 | 0.72 | -4.50 | -8.08 | -91.79 | 1.30 | 14.73 | -12 | -138 | 2 | 22 |
| 218 | 10.00 | -6.38 | 1.01 | -6.30 | -14.38 | -204.13 | 2.31 | 32.76 | -22 | -306 | 3 | 49 |
| 208 | 10.00 | -7.83 | 1.24 | -7.73 | -22.11 | -386.62 | 3.55 | 62.05 | -33 | -580 | 5 | 93 |
| 198 | 10.00 | -9.20 | 1.46 | -9.08 | -31.19 | -653.16 | 5.01 | 104.83 | -47 | -980 | 8 | 157 |
| 188 | 10.00 | -10.89 | 1.73 | -10.76 | -41.95 | -1018.87 | 6.73 | 163.52 | -63 | -1528 | 10 | 245 |
| 178 | 10.00 | -12.34 | 1.96 | -12.18 | -54.13 | -1499.28 | 8.69 | 240.63 | -81 | -2249 | 13 | 361 |
| 163.65 | 14.35 | -14.19 | 2.25 | -14.01 | -68.14 | -2376.56 | 10.94 | 381.42 | -102 | -3565 | 16 | 572 |
| 159 | 4.33 | -14.64 | 2.32 | -14.46 | -82.60 | -2702.52 | 13.26 | 433.74 | -124 | -4054 | 20 | 651 |
| 155.00 | 4.32 | -15.25 | 2.42 | -15.06 | -97.65 | -3092.31 | 15.67 | 496.30 | -146 | -4638 | 24 | 744 |
| 138 | 17.00 | -16.01 | 2.54 | -15.81 | -113.46 | -4886.80 | 18.21 | 784.31 | -170 | -7330 | 27 | 1176 |
| 128 | 10.00 | -16.26 | 2.58 | -16.06 | -129.52 | -6101.71 | 20.79 | 979.29 | -194 | -9153 | 31 | 1469 |
| 118 | 10.00 | -16.72 | 2.65 | -16.51 | -146.03 | -7479.47 | 23.44 | 1200.41 | -219 | -11219 | 35 | 1801 |
| 108 | 10.00 | -16.95 | 2.69 | -16.73 | -162.76 | -9023.43 | 26.12 | 1448.21 | -244 | -13535 | 39 | 2172 |
| 98 | 10.00 | -17.23 | 2.73 | -17.01 | -179.77 | -10736.11 | 28.85 | 1723.09 | -270 | -16104 | 43 | 2585 |
| 88 | 10.00 | -17.91 | 2.84 | -17.68 | -197.46 | -12622.25 | 31.69 | 2025.80 | -296 | -18933 | 48 | 3039 |
| 80.00 | 8.00 | -18.29 | 2.90 | -18.06 | -215.52 | -14274.15 | 34.59 | 2290.92 | -323 | -21411 | 52 | 3436 |
| 68 | 12.00 | -18.97 | 3.01 | -18.73 | -234.25 | -16972.75 | 37.60 | 2724.04 | -351 | -25459 | 56 | 4086 |
| 58 | 10.00 | -19.46 | 3.08 | -19.21 | -253.46 | -19411.31 | 40.68 | 3115.41 | -380 | -29117 | 61 | 4673 |
| 48 | 10.00 | -20.22 | 3.20 | -19.96 | -273.42 | -22045.73 | 43.88 | 3538.22 | -410 | -33069 | 66 | 5307 |
| 22 | 26.00 | -21.66 | 3.43 | -21.39 | -294.81 | -29432.72 | 47.32 | 4723.80 | -442 | -44149 | 71 | 7086 |
| 19 | 3.00 | -10.91 | 1.73 | -10.77 | -305.58 | -30333.30 | 49.04 | 4868.33 | -458 | -45500 | 74 | 7303 |
| 0 | 19.00 | -7.27 | 1.15 | -7.18 | -312.76 | -36207.53 | 50.20 | 5811.12 | -469 | -54311 | 75 | 8717 |
| | Σ = | 125 | lb | | | | | | | | | |
| | | at 1 g | | | Centre of gravity is | 116 | in from aircraft centreline | | | | | |
| | | | | | | 45 | % semispan | | | | | |

COMBINED ULTIMATE LOADS ( AERODYNAMIC + INERTIAL )

CONDITION. A BRAKES OUT cont...

| 1 | 44 A | 45 A | 46 A | 47 A | 48 A | 49 A |
|---|---|---|---|---|---|---|
| | ULT | ULT | ULT | ULT | ULT | ULT |
| | NORMAL | NORMAL | CHORD | CHORD | RESOLVED | RESOLVED |
| STATION | SHEAR | BEND MOMENT | SHEAR | BEND MOMENT | SHEAR | BEND MOMENT |
| (in) | COND. A | COND. A | COND. A | COND. A | COND. A | COND. A |
| | (lb) | (lb in) | (lb) | (lb in) | (lb) | (lb in) |
| 258 | 0 | 0 | 0 | 0 | 0 | 0 |
| 251.25 | 37 | 125 | -2 | -8 | 37 | 125 |
| 238 | 126 | 1207 | -10 | -91 | 127 | 1210 |
| 228 | 198 | 2830 | -16 | -222 | 199 | 2839 |
| 218 | 273 | 5186 | -23 | -418 | 274 | 5203 |
| 208 | 350 | 8299 | -31 | -686 | 351 | 8328 |
| 198 | 429 | 12191 | -39 | -1034 | 430 | 12235 |
| 188 | 508 | 16875 | -48 | -1467 | 510 | 16938 |
| 178 | 589 | 22360 | -56 | -1985 | 592 | 22448 |
| 163.65 | 715 | 31713 | -70 | -2892 | 718 | 31845 |
| 159 | 738 | 34856 | -72 | -3200 | 742 | 35002 |
| 155.00 | 762 | 38100 | -72 | -3510 | 765 | 38261 |
| 138 | 925 | 52438 | -71 | -4727 | 928 | 52651 |
| 128 | 1014 | 62131 | -70 | -5434 | 1016 | 62368 |
| 118 | 1103 | 72716 | -69 | -6128 | 1106 | 72974 |
| 108 | 1195 | 84206 | -68 | -6810 | 1197 | 84481 |
| 98 | 1287 | 96614 | -66 | -7480 | 1289 | 96903 |
| 88 | 1380 | 109948 | -65 | -8138 | 1381 | 110248 |
| 80.00 | 1449 | 121263 | -63 | -8653 | 1450 | 121571 |
| 68 | 1566 | 139353 | -70 | -9452 | 1568 | 139674 |
| 58 | 1658 | 155475 | -80 | -10200 | 1660 | 155809 |
| 48 | 1750 | 172518 | -90 | -11049 | 1753 | 172871 |
| 22 | 2039 | 221786 | -124 | -13830 | 2043 | 222217 |
| 19 | 2061 | 227936 | -126 | -14205 | 2064 | 228378 |
| 0 | 2287 | 269243 | -153 | -16857 | 2293 | 269770 |

| AERODYNAMIC TORQUE AT SHEAR CENTRE | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| CONDITION. A BRAKES OUT *cont...* | | | | | | | | | | |
| 1 | 50 | 74 | 51 | 52 | 53 | 54 | 55 | 56 | 57 | 58 |
| STATION | CLEAN + FLAPPED | LEAN + FLAPPE | LOCAL | AERO | X AC | X SC | DELTA X | Z AC | Z SC | DELTA Z |
| | LOCAL | LOCAL | $X_{CP}$ | CENTRE | (in) | (in) | (in) | (in) | (in) | (in) |
| (in) | $C_L$ | $C_{Mo}$ | | (in) | | using 38% chord | | | | |
| 258 | - | -0.025 | - | 0.00 | 0.00 | 13.30 | 13.30 | 0.00 | 2.39 | -2.39 |
| 251.25 | 0.68 | -0.025 | 0.28 | 9.73 | 9.73 | 13.37 | 3.64 | 0.00 | 2.40 | -2.40 |
| 238 | 0.84 | -0.025 | 0.27 | 9.59 | 9.59 | 13.50 | 3.91 | 0.00 | 2.44 | -2.44 |
| 228 | 0.93 | -0.025 | 0.27 | 9.56 | 9.56 | 13.60 | 4.05 | 0.00 | 2.47 | -2.47 |
| 218 | 0.98 | -0.025 | 0.27 | 9.57 | 9.57 | 13.71 | 4.13 | 0.00 | 2.49 | -2.49 |
| 208 | 1.03 | -0.025 | 0.26 | 9.60 | 9.60 | 13.81 | 4.20 | 0.00 | 2.52 | -2.52 |
| 198 | 1.07 | -0.025 | 0.26 | 9.64 | 9.64 | 13.91 | 4.27 | 0.00 | 2.54 | -2.54 |
| 188 | 1.10 | -0.025 | 0.26 | 9.69 | 9.69 | 14.01 | 4.32 | 0.00 | 2.57 | -2.57 |
| 178 | 1.13 | -0.025 | 0.26 | 9.74 | 9.74 | 14.11 | 4.37 | 0.00 | 2.60 | -2.60 |
| 163.65 | 1.15 | -0.025 | 0.26 | 9.82 | 9.82 | 14.26 | 4.44 | 0.00 | 2.64 | -2.64 |
| 159 | 1.17 | -0.025 | 0.26 | 9.84 | 9.84 | 14.30 | 4.47 | 0.00 | 2.65 | -2.65 |
| 155.00 | 1.19 | -0.025 | 0.26 | 9.85 | 9.85 | 14.35 | 4.49 | 0.00 | 2.66 | -2.66 |
| 138 | 1.22 | -0.025 | 0.26 | 9.95 | 9.95 | 14.52 | 4.56 | 0.00 | 2.70 | -2.70 |
| 128 | 1.24 | -0.025 | 0.26 | 10.01 | 10.01 | 14.62 | 4.61 | 0.00 | 2.73 | -2.73 |
| 118 | 1.25 | -0.025 | 0.26 | 10.07 | 10.07 | 14.72 | 4.65 | 0.00 | 2.76 | -2.76 |
| 108 | 1.26 | -0.025 | 0.26 | 10.14 | 10.14 | 14.82 | 4.69 | 0.00 | 2.78 | -2.78 |
| 98 | 1.27 | -0.025 | 0.26 | 10.20 | 10.20 | 14.93 | 4.72 | 0.00 | 2.81 | -2.81 |
| 88 | 1.27 | -0.025 | 0.26 | 10.27 | 10.27 | 15.03 | 4.76 | 0.00 | 2.84 | -2.84 |
| 80.00 | 1.28 | -0.025 | 0.26 | 10.32 | 10.32 | 15.11 | 4.79 | 0.00 | 2.86 | -2.86 |
| 68 | 1.27 | -0.025 | 0.26 | 10.41 | 10.41 | 15.23 | 4.82 | 0.00 | 2.89 | -2.89 |
| 58 | 1.27 | -0.025 | 0.26 | 10.48 | 10.48 | 15.33 | 4.85 | 0.00 | 2.92 | -2.92 |
| 48 | 1.27 | -0.025 | 0.26 | 10.55 | 10.55 | 15.43 | 4.89 | 0.00 | 2.94 | -2.94 |
| 22 | 1.27 | -0.025 | 0.26 | 10.73 | 10.73 | 15.70 | 4.97 | 0.00 | 3.01 | -3.01 |
| 19 | 1.27 | -0.025 | 0.26 | 10.75 | 10.75 | 15.73 | 4.98 | 0.00 | 3.01 | -3.01 |
| 0 | 1.26 | -0.025 | 0.26 | 10.88 | 10.88 | 15.92 | 5.04 | 0.00 | 1.25 | -1.25 |

AERODYNAMIC TORQUE AT SHEAR CENTRE
CONDITION. A BRAKES OUT cont...

| 1 | 55 | 56 | 23 | 24 | 59 | 75 | 60 | 61 | 62 | 63 | 64 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | $\Delta C_{Mo}$ 0 | | | | | |
| STATION (in) | DELTA X av (in) | DELTA Z av (in) | SPAN ELEMENT LIFT (lb) | SPAN ELEMENT DRAG (lb) | ELEMENT TORQUE DUE TO $C_{Mo}$ (lb in) | ELEMENT TORQUE DUE TO $\Delta C_{Mo}$ (lb in) | ELEMENT TORQUE DUE TO LIFT (lb in) | ELEMENT TORQUE DUE TO DRAG (lb in) | ELEMENT LIMIT TORQUE (lb in) | TOTAL LIMIT TORQUE (lb in) | TOTAL ULT TORQUE (lb in) |
| 258 | - | - | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 251.25 | 8.47 | 0.00 | 25.68 | -1.81 | -32.92 | 0.00 | 217.49 | 0.00 | 184.57 | 184.57 | 276.86 |
| 238 | 3.78 | 0.00 | 62.09 | -5.39 | -65.60 | 0.00 | 234.47 | 0.00 | 168.86 | 353.44 | 530.15 |
| 228 | 3.98 | 0.00 | 52.50 | -4.95 | -50.39 | 0.00 | 209.02 | 0.00 | 158.63 | 512.07 | 768.10 |
| 218 | 4.09 | 0.00 | 56.06 | -5.49 | -51.15 | 0.00 | 229.37 | 0.00 | 178.23 | 690.30 | 1035.44 |
| 208 | 4.17 | 0.00 | 59.00 | -6.30 | -51.91 | 0.00 | 245.97 | 0.00 | 194.06 | 884.36 | 1326.54 |
| 198 | 4.23 | 0.00 | 61.55 | -7.06 | -52.68 | 0.00 | 260.67 | 0.00 | 207.99 | 1092.34 | 1638.52 |
| 188 | 4.29 | 0.00 | 63.87 | -7.41 | -53.45 | 0.00 | 274.26 | 0.00 | 220.81 | 1313.15 | 1969.73 |
| 178 | 4.35 | 0.00 | 65.96 | -7.73 | -54.24 | 0.00 | 286.81 | 0.00 | 232.58 | 1545.73 | 2318.59 |
| 163.65 | 4.41 | 0.00 | 97.90 | -11.57 | -79.20 | 0.00 | 431.46 | 0.00 | 352.25 | 1897.98 | 2846.97 |
| 159 | 4.45 | 0.00 | 30.21 | -3.59 | -24.19 | 0.00 | 134.55 | 0.00 | 110.36 | 2008.34 | 3012.51 |
| 155.00 | 4.48 | 0.00 | 30.76 | -2.09 | -24.34 | 0.00 | 137.81 | 0.00 | 113.46 | 2121.80 | 3182.71 |
| 138 | 4.53 | 0.00 | 124.54 | -2.45 | -97.13 | 0.00 | 564.02 | 0.00 | 466.90 | 2588.70 | 3883.05 |
| 128 | 4.59 | 0.00 | 75.14 | -1.65 | -58.23 | 0.00 | 344.66 | 0.00 | 286.43 | 2875.13 | 4312.69 |
| 118 | 4.63 | 0.00 | 76.38 | -1.77 | -59.04 | 0.00 | 353.56 | 0.00 | 294.52 | 3169.65 | 4754.48 |
| 108 | 4.67 | 0.00 | 77.53 | -1.88 | -59.86 | 0.00 | 361.87 | 0.00 | 302.01 | 3471.66 | 5207.50 |
| 98 | 4.71 | 0.00 | 78.58 | -1.98 | -60.69 | 0.00 | 369.76 | 0.00 | 309.07 | 3780.73 | 5671.10 |
| 88 | 4.74 | 0.00 | 79.55 | -2.06 | -61.52 | 0.00 | 377.24 | 0.00 | 315.72 | 4096.45 | 6144.68 |
| 80.00 | 4.77 | 0.00 | 64.28 | -1.70 | -49.82 | 0.00 | 306.93 | 0.00 | 257.11 | 4353.56 | 6530.34 |
| 68 | 4.81 | 0.00 | 96.66 | -7.16 | -75.74 | 0.00 | 464.63 | 0.00 | 388.89 | 4742.45 | 7113.68 |
| 58 | 4.84 | 0.00 | 80.74 | -9.85 | -64.05 | 0.00 | 390.70 | 0.00 | 326.65 | 5069.10 | 7603.65 |
| 48 | 4.87 | 0.00 | 81.39 | -9.94 | -64.91 | 0.00 | 396.34 | 0.00 | 331.43 | 5400.53 | 8100.79 |
| 22 | 4.93 | 0.00 | 214.06 | -26.13 | -172.79 | 0.00 | 1054.85 | 0.00 | 882.06 | 6282.59 | 9423.88 |
| 19 | 4.97 | 0.00 | 24.91 | -3.04 | -20.32 | 0.00 | 123.88 | 0.00 | 103.56 | 6386.15 | 9579.23 |
| 0 | 5.01 | 0.00 | 158.42 | -19.31 | -130.51 | 0.00 | 793.32 | 0.00 | 662.81 | 7048.96 | 10573.45 |

DEAD WEIGHT ANALYSIS FOR WING TORQUE

CONDITION. A BRAKES OUT cont...

| 1 | 65 | 54 | 66 | 67 | 33 | - 68 | 69 | 70 |
|---|---|---|---|---|---|---|---|---|
| STATION | X CG | X SC | DELTA | DELTA | ELEMENT | ELEMENT | TOTAL | TOTAL |
| | (in) | (in) | X | X av | LOAD | LIMIT | LIMIT | ULT |
| (in) | | | (in) | (in) | (lb) | TORQUE | TORQUE | TORQUE |
| | using 40% chord | | | | | (lb in) | (lb in) | (lb in) |
| 258 | 14.00 | 13.30 | -0.70 | - | - | - | - | 0.00 |
| 251.25 | 14.07 | 13.37 | -0.70 | -0.70 | -0.99 | 0.69 | 0.69 | 1.04 |
| 238 | 14.21 | 13.50 | -0.71 | -0.71 | -2.63 | 1.86 | 2.56 | 3.84 |
| 228 | 14.32 | 13.60 | -0.72 | -0.71 | -4.56 | 3.25 | 5.81 | 8.72 |
| 218 | 14.43 | 13.71 | -0.72 | -0.72 | -6.38 | 4.59 | 10.40 | 15.60 |
| 208 | 14.53 | 13.81 | -0.73 | -0.72 | -7.83 | 5.67 | 16.07 | 24.10 |
| 198 | 14.64 | 13.91 | -0.73 | -0.73 | -9.20 | 6.71 | 22.78 | 34.16 |
| 188 | 14.75 | 14.01 | -0.74 | -0.73 | -10.89 | 8.00 | 30.78 | 46.17 |
| 178 | 14.86 | 14.11 | -0.74 | -0.74 | -12.34 | 9.13 | 39.91 | 59.87 |
| 163.65 | 15.01 | 14.26 | -0.75 | -0.75 | -14.19 | 10.59 | 50.50 | 75.75 |
| 159 | 15.06 | 14.30 | -0.75 | -0.75 | -14.64 | 11.01 | 61.51 | 92.26 |
| 155.00 | 15.10 | 14.35 | -0.76 | -0.75 | -15.25 | 11.50 | 73.01 | 109.51 |
| 138 | 15.28 | 14.52 | -0.76 | -0.76 | -16.01 | 12.16 | 85.17 | 127.75 |
| 128 | 15.39 | 14.62 | -0.77 | -0.77 | -16.26 | 12.47 | 97.64 | 146.46 |
| 118 | 15.50 | 14.72 | -0.77 | -0.77 | -16.72 | 12.91 | 110.55 | 165.83 |
| 108 | 15.60 | 14.82 | -0.78 | -0.78 | -16.95 | 13.18 | 123.73 | 185.60 |
| 98 | 15.71 | 14.93 | -0.79 | -0.78 | -17.23 | 13.49 | 137.22 | 205.83 |
| 88 | 15.82 | 15.03 | -0.79 | -0.79 | -17.91 | 14.12 | 151.34 | 227.00 |
| 80.00 | 15.90 | 15.11 | -0.80 | -0.79 | -18.29 | 14.51 | 165.84 | 248.76 |
| 68 | 16.03 | 15.23 | -0.80 | -0.80 | -18.97 | 15.15 | 180.99 | 271.49 |
| 58 | 16.14 | 15.33 | -0.81 | -0.80 | -19.46 | 15.65 | 196.64 | 294.96 |
| 48 | 16.25 | 15.43 | -0.81 | -0.81 | -20.22 | 16.37 | 213.01 | 319.51 |
| 22 | 16.52 | 15.70 | -0.83 | -0.82 | -21.66 | 17.75 | 230.75 | 346.13 |
| 19 | 16.56 | 15.73 | -0.83 | -0.83 | -10.91 | 9.02 | 239.77 | 359.66 |
| 0 | 16.76 | 15.92 | -0.84 | -0.83 | -7.27 | 6.06 | 245.83 | 368.75 |

| COMBINED ULTIMATE TORSION ( AERODYNAMIC + INERTIAL ) | | | |
|---|---|---|---|
| CONDITION. A BRAKES OUT cont... | | | |
| | | | |
| 1 | 71 BRAKES | | |
| STATION | COND. A | | |
| (in) | (lb in) | | |
| 258 | 0 | | |
| 251.25 | 278 | | |
| 238 | 534 | | |
| 228 | 777 | | |
| 218 | 1051 | | |
| 208 | 1351 | | |
| 198 | 1673 | | |
| 188 | 2016 | | |
| 178 | 2378 | | |
| 163.65 | 2923 | | |
| 159 | 3105 | | |
| 155.00 | 3292 | | |
| 138 | 4011 | | |
| 128 | 4459 | | |
| 118 | 4920 | | |
| 108 | 5393 | | |
| 98 | 5877 | | |
| 88 | 6372 | | |
| 80.00 | 6779 | | |
| 68 | 7385 | | |
| 58 | 7899 | | |
| 48 | 8420 | | |
| 22 | 9770 | | |
| 19 | 9939 | | |
| 0 | 10942 | | |

SPANWISE AERODYNAMIC LOAD DISTRIBUTION

CONDITION. C BRAKES OUT

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Brake angle = | 30.00 | deg | | | |
| | | | | | | | Brake load = | 97.42 | lb at 1g (30 deg def | | ECF = | 0.21 |
| $V_{sel}$ = | 175.68 | ft/s | $C_L$ = | 0.9 | alpha wrp = | 5.9468 | $\Delta C_L$ = | 0.00 | | | | |
| Lift = | 4353.86 | lb clean | $C_{Do}$ = | 0.008 | sin alpha = | -0.1036 | $\Delta C_D$ = | 0.58 | | | | |
| q = | 36.69 | psf | $C_D$ = | 0.030 | cos alpha = | 0.9946 | $\Delta C_{Mo}$ = | 0.00 | | | | |
| n = | 3.03 | g | $C_{Mo}$ = | -0.025 | | | S = | 4.60 | $ft^2$ | | | |
| q.$C_L$ = | 32.25 | q.$C_L$ =Lift/S | S = | 135.00 $ft^2$ | | | b = | 6.25 | ft | | | |
| | | | b = | 43.00 ft | | | AR = | 8.49 | | | | |

| 1 | 13 | 72 | 14 | 15 | 16 | 73 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| STATION | $C_L$ | FLAP | $C_{Lz}$ | $C_{Lz}$ | $C_D$ | FLAP | $C_{Dz}$ | $C_{Dz}$ | $C_{Lz}+C_{Dz}$ | $C_{Dz}-C_{Lz}$ | $(C_{Lz}+C_{Dz})_{AV}$ | $(C_{Dz}-C_{Lz})_{AV}$ | SPAN | SPAN |
| (in) | | $C_L$ | | | | $C_D$ | | | | | | | ELEMENT | ELEMENT |
| | | | | | | | | | | | | | LIFT | DRAG |
| | | | | | | | | | | | | | (lb) | (lb) |
| 258 | 0.4394 | 0.0000 | 0.0455 | 0.4371 | 0.0365 | 0.0000 | 0.0363 | 0.0038 | 0.4409 | -0.0092 | - | - | 0.00 | 0.00 |
| 251.25 | 0.5756 | 0.0000 | 0.0596 | 0.5725 | 0.0365 | 0.0000 | 0.0363 | 0.0038 | 0.5763 | -0.0233 | 0.5086 | -0.0163 | 30.70 | -0.98 |
| 238 | 0.6685 | 0.0000 | 0.0693 | 0.6649 | 0.0365 | 0.0000 | 0.0363 | 0.0038 | 0.6686 | -0.0329 | 0.6225 | -0.0281 | 74.31 | -3.36 |
| 228 | 0.7150 | 0.0000 | 0.0741 | 0.7112 | 0.0365 | 0.0000 | 0.0363 | 0.0038 | 0.7149 | -0.0377 | 0.6918 | -0.0353 | 62.88 | -3.21 |
| 218 | 0.7520 | 0.0000 | 0.0779 | 0.7480 | 0.0365 | 0.0000 | 0.0363 | 0.0038 | 0.7517 | -0.0416 | 0.7333 | -0.0397 | 67.16 | -3.63 |
| 208 | 0.7827 | 0.0000 | 0.0811 | 0.7785 | 0.0289 | 0.0000 | 0.0288 | 0.0030 | 0.7814 | -0.0523 | 0.7666 | -0.0470 | 70.72 | -4.33 |
| 198 | 0.8086 | 0.0000 | 0.0838 | 0.8043 | 0.0289 | 0.0000 | 0.0288 | 0.0030 | 0.8073 | -0.0550 | 0.7944 | -0.0537 | 73.83 | -4.99 |
| 188 | 0.8310 | 0.0000 | 0.0861 | 0.8265 | 0.0289 | 0.0000 | 0.0288 | 0.0030 | 0.8295 | -0.0573 | 0.8184 | -0.0562 | 76.62 | -5.26 |
| 178 | 0.8503 | 0.0000 | 0.0881 | 0.8457 | 0.0289 | 0.0000 | 0.0288 | 0.0030 | 0.8487 | -0.0593 | 0.8391 | -0.0583 | 79.13 | -5.50 |
| 163.65 | 0.8737 | 0.0000 | 0.0905 | 0.8690 | 0.0289 | 0.0000 | 0.0288 | 0.0030 | 0.8720 | -0.0618 | 0.8604 | -0.0605 | 117.45 | -8.27 |
| 159 | 0.8799 | 0.0000 | 0.0912 | 0.8752 | 0.0289 | 0.0000 | 0.0288 | 0.0030 | 0.8782 | -0.0624 | 0.8751 | -0.0621 | 36.25 | -2.57 |
| 155.00 | 0.8858 | 0.0000 | 0.0918 | 0.8810 | 0.0289 | 0.1194 | 0.1475 | 0.0154 | 0.8964 | 0.0558 | 0.8873 | -0.0033 | 36.86 | -0.14 |
| 138 | 0.9056 | 0.0000 | 0.0938 | 0.9007 | 0.0289 | 0.1194 | 0.1475 | 0.0154 | 0.9161 | 0.0537 | 0.9062 | 0.0547 | 149.11 | 9.01 |
| 128 | 0.9151 | 0.0000 | 0.0948 | 0.9102 | 0.0289 | 0.1194 | 0.1475 | 0.0154 | 0.9256 | 0.0527 | 0.9208 | 0.0532 | 89.97 | 5.20 |
| 118 | 0.9233 | 0.0000 | 0.0957 | 0.9183 | 0.0289 | 0.1194 | 0.1475 | 0.0154 | 0.9337 | 0.0519 | 0.9296 | 0.0523 | 91.46 | 5.15 |
| 108 | 0.9302 | 0.0000 | 0.0964 | 0.9252 | 0.0289 | 0.1194 | 0.1475 | 0.0154 | 0.9405 | 0.0512 | 0.9371 | 0.0515 | 92.84 | 5.10 |
| 98 | 0.9359 | 0.0000 | 0.0970 | 0.9308 | 0.0289 | 0.1194 | 0.1475 | 0.0154 | 0.9462 | 0.0506 | 0.9434 | 0.0509 | 94.10 | 5.07 |
| 88 | 0.9405 | 0.0000 | 0.0974 | 0.9355 | 0.0289 | 0.1194 | 0.1475 | 0.0154 | 0.9508 | 0.0501 | 0.9485 | 0.0503 | 95.26 | 5.05 |
| 80.00 | 0.9435 | 0.0000 | 0.0977 | 0.9384 | 0.0289 | 0.1194 | 0.1475 | 0.0154 | 0.9538 | 0.0498 | 0.9523 | 0.0499 | 76.98 | 4.04 |
| 68 | 0.9468 | 0.0000 | 0.0981 | 0.9417 | 0.0289 | 0.0000 | 0.0288 | 0.0030 | 0.9447 | -0.0693 | 0.9492 | -0.0098 | 115.88 | -1.19 |
| 58 | 0.9485 | 0.0000 | 0.0983 | 0.9434 | 0.0289 | 0.0000 | 0.0288 | 0.0030 | 0.9464 | -0.0695 | 0.9455 | -0.0694 | 96.90 | -7.11 |
| 48 | 0.9494 | 0.0000 | 0.0984 | 0.9443 | 0.0289 | 0.0000 | 0.0288 | 0.0030 | 0.9473 | -0.0696 | 0.9468 | -0.0696 | 97.68 | -7.18 |
| 22 | 0.9478 | 0.0000 | 0.0982 | 0.9427 | 0.0289 | 0.0000 | 0.0288 | 0.0030 | 0.9457 | -0.0694 | 0.9465 | -0.0695 | 256.89 | -18.87 |
| 19 | 0.9473 | 0.0000 | 0.0981 | 0.9422 | 0.0289 | 0.0000 | 0.0288 | 0.0030 | 0.9452 | -0.0694 | 0.9455 | -0.0694 | 29.89 | -2.19 |
| 0 | 0.9425 | 0.0000 | 0.0977 | 0.9375 | 0.0289 | 0.0000 | 0.0288 | 0.0030 | 0.9405 | -0.0689 | 0.9428 | -0.0691 | 190.11 | -13.94 |
| | | | | | | | | | | | | Σ = | 2202.97 | -54.10 |
| | | | | | | | | | | | | LIFT calc = | 4405.94 | |
| | | | | | | | | | | | | Lift = | 4353.86 | |

SPANWISE AERODYNAMIC LOAD DISTRIBUTION

CONDITION. C BRAKES OUT cont...

| 1 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 |
|---|---|---|---|---|---|---|---|---|
| STATION | LIMIT | LIMIT | LIMIT | LIMIT | ULT | ULT | ULT | ULT |
| (in) | NORMAL | NORMAL | CHORD | CHORD | NORMAL | NORMAL | CHORD | CHORD |
| | SHEAR | MOMENT | SHEAR | MOMENT | SHEAR | MOMENT | SHEAR | MOMENT |
| | (lb) | (lb in) | (lb) | (lb in) | (lb) | (lb in) | (lb) | (lb in) |
| 258 | 0.00 | 0.00 | 0.00 | 0.00 | 0 | 0 | 0 | 0 |
| 251.25 | 30.70 | 103.60 | -0.98 | -3.31 | 46 | 155 | -1 | -5 |
| 238 | 105.01 | 1002.65 | -4.34 | -38.54 | 158 | 1504 | -7 | -58 |
| 228 | 167.89 | 2367.13 | -7.55 | -97.97 | 252 | 3551 | -11 | -147 |
| 218 | 235.04 | 4381.78 | -11.18 | -191.62 | 353 | 6573 | -17 | -287 |
| 208 | 305.77 | 7085.82 | -15.51 | -325.09 | 459 | 10629 | -23 | -488 |
| 198 | 379.59 | 10512.60 | -20.50 | -505.15 | 569 | 15769 | -31 | -758 |
| 188 | 456.21 | 14691.60 | -25.76 | -736.45 | 684 | 22037 | -39 | -1105 |
| 178 | 535.34 | 19649.33 | -31.26 | -1021.55 | 803 | 29474 | -47 | -1532 |
| 163.65 | 652.79 | 28174.14 | -39.53 | -1529.43 | 979 | 42261 | -59 | -2294 |
| 159 | 689.04 | 31075.83 | -42.10 | -1705.94 | 1034 | 46614 | -63 | -2559 |
| 155.00 | 725.90 | 34135.63 | -42.23 | -1888.31 | 1089 | 51203 | -63 | -2832 |
| 138 | 875.01 | 47743.37 | -33.23 | -2529.75 | 1313 | 71615 | -50 | -3795 |
| 128 | 964.98 | 56943.33 | -28.03 | -2836.05 | 1447 | 85415 | -42 | -4254 |
| 118 | 1056.45 | 67050.47 | -22.88 | -3090.62 | 1585 | 100576 | -34 | -4636 |
| 108 | 1149.29 | 78079.13 | -17.78 | -3293.94 | 1724 | 117119 | -27 | -4941 |
| 98 | 1243.39 | 90042.51 | -12.71 | -3446.37 | 1865 | 135064 | -19 | -5170 |
| 88 | 1338.65 | 102952.72 | -7.65 | -3548.16 | 2008 | 154429 | -11 | -5322 |
| 80.00 | 1415.63 | 113969.87 | -3.61 | -3593.22 | 2123 | 170955 | -5 | -5390 |
| 68 | 1531.51 | 131652.73 | -4.81 | -3643.76 | 2297 | 197479 | -7 | -5466 |
| 58 | 1628.41 | 147452.31 | -11.92 | -3727.40 | 2443 | 221178 | -18 | -5591 |
| 48 | 1726.08 | 164224.75 | -19.10 | -3882.49 | 2589 | 246337 | -29 | -5824 |
| 22 | 1982.97 | 212442.39 | -37.96 | -4624.28 | 2974 | 318664 | -57 | -6936 |
| 19 | 2012.86 | 218436.13 | -40.16 | -4741.46 | 3019 | 327654 | -60 | -7112 |
| 0 | 2202.97 | 258486.47 | -54.10 | -5636.91 | 3304 | 387730 | -81 | -8455 |
| | | | | | | | | |
| Centre of lift is | 117 | in from aircraft centreline | | | | | | |
| | 45 | % semispan | | | | | | |

SPANWISE INERTIAL LOAD DISTRIBUTION

CONDITION. C BRAKES OUT cont...

| 1 | 3 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 | 41 | 42 | 43 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| STATION | dy | WEIGHT | ELEMENT | ELEMENT | LIMIT | LIMIT | LIMIT | LIMIT | ULT | ULT | ULT | ULT |
| (in) | (in) | nW | SHEAR | SHEAR | NORMAL | NORMAL | CHORD | CHORD | NORMAL | NORMAL | CHORD | CHORD |
| | | (lb) | FORCE | FORCE | SHEAR | MOMENT | SHEAR | MOMENT | SHEAR | MOMENT | SHEAR | MOMENT |
| | | | $V_x$ | $V_z$ | (lb) | (lb in) | (lb) | (lb in) | (lb) | (lb in) | (lb) | (lb in) |
| | | | (lb) | (lb) | | | | | | | | |
| 258 | - | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0 | 0 | 0 | 0 |
| 251.25 | 6.75 | -1.18 | 0.12 | -1.18 | -1.18 | -3.97 | 0.12 | 0.41 | -2 | -6 | 0 | 1 |
| 238 | 13.25 | -3.15 | 0.33 | -3.13 | -4.31 | -40.31 | 0.45 | 4.20 | -6 | -60 | 1 | 6 |
| 228 | 10.00 | -5.45 | 0.56 | -5.42 | -9.73 | -110.47 | 1.01 | 11.51 | -15 | -166 | 2 | 17 |
| 218 | 10.00 | -7.63 | 0.79 | -7.59 | -17.31 | -245.67 | 1.80 | 25.59 | -26 | -369 | 3 | 38 |
| 208 | 10.00 | -9.35 | 0.97 | -9.30 | -26.61 | -465.30 | 2.77 | 48.47 | -40 | -698 | 4 | 73 |
| 198 | 10.00 | -10.99 | 1.14 | -10.93 | -37.54 | -786.09 | 3.91 | 81.88 | -56 | -1179 | 6 | 123 |
| 188 | 10.00 | -13.01 | 1.35 | -12.94 | -50.49 | -1226.23 | 5.26 | 127.73 | -76 | -1839 | 8 | 192 |
| 178 | 10.00 | -14.74 | 1.53 | -14.66 | -65.15 | -1804.40 | 6.79 | 187.96 | -98 | -2707 | 10 | 282 |
| 163.65 | 14.35 | -16.95 | 1.76 | -16.86 | -82.01 | -2860.22 | 8.54 | 297.94 | -123 | -4290 | 13 | 447 |
| 159 | 4.33 | -17.49 | 1.81 | -17.40 | -99.41 | -3252.52 | 10.35 | 338.80 | -149 | -4879 | 16 | 508 |
| 155.00 | 4.32 | -18.22 | 1.89 | -18.12 | -117.53 | -3721.64 | 12.24 | 387.67 | -176 | -5582 | 18 | 581 |
| 138 | 17.00 | -19.13 | 1.98 | -19.03 | -136.55 | -5881.33 | 14.22 | 612.63 | -205 | -8822 | 21 | 919 |
| 128 | 10.00 | -19.43 | 2.01 | -19.33 | -155.88 | -7343.50 | 16.24 | 764.94 | -234 | -11015 | 24 | 1147 |
| 118 | 10.00 | -19.98 | 2.07 | -19.87 | -175.75 | -9001.65 | 18.31 | 937.66 | -264 | -13502 | 27 | 1406 |
| 108 | 10.00 | -20.25 | 2.10 | -20.14 | -195.89 | -10859.83 | 20.40 | 1131.22 | -294 | -16290 | 31 | 1697 |
| 98 | 10.00 | -20.58 | 2.13 | -20.47 | -216.36 | -12921.06 | 22.54 | 1345.93 | -325 | -19382 | 34 | 2019 |
| 88 | 10.00 | -21.40 | 2.22 | -21.28 | -237.64 | -15191.07 | 24.75 | 1582.38 | -356 | -22787 | 37 | 2374 |
| 80 00 | 8.00 | -21.85 | 2.26 | -21.73 | -259.38 | -17179.14 | 27.02 | 1789.47 | -389 | -25769 | 41 | 2684 |
| 68 | 12.00 | -22.67 | 2.35 | -22.55 | -281.92 | -20426.95 | 29.37 | 2127.78 | -423 | -30640 | 44 | 3192 |
| 58 | 10.00 | -23.24 | 2.41 | -23.12 | -305.04 | -23361.80 | 31.78 | 2433.49 | -458 | -35043 | 48 | 3650 |
| 48 | 10.00 | -24.15 | 2.50 | -24.02 | -329.07 | -26532.36 | 34.28 | 2763.75 | -494 | -39799 | 51 | 4146 |
| 22 | 26.00 | -25.88 | 2.68 | -25.74 | -354.81 | -35422.71 | 36.96 | 3689.82 | -532 | -53134 | 55 | 5535 |
| 19 | 3.00 | -13.03 | 1.35 | -12.96 | -367.77 | -36506.57 | 38.31 | 3802.72 | -552 | -54760 | 57 | 5704 |
| 0 | 19.00 | -8.69 | 0.90 | -8.64 | -376.41 | -43576.29 | 39.21 | 4539.14 | -565 | -65364 | 59 | 6809 |
| | $\Sigma =$ | 125 | lb | | | | | | | | | |
| | | at 1 g | | | Centre of gravity is | 116 | in from aircraft centreline | | | | | |
| | | | | | | 45 | % semispan | | | | | |

COMBINED ULTIMATE LOADS ( AERODYNAMIC + INERTIAL )

CONDITION. C BRAKES OUT cont...

| 1 | 44 C | 45 C | 46 C | 47 C | 48 C | 49 C |
|---|---|---|---|---|---|---|
| | ULT | ULT | ULT | ULT | ULT | ULT |
| | NORMAL | NORMAL | CHORD | CHORD | RESOLVED | RESOLVED |
| STATION | SHEAR | BEND MOMENT | SHEAR | BEND MOMENT | SHEAR | BEND MOMENT |
| (in) | COND. C | COND. C | COND. C | COND. C | COND. C | COND. C |
| | (lb) | (lb in) | (lb) | (lb in) | (lb) | (lb in) |
| 258 | 0 | 0 | 0 | 0 | 0 | 0 |
| 251.25 | 44 | 149 | -1 | -4 | 44 | 150 |
| 238 | 151 | 1444 | -6 | -52 | 151 | 1444 |
| 228 | 237 | 3385 | -10 | -130 | 237 | 3387 |
| 218 | 327 | 6204 | -14 | -249 | 327 | 6209 |
| 208 | 419 | 9931 | -19 | -415 | 419 | 9939 |
| 198 | 513 | 14590 | -25 | -635 | 514 | 14604 |
| 188 | 609 | 20198 | -31 | -913 | 609 | 20219 |
| 178 | 705 | 26767 | -37 | -1250 | 706 | 26797 |
| 163.65 | 856 | 37971 | -46 | -1847 | 857 | 38016 |
| 159 | 884 | 41735 | -48 | -2051 | 886 | 41785 |
| 155.00 | 913 | 45621 | -45 | -2251 | 914 | 45676 |
| 138 | 1108 | 62793 | -29 | -2876 | 1108 | 62859 |
| 128 | 1214 | 74400 | -18 | -3107 | 1214 | 74465 |
| 118 | 1321 | 87073 | -7 | -3229 | 1321 | 87133 |
| 108 | 1430 | 100829 | 4 | -3244 | 1430 | 100881 |
| 98 | 1541 | 115682 | 15 | -3151 | 1541 | 115725 |
| 88 | 1652 | 131642 | 26 | -2949 | 1652 | 131675 |
| 80.00 | 1734 | 145186 | 35 | -2706 | 1735 | 145211 |
| 68 | 1874 | 166839 | 37 | -2274 | 1875 | 166854 |
| 58 | 1985 | 186136 | 30 | -1941 | 1985 | 186146 |
| 48 | 2096 | 206539 | 23 | -1678 | 2096 | 206545 |
| 22 | 2442 | 265530 | -2 | -1402 | 2442 | 265533 |
| 19 | 2468 | 272894 | -3 | -1408 | 2468 | 272898 |
| 0 | 2740 | 322365 | -22 | -1647 | 2740 | 322369 |

AERODYNAMIC TORQUE AT SHEAR CENTRE

CONDITION. C BRAKES OUT cont...

| 1 | 50 | 74 | 51 | 52 | 53 | 54 | 55 | 56 | 57 | 58 |
|---|---|---|---|---|---|---|---|---|---|---|
| STATION | CLEAN + FLAPPED | CLEAN + FLAPPED | LOCAL | AERO | X AC | X SC | DELTA X | Z AC | Z SC | DELTA Z |
| | LOCAL | LOCAL | $X_{CP}$ | CENTRE | (in) | (in) | (in) | (in) | (in) | (in) |
| (in) | $C_L$ | $C_{Mo}$ | | (in) | | using 38% chord | | | | |
| 258 | - | -0.025 | - | 0.00 | 0.00 | 13.30 | 13.30 | 0.00 | 2.39 | -2.39 |
| 251.25 | 0.51 | -0.025 | 0.29 | 10.17 | 10.17 | 13.37 | 3.20 | 0.00 | 2.40 | -2.40 |
| 238 | 0.62 | -0.025 | 0.28 | 9.96 | 9.96 | 13.50 | 3.55 | 0.00 | 2.44 | -2.44 |
| 228 | 0.69 | -0.025 | 0.28 | 9.89 | 9.89 | 13.60 | 3.72 | 0.00 | 2.47 | -2.47 |
| 218 | 0.73 | -0.025 | 0.27 | 9.89 | 9.89 | 13.71 | 3.82 | 0.00 | 2.49 | -2.49 |
| 208 | 0.77 | -0.025 | 0.27 | 9.91 | 9.91 | 13.81 | 3.90 | 0.00 | 2.52 | -2.52 |
| 198 | 0.79 | -0.025 | 0.27 | 9.94 | 9.94 | 13.91 | 3.97 | 0.00 | 2.54 | -2.54 |
| 188 | 0.82 | -0.025 | 0.27 | 9.98 | 9.98 | 14.01 | 4.04 | 0.00 | 2.57 | -2.57 |
| 178 | 0.84 | -0.025 | 0.27 | 10.02 | 10.02 | 14.11 | 4.09 | 0.00 | 2.60 | -2.60 |
| 163.65 | 0.86 | -0.025 | 0.27 | 10.10 | 10.10 | 14.26 | 4.16 | 0.00 | 2.64 | -2.64 |
| 159 | 0.88 | -0.025 | 0.27 | 10.11 | 10.11 | 14.30 | 4.19 | 0.00 | 2.65 | -2.65 |
| 155.00 | 0.89 | -0.025 | 0.27 | 10.12 | 10.12 | 14.35 | 4.22 | 0.00 | 2.66 | -2.66 |
| 138 | 0.91 | -0.025 | 0.27 | 10.22 | 10.22 | 14.52 | 4.30 | 0.00 | 2.70 | -2.70 |
| 128 | 0.92 | -0.025 | 0.27 | 10.28 | 10.28 | 14.62 | 4.34 | 0.00 | 2.73 | -2.73 |
| 118 | 0.93 | -0.025 | 0.27 | 10.34 | 10.34 | 14.72 | 4.38 | 0.00 | 2.76 | -2.76 |
| 108 | 0.94 | -0.025 | 0.27 | 10.40 | 10.40 | 14.82 | 4.42 | 0.00 | 2.78 | -2.78 |
| 98 | 0.94 | -0.025 | 0.27 | 10.47 | 10.47 | 14.93 | 4.46 | 0.00 | 2.81 | -2.81 |
| 88 | 0.95 | -0.025 | 0.27 | 10.53 | 10.53 | 15.03 | 4.49 | 0.00 | 2.84 | -2.84 |
| 80.00 | 0.95 | -0.025 | 0.27 | 10.59 | 10.59 | 15.11 | 4.52 | 0.00 | 2.86 | -2.86 |
| 68 | 0.95 | -0.025 | 0.27 | 10.68 | 10.68 | 15.23 | 4.56 | 0.00 | 2.89 | -2.89 |
| 58 | 0.95 | -0.025 | 0.27 | 10.75 | 10.75 | 15.33 | 4.58 | 0.00 | 2.92 | -2.92 |
| 48 | 0.95 | -0.025 | 0.27 | 10.82 | 10.82 | 15.43 | 4.61 | 0.00 | 2.94 | -2.94 |
| 22 | 0.95 | -0.025 | 0.27 | 11.01 | 11.01 | 15.70 | 4.69 | 0.00 | 3.01 | -3.01 |
| 19 | 0.95 | -0.025 | 0.27 | 11.03 | 11.03 | 15.73 | 4.70 | 0.00 | 3.01 | -3.01 |
| 0 | 0.94 | -0.025 | 0.27 | 11.17 | 11.17 | 15.92 | 4.76 | 0.00 | 1.25 | -1.25 |

AERODYNAMIC TORQUE AT SHEAR CENTRE

CONDITION. C BRAKES OUT cont...

| | | | | | | $\Delta C_{Mo}$ 0 | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 55 | 56 | 23 | 24 | 59 | 75 | 60 | 61 | 62 | 63 | 64 |
| STATION | DELTA | DELTA | SPAN | SPAN | ELEMENT | ELEMENT | ELEMENT | ELEMENT | ELEMENT | TOTAL | TOTAL |
| | X av | Z av | ELEMENT | ELEMENT | TORQUE | TORQUE | TORQUE | TORQUE | LIMIT | LIMIT | ULT |
| (in) | (in) | (in) | LIFT | DRAG | DUE TO | DUE TO | DUE TO | DUE TO | TORQUE | TORQUE | TORQUE |
| | | | (lb) | (lb) | $C_{Mo}$ | $\Delta C_{Mo}$ | LIFT | DRAG | (lb in) | (lb in) | (lb in) |
| | | | | | (lb in) | (lb in) | (lb in) | (lb in) | | | |
| 258 | - | - | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 251.25 | 8.25 | 0.00 | 30.70 | -0.98 | -52.95 | 0.00 | 253.19 | 0.00 | 200.24 | 200.24 | 300.36 |
| 238 | 3.37 | 0.00 | 74.31 | -3.36 | -105.53 | 0.00 | 250.57 | 0.00 | 145.04 | 345.28 | 517.91 |
| 228 | 3.63 | 0.00 | 62.88 | -3.21 | -81.05 | 0.00 | 228.44 | 0.00 | 147.39 | 492.67 | 739.00 |
| 218 | 3.77 | 0.00 | 67.16 | -3.63 | -82.27 | 0.00 | 253.13 | 0.00 | 170.86 | 663.53 | 995.29 |
| 208 | 3.86 | 0.00 | 70.72 | -4.33 | -83.50 | 0.00 | 273.07 | 0.00 | 189.57 | 853.10 | 1279.65 |
| 198 | 3.94 | 0.00 | 73.83 | -4.99 | -84.74 | 0.00 | 290.69 | 0.00 | 205.95 | 1059.05 | 1588.57 |
| 188 | 4.00 | 0.00 | 76.62 | -5.26 | -85.98 | 0.00 | 306.79 | 0.00 | 220.80 | 1279.85 | 1919.78 |
| 178 | 4.06 | 0.00 | 79.13 | -5.50 | -87.24 | 0.00 | 321.61 | 0.00 | 234.37 | 1514.22 | 2271.33 |
| 163.65 | 4.13 | 0.00 | 117.45 | -8.27 | -127.40 | 0.00 | 484.84 | 0.00 | 357.44 | 1871.66 | 2807.48 |
| 159 | 4.18 | 0.00 | 36.25 | -2.57 | -38.91 | 0.00 | 151.46 | 0.00 | 112.55 | 1984.20 | 2976.30 |
| 155.00 | 4.21 | 0.00 | 36.86 | -0.14 | -39.15 | 0.00 | 155.13 | 0.00 | 115.97 | 2100.17 | 3150.26 |
| 138 | 4.26 | 0.00 | 149.11 | 9.01 | -156.24 | 0.00 | 635.00 | 0.00 | 478.76 | 2578.93 | 3868.40 |
| 128 | 4.32 | 0.00 | 89.97 | 5.20 | -93.66 | 0.00 | 388.56 | 0.00 | 294.90 | 2873.83 | 4310.74 |
| 118 | 4.36 | 0.00 | 91.46 | 5.15 | -94.97 | 0.00 | 398.99 | 0.00 | 304.01 | 3177.84 | 4766.76 |
| 108 | 4.40 | 0.00 | 92.84 | 5.10 | -96.29 | 0.00 | 408.64 | 0.00 | 312.35 | 3490.19 | 5235.28 |
| 98 | 4.44 | 0.00 | 94.10 | 5.07 | -97.62 | 0.00 | 417.77 | 0.00 | 320.15 | 3810.34 | 5715.51 |
| 88 | 4.48 | 0.00 | 95.26 | 5.05 | -98.96 | 0.00 | 426.41 | 0.00 | 327.46 | 4137.80 | 6206.70 |
| 80.00 | 4.51 | 0.00 | 76.98 | 4.04 | -80.14 | 0.00 | 347.06 | 0.00 | 266.93 | 4404.72 | 6607.09 |
| 68 | 4.54 | 0.00 | 115.88 | -1.19 | -121.83 | 0.00 | 525.98 | 0.00 | 404.15 | 4808.87 | 7213.31 |
| 58 | 4.57 | 0.00 | 96.90 | -7.11 | -103.03 | 0.00 | 442.71 | 0.00 | 339.68 | 5148.56 | 7722.83 |
| 48 | 4.60 | 0.00 | 97.68 | -7.18 | -104.40 | 0.00 | 449.10 | 0.00 | 344.70 | 5493.26 | 8239.88 |
| 22 | 4.65 | 0.00 | 256.89 | -18.87 | -277.95 | 0.00 | 1195.33 | 0.00 | 917.39 | 6410.64 | 9615.96 |
| 19 | 4.70 | 0.00 | 29.89 | -2.19 | -32.68 | 0.00 | 140.37 | 0.00 | 107.69 | 6518.33 | 9777.50 |
| 0 | 4.73 | 0.00 | 190.11 | -13.94 | -209.93 | 0.00 | 898.79 | 0.00 | 688.86 | 7207.19 | 10810.79 |

DEAD WEIGHT ANALYSIS FOR WING TORQUE

CONDITION. C BRAKES OUT cont...

| 1 | 65 | 54 | 66 | 67 | 33 | 68 | 69 | 70 |
|---|---|---|---|---|---|---|---|---|
| STATION | X CG | X SC | DELTA | DELTA | ELEMENT | ELEMENT | TOTAL | TOTAL |
| | (in) | (in) | X | X av | LOAD | LIMIT | LIMIT | ULT |
| (in) | | | (in) | (in) | (lb) | TORQUE | TORQUE | TORQUE |
| | using 40% chord | | | | | (lb in) | (lb in) | (lb in) |
| 258 | 14.00 | 13.30 | -0.70 | - | - | - | - | 0.00 |
| 251.25 | 14.07 | 13.37 | -0.70 | -0.70 | -1.18 | 0.83 | 0.83 | 1.25 |
| 238 | 14.21 | 13.50 | -0.71 | -0.71 | -3.15 | 2.23 | 3.06 | 4.58 |
| 228 | 14.32 | 13.60 | -0.72 | -0.71 | -5.45 | 3.89 | 6.94 | 10.41 |
| 218 | 14.43 | 13.71 | -0.72 | -0.72 | -7.63 | 5.48 | 12.42 | 18.64 |
| 208 | 14.53 | 13.81 | -0.73 | -0.72 | -9.35 | 6.77 | 19.20 | 28.79 |
| 198 | 14.64 | 13.91 | -0.73 | -0.73 | -10.99 | 8.01 | 27.21 | 40.82 |
| 188 | 14.75 | 14.01 | -0.74 | -0.73 | -13.01 | 9.56 | 36.77 | 55.16 |
| 178 | 14.86 | 14.11 | -0.74 | -0.74 | -14.74 | 10.91 | 47.68 | 71.52 |
| 163.65 | 15.01 | 14.26 | -0.75 | -0.75 | -16.95 | 12.65 | 60.34 | 90.51 |
| 159 | 15.06 | 14.30 | -0.75 | -0.75 | -17.49 | 13.15 | 73.49 | 110.23 |
| 155.00 | 15.10 | 14.35 | -0.76 | -0.75 | -18.22 | 13.74 | 87.22 | 130 83 |
| 138 | 15.28 | 14.52 | -0.76 | -0.76 | -19.13 | 14.53 | 101.75 | 152.63 |
| 128 | 15.39 | 14.62 | -0.77 | -0.77 | -19.43 | 14.90 | 116.66 | 174.98 |
| 118 | 15.50 | 14.72 | -0.77 | -0.77 | -19.98 | 15.43 | 132.08 | 198.12 |
| 108 | 15.60 | 14.82 | -0.78 | -0.78 | -20.25 | 15.74 | 147.83 | 221.74 |
| 98 | 15.71 | 14.93 | -0.79 | -0.78 | -20.58 | 16.11 | 163.94 | 245.91 |
| 88 | 15.82 | 15.03 | -0.79 | -0.79 | -21.40 | 16.87 | 180.81 | 271.21 |
| 80.00 | 15.90 | 15.11 | -0.80 | -0.79 | -21.85 | 17.33 | 198.14 | 297.20 |
| 68 | 16.03 | 15.23 | -0.80 | -0.80 | -22.67 | 18.10 | 216.24 | 324.35 |
| 58 | 16.14 | 15.33 | -0.81 | -0.80 | -23.24 | 18.70 | 234.93 | 352.40 |
| 48 | 16.25 | 15.43 | -0.81 | -0.81 | -24.15 | 19.56 | 254.49 | 381.73 |
| 22 | 16.52 | 15.70 | -0.83 | -0.82 | -25.88 | 21.20 | 275.69 | 413.53 |
| 19 | 16.56 | 15.73 | -0.83 | -0.83 | -13.03 | 10.78 | 286.47 | 429.70 |
| 0 | 16.76 | 15 92 | -0.84 | -0.83 | -8.69 | 7.24 | 293.71 | 440.56 |

COMBINED ULTIMATE TORSION ( AERODYNAMIC + INERTIAL )

CONDITION. C BRAKES OUT cont...

| | | | |
|---|---|---|---|
| | | | |
| | | | |
| 1 | 71 C | | |
| STATION | COND. C | | |
| (in) | (lb in) | | |
| 258 | 0 | | |
| 251.25 | 302 | | |
| 238 | 522 | | |
| 228 | 749 | | |
| 218 | 1014 | | |
| 208 | 1308 | | |
| 198 | 1629 | | |
| 188 | 1975 | | |
| 178 | 2343 | | |
| 163.65 | 2898 | | |
| 159 | 3087 | | |
| 155.00 | 3281 | | |
| 138 | 4021 | | |
| 128 | 4486 | | |
| 118 | 4965 | | |
| 108 | 5457 | | |
| 98 | 5961 | | |
| 88 | 6478 | | |
| 80.00 | 6904 | | |
| 68 | 7538 | | |
| 58 | 8075 | | |
| 48 | 8622 | | |
| 22 | 10029 | | |
| 19 | 10207 | | |
| 0 | 11251 | | |

SPANWISE AERODYNAMIC LOAD DISTRIBUTION

CONDITION. D BRAKES OUT

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| $V_{sal}$ = | 244.93 | ft/s | $C_L$ = | 0.4 | alpha wrp = | 0.7337 | Brake angle = | 30.00 | deg |
| Lift = | 3644.20 | lb clean | $C_{Do}$ = | 0.006 | sin alpha = | 0.0128 | Brake load = | 189.38 | lb at 1g (30 deg def) ECF = 0.21 |
| q = | 71.33 | psf | $C_D$ = | 0.010 | cos alpha = | 0.9999 | $\Delta C_L$ = | 0.00 | |
| n = | 2.53 | g | $C_{Mo}$ = | -0.025 | | | $\Delta C_D$ = | 0.58 | |
| $q.C_L$ = | 26.99 | $q.C_L$ = Lift/S | S = | 135.00 | ft² | | $\Delta C_{Mo}$ = | 0.00 | |
| | | | b = | 43.00 | ft | | S = | 4.60 | ft² |
| | | | | | | | b = | 6.25 | ft |
| | | | | | | | AR = | 8.49 | |

| 1 | 13 | 72 | 14 | 15 | 16 | 73 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| STATION (in) | $C_L$ | FLAP $C_L$ | $C_{Lx}$ | $C_{Lz}$ | $C_D$ | FLAP $C_D$ | $C_{Dx}$ | $C_{Dz}$ | $C_{Lz}+C_{Dz}$ | $C_{Dx}-C_{Lx}$ | $(C_{Lz}+C_{Dz})_{AV}$ | $(C_{Dx}-C_{Lx})_{AV}$ | SPAN ELEMENT LIFT (lb) | SPAN ELEMENT DRAG (lb) |
| 258 | 0.1892 | 0.0000 | 0.0024 | 0.1892 | 0.0122 | 0.0000 | 0.0122 | 0.0002 | 0.1894 | 0.0098 | - | - | 0.00 | 0.00 |
| 251.25 | 0.2478 | 0.0000 | 0.0032 | 0.2478 | 0.0122 | 0.0000 | 0.0122 | 0.0002 | 0.2480 | 0.0090 | 0.2187 | 0.0094 | 25.66 | 1.10 |
| 238 | 0.2878 | 0.0000 | 0.0037 | 0.2878 | 0.0122 | 0.0000 | 0.0122 | 0.0002 | 0.2880 | 0.0085 | 0.2680 | 0.0088 | 62.19 | 2.03 |
| 228 | 0.3079 | 0.0000 | 0.0039 | 0.3078 | 0.0122 | 0.0000 | 0.0122 | 0.0002 | 0.3080 | 0.0082 | 0.2980 | 0.0084 | 52.65 | 1.48 |
| 218 | 0.3238 | 0.0000 | 0.0041 | 0.3238 | 0.0122 | 0.0000 | 0.0122 | 0.0002 | 0.3239 | 0.0080 | 0.3160 | 0.0081 | 56.24 | 1.45 |
| 208 | 0.3370 | 0.0000 | 0.0043 | 0.3370 | 0.0097 | 0.0000 | 0.0097 | 0.0001 | 0.3371 | 0.0053 | 0.3305 | 0.0067 | 59.27 | 1.20 |
| 198 | 0.3482 | 0.0000 | 0.0045 | 0.3482 | 0.0097 | 0.0000 | 0.0097 | 0.0001 | 0.3483 | 0.0052 | 0.3427 | 0.0053 | 61.91 | 0.95 |
| 188 | 0.3578 | 0.0000 | 0.0046 | 0.3578 | 0.0097 | 0.0000 | 0.0097 | 0.0001 | 0.3579 | 0.0051 | 0.3531 | 0.0051 | 64.26 | 0.93 |
| 178 | 0.3661 | 0.0000 | 0.0047 | 0.3661 | 0.0097 | 0.0000 | 0.0097 | 0.0001 | 0.3662 | 0.0050 | 0.3621 | 0.0050 | 66.37 | 0.92 |
| 163.65 | 0.3762 | 0.0000 | 0.0048 | 0.3762 | 0.0097 | 0.0000 | 0.0097 | 0.0001 | 0.3763 | 0.0048 | 0.3713 | 0.0049 | 98.52 | 1.30 |
| 159 | 0.3789 | 0.0000 | 0.0049 | 0.3789 | 0.0097 | 0.0000 | 0.0097 | 0.0001 | 0.3790 | 0.0048 | 0.3776 | 0.0048 | 30.41 | 0.39 |
| 155.00 | 0.3814 | 0.0000 | 0.0049 | 0.3814 | 0.0097 | 0.1183 | 0.1279 | 0.0016 | 0.3830 | 0.1230 | 0.3810 | 0.0639 | 30.77 | 5.16 |
| 138 | 0.3899 | 0.0000 | 0.0050 | 0.3899 | 0.0097 | 0.1183 | 0.1279 | 0.0016 | 0.3915 | 0.1229 | 0.3873 | 0.1230 | 123.87 | 39.33 |
| 128 | 0.3940 | 0.0000 | 0.0050 | 0.3940 | 0.0097 | 0.1183 | 0.1279 | 0.0016 | 0.3956 | 0.1229 | 0.3936 | 0.1229 | 74.76 | 23.34 |
| 118 | 0.3975 | 0.0000 | 0.0051 | 0.3975 | 0.0097 | 0.1183 | 0.1279 | 0.0016 | 0.3992 | 0.1228 | 0.3974 | 0.1228 | 76.01 | 23.49 |
| 108 | 0.4005 | 0.0000 | 0.0051 | 0.4005 | 0.0097 | 0.1183 | 0.1279 | 0.0016 | 0.4021 | 0.1228 | 0.4006 | 0.1228 | 77.16 | 23.65 |
| 98 | 0.4030 | 0.0000 | 0.0052 | 0.4029 | 0.0097 | 0.1183 | 0.1279 | 0.0016 | 0.4046 | 0.1227 | 0.4034 | 0.1228 | 78.21 | 23.80 |
| 88 | 0.4050 | 0.0000 | 0.0052 | 0.4049 | 0.0097 | 0.1183 | 0.1279 | 0.0016 | 0.4066 | 0.1227 | 0.4056 | 0.1227 | 79.18 | 23.96 |
| 80.00 | 0.4062 | 0.0000 | 0.0052 | 0.4062 | 0.0097 | 0.1183 | 0.1279 | 0.0016 | 0.4079 | 0.1227 | 0.4072 | 0.1227 | 63.99 | 19.28 |
| 68 | 0.4077 | 0.0000 | 0.0052 | 0.4076 | 0.0097 | 0.0000 | 0.0097 | 0.0001 | 0.4078 | 0.0044 | 0.4078 | 0.0636 | 96.77 | 15.08 |
| 58 | 0.4084 | 0.0000 | 0.0052 | 0.4084 | 0.0097 | 0.0000 | 0.0097 | 0.0001 | 0.4085 | 0.0044 | 0.4081 | 0.0044 | 81.30 | 0.88 |
| 48 | 0.4088 | 0.0000 | 0.0052 | 0.4088 | 0.0097 | 0.0000 | 0.0097 | 0.0001 | 0.4089 | 0.0044 | 0.4087 | 0.0044 | 81.95 | 0.89 |
| 22 | 0.4081 | 0.0000 | 0.0052 | 0.4081 | 0.0097 | 0.0000 | 0.0097 | 0.0001 | 0.4082 | 0.0044 | 0.4085 | 0.0044 | 215.54 | 2.33 |
| 19 | 0.4079 | 0.0000 | 0.0052 | 0.4079 | 0.0097 | 0.0000 | 0.0097 | 0.0001 | 0.4080 | 0.0044 | 0.4081 | 0.0044 | 25.08 | 0.27 |
| 0 | 0.4058 | 0.0000 | 0.0052 | 0.4058 | 0.0097 | 0.0000 | 0.0097 | 0.0001 | 0.4059 | 0.0045 | 0.4070 | 0.0044 | 159.51 | 1.74 |
| | | | | | | | | | | | | Σ = | 1841.57 | 214.97 |
| | | | | | | | | | | | | LIFT calc = | 3683.13 | |
| | | | | | | | | | | | | Lift = | 3644.20 | |

| SPANWISE AERODYNAMIC LOAD DISTRIBUTION | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| CONDITION. D BRAKES OUT cont... | | | | | | | | |
| | | | | | | | | |
| 1 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 |
| STATION | LIMIT | LIMIT | LIMIT | LIMIT | ULT | ULT | ULT | ULT |
| (in) | NORMAL | NORMAL | CHORD | CHORD | NORMAL | NORMAL | CHORD | CHORD |
| | SHEAR | MOMENT | SHEAR | MOMENT | SHEAR | MOMENT | SHEAR | MOMENT |
| | (lb) | (lb in) | (lb) | (lb in) | (lb) | (lb in) | (lb) | (lb in) |
| 258 | 0.00 | 0.00 | 0.00 | 0.00 | 0 | 0 | 0 | 0 |
| 251.25 | 25.66 | 86.59 | 1.10 | 3.72 | 38 | 130 | 2 | 6 |
| 238 | 87.84 | 838.52 | 3.14 | 31.79 | 132 | 1258 | 5 | 48 |
| 228 | 140.49 | 1980.20 | 4.62 | 70.55 | 211 | 2970 | 7 | 106 |
| 218 | 196.74 | 3666.34 | 6.07 | 123.95 | 295 | 5500 | 9 | 186 |
| 208 | 256.01 | 5930.06 | 7.27 | 190.61 | 384 | 8895 | 11 | 286 |
| 198 | 317.92 | 8799.70 | 8.22 | 268.03 | 477 | 13200 | 12 | 402 |
| 188 | 382.18 | 12300.18 | 9.15 | 354.86 | 573 | 18450 | 14 | 532 |
| 178 | 448.54 | 16453.78 | 10.07 | 450.97 | 673 | 24681 | 15 | 676 |
| 163.65 | 547.07 | 23597.28 | 11.37 | 604.80 | 821 | 35396 | 17 | 907 |
| 159 | 577.47 | 26029.09 | 11.76 | 654.81 | 866 | 39044 | 18 | 982 |
| 155.00 | 608.24 | 28593.19 | 16.92 | 716.83 | 912 | 42890 | 25 | 1075 |
| 138 | 732.11 | 39986.16 | 56.25 | 1338.74 | 1098 | 59979 | 84 | 2008 |
| 128 | 806.86 | 47681.01 | 79.59 | 2017.91 | 1210 | 71522 | 119 | 3027 |
| 118 | 882.87 | 56129.67 | 103.08 | 2931.24 | 1324 | 84195 | 155 | 4397 |
| 108 | 960.02 | 65344.13 | 126.73 | 4080.26 | 1440 | 98016 | 190 | 6120 |
| 98 | 1038.24 | 75335.44 | 150.53 | 5466.53 | 1557 | 113003 | 226 | 8200 |
| 88 | 1117.42 | 86113.71 | 174.49 | 7091.61 | 1676 | 129171 | 262 | 10637 |
| 80.00 | 1181.41 | 95309.01 | 193.77 | 8564.65 | 1772 | 142964 | 291 | 12847 |
| 68 | 1278.18 | 110066.52 | 208.85 | 10980.39 | 1917 | 165100 | 313 | 16471 |
| 58 | 1359.48 | 123254.81 | 209.74 | 13073.34 | 2039 | 184882 | 315 | 19610 |
| 48 | 1441.43 | 137259.38 | 210.62 | 15175.13 | 2162 | 205889 | 316 | 22763 |
| 22 | 1656.98 | 177538.72 | 212.95 | 20681.62 | 2485 | 266308 | 319 | 31022 |
| 19 | 1682.05 | 182547.26 | 213.23 | 21320.89 | 2523 | 273821 | 320 | 31981 |
| 0 | 1841.57 | 216021.66 | 214.97 | 25388.73 | 2762 | 324032 | 322 | 38083 |
| | | | | | | | | |
| Centre of lift is | 117 | in from aircraft centreline | | | | | | |
| | 45 | % semispan | | | | | | |

SPANWISE INERTIAL LOAD DISTRIBUTION

CONDITION. D BRAKES OUT cont...

| 1 | 3 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 | 41 | 42 | 43 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| STATION | dy | WEIGHT | ELEMENT | ELEMENT | LIMIT | LIMIT | LIMIT | LIMIT | ULT | ULT | ULT | ULT |
| (in) | (in) | nW | SHEAR | SHEAR | NORMAL | NORMAL | CHORD | CHORD | NORMAL | NORMAL | CHORD | CHORD |
| | | (lb) | FORCE | FORCE | SHEAR | MOMENT | SHEAR | MOMENT | SHEAR | MOMENT | SHEAR | MOMENT |
| | | | $V_x$ | $V_z$ | (lb) | (lb in) | (lb) | (lb in) | (lb) | (lb in) | (lb) | (lb in) |
| | | | (lb) | (lb) | | | | | | | | |
| 258 | - | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0 | 0 | 0 | 0 |
| 251.25 | 6.75 | -0.99 | 0.01 | -0.99 | -0.99 | -3.34 | 0.01 | 0.04 | -1 | -5 | 0 | 0 |
| 238 | 13.25 | -2.63 | 0.03 | -2.63 | -3.62 | -33.92 | 0.05 | 0.43 | -5 | -51 | 0 | 1 |
| 228 | 10.00 | -4.56 | 0.06 | -4.56 | -8.18 | -92.96 | 0.10 | 1.19 | -12 | -139 | 0 | 2 |
| 218 | 10.00 | -6.38 | 0.08 | -6.38 | -14.57 | -206.72 | 0.19 | 2.65 | -22 | -310 | 0 | 4 |
| 208 | 10.00 | -7.83 | 0.10 | -7.83 | -22.40 | -391.54 | 0.29 | 5.01 | -34 | -587 | 0 | 8 |
| 198 | 10.00 | -9.20 | 0.12 | -9.20 | -31.59 | -661.46 | 0.40 | 8.47 | -47 | -992 | 1 | 13 |
| 188 | 10.00 | -10.89 | 0.14 | -10.89 | -42.48 | -1031.83 | 0.54 | 13.21 | -64 | -1548 | 1 | 20 |
| 178 | 10.00 | -12.34 | 0.16 | -12.34 | -54.82 | -1518.34 | 0.70 | 19.44 | -82 | -2278 | 1 | 29 |
| 163.65 | 14.35 | -14.19 | 0.18 | -14.19 | -69.00 | -2406.77 | 0.88 | 30.82 | -104 | -3610 | 1 | 46 |
| 159 | 4.33 | -14.64 | 0.19 | -14.64 | -83.65 | -2736.88 | 1.07 | 35.05 | -125 | -4105 | 2 | 53 |
| 155.00 | 4.32 | -15.25 | 0.20 | -15.25 | -98.90 | -3131.63 | 1.27 | 40.11 | -148 | -4697 | 2 | 60 |
| 138 | 17.00 | -16.01 | 0.21 | -16.01 | -114.90 | -4948.93 | 1.47 | 63.38 | -172 | -7423 | 2 | 95 |
| 128 | 10.00 | -16.26 | 0.21 | -16.26 | -131.17 | -6179.29 | 1.68 | 79.14 | -197 | -9269 | 3 | 119 |
| 118 | 10.00 | -16.72 | 0.21 | -16.72 | -147.89 | -7574.56 | 1.89 | 97.00 | -222 | -11362 | 3 | 146 |
| 108 | 10.00 | -16.95 | 0.22 | -16.95 | -164.83 | -9138.16 | 2.11 | 117.03 | -247 | -13707 | 3 | 176 |
| 98 | 10.00 | -17.23 | 0.22 | -17.23 | -182.06 | -10872.61 | 2.33 | 139.24 | -273 | -16309 | 3 | 209 |
| 88 | 10.00 | -17.91 | 0.23 | -17.91 | -199.97 | -12782.74 | 2.56 | 163.70 | -300 | -19174 | 4 | 246 |
| 80.00 | 8.00 | -18.29 | 0.23 | -18.29 | -218.26 | -14455.63 | 2.80 | 185.13 | -327 | -21683 | 4 | 278 |
| 68 | 12.00 | -18.97 | 0.24 | -18.97 | -237.23 | -17188.55 | 3.04 | 220.13 | -356 | -25783 | 5 | 330 |
| 58 | 10.00 | -19.46 | 0.25 | -19.45 | -256.68 | -19658.11 | 3.29 | 251.75 | -385 | -29487 | 5 | 378 |
| 48 | 10.00 | -20.22 | 0.26 | -20.21 | -276.90 | -22326.03 | 3.55 | 285.92 | -415 | -33489 | 5 | 429 |
| 22 | 26.00 | -21.66 | 0.28 | -21.66 | -298.56 | -29806.94 | 3.82 | 381.72 | -448 | -44710 | 6 | 573 |
| 19 | 3.00 | -10.91 | 0.14 | -10.91 | -309.46 | -30718.97 | 3.96 | 393.40 | -464 | -46078 | 6 | 590 |
| 0 | 19.00 | -7.27 | 0.09 | -7.27 | -316.74 | -36667.88 | 4.06 | 469.59 | -475 | -55002 | 6 | 704 |
| | $\Sigma =$ | 125 | lb | | | | | | | | | |
| | | at 1 g | | | Centre of gravity is | 116 | in from aircraft centreline | | | | | |
| | | | | | | 45 | % semispan | | | | | |

| COMBINED ULTIMATE LOADS ( AERODYNAMIC + INERTIAL ) | | | | | | |
|---|---|---|---|---|---|---|
| CONDITION. D BRAKES OUT cont... | | | | | | |
| 1 | 44 D | 45 D | 46 D | 47 D | 48 D | 49 D |
| | ULT | ULT | ULT | ULT | ULT | ULT |
| | NORMAL | NORMAL | CHORD | CHORD | RESOLVED | RESOLVED |
| STATION | SHEAR | BEND MOMENT | SHEAR | BEND MOMENT | SHEAR | BEND MOMENT |
| (in) | COND. D | COND. D | COND. D | COND. D | COND. D | COND. D |
| | (lb) | (lb in) | (lb) | (lb in) | (lb) | (lb in) |
| 258 | 0 | 0 | 0 | 0 | 0 | 0 |
| 251.25 | 37 | 125 | 2 | 6 | 37 | 125 |
| 238 | 126 | 1207 | 5 | 48 | 126 | 1208 |
| 228 | 198 | 2831 | 7 | 108 | 199 | 2833 |
| 218 | 273 | 5189 | 9 | 190 | 273 | 5193 |
| 208 | 350 | 8308 | 11 | 293 | 351 | 8313 |
| 198 | 429 | 12207 | 13 | 415 | 430 | 12214 |
| 188 | 510 | 16903 | 15 | 552 | 510 | 16912 |
| 178 | 591 | 22403 | 16 | 706 | 591 | 22414 |
| 163.65 | 717 | 31786 | 18 | 953 | 717 | 31800 |
| 159 | 741 | 34938 | 19 | 1035 | 741 | 34954 |
| 155.00 | 764 | 38192 | 27 | 1135 | 765 | 38209 |
| 138 | 926 | 52556 | 87 | 2103 | 930 | 52598 |
| 128 | 1014 | 62253 | 122 | 3146 | 1021 | 62332 |
| 118 | 1102 | 72833 | 157 | 4542 | 1114 | 72974 |
| 108 | 1193 | 84309 | 193 | 6296 | 1208 | 84544 |
| 98 | 1284 | 96694 | 229 | 8409 | 1305 | 97059 |
| 88 | 1376 | 109996 | 266 | 10883 | 1402 | 110534 |
| 80.00 | 1445 | 121280 | 295 | 13125 | 1475 | 121988 |
| 68 | 1561 | 139317 | 318 | 16801 | 1593 | 140326 |
| 58 | 1654 | 155395 | 320 | 19988 | 1685 | 156675 |
| 48 | 1747 | 172400 | 321 | 23192 | 1776 | 173953 |
| 22 | 2038 | 221598 | 325 | 31595 | 2063 | 223839 |
| 19 | 2059 | 227742 | 326 | 32571 | 2084 | 230060 |
| 0 | 2287 | 269031 | 329 | 38787 | 2311 | 271812 |

AERODYNAMIC TORQUE AT SHEAR CENTRE

CONDITION. D BRAKES OUT cont...

| 1 | 50 | 74 | 51 | 52 | 53 | 54 | 55 | 56 | 57 | 58 |
|---|---|---|---|---|---|---|---|---|---|---|
| STATION | CLEAN + FLAPPED | CLEAN + FLAPPED | LOCAL | AERO | X AC | - X SC | DELTA X | Z AC | Z SC | DELTA Z |
| | LOCAL | LOCAL | $X_{CP}$ | CENTRE | (in) | (in) | (in) | (in) | (in) | (in) |
| (in) | $C_L$ | $C_{Mo}$ | | (in) | | using 38% chord | | | | |
| 258 | - | -0.025 | - | 0.00 | 0.00 | 13.30 | 13.30 | 0.00 | 2.39 | -2.39 |
| 251.25 | 0.22 | -0.025 | 0.35 | 12.47 | 12.47 | 13.37 | 0.90 | 0.00 | 2.40 | -2.40 |
| 238 | 0.27 | -0.025 | 0.33 | 11.84 | 11.84 | 13.50 | 1.66 | 0.00 | 2.44 | -2.44 |
| 228 | 0.30 | -0.025 | 0.32 | 11.60 | 11.60 | 13.60 | 2.01 | 0.00 | 2.47 | -2.47 |
| 218 | 0.32 | -0.025 | 0.32 | 11.51 | 11.51 | 13.71 | 2.20 | 0.00 | 2.49 | -2.49 |
| 208 | 0.33 | -0.025 | 0.32 | 11.47 | 11.47 | 13.81 | 2.34 | 0.00 | 2.52 | -2.52 |
| 198 | 0.34 | -0.025 | 0.31 | 11.46 | 11.46 | 13.91 | 2.45 | 0.00 | 2.54 | -2.54 |
| 188 | 0.35 | -0.025 | 0.31 | 11.46 | 11.46 | 14.01 | 2.55 | 0.00 | 2.57 | -2.57 |
| 178 | 0.36 | -0.025 | 0.31 | 11.48 | 11.48 | 14.11 | 2.64 | 0.00 | 2.60 | -2.60 |
| 163.65 | 0.37 | -0.025 | 0.31 | 11.53 | 11.53 | 14.26 | 2.73 | 0.00 | 2.64 | -2.64 |
| 159 | 0.38 | -0.025 | 0.31 | 11.53 | 11.53 | 14.30 | 2.78 | 0.00 | 2.65 | -2.65 |
| 155.00 | 0.38 | -0.025 | 0.31 | 11.54 | 11.54 | 14.35 | 2.81 | 0.00 | 2.66 | -2.66 |
| 138 | 0.39 | -0.025 | 0.30 | 11.64 | 11.64 | 14.52 | 2.88 | 0.00 | 2.70 | -2.70 |
| 128 | 0.39 | -0.025 | 0.30 | 11.68 | 11.68 | 14.62 | 2.94 | 0.00 | 2.73 | -2.73 |
| 118 | 0.40 | -0.025 | 0.30 | 11.74 | 11.74 | 14.72 | 2.99 | 0.00 | 2.76 | -2.76 |
| 108 | 0.40 | -0.025 | 0.30 | 11.80 | 11.80 | 14.82 | 3.03 | 0.00 | 2.78 | -2.78 |
| 98 | 0.40 | -0.025 | 0.30 | 11.86 | 11.86 | 14.93 | 3.06 | 0.00 | 2.81 | -2.81 |
| 88 | 0.41 | -0.025 | 0.30 | 11.93 | 11.93 | 15.03 | 3.10 | 0.00 | 2.84 | -2.84 |
| 80.00 | 0.41 | -0.025 | 0.30 | 11.98 | 11.98 | 15.11 | 3.13 | 0.00 | 2.86 | -2.86 |
| 68 | 0.41 | -0.025 | 0.30 | 12.08 | 12.08 | 15.23 | 3.15 | 0.00 | 2.89 | -2.89 |
| 58 | 0.41 | -0.025 | 0.30 | 12.16 | 12.16 | 15.33 | 3.18 | 0.00 | 2.92 | -2.92 |
| 48 | 0.41 | -0.025 | 0.30 | 12.23 | 12.23 | 15.43 | 3.20 | 0.00 | 2.94 | -2.94 |
| 22 | 0.41 | -0.025 | 0.30 | 12.44 | 12.44 | 15.70 | 3.26 | 0.00 | 3.01 | -3.01 |
| 19 | 0.41 | -0.025 | 0.30 | 12.47 | 12.47 | 15.73 | 3.26 | 0.00 | 3.01 | -3.01 |
| 0 | 0.41 | -0.025 | 0.30 | 12.63 | 12.63 | 15.92 | 3.29 | 0.00 | 1.25 | -1.25 |

AERODYNAMIC TORQUE AT SHEAR CENTRE

CONDITION. D BRAKES OUT cont...

| 1 | 55 | 56 | 23 | 24 | 59 | 60 | 61 | 62 | 63 | 64 | 65 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | $\Delta C_{Mo}$ 0 | | | | | |
| STATION | DELTA X av | DELTA Z av | SPAN ELEMENT LIFT | SPAN ELEMENT DRAG | ELEMENT TORQUE DUE TO $C_{Mo}$ | ELEMENT TORQUE DUE TO $\Delta C_{Mo}$ | ELEMENT TORQUE DUE TO LIFT | ELEMENT TORQUE DUE TO DRAG | ELEMENT LIMIT TORQUE | TOTAL LIMIT TORQUE | TOTAL ULT TORQUE |
| (in) | (in) | (in) | (lb) | (lb) | (lb in) | (lb in) | (lb in) | (lb in) | (lb in) | (lb in) | (lb in) |
| 258 | - | - | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 251.25 | 7.10 | 0.00 | 25.66 | 1.10 | -102.93 | 0.00 | 182.20 | 0.00 | 79.27 | 79.27 | 118.91 |
| 238 | 1.28 | 0.00 | 62.19 | 2.03 | -205.13 | 0.00 | 79.69 | 0.00 | -125.44 | -46.17 | -69.25 |
| 228 | 1.83 | 0.00 | 52.65 | 1.48 | -157.55 | 0.00 | 96.56 | 0.00 | -60.99 | -107.16 | -160.74 |
| 218 | 2.10 | 0.00 | 56.24 | 1.45 | -159.92 | 0.00 | 118.24 | 0.00 | -41.69 | -148.84 | -223.27 |
| 208 | 2.27 | 0.00 | 59.27 | 1.20 | -162.31 | 0.00 | 134.39 | 0.00 | -27.93 | -176.77 | -265.16 |
| 198 | 2.40 | 0.00 | 61.91 | 0.95 | -164.72 | 0.00 | 148.37 | 0.00 | -16.35 | -193.12 | -289.69 |
| 188 | 2.50 | 0.00 | 64.26 | 0.93 | -167.14 | 0.00 | 160.83 | 0.00 | -6.32 | -199.44 | -299.16 |
| 178 | 2.59 | 0.00 | 66.37 | 0.92 | -169.59 | 0.00 | 172.11 | 0.00 | 2.52 | -196.92 | -295.38 |
| 163.65 | 2.68 | 0.00 | 98.52 | 1.30 | -247.66 | 0.00 | 264.12 | 0.00 | 16.46 | -180.46 | -270.69 |
| 159 | 2.75 | 0.00 | 30.41 | 0.39 | -75.64 | 0.00 | 83.68 | 0.00 | 8.04 | -172.42 | -258.63 |
| 155.00 | 2.79 | 0.00 | 30.77 | 5.16 | -76.11 | 0.00 | 85.94 | 0.00 | 9.83 | -162.59 | -243.89 |
| 138 | 2.85 | 0.00 | 123.87 | 39.33 | -303.71 | 0.00 | 352.47 | 0.00 | 48.76 | -113.83 | -170.75 |
| 128 | 2.91 | 0.00 | 74.76 | 23.34 | -182.06 | 0.00 | 217.74 | 0.00 | 35.68 | -78.15 | -117.23 |
| 118 | 2.96 | 0.00 | 76.01 | 23.49 | -184.61 | 0.00 | 225.34 | 0.00 | 40.73 | -37.43 | -56.14 |
| 108 | 3.01 | 0.00 | 77.16 | 23.65 | -187.18 | 0.00 | 232.01 | 0.00 | 44.83 | 7.41 | 11.11 |
| 98 | 3.05 | 0.00 | 78.21 | 23.80 | -189.76 | 0.00 | 238.23 | 0.00 | 48.46 | 55.87 | 83.81 |
| 88 | 3.08 | 0.00 | 79.18 | 23.96 | -192.37 | 0.00 | 244.01 | 0.00 | 51.65 | 107.52 | 161.28 |
| 80.00 | 3.11 | 0.00 | 63.99 | 19.28 | -155.78 | 0.00 | 199.14 | 0.00 | 43.37 | 150.89 | 226.33 |
| 68 | 3.14 | 0.00 | 96.77 | 15.08 | -236.83 | 0.00 | 303.85 | 0.00 | 67.02 | 217.90 | 326.86 |
| 58 | 3.17 | 0.00 | 81.30 | 0.88 | -200.28 | 0.00 | 257.38 | 0.00 | 57.10 | 275.01 | 412.51 |
| 48 | 3.19 | 0.00 | 81.95 | 0.89 | -202.95 | 0.00 | 261.39 | 0.00 | 58.45 | 333.45 | 500.18 |
| 22 | 3.23 | 0.00 | 215.54 | 2.33 | -540.29 | 0.00 | 695.92 | 0.00 | 155.63 | 489.08 | 733.62 |
| 19 | 3.26 | 0.00 | 25.08 | 0.27 | -63.53 | 0.00 | 81.69 | 0.00 | 18.17 | 507.24 | 760.87 |
| 0 | 3.28 | 0.00 | 159.51 | 1.74 | -408.09 | 0.00 | 522.51 | 0.00 | 114.43 | 621.67 | 932.50 |

AERODYNAMIC TORQUE AT SHEAR CENTRE

CONDITION. D BRAKES OUT cont...

| 1 | 55 | 56 | 23 | 24 | 59 | 60 | 61 | 62 | 63 | 64 | 65 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | $\Delta C_{Mo}$ 0 | | | | | |
| STATION | DELTA | DELTA | SPAN | SPAN | ELEMENT | ELEMENT | ELEMENT | ELEMENT | ELEMENT | TOTAL | TOTAL |
| | X av | Z av | ELEMENT | ELEMENT | TORQUE | TORQUE | TORQUE | TORQUE | LIMIT | LIMIT | ULT |
| (in) | (in) | (in) | LIFT | DRAG | DUE TO | DUE TO | DUE TO | DUE TO | TORQUE | TORQUE | TORQUE |
| | | | (lb) | (lb) | $C_{Mo}$ | $\Delta C_{Mo}$ | LIFT | DRAG | (lb in) | (lb in) | (lb in) |
| | | | | | (lb in) | (lb in) | (lb in) | (lb in) | | | |
| 258 | - | - | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 251.25 | 7.10 | 0.00 | 25.66 | 1.10 | -102.93 | 0.00 | 182.20 | 0.00 | 79.27 | 79.27 | 118.91 |
| 238 | 1.28 | 0.00 | 62.19 | 2.03 | -205.13 | 0.00 | 79.69 | 0.00 | -125.44 | -46.17 | -69.25 |
| 228 | 1.83 | 0.00 | 52.65 | 1.48 | -157.55 | 0.00 | 96.56 | 0.00 | -60.99 | -107.16 | -160.74 |
| 218 | 2.10 | 0.00 | 56.24 | 1.45 | -159.92 | 0.00 | 118.24 | 0.00 | -41.69 | -148.84 | -223.27 |
| 208 | 2.27 | 0.00 | 59.27 | 1.20 | -162.31 | 0.00 | 134.39 | 0.00 | -27.93 | -176.77 | -265.16 |
| 198 | 2.40 | 0.00 | 61.91 | 0.95 | -164.72 | 0.00 | 148.37 | 0.00 | -16.35 | -193.12 | -289.69 |
| 188 | 2.50 | 0.00 | 64.26 | 0.93 | -167.14 | 0.00 | 160.83 | 0.00 | -6.32 | -199.44 | -299.16 |
| 178 | 2.59 | 0.00 | 66.37 | 0.92 | -169.59 | 0.00 | 172.11 | 0.00 | 2.52 | -196.92 | -295.38 |
| 163.65 | 2.68 | 0.00 | 98.52 | 1.30 | -247.66 | 0.00 | 264.12 | 0.00 | 16.46 | -180.46 | -270.69 |
| 159 | 2.75 | 0.00 | 30.41 | 0.39 | -75.64 | 0.00 | 83.68 | 0.00 | 8.04 | -172.42 | -258.63 |
| 155.00 | 2.79 | 0.00 | 30.77 | 5.16 | -76.11 | 0.00 | 85.94 | 0.00 | 9.83 | -162.59 | -243.89 |
| 138 | 2.85 | 0.00 | 123.87 | 39.33 | -303.71 | 0.00 | 352.47 | 0.00 | 48.76 | -113.83 | -170.75 |
| 128 | 2.91 | 0.00 | 74.76 | 23.34 | -182.06 | 0.00 | 217.74 | 0.00 | 35.68 | -78.15 | -117.23 |
| 118 | 2.96 | 0.00 | 76.01 | 23.49 | -184.61 | 0.00 | 225.34 | 0.00 | 40.73 | -37.43 | -56.14 |
| 108 | 3.01 | 0.00 | 77.16 | 23.65 | -187.18 | 0.00 | 232.01 | 0.00 | 44.83 | 7.41 | 11.11 |
| 98 | 3.05 | 0.00 | 78.21 | 23.80 | -189.76 | 0.00 | 238.23 | 0.00 | 48.46 | 55.87 | 83.81 |
| 88 | 3.08 | 0.00 | 79.18 | 23.96 | -192.37 | 0.00 | 244.01 | 0.00 | 51.65 | 107.52 | 161.28 |
| 80.00 | 3.11 | 0.00 | 63.99 | 19.28 | -155.78 | 0.00 | 199.14 | 0.00 | 43.37 | 150.89 | 226.33 |
| 68 | 3.14 | 0.00 | 96.77 | 15.08 | -236.83 | 0.00 | 303.85 | 0.00 | 67.02 | 217.90 | 326.86 |
| 58 | 3.17 | 0.00 | 81.30 | 0.88 | -200.28 | 0.00 | 257.38 | 0.00 | 57.10 | 275.01 | 412.51 |
| 48 | 3.19 | 0.00 | 81.95 | 0.89 | -202.95 | 0.00 | 261.39 | 0.00 | 58.45 | 333.45 | 500.18 |
| 22 | 3.23 | 0.00 | 215.54 | 2.33 | -540.29 | 0.00 | 695.92 | 0.00 | 155.63 | 489.08 | 733.62 |
| 19 | 3.26 | 0.00 | 25.08 | 0.27 | -63.53 | 0.00 | 81.69 | 0.00 | 18.17 | 507.24 | 760.87 |
| 0 | 3.28 | 0.00 | 159.51 | 1.74 | -408.09 | 0.00 | 522.51 | 0.00 | 114.43 | 621.67 | 932.50 |

COMBINED ULTIMATE TORSION ( AERODYNAMIC + INERTIAL )

CONDITION. D BRAKES OUT cont...

| | | | |
|---|---|---|---|
| 1 | 71 D | | |
| STATION | COND. D | | |
| (in) | (lb in) | | |
| 258 | 0 | | |
| 251.25 | 120 | | |
| 238 | -65 | | |
| 228 | -152 | | |
| 218 | -208 | | |
| 208 | -241 | | |
| 198 | -256 | | |
| 188 | -253 | | |
| 178 | -236 | | |
| 163.65 | -195 | | |
| 159 | -166 | | |
| 155.00 | -134 | | |
| 138 | -43 | | |
| 128 | 29 | | |
| 118 | 110 | | |
| 108 | 197 | | |
| 98 | 290 | | |
| 88 | 388 | | |
| 80.00 | 475 | | |
| 68 | 598 | | |
| 58 | 707 | | |
| 48 | 820 | | |
| 22 | 1080 | | |
| 19 | 1121 | | |
| 0 | 1301 | | |

SPANWISE AERODYNAMIC LOAD DISTRIBUTION

CONDITION. D BRAKES OUT ZERO LIFT

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Brake angle = | 30.00 | deg | | | |
| | | | | | | Brake load = | 189.38 | lb at 1g (30 | ECF = | 0.21 | |
| $V_{sd}$ = | 244.93 | ft/s | $C_L$ = | 0.0 | alpha wrp = | -3.2083 | $\Delta C_L$ = | 0.00 | | | |
| Lift = | 1438.50 | lb clean | $C_{Do}$ = | 0.006 | sin alpha = | -0.0560 | $\Delta C_D$ = | 0.58 | | | |
| q = | 71.33 | psf | $C_D$ = | 0.006 | cos alpha = | 0.9984 | $\Delta C_{Mo}$ = | 0.00 | | | |
| n = | 0.00 | g | $C_{Mo}$ = | -0.025 | | | S = | 4.60 | ft² | | |
| $q.C_L$ = | 10.66 | $q.C_L$ =Lift/S | S = | 135.00 | ft² | | b = | 6.25 | ft | | |
| | | | b = | 43.00 | ft | | AR = | 8.49 | | | |

| 1 | 13 | 72 | 14 | 15 | 16 | 73 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| STATION | $C_L$ | FLAP | $C_{Lx}$ | $C_{Lz}$ | $C_D$ | FLAP | $C_{Dx}$ | $C_{Dz}$ | $C_{Lx}+C_{Dz}$ | $C_{Dx}-C_{Lz}$ | $(C_{Lx}+C_{Dz})_{AV}$ | $(C_{Dx}-C_{Lz})_{AV}$ | SPAN | SPAN |
| (in) | | $C_L$ | | | | $C_D$ | | | | | | | ELEMENT | ELEMENT |
| | | | | | | | | | | | | | LIFT | DRAG |
| | | | | | | | | | | | | | (lb) | (lb) |
| 258 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0072 | 0.0000 | 0.0072 | -0.0004 | -0.0004 | 0.0072 | - | - | 0.00 | 0.00 |
| 251.25 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0072 | 0.0000 | 0.0072 | -0.0004 | -0.0004 | 0.0072 | -0.0004 | 0.0072 | -0.05 | 0.84 |
| 238 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0072 | 0.0000 | 0.0072 | -0.0004 | -0.0004 | 0.0072 | -0.0004 | 0.0072 | -0.09 | 1.67 |
| 228 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0072 | 0.0000 | 0.0072 | -0.0004 | -0.0004 | 0.0072 | -0.0004 | 0.0072 | -0.07 | 1.27 |
| 218 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0072 | 0.0000 | 0.0072 | -0.0004 | -0.0004 | 0.0072 | -0.0004 | 0.0072 | -0.07 | 1.28 |
| 208 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0057 | 0.0000 | 0.0057 | -0.0003 | -0.0003 | 0.0057 | -0.0004 | 0.0064 | -0.06 | 1.15 |
| 198 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0057 | 0.0000 | 0.0057 | -0.0003 | -0.0003 | 0.0057 | -0.0003 | 0.0057 | -0.06 | 1.03 |
| 188 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0057 | 0.0000 | 0.0057 | -0.0003 | -0.0003 | 0.0057 | -0.0003 | 0.0057 | -0.06 | 1.04 |
| 178 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0057 | 0.0000 | 0.0057 | -0.0003 | -0.0003 | 0.0057 | -0.0003 | 0.0057 | -0.06 | 1.04 |
| 163.65 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0057 | 0.0000 | 0.0057 | -0.0003 | -0.0003 | 0.0057 | -0.0003 | 0.0057 | -0.08 | 1.51 |
| 159 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0057 | 0.0000 | 0.0057 | -0.0003 | -0.0003 | 0.0057 | -0.0003 | 0.0057 | -0.03 | 0.46 |
| 155.00 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0057 | 0.1183 | 0.1238 | -0.0069 | -0.0069 | 0.1238 | -0.0036 | 0.0647 | -0.29 | 5.23 |
| 138 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0057 | 0.1183 | 0.1238 | -0.0069 | -0.0069 | 0.1238 | -0.0069 | 0.1238 | -2.22 | 39.58 |
| 128 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0057 | 0.1183 | 0.1238 | -0.0069 | -0.0069 | 0.1238 | -0.0069 | 0.1238 | -1.32 | 23.51 |
| 118 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0057 | 0.1183 | 0.1238 | -0.0069 | -0.0069 | 0.1238 | -0.0069 | 0.1238 | -1.33 | 23.67 |
| 108 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0057 | 0.1183 | 0.1238 | -0.0069 | -0.0069 | 0.1238 | -0.0069 | 0.1238 | -1.34 | 23.83 |
| 98 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0057 | 0.1183 | 0.1238 | -0.0069 | -0.0069 | 0.1238 | -0.0069 | 0.1238 | -1.35 | 24.00 |
| 88 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0057 | 0.1183 | 0.1238 | -0.0069 | -0.0069 | 0.1238 | -0.0069 | 0.1238 | -1.35 | 24.16 |
| 80.00 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0057 | 0.1183 | 0.1238 | -0.0069 | -0.0069 | 0.1238 | -0.0069 | 0.1238 | -1.09 | 19.45 |
| 68 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0057 | 0.0000 | 0.0057 | -0.0003 | -0.0003 | 0.0057 | -0.0036 | 0.0647 | -0.86 | 15.36 |
| 58 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0057 | 0.0000 | 0.0057 | -0.0003 | -0.0003 | 0.0057 | -0.0003 | 0.0057 | -0.06 | 1.13 |
| 48 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0057 | 0.0000 | 0.0057 | -0.0003 | -0.0003 | 0.0057 | -0.0003 | 0.0057 | -0.06 | 1.14 |
| 22 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0057 | 0.0000 | 0.0057 | -0.0003 | -0.0003 | 0.0057 | -0.0003 | 0.0057 | -0.17 | 3.00 |
| 19 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0057 | 0.0000 | 0.0057 | -0.0003 | -0.0003 | 0.0057 | -0.0003 | 0.0057 | -0.02 | 0.35 |
| 0 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0057 | 0.0000 | 0.0057 | -0.0003 | -0.0003 | 0.0057 | -0.0003 | 0.0057 | -0.13 | 2.23 |
| | | | | | | | | | | | | Σ = | -12.22 | 217.94 |
| | | | | | | | | | | | | LIFT calc = | -24.43 | |
| | | | | | | | | | | | | Lift = | 1438.50 | |

SPANWISE AERODYNAMIC LOAD DISTRIBUTION

CONDITION. D BRAKES OUT cont...

| 1 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 |
|---|---|---|---|---|---|---|---|---|
| STATION | LIMIT | LIMIT | LIMIT | LIMIT | ULT | ULT | ULT | ULT |
| (in) | NORMAL | NORMAL | CHORD | CHORD | NORMAL | NORMAL | CHORD | CHORD |
| | SHEAR | MOMENT | SHEAR | MOMENT | SHEAR | MOMENT | SHEAR | MOMENT |
| | (lb) | (lb in) | (lb) | (lb in) | (lb) | (lb in) | (lb) | (lb in) |
| 258 | 0.00 | 0.00 | 0.00 | 0.00 | 0 | 0 | 0 | 0 |
| 251.25 | -0.05 | -0.16 | 0.84 | 2.85 | 0 | 0 | 1 | 4 |
| 238 | -0.14 | -1.41 | 2.51 | 25.07 | 0 | -2 | 4 | 38 |
| 228 | -0.21 | -3.17 | 3.78 | 56.54 | 0 | -5 | 6 | 85 |
| 218 | -0.28 | -5.65 | 5.06 | 100.76 | 0 | -8 | 8 | 151 |
| 208 | -0.35 | -8.81 | 6.22 | 157.15 | -1 | -13 | 9 | 236 |
| 198 | -0.41 | -12.58 | 7.24 | 224.45 | -1 | -19 | 11 | 337 |
| 188 | -0.46 | -16.93 | 8.28 | 302.08 | -1 | -25 | 12 | 453 |
| 178 | -0.52 | -21.87 | 9.32 | 390.09 | -1 | -33 | 14 | 585 |
| 163.65 | -0.61 | -29.97 | 10.83 | 534.72 | -1 | -45 | 16 | 802 |
| 159 | -0.63 | -32.66 | 11.29 | 582.57 | -1 | -49 | 17 | 874 |
| 155.00 | -0.93 | -36.03 | 16.52 | 642.71 | -1 | -54 | 25 | 964 |
| 138 | -3.14 | -70.63 | 56.10 | 1260.01 | -5 | -106 | 84 | 1890 |
| 128 | -4.46 | -108.67 | 79.61 | 1938.58 | -7 | -163 | 119 | 2908 |
| 118 | -5.79 | -159.93 | 103.28 | 2853.04 | -9 | -240 | 155 | 4280 |
| 108 | -7.13 | -224.50 | 127.12 | 4005.03 | -11 | -337 | 191 | 6008 |
| 98 | -8.47 | -302.48 | 151.11 | 5396.18 | -13 | -454 | 227 | 8094 |
| 88 | -9.83 | -393.96 | 175.28 | 7028.13 | -15 | -591 | 263 | 10542 |
| 80.00 | -10.92 | -476.92 | 194.72 | 8508.14 | -16 | -715 | 292 | 12762 |
| 68 | -11.78 | -613.07 | 210.08 | 10936.99 | -18 | -920 | 315 | 16405 |
| 58 | -11.84 | -731.15 | 211.22 | 13043.50 | -18 | -1097 | 317 | 19565 |
| 48 | -11.90 | -849.86 | 212.36 | 15161.39 | -18 | -1275 | 319 | 22742 |
| 22 | -12.07 | -1161.55 | 215.36 | 20721.76 | -18 | -1742 | 323 | 31083 |
| 19 | -12.09 | -1197.79 | 215.71 | 21368.37 | -18 | -1797 | 324 | 32053 |
| 0 | -12.22 | -1428.72 | 217.94 | 25488.08 | -18 | -2143 | 327 | 38232 |
| | | | | | | | | |
| Centre of lift is | 117 | in from aircraft centreline | | | | | | |
| | 45 | % semispan | | | | | | |

SPANWISE INERTIAL LOAD DISTRIBUTION

CONDITION. D BRAKES OUT cont...

| 1 | 3 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 | 41 | 42 | 43 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| STATION | dy | WEIGHT | ELEMENT | ELEMENT | LIMIT | LIMIT | LIMIT | LIMIT | ULT | ULT | ULT | ULT |
| (in) | (in) | nW | SHEAR | SHEAR | NORMAL | NORMAL | CHORD | CHORD | NORMAL | NORMAL | CHORD | CHORD |
| | | (lb) | FORCE | FORCE | SHEAR | MOMENT | SHEAR | MOMENT | SHEAR | MOMENT | SHEAR | MOMENT |
| | | | $V_x$ | $V_z$ | (lb) | (lb in) | (lb) | (lb in) | (lb) | (lb in) | (lb) | (lb in) |
| | | | (lb) | (lb) | | | | | | | | |
| 258 | - | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0 | 0 | 0 | 0 |
| 251.25 | 6.75 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0 | 0 | 0 | 0 |
| 238 | 13.25 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0 | 0 | 0 | 0 |
| 228 | 10.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0 | 0 | 0 | 0 |
| 218 | 10.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0 | 0 | 0 | 0 |
| 208 | 10.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0 | 0 | 0 | 0 |
| 198 | 10.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0 | 0 | 0 | 0 |
| 188 | 10.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0 | 0 | 0 | 0 |
| 178 | 10.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0 | 0 | 0 | 0 |
| 163.65 | 14.35 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0 | 0 | 0 | 0 |
| 159 | 4.33 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0 | 0 | 0 | 0 |
| 155.00 | 4.32 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0 | 0 | 0 | 0 |
| 138 | 17.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0 | 0 | 0 | 0 |
| 128 | 10.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0 | 0 | 0 | 0 |
| 118 | 10.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0 | 0 | 0 | 0 |
| 108 | 10.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0 | 0 | 0 | 0 |
| 98 | 10.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0 | 0 | 0 | 0 |
| 88 | 10.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0 | 0 | 0 | 0 |
| 80.00 | 8.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0 | 0 | 0 | 0 |
| 68 | 12.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0 | 0 | 0 | 0 |
| 58 | 10.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0 | 0 | 0 | 0 |
| 48 | 10.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0 | 0 | 0 | 0 |
| 22 | 26.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0 | 0 | 0 | 0 |
| 19 | 3.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0 | 0 | 0 | 0 |
| 0 | 19.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0 | 0 | 0 | 0 |
| | Σ = | #DIV/0! | lb | | | | | | | | | |
| | | at 1 g | | | Centre of gravity is | #DIV/0! | in from aircraft centreline | | | | | |
| | | | | | | #DIV/0! | % semispan | | | | | |

| COMBINED ULTIMATE LOADS ( AERODYNAMIC + INERTIAL ) | | | | | | |
|---|---|---|---|---|---|---|
| CONDITION. D BRAKES OUT cont... | | | | | | |
| 1 | 44 D | 45 D | 46 D | 47 D | 48 D | 49 D |
| | ULT | ULT | ULT | ULT | ULT | ULT |
| | NORMAL | NORMAL | CHORD | CHORD | RESOLVED | RESOLVED |
| STATION | SHEAR | BEND MOMENT | SHEAR | BEND MOMENT | SHEAR | BEND MOMENT |
| (in) | COND. D | COND. D | COND. D | COND. D | COND. D | COND. D |
| | (lb) | (lb in) | (lb) | (lb in) | (lb) | (lb in) |
| 258 | 0 | 0 | 0 | 0 | 0 | 0 |
| 251.25 | 0 | 0 | 1 | 4 | 1 | 4 |
| 238 | 0 | -2 | 4 | 38 | 4 | 38 |
| 228 | 0 | -5 | 6 | 85 | 6 | 85 |
| 218 | 0 | -8 | 8 | 151 | 8 | 151 |
| 208 | -1 | -13 | 9 | 236 | 9 | 236 |
| 198 | -1 | -19 | 11 | 337 | 11 | 337 |
| 188 | -1 | -25 | 12 | 453 | 12 | 454 |
| 178 | -1 | -33 | 14 | 585 | 14 | 586 |
| 163.65 | -1 | -45 | 16 | 802 | 16 | 803 |
| 159 | -1 | -49 | 17 | 874 | 17 | 875 |
| 155.00 | -1 | -54 | 25 | 964 | 25 | 966 |
| 138 | -5 | -106 | 84 | 1890 | 84 | 1893 |
| 128 | -7 | -163 | 119 | 2908 | 120 | 2912 |
| 118 | -9 | -240 | 155 | 4280 | 155 | 4286 |
| 108 | -11 | -337 | 191 | 6008 | 191 | 6017 |
| 98 | -13 | -454 | 227 | 8094 | 227 | 8107 |
| 88 | -15 | -591 | 263 | 10542 | 263 | 10559 |
| 80.00 | -16 | -715 | 292 | 12762 | 293 | 12782 |
| 68 | -18 | -920 | 315 | 16405 | 316 | 16431 |
| 58 | -18 | -1097 | 317 | 19565 | 317 | 19596 |
| 48 | -18 | -1275 | 319 | 22742 | 319 | 22778 |
| 22 | -18 | -1742 | 323 | 31083 | 324 | 31131 |
| 19 | -18 | -1797 | 324 | 32053 | 324 | 32103 |
| 0 | -18 | -2143 | 327 | 38232 | 327 | 38292 |

AERODYNAMIC TORQUE AT SHEAR CENTRE

CONDITION. D BRAKES OUT cont...

| 1 | 50 | 74 | 51 | 52 | 53 | 54 | 55 | 56 | 57 | 58 |
|---|---|---|---|---|---|---|---|---|---|---|
| STATION | CLEAN + FLAPPED | CLEAN + FLAPPEI | LOCAL | AERO | X AC | X SC | DELTA X | Z AC | Z SC | DELTA Z |
| | LOCAL | LOCAL | $X_{CP}$ | CENTRE | (in) | (in) | (in) | (in) | (in) | (in) |
| (in) | $C_L$ | $C_{Mo}$ | | (in) | | using 38% chord | | | | |
| 258 | - | -0.025 | 0.00 | 0.00 | 0.00 | 13.30 | 13.30 | 0.00 | 2.39 | -2.39 |
| 251.25 | 0.00 | -0.025 | -61.80 | -2174.19 | -2174.19 | 13.37 | 2187.56 | 0.00 | 2.40 | -2.40 |
| 238 | 0.00 | -0.025 | -61.80 | -2196.09 | -2196.09 | 13.50 | 2209.59 | 0.00 | 2.44 | -2.44 |
| 228 | 0.00 | -0.025 | -61.80 | -2212.62 | -2212.62 | 13.60 | 2226.22 | 0.00 | 2.47 | -2.47 |
| 218 | 0.00 | -0.025 | -61.80 | -2229.14 | -2229.14 | 13.71 | 2242.85 | 0.00 | 2.49 | -2.49 |
| 208 | 0.00 | -0.025 | -69.01 | -2507.81 | -2507.81 | 13.81 | 2521.62 | 0.00 | 2.52 | -2.52 |
| 198 | 0.00 | -0.025 | -78.13 | -2859.83 | -2859.83 | 13.91 | 2873.74 | 0.00 | 2.54 | -2.54 |
| 188 | 0.00 | -0.025 | -78.13 | -2880.72 | -2880.72 | 14.01 | 2894.73 | 0.00 | 2.57 | -2.57 |
| 178 | 0.00 | -0.025 | -78.13 | -2901.62 | -2901.62 | 14.11 | 2915.73 | 0.00 | 2.60 | -2.60 |
| 163.65 | 0.00 | -0.025 | -78.13 | -2931.60 | -2931.60 | 14.26 | 2945.86 | 0.00 | 2.64 | -2.64 |
| 159 | 0.00 | -0.025 | -78.13 | -2940.64 | -2940.64 | 14.30 | 2954.94 | 0.00 | 2.65 | -2.65 |
| 155.00 | 0.00 | -0.025 | -6.65 | -251.08 | -251.08 | 14.35 | 265.43 | 0.00 | 2.66 | -2.66 |
| 138 | -0.01 | -0.025 | -3.36 | -128.52 | -128.52 | 14.52 | 143.04 | 0.00 | 2.70 | -2.70 |
| 128 | -0.01 | -0.025 | -3.36 | -129.42 | -129.42 | 14.62 | 144.04 | 0.00 | 2.73 | -2.73 |
| 118 | -0.01 | -0.025 | -3.36 | -130.32 | -130.32 | 14.72 | 145.04 | 0.00 | 2.76 | -2.76 |
| 108 | -0.01 | -0.025 | -3.36 | -131.22 | -131.22 | 14.82 | 146.04 | 0.00 | 2.78 | -2.78 |
| 98 | -0.01 | -0.025 | -3.36 | -132.12 | -132.12 | 14.93 | 147.05 | 0.00 | 2.81 | -2.81 |
| 88 | -0.01 | -0.025 | -3.36 | -133.02 | -133.02 | 15.03 | 148.05 | 0.00 | 2.84 | -2.84 |
| 80.00 | -0.01 | -0.025 | -3.36 | -133.74 | -133.74 | 15.11 | 148.85 | 0.00 | 2.86 | -2.86 |
| 68 | 0.00 | -0.025 | -6.65 | -266.56 | -266.56 | 15.23 | 281.79 | 0.00 | 2.89 | -2.89 |
| 58 | 0.00 | -0.025 | -78.13 | -3152.35 | -3152.35 | 15.33 | 3167.68 | 0.00 | 2.92 | -2.92 |
| 48 | 0.00 | -0.025 | -78.13 | -3173.25 | -3173.25 | 15.43 | 3188.68 | 0.00 | 2.94 | -2.94 |
| 22 | 0.00 | -0.025 | -78.13 | -3227.57 | -3227.57 | 15.70 | 3243.27 | 0.00 | 3.01 | -3.01 |
| 19 | 0.00 | -0.025 | -78.13 | -3233.84 | -3233.84 | 15.73 | 3249.57 | 0.00 | 3.01 | -3.01 |
| 0 | 0.00 | -0.025 | -78.13 | -3273.54 | -3273.54 | 15.92 | 3289.46 | 0.00 | 1.25 | -1.25 |

AERODYNAMIC TORQUE AT SHEAR CENTRE

CONDITION. D BRAKES OUT cont...

| 1 | 55 | 56 | 23 | 24 | 59 | 75 | 60 | 61 | 62 | 63 | 64 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | $\Delta C_{Mo}$ 0 | | | | | |
| STATION | DELTA | DELTA | SPAN | SPAN | ELEMENT | ELEMENT | ELEMENT | ELEMENT | ELEMENT | TOTAL | TOTAL |
| | X av | Z av | ELEMENT | ELEMENT | TORQUE | TORQUE | TORQUE | TORQUE | LIMIT | LIMIT | ULT |
| (in) | (in) | (in) | LIFT | DRAG | DUE TO | DUE TO | DUE TO | DUE TO | TORQUE | TORQUE | TORQUE |
| | | | (lb) | (lb) | $C_{Mo}$ | $\Delta C_{Mo}$ | LIFT | DRAG | (lb in) | (lb in) | (lb in) |
| | | | | | (lb in) | (lb in) | (lb in) | (lb in) | | | |
| 258 | - | - | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 251.25 | 1100.43 | 0.00 | -0.05 | 0.84 | -102.93 | 0.00 | -52.03 | 0.00 | -154.95 | -154.95 | -232.43 |
| 238 | 2198.57 | 0.00 | -0.09 | 1.67 | -205.13 | 0.00 | -205.60 | 0.00 | -410.73 | -565.68 | -848.52 |
| 228 | 2217.91 | 0.00 | -0.07 | 1.27 | -157.55 | 0.00 | -157.91 | 0.00 | -315.46 | -881.14 | -1321.71 |
| 218 | 2234.54 | 0.00 | -0.07 | 1.28 | -159.92 | 0.00 | -160.28 | 0.00 | -320.21 | -1201.35 | -1802.03 |
| 208 | 2382.23 | 0.00 | -0.06 | 1.15 | -162.31 | 0.00 | -154.22 | 0.00 | -316.53 | -1517.88 | -2276.82 |
| 198 | 2697.68 | 0.00 | -0.06 | 1.03 | -164.72 | 0.00 | -155.47 | 0.00 | -320.19 | -1838.07 | -2757.11 |
| 188 | 2884.24 | 0.00 | -0.06 | 1.04 | -167.14 | 0.00 | -167.44 | 0.00 | -334.59 | -2172.66 | -3258.99 |
| 178 | 2905.23 | 0.00 | -0.06 | 1.04 | -169.59 | 0.00 | -169.89 | 0.00 | -339.48 | -2512.14 | -3768.21 |
| 163.65 | 2930.79 | 0.00 | -0.08 | 1.51 | -247.66 | 0.00 | -248.10 | 0.00 | -495.76 | -3007.90 | -4511.85 |
| 159 | 2950.40 | 0.00 | -0.03 | 0.46 | -75.64 | 0.00 | -75.78 | 0.00 | -151.42 | -3159.32 | -4738.98 |
| 155.00 | 1610.18 | 0.00 | -0.29 | 5.23 | -76.11 | 0.00 | -471.82 | 0.00 | -547.93 | -3707.25 | -5560.88 |
| 138 | 204.24 | 0.00 | -2.22 | 39.58 | -303.71 | 0.00 | -453.18 | 0.00 | -756.89 | -4464.14 | -6696.21 |
| 128 | 143.54 | 0.00 | -1.32 | 23.51 | -182.06 | 0.00 | -189.14 | 0.00 | -371.20 | -4835.34 | -7253.01 |
| 118 | 144.54 | 0.00 | -1.33 | 23.67 | -184.61 | 0.00 | -191.79 | 0.00 | -376.40 | -5211.74 | -7817.61 |
| 108 | 145.54 | 0.00 | -1.34 | 23.83 | -187.18 | 0.00 | -194.45 | 0.00 | -381.63 | -5593.37 | -8390.05 |
| 98 | 146.54 | 0.00 | -1.35 | 24.00 | -189.76 | 0.00 | -197.14 | 0.00 | -386.90 | -5980.27 | -8970.40 |
| 88 | 147.55 | 0.00 | -1.35 | 24.16 | -192.37 | 0.00 | -199.84 | 0.00 | -392.20 | -6372.47 | -9558.71 |
| 80.00 | 148.45 | 0.00 | -1.09 | 19.45 | -155.78 | 0.00 | -161.83 | 0.00 | -317.61 | -6690.08 | -10035.12 |
| 68 | 215.32 | 0.00 | -0.86 | 15.36 | -236.83 | 0.00 | -185.38 | 0.00 | -422.21 | -7112.29 | -10668.44 |
| 58 | 1724.74 | 0.00 | -0.06 | 1.13 | -200.28 | 0.00 | -109.60 | 0.00 | -309.88 | -7422.17 | -11133.26 |
| 48 | 3178.18 | 0.00 | -0.06 | 1.14 | -202.95 | 0.00 | -203.31 | 0.00 | -406.26 | -7828.43 | -11742.65 |
| 22 | 3215.98 | 0.00 | -0.17 | 3.00 | -540.29 | 0.00 | -541.26 | 0.00 | -1081.55 | -8909.98 | -13364.98 |
| 19 | 3246.42 | 0.00 | -0.02 | 0.35 | -63.53 | 0.00 | -63.64 | 0.00 | -127.17 | -9037.15 | -13555.73 |
| 0 | 3269.52 | 0.00 | -0.13 | 2.23 | -408.09 | 0.00 | -408.81 | 0.00 | -816.90 | -9854.05 | -14781.08 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| DEAD WEIGHT ANALYSIS FOR WING TORQUE | | | | | | | | |
| CONDITION. D BRAKES OUT cont... | | | | | | | | |
| 1 | 65 | 54 | 66 | 67 | 33 | 68 | 69 | 70 |
| STATION | X CG | X SC | DELTA | DELTA | ELEMENT | ELEMENT | TOTAL | TOTAL |
| | (in) | (in) | X | X av | LOAD | LIMIT | LIMIT | ULT |
| (in) | | | (in) | (in) | (lb) | TORQUE | TORQUE | TORQUE |
| · | using 40% chord | | | | | (lb in) | (lb in) | (lb in) |
| 258 | 14.00 | 13.30 | -0.70 | - | - | - | - | 0.00 |
| 251.25 | 14.07 | 13.37 | -0.70 | -0.70 | 0.00 | 0.00 | 0.00 | 0.00 |
| 238 | 14.21 | 13.50 | -0.71 | -0.71 | 0.00 | 0.00 | 0.00 | 0.00 |
| 228 | 14.32 | 13.60 | -0.72 | -0.71 | 0.00 | 0.00 | 0.00 | 0.00 |
| 218 | 14.43 | 13.71 | -0.72 | -0.72 | 0.00 | 0.00 | 0.00 | 0.00 |
| 208 | 14.53 | 13.81 | -0.73 | -0.72 | 0.00 | 0.00 | 0.00 | 0.00 |
| 198 | 14.64 | 13.91 | -0.73 | -0.73 | 0.00 | 0.00 | 0.00 | 0.00 |
| 188 | 14.75 | 14.01 | -0.74 | -0.73 | 0.00 | 0.00 | 0.00 | 0.00 |
| 178 | 14.86 | 14.11 | -0.74 | -0.74 | 0.00 | 0.00 | 0.00 | 0.00 |
| 163.65 | 15.01 | 14.26 | -0.75 | -0.75 | 0.00 | 0.00 | 0.00 | 0.00 |
| 159 | 15.06 | 14.30 | -0.75 | -0.75 | 0.00 | 0.00 | 0.00 | 0.00 |
| 155.00 | 15.10 | 14.35 | -0.76 | -0.75 | 0.00 | 0.00 | 0.00 | 0.00 |
| 138 | 15.28 | 14.52 | -0.76 | -0.76 | 0.00 | 0.00 | 0.00 | 0.00 |
| 128 | 15.39 | 14.62 | -0.77 | -0.77 | 0.00 | 0.00 | 0.00 | 0.00 |
| 118 | 15.50 | 14.72 | -0.77 | -0.77 | 0.00 | 0.00 | 0.00 | 0.00 |
| 108 | 15.60 | 14.82 | -0.78 | -0.78 | 0.00 | 0.00 | 0.00 | 0.00 |
| 98 | 15.71 | 14.93 | -0.79 | -0.78 | 0.00 | 0.00 | 0.00 | 0.00 |
| 88 | 15.82 | 15.03 | -0.79 | -0.79 | 0.00 | 0.00 | 0.00 | 0.00 |
| 80.00 | 15.90 | 15.11 | -0.80 | -0.79 | 0.00 | 0.00 | 0.00 | 0.00 |
| 68 | 16.03 | 15.23 | -0.80 | -0.80 | 0.00 | 0.00 | 0.00 | 0.00 |
| 58 | 16.14 | 15.33 | -0.81 | -0.80 | 0.00 | 0.00 | 0.00 | 0.00 |
| 48 | 16.25 | 15.43 | -0.81 | -0.81 | 0.00 | 0.00 | 0.00 | 0.00 |
| 22 | 16.52 | 15.70 | -0.83 | -0.82 | 0.00 | 0.00 | 0.00 | 0.00 |
| 19 | 16.56 | 15.73 | -0.83 | -0.83 | 0.00 | 0.00 | 0.00 | 0.00 |
| 0 | 16.76 | 15.92 | -0.84 | -0.83 | 0.00 | 0.00 | 0.00 | 0.00 |

| COMBINED ULTIMATE TORSION ( AERODYNAMIC + INERTIAL ) | | | |
|---|---|---|---|
| CONDITION. D BRAKES OUT cont... | | | |
| | | | |
| | | | |
| 1 | 71 D | | |
| STATION | COND. D | | |
| (in) | (lb in) | | |
| 258 | 0 | | |
| 251.25 | -232 | | |
| 238 | -849 | | |
| 228 | -1322 | | |
| 218 | -1802 | | |
| 208 | -2277 | | |
| 198 | -2757 | | |
| 188 | -3259 | | |
| 178 | -3768 | | |
| 163.65 | -4512 | | |
| 159 | -4739 | | |
| 155.00 | -5561 | | |
| 138 | -6696 | | |
| 128 | -7253 | | |
| 118 | -7818 | | |
| 108 | -8390 | | |
| 98 | -8970 | | |
| 88 | -9559 | | |
| 80.00 | -10035 | | |
| 68 | -10668 | | |
| 58 | -11133 | | |
| 48 | -11743 | | |
| 22 | -13365 | | |
| 19 | -13556 | | |
| 0 | -14781 | | |

## SPANWISE AERODYNAMIC LOAD DISTRIBUTION

CONDITION. E BRAKES OUT

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | | | Brake angle = | 30.00 | deg |
| | | | | | Brake load = | 189.38 | lb at 1g (30 |
| $V_{sal}$ = | 244.93 ft/s | $C_L$ = | -0.2 | alpha wrp = | -5.1794 | $\Delta C_L$ = | 0.00 |
| Lift = | -1822.10 lb clean | $C_{Do}$ = | 0.007 | sin alpha = | -0.0903 | $\Delta C_D$ = | 0.58 |
| q = | 71.33 psf | $C_D$ = | 0.008 | cos alpha = | 0.9959 | $\Delta C_{Mo}$ = | 0.00 |
| n = | -1.27 g | $C_{Mo}$ = | -0.025 | | | S = | 4.60 $ft^2$ |
| $q.C_L$ = | -13.50 $q.C_L$ =Lift/S | S = | 135.00 $ft^2$ | | | b = | 6.25 ft |
| | | b = | 43.00 ft | | | AR = | 8.49 |

ECF = 0.21

| 1 | 13 | 72 | 15 | 16 | 17 | 73 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| STATION | $C_L$ | FLAP | $C_{Lx}$ | $C_{Lz}$ | $C_D$ | FLAP | $C_{Dx}$ | $C_{Dz}$ | $C_{Lz}+C_{Dz}$ | $C_{Dx}-C_{Lx}$ | $(C_{Lz}+C_{Dz})_{AV}$ | $(C_{Dx}-C_{Lx})_{AV}$ | SPAN | SPAN |
| (in) | | $C_L$ | | | | $C_D$ | | | | | | | ELEMENT | ELEMENT |
| | | | | | | | | | | | | | LIFT | DRAG |
| | | | | | | | | | | | | | (lb) | (lb) |
| 258 | -0.0946 | 0.0000 | 0.0085 | -0.0942 | 0.0096 | 0.0000 | 0.0096 | -0.0009 | -0.0951 | 0.0011 | - | - | 0.00 | 0.00 |
| 251.25 | -0.1239 | 0.0000 | 0.0112 | -0.1234 | 0.0096 | 0.0000 | 0.0096 | -0.0009 | -0.1243 | -0.0016 | -0.1097 | -0.0003 | -12.87 | -0.03 |
| 238 | -0.1439 | 0.0000 | 0.0130 | -0.1433 | 0.0096 | 0.0000 | 0.0096 | -0.0009 | -0.1442 | -0.0034 | -0.1342 | -0.0025 | -31.15 | -0.58 |
| 228 | -0.1539 | 0.0000 | 0.0139 | -0.1533 | 0.0096 | 0.0000 | 0.0096 | -0.0009 | -0.1542 | -0.0043 | -0.1492 | -0.0038 | -26.36 | -0.68 |
| 218 | -0.1619 | 0.0000 | 0.0146 | -0.1612 | 0.0096 | 0.0000 | 0.0096 | -0.0009 | -0.1621 | -0.0050 | -0.1581 | -0.0046 | -28.15 | -0.83 |
| 208 | -0.1685 | 0.0000 | 0.0152 | -0.1678 | 0.0076 | 0.0000 | 0.0076 | -0.0007 | -0.1685 | -0.0076 | -0.1653 | -0.0063 | -29.65 | -1.13 |
| 198 | -0.1741 | 0.0000 | 0.0157 | -0.1734 | 0.0076 | 0.0000 | 0.0076 | -0.0007 | -0.1741 | -0.0081 | -0.1713 | -0.0079 | -30.94 | -1.42 |
| 188 | -0.1789 | 0.0000 | 0.0162 | -0.1782 | 0.0076 | 0.0000 | 0.0076 | -0.0007 | -0.1789 | -0.0085 | -0.1765 | -0.0083 | -32.11 | -1.52 |
| 178 | -0.1831 | 0.0000 | 0.0165 | -0.1823 | 0.0076 | 0.0000 | 0.0076 | -0.0007 | -0.1830 | -0.0089 | -0.1809 | -0.0087 | -33.17 | -1.60 |
| 163.65 | -0.1881 | 0.0000 | 0.0170 | -0.1873 | 0.0076 | 0.0000 | 0.0076 | -0.0007 | -0.1880 | -0.0094 | -0.1855 | -0.0091 | -49.23 | -2.43 |
| 159 | -0.1894 | 0.0000 | 0.0171 | -0.1887 | 0.0076 | 0.0000 | 0.0076 | -0.0007 | -0.1894 | -0.0095 | -0.1887 | -0.0094 | -15.19 | -0.76 |
| 155.00 | -0.1907 | 0.0000 | 0.0172 | -0.1899 | 0.0076 | 0.1188 | 0.1260 | -0.0114 | -0.2013 | 0.1087 | -0.1954 | 0.0496 | -15.78 | 4.01 |
| 138 | -0.1950 | 0.0000 | 0.0176 | -0.1942 | 0.0076 | 0.1188 | 0.1260 | -0.0114 | -0.2056 | 0.1084 | -0.2035 | 0.1085 | -65.08 | 34.72 |
| 128 | -0.1970 | 0.0000 | 0.0178 | -0.1962 | 0.0076 | 0.1188 | 0.1260 | -0.0114 | -0.2076 | 0.1082 | -0.2066 | 0.1083 | -39.24 | 20.56 |
| 118 | -0.1988 | 0.0000 | 0.0179 | -0.1980 | 0.0076 | 0.1188 | 0.1260 | -0.0114 | -0.2094 | 0.1080 | -0.2085 | 0.1081 | -39.88 | 20.67 |
| 108 | -0.2003 | 0.0000 | 0.0181 | -0.1994 | 0.0076 | 0.1188 | 0.1260 | -0.0114 | -0.2109 | 0.1079 | -0.2101 | 0.1079 | -40.47 | 20.79 |
| 98 | -0.2015 | 0.0000 | 0.0182 | -0.2007 | 0.0076 | 0.1188 | 0.1260 | -0.0114 | -0.2121 | 0.1078 | -0.2115 | 0.1078 | -41.01 | 20.91 |
| 88 | -0.2025 | 0.0000 | 0.0183 | -0.2017 | 0.0076 | 0.1188 | 0.1260 | -0.0114 | -0.2131 | 0.1077 | -0.2126 | 0.1077 | -41.50 | 21.03 |
| 80.00 | -0.2031 | 0.0000 | 0.0183 | -0.2023 | 0.0076 | 0.1188 | 0.1260 | -0.0114 | -0.2137 | 0.1076 | -0.2134 | 0.1076 | -33.53 | 16.92 |
| 68 | -0.2038 | 0.0000 | 0.0184 | -0.2030 | 0.0076 | 0.0000 | 0.0076 | -0.0007 | -0.2037 | -0.0108 | -0.2087 | 0.0484 | -49.52 | 11.49 |
| 58 | -0.2042 | 0.0000 | 0.0184 | -0.2034 | 0.0076 | 0.0000 | 0.0076 | -0.0007 | -0.2041 | -0.0108 | -0.2039 | -0.0108 | -40.61 | -2.15 |
| 48 | -0.2044 | 0.0000 | 0.0185 | -0.2036 | 0.0076 | 0.0000 | 0.0076 | -0.0007 | -0.2042 | -0.0108 | -0.2042 | -0.0108 | -40.94 | -2.17 |
| 22 | -0.2041 | 0.0000 | 0.0184 | -0.2032 | 0.0076 | 0.0000 | 0.0076 | -0.0007 | -0.2039 | -0.0108 | -0.2041 | -0.0108 | -107.67 | -5.71 |
| 19 | -0.2040 | 0.0000 | 0.0184 | -0.2031 | 0.0076 | 0.0000 | 0.0076 | -0.0007 | -0.2038 | -0.0108 | -0.2039 | -0.0108 | -12.53 | -0.66 |
| 0 | -0.2029 | 0.0000 | 0.0183 | -0.2021 | 0.0076 | 0.0000 | 0.0076 | -0.0007 | -0.2028 | -0.0107 | -0.2033 | -0.0108 | -79.68 | -4.22 |
| | | | | | | | | | | | | Σ = | -936.26 | 145.21 |
| | | | | | | | | | | | | LIFT calc = | -1872.53 | |
| | | | | | | | | | | | | Lift = | -1822.10 | |

SPANWISE AERODYNAMIC LOAD DISTRIBUTION

CONDITION. E BRAKES OUT cont...

| 1 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 |
|---|---|---|---|---|---|---|---|---|
| STATION | LIMIT | LIMIT | LIMIT | LIMIT | ULT | ULT | ULT | ULT |
| (in) | NORMAL | NORMAL | CHORD | CHORD | NORMAL | NORMAL | CHORD | CHORD |
| | SHEAR | MOMENT | SHEAR | MOMENT | SHEAR | MOMENT | SHEAR | MOMENT |
| | (lb) | (lb in) | (lb) | (lb in) | (lb) | (lb in) | (lb) | (lb in) |
| 258 | 0.00 | 0.00 | 0.00 | 0.00 | 0 | 0 | 0 | 0 |
| 251.25 | -12.87 | -43.44 | -0.03 | -0.10 | -19 | -65 | 0 | 0 |
| 238 | -44.02 | -420.35 | -0.61 | -4.31 | -66 | -631 | -1 | -6 |
| 228 | -70.38 | -992.38 | -1.28 | -13.76 | -106 | -1489 | -2 | -21 |
| 218 | -98.53 | -1836.95 | -2.11 | -30.72 | -148 | -2755 | -3 | -46 |
| 208 | -128.18 | -2970.51 | -3.24 | -57.48 | -192 | -4456 | -5 | -86 |
| 198 | -159.12 | -4407.01 | -4.66 | -96.99 | -239 | -6611 | -7 | -145 |
| 188 | -191.24 | -6158.81 | -6.18 | -151.17 | -287 | -9238 | -9 | -227 |
| 178 | -224.40 | -8237.02 | -7.78 | -220.93 | -337 | -12356 | -12 | -331 |
| 163.65 | -273.63 | -11810.43 | -10.20 | -349.94 | -410 | -17716 | -15 | -525 |
| 159 | -288.83 | -13026.75 | -10.96 | -395.71 | -433 | -19540 | -16 | -594 |
| 155.00 | -304.60 | -14310.04 | -6.96 | -434.46 | -457 | -21465 | -10 | -652 |
| 138 | -369.68 | -20041.44 | 27.76 | -257.60 | -555 | -30062 | 42 | -386 |
| 128 | -408.92 | -23934.45 | 48.33 | 122.84 | -613 | -35902 | 72 | 184 |
| 118 | -448.80 | -28223.05 | 69.00 | 709.46 | -673 | -42335 | 103 | 1064 |
| 108 | -489.26 | -32913.37 | 89.79 | 1503.39 | -734 | -49370 | 135 | 2255 |
| 98 | -530.27 | -38011.04 | 110.69 | 2505.80 | -795 | -57017 | 166 | 3759 |
| 88 | -571.77 | -43521.24 | 131.73 | 3717.90 | -858 | -65282 | 198 | 5577 |
| 80.00 | -605.30 | -48229.55 | 148.64 | 4839.36 | -908 | -72344 | 223 | 7259 |
| 68 | -654.83 | -55790.35 | 160.13 | 6691.98 | -982 | -83686 | 240 | 10038 |
| 58 | -695.44 | -62541.70 | 157.98 | 8282.50 | -1043 | -93813 | 237 | 12424 |
| 48 | -736.38 | -69700.81 | 155.80 | 9851.39 | -1105 | -104551 | 234 | 14777 |
| 22 | -844.05 | -90246.44 | 150.09 | 13827.98 | -1266 | -135370 | 225 | 20742 |
| 19 | -856.58 | -92797.39 | 149.42 | 14277.25 | -1285 | -139196 | 224 | 21416 |
| 0 | -936.26 | -109829.39 | 145.21 | 17076.26 | -1404 | -164744 | 218 | 25614 |
| | | | | | | | | |
| Centre of lift is | 117 | in from aircraft centreline | | | | | | |
| | 45 | % semispan | | | | | | |

SPANWISE INERTIAL LOAD DISTRIBUTION

CONDITION. E BRAKES OUT cont...

| 1 STATION (in) | 3 dy (in) | 33 WEIGHT nW (lb) | 34 ELEMENT SHEAR FORCE $V_x$ (lb) | 35 ELEMENT SHEAR FORCE $V_z$ (lb) | 36 LIMIT NORMAL SHEAR (lb) | 37 LIMIT NORMAL MOMENT (lb in) | 38 LIMIT CHORD SHEAR (lb) | 39 LIMIT CHORD MOMENT (lb in) | 40 ULT NORMAL SHEAR (lb) | 41 ULT NORMAL MOMENT (lb in) | 42 ULT CHORD SHEAR (lb) | 43 ULT CHORD MOMENT (lb in) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 258 | - | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0 | 0 | 0 | 0 |
| 251.25 | 6.75 | 0.50 | 0.04 | 0.49 | 0.49 | 1.66 | 0.04 | 0.15 | 1 | 2 | 0 | 0 |
| 238 | 13.25 | 1.32 | 0.12 | 1.31 | 1.81 | 16.89 | 0.16 | 1.53 | 3 | 25 | 0 | 2 |
| 228 | 10.00 | 2.28 | 0.21 | 2.27 | 4.08 | 46.29 | 0.37 | 4.20 | 6 | 69 | 1 | 6 |
| 218 | 10.00 | 3.19 | 0.29 | 3.18 | 7.25 | 102.95 | 0.66 | 9.33 | 11 | 154 | 1 | 14 |
| 208 | 10.00 | 3.91 | 0.35 | 3.90 | 11.15 | 194.98 | 1.01 | 17.67 | 17 | 292 | 2 | 27 |
| 198 | 10.00 | 4.60 | 0.42 | 4.58 | 15.73 | 329.41 | 1.43 | 29.86 | 24 | 494 | 2 | 45 |
| 188 | 10.00 | 5.45 | 0.49 | 5.42 | 21.16 | 513.85 | 1.92 | 46.58 | 32 | 771 | 3 | 70 |
| 178 | 10.00 | 6.17 | 0.56 | 6.14 | 27.30 | 756.13 | 2.47 | 68.54 | 41 | 1134 | 4 | 103 |
| 163.65 | 14.35 | 7.09 | 0.64 | 7.06 | 34.36 | 1198.57 | 3.11 | 108.64 | 52 | 1798 | 5 | 163 |
| 159 | 4.33 | 7.32 | 0.66 | 7.29 | 41.66 | 1362.97 | 3.78 | 123.54 | 62 | 2044 | 6 | 185 |
| 155.00 | 4.32 | 7.63 | 0.69 | 7.59 | 49.25 | 1559.55 | 4.46 | 141.36 | 74 | 2339 | 7 | 212 |
| 138 | 17.00 | 8.01 | 0.72 | 7.97 | 57.22 | 2464.56 | 5.19 | 223.40 | 86 | 3697 | 8 | 335 |
| 128 | 10.00 | 8.13 | 0.73 | 8.10 | 65.32 | 3077.28 | 5.92 | 278.94 | 98 | 4616 | 9 | 418 |
| 118 | 10.00 | 8.36 | 0.75 | 8.33 | 73.65 | 3772.13 | 6.68 | 341.92 | 110 | 5658 | 10 | 513 |
| 108 | 10.00 | 8.47 | 0.76 | 8.44 | 82.09 | 4550.80 | 7.44 | 412.50 | 123 | 6826 | 11 | 619 |
| 98 | 10.00 | 8.61 | 0.78 | 8.58 | 90.66 | 5414.55 | 8.22 | 490.80 | 136 | 8122 | 12 | 736 |
| 88 | 10.00 | 8.96 | 0.81 | 8.92 | 99.58 | 6365.79 | 9.03 | 577.02 | 149 | 9549 | 14 | 866 |
| 80.00 | 8.00 | 9.15 | 0.83 | 9.11 | 108.69 | 7198.90 | 9.85 | 652.54 | 163 | 10798 | 15 | 979 |
| 68 | 12.00 | 9.49 | 0.86 | 9.45 | 118.14 | 8559.89 | 10.71 | 775.90 | 177 | 12840 | 16 | 1164 |
| 58 | 10.00 | 9.73 | 0.88 | 9.69 | 127.83 | 9789.73 | 11.59 | 887.38 | 192 | 14685 | 17 | 1331 |
| 48 | 10.00 | 10.11 | 0.91 | 10.07 | 137.90 | 11118.35 | 12.50 | 1007.81 | 207 | 16678 | 19 | 1512 |
| 22 | 26.00 | 10.83 | 0.98 | 10.79 | 148.68 | 14843.83 | 13.48 | 1345.50 | 223 | 22266 | 20 | 2018 |
| 19 | 3.00 | 5.45 | 0.49 | 5.43 | 154.11 | 15298.03 | 13.97 | 1386.67 | 231 | 22947 | 21 | 2080 |
| 0 | 19.00 | 3.64 | 0.33 | 3.62 | 157.73 | 18260.58 | 14.30 | 1655.21 | 237 | 27391 | 21 | 2483 |
| | Σ = | 125 | lb | | | | | | | | | |
| | | at 1 g | | | Centre of gravity is | 116 | in from aircraft centreline | | | | | |
| | | | | | | 45 | % semispan | | | | | |

COMBINED ULTIMATE LOADS ( AERODYNAMIC + INERTIAL )

CONDITION. E BRAKES OUT cont...

| 1 | 44 E | 45 E | 46 E | 47 E | 48 E | 49 E |
|---|---|---|---|---|---|---|
| | ULT | ULT | ULT | ULT | ULT | ULT |
| | NORMAL | NORMAL | CHORD | CHORD | RESOLVED | RESOLVED |
| STATION | SHEAR | BEND MOMENT | SHEAR | BEND MOMENT | SHEAR | BEND MOMENT |
| (in) | COND. E | COND. E | COND. E | COND. E | COND. E | COND. E |
| | (lb) | (lb in) | (lb) | (lb in) | (lb) | (lb in) |
| 258 | 0 | 0 | 0 | 0 | 0 | 0 |
| 251.25 | -19 | -63 | 0 | 0 | 19 | 63 |
| 238 | -63 | -605 | -1 | -4 | 63 | 605 |
| 228 | -99 | -1419 | -1 | -14 | 99 | 1419 |
| 218 | -137 | -2601 | -2 | -32 | 137 | 2601 |
| 208 | -176 | -4163 | -3 | -60 | 176 | 4164 |
| 198 | -215 | -6116 | -5 | -101 | 215 | 6117 |
| 188 | -255 | -8467 | -6 | -157 | 255 | 8469 |
| 178 | -296 | -11221 | -8 | -229 | 296 | 11224 |
| 163.65 | -359 | -15918 | -11 | -362 | 359 | 15922 |
| 159 | -371 | -17496 | -11 | -408 | 371 | 17500 |
| 155.00 | -383 | -19126 | -4 | -440 | 383 | 19131 |
| 138 | -469 | -26365 | 49 | -51 | 471 | 26365 |
| 128 | -515 | -31286 | 81 | 603 | 522 | 31292 |
| 118 | -563 | -36676 | 114 | 1577 | 574 | 36710 |
| 108 | -611 | -42544 | 146 | 2874 | 628 | 42641 |
| 98 | -659 | -48895 | 178 | 4495 | 683 | 49101 |
| 88 | -708 | -55733 | 211 | 6442 | 739 | 56104 |
| 80.00 | -745 | -61546 | 238 | 8238 | 782 | 62095 |
| 68 | -805 | -70846 | 256 | 11202 | 845 | 71726 |
| 58 | -851 | -79128 | 254 | 13755 | 889 | 80315 |
| 48 | -898 | -87874 | 252 | 16289 | 933 | 89371 |
| 22 | -1043 | -113104 | 245 | 22760 | 1072 | 115371 |
| 19 | -1054 | -116249 | 245 | 23496 | 1082 | 118600 |
| 0 | -1168 | -137353 | 239 | 28097 | 1192 | 140198 |

AERODYNAMIC TORQUE AT SHEAR CENTRE

CONDITION. E BRAKES OUT cont...

| 1 | 50 | 74 | 51 | 52 | 53 | 54 | 55 | 56 | 57 | 58 |
|---|---|---|---|---|---|---|---|---|---|---|
| STATION | CLEAN + FLAPPED | CLEAN + FLAPPED | LOCAL | AERO | X AC | X SC | DELTA X | Z AC | Z SC | DELTA Z |
| | LOCAL | LOCAL | $X_{CP}$ | CENTRE | (in) | (in) | (in) | (in) | (in) | (in) |
| (in) | $C_L$ | $C_{Mo}$ | | (in) | | using 38% chord | | | | |
| 258 | - | -0.025 | - | 0.00 | 0.00 | 13.30 | 13.30 | 0.00 | 2.39 | -2.39 |
| 251.25 | -0.11 | -0.025 | 0.01 | 0.43 | 0.43 | 13.37 | 12.94 | 0.00 | 2.40 | -2.40 |
| 238 | -0.13 | -0.025 | 0.05 | 1.91 | 1.91 | 13.50 | 11.59 | 0.00 | 2.44 | -2.44 |
| 228 | -0.15 | -0.025 | 0.07 | 2.59 | 2.59 | 13.60 | 11.01 | 0.00 | 2.47 | -2.47 |
| 218 | -0.16 | -0.025 | 0.08 | 2.95 | 2.95 | 13.71 | 10.75 | 0.00 | 2.49 | -2.49 |
| 208 | -0.17 | -0.025 | 0.09 | 3.23 | 3.23 | 13.81 | 10.58 | 0.00 | 2.52 | -2.52 |
| 198 | -0.17 | -0.025 | 0.09 | 3.44 | 3.44 | 13.91 | 10.47 | 0.00 | 2.54 | -2.54 |
| 188 | -0.18 | -0.025 | 0.10 | 3.63 | 3.63 | 14.01 | 10.39 | 0.00 | 2.57 | -2.57 |
| 178 | -0.18 | -0.025 | 0.10 | 3.78 | 3.78 | 14.11 | 10.33 | 0.00 | 2.60 | -2.60 |
| 163.65 | -0.19 | -0.025 | 0.11 | 3.95 | 3.95 | 14.26 | 10.31 | 0.00 | 2.64 | -2.64 |
| 159 | -0.19 | -0.025 | 0.11 | 4.05 | 4.05 | 14.30 | 10.26 | 0.00 | 2.65 | -2.65 |
| 155.00 | -0.20 | -0.025 | 0.11 | 4.23 | 4.23 | 14.35 | 10.12 | 0.00 | 2.66 | -2.66 |
| 138 | -0.20 | -0.025 | 0.12 | 4.48 | 4.48 | 14.52 | 10.04 | 0.00 | 2.70 | -2.70 |
| 128 | -0.21 | -0.025 | 0.12 | 4.58 | 4.58 | 14.62 | 10.04 | 0.00 | 2.73 | -2.73 |
| 118 | -0.21 | -0.025 | 0.12 | 4.65 | 4.65 | 14.72 | 10.07 | 0.00 | 2.76 | -2.76 |
| 108 | -0.21 | -0.025 | 0.12 | 4.72 | 4.72 | 14.82 | 10.10 | 0.00 | 2.78 | -2.78 |
| 98 | -0.21 | -0.025 | 0.12 | 4.78 | 4.78 | 14.93 | 10.14 | 0.00 | 2.81 | -2.81 |
| 88 | -0.21 | -0.025 | 0.12 | 4.84 | 4.84 | 15.03 | 10.19 | 0.00 | 2.84 | -2.84 |
| 80.00 | -0.21 | -0.025 | 0.12 | 4.88 | 4.88 | 15.11 | 10.22 | 0.00 | 2.86 | -2.86 |
| 68 | -0.21 | -0.025 | 0.12 | 4.82 | 4.82 | 15.23 | 10.41 | 0.00 | 2.89 | -2.89 |
| 58 | -0.20 | -0.025 | 0.12 | 4.74 | 4.74 | 15.33 | 10.60 | 0.00 | 2.92 | -2.92 |
| 48 | -0.20 | -0.025 | 0.12 | 4.77 | 4.77 | 15.43 | 10.66 | 0.00 | 2.94 | -2.94 |
| 22 | -0.20 | -0.025 | 0.12 | 4.85 | 4.85 | 15.70 | 10.84 | 0.00 | 3.01 | -3.01 |
| 19 | -0.20 | -0.025 | 0.12 | 4.86 | 4.86 | 15.73 | 10.87 | 0.00 | 3.01 | -3.01 |
| 0 | -0.20 | -0.025 | 0.12 | 4.90 | 4.90 | 15.92 | 11.02 | 0.00 | 1.25 | -1.25 |

AERODYNAMIC TORQUE AT SHEAR CENTRE

CONDITION. E BRAKES OUT cont...

| 1 | 55 | 56 | 23 | 24 | 59 | $\Delta C_{Mo}$ 0 - 75 | 60 | 61 | 62 | 63 | 64 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| STATION | DELTA | DELTA | SPAN | SPAN | ELEMENT | ELEMENT | ELEMENT | ELEMENT | ELEMENT | TOTAL | TOTAL |
| | X av | Z av | ELEMENT | ELEMENT | TORQUE | TORQUE | TORQUE | TORQUE | LIMIT | LIMIT | ULT |
| (in) | (in) | (in) | LIFT | DRAG | DUE TO | DUE TO | DUE TO | DUE TO | TORQUE | TORQUE | TORQUE |
| | | | (lb) | (lb) | $C_{Mo}$ | $\Delta C_{Mo}$ | LIFT | DRAG | (lb in) | (lb in) | (lb in) |
| | | | | | (lb in) | (lb in) | (lb in) | (lb in) | | | |
| 258 | - | - | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 251.25 | 13.12 | 0.00 | -12.87 | -0.03 | -102.93 | 0.00 | -168.87 | 0.00 | -271.80 | -271.80 | -407.70 |
| 238 | 12.27 | 0.00 | -31.15 | -0.58 | -205.13 | 0.00 | -382.18 | 0.00 | -587.32 | -859.12 | -1288.68 |
| 228 | 11.30 | 0.00 | -26.36 | -0.68 | -157.55 | 0.00 | -297.91 | 0.00 | -455.47 | -1314.59 | -1971.88 |
| 218 | 10.88 | 0.00 | -28.15 | -0.83 | -159.92 | 0.00 | -306.34 | 0.00 | -466.26 | -1780.85 | -2671.27 |
| 208 | 10.67 | 0.00 | -29.65 | -1.13 | -162.31 | 0.00 | -316.23 | 0.00 | -478.54 | -2259.39 | -3389.08 |
| 198 | 10.52 | 0.00 | -30.94 | -1.42 | -164.72 | 0.00 | -325.69 | 0.00 | -490.41 | -2749.80 | -4124.70 |
| 188 | 10.43 | 0.00 | -32.11 | -1.52 | -167.14 | 0.00 | -334.84 | 0.00 | -501.98 | -3251.78 | -4877.67 |
| 178 | 10.36 | 0.00 | -33.17 | -1.60 | -169.59 | 0.00 | -343.56 | 0.00 | -513.14 | -3764.92 | -5647.39 |
| 163.65 | 10.32 | 0.00 | -49.23 | -2.43 | -247.66 | 0.00 | -508.07 | 0.00 | -755.73 | -4520.66 | -6780.99 |
| 159 | 10.28 | 0.00 | -15.19 | -0.76 | -75.64 | 0.00 | -156.23 | 0.00 | -231.87 | -4752.53 | -7128.79 |
| 155.00 | 10.19 | 0.00 | -15.78 | 4.01 | -76.11 | 0.00 | -160.71 | 0.00 | -236.83 | -4989.35 | -7484.03 |
| 138 | 10.08 | 0.00 | -65.08 | 34.72 | -303.71 | 0.00 | -656.02 | 0.00 | -959.73 | -5949.08 | -8923.62 |
| 128 | 10.04 | 0.00 | -39.24 | 20.56 | -182.06 | 0.00 | -394.12 | 0.00 | -576.18 | -6525.26 | -9787.89 |
| 118 | 10.06 | 0.00 | -39.88 | 20.67 | -184.61 | 0.00 | -401.02 | 0.00 | -585.63 | -7110.89 | -10666.34 |
| 108 | 10.09 | 0.00 | -40.47 | 20.79 | -187.18 | 0.00 | -408.15 | 0.00 | -595.33 | -7706.22 | -11559.33 |
| 98 | 10.12 | 0.00 | -41.01 | 20.91 | -189.76 | 0.00 | -415.10 | 0.00 | -604.86 | -8311.08 | -12466.61 |
| 88 | 10.16 | 0.00 | -41.50 | 21.03 | -192.37 | 0.00 | -421.87 | 0.00 | -614.23 | -8925.31 | -13387.97 |
| 80.00 | 10.21 | 0.00 | -33.53 | 16.92 | -155.78 | 0.00 | -342.23 | 0.00 | -498.01 | -9423.32 | -14134.98 |
| 68 | 10.32 | 0.00 | -49.52 | 11.49 | -236.83 | 0.00 | -511.02 | 0.00 | -747.85 | -10171.17 | -15256.75 |
| 58 | 10.50 | 0.00 | -40.61 | -2.15 | -200.28 | 0.00 | -426.63 | 0.00 | -626.90 | -10798.07 | -16197.11 |
| 48 | 10.63 | 0.00 | -40.94 | -2.17 | -202.95 | 0.00 | -435.11 | 0.00 | -638.06 | -11436.14 | -17154.20 |
| 22 | 10.75 | 0.00 | -107.67 | -5.71 | -540.29 | 0.00 | -1157.69 | 0.00 | -1697.98 | -13134.11 | -19701.17 |
| 19 | 10.86 | 0.00 | -12.53 | -0.66 | -63.53 | 0.00 | -136.02 | 0.00 | -199.55 | -13333.66 | -20000.49 |
| 0 | 10.94 | 0.00 | -79.68 | -4.22 | -408.09 | 0.00 | -872.11 | 0.00 | -1280.19 | -14613.85 | -21920.78 |

DEAD WEIGHT ANALYSIS FOR WING TORQUE

CONDITION. E BRAKES OUT cont...

| 1 | 65 | 54 | 66 | 67 | 33 | 68 | 69 | 70 |
|---|---|---|---|---|---|---|---|---|
| STATION | X CG | X SC | DELTA | DELTA | ELEMENT | ELEMENT | TOTAL | TOTAL |
| | (in) | (in) | X | X av | LOAD | LIMIT | LIMIT | ULT |
| (in) | | | (in) | (in) | (lb) | TORQUE | TORQUE | TORQUE |
| | using 40% chord | | | | | (lb in) | (lb in) | (lb in) |
| 258 | 14.00 | 13.30 | -0.70 | - | - | - | - | 0.00 |
| 251.25 | 14.07 | 13.37 | -0.70 | -0.70 | 0.50 | -0.35 | -0.35 | -0.52 |
| 238 | 14.21 | 13.50 | -0.71 | -0.71 | 1.32 | -0.93 | -1.28 | -1.92 |
| 228 | 14.32 | 13.60 | -0.72 | -0.71 | 2.28 | -1.63 | -2.91 | -4.36 |
| 218 | 14.43 | 13.71 | -0.72 | -0.72 | 3.19 | -2.29 | -5.20 | -7.80 |
| 208 | 14.53 | 13.81 | -0.73 | -0.72 | 3.91 | -2.83 | -8.03 | -12.05 |
| 198 | 14.64 | 13.91 | -0.73 | -0.73 | 4.60 | -3.35 | -11.39 | -17.08 |
| 188 | 14.75 | 14.01 | -0.74 | -0.73 | 5.45 | -4.00 | -15.39 | -23.08 |
| 178 | 14.86 | 14.11 | -0.74 | -0.74 | 6.17 | -4.57 | -19.96 | -29.93 |
| 163.65 | 15.01 | 14.26 | -0.75 | -0.75 | 7.09 | -5.30 | -25.25 | -37.88 |
| 159 | 15.06 | 14.30 | -0.75 | -0.75 | 7.32 | -5.50 | -30.75 | -46.13 |
| 155.00 | 15.10 | 14.35 | -0.76 | -0.75 | 7.63 | -5.75 | -36.50 | -54.75 |
| 138 | 15.28 | 14.52 | -0.76 | -0.76 | 8.01 | -6.08 | -42.58 | -63.88 |
| 128 | 15.39 | 14.62 | -0.77 | -0.77 | 8.13 | -6.24 | -48.82 | -73.23 |
| 118 | 15.50 | 14.72 | -0.77 | -0.77 | 8.36 | -6.46 | -55.28 | -82.91 |
| 108 | 15.60 | 14.82 | -0.78 | -0.78 | 8.47 | -6.59 | -61.87 | -92.80 |
| 98 | 15.71 | 14.93 | -0.79 | -0.78 | 8.61 | -6.74 | -68.61 | -102.91 |
| 88 | 15.82 | 15.03 | -0.79 | -0.79 | 8.96 | -7.06 | -75.67 | -113.50 |
| 80.00 | 15.90 | 15.11 | -0.80 | -0.79 | 9.15 | -7.25 | -82.92 | -124.38 |
| 68 | 16.03 | 15.23 | -0.80 | -0.80 | 9.49 | -7.57 | -90.50 | -135.74 |
| 58 | 16.14 | 15.33 | -0.81 | -0.80 | 9.73 | -7.82 | -98.32 | -147.48 |
| 48 | 16.25 | 15.43 | -0.81 | -0.81 | 10.11 | -8.18 | -106.50 | -159.76 |
| 22 | 16.52 | 15.70 | -0.83 | -0.82 | 10.83 | -8.87 | -115.38 | -173.06 |
| 19 | 16.56 | 15.73 | -0.83 | -0.83 | 5.45 | -4.51 | -119.89 | -179.83 |
| 0 | 16.76 | 15.92 | -0.84 | -0.83 | 3.64 | -3.03 | -122.92 | -184.37 |

| COMBINED ULTIMATE TORSION ( AERODYNAMIC + INERTIAL ) | | | |
|---|---|---|---|
| CONDITION. E BRAKES OUT cont... | | | |
| | | | |
| | | | |
| 1 | 71 E | | |
| STATION | COND. E | | |
| (in) | (lb in) | | |
| 258 | 0 | | |
| 251.25 | -408 | | |
| 238 | -1291 | | |
| 228 | -1976 | | |
| 218 | -2679 | | |
| 208 | -3401 | | |
| 198 | -4142 | | |
| 188 | -4901 | | |
| 178 | -5677 | | |
| 163.65 | -6819 | | |
| 159 | -7175 | | |
| 155.00 | -7539 | | |
| 138 | -8987 | | |
| 128 | -9861 | | |
| 118 | -10749 | | |
| 108 | -11652 | | |
| 98 | -12570 | | |
| 88 | -13501 | | |
| 80.00 | -14259 | | |
| 68 | -15392 | | |
| 58 | -16345 | | |
| 48 | -17314 | | |
| 22 | -19874 | | |
| 19 | -20180 | | |
| 0 | -22105 | | |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SPANWISE AERODYNAMIC LOAD DISTRIBUTION | | | | | | | | | | | | | | |
| CONDITION. F BRAKES OUT | | | | | | | | | Brake angle = | 30.00 | deg | | | |
| | | | | | | | | | Brake load = | 97.42 | lb at 1g (30 | ECF = | 0.21 | |
| $V_{sal}$ = | 175.68 | ft/s | $C_L$ = | -0.7 | | alpha wrp = | -10.8914 | | $\Delta C_L$ = | 0.00 | | | | |
| Lift = | -3653.79 | lb clean | $C_{Do}$ = | 0.009 | | sin alpha = | -0.1889 | | $\Delta C_D$ = | 0.58 | | | | |
| q = | 36.69 | psf | $C_D$ = | 0.025 | | cos alpha = | 0.9820 | | $\Delta C_{Mo}$ = | 0.00 | | | | |
| n = | -1.69 | g | $C_{Mo}$ = | -0.025 | | | | | S = | 4.60 | ft² | | | |
| $q.C_L$ = | -27.07 | $q.C_L$ =Lift/S | S = | 135.00 | ft² | | | | b = | 6.25 | ft | | | |
| | | | b = | 43.00 | ft | | | | AR = | 8.49 | | | | |
| 1 | 13 | 72 | 14 | 15 | 16 | 73 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 |
| STATION | $C_L$ | FLAP | $C_{Lx}$ | $C_{Lz}$ | $C_D$ | FLAP | $C_{Dx}$ | $C_{Dz}$ | $C_{Lz}+C_{Dz}$ | $C_{Dx}-C_{Lx}$ | $(C_{Lz}+C_{Dz})_{AV}$ | $(C_{Dx}-C_{Lx})_{AV}$ | SPAN | SPAN |
| (in) | | $C_L$ | | | | $C_D$ | | | | | | | ELEMENT | ELEMENT |
| | | | | | | | | | | | | | LIFT | DRAG |
| | | | | | | | | | | | | | (lb) | (lb) |
| 258 | -0.3688 | 0.0000 | 0.0697 | -0.3621 | 0.0298 | 0.0000 | 0.0292 | -0.0056 | -0.3678 | -0.0405 | - | - | 0.00 | 0.00 |
| 251.25 | -0.4831 | 0.0000 | 0.0913 | -0.4744 | 0.0298 | 0.0000 | 0.0292 | -0.0056 | -0.4800 | -0.0620 | -0.4239 | -0.0512 | -25.58 | -3.09 |
| 238 | -0.5610 | 0.0000 | 0.1060 | -0.5509 | 0.0298 | 0.0000 | 0.0292 | -0.0056 | -0.5565 | -0.0768 | -0.5182 | -0.0694 | -61.87 | -8.29 |
| 228 | -0.6000 | 0.0000 | 0.1134 | -0.5892 | 0.0298 | 0.0000 | 0.0292 | -0.0056 | -0.5949 | -0.0841 | -0.5757 | -0.0805 | -52.32 | -7.31 |
| 218 | -0.6311 | 0.0000 | 0.1192 | -0.6197 | 0.0298 | 0.0000 | 0.0292 | -0.0056 | -0.6253 | -0.0900 | -0.6101 | -0.0871 | -55.87 | -7.97 |
| 208 | -0.6568 | 0.0000 | 0.1241 | -0.6450 | 0.0236 | 0.0000 | 0.0231 | -0.0045 | -0.6494 | -0.1010 | -0.6374 | -0.0955 | -58.80 | -8.81 |
| 198 | -0.6786 | 0.0000 | 0.1282 | -0.6664 | 0.0236 | 0.0000 | 0.0231 | -0.0045 | -0.6709 | -0.1051 | -0.6601 | -0.1030 | -61.35 | -9.57 |
| 188 | -0.6974 | 0.0000 | 0.1318 | -0.6848 | 0.0236 | 0.0000 | 0.0231 | -0.0045 | -0.6892 | -0.1086 | -0.6801 | -0.1069 | -63.67 | -10.00 |
| 178 | -0.7136 | 0.0000 | 0.1348 | -0.7007 | 0.0236 | 0.0000 | 0.0231 | -0.0045 | -0.7052 | -0.1117 | -0.6972 | -0.1102 | -65.75 | -10.39 |
| 163.65 | -0.7333 | 0.0000 | 0.1385 | -0.7200 | 0.0236 | 0.0000 | 0.0231 | -0.0045 | -0.7245 | -0.1154 | -0.7148 | -0.1135 | -97.58 | -15.50 |
| 159 | -0.7385 | 0.0000 | 0.1395 | -0.7252 | 0.0236 | 0.0000 | 0.0231 | -0.0045 | -0.7296 | -0.1164 | -0.7271 | -0.1159 | -30.11 | -4.80 |
| 155.00 | -0.7434 | 0.0000 | 0.1405 | -0.7300 | 0.0236 | 0.1206 | 0.1415 | -0.0272 | -0.7572 | 0.0011 | -0.7434 | -0.0577 | -30.89 | -2.40 |
| 138 | -0.7600 | 0.0000 | 0.1436 | -0.7463 | 0.0236 | 0.1206 | 0.1415 | -0.0272 | -0.7735 | -0.0021 | -0.7654 | -0.0005 | -125.93 | -0.08 |
| 128 | -0.7680 | 0.0000 | 0.1451 | -0.7541 | 0.0236 | 0.1206 | 0.1415 | -0.0272 | -0.7814 | -0.0036 | -0.7774 | -0.0028 | -75.96 | -0.28 |
| 118 | -0.7748 | 0.0000 | 0.1464 | -0.7609 | 0.0236 | 0.1206 | 0.1415 | -0.0272 | -0.7881 | -0.0049 | -0.7847 | -0.0042 | -77.21 | -0.42 |
| 108 | -0.7806 | 0.0000 | 0.1475 | -0.7665 | 0.0236 | 0.1206 | 0.1415 | -0.0272 | -0.7938 | -0.0060 | -0.7909 | -0.0054 | -78.36 | -0.54 |
| 98 | -0.7854 | 0.0000 | 0.1484 | -0.7713 | 0.0236 | 0.1206 | 0.1415 | -0.0272 | -0.7985 | -0.0069 | -0.7961 | -0.0064 | -79.42 | -0.64 |
| 88 | -0.7893 | 0.0000 | 0.1491 | -0.7751 | 0.0236 | 0.1206 | 0.1415 | -0.0272 | -0.8023 | -0.0076 | -0.8004 | -0.0072 | -80.39 | -0.73 |
| 80.00 | -0.7918 | 0.0000 | 0.1496 | -0.7775 | 0.0236 | 0.1206 | 0.1415 | -0.0272 | -0.8047 | -0.0081 | -0.8035 | -0.0078 | -64.96 | -0.63 |
| 68 | -0.7945 | 0.0000 | 0.1501 | -0.7802 | 0.0236 | 0.0000 | 0.0231 | -0.0045 | -0.7847 | -0.1270 | -0.7947 | -0.0675 | -97.01 | -8.24 |
| 58 | -0.7960 | 0.0000 | 0.1504 | -0.7817 | 0.0236 | 0.0000 | 0.0231 | -0.0045 | -0.7861 | -0.1273 | -0.7854 | -0.1271 | -80.49 | -13.03 |
| 48 | -0.7967 | 0.0000 | 0.1505 | -0.7824 | 0.0236 | 0.0000 | 0.0231 | -0.0045 | -0.7868 | -0.1274 | -0.7865 | -0.1273 | -81.13 | -13.14 |
| 22 | -0.7954 | 0.0000 | 0.1503 | -0.7811 | 0.0236 | 0.0000 | 0.0231 | -0.0045 | -0.7856 | -0.1272 | -0.7862 | -0.1273 | -213.38 | -34.54 |
| 19 | -0.7950 | 0.0000 | 0.1502 | -0.7807 | 0.0236 | 0.0000 | 0.0231 | -0.0045 | -0.7851 | -0.1271 | -0.7854 | -0.1271 | -24.83 | -4.02 |
| 0 | -0.7910 | 0.0000 | 0.1495 | -0.7767 | 0.0236 | 0.0000 | 0.0231 | -0.0045 | -0.7812 | -0.1263 | -0.7832 | -0.1267 | -157.91 | -25.55 |
| | | | | | | | | | | | | Σ = | -1840.77 | -189.96 |
| | | | | | | | | | | | | LIFT calc = | -3681.53 | |
| | | | | | | | | | | | | Lift = | -3653.79 | |

SPANWISE AERODYNAMIC LOAD DISTRIBUTION

CONDITION. F BRAKES OUT cont...

| 1 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 |
|---|---|---|---|---|---|---|---|---|
| STATION | LIMIT | LIMIT | LIMIT | LIMIT | ULT | ULT - | ULT | ULT |
| (in) | NORMAL | NORMAL | CHORD | CHORD | NORMAL | NORMAL | CHORD | CHORD |
| | SHEAR | MOMENT | SHEAR | MOMENT | SHEAR | MOMENT | SHEAR | MOMENT |
| | (lb) | (lb in) | (lb) | (lb in) | (lb) | (lb in) | (lb) | (lb in) |
| 258 | 0.00 | 0.00 | 0.00 | 0.00 | 0 | 0 | 0 | 0 |
| 251.25 | -25.58 | -86.35 | -3.09 | -10.44 | -38 | -130 | -5 | -16 |
| 238 | -87.45 | -835.21 | -11.38 | -106.32 | -131 | -1253 | -17 | -159 |
| 228 | -139.78 | -1971.35 | -18.69 | -256.67 | -210 | -2957 | -28 | -385 |
| 218 | -195.65 | -3648.46 | -26.67 | -483.46 | -293 | -5473 | -40 | -725 |
| 208 | -254.45 | -5898.93 | -35.48 | -794.17 | -382 | -8848 | -53 | -1191 |
| 198 | -315.80 | -8750.18 | -45.05 | -1196.80 | -474 | -13125 | -68 | -1795 |
| 188 | -379.47 | -12226.51 | -55.05 | -1697.32 | -569 | -18340 | -83 | -2546 |
| 178 | -445.21 | -16349.90 | -65.44 | -2299.80 | -668 | -24525 | -98 | -3450 |
| 163.65 | -542.80 | -23438.88 | -80.94 | -3350.10 | -814 | -35158 | -121 | -5025 |
| 159 | -572.91 | -25851.60 | -85.74 | -3710.56 | -859 | -38777 | -129 | -5566 |
| 155.00 | -603.80 | -28396.23 | -88.14 | -4086.58 | -906 | -42594 | -132 | -6130 |
| 138 | -729.73 | -39731.19 | -88.22 | -5585.62 | -1095 | -59597 | -132 | -8378 |
| 128 | -805.69 | -47408.28 | -88.49 | -6469.19 | -1209 | -71112 | -133 | -9704 |
| 118 | -882.90 | -55851.23 | -88.91 | -7356.21 | -1324 | -83777 | -133 | -11034 |
| 108 | -961.26 | -65072.03 | -89.45 | -8248.00 | -1442 | -97608 | -134 | -12372 |
| 98 | -1040.67 | -75081.69 | -90.09 | -9145.66 | -1561 | -112623 | -135 | -13718 |
| 88 | -1121.06 | -85890.37 | -90.81 | -10050.16 | -1682 | -128836 | -136 | -15075 |
| 80.00 | -1186.02 | -95118.68 | -91.45 | -10779.19 | -1779 | -142678 | -137 | -16169 |
| 68 | -1283.03 | -109932.96 | -99.69 | -11926.01 | -1925 | -164899 | -150 | -17889 |
| 58 | -1363.52 | -123165.69 | -112.72 | -12988.05 | -2045 | -184749 | -169 | -19482 |
| 48 | -1444.65 | -137206.50 | -125.85 | -14180.90 | -2167 | -205810 | -189 | -21271 |
| 22 | -1658.02 | -177541.25 | -160.40 | -17902.14 | -2487 | -266312 | -241 | -26853 |
| 19 | -1682.85 | -182552.56 | -164.42 | -18389.36 | -2524 | -273829 | -247 | -27584 |
| 0 | -1840.77 | -216026.93 | -189.96 | -21755.94 | -2761 | -324040 | -285 | -32634 |
| | | | | | | | | |
| Centre of lift is | 117 | in from aircraft centreline | | | | | | |
| | 45 | % semispan | | | | | | |

SPANWISE INERTIAL LOAD DISTRIBUTION

CONDITION. F BRAKES OUT cont...

| 1 | 3 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 | 41 | 42 | 43 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| STATION | dy | WEIGHT | ELEMENT | ELEMENT | LIMIT | LIMIT | LIMIT | LIMIT | ULT | ULT | ULT | ULT |
| (in) | (in) | nW | SHEAR | SHEAR | NORMAL | NORMAL | CHORD | CHORD | NORMAL | NORMAL | CHORD | CHORD |
| | | (lb) | FORCE | FORCE | SHEAR | MOMENT | SHEAR | MOMENT | SHEAR | MOMENT | SHEAR | MOMENT |
| | | | $V_x$ | $V_z$ | (lb) | (lb in) | (lb) | (lb in) | (lb) | (lb in) | (lb) | (lb in) |
| | | | (lb) | (lb) | | | | | | | | |
| 258 | - | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0 | 0 | 0 | 0 |
| 251.25 | 6.75 | 0.66 | 0.13 | 0.65 | 0.65 | 2.19 | 0.13 | 0.42 | 1 | 3 | 0 | 1 |
| 238 | 13.25 | 1.76 | 0.33 | 1.73 | 2.38 | 22.26 | 0.46 | 4.28 | 4 | 33 | 1 | 6 |
| 228 | 10.00 | 3.05 | 0.58 | 2.99 | 5.37 | 61.02 | 1.03 | 11.74 | 8 | 92 | 2 | 18 |
| 218 | 10.00 | 4.27 | 0.81 | 4.19 | 9.56 | 135.70 | 1.84 | 26.11 | 14 | 204 | 3 | 39 |
| 208 | 10.00 | 5.23 | 0.99 | 5.14 | 14.70 | 257.02 | 2.83 | 49.45 | 22 | 386 | 4 | 74 |
| 198 | 10.00 | 6.15 | 1.16 | 6.04 | 20.74 | 434.21 | 3.99 | 83.55 | 31 | 651 | 6 | 125 |
| 188 | 10.00 | 7.28 | 1.38 | 7.15 | 27.89 | 677.33 | 5.37 | 130.33 | 42 | 1016 | 8 | 195 |
| 178 | 10.00 | 8.25 | 1.56 | 8.10 | 35.99 | 996.69 | 6.92 | 191.78 | 54 | 1495 | 10 | 288 |
| 163.65 | 14.35 | 9.48 | 1.79 | 9.31 | 45.30 | 1579.89 | 8.72 | 303.99 | 68 | 2370 | 13 | 456 |
| 159 | 4.33 | 9.79 | 1.85 | 9.61 | 54.91 | 1796.58 | 10.57 | 345.69 | 82 | 2695 | 16 | 519 |
| 155.00 | 4.32 | 10.19 | 1.93 | 10.01 | 64.92 | 2055.71 | 12.49 | 395.55 | 97 | 3084 | 19 | 593 |
| 138 | 17.00 | 10.70 | 2.02 | 10.51 | 75.43 | 3248.65 | 14.51 | 625.08 | 113 | 4873 | 22 | 938 |
| 128 | 10.00 | 10.87 | 2.05 | 10.68 | 86.10 | 4056.30 | 16.57 | 780.49 | 129 | 6084 | 25 | 1171 |
| 118 | 10.00 | 11.18 | 2.11 | 10.97 | 97.08 | 4972.21 | 18.68 | 956.72 | 146 | 7458 | 28 | 1435 |
| 108 | 10.00 | 11.33 | 2.14 | 11.12 | 108.20 | 5998.60 | 20.82 | 1154.21 | 162 | 8998 | 31 | 1731 |
| 98 | 10.00 | 11.51 | 2.18 | 11.31 | 119.51 | 7137.16 | 23.00 | 1373.29 | 179 | 10706 | 34 | 2060 |
| 88 | 10.00 | 11.97 | 2.26 | 11.76 | 131.27 | 8391.03 | 25.26 | 1614.55 | 197 | 12587 | 38 | 2422 |
| 80.00 | 8.00 | 12.23 | 2.31 | 12.01 | 143.27 | 9489.18 | 27.57 | 1825.85 | 215 | 14234 | 41 | 2739 |
| 68 | 12.00 | 12.68 | 2.40 | 12.45 | 155.73 | 11283.16 | 29.96 | 2171.03 | 234 | 16925 | 45 | 3257 |
| 58 | 10.00 | 13.00 | 2.46 | 12.77 | 168.50 | 12904.27 | 32.42 | 2482.96 | 253 | 19356 | 49 | 3724 |
| 48 | 10.00 | 13.51 | 2.55 | 13.27 | 181.77 | 14655.58 | 34.97 | 2819.93 | 273 | 21983 | 52 | 4230 |
| 22 | 26.00 | 14.48 | 2.74 | 14.22 | 195.98 | 19566.31 | 37.71 | 3764.82 | 294 | 29349 | 57 | 5647 |
| 19 | 3.00 | 7.29 | 1.38 | 7.16 | 203.14 | 20165.00 | 39.09 | 3880.02 | 305 | 30247 | 59 | 5820 |
| 0 | 19.00 | 4.86 | 0.92 | 4.77 | 207.92 | 24070.07 | 40.01 | 4631.41 | 312 | 36105 | 60 | 6947 |
| | $\Sigma =$ | 125 | lb | | | | | | | | | |
| | | at 1 g | | | Centre of gravity is | 116 | in from aircraft centreline | | | | | |
| | | | | | | 45 | % semispan | | | | | |

COMBINED ULTIMATE LOADS ( AERODYNAMIC + INERTIAL )

CONDITION. F BRAKES OUT cont...

| 1 | 44 F | 45 F | 46 F | 47 F | 48 F | 49 F |
|---|---|---|---|---|---|---|
| | ULT | ULT | ULT | ULT | ULT | ULT |
| | NORMAL | NORMAL | CHORD | CHORD | RESOLVED | RESOLVED |
| STATION | SHEAR | BEND MOMENT | SHEAR | BEND MOMENT | SHEAR | BEND MOMENT |
| (in) | COND. F | COND. F | COND. F | COND. F | COND. F | COND. F |
| | (lb) | (lb in) | (lb) | (lb in) | (lb) | (lb in) |
| 258 | 0 | 0 | 0 | 0 | 0 | 0 |
| 251.25 | -37 | -126 | -4 | -15 | 38 | 127 |
| 238 | -128 | -1219 | -16 | -153 | 129 | 1229 |
| 228 | -202 | -2865 | -26 | -367 | 203 | 2889 |
| 218 | -279 | -5269 | -37 | -686 | 282 | 5314 |
| 208 | -360 | -8463 | -49 | -1117 | 363 | 8536 |
| 198 | -443 | -12474 | -62 | -1670 | 447 | 12585 |
| 188 | -527 | -17324 | -75 | -2350 | 533 | 17482 |
| 178 | -614 | -23030 | -88 | -3162 | 620 | 23246 |
| 163.65 | -746 | -32788 | -108 | -4569 | 754 | 33105 |
| 159 | -777 | -36083 | -113 | -5047 | 785 | 36434 |
| 155.00 | -808 | -39511 | -113 | -5537 | 816 | 39897 |
| 138 | -981 | -54724 | -111 | -7441 | 988 | 55227 |
| 128 | -1079 | -65028 | -108 | -8533 | 1085 | 65585 |
| 118 | -1179 | -76319 | -105 | -9599 | 1183 | 76920 |
| 108 | -1280 | -88610 | -103 | -10641 | 1284 | 89247 |
| 98 | -1382 | -101917 | -101 | -11659 | 1385 | 102581 |
| 88 | -1485 | -116249 | -98 | -12653 | 1488 | 116936 |
| 80.00 | -1564 | -128444 | -96 | -13430 | 1567 | 129144 |
| 68 | -1691 | -147975 | -105 | -14632 | 1694 | 148696 |
| 58 | -1793 | -165392 | -120 | -15758 | 1797 | 166141 |
| 48 | -1894 | -183826 | -136 | -17041 | 1899 | 184615 |
| 22 | -2193 | -236962 | -184 | -21206 | 2201 | 237909 |
| 19 | -2220 | -243581 | -188 | -21764 | 2228 | 244552 |
| 0 | -2449 | -287935 | -225 | -25687 | 2460 | 289079 |

*AERODYNAMIC TORQUE AT SHEAR CENTRE*

CONDITION. F BRAKES OUT cont...

| 1 | 50 | 74 | 51 | 52 | 53 | 54 | 55 | 56 |
|---|---|---|---|---|---|---|---|---|
| STATION | CLEAN + FLAPPED | CLEAN + FLAPPED | LOCAL | AERO | X AC | X SC | DELTA X | Z AC |
| | LOCAL | LOCAL | $X_{CP}$ | CENTRE | (in) | (in) | (in) | (in) |
| (in) | $C_L$ | $C_{Mo}$ | | (in) | | using 38% chord | | |
| 258 | - | -0.025 | - | 0.00 | 0.00 | 13.30 | 13.30 | 0.00 |
| 251.25 | -0.42 | -0.025 | 0.18 | 6.37 | 6.37 | 13.37 | 7.00 | 0.00 |
| 238 | -0.52 | -0.025 | 0.19 | 6.81 | 6.81 | 13.50 | 6.69 | 0.00 |
| 228 | -0.58 | -0.025 | 0.20 | 7.04 | 7.04 | 13.60 | 6.57 | 0.00 |
| 218 | -0.61 | -0.025 | 0.20 | 7.18 | 7.18 | 13.71 | 6.53 | 0.00 |
| 208 | -0.64 | -0.025 | 0.20 | 7.30 | 7.30 | 13.81 | 6.51 | 0.00 |
| 198 | -0.66 | -0.025 | 0.20 | 7.40 | 7.40 | 13.91 | 6.51 | 0.00 |
| 188 | -0.68 | -0.025 | 0.20 | 7.49 | 7.49 | 14.01 | 6.52 | 0.00 |
| 178 | -0.70 | -0.025 | 0.20 | 7.58 | 7.58 | 14.11 | 6.53 | 0.00 |
| 163.65 | -0.71 | -0.025 | 0.21 | 7.69 | 7.69 | 14.26 | 6.57 | 0.00 |
| 159 | -0.73 | -0.025 | 0.21 | 7.74 | 7.74 | 14.30 | 6.56 | 0.00 |
| 155.00 | -0.74 | -0.025 | 0.21 | 7.79 | 7.79 | 14.35 | 6.56 | 0.00 |
| 138 | -0.77 | -0.025 | 0.21 | 7.92 | 7.92 | 14.52 | 6.60 | 0.00 |
| 128 | -0.78 | -0.025 | 0.21 | 8.00 | 8.00 | 14.62 | 6.62 | 0.00 |
| 118 | -0.78 | -0.025 | 0.21 | 8.06 | 8.06 | 14.72 | 6.66 | 0.00 |
| 108 | -0.79 | -0.025 | 0.21 | 8.13 | 8.13 | 14.82 | 6.69 | 0.00 |
| 98 | -0.80 | -0.025 | 0.21 | 8.19 | 8.19 | 14.93 | 6.73 | 0.00 |
| 88 | -0.80 | -0.025 | 0.21 | 8.26 | 8.26 | 15.03 | 6.77 | 0.00 |
| 80.00 | -0.80 | -0.025 | 0.21 | 8.31 | 8.31 | 15.11 | 6.80 | 0.00 |
| 68 | -0.79 | -0.025 | 0.21 | 8.36 | 8.36 | 15.23 | 6.87 | 0.00 |
| 58 | -0.79 | -0.025 | 0.21 | 8.40 | 8.40 | 15.33 | 6.93 | 0.00 |
| 48 | -0.79 | -0.025 | 0.21 | 8.46 | 8.46 | 15.43 | 6.98 | 0.00 |
| 22 | -0.79 | -0.025 | 0.21 | 8.60 | 8.60 | 15.70 | 7.10 | 0.00 |
| 19 | -0.79 | -0.025 | 0.21 | 8.62 | 8.62 | 15.73 | 7.11 | 0.00 |
| 0 | -0.78 | -0.025 | 0.21 | 8.72 | 8.72 | 15.92 | 7.20 | 0.00 |

AERODYNAMIC TORQUE AT SHEAR CENTRE

CONDITION. F BRAKES OUT cont...

| | | | | | | $\Delta C_{Mo}$ | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 0 | | | | | |
| 1 | 55 | 56 | 23 | 24 | 59 | _75 | 60 | 61 | 62 | 63 | 64 |
| STATION | DELTA | DELTA | SPAN | SPAN | ELEMENT | ELEMENT | ELEMENT | ELEMENT | ELEMENT | TOTAL | TOTAL |
| | X av | Z av | ELEMENT | ELEMENT | TORQUE | TORQUE | TORQUE | TORQUE | LIMIT | LIMIT | ULT |
| (in) | (in) | (in) | LIFT | DRAG | DUE TO | DUE TO | DUE TO | DUE TO | TORQUE | TORQUE | TORQUE |
| | | | (lb) | (lb) | $C_{Mo}$ | $\Delta C_{Mo}$ | LIFT | DRAG | (lb in) | (lb in) | (lb in) |
| | | | | | (lb in) | (lb in) | (lb in) | (lb in) | | | |
| 258 | - | - | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 251.25 | 10.15 | 0.00 | -25.58 | -3.09 | -52.95 | 0.00 | -259.68 | 0.00 | -312.63 | -312.63 | -468.94 |
| 238 | 6.84 | 0.00 | -61.87 | -8.29 | -105.53 | 0.00 | -423.47 | 0.00 | -528.99 | -841.62 | -1262.44 |
| 228 | 6.63 | 0.00 | -52.32 | -7.31 | -81.05 | 0.00 | -346.81 | 0.00 | -427.86 | -1269.49 | -1904.23 |
| 218 | 6.55 | 0.00 | -55.87 | -7.97 | -82.27 | 0.00 | -365.80 | 0.00 | -448.07 | -1717.56 | -2576.34 |
| 208 | 6.52 | 0.00 | -58.80 | -8.81 | -83.50 | 0.00 | -383.40 | 0.00 | -466.90 | -2184.46 | -3276.69 |
| 198 | 6.51 | 0.00 | -61.35 | -9.57 | -84.74 | 0.00 | -399.50 | 0.00 | -484.24 | -2668.70 | -4003.05 |
| 188 | 6.51 | 0.00 | -63.67 | -10.00 | -85.98 | 0.00 | -414.73 | 0.00 | -500.72 | -3169.42 | -4754.13 |
| 178 | 6.52 | 0.00 | -65.75 | -10.39 | -87.24 | 0.00 | -428.96 | 0.00 | -516.21 | -3685.62 | -5528.44 |
| 163.65 | 6.55 | 0.00 | -97.58 | -15.50 | -127.40 | 0.00 | -639.02 | 0.00 | -766.42 | -4452.05 | -6678.07 |
| 159 | 6.56 | 0.00 | -30.11 | -4.80 | -38.91 | 0.00 | -197.69 | 0.00 | -236.60 | -4688.65 | -7032.97 |
| 155.00 | 6.56 | 0.00 | -30.89 | -2.40 | -39.15 | 0.00 | -202.60 | 0.00 | -241.75 | -4930.39 | -7395.59 |
| 138 | 6.58 | 0.00 | -125.93 | -0.08 | -156.24 | 0.00 | -828.17 | 0.00 | -984.41 | -5914.80 | -8872.20 |
| 128 | 6.61 | 0.00 | -75.96 | -0.28 | -93.66 | 0.00 | -502.16 | 0.00 | -595.83 | -6510.63 | -9765.94 |
| 118 | 6.64 | 0.00 | -77.21 | -0.42 | -94.97 | 0.00 | -512.77 | 0.00 | -607.74 | -7118.37 | -10677.55 |
| 108 | 6.68 | 0.00 | -78.36 | -0.54 | -96.29 | 0.00 | -523.17 | 0.00 | -619.46 | -7737.83 | -11606.74 |
| 98 | 6.71 | 0.00 | -79.42 | -0.64 | -97.62 | 0.00 | -533.17 | 0.00 | -630.79 | -8368.61 | -12552.92 |
| 88 | 6.75 | 0.00 | -80.39 | -0.73 | -98.96 | 0.00 | -542.78 | 0.00 | -641.74 | -9010.35 | -13515.53 |
| 80.00 | 6.79 | 0.00 | -64.96 | -0.63 | -80.14 | 0.00 | -440.89 | 0.00 | -521.03 | -9531.38 | -14297.07 |
| 68 | 6.84 | 0.00 | -97.01 | -8.24 | -121.83 | 0.00 | -663.37 | 0.00 | -785.20 | -10316.59 | -15474.88 |
| 58 | 6.90 | 0.00 | -80.49 | -13.03 | -103.03 | 0.00 | -555.57 | 0.00 | -658.60 | -10975.19 | -16462.78 |
| 48 | 6.96 | 0.00 | -81.13 | -13.14 | -104.40 | 0.00 | -564.30 | 0.00 | -668.70 | -11643.89 | -17465.83 |
| 22 | 7.04 | 0.00 | -213.38 | -34.54 | -277.95 | 0.00 | -1501.61 | 0.00 | -1779.55 | -13423.44 | -20135.16 |
| 19 | 7.10 | 0.00 | -24.83 | -4.02 | -32.68 | 0.00 | -176.39 | 0.00 | -209.07 | -13632.51 | -20448.77 |
| 0 | 7.16 | 0.00 | -157.91 | -25.55 | -209.93 | 0.00 | -1130.35 | 0.00 | -1340.29 | -14972.80 | -22459.20 |

DEAD WEIGHT ANALYSIS FOR WING TORQUE

CONDITION. F BRAKES OUT cont...

| 1 | 65 | 54 | 66 | 67 | 33 | 68 | 69 | 70 |
|---|---|---|---|---|---|---|---|---|
| STATION | X CG | X SC | DELTA | DELTA | ELEMENT | ELEMENT | TOTAL | TOTAL |
| | (in) | (in) | X | X av | LOAD | LIMIT | LIMIT | ULT |
| (in) | | | (in) | (in) | (lb) | TORQUE | TORQUE | TORQUE |
| | using 40% chord | | | | | (lb in) | (lb in) | (lb in) |
| 258 | 14.00 | 13.30 | -0.70 | - | - | - | - | 0.00 |
| 251.25 | 14.07 | 13.37 | -0.70 | -0.70 | 0.66 | -0.46 | -0.46 | -0.70 |
| 238 | 14.21 | 13.50 | -0.71 | -0.71 | 1.76 | -1.25 | -1.71 | -2.56 |
| 228 | 14.32 | 13.60 | -0.72 | -0.71 | 3.05 | -2.17 | -3.88 | -5.83 |
| 218 | 14.43 | 13.71 | -0.72 | -0.72 | 4.27 | -3.07 | -6.95 | -10.43 |
| 208 | 14.53 | 13.81 | -0.73 | -0.72 | 5.23 | -3.79 | -10.74 | -16.11 |
| 198 | 14.64 | 13.91 | -0.73 | -0.73 | 6.15 | -4.48 | -15.22 | -22.84 |
| 188 | 14.75 | 14.01 | -0.74 | -0.73 | 7.28 | -5.35 | -20.57 | -30.86 |
| 178 | 14.86 | 14.11 | -0.74 | -0.74 | 8.25 | -6.10 | -26.68 | -40.02 |
| 163.65 | 15.01 | 14.26 | -0.75 | -0.75 | 9.48 | -7.08 | -33.76 | -50.64 |
| 159 | 15.06 | 14.30 | -0.75 | -0.75 | 9.79 | -7.36 | -41.11 | -61.67 |
| 155.00 | 15.10 | 14.35 | -0.76 | -0.75 | 10.19 | -7.69 | -48.80 | -73.20 |
| 138 | 15.28 | 14.52 | -0.76 | -0.76 | 10.70 | -8.13 | -56.93 | -85.39 |
| 128 | 15.39 | 14.62 | -0.77 | -0.77 | 10.87 | -8.34 | -65.27 | -97.90 |
| 118 | 15.50 | 14.72 | -0.77 | -0.77 | 11.18 | -8.63 | -73.90 | -110.84 |
| 108 | 15.60 | 14.82 | -0.78 | -0.78 | 11.33 | -8.81 | -82.70 | -124.06 |
| 98 | 15.71 | 14.93 | -0.79 | -0.78 | 11.51 | -9.01 | -91.72 | -137.58 |
| 88 | 15.82 | 15.03 | -0.79 | -0.79 | 11.97 | -9.44 | -101.16 | -151.73 |
| 80.00 | 15.90 | 15.11 | -0.80 | -0.79 | 12.23 | -9.70 | -110.85 | -166.28 |
| 68 | 16.03 | 15.23 | -0.80 | -0.80 | 12.68 | -10.13 | -120.98 | -181.47 |
| 58 | 16.14 | 15.33 | -0.81 | -0.80 | 13.00 | -10.46 | -131.44 | -197.16 |
| 48 | 16.25 | 15.43 | -0.81 | -0.81 | 13.51 | -10.94 | -142.38 | -213.57 |
| 22 | 16.52 | 15.70 | -0.83 | -0.82 | 14.48 | -11.86 | -154.24 | -231.36 |
| 19 | 16.56 | 15.73 | -0.83 | -0.83 | 7.29 | -6.03 | -160.27 | -240.41 |
| 0 | 16.76 | 15.92 | -0.84 | -0.83 | 4.86 | -4.05 | -164.32 | -246.48 |

| COMBINED ULTIMATE TORSION ( AERODYNAMIC + INER | | |
|---|---|---|
| CONDITION. F BRAKES OUT cont... | | |
| | | |
| 1 | 71 F | |
| STATION | COND. F | |
| (in) | (lb in) | |
| 258 | 0 | |
| 251.25 | -470 | |
| 238 | -1265 | |
| 228 | -1910 | |
| 218 | -2587 | |
| 208 | -3293 | |
| 198 | -4026 | |
| 188 | -4785 | |
| 178 | -5568 | |
| 163.65 | -6729 | |
| 159 | -7095 | |
| 155.00 | -7469 | |
| 138 | -8958 | |
| 128 | -9864 | |
| 118 | -10788 | |
| 108 | -11731 | |
| 98 | -12691 | |
| 88 | -13667 | |
| 80.00 | -14463 | |
| 68 | -15656 | |
| 58 | -16660 | |
| 48 | -17679 | |
| 22 | -20367 | |
| 19 | -20689 | |
| 0 | -22706 | |

SPANWISE AERODYNAMIC LOAD DISTRIBUTION

CONDITION. G BRAKES OUT

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Brake angle = | 30.00 | deg | | |
| | | | | | | | Brake load = | 60.57 | lb at 1g (30 | ECF = | 0.21 |
| $V_{ml}$ = | 138.51 | ft/s | $C_L$ = | -0.9 | alpha wrp = | -12.4530 | $\Delta C_L$ = | 0.00 | | | |
| Lift = | -2733.15 | lb clean | $C_{Do}$ = | 0.010 | sin alpha = | -0.2156 | $\Delta C_D$ = | 0.58 | | | |
| q = | 22.81 | psf | $C_D$ = | 0.033 | cos alpha = | 0.9765 | $\Delta C_{Mo}$ = | 0.00 | | | |
| n = | -1.27 | g | $C_{Mo}$ = | -0.025 | | | S = | 4.60 | ft² | | |
| $q.C_L$ = | -20.25 | $q.C_L$ = Lift/S | S = | 135.00 ft² | | | b = | 6.25 | ft | | |
| | | | b = | 43.00 ft | | | AR = | 8.49 | | | |

| 1 | 13 | 72 | 14 | 15 | 16 | 73 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| STATION | $C_L$ | FLAP | $C_{Lx}$ | $C_{Lz}$ | $C_D$ | FLAP | $C_{Dx}$ | $C_{Dz}$ | $C_{Lz}+C_{Dz}$ | $C_{Dx}-C_{Lx}$ | $(C_{Lz}+C_{Dz})_{AV}$ | $(C_{Dx}-C_{Lx})_{AV}$ | SPAN | SPAN |
| (in) | | $C_L$ | | | | $C_D$ | | | | | | | ELEMENT | ELEMENT |
| | | | | | | | | | | | | | LIFT | DRAG |
| | | | | | | | | | | | | | (lb) | (lb) |
| 258 | -0.4437 | 0.0000 | 0.0957 | -0.4333 | 0.0395 | 0.0000 | 0.0385 | -0.0085 | -0.4418 | -0.0572 | - | - | 0.00 | 0.00 |
| 251.25 | -0.5812 | 0.0000 | 0.1253 | -0.5676 | 0.0395 | 0.0000 | 0.0385 | -0.0085 | -0.5761 | -0.0868 | -0.5089 | -0.0720 | -19.10 | -2.70 |
| 238 | -0.6750 | 0.0000 | 0.1456 | -0.6591 | 0.0395 | 0.0000 | 0.0385 | -0.0085 | -0.6676 | -0.1070 | -0.6218 | -0.0969 | -46.15 | -7.19 |
| 228 | -0.7220 | 0.0000 | 0.1557 | -0.7050 | 0.0395 | 0.0000 | 0.0385 | -0.0085 | -0.7135 | -0.1172 | -0.6906 | -0.1121 | -39.02 | -6.33 |
| 218 | -0.7594 | 0.0000 | 0.1637 | -0.7415 | 0.0395 | 0.0000 | 0.0385 | -0.0085 | -0.7500 | -0.1252 | -0.7318 | -0.1212 | -41.66 | -6.90 |
| 208 | -0.7903 | 0.0000 | 0.1704 | -0.7717 | 0.0312 | 0.0000 | 0.0305 | -0.0067 | -0.7785 | -0.1399 | -0.7642 | -0.1326 | -43.83 | -7.60 |
| 198 | -0.8166 | 0.0000 | 0.1761 | -0.7973 | 0.0312 | 0.0000 | 0.0305 | -0.0067 | -0.8041 | -0.1456 | -0.7913 | -0.1428 | -45.72 | -8.25 |
| 188 | -0.8391 | 0.0000 | 0.1809 | -0.8194 | 0.0312 | 0.0000 | 0.0305 | -0.0067 | -0.8261 | -0.1504 | -0.8151 | -0.1480 | -47.44 | -8.61 |
| 178 | -0.8586 | 0.0000 | 0.1852 | -0.8384 | 0.0312 | 0.0000 | 0.0305 | -0.0067 | -0.8452 | -0.1547 | -0.8356 | -0.1525 | -48.99 | -8.94 |
| 163.65 | -0.8823 | 0.0000 | 0.1903 | -0.8615 | 0.0312 | 0.0000 | 0.0305 | -0.0067 | -0.8683 | -0.1598 | -0.8567 | -0.1572 | -72.71 | -13.34 |
| 159 | -0.8886 | 0.0000 | 0.1916 | -0.8676 | 0.0312 | 0.0000 | 0.0305 | -0.0067 | -0.8744 | -0.1611 | -0.8713 | -0.1604 | -22.44 | -4.13 |
| 155.00 | -0.8945 | 0.0000 | 0.1929 | -0.8734 | 0.0312 | 0.1211 | 0.1488 | -0.0329 | -0.9063 | -0.0441 | -0.8903 | -0.1026 | -23.00 | -2.65 |
| 138 | -0.9144 | 0.0000 | 0.1972 | -0.8929 | 0.0312 | 0.1211 | 0.1488 | -0.0329 | -0.9258 | -0.0484 | -0.9160 | -0.0462 | -93.70 | -4.73 |
| 128 | -0.9241 | 0.0000 | 0.1993 | -0.9023 | 0.0312 | 0.1211 | 0.1488 | -0.0329 | -0.9352 | -0.0505 | -0.9305 | -0.0494 | -56.52 | -3.00 |
| 118 | -0.9323 | 0.0000 | 0.2010 | -0.9104 | 0.0312 | 0.1211 | 0.1488 | -0.0329 | -0.9432 | -0.0522 | -0.9392 | -0.0514 | -57.45 | -3.14 |
| 108 | -0.9393 | 0.0000 | 0.2025 | -0.9172 | 0.0312 | 0.1211 | 0.1488 | -0.0329 | -0.9500 | -0.0537 | -0.9466 | -0.0530 | -58.30 | -3.26 |
| 98 | -0.9450 | 0.0000 | 0.2038 | -0.9228 | 0.0312 | 0.1211 | 0.1488 | -0.0329 | -0.9557 | -0.0550 | -0.9528 | -0.0544 | -59.09 | -3.37 |
| 88 | -0.9497 | 0.0000 | 0.2048 | -0.9274 | 0.0312 | 0.1211 | 0.1488 | -0.0329 | -0.9602 | -0.0560 | -0.9579 | -0.0555 | -59.81 | -3.47 |
| 80.00 | -0.9527 | 0.0000 | 0.2054 | -0.9303 | 0.0312 | 0.1211 | 0.1488 | -0.0329 | -0.9632 | -0.0566 | -0.9617 | -0.0563 | -48.33 | -2.83 |
| 68 | -0.9560 | 0.0000 | 0.2062 | -0.9335 | 0.0312 | 0.0000 | 0.0305 | -0.0067 | -0.9403 | -0.1757 | -0.9517 | -0.1162 | -72.23 | -8.81 |
| 58 | -0.9578 | 0.0000 | 0.2065 | -0.9353 | 0.0312 | 0.0000 | 0.0305 | -0.0067 | -0.9420 | -0.1760 | -0.9411 | -0.1758 | -59.96 | -11.20 |
| 48 | -0.9587 | 0.0000 | 0.2067 | -0.9361 | 0.0312 | 0.0000 | 0.0305 | -0.0067 | -0.9428 | -0.1762 | -0.9424 | -0.1761 | -60.44 | -11.30 |
| 22 | -0.9571 | 0.0000 | 0.2064 | -0.9346 | 0.0312 | 0.0000 | 0.0305 | -0.0067 | -0.9413 | -0.1759 | -0.9421 | -0.1761 | -158.95 | -29.71 |
| 19 | -0.9566 | 0.0000 | 0.2063 | -0.9341 | 0.0312 | 0.0000 | 0.0305 | -0.0067 | -0.9408 | -0.1758 | -0.9411 | -0.1758 | -18.49 | -3.46 |
| 0 | -0.9518 | 0.0000 | 0.2052 | -0.9294 | 0.0312 | 0.0000 | 0.0305 | -0.0067 | -0.9361 | -0.1747 | -0.9385 | -0.1753 | -117.64 | -21.97 |
| | | | | | | | | | | | | Σ = | -1370.95 | -186.90 |
| | | | | | | | | | | | | LIFT calc = | -2741.90 | |
| | | | | | | | | | | | | Lift = | -2733.15 | |

| SPANWISE AERODYNAMIC LOAD DISTRIBUTION | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| CONDITION. G BRAKES OUT cont... | | | | | | | | |
| 1 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 |
| STATION | LIMIT | LIMIT | LIMIT | LIMIT | ULT | ULT | ULT | ULT |
| (in) | NORMAL | NORMAL | CHORD | CHORD | NORMAL | NORMAL | CHORD | CHORD |
| | SHEAR | MOMENT | SHEAR | MOMENT | SHEAR | MOMENT | SHEAR | MOMENT |
| | (lb) | (lb in) | (lb) | (lb in) | (lb) | (lb in) | (lb) | (lb in) |
| 258 | 0.00 | 0.00 | 0.00 | 0.00 | 0 | 0 | 0 | 0 |
| 251.25 | -19.10 | -64.45 | -2.70 | -9.12 | -29 | -97 | -4 | -14 |
| 238 | -65.25 | -623.24 | -9.89 | -92.56 | -98 | -935 | -15 | -139 |
| 228 | -104.27 | -1470.83 | -16.23 | -223.17 | -156 | -2206 | -24 | -335 |
| 218 | -145.93 | -2721.82 | -23.13 | -419.94 | -219 | -4083 | -35 | -630 |
| 208 | -189.76 | -4400.25 | -30.73 | -689.22 | -285 | -6600 | -46 | -1034 |
| 198 | -235.48 | -6526.42 | -38.98 | -1037.76 | -353 | -9790 | -58 | -1557 |
| 188 | -282.91 | -9118.37 | -47.59 | -1470.61 | -424 | -13678 | -71 | -2206 |
| 178 | -331.90 | -12192.45 | -56.53 | -1991.25 | -498 | -18289 | -85 | -2987 |
| 163.65 | -404.61 | -17476.90 | -69.88 | -2898.24 | -607 | -26215 | -105 | -4347 |
| 159 | -427.04 | -19275.35 | -74.01 | -3209.39 | -641 | -28913 | -111 | -4814 |
| 155.00 | -450.04 | -21172.04 | -76.66 | -3535.20 | -675 | -31758 | -115 | -5303 |
| 138 | -543.74 | -29619.14 | -81.39 | -4878.56 | -816 | -44429 | -122 | -7318 |
| 128 | -600.26 | -35339.12 | -84.39 | -5707.44 | -900 | -53009 | -127 | -8561 |
| 118 | -657.71 | -41628.94 | -87.53 | -6567.04 | -987 | -62443 | -131 | -9851 |
| 108 | -716.01 | -48497.51 | -90.79 | -7458.66 | -1074 | -72746 | -136 | -11188 |
| 98 | -775.10 | -55953.04 | -94.17 | -8383.47 | -1163 | -83930 | -141 | -12575 |
| 88 | -834.91 | -64003.07 | -97.63 | -9342.46 | -1252 | -96005 | -146 | -14014 |
| 80.00 | -883.24 | -70875.66 | -100.46 | -10134.83 | -1325 | -106313 | -151 | -15202 |
| 68 | -955.46 | -81907.87 | -109.28 | -11393.27 | -1433 | -122862 | -164 | -17090 |
| 58 | -1015.42 | -91762.29 | -120.48 | -12542.05 | -1523 | -137643 | -181 | -18813 |
| 48 | -1075.86 | -102218.70 | -131.77 | -13803.32 | -1614 | -153328 | -198 | -20705 |
| 22 | -1234.81 | -132257.47 | -161.48 | -17615.63 | -1852 | -198386 | -242 | -26423 |
| 19 | -1253.31 | -135989.66 | -164.94 | -18105.25 | -1880 | -203984 | -247 | -27158 |
| 0 | -1370.95 | -160920.10 | -186.90 | -21447.73 | -2056 | -241380 | -280 | -32172 |
| | | | | | | | | |
| Centre of lift is | 117 | in from aircraft centreline | | | | | | |
| | 45 | % semispan | | | | | | |

| SPANWISE AERODYNAMIC LOAD DISTRIBUTION | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| CONDITION. G cont. | | | | | | | | |
| | | | | | | | | |
| 1 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 |
| STATION | LIMIT | LIMIT | LIMIT | LIMIT | ULT | ULT | ULT | ULT |
| (in) | NORMAL | NORMAL | CHORD | CHORD | NORMAL | NORMAL | CHORD | CHORD |
| | SHEAR | MOMENT | SHEAR | MOMENT | SHEAR | MOMENT | SHEAR | MOMENT |
| | (lb) | (lb) | (lb) | (lb) | (lb) | (lb) | (lb) | (lb) |
| 258 | 0.00 | 0.00 | 0.00 | 0.00 | 0 | 0 | 0 | 0 |
| 251.25 | -12.03 | -40.59 | -0.71 | -2.40 | -18 | -61 | -1 | -4 |
| 238 | -39.83 | -384.16 | -2.72 | -25.13 | -60 | -576 | -4 | -38 |
| 228 | -63.62 | -901.43 | -4.68 | -62.11 | -95 | -1352 | -7 | -93 |
| 218 | -89.16 | -1665.35 | -6.91 | -120.06 | -134 | -2498 | -10 | -180 |
| 208 | -116.16 | -2691.95 | -9.57 | -202.46 | -174 | -4038 | -14 | -304 |
| 198 | -144.40 | -3994.74 | -12.62 | -313.39 | -217 | -5992 | -19 | -470 |
| 188 | -173.79 | -5585.70 | -15.84 | -455.68 | -261 | -8379 | -24 | -684 |
| 178 | -204.20 | -7475.65 | -19.22 | -631.02 | -306 | -11213 | -29 | -947 |
| 163.65 | -249.43 | -10730.46 | -24.32 | -943.46 | -374 | -16096 | -36 | -1415 |
| 159 | -263.97 | -11840.69 | -26.02 | -1052.33 | -396 | -17761 | -39 | -1578 |
| 155.00 | -279.23 | -13015.36 | -27.87 | -1168.87 | -419 | -19523 | -42 | -1753 |
| 138 | -340.51 | -18283.12 | -35.30 | -1705.81 | -511 | -27425 | -53 | -2559 |
| 128 | -377.49 | -21873.13 | -39.82 | -2081.42 | -566 | -32810 | -60 | -3122 |
| 118 | -415.09 | -25836.07 | -44.42 | -2502.64 | -623 | -38754 | -67 | -3754 |
| 108 | -453.26 | -30177.86 | -49.11 | -2970.32 | -680 | -45267 | -74 | -4455 |
| 98 | -491.96 | -34903.96 | -53.88 | -3485.26 | -738 | -52356 | -81 | -5228 |
| 88 | -531.13 | -40019.36 | -58.71 | -4048.17 | -797 | -60029 | -88 | -6072 |
| 80.00 | -562.78 | -44394.98 | -62.62 | -4533.46 | -844 | -66592 | -94 | -6800 |
| 68 | -610.74 | -51436.09 | -68.55 | -5320.43 | -916 | -77154 | -103 | -7981 |
| 58 | -651.11 | -57745.32 | -73.54 | -6030.87 | -977 | -86618 | -110 | -9046 |
| 48 | -691.80 | -64459.84 | -78.58 | -6791.47 | -1038 | -96690 | -118 | -10187 |
| 22 | -798.82 | -83837.80 | -91.83 | -9006.76 | -1198 | -125757 | -138 | -13510 |
| 19 | -811.27 | -86252.93 | -93.37 | -9284.55 | -1217 | -129379 | -140 | -13927 |
| 0 | -890.47 | -102419.41 | -103.16 | -11151.57 | -1336 | -153629 | -155 | -16727 |
| | | | | | | | | |
| Centre of lift is | 115 | in from aircraft centreline | | | | | | |
| | 45 | % semispan | | | | | | |

SPANWISE INERTIAL LOAD DISTRIBUTION

CONDITION. G BRAKES OUT cont...

| 1 | 3 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 | 41 | 42 | 43 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| STATION | dy | WEIGHT | ELEMENT | ELEMENT | LIMIT | LIMIT | LIMIT | LIMIT | ULT | ULT | ULT | ULT |
| (in) | (in) | nW | SHEAR | SHEAR | NORMAL | NORMAL | CHORD | CHORD | NORMAL | NORMAL | CHORD | CHORD |
| | | (lb) | FORCE | FORCE | SHEAR | MOMENT | SHEAR | MOMENT | SHEAR | MOMENT | SHEAR | MOMENT |
| | | | $V_x$ | $V_z$ | (lb) | (lb in) | (lb) | (lb in) | (lb) | (lb in) | (lb) | (lb in) |
| | | | (lb) | (lb) | | | | | | | | |
| 258 | - | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0 | 0 | 0 | 0 |
| 251.25 | 6.75 | 0.50 | 0.11 | 0.48 | 0.48 | 1.63 | 0.11 | 0.36 | 1 | 2 | 0 | 1 |
| 238 | 13.25 | 1.32 | 0.28 | 1.29 | 1.77 | 16.56 | 0.39 | 3.66 | 3 | 25 | 1 | 5 |
| 228 | 10.00 | 2.28 | 0.49 | 2.23 | 4.00 | 45.39 | 0.88 | 10.02 | 6 | 68 | 1 | 15 |
| 218 | 10.00 | 3.19 | 0.69 | 3.12 | 7.11 | 100.94 | 1.57 | 22.29 | 11 | 151 | 2 | 33 |
| 208 | 10.00 | 3.91 | 0.84 | 3.82 | 10.94 | 191.18 | 2.41 | 42.22 | 16 | 287 | 4 | 63 |
| 198 | 10.00 | 4.60 | 0.99 | 4.49 | 15.42 | 322.98 | 3.41 | 71.32 | 23 | 484 | 5 | 107 |
| 188 | 10.00 | 5.45 | 1.17 | 5.32 | 20.74 | 503.82 | 4.58 | 111.26 | 31 | 756 | 7 | 167 |
| 178 | 10.00 | 6.17 | 1.33 | 6.02 | 26.77 | 741.37 | 5.91 | 163.72 | 40 | 1112 | 9 | 246 |
| 163.65 | 14.35 | 7.09 | 1.53 | 6.93 | 33.69 | 1175.17 | 7.44 | 259.52 | 51 | 1763 | 11 | 389 |
| 159 | 4.33 | 7.32 | 1.58 | 7.15 | 40.84 | 1336.36 | 9.02 | 295.11 | 61 | 2005 | 14 | 443 |
| 155.00 | 4.32 | 7.63 | 1.64 | 7.45 | 48.29 | 1529.10 | 10.66 | 337.68 | 72 | 2294 | 16 | 507 |
| 138 | 17.00 | 8.01 | 1.73 | 7.82 | 56.11 | 2416.45 | 12.39 | 533.63 | 84 | 3625 | 19 | 800 |
| 128 | 10.00 | 8.13 | 1.75 | 7.94 | 64.05 | 3017.20 | 14.14 | 666.30 | 96 | 4526 | 21 | 999 |
| 118 | 10.00 | 8.36 | 1.80 | 8.16 | 72.21 | 3698.48 | 15.95 | 816.75 | 108 | 5548 | 24 | 1225 |
| 108 | 10.00 | 8.47 | 1.83 | 8.27 | 80.48 | 4461.95 | 17.77 | 985.35 | 121 | 6693 | 27 | 1478 |
| 98 | 10.00 | 8.61 | 1.86 | 8.41 | 88.89 | 5308.84 | 19.63 | 1172.38 | 133 | 7963 | 29 | 1759 |
| 88 | 10.00 | 8.96 | 1.93 | 8.74 | 97.64 | 6241.51 | 21.56 | 1378.34 | 146 | 9362 | 32 | 2068 |
| 80.00 | 8.00 | 9.15 | 1.97 | 8.93 | 106.57 | 7058.35 | 23.53 | 1558.73 | 160 | 10588 | 35 | 2338 |
| 68 | 12.00 | 9.49 | 2.05 | 9.26 | 115.83 | 8392.77 | 25.58 | 1853.41 | 174 | 12589 | 38 | 2780 |
| 58 | 10.00 | 9.73 | 2.10 | 9.50 | 125.33 | 9598.60 | 27.68 | 2119.70 | 188 | 14398 | 42 | 3180 |
| 48 | 10.00 | 10.11 | 2.18 | 9.87 | 135.20 | 10901.28 | 29.86 | 2407.38 | 203 | 16352 | 45 | 3611 |
| 22 | 26.00 | 10.83 | 2.34 | 10.58 | 145.78 | 14554.03 | 32.19 | 3214.03 | 219 | 21831 | 48 | 4821 |
| 19 | 3.00 | 5.45 | 1.18 | 5.33 | 151.10 | 14999.35 | 33.37 | 3312.37 | 227 | 22499 | 50 | 4969 |
| 0 | 19.00 | 3.64 | 0.78 | 3.55 | 154.66 | 17904.07 | 34.15 | 3953.84 | 232 | 26856 | 51 | 5931 |
| | Σ = | 125 | lb | | | | | | | | | |
| | | at 1 g | | | Centre of gravity is | 116 | in from aircraft centreline | | | | | |
| | | | | | | 45 | % semispan | | | | | |

*COMBINED ULTIMATE LOADS ( AERODYNAMIC + INERTIAL )*

CONDITION. G BRAKES OUT cont...

| 1 | 44 G | 45 G | 46 G | 47 G | 48 G | 49 G |
|---|---|---|---|---|---|---|
| | ULT | ULT | ULT | ULT | ULT | ULT |
| | NORMAL | NORMAL | CHORD | CHORD | RESOLVED | RESOLVED |
| STATION | SHEAR | BEND MOMENT | SHEAR | BEND MOMENT | SHEAR | BEND MOMENT |
| (in) | COND. G | COND. G | COND. G | COND. G | COND. G | COND. G |
| | (lb) | (lb in) | (lb) | (lb in) | (lb) | (lb in) |
| 258 | 0 | 0 | 0 | 0 | 0 | 0 |
| 251.25 | -28 | -94 | -4 | -13 | 28 | 95 |
| 238 | -95 | -910 | -14 | -133 | 96 | 920 |
| 228 | -150 | -2138 | -23 | -320 | 152 | 2162 |
| 218 | -208 | -3931 | -32 | -596 | 211 | 3976 |
| 208 | -268 | -6314 | -42 | -971 | 272 | 6388 |
| 198 | -330 | -9305 | -53 | -1450 | 334 | 9417 |
| 188 | -393 | -12922 | -65 | -2039 | 399 | 13082 |
| 178 | -458 | -17177 | -76 | -2741 | 464 | 17394 |
| 163.65 | -556 | -24453 | -94 | -3958 | 564 | 24771 |
| 159 | -579 | -26908 | -97 | -4371 | 587 | 27261 |
| 155.00 | -603 | -29464 | -99 | -4796 | 611 | 29852 |
| 138 | -731 | -40804 | -103 | -6517 | 739 | 41321 |
| 128 | -804 | -48483 | -105 | -7562 | 811 | 49069 |
| 118 | -878 | -56896 | -107 | -8625 | 885 | 57546 |
| 108 | -953 | -66053 | -110 | -9710 | 960 | 66763 |
| 98 | -1029 | -75966 | -112 | -10817 | 1035 | 76733 |
| 88 | -1106 | -86642 | -114 | -11946 | 1112 | 87462 |
| 80.00 | -1165 | -95726 | -115 | -12864 | 1171 | 96586 |
| 68 | -1259 | -110273 | -126 | -14310 | 1266 | 111197 |
| 58 | -1335 | -123246 | -139 | -15634 | 1342 | 124233 |
| 48 | -1411 | -136976 | -153 | -17094 | 1419 | 138039 |
| 22 | -1634 | -176555 | -194 | -21602 | 1645 | 177872 |
| 19 | -1653 | -181485 | -197 | -22189 | 1665 | 182837 |
| 0 | -1824 | -214524 | -229 | -26241 | 1839 | 216123 |

AERODYNAMIC TORQUE AT SHEAR CENTRE

CONDITION. G BRAKES OUT cont...

| 1 | 50 | 74 | 51 | 52 | 53 | 54 | 55 | 56 | 57 | 58 |
|---|---|---|---|---|---|---|---|---|---|---|
| STATION | CLEAN + FLAPPED | LEAN + FLAPPE | LOCAL | AERO | X AC | X SC | DELTA X | Z AC | Z SC | DELTA Z |
| | LOCAL | LOCAL | $X_{CP}$ | CENTRE | (in) | (in) | (in) | (in) | (in) | (in) |
| (in) | $C_L$ | $C_{Mo}$ | | (in) | | using 38% chord | | | | |
| 258 | - | -0.025 | - | 0.00 | 0.00 | 13.30 | 13.30 | 0.00 | 2.39 | -2.39 |
| 251.25 | -0.51 | -0.025 | 0.19 | 6.72 | 6.72 | 13.37 | 6.65 | 0.00 | 2.40 | -2.40 |
| 238 | -0.62 | -0.025 | 0.20 | 7.10 | 7.10 | 13.50 | 6.40 | 0.00 | 2.44 | -2.44 |
| 228 | -0.69 | -0.025 | 0.20 | 7.30 | 7.30 | 13.60 | 6.31 | 0.00 | 2.47 | -2.47 |
| 218 | -0.73 | -0.025 | 0.21 | 7.42 | 7.42 | 13.71 | 6.28 | 0.00 | 2.49 | -2.49 |
| 208 | -0.76 | -0.025 | 0.21 | 7.53 | 7.53 | 13.81 | 6.28 | 0.00 | 2.52 | -2.52 |
| 198 | -0.79 | -0.025 | 0.21 | 7.63 | 7.63 | 13.91 | 6.28 | 0.00 | 2.54 | -2.54 |
| 188 | -0.82 | -0.025 | 0.21 | 7.72 | 7.72 | 14.01 | 6.29 | 0.00 | 2.57 | -2.57 |
| 178 | -0.84 | -0.025 | 0.21 | 7.80 | 7.80 | 14.11 | 6.31 | 0.00 | 2.60 | -2.60 |
| 163.65 | -0.86 | -0.025 | 0.21 | 7.91 | 7.91 | 14.26 | 6.35 | 0.00 | 2.64 | -2.64 |
| 159 | -0.87 | -0.025 | 0.21 | 7.95 | 7.95 | 14.30 | 6.35 | 0.00 | 2.65 | -2.65 |
| 155.00 | -0.89 | -0.025 | 0.21 | 8.00 | 8.00 | 14.35 | 6.35 | 0.00 | 2.66 | -2.66 |
| 138 | -0.92 | -0.025 | 0.21 | 8.13 | 8.13 | 14.52 | 6.39 | 0.00 | 2.70 | -2.70 |
| 128 | -0.93 | -0.025 | 0.21 | 8.20 | 8.20 | 14.62 | 6.42 | 0.00 | 2.73 | -2.73 |
| 118 | -0.94 | -0.025 | 0.21 | 8.27 | 8.27 | 14.72 | 6.46 | 0.00 | 2.76 | -2.76 |
| 108 | -0.95 | -0.025 | 0.21 | 8.33 | 8.33 | 14.82 | 6.49 | 0.00 | 2.78 | -2.78 |
| 98 | -0.95 | -0.025 | 0.21 | 8.40 | 8.40 | 14.93 | 6.53 | 0.00 | 2.81 | -2.81 |
| 88 | -0.96 | -0.025 | 0.21 | 8.46 | 8.46 | 15.03 | 6.57 | 0.00 | 2.84 | -2.84 |
| 80.00 | -0.96 | -0.025 | 0.21 | 8.51 | 8.51 | 15.11 | 6.60 | 0.00 | 2.86 | -2.86 |
| 68 | -0.95 | -0.025 | 0.21 | 8.57 | 8.57 | 15.23 | 6.66 | 0.00 | 2.89 | -2.89 |
| 58 | -0.94 | -0.025 | 0.21 | 8.61 | 8.61 | 15.33 | 6.72 | 0.00 | 2.92 | -2.92 |
| 48 | -0.94 | -0.025 | 0.21 | 8.67 | 8.67 | 15.43 | 6.76 | 0.00 | 2.94 | -2.94 |
| 22 | -0.94 | -0.025 | 0.21 | 8.82 | 8.82 | 15.70 | 6.88 | 0.00 | 3.01 | -3.01 |
| 19 | -0.94 | -0.025 | 0.21 | 8.83 | 8.83 | 15.73 | 6.89 | 0.00 | 3.01 | -3.01 |
| 0 | -0.94 | -0.025 | 0.21 | 8.94 | 8.94 | 15.92 | 6.98 | 0.00 | 1.25 | -1.25 |

AERODYNAMIC TORQUE AT SHEAR CENTRE

CONDITION. G BRAKES OUT cont...

| 1 | 65 | 54 | 66 | 67 | 33 | 68 | 69 | 70 |
|---|---|---|---|---|---|---|---|---|
| STATION | X CG | X SC | DELTA | DELTA | ELEMENT | ELEMENT | TOTAL | TOTAL |
| | (in) | (in) | X | X av | LOAD | LIMIT | LIMIT | ULT |
| (in) | | | (in) | (in) | (lb) | TORQUE | TORQUE | TORQUE |
| | using 40% chord | | | | | (lb in) | (lb in) | (lb in) |
| 258 | 14.00 | 13.30 | -0.70 | - | - | - | - | 0.00 |
| 251.25 | 14.07 | 13.37 | -0.70 | -0.70 | 0.50 | -0.35 | -0.35 | -0.52 |
| 238 | 14.21 | 13.50 | -0.71 | -0.71 | 1.32 | -0.93 | -1.28 | -1.92 |
| 228 | 14.32 | 13.60 | -0.72 | -0.71 | 2.28 | -1.63 | -2.91 | -4.36 |
| 218 | 14.43 | 13.71 | -0.72 | -0.72 | 3.19 | -2.29 | -5.20 | -7.80 |
| 208 | 14.53 | 13.81 | -0.73 | -0.72 | 3.91 | -2.83 | -8.03 | -12.05 |
| 198 | 14.64 | 13.91 | -0.73 | -0.73 | 4.60 | -3.35 | -11.39 | -17.08 |
| 188 | 14.75 | 14.01 | -0.74 | -0.73 | 5.45 | -4.00 | -15.39 | -23.08 |
| 178 | 14.86 | 14.11 | -0.74 | -0.74 | 6.17 | -4.57 | -19.96 | -29.93 |
| 163.65 | 15.01 | 14.26 | -0.75 | -0.75 | 7.09 | -5.30 | -25.25 | -37.88 |
| 159 | 15.06 | 14.30 | -0.75 | -0.75 | 7.32 | -5.50 | -30.75 | -46.13 |
| 155.00 | 15.10 | 14.35 | -0.76 | -0.75 | 7.63 | -5.75 | -36.50 | -54.75 |
| 138 | 15.28 | 14.52 | -0.76 | -0.76 | 8.01 | -6.08 | -42.58 | -63.88 |
| 128 | 15.39 | 14.62 | -0.77 | -0.77 | 8.13 | -6.24 | -48.82 | -73.23 |
| 118 | 15.50 | 14.72 | -0.77 | -0.77 | 8.36 | -6.46 | -55.28 | -82.91 |
| 108 | 15.60 | 14.82 | -0.78 | -0.78 | 8.47 | -6.59 | -61.87 | -92.80 |
| 98 | 15.71 | 14.93 | -0.79 | -0.78 | 8.61 | -6.74 | -68.61 | -102.91 |
| 88 | 15.82 | 15.03 | -0.79 | -0.79 | 8.96 | -7.06 | -75.67 | -113.50 |
| 80.00 | 15.90 | 15.11 | -0.80 | -0.79 | 9.15 | -7.25 | -82.92 | -124.38 |
| 68 | 16.03 | 15.23 | -0.80 | -0.80 | 9.49 | -7.57 | -90.50 | -135.74 |
| 58 | 16.14 | 15.33 | -0.81 | -0.80 | 9.73 | -7.82 | -98.32 | -147.48 |
| 48 | 16.25 | 15.43 | -0.81 | -0.81 | 10.11 | -8.18 | -106.50 | -159.76 |
| 22 | 16.52 | 15.70 | -0.83 | -0.82 | 10.83 | -8.87 | -115.38 | -173.06 |
| 19 | 16.56 | 15.73 | -0.83 | -0.83 | 5.45 | -4.51 | -119.89 | -179.83 |
| 0 | 16.76 | 15.92 | -0.84 | -0.83 | 3.64 | -3.03 | -122.92 | -184.37 |

COMBINED ULTIMATE TORSION ( AERODYNAMIC + INERTIAL )

CONDITION. G BRAKES OUT cont...

| | | | |
|---|---|---|---|
| I | 71 G | | |
| STATION | COND. G | | |
| (in) | (lb in) | | |
| 258 | 0 | | |
| 251.25 | -336 | | |
| 238 | -887 | | |
| 228 | -1337 | | |
| 218 | -1811 | | |
| 208 | -2306 | | |
| 198 | -2821 | | |
| 188 | -3354 | | |
| 178 | -3905 | | |
| 163.65 | -4722 | | |
| 159 | -4981 | | |
| 155.00 | -5245 | | |
| 138 | -6295 | | |
| 128 | -6934 | | |
| 118 | -7587 | | |
| 108 | -8253 | | |
| 98 | -8932 | | |
| 88 | -9622 | | |
| 80.00 | -10185 | | |
| 68 | -11028 | | |
| 58 | -11738 | | |
| 48 | -12459 | | |
| 22 | -14358 | | |
| 19 | -14586 | | |
| 0 | -16011 | | |

# APPENDIX D: SPANWISE LOADS DETERMINATION: ASYMMETRIC AILERON DEFLECTION CONDITIONS A THROUGH G

EUROPA GLIDER WING LOADING ANALYSIS

SPANWISE AERODYNAMIC LOAD DISTRIBUTION WITH AILERON DEFLECTION

Europa Glider Wing Unsymmetric Flight Conditons

JAR A23.99 (c) *Unsymmetric Flight Loads* states:

The wing must be designed for the following loading conditions:

The wing and wing carry through structures must be designed for the loads resulting from the combination of 75% of the positive manoeuvring wing loading on both sides of the plane of symmetry and the maximum wing torsion resulting from aileron displacement of $V_C$ or $V_A$ using basic aerofoil moment coefficient modified over the aileron portion of the span must be computed as follows:

| | |
|---|---|
| $C_m = C_m + 0.01\ \delta_u$ | (up aileron side) wing basic aerofoil |
| $C_m = C_m - 0.01\ \delta_d$ | (dwn aileron side) wing basic aerofoil |
| | where $\delta_u$ is the up aileron deflection and $\delta_d$ is |
| | the down aileron deflection |
| | |
| $\Delta_a = V_A/V_C\ \Delta_p$ | In this case a maximum full-aileron deflection speed, $V_{FULL\ DEF}$ |
| $\Delta_b = 0.5{*}V_A/V_D\ \Delta_p$ | 119.6 mph has been chosen |
| $\Delta_p =$ | maximum total deflection at $V_A$ |

$K = (C_m - 0.01\delta_b)V_D^2/(C_m - 0.01\delta_a)V_C^2$

If $K < 1$ then $\Delta_a$ is $\Delta$ critical and must be used to determine $\delta_u$ and $\delta_d$. In this case $V_C$ is the critical speed which must be used in computing the wing torsion loads over the aileron span

If $K > 1$ then $\Delta_b$ is $\Delta$ critical and must be used to determine $\delta_u$ and $\delta_d$. In this case $V_D$ is the critical speed which must be used in computing the wing torsion loads over the aileron span

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| AILERON TORSION | | | | | | | |
| | | | | | | | |
| (Condition A) with max. wing torsion resulting from aileron displacement | | | | | | | |
| | | | | | | | |
| $C_m = C_m + 0.01\ \delta_u$ | | | | Max up | 19.00 | deg | |
| $C_m = C_m - 0.01\ \delta_d$ | | | | Max dwn | 26.00 | deg | |
| | $C_m =$ | -0.025 | | $\Delta p =$ | 45.00 | deg | |
| | $V_A =$ | 94 | mph | $\Delta a =$ | 35.48 | deg | |
| Design cruising speed $V_C$ | $V_C =$ | 120 | mph | $\Delta b =$ | 12.72 | deg | |
| Design diving speed $V_D$ | $V_D =$ | 167 | mph | $K =$ | 0.78 | < 1 | |
| | | | K less than 1 here | | | | |
| | | | | | | | |
| Since K<1, $\Delta_a$ is critical for $\delta_u$ and $\delta_d$. $V_C$ is critical speed for torque condition | | | | | | | |
| | | | | | | | |
| $\Delta a =$ | 35.48 | deg | | | | | |
| $\delta_u =$ | 19.00 | deg | | | | | |
| $\delta_d =$ | 26.00 | deg | | | | | |
| | | | | | | | |
| $C_m$ up = | 0.165 | up (Limit) | | | | | |
| $C_m$ dwn = | -0.285 | dwn (Limit) | | | | | |
| | | | | | | | |
| Since 2/3 condition A includes $C_{mo}$ term, then $C_m$ for aileron span should be reduced before | | | | | | | |
| combining with 2/3 condition A | | | | | | | |
| | | | | | | | |
| Therefore | 3/4 COND.A (Full Def) | | | 2/3 COND.A (Full Def) | | 2/3 COND.D (1/3 Def) | |
| $C_m$ up = | 0.171 | up (Limit) | | 0.173 | up (Limit) | 0.058 | up (Limit) |
| $C_m$ dwn = | -0.279 | dwn (Limit) | | -0.277 | dwn (Limit) | -0.092 | dwn (Limit) |

| | | | |
|---|---|---|---|
| Aileron deflection = | 180.00 | lb at limit load | |
| Aileron deflection = | 120.00 | at 2/3 $n_1$ | |

SPANWISE AERODYNAMIC LOAD DISTRIBUTION

CONDITION. A 2/3 n

AILERON UP

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Aileron deflection = | UP | | | | |
| | | | | | | | | Aileron angle = | -26.00 | deg | | | |
| | | | | | | | | Aileron load = | 120.00 | lb | | | |
| $V_{sal}$ = | 138.51 | ft/s | $C_L$ = | 1.2 | alpha wrp = | 9.1179 | | $\Delta C_L$ = | -1.12 | ileron load = | -120.00 | lb | |
| Lift = | 3644.20 | lb clean | $C_{Do}$ = | 0.017 | sin alpha = | 0.1585 | | $\Delta C_D$ = | 0.05 | ileron drag = | 5.36 | lb | |
| q = | 22.81 | psf | $C_D$ = | 0.058 | cos alpha = | 0.9874 | | $\Delta C_{Mo}$ = | 0.26 | ECF = | 0.22 | | |
| n = | 2.53 | g | $C_{Mo}$ = | -0.025 | | | | Sa = | 4.71 | ft² | | | |
| q.$C_L$ = | 26.99 | q.$C_L$ =Lift/S | S = | 135.00 | ft² | | | ba = | 7.30 | ft | | | |
| | | | b = | 43.00 | ft | | | AR = | 11.31 | | | | |

| 1 | 13 | 72 | 14 | 15 | 16 | 73 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| STATION (in) | $C_L$ | FLAP $C_L$ | $C_{Lx}$ | $C_{Lz}$ | $C_D$ | FLAP $C_D$ | $C_{Dx}$ | $C_{Dz}$ | $C_{Lz}+C_{Dz}$ | $C_{Dx}-C_{Lx}$ | $(C_{Lz}+C_{Dz})_{AV}$ | $(C_{Dx}-C_{Lx})_{AV}$ | SPAN ELEMENT LIFT (lb) | SPAN ELEMENT DRAG (lb) |
| 258 | 0.5917 | 0.0000 | 0.0938 | 0.5842 | 0.0692 | 0.0000 | 0.0683 | 0.0110 | 0.5952 | -0.0254 | - | - | 0.00 | 0.00 |
| 251.25 | 0.7750 | -0.2457 | 0.0839 | 0.5226 | 0.0692 | 0.0110 | 0.0792 | 0.0127 | 0.5353 | -0.0047 | 0.5652 | -0.0151 | 21.21 | -0.57 |
| 238 | 0.9000 | -0.2457 | 0.1037 | 0.6460 | 0.0692 | 0.0110 | 0.0792 | 0.0127 | 0.6587 | -0.0245 | 0.5970 | -0.0146 | 44.31 | -1.08 |
| 228 | 0.9627 | -0.2457 | 0.1136 | 0.7079 | 0.0692 | 0.0110 | 0.0792 | 0.0127 | 0.7206 | -0.0344 | 0.6897 | -0.0295 | 38.97 | -1.67 |
| 218 | 1.0125 | -0.2457 | 0.1215 | 0.7571 | 0.0692 | 0.0110 | 0.0792 | 0.0127 | 0.7698 | -0.0423 | 0.7452 | -0.0384 | 42.42 | -2.19 |
| 208 | 1.0538 | -0.2457 | 0.1280 | 0.7978 | 0.0548 | 0.0110 | 0.0649 | 0.0104 | 0.8083 | -0.0631 | 0.7890 | -0.0527 | 45.25 | -3.02 |
| 198 | 1.0887 | -0.2457 | 0.1336 | 0.8324 | 0.0548 | 0.0110 | 0.0649 | 0.0104 | 0.8428 | -0.0687 | 0.8255 | -0.0659 | 47.70 | -3.81 |
| 188 | 1.1188 | -0.2457 | 0.1384 | 0.8621 | 0.0548 | 0.0110 | 0.0649 | 0.0104 | 0.8725 | -0.0734 | 0.8576 | -0.0710 | 49.92 | -4.13 |
| 178 | 1.1448 | -0.2457 | 0.1425 | 0.8878 | 0.0548 | 0.0110 | 0.0649 | 0.0104 | 0.8982 | -0.0775 | 0.8853 | -0.0755 | 51.90 | -4.43 |
| 163.65 | 1.1764 | -0.2457 | 0.1475 | 0.9189 | 0.0548 | 0.0110 | 0.0649 | 0.0104 | 0.9293 | -0.0825 | 0.9138 | -0.0800 | 77.55 | -6.79 |
| 159 | 1.1847 | 0.0000 | 0.1877 | 1.1698 | 0.0548 | 0.0000 | 0.0541 | 0.0087 | 1.1785 | -0.1336 | 1.0539 | -0.1081 | 27.14 | -2.78 |
| 155.00 | 1.1926 | 0.0000 | 0.1890 | 1.1775 | 0.0548 | 0.0000 | 0.0541 | 0.0087 | 1.1862 | -0.1349 | 1.1823 | -0.1343 | 30.54 | -3.47 |
| 138 | 1.2193 | 0.0000 | 0.1932 | 1.2038 | 0.0548 | 0.0000 | 0.0541 | 0.0087 | 1.2125 | -0.1391 | 1.1994 | -0.1370 | 122.68 | -14.01 |
| 128 | 1.2321 | 0.0000 | 0.1952 | 1.2165 | 0.0548 | 0.0000 | 0.0541 | 0.0087 | 1.2252 | -0.1411 | 1.2189 | -0.1401 | 74.04 | -8.51 |
| 118 | 1.2431 | 0.0000 | 0.1970 | 1.2274 | 0.0548 | 0.0000 | 0.0541 | 0.0087 | 1.2361 | -0.1429 | 1.2306 | -0.1420 | 75.27 | -8.69 |
| 108 | 1.2524 | 0.0000 | 0.1985 | 1.2365 | 0.0548 | 0.0000 | 0.0541 | 0.0087 | 1.2452 | -0.1444 | 1.2406 | -0.1436 | 76.41 | -8.85 |
| 98 | 1.2601 | 0.0000 | 0.1997 | 1.2441 | 0.0548 | 0.0000 | 0.0541 | 0.0087 | 1.2528 | -0.1456 | 1.2490 | -0.1450 | 77.46 | -8.99 |
| 88 | 1.2663 | 0.0000 | 0.2007 | 1.2503 | 0.0548 | 0.0000 | 0.0541 | 0.0087 | 1.2590 | -0.1466 | 1.2559 | -0.1461 | 78.41 | -9.12 |
| 80.00 | 1.2703 | 0.0000 | 0.2013 | 1.2542 | 0.0548 | 0.0000 | 0.0541 | 0.0087 | 1.2629 | -0.1472 | 1.2609 | -0.1469 | 63.37 | -7.38 |
| 68 | 1.2747 | 0.0000 | 0.2020 | 1.2586 | 0.0548 | 0.0000 | 0.0541 | 0.0087 | 1.2673 | -0.1479 | 1.2651 | -0.1475 | 96.01 | -11.20 |
| 58 | 1.2770 | 0.0000 | 0.2024 | 1.2609 | 0.0548 | 0.0000 | 0.0541 | 0.0087 | 1.2696 | -0.1483 | 1.2684 | -0.1481 | 80.81 | -9.43 |
| 48 | 1.2782 | 0.0000 | 0.2026 | 1.2621 | 0.0548 | 0.0000 | 0.0541 | 0.0087 | 1.2708 | -0.1485 | 1.2702 | -0.1484 | 81.46 | -9.51 |
| 22 | 1.2762 | 0.0000 | 0.2022 | 1.2600 | 0.0548 | 0.0000 | 0.0541 | 0.0087 | 1.2687 | -0.1481 | 1.2697 | -0.1483 | 214.24 | -25.02 |
| 19 | 1.2755 | 0.0000 | 0.2021 | 1.2594 | 0.0548 | 0.0000 | 0.0541 | 0.0087 | 1.2680 | -0.1480 | 1.2684 | -0.1481 | 24.93 | -2.91 |
| 0 | 1.2690 | 0.0000 | 0.2011 | 1.2530 | 0.0548 | 0.0000 | 0.0541 | 0.0087 | 1.2617 | -0.1470 | 1.2648 | -0.1475 | 158.55 | -18.49 |
| | | | | | | | | | | | | Σ = | 1700.53 | -176.05 |
| | | | | | | | | | | | | LIFT calc = | 3401.06 | -352.10 |
| | | | | | | | | | | | | Lift = | 3644.20 | |

SPANWISE AERODYNAMIC LOAD DISTRIBUTION

CONDITION. A cont..

| 1 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 |
|---|---|---|---|---|---|---|---|---|
| STATION | LIMIT | LIMIT | LIMIT | LIMIT | ULT | ULT | ULT | ULT |
| (in) | NORMAL | NORMAL | CHORD | CHORD | NORMAL | NORMAL | CHORD | CHORD |
| | SHEAR | MOMENT | SHEAR | MOMENT | SHEAR | MOMENT | SHEAR | MOMENT |
| | (lb) | (lb in) | (lb) | (lb in) | (lb) | (lb in) | (lb) | (lb in) |
| 258 | 0.00 | 0.00 | 0.00 | 0.00 | 0 | 0 | 0 | 0 |
| 251.25 | 21.21 | 71.58 | -0.57 | -1.91 | 32 | 107 | -1 | -3 |
| 238 | 65.52 | 646.14 | -1.65 | -16.58 | 98 | 969 | -2 | -25 |
| 228 | 104.49 | 1496.16 | -3.31 | -41.40 | 157 | 2244 | -5 | -62 |
| 218 | 146.91 | 2753.14 | -5.50 | -85.47 | 220 | 4130 | -8 | -128 |
| 208 | 192.16 | 4448.50 | -8.52 | -155.59 | 288 | 6673 | -13 | -233 |
| 198 | 239.86 | 6608.62 | -12.33 | -259.87 | 360 | 9913 | -18 | -390 |
| 188 | 289.77 | 9256.79 | -16.47 | -403.85 | 435 | 13885 | -25 | -606 |
| 178 | 341.68 | 12414.04 | -20.89 | -590.64 | 513 | 18621 | -31 | -886 |
| 163.65 | 419.22 | 17873.50 | -27.68 | -939.16 | 629 | 26810 | -42 | -1409 |
| 159 | 446.36 | 19745.33 | -30.47 | -1064.92 | 670 | 29618 | -46 | -1597 |
| 155.00 | 476.90 | 21741.87 | -33.94 | -1204.19 | 715 | 32613 | -51 | -1806 |
| 138 | 599.58 | 30891.94 | -47.95 | -1900.20 | 899 | 46338 | -72 | -2850 |
| 128 | 673.62 | 37257.94 | -56.46 | -2422.25 | 1010 | 55887 | -85 | -3633 |
| 118 | 748.89 | 44370.48 | -65.15 | -3030.28 | 1123 | 66556 | -98 | -4545 |
| 108 | 825.30 | 52241.43 | -73.99 | -3725.98 | 1238 | 78362 | -111 | -5589 |
| 98 | 902.76 | 60881.72 | -82.98 | -4510.85 | 1354 | 91323 | -124 | -6766 |
| 88 | 981.17 | 70301.35 | -92.10 | -5386.27 | 1472 | 105452 | -138 | -8079 |
| 80.00 | 1044.54 | 78404.18 | -99.48 | -6152.61 | 1567 | 117606 | -149 | -9229 |
| 68 | 1140.55 | 91514.69 | -110.68 | -7413.59 | 1711 | 137272 | -166 | -11120 |
| 58 | 1221.36 | 103324.20 | -120.11 | -8567.57 | 1832 | 154986 | -180 | -12851 |
| 48 | 1302.81 | 115945.06 | -129.63 | -9816.29 | 1954 | 173918 | -194 | -14724 |
| 22 | 1517.05 | 152603.30 | -154.65 | -13511.92 | 2276 | 228905 | -232 | -20268 |
| 19 | 1541.98 | 157191.84 | -157.56 | -13980.23 | 2313 | 235788 | -236 | -20970 |
| 0 | 1700.53 | 187995.64 | -176.05 | -17149.52 | 2551 | 281993 | -264 | -25724 |
| | | | | | | | | |
| Centre of lift is | 111 | in from aircraft centreline | | | | | | |
| | 43 | % semispan | | | | | | |

SPANWISE INERTIAL LOAD DISTRIBUTION

CONDITION. A cont..

| 1 | 3 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 | 41 | 42 | 43 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| STATION | dy | WEIGHT | ELEMENT | ELEMENT | LIMIT | LIMIT | LIMIT | LIMIT | ULT | ULT | ULT | ULT |
| (in) | (in) | nW | SHEAR | SHEAR | NORMAL | NORMAL | CHORD | CHORD | NORMAL | NORMAL | CHORD | CHORD |
| | | (lb) | FORCE | FORCE | SHEAR | MOMENT | SHEAR | MOMENT | SHEAR | MOMENT | SHEAR | MOMENT |
| | | | $V_x$ | $V_z$ | (lb) | (lb in) | (lb) | (lb in) | (lb) | (lb in) | (lb) | (lb in) |
| | | | (lb) | (lb) | | | | | | | | |
| 258 | - | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0 | 0 | 0 | 0 |
| 251.25 | 6.75 | -0.99 | 0.16 | -0.98 | -0.98 | -3.30 | 0.16 | 0.53 | -1 | -5 | 0 | 1 |
| 238 | 13.25 | -2.63 | 0.42 | -2.60 | -3.58 | -33.49 | 0.57 | 5.37 | -5 | -50 | 1 | 8 |
| 228 | 10.00 | -4.56 | 0.72 | -4.50 | -8.08 | -91.79 | 1.30 | 14.73 | -12 | -138 | 2 | 22 |
| 218 | 10.00 | -6.38 | 1.01 | -6.30 | -14.38 | -204.13 | 2.31 | 32.76 | -22 | -306 | 3 | 49 |
| 208 | 10.00 | -7.83 | 1.24 | -7.73 | -22.11 | -386.62 | 3.55 | 62.05 | -33 | -580 | 5 | 93 |
| 198 | 10.00 | -9.20 | 1.46 | -9.08 | -31.19 | -653.16 | 5.01 | 104.83 | -47 | -980 | 8 | 157 |
| 188 | 10.00 | -10.89 | 1.73 | -10.76 | -41.95 | -1018.87 | 6.73 | 163.52 | -63 | -1528 | 10 | 245 |
| 178 | 10.00 | -12.34 | 1.96 | -12.18 | -54.13 | -1499.28 | 8.69 | 240.63 | -81 | -2249 | 13 | 361 |
| 163.65 | 14.35 | -14.19 | 2.25 | -14.01 | -68.14 | -2376.56 | 10.94 | 381.42 | -102 | -3565 | 16 | 572 |
| 159 | 4.33 | -14.64 | 2.32 | -14.46 | -82.60 | -2702.52 | 13.26 | 433.74 | -124 | -4054 | 20 | 651 |
| 155.00 | 4.32 | -15.25 | 2.42 | -15.06 | -97.65 | -3092.31 | 15.67 | 496.30 | -146 | -4638 | 24 | 744 |
| 138 | 17.00 | -16.01 | 2.54 | -15.81 | -113.46 | -4886.80 | 18.21 | 784.31 | -170 | -7330 | 27 | 1176 |
| 128 | 10.00 | -16.26 | 2.58 | -16.06 | -129.52 | -6101.71 | 20.79 | 979.29 | -194 | -9153 | 31 | 1469 |
| 118 | 10.00 | -16.72 | 2.65 | -16.51 | -146.03 | -7479.47 | 23.44 | 1200.41 | -219 | -11219 | 35 | 1801 |
| 108 | 10.00 | -16.95 | 2.69 | -16.73 | -162.76 | -9023.43 | 26.12 | 1448.21 | -244 | -13535 | 39 | 2172 |
| 98 | 10.00 | -17.23 | 2.73 | -17.01 | -179.77 | -10736.11 | 28.85 | 1723.09 | -270 | -16104 | 43 | 2585 |
| 88 | 10.00 | -17.91 | 2.84 | -17.68 | -197.46 | -12622.25 | 31.69 | 2025.80 | -296 | -18933 | 48 | 3039 |
| 80.00 | 8.00 | -18.29 | 2.90 | -18.06 | -215.52 | -14274.15 | 34.59 | 2290.92 | -323 | -21411 | 52 | 3436 |
| 68 | 12.00 | -18.97 | 3.01 | -18.73 | -234.25 | -16972.75 | 37.60 | 2724.04 | -351 | -25459 | 56 | 4086 |
| 58 | 10.00 | -19.46 | 3.08 | -19.21 | -253.46 | -19411.31 | 40.68 | 3115.41 | -380 | -29117 | 61 | 4673 |
| 48 | 10.00 | -20.22 | 3.20 | -19.96 | -273.42 | -22045.73 | 43.88 | 3538.22 | -410 | -33069 | 66 | 5307 |
| 22 | 26.00 | -21.66 | 3.43 | -21.39 | -294.81 | -29432.72 | 47.32 | 4723.80 | -442 | -44149 | 71 | 7086 |
| 19 | 3.00 | -10.91 | 1.73 | -10.77 | -305.58 | -30333.30 | 49.04 | 4868.33 | -458 | -45500 | 74 | 7303 |
| 0 | 19.00 | -7.27 | 1.15 | -7.18 | -312.76 | -36207.53 | 50.20 | 5811.12 | -469 | -54311 | 75 | 8717 |
| | Σ = | 125 | lb | | | | | | | | | |
| | | at 1 g | | | Centre of gravity is | 116 | in from aircraft centreline | | | | | |
| | | | | | | 45 | % semispan | | | | | |

COMBINED ULTIMATE LOADS ( AERODYNAMIC + INERTIAL )

CONDITION. A cont..

| 1 | 44 A | 45 A | 46 A | 47 A | 48 A | 49 A |
|---|---|---|---|---|---|---|
| | ULT | ULT | ULT | ULT | ULT | ULT |
| | NORMAL | NORMAL . | CHORD | CHORD | RESOLVED | RESOLVED |
| STATION | SHEAR | BEND MOMENT | SHEAR | BEND MOMENT | SHEAR | BEND MOMENT |
| (in) | COND. A | COND. A | COND. A | COND. A | COND. A | COND. A |
| | (lb) | (lb in) | (lb) | (lb in) | (lb) | (lb in) |
| 258 | 0 | 0 | 0 | 0 | 0 | 0 |
| 251.25 | 30 | 102 | -1 | -2 | 30 | 102 |
| 238 | 93 | 919 | -2 | -17 | 93 | 919 |
| 228 | 145 | 2107 | -3 | -40 | 145 | 2107 |
| 218 | 199 | 3824 | -5 | -79 | 199 | 3824 |
| 208 | 255 | 6093 | -7 | -140 | 255 | 6094 |
| 198 | 313 | 8933 | -11 | -233 | 313 | 8936 |
| 188 | 372 | 12357 | -15 | -360 | 372 | 12362 |
| 178 | 431 | 16372 | -18 | -525 | 432 | 16381 |
| 163.65 | 527 | 23245 | -25 | -837 | 527 | 23260 |
| 159 | 546 | 25564 | -26 | -947 | 546 | 25582 |
| 155.00 | 569 | 27974 | -27 | -1062 | 570 | 27994 |
| 138 | 729 | 39008 | -45 | -1674 | 731 | 39044 |
| 128 | 816 | 46734 | -54 | -2164 | 818 | 46784 |
| 118 | 904 | 55337 | -63 | -2745 | 906 | 55405 |
| 108 | 994 | 64827 | -72 | -3417 | 996 | 64917 |
| 98 | 1084 | 75218 | -81 | -4182 | 1088 | 75335 |
| 88 | 1176 | 86519 | -91 | -5041 | 1179 | 86665 |
| 80.00 | 1244 | 96195 | -97 | -5793 | 1247 | 96369 |
| 68 | 1359 | 111813 | -110 | -7034 | 1364 | 112034 |
| 58 | 1452 | 125869 | -119 | -8178 | 1457 | 126135 |
| 48 | 1544 | 140849 | -129 | -9417 | 1549 | 141163 |
| 22 | 1833 | 184756 | -161 | -13182 | 1840 | 185226 |
| 19 | 1855 | 190288 | -163 | -13668 | 1862 | 190778 |
| 0 | 2082 | 227682 | -189 | -17008 | 2090 | 228317 |

AERODYNAMIC TORQUE AT SHEAR CENTRE

CONDITION. A

| 1 | 50 | 74 | 51 | 52 | 53 | 54 | 55 | 56 | 57 | 58 |
|---|---|---|---|---|---|---|---|---|---|---|
| STATION | CLEAN + FLAPPED | CLEAN + FLAPPED | LOCAL | AERO | X AC | X SC | DELTA X | Z AC | Z SC | DELTA Z |
| | LOCAL | LOCAL | $X_{CP}$ | CENTRE | (in) | (in) | (in) | (in) | (in) | (in) |
| (in) | $C_L$ | $C_{Mo}$ | | (in) | | using 38% chord | | using 0.5*wing depth at spar | | |
| 258 | - | -0.025 | - | 0.00 | 0.00 | 13.30 | 13.30 | 0.00 | 2.39 | -2.39 |
| 251.25 | 0.57 | 0.235 | 0.70 | 24.63 | 24.63 | 13.37 | -11.26 | 0.00 | 2.40 | -2.40 |
| 238 | 0.60 | 0.235 | 0.70 | 24.87 | 24.87 | 13.50 | -11.37 | 0.00 | 2.44 | -2.44 |
| 228 | 0.69 | 0.235 | 0.70 | 25.06 | 25.06 | 13.60 | -11.46 | 0.00 | 2.47 | -2.47 |
| 218 | 0.75 | 0.235 | 0.70 | 25.25 | 25.25 | 13.71 | -11.54 | 0.00 | 2.49 | -2.49 |
| 208 | 0.79 | 0.235 | 0.70 | 25.44 | 25.44 | 13.81 | -11.63 | 0.00 | 2.52 | -2.52 |
| 198 | 0.83 | 0.235 | 0.70 | 25.62 | 25.62 | 13.91 | -11.71 | 0.00 | 2.54 | -2.54 |
| 188 | 0.86 | 0.235 | 0.70 | 25.81 | 25.81 | 14.01 | -11.80 | 0.00 | 2.57 | -2.57 |
| 178 | 0.89 | 0.235 | 0.70 | 26.00 | 26.00 | 14.11 | -11.88 | 0.00 | 2.60 | -2.60 |
| 163.65 | 0.91 | 0.235 | 0.70 | 26.27 | 26.27 | 14.26 | -12.01 | 0.00 | 2.64 | -2.64 |
| 159 | 1.05 | -0.025 | 0.26 | 9.93 | 9.93 | 14.30 | 4.38 | 0.00 | 2.65 | -2.65 |
| 155.00 | 1.18 | -0.025 | 0.26 | 9.86 | 9.86 | 14.35 | 4.49 | 0.00 | 2.66 | -2.66 |
| 138 | 1.20 | -0.025 | 0.26 | 9.97 | 9.97 | 14.52 | 4.55 | 0.00 | 2.70 | -2.70 |
| 128 | 1.22 | -0.025 | 0.26 | 10.02 | 10.02 | 14.62 | 4.60 | 0.00 | 2.73 | -2.73 |
| 118 | 1.23 | -0.025 | 0.26 | 10.09 | 10.09 | 14.72 | 4.64 | 0.00 | 2.76 | -2.76 |
| 108 | 1.24 | -0.025 | 0.26 | 10.15 | 10.15 | 14.82 | 4.68 | 0.00 | 2.78 | -2.78 |
| 98 | 1.25 | -0.025 | 0.26 | 10.21 | 10.21 | 14.93 | 4.71 | 0.00 | 2.81 | -2.81 |
| 88 | 1.26 | -0.025 | 0.26 | 10.28 | 10.28 | 15.03 | 4.75 | 0.00 | 2.84 | -2.84 |
| 80.00 | 1.26 | -0.025 | 0.26 | 10.33 | 10.33 | 15.11 | 4.78 | 0.00 | 2.86 | -2.86 |
| 68 | 1.27 | -0.025 | 0.26 | 10.41 | 10.41 | 15.23 | 4.82 | 0.00 | 2.89 | -2.89 |
| 58 | 1.27 | -0.025 | 0.26 | 10.48 | 10.48 | 15.33 | 4.85 | 0.00 | 2.92 | -2.92 |
| 48 | 1.27 | -0.025 | 0.26 | 10.55 | 10.55 | 15.43 | 4.89 | 0.00 | 2.94 | -2.94 |
| 22 | 1.27 | -0.025 | 0.26 | 10.73 | 10.73 | 15.70 | 4.97 | 0.00 | 3.01 | -3.01 |
| 19 | 1.27 | -0.025 | 0.26 | 10.75 | 10.75 | 15.73 | 4.98 | 0.00 | 3.01 | -3.01 |
| 0 | 1.26 | -0.025 | 0.26 | 10.88 | 10.88 | 15.92 | 5.04 | 0.00 | 1.25 | -1.25 |

AERODYNAMIC TORQUE AT SHEAR CENTRE

CONDITION. A

| 1 | 55 | 56 | 23 | 24 | 59 | 75 | 60 | 61 | 62 | 63 | 64 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | $\Delta C_{Mo}$ 0 | | | | | |
| STATION | DELTA X av | DELTA Z av | SPAN ELEMENT LIFT | SPAN ELEMENT DRAG | ELEMENT TORQUE DUE TO $C_{Mo}$ | ELEMENT TORQUE DUE TO $\Delta C_{Mo}$ | ELEMENT TORQUE DUE TO LIFT | ELEMENT TORQUE DUE TO DRAG | ELEMENT LIMIT TORQUE | TOTAL LIMIT TORQUE | TOTAL ULT TORQUE |
| (in) | (in) | (in) | (lb) | (lb) | (lb in) | (lb in) | (lb in) | (lb in) | (lb in) | (lb in) | (lb in) |
| 258 | - | - | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 251.25 | 1.02 | 0.00 | 21.21 | -0.57 | -32.92 | 342.34 | 21.66 | 0.00 | 331.08 | 331.08 | 496.62 |
| 238 | -11.31 | 0.00 | 44.31 | -1.08 | -65.60 | 682.28 | -501.32 | 0.00 | 115.35 | 446.43 | 669.64 |
| 228 | -11.41 | 0.00 | 38.97 | -1.67 | -50.39 | 524.02 | -444.80 | 0.00 | 28.84 | 475.26 | 712.90 |
| 218 | -11.50 | 0.00 | 42.42 | -2.19 | -51.15 | 531.91 | -487.85 | 0.00 | -7.09 | 468.18 | 702.27 |
| 208 | -11.59 | 0.00 | 45.25 | -3.02 | -51.91 | 539.86 | -524.26 | 0.00 | -36.31 | 431.86 | 647.80 |
| 198 | -11 67 | 0.00 | 47.70 | -3.81 | -52.68 | 547.86 | -556.65 | 0.00 | -61.47 | 370.39 | 555.59 |
| 188 | -11.76 | 0.00 | 49.92 | -4.13 | -53.45 | 555.93 | -586.82 | 0.00 | -84.34 | 286.05 | 429.07 |
| 178 | -11.84 | 0.00 | 51.90 | -4.43 | -54.24 | 564.05 | -614.61 | 0.00 | -104.80 | 181.25 | 271.88 |
| 163.65 | -11.95 | 0.00 | 77.55 | -6.79 | -79.20 | 823.72 | -926.38 | 0.00 | -181.87 | -0.62 | -0.93 |
| 159 | -3.82 | 0.00 | 27.14 | -2.78 | -24.19 | 0.00 | -103.54 | 0.00 | -127.73 | -128.35 | -192.52 |
| 155.00 | 4.43 | 0.00 | 30.54 | -3.47 | -24.34 | 0.00 | 135.34 | 0.00 | 111.00 | -17.35 | -26.02 |
| 138 | 4.52 | 0.00 | 122.68 | -14.01 | -97.13 | 0.00 | 554.54 | 0.00 | 457.41 | 440.06 | 660.10 |
| 128 | 4.58 | 0.00 | 74.04 | -8.51 | -58.23 | 0.00 | 338.73 | 0.00 | 280.51 | 720.57 | 1080.86 |
| 118 | 4.62 | 0.00 | 75.27 | -8.69 | -59.04 | 0.00 | 347.56 | 0.00 | 288.52 | 1009.09 | 1513.64 |
| 108 | 4.66 | 0.00 | 76.41 | -8.85 | -59.86 | 0.00 | 355.79 | 0.00 | 295.93 | 1305.02 | 1957.53 |
| 98 | 4.69 | 0.00 | 77.46 | -8.99 | -60.69 | 0.00 | 363.59 | 0.00 | 302.90 | 1607.92 | 2411.88 |
| 88 | 4.73 | 0.00 | 78.41 | -9.12 | -61.52 | 0.00 | 370.98 | 0.00 | 309.46 | 1917.38 | 2876.07 |
| 80.00 | 4.76 | 0.00 | 63.37 | -7.38 | -49.82 | 0.00 | 301.87 | 0.00 | 252.05 | 2169.43 | 3254.15 |
| 68 | 4.80 | 0.00 | 96.01 | -11.20 | -75.74 | 0.00 | 460.72 | 0.00 | 384.98 | 2554.41 | 3831.62 |
| 58 | 4.84 | 0.00 | 80.81 | -9.43 | -64.05 | 0.00 | 390.83 | 0.00 | 326.78 | 2881.19 | 4321.79 |
| 48 | 4.87 | 0.00 | 81.46 | -9.51 | -64.91 | 0.00 | 396.72 | 0.00 | 331.81 | 3213.01 | 4819.51 |
| 22 | 4.93 | 0.00 | 214.24 | -25.02 | -172.79 | 0.00 | 1055.87 | 0.00 | 883.08 | 4096.09 | 6144.13 |
| 19 | 4.97 | 0.00 | 24.93 | -2.91 | -20.32 | 0.00 | 124.00 | 0.00 | 103.68 | 4199.77 | 6299.66 |
| 0 | 5.01 | 0.00 | 158.55 | -18.49 | -130.51 | 0.00 | 794.09 | 0.00 | 663 58 | 4863.35 | 7295.03 |

DEAD WEIGHT ANALYSIS FOR WING TORQUE

CONDITION. A

| 1 | 65 | 54 | 66 | 67 | 33 | 68 | 69 | 70 |
|---|---|---|---|---|---|---|---|---|
| STATION | X CG | X SC | DELTA | DELTA | ELEMENT | ELEMENT | TOTAL | TOTAL |
| | (in) | (in) | X | X av | LOAD | LIMIT | LIMIT | ULT |
| (in) | | | (in) | (in) | (lb) | TORQUE | TORQUE | TORQUE |
| | using 40% chord | | | | | (lb in) | (lb in) | (lb in) |
| 258 | 14.00 | 13.30 | -0.70 | - | - | - | - | 0.00 |
| 251.25 | 14.07 | 13.37 | -0.70 | -0.70 | -0.99 | 0.69 | 0.69 | 1.04 |
| 238 | 14.21 | 13.50 | -0.71 | -0.71 | -2.63 | 1.86 | 2.56 | 3.84 |
| 228 | 14.32 | 13.60 | -0.72 | -0.71 | -4.56 | 3.25 | 5.81 | 8.72 |
| 218 | 14.43 | 13.71 | -0.72 | -0.72 | -6.38 | 4.59 | 10.40 | 15.60 |
| 208 | 14.53 | 13.81 | -0.73 | -0.72 | -7.83 | 5.67 | 16.07 | 24.10 |
| 198 | 14.64 | 13.91 | -0.73 | -0.73 | -9.20 | 6.71 | 22.78 | 34.16 |
| 188 | 14.75 | 14.01 | -0.74 | -0.73 | -10.89 | 8.00 | 30.78 | 46.17 |
| 178 | 14.86 | 14.11 | -0.74 | -0.74 | -12.34 | 9.13 | 39.91 | 59.87 |
| 163.65 | 15.01 | 14.26 | -0.75 | -0.75 | -14.19 | 10.59 | 50.50 | 75.75 |
| 159 | 15.06 | 14.30 | -0.75 | -0.75 | -14.64 | 11.01 | 61.51 | 92.26 |
| 155.00 | 15.10 | 14.35 | -0.76 | -0.75 | -15.25 | 11.50 | 73.01 | 109.51 |
| 138 | 15.28 | 14.52 | -0.76 | -0.76 | -16.01 | 12.16 | 85.17 | 127.75 |
| 128 | 15.39 | 14.62 | -0.77 | -0.77 | -16.26 | 12.47 | 97.64 | 146.46 |
| 118 | 15.50 | 14.72 | -0.77 | -0.77 | -16.72 | 12.91 | 110.55 | 165.83 |
| 108 | 15.60 | 14.82 | -0.78 | -0.78 | -16.95 | 13.18 | 123.73 | 185.60 |
| 98 | 15.71 | 14.93 | -0.79 | -0.78 | -17.23 | 13.49 | 137.22 | 205.83 |
| 88 | 15.82 | 15.03 | -0.79 | -0.79 | -17.91 | 14.12 | 151.34 | 227.00 |
| 80.00 | 15.90 | 15.11 | -0.80 | -0.79 | -18.29 | 14.51 | 165.84 | 248.76 |
| 68 | 16.03 | 15.23 | -0.80 | -0.80 | -18.97 | 15.15 | 180.99 | 271.49 |
| 58 | 16.14 | 15.33 | -0.81 | -0.80 | -19.46 | 15.65 | 196.64 | 294.96 |
| 48 | 16.25 | 15.43 | -0.81 | -0.81 | -20.22 | 16.37 | 213.01 | 319.51 |
| 22 | 16.52 | 15.70 | -0.83 | -0.82 | -21.66 | 17.75 | 230.75 | 346.13 |
| 19 | 16.56 | 15.73 | -0.83 | -0.83 | -10.91 | 9.02 | 239.77 | 359.66 |
| 0 | 16.76 | 15.92 | -0.84 | -0.83 | -7.27 | 6.06 | 245.83 | 368.75 |

| COMBINED ULTIMATE TORSION ( AERODYNAMIC + INERTIAL ) | | | |
|---|---|---|---|
| CONDITION. A | | | |
| | | | |
| 1 | 71 A | | |
| STATION | COND. A | | |
| (in) | (lb in) | | |
| 258 | 0 | | |
| 251.25 | 498 | | |
| 238 | 673 | | |
| 228 | 722 | | |
| 218 | 718 | | |
| 208 | 672 | | |
| 198 | 590 | | |
| 188 | 475 | | |
| 178 | 332 | | |
| 163.65 | 75 | | |
| 159 | -100 | | |
| 155.00 | 83 | | |
| 138 | 788 | | |
| 128 | 1227 | | |
| 118 | 1679 | | |
| 108 | 2143 | | |
| 98 | 2618 | | |
| 88 | 3103 | | |
| 80.00 | 3503 | | |
| 68 | 4103 | | |
| 58 | 4617 | | |
| 48 | 5139 | | |
| 22 | 6490 | | |
| 19 | 6659 | | |
| 0 | 7664 | | |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SPANWISE AERODYNAMIC LOAD DISTRIBUTION | | | | | | | | | Aileron deflection = | DWN | | ECF = | 0.19 | |
| CONDITION. A 2/3 n | | | | | | | | | Aileron angle = | 19.00 | deg | | 0.00 | |
| AILERON DOWN | | | | | | | | | Aileron load = | 120.00 | lb | | | |
| $V_{sel}$ = | 138.51 | ft/s | $C_L$ = | 1.2 | | alpha wrp = | 9.1179 | | $\Delta C_L$ = | 1.12 | | | | |
| Lift = | 3644.20 | lb clean | $C_{Do}$ = | 0.017 | | sin alpha = | 0.1585 | | $\Delta C_D$ = | 0.05 | | | | |
| q = | 22.81 | psf | $C_D$ = | 0.058 | | cos alpha = | 0.9874 | | $\Delta C_{Mo}$ = | -0.19 | | | | |
| n = | 2.53 | g | $C_{Mo}$ = | -0.025 | | | | | Sa = | 4.71 | $ft^2$ | | | |
| $q.C_L$ = | 26.99 | $q.C_L$ = Lift/S | S = | 135.00 | $ft^2$ | | | | b = | 7.30 | ft | | | |
| | | | b = | 43.00 | ft | | | | AR = | 11.31 | | | | |
| 1 | 13 | 72 | 14 | 15 | 16 | 73 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 |
| STATION | $C_L$ | FLAP | $C_{Lx}$ | $C_{Lz}$ | $C_D$ | FLAP | $C_{Dx}$ | $C_{Dz}$ | $C_{Lz}+C_{Dz}$ | $C_{Dx}-C_{Lx}$ | $(C_{Lz}+C_{Dz})_{AV}$ | $(C_{Dx}-C_{Lx})_{AV}$ | SPAN | SPAN |
| (in) | | $C_L$ | | | | $C_D$ | | | | | | | ELEMENT | ELEMENT |
| | | | | | | | | | | | | | LIFT | DRAG |
| | | | | | | | | | | | | | (lb) | (lb) |
| 258 | 0.5917 | 0.0000 | 0.0938 | 0.5842 | 0.0692 | 0.0000 | 0.0683 | 0.0110 | 0.5952 | -0.0254 | - | - | 0.00 | 0.00 |
| 251.25 | 0.7750 | 0.2122 | 0.1564 | 0.9747 | 0.0692 | 0.0095 | 0.0777 | 0.0125 | 0.9872 | -0.0787 | 0.7912 | -0.0521 | 29.69 | -1.95 |
| 238 | 0.9000 | 0.2122 | 0.1762 | 1.0981 | 0.0692 | 0.0095 | 0.0777 | 0.0125 | 1.1106 | -0.0986 | 1.0489 | -0.0886 | 77.85 | -6.58 |
| 228 | 0.9627 | 0.2122 | 0.1862 | 1.1600 | 0.0692 | 0.0095 | 0.0777 | 0.0125 | 1.1725 | -0.1085 | 1.1415 | -0.1035 | 64.50 | -5.85 |
| 218 | 1.0125 | 0.2122 | 0.1941 | 1.2092 | 0.0692 | 0.0095 | 0.0777 | 0.0125 | 1.2217 | -0.1164 | 1.1971 | -0.1124 | 68.15 | -6.40 |
| 208 | 1.0538 | 0.2122 | 0.2006 | 1.2500 | 0.0548 | 0.0095 | 0.0635 | 0.0102 | 1.2601 | -0.1372 | 1.2409 | -0.1268 | 71.17 | -7.27 |
| 198 | 1.0887 | 0.2122 | 0.2062 | 1.2845 | 0.0548 | 0.0095 | 0.0635 | 0.0102 | 1.2947 | -0.1427 | 1.2774 | -0.1399 | 73.80 | -8.08 |
| 188 | 1.1188 | 0.2122 | 0.2109 | 1.3142 | 0.0548 | 0.0095 | 0.0635 | 0.0102 | 1.3244 | -0.1475 | 1.3095 | -0.1451 | 76.21 | -8.44 |
| 178 | 1.1448 | 0.2122 | 0.2150 | 1.3399 | 0.0548 | 0.0095 | 0.0635 | 0.0102 | 1.3501 | -0.1516 | 1.3372 | -0.1495 | 78.39 | -8.77 |
| 163.65 | 1.1764 | 0.2122 | 0.2200 | 1.3710 | 0.0548 | 0.0095 | 0.0635 | 0.0102 | 1.3812 | -0.1566 | 1.3657 | -0.1541 | 115.90 | -13.08 |
| 159 | 1.1847 | 0.0000 | 0.1877 | 1.1698 | 0.0548 | 0.0000 | 0.0541 | 0.0087 | 1.1785 | -0.1336 | 1.2798 | -0.1451 | 32.95 | -3.74 |
| 155.00 | 1.1926 | 0.0000 | 0.1890 | 1.1775 | 0.0548 | 0.0000 | 0.0541 | 0.0087 | 1.1862 | -0.1349 | 1.1823 | -0.1343 | 30.54 | -3.47 |
| 138 | 1.2193 | 0.0000 | 0.1932 | 1.2038 | 0.0548 | 0.0000 | 0.0541 | 0.0087 | 1.2125 | -0.1391 | 1.1994 | -0.1370 | 122.68 | -14.01 |
| 128 | 1.2321 | 0.0000 | 0.1952 | 1.2165 | 0.0548 | 0.0000 | 0.0541 | 0.0087 | 1.2252 | -0.1411 | 1.2189 | -0.1401 | 74.04 | -8.51 |
| 118 | 1.2431 | 0.0000 | 0.1970 | 1.2274 | 0.0548 | 0.0000 | 0.0541 | 0.0087 | 1.2361 | -0.1429 | 1.2306 | -0.1420 | 75.27 | -8.69 |
| 108 | 1.2524 | 0.0000 | 0.1985 | 1.2365 | 0.0548 | 0.0000 | 0.0541 | 0.0087 | 1.2452 | -0.1444 | 1.2406 | -0.1436 | 76.41 | -8.85 |
| 98 | 1.2601 | 0.0000 | 0.1997 | 1.2441 | 0.0548 | 0.0000 | 0.0541 | 0.0087 | 1.2528 | -0.1456 | 1.2490 | -0.1450 | 77.46 | -8.99 |
| 88 | 1.2663 | 0.0000 | 0.2007 | 1.2503 | 0.0548 | 0.0000 | 0.0541 | 0.0087 | 1.2590 | -0.1466 | 1.2559 | -0.1461 | 78.41 | -9.12 |
| 80.00 | 1.2703 | 0.0000 | 0.2013 | 1.2542 | 0.0548 | 0.0000 | 0.0541 | 0.0087 | 1.2629 | -0.1472 | 1.2609 | -0.1469 | 63.37 | -7.38 |
| 68 | 1.2747 | 0.0000 | 0.2020 | 1.2586 | 0.0548 | 0.0000 | 0.0541 | 0.0087 | 1.2673 | -0.1479 | 1.2651 | -0.1475 | 96.01 | -11.20 |
| 58 | 1.2770 | 0.0000 | 0.2024 | 1.2609 | 0.0548 | 0.0000 | 0.0541 | 0.0087 | 1.2696 | -0.1483 | 1.2684 | -0.1481 | 80.81 | -9.43 |
| 48 | 1.2782 | 0.0000 | 0.2026 | 1.2621 | 0.0548 | 0.0000 | 0.0541 | 0.0087 | 1.2708 | -0.1485 | 1.2702 | -0.1484 | 81.46 | -9.51 |
| 22 | 1.2762 | 0.0000 | 0.2022 | 1.2600 | 0.0548 | 0.0000 | 0.0541 | 0.0087 | 1.2687 | -0.1481 | 1.2697 | -0.1483 | 214.24 | -25.02 |
| 19 | 1.2755 | 0.0000 | 0.2021 | 1.2594 | 0.0548 | 0.0000 | 0.0541 | 0.0087 | 1.2680 | -0.1480 | 1.2684 | -0.1481 | 24.93 | -2.91 |
| 0 | 1.2690 | 0.0000 | 0.2011 | 1.2530 | 0.0548 | 0.0000 | 0.0541 | 0.0087 | 1.2617 | -0.1470 | 1.2648 | -0.1475 | 158.55 | -18.49 |
| | | | | | | | | | | | | Σ = | 1942.79 | -215.74 |
| | | | | | | | | | | | | LIFT calc = | 3885.57 | |
| | | | | | | | | | | | | Lift = | 3644.20 | |

SPANWISE AERODYNAMIC LOAD DISTRIBUTION

CONDITION. A cont..

| 1 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 |
|---|---|---|---|---|---|---|---|---|
| STATION | LIMIT | LIMIT | LIMIT | LIMIT | ULT | ULT | ULT | ULT |
| (in) | NORMAL | NORMAL | CHORD | CHORD | NORMAL | NORMAL | CHORD | CHORD |
| | SHEAR | MOMENT | SHEAR | MOMENT | SHEAR | MOMENT | SHEAR | MOMENT |
| | (lb) | (lb in) | (lb) | (lb in) | (lb) | (lb in) | (lb) | (lb in) |
| 258 | 0.00 | 0.00 | 0.00 | 0.00 | 0 | 0 | 0 | 0 |
| 251.25 | 29.69 | 100.19 | -1.95 | -6.60 | 45 | 150 | -3 | -10 |
| 238 | 107.53 | 1009.27 | -8.53 | -76.08 | 161 | 1514 | -13 | -114 |
| 228 | 172.04 | 2407.11 | -14.38 | -190.65 | 258 | 3611 | -22 | -286 |
| 218 | 240.18 | 4468.22 | -20.78 | -366.48 | 360 | 6702 | -31 | -550 |
| 208 | 311.35 | 7225.91 | -28.05 | -610.67 | 467 | 10839 | -42 | -916 |
| 198 | 385.16 | 10708.49 | -36.14 | -931.62 | 578 | 16063 | -54 | -1397 |
| 188 | 461.37 | 14941.15 | -44.58 | -1335.22 | 692 | 22412 | -67 | -2003 |
| 178 | 539.77 | 19946.86 | -53.35 | -1824.87 | 810 | 29920 | -80 | -2737 |
| 163.65 | 655.66 | 28524.08 | -66.42 | -2684.23 | 983 | 42786 | -100 | -4026 |
| 159 | 688.62 | 31431.09 | -70.16 | -2979.60 | 1033 | 47147 | -105 | -4469 |
| 155.00 | 719.16 | 34475.40 | -73.63 | -3290.55 | 1079 | 51713 | -110 | -4936 |
| 138 | 841.84 | 47743.86 | -87.64 | -4661.35 | 1263 | 71616 | -131 | -6992 |
| 128 | 915.88 | 56532.43 | -96.15 | -5580.33 | 1374 | 84799 | -144 | -8370 |
| 118 | 991.15 | 66067.55 | -104.84 | -6585.30 | 1487 | 99101 | -157 | -9878 |
| 108 | 1067.56 | 76361.09 | -113.69 | -7677.92 | 1601 | 114542 | -171 | -11517 |
| 98 | 1145.01 | 87423.95 | -122.68 | -8859.73 | 1718 | 131136 | -184 | -13290 |
| 88 | 1223.43 | 99266.16 | -131.80 | -10132.08 | 1835 | 148899 | -198 | -15198 |
| 80.00 | 1286.80 | 109307.05 | -139.18 | -11215.97 | 1930 | 163961 | -209 | -16824 |
| 68 | 1382.80 | 125324.66 | -150.37 | -12953.28 | 2074 | 187987 | -226 | -19430 |
| 58 | 1463.61 | 139556.75 | -159.81 | -14504.19 | 2195 | 209335 | -240 | -21756 |
| 48 | 1545.07 | 154600.18 | -169.32 | -16149.84 | 2318 | 231900 | -254 | -24225 |
| 22 | 1759.31 | 197557.13 | -194.34 | -20877.49 | 2639 | 296336 | -292 | -31316 |
| 19 | 1784.24 | 202872.45 | -197.25 | -21464.89 | 2676 | 304309 | -296 | -32197 |
| 0 | 1942.79 | 238279.15 | -215.74 | -25388.35 | 2914 | 357419 | -324 | -38083 |
| | | | | | | | | |
| Centre of lift is | 123 | in from aircraft centreline | | | | | | |
| | 48 | % semispan | | | | | | |

COMBINED ULTIMATE LOADS ( AERODYNAMIC + INERTIAL )

CONDITION. A cont..

| 1 | 44 A | 45 A | 46 A | 47 A | 48 A | 49 A |
|---|---|---|---|---|---|---|
| | ULT | ULT | ULT | ULT | ULT | ULT |
| | NORMAL | NORMAL | CHORD | CHORD | RESOLVED | RESOLVED |
| STATION | SHEAR | BEND MOMENT | SHEAR | BEND MOMENT | SHEAR | BEND MOMENT |
| (in) | COND. A | COND. A | COND. A | COND. A | COND. A | COND. A |
| | (lb) | (lb in) | (lb) | (lb in) | (lb) | (lb in) |
| 258 | 0 | 0 | 0 | 0 | 0 | 0 |
| 251.25 | 43 | 145 | -3 | -9 | 43 | 146 |
| 238 | 156 | 1464 | -12 | -106 | 156 | 1468 |
| 228 | 246 | 3473 | -20 | -264 | 247 | 3483 |
| 218 | 339 | 6396 | -28 | -501 | 340 | 6416 |
| 208 | 434 | 10259 | -37 | -823 | 435 | 10292 |
| 198 | 531 | 15083 | -47 | -1240 | 533 | 15134 |
| 188 | 629 | 20883 | -57 | -1758 | 632 | 20957 |
| 178 | 728 | 27671 | -67 | -2376 | 732 | 27773 |
| 163.65 | 881 | 39221 | -83 | -3454 | 885 | 39373 |
| 159 | 909 | 43093 | -85 | -3819 | 913 | 43262 |
| 155.00 | 932 | 47075 | -87 | -4191 | 936 | 47261 |
| 138 | 1093 | 64286 | -104 | -5816 | 1098 | 64548 |
| 128 | 1180 | 75646 | -113 | -6902 | 1185 | 75960 |
| 118 | 1268 | 87882 | -122 | -8077 | 1274 | 88253 |
| 108 | 1357 | 101006 | -131 | -9345 | 1364 | 101438 |
| 98 | 1448 | 115032 | -141 | -10705 | 1455 | 115529 |
| 88 | 1539 | 129966 | -150 | -12159 | 1546 | 130533 |
| 80.00 | 1607 | 142549 | -157 | -13388 | 1615 | 143177 |
| 68 | 1723 | 162528 | -169 | -15344 | 1731 | 163251 |
| 58 | 1815 | 180218 | -179 | -17083 | 1824 | 181026 |
| 48 | 1907 | 198832 | -188 | -18917 | 1917 | 199730 |
| 22 | 2197 | 252187 | -221 | -24231 | 2208 | 253348 |
| 19 | 2218 | 258809 | -222 | -24895 | 2229 | 260003 |
| 0 | 2445 | 303107 | -248 | -29366 | 2458 | 304527 |

SPANWISE INERTIAL LOAD DISTRIBUTION

CONDITION. A cont.

| 1 | 3 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 | 41 | 42 | 43 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| STATION (in) | dy (in) | WEIGHT nW (lb) | ELEMENT SHEAR FORCE $V_x$ (lb) | ELEMENT SHEAR FORCE $V_z$ (lb) | LIMIT NORMAL SHEAR (lb) | LIMIT NORMAL MOMENT (lb in) | LIMIT CHORD SHEAR (lb) | LIMIT CHORD MOMENT (lb in) | ULT NORMAL SHEAR (lb) | ULT NORMAL MOMENT (lb in) | ULT CHORD SHEAR (lb) | ULT CHORD MOMENT (lb in) |
| 258 | - | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0 | 0 | 0 | 0 |
| 251.25 | 6.75 | -0.99 | 0.16 | -0.98 | -0.98 | -3.30 | 0.16 | 0.53 | -1 | -5 | 0 | 1 |
| 238 | 13.25 | -2.63 | 0.42 | -2.60 | -3.58 | -33.49 | 0.57 | 5.37 | -5 | -50 | 1 | 8 |
| 228 | 10.00 | -4.56 | 0.72 | -4.50 | -8.08 | -91.79 | 1.30 | 14.73 | -12 | -138 | 2 | 22 |
| 218 | 10.00 | -6.38 | 1.01 | -6.30 | -14.38 | -204.13 | 2.31 | 32.76 | -22 | -306 | 3 | 49 |
| 208 | 10.00 | -7.83 | 1.24 | -7.73 | -22.11 | -386.62 | 3.55 | 62.05 | -33 | -580 | 5 | 93 |
| 198 | 10.00 | -9.20 | 1.46 | -9.08 | -31.19 | -653.16 | 5.01 | 104.83 | -47 | -980 | 8 | 157 |
| 188 | 10.00 | -10.89 | 1.73 | -10.76 | -41.95 | -1018.87 | 6.73 | 163.52 | -63 | -1528 | 10 | 245 |
| 178 | 10.00 | -12.34 | 1.96 | -12.18 | -54.13 | -1499.28 | 8.69 | 240.63 | -81 | -2249 | 13 | 361 |
| 163.65 | 14.35 | -14.19 | 2.25 | -14.01 | -68.14 | -2376.56 | 10.94 | 381.42 | -102 | -3565 | 16 | 572 |
| 159 | 4.33 | -14.64 | 2.32 | -14.46 | -82.60 | -2702.52 | 13.26 | 433.74 | -124 | -4054 | 20 | 651 |
| 155.00 | 4.32 | -15.25 | 2.42 | -15.06 | -97.65 | -3092.31 | 15.67 | 496.30 | -146 | -4638 | 24 | 744 |
| 138 | 17.00 | -16.01 | 2.54 | -15.81 | -113.46 | -4886.80 | 18.21 | 784.31 | -170 | -7330 | 27 | 1176 |
| 128 | 10.00 | -16.26 | 2.58 | -16.06 | -129.52 | -6101.71 | 20.79 | 979.29 | -194 | -9153 | 31 | 1469 |
| 118 | 10.00 | -16.72 | 2.65 | -16.51 | -146.03 | -7479.47 | 23.44 | 1200.41 | -219 | -11219 | 35 | 1801 |
| 108 | 10.00 | -16.95 | 2.69 | -16.73 | -162.76 | -9023.43 | 26.12 | 1448.21 | -244 | -13535 | 39 | 2172 |
| 98 | 10.00 | -17.23 | 2.73 | -17.01 | -179.77 | -10736.11 | 28.85 | 1723.09 | -270 | -16104 | 43 | 2585 |
| 88 | 10.00 | -17.91 | 2.84 | -17.68 | -197.46 | -12622.25 | 31.69 | 2025.80 | -296 | -18933 | 48 | 3039 |
| 80.00 | 8.00 | -18.29 | 2.90 | -18.06 | -215.52 | -14274.15 | 34.59 | 2290.92 | -323 | -21411 | 52 | 3436 |
| 68 | 12.00 | -18.97 | 3.01 | -18.73 | -234.25 | -16972.75 | 37.60 | 2724.04 | -351 | -25459 | 56 | 4086 |
| 58 | 10.00 | -19.46 | 3.08 | -19.21 | -253.46 | -19411.31 | 40.68 | 3115.41 | -380 | -29117 | 61 | 4673 |
| 48 | 10.00 | -20.22 | 3.20 | -19.96 | -273.42 | -22045.73 | 43.88 | 3538.22 | -410 | -33069 | 66 | 5307 |
| 22 | 26.00 | -21.66 | 3.43 | -21.39 | -294.81 | -29432.72 | 47.32 | 4723.80 | -442 | -44149 | 71 | 7086 |
| 19 | 3.00 | -10.91 | 1.73 | -10.77 | -305.58 | -30333.30 | 49.04 | 4868.33 | -458 | -45500 | 74 | 7303 |
| 0 | 19.00 | -7.27 | 1.15 | -7.18 | -312.76 | -36207.53 | 50.20 | 5811.12 | -469 | -54311 | 75 | 8717 |
| | Σ = | 125 | lb | | | | | | | | | |
| | | at 1 g | | | Centre of gravity is | 116 | in from aircraft centreline | | | | | |
| | | | | | | 45 | % semispan | | | | | |

AERODYNAMIC TORQUE AT SHEAR CENTRE

CONDITION. A

| 1 | 50 | 74 | 51 | 52 | 53 | 54 | 55 | 56 | 57 | 58 |
|---|---|---|---|---|---|---|---|---|---|---|
| STATION | CLEAN + FLAPPED | LEAN + FLAPPE | LOCAL | AERO | X AC | X SC | DELTA X | Z AC | Z SC | DELTA Z |
| | LOCAL | LOCAL | $X_{CP}$ | CENTRE | (in) | (in) | (in) | (in) | (in) | (in) |
| (in) | $C_L$ | $C_{Mo}$ | | (in) | | using 38% chord | | | | |
| 258 | - | -0.025 | - | 0.00 | 0.00 | 13.30 | 13.30 | 0.00 | 2.39 | -2.39 |
| 251.25 | 0.79 | -0.215 | 0.70 | 24.63 | 24.63 | 13.37 | -11.26 | 0.00 | 2.40 | -2.40 |
| 238 | 1.05 | -0.215 | 0.70 | 24.87 | 24.87 | 13.50 | -11.37 | 0.00 | 2.44 | -2.44 |
| 228 | 1.14 | -0.215 | 0.70 | 25.06 | 25.06 | 13.60 | -11.46 | 0.00 | 2.47 | -2.47 |
| 218 | 1.20 | -0.215 | 0.70 | 25.25 | 25.25 | 13.71 | -11.54 | 0.00 | 2.49 | -2.49 |
| 208 | 1.24 | -0.215 | 0.70 | 25.44 | 25.44 | 13.81 | -11.63 | 0.00 | 2.52 | -2.52 |
| 198 | 1.28 | -0.215 | 0.70 | 25.62 | 25.62 | 13.91 | -11.71 | 0.00 | 2.54 | -2.54 |
| 188 | 1.31 | -0.215 | 0.70 | 25.81 | 25.81 | 14.01 | -11.80 | 0.00 | 2.57 | -2.57 |
| 178 | 1.34 | -0.215 | 0.70 | 26.00 | 26.00 | 14.11 | -11.88 | 0.00 | 2.60 | -2.60 |
| 163.65 | 1.37 | -0.215 | 0.70 | 26.27 | 26.27 | 14.26 | -12.01 | 0.00 | 2.64 | -2.64 |
| 159 | 1.28 | -0.025 | 0.26 | 9.77 | 9.77 | 14.30 | 4.53 | 0.00 | 2.65 | -2.65 |
| 155.00 | 1.18 | -0.025 | 0.26 | 9.86 | 9.86 | 14.35 | 4.49 | 0.00 | 2.66 | -2.66 |
| 138 | 1.20 | -0.025 | 0.26 | 9.97 | 9.97 | 14.52 | 4.55 | 0.00 | 2.70 | -2.70 |
| 128 | 1.22 | -0.025 | 0.26 | 10.02 | 10.02 | 14.62 | 4.60 | 0.00 | 2.73 | -2.73 |
| 118 | 1.23 | -0.025 | 0.26 | 10.09 | 10.09 | 14.72 | 4.64 | 0.00 | 2.76 | -2.76 |
| 108 | 1.24 | -0.025 | 0.26 | 10.15 | 10.15 | 14.82 | 4.68 | 0.00 | 2.78 | -2.78 |
| 98 | 1.25 | -0.025 | 0.26 | 10.21 | 10.21 | 14.93 | 4.71 | 0.00 | 2.81 | -2.81 |
| 88 | 1.26 | -0.025 | 0.26 | 10.28 | 10.28 | 15.03 | 4.75 | 0.00 | 2.84 | -2.84 |
| 80.00 | 1.26 | -0.025 | 0.26 | 10.33 | 10.33 | 15.11 | 4.78 | 0.00 | 2.86 | -2.86 |
| 68 | 1.27 | -0.025 | 0.26 | 10.41 | 10.41 | 15.23 | 4.82 | 0.00 | 2.89 | -2.89 |
| 58 | 1.27 | -0.025 | 0.26 | 10.48 | 10.48 | 15.33 | 4.85 | 0.00 | 2.92 | -2.92 |
| 48 | 1.27 | -0.025 | 0.26 | 10.55 | 10.55 | 15.43 | 4.89 | 0.00 | 2.94 | -2.94 |
| 22 | 1.27 | -0.025 | 0.26 | 10.73 | 10.73 | 15.70 | 4.97 | 0.00 | 3.01 | -3.01 |
| 19 | 1.27 | -0.025 | 0.26 | 10.75 | 10.75 | 15.73 | 4.98 | 0.00 | 3.01 | -3.01 |
| 0 | 1.26 | -0.025 | 0.26 | 10.88 | 10.88 | 15.92 | 5.04 | 0.00 | 1.25 | -1.25 |

| AERODYNAMIC TORQUE AT SHEAR CENTRE | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| CONDITION. A | | | | | | $\Delta C_{Mo}$ | | | | | |
| | | | | | | 0 | | | | | |
| 1 | 55 | 56 | 57 | 58 | 59 | 75 | 60 | 61 | 62 | 63 | 64 |
| STATION | DELTA | DELTA | SPAN | SPAN | ELEMENT | ELEMENT | ELEMENT | ELEMENT | ELEMENT | TOTAL | TOTAL |
| | X av | Z av | ELEMENT | ELEMENT | TORQUE | TORQUE | TORQUE | TORQUE | LIMIT | LIMIT | ULT |
| (in) | (in) | (in) | LIFT | DRAG | DUE TO | DUE TO | DUE TO | DUE TO | TORQUE | TORQUE | TORQUE |
| | | | (lb) | (lb) | $C_{Mo}$ | $\Delta C_{Mo}$ | LIFT | DRAG | (lb in) | (lb in) | (lb in) |
| | | | | | (lb in) | (lb in) | (lb in) | (lb in) | | | |
| 258 | - | - | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 251.25 | 1.02 | 0.00 | 29.69 | -1.95 | -32.92 | -250.17 | 30.31 | 0.00 | -252.77 | -252.77 | -379.16 |
| 238 | -11.31 | 0.00 | 77.85 | -6.58 | -65.60 | -498.59 | -880.78 | 0.00 | -1444.97 | -1697.75 | -2546.62 |
| 228 | -11.41 | 0.00 | 64.50 | -5.85 | -50.39 | -382.94 | -736.24 | 0.00 | -1169.57 | -2867.31 | -4300.97 |
| 218 | -11.50 | 0.00 | 68.15 | -6.40 | -51.15 | -388.70 | -783.68 | 0.00 | -1223.53 | -4090.84 | -6136.26 |
| 208 | -11.59 | 0.00 | 71.17 | -7.27 | -51.91 | -394.51 | -824.51 | 0.00 | -1270.93 | -5361.77 | -8042.66 |
| 198 | -11.67 | 0.00 | 73.80 | -8.08 | -52.68 | -400.36 | -861.35 | 0.00 | -1314.39 | -6676.16 | -10014.25 |
| 188 | -11.76 | 0.00 | 76.21 | -8.44 | -53.45 | -406.25 | -896.00 | 0.00 | -1355.71 | -8031.87 | -12047.81 |
| 178 | -11.84 | 0.00 | 78.39 | -8.77 | -54.24 | -412.19 | -928.32 | 0.00 | -1394.74 | -9426.62 | -14139.93 |
| 163.65 | -11.95 | 0.00 | 115.90 | -13.08 | -79.20 | -601.95 | -1384.50 | 0.00 | -2065.66 | -11492.27 | -17238.41 |
| 159 | -3.74 | 0.00 | 32.95 | -3.74 | -24.19 | 0.00 | -123.14 | 0.00 | -147.33 | -11639.60 | -17459.41 |
| 155.00 | 4.51 | 0.00 | 30.54 | -3.47 | -24.34 | 0.00 | 137.75 | 0.00 | 113.41 | -11526.20 | -17289.29 |
| 138 | 4.52 | 0.00 | 122.68 | -14.01 | -97.13 | 0.00 | 554.54 | 0.00 | 457.41 | -11068.78 | -16603.18 |
| 128 | 4.58 | 0.00 | 74.04 | -8.51 | -58.23 | 0.00 | 338.73 | 0.00 | 280.51 | -10788.28 | -16182.42 |
| 118 | 4.62 | 0.00 | 75.27 | -8.69 | -59.04 | 0.00 | 347.56 | 0.00 | 288.52 | -10499.76 | -15749.64 |
| 108 | 4.66 | 0.00 | 76.41 | -8.85 | -59.86 | 0.00 | 355.79 | 0.00 | 295.93 | -10203.83 | -15305.75 |
| 98 | 4.69 | 0.00 | 77.46 | -8.99 | -60.69 | 0.00 | 363.59 | 0.00 | 302.90 | -9900.93 | -14851.39 |
| 88 | 4.73 | 0.00 | 78.41 | -9.12 | -61.52 | 0.00 | 370.98 | 0.00 | 309.46 | -9591.47 | -14387.20 |
| 80.00 | 4.76 | 0.00 | 63.37 | -7.38 | -49.82 | 0.00 | 301.87 | 0.00 | 252.05 | -9339.42 | -14009.13 |
| 68 | 4.80 | 0.00 | 96.01 | -11.20 | -75.74 | 0.00 | 460.72 | 0.00 | 384.98 | -8954.44 | -13431.66 |
| 58 | 4.84 | 0.00 | 80.81 | -9.43 | -64.05 | 0.00 | 390.83 | 0.00 | 326.78 | -8627.66 | -12941.48 |
| 48 | 4.87 | 0.00 | 81.46 | -9.51 | -64.91 | 0.00 | 396.72 | 0.00 | 331.81 | -8295.84 | -12443.76 |
| 22 | 4.93 | 0.00 | 214.24 | -25.02 | -172.79 | 0.00 | 1055.87 | 0.00 | 883.08 | -7412.76 | -11119.14 |
| 19 | 4.97 | 0.00 | 24.93 | -2.91 | -20.32 | 0.00 | 124.00 | 0.00 | 103.68 | -7309.08 | -10963.61 |
| 0 | 5.01 | 0.00 | 158.55 | -18.49 | -130.51 | 0.00 | 794.09 | 0.00 | 663.58 | -6645.50 | -9968.24 |

| DEAD WEIGHT ANALYSIS FOR WING TORQUE | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| CONDITION. A | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| 1 | 65 | 54 | 66 | 67 | 33 | 68 | 69 | 70 |
| STATION | X CG | X SC | DELTA | DELTA | ELEMENT | ELEMENT | TOTAL | TOTAL |
| | (in) | (in) | X | X av | LOAD | LIMIT | LIMIT | ULT |
| (in) | | | (in) | (in) | (lb) | TORQUE | TORQUE | TORQUE |
| | using 40% chord | | | | | (lb in) | (lb in) | (lb in) |
| 258 | 14.00 | 13.30 | -0.70 | - | - | - | - | 0.00 |
| 251.25 | 14.07 | 13.37 | -0.70 | -0.70 | -0.99 | 0.69 | 0.69 | 1.04 |
| 238 | 14.21 | 13.50 | -0.71 | -0.71 | -2.63 | 1.86 | 2.56 | 3.84 |
| 228 | 14.32 | 13.60 | -0.72 | -0.71 | -4.56 | 3.25 | 5.81 | 8.72 |
| 218 | 14.43 | 13.71 | -0.72 | -0.72 | -6.38 | 4.59 | 10.40 | 15.60 |
| 208 | 14.53 | 13.81 | -0.73 | -0.72 | -7.83 | 5.67 | 16.07 | 24.10 |
| 198 | 14.64 | 13.91 | -0.73 | -0.73 | -9.20 | 6.71 | 22.78 | 34.16 |
| 188 | 14.75 | 14.01 | -0.74 | -0.73 | -10.89 | 8.00 | 30.78 | 46.17 |
| 178 | 14.86 | 14.11 | -0.74 | -0.74 | -12.34 | 9.13 | 39.91 | 59.87 |
| 163.65 | 15.01 | 14.26 | -0.75 | -0.75 | -14.19 | 10.59 | 50.50 | 75.75 |
| 159 | 15.06 | 14.30 | -0.75 | -0.75 | -14.64 | 11.01 | 61.51 | 92.26 |
| 155.00 | 15.10 | 14.35 | -0.76 | -0.75 | -15.25 | 11.50 | 73.01 | 109.51 |
| 138 | 15.28 | 14.52 | -0.76 | -0.76 | -16.01 | 12.16 | 85.17 | 127.75 |
| 128 | 15.39 | 14.62 | -0.77 | -0.77 | -16.26 | 12.47 | 97.64 | 146.46 |
| 118 | 15.50 | 14.72 | -0.77 | -0.77 | -16.72 | 12.91 | 110.55 | 165.83 |
| 108 | 15.60 | 14.82 | -0.78 | -0.78 | -16.95 | 13.18 | 123.73 | 185.60 |
| 98 | 15.71 | 14.93 | -0.79 | -0.78 | -17.23 | 13.49 | 137.22 | 205.83 |
| 88 | 15.82 | 15.03 | -0.79 | -0.79 | -17.91 | 14.12 | 151.34 | 227.00 |
| 80.00 | 15.90 | 15.11 | -0.80 | -0.79 | -18.29 | 14.51 | 165.84 | 248.76 |
| 68 | 16.03 | 15.23 | -0.80 | -0.80 | -18.97 | 15.15 | 180.99 | 271.49 |
| 58 | 16.14 | 15.33 | -0.81 | -0.80 | -19.46 | 15.65 | 196.64 | 294.96 |
| 48 | 16.25 | 15.43 | -0.81 | -0.81 | -20.22 | 16.37 | 213.01 | 319.51 |
| 22 | 16.52 | 15.70 | -0.83 | -0.82 | -21.66 | 17.75 | 230.75 | 346.13 |
| 19 | 16.56 | 15.73 | -0.83 | -0.83 | -10.91 | 9.02 | 239.77 | 359.66 |
| 0 | 16.76 | 15.92 | -0.84 | -0.83 | -7.27 | 6.06 | 245.83 | 368.75 |

COMBINED ULTIMATE TORSION ( AERODYNAMIC + INERTIAL )

| CONDITION. A | | | |
|---|---|---|---|
| | | | |
| | | | |
| 1 | 71 A | | |
| STATION | COND. A | | |
| (in) | (lb in) | | |
| 258 | 0 | | |
| 251.25 | -378 | | |
| 238 | -2543 | | |
| 228 | -4292 | | |
| 218 | -6121 | | |
| 208 | -8019 | | |
| 198 | -9980 | | |
| 188 | -12002 | | |
| 178 | -14080 | | |
| 163.65 | -17163 | | |
| 159 | -17367 | | |
| 155.00 | -17180 | | |
| 138 | -16475 | | |
| 128 | -16036 | | |
| 118 | -15584 | | |
| 108 | -15120 | | |
| 98 | -14646 | | |
| 88 | -14160 | | |
| 80.00 | -13760 | | |
| 68 | -13160 | | |
| 58 | -12647 | | |
| 48 | -12124 | | |
| 22 | -10773 | | |
| 19 | -10604 | | |
| 0 | -9599 | | |

SPANWISE AERODYNAMIC LOAD DISTRIBUTION

CONDITION. C 2/3 n

AILERON UP

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | | | | Aileron deflection = | UP |
| | | | | | | Aileron angle = | -8.67 deg |
| | | | | | | Aileron load = | 76.87 lb |
| $V_{sel}$ = | 175.68 ft/s | $C_L$ = | 0.9 | alpha wrp = | 5.9468 | $\Delta C_L$ = | -0.44 |
| Lift = | 4353.86 lb clean | $C_{Do}$ = | 0.017 | sin alpha = | 0.1036 | $\Delta C_D$ = | 0.01 |
| q = | 36.69 psf | $C_D$ = | 0.039 | cos alpha = | 0.9946 | $\Delta C_{Mo}$ = | 0.09 |
| n = | 3.03 g | $C_{Mo}$ = | -0.025 | | | S = | 4.71 ft² |
| $q.C_L$ = | 32.25 $q.C_L$ =Lift/S | S = | 135.00 ft² | | | b = | 7.30 ft |
| | | b = | 43.00 ft | | | AR = | 11.31 |

ECF = 0.25

| 1 | 13 | 72 | 14 | 15 | 16 | 73 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| STATION | $C_L$ | FLAP | $C_{Lx}$ | $C_{Lz}$ | $C_D$ | FLAP | $C_{Dx}$ | $C_{Dz}$ | $C_{Lz}+C_{Dz}$ | $C_{Dx}-C_{Lx}$ | $(C_{Lz}+C_{Dz})_{AV}$ | $(C_{Dx}-C_{Lx})_{AV}$ | SPAN | SPAN |
| (in) | | $C_L$ | | | | $C_D$ | | | | | | | ELEMENT | ELEMENT |
| | | | | | | | | | | | | | LIFT | DRAG |
| | | | | | | | | | | | | | (lb) | (lb) |
| 258 | 0.4394 | 0.0000 | 0.0455 | 0.4371 | 0.0473 | 0.0000 | 0.0471 | 0.0049 | 0.4420 | 0.0015 | - | - | 0.00 | 0.00 |
| 251.25 | 0.5756 | -0.1112 | 0.0481 | 0.4619 | 0.0473 | 0.0032 | 0.0503 | 0.0052 | 0.4672 | 0.0022 | 0.4546 | 0.0019 | 27.44 | 0.11 |
| 238 | 0.6685 | -0.1112 | 0.0577 | 0.5543 | 0.0473 | 0.0032 | 0.0503 | 0.0052 | 0.5595 | -0.0074 | 0.5133 | -0.0026 | 61.28 | -0.31 |
| 228 | 0.7150 | -0.1112 | 0.0626 | 0.6006 | 0.0473 | 0.0032 | 0.0503 | 0.0052 | 0.6058 | -0.0123 | 0.5826 | -0.0099 | 52.96 | -0.90 |
| 218 | 0.7520 | -0.1112 | 0.0664 | 0.6374 | 0.0473 | 0.0032 | 0.0503 | 0.0052 | 0.6426 | -0.0161 | 0.6242 | -0.0142 | 57.16 | -1.30 |
| 208 | 0.7827 | -0.1112 | 0.0696 | 0.6679 | 0.0375 | 0.0032 | 0.0405 | 0.0042 | 0.6721 | -0.0291 | 0.6573 | -0.0226 | 60.64 | -2.08 |
| 198 | 0.8086 | -0.1112 | 0.0723 | 0.6937 | 0.0375 | 0.0032 | 0.0405 | 0.0042 | 0.6979 | -0.0318 | 0.6850 | -0.0304 | 63.66 | -2.83 |
| 188 | 0.8310 | -0.1112 | 0.0746 | 0.7159 | 0.0375 | 0.0032 | 0.0405 | 0.0042 | 0.7201 | -0.0341 | 0.7090 | -0.0329 | 66.38 | -3.08 |
| 178 | 0.8503 | -0.1112 | 0.0766 | 0.7351 | 0.0375 | 0.0032 | 0.0405 | 0.0042 | 0.7394 | -0.0361 | 0.7297 | -0.0351 | 68.81 | -3.31 |
| 163.65 | 0.8737 | -0.1112 | 0.0790 | 0.7584 | 0.0375 | 0.0032 | 0.0405 | 0.0042 | 0.7627 | -0.0385 | 0.7510 | -0.0373 | 102.52 | -5.09 |
| 159 | 0.8799 | 0.0000 | 0.0912 | 0.8752 | 0.0375 | 0.0000 | 0.0373 | 0.0039 | 0.8791 | -0.0539 | 0.8209 | -0.0462 | 34.00 | -1.91 |
| 155.00 | 0.8858 | 0.0000 | 0.0918 | 0.8810 | 0.0375 | 0.0000 | 0.0373 | 0.0039 | 0.8849 | -0.0545 | 0.8820 | -0.0542 | 36.64 | -2.25 |
| 138 | 0.9056 | 0.0000 | 0.0938 | 0.9007 | 0.0375 | 0.0000 | 0.0373 | 0.0039 | 0.9046 | -0.0566 | 0.8947 | -0.0555 | 147.22 | -9.14 |
| 128 | 0.9151 | 0.0000 | 0.0948 | 0.9102 | 0.0375 | 0.0000 | 0.0373 | 0.0039 | 0.9141 | -0.0575 | 0.9093 | -0.0571 | 88.85 | -5.57 |
| 118 | 0.9233 | 0.0000 | 0.0957 | 0.9183 | 0.0375 | 0.0000 | 0.0373 | 0.0039 | 0.9222 | -0.0584 | 0.9181 | -0.0580 | 90.33 | -5.70 |
| 108 | 0.9302 | 0.0000 | 0.0964 | 0.9252 | 0.0375 | 0.0000 | 0.0373 | 0.0039 | 0.9290 | -0.0591 | 0.9256 | -0.0587 | 91.70 | -5.82 |
| 98 | 0.9359 | 0.0000 | 0.0970 | 0.9308 | 0.0375 | 0.0000 | 0.0373 | 0.0039 | 0.9347 | -0.0597 | 0.9319 | -0.0594 | 92.96 | -5.93 |
| 88 | 0.9405 | 0.0000 | 0.0974 | 0.9355 | 0.0375 | 0.0000 | 0.0373 | 0.0039 | 0.9393 | -0.0602 | 0.9370 | -0.0599 | 94.11 | -6.02 |
| 80.00 | 0.9435 | 0.0000 | 0.0977 | 0.9384 | 0.0375 | 0.0000 | 0.0373 | 0.0039 | 0.9423 | -0.0605 | 0.9408 | -0.0603 | 76.05 | -4.88 |
| 68 | 0.9468 | 0.0000 | 0.0981 | 0.9417 | 0.0375 | 0.0000 | 0.0373 | 0.0039 | 0.9456 | -0.0608 | 0.9439 | -0.0607 | 115.23 | -7.40 |
| 58 | 0.9485 | 0.0000 | 0.0983 | 0.9434 | 0.0375 | 0.0000 | 0.0373 | 0.0039 | 0.9473 | -0.0610 | 0.9464 | -0.0609 | 96.99 | -6.24 |
| 48 | 0.9494 | 0.0000 | 0.0984 | 0.9443 | 0.0375 | 0.0000 | 0.0373 | 0.0039 | 0.9482 | -0.0611 | 0.9477 | -0.0610 | 97.77 | -6.30 |
| 22 | 0.9478 | 0.0000 | 0.0982 | 0.9427 | 0.0375 | 0.0000 | 0.0373 | 0.0039 | 0.9466 | -0.0609 | 0.9474 | -0.0610 | 257.13 | -16.56 |
| 19 | 0.9473 | 0.0000 | 0.0981 | 0.9422 | 0.0375 | 0.0000 | 0.0373 | 0.0039 | 0.9461 | -0.0609 | 0.9464 | -0.0609 | 29.92 | -1.93 |
| 0 | 0.9425 | 0.0000 | 0.0977 | 0.9375 | 0.0375 | 0.0000 | 0.0373 | 0.0039 | 0.9413 | -0.0604 | 0.9437 | -0.0606 | 190.29 | -12.23 |
| | | | | | | | | | | | | Σ = | 2100.04 | -116.67 |
| | | | | | | | | | | | | LIFT calc = | 4200.08 | |
| | | | | | | | | | | | | Lift = | 4353.86 | |

SPANWISE AERODYNAMIC LOAD DISTRIBUTION

CONDITION. C cont..

| 1 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 |
|---|---|---|---|---|---|---|---|---|
| STATION | LIMIT | LIMIT | LIMIT | LIMIT | ULT | ULT | ULT | ULT |
| (in) | NORMAL | NORMAL | CHORD | CHORD | NORMAL | NORMAL | CHORD | CHORD |
| | SHEAR | MOMENT | SHEAR | MOMENT | SHEAR | MOMENT | SHEAR | MOMENT |
| | (lb) | (lb in) | (lb) | (lb in) | (lb) | (lb in) | (lb) | (lb in) |
| 258 | 0.00 | 0.00 | 0.00 | 0.00 | 0 | 0 | 0 | 0 |
| 251.25 | 27.44 | 92.60 | 0.11 | 0.38 | 41 | 139 | 0 | 1 |
| 238 | 88.72 | 862.13 | -0.20 | -0.21 | 133 | 1293 | 0 | 0 |
| 228 | 141.68 | 2014.11 | -1.10 | -6.70 | 213 | 3021 | -2 | -10 |
| 218 | 198.84 | 3716.69 | -2.40 | -24.16 | 298 | 5575 | -4 | -36 |
| 208 | 259.48 | 6008.28 | -4.48 | -58.53 | 389 | 9012 | -7 | -88 |
| 198 | 323.14 | 8921.40 | -7.31 | -117.46 | 485 | 13382 | -11 | -176 |
| 188 | 389.52 | 12484.71 | -10.39 | -205.94 | 584 | 18727 | -16 | -309 |
| 178 | 458.33 | 16723.98 | -13.70 | -326.38 | 688 | 25086 | -21 | -490 |
| 163.65 | 560.86 | 24036.66 | -18.79 | -559.48 | 841 | 36055 | -28 | -839 |
| 159 | 594.86 | 26535.89 | -20.70 | -644.88 | 892 | 39804 | -31 | -967 |
| 155.00 | 631.50 | 29187.88 | -22.96 | -739.30 | 947 | 43782 | -34 | -1109 |
| 138 | 778.72 | 41174.74 | -32.09 | -1207.21 | 1168 | 61762 | -48 | -1811 |
| 128 | 867.57 | 49406.18 | -37.67 | -1556.00 | 1301 | 74109 | -57 | -2334 |
| 118 | 957.90 | 58533.54 | -43.37 | -1961.19 | 1437 | 87800 | -65 | -2942 |
| 108 | 1049.60 | 68571.08 | -49.19 | -2423.99 | 1574 | 102857 | -74 | -3636 |
| 98 | 1142.56 | 79531.92 | -55.12 | -2945.52 | 1714 | 119298 | -83 | -4418 |
| 88 | 1236.67 | 91428.10 | -61.13 | -3526.77 | 1855 | 137142 | -92 | -5290 |
| 80.00 | 1312.73 | 101625.69 | -66.01 | -4035.36 | 1969 | 152439 | -99 | -6053 |
| 68 | 1427.95 | 118069.77 | -73.42 | -4871.92 | 2142 | 177105 | -110 | -7308 |
| 58 | 1524.94 | 132834.25 | -79.66 | -5637.30 | 2287 | 199251 | -119 | -8456 |
| 48 | 1622.71 | 148572.50 | -85.96 | -6465.37 | 2434 | 222859 | -129 | -9698 |
| 22 | 1879.83 | 194105.55 | -102.52 | -8915.50 | 2820 | 291158 | -154 | -13373 |
| 19 | 1909.75 | 199789.93 | -104.44 | -9225.93 | 2865 | 299685 | -157 | -13839 |
| 0 | 2100.04 | 237882.97 | -116.67 | -11326.46 | 3150 | 356824 | -175 | -16990 |
| | | | | | | | | |
| Centre of lift is | 113 | in from aircraft centreline | | | | | | |
| | 44 | % semispan | | | | | | |

SPANWISE INERTIAL LOAD DISTRIBUTION
CONDITION. C cont.

| 1 | 3 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 | 41 | 42 | 43 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| STATION | dy | WEIGHT | ELEMENT | ELEMENT | LIMIT | LIMIT | LIMIT | LIMIT | ULT | ULT | ULT | ULT |
| (in) | (in) | nW | SHEAR | SHEAR | NORMAL | NORMAL | CHORD | CHORD | NORMAL | NORMAL | CHORD | CHORD |
| | | (lb) | FORCE | FORCE | SHEAR | MOMENT | SHEAR | MOMENT | SHEAR | MOMENT | SHEAR | MOMENT |
| | | | $V_x$ | $V_z$ | (lb) | (lb in) | (lb) | (lb in) | (lb) | (lb in) | (lb) | (lb in) |
| | | | (lb) | (lb) | | | | | | | | |
| 258 | - | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0 | 0 | 0 | 0 |
| 251.25 | 6.75 | -1.18 | 0.12 | -1.18 | -1.18 | -3.97 | 0.12 | 0.41 | -2 | -6 | 0 | 1 |
| 238 | 13.25 | -3.15 | 0.33 | -3.13 | -4.31 | -40.31 | 0.45 | 4.20 | -6 | -60 | 1 | 6 |
| 228 | 10.00 | -5.45 | 0.56 | -5.42 | -9.73 | -110.47 | 1.01 | 11.51 | -15 | -166 | 2 | 17 |
| 218 | 10.00 | -7.63 | 0.79 | -7.59 | -17.31 | -245.67 | 1.80 | 25.59 | -26 | -369 | 3 | 38 |
| 208 | 10.00 | -9.35 | 0.97 | -9.30 | -26.61 | -465.30 | 2.77 | 48.47 | -40 | -698 | 4 | 73 |
| 198 | 10.00 | -10.99 | 1.14 | -10.93 | -37.54 | -786.09 | 3.91 | 81.88 | -56 | -1179 | 6 | 123 |
| 188 | 10.00 | -13.01 | 1.35 | -12.94 | -50.49 | -1226.23 | 5.26 | 127.73 | -76 | -1839 | 8 | 192 |
| 178 | 10.00 | -14.74 | 1.53 | -14.66 | -65.15 | -1804.40 | 6.79 | 187.96 | -98 | -2707 | 10 | 282 |
| 163.65 | 14.35 | -16.95 | 1.76 | -16.86 | -82.01 | -2860.22 | 8.54 | 297.94 | -123 | -4290 | 13 | 447 |
| 159 | 4.33 | -17.49 | 1.81 | -17.40 | -99.41 | -3252.52 | 10.35 | 338.80 | -149 | -4879 | 16 | 508 |
| 155.00 | 4.32 | -18.22 | 1.89 | -18.12 | -117.53 | -3721.64 | 12.24 | 387.67 | -176 | -5582 | 18 | 581 |
| 138 | 17.00 | -19.13 | 1.98 | -19.03 | -136.55 | -5881.33 | 14.22 | 612.63 | -205 | -8822 | 21 | 919 |
| 128 | 10.00 | -19.43 | 2.01 | -19.33 | -155.88 | -7343.50 | 16.24 | 764.94 | -234 | -11015 | 24 | 1147 |
| 118 | 10.00 | -19.98 | 2.07 | -19.87 | -175.75 | -9001.65 | 18.31 | 937.66 | -264 | -13502 | 27 | 1406 |
| 108 | 10.00 | -20.25 | 2.10 | -20.14 | -195.89 | -10859.83 | 20.40 | 1131.22 | -294 | -16290 | 31 | 1697 |
| 98 | 10.00 | -20.58 | 2.13 | -20.47 | -216.36 | -12921.06 | 22.54 | 1345.93 | -325 | -19382 | 34 | 2019 |
| 88 | 10.00 | -21.40 | 2.22 | -21.28 | -237.64 | -15191.07 | 24.75 | 1582.38 | -356 | -22787 | 37 | 2374 |
| 80.00 | 8.00 | -21.85 | 2.26 | -21.73 | -259.38 | -17179.14 | 27.02 | 1789.47 | -389 | -25769 | 41 | 2684 |
| 68 | 12.00 | -22.67 | 2.35 | -22.55 | -281.92 | -20426.95 | 29.37 | 2127.78 | -423 | -30640 | 44 | 3192 |
| 58 | 10.00 | -23.24 | 2.41 | -23.12 | -305.04 | -23361.80 | 31.78 | 2433.49 | -458 | -35043 | 48 | 3650 |
| 48 | 10.00 | -24.15 | 2.50 | -24.02 | -329.07 | -26532.36 | 34.28 | 2763.75 | -494 | -39799 | 51 | 4146 |
| 22 | 26.00 | -25.88 | 2.68 | -25.74 | -354.81 | -35422.71 | 36.96 | 3689.82 | -532 | -53134 | 55 | 5535 |
| 19 | 3.00 | -13.03 | 1.35 | -12.96 | -367.77 | -36506.57 | 38.31 | 3802.72 | -552 | -54760 | 57 | 5704 |
| 0 | 19.00 | -8.69 | 0.90 | -8.64 | -376.41 | -43576.29 | 39.21 | 4539.14 | -565 | -65364 | 59 | 6809 |
| | Σ = | 125 | lb | | | | | | | | | |
| | | at 1 g | | | Centre of gravity is | 116 | in from aircraft centreline | | | | | |
| | | | | | | 45 | % semispan | | | | | |

COMBINED ULTIMATE LOADS ( AERODYNAMIC + INERTIAL )

CONDITION. C cont..

| 1 | 44 C | 45 C | 46 C | 47 C | 48 C | 49 C |
|---|---|---|---|---|---|---|
| | ULT | ULT | ULT | ULT | ULT | ULT |
| | NORMAL | NORMAL | CHORD | CHORD | RESOLVED | RESOLVED |
| STATION | SHEAR | BEND MOMENT | SHEAR | BEND MOMENT | SHEAR | BEND MOMENT |
| (in) | COND. C | COND. C | COND. C | COND. C | COND. C | COND. C |
| | (lb) | (lb in) | (lb) | (lb in) | (lb) | (lb in) |
| 258 | 0 | 0 | 0 | 0 | 0 | 0 |
| 251.25 | 39 | 133 | 0 | 1 | 39 | 133 |
| 238 | 127 | 1233 | 0 | 6 | 127 | 1233 |
| 228 | 198 | 2855 | 0 | 7 | 198 | 2855 |
| 218 | 272 | 5207 | -1 | 2 | 272 | 5207 |
| 208 | 349 | 8314 | -3 | -15 | 349 | 8314 |
| 198 | 428 | 12203 | -5 | -53 | 428 | 12203 |
| 188 | 509 | 16888 | -8 | -117 | 509 | 16888 |
| 178 | 590 | 22379 | -10 | -208 | 590 | 22380 |
| 163.65 | 718 | 31765 | -15 | -392 | 718 | 31767 |
| 159 | 743 | 34925 | -16 | -459 | 743 | 34928 |
| 155.00 | 771 | 38199 | -16 | -527 | 771 | 38203 |
| 138 | 963 | 52940 | -27 | -892 | 964 | 52948 |
| 128 | 1068 | 63094 | -32 | -1187 | 1068 | 63105 |
| 118 | 1173 | 74298 | -38 | -1535 | 1174 | 74314 |
| 108 | 1281 | 86567 | -43 | -1939 | 1281 | 86589 |
| 98 | 1389 | 99916 | -49 | -2399 | 1390 | 99945 |
| 88 | 1499 | 114356 | -55 | -2917 | 1500 | 114393 |
| 80.00 | 1580 | 126670 | -58 | -3369 | 1581 | 126715 |
| 68 | 1719 | 146464 | -66 | -4116 | 1720 | 146522 |
| 58 | 1830 | 164209 | -72 | -4806 | 1831 | 164279 |
| 48 | 1940 | 183060 | -78 | -5552 | 1942 | 183144 |
| 22 | 2288 | 238024 | -98 | -7839 | 2290 | 238153 |
| 19 | 2313 | 244925 | -99 | -8135 | 2315 | 245060 |
| 0 | 2585 | 291460 | -116 | -10181 | 2588 | 291638 |

AERODYNAMIC TORQUE AT SHEAR CENTRE

CONDITION. C

| 1 | 50 | 74 | 51 | 52 | 53 | 54 | 55 | 56 | 57 | 58 |
|---|---|---|---|---|---|---|---|---|---|---|
| STATION | CLEAN + FLAPPED | CLEAN + FLAPPED | LOCAL | AERO | X AC | X SC | DELTA X | Z AC | Z SC | DELTA Z |
| | LOCAL | LOCAL | $X_{CP}$ | CENTRE | (in) | (in) | (in) | (in) | (in) | (in) |
| (in) | $C_L$ | $C_{Mo}$ | | (in) | | using 38% chord | | | | |
| 258 | - | -0.025 | - | 0.00 | 0.00 | 13.30 | 13.30 | 0.00 | 2.39 | -2.39 |
| 251.25 | 0.45 | 0.062 | 0.70 | 24.63 | 24.63 | 13.37 | -11.26 | 0.00 | 2.40 | -2.40 |
| 238 | 0.51 | 0.062 | 0.70 | 24.87 | 24.87 | 13.50 | -11.37 | 0.00 | 2.44 | -2.44 |
| 228 | 0.58 | 0.062 | 0.70 | 25.06 | 25.06 | 13.60 | -11.46 | 0.00 | 2.47 | -2.47 |
| 218 | 0.62 | 0.062 | 0.70 | 25.25 | 25.25 | 13.71 | -11.54 | 0.00 | 2.49 | -2.49 |
| 208 | 0.66 | 0.062 | 0.70 | 25.44 | 25.44 | 13.81 | -11.63 | 0.00 | 2.52 | -2.52 |
| 198 | 0.68 | 0.062 | 0.70 | 25.62 | 25.62 | 13.91 | -11.71 | 0.00 | 2.54 | -2.54 |
| 188 | 0.71 | 0.062 | 0.70 | 25.81 | 25.81 | 14.01 | -11.80 | 0.00 | 2.57 | -2.57 |
| 178 | 0.73 | 0.062 | 0.70 | 26.00 | 26.00 | 14.11 | -11.88 | 0.00 | 2.60 | -2.60 |
| 163.65 | 0.75 | 0.062 | 0.70 | 26.27 | 26.27 | 14.26 | -12.01 | 0.00 | 2.64 | -2.64 |
| 159 | 0.82 | -0.025 | 0.27 | 10.18 | 10.18 | 14.30 | 4.12 | 0.00 | 2.65 | -2.65 |
| 155.00 | 0.88 | -0.025 | 0.27 | 10.13 | 10.13 | 14.35 | 4.22 | 0.00 | 2.66 | -2.66 |
| 138 | 0.89 | -0.025 | 0.27 | 10.24 | 10.24 | 14.52 | 4.28 | 0.00 | 2.70 | -2.70 |
| 128 | 0.91 | -0.025 | 0.27 | 10.29 | 10.29 | 14.62 | 4.33 | 0.00 | 2.73 | -2.73 |
| 118 | 0.92 | -0.025 | 0.27 | 10.35 | 10.35 | 14.72 | 4.37 | 0.00 | 2.76 | -2.76 |
| 108 | 0.93 | -0.025 | 0.27 | 10.42 | 10.42 | 14.82 | 4.41 | 0.00 | 2.78 | -2.78 |
| 98 | 0.93 | -0.025 | 0.27 | 10.48 | 10.48 | 14.93 | 4.45 | 0.00 | 2.81 | -2.81 |
| 88 | 0.94 | -0.025 | 0.27 | 10.55 | 10.55 | 15.03 | 4.48 | 0.00 | 2.84 | -2.84 |
| 80.00 | 0.94 | -0.025 | 0.27 | 10.60 | 10.60 | 15.11 | 4.51 | 0.00 | 2.86 | -2.86 |
| 68 | 0.94 | -0.025 | 0.27 | 10.68 | 10.68 | 15.23 | 4.55 | 0.00 | 2.89 | -2.89 |
| 58 | 0.95 | -0.025 | 0.27 | 10.75 | 10.75 | 15.33 | 4.58 | 0.00 | 2.92 | -2.92 |
| 48 | 0.95 | -0.025 | 0.27 | 10.82 | 10.82 | 15.43 | 4.61 | 0.00 | 2.94 | -2.94 |
| 22 | 0.95 | -0.025 | 0.27 | 11.00 | 11.00 | 15.70 | 4.69 | 0.00 | 3.01 | -3.01 |
| 19 | 0.95 | -0.025 | 0.27 | 11.03 | 11.03 | 15.73 | 4.70 | 0.00 | 3.01 | -3.01 |
| 0 | 0.94 | -0.025 | 0.27 | 11.17 | 11.17 | 15.92 | 4.76 | 0.00 | 1.25 | -1.25 |

AERODYNAMIC TORQUE AT SHEAR CENTRE

CONDITION. C

| | | | | | | $\Delta C_{Mo}$ 0 | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 55 | 56 | 23 | 24 | 57 | 75 | 58 | 59 | 60 | 61 | 62 |
| STATION (in) | DELTA X av (in) | DELTA Z av (in) | SPAN ELEMENT LIFT (lb) | SPAN ELEMENT DRAG (lb) | ELEMENT TORQUE DUE TO $C_{Mo}$ (lb in) | ELEMENT TORQUE DUE TO $\Delta C_{Mo}$ (lb in) | ELEMENT TORQUE DUE TO LIFT (lb in) | ELEMENT TORQUE DUE TO DRAG (lb in) | ELEMENT LIMIT TORQUE (lb in) | TOTAL LIMIT TORQUE (lb in) | TOTAL ULT TORQUE (lb in) |
| 258 | - | - | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 251.25 | 1.02 | 0.00 | 27.44 | 0.11 | -52.95 | 183.56 | 28.02 | 0.00 | 158.62 | 158.62 | 237.94 |
| 238 | -11.31 | 0.00 | 61.28 | -0.31 | -105.53 | 365.83 | -693.38 | 0.00 | -433.07 | -274.45 | -411.67 |
| 228 | -11.41 | 0.00 | 52.96 | -0.90 | -81.05 | 280.97 | -604.46 | 0.00 | -404.54 | -678.99 | -1018.48 |
| 218 | -11.50 | 0.00 | 57.16 | -1.30 | -82.27 | 285.20 | -657.32 | 0.00 | -454.39 | -1133.37 | -1700.06 |
| 208 | -11.59 | 0.00 | 60.64 | -2.08 | -83.50 | 289.46 | -702.56 | 0.00 | -496.59 | -1629.97 | -2444.95 |
| 198 | -11.67 | 0.00 | 63.66 | -2.83 | -84.74 | 293.76 | -742.97 | 0.00 | -533.95 | -2163.92 | -3245.88 |
| 188 | -11.76 | 0.00 | 66.38 | -3.08 | -85.98 | 298.08 | -780.35 | 0.00 | -568.26 | -2732.18 | -4098.27 |
| 178 | -11.84 | 0.00 | 68.81 | -3.31 | -87.24 | 302.44 | -814.89 | 0.00 | -599.69 | -3331.87 | -4997.81 |
| 163.65 | -11.95 | 0.00 | 102.52 | -5.09 | -127.40 | 441.67 | -1224.72 | 0.00 | -910.46 | -4242.33 | -6363.50 |
| 159 | -3.94 | 0.00 | 34.00 | -1.91 | -38.91 | 0.00 | -134.03 | 0.00 | -172.95 | -4415.28 | -6622.92 |
| 155.00 | 4.17 | 0.00 | 36.64 | -2.25 | -39.15 | 0.00 | 152.78 | 0.00 | 113.63 | -4301.65 | -6452.48 |
| 138 | 4.25 | 0.00 | 147.22 | -9.14 | -156.24 | 0.00 | 625.48 | 0.00 | 469.24 | -3832.41 | -5748.61 |
| 128 | 4.31 | 0.00 | 88.85 | -5.57 | -93.66 | 0.00 | 382.52 | 0.00 | 288.86 | -3543.55 | -5315.32 |
| 118 | 4.35 | 0.00 | 90.33 | -5.70 | -94.97 | 0.00 | 392.87 | 0.00 | 297.90 | -3245.65 | -4868.47 |
| 108 | 4.39 | 0.00 | 91.70 | -5.82 | -96.29 | 0.00 | 402.44 | 0.00 | 306.15 | -2939.50 | -4409.25 |
| 98 | 4.43 | 0.00 | 92.96 | -5.93 | -97.62 | 0.00 | 411.49 | 0.00 | 313.87 | -2625.63 | -3938.44 |
| 88 | 4.46 | 0.00 | 94.11 | -6.02 | -98.96 | 0.00 | 420.05 | 0.00 | 321.09 | -2304.54 | -3456.81 |
| 80.00 | 4.50 | 0.00 | 76.05 | -4.88 | -80.14 | 0.00 | 341.91 | 0.00 | 261.77 | -2042.77 | -3064.15 |
| 68 | 4.53 | 0.00 | 115.23 | -7.40 | -121.83 | 0.00 | 521.97 | 0.00 | 400.14 | -1642.63 | -2463.95 |
| 58 | 4.57 | 0.00 | 96.99 | -6.24 | -103.03 | 0.00 | 442.89 | 0.00 | 339.86 | -1302.78 | -1954.16 |
| 48 | 4.60 | 0.00 | 97.77 | -6.30 | -104.40 | 0.00 | 449.62 | 0.00 | 345.22 | -957.56 | -1436.34 |
| 22 | 4.65 | 0.00 | 257.13 | -16.56 | -277.95 | 0.00 | 1196.71 | 0.00 | 918.76 | -38.79 | -58.19 |
| 19 | 4.70 | 0.00 | 29.92 | -1.93 | -32.68 | 0.00 | 140.53 | 0.00 | 107.85 | 69.06 | 103.59 |
| 0 | 4.73 | 0.00 | 190.29 | -12.23 | -209.93 | 0.00 | 899.84 | 0.00 | 689.90 | 758.96 | 1138.44 |

DEAD WEIGHT ANALYSIS FOR WING TORQUE

CONDITION. C

| 1 | 65 | 54 | 66 | 67 | 33 | 68 | 69 | 70 |
|---|---|---|---|---|---|---|---|---|
| STATION | X CG | X SC | DELTA | DELTA | ELEMENT | ELEMENT | TOTAL | TOTAL |
| | (in) | (in) | X | X av | LOAD | LIMIT | LIMIT | ULT |
| (in) | | | (in) | (in) | (lb) | TORQUE | TORQUE | TORQUE |
| | using 40% chord | | | | | (lb in) | (lb in) | (lb in) |
| 258 | 14.00 | 13.30 | -0.70 | - | - | - | - | 0.00 |
| 251.25 | 14.07 | 13.37 | -0.70 | -0.70 | -1.18 | 0.83 | 0.83 | 1.25 |
| 238 | 14.21 | 13.50 | -0.71 | -0.71 | -3.15 | 2.23 | 3.06 | 4.58 |
| 228 | 14.32 | 13.60 | -0.72 | -0.71 | -5.45 | 3.89 | 6.94 | 10.41 |
| 218 | 14.43 | 13.71 | -0.72 | -0.72 | -7.63 | 5.48 | 12.42 | 18.64 |
| 208 | 14.53 | 13.81 | -0.73 | -0.72 | -9.35 | 6.77 | 19.20 | 28.79 |
| 198 | 14.64 | 13.91 | -0.73 | -0.73 | -10.99 | 8.01 | 27.21 | 40.82 |
| 188 | 14.75 | 14.01 | -0.74 | -0.73 | -13.01 | 9.56 | 36.77 | 55.16 |
| 178 | 14.86 | 14.11 | -0.74 | -0.74 | -14.74 | 10.91 | 47.68 | 71.52 |
| 163.65 | 15.01 | 14.26 | -0.75 | -0.75 | -16.95 | 12.65 | 60.34 | 90.51 |
| 159 | 15.06 | 14.30 | -0.75 | -0.75 | -17.49 | 13.15 | 73.49 | 110.23 |
| 155.00 | 15.10 | 14.35 | -0.76 | -0.75 | -18.22 | 13.74 | 87.22 | 130.83 |
| 138 | 15.28 | 14.52 | -0.76 | -0.76 | -19.13 | 14.53 | 101.75 | 152.63 |
| 128 | 15.39 | 14.62 | -0.77 | -0.77 | -19.43 | 14.90 | 116.66 | 174.98 |
| 118 | 15.50 | 14.72 | -0.77 | -0.77 | -19.98 | 15.43 | 132.08 | 198.12 |
| 108 | 15.60 | 14.82 | -0.78 | -0.78 | -20.25 | 15.74 | 147.83 | 221.74 |
| 98 | 15.71 | 14.93 | -0.79 | -0.78 | -20.58 | 16.11 | 163.94 | 245.91 |
| 88 | 15.82 | 15.03 | -0.79 | -0.79 | -21.40 | 16.87 | 180.81 | 271.21 |
| 80.00 | 15.90 | 15.11 | -0.80 | -0.79 | -21.85 | 17.33 | 198.14 | 297.20 |
| 68 | 16.03 | 15.23 | -0.80 | -0.80 | -22.67 | 18.10 | 216.24 | 324.35 |
| 58 | 16.14 | 15.33 | -0.81 | -0.80 | -23.24 | 18.70 | 234.93 | 352.40 |
| 48 | 16.25 | 15.43 | -0.81 | -0.81 | -24.15 | 19.56 | 254.49 | 381.73 |
| 22 | 16.52 | 15.70 | -0.83 | -0.82 | -25.88 | 21.20 | 275.69 | 413.53 |
| 19 | 16.56 | 15.73 | -0.83 | -0.83 | -13.03 | 10.78 | 286.47 | 429.70 |
| 0 | 16.76 | 15.92 | -0.84 | -0.83 | -8.69 | 7.24 | 293.71 | 440.56 |

COMBINED ULTIMATE TORSION ( AERODYNAMIC + INERTIAL )

| CONDITION. C | | | |
|---|---|---|---|
| | | | |
| 1 | 71 C | | |
| STATION | COND. C | | |
| (in) | (lb in) | | |
| 258 | 0 | | |
| 251.25 | 239 | | |
| 238 | -407 | | |
| 228 | -1008 | | |
| 218 | -1681 | | |
| 208 | -2416 | | |
| 198 | -3205 | | |
| 188 | -4043 | | |
| 178 | -4926 | | |
| 163.65 | -6273 | | |
| 159 | -6513 | | |
| 155.00 | -6322 | | |
| 138 | -5596 | | |
| 128 | -5140 | | |
| 118 | -4670 | | |
| 108 | -4188 | | |
| 98 | -3693 | | |
| 88 | -3186 | | |
| 80.00 | -2767 | | |
| 68 | -2140 | | |
| 58 | -1602 | | |
| 48 | -1055 | | |
| 22 | 355 | | |
| 19 | 533 | | |
| 0 | 1579 | | |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SPANWISE AERODYNAMIC LOAD DISTRIBUTION | | | | | | | | | | | | | | |
| CONDITION. C 2/3 n | | | | | | | | | Aileron deflection = | DWN | | ECF = | 0.15 | |
| AILERON DOWN | | | | | | | | | Aileron angle = | 6.33 | deg | | | |
| | | | | | | | | | Aileron load = | 76.87 | lb | | | |
| $V_{eq}$ = | 175.68 | ft/s | $C_L$ = | 0.9 | | alpha wrp = | -5.9468 | | $\Delta C_L$ = | 0.44 | | | | |
| Lift = | 4353.86 | lb clean | $C_{Do}$ = | 0.017 | | sin alpha = | 0.1036 | | $\Delta C_D$ = | 0.01 | | | | |
| q = | 36.69 | psf | $C_D$ = | 0.039 | | cos alpha = | 0.9946 | | $\Delta C_{Mo}$ = | -0.06 | | | | |
| n = | 3.03 | g | $C_{Mo}$ = | -0.025 | | | | | S = | 4.71 | $ft^2$ | | | |
| $q.C_L$ = | 32.25 | $q.C_L$ =Lift/S | S = | 135.00 | $ft^2$ | | | | b = | 7.30 | ft | | | |
| | | | b = | 43.00 | ft | | | | AR = | 11.31 | | | | |
| 1 | 13 | 72 | 14 | 15 | 16 | 73 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 |
| STATION (in) | $C_L$ | FLAP $C_L$ | $C_{Lx}$ | $C_{Lz}$ | $C_D$ | FLAP $C_D$ | $C_{Dx}$ | $C_{Dz}$ | $C_{Lz}+C_{Dz}$ | $C_{Dx}-C_{Lx}$ | $(C_{Lz}+C_{Dz})_{AV}$ | $(C_{Dx}-C_{Lx})_{AV}$ | SPAN ELEMENT LIFT (lb) | SPAN ELEMENT DRAG (lb) |
| 258 | 0.4394 | 0.0000 | 0.0455 | 0.4371 | 0.0473 | 0.0000 | 0.0471 | 0.0049 | 0.4420 | 0.0015 | - | - | 0.00 | 0.00 |
| 251.25 | 0.5756 | 0.0681 | 0.0667 | 0.6402 | 0.0473 | 0.0020 | 0.0490 | 0.0051 | 0.6453 | -0.0176 | 0.5436 | -0.0080 | 32.81 | -0.49 |
| 238 | 0.6685 | 0.0681 | 0.0763 | 0.7325 | 0.0473 | 0.0020 | 0.0490 | 0.0051 | 0.7376 | -0.0273 | 0.6915 | -0.0225 | 82.55 | -2.68 |
| 228 | 0.7150 | 0.0681 | 0.0811 | 0.7788 | 0.0473 | 0.0020 | 0.0490 | 0.0051 | 0.7839 | -0.0321 | 0.7608 | -0.0297 | 69.15 | -2.70 |
| 218 | 0.7520 | 0.0681 | 0.0850 | 0.8156 | 0.0473 | 0.0020 | 0.0490 | 0.0051 | 0.8208 | -0.0359 | 0.8024 | -0.0340 | 73.47 | -3.11 |
| 208 | 0.7827 | 0.0681 | 0.0881 | 0.8461 | 0.0375 | 0.0020 | 0.0392 | 0.0041 | 0.8502 | -0.0489 | 0.8355 | -0.0424 | 77.08 | -3.91 |
| 198 | 0.8086 | 0.0681 | 0.0908 | 0.8720 | 0.0375 | 0.0020 | 0.0392 | 0.0041 | 0.8761 | -0.0516 | 0.8631 | -0.0502 | 80.22 | -4.67 |
| 188 | 0.8310 | 0.0681 | 0.0931 | 0.8942 | 0.0375 | 0.0020 | 0.0392 | 0.0041 | 0.8983 | -0.0539 | 0.8872 | -0.0527 | 83.06 | -4.94 |
| 178 | 0.8503 | 0.0681 | 0.0951 | 0.9134 | 0.0375 | 0.0020 | 0.0392 | 0.0041 | 0.9175 | -0.0559 | 0.9079 | -0.0549 | 85.61 | -5.18 |
| 163.65 | 0.8737 | 0.0681 | 0.0976 | 0.9367 | 0.0375 | 0.0020 | 0.0392 | 0.0041 | 0.9408 | -0.0583 | 0.9292 | -0.0571 | 126.84 | -7.80 |
| 159 | 0.8799 | 0.0000 | 0.0912 | 0.8752 | 0.0375 | 0.0000 | 0.0373 | 0.0039 | 0.8791 | -0.0539 | 0.9100 | -0.0561 | 37.69 | -2.32 |
| 155.00 | 0.8858 | 0.0000 | 0.0918 | 0.8810 | 0.0375 | 0.0000 | 0.0373 | 0.0039 | 0.8849 | -0.0545 | 0.8820 | -0.0542 | 36.64 | -2.25 |
| 138 | 0.9056 | 0.0000 | 0.0938 | 0.9007 | 0.0375 | 0.0000 | 0.0373 | 0.0039 | 0.9046 | -0.0566 | 0.8947 | -0.0555 | 147.22 | -9.14 |
| 128 | 0.9151 | 0.0000 | 0.0948 | 0.9102 | 0.0375 | 0.0000 | 0.0373 | 0.0039 | 0.9141 | -0.0575 | 0.9093 | -0.0571 | 88.85 | -5.57 |
| 118 | 0.9233 | 0.0000 | 0.0957 | 0.9183 | 0.0375 | 0.0000 | 0.0373 | 0.0039 | 0.9222 | -0.0584 | 0.9181 | -0.0580 | 90.33 | -5.70 |
| 108 | 0.9302 | 0.0000 | 0.0964 | 0.9252 | 0.0375 | 0.0000 | 0.0373 | 0.0039 | 0.9290 | -0.0591 | 0.9256 | -0.0587 | 91.70 | -5.82 |
| 98 | 0.9359 | 0.0000 | 0.0970 | 0.9308 | 0.0375 | 0.0000 | 0.0373 | 0.0039 | 0.9347 | -0.0597 | 0.9319 | -0.0594 | 92.96 | -5.93 |
| 88 | 0.9405 | 0.0000 | 0.0974 | 0.9355 | 0.0375 | 0.0000 | 0.0373 | 0.0039 | 0.9393 | -0.0602 | 0.9370 | -0.0599 | 94.11 | -6.02 |
| 80.00 | 0.9435 | 0.0000 | 0.0977 | 0.9384 | 0.0375 | 0.0000 | 0.0373 | 0.0039 | 0.9423 | -0.0605 | 0.9408 | -0.0603 | 76.05 | -4.88 |
| 68 | 0.9468 | 0.0000 | 0.0981 | 0.9417 | 0.0375 | 0.0000 | 0.0373 | 0.0039 | 0.9456 | -0.0608 | 0.9439 | -0.0607 | 115.23 | -7.40 |
| 58 | 0.9485 | 0.0000 | 0.0983 | 0.9434 | 0.0375 | 0.0000 | 0.0373 | 0.0039 | 0.9473 | -0.0610 | 0.9464 | -0.0609 | 96.99 | -6.24 |
| 48 | 0.9494 | 0.0000 | 0.0984 | 0.9443 | 0.0375 | 0.0000 | 0.0373 | 0.0039 | 0.9482 | -0.0611 | 0.9477 | -0.0610 | 97.77 | -6.30 |
| 22 | 0.9478 | 0.0000 | 0.0982 | 0.9427 | 0.0375 | 0.0000 | 0.0373 | 0.0039 | 0.9466 | -0.0609 | 0.9474 | -0.0610 | 257.13 | -16.56 |
| 19 | 0.9473 | 0.0000 | 0.0981 | 0.9422 | 0.0375 | 0.0000 | 0.0373 | 0.0039 | 0.9461 | -0.0609 | 0.9464 | -0.0609 | 29.92 | -1.93 |
| 0 | 0.9425 | 0.0000 | 0.0977 | 0.9375 | 0.0375 | 0.0000 | 0.0373 | 0.0039 | 0.9413 | -0.0604 | 0.9437 | -0.0606 | 190.29 | -12.23 |
| | | | | | | | | | | | | Σ = | 2253.67 | -133.76 |
| | | | | | | | | | | | | LIFT calc = | 4507.35 | |
| | | | | | | | | | | | | Lift = | 4353.86 | |

SPANWISE AERODYNAMIC LOAD DISTRIBUTION

CONDITION. C cont..

| 1 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 |
|---|---|---|---|---|---|---|---|---|
| STATION | LIMIT | LIMIT | LIMIT | LIMIT | ULT | ULT | ULT | ULT |
| (in) | NORMAL | NORMAL | CHORD | CHORD | NORMAL | NORMAL | CHORD | CHORD |
| | SHEAR | MOMENT | SHEAR | MOMENT | SHEAR | MOMENT | SHEAR | MOMENT |
| | (lb) | (lb in) | (lb) | (lb in) | (lb) | (lb in) | (lb) | (lb in) |
| 258 | 0.00 | 0.00 | 0.00 | 0.00 | 0 | 0 | 0 | 0 |
| 251.25 | 32.81 | 110.74 | -0.49 | -1.64 | 49 | 166 | -1 | -2 |
| 238 | 115.36 | 1092.42 | -3.17 | -25.83 | 173 | 1639 | -5 | -39 |
| 228 | 184.51 | 2591.81 | -5.86 | -70.98 | 277 | 3888 | -9 | -106 |
| 218 | 257.99 | 4804.33 | -8.98 | -145.17 | 387 | 7206 | -13 | -218 |
| 208 | 335.07 | 7769.61 | -12.89 | -254.50 | 503 | 11654 | -19 | -382 |
| 198 | 415.29 | 11521.38 | -17.56 | -406.73 | 623 | 17282 | -26 | -610 |
| 188 | 498.34 | 16089.52 | -22.50 | -607.01 | 748 | 24134 | -34 | -911 |
| 178 | 583.96 | 21501.01 | -27.67 | -857.86 | 876 | 32252 | -42 | -1287 |
| 163.65 | 710.80 | 30790.86 | -35.47 | -1310.94 | 1066 | 46186 | -53 | -1966 |
| 159 | 748.49 | 33946.56 | -37.80 | -1469.38 | 1123 | 50920 | -57 | -2204 |
| 155.00 | 785.13 | 37263.01 | -40.05 | -1637.72 | 1178 | 55895 | -60 | -2457 |
| 138 | 932.35 | 51861.60 | -49.19 | -2396.21 | 1399 | 77792 | -74 | -3594 |
| 128 | 1021.20 | 61629.35 | -54.76 | -2915.93 | 1532 | 92444 | -82 | -4374 |
| 118 | 1111.53 | 72293.02 | -60.46 | -3492.05 | 1667 | 108440 | -91 | -5238 |
| 108 | 1203.24 | 83866.87 | -66.28 | -4125.77 | 1805 | 125800 | -99 | -6189 |
| 98 | 1296.19 | 96364.01 | -72.21 | -4818.23 | 1944 | 144546 | -108 | -7227 |
| 88 | 1390.30 | 109796.50 | -78.23 | -5570.41 | 2085 | 164695 | -117 | -8356 |
| 80.00 | 1466.36 | 121223.14 | -83.10 | -6215.74 | 2200 | 181835 | -125 | -9324 |
| 68 | 1581.59 | 139510.79 | -90.51 | -7257.42 | 2372 | 209266 | -136 | -10886 |
| 58 | 1678.57 | 155811.58 | -96.75 | -8193.72 | 2518 | 233717 | -145 | -12291 |
| 48 | 1776.34 | 173086.14 | -103.05 | -9192.71 | 2665 | 259629 | -155 | -13789 |
| 22 | 2033.47 | 222613.60 | -119.61 | -12087.26 | 3050 | 333920 | -179 | -18131 |
| 19 | 2063.38 | 228758.87 | -121.53 | -12448.97 | 3095 | 343138 | -182 | -18673 |
| 0 | 2253.67 | 269770.90 | -133.76 | -14874.26 | 3381 | 404656 | -201 | -22311 |
| | | | | | | | | |
| Centre of lift is | 120 | in from aircraft centreline | | | | | | |
| | 46 | % semispan | | | | | | |

SPANWISE INERTIAL LOAD DISTRIBUTION

CONDITION. C cont.

| 1 | 3 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 | 41 | 42 | 43 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| STATION | dy | WEIGHT | ELEMENT | ELEMENT | LIMIT | LIMIT | LIMIT | LIMIT | ULT | ULT | ULT | ULT |
| (in) | (in) | nW | SHEAR | SHEAR | NORMAL | NORMAL | CHORD | CHORD | NORMAL | NORMAL | CHORD | CHORD |
| | | (lb) | FORCE | FORCE | SHEAR | MOMENT | SHEAR | MOMENT | SHEAR | MOMENT | SHEAR | MOMENT |
| | | | $V_x$ | $V_z$ | (lb) | (lb in) | (lb) | (lb in) | (lb) | (lb in) | (lb) | (lb in) |
| | | | (lb) | (lb) | | | | | | | | |
| 258 | - | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0 | 0 | 0 | 0 |
| 251.25 | 6.75 | -1.18 | 0.12 | -1.18 | -1.18 | -3.97 | 0.12 | 0.41 | -2 | -6 | 0 | 1 |
| 238 | 13.25 | -3.15 | 0.33 | -3.13 | -4.31 | -40.31 | 0.45 | 4.20 | -6 | -60 | 1 | 6 |
| 228 | 10.00 | -5.45 | 0.56 | -5.42 | -9.73 | -110.47 | 1.01 | 11.51 | -15 | -166 | 2 | 17 |
| 218 | 10.00 | -7.63 | 0.79 | -7.59 | -17.31 | -245.67 | 1.80 | 25.59 | -26 | -369 | 3 | 38 |
| 208 | 10.00 | -9.35 | 0.97 | -9.30 | -26.61 | -465.30 | 2.77 | 48.47 | -40 | -698 | 4 | 73 |
| 198 | 10.00 | -10.99 | 1.14 | -10.93 | -37.54 | -786.09 | 3.91 | 81.88 | -56 | -1179 | 6 | 123 |
| 188 | 10.00 | -13.01 | 1.35 | -12.94 | -50.49 | -1226.23 | 5.26 | 127.73 | -76 | -1839 | 8 | 192 |
| 178 | 10.00 | -14.74 | 1.53 | -14.66 | -65.15 | -1804.40 | 6.79 | 187.96 | -98 | -2707 | 10 | 282 |
| 163.65 | 14.35 | -16.95 | 1.76 | -16.86 | -82.01 | -2860.22 | 8.54 | 297.94 | -123 | -4290 | 13 | 447 |
| 159 | 4.33 | -17.49 | 1.81 | -17.40 | -99.41 | -3252.52 | 10.35 | 338.80 | -149 | -4879 | 16 | 508 |
| 155.00 | 4.32 | -18.22 | 1.89 | -18.12 | -117.53 | -3721.64 | 12.24 | 387.67 | -176 | -5582 | 18 | 581 |
| 138 | 17.00 | -19.13 | 1.98 | -19.03 | -136.55 | -5881.33 | 14.22 | 612.63 | -205 | -8822 | 21 | 919 |
| 128 | 10.00 | -19.43 | 2.01 | -19.33 | -155.88 | -7343.50 | 16.24 | 764.94 | -234 | -11015 | 24 | 1147 |
| 118 | 10.00 | -19.98 | 2.07 | -19.87 | -175.75 | -9001.65 | 18.31 | 937.66 | -264 | -13502 | 27 | 1406 |
| 108 | 10.00 | -20.25 | 2.10 | -20.14 | -195.89 | -10859.83 | 20.40 | 1131.22 | -294 | -16290 | 31 | 1697 |
| 98 | 10.00 | -20.58 | 2.13 | -20.47 | -216.36 | -12921.06 | 22.54 | 1345.93 | -325 | -19382 | 34 | 2019 |
| 88 | 10.00 | -21.40 | 2.22 | -21.28 | -237.64 | -15191.07 | 24.75 | 1582.38 | -356 | -22787 | 37 | 2374 |
| 80.00 | 8.00 | -21.85 | 2.26 | -21.73 | -259.38 | -17179.14 | 27.02 | 1789.47 | -389 | -25769 | 41 | 2684 |
| 68 | 12.00 | -22.67 | 2.35 | -22.55 | -281.92 | -20426.95 | 29.37 | 2127.78 | -423 | -30640 | 44 | 3192 |
| 58 | 10.00 | -23.24 | 2.41 | -23.12 | -305.04 | -23361.80 | 31.78 | 2433.49 | -458 | -35043 | 48 | 3650 |
| 48 | 10.00 | -24.15 | 2.50 | -24.02 | -329.07 | -26532.36 | 34.28 | 2763.75 | -494 | -39799 | 51 | 4146 |
| 22 | 26.00 | -25.88 | 2.68 | -25.74 | -354.81 | -35422.71 | 36.96 | 3689.82 | -532 | -53134 | 55 | 5535 |
| 19 | 3.00 | -13.03 | 1.35 | -12.96 | -367.77 | -36506.57 | 38.31 | 3802.72 | -552 | -54760 | 57 | 5704 |
| 0 | 19.00 | -8.69 | 0.90 | -8.64 | -376.41 | -43576.29 | 39.21 | 4539.14 | -565 | -65364 | 59 | 6809 |
| | Σ = | 125 | lb | | | | | | | | | |
| | | at 1 g | | | Centre of gravity is | 116 | in from aircraft centreline | | | | | |
| | | | | | | 45 | % semispan | | | | | |

COMBINED ULTIMATE LOADS ( AERODYNAMIC + INERTIAL )

CONDITION. C cont..

| 1 | 44 C | 45 C | 46 C | 47 C | 48 C | 49 C |
|---|---|---|---|---|---|---|
| | ULT | ULT | ULT | ULT | ULT | ULT |
| | NORMAL | NORMAL | CHORD | CHORD | RESOLVED | RESOLVED |
| STATION | SHEAR | BEND MOMENT | SHEAR | BEND MOMENT | SHEAR | BEND MOMENT |
| (in) | COND. C | COND. C | COND. C | COND. C | COND. C | COND. C |
| | (lb) | (lb in) | (lb) | (lb in) | (lb) | (lb in) |
| 258 | 0 | 0 | 0 | 0 | 0 | 0 |
| 251.25 | 47 | 160 | -1 | -2 | 47 | 160 |
| 238 | 167 | 1578 | -4 | -32 | 167 | 1578 |
| 228 | 262 | 3722 | -7 | -89 | 262 | 3723 |
| 218 | 361 | 6838 | -11 | -179 | 361 | 6840 |
| 208 | 463 | 10956 | -15 | -309 | 463 | 10961 |
| 198 | 567 | 16103 | -20 | -487 | 567 | 16110 |
| 188 | 672 | 22295 | -26 | -719 | 672 | 22307 |
| 178 | 778 | 29545 | -31 | -1005 | 779 | 29562 |
| 163.65 | 943 | 41896 | -40 | -1520 | 944 | 41924 |
| 159 | 974 | 46041 | -41 | -1696 | 974 | 46072 |
| 155.00 | 1001 | 50312 | -42 | -1875 | 1002 | 50347 |
| 138 | 1194 | 68970 | -52 | -2675 | 1195 | 69022 |
| 128 | 1298 | 81429 | -58 | -3226 | 1299 | 81493 |
| 118 | 1404 | 94937 | -63 | -3832 | 1405 | 95014 |
| 108 | 1511 | 109511 | -69 | -4492 | 1513 | 109603 |
| 98 | 1620 | 125164 | -75 | -5208 | 1621 | 125273 |
| 88 | 1729 | 141908 | -80 | -5982 | 1731 | 142034 |
| 80.00 | 1810 | 156066 | -84 | -6639 | 1812 | 156207 |
| 68 | 1949 | 178626 | -92 | -7694 | 1952 | 178791 |
| 58 | 2060 | 198675 | -97 | -8640 | 2063 | 198862 |
| 48 | 2171 | 219831 | -103 | -9643 | 2173 | 220042 |
| 22 | 2518 | 280786 | -124 | -12596 | 2521 | 281069 |
| 19 | 2543 | 288378 | -125 | -12969 | 2546 | 288670 |
| 0 | 2816 | 339292 | -142 | -15503 | 2819 | 339646 |

AERODYNAMIC TORQUE AT SHEAR CENTRE

CONDITION. C

| 1 | 50 | 74 | 51 | 52 | 53 | 54 | 55 | 56 | 57 | 58 |
|---|---|---|---|---|---|---|---|---|---|---|
| STATION | CLEAN + FLAPPED | LEAN + FLAPPE | LOCAL | AERO | X AC | X SC | DELTA X | Z AC | Z SC | DELTA Z |
| | LOCAL | LOCAL | $X_{CP}$ | CENTRE | (in) | (in) | (in) | (in) | (in) | (in) |
| (in) | $C_L$ | $C_{Mo}$ | | (in) | | using 38% chord | | | | |
| 258 | - | -0.025 | - | 0.00 | 0.00 | 13.30 | 13.30 | 0.00 | 2.39 | -2.39 |
| 251.25 | 0.54 | -0.088 | 0.70 | 24.63 | 24.63 | 13.37 | -11.26 | 0.00 | 2.40 | -2.40 |
| 238 | 0.69 | -0.088 | 0.70 | 24.87 | 24.87 | 13.50 | -11.37 | 0.00 | 2.44 | -2.44 |
| 228 | 0.76 | -0.088 | 0.70 | 25.06 | 25.06 | 13.60 | -11.46 | 0.00 | 2.47 | -2.47 |
| 218 | 0.80 | -0.088 | 0.70 | 25.25 | 25.25 | 13.71 | -11.54 | 0.00 | 2.49 | -2.49 |
| 208 | 0.84 | -0.088 | 0.70 | 25.44 | 25.44 | 13.81 | -11.63 | 0.00 | 2.52 | -2.52 |
| 198 | 0.86 | -0.088 | 0.70 | 25.62 | 25.62 | 13.91 | -11.71 | 0.00 | 2.54 | -2.54 |
| 188 | 0.89 | -0.088 | 0.70 | 25.81 | 25.81 | 14.01 | -11.80 | 0.00 | 2.57 | -2.57 |
| 178 | 0.91 | -0.088 | 0.70 | 26.00 | 26.00 | 14.11 | -11.88 | 0.00 | 2.60 | -2.60 |
| 163.65 | 0.93 | -0.088 | 0.70 | 26.27 | 26.27 | 14.26 | -12.01 | 0.00 | 2.64 | -2.64 |
| 159 | 0.91 | -0.025 | 0.27 | 10.07 | 10.07 | 14.30 | 4.24 | 0.00 | 2.65 | -2.65 |
| 155.00 | 0.88 | -0.025 | 0.27 | 10.13 | 10.13 | 14.35 | 4.22 | 0.00 | 2.66 | -2.66 |
| 138 | 0.89 | -0.025 | 0.27 | 10.24 | 10.24 | 14.52 | 4.28 | 0.00 | 2.70 | -2.70 |
| 128 | 0.91 | -0.025 | 0.27 | 10.29 | 10.29 | 14.62 | 4.33 | 0.00 | 2.73 | -2.73 |
| 118 | 0.92 | -0.025 | 0.27 | 10.35 | 10.35 | 14.72 | 4.37 | 0.00 | 2.76 | -2.76 |
| 108 | 0.93 | -0.025 | 0.27 | 10.42 | 10.42 | 14.82 | 4.41 | 0.00 | 2.78 | -2.78 |
| 98 | 0.93 | -0.025 | 0.27 | 10.48 | 10.48 | 14.93 | 4.45 | 0.00 | 2.81 | -2.81 |
| 88 | 0.94 | -0.025 | 0.27 | 10.55 | 10.55 | 15.03 | 4.48 | 0.00 | 2.84 | -2.84 |
| 80.00 | 0.94 | -0.025 | 0.27 | 10.60 | 10.60 | 15.11 | 4.51 | 0.00 | 2.86 | -2.86 |
| 68 | 0.94 | -0.025 | 0.27 | 10.68 | 10.68 | 15.23 | 4.55 | 0.00 | 2.89 | -2.89 |
| 58 | 0.95 | -0.025 | 0.27 | 10.75 | 10.75 | 15.33 | 4.58 | 0.00 | 2.92 | -2.92 |
| 48 | 0.95 | -0.025 | 0.27 | 10.82 | 10.82 | 15.43 | 4.61 | 0.00 | 2.94 | -2.94 |
| 22 | 0.95 | -0.025 | 0.27 | 11.00 | 11.00 | 15.70 | 4.69 | 0.00 | 3.01 | -3.01 |
| 19 | 0.95 | -0.025 | 0.27 | 11.03 | 11.03 | 15.73 | 4.70 | 0.00 | 3.01 | -3.01 |
| 0 | 0.94 | -0.025 | 0.27 | 11.17 | 11.17 | 15.92 | 4.76 | 0.00 | 1.25 | -1.25 |

| AERODYNAMIC TORQUE AT SHEAR CENTRE | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| CONDITION. C | | | | | | $\Delta C_{Mo}$ | | | | | |
| | | | | | | 0 | | | | | |
| 1 | 55 | 56 | 23 | 24 | 59 | 75 | 60 | 61 | 62 | 63 | 64 |
| STATION | DELTA | DELTA | SPAN | SPAN | ELEMENT | ELEMENT | ELEMENT | ELEMENT | ELEMENT | TOTAL | TOTAL |
| | X av | Z av | ELEMENT | ELEMENT | TORQUE | TORQUE | TORQUE | TORQUE | LIMIT | LIMIT | ULT |
| (in) | (in) | (in) | LIFT | DRAG | DUE TO | DUE TO | DUE TO | DUE TO | TORQUE | TORQUE | TORQUE |
| | | | (lb) | (lb) | $C_{Mo}$ | $\Delta C_{Mo}$ | LIFT | DRAG | (lb in) | (lb in) | (lb in) |
| | | | | | (lb in) | (lb in) | (lb in) | (lb in) | | | |
| 258 | - | - | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 251.25 | 1.02 | 0.00 | 32.81 | -0.49 | -52.95 | -134.14 | 33.51 | 0.00 | -153.58 | -153.58 | -230.37 |
| 238 | -11.31 | 0.00 | 82.55 | -2.68 | -105.53 | -267.34 | -934.01 | 0.00 | -1306.88 | -1460.46 | -2190.69 |
| 228 | -11.41 | 0.00 | 69.15 | -2.70 | -81.05 | -205.33 | -789.29 | 0.00 | -1075.66 | -2536.12 | -3804.19 |
| 218 | -11.50 | 0.00 | 73.47 | -3.11 | -82.27 | -208.42 | -844.92 | 0.00 | -1135.61 | -3671.74 | -5507.60 |
| 208 | -11.59 | 0.00 | 77.08 | -3.91 | -83.50 | -211.53 | -892.96 | 0.00 | -1188.00 | -4859.73 | -7289.60 |
| 198 | -11.67 | 0.00 | 80.22 | -4.67 | -84.74 | -214.67 | -936.20 | 0.00 | -1235.61 | -6095.34 | -9143.01 |
| 188 | -11.76 | 0.00 | 83.06 | -4.94 | -85.98 | -217.83 | -976.43 | 0.00 | -1280.24 | -7375.58 | -11063.38 |
| 178 | -11.84 | 0.00 | 85.61 | -5.18 | -87.24 | -221.01 | -1013.83 | 0.00 | -1322.08 | -8697.67 | -13046.50 |
| 163.65 | -11.95 | 0.00 | 126.84 | -7.80 | -127.40 | -322.76 | -1515.25 | 0.00 | -1965.41 | -10663.08 | -15994.61 |
| 159 | -3.89 | 0.00 | 37.69 | -2.32 | -38.91 | 0.00 | -146.46 | 0.00 | -185.38 | -10848.45 | -16272.68 |
| 155.00 | 4.23 | 0.00 | 36.64 | -2.25 | -39.15 | 0.00 | 154.84 | 0.00 | 115.68 | -10732.77 | -16099.16 |
| 138 | 4.25 | 0.00 | 147.22 | -9.14 | -156.24 | 0.00 | 625.48 | 0.00 | 469.24 | -10263.53 | -15395.29 |
| 128 | 4.31 | 0.00 | 88.85 | -5.57 | -93.66 | 0.00 | 382.52 | 0.00 | 288.86 | -9974.66 | -14962.00 |
| 118 | 4.35 | 0.00 | 90.33 | -5.70 | -94.97 | 0.00 | 392.87 | 0.00 | 297.90 | -9676.77 | -14515.15 |
| 108 | 4.39 | 0.00 | 91.70 | -5.82 | -96.29 | 0.00 | 402.44 | 0.00 | 306.15 | -9370.62 | -14055.92 |
| 98 | 4.43 | 0.00 | 92.96 | -5.93 | -97.62 | 0.00 | 411.49 | 0.00 | 313.87 | -9056.75 | -13585.12 |
| 88 | 4.46 | 0.00 | 94.11 | -6.02 | -98.96 | 0.00 | 420.05 | 0.00 | 321.09 | -8735.66 | -13103.49 |
| 80.00 | 4.50 | 0.00 | 76.05 | -4.88 | -80.14 | 0.00 | 341.91 | 0.00 | 261.77 | -8473.89 | -12710.83 |
| 68 | 4.53 | 0.00 | 115.23 | -7.40 | -121.83 | 0.00 | 521.97 | 0.00 | 400.14 | -8073.75 | -12110.62 |
| 58 | 4.57 | 0.00 | 96.99 | -6.24 | -103.03 | 0.00 | 442.89 | 0.00 | 339.86 | -7733.89 | -11600.84 |
| 48 | 4.60 | 0.00 | 97.77 | -6.30 | -104.40 | 0.00 | 449.62 | 0.00 | 345.22 | -7388.68 | -11083.01 |
| 22 | 4.65 | 0.00 | 257.13 | -16.56 | -277.95 | 0.00 | 1196.71 | 0.00 | 918.76 | -6469.91 | -9704.87 |
| 19 | 4.70 | 0.00 | 29.92 | -1.93 | -32.68 | 0.00 | 140.53 | 0.00 | 107.85 | -6362.06 | -9543.09 |
| 0 | 4.73 | 0.00 | 190.29 | -12.23 | -209.93 | 0.00 | 899.84 | 0.00 | 689.90 | -5672.16 | -8508.23 |

DEAD WEIGHT ANALYSIS FOR WING TORQUE

CONDITION. C

| 1 | 65 | 54 | 66 | 67 | 33 | 68 | 69 | 70 |
|---|---|---|---|---|---|---|---|---|
| STATION | X CG | X SC | DELTA | DELTA | ELEMENT | ELEMENT | TOTAL | TOTAL |
| | (in) | (in) | X | X av | LOAD | LIMIT | LIMIT | ULT |
| (in) | | | (in) | (in) | (lb) | TORQUE | TORQUE | TORQUE |
| | using 40% chord | | | | | (lb in) | (lb in) | (lb in) |
| 258 | 14.00 | 13.30 | -0.70 | - | - | - | - | 0.00 |
| 251.25 | 14.07 | 13.37 | -0.70 | -0.70 | -1.18 | 0.83 | 0.83 | 1.25 |
| 238 | 14.21 | 13.50 | -0.71 | -0.71 | -3.15 | 2.23 | 3.06 | 4.58 |
| 228 | 14.32 | 13.60 | -0.72 | -0.71 | -5.45 | 3.89 | 6.94 | 10.41 |
| 218 | 14.43 | 13.71 | -0.72 | -0.72 | -7.63 | 5.48 | 12.42 | 18.64 |
| 208 | 14.53 | 13.81 | -0.73 | -0.72 | -9.35 | 6.77 | 19.20 | 28.79 |
| 198 | 14.64 | 13.91 | -0.73 | -0.73 | -10.99 | 8.01 | 27.21 | 40.82 |
| 188 | 14.75 | 14.01 | -0.74 | -0.73 | -13.01 | 9.56 | 36.77 | 55.16 |
| 178 | 14.86 | 14.11 | -0.74 | -0.74 | -14.74 | 10.91 | 47.68 | 71.52 |
| 163.65 | 15.01 | 14.26 | -0.75 | -0.75 | -16.95 | 12.65 | 60.34 | 90.51 |
| 159 | 15.06 | 14.30 | -0.75 | -0.75 | -17.49 | 13.15 | 73.49 | 110.23 |
| 155.00 | 15.10 | 14.35 | -0.76 | -0.75 | -18.22 | 13.74 | 87.22 | 130.83 |
| 138 | 15.28 | 14.52 | -0.76 | -0.76 | -19.13 | 14.53 | 101.75 | 152.63 |
| 128 | 15.39 | 14.62 | -0.77 | -0.77 | -19.43 | 14.90 | 116.66 | 174.98 |
| 118 | 15.50 | 14.72 | -0.77 | -0.77 | -19.98 | 15.43 | 132.08 | 198.12 |
| 108 | 15.60 | 14.82 | -0.78 | -0.78 | -20.25 | 15.74 | 147.83 | 221.74 |
| 98 | 15.71 | 14.93 | -0.79 | -0.78 | -20.58 | 16.11 | 163.94 | 245.91 |
| 88 | 15.82 | 15.03 | -0.79 | -0.79 | -21.40 | 16.87 | 180.81 | 271.21 |
| 80.00 | 15.90 | 15.11 | -0.80 | -0.79 | -21.85 | 17.33 | 198.14 | 297.20 |
| 68 | 16.03 | 15.23 | -0.80 | -0.80 | -22.67 | 18.10 | 216.24 | 324.35 |
| 58 | 16.14 | 15.33 | -0.81 | -0.80 | -23.24 | 18.70 | 234.93 | 352.40 |
| 48 | 16.25 | 15.43 | -0.81 | -0.81 | -24.15 | 19.56 | 254.49 | 381.73 |
| 22 | 16.52 | 15.70 | -0.83 | -0.82 | -25.88 | 21.20 | 275.69 | 413.53 |
| 19 | 16.56 | 15.73 | -0.83 | -0.83 | -13.03 | 10.78 | 286.47 | 429.70 |
| 0 | 16.76 | 15.92 | -0.84 | -0.83 | -8.69 | 7.24 | 293.71 | 440.56 |

COMBINED ULTIMATE TORSION ( AERODYNAMIC + INERTIAL )

| CONDITION. C | | | |
|---|---|---|---|
| | | | |
| 1 | 71 C | | |
| STATION | COND. C | | |
| (in) | (lb in) | | |
| 258 | 0 | | |
| 251.25 | -229 | | |
| 238 | -2186 | | |
| 228 | -3794 | | |
| 218 | -5489 | | |
| 208 | -7261 | | |
| 198 | -9102 | | |
| 188 | -11008 | | |
| 178 | -12975 | | |
| 163.65 | -15904 | | |
| 159 | -16162 | | |
| 155.00 | -15968 | | |
| 138 | -15243 | | |
| 128 | -14787 | | |
| 118 | -14317 | | |
| 108 | -13834 | | |
| 98 | -13339 | | |
| 88 | -12832 | | |
| 80.00 | -12414 | | |
| 68 | -11786 | | |
| 58 | -11248 | | |
| 48 | -10701 | | |
| 22 | -9291 | | |
| 19 | -9113 | | |
| 0 | -8068 | | |

| SPANWISE AERODYNAMIC LOAD DISTRIBUTION | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CONDITION: D 2/3 n | | | | | | | | | Aileron deflection = | UP | | | | |
| AILERON UP | | | | | | | | | Aileron angle = | -8.67 | deg | ECF = | 0.23 | |
| | | | | | | | | | Aileron load = | 125.07 | lb | | | |
| $V_{sat}$ = | 244.93 | ft/s | $C_L$ = | 0.4 | | alpha wrp = | -0.7337 | | $\Delta C_L$ = | -0.37 | | | | |
| Lift = | 3644.20 | lb clean | $C_{D0}$ = | 0.017 | | sin alpha = | 0.0128 | | $\Delta C_D$ = | 0.01 | | | | |
| q = | 71.33 | psf | $C_D$ = | 0.021 | | cos alpha = | 0.9999 | | $\Delta C_{M0}$ = | 0.09 | | | | |
| n = | 2.53 | g | $C_{M0}$ = | -0.025 | | | | | S = | 4.71 | ft² | | | |
| $q.C_L$ = | 26.99 | $q.C_L$ = Lift/S | S = | 135.00 | ft² | | | | b = | 7.30 | ft | | | |
| | | | b = | 43.00 | ft | | | | AR = | 11.31 | | | | |
| 1 | 13 | 72 | 14 | 15 | 16 | 73 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 |
| STATION | $C_L$ | FLAP | $C_{Lx}$ | $C_{Ls}$ | $C_D$ | FLAP | $C_{Dx}$ | $C_{Ds}$ | $C_{Ls}+C_{Ds}$ | $C_{Dx}-C_{Lx}$ | $(C_{Ls}+C_{Ds})_{AV}$ | $(C_{Dx}-C_{Lx})_{AV}$ | SPAN | SPAN |
| (in) | | $C_L$ | | | | $C_D$ | | | | | | | ELEMENT | ELEMENT |
| | | | | | | | | | | | | | LIFT | DRAG |
| | | | | | | | | | | | | | (lb) | (lb) |
| 258 | 0.1892 | 0.0000 | 0.0024 | 0.1892 | 0.0254 | 0.0000 | 0.0254 | 0.0003 | 0.1895 | 0.0230 | - | - | 0.00 | 0.00 |
| 251.25 | 0.2478 | -0.0853 | 0.0021 | 0.1626 | 0.0254 | 0.0025 | 0.0279 | 0.0004 | 0.1629 | 0.0258 | 0.1762 | 0.0244 | 20.68 | 2.86 |
| 238 | 0.2878 | -0.0853 | 0.0026 | 0.2026 | 0.0254 | 0.0025 | 0.0279 | 0.0004 | 0.2029 | 0.0253 | 0.1829 | 0.0255 | 42.45 | 5.93 |
| 228 | 0.3079 | -0.0853 | 0.0029 | 0.2226 | 0.0254 | 0.0025 | 0.0279 | 0.0004 | 0.2230 | 0.0250 | 0.2129 | 0.0252 | 37.62 | 4.45 |
| 218 | 0.3238 | -0.0853 | 0.0031 | 0.2385 | 0.0254 | 0.0025 | 0.0279 | 0.0004 | 0.2389 | 0.0248 | 0.2309 | 0.0249 | 41.11 | 4.44 |
| 208 | 0.3370 | -0.0853 | 0.0032 | 0.2517 | 0.0201 | 0.0025 | 0.0226 | 0.0003 | 0.2520 | 0.0194 | 0.2455 | 0.0221 | 44.02 | 3.96 |
| 198 | 0.3482 | -0.0853 | 0.0034 | 0.2629 | 0.0201 | 0.0025 | 0.0226 | 0.0003 | 0.2632 | 0.0192 | 0.2576 | 0.0193 | 46.54 | 3.49 |
| 188 | 0.3578 | -0.0853 | 0.0035 | 0.2725 | 0.0201 | 0.0025 | 0.0226 | 0.0003 | 0.2728 | 0.0191 | 0.2680 | 0.0192 | 48.77 | 3.49 |
| 178 | 0.3661 | -0.0853 | 0.0036 | 0.2809 | 0.0201 | 0.0025 | 0.0226 | 0.0003 | 0.2811 | 0.0190 | 0.2770 | 0.0190 | 50.77 | 3.49 |
| 163.65 | 0.3762 | -0.0853 | 0.0037 | 0.2909 | 0.0201 | 0.0025 | 0.0226 | 0.0003 | 0.2912 | 0.0189 | 0.2862 | 0.0189 | 75.94 | 5.02 |
| 159 | 0.3789 | 0.0000 | 0.0049 | 0.3789 | 0.0201 | 0.0000 | 0.0201 | 0.0003 | 0.3791 | 0.0152 | 0.3352 | 0.0171 | 26.99 | 1.37 |
| 155.00 | 0.3814 | 0.0000 | 0.0049 | 0.3814 | 0.0201 | 0.0000 | 0.0201 | 0.0003 | 0.3816 | 0.0152 | 0.3804 | 0.0152 | 30.72 | 1.23 |
| 138 | 0.3899 | 0.0000 | 0.0050 | 0.3899 | 0.0201 | 0.0000 | 0.0201 | 0.0003 | 0.3902 | 0.0151 | 0.3859 | 0.0152 | 123.43 | 4.85 |
| 128 | 0.3940 | 0.0000 | 0.0050 | 0.3940 | 0.0201 | 0.0000 | 0.0201 | 0.0003 | 0.3943 | 0.0151 | 0.3922 | 0.0151 | 74.49 | 2.86 |
| 118 | 0.3975 | 0.0000 | 0.0051 | 0.3975 | 0.0201 | 0.0000 | 0.0201 | 0.0003 | 0.3978 | 0.0150 | 0.3960 | 0.0150 | 75.74 | 2.88 |
| 108 | 0.4005 | 0.0000 | 0.0051 | 0.4005 | 0.0201 | 0.0000 | 0.0201 | 0.0003 | 0.4007 | 0.0150 | 0.3993 | 0.0150 | 76.89 | 2.89 |
| 98 | 0.4030 | 0.0000 | 0.0052 | 0.4029 | 0.0201 | 0.0000 | 0.0201 | 0.0003 | 0.4032 | 0.0149 | 0.4020 | 0.0150 | 77.94 | 2.90 |
| 88 | 0.4050 | 0.0000 | 0.0052 | 0.4049 | 0.0201 | 0.0000 | 0.0201 | 0.0003 | 0.4052 | 0.0149 | 0.4042 | 0.0149 | 78.91 | 2.91 |
| 80.00 | 0.4062 | 0.0000 | 0.0052 | 0.4062 | 0.0201 | 0.0000 | 0.0201 | 0.0003 | 0.4065 | 0.0149 | 0.4058 | 0.0149 | 63.77 | 2.34 |
| 68 | 0.4077 | 0.0000 | 0.0052 | 0.4076 | 0.0201 | 0.0000 | 0.0201 | 0.0003 | 0.4079 | 0.0149 | 0.4072 | 0.0149 | 96.62 | 3.53 |
| 58 | 0.4084 | 0.0000 | 0.0052 | 0.4084 | 0.0201 | 0.0000 | 0.0201 | 0.0003 | 0.4086 | 0.0149 | 0.4083 | 0.0149 | 81.33 | 2.96 |
| 48 | 0.4088 | 0.0000 | 0.0052 | 0.4088 | 0.0201 | 0.0000 | 0.0201 | 0.0003 | 0.4090 | 0.0149 | 0.4088 | 0.0149 | 81.98 | 2.98 |
| 22 | 0.4081 | 0.0000 | 0.0052 | 0.4081 | 0.0201 | 0.0000 | 0.0201 | 0.0003 | 0.4084 | 0.0149 | 0.4087 | 0.0149 | 215.61 | 7.85 |
| 19 | 0.4079 | 0.0000 | 0.0052 | 0.4079 | 0.0201 | 0.0000 | 0.0201 | 0.0003 | 0.4081 | 0.0149 | 0.4082 | 0.0149 | 25.09 | 0.91 |
| 0 | 0.4058 | 0.0000 | 0.0052 | 0.4058 | 0.0201 | 0.0000 | 0.0201 | 0.0003 | 0.4061 | 0.0149 | 0.4071 | 0.0149 | 159.57 | 5.84 |
| | | | | | | | | | | | | Σ = | 1696.98 | 85.43 |
| | | | | | | | | | | | | LIFT calc = | 3393.97 | |
| | | | | | | | | | | | | Lift = | 3644.20 | |

SPANWISE AERODYNAMIC LOAD DISTRIBUTION

CONDITION. D cont..

| 1 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 |
|---|---|---|---|---|---|---|---|---|
| STATION | LIMIT | LIMIT | LIMIT | LIMIT | ULT | ULT | ULT | ULT |
| (in) | NORMAL | NORMAL | CHORD | CHORD | NORMAL | NORMAL | CHORD | CHORD |
| | SHEAR | MOMENT | SHEAR | MOMENT | SHEAR | MOMENT | SHEAR | MOMENT |
| | (lb) | (lb in) | (lb) | (lb in) | (lb) | (lb in) | (lb) | (lb in) |
| 258 | 0.00 | 0.00 | 0.00 | 0.00 | 0 | 0 | 0 | 0 |
| 251.25 | 20.68 | 69.79 | 2.86 | 9.66 | 31 | 105 | 4 | 14 |
| 238 | 63.13 | 625.00 | 8.79 | 86.83 | 95 | 937 | 13 | 130 |
| 228 | 100.75 | 1444.39 | 13.23 | 196.94 | 151 | 2167 | 20 | 295 |
| 218 | 141.86 | 2657.42 | 17.67 | 351.46 | 213 | 3986 | 27 | 527 |
| 208 | 185.87 | 4296.07 | 21.63 | 547.98 | 279 | 6444 | 32 | 822 |
| 198 | 232.41 | 6387.51 | 25.12 | 781.74 | 349 | 9581 | 38 | 1173 |
| 188 | 281.19 | 8955.52 | 28.61 | 1050.37 | 422 | 13433 | 43 | 1576 |
| 178 | 331.96 | 12021.26 | 32.10 | 1353.89 | 498 | 18032 | 48 | 2031 |
| 163.65 | 407.90 | 17329.79 | 37.12 | 1850.54 | 612 | 25995 | 56 | 2776 |
| 159 | 434.89 | 19152.33 | 38.49 | 2014.06 | 652 | 28728 | 58 | 3021 |
| 155.00 | 465.61 | 21099.66 | 39.72 | 2183.21 | 698 | 31649 | 60 | 3275 |
| 138 | 589.04 | 30064.15 | 44.57 | 2899.74 | 884 | 45096 | 67 | 4350 |
| 128 | 663.53 | 36326.97 | 47.44 | 3359.81 | 995 | 54490 | 71 | 5040 |
| 118 | 739.27 | 43340.96 | 50.31 | 3848.57 | 1109 | 65011 | 75 | 5773 |
| 108 | 816.16 | 51118.10 | 53.20 | 4366.14 | 1224 | 76677 | 80 | 6549 |
| 98 | 894.10 | 59669.41 | 56.10 | 4912.64 | 1341 | 89504 | 84 | 7369 |
| 88 | 973.02 | 69005.02 | 59.02 | 5488.22 | 1460 | 103508 | 89 | 8232 |
| 80.00 | 1036.79 | 77044.23 | 61.36 | 5969.71 | 1555 | 115566 | 92 | 8955 |
| 68 | 1133.41 | 90065.43 | 64.89 | 6727.20 | 1700 | 135098 | 97 | 10091 |
| 58 | 1214.74 | 101806.19 | 67.85 | 7390.93 | 1822 | 152709 | 102 | 11086 |
| 48 | 1296.72 | 114363.49 | 70.84 | 8084.38 | 1945 | 171545 | 106 | 12127 |
| 22 | 1512.33 | 150881.19 | 78.68 | 10028.09 | 2268 | 226322 | 118 | 15042 |
| 19 | 1537.42 | 155455.82 | 79.60 | 10265.50 | 2306 | 233184 | 119 | 15398 |
| 0 | 1696.98 | 186182.67 | 85.43 | 11833.26 | 2545 | 279274 | 128 | 17750 |
| | | | | | | | | |
| Centre of lift is | 110 | in from aircraft centreline | | | | | | |
| | 43 | % semispan | | | | | | |

SPANWISE INERTIAL LOAD DISTRIBUTION

CONDITION. D cont..

| 1 | 3 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 | 41 | 42 | 43 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| STATION | dy | WEIGHT | ELEMENT | ELEMENT | LIMIT | LIMIT | LIMIT | LIMIT | ULT | ULT | ULT | ULT |
| (in) | (in) | nW | SHEAR | SHEAR | NORMAL | NORMAL | CHORD | CHORD | NORMAL | NORMAL | CHORD | CHORD |
| | | (lb) | FORCE | FORCE | SHEAR | MOMENT | SHEAR | MOMENT | SHEAR | MOMENT | SHEAR | MOMENT |
| | | | $V_z$ | $V_z$ | (lb) | (lb in) | (lb) | (lb in) | (lb) | (lb in) | (lb) | (lb in) |
| | | | (lb) | (lb) | | | | | | | | |
| 258 | - | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0 | 0 | 0 | 0 |
| 251.25 | 6.75 | -0.99 | 0.01 | -0.99 | -0.99 | -3.34 | 0.01 | 0.04 | -1 | -5 | 0 | 0 |
| 238 | 13.25 | -2.63 | 0.03 | -2.63 | -3.62 | -33.92 | 0.05 | 0.43 | -5 | -51 | 0 | 1 |
| 228 | 10.00 | -4.56 | 0.06 | -4.56 | -8.18 | -92.96 | 0.10 | 1.19 | -12 | -139 | 0 | 2 |
| 218 | 10.00 | -6.38 | 0.08 | -6.38 | -14.57 | -206.72 | 0.19 | 2.65 | -22 | -310 | 0 | 4 |
| 208 | 10.00 | -7.83 | 0.10 | -7.83 | -22.40 | -391.54 | 0.29 | 5.01 | -34 | -587 | 0 | 8 |
| 198 | 10.00 | -9.20 | 0.12 | -9.20 | -31.59 | -661.46 | 0.40 | 8.47 | -47 | -992 | 1 | 13 |
| 188 | 10.00 | -10.89 | 0.14 | -10.89 | -42.48 | -1031.83 | 0.54 | 13.21 | -64 | -1548 | 1 | 20 |
| 178 | 10.00 | -12.34 | 0.16 | -12.34 | -54.82 | -1518.34 | 0.70 | 19.44 | -82 | -2278 | 1 | 29 |
| 163.65 | 14.35 | -14.19 | 0.18 | -14.19 | -69.00 | -2406.77 | 0.88 | 30.82 | -104 | -3610 | 1 | 46 |
| 159 | 4.33 | -14.64 | 0.19 | -14.64 | -83.65 | -2736.88 | 1.07 | 35.05 | -125 | -4105 | 2 | 53 |
| 155.00 | 4.32 | -15.25 | 0.20 | -15.25 | -98.90 | -3131.63 | 1.27 | 40.11 | -148 | -4697 | 2 | 60 |
| 138 | 17.00 | -16.01 | 0.21 | -16.01 | -114.90 | -4948.93 | 1.47 | 63.38 | -172 | -7423 | 2 | 95 |
| 128 | 10.00 | -16.26 | 0.21 | -16.26 | -131.17 | -6179.29 | 1.68 | 79.14 | -197 | -9269 | 3 | 119 |
| 118 | 10.00 | -16.72 | 0.21 | -16.72 | -147.89 | -7574.56 | 1.89 | 97.00 | -222 | -11362 | 3 | 146 |
| 108 | 10.00 | -16.95 | 0.22 | -16.95 | -164.83 | -9138.16 | 2.11 | 117.03 | -247 | -13707 | 3 | 176 |
| 98 | 10.00 | -17.23 | 0.22 | -17.23 | -182.06 | -10872.61 | 2.33 | 139.24 | -273 | -16309 | 3 | 209 |
| 88 | 10.00 | -17.91 | 0.23 | -17.91 | -199.97 | -12782.74 | 2.56 | 163.70 | -300 | -19174 | 4 | 246 |
| 80.00 | 8.00 | -18.29 | 0.23 | -18.29 | -218.26 | -14455.63 | 2.80 | 185.13 | -327 | -21683 | 4 | 278 |
| 68 | 12.00 | -18.97 | 0.24 | -18.97 | -237.23 | -17188.55 | 3.04 | 220.13 | -356 | -25783 | 5 | 330 |
| 58 | 10.00 | -19.46 | 0.25 | -19.45 | -256.68 | -19658.11 | 3.29 | 251.75 | -385 | -29487 | 5 | 378 |
| 48 | 10.00 | -20.22 | 0.26 | -20.21 | -276.90 | -22326.03 | 3.55 | 285.92 | -415 | -33489 | 5 | 429 |
| 22 | 26.00 | -21.66 | 0.28 | -21.66 | -298.56 | -29806.94 | 3.82 | 381.72 | -448 | -44710 | 6 | 573 |
| 19 | 3.00 | -10.91 | 0.14 | -10.91 | -309.46 | -30718.97 | 3.96 | 393.40 | -464 | -46078 | 6 | 590 |
| 0 | 19.00 | -7.27 | 0.09 | -7.27 | -316.74 | -36667.88 | 4.06 | 469.59 | -475 | -55002 | 6 | 704 |
| | Σ = | 125 | lb | | | | | | | | | |
| | | at 1 g | | | Centre of gravity is | 116 | in from aircraft centreline | | | | | |
| | | | | | | 45 | % semispan | | | | | |

COMBINED ULTIMATE LOADS ( AERODYNAMIC + INERTIAL )

CONDITION. D cont..

| 1 | 44 D | 45 D | 46 D | 47 D | 48 D | 49 D |
|---|---|---|---|---|---|---|
| | ULT | ULT | ULT | ULT | ULT | ULT |
| | NORMAL | NORMAL | CHORD | CHORD | RESOLVED | RESOLVED |
| STATION | SHEAR | BEND MOMENT | SHEAR | BEND MOMENT | SHEAR | BEND MOMENT |
| (in) | COND. D | COND. D | COND. D | COND. D | COND. D | COND. D |
| | (lb) | (lb in) | (lb) | (lb in) | (lb) | (lb in) |
| 258 | 0 | 0 | 0 | 0 | 0 | 0 |
| 251.25 | 30 | 100 | 4 | 15 | 30 | 101 |
| 238 | 89 | 887 | 13 | 131 | 90 | 896 |
| 228 | 139 | 2027 | 20 | 297 | 140 | 2049 |
| 218 | 191 | 3676 | 27 | 531 | 193 | 3714 |
| 208 | 245 | 5857 | 33 | 829 | 247 | 5915 |
| 198 | 301 | 8589 | 38 | 1185 | 304 | 8670 |
| 188 | 358 | 11886 | 44 | 1595 | 361 | 11992 |
| 178 | 416 | 15754 | 49 | 2060 | 419 | 15888 |
| 163.65 | 508 | 22385 | 57 | 2822 | 512 | 22562 |
| 159 | 527 | 24623 | 59 | 3074 | 530 | 24814 |
| 155.00 | 550 | 26952 | 61 | 3335 | 553 | 27158 |
| 138 | 711 | 37673 | 69 | 4445 | 715 | 37934 |
| 128 | 799 | 45222 | 74 | 5158 | 802 | 45515 |
| 118 | 887 | 53650 | 78 | 5918 | 891 | 53975 |
| 108 | 977 | 62970 | 83 | 6725 | 981 | 63328 |
| 98 | 1068 | 73195 | 88 | 7578 | 1072 | 73586 |
| 88 | 1160 | 84333 | 92 | 8478 | 1163 | 84758 |
| 80.00 | 1228 | 93883 | 96 | 9232 | 1232 | 94336 |
| 68 | 1344 | 109315 | 102 | 10421 | 1348 | 109811 |
| 58 | 1437 | 123222 | 107 | 11464 | 1441 | 123754 |
| 48 | 1530 | 138056 | 112 | 12555 | 1534 | 138626 |
| 22 | 1821 | 181611 | 124 | 15615 | 1825 | 182281 |
| 19 | 1842 | 187105 | 125 | 15988 | 1846 | 187787 |
| 0 | 2070 | 224272 | 134 | 18454 | 2075 | 225030 |

AERODYNAMIC TORQUE AT SHEAR CENTRE

CONDITION. D

| 1 | 50 | 74 | 51 | 52 | 53 | 54 | 55 | 56 | 57 | 58 |
|---|---|---|---|---|---|---|---|---|---|---|
| STATION | CLEAN + FLAPPED | CLEAN + FLAPPED | LOCAL | AERO | X AC | - X SC | DELTA X | Z AC | Z SC | DELTA Z |
| | LOCAL | LOCAL | $X_{CP}$ | CENTRE | (in) | (in) | (in) | (in) | (in) | (in) |
| (in) | $C_L$ | $C_{Mo}$ | | (in) | | using 38% chord | | | | |
| 258 | - | -0.025 | - | 0.00 | 0.00 | 13.30 | 13.30 | 0.00 | 2.39 | -2.39 |
| 251.25 | 0.18 | 0.062 | 0.70 | 24.63 | 24.63 | 13.37 | -11.26 | 0.00 | 2.40 | -2.40 |
| 238 | 0.18 | 0.062 | 0.70 | 24.87 | 24.87 | 13.50 | -11.37 | 0.00 | 2.44 | -2.44 |
| 228 | 0.21 | 0.062 | 0.70 | 25.06 | 25.06 | 13.60 | -11.46 | 0.00 | 2.47 | -2.47 |
| 218 | 0.23 | 0.062 | 0.70 | 25.25 | 25.25 | 13.71 | -11.54 | 0.00 | 2.49 | -2.49 |
| 208 | 0.25 | 0.062 | 0.70 | 25.44 | 25.44 | 13.81 | -11.63 | 0.00 | 2.52 | -2.52 |
| 198 | 0.26 | 0.062 | 0.70 | 25.62 | 25.62 | 13.91 | -11.71 | 0.00 | 2.54 | -2.54 |
| 188 | 0.27 | 0.062 | 0.70 | 25.81 | 25.81 | 14.01 | -11.80 | 0.00 | 2.57 | -2.57 |
| 178 | 0.28 | 0.062 | 0.70 | 26.00 | 26.00 | 14.11 | -11.88 | 0.00 | 2.60 | -2.60 |
| 163.65 | 0.29 | 0.062 | 0.70 | 26.27 | 26.27 | 14.26 | -12.01 | 0.00 | 2.64 | -2.64 |
| 159 | 0.34 | -0.025 | 0.31 | 11.84 | 11.84 | 14.30 | 2.46 | 0.00 | 2.65 | -2.65 |
| 155.00 | 0.38 | -0.025 | 0.31 | 11.54 | 11.54 | 14.35 | 2.80 | 0.00 | 2.66 | -2.66 |
| 138 | 0.39 | -0.025 | 0.30 | 11.65 | 11.65 | 14.52 | 2.87 | 0.00 | 2.70 | -2.70 |
| 128 | 0.39 | -0.025 | 0.30 | 11.69 | 11.69 | 14.62 | 2.93 | 0.00 | 2.73 | -2.73 |
| 118 | 0.40 | -0.025 | 0.30 | 11.74 | 11.74 | 14.72 | 2.98 | 0.00 | 2.76 | -2.76 |
| 108 | 0.40 | -0.025 | 0.30 | 11.81 | 11.81 | 14.82 | 3.02 | 0.00 | 2.78 | -2.78 |
| 98 | 0.40 | -0.025 | 0.30 | 11.87 | 11.87 | 14.93 | 3.06 | 0.00 | 2.81 | -2.81 |
| 88 | 0.40 | -0.025 | 0.30 | 11.94 | 11.94 | 15.03 | 3.09 | 0.00 | 2.84 | -2.84 |
| 80.00 | 0.41 | -0.025 | 0.30 | 11.99 | 11.99 | 15.11 | 3.12 | 0.00 | 2.86 | -2.86 |
| 68 | 0.41 | -0.025 | 0.30 | 12.08 | 12.08 | 15.23 | 3.15 | 0.00 | 2.89 | -2.89 |
| 58 | 0.41 | -0.025 | 0.30 | 12.15 | 12.15 | 15.33 | 3.18 | 0.00 | 2.92 | -2.92 |
| 48 | 0.41 | -0.025 | 0.30 | 12.23 | 12.23 | 15.43 | 3.20 | 0.00 | 2.94 | -2.94 |
| 22 | 0.41 | -0.025 | 0.30 | 12.44 | 12.44 | 15.70 | 3.26 | 0.00 | 3.01 | -3.01 |
| 19 | 0.41 | -0.025 | 0.30 | 12.47 | 12.47 | 15.73 | 3.26 | 0.00 | 3.01 | -3.01 |
| 0 | 0.41 | -0.025 | 0.30 | 12.63 | 12.63 | 15.92 | 3.29 | 0.00 | 1.25 | -1.25 |

| AERODYNAMIC TORQUE AT SHEAR CENTRE | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| CONDITION. D | | | | | | $\Delta C_{Mo}$ | | | | | |
| | | | | | | 0 | | | | | |
| 1 | 55 | 56 | 23 | 24 | 59 | 75 | 60 | 61 | 62 | 63 | 64 |
| STATION | DELTA | DELTA | SPAN | SPAN | ELEMENT | ELEMENT | ELEMENT | ELEMENT | ELEMENT | TOTAL | TOTAL |
| | X av | Z av | ELEMENT | ELEMENT | TORQUE | TORQUE | TORQUE | TORQUE | LIMIT | LIMIT | ULT |
| (in) | (in) | (in) | LIFT | DRAG | DUE TO | DUE TO | DUE TO | DUE TO | TORQUE | TORQUE | TORQUE |
| | | | (lb) | (lb) | $C_{Mo}$ | $\Delta C_{Mo}$ | LIFT | DRAG | (lb in) | (lb in) | (lb in) |
| | | | | | (lb in) | (lb in) | (lb in) | (lb in) | | | |
| 258 | - | - | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 251.25 | 1.02 | 0.00 | 20.68 | 2.86 | -102.93 | 356.81 | 21.11 | 0.00 | 275.00 | 275.00 | 412.50 |
| 238 | -11.31 | 0.00 | 42.45 | 5.93 | -205.13 | 711.13 | -480.31 | 0.00 | 25.69 | 300.69 | 451.03 |
| 228 | -11.41 | 0.00 | 37.62 | 4.45 | -157.55 | 546.18 | -429.42 | 0.00 | -40.79 | 259.90 | 389.85 |
| 218 | -11.50 | 0.00 | 41.11 | 4.44 | -159.92 | 554.40 | -472.70 | 0.00 | -78.22 | 181.68 | 272.52 |
| 208 | -11.59 | 0.00 | 44.02 | 3.96 | -162.31 | 562.68 | -509.95 | 0.00 | -109.58 | 72.10 | 108.14 |
| 198 | -11.67 | 0.00 | 46.54 | 3.49 | -164.72 | 571.03 | -543.15 | 0.00 | -136.85 | -64.75 | -97.12 |
| 188 | -11.76 | 0.00 | 48.77 | 3.49 | -167.14 | 579.43 | -573.40 | 0.00 | -161.11 | -225.86 | -338.79 |
| 178 | -11.84 | 0.00 | 50.77 | 3.49 | -169.59 | 587.90 | -601.24 | 0.00 | -182.93 | -408.79 | -613.18 |
| 163.65 | -11.95 | 0.00 | 75.94 | 5.02 | -247.66 | 858.55 | -907.22 | 0.00 | -296.33 | -705.12 | -1057.68 |
| 159 | -4.77 | 0.00 | 26.99 | 1.37 | -75.64 | 0.00 | -128.80 | 0.00 | -204.44 | -909.56 | -1364.35 |
| 155.00 | 2.63 | 0.00 | 30.72 | 1.23 | -76.11 | 0.00 | 80.89 | 0.00 | 4.78 | -904.79 | -1357.18 |
| 138 | 2.84 | 0.00 | 123.43 | 4.85 | -303.71 | 0.00 | 350.42 | 0.00 | 46.71 | -858.08 | -1287.12 |
| 128 | 2.90 | 0.00 | 74.49 | 2.86 | -182.06 | 0.00 | 216.33 | 0.00 | 34.27 | -823.81 | -1235.72 |
| 118 | 2.96 | 0.00 | 75.74 | 2.88 | -184.61 | 0.00 | 223.91 | 0.00 | 39.30 | -784.51 | -1176.77 |
| 108 | 3.00 | 0.00 | 76.89 | 2.89 | -187.18 | 0.00 | 230.56 | 0.00 | 43.38 | -741.13 | -1111.70 |
| 98 | 3.04 | 0.00 | 77.94 | 2.90 | -189.76 | 0.00 | 236.76 | 0.00 | 47.00 | -694.14 | -1041.21 |
| 88 | 3.07 | 0.00 | 78.91 | 2.91 | -192.37 | 0.00 | 242.52 | 0.00 | 50.16 | -643.98 | -965.97 |
| 80.00 | 3.10 | 0.00 | 63.77 | 2.34 | -155.78 | 0.00 | 197.94 | 0.00 | 42.16 | -601.82 | -902.73 |
| 68 | 3.13 | 0.00 | 96.62 | 3.53 | -236.83 | 0.00 | 302.80 | 0.00 | 65.97 | -535.85 | -803.77 |
| 58 | 3.16 | 0.00 | 81.33 | 2.96 | -200.28 | 0.00 | 257.34 | 0.00 | 57.07 | -478.78 | -718.17 |
| 48 | 3.19 | 0.00 | 81.98 | 2.98 | -202.95 | 0.00 | 261.55 | 0.00 | 58.60 | -420.18 | -630.27 |
| 22 | 3.23 | 0.00 | 215.61 | 7.85 | -540.29 | 0.00 | 696.32 | 0.00 | 156.03 | -264.15 | -396.22 |
| 19 | 3.26 | 0.00 | 25.09 | 0.91 | -63.53 | 0.00 | 81.74 | 0.00 | 18.21 | -245.94 | -368.90 |
| 0 | 3.28 | 0.00 | 159.57 | 5.84 | -408.09 | 0.00 | 522.82 | 0.00 | 114.73 | -131.21 | -196.81 |

| DEAD WEIGHT ANALYSIS FOR WING TORQUE | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| CONDITION. D | | | | | | | | |
| 1 | 65 | 54 | 66 | 67 | 33 | - 68 | 69 | 70 |
| STATION | X CG | X SC | DELTA | DELTA | ELEMENT | ELEMENT | TOTAL | TOTAL |
| | (in) | (in) | X | X av | LOAD | LIMIT | LIMIT | ULT |
| (in) | | | (in) | (in) | (lb) | TORQUE | TORQUE | TORQUE |
| | using 40% chord | | | | | (lb in) | (lb in) | (lb in) |
| 258 | 14.00 | 13.30 | -0.70 | - | - | - | - | 0.00 |
| 251.25 | 14.07 | 13.37 | -0.70 | -0.70 | -0.99 | 0.69 | 0.69 | 1.04 |
| 238 | 14.21 | 13.50 | -0.71 | -0.71 | -2.63 | 1.86 | 2.56 | 3.84 |
| 228 | 14.32 | 13.60 | -0.72 | -0.71 | -4.56 | 3.25 | 5.81 | 8.72 |
| 218 | 14.43 | 13.71 | -0.72 | -0.72 | -6.38 | 4.59 | 10.40 | 15.60 |
| 208 | 14.53 | 13.81 | -0.73 | -0.72 | -7.83 | 5.67 | 16.07 | 24.10 |
| 198 | 14.64 | 13.91 | -0.73 | -0.73 | -9.20 | 6.71 | 22.78 | 34.16 |
| 188 | 14.75 | 14.01 | -0.74 | -0.73 | -10.89 | 8.00 | 30.78 | 46.17 |
| 178 | 14.86 | 14.11 | -0.74 | -0.74 | -12.34 | 9.13 | 39.91 | 59.87 |
| 163.65 | 15.01 | 14.26 | -0.75 | -0.75 | -14.19 | 10.59 | 50.50 | 75.75 |
| 159 | 15.06 | 14.30 | -0.75 | -0.75 | -14.64 | 11.01 | 61.51 | 92.26 |
| 155.00 | 15.10 | 14.35 | -0.76 | -0.75 | -15.25 | 11.50 | 73.01 | 109.51 |
| 138 | 15.28 | 14.52 | -0.76 | -0.76 | -16.01 | 12.16 | 85.17 | 127.75 |
| 128 | 15.39 | 14.62 | -0.77 | -0.77 | -16.26 | 12.47 | 97.64 | 146.46 |
| 118 | 15.50 | 14.72 | -0.77 | -0.77 | -16.72 | 12.91 | 110.55 | 165.83 |
| 108 | 15.60 | 14.82 | -0.78 | -0.78 | -16.95 | 13.18 | 123.73 | 185.60 |
| 98 | 15.71 | 14.93 | -0.79 | -0.78 | -17.23 | 13.49 | 137.22 | 205.83 |
| 88 | 15.82 | 15.03 | -0.79 | -0.79 | -17.91 | 14.12 | 151.34 | 227.00 |
| 80.00 | 15.90 | 15.11 | -0.80 | -0.79 | -18.29 | 14.51 | 165.84 | 248.76 |
| 68 | 16.03 | 15.23 | -0.80 | -0.80 | -18.97 | 15.15 | 180.99 | 271.49 |
| 58 | 16.14 | 15.33 | -0.81 | -0.80 | -19.46 | 15.65 | 196.64 | 294.96 |
| 48 | 16.25 | 15.43 | -0.81 | -0.81 | -20.22 | 16.37 | 213.01 | 319.51 |
| 22 | 16.52 | 15.70 | -0.83 | -0.82 | -21.66 | 17.75 | 230.75 | 346.13 |
| 19 | 16.56 | 15.73 | -0.83 | -0.83 | -10.91 | 9.02 | 239.77 | 359.66 |
| 0 | 16.76 | 15.92 | -0.84 | -0.83 | -7.27 | 6.06 | 245.83 | 368.75 |

| COMBINED ULTIMATE TORSION ( AERODYNAMIC + INERTIAL ) | | | |
|---|---|---|---|
| CONDITION. D | | | |
| | | | |
| | | | |
| 1 | 71 D | | |
| STATION | COND. D | | |
| (in) | (lb in) | | |
| 258 | 0 | | |
| 251.25 | 414 | | |
| 238 | 455 | | |
| 228 | 399 | | |
| 218 | 288 | | |
| 208 | 132 | | |
| 198 | -63 | | |
| 188 | -293 | | |
| 178 | -553 | | |
| 163.65 | -982 | | |
| 159 | -1272 | | |
| 155.00 | -1248 | | |
| 138 | -1159 | | |
| 128 | -1089 | | |
| 118 | -1011 | | |
| 108 | -926 | | |
| 98 | -835 | | |
| 88 | -739 | | |
| 80.00 | -654 | | |
| 68 | -532 | | |
| 58 | -423 | | |
| 48 | -311 | | |
| 22 | -50 | | |
| 19 | -9 | | |
| 0 | 172 | | |

SPANWISE AERODYNAMIC LOAD DISTRIBUTION
CONDITION. D 2/3 n
AILERON DOWN

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | Aileron deflection = | DWN | | ECF = | 0.17 |
| | | | | Aileron angle = | 6.33 deg | | | |
| | | | | Aileron load = | 125.07 lb | | | |
| $V_{sd}$ = | 244.93 ft/s | $C_L$ = | 0.4 | alpha wrp = | -0.7337 | $\Delta C_L$ = | 0.37 | |
| Lift = | 3644.20 lb clean | $C_{Do}$ = | 0.017 | sin alpha = | 0.0128 | $\Delta C_D$ = | 0.01 | |
| q = | 71.33 psf | $C_D$ = | 0.021 | cos alpha = | 0.9999 | $\Delta C_{Mo}$ = | -0.06 | |
| n = | 2.53 g | $C_{Mo}$ = | -0.025 | | | S = | 4.71 $ft^2$ | |
| $q.C_L$ = | 26.99 $q.C_L$ = Lift/S | S = | 135.00 $ft^2$ | | | b = | 7.30 ft | |
| | | b = | 43.00 ft | | | AR = | 11.31 | |

| 1 | 13 | 72 | 14 | 15 | 16 | 73 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| STATION (in) | $C_L$ | FLAP $C_L$ | $C_{Lx}$ | $C_{Lz}$ | $C_D$ | FLAP $C_D$ | $C_{Dx}$ | $C_{Dz}$ | $C_{Lz}+C_{Dz}$ | $C_{Dx}-C_{Lx}$ | $(C_{Lz}+C_{Dz})_{AV}$ | $(C_{Dx}-C_{Lx})_{AV}$ | SPAN ELEMENT LIFT (lb) | SPAN ELEMENT DRAG (lb) |
| 258 | 0.1892 | 0.0000 | 0.0024 | 0.1892 | 0.0254 | 0.0000 | 0.0254 | 0.0003 | 0.1895 | 0.0230 | - | - | 0.00 | 0.00 |
| 251.25 | 0.2478 | 0.0640 | 0.0040 | 0.3119 | 0.0254 | 0.0019 | 0.0273 | 0.0003 | 0.3122 | 0.0233 | 0.2509 | 0.0231 | 29.43 | 2.71 |
| 238 | 0.2878 | 0.0640 | 0.0045 | 0.3518 | 0.0254 | 0.0019 | 0.0273 | 0.0003 | 0.3522 | 0.0228 | 0.3322 | 0.0230 | 77.09 | 5.34 |
| 228 | 0.3079 | 0.0640 | 0.0048 | 0.3719 | 0.0254 | 0.0019 | 0.0273 | 0.0003 | 0.3722 | 0.0225 | 0.3622 | 0.0226 | 63.99 | 4.00 |
| 218 | 0.3238 | 0.0640 | 0.0050 | 0.3878 | 0.0254 | 0.0019 | 0.0273 | 0.0003 | 0.3882 | 0.0223 | 0.3802 | 0.0224 | 67.68 | 3.99 |
| 208 | 0.3370 | 0.0640 | 0.0051 | 0.4010 | 0.0201 | 0.0019 | 0.0220 | 0.0003 | 0.4013 | 0.0168 | 0.3947 | 0.0196 | 70.79 | 3.51 |
| 198 | 0.3482 | 0.0640 | 0.0053 | 0.4122 | 0.0201 | 0.0019 | 0.0220 | 0.0003 | 0.4125 | 0.0167 | 0.4069 | 0.0168 | 73.51 | 3.03 |
| 188 | 0.3578 | 0.0640 | 0.0054 | 0.4218 | 0.0201 | 0.0019 | 0.0220 | 0.0003 | 0.4221 | 0.0166 | 0.4173 | 0.0166 | 75.94 | 3.03 |
| 178 | 0.3661 | 0.0640 | 0.0055 | 0.4301 | 0.0201 | 0.0019 | 0.0220 | 0.0003 | 0.4304 | 0.0165 | 0.4262 | 0.0165 | 78.13 | 3.03 |
| 163.65 | 0.3762 | 0.0640 | 0.0056 | 0.4402 | 0.0201 | 0.0019 | 0.0220 | 0.0003 | 0.4405 | 0.0163 | 0.4355 | 0.0164 | 115.55 | 4.35 |
| 159 | 0.3789 | 0.0000 | 0.0049 | 0.3789 | 0.0201 | 0.0000 | 0.0201 | 0.0003 | 0.3791 | 0.0152 | 0.4098 | 0.0158 | 33.00 | 1.27 |
| 155.00 | 0.3814 | 0.0000 | 0.0049 | 0.3814 | 0.0201 | 0.0000 | 0.0201 | 0.0003 | 0.3816 | 0.0152 | 0.3804 | 0.0152 | 30.72 | 1.23 |
| 138 | 0.3899 | 0.0000 | 0.0050 | 0.3899 | 0.0201 | 0.0000 | 0.0201 | 0.0003 | 0.3902 | 0.0151 | 0.3859 | 0.0152 | 123.43 | 4.85 |
| 128 | 0.3940 | 0.0000 | 0.0050 | 0.3940 | 0.0201 | 0.0000 | 0.0201 | 0.0003 | 0.3943 | 0.0151 | 0.3922 | 0.0151 | 74.49 | 2.86 |
| 118 | 0.3975 | 0.0000 | 0.0051 | 0.3975 | 0.0201 | 0.0000 | 0.0201 | 0.0003 | 0.3978 | 0.0150 | 0.3960 | 0.0150 | 75.74 | 2.88 |
| 108 | 0.4005 | 0.0000 | 0.0051 | 0.4005 | 0.0201 | 0.0000 | 0.0201 | 0.0003 | 0.4007 | 0.0150 | 0.3993 | 0.0150 | 76.89 | 2.89 |
| 98 | 0.4030 | 0.0000 | 0.0052 | 0.4029 | 0.0201 | 0.0000 | 0.0201 | 0.0003 | 0.4032 | 0.0149 | 0.4020 | 0.0150 | 77.94 | 2.90 |
| 88 | 0.4050 | 0.0000 | 0.0052 | 0.4049 | 0.0201 | 0.0000 | 0.0201 | 0.0003 | 0.4052 | 0.0149 | 0.4042 | 0.0149 | 78.91 | 2.91 |
| 80.00 | 0.4062 | 0.0000 | 0.0052 | 0.4062 | 0.0201 | 0.0000 | 0.0201 | 0.0003 | 0.4065 | 0.0149 | 0.4058 | 0.0149 | 63.77 | 2.34 |
| 68 | 0.4077 | 0.0000 | 0.0052 | 0.4076 | 0.0201 | 0.0000 | 0.0201 | 0.0003 | 0.4079 | 0.0149 | 0.4072 | 0.0149 | 96.62 | 3.53 |
| 58 | 0.4084 | 0.0000 | 0.0052 | 0.4084 | 0.0201 | 0.0000 | 0.0201 | 0.0003 | 0.4086 | 0.0149 | 0.4083 | 0.0149 | 81.33 | 2.96 |
| 48 | 0.4088 | 0.0000 | 0.0052 | 0.4088 | 0.0201 | 0.0000 | 0.0201 | 0.0003 | 0.4090 | 0.0149 | 0.4088 | 0.0149 | 81.98 | 2.98 |
| 22 | 0.4081 | 0.0000 | 0.0052 | 0.4081 | 0.0201 | 0.0000 | 0.0201 | 0.0003 | 0.4084 | 0.0149 | 0.4087 | 0.0149 | 215.61 | 7.85 |
| 19 | 0.4079 | 0.0000 | 0.0052 | 0.4079 | 0.0201 | 0.0000 | 0.0201 | 0.0003 | 0.4081 | 0.0149 | 0.4082 | 0.0149 | 25.09 | 0.91 |
| 0 | 0.4058 | 0.0000 | 0.0052 | 0.4058 | 0.0201 | 0.0000 | 0.0201 | 0.0003 | 0.4061 | 0.0149 | 0.4071 | 0.0149 | 159.57 | 5.84 |
| | | | | | | | | | | | | Σ = | 1947.20 | 81.19 |
| | | | | | | | | | | | | LIFT calc = | 3894.40 | |
| | | | | | | | | | | | | Lift = | 3644.20 | |

SPANWISE AERODYNAMIC LOAD DISTRIBUTION

CONDITION. D cont..

| 1 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 |
|---|---|---|---|---|---|---|---|---|
| STATION | LIMIT | LIMIT | LIMIT | LIMIT | ULT | ULT | ULT | ULT |
| (in) | NORMAL | NORMAL | CHORD | CHORD | NORMAL | NORMAL | CHORD | CHORD |
| | SHEAR | MOMENT | SHEAR | MOMENT | SHEAR | MOMENT | SHEAR | MOMENT |
| | (lb) | (lb in) | (lb) | (lb in) | (lb) | (lb in) | (lb) | (lb in) |
| 258 | 0.00 | 0.00 | 0.00 | 0.00 | 0 | 0 | 0 | 0 |
| 251.25 | 29.43 | 99.34 | 2.71 | 9.15 | 44 | 149 | 4 | 14 |
| 238 | 106.52 | 1000.06 | 8.05 | 80.47 | 160 | 1500 | 12 | 121 |
| 228 | 170.52 | 2385.27 | 12.05 | 180.98 | 256 | 3578 | 18 | 271 |
| 218 | 238.20 | 4428.84 | 16.04 | 321.42 | 357 | 6643 | 24 | 482 |
| 208 | 308.98 | 7164.73 | 19.55 | 499.33 | 463 | 10747 | 29 | 749 |
| 198 | 382.49 | 10622.08 | 22.57 | 709.93 | 574 | 15933 | 34 | 1065 |
| 188 | 458.43 | 14826.64 | 25.60 | 950.80 | 688 | 22240 | 38 | 1426 |
| 178 | 536.56 | 19801.57 | 28.63 | 1221.94 | 805 | 29702 | 43 | 1833 |
| 163.65 | 652.11 | 28330.29 | 32.98 | 1663.98 | 978 | 42495 | 49 | 2496 |
| 159 | 685.11 | 31222.03 | 34.25 | 1809.36 | 1028 | 46833 | 51 | 2714 |
| 155.00 | 715.83 | 34251.55 | 35.48 | 1960.16 | 1074 | 51377 | 53 | 2940 |
| 138 | 839.25 | 47469.72 | 40.33 | 2604.56 | 1259 | 71205 | 60 | 3907 |
| 128 | 913.75 | 56234.71 | 43.20 | 3022.18 | 1371 | 84352 | 65 | 4533 |
| 118 | 989.49 | 65750.88 | 46.07 | 3468.51 | 1484 | 98626 | 69 | 5203 |
| 108 | 1066.38 | 76030.19 | 48.96 | 3943.65 | 1600 | 114045 | 73 | 5915 |
| 98 | 1144.32 | 87083.68 | 51.86 | 4447.72 | 1716 | 130626 | 78 | 6672 |
| 88 | 1223.23 | 98921.45 | 54.77 | 4980.86 | 1835 | 148382 | 82 | 7471 |
| 80.00 | 1287.01 | 108962.41 | 57.11 | 5428.40 | 1931 | 163444 | 86 | 8143 |
| 68 | 1383.63 | 124986.21 | 60.65 | 6134.97 | 2075 | 187479 | 91 | 9202 |
| 58 | 1464.96 | 139229.14 | 63.61 | 6756.26 | 2197 | 208844 | 95 | 10134 |
| 48 | 1546.94 | 154288.62 | 66.59 | 7407.27 | 2320 | 231433 | 100 | 11111 |
| 22 | 1762.55 | 197311.97 | 74.44 | 9240.66 | 2644 | 295968 | 112 | 13861 |
| 19 | 1787.64 | 202637.25 | 75.35 | 9465.34 | 2681 | 303956 | 113 | 14198 |
| 0 | 1947.20 | 238118.22 | 81.19 | 10952.46 | 2921 | 357177 | 122 | 16429 |
| | | | | | | | | |
| Centre of lift is | 122 | in from aircraft centreline | | | | | | |
| | 47 | % semispan | | | | | | |

SPANWISE INERTIAL LOAD DISTRIBUTION

CONDITION. D cont..

| 1 | 3 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 | 41 | 42 | 43 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| STATION | dy | WEIGHT | ELEMENT | ELEMENT | LIMIT | LIMIT | LIMIT | LIMIT | ULT | ULT | ULT | ULT |
| (in) | (in) | nW | SHEAR | SHEAR | NORMAL | NORMAL | CHORD | CHORD | NORMAL | NORMAL | CHORD | CHORD |
| | | (lb) | FORCE | FORCE | SHEAR | MOMENT | SHEAR | MOMENT | SHEAR | MOMENT | SHEAR | MOMENT |
| | | | $V_x$ | $V_z$ | (lb) | (lb in) | (lb) | (lb in) | (lb) | (lb in) | (lb) | (lb in) |
| | | | (lb) | (lb) | | | | | | | | |
| 258 | - | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0 | 0 | 0 | 0 |
| 251.25 | 6.75 | -0.99 | 0.01 | -0.99 | -0.99 | -3.34 | 0.01 | 0.04 | -1 | -5 | 0 | 0 |
| 238 | 13.25 | -2.63 | 0.03 | -2.63 | -3.62 | -33.92 | 0.05 | 0.43 | -5 | -51 | 0 | 1 |
| 228 | 10.00 | -4.56 | 0.06 | -4.56 | -8.18 | -92.96 | 0.10 | 1.19 | -12 | -139 | 0 | 2 |
| 218 | 10.00 | -6.38 | 0.08 | -6.38 | -14.57 | -206.72 | 0.19 | 2.65 | -22 | -310 | 0 | 4 |
| 208 | 10.00 | -7.83 | 0.10 | -7.83 | -22.40 | -391.54 | 0.29 | 5.01 | -34 | -587 | 0 | 8 |
| 198 | 10.00 | -9.20 | 0.12 | -9.20 | -31.59 | -661.46 | 0.40 | 8.47 | -47 | -992 | 1 | 13 |
| 188 | 10.00 | -10.89 | 0.14 | -10.89 | -42.48 | -1031.83 | 0.54 | 13.21 | -64 | -1548 | 1 | 20 |
| 178 | 10.00 | -12.34 | 0.16 | -12.34 | -54.82 | -1518.34 | 0.70 | 19.44 | -82 | -2278 | 1 | 29 |
| 163.65 | 14.35 | -14.19 | 0.18 | -14.19 | -69.00 | -2406.77 | 0.88 | 30.82 | -104 | -3610 | 1 | 46 |
| 159 | 4.33 | -14.64 | 0.19 | -14.64 | -83.65 | -2736.88 | 1.07 | 35.05 | -125 | -4105 | 2 | 53 |
| 155.00 | 4.32 | -15.25 | 0.20 | -15.25 | -98.90 | -3131.63 | 1.27 | 40.11 | -148 | -4697 | 2 | 60 |
| 138 | 17.00 | -16.01 | 0.21 | -16.01 | -114.90 | -4948.93 | 1.47 | 63.38 | -172 | -7423 | 2 | 95 |
| 128 | 10.00 | -16.26 | 0.21 | -16.26 | -131.17 | -6179.29 | 1.68 | 79.14 | -197 | -9269 | 3 | 119 |
| 118 | 10.00 | -16.72 | 0.21 | -16.72 | -147.89 | -7574.56 | 1.89 | 97.00 | -222 | -11362 | 3 | 146 |
| 108 | 10.00 | -16.95 | 0.22 | -16.95 | -164.83 | -9138.16 | 2.11 | 117.03 | -247 | -13707 | 3 | 176 |
| 98 | 10.00 | -17.23 | 0.22 | -17.23 | -182.06 | -10872.61 | 2.33 | 139.24 | -273 | -16309 | 3 | 209 |
| 88 | 10.00 | -17.91 | 0.23 | -17.91 | -199.97 | -12782.74 | 2.56 | 163.70 | -300 | -19174 | 4 | 246 |
| 80.00 | 8.00 | -18.29 | 0.23 | -18.29 | -218.26 | -14455.63 | 2.80 | 185.13 | -327 | -21683 | 4 | 278 |
| 68 | 12.00 | -18.97 | 0.24 | -18.97 | -237.23 | -17188.55 | 3.04 | 220.13 | -356 | -25783 | 5 | 330 |
| 58 | 10.00 | -19.46 | 0.25 | -19.45 | -256.68 | -19658.11 | 3.29 | 251.75 | -385 | -29487 | 5 | 378 |
| 48 | 10.00 | -20.22 | 0.26 | -20.21 | -276.90 | -22326.03 | 3.55 | 285.92 | -415 | -33489 | 5 | 429 |
| 22 | 26.00 | -21.66 | 0.28 | -21.66 | -298.56 | -29806.94 | 3.82 | 381.72 | -448 | -44710 | 6 | 573 |
| 19 | 3.00 | -10.91 | 0.14 | -10.91 | -309.46 | -30718.97 | 3.96 | 393.40 | -464 | -46078 | 6 | 590 |
| 0 | 19.00 | -7.27 | 0.09 | -7.27 | -316.74 | -36667.88 | 4.06 | 469.59 | -475 | -55002 | 6 | 704 |
| | $\Sigma =$ | 125 | lb | | | | | | | | | |
| | | at 1 g | | | Centre of gravity is | 116 | in from aircraft centreline | | | | | |
| | | | | | | 45 | % semispan | | | | | |

COMBINED ULTIMATE LOADS ( AERODYNAMIC + INERTIAL )

CONDITION. D cont..

| 1 | 44 D | 45 D | 46 D | 47 D | 48 D | 49 D |
|---|---|---|---|---|---|---|
| | ULT | ULT | ULT | ULT | ULT | ULT |
| | NORMAL | NORMAL | CHORD | CHORD | RESOLVED | RESOLVED |
| STATION | SHEAR | BEND MOMENT | SHEAR | BEND MOMENT | SHEAR | BEND MOMENT |
| (in) | COND. D | COND. D | COND. D | COND. D | COND. D | COND. D |
| | (lb) | (lb in) | (lb) | (lb in) | (lb) | (lb in) |
| 258 | 0 | 0 | 0 | 0 | 0 | 0 |
| 251.25 | 43 | 144 | 4 | 14 | 43 | 145 |
| 238 | 154 | 1449 | 12 | 121 | 155 | 1454 |
| 228 | 244 | 3438 | 18 | 273 | 244 | 3449 |
| 218 | 335 | 6333 | 24 | 486 | 336 | 6352 |
| 208 | 430 | 10160 | 30 | 757 | 431 | 10188 |
| 198 | 526 | 14941 | 34 | 1078 | 527 | 14980 |
| 188 | 624 | 20692 | 39 | 1446 | 625 | 20743 |
| 178 | 723 | 27425 | 44 | 1862 | 724 | 27488 |
| 163.65 | 875 | 38885 | 51 | 2542 | 876 | 38968 |
| 159 | 902 | 42728 | 53 | 2767 | 904 | 42817 |
| 155.00 | 925 | 46680 | 55 | 3000 | 927 | 46776 |
| 138 | 1087 | 63781 | 63 | 4002 | 1088 | 63907 |
| 128 | 1174 | 75083 | 67 | 4652 | 1176 | 75227 |
| 118 | 1262 | 87264 | 72 | 5348 | 1264 | 87428 |
| 108 | 1352 | 100338 | 77 | 6091 | 1354 | 100523 |
| 98 | 1443 | 114317 | 81 | 6880 | 1446 | 114523 |
| 88 | 1535 | 129208 | 86 | 7717 | 1537 | 129438 |
| 80.00 | 1603 | 141760 | 90 | 8420 | 1606 | 142010 |
| 68 | 1720 | 161696 | 96 | 9533 | 1722 | 161977 |
| 58 | 1812 | 179357 | 100 | 10512 | 1815 | 179664 |
| 48 | 1905 | 197944 | 105 | 11540 | 1908 | 198280 |
| 22 | 2196 | 251258 | 117 | 14434 | 2199 | 251672 |
| 19 | 2217 | 257877 | 119 | 14788 | 2220 | 258301 |
| 0 | 2446 | 302176 | 128 | 17133 | 2449 | 302661 |

| AERODYNAMIC TORQUE AT SHEAR CENTRE | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| CONDITION. D | | | | | | | | | | |
| | | | | | | | | | | |
| 1 | 50 | 74 | 51 | 52 | 53 | 54 | 55 | 56 | 57 | 58 |
| STATION | CLEAN + FLAPPED | LEAN + FLAPPE | LOCAL | AERO | X AC | X SC | DELTA X | Z AC | Z SC | DELTA Z |
| | LOCAL | LOCAL | $X_{CP}$ | CENTRE | (in) | (in) | (in) | (in) | (in) | (in) |
| (in) | $C_L$ | $C_{Mo}$ | | (in) | | using 38% chord | | | | |
| 258 | - | -0.025 | - | 0.00 | 0.00 | 13.30 | 13.30 | 0.00 | 2.39 | -2.39 |
| 251.25 | 0.25 | -0.088 | 0.70 | 24.63 | 24.63 | 13.37 | -11.26 | 0.00 | 2.40 | -2.40 |
| 238 | 0.33 | -0.088 | 0.70 | 24.87 | 24.87 | 13.50 | -11.37 | 0.00 | 2.44 | -2.44 |
| 228 | 0.36 | -0.088 | 0.70 | 25.06 | 25.06 | 13.60 | -11.46 | 0.00 | 2.47 | -2.47 |
| 218 | 0.38 | -0.088 | 0.70 | 25.25 | 25.25 | 13.71 | -11.54 | 0.00 | 2.49 | -2.49 |
| 208 | 0.39 | -0.088 | 0.70 | 25.44 | 25.44 | 13.81 | -11.63 | 0.00 | 2.52 | -2.52 |
| 198 | 0.41 | -0.088 | 0.70 | 25.62 | 25.62 | 13.91 | -11.71 | 0.00 | 2.54 | -2.54 |
| 188 | 0.42 | -0.088 | 0.70 | 25.81 | 25.81 | 14.01 | -11.80 | 0.00 | 2.57 | -2.57 |
| 178 | 0.43 | -0.088 | 0.70 | 26.00 | 26.00 | 14.11 | -11.88 | 0.00 | 2.60 | -2.60 |
| 163.65 | 0.44 | -0.088 | 0.70 | 26.27 | 26.27 | 14.26 | -12.01 | 0.00 | 2.64 | -2.64 |
| 159 | 0.41 | -0.025 | 0.30 | 11.33 | 11.33 | 14.30 | 2.97 | 0.00 | 2.65 | -2.65 |
| 155.00 | 0.38 | -0.025 | 0.31 | 11.54 | 11.54 | 14.35 | 2.80 | 0.00 | 2.66 | -2.66 |
| 138 | 0.39 | -0.025 | 0.30 | 11.65 | 11.65 | 14.52 | 2.87 | 0.00 | 2.70 | -2.70 |
| 128 | 0.39 | -0.025 | 0.30 | 11.69 | 11.69 | 14.62 | 2.93 | 0.00 | 2.73 | -2.73 |
| 118 | 0.40 | -0.025 | 0.30 | 11.74 | 11.74 | 14.72 | 2.98 | 0.00 | 2.76 | -2.76 |
| 108 | 0.40 | -0.025 | 0.30 | 11.81 | 11.81 | 14.82 | 3.02 | 0.00 | 2.78 | -2.78 |
| 98 | 0.40 | -0.025 | 0.30 | 11.87 | 11.87 | 14.93 | 3.06 | 0.00 | 2.81 | -2.81 |
| 88 | 0.40 | -0.025 | 0.30 | 11.94 | 11.94 | 15.03 | 3.09 | 0.00 | 2.84 | -2.84 |
| 80.00 | 0.41 | -0.025 | 0.30 | 11.99 | 11.99 | 15.11 | 3.12 | 0.00 | 2.86 | -2.86 |
| 68 | 0.41 | -0.025 | 0.30 | 12.08 | 12.08 | 15.23 | 3.15 | 0.00 | 2.89 | -2.89 |
| 58 | 0.41 | -0.025 | 0.30 | 12.15 | 12.15 | 15.33 | 3.18 | 0.00 | 2.92 | -2.92 |
| 48 | 0.41 | -0.025 | 0.30 | 12.23 | 12.23 | 15.43 | 3.20 | 0.00 | 2.94 | -2.94 |
| 22 | 0.41 | -0.025 | 0.30 | 12.44 | 12.44 | 15.70 | 3.26 | 0.00 | 3.01 | -3.01 |
| 19 | 0.41 | -0.025 | 0.30 | 12.47 | 12.47 | 15.73 | 3.26 | 0.00 | 3.01 | -3.01 |
| 0 | 0.41 | -0.025 | 0.30 | 12.63 | 12.63 | 15.92 | 3.29 | 0.00 | 1.25 | -1.25 |

| AERODYNAMIC TORQUE AT SHEAR CENTRE | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| CONDITION. D | | | | | | | | | | | |
| | | | | | | $\Delta C_{Mo}$ | | | | | |
| | | | | | | 0 | | | | | |
| 1 | 55 | 56 | 23 | 24 | 59 | 75 | 60 | 61 | 62 | 63 | 64 |
| STATION | DELTA | DELTA | SPAN | SPAN | ELEMENT | ELEMENT | ELEMENT | ELEMENT | ELEMENT | TOTAL | TOTAL |
| | X av | Z av | ELEMENT | ELEMENT | TORQUE | TORQUE | TORQUE | TORQUE | LIMIT | LIMIT | ULT |
| (in) | (in) | (in) | LIFT | DRAG | DUE TO | DUE TO | DUE TO | DUE TO | TORQUE | TORQUE | TORQUE |
| | | | (lb) | (lb) | $C_{Mo}$ | $\Delta C_{Mo}$ | LIFT | DRAG | (lb in) | (lb in) | (lb in) |
| | | | | | (lb in) | (lb in) | (lb in) | (lb in) | | | |
| 258 | - | - | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 251.25 | 1.02 | 0.00 | 29.43 | 2.71 | -102.93 | -260.75 | 30.06 | 0.00 | -333.62 | -333.62 | -500.43 |
| 238 | -11.31 | 0.00 | 77.09 | 5.34 | -205.13 | -519.67 | -872.24 | 0.00 | -1597.04 | -1930.66 | -2895.99 |
| 228 | -11.41 | 0.00 | 63.99 | 4.00 | -157.55 | -399.13 | -730.43 | 0.00 | -1287.12 | -3217.78 | -4826.67 |
| 218 | -11.50 | 0.00 | 67.68 | 3.99 | -159.92 | -405.14 | -778.25 | 0.00 | -1343.31 | -4561.09 | -6841.64 |
| 208 | -11.59 | 0.00 | 70.79 | 3.51 | -162.31 | -411.19 | -820.07 | 0.00 | -1393.57 | -5954.66 | -8931.99 |
| 198 | -11.67 | 0.00 | 73.51 | 3.03 | -164.72 | -417.29 | -857.87 | 0.00 | -1439.88 | -7394.54 | -11091.81 |
| 188 | -11.76 | 0.00 | 75.94 | 3.03 | -167.14 | -423.43 | -892.74 | 0.00 | -1483.32 | -8877.86 | -13316.79 |
| 178 | -11.84 | 0.00 | 78.13 | 3.03 | -169.59 | -429.62 | -925.26 | 0.00 | -1524.46 | -10402.32 | -15603.48 |
| 163.65 | -11.95 | 0.00 | 115.55 | 4.35 | -247.66 | -627.40 | -1380.40 | 0.00 | -2255.46 | -12657.78 | -18986.67 |
| 159 | -4.52 | 0.00 | 33.00 | 1.27 | -75.64 | 0.00 | -149.04 | 0.00 | -224.69 | -12882.47 | -19323.70 |
| 155.00 | 2.89 | 0.00 | 30.72 | 1.23 | -76.11 | 0.00 | 88.74 | 0.00 | 12.63 | -12869.83 | -19304.75 |
| 138 | 2.84 | 0.00 | 123.43 | 4.85 | -303.71 | 0.00 | 350.42 | 0.00 | 46.71 | -12823.13 | -19234.69 |
| 128 | 2.90 | 0.00 | 74.49 | 2.86 | -182.06 | 0.00 | 216.33 | 0.00 | 34.27 | -12788.86 | -19183.29 |
| 118 | 2.96 | 0.00 | 75.74 | 2.88 | -184.61 | 0.00 | 223.91 | 0.00 | 39.30 | -12749.56 | -19124.34 |
| 108 | 3.00 | 0.00 | 76.89 | 2.89 | -187.18 | 0.00 | 230.56 | 0.00 | 43.38 | -12706.18 | -19059.27 |
| 98 | 3.04 | 0.00 | 77.94 | 2.90 | -189.76 | 0.00 | 236.76 | 0.00 | 47.00 | -12659.19 | -18988.78 |
| 88 | 3.07 | 0.00 | 78.91 | 2.91 | -192.37 | 0.00 | 242.52 | 0.00 | 50.16 | -12609.03 | -18913.54 |
| 80.00 | 3.10 | 0.00 | 63.77 | 2.34 | -155.78 | 0.00 | 197.94 | 0.00 | 42.16 | -12566.87 | -18850.30 |
| 68 | 3.13 | 0.00 | 96.62 | 3.53 | -236.83 | 0.00 | 302.80 | 0.00 | 65.97 | -12500.90 | -18751.34 |
| 58 | 3.16 | 0.00 | 81.33 | 2.96 | -200.28 | 0.00 | 257.34 | 0.00 | 57.07 | -12443.83 | -18665.74 |
| 48 | 3.19 | 0.00 | 81.98 | 2.98 | -202.95 | 0.00 | 261.55 | 0.00 | 58.60 | -12385.23 | -18577.84 |
| 22 | 3.23 | 0.00 | 215.61 | 7.85 | -540.29 | 0.00 | 696.32 | 0.00 | 156.03 | -12229.20 | -18343.80 |
| 19 | 3.26 | 0.00 | 25.09 | 0.91 | -63.53 | 0.00 | 81.74 | 0.00 | 18.21 | -12210.98 | -18316.48 |
| 0 | 3.28 | 0.00 | 159.57 | 5.84 | -408.09 | 0.00 | 522.82 | 0.00 | 114.73 | -12096.25 | -18144.38 |

| DEAD WEIGHT ANALYSIS FOR WING TORQUE | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| CONDITION. D | | | | | | | | |
| | | | | | | | | |
| 1 | 65 | 54 | 66 | 67 | 33 | 68 | 69 | 70 |
| STATION | X CG | X SC | DELTA | DELTA | ELEMENT | ELEMENT | TOTAL | TOTAL |
| | (in) | (in) | X | X av | LOAD | LIMIT | LIMIT | ULT |
| (in) | | | (in) | (in) | (lb) | TORQUE | TORQUE | TORQUE |
| | using 40% chord | | | | | (lb in) | (lb in) | (lb in) |
| 258 | 14.00 | 13.30 | -0.70 | - | - | - | - | 0.00 |
| 251.25 | 14.07 | 13.37 | -0.70 | -0.70 | -0.99 | 0.69 | 0.69 | 1.04 |
| 238 | 14.21 | 13.50 | -0.71 | -0.71 | -2.63 | 1.86 | 2.56 | 3.84 |
| 228 | 14.32 | 13.60 | -0.72 | -0.71 | -4.56 | 3.25 | 5.81 | 8.72 |
| 218 | 14.43 | 13.71 | -0.72 | -0.72 | -6.38 | 4.59 | 10.40 | 15.60 |
| 208 | 14.53 | 13.81 | -0.73 | -0.72 | -7.83 | 5.67 | 16.07 | 24.10 |
| 198 | 14.64 | 13.91 | -0.73 | -0.73 | -9.20 | 6.71 | 22.78 | 34.16 |
| 188 | 14.75 | 14.01 | -0.74 | -0.73 | -10.89 | 8.00 | 30.78 | 46.17 |
| 178 | 14.86 | 14.11 | -0.74 | -0.74 | -12.34 | 9.13 | 39.91 | 59.87 |
| 163.65 | 15.01 | 14.26 | -0.75 | -0.75 | -14.19 | 10.59 | 50.50 | 75.75 |
| 159 | 15.06 | 14.30 | -0.75 | -0.75 | -14.64 | 11.01 | 61.51 | 92.26 |
| 155.00 | 15.10 | 14.35 | -0.76 | -0.75 | -15.25 | 11.50 | 73.01 | 109.51 |
| 138 | 15.28 | 14.52 | -0.76 | -0.76 | -16.01 | 12.16 | 85.17 | 127.75 |
| 128 | 15.39 | 14.62 | -0.77 | -0.77 | -16.26 | 12.47 | 97.64 | 146.46 |
| 118 | 15.50 | 14.72 | -0.77 | -0.77 | -16.72 | 12.91 | 110.55 | 165.83 |
| 108 | 15.60 | 14.82 | -0.78 | -0.78 | -16.95 | 13.18 | 123.73 | 185.60 |
| 98 | 15.71 | 14.93 | -0.79 | -0.78 | -17.23 | 13.49 | 137.22 | 205.83 |
| 88 | 15.82 | 15.03 | -0.79 | -0.79 | -17.91 | 14.12 | 151.34 | 227.00 |
| 80.00 | 15.90 | 15.11 | -0.80 | -0.79 | -18.29 | 14.51 | 165.84 | 248.76 |
| 68 | 16.03 | 15.23 | -0.80 | -0.80 | -18.97 | 15.15 | 180.99 | 271.49 |
| 58 | 16.14 | 15.33 | -0.81 | -0.80 | -19.46 | 15.65 | 196.64 | 294.96 |
| 48 | 16.25 | 15.43 | -0.81 | -0.81 | -20.22 | 16.37 | 213.01 | 319.51 |
| 22 | 16.52 | 15.70 | -0.83 | -0.82 | -21.66 | 17.75 | 230.75 | 346.13 |
| 19 | 16.56 | 15.73 | -0.83 | -0.83 | -10.91 | 9.02 | 239.77 | 359.66 |
| 0 | 16.76 | 15.92 | -0.84 | -0.83 | -7.27 | 6.06 | 245.83 | 368.75 |

| COMBINED ULTIMATE TORSION ( AERODYNAMIC + INERTIAL ) | | | |
|---|---|---|---|
| CONDITION. D | | | |
| | | | |
| 1 | 71 D | | |
| STATION | COND. D | | |
| (in) | (lb in) | | |
| 258 | 0 | | |
| 251.25 | -499 | | |
| 238 | -2892 | | |
| 228 | -4818 | | |
| 218 | -6826 | | |
| 208 | -8908 | | |
| 198 | -11058 | | |
| 188 | -13271 | | |
| 178 | -15544 | | |
| 163.65 | -18911 | | |
| 159 | -19231 | | |
| 155.00 | -19195 | | |
| 138 | -19107 | | |
| 128 | -19037 | | |
| 118 | -18959 | | |
| 108 | -18874 | | |
| 98 | -18783 | | |
| 88 | -18687 | | |
| 80.00 | -18602 | | |
| 68 | -18480 | | |
| 58 | -18371 | | |
| 48 | -18258 | | |
| 22 | -17998 | | |
| 19 | -17957 | | |
| 0 | -17776 | | |

| SPANWISE AERODYNAMIC LOAD DISTRIBUTION | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CONDITION. E 2/3 n | | | | | | | | | Aileron deflection = | UP | | | | |
| AILERON UP | | | | | | | | | Aileron angle = | -8.67 | deg | ECF = | 0.24 | |
| | | | | | | | | | Aileron load = | 62.54 | lb | | | |
| $V_{sel}$ = | 244.93 | ft/s | $C_L$ = | -0.2 | | alpha wrp = | -5.1794 | | $\Delta C_L$ = | -0.19 | | | | |
| Lift = | -1822.10 | lb clean | $C_{Do}$ = | 0.017 | | sin alpha = | -0.0903 | | $\Delta C_D$ = | 0.01 | | | | |
| q = | 71.33 | psf | $C_D$ = | 0.018 | | cos alpha = | 0.9959 | | $\Delta C_{Mo}$ = | 0.09 | | | | |
| n = | -1.27 | g | $C_{Mo}$ = | -0.025 | | | | | S = | 4.71 | ft² | | | |
| $q.C_L$ = | -13.50 | $q.C_L$ =Lift/S | S = | 135.00 | ft² | | | | b = | 7.30 | ft | | | |
| | | | b = | 43.00 | ft | | | | AR = | 11.31 | | | | |
| 1 | 13 | 72 | 14 | 15 | 16 | 73 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 |
| STATION | $C_L$ | FLAP | $C_{Lx}$ | $C_{Lz}$ | $C_D$ | FLAP | $C_{Dx}$ | $C_{Dz}$ | $C_{Lz}+C_{Dx}$ | $C_{Dz}-C_{Lx}$ | $(C_{Lz}+C_{Dx})_{AV}$ | $(C_{Dz}-C_{Lx})_{AV}$ | SPAN | SPAN |
| (in) | | $C_L$ | | | | $C_D$ | | | | | | | ELEMENT | ELEMENT |
| | | | | | | | | | | | | | LIFT | DRAG |
| | | | | | | | | | | | | | (lb) | (lb) |
| 258 | -0.0946 | 0.0000 | 0.0085 | -0.0942 | 0.0216 | 0.0000 | 0.0216 | -0.0020 | -0.0962 | 0.0130 | - | - | 0.00 | 0.00 |
| 251.25 | -0.1239 | -0.0450 | 0.0153 | -0.1683 | 0.0216 | 0.0017 | 0.0233 | -0.0021 | -0.1704 | 0.0080 | -0.1333 | 0.0105 | -15.64 | 1.24 |
| 238 | -0.1439 | -0.0450 | 0.0171 | -0.1882 | 0.0216 | 0.0017 | 0.0233 | -0.0021 | -0.1903 | 0.0062 | -0.1803 | 0.0071 | -41.85 | 1.66 |
| 228 | -0.1539 | -0.0450 | 0.0180 | -0.1982 | 0.0216 | 0.0017 | 0.0233 | -0.0021 | -0.2003 | 0.0053 | -0.1953 | 0.0058 | -34.50 | 1.02 |
| 218 | -0.1619 | -0.0450 | 0.0187 | -0.2061 | 0.0216 | 0.0017 | 0.0233 | -0.0021 | -0.2082 | 0.0046 | -0.2042 | 0.0050 | -36.36 | 0.89 |
| 208 | -0.1685 | -0.0450 | 0.0193 | -0.2127 | 0.0171 | 0.0017 | 0.0188 | -0.0017 | -0.2144 | -0.0005 | -0.2113 | 0.0021 | -37.89 | 0.37 |
| 198 | -0.1741 | -0.0450 | 0.0198 | -0.2182 | 0.0171 | 0.0017 | 0.0188 | -0.0017 | -0.2200 | -0.0010 | -0.2172 | -0.0007 | -39.23 | -0.13 |
| 188 | -0.1789 | -0.0450 | 0.0202 | -0.2230 | 0.0171 | 0.0017 | 0.0188 | -0.0017 | -0.2247 | -0.0014 | -0.2223 | -0.0012 | -40.46 | -0.22 |
| 178 | -0.1831 | -0.0450 | 0.0206 | -0.2272 | 0.0171 | 0.0017 | 0.0188 | -0.0017 | -0.2289 | -0.0018 | -0.2268 | -0.0016 | -41.58 | -0.29 |
| 163.65 | -0.1881 | -0.0450 | 0.0210 | -0.2322 | 0.0171 | 0.0017 | 0.0188 | -0.0017 | -0.2339 | -0.0022 | -0.2314 | -0.0020 | -61.40 | -0.53 |
| 159 | -0.1894 | 0.0000 | 0.0171 | -0.1887 | 0.0171 | 0.0000 | 0.0171 | -0.0015 | -0.1902 | 0.0000 | -0.2121 | -0.0011 | -17.07 | -0.09 |
| 155.00 | -0.1907 | 0.0000 | 0.0172 | -0.1899 | 0.0171 | 0.0000 | 0.0171 | -0.0015 | -0.1915 | -0.0001 | -0.1908 | -0.0001 | -15.41 | -0.01 |
| 138 | -0.1950 | 0.0000 | 0.0176 | -0.1942 | 0.0171 | 0.0000 | 0.0171 | -0.0015 | -0.1957 | -0.0005 | -0.1936 | -0.0003 | -61.92 | -0.11 |
| 128 | -0.1970 | 0.0000 | 0.0178 | -0.1962 | 0.0171 | 0.0000 | 0.0171 | -0.0015 | -0.1978 | -0.0007 | -0.1967 | -0.0006 | -37.37 | -0.12 |
| 118 | -0.1988 | 0.0000 | 0.0179 | -0.1980 | 0.0171 | 0.0000 | 0.0171 | -0.0015 | -0.1995 | -0.0009 | -0.1986 | -0.0008 | -37.99 | -0.15 |
| 108 | -0.2003 | 0.0000 | 0.0181 | -0.1994 | 0.0171 | 0.0000 | 0.0171 | -0.0015 | -0.2010 | -0.0010 | -0.2002 | -0.0009 | -38.56 | -0.18 |
| 98 | -0.2015 | 0.0000 | 0.0182 | -0.2007 | 0.0171 | 0.0000 | 0.0171 | -0.0015 | -0.2022 | -0.0011 | -0.2016 | -0.0011 | -39.09 | -0.21 |
| 88 | -0.2025 | 0.0000 | 0.0183 | -0.2017 | 0.0171 | 0.0000 | 0.0171 | -0.0015 | -0.2032 | -0.0012 | -0.2027 | -0.0012 | -39.58 | -0.23 |
| 80.00 | -0.2031 | 0.0000 | 0.0183 | -0.2023 | 0.0171 | 0.0000 | 0.0171 | -0.0015 | -0.2038 | -0.0013 | -0.2035 | -0.0012 | -31.98 | -0.19 |
| 68 | -0.2038 | 0.0000 | 0.0184 | -0.2030 | 0.0171 | 0.0000 | 0.0171 | -0.0015 | -0.2045 | -0.0013 | -0.2042 | -0.0013 | -48.45 | -0.31 |
| 58 | -0.2042 | 0.0000 | 0.0184 | -0.2034 | 0.0171 | 0.0000 | 0.0171 | -0.0015 | -0.2049 | -0.0014 | -0.2047 | -0.0013 | -40.78 | -0.27 |
| 48 | -0.2044 | 0.0000 | 0.0185 | -0.2036 | 0.0171 | 0.0000 | 0.0171 | -0.0015 | -0.2051 | -0.0014 | -0.2050 | -0.0014 | -41.11 | -0.28 |
| 22 | -0.2041 | 0.0000 | 0.0184 | -0.2032 | 0.0171 | 0.0000 | 0.0171 | -0.0015 | -0.2048 | -0.0014 | -0.2049 | -0.0014 | -108.12 | -0.72 |
| 19 | -0.2040 | 0.0000 | 0.0184 | -0.2031 | 0.0171 | 0.0000 | 0.0171 | -0.0015 | -0.2047 | -0.0013 | -0.2047 | -0.0013 | -12.58 | -0.08 |
| 0 | -0.2029 | 0.0000 | 0.0183 | -0.2021 | 0.0171 | 0.0000 | 0.0171 | -0.0015 | -0.2036 | -0.0013 | -0.2042 | -0.0013 | -80.02 | -0.51 |
| | | | | | | | | | | | | Σ = | -998.97 | 0.54 |
| | | | | | | | | | | | | LIFT calc = | -1997.94 | |
| | | | | | | | | | | | | Lift = | -1822.10 | |

SPANWISE AERODYNAMIC LOAD DISTRIBUTION

CONDITION. E cont..

| 1 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 |
|---|---|---|---|---|---|---|---|---|
| STATION | LIMIT | LIMIT | LIMIT | LIMIT | ULT | ULT | ULT | ULT |
| (in) | NORMAL | NORMAL | CHORD | CHORD | NORMAL | NORMAL | CHORD | CHORD |
| | SHEAR | MOMENT | SHEAR | MOMENT | SHEAR | MOMENT | SHEAR | MOMENT |
| | (lb) | (lb in) | (lb) | (lb in) | (lb) | (lb in) | (lb) | (lb in) |
| 258 | 0.00 | 0.00 | 0.00 | 0.00 | 0 | 0 | 0 | 0 |
| 251.25 | -15.64 | -52.78 | 1.24 | 4.17 | -23 | -79 | 2 | 6 |
| 238 | -57.49 | -537.25 | 2.89 | 31.53 | -86 | -806 | 4 | 47 |
| 228 | -91.99 | -1284.68 | 3.92 | 65.58 | -138 | -1927 | 6 | 98 |
| 218 | -128.35 | -2386.42 | 4.80 | 109.17 | -193 | -3580 | 7 | 164 |
| 208 | -166.25 | -3859.41 | 5.17 | 159.06 | -249 | -5789 | 8 | 239 |
| 198 | -205.48 | -5718.03 | 5.04 | 210.15 | -308 | -8577 | 8 | 315 |
| 188 | -245.94 | -7975.13 | 4.83 | 259.50 | -369 | -11963 | 7 | 389 |
| 178 | -287.52 | -10642.42 | 4.53 | 306.31 | -431 | -15964 | 7 | 459 |
| 163.65 | -348.92 | -15208.88 | 4.00 | 367.54 | -523 | -22813 | 6 | 551 |
| 159 | -366.00 | -16754.89 | 3.91 | 384.64 | -549 | -25132 | 6 | 577 |
| 155.00 | -381.41 | -18371.15 | 3.90 | 401.53 | -572 | -27557 | 6 | 602 |
| 138 | -443.33 | -25381.42 | 3.79 | 466.93 | -665 | -38072 | 6 | 700 |
| 128 | -480.70 | -30001.54 | 3.67 | 504.27 | -721 | -45002 | 6 | 756 |
| 118 | -518.69 | -34998.45 | 3.52 | 540.25 | -778 | -52498 | 5 | 810 |
| 108 | -557.25 | -40378.13 | 3.34 | 574.56 | -836 | -60567 | 5 | 862 |
| 98 | -596.34 | -46146.09 | 3.13 | 606.92 | -895 | -69219 | 5 | 910 |
| 88 | -635.92 | -52307.38 | 2.91 | 637.12 | -954 | -78461 | 4 | 956 |
| 80.00 | -667.90 | -57522.64 | 2.71 | 659.59 | -1002 | -86284 | 4 | 989 |
| 68 | -716.35 | -65828.15 | 2.40 | 690.27 | -1075 | -98742 | 4 | 1035 |
| 58 | -757.14 | -73195.61 | 2.13 | 712.95 | -1136 | -109793 | 3 | 1069 |
| 48 | -798.25 | -80972.54 | 1.86 | 732.91 | -1197 | -121459 | 3 | 1099 |
| 22 | -906.37 | -103132.61 | 1.14 | 771.83 | -1360 | -154699 | 2 | 1158 |
| 19 | -918.95 | -105870.59 | 1.05 | 775.11 | -1378 | -158806 | 2 | 1163 |
| 0 | -998.97 | -124090.87 | 0.54 | 790.29 | -1498 | -186136 | 1 | 1185 |
| | | | | | | | | |
| Centre of lift is | 124 | in from aircraft centreline | | | | | | |
| | 48 | % semispan | | | | | | |

SPANWISE INERTIAL LOAD DISTRIBUTION

CONDITION. E cont.

| 1 | 3 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 | 41 | 42 | 43 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| STATION | dy | WEIGHT | ELEMENT | ELEMENT | LIMIT | LIMIT | LIMIT | LIMIT | ULT | ULT | ULT | ULT |
| (in) | (in) | nW | SHEAR | SHEAR | NORMAL | NORMAL | CHORD | CHORD | NORMAL | NORMAL | CHORD | CHORD |
| | | (lb) | FORCE | FORCE | SHEAR | MOMENT | SHEAR | MOMENT | SHEAR | MOMENT | SHEAR | MOMENT |
| | | | $V_x$ | $V_z$ | (lb) | (lb in) | (lb) | (lb in) | (lb) | (lb in) | (lb) | (lb in) |
| | | | (lb) | (lb) | | | | | | | | |
| 258 | - | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0 | 0 | 0 | 0 |
| 251.25 | 6.75 | 0.50 | 0.04 | 0.49 | 0.49 | 1.66 | 0.04 | 0.15 | 1 | 2 | 0 | 0 |
| 238 | 13.25 | 1.32 | 0.12 | 1.31 | 1.81 | 16.89 | 0.16 | 1.53 | 3 | 25 | 0 | 2 |
| 228 | 10.00 | 2.28 | 0.21 | 2.27 | 4.08 | 46.29 | 0.37 | 4.20 | 6 | 69 | 1 | 6 |
| 218 | 10.00 | 3.19 | 0.29 | 3.18 | 7.25 | 102.95 | 0.66 | 9.33 | 11 | 154 | 1 | 14 |
| 208 | 10.00 | 3.91 | 0.35 | 3.90 | 11.15 | 194.98 | 1.01 | 17.67 | 17 | 292 | 2 | 27 |
| 198 | 10.00 | 4.60 | 0.42 | 4.58 | 15.73 | 329.41 | 1.43 | 29.86 | 24 | 494 | 2 | 45 |
| 188 | 10.00 | 5.45 | 0.49 | 5.42 | 21.16 | 513.85 | 1.92 | 46.58 | 32 | 771 | 3 | 70 |
| 178 | 10.00 | 6.17 | 0.56 | 6.14 | 27.30 | 756.13 | 2.47 | 68.54 | 41 | 1134 | 4 | 103 |
| 163.65 | 14.35 | 7.09 | 0.64 | 7.06 | 34.36 | 1198.57 | 3.11 | 108.64 | 52 | 1798 | 5 | 163 |
| 159 | 4.33 | 7.32 | 0.66 | 7.29 | 41.66 | 1362.97 | 3.78 | 123.54 | 62 | 2044 | 6 | 185 |
| 155.00 | 4.32 | 7.63 | 0.69 | 7.59 | 49.25 | 1559.55 | 4.46 | 141.36 | 74 | 2339 | 7 | 212 |
| 138 | 17.00 | 8.01 | 0.72 | 7.97 | 57.22 | 2464.56 | 5.19 | 223.40 | 86 | 3697 | 8 | 335 |
| 128 | 10.00 | 8.13 | 0.73 | 8.10 | 65.32 | 3077.28 | 5.92 | 278.94 | 98 | 4616 | 9 | 418 |
| 118 | 10.00 | 8.36 | 0.75 | 8.33 | 73.65 | 3772.13 | 6.68 | 341.92 | 110 | 5658 | 10 | 513 |
| 108 | 10.00 | 8.47 | 0.76 | 8.44 | 82.09 | 4550.80 | 7.44 | 412.50 | 123 | 6826 | 11 | 619 |
| 98 | 10.00 | 8.61 | 0.78 | 8.58 | 90.66 | 5414.55 | 8.22 | 490.80 | 136 | 8122 | 12 | 736 |
| 88 | 10.00 | 8.96 | 0.81 | 8.92 | 99.58 | 6365.79 | 9.03 | 577.02 | 149 | 9549 | 14 | 866 |
| 80.00 | 8.00 | 9.15 | 0.83 | 9.11 | 108.69 | 7198.90 | 9.85 | 652.54 | 163 | 10798 | 15 | 979 |
| 68 | 12.00 | 9.49 | 0.86 | 9.45 | 118.14 | 8559.89 | 10.71 | 775.90 | 177 | 12840 | 16 | 1164 |
| 58 | 10.00 | 9.73 | 0.88 | 9.69 | 127.83 | 9789.73 | 11.59 | 887.38 | 192 | 14685 | 17 | 1331 |
| 48 | 10.00 | 10.11 | 0.91 | 10.07 | 137.90 | 11118.35 | 12.50 | 1007.81 | 207 | 16678 | 19 | 1512 |
| 22 | 26.00 | 10.83 | 0.98 | 10.79 | 148.68 | 14843.83 | 13.48 | 1345.50 | 223 | 22266 | 20 | 2018 |
| 19 | 3.00 | 5.45 | 0.49 | 5.43 | 154.11 | 15298.03 | 13.97 | 1386.67 | 231 | 22947 | 21 | 2080 |
| 0 | 19.00 | 3.64 | 0.33 | 3.62 | 157.73 | 18260.58 | 14.30 | 1655.21 | 237 | 27391 | 21 | 2483 |
| | Σ = | 125 | lb | | | | | | | | | |
| | | at 1 g | | | Centre of gravity is | 116 | in from aircraft centreline | | | | | |
| | | | | | | 45 | % semispan | | | | | |

| COMBINED ULTIMATE LOADS ( AERODYNAMIC + INERTIAL ) | | | | | | |
|---|---|---|---|---|---|---|
| CONDITION. E cont.. | | | | | | |
| 1 | 44 E | 45 E | 46 E | 47 E | 48 E | 49 E |
| | ULT | ULT | ULT | ULT | ULT | ULT |
| | NORMAL | NORMAL | CHORD | CHORD | RESOLVED | RESOLVED |
| STATION | SHEAR | BEND MOMENT | SHEAR | BEND MOMENT | SHEAR | BEND MOMENT |
| (in) | COND. E | COND. E | COND. E | COND. E | COND. E | COND. E |
| | (lb) | (lb in) | (lb) | (lb in) | (lb) | (lb in) |
| 258 | 0 | 0 | 0 | 0 | 0 | 0 |
| 251.25 | -23 | -77 | 2 | 6 | 23 | 77 |
| 238 | -84 | -781 | 5 | 50 | 84 | 782 |
| 228 | -132 | -1858 | 6 | 105 | 132 | 1861 |
| 218 | -182 | -3425 | 8 | 178 | 182 | 3430 |
| 208 | -233 | -5497 | 9 | 265 | 233 | 5503 |
| 198 | -285 | -8083 | 10 | 360 | 285 | 8091 |
| 188 | -337 | -11192 | 10 | 459 | 337 | 11201 |
| 178 | -390 | -14829 | 11 | 562 | 390 | 14840 |
| 163.65 | -472 | -21015 | 11 | 714 | 472 | 21028 |
| 159 | -487 | -23088 | 12 | 762 | 487 | 23100 |
| 155.00 | -498 | -25217 | 13 | 814 | 498 | 25231 |
| 138 | -579 | -34375 | 13 | 1035 | 579 | 34391 |
| 128 | -623 | -40386 | 14 | 1175 | 623 | 40403 |
| 118 | -668 | -46839 | 15 | 1323 | 668 | 46858 |
| 108 | -713 | -53741 | 16 | 1481 | 713 | 53761 |
| 98 | -759 | -61097 | 17 | 1647 | 759 | 61119 |
| 88 | -805 | -68912 | 18 | 1821 | 805 | 68936 |
| 80.00 | -839 | -75486 | 19 | 1968 | 839 | 75511 |
| 68 | -897 | -85902 | 20 | 2199 | 898 | 85931 |
| 58 | -944 | -95109 | 21 | 2400 | 944 | 95139 |
| 48 | -991 | -104781 | 22 | 2611 | 991 | 104814 |
| 22 | -1137 | -132433 | 22 | 3176 | 1137 | 132471 |
| 19 | -1147 | -135859 | 23 | 3243 | 1147 | 135898 |
| 0 | -1262 | -158745 | 22 | 3668 | 1262 | 158788 |

| AERODYNAMIC TORQUE AT SHEAR CENTRE | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| CONDITION. E | | | | | | | | | | |
| | | | | | | | | | | |
| 1 | 50 | 74 | 51 | 52 | 53 | 54 | 55 | 56 | 57 | 58 |
| STATION | CLEAN + FLAPPED | CLEAN + FLAPPED | LOCAL | AERO | X AC | X SC | DELTA X | Z AC | Z SC | DELTA Z |
| | LOCAL | LOCAL | $X_{CP}$ | CENTRE | (in) | (in) | (in) | (in) | (in) | (in) |
| (in) | $C_L$ | $C_{Mo}$ | | (in) | | using 38% chord | | | | |
| 258 | - | -0.025 | - | 0.00 | 0.00 | 13.30 | 13.30 | 0.00 | 2.39 | -2.39 |
| 251.25 | -0.13 | 0.062 | 0.70 | 24.63 | 24.63 | 13.37 | -11.26 | 0.00 | 2.40 | -2.40 |
| 238 | -0.18 | 0.062 | 0.70 | 24.87 | 24.87 | 13.50 | -11.37 | 0.00 | 2.44 | -2.44 |
| 228 | -0.20 | 0.062 | 0.70 | 25.06 | 25.06 | 13.60 | -11.46 | 0.00 | 2.47 | -2.47 |
| 218 | -0.20 | 0.062 | 0.70 | 25.25 | 25.25 | 13.71 | -11.54 | 0.00 | 2.49 | -2.49 |
| 208 | -0.21 | 0.062 | 0.70 | 25.44 | 25.44 | 13.81 | -11.63 | 0.00 | 2.52 | -2.52 |
| 198 | -0.22 | 0.062 | 0.70 | 25.62 | 25.62 | 13.91 | -11.71 | 0.00 | 2.54 | -2.54 |
| 188 | -0.22 | 0.062 | 0.70 | 25.81 | 25.81 | 14.01 | -11.80 | 0.00 | 2.57 | -2.57 |
| 178 | -0.23 | 0.062 | 0.70 | 26.00 | 26.00 | 14.11 | -11.88 | 0.00 | 2.60 | -2.60 |
| 163.65 | -0.23 | 0.062 | 0.70 | 26.27 | 26.27 | 14.26 | -12.01 | 0.00 | 2.64 | -2.64 |
| 159 | -0.21 | -0.025 | 0.12 | 4.60 | 4.60 | 14.30 | 9.71 | 0.00 | 2.65 | -2.65 |
| 155.00 | -0.19 | -0.025 | 0.11 | 4.12 | 4.12 | 14.35 | 10.23 | 0.00 | 2.66 | -2.66 |
| 138 | -0.19 | -0.025 | 0.11 | 4.24 | 4.24 | 14.52 | 10.28 | 0.00 | 2.70 | -2.70 |
| 128 | -0.20 | -0.025 | 0.11 | 4.35 | 4.35 | 14.62 | 10.28 | 0.00 | 2.73 | -2.73 |
| 118 | -0.20 | -0.025 | 0.11 | 4.42 | 4.42 | 14.72 | 10.30 | 0.00 | 2.76 | -2.76 |
| 108 | -0.20 | -0.025 | 0.12 | 4.49 | 4.49 | 14.82 | 10.33 | 0.00 | 2.78 | -2.78 |
| 98 | -0.20 | -0.025 | 0.12 | 4.56 | 4.56 | 14.93 | 10.37 | 0.00 | 2.81 | -2.81 |
| 88 | -0.20 | -0.025 | 0.12 | 4.61 | 4.61 | 15.03 | 10.41 | 0.00 | 2.84 | -2.84 |
| 80.00 | -0.20 | -0.025 | 0.12 | 4.66 | 4.66 | 15.11 | 10.45 | 0.00 | 2.86 | -2.86 |
| 68 | -0.20 | -0.025 | 0.12 | 4.71 | 4.71 | 15.23 | 10.52 | 0.00 | 2.89 | -2.89 |
| 58 | -0.20 | -0.025 | 0.12 | 4.76 | 4.76 | 15.33 | 10.58 | 0.00 | 2.92 | -2.92 |
| 48 | -0.21 | -0.025 | 0.12 | 4.80 | 4.80 | 15.43 | 10.64 | 0.00 | 2.94 | -2.94 |
| 22 | -0.20 | -0.025 | 0.12 | 4.88 | 4.88 | 15.70 | 10.82 | 0.00 | 3.01 | -3.01 |
| 19 | -0.20 | -0.025 | 0.12 | 4.88 | 4.88 | 15.73 | 10.85 | 0.00 | 3.01 | -3.01 |
| 0 | -0.20 | -0.025 | 0.12 | 4.93 | 4.93 | 15.92 | 11.00 | 0.00 | 1.25 | -1.25 |

| AERODYNAMIC TORQUE AT SHEAR CENTRE | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| CONDITION. E | | | | | | $\Delta C_{Mo}$ | | | | | |
| | | | | | | 0 | | | | | |
| 1 | 55 | 56 | 23 | 24 | 59 | 75 | 60 | 61 | 62 | 63 | 64 |
| STATION | DELTA | DELTA | SPAN | SPAN | ELEMENT | ELEMENT | ELEMENT | ELEMENT | ELEMENT | TOTAL | TOTAL |
| | X av | Z av | ELEMENT | ELEMENT | TORQUE | TORQUE | TORQUE | TORQUE | LIMIT | LIMIT | ULT |
| (in) | (in) | (in) | LIFT | DRAG | DUE TO | DUE TO | DUE TO | DUE TO | TORQUE | TORQUE | TORQUE |
| | | | (lb) | (lb) | $C_{Mo}$ | $\Delta C_{Mo}$ | LIFT | DRAG | (lb in) | (lb in) | (lb in) |
| | | | | | (lb in) | (lb in) | (lb in) | (lb in) | | | |
| 258 | - | - | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 251.25 | 1.02 | 0.00 | -15.64 | 1.24 | -102.93 | 356.81 | -15.97 | 0.00 | 237.92 | 237.92 | 356.88 |
| 238 | -11.31 | 0.00 | -41.85 | 1.66 | -205.13 | 711.13 | 473.53 | 0.00 | 979.53 | 1217.45 | 1826.17 |
| 228 | -11.41 | 0.00 | -34.50 | 1.02 | -157.55 | 546.18 | 393.83 | 0.00 | 782.46 | 1999.91 | 2999.87 |
| 218 | -11.50 | 0.00 | -36.36 | 0.89 | -159.92 | 554.40 | 418.10 | 0.00 | 812.58 | 2812.49 | 4218.73 |
| 208 | -11.59 | 0.00 | -37.89 | 0.37 | -162.31 | 562.68 | 438.99 | 0.00 | 839.36 | 3651.85 | 5477.78 |
| 198 | -11.67 | 0.00 | -39.23 | -0.13 | -164.72 | 571.03 | 457.88 | 0.00 | 864.18 | 4516.04 | 6774.05 |
| 188 | -11.76 | 0.00 | -40.46 | -0.22 | -167.14 | 579.43 | 475.70 | 0.00 | 887.99 | 5404.02 | 8106.03 |
| 178 | -11.84 | 0.00 | -41.58 | -0.29 | -169.59 | 587.90 | 492.34 | 0.00 | 910.66 | 6314.68 | 9472.02 |
| 163.65 | -11.95 | 0.00 | -61.40 | -0.53 | -247.66 | 858.55 | 733.53 | 0.00 | 1344.42 | 7659.10 | 11488.65 |
| 159 | -1.15 | 0.00 | -17.07 | -0.09 | -75.64 | 0.00 | 19.64 | 0.00 | -56.00 | 7603.10 | 11404.65 |
| 155.00 | 9.97 | 0.00 | -15.41 | -0.01 | -76.11 | 0.00 | -153.65 | 0.00 | -229.76 | 7373.34 | 11060.01 |
| 138 | 10.26 | 0.00 | -61.92 | -0.11 | -303.71 | 0.00 | -635.14 | 0.00 | -938.85 | 6434.49 | 9651.74 |
| 128 | 10.28 | 0.00 | -37.37 | -0.12 | -182.06 | 0.00 | -384.12 | 0.00 | -566.19 | 5868.30 | 8802.45 |
| 118 | 10.29 | 0.00 | -37.99 | -0.15 | -184.61 | 0.00 | -390.86 | 0.00 | -575.47 | 5292.83 | 7939.25 |
| 108 | 10.32 | 0.00 | -38.56 | -0.18 | -187.18 | 0.00 | -397.84 | 0.00 | -585.02 | 4707.82 | 7061.72 |
| 98 | 10.35 | 0.00 | -39.09 | -0.21 | -189.76 | 0.00 | -404.64 | 0.00 | -594.40 | 4113.42 | 6170.12 |
| 88 | 10.39 | 0.00 | -39.58 | -0.23 | -192.37 | 0.00 | -411.26 | 0.00 | -603.63 | 3509.79 | 5264.68 |
| 80.00 | 10.43 | 0.00 | -31.98 | -0.19 | -155.78 | 0.00 | -333.63 | 0.00 | -489.41 | 3020.38 | 4530.57 |
| 68 | 10.48 | 0.00 | -48.45 | -0.31 | -236.83 | 0.00 | -508.03 | 0.00 | -744.86 | 2275.52 | 3413.28 |
| 58 | 10.55 | 0.00 | -40.78 | -0.27 | -200.28 | 0.00 | -430.16 | 0.00 | -630.44 | 1645.08 | 2467.63 |
| 48 | 10.61 | 0.00 | -41.11 | -0.28 | -202.95 | 0.00 | -436.09 | 0.00 | -639.04 | 1006.05 | 1509.07 |
| 22 | 10.73 | 0.00 | -108.12 | -0.72 | -540.29 | 0.00 | -1160.28 | 0.00 | -1700.57 | -694.53 | -1041.79 |
| 19 | 10.84 | 0.00 | -12.58 | -0.08 | -63.53 | 0.00 | -136.32 | 0.00 | -199.85 | -894.38 | -1341.57 |
| 0 | 10.92 | 0.00 | -80.02 | -0.51 | -408.09 | 0.00 | -874.07 | 0.00 | -1282.15 | -2176.53 | -3264.80 |

| DEAD WEIGHT ANALYSIS FOR WING TORQUE | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| CONDITION. E | | | | | | | | |
| 1 | 65 | 54 | 66 | 67 | 33 | 68 | 69 | 70 |
| STATION | X CG | X SC | DELTA | DELTA | ELEMENT | ELEMENT | TOTAL | TOTAL |
| | (in) | (in) | X | X av | LOAD | LIMIT | LIMIT | ULT |
| (in) | | | (in) | (in) | (lb) | TORQUE | TORQUE | TORQUE |
| | using 40% chord | | | | | (lb in) | (lb in) | (lb in) |
| 258 | 14.00 | 13.30 | -0.70 | - | - | - | - | 0.00 |
| 251.25 | 14.07 | 13.37 | -0.70 | -0.70 | 0.50 | -0.35 | -0.35 | -0.52 |
| 238 | 14.21 | 13.50 | -0.71 | -0.71 | 1.32 | -0.93 | -1.28 | -1.92 |
| 228 | 14.32 | 13.60 | -0.72 | -0.71 | 2.28 | -1.63 | -2.91 | -4.36 |
| 218 | 14.43 | 13.71 | -0.72 | -0.72 | 3.19 | -2.29 | -5.20 | -7.80 |
| 208 | 14.53 | 13.81 | -0.73 | -0.72 | 3.91 | -2.83 | -8.03 | -12.05 |
| 198 | 14.64 | 13.91 | -0.73 | -0.73 | 4.60 | -3.35 | -11.39 | -17.08 |
| 188 | 14.75 | 14.01 | -0.74 | -0.73 | 5.45 | -4.00 | -15.39 | -23.08 |
| 178 | 14.86 | 14.11 | -0.74 | -0.74 | 6.17 | -4.57 | -19.96 | -29.93 |
| 163.65 | 15.01 | 14.26 | -0.75 | -0.75 | 7.09 | -5.30 | -25.25 | -37.88 |
| 159 | 15.06 | 14.30 | -0.75 | -0.75 | 7.32 | -5.50 | -30.75 | -46.13 |
| 155.00 | 15.10 | 14.35 | -0.76 | -0.75 | 7.63 | -5.75 | -36.50 | -54.75 |
| 138 | 15.28 | 14.52 | -0.76 | -0.76 | 8.01 | -6.08 | -42.58 | -63.88 |
| 128 | 15.39 | 14.62 | -0.77 | -0.77 | 8.13 | -6.24 | -48.82 | -73.23 |
| 118 | 15.50 | 14.72 | -0.77 | -0.77 | 8.36 | -6.46 | -55.28 | -82.91 |
| 108 | 15.60 | 14.82 | -0.78 | -0.78 | 8.47 | -6.59 | -61.87 | -92.80 |
| 98 | 15.71 | 14.93 | -0.79 | -0.78 | 8.61 | -6.74 | -68.61 | -102.91 |
| 88 | 15.82 | 15.03 | -0.79 | -0.79 | 8.96 | -7.06 | -75.67 | -113.50 |
| 80.00 | 15.90 | 15.11 | -0.80 | -0.79 | 9.15 | -7.25 | -82.92 | -124.38 |
| 68 | 16.03 | 15.23 | -0.80 | -0.80 | 9.49 | -7.57 | -90.50 | -135.74 |
| 58 | 16.14 | 15.33 | -0.81 | -0.80 | 9.73 | -7.82 | -98.32 | -147.48 |
| 48 | 16.25 | 15.43 | -0.81 | -0.81 | 10.11 | -8.18 | -106.50 | -159.76 |
| 22 | 16.52 | 15.70 | -0.83 | -0.82 | 10.83 | -8.87 | -115.38 | -173.06 |
| 19 | 16.56 | 15.73 | -0.83 | -0.83 | 5.45 | -4.51 | -119.89 | -179.83 |
| 0 | 16.76 | 15.92 | -0.84 | -0.83 | 3.64 | -3.03 | -122.92 | -184.37 |

| COMBINED ULTIMATE TORSION ( AERODYNAMIC + INERTIAL ) | | | |
|---|---|---|---|
| CONDITION. E | | | |
| | | | |
| 1 | 71 E | | |
| STATION | COND. E | | |
| (in) | (lb in) | | |
| 258 | 0 | | |
| 251.25 | 356 | | |
| 238 | 1824 | | |
| 228 | 2996 | | |
| 218 | 4211 | | |
| 208 | 5466 | | |
| 198 | 6757 | | |
| 188 | 8083 | | |
| 178 | 9442 | | |
| 163.65 | 11451 | | |
| 159 | 11359 | | |
| 155.00 | 11005 | | |
| 138 | 9588 | | |
| 128 | 8729 | | |
| 118 | 7856 | | |
| 108 | 6969 | | |
| 98 | 6067 | | |
| 88 | 5151 | | |
| 80.00 | 4406 | | |
| 68 | 3278 | | |
| 58 | 2320 | | |
| 48 | 1349 | | |
| 22 | -1215 | | |
| 19 | -1521 | | |
| 0 | -3449 | | |

SPANWISE AERODYNAMIC LOAD DISTRIBUTION
CONDITION. E 2/3 n
AILERON DOWN

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | Aileron deflection = | DWN | | | |
| | | | | | | | | | Aileron angle = | 6.33 | deg | | |
| | | | | | | | | | Aileron load = | 62.54 | lb | ECF = | 0.27 |
| $V_{ad}$ = | 244.93 | ft/s | $C_L$ = | -0.2 | | alpha wrp = | -5.1794 | | $\Delta C_L$ = | 0.19 | | | |
| Lift = | -1822.10 | lb clean | $C_{Do}$ = | 0.017 | | sin alpha = | -0.0903 | | $\Delta C_D$ = | 0.01 | | | |
| q = | 71.33 | psf | $C_D$ = | 0.018 | | cos alpha = | 0.9959 | | $\Delta C_{Mo}$ = | -0.06 | | | |
| n = | -1.27 | g | $C_{Mo}$ = | -0.025 | | | | | S = | 4.71 | ft² | | |
| $q.C_L$ = | -13.50 | $q.C_L$ =Lift/S | S = | 135.00 | ft² | | | | b = | 7.30 | ft | | |
| | | | b = | 43.00 | ft | | | | AR = | 11.31 | | | |

| 1 | 13 | 72 | 14 | 15 | 16 | 73 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| STATION | $C_L$ | FLAP | $C_{Lx}$ | $C_{Lz}$ | $C_D$ | FLAP | $C_{Dz}$ | $C_{Dx}$ | $C_{Lz}+C_{Dx}$ | $C_{Dz}-C_{Lx}$ | $(C_{Lz}+C_{Dx})_{AV}$ | $(C_{Dz}-C_{Lx})_{AV}$ | SPAN | SPAN |
| (in) | | $C_L$ | | | | $C_D$ | | | | | | | ELEMENT | ELEMENT |
| | | | | | | | | | | | | | LIFT | DRAG |
| | | | | | | | | | | | | | (lb) | (lb) |
| 258 | -0.0946 | 0.0000 | 0.0085 | -0.0942 | 0.0216 | 0.0000 | 0.0216 | -0.0020 | -0.0962 | 0.0130 | - | - | 0.00 | 0.00 |
| 251.25 | -0.1239 | 0.0503 | 0.0067 | -0.0734 | 0.0216 | 0.0019 | 0.0235 | -0.0021 | -0.0755 | 0.0169 | -0.0858 | 0.0149 | -10.07 | 1.75 |
| 238 | -0.1439 | 0.0503 | 0.0085 | -0.0933 | 0.0216 | 0.0019 | 0.0235 | -0.0021 | -0.0954 | 0.0150 | -0.0854 | 0.0159 | -19.83 | 3.70 |
| 228 | -0.1539 | 0.0503 | 0.0094 | -0.1033 | 0.0216 | 0.0019 | 0.0235 | -0.0021 | -0.1054 | 0.0141 | -0.1004 | 0.0146 | -17.74 | 2.58 |
| 218 | -0.1619 | 0.0503 | 0.0101 | -0.1112 | 0.0216 | 0.0019 | 0.0235 | -0.0021 | -0.1133 | 0.0134 | -0.1094 | 0.0138 | -19.47 | 2.45 |
| 208 | -0.1685 | 0.0503 | 0.0107 | -0.1178 | 0.0171 | 0.0019 | 0.0190 | -0.0017 | -0.1195 | 0.0083 | -0.1164 | 0.0109 | -20.87 | 1.95 |
| 198 | -0.1741 | 0.0503 | 0.0112 | -0.1233 | 0.0171 | 0.0019 | 0.0190 | -0.0017 | -0.1251 | 0.0078 | -0.1223 | 0.0081 | -22.09 | 1.46 |
| 188 | -0.1789 | 0.0503 | 0.0116 | -0.1281 | 0.0171 | 0.0019 | 0.0190 | -0.0017 | -0.1298 | 0.0074 | -0.1274 | 0.0076 | -23.19 | 1.39 |
| 178 | -0.1831 | 0.0503 | 0.0120 | -0.1323 | 0.0171 | 0.0019 | 0.0190 | -0.0017 | -0.1340 | 0.0070 | -0.1319 | 0.0072 | -24.18 | 1.32 |
| 163.65 | -0.1881 | 0.0503 | 0.0124 | -0.1373 | 0.0171 | 0.0019 | 0.0190 | -0.0017 | -0.1390 | 0.0066 | -0.1365 | 0.0068 | -36.22 | 1.80 |
| 159 | -0.1894 | 0.0000 | 0.0171 | -0.1887 | 0.0171 | 0.0000 | 0.0171 | -0.0015 | -0.1902 | 0.0000 | -0.1646 | 0.0033 | -13.25 | 0.26 |
| 155.00 | -0.1907 | 0.0000 | 0.0172 | -0.1899 | 0.0171 | 0.0000 | 0.0171 | -0.0015 | -0.1915 | -0.0001 | -0.1908 | -0.0001 | -15.41 | -0.01 |
| 138 | -0.1950 | 0.0000 | 0.0176 | -0.1942 | 0.0171 | 0.0000 | 0.0171 | -0.0015 | -0.1957 | -0.0005 | -0.1936 | -0.0003 | -61.92 | -0.11 |
| 128 | -0.1970 | 0.0000 | 0.0178 | -0.1962 | 0.0171 | 0.0000 | 0.0171 | -0.0015 | -0.1978 | -0.0007 | -0.1967 | -0.0006 | -37.37 | -0.12 |
| 118 | -0.1988 | 0.0000 | 0.0179 | -0.1980 | 0.0171 | 0.0000 | 0.0171 | -0.0015 | -0.1995 | -0.0009 | -0.1986 | -0.0008 | -37.99 | -0.15 |
| 108 | -0.2003 | 0.0000 | 0.0181 | -0.1994 | 0.0171 | 0.0000 | 0.0171 | -0.0015 | -0.2010 | -0.0010 | -0.2002 | -0.0009 | -38.56 | -0.18 |
| 98 | -0.2015 | 0.0000 | 0.0182 | -0.2007 | 0.0171 | 0.0000 | 0.0171 | -0.0015 | -0.2022 | -0.0011 | -0.2016 | -0.0011 | -39.09 | -0.21 |
| 88 | -0.2025 | 0.0000 | 0.0183 | -0.2017 | 0.0171 | 0.0000 | 0.0171 | -0.0015 | -0.2032 | -0.0012 | -0.2027 | -0.0012 | -39.58 | -0.23 |
| 80.00 | -0.2031 | 0.0000 | 0.0183 | -0.2023 | 0.0171 | 0.0000 | 0.0171 | -0.0015 | -0.2038 | -0.0013 | -0.2035 | -0.0012 | -31.98 | -0.19 |
| 68 | -0.2038 | 0.0000 | 0.0184 | -0.2030 | 0.0171 | 0.0000 | 0.0171 | -0.0015 | -0.2045 | -0.0013 | -0.2042 | -0.0013 | -48.45 | -0.31 |
| 58 | -0.2042 | 0.0000 | 0.0184 | -0.2034 | 0.0171 | 0.0000 | 0.0171 | -0.0015 | -0.2049 | -0.0014 | -0.2047 | -0.0013 | -40.78 | -0.27 |
| 48 | -0.2044 | 0.0000 | 0.0185 | -0.2036 | 0.0171 | 0.0000 | 0.0171 | -0.0015 | -0.2051 | -0.0014 | -0.2050 | -0.0014 | -41.11 | -0.28 |
| 22 | -0.2041 | 0.0000 | 0.0184 | -0.2032 | 0.0171 | 0.0000 | 0.0171 | -0.0015 | -0.2048 | -0.0014 | -0.2049 | -0.0014 | -108.12 | -0.72 |
| 19 | -0.2040 | 0.0000 | 0.0184 | -0.2031 | 0.0171 | 0.0000 | 0.0171 | -0.0015 | -0.2047 | -0.0013 | -0.2047 | -0.0013 | -12.58 | -0.08 |
| 0 | -0.2029 | 0.0000 | 0.0183 | -0.2021 | 0.0171 | 0.0000 | 0.0171 | -0.0015 | -0.2036 | -0.0013 | -0.2042 | -0.0013 | -80.02 | -0.51 |
| | | | | | | | | | | | | Σ = | -839.89 | 15.30 |
| | | | | | | | | | | | | LIFT calc = | -1679.79 | |
| | | | | | | | | | | | | Lift = | -1822.10 | |

SPANWISE AERODYNAMIC LOAD DISTRIBUTION

CONDITION. E cont..

| 1 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 |
|---|---|---|---|---|---|---|---|---|
| STATION | LIMIT | LIMIT | LIMIT | LIMIT | ULT | ULT | ULT | ULT |
| (in) | NORMAL | NORMAL | CHORD | CHORD | NORMAL | NORMAL | CHORD | CHORD |
| | SHEAR | MOMENT | SHEAR | MOMENT | SHEAR | MOMENT | SHEAR | MOMENT |
| | (lb) | (lb in) | (lb) | (lb in) | (lb) | (lb in) | (lb) | (lb in) |
| 258 | 0.00 | 0.00 | 0.00 | 0.00 | 0 | 0 | 0 | 0 |
| 251.25 | -10.07 | -33.99 | 1.75 | 5.91 | -15 | -51 | 3 | 9 |
| 238 | -29.90 | -298.80 | 5.45 | 53.65 | -45 | -448 | 8 | 80 |
| 228 | -47.64 | -686.50 | 8.03 | 121.08 | -71 | -1030 | 12 | 182 |
| 218 | -67.10 | -1260.21 | 10.49 | 213.66 | -101 | -1890 | 16 | 320 |
| 208 | -87.98 | -2035.62 | 12.44 | 328.27 | -132 | -3053 | 19 | 492 |
| 198 | -110.07 | -3025.85 | 13.90 | 459.93 | -165 | -4539 | 21 | 690 |
| 188 | -133.26 | -4242.49 | 15.28 | 605.82 | -200 | -6364 | 23 | 909 |
| 178 | -157.44 | -5696.01 | 16.60 | 765.25 | -236 | -8544 | 25 | 1148 |
| 163.65 | -193.66 | -8215.19 | 18.41 | 1016.43 | -290 | -12323 | 28 | 1525 |
| 159 | -206.92 | -9081.45 | 18.67 | 1096.60 | -310 | -13622 | 28 | 1645 |
| 155.00 | -222.33 | -10009.70 | 18.66 | 1177.33 | -333 | -15015 | 28 | 1766 |
| 138 | -284.25 | -14315.63 | 18.55 | 1493.64 | -426 | -21473 | 28 | 2240 |
| 128 | -321.62 | -17344.97 | 18.43 | 1678.58 | -482 | -26017 | 28 | 2518 |
| 118 | -359.61 | -20751.09 | 18.28 | 1862.15 | -539 | -31127 | 27 | 2793 |
| 108 | -398.17 | -24539.99 | 18.10 | 2044.06 | -597 | -36810 | 27 | 3066 |
| 98 | -437.26 | -28717.16 | 17.89 | 2224.02 | -656 | -43076 | 27 | 3336 |
| 88 | -476.84 | -33287.67 | 17.67 | 2401.82 | -715 | -49932 | 26 | 3603 |
| 80.00 | -508.82 | -37230.31 | 17.47 | 2542.36 | -763 | -55845 | 26 | 3814 |
| 68 | -557.28 | -43626.88 | 17.16 | 2750.16 | -836 | -65440 | 26 | 4125 |
| 58 | -598.06 | -49403.55 | 16.89 | 2920.44 | -897 | -74105 | 25 | 4381 |
| 48 | -639.17 | -55589.70 | 16.62 | 3087.99 | -959 | -83385 | 25 | 4632 |
| 22 | -747.29 | -73613.73 | 15.90 | 3510.66 | -1121 | -110421 | 24 | 5266 |
| 19 | -759.87 | -75874.48 | 15.81 | 3558.23 | -1140 | -113812 | 24 | 5337 |
| 0 | -839.89 | -91072.27 | 15.30 | 3853.84 | -1260 | -136608 | 23 | 5781 |
| | | | | | | | | |
| Centre of lift is | 108 | in from aircraft centreline | | | | | | |
| | 42 | % semispan | | | | | | |

SPANWISE INERTIAL LOAD DISTRIBUTION

CONDITION. E cont..

| 1 | 3 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 | 41 | 42 | 43 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| STATION | dy | WEIGHT | ELEMENT | ELEMENT | LIMIT | LIMIT | LIMIT | LIMIT | ULT | ULT | ULT | ULT |
| (in) | (in) | nW | SHEAR | SHEAR | NORMAL | NORMAL | CHORD | CHORD | NORMAL | NORMAL | CHORD | CHORD |
| | | (lb) | FORCE | FORCE | SHEAR | MOMENT | SHEAR | MOMENT | SHEAR | MOMENT | SHEAR | MOMENT |
| | | | $V_x$ | $V_z$ | (lb) | (lb in) | (lb) | (lb in) | (lb) | (lb in) | (lb) | (lb in) |
| | | | (lb) | (lb) | | | | | | | | |
| 258 | - | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0 | 0 | 0 | 0 |
| 251.25 | 6.75 | 0.50 | 0.04 | 0.49 | 0.49 | 1.66 | 0.04 | 0.15 | 1 | 2 | 0 | 0 |
| 238 | 13.25 | 1.32 | 0.12 | 1.31 | 1.81 | 16.89 | 0.16 | 1.53 | 3 | 25 | 0 | 2 |
| 228 | 10.00 | 2.28 | 0.21 | 2.27 | 4.08 | 46.29 | 0.37 | 4.20 | 6 | 69 | 1 | 6 |
| 218 | 10.00 | 3.19 | 0.29 | 3.18 | 7.25 | 102.95 | 0.66 | 9.33 | 11 | 154 | 1 | 14 |
| 208 | 10.00 | 3.91 | 0.35 | 3.90 | 11.15 | 194.98 | 1.01 | 17.67 | 17 | 292 | 2 | 27 |
| 198 | 10.00 | 4.60 | 0.42 | 4.58 | 15.73 | 329.41 | 1.43 | 29.86 | 24 | 494 | 2 | 45 |
| 188 | 10.00 | 5.45 | 0.49 | 5.42 | 21.16 | 513.85 | 1.92 | 46.58 | 32 | 771 | 3 | 70 |
| 178 | 10.00 | 6.17 | 0.56 | 6.14 | 27.30 | 756.13 | 2.47 | 68.54 | 41 | 1134 | 4 | 103 |
| 163.65 | 14.35 | 7.09 | 0.64 | 7.06 | 34.36 | 1198.57 | 3.11 | 108.64 | 52 | 1798 | 5 | 163 |
| 159 | 4.33 | 7.32 | 0.66 | 7.29 | 41.66 | 1362.97 | 3.78 | 123.54 | 62 | 2044 | 6 | 185 |
| 155.00 | 4.32 | 7.63 | 0.69 | 7.59 | 49.25 | 1559.55 | 4.46 | 141.36 | 74 | 2339 | 7 | 212 |
| 138 | 17.00 | 8.01 | 0.72 | 7.97 | 57.22 | 2464.56 | 5.19 | 223.40 | 86 | 3697 | 8 | 335 |
| 128 | 10.00 | 8.13 | 0.73 | 8.10 | 65.32 | 3077.28 | 5.92 | 278.94 | 98 | 4616 | 9 | 418 |
| 118 | 10.00 | 8.36 | 0.75 | 8.33 | 73.65 | 3772.13 | 6.68 | 341.92 | 110 | 5658 | 10 | 513 |
| 108 | 10.00 | 8.47 | 0.76 | 8.44 | 82.09 | 4550.80 | 7.44 | 412.50 | 123 | 6826 | 11 | 619 |
| 98 | 10.00 | 8.61 | 0.78 | 8.58 | 90.66 | 5414.55 | 8.22 | 490.80 | 136 | 8122 | 12 | 736 |
| 88 | 10.00 | 8.96 | 0.81 | 8.92 | 99.58 | 6365.79 | 9.03 | 577.02 | 149 | 9549 | 14 | 866 |
| 80.00 | 8.00 | 9.15 | 0.83 | 9.11 | 108.69 | 7198.90 | 9.85 | 652.54 | 163 | 10798 | 15 | 979 |
| 68 | 12.00 | 9.49 | 0.86 | 9.45 | 118.14 | 8559.89 | 10.71 | 775.90 | 177 | 12840 | 16 | 1164 |
| 58 | 10.00 | 9.73 | 0.88 | 9.69 | 127.83 | 9789.73 | 11.59 | 887.38 | 192 | 14685 | 17 | 1331 |
| 48 | 10.00 | 10.11 | 0.91 | 10.07 | 137.90 | 11118.35 | 12.50 | 1007.81 | 207 | 16678 | 19 | 1512 |
| 22 | 26.00 | 10.83 | 0.98 | 10.79 | 148.68 | 14843.83 | 13.48 | 1345.50 | 223 | 22266 | 20 | 2018 |
| 19 | 3.00 | 5.45 | 0.49 | 5.43 | 154.11 | 15298.03 | 13.97 | 1386.67 | 231 | 22947 | 21 | 2080 |
| 0 | 19.00 | 3.64 | 0.33 | 3.62 | 157.73 | 18260.58 | 14.30 | 1655.21 | 237 | 27391 | 21 | 2483 |
| | $\Sigma =$ | 125 | lb | | | | | | | | | |
| | | at 1 g | | | Centre of gravity is | 116 | in from aircraft centreline | | | | | |
| | | | | | | 45 | % semispan | | | | | |

COMBINED ULTIMATE LOADS ( AERODYNAMIC + INERTIAL )

CONDITION. E cont..

| 1 | 44 E | 45 E | 46 E | 47 E | 48 E | 49 E |
|---|---|---|---|---|---|---|
| | ULT | ULT | ULT | ULT | ULT | ULT |
| | NORMAL | NORMAL | CHORD | CHORD | RESOLVED | RESOLVED |
| STATION | SHEAR | BEND MOMENT | SHEAR | BEND MOMENT | ULT SHEAR | ULT BEND MOM |
| (in) | COND. E | COND. E | COND. E | COND. E | COND. E | COND. E |
| | (lb) | (lb in) | (lb) | (lb in) | (lb) | (lb in) |
| 258 | 0 | 0 | 0 | 0 | 0 | 0 |
| 251.25 | -14 | -48 | 3 | 9 | 15 | 49 |
| 238 | -42 | -423 | 8 | 83 | 43 | 431 |
| 228 | -65 | -960 | 13 | 188 | 67 | 979 |
| 218 | -90 | -1736 | 17 | 334 | 91 | 1768 |
| 208 | -115 | -2761 | 20 | 519 | 117 | 2809 |
| 198 | -142 | -4045 | 23 | 735 | 143 | 4111 |
| 188 | -168 | -5593 | 26 | 979 | 170 | 5678 |
| 178 | -195 | -7410 | 29 | 1251 | 197 | 7515 |
| 163.65 | -239 | -10525 | 32 | 1688 | 241 | 10659 |
| 159 | -248 | -11578 | 34 | 1830 | 250 | 11721 |
| 155.00 | -260 | -12675 | 35 | 1978 | 262 | 12829 |
| 138 | -341 | -17777 | 36 | 2576 | 342 | 17962 |
| 128 | -384 | -21402 | 37 | 2936 | 386 | 21602 |
| 118 | -429 | -25468 | 37 | 3306 | 431 | 25682 |
| 108 | -474 | -29984 | 38 | 3685 | 476 | 30209 |
| 98 | -520 | -34954 | 39 | 4072 | 521 | 35190 |
| 88 | -566 | -40383 | 40 | 4468 | 567 | 40629 |
| 80.00 | -600 | -45047 | 41 | 4792 | 602 | 45301 |
| 68 | -659 | -52600 | 42 | 5289 | 660 | 52866 |
| 58 | -705 | -59421 | 43 | 5712 | 707 | 59695 |
| 48 | -752 | -66707 | 44 | 6144 | 753 | 66989 |
| 22 | -898 | -88155 | 44 | 7284 | 899 | 88455 |
| 19 | -909 | -90865 | 45 | 7417 | 910 | 91167 |
| 0 | -1023 | -109218 | 44 | 8264 | 1024 | 109530 |

AERODYNAMIC TORQUE AT SHEAR CENTRE

CONDITION. E

| 1 | 50 | 74 | 51 | 52 | 53 | 54 | 55 | 56 | 57 | 58 |
|---|---|---|---|---|---|---|---|---|---|---|
| STATION | CLEAN + FLAPPED | CLEAN + FLAPPED | LOCAL | AERO | X AC | X SC | DELTA X | Z AC | Z SC | DELTA Z |
| | LOCAL | LOCAL | $X_{cp}$ | CENTRE | (in) | (in) | (in) | (in) | (in) | (in) |
| (in) | $C_L$ | $C_{Mo}$ | | (in) | | using 38% chord | | | | |
| 258 | - | -0.025 | - | 0.00 | 0.00 | 13.30 | 13.30 | 0.00 | 2.39 | -2.39 |
| 251.25 | -0.09 | -0.088 | 0.70 | 24.63 | 24.63 | 13.37 | -11.26 | 0.00 | 2.40 | -2.40 |
| 238 | -0.09 | -0.088 | 0.70 | 24.87 | 24.87 | 13.50 | -11.37 | 0.00 | 2.44 | -2.44 |
| 228 | -0.10 | -0.088 | 0.70 | 25.06 | 25.06 | 13.60 | -11.46 | 0.00 | 2.47 | -2.47 |
| 218 | -0.11 | -0.088 | 0.70 | 25.25 | 25.25 | 13.71 | -11.54 | 0.00 | 2.49 | -2.49 |
| 208 | -0.12 | -0.088 | 0.70 | 25.44 | 25.44 | 13.81 | -11.63 | 0.00 | 2.52 | -2.52 |
| 198 | -0.12 | -0.088 | 0.70 | 25.62 | 25.62 | 13.91 | -11.71 | 0.00 | 2.54 | -2.54 |
| 188 | -0.13 | -0.088 | 0.70 | 25.81 | 25.81 | 14.01 | -11.80 | 0.00 | 2.57 | -2.57 |
| 178 | -0.13 | -0.088 | 0.70 | 26.00 | 26.00 | 14.11 | -11.88 | 0.00 | 2.60 | -2.60 |
| 163.65 | -0.14 | -0.088 | 0.70 | 26.27 | 26.27 | 14.26 | -12.01 | 0.00 | 2.64 | -2.64 |
| 159 | -0.16 | -0.025 | 0.09 | 3.32 | 3.32 | 14.30 | 10.99 | 0.00 | 2.65 | -2.65 |
| 155.00 | -0.19 | -0.025 | 0.11 | 4.12 | 4.12 | 14.35 | 10.23 | 0.00 | 2.66 | -2.66 |
| 138 | -0.19 | -0.025 | 0.11 | 4.24 | 4.24 | 14.52 | 10.28 | 0.00 | 2.70 | -2.70 |
| 128 | -0.20 | -0.025 | 0.11 | 4.35 | 4.35 | 14.62 | 10.28 | 0.00 | 2.73 | -2.73 |
| 118 | -0.20 | -0.025 | 0.11 | 4.42 | 4.42 | 14.72 | 10.30 | 0.00 | 2.76 | -2.76 |
| 108 | -0.20 | -0.025 | 0.12 | 4.49 | 4.49 | 14.82 | 10.33 | 0.00 | 2.78 | -2.78 |
| 98 | -0.20 | -0.025 | 0.12 | 4.56 | 4.56 | 14.93 | 10.37 | 0.00 | 2.81 | -2.81 |
| 88 | -0.20 | -0.025 | 0.12 | 4.61 | 4.61 | 15.03 | 10.41 | 0.00 | 2.84 | -2.84 |
| 80.00 | -0.20 | -0.025 | 0.12 | 4.66 | 4.66 | 15.11 | 10.45 | 0.00 | 2.86 | -2.86 |
| 68 | -0.20 | -0.025 | 0.12 | 4.71 | 4.71 | 15.23 | 10.52 | 0.00 | 2.89 | -2.89 |
| 58 | -0.20 | -0.025 | 0.12 | 4.76 | 4.76 | 15.33 | 10.58 | 0.00 | 2.92 | -2.92 |
| 48 | -0.21 | -0.025 | 0.12 | 4.80 | 4.80 | 15.43 | 10.64 | 0.00 | 2.94 | -2.94 |
| 22 | -0.20 | -0.025 | 0.12 | 4.88 | 4.88 | 15.70 | 10.82 | 0.00 | 3.01 | -3.01 |
| 19 | -0.20 | -0.025 | 0.12 | 4.88 | 4.88 | 15.73 | 10.85 | 0.00 | 3.01 | -3.01 |
| 0 | -0.20 | -0.025 | 0.12 | 4.93 | 4.93 | 15.92 | 11.00 | 0.00 | 1.25 | -1.25 |

AERODYNAMIC TORQUE AT SHEAR CENTRE

CONDITION. E

| 1 | 55 | 56 | 23 | 24 | 59 | 75 ($\Delta C_{Mo}$ = 0) | 60 | 61 | 62 | 63 | 64 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| STATION (in) | DELTA X av (in) | DELTA Z av (in) | SPAN ELEMENT LIFT (lb) | SPAN ELEMENT DRAG (lb) | ELEMENT TORQUE DUE TO $C_{Mo}$ (lb in) | ELEMENT TORQUE DUE TO $\Delta C_{Mo}$ (lb in) | ELEMENT TORQUE DUE TO LIFT (lb in) | ELEMENT TORQUE DUE TO DRAG (lb in) | ELEMENT LIMIT TORQUE (lb in) | TOTAL LIMIT TORQUE (lb in) | TOTAL ULT TORQUE (lb in) |
| 258 | - | - | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 251.25 | 1.02 | 0.00 | -10.07 | 1.75 | -102.93 | -260.75 | -10.28 | 0.00 | -373.96 | -373.96 | -560.94 |
| 238 | -11.31 | 0.00 | -19.83 | 3.70 | -205.13 | -519.67 | 224.36 | 0.00 | -500.44 | -874.40 | -1311.60 |
| 228 | -11.41 | 0.00 | -17.74 | 2.58 | -157.55 | -399.13 | 202.46 | 0.00 | -354.23 | -1228.63 | -1842.94 |
| 218 | -11.50 | 0.00 | -19.47 | 2.45 | -159.92 | -405.14 | 223.84 | 0.00 | -341.22 | -1569.85 | -2354.77 |
| 208 | -11.59 | 0.00 | -20.87 | 1.95 | -162.31 | -411.19 | 241.83 | 0.00 | -331.67 | -1901.52 | -2852.28 |
| 198 | -11.67 | 0.00 | -22.09 | 1.46 | -164.72 | -417.29 | 257.79 | 0.00 | -324.22 | -2225.73 | -3338.60 |
| 188 | -11.76 | 0.00 | -23.19 | 1.39 | -167.14 | -423.43 | 272.67 | 0.00 | -317.91 | -2543.64 | -3815.46 |
| 178 | -11.84 | 0.00 | -24.18 | 1.32 | -169.59 | -429.62 | 286.35 | 0.00 | -312.86 | -2856.50 | -4284.75 |
| 163.65 | -11.95 | 0.00 | -36.22 | 1.80 | -247.66 | -627.40 | 432.71 | 0.00 | -442.35 | -3298.85 | -4948.28 |
| 159 | -0.51 | 0.00 | -13.25 | 0.26 | -75.64 | 0.00 | 6.77 | 0.00 | -68.87 | -3367.72 | -5051.59 |
| 155.00 | 10.61 | 0.00 | -15.41 | -0.01 | -76.11 | 0.00 | -163.51 | 0.00 | -239.62 | -3607.34 | -5411.01 |
| 138 | 10.26 | 0.00 | -61.92 | -0.11 | -303.71 | 0.00 | -635.14 | 0.00 | -938.85 | -4546.19 | -6819.28 |
| 128 | 10.28 | 0.00 | -37.37 | -0.12 | -182.06 | 0.00 | -384.12 | 0.00 | -566.19 | -5112.38 | -7668.57 |
| 118 | 10.29 | 0.00 | -37.99 | -0.15 | -184.61 | 0.00 | -390.86 | 0.00 | -575.47 | -5687.85 | -8531.77 |
| 108 | 10.32 | 0.00 | -38.56 | -0.18 | -187.18 | 0.00 | -397.84 | 0.00 | -585.02 | -6272.86 | -9409.30 |
| 98 | 10.35 | 0.00 | -39.09 | -0.21 | -189.76 | 0.00 | -404.64 | 0.00 | -594.40 | -6867.26 | -10300.90 |
| 88 | 10.39 | 0.00 | -39.58 | -0.23 | -192.37 | 0.00 | -411.26 | 0.00 | -603.63 | -7470.89 | -11206.34 |
| 80.00 | 10.43 | 0.00 | -31.98 | -0.19 | -155.78 | 0.00 | -333.63 | 0.00 | -489.41 | -7960.30 | -11940.45 |
| 68 | 10.48 | 0.00 | -48.45 | -0.31 | -236.83 | 0.00 | -508.03 | 0.00 | -744.86 | -8705.16 | -13057.74 |
| 58 | 10.55 | 0.00 | -40.78 | -0.27 | -200.28 | 0.00 | -430.16 | 0.00 | -630.44 | -9335.60 | -14003.39 |
| 48 | 10.61 | 0.00 | -41.11 | -0.28 | -202.95 | 0.00 | -436.09 | 0.00 | -639.04 | -9974.63 | -14961.95 |
| 22 | 10.73 | 0.00 | -108.12 | -0.72 | -540.29 | 0.00 | -1160.28 | 0.00 | -1700.57 | -11675.21 | -17512.81 |
| 19 | 10.84 | 0.00 | -12.58 | -0.08 | -63.53 | 0.00 | -136.32 | 0.00 | -199.85 | -11875.06 | -17812.59 |
| 0 | 10.92 | 0.00 | -80.02 | -0.51 | -408.09 | 0.00 | -874.07 | 0.00 | -1282.15 | -13157.21 | -19735.82 |

DEAD WEIGHT ANALYSIS FOR WING TORQUE

CONDITION. E

| 1 | 65 | 54 | 66 | 67 | 33 | 68 | 69 | 70 |
|---|---|---|---|---|---|---|---|---|
| STATION | X CG | X SC | DELTA | DELTA | ELEMENT | ELEMENT | TOTAL | TOTAL |
| | (in) | (in) | X | X av | LOAD | LIMIT | LIMIT | ULT |
| (in) | | | (in) | (in) | (lb) | TORQUE | TORQUE | TORQUE |
| | using 40% chord | | | | | (lb in) | (lb in) | (lb in) |
| 258 | 14.00 | 13.30 | -0.70 | - | - | - | - | 0.00 |
| 251.25 | 14.07 | 13.37 | -0.70 | -0.70 | 0.50 | -0.35 | -0.35 | -0.52 |
| 238 | 14.21 | 13.50 | -0.71 | -0.71 | 1.32 | -0.93 | -1.28 | -1.92 |
| 228 | 14.32 | 13.60 | -0.72 | -0.71 | 2.28 | -1.63 | -2.91 | -4.36 |
| 218 | 14.43 | 13.71 | -0.72 | -0.72 | 3.19 | -2.29 | -5.20 | -7.80 |
| 208 | 14.53 | 13.81 | -0.73 | -0.72 | 3.91 | -2.83 | -8.03 | -12.05 |
| 198 | 14.64 | 13.91 | -0.73 | -0.73 | 4.60 | -3.35 | -11.39 | -17.08 |
| 188 | 14.75 | 14.01 | -0.74 | -0.73 | 5.45 | -4.00 | -15.39 | -23.08 |
| 178 | 14.86 | 14.11 | -0.74 | -0.74 | 6.17 | -4.57 | -19.96 | -29.93 |
| 163.65 | 15.01 | 14.26 | -0.75 | -0.75 | 7.09 | -5.30 | -25.25 | -37.88 |
| 159 | 15.06 | 14.30 | -0.75 | -0.75 | 7.32 | -5.50 | -30.75 | -46.13 |
| 155.00 | 15.10 | 14.35 | -0.76 | -0.75 | 7.63 | -5.75 | -36.50 | -54.75 |
| 138 | 15.28 | 14.52 | -0.76 | -0.76 | 8.01 | -6.08 | -42.58 | -63.88 |
| 128 | 15.39 | 14.62 | -0.77 | -0.77 | 8.13 | -6.24 | -48.82 | -73.23 |
| 118 | 15.50 | 14.72 | -0.77 | -0.77 | 8.36 | -6.46 | -55.28 | -82.91 |
| 108 | 15.60 | 14.82 | -0.78 | -0.78 | 8.47 | -6.59 | -61.87 | -92.80 |
| 98 | 15.71 | 14.93 | -0.79 | -0.78 | 8.61 | -6.74 | -68.61 | -102.91 |
| 88 | 15.82 | 15.03 | -0.79 | -0.79 | 8.96 | -7.06 | -75.67 | -113.50 |
| 80.00 | 15.90 | 15.11 | -0.80 | -0.79 | 9.15 | -7.25 | -82.92 | -124.38 |
| 68 | 16.03 | 15.23 | -0.80 | -0.80 | 9.49 | -7.57 | -90.50 | -135.74 |
| 58 | 16.14 | 15.33 | -0.81 | -0.80 | 9.73 | -7.82 | -98.32 | -147.48 |
| 48 | 16.25 | 15.43 | -0.81 | -0.81 | 10.11 | -8.18 | -106.50 | -159.76 |
| 22 | 16.52 | 15.70 | -0.83 | -0.82 | 10.83 | -8.87 | -115.38 | -173.06 |
| 19 | 16.56 | 15.73 | -0.83 | -0.83 | 5.45 | -4.51 | -119.89 | -179.83 |
| 0 | 16.76 | 15.92 | -0.84 | -0.83 | 3.64 | -3.03 | -122.92 | -184.37 |

| COMBINED ULTIMATE TORSION ( AERODYNAMIC + INERTIAL ) | | | |
|---|---|---|---|
| CONDITION. E | | | |
| | | | |
| 1 | 71 E | | |
| STATION | COND. E | | |
| (in) | (lb in) | | |
| 258 | 0 | | |
| 251.25 | -561 | | |
| 238 | -1314 | | |
| 228 | -1847 | | |
| 218 | -2363 | | |
| 208 | -2864 | | |
| 198 | -3356 | | |
| 188 | -3839 | | |
| 178 | -4315 | | |
| 163.65 | -4986 | | |
| 159 | -5098 | | |
| 155.00 | -5466 | | |
| 138 | -6883 | | |
| 128 | -7742 | | |
| 118 | -8615 | | |
| 108 | -9502 | | |
| 98 | -10404 | | |
| 88 | -11320 | | |
| 80.00 | -12065 | | |
| 68 | -13193 | | |
| 58 | -14151 | | |
| 48 | -15122 | | |
| 22 | -17686 | | |
| 19 | -17992 | | |
| 0 | -19920 | | |

SPANWISE AERODYNAMIC LOAD DISTRIBUTION

CONDITION. F 2/3 n

AILERON UP

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Aileron deflection = | UP | | |
| | | | | | | Aileron angle = | -8.67 | deg | |
| | | | | | | Aileron load = | 43.01 | lb | ECF = 0.17 |
| $V_{sel}$ = | 175.68 ft/s | $C_L$ = | -0.5 | alpha wrp = | -8.3304 | $\Delta C_L$ = | -0.25 | | |
| Lift = | -2435.86 lb clean | $C_{Do}$ = | 0.017 | sin alpha = | -0.1449 | $\Delta C_D$ = | 0.01 | | |
| q = | 36.69 psf | $C_D$ = | 0.024 | cos alpha = | 0.9894 | $\Delta C_{Mo}$ = | 0.09 | | |
| n = | -1.69 g | $C_{Mo}$ = | -0.025 | | | S = | 4.71 | $ft^2$ | |
| $q.C_L$ = | -18.04 $q.C_L$ =Lift/S | S = | 135.00 $ft^2$ | | | b = | 7.30 | ft | |
| | | b = | 43.00 ft | | | AR = | 11.31 | | |

| 1 | 13 | 72 | 14 | 15 | 16 | 73 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| STATION | $C_L$ | FLAP | $C_{Lx}$ | $C_{Lz}$ | $C_D$ | FLAP | $C_{Dx}$ | $C_{Dz}$ | $C_{Lz}+C_{Dz}$ | $C_{Dx}-C_{Lx}$ | $(C_{Lz}+C_{Dz})_{AV}$ | $(C_{Dx}-C_{Lx})_{AV}$ | SPAN | SPAN |
| (in) | | $C_L$ | | | | $C_D$ | | | | | | | ELEMENT | ELEMENT |
| | | | | | | | | | | | | | LIFT | DRAG |
| | | | | | | | | | | | | | (lb) | (lb) |
| 258 | -0.2459 | 0.0000 | 0.0356 | -0.2433 | 0.0288 | 0.0000 | 0.0285 | -0.0042 | -0.2474 | -0.0071 | - | - | 0.00 | 0.00 |
| 251.25 | -0.3220 | -0.0423 | 0.0528 | -0.3605 | 0.0288 | 0.0014 | 0.0299 | -0.0044 | -0.3649 | -0.0229 | -0.3062 | -0.0150 | -18.48 | -0.90 |
| 238 | -0.3740 | -0.0423 | 0.0603 | -0.4119 | 0.0288 | 0.0014 | 0.0299 | -0.0044 | -0.4163 | -0.0304 | -0.3906 | -0.0266 | -46.63 | -3.18 |
| 228 | -0.4000 | -0.0423 | 0.0641 | -0.4377 | 0.0288 | 0.0014 | 0.0299 | -0.0044 | -0.4420 | -0.0342 | -0.4292 | -0.0323 | -39.01 | -2.94 |
| 218 | -0.4207 | -0.0423 | 0.0671 | -0.4581 | 0.0288 | 0.0014 | 0.0299 | -0.0044 | -0.4625 | -0.0372 | -0.4523 | -0.0357 | -41.42 | -3.27 |
| 208 | -0.4379 | -0.0423 | 0.0696 | -0.4751 | 0.0228 | 0.0014 | 0.0240 | -0.0035 | -0.4786 | -0.0456 | -0.4706 | -0.0414 | -43.41 | -3.82 |
| 198 | -0.4524 | -0.0423 | 0.0717 | -0.4895 | 0.0228 | 0.0014 | 0.0240 | -0.0035 | -0.4930 | -0.0477 | -0.4858 | -0.0467 | -45.15 | -4.34 |
| 188 | -0.4649 | -0.0423 | 0.0735 | -0.5019 | 0.0228 | 0.0014 | 0.0240 | -0.0035 | -0.5054 | -0.0495 | -0.4992 | -0.0486 | -46.73 | -4.55 |
| 178 | -0.4757 | -0.0423 | 0.0751 | -0.5126 | 0.0228 | 0.0014 | 0.0240 | -0.0035 | -0.5161 | -0.0511 | -0.5107 | -0.0503 | -48.16 | -4.74 |
| 163.65 | -0.4888 | -0.0423 | 0.0770 | -0.5255 | 0.0228 | 0.0014 | 0.0240 | -0.0035 | -0.5290 | -0.0530 | -0.5226 | -0.0520 | -71.33 | -7.10 |
| 159 | -0.4923 | 0.0000 | 0.0713 | -0.4871 | 0.0228 | 0.0000 | 0.0226 | -0.0033 | -0.4904 | -0.0487 | -0.5097 | -0.0509 | -21.11 | -2.11 |
| 155.00 | -0.4956 | 0.0000 | 0.0718 | -0.4903 | 0.0228 | 0.0000 | 0.0226 | -0.0033 | -0.4936 | -0.0492 | -0.4920 | -0.0490 | -20.44 | -2.03 |
| 138 | -0.5066 | 0.0000 | 0.0734 | -0.5013 | 0.0228 | 0.0000 | 0.0226 | -0.0033 | -0.5046 | -0.0508 | -0.4991 | -0.0500 | -82.13 | -8.23 |
| 128 | -0.5120 | 0.0000 | 0.0742 | -0.5066 | 0.0228 | 0.0000 | 0.0226 | -0.0033 | -0.5099 | -0.0516 | -0.5072 | -0.0512 | -49.56 | -5.00 |
| 118 | -0.5165 | 0.0000 | 0.0748 | -0.5111 | 0.0228 | 0.0000 | 0.0226 | -0.0033 | -0.5144 | -0.0523 | -0.5121 | -0.0519 | -50.39 | -5.11 |
| 108 | -0.5204 | 0.0000 | 0.0754 | -0.5149 | 0.0228 | 0.0000 | 0.0226 | -0.0033 | -0.5182 | -0.0528 | -0.5163 | -0.0525 | -51.15 | -5.20 |
| 98 | -0.5236 | 0.0000 | 0.0759 | -0.5181 | 0.0228 | 0.0000 | 0.0226 | -0.0033 | -0.5214 | -0.0533 | -0.5198 | -0.0530 | -51.85 | -5.29 |
| 88 | -0.5262 | 0.0000 | 0.0762 | -0.5206 | 0.0228 | 0.0000 | 0.0226 | -0.0033 | -0.5239 | -0.0537 | -0.5227 | -0.0535 | -52.49 | -5.37 |
| 80.00 | -0.5279 | 0.0000 | 0.0765 | -0.5223 | 0.0228 | 0.0000 | 0.0226 | -0.0033 | -0.5256 | -0.0539 | -0.5248 | -0.0538 | -42.42 | -4.35 |
| 68 | -0.5297 | 0.0000 | 0.0767 | -0.5241 | 0.0228 | 0.0000 | 0.0226 | -0.0033 | -0.5274 | -0.0542 | -0.5265 | -0.0540 | -64.27 | -6.60 |
| 58 | -0.5307 | 0.0000 | 0.0769 | -0.5251 | 0.0228 | 0.0000 | 0.0226 | -0.0033 | -0.5284 | -0.0543 | -0.5279 | -0.0542 | -54.10 | -5.56 |
| 48 | -0.5312 | 0.0000 | 0.0770 | -0.5255 | 0.0228 | 0.0000 | 0.0226 | -0.0033 | -0.5289 | -0.0544 | -0.5286 | -0.0543 | -54.53 | -5.61 |
| 22 | -0.5303 | 0.0000 | 0.0768 | -0.5247 | 0.0228 | 0.0000 | 0.0226 | -0.0033 | -0.5280 | -0.0542 | -0.5284 | -0.0543 | -143.42 | -14.74 |
| 19 | -0.5300 | 0.0000 | 0.0768 | -0.5244 | 0.0228 | 0.0000 | 0.0226 | -0.0033 | -0.5277 | -0.0542 | -0.5279 | -0.0542 | -16.69 | -1.71 |
| 0 | -0.5273 | 0.0000 | 0.0764 | -0.5218 | 0.0228 | 0.0000 | 0.0226 | -0.0033 | -0.5251 | -0.0538 | -0.5264 | -0.0540 | -106.14 | -10.89 |
| | | | | | | | | | | | | Σ = | -1261.02 | -122.65 |
| | | | | | | | | | | | | LIFT calc = | -2522.03 | |
| | | | | | | | | | | | | Lift = | -2435.86 | |

SPANWISE AERODYNAMIC LOAD DISTRIBUTION

CONDITION. F cont..

| 1 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 |
|---|---|---|---|---|---|---|---|---|
| STATION | LIMIT | LIMIT | LIMIT | LIMIT | ULT | ULT | ULT | ULT |
| (in) | NORMAL | NORMAL | CHORD | CHORD | NORMAL | NORMAL | CHORD | CHORD |
| | SHEAR | MOMENT | SHEAR | MOMENT | SHEAR | MOMENT | SHEAR | MOMENT |
| | (lb) | (lb in) | (lb) | (lb in) | (lb) | (lb in) | (lb) | (lb in) |
| 258 | 0.00 | 0.00 | 0.00 | 0.00 | 0 | 0 | 0 | 0 |
| 251.25 | -18.48 | -62.37 | -0.90 | -3.05 | -28 | -94 | -1 | -5 |
| 238 | -65.11 | -616.12 | -4.09 | -36.12 | -98 | -924 | -6 | -54 |
| 228 | -104.11 | -1462.22 | -7.02 | -91.66 | -156 | -2193 | -11 | -137 |
| 218 | -145.53 | -2710.44 | -10.29 | -178.21 | -218 | -4066 | -15 | -267 |
| 208 | -188.94 | -4382.81 | -14.11 | -300.20 | -283 | -6574 | -21 | -450 |
| 198 | -234.09 | -6497.99 | -18.45 | -462.98 | -351 | -9747 | -28 | -694 |
| 188 | -280.83 | -9072.59 | -23.00 | -670.19 | -421 | -13609 | -34 | -1005 |
| 178 | -328.99 | -12121.66 | -27.74 | -923.89 | -493 | -18182 | -42 | -1386 |
| 163.65 | -400.32 | -17354.46 | -34.85 | -1372.96 | -600 | -26032 | -52 | -2059 |
| 159 | -421.43 | -19131.51 | -36.95 | -1528.22 | -632 | -28697 | -55 | -2292 |
| 155.00 | -441.88 | -20998.42 | -38.99 | -1692.45 | -663 | -31498 | -58 | -2539 |
| 138 | -524.00 | -29208.40 | -47.22 | -2425.20 | -786 | -43813 | -71 | -3638 |
| 128 | -573.57 | -34696.24 | -52.22 | -2922.40 | -860 | -52044 | -78 | -4384 |
| 118 | -623.95 | -40683.84 | -57.33 | -3470.17 | -936 | -61026 | -86 | -5205 |
| 108 | -675.11 | -47179.15 | -62.54 | -4069.50 | -1013 | -70769 | -94 | -6104 |
| 98 | -726.96 | -54189.47 | -67.83 | -4721.31 | -1090 | -81284 | -102 | -7082 |
| 88 | -779.45 | -61721.51 | -73.20 | -5426.42 | -1169 | -92582 | -110 | -8140 |
| 80.00 | -821.87 | -68126.80 | -77.54 | -6029.38 | -1233 | -102190 | -116 | -9044 |
| 68 | -886.14 | -78374.89 | -84.14 | -6999.47 | -1329 | -117562 | -126 | -10499 |
| 58 | -940.24 | -87506.81 | -89.70 | -7868.64 | -1410 | -131260 | -135 | -11803 |
| 48 | -994.77 | -97181.88 | -95.30 | -8793.63 | -1492 | -145773 | -143 | -13190 |
| 22 | -1138.19 | -124910.39 | -110.04 | -11463.08 | -1707 | -187366 | -165 | -17195 |
| 19 | -1154.88 | -128349.99 | -111.76 | -11795.78 | -1732 | -192525 | -168 | -17694 |
| 0 | -1261.02 | -151301.00 | -122.65 | -14022.59 | -1892 | -226951 | -184 | -21034 |
| | | | | | | | | |
| Centre of lift is | 120 | in from aircraft centreline | | | | | | |
| | 47 | % semispan | | | | | | |

| SPANWISE INERTIAL LOAD DISTRIBUTION | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CONDITION. F cont.. | | | | | | | | | | | | |
| 1 | 3 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 | 41 | 42 | 43 |
| STATION | dy | WEIGHT | ELEMENT | ELEMENT | LIMIT | LIMIT | LIMIT | LIMIT | ULT | ULT | ULT | ULT |
| (in) | (in) | nW | SHEAR | SHEAR | NORMAL | NORMAL | CHORD | CHORD | NORMAL | NORMAL | CHORD | CHORD |
| | | (lb) | FORCE | FORCE | SHEAR | MOMENT | SHEAR | MOMENT | SHEAR | MOMENT | SHEAR | MOMENT |
| | | | $V_x$ | $V_z$ | (lb) | (lb in) | (lb) | (lb in) | (lb) | (lb in) | (lb) | (lb in) |
| | | | (lb) | (lb) | | | | | | | | |
| 258 | - | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0 | 0 | 0 | 0 |
| 251.25 | 6.75 | 0.66 | 0.10 | 0.65 | 0.65 | 2.21 | 0.10 | 0.32 | 1 | 3 | 0 | 0 |
| 238 | 13.25 | 1.76 | 0.26 | 1.74 | 2.40 | 22.43 | 0.35 | 3.28 | 4 | 34 | 1 | 5 |
| 228 | 10.00 | 3.05 | 0.44 | 3.02 | 5.41 | 61.49 | 0.79 | 9.00 | 8 | 92 | 1 | 14 |
| 218 | 10.00 | 4.27 | 0.62 | 4.22 | 9.64 | 136.73 | 1.41 | 20.02 | 14 | 205 | 2 | 30 |
| 208 | 10.00 | 5.23 | 0.76 | 5.18 | 14.81 | 258.97 | 2.17 | 37.92 | 22 | 388 | 3 | 57 |
| 198 | 10.00 | 6.15 | 0.89 | 6.08 | 20.89 | 437.51 | 3.06 | 64.06 | 31 | 656 | 5 | 96 |
| 188 | 10.00 | 7.28 | 1.05 | 7.20 | 28.10 | 682.48 | 4.11 | 99.93 | 42 | 1024 | 6 | 150 |
| 178 | 10.00 | 8.25 | 1.19 | 8.16 | 36.26 | 1004.26 | 5.31 | 147.05 | 54 | 1506 | 8 | 221 |
| 163.65 | 14.35 | 9.48 | 1.37 | 9.38 | 45.64 | 1591.90 | 6.68 | 233.09 | 68 | 2388 | 10 | 350 |
| 159 | 4.33 | 9.79 | 1.42 | 9.68 | 55.33 | 1810.24 | 8.10 | 265.06 | 83 | 2715 | 12 | 398 |
| 155.00 | 4.32 | 10.19 | 1.48 | 10.09 | 65.41 | 2071.33 | 9.58 | 303.30 | 98 | 3107 | 14 | 455 |
| 138 | 17.00 | 10.70 | 1.55 | 10.59 | 76.00 | 3273.34 | 11.13 | 479.30 | 114 | 4910 | 17 | 719 |
| 128 | 10.00 | 10.87 | 1.58 | 10.76 | 86.76 | 4087.13 | 12.70 | 598.46 | 130 | 6131 | 19 | 898 |
| 118 | 10.00 | 11.18 | 1.62 | 11.06 | 97.82 | 5009.99 | 14.32 | 733.59 | 147 | 7515 | 21 | 1100 |
| 108 | 10.00 | 11.33 | 1.64 | 11.21 | 109.02 | 6044.19 | 15.96 | 885.02 | 164 | 9066 | 24 | 1328 |
| 98 | 10.00 | 11.51 | 1.67 | 11.39 | 120.42 | 7191.39 | 17.63 | 1053.00 | 181 | 10787 | 26 | 1580 |
| 88 | 10.00 | 11.97 | 1.73 | 11.85 | 132.26 | 8454.80 | 19.37 | 1238.00 | 198 | 12682 | 29 | 1857 |
| 80.00 | 8.00 | 12.23 | 1.77 | 12.10 | 144.36 | 9561.29 | 21.14 | 1400.01 | 217 | 14342 | 32 | 2100 |
| 68 | 12.00 | 12.68 | 1.84 | 12.55 | 156.91 | 11368.90 | 22.98 | 1664.70 | 235 | 17053 | 34 | 2497 |
| 58 | 10.00 | 13.00 | 1.88 | 12.87 | 169.78 | 13002.33 | 24.86 | 1903.87 | 255 | 19503 | 37 | 2856 |
| 48 | 10.00 | 13.51 | 1.96 | 13.37 | 183.15 | 14766.94 | 26.82 | 2162.26 | 275 | 22150 | 40 | 3243 |
| 22 | 26.00 | 14.48 | 2.10 | 14.33 | 197.47 | 19714.99 | 28.91 | 2886.77 | 296 | 29572 | 43 | 4330 |
| 19 | 3.00 | 7.29 | 1.06 | 7.21 | 204.69 | 20318.23 | 29.97 | 2975.10 | 307 | 30477 | 45 | 4463 |
| 0 | 19.00 | 4.86 | 0.70 | 4.81 | 209.50 | 24252.98 | 30.68 | 3551.25 | 314 | 36379 | 46 | 5327 |
| | Σ = | 125 | lb | | | | | | | | | |
| | | at 1 g | | | Centre of gravity is | 116 | in from aircraft centreline | | | | | |
| | | | | | | 45 | % semispan | | | | | |

COMBINED ULTIMATE LOADS ( AERODYNAMIC + INERTIAL )

CONDITION. F cont.

| 1 | 44 F | 45 F | 46 F | 47 F | 48 F | 49 F |
|---|---|---|---|---|---|---|
| | ULT | ULT | ULT | ULT | ULT | ULT |
| | NORMAL | NORMAL | CHORD | CHORD | RESOLVED | RESOLVED |
| STATION | SHEAR | BEND MOMENT | SHEAR | BEND MOMENT | SHEAR | BEND MOMENT |
| (in) | COND. F | COND. F | COND. F | COND. F | COND. F | COND. F |
| | (lb) | (lb in) | (lb) | (lb in) | (lb) | (lb in) |
| 258 | 0 | 0 | 0 | 0 | 0 | 0 |
| 251.25 | -27 | -90 | -1 | -4 | 27 | 90 |
| 238 | -94 | -891 | -6 | -49 | 94 | 892 |
| 228 | -148 | -2101 | -9 | -124 | 148 | 2105 |
| 218 | -204 | -3861 | -13 | -237 | 204 | 3868 |
| 208 | -261 | -6186 | -18 | -393 | 262 | 6198 |
| 198 | -320 | -9091 | -23 | -598 | 321 | 9110 |
| 188 | -379 | -12585 | -28 | -855 | 380 | 12614 |
| 178 | -439 | -16676 | -34 | -1165 | 440 | 16717 |
| 163.65 | -532 | -23644 | -42 | -1710 | 534 | 23706 |
| 159 | -549 | -25982 | -43 | -1895 | 551 | 26051 |
| 155.00 | -565 | -28391 | -44 | -2084 | 566 | 28467 |
| 138 | -672 | -38903 | -54 | -2919 | 674 | 39012 |
| 128 | -730 | -45914 | -59 | -3486 | 733 | 46046 |
| 118 | -789 | -53511 | -65 | -4105 | 792 | 53668 |
| 108 | -849 | -61702 | -70 | -4777 | 852 | 61887 |
| 98 | -910 | -70497 | -75 | -5502 | 913 | 70712 |
| 88 | -971 | -79900 | -81 | -6283 | 974 | 80147 |
| 80.00 | -1016 | -87848 | -85 | -6944 | 1020 | 88122 |
| 68 | -1094 | -100509 | -92 | -8002 | 1098 | 100827 |
| 58 | -1156 | -111757 | -97 | -8947 | 1160 | 112114 |
| 48 | -1217 | -123622 | -103 | -9947 | 1222 | 124022 |
| 22 | -1411 | -157793 | -122 | -12864 | 1416 | 158317 |
| 19 | -1425 | -162048 | -123 | -13231 | 1431 | 162587 |
| 0 | -1577 | -190572 | -138 | -15707 | 1583 | 191218 |

| AERODYNAMIC TORQUE AT SHEAR CENTRE | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| CONDITION. F | | | | | | | | | | |
| | | | | | | | | | | |
| 1 | 50 | 74 | 51 | 52 | 53 | 54 | 55 | 56 | 57 | 58 |
| STATION | CLEAN + FLAPPED | CLEAN + FLAPPED | LOCAL | AERO | X AC | -X SC | DELTA X | Z AC | Z SC | DELTA Z |
| | LOCAL | LOCAL | $X_{CP}$ | CENTRE | (in) | (in) | (in) | (in) | (in) | (in) |
| (in) | $C_L$ | $C_{Mo}$ | | (in) | | using 38% chord | | | | |
| 258 | - | -0.025 | - | 0.00 | 0.00 | 13.30 | 13.30 | 0.00 | 2.39 | -2.39 |
| 251.25 | -0.31 | 0.062 | 0.70 | 24.63 | 24.63 | 13.37 | -11.26 | 0.00 | 2.40 | -2.40 |
| 238 | -0.39 | 0.062 | 0.70 | 24.87 | 24.87 | 13.50 | -11.37 | 0.00 | 2.44 | -2.44 |
| 228 | -0.43 | 0.062 | 0.70 | 25.06 | 25.06 | 13.60 | -11.46 | 0.00 | 2.47 | -2.47 |
| 218 | -0.45 | 0.062 | 0.70 | 25.25 | 25.25 | 13.71 | -11.54 | 0.00 | 2.49 | -2.49 |
| 208 | -0.47 | 0.062 | 0.70 | 25.44 | 25.44 | 13.81 | -11.63 | 0.00 | 2.52 | -2.52 |
| 198 | -0.49 | 0.062 | 0.70 | 25.62 | 25.62 | 13.91 | -11.71 | 0.00 | 2.54 | -2.54 |
| 188 | -0.50 | 0.062 | 0.70 | 25.81 | 25.81 | 14.01 | -11.80 | 0.00 | 2.57 | -2.57 |
| 178 | -0.51 | 0.062 | 0.70 | 26.00 | 26.00 | 14.11 | -11.88 | 0.00 | 2.60 | -2.60 |
| 163.65 | -0.52 | 0.062 | 0.70 | 26.27 | 26.27 | 14.26 | -12.01 | 0.00 | 2.64 | -2.64 |
| 159 | -0.51 | -0.025 | 0.19 | 7.19 | 7.19 | 14.30 | 7.12 | 0.00 | 2.65 | -2.65 |
| 155.00 | -0.49 | -0.025 | 0.19 | 7.14 | 7.14 | 14.35 | 7.20 | 0.00 | 2.66 | -2.66 |
| 138 | -0.50 | -0.025 | 0.19 | 7.26 | 7.26 | 14.52 | 7.26 | 0.00 | 2.70 | -2.70 |
| 128 | -0.51 | -0.025 | 0.19 | 7.34 | 7.34 | 14.62 | 7.28 | 0.00 | 2.73 | -2.73 |
| 118 | -0.51 | -0.025 | 0.19 | 7.41 | 7.41 | 14.72 | 7.32 | 0.00 | 2.76 | -2.76 |
| 108 | -0.52 | -0.025 | 0.19 | 7.47 | 7.47 | 14.82 | 7.35 | 0.00 | 2.78 | -2.78 |
| 98 | -0.52 | -0.025 | 0.19 | 7.54 | 7.54 | 14.93 | 7.39 | 0.00 | 2.81 | -2.81 |
| 88 | -0.52 | -0.025 | 0.19 | 7.60 | 7.60 | 15.03 | 7.43 | 0.00 | 2.84 | -2.84 |
| 80.00 | -0.52 | -0.025 | 0.19 | 7.65 | 7.65 | 15.11 | 7.46 | 0.00 | 2.86 | -2.86 |
| 68 | -0.53 | -0.025 | 0.19 | 7.72 | 7.72 | 15.23 | 7.51 | 0.00 | 2.89 | -2.89 |
| 58 | -0.53 | -0.025 | 0.19 | 7.77 | 7.77 | 15.33 | 7.56 | 0.00 | 2.92 | -2.92 |
| 48 | -0.53 | -0.025 | 0.19 | 7.83 | 7.83 | 15.43 | 7.61 | 0.00 | 2.94 | -2.94 |
| 22 | -0.53 | -0.025 | 0.19 | 7.96 | 7.96 | 15.70 | 7.74 | 0.00 | 3.01 | -3.01 |
| 19 | -0.53 | -0.025 | 0.19 | 7.97 | 7.97 | 15.73 | 7.76 | 0.00 | 3.01 | -3.01 |
| 0 | -0.53 | -0.025 | 0.19 | 8.07 | 8.07 | 15.92 | 7.86 | 0.00 | 1.25 | -1.25 |

AERODYNAMIC TORQUE AT SHEAR CENTRE

CONDITION. F

$\Delta C_{Mo}$ = 0

| 1 | 55 | 56 | 23 | 24 | 59 | 75 | 60 | 61 | 62 | 63 | 64 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| STATION (in) | DELTA X av (in) | DELTA Z av (in) | SPAN ELEMENT LIFT (lb) | SPAN ELEMENT DRAG (lb) | ELEMENT TORQUE DUE TO $C_{Mo}$ (lb in) | ELEMENT TORQUE DUE TO $\Delta C_{Mo}$ (lb in) | ELEMENT TORQUE DUE TO LIFT (lb in) | ELEMENT TORQUE DUE TO DRAG (lb in) | ELEMENT LIMIT TORQUE (lb in) | TOTAL LIMIT TORQUE (lb in) | TOTAL ULT TORQUE (lb in) |
| 258 | - | - | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 251.25 | - | 0.00 | -18.48 | -0.90 | -52.95 | 183.56 | 0.00 | 0.00 | 130.61 | 130.61 | 195.91 |
| 238 | -11.31 | 0.00 | -46.63 | -3.18 | -105.53 | 365.83 | 527.57 | 0.00 | 787.87 | 918.48 | 1377.71 |
| 228 | -11.41 | 0.00 | -39.01 | -2.94 | -81.05 | 280.97 | 445.22 | 0.00 | 645.15 | 1563.62 | 2345.43 |
| 218 | -11.50 | 0.00 | -41.42 | -3.27 | -82.27 | 285.20 | 476.28 | 0.00 | 679.21 | 2242.83 | 3364.25 |
| 208 | -11.59 | 0.00 | -43.41 | -3.82 | -83.50 | 289.46 | 502.94 | 0.00 | 708.91 | 2951.74 | 4427.61 |
| 198 | -11.67 | 0.00 | -45.15 | -4.34 | -84.74 | 293.76 | 526.94 | 0.00 | 735.95 | 3687.70 | 5531.55 |
| 188 | -11.76 | 0.00 | -46.73 | -4.55 | -85.98 | 298.08 | 549.41 | 0.00 | 761.50 | 4449.20 | 6673.80 |
| 178 | -11.84 | 0.00 | -48.16 | -4.74 | -87.24 | 302.44 | 570.31 | 0.00 | 785.51 | 5234.71 | 7852.06 |
| 163.65 | -11.95 | 0.00 | -71.33 | -7.10 | -127.40 | 441.67 | 852.17 | 0.00 | 1166.43 | 6401.14 | 9601.71 |
| 159 | -2.45 | 0.00 | -21.11 | -2.11 | -38.91 | 0.00 | 51.64 | 0.00 | 12.73 | 6413.87 | 9620.80 |
| 155.00 | 7.16 | 0.00 | -20.44 | -2.03 | -39.15 | 0.00 | -146.36 | 0.00 | -185.51 | 6228.35 | 9342.53 |
| 138 | 7.23 | 0.00 | -82.13 | -8.23 | -156.24 | 0.00 | -594.06 | 0.00 | -750.30 | 5478.05 | 8217.08 |
| 128 | 7.27 | 0.00 | -49.56 | -5.00 | -93.66 | 0.00 | -360.47 | 0.00 | -454.13 | 5023.92 | 7535.88 |
| 118 | 7.30 | 0.00 | -50.39 | -5.11 | -94.97 | 0.00 | -367.81 | 0.00 | -462.78 | 4561.14 | 6841.71 |
| 108 | 7.33 | 0.00 | -51.15 | -5.20 | -96.29 | 0.00 | -375.09 | 0.00 | -471.39 | 4089.76 | 6134.64 |
| 98 | 7.37 | 0.00 | -51.85 | -5.29 | -97.62 | 0.00 | -382.11 | 0.00 | -479.73 | 3610.02 | 5415.04 |
| 88 | 7.41 | 0.00 | -52.49 | -5.37 | -98.96 | 0.00 | -388.88 | 0.00 | -487.84 | 3122.19 | 4683.28 |
| 80.00 | 7.44 | 0.00 | -42.42 | -4.35 | -80.14 | 0.00 | -315.80 | 0.00 | -395.93 | 2726.25 | 4089.38 |
| 68 | 7.49 | 0.00 | -64.27 | -6.60 | -121.83 | 0.00 | -481.24 | 0.00 | -603.08 | 2123.17 | 3184.76 |
| 58 | 7.54 | 0.00 | -54.10 | -5.56 | -103.03 | 0.00 | -407.74 | 0.00 | -510.77 | 1612.41 | 2418.61 |
| 48 | 7.58 | 0.00 | -54.53 | -5.61 | -104.40 | 0.00 | -413.54 | 0.00 | -517.94 | 1094.47 | 1641.70 |
| 22 | 7.67 | 0.00 | -143.42 | -14.74 | -277.95 | 0.00 | -1100.39 | 0.00 | -1378.34 | -283.87 | -425.81 |
| 19 | 7.75 | 0.00 | -16.69 | -1.71 | -32.68 | 0.00 | -129.27 | 0.00 | -161.95 | -445.82 | -668.73 |
| 0 | 7.81 | 0.00 | -106.14 | -10.89 | -209.93 | 0.00 | -828.49 | 0.00 | -1038.42 | -1484.24 | -2226.36 |

| DEAD WEIGHT ANALYSIS FOR WING TORQUE | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| CONDITION. F | | | | | | | | |
| 1 | 65 | 54 | 66 | 67 | 33 | 68 | 69 | 70 |
| STATION | X CG | X SC | DELTA | DELTA | ELEMENT | ELEMENT | TOTAL | TOTAL |
| | (in) | (in) | X | X av | LOAD | LIMIT | LIMIT | ULT |
| (in) | | | (in) | (in) | (lb) | TORQUE | TORQUE | TORQUE |
| | using 40% chord | | | | | (lb in) | (lb in) | (lb in) |
| 258 | 14.00 | 13.30 | -0.70 | - | - | - | - | 0.00 |
| 251.25 | 14.07 | 13.37 | -0.70 | -0.70 | 0.66 | -0.46 | -0.46 | -0.70 |
| 238 | 14.21 | 13.50 | -0.71 | -0.71 | 1.76 | -1.25 | -1.71 | -2.56 |
| 228 | 14.32 | 13.60 | -0.72 | -0.71 | 3.05 | -2.17 | -3.88 | -5.83 |
| 218 | 14.43 | 13.71 | -0.72 | -0.72 | 4.27 | -3.07 | -6.95 | -10.43 |
| 208 | 14.53 | 13.81 | -0.73 | -0.72 | 5.23 | -3.79 | -10.74 | -16.11 |
| 198 | 14.64 | 13.91 | -0.73 | -0.73 | 6.15 | -4.48 | -15.22 | -22.84 |
| 188 | 14.75 | 14.01 | -0.74 | -0.73 | 7.28 | -5.35 | -20.57 | -30.86 |
| 178 | 14.86 | 14.11 | -0.74 | -0.74 | 8.25 | -6.10 | -26.68 | -40.02 |
| 163.65 | 15.01 | 14.26 | -0.75 | -0.75 | 9.48 | -7.08 | -33.76 | -50.64 |
| 159 | 15.06 | 14.30 | -0.75 | -0.75 | 9.79 | -7.36 | -41.11 | -61.67 |
| 155.00 | 15.10 | 14.35 | -0.76 | -0.75 | 10.19 | -7.69 | -48.80 | -73.20 |
| 138 | 15.28 | 14.52 | -0.76 | -0.76 | 10.70 | -8.13 | -56.93 | -85.39 |
| 128 | 15.39 | 14.62 | -0.77 | -0.77 | 10.87 | -8.34 | -65.27 | -97.90 |
| 118 | 15.50 | 14.72 | -0.77 | -0.77 | 11.18 | -8.63 | -73.90 | -110.84 |
| 108 | 15.60 | 14.82 | -0.78 | -0.78 | 11.33 | -8.81 | -82.70 | -124.06 |
| 98 | 15.71 | 14.93 | -0.79 | -0.78 | 11.51 | -9.01 | -91.72 | -137.58 |
| 88 | 15.82 | 15.03 | -0.79 | -0.79 | 11.97 | -9.44 | -101.16 | -151.73 |
| 80.00 | 15.90 | 15.11 | -0.80 | -0.79 | 12.23 | -9.70 | -110.85 | -166.28 |
| 68 | 16.03 | 15.23 | -0.80 | -0.80 | 12.68 | -10.13 | -120.98 | -181.47 |
| 58 | 16.14 | 15.33 | -0.81 | -0.80 | 13.00 | -10.46 | -131.44 | -197.16 |
| 48 | 16.25 | 15.43 | -0.81 | -0.81 | 13.51 | -10.94 | -142.38 | -213.57 |
| 22 | 16.52 | 15.70 | -0.83 | -0.82 | 14.48 | -11.86 | -154.24 | -231.36 |
| 19 | 16.56 | 15.73 | -0.83 | -0.83 | 7.29 | -6.03 | -160.27 | -240.41 |
| 0 | 16.76 | 15.92 | -0.84 | -0.83 | 4.86 | -4.05 | -164.32 | -246.48 |

| COMBINED ULTIMATE TORSION ( AERODYNAMIC + INERTIAL ) | | | |
|---|---|---|---|
| CONDITION. F | | | |
| | | | |
| 1 | 71 F | | |
| STATION | COND. F | | |
| (in) | (lb in) | | |
| 258 | 0 | | |
| 251.25 | 195 | | |
| 238 | 1375 | | |
| 228 | 2340 | | |
| 218 | 3354 | | |
| 208 | 4412 | | |
| 198 | 5509 | | |
| 188 | 6643 | | |
| 178 | 7812 | | |
| 163.65 | 9551 | | |
| 159 | 9559 | | |
| 155.00 | 9269 | | |
| 138 | 8132 | | |
| 128 | 7438 | | |
| 118 | 6731 | | |
| 108 | 6011 | | |
| 98 | 5277 | | |
| 88 | 4532 | | |
| 80.00 | 3923 | | |
| 68 | 3003 | | |
| 58 | 2221 | | |
| 48 | 1428 | | |
| 22 | -657 | | |
| 19 | -909 | | |
| 0 | -2473 | | |

| SPANWISE AERODYNAMIC LOAD DISTRIBUTION | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CONDITION. F 2/3 n | | | | | | | | | Aileron deflection = | DWN | | | | |
| AILERON DOWN | | | | | | | | | Aileron angle = | 19.00 | deg | | | |
| | | | | | | | | | Aileron load = | 43.01 | lb | ECF = | 0.24 | |
| $V_{ssl}$ = | 175.68 | ft/s | $C_L$ = | -0.5 | | alpha wrp = | -8.3304 | | $\Delta C_L$ = | 0.25 | | | | |
| Lift = | -2435.86 | lb clean | $C_{Do}$ = | 0.017 | | sin alpha = | -0.1449 | | $\Delta C_D$ = | 0.01 | | | | |
| q = | 36.69 | psf | $C_D$ = | 0.024 | | cos alpha = | 0.9894 | | $\Delta C_{Mo}$ = | -0.19 | | | | |
| n = | -1.69 | g | $C_{Mo}$ = | -0.025 | | | | | S = | 4.71 | ft² | | | |
| $q.C_L$ = | -18.04 | $q.C_L$ = Lift/S | S = | 135.00 | ft² | | | | b = | 7.30 | ft | | | |
| | | | b = | 43.00 | ft | | | | AR = | 11.31 | | | | |
| 1 | 13 | 72 | 14 | 15 | 16 | 73 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 |
| STATION | $C_L$ | FLAP | $C_{Lz}$ | $C_{Lx}$ | $C_D$ | FLAP | $C_{Dz}$ | $C_{Dx}$ | $C_{Lx}+C_{Dx}$ | $C_{Dz}-C_{Lx}$ | $(C_{Lx}+C_{Dx})_{AV}$ | $(C_{Dz}-C_{Lx})_{AV}$ | SPAN | SPAN |
| (in) | | $C_L$ | | | | $C_D$ | | | | | | | ELEMENT | ELEMENT |
| | | | | | | | | | | | | | LIFT | DRAG |
| | | | | | | | | | | | | | (lb) | (lb) |
| 258 | -0.2459 | 0.0000 | 0.0356 | -0.2433 | 0.0288 | 0.0000 | 0.0285 | -0.0042 | -0.2474 | -0.0071 | - | - | 0.00 | 0.00 |
| 251.25 | -0.3220 | 0.0587 | 0.0381 | -0.2605 | 0.0288 | 0.0019 | 0.0304 | -0.0045 | -0.2650 | -0.0077 | -0.2562 | -0.0074 | -15.46 | -0.45 |
| 238 | -0.3740 | 0.0587 | 0.0457 | -0.3119 | 0.0288 | 0.0019 | 0.0304 | -0.0045 | -0.3164 | -0.0152 | -0.2907 | -0.0115 | -34.70 | -1.37 |
| 228 | -0.4000 | 0.0587 | 0.0494 | -0.3377 | 0.0288 | 0.0019 | 0.0304 | -0.0045 | -0.3422 | -0.0190 | -0.3293 | -0.0171 | -29.93 | -1.56 |
| 218 | -0.4207 | 0.0587 | 0.0524 | -0.3582 | 0.0288 | 0.0019 | 0.0304 | -0.0045 | -0.3626 | -0.0220 | -0.3524 | -0.0205 | -32.27 | -1.88 |
| 208 | -0.4379 | 0.0587 | 0.0549 | -0.3752 | 0.0228 | 0.0019 | 0.0245 | -0.0036 | -0.3787 | -0.0304 | -0.3707 | -0.0262 | -34.20 | -2.42 |
| 198 | -0.4524 | 0.0587 | 0.0570 | -0.3895 | 0.0228 | 0.0019 | 0.0245 | -0.0036 | -0.3931 | -0.0325 | -0.3859 | -0.0315 | -35.87 | -2.93 |
| 188 | -0.4649 | 0.0587 | 0.0588 | -0.4019 | 0.0228 | 0.0019 | 0.0245 | -0.0036 | -0.4055 | -0.0344 | -0.3993 | -0.0335 | -37.38 | -3.13 |
| 178 | -0.4757 | 0.0587 | 0.0604 | -0.4126 | 0.0228 | 0.0019 | 0.0245 | -0.0036 | -0.4162 | -0.0359 | -0.4108 | -0.0351 | -38.74 | -3.31 |
| 163.65 | -0.4888 | 0.0587 | 0.0623 | -0.4256 | 0.0228 | 0.0019 | 0.0245 | -0.0036 | -0.4292 | -0.0378 | -0.4227 | -0.0369 | -57.70 | -5.03 |
| 159 | -0.4923 | 0.0000 | 0.0713 | -0.4871 | 0.0228 | 0.0000 | 0.0226 | -0.0033 | -0.4904 | -0.0487 | -0.4598 | -0.0433 | -19.04 | -1.79 |
| 155.00 | -0.4956 | 0.0000 | 0.0718 | -0.4903 | 0.0228 | 0.0000 | 0.0226 | -0.0033 | -0.4936 | -0.0492 | -0.4920 | -0.0490 | -20.44 | -2.03 |
| 138 | -0.5066 | 0.0000 | 0.0734 | -0.5013 | 0.0228 | 0.0000 | 0.0226 | -0.0033 | -0.5046 | -0.0508 | -0.4991 | -0.0500 | -82.13 | -8.23 |
| 128 | -0.5120 | 0.0000 | 0.0742 | -0.5066 | 0.0228 | 0.0000 | 0.0226 | -0.0033 | -0.5099 | -0.0516 | -0.5072 | -0.0512 | -49.56 | -5.00 |
| 118 | -0.5165 | 0.0000 | 0.0748 | -0.5111 | 0.0228 | 0.0000 | 0.0226 | -0.0033 | -0.5144 | -0.0523 | -0.5121 | -0.0519 | -50.39 | -5.11 |
| 108 | -0.5204 | 0.0000 | 0.0754 | -0.5149 | 0.0228 | 0.0000 | 0.0226 | -0.0033 | -0.5182 | -0.0528 | -0.5163 | -0.0525 | -51.15 | -5.20 |
| 98 | -0.5236 | 0.0000 | 0.0759 | -0.5181 | 0.0228 | 0.0000 | 0.0226 | -0.0033 | -0.5214 | -0.0533 | -0.5198 | -0.0530 | -51.85 | -5.29 |
| 88 | -0.5262 | 0.0000 | 0.0762 | -0.5206 | 0.0228 | 0.0000 | 0.0226 | -0.0033 | -0.5239 | -0.0537 | -0.5227 | -0.0535 | -52.49 | -5.37 |
| 80.00 | -0.5279 | 0.0000 | 0.0765 | -0.5223 | 0.0228 | 0.0000 | 0.0226 | -0.0033 | -0.5256 | -0.0539 | -0.5248 | -0.0538 | -42.42 | -4.35 |
| 68 | -0.5297 | 0.0000 | 0.0767 | -0.5241 | 0.0228 | 0.0000 | 0.0226 | -0.0033 | -0.5274 | -0.0542 | -0.5265 | -0.0540 | -64.27 | -6.60 |
| 58 | -0.5307 | 0.0000 | 0.0769 | -0.5251 | 0.0228 | 0.0000 | 0.0226 | -0.0033 | -0.5284 | -0.0543 | -0.5279 | -0.0542 | -54.10 | -5.56 |
| 48 | -0.5312 | 0.0000 | 0.0770 | -0.5255 | 0.0228 | 0.0000 | 0.0226 | -0.0033 | -0.5289 | -0.0544 | -0.5286 | -0.0543 | -54.53 | -5.61 |
| 22 | -0.5303 | 0.0000 | 0.0768 | -0.5247 | 0.0228 | 0.0000 | 0.0226 | -0.0033 | -0.5280 | -0.0542 | -0.5284 | -0.0543 | -143.42 | -14.74 |
| 19 | -0.5300 | 0.0000 | 0.0768 | -0.5244 | 0.0228 | 0.0000 | 0.0226 | -0.0033 | -0.5277 | -0.0542 | -0.5279 | -0.0542 | -16.69 | -1.71 |
| 0 | -0.5273 | 0.0000 | 0.0764 | -0.5218 | 0.0228 | 0.0000 | 0.0226 | -0.0033 | -0.5251 | -0.0538 | -0.5264 | -0.0540 | -106.14 | -10.89 |
| | | | | | | | | | | | | Σ = | -1174.88 | -109.56 |
| | | | | | | | | | | | | LIFT calc = | -2349.76 | |
| | | | | | | | | | | | | Lift = | -2435.86 | |

SPANWISE AERODYNAMIC LOAD DISTRIBUTION

CONDITION. F cont..

| 1 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 |
|---|---|---|---|---|---|---|---|---|
| STATION | LIMIT | LIMIT | LIMIT | LIMIT | ULT | ULT | ULT | ULT |
| (in) | NORMAL | NORMAL | CHORD | CHORD | NORMAL | NORMAL | CHORD | CHORD |
| | SHEAR | MOMENT | SHEAR | MOMENT | SHEAR | MOMENT | SHEAR | MOMENT |
| | (lb) | (lb in) | (lb) | (lb in) | (lb) | (lb in) | (lb) | (lb in) |
| 258 | 0.00 | 0.00 | 0.00 | 0.00 | 0 | 0 | 0 | 0 |
| 251.25 | -15.46 | -52.19 | -0.45 | -1.51 | -23 | -78 | -1 | -2 |
| 238 | -50.17 | -487.00 | -1.82 | -16.51 | -75 | -731 | -3 | -25 |
| 228 | -80.10 | -1138.32 | -3.37 | -42.46 | -120 | -1707 | -5 | -64 |
| 218 | -112.37 | -2100.62 | -5.25 | -85.59 | -169 | -3151 | -8 | -128 |
| 208 | -146.56 | -3395.27 | -7.67 | -150.21 | -220 | -5093 | -12 | -225 |
| 198 | -182.43 | -5040.24 | -10.60 | -241.56 | -274 | -7560 | -16 | -362 |
| 188 | -219.81 | -7051.46 | -13.73 | -363.21 | -330 | -10577 | -21 | -545 |
| 178 | -258.55 | -9443.29 | -17.04 | -517.08 | -388 | -14165 | -26 | -776 |
| 163.65 | -316.25 | -13567.53 | -22.08 | -797.77 | -474 | -20351 | -33 | -1197 |
| 159 | -335.30 | -14976.51 | -23.87 | -897.14 | -503 | -22465 | -36 | -1346 |
| 155.00 | -355.74 | -16470.88 | -25.91 | -1004.77 | -534 | -24706 | -39 | -1507 |
| 138 | -437.87 | -23216.52 | -34.14 | -1515.12 | -657 | -34825 | -51 | -2273 |
| 128 | -487.43 | -27842.99 | -39.14 | -1881.49 | -731 | -41764 | -59 | -2822 |
| 118 | -537.82 | -32969.21 | -44.25 | -2298.42 | -807 | -49454 | -66 | -3448 |
| 108 | -588.97 | -38603.14 | -49.45 | -2766.92 | -883 | -57905 | -74 | -4150 |
| 98 | -640.82 | -44752.09 | -54.74 | -3287.90 | -961 | -67128 | -82 | -4932 |
| 88 | -693.31 | -51422.75 | -60.11 | -3862.18 | -1040 | -77134 | -90 | -5793 |
| 80.00 | -735.73 | -57138.94 | -64.46 | -4360.47 | -1104 | -85708 | -97 | -6541 |
| 68 | -800.01 | -66353.39 | -71.06 | -5173.57 | -1200 | -99530 | -107 | -7760 |
| 58 | -854.10 | -74623.93 | -76.61 | -5911.91 | -1281 | -111936 | -115 | -8868 |
| 48 | -908.63 | -83437.62 | -82.22 | -6706.07 | -1363 | -125156 | -123 | -10059 |
| 22 | -1052.05 | -108926.57 | -96.96 | -9035.36 | -1578 | -163390 | -145 | -13553 |
| 19 | -1068.74 | -112107.76 | -98.67 | -9328.80 | -1603 | -168162 | -148 | -13993 |
| 0 | -1174.88 | -133422.15 | -109.56 | -11307.04 | -1762 | -200133 | -164 | -16961 |
| | | | | | | | | |
| Centre of lift is | 114 | in from aircraft centreline | | | | | | |
| | 44 | % semispan | | | | | | |

SPANWISE INERTIAL LOAD DISTRIBUTION
CONDITION. F cont..

| 1 | 3 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 | 41 | 42 | 43 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| STATION | dy | WEIGHT | ELEMENT | ELEMENT | LIMIT | LIMIT | LIMIT | LIMIT | ULT | ULT | ULT | ULT |
| (in) | (in) | nW | SHEAR | SHEAR | NORMAL | NORMAL | CHORD | CHORD | NORMAL | NORMAL | CHORD | CHORD |
| | | (lb) | FORCE | FORCE | SHEAR | MOMENT | SHEAR | MOMENT | SHEAR | MOMENT | SHEAR | MOMENT |
| | | | $V_x$ | $V_z$ | (lb) | (lb in) | (lb) | (lb in) | (lb) | (lb in) | (lb) | (lb in) |
| | | | (lb) | (lb) | | | | | | | | |
| 258 | - | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0 | 0 | 0 | 0 |
| 251.25 | 6.75 | 0.66 | 0.10 | 0.65 | 0.65 | 2.21 | 0.10 | 0.32 | 1 | 3 | 0 | 0 |
| 238 | 13.25 | 1.76 | 0.26 | 1.74 | 2.40 | 22.43 | 0.35 | 3.28 | 4 | 34 | 1 | 5 |
| 228 | 10.00 | 3.05 | 0.44 | 3.02 | 5.41 | 61.49 | 0.79 | 9.00 | 8 | 92 | 1 | 14 |
| 218 | 10.00 | 4.27 | 0.62 | 4.22 | 9.64 | 136.73 | 1.41 | 20.02 | 14 | 205 | 2 | 30 |
| 208 | 10.00 | 5.23 | 0.76 | 5.18 | 14.81 | 258.97 | 2.17 | 37.92 | 22 | 388 | 3 | 57 |
| 198 | 10.00 | 6.15 | 0.89 | 6.08 | 20.89 | 437.51 | 3.06 | 64.06 | 31 | 656 | 5 | 96 |
| 188 | 10.00 | 7.28 | 1.05 | 7.20 | 28.10 | 682.48 | 4.11 | 99.93 | 42 | 1024 | 6 | 150 |
| 178 | 10.00 | 8.25 | 1.19 | 8.16 | 36.26 | 1004.26 | 5.31 | 147.05 | 54 | 1506 | 8 | 221 |
| 163.65 | 14.35 | 9.48 | 1.37 | 9.38 | 45.64 | 1591.90 | 6.68 | 233.09 | 68 | 2388 | 10 | 350 |
| 159 | 4.33 | 9.79 | 1.42 | 9.68 | 55.33 | 1810.24 | 8.10 | 265.06 | 83 | 2715 | 12 | 398 |
| 155.00 | 4.32 | 10.19 | 1.48 | 10.09 | 65.41 | 2071.33 | 9.58 | 303.30 | 98 | 3107 | 14 | 455 |
| 138 | 17.00 | 10.70 | 1.55 | 10.59 | 76.00 | 3273.34 | 11.13 | 479.30 | 114 | 4910 | 17 | 719 |
| 128 | 10.00 | 10.87 | 1.58 | 10.76 | 86.76 | 4087.13 | 12.70 | 598.46 | 130 | 6131 | 19 | 898 |
| 118 | 10.00 | 11.18 | 1.62 | 11.06 | 97.82 | 5009.99 | 14.32 | 733.59 | 147 | 7515 | 21 | 1100 |
| 108 | 10.00 | 11.33 | 1.64 | 11.21 | 109.02 | 6044.19 | 15.96 | 885.02 | 164 | 9066 | 24 | 1328 |
| 98 | 10.00 | 11.51 | 1.67 | 11.39 | 120.42 | 7191.39 | 17.63 | 1053.00 | 181 | 10787 | 26 | 1580 |
| 88 | 10.00 | 11.97 | 1.73 | 11.85 | 132.26 | 8454.80 | 19.37 | 1238.00 | 198 | 12682 | 29 | 1857 |
| 80.00 | 8.00 | 12.23 | 1.77 | 12.10 | 144.36 | 9561.29 | 21.14 | 1400.01 | 217 | 14342 | 32 | 2100 |
| 68 | 12.00 | 12.68 | 1.84 | 12.55 | 156.91 | 11368.90 | 22.98 | 1664.70 | 235 | 17053 | 34 | 2497 |
| 58 | 10.00 | 13.00 | 1.88 | 12.87 | 169.78 | 13002.33 | 24.86 | 1903.87 | 255 | 19503 | 37 | 2856 |
| 48 | 10.00 | 13.51 | 1.96 | 13.37 | 183.15 | 14766.94 | 26.82 | 2162.26 | 275 | 22150 | 40 | 3243 |
| 22 | 26.00 | 14.48 | 2.10 | 14.33 | 197.47 | 19714.99 | 28.91 | 2886.77 | 296 | 29572 | 43 | 4330 |
| 19 | 3.00 | 7.29 | 1.06 | 7.21 | 204.69 | 20318.23 | 29.97 | 2975.10 | 307 | 30477 | 45 | 4463 |
| 0 | 19.00 | 4.86 | 0.70 | 4.81 | 209.50 | 24252.98 | 30.68 | 3551.25 | 314 | 36379 | 46 | 5327 |
| | Σ= | 125 | lb | | | | | | | | | |
| | | at 1 g | | | Centre of gravity is | 116 | in from aircraft centreline | | | | | |
| | | | | | | 45 | % semispan | | | | | |

COMBINED ULTIMATE LOADS ( AERODYNAMIC + INERTIAL )

CONDITION. F cont..

| 1 | 44 F | 45 F | 46 F | 47 F | 48 F | 49 F |
|---|---|---|---|---|---|---|
| | ULT | ULT | ULT | ULT | ULT | ULT |
| | NORMAL | NORMAL | CHORD | CHORD | RESOLVED | RESOLVED |
| STATION | SHEAR | BEND MOMENT | SHEAR | BEND MOMENT | SHEAR | BEND MOMENT |
| (in) | COND. F | COND. F | COND. F | COND. F | COND. F | COND. F |
| | (lb) | (lb in) | (lb) | (lb in) | (lb) | (lb in) |
| 258 | 0 | 0 | 0 | 0 | 0 | 0 |
| 251.25 | -22 | -75 | -1 | -2 | 22 | 75 |
| 238 | -72 | -697 | -2 | -20 | 72 | 697 |
| 228 | -112 | -1615 | -4 | -50 | 112 | 1616 |
| 218 | -154 | -2946 | -6 | -98 | 154 | 2947 |
| 208 | -198 | -4704 | -8 | -168 | 198 | 4707 |
| 198 | -242 | -6904 | -11 | -266 | 243 | 6909 |
| 188 | -288 | -9553 | -14 | -395 | 288 | 9562 |
| 178 | -333 | -12659 | -18 | -555 | 334 | 12671 |
| 163.65 | -406 | -17963 | -23 | -847 | 407 | 17983 |
| 159 | -420 | -19749 | -24 | -948 | 421 | 19772 |
| 155.00 | -435 | -21599 | -24 | -1052 | 436 | 21625 |
| 138 | -543 | -29915 | -35 | -1554 | 544 | 29955 |
| 128 | -601 | -35634 | -40 | -1925 | 602 | 35686 |
| 118 | -660 | -41939 | -45 | -2347 | 662 | 42004 |
| 108 | -720 | -48838 | -50 | -2823 | 722 | 48920 |
| 98 | -781 | -56341 | -56 | -3352 | 783 | 56441 |
| 88 | -842 | -64452 | -61 | -3936 | 844 | 64572 |
| 80.00 | -887 | -71366 | -65 | -4441 | 889 | 71505 |
| 68 | -965 | -82477 | -72 | -5263 | 967 | 82645 |
| 58 | -1026 | -92432 | -78 | -6012 | 1029 | 92628 |
| 48 | -1088 | -103006 | -83 | -6816 | 1091 | 103231 |
| 22 | -1282 | -133817 | -102 | -9223 | 1286 | 134135 |
| 19 | -1296 | -137684 | -103 | -9531 | 1300 | 138014 |
| 0 | -1448 | -163754 | -118 | -11634 | 1453 | 164166 |

AERODYNAMIC TORQUE AT SHEAR CENTRE
CONDITION. F cont..

| 1 | 50 | 74 | 51 | 52 | 53 | 54 | 55 | 56 | 57 | 58 |
|---|---|---|---|---|---|---|---|---|---|---|
| STATION | CLEAN + FLAPPED | CLEAN + FLAPPED | LOCAL | AERO | X AC | X SC | DELTA X | Z AC | Z SC | DELTA Z |
| | LOCAL | LOCAL | $X_{CP}$ | CENTRE | (in) | (in) | (in) | (in) | (in) | (in) |
| (in) | $C_L$ | $C_{Mo}$ | | (in) | | using 38% chord | | | | |
| 258 | - | -0.025 | - | 0.00 | 0.00 | 13.30 | 13.30 | 0.00 | 2.39 | -2.39 |
| 251.25 | -0.26 | -0.215 | 0.70 | 24.63 | 24.63 | 13.37 | -11.26 | 0.00 | 2.40 | -2.40 |
| 238 | -0.29 | -0.215 | 0.70 | 24.87 | 24.87 | 13.50 | -11.37 | 0.00 | 2.44 | -2.44 |
| 228 | -0.33 | -0.215 | 0.70 | 25.06 | 25.06 | 13.60 | -11.46 | 0.00 | 2.47 | -2.47 |
| 218 | -0.35 | -0.215 | 0.70 | 25.25 | 25.25 | 13.71 | -11.54 | 0.00 | 2.49 | -2.49 |
| 208 | -0.37 | -0.215 | 0.70 | 25.44 | 25.44 | 13.81 | -11.63 | 0.00 | 2.52 | -2.52 |
| 198 | -0.39 | -0.215 | 0.70 | 25.62 | 25.62 | 13.91 | -11.71 | 0.00 | 2.54 | -2.54 |
| 188 | -0.40 | -0.215 | 0.70 | 25.81 | 25.81 | 14.01 | -11.80 | 0.00 | 2.57 | -2.57 |
| 178 | -0.41 | -0.215 | 0.70 | 26.00 | 26.00 | 14.11 | -11.88 | 0.00 | 2.60 | -2.60 |
| 163.65 | -0.42 | -0.215 | 0.70 | 26.27 | 26.27 | 14.26 | -12.01 | 0.00 | 2.64 | -2.64 |
| 159 | -0.46 | -0.025 | 0.19 | 6.99 | 6.99 | 14.30 | 7.32 | 0.00 | 2.65 | -2.65 |
| 155.00 | -0.49 | -0.025 | 0.19 | 7.14 | 7.14 | 14.35 | 7.20 | 0.00 | 2.66 | -2.66 |
| 138 | -0.50 | -0.025 | 0.19 | 7.26 | 7.26 | 14.52 | 7.26 | 0.00 | 2.70 | -2.70 |
| 128 | -0.51 | -0.025 | 0.19 | 7.34 | 7.34 | 14.62 | 7.28 | 0.00 | 2.73 | -2.73 |
| 118 | -0.51 | -0.025 | 0.19 | 7.41 | 7.41 | 14.72 | 7.32 | 0.00 | 2.76 | -2.76 |
| 108 | -0.52 | -0.025 | 0.19 | 7.47 | 7.47 | 14.82 | 7.35 | 0.00 | 2.78 | -2.78 |
| 98 | -0.52 | -0.025 | 0.19 | 7.54 | 7.54 | 14.93 | 7.39 | 0.00 | 2.81 | -2.81 |
| 88 | -0.52 | -0.025 | 0.19 | 7.60 | 7.60 | 15.03 | 7.43 | 0.00 | 2.84 | -2.84 |
| 80.00 | -0.52 | -0.025 | 0.19 | 7.65 | 7.65 | 15.11 | 7.46 | 0.00 | 2.86 | -2.86 |
| 68 | -0.53 | -0.025 | 0.19 | 7.72 | 7.72 | 15.23 | 7.51 | 0.00 | 2.89 | -2.89 |
| 58 | -0.53 | -0.025 | 0.19 | 7.77 | 7.77 | 15.33 | 7.56 | 0.00 | 2.92 | -2.92 |
| 48 | -0.53 | -0.025 | 0.19 | 7.83 | 7.83 | 15.43 | 7.61 | 0.00 | 2.94 | -2.94 |
| 22 | -0.53 | -0.025 | 0.19 | 7.96 | 7.96 | 15.70 | 7.74 | 0.00 | 3.01 | -3.01 |
| 19 | -0.53 | -0.025 | 0.19 | 7.97 | 7.97 | 15.73 | 7.76 | 0.00 | 3.01 | -3.01 |
| 0 | -0.53 | -0.025 | 0.19 | 8.07 | 8.07 | 15.92 | 7.86 | 0.00 | 1.25 | -1.25 |

AERODYNAMIC TORQUE AT SHEAR CENTRE

CONDITION. F cont..

| | | | | | | $\Delta C_{Mo}$ 0 | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 55 | 56 | 23 | 24 | 59 | 75 | 60 | 61 | 62 | 63 | 64 |
| STATION | DELTA | DELTA | SPAN | SPAN | ELEMENT | ELEMENT | ELEMENT | ELEMENT | ELEMENT | TOTAL | TOTAL |
| | X av | Z av | ELEMENT | ELEMENT | TORQUE | TORQUE | TORQUE | TORQUE | LIMIT | LIMIT | ULT |
| (in) | (in) | (in) | LIFT | DRAG | DUE TO | DUE TO | DUE TO | DUE TO | TORQUE | TORQUE | TORQUE |
| | | | (lb) | (lb) | $C_{Mo}$ | $\Delta C_{Mo}$ | LIFT | DRAG | (lb in) | (lb in) | (lb in) |
| | | | | | (lb in) | (lb in) | (lb in) | (lb in) | | | |
| 258 | - | - | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 251.25 | 1.02 | 0.00 | -15.46 | -0.45 | -52.95 | -402.41 | -15.79 | 0.00 | -471.15 | -471.15 | -706.73 |
| 238 | -11.31 | 0.00 | -34.70 | -1.37 | -105.53 | -802.01 | 392.64 | 0.00 | -514.89 | -986.05 | -1479.07 |
| 228 | -11.41 | 0.00 | -29.93 | -1.56 | -81.05 | -615.98 | 341.60 | 0.00 | -355.44 | -1341.48 | -2012.23 |
| 218 | -11.50 | 0.00 | -32.27 | -1.88 | -82.27 | -625.25 | 371.09 | 0.00 | -336.43 | -1677.92 | -2516.88 |
| 208 | -11.59 | 0.00 | -34.20 | -2.42 | -83.50 | -634.60 | 396.19 | 0.00 | -321.91 | -1999.83 | -2999.74 |
| 198 | -11.67 | 0.00 | -35.87 | -2.93 | -84.74 | -644.01 | 418.59 | 0.00 | -310.15 | -2309.97 | -3464.96 |
| 188 | -11.76 | 0.00 | -37.38 | -3.13 | -85.98 | -653.49 | 439.47 | 0.00 | -300.00 | -2609.97 | -3914.96 |
| 178 | -11.84 | 0.00 | -38.74 | -3.31 | -87.24 | -663.03 | 458.77 | 0.00 | -291.51 | -2901.48 | -4352.22 |
| 163.65 | -11.95 | 0.00 | -57.70 | -5.03 | -127.40 | -968.27 | 689.28 | 0.00 | -406.40 | -3307.87 | -4961.81 |
| 159 | -2.35 | 0.00 | -19.04 | -1.79 | -38.91 | 0.00 | 44.67 | 0.00 | 5.76 | -3302.12 | -4953.18 |
| 155.00 | 7.26 | 0.00 | -20.44 | -2.03 | -39.15 | 0.00 | -148.41 | 0.00 | -187.56 | -3489.68 | -5234.52 |
| 138 | 7.23 | 0.00 | -82.13 | -8.23 | -156.24 | 0.00 | -594.06 | 0.00 | -750.30 | -4239.98 | -6359.97 |
| 128 | 7.27 | 0.00 | -49.56 | -5.00 | -93.66 | 0.00 | -360.47 | 0.00 | -454.13 | -4694.11 | -7041.17 |
| 118 | 7.30 | 0.00 | -50.39 | -5.11 | -94.97 | 0.00 | -367.81 | 0.00 | -462.78 | -5156.89 | -7735.34 |
| 108 | 7.33 | 0.00 | -51.15 | -5.20 | -96.29 | 0.00 | -375.09 | 0.00 | -471.39 | -5628.28 | -8442.41 |
| 98 | 7.37 | 0.00 | -51.85 | -5.29 | -97.62 | 0.00 | -382.11 | 0.00 | -479.73 | -6108.01 | -9162.01 |
| 88 | 7.41 | 0.00 | -52.49 | -5.37 | -98.96 | 0.00 | -388.88 | 0.00 | -487.84 | -6595.85 | -9893.77 |
| 80.00 | 7.44 | 0.00 | -42.42 | -4.35 | -80.14 | 0.00 | -315.80 | 0.00 | -395.93 | -6991.78 | -10487.67 |
| 68 | 7.49 | 0.00 | -64.27 | -6.60 | -121.83 | 0.00 | -481.24 | 0.00 | -603.08 | -7594.86 | -11392.29 |
| 58 | 7.54 | 0.00 | -54.10 | -5.56 | -103.03 | 0.00 | -407.74 | 0.00 | -510.77 | -8105.63 | -12158.44 |
| 48 | 7.58 | 0.00 | -54.53 | -5.61 | -104.40 | 0.00 | -413.54 | 0.00 | -517.94 | -8623.57 | -12935.35 |
| 22 | 7.67 | 0.00 | -143.42 | -14.74 | -277.95 | 0.00 | -1100.39 | 0.00 | -1378.34 | -10001.91 | -15002.86 |
| 19 | 7.75 | 0.00 | -16.69 | -1.71 | -32.68 | 0.00 | -129.27 | 0.00 | -161.95 | -10163.86 | -15245.79 |
| 0 | 7.81 | 0.00 | -106.14 | -10.89 | -209.93 | 0.00 | -828.49 | 0.00 | -1038.42 | -11202.28 | -16803.41 |

DEAD WEIGHT ANALYSIS FOR WING TORQUE

CONDITION. F

| 1 | 65 | 54 | 66 | 67 | 33 | 68 | 69 | 70 |
|---|---|---|---|---|---|---|---|---|
| STATION | X CG | X SC | DELTA | DELTA | ELEMENT | ELEMENT | TOTAL | TOTAL |
| | (in) | (in) | X | X av | LOAD | LIMIT | LIMIT | ULT |
| (in) | | | (in) | (in) | (lb) | TORQUE | TORQUE | TORQUE |
| | using 40% chord | | | | | (lb in) | (lb in) | (lb in) |
| 258 | 14.00 | 13.30 | -0.70 | - | - | - | - | 0.00 |
| 251.25 | 14.07 | 13.37 | -0.70 | -0.70 | 0.66 | -0.46 | -0.46 | -0.70 |
| 238 | 14.21 | 13.50 | -0.71 | -0.71 | 1.76 | -1.25 | -1.71 | -2.56 |
| 228 | 14.32 | 13.60 | -0.72 | -0.71 | 3.05 | -2.17 | -3.88 | -5.83 |
| 218 | 14.43 | 13.71 | -0.72 | -0.72 | 4.27 | -3.07 | -6.95 | -10.43 |
| 208 | 14.53 | 13.81 | -0.73 | -0.72 | 5.23 | -3.79 | -10.74 | -16.11 |
| 198 | 14.64 | 13.91 | -0.73 | -0.73 | 6.15 | -4.48 | -15.22 | -22.84 |
| 188 | 14.75 | 14.01 | -0.74 | -0.73 | 7.28 | -5.35 | -20.57 | -30.86 |
| 178 | 14.86 | 14.11 | -0.74 | -0.74 | 8.25 | -6.10 | -26.68 | -40.02 |
| 163.65 | 15.01 | 14.26 | -0.75 | -0.75 | 9.48 | -7.08 | -33.76 | -50.64 |
| 159 | 15.06 | 14.30 | -0.75 | -0.75 | 9.79 | -7.36 | -41.11 | -61.67 |
| 155.00 | 15.10 | 14.35 | -0.76 | -0.75 | 10.19 | -7.69 | -48.80 | -73.20 |
| 138 | 15.28 | 14.52 | -0.76 | -0.76 | 10.70 | -8.13 | -56.93 | -85.39 |
| 128 | 15.39 | 14.62 | -0.77 | -0.77 | 10.87 | -8.34 | -65.27 | -97.90 |
| 118 | 15.50 | 14.72 | -0.77 | -0.77 | 11.18 | -8.63 | -73.90 | -110.84 |
| 108 | 15.60 | 14.82 | -0.78 | -0.78 | 11.33 | -8.81 | -82.70 | -124.06 |
| 98 | 15.71 | 14.93 | -0.79 | -0.78 | 11.51 | -9.01 | -91.72 | -137.58 |
| 88 | 15.82 | 15.03 | -0.79 | -0.79 | 11.97 | -9.44 | -101.16 | -151.73 |
| 80.00 | 15.90 | 15.11 | -0.80 | -0.79 | 12.23 | -9.70 | -110.85 | -166.28 |
| 68 | 16.03 | 15.23 | -0.80 | -0.80 | 12.68 | -10.13 | -120.98 | -181.47 |
| 58 | 16.14 | 15.33 | -0.81 | -0.80 | 13.00 | -10.46 | -131.44 | -197.16 |
| 48 | 16.25 | 15.43 | -0.81 | -0.81 | 13.51 | -10.94 | -142.38 | -213.57 |
| 22 | 16.52 | 15.70 | -0.83 | -0.82 | 14.48 | -11.86 | -154.24 | -231.36 |
| 19 | 16.56 | 15.73 | -0.83 | -0.83 | 7.29 | -6.03 | -160.27 | -240.41 |
| 0 | 16.76 | 15.92 | -0.84 | -0.83 | 4.86 | -4.05 | -164.32 | -246.48 |

SPANWISE AERODYNAMIC LOAD DISTRIBUTION

CONDITION. G 2/3 n

AILERON UP

| | | | | | | |
|---|---|---|---|---|---|---|
| | | | | | Aileron deflection = | UP |
| | | | | | Aileron angle = | -26.00 deg |
| | | | | | Aileron load = | 20.00 lb |
| $V_{ml}$ = | 138.51 ft/s | $C_L$ = | -0.6 | alpha wrp = -9.3715 | $\Delta C_L$ = | -0.19 |
| Lift = | -1822.10 lb clean | $C_{Do}$ = | 0.017 | sin alpha = -0.1628 | $\Delta C_D$ = | 0.01 |
| q = | 22.81 psf | $C_D$ = | 0.027 | cos alpha = 0.9867 | $\Delta C_{Mo}$ = | 0.26 |
| n = | -1.27 g | $C_{Mo}$ = | -0.025 | | S = | 4.71 ft² |
| $q.C_L$ = | -13.50 $q.C_L$ =Lift/S | S = | 135.00 ft² | | b = | 7.30 ft |
| | | b = | 43.00 ft | | AR = | 11.31 |

ECF = 0.24

| 1 | 13 | 72 | 14 | 15 | 16 | 73 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| STATION (in) | $C_L$ | FLAP $C_L$ | $C_{Lx}$ | $C_{Lz}$ | $C_D$ | FLAP $C_D$ | $C_{Dx}$ | $C_{Dz}$ | $C_{Lz}+C_{Dz}$ | $C_{Dx}-C_{Lx}$ | $(C_{Lz}+C_{Dz})_{AV}$ | $(C_{Dx}-C_{Lx})_{AV}$ | SPAN ELEMENT LIFT (lb) | SPAN ELEMENT DRAG (lb) |
| 258 | -0.2958 | 0.0000 | 0.0482 | -0.2919 | 0.0326 | 0.0000 | 0.0322 | -0.0053 | -0.2972 | -0.0160 | - | - | 0.00 | 0.00 |
| 251.25 | -0.3875 | -0.0443 | 0.0703 | -0.4260 | 0.0326 | 0.0017 | 0.0339 | -0.0056 | -0.4316 | -0.0364 | -0.3644 | -0.0262 | -13.67 | -0.98 |
| 238 | -0.4500 | -0.0443 | 0.0805 | -0.4877 | 0.0326 | 0.0017 | 0.0339 | -0.0056 | -0.4933 | -0.0466 | -0.4625 | -0.0415 | -34.32 | -3.08 |
| 228 | -0.4813 | -0.0443 | 0.0856 | -0.5186 | 0.0326 | 0.0017 | 0.0339 | -0.0056 | -0.5242 | -0.0517 | -0.5087 | -0.0492 | -28.75 | -2.78 |
| 218 | -0.5062 | -0.0443 | 0.0896 | -0.5432 | 0.0326 | 0.0017 | 0.0339 | -0.0056 | -0.5488 | -0.0558 | -0.5365 | -0.0538 | -30.54 | -3.06 |
| 208 | -0.5269 | -0.0443 | 0.0930 | -0.5636 | 0.0258 | 0.0017 | 0.0272 | -0.0045 | -0.5680 | -0.0658 | -0.5584 | -0.0608 | -32.03 | -3.49 |
| 198 | -0.5444 | -0.0443 | 0.0959 | -0.5808 | 0.0258 | 0.0017 | 0.0272 | -0.0045 | -0.5853 | -0.0687 | -0.5767 | -0.0673 | -33.32 | -3.89 |
| 188 | -0.5594 | -0.0443 | 0.0983 | -0.5956 | 0.0258 | 0.0017 | 0.0272 | -0.0045 | -0.6001 | -0.0711 | -0.5927 | -0.0699 | -34.50 | -4.07 |
| 178 | -0.5724 | -0.0443 | 0.1004 | -0.6085 | 0.0258 | 0.0017 | 0.0272 | -0.0045 | -0.6130 | -0.0733 | -0.6065 | -0.0722 | -35.56 | -4.23 |
| 163.65 | -0.5882 | -0.0443 | 0.1030 | -0.6241 | 0.0258 | 0.0017 | 0.0272 | -0.0045 | -0.6285 | -0.0758 | -0.6208 | -0.0745 | -52.68 | -6.33 |
| 159 | -0.5924 | 0.0000 | 0.0965 | -0.5845 | 0.0258 | 0.0000 | 0.0255 | -0.0042 | -0.5887 | -0.0710 | -0.6086 | -0.0734 | -15.67 | -1.89 |
| 155.00 | -0.5963 | 0.0000 | 0.0971 | -0.5883 | 0.0258 | 0.0000 | 0.0255 | -0.0042 | -0.5925 | -0.0716 | -0.5906 | -0.0713 | -15.25 | -1.84 |
| 138 | -0.6096 | 0.0000 | 0.0993 | -0.6015 | 0.0258 | 0.0000 | 0.0255 | -0.0042 | -0.6057 | -0.0738 | -0.5991 | -0.0727 | -61.28 | -7.44 |
| 128 | -0.6160 | 0.0000 | 0.1003 | -0.6078 | 0.0258 | 0.0000 | 0.0255 | -0.0042 | -0.6120 | -0.0748 | -0.6089 | -0.0743 | -36.98 | -4.51 |
| 118 | -0.6215 | 0.0000 | 0.1012 | -0.6132 | 0.0258 | 0.0000 | 0.0255 | -0.0042 | -0.6174 | -0.0757 | -0.6147 | -0.0753 | -37.60 | -4.61 |
| 108 | -0.6262 | 0.0000 | 0.1020 | -0.6178 | 0.0258 | 0.0000 | 0.0255 | -0.0042 | -0.6220 | -0.0765 | -0.6197 | -0.0761 | -38.17 | -4.69 |
| 98 | -0.6300 | 0.0000 | 0.1026 | -0.6216 | 0.0258 | 0.0000 | 0.0255 | -0.0042 | -0.6258 | -0.0771 | -0.6239 | -0.0768 | -38.69 | -4.76 |
| 88 | -0.6331 | 0.0000 | 0.1031 | -0.6247 | 0.0258 | 0.0000 | 0.0255 | -0.0042 | -0.6289 | -0.0776 | -0.6274 | -0.0774 | -39.17 | -4.83 |
| 80.00 | -0.6351 | 0.0000 | 0.1034 | -0.6267 | 0.0258 | 0.0000 | 0.0255 | -0.0042 | -0.6309 | -0.0780 | -0.6299 | -0.0778 | -31.65 | -3.91 |
| 68 | -0.6374 | 0.0000 | 0.1038 | -0.6288 | 0.0258 | 0.0000 | 0.0255 | -0.0042 | -0.6331 | -0.0783 | -0.6320 | -0.0781 | -47.96 | -5.93 |
| 58 | -0.6385 | 0.0000 | 0.1040 | -0.6300 | 0.0258 | 0.0000 | 0.0255 | -0.0042 | -0.6342 | -0.0785 | -0.6336 | -0.0784 | -40.37 | -5.00 |
| 48 | -0.6391 | 0.0000 | 0.1041 | -0.6306 | 0.0258 | 0.0000 | 0.0255 | -0.0042 | -0.6348 | -0.0786 | -0.6345 | -0.0786 | -40.69 | -5.04 |
| 22 | -0.6381 | 0.0000 | 0.1039 | -0.6296 | 0.0258 | 0.0000 | 0.0255 | -0.0042 | -0.6338 | -0.0784 | -0.6343 | -0.0785 | -107.02 | -13.25 |
| 19 | -0.6377 | 0.0000 | 0.1038 | -0.6292 | 0.0258 | 0.0000 | 0.0255 | -0.0042 | -0.6334 | -0.0784 | -0.6336 | -0.0784 | -12.45 | -1.54 |
| 0 | -0.6345 | 0.0000 | 0.1033 | -0.6260 | 0.0258 | 0.0000 | 0.0255 | -0.0042 | -0.6302 | -0.0779 | -0.6318 | -0.0781 | -79.20 | -9.79 |
| | | | | | | | | | | | | Σ = | -937.53 | -110.93 |
| | | | | | | | | | | | | LIFT calc = | -1875.06 | |
| | | | | | | | | | | | | Lift = | -1822.10 | |

SPANWISE AERODYNAMIC LOAD DISTRIBUTION

CONDITION. G cont..

| 1 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 |
|---|---|---|---|---|---|---|---|---|
| STATION | LIMIT | LIMIT | LIMIT | LIMIT | ULT | ULT | ULT | ULT |
| (in) | NORMAL | NORMAL | CHORD | CHORD | NORMAL | NORMAL | CHORD | CHORD |
| | SHEAR | MOMENT | SHEAR | MOMENT | SHEAR | MOMENT | SHEAR | MOMENT |
| | (lb) | (lb in) | (lb) | (lb in) | (lb) | (lb in) | (lb) | (lb in) |
| 258 | 0.00 | 0.00 | 0.00 | 0.00 | 0 | 0 | 0 | 0 |
| 251.25 | -13.67 | -46.15 | -0.98 | -3.32 | -21 | -69 | -1 | -5 |
| 238 | -48.00 | -454.70 | -4.07 | -36.78 | -72 | -682 | -6 | -55 |
| 228 | -76.74 | -1078.39 | -6.85 | -91.34 | -115 | -1618 | -10 | -137 |
| 218 | -107.28 | -1998.53 | -9.91 | -175.10 | -161 | -2998 | -15 | -263 |
| 208 | -139.31 | -3231.50 | -13.39 | -291.60 | -209 | -4847 | -20 | -437 |
| 198 | -172.63 | -4791.20 | -17.28 | -444.97 | -259 | -7187 | -26 | -667 |
| 188 | -207.12 | -6689.97 | -21.35 | -638.12 | -311 | -10035 | -32 | -957 |
| 178 | -242.68 | -8939.01 | -25.58 | -872.77 | -364 | -13409 | -38 | -1309 |
| 163.65 | -295.36 | -12799.50 | -31.91 | -1285.27 | -443 | -19199 | -48 | -1928 |
| 159 | -311.03 | -14110.84 | -33.80 | -1427.37 | -467 | -21166 | -51 | -2141 |
| 155.00 | -326.29 | -15489.05 | -35.64 | -1577.53 | -489 | -23234 | -53 | -2366 |
| 138 | -387.57 | -21556.87 | -43.08 | -2246.65 | -581 | -32335 | -65 | -3370 |
| 128 | -424.56 | -25617.51 | -47.59 | -2700.01 | -637 | -38426 | -71 | -4050 |
| 118 | -462.16 | -30051.07 | -52.20 | -3198.97 | -693 | -45077 | -78 | -4798 |
| 108 | -500.33 | -34863.48 | -56.89 | -3744.40 | -750 | -52295 | -85 | -5617 |
| 98 | -539.02 | -40060.20 | -61.65 | -4337.09 | -809 | -60090 | -92 | -6506 |
| 88 | -578.19 | -45646.23 | -66.48 | -4977.75 | -867 | -68469 | -100 | -7467 |
| 80.00 | -609.84 | -50398.35 | -70.39 | -5525.24 | -915 | -75598 | -106 | -8288 |
| 68 | -657.80 | -58004.21 | -76.32 | -6405.51 | -987 | -87006 | -114 | -9608 |
| 58 | -698.17 | -64784.06 | -81.32 | -7193.69 | -1047 | -97176 | -122 | -10791 |
| 48 | -738.86 | -71969.20 | -86.35 | -8032.05 | -1108 | -107954 | -130 | -12048 |
| 22 | -845.88 | -92570.79 | -99.60 | -10449.48 | -1269 | -138856 | -149 | -15674 |
| 19 | -858.33 | -95127.10 | -101.14 | -10750.60 | -1287 | -142691 | -152 | -16126 |
| 0 | -937.53 | -112187.77 | -110.93 | -12765.34 | -1406 | -168282 | -166 | -19148 |
| | | | | | | | | |
| Centre of lift is | 120 | in from aircraft centreline | | | | | | |
| | 46 | % semispan | | | | | | |

SPANWISE INERTIAL LOAD DISTRIBUTION

CONDITION. G cont..

| 1 | 3 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 | 41 | 42 | 43 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| STATION | dy | WEIGHT | ELEMENT | ELEMENT | LIMIT | LIMIT | LIMIT | LIMIT | ULT | ULT | ULT | ULT |
| (in) | (in) | nW | SHEAR | SHEAR | NORMAL | NORMAL | CHORD | CHORD | NORMAL | NORMAL | CHORD | CHORD |
| | | (lb) | FORCE | FORCE | SHEAR | MOMENT | SHEAR | MOMENT | SHEAR | MOMENT | SHEAR | MOMENT |
| | | | $V_x$ | $V_z$ | (lb) | (lb in) | (lb) | (lb in) | (lb) | (lb in) | (lb) | (lb in) |
| | | | (lb) | (lb) | | | | | | | | |
| 258 | - | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0 | 0 | 0 | 0 |
| 251.25 | 6.75 | 0.50 | 0.08 | 0.49 | 0.49 | 1.65 | 0.08 | 0.27 | 1 | 2 | 0 | 0 |
| 238 | 13.25 | 1.32 | 0.21 | 1.30 | 1.79 | 16.73 | 0.30 | 2.76 | 3 | 25 | 0 | 4 |
| 228 | 10.00 | 2.28 | 0.37 | 2.25 | 4.04 | 45.86 | 0.67 | 7.57 | 6 | 69 | 1 | 11 |
| 218 | 10.00 | 3.19 | 0.52 | 3.15 | 7.19 | 101.99 | 1.19 | 16.83 | 11 | 153 | 2 | 25 |
| 208 | 10.00 | 3.91 | 0.64 | 3.86 | 11.05 | 193.17 | 1.82 | 31.88 | 17 | 290 | 3 | 48 |
| 198 | 10.00 | 4.60 | 0.75 | 4.54 | 15.59 | 326.34 | 2.57 | 53.86 | 23 | 490 | 4 | 81 |
| 188 | 10.00 | 5.45 | 0.89 | 5.37 | 20.96 | 509.07 | 3.46 | 84.02 | 31 | 764 | 5 | 126 |
| 178 | 10.00 | 6.17 | 1.00 | 6.09 | 27.05 | 749.10 | 4.46 | 123.63 | 41 | 1124 | 7 | 185 |
| 163.65 | 14.35 | 7.09 | 1.16 | 7.00 | 34.04 | 1187.42 | 5.62 | 195.97 | 51 | 1781 | 8 | 294 |
| 159 | 4.33 | 7.32 | 1.19 | 7.22 | 41.27 | 1350.29 | 6.81 | 222.85 | 62 | 2025 | 10 | 334 |
| 155.00 | 4.32 | 7.63 | 1.24 | 7.52 | 48.79 | 1545.04 | 8.05 | 254.99 | 73 | 2318 | 12 | 382 |
| 138 | 17.00 | 8.01 | 1.30 | 7.90 | 56.69 | 2441.64 | 9.36 | 402.96 | 85 | 3662 | 14 | 604 |
| 128 | 10.00 | 8.13 | 1.32 | 8.02 | 64.71 | 3048.66 | 10.68 | 503.14 | 97 | 4573 | 16 | 755 |
| 118 | 10.00 | 8.36 | 1.36 | 8.25 | 72.96 | 3737.04 | 12.04 | 616.75 | 109 | 5606 | 18 | 925 |
| 108 | 10.00 | 8.47 | 1.38 | 8.36 | 81.32 | 4508.47 | 13.42 | 744.06 | 122 | 6763 | 20 | 1116 |
| 98 | 10.00 | 8.61 | 1.40 | 8.50 | 89.82 | 5364.19 | 14.82 | 885.29 | 135 | 8046 | 22 | 1328 |
| 88 | 10.00 | 8.96 | 1.46 | 8.84 | 98.66 | 6306.58 | 16.28 | 1040.82 | 148 | 9460 | 24 | 1561 |
| 80.00 | 8.00 | 9.15 | 1.49 | 9.02 | 107.68 | 7131.93 | 17.77 | 1177.03 | 162 | 10698 | 27 | 1766 |
| 68 | 12.00 | 9.49 | 1.54 | 9.36 | 117.04 | 8480.27 | 19.32 | 1399.56 | 176 | 12720 | 29 | 2099 |
| 58 | 10.00 | 9.73 | 1.58 | 9.60 | 126.64 | 9698.67 | 20.90 | 1600.64 | 190 | 14548 | 31 | 2401 |
| 48 | 10.00 | 10.11 | 1.65 | 9.97 | 136.61 | 11014.93 | 22.55 | 1817.87 | 205 | 16522 | 34 | 2727 |
| 22 | 26.00 | 10.83 | 1.76 | 10.69 | 147.30 | 14705.76 | 24.31 | 2427.00 | 221 | 22059 | 36 | 3640 |
| 19 | 3.00 | 5.45 | 0.89 | 5.38 | 152.68 | 15155.73 | 25.20 | 2501.26 | 229 | 22734 | 38 | 3752 |
| 0 | 19.00 | 3.64 | 0.59 | 3.59 | 156.27 | 18090.73 | 25.79 | 2985.64 | 234 | 27136 | 39 | 4478 |
| | $\Sigma =$ | 125 | lb | | | | | | | | | |
| | | at 1 g | | | Centre of gravity is | 116 | in from aircraft centreline | | | | | |
| | | | | | | 45 | % semispan | | | | | |

COMBINED ULTIMATE LOADS ( AERODYNAMIC + INERTIAL )

CONDITION. G cont..

| 1 | 44 G | 45 G | 46 G | 47 G | 48 G | 49 G |
|---|---|---|---|---|---|---|
| | ULT | ULT | ULT | ULT | ULT | ULT |
| | NORMAL | NORMAL | ULT CHORD | ULT CHORD | RESOLVED | RESOLVED |
| STATION | SHEAR | BEND MOMENT | SHEAR | BEND MOMENT | SHEAR | BEND MOMENT |
| (in) | COND. G | COND. G | COND. G | COND. G | COND. G | COND. G |
| | (lb) | (lb in) | (lb) | (lb in) | (lb) | (lb in) |
| 258 | 0 | 0 | 0 | 0 | 0 | 0 |
| 251.25 | -20 | -67 | -1 | -5 | 20 | 67 |
| 238 | -69 | -657 | -6 | -51 | 70 | 659 |
| 228 | -109 | -1549 | -9 | -126 | 109 | 1554 |
| 218 | -150 | -2845 | -13 | -237 | 151 | 2855 |
| 208 | -192 | -4558 | -17 | -390 | 193 | 4574 |
| 198 | -236 | -6697 | -22 | -587 | 237 | 6723 |
| 188 | -279 | -9271 | -27 | -831 | 281 | 9309 |
| 178 | -323 | -12285 | -32 | -1124 | 325 | 12336 |
| 163.65 | -392 | -17418 | -39 | -1634 | 394 | 17495 |
| 159 | -405 | -19141 | -40 | -1807 | 407 | 19226 |
| 155.00 | -416 | -20916 | -41 | -1984 | 418 | 21010 |
| 138 | -496 | -28673 | -51 | -2766 | 499 | 28806 |
| 128 | -540 | -33853 | -55 | -3295 | 543 | 34013 |
| 118 | -584 | -39471 | -60 | -3873 | 587 | 39661 |
| 108 | -629 | -45533 | -65 | -4501 | 632 | 45754 |
| 98 | -674 | -52044 | -70 | -5178 | 677 | 52301 |
| 88 | -719 | -59009 | -75 | -5905 | 723 | 59304 |
| 80.00 | -753 | -64900 | -79 | -6522 | 757 | 65227 |
| 68 | -811 | -74286 | -86 | -7509 | 816 | 74664 |
| 58 | -857 | -82628 | -91 | -8390 | 862 | 83053 |
| 48 | -903 | -91431 | -96 | -9321 | 908 | 91905 |
| 22 | -1048 | -116798 | -113 | -12034 | 1054 | 117416 |
| 19 | -1058 | -119957 | -114 | -12374 | 1065 | 120594 |
| 0 | -1172 | -141146 | -128 | -14670 | 1179 | 141906 |

AERODYNAMIC TORQUE AT SHEAR CENTRE

CONDITION. G

| 1 | 50 | 74 | 51 | 52 | 53 | 54 | 55 | 56 | 57 | 58 |
|---|---|---|---|---|---|---|---|---|---|---|
| STATION | CLEAN + FLAPPED | LEAN + FLAPPE | LOCAL | AERO | X AC | X SC | DELTA X | Z AC | Z SC | DELTA Z |
| | LOCAL | LOCAL | $X_{CP}$ | CENTRE | (in) | (in) | (in) | (in) | (in) | (in) |
| (in) | $C_L$ | $C_{Mo}$ | | (in) | | using 38% chord | | | | |
| 258 | - | -0.025 | - | 0.00 | 0.00 | 13.30 | 13.30 | 0.00 | 2.39 | -2.39 |
| 251.25 | -0.36 | 0.235 | 0.70 | 24.63 | 24.63 | 13.37 | -11.26 | 0.00 | 2.40 | -2.40 |
| 238 | -0.46 | 0.235 | 0.70 | 24.87 | 24.87 | 13.50 | -11.37 | 0.00 | 2.44 | -2.44 |
| 228 | -0.51 | 0.235 | 0.70 | 25.06 | 25.06 | 13.60 | -11.46 | 0.00 | 2.47 | -2.47 |
| 218 | -0.54 | 0.235 | 0.70 | 25.25 | 25.25 | 13.71 | -11.54 | 0.00 | 2.49 | -2.49 |
| 208 | -0.56 | 0.235 | 0.70 | 25.44 | 25.44 | 13.81 | -11.63 | 0.00 | 2.52 | -2.52 |
| 198 | -0.58 | 0.235 | 0.70 | 25.62 | 25.62 | 13.91 | -11.71 | 0.00 | 2.54 | -2.54 |
| 188 | -0.59 | 0.235 | 0.70 | 25.81 | 25.81 | 14.01 | -11.80 | 0.00 | 2.57 | -2.57 |
| 178 | -0.61 | 0.235 | 0.70 | 26.00 | 26.00 | 14.11 | -11.88 | 0.00 | 2.60 | -2.60 |
| 163.65 | -0.62 | 0.235 | 0.70 | 26.27 | 26.27 | 14.26 | -12.01 | 0.00 | 2.64 | -2.64 |
| 159 | -0.61 | -0.025 | 0.20 | 7.49 | 7.49 | 14.30 | 6.82 | 0.00 | 2.65 | -2.65 |
| 155.00 | -0.59 | -0.025 | 0.20 | 7.46 | 7.46 | 14.35 | 6.88 | 0.00 | 2.66 | -2.66 |
| 138 | -0.60 | -0.025 | 0.20 | 7.58 | 7.58 | 14.52 | 6.94 | 0.00 | 2.70 | -2.70 |
| 128 | -0.61 | -0.025 | 0.20 | 7.65 | 7.65 | 14.62 | 6.97 | 0.00 | 2.73 | -2.73 |
| 118 | -0.61 | -0.025 | 0.20 | 7.72 | 7.72 | 14.72 | 7.00 | 0.00 | 2.76 | -2.76 |
| 108 | -0.62 | -0.025 | 0.20 | 7.79 | 7.79 | 14.82 | 7.04 | 0.00 | 2.78 | -2.78 |
| 98 | -0.62 | -0.025 | 0.20 | 7.85 | 7.85 | 14.93 | 7.07 | 0.00 | 2.81 | -2.81 |
| 88 | -0.63 | -0.025 | 0.20 | 7.92 | 7.92 | 15.03 | 7.11 | 0.00 | 2.84 | -2.84 |
| 80.00 | -0.63 | -0.025 | 0.20 | 7.96 | 7.96 | 15.11 | 7.14 | 0.00 | 2.86 | -2.86 |
| 68 | -0.63 | -0.025 | 0.20 | 8.03 | 8.03 | 15.23 | 7.20 | 0.00 | 2.89 | -2.89 |
| 58 | -0.63 | -0.025 | 0.20 | 8.09 | 8.09 | 15.33 | 7.24 | 0.00 | 2.92 | -2.92 |
| 48 | -0.63 | -0.025 | 0.20 | 8.15 | 8.15 | 15.43 | 7.29 | 0.00 | 2.94 | -2.94 |
| 22 | -0.63 | -0.025 | 0.20 | 8.29 | 8.29 | 15.70 | 7.41 | 0.00 | 3.01 | -3.01 |
| 19 | -0.63 | -0.025 | 0.20 | 8.30 | 8.30 | 15.73 | 7.43 | 0.00 | 3.01 | -3.01 |
| 0 | -0.63 | -0.025 | 0.20 | 8.40 | 8.40 | 15.92 | 7.52 | 0.00 | 1.25 | -1.25 |

AERODYNAMIC TORQUE AT SHEAR CENTRE

CONDITION. G

| | | | | | | $\Delta C_{Mo}$ | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 0 | | | | | |
| 1 | 55 | 56 | 23 | 24 | 59 | 75 | 60 | 61 | 62 | 63 | 64 |
| STATION | DELTA | DELTA | SPAN | SPAN | ELEMENT | ELEMENT | ELEMENT | ELEMENT | ELEMENT | TOTAL | TOTAL |
| | X av | Z av | ELEMENT | ELEMENT | TORQUE | TORQUE | TORQUE | TORQUE | LIMIT | LIMIT | ULT |
| (in) | (in) | (in) | LIFT | DRAG | DUE TO | DUE TO | DUE TO | DUE TO | TORQUE | TORQUE | TORQUE |
| | | | (lb) | (lb) | $C_{Mo}$ | $\Delta C_{Mo}$ | LIFT | DRAG | (lb in) | (lb in) | (lb in) |
| | | | | | (lb in) | (lb in) | (lb in) | (lb in) | | | |
| 258 | - | - | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 251.25 | 1.02 | 0.00 | -13.67 | -0.98 | -32.92 | 342.34 | -13.96 | 0.00 | 295.46 | 295.46 | 443.19 |
| 238 | -11.31 | 0.00 | -34.32 | -3.08 | -65.60 | 682.28 | 388.33 | 0.00 | 1005.01 | 1300.47 | 1950.70 |
| 228 | -11.41 | 0.00 | -28.75 | -2.78 | -50.39 | 524.02 | 328.12 | 0.00 | 801.75 | 2102.22 | 3153.33 |
| 218 | -11.50 | 0.00 | -30.54 | -3.06 | -51.15 | 531.91 | 351.22 | 0.00 | 831.98 | 2934.20 | 4401.30 |
| 208 | -11.59 | 0.00 | -32.03 | -3.49 | -51.91 | 539.86 | 371.03 | 0.00 | 858.98 | 3793.18 | 5689.77 |
| 198 | -11.67 | 0.00 | -33.32 | -3.89 | -52.68 | 547.86 | 388.84 | 0.00 | 884.03 | 4677.21 | 7015.81 |
| 188 | -11.76 | 0.00 | -34.50 | -4.07 | -53.45 | 555.93 | 405.54 | 0.00 | 908.02 | 5585.22 | 8377.83 |
| 178 | -11.84 | 0.00 | -35.56 | -4.23 | -54.24 | 564.05 | 421.08 | 0.00 | 930.89 | 6516.11 | 9774.17 |
| 163.65 | -11.95 | 0.00 | -52.68 | -6.33 | -79.20 | 823.72 | 629.32 | 0.00 | 1373.84 | 7889.95 | 11834.92 |
| 159 | -2.60 | 0.00 | -15.67 | -1.89 | -24.19 | 0.00 | 40.68 | 0.00 | 16.49 | 7906.44 | 11859.65 |
| 155.00 | 6.85 | 0.00 | -15.25 | -1.84 | -24.34 | 0.00 | -104.49 | 0.00 | -128.83 | 7777.61 | 11666.41 |
| 138 | 6.91 | 0.00 | -61.28 | -7.44 | -97.13 | 0.00 | -423.70 | 0.00 | -520.83 | 7256.78 | 10885.17 |
| 128 | 6.96 | 0.00 | -36.98 | -4.51 | -58.23 | 0.00 | -257.23 | 0.00 | -315.45 | 6941.33 | 10411.99 |
| 118 | 6.98 | 0.00 | -37.60 | -4.61 | -59.04 | 0.00 | -262.58 | 0.00 | -321.62 | 6619.71 | 9929.57 |
| 108 | 7.02 | 0.00 | -38.17 | -4.69 | -59.86 | 0.00 | -267.86 | 0.00 | -327.72 | 6291.99 | 9437.99 |
| 98 | 7.05 | 0.00 | -38.69 | -4.76 | -60.69 | 0.00 | -272.93 | 0.00 | -333.62 | 5958.37 | 8937.56 |
| 88 | 7.09 | 0.00 | -39.17 | -4.83 | -61.52 | 0.00 | -277.82 | 0.00 | -339.34 | 5619.03 | 8428.54 |
| 80.00 | 7.13 | 0.00 | -31.65 | -3.91 | -49.82 | 0.00 | -225.65 | 0.00 | -275.47 | 5343.56 | 8015.34 |
| 68 | 7.17 | 0.00 | -47.96 | -5.93 | -75.74 | 0.00 | -343.91 | 0.00 | -419.65 | 4923.92 | 7385.87 |
| 58 | 7.22 | 0.00 | -40.37 | -5.00 | -64.05 | 0.00 | -291.41 | 0.00 | -355.46 | 4568.46 | 6852.69 |
| 48 | 7.26 | 0.00 | -40.69 | -5.04 | -64.91 | 0.00 | -295.57 | 0.00 | -360.47 | 4207.98 | 6311.98 |
| 22 | 7.35 | 0.00 | -107.02 | -13.25 | -172.79 | 0.00 | -786.50 | 0.00 | -959.29 | 3248.69 | 4873.03 |
| 19 | 7.42 | 0.00 | -12.45 | -1.54 | -20.32 | 0.00 | -92.39 | 0.00 | -112.71 | 3135.98 | 4703.97 |
| 0 | 7.48 | 0.00 | -79.20 | -9.79 | -130.51 | 0.00 | -592.11 | 0.00 | -722.62 | 2413.36 | 3620.05 |

DEAD WEIGHT ANALYSIS FOR WING TORQUE

CONDITION. G

| 1 | 65 | 54 | 66 | 67 | 33 | 68 | 69 | 70 |
|---|---|---|---|---|---|---|---|---|
| STATION | X CG | X SC | DELTA | DELTA | ELEMENT | ELEMENT | TOTAL | TOTAL |
| | (in) | (in) | X | X av | LOAD | LIMIT | LIMIT | ULT |
| (in) | | | (in) | (in) | (lb) | TORQUE | TORQUE | TORQUE |
| | using 40% chord | | | | | (lb in) | (lb in) | (lb in) |
| 258 | 14.00 | 13.30 | -0.70 | - | - | - | - | 0.00 |
| 251.25 | 14.07 | 13.37 | -0.70 | -0.70 | 0.50 | -0.35 | -0.35 | -0.52 |
| 238 | 14.21 | 13.50 | -0.71 | -0.71 | 1.32 | -0.93 | -1.28 | -1.92 |
| 228 | 14.32 | 13.60 | -0.72 | -0.71 | 2.28 | -1.63 | -2.91 | -4.36 |
| 218 | 14.43 | 13.71 | -0.72 | -0.72 | 3.19 | -2.29 | -5.20 | -7.80 |
| 208 | 14.53 | 13.81 | -0.73 | -0.72 | 3.91 | -2.83 | -8.03 | -12.05 |
| 198 | 14.64 | 13.91 | -0.73 | -0.73 | 4.60 | -3.35 | -11.39 | -17.08 |
| 188 | 14.75 | 14.01 | -0.74 | -0.73 | 5.45 | -4.00 | -15.39 | -23.08 |
| 178 | 14.86 | 14.11 | -0.74 | -0.74 | 6.17 | -4.57 | -19.96 | -29.93 |
| 163.65 | 15.01 | 14.26 | -0.75 | -0.75 | 7.09 | -5.30 | -25.25 | -37.88 |
| 159 | 15.06 | 14.30 | -0.75 | -0.75 | 7.32 | -5.50 | -30.75 | -46.13 |
| 155.00 | 15.10 | 14.35 | -0.76 | -0.75 | 7.63 | -5.75 | -36.50 | -54.75 |
| 138 | 15.28 | 14.52 | -0.76 | -0.76 | 8.01 | -6.08 | -42.58 | -63.88 |
| 128 | 15.39 | 14.62 | -0.77 | -0.77 | 8.13 | -6.24 | -48.82 | -73.23 |
| 118 | 15.50 | 14.72 | -0.77 | -0.77 | 8.36 | -6.46 | -55.28 | -82.91 |
| 108 | 15.60 | 14.82 | -0.78 | -0.78 | 8.47 | -6.59 | -61.87 | -92.80 |
| 98 | 15.71 | 14.93 | -0.79 | -0.78 | 8.61 | -6.74 | -68.61 | -102.91 |
| 88 | 15.82 | 15.03 | -0.79 | -0.79 | 8.96 | -7.06 | -75.67 | -113.50 |
| 80.00 | 15.90 | 15.11 | -0.80 | -0.79 | 9.15 | -7.25 | -82.92 | -124.38 |
| 68 | 16.03 | 15.23 | -0.80 | -0.80 | 9.49 | -7.57 | -90.50 | -135.74 |
| 58 | 16.14 | 15.33 | -0.81 | -0.80 | 9.73 | -7.82 | -98.32 | -147.48 |
| 48 | 16.25 | 15.43 | -0.81 | -0.81 | 10.11 | -8.18 | -106.50 | -159.76 |
| 22 | 16.52 | 15.70 | -0.83 | -0.82 | 10.83 | -8.87 | -115.38 | -173.06 |
| 19 | 16.56 | 15.73 | -0.83 | -0.83 | 5.45 | -4.51 | -119.89 | -179.83 |
| 0 | 16.76 | 15.92 | -0.84 | -0.83 | 3.64 | -3.03 | -122.92 | -184.37 |

| COMBINED ULTIMATE TORSION ( AERODYNAMIC + INERTIAL ) | | | |
|---|---|---|---|
| CONDITION. G | | | |
| | | | |
| | | | |
| 1 | 71 G | | |
| STATION | COND. G | | |
| (in) | (lb in) | | |
| 258 | 0 | | |
| 251.25 | 443 | | |
| 238 | 1949 | | |
| 228 | 3149 | | |
| 218 | 4394 | | |
| 208 | 5678 | | |
| 198 | 6999 | | |
| 188 | 8355 | | |
| 178 | 9744 | | |
| 163.65 | 11797 | | |
| 159 | 11814 | | |
| 155.00 | 11612 | | |
| 138 | 10821 | | |
| 128 | 10339 | | |
| 118 | 9847 | | |
| 108 | 9345 | | |
| 98 | 8835 | | |
| 88 | 8315 | | |
| 80.00 | 7891 | | |
| 68 | 7250 | | |
| 58 | 6705 | | |
| 48 | 6152 | | |
| 22 | 4700 | | |
| 19 | 4524 | | |
| 0 | 3436 | | |

SPANWISE AERODYNAMIC LOAD DISTRIBUTION

CONDITION. G 2/3 n

AILERON DOWN

| | | | | | |
|---|---|---|---|---|---|
| | | | | Aileron deflection = | DWN |
| | | | | Aileron angle = | 19.00 deg |
| | | | | Aileron load = | 20.00 lb |
| $V_{eas}$ = 138.51 ft/s | $C_L$ = -0.6 | alpha wrp = -9.3715 | $\Delta C_L$ = 0.19 | ECF = 0.24 | |
| Lift = -1822.10 lb clean | $C_{Do}$ = 0.017 | sin alpha = -0.1628 | $\Delta C_D$ = 0.01 | | |
| q = 22.81 psf | $C_D$ = 0.027 | cos alpha = 0.9867 | $\Delta C_{Mo}$ = -0.19 | | |
| n = -1.27 g | $C_{Mo}$ = -0.025 | | S = 4.71 $ft^2$ | | |
| $q.C_L$ = -13.50 ($q.C_L$ = Lift/S) | S = 135.00 $ft^2$ | | b = 7.30 ft | | |
| | b = 43.00 ft | | AR = 11.31 | | |

| 1 | 13 | 72 | 14 | 15 | 16 | 73 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| STATION (in) | $C_L$ | FLAP $C_L$ | $C_{Lx}$ | $C_{Lz}$ | $C_D$ | FLAP $C_D$ | $C_{Dx}$ | $C_{Dz}$ | $C_{Lz}+C_{Dz}$ | $C_{Dx}-C_{Lx}$ | $(C_{Lz}+C_{Dz})_{AV}$ | $(C_{Dx}-C_{Lx})_{AV}$ | SPAN ELEMENT LIFT (lb) | SPAN ELEMENT DRAG (lb) |
| 258 | -0.2958 | 0.0000 | 0.0482 | -0.2919 | 0.0326 | 0.0000 | 0.0322 | -0.0053 | -0.2972 | -0.0160 | - | - | 0.00 | 0.00 |
| 251.25 | -0.3875 | 0.0447 | 0.0558 | -0.3382 | 0.0326 | 0.0017 | 0.0339 | -0.0056 | -0.3438 | -0.0219 | -0.3205 | -0.0190 | -12.03 | -0.71 |
| 238 | -0.4500 | 0.0447 | 0.0660 | -0.3999 | 0.0326 | 0.0017 | 0.0339 | -0.0056 | -0.4055 | -0.0321 | -0.3747 | -0.0270 | -27.81 | -2.01 |
| 228 | -0.4813 | 0.0447 | 0.0711 | -0.4308 | 0.0326 | 0.0017 | 0.0339 | -0.0056 | -0.4364 | -0.0372 | -0.4210 | -0.0347 | -23.79 | -1.96 |
| 218 | -0.5062 | 0.0447 | 0.0752 | -0.4554 | 0.0326 | 0.0017 | 0.0339 | -0.0056 | -0.4610 | -0.0413 | -0.4487 | -0.0393 | -25.54 | -2.23 |
| 208 | -0.5269 | 0.0447 | 0.0785 | -0.4758 | 0.0258 | 0.0017 | 0.0272 | -0.0045 | -0.4803 | -0.0513 | -0.4706 | -0.0463 | -26.99 | -2.66 |
| 198 | -0.5444 | 0.0447 | 0.0814 | -0.4930 | 0.0258 | 0.0017 | 0.0272 | -0.0045 | -0.4975 | -0.0542 | -0.4889 | -0.0528 | -28.25 | -3.05 |
| 188 | -0.5594 | 0.0447 | 0.0838 | -0.5079 | 0.0258 | 0.0017 | 0.0272 | -0.0045 | -0.5123 | -0.0566 | -0.5049 | -0.0554 | -29.39 | -3.23 |
| 178 | -0.5724 | 0.0447 | 0.0859 | -0.5207 | 0.0258 | 0.0017 | 0.0272 | -0.0045 | -0.5252 | -0.0588 | -0.5188 | -0.0577 | -30.41 | -3.38 |
| 163.65 | -0.5882 | 0.0447 | 0.0885 | -0.5363 | 0.0258 | 0.0017 | 0.0272 | -0.0045 | -0.5408 | -0.0613 | -0.5330 | -0.0600 | -45.23 | -5.10 |
| 159 | -0.5924 | 0.0000 | 0.0965 | -0.5845 | 0.0258 | 0.0000 | 0.0255 | -0.0042 | -0.5887 | -0.0710 | -0.5647 | -0.0662 | -14.54 | -1.70 |
| 155.00 | -0.5963 | 0.0000 | 0.0971 | -0.5883 | 0.0258 | 0.0000 | 0.0255 | -0.0042 | -0.5925 | -0.0716 | -0.5906 | -0.0713 | -15.25 | -1.84 |
| 138 | -0.6096 | 0.0000 | 0.0993 | -0.6015 | 0.0258 | 0.0000 | 0.0255 | -0.0042 | -0.6057 | -0.0738 | -0.5991 | -0.0727 | -61.28 | -7.44 |
| 128 | -0.6160 | 0.0000 | 0.1003 | -0.6078 | 0.0258 | 0.0000 | 0.0255 | -0.0042 | -0.6120 | -0.0748 | -0.6089 | -0.0743 | -36.98 | -4.51 |
| 118 | -0.6215 | 0.0000 | 0.1012 | -0.6132 | 0.0258 | 0.0000 | 0.0255 | -0.0042 | -0.6174 | -0.0757 | -0.6147 | -0.0753 | -37.60 | -4.61 |
| 108 | -0.6262 | 0.0000 | 0.1020 | -0.6178 | 0.0258 | 0.0000 | 0.0255 | -0.0042 | -0.6220 | -0.0765 | -0.6197 | -0.0761 | -38.17 | -4.69 |
| 98 | -0.6300 | 0.0000 | 0.1026 | -0.6216 | 0.0258 | 0.0000 | 0.0255 | -0.0042 | -0.6258 | -0.0771 | -0.6239 | -0.0768 | -38.69 | -4.76 |
| 88 | -0.6331 | 0.0000 | 0.1031 | -0.6247 | 0.0258 | 0.0000 | 0.0255 | -0.0042 | -0.6289 | -0.0776 | -0.6274 | -0.0774 | -39.17 | -4.83 |
| 80.00 | -0.6351 | 0.0000 | 0.1034 | -0.6267 | 0.0258 | 0.0000 | 0.0255 | -0.0042 | -0.6309 | -0.0780 | -0.6299 | -0.0778 | -31.65 | -3.91 |
| 68 | -0.6374 | 0.0000 | 0.1038 | -0.6288 | 0.0258 | 0.0000 | 0.0255 | -0.0042 | -0.6331 | -0.0783 | -0.6320 | -0.0781 | -47.96 | -5.93 |
| 58 | -0.6385 | 0.0000 | 0.1040 | -0.6300 | 0.0258 | 0.0000 | 0.0255 | -0.0042 | -0.6342 | -0.0785 | -0.6336 | -0.0784 | -40.37 | -5.00 |
| 48 | -0.6391 | 0.0000 | 0.1041 | -0.6306 | 0.0258 | 0.0000 | 0.0255 | -0.0042 | -0.6348 | -0.0786 | -0.6345 | -0.0786 | -40.69 | -5.04 |
| 22 | -0.6381 | 0.0000 | 0.1039 | -0.6296 | 0.0258 | 0.0000 | 0.0255 | -0.0042 | -0.6338 | -0.0784 | -0.6343 | -0.0785 | -107.02 | -13.25 |
| 19 | -0.6377 | 0.0000 | 0.1038 | -0.6292 | 0.0258 | 0.0000 | 0.0255 | -0.0042 | -0.6334 | -0.0784 | -0.6336 | -0.0784 | -12.45 | -1.54 |
| 0 | -0.6345 | 0.0000 | 0.1033 | -0.6260 | 0.0258 | 0.0000 | 0.0255 | -0.0042 | -0.6302 | -0.0779 | -0.6318 | -0.0781 | -79.20 | -9.79 |
| | | | | | | | | | | | | Σ = | -890.47 | -103.16 |
| | | | | | | | | | | | | LIFT calc = | -1780.94 | |
| | | | | | | | | | | | | Lift = | -1822.10 | |

SPANWISE AERODYNAMIC LOAD DISTRIBUTION

CONDITION. G cont..

| 1 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 |
|---|---|---|---|---|---|---|---|---|
| STATION | LIMIT | LIMIT | LIMIT | LIMIT | ULT | ULT | ULT | ULT |
| (in) | NORMAL | NORMAL | CHORD | CHORD | NORMAL | NORMAL | CHORD | CHORD |
| | SHEAR | MOMENT | SHEAR | MOMENT | SHEAR | MOMENT | SHEAR | MOMENT |
| | (lb) | (lb in) | (lb) | (lb in) | (lb) | (lb in) | (lb) | (lb in) |
| 258 | 0.00 | 0.00 | 0.00 | 0.00 | 0 | 0 | 0 | 0 |
| 251.25 | -12.03 | -40.59 | -0.71 | -2.40 | -18 | -61 | -1 | -4 |
| 238 | -39.83 | -384.16 | -2.72 | -25.13 | -60 | -576 | -4 | -38 |
| 228 | -63.62 | -901.43 | -4.68 | -62.11 | -95 | -1352 | -7 | -93 |
| 218 | -89.16 | -1665.35 | -6.91 | -120.06 | -134 | -2498 | -10 | -180 |
| 208 | -116.16 | -2691.95 | -9.57 | -202.46 | -174 | -4038 | -14 | -304 |
| 198 | -144.40 | -3994.74 | -12.62 | -313.39 | -217 | -5992 | -19 | -470 |
| 188 | -173.79 | -5585.70 | -15.84 | -455.68 | -261 | -8379 | -24 | -684 |
| 178 | -204.20 | -7475.65 | -19.22 | -631.02 | -306 | -11213 | -29 | -947 |
| 163.65 | -249.43 | -10730.46 | -24.32 | -943.46 | -374 | -16096 | -36 | -1415 |
| 159 | -263.97 | -11840.69 | -26.02 | -1052.33 | -396 | -17761 | -39 | -1578 |
| 155.00 | -279.23 | -13015.36 | -27.87 | -1168.87 | -419 | -19523 | -42 | -1753 |
| 138 | -340.51 | -18283.12 | -35.30 | -1705.81 | -511 | -27425 | -53 | -2559 |
| 128 | -377.49 | -21873.13 | -39.82 | -2081.42 | -566 | -32810 | -60 | -3122 |
| 118 | -415.09 | -25836.07 | -44.42 | -2502.64 | -623 | -38754 | -67 | -3754 |
| 108 | -453.26 | -30177.86 | -49.11 | -2970.32 | -680 | -45267 | -74 | -4455 |
| 98 | -491.96 | -34903.96 | -53.88 | -3485.26 | -738 | -52356 | -81 | -5228 |
| 88 | -531.13 | -40019.36 | -58.71 | -4048.17 | -797 | -60029 | -88 | -6072 |
| 80.00 | -562.78 | -44394.98 | -62.62 | -4533.46 | -844 | -66592 | -94 | -6800 |
| 68 | -610.74 | -51436.09 | -68.55 | -5320.43 | -916 | -77154 | -103 | -7981 |
| 58 | -651.11 | -57745.32 | -73.54 | -6030.87 | -977 | -86618 | -110 | -9046 |
| 48 | -691.80 | -64459.84 | -78.58 | -6791.47 | -1038 | -96690 | -118 | -10187 |
| 22 | -798.82 | -83837.80 | -91.83 | -9006.76 | -1198 | -125757 | -138 | -13510 |
| 19 | -811.27 | -86252.93 | -93.37 | -9284.55 | -1217 | -129379 | -140 | -13927 |
| 0 | -890.47 | -102419.41 | -103.16 | -11151.57 | -1336 | -153629 | -155 | -16727 |
| | | | | | | | | |
| Centre of lift is | 115 | in from aircraft centreline | | | | | | |
| | 45 | % semispan | | | | | | |

SPANWISE INERTIAL LOAD DISTRIBUTION

CONDITION. G cont..

| 1 | 3 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 | 41 | 42 | 43 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| STATION | dy | WEIGHT | ELEMENT | ELEMENT | LIMIT | LIMIT | LIMIT | LIMIT | ULT | ULT | ULT | ULT |
| (in) | (in) | nW | SHEAR | SHEAR | NORMAL | NORMAL | CHORD | CHORD | NORMAL | NORMAL | CHORD | CHORD |
| | | (lb) | FORCE | FORCE | SHEAR | MOMENT | SHEAR | MOMENT | SHEAR | MOMENT | SHEAR | MOMENT |
| | | | $V_x$ | $V_z$ | (lb) | (lb in) | (lb) | (lb in) | (lb) | (lb in) | (lb) | (lb in) |
| | | | (lb) | (lb) | | | | | | | | |
| 258 | - | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0 | 0 | 0 | 0 |
| 251.25 | 6.75 | 0.50 | 0.08 | 0.49 | 0.49 | 1.65 | 0.08 | 0.27 | 1 | 2 | 0 | 0 |
| 238 | 13.25 | 1.32 | 0.21 | 1.30 | 1.79 | 16.73 | 0.30 | 2.76 | 3 | 25 | 0 | 4 |
| 228 | 10.00 | 2.28 | 0.37 | 2.25 | 4.04 | 45.86 | 0.67 | 7.57 | 6 | 69 | 1 | 11 |
| 218 | 10.00 | 3.19 | 0.52 | 3.15 | 7.19 | 101.99 | 1.19 | 16.83 | 11 | 153 | 2 | 25 |
| 208 | 10.00 | 3.91 | 0.64 | 3.86 | 11.05 | 193.17 | 1.82 | 31.88 | 17 | 290 | 3 | 48 |
| 198 | 10.00 | 4.60 | 0.75 | 4.54 | 15.59 | 326.34 | 2.57 | 53.86 | 23 | 490 | 4 | 81 |
| 188 | 10.00 | 5.45 | 0.89 | 5.37 | 20.96 | 509.07 | 3.46 | 84.02 | 31 | 764 | 5 | 126 |
| 178 | 10.00 | 6.17 | 1.00 | 6.09 | 27.05 | 749.10 | 4.46 | 123.63 | 41 | 1124 | 7 | 185 |
| 163.65 | 14.35 | 7.09 | 1.16 | 7.00 | 34.04 | 1187.42 | 5.62 | 195.97 | 51 | 1781 | 8 | 294 |
| 159 | 4.33 | 7.32 | 1.19 | 7.22 | 41.27 | 1350.29 | 6.81 | 222.85 | 62 | 2025 | 10 | 334 |
| 155.00 | 4.32 | 7.63 | 1.24 | 7.52 | 48.79 | 1545.04 | 8.05 | 254.99 | 73 | 2318 | 12 | 382 |
| 138 | 17.00 | 8.01 | 1.30 | 7.90 | 56.69 | 2441.64 | 9.36 | 402.96 | 85 | 3662 | 14 | 604 |
| 128 | 10.00 | 8.13 | 1.32 | 8.02 | 64.71 | 3048.66 | 10.68 | 503.14 | 97 | 4573 | 16 | 755 |
| 118 | 10.00 | 8.36 | 1.36 | 8.25 | 72.96 | 3737.04 | 12.04 | 616.75 | 109 | 5606 | 18 | 925 |
| 108 | 10.00 | 8.47 | 1.38 | 8.36 | 81.32 | 4508.47 | 13.42 | 744.06 | 122 | 6763 | 20 | 1116 |
| 98 | 10.00 | 8.61 | 1.40 | 8.50 | 89.82 | 5364.19 | 14.82 | 885.29 | 135 | 8046 | 22 | 1328 |
| 88 | 10.00 | 8.96 | 1.46 | 8.84 | 98.66 | 6306.58 | 16.28 | 1040.82 | 148 | 9460 | 24 | 1561 |
| 80.00 | 8.00 | 9.15 | 1.49 | 9.02 | 107.68 | 7131.93 | 17.77 | 1177.03 | 162 | 10698 | 27 | 1766 |
| 68 | 12.00 | 9.49 | 1.54 | 9.36 | 117.04 | 8480.27 | 19.32 | 1399.56 | 176 | 12720 | 29 | 2099 |
| 58 | 10.00 | 9.73 | 1.58 | 9.60 | 126.64 | 9698.67 | 20.90 | 1600.64 | 190 | 14548 | 31 | 2401 |
| 48 | 10.00 | 10.11 | 1.65 | 9.97 | 136.61 | 11014.93 | 22.55 | 1817.87 | 205 | 16522 | 34 | 2727 |
| 22 | 26.00 | 10.83 | 1.76 | 10.69 | 147.30 | 14705.76 | 24.31 | 2427.00 | 221 | 22059 | 36 | 3640 |
| 19 | 3.00 | 5.45 | 0.89 | 5.38 | 152.68 | 15155.73 | 25.20 | 2501.26 | 229 | 22734 | 38 | 3752 |
| 0 | 19.00 | 3.64 | 0.59 | 3.59 | 156.27 | 18090.73 | 25.79 | 2985.64 | 234 | 27136 | 39 | 4478 |
| | Σ= | 125 | lb | | | | | | | | | |
| | | at 1 g | | | Centre of gravity is | 116 | in from aircraft centreline | | | | | |
| | | | | | | 45 | % semispan | | | | | |

COMBINED ULTIMATE LOADS ( AERODYNAMIC + INERTIAL )

CONDITION. G cont..

| 1 | 44 G | 45 G | 46 G | 47 G | 48 G | 49 G |
|---|---|---|---|---|---|---|
| | ULT | ULT | ULT | ULT | ULT | ULT |
| | NORMAL | NORMAL | CHORD | CHORD | RESOLVED | RESOLVED |
| STATION | SHEAR | BEND MOMENT | SHEAR | BEND MOMENT | SHEAR | BEND MOMENT |
| (in) | COND. G | COND. G | COND. G | COND. G | COND. G | COND. G |
| | (lb) | (lb in) | (lb) | (lb in) | (lb) | (lb in) |
| 258 | 0 | 0 | 0 | 0 | 0 | 0 |
| 251.25 | -17 | -58 | -1 | -3 | 17 | 58 |
| 238 | -57 | -551 | -4 | -34 | 57 | 552 |
| 228 | -89 | -1283 | -6 | -82 | 90 | 1286 |
| 218 | -123 | -2345 | -9 | -155 | 123 | 2350 |
| 208 | -158 | -3748 | -12 | -256 | 158 | 3757 |
| 198 | -193 | -5503 | -15 | -389 | 194 | 5516 |
| 188 | -229 | -7615 | -19 | -558 | 230 | 7635 |
| 178 | -266 | -10090 | -22 | -761 | 267 | 10118 |
| 163.65 | -323 | -14315 | -28 | -1121 | 324 | 14358 |
| 159 | -334 | -15736 | -29 | -1244 | 335 | 15785 |
| 155.00 | -346 | -17205 | -30 | -1371 | 347 | 17260 |
| 138 | -426 | -23762 | -39 | -1954 | 428 | 23842 |
| 128 | -469 | -28237 | -44 | -2367 | 471 | 28336 |
| 118 | -513 | -33149 | -49 | -2829 | 515 | 33269 |
| 108 | -558 | -38504 | -54 | -3339 | 560 | 38649 |
| 98 | -603 | -44310 | -59 | -3900 | 606 | 44481 |
| 88 | -649 | -50569 | -64 | -4511 | 652 | 50770 |
| 80.00 | -683 | -55895 | -67 | -5035 | 686 | 56121 |
| 68 | -741 | -64434 | -74 | -5881 | 744 | 64702 |
| 58 | -787 | -72070 | -79 | -6645 | 791 | 72376 |
| 48 | -833 | -80167 | -84 | -7460 | 837 | 80514 |
| 22 | -977 | -103698 | -101 | -9870 | 983 | 104167 |
| 19 | -988 | -106646 | -102 | -10175 | 993 | 107130 |
| 0 | -1101 | -126493 | -116 | -12249 | 1107 | 127085 |

AERODYNAMIC TORQUE AT SHEAR CENTRE

CONDITION. G

| 1 | 50 | 74 | 51 | 52 | 53 | 54 | 55 | 56 | 57 | 58 |
|---|---|---|---|---|---|---|---|---|---|---|
| STATION | CLEAN + FLAPPED | CLEAN + FLAPPED | LOCAL | AERO | X AC | X SC | DELTA X | Z AC | Z SC | DELTA Z |
| | LOCAL | LOCAL | $X_{CP}$ | CENTRE | (in) | (in) | (in) | (in) | (in) | (in) |
| (in) | $C_L$ | $C_{Mo}$ | | (in) | | using 38% chord | | | | |
| 258 | - | -0.025 | - | 0.00 | 0.00 | 13.30 | 13.30 | 0.00 | 2.39 | -2.39 |
| 251.25 | -0.32 | -0.215 | 0.70 | 24.63 | 24.63 | 13.37 | -11.26 | 0.00 | 2.40 | -2.40 |
| 238 | -0.37 | -0.215 | 0.70 | 24.87 | 24.87 | 13.50 | -11.37 | 0.00 | 2.44 | -2.44 |
| 228 | -0.42 | -0.215 | 0.70 | 25.06 | 25.06 | 13.60 | -11.46 | 0.00 | 2.47 | -2.47 |
| 218 | -0.45 | -0.215 | 0.70 | 25.25 | 25.25 | 13.71 | -11.54 | 0.00 | 2.49 | -2.49 |
| 208 | -0.47 | -0.215 | 0.70 | 25.44 | 25.44 | 13.81 | -11.63 | 0.00 | 2.52 | -2.52 |
| 198 | -0.49 | -0.215 | 0.70 | 25.62 | 25.62 | 13.91 | -11.71 | 0.00 | 2.54 | -2.54 |
| 188 | -0.50 | -0.215 | 0.70 | 25.81 | 25.81 | 14.01 | -11.80 | 0.00 | 2.57 | -2.57 |
| 178 | -0.52 | -0.215 | 0.70 | 26.00 | 26.00 | 14.11 | -11.88 | 0.00 | 2.60 | -2.60 |
| 163.65 | -0.53 | -0.215 | 0.70 | 26.27 | 26.27 | 14.26 | -12.01 | 0.00 | 2.64 | -2.64 |
| 159 | -0.56 | -0.025 | 0.20 | 7.37 | 7.37 | 14.30 | 6.94 | 0.00 | 2.65 | -2.65 |
| 155.00 | -0.59 | -0.025 | 0.20 | 7.46 | 7.46 | 14.35 | 6.88 | 0.00 | 2.66 | -2.66 |
| 138 | -0.60 | -0.025 | 0.20 | 7.58 | 7.58 | 14.52 | 6.94 | 0.00 | 2.70 | -2.70 |
| 128 | -0.61 | -0.025 | 0.20 | 7.65 | 7.65 | 14.62 | 6.97 | 0.00 | 2.73 | -2.73 |
| 118 | -0.61 | -0.025 | 0.20 | 7.72 | 7.72 | 14.72 | 7.00 | 0.00 | 2.76 | -2.76 |
| 108 | -0.62 | -0.025 | 0.20 | 7.79 | 7.79 | 14.82 | 7.04 | 0.00 | 2.78 | -2.78 |
| 98 | -0.62 | -0.025 | 0.20 | 7.85 | 7.85 | 14.93 | 7.07 | 0.00 | 2.81 | -2.81 |
| 88 | -0.63 | -0.025 | 0.20 | 7.92 | 7.92 | 15.03 | 7.11 | 0.00 | 2.84 | -2.84 |
| 80.00 | -0.63 | -0.025 | 0.20 | 7.96 | 7.96 | 15.11 | 7.14 | 0.00 | 2.86 | -2.86 |
| 68 | -0.63 | -0.025 | 0.20 | 8.03 | 8.03 | 15.23 | 7.20 | 0.00 | 2.89 | -2.89 |
| 58 | -0.63 | -0.025 | 0.20 | 8.09 | 8.09 | 15.33 | 7.24 | 0.00 | 2.92 | -2.92 |
| 48 | -0.63 | -0.025 | 0.20 | 8.15 | 8.15 | 15.43 | 7.29 | 0.00 | 2.94 | -2.94 |
| 22 | -0.63 | -0.025 | 0.20 | 8.29 | 8.29 | 15.70 | 7.41 | 0.00 | 3.01 | -3.01 |
| 19 | -0.63 | -0.025 | 0.20 | 8.30 | 8.30 | 15.73 | 7.43 | 0.00 | 3.01 | -3.01 |
| 0 | -0.63 | -0.025 | 0.20 | 8.40 | 8.40 | 15.92 | 7.52 | 0.00 | 1.25 | -1.25 |

| AERODYNAMIC TORQUE AT SHEAR CENTRE | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| CONDITION. G | | | | | | $\Delta C_{Mo}$ | | | | | |
| | | | | | | 0 | | | | | |
| 1 | 55 | 56 | 23 | 24 | 59 | 75 | 60 | 61 | 62 | 63 | 64 |
| STATION | DELTA | DELTA | SPAN | SPAN | ELEMENT | ELEMENT | ELEMENT | ELEMENT | ELEMENT | TOTAL | TOTAL |
| | X av | Z av | ELEMENT | ELEMENT | TORQUE | TORQUE | TORQUE | TORQUE | LIMIT | LIMIT | ULT |
| (in) | (in) | (in) | LIFT | DRAG | DUE TO | DUE TO | DUE TO | DUE TO | TORQUE | TORQUE | TORQUE |
| | | | (lb) | (lb) | $C_{Mo}$ | $\Delta C_{Mo}$ | LIFT | DRAG | (lb in) | (lb in) | (lb in) |
| | | | | | (lb in) | (lb in) | (lb in) | (lb in) | | | |
| 258 | - | - | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 251.25 | 1.02 | 0.00 | -12.03 | -0.71 | -32.92 | -250.17 | -12.28 | 0.00 | -295.37 | -295.37 | -443.05 |
| 238 | -11.31 | 0.00 | -27.81 | -2.01 | -65.60 | -498.59 | 314.62 | 0.00 | -249.57 | -544.94 | -817.41 |
| 228 | -11.41 | 0.00 | -23.79 | -1.96 | -50.39 | -382.94 | 271.50 | 0.00 | -161.83 | -706.77 | -1060.15 |
| 218 | -11.50 | 0.00 | -25.54 | -2.23 | -51.15 | -388.70 | 293.75 | 0.00 | -146.10 | -852.86 | -1279.30 |
| 208 | -11.59 | 0.00 | -26.99 | -2.66 | -51.91 | -394.51 | 312.70 | 0.00 | -133.72 | -986.58 | -1479.87 |
| 198 | -11.67 | 0.00 | -28.25 | -3.05 | -52.68 | -400.36 | 329.65 | 0.00 | -123.39 | -1109.97 | -1664.95 |
| 188 | -11.76 | 0.00 | -29.39 | -3.23 | -53.45 | -406.25 | 345.48 | 0.00 | -114.23 | -1224.20 | -1836.29 |
| 178 | -11.84 | 0.00 | -30.41 | -3.38 | -54.24 | -412.19 | 360.13 | 0.00 | -106.29 | -1330.49 | -1995.73 |
| 163.65 | -11.95 | 0.00 | -45.23 | -5.10 | -79.20 | -601.95 | 540.33 | 0.00 | -140.82 | -1471.31 | -2206.97 |
| 159 | -2.54 | 0.00 | -14.54 | -1.70 | -24.19 | 0.00 | 36.87 | 0.00 | 12.68 | -1458.63 | -2187.95 |
| 155.00 | 6.91 | 0.00 | -15.25 | -1.84 | -24.34 | 0.00 | -105.40 | 0.00 | -129.74 | -1588.38 | -2382.56 |
| 138 | 6.91 | 0.00 | -61.28 | -7.44 | -97.13 | 0.00 | -423.70 | 0.00 | -520.83 | -2109.20 | -3163.81 |
| 128 | 6.96 | 0.00 | -36.98 | -4.51 | -58.23 | 0.00 | -257.23 | 0.00 | -315.45 | -2424.66 | -3636.98 |
| 118 | 6.98 | 0.00 | -37.60 | -4.61 | -59.04 | 0.00 | -262.58 | 0.00 | -321.62 | -2746.27 | -4119.41 |
| 108 | 7.02 | 0.00 | -38.17 | -4.69 | -59.86 | 0.00 | -267.86 | 0.00 | -327.72 | -3073.99 | -4610.98 |
| 98 | 7.05 | 0.00 | -38.69 | -4.76 | -60.69 | 0.00 | -272.93 | 0.00 | -333.62 | -3407.61 | -5111.42 |
| 88 | 7.09 | 0.00 | -39.17 | -4.83 | -61.52 | 0.00 | -277.82 | 0.00 | -339.34 | -3746.96 | -5620.43 |
| 80.00 | 7.13 | 0.00 | -31.65 | -3.91 | -49.82 | 0.00 | -225.65 | 0.00 | -275.47 | -4022.42 | -6033.63 |
| 68 | 7.17 | 0.00 | -47.96 | -5.93 | -75.74 | 0.00 | -343.91 | 0.00 | -419.65 | -4442.07 | -6663.10 |
| 58 | 7.22 | 0.00 | -40.37 | -5.00 | -64.05 | 0.00 | -291.41 | 0.00 | -355.46 | -4797.53 | -7196.29 |
| 48 | 7.26 | 0.00 | -40.69 | -5.04 | -64.91 | 0.00 | -295.57 | 0.00 | -360.47 | -5158.00 | -7737.00 |
| 22 | 7.35 | 0.00 | -107.02 | -13.25 | -172.79 | 0.00 | -786.50 | 0.00 | -959.29 | -6117.30 | -9175.94 |
| 19 | 7.42 | 0.00 | -12.45 | -1.54 | -20.32 | 0.00 | -92.39 | 0.00 | -112.71 | -6230.00 | -9345.01 |
| 0 | 7.48 | 0.00 | -79.20 | -9.79 | -130.51 | 0.00 | -592.11 | 0.00 | -722.62 | -6952.62 | -10428.93 |

| DEAD WEIGHT ANALYSIS FOR WING TORQUE | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| CONDITION. G | | | | | | | | |
| | | | | | | | | |
| 1 | 65 | 54 | 66 | 67 | 33 | 68 | 69 | 70 |
| STATION | X CG | X SC | DELTA | DELTA | ELEMENT | ELEMENT | TOTAL | TOTAL |
| | (in) | (in) | X | X av | LOAD | LIMIT | LIMIT | ULT |
| (in) | | | (in) | (in) | (lb) | TORQUE | TORQUE | TORQUE |
| | using 40% chord | | | | | (lb in) | (lb in) | (lb in) |
| 258 | 14.00 | 13.30 | -0.70 | - | - | - | - | 0.00 |
| 251.25 | 14.07 | 13.37 | -0.70 | -0.70 | 0.50 | -0.35 | -0.35 | -0.52 |
| 238 | 14.21 | 13.50 | -0.71 | -0.71 | 1.32 | -0.93 | -1.28 | -1.92 |
| 228 | 14.32 | 13.60 | -0.72 | -0.71 | 2.28 | -1.63 | -2.91 | -4.36 |
| 218 | 14.43 | 13.71 | -0.72 | -0.72 | 3.19 | -2.29 | -5.20 | -7.80 |
| 208 | 14.53 | 13.81 | -0.73 | -0.72 | 3.91 | -2.83 | -8.03 | -12.05 |
| 198 | 14.64 | 13.91 | -0.73 | -0.73 | 4.60 | -3.35 | -11.39 | -17.08 |
| 188 | 14.75 | 14.01 | -0.74 | -0.73 | 5.45 | -4.00 | -15.39 | -23.08 |
| 178 | 14.86 | 14.11 | -0.74 | -0.74 | 6.17 | -4.57 | -19.96 | -29.93 |
| 163.65 | 15.01 | 14.26 | -0.75 | -0.75 | 7.09 | -5.30 | -25.25 | -37.88 |
| 159 | 15.06 | 14.30 | -0.75 | -0.75 | 7.32 | -5.50 | -30.75 | -46.13 |
| 155.00 | 15.10 | 14.35 | -0.76 | -0.75 | 7.63 | -5.75 | -36.50 | -54.75 |
| 138 | 15.28 | 14.52 | -0.76 | -0.76 | 8.01 | -6.08 | -42.58 | -63.88 |
| 128 | 15.39 | 14.62 | -0.77 | -0.77 | 8.13 | -6.24 | -48.82 | -73.23 |
| 118 | 15.50 | 14.72 | -0.77 | -0.77 | 8.36 | -6.46 | -55.28 | -82.91 |
| 108 | 15.60 | 14.82 | -0.78 | -0.78 | 8.47 | -6.59 | -61.87 | -92.80 |
| 98 | 15.71 | 14.93 | -0.79 | -0.78 | 8.61 | -6.74 | -68.61 | -102.91 |
| 88 | 15.82 | 15.03 | -0.79 | -0.79 | 8.96 | -7.06 | -75.67 | -113.50 |
| 80.00 | 15.90 | 15.11 | -0.80 | -0.79 | 9.15 | -7.25 | -82.92 | -124.38 |
| 68 | 16.03 | 15.23 | -0.80 | -0.80 | 9.49 | -7.57 | -90.50 | -135.74 |
| 58 | 16.14 | 15.33 | -0.81 | -0.80 | 9.73 | -7.82 | -98.32 | -147.48 |
| 48 | 16.25 | 15.43 | -0.81 | -0.81 | 10.11 | -8.18 | -106.50 | -159.76 |
| 22 | 16.52 | 15.70 | -0.83 | -0.82 | 10.83 | -8.87 | -115.38 | -173.06 |
| 19 | 16.56 | 15.73 | -0.83 | -0.83 | 5.45 | -4.51 | -119.89 | -179.83 |
| 0 | 16.76 | 15.92 | -0.84 | -0.83 | 3.64 | -3.03 | -122.92 | -184.37 |

COMBINED ULTIMATE TORSION ( AERODYNAMIC + INERTIAL )

| CONDITION. G | | | |
|---|---|---|---|
| | | | |
| | | | |
| 1 | 71 G | | |
| STATION | COND. G | | |
| (in) | (lb in) | | |
| 258 | 0 | | |
| 251.25 | -444 | | |
| 238 | -819 | | |
| 228 | -1065 | | |
| 218 | -1287 | | |
| 208 | -1492 | | |
| 198 | -1682 | | |
| 188 | -1859 | | |
| 178 | -2026 | | |
| 163.65 | -2245 | | |
| 159 | -2234 | | |
| 155.00 | -2437 | | |
| 138 | -3228 | | |
| 128 | -3710 | | |
| 118 | -4202 | | |
| 108 | -4704 | | |
| 98 | -5214 | | |
| 88 | -5734 | | |
| 80.00 | -6158 | | |
| 68 | -6799 | | |
| 58 | -7344 | | |
| 48 | -7897 | | |
| 22 | -9349 | | |
| 19 | -9525 | | |
| 0 | -10613 | | |

# APPENDIX E: SUMMARY OF MOST UNFAVOURABLE COMBINATIONS OF SPANWISE LOAD

SUMMARY OF RESULTS FROM FLIGHT ENVELOPE ANALYSIS

RESOLVED ULTIMATE SHEAR

| STATION (in) | COND. A (lb) | COND. C (lb) | COND. D (lb) | COND. E (lb) | COND. F (lb) | COND. G (lb) |
|---|---|---|---|---|---|---|
| | COND. A | COND. C | COND. D | COND. E | COND. F | COND. G |
| 258 | 0 | 0 | 0 | 0 | 0 | 0 |
| 251 | 56 | 67 | 56 | 28 | 37 | 28 |
| 238 | 191 | 227 | 190 | 95 | 127 | 95 |
| 228 | 299 | 357 | 298 | 149 | 199 | 149 |
| 218 | 412 | 491 | 410 | 205 | 274 | 205 |
| 208 | 528 | 630 | 526 | 263 | 352 | 263 |
| 198 | 647 | 772 | 645 | 322 | 431 | 322 |
| 188 | 767 | 916 | 765 | 382 | 511 | 383 |
| 178 | 889 | 1061 | 886 | 443 | 593 | 443 |
| 164 | 1079 | 1288 | 1076 | 538 | 720 | 538 |
| 159 | 1115 | 1331 | 1111 | 556 | 743 | 556 |
| 155 | 1150 | 1372 | 1146 | 573 | 767 | 573 |
| 138 | 1392 | 1661 | 1388 | 694 | 928 | 694 |
| 128 | 1523 | 1818 | 1519 | 760 | 1016 | 760 |
| 118 | 1656 | 1977 | 1652 | 826 | 1104 | 826 |
| 108 | 1791 | 2138 | 1786 | 894 | 1195 | 894 |
| 98 | 1928 | 2301 | 1923 | 962 | 1286 | 962 |
| 88 | 2066 | 2466 | 2060 | 1030 | 1378 | 1031 |
| 80 | 2168 | 2588 | 2163 | 1082 | 1446 | 1082 |
| 68 | 2343 | 2797 | 2337 | 1169 | 1563 | 1169 |
| 58 | 2483 | 2963 | 2476 | 1239 | 1656 | 1239 |
| 48 | 2622 | 3130 | 2615 | 1308 | 1749 | 1308 |
| 22 | 3059 | 3651 | 3052 | 1526 | 2040 | 1526 |
| 19 | 3091 | 3689 | 3084 | 1542 | 2062 | 1542 |
| 0 | 3434 | 4099 | 3426 | 1713 | 2291 | 1714 |

SUMMARY OF RESULTS FROM FLIGHT ENVELOPE ANALYSIS

RESOLVED ULTIMATE BENDING MOMENT

| STATION (in) | COND. A (lb in) | COND. C (lb in) | COND. D (lb in) | COND. E (lb in) | COND. F (lb in) | COND. G (lb in) |
|---|---|---|---|---|---|---|
| | COND. A | COND. C | COND. D | COND. E | COND. F | COND. G |
| 258 | 0 | 0 | 0 | 0 | 0 | 0 |
| 251 | 189 | 225 | 188 | 94 | 125 | 94 |
| 238 | 1823 | 2173 | 1812 | 907 | 1212 | 907 |
| 228 | 4273 | 5094 | 4249 | 2126 | 2842 | 2127 |
| 218 | 7830 | 9336 | 7789 | 3897 | 5210 | 3898 |
| 208 | 12531 | 14943 | 12470 | 6238 | 8340 | 6240 |
| 198 | 18407 | 21952 | 18322 | 9166 | 12254 | 9168 |
| 188 | 25479 | 30390 | 25368 | 12690 | 16966 | 12693 |
| 178 | 33762 | 40272 | 33622 | 16819 | 22486 | 16822 |
| 164 | 47887 | 57126 | 47701 | 23861 | 31900 | 23866 |
| 159 | 52632 | 62789 | 52431 | 26227 | 35064 | 26232 |
| 155 | 57530 | 68633 | 57314 | 28669 | 38328 | 28674 |
| 138 | 79137 | 94417 | 78854 | 39443 | 52732 | 39450 |
| 128 | 93713 | 111812 | 93388 | 46713 | 62451 | 46721 |
| 118 | 109611 | 130785 | 109241 | 54642 | 73051 | 54651 |
| 108 | 126849 | 151358 | 126432 | 63240 | 84546 | 63250 |
| 98 | 145447 | 173555 | 144979 | 72516 | 96948 | 72528 |
| 88 | 165417 | 197389 | 164896 | 82478 | 110265 | 82490 |
| 80 | 182353 | 217602 | 181788 | 90926 | 121560 | 90940 |
| 68 | 209422 | 249910 | 208787 | 104430 | 139612 | 104445 |
| 58 | 233552 | 278711 | 232855 | 116467 | 155706 | 116484 |
| 48 | 259075 | 309175 | 258314 | 129201 | 172729 | 129219 |
| 22 | 332924 | 397323 | 331986 | 166047 | 221987 | 166069 |
| 19 | 342148 | 408333 | 341189 | 170649 | 228141 | 170672 |
| 0 | 404131 | 482321 | 403030 | 201578 | 269489 | 201605 |

| SUMMARY OF RESULTS FROM FLIGHT ENVELOPE ANALYSIS | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| STATION | NORMAL SHEAR | | | | | | | | | | | | | | | | | | | | | | |
| (in) | | | | | | | | | | | | | | | | | | | | | | | |
| | A | A UP | A DWN | | C | C UP | C DWN | | D | D UP | D DWN | | E | E UP | E DWN | | F | F UP | F DWN | | G | G UP | G DWN |
| 258 | 0 | 0 | 0 | 258 | 0 | 0 | 0 | 258 | 0 | 0 | 0 | 258 | 0 | 0 | 0 | 258 | 0 | 0 | 0 | 258 | 0 | 0 | 0 |
| 251 | 56 | 30 | 43 | 251 | 66 | 39 | 47 | 251 | 56 | 30 | 43 | 251 | -28 | -23 | 43 | 251 | -37 | -27 | -22 | 251 | -28 | -20 | -17 |
| 238 | 189 | 93 | 156 | 238 | 226 | 127 | 167 | 238 | 190 | 89 | 154 | 238 | -95 | -84 | 154 | 238 | -126 | -94 | -72 | 238 | -94 | -69 | -57 |
| 228 | 296 | 145 | 246 | 228 | 355 | 198 | 262 | 228 | 298 | 139 | 244 | 228 | -149 | -132 | 244 | 228 | -198 | -148 | -112 | 228 | -148 | -109 | -89 |
| 218 | 408 | 199 | 339 | 218 | 489 | 272 | 361 | 218 | 410 | 191 | 335 | 218 | -205 | -182 | 335 | 218 | -272 | -204 | -154 | 218 | -203 | -150 | -123 |
| 208 | 522 | 255 | 434 | 208 | 627 | 349 | 463 | 208 | 526 | 245 | 430 | 208 | -263 | -233 | 430 | 208 | -349 | -261 | -198 | 208 | -260 | -192 | -158 |
| 198 | 639 | 313 | 531 | 198 | 768 | 428 | 567 | 198 | 645 | 301 | 526 | 198 | -322 | -285 | 526 | 198 | -427 | -320 | -242 | 198 | -319 | -236 | -193 |
| 188 | 758 | 372 | 629 | 188 | 911 | 509 | 672 | 188 | 765 | 358 | 624 | 188 | -382 | -337 | 624 | 188 | -506 | -379 | -288 | 188 | -378 | -279 | -229 |
| 178 | 878 | 431 | 728 | 178 | 1055 | 590 | 778 | 178 | 886 | 416 | 723 | 178 | -443 | -390 | 723 | 178 | -587 | -439 | -333 | 178 | -438 | -323 | -266 |
| 164 | 1065 | 527 | 881 | 164 | 1280 | 718 | 943 | 164 | 1076 | 508 | 875 | 164 | -537 | -472 | 875 | 164 | -712 | -532 | -406 | 164 | -532 | -392 | -323 |
| 159 | 1100 | 546 | 909 | 159 | 1323 | 743 | 974 | 159 | 1111 | 527 | 902 | 159 | -555 | -487 | 902 | 159 | -736 | -549 | -420 | 159 | -550 | -405 | -334 |
| 155 | 1135 | 569 | 932 | 155 | 1364 | 771 | 1001 | 155 | 1146 | 550 | 925 | 155 | -572 | -498 | 925 | 155 | -759 | -565 | -435 | 155 | -567 | -416 | -346 |
| 138 | 1373 | 729 | 1093 | 138 | 1651 | 963 | 1194 | 138 | 1388 | 711 | 1087 | 138 | -693 | -579 | 1087 | 138 | -919 | -672 | -543 | 138 | -686 | -496 | -426 |
| 128 | 1502 | 816 | 1180 | 128 | 1806 | 1068 | 1298 | 128 | 1519 | 799 | 1174 | 128 | -758 | -623 | 1174 | 128 | -1005 | -730 | -601 | 128 | -751 | -540 | -469 |
| 118 | 1633 | 904 | 1268 | 118 | 1964 | 1173 | 1404 | 118 | 1652 | 887 | 1262 | 118 | -824 | -668 | 1262 | 118 | -1093 | -789 | -660 | 118 | -816 | -584 | -513 |
| 108 | 1765 | 994 | 1357 | 108 | 2124 | 1281 | 1511 | 108 | 1786 | 977 | 1352 | 108 | -892 | -713 | 1352 | 108 | -1182 | -849 | -720 | 108 | -883 | -629 | -558 |
| 98 | 1900 | 1084 | 1448 | 98 | 2286 | 1389 | 1620 | 98 | 1923 | 1068 | 1443 | 98 | -960 | -759 | 1443 | 98 | -1272 | -910 | -781 | 98 | -950 | -674 | -603 |
| 88 | 2035 | 1176 | 1539 | 88 | 2449 | 1499 | 1729 | 88 | 2060 | 1160 | 1535 | 88 | -1028 | -805 | 1535 | 88 | -1363 | -971 | -842 | 88 | -1018 | -719 | -649 |
| 80 | 2136 | 1244 | 1607 | 80 | 2570 | 1580 | 1810 | 80 | 2162 | 1228 | 1603 | 80 | -1079 | -839 | 1603 | 80 | -1431 | -1016 | -887 | 80 | -1069 | -753 | -683 |
| 68 | 2308 | 1359 | 1723 | 68 | 2778 | 1719 | 1949 | 68 | 2337 | 1344 | 1720 | 68 | -1167 | -897 | 1720 | 68 | -1546 | -1094 | -965 | 68 | -1155 | -811 | -741 |
| 58 | 2445 | 1452 | 1815 | 58 | 2943 | 1830 | 2060 | 58 | 2476 | 1437 | 1812 | 58 | -1236 | -944 | 1812 | 58 | -1638 | -1156 | -1026 | 58 | -1224 | -857 | -787 |
| 48 | 2582 | 1544 | 1907 | 48 | 3108 | 1940 | 2171 | 48 | 2615 | 1530 | 1905 | 48 | -1305 | -991 | 1905 | 48 | -1730 | -1217 | -1088 | 48 | -1292 | -903 | -833 |
| 22 | 3011 | 1833 | 2197 | 22 | 3625 | 2288 | 2518 | 22 | 3051 | 1821 | 2196 | 22 | -1523 | -1137 | 2196 | 22 | -2018 | -1411 | -1282 | 22 | -1507 | -1048 | -977 |
| 19 | 3043 | 1855 | 2218 | 19 | 3663 | 2313 | 2543 | 19 | 3083 | 1842 | 2217 | 19 | -1539 | -1147 | 2217 | 19 | -2039 | -1425 | -1296 | 19 | -1523 | -1058 | -988 |
| 0 | 3379 | 2082 | 2445 | 0 | 4069 | 2585 | 2816 | 0 | 3426 | 2070 | 2446 | 0 | -1710 | -1262 | 2446 | 0 | -2265 | -1577 | -1448 | 0 | -1692 | -1172 | -1101 |

| SUMMARY OF RESULTS FROM FLIGHT ENVELOPE ANALYSIS | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| STATION | NORMAL MOMENT | | | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | | | | |
| | A | A UP | A DWN | | C | C UP | C DWN | | D | D UP | D DWN | | E | E UP | E DWN | | F | F UP | F DWN | | G | G UP | G DWN |
| 258 | 0 | 0 | 0 | 258 | 0 | 0 | 0 | 258 | 0 | 0 | 0 | 258 | 0 | 0 | 0 | 258 | 0 | 0 | 0 | 258 | 0 | 0 | 0 |
| 251 | 187 | 102 | 145 | 251 | 224 | 133 | 160 | 251 | 187 | 100 | 144 | 251 | -94 | -77 | -48 | 251 | -125 | -90 | -75 | 251 | -93 | -67 | -58 |
| 238 | 1807 | 919 | 1464 | 238 | 2165 | 1233 | 1578 | 238 | 1812 | 887 | 1449 | 238 | -906 | -781 | -423 | 238 | -1203 | -891 | -697 | 238 | -899 | -657 | -551 |
| 228 | 4233 | 2107 | 3473 | 228 | 5075 | 2855 | 3722 | 228 | 4249 | 2027 | 3438 | 228 | -2124 | -1858 | -960 | 228 | -2820 | -2101 | -1615 | 228 | -2107 | -1549 | -1283 |
| 218 | 7753 | 3824 | 6396 | 218 | 9299 | 5207 | 6838 | 218 | 7789 | 3676 | 6333 | 218 | -3893 | -3425 | -1736 | 218 | -5167 | -3861 | -2946 | 218 | -3862 | -2845 | -2345 |
| 208 | 12404 | 6093 | 10259 | 208 | 14880 | 8314 | 10956 | 208 | 12470 | 5857 | 10160 | 208 | -6231 | -5497 | -2761 | 208 | -8270 | -6186 | -4704 | 208 | -6180 | -4558 | -3748 |
| 198 | 18212 | 8933 | 15083 | 198 | 21854 | 12203 | 16103 | 198 | 18322 | 8589 | 14941 | 198 | -9154 | -8083 | -4045 | 198 | -12148 | -9091 | -6904 | 198 | -9078 | -6697 | -5503 |
| 188 | 25198 | 12357 | 20883 | 188 | 30247 | 16888 | 22295 | 188 | 25368 | 11886 | 20692 | 188 | -12673 | -11192 | -5593 | 188 | -16816 | -12585 | -9553 | 188 | -12565 | -9271 | -7615 |
| 178 | 33376 | 16372 | 27671 | 178 | 40074 | 22379 | 29545 | 178 | 33622 | 15754 | 27425 | 178 | -16795 | -14829 | -7410 | 178 | -22283 | -16676 | -12659 | 178 | -16649 | -12285 | -10090 |
| 164 | 47313 | 23245 | 39221 | 164 | 56829 | 31765 | 41896 | 164 | 47700 | 22385 | 38885 | 164 | -23825 | -21015 | -10525 | 164 | -31604 | -23644 | -17963 | 164 | -23613 | -17418 | -14315 |
| 159 | 51995 | 25564 | 43093 | 159 | 62457 | 34925 | 46041 | 159 | 52431 | 24623 | 42728 | 159 | -26187 | -23088 | -11578 | 159 | -34736 | -25982 | -19749 | 159 | -25953 | -19141 | -15736 |
| 155 | 56828 | 27974 | 47075 | 155 | 68267 | 38199 | 50312 | 155 | 57313 | 26952 | 46680 | 155 | -28624 | -25217 | -12675 | 155 | -37968 | -28391 | -21599 | 155 | -28368 | -20916 | -17205 |
| 138 | 78140 | 39008 | 64286 | 138 | 93894 | 52940 | 68970 | 138 | 78853 | 37673 | 63781 | 138 | -39379 | -34375 | -17777 | 138 | -52227 | -38903 | -29915 | 138 | -39020 | -28673 | -23762 |
| 128 | 92511 | 46734 | 75646 | 128 | 111178 | 63094 | 81429 | 128 | 93386 | 45222 | 75083 | 128 | -46634 | -40386 | -21402 | 128 | -61845 | -45914 | -35634 | 128 | -46206 | -33853 | -28237 |
| 118 | 108182 | 55337 | 87882 | 118 | 130028 | 74298 | 94937 | 118 | 109238 | 53650 | 87264 | 118 | -54548 | -46839 | -25468 | 118 | -72335 | -53511 | -41939 | 118 | -54042 | -39471 | -33149 |
| 108 | 125172 | 64827 | 101006 | 108 | 150467 | 86567 | 109511 | 108 | 126428 | 62970 | 100338 | 108 | -63128 | -53741 | -29984 | 108 | -83710 | -61702 | -48838 | 108 | -62540 | -45533 | -38504 |
| 98 | 143500 | 75218 | 115032 | 98 | 172516 | 99916 | 125164 | 98 | 144975 | 73195 | 114317 | 98 | -72387 | -61097 | -34954 | 98 | -95982 | -70497 | -56341 | 98 | -71707 | -52044 | -44310 |
| 88 | 163177 | 86519 | 129966 | 88 | 196191 | 114356 | 141908 | 88 | 164890 | 84333 | 129208 | 88 | -82328 | -68912 | -40383 | 88 | -109158 | -79900 | -64452 | 88 | -81550 | -59009 | -50569 |
| 80 | 179863 | 96195 | 142549 | 80 | 216268 | 126670 | 156066 | 80 | 181781 | 93883 | 141760 | 80 | -90758 | -75486 | -45047 | 80 | -120333 | -87848 | -71366 | 80 | -89898 | -64900 | -55895 |
| 68 | 206529 | 111813 | 162528 | 68 | 248356 | 146464 | 178626 | 68 | 208778 | 109315 | 161696 | 68 | -104234 | -85902 | -52600 | 68 | -138194 | -100509 | -82477 | 68 | -103240 | -74286 | -64434 |
| 58 | 230297 | 125869 | 180218 | 58 | 276958 | 164209 | 198675 | 58 | 232845 | 123222 | 179357 | 58 | -116246 | -95109 | -59421 | 58 | -154114 | -111757 | -92432 | 58 | -115133 | -82628 | -72070 |
| 48 | 255436 | 140849 | 198832 | 48 | 307212 | 183060 | 219831 | 48 | 258302 | 138056 | 197944 | 48 | -128952 | -104781 | -66707 | 48 | -170954 | -123622 | -103006 | 48 | -127712 | -91431 | -80167 |
| 22 | 328152 | 184756 | 252187 | 22 | 394736 | 238024 | 280786 | 22 | 331968 | 181611 | 251258 | 22 | -165718 | -132433 | -88155 | 22 | -219677 | -157793 | -133817 | 22 | -164108 | -116798 | -103698 |
| 19 | 337233 | 190288 | 258809 | 19 | 405667 | 244925 | 288378 | 19 | 341170 | 187105 | 257877 | 19 | -170310 | -135859 | -90865 | 19 | -225763 | -162048 | -137684 | 19 | -168654 | -119957 | -106646 |
| 0 | 398243 | 227682 | 303107 | 0 | 479117 | 291460 | 339292 | 0 | 403005 | 224272 | 302176 | 0 | -201170 | -158745 | -109218 | 0 | -266655 | -190572 | -163754 | 0 | -199199 | -141146 | -126493 |

SUMMARY OF RESULTS FROM FLIGHT ENVELOPE ANALYSIS

CHORDWISE SHEAR

| STATION (in) | A | AUP | ADN | A BRAKES |
|---|---|---|---|---|
| 258 | 0 | 0 | 0 | 0 |
| 251 | -7 | -1 | -3 | -2 |
| 238 | -26 | -2 | -12 | -10 |
| 228 | -42 | -3 | -20 | -16 |
| 218 | -60 | -5 | -28 | -23 |
| 208 | -79 | -7 | -37 | -31 |
| 198 | -100 | -11 | -47 | -39 |
| 188 | -121 | -15 | -57 | -48 |
| 178 | -143 | -18 | -67 | -56 |
| 164 | -177 | -25 | -83 | -70 |
| 159 | -182 | -26 | -85 | -72 |
| 155 | -187 | -27 | -87 | -72 |
| 138 | -232 | -45 | -104 | -71 |
| 128 | -256 | -54 | -113 | -70 |
| 118 | -280 | -63 | -122 | -69 |
| 108 | -304 | -72 | -131 | -68 |
| 98 | -329 | -81 | -141 | -66 |
| 88 | -354 | -91 | -150 | -65 |
| 80 | -372 | -97 | -157 | -63 |
| 68 | -404 | -110 | -169 | -70 |
| 58 | -429 | -119 | -179 | -80 |
| 48 | -454 | -129 | -188 | -90 |
| 22 | -538 | -161 | -221 | -124 |
| 19 | -543 | -163 | -222 | -126 |
| 0 | -610 | -189 | -248 | -153 |

| | C | CUP | CDN | C BRAKES |
|---|---|---|---|---|
| 258 | 0 | 0 | 0 | 0 |
| 251 | -5 | 0 | -1 | -1 |
| 238 | -20 | 0 | -4 | -6 |
| 228 | -33 | 0 | -7 | -10 |
| 218 | -46 | -1 | -11 | -14 |
| 208 | -61 | -3 | -15 | -19 |
| 198 | -78 | -5 | -20 | -25 |
| 188 | -96 | -8 | -26 | -31 |
| 178 | -113 | -10 | -31 | -37 |
| 164 | -142 | -15 | -40 | -46 |
| 159 | -146 | -16 | -41 | -48 |
| 155 | -149 | -16 | -42 | -45 |
| 138 | -186 | -27 | -52 | -29 |
| 128 | -206 | -32 | -58 | -18 |
| 118 | -225 | -38 | -63 | -7 |
| 108 | -245 | -43 | -69 | 4 |
| 98 | -266 | -49 | -75 | 15 |
| 88 | -286 | -55 | -80 | 26 |
| 80 | -301 | -58 | -84 | 35 |
| 68 | -327 | -66 | -92 | 37 |
| 58 | -348 | -72 | -97 | 30 |
| 48 | -368 | -78 | -103 | 23 |
| 22 | -438 | -98 | -124 | -2 |
| 19 | -442 | -99 | -125 | -3 |
| 0 | -497 | -116 | -142 | -72 |

| | D | DUP | DDN | D BRAKES | BRAKES ZL |
|---|---|---|---|---|---|
| 258 | 0 | 0 | 0 | 0 | 0 |
| 251 | 1 | 4 | 4 | 2 | 1 |
| 238 | 1 | 13 | 12 | 5 | 4 |
| 228 | 1 | 20 | 18 | 7 | 6 |
| 218 | 0 | 27 | 24 | 9 | 8 |
| 208 | -1 | 33 | 30 | 11 | 9 |
| 198 | -3 | 38 | 34 | 13 | 11 |
| 188 | -4 | 44 | 39 | 15 | 12 |
| 178 | -6 | 49 | 44 | 16 | 14 |
| 164 | -9 | 57 | 51 | 18 | 16 |
| 159 | -9 | 59 | 53 | 19 | 17 |
| 155 | -9 | 61 | 55 | 27 | 25 |
| 138 | -13 | 69 | 63 | 87 | 84 |
| 128 | -15 | 74 | 67 | 122 | 119 |
| 118 | -17 | 78 | 72 | 157 | 155 |
| 108 | -19 | 83 | 77 | 193 | 191 |
| 98 | -22 | 88 | 81 | 229 | 227 |
| 88 | -24 | 92 | 86 | 266 | 263 |
| 80 | -25 | 96 | 90 | 295 | 292 |
| 68 | -28 | 102 | 96 | 318 | 315 |
| 58 | -30 | 107 | 100 | 320 | 317 |
| 48 | -33 | 112 | 105 | 321 | 319 |
| 22 | -42 | 124 | 117 | 325 | 323 |
| 19 | -41 | 125 | 119 | 326 | 324 |
| 0 | -49 | 134 | 128 | 329 | 327 |

| | E | EUP | EDN | E BRAKES |
|---|---|---|---|---|
| 258 | 0 | 0 | 0 | 0 |
| 251 | -1 | 2 | 3 | 0 |
| 238 | -4 | 5 | 8 | -1 |
| 228 | -7 | 6 | 13 | -1 |
| 218 | -10 | 8 | 17 | -2 |
| 208 | -14 | 9 | 20 | -3 |
| 198 | -18 | 10 | 23 | -5 |
| 188 | -22 | 10 | 26 | -6 |
| 178 | -26 | 11 | 29 | -8 |
| 164 | -33 | 11 | 32 | -11 |
| 159 | -33 | 12 | 34 | -11 |
| 155 | -34 | 13 | 35 | -4 |
| 138 | -43 | 13 | 36 | 49 |
| 128 | -47 | 14 | 37 | 81 |
| 118 | -52 | 15 | 37 | 114 |
| 108 | -57 | 16 | 38 | 146 |
| 98 | -61 | 17 | 39 | 178 |
| 88 | -66 | 18 | 40 | 211 |
| 80 | -70 | 19 | 41 | 238 |
| 68 | -76 | 20 | 42 | 256 |
| 58 | -81 | 21 | 43 | 254 |
| 48 | -85 | 22 | 44 | 252 |
| 22 | -102 | 22 | 44 | 245 |
| 19 | -103 | 23 | 45 | 245 |
| 0 | -116 | 22 | 44 | 239 |

| | F | FUP | FDN | F BRAKES |
|---|---|---|---|---|
| 258 | 0 | 0 | 0 | 0 |
| 251 | -4 | -1 | -1 | -4 |
| 238 | -16 | -6 | -2 | -16 |
| 228 | -26 | -9 | -4 | -26 |
| 218 | -36 | -13 | -6 | -37 |
| 208 | -47 | -18 | -8 | -49 |
| 198 | -59 | -23 | -11 | -62 |
| 188 | -70 | -28 | -14 | -75 |
| 178 | -83 | -34 | -18 | -88 |
| 164 | -102 | -42 | -21 | -108 |
| 159 | -105 | -43 | -24 | -113 |
| 155 | -108 | -44 | -24 | -113 |
| 138 | -132 | -54 | -35 | -111 |
| 128 | -146 | -59 | -40 | -108 |
| 118 | -159 | -65 | -45 | -105 |
| 108 | -173 | -70 | -50 | -103 |
| 98 | -186 | -75 | -56 | -101 |
| 88 | -200 | -81 | -61 | -98 |
| 80 | -210 | -85 | -65 | -96 |
| 68 | -228 | -92 | -72 | -105 |
| 58 | -242 | -97 | -78 | -120 |
| 48 | -256 | -103 | -83 | -136 |
| 22 | -302 | -122 | -102 | -184 |
| 19 | -305 | -123 | -103 | -188 |
| 0 | -341 | -138 | -118 | -225 |

| | G | GUP | GDN | G BRAKES |
|---|---|---|---|---|
| 258 | 0 | 0 | 0 | 0 |
| 251 | -5 | -1 | -1 | -4 |
| 238 | -13 | -6 | -4 | -14 |
| 228 | -21 | -9 | -6 | -23 |
| 218 | -29 | -13 | -9 | -32 |
| 208 | -37 | -17 | -12 | -42 |
| 198 | -47 | -22 | -15 | -53 |
| 188 | -56 | -27 | -19 | -65 |
| 178 | -66 | -32 | -22 | -76 |
| 164 | -81 | -39 | -28 | -94 |
| 159 | -83 | -40 | -29 | -97 |
| 155 | -86 | -41 | -30 | -99 |
| 138 | -106 | -51 | -39 | -103 |
| 128 | -116 | -55 | -44 | -105 |
| 118 | -127 | -60 | -49 | -107 |
| 108 | -137 | -65 | -54 | -110 |
| 98 | -148 | -70 | -59 | -112 |
| 88 | -159 | -75 | -64 | -114 |
| 80 | -167 | -79 | -67 | -115 |
| 68 | -182 | -86 | -74 | -126 |
| 58 | -193 | -91 | -79 | -139 |
| 48 | -204 | -96 | -84 | -153 |
| 22 | -240 | -113 | -101 | -194 |
| 19 | -242 | -114 | -102 | -197 |
| 0 | -271 | -128 | -116 | -229 |

SUMMARY OF RESULTS FROM FLIGHT ENVELOPE ANALYSIS

CHORDWISE MOMENT

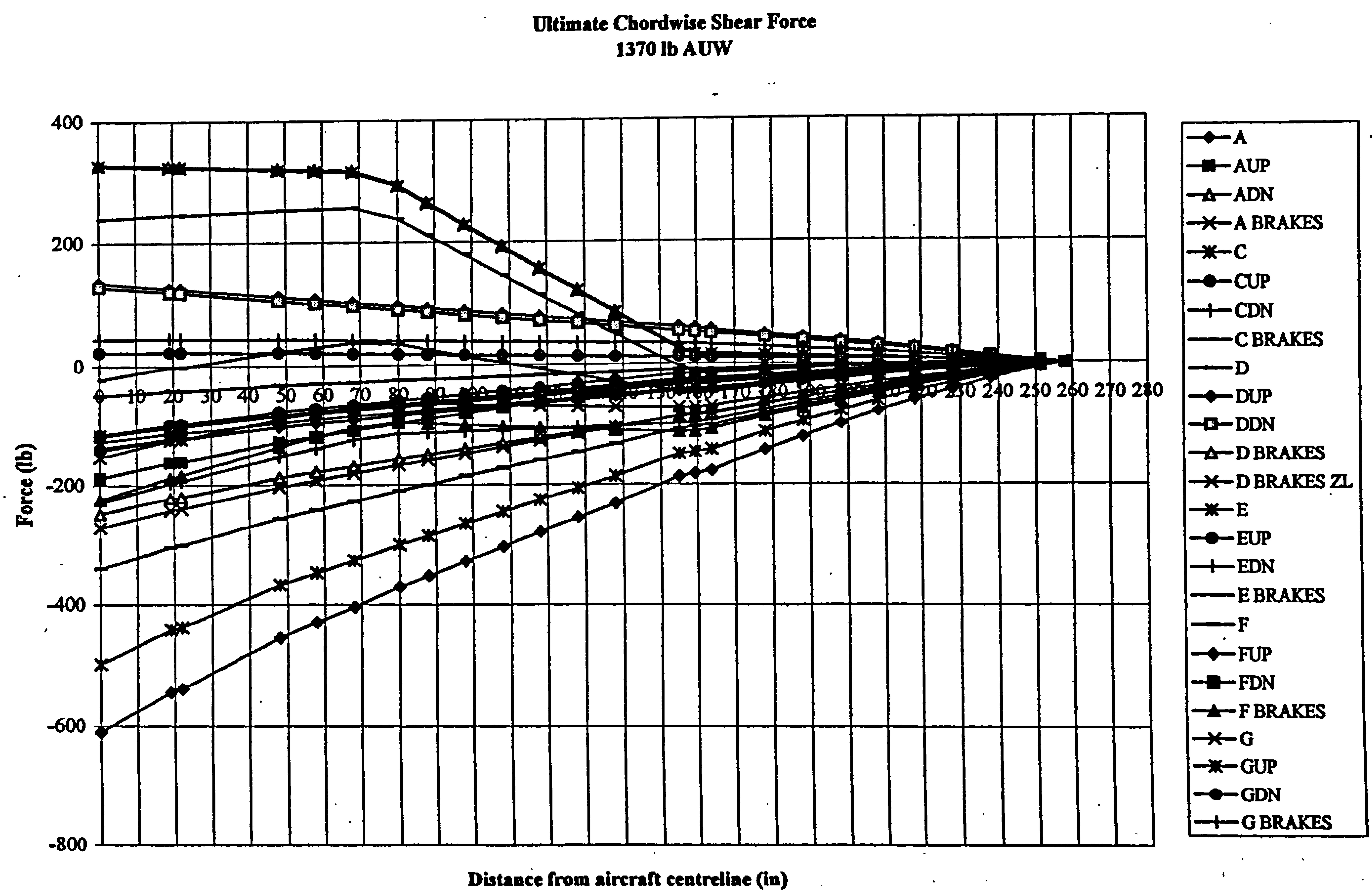
| | A | AUP | ADN | A BRAKES | | C | CUP | CDN | C BRAKES |
|---|---|---|---|---|---|---|---|---|---|
| 258 | 0 | 0 | 0 | 0 | 258 | 0 | 0 | 0 | 0 |
| 251 | -23 | -2 | -9 | -8 | 251 | -16 | 1 | -2 | -4 |
| 238 | -240 | -17 | -106 | -91 | 238 | -180 | 6 | -32 | -52 |
| 228 | -582 | -40 | -364 | -222 | 228 | -442 | 7 | -89 | -130 |
| 218 | -1092 | -79 | -501 | -418 | 218 | -835 | 2 | -179 | -249 |
| 208 | -1783 | -140 | -823 | -686 | 208 | -1372 | -15 | -309 | -415 |
| 198 | -2675 | -233 | -1240 | -1034 | 198 | -2072 | -53 | -487 | -635 |
| 188 | -3778 | -360 | -1758 | -1467 | 188 | -2943 | -117 | -719 | -913 |
| 178 | -5096 | -525 | -2376 | -1985 | 178 | -3989 | -208 | -1005 | -1250 |
| 164 | -7389 | -837 | -3454 | -2892 | 164 | -5820 | -392 | -1520 | -1847 |
| 159 | -8166 | -947 | -3819 | -3200 | 159 | -6441 | -459 | -1696 | -2051 |
| 155 | -8964 | -1062 | -4191 | -3510 | 155 | -7079 | -527 | -1875 | -2251 |
| 138 | -12525 | -1674 | -5816 | -4727 | 138 | -9932 | -892 | -2675 | -2876 |
| 128 | -14963 | -2164 | -6902 | -5434 | 128 | -11892 | -1187 | -3226 | -3107 |
| 118 | -17638 | -2745 | -8077 | -6128 | 118 | -14067 | -1535 | -3832 | -3229 |
| 108 | -20556 | -3417 | -9345 | -6810 | 108 | -16400 | -1959 | -4492 | -3244 |
| 98 | -23719 | -4182 | -10705 | -7480 | 98 | -18855 | -2399 | -5208 | -3151 |
| 88 | -27131 | -5041 | -12159 | -8138 | 88 | -21714 | -2917 | -5982 | -2949 |
| 80 | -30033 | -5793 | -13388 | -8653 | 80 | -24061 | -3349 | -6639 | -2706 |
| 68 | -34686 | -7034 | -15344 | -9452 | 68 | -27828 | -4116 | -7694 | -2274 |
| 58 | -38851 | -8178 | -17083 | -10200 | 58 | -31204 | -4806 | -8640 | -1941 |
| 48 | -43268 | -9417 | -18917 | -11049 | 48 | -34785 | -5552 | -9643 | -1678 |
| 22 | -56165 | -13182 | -24231 | -13830 | 22 | -45265 | -7839 | -12596 | -1402 |
| 19 | -57786 | -13668 | -24895 | -14205 | 19 | -46585 | -8135 | -12960 | -1408 |
| 0 | -68735 | -17008 | -29366 | -16857 | 0 | -55506 | -10181 | -15503 | -1647 |

| | D | DUP | DDN | D BRAKES | BRAKES ZL | | E | EUP | EDN | E BRAKES |
|---|---|---|---|---|---|---|---|---|---|---|
| 258 | 0 | 0 | 0 | 0 | 0 | 258 | 0 | 0 | 0 | 0 |
| 251 | 2 | 15 | 14 | 6 | 4 | 251 | -3 | 6 | 9 | 0 |
| 238 | 11 | 131 | 121 | 48 | 38 | 238 | -39 | 50 | 83 | -4 |
| 228 | 17 | 297 | 272 | 108 | 85 | 228 | -96 | 105 | 188 | -14 |
| 218 | 21 | 551 | 486 | 190 | 151 | 218 | -183 | 178 | 334 | -32 |
| 208 | 17 | 829 | 757 | 293 | 236 | 208 | -308 | 265 | 519 | -60 |
| 198 | 0 | 1185 | 1078 | 415 | 337 | 198 | -460 | 360 | 735 | -102 |
| 188 | -33 | 1595 | 1446 | 552 | 453 | 188 | -457 | 459 | 979 | -157 |
| 178 | -84 | 2060 | 1862 | 706 | 585 | 178 | -895 | 562 | 1251 | -229 |
| 164 | -191 | 2822 | 2542 | 953 | 802 | 164 | -1314 | 714 | 1608 | -362 |
| 159 | -230 | 3074 | 2767 | 1035 | 874 | 159 | -1456 | 762 | 1830 | -408 |
| 155 | -268 | 3335 | 3000 | 1135 | 964 | 155 | -1602 | 814 | 1978 | -440 |
| 138 | -455 | 4445 | 4002 | 2103 | 1890 | 138 | -2257 | 1035 | 2576 | -51 |
| 128 | -597 | 5158 | 4652 | 3146 | 2908 | 128 | -2708 | 1175 | 2936 | 603 |
| 118 | -759 | 5918 | 5348 | 4542 | 4280 | 118 | -3205 | 1323 | 3306 | 1577 |
| 108 | -943 | 6725 | 6091 | 6296 | 6008 | 108 | -3748 | 1481 | 3685 | 2874 |
| 98 | -1148 | 7578 | 6880 | 8489 | 8094 | 98 | -4339 | 1647 | 4072 | 4495 |
| 88 | -1375 | 8478 | 7717 | 10883 | 10542 | 88 | -4977 | 1821 | 4468 | 6442 |
| 80 | -1571 | 9232 | 8420 | 13125 | 12762 | 80 | -5520 | 1968 | 4792 | 8238 |
| 68 | -1891 | 10421 | 9533 | 16801 | 16465 | 68 | -6392 | 2199 | 5289 | 11202 |
| 58 | -2185 | 11464 | 10512 | 19988 | 19545 | 58 | -7175 | 2400 | 5712 | 13755 |
| 48 | -2499 | 12535 | 11540 | 23192 | 22742 | 48 | -8006 | 2611 | 6144 | 16289 |
| 22 | -3463 | 15615 | 14434 | 31595 | 31083 | 22 | -10441 | 3176 | 7284 | 22760 |
| 19 | -3588 | 15988 | 14788 | 32571 | 32053 | 19 | -10748 | 3243 | 7417 | 23496 |
| 0 | -4453 | 18454 | 17133 | 38787 | 38232 | 0 | -12826 | 3668 | 8264 | 28097 |

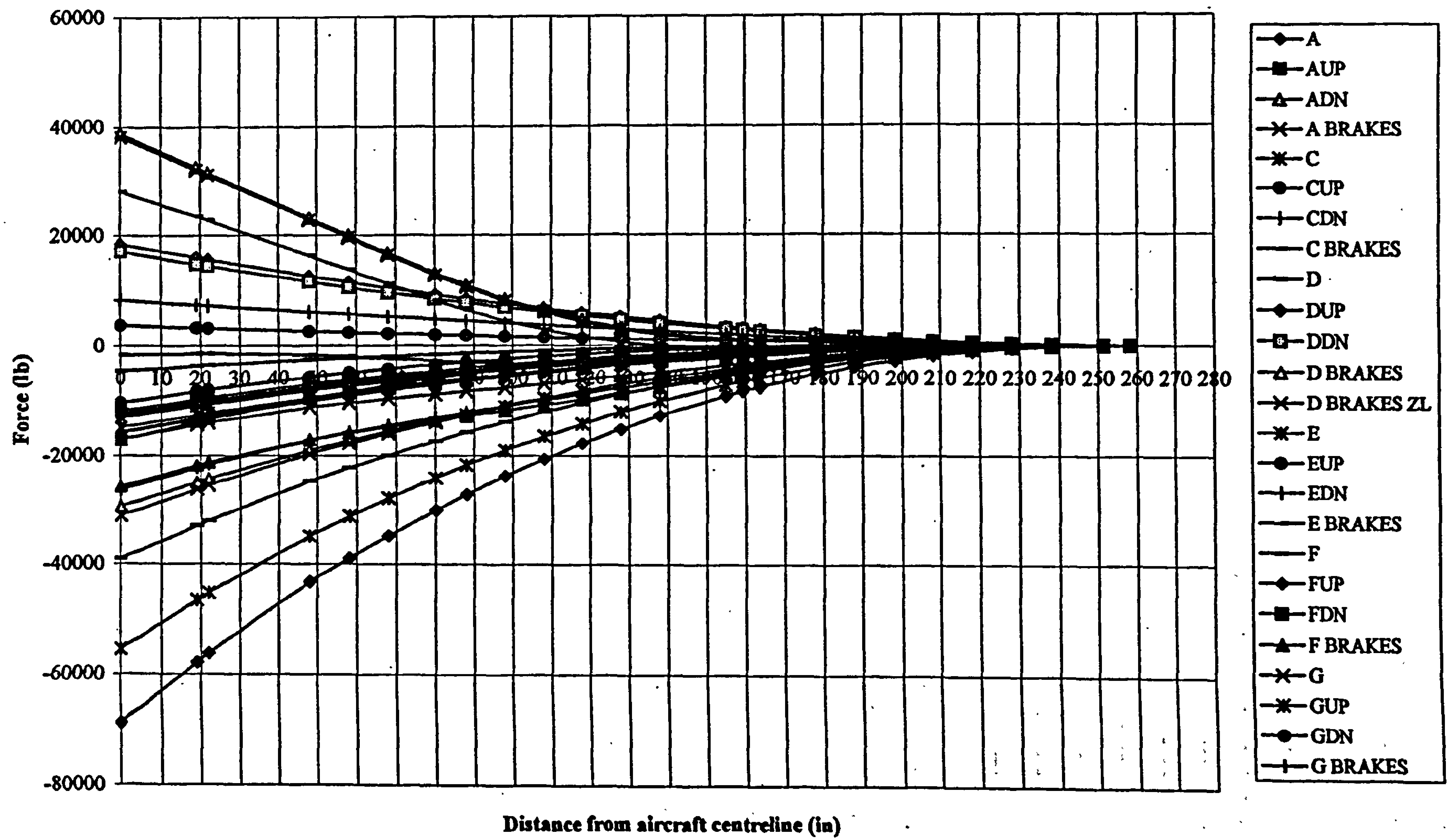
| | F | FUP | FDN | F BRAKES | | G | GUP | GDN | G BRAKES |
|---|---|---|---|---|---|---|---|---|---|
| 258 | 0 | 0 | 0 | 0 | 258 | 0 | 0 | 0 | 0 |
| 251 | -15 | -4 | -2 | -15 | 251 | -12 | -5 | -4 | -13 |
| 238 | -150 | -49 | -20 | -153 | 238 | -120 | -51 | -34 | -133 |
| 228 | -358 | -124 | -50 | -367 | 228 | -286 | -126 | -82 | -320 |
| 218 | -666 | -237 | -98 | -686 | 218 | -532 | -237 | -155 | -596 |
| 208 | -1079 | -393 | -168 | -1117 | 208 | -862 | -390 | -256 | -971 |
| 198 | -1606 | -598 | -266 | -1670 | 198 | -1282 | -587 | -389 | -1450 |
| 188 | -2251 | -835 | -395 | -2350 | 188 | -1797 | -831 | -558 | -2039 |
| 178 | -3016 | -1165 | -555 | -3162 | 178 | -3406 | -1124 | -761 | -2741 |
| 164 | -4338 | -1710 | -847 | -4569 | 164 | -3460 | -1634 | -1121 | -3958 |
| 159 | -4785 | -1895 | -948 | -5047 | 159 | -3816 | -1807 | -1244 | -4371 |
| 155 | -5244 | -2084 | -1052 | -5537 | 155 | -4182 | -1904 | -1371 | -4796 |
| 138 | -7286 | -2919 | -1554 | -7441 | 138 | -5809 | -2766 | -1954 | -6517 |
| 128 | -8676 | -3486 | -1925 | -8533 | 128 | -6917 | -3295 | -2367 | -7562 |
| 118 | -10199 | -4105 | -2347 | -9599 | 118 | -8130 | -3873 | -2829 | -8625 |
| 108 | -11857 | -4777 | -2823 | -10641 | 108 | -9451 | -4501 | -3339 | -9710 |
| 98 | -13451 | -5502 | -3352 | -11659 | 98 | -10880 | -5178 | -3900 | -10817 |
| 88 | -15583 | -6283 | -3936 | -12653 | 88 | -12419 | -5905 | -4511 | -11946 |
| 80 | -17225 | -6944 | -4441 | -13430 | 80 | -13726 | -6522 | -5035 | -12864 |
| 68 | -19854 | -8082 | -5263 | -14632 | 68 | -15820 | -7589 | -5881 | -14310 |
| 58 | -22204 | -8947 | -6012 | -15738 | 58 | -17692 | -8390 | -6645 | -15634 |
| 48 | -24695 | -9947 | -6816 | -17041 | 48 | -19675 | -9321 | -7460 | -17094 |
| 22 | -31943 | -12864 | -9223 | -21206 | 22 | -25447 | -12034 | -9670 | -21692 |
| 19 | -32853 | -13231 | -9531 | -21764 | 19 | -26171 | -12374 | -10175 | -22189 |
| 0 | -38983 | -15707 | -11634 | -25687 | 0 | -31052 | -14670 | -12249 | -26241 |

SUMMARY OF RESULTS FROM FLIGHT ENVELOPE ANALYSIS

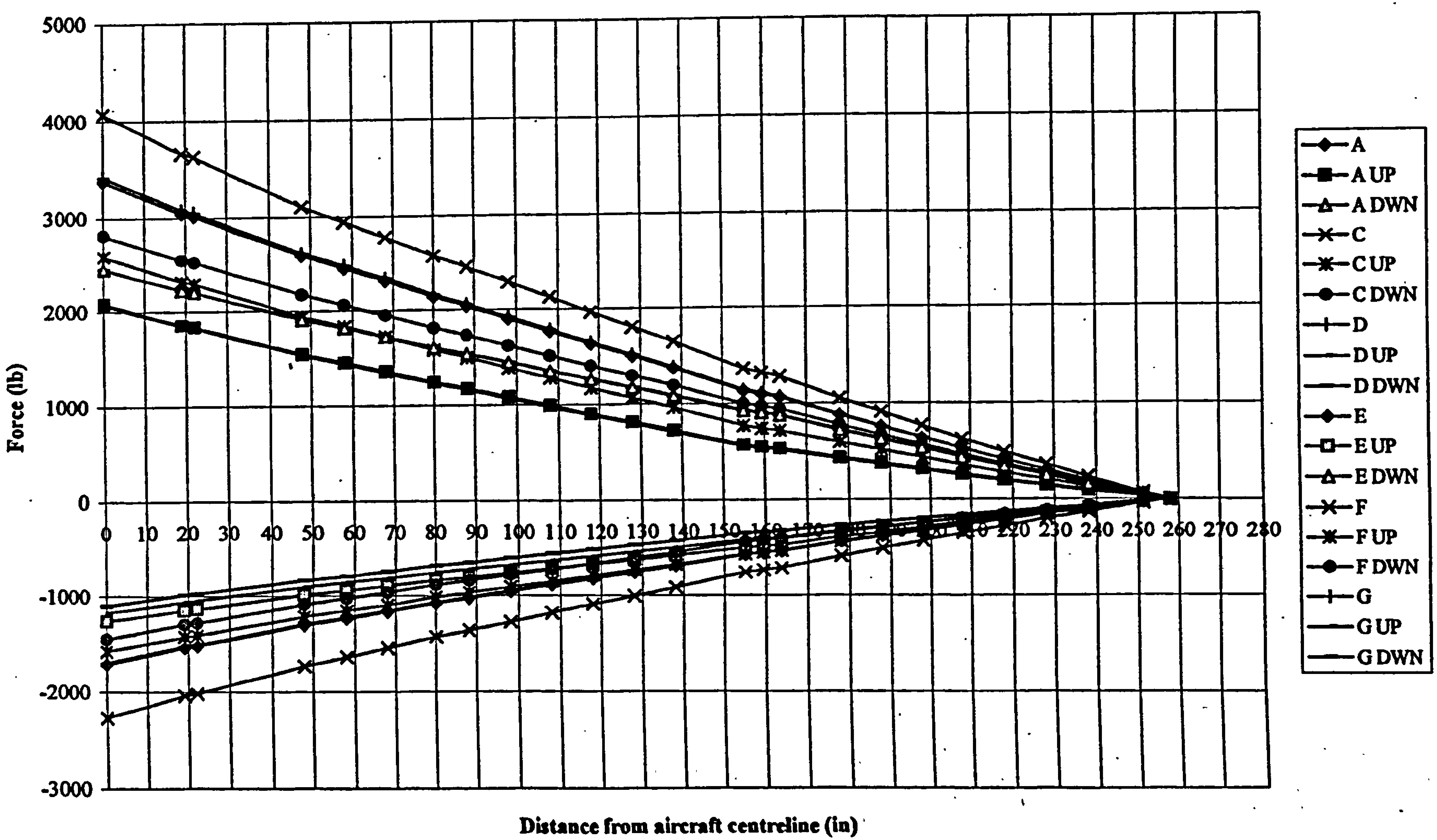
| STATION (in) | TORSION A | A UP | A DWN | A BRAKES | | C | C UP | C DWN | C BRAKES | | D | D UP | D DWN | D BRAKES | BRAKES ZL | | E | E UP | E DWN | E BRAKES | | F | F UP | F DWN | F BRAKES | | G | G UP | G DWN | G BRAKES |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 258 | 0 | 0 | 0 | 0 | 258 | 0 | 0 | 0 | 0 | 258 | 0 | 0 | 0 | 0 | 0 | 258 | 0 | 0 | 0 | 0 | 258 | 0 | 0 | 0 | 0 | 258 | 0 | 0 | 0 | 0 |
| 251 | 450 | 498 | -378 | 278 | 251 | 512 | 239 | -229 | 302 | 251 | 296 | 414 | -499 | 120 | -232 | 251 | -496 | 356 | -561 | -408 | 251 | -470 | 195 | -707 | -470 | 251 | -344 | 443 | -444 | -336 |
| 238 | 926 | 673 | -2543 | 534 | 238 | 1009 | -407 | -2186 | 522 | 238 | 343 | 455 | -2892 | -65 | -849 | 238 | -1495 | 1834 | -1314 | -1291 | 238 | -1267 | 1375 | -1482 | -1265 | 238 | -920 | 1949 | -819 | -887 |
| 228 | 1358 | 722 | -4292 | 777 | 228 | 1473 | -1008 | -3794 | 749 | 228 | 456 | 399 | -4818 | -152 | -1322 | 228 | -2280 | 2996 | -1847 | -1976 | 228 | -1914 | 2340 | -2018 | -1910 | 228 | -1389 | 3149 | -1065 | -1337 |
| 218 | 1836 | 718 | -6121 | 1051 | 218 | 1992 | -1681 | -5489 | 1014 | 218 | 616 | 288 | -6826 | -208 | -1802 | 218 | -3098 | 4211 | -2363 | -2679 | 218 | -2593 | 3354 | -2527 | -2587 | 218 | -1882 | 4394 | -1287 | -1811 |
| 208 | 2351 | 672 | -8019 | 1351 | 208 | 2557 | -2416 | -7261 | 1308 | 208 | 811 | 132 | -8908 | -241 | -2277 | 208 | -3927 | 5466 | -2864 | -3401 | 208 | -3302 | 4412 | -3016 | -3293 | 208 | -2397 | 5678 | -1492 | -2306 |
| 198 | 2900 | 590 | -9980 | 1673 | 198 | 3162 | -3205 | -9102 | 1629 | 198 | 1039 | -43 | -11058 | -256 | -2757 | 198 | -4788 | 6757 | -3356 | -4142 | 198 | -4039 | 5509 | -3488 | -4036 | 198 | -2932 | 6999 | -1682 | -2821 |
| 188 | 3480 | 475 | -12002 | 2016 | 188 | 3805 | -4043 | -11008 | 1975 | 188 | 1295 | -293 | -13271 | -253 | -3259 | 188 | -5674 | 8083 | -3839 | -4901 | 188 | -4802 | 6643 | -3946 | -4785 | 188 | -3487 | 8355 | -1859 | -3334 |
| 178 | 4091 | 332 | -14080 | 2378 | 178 | 4483 | -4926 | -12975 | 2343 | 178 | 1576 | -553 | -15544 | -236 | -3768 | 178 | -6582 | 9442 | -4315 | -5677 | 178 | -5590 | 7812 | -4392 | -5568 | 178 | -4061 | 9744 | -2026 | -3865 |
| 164 | 5004 | 75 | -17163 | 2923 | 164 | 5508 | -6273 | -15904 | 2898 | 164 | 2010 | -983 | -18911 | -195 | -4512 | 164 | -7920 | 11451 | -4986 | -6819 | 164 | -6756 | 9551 | -5012 | -6729 | 164 | -4909 | 11797 | -2245 | -4722 |
| 159 | 5306 | -100 | -17367 | 3105 | 159 | 5838 | -6513 | -16162 | 3087 | 159 | 2167 | -1272 | -19231 | -166 | -4739 | 159 | -8340 | 11359 | -5098 | -7175 | 159 | -7128 | 9559 | -5015 | -7095 | 159 | -5180 | 11814 | -2234 | -4981 |
| 155 | 5614 | 83 | -17180 | 3292 | 155 | 6184 | -6322 | -15968 | 3281 | 155 | 2328 | -1248 | -19195 | -134 | -5561 | 155 | -8764 | 11005 | -5466 | -7539 | 155 | -7503 | 9260 | -5308 | -7469 | 155 | -5454 | 11612 | -2437 | -5245 |
| 138 | 6786 | 788 | -16475 | 4011 | 138 | 7495 | -5596 | -15243 | 4021 | 138 | 2916 | -1159 | -19107 | -43 | -6696 | 138 | -10429 | 9588 | -6083 | -8987 | 138 | -8967 | 8132 | -6445 | -8958 | 138 | -6520 | 10821 | -3228 | -6295 |
| 128 | 7514 | 1227 | -16036 | 4459 | 128 | 8311 | -5140 | -14787 | 4486 | 128 | 3295 | -1089 | -19037 | 29 | -7253 | 128 | -11440 | 8729 | -7742 | -9861 | 128 | -9862 | 7438 | -7139 | -9864 | 128 | -7172 | 10339 | -3710 | -6934 |
| 118 | 8262 | 1679 | -15584 | 4920 | 118 | 9151 | -4670 | -14317 | 4965 | 118 | 3689 | -1011 | -18959 | 110 | -7818 | 118 | -12470 | 7856 | -8615 | -10749 | 118 | -10775 | 6731 | -7846 | -10788 | 118 | -7837 | 9847 | -4202 | -7587 |
| 108 | 9028 | 2143 | -15120 | 5393 | 108 | 10012 | -4188 | -13834 | 5457 | 108 | 4097 | -926 | -18874 | 197 | -8390 | 108 | -13517 | 6969 | -9502 | -11652 | 108 | -11706 | 6011 | -8566 | -11731 | 108 | -8516 | 9345 | -4704 | -8253 |
| 98 | 9811 | 2618 | -14646 | 5877 | 98 | 10892 | -3693 | -13339 | 5961 | 98 | 4517 | -835 | -18783 | 290 | -8970 | 98 | -14582 | 6067 | -10404 | -12570 | 98 | -12654 | 5277 | -9308 | -12691 | 98 | -9207 | 8835 | -5214 | -8932 |
| 88 | 10612 | 3103 | -14160 | 6372 | 88 | 11798 | -3186 | -12832 | 6478 | 88 | 4949 | -739 | -18687 | 388 | -9559 | 88 | -15665 | 5151 | -11320 | -13501 | 88 | -13619 | 4532 | -10046 | -13667 | 88 | -9911 | 8315 | -5734 | -9622 |
| 80 | 11270 | 3503 | -13760 | 6779 | 80 | 12534 | -2767 | -12414 | 6904 | 80 | 5310 | -654 | -18602 | 475 | -10035 | 80 | -16546 | 4406 | -12063 | -14259 | 80 | -14407 | 3923 | -10654 | -14463 | 80 | -10485 | 7891 | -6158 | -10185 |
| 68 | 12259 | 4103 | -13160 | 7385 | 68 | 13647 | -2140 | -11786 | 7538 | 68 | 5847 | -532 | -18480 | 598 | -10668 | 68 | -17880 | 3278 | -13193 | -15392 | 68 | -15598 | 3003 | -11574 | -15656 | 68 | -11353 | 7250 | -6799 | -11028 |
| 58 | 13104 | 4617 | -12647 | 7899 | 58 | 14599 | -1602 | -11248 | 8075 | 58 | 6310 | -423 | -18371 | 707 | -11133 | 58 | -19013 | 2320 | -14151 | -16345 | 58 | -16611 | 2221 | -12356 | -16660 | 58 | -12092 | 6705 | -7344 | -11738 |
| 48 | 13963 | 5139 | -12124 | 8420 | 48 | 15567 | -1055 | -10701 | 8622 | 48 | 6782 | -311 | -18258 | 830 | -11743 | 48 | -20162 | 1349 | -15122 | -17314 | 48 | -17639 | 1428 | -13149 | -17679 | 48 | -12841 | 6152 | -7897 | -12459 |
| 22 | 16192 | 6490 | -10773 | 9770 | 22 | 18074 | 355 | -9291 | 10029 | 22 | 7981 | -50 | -17998 | 1080 | -13365 | 22 | -23191 | -1215 | -17686 | -19874 | 22 | -20335 | -657 | -15234 | -20367 | 22 | -14807 | 4700 | -9549 | -14358 |
| 22 | 0 | 0 | 0 | 0 | 22 | 0 | 0 | 0 | 0 | 22 | 0 | 0 | 0 | 0 | 0 | 22 | 0 | 0 | 0 | 0 | 22 | 0 | 0 | 0 | 0 | 22 | 0 | 0 | 0 | 0 |
| 19 | 0 | 0 | 0 | 0 | 19 | 0 | 0 | 0 | 0 | 19 | 0 | 0 | 0 | 0 | 0 | 19 | 0 | 0 | 0 | 0 | 19 | 0 | 0 | 0 | 0 | 19 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |


Ultimate Chordwise Shear Force
1370 lb AUW
Force (lb)
400
200
0
-200
-400
-600
-800
0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180 190 200 210 220 230 240 250 260 270 280
Distance from aircraft centreline (in)
A
AUP
ADN
A BRAKES
C
CUP
CDN
C BRAKES
D
DUP
DDN
D BRAKES
D BRAKES ZL
E
EUP
EDN
E BRAKES
F
FUP
FDN
F BRAKES
G
GUP
GDN
G BRAKES

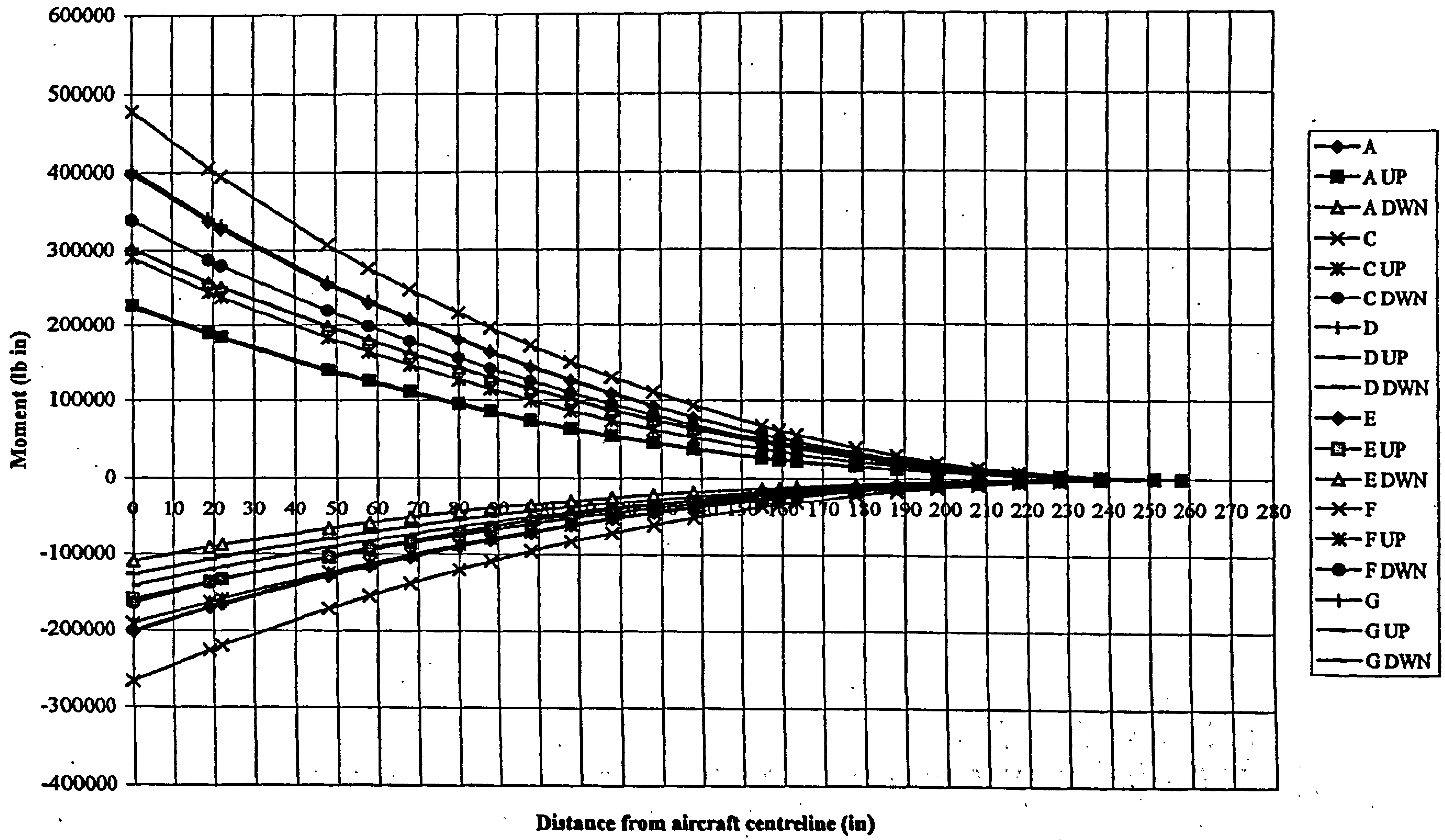
Ultimate Chordwise Bending Moment
1370 lb AUW

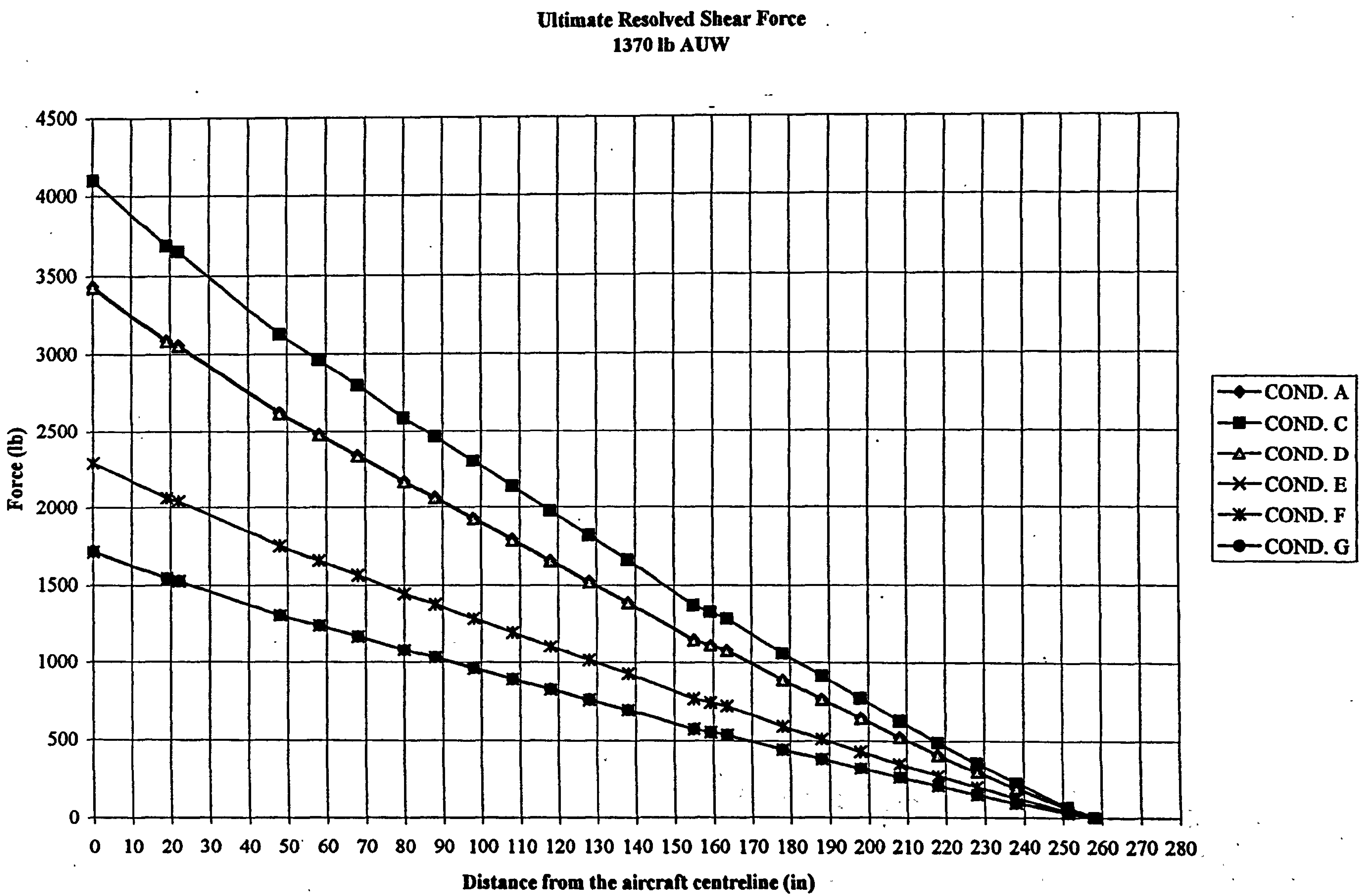


Ultimate Normal Shear Force
1370 lb AUW



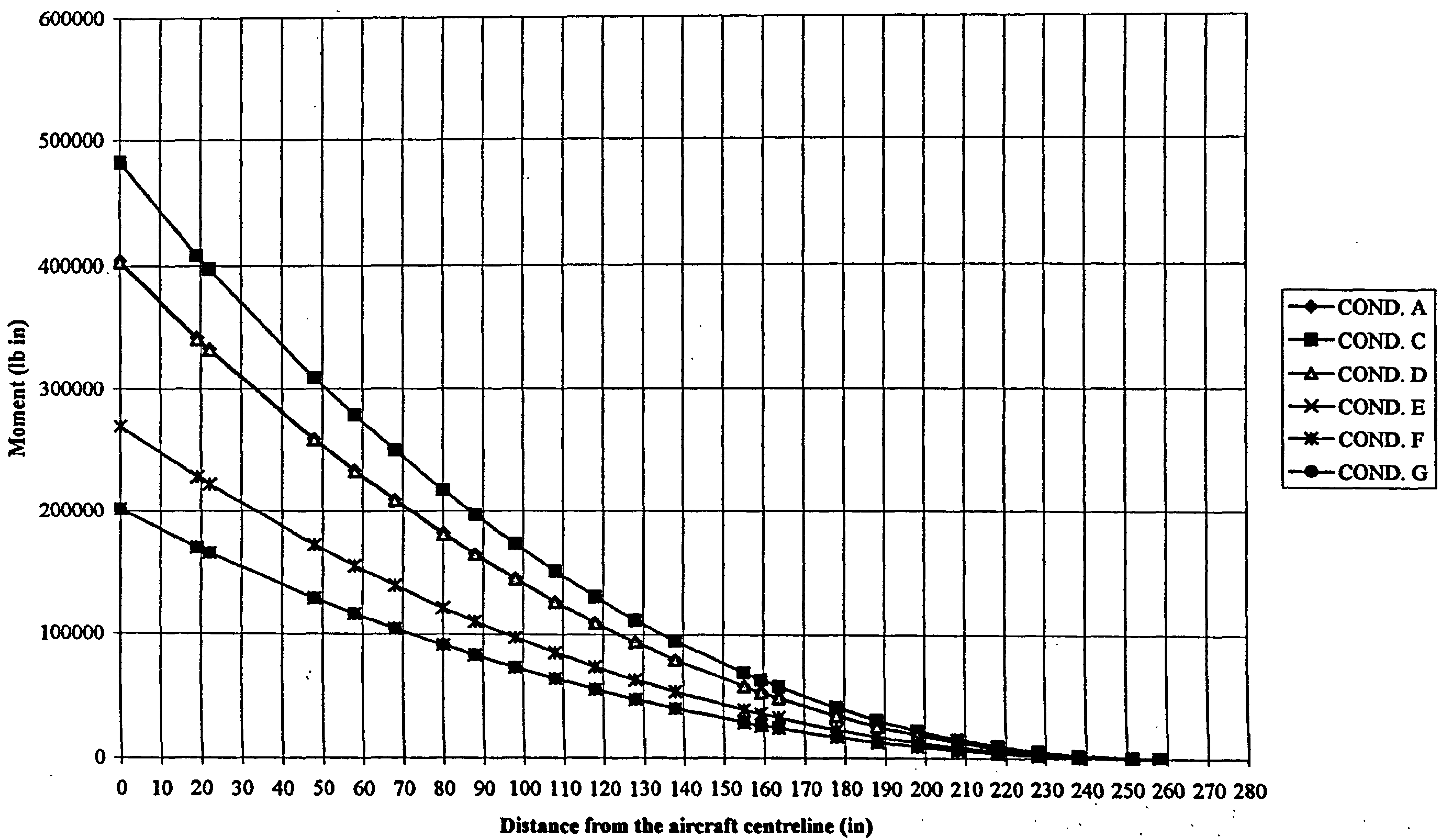
Ultimate Normal Bending Moment
1370 lb AUW



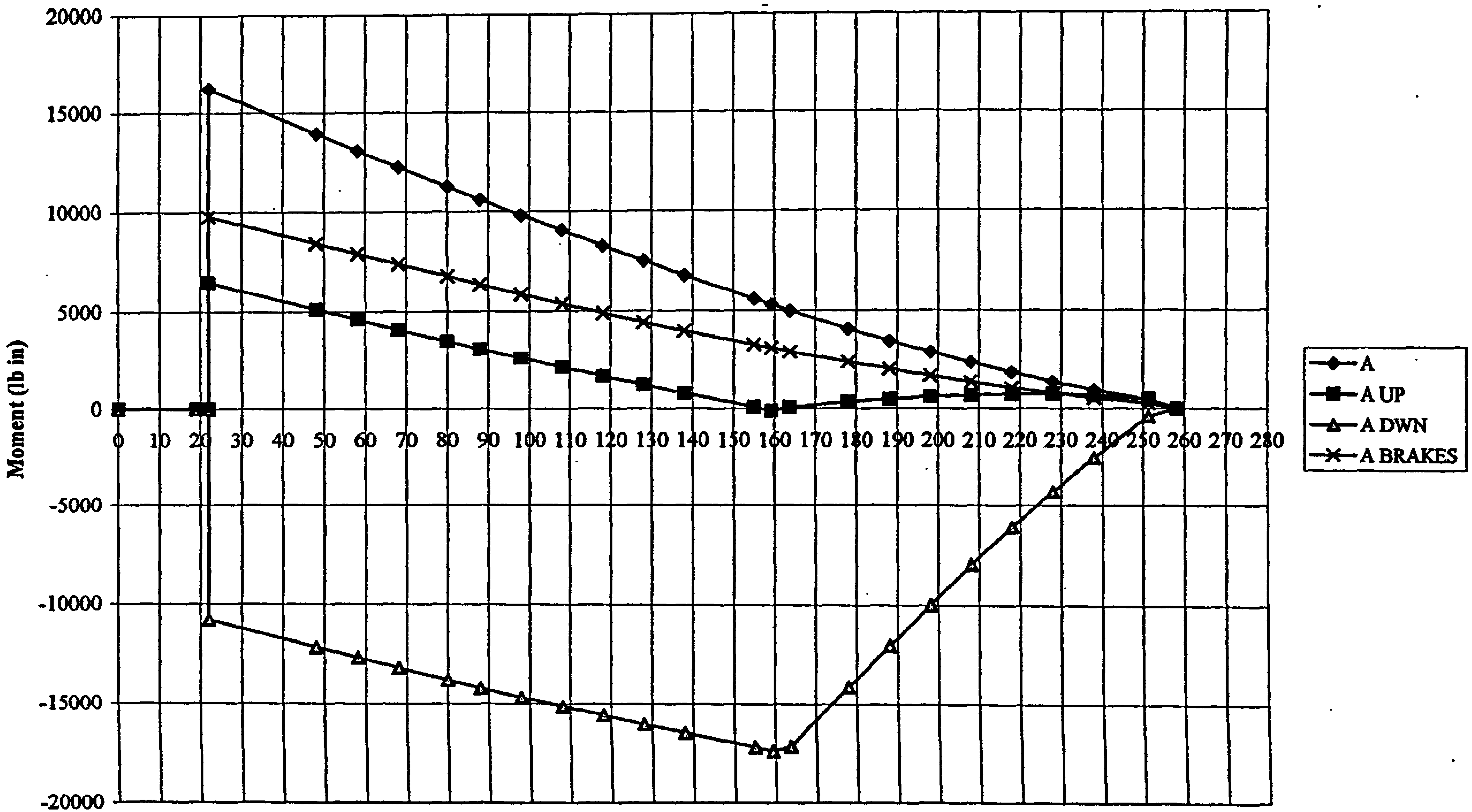


Ultimate Resolved Shear Force
1370 lb AUW
Force (lb)
4500
4000
3500
3000
2500
2000
1500
1000
500
0
0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180 190 200 210 220 230 240 250 260 270 280
Distance from the aircraft centreline (in)
COND. A
COND. C
COND. D
COND. E
COND. F
COND. G

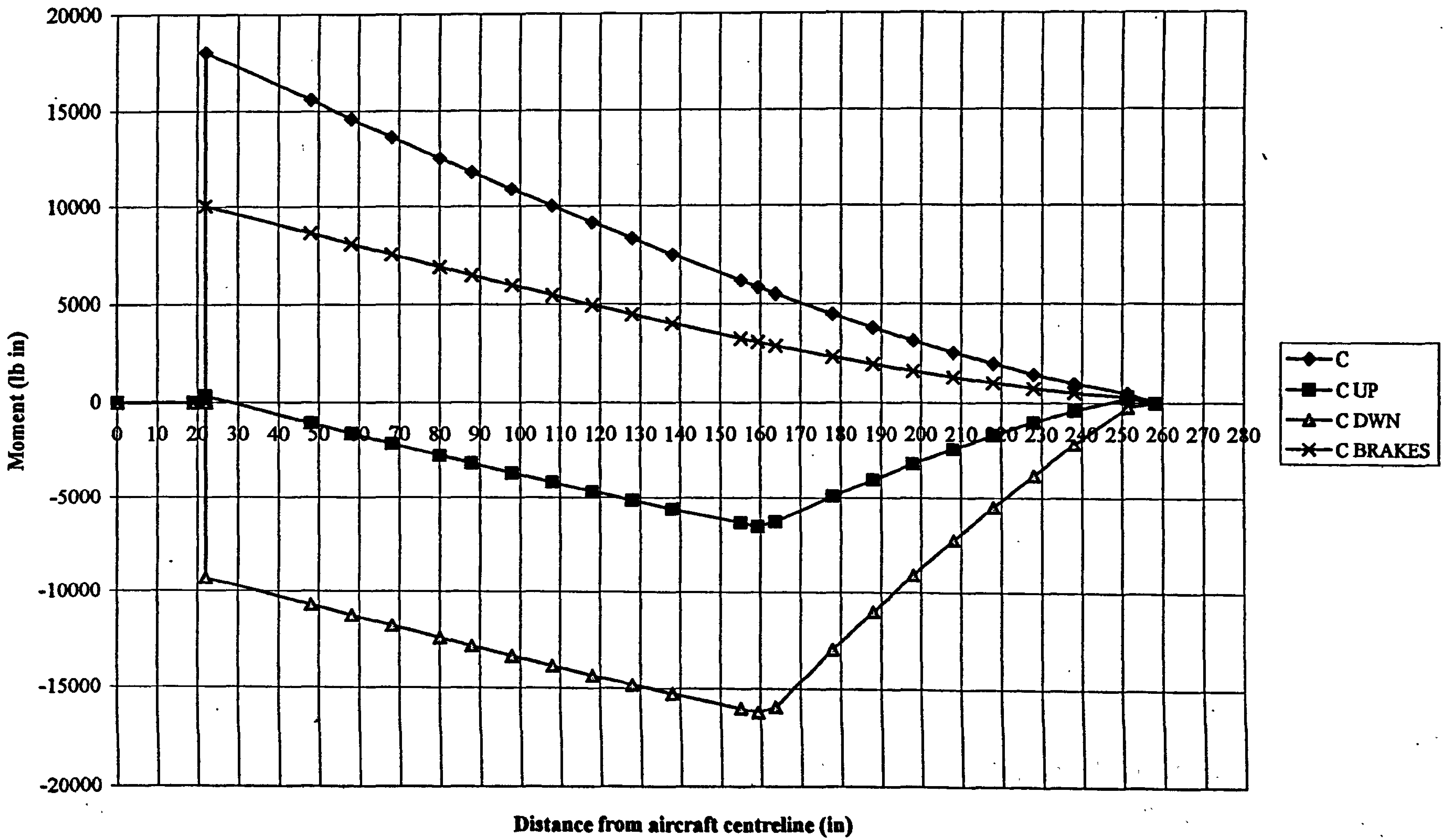
**Ultimate Resolved Bending Moment**
**1370 lb AUW**

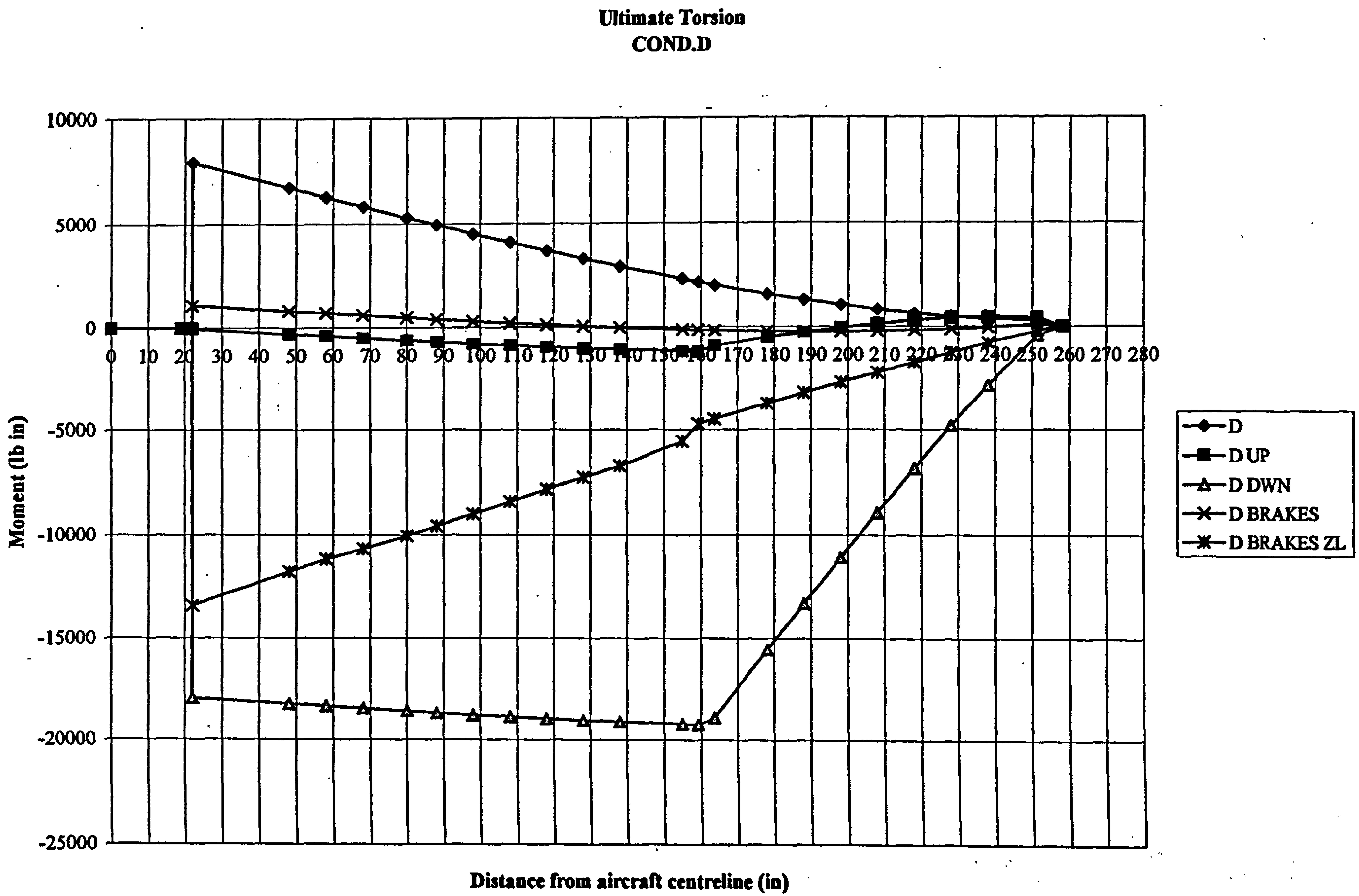


## Ultimate Torsion
## COND.A

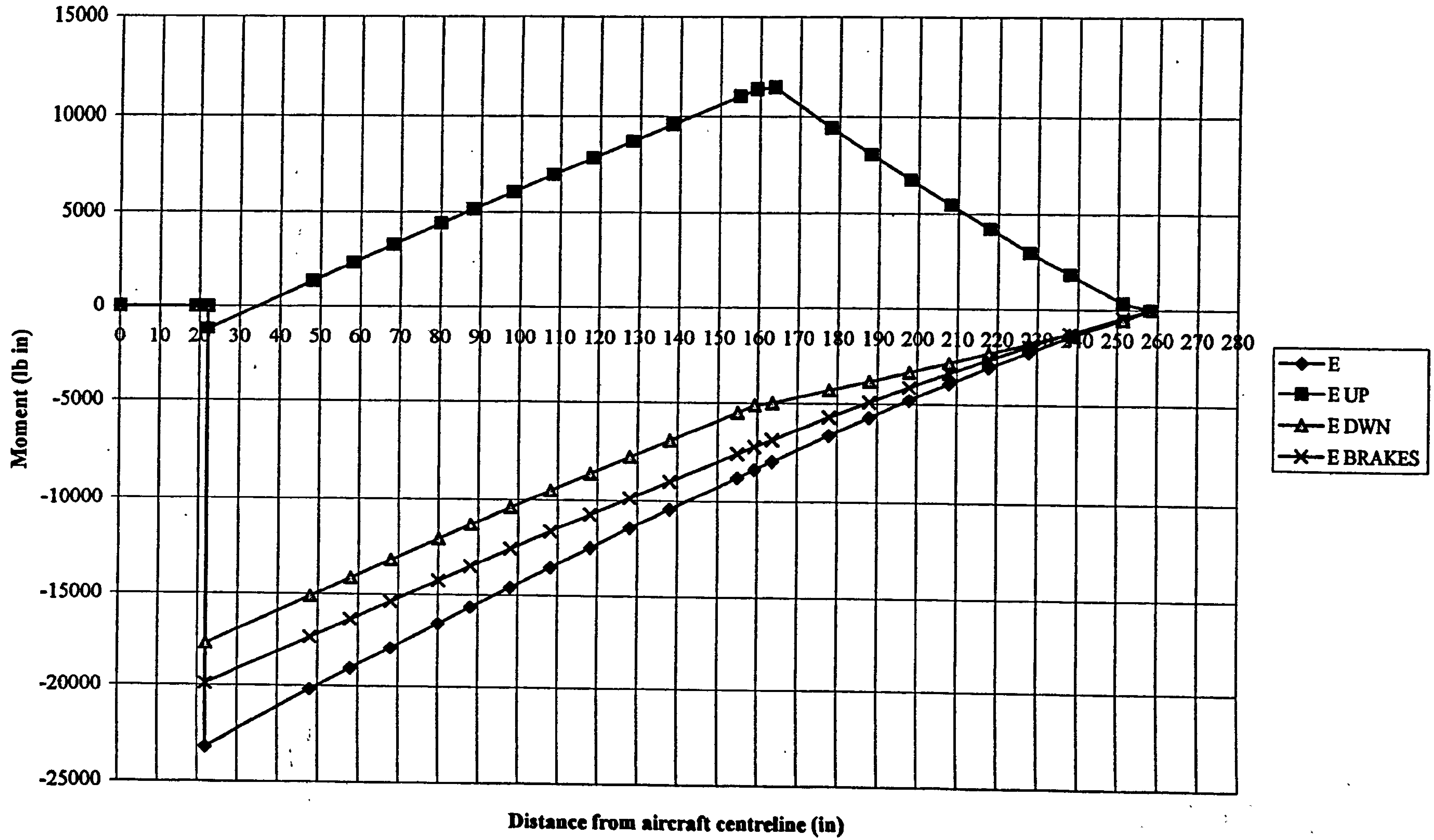


Ultimate Torsion
COND.C

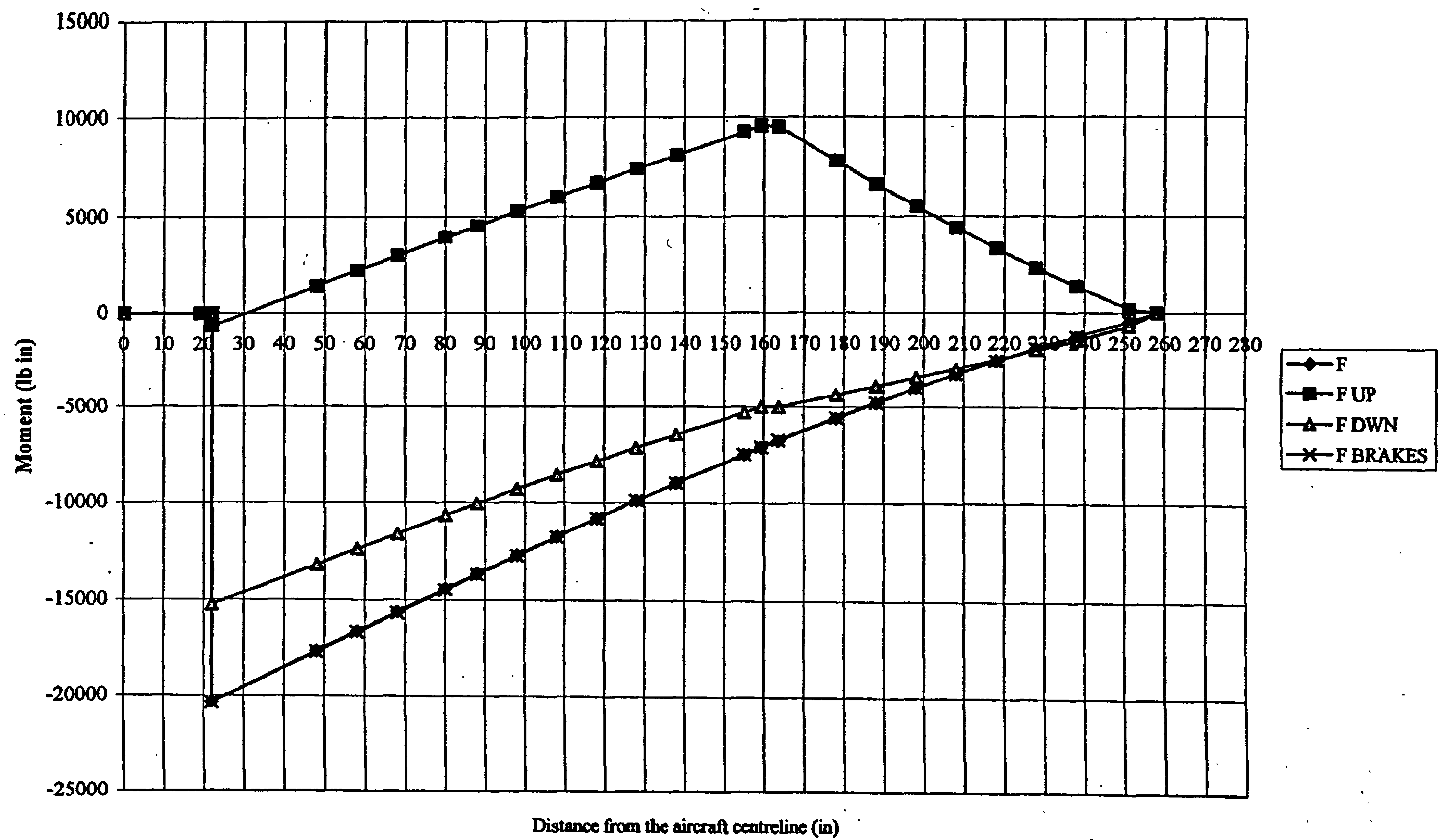


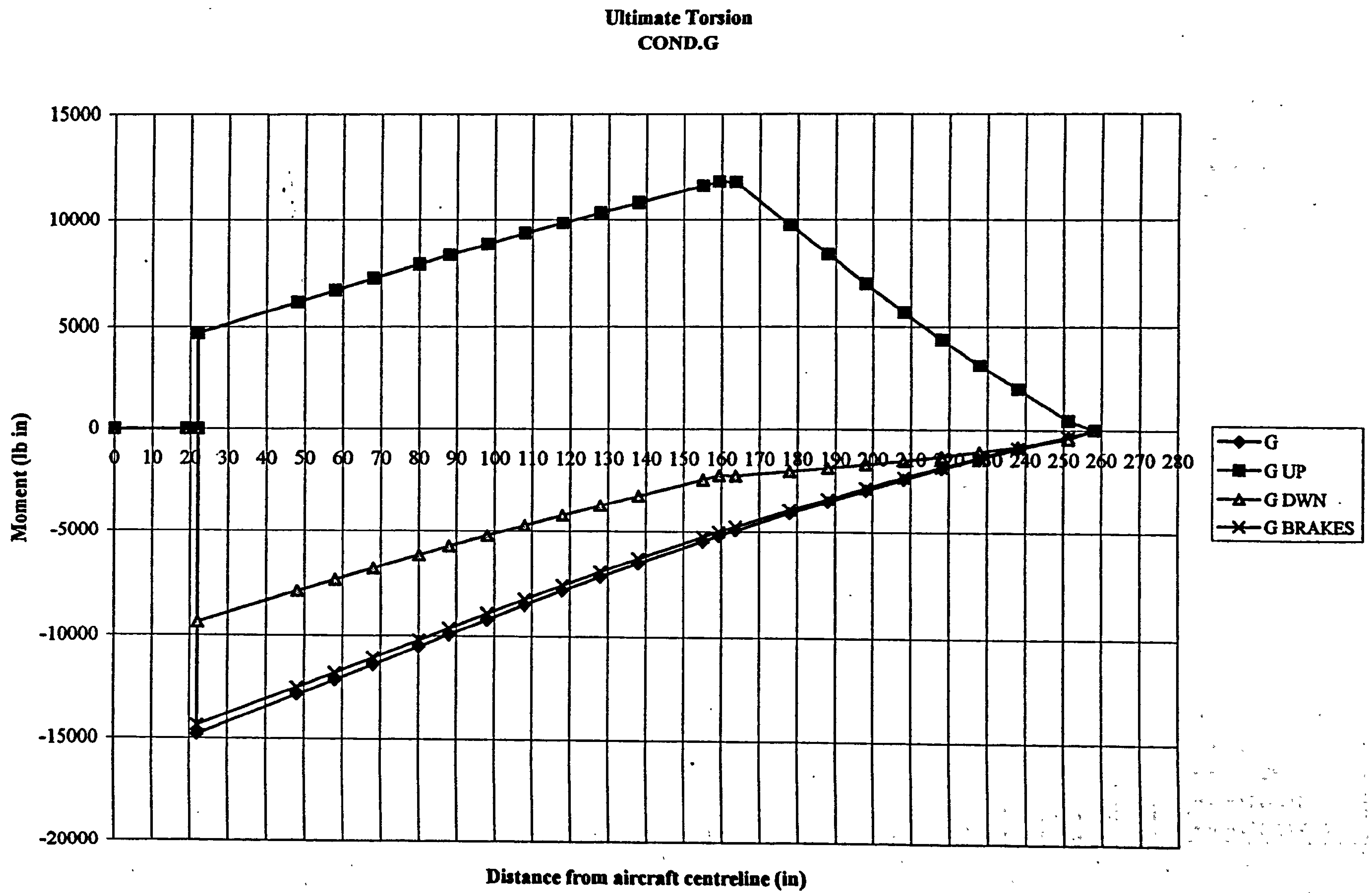

Ultimate Torsion
COND.D
Moment (lb in)
10000
5000
0
-5000
-10000
-15000
-20000
-25000
0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180 190 200 210 220 230 240 250 260 270 280
Distance from aircraft centreline (in)
D
D UP
D DWN
D BRAKES
D BRAKES ZL

**Ultimate Torsion**
**COND.E**

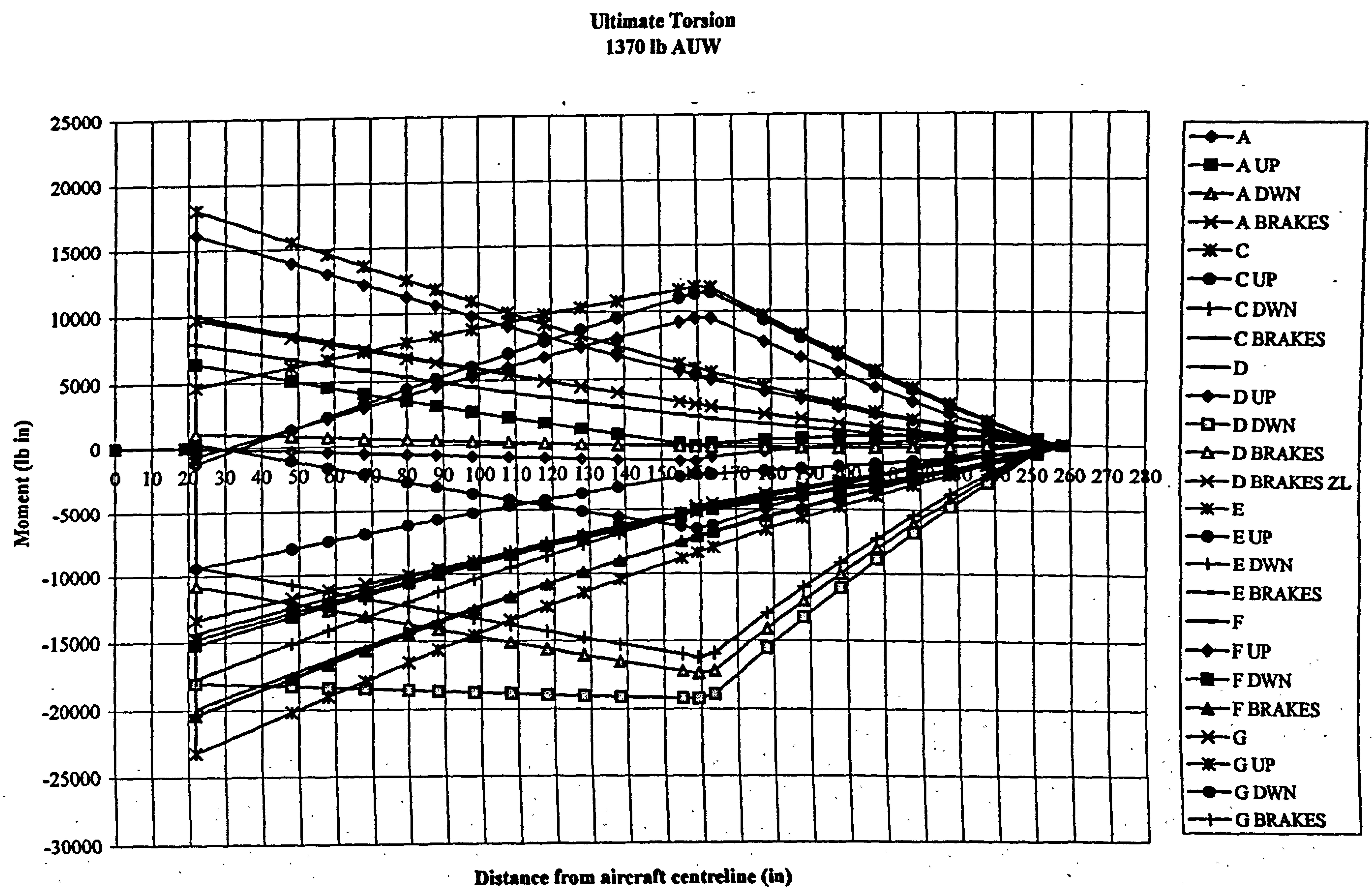


## Ultimate Torsion
## COND.F





Ultimate Torsion
COND.G
Moment (lb in)
15000
10000
5000
0
-5000
-10000
-15000
-20000
0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180 190 200 210 220 230 240 250 260 270 280
Distance from aircraft centreline (in)
G
G UP
G DWN
G BRAKES



Ultimate Torsion
1370 lb AUW
Moment (lb in)
25000
20000
15000
10000
5000
0
-5000
-10000
-15000
-20000
-25000
-30000
0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180 190 200 210 220 230 240 250 260 270 280
Distance from aircraft centreline (in)
A
A UP
A DWN
A BRAKES
C
C UP
C DWN
C BRAKES
D
D UP
D DWN
D BRAKES
D BRAKES ZL
E
E UP
E DWN
E BRAKES
F
F UP
F DWN
F BRAKES
G
G UP
G DWN
G BRAKES

SHRENK APPROXIMATION

CONDITION. C

STATIC TEST

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| STATION | 2y/b | dy | CHORD | CHORD | c av | ELEM AREA | ELLIPSE | SHRENK | UNIT | | dy c av$^2$ | |
| (in) | | (ft) | (in) | (ft) | (ft) | dy * c av ($ft^2$) | | Cla | Cla | av Cla | | |
| 258 | 1.000 | - | 35.00 | 2.917 | - | - | 0.000 | 1.458 | 0.500 | - | - | |
| 234.40 | 0.909 | 1.97 | 35.63 | 2.969 | 2.943 | 5.788 | 1.670 | 2.320 | 0.781 | 0.641 | 17.0334 | |
| 210.80 | 0.817 | 1.97 | 36.26 | 3.022 | 2.996 | 5.891 | 2.305 | 2.663 | 0.881 | 0.831 | 17.6477 | |
| 187.20 | 0.726 | 1.97 | 36.89 | 3.074 | 3.048 | 5.995 | 2.751 | 2.913 | 0.947 | 0.914 | 18.2728 | |
| 163.60 | 0.634 | 1.97 | 37.52 | 3.127 | 3.101 | 6.098 | 3.091 | 3.109 | 0.994 | 0.971 | 18.9089 | |
| 140.00 | 0.543 | 1.97 | 38.16 | 3.180 | 3.153 | 6.202 | 3.358 | 3.269 | 1.028 | 1.011 | 19.5558 | |
| 116.40 | 0.451 | 1.97 | 38.79 | 3.232 | 3.206 | 6.305 | 3.567 | 3.400 | 1.052 | 1.040 | 20.2136 | |
| 92.80 | 0.360 | 1.97 | 39.42 | 3.285 | 3.259 | 6.408 | 3.730 | 3.507 | 1.068 | 1.060 | 20.8823 | |
| 69.20 | 0.268 | 1.97 | 40.05 | 3.337 | 3.311 | 6.512 | 3.851 | 3.594 | 1.077 | 1.072 | 21.5619 | |
| 45.60 | 0.177 | 1.97 | 40.68 | 3.390 | 3.364 | 6.615 | 3.934 | 3.662 | 1.080 | 1.079 | 22.2523 | |
| 22.00 | 0.085 | 1.97 | 41.31 | 3.443 | 3.416 | 6.719 | 3.983 | 3.713 | 1.078 | 1.079 | 22.9537 | |
| 0.00 | 0.000 | 1.83 | 41.90 | 3.492 | 3.467 | 6.356 | 3.997 | 3.745 | 1.072 | 1.075 | 22.0388 | |
| | | | | | Σ = | 68.89 | | | | Σ = | 221.32 | |
| | | | | | Area calc = | 137.78 | $ft^2$ | | | MAC calc = | 3.21 | ft |
| | | | | | | | | | | MAC calc = | 38.55 | in |

SPANWISE AERODYNAMIC LOAD DISTRIBUTION

CONDITION. C

STATIC TEST

| | | | | | |
|---|---|---|---|---|---|
| $V_{sel}$ = | 175.68 ft/s | $C_L$ = | 1.3 | alpha wrp = | 10.5128 |
| Lift = | 6530.79 lb | $C_{Do}$ = | 0.017 | sin alpha = | 0.1825 |
| q = | 36.73 psf | $C_D$ = | 0.067 | cos alpha = | 0.9832 |
| n = | 4.54 g | $C_{Mo}$ = | -0.025 | | |
| $q.C_L$ = | 48.38 $q.C_L$ =Lift/S | S = | 135.00 ft² | | |
| | | b = | 43.00 ft | | |

| 1 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| STATION | $C_L$ | $C_{Lx}$ | $C_{Lz}$ | $C_D$ | $C_{Dx}$ | $C_{Dz}$ | $C_{Lz}+C_{Dz}$ | $C_{Dx}-C_{Lx}$ | $(C_{Lz}+C_{Dz})_{AV}$ | $(C_{Dx}-C_{Lx})_{AV}$ | SPAN | SPAN |
| (in) | | | | | | | | | | | ELEMENT | ELEMENT |
| | | | | | | | | | | | LIFT | DRAG |
| | | | | | | | | | | | (lb) | (lb) |
| 258 | 0.6586 | 0.1202 | 0.6476 | 0.0809 | 0.0795 | 0.0148 | 0.6623 | -0.0406 | - | - | 0.00 | 0.00 |
| 234.40 | 1.0291 | 0.1878 | 1.0118 | 0.0809 | 0.0795 | 0.0148 | 1.0266 | -0.1082 | 0.8444 | -0.0744 | 179.50 | -15.82 |
| 210.80 | 1.1609 | 0.2118 | 1.1414 | 0.0809 | 0.0795 | 0.0148 | 1.1562 | -0.1323 | 1.0914 | -0.1203 | 236.13 | -26.02 |
| 187.20 | 1.2479 | 0.2277 | 1.2269 | 0.0809 | 0.0795 | 0.0148 | 1.2417 | -0.1482 | 1.1989 | -0.1402 | 263.96 | -30.87 |
| 163.60 | 1.3096 | 0.2389 | 1.2876 | 0.0809 | 0.0795 | 0.0148 | 1.3024 | -0.1594 | 1.2720 | -0.1538 | 284.89 | -34.44 |
| 140.00 | 1.3541 | 0.2471 | 1.3314 | 0.0640 | 0.0630 | 0.0117 | 1.3431 | -0.1841 | 1.3227 | -0.1718 | 301.26 | -39.12 |
| 116.40 | 1.3855 | 0.2528 | 1.3623 | 0.0640 | 0.0630 | 0.0117 | 1.3740 | -0.1898 | 1.3585 | -0.1870 | 314.57 | -43.29 |
| 92.80 | 1.4065 | 0.2566 | 1.3828 | 0.0640 | 0.0630 | 0.0117 | 1.3945 | -0.1937 | 1.3842 | -0.1917 | 325.79 | -45.13 |
| 69.20 | 1.4186 | 0.2588 | 1.3947 | 0.0640 | 0.0630 | 0.0117 | 1.4064 | -0.1959 | 1.4005 | -0.1948 | 334.93 | -46.58 |
| 45.60 | 1.4230 | 0.2596 | 1.3991 | 0.0640 | 0.0630 | 0.0117 | 1.4108 | -0.1967 | 1.4086 | -0.1963 | 342.23 | -47.68 |
| 22.00 | 1.4206 | 0.2592 | 1.3967 | 0.0640 | 0.0630 | 0.0117 | 1.4084 | -0.1962 | 1.4096 | -0.1965 | 347.82 | -48.48 |
| 0.00 | 1.4126 | 0.2577 | 1.3889 | 0.0640 | 0.0630 | 0.0117 | 1.4006 | -0.1948 | 1.4045 | -0.1955 | 327.87 | -45.64 |
| | | | | | | | | | | Σ = | 3258.96 | -423.07 |
| | | | | | | | | | | LIFT calc = | 6517.92 | |
| | | | | | | | | | | Lift = | 6530.79 | |
| | | | | | | | | | | error = | 0.2 | % |

SPANWISE AERODYNAMIC LOAD DISTRIBUTION

CONDITION. C cont..

| 1 | 3 | 4 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 |
|---|---|---|---|---|---|---|---|---|---|---|
| STATION | dy | CHORD | LIMIT | LIMIT | LIMIT | LIMIT | ULT | ULT | ULT | ULT |
| (in) | (in) | (in) | NORMAL | NORMAL | CHORD | CHORD | NORMAL | NORMAL | CHORD | CHORD |
| | | | SHEAR | MOMENT | SHEAR | MOMENT | SHEAR | MOMENT | SHEAR | MOMENT |
| | | | (lb) | (lb in) | (lb) | (lb in) | (lb) | (lb in) | (lb) | (lb in) |
| 258 | - | - | 0.00 | 0.00 | 0.00 | 0.00 | 0 | 0 | 0 | 0 |
| 234.40 | 23.60 | 35.63 | 179.50 | 2118.06 | -15.82 | -186.70 | 269 | 3177 | -24 | -280 |
| 210.80 | 23.60 | 36.26 | 415.63 | 9140.57 | -41.84 | -867.14 | 623 | 13711 | -63 | -1301 |
| 187.20 | 23.60 | 36.89 | 679.59 | 22064.19 | -72.71 | -2218.89 | 1019 | 33096 | -109 | -3328 |
| 163.60 | 23.60 | 37.52 | 964.48 | 41464.21 | -107.16 | -4341.34 | 1447 | 62196 | -161 | -6512 |
| 140.00 | 23.60 | 38.16 | 1265.74 | 67780.80 | -146.28 | -7331.81 | 1899 | 101671 | -219 | -10998 |
| 116.40 | 23.60 | 38.79 | 1580.31 | 101364.22 | -189.57 | -11294.78 | 2370 | 152046 | -284 | -16942 |
| 92.80 | 23.60 | 39.42 | 1906.10 | 142503.90 | -234.70 | -16301.12 | 2859 | 213756 | -352 | -24452 |
| 69.20 | 23.60 | 40.05 | 2241.03 | 191440.09 | -281.27 | -22389.60 | 3362 | 287160 | -422 | -33584 |
| 45.60 | 23.60 | 40.68 | 2583.26 | 248366.76 | -328.96 | -29590.36 | 3875 | 372550 | -493 | -44386 |
| 22.00 | 23.60 | 41.31 | 2931.08 | 313436.03 | -377.43 | -37925.80 | 4397 | 470154 | -566 | -56889 |
| 0.00 | 22.00 | 41.90 | 3258.96 | 381526.50 | -423.07 | -46731.38 | 4888 | 572290 | -635 | -70097 |
| | | | | | | | | | | |
| | | Centre of lift is | 117 | in from aircraft centreline | | | | | | |
| | | | 45 | % semispan | | | | | | |

SPANWISE INERTIAL LOAD DISTRIBUTION

CONDITION. C cont..

| 1 | 3 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 | 41 | 42 | 43 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| STATION | dy | WEIGHT | ELEMENT | ELEMENT | LIMIT | LIMIT | LIMIT | LIMIT | ULT | ULT | ULT | ULT |
| (in) | (in) | nW | SHEAR | SHEAR | NORMAL | NORMAL | CHORD | CHORD | NORMAL | NORMAL | CHORD | CHORD |
| | | (lb) | FORCE | FORCE | SHEAR | MOMENT | SHEAR | MOMENT | SHEAR | MOMENT | SHEAR | MOMENT |
| | | | $V_x$ | $V_z$ | (lb) | (lb in) | (lb) | (lb in) | (lb) | (lb in) | (lb) | (lb in) |
| | | | (lb) | (lb) | | | | | | | | |
| 258 | - | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0 | 0 | 0 | 0 |
| 234.40 | 23.60 | -13.43 | 2.45 | -13.20 | -13.20 | -155.79 | 2.45 | 28.91 | -20 | -234 | 4 | 43 |
| 210.80 | 23.60 | -28.38 | 5.18 | -27.91 | -41.11 | -796.68 | 7.63 | 147.84 | -62 | -1195 | 11 | 222 |
| 187.20 | 23.60 | -43.43 | 7.92 | -42.70 | -83.81 | -2270.74 | 15.55 | 421.38 | -126 | -3406 | 23 | 632 |
| 163.60 | 23.60 | -56.33 | 10.28 | -55.39 | -139.20 | -4902.19 | 25.83 | 909.70 | -209 | -7353 | 39 | 1365 |
| 140.00 | 23.60 | -62.45 | 11.39 | -61.40 | -200.59 | -8911.70 | 37.22 | 1653.75 | -301 | -13368 | 56 | 2481 |
| 116.40 | 23.60 | -65.66 | 11.98 | -64.55 | -265.15 | -14407.41 | 49.20 | 2673.59 | -398 | -21611 | 74 | 4010 |
| 92.80 | 23.60 | -69.00 | 12.59 | -67.84 | -332.98 | -21465.34 | 61.79 | 3983.33 | -499 | -32198 | 93 | 5975 |
| 69.20 | 23.60 | -75.26 | 13.73 | -74.00 | -406.98 | -30196.93 | 75.52 | 5603.65 | -610 | -45295 | 113 | 8405 |
| 45.60 | 23.60 | -84.28 | 15.38 | -82.86 | -489.85 | -40779.51 | 90.90 | 7567.46 | -735 | -61169 | 136 | 11351 |
| 22.00 | 23.60 | -41.29 | 7.53 | -40.60 | -530.44 | -52818.91 | 98.43 | 9801.62 | -796 | -79228 | 148 | 14702 |
| 0.00 | 22.00 | -28.46 | 5.19 | -27.98 | -558.42 | -64796.41 | 103.63 | 12024.29 | -838 | -97195 | 155 | 18036 |
| | Σ = | 125 | lb | | | | | | | | | |
| | | at 1 g | | | Centre of gravity is | 116 | in from aircraft centreline | | | | | |
| | | | | | | 45 | % semispan | | | | | |

| COMBINED ULTIMATE LOADS ( AERODYNAMIC + INERTIAL ) | | | | | | |
|---|---|---|---|---|---|---|
| CONDITION. C cont.. | | | | | | |
| | | | | | | |
| | | | | | | |
| 1 | 44 C | 45 C | 46 C | 47 C | 48 C | 49 C |
| | ULT | ULT | ULT | ULT | ULT | ULT |
| | NORMAL | NORMAL | CHORD | CHORD | RESOLVED | RESOLVED |
| STATION | SHEAR | BEND MOMENT | SHEAR | BEND MOMENT | SHEAR | BEND MOMENT |
| (in) | COND. C | COND. C | COND. C | COND. C | COND. C | COND. C |
| | (lb) | (lb in) | (lb) | (lb in) | (lb) | (lb in) |
| | | | | | | |
| 258 | 0 | 0 | 0 | 0 | 0 | 0 |
| 234.40 | 249 | 2943 | -20 | -237 | 250 | 2953 |
| 210.80 | 562 | 12516 | -51 | -1079 | 564 | 12562 |
| 187.20 | 894 | 29690 | -86 | -2696 | 898 | 29812 |
| 163.60 | 1238 | 54843 | -122 | -5147 | 1244 | 55084 |
| 140.00 | 1598 | 88304 | -164 | -8517 | 1606 | 88713 |
| 116.40 | 1973 | 130435 | -211 | -12932 | 1984 | 131075 |
| 92.80 | 2360 | 181558 | -259 | -18477 | 2374 | 182496 |
| 69.20 | 2751 | 241865 | -309 | -25179 | 2768 | 243172 |
| 45.60 | 3140 | 311381 | -357 | -33034 | 3160 | 313128 |
| 22.00 | 3601 | 390926 | -418 | -42186 | 3625 | 393195 |
| 0.00 | 4051 | 475095 | -479 | -52061 | 4079 | 477939 |

| AERODYNAMIC TORQUE AT SHEAR CENTRE | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| CONDITION. C cont.. | | | | | | | | | |
| | | | | | | | | | |
| 1 | 50 | 51 | 52 | 53 | 54 | 55 | 56 | 57 | 58 |
| STATION | LOCAL | LOCAL | AERO | X AC | X SC | DELTA X | Z AC | Z SC | DELTA Z |
| | $C_L$ | $X_{CP}$ | CENTRE | (in) | (in) | (in) | (in) | (in) | (in) |
| (in) | | | (in) | using 38% chord | | | | | |
| 258 | - | - | 0.00 | 0.00 | 13.30 | 13.30 | 0.00 | 2.39 | -2.39 |
| 234.40 | 0.84 | 0.27 | 9.61 | 9.61 | 13.54 | 3.93 | 0.00 | 2.45 | -2.45 |
| 210.80 | 1.09 | 0.26 | 9.53 | 9.53 | 13.78 | 4.25 | 0.00 | 2.51 | -2.51 |
| 187.20 | 1.20 | 0.26 | 9.62 | 9.62 | 14.02 | 4.40 | 0.00 | 2.57 | -2.57 |
| 163.60 | 1.27 | 0.26 | 9.74 | 9.74 | 14.26 | 4.52 | 0.00 | 2.64 | -2.64 |
| 140.00 | 1.32 | 0.26 | 9.88 | 9.88 | 14.50 | 4.62 | 0.00 | 2.70 | -2.70 |
| 116.40 | 1.36 | 0.26 | 10.02 | 10.02 | 14.74 | 4.72 | 0.00 | 2.76 | -2.76 |
| 92.80 | 1.38 | 0.26 | 10.17 | 10.17 | 14.98 | 4.81 | 0.00 | 2.82 | -2.82 |
| 69.20 | 1.40 | 0.26 | 10.33 | 10.33 | 15.22 | 4.89 | 0.00 | 2.89 | -2.89 |
| 45.60 | 1.41 | 0.26 | 10.49 | 10.49 | 15.46 | 4.97 | 0.00 | 2.95 | -2.95 |
| 22.00 | 1.41 | 0.26 | 10.65 | 10.65 | 15.70 | 5.05 | 0.00 | 3.01 | -3.01 |
| 0.00 | 1.40 | 0.26 | 10.80 | 10.80 | 15.92 | 5.12 | 0.00 | 3.07 | -3.07 |

AERODYNAMIC TORQUE AT SHEAR CENTRE

CONDITION. C cont..

| 1 | 55 | 56 | 23 | 24 | 59 | 60 | 61 | 62 | 63 | 64 |
|---|---|---|---|---|---|---|---|---|---|---|
| STATION | DELTA | DELTA | SPAN | SPAN | ELEMENT | ELEMENT | ELEMENT | ELEMENT | TOTAL | TOTAL |
| | X av | Z av | ELEMENT | ELEMENT | TORQUE | TORQUE | TORQUE | LIMIT | LIMIT | ULT |
| (in) | (in) | (in) | LIFT | DRAG | DUE TO | DUE TO | DUE TO | TORQUE | TORQUE | TORQUE |
| | | | (lb) | (lb) | $C_{Mo}$ | LIFT | DRAG | (lb in) | (lb in) | (lb in) |
| | | | | | (lb in) | (lb in) | (lb in) | | | |
| 258 | - | - | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 234.40 | 8.62 | 0.00 | 179.50 | -15.82 | -187.67 | 1546.68 | 0.00 | 1359.01 | 1359.01 | 2038.52 |
| 210.80 | 4.09 | 0.00 | 236.13 | -26.02 | -194.44 | 965.74 | 0.00 | 771.30 | 2130.31 | 3195.46 |
| 187.20 | 4.32 | 0.00 | 263.96 | -30.87 | -201.32 | 1140.56 | 0.00 | 939.23 | 3069.54 | 4604.32 |
| 163.60 | 4.46 | 0.00 | 284.89 | -34.44 | -208.33 | 1269.42 | 0.00 | 1061.09 | 4130.63 | 6195.95 |
| 140.00 | 4.57 | 0.00 | 301.26 | -39.12 | -215.46 | 1376.26 | 0.00 | 1160.80 | 5291.43 | 7937.15 |
| 116.40 | 4.67 | 0.00 | 314.57 | -43.29 | -222.71 | 1468.59 | 0.00 | 1245.88 | 6537.31 | 9805.97 |
| 92.80 | 4.76 | 0.00 | 325.79 | -45.13 | -230.08 | 1551.25 | 0.00 | 1321.18 | 7858.49 | 11787.73 |
| 69.20 | 4.85 | 0.00 | 334.93 | -46.58 | -237.56 | 1624.18 | 0.00 | 1386.62 | 9245.11 | 13867.66 |
| 45.60 | 4.93 | 0.00 | 342.23 | -47.68 | -245.17 | 1688.08 | 0.00 | 1442.91 | 10688.02 | 16032.03 |
| 22.00 | 5.01 | 0.00 | 347.82 | -48.48 | -252.90 | 1743.33 | 0.00 | 1490.43 | 12178.45 | 18267.68 |
| 0.00 | 5.09 | 0.00 | 327.87 | -45.64 | -242.82 | 1667.42 | 0.00 | 1424.61 | 13603.06 | 20404.59 |

DEAD WEIGHT ANALYSIS FOR WING TORQUE

CONDITION. C cont..

| 1 | 65 | 54 | 66 | 67 | 33 | 68 | 69 | 70 |
|---|---|---|---|---|---|---|---|---|
| STATION | X CG | X SC | DELTA | DELTA | ELEMENT | ELEMENT | TOTAL | TOTAL |
| | (in) | (in) | X | X av | LOAD | LIMIT | LIMIT | ULT |
| (in) | | | (in) | (in) | (lb) | TORQUE | TORQUE | TORQUE |
| | using 40% chord | | | | | (lb in) | (lb in) | (lb in) |
| 258 | 14.00 | 13.30 | -0.70 | - | - | - | - | 0.00 |
| 234.40 | 14.25 | 13.54 | -0.71 | -0.71 | -13.43 | 9.48 | 9.48 | 14.23 |
| 210.80 | 14.50 | 13.78 | -0.73 | -0.72 | -28.38 | 20.41 | 29.89 | 44.84 |
| 187.20 | 14.76 | 14.02 | -0.74 | -0.73 | -43.43 | 31.77 | 61.66 | 92.49 |
| 163.60 | 15.01 | 14.26 | -0.75 | -0.74 | -56.33 | 41.92 | 103.58 | 155.37 |
| 140.00 | 15.26 | 14.50 | -0.76 | -0.76 | -62.45 | 47.26 | 150.84 | 226.26 |
| 116.40 | 15.51 | 14.74 | -0.78 | -0.77 | -65.66 | 50.52 | 201.36 | 302.04 |
| 92.80 | 15.77 | 14.98 | -0.79 | -0.78 | -69.00 | 53.96 | 255.32 | 382.97 |
| 69.20 | 16.02 | 15.22 | -0.80 | -0.79 | -75.26 | 59.81 | 315.12 | 472.69 |
| 45.60 | 16.27 | 15.46 | -0.81 | -0.81 | -84.28 | 68.04 | 383.16 | 574.74 |
| 22.00 | 16.52 | 15.70 | -0.83 | -0.82 | -41.29 | 33.85 | 417.02 | 625.52 |
| 0.00 | 16.76 | 15.92 | -0.84 | -0.83 | -28.46 | 23.68 | 440.70 | 661.04 |

| COMBINED ULTIMATE TORSION ( AERODYNAMIC + INERTIAL ) | | | | |
|---|---|---|---|---|
| CONDITION. C cont.. | | | | |
| | | | | |
| 1 | 71 C | | | |
| STATION | COND. C | | | |
| (in) | (lb in) | | | |
| 258 | 0 | | | |
| 234.40 | 2053 | | | |
| 210.80 | 3240 | | | |
| 187.20 | 4697 | | | |
| 163.60 | 6351 | | | |
| 140.00 | 8163 | | | |
| 116.40 | 10108 | | | |
| 92.80 | 12171 | | | |
| 69.20 | 14340 | | | |
| 45.60 | 16607 | | | |
| 22.00 | 18893 | | | |
| 0.00 | 21066 | | | |

# APPENDIX F: STRUCTURAL SIZING OF WING SPAR & SKIN USING MOST UNFAVOURABLE COMBINATION OF SPANWISE LOAD

EUROPA GLIDER WING LOADING ANALYSIS

SPAR BENDING STRENGTH

MOST UNFAVOURABLE LOADS EXPERIENCED BY WING SPAR

GLASS SHEAR WEBS

| 1 | 44C | 45C | 76 | 77 | 78 | 79 | 80 | 81 | 82 | 83 | 84 | 85 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | NORMAL | NORMAL | | 1.125 | | 0.010 | TOTAL | | | | SINGLE | |
| STATION | ULT SHEAR | ULT BEND MOM | SPAR DEPTH | SPAR WIDTH | NO SHEAR WEB | SPAR WEB | SHEAR WEB | CAP WEB | SPAR BOOM | SPAR BOOM | SPAR BOOM | GAP SIZE |
| (in) | COND. C | COND. C | (in) | (in) | PLIES/SIDE | WIDTH | AREA | AREA | WIDTH | DEPTH | AREA | (in) |
| | (lb) | (lb in) | | | | (in) | ($in^2$) | ($in^2$) | (in) | (in) | ($in^2$) | |
| 258 | 0 | 0 | 4.772 | 1.125 | 2 | 0.020 | 0.191 | 0.022 | 1.085 | 0.000 | 0.000 | 4.732 |
| 251 | 66 | 224 | 4.808 | 1.125 | 2 | 0.020 | 0.192 | 0.022 | 1.085 | 0.000 | 0.000 | 4.768 |
| 238 | 226 | 2165 | 4.878 | 1.125 | 2 | 0.020 | 0.195 | 0.022 | 1.085 | 0.000 | 0.000 | 4.838 |
| 228 | 355 | 5075 | 4.931 | 1.125 | 2 | 0.020 | 0.197 | 0.022 | 1.085 | 0.010 | 0.011 | 4.871 |
| 218 | 489 | 9299 | 4.984 | 1.125 | 3 | 0.030 | 0.299 | 0.032 | 1.065 | 0.017 | 0.018 | 4.890 |
| 208 | 627 | 14880 | 5.037 | 1.125 | 3 | 0.030 | 0.302 | 0.032 | 1.065 | 0.035 | 0.037 | 4.907 |
| 198 | 768 | 21854 | 5.090 | 1.125 | 4 | 0.040 | 0.407 | 0.042 | 1.045 | 0.054 | 0.056 | 4.902 |
| 188 | 911 | 30247 | 5.143 | 1.125 | 5 | 0.050 | 0.514 | 0.051 | 1.025 | 0.078 | 0.080 | 4.887 |
| 178 | 1055 | 40074 | 5.196 | 1.125 | 5 | 0.050 | 0.520 | 0.051 | 1.025 | 0.112 | 0.115 | 4.872 |
| 164 | 1280 | 56829 | 5.272 | 1.125 | 6 | 0.060 | 0.633 | 0.060 | 1.005 | 0.170 | 0.171 | 4.812 |
| 159 | 1323 | 62457 | 5.295 | 1.125 | 6 | 0.060 | 0.635 | 0.060 | 1.005 | 0.190 | 0.191 | 4.795 |
| 155 | 1364 | 68267 | 5.318 | 1.125 | 6 | 0.060 | 0.638 | 0.060 | 1.005 | 0.210 | 0.211 | 4.778 |
| 138 | 1651 | 93894 | 5.408 | 1.125 | 7 | 0.070 | 0.757 | 0.069 | 0.985 | 0.310 | 0.305 | 4.648 |
| 128 | 1806 | 111178 | 5.461 | 1.125 | 8 | 0.080 | 0.874 | 0.077 | 0.965 | 0.384 | 0.371 | 4.533 |
| 118 | 1964 | 130028 | 5.514 | 1.125 | 9 | 0.090 | 0.992 | 0.085 | 0.945 | 0.470 | 0.444 | 4.394 |
| 108 | 2124 | 150467 | 5.566 | 1.125 | 9 | 0.090 | 1.002 | 0.085 | 0.945 | 0.570 | 0.539 | 4.246 |
| 98 | 2286 | 172516 | 5.619 | 1.125 | 10 | 0.100 | 1.124 | 0.093 | 0.925 | 0.700 | 0.648 | 4.019 |
| 88 | 2449 | 196191 | 5.672 | 1.125 | 10 | 0.100 | 1.134 | 0.093 | 0.925 | 0.870 | 0.805 | 3.732 |
| 80 | 2570 | 216268 | 5.715 | 1.125 | 11 | 0.110 | 1.257 | 0.100 | 0.905 | 1.050 | 0.950 | 3.395 |
| 68 | 2778 | 248356 | 5.778 | 1.125 | 11 | 0.110 | 1.271 | 0.100 | 0.905 | 1.340 | 1.213 | 2.878 |
| 58 | 2943 | 276958 | 5.831 | 1.125 | 12 | 0.120 | 1.400 | 0.106 | 0.885 | 1.800 | 1.593 | 1.991 |
| 48 | 3108 | 307212 | 5.884 | 1.125 | 13 | 0.130 | 1.530 | 0.112 | 0.865 | 2.810 | 2.431 | 0.004 |
| 22 | 3625 | 394736 | 6.022 | 1.125 | 14 | 0.140 | 1.686 | 0.118 | 0.845 | 2.870 | 2.425 | 0.002 |
| 19 | 3663 | 405667 | 6.022 | 1.125 | 14 | 0.140 | 1.686 | 0.118 | 0.845 | 2.496 | 2.109 | 0.750 |
| 0 | 4069 | 479117 | 4.300 | 1.125 | 14 | 0.140 | 1.204 | 0.118 | 0.845 | 2.000 | 1.690 | 0.020 |

SPAR MOMENT OF INERTIA TRANSFORMATION

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $E_{BOOM}$ = | 10000000 | psi | | | | | | | | | | | | |
| $E_{SHEAR\ WEB}$ = | 1800000 | psi | | | | | | | | | | | | |
| $E_2 / E_1$ = | 5.56 | | | | | | | | | | | | | |
| 1 | 86 | 87 | 88 | 89 | 90 | 91 | 92 | 93 | 94 | 95 | 96 | 97 | 98 | 99 |
| COMPRESSION | | | | | | | | | | | | | | |
| | 1800000 | | | | | | | 1800000 | | | | | | |
| STATION (in) | SHEAR WEB TRANSFORMED WIDTH (in) | SHEAR WEB DEPTH (in) | SHEAR WEB TRANSFORMED AREA (in2) | Y | AY | $AY^2$ | Io | GLASS CAP TRANSFORMED WIDTH (in) | GLASS CAP DEPTH (in) | GLASS CAP TRANSFORMED AREA (in2) | Y | AY | $AY^2$ | Io |
| 258 | 0.040 | 4.772 | 0.191 | 2.386 | 0.455 | 1.08668 | 0.36223 | 1.085 | 0.020 | 0.022 | 4.762 | 0.103 | 0.49208 | 0.00000 |
| 251 | 0.040 | 4.808 | 0.192 | 2.404 | 0.462 | 1.11129 | 0.37043 | 1.085 | 0.020 | 0.022 | 4.798 | 0.104 | 0.49950 | 0.00000 |
| 238 | 0.040 | 4.878 | 0.195 | 2.439 | 0.476 | 1.16067 | 0.38689 | 1.085 | 0.020 | 0.022 | 4.868 | 0.106 | 0.51422 | 0.00000 |
| 228 | 0.040 | 4.931 | 0.197 | 2.465 | 0.486 | 1.19889 | 0.39963 | 1.085 | 0.020 | 0.022 | 4.921 | 0.107 | 0.52547 | 0.00000 |
| 218 | 0.060 | 4.984 | 0.299 | 2.492 | 0.745 | 1.85691 | 0.61897 | 1.065 | 0.030 | 0.032 | 4.969 | 0.159 | 0.78883 | 0.00000 |
| 208 | 0.060 | 5.037 | 0.302 | 2.518 | 0.761 | 1.91674 | 0.63891 | 1.065 | 0.030 | 0.032 | 5.022 | 0.160 | 0.80574 | 0.00000 |
| 198 | 0.080 | 5.090 | 0.407 | 2.545 | 1.036 | 2.63713 | 0.87904 | 1.045 | 0.040 | 0.042 | 5.070 | 0.212 | 1.07438 | 0.00001 |
| 188 | 0.100 | 5.143 | 0.514 | 2.571 | 1.322 | 3.40040 | 1.13347 | 1.025 | 0.050 | 0.051 | 5.118 | 0.262 | 1.34231 | 0.00001 |
| 178 | 0.100 | 5.196 | 0.520 | 2.598 | 1.350 | 3.50655 | 1.16885 | 1.025 | 0.050 | 0.051 | 5.171 | 0.265 | 1.37024 | 0.00001 |
| 164 | 0.120 | 5.272 | 0.633 | 2.636 | 1.667 | 4.39523 | 1.46508 | 1.005 | 0.060 | 0.060 | 5.242 | 0.316 | 1.65679 | 0.00002 |
| 159 | 0.120 | 5.295 | 0.635 | 2.647 | 1.682 | 4.45278 | 1.48426 | 1.005 | 0.060 | 0.060 | 5.265 | 0.317 | 1.67130 | 0.00002 |
| 155 | 0.120 | 5.318 | 0.638 | 2.659 | 1.697 | 4.51083 | 1.50361 | 1.005 | 0.060 | 0.060 | 5.288 | 0.319 | 1.68588 | 0.00002 |
| 138 | 0.140 | 5.408 | 0.757 | 2.704 | 2.047 | 5.53452 | 1.84484 | 0.985 | 0.070 | 0.069 | 5.373 | 0.370 | 1.99023 | 0.00003 |
| 128 | 0.160 | 5.461 | 0.874 | 2.730 | 2.385 | 6.51285 | 2.17095 | 0.965 | 0.080 | 0.077 | 5.421 | 0.418 | 2.26833 | 0.00004 |
| 118 | 0.180 | 5.514 | 0.992 | 2.757 | 2.736 | 7.54225 | 2.51408 | 0.945 | 0.090 | 0.085 | 5.469 | 0.465 | 2.54340 | 0.00006 |
| 108 | 0.180 | 5.566 | 1.002 | 2.783 | 2.789 | 7.76171 | 2.58724 | 0.945 | 0.090 | 0.085 | 5.521 | 0.470 | 2.59291 | 0.00006 |
| 98 | 0.200 | 5.619 | 1.124 | 2.810 | 3.158 | 8.87265 | 2.95755 | 0.925 | 0.100 | 0.093 | 5.569 | 0.515 | 2.86924 | 0.00008 |
| 88 | 0.200 | 5.672 | 1.134 | 2.836 | 3.218 | 9.12591 | 3.04197 | 0.925 | 0.100 | 0.093 | 5.622 | 0.520 | 2.92408 | 0.00008 |
| 80 | 0.220 | 5.715 | 1.257 | 2.857 | 3.592 | 10.26514 | 3.42171 | 0.905 | 0.110 | 0.100 | 5.660 | 0.563 | 3.18891 | 0.00010 |
| 68 | 0.220 | 5.778 | 1.271 | 2.889 | 3.673 | 10.61147 | 3.53716 | 0.905 | 0.110 | 0.100 | 5.723 | 0.570 | 3.26094 | 0.00010 |
| 58 | 0.240 | 5.831 | 1.400 | 2.916 | 4.081 | 11.89741 | 3.96580 | 0.885 | 0.120 | 0.106 | 5.771 | 0.613 | 3.53733 | 0.00013 |
| 48 | 0.260 | 5.884 | 1.530 | 2.942 | 4.501 | 13.24327 | 4.41442 | 0.865 | 0.130 | 0.112 | 5.819 | 0.654 | 3.80802 | 0.00016 |
| 22 | 0.280 | 6.022 | 1.686 | 3.011 | 5.077 | 15.28693 | 5.09564 | 0.845 | 0.140 | 0.118 | 5.952 | 0.704 | 4.19093 | 0.00019 |
| 19 | 0.280 | 6.022 | 1.686 | 3.011 | 5.077 | 15.28693 | 5.09564 | 0.845 | 0.140 | 0.118 | 5.952 | 0.704 | 4.19093 | 0.00019 |
| 0 | 0 280 | 4.300 | 1.204 | 2.150 | 2.589 | 5.56549 | 1.85516 | 0.845 | 0.140 | 0.118 | 4.230 | 0.500 | 2.11673 | 0.00019 |

SPAR MOMENT OF INERTIA TRANSFORMATION

COMPRESSION

| 1 | 100 | 101 | 102 | 103 | 104 | 105 | 106 | 107 | 108 | 109 | 110 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| COMPRESSION | | | | | | | | | | | |
| | 10000000 | | | | | | | | | | |
| STATION (in) | SPAR BOOM TRANSFORMED WIDTH (in) | SPAR BOOM DEPTH (in) | SPAR BOOM TRANSFORMED AREA (in2) | Y | AY | $AY^2$ | Io | Σ A | Σ AY | $\Sigma AY^2$ | Σ Io |
| 258 | 6.028 | 0.000 | 0.000 | 4.752 | 0.000 | 0.00000 | 0.00000 | 0.213 | 0.559 | 1.579 | 0.362 |
| 251 | 6.028 | 0.000 | 0.000 | 4.788 | 0.000 | 0.00000 | 0.00000 | 0.214 | 0.566 | 1.611 | 0.370 |
| 238 | 6.028 | 0.000 | 0.000 | 4.858 | 0.000 | 0.00000 | 0.00000 | 0.217 | 0.582 | 1.675 | 0.387 |
| 228 | 6.028 | 0.010 | 0.060 | 4.906 | 0.296 | 1.45076 | 0.00000 | 0.279 | 0.889 | 3.175 | 0.400 |
| 218 | 5.917 | 0.017 | 0.101 | 4.945 | 0.497 | 2.45993 | 0.00000 | 0.432 | 1.401 | 5.106 | 0.619 |
| 208 | 5.917 | 0.035 | 0.207 | 4.989 | 1.033 | 5.15501 | 0.00002 | 0.541 | 1.955 | 7.877 | 0.639 |
| 198 | 5.806 | 0.054 | 0.314 | 5.023 | 1.575 | 7.90913 | 0.00008 | 0.762 | 2.823 | 11.621 | 0.879 |
| 188 | 5.694 | 0.078 | 0.444 | 5.054 | 2.245 | 11.34425 | 0.00023 | 1.010 | 3.829 | 16.087 | 1.134 |
| 178 | 5.694 | 0.112 | 0.638 | 5.090 | 3.246 | 16.52185 | 0.00067 | 1.209 | 4.861 | 21.399 | 1.170 |
| 164 | 5.583 | 0.170 | 0.949 | 5.127 | 4.866 | 24.94734 | 0.00229 | 1.642 | 6.850 | 30.999 | 1.467 |
| 159 | 5.583 | 0.190 | 1.061 | 5.140 | 5.452 | 28.02290 | 0.00319 | 1.756 | 7.452 | 34.147 | 1.487 |
| 155 | 5.583 | 0.210 | 1.173 | 5.153 | 6.041 | 31.12844 | 0.00431 | 1.871 | 8.057 | 37.325 | 1.508 |
| 138 | 5.472 | 0.310 | 1.696 | 5.183 | 8.792 | 45.56377 | 0.01359 | 2.522 | 11.209 | 53.089 | 1.858 |
| 128 | 5.361 | 0.384 | 2.059 | 5.189 | 10.682 | 55.42167 | 0.02530 | 3.010 | 13.485 | 64.203 | 2.196 |
| 118 | 5.250 | 0.470 | 2.468 | 5.189 | 12.803 | 66.42706 | 0.04542 | 3.545 | 16.004 | 76.513 | 2.560 |
| 108 | 5.250 | 0.570 | 2.993 | 5.191 | 15.536 | 80.65262 | 0.08102 | 4.080 | 18.794 | 91.007 | 2.668 |
| 98 | 5.139 | 0.700 | 3.597 | 5.169 | 18.596 | 96.12962 | 0.14689 | 4.814 | 22.269 | 107.872 | 3.105 |
| 88 | 5.139 | 0.870 | 4.471 | 5.137 | 22.969 | 117.99925 | 0.28200 | 5.698 | 26.706 | 130.049 | 3.324 |
| 80 | 5.028 | 1.050 | 5.279 | 5.080 | 26.817 | 136.22538 | 0.48502 | 6.636 | 30.973 | 149.679 | 3.907 |
| 68 | 5.028 | 1.340 | 6.737 | 4.998 | 33.675 | 168.31981 | 1.00811 | 8.108 | 37.918 | 182.192 | 4.545 |
| 58 | 4.917 | 1.800 | 8.850 | 4.811 | 42.580 | 204.86705 | 2.38950 | 10.356 | 47.274 | 220.302 | 6.355 |
| 48 | 4.806 | 2.810 | 13.504 | 4.349 | 58.731 | 255.43846 | 8.88549 | 15.146 | 63.887 | 272.490 | 13.300 |
| 22 | 4.694 | 2.870 | 13.473 | 4.447 | 59.915 | 266.44057 | 9.24802 | 15.278 | 65.696 | 285.918 | 14.344 |
| 19 | 4.694 | 2.496 | 11.717 | 4.634 | 54.298 | 251.61750 | 6.08326 | 13.522 | 60.079 | 271.095 | 11.179 |
| 0 | 4.694 | 2.000 | 9.389 | 3.160 | 29.669 | 93.75369 | 3.12963 | 10.711 | 32.758 | 101.436 | 4.985 |

| 1 | 111 | 112 | 113 | 114 | 115 | 116 | 117 | 118 | 119 | 120 | 121 | 122 | 123 | 124 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TENSION | | | | | | | | | | | | | | |
| | GLASS CAP | GLASS CAP | GLASS CAP | | | | | SPAR BOOM | SPAR BOOM | SPAR BOOM | | | | |
| STATION | TRANSFORMED | DEPTH | TRANSFORMED | Y | AY | $AY^2$ | Io | TRANSFORMED | DEPTH | TRANSFORMED | Y | AY | $AY^2$ | Io |
| (in) | WIDTH | (in) | AREA | | | | | WIDTH | (in) | AREA | | | | |
| | (in) | | (in2) | | | | | (in) | | (in2) | | | | |
| 258 | 1.085 | 0.020 | 0.022 | 0.010 | 0.000 | 0.00000 | 0.00000 | 6.028 | 0.000 | 0.000 | 0.020 | 0.000 | 0.00000 | 0.00000 |
| 251 | 1.085 | 0.020 | 0.022 | 0.010 | 0.000 | 0.00000 | 0.00000 | 6.028 | 0.000 | 0.000 | 0.020 | 0.000 | 0.00000 | 0.00000 |
| 238 | 1.085 | 0.020 | 0.022 | 0.010 | 0.000 | 0.00000 | 0.00000 | 6.028 | 0.000 | 0.000 | 0.020 | 0.000 | 0.00000 | 0.00000 |
| 228 | 1.085 | 0.020 | 0.022 | 0.010 | 0.000 | 0.00000 | 0.00000 | 6.028 | 0.010 | 0.060 | 0.025 | 0.002 | 0.00004 | 0.00000 |
| 218 | 1.065 | 0.030 | 0.032 | 0.015 | 0.000 | 0.00001 | 0.00000 | 5.917 | 0.017 | 0.101 | 0.039 | 0.004 | 0.00015 | 0.00000 |
| 208 | 1.065 | 0.030 | 0.032 | 0.015 | 0.000 | 0.00001 | 0.00000 | 5.917 | 0.035 | 0.207 | 0.048 | 0.010 | 0.00047 | 0.00002 |
| 198 | 1.045 | 0.040 | 0.042 | 0.020 | 0.001 | 0.00002 | 0.00001 | 5.806 | 0.054 | 0.314 | 0.067 | 0.021 | 0.00141 | 0.00008 |
| 188 | 1.025 | 0.050 | 0.051 | 0.025 | 0.001 | 0.00003 | 0.00001 | 5.694 | 0.078 | 0.444 | 0.089 | 0.040 | 0.00352 | 0.00023 |
| 178 | 1.025 | 0.050 | 0.051 | 0.025 | 0.001 | 0.00003 | 0.00001 | 5.694 | 0.112 | 0.638 | 0.106 | 0.068 | 0.00717 | 0.00067 |
| 164 | 1.005 | 0.060 | 0.060 | 0.030 | 0.002 | 0.00005 | 0.00002 | 5.583 | 0.170 | 0.949 | 0.145 | 0.138 | 0.01996 | 0.00229 |
| 159 | 1.005 | 0.060 | 0.060 | 0.030 | 0.002 | 0.00005 | 0.00002 | 5.583 | 0.190 | 1.061 | 0.155 | 0.164 | 0.02549 | 0.00319 |
| 155 | 1.005 | 0.060 | 0.060 | 0.030 | 0.002 | 0.00005 | 0.00002 | 5.583 | 0.210 | 1.173 | 0.165 | 0.193 | 0.03192 | 0.00431 |
| 138 | 0.985 | 0.070 | 0.069 | 0.035 | 0.002 | 0.00008 | 0.00003 | 5.472 | 0.310 | 1.696 | 0.225 | 0.382 | 0.08588 | 0.01359 |
| 128 | 0.965 | 0.080 | 0.077 | 0.040 | 0.003 | 0.00012 | 0.00004 | 5.361 | 0.384 | 2.059 | 0.272 | 0.560 | 0.15231 | 0.02530 |
| 118 | 0.945 | 0.090 | 0.085 | 0.045 | 0.004 | 0.00017 | 0.00006 | 5.250 | 0.470 | 2.468 | 0.325 | 0.802 | 0.26063 | 0.04542 |
| 108 | 0.945 | 0.090 | 0.085 | 0.045 | 0.004 | 0.00017 | 0.00006 | 5.250 | 0.570 | 2.993 | 0.375 | 1.122 | 0.42082 | 0.08102 |
| 98 | 0.925 | 0.100 | 0.093 | 0.050 | 0.005 | 0.00023 | 0.00008 | 5.139 | 0.700 | 3.597 | 0.450 | 1.619 | 0.72844 | 0.14689 |
| 88 | 0.925 | 0.100 | 0.093 | 0.050 | 0.005 | 0.00023 | 0.00008 | 5.139 | 0.870 | 4.471 | 0.535 | 2.392 | 1.27966 | 0.28200 |
| 80 | 0.905 | 0.110 | 0.100 | 0.055 | 0.005 | 0.00030 | 0.00010 | 5.028 | 1.050 | 5.279 | 0.635 | 3.352 | 2.12869 | 0.48502 |
| 68 | 0.905 | 0.110 | 0.100 | 0.055 | 0.005 | 0.00030 | 0.00010 | 5.028 | 1.340 | 6.737 | 0.780 | 5.255 | 4.09893 | 1.00811 |
| 58 | 0.885 | 0.120 | 0.106 | 0.060 | 0.006 | 0.00038 | 0.00013 | 4.917 | 1.800 | 8.850 | 1.020 | 9.027 | 9.20754 | 2.38950 |
| 48 | 0.865 | 0.130 | 0.112 | 0.065 | 0.007 | 0.00048 | 0.00016 | 4.806 | 2.810 | 13.504 | 1.535 | 20.728 | 31.81755 | 8.88549 |
| 22 | 0.845 | 0.140 | 0.118 | 0.070 | 0.008 | 0.00058 | 0.00019 | 4.694 | 2.870 | 13.473 | 1.575 | 21.220 | 33.42160 | 9.24802 |
| 19 | 0.845 | 0.140 | 0.118 | 0.070 | 0.008 | 0.00058 | 0.00019 | 4.694 | 2.496 | 11.717 | 1.388 | 16.264 | 22.57396 | 6.08326 |
| 0 | 0.845 | 0.140 | 0.118 | 0.070 | 0.008 | 0.00058 | 0.00019 | 4.694 | 2.000 | 9.389 | 1.140 | 10.703 | 12.20180 | 3.12963 |

| 1 | 111 | 112 | 113 | 114 | 115 | 116 | 117 | 118 | 119 | 120 | 121 | 122 | 123 | 124 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TENSION | | | | | | | | | | | | | | |
| | GLASS CAP | GLASS CAP | GLASS CAP | | | | | SPAR BOOM | SPAR BOOM | SPAR BOOM | | | | |
| STATION | TRANSFORMED | DEPTH | TRANSFORMED | Y | AY | $AY^2$ | Io | TRANSFORMED | DEPTH | TRANSFORMED | Y | AY | $AY^2$ | Io |
| (in) | WIDTH | (in) | AREA | | | | | WIDTH | (in) | AREA | | | | |
| | (in) | | (in2) | | | | | (in) | | (in2) | | | | |
| 258 | 1.085 | 0.020 | 0.022 | 0.010 | 0.000 | 0.00000 | 0.00000 | 6.028 | 0.000 | 0.000 | 0.020 | 0.000 | 0.00000 | 0.00000 |
| 251 | 1.085 | 0.020 | 0.022 | 0.010 | 0.000 | 0.00000 | 0.00000 | 6.028 | 0.000 | 0.000 | 0.020 | 0.000 | 0.00000 | 0.00000 |
| 238 | 1.085 | 0.020 | 0.022 | 0.010 | 0.000 | 0.00000 | 0.00000 | 6.028 | 0.000 | 0.000 | 0.020 | 0.000 | 0.00000 | 0.00000 |
| 228 | 1.085 | 0.020 | 0.022 | 0.010 | 0.000 | 0.00000 | 0.00000 | 6.028 | 0.010 | 0.060 | 0.025 | 0.002 | 0.00004 | 0.00000 |
| 218 | 1.065 | 0.030 | 0.032 | 0.015 | 0.000 | 0.00001 | 0.00000 | 5.917 | 0.017 | 0.101 | 0.039 | 0.004 | 0.00015 | 0.00000 |
| 208 | 1.065 | 0.030 | 0.032 | 0.015 | 0.000 | 0.00001 | 0.00000 | 5.917 | 0.035 | 0.207 | 0.048 | 0.010 | 0.00047 | 0.00002 |
| 198 | 1.045 | 0.040 | 0.042 | 0.020 | 0.001 | 0.00002 | 0.00001 | 5.806 | 0.054 | 0.314 | 0.067 | 0.021 | 0.00141 | 0.00008 |
| 188 | 1.025 | 0.050 | 0.051 | 0.025 | 0.001 | 0.00003 | 0.00001 | 5.694 | 0.078 | 0.444 | 0.089 | 0.040 | 0.00352 | 0.00023 |
| 178 | 1.025 | 0.050 | 0.051 | 0.025 | 0.001 | 0.00003 | 0.00001 | 5.694 | 0.112 | 0.638 | 0.106 | 0.068 | 0.00717 | 0.00067 |
| 164 | 1.005 | 0.060 | 0.060 | 0.030 | 0.002 | 0.00005 | 0.00002 | 5.583 | 0.170 | 0.949 | 0.145 | 0.138 | 0.01996 | 0.00229 |
| 159 | 1.005 | 0.060 | 0.060 | 0.030 | 0.002 | 0.00005 | 0.00002 | 5.583 | 0.190 | 1.061 | 0.155 | 0.164 | 0.02549 | 0.00319 |
| 155 | 1.005 | 0.060 | 0.060 | 0.030 | 0.002 | 0.00005 | 0.00002 | 5.583 | 0.210 | 1.173 | 0.165 | 0.193 | 0.03192 | 0.00431 |
| 138 | 0.985 | 0.070 | 0.069 | 0.035 | 0.002 | 0.00008 | 0.00003 | 5.472 | 0.310 | 1.696 | 0.225 | 0.382 | 0.08588 | 0.01359 |
| 128 | 0.965 | 0.080 | 0.077 | 0.040 | 0.003 | 0.00012 | 0.00004 | 5.361 | 0.384 | 2.059 | 0.272 | 0.560 | 0.15231 | 0.02530 |
| 118 | 0.945 | 0.090 | 0.085 | 0.045 | 0.004 | 0.00017 | 0.00006 | 5.250 | 0.470 | 2.468 | 0.325 | 0.802 | 0.26063 | 0.04542 |
| 108 | 0.945 | 0.090 | 0.085 | 0.045 | 0.004 | 0.00017 | 0.00006 | 5.250 | 0.570 | 2.993 | 0.375 | 1.122 | 0.42082 | 0.08102 |
| 98 | 0.925 | 0.100 | 0.093 | 0.050 | 0.005 | 0.00023 | 0.00008 | 5.139 | 0.700 | 3.597 | 0.450 | 1.619 | 0.72844 | 0.14689 |
| 88 | 0.925 | 0.100 | 0.093 | 0.050 | 0.005 | 0.00023 | 0.00008 | 5.139 | 0.870 | 4.471 | 0.535 | 2.392 | 1.27966 | 0.28200 |
| 80 | 0.905 | 0.110 | 0.100 | 0.055 | 0.005 | 0.00030 | 0.00010 | 5.028 | 1.050 | 5.279 | 0.635 | 3.352 | 2.12869 | 0.48502 |
| 68 | 0.905 | 0.110 | 0.100 | 0.055 | 0.005 | 0.00030 | 0.00010 | 5.028 | 1.340 | 6.737 | 0.780 | 5.255 | 4.09893 | 1.00811 |
| 58 | 0.885 | 0.120 | 0.106 | 0.060 | 0.006 | 0.00038 | 0.00013 | 4.917 | 1.800 | 8.850 | 1.020 | 9.027 | 9.20754 | 2.38950 |
| 48 | 0.865 | 0.130 | 0.112 | 0.065 | 0.007 | 0.00048 | 0.00016 | 4.806 | 2.810 | 13.504 | 1.535 | 20.728 | 31.81755 | 8.88549 |
| 22 | 0.845 | 0.140 | 0.118 | 0.070 | 0.008 | 0.00058 | 0.00019 | 4.694 | 2.870 | 13.473 | 1.575 | 21.220 | 33.42160 | 9.24802 |
| 19 | 0.845 | 0.140 | 0.118 | 0.070 | 0.008 | 0.00058 | 0.00019 | 4.694 | 2.496 | 11.717 | 1.388 | 16.264 | 22.57396 | 6.08326 |
| 0 | 0.845 | 0.140 | 0.118 | 0.070 | 0.008 | 0.00058 | 0.00019 | 4.694 | 2.000 | 9.389 | 1.140 | 10.703 | 12.20180 | 3.12963 |

| 1 | 125 | 126 | 127 | 128 | 129 | 130 | 131 | 132 | 133 | 134 | 135 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| TENSION | | | | | | | | | | | |
| | | | | | TOTAL | TOTAL | TOTAL | TOTAL | MOI | DIST TO | MOI |
| STATION | Σ A | Σ AY | Σ AY² | Σ Io | Σ A | Σ AY | Σ AY² | Σ Io | ABT DATUM | NA | ABT NA |
| (in) | | | | | | | | | | | |
| | | | | | | | | | | | |
| | 0.022 | 0.000 | 0.000 | 0.000 | 0.234 | 0.559 | 1.579 | 0.362 | 1.941 | 2.386 | 0.607 |
| 251 | 0.022 | 0.000 | 0.000 | 0.000 | 0.236 | 0.567 | 1.611 | 0.370 | 1.981 | 2.404 | 0.619 |
| 238 | 0.022 | 0.000 | 0.000 | 0.000 | 0.239 | 0.582 | 1.675 | 0.387 | 2.062 | 2.439 | 0.643 |
| 228 | 0.082 | 0.002 | 0.000 | 0.000 | 0.361 | 0.890 | 3.175 | 0.400 | 3.575 | 2.465 | 1.379 |
| 218 | 0.133 | 0.004 | 0.000 | 0.000 | 0.564 | 1.406 | 5.106 | 0.619 | 5.725 | 2.492 | 2.222 |
| 208 | 0.239 | 0.010 | 0.000 | 0.000 | 0.780 | 1.965 | 7.878 | 0.639 | 8.517 | 2.518 | 3.568 |
| 198 | 0.355 | 0.022 | 0.001 | 0.000 | 1.118 | 2.845 | 11.622 | 0.879 | 12.501 | 2.545 | 5.262 |
| 188 | 0.495 | 0.041 | 0.004 | 0.000 | 1.505 | 3.870 | 16.091 | 1.134 | 17.224 | 2.571 | 7.273 |
| 178 | 0.689 | 0.069 | 0.007 | 0.001 | 1.898 | 4.930 | 21.406 | 1.170 | 22.576 | 2.598 | 9.769 |
| 164 | 1.009 | 0.139 | 0.020 | 0.002 | 2.652 | 6.989 | 31.019 | 1.470 | 32.489 | 2.636 | 14.067 |
| 159 | 1.121 | 0.166 | 0.026 | 0.003 | 2.878 | 7.618 | 34.173 | 1.491 | 35.663 | 2.647 | 15.496 |
| 155 | 1.233 | 0.195 | 0.032 | 0.004 | 3.104 | 8.252 | 37.357 | 1.512 | 38.869 | 2.659 | 16.929 |
| 138 | 1.765 | 0.384 | 0.086 | 0.014 | 4.288 | 11.593 | 53.174 | 1.872 | 55.047 | 2.704 | 23.701 |
| 128 | 2.136 | 0.563 | 0.152 | 0.025 | 5.145 | 14.048 | 64.355 | 2.222 | 66.577 | 2.730 | 28.221 |
| 118 | 2.553 | 0.806 | 0.261 | 0.045 | 6.098 | 16.809 | 76.774 | 2.605 | 79.379 | 2.757 | 33.039 |
| 108 | 3.078 | 1.126 | 0.421 | 0.081 | 7.157 | 19.920 | 91.428 | 2.749 | 94.178 | 2.783 | 38.736 |
| 98 | 3.690 | 1.623 | 0.729 | 0.147 | 8.503 | 23.892 | 108.600 | 3.251 | 111.852 | 2.810 | 44.721 |
| 88 | 4.563 | 2.397 | 1.280 | 0.282 | 10.261 | 29.103 | 131.329 | 3.606 | 134.935 | 2.836 | 52.394 |
| 80 | 5.379 | 3.358 | 2.129 | 0.485 | 12.015 | 34.331 | 151.808 | 4.392 | 156.200 | 2.857 | 58.104 |
| 68 | 6.837 | 5.261 | 4.099 | 1.008 | 14.945 | 43.178 | 186.291 | 5.554 | 191.845 | 2.889 | 67.096 |
| 58 | 8.956 | 9.033 | 9.208 | 2.390 | 19.312 | 56.307 | 229.510 | 8.745 | 238.255 | 2.916 | 74.083 |
| 48 | 13.616 | 20.735 | 31.818 | 8.886 | 28.762 | 84.622 | 304.308 | 22.186 | 326.493 | 2.942 | 77.523 |
| 22 | 13.591 | 21.228 | 33.422 | 9.248 | 28.869 | 86.924 | 319.341 | 23.592 | 342.933 | 3.011 | 81.204 |
| 19 | 11.836 | 16.272 | 22.575 | 6.083 | 25.357 | 76.351 | 293.670 | 17.263 | 310.932 | 3.011 | 81.039 |
| 0 | 9.507 | 10.712 | 12.202 | 3.130 | 20.218 | 43.470 | 113.638 | 8.115 | 121.753 | 2.150 | 28.294 |

SPAR STRESSING

| | | |
|---|---|---|
| $F_{CU\ BOOM}$ = | 116000 | psi |
| $F_{CU\ 45\ SHEAR\ WEB}$ = | 15800 | psi |
| $F_{SU\ SHEAR\ WEB}$ = | 6500 | psi |

| 1 | 136 | 137 | 138 | 139 | 140 | 141 | 142 | 143 | 144 | 145 |
|---|---|---|---|---|---|---|---|---|---|---|
| STATION (in) | CALCULATED MOI ABT NA | TEST FACTORED ULT MOMENT (lb in) | QUICK BENDING STRESS CHECK AT EXTREME FIBRE (psi) | COMPRESSIVE BENDING STRESS ON BOOM CENTROID (psi) | RF BENDING | COMPRESSIVE BENDING STRESS ON BOOM INNER FIBRE (psi) | RF BENDING | COMPRESSIVE BENDING STRESS ON BOOM OUTER FIBRE (psi) | RF BENDING | ULT STRAIN |
| 258 | 0.607 | 0 | 0 | 0 | - | 0 | - | 0 | - | 0.000 |
| 251 | 0.619 | 337 | 7260 | 7200 | 16.11 | 7200 | 16.11 | 7200 | 16.11 | 0.001 |
| 238 | 0.643 | 3248 | 68443 | 67882 | 1.71 | 67882 | 1.71 | 67882 | 1.71 | 0.007 |
| 228 | 1.379 | 7612 | 75592 | 74826 | 1.55 | 74673 | 1.55 | 74979 | 1.55 | 0.007 |
| 218 | 2.222 | 13948 | 86905 | 85563 | 1.36 | 85266 | 1.36 | 85859 | 1.35 | 0.009 |
| 208 | 3.568 | 22320 | 87520 | 85870 | 1.35 | 85261 | 1.36 | 86478 | 1.34 | 0.009 |
| 198 | 5.262 | 32782 | 88081 | 85762 | 1.35 | 84828 | 1.37 | 86697 | 1.34 | 0.009 |
| 188 | 7.273 | 45370 | 89119 | 86034 | 1.35 | 84683 | 1.37 | 87386 | 1.33 | 0.009 |
| 178 | 9.769 | 60111 | 88806 | 85183 | 1.36 | 83269 | 1.39 | 87097 | 1.33 | 0.009 |
| 164 | 14.067 | 85243 | 88740 | 83859 | 1.38 | 80997 | 1.43 | 86720 | 1.34 | 0.009 |
| 159 | 15.496 | 93686 | 88918 | 83712 | 1.39 | 80521 | 1.44 | 86903 | 1.33 | 0.009 |
| 155 | 16.929 | 102401 | 89347 | 83803 | 1.38 | 80274 | 1.45 | 87331 | 1.33 | 0.009 |
| 138 | 23.701 | 140840 | 89261 | 81833 | 1.42 | 76716 | 1.51 | 86950 | 1.33 | 0.009 |
| 128 | 28.221 | 166767 | 89635 | 80705 | 1.44 | 74402 | 1.56 | 87009 | 1.33 | 0.009 |
| 118 | 33.039 | 195043 | 90413 | 79754 | 1.45 | 72047 | 1.61 | 87461 | 1.33 | 0.009 |
| 108 | 38.736 | 225701 | 90095 | 77956 | 1.49 | 68730 | 1.69 | 87182 | 1.33 | 0.009 |
| 98 | 44.721 | 258775 | 90323 | 75857 | 1.53 | 64606 | 1.80 | 87108 | 1.33 | 0.009 |
| 88 | 52.394 | 294286 | 88503 | 71809 | 1.62 | 58235 | 1.99 | 85383 | 1.36 | 0.009 |
| 80 | 58.104 | 324402 | 88629 | 68933 | 1.68 | 52649 | 2.20 | 85217 | 1.36 | 0.009 |
| 68 | 67.096 | 372534 | 89120 | 65060 | 1.78 | 44393 | 2.61 | 85727 | 1.35 | 0.009 |
| 58 | 74.083 | 415438 | 90835 | 59058 | 1.96 | 31019 | 3.74 | 87097 | 1.33 | 0.009 |
| 48 | 77.523 | 460817 | 97160 | 46469 | 2.50 | 71 | 1638.31 | 92867 | 1.25 | 0.009 |
| 22 | 81.204 | 592104 | 121972 | 58170 | 1.99 | 41 | 2863.59 | 116300 | 1.00 | 0.012 |
| 19 | 81.039 | 608501 | 125605 | 67704 | 1.71 | 15643 | 7.42 | 119765 | 0.97 | 0.012 |
| 0 | 28.294 | 718675 | 303396 | 142525 | 0.81 | 1411 | 82.20 | 283640 | 0.41 | 0.028 |

| SPAR STRESSING | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | | | | | |
| 1 | 146 | 147 | 148 | 149 | 150 | 151 | 152 |
| | COMPRESSIVE BENDING STRESS ON GLASS CENTROID (psi) | | COMPRESSIVE BENDING STRESS ON GLASS INNER FIBRE (psi) | RF BENDING | COMPRESSIVE BENDING STRESS ON GLASS OUTER FIBRE (psi) | RF BENDING | ULT STRAIN |
| STATION (in) | | | | | | | |
| 258 | 0 | - | 0 | - | 0 | - | 0.000 |
| 251 | 1301 | 12.14 | 1296 | 12.19 | 1307 | 12.09 | 0.001 |
| 238 | 12269 | 1.29 | 12219 | 1.29 | 12320 | 1.28 | 0.007 |
| 228 | 13551 | 1.17 | 13496 | 1.17 | 13607 | 1.16 | 0.008 |
| 218 | 15549 | 1.02 | 15455 | 1.02 | 15643 | 1.01 | 0.009 |
| 208 | 15660 | 1.01 | 15566 | 1.02 | 15754 | 1.00 | 0.009 |
| 198 | 15730 | 1.00 | 15605 | 1.01 | 15855 | 1.00 | 0.009 |
| 188 | 15885 | 0.99 | 15729 | 1.00 | 16041 | 0.98 | 0.009 |
| 178 | 15831 | 1.00 | 15677 | 1.01 | 15985 | 0.99 | 0.009 |
| 164 | 15791 | 1.00 | 15610 | 1.01 | 15973 | 0.99 | 0.009 |
| 159 | 15824 | 1.00 | 15643 | 1.01 | 16005 | 0.99 | 0.009 |
| 155 | 15901 | 0.99 | 15720 | 1.01 | 16083 | 0.98 | 0.009 |
| 138 | 15859 | 1.00 | 15651 | 1.01 | 16067 | 0.98 | 0.009 |
| 128 | 15898 | 0.99 | 15662 | 1.01 | 16134 | 0.98 | 0.009 |
| 118 | 16009 | 0.99 | 15743 | 1.00 | 16274 | 0.97 | 0.009 |
| 108 | 15955 | 0.99 | 15693 | 1.01 | 16217 | 0.97 | 0.009 |
| 98 | 15969 | 0.99 | 15679 | 1.01 | 16258 | 0.97 | 0.009 |
| 88 | 15650 | 1.01 | 15369 | 1.03 | 15931 | 0.99 | 0.009 |
| 80 | 15646 | 1.01 | 15339 | 1.03 | 15953 | 0.99 | 0.009 |
| 68 | 15736 | 1.00 | 15431 | 1.02 | 16042 | 0.98 | 0.009 |
| 58 | 16014 | 0.99 | 15677 | 1.01 | 16350 | 0.97 | 0.009 |
| 48 | 17102 | 0.92 | 16716 | 0.95 | 17489 | 0.90 | 0.010 |
| 22 | 21444 | 0.74 | 20934 | 0.75 | 21955 | 0.72 | 0.012 |
| 19 | 22083 | 0.72 | 21558 | 0.73 | 22609 | 0.70 | 0.013 |
| 0 | 52833 | 0.30 | 51055 | 0.31 | 54611 | 0.29 | 0.030 |

| SPAR STRESSING | | | | | | |
|---|---|---|---|---|---|---|
| 1 | 153 | 154 | 155 | 156 | 157 | 158 |
| | WEB | | BOOM | | GLASS | |
| | COMPRESSIVE | | COMPRESSIVE | | COMPRESSIVE | |
| STATION (in) | LOAD DUE TO BENDING (lb) | SHEAR STRESS (psi) | LOAD DUE TO BENDING (lb) | SHEAR STRESS (psi) | LOAD DUE TO BENDING (lb) | SHEAR STRESS (psi) |
| 258 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 251 | 346.15 | 1282.05 | 0.00 | 0.00 | 28.24 | 3.86 |
| 238 | 3311.23 | 5594.47 | 0.00 | 0.00 | 266.24 | 16.56 |
| 228 | 3682.03 | 927.00 | 405.93 | 37.41 | 294.07 | 2.56 |
| 218 | 6374.34 | 4487.19 | 774.56 | 34.61 | 496.78 | 19.03 |
| 208 | 6441.71 | 112.29 | 1600.39 | 77.54 | 500.33 | 0.33 |
| 198 | 8635.11 | 2741.75 | 2419.78 | 78.41 | 657.51 | 15.04 |
| 188 | 10887.58 | 2252.46 | 3439.22 | 99.46 | 814.13 | 15.28 |
| 178 | 10816.02 | -71.56 | 4889.50 | 141.49 | 811.36 | -0.27 |
| 164 | 12809.82 | 1157.84 | 7163.62 | 157.69 | 952.22 | 9.77 |
| 159 | 12789.97 | -38.26 | 7992.43 | 190.68 | 954.18 | 0.45 |
| 155 | 12805.84 | 30.58 | 8843.26 | 195.75 | 958.83 | 1.07 |
| 138 | 14519.74 | 720.12 | 12493.88 | 218.01 | 1093.48 | 8.04 |
| 128 | 16251.03 | 1082.06 | 14953.06 | 254.84 | 1227.32 | 13.87 |
| 118 | 17875.45 | 902.46 | 17711.40 | 291.89 | 1361.54 | 14.20 |
| 108 | 17216.43 | -366.12 | 20995.50 | 347.52 | 1356.96 | -0.48 |
| 98 | 18152.46 | 468.01 | 24558.70 | 385.21 | 1477.11 | 12.99 |
| 88 | 16516.54 | -817.96 | 28893.96 | 468.68 | 1447.60 | -3.19 |
| 80 | 16548.31 | 18.05 | 32751.88 | 532.86 | 1557.58 | 15.19 |
| 68 | 14108.48 | -924.18 | 39448.95 | 616.67 | 1566.53 | 0.82 |
| 58 | 10852.92 | -1356.48 | 47039.58 | 857.70 | 1700.67 | 15.16 |
| 48 | 27.08 | -4163.79 | 56474.92 | 1090.79 | 1923.17 | 25.72 |
| 22 | 17.08 | -1.37 | 70536.01 | 640.01 | 2536.88 | 27.93 |
| 19 | 6594.24 | 7829.96 | 71397.78 | 339.95 | 2612.45 | 29.81 |
| 0 | 424.75 | -1159.68 | 120434.00 | 3054.26 | 6250.17 | 226.58 |

| SPAR STRESSING | | | | | | |
|---|---|---|---|---|---|---|
| 1 | 158 | 159 | 160 | 161 | 162 | 163 |
| | | | | 3/2(V/A) | | |
| | | | | MAX SHEAR | | |
| | CALCULATED | TEST FACTORED | SHEAR WEB | STRESS | RF | ULT |
| STATION | MOI | ULT SHEAR | AREA | INTRA | SHEAR | STRAIN |
| (in) | ABT NA | (lb) | (in2) | AT NA | | |
| | | | | (psi) | | |
| 258 | 0.607 | 0 | 0.191 | 0.00 | 0.00 | 0.000 |
| 251 | 0.619 | 100 | 0.192 | 777.90 | 8.36 | 0.000 |
| 238 | 0.643 | 340 | 0.195 | 2611.30 | 2.49 | 0.001 |
| 228 | 1.379 | 533 | 0.197 | 4055.42 | 1.60 | 0.002 |
| 218 | 2.222 | 734 | 0.299 | 3681.26 | 1.77 | 0.002 |
| 208 | 3.568 | 940 | 0.302 | 4668.11 | 1.39 | 0.003 |
| 198 | 5.262 | 1152 | 0.407 | 4243.28 | 1.53 | 0.002 |
| 188 | 7.273 | 1366 | 0.514 | 3983.72 | 1.63 | 0.002 |
| 178 | 9.769 | 1582 | 0.520 | 4568.50 | 1.42 | 0.003 |
| 164 | 14.067 | 1920 | 0.633 | 4553.25 | 1.43 | 0.003 |
| 159 | 15.496 | 1984 | 0.635 | 4683.60 | 1.39 | 0.003 |
| 155 | 16.929 | 2046 | 0.638 | 4809.98 | 1.35 | 0.003 |
| 138 | 23.701 | 2476 | 0.757 | 4905.96 | 1.32 | 0.003 |
| 128 | 28.221 | 2709 | 0.874 | 4651.54 | 1.40 | 0.003 |
| 118 | 33.039 | 2946 | 0.992 | 4452.30 | 1.46 | 0.002 |
| 108 | 38.736 | 3186 | 1.002 | 4769.34 | 1.36 | 0.003 |
| 98 | 44.721 | 3429 | 1.124 | 4576.50 | 1.42 | 0.003 |
| 88 | 52.394 | 3673 | 1.134 | 4856.79 | 1.34 | 0.003 |
| 80 | 58.104 | 3856 | 1.257 | 4600.03 | 1.41 | 0.003 |
| 68 | 67.096 | 4166 | 1.271 | 4916.21 | 1.32 | 0.003 |
| 58 | 74.083 | 4414 | 1.400 | 4731.20 | 1.37 | 0.003 |
| 48 | 77.523 | 4662 | 1.530 | 4570.52 | 1.42 | 0.003 |
| 22 | 81.204 | 5437 | 1.686 | 4836.98 | 1.34 | 0.003 |
| 19 | 81.039 | 5494 | 1.686 | 4887.67 | 1.33 | 0.003 |
| 0 | 28.294 | 6103 | 1.204 | 7603.39 | 0.85 | 0.004 |
| | | | (Both webs) | | | |
| | | | | | | |
| Fatigue allow = 58000 psi at test factored limit ≅ Ftu/2 from JAR-VLA ACJ-572 | | | | | | |
| Maximum permissible stress level at test factored ultimate loads = 58000*1.5 = 87000 psi to avoid fatigue | | | | | | |
| This suggests an acceptable RF to avoid fatigue of 116000/87000 = 1.33 | | | | | | |

| 1 | 164 | 165 | 166 | 167 | 168 | 169 |
|---|---|---|---|---|---|---|
| | | | | | | |
| | MAX SHEAR | | MAX SHEAR | | MAX SHEAR | |
| | STRESS | | STRESS | | STRESS | |
| | INTRA | RF | BTWN CORE | RF | BTWN BOOM | RF |
| STATION | AT NA | SHEAR | AND BOOM | SHEAR | AND GLASS | SHEAR |
| (in) | CHECK | | (psi) | | (psi) | |
| | (psi) | | | | | |
| 258.00 | 0.00 | - | 0.00 | - | 0.00 | - |
| 251.25 | 1140.89 | 5.70 | 15.46 | 420.54 | 15.46 | 420.54 |
| 238.00 | 3841.70 | 1.69 | 51.44 | 126.37 | 51.44 | 126.37 |
| 228.00 | 4303.43 | 1.51 | 143.42 | 45.32 | 38.05 | 170.83 |
| 218.00 | 3869.08 | 1.68 | 203.50 | 31.94 | 49.24 | 132.02 |
| 208.00 | 4316.35 | 1.51 | 295.43 | 22.00 | 39.71 | 163.68 |
| 198.00 | 3891.92 | 1.67 | 374.25 | 17.37 | 44.39 | 146.42 |
| 188.00 | 3634.17 | 1.79 | 459.34 | 14.15 | 48.06 | 135.26 |
| 178.00 | 3992.73 | 1.63 | 554.87 | 11.71 | 41.88 | 155.21 |
| 163.65 | 3975.43 | 1.64 | 703.92 | 9.23 | 42.93 | 151.40 |
| 159.33 | 4063.67 | 1.60 | 734.99 | 8.84 | 40.44 | 160.73 |
| 155.00 | 4155.89 | 1.56 | 764.92 | 8.50 | 38.35 | 169.51 |
| 138.00 | 4325.57 | 1.50 | 971.76 | 6.69 | 39.29 | 165.44 |
| 128.00 | 4214.76 | 1.54 | 1104.31 | 5.89 | 41.63 | 156.13 |
| 118.00 | 4163.14 | 1.56 | 1251.80 | 5.19 | 43.88 | 148.13 |
| 108.00 | 4550.87 | 1.43 | 1392.96 | 4.67 | 40.87 | 159.04 |
| 98.00 | 4579.78 | 1.42 | 1584.13 | 4.10 | 42.70 | 152.21 |
| 88.00 | 5100.98 | 1.27 | 1780.31 | 3.65 | 39.42 | 164.90 |
| 80.00 | 5177.49 | 1.26 | 2007.62 | 3.24 | 41.31 | 157.34 |
| 68.00 | 6093.72 | 1.07 | 2349.73 | 2.77 | 39.09 | 166.26 |
| 58.00 | 6989.77 | 0.93 | 2908.13 | 2.24 | 41.27 | 157.51 |
| 48.00 | 9785.66 | 0.66 | 4128.33 | 1.57 | 45.49 | 142.89 |
| 22.00 | 10393.37 | 0.63 | 4803.47 | 1.35 | 55.79 | 116.50 |
| 19.00 | 9243.65 | 0.70 | 4413.05 | 1.47 | 56.49 | 115.06 |
| 0.00 | 16743.66 | 0.39 | 7701.27 | 0.84 | 127.74 | 50.89 |
| | | | ignoring contribution from s web | | | |

SPAR WEIGHT ESTIMATE

| 1 | 3 | 170 | 171 | 172 | 173 | 174 | 175 | 176 | |
|---|---|---|---|---|---|---|---|---|---|
| | | 0.055 | 0.076 | | | | | | |
| | dy | TOTAL | SHEAR | GLASS | TOTAL | BOOM + WEB | XTRAS | SPAR TOTAL | |
| STATION | (in) | BOOM WEIGHT | WEB WEIGHT | CAP WEIGHT | WEB WEIGHT | TOTAL WEIGH | 0.10 | WEIGHT EST | |
| (in) | | (lb) | (lb) | (lb) | (lb) | (lb) | (lb) | (lb) | |
| 258 | 6.75 | 0.000 | 0.098 | 0.011 | 0.109 | 0.109 | 0.011 | 0.120 | |
| 251 | 13.25 | 0.000 | 0.194 | 0.022 | 0.216 | 0.216 | 0.022 | 0.237 | |
| 238 | 10.00 | 0.000 | 0.148 | 0.016 | 0.165 | 0.165 | 0.016 | 0.181 | |
| 228 | 10.00 | 0.012 | 0.150 | 0.016 | 0.166 | 0.178 | 0.018 | 0.196 | |
| 218 | 10.00 | 0.020 | 0.227 | 0.024 | 0.252 | 0.271 | 0.027 | 0.299 | |
| 208 | 10.00 | 0.041 | 0.230 | 0.024 | 0.254 | 0.295 | 0.029 | 0.324 | |
| 198 | 10.00 | 0.062 | 0.309 | 0.032 | 0.341 | 0.403 | 0.040 | 0.444 | |
| 188 | 10.00 | 0.088 | 0.391 | 0.039 | 0.430 | 0.518 | 0.052 | 0.570 | |
| 178 | 14.35 | 0.181 | 0.567 | 0.056 | 0.623 | 0.804 | 0.080 | 0.884 | |
| 164 | 4.33 | 0.081 | 0.208 | 0.020 | 0.228 | 0.309 | 0.031 | 0.340 | |
| 159 | 4.32 | 0.091 | 0.209 | 0.020 | 0.229 | 0.320 | 0.032 | 0.351 | |
| 155 | 17.00 | 0.395 | 0.824 | 0.078 | 0.902 | 1.297 | 0.130 | 1.427 | |
| 138 | 10.00 | 0.336 | 0.575 | 0.052 | 0.628 | 0.964 | 0.096 | 1.060 | |
| 128 | 10.00 | 0.408 | 0.664 | 0.059 | 0.723 | 1.130 | 0.113 | 1.243 | |
| 118 | 10.00 | 0.489 | 0.754 | 0.065 | 0.819 | 1.307 | 0.131 | 1.438 | |
| 108 | 10.00 | 0.593 | 0.761 | 0.065 | 0.826 | 1.419 | 0.142 | 1.561 | |
| 98 | 10.00 | 0.712 | 0.854 | 0.070 | 0.924 | 1.637 | 0.164 | 1.800 | |
| 88 | 8.00 | 0.708 | 0.690 | 0.056 | 0.746 | 1.454 | 0.145 | 1.600 | |
| 80 | 12.00 | 1.254 | 1.147 | 0.091 | 1.237 | 2.492 | 0.249 | 2.741 | |
| 68 | 10.00 | 1.334 | 0.966 | 0.076 | 1.042 | 2.376 | 0.238 | 2.613 | |
| 58 | 10.00 | 1.752 | 1.064 | 0.081 | 1.144 | 2.897 | 0.290 | 3.186 | |
| 48 | 26.00 | 6.952 | 3.023 | 0.222 | 3.245 | 10.197 | 1.020 | 11.217 | |
| 22 | 3.00 | 0.800 | 0.384 | 0.027 | 0.411 | 1.212 | 0.121 | 1.333 | |
| 19 | 19.00 | 4.408 | 2.435 | 0.171 | 2.606 | 7.014 | 0.701 | 7.715 | |
| 0 | Σ= | 20.717 | 16.873 | 1.393 | 18.265 | 38.982 | Σ= | 42.880 | |
| | Σ= | 9.400 | 7.655 | kg | | | 3.90 | 94.508 | kg |
| | | | | | | (PLY+FOAM+BELLCRANKS) | | | |

SPAR BENDING STRENGTH

MOST UNFAVOURABLE LOADS EXPERIENCED BY WING SPAR

CARBON SHEAR WEBS

| 1 | 44C | 45C | 76 | 77 | 78 | 79 | 80 | 81 | 82 | 83 | 84 | 85 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | NORMAL | NORMAL | | 1.125 | | 0.010 | TOTAL | | | | SINGLE | |
| STATION | ULT SHEAR | ULT BEND MOM | SPAR DEPTH | SPAR WIDTH | O SHEAR WE | SPAR WEB | SHEAR WEB | CAP WEB | SPAR BOOM | SPAR BOOM | SPAR BOOM | GAP SIZE |
| (in) | COND. C | COND. C | (in) | (in) | PLIES/SIDE | WIDTH | AREA | AREA | WIDTH | DEPTH | AREA | (in) |
| | (lb) | (lb in) | | | | (in) | ($in^2$) | ($in^2$) | (in) | (in) | ($in^2$) | |
| | COND. C | COND. C | | | | | | | | | | |
| 258 | 0 | 0 | 4.772 | 1.125 | 2 | 0.020 | 0.191 | 0.022 | 1.085 | 0.000 | 0.000 | 4.732 |
| 251 | 66 | 224 | 4.808 | 1.125 | 2 | 0.020 | 0.192 | 0.022 | 1.085 | 0.000 | 0.000 | 4.768 |
| 238 | 226 | 2165 | 4.878 | 1.125 | 2 | 0.020 | 0.195 | 0.022 | 1.085 | 0.000 | 0.000 | 4.838 |
| 228 | 355 | 5075 | 4.931 | 1.125 | 2 | 0.020 | 0.197 | 0.022 | 1.085 | 0.000 | 0.000 | 4.891 |
| 218 | 489 | 9299 | 4.984 | 1.125 | 2 | 0.020 | 0.199 | 0.022 | 1.085 | 0.010 | 0.011 | 4.924 |
| 208 | 627 | 14880 | 5.037 | 1.125 | 2 | 0.020 | 0.201 | 0.022 | 1.085 | 0.022 | 0.024 | 4.953 |
| 198 | 768 | 21854 | 5.090 | 1.125 | 2 | 0.020 | 0.204 | 0.022 | 1.085 | 0.045 | 0.049 | 4.960 |
| 188 | 911 | 30247 | 5.143 | 1.125 | 2 | 0.020 | 0.206 | 0.022 | 1.085 | 0.072 | 0.078 | 4.959 |
| 178 | 1055 | 40074 | 5.196 | 1.125 | 2 | 0.020 | 0.208 | 0.022 | 1.085 | 0.103 | 0.112 | 4.950 |
| 164 | 1280 | 56829 | 5.272 | 1.125 | 3 | 0.030 | 0.316 | 0.032 | 1.065 | 0.147 | 0.157 | 4.918 |
| 159 | 1323 | 62457 | 5.295 | 1.125 | 3 | 0.030 | 0.318 | 0.032 | 1.065 | 0.167 | 0.178 | 4.901 |
| 155 | 1364 | 68267 | 5.318 | 1.125 | 3 | 0.030 | 0.319 | 0.032 | 1.065 | 0.182 | 0.194 | 4.894 |
| 138 | 1651 | 93894 | 5.408 | 1.125 | 3 | 0.030 | 0.324 | 0.032 | 1.065 | 0.270 | 0.288 | 4.808 |
| 128 | 1806 | 111178 | 5.461 | 1.125 | 3 | 0.030 | 0.328 | 0.032 | 1.065 | 0.330 | 0.351 | 4.741 |
| 118 | 1964 | 130028 | 5.514 | 1.125 | 4 | 0.040 | 0.441 | 0.042 | 1.045 | 0.400 | 0.418 | 4.634 |
| 108 | 2124 | 150467 | 5.566 | 1.125 | 4 | 0.040 | 0.445 | 0.042 | 1.045 | 0.470 | 0.491 | 4.546 |
| 98 | 2286 | 172516 | 5.619 | 1.125 | 4 | 0.040 | 0.450 | 0.042 | 1.045 | 0.560 | 0.585 | 4.419 |
| 88 | 2449 | 196191 | 5.672 | 1.125 | 4 | 0.040 | 0.454 | 0.042 | 1.045 | 0.670 | 0.700 | 4.252 |
| 80 | 2570 | 216268 | 5.715 | 1.125 | 4 | 0.040 | 0.457 | 0.042 | 1.045 | 0.760 | 0.794 | 4.115 |
| 68 | 2778 | 248356 | 5.778 | 1.125 | 5 | 0.050 | 0.578 | 0.051 | 1.025 | 0.950 | 0.974 | 3.778 |
| 58 | 2943 | 276958 | 5.831 | 1.125 | 5 | 0.050 | 0.583 | 0.051 | 1.025 | 1.200 | 1.230 | 3.331 |
| 48 | 3108 | 307212 | 5.884 | 1.125 | 5 | 0.050 | 0.588 | 0.051 | 1.025 | 1.500 | 1.538 | 2.784 |
| 22 | 3625 | 394736 | 6.022 | 1.125 | 6 | 0.060 | 0.723 | 0.060 | 1.005 | 2.870 | 2.884 | 0.162 |
| 19 | 3663 | 405667 | 6.022 | 1.125 | 6 | 0.060 | 0.723 | 0.060 | 1.005 | 2.496 | 2.508 | 0.910 |
| 0 | 4069 | 479117 | 4.300 | 1.125 | 6 | 0.060 | 0.516 | 0.060 | 1.005 | 2.000 | 2.010 | 0.180 |

| SPAR MOMENT OF INERTIA | TRANSFORMATION | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $E_{BOOM}$ = | 10000000 | psi | | | | | | | | | | | | |
| $E_{SHEAR\ WEB}$ = | 5000000 | psi | | | | | | | | | | | | |
| $E_2 / E_1$ = | 2.00 | | | | | | | | | | | | | |
| 1 | 86 | 87 | 88 | 89 | 90 | 91 | 92 | 93 | 94 | 95 | 96 | 97 | 98 | 99 |
| COMPRESSION | | | | | | | | | | | | | | |
| | 5000000 | | | | | | | 5000000 | | | | | | |
| STATION | SHEAR WEB | SHEAR WEB | SHEAR WEB | | | | | CARBON CAP | CARBON CAP | CARBON CAP | | | | |
| (in) | TRANSFORMED | DEPTH | TRANSFORMED | Y | AY | $AY^2$ | Io | TRANSFORMED | DEPTH | TRANSFORMED | Y | AY | $AY^2$ | Io |
| | WIDTH | (in) | AREA | | | | | WIDTH | (in) | AREA | | | | |
| | (in) | | (in2) | | | | | (in) | | (in2) | | | | |
| 258 | 0.040 | 4.772 | 0.191 | 2.386 | 0.455 | 1.08668 | 0.36223 | 1.085 | 0.020 | 0.022 | 4.762 | 0.103 | 0.49208 | 0.00000 |
| 251 | 0.040 | 4.808 | 0.192 | 2.404 | 0.462 | 1.11129 | 0.37043 | 1.085 | 0.020 | 0.022 | 4.798 | 0.104 | 0.49950 | 0.00000 |
| 238 | 0.040 | 4.878 | 0.195 | 2.439 | 0.476 | 1.16067 | 0.38689 | 1.085 | 0.020 | 0.022 | 4.868 | 0.106 | 0.51422 | 0.00000 |
| 228 | 0.040 | 4.931 | 0.197 | 2.465 | 0.486 | 1.19889 | 0.39963 | 1.085 | 0.020 | 0.022 | 4.921 | 0.107 | 0.52547 | 0.00000 |
| 218 | 0.040 | 4.984 | 0.199 | 2.492 | 0.497 | 1.23794 | 0.41265 | 1.085 | 0.020 | 0.022 | 4.974 | 0.108 | 0.53684 | 0.00000 |
| 208 | 0.040 | 5.037 | 0.201 | 2.518 | 0.507 | 1.27783 | 0.42594 | 1.085 | 0.020 | 0.022 | 5.027 | 0.109 | 0.54834 | 0.00000 |
| 198 | 0.040 | 5.090 | 0.204 | 2.545 | 0.518 | 1.31856 | 0.43952 | 1.085 | 0.020 | 0.022 | 5.080 | 0.110 | 0.55995 | 0.00000 |
| 188 | 0.040 | 5.143 | 0.206 | 2.571 | 0.529 | 1.36016 | 0.45339 | 1.085 | 0.020 | 0.022 | 5.133 | 0.111 | 0.57169 | 0.00000 |
| 178 | 0.040 | 5.196 | 0.208 | 2.598 | 0.540 | 1.40262 | 0.46754 | 1.085 | 0.020 | 0.022 | 5.186 | 0.113 | 0.58355 | 0.00000 |
| 164 | 0.060 | 5.272 | 0.316 | 2.636 | 0.834 | 2.19762 | 0.73254 | 1.065 | 0.030 | 0.032 | 5.257 | 0.168 | 0.88288 | 0.00000 |
| 159 | 0.060 | 5.295 | 0.318 | 2.647 | 0.841 | 2.22639 | 0.74213 | 1.065 | 0.030 | 0.032 | 5.280 | 0.169 | 0.89059 | 0.00000 |
| 155 | 0.060 | 5.318 | 0.319 | 2.659 | 0.848 | 2.25541 | 0.75180 | 1.065 | 0.030 | 0.032 | 5.303 | 0.169 | 0.89834 | 0.00000 |
| 138 | 0.060 | 5.408 | 0.324 | 2.704 | 0.877 | 2.37194 | 0.79065 | 1.065 | 0.030 | 0.032 | 5.393 | 0.172 | 0.92911 | 0.00000 |
| 128 | 0.060 | 5.461 | 0.328 | 2.730 | 0.895 | 2.44232 | 0.81411 | 1.065 | 0.030 | 0.032 | 5.446 | 0.174 | 0.94745 | 0.00000 |
| 118 | 0.080 | 5.514 | 0.441 | 2.757 | 1.216 | 3.35211 | 1.11737 | 1.045 | 0.040 | 0.042 | 5.494 | 0.230 | 1.26147 | 0.00001 |
| 108 | 0.080 | 5.566 | 0.445 | 2.783 | 1.239 | 3.44965 | 1.14988 | 1.045 | 0.040 | 0.042 | 5.546 | 0.232 | 1.28592 | 0.00001 |
| 98 | 0.080 | 5.619 | 0.450 | 2.810 | 1.263 | 3.54906 | 1.18302 | 1.045 | 0.040 | 0.042 | 5.599 | 0.234 | 1.31059 | 0.00001 |
| 88 | 0.080 | 5.672 | 0.454 | 2.836 | 1.287 | 3.65036 | 1.21679 | 1.045 | 0.040 | 0.042 | 5.652 | 0.236 | 1.33551 | 0.00001 |
| 80 | 0.080 | 5.715 | 0.457 | 2.857 | 1.306 | 3.73278 | 1.24426 | 1.045 | 0.040 | 0.042 | 5.695 | 0.238 | 1.35560 | 0.00001 |
| 68 | 0.100 | 5.778 | 0.578 | 2.889 | 1.669 | 4.82340 | 1.60780 | 1.025 | 0.050 | 0.051 | 5.753 | 0.295 | 1.69643 | 0.00001 |
| 58 | 0.100 | 5.831 | 0.583 | 2.916 | 1.700 | 4.95725 | 1.65242 | 1.025 | 0.050 | 0.051 | 5.806 | 0.298 | 1.72781 | 0.00001 |
| 48 | 0.100 | 5.884 | 0.588 | 2.942 | 1.731 | 5.09356 | 1.69785 | 1.025 | 0.050 | 0.051 | 5.859 | 0.300 | 1.75948 | 0.00001 |
| 22 | 0.120 | 6.022 | 0.723 | 3.011 | 2.176 | 6.55154 | 2.18385 | 1.005 | 0.060 | 0.060 | 5.992 | 0.361 | 2.16502 | 0.00002 |
| 19 | 0.120 | 6.022 | 0.723 | 3.011 | 2.176 | 6.55154 | 2.18385 | 1.005 | 0.060 | 0.060 | 5.992 | 0.361 | 2.16502 | 0.00002 |
| 0 | 0.120 | 4.300 | 0.516 | 2.150 | 1.109 | 2.38521 | 0.79507 | 1.005 | 0.060 | 0.060 | 4.270 | 0.257 | 1.09944 | 0.00002 |

| SPAR MOMENT OF INERTIA TRANSFORMATION | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 100 | 101 | 102 | 103 | 104 | 105 | 106 | 107 | 108 | 109 | 110 |
| COMPRESSION | | | | | | | | | | | |
| | 10000000 | | | | | | | | | | |
| STATION (in) | SPAR BOOM TRANSFORMED WIDTH (in) | SPAR BOOM DEPTH (in) | SPAR BOOM TRANSFORMED AREA (in2) | Y | AY | $AY^2$ | Io | ΣA | ΣAY | $\Sigma AY^2$ | ΣIo |
| 258 | 2.170 | 0.000 | 0.000 | 4.752 | 0.000 | 0.00000 | 0.00000 | 0.213 | 0.559 | 1.579 | 0.362 |
| 251 | 2.170 | 0.000 | 0.000 | 4.788 | 0.000 | 0.00000 | 0.00000 | 0.214 | 0.566 | 1.611 | 0.370 |
| 238 | 2.170 | 0.000 | 0.000 | 4.858 | 0.000 | 0.00000 | 0.00000 | 0.217 | 0.582 | 1.675 | 0.387 |
| 228 | 2.170 | 0.000 | 0.000 | 4.911 | 0.000 | 0.00000 | 0.00000 | 0.219 | 0.593 | 1.724 | 0.400 |
| 218 | 2.170 | 0.010 | 0.022 | 4.959 | 0.108 | 0.53361 | 0.00000 | 0.243 | 0.712 | 2.308 | 0.413 |
| 208 | 2.170 | 0.022 | 0.048 | 5.006 | 0.239 | 1.19629 | 0.00000 | 0.271 | 0.855 | 3.022 | 0.426 |
| 198 | 2.170 | 0.045 | 0.098 | 5.047 | 0.493 | 2.48765 | 0.00002 | 0.323 | 1.121 | 4.366 | 0.440 |
| 188 | 2.170 | 0.072 | 0.156 | 5.087 | 0.795 | 4.04273 | 0.00007 | 0.384 | 1.435 | 5.975 | 0.453 |
| 178 | 2.170 | 0.103 | 0.224 | 5.124 | 1.145 | 5.86886 | 0.00020 | 0.453 | 1.798 | 7.855 | 0.468 |
| 164 | 2.130 | 0.147 | 0.313 | 5.168 | 1.618 | 8.36337 | 0.00056 | 0.661 | 2.620 | 11.444 | 0.733 |
| 159 | 2.130 | 0.167 | 0.356 | 5.181 | 1.843 | 9.54877 | 0.00083 | 0.705 | 2.853 | 12.666 | 0.743 |
| 155 | 2.130 | 0.182 | 0.388 | 5.197 | 2.014 | 10.46843 | 0.00107 | 0.739 | 3.032 | 13.622 | 0.753 |
| 138 | 2.130 | 0.270 | 0.575 | 5.243 | 3.015 | 15.80650 | 0.00349 | 0.932 | 4.065 | 19.108 | 0.794 |
| 128 | 2.130 | 0.330 | 0.703 | 5.266 | 3.701 | 19.48869 | 0.00638 | 1.062 | 4.770 | 22.878 | 0.820 |
| 118 | 2.090 | 0.400 | 0.836 | 5.274 | 4.409 | 23.24922 | 0.01115 | 1.319 | 5.854 | 27.863 | 1.129 |
| 108 | 2.090 | 0.470 | 0.982 | 5.291 | 5.198 | 27.50428 | 0.01808 | 1.469 | 6.669 | 32.240 | 1.168 |
| 98 | 2.090 | 0.560 | 1.170 | 5.299 | 6.202 | 32.86981 | 0.03059 | 1.662 | 7.700 | 37.729 | 1.214 |
| 88 | 2.090 | 0.670 | 1.400 | 5.297 | 7.418 | 39.29620 | 0.05238 | 1.896 | 8.941 | 44.282 | 1.269 |
| 80 | 2.090 | 0.760 | 1.588 | 5.295 | 8.410 | 44.53059 | 0.07645 | 2.087 | 9.955 | 49.619 | 1.321 |
| 68 | 2.050 | 0.950 | 1.948 | 5.253 | 10.231 | 53.74662 | 0.14647 | 2.577 | 12.195 | 60.266 | 1.754 |
| 58 | 2.050 | 1.200 | 2.460 | 5.181 | 12.746 | 66.04140 | 0.29520 | 3.094 | 14.744 | 72.726 | 1.948 |
| 48 | 2.050 | 1.500 | 3.075 | 5.084 | 15.634 | 79.48871 | 0.57656 | 3.715 | 17.666 | 86.342 | 2.274 |
| 22 | 2.010 | 2.870 | 5.769 | 4.527 | 26.115 | 118.22217 | 3.95968 | 6.552 | 28.652 | 126.939 | 6.144 |
| 19 | 2.010 | 2.496 | 5.017 | 4.714 | 23.650 | 111.48586 | 2.60465 | 5.800 | 26.187 | 120.202 | 4.789 |
| 0 | 2.010 | 2.000 | 4.020 | 3.240 | 13.025 | 42.20035 | 1.34000 | 4.596 | 14.392 | 45.685 | 2.135 |

| TENSION | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 111 | 112 | 113 | 114 | 115 | 116 | 117 | 118 | 119 | 120 | 121 | 122 | 123 | 124 |
| | CARBON CAP | CARBON CA | CARBON CAP | | | | | SPAR BOOM | SPAR BOOM | SPAR BOOM | | | | |
| STATION | TRANSFORMED | DEPTH | TRANSFORMED | Y | AY | AY² | Io | TRANSFORMED | DEPTH | TRANSFORMED | Y | AY | AY² | Io |
| (in) | WIDTH | (in) | AREA | | | | | WIDTH | (in) | AREA | | | | |
| | (in) | | (in2) | | | | | (in) | | (in2) | | | | |
| 258 | 1.085 | 0.020 | 0.022 | 0.010 | 0.000 | 0.00000 | 0.00000 | 2.170 | 0.000 | 0.000 | 0.020 | 0.000 | 0.00000 | 0.00000 |
| 251 | 1.085 | 0.020 | 0.022 | 0.010 | 0.000 | 0.00000 | 0.00000 | 2.170 | 0.000 | 0.000 | 0.020 | 0.000 | 0.00000 | 0.00000 |
| 238 | 1.085 | 0.020 | 0.022 | 0.010 | 0.000 | 0.00000 | 0.00000 | 2.170 | 0.000 | 0.000 | 0.020 | 0.000 | 0.00000 | 0.00000 |
| 228 | 1.085 | 0.020 | 0.022 | 0.010 | 0.000 | 0.00000 | 0.00000 | 2.170 | 0.000 | 0.000 | 0.020 | 0.000 | 0.00000 | 0.00000 |
| 218 | 1.085 | 0.020 | 0.022 | 0.010 | 0.000 | 0.00000 | 0.00000 | 2.170 | 0.010 | 0.022 | 0.025 | 0.001 | 0.00001 | 0.00000 |
| 208 | 1.085 | 0.020 | 0.022 | 0.010 | 0.000 | 0.00000 | 0.00000 | 2.170 | 0.022 | 0.048 | 0.031 | 0.001 | 0.00005 | 0.00000 |
| 198 | 1.085 | 0.020 | 0.022 | 0.010 | 0.000 | 0.00000 | 0.00000 | 2.170 | 0.045 | 0.098 | 0.043 | 0.004 | 0.00018 | 0.00002 |
| 188 | 1.085 | 0.020 | 0.022 | 0.010 | 0.000 | 0.00000 | 0.00000 | 2.170 | 0.072 | 0.156 | 0.056 | 0.009 | 0.00049 | 0.00007 |
| 178 | 1.085 | 0.020 | 0.022 | 0.010 | 0.000 | 0.00000 | 0.00000 | 2.170 | 0.103 | 0.224 | 0.072 | 0.016 | 0.00114 | 0.00020 |
| 164 | 1.065 | 0.030 | 0.032 | 0.015 | 0.000 | 0.00001 | 0.00000 | 2.130 | 0.147 | 0.313 | 0.104 | 0.032 | 0.00335 | 0.00056 |
| 159 | 1.065 | 0.030 | 0.032 | 0.015 | 0.000 | 0.00001 | 0.00000 | 2.130 | 0.167 | 0.356 | 0.114 | 0.040 | 0.00458 | 0.00083 |
| 155 | 1.065 | 0.030 | 0.032 | 0.015 | 0.000 | 0.00001 | 0.00000 | 2.130 | 0.182 | 0.388 | 0.121 | 0.047 | 0.00568 | 0.00107 |
| 138 | 1.065 | 0.030 | 0.032 | 0.015 | 0.000 | 0.00001 | 0.00000 | 2.130 | 0.270 | 0.575 | 0.165 | 0.095 | 0.01566 | 0.00349 |
| 128 | 1.065 | 0.030 | 0.032 | 0.015 | 0.000 | 0.00001 | 0.00000 | 2.130 | 0.330 | 0.703 | 0.195 | 0.137 | 0.02673 | 0.00638 |
| 118 | 1.045 | 0.040 | 0.042 | 0.020 | 0.001 | 0.00002 | 0.00001 | 2.090 | 0.400 | 0.836 | 0.240 | 0.201 | 0.04815 | 0.01115 |
| 108 | 1.045 | 0.040 | 0.042 | 0.020 | 0.001 | 0.00002 | 0.00001 | 2.090 | 0.470 | 0.982 | 0.275 | 0.270 | 0.07429 | 0.01808 |
| 98 | 1.045 | 0.040 | 0.042 | 0.020 | 0.001 | 0.00002 | 0.00001 | 2.090 | 0.560 | 1.170 | 0.320 | 0.375 | 0.11985 | 0.03059 |
| 88 | 1.045 | 0.040 | 0.042 | 0.020 | 0.001 | 0.00002 | 0.00001 | 2.090 | 0.670 | 1.400 | 0.375 | 0.525 | 0.19692 | 0.05238 |
| 80 | 1.045 | 0.040 | 0.042 | 0.020 | 0.001 | 0.00002 | 0.00001 | 2.090 | 0.760 | 1.588 | 0.420 | 0.667 | 0.28019 | 0.07645 |
| 68 | 1.025 | 0.050 | 0.051 | 0.025 | 0.001 | 0.00003 | 0.00001 | 2.050 | 0.950 | 1.948 | 0.525 | 1.022 | 0.53678 | 0.14647 |
| 58 | 1.025 | 0.050 | 0.051 | 0.025 | 0.001 | 0.00003 | 0.00001 | 2.050 | 1.200 | 2.460 | 0.650 | 1.599 | 1.03935 | 0.29520 |
| 48 | 1.025 | 0.050 | 0.051 | 0.025 | 0.001 | 0.00003 | 0.00001 | 2.050 | 1.500 | 3.075 | 0.800 | 2.460 | 1.96800 | 0.57656 |
| 22 | 1.005 | 0.060 | 0.060 | 0.030 | 0.002 | 0.00005 | 0.00002 | 2.010 | 2.870 | 5.769 | 1.495 | 8.624 | 12.89319 | 3.95968 |
| 19 | 1.005 | 0.060 | 0.060 | 0.030 | 0.002 | 0.00005 | 0.00002 | 2.010 | 2.496 | 5.017 | 1.308 | 6.562 | 8.58334 | 2.60465 |
| 0 | 1.005 | 0.060 | 0.060 | 0.030 | 0.002 | 0.00005 | 0.00002 | 2.010 | 2.000 | 4.020 | 1.060 | 4.261 | 4.51687 | 1.34000 |

| TENSION | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 125 | 126 | 127 | 128 | 129 | 130 | 131 | 132 | 133 | 134 | 135 |
| | | | | | TOTAL | TOTAL | TOTAL | TOTAL | MOI | DIST TO | MOI |
| STATION | Σ A | Σ AY | Σ AY² | Σ Io | Σ A | Σ AY | Σ AY² | Σ Io | ABT DATUM | NA | ABT NA |
| (in) | | | | | | | | | | | |
| | | | | | | | | | | | |
| 258 | 0.022 | 0.000 | 0.000 | 0.000 | 0.234 | 0.559 | 1.579 | 0.362 | 1.941 | 2.386 | 0.607 |
| 251 | 0.022 | 0.000 | 0.000 | 0.000 | 0.236 | 0.567 | 1.611 | 0.370 | 1.981 | 2.404 | 0.619 |
| 238 | 0.022 | 0.000 | 0.000 | 0.000 | 0.239 | 0.582 | 1.675 | 0.387 | 2.062 | 2.439 | 0.643 |
| 228 | 0.022 | 0.000 | 0.000 | 0.000 | 0.241 | 0.593 | 1.724 | 0.400 | 2.124 | 2.465 | 0.661 |
| 218 | 0.043 | 0.001 | 0.000 | 0.000 | 0.286 | 0.713 | 2.308 | 0.413 | 2.721 | 2.492 | 0.944 |
| 208 | 0.069 | 0.002 | 0.000 | 0.000 | 0.340 | 0.857 | 3.022 | 0.426 | 3.448 | 2.518 | 1.290 |
| 198 | 0.119 | 0.004 | 0.000 | 0.000 | 0.442 | 1.126 | 4.366 | 0.440 | 4.806 | 2.545 | 1.941 |
| 188 | 0.178 | 0.009 | 0.000 | 0.000 | 0.562 | 1.444 | 5.975 | 0.454 | 6.429 | 2.571 | 2.715 |
| 178 | 0.245 | 0.016 | 0.001 | 0.000 | 0.698 | 1.814 | 7.856 | 0.468 | 8.324 | 2.598 | 3.612 |
| 164 | 0.345 | 0.033 | 0.003 | 0.001 | 1.006 | 2.653 | 11.447 | 0.734 | 12.181 | 2.636 | 5.188 |
| 159 | 0.388 | 0.041 | 0.005 | 0.001 | 1.093 | 2.894 | 12.670 | 0.744 | 13.414 | 2.647 | 5.754 |
| 155 | 0.420 | 0.047 | 0.006 | 0.001 | 1.158 | 3.080 | 13.628 | 0.754 | 14.382 | 2.659 | 6.194 |
| 138 | 0.607 | 0.095 | 0.016 | 0.003 | 1.539 | 4.160 | 19.123 | 0.798 | 19.921 | 2.704 | 8.673 |
| 128 | 0.735 | 0.138 | 0.027 | 0.006 | 1.797 | 4.907 | 22.905 | 0.827 | 23.732 | 2.730 | 10.334 |
| 118 | 0.878 | 0.201 | 0.048 | 0.011 | 2.197 | 6.056 | 27.911 | 1.140 | 29.051 | 2.757 | 12.356 |
| 108 | 1.024 | 0.271 | 0.074 | 0.018 | 2.494 | 6.940 | 32.314 | 1.186 | 33.500 | 2.783 | 14.184 |
| 98 | 1.212 | 0.375 | 0.120 | 0.031 | 2.874 | 8.075 | 37.849 | 1.244 | 39.094 | 2.810 | 16.405 |
| 88 | 1.442 | 0.526 | 0.197 | 0.052 | 3.338 | 9.467 | 44.479 | 1.322 | 45.801 | 2.836 | 18.949 |
| 80 | 1.630 | 0.668 | 0.280 | 0.076 | 3.718 | 10.623 | 49.899 | 1.397 | 51.296 | 2.857 | 20.943 |
| 68 | 1.999 | 1.024 | 0.537 | 0.146 | 4.575 | 13.219 | 60.803 | 1.901 | 62.704 | 2.889 | 24.512 |
| 58 | 2.511 | 1.600 | 1.039 | 0.295 | 5.606 | 16.344 | 73.766 | 2.243 | 76.009 | 2.916 | 28.355 |
| 48 | 3.126 | 2.461 | 1.968 | 0.577 | 6.841 | 20.127 | 88.310 | 2.851 | 91.161 | 2.942 | 31.944 |
| 22 | 5.829 | 8.626 | 12.893 | 3.960 | 12.381 | 37.278 | 139.832 | 10.103 | 149.935 | 3.011 | 37.691 |
| 19 | 5.077 | 6.564 | 8.583 | 2.605 | 10.877 | 32.751 | 128.786 | 7.393 | 136.179 | 3.011 | 37.565 |
| 0 | 4.080 | 4.263 | 4.517 | 1.340 | 8.677 | 18.655 | 50.202 | 3.475 | 53.677 | 2.150 | 13.569 |

SPAR STRESSING

$F_{CU\ BOOM}$ = 116000 psi

$F_{CU\ 45\ SHEAR\ WEB}$ = 40000 psi

$F_{SU\ SHEAR\ WEB}$ = 16667 psi

| 1 | 136 | 137 | 138 | 139 | 140 | 141 | 142 | 143 | 144 | 145 |
|---|---|---|---|---|---|---|---|---|---|---|
| STATION (in) | CALCULATED MOI ABT NA | TEST FACTORED ULT MOMENT (lb in) | QUICK BENDING STRESS CHECK AT EXTREME FIBRE (psi) | COMPRESSIVE BENDING STRESS ON BOOM CENTROID (psi) | RF BENDING | COMPRESSIVE BENDING STRESS ON BOOM INNER FIBRE (psi) | RF BENDING | COMPRESSIVE BENDING STRESS ON BOOM OUTER FIBRE (psi) | RF BENDING | ULT STRAIN |
| 258 | 0.607 | 0 | 0 | 0 | - | 0 | - | 0 | - | 0.000 |
| 251 | 0.619 | 337 | 2614 | 2592 | 44.75 | 2592 | 44.75 | 2592 | 44.75 | 0.000 |
| 238 | 0.643 | 3248 | 24639 | 24437 | 4.75 | 24437 | 4.75 | 24437 | 4.75 | 0.002 |
| 228 | 0.661 | 7612 | 56760 | 56300 | 2.06 | 56300 | 2.06 | 56300 | 2.06 | 0.006 |
| 218 | 0.944 | 13948 | 73629 | 72891 | 1.59 | 72743 | 1.59 | 73038 | 1.59 | 0.007 |
| 208 | 1.290 | 22320 | 87163 | 86090 | 1.35 | 85709 | 1.35 | 86470 | 1.34 | 0.009 |
| 198 | 1.941 | 32782 | 85944 | 84509 | 1.37 | 83749 | 1.39 | 85269 | 1.36 | 0.009 |
| 188 | 2.715 | 45370 | 85929 | 84057 | 1.38 | 82854 | 1.40 | 85260 | 1.36 | 0.009 |
| 178 | 3.612 | 60111 | 86475 | 84095 | 1.38 | 82381 | 1.41 | 85809 | 1.35 | 0.009 |
| 164 | 5.188 | 85243 | 86611 | 83210 | 1.39 | 80795 | 1.44 | 85626 | 1.35 | 0.009 |
| 159 | 5.754 | 93686 | 86206 | 82510 | 1.41 | 79791 | 1.45 | 85229 | 1.36 | 0.009 |
| 155 | 6.194 | 102401 | 87913 | 83912 | 1.38 | 80903 | 1.43 | 86921 | 1.33 | 0.009 |
| 138 | 8.673 | 140840 | 87811 | 82453 | 1.41 | 78068 | 1.49 | 86837 | 1.34 | 0.009 |
| 128 | 10.334 | 166767 | 88121 | 81828 | 1.42 | 76502 | 1.52 | 87153 | 1.33 | 0.009 |
| 118 | 12.356 | 195043 | 87029 | 79453 | 1.46 | 73139 | 1.59 | 85767 | 1.35 | 0.009 |
| 108 | 14.184 | 225701 | 88574 | 79823 | 1.45 | 72344 | 1.60 | 87301 | 1.33 | 0.009 |
| 98 | 16.405 | 258775 | 88643 | 78547 | 1.48 | 69714 | 1.66 | 87381 | 1.33 | 0.009 |
| 88 | 18.949 | 294286 | 88093 | 76446 | 1.52 | 66041 | 1.76 | 86851 | 1.34 | 0.009 |
| 80 | 20.943 | 324402 | 88519 | 75508 | 1.54 | 63736 | 1.82 | 87280 | 1.33 | 0.009 |
| 68 | 24.512 | 372534 | 87819 | 71861 | 1.61 | 57423 | 2.02 | 86300 | 1.34 | 0.009 |
| 58 | 28.355 | 415438 | 85437 | 66390 | 1.75 | 48809 | 2.38 | 83972 | 1.38 | 0.008 |
| 48 | 31.944 | 460817 | 84885 | 61804 | 1.88 | 40165 | 2.89 | 83442 | 1.39 | 0.008 |
| 22 | 37.691 | 592104 | 94603 | 47631 | 2.44 | 2545 | 45.58 | 92717 | 1.25 | 0.009 |
| 19 | 37.565 | 608501 | 97547 | 55172 | 2.10 | 14741 | 7.87 | 95603 | 1.21 | 0.010 |
| 0 | 13.569 | 718675 | 227740 | 115459 | 1.00 | 9533 | 12.17 | 221384 | 0.52 | 0.022 |

| 1 | 146 | 147 | 148 | 149 | 150 | 151 | 152 |
|---|---|---|---|---|---|---|---|
| STATION (in) | COMPRESSIVE BENDING STRESS ON CARBON CENTROID (psi) | RF | COMPRESSIVE BENDING STRESS ON CARBON INNER FIBRE (psi) | RF BENDING | COMPRESSIVE BENDING STRESS ON CARBON OUTER FIBRE (psi) | RF BENDING | ULT STRAIN |
| 258 | 0 | - | 0 | - | 0 | - | 0.000 |
| 251 | 1301 | 30.74 | 1296 | 30.86 | 1307 | 30.61 | 0.000 |
| 238 | 12269 | 3.26 | 12219 | 3.27 | 12320 | 3.25 | 0.002 |
| 228 | 28265 | 1.42 | 28150 | 1.42 | 28380 | 1.41 | 0.006 |
| 218 | 36667 | 1.09 | 36519 | 1.10 | 36815 | 1.09 | 0.007 |
| 208 | 43408 | 0.92 | 43235 | 0.93 | 43581 | 0.92 | 0.009 |
| 198 | 42803 | 0.93 | 42634 | 0.94 | 42972 | 0.93 | 0.009 |
| 188 | 42797 | 0.93 | 42630 | 0.94 | 42964 | 0.93 | 0.009 |
| 178 | 43071 | 0.93 | 42905 | 0.93 | 43238 | 0.93 | 0.009 |
| 164 | 43059 | 0.93 | 42813 | 0.93 | 43306 | 0.92 | 0.009 |
| 159 | 42859 | 0.93 | 42615 | 0.94 | 43103 | 0.93 | 0.009 |
| 155 | 43709 | 0.92 | 43461 | 0.92 | 43957 | 0.91 | 0.009 |
| 138 | 43662 | 0.92 | 43419 | 0.92 | 43906 | 0.91 | 0.009 |
| 128 | 43819 | 0.91 | 43577 | 0.92 | 44061 | 0.91 | 0.009 |
| 118 | 43199 | 0.93 | 42883 | 0.93 | 43515 | 0.92 | 0.009 |
| 108 | 43969 | 0.91 | 43651 | 0.92 | 44287 | 0.90 | 0.009 |
| 98 | 44006 | 0.91 | 43690 | 0.92 | 44321 | 0.90 | 0.009 |
| 88 | 43736 | 0.91 | 43425 | 0.92 | 44047 | 0.91 | 0.009 |
| 80 | 43950 | 0.91 | 43640 | 0.92 | 44260 | 0.90 | 0.009 |
| 68 | 43530 | 0.92 | 43150 | 0.93 | 43910 | 0.91 | 0.009 |
| 58 | 42352 | 0.94 | ·41986 | 0.95 | 42719 | 0.94 | 0.009 |
| 48 | 42082 | 0.95 | 41721 | 0.96 | 42442 | 0.94 | 0.008 |
| 22 | 46830 | 0.85 | 46359 | 0.86 | 47301 | 0.85 | 0.009 |
| 19 | 48288 | 0.83 | 47802 | 0.84 | 48774 | 0.82 | 0.010 |
| 0 | 112281 | 0.36 | 110692 | 0.36 | 113870 | 0.35 | 0.023 |

| 1 | 153 | 154 | 155 | 156 | 157 | 158 |
|---|---|---|---|---|---|---|
| | WEB | | BOOM | | CARBON | |
| | COMPRESSIVE | | COMPRESSIVE | | COMPRESSIVE | |
| | LOAD DUE | SHEAR | LOAD DUE | SHEAR | LOAD DUE | SHEAR |
| STATION | TO BENDING | STRESS | TO BENDING | STRESS | TO BENDING | STRESS |
| (in) | (lb) | (psi) | (lb) | (psi) | (lb) | (psi) |
| | | | | | | |
| 258 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 251 | 124.62 | 461.54 | 0.00 | 0.00 | 28.24 | 3.86 |
| 238 | 1192.04 | 2014.01 | 0.00 | 0.00 | 266.24 | 16.56 |
| 228 | 2776.07 | 3960.08 | 0.00 | 0.00 | 613.35 | 31.99 |
| 218 | 3625.41 | 2123.35 | 395.43 | 36.45 | 795.67 | 16.80 |
| 208 | 4317.02 | 1729.01 | 1027.48 | 58.25 | 941.96 | 13.48 |
| 198 | 4262.65 | -135.92 | 2063.07 | 95.45 | 928.83 | -1.21 |
| 188 | 4261.00 | -4.13 | 3283.28 | 112.46 | 928.70 | -0.01 |
| 178 | 4280.28 | 48.22 | 4699.02 | 130.48 | 934.64 | 0.55 |
| 164 | 6388.98 | 2449.12 | 6513.51 | 118.73 | 1375.74 | 28.86 |
| 159 | 6336.98 | -200.38 | 7337.42 | 178.87 | 1369.34 | -1.39 |
| 155 | 6453.10 | 447.50 | 8132.34 | 172.58 | 1396.49 | 5.89 |
| 138 | 6332.42 | -118.31 | 11854.64 | 205.59 | 1395.00 | -0.08 |
| 128 | 6266.17 | -110.43 | 14379.15 | 237.04 | 1400.00 | 0.47 |
| 118 | 8065.06 | 2248.62 | 16605.62 | 213.06 | 1805.72 | 38.82 |
| 108 | 8054.04 | -13.78 | 19602.43 | 286.78 | 1837.90 | 3.08 |
| 98 | 7835.06 | -273.72 | 22982.94 | 323.49 | 1839.45 | 0.15 |
| 88 | 7492.20 | -428.58 | 26761.72 | 361.61 | 1828.17 | -1.08 |
| 80 | 7284.79 | -324.08 | 29984.32 | 385.48 | 1837.11 | 1.07 |
| 68 | 8295.32 | 842.11 | 34987.54 | 406.77 | 2230.90 | 32.02 |
| 58 | 7115.47 | -1179.85 | 40830.05 | 570.00 | 2170.56 | -5.89 |
| 48 | 5908.59 | -1206.87 | 47511.62 | 651.86 | 2156.69 | -1.35 |
| 22 | 459.77 | -1746.42 | 68692.46 | 810.59 | 2823.85 | 25.53 |
| 19 | 2663.04 | 6120.20 | 69198.92 | 167.98 | 2911.74 | 29.15 |
| 0 | 1229.79 | -628.62 | 116035.97 | 2452.84 | 6770.54 | 202.08 |

| SPAR STRESSING | | | | | | |
|---|---|---|---|---|---|---|
| 1 | 158 | 159 | 160 | 161 | 162 | 163 |
| | | | | 3/2(V/A) | | |
| | | | | MAX SHEAR | | |
| | CALCULATED | TEST FACTORED | SHEAR WEB | STRESS | RF | ULT |
| STATION | MOI | ULT SHEAR | AREA | INTRA | SHEAR | STRAIN |
| (in) | ABT NA | (lb) | (in2) | AT NA | | |
| | | | | (psi) | | |
| 258 | 0.607 | 0 | 0.191 | 0.00 | 0.00 | 0.000 |
| 251 | 0.619 | 100 | 0.192 | 777.90 | 21.43 | 0.000 |
| 238 | 0.643 | 340 | 0.195 | 2611.30 | 6.38 | 0.001 |
| 228 | 0.661 | 533 | 0.197 | 4055.42 | 4.11 | 0.001 |
| 218 | 0.944 | 734 | 0.199 | 5521.90 | 3.02 | 0.001 |
| 208 | 1.290 | 940 | 0.201 | 7002.16 | 2.38 | 0.001 |
| 198 | 1.941 | 1152 | 0.204 | 8486.57 | 1.96 | 0.002 |
| 188 | 2.715 | 1366 | 0.206 | 9959.30 | 1.67 | 0.002 |
| 178 | 3.612 | 1582 | 0.208 | 11421.24 | 1.46 | 0.002 |
| 164 | 5.188 | 1920 | 0.316 | 9106.51 | 1.83 | 0.002 |
| 159 | 5.754 | 1984 | 0.318 | 9367.19 | 1.78 | 0.002 |
| 155 | 6.194 | 2046 | 0.319 | 9619.96 | 1.73 | 0.002 |
| 138 | 8.673 | 2476 | 0.324 | 11447.24 | 1.46 | 0.002 |
| 128 | 10.334 | 2709 | 0.328 | 12404.10 | 1.34 | 0.002 |
| 118 | 12.356 | 2946 | 0.441 | 10017.67 | 1.66 | 0.002 |
| 108 | 14.184 | 3186 | 0.445 | 10731.02 | 1.55 | 0.002 |
| 98 | 16.405 | 3429 | 0.450 | 11441.25 | 1.46 | 0.002 |
| 88 | 18.949 | 3673 | 0.454 | 12141.98 | 1.37 | 0.002 |
| 80 | 20.943 | 3856 | 0.457 | 12650.08 | 1.32 | 0.003 |
| 68 | 24.512 | 4166 | 0.578 | 10815.66 | 1.54 | 0.002 |
| 58 | 28.355 | 4414 | 0.583 | 11354.88 | 1.47 | 0.002 |
| 48 | 31.944 | 4662 | 0.588 | 11883.36 | 1.40 | 0.002 |
| 22 | 37.691 | 5437 | 0.723 | 11286.28 | 1.48 | 0.002 |
| 19 | 37.565 | 5494 | 0.723 | 11404.56 | 1.46 | 0.002 |
| 0 | 13.569 | 6103 | 0.516 | 17741.25 | 0.94 | 0.004 |
| | | | (Both webs) | | | |

| SPAR STRESSING | | | | | | |
|---|---|---|---|---|---|---|
| 1 | 164 | 165 | 166 | 167 | 168 | 169 |
| | MAX SHEAR | | MAX SHEAR | | MAX SHEAR | |
| | STRESS | | STRESS | | STRESS | |
| | INTRA | RF | BTWN CORE | RF | BTWN BOOM | RF |
| STATION | AT NA | SHEAR | AND BOOM | SHEAR | AND GLASS | SHEAR |
| (in) | CHECK | | (psi) | | (psi) | |
| | (psi) | | | | | |
| 258 | 0.00 | - | 0.00 | - | 0.00 | - |
| 251 | 1140.89 | 14.61 | 15.46 | 1078.30 | 15.46 | 1078.30 |
| 238 | 3841.70 | 4.34 | 51.44 | 324.03 | 51.44 | 324.03 |
| 228 | 5979.98 | 2.79 | 79.36 | 210.01 | 79.36 | 210.01 |
| 218 | 6928.61 | 2.41 | 154.42 | 107.93 | 77.33 | 215.54 |
| 208 | 7812.83 | 2.13 | 233.92 | 71.25 | 73.31 | 227.34 |
| 198 | 8347.87 | 2.00 | 329.80 | 50.54 | 60.28 | 276.49 |
| 188 | 9079.51 | 1.84 | 420.08 | 39.68 | 51.64 | 322.78 |
| 178 | 9934.68 | 1.68 | 507.94 | 32.81 | 45.44 | 366.77 |
| 164 | 8181.80 | 2.04 | 620.73 | 26.85 | 58.37 | 285.55 |
| 159 | 8313.37 | 2.00 | 651.24 | 25.59 | 54.61 | 305.20 |
| 155 | 8478.00 | 1.97 | 677.44 | 24.60 | 52.55 | 317.15 |
| 138 | 9896.71 | 1.68 | 854.40 | 19.51 | 46.19 | 360.87 |
| 128 | 10721.36 | 1.55 | 953.97 | 17.47 | 42.83 | 389.13 |
| 118 | 9022.95 | 1.85 | 1058.14 | 15.75 | 52.39 | 318.15 |
| 108 | 9742.24 | 1.71 | 1167.00 | 14.28 | 49.83 | 334.47 |
| 98 | 10549.18 | 1.58 | 1287.45 | 12.95 | 46.82 | 356.00 |
| 88 | 11470.05 | 1.45 | 1419.87 | 11.74 | 43.83 | 380.27 |
| 80 | 12222.47 | 1.36 | 1523.57 | 10.94 | 41.94 | 397.43 |
| 68 | 11234.48 | 1.48 | 1745.48 | 9.55 | 48.90 | 340.86 |
| 58 | 12722.25 | 1.31 | 1981.10 | 8.41 | 45.20 | 368.76 |
| 48 | 14685.81 | 1.13 | 2268.63 | 7.35 | 42.75 | 389.84 |
| 22 | 22407.23 | 0.74 | 3800.45 | 4.39 | 51.86 | 321.35 |
| 19 | 19958.93 | 0.84 | 3494.39 | 4.77 | 52.58 | 316.96 |
| 0 | 34958.85 | 0.48 | 5944.11 | 2.80 | 115.23 | 144.64 |
| | | ignoring contribution from s web | | | | |

| SPAR WEIGHT ESTIMATE | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 3 | 170 | 171 | 172 | 173 | 174 | 175 | 176 | |
| | | 0.055 | 0.055 | | | | | | |
| | dy | TOTAL | SHEAR | CARBON | TOTAL | BOOM + WEB | XTRAS | SPAR TOTAL | |
| STATION | (in) | BOOM WEIGHT | WEB WEIGHT | CAP WEIGHT | WEB WEIGHT | TOTAL WEIGHT | 0.10 | WEIGHT EST | |
| (in) | | (lb) | (lb) | (lb) | (lb) | (lb) | (lb) | (lb) | |
| 258 | 6.75 | 0.000 | 0.071 | 0.008 | 0.079 | 0.079 | 0.008 | 0.087 | |
| 251 | 13.25 | 0.000 | 0.140 | 0.016 | 0.156 | 0.156 | 0.016 | 0.172 | |
| 238 | 10.00 | 0.000 | 0.107 | 0.012 | 0.119 | 0.119 | 0.012 | 0.131 | |
| 228 | 10.00 | 0.000 | 0.108 | 0.012 | 0.120 | 0.120 | 0.012 | 0.132 | |
| 218 | 10.00 | 0.012 | 0.110 | 0.012 | 0.122 | 0.134 | 0.013 | 0.147 | |
| 208 | 10.00 | 0.026 | 0.111 | 0.012 | 0.123 | 0.149 | 0.015 | 0.164 | |
| 198 | 10.00 | 0.054 | 0.112 | 0.012 | 0.124 | 0.178 | 0.018 | 0.195 | |
| 188 | 10.00 | 0.086 | 0.113 | 0.012 | 0.125 | 0.211 | 0.021 | 0.232 | |
| 178 | 14.35 | 0.176 | 0.164 | 0.017 | 0.181 | 0.358 | 0.036 | 0.393 | |
| 164 | 4.33 | 0.074 | 0.075 | 0.008 | 0.083 | 0.157 | 0.016 | 0.173 | |
| 159 | 4.32 | 0.085 | 0.076 | 0.008 | 0.083 | 0.168 | 0.017 | 0.185 | |
| 155 | 17.00 | 0.362 | 0.298 | 0.030 | 0.328 | 0.691 | 0.069 | 0.760 | |
| 138 | 10.00 | 0.316 | 0.178 | 0.018 | 0.196 | 0.512 | 0.051 | 0.564 | |
| 128 | 10.00 | 0.387 | 0.180 | 0.018 | 0.198 | 0.584 | 0.058 | 0.643 | |
| 118 | 10.00 | 0.460 | 0.243 | 0.023 | 0.266 | 0.725 | 0.073 | 0.798 | |
| 108 | 10.00 | 0.540 | 0.245 | 0.023 | 0.268 | 0.808 | 0.081 | 0.889 | |
| 98 | 10.00 | 0.644 | 0.247 | 0.023 | 0.270 | 0.914 | 0.091 | 1.005 | |
| 88 | 8.00 | 0.616 | 0.200 | 0.018 | 0.218 | 0.834 | 0.083 | 0.918 | |
| 80 | 12.00 | 1.048 | 0.302 | 0.028 | 0.329 | 1.378 | 0.138 | 1.515 | |
| 68 | 10.00 | 1.071 | 0.318 | 0.028 | 0.346 | 1.417 | 0.142 | 1.559 | |
| 58 | 10.00 | 1.353 | 0.321 | 0.028 | 0.349 | 1.702 | 0.170 | 1.872 | |
| 48 | 26.00 | 4.397 | 0.841 | 0.073 | 0.915 | 5.312 | 0.531 | 5.843 | |
| 22 | 3.00 | 0.952 | 0.119 | 0.010 | 0.129 | 1.081 | 0.108 | 1.189 | |
| 19 | 19.00 | 5.243 | 0.755 | 0.063 | 0.818 | 6.061 | 0.606 | 6.667 | |
| 0 | Σ= | 17.903 | 5.435 | 0.510 | 5.945 | 23.848 | Σ= | 26.233 | |
| | Σ= | 39.458 | 11.978 | kg | | | 2.38 | 57.817 | kg |
| | | | | | | (PLY+FOAM+BELLCRANKS) | | | |

SPAR BENDING STRENGTH
MOST UNFAVOURABLE LOADS EXPERIENCED BY WING SPAR
CARBON SHEAR WEBS
ACTUAL GEOMETRY

| 1 | 44C | 45C | 76 | 77 | 78 | 79 | 80 | 81 | 82 | 83 | 84 | 85 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | NORMAL | NORMAL | | 1.125 | | 0.010 | TOTAL | | | | SINGLE | |
| STATION | ULT SHEAR | ULT BEND MOM | SPAR DEPTH | SPAR WIDTH | NO SHEAR WEB | SPAR WEB | SHEAR WEB | CAP WEB | SPAR BOOM | SPAR BOOM | SPAR BOOM | GAP SIZE |
| (in) | COND. C | COND. C | (in) | (in) | PLIES/SIDE | WIDTH | AREA | AREA | WIDTH | DEPTH | AREA | (in) |
| | (lb) | (lb in) | | | | (in) | (in$^2$) | (in$^2$) | (in) | (in) | (in$^2$) | |
| | COND. C | COND. C | | | | | | | | | | |
| 258 | 0 | 0 | 4.97 | 1.125 | 2 | 0.020 | 0.199 | 0.022 | 1.085 | 0.000 | 0.000 | 4.925 |
| 251 | 66 | 224 | 5.01 | 1.125 | 2 | 0.020 | 0.201 | 0.022 | 1.085 | 0.000 | 0.000 | 4.975 |
| 238 | 226 | 2165 | 5.05 | 1.125 | 2 | 0.020 | 0.202 | 0.022 | 1.085 | 0.000 | 0.000 | 5.012 |
| 228 | 355 | 5075 | 5.09 | 1.125 | 2 | 0.020 | 0.204 | 0.022 | 1.085 | 0.000 | 0.000 | 5.050 |
| 218 | 489 | 9299 | 5.13 | 1.125 | 2 | 0.020 | 0.205 | 0.022 | 1.085 | 0.010 | 0.011 | 5.067 |
| 208 | 627 | 14880 | 5.16 | 1.125 | 2 | 0.020 | 0.207 | 0.022 | 1.085 | 0.022 | 0.024 | 5.081 |
| 198 | 768 | 21854 | 5.20 | 1.125 | 2 | 0.020 | 0.208 | 0.022 | 1.085 | 0.045 | 0.049 | 5.072 |
| 188 | 911 | 30247 | 5.24 | 1.125 | 2 | 0.020 | 0.210 | 0.022 | 1.085 | 0.072 | 0.078 | 5.056 |
| 178 | 1055 | 40074 | 5.29 | 1.125 | 2 | 0.020 | 0.212 | 0.022 | 1.085 | 0.103 | 0.112 | 5.048 |
| 164 | 1280 | 56829 | 5.31 | 1.125 | 3 | 0.030 | 0.319 | 0.032 | 1.065 | 0.147 | 0.157 | 4.956 |
| 159 | 1323 | 62457 | 5.33 | 1.125 | 3 | 0.030 | 0.320 | 0.032 | 1.065 | 0.167 | 0.178 | 4.932 |
| 155 | 1364 | 68267 | 5.39 | 1.125 | 3 | 0.030 | 0.323 | 0.032 | 1.065 | 0.182 | 0.194 | 4.966 |
| 138 | 1651 | 93894 | 5.43 | 1.125 | 3 | 0.030 | 0.326 | 0.032 | 1.065 | 0.270 | 0.288 | 4.827 |
| 128 | 1806 | 111178 | 5.46 | 1.125 | 3 | 0.030 | 0.328 | 0.032 | 1.065 | 0.330 | 0.351 | 4.745 |
| 118 | 1964 | 130028 | 5.50 | 1.125 | 4 | 0.040 | 0.440 | 0.042 | 1.045 | 0.400 | 0.418 | 4.622 |
| 108 | 2124 | 150467 | 5.54 | 1.125 | 4 | 0.040 | 0.443 | 0.042 | 1.045 | 0.470 | 0.491 | 4.520 |
| 98 | 2286 | 172516 | 5.58 | 1.125 | 4 | 0.040 | 0.446 | 0.042 | 1.045 | 0.560 | 0.585 | 4.377 |
| 88 | 2449 | 196191 | 5.61 | 1.125 | 4 | 0.040 | 0.449 | 0.042 | 1.045 | 0.670 | 0.700 | 4.187 |
| 80 | 2570 | 216268 | 5.65 | 1.125 | 4 | 0.040 | 0.452 | 0.042 | 1.045 | 0.760 | 0.794 | 4.052 |
| 68 | 2778 | 248356 | 5.69 | 1.125 | 5 | 0.050 | 0.569 | 0.051 | 1.025 | 0.950 | 0.974 | 3.690 |
| 58 | 2943 | 276958 | 5.73 | 1.125 | 5 | 0.050 | 0.573 | 0.051 | 1.025 | 1.200 | 1.230 | 3.227 |
| 48 | 3108 | 307212 | 5.82 | 1.125 | 5 | 0.050 | 0.582 | 0.051 | 1.025 | 1.500 | 1.538 | 2.725 |
| 22 | 3625 | 394736 | 5.84 | 1.125 | 6 | 0.060 | 0.700 | 0.060 | 1.005 | 2.918 | 2.933 | -0.120 |
| 19 | 3663 | 405667 | 5.91 | 1.125 | 6 | 0.060 | 0.709 | 0.060 | 1.005 | 2.496 | 2.508 | 0.795 |
| 0 | 4069 | 479117 | 4.30 | 1.125 | 6 | 0.060 | 0.516 | 0.060 | 1.005 | 2.000 | 2.010 | 0.180 |

SPAR MOMENT OF INERTIA TRANSFORMATION

| | | | |
|---|---|---|---|
| $E_{BOOM}$ = | 10000000 | psi | |
| $E_{SHEAR\ WEB}$ = | 5000000 | psi | |
| $E_2/E_1$ = | 2.00 | | |

| 1 | 86 | 87 | 88 | 89 | 90 | 91 | 92 | 93 | 94 | 95 | 96 | 97 | 98 | 99 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| COMPRESSION | | | | | | | | | | | | | | |
| | 5000000 | FROM FEA | | | | | | 5000000 | | | | | | |
| STATION | SHEAR WEB | SHEAR WEB | SHEAR WEB | | | | | CARBON CAP | CARBON CAP | CARBON CAP | | | | |
| (in) | TRANSFORMED | DEPTH | TRANSFORMED | Y | AY | $AY^2$ | Io | TRANSFORMED | DEPTH | TRANSFORMED | Y | AY | $AY^2$ | Io |
| | WIDTH | (in) | AREA | | | | | WIDTH | (in) | AREA | | | | |
| | (in) | | (in2) | | | | | (in) | | (in2) | | | | |
| 258 | 0.040 | 4.965 | 0.199 | 2.483 | 0.493 | 1.22394 | 0.40798 | 1.085 | 0.020 | 0.022 | 4.955 | 0.108 | 0.53278 | 0.00000 |
| 251 | 0.040 | 5.015 | 0.201 | 2.507 | 0.503 | 1.26106 | 0.42035 | 1.085 | 0.020 | 0.022 | 5.005 | 0.109 | 0.54352 | 0.00000 |
| 238 | 0.040 | 5.052 | 0.202 | 2.526 | 0.510 | 1.28956 | 0.42985 | 1.085 | 0.020 | 0.022 | 5.042 | 0.109 | 0.55170 | 0.00000 |
| 228 | 0.040 | 5.090 | 0.204 | 2.545 | 0.518 | 1.31849 | 0.43950 | 1.085 | 0.020 | 0.022 | 5.080 | 0.110 | 0.55993 | 0.00000 |
| 218 | 0.040 | 5.127 | 0.205 | 2.564 | 0.526 | 1.34785 | 0.44928 | 1.085 | 0.020 | 0.022 | 5.117 | 0.111 | 0.56823 | 0.00000 |
| 208 | 0.040 | 5.165 | 0.207 | 2.582 | 0.533 | 1.37764 | 0.45921 | 1.085 | 0.020 | 0.022 | 5.155 | 0.112 | 0.57659 | 0.00000 |
| 198 | 0.040 | 5.202 | 0.208 | 2.601 | 0.541 | 1.40787 | 0.46929 | 1.085 | 0.020 | 0.022 | 5.192 | 0.113 | 0.58501 | 0.00000 |
| 188 | 0.040 | 5.240 | 0.210 | 2.620 | 0.549 | 1.43853 | 0.47951 | 1.085 | 0.020 | 0.022 | 5.230 | 0.113 | 0.59349 | 0.00000 |
| 178 | 0.040 | 5.294 | 0.212 | 2.647 | 0.560 | 1.48331 | 0.49444 | 1.085 | 0.020 | 0.022 | 5.284 | 0.115 | 0.60577 | 0.00000 |
| 164 | 0.060 | 5.310 | 0.319 | 2.655 | 0.846 | 2.24548 | 0.74849 | 1.065 | 0.030 | 0.032 | 5.295 | 0.169 | 0.89569 | 0.00000 |
| 159 | 0.060 | 5.326 | 0.320 | 2.663 | 0.851 | 2.26612 | 0.75537 | 1.065 | 0.030 | 0.032 | 5.311 | 0.170 | 0.90119 | 0.00000 |
| 155 | 0.060 | 5.390 | 0.323 | 2.695 | 0.871 | 2.34847 | 0.78282 | 1.065 | 0.030 | 0.032 | 5.375 | 0.172 | 0.92295 | 0.00000 |
| 138 | 0.060 | 5.427 | 0.326 | 2.714 | 0.884 | 2.39783 | 0.79928 | 1.065 | 0.030 | 0.032 | 5.412 | 0.173 | 0.93588 | 0.00000 |
| 128 | 0.060 | 5.465 | 0.328 | 2.732 | 0.896 | 2.44788 | 0.81596 | 1.065 | 0.030 | 0.032 | 5.450 | 0.174 | 0.94889 | 0.00000 |
| 118 | 0.080 | 5.502 | 0.440 | 2.751 | 1.211 | 3.33149 | 1.11050 | 1.045 | 0.040 | 0.042 | 5.482 | 0.229 | 1.25628 | 0.00001 |
| 108 | 0.080 | 5.540 | 0.443 | 2.770 | 1.228 | 3.40008 | 1.13336 | 1.045 | 0.040 | 0.042 | 5.520 | 0.231 | 1.27352 | 0.00001 |
| 98 | 0.080 | 5.577 | 0.446 | 2.789 | 1.244 | 3.46959 | 1.15653 | 1.045 | 0.040 | 0.042 | 5.557 | 0.232 | 1.29089 | 0.00001 |
| 88 | 0.080 | 5.607 | 0.449 | 2.804 | 1.258 | 3.52588 | 1.17529 | 1.045 | 0.040 | 0.042 | 5.587 | 0.234 | 1.30486 | 0.00001 |
| 80 | 0.080 | 5.652 | 0.452 | 2.826 | 1.278 | 3.61146 | 1.20382 | 1.045 | 0.040 | 0.042 | 5.632 | 0.235 | 1.32597 | 0.00001 |
| 68 | 0.100 | 5.690 | 0.569 | 2.845 | 1.619 | 4.60477 | 1.53492 | 1.025 | 0.050 | 0.051 | 5.665 | 0.290 | 1.64455 | 0.00001 |
| 58 | 0.100 | 5.727 | 0.573 | 2.864 | 1.640 | 4.69642 | 1.56547 | 1.025 | 0.050 | 0.051 | 5.702 | 0.292 | 1.66640 | 0.00001 |
| 48 | 0.100 | 5.825 | 0.582 | 2.912 | 1.696 | 4.94038 | 1.64679 | 1.025 | 0.050 | 0.051 | 5.800 | 0.297 | 1.72387 | 0.00001 |
| 22 | 0.120 | 5.836 | 0.700 | 2.918 | 2.043 | 5.96288 | 1.98763 | 1.005 | 0.060 | 0.060 | 5.806 | 0.350 | 2.03266 | 0.00002 |
| 19 | 0.120 | 5.907 | 0.709 | 2.954 | 2.094 | 6.18395 | 2.06132 | 1.005 | 0.060 | 0.060 | 5.877 | 0.354 | 2.08285 | 0.00002 |
| 0 | 0.120 | 4.300 | 0.516 | 2.150 | 1.109 | 2.38521 | 0.79507 | 1.005 | 0.060 | 0.060 | 4.270 | 0.257 | 1.09944 | 0.00002 |

SPAR MOMENT OF INERTIA TRANSFORMATION

| 1 | 100 | 101 | 102 | 103 | 104 | 105 | 106 | 107 | 108 | 109 | 110 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| COMPRESSION | | | | | | | | | | | |
| | 10000000 | | | | | | | | | | |
| STATION | SPAR BOOM | SPAR BOOM | SPAR BOOM | | | | | | | | |
| (in) | TRANSFORMED | DEPTH | TRANSFORMED | Y | AY | $AY^2$ | Io | Σ A | Σ AY | Σ $AY^2$ | Σ Io |
| | WIDTH | (in) | AREA | | | | | | | | |
| | (in) | | (in2) | | | | | | | | |
| 258 | 2.170 | 0.000 | 0.000 | 4.945 | 0.000 | 0.00000 | 0.00000 | 0.220 | 0.601 | 1.757 | 0.408 |
| 251 | 2.170 | 0.000 | 0.000 | 4.995 | 0.000 | 0.00000 | 0.00000 | 0.222 | 0.612 | 1.805 | 0.420 |
| 238 | 2.170 | 0.000 | 0.000 | 5.032 | 0.000 | 0.00000 | 0.00000 | 0.224 | 0.620 | 1.841 | 0.430 |
| 228 | 2.170 | 0.000 | 0.000 | 5.070 | 0.000 | 0.00000 | 0.00000 | 0.225 | 0.628 | 1.878 | 0.439 |
| 218 | 2.170 | 0.010 | 0.022 | 5.102 | 0.111 | 0.56490 | 0.00000 | 0.248 | 0.748 | 2.481 | 0.449 |
| 208 | 2.170 | 0.022 | 0.048 | 5.134 | 0.245 | 1.25818 | 0.00000 | 0.276 | 0.890 | 3.212 | 0.459 |
| 198 | 2.170 | 0.045 | 0.098 | 5.160 | 0.504 | 2.59969 | 0.00002 | 0.327 | 1.158 | 4.593 | 0.469 |
| 188 | 2.170 | 0.072 | 0.156 | 5.184 | 0.810 | 4.19829 | 0.00007 | 0.388 | 1.472 | 6.230 | 0.480 |
| 178 | 2.170 | 0.103 | 0.224 | 5.222 | 1.167 | 6.09499 | 0.00020 | 0.457 | 1.842 | 8.184 | 0.495 |
| 164 | 2.130 | 0.147 | 0.313 | 5.206 | 1.630 | 8.48680 | 0.00056 | 0.664 | 2.645 | 11.628 | 0.749 |
| 159 | 2.130 | 0.167 | 0.356 | 5.212 | 1.854 | 9.66451 | 0.00083 | 0.707 | 2.875 | 12.832 | 0.756 |
| 155 | 2.130 | 0.182 | 0.388 | 5.269 | 2.042 | 10.76113 | 0.00107 | 0.743 | 3.086 | 14.033 | 0.784 |
| 138 | 2.130 | 0.270 | 0.575 | 5.262 | 3.026 | 15.92495 | 0.00349 | 0.933 | 4.083 | 19.259 | 0.803 |
| 128 | 2.130 | 0.330 | 0.703 | 5.270 | 3.704 | 19.51935 | 0.00638 | 1.063 | 4.774 | 22.916 | 0.822 |
| 118 | 2.090 | 0.400 | 0.836 | 5.262 | 4.399 | 23.14947 | 0.01115 | 1.318 | 5.839 | 27.737 | 1.122 |
| 108 | 2.090 | 0.470 | 0.982 | 5.265 | 5.172 | 27.22647 | 0.01808 | 1.467 | 6.630 | 31.900 | 1.151 |
| 98 | 2.090 | 0.560 | 1.170 | 5.257 | 6.153 | 32.34769 | 0.03059 | 1.658 | 7.630 | 37.108 | 1.187 |
| 88 | 2.090 | 0.670 | 1.400 | 5.232 | 7.327 | 38.33450 | 0.05238 | 1.891 | 8.818 | 43.165 | 1.228 |
| 80 | 2.090 | 0.760 | 1.588 | 5.232 | 8.311 | 43.48391 | 0.07645 | 2.082 | 9.824 | 48.421 | 1.280 |
| 68 | 2.050 | 0.950 | 1.948 | 5.165 | 10.058 | 51.94786 | 0.14647 | 2.568 | 11.967 | 58.197 | 1.681 |
| 58 | 2.050 | 1.200 | 2.460 | 5.077 | 12.490 | 63.41378 | 0.29520 | 3.084 | 14.422 | 69.777 | 1.861 |
| 48 | 2.050 | 1.500 | 3.075 | 5.025 | 15.451 | 77.63640 | 0.57656 | 3.709 | 17.445 | 84.301 | 2.223 |
| 22 | 2.010 | 2.918 | 5.865 | 4.317 | 25.320 | 109.30353 | 4.16159 | 6.626 | 27.713 | 117.299 | 6.149 |
| 19 | 2.010 | 2.496 | 5.017 | 4.599 | 23.074 | 106.12195 | 2.60465 | 5.786 | 25.522 | 114.389 | 4.666 |
| 0 | 2.010 | 2.000 | 4.020 | 3.240 | 13.025 | 42.20035 | 1.34000 | 4.596 | 14.392 | 45.685 | 2.135 |

| TENSION | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 111 | 112 | 113 | 114 | 115 | 116 | 117 | 118 | 119 | 120 | 121 | 122 | 123 | 124 |
| | CARBON CAP | CARBON CAP | CARBON CAP | | | | | SPAR BOOM | SPAR BOOM | SPAR BOOM | | | | |
| STATION | TRANSFORMED | DEPTH | TRANSFORMED | Y | AY | $AY^2$ | Io | TRANSFORMED | DEPTH | TRANSFORMED | Y | AY | $AY^2$ | Io |
| (in) | WIDTH | (in) | AREA | | | | | WIDTH | (in) | AREA | | | | |
| | (in) | | (in2) | | | | | (in) | | (in2) | | | | |
| 258 | 1.085 | 0.020 | 0.022 | 0.010 | 0.000 | 0.00000 | 0.00000 | 2.170 | 0.000 | 0.000 | 0.020 | 0.000 | 0.00000 | 0.00000 |
| 251 | 1.085 | 0.020 | 0.022 | 0.010 | 0.000 | 0.00000 | 0.00000 | 2.170 | 0.000 | 0.000 | 0.020 | 0.000 | 0.00000 | 0.00000 |
| 238 | 1.085 | 0.020 | 0.022 | 0.010 | 0.000 | 0.00000 | 0.00000 | 2.170 | 0.000 | 0.000 | 0.020 | 0.000 | 0.00000 | 0.00000 |
| 228 | 1.085 | 0.020 | 0.022 | 0.010 | 0.000 | 0.00000 | 0.00000 | 2.170 | 0.000 | 0.000 | 0.020 | 0.000 | 0.00000 | 0.00000 |
| 218 | 1.085 | 0.020 | 0.022 | 0.010 | 0.000 | 0.00000 | 0.00000 | 2.170 | 0.010 | 0.022 | 0.025 | 0.001 | 0.00001 | 0.00000 |
| 208 | 1.085 | 0.020 | 0.022 | 0.010 | 0.000 | 0.00000 | 0.00000 | 2.170 | 0.022 | 0.048 | 0.031 | 0.001 | 0.00005 | 0.00000 |
| 198 | 1.085 | 0.020 | 0.022 | 0.010 | 0.000 | 0.00000 | 0.00000 | 2.170 | 0.045 | 0.098 | 0.043 | 0.004 | 0.00018 | 0.00002 |
| 188 | 1.085 | 0.020 | 0.022 | 0.010 | 0.000 | 0.00000 | 0.00000 | 2.170 | 0.072 | 0.156 | 0.056 | 0.009 | 0.00049 | 0.00007 |
| 178 | 1.085 | 0.020 | 0.022 | 0.010 | 0.000 | 0.00000 | 0.00000 | 2.170 | 0.103 | 0.224 | 0.072 | 0.016 | 0.00114 | 0.00020 |
| 164 | 1.065 | 0.030 | 0.032 | 0.015 | 0.000 | 0.00001 | 0.00000 | 2.130 | 0.147 | 0.313 | 0.104 | 0.032 | 0.00335 | 0.00056 |
| 159 | 1.065 | 0.030 | 0.032 | 0.015 | 0.000 | 0.00001 | 0.00000 | 2.130 | 0.167 | 0.356 | 0.114 | 0.040 | 0.00458 | 0.00083 |
| 155 | 1.065 | 0.030 | 0.032 | 0.015 | 0.000 | 0.00001 | 0.00000 | 2.130 | 0.182 | 0.388 | 0.121 | 0.047 | 0.00568 | 0.00107 |
| 138 | 1.065 | 0.030 | 0.032 | 0.015 | 0.000 | 0.00001 | 0.00000 | 2.130 | 0.270 | 0.575 | 0.165 | 0.095 | 0.01566 | 0.00349 |
| 128 | 1.065 | 0.030 | 0.032 | 0.015 | 0.000 | 0.00001 | 0.00000 | 2.130 | 0.330 | 0.703 | 0.195 | 0.137 | 0.02673 | 0.00638 |
| 118 | 1.045 | 0.040 | 0.042 | 0.020 | 0.001 | 0.00002 | 0.00001 | 2.090 | 0.400 | 0.836 | 0.240 | 0.201 | 0.04815 | 0.01115 |
| 108 | 1.045 | 0.040 | 0.042 | 0.020 | 0.001 | 0.00002 | 0.00001 | 2.090 | 0.470 | 0.982 | 0.275 | 0.270 | 0.07429 | 0.01808 |
| 98 | 1.045 | 0.040 | 0.042 | 0.020 | 0.001 | 0.00002 | 0.00001 | 2.090 | 0.560 | 1.170 | 0.320 | 0.375 | 0.11985 | 0.03059 |
| 88 | 1.045 | 0.040 | 0.042 | 0.020 | 0.001 | 0.00002 | 0.00001 | 2.090 | 0.670 | 1.400 | 0.375 | 0.525 | 0.19692 | 0.05238 |
| 80 | 1.045 | 0.040 | 0.042 | 0.020 | 0.001 | 0.00002 | 0.00001 | 2.090 | 0.760 | 1.588 | 0.420 | 0.667 | 0.28019 | 0.07645 |
| 68 | 1.025 | 0.050 | 0.051 | 0.025 | 0.001 | 0.00003 | 0.00001 | 2.050 | 0.950 | 1.948 | 0.525 | 1.022 | 0.53678 | 0.14647 |
| 58 | 1.025 | 0.050 | 0.051 | 0.025 | 0.001 | 0.00003 | 0.00001 | 2.050 | 1.200 | 2.460 | 0.650 | 1.599 | 1.03935 | 0.29520 |
| 48 | 1.025 | 0.050 | 0.051 | 0.025 | 0.001 | 0.00003 | 0.00001 | 2.050 | 1.500 | 3.075 | 0.800 | 2.460 | 1.96800 | 0.57656 |
| 22 | 1.005 | 0.060 | 0.060 | 0.030 | 0.002 | 0.00005 | 0.00002 | 2.010 | 2.918 | 5.865 | 1.519 | 8.909 | 13.53275 | 4.16159 |
| 19 | 1.005 | 0.060 | 0.060 | 0.030 | 0.002 | 0.00005 | 0.00002 | 2.010 | 2.496 | 5.017 | 1.308 | 6.562 | 8.58334 | 2.60465 |
| 0 | 1.005 | 0.060 | 0.060 | 0.030 | 0.002 | 0.00005 | 0.00002 | 2.010 | 2.000 | 4.020 | 1.060 | 4.261 | 4.51687 | 1.34000 |

| TENSION | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 125 | 126 | 127 | 128 | 129 | 130 | 131 | 132 | 133 | 134 | 135 |
| | | | | | TOTAL | TOTAL | TOTAL | TOTAL | MOI | DIST TO | MOI |
| STATION | Σ A | Σ AY | Σ AY² | Σ Io | Σ A | Σ AY | Σ AY² | Σ Io | ABT DATUM | NA | ABT NA |
| (in) | | | | | | | | - | | | |
| | | | | | | | | | | | |
| 258 | 0.022 | 0.000 | 0.000 | 0.000 | 0.242 | 0.601 | 1.757 | 0.408 | 2.165 | 2.483 | 0.673 |
| 251 | 0.022 | 0.000 | 0.000 | 0.000 | 0.244 | 0.612 | 1.805 | 0.420 | 2.225 | 2.507 | 0.691 |
| 238 | 0.022 | 0.000 | 0.000 | 0.000 | 0.245 | 0.620 | 1.841 | 0.430 | 2.271 | 2.526 | 0.705 |
| 228 | 0.022 | 0.000 | 0.000 | 0.000 | 0.247 | 0.629 | 1.878 | 0.439 | 2.318 | 2.545 | 0.718 |
| 218 | 0.043 | 0.001 | 0.000 | 0.000 | 0.292 | 0.748 | 2.481 | 0.449 | 2.930 | 2.564 | 1.012 |
| 208 | 0.069 | 0.002 | 0.000 | 0.000 | 0.345 | 0.892 | 3.212 | 0.459 | 3.672 | 2.582 | 1.368 |
| 198 | 0.119 | 0.004 | 0.000 | 0.000 | 0.447 | 1.162 | 4.593 | 0.469 | 5.062 | 2.601 | 2.039 |
| 188 | 0.178 | 0.009 | 0.000 | 0.000 | 0.565 | 1.481 | 6.231 | 0.480 | 6.710 | 2.620 | 2.829 |
| 178 | 0.245 | 0.016 | 0.001 | 0.000 | 0.702 | 1.858 | 8.185 | 0.495 | 8.680 | 2.647 | 3.761 |
| 164 | 0.345 | 0.033 | 0.003 | 0.001 | 1.009 | 2.678 | 11.631 | 0.750 | 12.381 | 2.655 | 5.271 |
| 159 | 0.388 | 0.041 | 0.005 | 0.001 | 1.095 | 2.916 | 12.836 | 0.757 | 13.593 | 2.663 | 5.829 |
| 155 | 0.420 | 0.047 | 0.006 | 0.001 | 1.163 | 3.133 | 14.038 | 0.785 | 14.823 | 2.695 | 6.380 |
| 138 | 0.607 | 0.095 | 0.016 | 0.003 | 1.540 | 4.178 | 19.274 | 0.806 | 20.081 | 2.714 | 8.743 |
| 128 | 0.735 | 0.138 | 0.027 | 0.006 | 1.798 | 4.912 | 22.943 | 0.829 | 23.772 | 2.732 | 10.351 |
| 118 | 0.878 | 0.201 | 0.048 | 0.011 | 2.196 | 6.041 | 27.785 | 1.133 | 28.918 | 2.751 | 12.299 |
| 108 | 1.024 | 0.271 | 0.074 | 0.018 | 2.491 | 6.901 | 31.974 | 1.170 | 33.144 | 2.770 | 14.030 |
| 98 | 1.212 | 0.375 | 0.120 | 0.031 | 2.871 | 8.005 | 37.228 | 1.218 | 38.446 | 2.789 | 16.123 |
| 88 | 1.442 | 0.526 | 0.197 | 0.052 | 3.333 | 9.344 | 43.362 | 1.280 | 44.642 | 2.804 | 18.446 |
| 80 | 1.630 | 0.668 | 0.280 | 0.076 | 3.713 | 10.492 | 48.702 | 1.357 | 50.058 | 2.826 | 20.407 |
| 68 | 1.999 | 1.024 | 0.537 | 0.146 | 4.566 | 12.991 | 58.734 | 1.828 | 60.562 | 2.845 | 23.605 |
| 58 | 2.511 | 1.600 | 1.039 | 0.295 | 5.595 | 16.022 | 70.816 | 2.156 | 72.972 | 2.864 | 27.090 |
| 48 | 3.126 | 2.461 | 1.968 | 0.577 | 6.835 | 19.906 | 86.269 | 2.800 | 89.069 | 2.912 | 31.096 |
| 22 | 5.925 | 8.911 | 13.533 | 4.162 | 12.551 | 36.624 | 130.832 | 10.311 | 141.143 | 2.918 | 34.275 |
| 19 | 5.077 | 6.564 | 8.583 | 2.605 | 10.863 | 32.086 | 122.972 | 7.271 | 130.243 | 2.954 | 35.473 |
| 0 | 4.080 | 4.263 | 4.517 | 1.340 | 8.677 | 18.655 | 50.202 | 3.475 | 53.677 | 2.150 | 13.569 |

| SPAR STRESSING | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | ACTUAL STRENGTHS | | | | | | | | | |
| $F_{cu\ boom}$ = | 130000 | psi | | | | | | | | |
| $F_{cu\ 45\ shear\ web}$ = | 40000 | psi | | | | | | | | |
| $F_{su\ shear\ web}$ = | 16667 | psi | | | | | | | | |
| | | | | | | | | | | |
| 1 | 136 | 137 | 138 | 139 | 140 | 141 | 142 | 143 | 144 | 145 |
| STATION (in) | CALCULATED MOI ABT NA | TEST FACTORED ULT MOMENT (lb in) | QUICK BENDING STRESS CHECK AT EXTREME FIBRE (psi) | COMPRESSIVE BENDING STRESS ON BOOM CENTROID (psi) | RF BENDING | COMPRESSIVE BENDING STRESS ON BOOM INNER FIBRE (psi) | RF BENDING | COMPRESSIVE BENDING STRESS ON BOOM OUTER FIBRE (psi) | RF BENDING | ULT STRAIN |
| 258 | 0.673 | 0 | 0 | 0 | #DIV/0! | 0 | - | 0 | - | 0.000 |
| 251 | 0.691 | 337 | 2443 | 2423 | 53.65 | 2423 | 53.65 | 2423 | 53.65 | 0.000 |
| 238 | 0.705 | 3248 | 23286 | 23102 | 5.63 | 23102 | 5.63 | 23102 | 5.63 | 0.002 |
| 228 | 0.718 | 7612 | 53934 | 53510 | 2.43 | 53510 | 2.43 | 53510 | 2.43 | 0.005 |
| 218 | 1.012 | 13948 | 70667 | 69978 | 1.86 | 69840 | 1.86 | 70116 | 1.85 | 0.007 |
| 208 | 1.368 | 22320 | 84271 | 83259 | 1.56 | 82900 | 1.57 | 83618 | 1.55 | 0.008 |
| 198 | 2.039 | 32782 | 83628 | 82262 | 1.58 | 81538 | 1.59 | 82985 | 1.57 | 0.008 |
| 188 | 2.829 | 45370 | 84023 | 82227 | 1.58 | 81072 | 1.60 | 83381 | 1.56 | 0.008 |
| 178 | 3.761 | 60111 | 84601 | 82316 | 1.58 | 80670 | 1.61 | 83962 | 1.55 | 0.008 |
| 164 | 5.271 | 85243 | 85865 | 82518 | 1.58 | 80140 | 1.62 | 84895 | 1.53 | 0.008 |
| 159 | 5.829 | 93686 | 85598 | 81950 | 1.59 | 79266 | 1.64 | 84634 | 1.54 | 0.008 |
| 155 | 6.380 | 102401 | 86505 | 82620 | 1.57 | 79699 | 1.63 | 85542 | 1.52 | 0.009 |
| 138 | 8.743 | 140840 | 87430 | 82114 | 1.58 | 77765 | 1.67 | 86464 | 1.50 | 0.009 |
| 128 | 10.351 | 166767 | 88040 | 81757 | 1.59 | 76441 | 1.70 | 87074 | 1.49 | 0.009 |
| 118 | 12.299 | 195043 | 87254 | 79642 | 1.63 | 73299 | 1.77 | 85985 | 1.51 | 0.009 |
| 108 | 14.030 | 225701 | 89118 | 80270 | 1.62 | 72709 | 1.79 | 87831 | 1.48 | 0.009 |
| 98 | 16.123 | 258775 | 89512 | 79241 | 1.64 | 70253 | 1.85 | 88228 | 1.47 | 0.009 |
| 88 | 18.446 | 294286 | 89457 | 77491 | 1.68 | 66802 | 1.95 | 88180 | 1.47 | 0.009 |
| 80 | 20.407 | 324402 | 89853 | 76499 | 1.70 | 64418 | 2.02 | 88581 | 1.47 | 0.009 |
| 68 | 23.605 | 372534 | 89796 | 73225 | 1.78 | 58232 | 2.23 | 88218 | 1.47 | 0.009 |
| 58 | 27.090 | 415438 | 87829 | 67893 | 1.91 | 49491 | 2.63 | 86296 | 1.51 | 0.009 |
| 48 | 31.096 | 460817 | 86318 | 62607 | 2.08 | 40378 | 3.22 | 84836 | 1.53 | 0.008 |
| 22 | 34.275 | 592104 | 100817 | 48336 | 2.69 | -2073 | -62.71 | 98744 | 1.32 | 0.010 |
| 19 | 35.473 | 608501 | 101331 | 56456 | 2.30 | 13641 | 9.53 | 99272 | 1.31 | 0.010 |
| 0 | 13.569 | 718675 | 227740 | 115459 | 1.13 | 9533 | 13.64 | 221384 | 0.59 | 0.022 |

SPAR STRESSING

| 1 | 146 | 147 | 148 | 149 | 150 | 151 | 152 |
|---|---|---|---|---|---|---|---|
| | COMPRESSIVE | | COMPRESSIVE | | COMPRESSIVE | | |
| | BENDING | | BENDING | | BENDING | | |
| | STRESS | RF | STRESS | RF | STRESS | RF | |
| STATION | ON CARBON | | ON CARBON | BENDING | ON CARBON | BENDING | ULT |
| (in) | CENTROID | | INNER FIBRE | | OUTER FIBRE | | STRAIN |
| | (psi) | | (psi) | | (psi) | | |
| 258 | 0 | - | 0 | - | 0 | - | 0.000 |
| 251 | 1216 | 32.88 | 1212 | 33.02 | 1221 | 32.75 | 0.000 |
| 238 | 11597 | 3.45 | 11551 | 3.46 | 11643 | 3.44 | 0.002 |
| 228 | 26861 | 1.49 | 26755 | 1.50 | 26967 | 1.48 | 0.005 |
| 218 | 35196 | 1.14 | 35058 | 1.14 | 35334 | 1.13 | 0.007 |
| 208 | 41972 | 0.95 | 41809 | 0.96 | 42135 | 0.95 | 0.008 |
| 198 | 41653 | 0.96 | 41493 | 0.96 | 41814 | 0.96 | 0.008 |
| 188 | 41851 | 0.96 | 41691 | 0.96 | 42011 | 0.95 | 0.008 |
| 178 | 42141 | 0.95 | 41981 | 0.95 | 42301 | 0.95 | 0.008 |
| 164 | 42690 | 0.94 | 42447 | 0.94 | 42932 | 0.93 | 0.009 |
| 159 | 42558 | 0.94 | 42317 | 0.95 | 42799 | 0.93 | 0.009 |
| 155 | 43012 | 0.93 | 42771 | 0.94 | 43252 | 0.92 | 0.009 |
| 138 | 43474 | 0.92 | 43232 | 0.93 | 43715 | 0.92 | 0.009 |
| 128 | 43779 | 0.91 | 43537 | 0.92 | 44020 | 0.91 | 0.009 |
| 118 | 43310 | 0.92 | 42992 | 0.93 | 43627 | 0.92 | 0.009 |
| 108 | 44237 | 0.90 | 43915 | 0.91 | 44559 | 0.90 | 0.009 |
| 98 | 44435 | 0.90 | 44114 | 0.91 | 44756 | 0.89 | 0.009 |
| 88 | 44409 | 0.90 | 44090 | 0.91 | 44728 | 0.89 | 0.009 |
| 80 | 44608 | 0.90 | 44291 | 0.90 | 44926 | 0.89 | 0.009 |
| 68 | 44504 | 0.90 | 44109 | 0.91 | 44898 | 0.89 | 0.009 |
| 58 | 43531 | 0.92 | 43148 | 0.93 | 43915 | 0.91 | 0.009 |
| 48 | 42788 | 0.93 | 42418 | 0.94 | 43159 | 0.93 | 0.009 |
| 22 | 49890 | 0.80 | 49372 | 0.81 | 50409 | 0.79 | 0.010 |
| 19 | 50151 | 0.80 | 49636 | 0.81 | 50665 | 0.79 | 0.010 |
| 0 | 112281 | 0.36 | 110692 | 0.36 | 113870 | 0.35 | 0.023 |

| 1 | 153 | 154 | 155 | 156 | 157 | 158 |
|---|---|---|---|---|---|---|
| | WEB | | BOOM | | GLASS | |
| | COMPRESSIVE | | COMPRESSIVE | | COMPRESSIVE | |
| | LOAD DUE | SHEAR | LOAD DUE | SHEAR | LOAD DUE | SHEAR |
| STATION | TO BENDING | STRESS | TO BENDING | STRESS | TO BENDING | STRESS |
| (in) | (lb) | (psi) | (lb) | (psi) | (lb) | (psi) |
| | | | | | | |
| 258 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 251 | 121.51 | 450.05 | 0.00 | 0.00 | 26.40 | 3.60 |
| 238 | 1167.16 | 1972.92 | 0.00 | 0.00 | 251.66 | 15.67 |
| 228 | 2723.50 | 3890.86 | 0.00 | 0.00 | 582.88 | 30.53 |
| 218 | 3580.84 | 2143.34 | 379.63 | 34.99 | 763.75 | 16.67 |
| 208 | 4281.55 | 1751.76 | 993.70 | 56.60 | 910.80 | 13.55 |
| 198 | 4241.79 | -99.38 | 2008.22 | 93.50 | 903.88 | -0.64 |
| 188 | 4247.95 | 15.39 | 3211.78 | 110.93 | 908.17 | 0.40 |
| 178 | 4270.25 | 55.76 | 4599.59 | 127.91 | 914.45 | 0.58 |
| 164 | 6382.86 | 2453.67 | 6459.27 | 121.68 | 1363.94 | 29.41 |
| 159 | 6332.48 | -194.11 | 7287.59 | 179.83 | 1359.73 | -0.92 |
| 155 | 6443.33 | 427.16 | 8007.16 | 156.22 | 1374.22 | 3.15 |
| 138 | 6330.67 | -110.46 | 11805.98 | 209.82 | 1388.98 | 0.82 |
| 128 | 6265.88 | -107.97 | 14366.79 | 240.45 | 1398.73 | 0.91 |
| 118 | 8066.07 | 2250.23 | 16645.13 | 218.02 | 1810.34 | 39.39 |
| 108 | 8055.71 | -12.95 | 19712.26 | 293.51 | 1849.11 | 3.71 |
| 98 | 7836.28 | -274.29 | 23185.80 | 332.40 | 1857.39 | 0.79 |
| 88 | 7491.45 | -431.03 | 27127.73 | 377.22 | 1856.31 | -0.10 |
| 80 | 7282.03 | -327.22 | 30377.90 | 388.78 | 1864.63 | 1.00 |
| 68 | 8283.02 | 834.16 | 35651.33 | 428.73 | 2280.81 | 33.84 |
| 58 | 7086.08 | -1196.94 | 41754.40 | 595.42 | 2230.98 | -4.86 |
| 48 | 5879.74 | -1206.35 | 48128.98 | 621.91 | 2192.90 | -3.72 |
| 22 | -362.94 | -2000.86 | 70873.64 | 870.44 | 3008.39 | 31.21 |
| 19 | 2417.35 | 7723.02 | 70809.98 | -21.12 | 3024.09 | 5.21 |
| 0 | 1229.79 | -520.86 | 116035.97 | 2368.47 | 6770.54 | 196.20 |

| 1 | 164 | 165 | 166 | 167 | 168 | 169 |
|---|---|---|---|---|---|---|
| | MAX SHEAR | | MAX SHEAR | | MAX SHEAR | |
| | STRESS | | STRESS | | STRESS | |
| | INTRA | RF | BTWN CORE | RF | BTWN BOOM | RF |
| STATION | AT NA | SHEAR | AND BOOM | SHEAR | AND GLASS | SHEAR |
| (in) | CHECK | | (psi) | | (psi) | |
| | (psi) | | | | | |
| 258 | 0.00 | - | 0.00 | - | 0.00 | - |
| 251 | 1103.64 | 15.10 | 14.45 | 1153.73 | 14.45 | 1153.73 |
| 238 | 3736.83 | 4.46 | 48.61 | 342.84 | 48.61 | 342.84 |
| 228 | 5832.23 | 2.86 | 75.41 | 221.00 | 75.41 | 221.00 |
| 218 | 6783.09 | 2.46 | 148.22 | 112.45 | 74.22 | 224.56 |
| 208 | 7667.13 | 2.17 | 226.19 | 73.69 | 70.88 | 235.13 |
| 198 | 8205.51 | 2.03 | 320.96 | 51.93 | 58.66 | 284.14 |
| 188 | 8939.45 | 1.86 | 410.84 | 40.57 | 50.49 | 330.08 |
| 178 | 9773.82 | 1.71 | 497.05 | 33.53 | 44.46 | 374.88 |
| 164 | 8129.67 | 2.05 | 615.46 | 27.08 | 57.86 | 288.03 |
| 159 | 8268.93 | 2.02 | 646.72 | 25.77 | 54.22 | 307.37 |
| 155 | 8373.35 | 1.99 | 666.78 | 25.00 | 51.71 | 322.30 |
| 138 | 9861.31 | 1.69 | 850.78 | 19.59 | 45.99 | 362.43 |
| 128 | 10713.00 | 1.56 | 953.12 | 17.49 | 42.79 | 389.48 |
| 118 | 9042.46 | 1.84 | 1060.77 | 15.71 | 52.52 | 317.34 |
| 108 | 9793.59 | 1.70 | 1173.88 | 14.20 | 50.14 | 332.43 |
| 98 | 10640.14 | 1.57 | 1299.51 | 12.83 | 47.27 | 352.55 |
| 88 | 11629.36 | 1.43 | 1440.69 | 11.57 | 44.50 | 374.49 |
| 80 | 12389.86 | 1.35 | 1545.19 | 10.79 | 42.57 | 391.55 |
| 68 | 11465.11 | 1.45 | 1782.07 | 9.35 | 49.99 | 333.38 |
| 58 | 13054.19 | 1.28 | 2032.03 | 8.20 | 46.46 | 358.75 |
| 48 | 14920.69 | 1.12 | 2303.27 | 7.24 | 43.47 | 383.38 |
| 22 | 24208.15 | 0.69 | 4051.92 | 4.11 | 55.26 | 301.59 |
| 19 | 20706.81 | 0.80 | 3610.64 | 4.62 | 54.62 | 305.15 |
| 0 | 34958.85 | 0.48 | 5944.11 | 2.80 | 115.23 | 144.64 |
| | | | ignoring contribution from s web | | | |

| SPAR WEIGHT ESTIMATE | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 3 | 170 | 171 | 172 | 173 | 174 | 175 | 176 | |
| | | 0.055 | 0.055 | | | | | | |
| | dy | TOTAL | SHEAR | CARBON | TOTAL | BOOM + WEB | XTRAS | SPAR TOTAL | |
| STATION | (in) | BOOM WEIGHT | WEB WEIGHT | CAP WEIGHT | WEB WEIGHT | TOTAL WEIGH | 0.10 | WEIGHT EST | |
| (in) | | (lb) | (lb) | (lb) | (lb) | (lb) | (lb) | (lb) | |
| 258 | 6.75 | 0.000 | 0.074 | 0.008 | 0.082 | 0.082 | 0.008 | 0.090 | |
| 251 | 13.25 | 0.000 | 0.146 | 0.016 | 0.162 | 0.162 | 0.016 | 0.178 | |
| 238 | 10.00 | 0.000 | 0.111 | 0.012 | 0.123 | 0.123 | 0.012 | 0.135 | |
| 228 | 10.00 | 0.000 | 0.112 | 0.012 | 0.124 | 0.124 | 0.012 | 0.136 | |
| 218 | 10.00 | 0.012 | 0.113 | 0.012 | 0.125 | 0.137 | 0.014 | 0.150 | |
| 208 | 10.00 | 0.026 | 0.114 | 0.012 | 0.126 | 0.152 | 0.015 | 0.167 | |
| 198 | 10.00 | 0.054 | 0.114 | 0.012 | 0.126 | 0.180 | 0.018 | 0.198 | |
| 188 | 10.00 | 0.086 | 0.115 | 0.012 | 0.127 | 0.213 | 0.021 | 0.234 | |
| 178 | 14.35 | 0.176 | 0.167 | 0.017 | 0.184 | 0.361 | 0.036 | 0.397 | |
| 164 | 4.33 | 0.074 | 0.076 | 0.008 | 0.083 | 0.158 | 0.016 | 0.174 | |
| 159 | 4.32 | 0.085 | 0.076 | 0.008 | 0.084 | 0.168 | 0.017 | 0.185 | |
| 155 | 17.00 | 0.362 | 0.302 | 0.030 | 0.332 | 0.695 | 0.069 | 0.764 | |
| 138 | 10.00 | 0.316 | 0.179 | 0.018 | 0.197 | 0.513 | 0.051 | 0.564 | |
| 128 | 10.00 | 0.387 | 0.180 | 0.018 | 0.198 | 0.585 | 0.058 | 0.643 | |
| 118 | 10.00 | 0.460 | 0.242 | 0.023 | 0.265 | 0.725 | 0.072 | 0.797 | |
| 108 | 10.00 | 0.540 | 0.244 | 0.023 | 0.267 | 0.807 | 0.081 | 0.888 | |
| 98 | 10.00 | 0.644 | 0.245 | 0.023 | 0.268 | 0.912 | 0.091 | 1.003 | |
| 88 | 8.00 | 0.616 | 0.197 | 0.018 | 0.216 | 0.832 | 0.083 | 0.915 | |
| 80 | 12.00 | 1.048 | 0.298 | 0.028 | 0.326 | 1.374 | 0.137 | 1.512 | |
| 68 | 10.00 | 1.071 | 0.313 | 0.028 | 0.341 | 1.412 | 0.141 | 1.553 | |
| 58 | 10.00 | 1.353 | 0.315 | 0.028 | 0.343 | 1.696 | 0.170 | 1.866 | |
| 48 | 26.00 | 4.397 | 0.833 | 0.073 | 0.906 | 5.303 | 0.530 | 5.834 | |
| 22 | 3.00 | 0.968 | 0.116 | 0.010 | 0.126 | 1.093 | 0.109 | 1.203 | |
| 19 | 19.00 | 5.243 | 0.741 | 0.063 | 0.804 | 6.046 | 0.605 | 6.651 | |
| 0 | Σ= | 17.919 | 5.424 | 0.510 | 5.935 | 23.853 | Σ= | 26.239 | |
| | Σ= | 39.493 | 11.955 | kg | | | 2.39 | 57.830 | kg |
| | | | | | | (PLY+FOAM+BELLCRANKS) | | | |

# APPENDIX G: SUMMARY OF MOST UNFAVOURABLE COMBINATIONS OF CHORDWISE LOAD

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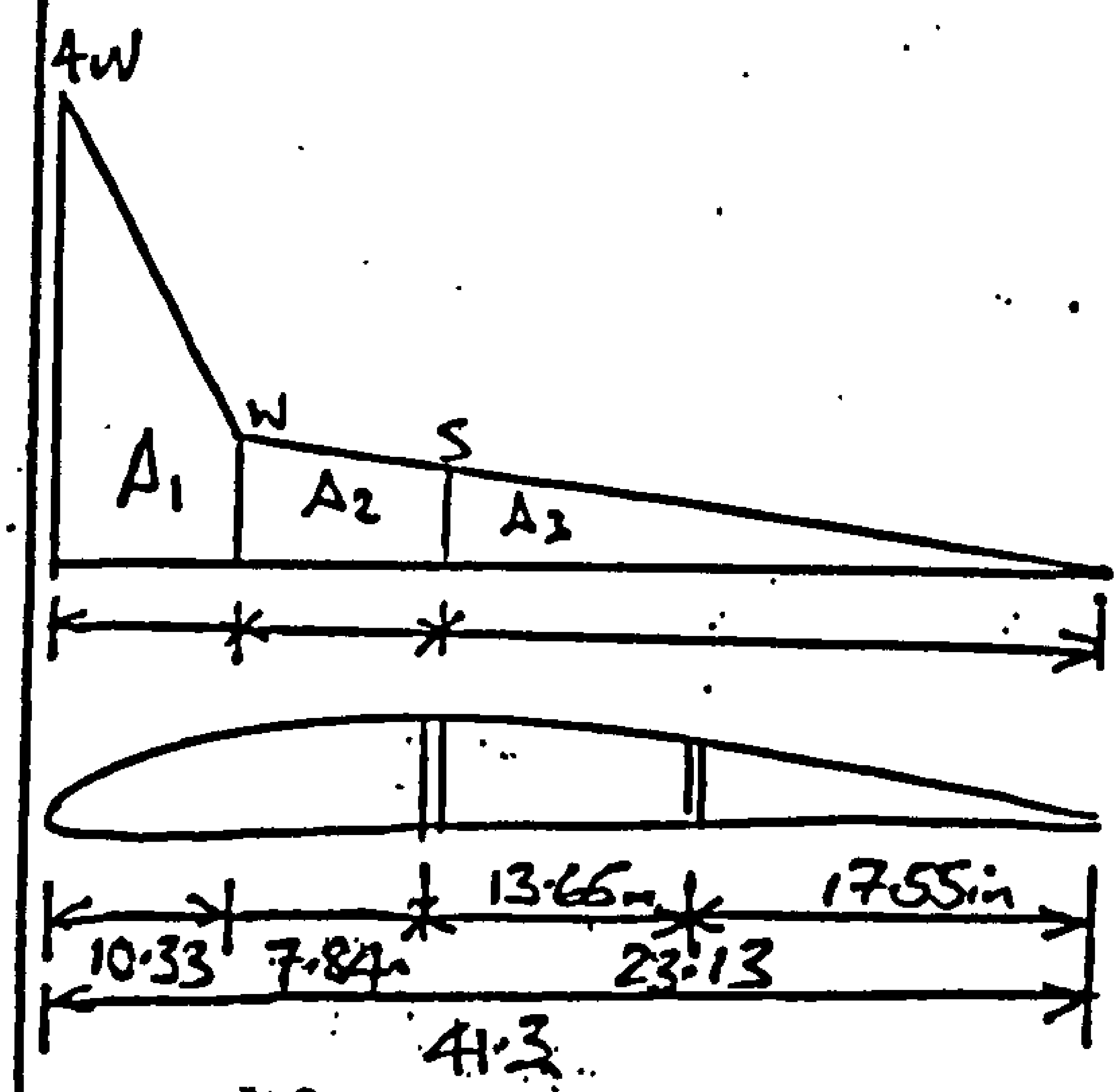
|---|---|---|
| Checked by: | | Issue: |
| Date: | | Page of |

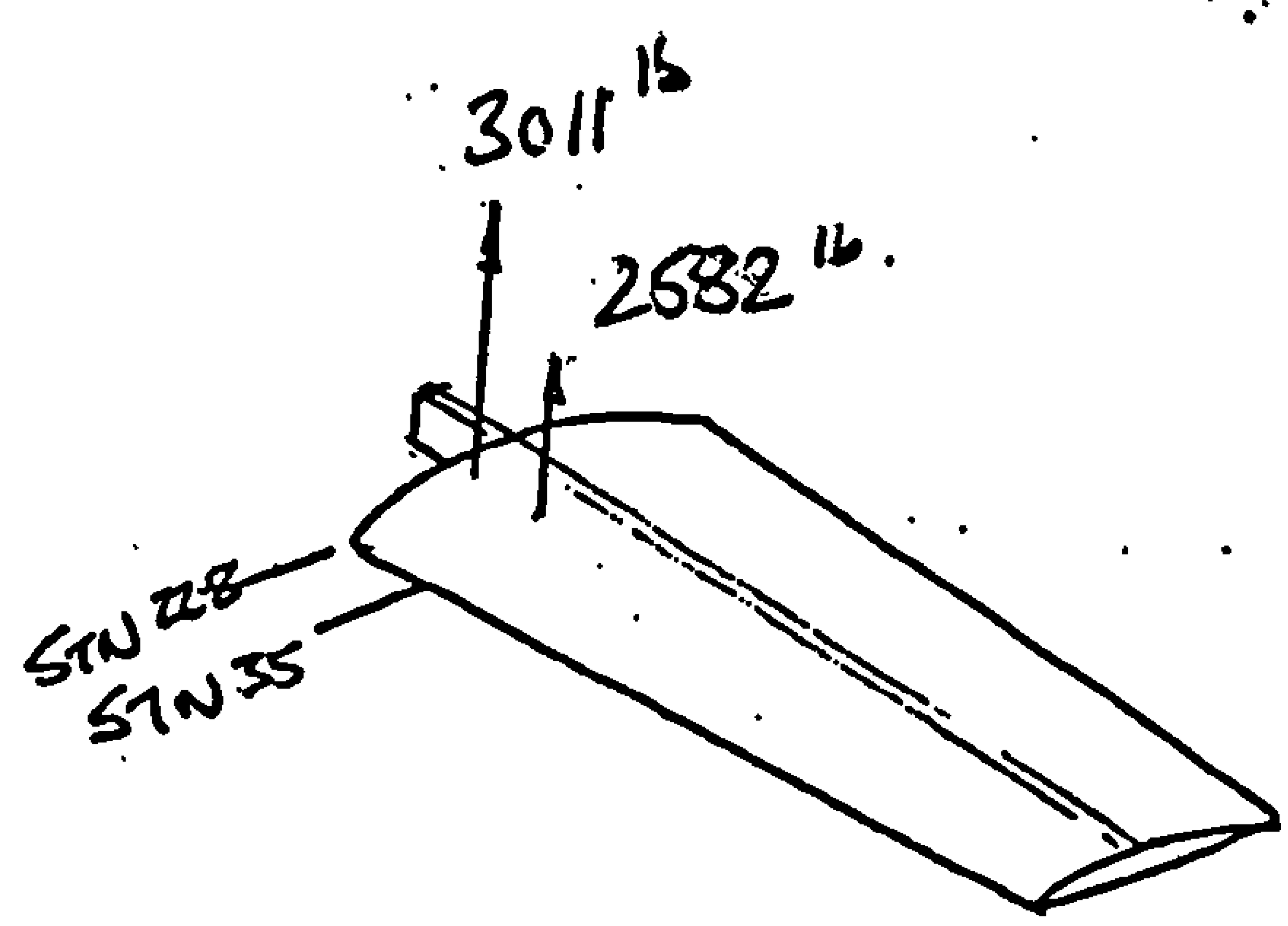
Subject:
DERIVATION OF MAIN WING LOADS

INTRODUCTION:

CHORDWISE PRESSURE DISTRIBUTION

CONSIDER HIGH ANGLE OF ATTACK, FWD CP CASE
SPANWISE LOAD FROM CONDITION A ULTIMATE LOAD CASE,
NORMAL SHEAR AT 3.8g.




$C/4 = 41.3/4 = 10.33in$

SHEAR OVER ROOT PANEL FROM SHRENK APPROXIMATION

$= 3011 - 2582 = 429$ lb.

$\varpi = 429$ lb.

STRIP LOAD w $= \dfrac{429}{41.3} = 10.39$ lb/in

USING JAR-VLA DISTRIBUTION

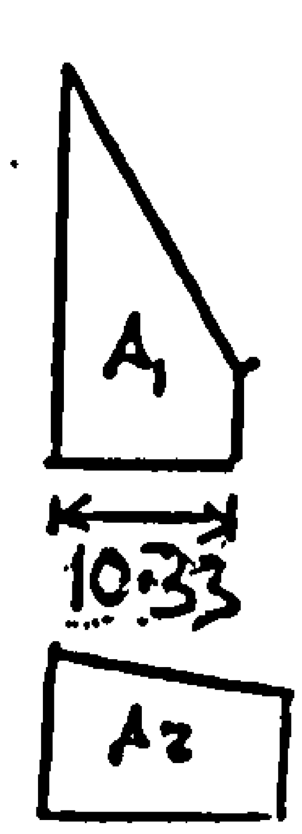
$w = 10.39$ lb/in

$4w = 41.56$ lb/in

$$S = \left[\frac{41.3 - 18.17}{41.3 - 10.33}\right] * 10.39$$

$= 7.76$ lb/in AT SPAR LOCATION

$$A_1 = \left[\left[\frac{41.56 - 10.39}{2}\right] + 10.39\right] * 10.33 = 268.32$$




$$A_2 = \left[\left[\frac{10.39 - 7.76}{2}\right] + 7.76\right] * 7.84 = 71.15 \text{ lb}$$

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|---|---|---|
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Subject:

DERIVATION OF MAIN WING LOADS

INTRODUCTION:

DISTANCE FROM SPAR

$$X_1 = \frac{10.33}{3}\left[\frac{(2*41.56)+(10.39)}{(41.56)+(10.39)}\right] = 6.198 \text{ in} \qquad \bar{X}_1 = 6.198 + 7.84 = 14.04 \text{ in}$$

$$X_2 = \frac{7.84}{3}\left[\frac{(2*10.39)+(7.76)}{(10.39)+(7.76)}\right] = 4.11 \text{ in} \qquad \bar{X}_2 = 4.11 \text{ in}$$

$$X_3 = \frac{(23.13)}{3} = 7.71 \text{ in} \qquad \bar{X}_3 = 23.13/3 = 7.71$$

LOAD FWD OF SPAR

$= A_1 + A_2$

$= 268.32 + 71.15$

$= 339.47$

LOAD AFT OF SPAR

$= A_3$

$= 89.74$ lb.

TOTAL LOAD CHECK

$= 339.47 + 89.74$

$= 429.21$ OK.

MOMENT FWD OF SPAR

$= A_1\bar{X}_1 + A_2\bar{X}_2$

$= [268.32 * 14.04] + [71.15 * 4.11]$

$= 3767.21 + 292.43$

$= 4059.64$ lbin

MOMENT AFT OF SPAR

$= A_3\bar{X}_3$

$= [89.74 * 7.71]$

$= 691.90$ lbin

$$\% \text{LOAD} = \frac{339.47}{429.21} \Rightarrow 79\% \text{ LOAD}$$

$$\% \text{LOAD} = \frac{89.74}{429.21} \Rightarrow 21\% \text{ LOAD}$$

∴ 79% LOAD ACTS FWD OF THE WING SPAR,
21% LOAD ACTS AFT OF THE WING SPAR.

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Subject:
DERIVATION OF MAIN WING LOADS

INTRODUCTION:

$$X_{cp_{FWD}} = \frac{0.44c - \left(\frac{4059.64}{339.47}\right)}{41.3} = 0.150 \Rightarrow 15\%c$$

$$X_{cp_{AFT}} = \frac{0.44c + \left(\frac{691.90}{89.74}\right)}{41.3} = 0.627 \Rightarrow 63\%c$$

CHECKING POSN LOAD = 79 % LOAD @ 15 %c
21 % LOAD @ 63 %c

$$X_{cp} = (0.79 * 0.15) + (0.21 * 0.63) = 0.2508 \Rightarrow 25\%c$$

CHECKING

$$X_{cp} = 0.24 - \frac{C_{M_0}}{C_L}$$

$$= 0.24 - \frac{-0.025}{1.7}$$

$$= 0.2547$$

$$= 25\%c$$

AGREES WITH DON DYKINS PRESSURE DISTRIBUTION AT $C_{L_{MAX}}$

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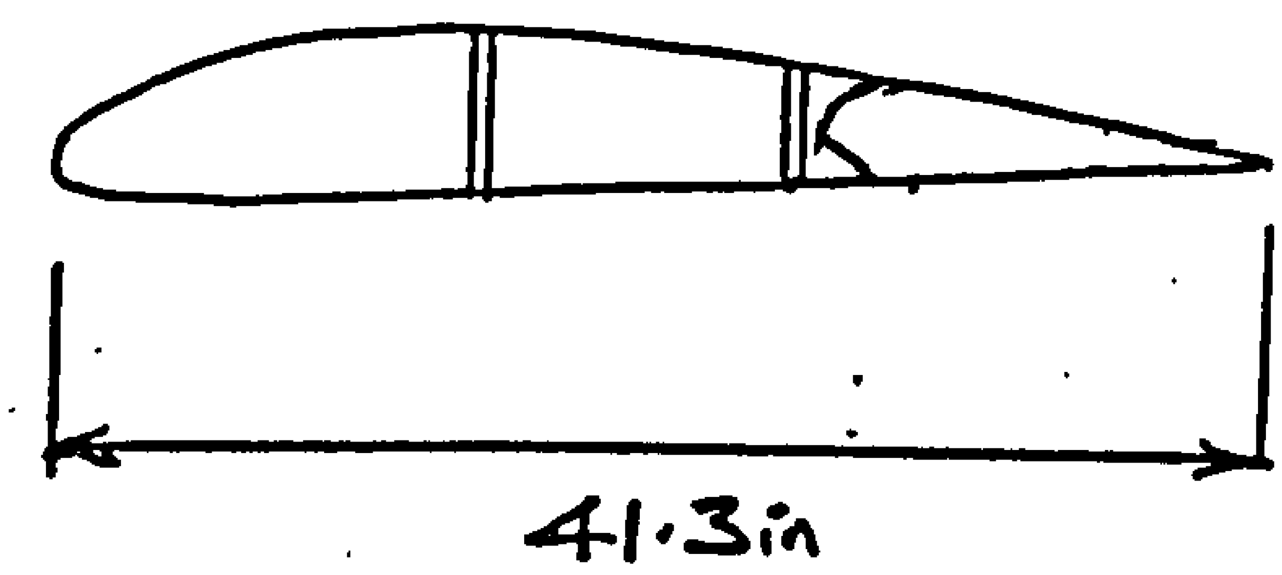
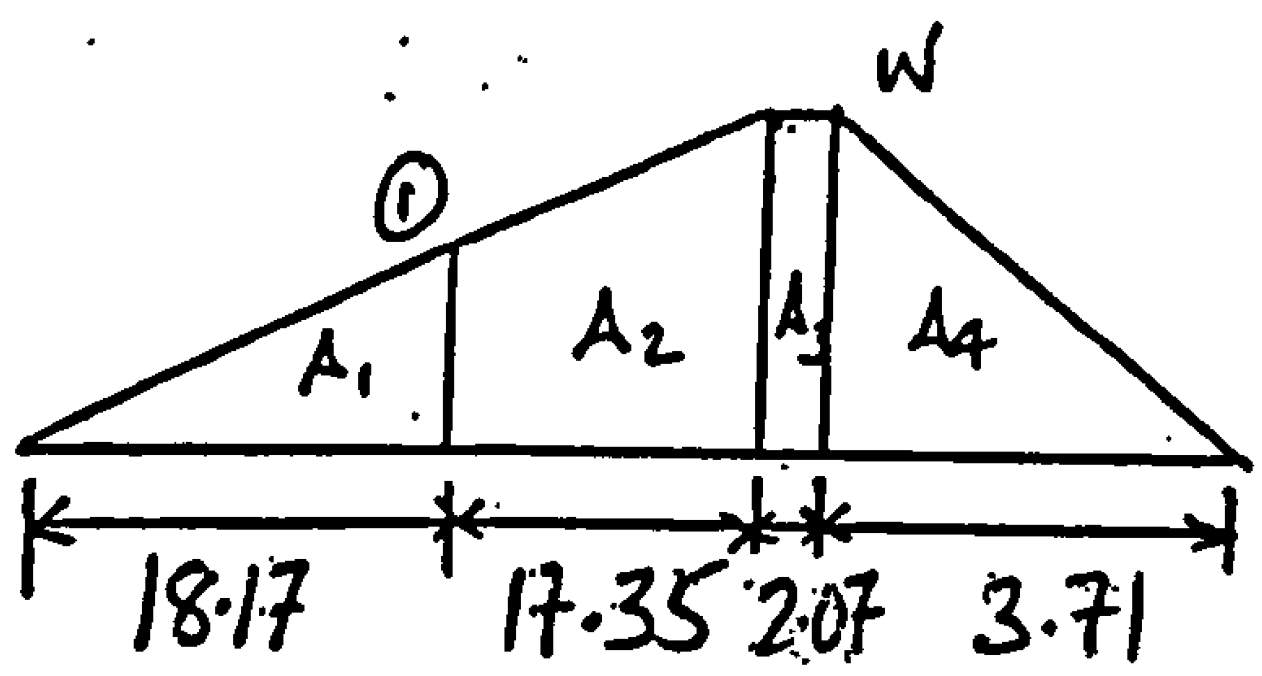
Subject:
DERIVATION OF MAIN WING LOADS

INTRODUCTION:

FROM TABLE 2 – AVERAGE LIMIT CONTROL SURFACE LOADING. LOW ANGLE OF ATTACK CHORDWISE LOADING.

BRAKE LE @ 81%c = 33.45 in
BRAKE HINGE @ 86%c = 35.52 in




EQUATION OF LINE 1

$$M = \frac{Y_2 - Y_1}{X_2 - X_1} = \frac{W - 0}{33.45} = \frac{W}{33.45}$$

$$y - b = M(x - a)$$

$$y = M(x - a) + b$$

$$y = \frac{W}{33.45} x$$

$$x = 18.17$$

$$y = \frac{W}{33.45} * 18.17$$

$$= 0.543W$$

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Subject:
DERIVATION OF MAIN WING LOADS

INTRODUCTION:

$A_1 = \frac{1}{2} * 18.17 * 0.543 = 4.93\,W.$

$A_2 = \left[\left[\frac{W - 0.543W}{2}\right] + 0.543W\right] * 17.35 = 13.23\,W$

$A_3 = 2.07\,W = 2.07\,W$

$A_4 = \frac{1}{2} * 3.71 * W = 1.855\,W.$

DISTANCE FROM SPAR

$X_1 = 18.17/3 = 6.06\text{ in}$ — $\overline{X}_1 = 6.06$

$X_2 = 17.35/3 * \left[\frac{2*W + 0.543W}{W + 0.543W}\right] = 9.53\text{ in}$ — $\overline{X}_2 = 9.53$

$X_3 = 2.07/2 = 1.04$ — $\overline{X}_3 = 17.35 + 1.04 = 18.39\text{ in}$

$X_4 = 3.71/3 = 1.24\text{ in}$ — $\overline{X}_4 = 17.35 + 2.07 + 1.24 = 20.66$

TOTAL LOAD

$= (4.93 + 13.23 + 2.07 + 1.855)\,W$

$= 22.09\,W$

TOTAL LOAD FWD SPAR

$= \frac{4.93W}{22.09W} = 0.22$

$= 22\%$ LOAD

TOTAL LOAD AFT SPAR

$= \frac{13.23 + 2.07 + 1.855}{22.09}W = 0.78$

$= 78\%$ LOAD.

MOMENT FWD OF SPAR

$= A_1\overline{X}_1$

$= 4.93W * 6.06$

$= 29.88\,W\text{ lbin}$

MOMENT AFT OF SPAR

$A_2\overline{X}_2 + A_3\overline{X}_3 + A_4\overline{X}_4$

$= (13.23 * 9.53) +$
$(2.07 * 18.39) +$
$(1.855 * 20.66)$

$= 202.47\,W\text{ lbin}$

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|---|---|---|
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Subject:
DERIVATION OF MAIN WING LOADS

INTRODUCTION:

$X_{CP}$ INFRONT OF SPAR

$$= \frac{0.44c - \left(\frac{29.88\,W}{4.93\,W}\right)}{41.3}$$

$= 0.293$

$= 29\ \%c$

$X_{CP}$ AFT OF SPAR

$$= \frac{0.44c + \left(\frac{202.47\,W}{17.16\,W}\right)}{41.3}$$

$= 0.726$

$= 73\ \%c$

CHECKING POSITION..

FWD POSN LOAD 22% @ 29 %c

AFT POSN LOAD 78% @ 73 %c

$\Rightarrow (0.22 * 0.29) + (0.78 * 0.73) = 0.633$

$\Rightarrow 63\ \%c.$

SEEMS FAR AFT!

QUICK CHECK ON AFT Cp. AT CONDITION D WHERE $C_L = 0.57$

$X_{cp} = 0.24 - \left(\frac{C_{M0}}{C_L}\right)$

$= 0.24 - \left(\frac{-0.025}{0.57}\right)$

$= 28\ \%$ CHORD.

VLA CHORDWISE DISTRIBUTION AT LAA WOULD APPEAR VERY CONSERVATIVE.

| | | |
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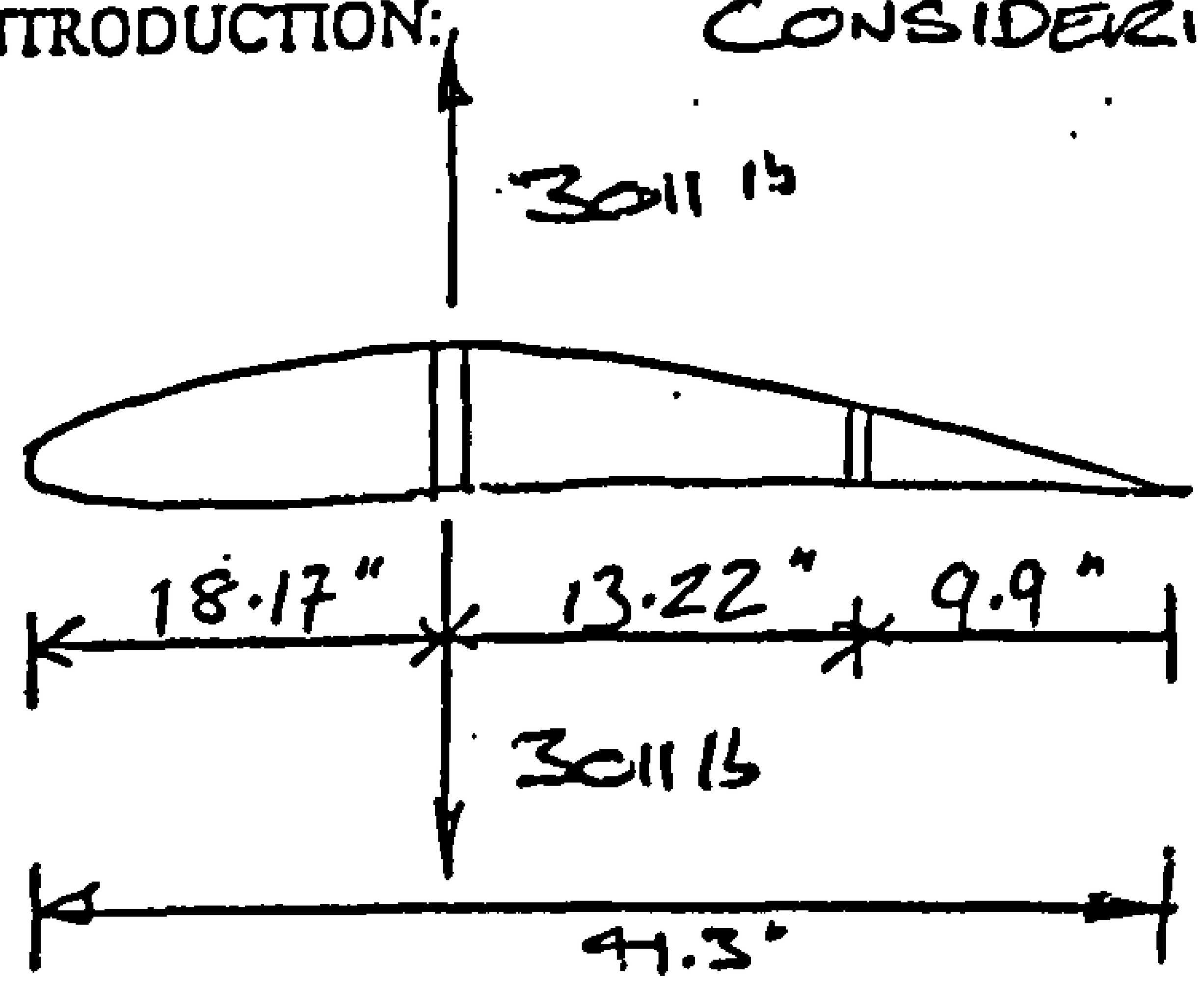
DERIVATION OF MAIN WING LOADS

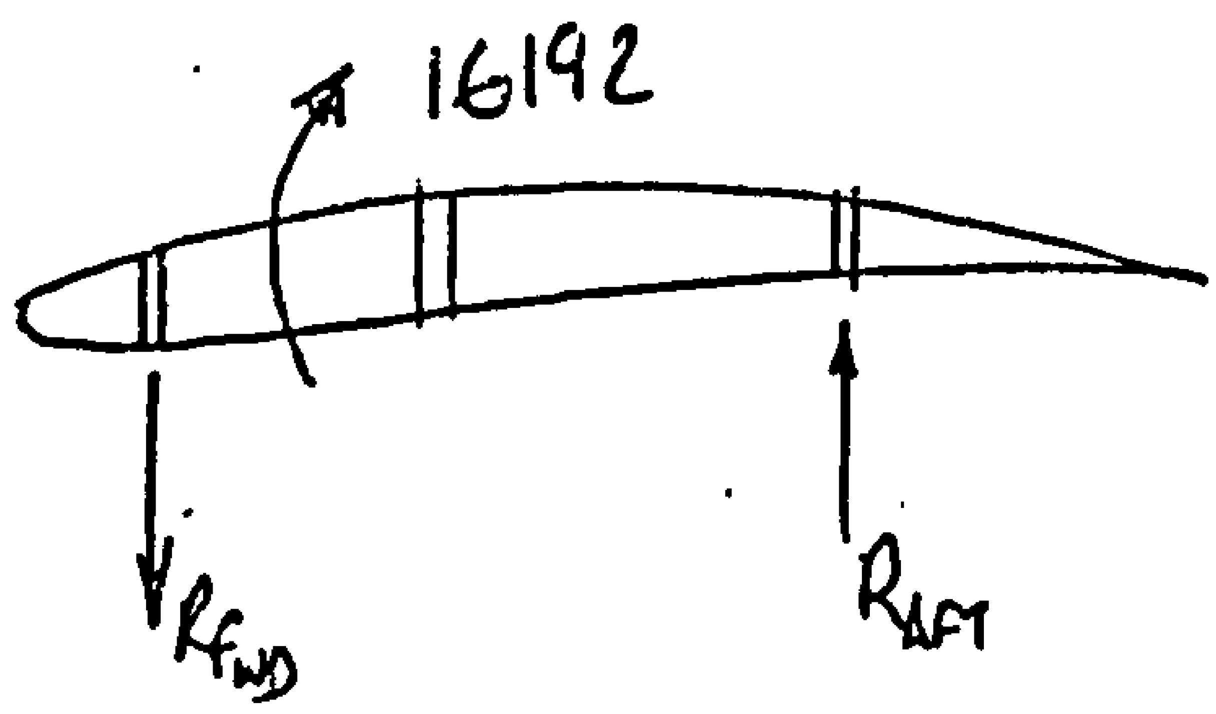
INTRODUCTION: CONSIDERING CONDITION A ULTIMATE LOADS




NORMAL SHEAR.

ASSUMING 100% NORMAL SHEAR ACTS AT SPAR

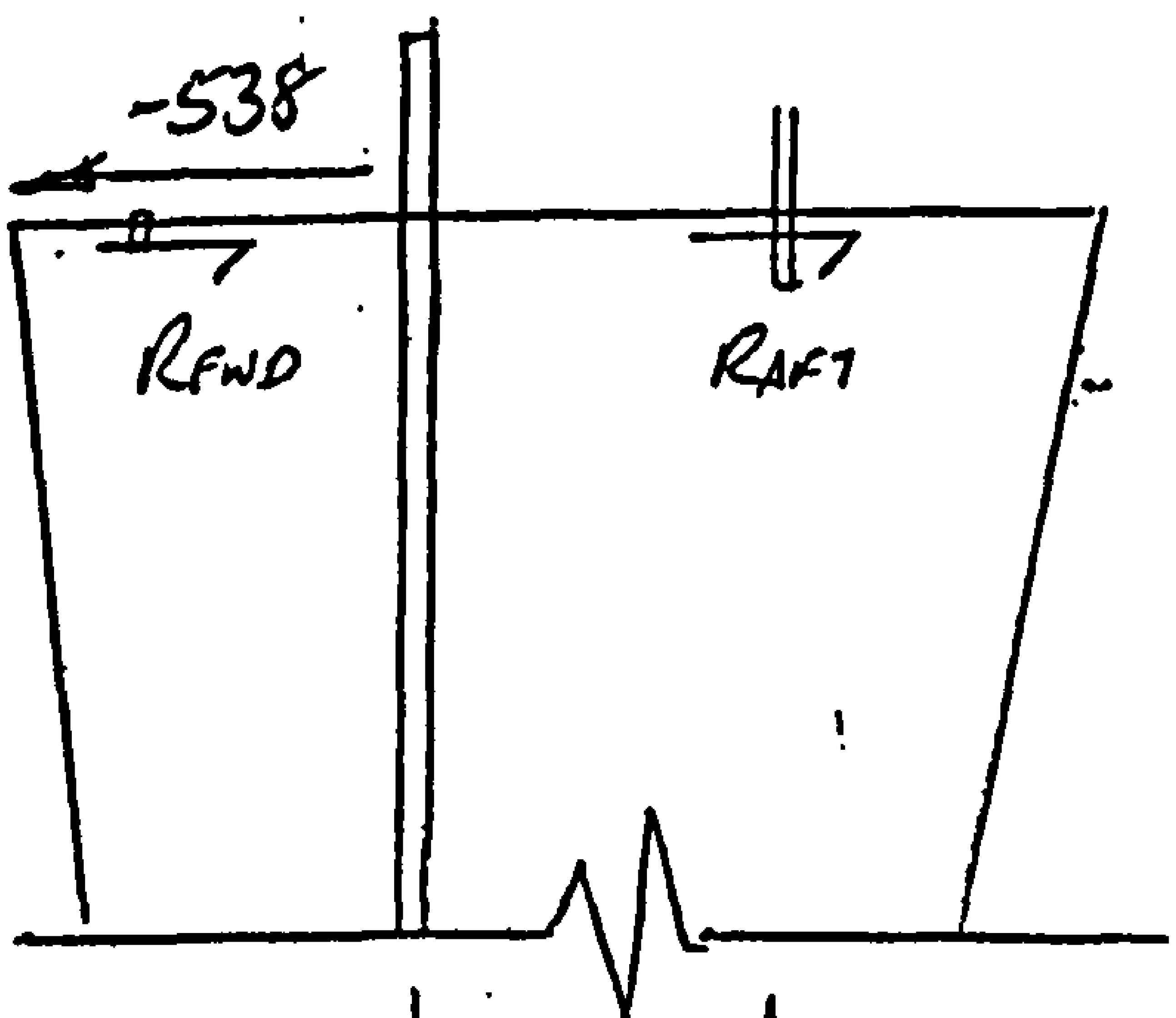
$R_{FWD} = 3011$ lb




TORSION ABOUT SPAR

ASSUMING 100% TORQUE TAKEN BY FORE & AFT PINS.

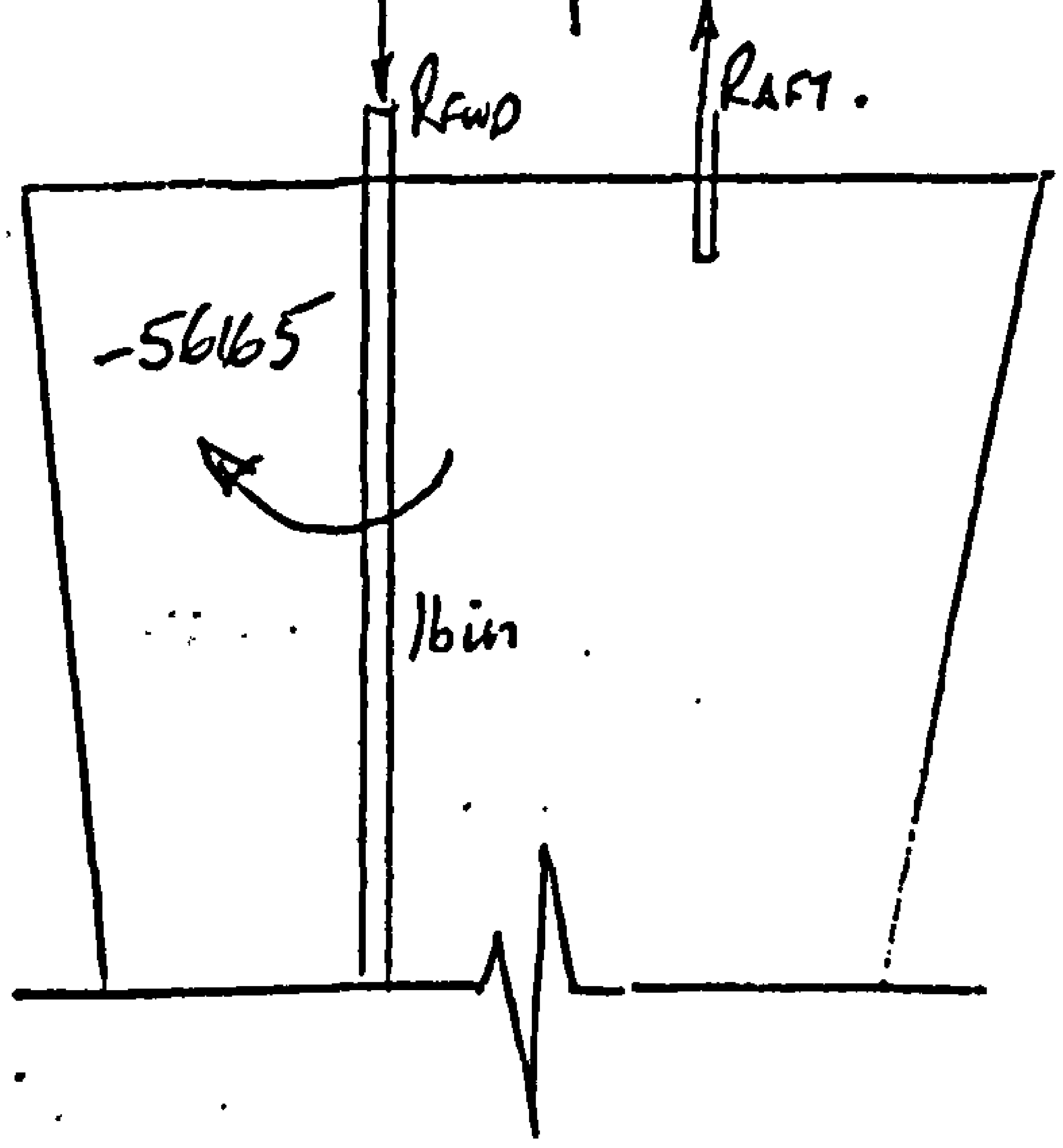
$$R_{FWD} = R_{AFT} = \frac{16192}{30} = 540 \text{ lb.}$$




CHORDWISE SHEAR

ASSUMING 100% CHORDWISE SHEAR TAKEN BY FORE & AFT PINS.

$$R_{FWD} = R_{AFT} = -538/2 = 269 \text{ lb.}$$




CHORDWISE BENDING MOMENT.

ASSUMING 100% CHORDWISE BENDING MOMENT IS TAKEN BY MAIN SPAR & CARRY THROUGH.

$$R_{FWD} = R_{AFT} = \frac{-56165}{13.22} = 4248 \text{ lb.}$$

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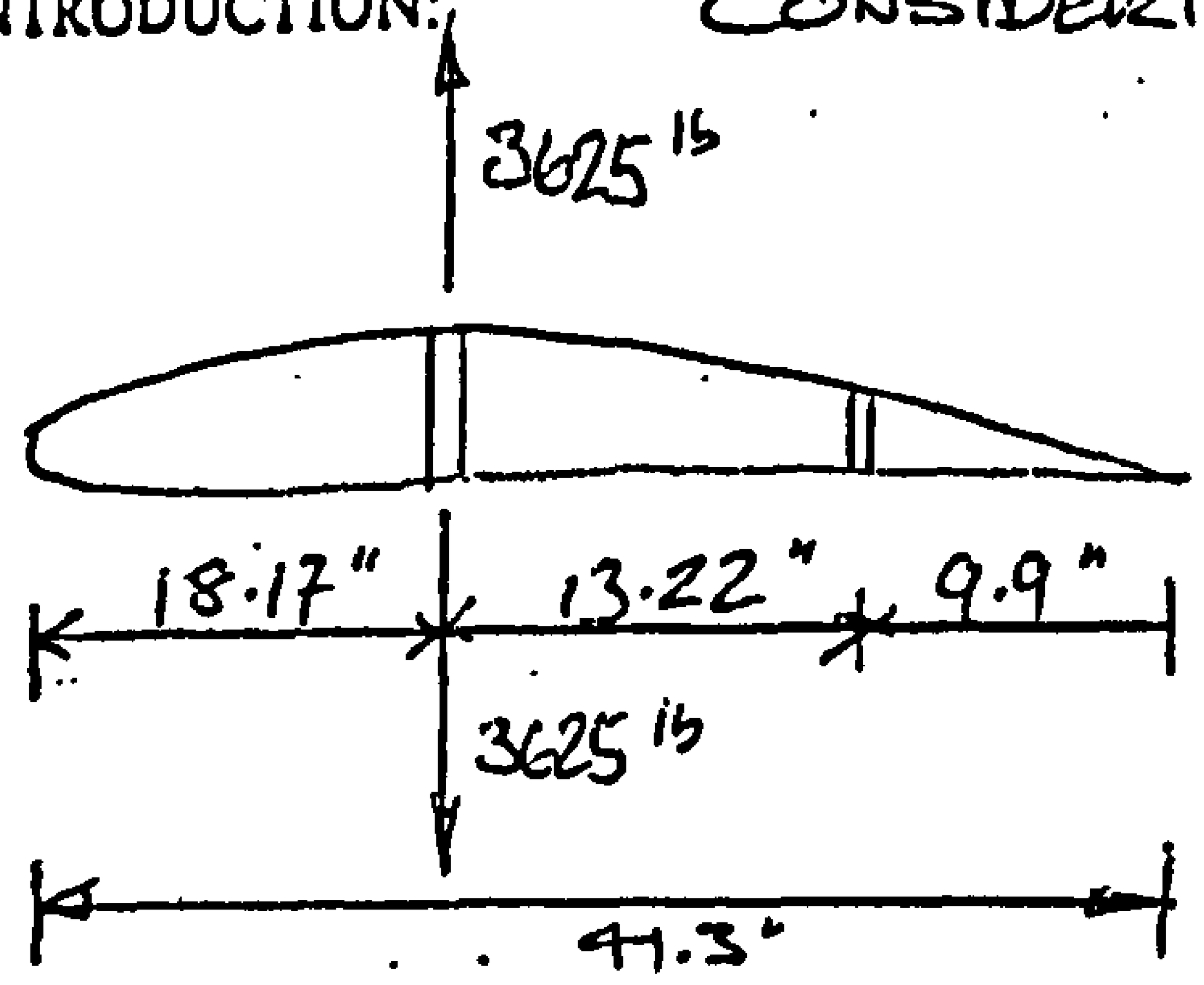
DERIVATION OF MAIN WING LOADS

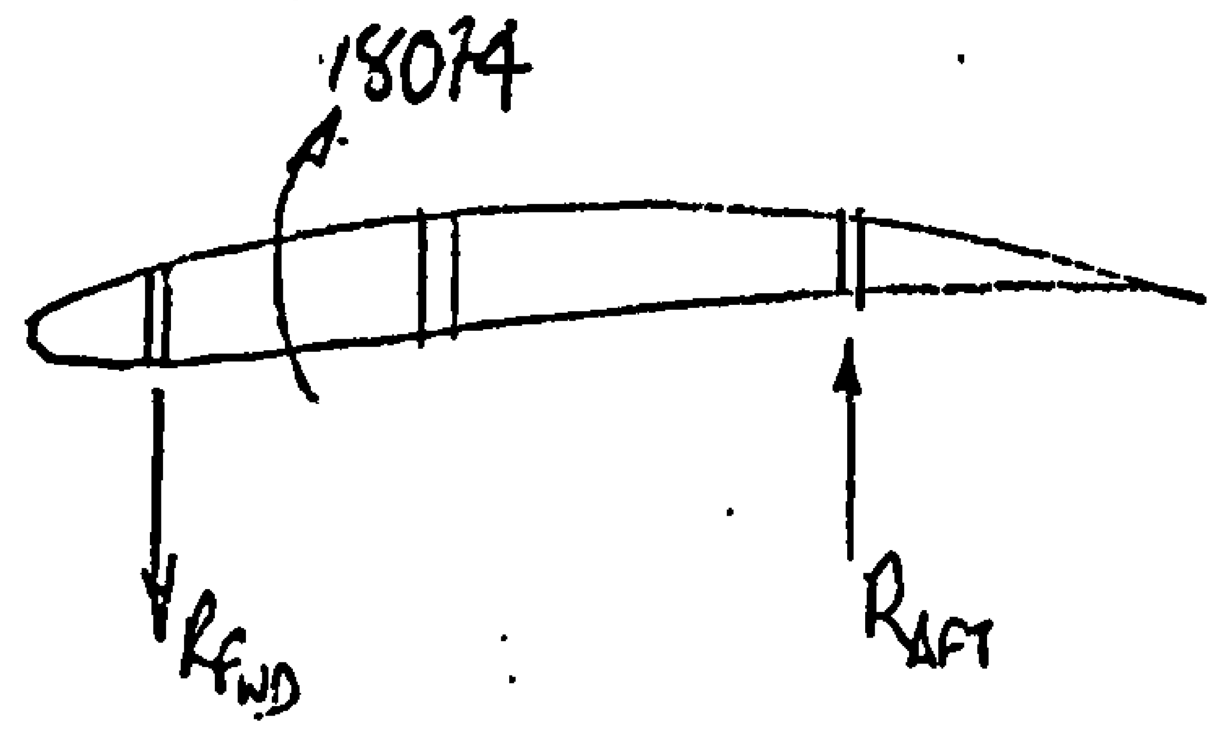
INTRODUCTION: CONSIDERING CONDITION C ULTIMATE LOADS




NORMAL SHEAR.

ASSUMING 100% NORMAL SHEAR ACTS AT SPAR

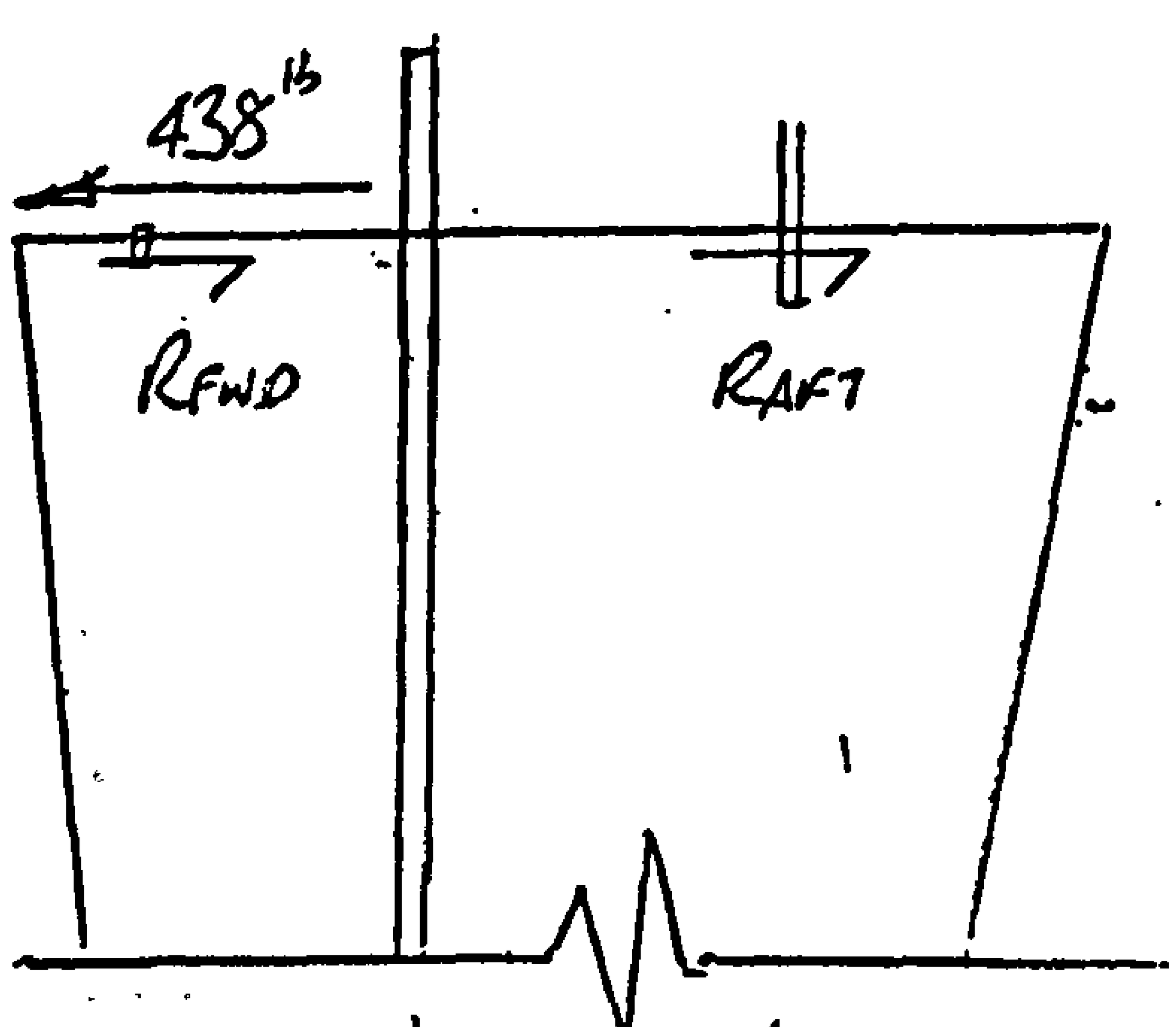
$R_{FWD} = 3625$ lb.




TORSION ABOUT SPAR

ASSUMING 100% TORQUE TAKEN BY FORE & AFT PINS.

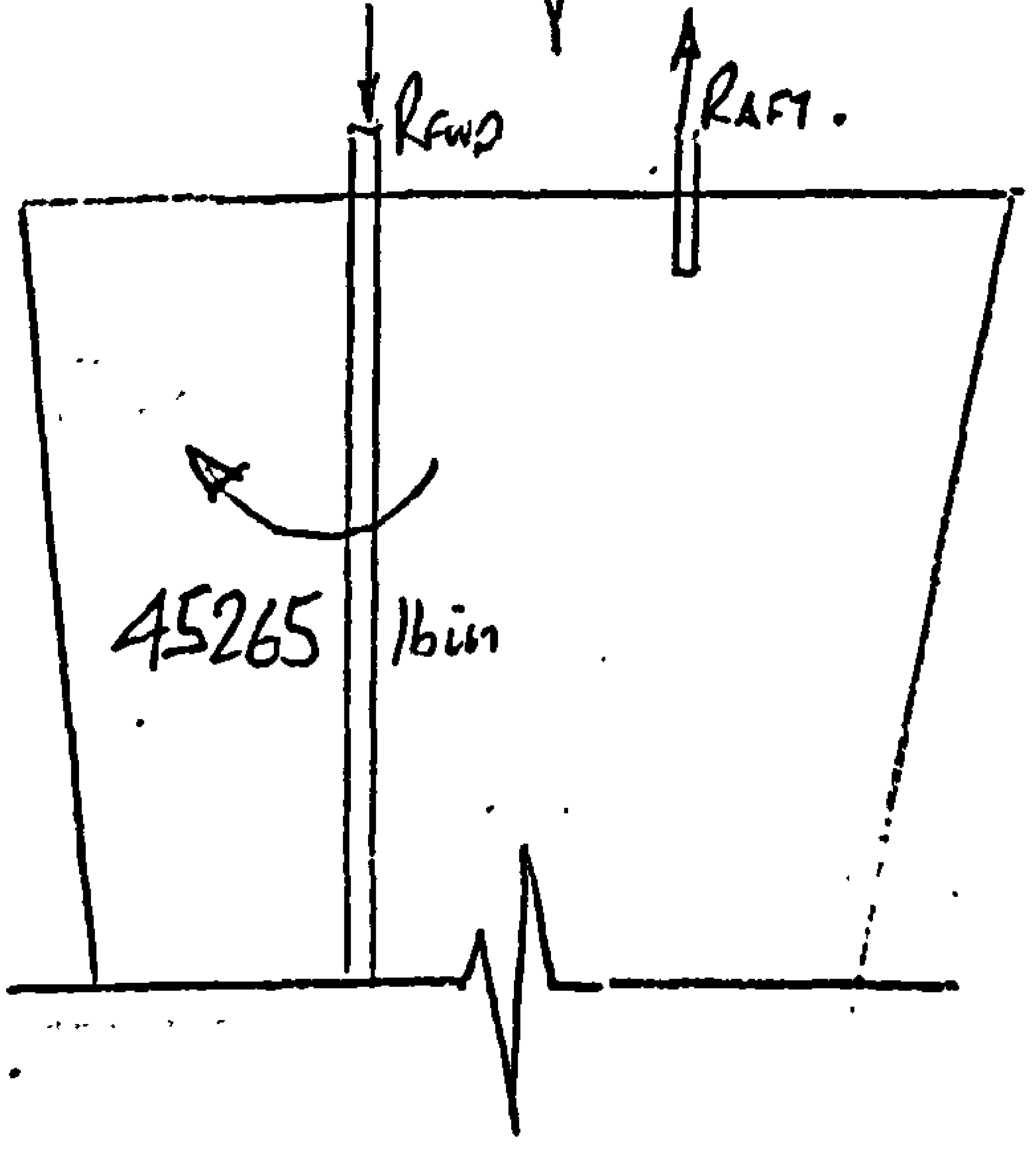
$$R_{FWD} = R_{AFT} = \frac{18074}{30}$$
$$= 602 \text{ lb.}$$




CHORDWISE SHEAR

ASSUMING 100% CHORDWISE SHEAR TAKEN BY FORE & AFT PINS.

$R_{FWD} = R_{AFT} = 219$ lb.




CHORDWISE BENDING MOMENT.

ASSUMING 100% CHORDWISE BENDING MOMENT IS TAKEN BY MAIN SPAR & CARRY THROUGH.

$$R_{FWD} = R_{AFT} = \frac{45265}{13.22}$$
$$= 3424 \text{ lb.}$$

| | | |
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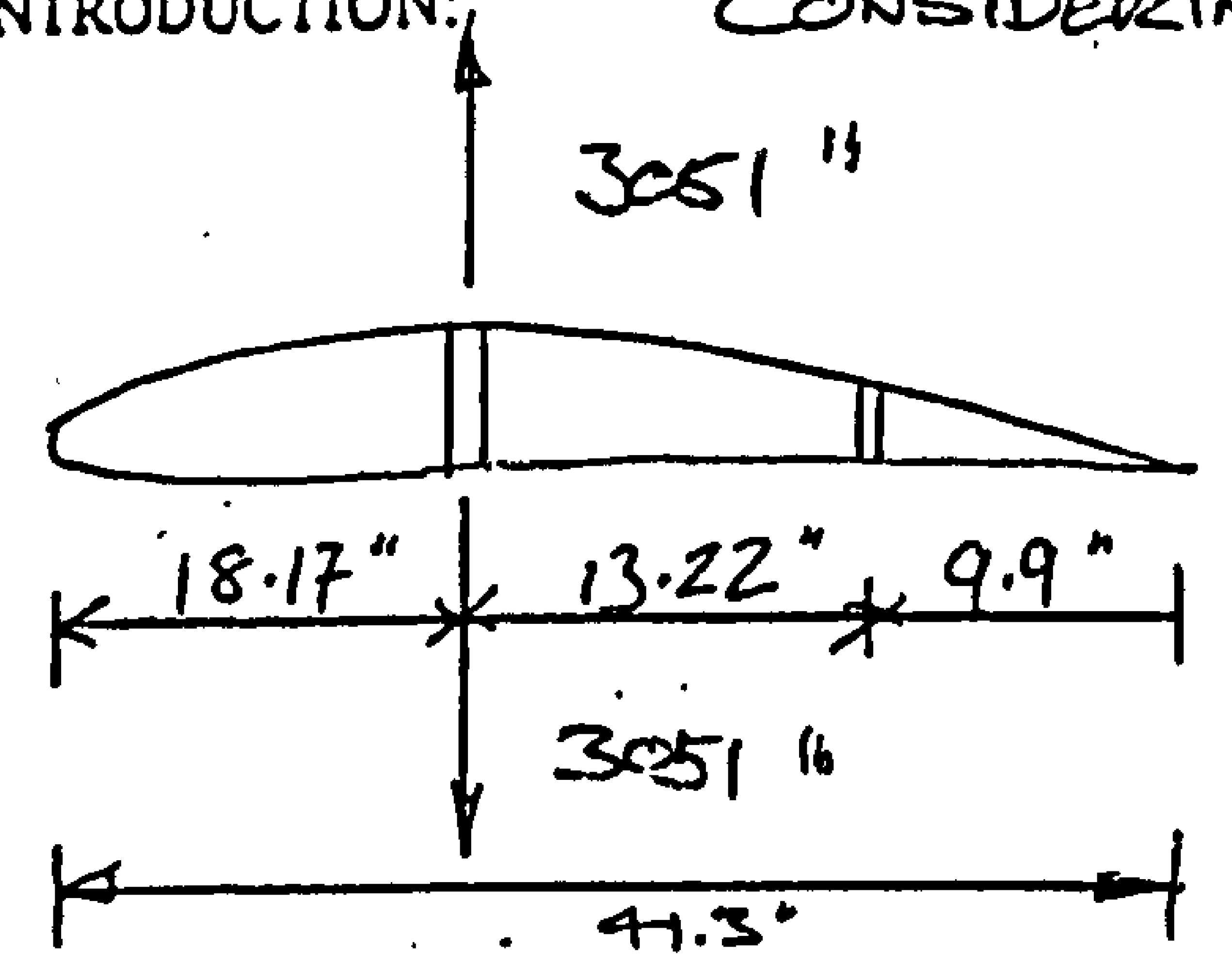
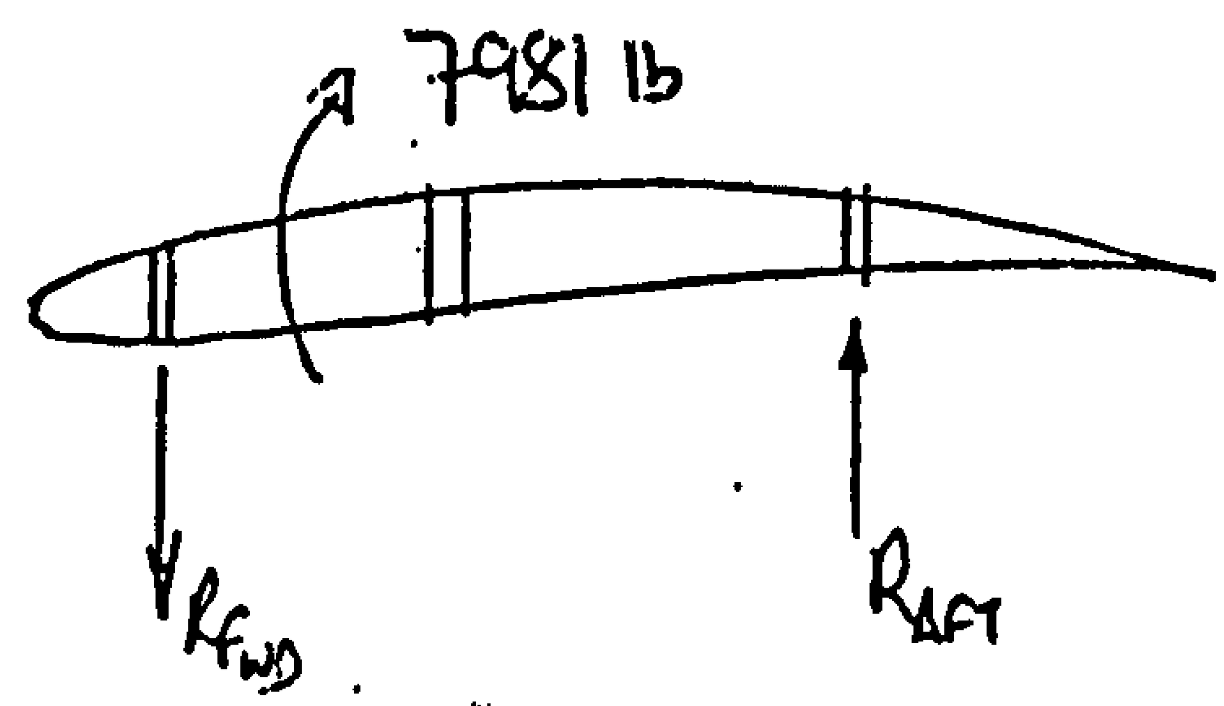



## NORMAL SHEAR.

ASSUMING 100% NORMAL SHEAR ACTS AT SPAR

$R_{FWD} = 3051$ lb

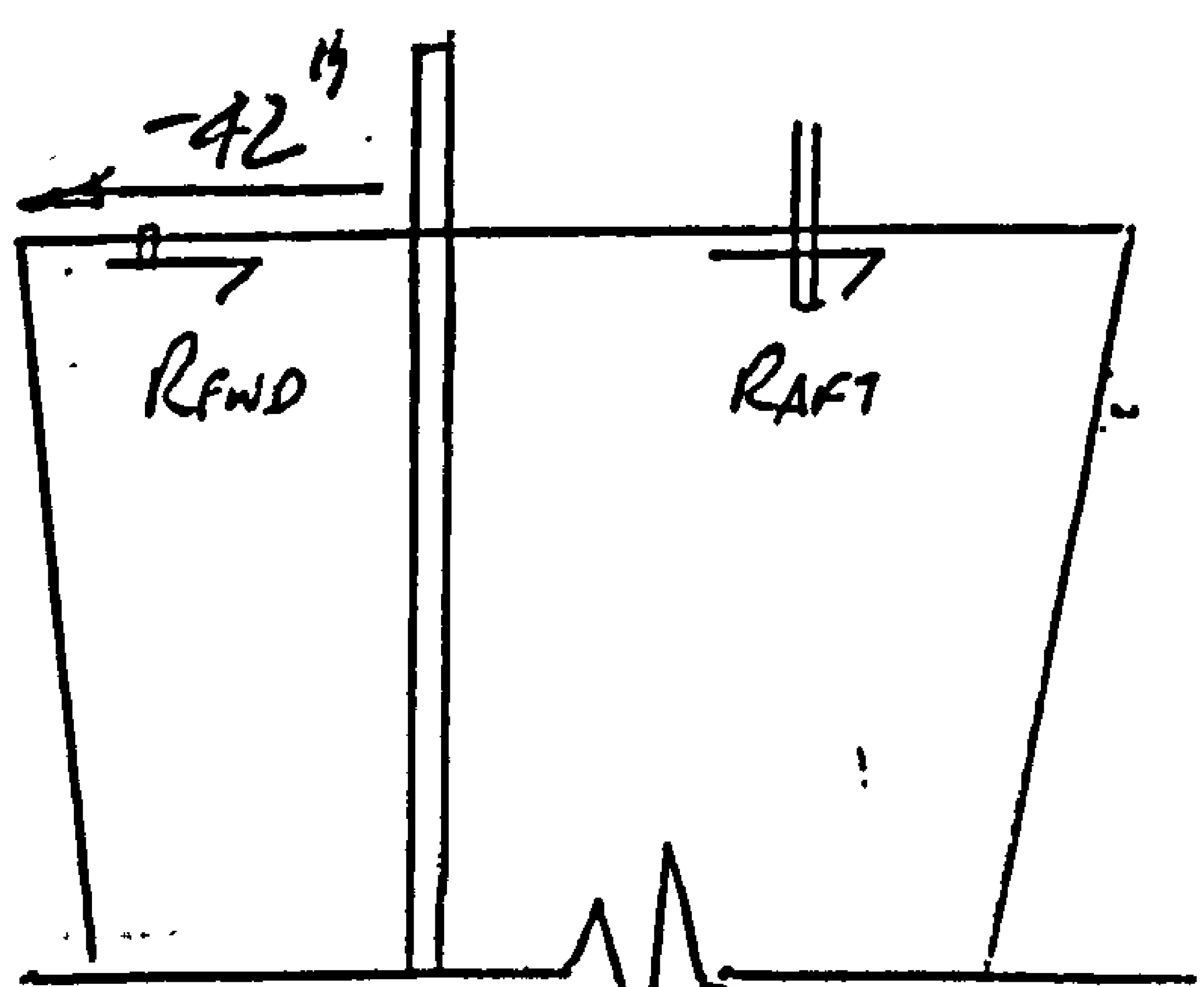



## TORSION ABOUT SPAR

ASSUMING 100% TORQUE TAKEN BY FORE & AFT PINS.

$R_{FWD} = R_{AFT} = \dfrac{7981}{30}$

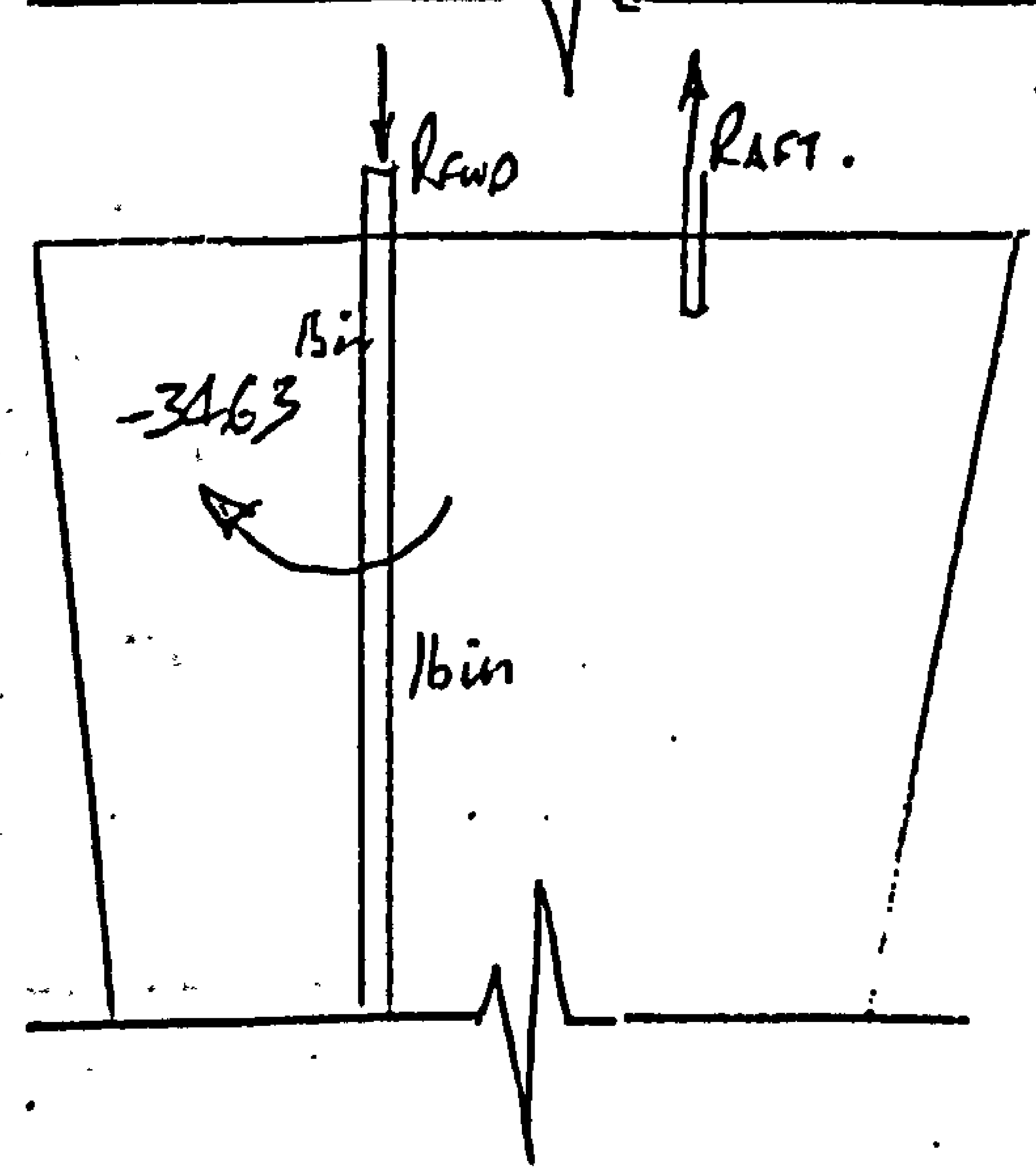
$= 266$ lb.




## CHORDWISE SHEAR

ASSUMING 100% CHORDWISE SHEAR TAKEN BY FORE & AFT PINS.

$R_{FWD} = R_{AFT} = \dfrac{-42}{2} = -21$ lb




## CHORDWISE BENDING MOMENT.

ASSUMING 100% CHORDWISE BENDING MOMENT IS TAKEN BY MAIN SPAR & CARRY THROUGH.

$R_{FWD} = R_{AFT} = \dfrac{-3463}{13.22}$

$= 262$ lb

| | | |
|---|---|---|
| Compiled by: J RUSSELL | EUROPA DEVELOPMENTS LTD | Report No: |
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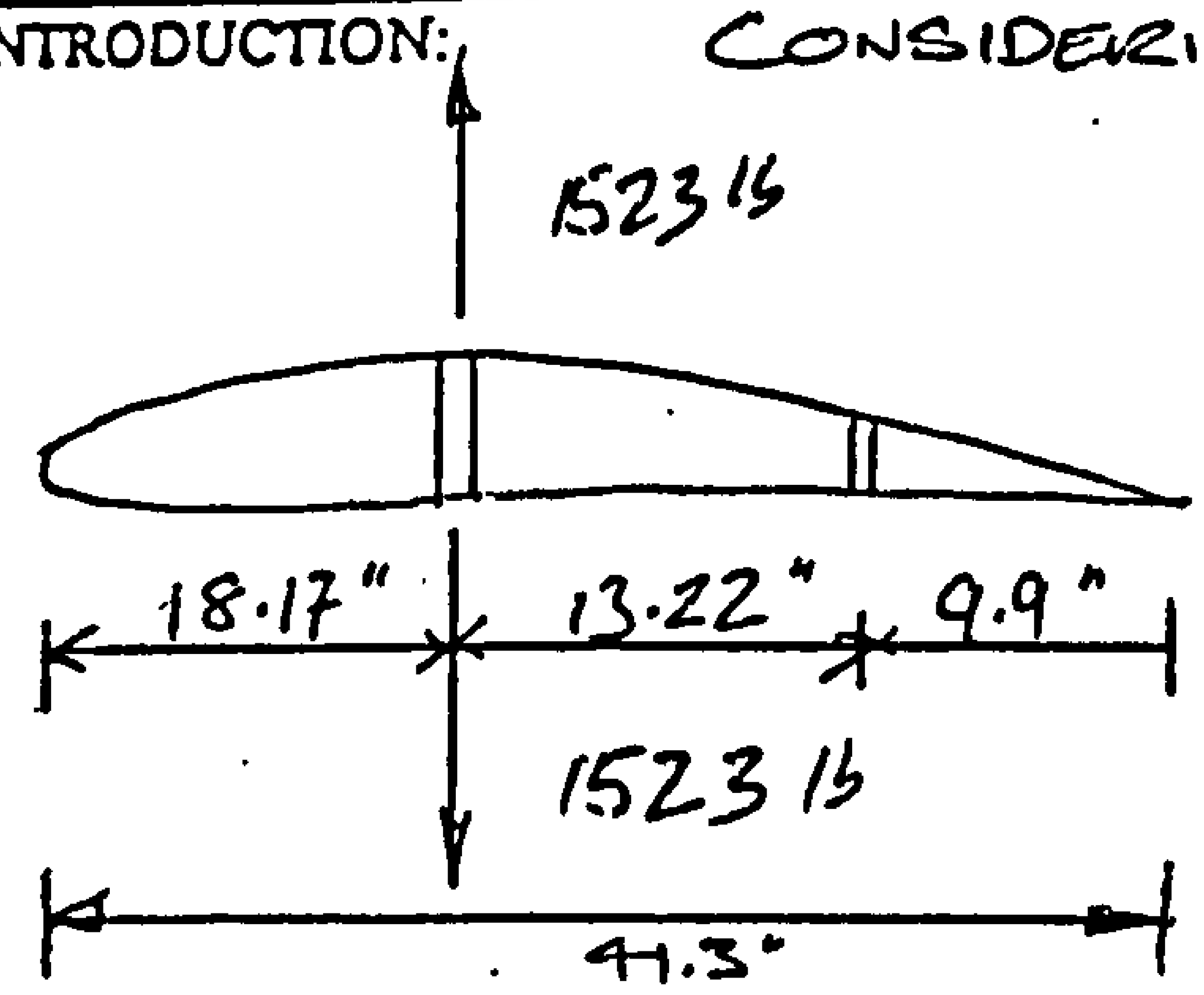
DERIVATION OF MAIN WING LOADS

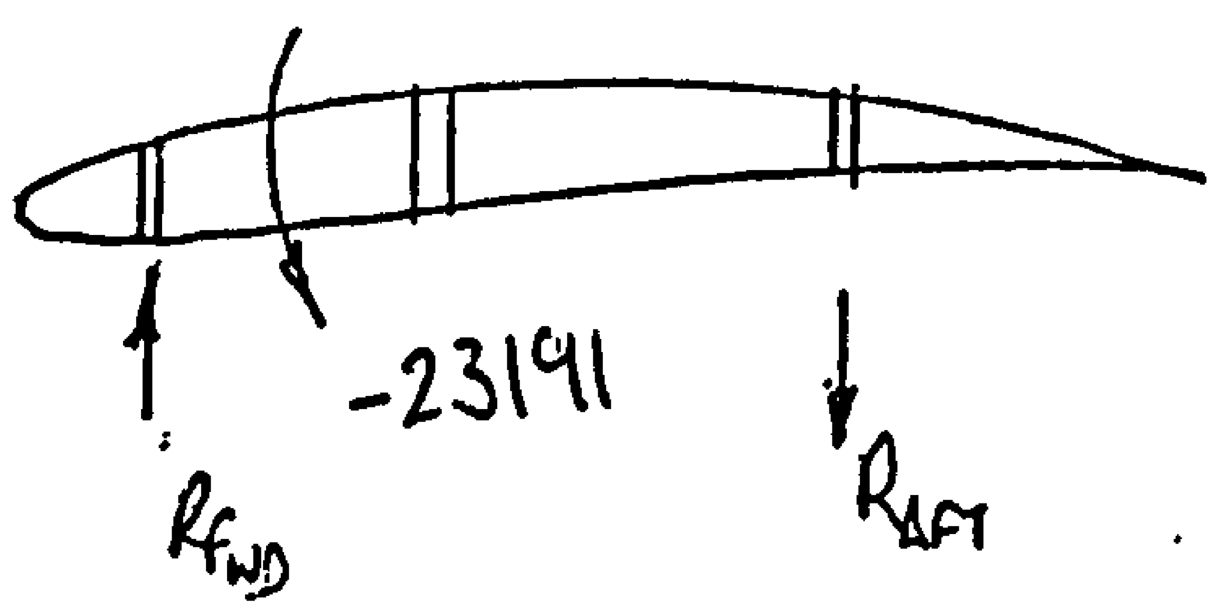
INTRODUCTION: CONSIDERING CONDITION E ULTIMATE LOADS




NORMAL SHEAR.

ASSUMING 100% NORMAL SHEAR ACTS AT SPAR

$R_{FWD} = -1523$ lb

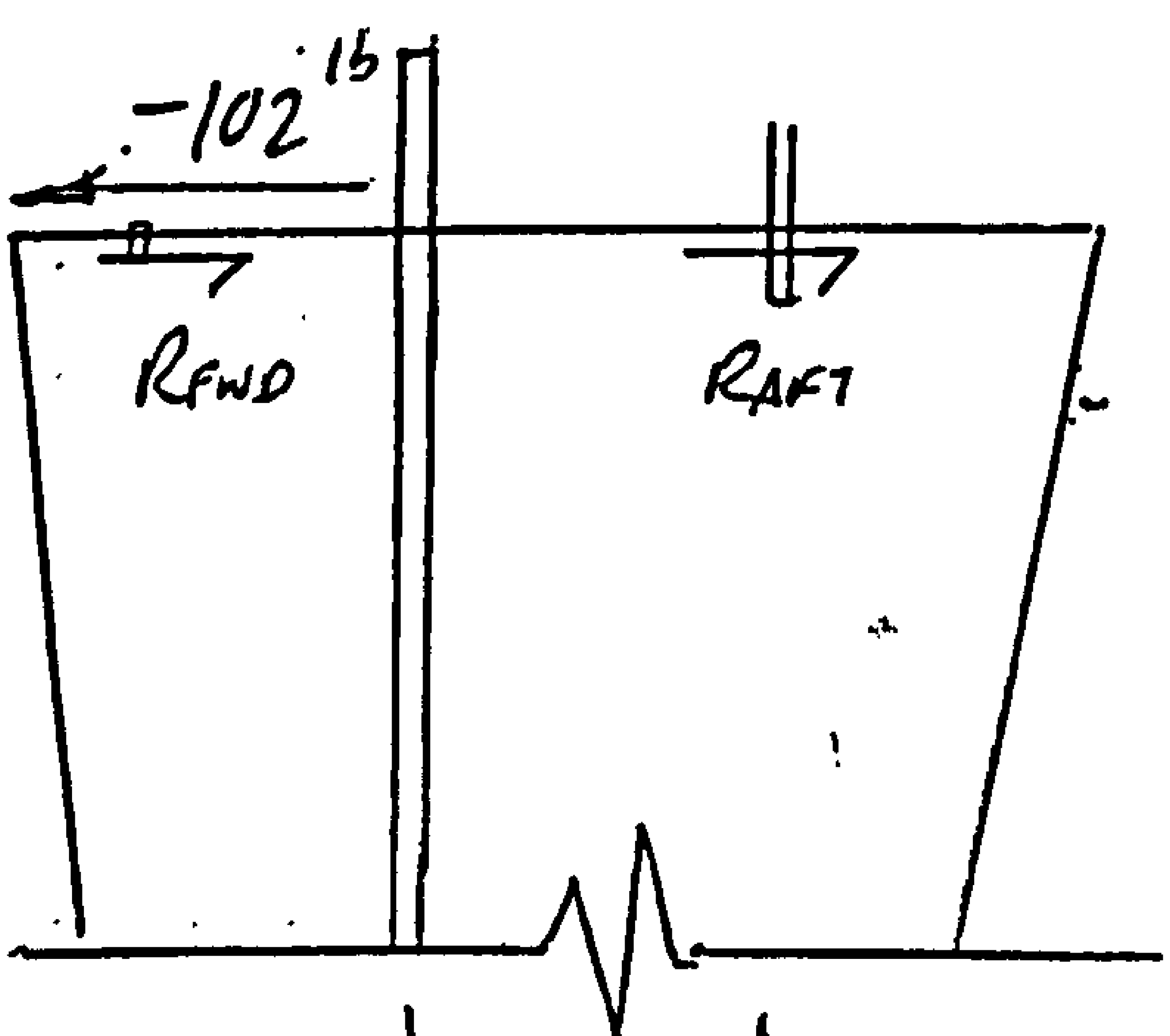



TORSION ABOUT SPAR

ASSUMING 100% TORQUE TAKEN BY FORE & AFT PINS.

$R_{FWD} \cdot R_{AFT} = \dfrac{-23191}{30}$

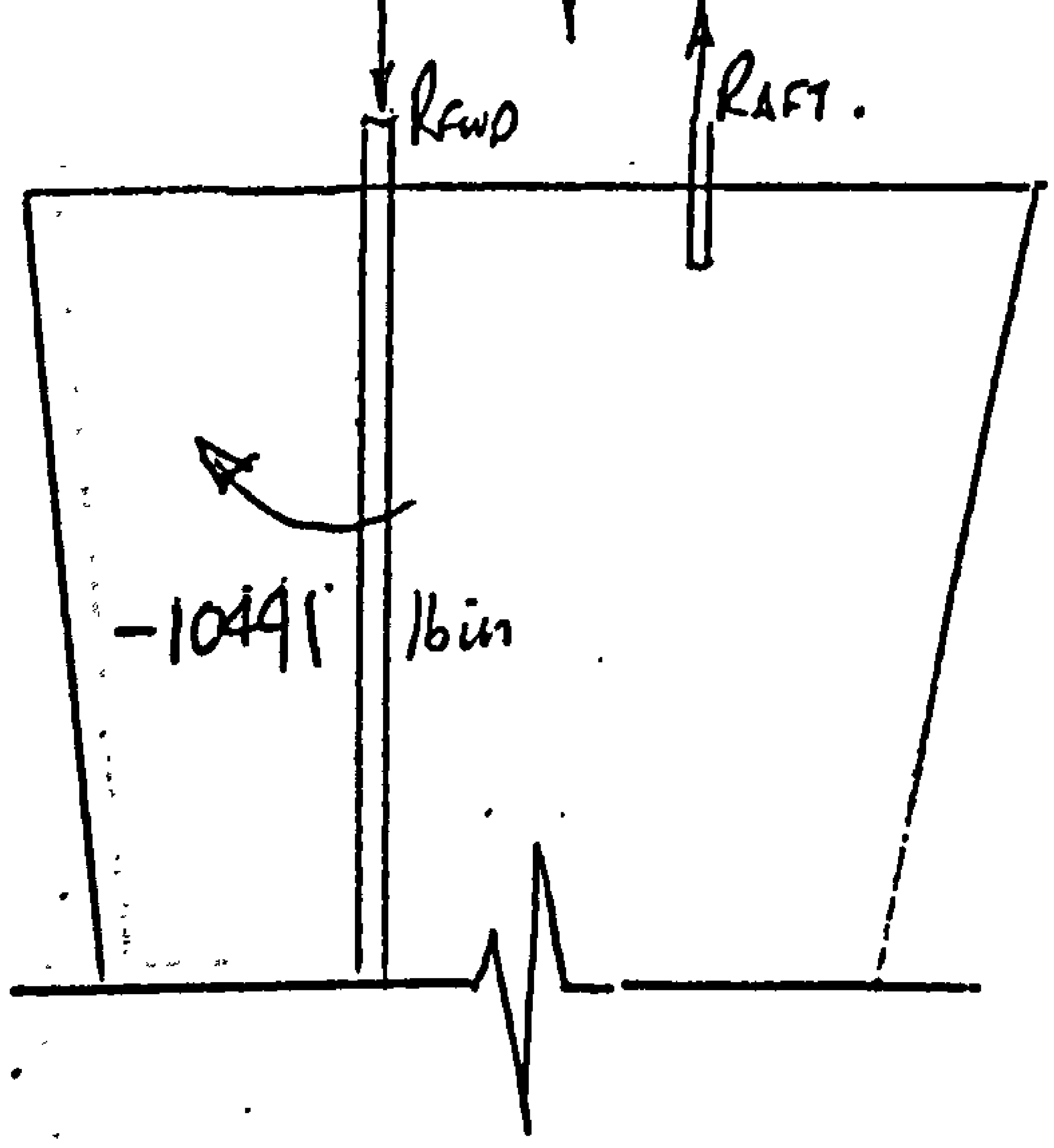
$= 773$ lb.




CHORDWISE SHEAR

ASSUMING 100% CHORDWISE SHEAR TAKEN BY FORE & AFT PINS.

$R_{FWD} = R_{AFT} = -\dfrac{102}{2} = 51$ lb




CHORDWISE BENDING MOMENT.

ASSUMING 100% CHORDWISE BENDING MOMENT IS TAKEN BY MAIN SPAR & CARRY THROUGH.

$R_{FWD} = R_{AFT} = \dfrac{-10441}{13.22}$

$= 790$ lb.

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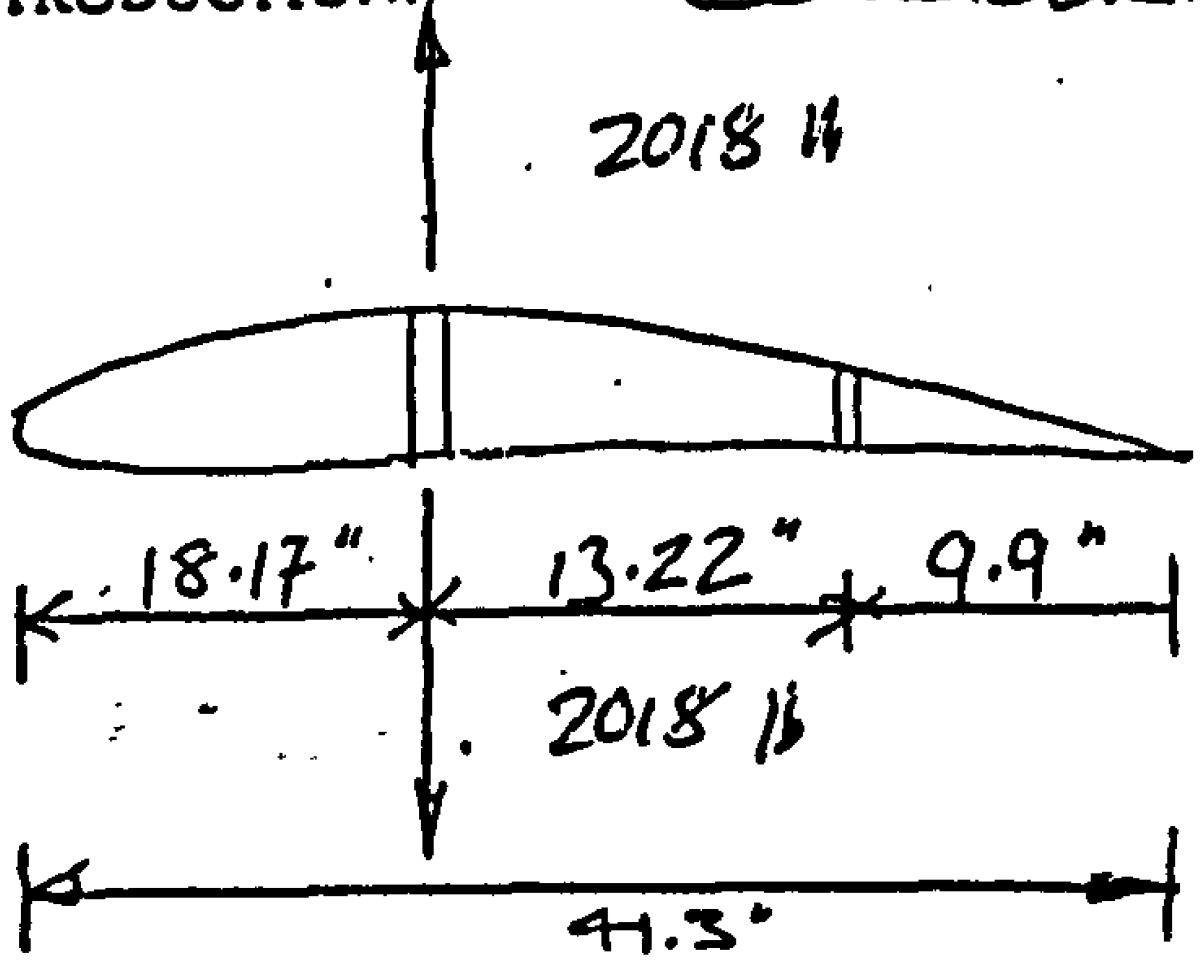
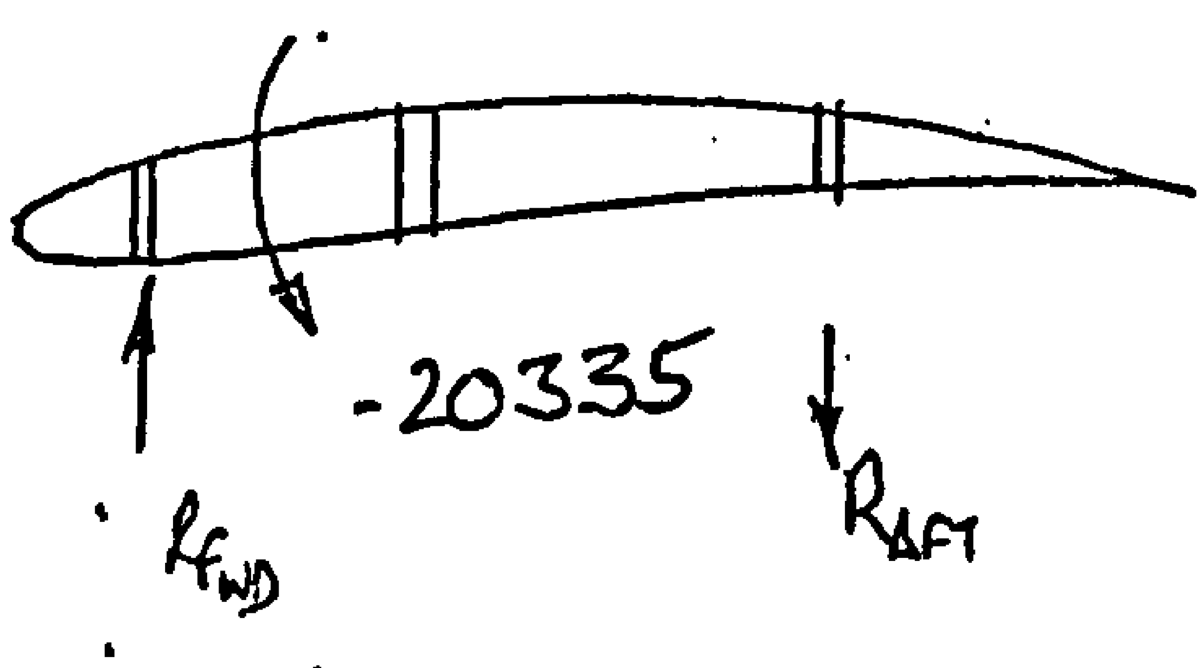
INTRODUCTION: CONSIDERING CONDITION F ULTIMATE LOADS




NORMAL SHEAR.

ASSUMING 100% NORMAL SHEAR ACTS AT SPAR

$R_{FWD} = -2018$ lb

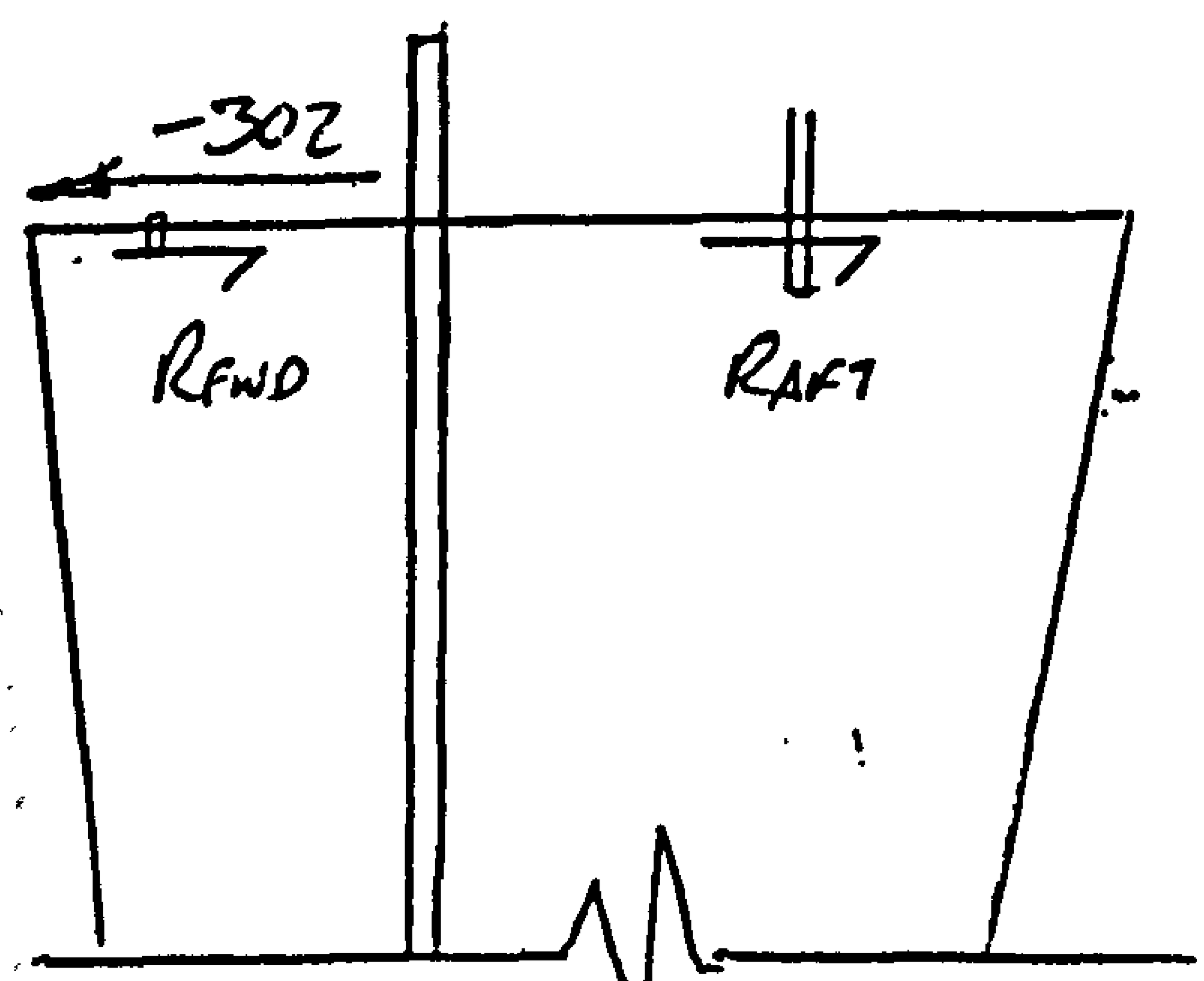



TORSION ABOUT SPAR

ASSUMING 100% TORQUE TAKEN BY FORE & AFT PINS.

$$R_{FWD} = R_{AFT} = \frac{-20335}{30}$$

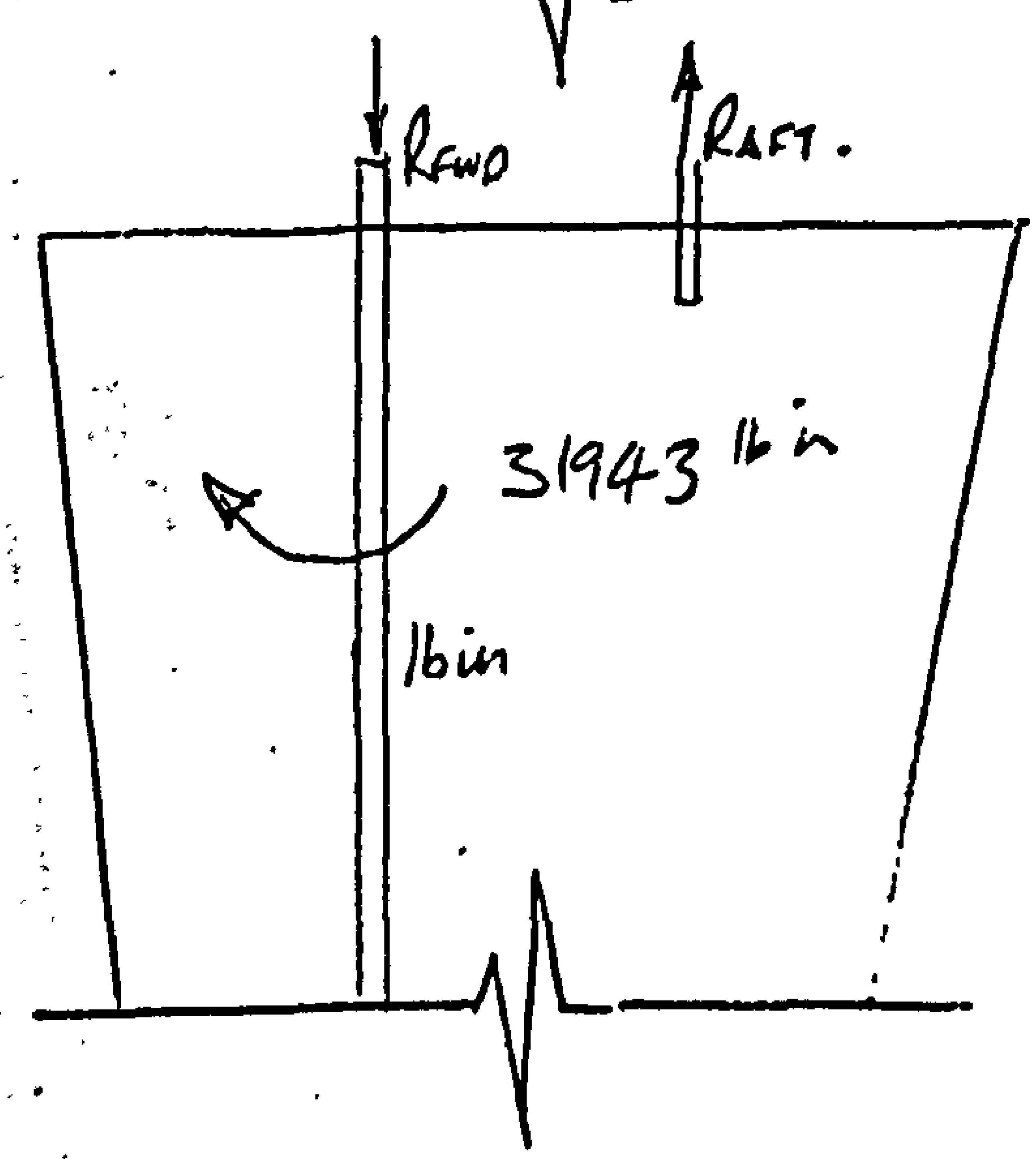
$$= 678 \text{ lb}$$




CHORDWISE SHEAR

ASSUMING 100% CHORDWISE SHEAR TAKEN BY FORE & AFT PINS.

$$R_{FWD} = R_{AFT} = \frac{-302}{2} = 151 \text{ lb}$$




CHORDWISE BENDING MOMENT.

ASSUMING 100% CHORDWISE BENDING MOMENT IS TAKEN BY MAIN SPAR & CARRY THROUGH.

$$R_{FWD} = R_{AFT} = \frac{-31943}{13.22}$$

$$= 2416 \text{ lb}.$$

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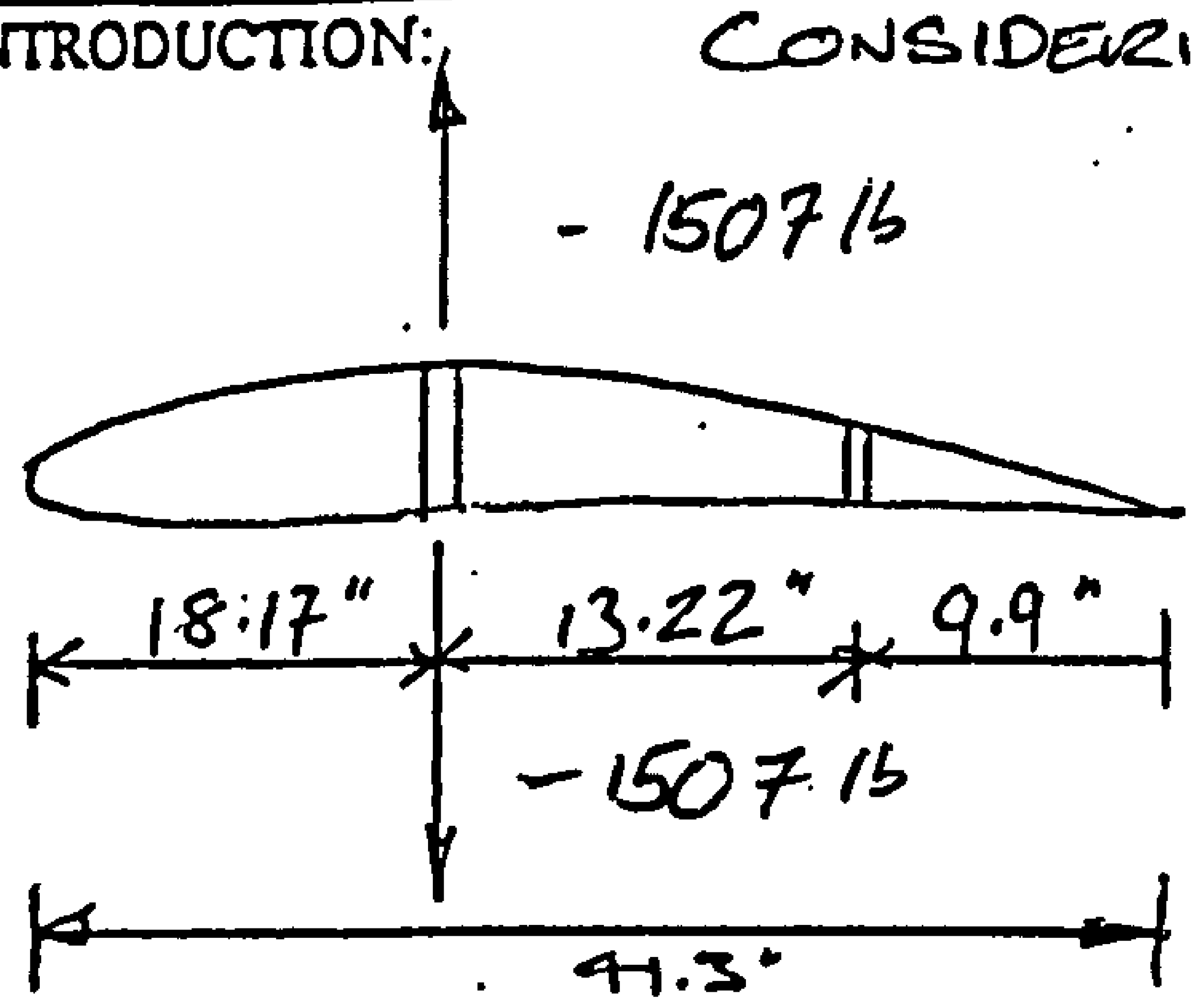
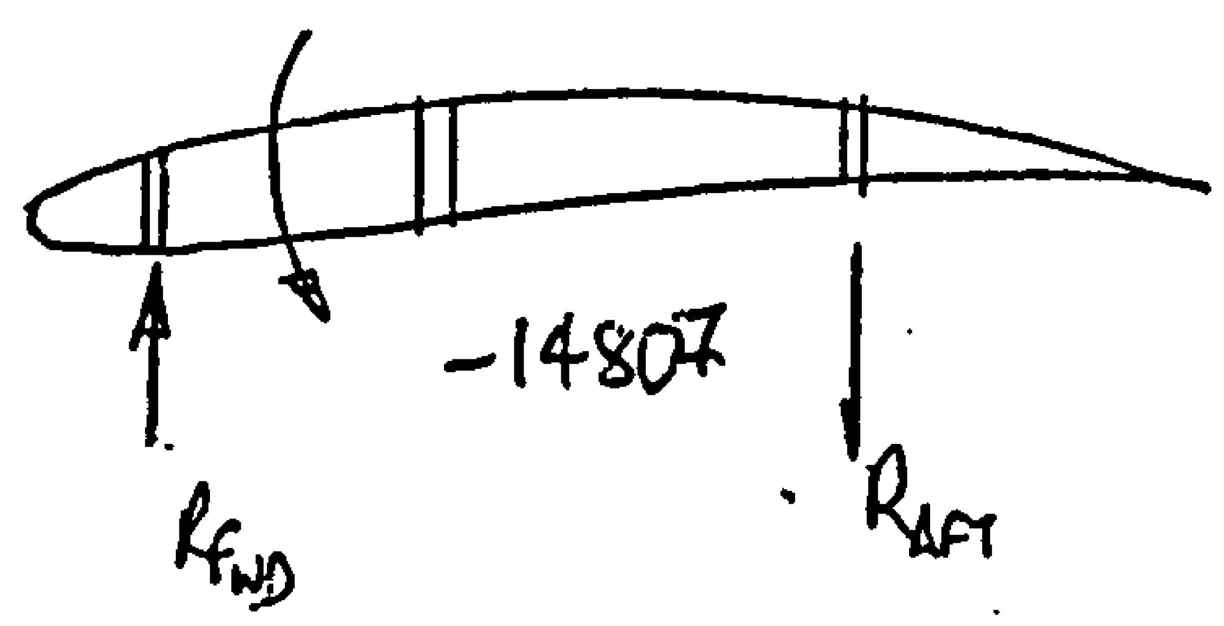
INTRODUCTION: CONSIDERING CONDITION G ULTIMATE LOADS




NORMAL SHEAR.

ASSUMING 100% NORMAL SHEAR ACTS AT SPAR

$R_{FWD} = -1507$ lb.

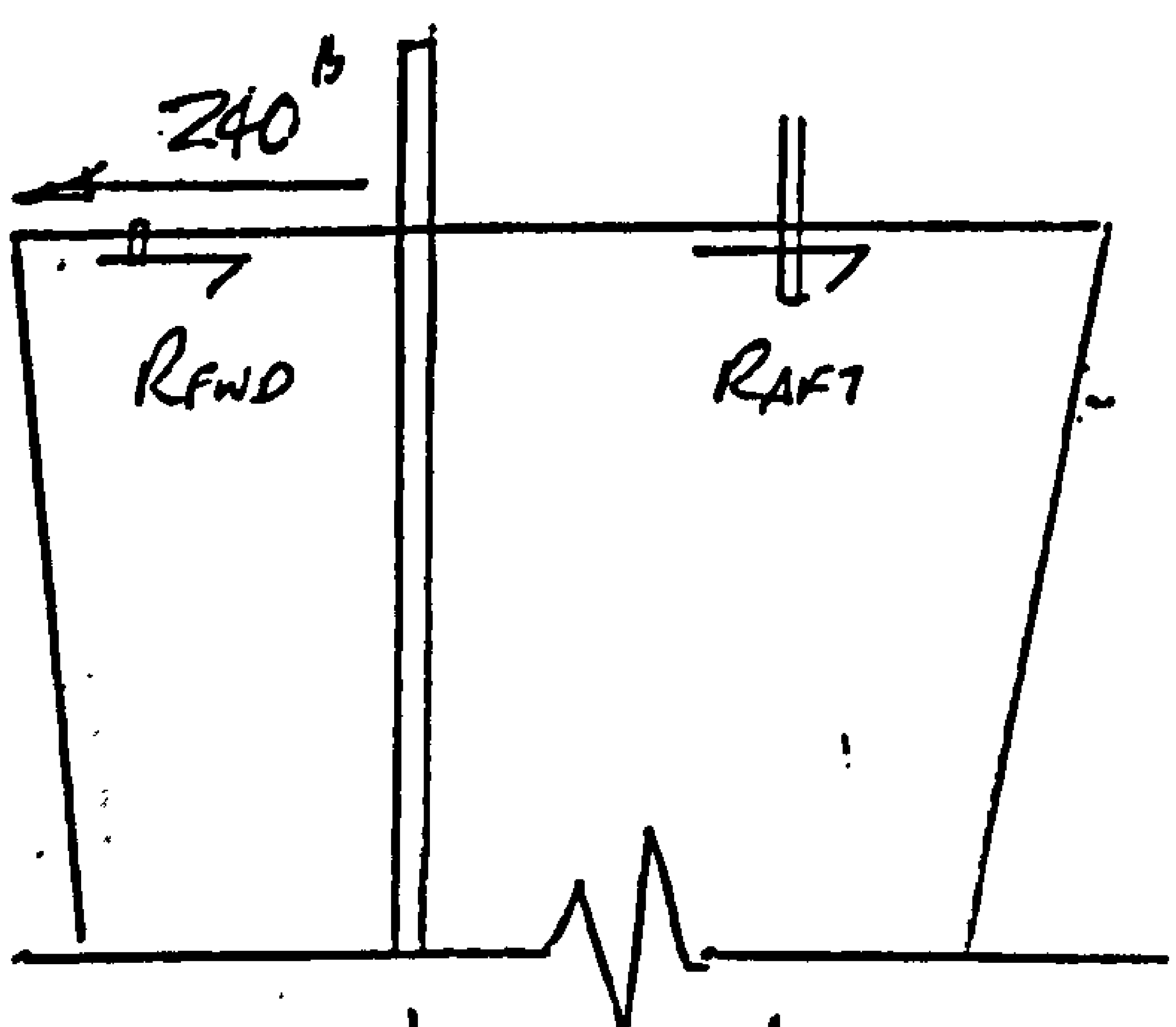



TORSION ABOUT SPAR

ASSUMING 100% TORQUE TAKEN BY FORE & AFT PINS.

$R_{FWD} = R_{AFT} = \frac{-14807}{30}$

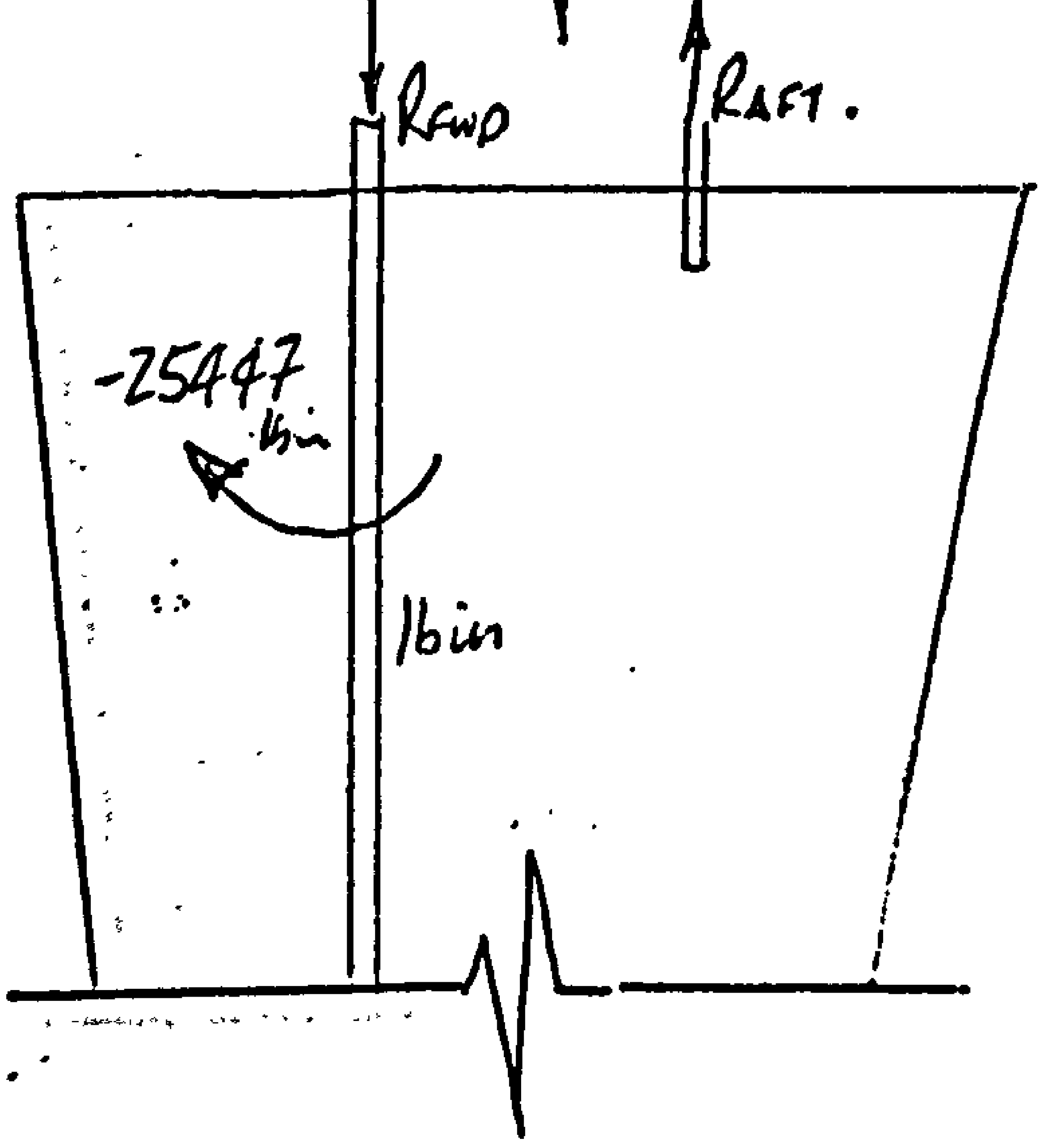
$= 494$ lb.




CHORDWISE SHEAR

ASSUMING 100% CHORDWISE SHEAR TAKEN BY FORE & AFT PINS.

$R_{FWD} = R_{AFT} = \frac{-240}{2} = -120$ lb




CHORDWISE BENDING MOMENT.

ASSUMING 100% CHORDWISE BENDING MOMENT IS TAKEN BY MAIN SPAR & CARRY THROUGH.

$R_{FWD} = R_{AFT} = \frac{-25447}{13.22}$

$= 1925$ lb.

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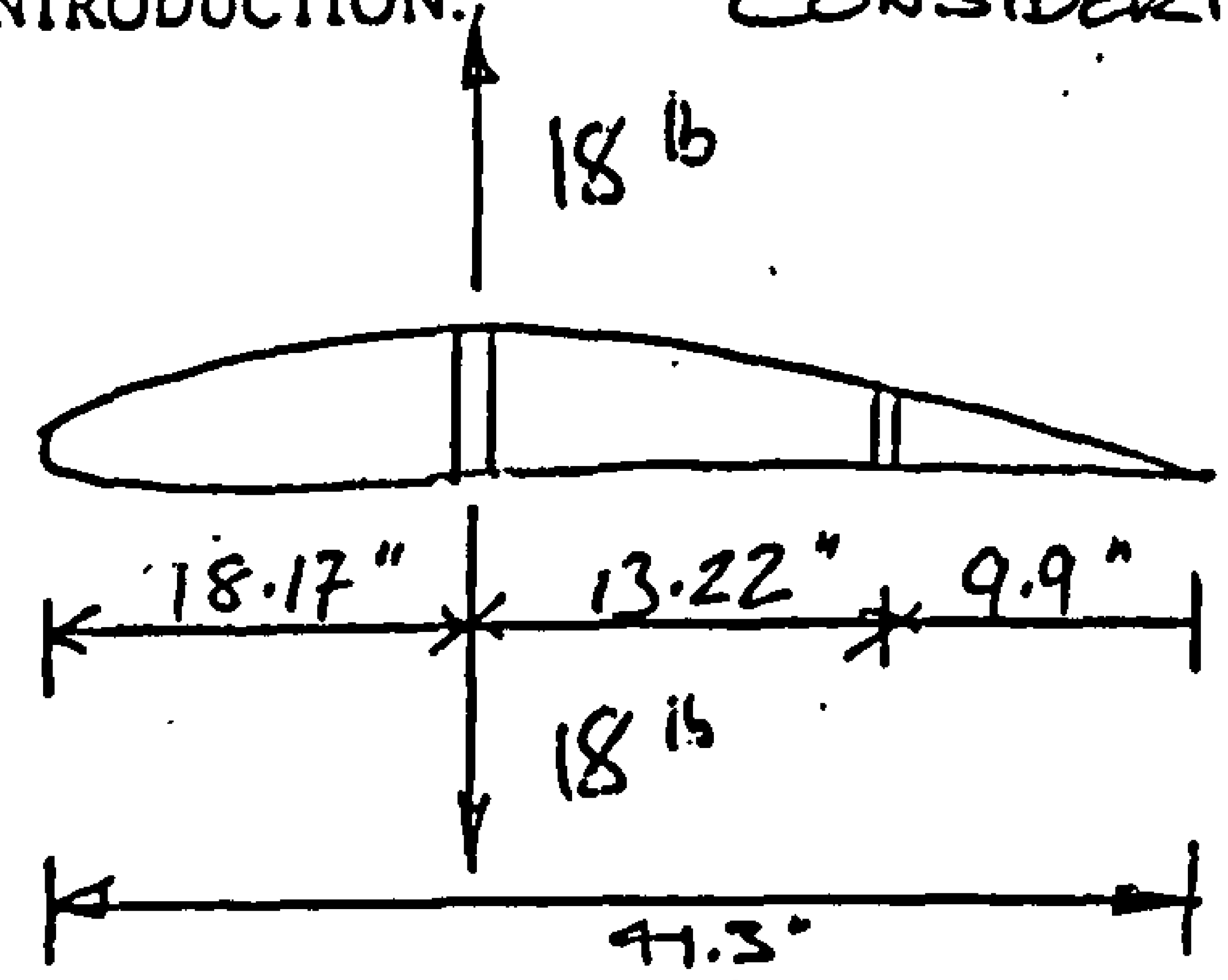
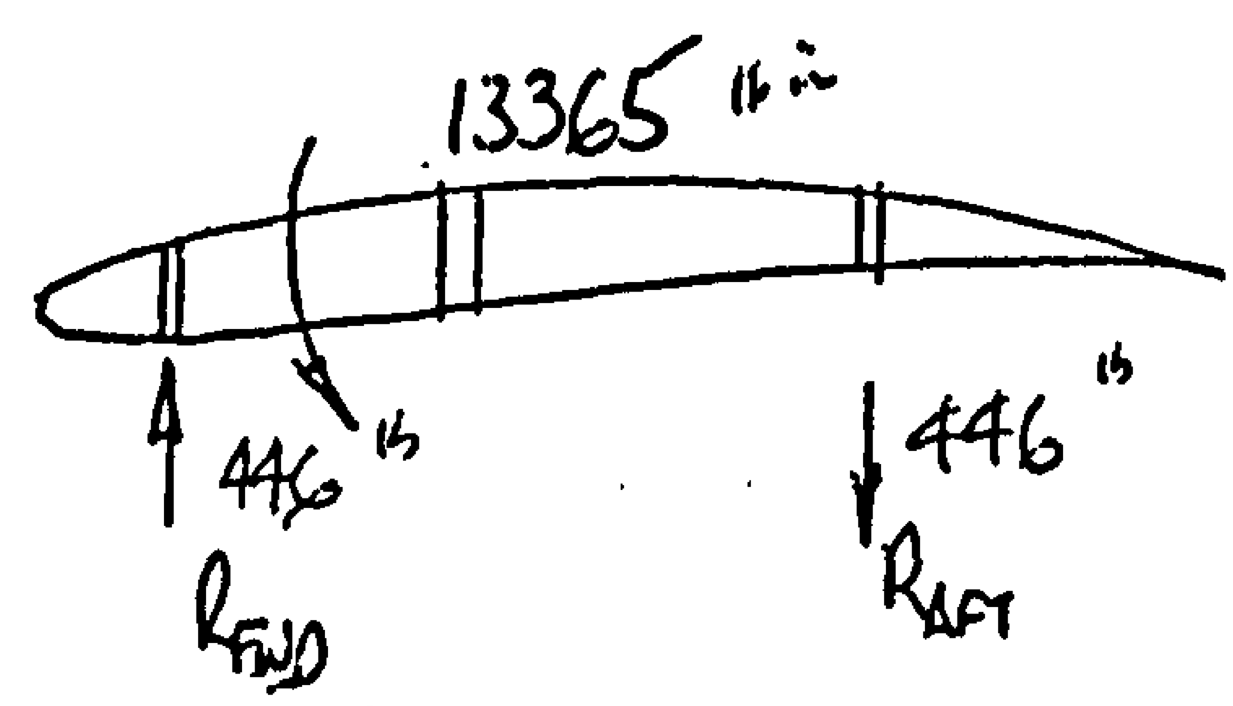
INTRODUCTION: CONSIDERING CONDITION D ULTIMATE LOADS
BRAKES ZL




## NORMAL SHEAR.

ASSUMING 100% NORMAL SHEAR ACTS AT SPAR

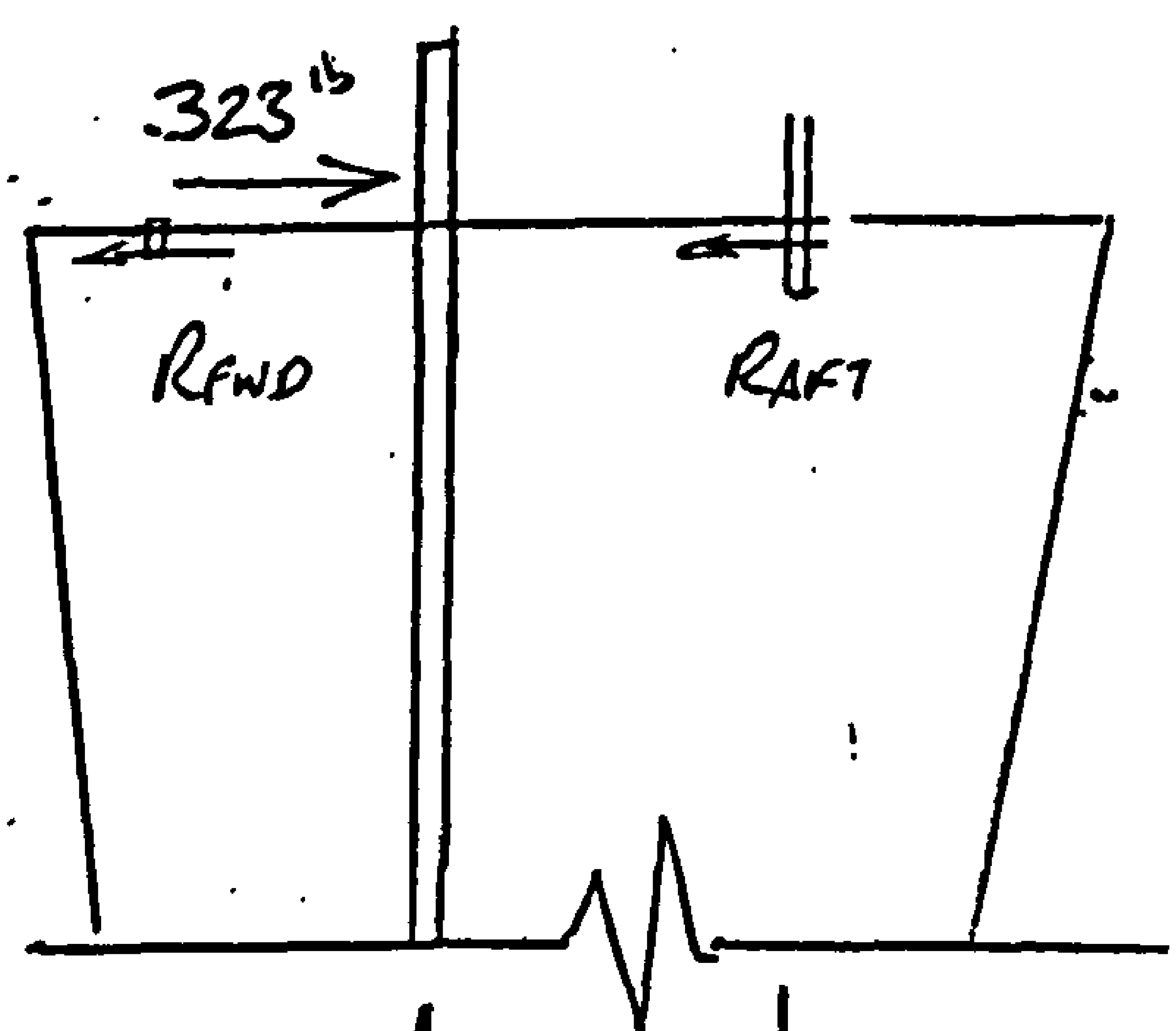
$R_{FWD} = 18$ lb




## TORSION ABOUT SPAR

ASSUMING 100% TORQUE TAKEN BY FORE & AFT PINS.

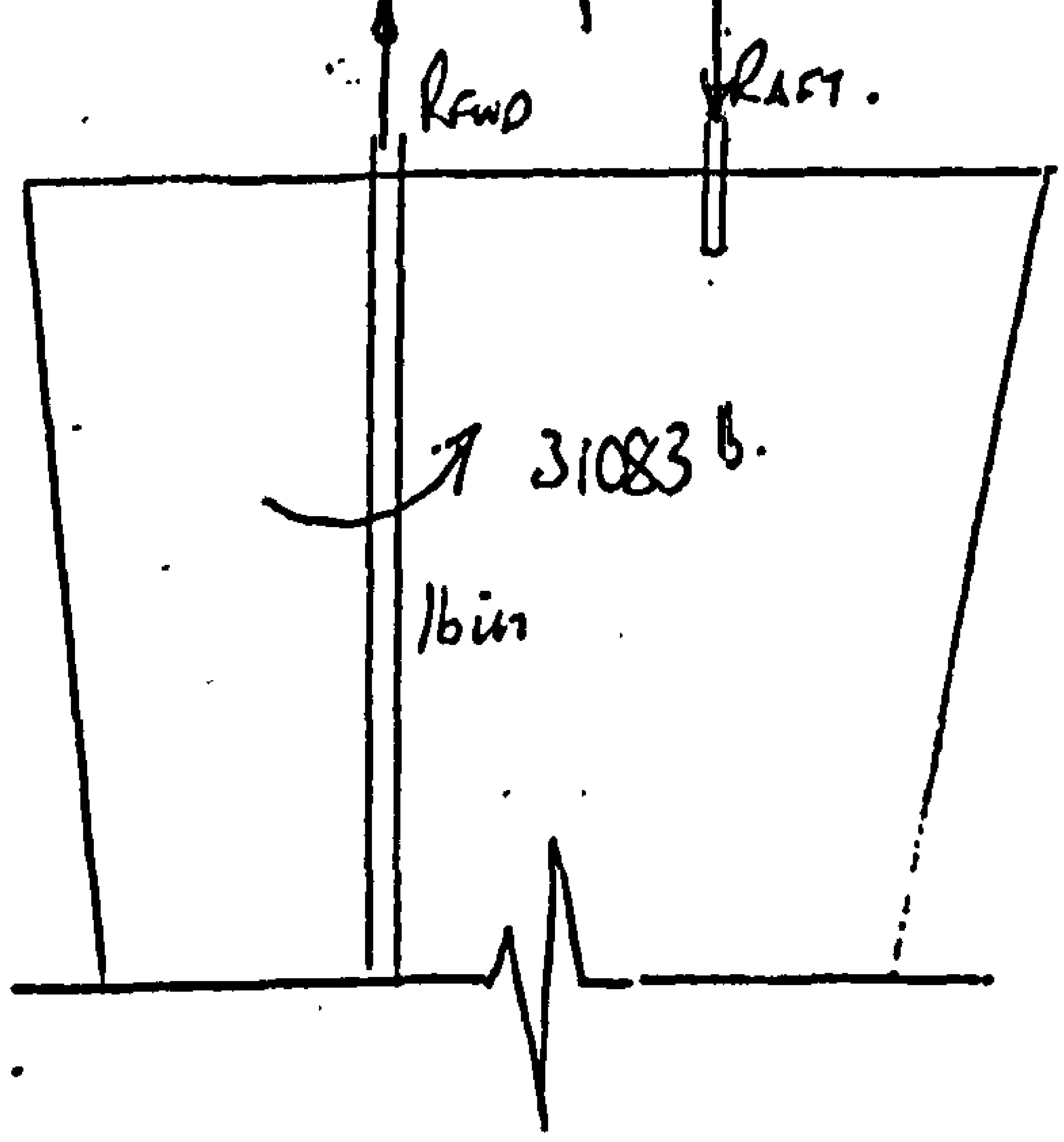
$R_{FWD} \cdot R_{AFT} = \frac{-13365}{30}$




## CHORDWISE SHEAR

ASSUMING 100% CHORDWISE SHEAR TAKEN BY FORE & AFT PINS.

$R_{FWD} = R_{AFT} = 323/2 = 162$ lb




## CHORDWISE BENDING MOMENT.

ASSUMING 100% CHORDWISE BENDING MOMENT IS TAKEN BY MAIN SPAR & CARRY THROUGH.

$R_{FWD} - R_{AFT} = \frac{31083}{13.22}$

$= 2352$ lb

APPENDIX A9 CARRY THROUGH LOADS

75% COND A one side 75% COND A other

75% manoeuvre loads plus max wing torque from aileron deflection

A9 (C) (3)

| STATION | % 75 ULT SHEAR COND. A (lb) | % 75 ULT BEND MOMENT COND. A (lb in) | % 75 ULT SHEAR COND. A (lb) | % 75 ULT BEND MOMENT COND. A (lb in) | % 75 ULT TORSION CLEAN COND. A (lb in) |
|---|---|---|---|---|---|
| 258 | 0 | 0 | 0 | 0 | 0 |
| 251 | 42 | 141 | -5 | -17 | 338 |
| 238 | 142 | 1355 | -20 | -180 | 694 |
| 228 | 222 | 3175 | -32 | -437 | 1018 |
| 218 | 306 | 5815 | -45 | -819 | 1377 |
| 208 | 392 | 9303 | -59 | -1338 | 1763 |
| 198 | 480 | 13659 | -75 | -2007 | 2175 |
| 188 | 568 | 18898 | -91 | -2834 | 2610 |
| 178 | 658 | 25032 | -107 | -3822 | 3068 |
| 164 | 799 | 35485 | -133 | -5542 | 3753 |
| 159 | 825 | 38996 | -137 | -6125 | 3979 |
| 155 | 851 | 42621 | -140 | -6723 | 4210 |
| 138 | 1029 | 58605 | -174 | -9394 | 5089 |
| 128 | 1126 | 69383 | -192 | -11222 | 5636 |
| 118 | 1224 | 81137 | -210 | -13229 | 6197 |
| 108 | 1324 | 93879 | -228 | -15417 | 6771 |
| 98 | 1425 | 107625 | -247 | -17789 | 7358 |
| 88 | 1526 | 122382 | -265 | -20349 | 7959 |
| 80 | 1602 | 134897 | -279 | -22525 | 8452 |
| 68 | 1731 | 154897 | -303 | -26015 | 9194 |
| 58 | 1834 | 172723 | -322 | -29139 | 9828 |
| 48 | 1937 | 191577 | -341 | -32451 | 10472 |
| 22 | 2258 | 246114 | -403 | -42124 | 12144 |
| 19 | 2282 | 252925 | -407 | -43339 | 0 |
| 0 | 2534 | 298682 | -457 | -51551 | 0 |

APPENDIX A9 CARRY THROUGH LOADS

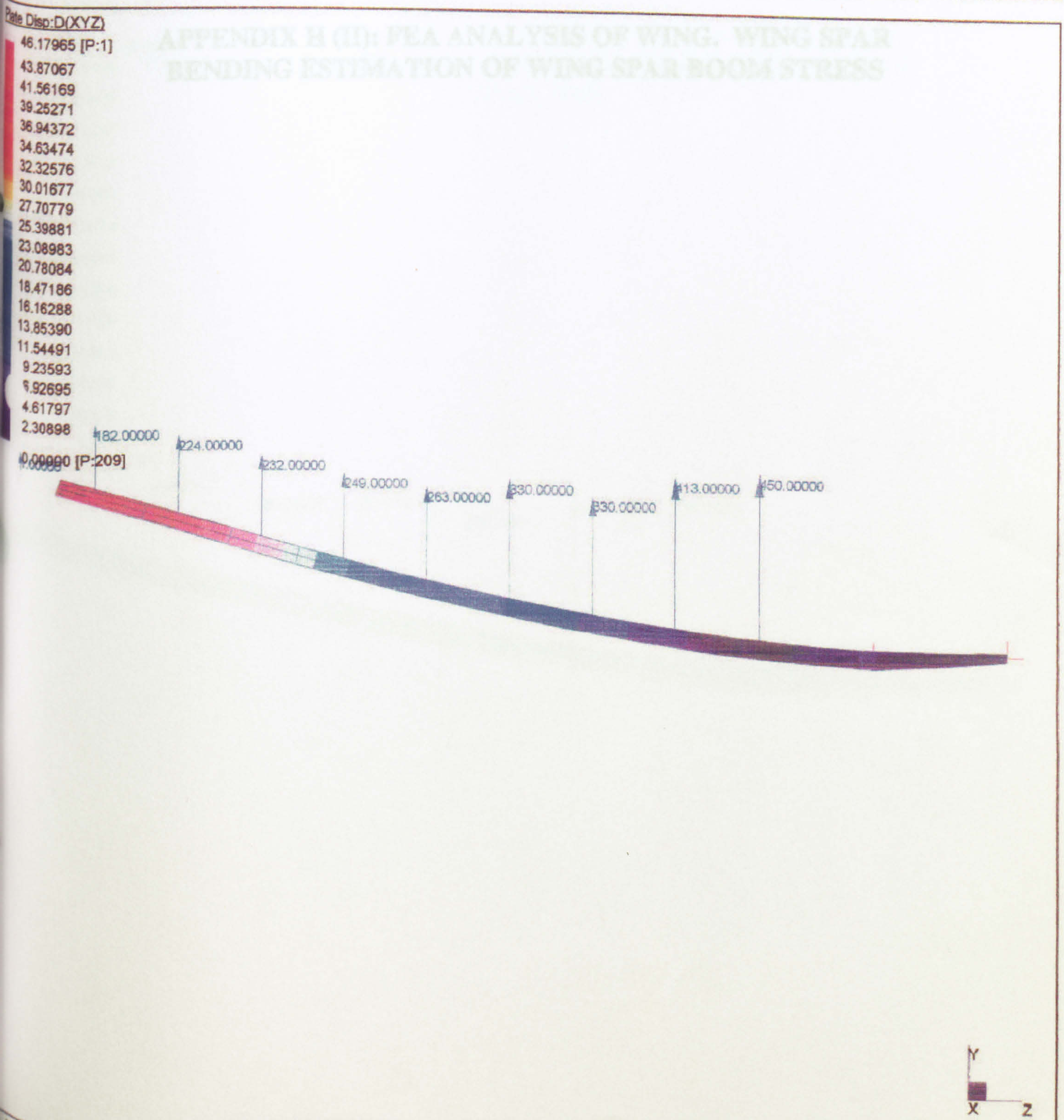
100% COND A one side 70% COND A other

A9 (C) (2)

| STATION | % 100 ULT SHEAR COND. A (lb) | % 100 ULT BEND MOMENT COND. A (lb in) | % 100 ULT SHEAR COND. A (lb) | % 100 ULT BEND MOMENT COND. A (lb in) | % 70 ULT NORMAL SHEAR COND. A (lb) | % 70 ULT NORMAL BEND MOMENT COND. A (lb in) | % 70 ULT CHORD SHEAR COND. A (lb) | % 70 ULT CHORD BEND MOMENT COND. A (lb in) |
|---|---|---|---|---|---|---|---|---|
| 258 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 251 | 56 | 187 | -7 | -23 | 39 | 131 | -5 | -16 |
| 238 | 189 | 1807 | -26 | -240 | 132 | 1265 | -18 | -168 |
| 228 | 296 | 4233 | -42 | -582 | 207 | 2963 | -30 | -408 |
| 218 | 408 | 7753 | -60 | -1092 | 285 | 5427 | -42 | -764 |
| 208 | 522 | 12404 | -79 | -1783 | 366 | 8683 | -55 | -1248 |
| 198 | 639 | 18212 | -100 | -2675 | 448 | 12748 | -70 | -1873 |
| 188 | 758 | 25198 | -121 | -3778 | 530 | 17638 | -85 | -2645 |
| 178 | 878 | 33376 | -143 | -5096 | 614 | 23363 | -100 | -3567 |
| 164 | 1065 | 47313 | -177 | -7389 | 745 | 33119 | -124 | -5172 |
| 159 | 1100 | 51995 | -182 | -8166 | 770 | 36396 | -128 | -5716 |
| 155 | 1135 | 56828 | -187 | -8964 | 794 | 39779 | -131 | -6275 |
| 138 | 1373 | 78140 | -232 | -12525 | 961 | 54698 | -162 | -8768 |
| 128 | 1502 | 92511 | -256 | -14963 | 1051 | 64758 | -179 | -10474 |
| 118 | 1633 | 108182 | -280 | -17638 | 1143 | 75728 | -196 | -12347 |
| 108 | 1765 | 125172 | -304 | -20556 | 1236 | 87621 | -213 | -14389 |
| 98 | 1900 | 143500 | -329 | -23719 | 1330 | 100450 | -230 | -16603 |
| 88 | 2035 | 163177 | -354 | -27131 | 1425 | 114224 | -248 | -18992 |
| 80 | 2136 | 179863 | -372 | -30033 | 1495 | 125904 | -260 | -21023 |
| 68 | 2308 | 206529 | -404 | -34686 | 1616 | 144570 | -283 | -24280 |
| 58 | 2445 | 230297 | -429 | -38851 | 1712 | 161208 | -300 | -27196 |
| 48 | 2582 | 255436 | -454 | -43268 | 1808 | 178805 | -318 | -30288 |
| 22 | 3011 | 328152 | -538 | -56165 | 2108 | 229707 | -377 | -39315 |
| 19 | 3043 | 337233 | -543 | -57786 | 2130 | 236063 | -380 | -40450 |
| 0 | 3379 | 398243 | -610 | -68735 | 2365 | 278770 | -427 | -48115 |
| | | | | | | | | |
| | NS | NM | CS | CM | | | | |
| DELTA 19 | 913 | 101170 | - | - | | | | |
| DELTA 22 | - | - | -161 | -16849 | | | | |

# APPENDIX H (I): FEA ANALYSIS OF WING. WING SPAR BENDING ESTIMATION OF WING SPAR DEFLECTION

| Title: WING SPAR BENDING TEST | |
|---|---|
| Project: PREMOULDED GLIDER WING | |
| Author: J RUSSELL | Reference: |




274 Nodes
0 Beams
243 Plates
90 Bricks
71 Links

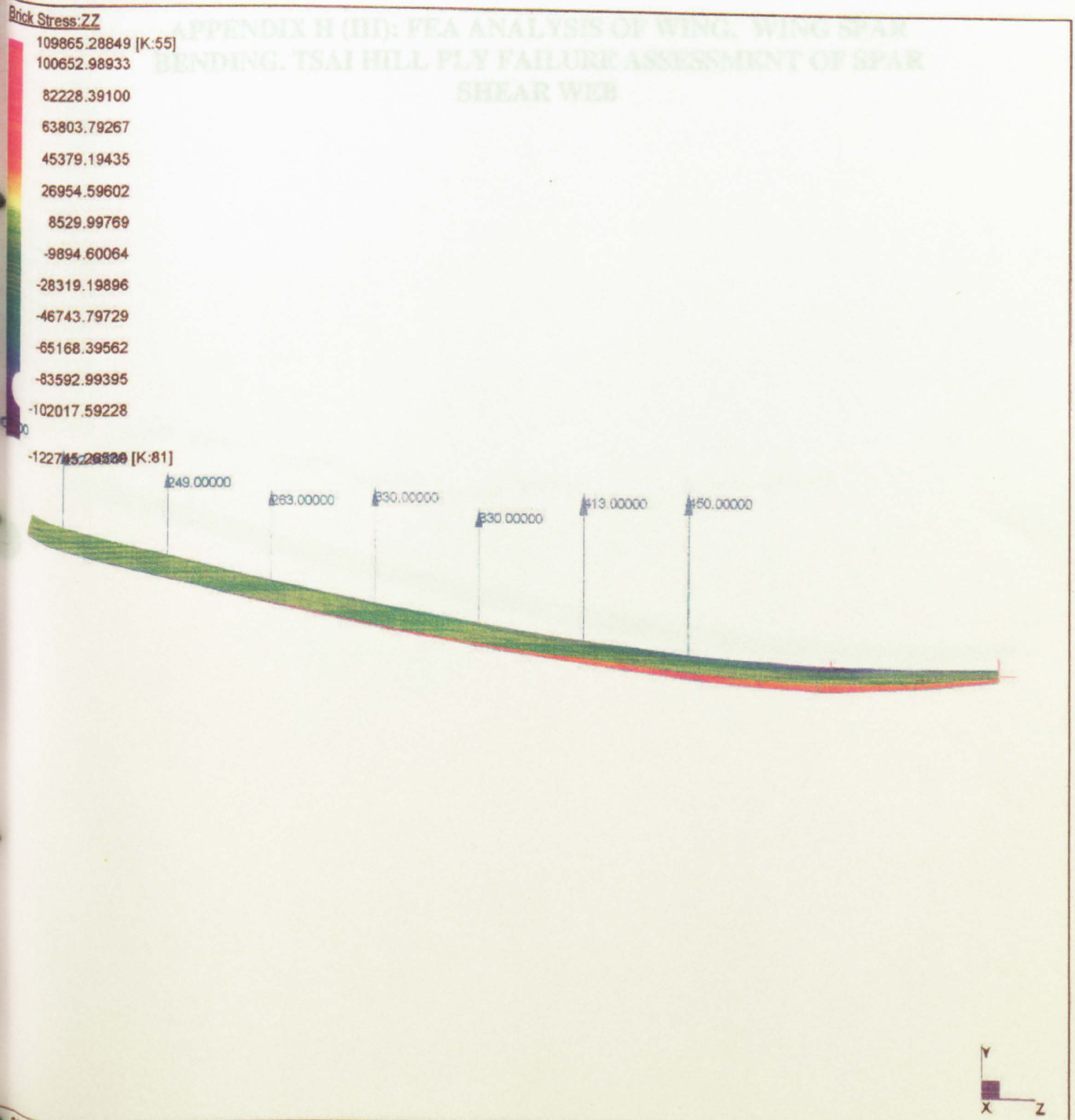
| View | |
|---|---|
| RX: | 0.0 |
| RY: | 90.0 |
| RZ: | 0.0 |

2: VC Ultimate load
Freedom Case 1
Scale: 18.0 %

Release 1.05.7
FINITE ELEMENT ANALYSIS\GWG9CRPSPAR.st7
2000 6:08 pm

# APPENDIX H (II): FEA ANALYSIS OF WING. WING SPAR BENDING ESTIMATION OF WING SPAR BOOM STRESS

| Title: | |
|---|---|
| **WING SPAR BENDING TEST** | |
| Project: | |
| **PREMOULDED GLIDER WING** | |
| Author: | Reference: |
| **J RUSSELL** | |

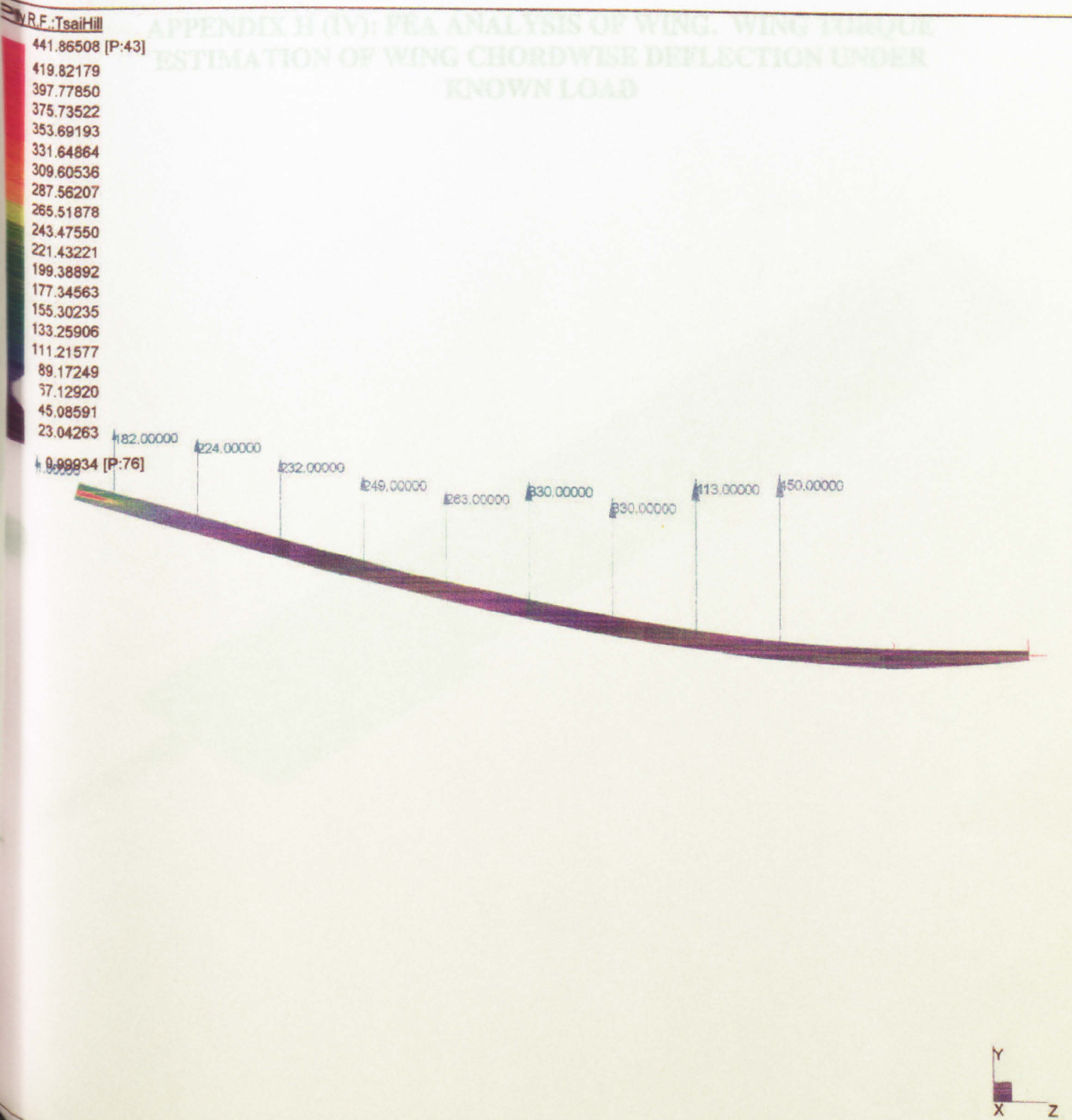



| | | |
|---|---|---|
| 274 Nodes<br>0 Beams<br>243 Plates<br>90 Bricks<br>71 Links | View<br>RX: 0.0<br>RY: 90.0<br>RZ: 0.0 | 2: VC Ultimate load<br>Freedom Case 1<br>Scale: 18.0 % |

Straand7 Release 1.05.7
...JASON\FINITE ELEMENT ANALYSIS\GWG9CRPSPAR.st7
...2000 6:06 pm

# APPENDIX H (III): FEA ANALYSIS OF WING. WING SPAR BENDING. TSAI HILL PLY FAILURE ASSESSMENT OF SPAR SHEAR WEB

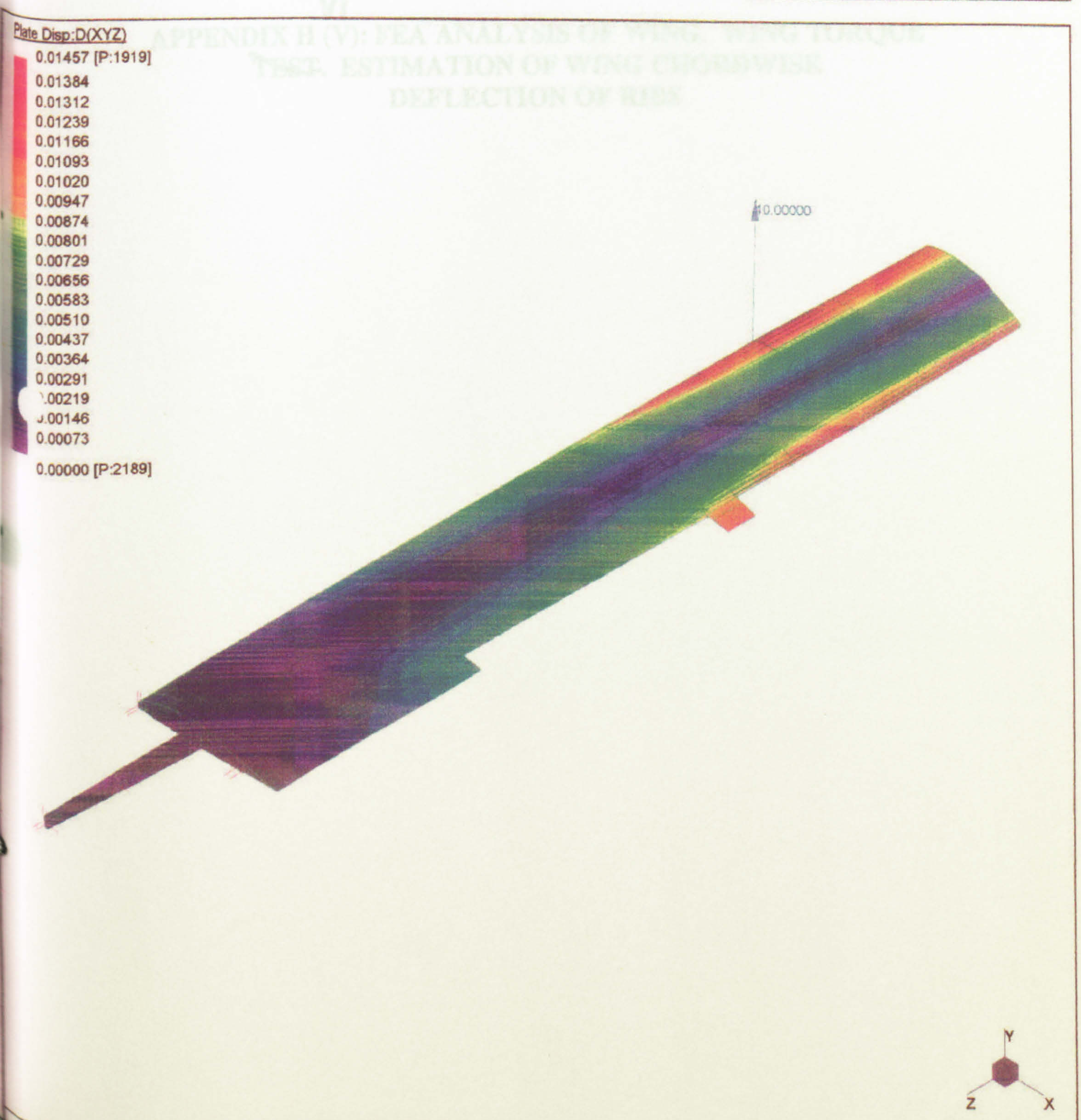
| Title: | |
|---|---|
| **WING SPAR BENDING TEST** | |
| Project: | |
| **PREMOULDED GLIDER WING** | |
| Author: **J RUSSELL** | Reference: |




| | | |
|---|---|---|
| 274 Nodes<br>0 Beams<br>243 Plates<br>90 Bricks<br>71 Links | View<br>RX: 0.0<br>RY: 90.0<br>RZ: 0.0 | 2: VC Ultimate load<br>Freedom Case 1<br>Scale: 18.0 % |

# APPENDIX H (IV): FEA ANALYSIS OF WING. WING TORQUE ESTIMATION OF WING CHORDWISE DEFLECTION UNDER KNOWN LOAD

| Title: | |
|---|---|
| WING TORQUE TEST | |
| Project: | |
| PREMOULDED GLIDER WING | |
| Author: | Reference: |
| J RUSSELL | |

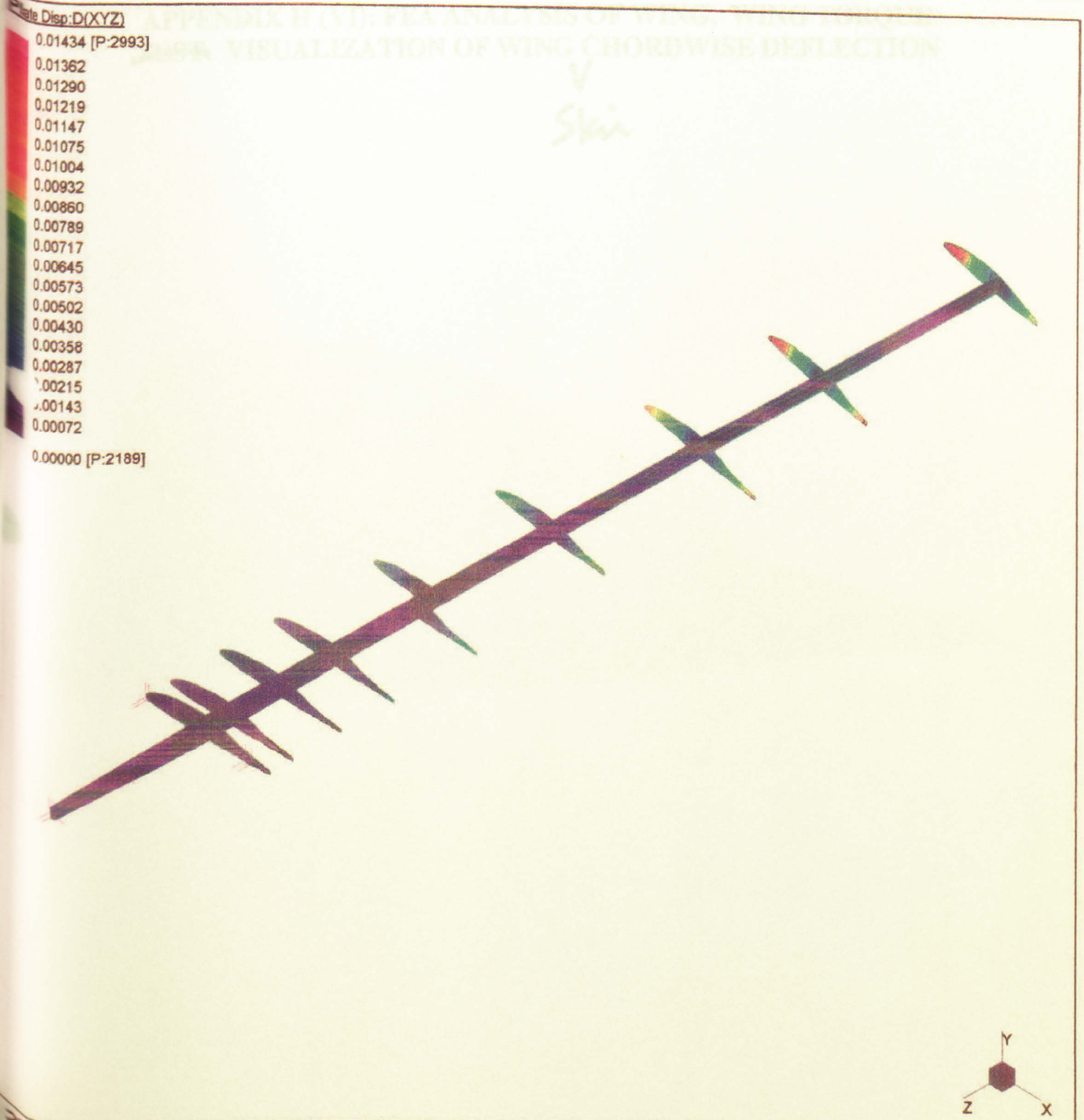



| | | |
|---|---|---|
| 2729 Nodes<br>0 Beams<br>3081 Plates<br>1076 Bricks<br>186 Links | View<br>RX: 35.3<br>RY: -45.0<br>RZ: 0.0 | 1: SC1<br>Freedom Case 1<br>Scale: 5.0 % |

Strand7 Release 1.05.7
C:\JASON\FINITE ELEMENT ANALYSIS\GLIDER\NEWGWG8.st7
May 2000 6:00 pm

# APPENDIX H (V) VI: FEA ANALYSIS OF WING. WING TORQUE ~~TEST~~. ESTIMATION OF WING CHORDWISE DEFLECTION OF RIBS

| Title: | |
|---|---|
| WING TORQUE TEST | |
| Project: | |
| PREMOULDED GLIDER WING | |
| Author: | Reference: |
| J RUSSELL | |



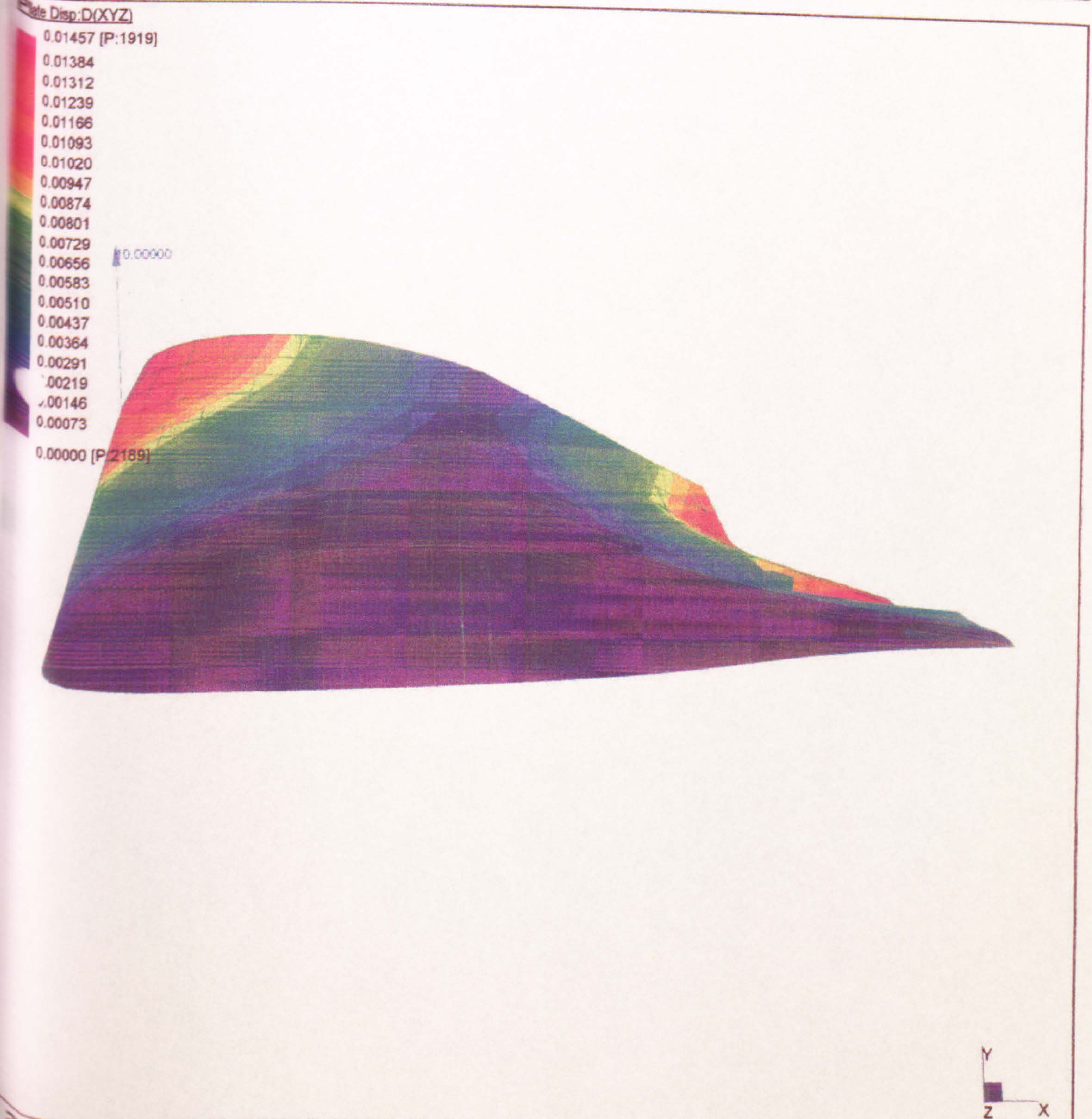

| | | |
|---|---|---|
| 2729 Nodes | View | 1: SC1 |
| 0 Beams | RX: 35.3 | Freedom Case 1 |
| 3081 Plates | RY: -45.0 | Scale: 5.0 % |
| 1076 Bricks | RZ: 0.0 | |
| 186 Links | | |

Release 1.05.7
...\FINITE ELEMENT ANALYSIS\GLIDER\NEWGWG8.st7
2000 8:02 pm

# APPENDIX H (VI): FEA ANALYSIS OF WING. WING TORQUE ~~TEST.~~ VISUALIZATION OF WING CHORDWISE DEFLECTION

V
Skin

| | |
|---|---|
| Title: **WING TORQUE TEST** | |
| Project: **PREMOULDED GLIDER WING** | |
| Author: **J RUSSELL** | Reference: |




| | | |
|---|---|---|
| 729 Nodes<br>0 Beams<br>081 Plates<br>076 Bricks<br>186 Links | View<br>RX: 2.3<br>RY: 0.3<br>RZ: 3.0 | 1: SC1<br>Freedom Case 1<br>Scale: 5.0 % |

Release 1.05.7
\FINITE ELEMENT ANALYSIS\GLIDER\NEWGWG8.st7
2000 6:00 pm

# APPENDIX I: DERIVATION OF MATERIAL ALLOWABLE STRENGTH VALUES USING JAR-VLA COMPOSITE METHODOLOGY

BB/DC028/JB

The ADVANCED COMPOSITES GROUP

Advanced Composites Group Ltd
Composites House, Adams Close
Heanor Gate Industrial Estate
Heanor, Derbys DE75 7SW
Telephone: 01773 763441
Fax: 01773 530245
E-Mail: info@acg.co.uk

3D Mouldings
Unit 6
Pennine Industrial Estate
Hebden Bridge
HX7 8BZ

28 November 1997

## MATERIAL SPECIFICATION

### PRODUCT DESIGNATION/DESCRIPTION

Uni-directional Epoxy/Glass Fibre Prepreg
LTM26- 'E' Glass-120-41%Vf (40%RW)

### RESIN SYSTEM

Advanced Composite Materials Ltd formulated epoxy system
Reference LTM26

### REINFORCEMENT

Collimated 600 Tex E-Glass Rovings at 120gsm ±5% (average) areal wt.

### MATERIAL WIDTH

600mm –0, +0.125mm

### VOLATILE CONTENT

Less than 2%

### FORMAT

Supplied in roll from with single separator paper.

SLINGSBY AVIATION Ltd

Occasional Test Report No : 19

TEST REPORT

DATE : 27 / 11 / '97

Test Engineer : Neil Mudie

SHEET : 1 of 3

CHECKED Neil Mudie

DISTRIBUTION :
Europa Services Ltd
File.

---

**Aim of test**

To determine the tensile strength of sections of the prepreg assembly wing skin at various locations on the wing.

---

**Details of test Specimens**

Tensile test specimens were prepared from production wing skins ( see appendix A for diagram ), as standard composite samples 250 mm long and 25 mm wide, with end pads to prevent jaw failure.
Samples were produced from 3 areas of the wing, each of which showed a different lay up of the glass reinforcement.
Checks to prove the validity of the structural composition were made by performing burn offs of sections of the test pieces, cut to 20 x 25 mm pieces, to ensure the alignment could not be confused.

---

**Method**

All the tensile test pieces were pulled from zero load to destruction within 30 to 60 seconds ( to be in compliance with CRAG test methods ) in a Denison machine.
Resin burn offs were performed on the above sections at 575°C for 45 minutes.

---

**Results**

See pages 2 & 3.

---

**Conclusions**

Samples 1 - 6 (in the line of the rib ) = mean strength of 138.8 N/mm²
Samples 1a - 6a ( at 90° to the rib ) = mean strength of 133.4 N/mm²
Samples 1b - 9b (in the line of the rib ) = mean strength of 292.4 N/mm²
Samples R1 - R9 (in the line of the rib ) = mean strength of 344.5 N/mm²
Samples F1 - F9 ( at 90° to the rib ) = mean strength of 122.4 N/mm²

The burn off tests confirm that the reinforcement is as design.

The approximate ultimate tensile strengths for the wing shear pins by diamond hardness testing is $1.21 \times 10^5$ p.s.i. in the unthreaded portion, $1.67 \times 10^5$ in the threaded portion.

---

Europa wing skin material

| | Sample | width mm | thickness mm | LOAD KN | Strength per layer | | Stress in glass only (N/mm²) |
|---|---|---|---|---|---|---|---|
| 45°/45° | 1 | 24.75 | 2.91 | 1.7 | 17.17 | N/mm/layer | 140.18 |
| in the line | 2 | 24.87 | 2.84 | 1.64 | 16.49 | | 134.58 |
| of the spar | 3 | 24.78 | 2.81 | 1.66 | 16.75 | | 136.71 |
| | 4 | 24.82 | 2.85 | 1.7 | 17.12 | | 139.78 |
| | 5 | 24.89 | 2.79 | 1.66 | 16.67 | | 136.11 |
| | 6 | 24.74 | 2.86 | 1.76 | 17.78 | | 145.18 |
| | | | | | | Mean = | 138.76 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 45°/45° | 1a | 24.74 | 2.78 | 1.66 | 16.77 | | 136.93 |
| 90° to the line | 2a | 24.86 | 2.79 | 1.56 | 15.69 | | 128.06 |
| of the spar | 3a | 24.79 | 2.84 | 1.68 | 16.94 | | 138.30 |
| | 4a | 24.8 | 2.9 | 1.64 | 16.53 | | 134.96 |
| | 5a | 24.76 | 2.81 | 1.58 | 15.95 | | 130.23 |
| | 6a | 24.74 | 2.86 | 1.6 | 16.17 | | 131.98 |
| | | | | | | Mean = | 133.41 |

by burn off 2 layers of 0.31mm @ + 4 layers 0.123mm thick total= 1.11 mm thickness

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 2layers | 1b | 25.05 | | 8.06 | 53.63 | | 289.87 |
| +/- 45° | 2b | 25.18 | | 7.4 | 48.98 | | 264.76 |
| 2 layers of | 3b | 25.06 | | 8.44 | 56.13 | | 303.42 |
| cloth 0.31 mm | 4b | 25.09 | | 7.84 | 52.08 | | 281.51 |
| thick. 22 pick | 5b | 25.13 | | 8.64 | 57.30 | | 309.74 |
| per cm | 6b | 25.07 | | 7.4 | 49.20 | | 265.92 |
| (250 - 300gm) | 7b | 25.28 | | 8.62 | 56.83 | | 307.19 |
| Sample from | 8b | 25.29 | | 8.64 | 56.94 | | 307.78 |
| walkway area | 9b | 25.24 | | 8.44 | 55.73 | | 301.25 |
| | | | | | | Mean = | 292.38 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | R1 | 24.58 | | 6.46 | 43.80 | | 355.16 |
| 2 extra layers | R2 | 24.73 | | 6.42 | 43.27 | | 350.82 |
| of unidirect. | R3 | 24.8 | | 6.14 | 41.26 | | 334.57 |
| cloth. in line | R4 | 24.59 | | 6.08 | 41.21 | | 334.13 |
| of spar | R5 | 24.88 | | 6.86 | 45.95 | | 372.60 |
| | R6 | 24.55 | | 5.6 | 38.02 | | 308.25 |
| | R7 | 24.48 | | 6.76 | 46.02 | | 373.17 |
| | R8 | 24.36 | | 6.62 | 45.29 | | 367.24 |
| | R9 | 24.58 | | 5.54 | 37.56 | | 304.58 |
| | | | | | | Mean = | 344.50 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | F1 | 24.63 | | 2.40 | 16.24 | | 131.68 |
| 2 extra layers | F2 | 24.65 | | 2.22 | 15.01 | | 121.70 |
| of unidirect. | F3 | 24.59 | | 2.32 | 15.72 | | 127.50 |
| cloth. 90° to | F4 | 24.51 | | 2.28 | 15.50 | | 125.71 |
| line of spar | F5 | 24.53 | | 2.24 | 15.22 | | 123.40 |
| | F6 | 24.61 | | 2.00 | 13.54 | | 109.82 |
| | F7 | 24.65 | | 2.10 | 14.20 | | 115.13 |
| | F8 | 24.84 | | 2.28 | 15.30 | | 124.04 |
| | | | | | | Mean = | 122.37 |

Vickers hardness diamond diameters, microns

| A Unthreaded portion, 30Kg Load | | | Mean | Ult tensile | (approx) psi |
|---|---|---|---|---|---|
| 464 | 463 | 462 | 463 | 121,000 | |
| 464 | 462 | 463 | | | |

| B Threaded portion, 30 Kg Load | | | Mean | Ult tensile | (approx) psi |
|---|---|---|---|---|---|
| 397 | 396 | 396 | 396.5 | 167,000 | |
| 396 | 398 | 396.5 | | | |

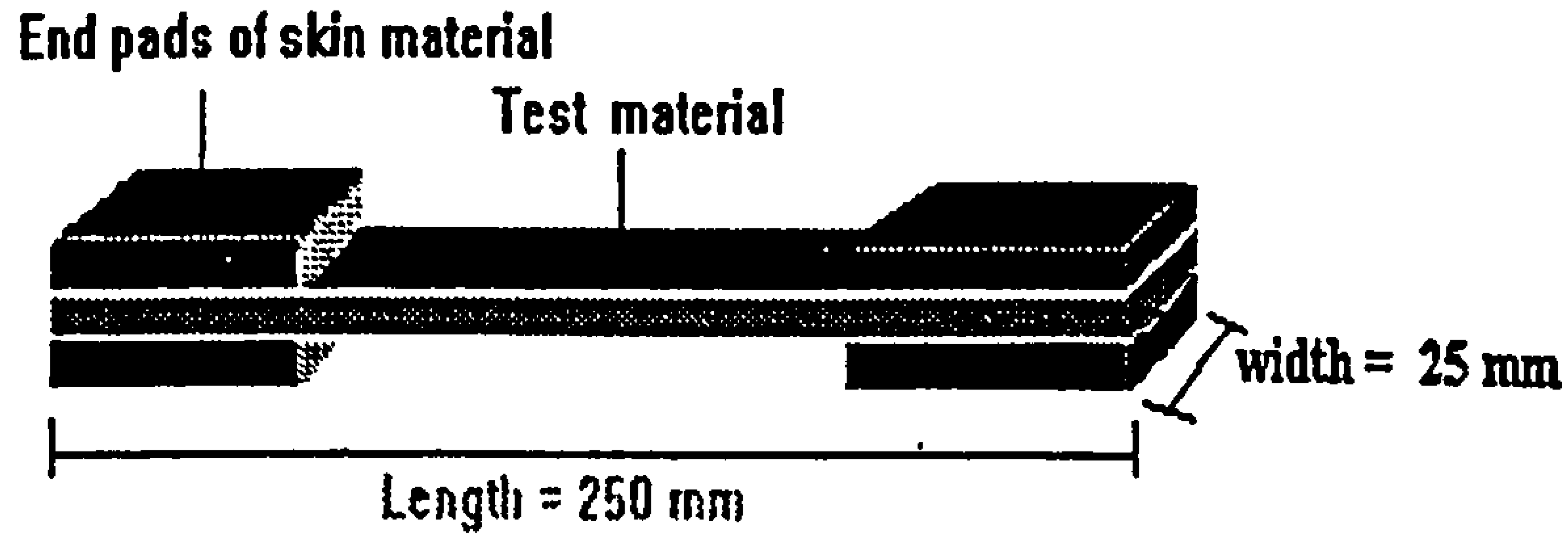
| C Unthreaded portion, 50 Kg load | | | Mean | Ult tensile | (approx) psi |
|---|---|---|---|---|---|
| 596 | 596 | 597 | 596 | 121,500 | |
| 598 | 595 | 596 | | | |

| D Threaded portion, 50 Kg Load | | | Mean | Ult tensile | (approx) psi |
|---|---|---|---|---|---|
| 511 | 512 | 509 | 510.5 | 168,000 | |
| 508 | 512 | 510 | | | |

| Samples | Resin burn off results |
|---|---|
| Z 1 to 6 | 2 layers of unidirectional glass 1 at -45°, 1 at +45°,either side of residues of the foam |
| Y 1a to 6a | as Z |
| X 1b to 9b | as Z but with 2 extra layers of bidirectional glass 0.31 mm thick,on the outside of upper skin . |
| W R1 to R9 | as Z but with 2 extra layers of the unidirectional cloth in the line of the rib. |
| V F1 to F8 | as Z but with 2 extra layers of the unidirectional cloth at 90° to the line of the rib. |

Appendix A

## Figure 1 - Tensile test specimens

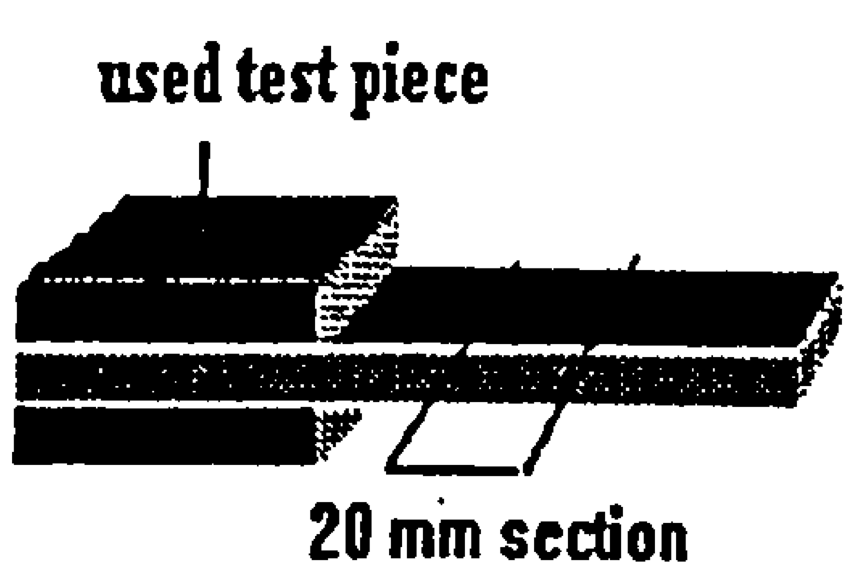



- test pieces accurately measured individually

End pads bonded to test material with Araldite 420,

both surfaces abraded with 1000 grit wet and dry

## Figure 2 - Burn off specimens



SLINGSBY AVIATION Ltd

Occasional Test Report No : 20

TEST REPORT

DATE : 17 / 12 / '97

Test Engineer : Neil Mudie

SHEET : 1 of 2

CHECKED

DISTRIBUTION :
Europa Services Ltd
File

**Aim of test**

To determine the tensile strength of sections of the prepreg assembly wing skin at various locations on the wing.

---

**Details of test Specimens**

Tensile test specimens were prepared from production wing skins ( see appendix A for diagram ), as standard composite samples 250 mm long and 25 mm wide, with end pads to prevent jaw failure.
Samples were produced from 3 areas of the wing, each of which showed a different lay up of the glass reinforcement.
Checks to prove the validity of the structural composition were made by performing burn offs of sections of the test pieces, cut to 20 x 25 mm pieces, to ensure the alignment could not be confused.

---

**Method**

All the tensile test pieces were pulled from zero load to destruction within 30 to 60 seconds ( to be in compliance with CRAG test methods ) in a Denison machine.
Resin burn offs were performed on the above sections at 575°C for 45 minutes.

---

**Results**

Attached - ( See page 2 ).

---

**Conclusions**

Samples 1 - 6 (in the line of the spar ) = mean strength of 138.8 N/mm²
Samples 1a - 6a ( at 90° to the spar ) = mean strength of 133.4 N/mm²
Samples 1b - 9b (in the line of the spar ) = mean strength of 292.4 N/mm²
Samples R1 - R9 (in the line of the spar ) = mean strength of 344.5 N/mm²
Samples F1 - F9 ( at 90° to the spar ) = mean strength of 122.4 N/mm²

The burn off tests confirm that the reinforcement is as design.

---

Europa wing skin material

45°/45° in the line of the spar

| Sample | width mm | thickness mm | LOAD KN | Strength per layer | | Stress in glass only ($N/mm^2$) |
|---|---|---|---|---|---|---|
| 1 | 24.75 | 2.91 | 1.7 | 17.17 | N/mm/layer | 140.18 |
| 2 | 24.87 | 2.84 | 1.64 | 16.49 | | 134.58 |
| 3 | 24.78 | 2.81 | 1.66 | 16.75 | | 136.71 |
| 4 | 24.82 | 2.85 | 1.7 | 17.12 | | 139.78 |
| 5 | 24.89 | 2.79 | 1.66 | 16.67 | | 136.11 |
| 6 | 24.74 | 2.86 | 1.76 | 17.78 | | 145.18 |
| | | | | | Mean = | 138.76 |

45°/45° 90° to the line of the spar

| | | | | | | |
|---|---|---|---|---|---|---|
| 1a | 24.74 | 2.78 | 1.66 | 16.77 | | 136.93 |
| 2a | 24.86 | 2.79 | 1.56 | 15.69 | | 128.06 |
| 3a | 24.79 | 2.84 | 1.68 | 16.94 | | 138.30 |
| 4a | 24.8 | 2.9 | 1.64 | 16.53 | | 134.96 |
| 5a | 24.76 | 2.81 | 1.58 | 15.95 | | 130.23 |
| 6a | 24.74 | 2.86 | 1.6 | 16.17 | | 131.98 |
| | | | | | Mean = | 133.41 |

by burn off 2 layers of 0.31mm @ + 4 layers 0.123mm thick · total= 1.11 mm thickness

2layers .+/- 45° 2 layers of cloth 0.31 mm thick. 22 pick per cm (250 - 300gm) Sample from walkway area

| | | | | | | |
|---|---|---|---|---|---|---|
| 1b | 25.05 | | 8.06 | 53.63 | | 289.87 |
| 2b | 25.18 | | 7.4 | 48.98 | | 264.76 |
| 3b | 25.06 | | 8.44 | 56.13 | | 303.42 |
| 4b | 25.09 | | 7.84 | 52.08 | | 281.51 |
| 5b | 25.13 | | 8.64 | 57.30 | | 309.74 |
| 6b | 25.07 | | 7.4 | 49.20 | | 265.92 |
| 7b | 25.28 | | 8.62 | 56.83 | | 307.19 |
| 8b | 25.29 | | 8.64 | 56.94 | | 307.78 |
| 9b | 25.24 | | 8.44 | 55.73 | | 301.25 |
| | | | | | Mean = | 292.38 |

2 extra layers of unidirect. cloth, in line of spar

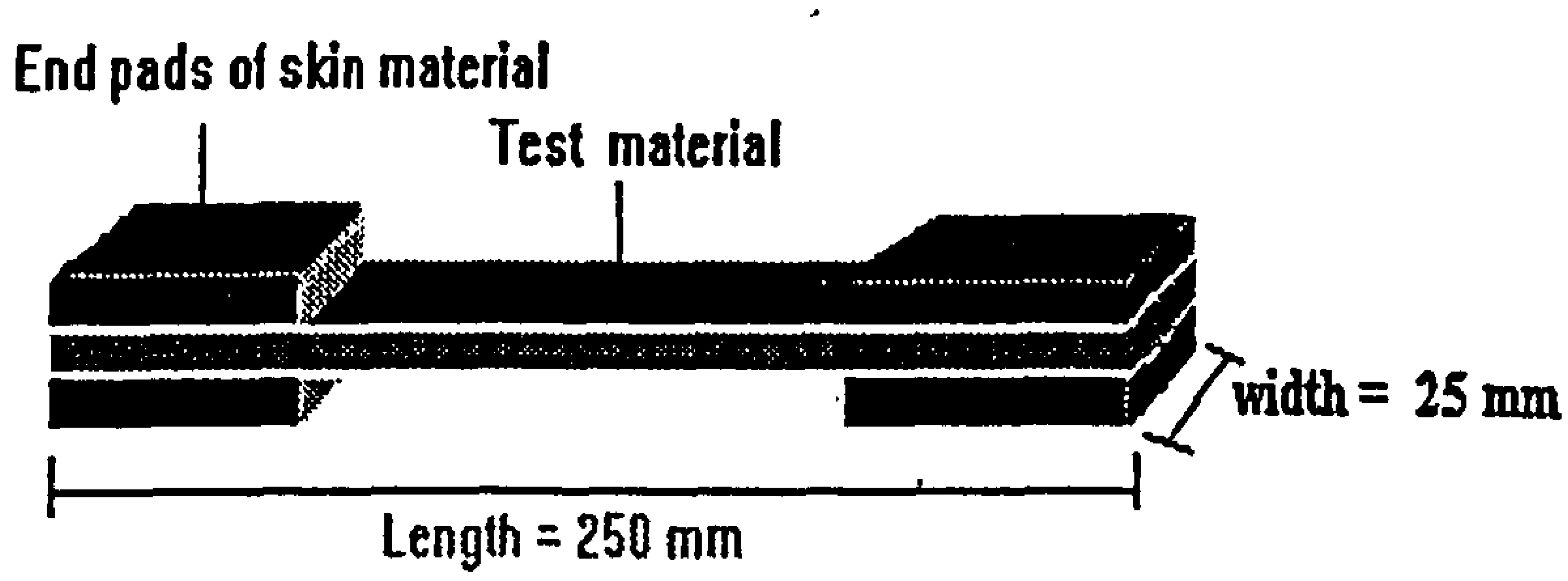
| | | | | | | |
|---|---|---|---|---|---|---|
| R1 | 24.58 | | 6.46 | 43.80 | | 355.16 |
| R2 | 24.73 | | 6.42 | 43.27 | | 350.82 |
| R3 | 24.8 | | 6.14 | 41.26 | | 334.57 |
| R4 | 24.59 | | 6.08 | 41.21 | | 334.13 |
| R5 | 24.88 | | 6.86 | 45.95 | | 372.60 |
| R6 | 24.55 | | 5.6 | 38.02 | | 308.25 |
| R7 | 24.48 | | 6.76 | 46.02 | | 373.17 |
| R8 | 24.36 | | 6.62 | 45.29 | | 367.24 |
| R9 | 24.58 | | 5.54 | 37.56 | | 304.58 |
| | | | | | Mean = | 344.50 |

2 extra layers of unidirect. cloth, 90° to line of spar

| | | | | | | |
|---|---|---|---|---|---|---|
| F1 | 24.63 | | 2.40 | 16.24 | | 131.68 |
| F2 | 24.65 | | 2.22 | 15.01 | | 121.70 |
| F3 | 24.59 | | 2.32 | 15.72 | | 127.50 |
| F4 | 24.51 | | 2.28 | 15.50 | | 125.71 |
| F5 | 24.53 | | 2.24 | 15.22 | | 123.40 |
| F6 | 24.61 | | 2.00 | 13.54 | | 109.82 |
| F7 | 24.65 | | 2.10 | 14.20 | | 115.13 |
| F8 | 24.84 | | 2.28 | 15.30 | | 124.04 |
| | | | | | Mean = | 122.37 |

| Samples | Resin burn off results |
|---|---|
| Z 1 to 6 | 2 layers of unidirectional glass 1 at -45°, 1 at +45°, either side of residues of the foam |
| Y 1a to 6a | as Z |
| X 1b to 9b | as Z but with 2 extra layers of bidirectional glass 0.31 mm thick, on the outside of upper skin. |
| W R1 to R9 | as Z but with 2 extra layers of the unidirectional cloth in the line of the spar. |
| V F1 to F8 | as Z but with 2 extra layers of the unidirectional cloth at 90° to the line of the spar. |

## Figure 1 - Tensile test specimens

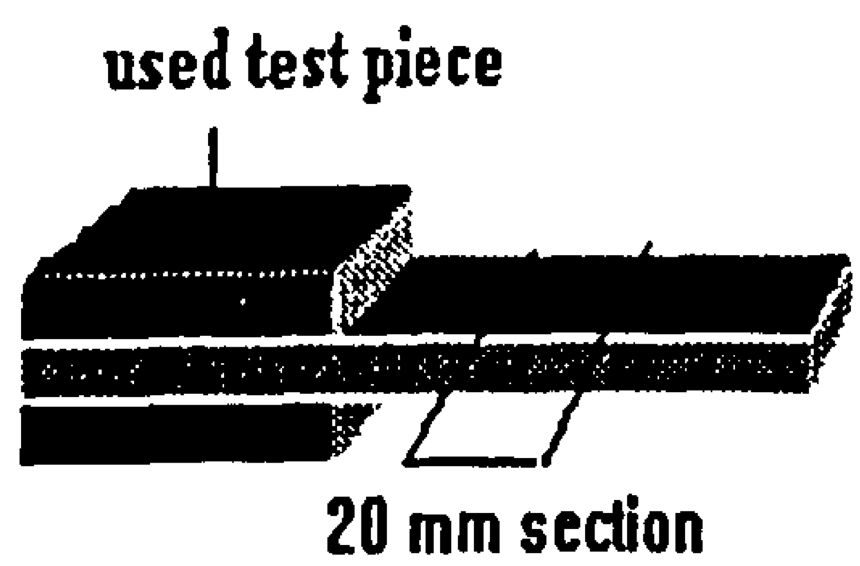



- test pieces accurately measured individually

End pads bonded to test material with Araldite 420,

both surfaces abraded with 1000 grit wet and dry

## Figure 2 - Burn off specimens



COEFFICIENT OF VARIATION OF COMPOSITE MATERIAL

JAR-VLA ACJ-VLA 619

Special Fcators (Acceptable Means of Compliance)

Table 1

| Coefficient of Variation % | Test Factor |
|---|---|
| 5 | 1.00 |
| 6 | 1.03 |
| 7 | 1.06 |
| 8 | 1.10 |
| 9 | 1.12 |
| 10 | 1.15 |
| 12 | 1.22 |
| 14 | 1.30 |
| 15 | 1.33 |
| 20 | 1.55 |

Coefficient of variation

For a population with a mean M and a standard deviation $\sigma$, the coefficient of variation, Cv is defined by-

$Cv = \sigma/M$

$Cv\ (\%) = 100\ \sigma/M$

Additional advisory material

When the population coefficient of variation is estimated from tests of critical structural features the results from tests of at leats 6 specimens should be used

The sample coefficient of variation should be adjusted to obtain 95% confidence estimate of the population coefficient of variation which may be used in Table 1

In the absence of a more rational method, this may be done by multiplying the sample coefficient of variation by a Factor F, defined by ACJ-VLA 619

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| GENERAL COMPOSITE MATERIAL STRENGTH | | | | | | | | | |
| Resin system AMPREG 20 | | | | | | | | | |
| | | | | | | | | | |
| TEST RESULTS | TENSION | | | | | | | | |
| | | | | | | | | | |
| | GLASS REINFORCEMENT | | | | | | | | |
| | Bi-directional 0/90 92125 | | | .+/- 45 deg | .+/- 45 deg | | Sample variance | | |
| Specimen | Width | Thickness | Failure | Stress | Stress | | | | |
| | (mm) | (mm) | KN | N/mm² | psi | | | | |
| 1 | 24.92 | 2.99 | 5.42 | 72.74 | 10547.30 | | 59623.87 | | |
| 2 | 25.08 | 2.79 | 5.40 | 77.17 | 11189.65 | | 158539.35 | | |
| 3 | 25.12 | 2.94 | 5.34 | 72.31 | 10484.95 | | 93960.64 | | |
| 4 | 25.04 | 2.74 | 5.50 | 80.16 | 11623.20 | | 691758.16 | | |
| 5 | 24.86 | 2.78 | 4.82 | 69.74 | 10112.30 | | 461285.47 | | |
| | | | Σ = | 372.12 | 53957.40 | Σ = | 1465167.49 | | |
| | | | M = | 74.42 | 10791.48 | $s^2$ = | 366291.87 | | |
| | | | M / 2 = | 37.21 | 5395.74 | σ = | 605.22 | | |
| | | | | | | Cv = | 0.06 | | Test factor |
| | | | | | | Adjusted Cv (%) = | 9.14 | .=> | 1.12 |
| | | | | | | | | | |
| | GLASS REINFORCEMENT | | | | | | | | |
| | Bi-axial SP Systems XE 481 | | | 0/90 | 0/90 | | Sample variance | | |
| Specimen | Width | Thickness | Failure | Stress | Stress | | | | |
| | (mm) | (mm) | KN | N/mm² | psi | | | | |
| 1 | 24.91 | 1.82 | 13.24 | 292.04 | 42345.80 | | 1895908.69 | | |
| 2 | 24.91 | 1.87 | 14.32 | 307.42 | 44575.90 | | 13010593.28 | | |
| 3 | 25.03 | 1.84 | 13.24 | 287.48 | 41684.60 | | 512255.12 | | |
| 4 | 24.95 | 1.89 | 13.28 | 281.62 | 40834.90 | | 17950.64 | | |
| 5 | 24.96 | 1.91 | 11.64 | 244.16 | 35403.20 | | 30976793.86 | | |
| | | | Σ = | 1412.72 | 204844.40 | Σ = | 46413501.59 | | |
| | | | M = | 282.54 | 40968.88 | $s^2$ = | 11603375.40 | | |
| | | | M / 2 = | 141.27 | 20484.44 | σ = | 3406.37 | | |
| | | | | | | Cv = | 0.08 | | Test factor |
| | | | | | | Adjusted Cv (%) = | 13.55 | .=> | 1.30 |
| | | | | | | | | | |
| | GLASS REINFORCEMENT | | | | | | | | |
| | Unidirectional 92145 | | | 0/90 | 0/90 | | Sample variance | | |
| Specimen | Width | Thickness | Failure | Stress | Stress | | | | |
| | (mm) | (mm) | KN | N/mm² | psi | | | | |
| 1 | 24.85 | 2.02 | 13.76 | 274.12 | 39747.40 | | 42833359.88 | | |
| 2 | 24.96 | 2.04 | 16.92 | 332.30 | 48183.50 | | 3577318.30 | | |
| 3 | 24.80 | 2.09 | 17.90 | 345.35 | 50075.75 | | 14315855.98 | | |
| 4 | 24.92 | 2.05 | 16.60 | 324.94 | 47116.30 | | 679272.67 | | |
| 5 | 24.91 | 2.02 | 16.08 | 319.57 | 46337.65 | | 2072.98 | | |
| | | | Σ = | 1596.28 | 231460.60 | Σ = | 61407879.81 | | |
| | | | M = | 319.26 | 46292.12 | $s^2$ = | 15351969.95 | | |
| | | | M / 2 = | 159.63 | 23146.06 | σ = | 3918.16 | | |
| | | | | | | Cv = | 0.08 | | Test factor |
| | | | | | | Adjusted Cv (%) = | 13.80 | .=> | 1.30 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| GENERAL COMPOSITE MATERIAL STRENGTH | | | | | | | | | |
| Resin system AMPREG 20 | | | | | | | | | |
| | | | | | | | | | |
| TEST RESULTS | ILS | | | | | | | | |
| | | | | | | | | | |
| | GLASS REINFORCEMENT | | | | | | | | |
| | Bi-directional 0/90 92125 | | | .+/- 45 deg | .+/- 45 deg | | Sample variance | | |
| Specimen | Width | Thickness | Failure | Stress | Stress | | | | |
| | (mm) | (mm) | KN | $N/mm^2$ | psi | | | | |
| 1 | 10.10 | 3.29 | 1.62 | 36.56 | 5301.20 | | 210.25 | | |
| 2 | 10.08 | 3.38 | 1.64 | 36.10 | 5234.50 | | 2724.84 | | |
| 3 | 10.07 | 3.31 | 1.62 | 36.45 | 5285.25 | | 2.10 | | |
| 4 | 10.19 | 3.11 | 1.56 | 36.92 | 5353.40 | | 4448.89 | | |
| 5 | 10.10 | 3.44 | 1.68 | 36.27 | 5259.15 | | 759.00 | | |
| | | | $\Sigma =$ | 182.30 | 26433.50 | $\Sigma =$ | 8145.09 | | |
| | | | M = | 36.46 | 5286.70 | $s^2 =$ | 2036.27 | | |
| | | | M / 2 = | 18.23 | 2643.35 | $\sigma =$ | 45.13 | | |
| | | | | | | Cv = | 0.01 | | Test factor |
| | | | | | Adjusted Cv (%) = | | 1.39 | .=> | 1.00 |
| | | | | | | | | | |
| | GLASS REINFORCEMENT | | | | | | | | |
| | Bi-axial SP Systems XE 481 | | | 0/90 | 0/90 | | Sample variance | | |
| Specimen | Width | Thickness | Failure | Stress | Stress | | | | |
| | (mm) | (mm) | KN | $N/mm^2$ | psi | | | | |
| 1 | 9.95 | 3.47 | 1.24 | 26.94 | 3906.30 | | 18106.39 | | |
| 2 | 10.05 | 3.19 | 1.00 | 23.39 | 3391.55 | | 144544.44 | | |
| 3 | 10.00 | 3.64 | 1.32 | 27.20 | 3944.00 | | 29673.51 | | |
| 4 | 10.08 | 3.57 | 1.30 | 27.09 | 3928.05 | | 24432.82 | | |
| 5 | 10.08 | 3.51 | 1.20 | 25.44 | 3688.80 | | 6879.04 | | |
| | | | $\Sigma =$ | 130.06 | 18858.70 | $\Sigma =$ | 223636.20 | | |
| | | | M = | 26.01 | 3771.74 | $s^2 =$ | 55909.05 | | |
| | | | M / 2 = | 13.01 | 1885.87 | $\sigma =$ | 236.45 | | |
| | | | | | | Cv = | 0.06 | | Test factor |
| | | | | | Adjusted Cv (%) = | | 10.22 | .=> | 1.15 |
| | | | | | | | | | |
| | GLASS REINFORCEMENT | | | | | | | | |
| | Unidirectional 92145 | | | 0/90 | 0/90 | | Sample variance | | |
| Specimen | Width | Thickness | Failure | Stress | Stress | | | | |
| | (mm) | (mm) | KN | $N/mm^2$ | psi | | | | |
| 1 | 10.22 | 3.46 | 1.68 | 35.63 | 5166.35 | | 23180.06 | | |
| 2 | 10.23 | 3.44 | 1.76 | 37.51 | 5438.95 | | 14484.12 | | |
| 3 | 10.25 | 3.30 | 1.60 | 35.48 | 5144.60 | | 30276.00 | | |
| 4 | 10.16 | 3.39 | 1.70 | 37.02 | 5367.90 | | 2430.49 | | |
| 5 | 10.19 | 3.47 | 1.78 | 37.76 | 5475.20 | | 24523.56 | | |
| | | | $\Sigma =$ | 183.40 | 26593.00 | $\Sigma =$ | 94894.24 | | |
| | | | M = | 36.68 | 5318.60 | $s^2 =$ | 23723.56 | | |
| | | | M / 2 = | 18.34 | 2659.30 | $\sigma =$ | 154.02 | | |
| | | | | | | Cv = | 0.03 | | Test factor |
| | | | | | Adjusted Cv (%) = | | 4.72 | .=> | 1.00 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| GENERAL COMPOSITE MATERIAL STRENGTH | | | | | | | | | |
| Resin system AMPREG 20 | | | | | | | | | |
| | | | | | | | | | |
| TEST RESULTS | INTRALAMINAR SHEAR | | | | | | | | |
| | | | | | | | | | |
| | GLASS REINFORCEMENT | | | | | | | | |
| | Bi-directional 0/90 92125 | | | .+/- 45 deg | .+/- 45 deg | | Sample variance | | |
| Specimen | Width | Thickness | Failure | Stress | Stress | | | | |
| | (mm) | (mm) | KN | N/mm$^2$ | psi | | | | |
| 1 | 130.00 | 1.86 | 31.56 | 130.52 | 18925.40 | | 661229.19 | | |
| 2 | 130.00 | 1.85 | 31.20 | 129.73 | 18810.85 | | 488055.93 | | |
| 3 | 130.00 | 1.80 | 29.12 | 124.44 | 18043.80 | | 4684.03 | | |
| 4 | 130.00 | 1.79 | 27.82 | 119.55 | 17334.75 | | 604490.70 | | |
| 5 | 130.00 | 1.90 | 29.72 | 120.32 | 17446.40 | | 443342.91 | | |
| | | | $\Sigma$ = | 624.56 | 90561.20 | $\Sigma$ = | 2201802.76 | | |
| | | | M = | 124.91 | 18112.24 | $s^2$ = | 550450.69 | | |
| | | | M / 2 = | 62.46 | 9056.12 | $\sigma$ = | 741.92 | | |
| | | | | | | Cv = | 0.04 | | Test factor |
| | | | | | | Adjusted Cv (%) = | 6.68 | .=> | 1.06 |
| | | | | | | | | | |
| | GLASS REINFORCEMENT | | | | | | | | |
| | Bi-axial SP Systems XE 481 | | | 0/90 | 0/90 | | Sample variance | | |
| Specimen | Width | Thickness | Failure | Stress | Stress | | | | |
| | (mm) | (mm) | KN | N/mm$^2$ | psi | | | | |
| 1 | 130.00 | 2.83 | 36.64 | 99.59 | 14440.55 | | 259325.38 | | |
| 2 | 130.00 | 2.81 | 39.04 | 106.87 | 15496.15 | | 2448724.23 | | |
| 3 | 130.00 | 2.80 | 33.28 | 91.43 | 13257.35 | | 454222.08 | | |
| 4 | 130.00 | 2.98 | 31.68 | 81.78 | 11858.10 | | 4298199.70 | | |
| 5 | 130.00 | 2.45 | 32.08 | 100.72 | 14604.40 | | 453050.15 | | |
| | | | $\Sigma$ = | 480.39 | 69656.55 | $\Sigma$ = | 7913521.54 | | |
| | | | M = | 96.08 | 13931.31 | $s^2$ = | 1978380.38 | | |
| | | | M / 2 = | 48.04 | 6965.66 | $\sigma$ = | 1406.55 | | |
| | | | | | | Cv = | 0.10 | | Test factor |
| | | | | | | Adjusted Cv (%) = | 16.46 | .=> | 1.40 |
| | | | | | | | | | |
| | GLASS REINFORCEMENT | | | | | | | | |
| | Unidirectional 92145 | | | 0/90 | 0/90 | | Sample variance | | |
| Specimen | Width | Thickness | Failure | Stress | Stress | | | | |
| | (mm) | (mm) | KN | N/mm$^2$ | psi | | | | |
| 1 | 130.00 | 1.95 | 31.40 | 123.87 | 17961.15 | | 6155112.90 | | |
| 2 | 130.00 | 1.97 | 30.20 | 117.92 | 17098.40 | | 2618571.24 | | |
| 3 | 130.00 | 2.01 | 24.48 | 93.69 | 13585.05 | | 3591593.52 | | |
| 4 | 130.00 | 2.03 | 26.56 | 100.64 | 14592.80 | | 787478.76 | | |
| 5 | 130.00 | 2.06 | 26.16 | 97.68 | 14163.60 | | 1733435.56 | | |
| | | | $\Sigma$ = | 533.80 | 77401.00 | $\Sigma$ = | 14886191.99 | | |
| | | | M = | 106.76 | 15480.20 | $s^2$ = | 3721548.00 | | |
| | | | M / 2 = | 53.38 | 7740.10 | $\sigma$ = | 1929.13 | | |
| | | | | | | Cv = | 0.12 | | Test factor |
| | | | | | | Adjusted Cv (%) = | 20.31 | .=> | 1.55 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| PREPREG WING SKIN MATERIAL | | | | | | | | | | |
| Ref Slingsby Occ.Test Report 19 | | | | | | | | | | |
| | | | | | | | | | | |
| Samples 1-6 | | | | | | | | | | |
| Specimen | Width | Thickness | Failure | Strength | Stress | Stress | | Sample variance | | |
| | (mm) | (mm) | Load | per layer | N/mm². | psi | | | | |
| | | | KN | (N/mm/Layer) | | | | | | |
| 1 | 24.75 | 2.91 | 1.70 | 17.17 | 140.18 | 20326.10 | | 42594.08 | | |
| 2 | 24.87 | 2.84 | 1.64 | 16.49 | 134.58 | 19514.10 | | 366771.55 | | |
| 3 | 24.78 | 2.81 | 1.66 | 16.75 | 136.71 | 19822.95 | | 88070.45 | | |
| 4 | 24.82 | 2.85 | 1.70 | 17.12 | 139.78 | 20268.10 | | 22017.61 | | |
| 5 | 24.89 | 2.79 | 1.66 | 16.67 | 136.11 | 19735.95 | | 147276.85 | | |
| 6 | 24.74 | 2.86 | 1.76 | 17.78 | 145.18 | 21051.10 | | 867474.91 | | |
| | | | | Σ = | 832.54 | 120718.30 | Σ = | 1534205.46 | | |
| | | | | M = | 138.76 | 20119.72 | $s^2$ = | 306841.09 | | |
| | | | | M / 2 = | 69.38 | 10059.86 | σ = | 553.93 | | |
| | | | | | | | Cv = | 0.03 | | Test factor |
| | | | | | | Adjusted Cv (%) = | | 4.29 | => | 1.00 |
| | | | | | | | | | | |
| Samples 1a-6a | | | | | | | | | | |
| Specimen | Width | Thickness | Failure | Strength | Stress | Stress | | Sample variance | | |
| | (mm) | (mm) | Load | per layer | N/mm² | psi | | | | |
| | | | KN | (N/mm/Layer) | | | | | | |
| 1 | 24.74 | 2.78 | 1.66 | 16.77 | 136.93 | 19854.85 | | 260508.16 | | |
| 2 | 24.86 | 2.79 | 1.56 | 15.69 | 128.06 | 18568.70 | | 601788.06 | | |
| 3 | 24.79 | 2.84 | 1.68 | 16.94 | 138.30 | 20053.50 | | 502751.90 | | |
| 4 | 24.80 | 2.90 | 1.64 | 16.53 | 134.96 | 19569.20 | | 50512.56 | | |
| 5 | 24.76 | 2.81 | 1.58 | 15.95 | 130.23 | 18883.35 | | 212613.21 | | |
| 6 | 24.74 | 2.86 | 1.60 | 16.17 | 131.98 | 19137.10 | | 42994.02 | | |
| | | | | Σ = | 800.46 | 116066.70 | Σ = | 1671167.92 | | |
| | | | | M = | 133.41 | 19344.45 | $s^2$ = | 334233.58 | | |
| | | | | M / 2 = | 66.71 | 9672.23 | σ = | 578.13 | | |
| | | | | | | | Cv = | 0.03 | | Test factor |
| | | | | | | Adjusted Cv (%) = | | 4.66 | => | 1.00 |
| | | | | | | | | | | |
| Samples 1b-9b | | | | | | | | | | |
| Specimen | Width | Thickness | Failure | Strength | Stress | Stress | | Sample variance | | |
| | (mm) | (mm) | Load | per layer | N/mm² | psi | | | | |
| | | | KN | (N/mm/Layer) | | | | | | |
| 1 | 25.05 | | 8.06 | 53.63 | 289.87 | 42031.15 | | 132694.25 | | |
| 2 | 25.18 | | 7.40 | 48.98 | 264.76 | 38390.20 | | 16041805.05 | | |
| 3 | 25.06 | | 8.44 | 56.13 | 303.42 | 43995.90 | | 2561529.12 | | |
| 4 | 25.09 | | 7.84 | 52.08 | 281.51 | 40818.95 | | 2485264.67 | | |
| 5 | 25.13 | | 8.64 | 57.30 | 309.74 | 44912.30 | | 6334673.75 | | |
| 6 | 25.07 | | 7.40 | 49.20 | 265.92 | 38558.40 | | 14722739.53 | | |
| 7 | 25.28 | | 8.62 | 56.83 | 307.19 | 44542.55 | | 4610157.69 | | |
| 8 | 25.29 | | 8.64 | 56.94 | 307.78 | 44628.10 | | 4984850.06 | | |
| 9 | 25.24 | | 8.44 | 55.73 | 301.25 | 43681.25 | | 1653353.07 | | |
| | | | | Σ = | 2631.44 | 381558.80 | Σ = | 53527067.20 | | |
| | | | | M = | 292.38 | 42395.42 | $s^2$ = | 6690883.40 | | |
| | | | | M / 2 = | 146.19 | 21197.71 | σ = | 2586.67 | | |
| | | | | | | | Cv = | 0.06 | | Test factor |
| | | | | | | Adjusted Cv (%) = | | 8.79 | => | 1.11 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| PREPREG WING SKIN MATERIAL | | | | | | | | | | |
| Ref Slingsby Occ.Test Report 19 | | | | | | | | | | |
| | | | | | | | | | | |
| Samples R1-R9 | | | | | | | | | | |
| Specimen | Width | Thickness | Failure | Strength | Stress | Stress | | Sample variance | | |
| | (mm) | (mm) | Load | per layer | N/mm$^2$ | psi | | | | |
| | | | KN | (N/mm/Layer) | | | | | | |
| 1 | 24.58 | | 6.46 | 43.80 | 355.16 | 51498.20 | | 2388192.48 | | |
| 2 | 24.73 | | 6.42 | 43.27 | 350.82 | 50868.90 | | 839198.49 | | |
| 3 | 24.80 | | 6.14 | 41.26 | 334.57 | 48512.65 | | 2074096.03 | | |
| 4 | 24.59 | | 6.08 | 41.21 | 334.13 | 48448.85 | | 2261932.45 | | |
| 5 | 24.88 | | 6.86 | 45.95 | 372.60 | 54027.00 | | 16598924.56 | | |
| 6 | 24.55 | | 5.60 | 38.02 | 308.25 | 44696.25 | | 27631551.53 | | |
| 7 | 24.48 | | 6.76 | 46.02 | 373.17 | 54109.65 | | 17279217.17 | | |
| 8 | 24.36 | | 6.62 | 45.29 | 367.24 | 53249.80 | | 10870062.47 | | |
| 9 | 24.58 | | 5.54 | 37.56 | 304.58 | 44164.10 | | 33509304.97 | | |
| | | | | $\Sigma =$ | 3100.52 | 449575.40 | $\Sigma =$ | 113452480.15 | | |
| | | | | M = | 344.50 | 49952.82 | $s^2 =$ | 14181560.02 | | |
| | | | | M / 2 = | 172.25 | 24976.41 | $\sigma =$ | 3765.84 | | |
| | | | | | | | Cv = | 0.08 | | Test factor |
| | | | | | | | Adjusted Cv (%) = | 10.86 | => | 1.17 |
| | | | | | | | | | | |
| Samples F1-F8 | | | | | | | | | | |
| Specimen | Width | Thickness | Failure | Strength | Stress | Stress | | Sample variance | | |
| | (mm) | (mm) | Load | per layer | N/mm$^2$ | psi | | | | |
| | | | KN | (N/mm/Layer) | | | | | | |
| 1 | 24.58 | | 6.46 | 43.80 | 355.16 | 51498.20 | | 675334.70 | | |
| 2 | 24.73 | | 6.42 | 43.27 | 350.82 | 50868.90 | | 37051.44 | | |
| 3 | 24.80 | | 6.14 | 41.26 | 334.57 | 48512.65 | | 4681868.16 | | |
| 4 | 24.59 | | 6.08 | 41.21 | 334.13 | 48448.85 | | 4962034.69 | | |
| 5 | 24.88 | | 6.86 | 45.95 | 372.60 | 54027.00 | | 11226436.60 | | |
| 6 | 24.55 | | 5.60 | 38.02 | 308.25 | 44696.25 | | 35762343.53 | | |
| 7 | 24.48 | | 6.76 | 46.02 | 373.17 | 54109.65 | | 11787119.73 | | |
| 8 | 24.36 | | 6.62 | 45.29 | 367.24 | 53249.80 | | 6622323.23 | | |
| | | | | $\Sigma =$ | 2795.94 | 405411.30 | $\Sigma =$ | 75754512.06 | | |
| | | | | M = | 349.49 | 50676.41 | $s^2 =$ | 10822073.15 | | |
| | | | | M / 2 = | 174.75 | 25338.21 | $\sigma =$ | 3289.69 | | |
| | | | | | | | Cv = | 0.06 | | Test factor |
| | | | | | | | Adjusted Cv (%) = | 9.54 | => | 1.15 |
| Adjustment Factor | | | | | | | | | | |
| n = | 5.00 | 6.00 | 8.00 | 9.00 | 100.00 | | | | | |
| Up = | 1.6452 | 1.6452 | 1.6452 | 1.6452 | 1.6452 | | | | | |
| f = | 4.00 | 5.00 | 7.00 | 8.00 | 99.00 | | | | | |
| c = | 0.20 | 0.20 | 0.20 | 0.20 | 0.20 | | | | | |
| F = | 1.63 | 1.56 | 1.47 | 1.44 | 1.12 | | | | | |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| EUROPA GLIDER MATERIALS | | | | | | | | | | |
| Carbon 2x2 twill cloth | | | | | | | | | | |
| Flexural Strengths | | | | | | | | | | |
| Slow hardener GREP | | | | | | | | | | |
| TEST RESULTS | Pulled at 45 deg | | | | | | | | | |
| | | | | | | | Sample variance | | | |
| Specimen | Width | Depth | Failure | Stress | Stress | | | | | |
| | (mm) | (mm) | KN | $N/mm^2$ | psi | | | | | |
| 1 | 20 53 | 3 38 | 0.53 | 271.17 | 39319 65 | | 1130335.17 | | | |
| 2 | 20.30 | 3 19 | 0.50 | 290 45 | 42115 25 | | 3001306 01 | | | |
| 3 | 20 52 | 3.36 | 0.52 | 269 36 | 39057.20 | | 1757274.28 | | | |
| 4 | 20.29 | 3 18 | 0.50 | 292 43 | 42402.35 | | 4078492 45 | | | |
| 5 | 20.54 | 3.29 | 0.52 | 280 67 | 40697.15 | | 98801.95 | | | |
| 6 | 20.63 | 3.27 | 0.50 | 271.99 | 39438 55 | | 891650 03 | | | |
| 7 | 20.56 | 3.33 | 0 52 | 273.70 | 39686 50 | | 484864 64 | | | |
| 8 | 20 58 | 3 36 | 0.52 | 268.57 | 38942.65 | | 2074096 03 | | | |
| 9 | 20.53 | 3.34 | 0.55 | 288.18 | 41786 10 | | 1969188.52 | | | |
| | | | $\Sigma$ = | 2506.52 | 363445.40 | $\Sigma$ = | 15486009.07 | | | |
| | | | M $\pm$ 45 = | 278.50 | 40382.82 | $s^2$ = | 1935751.13 | | | |
| | | | | | | $\sigma$ = | 1391.31 | | | |
| | | | | | | Cv = | 0 03 | | Test factor | |
| | | | | | | Adjusted Cv (%) = | 4 96 | => | 1 00 | |
| | | | B value = | 251.68 | 36493.60 | psi | | | | |
| | | | | M 0/90 = | 51610 | psi | | | | |
| Interlaminar Shear | | | | | | | | | | |
| Slow hardener GREP | | | | | | | | | | |
| TEST RESULTS | Pulled at 45 deg | | | | | | | | | |
| | | | | | | | Sample variance | | | |
| Specimen | Width | Depth | Failure | Stress | Stress | | | | | |
| | (mm) | (mm) | KN | $N/mm^2$ | psi | | | | | |
| 1 | 10.18 | 3.31 | 1.74 | 38.73 | 5615 71 | | 237332 44 | | | |
| 2 | 10.17 | 3.30 | 1 92 | 42.91 | 6221.52 | | 14075.98 | | | |
| 3 | 10 03 | 3.53 | 2.02 | 42.79 | 6204 41 | | 10308 79 | | | |
| 4 | 10.16 | 3.46 | 1 92 | 40 96 | 5939 64 | | 26646.57 | | | |
| 5 | 10.36 | 3.37 | 1.90 | 40 82 | 5918.32 | | 34059.73 | | | |
| 6 | 10 24 | 3.17 | 2 02 | 46 67 | 6767.44 | | 441649.59 | | | |
| 7 | 10 24 | 3 32 | 1.92 | 42.36 | 6141.77 | | 1512 60 | | | |
| 8 | 10.25 | 3.32 | 1 80 | 39.67 | 5752.30 | | 122904 78 | | | |
| 9 | 10.21 | 3.28 | 1.96 | 43.90 | 6364.78 | | 68592.77 | | | |
| | | | $\Sigma$ = | 378 80 | 54925.86 | $\Sigma$ = | 957083 26 | | | |
| | | | M $\pm$ 45 = | 42.09 | 6102.87 | $s^2$ = | 119635.41 | | | |
| | | | | | | $\sigma$ = | 345 88 | | | |
| | | | | | | Cv = | 0 06 | | Test factor | |
| | | | | | | Adjusted Cv (%) = | 8.16 | => | 1.12 | |
| | | | B value = | 36 24 | 5254.08 | psi | | | | |
| | | | | M 0/90 = | 7430 | psi | | | | |

# APPENDIX J: EUROPA XS FASTBUILD LIGHT AIRCRAFT WING ULTIMATE STATIC STRENGTH TEST

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EURO/015/STR

# EUROPA FASTBUILD (XS) WING

## ULTIMATE STATIC STRENGTH TESTING OF THE EUROPA XS WING

| Rev | Date | Compiled | Checked | Approved | Notes / ref. |
|---|---|---|---|---|---|
| 5 | | | | | |
| 4 | | | | | |
| 3 | | | | | |
| 2 | | | | | |
| 1 | | | | | |
| 0 | 10/03/98 | | | | EURO/016/STR<br>EURO/017/STR |

# ULTIMATE STATIC STRENGTH TESTING OF THE EUROPA XS WING

## Introduction

A set of XS wings, mounted within a fuselage, were static strength tested to demonstrate that the new pre-moulded wing design satisfies the requirements of JAR-VLA 305 (a) and (b). This should enable the wings to be used on the Europa aircraft operating on a Permit to Fly, based on an aircraft gross weight of 1370 lb, a $V_A$ of 97 kts and a $V_{NE}$ of 165 kts.

## Wing Construction

The wing is supported by a GRP composite spar. The spar is identical in construction and geometry to the spar supplied as part of the classic Europa wet lay up wing kit. The wing skins are of foam core sandwich construction. The skin thickness has been tailored to meet the most unfavourable factored g loading specified within JAR-VLA, (factored +3.8g, and factored -1.9g). C – section wing ribs are used fore and aft of the spar. The outboard wing ribs are constructed from 3 plies of Bi-directional glass cloth. Full details of the pre-moulded XS wing construction are made available in appendix D at the back of this report.

## Structural modifications applied to the Europa XS wings prior to test.

The following modifications were applied to the Europa XS wings prior to the Ultimate Static Strength Test:

1. 5mm thick Airex foam was used as the skin core material.
2. A 50mm * 5mm foam core stiffener, was bonded to the inside of each the leading and trailing edge upper surface wing skins.
3. One additional facing ply was added to the upper skin at the wing root region.
4. Additional layers of Bi-directional cloth were added to the trailing edge wing-root-rib adjacent to the pin mounting plates, to improve shear diffusion across the rib flange.
5. The composite top-hat stiffener on the baggage bay fuselage side, immediately behind the wing drag/anti-drag sockets were removed.

6. The trailing edge drag/anti-drag pin sockets were replaced with sockets that articulate. These sockets rotate in one plane and were employed to remove offset bending from the drag/anti-drag pins.
7. A tie bar connecting the drag/anti-drag sockets, using 0.75" dia x 0.035" wall 4130 steel tubing was installed. This tie-bar connected both drag/anti-drag sockets together.
8. The spar-rigging pins and their bushes were increased in diameter from 3/8" to 1/2". The spar rigging pins were threaded at the ends. The threaded portion of the rigging pins located into nuts behind the aft spar, clamping both spars and the seat back bulkhead together.
9. A buckling restraint was laid-up over the centre section of both spars in the form of a GRP strap. The strap is permanently attached to the port spar. The strap was constructed from both Uni-directional and Bi-directional GRP.

Lay-up details of item 9, and strength checking of items 4, 6 and 7 is conducted within report EURO/017/STR

**Test Factors**

The test factors fixed for the Europa XS static strength tests were:

1. Manufacturing variability $K_V = 1.20$ ACJ-VLA 619 (a)
2. Thermal degradation $K_T = 1.25$ (ACJ-VLA 613 c (a)), (as tests were conducted at room temperature)
3. Moisture degradation $K_M = 1.0$

| | |
|---|---|
| This gave a total test factor of: | 1.2*1.25*1.0 = 1.5 |
| Giving a test factored JAR-VLA limit load of: | 3.8g*1.5 = 5.7g |
| Which resulted in a test factored JAR-VLA ultimate load of: | 3.8g*1.5*1.5 = 8.55g |

**Test Objectives**

Two separate tests were conducted on one set of XS wings. The first test aimed to simulate the most unfavourable aerodynamic loading that occurs on the wing at factored limit and factored ultimate load with a High Angle of Attack (HAA). The HAA case represents the slowest speed in the flight envelope at which maximum load factor can be reached without stalling.

This test aimed to prove:

1. The leading edge wing skin stability and strength in combined tension & shear, and combined compression and shear.
2. The leading-edge skin-to-spar and skin-to-rib bond strength together with the through-thickness-shear strength of the leading edge skins.
3. The bending and shear strength of the leading edge ribs together with the strength of leading edge rib to spar bond.
4. The overall strength of the wing root rib arrangement when the wing was subjected to the most unfavourable torsional loads experienced within the aircraft flight envelope.

The second test aimed to simulate the most unfavourable aerodynamic loading that occurs on the wing at test factored limit and test factored ultimate load with a Low Angle of Attack (LAA). The LAA case represents the limit load case at $V_D$, which produces maximum dynamic pressure on the wing structure.

This test aimed to prove:

1. The trailing-edge wing skin strength in combined tension & shear and combined compression and shear. (To some extent proved by the HAA test, given the similar

facing ply arrangement, sandwich thickness and overall dimensional similarity of leading edge rib 'D' box and the trailing edge rib box)

2. The trailing-edge skin-to-spar and skin-to-rib bond strength together with the through-thickness-shear strength of the trailing edge skins.
3. The bending and shear strength of the trailing edge ribs together with the strength of trailing edge rib to spar bond.
4. Wing spar bending strength and stiffness

**Test Rig**

A standard Europa pre-moulded fuselage complete with cockpit module was assembled and mounted inverted on a supporting rig which was bolted to the ground. see figure 1. Loads were reacted by supporting the fuselage through the seat pan area and thigh support, firewall bulkhead and at the tail-plane torque tube, simulating fuselage reactions experienced in flight. Padded spreader blocks at the seat pan positions were used to distribute the applied load. The fuselage was secured to the rig with straps. This safety measure aimed to prevent asymmetric bending of the wing, should the weights become displaced during the test.

**Test Method**

Test 1: High Angle of Attack. (HAA)

The fuselage was set at an angle of 12.5 degrees declination to the horizontal, see figure 1. (Calculations used to derive the test angle are made available within appendix A)

Stations were marked out from the leading edge of the wing, as lines running chord-wise, at 161.5", 156", 140", 120", 100", 80", 60", 41", & 27" from the aircraft centreline, see figure 1. The chord-wise locations of the applied weights were marked out from the wing root, as two lines running span-wise at 14% chord and 60% chord. Weights were initially applied directly at the intersection of the span-wise and chord-wise lines. Additional weights were applied on top or equally spaced about the intersection point. Short span, angled foam blocks were attached to the wing skins so that the weights would not topple as wing deflection increased throughout the test. The foam blocks also served to prevent point loading the skins and bridging between the ribs.

The applied load was distributed in accordance with the span-wise and chord-wise aerodynamic loading. This load was evaluated in terms of the amount of weight that should be applied at the above defined span-wise and chord-wise wing stations.

The span-wise wing loading was derived at HAA using the Shrenk approximation. The chord-wise wing loading was derived using JAR-VLA, Appendix A Section 1, Table 2 – Average limit control surface loading, chord-wise distribution B. Resolution of the chord-wise loading about the wing spar resulted in an applied weight distribution where (a) 76% of the load should be applied at 14% chord and (b) 24% of the load should be applied at 60% chord. This results in a chord-wise position of the centre of applied load equal to 25% chord. The above chord-wise distribution ensures correct wing torsion at test factored limit load at the predetermined angle of declination. 50% of the wing weight was then removed from both (a) and (b).

The resulting net load equal to (76% aerodynamic load - 50% of the wing weight) was applied as discrete 10 or 5 kilogram weights distributed evenly about the intersection between the 14% chord line and the span-wise station lines defined above. Similarly, a resulting net load equal to (24% aerodynamic load - 50% of the wing weight) was applied as discrete 10 or 5 kilogram weights, distributed evenly about the intersection of the 60% chord line and the span-wise stations defined above. The resulting net loads were tabulated for increasing g increments from 1 to 8.55g. Appendix A contains the applied load schedule used during the HAA test. Comparison of weights applied during the HAA test with theoretical load distribution is also made in appendix A.

At each g increment, the weights were applied at the intersecting lines, starting at the wing tip and working inboard. During weight application the wing tips were supported with jacks to prevent inadvertent overloading. After each application of weight, the weight distribution was checked in both the span-wise and chord-wise directions. With the wing tip supports removed, the wing was allowed to deflect under load.

Test Measurements

Fuselage side angular deflection measurement

Angular deflection of the fuselage sides was measured using a calibrated arc and pointer. As the fuselage rotated due to the applied loading, the pointer would be displaced from its neutral position, therefore measuring angular deflection of the fuselage side in degrees.

Wing tip deflection measurement

Wing tip deflection was measured using 'tape measures' attached at the leading edge of each wing tip. Once the discrete weights were applied to the wing at a specific g load, the wing was left unsupported and allowed to deflected under the applied loading. Measurements of both the starboard and port wing-tip deflections were then recorded. Due to the excessive time taken to obtain all deflection and strain measurements at each g load, no tape measures were used at the wing tip trailing edge, or wing root. As a result no measurements of wing tip torsion could be obtained during either the HAA and LAA test.

Strain gauge measurement

Strain gauges attached to the wing root rib flanges, and wing-spar booms and shear webs were used to measure root rib flange and spar strain. Once the discrete weights were applied to the wing at a specific g load, the wing was left unsupported and allowed to deflect under the applied loading. Measurements of root rib flange and spar were then recorded. All strain gauges were aligned in principal strain directions.

From 1g to test factored limit load (5.7g) spar and wing-root-rib strain measurement, vertical deflection of the wing tips, and angular deflection of the fuselage sides were recorded. The results are presented in appendix C. Beyond test factored limit load (5.7g) the wings were unsupported for three seconds only. No strain or deflection measurements were recorded beyond 5.7g, due to the excessive time required to take readings. Video footage of this test is available on request from Europa Aviation.

After the test was complete, the weights were removed from both wings in a syncronised way, keeping the load on each wing matched. The deflection of the wing tips after unloading was checked for reference purposes. The wings were then removed from the aircraft and a detailed post test examination of the wing and fuselage was conducted.

Following the HAA test the wings were re-rigged on the fuselage mounted inverted on the test rig.

Test 2: Low Angle of Attack. (LAA)

The fuselage was reset at an angle of 0.33 degrees declination to the horizontal. See figure 1. (Calculations used to derive the test angle are made available within appendix B)

A similar test method to that of the HAA test was adopted for the LAA test (see Test 1 for load application details) with the exceptions of: (1) The test angle was set at 0.33 degrees declination. (2) The chord-wise wing loading was derived using pressure distribution information supplied by Don Dykins. Resolution of the LAA chord-wise loading about the wing spar resulted in an applied weight distribution where, (a) 73% of the load should be applied at 19% chord and (b) 27% of the load should be applied at 61% chord. This results in a chord-wise position of the centre of applied load equal to approximately 30% chord. The above chord-wise distribution ensures correct wing torsion at the predetermined angle of declination. 50% of the wing weight was then removed from both (a) and (b).

The resulting net load equal to (73% aerodynamic load - 50% of the wing weight) was applied as discrete 10 and 5 kilogram weights, distributed evenly about the intersection between the 19% chord line and the span-wise station lines defined above. Similarly, a resulting net load equal to (27% aerodynamic load - 50% of the wing weight) was applied as discrete 10 and 5 kilogram weights to the wing at the intersection between the 61% chord line and the span-wise stations defined above. The resulting net loads were tabulated for increasing g increments from 1 to 8.55g. Appendix B contains the applied load schedule used during the LAA tests. Comparison between the weight-applied during the LAA test and the theoretical-load-distribution are made in appendix B. Spar and wing-root-rib strain measurement, vertical deflection of the wing tips, and angular deflection of the fuselage sides were recorded for the LAA test, up to test factored limit load 5.7g. These results are presented in appendix C. Beyond test factored limit load (5.7g) the wings were unsupported for three seconds only. No strain or deflection measurements were recorded beyond 5.7g. Photographs were taken to document loads above 5.7g. These photographs are presented in appendix D. Video footage of this test is available on request from Europa Aviation.

**Test Results**

Fuselage side angular deflection measurement

Test 1: High Angle of Attack. (HAA)

Port and starboard fuselage sides adjacent to the front lift pin experienced a similar angular deflection and deflection per g, (Port: 0.21 deg/g, Stbd: 0.21 deg/g).
Port and starboard fuselage sides adjacent to the aft drag/anti-drag pin experienced a similar angular deflection and deflection per g, (Port: 0.08 deg/g, Stbd: 0.08 deg/g).

Port and starboard fuselage sides adjacent to the aft drag/anti-drag pin experienced less angular deflection and less angular deflection per g, than port and starboard fuselage sides adjacent to the front lift pins.

The use of articulated sockets on the port and starboard fuselage sides adjacent to the aft drag/anti-drag pins resulted in reduced angular deflection, relative to that measured in previous tests. This demonstrates the benefit of the combined tie-bar and articulated socket arrangement in relieving bending of the fuselage sides adjacent to the aft drag/anti-drag pins.

Test 2: High Angle of Attack. (LAA)

Both port and starboard fuselage sides adjacent to the front lift pin experienced a similar angular deflection and deflection per g, (Port: 0.21 deg/g, Stbd: 0.19 deg/g).

Both port and starboard fuselage sides adjacent to the aft drag/anti-drag pin experienced a similar angular deflection and deflection per g, (Port: 0.07 deg/g, Stbd: 0.06 deg/g).

Both port and starboard fuselage sides adjacent to the aft drag/anti-drag pin experienced less angular deflection, and less angular deflection per g, than port and starboard fuselage sides adjacent to the front lift pins.

The use of articulated sockets on the port and starboard fuselage sides adjacent to the aft drag/anti-drag pins resulted in reduced angular deflection, relative to that measured in previous tests. This again demonstrates the benefit of the combined tie-bar and articulated socket arrangement in relieving bending of the fuselage sides adjacent to the aft drag/anti-drag pins.

Lines marked onto the fixed and rotating parts of the articulating sockets indicated a rotation of less than 5 degrees at 8.55g.

Comparison between HAA and LAA results

Comparing fuselage side, angular deflection results obtained during the HAA test with those obtained during the LAA test revealed that:

1. During both the HAA and the LAA tests, the port and starboard fuselage sides adjacent to the front lift pin deflect by a similar amount and a similar amount per g, (HAA: Port: 0.21 deg/g, Stbd: 0.21 deg/g) - (LAA: Port: 0.21 deg/g, Stbd: 0.19 deg/g).

2. During both the HAA and the LAA tests, the port and starboard fuselage sides adjacent to the aft drag/anti-drag pin deflect by a similar amount and a similar amount per g, (HAA: Port: 0.08 deg/g, Stbd: 0.08 deg/g) - (LAA: Port: 0.07 deg/g, Stbd: 0.06 deg/g).

Wing tip deflection measurement

Test 1: High Angle of Attack. (HAA) Net load applied at 14% and 60% chord

Both port and starboard wings experienced a similar amount of tip deflection, (Port: 465mm at 5.7g, Stbd: 468mm at 5.7g). Between 3 and 5.7g, both port and starboard wings also experienced a similar amount of tip deflection per g, (Port: 79.96mm/g, Stbd: 84.18mm/g). The starboard wing also experienced marginally more tip deflection than the port wing between 3 and 5.7g. For example, at 5.7g (Stbd tip deflection: 468mm compared with Port tip deflection: 465mm)

Test 2: Low Angle of Attack. (LAA) Net load applied at 19% and 61% chord

Both port and starboard wings experienced a similar amount of tip deflection. (Port: 462mm at 5.7g, Stbd: 488mm at 5.7g). Between 3 and 5.7g Both port and starboard wings also experienced a similar amount of tip deflection per g, (Port: 82.5mm/g, Stbd: 86.61mm/g). Once again, the starboard wing experienced more tip deflection than the port wing between 3 and 5.7g. For example at 5.7g (Stbd tip deflection: 488mm compared with Port tip deflection: 462mm).

This behaviour could result from the overlapping nature of the spar coupling mechanism.

Comparison between HAA and LAA results

Comparing results from wing tip deflection obtained during the HAA test with those obtained during the LAA test in particular, comparison of average tip deflection and average tip deflections per g between 3 and 5.7g revealed that:

1. At 5.7g, LAA average tip deflection is greater than HAA average tip deflection. (LAA: (488+462)/2 = 475mm, compared with HAA: (468+465)/2 = 467mm)

2. At 5.7g, LAA average tip deflection per g is greater than HAA tip deflection per g (LAA: (82.5+86.61)/2 = 84.55mm/g, compared with HAA: (84.18+79.96)/2 = 82.07mm/g)
3. Average permanent set obtained during the LAA test is greater than the permanent set obtained during the HAA test. (LAA: (20+26)/2 = 23mm, compared with HAA: (17+22)/2 = 19.5mm)

1,2 and 3 above can be attributed to the higher bending moment experienced by the wings during the LAA test. (Note average tip deflection & average permanent set, are defined here as the mean of both port and starboard tip-deflections-per-g, and permanent sets obtained during each test).

Strain gauge measurement

Test 1: High Angle of Attack. (HAA)

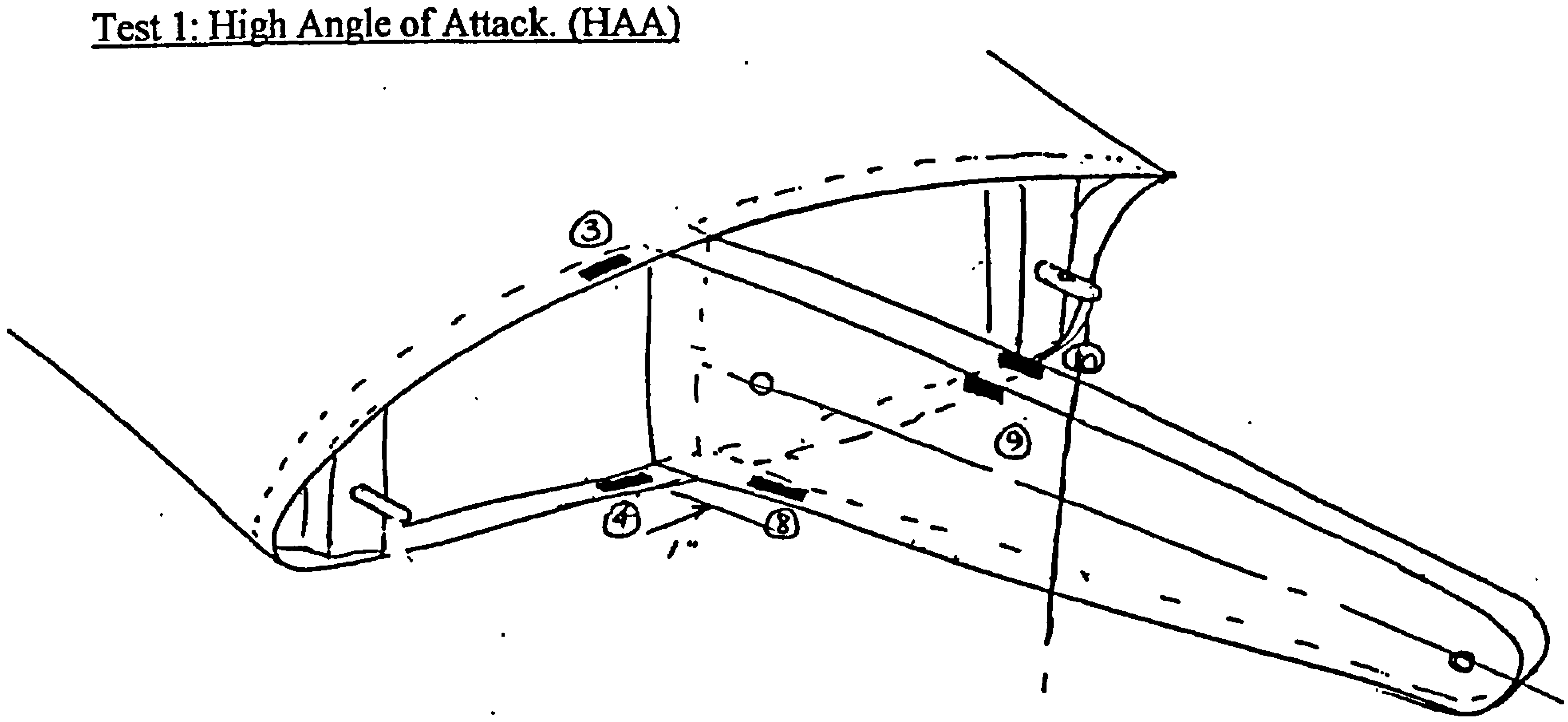


*Fig 2. Strain Gauge Locations*

Gauge 3: (measuring upper leading edge root rib flange strain) recorded a linearly increasing compressive strain with increasing g.

Gauge 4: (measuring lower leading edge root rib flange strain) recorded a linearly increasing tensile strain with increasing g.

Gauge 8: (measuring spar outer fibre strain) recorded a linearly increasing tensile strain with increasing g load.
Gauge 9 (measuring spar shear web strain) recorded a linear increase in compressive strain with increasing g load.
Gauge 10 (also measuring spar shear web strain) recorded a linear increase in compressive strain with increasing g.

Comparing gauge 9 with gauge 10, the gradually increasing gradient of the gauge 10 plot, when compared with the gauge 9 plot, would indicate an increase in spar-shear-web stiffness. (Gauge 10: -2331 microstrain at 3g, to -4125 microstrain at 5.7g, Gauge 9: -2425 microstrain at 3g, to -4570 microstrain at 5.7g). This could result from one, or a combination of the following:

(a) The declination of the fuselage relative to horizontal during the HAA test causes the spar to be angled relative to the applied load. The overall result is normal bending of an angled spar. The angled spar has a higher sectional moment of inertia than a spar that is normal to the horizontal datum. This results in an angled spar having a higher value of bending stiffness than a spar normal to the horizontal datum.
(b) The single-shear seat back/overlapping-spar-coupling arrangement used in the Europa aircraft leads to twisting of the spar between the spar pins. Twisting between the spar pins is kept to a minimum by the buckling prevention strap and by bolting the two spars together.

It is apparent that from the plot of spar shear web strain versus applied load, from 5g onward, the presence of the buckling prevention strap in combination with (a) and the effect of bolting both spars together, leads to a definite increase in bending stiffness at higher g loads. To what degree (a), (b), the buckling prevention strap or clamping the spars together affects the bending stiffness of the spar is unknown.

Test 2: Low Angle of Attack. (LAA)

Gauge 3: (measuring upper leading edge root rib flange strain) recorded a linearly increasing compressive strain with increasing g.

Gauge 4: (measuring lower leading edge root rib flange strain) recorded a linearly increasing tensile strain with increasing g.

Gauge 8: (measuring spar outer fibre strain) recorded a linearly increasing tensile strain with increasing g load.

Gauge 9 (measuring spar shear web strain) recorded a linear increase in compressive strain with increasing g load.

Gauge 10 (also measuring spar shear web strain) recorded a linear increase in compressive strain with increasing g.

Comparing gauge 9 with gauge 10, the marginal increase in gradient of the gauge 10 plot when compared with the gauge 9 plot. (Gauge 10: -2372 microstrain at 3g, to -3792 microstrain at 5.0g, Gauge 9: -2420 microstrain at 3g, to -4026 microstrain at 5.0g). This would again indicate an increase in spar-shear-web stiffness. From the plot of Spar Shear Web Strain versus Applied Load (appendix D), it is apparent that during the LAA test, this behaviour was not as pronounced as that experienced during the HAA test.

Comparison between HAA and LAA results

Comparing results from strain measurement of the wing spar and wing-root-rib-flange obtained during the HAA test with those obtained during the LAA test, in particular, comparison of strain measurements per g obtained between 3 and 5.0g, it is apparent from the graphs of Strain versus Applied Load that:

1. Gauge 3: HAA average strain per g is less than LAA average strain per g. Strain for both tests is of a similar order of magnitude. (HAA: 253.31 microstrain/g, LAA: 286.88 microstrain/g)
2. Gauge 4: HAA average strain per g is greater than LAA average strain per g. Strain for both tests is of a similar order of magnitude. (HAA: -297.91 microstrain/g, LAA: -250.22 microstrain/g)

3. Gauge 8: HAA average strain per g is less than LAA average strain per g. Strain for both tests is of a similar order of magnitude. (HAA: 931.29 microstrain/g, LAA: 979.23 microstrain/g)
4. Gauge 9: HAA average strain per g is very similar in magnitude to gauge 9 strain per g obtained during the LAA test. (HAA: -808.90 microstrain/g, LAA: -807.90 microstrain/g)
5. Gauge 10: HAA average strain per g is less than LAA strain per g. (HAA: -762.50 microstrain/g, LAA: -777.15 microstrain/g)

It is difficult to theoretically assess the stiffness of the root rib arrangement, due to the complexity of the root rib load path. However examination of results from gauges 3 and 4 from both tests demonstrate the effect of reduced chord-wise load on the root rib at a lower angle of attack.

In general, strain measurements are higher for the LAA test than for the HAA test, due to the higher resulting bending moment experienced by the wing during the LAA test.

**Test Observations**

Test 1: High Angle of Attack. (HAA)

General

At all loads up to test factored limit load, (5.7g) no permanent deformation or elastic buckling was observed. Both port and starboard wings supported an applied load representing 5.7g without detrimental, permanent deformation or elastic buckling. More wing twist-per-g was observed during the HAA test, than during the LAA test.

Wing Root Ribs

Post-test examination of the wing root rib revealed no permanent damage or delamination.

Upper Leading Edge Wing Skins

At all loads up to test factored limit load, 5.7g, no permanent deformation or elastic buckling was observed. At span-wise stations 33 and 65, on both the port and starboard wings, elastic buckling was observed at 7g. At 8.1g, a sharp crack was heard from the port wing and a crease was observed at span-wise station 33.

Post-test examination of the upper leading edge skins on both wings revealed permanent kinks between span-wise stations 33 & 65 on both port and starboard wings and between span-wise stations 65 & 80 on the starboard wing. It should be noted that the kinked panels continued to carry diagonal semi-tension at an applied load of 8.55g

Upper Trailing Edge Wing Skins

At all loads up to ultimate load no permanent deformation was observed. At span-wise stations 55, on both the port and starboard wings, elastic buckling was observed at 7g. At 8.1g, the magnitude of this buckle increased. At 8.55g this buckle appeared to remain elastic. Post-test examination, of the upper trailing edge skins, revealed no visible, permanent damage to this region of the wing.

Spar Tangs

Post-test examination of both wing spar tangs revealed no permanent damage. Minor delamination was noted at the corners of the buckling prevention strap. This could result from both spars deflecting between the spar rigging pins. The overlapping starboard spar would cause a peel load between the port-spar and the buckling-prevention-strap bond. This would be more pronounced at higher g levels. Minor delamination was also recorded at the wing spar-rigging pin bushes.

Fuselage

Post-test examination of the fuselage seatback bulkhead and fuselage sides adjacent to the sockets revealed no permanent damage or delamination.

Test 2: Low Angle of Attack. (LAA)

General

At all loads up to test factored limit load, (5.7g) no additional deformation or elastic buckling, to that obtained at 7g during the HAA test was observed. Both port and starboard wings supported an applied 5.7g without additional detrimental, permanent deformation or elastic buckling. More wing bending-per-g was observed during the LAA test than during the HAA test.

Wing Root Ribs

Post-test examination of the wing root rib revealed no permanent damage or delamination.

Upper Leading Edge Wing Skins

At all loads up to test factored limit load, (5.7g) no additional deformation or elastic buckling, to that obtained at 7g during the HAA test was observed. At span-wise stations 33 and 65, on both the port and starboard wings, skin buckling was observed at 7g. At 8.1g the magnitude of buckling increased.

Post-test examination, of the upper leading edge skins revealed no additional permanent kinks between span-wise stations 33 & 65 and between span-wise stations 65 & 80, other than those obtained at 7g during the HAA test. It should be noted that the panels that kinked during the HAA test continued to carry diagonal semi-tension at 8.55g during the LAA test.

Upper Trailing Edge Wing Skins

At all loads up to ultimate load no additional deformation or elastic buckling, to that obtained at 7g during the HAA test, was observed. At span-wise stations 55, on both the port and starboard wings, buckling was observed at 7g. At 8.1g, the magnitude of this buckle increased. At 8.55g this buckle, again, appeared to remain elastic. Post-test examination of the upper trailing edge skins revealed no visible, permanent damage to this region of the wing.

Spar Tangs

Post-test examination of both wing spar tangs revealed no additional, permanent damage, other than that obtained on the buckling prevention strap during the HAA test.

Fuselage

Post-test examination of the fuselage seat-back bulkhead and fuselage sides adjacent to the sockets, revealed no permanent damage or delamination.

**Discussion**

Positive g, HAA static strength tests on XS wings have revealed that:

1. Wing skins using 5mm foam core with 50mm x 5mm foam core stiffeners, running span-wise across the centre of the leading & trailing edge upper-inner wing skins, together with an additional facing ply, is sufficient to prevent elastic buckling of all XS upper wing skin panels, up to, and including an applied load of 5.7g
2. Wing skins using 5mm foam core with 50mm x 5mm foam core stiffeners, running span-wise across the centre of the leading & trailing edge upper-inner wing skins, together with an additional facing ply, is sufficient to prevent catastrophic failure of all XS upper wing skin panels at an applied load of 8.55g. In addition, this arrangement is sufficient to prevent catastrophic failure of all XS upper wing skin panels during a second cycled over-load of 8.55g (The LAA test)

Negative g flight envelope

Examination of loads derived by the Shrenk approximation demonstrate that the most unfavourable negative g torsion that the wing skins will experience, occurs at point 'G' on the flight envelope. Here the test factored limit load is -1.9g*1.5 = -2.85g, with a test factored ultimate load = -4.28g.

It is rational and conservative to assume that the use of a 5mm foam core within the skins, combined with additional reinforcing plies alone, without span-wise stiffeners on the lower leading and trailing edge skins, will prevent elastic buckling at a test factored load of -2.85g.

This method of reinforcement will also prevent catastrophic failure at -4.28g.

This assumption is based on the near symmetry of the profile section and results from previous prototype XS wing tests. Previous prototype XS wing tests have demonstrated that wing skins with 5mm foam cores, combined with additional reinforcing plies but without span-wise stiffeners, prevented elastic buckling of all XS upper wing skin panels, up to, and including, an applied load of 5.0g

**Conclusions**

The HAA and LAA tests carried out within this report have demonstrated that:

1. The XS pre-moulded wing supported a test factored JAR-VLA limit load of 5.7g, without detrimental, permanent deformation or elastic buckling of the wing skins
2. No permanent deformation was observed on the wing at all loads up to, and including, the test factored JAR-VLA limit load of 5.7g
3. The wing supported a test factored JAR-VLA ultimate load, equal to (5.7g, multiplied by the test factor of 1.5 for thermal degradation and manufacturing variability) 8.55g for 3 seconds without catastrophic failure

Applying these factors excludes the need for temperature tests on materials or structure and should permit the wing to be operated within the JAR-VLA requirements.

The Europa XS wing defined within this report (in conjunction with a standard Europa fuselage incorporating a tie bar between articulating drag/anti-drag pin sockets) has been proved by static load test to comply with the requirements of JAR-VLA 305 parts (a) and (b). This is based on an aircraft gross weight of 1370 lb and a $V_A$ of 97 kts and a $V_{NE}$ of 165 kts,

In conclusion:

- The XS primary wing structure, incorporating modifications, should be cleared for an aircraft gross weight of 1370 lb
- The XS primary wing structure, incorporating modifications, should be cleared for a $V_A$ of 97 kts and a $V_{NE}$ of 165 kts.

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| APPENDIX A. | JASON RUSSELL | | | 0 |

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| EUROPA XS. | / |

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| VA HIGH ANGLE OF ATTACK TEST 1 (HAA). | |

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**Europa Aviation Ltd** **Calculation Sheet**

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| | JASON RUSSELL | | 03/02/98 | 0 |

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| EUROPA XS | |

| Subject | Page | of |
|---|---|---|
| $V_A$ HIGH ANGLE OF ATTACK. | 1 | 1 |

DENSITY = 0.00238 slug/ft³
WING AREA = 101.8 ft²
AIRSPEED = 164 ft/sec
AUW = 1370 lb
AR = 7.12

$nW = 3.8 * 1370$
$= 5206$ lb.

$Lt = -112.77$ lb SUPPLIED BY DON DYKIN

$LIFT = nW - Lt$
$= 5206 + 112.77$
$= 5318.77$ lb.

$$q = \frac{LIFT}{S C_L} = \frac{5318.77}{101.8 * 1.6} = 32.65 \text{ psf}.$$

LOCAL $C_L$ ON WING @ STN 22 = 1.7.

$$\alpha = \frac{C_L - C_{L\alpha=0}}{0.081} = \frac{1.6 - 0.25}{0.081} = 16.67° \text{ FUSELAGE}$$

$$\text{WING} = 16.67 + 2.5 = 19.17°$$

$$C_{D_i} = \frac{C_L^2}{\pi A e} = \frac{(1.6)^2}{(\pi * 7.12 * 0.8)} = 0.14.$$

$C_{D_p} = 0.021$ FOR HIGH $\alpha$OA

$C_D = C_{D_p} + C_{D_i}$
$= 0.02 + 0.14$
$= 0.164$

$DRAG = q S C_D$
$= 545$ lb.

$$\text{ANGLE} = \text{ATAN}\left(\frac{545}{5319}\right) = 5.85°$$

FUSELAGE SETTING ANGLE = $16.67 - 5.85 = 11°$

PREVIOUSLY $C_{D_i}$ WAS LOWER $\left(C_{D_i} = \frac{C_L^2}{\pi A R}\right)$ No e=0.8. AS A RESULT FUSELAGE SETTING ANGLE DROPS FROM 12.2° TO 11°

ANGLE USED DURING TEST = 12.5°

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| EUROPA XS WING LOADING ANALYSIS | | | | | | | | | | | |
| SPANWISE AERODYNAMIC LOAD DISTRIBUTION | | | | | | | | | | | |
| CONDITION. A | | | | | | | | | | | |
| $V_{ed}$ = | 164.00 | ft/s | | | $C_L$ = | 1.6 | | alpha wrp = | 19.1700 | | |
| Lift = | 5318.77 | | | | $C_{Do}$ = | 0.021 | | sin alpha = | 0.3284 | | |
| q = | 32.65 | psf | | | S = | 101.800 | $ft^2$ | cos alpha = | 0.9445 | | |
| n = | 3.80 | g | | | $C_{Mo}$ = | -0.020 | | | | | |
| $q.C_L$ = | 52.25 | $q.C_L$ = Lift/S | | | b = | 26.92 | ft | | | | |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| STATION | 2y/b | dy | CHORD | CHORD | c av | ELEM AREA | ELLIPSE | SHRENK | UNIT | | dy $c^2$ |
| (in) | | (ft) | (in) | (ft) | (ft) | dy * c av | | Cla | Cla | av Cla | |
| | | | | | | ($ft^2$) | | | | | |
| 161.5 | 1.000 | - | 39.00 | 3.250 | - | - | 0.000 | 1.625 | 0.500 | - | - |
| 150 | 0.929 | 0.96 | 39.91 | 3.326 | 3.288 | 3.151 | 1.785 | 2.555 | 0.768 | 0.634 | 10.3600 |
| 130 | 0.805 | 1.67 | 41.49 | 3.458 | 3.392 | 5.653 | 2.857 | 3.157 | 0.913 | 0.841 | 19.1736 |
| 110 | 0.681 | 1.67 | 43.08 | 3.590 | 3.524 | 5.873 | 3.526 | 3.558 | 0.991 | 0.952 | 20.6937 |
| 90 | 0.557 | 1.67 | 44.66 | 3.722 | 3.656 | 6.093 | 3.998 | 3.860 | 1.037 | 1.014 | 22.2718 |
| 70 | 0.433 | 1.67 | 46.24 | 3.853 | 3.787 | 6.312 | 4.340 | 4.096 | 1.063 | 1.050 | 23.9079 |
| 50 | 0.310 | 1.67 | 47.82 | 3.985 | 3.919 | 6.532 | 4.579 | 4.282 | 1.074 | 1.069 | 25.6020 |
| 31 | 0.192 | 1.58 | 49.33 | 4.111 | 4.048 | 6.409 | 4.726 | 4.418 | 1.075 | 1.075 | 25.9440 |
| 22 | 0.136 | 0.75 | 50.04 | 4.170 | 4.140 | 3.105 | 4.771 | 4.470 | 1.072 | 1.073 | 12.8562 |
| 19 | 0.118 | 0.25 | 50.28 | 4.190 | 4.180 | 1.045 | 4.782 | 4.486 | 1.071 | 1.071 | 4.3677 |
| 0 | 0.000 | 1.58 | 51.78 | 4.315 | 4.252 | 6.733 | 4.815 | 4.565 | 1.058 | 1.064 | 28.6306 |
| | | | | | Σ = | 50.91 | | | | Σ = | 193.81 |
| | | | | | Area calc = | 101.81 | $ft^2$ | | | MAC calc = | 3.81 |
| | | | | | | | | | | MAC calc = | 45.69 |

CELL INFORMATION IS SAME AS PREVIOUS ISSUE OF SHRENK DATA.

| 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $C_L$ | $C_{Lx}$ | $C_{Lz}$ | $C_D$ | $C_{Dx}$ | $C_{Dz}$ | $C_{Lz}+C_{Dz}$ | $C_{Dx}-C_{Lx}$ | $(C_{Lz}+C_{Dz})_{AV}$ | $(C_{Dx}-C_{Lx})_{AV}$ | SPAN ELEMENT LIFT (lb) | SPAN ELEMENT DRAG (lb) | SPAN ELEMENT LIFT CHECK |
| 0.8150 | 0.2676 | 0.7698 | 0.1640 | 0.1549 | 0.0539 | 0.8237 | -0.1127 | - | - | 0.00 | 0.00 | 0.00 |
| 1.2523 | 0.4112 | 1.1829 | 0.1640 | 0.1549 | 0.0539 | 1.2367 | -0.2563 | 1.0302 | -0.1845 | 105.98 | -18.98 | 104.40 |
| 1.4885 | 0.4888 | 1.4059 | 0.1640 | 0.1549 | 0.0539 | 1.4598 | -0.3339 | 1.3482 | -0.2951 | 248.85 | -54.46 | 248.31 |
| 1.6155 | 0.5305 | 1.5259 | 0.1640 | 0.1549 | 0.0539 | 1.5798 | -0.3756 | 1.5198 | -0.3547 | 291.41 | -68.02 | 292.15 |
| 1.6906 | 0.5552 | 1.5969 | 0.1640 | 0.1549 | 0.0539 | 1.6507 | -0.4003 | 1.6153 | -0.3879 | 321.31 | -77.17 | 322.83 |
| 1.7328 | 0.5690 | 1.6367 | 0.1640 | 0.1549 | 0.0539 | 1.6906 | -0.4141 | 1.6707 | -0.4072 | 344.33 | -83.92 | 346.34 |
| 1.7514 | 0.5751 | 1.6543 | 0.1640 | 0.1549 | 0.0539 | 1.7081 | -0.4202 | 1.6994 | -0.4172 | 362.44 | -88.97 | 364.76 |
| 1.7520 | 0.5753 | 1.6549 | 0.1640 | 0.1549 | 0.0539 | 1.7087 | -0.4204 | 1.7084 | -0.4203 | 357.50 | -87.95 | 359.86 |
| 1.7474 | 0.5738 | 1.6505 | 0.1640 | 0.1549 | 0.0539 | 1.7044 | -0.4189 | 1.7065 | -0.4196 | 173.02 | -42.55 | 174.15 |
| 1.7452 | 0.5731 | 1.6484 | 0.1640 | 0.1549 | 0.0539 | 1.7023 | -0.4182 | 1.7033 | -0.4185 | 58.11 | -14.28 | 58.49 |
| 1.7245 | 0.5663 | 1.6289 | 0.1640 | 0.1549 | 0.0539 | 1.6827 | -0.4114 | 1.6925 | -0.4148 | 372.07 | -91.18 | 374.41 |
| | | | | | | | | | Σ = | 2635.01 | -627.48 | 2645.71 |
| ft | | | | | | | | | LIFT calc = | 5270.02 | | 5291.42 |
| in | | | | | | | | | Lift = | 5318.77 | | 5318.77 |
| | | | | | | | | | error = | 0.9 | % | 0.5 |

SPANWISE AERODYNAMIC LOAD DISTRIBUTION

CONDITION. A cont..

| 1 | 3 | 4 | 21 | 22 A | 23 A | 24 A | 25 A | 26 | 27 | 28 |
|---|---|---|---|---|---|---|---|---|---|---|
| STATION | dy | CHORD | LIMIT | LIMIT | LIMIT | LIMIT | ULT | ULT | ULT | ULT |
| (in) | (in) | (in) | NORMAL | NORMAL | CHORD | CHORD | NORMAL | NORMAL | CHORD | CHORD |
| | | | SHEAR | MOMENT | SHEAR | MOMENT | SHEAR | MOMENT | SHEAR | MOMENT |
| | | | (lb) | (lb) | (lb) | (lb) | (lb) | (lb) | (lb) | (lb) |
| 161.5 | - | 39.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0 | 0 | 0 | 0 |
| 150 | 11.50 | 39.91 | 105.98 | 609.41 | -18.98 | -109.15 | 159 | 914 | -28 | -164 |
| 130 | 20.00 | 41.49 | 354.83 | 5217.54 | -73.45 | -1033.45 | 532 | 7826 | -110 | -1550 |
| 110 | 20.00 | 43.08 | 646.24 | 15228.23 | -141.46 | -3182.57 | 969 | 22842 | -212 | -4774 |
| 90 | 20.00 | 44.66 | 967.55 | 31366.16 | -218.63 | -6783.49 | 1451 | 47049 | -328 | -10175 |
| 70 | 20.00 | 46.24 | 1311.88 | 54160.47 | -302.55 | -11995.28 | 1968 | 81241 | -454 | -17993 |
| 50 | 20.00 | 47.82 | 1674.31 | 84022.39 | -391.52 | -18935.96 | 2511 | 126034 | -587 | -28404 |
| 31 | 19.00 | 49.33 | 2031.82 | 119230.63 | -479.47 | -27210.37 | 3048 | 178846 | -719 | -40816 |
| 22 | 9.00 | 50.04 | 2204.83 | 138295.56 | -522.02 | -31717.06 | 3307 | 207443 | -783 | -47576 |
| 19 | 3.00 | 50.28 | 2262.95 | 144997.23 | -536.30 | -33304.53 | 3394 | 217496 | -804 | -49957 |
| 0 | 19.00 | 51.78 | 2635.01 | 191527.83 | -627.48 | -44360.37 | 3953 | 287292 | -941 | -66541 |
| | | Centre of lift is | 73 | in from aircraft centreline | | | | | | |
| | | | 45 | % semispan | | | | | | |

SPANWISE INERTIAL LOAD DISTRIBUTION

CONDITION. A cont..

| 1 | 3 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| STATION (in) | dy (in) | WEIGHT nW (lb) | ELEMENT SHEAR FORCE $V_z$ (lb) | ELEMENT SHEAR FORCE $V_z$ (lb) | LIMIT NORMAL SHEAR (lb) | LIMIT NORMAL MOMENT (lb) | LIMIT CHORD SHEAR (lb) | LIMIT CHORD MOMENT (lb) | ULT NORMAL SHEAR (lb) | ULT NORMAL MOMENT (lb) | ULT CHORD SHEAR (lb) | ULT CHORD MOMENT (lb) |
| 161.5 | - | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0 | 0 | 0 | 0 |
| 150 | 11.50 | -24.30 | 7.98 | -22.96 | -22.96 | -132.00 | 7.98 | 45.89 | -34 | -198 | 12 | 69 |
| 130 | 20.00 | -42.28 | 13.88 | -39.93 | -62.89 | -990.45 | 21.86 | 344.33 | -94 | -1486 | 33 | 516 |
| 110 | 20.00 | -42.28 | 13.88 | -39.93 | -102.82 | -2647.52 | 35.74 | 920.41 | -154 | -3971 | 54 | 1381 |
| 90 | 20.00 | -42.28 | 13.88 | -39.93 | -142.75 | -5103.20 | 49.63 | 1774.12 | -214 | -7655 | 74 | 2661 |
| 70 | 20.00 | -42.28 | 13.88 | -39.93 | -182.68 | -8357.49 | 63.51 | 2905.48 | -274 | -12536 | 95 | 4358 |
| 50 | 20.00 | -42.28 | 13.88 | -39.93 | -222.61 | -12410.41 | 77.39 | 4314.47 | -334 | -18616 | 116 | 6472 |
| 31 | 19.00 | -40.16 | 13.19 | -37.93 | -260.54 | -17000.37 | 90.58 | 5910.17 | -391 | -25501 | 136 | 8865 |
| 22 | 9.00 | -19.02 | 6.25 | -17.97 | -278.51 | -19426.10 | 96.82 | 6753.48 | -418 | -29139 | 145 | 10130 |
| 19 | 3.00 | -6.33 | 2.08 | -5.98 | -284.49 | -20270.61 | 98.90 | 7047.07 | -427 | -30406 | 148 | 10571 |
| 0 | 19.00 | -40.16 | 13.19 | -37.93 | -322.43 | -26036.36 | 112.09 | 9051.53 | -484 | -39055 | 168 | 13577 |
| | Σ = | 90 | lb | | | | | | | | | |
| | | at 1 g | | | Centre of gravity is | 81 | in from aircraft centreline | | | | | |
| | | | | | | 50 | % semispan | | | | | |

COMBINED ULTIMATE LOADS ( AERODYNAMIC + INERTIAL )

NORMAL LOADS

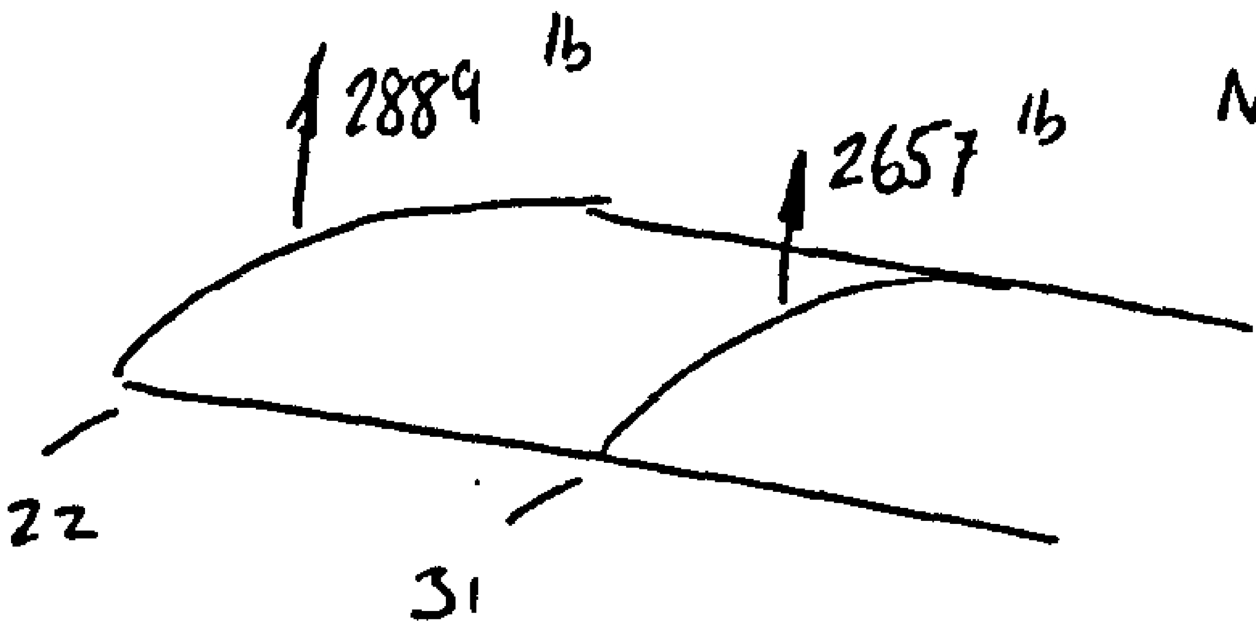
| 1 | 40 A | 41 A | 42 A | 43 A | 41 A | 40 A |
|---|---|---|---|---|---|---|
| | ULT NORMAL | ULT NORMAL | ULT CHORD | ULT CHORD | ULT RESOLVED | ULT RESOLVED |
| STATION | SHEAR | BEND MOM | SHEAR | BEND MOM | BEND MOM | SHEAR |
| (in) | COND. A | COND. A | COND. A | COND. A | COND. A | COND. A |
| | (lb) | (lb in) | (lb) | (lb in) | (lb in) | (lb) |
| 161.5 | 0 | 0 | 0 | 0 | 0 | 0 |
| 150 | 125 | 716 | -17 | -95 | 722 | 126 |
| 130 | 438 | 6341 | -77 | -1034 | 6424 | 445 |
| 110 | 815 | 18871 | -159 | -3393 | 19174 | 830 |
| 90 | 1237 | 39394 | -254 | -7514 | 40105 | 1263 |
| 70 | 1694 | 68704 | -359 | -13635 | 70044 | 1731 |
| 50 | 2178 | 107418 | -471 | -21932 | 109634 | 2228 |
| 31 | 2657 | 153345 | -583 | -31950 | 156639 | 2720 |
| 22 | 2889 | 178304 | -638 | -37445 | 182194 | 2959 |
| 19 | 2968 | 187090 | -656 | -39386 | 191191 | 3039 |
| 0 | 3469 | 248237 | -773 | -52963 | 253824 | 3554 |

| Title | Made by | Checked by | Date | Rev |
|---|---|---|---|---|
| HAA TEST 1 | JASON RUSSELL | | 16/02/98 | 0 |

| Project | Ref |
|---|---|
| EUROPA XS | |

| Subject | Page of |
|---|---|
| CHORDWISE PRESSURE DISTRIBUTION @ VA | 1 of 3 |

SPANWISE DISTRIBUTION FROM SHRENK APPROXIMATION.

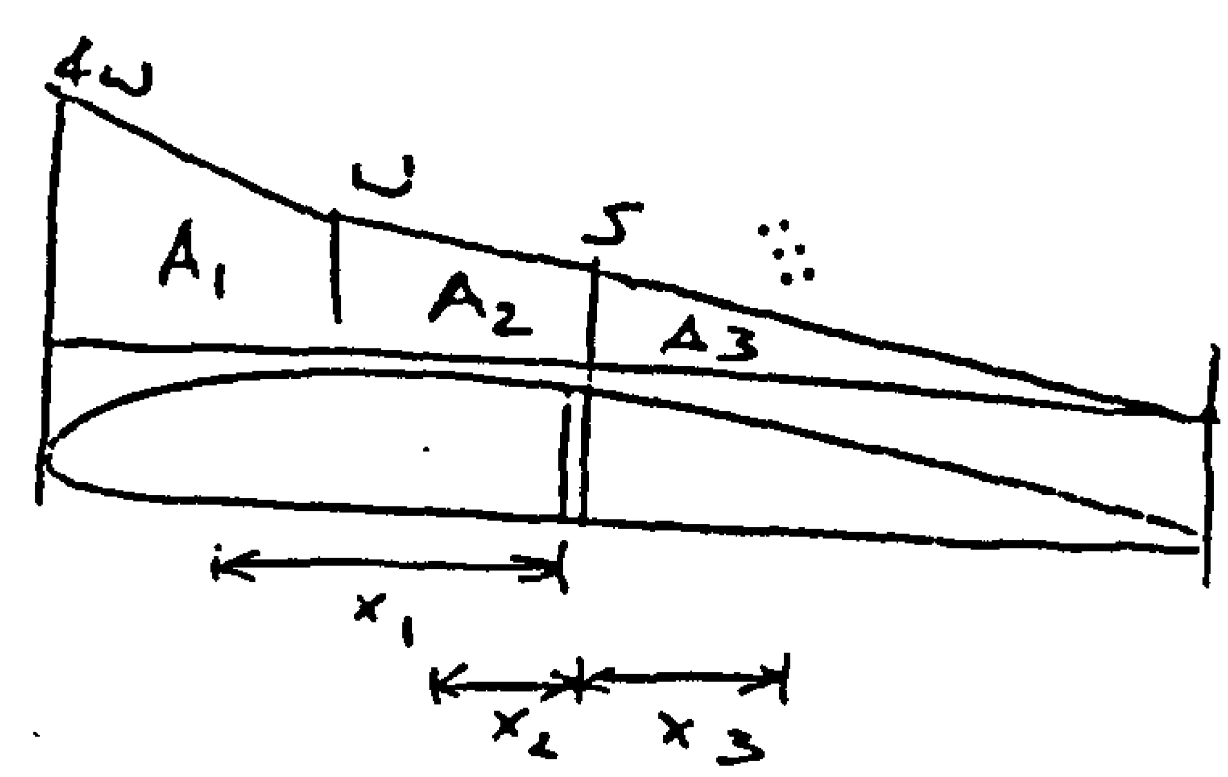



NORMAL SHEAR @ $(3.8 * 1.5)$

SHEAR OVER PANEL = 2889 − 2657
= 232 lb.

W = 232 lb.
STRIP LOAD w @ STN 22 = $\frac{232}{50}$ = 4.64 lb/in

USING VLA DISTRIBUTION,




w = 4.64 lb/in
4w = 18.56 lb/in
s = 3.71 lb/in

$X_1$ = 15.0 in
$X_2$ = 3.89 in
$X_3$ = 10 in

$$A_1 = \left(\left(\frac{18.56 - 4.64}{2}\right) + 4.64\right) * 12\tfrac{1}{2} = 145 \text{ lb}$$

$$A_2 = \left(\left(\frac{4.64 - 3.71}{2}\right) + 3.71\right) * 7\tfrac{1}{2} = 31 \text{ lb}.$$

$A_3$ = 55.65 lb.

TOTAL AIRLOAD FWD OF SPAR

= 


= $A_1 + A_2$
= 145 + 31
= 176 lb.

TOTAL AIRLOAD AFT OF SPAR

= 


= $A_3$
= 55.65 lb.

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Calculation Sheet

| Title | Made by | Checked by | Date | Rev |
|---|---|---|---|---|
| HAA TEST 1 | JASON RUSSELL | | 16/02/98 | 0 |

| Project | Ref |
|---|---|
| EUROPA XS | |

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|---|---|---|
| CHORDWISE PRESSURE DISTRIBUTION @ $V_A$. | 2 | 3 |

TOTAL TORQUE FWD OF SPAR

$= A_1 x_1 + A_2 x_2$

$= 2175 + 120 \cdot 6$

$= 2296$ lbin

TOTAL TORQUE AFT OF SPAR

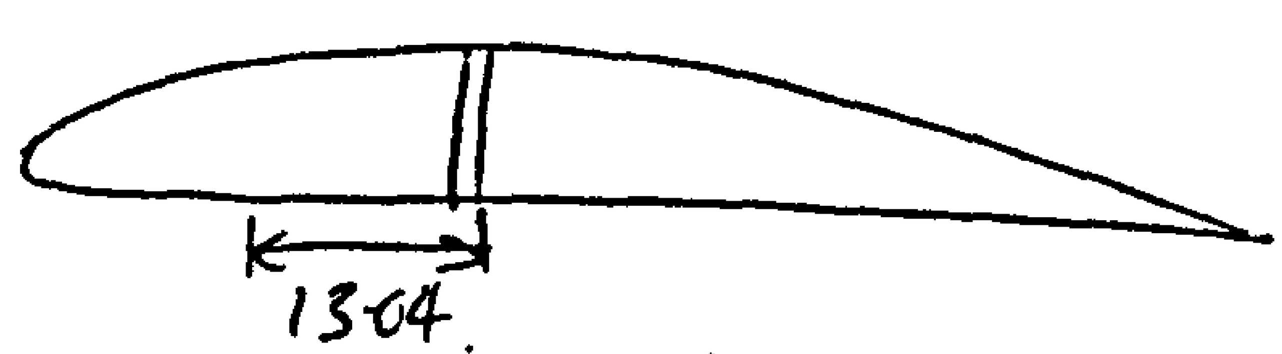
$\therefore = A_3 X_3$

$= 55 \cdot 65 * 10$

$= 557$ lbin

$\therefore$ LOAD FWD OF SPAR SHOULD BE APPLIED AT $\bar{X}_1$ % CHORD.

$\Rightarrow \dfrac{2296}{176} = 13 \cdot 04$ in INFRONT OF SPAR.

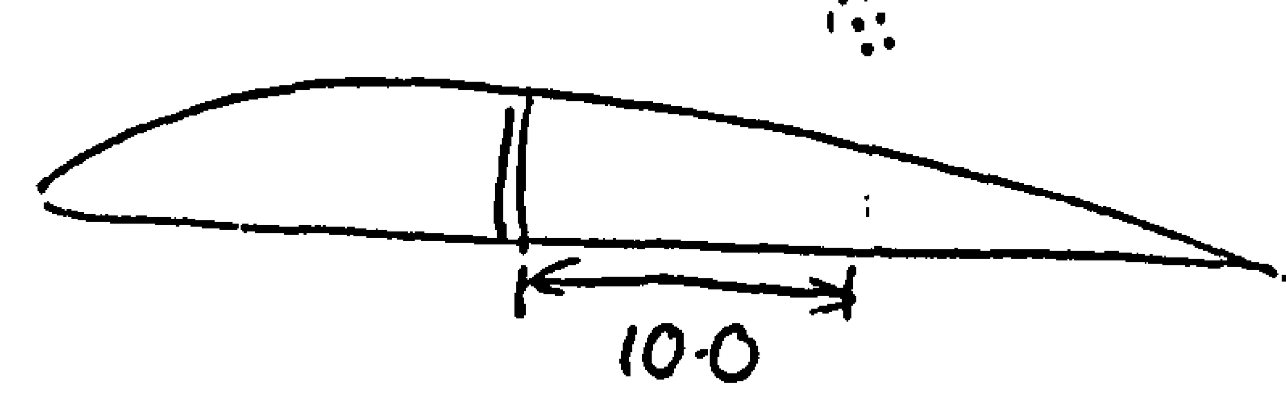



$\left(\dfrac{0.4c - 13.04}{50}\right) * 100 = 13 \cdot 95$

$X_1 = 14\%c$

$\therefore$ LOAD AFT OF SPAR SHOULD BE APPLIED AT $\bar{X}_2$ % CHORD

$\dfrac{557}{55 \cdot 65} = 10 \cdot 0$ in AFT OF SPAR




$\left(\dfrac{0.4c + 10}{50}\right) * 100 = 60$

$X_2 = 60\%c.$

THESE VALUES WERE DERIVED FROM AIRLOAD ALONE, IGNORING RELIEVING EFFECT OF SHEAR FLOW $\therefore$ APPROACH IS CONSERVATIVE.

AIRLOAD INFRONT OF SPAR = 176 lb.

$\Rightarrow \left(\dfrac{176}{232}\right) * 100 = 76\%$ LOAD AT 14% CHORD.

AIRLOAD AFT OF SPAR = 55·65 lb

$\Rightarrow \left(\dfrac{55 \cdot 65}{232}\right) * 100 = 24\%$ LOAD AT 60% CHORD

| Title | Made by | Checked by | Date | Rev |
|---|---|---|---|---|
| HAA TEST 1 | JASON RUSSELL | | 16/02/98 | 0 |
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| CHORDWISE PRESSURE DISTRIBUTION @ VA. | | | 3 of 3 | |

$$X_{cp} = 0.76*0.14 + 0.24*0.60$$
$$= 0.1064 + 0.144$$
$$= 0.25$$

25 % CHORD.

$$X_{cp\,\text{CHECK}} = 0.24 + \frac{0.02}{1.6}$$
$$= 0.25$$

25 % CHORD.

| | | g LOAD (kg) | | g LOAD (kg) | | g LOAD (kg) | | g LOAD (kg) | | g LOAD (kg) | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1.00 | | 2.00 | | 3.00 | | 3.80 | | 5.00 | |
| APPLIED LOAD | | 14% c | 60% c | 14% c | 60% c | 14% c | 60% c | 14% c | 60% c | 14% c | 60% c |
| STN TOTALS | MID STN | FORE | AFT | FORE | AFT | FORE | AFT | FORE | AFT | FORE | AFT |
| | LOCATION | | | | | | | | | | |
| | (in) | | | | | | | | | | |
| | 161.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 156 | 10 | 0 | 15 | 5 | 25 | 5 | 30 | 5 | 40 | 10 |
| | 140 | 20 | 5 | 40 | 10 | 60 | 15 | 80 | 20 | 105 | 25 |
| | 120 | 25 | 5 | 50 | 10 | 75 | 15 | 95 | 25 | 120 | 30 |
| | 100 | 30 | 5 | 55 | 15 | 80 | 20 | 105 | 25 | 140 | 35 |
| | 80 | 30 | 5 | 65 | 15 | 90 | 20 | 110 | 30 | 150 | 35 |
| | 60 | 30 | 10 | 60 | 15 | 95 | 25 | 120 | 30 | 155 | 40 |
| | 41 | 30 | 10 | 60 | 15 | 95 | 25 | 120 | 30 | 155 | 40 |
| | 27 | 15 | 5 | 30 | 10 | 45 | 15 | 55 | 15 | 75 | 20 |
| | 1 WING | 190 | 45 | 375 | 95 | 565 | 140 | 715 | 180 | 940 | 235 |
| | | 235 | | 470 | | 705 | | 895 | | 1175 | |
| | 2 WINGS | 470 | | 940 | | 1410 | | 1790 | | 2350 | |

| | | g LOAD (kg) | | g LOAD (kg) | | g LOAD (kg) | | g LOAD (kg) | | g LOAD (kg) | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1.00 | | 2.00 | | 3.00 | | 3.80 | | 5.00 | |
| APPLIED LOAD | | 14% c | 60% c | 14% c | 60% c | 14% c | 60% c | 14% c | 60% c | 14% c | 60% c |
| STN | MID STN | FORE | AFT | FORE | AFT | FORE | AFT | FORE | AFT | FORE | AFT |
| INCREMENTS | LOCATION | | | | | | | | | | |
| | (in) | | | | | | | | | | |
| | 161.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 156 | 10 | 0 | 5 | 5 | 10 | 0 | 5 | 0 | 10 | 5 |
| | 140 | 20 | 5 | 20 | 5 | 20 | 5 | 20 | 5 | 25 | 5 |
| | 120 | 25 | 5 | 25 | 5 | 25 | 5 | 20 | 10 | 25 | 5 |
| | 100 | 30 | 5 | 25 | 10 | 25 | 5 | 25 | 5 | 35 | 10 |
| | 80 | 30 | 5 | 35 | 10 | 25 | 5 | 20 | 10 | 40 | 5 |
| | 60 | 30 | 10 | 30 | 5 | 35 | 10 | 25 | 5 | 35 | 10 |
| | 41 | 30 | 10 | 30 | 5 | 35 | 10 | 25 | 5 | 35 | 10 |
| | 27 | 15 | 5 | 15 | 5 | 15 | 5 | 10 | 0 | 20 | 5 |
| | 1 WING | 190 | 45 | 375 | 95 | 565 | 140 | 715 | 180 | 940 | 235 |
| | | 235 | | 470 | | 705 | | 895 | | 1175 | |
| | | | | | | | | | | 2350 | |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| g LOAD (kg) | | g LOAD (kg) | | g LOAD (kg) | | | g LOAD (kg) | | g LOAD (kg) | |
| 5.70 | | 7.00 | | 8.00 | | | 8.13 | | 8.55 | |
| 14% c | 60% c | 14% c | 60% c | 14% c | 60% c | | 14% c | 60% c | 14% c | 60% c |
| FORE | AFT | FORE | AFT | FORE | AFT | MID STN | FORE | AFT | FORE | AFT |
| | | | | | | LOCATION | | | | |
| | | | | | | (in) | | | | |
| 0 | 0 | 0 | 0 | 0 | 0 | 161.5 | 0 | 0 | 0 | 0 |
| 45 | 10 | 60 | 10 | 65 | 15 | 156 | 70 | 15 | 70 | 15 |
| 120 | 25 | 145 | 35 | 165 | 40 | 140 | 170 | 40 | 175 | 40 |
| 140 | 35 | 170 | 40 | 195 | 50 | 120 | 200 | 50 | 210 | 50 |
| 155 | 40 | 190 | 50 | 220 | 55 | 100 | 225 | 55 | 235 | 60 |
| 170 | 45 | 210 | 50 | 235 | 60 | 80 | 240 | 60 | 255 | 65 |
| 180 | 45 | 220 | 60 | 255 | 65 | 60 | 255 | 65 | 270 | 70 |
| 175 | 45 | 215 | 60 | 250 | 65 | 41 | 250 | 65 | 265 | 70 |
| 85 | 25 | 105 | 25 | 120 | 30 | 27 | 120 | 35 | 130 | 35 |
| | | | | | | | | | | |
| 1070 | 270 | 1315 | 330 | 1505 | 380 | 1 WING | 1530 | 385 | 1610 | 405 |
| 1340 | | 1645 | | 1885 | | | 1915 | | 2015 | |
| 2680 | | 3290 | | 3770 | | 2 WINGS | 3830 | | 4030 | |
| | | | | | | | | | | |
| g LOAD (kg) | | g LOAD (kg) | | g LOAD (kg) | | | g LOAD (kg) | | g LOAD (kg) | |
| 5.70 | | 7.00 | | 8.00 | | | 8.13 | | 8.55 | |
| 14% c | 60% c | 14% c | 60% c | 14% c | 60% c | | 14% c | 60% c | 14% c | 60% c |
| FORE | AFT | FORE | AFT | FORE | AFT | MID STN | FORE | AFT | FORE | AFT |
| | | | | | | LOCATION | | | | |
| | | | | | | (in) | | | | |
| 0 | 0 | 0 | 0 | 0 | 0 | 161.5 | 0 | 0 | 0 | 0 |
| 5 | 0 | 15 | 0 | 5 | 5 | 156 | 5 | 0 | 0 | 0 |
| 15 | 0 | 25 | 10 | 20 | 5 | 140 | 5 | 0 | 5 | 0 |
| 20 | 5 | 30 | 5 | 25 | 10 | 120 | 5 | 0 | 10 | 0 |
| 15 | 5 | 35 | 10 | 30 | 5 | 100 | 5 | 0 | 10 | 5 |
| 20 | 10 | 40 | 5 | 25 | 10 | 80 | 5 | 0 | 15 | 5 |
| 25 | 5 | 40 | 15 | 35 | 5 | 60 | 0 | 0 | 15 | 5 |
| 20 | 5 | 40 | 15 | 35 | 5 | 41 | 0 | 0 | 15 | 5 |
| 10 | 5 | 20 | 0 | 15 | 5 | 27 | 0 | 5 | 10 | 0 |
| | | | | | | | | | | |
| 1070 | 270 | 1315 | 330 | 1505 | 380 | 1 WING | 1530 | 385 | 1610 | 405 |
| 1340 | | 1645 | | 1885 | | | 1915 | | 2015 | |
| 2680 | | 3290 | | 3770 | | 2 WINGS | 3830 | | 4030 | |

COMPARISON BETWEEN APPLIED AND THEORETICAL LOAD
CHECK PERFORMED AT 3.8g*1.5 = 5.7g

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | |
|---|---|---|---|---|---|---|---|---|
| SHRENK SPAN-WISE | MID-BAY | 5.7g | 5.7g | | | | | |
| STATION | APPLIED LOAD | APPLIED LOAD | APPLIED LOAD | APPLIED LOAD | APPLIED LOAD | MIDBAY - 22 | MOMENT | |
| (in) | STATION | 76% load at 14% c | 24% load at 60% c | 100% load | 100% load | ARM | INCREMENT | |
| | (in) | (kg) | (kg) | (kg) | (lb) | (in) | (lb in) | |
| 161.5 | 161.5 | 0 | 0 | 0 | 0 | 139.50 | 0 | |
| 150 | 156 | 45 | 10 | 55 | 121 | 134.00 | 16243 | |
| 130 | 140 | 120 | 25 | 145 | 320 | 118.00 | 37710 | |
| 110 | 120 | 140 | 35 | 175 | 386 | 98.00 | 37799 | |
| 90 | 100 | 155 | 40 | 195 | 430 | 78.00 | 33523 | |
| 70 | 80 | 170 | 45 | 215 | 474 | 58.00 | 27484 | |
| 50 | 60 | 180 | 45 | 225 | 496 | 38.00 | 18844 | |
| 31 | 41 | 175 | 45 | 220 | 485 | 19.00 | 9213 | |
| 22 | 27 | 85 | 25 | 110 | 242 | 5.00 | 1212 | |
| | | | | | | Σ | 182028 | Bending moment at stn 22 from applied weights |
| | | | | | | | 182194 | Resolved bending moment at stn 22 from shrenk approximation |

| 1 | 2 | 3 | 4 | 5 | 6 | 9 | 10 |
|---|---|---|---|---|---|---|---|
| SHRENK SPAN-WISE | MID-BAY | 5.7g | 5.7g | | | | RESOLVED |
| STATION | APPLIED LOAD | APPLIED LOAD | APPLIED LOAD | APPLIED LOAD | APPLIED LOAD | APPLIED SHEAR | SHRENK |
| (in) | STATION | 76% load at 14% c | 24% load at 60% c | 100% load | 100% load | (lb) | SHEAR |
| | (in) | (kg) | (kg) | (kg) | (lb) | | (lb) |
| 161.5 | 161.5 | 0 | 0 | 0 | 0 | 0 | 0 |
| 150 | 156 | 45 | 10 | 55 | 121 | 121 | 126 |
| 130 | 140 | 120 | 25 | 145 | 320 | 441 | 445 |
| 110 | 120 | 140 | 35 | 175 | 386 | 827 | 830 |
| 90 | 100 | 155 | 40 | 195 | 430 | 1256 | 1263 |
| 70 | 80 | 170 | 45 | 215 | 474 | 1730 | 1731 |
| 50 | 60 | 180 | 45 | 225 | 496 | 2226 | 2228 |
| 31 | 41 | 175 | 45 | 220 | 485 | 2711 | 2720 |
| 22 | 27 | 85 | 25 | 110 | 242 | 2953 | 2959 |

Applied shear and bending moment calculated from discrete kilogram weights, are within 1% of theoretica values predicted by Shrenk approximation

LUMN 5 = 3 + 4
6 = 5 * 2.204
7 = 2 - 22
8 = 7 * 6

NDING MOMENT AT STN 22 FROM APPLIED WEIGHT = 182028 = SUM COLUMN 8
9 = INCREMENT SUMMATION OF COLUMN 6

Europa Aviation Ltd

Calculation Sheet

| Title | Made by | Checked by | Date | Rev |
|---|---|---|---|---|
| APPENDIX B. | JASON RUSSELL | | | 0 |

| Project | Ref |
|---|---|
| EUROPA XS | — |

| Subject | Page of |
|---|---|
| VD LOW ANGLE OF ATTACK TEST 2 (LAA) | |

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| Title | Made by | Checked by | Date | Rev |
|---|---|---|---|---|
| | JASON RUSSELL | | | 1 |
| Project: EUROPA XS | | | Ref | |
| Subject: VD LOW ANGLE OF ATTACK. | | | Page 1 of 1 | |

DENSITY = 0.00238 slug/ft$^3$
WING AREA = 101.8 ft$^2$
AIRSPEED = 307 fps
AUW = 1370 lb
AR = 7.12.

$q = \frac{1}{2}\rho V^2$
$= \frac{1}{2} * 0.00238 * 307^2$
$= 112$ psf

$nW = 3.8 * 1370$
$= 5206$.

$\ell t$ ASSUMING 5% OF nW = -260 lb
$\therefore$ LIFT = $nW - \ell t$
$= 5206 + 260$
$= 5466$ lb.

$C_L = \frac{LIFT}{qS} = \frac{5466}{112*101.8} = 0.479.$ ⇒ LOCAL $C_L$ ON WING @ STN 22 $= 0.51$

$\alpha = \frac{C_L - C_{L\alpha=0}}{0.081} = \frac{0.479-0.25}{0.081} = 2.83°$ FUSELAGE $\therefore$ WING $= 2.83+2.5$
$= 5.33°$

$C_{D_i} = \frac{C_L^2}{\pi A R e}$
$= \frac{(0.479)^2}{(\pi * 7.12 * 0.8)}$
$= 0.013$.

$C_{D_P} = 0.008$ FOR LOW $\alpha$
$C_D = 0.008 + 0.013$
$= 0.021$

DRAG = $qSC_D$
$= 112 * 101.8 * 0.021$
$= 239$ lb.

ANGLE = ATAN$\left(\frac{239}{5466}\right) = 2.5°$

FUSELAGE SETTING ANGLE = $2.83 - 2.5° = 0.33°$ = ANGLE USED DURING TEST

EUROPA XS WING LOADING ANALYSIS

SPANWISE AERODYNAMIC LOAD DISTRIBUTION

CONDITION. D

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| $V_{stl}$ = | 307.00 | ft/s | | | $C_L$ = | 0.5 | | alpha wrp = | 5.3300 | | |
| Lift = | 5466.00 | lb | | | $C_{Do}$ = | 0.008 | | sin alpha = | 0.0929 | | |
| q = | 112.00 | psf | | | S = | 101.800 | $ft^2$ | cos alpha = | 0.9957 | | |
| n = | 3.80 | g | | | $C_{Mo}$ = | -0.020 | | | | | |
| $q.C_L$ = | 53.69 | $q.C_L$ =Lift/S | | | b = | 26.92 | ft | | | | |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| STATION | 2y/b | dy | CHORD | CHORD | c av | ELEM AREA | ELLIPSE | SHRENK | UNIT | | $dy\ c^2$ |
| (in) | | (ft) | (in) | (ft) | (ft) | dy * c av | | Cla | Cla | av Cla | |
| | | | | | | $(ft^2)$ | | | | | |
| 161.5 | 1.000 | - | 39.00 | 3.250 | - | - | 0.000 | 1.625 | 0.500 | - | - |
| 150 | 0.929 | 0.96 | 39.91 | 3.326 | 3.288 | 3.151 | 1.785 | 2.555 | 0.768 | 0.634 | 10.3600 |
| 130 | 0.805 | 1.67 | 41.49 | 3.458 | 3.392 | 5.653 | 2.857 | 3.157 | 0.913 | 0.841 | 19.1736 |
| 110 | 0.681 | 1.67 | 43.08 | 3.590 | 3.524 | 5.873 | 3.526 | 3.558 | 0.991 | 0.952 | 20.6937 |
| 90 | 0.557 | 1.67 | 44.66 | 3.722 | 3.656 | 6.093 | 3.998 | 3.860 | 1.037 | 1.014 | 22.2718 |
| 70 | 0.433 | 1.67 | 46.24 | 3.853 | 3.787 | 6.312 | 4.340 | 4.096 | 1.063 | 1.050 | 23.9079 |
| 50 | 0.310 | 1.67 | 47.82 | 3.985 | 3.919 | 6.532 | 4.579 | 4.282 | 1.074 | 1.069 | 25.6020 |
| 31 | 0.192 | 1.58 | 49.33 | 4.111 | 4.048 | 6.409 | 4.726 | 4.418 | 1.075 | 1.075 | 25.9440 |
| 22 | 0.136 | 0.75 | 50.04 | 4.170 | 4.140 | 3.105 | 4.771 | 4.470 | 1.072 | 1.073 | 12.8562 |
| 19 | 0.118 | 0.25 | 50.28 | 4.190 | 4.180 | 1.045 | 4.782 | 4.486 | 1.071 | 1.071 | 4.3677 |
| 0 | 0.000 | 1.58 | 51.78 | 4.315 | 4.252 | 6.733 | 4.815 | 4.565 | 1.058 | 1.064 | 28.6306 |
| | | | | | Σ = | 50.91 | | | | Σ = | 193.81 |
| | | | | | Area calc = | 101.81 | $ft^2$ | | | MAC calc = | 3.81 |
| | | | | | | | | | | MAC calc = | 45.69 |

| | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $C_L$ | $C_{Lx}$ | $C_{Lz}$ | $C_D$ | $C_{Dx}$ | $C_{Dz}$ | $C_{Lz}+C_{Dz}$ | $C_{Dx}-C_{Lx}$ | $(C_{Lz}+C_{Dz})_{AV}$ | $(C_{Dx}-C_{Lx})_{AV}$ | SPAN ELEMENT LIFT (lb) | SPAN ELEMENT DRAG (lb) | SPAN ELEMENT LIFT CHECK |
| | 0.2395 | 0.0222 | 0.2385 | 0.0210 | 0.0209 | 0.0020 | 0.2404 | -0.0013 | - | - | 0.00 | 0.00 | 0.00 |
| | 0.3680 | 0.0342 | 0.3664 | 0.0210 | 0.0209 | 0.0020 | 0.3684 | -0.0133 | 0.3044 | -0.0073 | 107.42 | -2.58 | 107.29 |
| | 0.4374 | 0.0406 | 0.4355 | 0.0210 | 0.0209 | 0.0020 | 0.4375 | -0.0197 | 0.4029 | -0.0165 | 255.10 | -10.45 | 255.18 |
| | 0.4747 | 0.0441 | 0.4727 | 0.0210 | 0.0209 | 0.0020 | 0.4746 | -0.0232 | 0.4561 | -0.0215 | 299.97 | -14.11 | 300.24 |
| | 0.4968 | 0.0462 | 0.4947 | 0.0210 | 0.0209 | 0.0020 | 0.4966 | -0.0252 | 0.4856 | -0.0242 | 331.38 | -16.52 | 331.76 |
| | 0.5092 | 0.0473 | 0.5070 | 0.0210 | 0.0209 | 0.0020 | 0.5090 | -0.0264 | 0.5028 | -0.0258 | 355.47 | -18.25 | 355.93 |
| | 0.5147 | 0.0478 | 0.5124 | 0.0210 | 0.0209 | 0.0020 | 0.5144 | -0.0269 | 0.5117 | -0.0266 | 374.35 | -19.49 | 374.86 |
| | 0.5149 | 0.0478 | 0.5126 | 0.0210 | 0.0209 | 0.0020 | 0.5146 | -0.0269 | 0.5145 | -0.0269 | 369.32 | -19.32 | 369.83 |
| | 0.5135 | 0.0477 | 0.5113 | 0.0210 | 0.0209 | 0.0020 | 0.5132 | -0.0268 | 0.5139 | -0.0269 | 178.73 | -9.34 | 178.97 |
| | 0.5129 | 0.0476 | 0.5106 | 0.0210 | 0.0209 | 0.0020 | 0.5126 | -0.0267 | 0.5129 | -0.0268 | 60.03 | -3.13 | 60.11 |
| | 0.5068 | 0.0471 | 0.5046 | 0.0210 | 0.0209 | 0.0020 | 0.5065 | -0.0262 | 0.5096 | -0.0264 | 384.25 | -19.94 | 384.77 |
| | | | | | | | | | | $\Sigma$ = | 2716.02 | -133.14 | 2718.95 |
| ft | | | | | | | | | | LIFT calc = | 5432.03 | | 5437.89 |
| in | | | | | | | | | | Lift = | 5466.00 | | 5466.00 |
| | | | | | | | | | | error = | 0.6 % | | 0.5 % |

SPANWISE AERODYNAMIC LOAD DISTRIBUTION

CONDITION. D cont.

| 1 | 3 | 4 | 21 D | 22 D | 23 D | 24 D | 25 D | 26 | 27 | 28 |
|---|---|---|---|---|---|---|---|---|---|---|
| STATION | dy | CHORD | LIMIT | LIMIT | LIMIT | LIMIT | ULT | ULT | ULT | ULT |
| (in) | (in) | (in) | NORMAL | NORMAL | CHORD | CHORD | NORMAL | NORMAL | CHORD | CHORD |
| | | | SHEAR | MOMENT | SHEAR | MOMENT | SHEAR | MOMENT | SHEAR | MOMENT |
| | | | (lb) | (lb) | (lb) | (lb) | (lb) | (lb) | (lb) | (lb) |
| 161.5 | - | 39.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0 | 0 | 0 | 0 |
| 150 | 11.50 | 39.91 | 107.42 | 617.67 | -2.58 | -14.83 | 161 | 927 | -4 | -22 |
| 130 | 20.00 | 41.49 | 362.52 | 5317.11 | -13.02 | -170.86 | 544 | 7976 | -20 | -256 |
| 110 | 20.00 | 43.08 | 662.49 | 15567.23 | -27.14 | -572.49 | 994 | 23351 | -41 | -859 |
| 90 | 20.00 | 44.66 | 993.87 | 32130.82 | -43.66 | -1280.49 | 1491 | 48196 | -65 | -1921 |
| 70 | 20.00 | 46.24 | 1349.34 | 55562.93 | -61.91 | -2336.25 | 2024 | 83344 | -93 | -3504 |
| 50 | 20.00 | 47.82 | 1723.69 | 86293.28 | -81.41 | -3769.49 | 2586 | 129440 | -122 | -5654 |
| 31 | 19.00 | 49.33 | 2093.01 | 122551.95 | -100.72 | -5499.76 | 3140 | 183828 | -151 | -8250 |
| 22 | 9.00 | 50.04 | 2271.73 | 142193.29 | -110.06 | -6448.30 | 3408 | 213290 | -165 | -9672 |
| 19 | 3.00 | 50.28 | 2331.76 | 149098.53 | -113.20 | -6783.19 | 3498 | 223648 | -170 | -10175 |
| 0 | 19.00 | 51.78 | 2716.02 | 197052.43 | -133.14 | -9123.38 | 4074 | 295579 | -200 | -13685 |
| | | Centre of lift is | 73 | in from aircraft centreline | | | | | | |
| | | | 45 | % semispan | | | | | | |

SPANWISE INERTIAL LOAD DISTRIBUTION

CONDITION. D cont..

| 1 | 3 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| STATION | dy | WEIGHT | ELEMENT | ELEMENT | LIMIT | LIMIT | LIMIT | LIMIT | ULT | ULT | ULT | ULT |
| (in) | (in) | nW | SHEAR | SHEAR | NORMAL | NORMAL | CHORD | CHORD | NORMAL | NORMAL | CHORD | CHORD |
| | | (lb) | FORCE | FORCE | SHEAR | MOMENT | SHEAR | MOMENT | SHEAR | MOMENT | SHEAR | MOMENT |
| | | | $V_x$ | $V_z$ | (lb) | (lb) | (lb) | (lb) | (lb) | (lb) | (lb) | (lb) |
| | | | (lb) | (lb) | | | | | | | | |
| 161.5 | - | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0 | 0 | 0 | 0 |
| 150 | 11.50 | -24.30 | 2.26 | -24.20 | -24.20 | -139.15 | 2.26 | 12.98 | -36 | -209 | 3 | 19 |
| 130 | 20.00 | -42.28 | 3.93 | -42.09 | -66.29 | -1044.06 | 6.18 | 97.41 | -99 | -1566 | 9 | 146 |
| 110 | 20.00 | -42.28 | 3.93 | -42.09 | -108.38 | -2790.83 | 10.11 | 260.37 | -163 | -4186 | 15 | 391 |
| 90 | 20.00 | -42.28 | 3.93 | -42.09 | -150.48 | -5379.43 | 14.04 | 501.88 | -226 | -8069 | 21 | 753 |
| 70 | 20.00 | -42.28 | 3.93 | -42.09 | -192.57 | -8809.88 | 17.97 | 821.92 | -289 | -13215 | 27 | 1233 |
| 50 | 20.00 | -42.28 | 3.93 | -42.09 | -234.66 | -13082.17 | 21.89 | 1220.50 | -352 | -19623 | 33 | 1831 |
| 31 | 19.00 | -40.16 | 3.73 | -39.98 | -274.65 | -17920.58 | 25.62 | 1671.91 | -412 | -26881 | 38 | 2508 |
| 22 | 9.00 | -19.02 | 1.77 | -18.94 | -293.59 | -20477.62 | 27.39 | 1910.47 | -440 | -30716 | 41 | 2866 |
| 19 | 3.00 | -6.33 | 0.59 | -6.31 | -299.89 | -21367.84 | 27.98 | 1993.52 | -450 | -32052 | 42 | 2990 |
| 0 | 19.00 | -40.16 | 3.73 | -39.99 | -339.88 | -27445.69 | 31.71 | 2560.55 | -510 | -41169 | 48 | 3841 |
| | Σ = | 90 | lb | | | | | | | | | |
| | | at 1 g | | | Centre of gravity is | 81 | in from aircraft centreline | | | | | |
| | | | | | | 50 | % semispan | | | | | |

| COMBINED ULTIMATE LOADS ( AERODYNAMIC + INERTIAL ) | | | | | | |
|---|---|---|---|---|---|---|
| NORMAL LOADS | | | | | | |
| 1 | 40 D | 41 D | 42 D | 43 D | 41 D | 40 D |
| | ULT NORMAL | ULT NORMAL | ULT CHORD | ULT CHORD | ULT RESOLVED | ULT RESOLVED |
| STATION | SHEAR | BEND MOM | SHEAR | BEND MOM | BEND MOM | SHEAR |
| (in) | COND. D | COND. D | COND. D | COND. D | COND. D | COND. D |
| | (lb) | (lb in) | (lb) | (lb in) | (lb in) | (lb) |
| 161.5 | 0 | 0 | 0 | 0 | 0 | 0 |
| 150 | 125 | 718 | 0 | -3 | 718 | 125 |
| 130 | 444 | 6410 | -10 | -110 | 6411 | 444 |
| 110 | 831 | 19165 | -26 | -468 | 19170 | 832 |
| 90 | 1265 | 40127 | -44 | -1168 | 40144 | 1266 |
| 70 | 1735 | 70130 | -66 | -2271 | 70166 | 1736 |
| 50 | 2234 | 109817 | -89 | -3823 | 109883 | 2235 |
| 31 | 2728 | 156947 | -113 | -5742 | 157052 | 2730 |
| 22 | 2967 | 182573 | -124 | -6807 | 182700 | 2970 |
| 19 | 3048 | 191596 | -128 | -7185 | 191731 | 3050 |
| 0 | 3564 | 254410 | -152 | -9844 | 254600 | 3567 |

Europa Aviation Ltd — Calculation Sheet

| Title | Made by | Checked by | Date | Rev |
|---|---|---|---|---|
| LAA TEST 2. | JASON RUSSELL | | 16/02/98 | 2 |
| Project | | | Ref | |
| EUROPA XS | | | | |
| Subject | | | Page 2 of 4 | |
| CHORDWISE PRESSURE DISTRIBUTION @ $V_D$ | | | | |

$A_1 = \left(\left(\frac{8.8-5.2}{2}\right)+5.2\right)10 = 70\text{ lb.}$

$A_2 = \left(\left(\frac{5.2-4.55}{2}\right)+4.55\right)10 = 49\text{ lb.}$

$A_3 = \left(\left(\frac{4.55-2.23}{2}\right)+2.23\right)5\tfrac{1}{2} = 18.6\text{ lb.}$

$A_4 = \left(\left(\frac{2.23-1.24}{2}\right)+1.24\right)10 = 17.4\text{ lb.}$

$A_5 = \tfrac{1}{2} * 1.24 * 14\tfrac{1}{2} = 9\text{ lb.}$

$\Sigma\ 164$

SHRENK GIVES 159 lb.

$\text{ERROR} = \left(1-\left(\frac{159}{164}\right)\right)*100 = 3\%.$

$\bar{X}_1 = \frac{10}{3}\left(\frac{(2*8.8)+5.2}{8.8+5.2}\right) = 5.43\text{ in}$

$\bar{X}_2 = \frac{10}{3}\left(\frac{(2*5.2)+4.55}{5.2+4.55}\right) = 5.11\text{ in}$

$\bar{X}_3 = \frac{5\frac{1}{2}}{3}\left(\frac{(2*4.55)+2.23}{2.23+4.55}\right) = 3.06\text{ in}$

$\bar{X}_4 = \frac{10}{3}\left(\frac{(2*2.23)+1.24}{2.23+1.24}\right) = 5.48\text{ in}$

$\bar{X}_5 = \frac{14\frac{1}{2}}{3} = 4.83\text{ IN}$

FROM SPAR

$X_1 = 10+5.43 = 15.43\text{ in}$

$X_2 = 5.11\text{ in}$

$X_3 = 5\tfrac{1}{2}-3.06 = 2.44\text{ in}$

$X_4 = 5\tfrac{1}{2}+(10-5.48) = 10.02\text{ in}$

$X_5 = 15\tfrac{1}{2}+4.83 = 20.33\text{ in.}$

INFRONT OF SPAR.

$\text{LOAD} = A_1+A_2 = 70+49 = 119\text{ lb.}$

$\% = \frac{119}{164} = 73\%$ LOAD INFRONT OF SPAR.

$A_1X_1 + A_2X_2$

$= (70*15.43)+(5.11*49)$

$= 1080 + 250.4$

$= 1330.4\text{ lb in}$

$\%c$

$= \dfrac{0.4c - \left(\frac{1330.4}{119}\right)}{50}$

$= 18\%c.$

AFT OF SPAR

$\text{LOAD} = A_3+A_4+A_5$

$= 18.6+17.4+9$

$= 45\text{ lb.}$

$\% = \frac{45}{164} = 27\%$ LOAD AFT OF SPAR

$A_3X_3 + A_4X_4 + A_5X_5$

$= (18.6*2.44)+(17.4*10.02)+(9*20.33)$

$= (45.4)+(174.5)+(183)$

$= 403\text{ lb in}$

$\%c$

$= \dfrac{0.4c + \left(\frac{403}{45}\right)}{50}$

$= 58\%c.$

| Title | Made by | Checked by | Date | Rev |
|---|---|---|---|---|
| LAA TEST 2. | JASON RUSSELL | | 10/2/98 | 2 |
| Project: EUROPA XS | | | Ref | |
| Subject: CHORDWISE PRESSURE DISTRIBUTION @ $V_D$. | | | Page 3 of 4 | |

∴ 73% LOAD INFRONT OF SPAR @ 18%c
27% LOAD AFT OF SPAR @ 58%c.

$\Sigma M$ ABT LE

$X_1 = 10 - 5.43 = 4.57$ in
$X_2 = 10 + (10 - 5.11) = 14.89$ in
$X_3 = 2.44 + 20 = 22.44$ in
$X_4 = 10.02 + 20 = 30.02$
$X_5 = 20.33 + 20 = 40.33$.

$A_1X_1 + A_2X_2 + A_3X_3 + A_4X_4 + A_5X_5$

$(70 * 4.57) + (49 * 14.89) + (186 * 22.44) + (174 * 30.02) + (40.33 * 9)$

$320 + 730 + 417 + 522 + 363$

$= 2352$ lbin

$\therefore \dfrac{2352}{164} = 14.3$ in

$\%c = \dfrac{14.3}{50} = 28.6\%$ CHORD. = CENTRE OF APPLIED LOAD.

CHECK: FROM PFA FAX 16/12/97

$X_{cp} = 0.24 + \dfrac{0.02}{0.48}$

$= 0.28\%$ CHORD.

$X_{cp} = 0.73 * 0.18 + 0.27 * 0.58$
$= 0.288c$. REASONABLE AGREEMENT

HOWEVER, P.T.O.

Europa Aviation Ltd | Calculation Sheet

| Title | Made by | Checked by | Date | Rev |
|---|---|---|---|---|
| LAA TEST 2 | JASON RUSSELL | | | 0 |

| Project | Ref |
|---|---|
| EUROPA XS | PFA FAX 17/02/98 |

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|---|---|
| CHORDWISE PRESSURE DISTRIBUTION. | |

HOWEVER –

REF PFA FAX 17/02/98

$$X_{cp} = 0.25 + \frac{0.02}{0.48} = 29.2\% \text{ CHORD.}$$

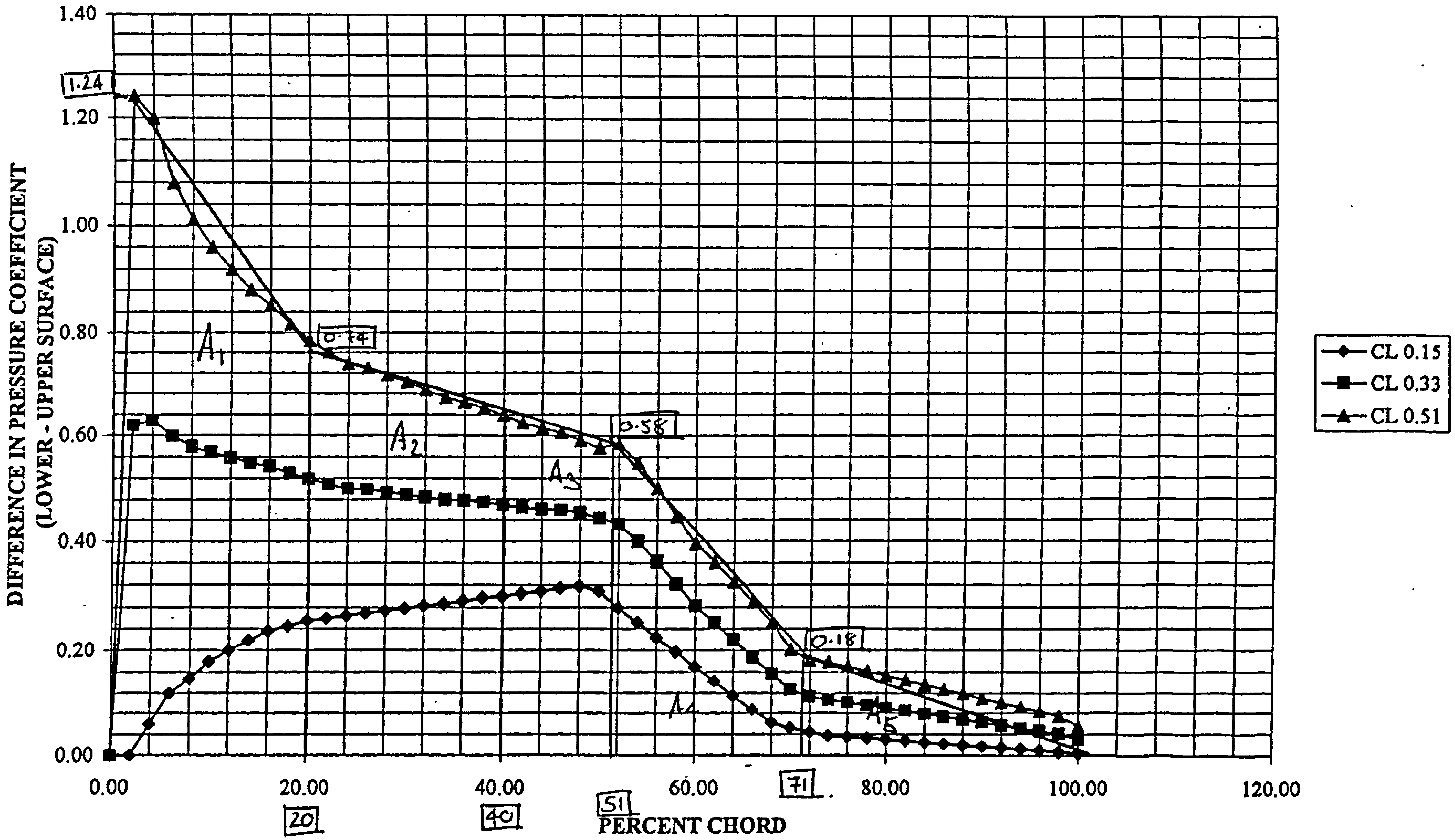
RESOLUTION OF LOADS VIA FAX =

27% LOAD @ 61% C. &

73% LOAD @ 19% C

THIS DISTRIBUTION WAS USED FOR TEST.

**DIFFERENCE IN PRESSURE COEFF**
**VARIATION WITH CHORD**



| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | g LOAD (kg) | | g LOAD (kg) | | g LOAD (kg) | | g LOAD (kg) | |
| | | 1.00 | | 2.00 | | 3.00 | | 3.80 | |
| APPLIED LOAD | MID STN | 19% c | 61% c | 19% c | 61% c | 19% c | 61% c | 19% c | 61% c |
| STN TOTALS | LOCATION | FORE | AFT | FORE | AFT | FORE | AFT | FORE | AFT |
| | (in) | | | | | | | | |
| | 161.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 156 | 10 | 0 | 15 | 5 | 25 | 5 | 30 | 10 |
| | 140 | 20 | 5 | 40 | 10 | 60 | 15 | 75 | 20 |
| | 120 | 25 | 5 | 45 | 15 | 70 | 20 | 90 | 25 |
| | 100 | 25 | 10 | 50 | 15 | 80 | 25 | 100 | 30 |
| | 80 | 30 | 10 | 55 | 15 | 85 | 25 | 110 | 35 |
| | 60 | 30 | 10 | 60 | 20 | 90 | 30 | 115 | 35 |
| | 41 | 30 | 10 | 60 | 20 | 90 | 30 | 115 | 35 |
| | 27 | 10 | 5 | 35 | 10 | 40 | 15 | 50 | 20 |
| | 1 WING | 180 | 55 | 360 | 110 | 540 | 165 | 685 | 210 |
| | | 235 | | 470 | | 705 | | 895 | |
| | 2 WINGS | 470 | | 940 | | 1410 | | 1790 | |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | g LOAD (kg) | | g LOAD (kg) | | g LOAD (kg) | | g LOAD (kg) | |
| | | 1.00 | | 2.00 | | 3.00 | | 3.80 | |
| APPLIED LOAD | MID STN | 19% c | 61% c | 19% c | 61% c | 19% c | 61% c | 19% c | 61% c |
| STN | LOCATION | FORE | AFT | FORE | AFT | FORE | AFT | FORE | AFT |
| INCREMENTS | | | | | | | | | |
| | (in) | | | | | | | | |
| | 161.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 156 | 10 | 0 | 5 | 5 | 10 | 0 | 5 | 5 |
| | 140 | 20 | 5 | 20 | 5 | 20 | 5 | 15 | 5 |
| | 120 | 25 | 5 | 20 | 10 | 25 | 5 | 20 | 5 |
| | 100 | 25 | 10 | 25 | 5 | 30 | 10 | 20 | 5 |
| | 80 | 30 | 10 | 25 | 5 | 30 | 10 | 25 | 10 |
| | 60 | 30 | 10 | 30 | 10 | 30 | 10 | 25 | 5 |
| | 41 | 30 | 10 | 30 | 10 | 30 | 10 | 25 | 5 |
| | 27 | 10 | 5 | 25 | 5 | 5 | 5 | 10 | 5 |
| | 1 WING | 180 | 55 | 360 | 110 | 540 | 165 | 685 | 210 |
| | | 235 | | 470 | | 705 | | 895 | |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | g LOAD (kg) | | g LOAD (kg) | | g LOAD (kg) | | g LOAD (kg) | | | g LOAD (kg) | | g LOAD (kg) | |
| | 5.00 | | 5.70 | | 7.00 | | 8.00 | | | 8.13 | | 8.55 | |
| MID STN | 19% c | 61% c | 19% c | 61% c | 19% c | 61% c | 19% c | 61% c | MID STN | 19% c | 61% c | 19% c | 61% c |
| LOCATION | FORE | AFT | FORE | AFT | FORE | AFT | FORE | AFT | LOCATION | FORE | AFT | FORE | AFT |
| (in) | | | | | | | | | (in) | | | | |
| 161.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 161.5 | 0 | 0 | 0 | 0 |
| 156 | 40 | 10 | 45 | 10 | 55 | 15 | 65 | 15 | 156 | 65 | 15 | 70 | 15 |
| 140 | 100 | 30 | 110 | 35 | 140 | 40 | 160 | 45 | 140 | 160 | 45 | 170 | 50 |
| 120 | 120 | 35 | 135 | 40 | 165 | 50 | 190 | 60 | 120 | 190 | 60 | 200 | 60 |
| 100 | 130 | 40 | 150 | 45 | 185 | 60 | 210 | 65 | 100 | 215 | 65 | 225 | 70 |
| 80 | 145 | 45 | 165 | 50 | 200 | 60 | 230 | 70 | 80 | 230 | 75 | 245 | 75 |
| 60 | 150 | 50 | 170 | 55 | 210 | 65 | 240 | 75 | 60 | 245 | 80 | 255 | 85 |
| 41 | 150 | 50 | 170 | 55 | 210 | 65 | 240 | 75 | 41 | 245 | 75 | 255 | 80 |
| 27 | 70 | 20 | 85 | 25 | 100 | 35 | 110 | 40 | 27 | 120 | 40 | 125 | 40 |
| 1 WING | 905 | 280 | 1030 | 315 | 1265 | 390 | 1445 | 445 | 1 WING | 1470 | 455 | 1545 | 475 |
| | 1185 | | 1345 | | 1655 | | 1890 | | | 1925 | | 2020 | |
| 2 WINGS | 2370 | | 2690 | | 3310 | | 3780 | | 2 WINGS | 3850 | | 4040 | |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | g LOAD (kg) | | g LOAD (kg) | | g LOAD (kg) | | g LOAD (kg) | | | g LOAD (kg) | | g LOAD (kg) | |
| | 5.00 | | 5.70 | | 7.00 | | 8.00 | | | 8.13 | | 8.55 | |
| MID STN | 19% c | 61% c | 19% c | 61% c | 19% c | 61% c | 19% c | 61% c | MID STN | 19% c | 61% c | 19% c | 61% c |
| LOCATION | FORE | AFT | FORE | AFT | FORE | AFT | FORE | AFT | LOCATION | FORE | AFT | FORE | AFT |
| (in) | | | | | | | | | (in) | | | | |
| 161.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 161.5 | 0 | 0 | 0 | 0 |
| 156 | 10 | 0 | 5 | 0 | 10 | 5 | 10 | 0 | 156 | 0 | 0 | 5 | 0 |
| 140 | 25 | 10 | 10 | 5 | 30 | 5 | 20 | 5 | 140 | 0 | 0 | 10 | 5 |
| 120 | 30 | 10 | 15 | 5 | 30 | 10 | 25 | 10 | 120 | 0 | 0 | 10 | 0 |
| 100 | 30 | 10 | 20 | 5 | 35 | 15 | 25 | 5 | 100 | 5 | 0 | 10 | 5 |
| 80 | 35 | 10 | 20 | 5 | 35 | 10 | 30 | 10 | 80 | 0 | 5 | 15 | 0 |
| 60 | 35 | 15 | 20 | 5 | 40 | 10 | 30 | 10 | 60 | 5 | 5 | 10 | 5 |
| 41 | 35 | 15 | 20 | 5 | 40 | 10 | 30 | 10 | 41 | 5 | 0 | 10 | 5 |
| 27 | 20 | 0 | 15 | 5 | 15 | 10 | 10 | 5 | 27 | 10 | 0 | 5 | 0 |
| 1 WING | 905 | 280 | 1030 | 315 | 1265 | 390 | 1445 | 445 | 1 WING | 1470 | 455 | 1545 | 475 |
| | 1185 | | 1345 | | 1655 | | 1890 | | | 1925 | | 2020 | |
| 2 WINGS | 2370 | | 2690 | | 3310 | | 3780 | | 2 WINGS | 3850 | | 4040 | |

COMPARISON BETWEEN APPLIED AND THEORETICAL LOAD

CHECK PERFORMED AT 3.8g*1.5 = 5.7g

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | |
|---|---|---|---|---|---|---|---|---|
| SHRENK SPAN-WISE | MID-BAY | 5.7g | 5.7g | | | | | |
| STATION | APPLIED LOAD | APPLIED LOAD | APPLIED LOAD | APPLIED LOAD | APPLIED LOAD | MIDBAY - 22 | MOMENT | |
| (in) | STATION | 73% load at 19% c | 27% load at 61% c | 100% load | 100% load | ARM | INCREMENT | |
| | (in) | (kg) | (kg) | (kg) | (lb) | | (lb in) | |
| 161.5 | 161.5 | 0 | 0 | 0 | 0 | 140 | 0 | |
| 150 | 156 | 45 | 10 | 55 | 121 | 134 | 16243 | |
| 130 | 140 | 110 | 35 | 145 | 320 | 118 | 37710 | |
| 110 | 120 | 135 | 40 | 175 | 386 | 98 | 37799 | |
| 90 | 100 | 150 | 45 | 195 | 430 | 78 | 33523 | |
| 70 | 80 | 165 | 50 | 215 | 474 | 58 | 27484 | |
| 50 | 60 | 170 | 55 | 225 | 496 | 38 | 18844 | |
| 31 | 41 | 170 | 55 | 225 | 496 | 19 | 9422 | |
| 22 | 27 | 85 | 25 | 110 | 242 | 5 | 1212 | |
| | | | | | | Σ | 182238 | Bending moment at stn 22, from applied weights |
| | | | | | | | 182700 | Resolved bending moment at stn 22 from shrenk approximation |

| 1 | 2 | 3 | 4 | 5 | 6 | 9 | 10 |
|---|---|---|---|---|---|---|---|
| SHRENK SPAN-WISE | MID-BAY | 5.7g | 5.7g | | | | RESOLVED |
| STATION | APPLIED LOAD | APPLIED LOAD | APPLIED LOAD | APPLIED LOAD | APPLIED LOAD | APPLIED | SHRENK |
| (in) | STATION | 73% load at 19% c | 27% load at 61% c | 100% load | 100% load | SHEAR | SHEAR |
| | (in) | (kg) | (kg) | (kg) | (lb) | (lb) | (lb) |
| 161.5 | 161.5 | 0 | 0 | 0 | 0 | 0 | 0 |
| 150 | 156 | 45 | 10 | 55 | 121 | 121 | 125 |
| 130 | 140 | 110 | 35 | 145 | 320 | 441 | 444 |
| 110 | 120 | 135 | 40 | 175 | 386 | 827 | 832 |
| 90 | 100 | 150 | 45 | 195 | 430 | 1256 | 1266 |
| 70 | 80 | 165 | 50 | 215 | 474 | 1730 | 1736 |
| 50 | 60 | 170 | 55 | 225 | 496 | 2226 | 2235 |
| 31 | 41 | 170 | 55 | 225 | 496 | 2722 | 2730 |
| 22 | 27 | 85 | 25 | 110 | 242 | 2964 | 2970 |

Applied shear and bending moment calculated from discrete kilogram weights, are within 1% of theoretical values predicted by Shrenk approximation

| Title | Made by | Checked by | Date | Rev |
| --- | --- | --- | --- | --- |
| APPENDIX C | JARON RUSSELL | | | 0 |
| **Project** | | | **Ref** | |
| EUROPA XS. | | | / | |
| **Subject** | | | **Page of** | |
| HAA & LAA STRAIN & DEFLECTION MEASUREMENTS | | | | |

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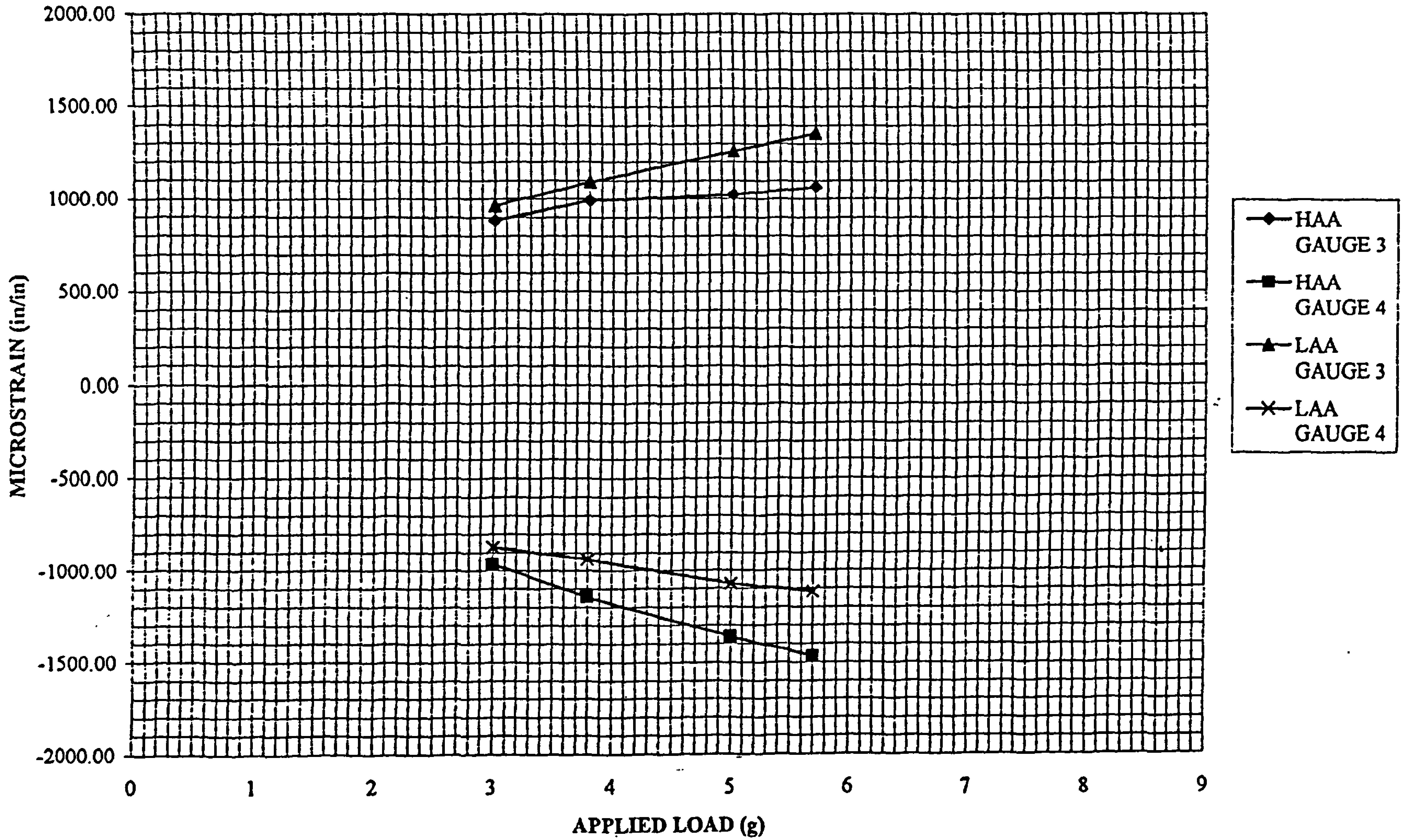
|---|---|---|---|---|---|---|---|---|
| XS WING | TEST 1 | HAA 16.02.98 | | | | | | |
| | TEST 2 | LAA 17.02.98 | | | | | | |
| | | | | | | | | |
| FUSELAGE MEASUREMENTS | | | | | | | | |
| | | | | | | | | |
| FUSELAGE SIDE CORRECTED TOTAL ANGULAR DEFLECTION | | | | | | | | |
| | | | | | | | | |
| | HAA | HAA | HAA | HAA | LAA | LAA | LAA | LAA |
| | STBD ROOT | PORT ROOT | STBD ROOT | PORT ROOT | STBD ROOT | PORT ROOT | STBD ROOT | PORT ROOT |
| | LE | LE | TE | TE | LE | LE | TE | TE |
| g | ANG DEF | ANG DEF | ANG DEF | ANG DEF | ANG DEF | ANG DEF | ANG DEF | ANG DEF |
| LOAD | (deg) | (deg) | (deg) | (deg) | (deg) | (deg) | (deg) | (deg) |
| 1 | - | - | - | - | - | - | - | - |
| 2 | - | - | - | - | - | - | - | - |
| 3 | 0.60 | 0.60 | 0.13 | 0.13 | 0.50 | 0.50 | 0.13 | 0.13 |
| 3.8 | 0.80 | 0.80 | 0.30 | 0.30 | 0.80 | 0.75 | 0.25 | 0.25 |
| 5 | 1.10 | 1.10 | 0.50 | 0.50 | 1.20 | 1.00 | 0.30 | 0.30 |
| 5.7 | 1.20 | 1.20 | 0.50 | 0.50 | 1.20 | 1.10 | 0.60 | 0.50 |
| 7 | - | - | - | - | - | - | - | - |
| 8.13 | - | - | - | - | - | - | - | - |
| 8.55 | - | - | - | - | - | - | - | - |
| | | | | | | | | |
| | HAA | HAA | HAA | HAA | LAA | LAA | LAA | LAA |
| | STBD ROOT | PORT ROOT | STBD ROOT | PORT ROOT | STBD ROOT | PORT ROOT | STBD ROOT | PORT ROOT |
| | LE | LE | TE | TE | LE | LE | TE | TE |
| | ANG DEF | ANG DEF | ANG DEF | ANG DEF | ANG DEF | ANG DEF | ANG DEF | ANG DEF |
| g | PER g | PER g | PER g | PER g | PER g | PER g | PER g | PER g |
| LOAD | (deg) | (deg) | (deg) | (deg) | (deg) | (deg) | (deg) | (deg) |
| 1 | - | - | - | - | - | - | - | - |
| 2 | - | - | - | - | - | - | - | - |
| 3 | 0.20 | 0.20 | 0.04 | 0.04 | 0.17 | 0.17 | 0.04 | 0.04 |
| 3.8 | 0.21 | 0.21 | 0.08 | 0.08 | 0.21 | 0.20 | 0.07 | 0.07 |
| 5 | 0.22 | 0.22 | 0.10 | 0.10 | 0.24 | 0.20 | 0.06 | 0.06 |
| 5.7 | 0.21 | 0.21 | 0.09 | 0.09 | 0.21 | 0.19 | 0.11 | 0.09 |
| 7 | - | - | - | - | - | - | - | - |
| 8.13 | - | - | - | - | - | - | - | - |
| 8.55 | - | - | - | - | - | - | - | - |
| | | | | | | | | |
| AVERAGE | HAA | HAA | HAA | HAA | LAA | LAA | LAA | LAA |
| ANG DEF | STBD ROOT | PORT ROOT | STBD ROOT | PORT ROOT | STBD ROOT | PORT ROOT | STBD ROOT | PORT ROOT |
| PER g | LE | LE | TE | TE | LE | LE | TE | TE |
| deg | 0.21 | 0.21 | 0.08 | 0.08 | 0.21 | 0.19 | 0.07 | 0.06 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| XS WING | TEST 1 | HAA 16.02.98 | | | | | | | | | | |
| | TEST 2 | LAA 17.02.98 | | | | | | | | | | |
| | | | | | | | | | | | | |
| | | | | | | | | | | | | |
| WING TIP DEFLECTION | | | | | | | | | | | | |
| | | | | | | | | | | | | |
| | HAA | HAA | HAA | HAA | HAA | HAA | LAA | LAA | LAA | LAA | LAA | LAA |
| | STBD TIP | PORT TIP | STBD TIP | PORT TIP | STBD TIP | PORT TIP | STBD TIP | PORT TIP | STBD TIP | PORT TIP | STBD TIP | PORT TIP |
| | LE | LE | LE | LE | LE | LE | LE | LE | LE | LE | LE | LE |
| | MEASURED | MEASURED | TOTAL | TOTAL | DEFLECT | DEFLECT | MEASURED | MEASURED | TOTAL | TOTAL | DEFLECT | DEFLECT |
| g | DEFLECT | DEFLECT | DEFLECT | DEFLECT | PER g | PER g | DEFLECT | DEFLECT | DEFLECT | DEFLECT | PER g | PER g |
| LOAD | (mm) | (mm) | (mm) | (mm) | (mm) | (mm) | (mm) | (mm) | (mm) | (mm) | (mm) | (mm) |
| UNLOADED | 1407.00 | 1454.00 | - | - | - | - | 1400.00 | 1464.00 | - | - | - | - |
| 1 | - | - | - | - | - | - | - | - | - | - | - | - |
| 2 | - | - | - | - | - | - | - | - | - | - | - | - |
| 3 | 1149.00 | 1224.00 | 258.00 | 230.00 | 86.00 | 76.67 | 1138.00 | 1210.00 | 262.00 | 254.00 | 87.33 | 84.67 |
| 3.8 | 1084.00 | 1150.00 | 323.00 | 304.00 | 85.00 | 80.00 | 1069.00 | 1146.00 | 331.00 | 318.00 | 87.11 | 83.68 |
| 5 | 989.00 | 1046.00 | 418.00 | 408.00 | 83.60 | 81.60 | 968.00 | 1061.00 | 432.00 | 403.00 | 86.40 | 80.60 |
| 5.7 | 939.00 | 989.00 | 468.00 | 465.00 | 82.11 | 81.58 | 912.00 | 1002.00 | 488.00 | 462.00 | 85.61 | 81.05 |
| 7 | 840.00 | 865.00 | 567.00 | 589.00 | 81.00 | 84.14 | - | - | - | - | - | - |
| 8.13 | - | - | - | - | - | - | - | - | - | - | - | - |
| 8.55 | - | - | - | - | - | - | - | - | - | - | - | - |
| REST | 1390.00 | 1432.00 | | | | | 1380.00 | 1438.00 | | | | |
| PERM SET | 17.00 | 22.00 | | | | | 20.00 | 26.00 | | | | |
| | | | | | | | | | | | | |
| AVERAGE | HAA | HAA | LAA | LAA | | | | | | | | |
| DEFLECT | STBD TIP | PORT TIP | STBD TIP | PORT TIP | | | | | | | | |
| PER g | LE | LE | LE | LE | | | | | | | | |
| | | | | | | | | | | | | |
| (mm) | 84.18 | 79.96 | 86.61 | 82.50 | | | | | | | | |
| (in) | 3.31 | 3.15 | 3.41 | 3.25 | | | | | | | | |

| XS WING | TEST 1 | HAA 16.02.98 | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | TEST 2 | LAA 17.02.98 | | | | | | | | |
| | | | | | | | | | | |
| | | | | | | | | | | |
| STRAIN MEASUREMENTS | | | | | | | | | | |
| | | | | | | | | | | |
| | | | | | | | | | | |
| | | | | | | | | | | |
| | HAA | HAA | HAA | HAA | HAA | LAA | LAA | LAA | LAA | LAA |
| | GAUGE | GAUGE | GAUGE | GAUGE | GAUGE | GAUGE | GAUGE | GAUGE | GAUGE | GAUGE |
| g | 3 | 4 | 8 | 9 | 10 | 3 | 4 | 8 | 9 | 10 |
| LOAD | (in/in) | (in/in) | (in/in) | (in/in) | (in/in) | (in/in) | (in/in) | (in/in) | (in/in) | (in/in) |
| UNLOADED | - | - | - | - | - | - | - | - | - | - |
| 1 | - | - | - | - | - | - | - | - | - | - |
| 2 | - | - | - | - | - | - | - | - | - | - |
| 3 | 885.00 | -962.00 | 2774.00 | -2425.00 | -2331.00 | 963.00 | -870.00 | 2920.00 | -2420.00 | -2372.00 |
| 3.8 | 990.00 | -1144.00 | 3550.00 | -3088.00 | -2918.00 | 1093.00 | -935.00 | 3736.00 | -3085.00 | -2973.00 |
| 5 | 1022.00 | -1360.00 | 4675.00 | -4030.00 | -3713.00 | 1260.00 | -1073.00 | 4906.00 | -4026.00 | -3792.00 |
| 5.7 | 1065.00 | -1465.00 | 5272.00 | -4570.00 | -4125.00 | 1355.00 | -1120.00 | 5522.00 | - | -4199.00 |
| 7 | - | - | - | -5648.00 | -4760.00 | - | - | - | - | -4980.00 |
| 8.13 | - | - | - | - | - | - | - | - | - | -5618.00 |
| 8.55 | - | - | - | - | - | - | - | - | - | - |
| | | | | | | | | | | |
| STRAIN PER g | | | | | | | | | | |
| | | | | | | | | | | |
| g | HAA | HAA | HAA | HAA | HAA | LAA | LAA | LAA | LAA | LAA |
| LOAD | GAUGE | GAUGE | GAUGE | GAUGE | GAUGE | GAUGE | GAUGE | GAUGE | GAUGE | GAUGE |
| | 3 | 4 | 8 | 9 | 10 | 3 | 4 | 8 | 9 | 10 |
| 1 | - | - | - | - | - | - | - | - | - | - |
| 2 | - | - | - | - | - | - | - | - | - | - |
| 3 | 295.00 | -320.67 | 924.67 | -808.33 | -777.00 | 321.00 | -290.00 | 973.33 | -806.67 | -790.67 |
| 3.8 | 260.53 | -301.05 | 934.21 | -812.63 | -767.89 | 287.63 | -246.05 | 983.16 | -811.84 | -782.37 |
| 5 | 204.40 | -272.00 | 935.00 | -806.00 | -742.60 | 252.00 | -214.60 | 981.20 | -805.20 | -758.40 |
| 5.7 | 186.84 | -257.02 | 924.91 | -801.75 | -723.68 | 237.72 | -196.49 | 968.77 | - | -736.67 |
| 7 | - | - | - | -806.86 | -680.00 | - | - | - | - | -711.43 |
| 8.13 | - | - | - | - | - | - | - | - | - | - |
| 8.55 | - | - | - | - | - | - | - | - | - | - |
| | | | | | | | | | | |
| | | | | | | | | | | |
| BETWEEN | HAA | HAA | HAA | HAA | HAA | LAA | LAA | LAA | LAA | LAA |
| 3 & 5.0g | GAUGE | GAUGE | GAUGE | GAUGE | GAUGE | GAUGE | GAUGE | GAUGE | GAUGE | GAUGE |
| AVERAGE | 3 | 4 | 8 | 9 | 10 | 3 | 4 | 8 | 9 | 10 |
| STRAIN PER g | 253.31 | -297.91 | 931.29 | -808.99 | -762.50 | 286.88 | -250.22 | 979.23 | -807.90 | -777.15 |

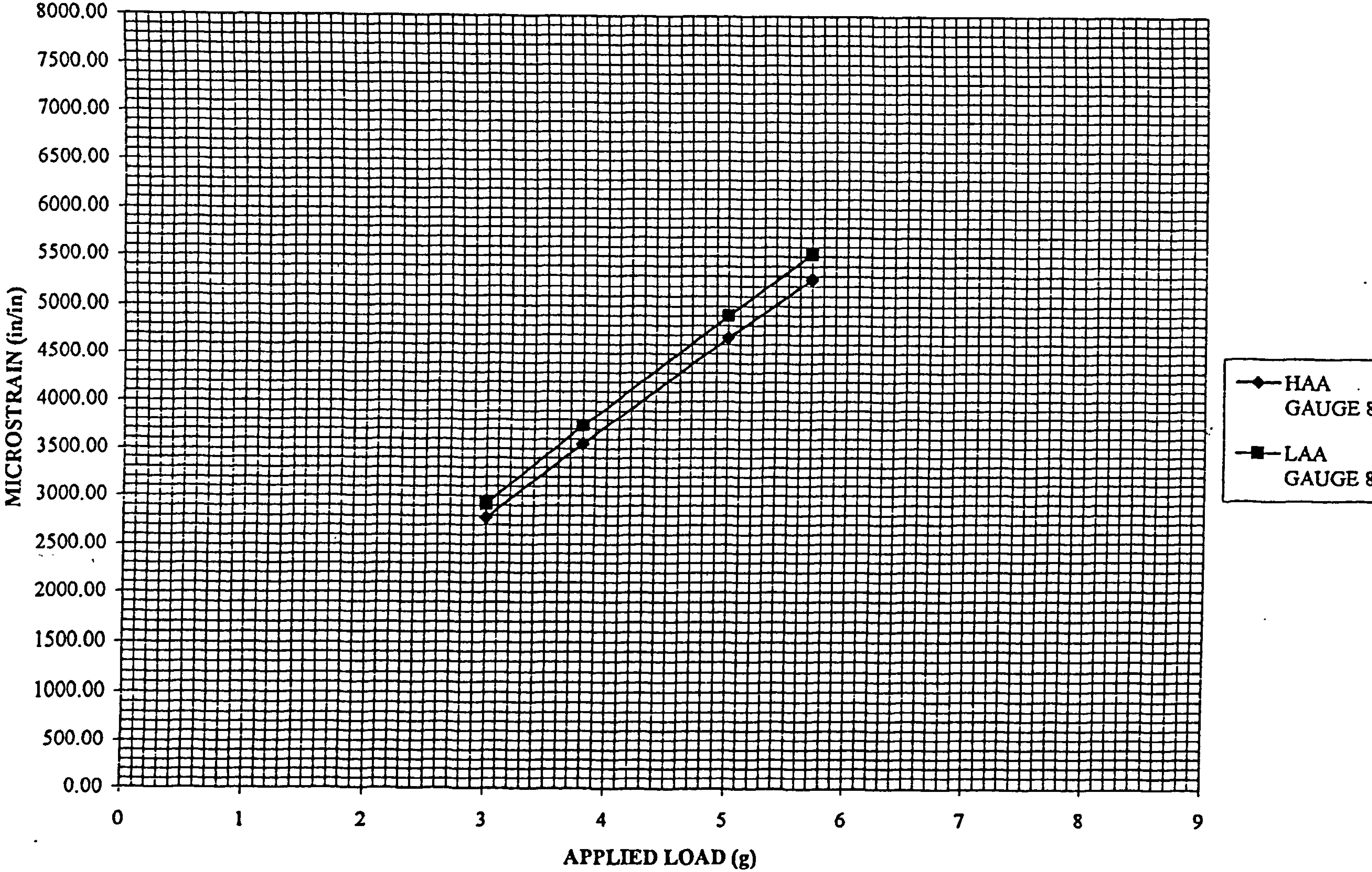
APPENDIX C

**XS WING ULTIMATE LOAD TEST**
**ROOT RIB FLANGE STRAIN**

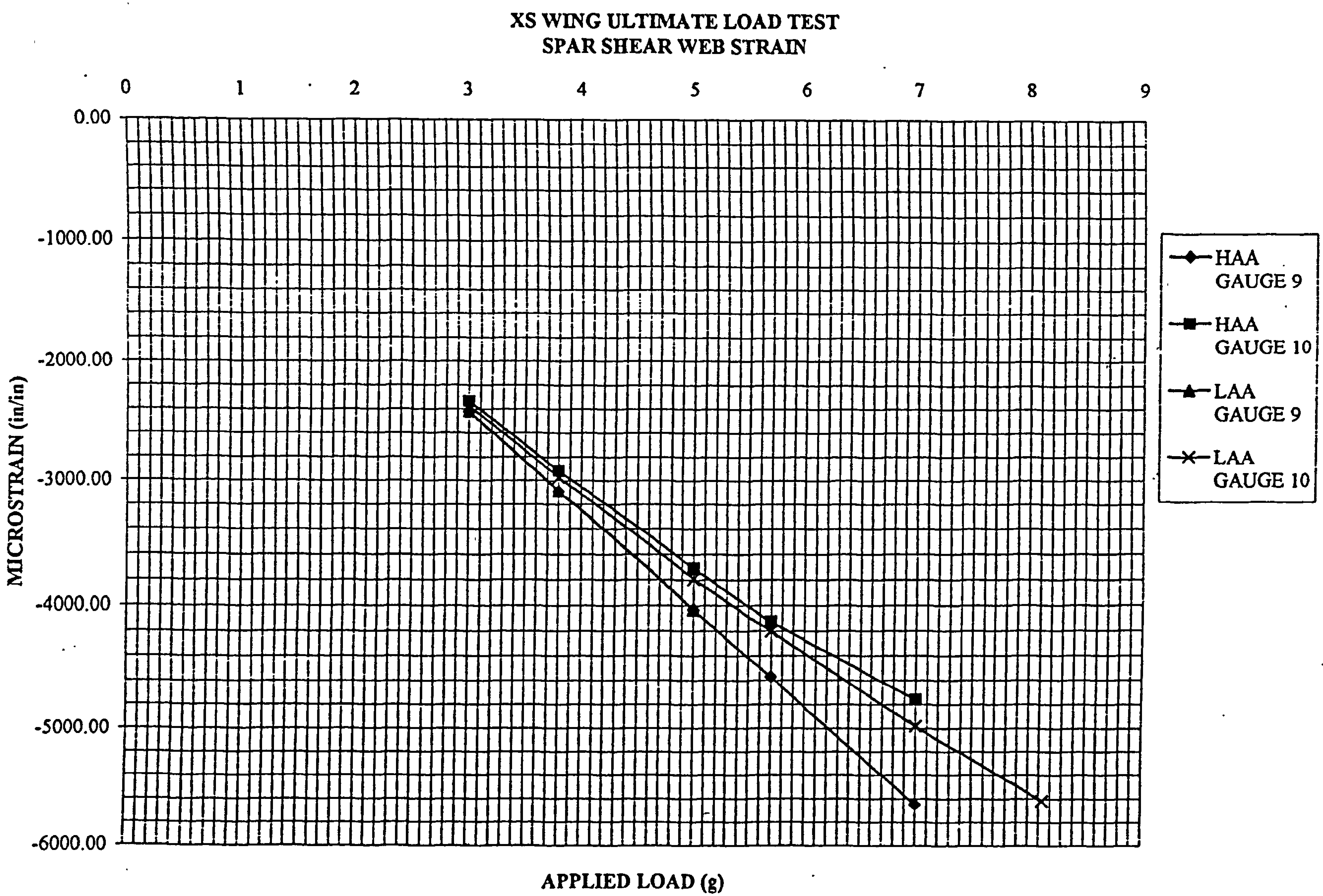


APPENDIX C

XS WING ULTIMATE LOAD TEST
SPAR BOOM OUTER FIBRE STRAIN



APPENDIX C



XS WING ULTIMATE LOAD TEST
SPAR SHEAR WEB STRAIN
0
1
2
3
4
5
6
7
8
9
0.00
-1000.00
-2000.00
-3000.00
-4000.00
-5000.00
-6000.00
MICROSTRAIN (in/in)
APPLIED LOAD (g)
HAA GAUGE 9
HAA GAUGE 10
LAA GAUGE 9
LAA GAUGE 10

| Title | Made by | Checked by | Date | Rev |
|---|---|---|---|---|
| APPENDIX D | JASON RUSSELL | | | 0 |

| Project | Ref |
|---|---|
| EUROPA XS. | |

| Subject | Page of |
|---|---|
| PHOTOGRAPHIC RECORDS OF HAA & LAA TESTS | |

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Europa Aviation Ltd

Calculation Sheet

| Title | Made by | Checked by | Date | Rev |
|---|---|---|---|---|
| APPENDIX D | | | | 0 |

| Project | Ref |
|---|---|
| EUROPA XS | |

| Subject | Page of |
|---|---|
| LAA TEST. DIGITAL PHOTOGRAPHS | |

(HAA TEST & LAA TEST COVERED IN MORE DETAIL BY VIDEO FOOTAGE)

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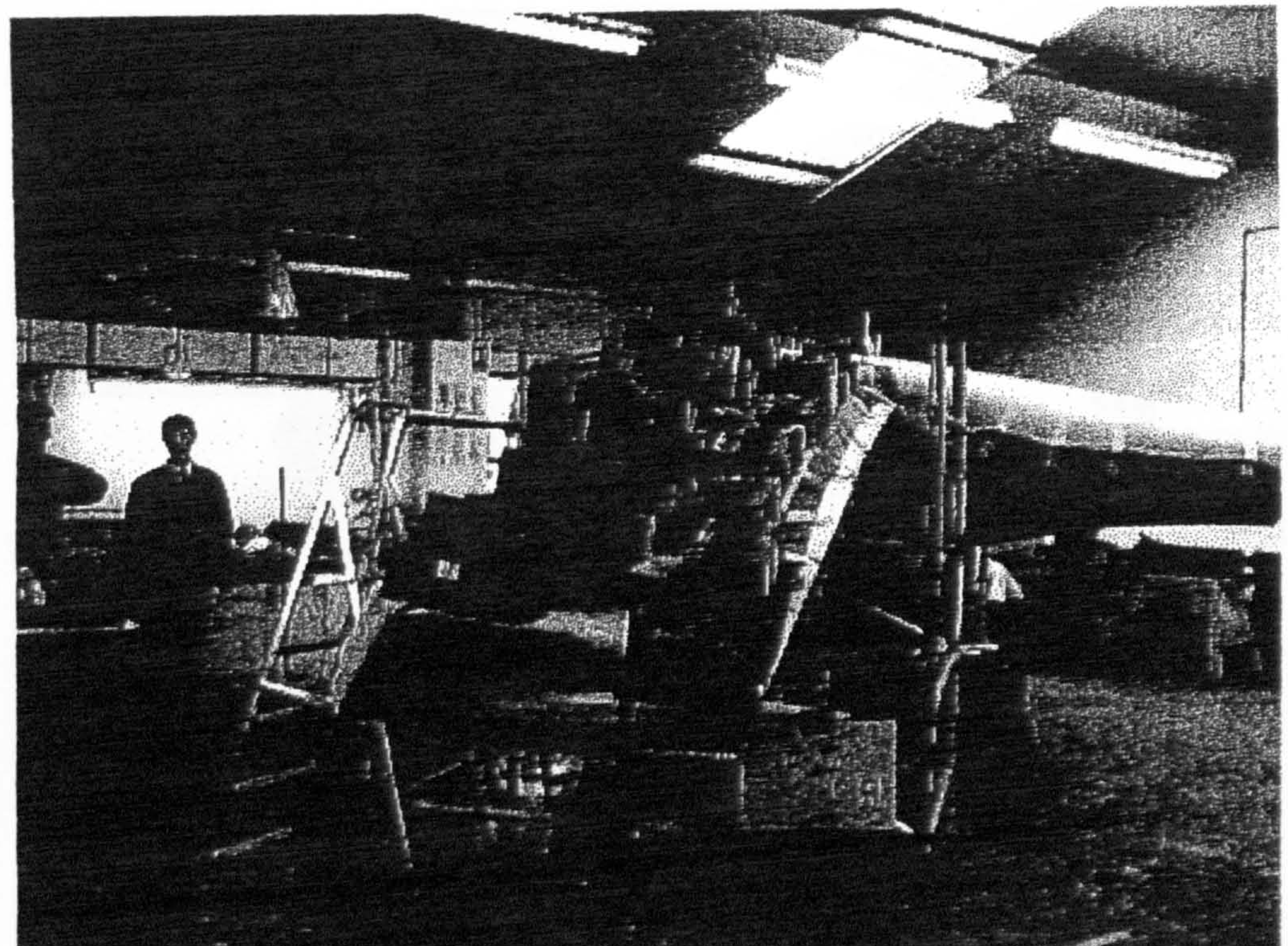
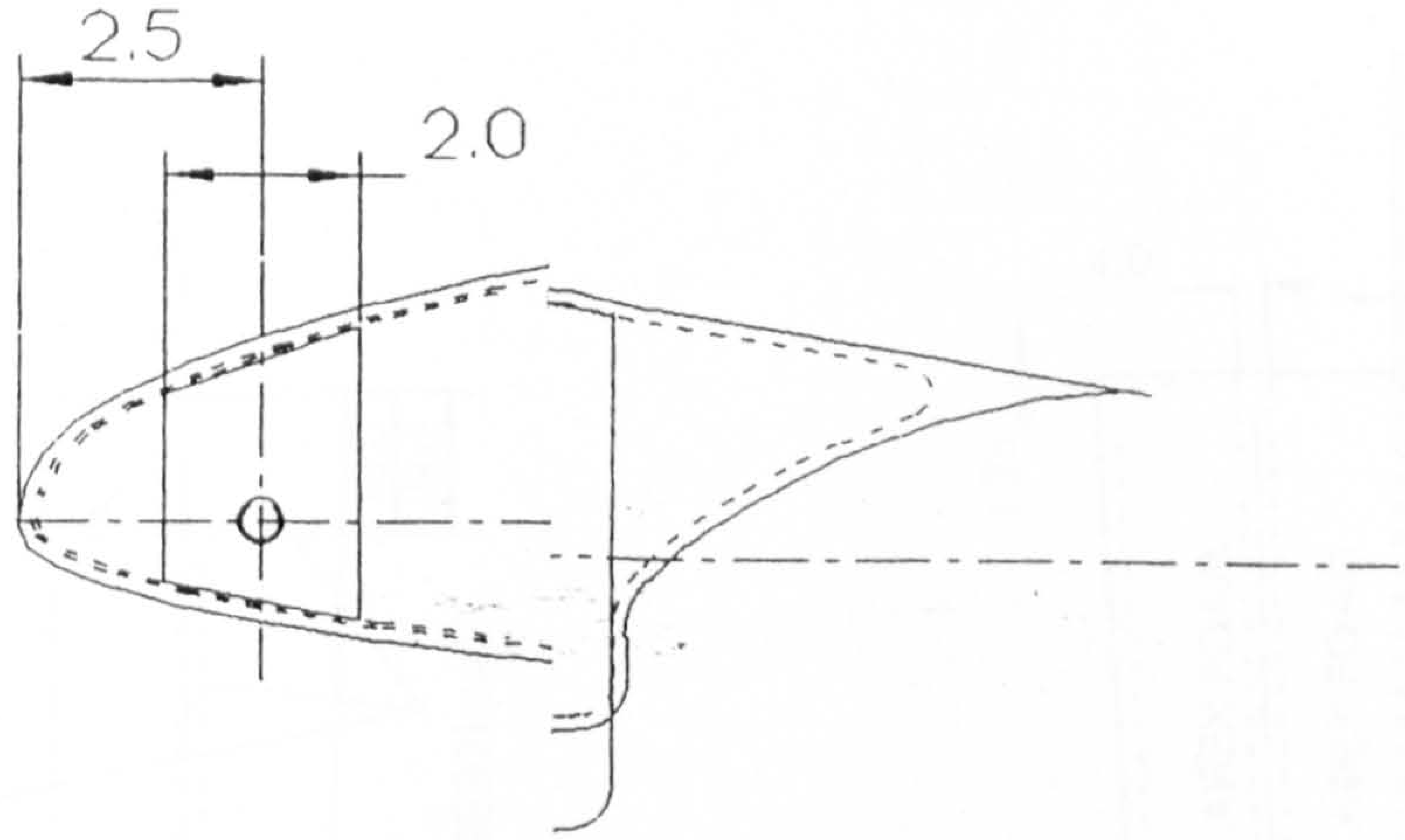
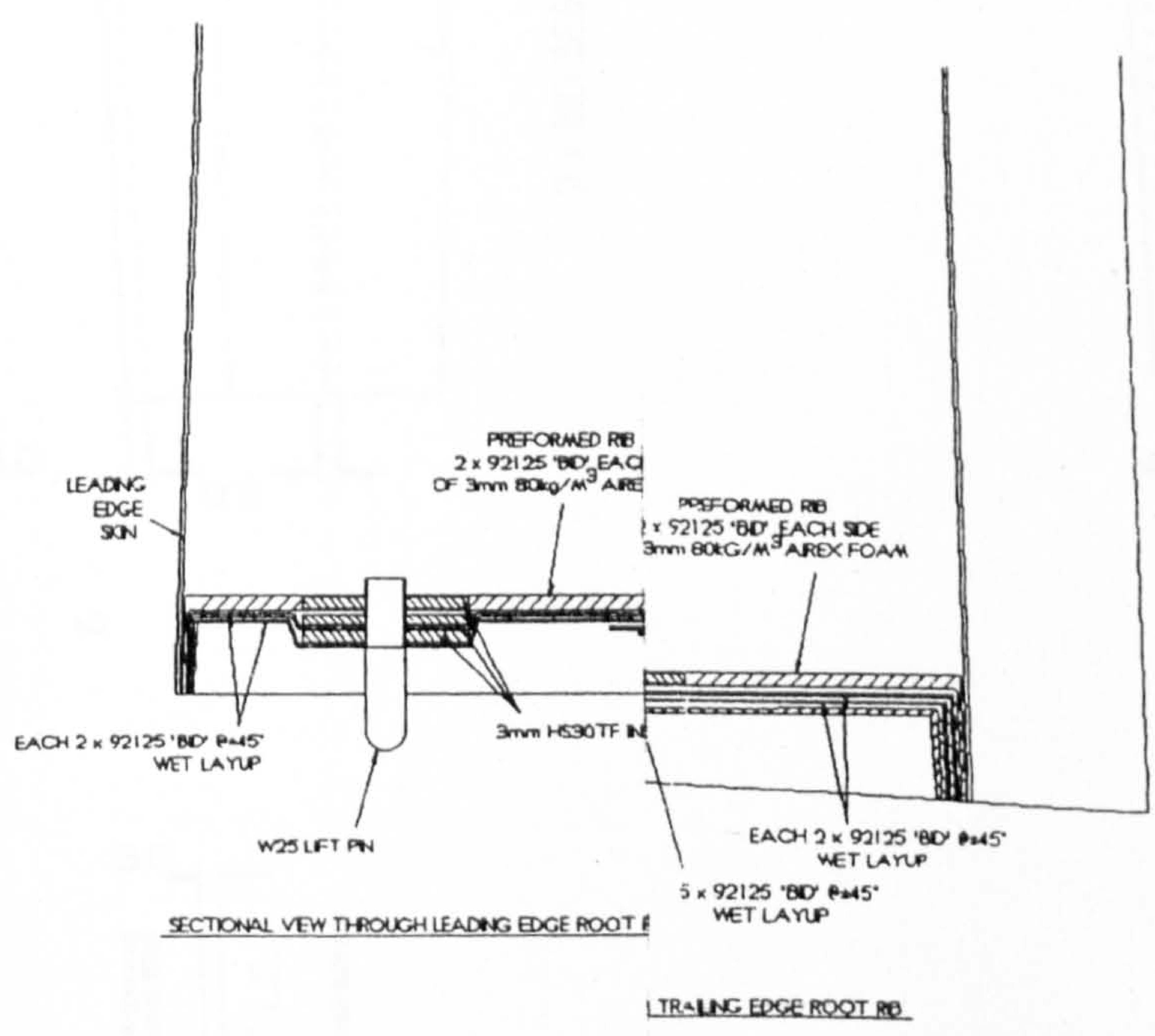
TIE BAR ARRANGEMENT



LAA TEST. APPLIED LOAD OF 5.7g

LAA TEST. APPLIED LOAD OF 855g

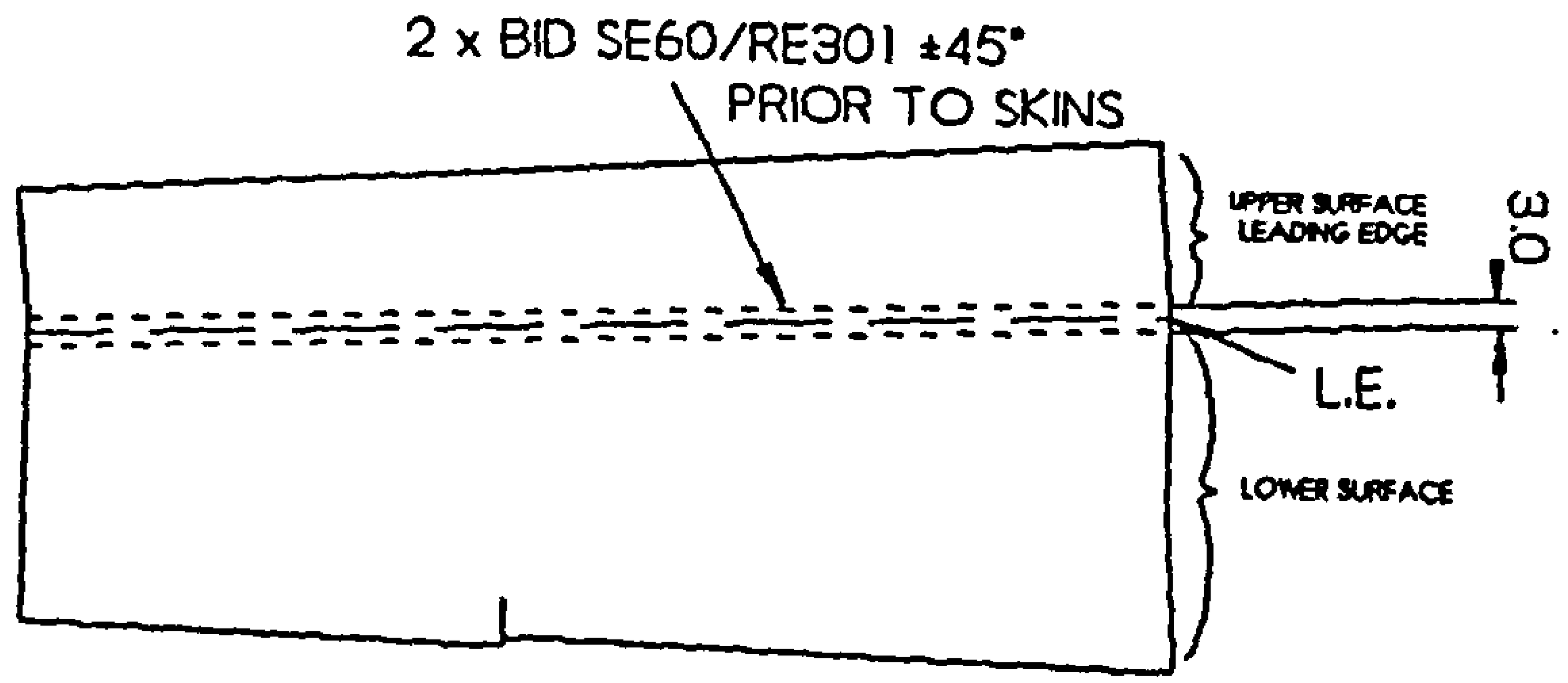


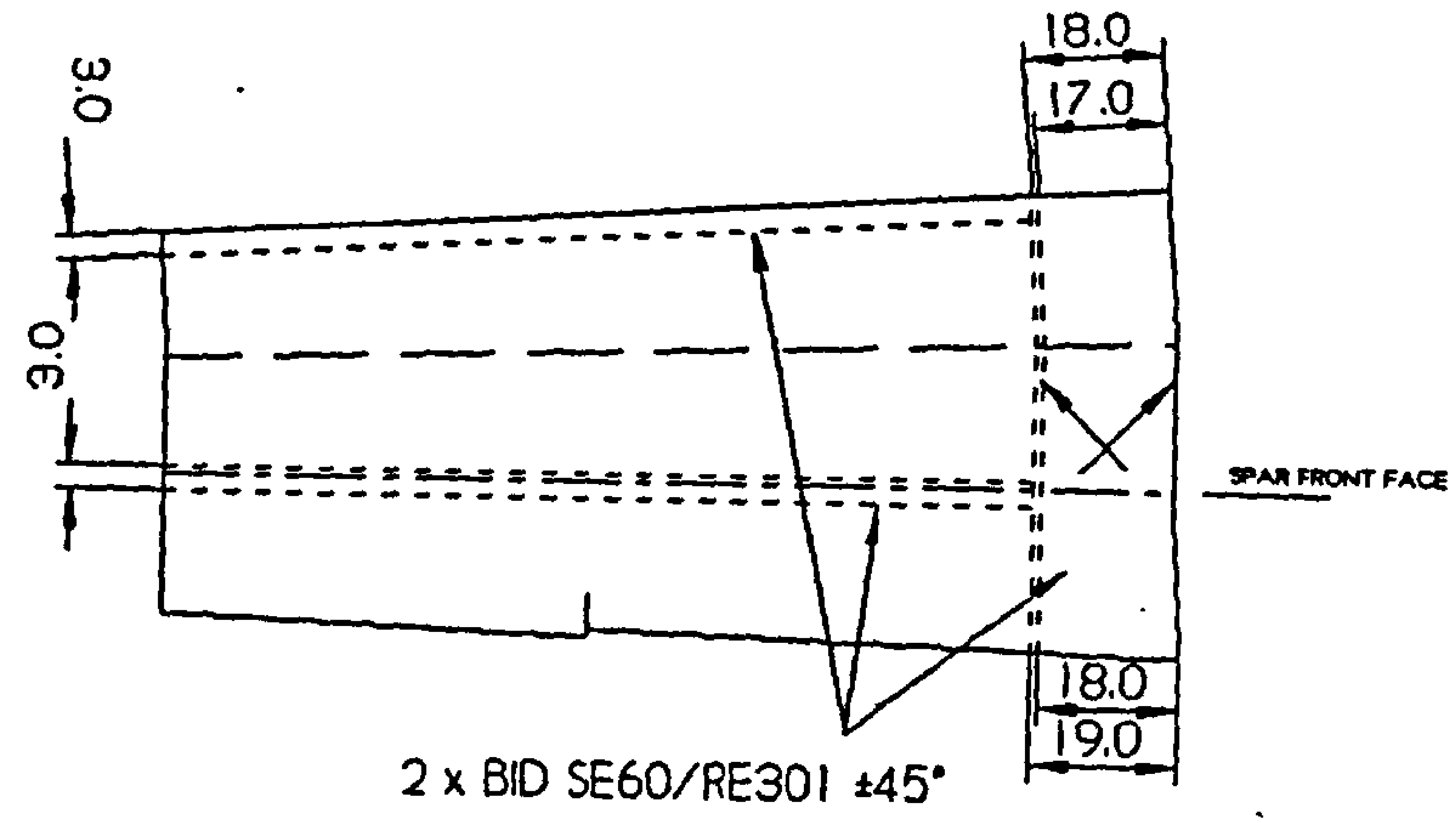

EUROPA XS WING. E

SEE ENLARGED DE

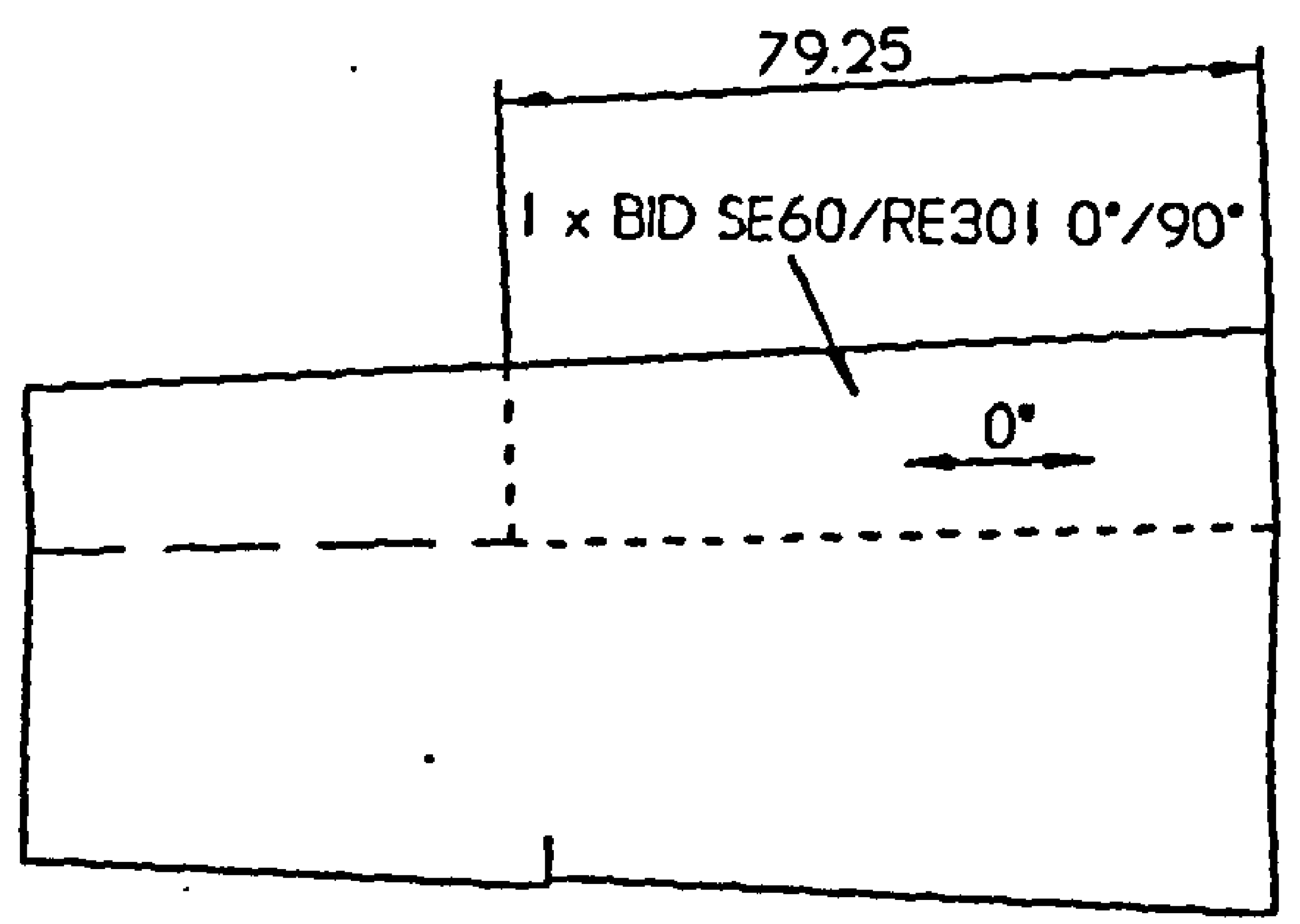
1



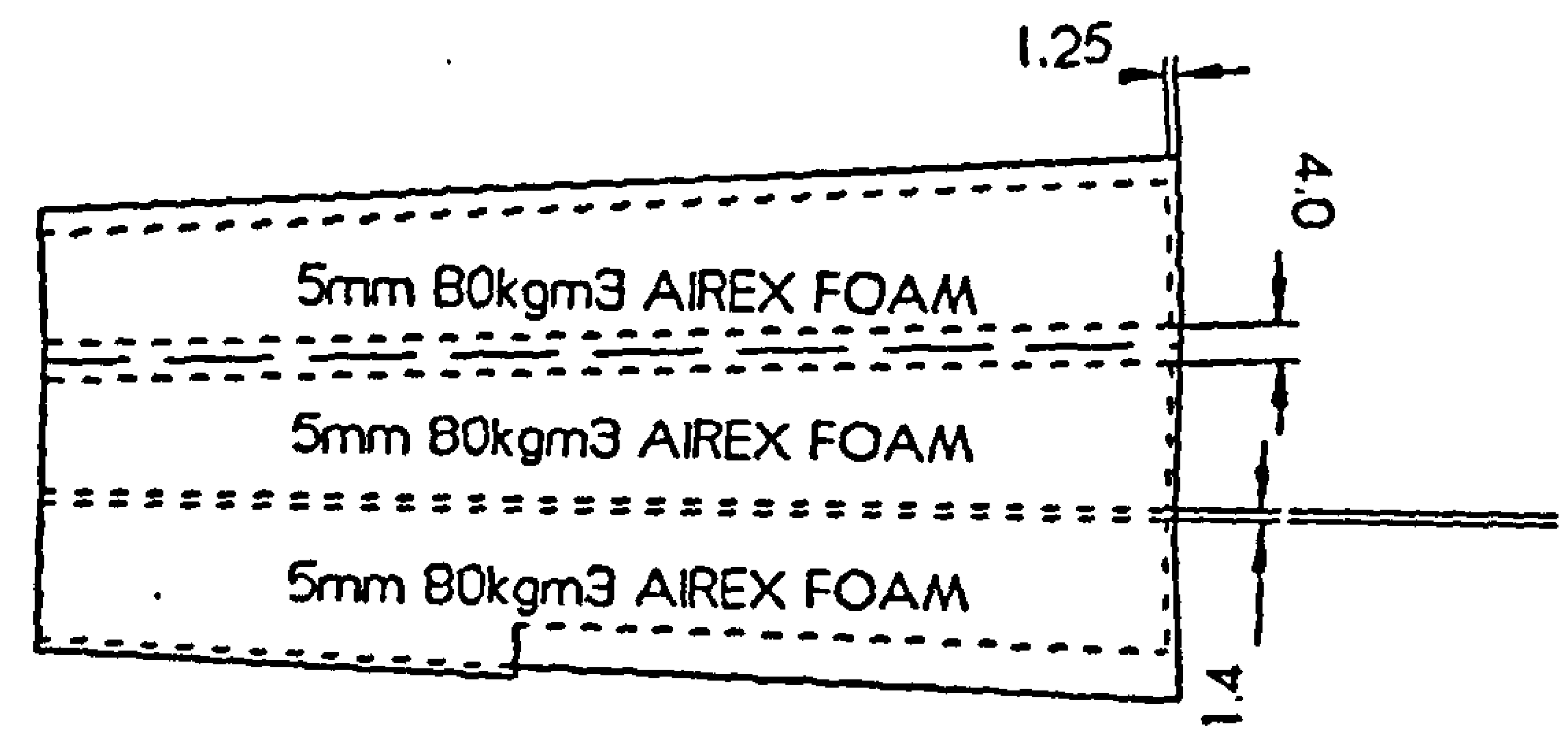

5




2

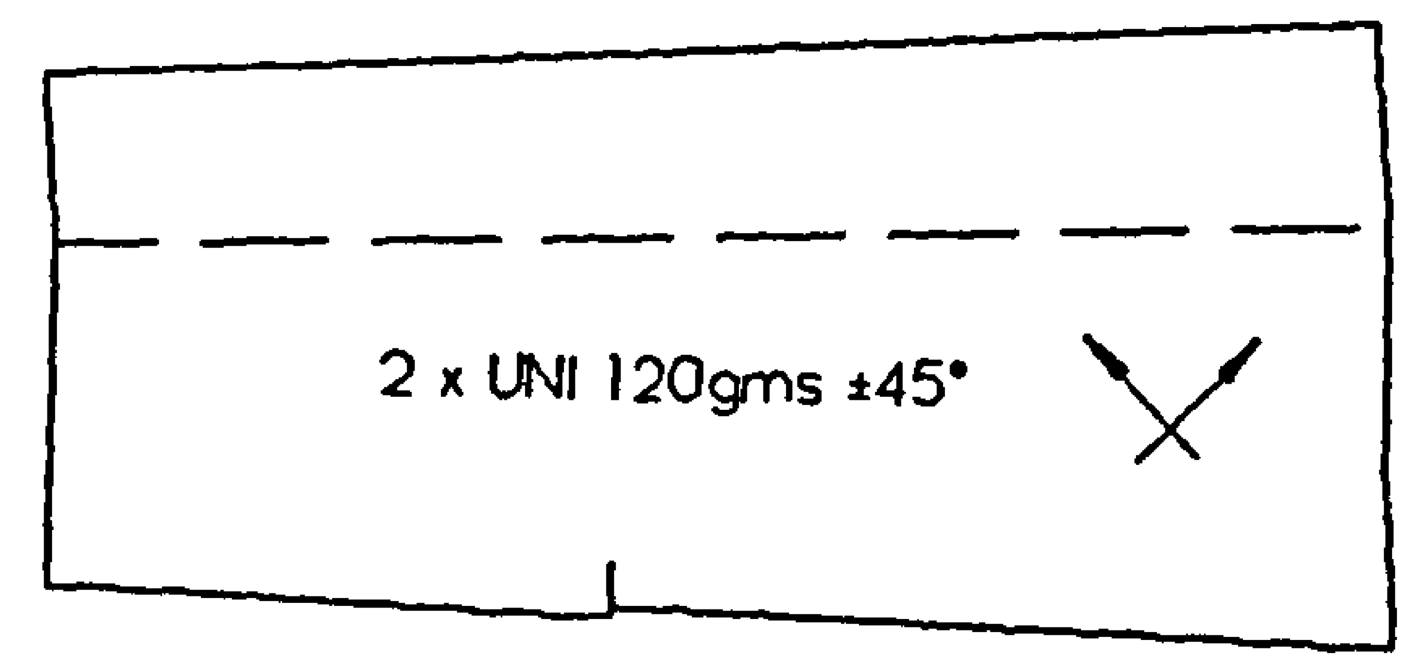



6

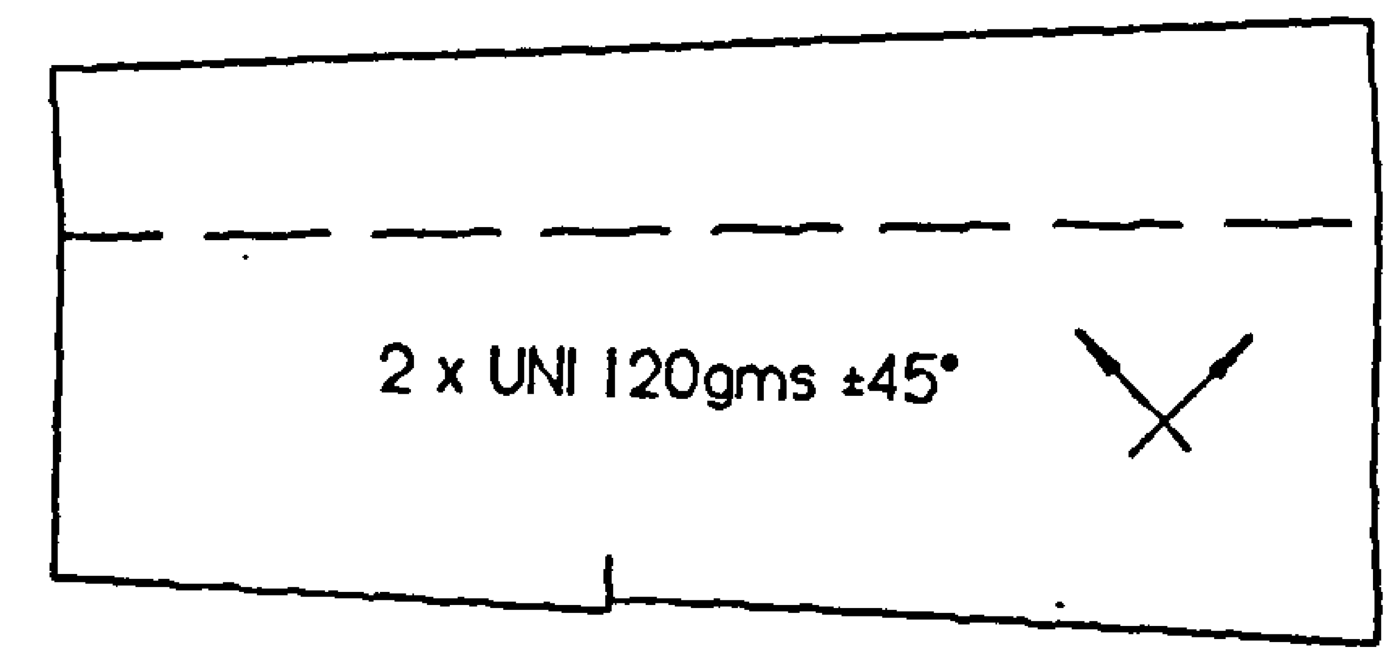



EUROPA XS WING LAYUP SEQUENCE

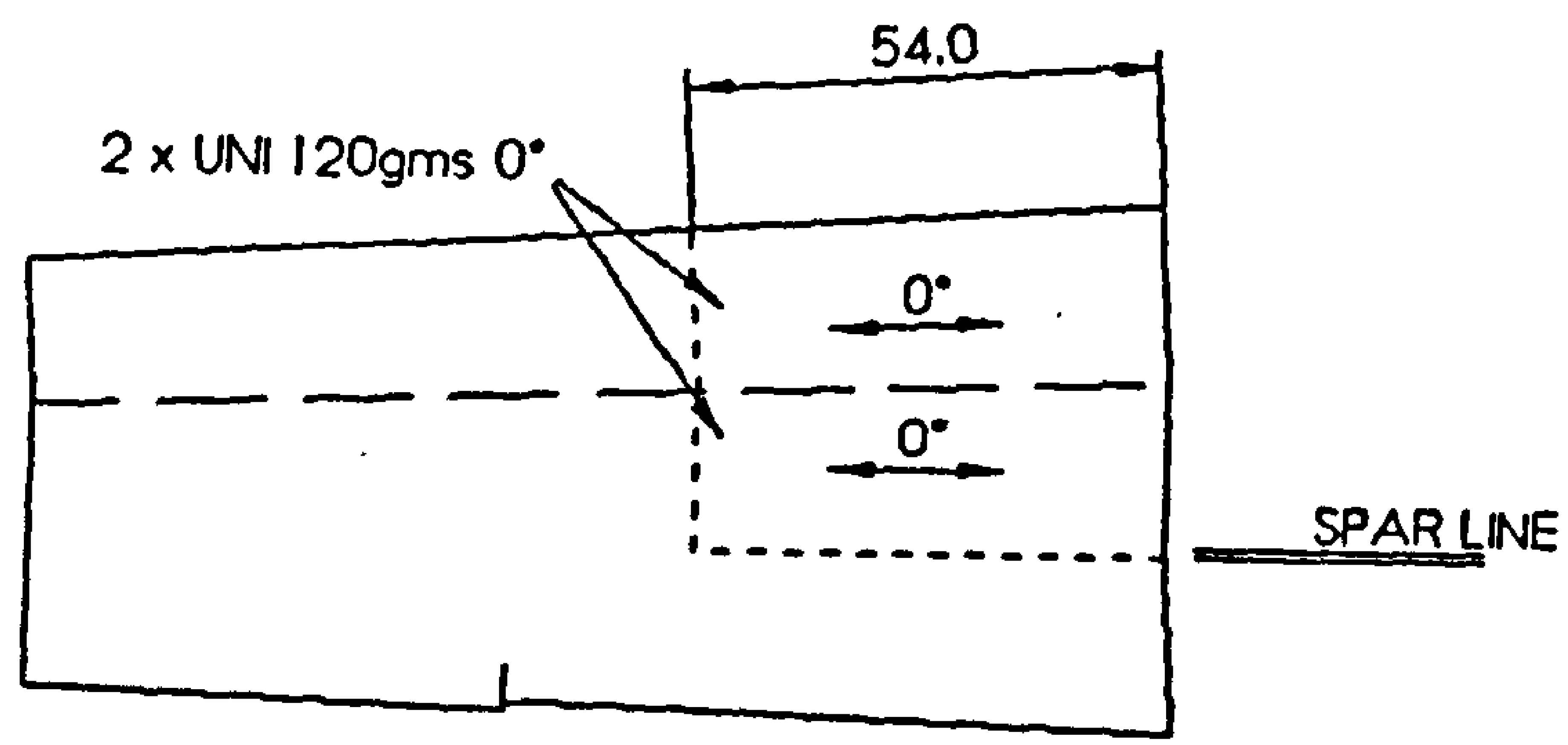
3



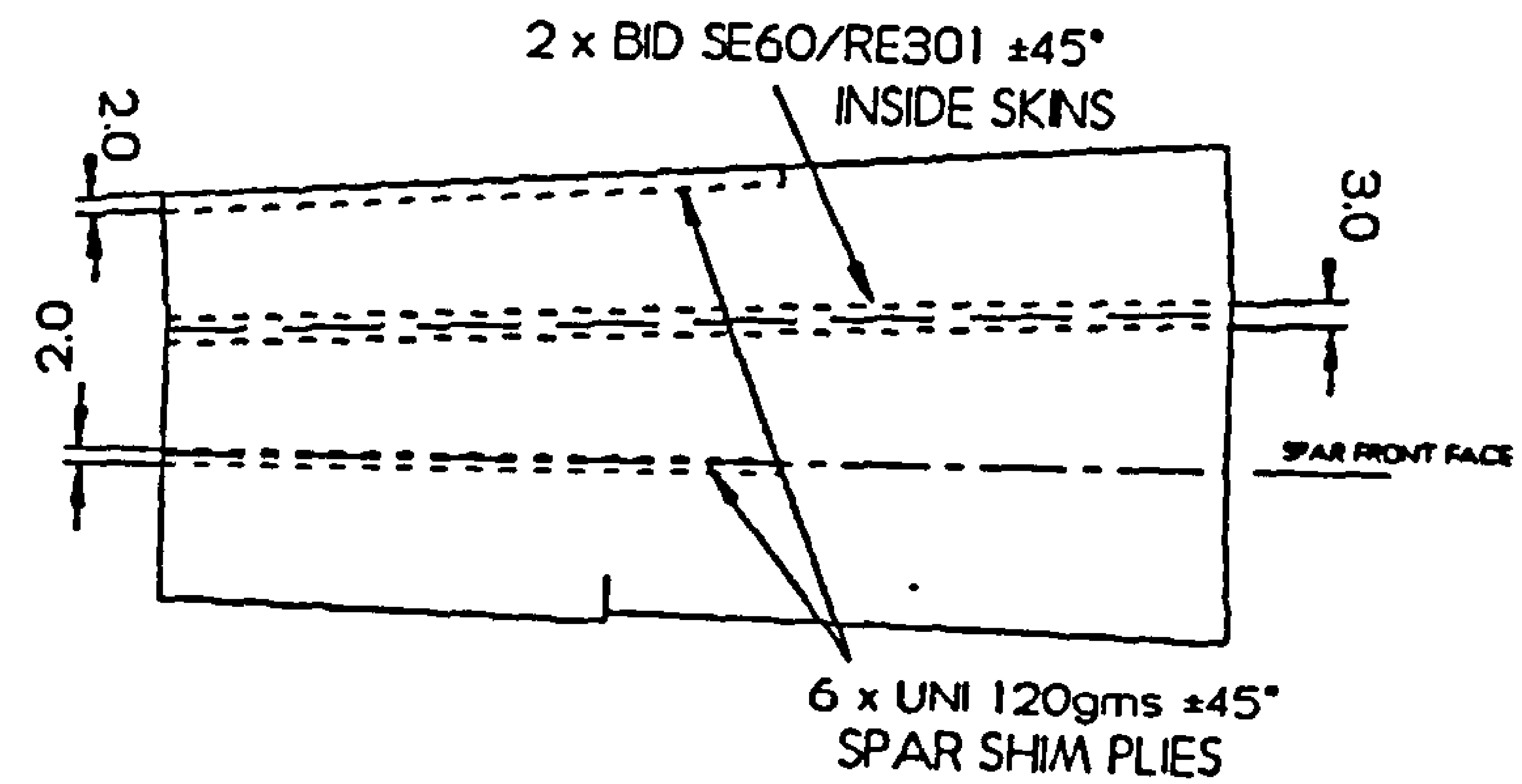

7



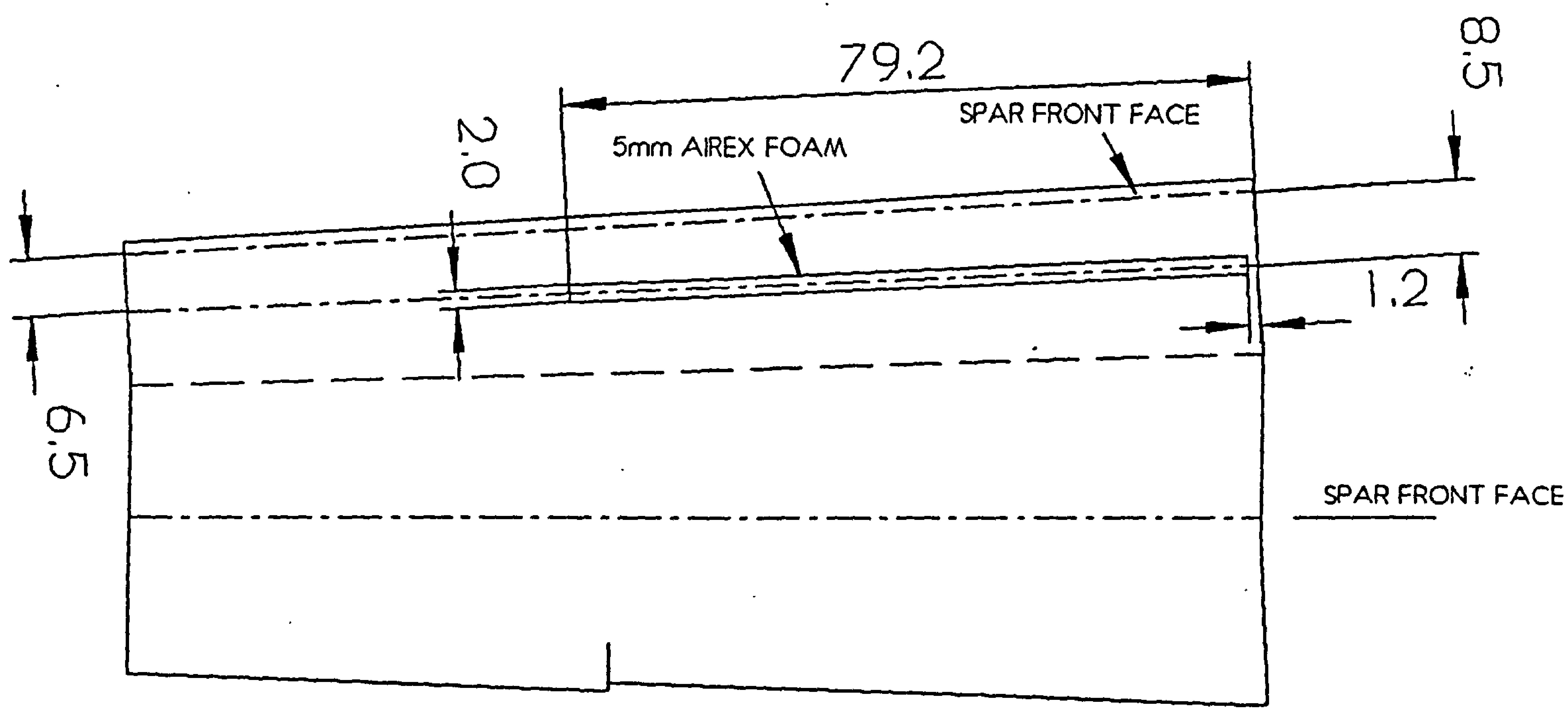

4




8

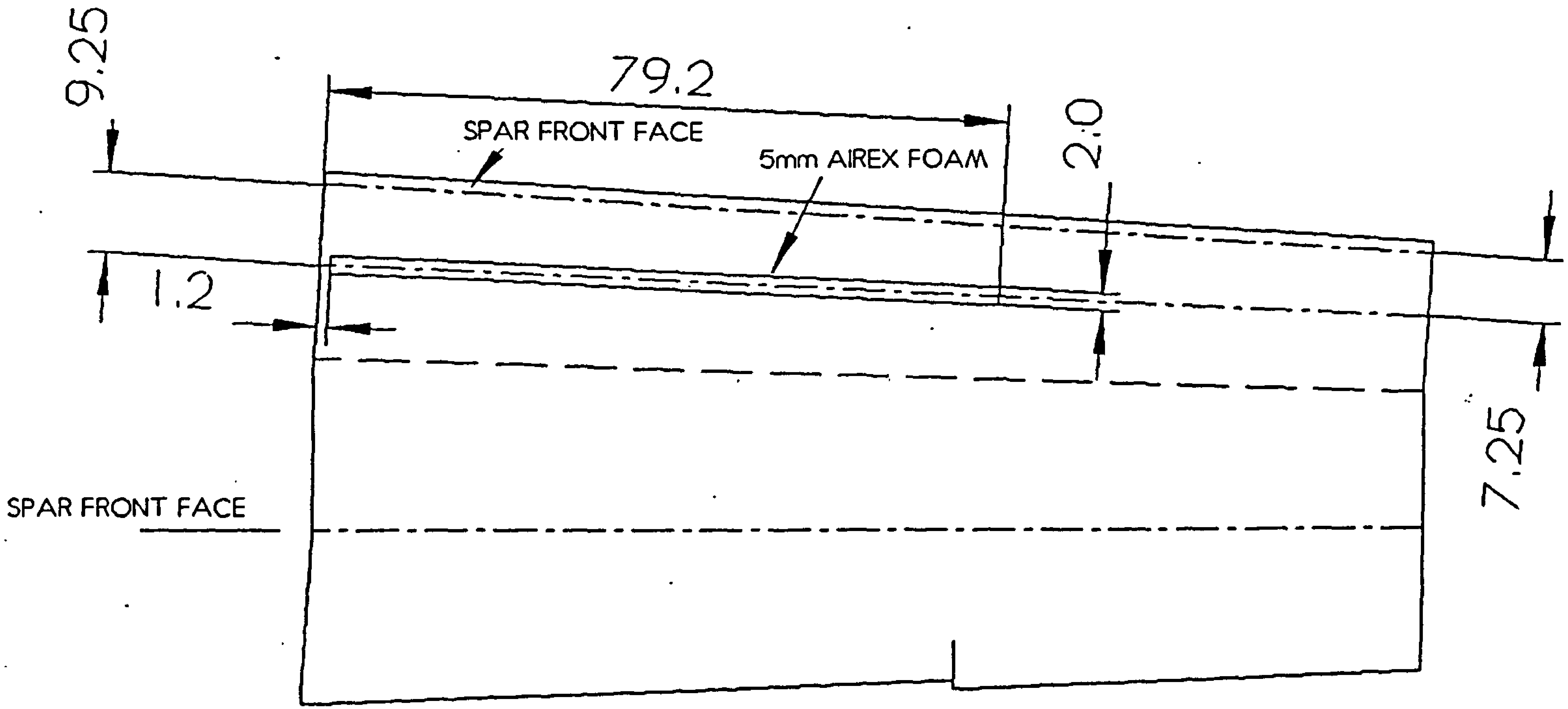



[illegible] WING LAYUP SEQUENCE



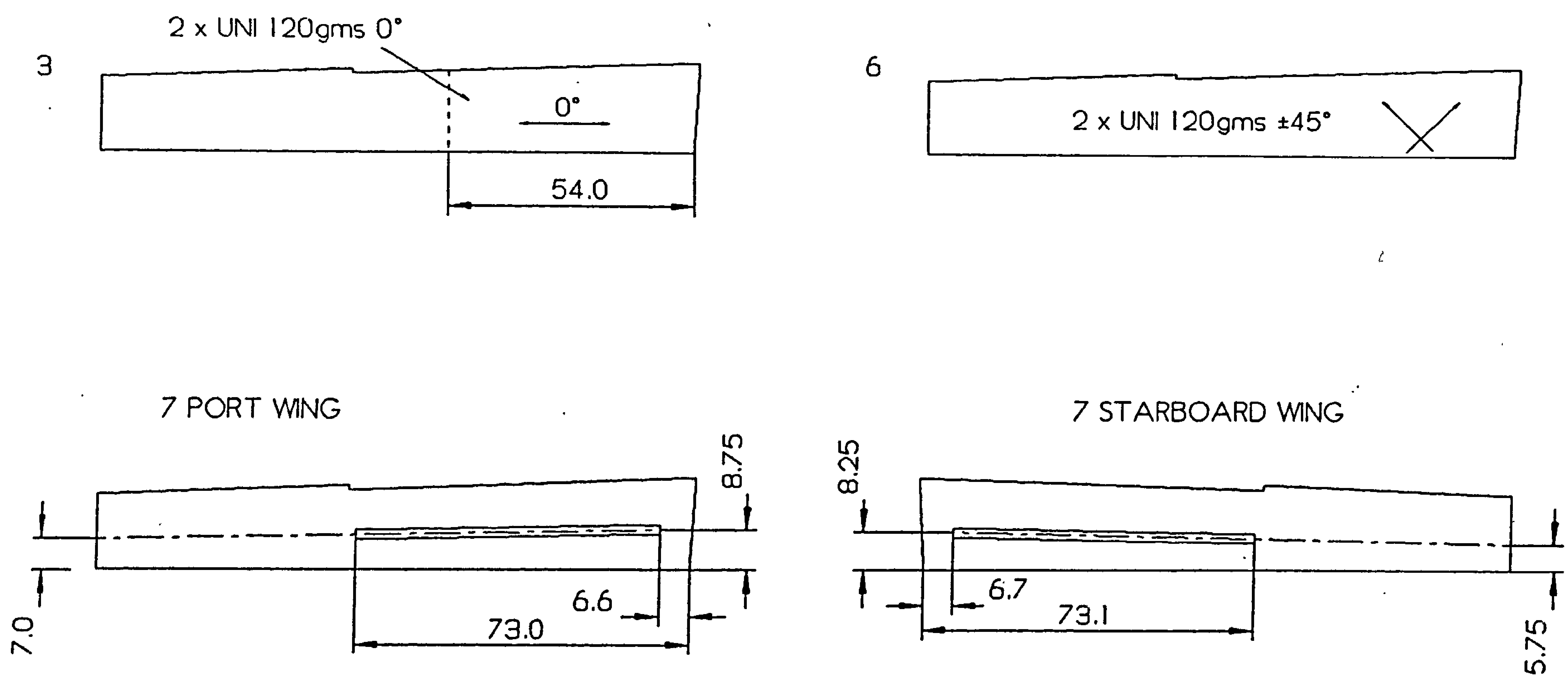

9 PORT WING

EUROPA XS WING STIFFENER LOCATION



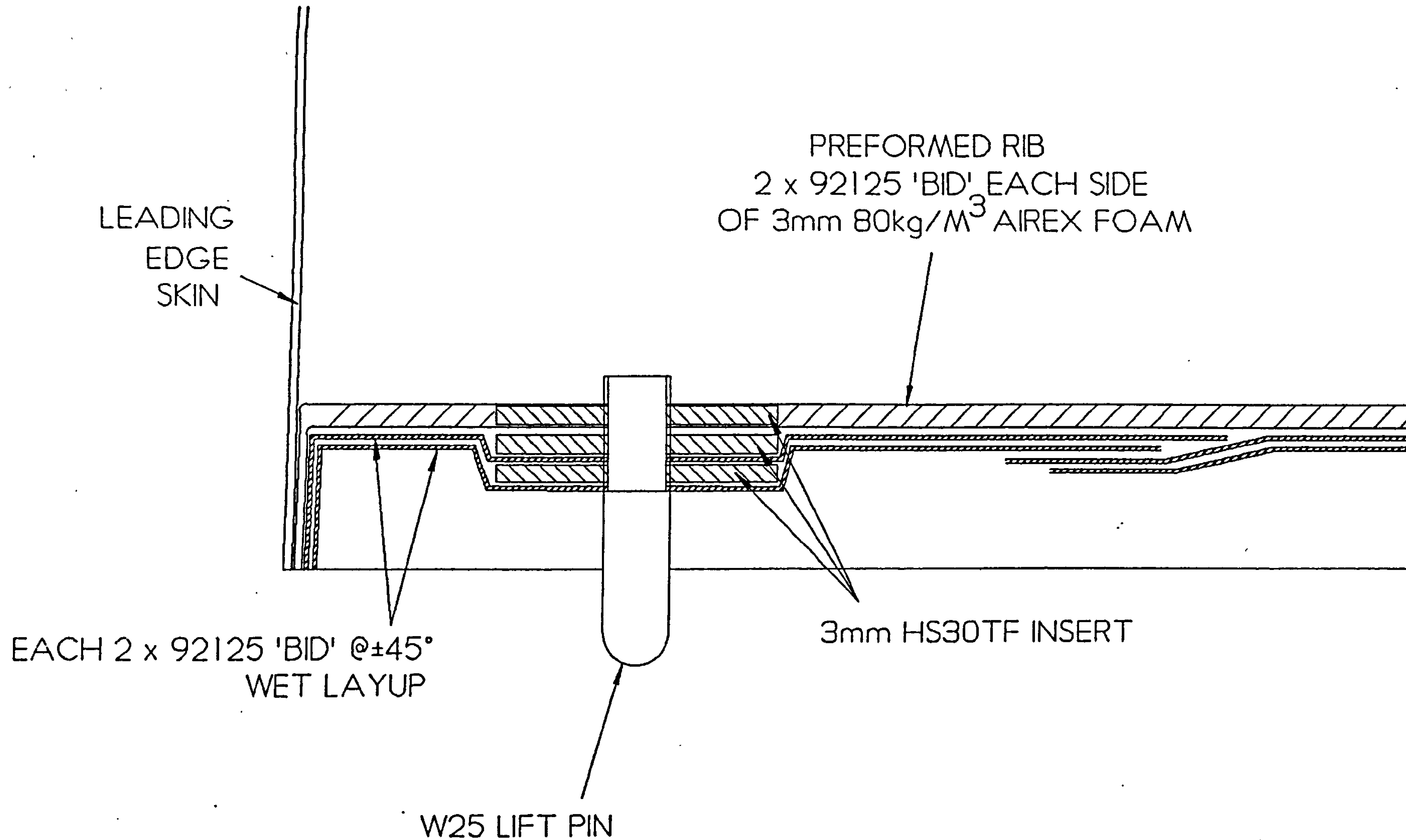

9 STARBOARD WING

EUROPA XS WING STIFFENER LOCATION

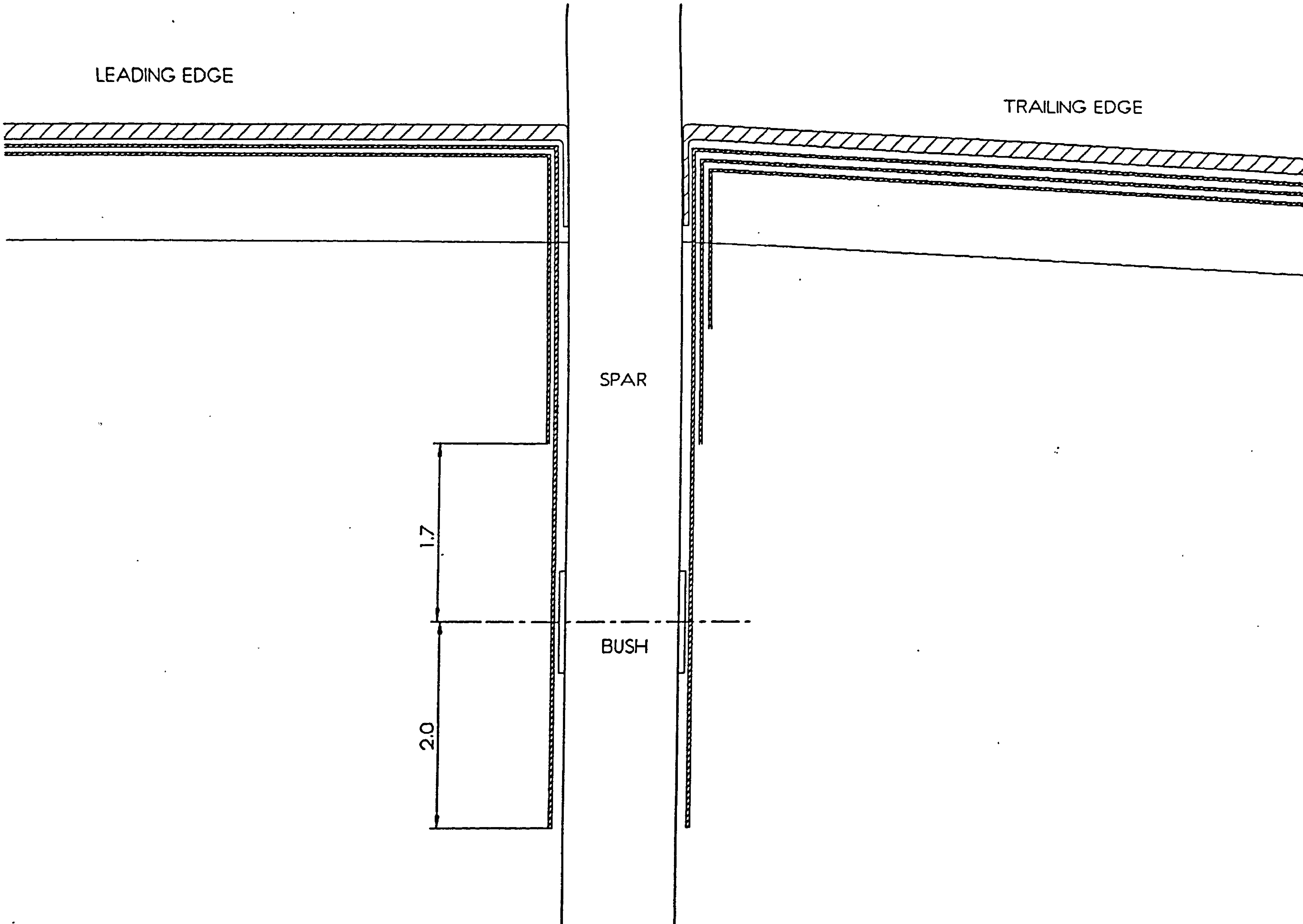



EUROPA XS WING UPPER TRAILING EDGE SKIN LAYUP SCHEDULE.

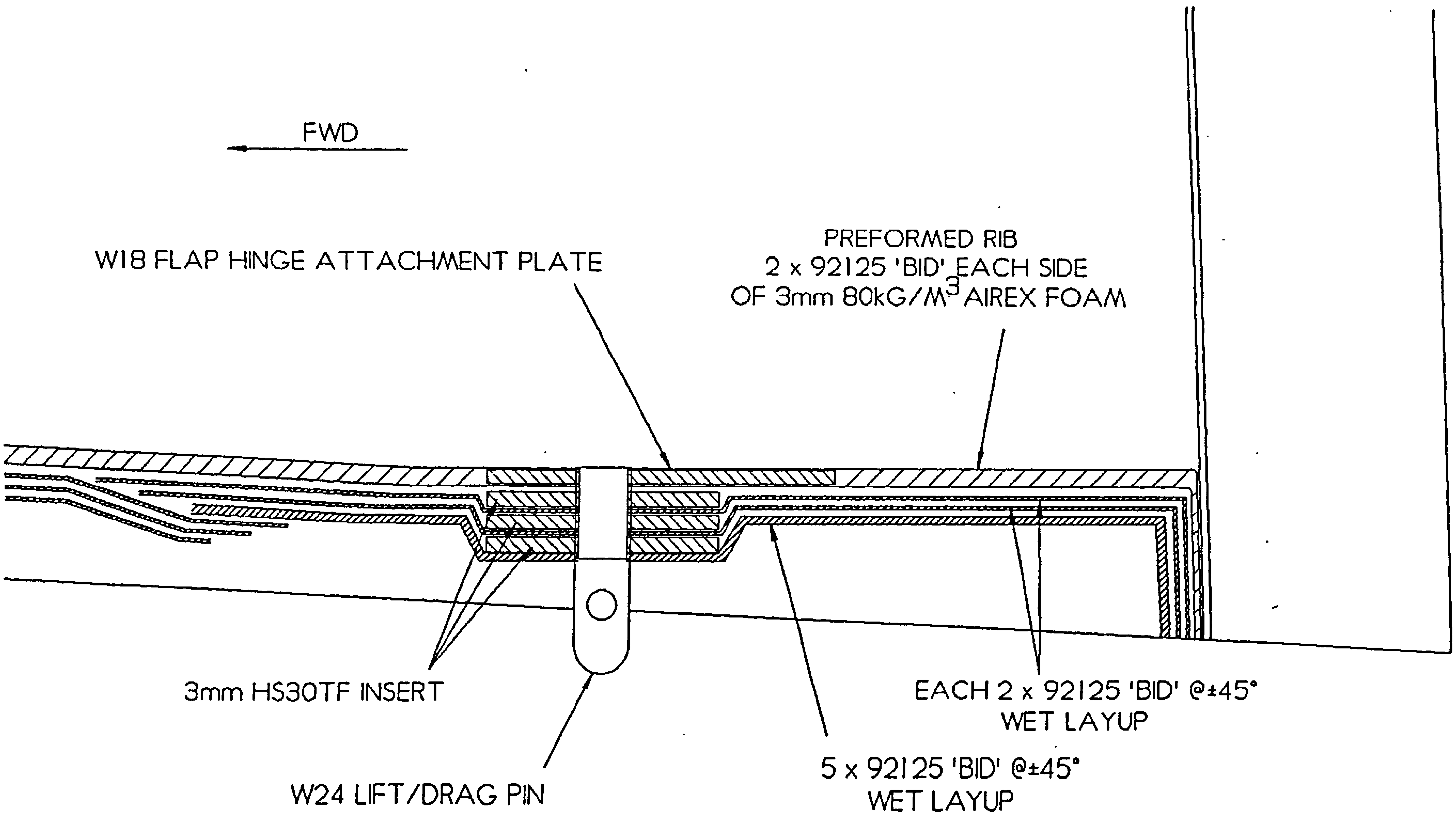
28/01/98



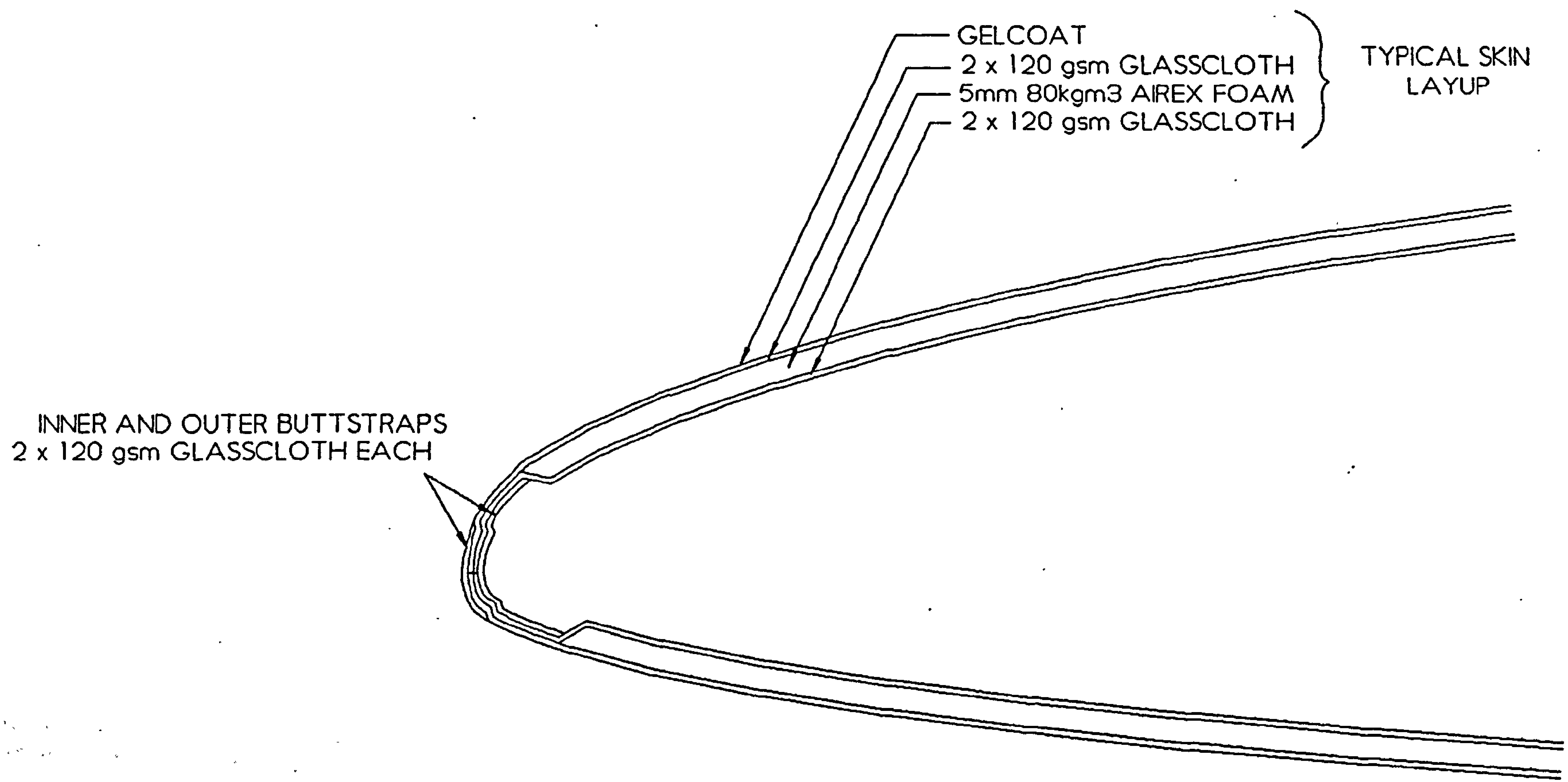

SECTIONAL VIEW THROUGH LEADING EDGE ROOT RIB



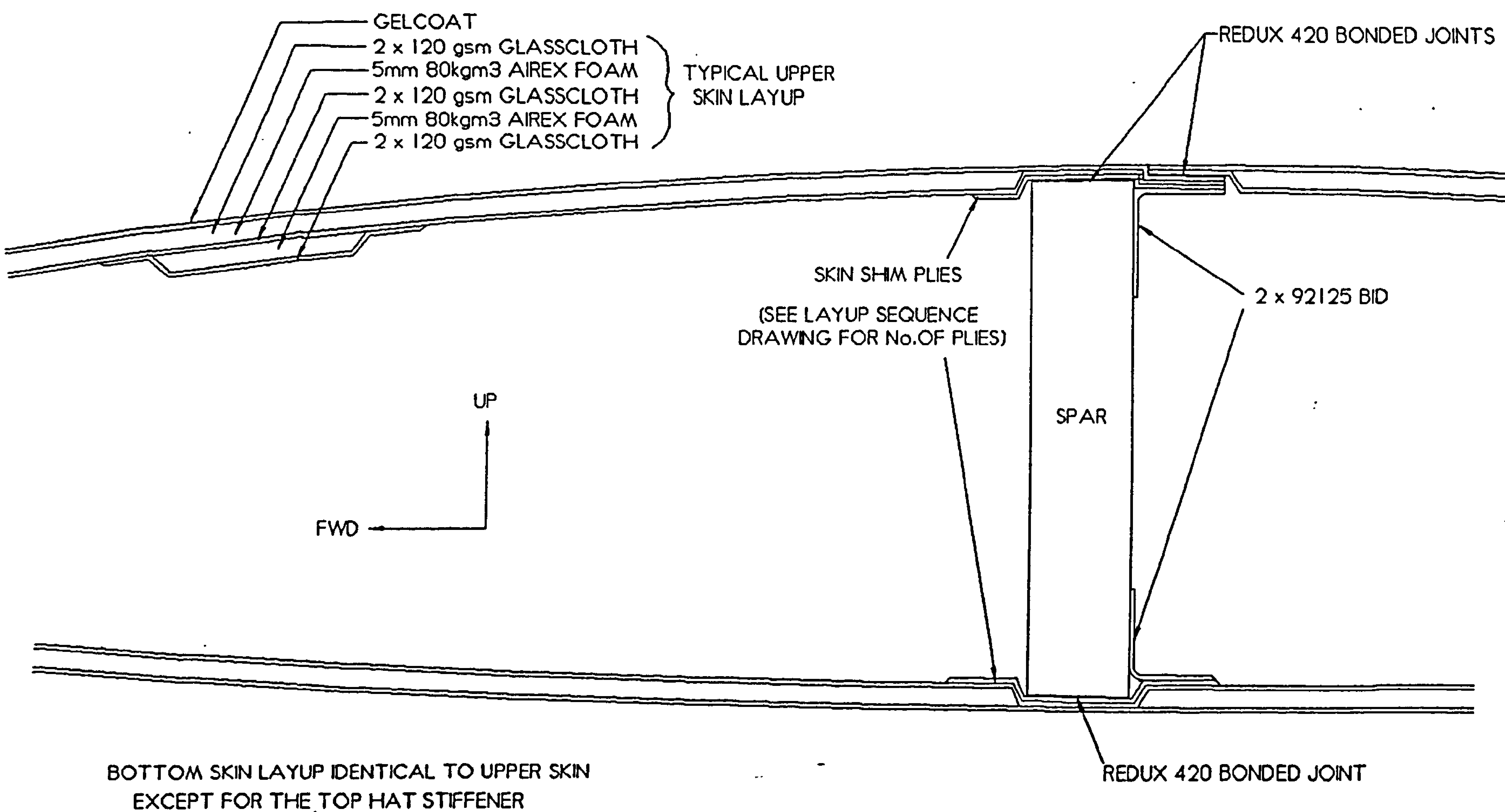
LEADING EDGE
TRAILING EDGE
SPAR
BUSH
1.7
2.0



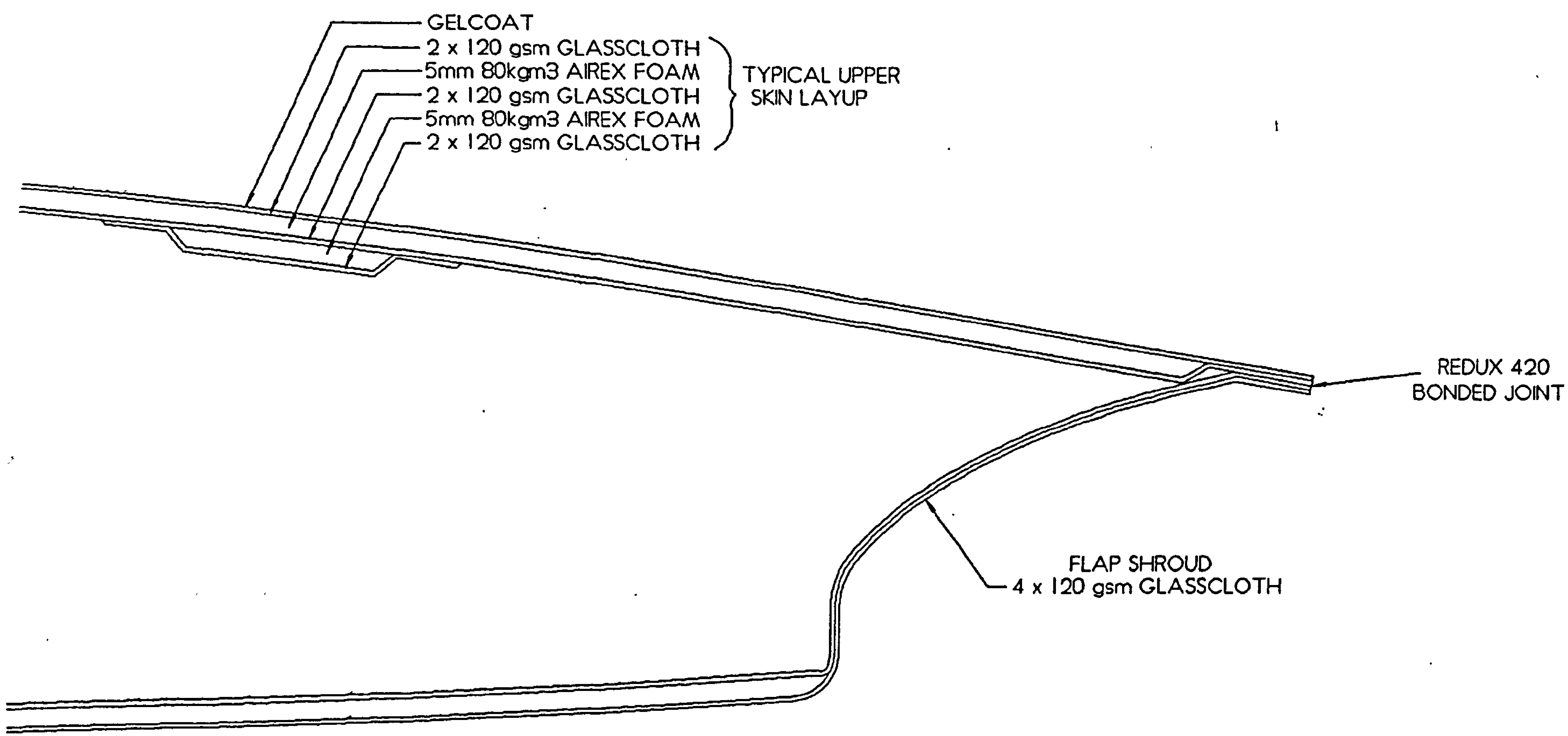

SECTIONAL VIEW THROUGH TRAILING EDGE ROOT RIB



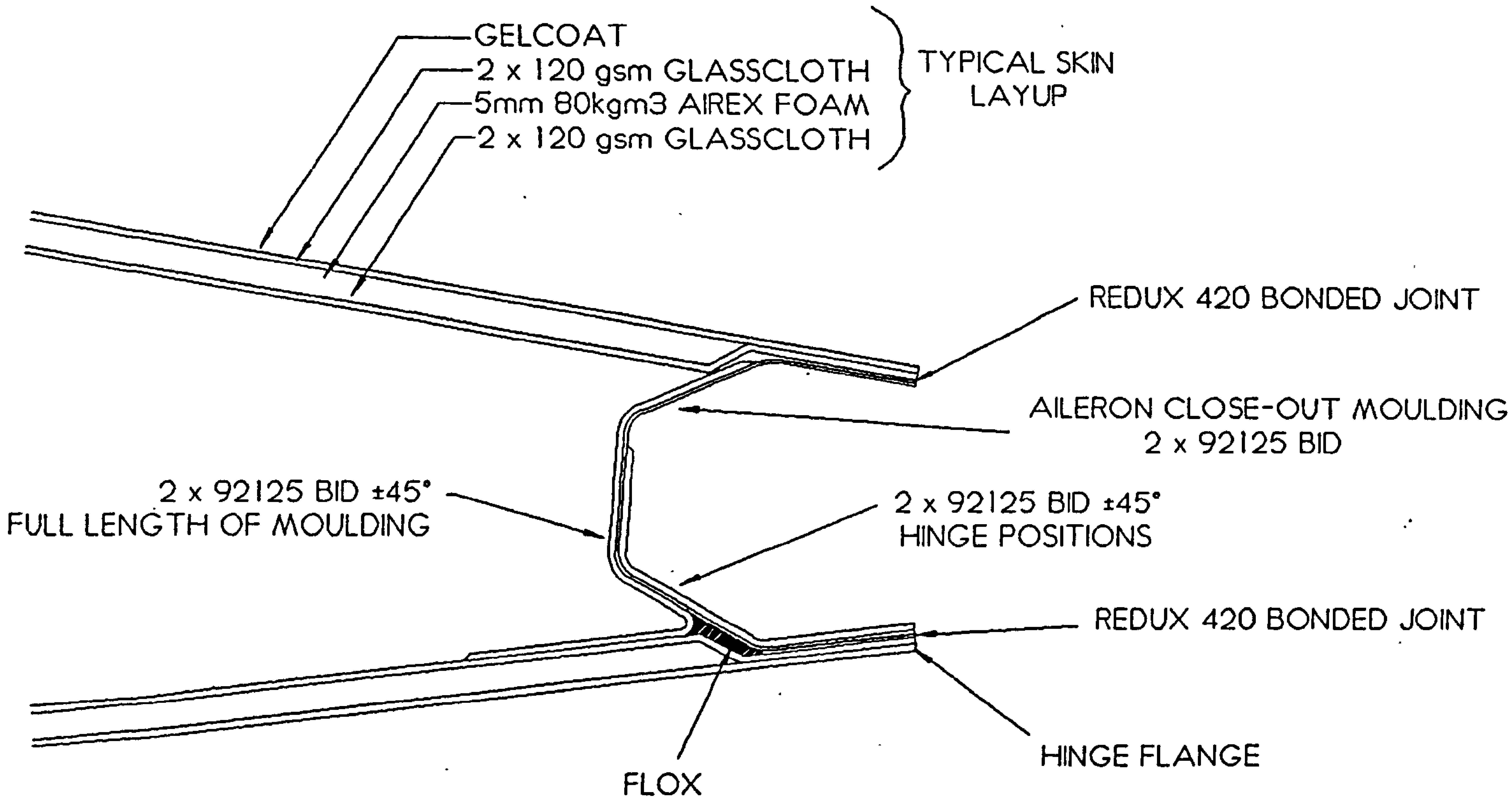

SECTION THROUGH EUROPA XS WING LEADING EDGE



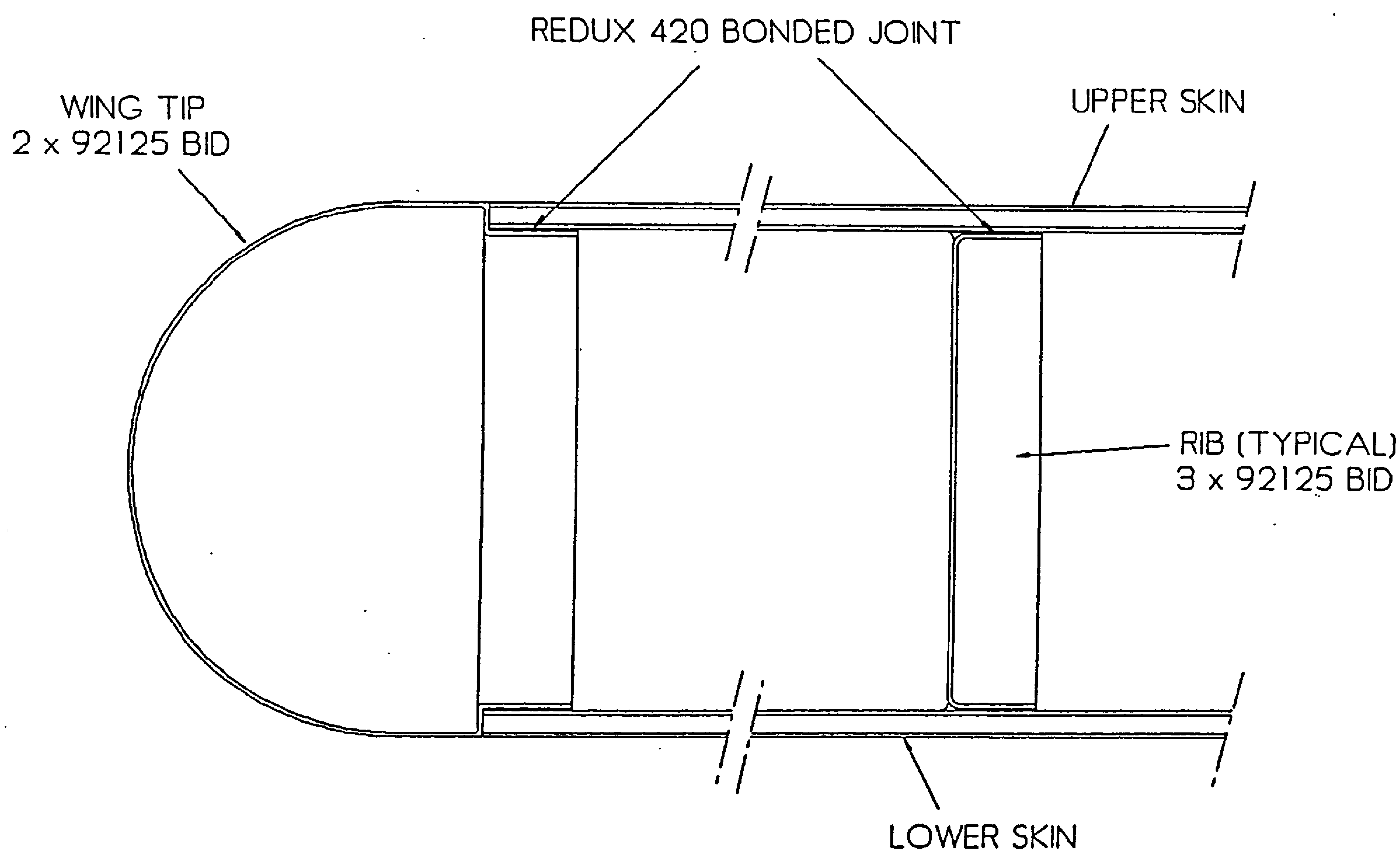

SECTION THROUGH EUROPA XS WING AT MID CHORD



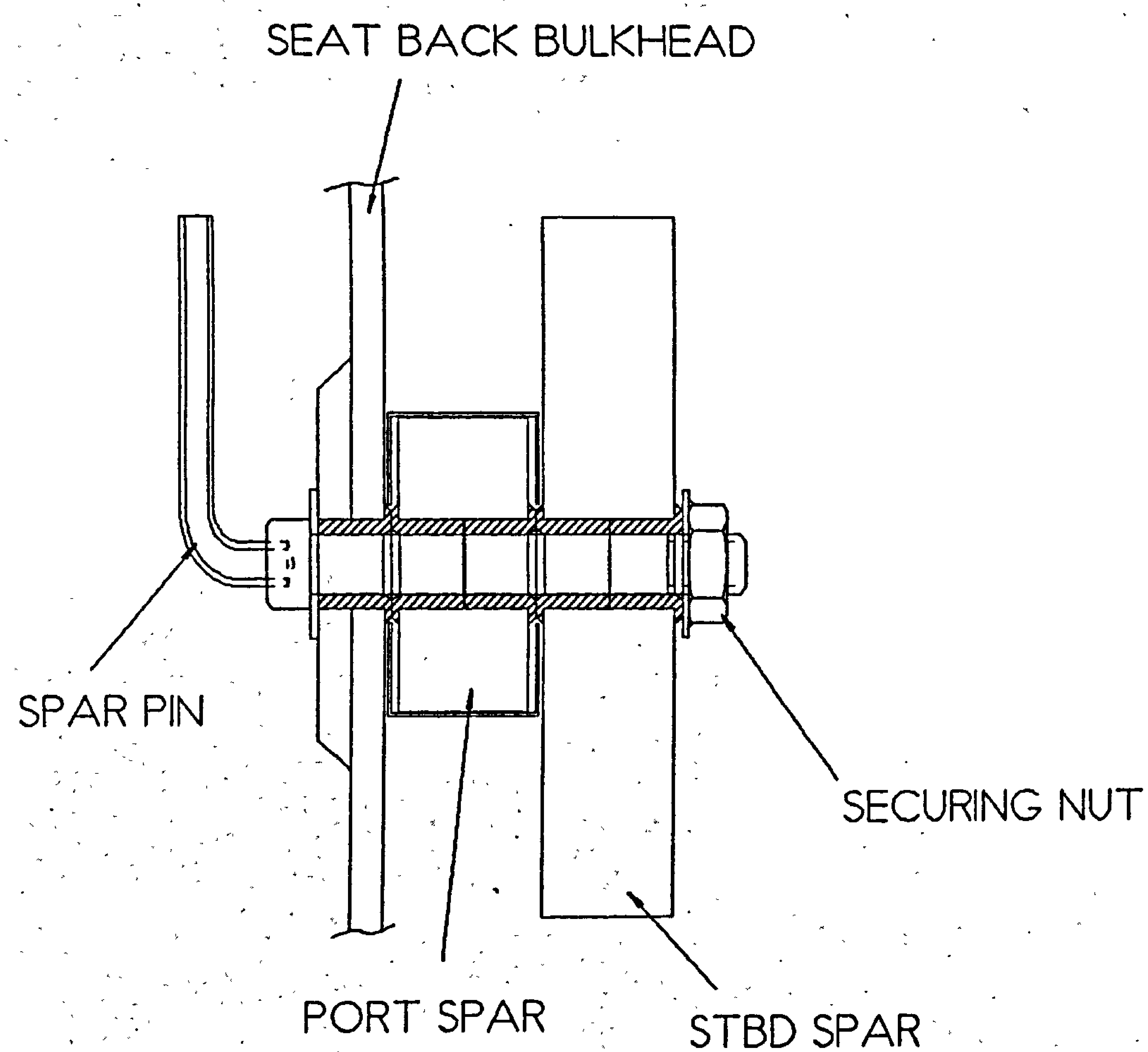

SECTION THROUGH EUROPA XS WING TRAILING EDGE AT FLAP SHROUD



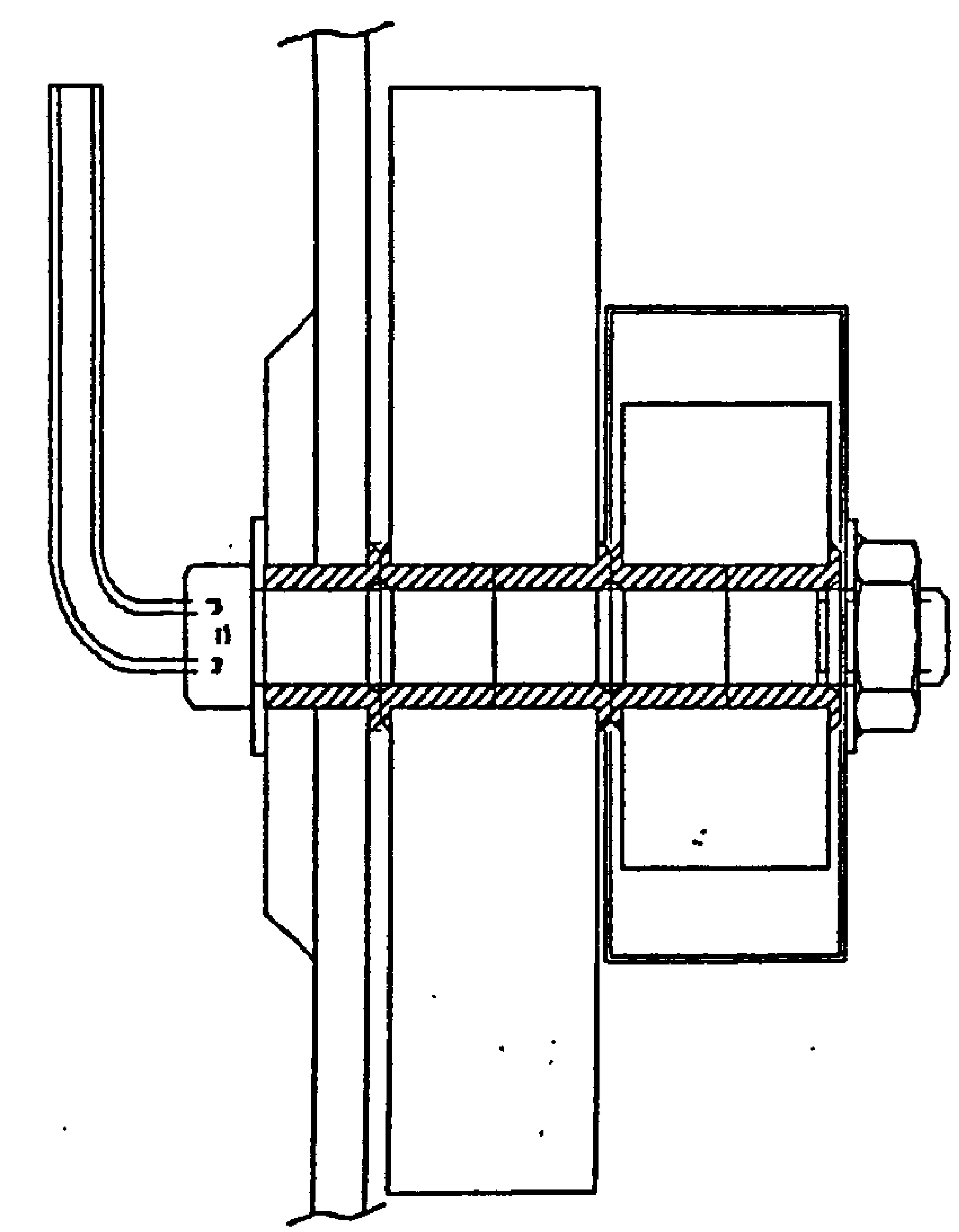

SECTION THROUGH EUROPA XS WING TRAILING EDGE AT AILERON CLOSE-OUT




EUROPA XS WING. SECTION THROUGH WING TIP AND RIB

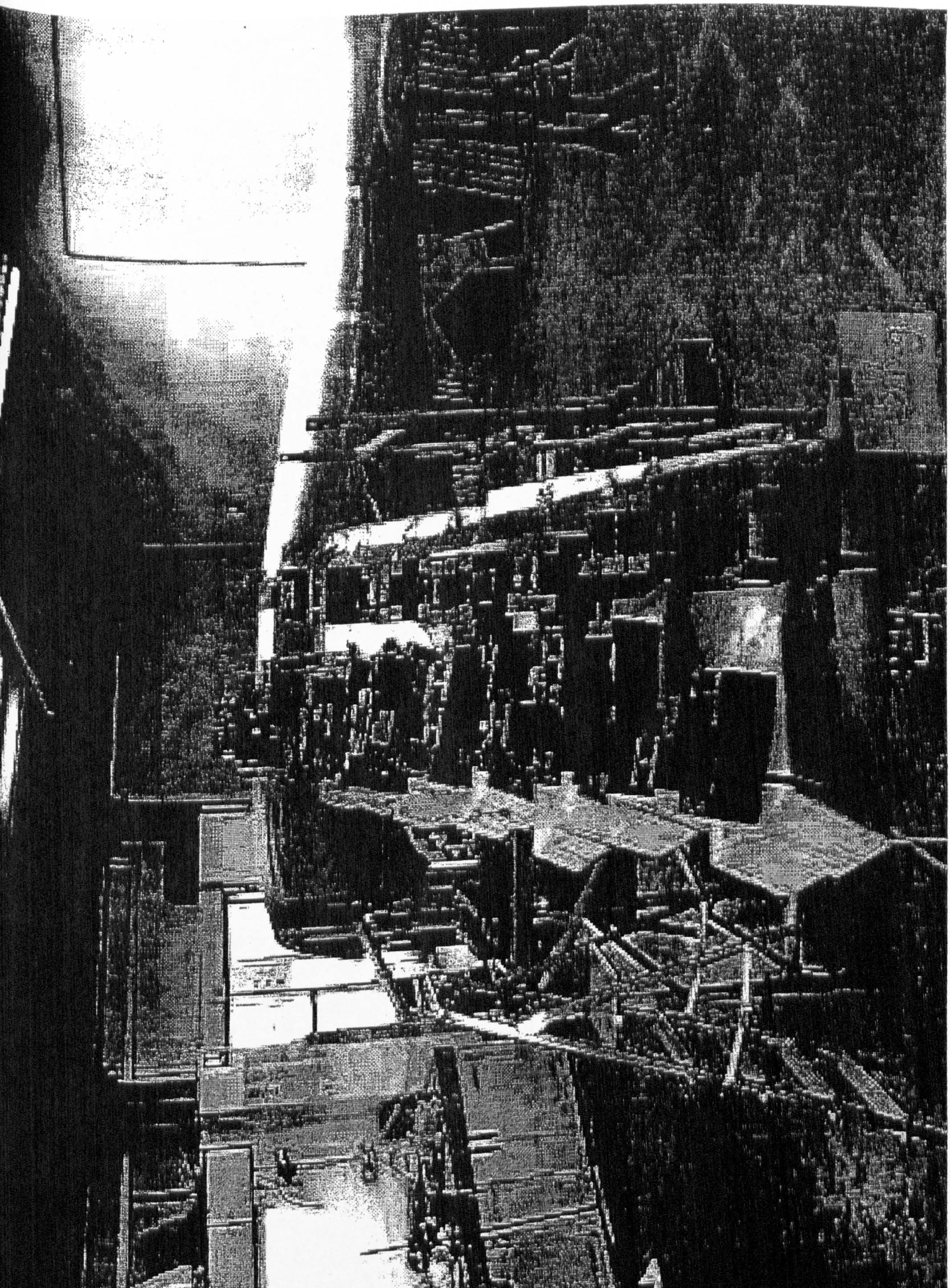


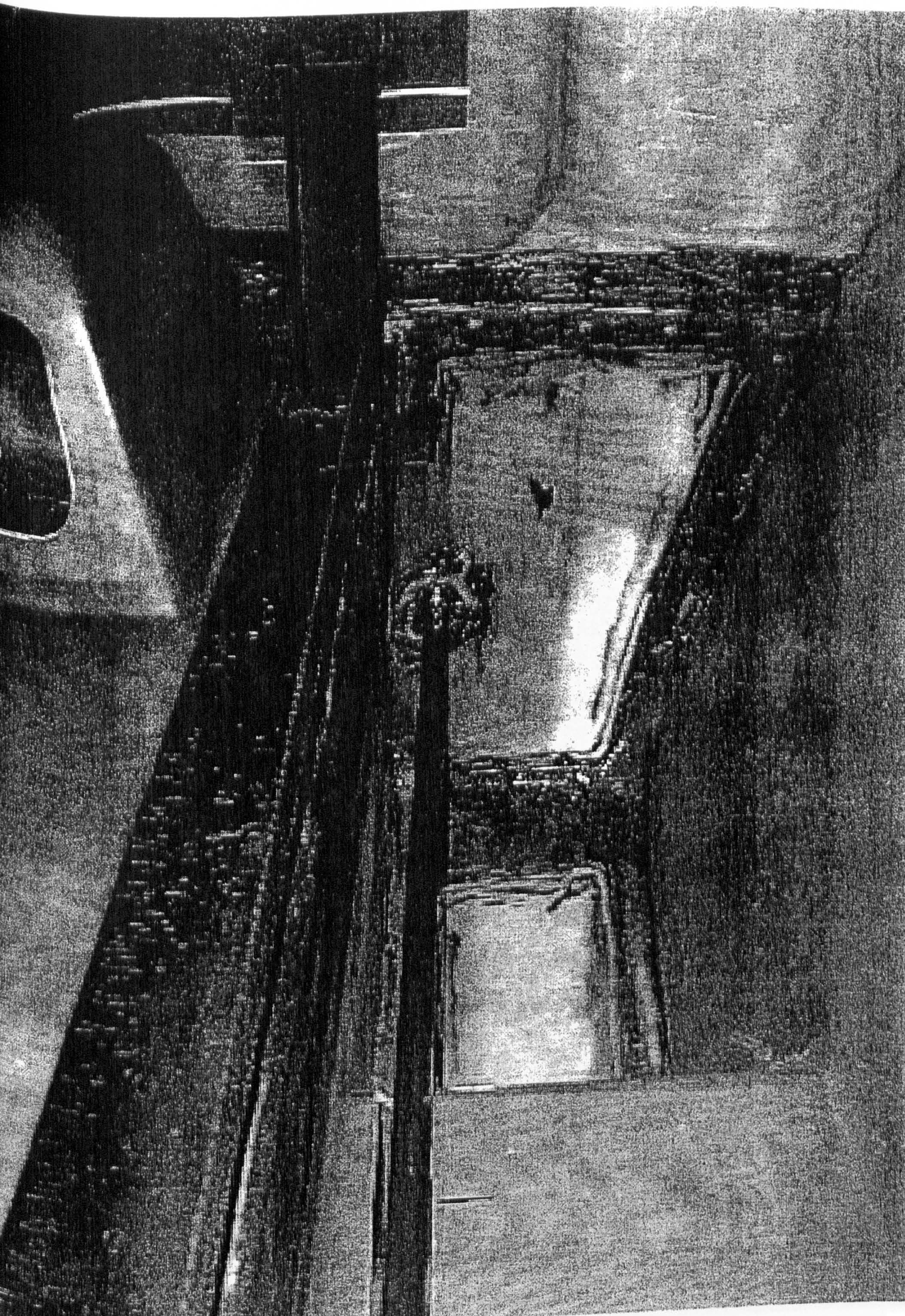

STARBOARD SIDE

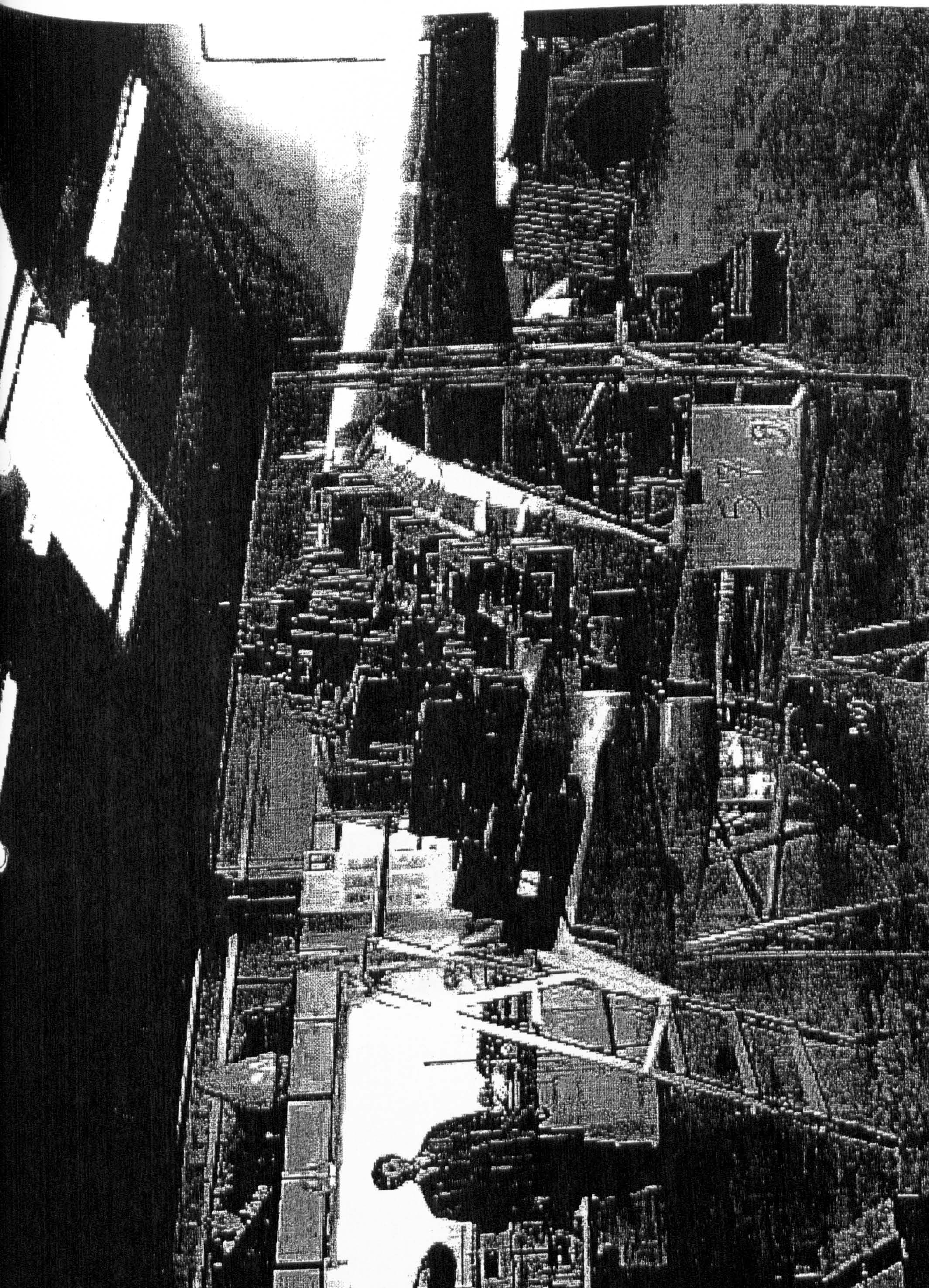


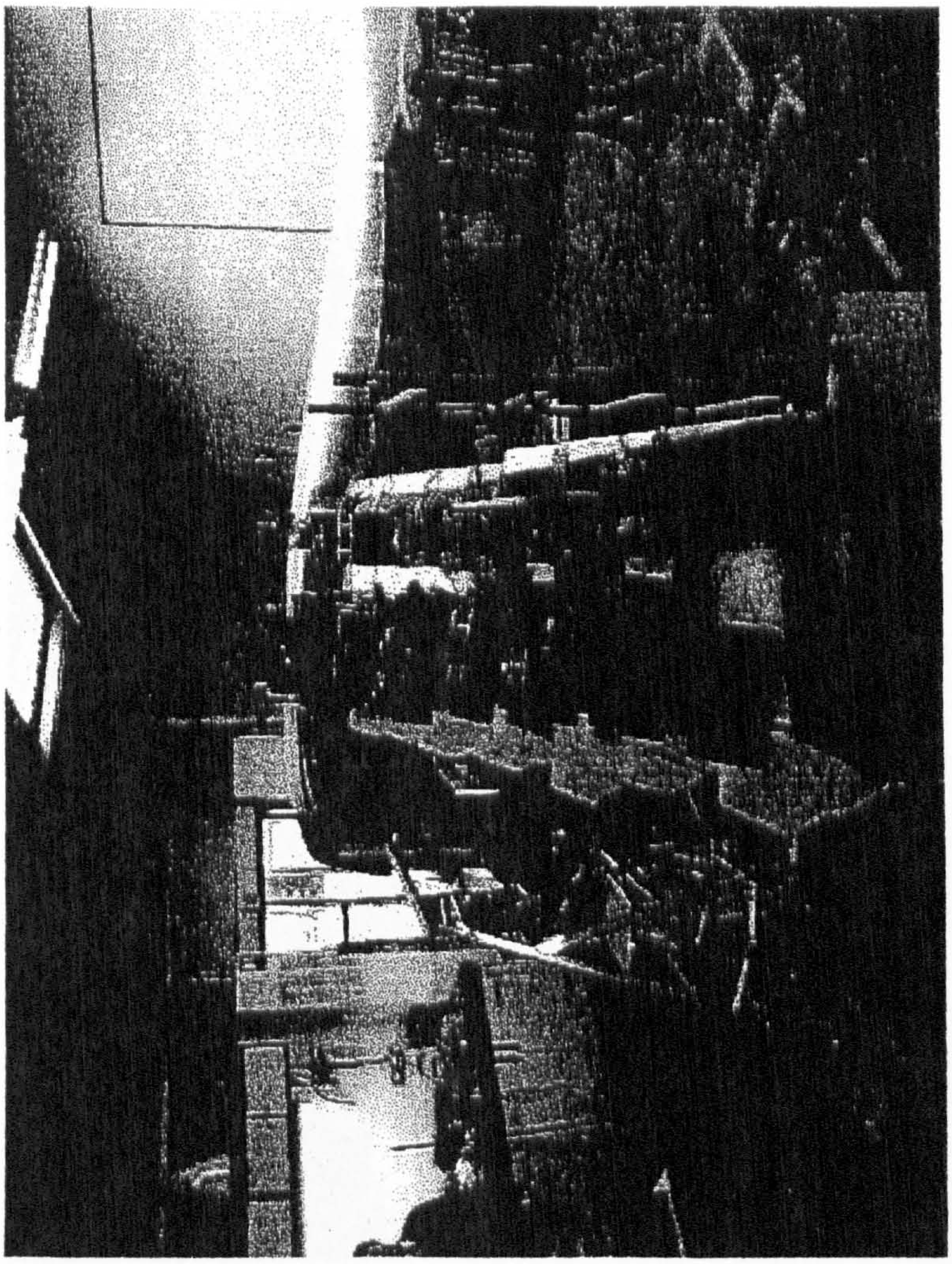
PORT SIDE

SPAR COUPLING ARRANGEMENT (SECTIONAL VIEWS)









# APPENDIX K: EUROPA PROTOTYPE GLIDER WING PROOF LOAD STATIC STRENGTH TEST

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EURO/019/STR

# EUROPA MOTORGLIDER WING

# PROOF STRENGTH TESTING OF THE PROTOTYPE EUROPA MOTORGLIDER WING

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| Rev | Date | Compiled | Checked | Approved | Notes/ref. |

# PROOF STRENGTH TESTING OF THE PROTOTYPE EUROPA MOTOR GLIDER WING

## Introduction

The prototype Europa motorglider wings, were mounted within the fuselage of Europa G-ODTI, and were proof strength tested to demonstrate that the wing design satisfies the requirements of JAR 22-305 part (a) on a restricted flight envelope defined for prototype gliderwing flight testing. This should allow the wings to be used for evaluation purposes on Europa aircraft G-ODTI operating on a certificate of fitness for flight, based on a maximum take-off weight of 1200 lb, a $V_A$ of 80 kts and a $V_{DF}$ of 120 kts.

## Wing Construction

The wing is supported by a CFRP / GFRP composite spar. The spar was constructed using similar wet lay up techniques to those used during fabrication of the classic Europa wing spar. The aerodynamic surfaces are comprised of Dow-Corning Styrofoam reinforced with wing skins of wet lay up Uni-directional and Bi-directional glass cloth. The glass cloth skin thickness has been tailored to meet the most unfavourable factored g loading specified within JAR-22, (1.5 * +5.3g, and 1.5 * –2.65g at an AUW of 1300). C – section wing ribs are used between the Styrofoam cores, both fore and aft of the spar. The outboard wing ribs are constructed from 3 plies of Bi-directional glass cloth. Full details of the prototype motorglider wing construction are made available within EUR/001/DES

## Structural modifications applied to the Europa airframe G-ODTI and to the glider wings prior to both proof strength tests.

The following modifications were applied to the Europa airframe G-ODTI and to the glider wings prior to both proof strength tests:

AIRFRAME G-ODTI:

1. An airbrake lever and control mechanism was installed on the passenger side of the aircraft cockpit module.
2. A larger Styrofoam top-hat stiffener was used to locally reinforce the aft baggage bay. The stiffener ran fore and aft and reinforced the area opposing the trailing edge drag/anti-drag pin sockets on the inside of the fuselage. 5 additional layers of Bi-directional cloth were added to reinforce the foam stiffener and fuselage.
3. Trailing edge drag/anti-drag pin sockets were of the basic, fixed, non-articulating type. These sockets were rigid and did not rotate in any plane unlike the sockets recently cleared for service on the Europa XS aircraft.

It should be noted that during both proof tests no tie-bar was used to connect the drag/anti-drag sockets.

PROTOTYPE MOTORGLIDER WING:

1. The spar-rigging pins and their bushes were increased in diameter from 3/8", used on the classic aircraft, to 1/2". The spar bushes were manufactured from S514 steel as opposed to anodised aluminium. The 1/2" rigging pins were free to rotate and did not use nuts to clamp the spars and the seat back bulkhead together.
2. A buckling restraint was laid-up over the centre section of both spars in the form of a GFRP strap. The strap is permanently attached to the port spar. The strap was constructed from both Uni-directional and Bi-directional GFRP. Lay-up details of this item is made available within EUROPA XS wing report EURO/017/STR

**Test Factors**

No test factors for manufacturing variability, thermal degradation, or moisture degradation were considered during the proof strength testing of the prototype motorglider wing to 5.3g at 1300 lb AUW. This approach is consistent with tests conducted on the classic Europa wet-lay up winged aircraft which were accepted by the PFA for prototype flight trials on a restricted flight envelope.

Load factor used for proof test: 5.3g

In light of work conducted by the Europa Aircraft Company on the Europa XS wing design, test factors for manufacturing variability, thermal degradation, and moisture degradation will be considered during the static strength testing of the future production prototype motorglider wings to 5.3g at 1300 lb. It is anticipated that production motorglider wings will be of a similar construction to the Europa XS wings.

The proposed initial restricted flight test envelope outlined within this report does however account for the effects of material variability and degradation due to the effects of temperature and moisture.

**Test Objectives**

Two separate tests were conducted on the prototype motorglider wings.

The first test aimed to simulate the most unfavourable aerodynamic loading that occurs on the wing at proof load with a Low Angle of Attack (LAA). The LAA case represented the proof load case at a $V_D$ of 165 kts and an AUW of 1300 lb, which produces maximum dynamic pressure on the wing structure.

This test aimed to prove:

1. The wing skin strength in combined tension & shear and combined compression and shear. (To some extent this was proved by the HAA test, given the similar facing ply arrangement and overall dimensional similarity of leading edge rib 'D' box and the trailing edge rib box)
2. Wing spar bending strength and stiffness

The second test aimed to simulate the most unfavourable aerodynamic loading that occurs on the wing at a $V_A$ of 94 kts and an AUW of 1300 lb with a High Angle of Attack (HAA). The HAA case represents the slowest speed in the flight envelope at which maximum load factor can be reached without stalling.

This test aimed to prove:

1. Leading edge wing skin strength in combined tension & shear, and combined compression and shear.
2. The leading-edge skin-to-spar and skin-to-rib bond strength together with the skin-to-foam bond strength
3. The bending and shear strength of the leading edge ribs together with the strength of leading edge rib to spar bond.
4. The overall strength of the wing root rib arrangement when the wing was subjected to the most unfavourable torsional loads experienced within the aircraft flight envelope.

**Test Rig**

The Europa fuselage G-ODTI was mounted inverted on a supporting rig which was bolted to the ground. see figure 1. Loads were reacted by supporting the fuselage through the seat pan area and thigh support, firewall bulkhead and at the tail-plane torque tube, simulating fuselage reactions experienced in flight. Padded spreader blocks at the seat pan positions were used to distribute the applied load. The fuselage was secured to the rig with straps. This safety measure aimed to prevent asymmetric bending of the wing, should the weights become displaced during the test.

**Test Method**

Test 1: Low Angle of Attack. (LAA)

The fuselage was set at an angle of 0 degrees declination to the horizontal, see figure 1. (Calculations used to derive the test angle are made available within appendix A)

Stations were marked out from the leading edge of the wing, as lines running chord-wise, at 27", 52", 72", 92", 112", 132", 152", 172", 192", 212", 232" and 249 inches from the aircraft centreline, see figure 1. The chord-wise location of the applied weights was marked out from the wing root, as one line running span-wise at 25% chord. Weights were initially applied directly at the intersection of the span-wise and chord-wise lines. Additional weights were applied on top or equally spaced about the intersection point. Short span, angled foam blocks were attached to the wing skins so that the weights would not topple as wing deflection increased throughout the test.

The applied load was distributed in accordance with the span-wise, normal, aerodynamic loading. This load was evaluated in terms of the amount of weight that should be applied at the above, defined span-wise wing stations.

The span-wise wing loading was derived at LAA using the Shrenk approximation. The chord-wise wing loading was derived using an applied weight distribution where 100% of the load was applied at 25% chord at the wing chord-wise centre of pressure. The above chord-wise distribution aimed to ensure correct wing bending at test factored limit load at the predetermined angle of declination. 100% of the wing weight was then removed from the aerodynamic load

The resulting net load equal to (100% aerodynamic load - 100% of the wing weight) was applied as discrete 10 or 5 kilogram weights distributed evenly about the intersection between the 25% chord line and the span-wise station lines defined above. The resulting net loads were tabulated for increasing g increments from 1 to 5.3g. Appendix A contains the applied load schedule used during the LAA test. Comparison of weights applied during the LAA test with theoretical load distribution is also made in appendix A.

At each g increment, the weights were applied at the intersecting lines, starting at the wing tip and working inboard. During weight application the wing tips were supported to prevent inadvertent overloading. After each application of weight, the weight distribution was checked in both the span-wise and chord-wise directions. With the wing tip supports removed, both wings were allowed to deflect under load.

Test Measurements

Wing tip deflection measurement

Wing tip deflection was measured using 'tape measures' attached at the leading and trailing edge of each wing tip. Once the discrete weights were applied to the wing at a specific g load, the wing was left unsupported and allowed to deflected under the applied loading. Measurements of both the starboard and port wing-tip deflections were then recorded. This allowed values of wing angular deflection to be obtained. No strain gauging was conducted during either test.

From 1g to proof load (5.3g), vertical deflection of both wing tips was recorded. The results are presented in appendix C. Video footage of this test is available on request from the Europa Aircraft Company.

After the test was complete, the weights were removed from both wings in a syncronised way, keeping the load on each wing matched. The deflection of the wing tips after unloading was checked for reference purposes. The wings were then removed from the aircraft and a detailed post test examination of the wing and fuselage was conducted.

Following the LAA test, the wings were then re-rigged on fuselage G-ODTI and the HAA test was conducted.

Test 2: High Angle of Attack. (HAA)

The fuselage was reset at an angle of 11 degrees declination to the horizontal. See figure 1. (Calculations used to derive the test angle are made available within appendix B)

A similar test method to that of the LAA test was adopted for the HAA test (see Test 1 for load application details) with the exception that the test angle was set at 11 degrees declination.

Once again, the resulting net load equal to (100% aerodynamic load - 100% of the wing weight) was applied as discrete 10 and 5 kilogram weights, distributed evenly about the intersection between the 25% chord line and the span-wise station lines defined previously. The above chord-wise distribution aimed to ensure correct wing bending and torsion at test factored limit load at the predetermined angle of declination. The resulting net loads were tabulated for increasing g increments from 1 to 5.3g. Appendix B contains the applied load schedule used during the HAA tests. Comparison between the weight-applied during the HAA test and the theoretical-load-distribution are made in appendix B. Vertical deflection of the wing tips was recorded for the HAA test. These results are presented in appendix C. Video footage of this test is available on request from the Europa Aircraft Company.

**Test Results**

Wing tip deflection measurement

Test 1: Low Angle of Attack. (LAA) 100% Net load applied at 25% chord

Both starboard and port wings experienced a similar amount of tip deflection, (Stbd: ((28.25 + 28.75)/2) = 28.5 in at 5.3g, Port: ((28.00 + 27.50)/2) = 27.75 in at 5.3g) The starboard wing experienced a greater amount of average tip deflection per g, (Stbd: 4.25 in /g at 5.3g, Port: 2.75 in/g at 5.3g). The starboard wing experienced more set than the port wing at 5.3g. For example, at 5.3g (Stbd set: 2.38 in compared with Port set: 1.13 in)

Between 1g and 5.3g both starboard and port wings appeared to experience similar torsional deflections (Stbd: 0.819 deg at 5.3g, Port: 0.819 deg at 5.3g) Between 1g and 5.3g the stbd wing experienced marginally more torsional deflection per g. This could be attributed to the increase in distance between the centroid of the aft spar and the quarter chord point.

Test 2: High Angle of Attack. (HAA)          100% Net load applied at 25% chord

The starboard wing appears to have experienced more tip deflection than the port wing, (Stbd: ((25.25 + 24.75)/2) = 25 in at 5.3g, Port: ((19.91 + 19.22)/2) = 19.56 in at 5.3g) suggesting either measurement error due to the inaccurate application of weights onto the starboard wing. The starboard wing also experienced a greater amount of average tip deflection per g, (Stbd: 2.00 in / g at 5.3g, Port: 0.14 in / g at 5.3g). The starboard wing experienced marginally less set than the port wing at 5.3g. For example, at 5.3g (Stbd set: 2.25 in, compared with Port set: 2.53 in)

The starboard wing appears to have experienced less torsion than the port wing, (Stbd: 0.819 deg at 5.3g, Port: 1.125 in at 5.3g) once again suggesting either measurement error or inaccurate application of weights to the wings. The largest torsional deflection per g experienced by either wing from 1g to 5.3g remained less than 1.25 deg per g

Comparison between LAA and HAA results

Comparing results from wing tip deflection obtained during the LAA test with those obtained during the HAA test in particular, comparison of average tip deflection and average tip deflections per g between 1 and 5.3g revealed that:

1. At 5.3g, LAA average tip deflection is greater than HAA average tip deflection. (LAA: (28.5 + 27.75)/2 = 28.125, compared with HAA: (25 in maximum)
2. At 5.3g, LAA average tip deflection per g is greater than HAA tip deflection per g (LAA: (4.25 + 2.75)/2 = 3.5 in/g at 5.3g, compared with HAA: (2.00 + 0.14)/2 = 1.07 in/g at 5.3g
3. Average set obtained during the LAA test was less than the set obtained during the HAA test. (LAA: (2.38 + 1.13)/2 = 1.76 in, compared with HAA: (2.25 + 2.53)/2 = 2.39 in)

1,2 and 3 above can be attributed to the higher bending moment experienced by the wings during the LAA test. (Note average tip deflection & average set, are defined here as the mean of both port and starboard tip-deflections-per-g, and sets obtained during each test).

(a) By comparing the results from both proof tests, the discrepancy between port and starboard wing tip deflection measurements on the HAA test can be attributed to inaccurate measurement of tip deflection (see Appendix A). No asymmetric bending of the wings occurred during the LAA test, which would indicate that there is no difference in spar boom bending stiffness if you compare both port and starboard spars.
(b) The single-shear seat back/overlapping-spar-coupling arrangement used in the Europa aircraft leads to twisting of the spar between the spar pins. Twisting between the spar pins is kept to a minimum by the buckling prevention strap. In the case of the motorglider wing, spar twisting is not as pronounced as that experienced by the XS wing during test. This is attributed to the lower strain rate of CFRP under load, when compared with GFRP.
(c) The higher value of set obtained during the HAA test can be attributed to the fact that set here is defined as temporary hysterisis. Both wings did return to their original datums after test.

**Test Observations**

Test 1: Low Angle of Attack. (LAA)

General

At all loads up to limit load, (5.3g) no permanent deformation was observed. Both port and starboard wings supported an applied load representing 5.3g without detrimental, permanent deformation or elastic buckling of the wing skins.

Wing Root Ribs

Post-test examination of the wing root rib revealed no permanent damage or delamination.

Upper Leading and Trailing Edge Wing Skins

At all loads up to 5.3g, no permanent deformation was observed.

Spar Tangs

Post-test examination of both wing spar tangs revealed no permanent damage or distortion. Minor delamination was noted at the corners of the buckling prevention strap. This could result from both spars deflecting between the spar rigging pins. The overlapping starboard spar would cause a peel load between the port-spar and the buckling-prevention-strap bond. This would be more pronounced at higher g levels. Minor delamination was also recorded at the wing spar-rigging pin bushes.

Fuselage

Post-test examination of the fuselage seatback bulkhead and fuselage sides adjacent to the sockets revealed no permanent damage or delamination.

Test 2: High Angle of Attack. (HAA)

General

At all loads up to limit load, (5.3g) no permanent deformation was observed. Both port and starboard wings supported an applied load representing 5.3g without detrimental, permanent deformation or elastic buckling. More wing twist-per-g was observed during the HAA test, than during the LAA test.

Wing Root Ribs

Post-test examination of the wing root rib revealed no permanent damage or delamination.

Upper Leading and Trailing Edge Wing Skins

At all loads up to 5.3g, no permanent deformation was observed.

Spar Tangs

Post-test examination of both wing spar tangs revealed no permanent damage. Minor delamination was noted at the corners of the buckling prevention strap. This could result from both spars deflecting between the spar rigging pins. The overlapping starboard spar would cause a peel load between the port-spar and the buckling-prevention-strap bond. This would be more pronounced at higher g levels. Minor delamination was also recorded at the wing spar-rigging pin bushes.

Fuselage

Post-test examination of the fuselage seatback bulkhead and fuselage sides adjacent to the sockets revealed no permanent damage or delamination.

**Discussion**

Comparison of theoretically derived loads with those applied to the motorglider wing during both the LAA and HAA proof tests.

1. Checking both the LAA and the HAA span-wise distribution of weight applied to the motorglider wing during test, with the theoretical Shrenk approximation check supplied by the PFA, showed that the bending moment and vertical shear force experienced at the wing root rib, therefore spar pins, is representative of actual flight loads at an AUW of 1300 lb with a $V_D$ of 165 kts, or at a $V_A$ of 94 kts.

2. Checking both the LAA and HAA torsional load applied to the motorglider wing during test with theoretical torsional distributions, suggests that the torque experienced at the wing root rib is not fully representative of actual flight loads at an AUW of 1300 lb with a $V_A$ of 94 kts. (see Appendix A)

By comparing the HAA distribution outlined in JAR-VLA with the distribution applied during the HAA test, suggests that the leading edge ribs experienced a chord-wise bending moment which is 24% lower than theoretically predicted. By placing 100% of the derived load infront of the spar during both LAA and HAA tests did however put a 24% higher vertical shear load into the bond between the wing ribs and the wing spar.

By comparing the LAA distribution supplied by Don Dykin with the distribution applied during the LAA test, suggests that the trailing edge rib bending strength has not been fully proved. Trailing edge rib bending strength and rib to spar bonds outboard of the root rib have however been demonstrated to an extent by both proof tests, given the overall dimensional similarity of the leading edge rib 'D' box with the trailing edge rib 'D' box.

3. Checking the LAA and HAA test angles of declination with theoretical angles of declination suggests that the test angles are reasonably representative of actual flight loads at a $V_D$ of 165 kts and at an all up weight of 1300 lb and at a $V_A$ of 94 kts and at an all up weight of 1300 lb. This result suggests that the wings experienced realistic values of chord-wise shear force and bending moment during both tests.

**Conclusions**

The LAA and HAA tests carried out within this report have demonstrated that:

1. The prototype motorglider wing experienced representative values of normal and chord-wise, bending moment and shear force during both the HAA and LAA tests.
2. The prototype motorglider wing skins experienced correct tension, compression and shear however all wing ribs did not experience representative values of rib bending during either test.
3. Although both proof strength tests were not fully representative of actual in-flight loads, they did however test the strength of the wing in shear to a higher degree than tests conducted previously on classic light aircraft wings of similar construction which have been accepted and cleared for first flight by the PFA.

4. Based on these tests and analysis work included within appendix A of this report, the strength of the prototype Europa motorglider wings will be sufficient for first flight if operated on a restricted flight envelope. The analysis work contained within appendix A covers flight envelope growth during the prototype glider wing flight test programme

**Recommendations**

A. Structural modifications to be applied to the prototype motorglider wings and to the fuselage G-ODTI prior to first flight.

Prior to first flight, the following structural modifications will be applied to the prototype motorglider wings and to the fuselage G-ODTI.

1. A tiebar will be fitted to the airframe G-ODTI. This will be sized for the most unfavourable chord-wise loads that the aircraft will experience within its flight envelope. (see report EURO/021/STR)
2. The wing spars will be constrained from moving rearwards along the shank of the spar pins through the use one 1/2" pippin, and a close fitting composite anti-buckling restraint. The pippin will use a lanyard, and will only engage in the starboard spar pin hole. S514 bushes will be used. A plain shank bolt, without a nut will be used in the other hole.
3. Articulating drag/anti-drag sockets will be used to offset normal bending on the fuselage side.
4. EN57 pins will be used at the wing root.

B. Restricted flight envelope for prototype flight test evaluation

In light of the conclusions reached within this report, combined with the lessons learned from tests conducted four months after these tests on the Europa XS light aircraft wings, it is recommended that the Europa aircraft G-ODTI fitted with the prototype motorglider wings be cleared to operate on a permit to test with the following restricted flight envelope (see Appendix A for derivation of restricted envelope)

Note: This 'limit load' flight envelope is based on results from both static strength tests, results from both wing stiffness tests and reserve factors on material strengths on modifications made to the airframe G-ODTI prior to first flight

1. $V_A$ = 80 kts
2. $V_{NE}$ = 108 kts
3. $V_{DF}$ = 120 kts
4. Maximum take off weight = 1200 lb
5. Maximum permissible positive g loading clean +3.8g
6. Maximum permissible negative g loading -1.9g
7. Maximum permissible positive g loading brakes deployed +2.5g
8. Maximum permissible negative g loading brakes deployed 0.0g
9. Flights should be limited to days with an OAT not greater than 25 deg c

The above restricted flight envelope accounts for the effects of the following:

- Reduced prototype aircraft weight
- Factors for material variability, and degradation due to moisture and elevated temperature

Both the HAA and LAA tests described above supplied sufficient proof load to the glider wing structure as a result extensions to the flight envelope for prototype flight testing can be made without additional proof loading of the main wing structure. Additional proof load tests will however be used to clear the ailerons and airbrakes for higher design dive speeds.

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| | EUROPA DEVELOPMENTS LTD | Report No. EURO/019/STR |
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| Date: 13/10/98 | | Page of |

Subject:
GLIDER WING PROOF LOAD TEST

INTRODUCTION:

APPENDIX A.

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| STATIC STRUCTURAL DATA | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | LOADING REQUIRED FOR OVERAL WING LIFT OF 1332 lb | | | | | | | |
| | | | | | | INERTIA LOAD FACTOR (g) | | | | | | | | |
| WING STN (in) | LOAD STN | AERO LOAD (in) | INERTIA LOAD (lb) | | 1.00 | 1.50 | 2.00 | 2.50 | 3.00 | 3.50 | 4.00 | 4.50 | 5.00 | 5.30 |
| | Mid Posn (in) | | 140 lb per wing | | Loading at each station in (lb) | | | | | | | | | |
| centre | 0 | 109.43 | | | | | | | | | | | | |
| | 11 | 28.89 | -6.03 | | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 19 | 17.28 | -3.60 | | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| root 23 | 27 | 28.68 | -11.90 | | 16.78 | 25.18 | 33.57 | 41.96 | 50.35 | 58.74 | 67.14 | 75.53 | 83.92 | 88.95 |
| 39.49 | 52 | 56.45 | -11.75 | | 44.71 | 67.06 | 89.42 | 111.77 | 134.12 | 156.48 | 178.83 | 201.18 | 223.54 | 236.95 |
| 62.00 | 72 | 55.51 | -11.59 | | 43.92 | 65.88 | 87.84 | 109.80 | 131.76 | 153.72 | 175.68 | 197.64 | 219.60 | 232.77 |
| 82.00 | 92 | 54.35 | -11.44 | | 42.92 | 64.38 | 85.84 | 107.30 | 128.75 | 150.21 | 171.67 | 193.13 | 214.59 | 227.47 |
| 102.00 | 112 | 52.97 | -11.28 | | 41.68 | 62.53 | 83.37 | 104.21 | 125.05 | 145.90 | 166.74 | 187.58 | 208.42 | 220.93 |
| 122.00 | 132 | 51.32 | -11.13 | | 40.19 | 60.29 | 80.38 | 100.48 | 120.57 | 140.67 | 160.76 | 180.86 | 200.96 | 213.01 |
| 142.00 | 152 | 49.37 | -10.97 | | 38.40 | 57.60 | 76.79 | 95.99 | 115.19 | 134.39 | 153.59 | 172.79 | 191.99 | 203.51 |
| 162.00 | 172 | 47.06 | -10.82 | | 36.24 | 54.36 | 72.48 | 90.60 | 108.72 | 126.84 | 144.96 | 163.08 | 181.20 | 192.07 |
| 182.00 | 192 | 44.27 | -10.66 | | 33.61 | 50.42 | 67.22 | 84.03 | 100.84 | 117.64 | 134.45 | 151.25 | 168.06 | 178.14 |
| 202.00 | 212 | 40.82 | -10.51 | | 30.31 | 45.47 | 60.62 | 75.78 | 90.93 | 106.09 | 121.24 | 136.40 | 151.55 | 160.65 |
| 222.00 | 232 | 36.17 | -10.35 | | 25.82 | 38.73 | 51.64 | 64.55 | 77.46 | 90.37 | 103.28 | 116.19 | 129.10 | 136.84 |
| 241.00 | 249 | 22.32 | -8.17 | | 14.15 | 21.22 | 28.30 | 35.37 | 42.45 | 49.52 | 56.60 | 63.67 | 70.75 | 74.99 |
| tip 258 | 258 | | | | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | | 666.00 | -140.19 | 1 WING | 408.73 | 613.10 | 817.47 | 1021.83 | 1226.20 | 1430.57 | 1634.93 | 1839.30 | 2043.66 | 2166.28 |
| Both wings and fuselage = | | 1332.00 | | 2 WINGS | 817.47 | 1226.20 | 1634.93 | 2043.66 | 2452.40 | 2861.13 | 3269.86 | 3678.60 | 4087.33 | 4332.57 |
| | | | | | INERTIA LOAD FACTOR (g) | | | | | | | | | |
| | | | | | 1.00 | 1.50 | 2.00 | 2.50 | 3.00 | 3.50 | 4.00 | 4.50 | 5.00 | 5.30 |
| | | | | | Loading at each station in (kg) | | | | | | | | | |
| | | | 11 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | | 19 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | | 27 | | 8 | 11 | 15 | 19 | 23 | 27 | 30 | 34 | 38 | 40 |
| | | | 52 | | 20 | 30 | 41 | 51 | 61 | 71 | 81 | 91 | 101 | 108 |
| | | | 72 | | 20 | 30 | 40 | 50 | 60 | 70 | 80 | 90 | 100 | 106 |
| | | | 92 | | 19 | 29 | 39 | 49 | 58 | 68 | 78 | 88 | 97 | 103 |
| | | | 112 | | 19 | 28 | 38 | 47 | 57 | 66 | 76 | 85 | 95 | 100 |
| | | | 132 | | 18 | 27 | 36 | 46 | 55 | 64 | 73 | 82 | 91 | 97 |
| | | | 152 | | 17 | 26 | 35 | 44 | 52 | 61 | 70 | 78 | 87 | 92 |
| | | | 172 | | 16 | 25 | 33 | 41 | 49 | 58 | 66 | 74 | 82 | 87 |
| | | | 192 | | 15 | 23 | 31 | 38 | 46 | 53 | 61 | 69 | 76 | 81 |
| | | | 212 | | 14 | 21 | 28 | 34 | 41 | 48 | 55 | 62 | 69 | 73 |
| | | | 232 | | 12 | 18 | 23 | 29 | 35 | 41 | 47 | 53 | 59 | 62 |
| | | | 249 | | 6 | 10 | 13 | 16 | 19 | 22 | 26 | 29 | 32 | 34 |
| | | | 258 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | | | 1 WING | 185 | 278 | 371 | 464 | 556 | 649 | 742 | 835 | 927 | 983 |
| | | | | 2 WINGS | 371 | 556 | 742 | 927 | 1113 | 1298 | 1484 | 1669 | 1855 | 1966 |

STATIC STRUCTURAL DATA

| WING STN (in) | LOAD STN Mid Posn (in) | AERO LOAD (in) | INERTIA LOAD (lb) 140 lb per wing | | 1.00 | 1.50 | 2.00 | 2.50 | 3.00 | 3.50 | 4.00 | 4.50 | 5.00 | 5.30 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | LOADING REQUIRED FOR OVERAL WING LIFT OF 1332 lb — INERTIA LOAD FACTOR (g) — Loading at each station in (lb) | | | | | | | | | |
| centre | 0 | 109.43 | | | | | | | | | | | | |
| | 11 | 28.89 | -6.03 | | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 19 | 17.28 | -3.60 | | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| root 23 | 27 | 28.68 | -11.90 | | 16.78 | 25.18 | 33.57 | 41.96 | 50.35 | 58.74 | 67.14 | 75.53 | 83.92 | 88.95 |
| 39.49 | 52 | 56.45 | -11.75 | | 44.71 | 67.06 | 89.42 | 111.77 | 134.12 | 156.48 | 178.83 | 201.18 | 223.54 | 236.95 |
| 62.00 | 72 | 55.51 | -11.59 | | 43.92 | 65.88 | 87.84 | 109.80 | 131.76 | 153.72 | 175.68 | 197.64 | 219.60 | 232.77 |
| 82.00 | 92 | 54.35 | -11.44 | | 42.92 | 64.38 | 85.84 | 107.30 | 128.75 | 150.21 | 171.67 | 193.13 | 214.59 | 227.47 |
| 102.00 | 112 | 52.97 | -11.28 | | 41.68 | 62.53 | 83.37 | 104.21 | 125.05 | 145.90 | 166.74 | 187.58 | 208.42 | 220.93 |
| 122.00 | 132 | 51.32 | -11.13 | | 40.19 | 60.29 | 80.38 | 100.48 | 120.57 | 140.67 | 160.76 | 180.86 | 200.96 | 213.01 |
| 142.00 | 152 | 49.37 | -10.97 | | 38.40 | 57.60 | 76.79 | 95.99 | 115.19 | 134.39 | 153.59 | 172.79 | 191.99 | 203.51 |
| 162.00 | 172 | 47.06 | -10.82 | | 36.24 | 54.36 | 72.48 | 90.60 | 108.72 | 126.84 | 144.96 | 163.08 | 181.20 | 192.07 |
| 182.00 | 192 | 44.27 | -10.66 | | 33.61 | 50.42 | 67.22 | 84.03 | 100.84 | 117.64 | 134.45 | 151.25 | 168.06 | 178.14 |
| 202.00 | 212 | 40.82 | -10.51 | | 30.31 | 45.47 | 60.62 | 75.78 | 90.93 | 106.09 | 121.24 | 136.40 | 151.55 | 160.65 |
| 222.00 | 232 | 36.17 | -10.35 | | 25.82 | 38.73 | 51.64 | 64.55 | 77.46 | 90.37 | 103.28 | 116.19 | 129.10 | 136.84 |
| 241.00 | 249 | 22.32 | -8.17 | | 14.15 | 21.22 | 28.30 | 35.37 | 42.45 | 49.52 | 56.60 | 63.67 | 70.75 | 74.99 |
| tip 258 | 258 | | | | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | | 666.00 | -140.19 | 1 WING | 408.73 | 613.10 | 817.47 | 1021.83 | 1226.20 | 1430.57 | 1634.93 | 1839.30 | 2043.66 | 2166.28 |
| Both wings and fuselage = | | 1332.00 | | 2 WINGS | 817.47 | 1226.20 | 1634.93 | 2043.66 | 2452.40 | 2861.13 | 3269.86 | 3678.60 | 4087.33 | 4332.57 |

INERTIA LOAD FACTOR (g)

| LOAD STN | | 1.00 | 1.50 | 2.00 | 2.50 | 3.00 | 3.50 | 4.00 | 4.50 | 5.00 | 5.30 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Loading at each station in (kg) | | | | | | | | | |
| 11 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 19 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 27 | | 8 | 11 | 15 | 19 | 23 | 27 | 30 | 34 | 38 | 40 |
| 52 | | 20 | 30 | 41 | 51 | 61 | 71 | 81 | 91 | 101 | 108 |
| 72 | | 20 | 30 | 40 | 50 | 60 | 70 | 80 | 90 | 100 | 106 |
| 92 | | 19 | 29 | 39 | 49 | 58 | 68 | 78 | 88 | 97 | 103 |
| 112 | | 19 | 28 | 38 | 47 | 57 | 66 | 76 | 85 | 95 | 100 |
| 132 | | 18 | 27 | 36 | 46 | 55 | 64 | 73 | 82 | 91 | 97 |
| 152 | | 17 | 26 | 35 | 44 | 52 | 61 | 70 | 78 | 87 | 92 |
| 172 | | 16 | 25 | 33 | 41 | 49 | 58 | 66 | 74 | 82 | 87 |
| 192 | | 15 | 23 | 31 | 38 | 46 | 53 | 61 | 69 | 76 | 81 |
| 212 | | 14 | 21 | 28 | 34 | 41 | 48 | 55 | 62 | 69 | 73 |
| 232 | | 12 | 18 | 23 | 29 | 35 | 41 | 47 | 53 | 59 | 62 |
| 249 | | 6 | 10 | 13 | 16 | 19 | 22 | 26 | 29 | 32 | 34 |
| 258 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 1 WING | 185 | 278 | 371 | 464 | 556 | 649 | 742 | 835 | 927 | 983 |
| | 2 WINGS | 371 | 556 | 742 | 927 | 1113 | 1298 | 1484 | 1669 | 1855 | 1966 |

**TEST 1**

**LAA STATIC STRENGTH TEST**

**TABLE 1 MEASURED DEFLECTIONS**

| STARBOARD WING | | | | | PORT WING | | | |
|---|---|---|---|---|---|---|---|---|
| g | ROOT | TIP | | | g | ROOT | TIP | |
| | | LE | TE | | | | LE | TE |
| ZERO | 0.00 | 53.50 | 55.50 | | ZERO | 0.00 | 63.00 | 62.50 |
| 1.0 | 0.00 | 48.50 | 50.50 | | 1.0 | 0.02 | 58.98 | 58.61 |
| 2.0 | 0.01 | 42.49 | 44.49 | | 2.0 | 0.00 | 53.25 | 52.75 |
| 3.0 | 0.01 | 38.00 | 40.00 | | 3.0 | 0.00 | 48.00 | 47.50 |
| 4.0 | 0.00 | 33.50 | 36.25 | | 4.0 | 0.00 | 43.00 | 42.75 |
| 4.5 | 0.01 | 31.49 | 33.74 | | 4.5 | 0.01 | 39.99 | 39.62 |
| 5.0 | 0.00 | 28.75 | 31.75 | | 5.0 | 0.00 | 37.75 | 37.75 |
| 5.3 | 0.00 | 24.75 | 27.25 | | 5.3 | 0.00 | 35.00 | 35.00 |
| RE-ZERO | 0.00 | 51.00 | 53.25 | | RE-ZERO | 0.00 | 62.00 | 61.25 |
| PERM SET | | 2.50 | 2.25 | | PERM SET | | 1.00 | 1.25 |

**TABLE 2 DEFLECTIONS**

| STARBOARD WING | | | | | PORT WING | | | |
|---|---|---|---|---|---|---|---|---|
| | g | LE | TE | | | g | LE | TE |
| | 1.0 | 5.00 | 5.00 | | | 1.0 | 4.02 | 3.89 |
| | 2.0 | 11.01 | 11.01 | | | 2.0 | 9.75 | 9.75 |
| | 3.0 | 15.50 | 15.50 | | | 3.0 | 15.00 | 15.00 |
| | 4.0 | 20.00 | 19.25 | | | 4.0 | 20.00 | 19.75 |
| | 4.5 | 22.01 | 21.76 | | | 4.5 | 23.01 | 22.88 |
| | 5.0 | 24.75 | 23.75 | | | 5.0 | 25.25 | 24.75 |
| | 5.3 | 28.75 | 28.25 | | | 5.3 | 28.00 | 27.50 |

**TABLE 3 DEFLECTION PER G**

| STARBOARD WING | | | | | PORT WING | | | |
|---|---|---|---|---|---|---|---|---|
| | g | LE | TE | | | g | LE | TE |
| | 1.0 | 5.00 | 5.00 | | | 1.0 | 4.02 | 3.89 |
| | 2.0 | 6.01 | 6.01 | | | 2.0 | 5.73 | 5.86 |
| | 3.0 | 4.49 | 4.49 | | | 3.0 | 5.25 | 5.25 |
| | 4.0 | 4.50 | 3.75 | | | 4.0 | 5.00 | 4.75 |
| | 4.5 | 2.01 | 2.51 | | | 4.5 | 3.01 | 3.13 |
| | 5.0 | 2.74 | 1.99 | | | 5.0 | 2.24 | 1.87 |
| | 5.3 | 4.00 | 4.50 | | | 5.3 | 2.75 | 2.75 |

| | | | |
|---|---|---|---|
| | | LAA STBD A | A PORT AV DEF |
| | 1.0 | 5.00 | 3.96 |
| | 2.0 | 11.01 | 9.75 |
| | 3.0 | 15.50 | 15.00 |
| | 4.0 | 19.63 | 19.88 |
| | 4.5 | 21.89 | 22.95 |
| | 5.0 | 24.25 | 25.00 |
| | 5.3 | 28.50 | 27.75 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| TEST 1 | | | | | | | |
| LAA STATIC STRENGTH TEST | | | | | | | |
| | | | | | | | |
| TABLE 4 TORSIONAL DEFLECTIONS | | | | | | | |
| | | | | | | | |
| STARBOARD WING | | | | | PORT WING | | |
| | | | | | | | |
| | g | $\Delta_Z$ | DEG | | g | $\Delta_Z$ | DEG |
| | 1.0 | 0.00 | 0.00 | | 1.0 | 0.13 | 0.21 |
| | 2.0 | 0.00 | 0.00 | | 2.0 | 0.00 | 0.00 |
| | 3.0 | 0.00 | 0.00 | | 3.0 | 0.00 | 0.00 |
| | 4.0 | 0.75 | 1.23 | | 4.0 | 0.25 | 0.41 |
| | 4.5 | 0.25 | 0.41 | | 4.5 | 0.13 | 0.21 |
| | 5.0 | 1.00 | 1.64 | | 5.0 | 0.50 | 0.82 |
| | 5.3 | 0.50 | 0.82 | | 5.3 | 0.50 | 0.82 |
| | | | | | | | |
| TABLE 5 TORSIONAL DEFLECTION PER G | | | | | | | |
| | | | | | | | |
| STARBOARD WING | | | | | PORT WING | | |
| | | | | | | | |
| | g | $\Delta_Z$ | DEG | | g | $\Delta_Z$ | DEG |
| | 1.0 | 0.00 | 0.00 | | 1.0 | 0.13 | 0.21 |
| | 2.0 | 0.00 | 0.00 | | 2.0 | -0.13 | -0.21 |
| | 3.0 | 0.00 | 0.00 | | 3.0 | 0.00 | 0.00 |
| | 4.0 | 0.75 | 1.23 | | 4.0 | 0.25 | 0.41 |
| | 4.5 | -0.50 | -0.82 | | 4.5 | -0.12 | -0.20 |
| | 5.0 | 0.75 | 1.23 | | 5.0 | 0.37 | 0.61 |
| | 5.3 | -0.50 | -0.82 | | 5.3 | 0.00 | 0.00 |

| | | |
|---|---|---|
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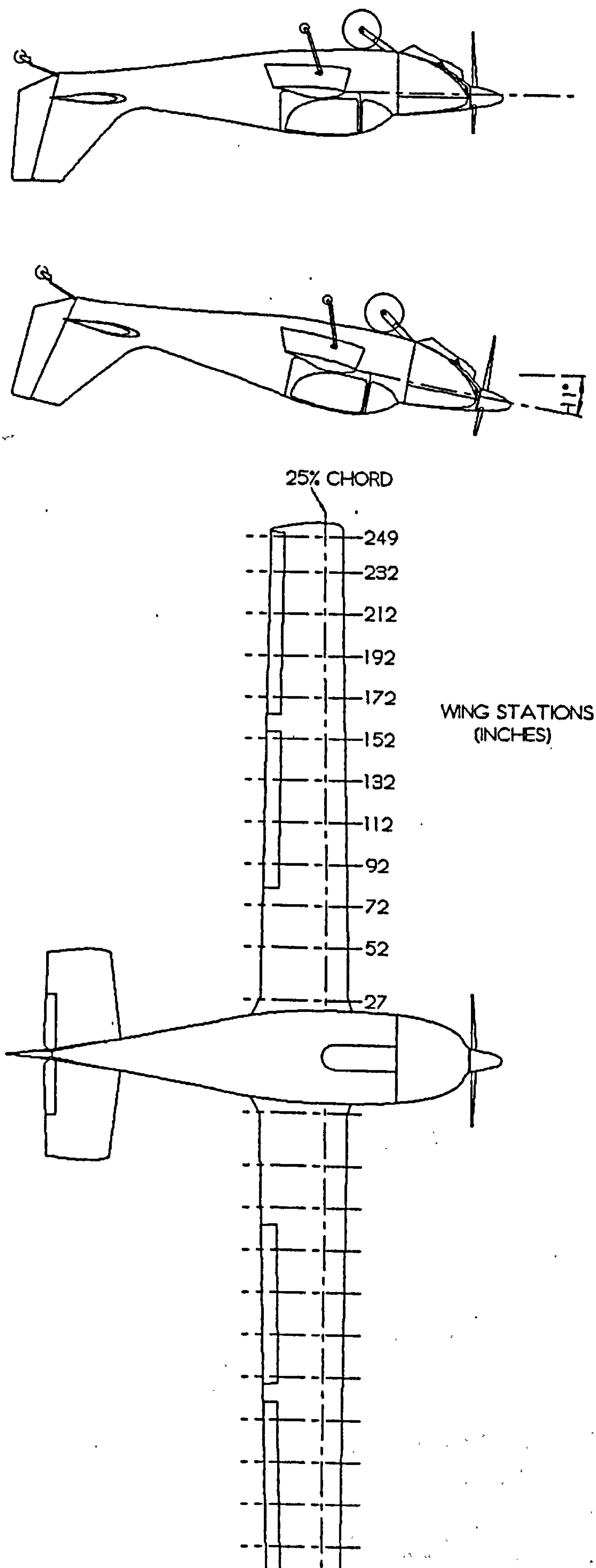
| Checked by: | | Issue: 01 |
| Date: 13/10/98 | | Page of |

Subject:
GLIDER WING PROOF LOAD TEST

INTRODUCTION:

APPENDIX B

INTENTIONALLY BLANK.


11°
25% CHORD
249
232
212
192
172
152
132
112
92
72
52
27
WING STATIONS
(INCHES)

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| STATIC STRUCTURAL DATA | | | | | | | | | | | | | | |
| | | | | | | | LOADING REQUIRED FOR OVERAL WING LIFT OF 1332 lb | | | | | | | |
| | | | | | | INERTIA LOAD FACTOR (g) | | | | | | | | |
| WING STN (in) | LOAD STN | AERO LOAD (in) | INERTIA LOAD (lb) | | 1.00 | 1.50 | 2.00 | 2.50 | 3.00 | 3.50 | 4.00 | 4.50 | 5.00 | 5.30 |
| | Mid Posn (in) | | 140 lb per wing | | Loading at each station in (lb) | | | | | | | | | |
| centre | 0 | 109.43 | | | | | | | | | | | | |
| | 11 | 28.89 | -6.03 | | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 19 | 17.28 | -3.60 | | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| root 23 | 27 | 28.68 | -11.90 | | 16.78 | 25.18 | 33.57 | 41.96 | 50.35 | 58.74 | 67.14 | 75.53 | 83.92 | 88.95 |
| 39.49 | 52 | 56.45 | -11.75 | | 44.71 | 67.06 | 89.42 | 111.77 | 134.12 | 156.48 | 178.83 | 201.18 | 223.54 | 236.95 |
| 62.00 | 72 | 55.51 | -11.59 | | 43.92 | 65.88 | 87.84 | 109.80 | 131.76 | 153.72 | 175.68 | 197.64 | 219.60 | 232.77 |
| 82.00 | 92 | 54.35 | -11.44 | | 42.92 | 64.38 | 85.84 | 107.30 | 128.75 | 150.21 | 171.67 | 193.13 | 214.59 | 227.47 |
| 102.00 | 112 | 52.97 | -11.28 | | 41.68 | 62.53 | 83.37 | 104.21 | 125.05 | 145.90 | 166.74 | 187.58 | 208.42 | 220.93 |
| 122.00 | 132 | 51.32 | -11.13 | | 40.19 | 60.29 | 80.38 | 100.48 | 120.57 | 140.67 | 160.76 | 180.86 | 200.96 | 213.01 |
| 142.00 | 152 | 49.37 | -10.97 | | 38.40 | 57.60 | 76.79 | 95.99 | 115.19 | 134.39 | 153.59 | 172.79 | 191.99 | 203.51 |
| 162.00 | 172 | 47.06 | -10.82 | | 36.24 | 54.36 | 72.48 | 90.60 | 108.72 | 126.84 | 144.96 | 163.08 | 181.20 | 192.07 |
| 182.00 | 192 | 44.27 | -10.66 | | 33.61 | 50.42 | 67.22 | 84.03 | 100.84 | 117.64 | 134.45 | 151.25 | 168.06 | 178.14 |
| 202.00 | 212 | 40.82 | -10.51 | | 30.31 | 45.47 | 60.62 | 75.78 | 90.93 | 106.09 | 121.24 | 136.40 | 151.55 | 160.65 |
| 222.00 | 232 | 36.17 | -10.35 | | 25.82 | 38.73 | 51.64 | 64.55 | 77.46 | 90.37 | 103.28 | 116.19 | 129.10 | 136.84 |
| 241.00 | 249 | 22.32 | -8.17 | | 14.15 | 21.22 | 28.30 | 35.37 | 42.45 | 49.52 | 56.60 | 63.67 | 70.75 | 74.99 |
| tip 258 | 258 | | | | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | | 666.00 | -140.19 | 1 WING | 408.73 | 613.10 | 817.47 | 1021.83 | 1226.20 | 1430.57 | 1634.93 | 1839.30 | 2043.66 | 2166.28 |
| Both wings and fuselage = | | 1332.00 | | 2 WINGS | 817.47 | 1226.20 | 1634.93 | 2043.66 | 2452.40 | 2861.13 | 3269.86 | 3678.60 | 4087.33 | 4332.57 |
| | | | | | INERTIA LOAD FACTOR (g) | | | | | | | | | |
| | | | | | 1.00 | 1.50 | 2.00 | 2.50 | 3.00 | 3.50 | 4.00 | 4.50 | 5.00 | 5.30 |
| | | | | | Loading at each station in (kg) | | | | | | | | | |
| | | | 11 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | | 19 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | | 27 | | 8 | 11 | 15 | 19 | 23 | 27 | 30 | 34 | 38 | 40 |
| | | | 52 | | 20 | 30 | 41 | 51 | 61 | 71 | 81 | 91 | 101 | 108 |
| | | | 72 | | 20 | 30 | 40 | 50 | 60 | 70 | 80 | 90 | 100 | 106 |
| | | | 92 | | 19 | 29 | 39 | 49 | 58 | 68 | 78 | 88 | 97 | 103 |
| | | | 112 | | 19 | 28 | 38 | 47 | 57 | 66 | 76 | 85 | 95 | 100 |
| | | | 132 | | 18 | 27 | 36 | 46 | 55 | 64 | 73 | 82 | 91 | 97 |
| | | | 152 | | 17 | 26 | 35 | 44 | 52 | 61 | 70 | 78 | 87 | 92 |
| | | | 172 | | 16 | 25 | 33 | 41 | 49 | 58 | 66 | 74 | 82 | 87 |
| | | | 192 | | 15 | 23 | 31 | 38 | 46 | 53 | 61 | 69 | 76 | 81 |
| | | | 212 | | 14 | 21 | 28 | 34 | 41 | 48 | 55 | 62 | 69 | 73 |
| | | | 232 | | 12 | 18 | 23 | 29 | 35 | 41 | 47 | 53 | 59 | 62 |
| | | | 249 | | 6 | 10 | 13 | 16 | 19 | 22 | 26 | 29 | 32 | 34 |
| | | | 258 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | | | 1 WING | 185 | 278 | 371 | 464 | 556 | 649 | 742 | 835 | 927 | 983 |
| | | | | 2 WINGS | 371 | 556 | 742 | 927 | 1113 | 1298 | 1484 | 1669 | 1855 | 1966 |

**TEST 2**

**HAA STATIC STRENGTH TEST**

**TABLE 1 MEASURED DEFLECTIONS**

| STARBOARD WING | | | | | PORT WING | | | |
|---|---|---|---|---|---|---|---|---|
| g | ROOT | TIP | | | g | ROOT | TIP | |
| | | LE | TE | | | | LE | TE |
| ZERO | 0.00 | 54.25 | 62.25 | | ZERO | 0.00 | 60.88 | 66.19 |
| 1.0 | 0.00 | 49.50 | 57.75 | | 1.0 | 0.02 | 57.48 | 63.73 |
| 2.0 | 0.01 | 44.49 | 52.74 | | 2.0 | 0.00 | 53.75 | 59.75 |
| 3.0 | 0.01 | 38.80 | 47.49 | | 3.0 | 0.00 | 50.00 | 56.00 |
| 4.0 | 0.00 | 34.75 | 43.00 | | 4.0 | 0.00 | 46.00 | 52.00 |
| 4.5 | 0.02 | 32.98 | 40.98 | | 4.5 | 0.00 | 44.00 | 50.00 |
| 5.0 | 0.00 | 31.00 | 39.50 | | 5.0 | 0.01 | 41.49 | 46.99 |
| 5.3 | 0.00 | 29.00 | 37.50 | | 5.3 | 0.03 | 40.97 | 46.97 |
| RE-ZERO | 0.00 | 52.00 | 60.00 | | RE-ZERO | 0.00 | 58.50 | 63.50 |
| PERM SET | | 2.25 | 2.25 | | PERM SET | | 2.38 | 2.69 |

**TABLE 2 DEFLECTIONS**

| STARBOARD WING | | | | | PORT WING | | | |
|---|---|---|---|---|---|---|---|---|
| | g | LE | TE | | | g | LE | TE |
| | 1.0 | 4.75 | 4.50 | | | 1.0 | 3.40 | 2.46 |
| | 2.0 | 9.76 | 9.51 | | | 2.0 | 7.13 | 6.44 |
| | 3.0 | 15.45 | 14.76 | | | 3.0 | 10.88 | 10.19 |
| | 4.0 | 19.50 | 19.25 | | | 4.0 | 14.88 | 14.19 |
| | 4.5 | 21.27 | 21.27 | | | 4.5 | 16.88 | 16.19 |
| | 5.0 | 23.25 | 22.75 | | | 5.0 | 19.39 | 19.20 |
| | 5.3 | 25.25 | 24.75 | | | 5.3 | 19.91 | 19.22 |

**TABLE 3 DEFLECTION PER G**

| STARBOARD WING | | | | | PORT WING | | | |
|---|---|---|---|---|---|---|---|---|
| | g | LE | TE | | | g | LE | TE |
| | 1.0 | 4.75 | 4.50 | | | 1.0 | 3.40 | 2.46 |
| | 2.0 | 5.01 | 5.01 | | | 2.0 | 3.73 | 3.98 |
| | 3.0 | 5.69 | 5.25 | | | 3.0 | 3.75 | 3.75 |
| | 4.0 | 4.05 | 4.49 | | | 4.0 | 4.00 | 4.00 |
| | 4.5 | 1.77 | 2.02 | | | 4.5 | 2.00 | 2.00 |
| | 5.0 | 1.98 | 1.48 | | | 5.0 | 2.51 | 3.01 |
| | 5.3 | 2.00 | 2.00 | | | 5.3 | 0.52 | 0.02 |

| | HAA STBD A | PORT AV DEF |
|---|---|---|
| 1.0 | 4.63 | 2.93 |
| 2.0 | 9.64 | 6.79 |
| 3.0 | 15.11 | 10.54 |
| 4.0 | 19.38 | 14.54 |
| 4.5 | 21.27 | 16.54 |
| 5.0 | 23.00 | 19.30 |
| 5.3 | 25.00 | 19.57 |

| TEST 2 | | | | | | | |
|---|---|---|---|---|---|---|---|
| HAA STATIC STRENGTH TEST | | | | | | | |
| | | | | | | | |
| TABLE 4 TORSIONAL DEFLECTIONS | | | | | | | |
| | | | | | | | |
| STARBOARD WING | | | | | PORT WING | | |
| | | | | | | | |
| | g | $\Delta_Z$ | DEG | | g | $\Delta_Z$ | DEG |
| | 1.0 | 0.25 | 0.41 | | 1.0 | 0.94 | 1.54 |
| | 2.0 | 0.25 | 0.41 | | 2.0 | 0.69 | 1.13 |
| | 3.0 | 0.69 | 1.13 | | 3.0 | 0.69 | 1.13 |
| | 4.0 | 0.25 | 0.41 | | 4.0 | 0.69 | 1.13 |
| | 4.5 | 0.00 | 0.00 | | 4.5 | 0.69 | 1.13 |
| | 5.0 | 0.50 | 0.82 | | 5.0 | 0.19 | 0.31 |
| | 5.3 | 0.50 | 0.82 | | 5.3 | 0.69 | 1.13 |
| | | | | | | | |
| TABLE 5 TORSIONAL DEFLECTION PER G | | | | | | | |
| | | | | | | | |
| STARBOARD WING | | | | | PORT WING | | |
| | | | | | | | |
| | g | $\Delta_Z$ | DEG | | g | $\Delta_Z$ | DEG |
| | 1.0 | 0.25 | 0.41 | | 1.0 | 0.94 | 1.54 |
| | 2.0 | 0.00 | 0.00 | | 2.0 | -0.25 | -0.41 |
| | 3.0 | 0.44 | 0.72 | | 3.0 | 0.00 | 0.00 |
| | 4.0 | -0.44 | -0.72 | | 4.0 | 0.00 | 0.00 |
| | 4.5 | -0.25 | -0.41 | | 4.5 | 0.00 | 0.00 |
| | 5.0 | 0.50 | 0.82 | | 5.0 | -0.50 | -0.82 |
| | 5.3 | 0.00 | 0.00 | | 5.3 | 0.50 | 0.82 |

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Subject:

GLIDER WING PROOF LOAD TEST

INTRODUCTION:

APPENDIX C

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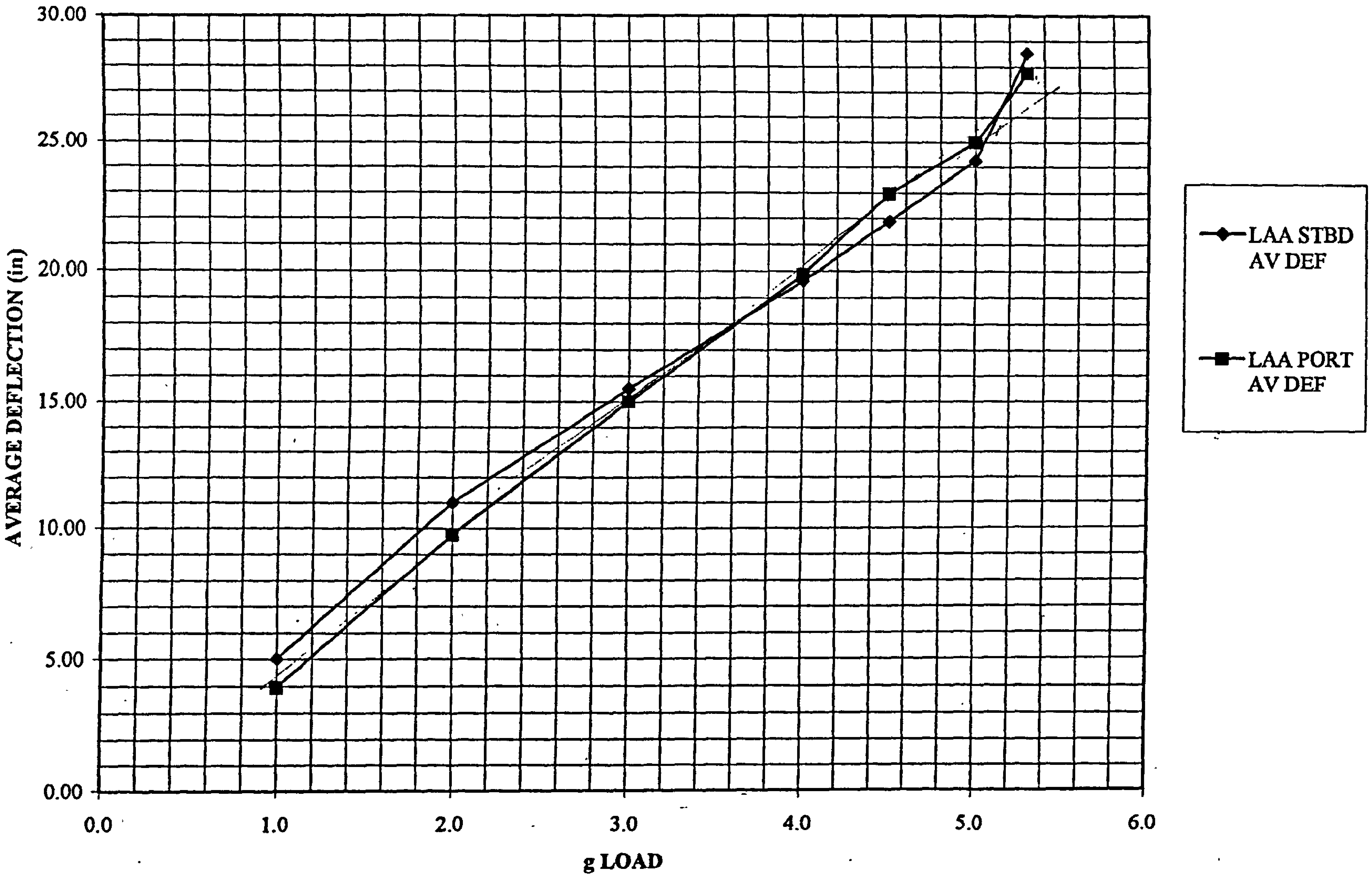
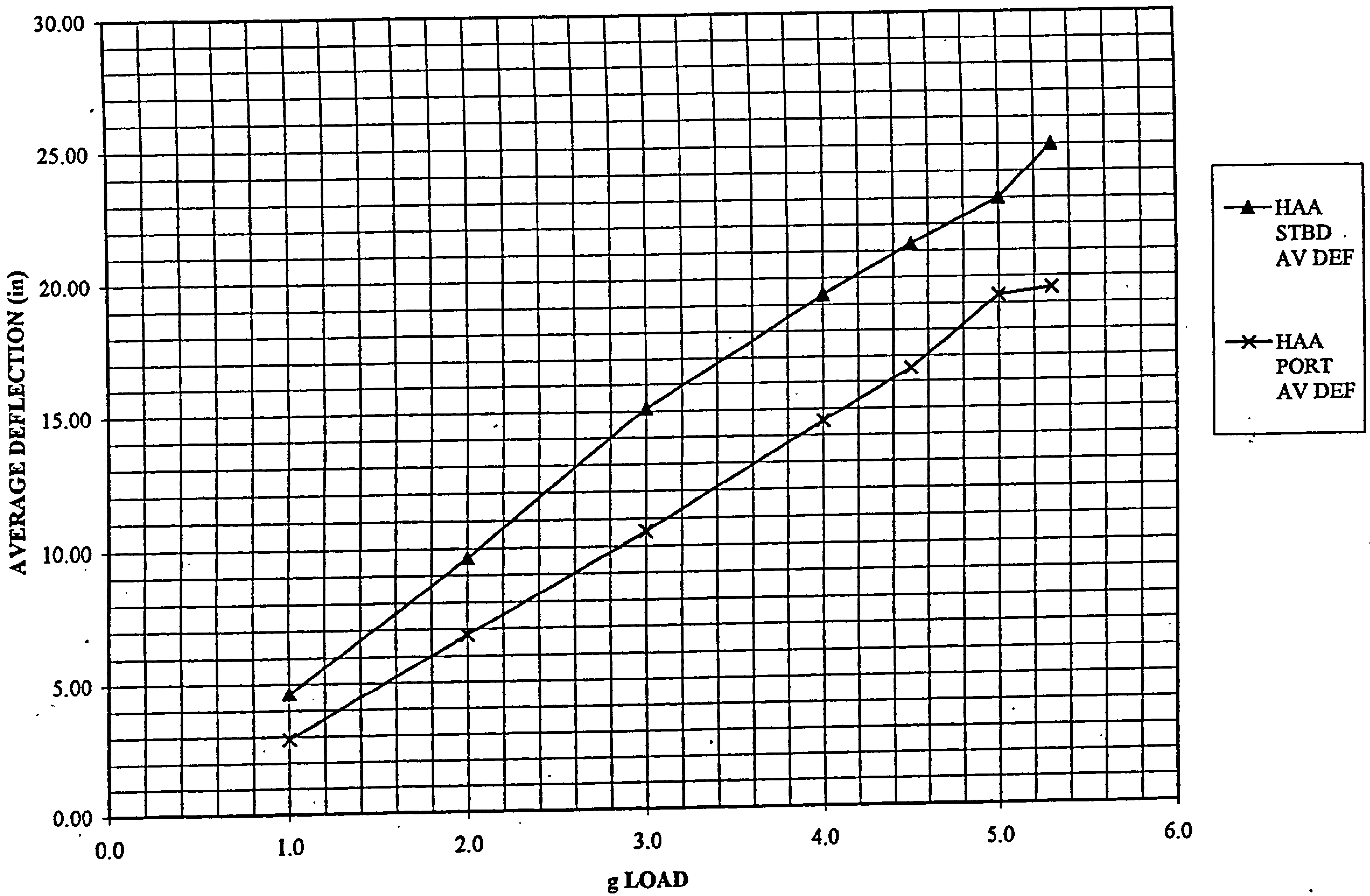
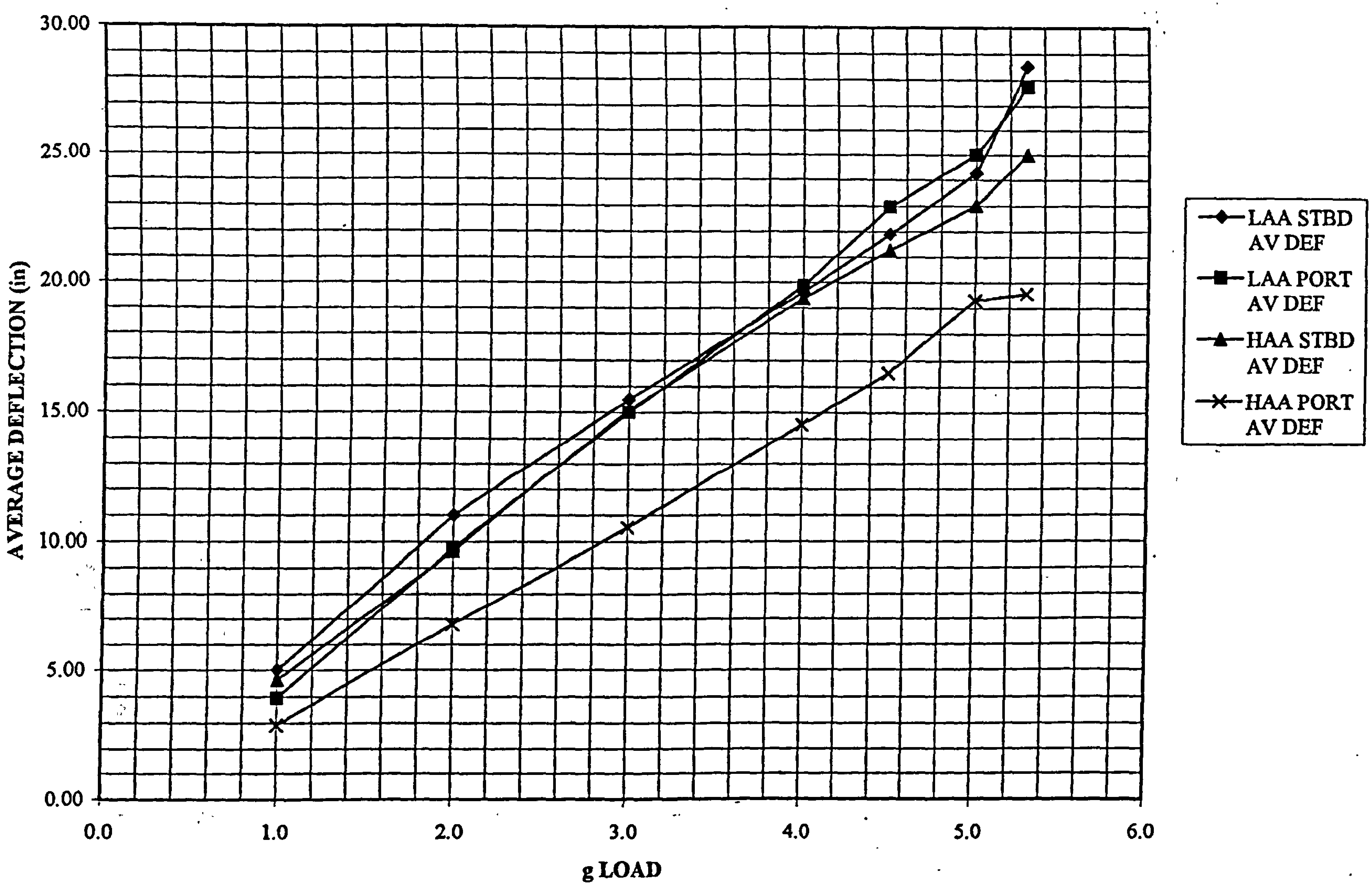
# TEST 1
## LAA STATIC STRENGTH TEST



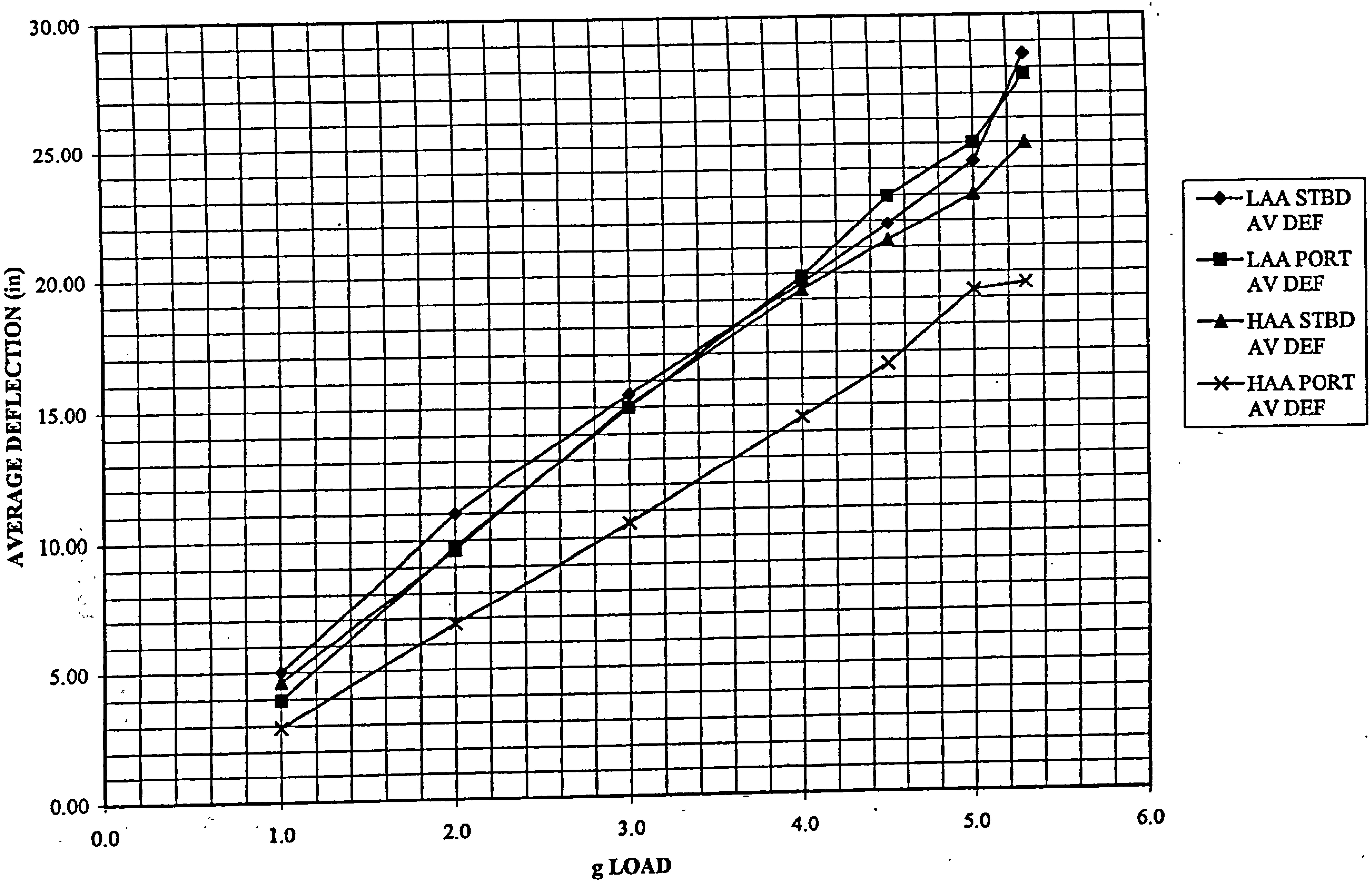
**TEST 2**
**HAA STATIC STRENGTH TEST**



LAA & HAA STATIC STRENGTH TEST



LAA & HAA STATIC STRENGTH TEST



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Subject: APPLIED WEIGHT CHECK

INTRODUCTION:

(A)

NORMAL SHEAR FORCE FROM PFA CHECK @ STN 22 = 2366 lb.
NORMAL SHEAR FORCE FROM APPLIED LOADING = 2836 lb.

(B)

NORMAL BENDING MOMENT FROM PFA CHECK @ STN22 = 247687 lbin

NORMAL BENDING MOMENT FROM APPLIED LOADING @ STN 22 = 240141 lbin

(C)

TORSION APPLIED TO WING

HAA & LAA TEST.

100% LOAD @ 25% CHORD
MOMENT ABT SPAR = $(0.4-0.25)1 = 0.15$

HAA THEORY

76% LOAD @ 14% CHORD
24% LOAD @ 60% CHORD FROM JAR VLA.

MOMENT ABT SPAR

$= (0.4-0.14)*0.76 - (0.6-0.4)*0.24$

$= 0.1976 - 0.048$

$= 0.15$

GIVES SAME RESULTANT MOMENT ⇒ HAA SKIN COMBINED TENSION/COMPRESSION & SHEAR IS CORRECT.

HAA THEORY GIVES A RIB BENDING MOMENT WHICH IS $\left(1-\frac{0.15}{0.1976}\right)*100 =$ 24% HIGHER THAN TESTED

TEST GAVE 24% HIGHER VERTICAL SHEAR IN LE RIB TO SPAR BOND THAN TESTED.

LAA THEORY

/PTO

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Subject:

APPLIED WEIGHT CHECK

INTRODUCTION:

LAA THEORY

73% LOAD @ 19% CHORD &
27% LOAD @ 61% CHORD.

MOMENT ABT SPAR

$= 0.73 * (0.4 - 0.19) - (0.61 - 0.4) * 0.27$
$= 0.1533 - 0.0567$
$= 0.0966.$

LAA TEST GIVES HIGHER LOAD IN SKINS

$\left(1 - \frac{0.0966}{0.15}\right) * 100 =$ 35% HIGHER TENSION/COMPRESSION & SHEAR IN SKINS WAS EXPERIENCED DURING TEST.

LAA TEST GIVES SIMILAR LE RIB BENDING MOMENT TO THAT OF LAA THEORY
0.15 COMPARED WITH 0.1533.

LAA TEST PUT 100-35 = 65% MORE VERTICAL SHEAR IN LESPAR TO RIB BOND THAN THEORY.

TEST ANGLES.

$\rho = 0.00238$
WING AREA $= 135 ft^2$
AIRSPEED = 94kts $= \sqrt{5.3} * 41$
$= 158.9$ ft/sec
AUW = 1300 lb
$AR = \frac{b^2}{S} = 13.70$
$e = 0.8.$

Subject:
APPLIED WEIGHT CHECK

INTRODUCTION:

HAA TEST

$C_L = 1.7$

$LIFT = qSC_L = 6885.27$ lb

$g = 5.3$

$$\alpha = \left(\frac{C_L - 0.5}{0.096}\right) + 2 = 14\tfrac{1}{2} \text{ DEG}$$

$C_{Dp} = 0.021$

$$C_{Di} = \frac{C_L^2}{\pi ARe} = 0.084$$

$C_D = C_{Dp} + C_{Di}$
$= 0.021 + 0.084$
$= 0.105$

$DRAG = qSC_D$
$= 425.09$ lb

$$ATAN\left(\frac{425.09}{6885.27}\right) = 3.53°$$

$14\tfrac{1}{2} - 3.53 = 10.97°$
$= 11°$

TEST RIG SET AT 11° DECLINATION

LAA TEST

AIRSPEED = 183.3 kts
= 309.69 ft/sec

$C_L = 0.338$

$LIFT = 5200$ lb

$g = 4.0$

$\alpha = 0.31$

$C_{Dp} = 0.005$

$C_{Di} = 0.003$

$C_D = 0.008$

$DRAG = qSC_D$
$= 128.02$ lb

$$ATAN = \left(\frac{128.02}{5200}\right) = 1.41$$

$0.31 - (1.41) = -1.1°$

TEST RIG SET AT 0° DECLINATION

| | | | |
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Subject: GLIDER WING FLIGHT ENVELOPE

INTRODUCTION:

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Subject:
GLIDER WING FLIGHT ENVELOPE

INTRODUCTION:

AIRCRAFT WEIGHT ESTIMATE FOR SINGLE PILOT FLIGHT TESTS.

| | | |
|---|---|---|
| G-ODTI | EMPTY WT | 882 lb |
| | XS WINGS | 180 lb |
| | | 702 lb |

| | |
|---|---|
| G-ODTI EMPTY WT | 702 lb |
| MOTORGLIDER WINGS | 280 lb |
| PILOT | 200 lb |
| FUEL / BALLAST | 18 lb |
| | 1200 lb |

$n_1 = \frac{1300}{1200} * 5.3g \Rightarrow 5.74g$ LIMIT.

CONSIDERING TEST FACTORS FOR MANU' VARIABILITY $K_V = 1.20$ FROM ACJ-VLA 619(a) & ASSUMING A FULLY MOISTURE CONDITIONED SPECIMAN OF $K_M = 1.0$

THEN TEST FACTOR $= 1.2 * 1.0 = 1.2$.

$\therefore n_1 = \frac{5.74}{1.2} = 4.78g$.

AIRBRAKE g LOAD $= \frac{2}{3} n_1 = \frac{2}{3} * 4.78$
$= 3.2g$

NEGATIVE g LOAD $= \frac{n_1}{2} = \frac{4.78}{2} = -2.39g$.

EUROPA DEVELOPMENTS DEFINED ENVELOPE

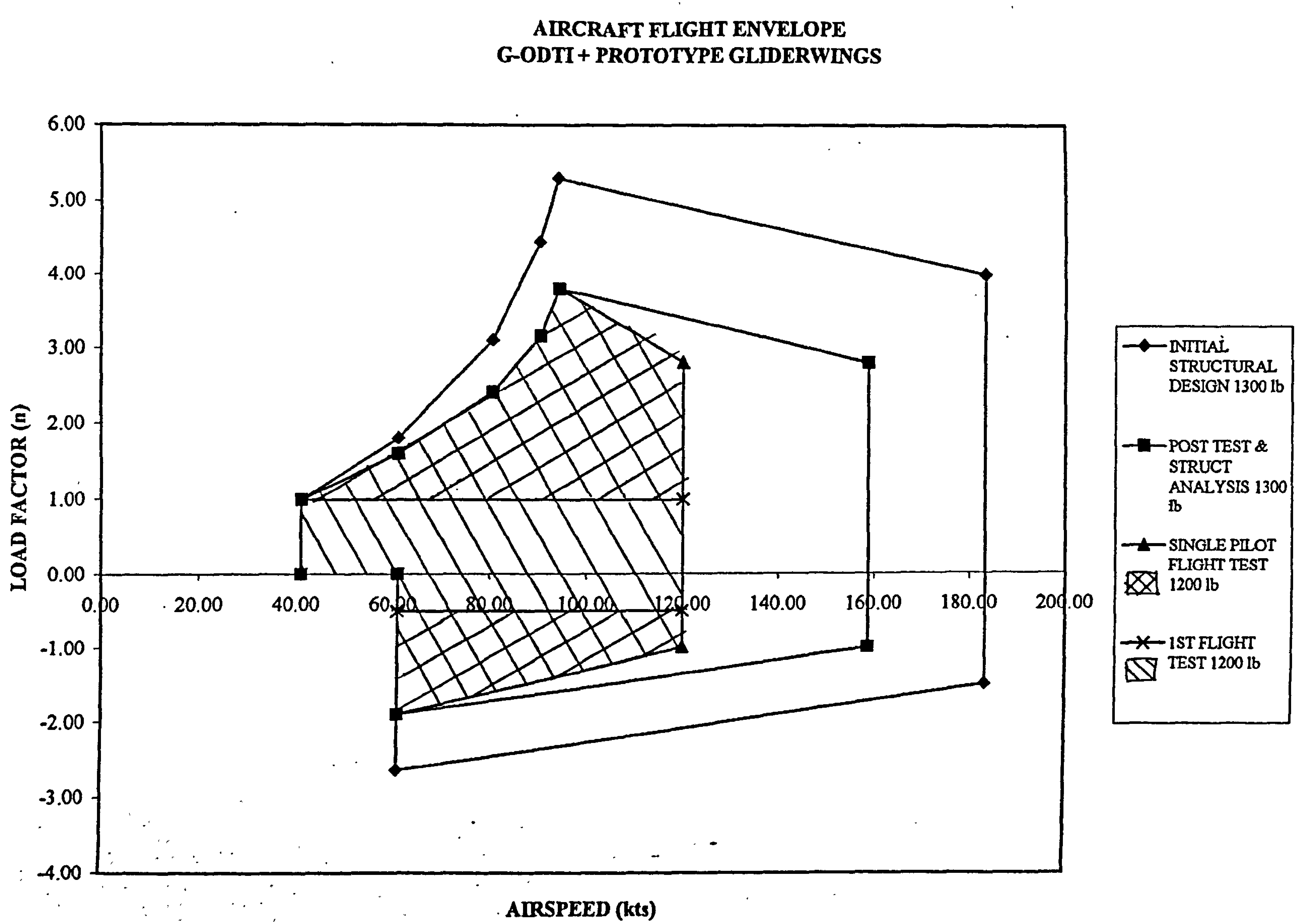
$n_1 = 3.8g$.

$-\frac{n_1}{2} = -1.9g$ NEGATIVE g

$\frac{2}{3} n_1 = 2.5g$ + AIRBRAKE DEPLOYMENT
0.0g

SCALING SIMILAR TO JAR 22 APPROACH

| FLT ENV TYPE | | INITIAL STRUCTURAL DESIGN 1300 lb | | POST TEST & STRUCT ANALYSIS 1300 lb | | SINGLE PILOT FLIGHT TEST 1200 lb | | 1ST FLIGHT TEST 1200 lb |
|---|---|---|---|---|---|---|---|---|
| W | 1300 | | 1300 | | 1200 | | | |
| | V | n | V | n | V | n | V | n |
| $V_{S0}$ | 41.00 | 1.00 | 41.00 | 1.00 | 41.00 | 1.00 | 41.00 | 1.00 |
| $V_{S1}$ | 41.00 | 1.00 | 41.00 | 1.00 | 41.00 | 1.00 | 41.00 | 1.00 |
| $V_A$ | 94.00 | 5.30 | 94.00 | 3.80 | 80.00 | 3.80 | 80.00 | 3.80 |
| $V_{A\,neg}$ | 61.00 | -1.50 | 61.00 | -1.00 | 61.00 | -1.00 | 61.00 | -1.00 |
| $V_{C\,GUST}$ | 94.00 | 5.30 | 94.00 | 3.80 | 80.00 | 3.80 | 80.00 | 3.80 |
| $V_{NE}$ | 165.00 | 4.00 | 143.00 | 2.80 | 108.00 | 2.80 | 108.00 | 2.80 |
| $V_D$ | 183.33 | 4.00 | 158.89 | 2.80 | 120.00 | 2.80 | 120.00 | 2.80 |
| $V_{D\,neg}$ | 183.33 | -2.65 | 158.89 | -1.90 | 120.00 | -1.90 | 120.00 | -1.90 |
| $V_{D\,brakes}$ | 183.33 | 3.50 | 158.89 | 2.50 | 120.00 | 2.50 | 120.00 | 2.50 |
| $V_{D\,FLUTTER}$ | 220.00 | 4.00 | 190.67 | 2.80 | 144.00 | 2.80 | 144.00 | 2.80 |


AIRCRAFT FLIGHT ENVELOPE
G-ODTI + PROTOTYPE GLIDERWINGS
6.00
5.00
4.00
3.00
2.00
1.00
0.00
-1.00
-2.00
-3.00
-4.00
LOAD FACTOR (n)
0.00
20.00
40.00
60.00
80.00
100.00
120.00
140.00
160.00
180.00
200.00
AIRSPEED (kts)
INITIAL STRUCTURAL DESIGN 1300 lb
POST TEST & STRUCT ANALYSIS 1300 lb
SINGLE PILOT FLIGHT TEST 1200 lb
1ST FLIGHT TEST 1200 lb