THE FORMATION, PROPERTIES AND BEHAVIOUR OF COASTAL SOFT SOIL DEPOSITS AT PERLIS AND OTHER SITES IN PENINSULAR MALAYSIA

by

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VOLUME II

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Glasgow

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بِسْمِ اللَّهِ الرَّحْمَٰنِ الرَّحِيمِ

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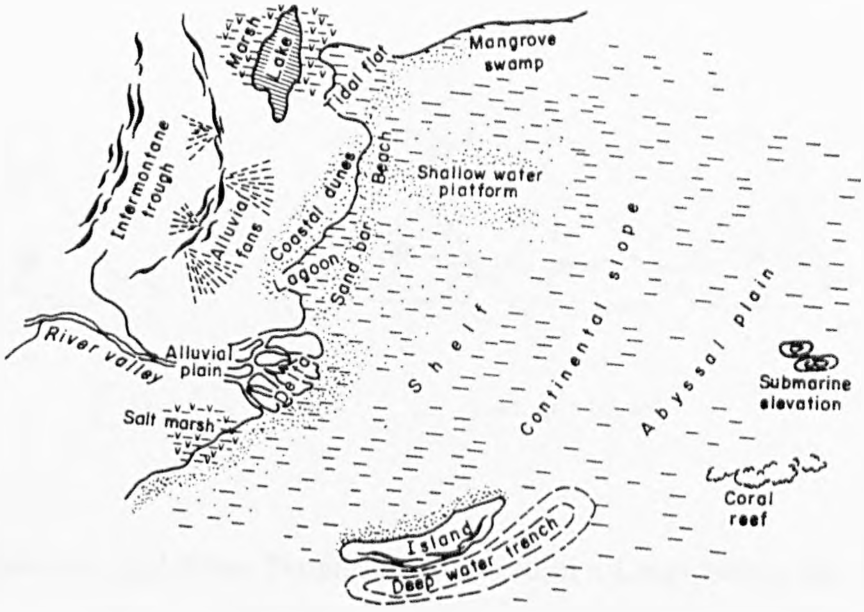

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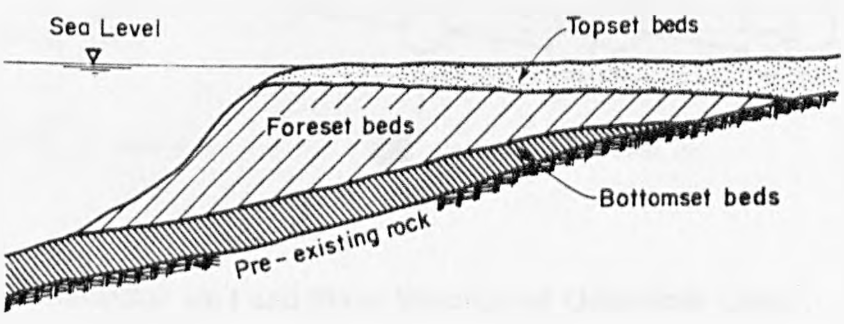

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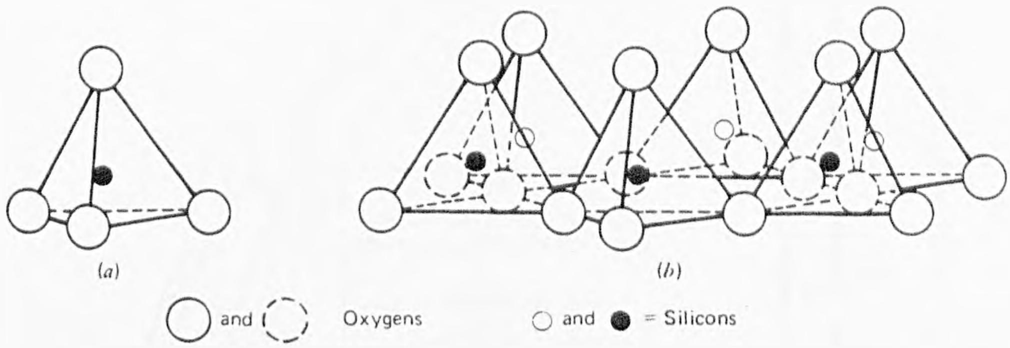

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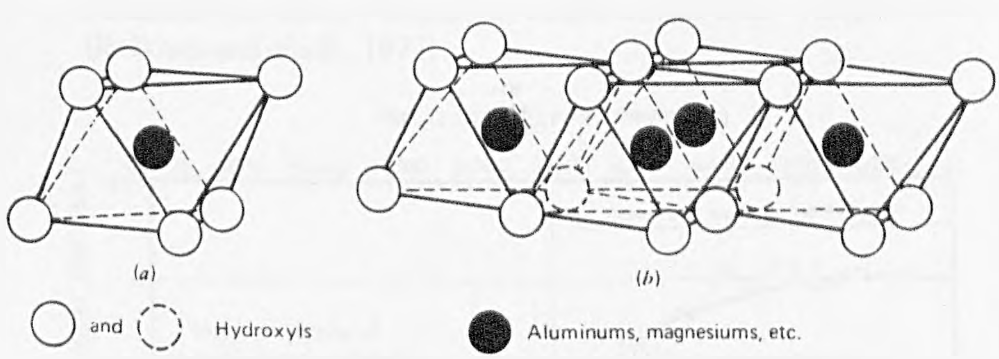

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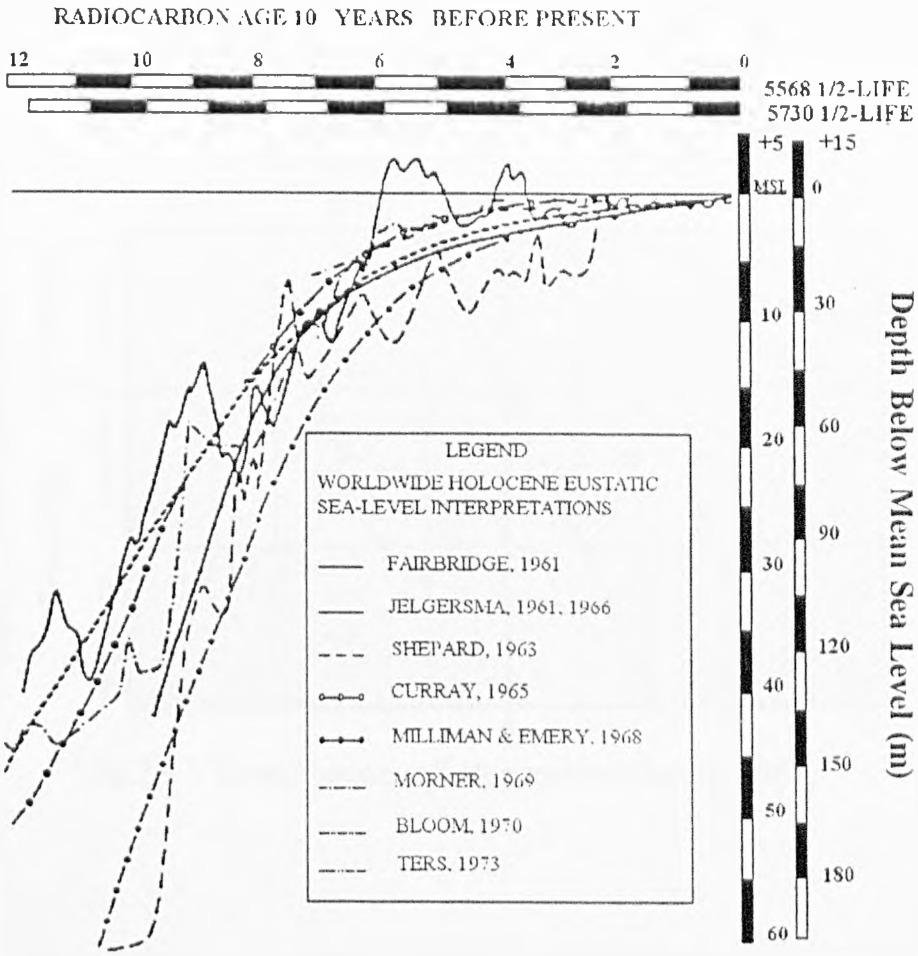

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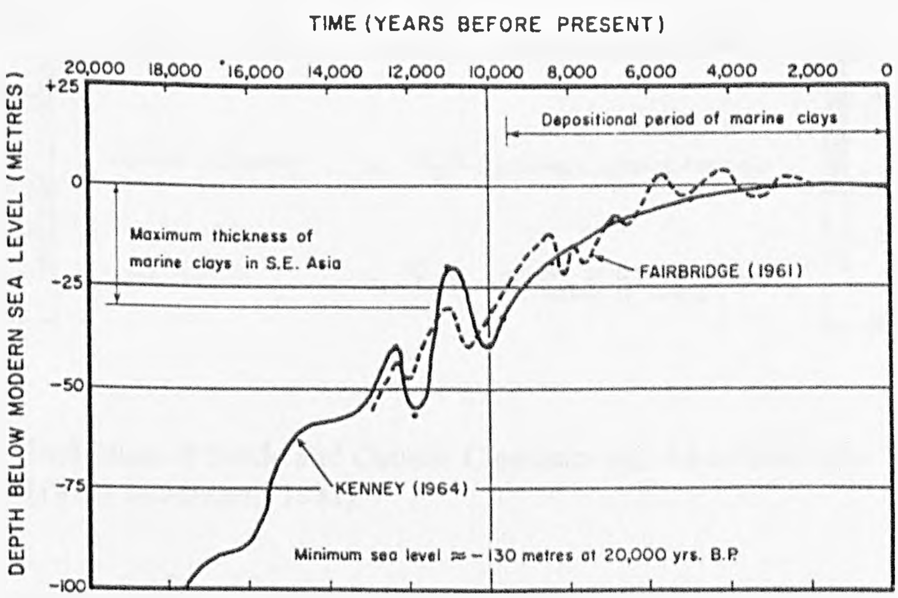

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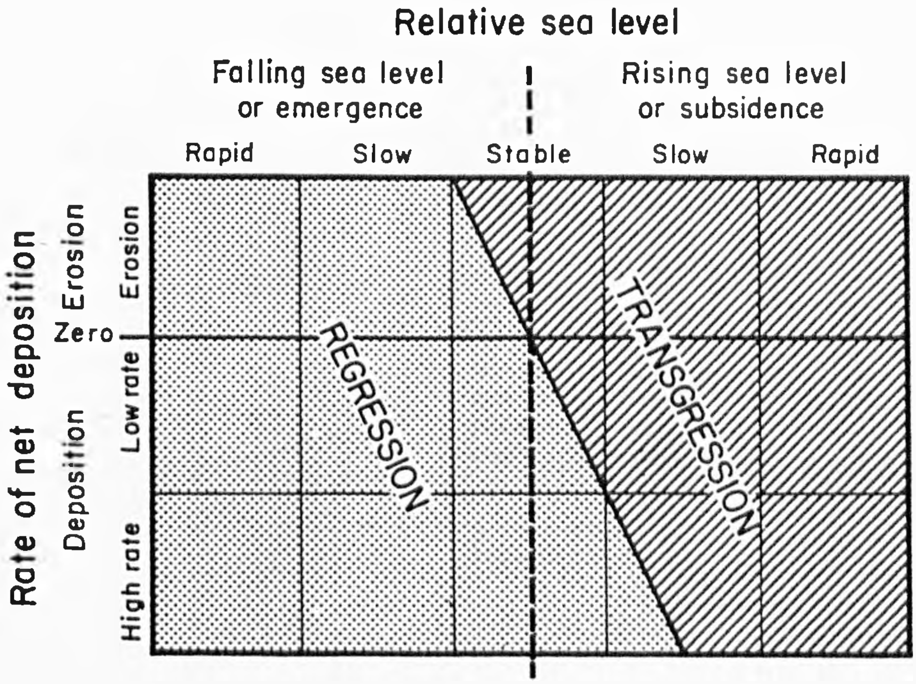

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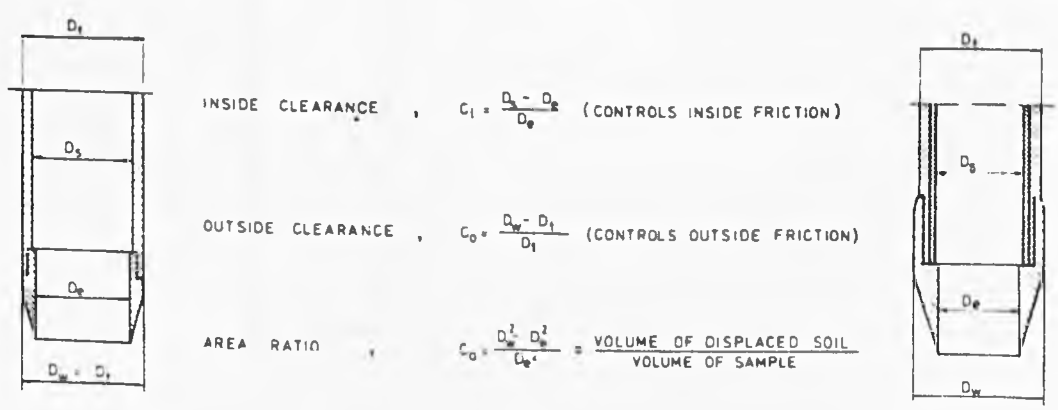

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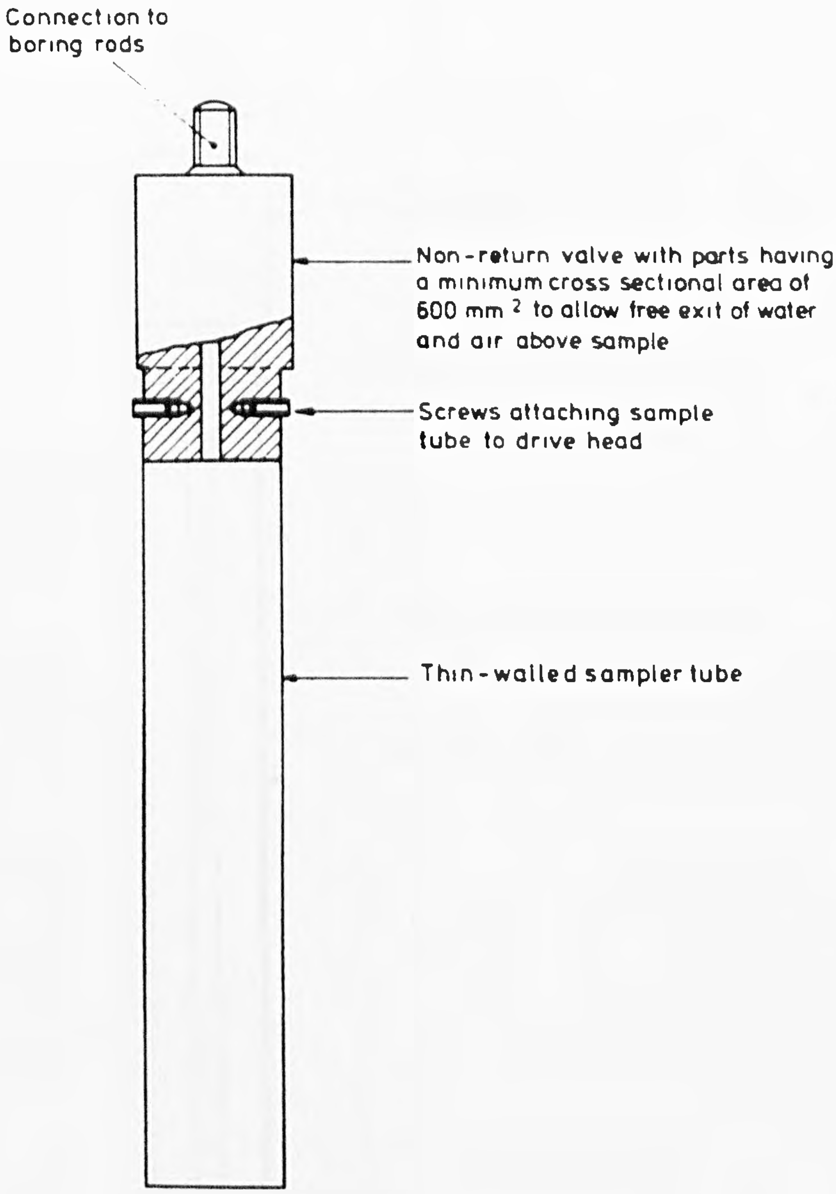

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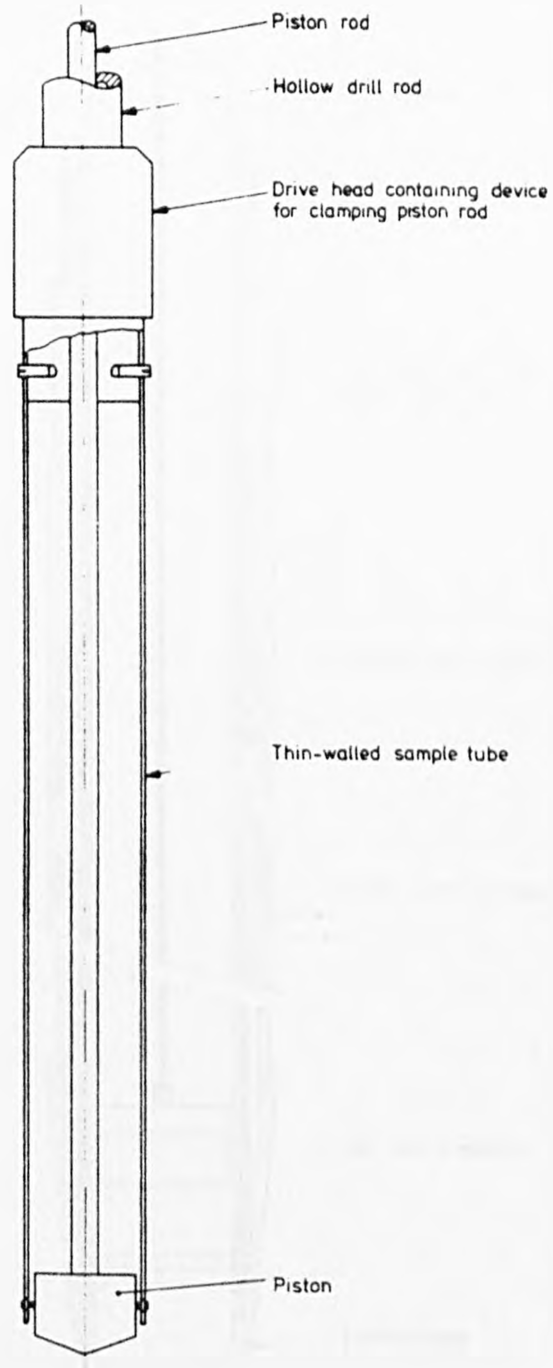

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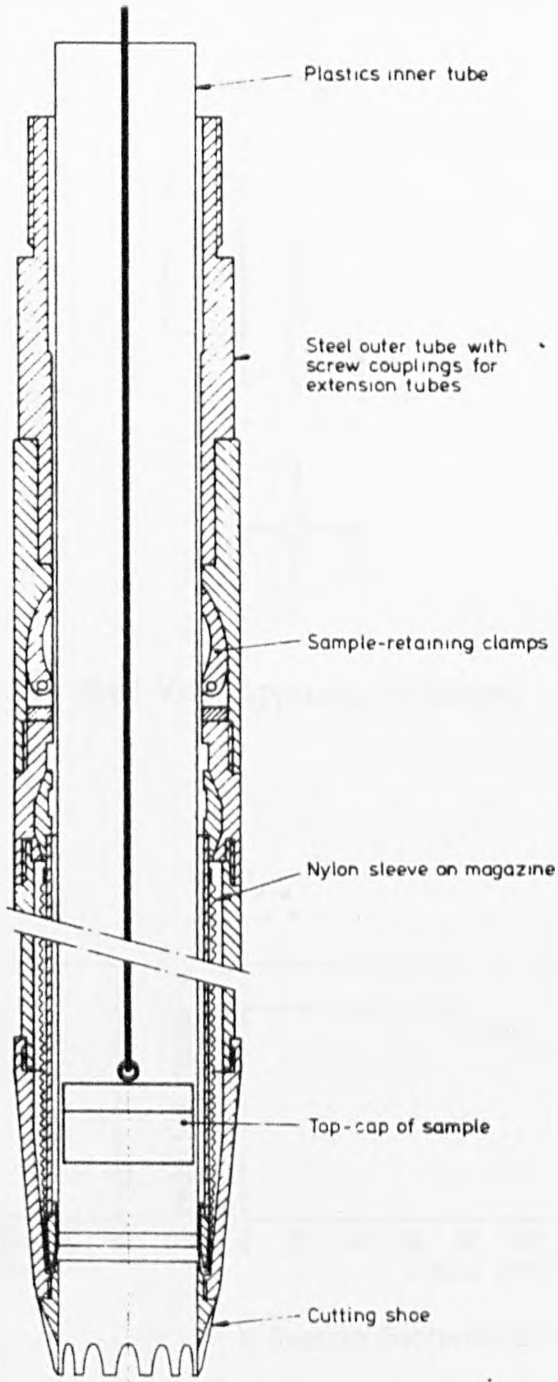

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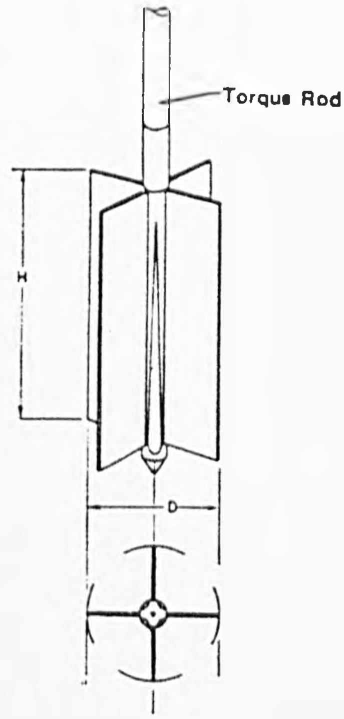

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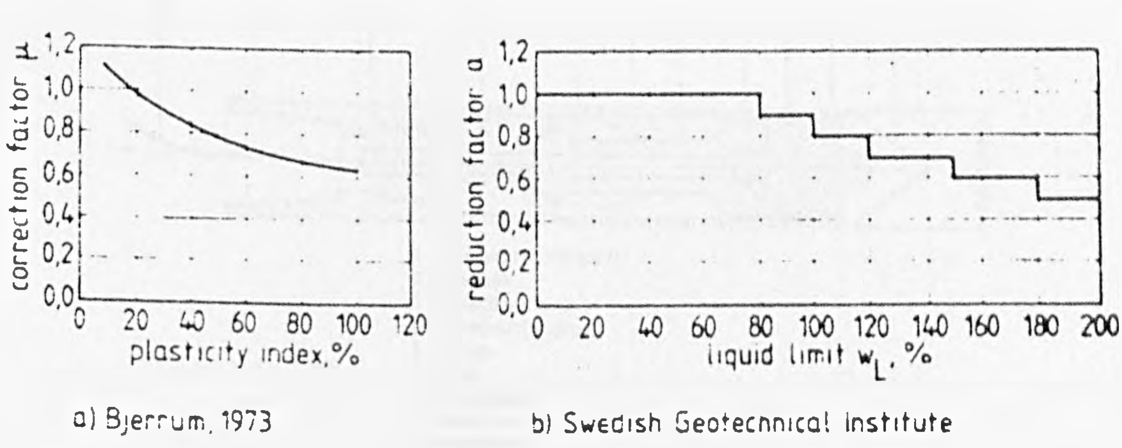

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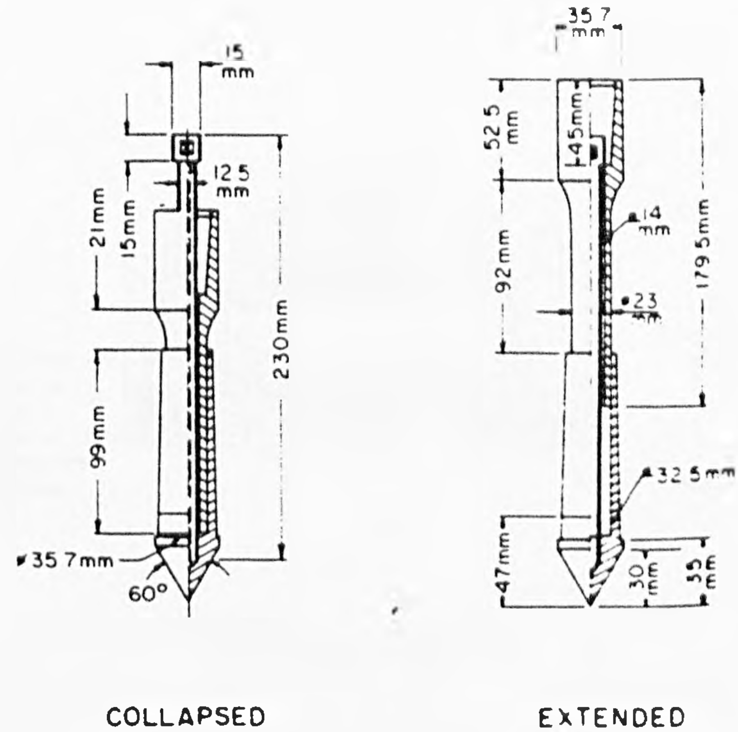
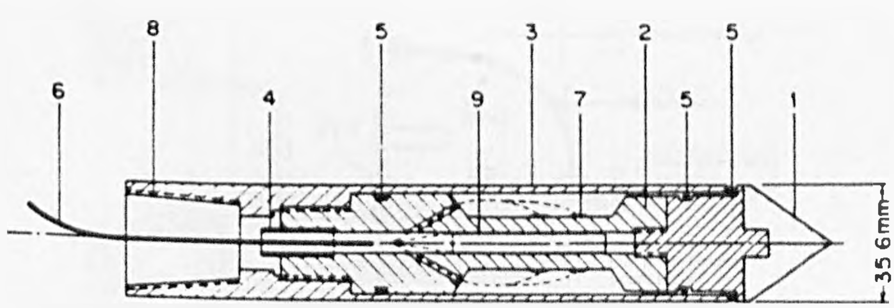


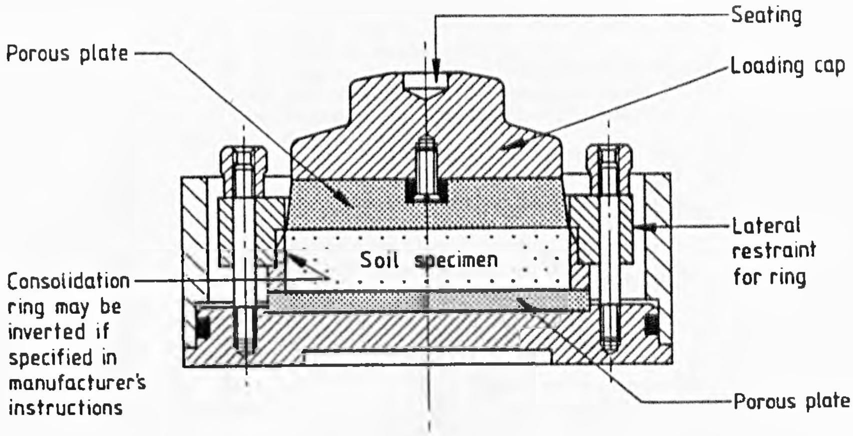
a. Dutch Cone Penetrometer Tip



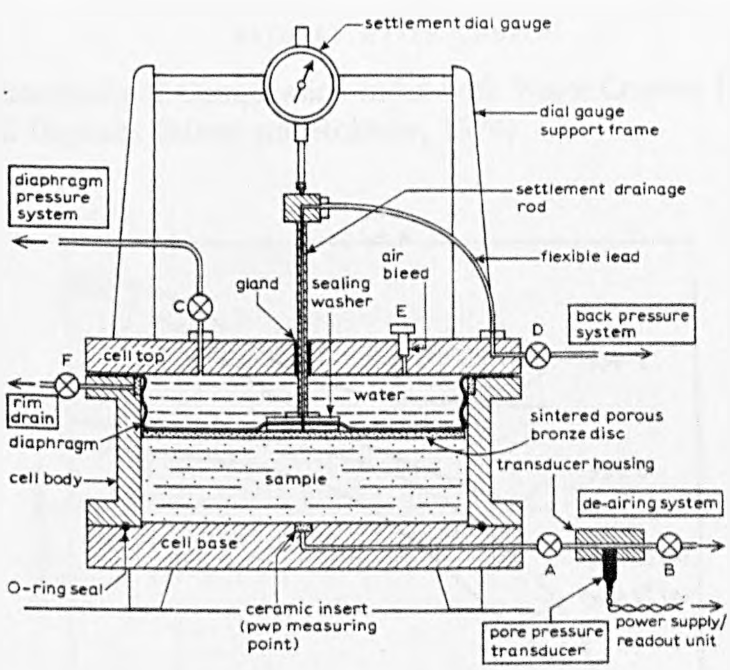
1 Conical point (10 cm²)
2 Load cell
3 Protective mantle
4 Waterproof bushing
5 O-rings
6 Cable
7 Strain gages
8 Connection with rods
9 Inclinometer

b. Electric Cone Penetrometer Tip

Fig.2.13 : Dutch Cone and Electric Cone Penetrometer (ASTM, 1986)



a. Standard Oedometer



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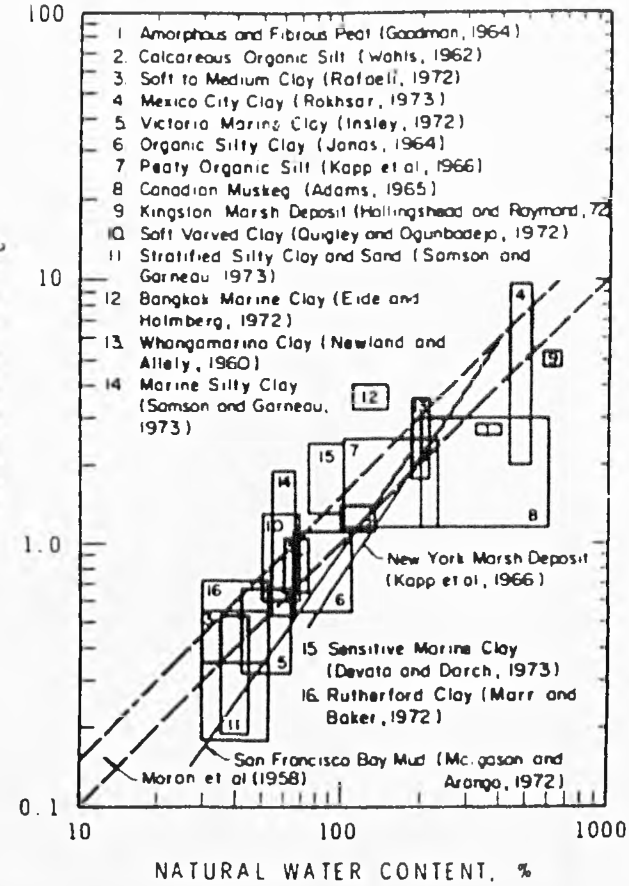

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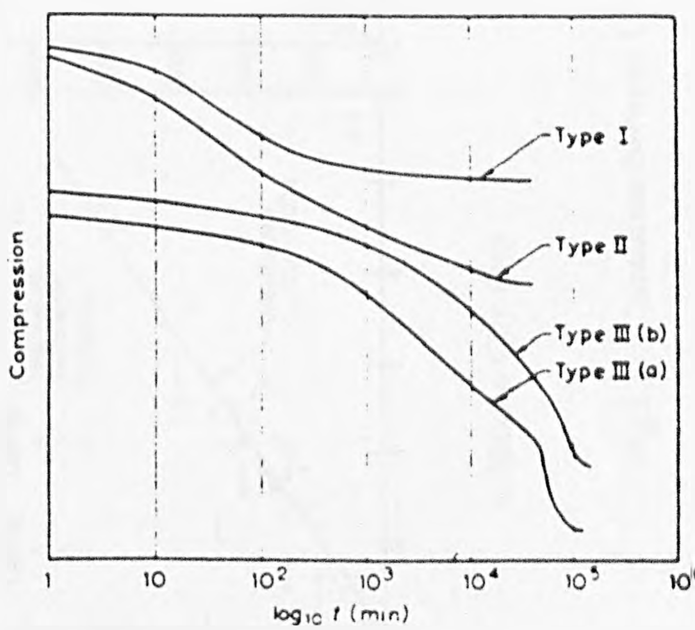

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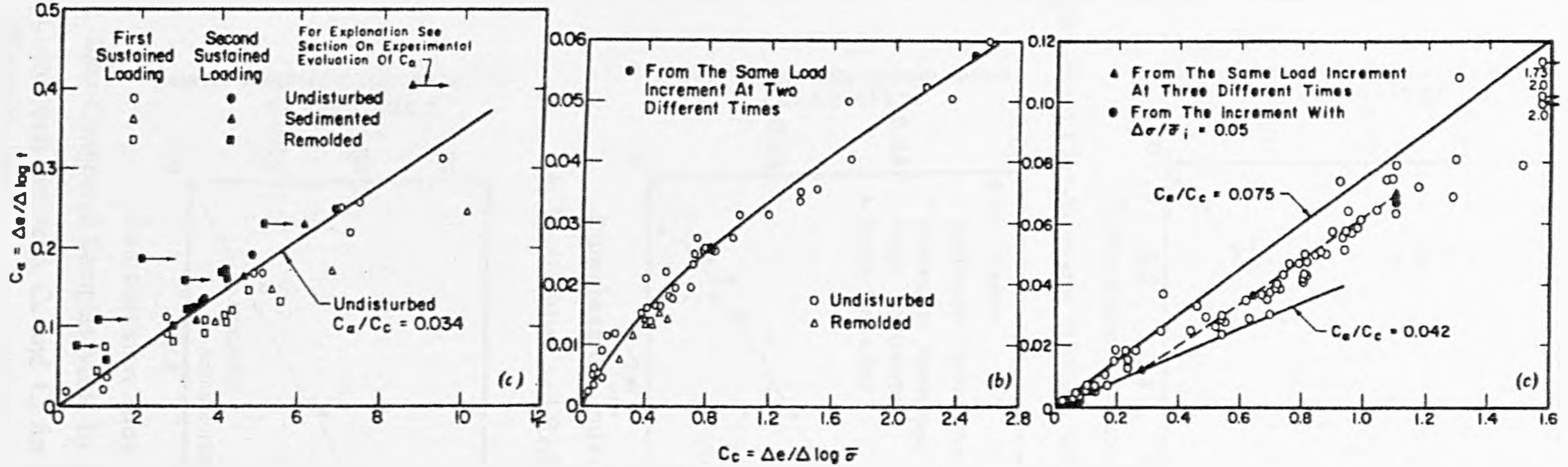

a. Mexico City Clay

b. Leda Clay

c. Undisturbed New Haven Organic Clay Silt

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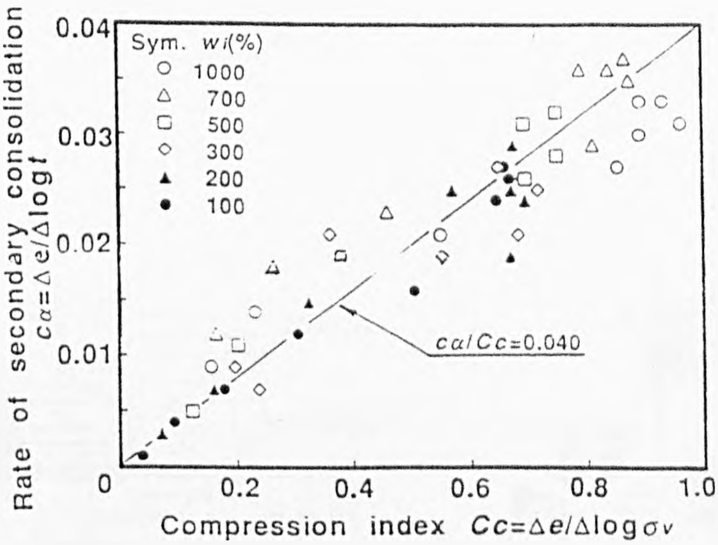

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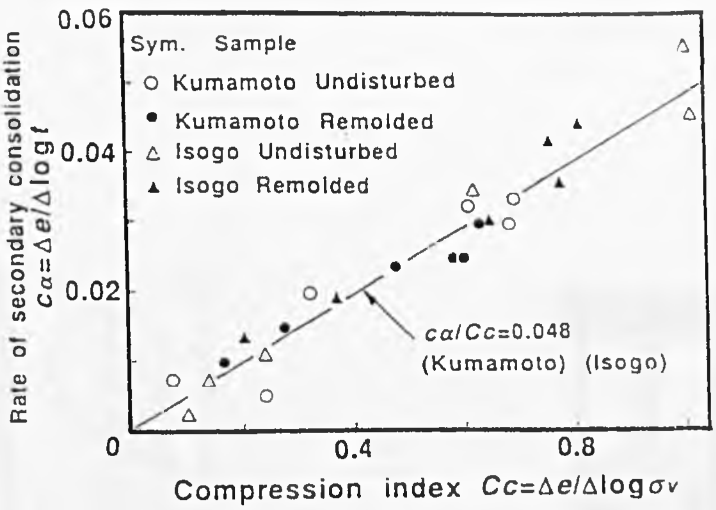

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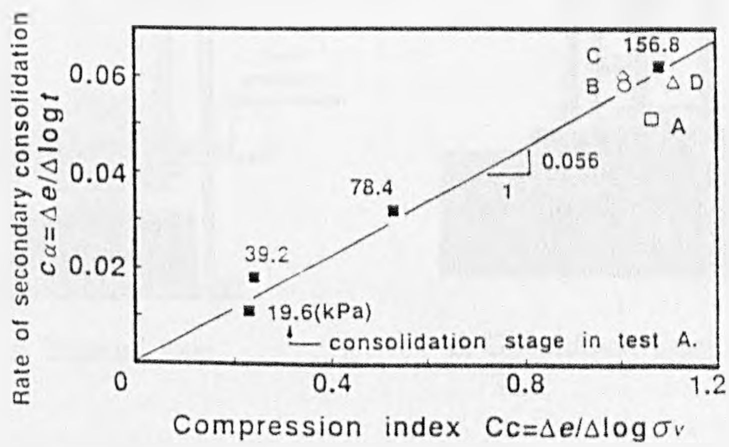

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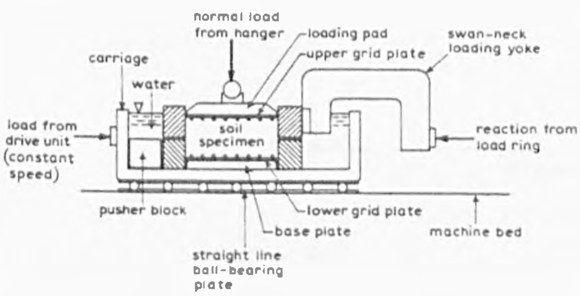
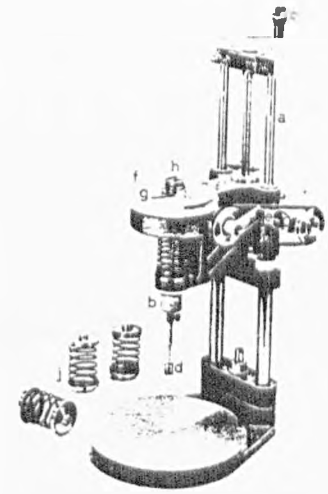
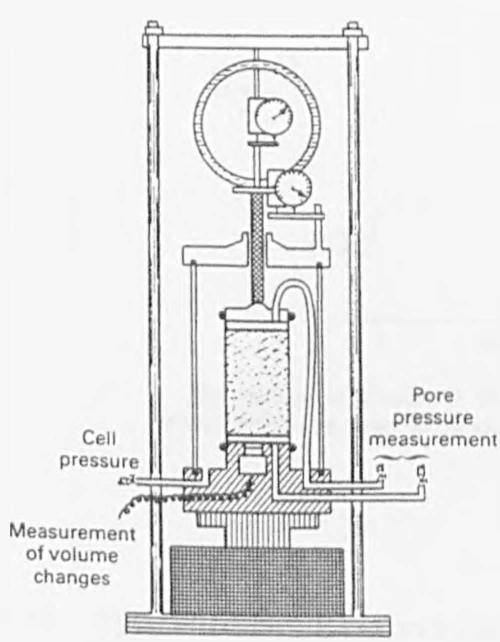


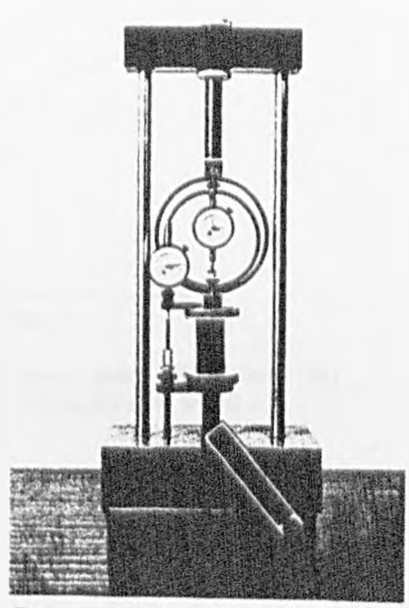
a. Direct Shear Test



b. Laboratory Vane
Test



c. Triaxial Test



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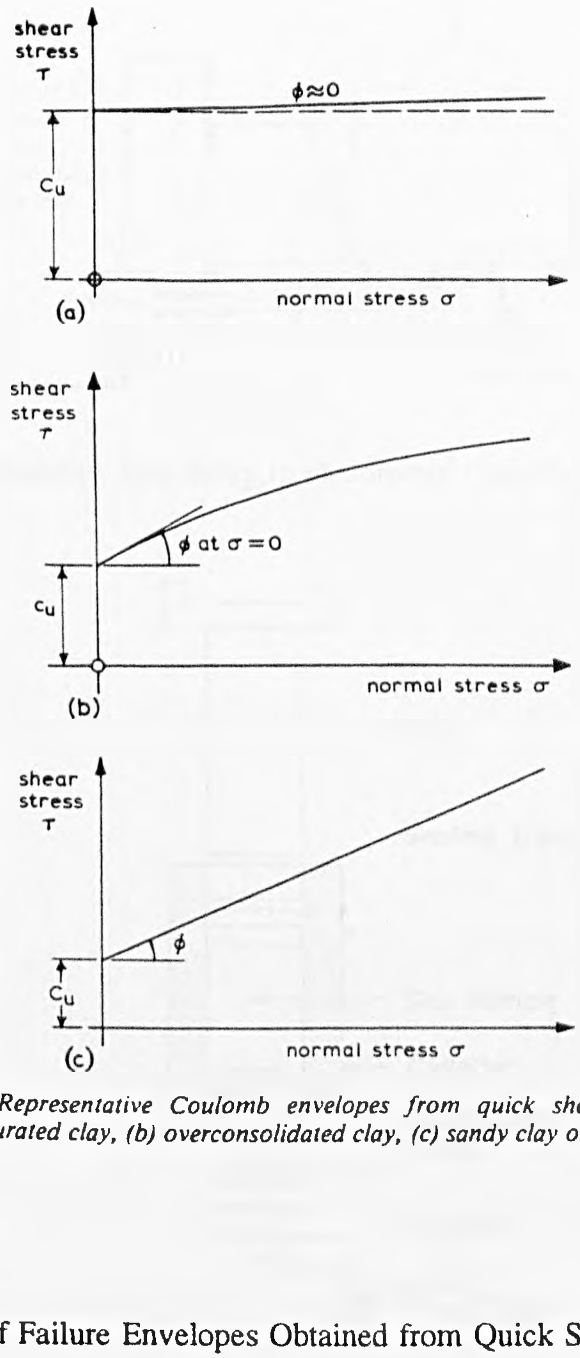

Representative Coulomb envelopes from quick shear tests: (a) saturated clay, (b) overconsolidated clay, (c) sandy clay or silt

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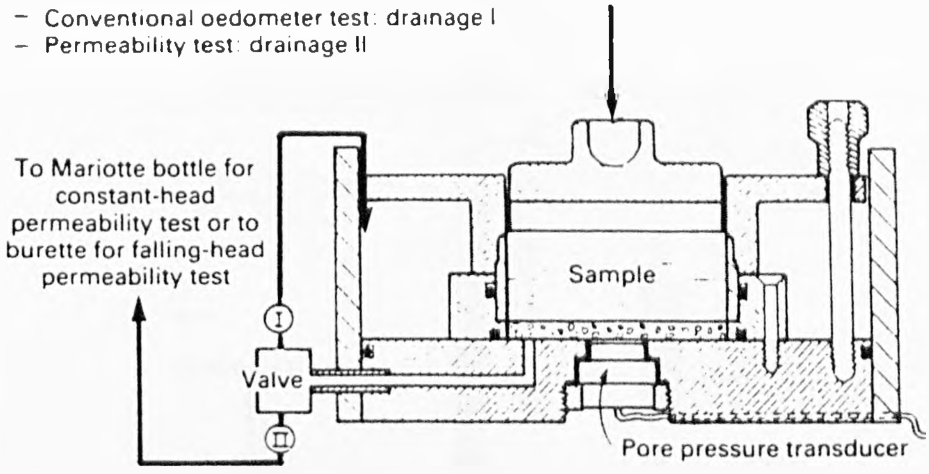

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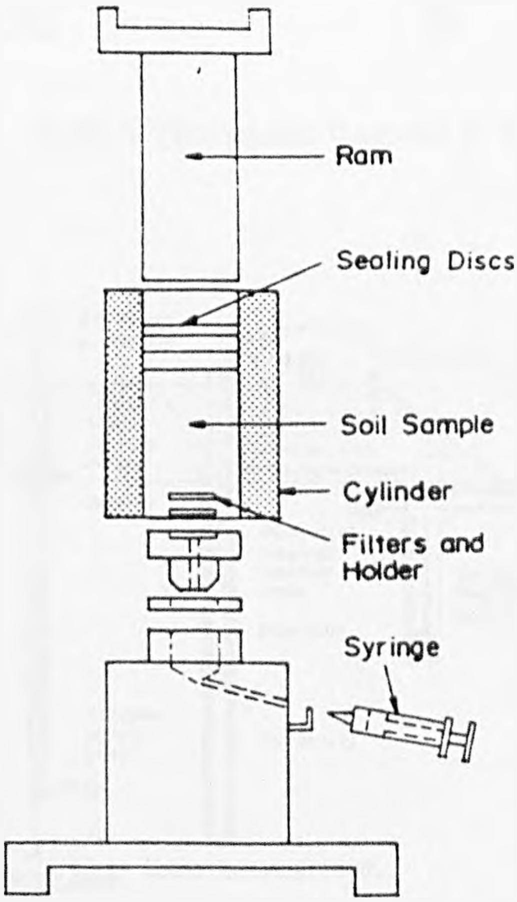

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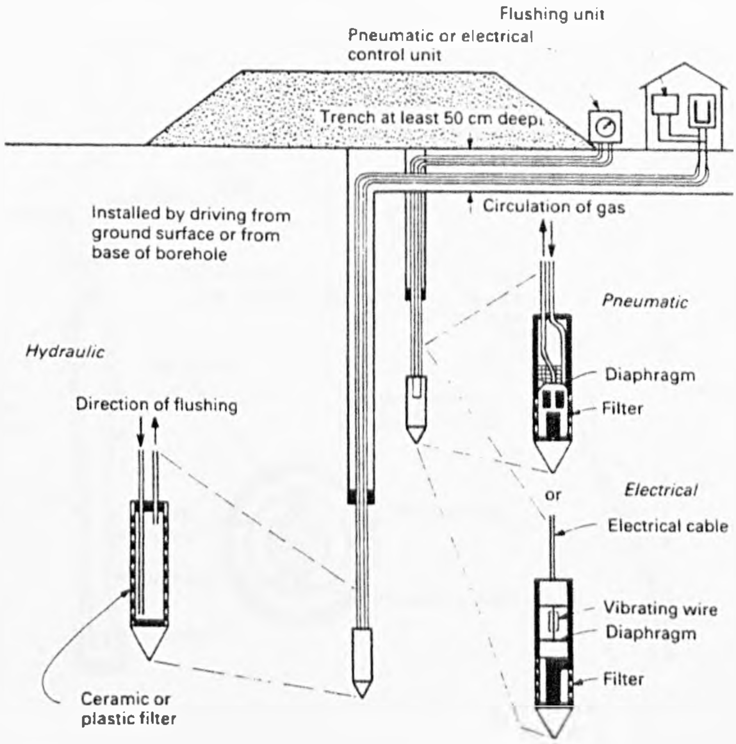

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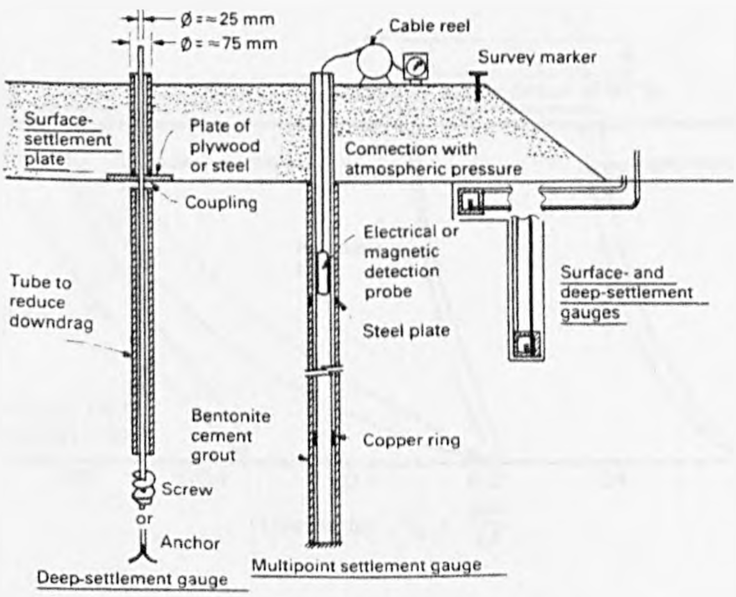

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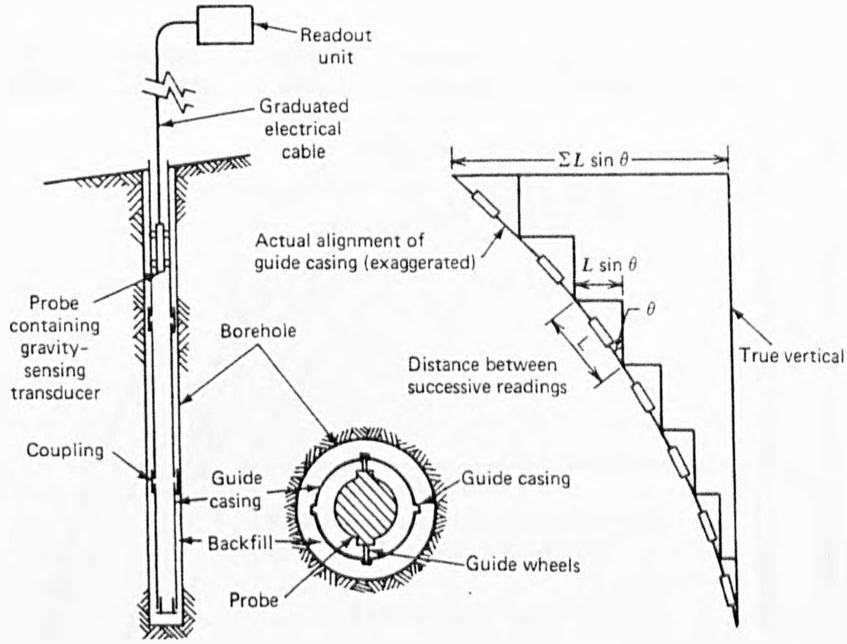

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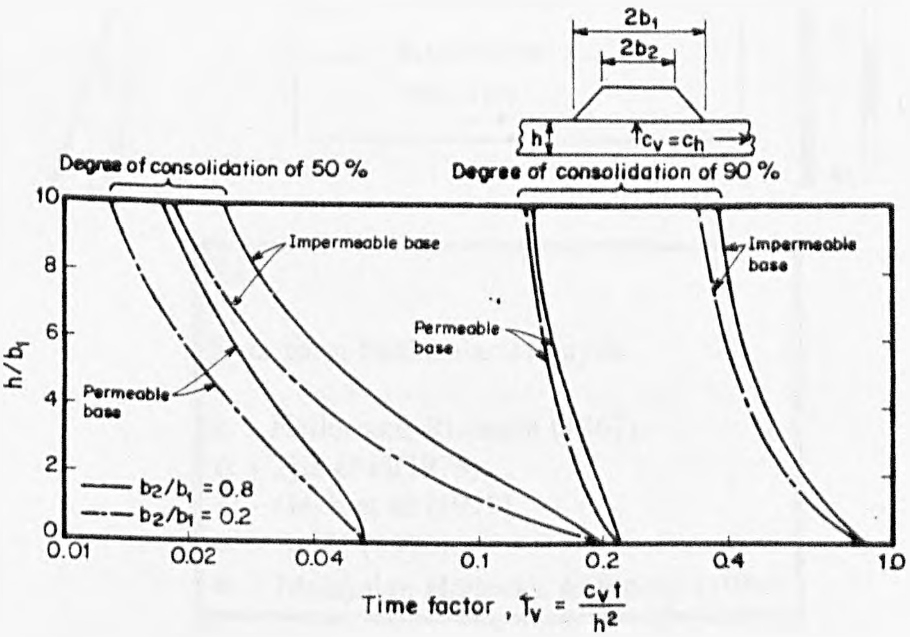

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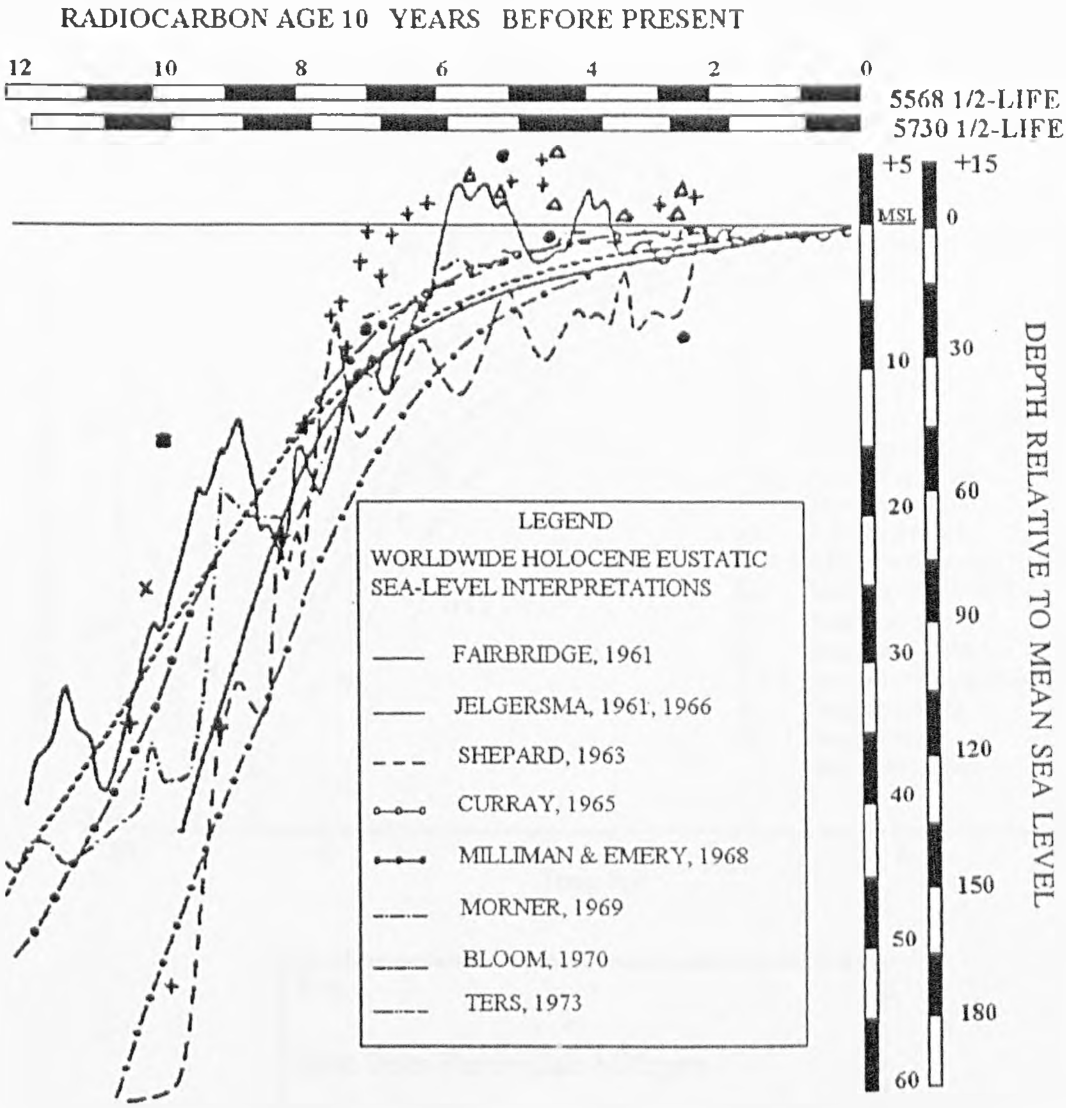
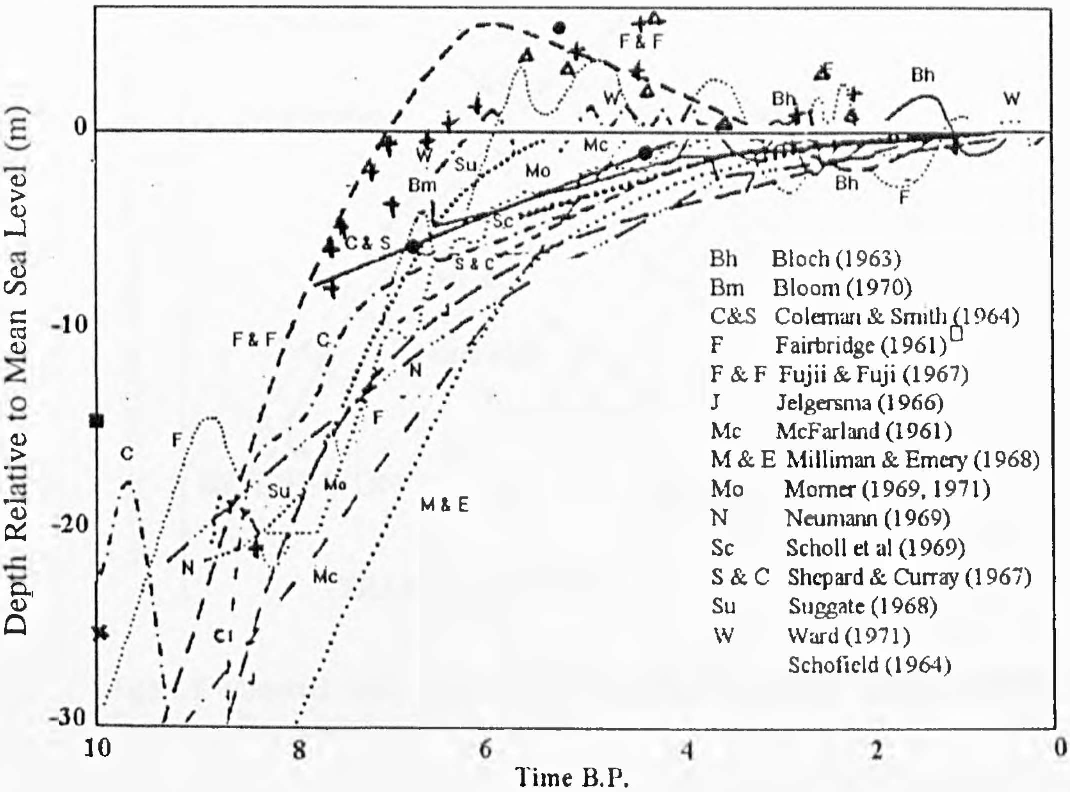


Key :

Data from Peninsular Malaysia

x - Keller and Richards (1967)
Δ - Tjia et al(1975)
\+ - Geyh et al (1979)
● - Streif (1979)
■ - Malaysian Highway Authority (1989)

Fig.3.1: Comparison of Radiocarbon Dated Samples Obtained in Peninsular Malaysia to Other Data on Sea-Level Changes



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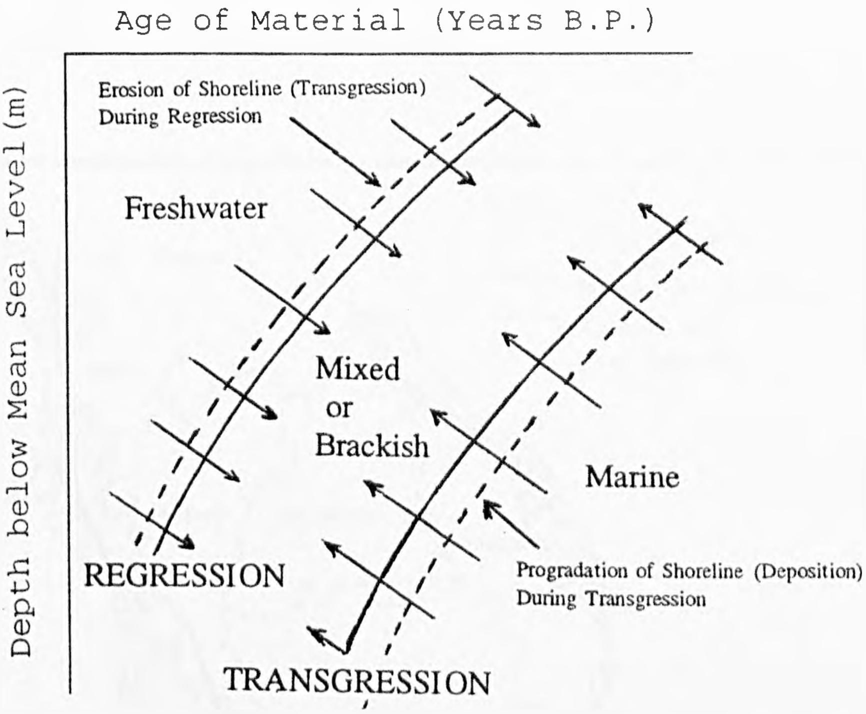

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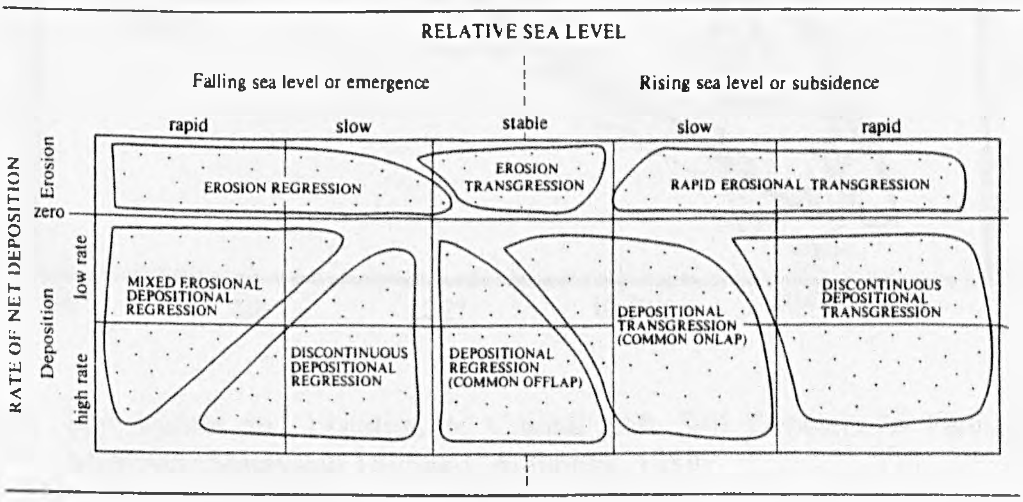

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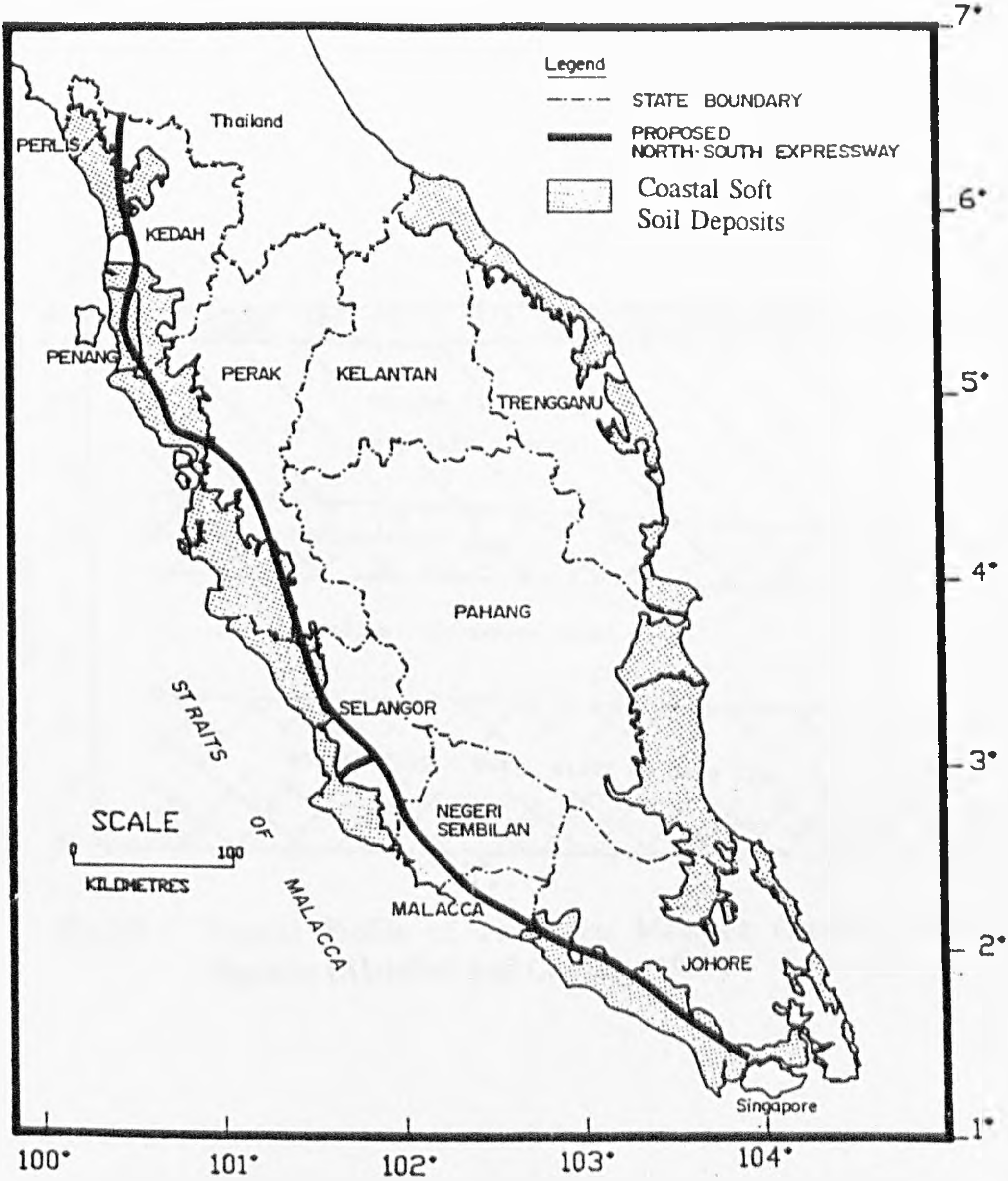

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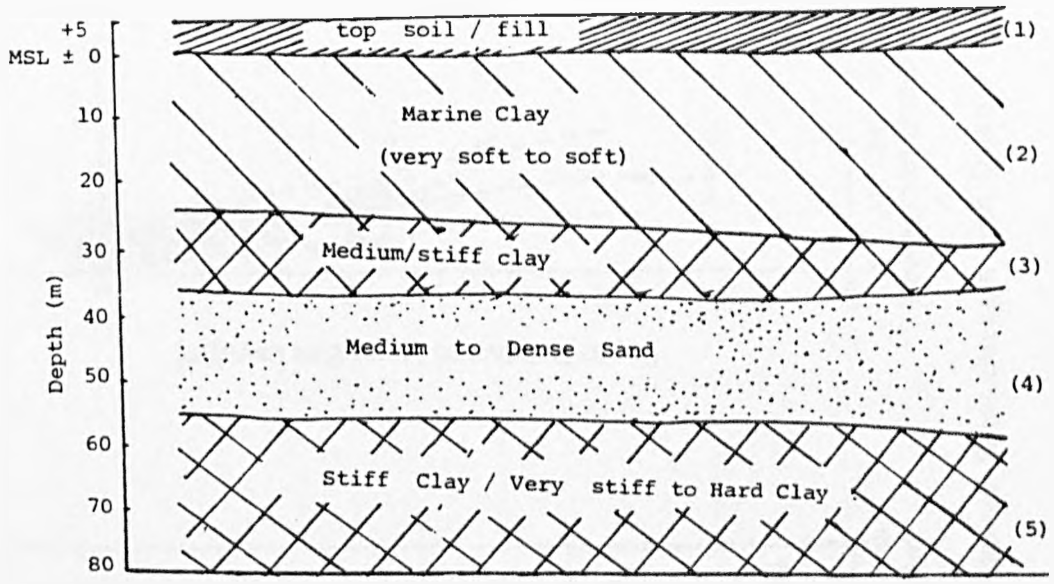

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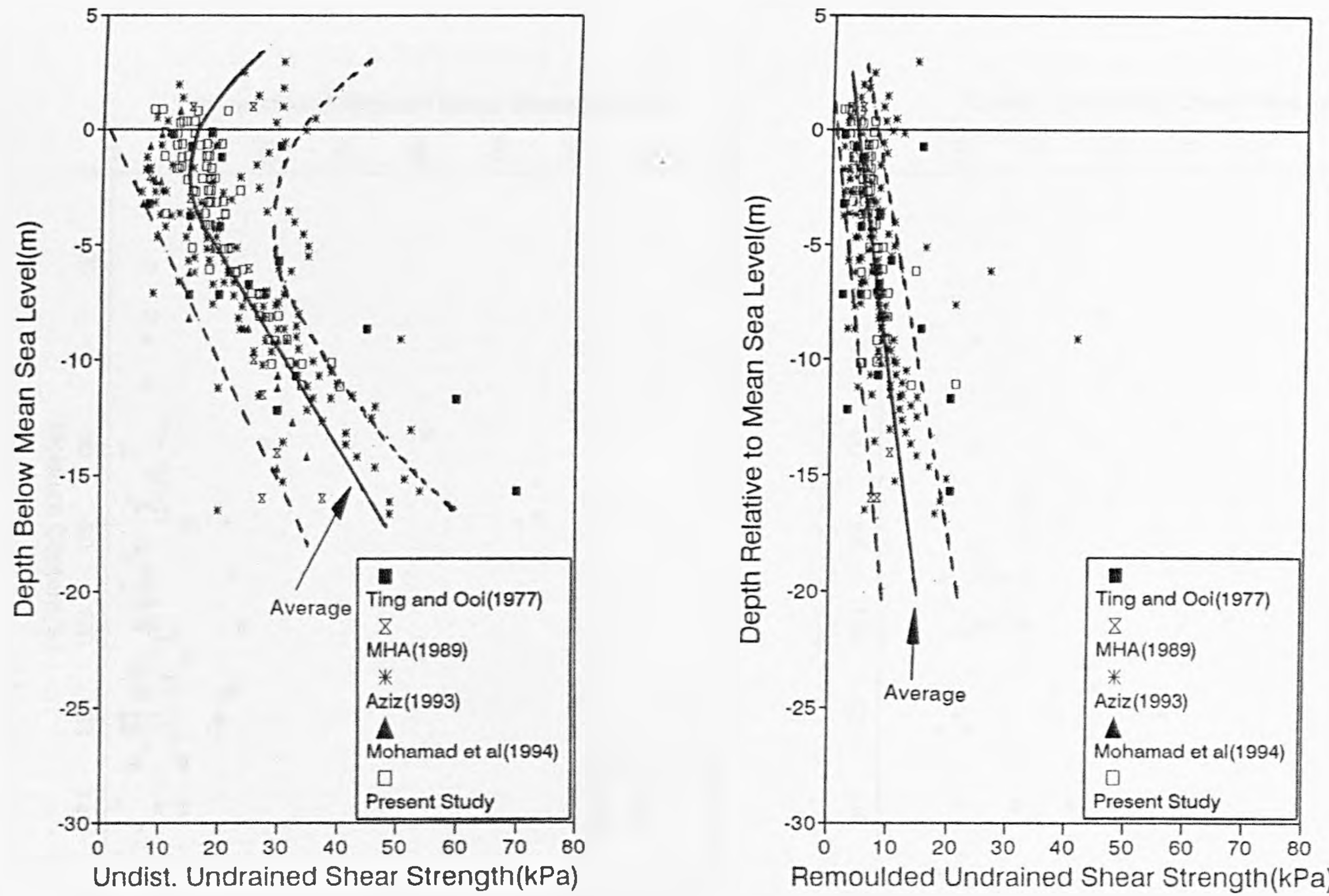

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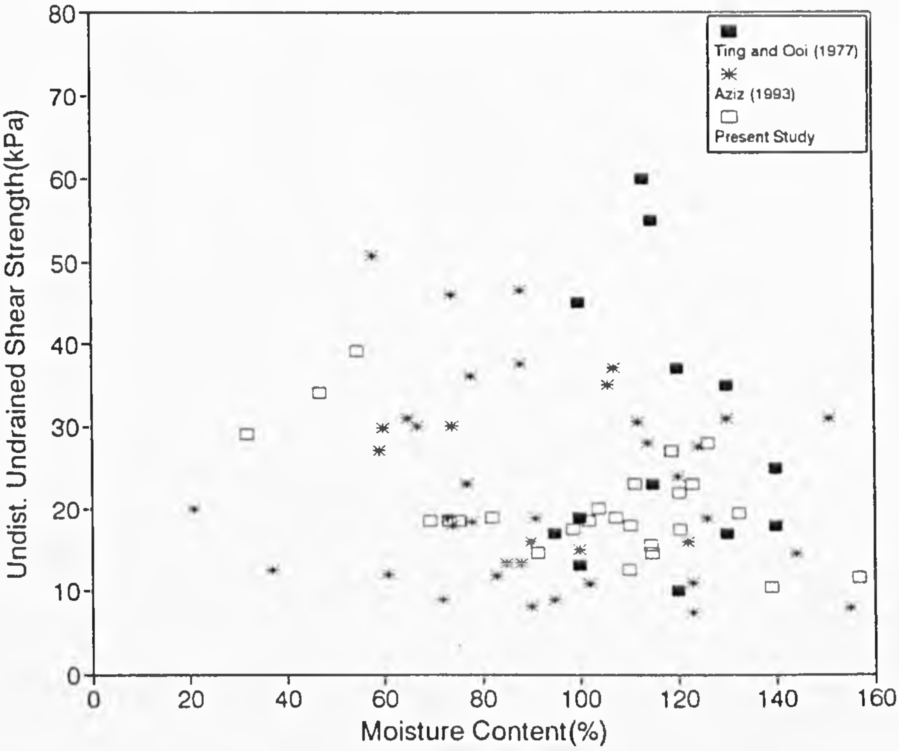

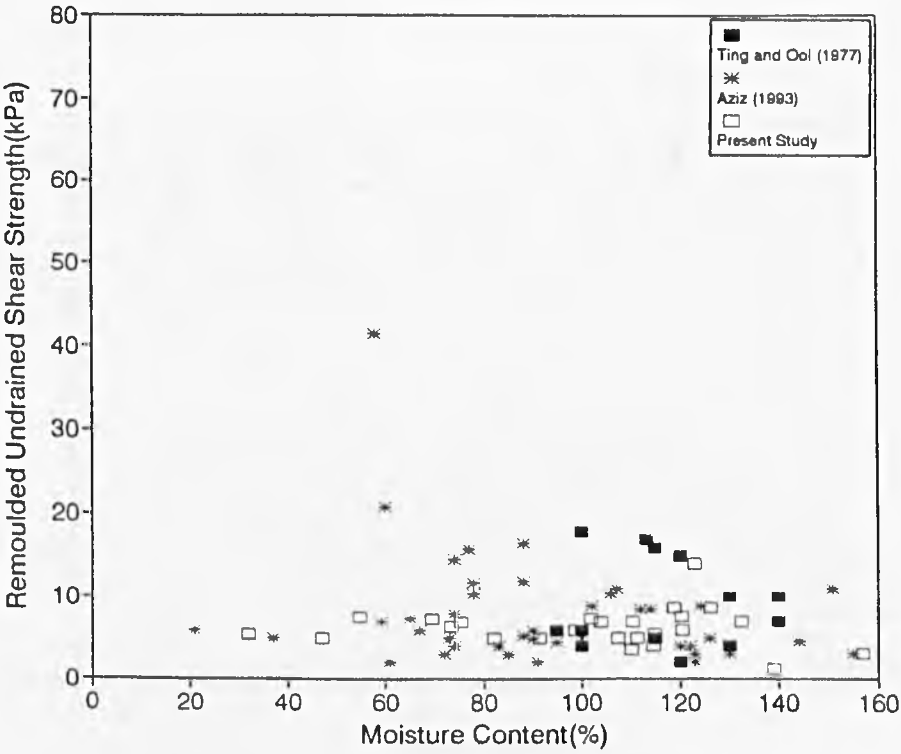

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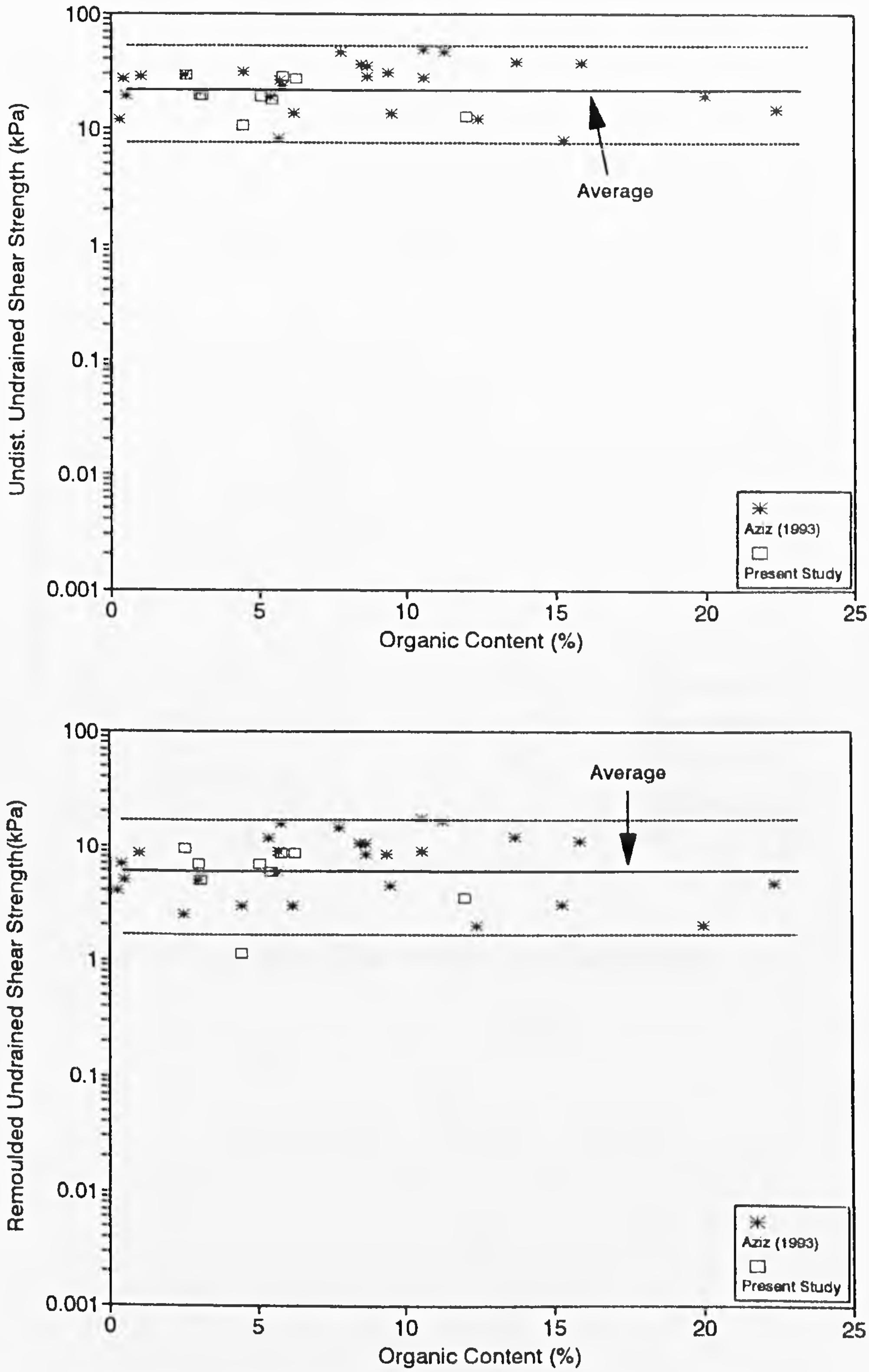

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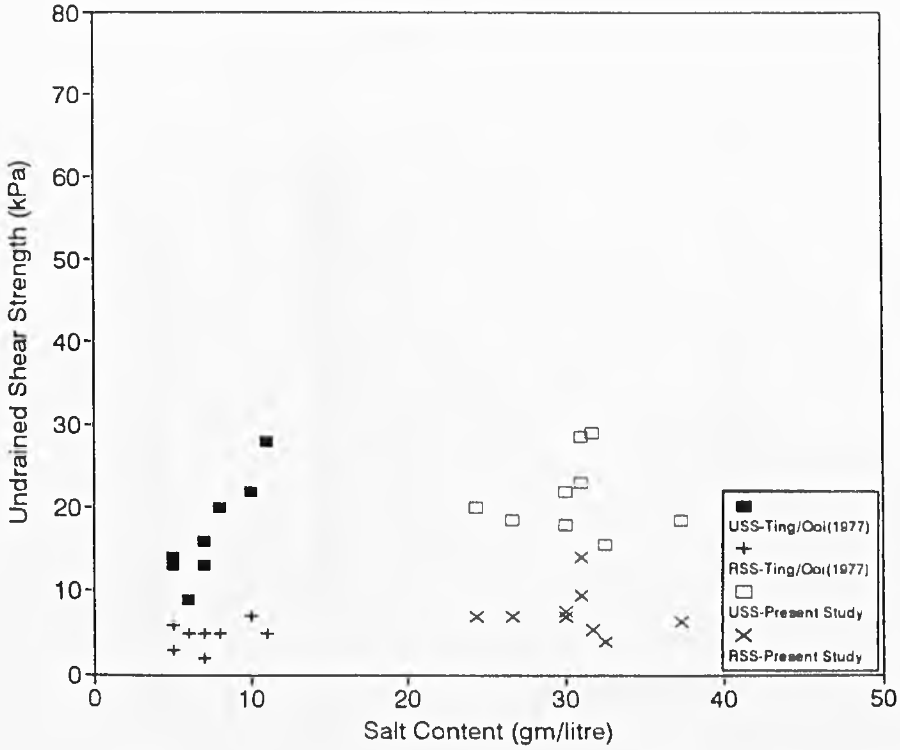

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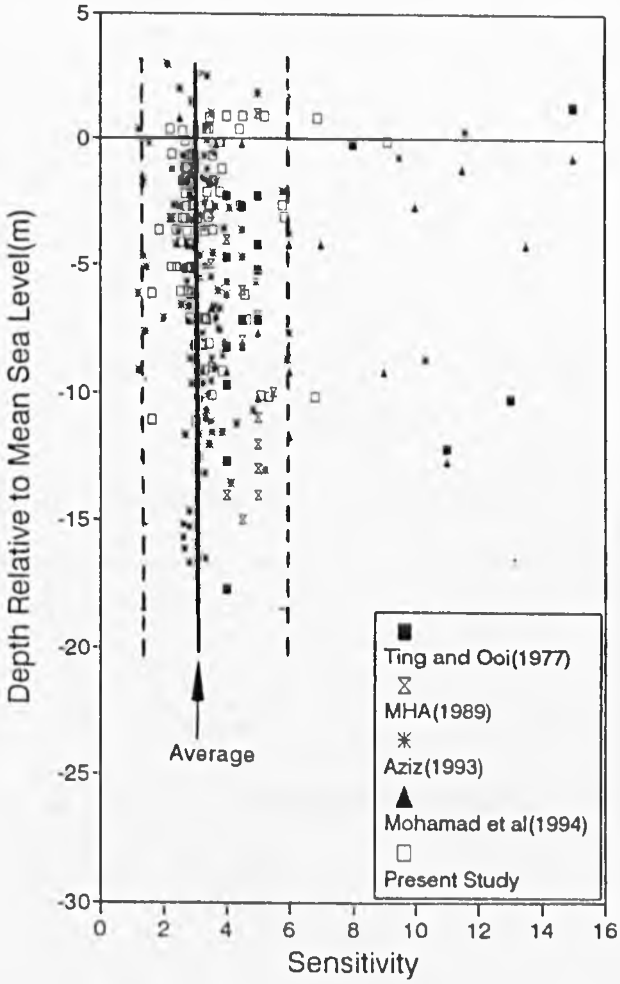

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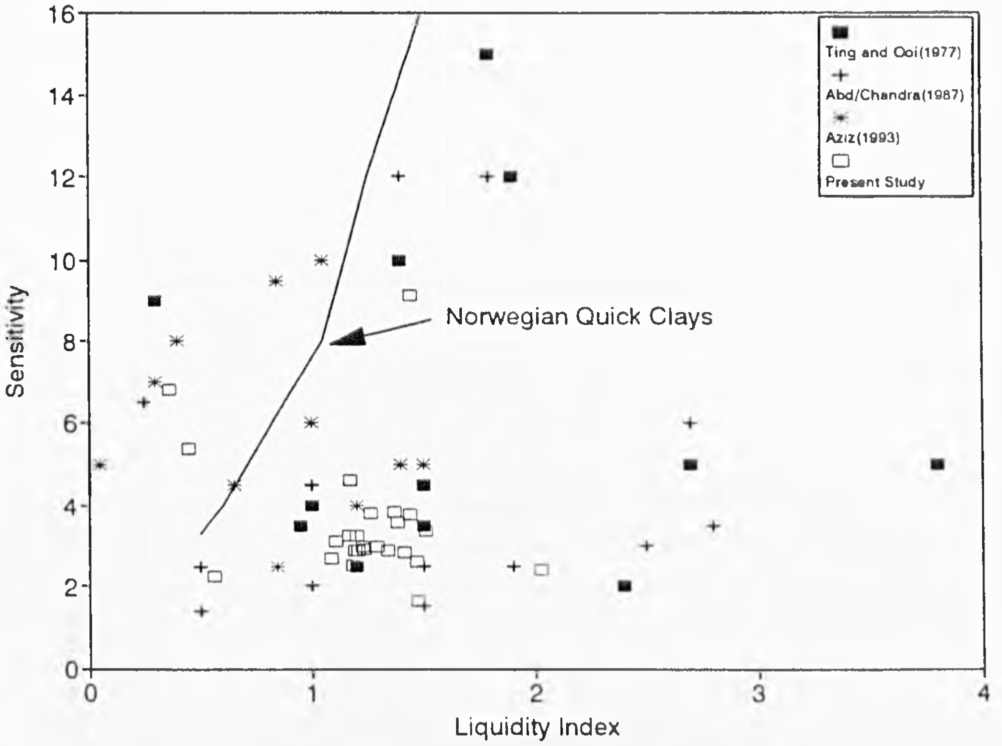

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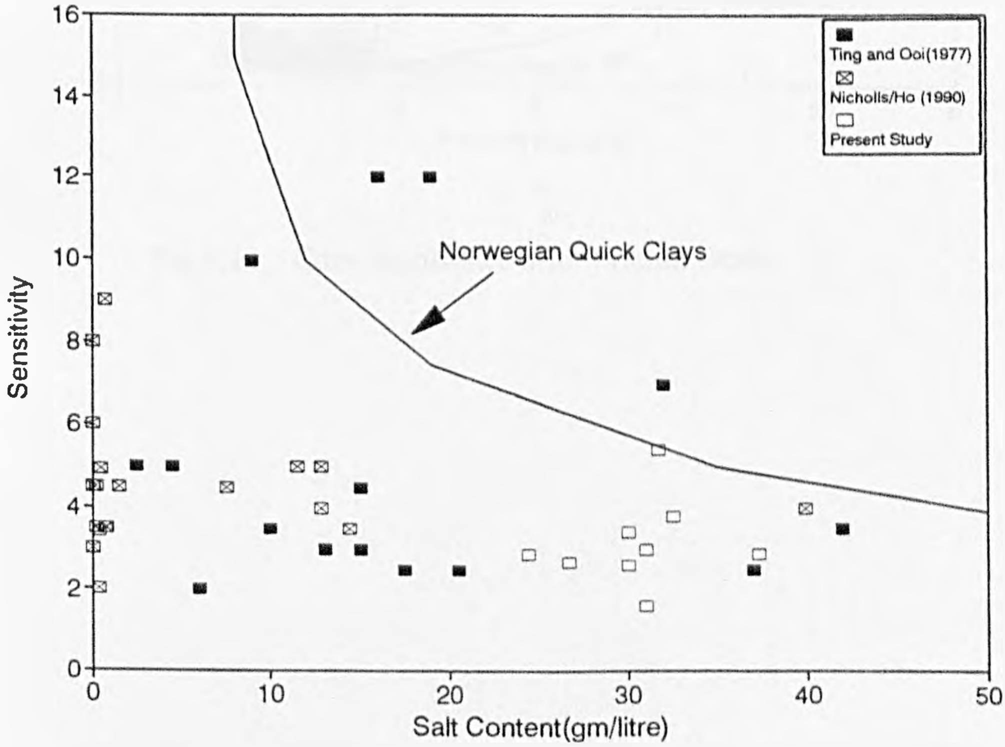

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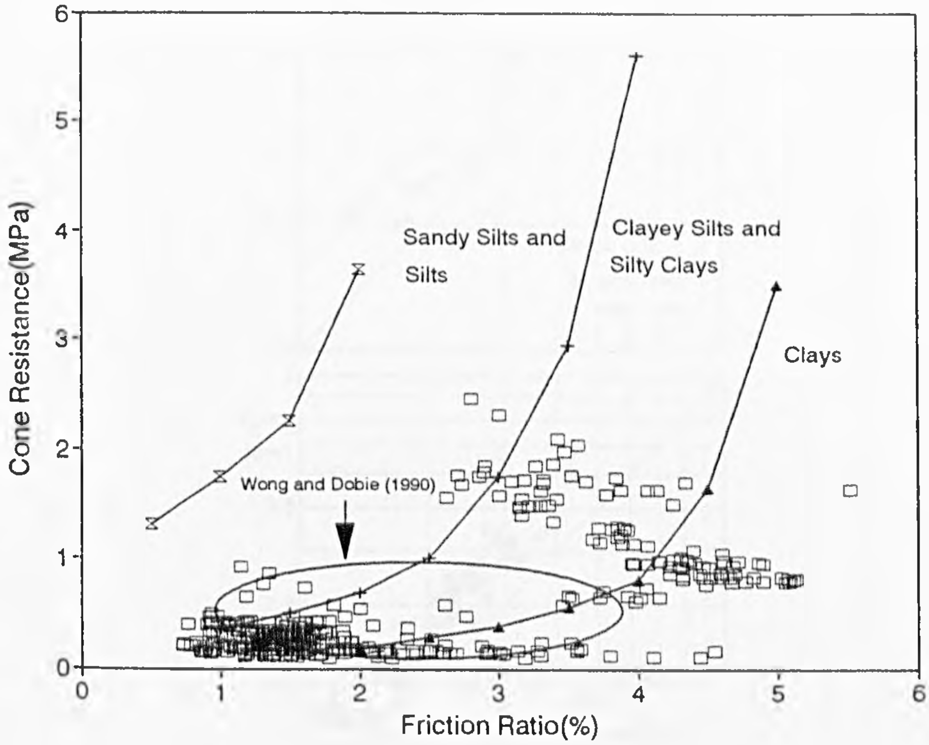

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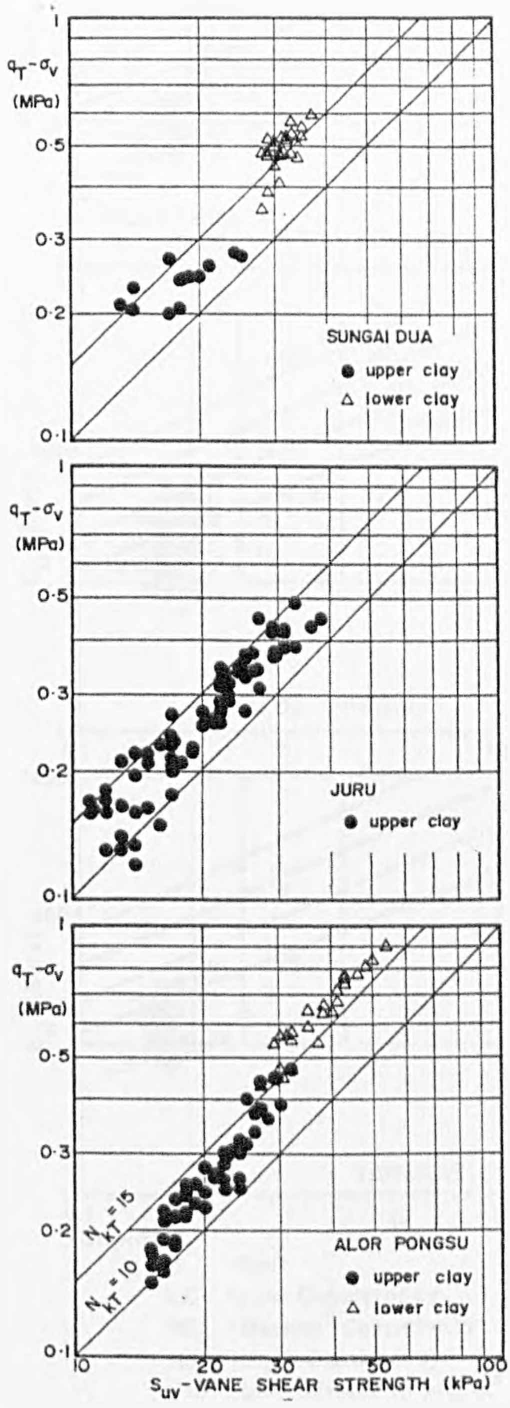

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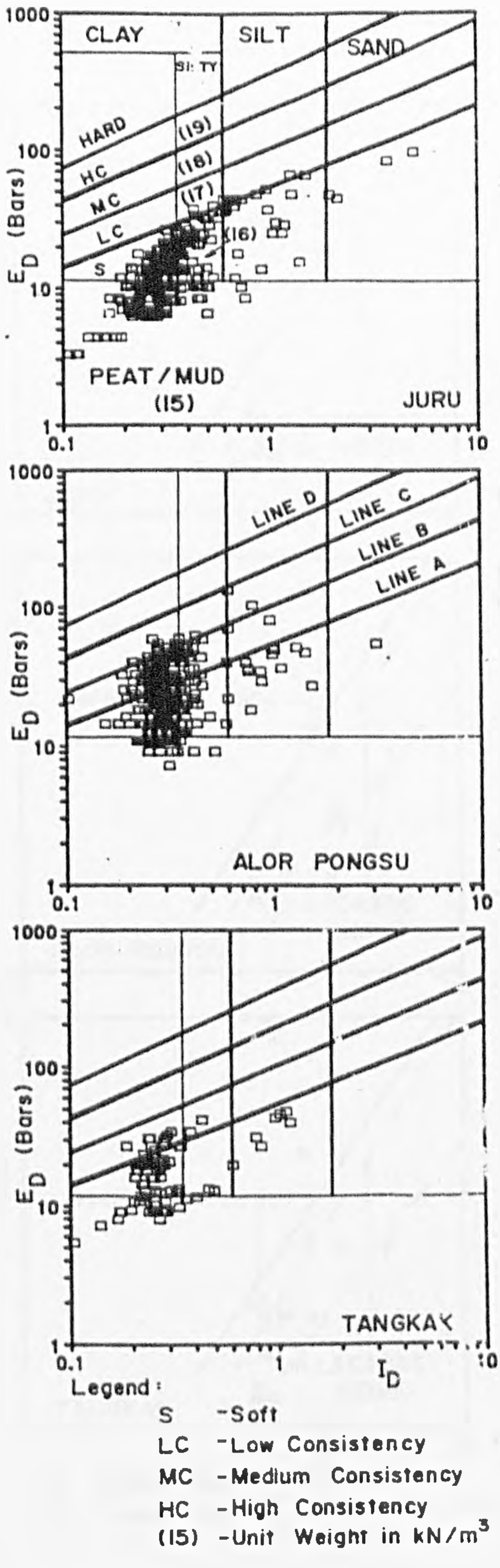

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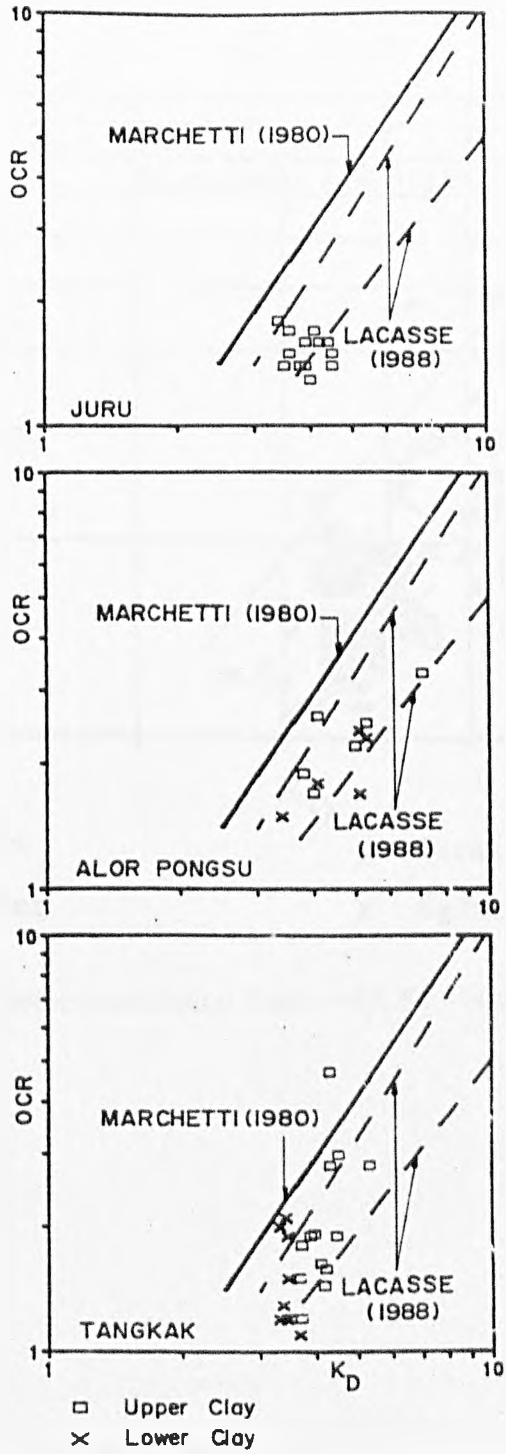

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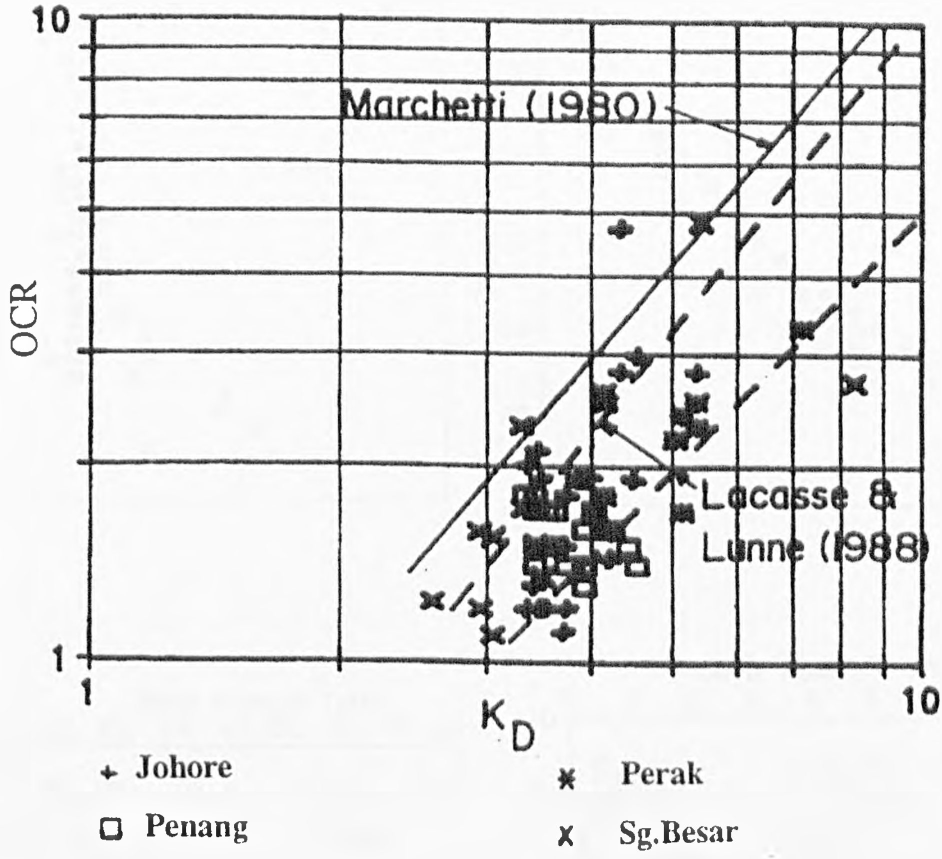

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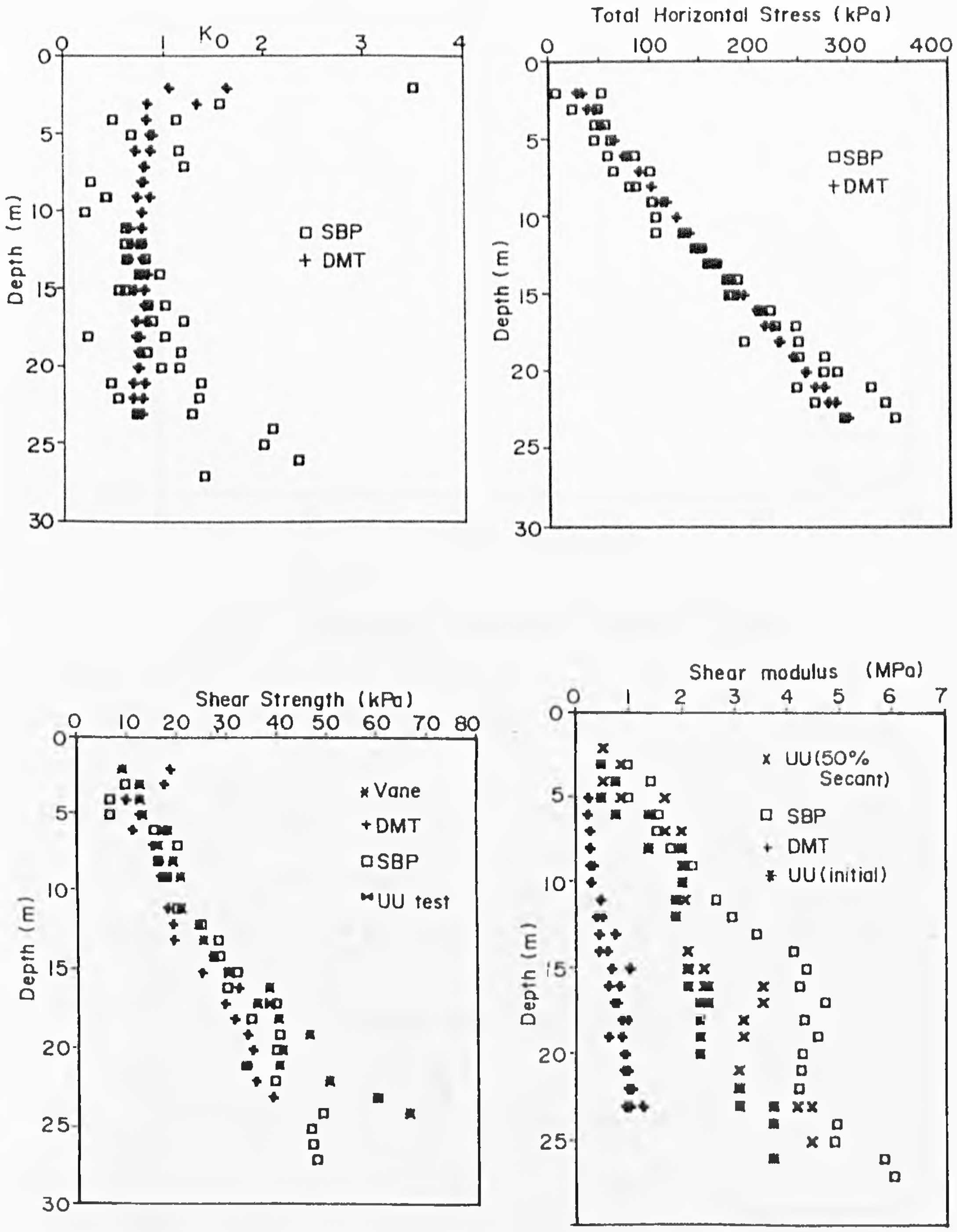

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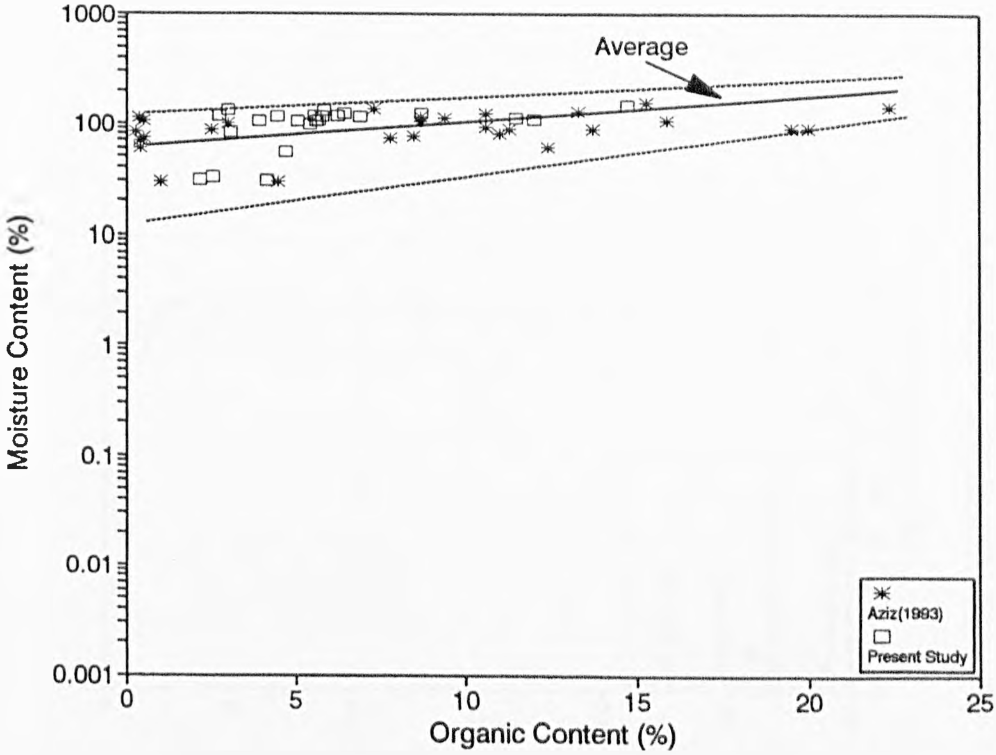

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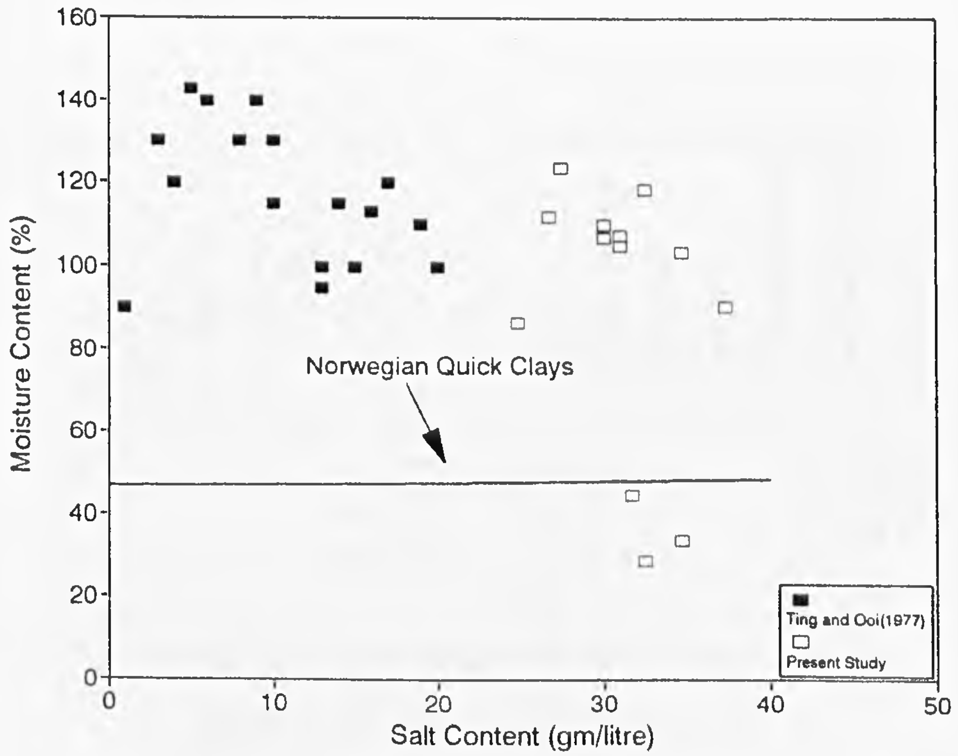

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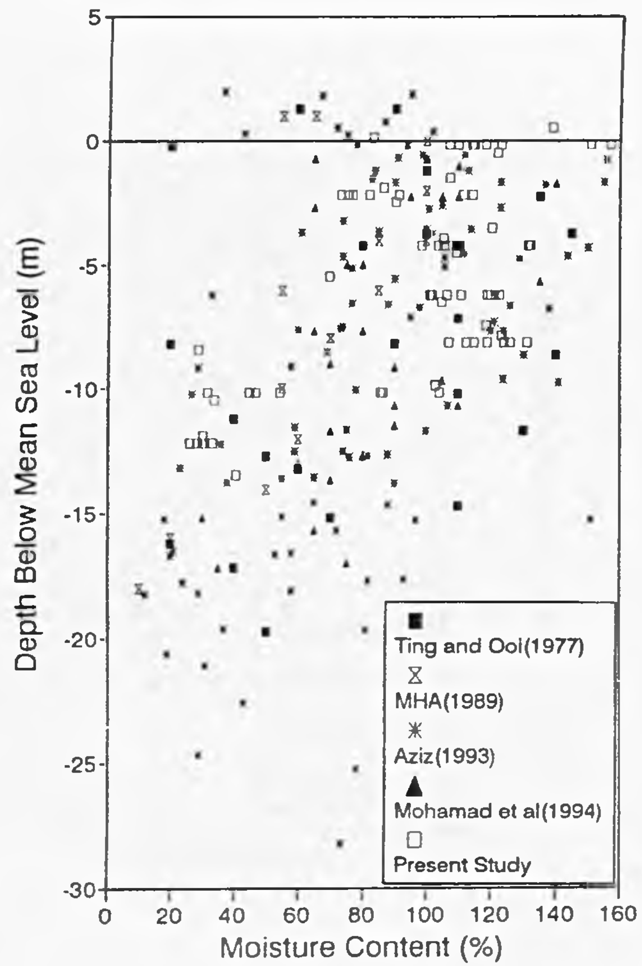

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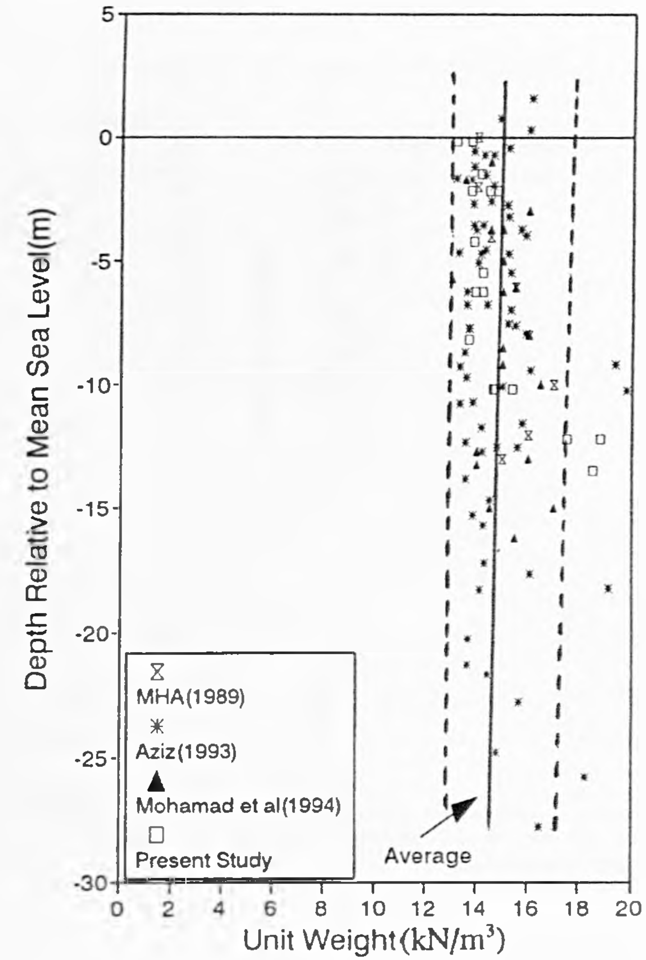

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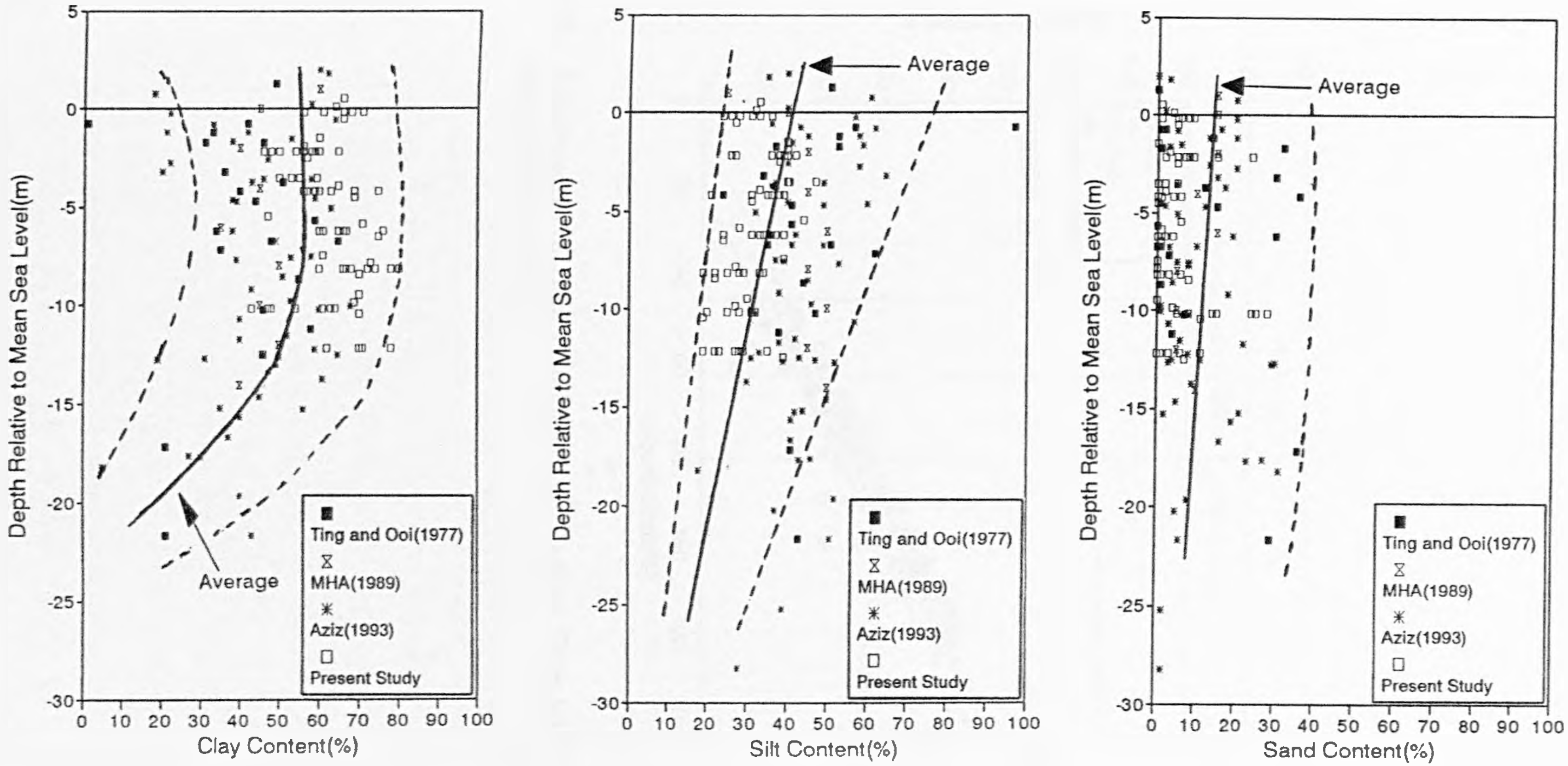

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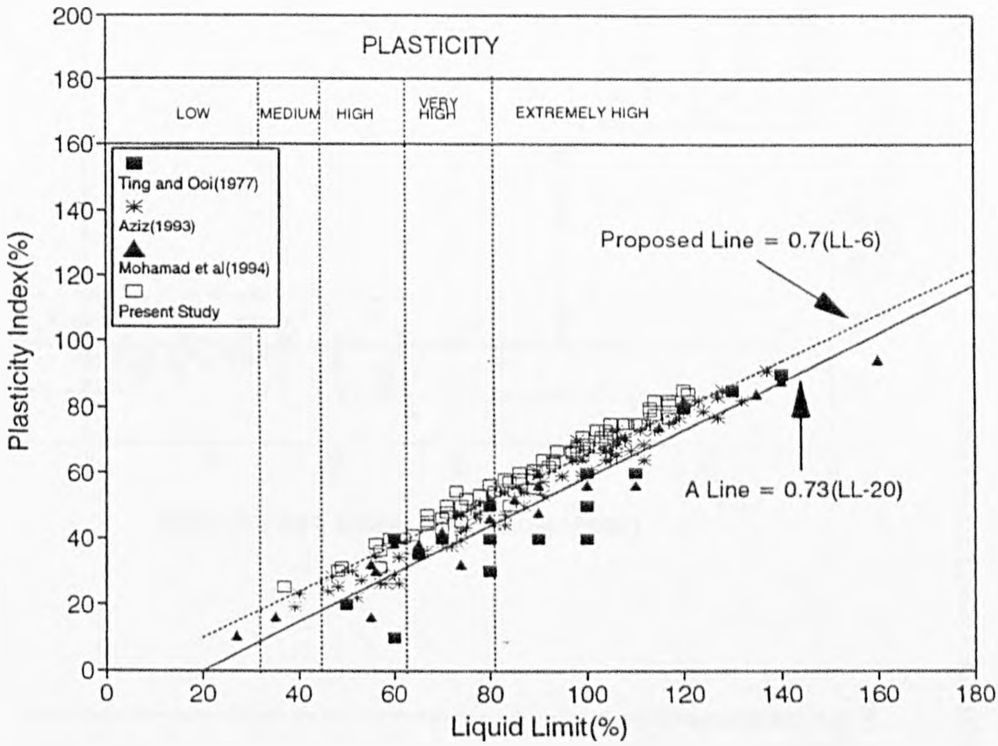


Fig.3.25 : Relationship of Data Obtained from Various Sites with Reference to the Casagrande A-Line

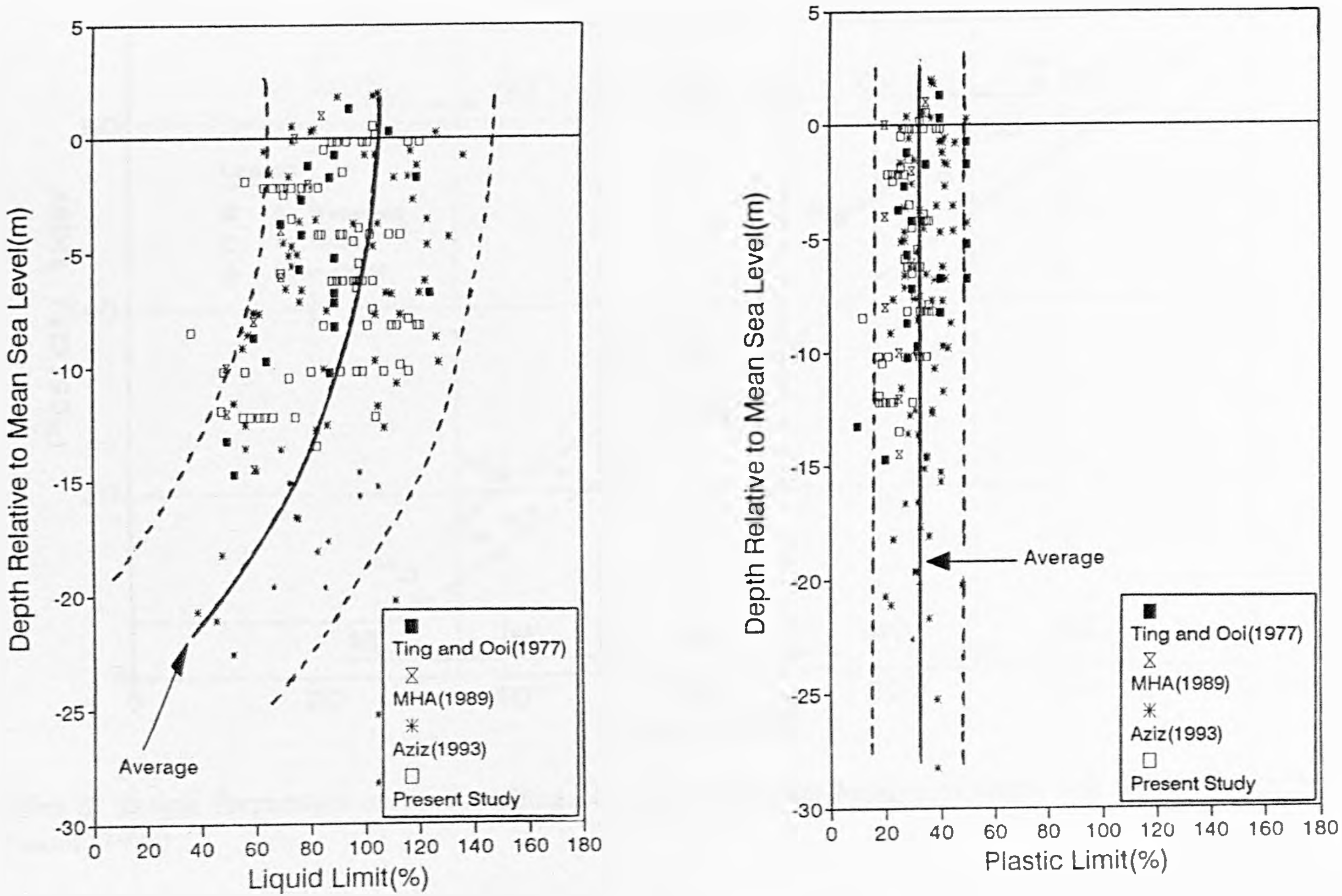


Fig.3.26: Atterberg Limits with Depth

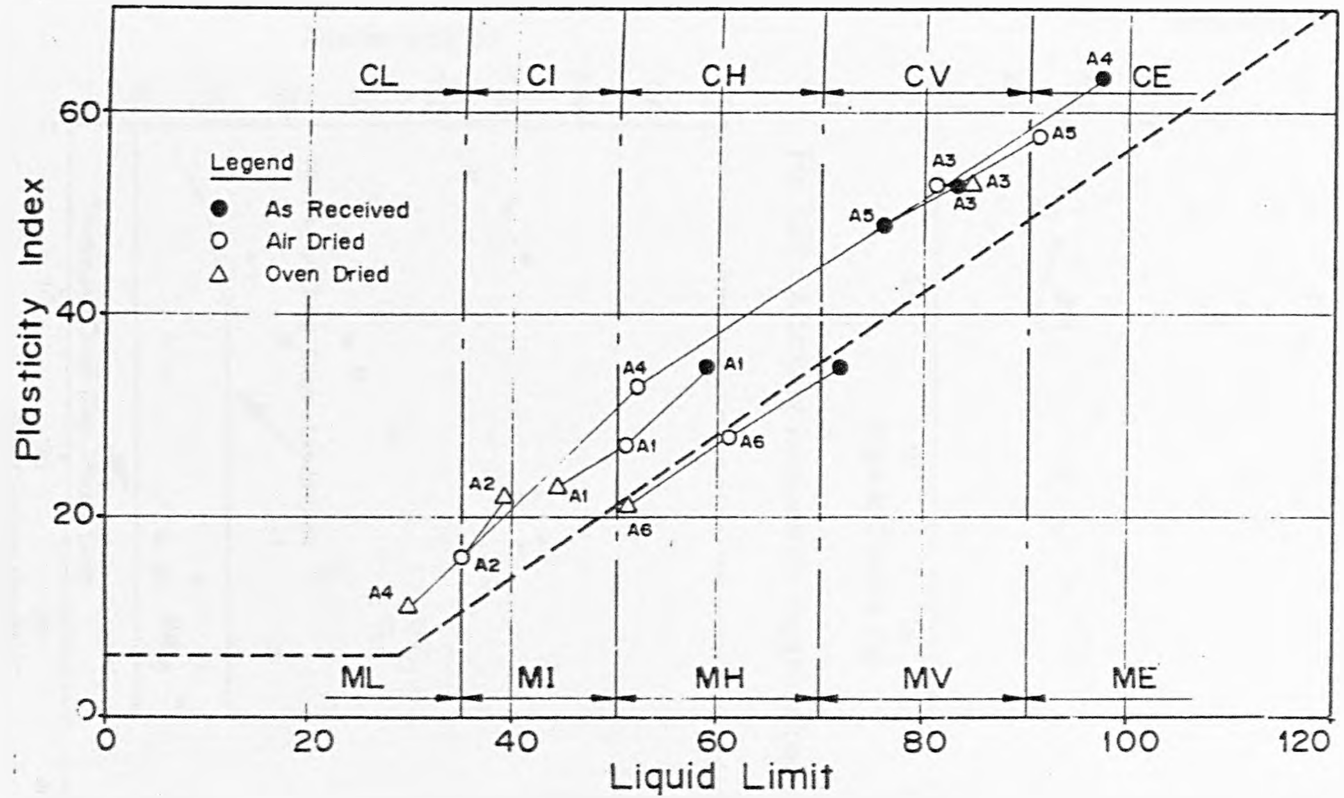


Fig.3.27 : Effect of Sample Preparation on the Atterberg Limits of Peninsular Malaysia Coastal Soft Soil Deposits (Mohammad Nor and Yusouf, 1990)

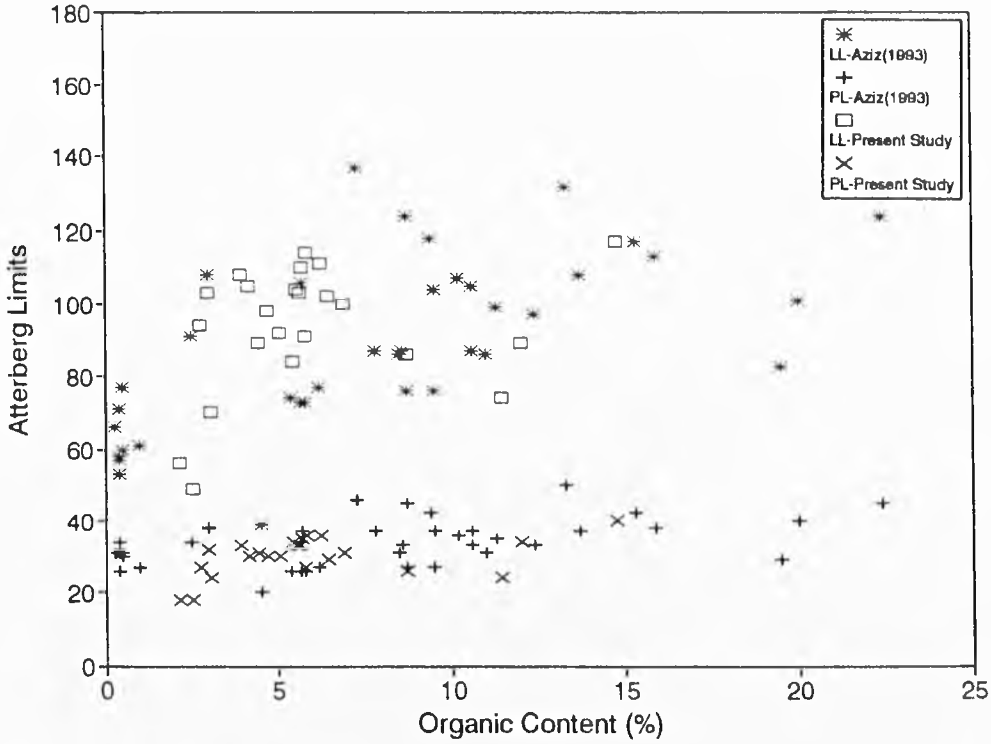


Fig.3.28 : Atterberg Limits with Organic Content

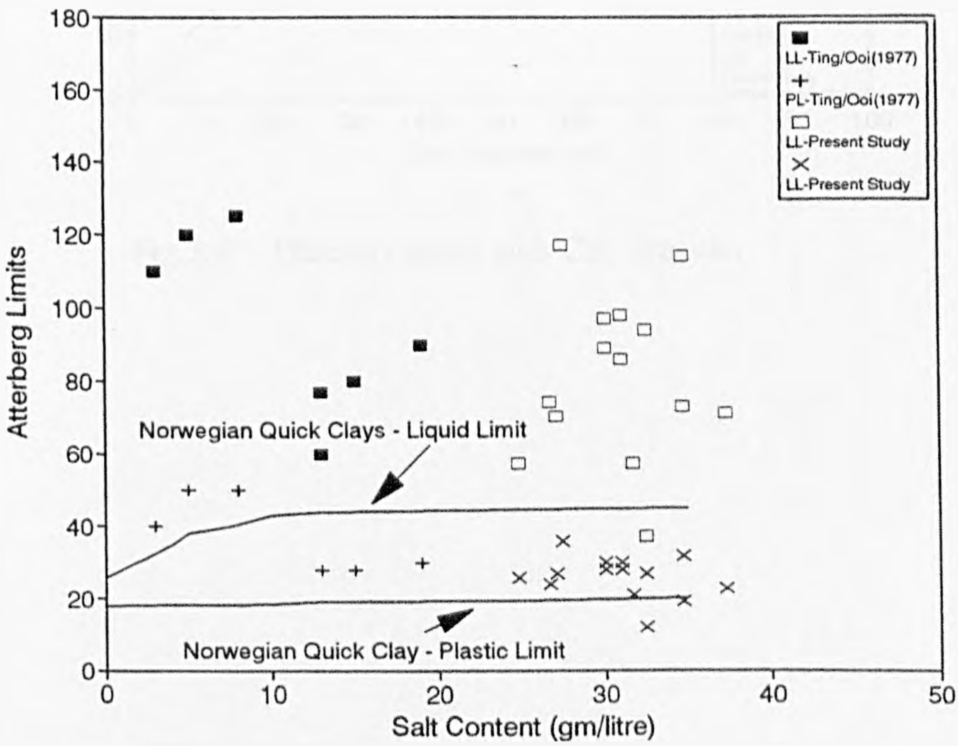


Fig.3.29 : Atterberg Limits with Salt Content

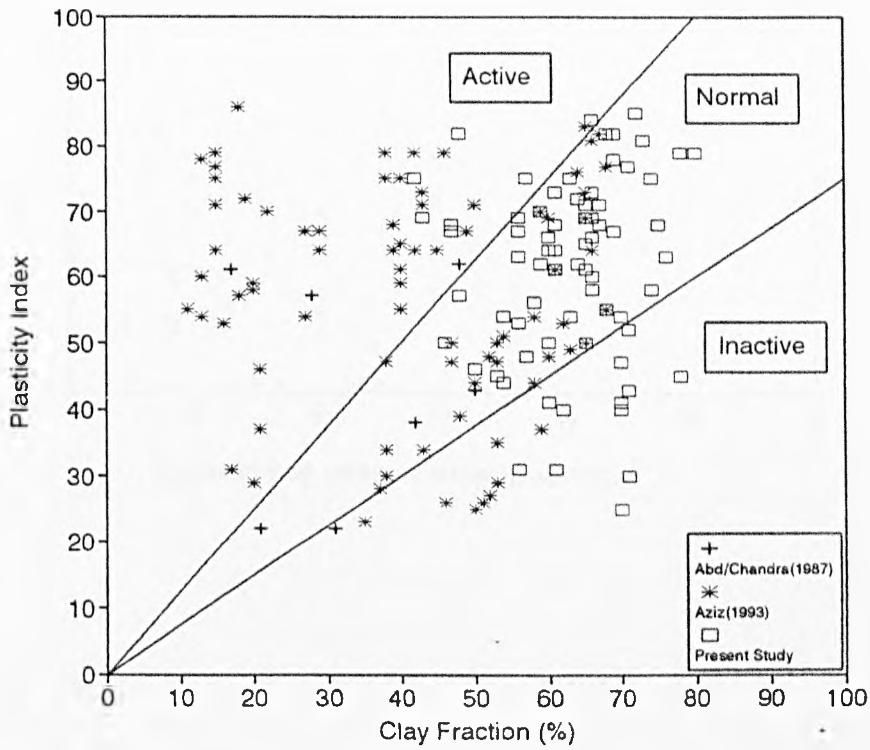


Fig.3.30 : Plasticity Index with Clay Fraction

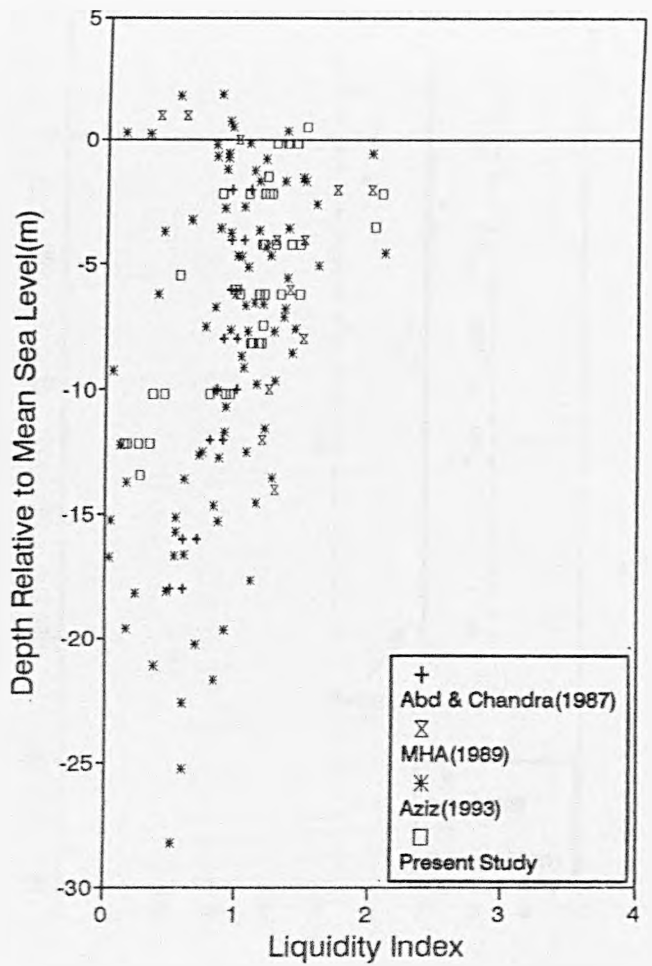


Fig.3.31 : Liquidity Index with Depth

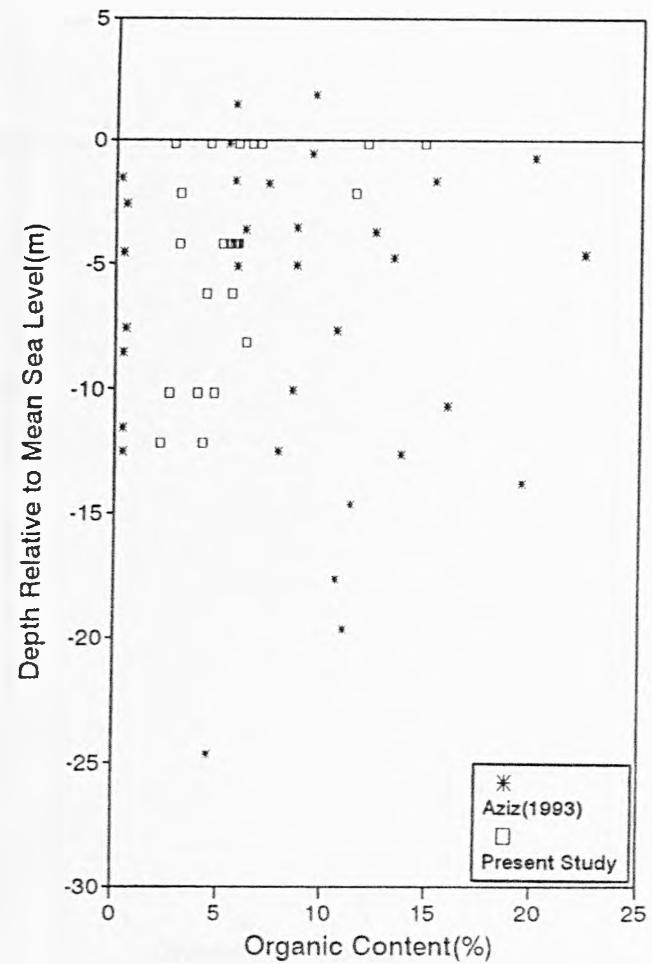


Fig.3.32 : Organic Content with Depth

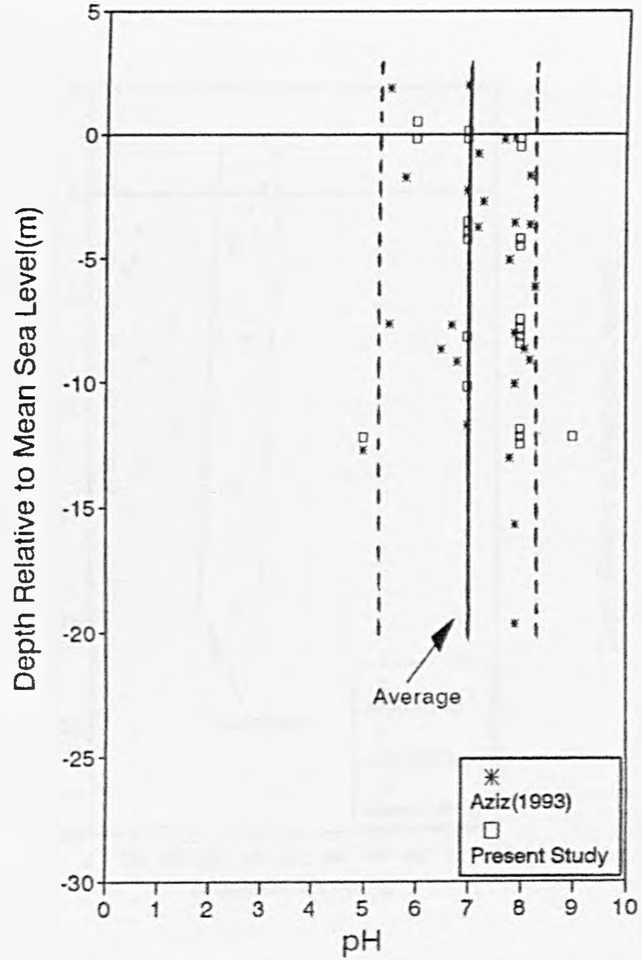


Fig.3.33 : pH with Depth

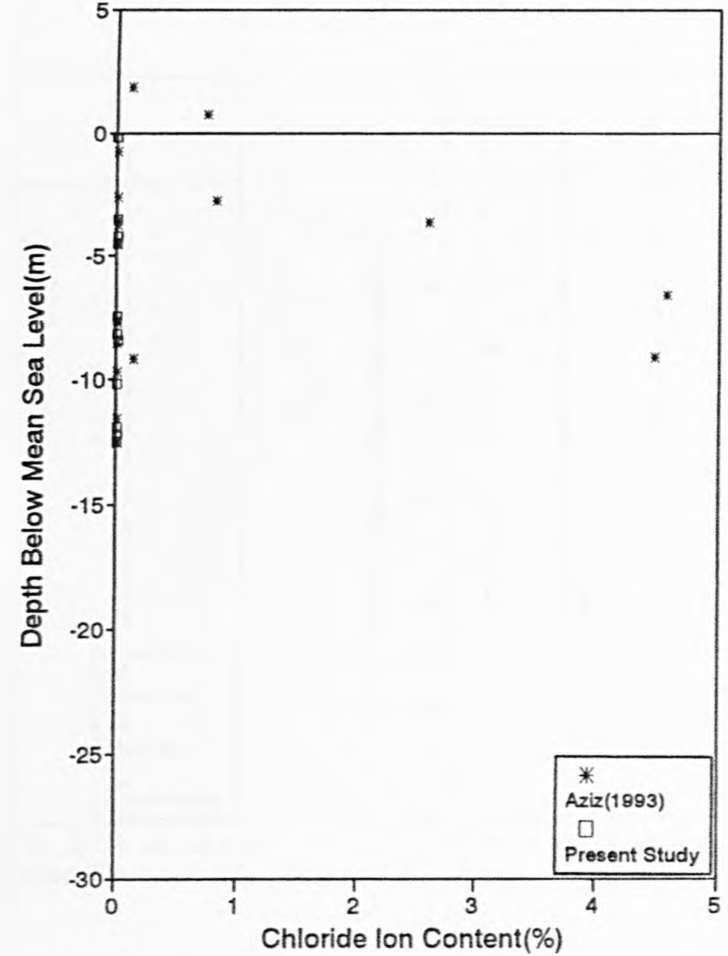


Fig.3.34 : Chloride Ion Content with Depth

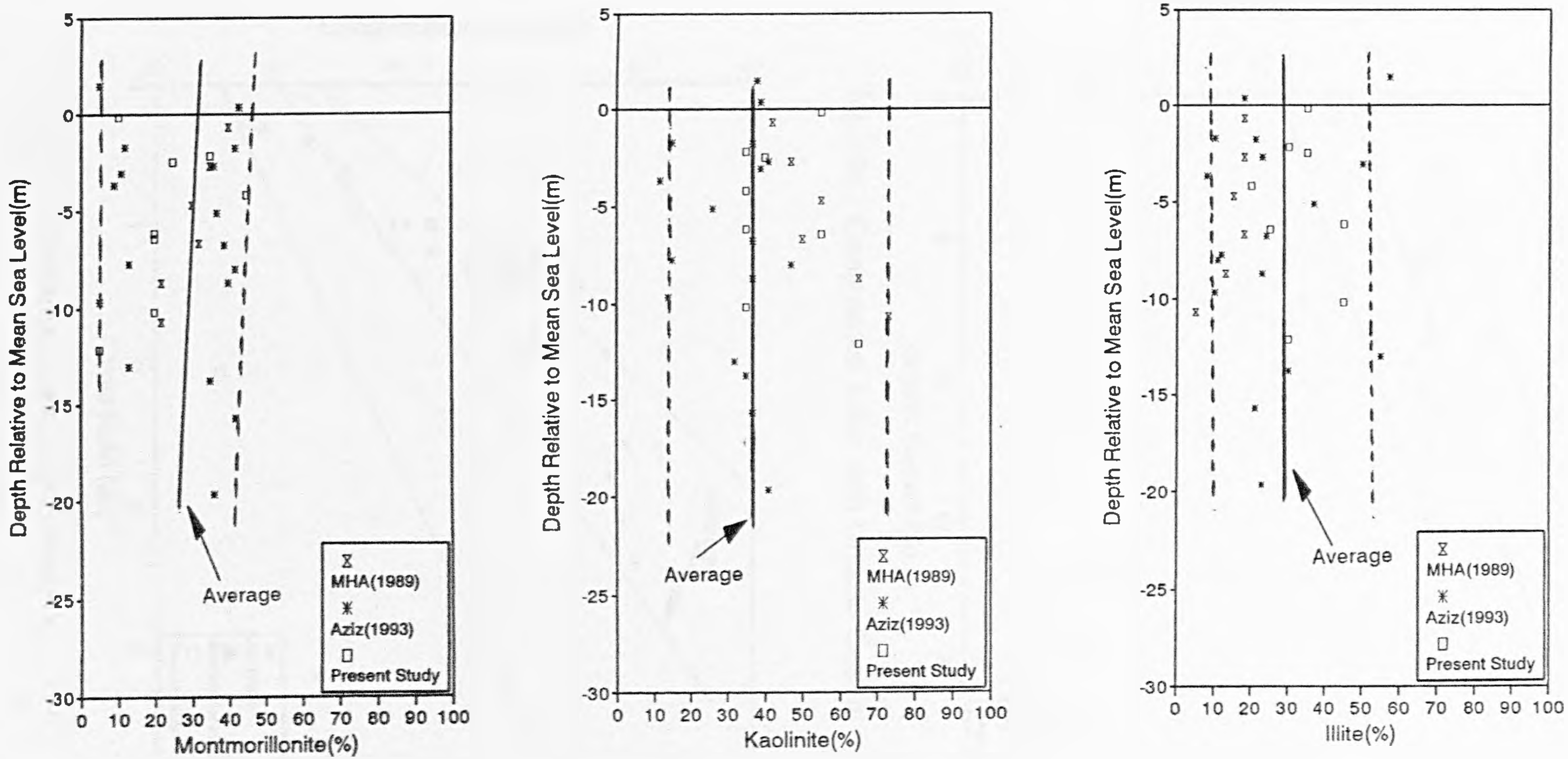


Fig.3.35 : Mineralogy with Depth

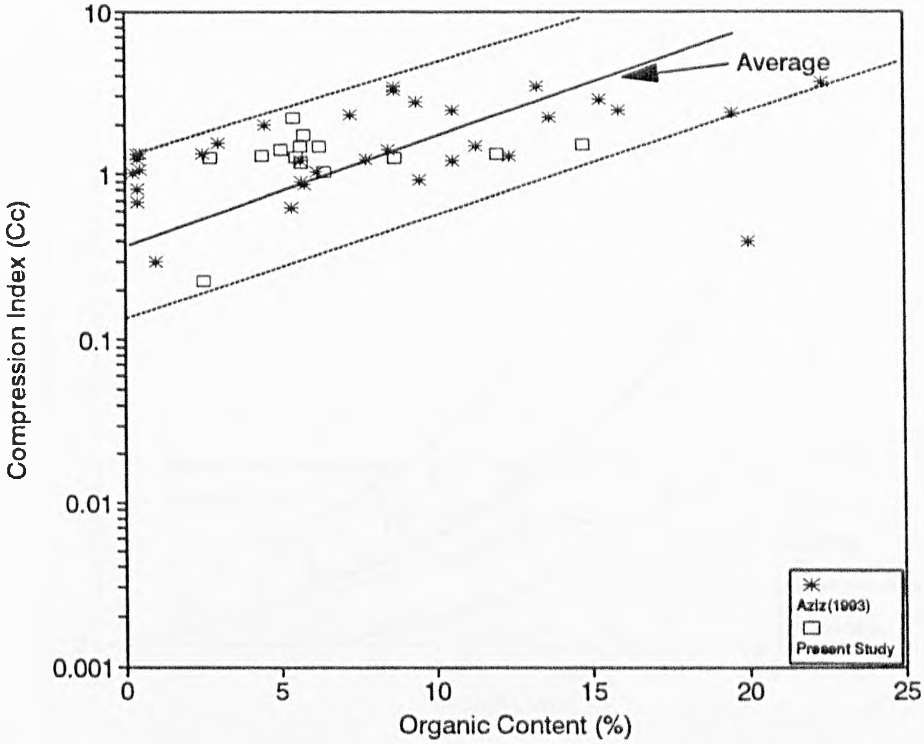


Fig.3.36 : Compression Index with Organic Content

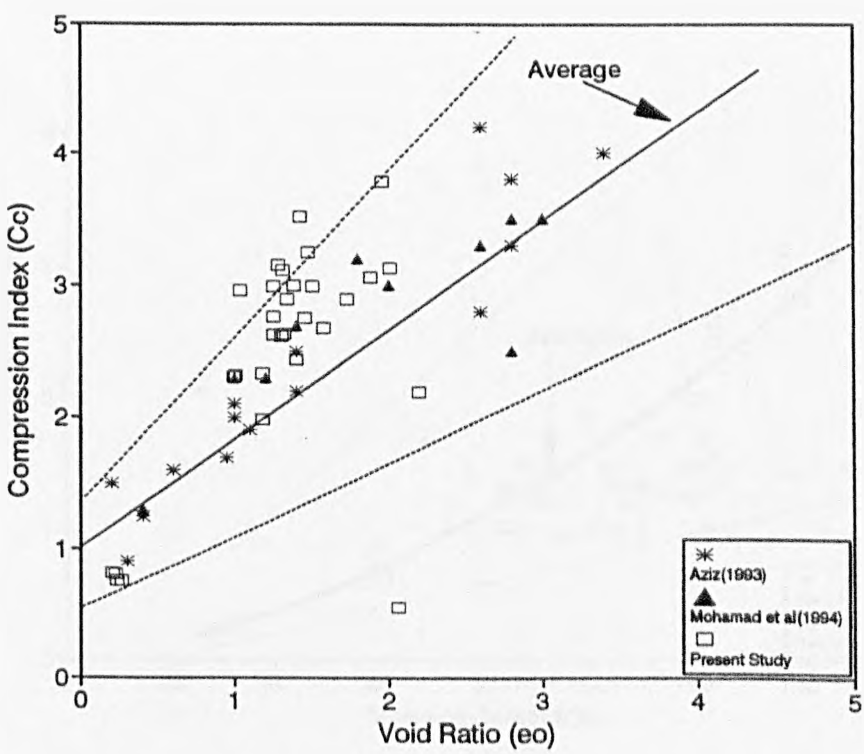


Fig.3.37 : Compression Index with Initial Void Ratio

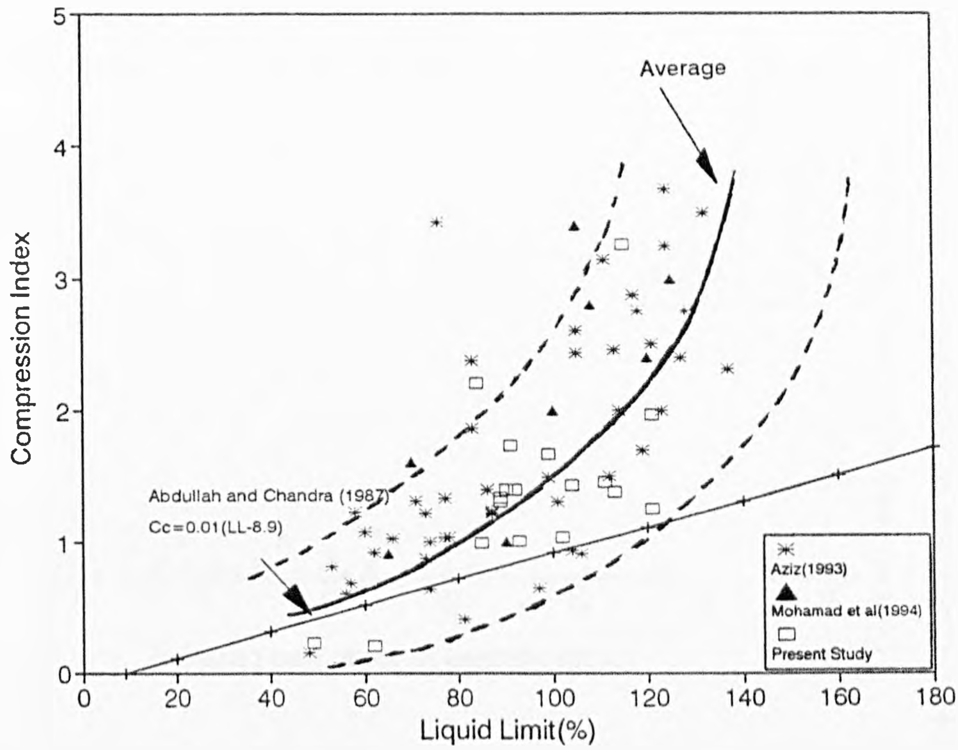


Fig.3.38 : Compression Index with Liquid Limit

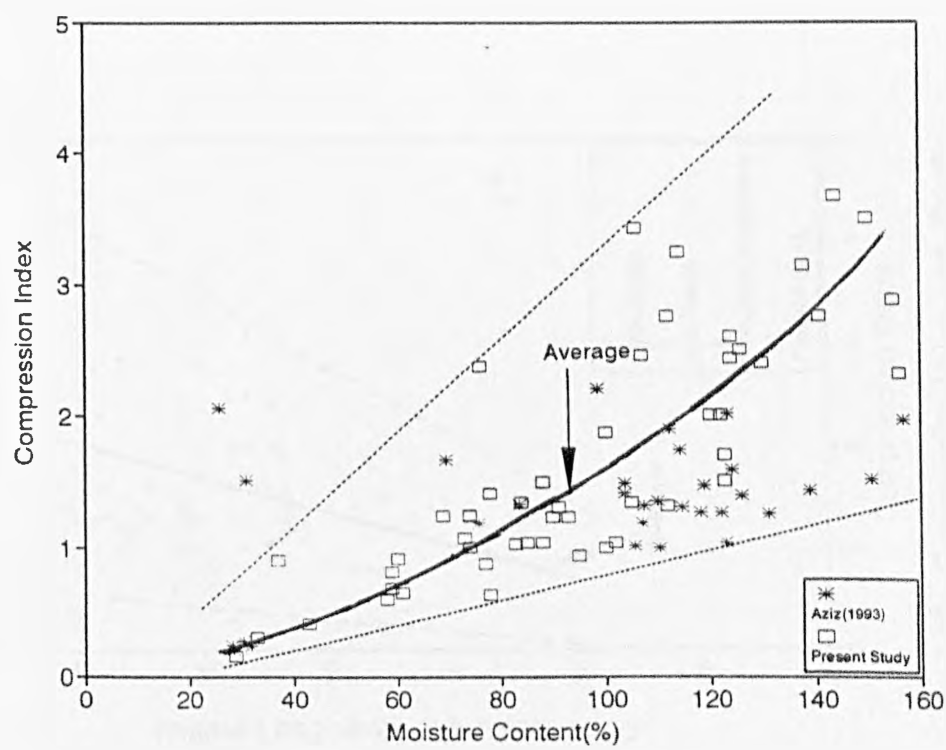


Fig.3.39 : Compression Index with Natural Moisture Content

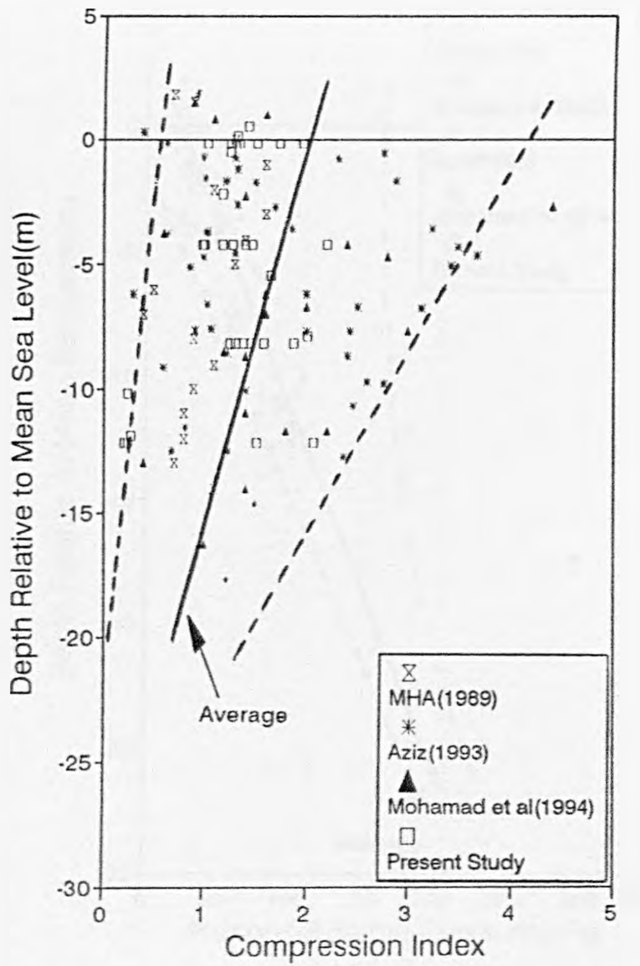


Fig.3.40 : Compression Index with Depth

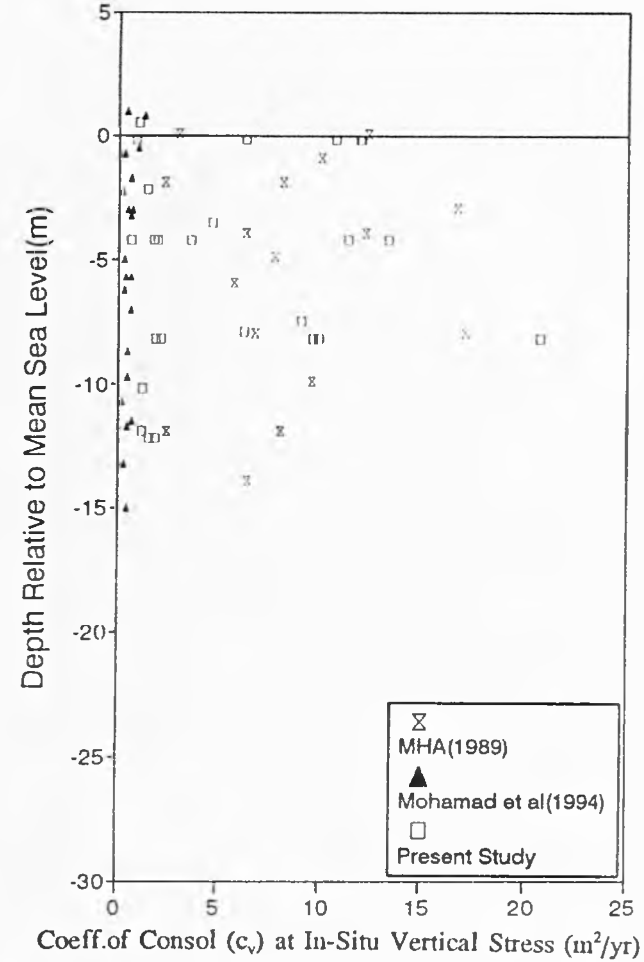


Fig.3.41 : Coefficient of Consolidation at In-Situ Vertical Stress with Depth

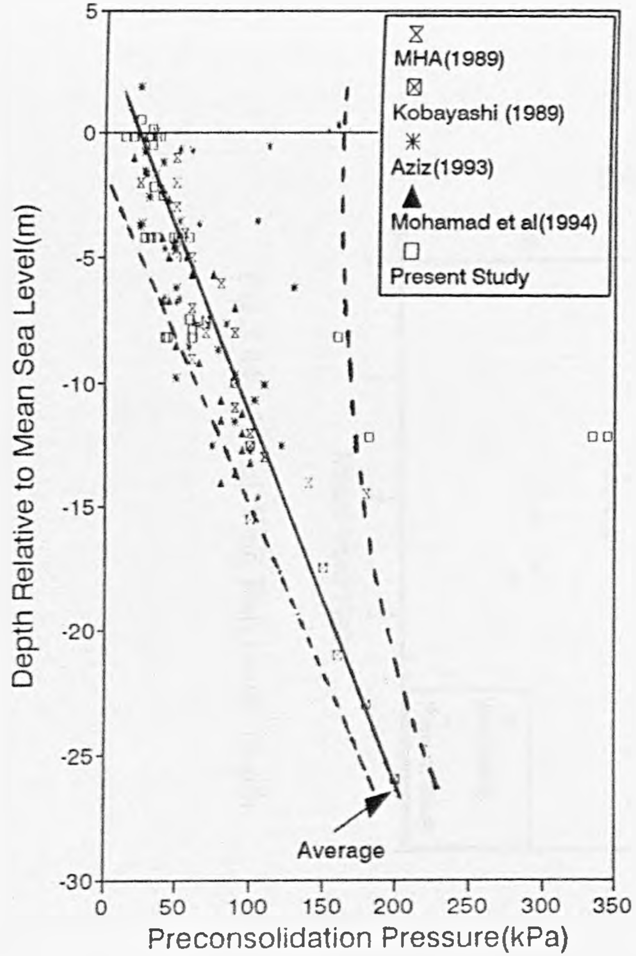


Fig.3.42 : Preconsolidation Pressure with Depth

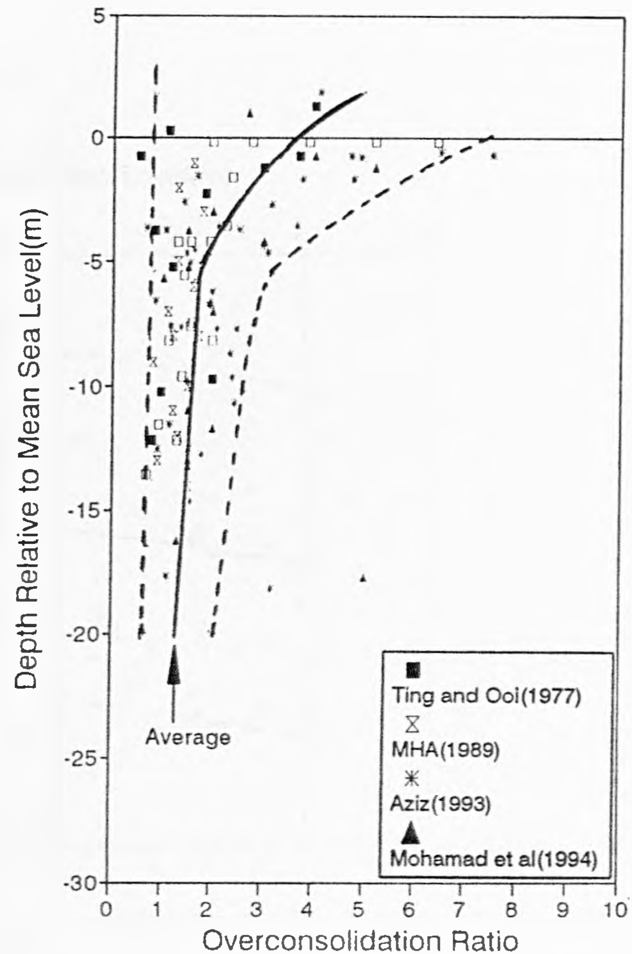


Fig.3.43 : Overconsolidation Ratio with Depth

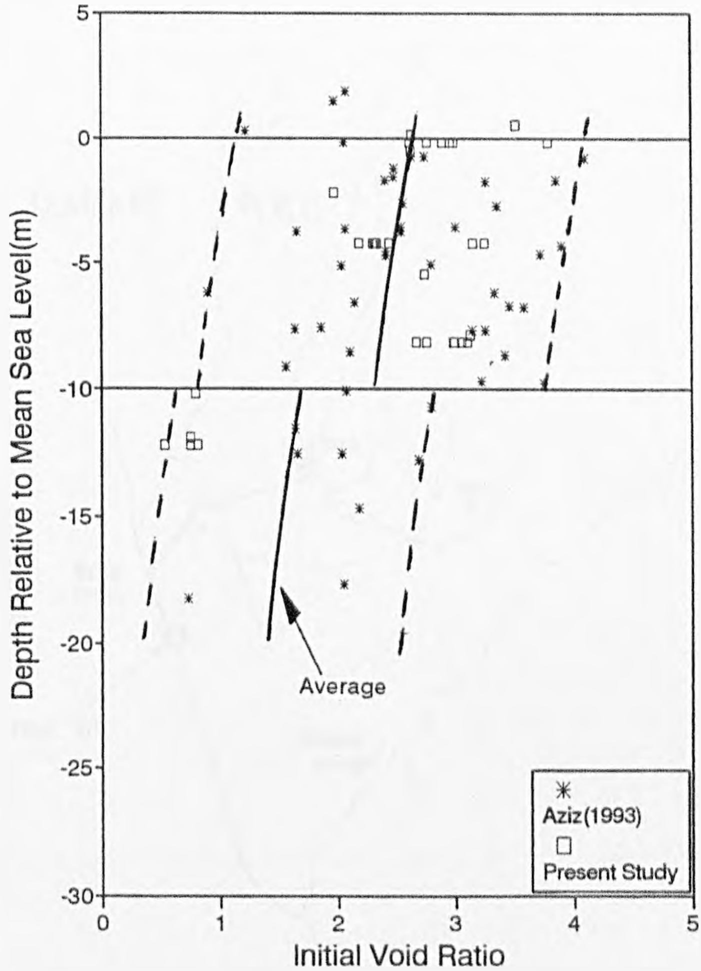


Fig.3.44 : Initial Void Ratio with Depth

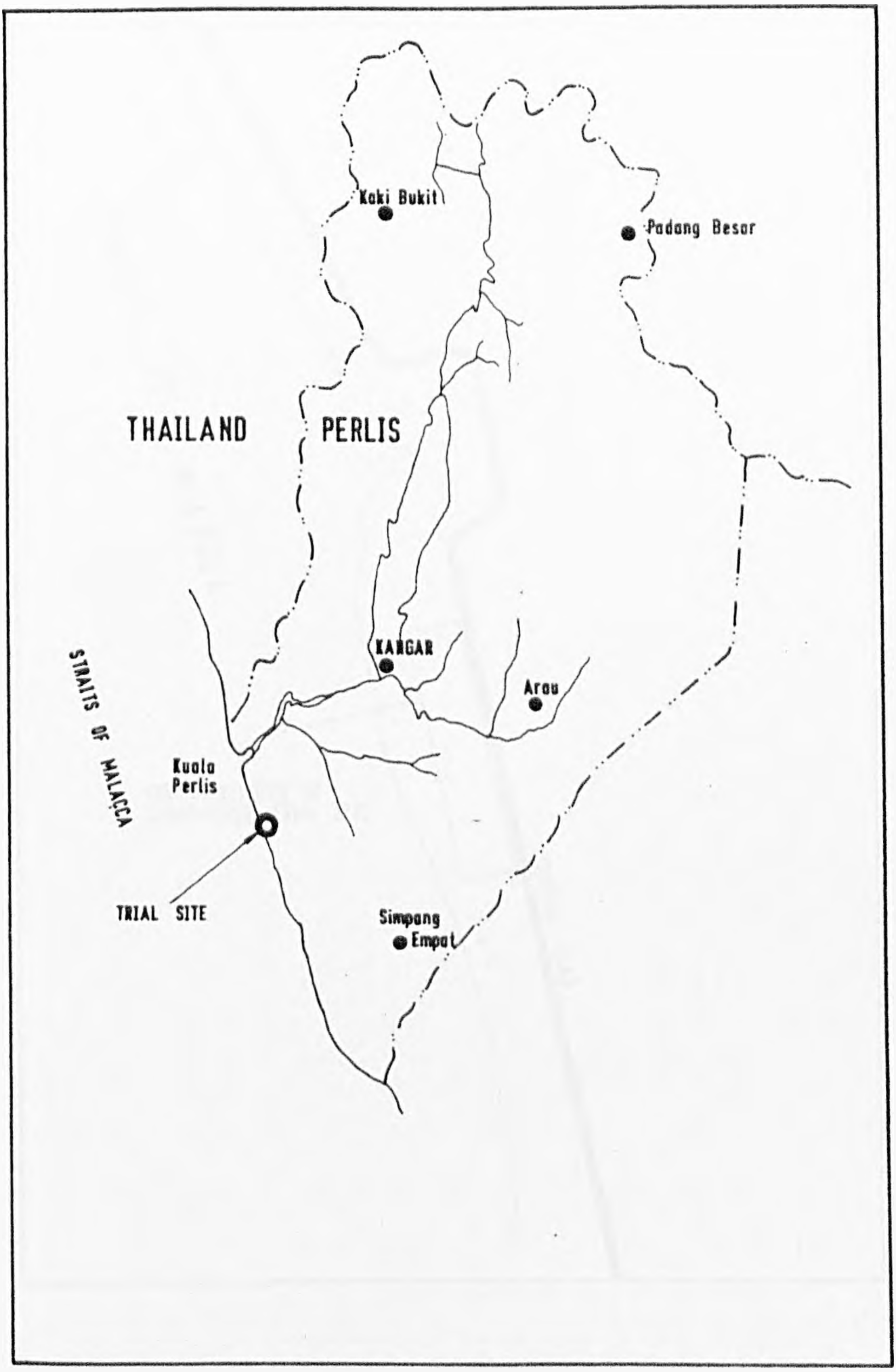


Fig.4.1 : Location of the Trial Embankment Site in the State of Perlis, Northwest Peninsular Malaysia

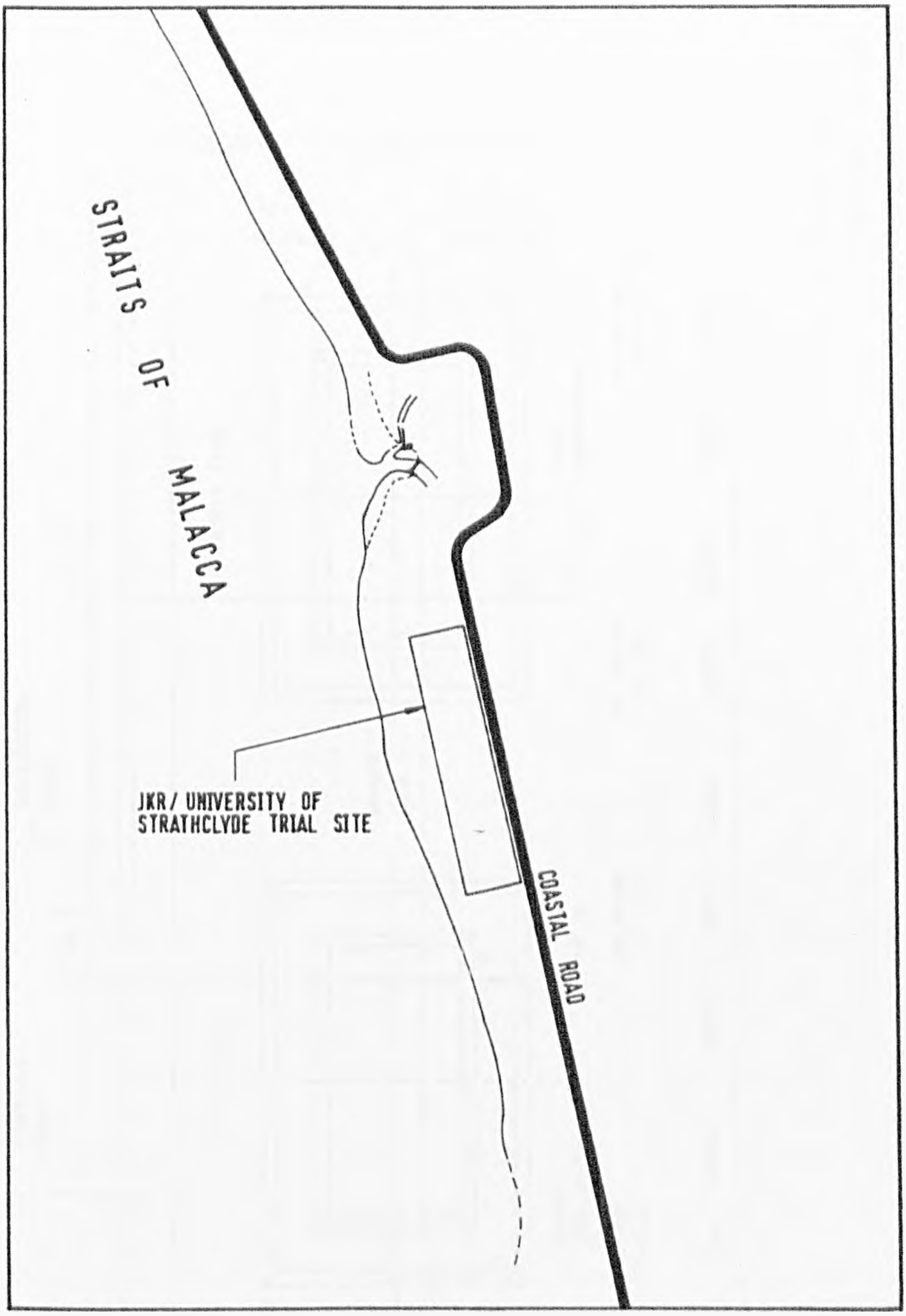


Fig.4.2 : Actual Location of the Trial Embankment Site Near Kuala Perlis, Perlis

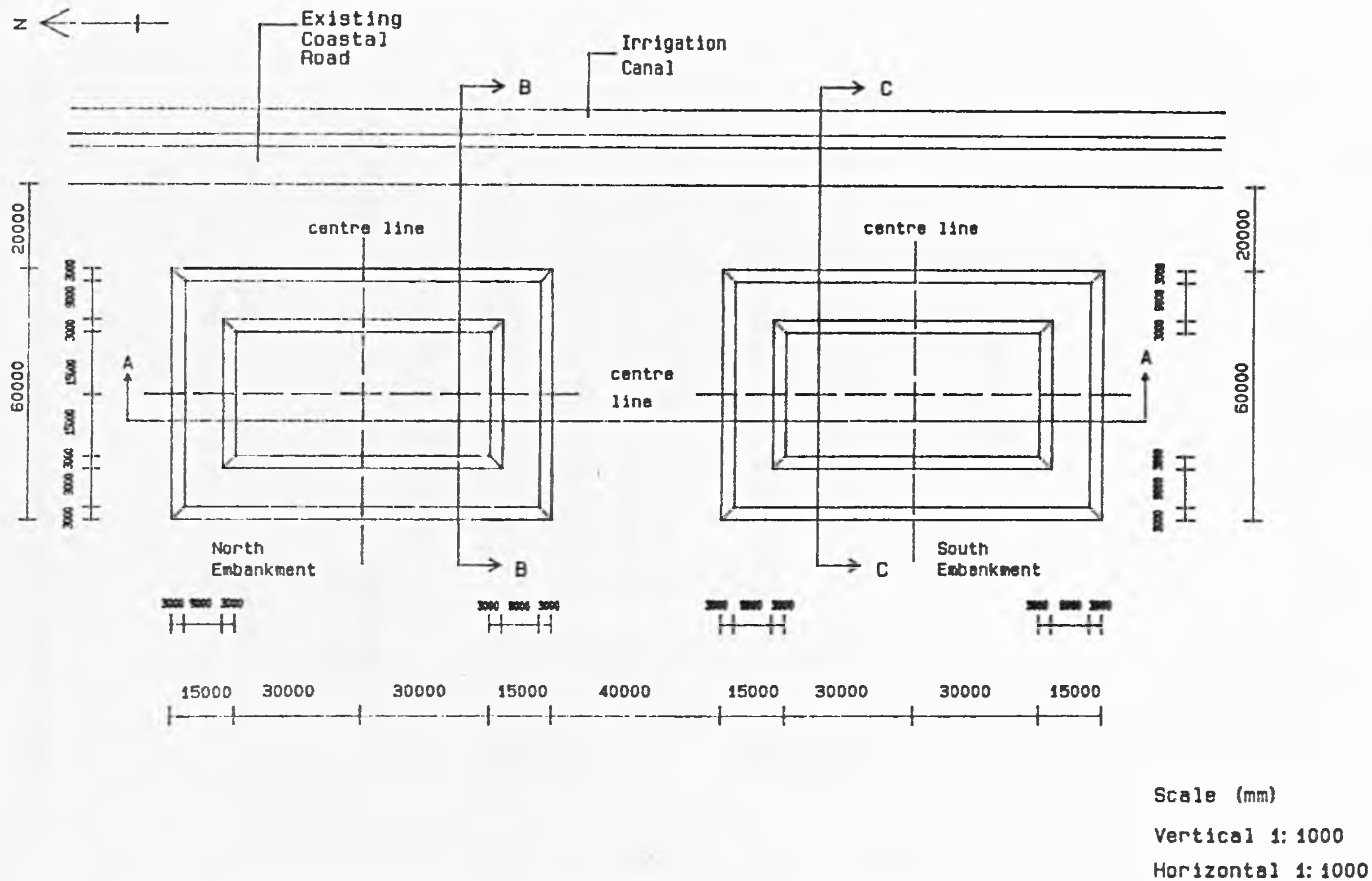


Fig.4.3 : Details of the Layout of the North and South Trial Embankments

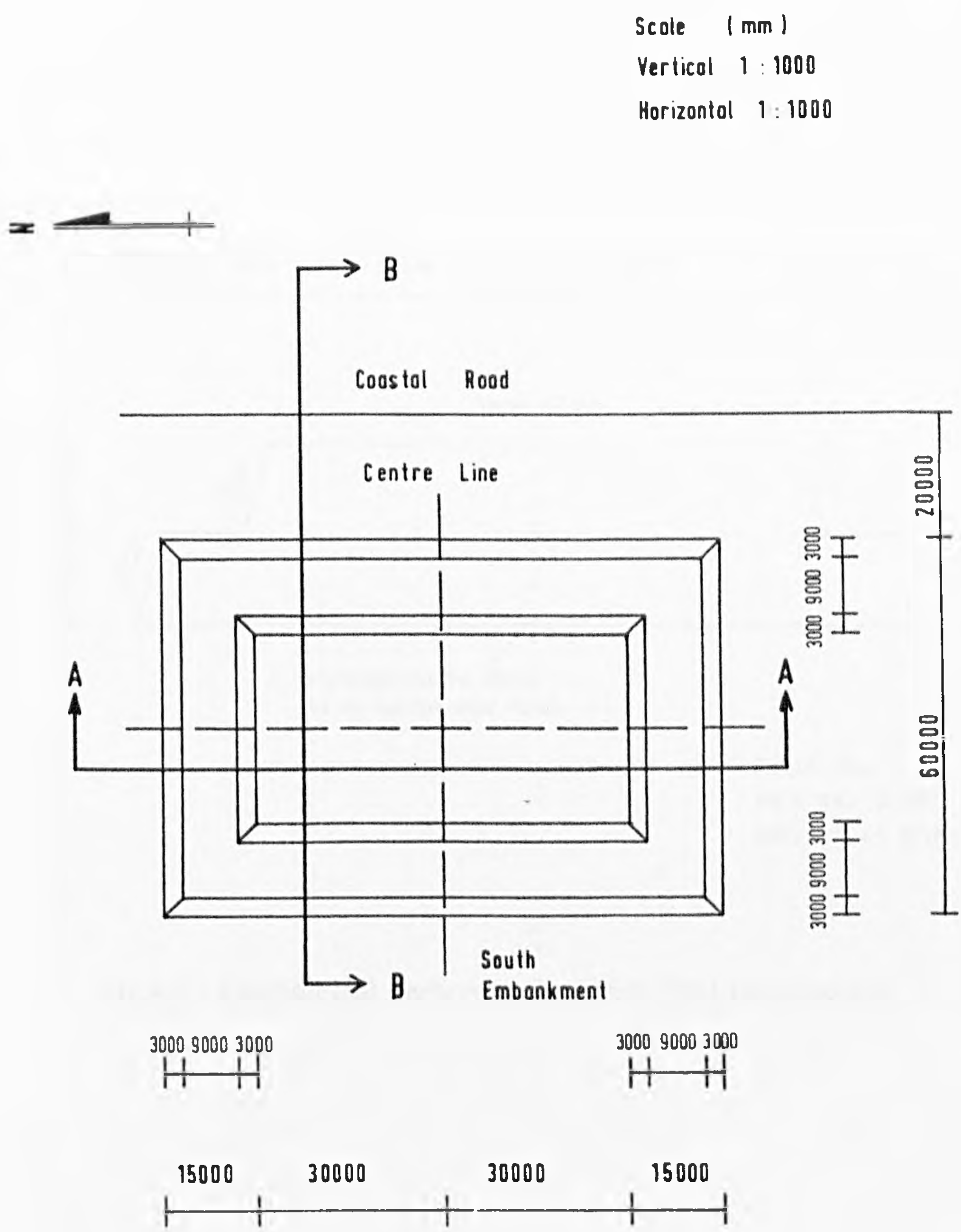


Fig.4.4 : Details of the Layout of the South Trial Embankment

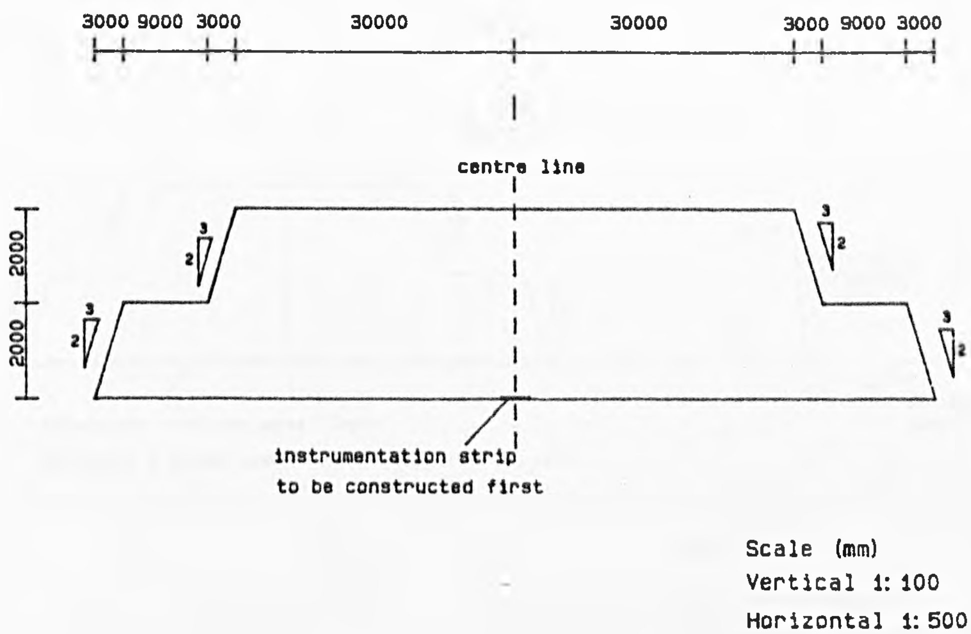


Fig.4.5 : Longitudinal Section of the South Trial Embankment

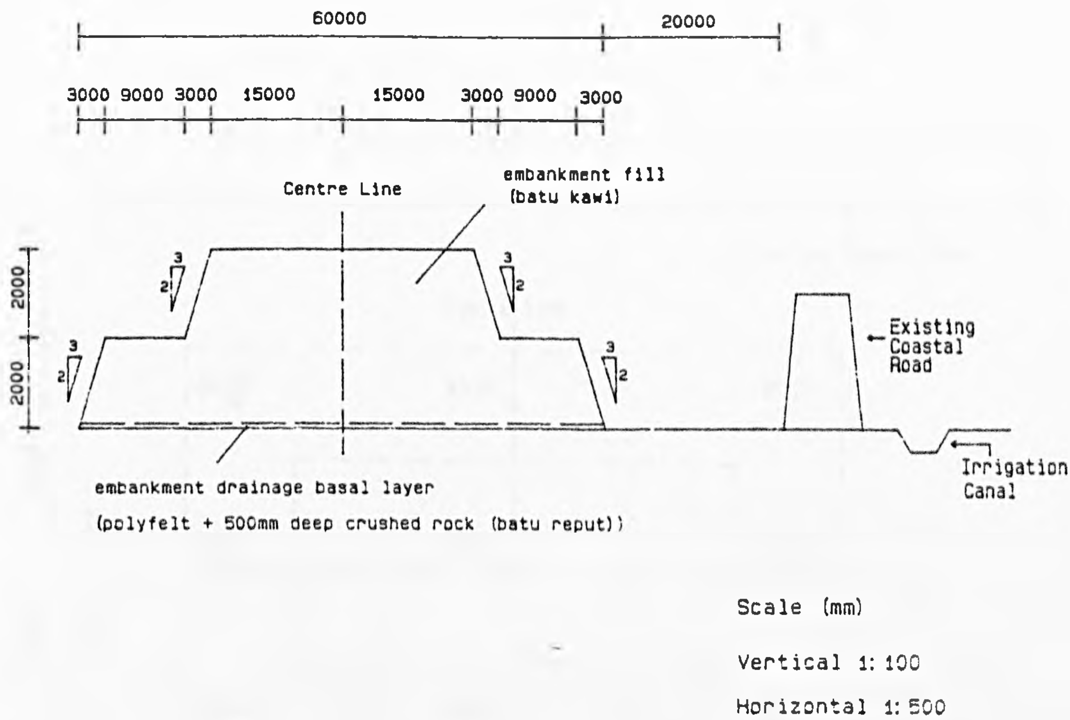


Fig.4.6 : Cross Section of the South Trial Embankment

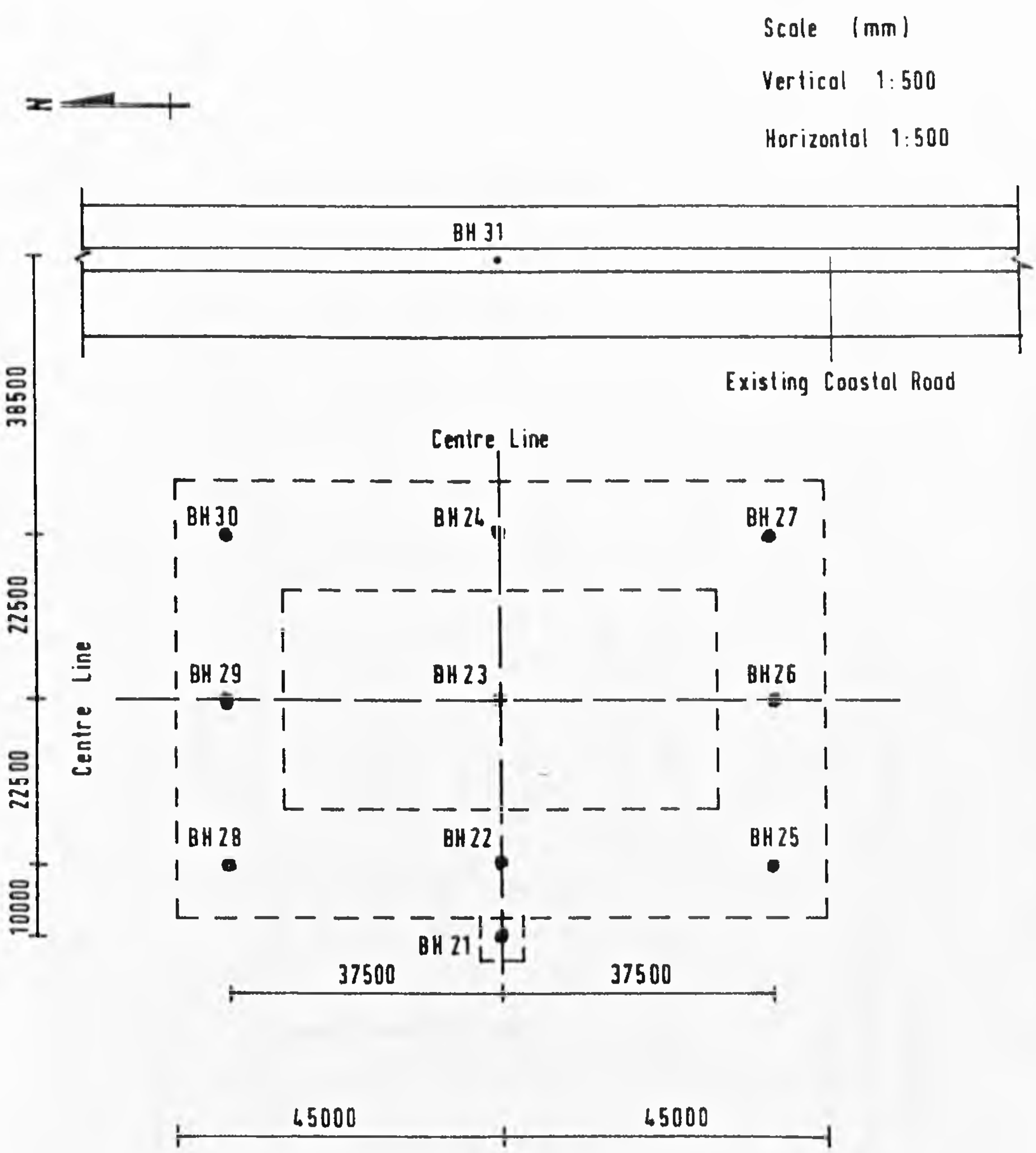


Fig.4.7 : Location of Boreholes on the South Trial Embankment

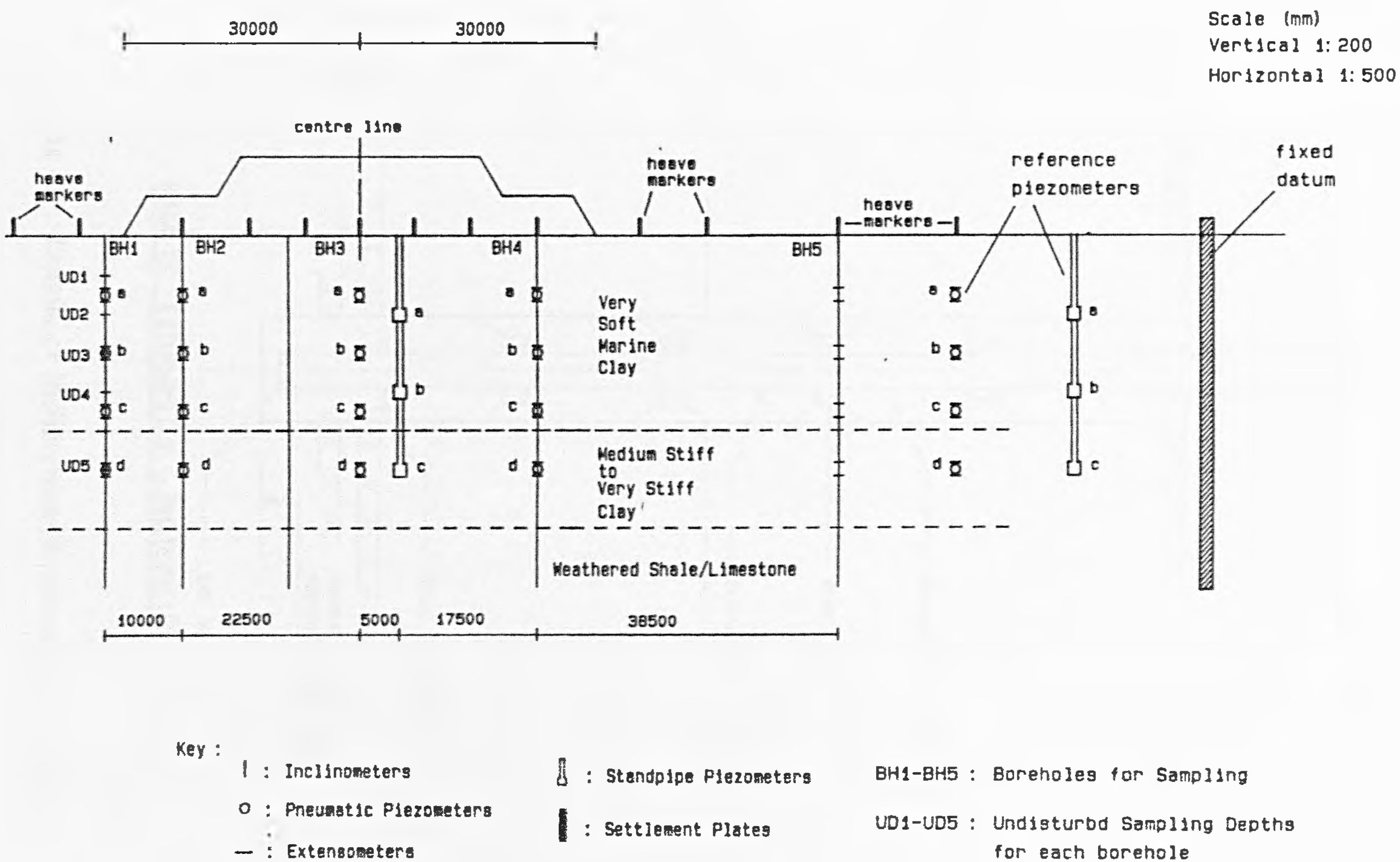


Fig.4.8 : Detail Layout of Instrumentation Work

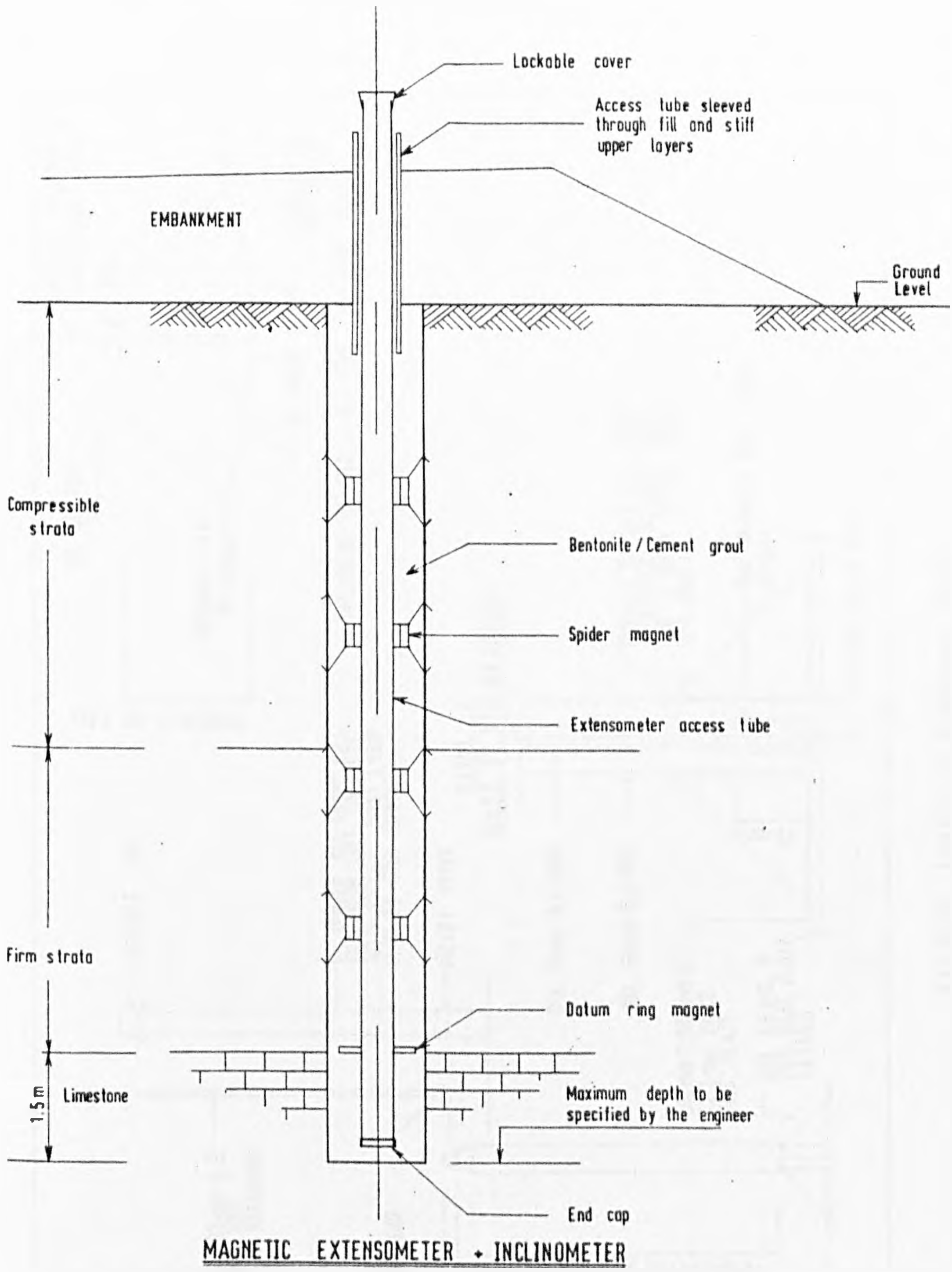


Fig.4.9 : Details of Inclinometer/Extensometer System

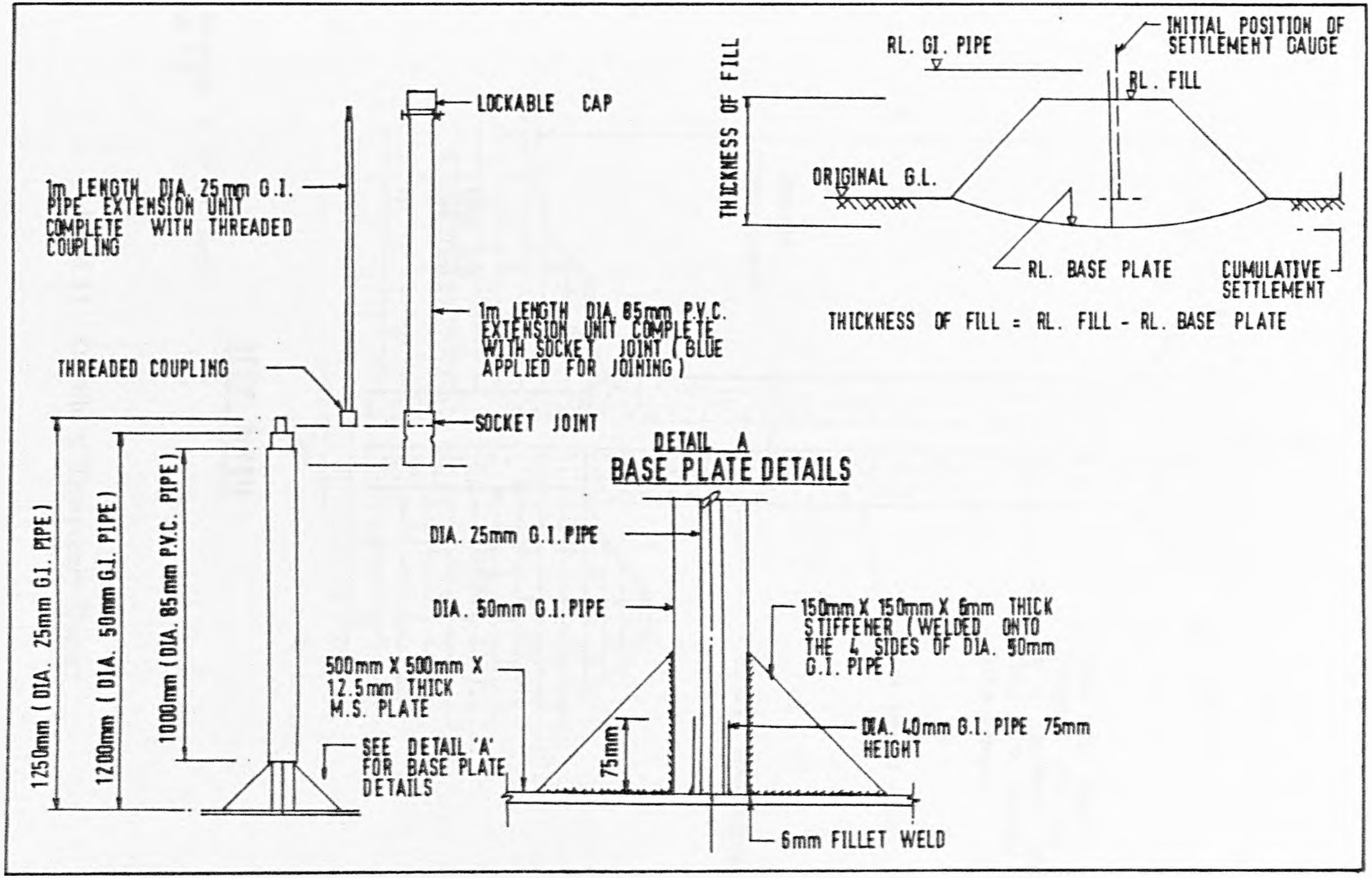


Fig.4.10 : Details of Settlement Plates

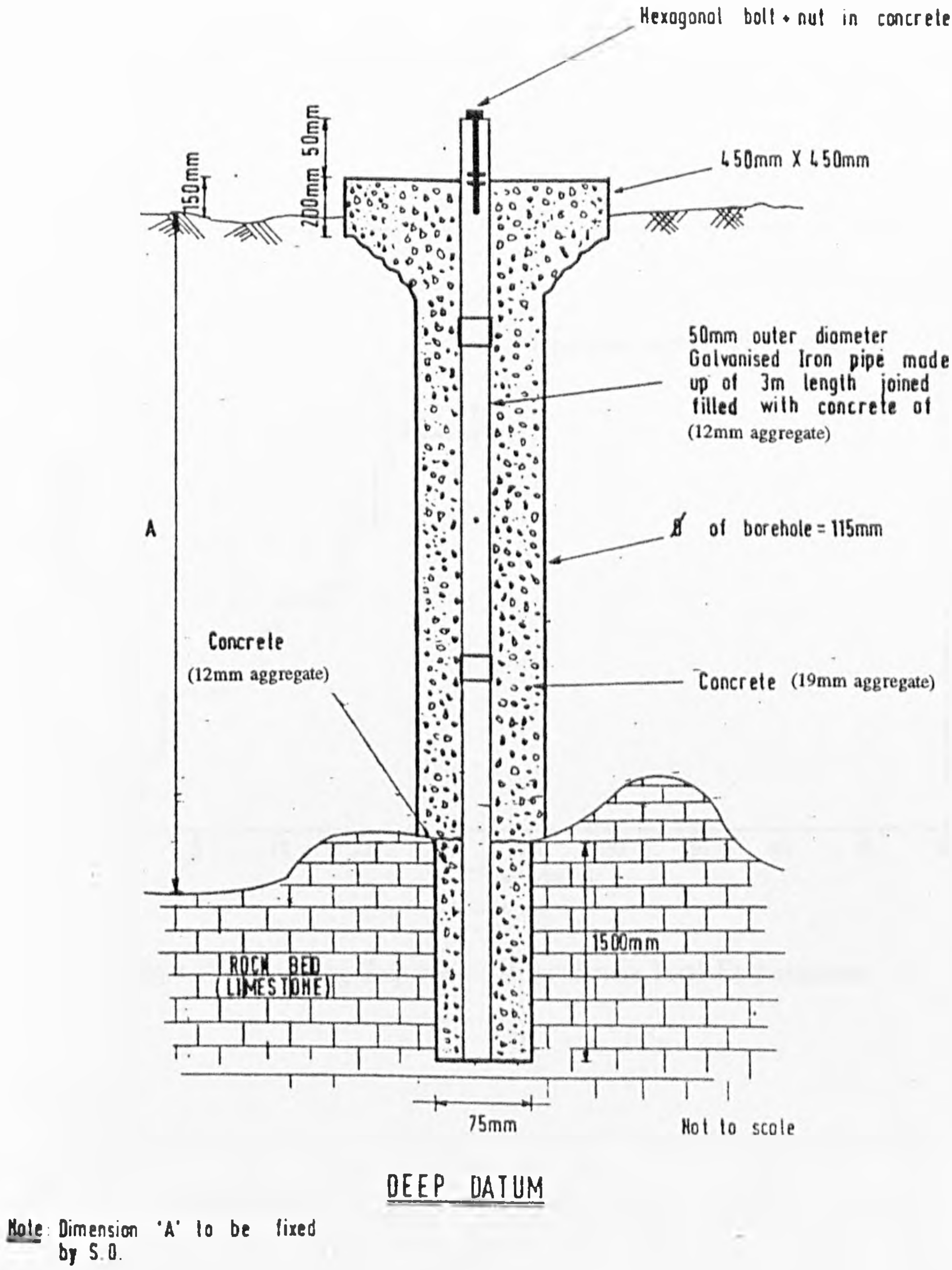


Fig.4.11 : Details of Temporary Datum

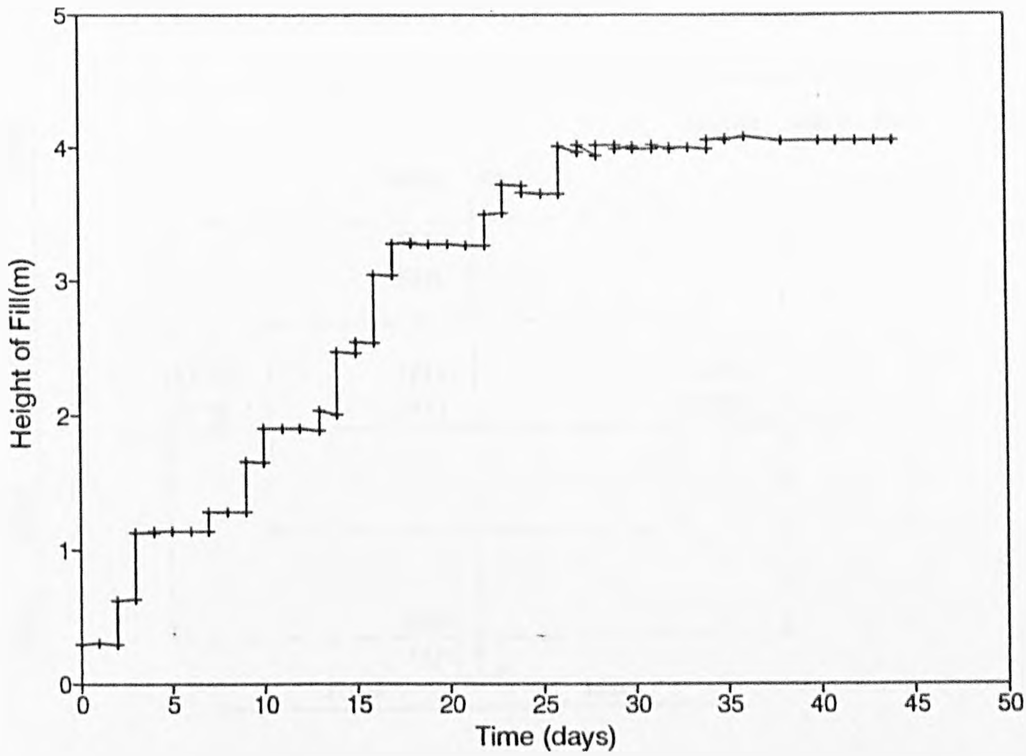


Fig.4.12 : Loading Sequence for the South Trial Embankment

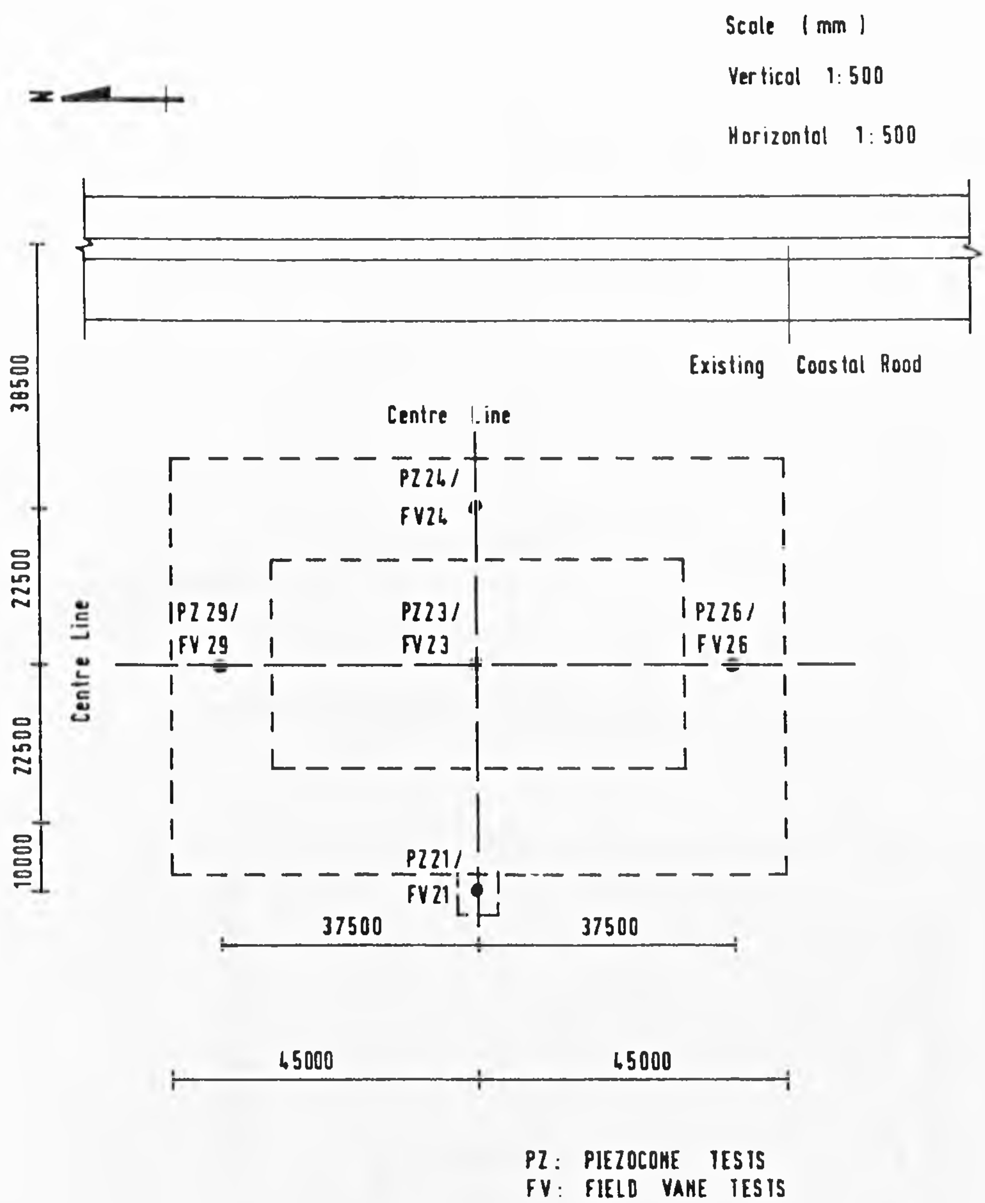


Fig.4.13 : Locations of Field Vane and Piezcone Tests

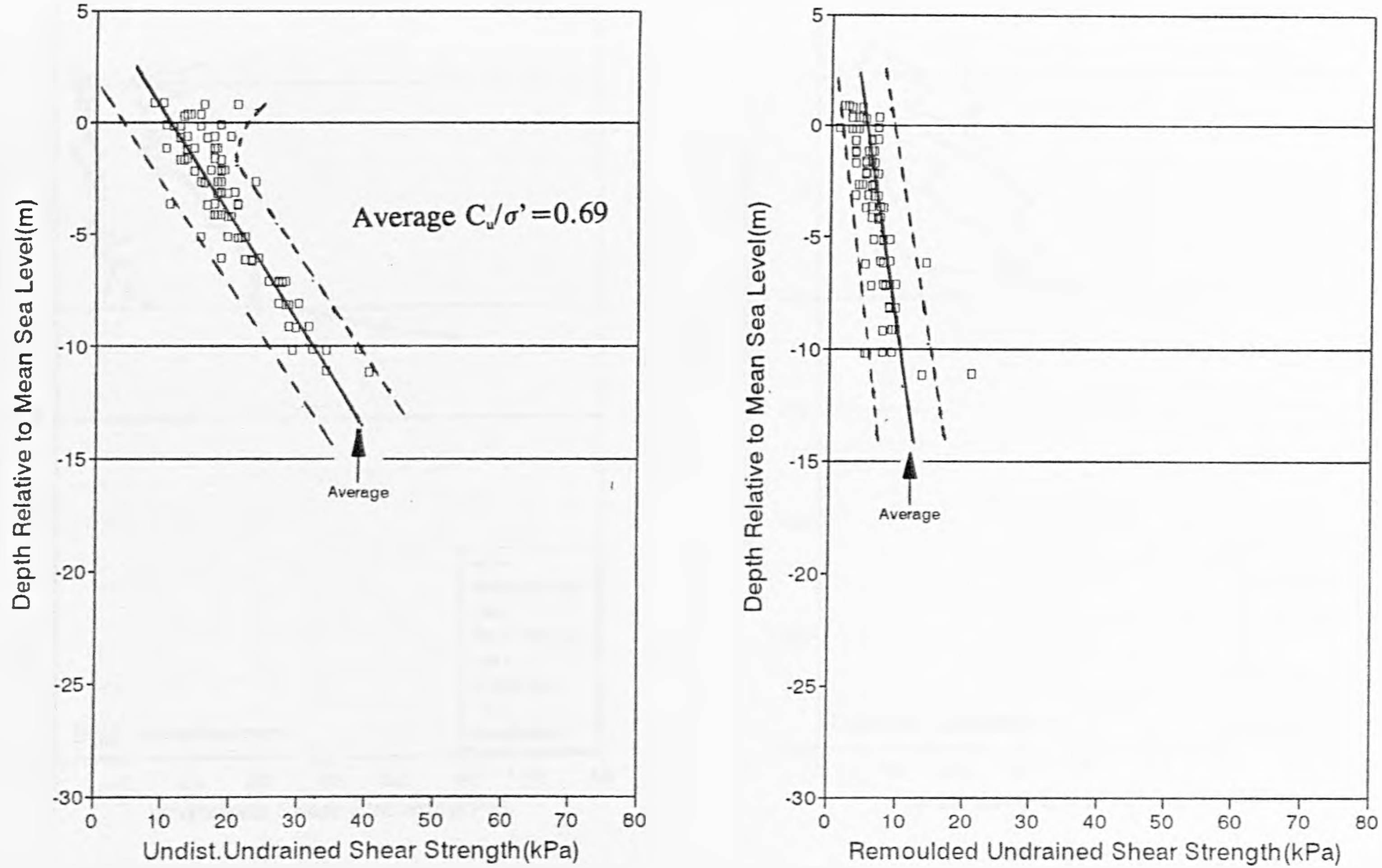


Fig.5.1 : Undrained Shear Strength with Depth from Field Vane Tests Before Construction of the Trial Embankment

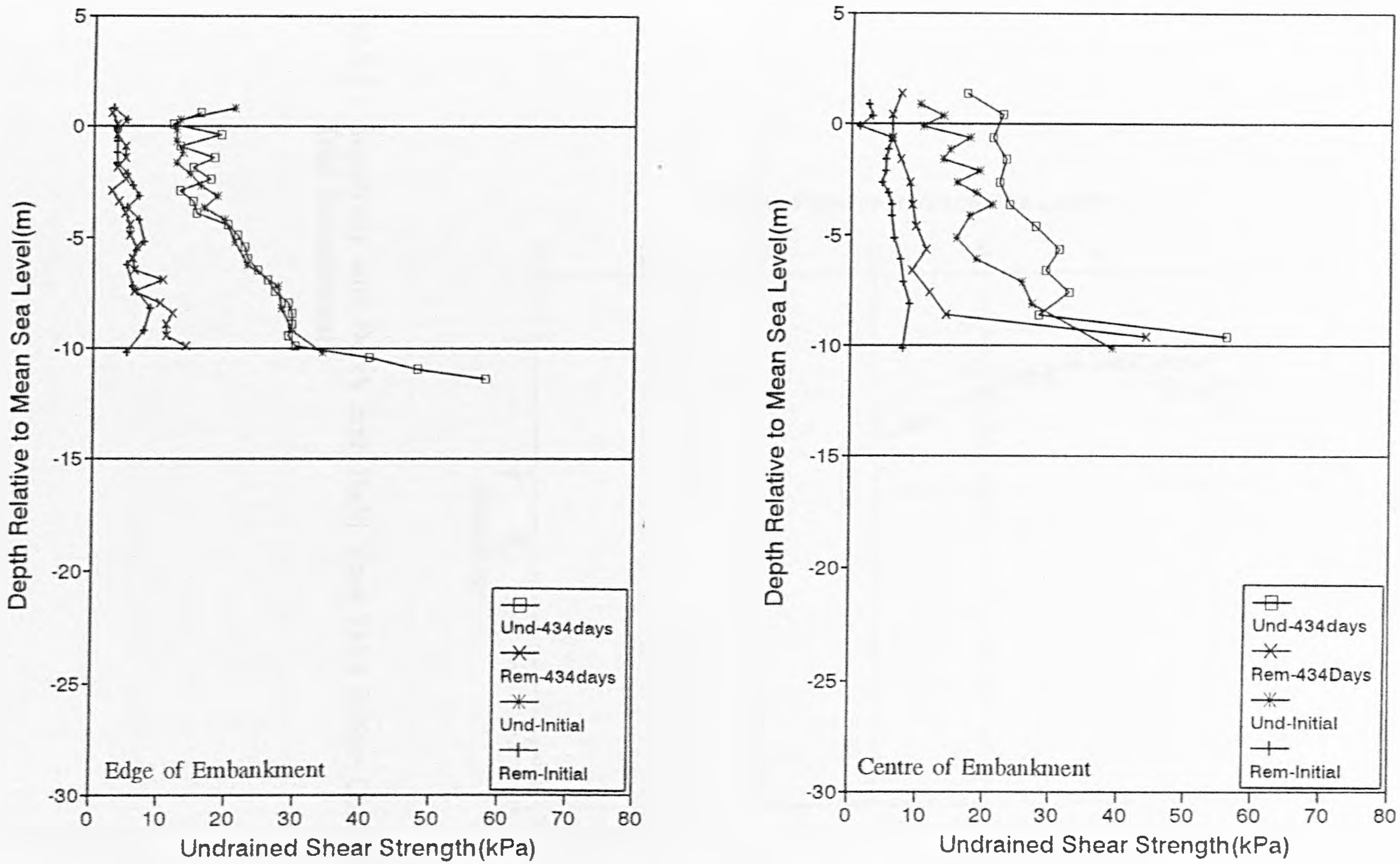


Fig.5.2 : Undrained Shear Strength with Depth from Field Vane Tests 434 days After The Start of Construction of the Trial Embankment

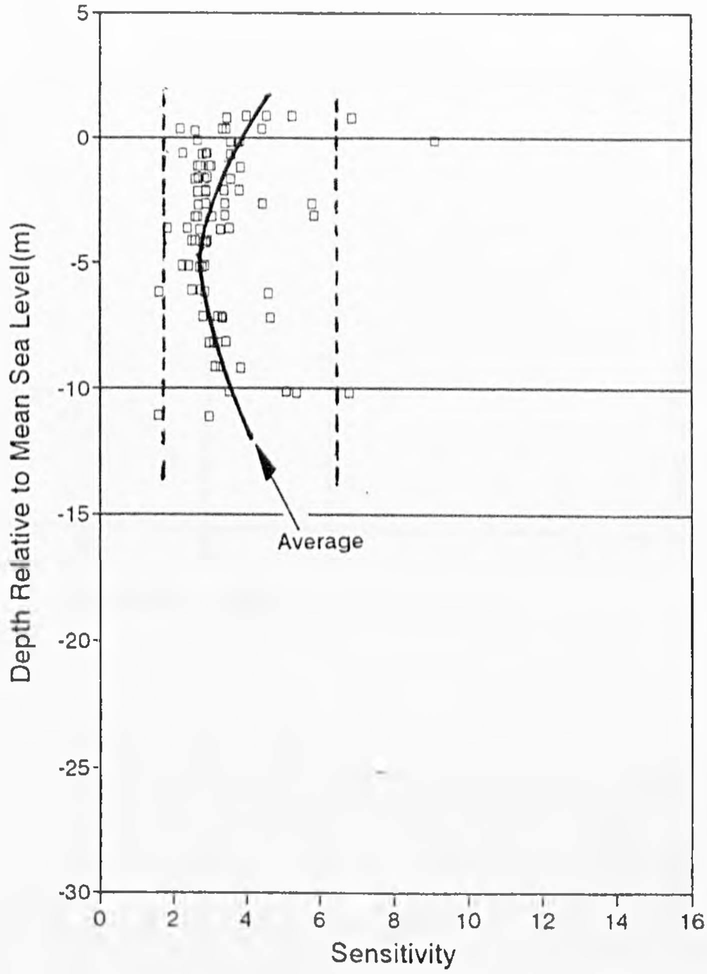


Fig.5.3 : Sensitivity with Depth from Field Vane Tests Before Construction of the Trial Embankment

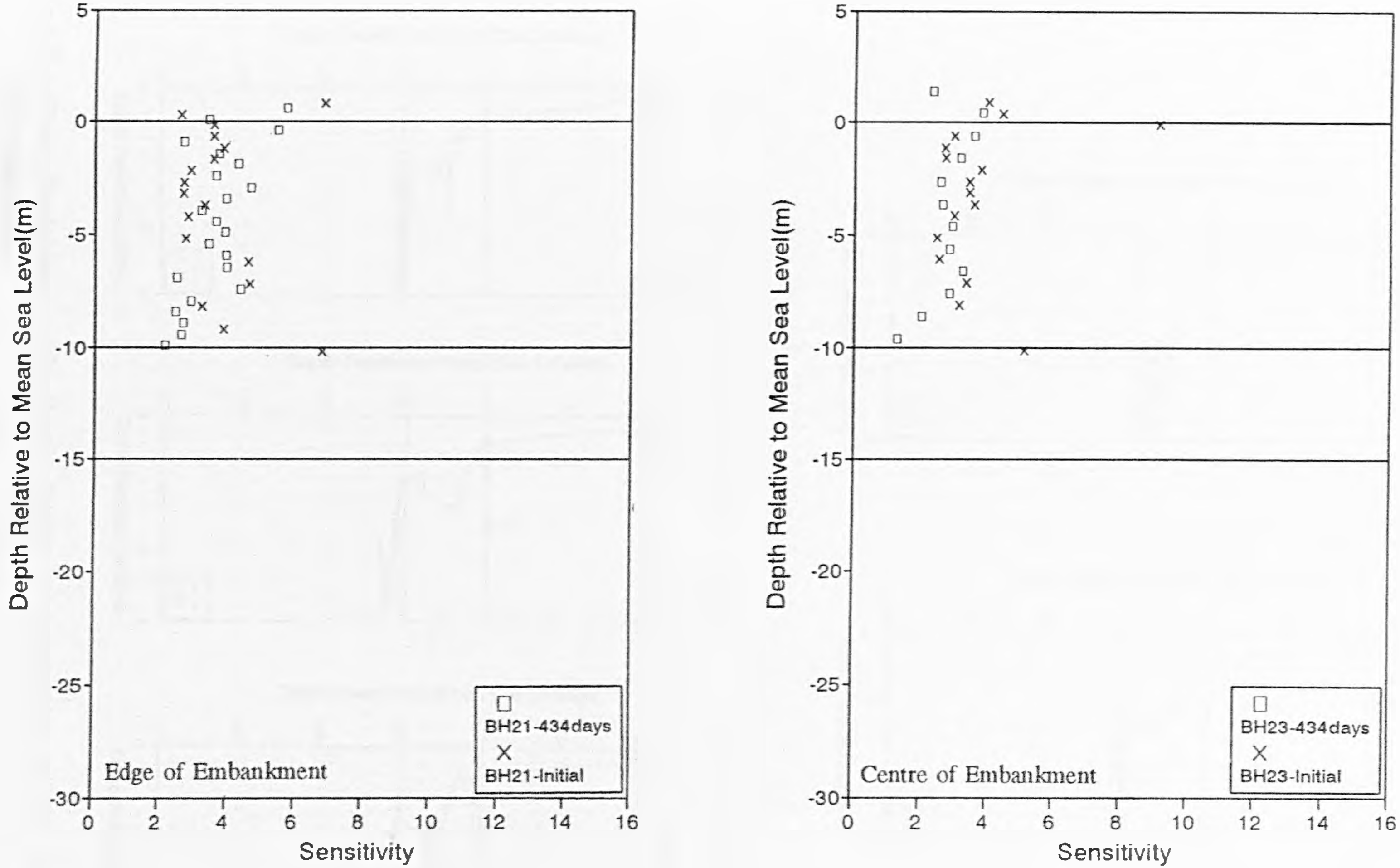


Fig.5.4 : Sensitivity with Depth from Field Vane Tests 434 days After The Start of Construction of the Trial Embankment

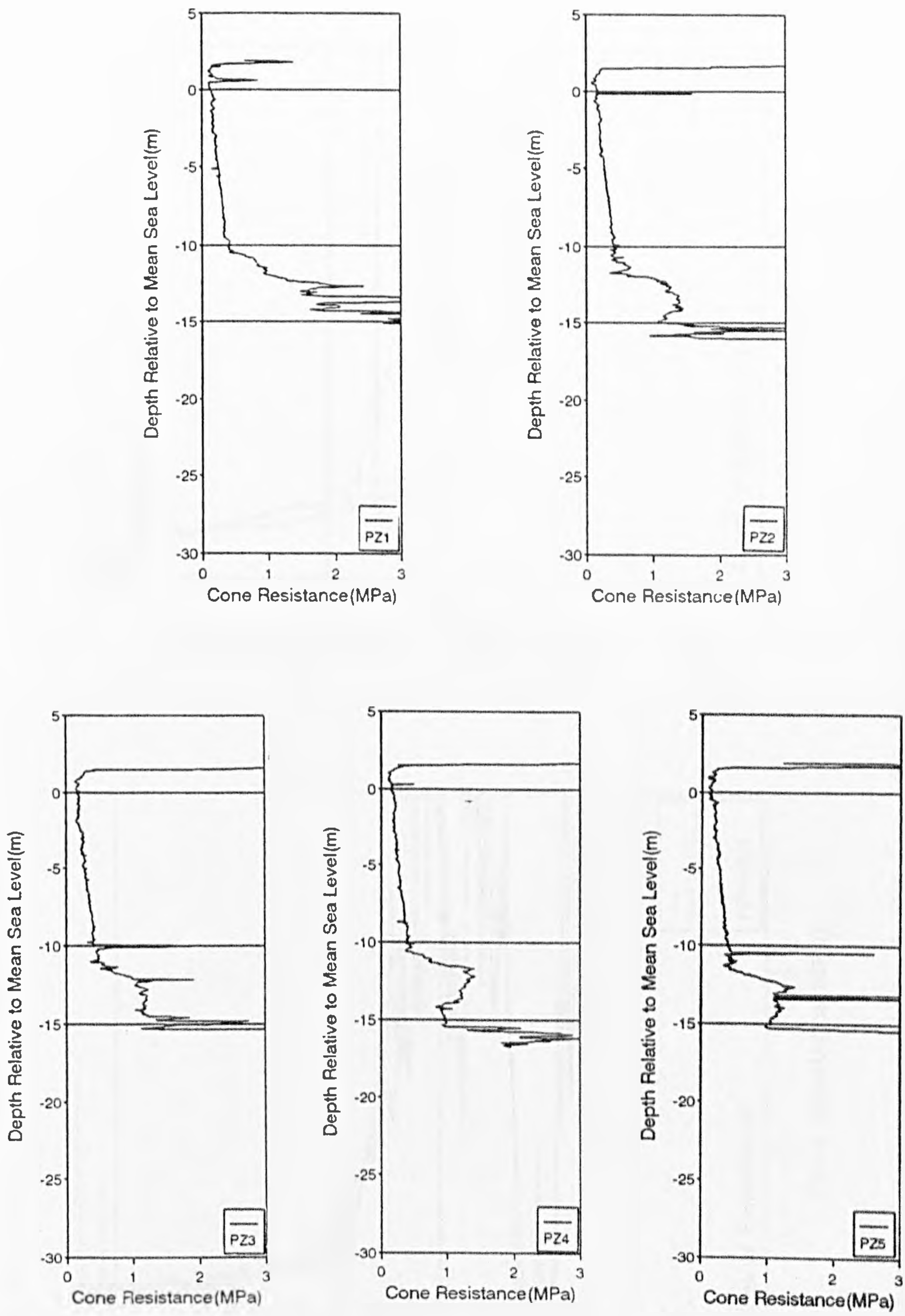


Fig.5.5 : Cone Resistance with Depth Before Construction of the South Trial Embankment

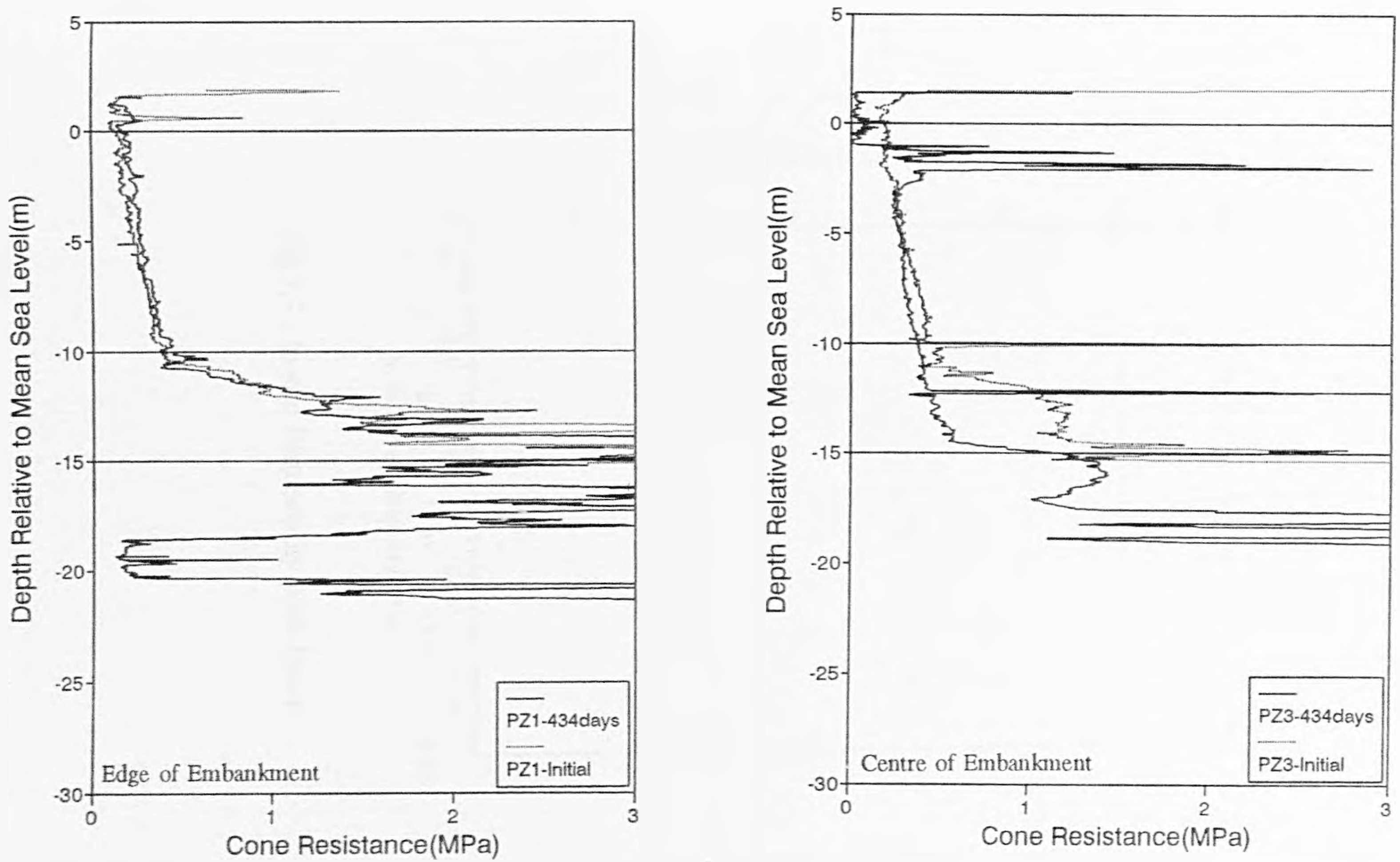


Fig.5.6 : Cone Resistance with Depth 594 days After the Start of Construction of the Trial Embankment

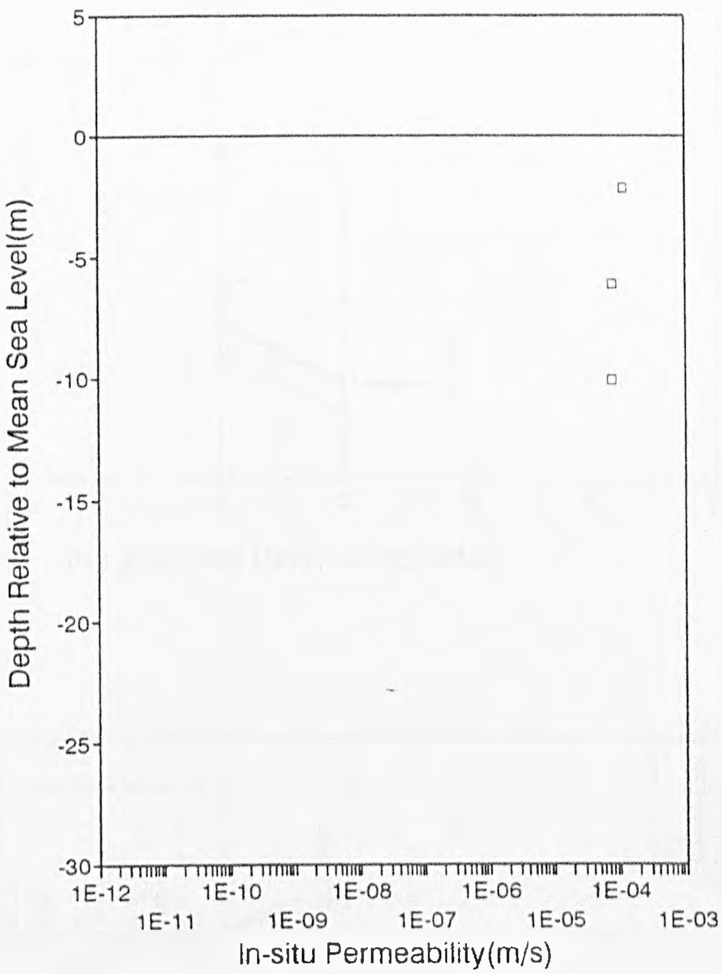


Fig.5.7 : In-situ Permeability with Depth

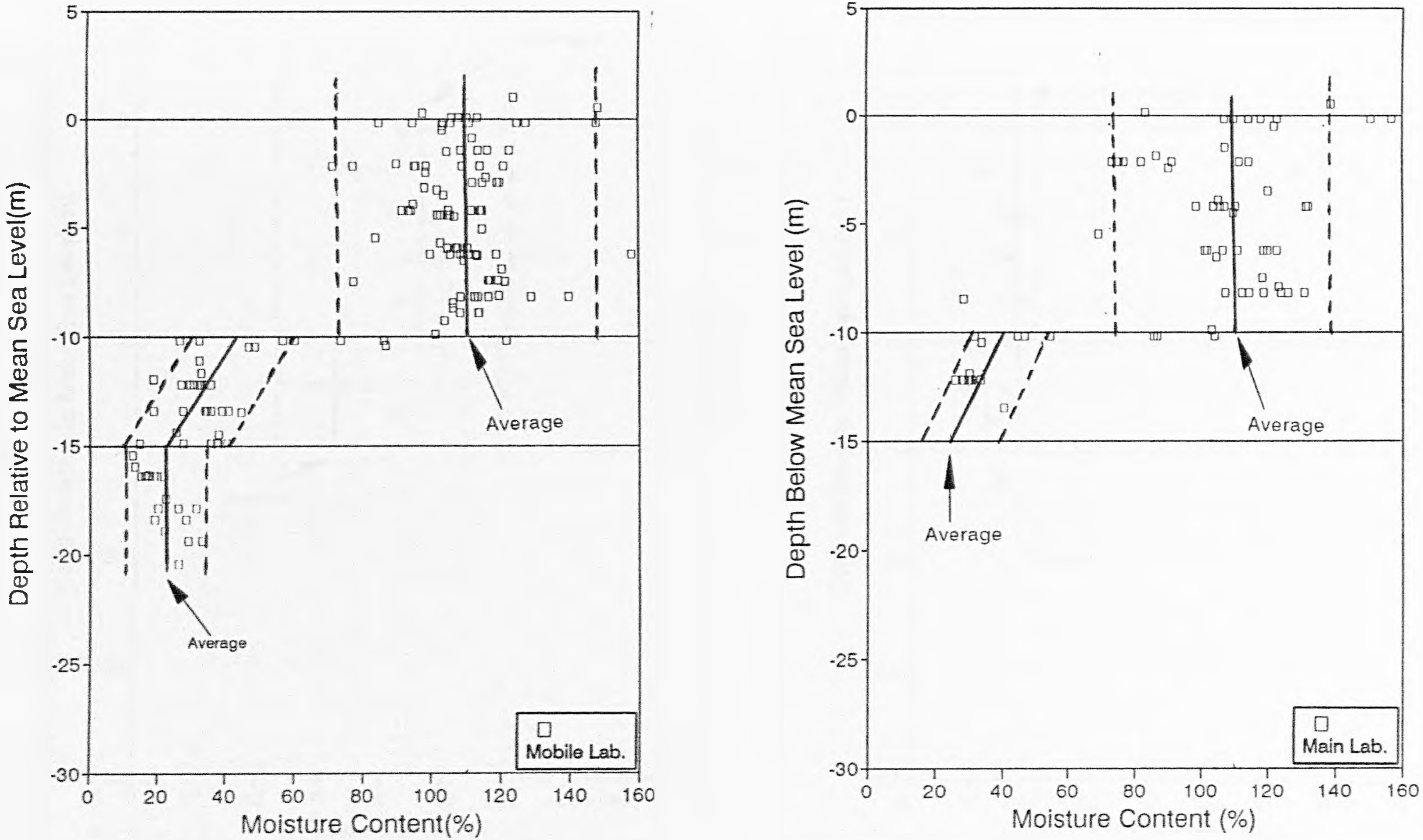


Fig.5.8 : Moisture Content with Depth

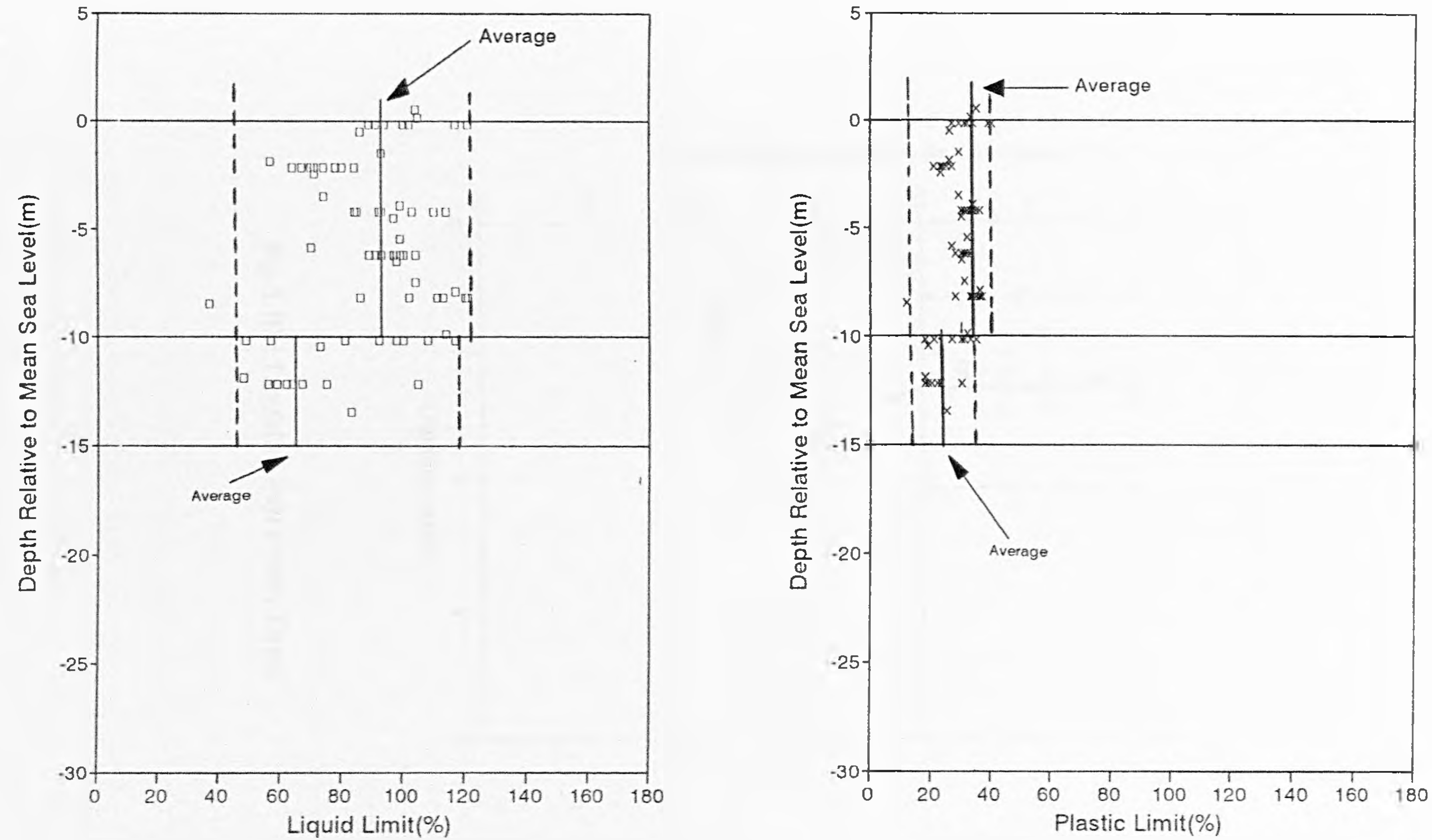


Fig.5.9: Atterberg Limits with Depth

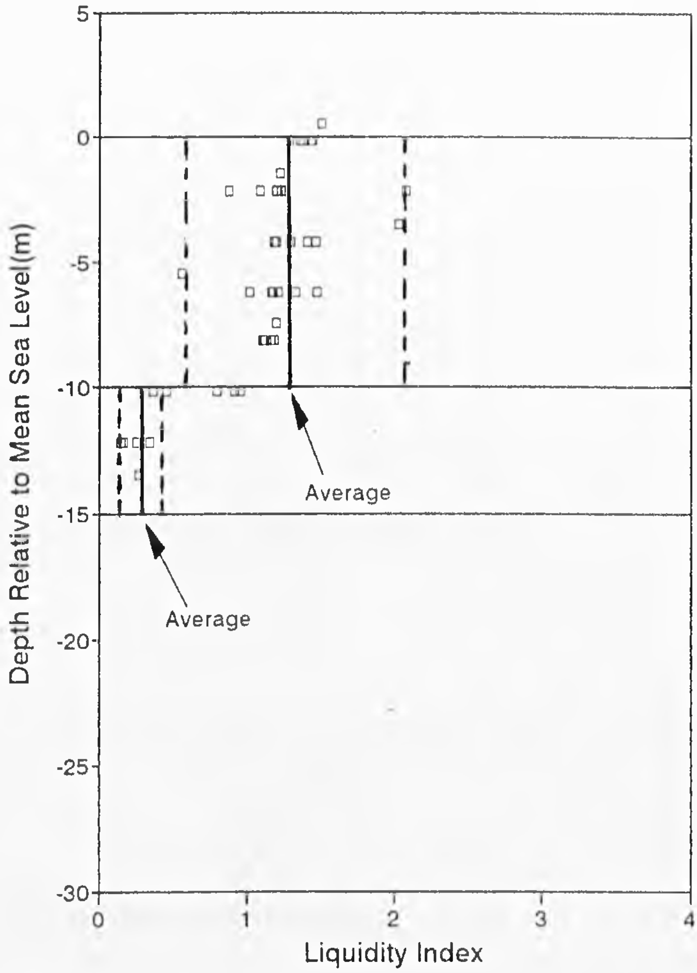


Fig.5.10 : Liquidity Index with Depth

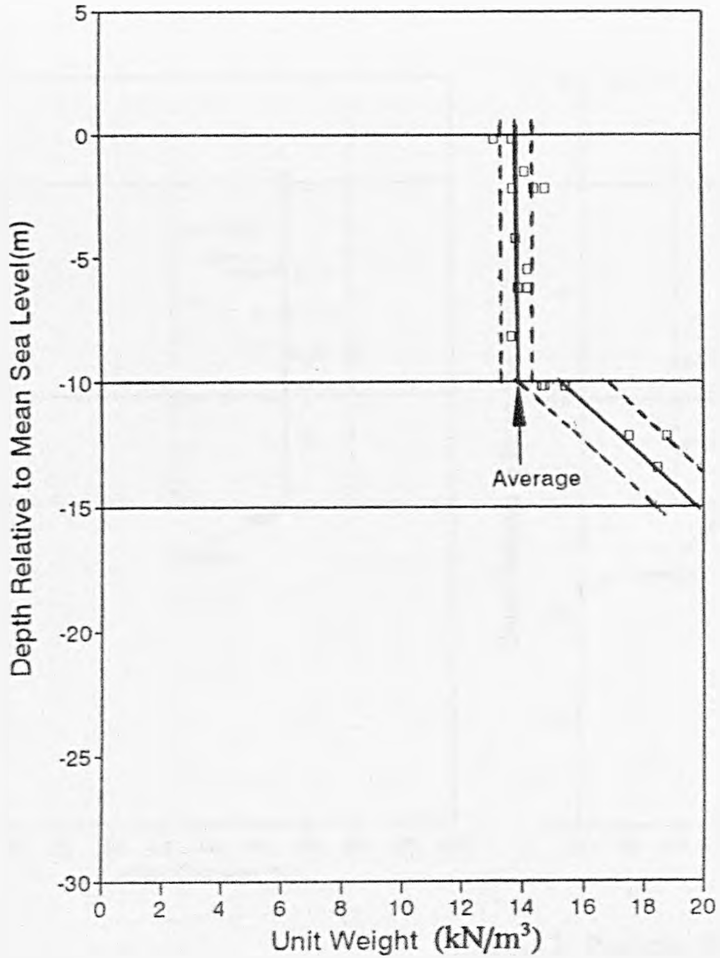


Fig.5.11 : Unit Weight with Depth

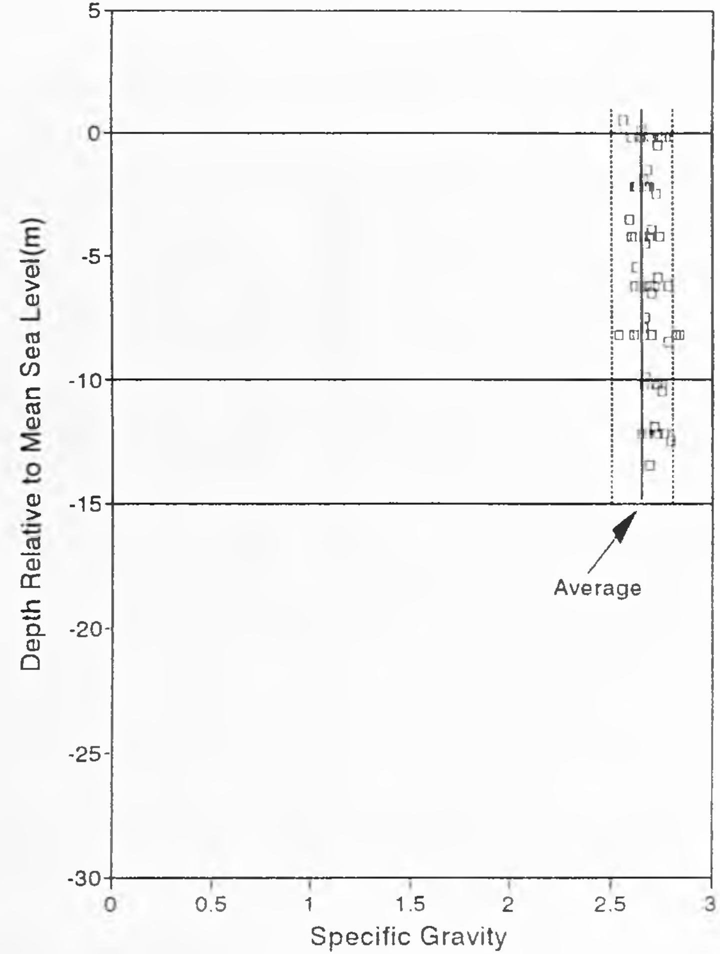


Fig.5.12 : Specific Gravity with Depth

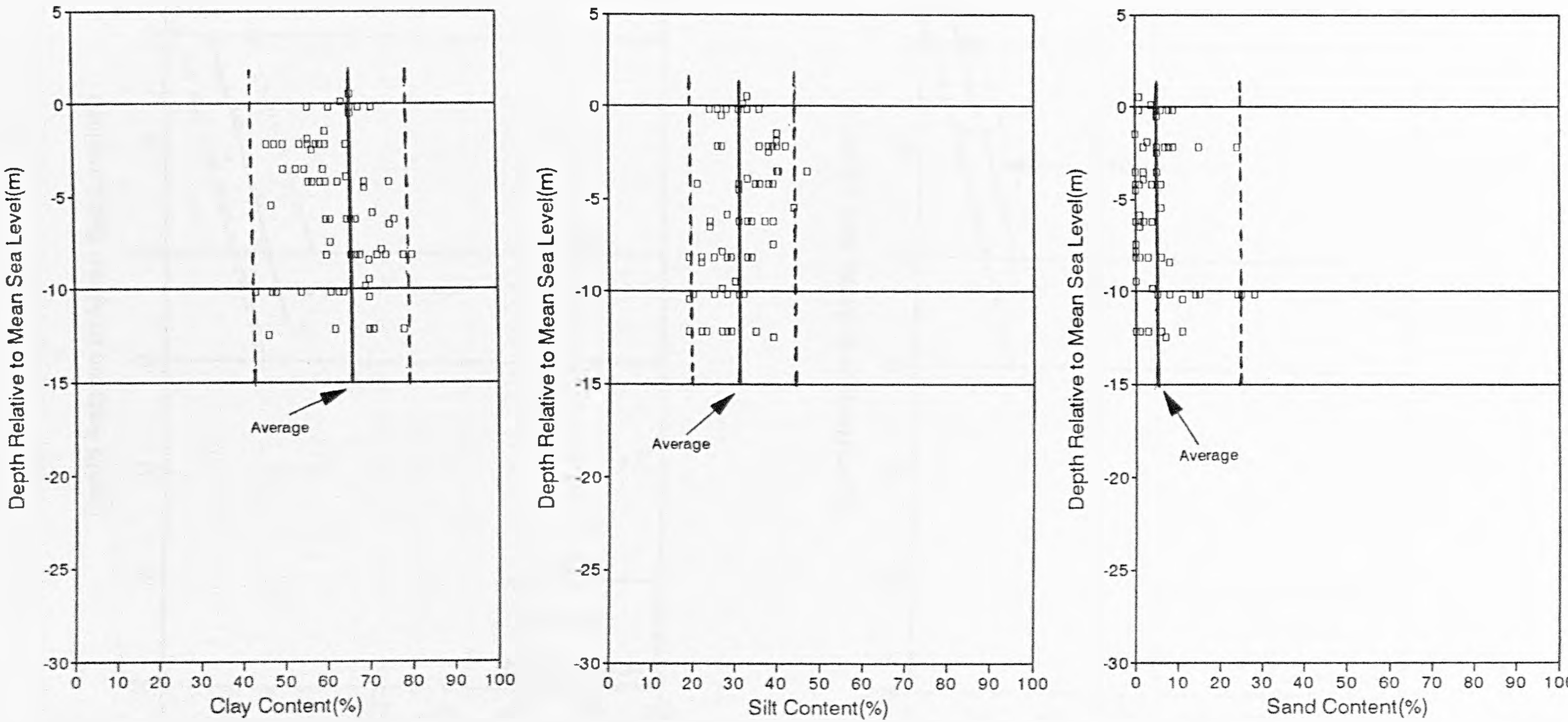


Fig.5.13: Particle Size Distribution with Depth

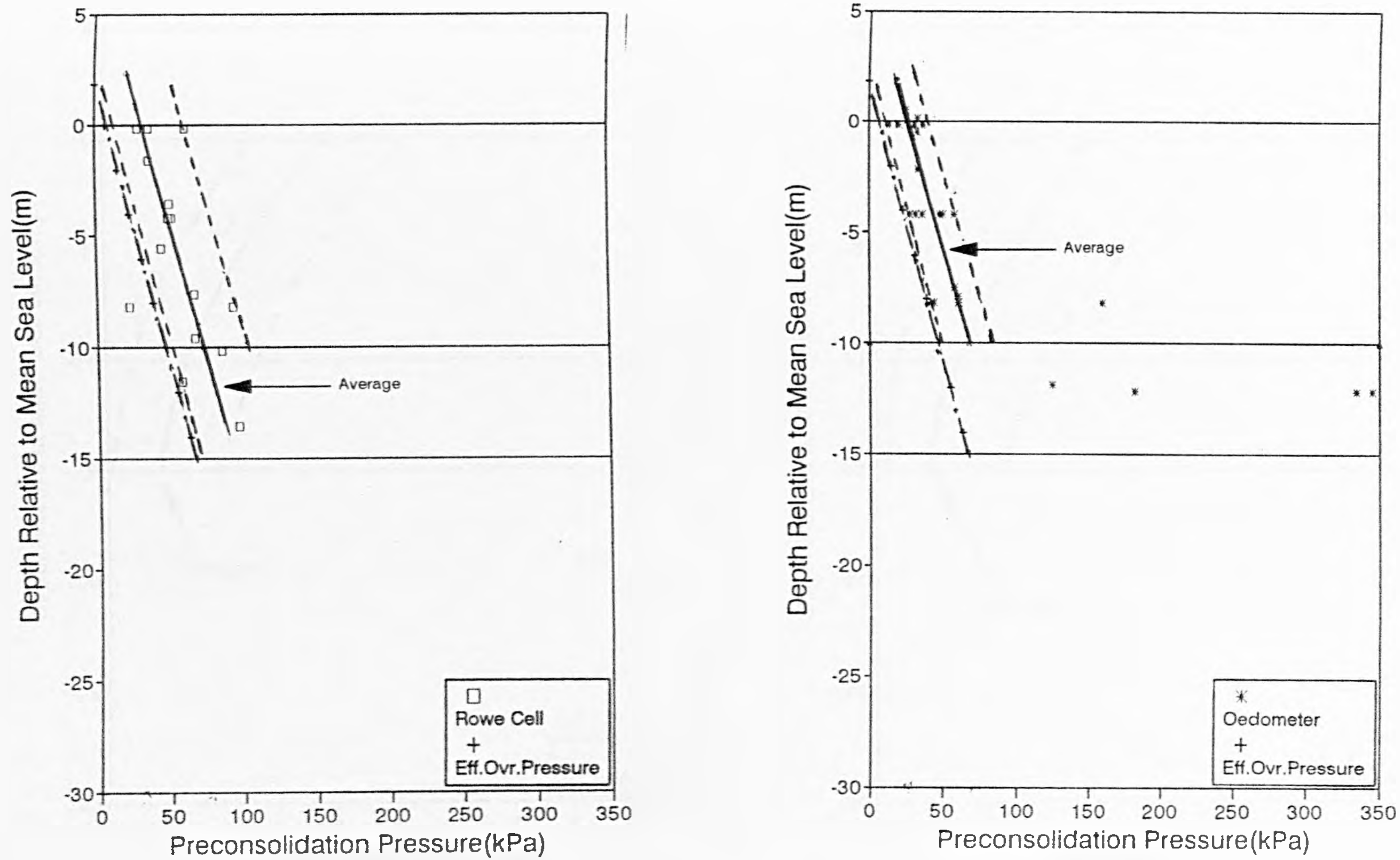


Fig.5.14: Preconsolidation Pressure with Depth

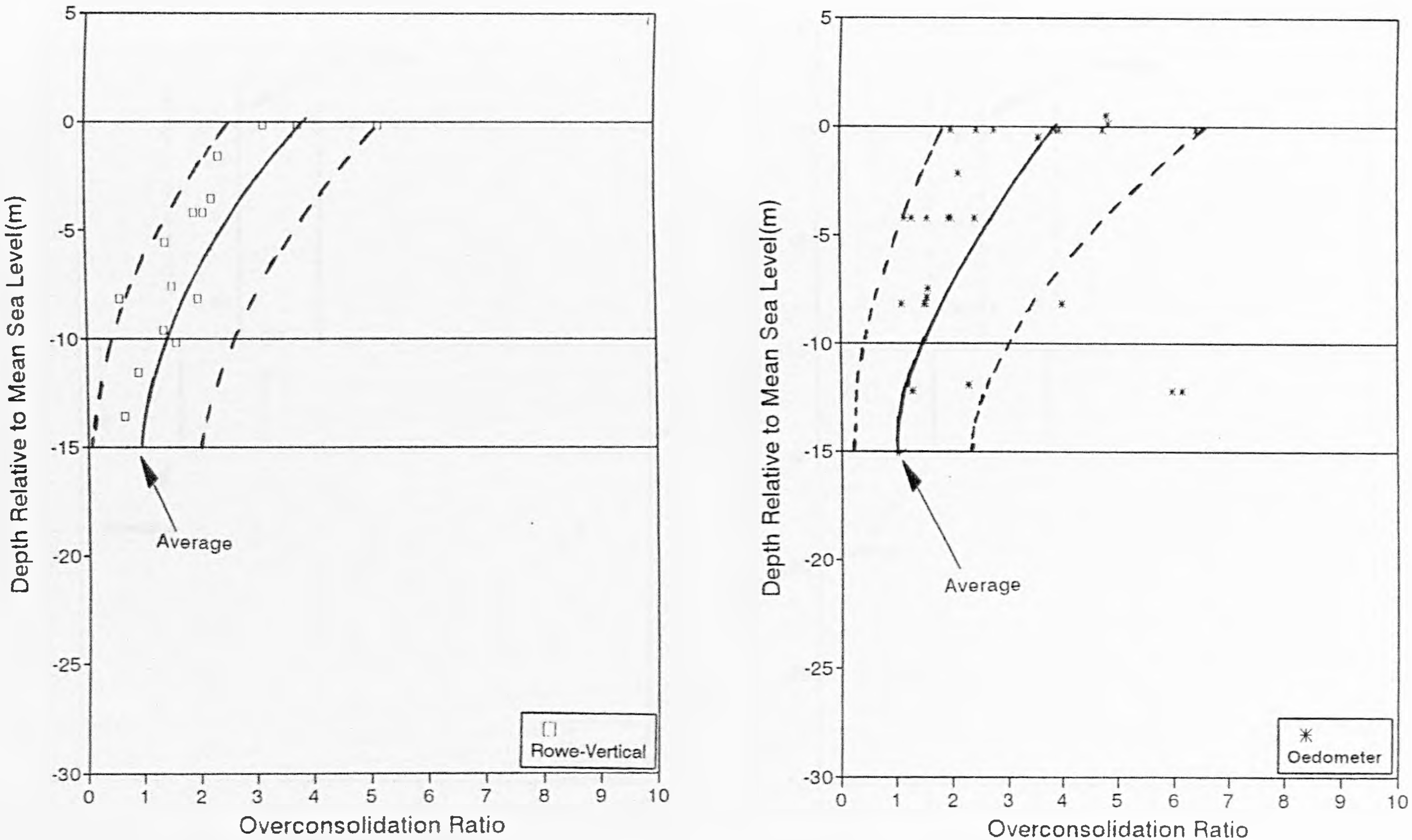


Fig.5.15: Overconsolidation Ratio with Depth

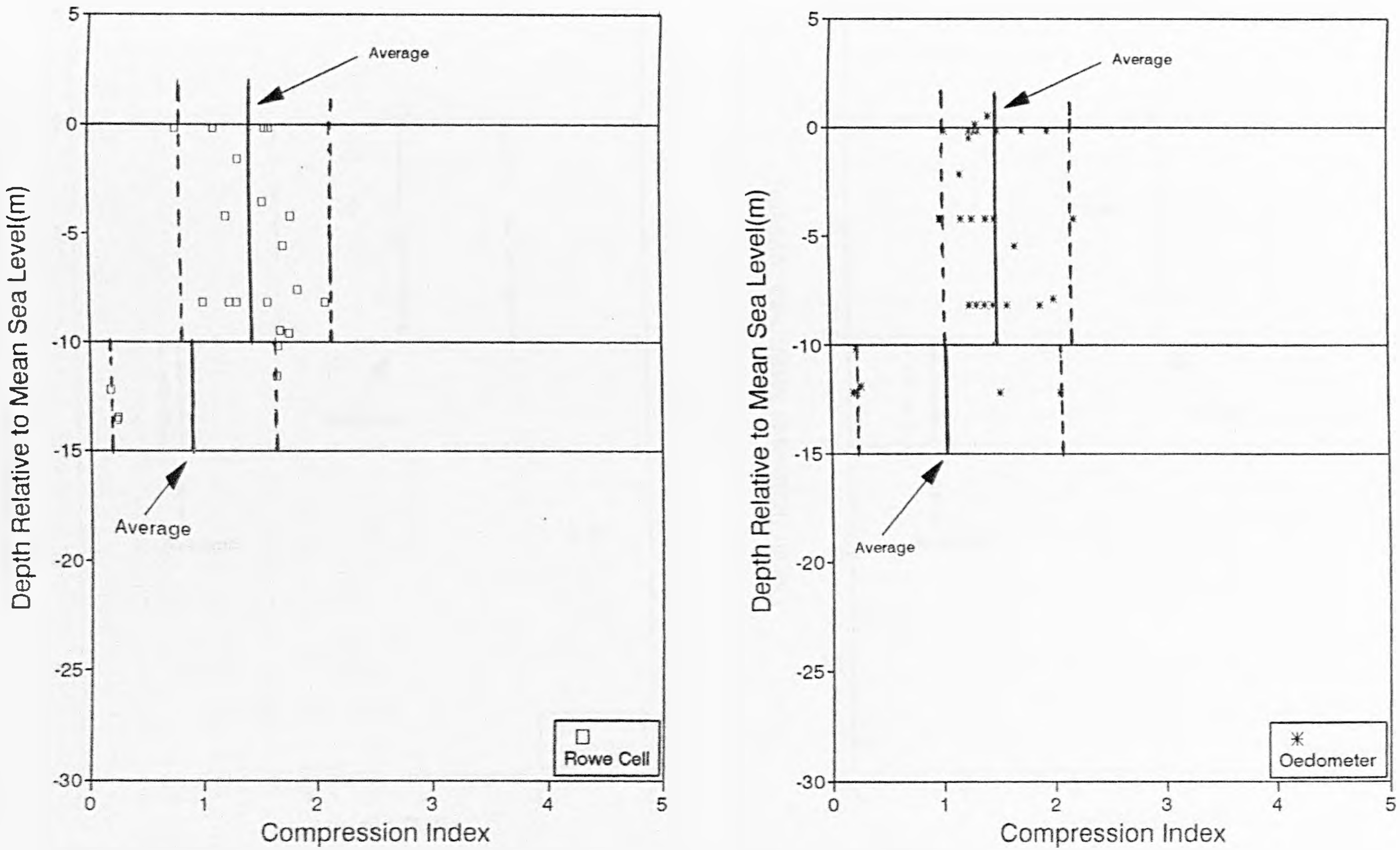


Fig.5.16 : Compression Index with Depth

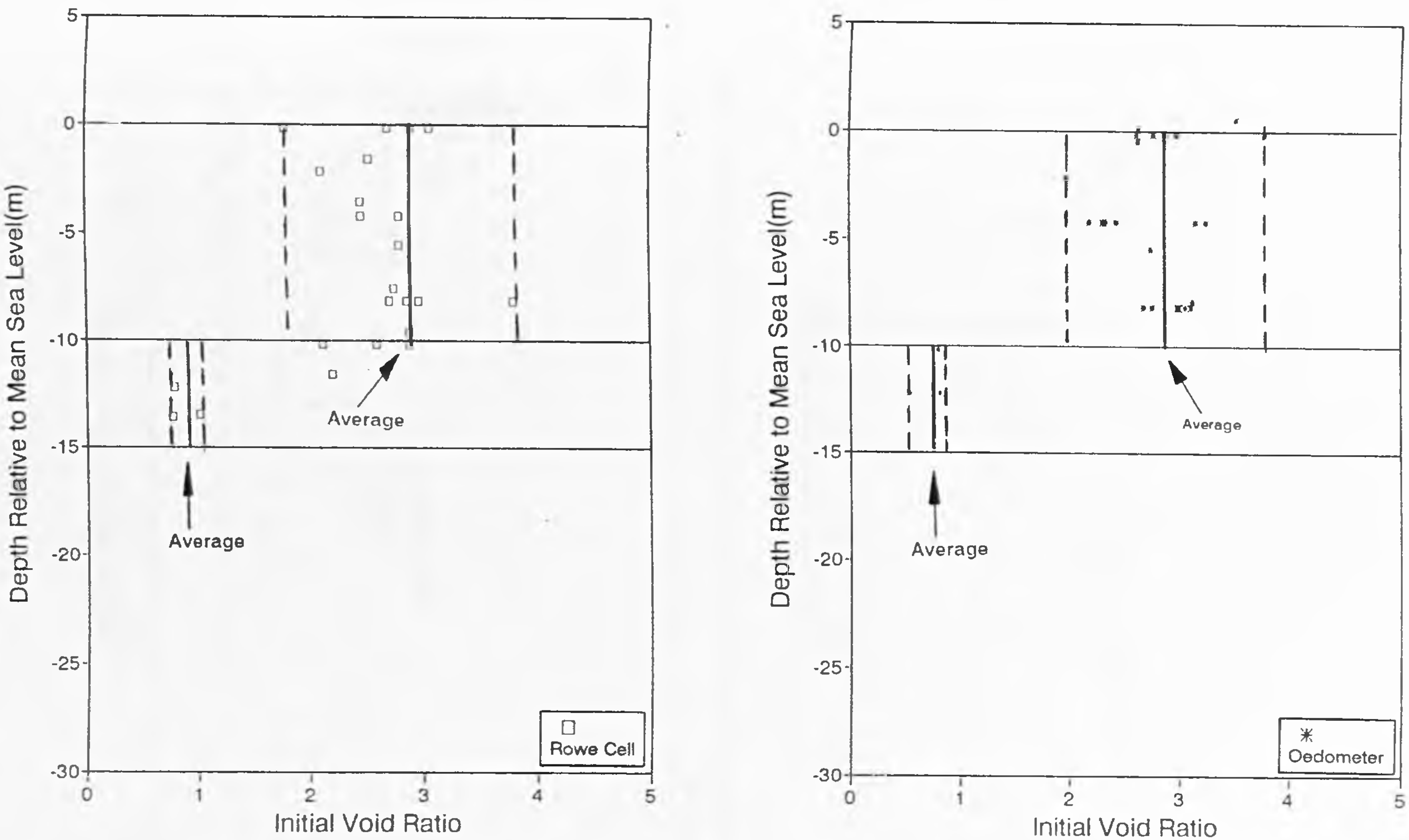


Fig.5.17 : Initial Void Ratio with Depth

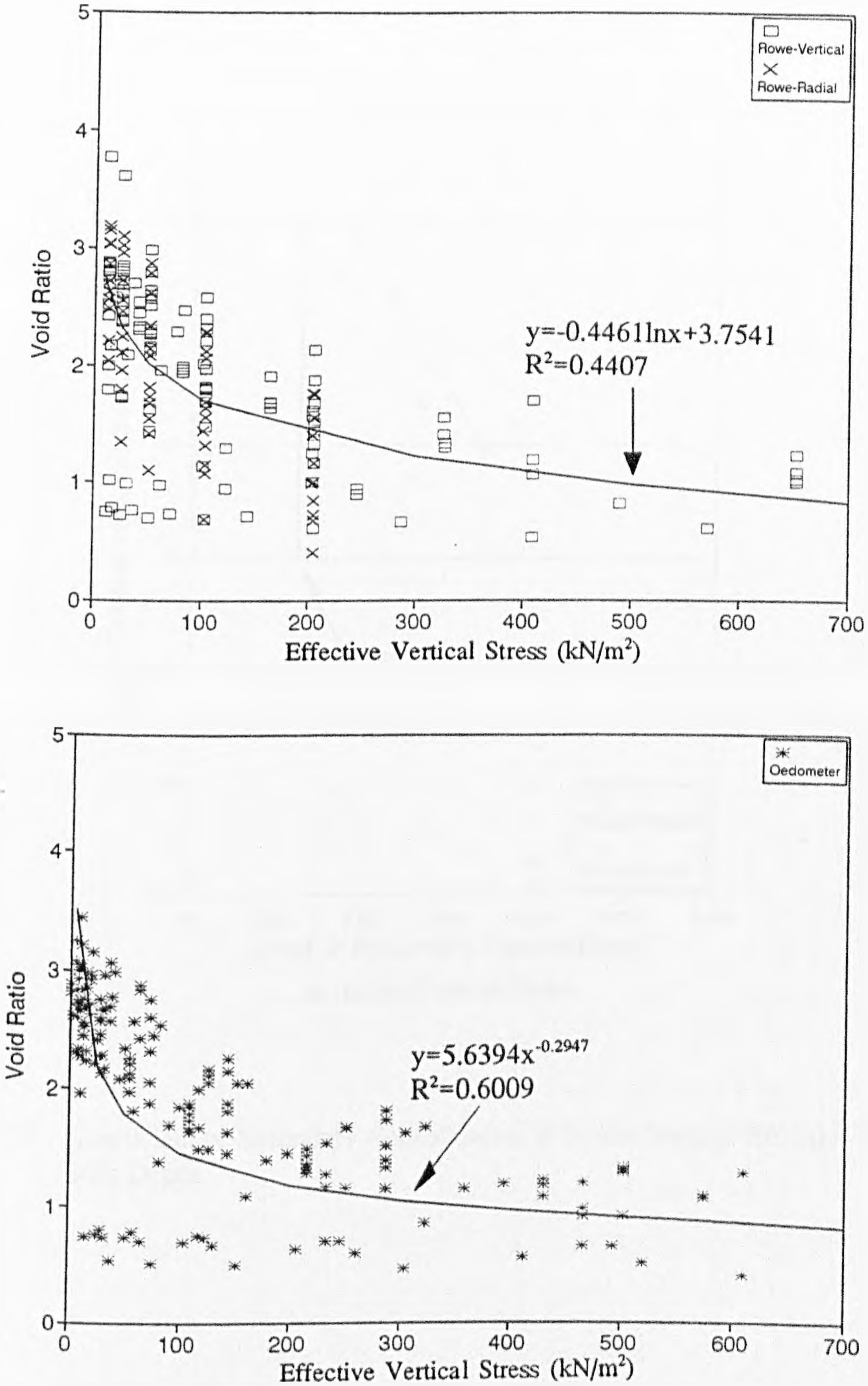


Fig.5.18 : Void Ratio with Effective Vertical Stress

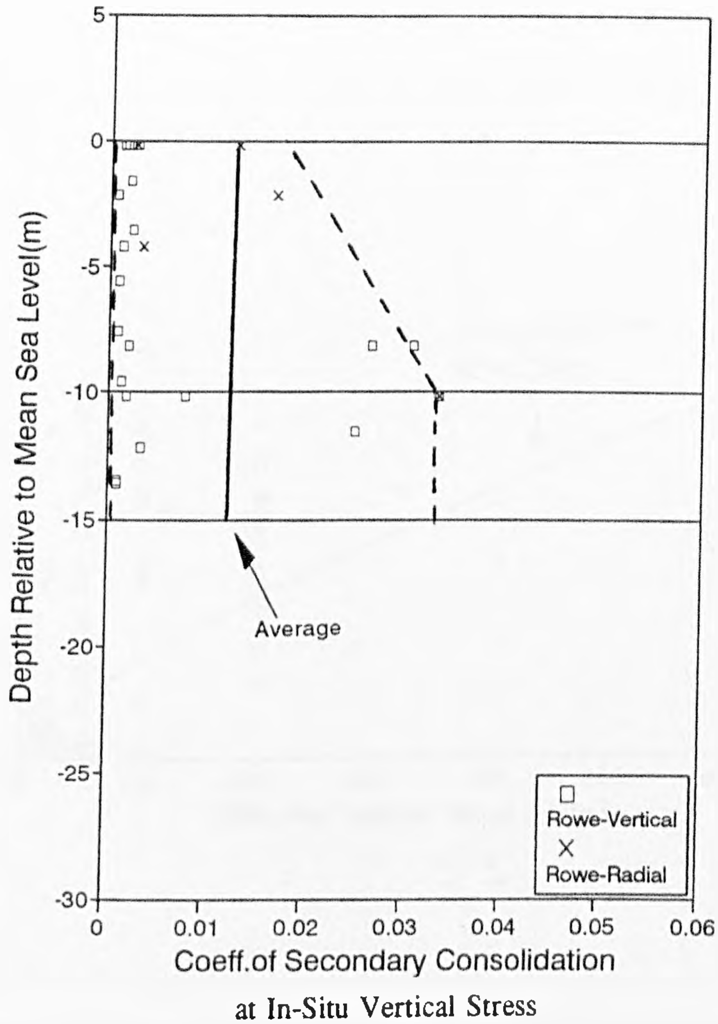


Fig.5.19 : Coefficient of Secondary Consolidation at In-situ Vertical Effective Stress with Depth

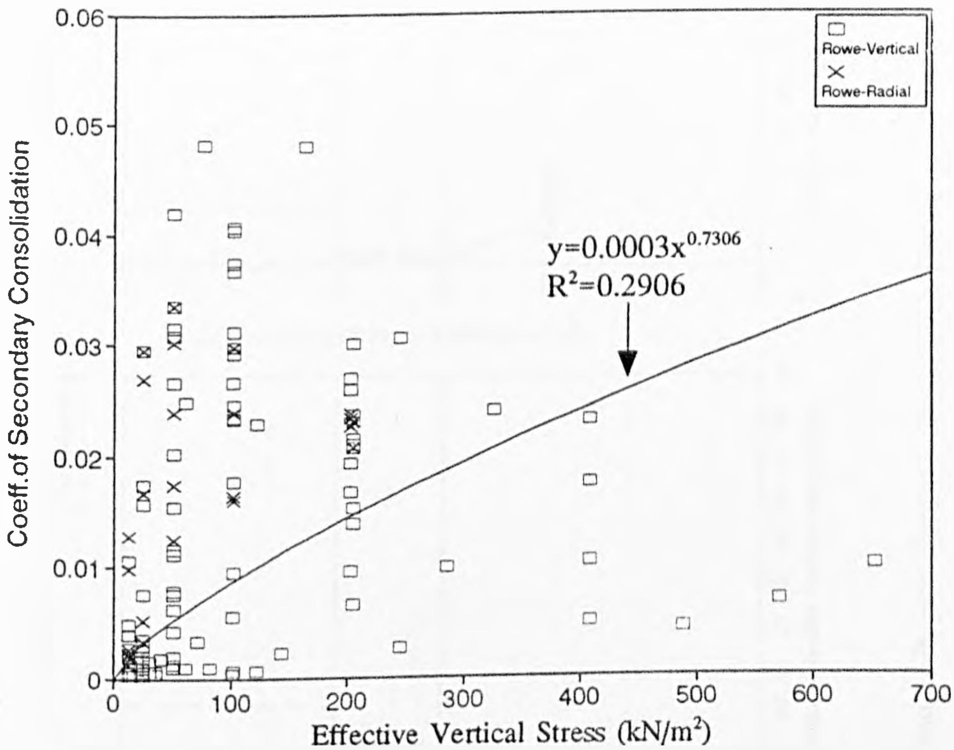


Fig.5.20 : Coefficient of Secondary Consolidation with Effective Vertical Stress

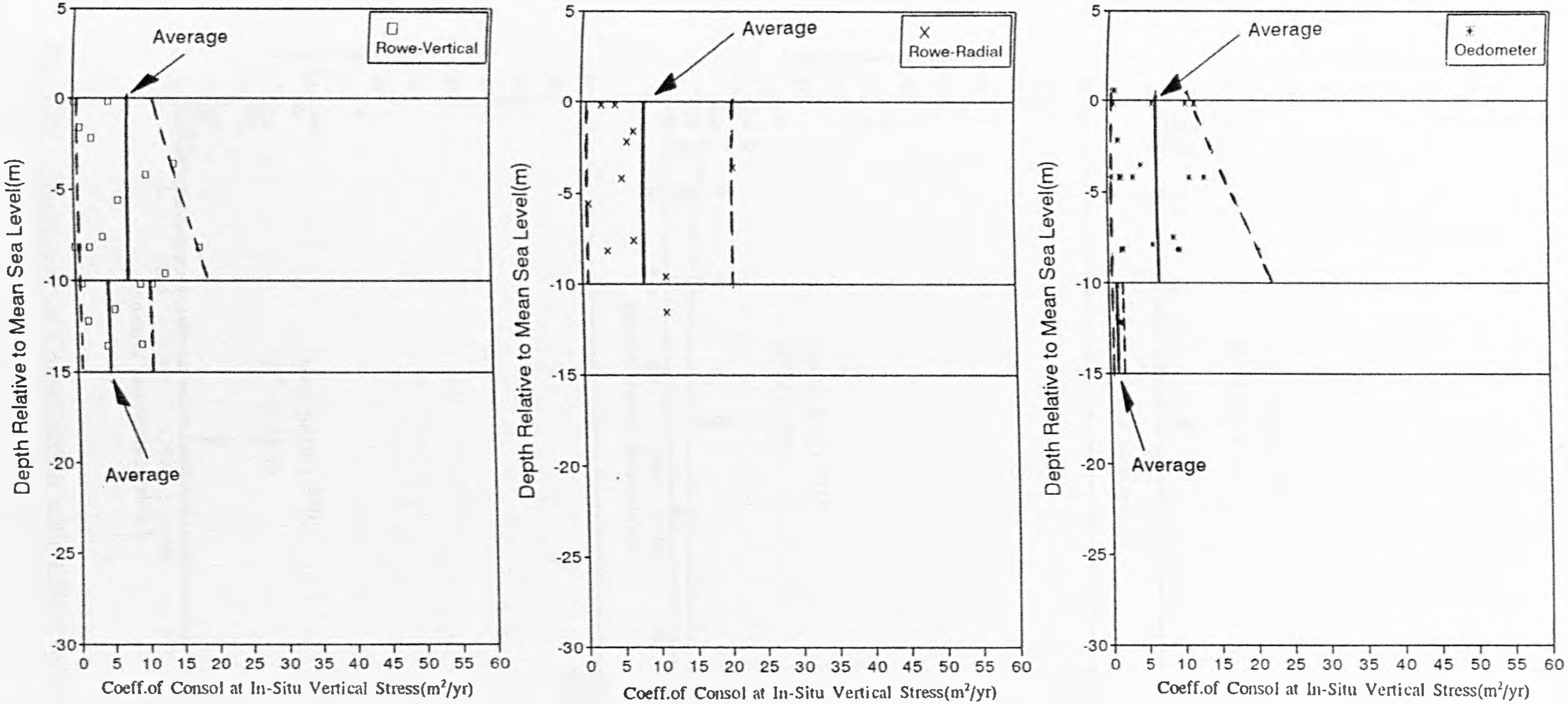


Fig.5.21 : Coefficient of Consolidation at In-situ Vertical Stress with Depth

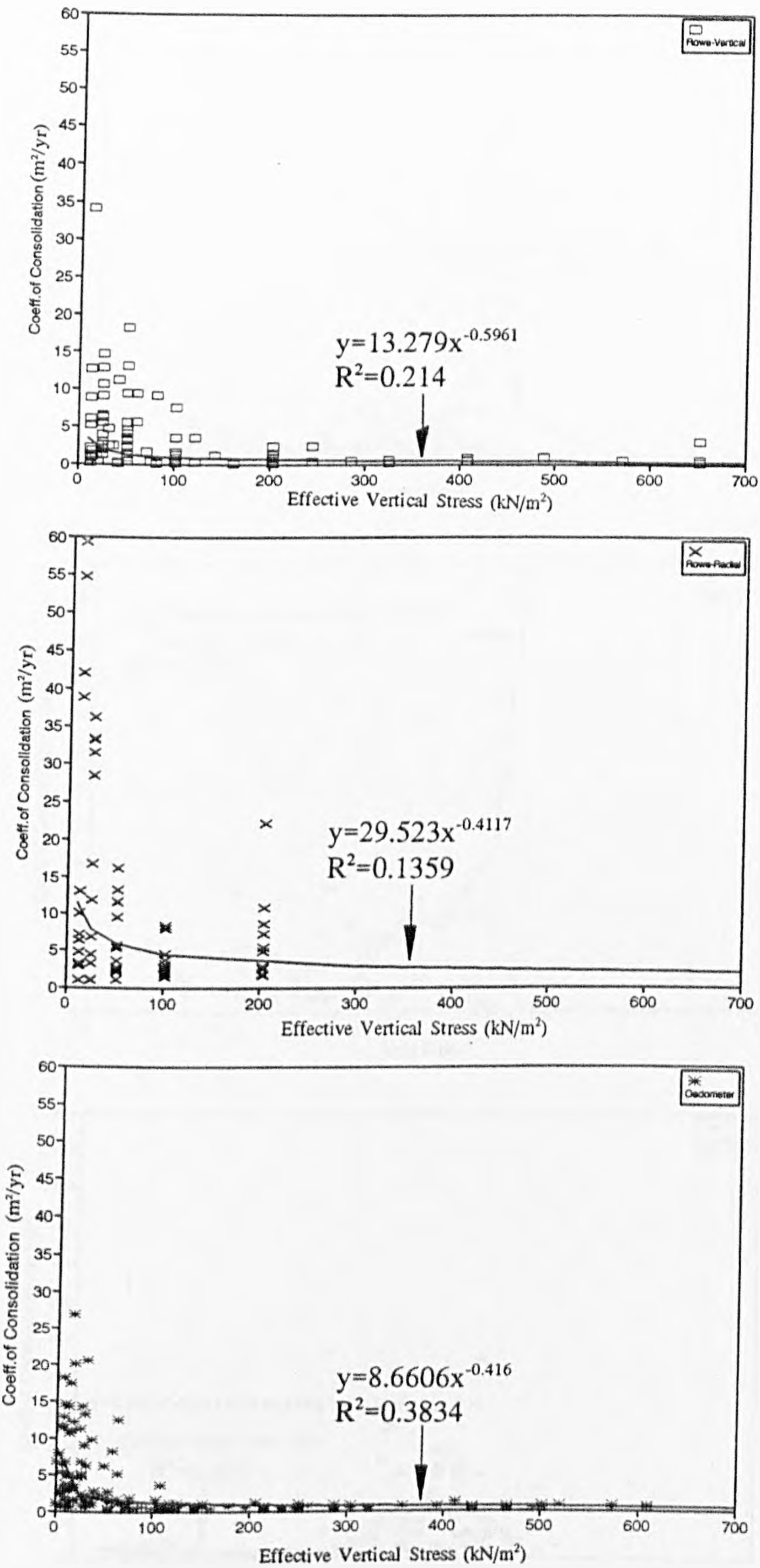


Fig.5.22 : Coefficient of Consolidation with Effective Vertical Stress

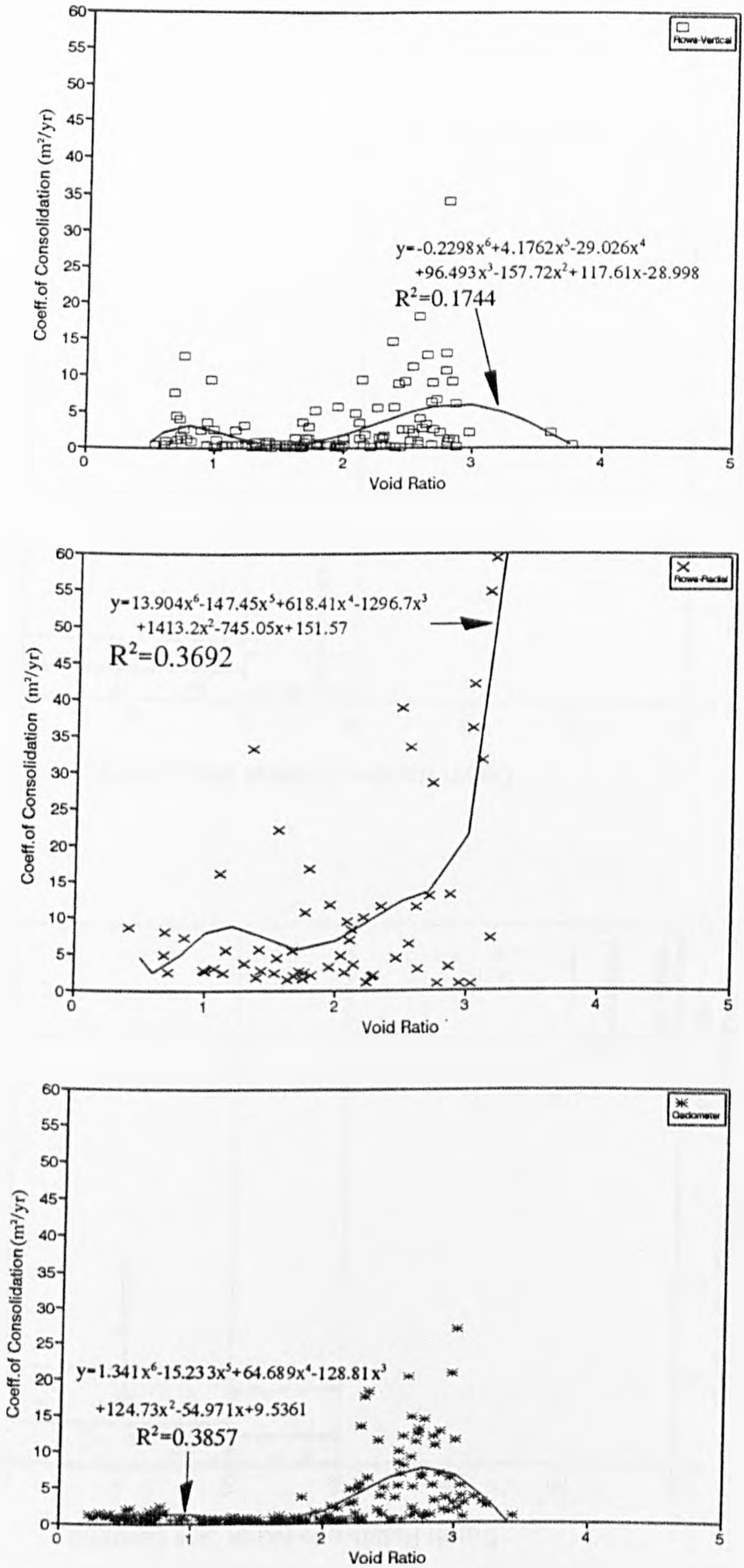


Fig.5.23 : Coefficient of Consolidation with Void Ratio

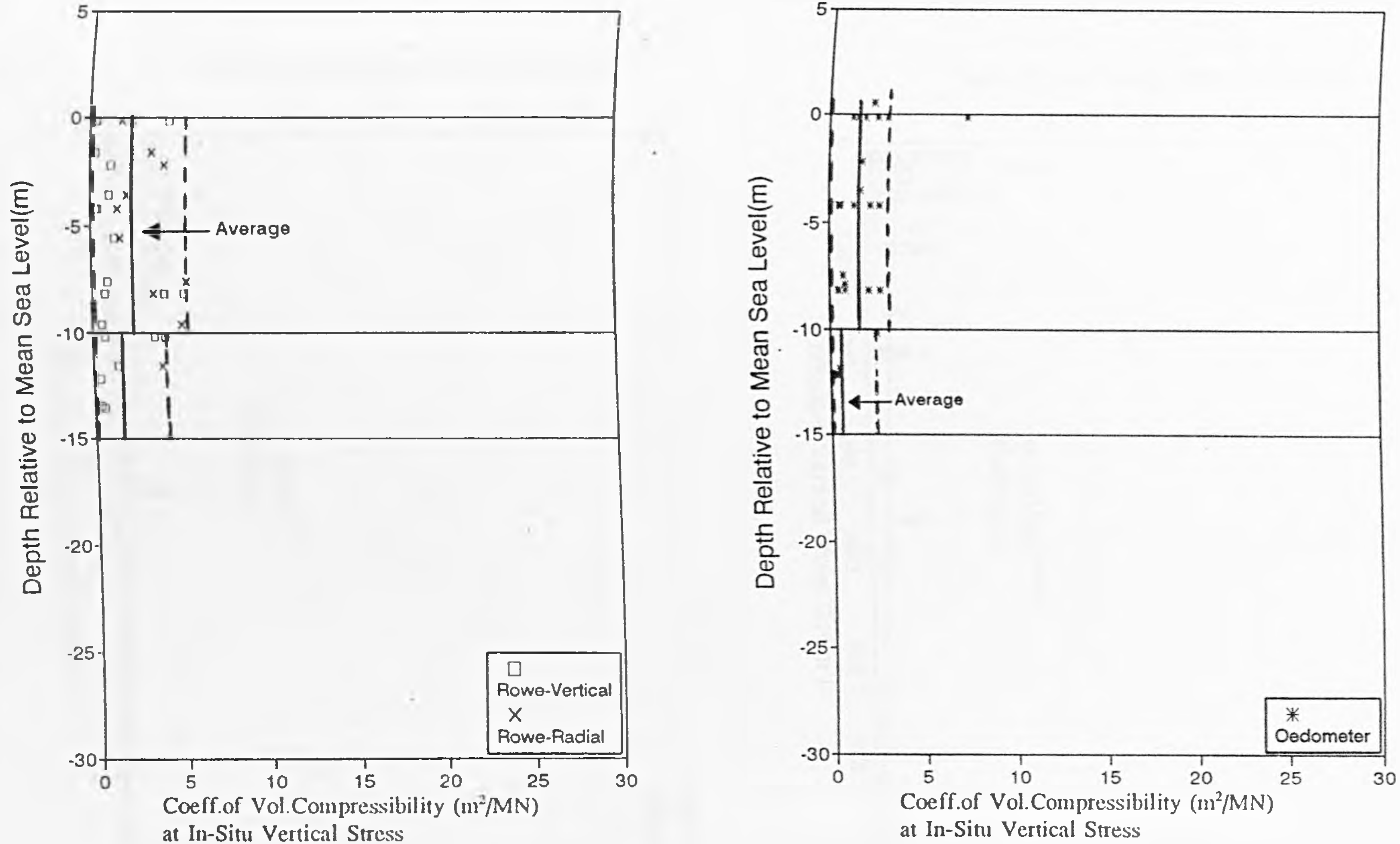
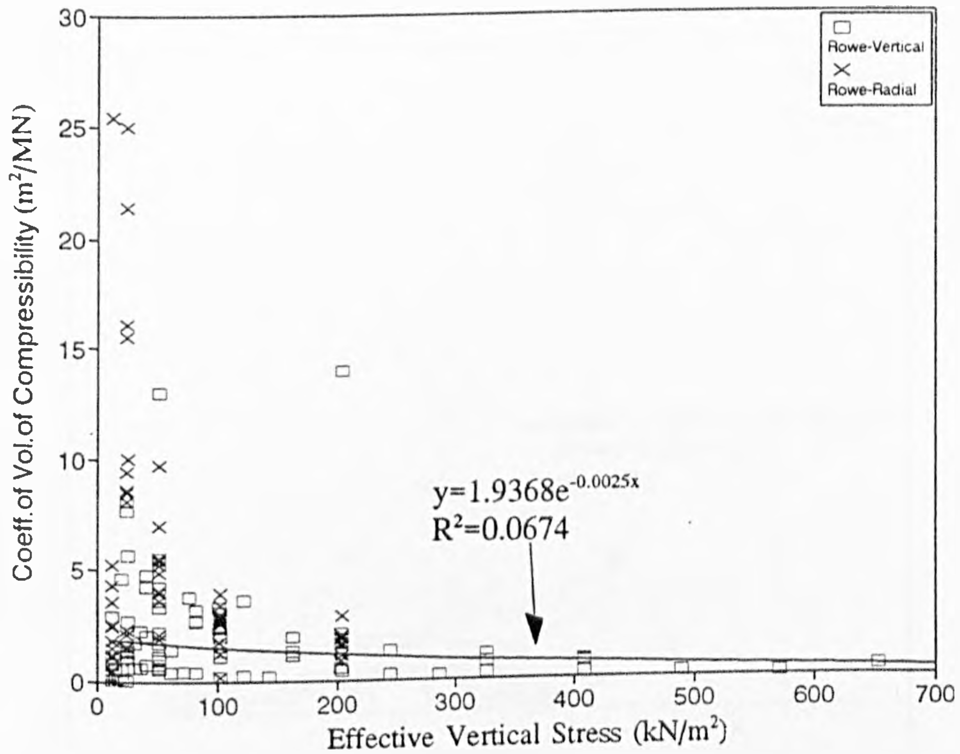


Fig.5.24 : Coefficient of Volume of Compressibility at In-situ Vertical Stress with Depth



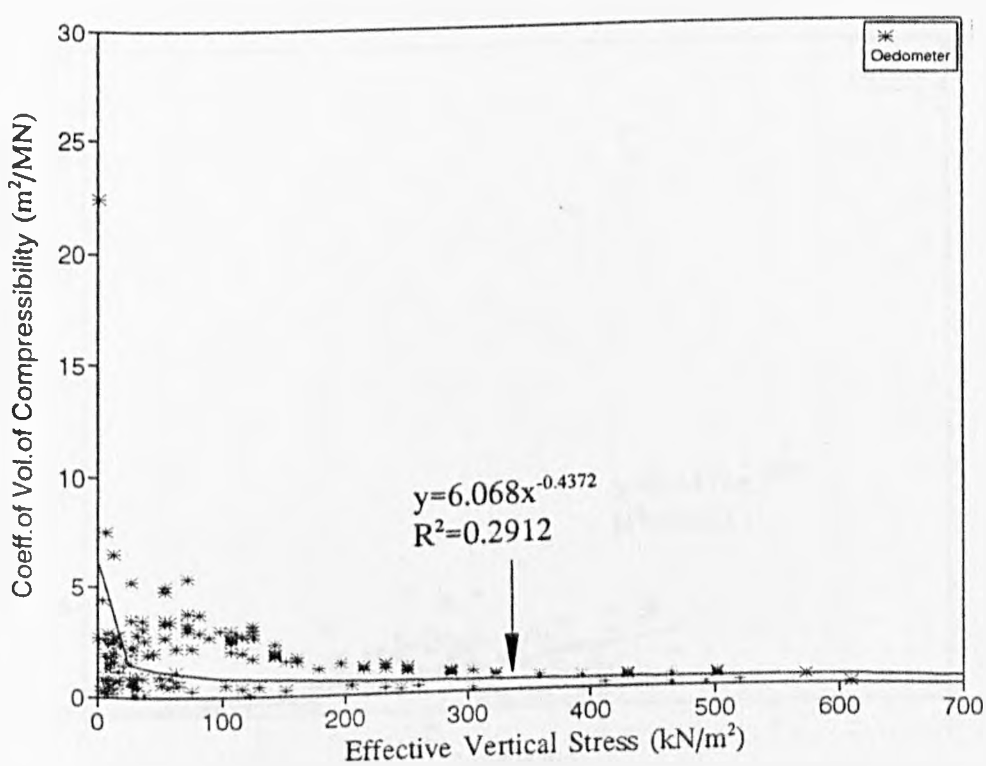


Fig.5.25 : Coefficient of Volume of Compressibility with Effective Vertical Stress

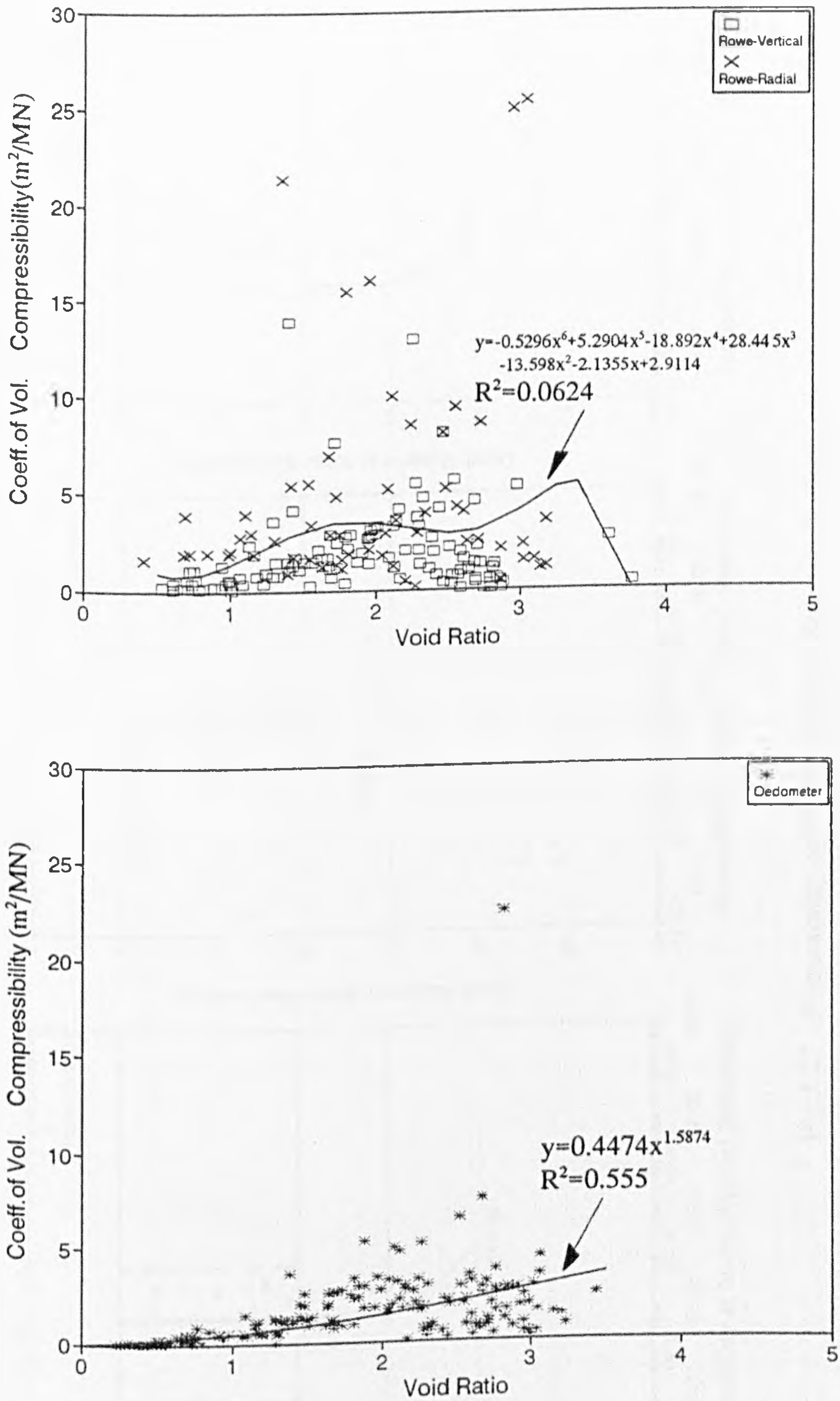


Fig.5.26 : Coefficient of Volume Compressibility with Void Ratio

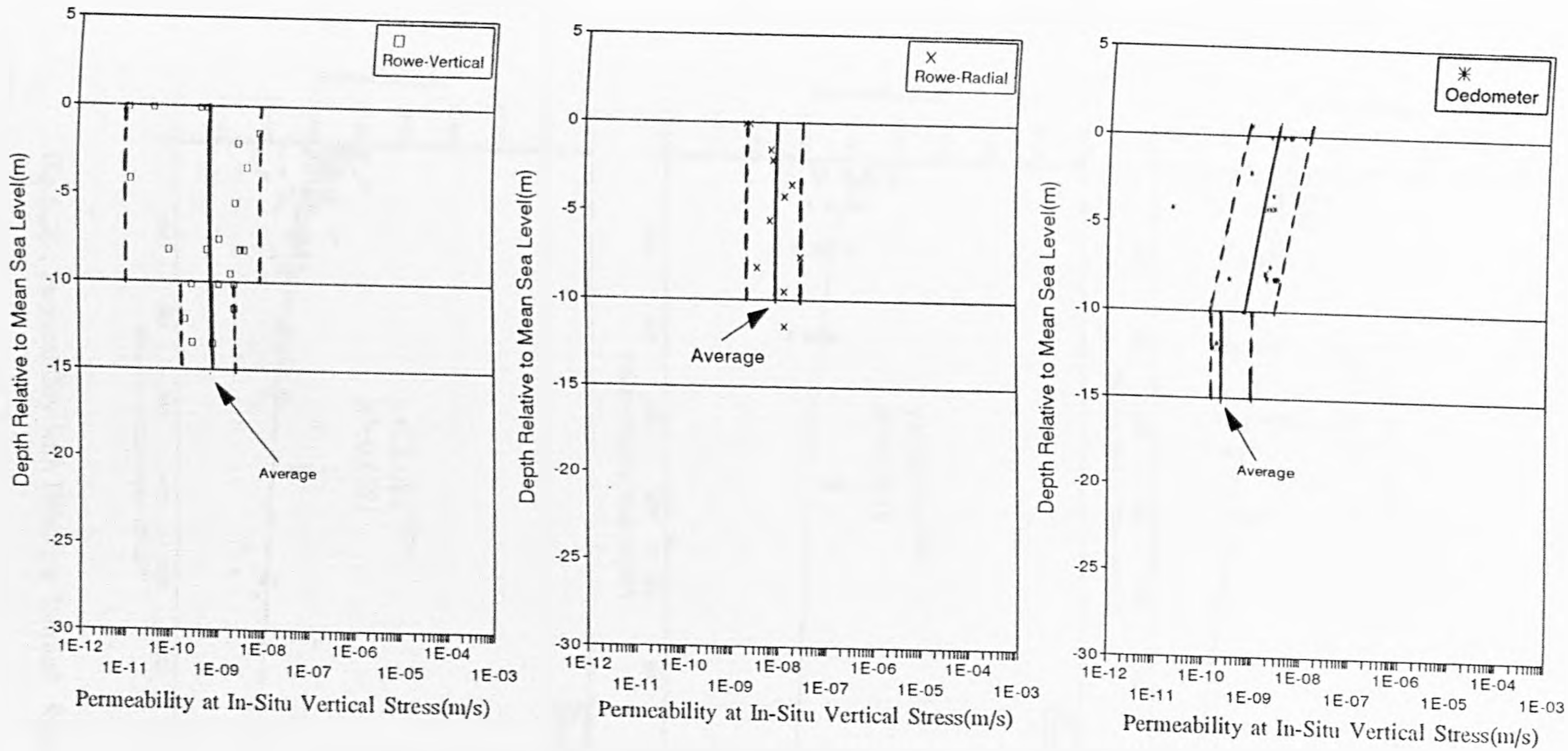


Fig.5.27 : Permeability at In-situ Vertical Stress with Depth

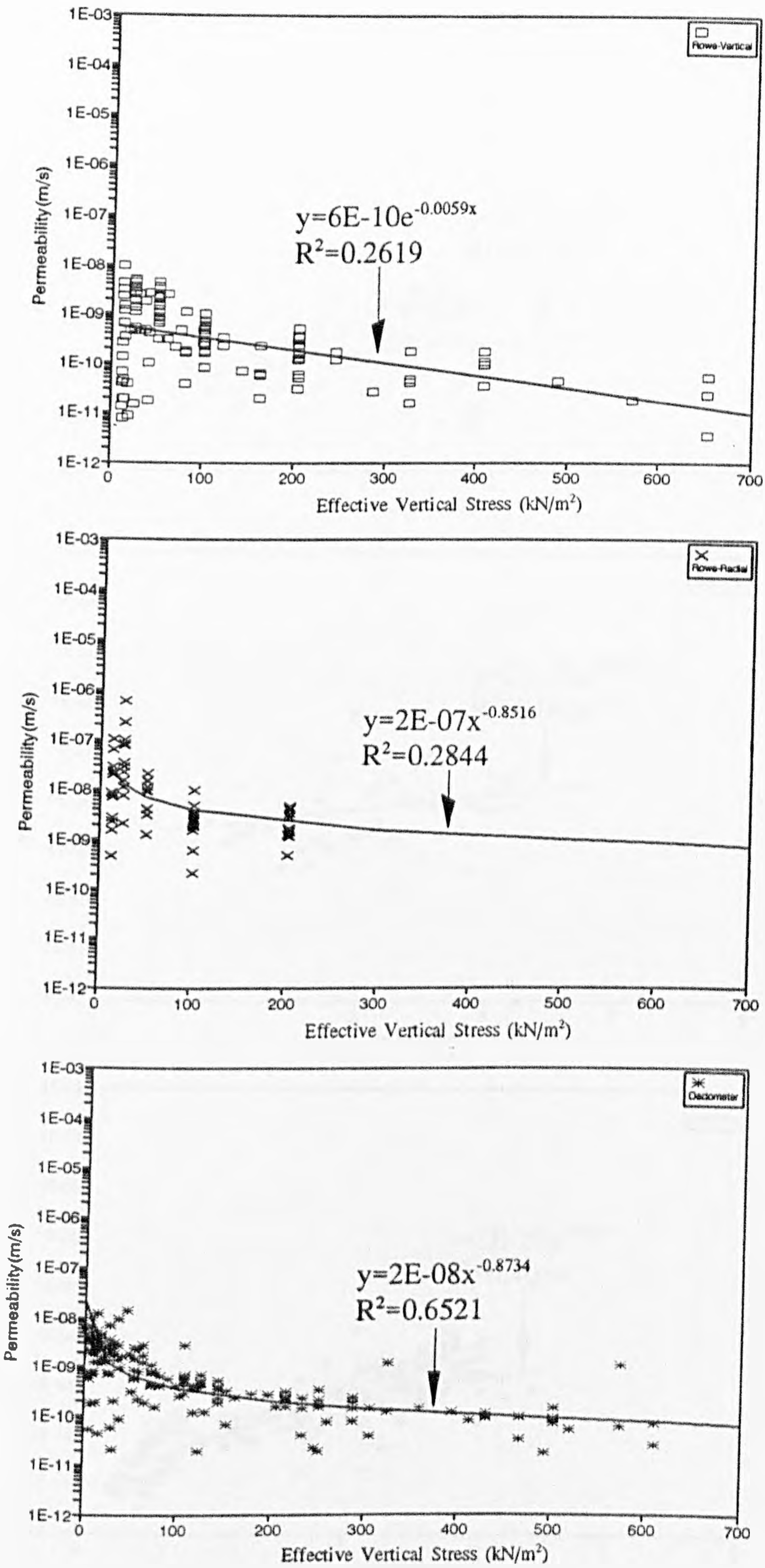


Fig.5.28 : Permeability with Effective Vertical Stress

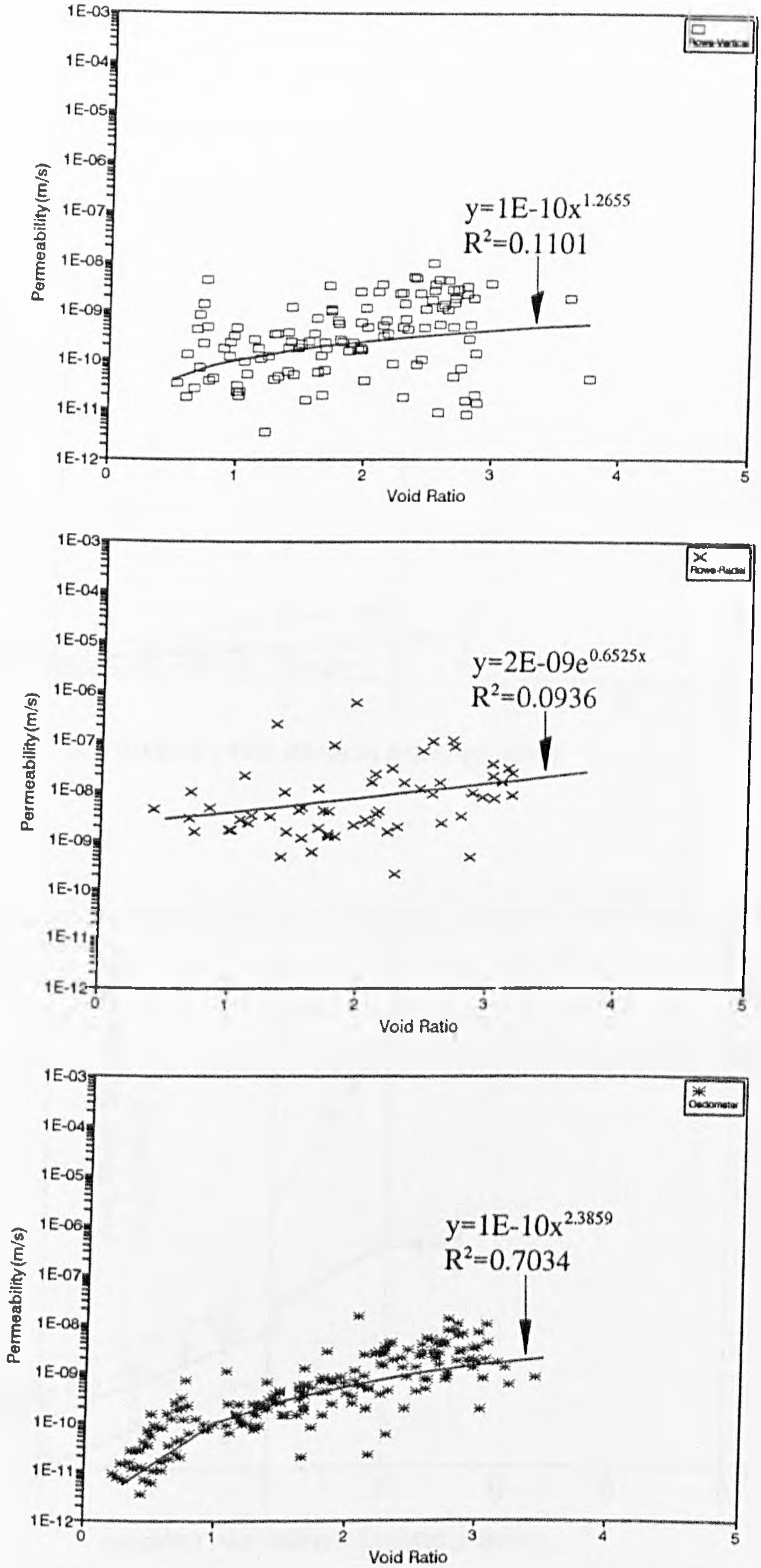


Fig.5.29 : Permeability with Void Ratio

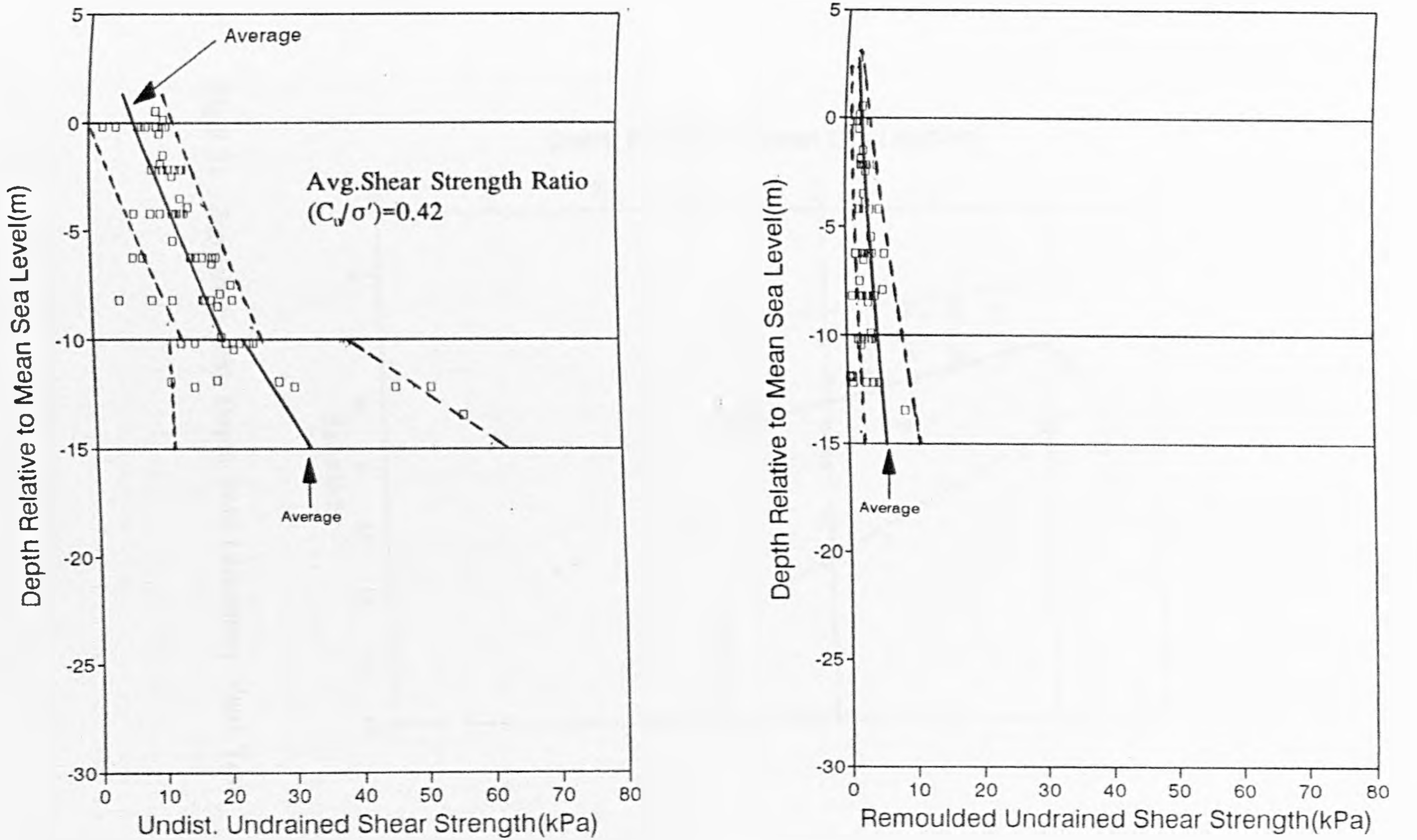


Fig.5.30 : Undrained Shear Strength from Laboratory Vane Tests

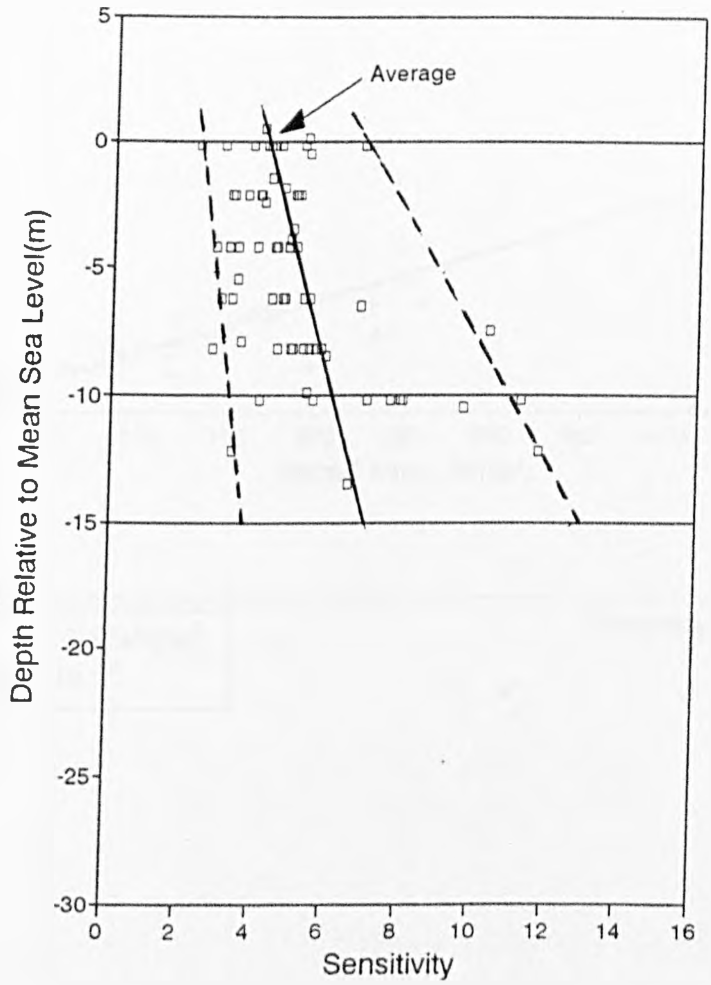
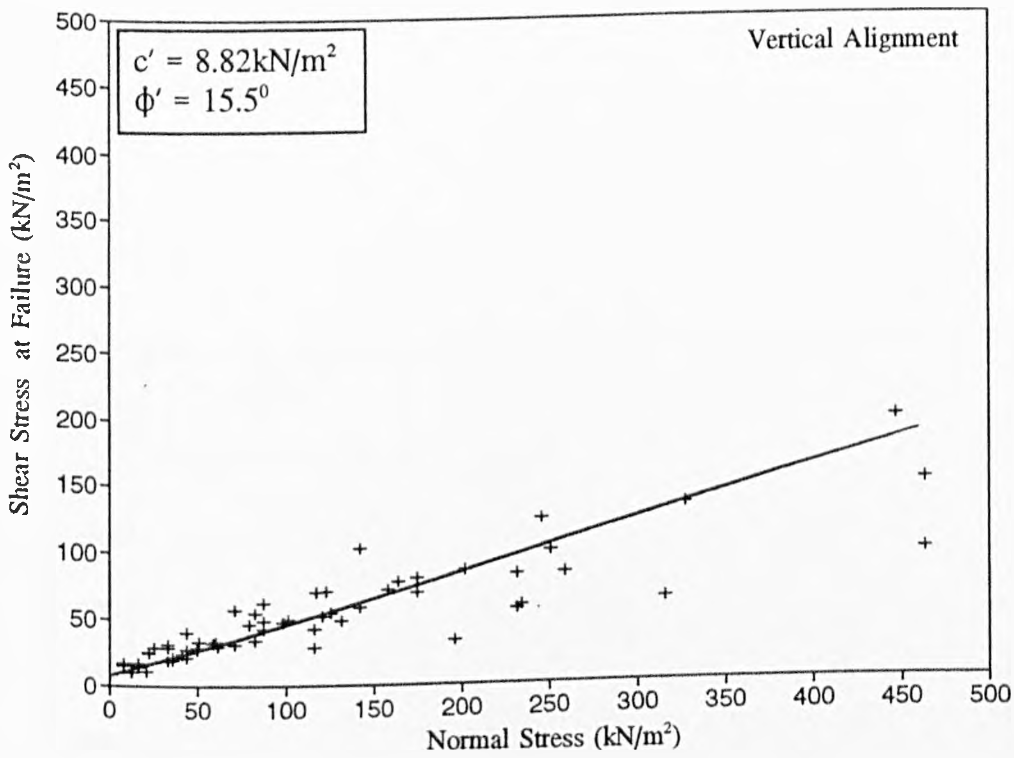


Fig.5.31 : Sensitivity with Depth from Laboratory Vane Tests



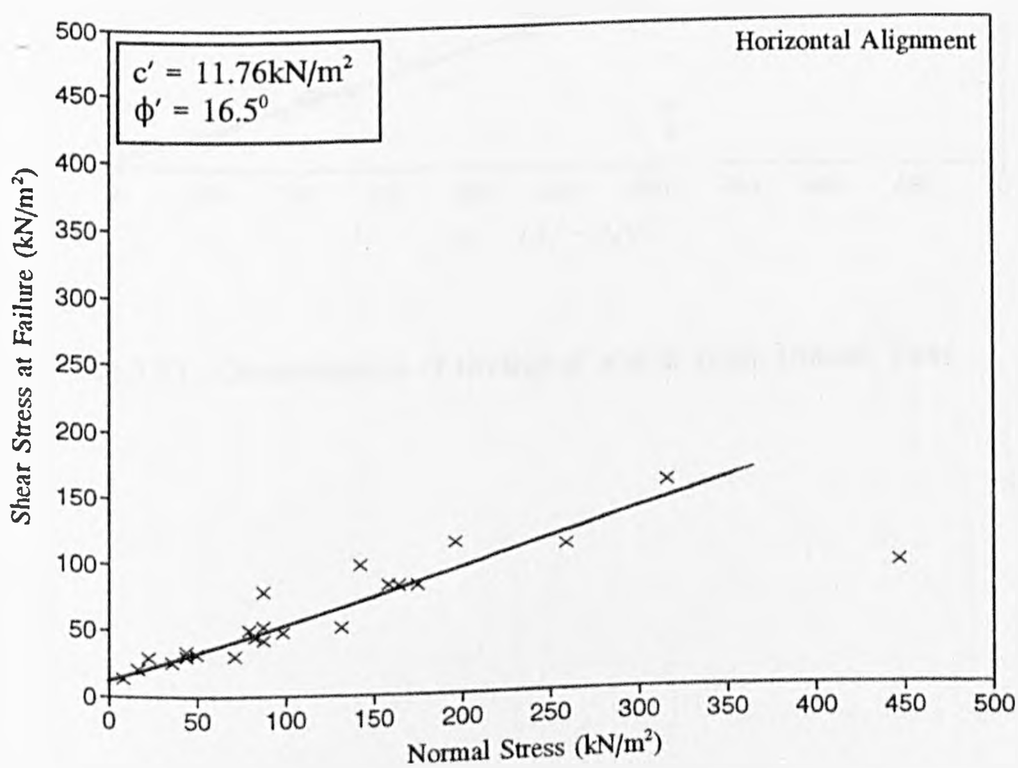


Fig.5.32 : Determination of average c′ and ϕ′ from Direct Shearbox Tests

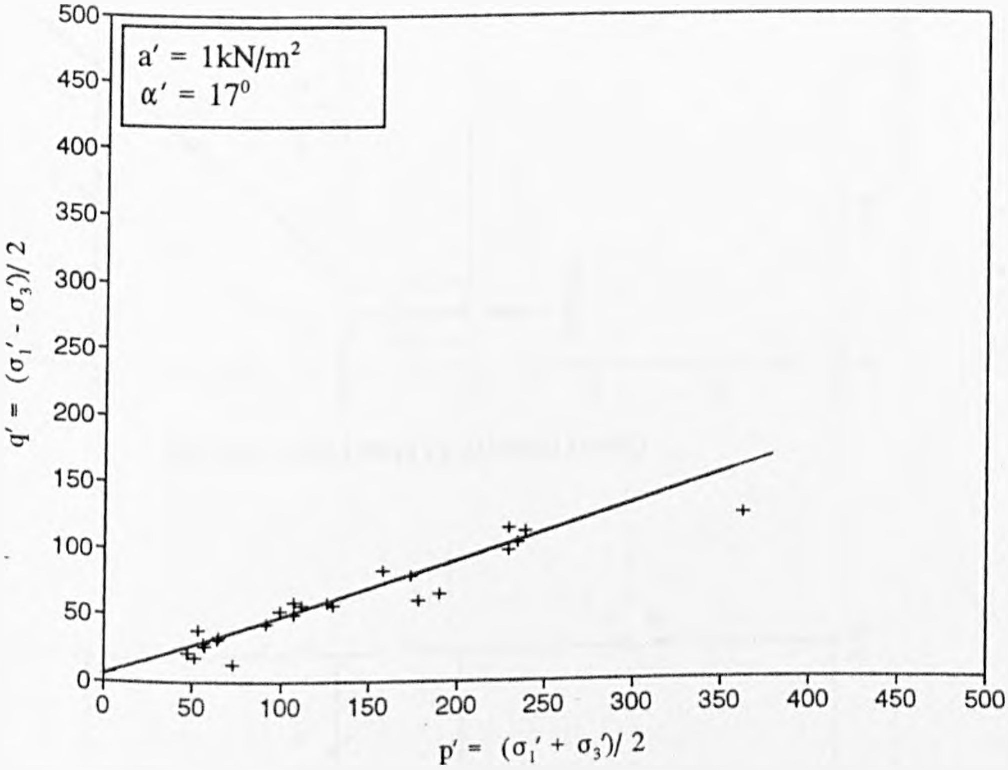


Fig.5.33 : Determination of average c′ and ϕ′ from Triaxial Tests

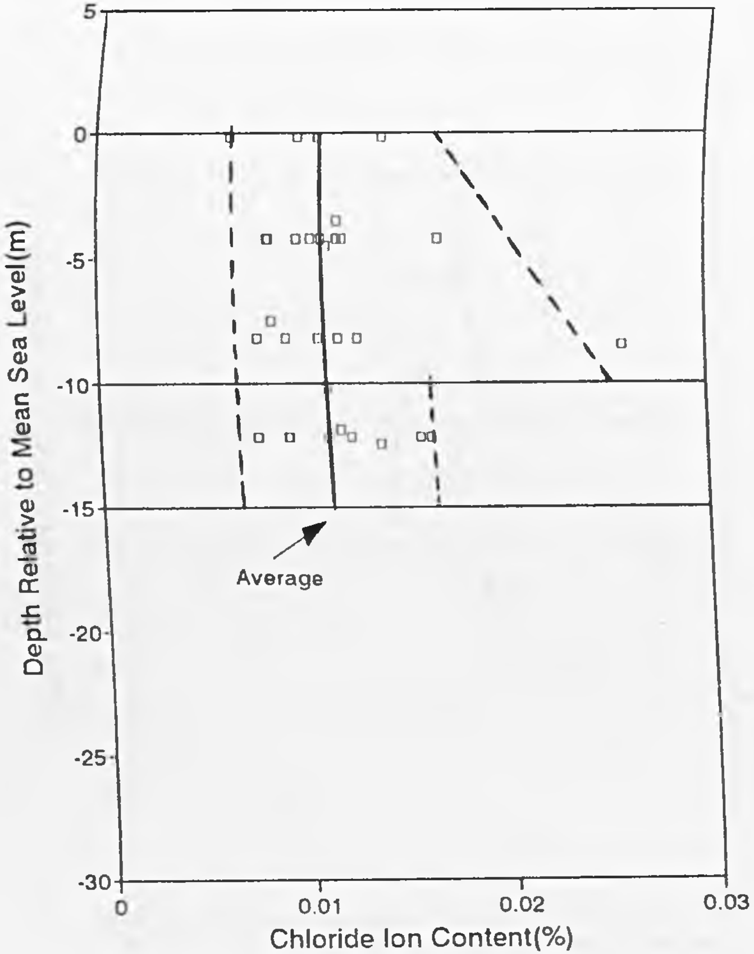


Fig.5.34 : Chloride Content with Depth

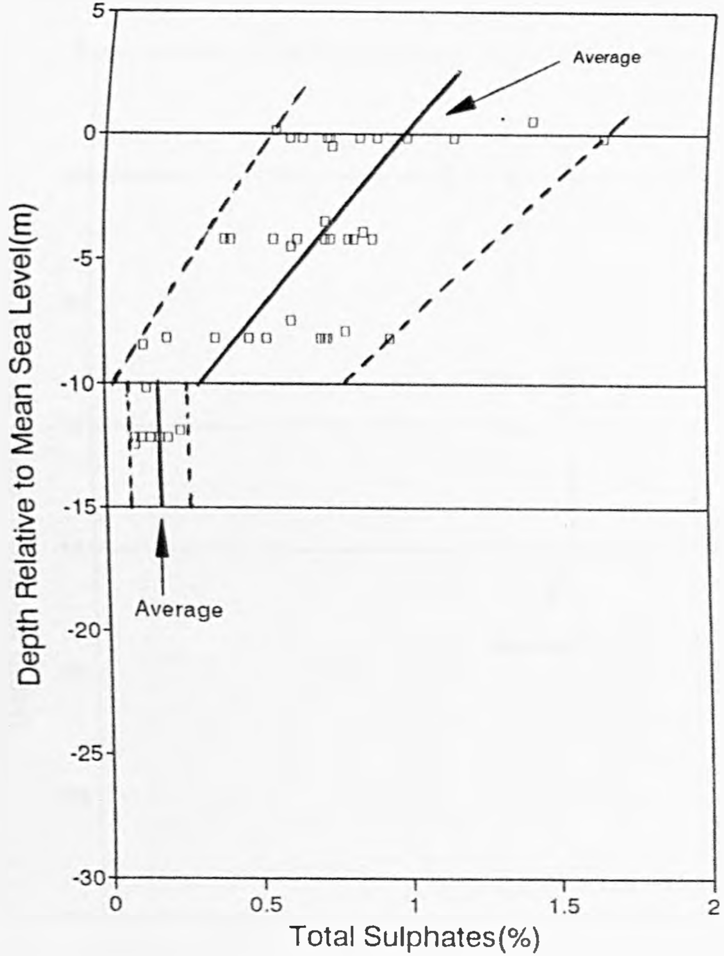


Fig.5.35 : Sulphate Content with Depth

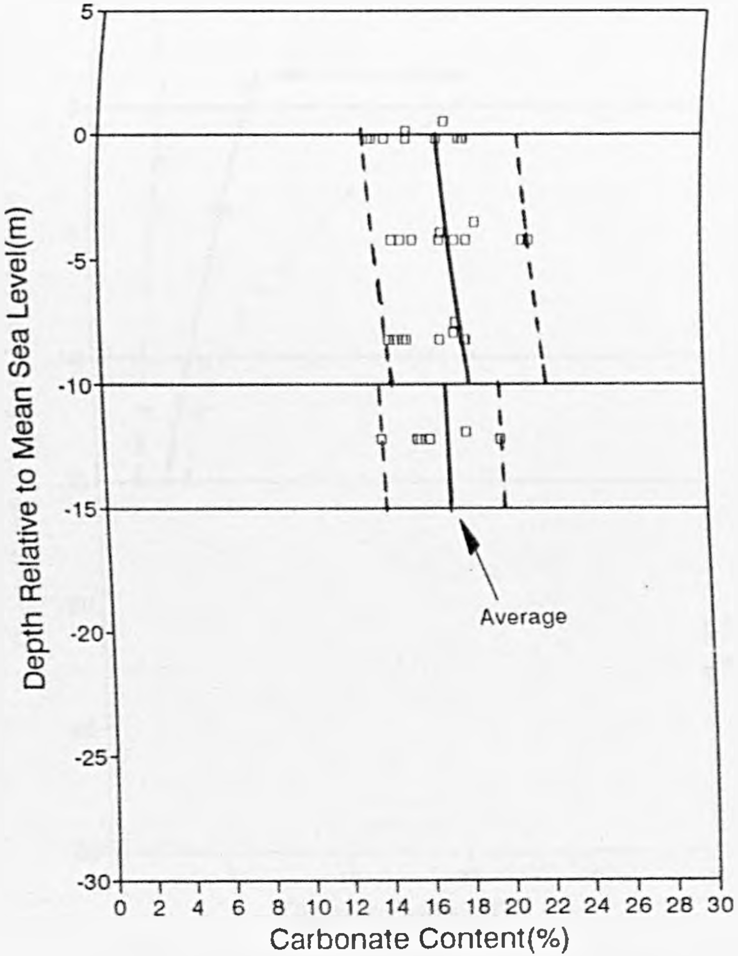


Fig.5.36 : Carbonate Content with Depth

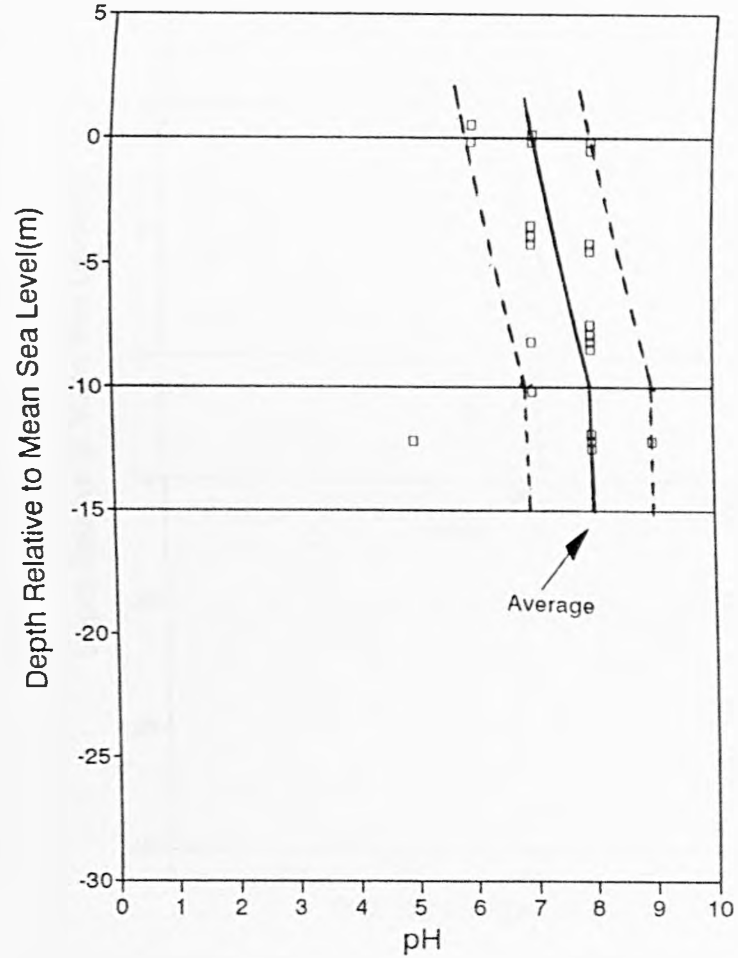


Fig.5.37 : pH with Depth

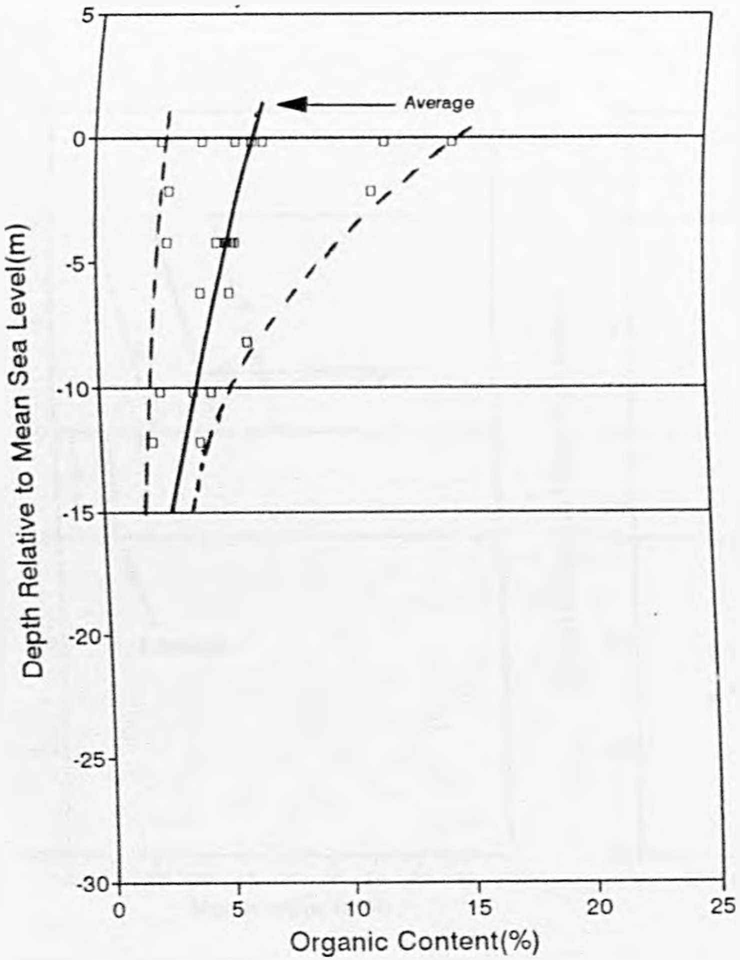


Fig.5.38 : Organic Content with Depth

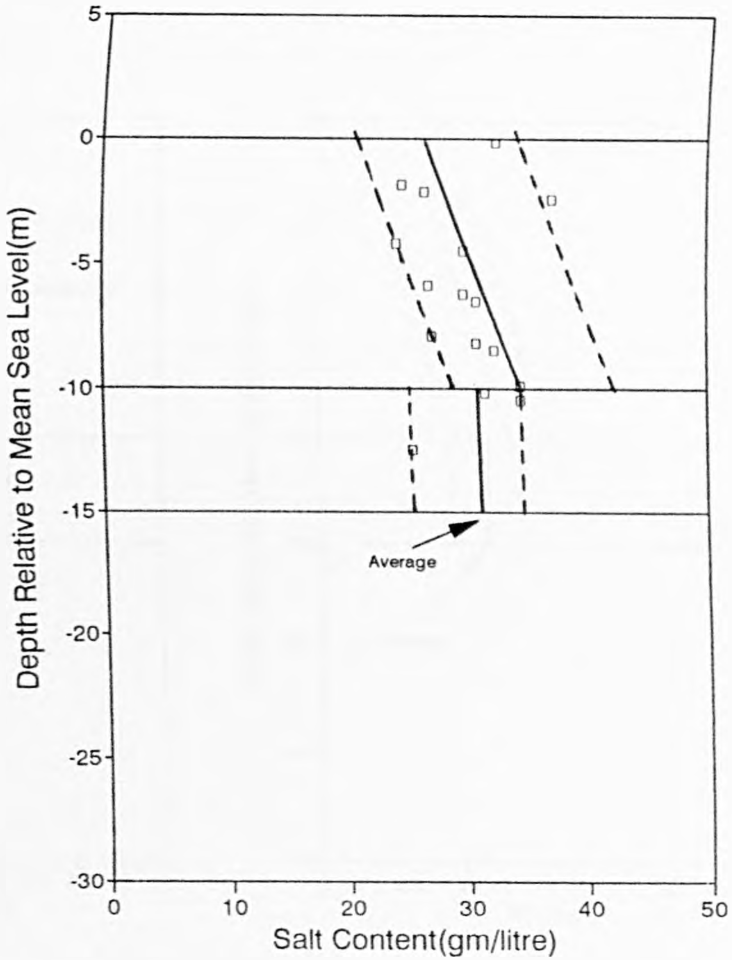


Fig.5.39 : Pore Water Salinity with Depth

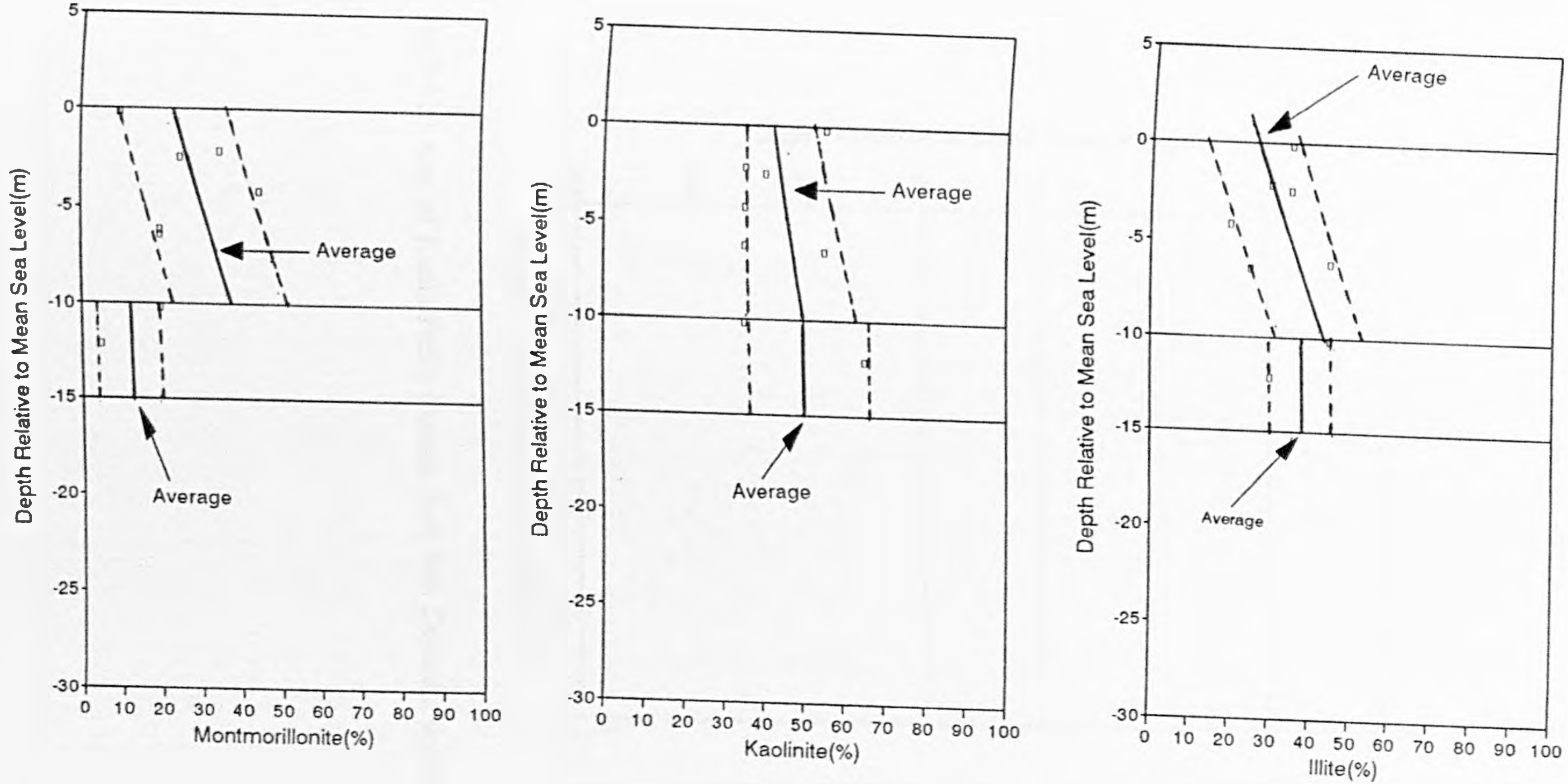


Fig.5.40 : Mineralogy with Depth

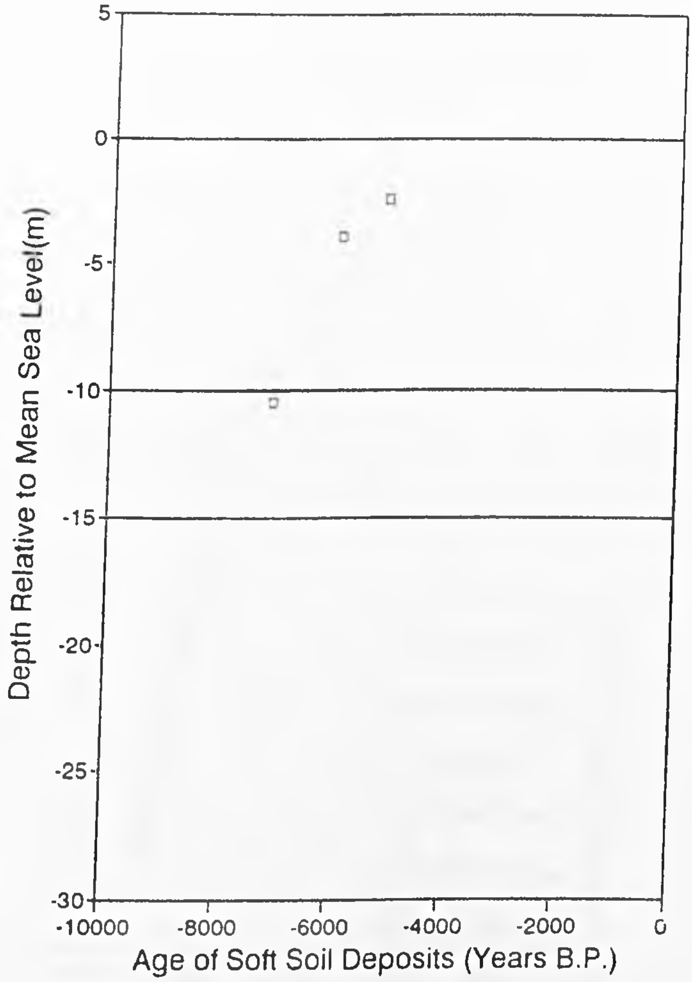


Fig.5.41 : Age of Kuala Perlis Coastal Soft Soil Deposits with Depth

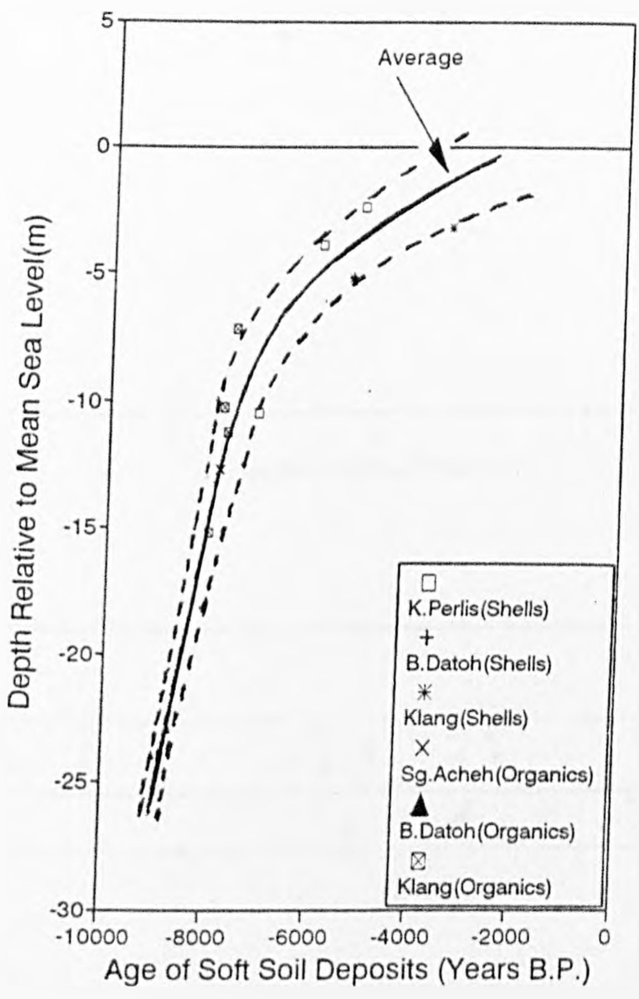
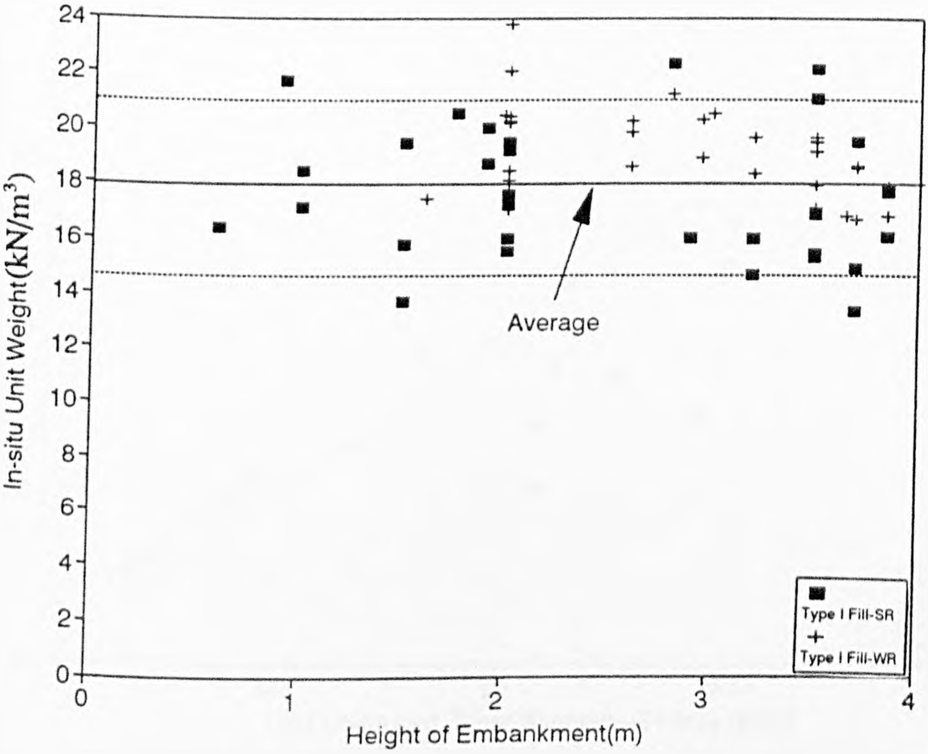


Fig.5.42 : Age of Peninsular Malaysia Coastal Soft Soil Deposits with Depth



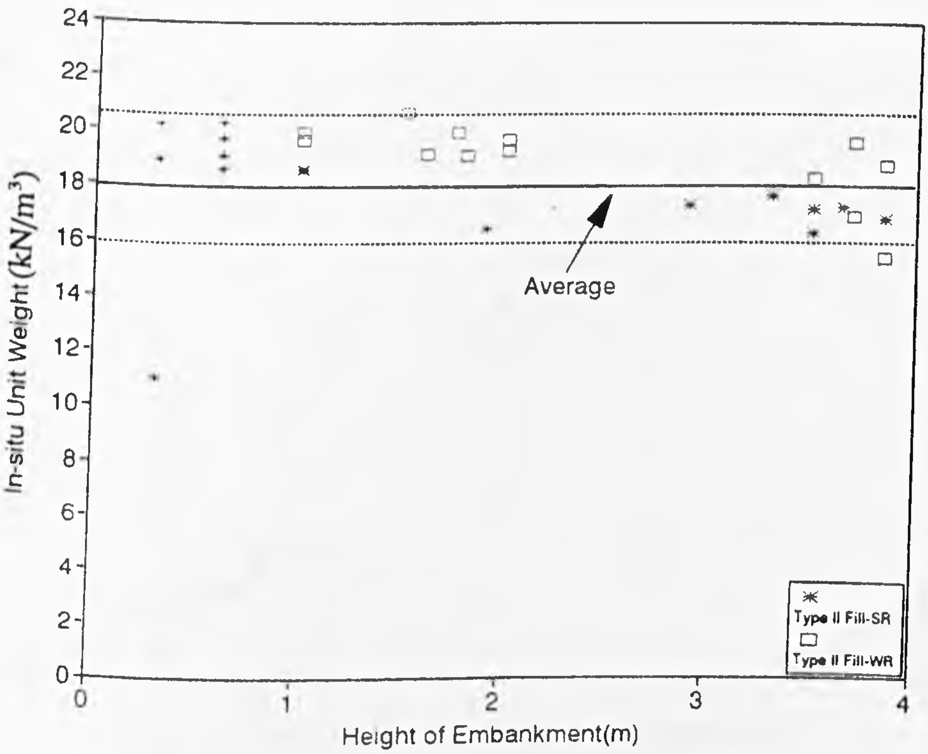
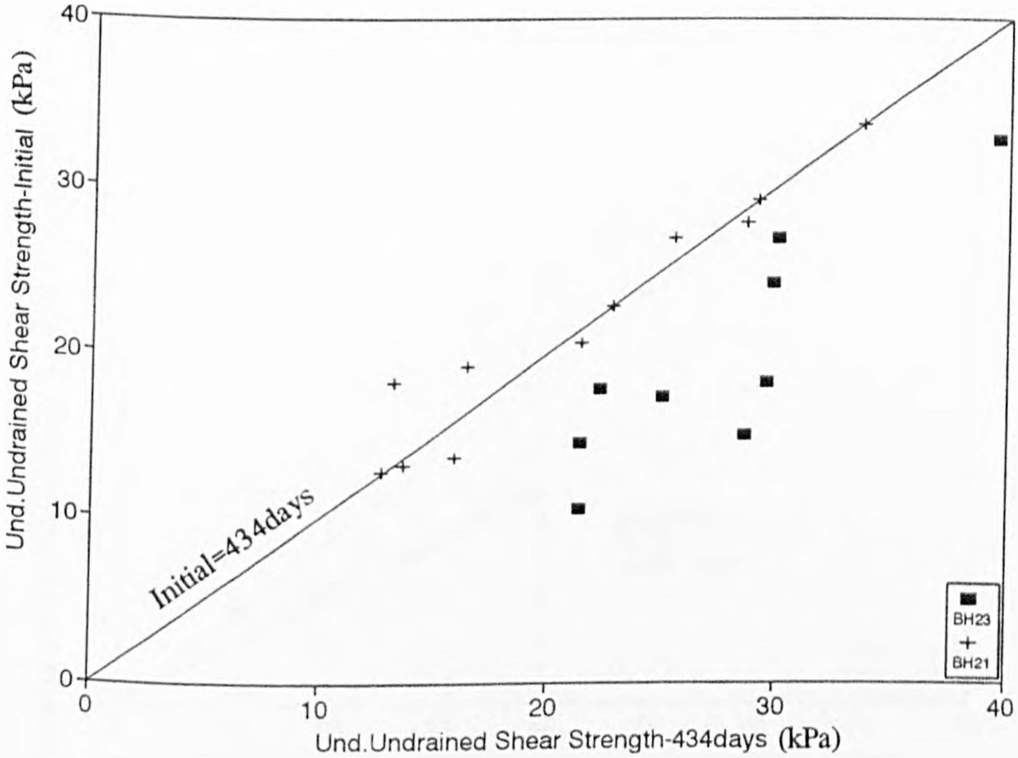


Fig.5.43 : In-situ Unit Weight with Height of Embankment



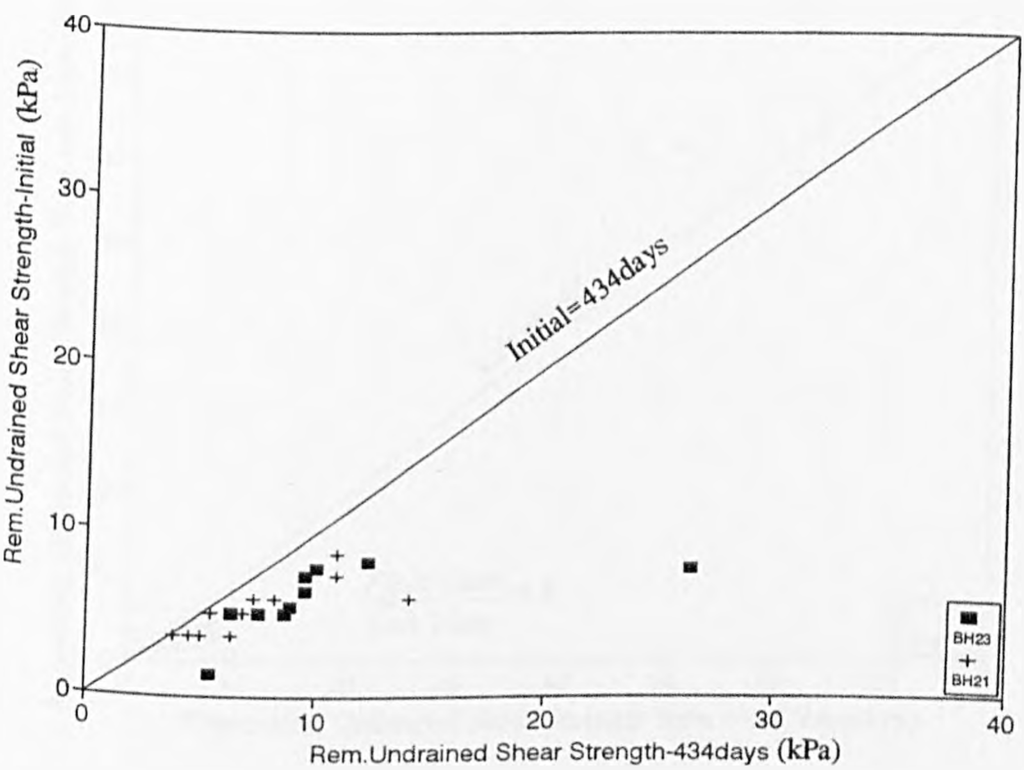


Fig.5.44 : Comparison of Undrained Shear Strength Before Construction and 434 days after the Start of Construction of the South Trial Embankment

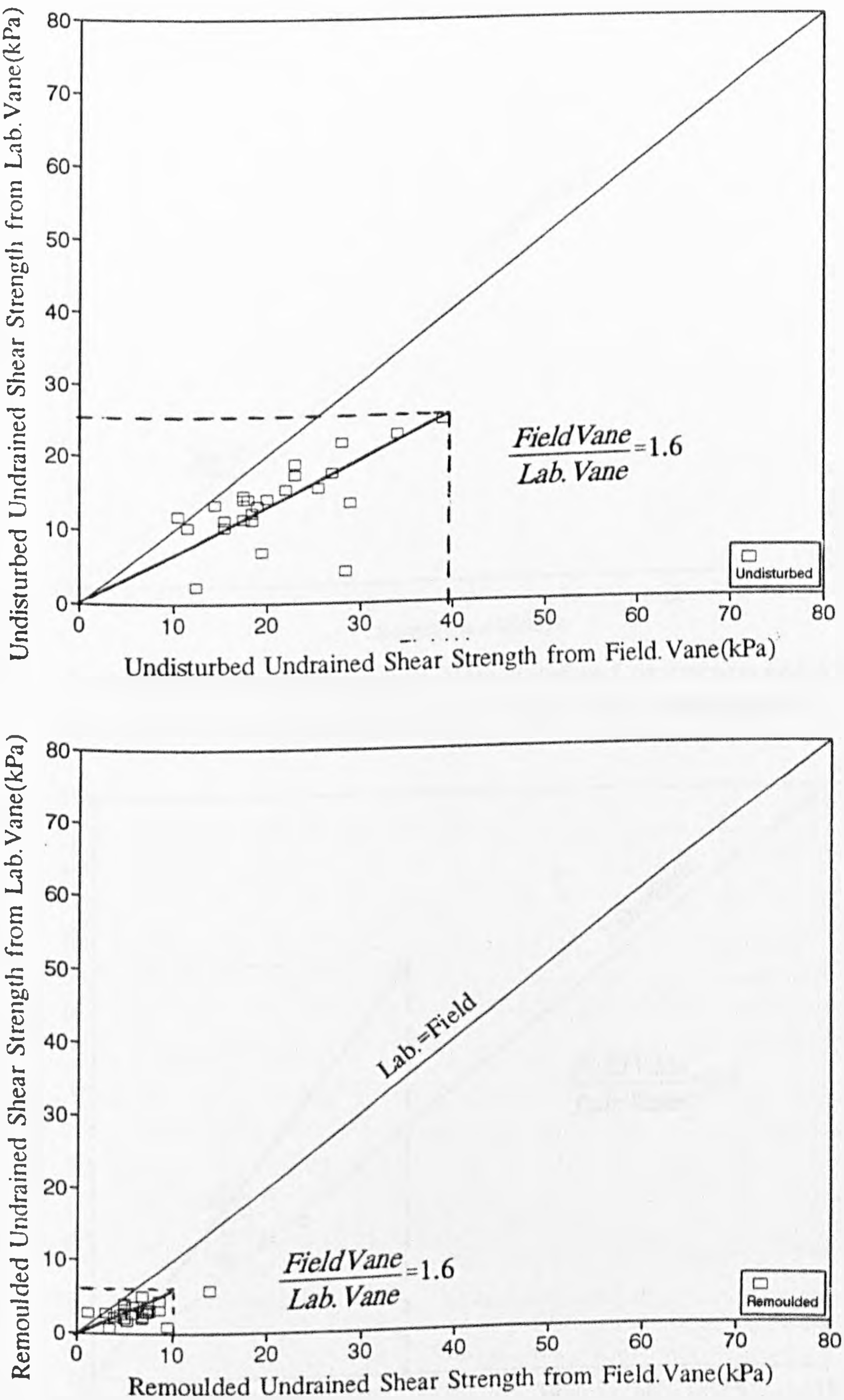


Fig.5.45 : Comparison of Undrained Shear Strength from Laboratory Vane and Field Vane Tests

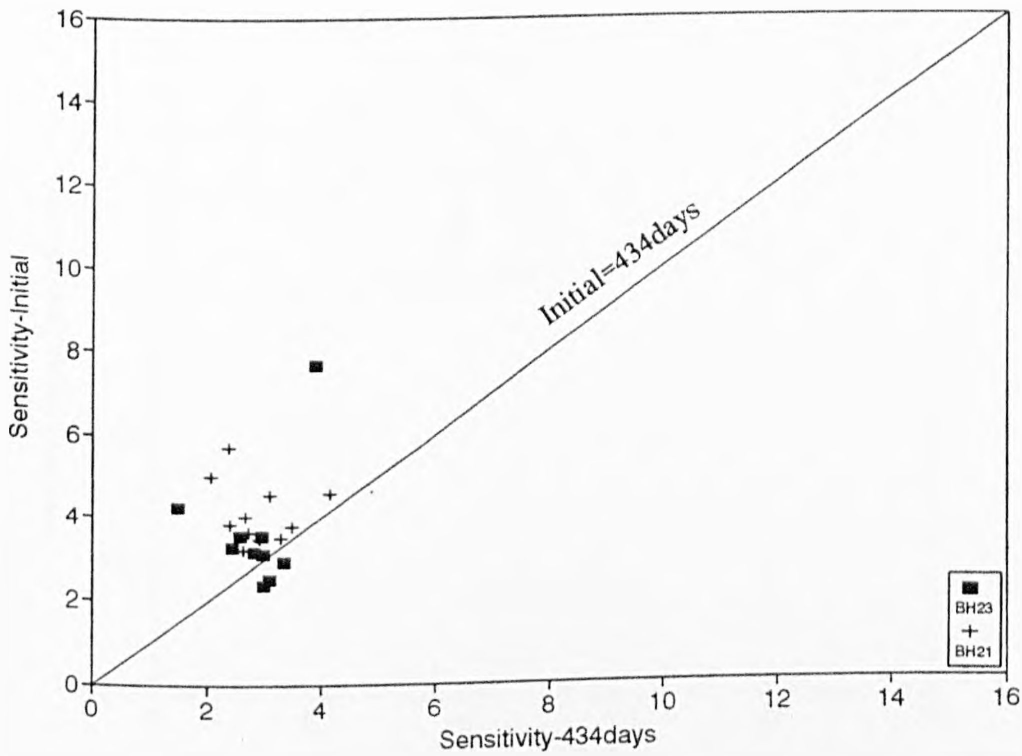


Fig.5.46 : Comparison between Sensitivity Values Before Construction and 434 days after the Start of Construction of the South Trial Embankment

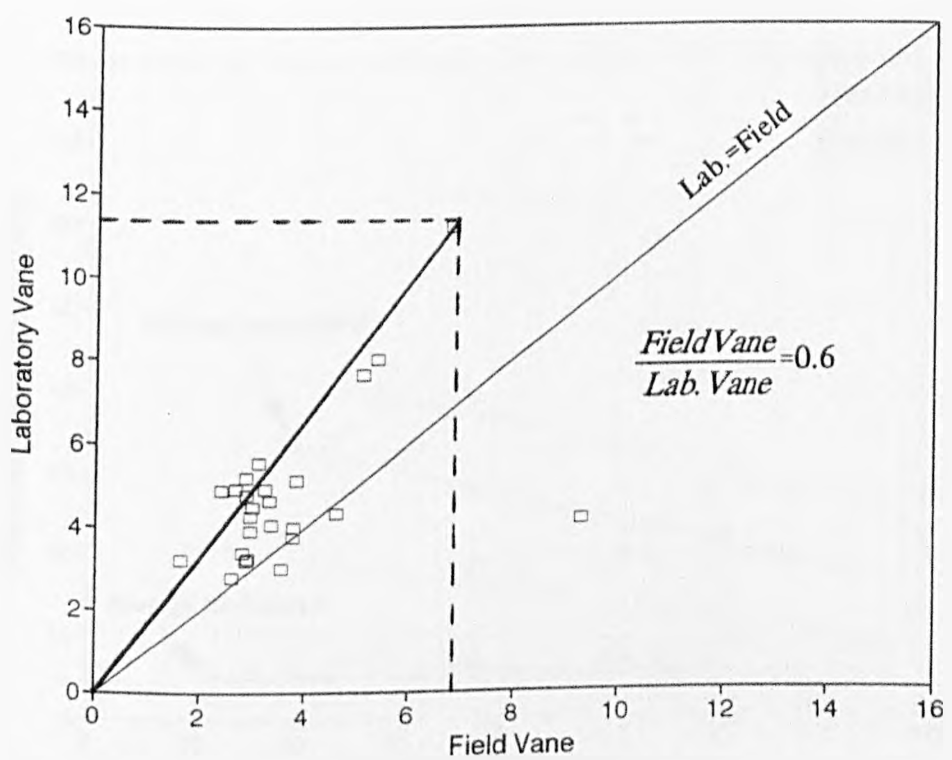


Fig.5.47 : Comparison of Sensitivity Values from Laboratory Vane and Field Vane Tests

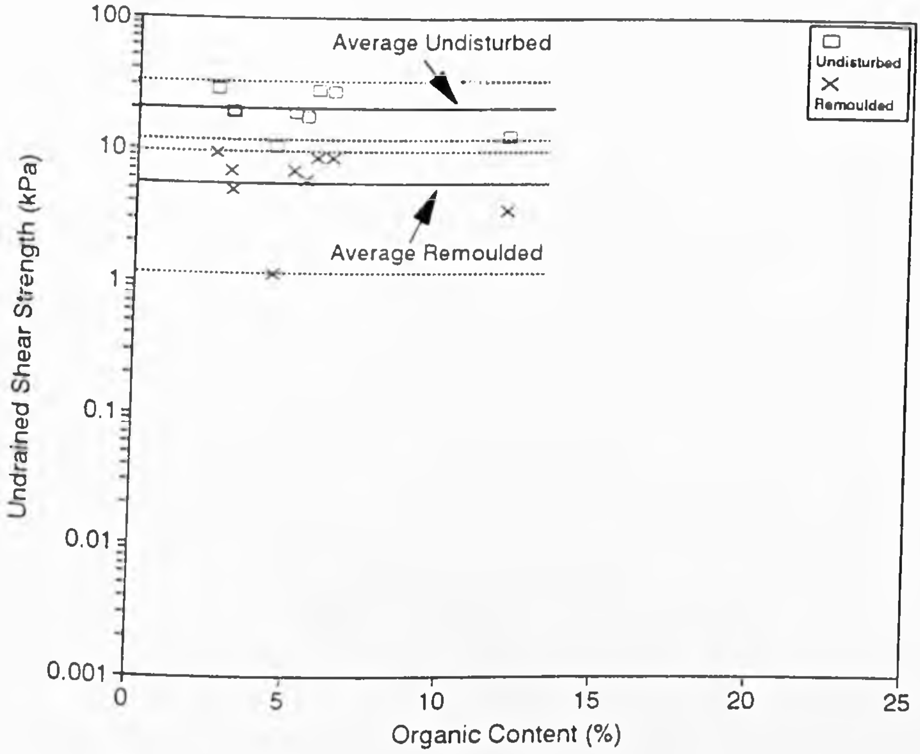


Fig.5.48 : Undrained Shear Strength with Organic Content

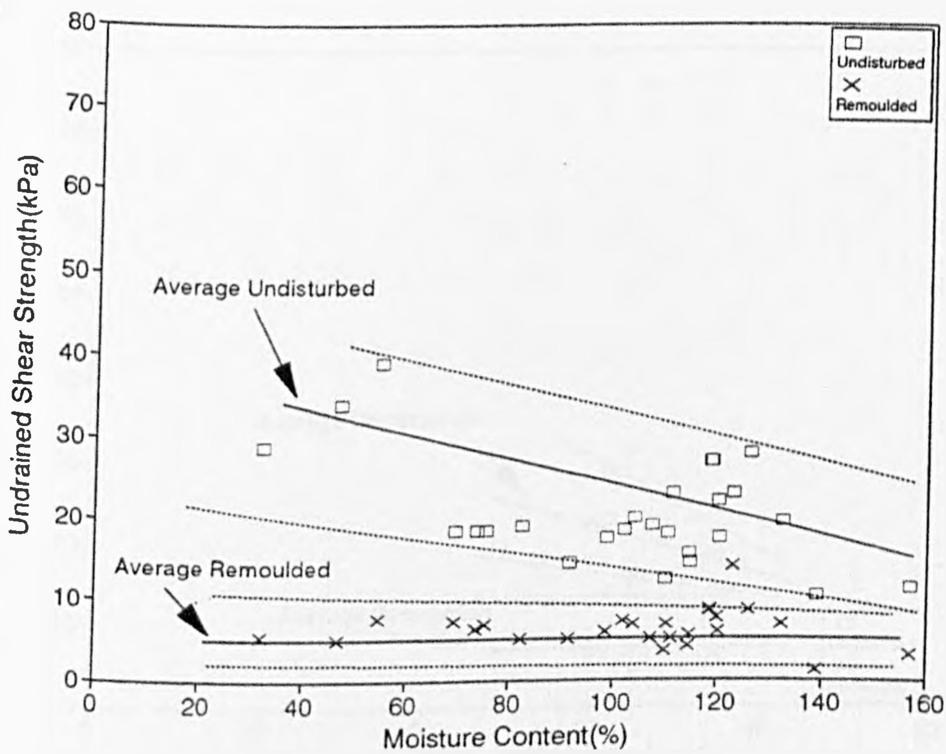


Fig.5.49 : Undrained Shear Strength with Moisture Content

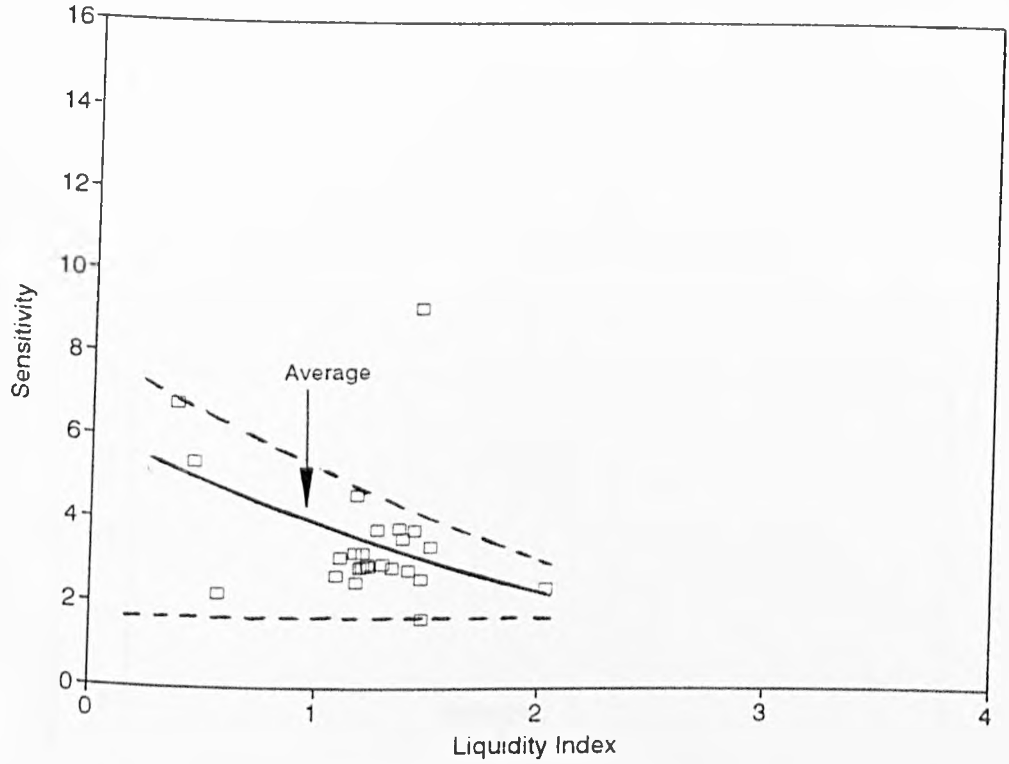


Fig.5.50 : Undrained Shear Strength with Salt Content

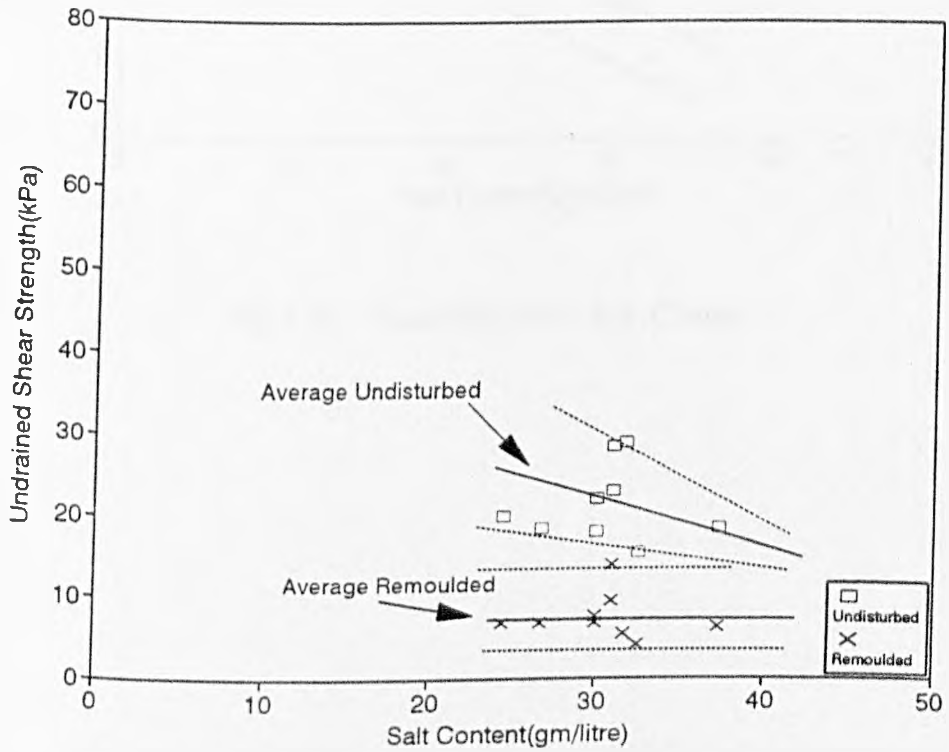


Fig.5.51 : Sensitivity with Liquidity Index

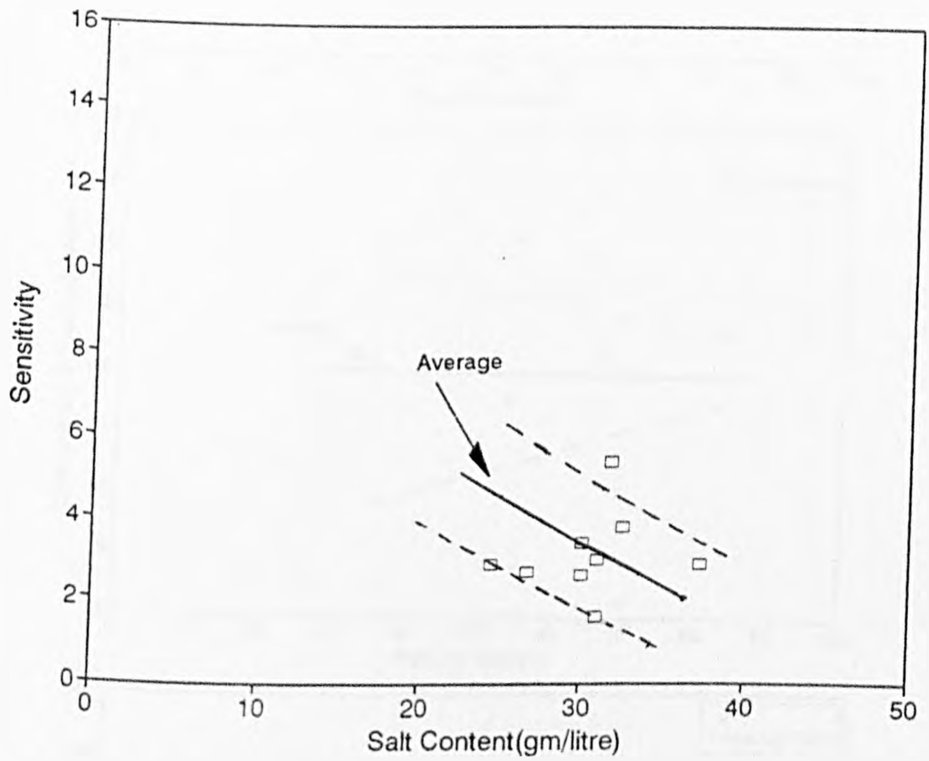


Fig.5.52 : Sensitivity with Salt Content

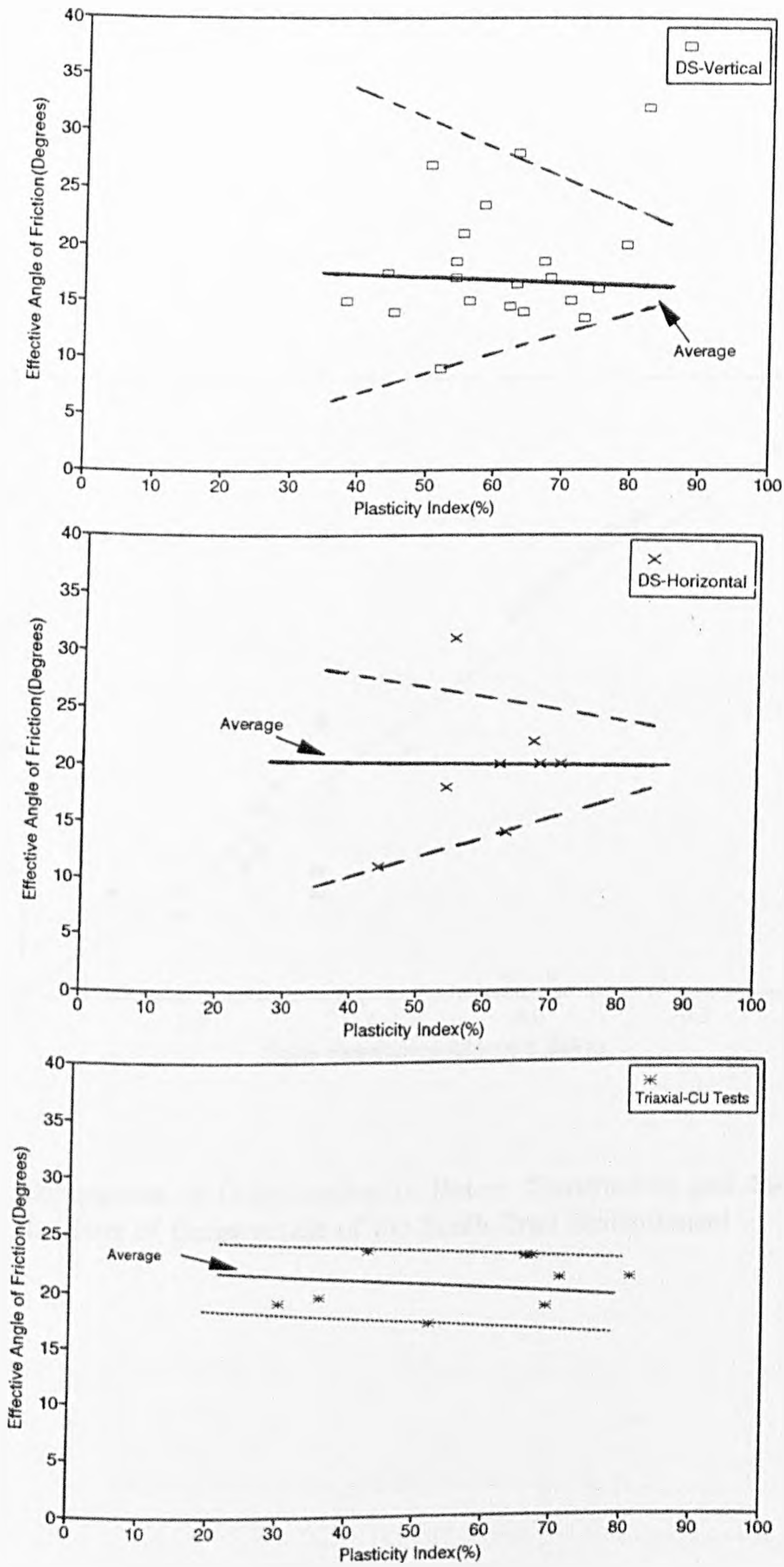


Fig.5.53 : Effective Angle of Friction with Plasticity Index

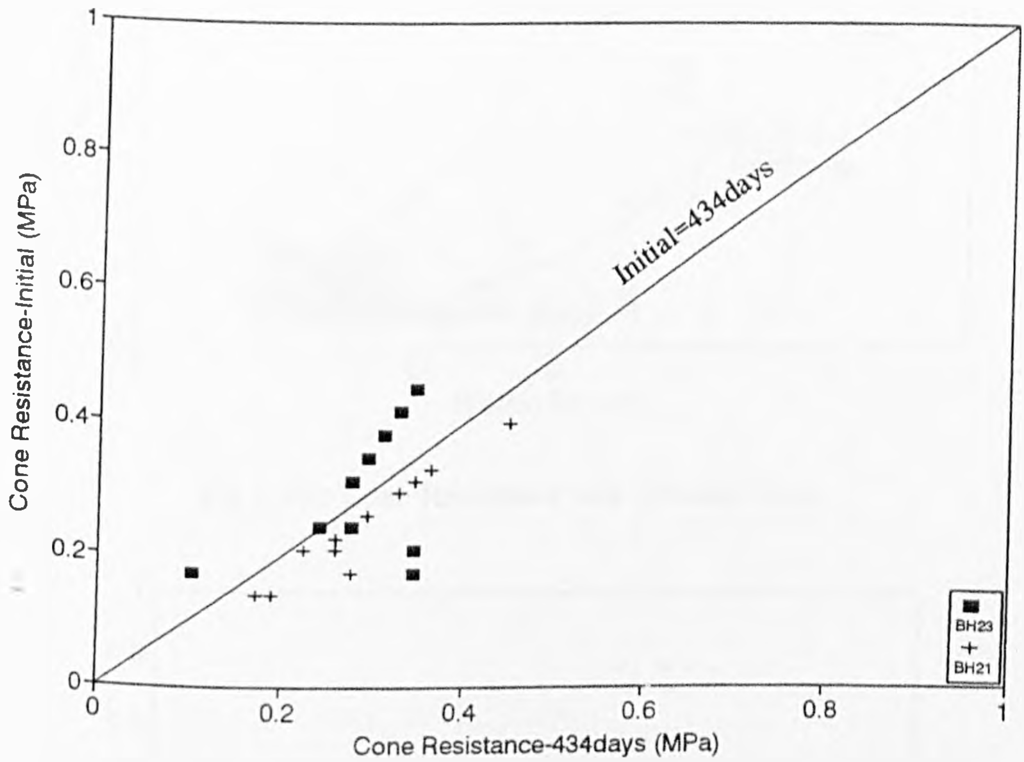


Fig.5.54 : Comparison of Cone Resistance Before Construction and 434 days after the Start of Construction of the South Trial Embankment

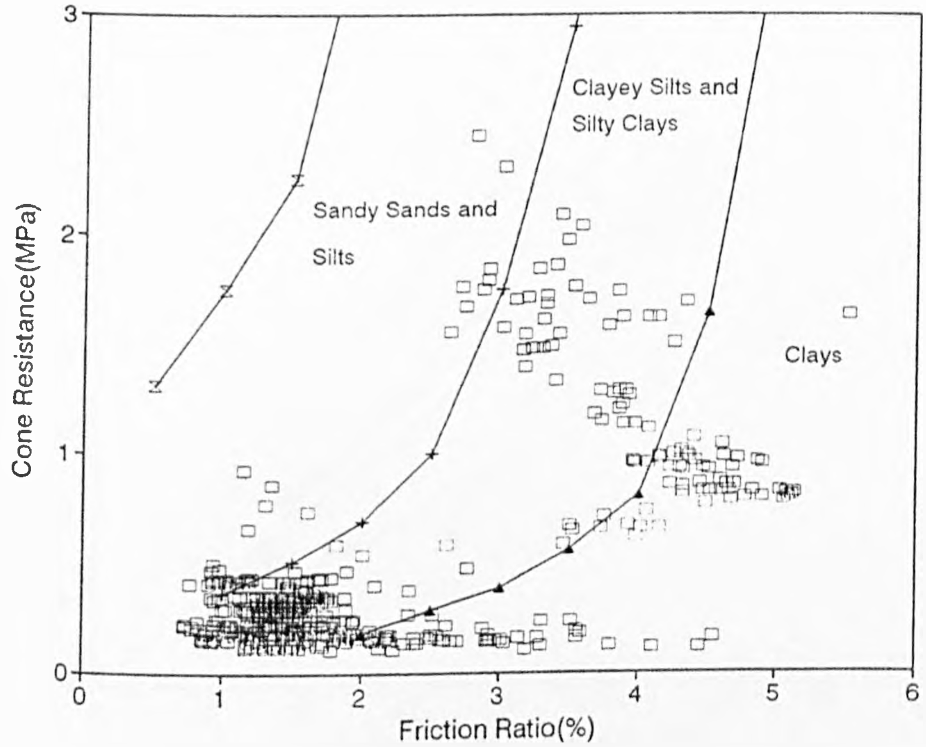


Fig.5.55 : Cone Resistance with Friction Ratio

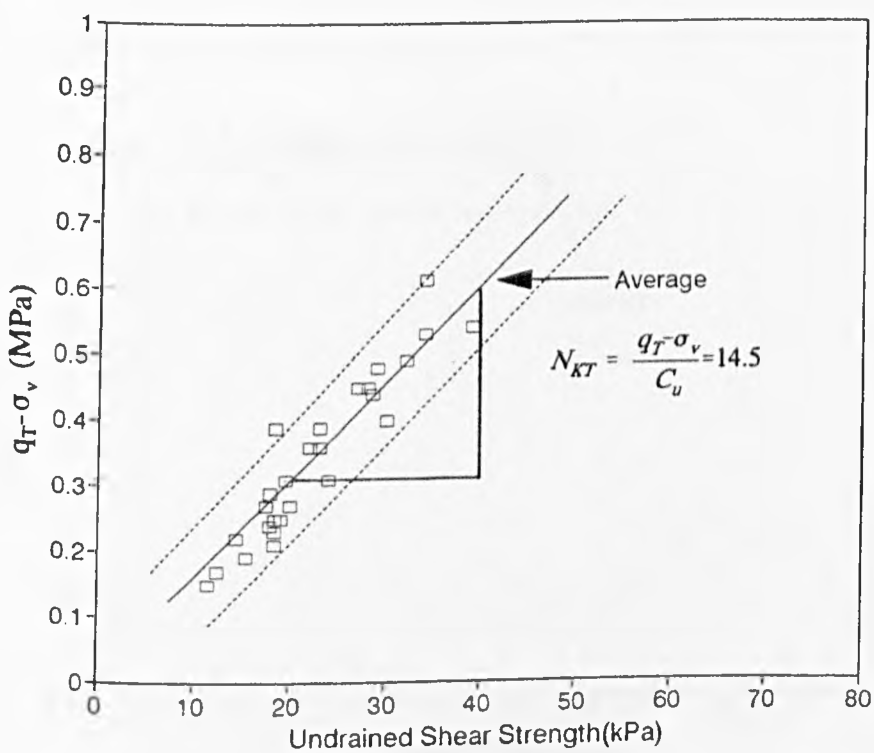


Fig.5.56 : q_T-σ_v with Undrained Shear Strength from Field Vane Tests

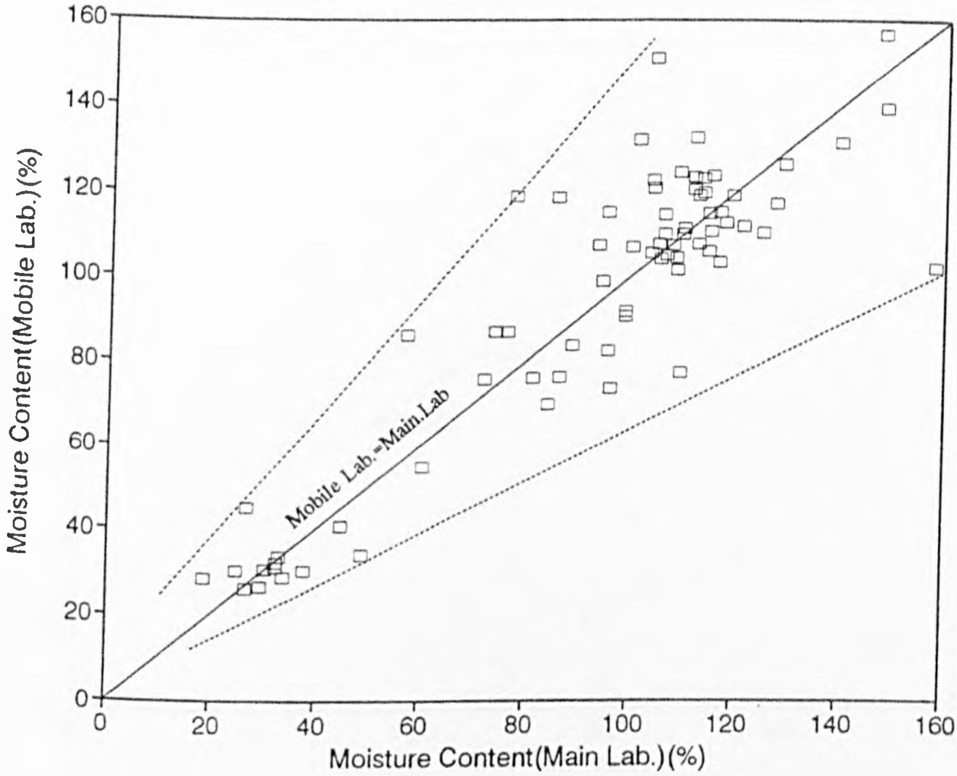


Fig.5.57 : Comparison of Moisture Content Values

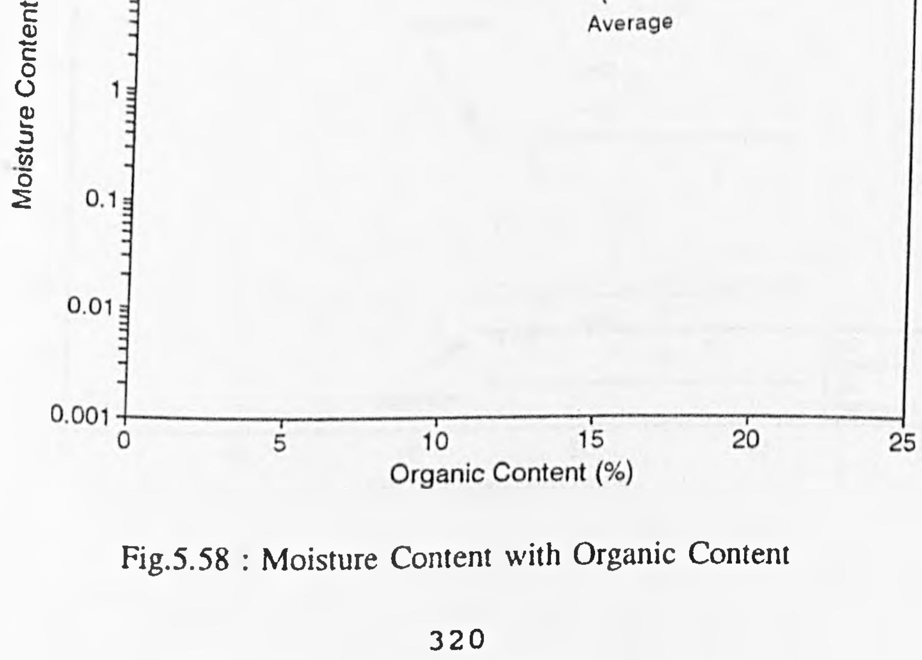


Fig.5.58 : Moisture Content with Organic Content

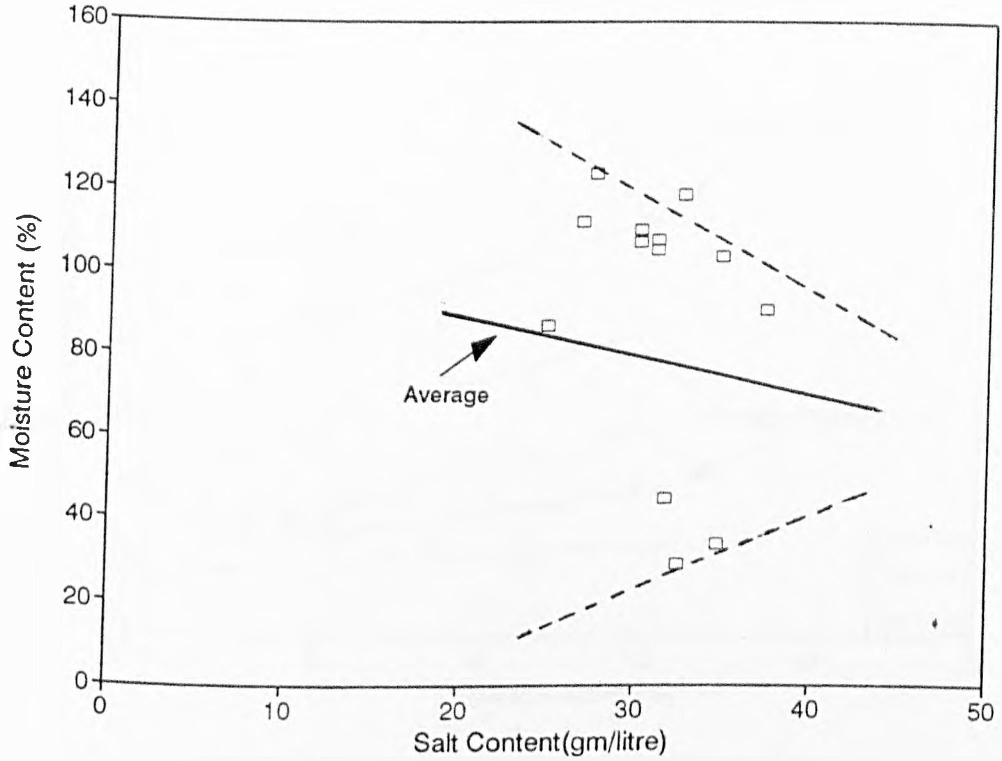


Fig.5.59 : Moisture Content with Salt Content

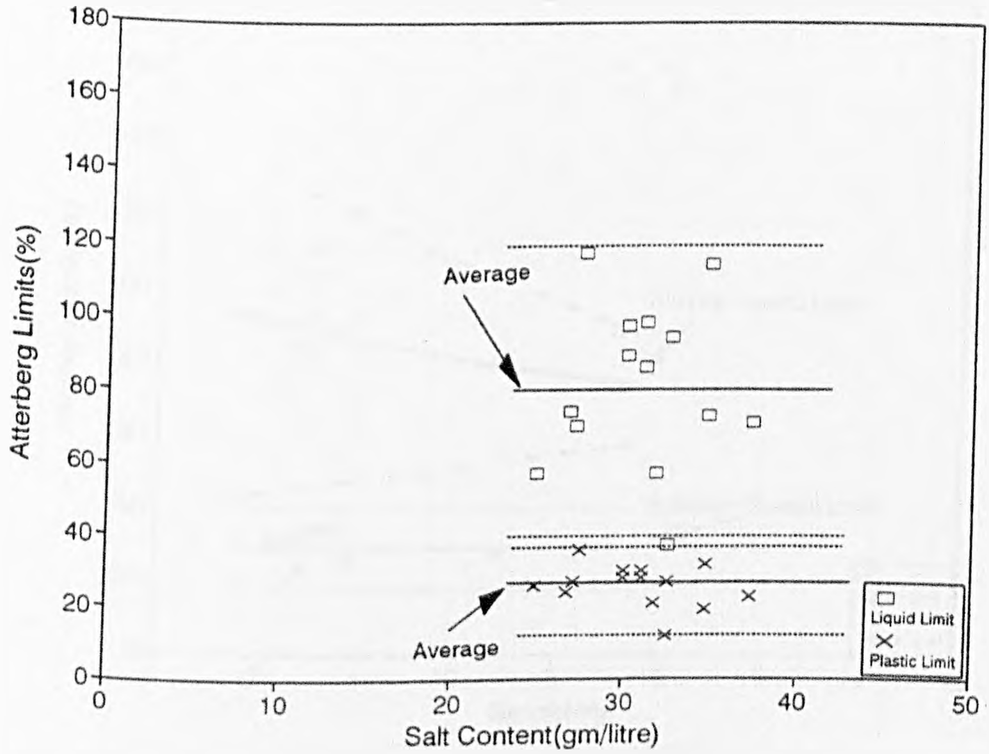


Fig.5.60 : Atterberg Limits with Salt Content

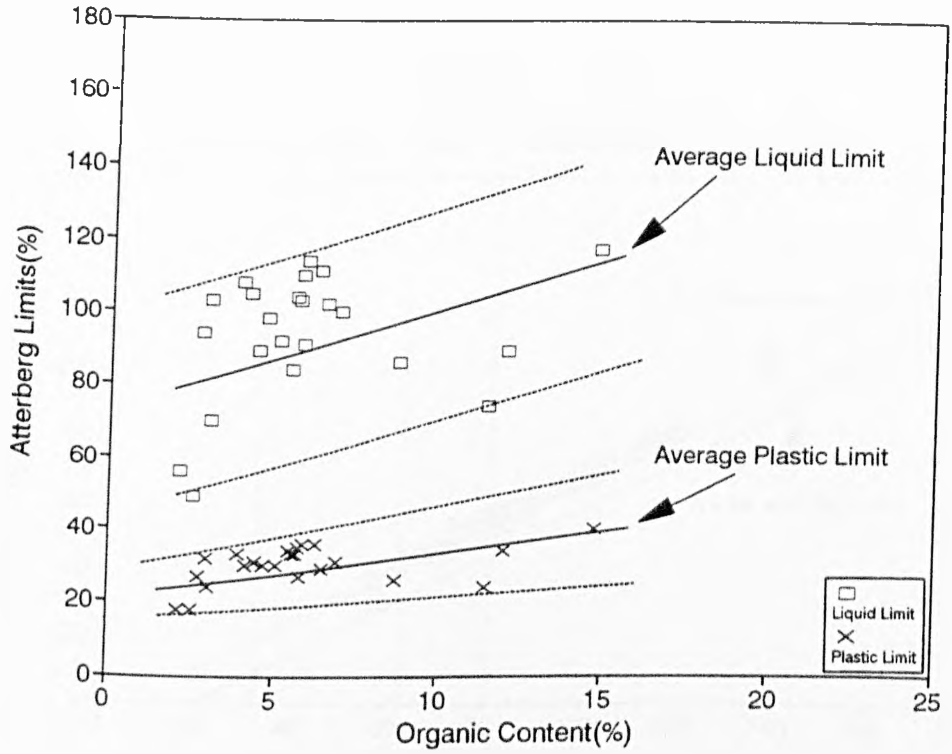


Fig.5.61 : Atterberg Limits with Organic Content

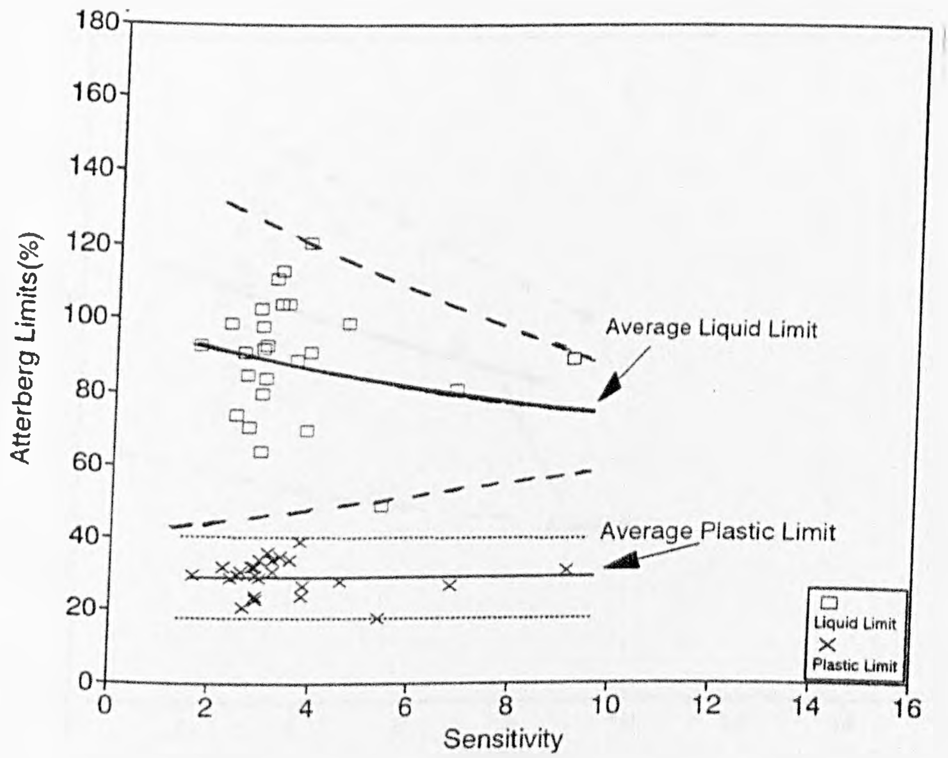


Fig.5.62 : Atterberg Limits with Sensitivity

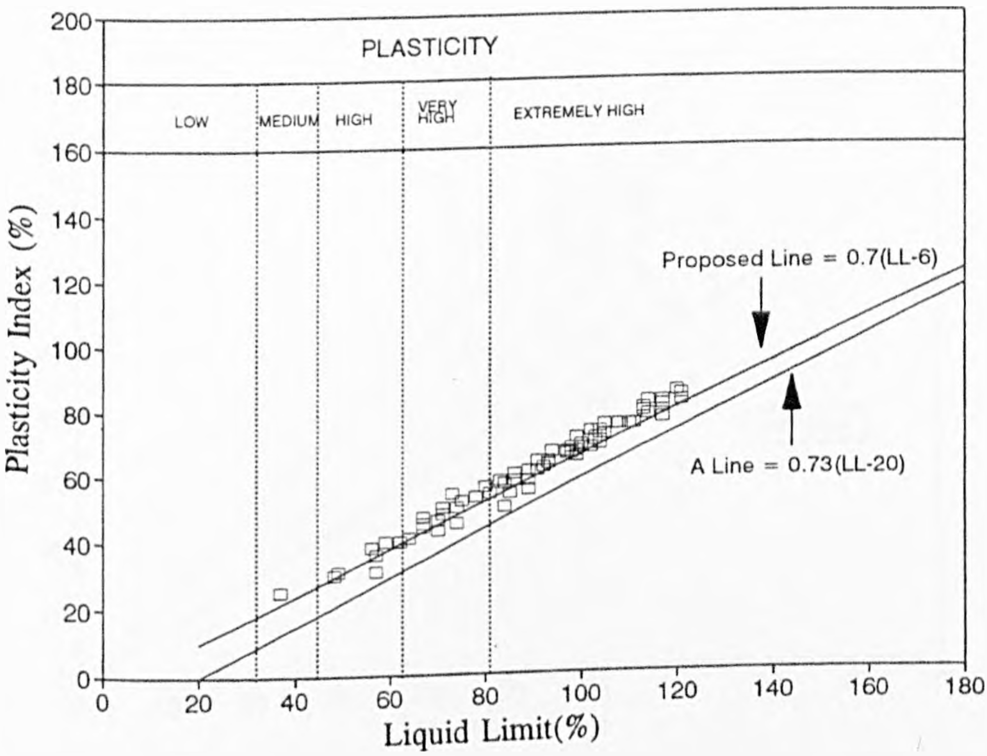


Fig.5.63 : Plasticity Index with Liquid Limit

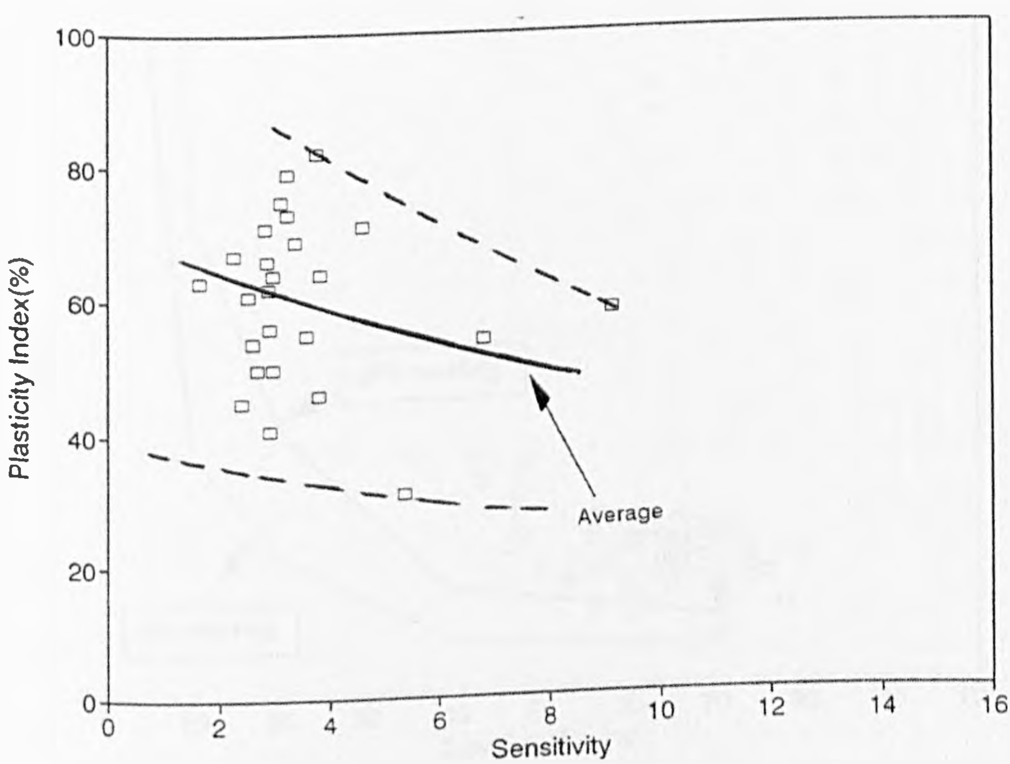


Fig.5.64 : Plasticity Index with Sensitivity

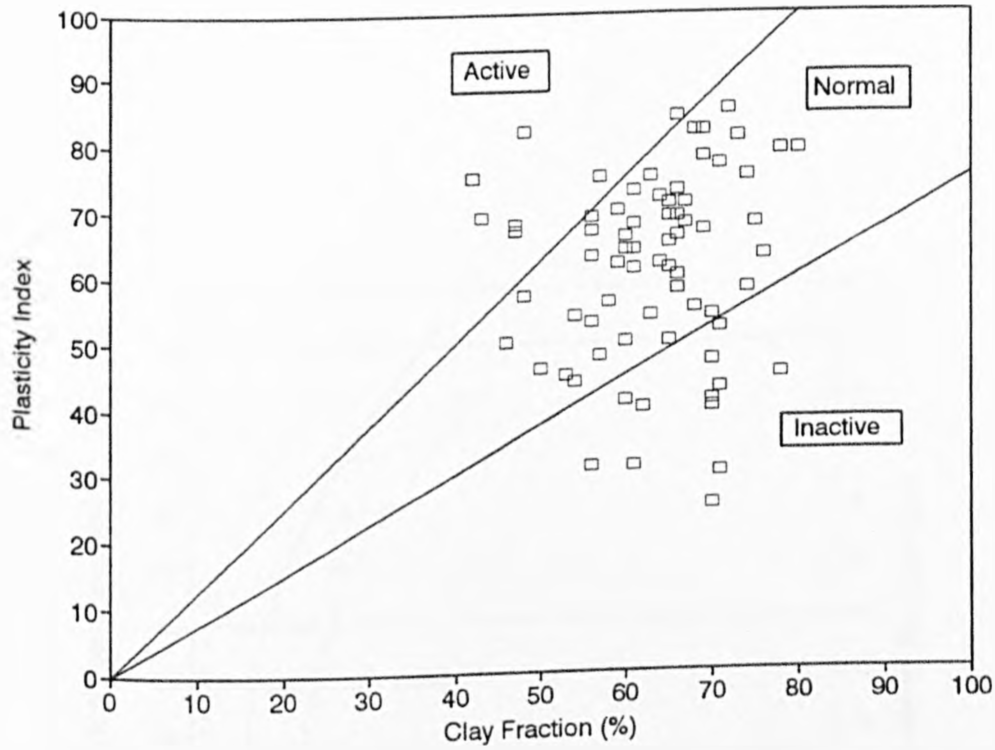


Fig.5.65 : Plasticity Index with Clay Fraction

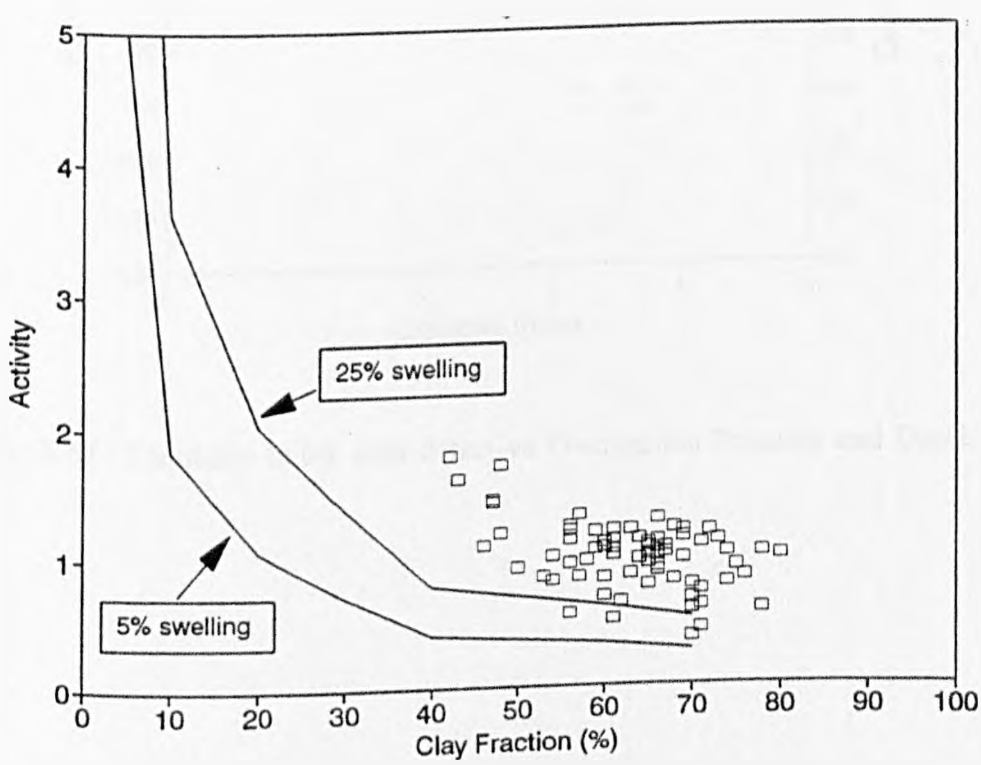


Fig.5.66 : Activity with Clay Fraction

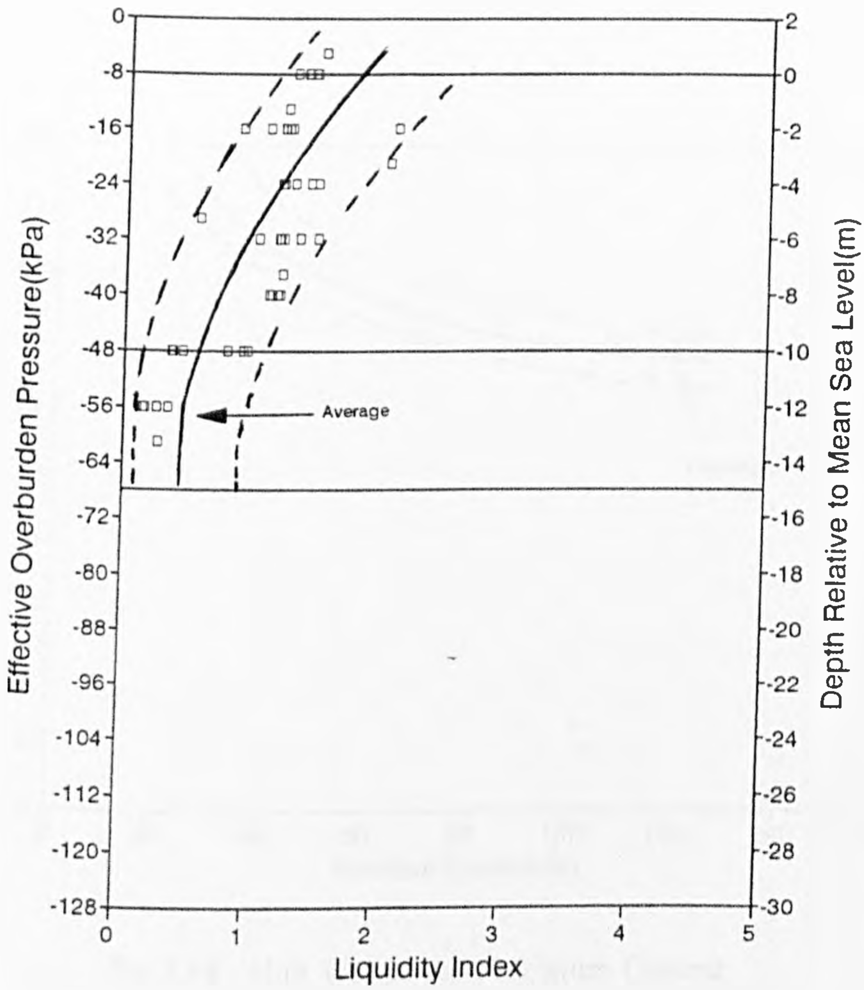


Fig.5.67 : Liquidity Index with Effective Overburden Pressure and Depth

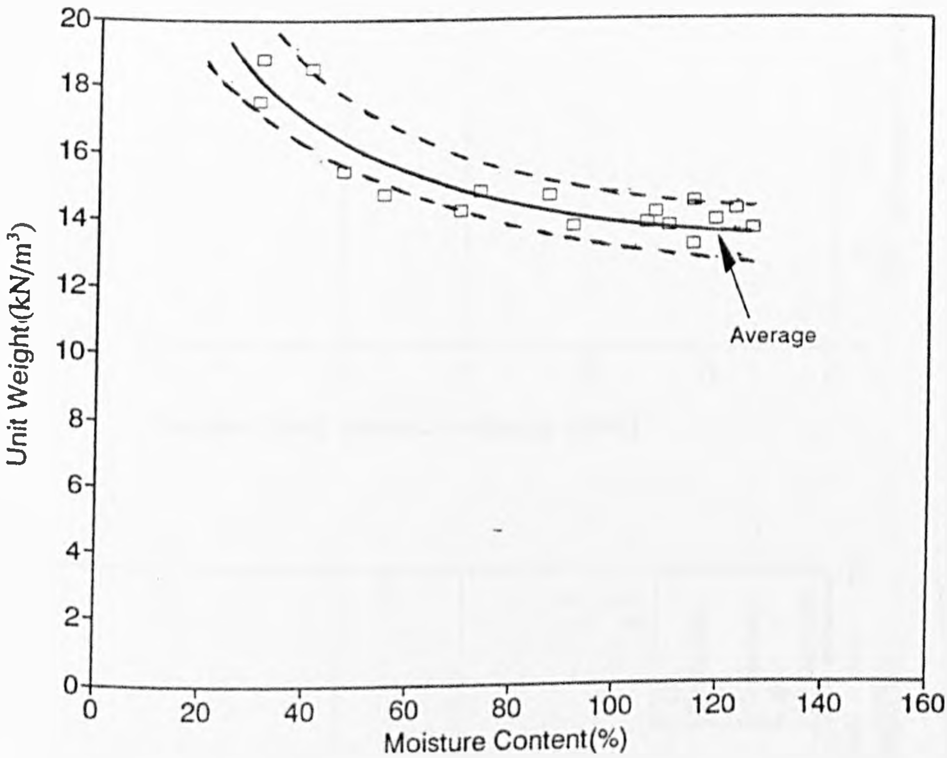


Fig.5.68 : Unit Weight with Moisture Content

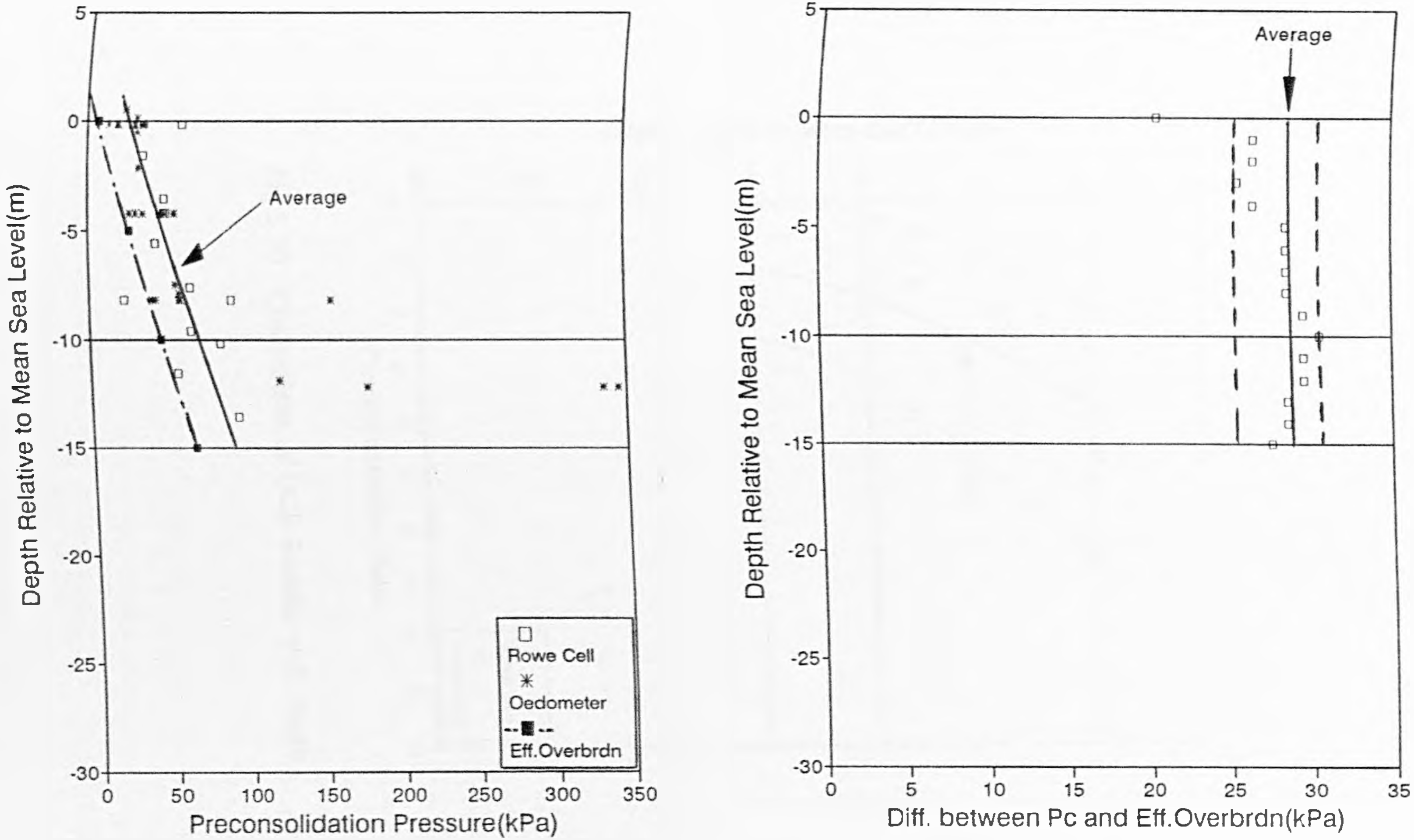


Fig.5.69 : Comparison of Preconsolidation Pressure Results with Depth

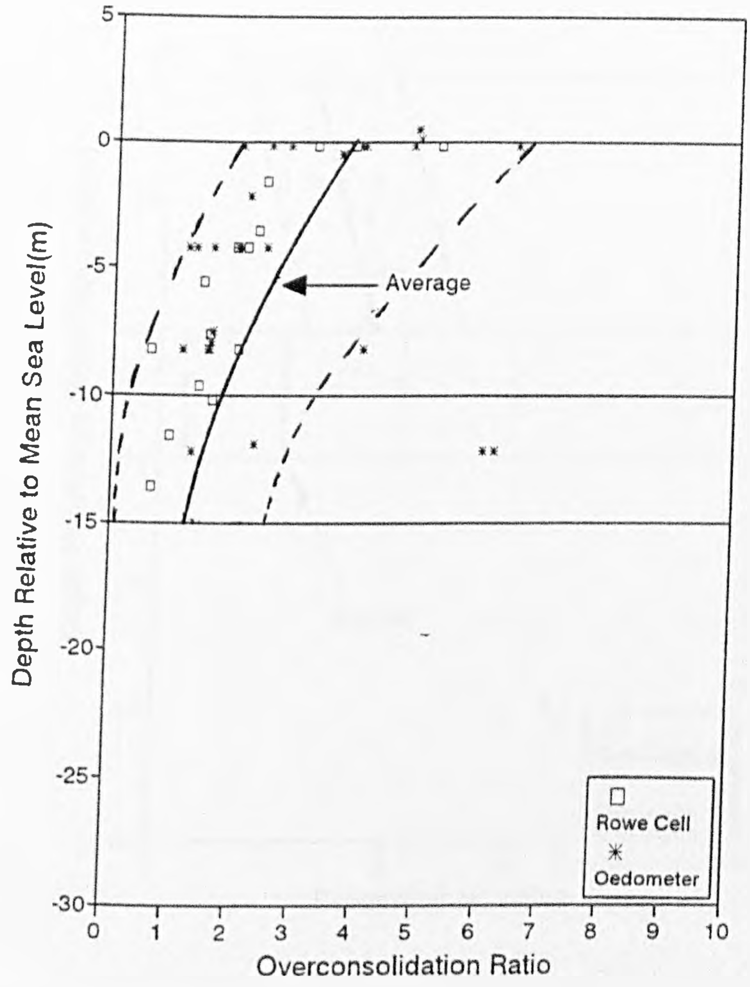


Fig.5.70 : Comparison of OCR Results with Depth

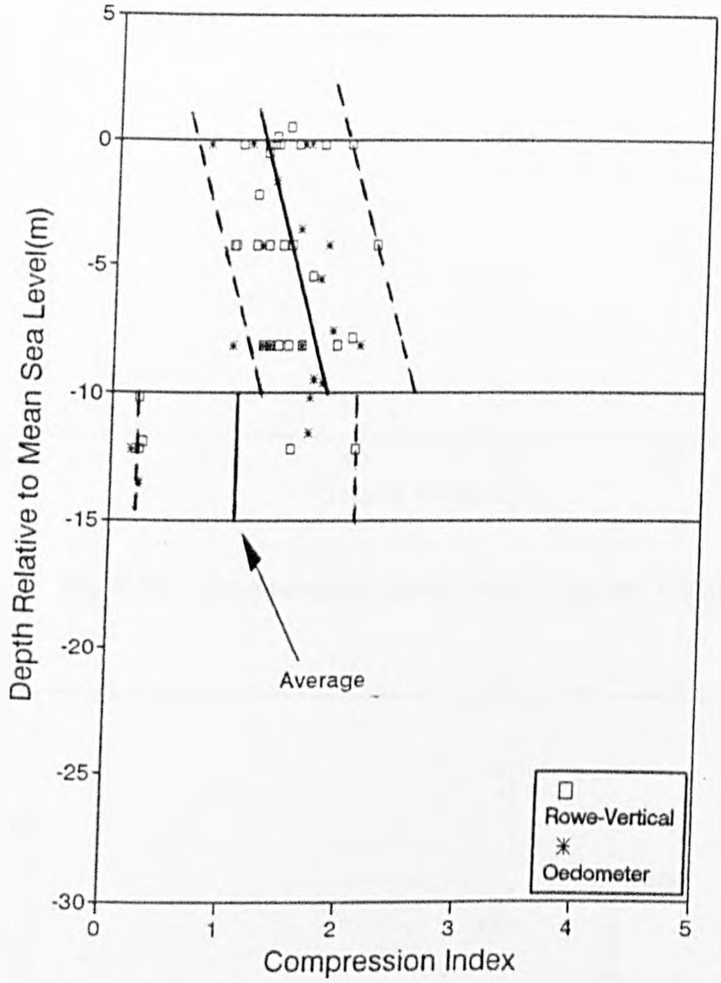


Fig.5.71 : Comparison of Compression Index Results with Depth

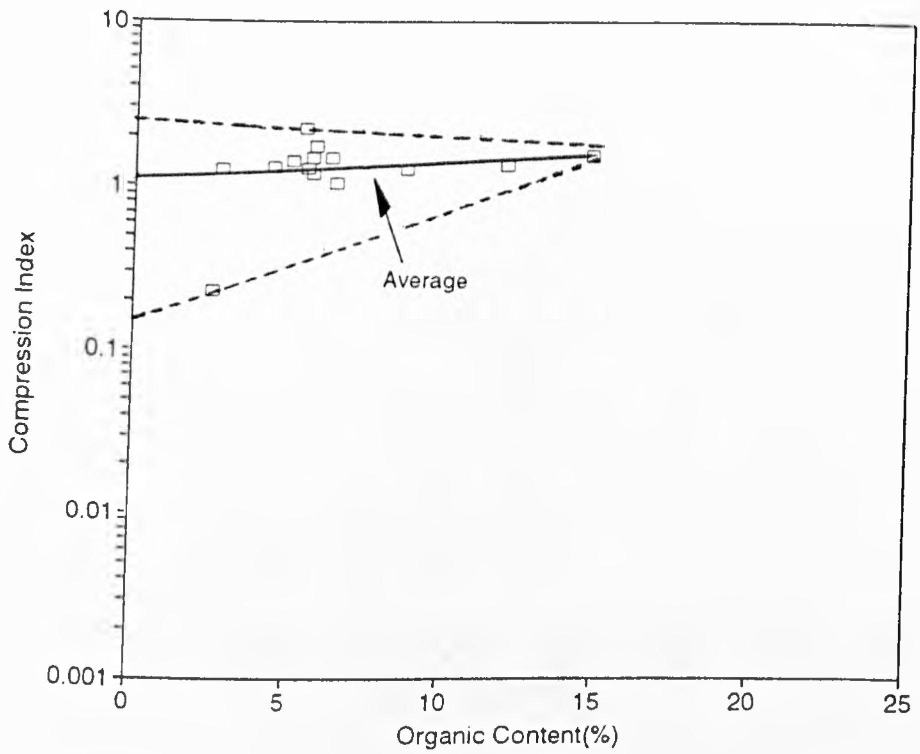


Fig.5.72 : Compression Index with Organic Content

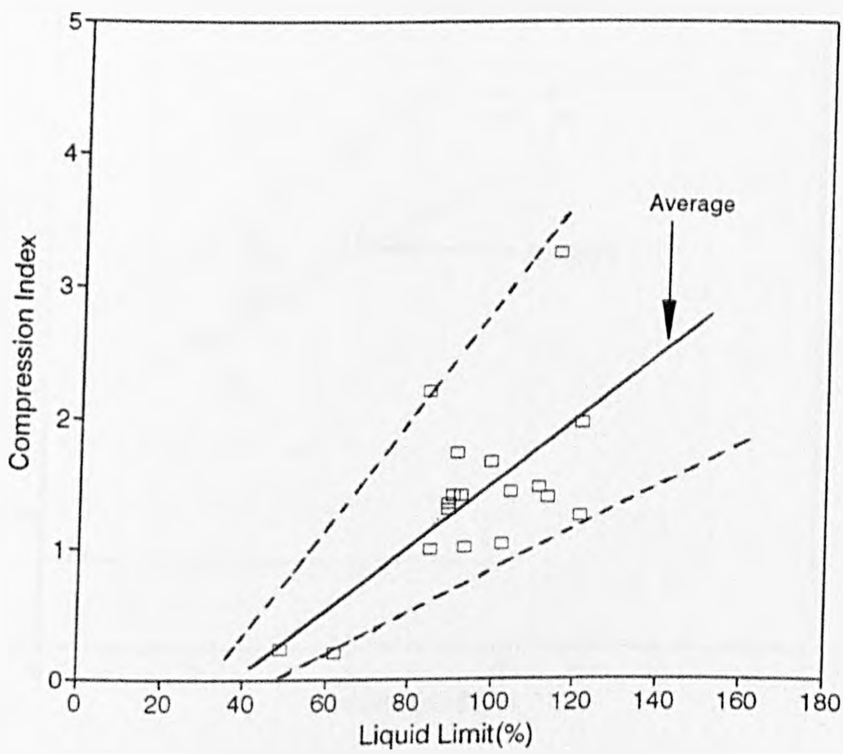


Fig.5.73 : Compression Index with Liquid Limit

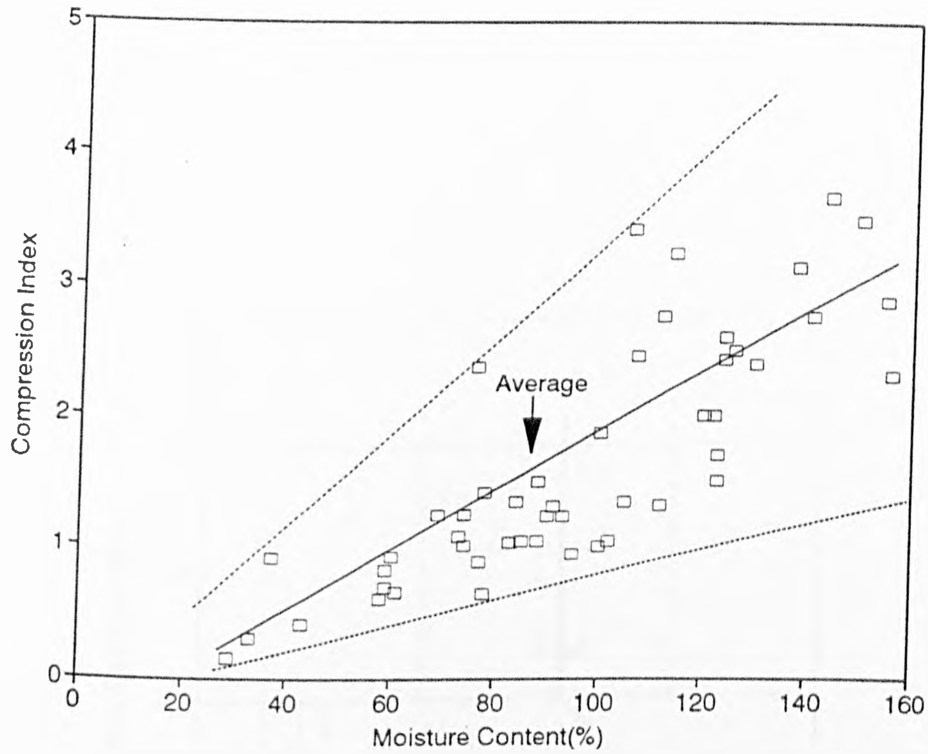


Fig.5.74 : Compression Index with Moisture Content

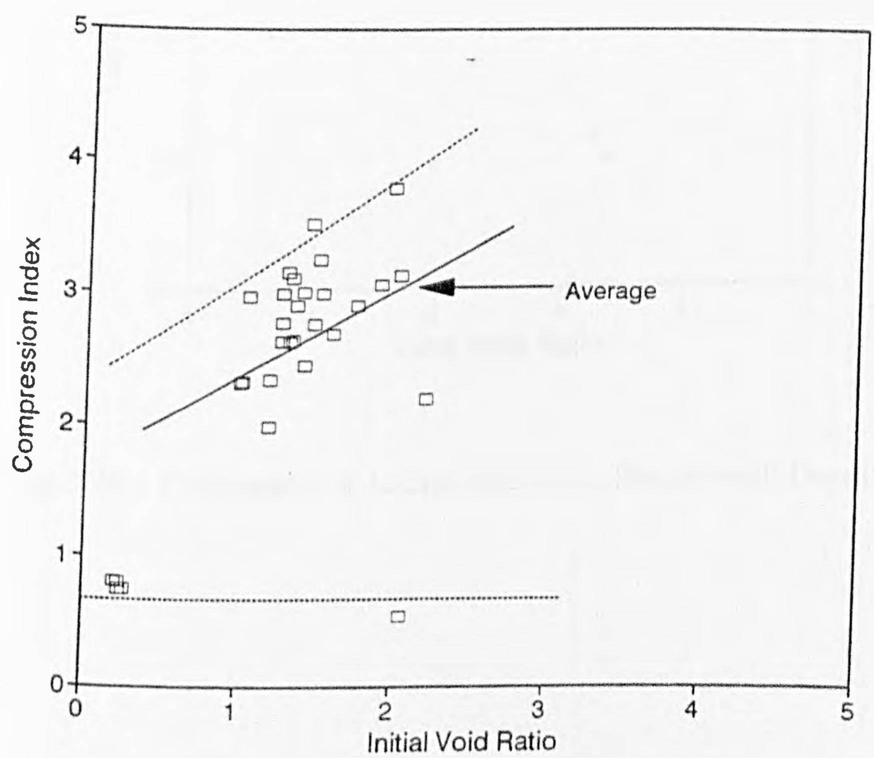


Fig.5.75 : Compression Index with Initial Void Ratio

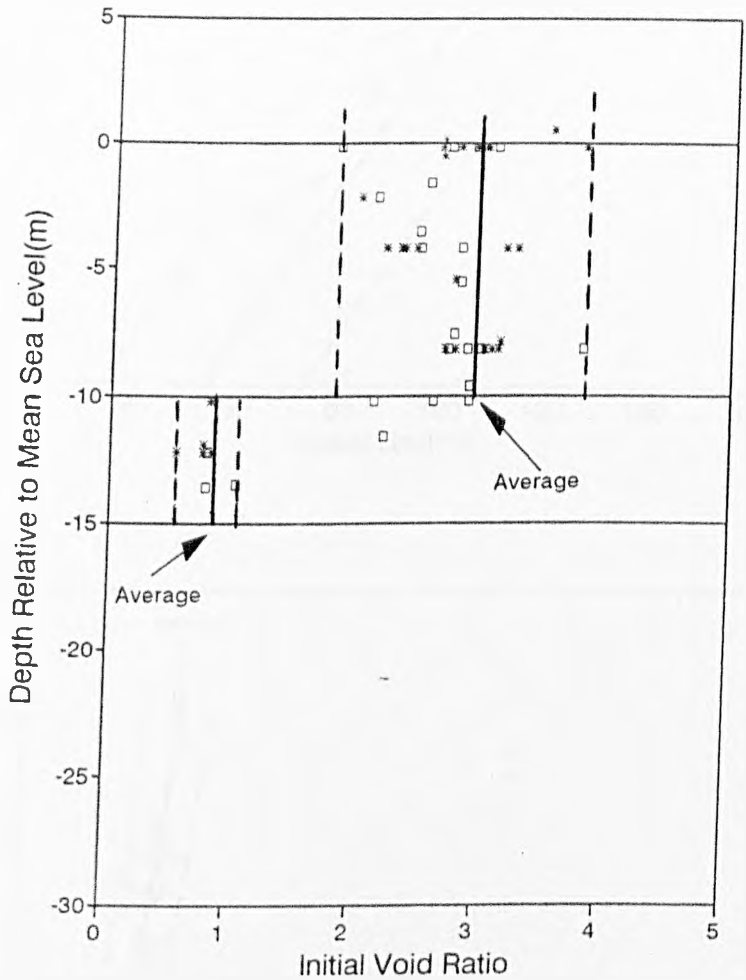
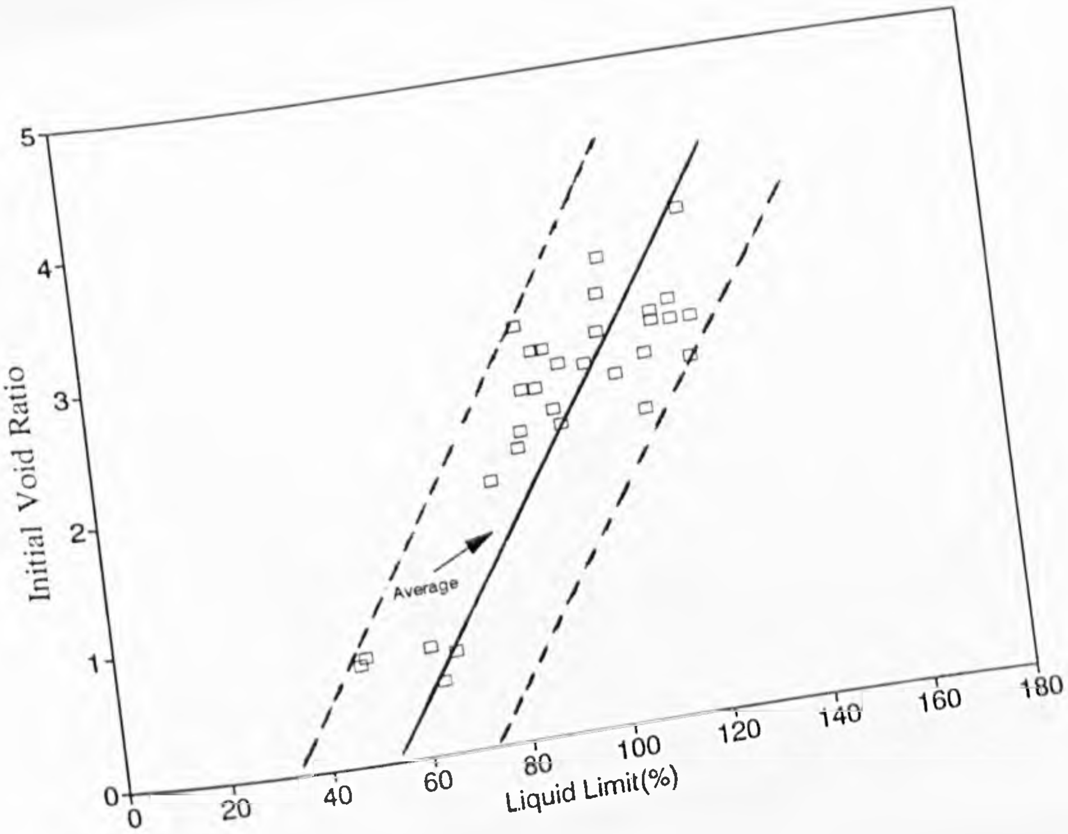


Fig.5.76 : Comparison of Initial Void Ratio Results with Depth



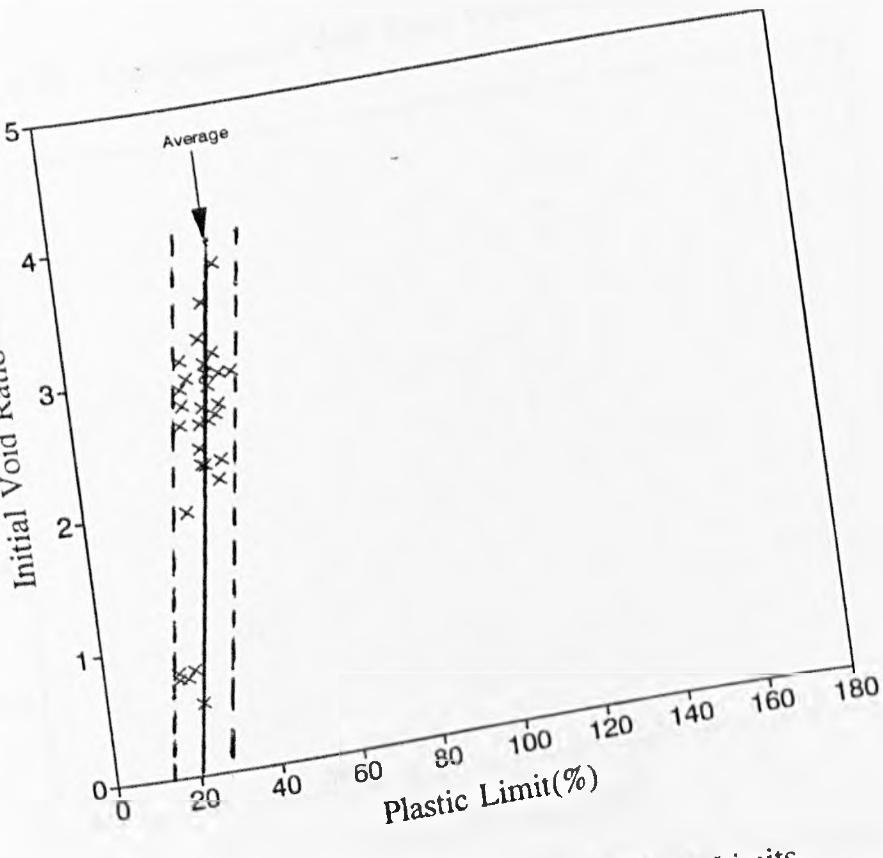


Fig.5.77 : Initial Void Ratio with Atterberg Limits

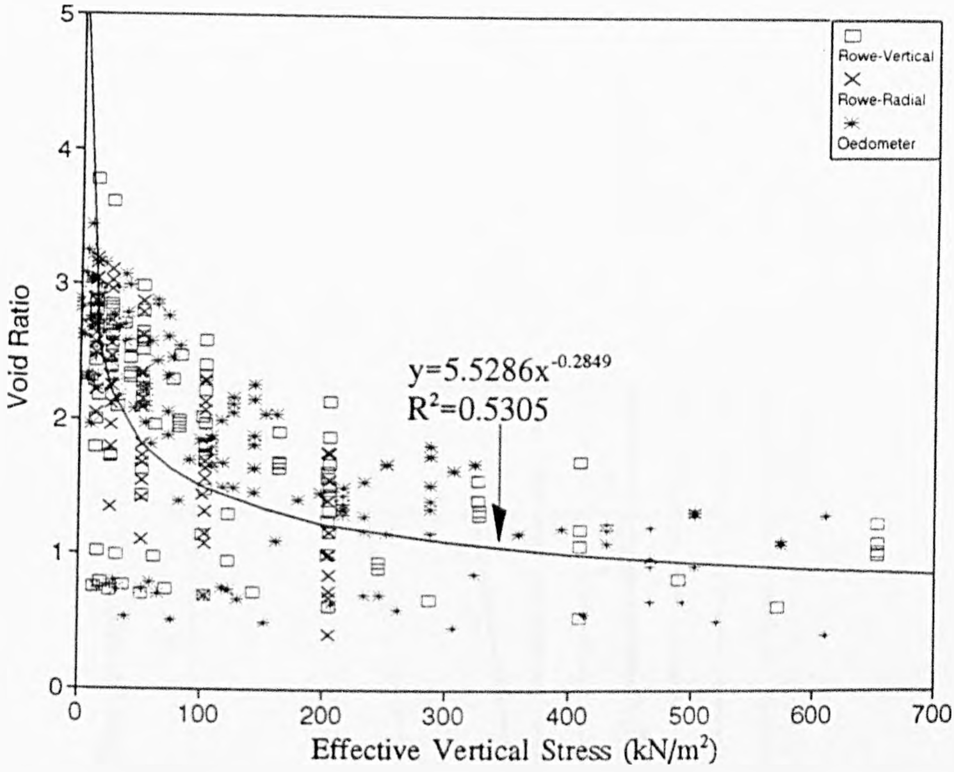


Fig.5.78 : Comparison of Void Ratio Values with Effective Vertical Stress

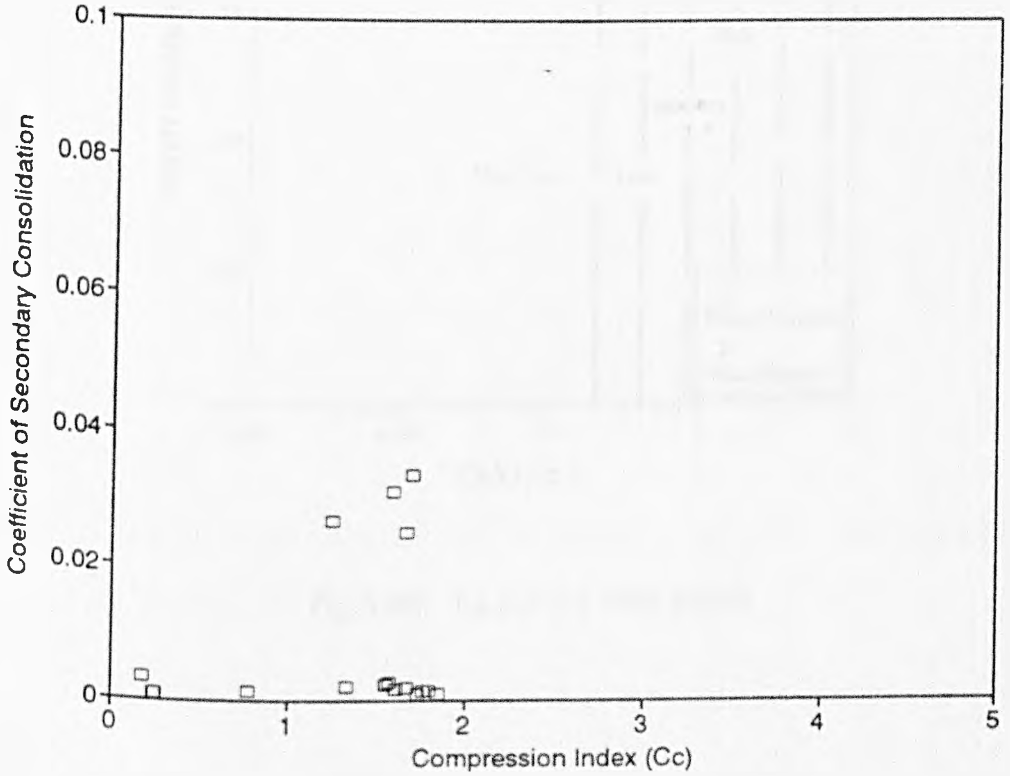


Fig.5.79 : Coefficient of Secondary Consolidation with Compression Index

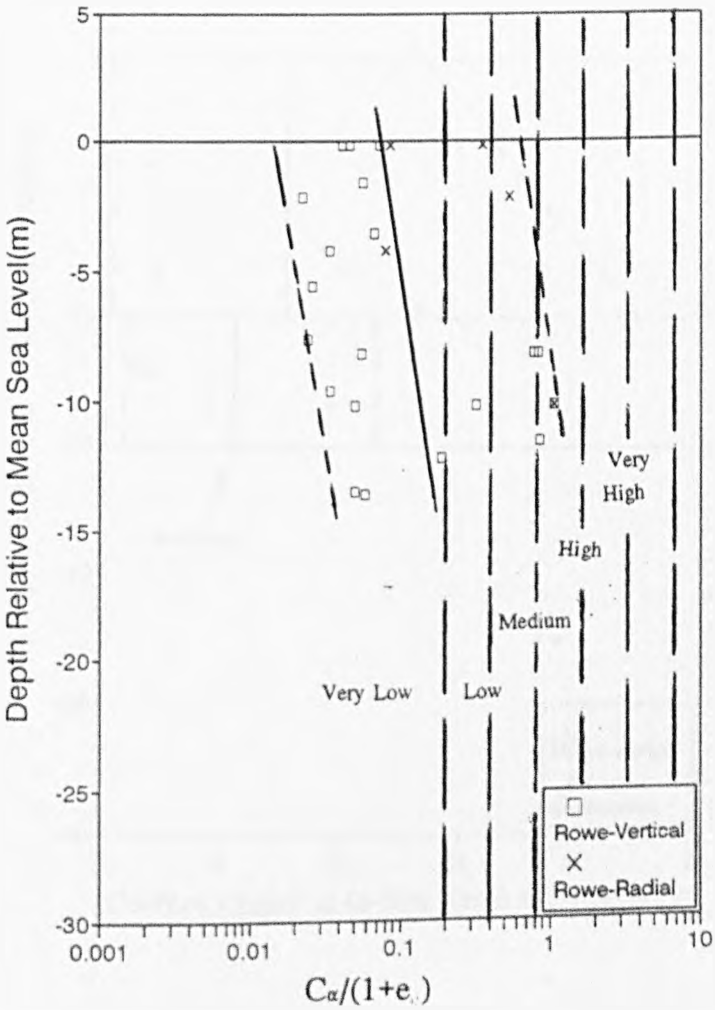


Fig.5.80: C_α /(1+e.) with Depth

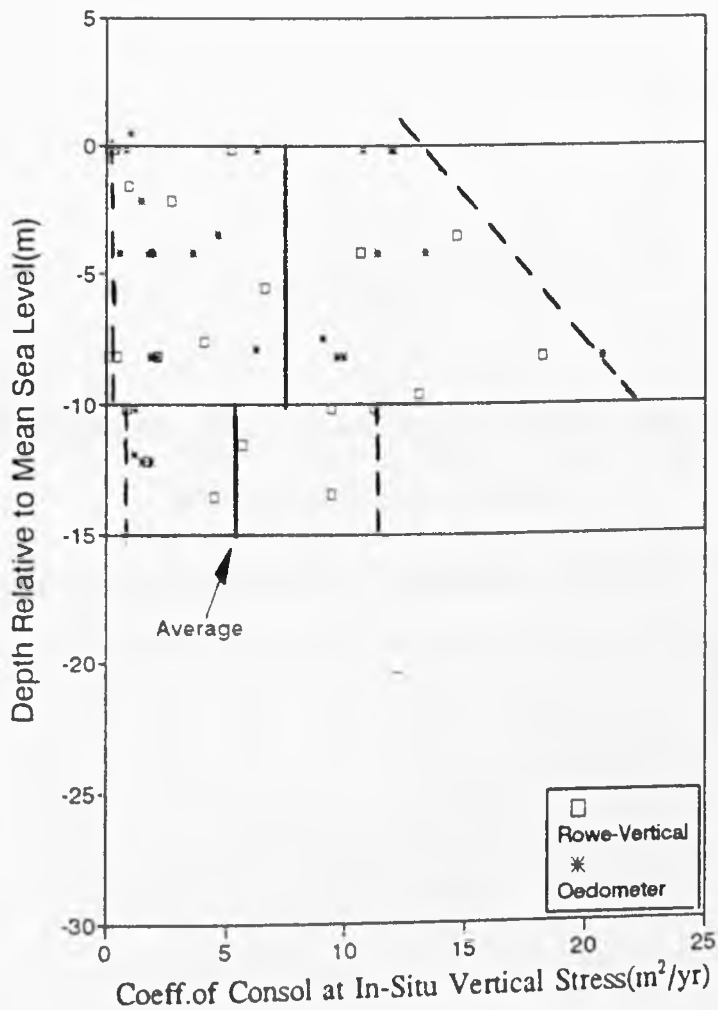


Fig.5.81 : Comparison of Coefficient of Consolidation Values at In-Situ Vertical Stress with Depth

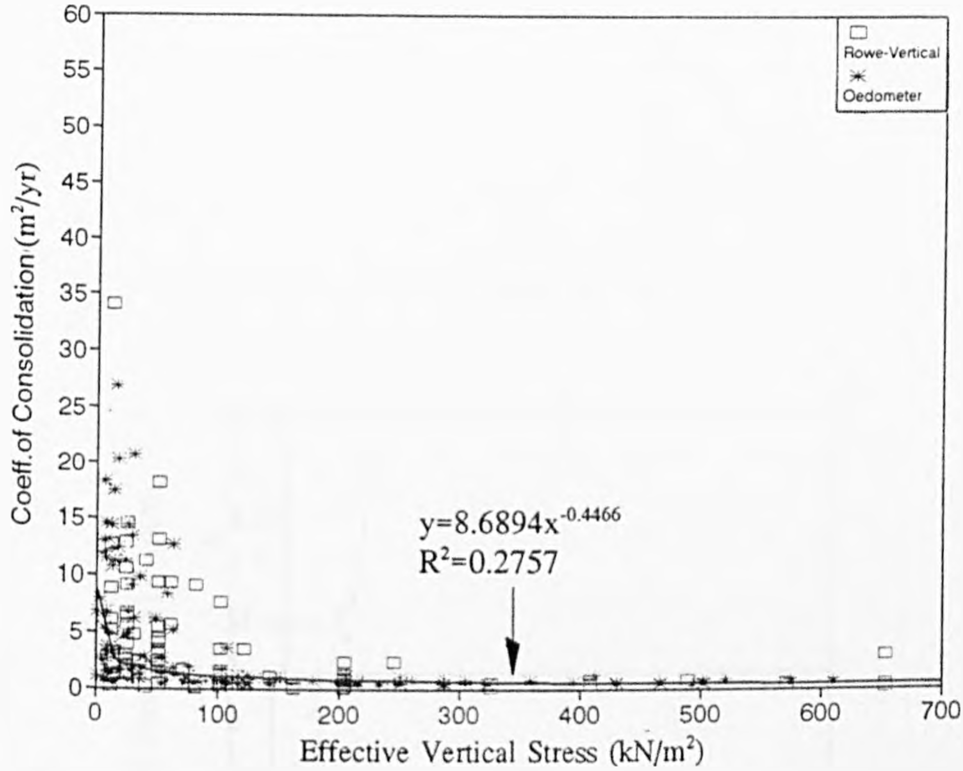


Fig.5.82 : Comparison of Coefficient of Consolidation Values with Effective Stress

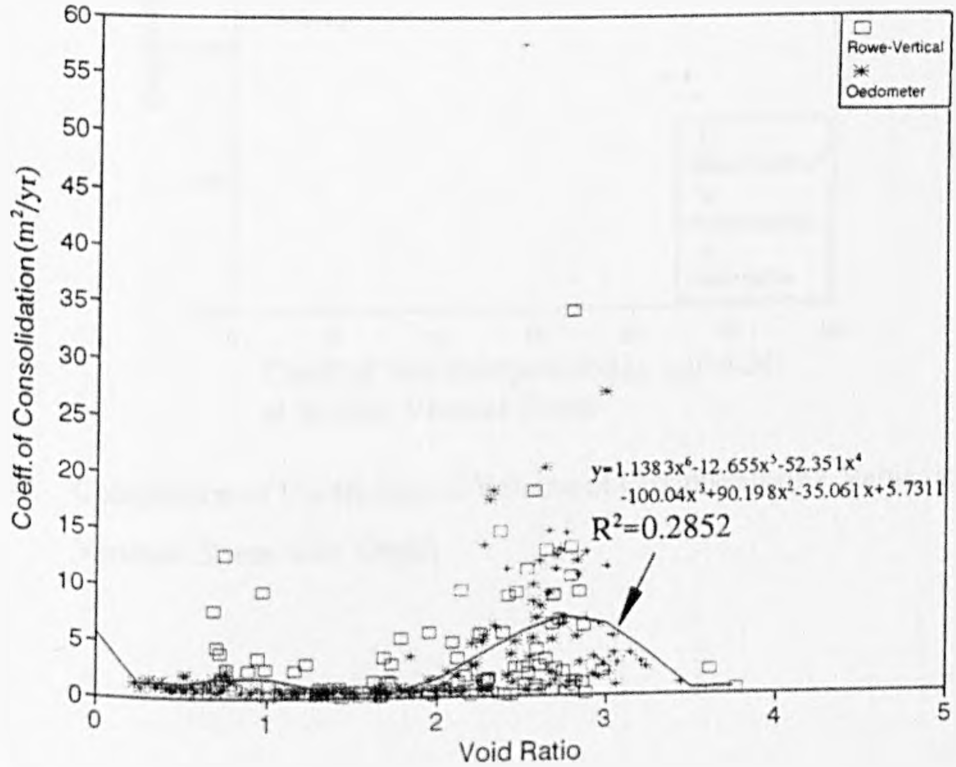


Fig.5.83 : Comparison of Coefficient of Consolidation Values with Void Ratio

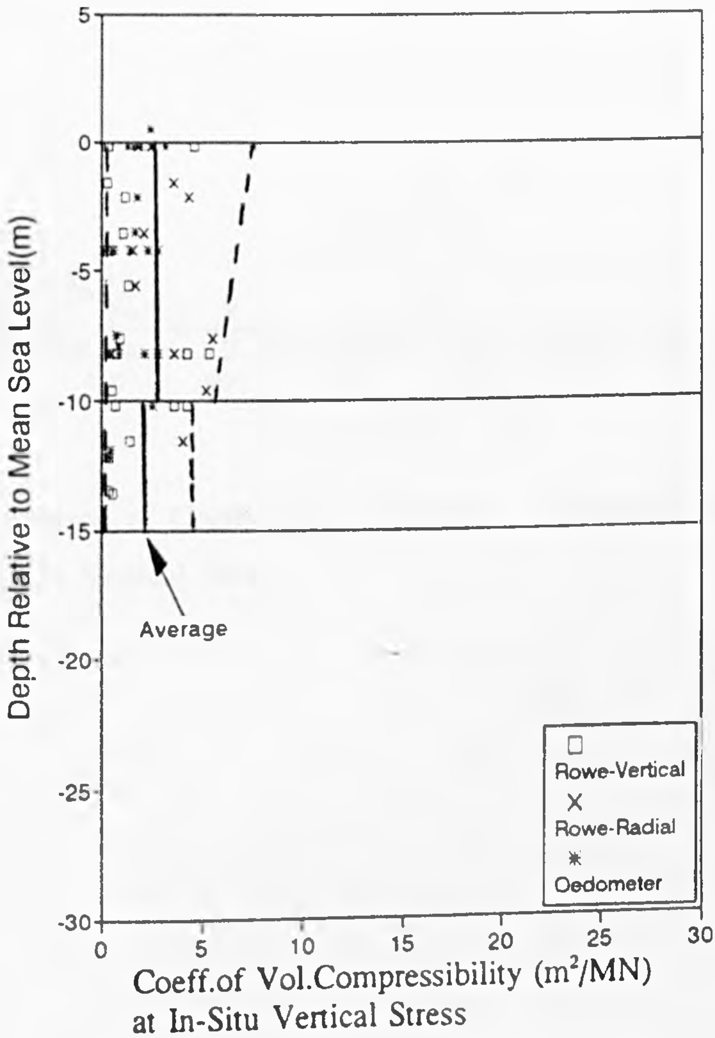


Fig.5.84 : Comparison of Coefficient of Volume of Compressibility Values at In-Situ Vertical Stress with Depth

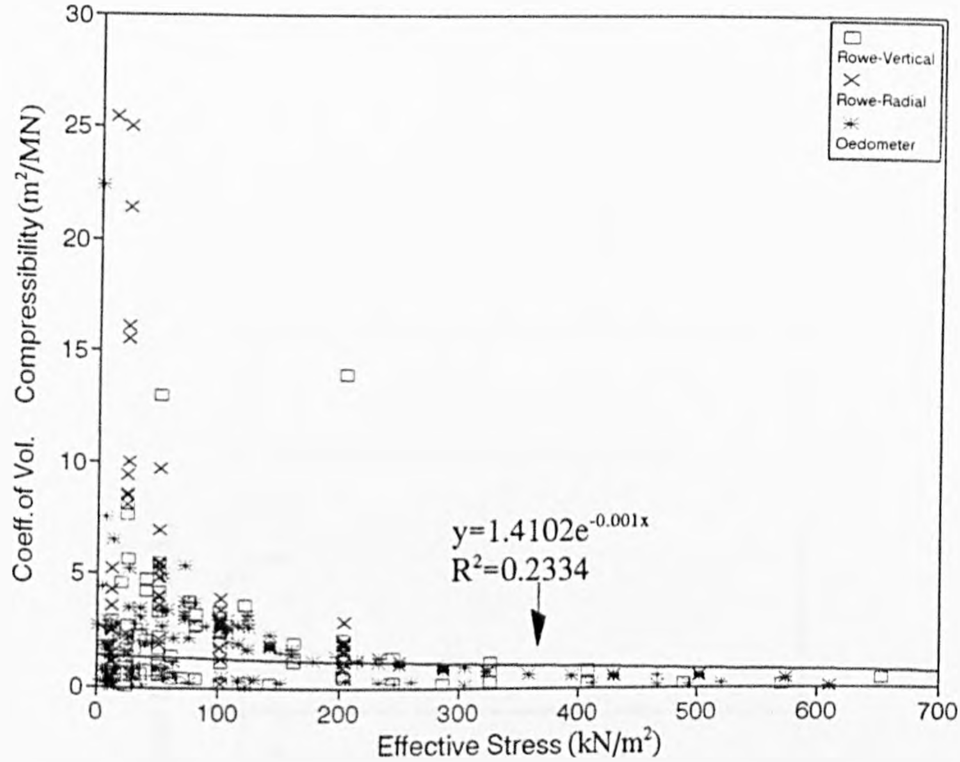


Fig.5.85 : Comparison of Coefficient of Volume Compressibility Values with Effective Vertical Stress

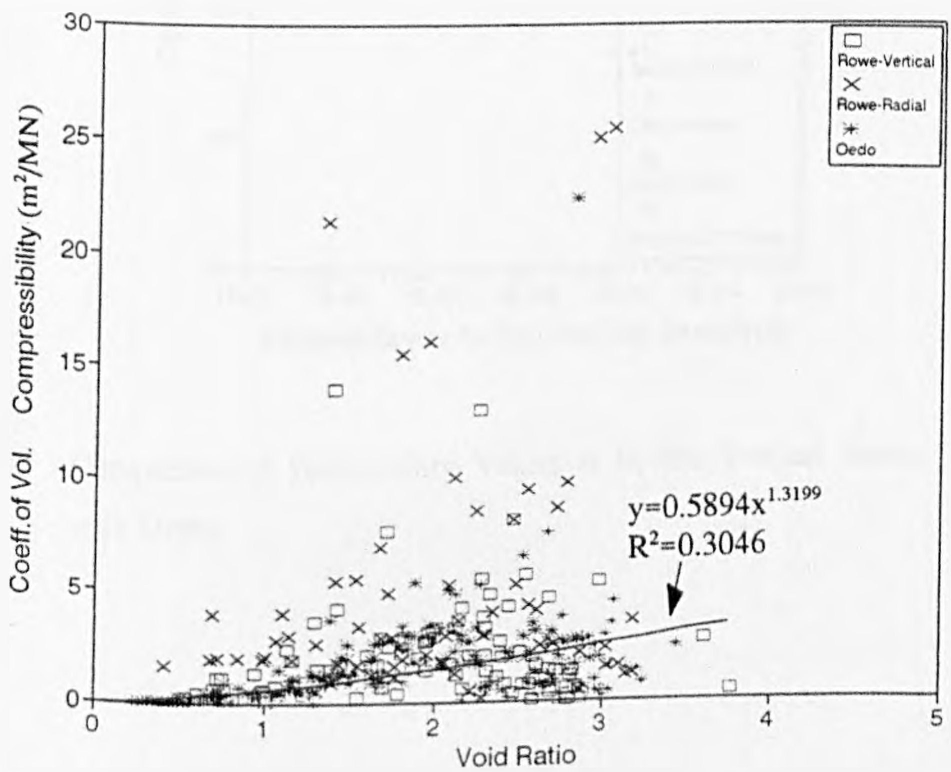


Fig.5.86 : Comparison of Coefficient of Volume Compressibility Values with Void Ratio

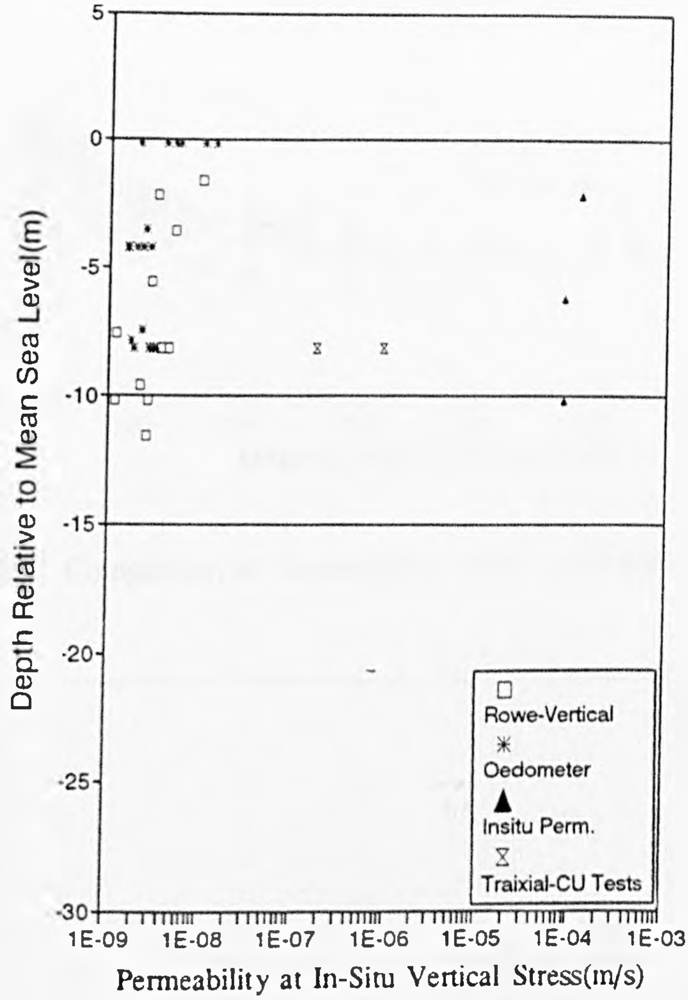


Fig.5.87 : Comparison of Permeability Values at In-Situ Vertical Stress with Depth

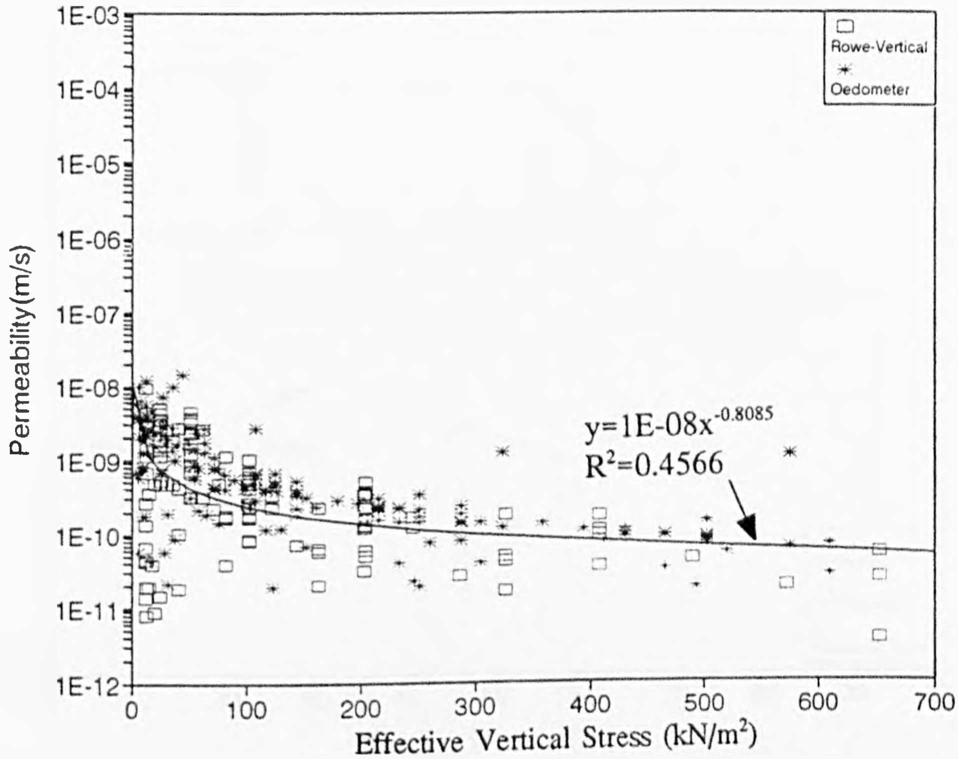


Fig.5.88 : Comparison of Permeability Values with Effective Vertical Stress

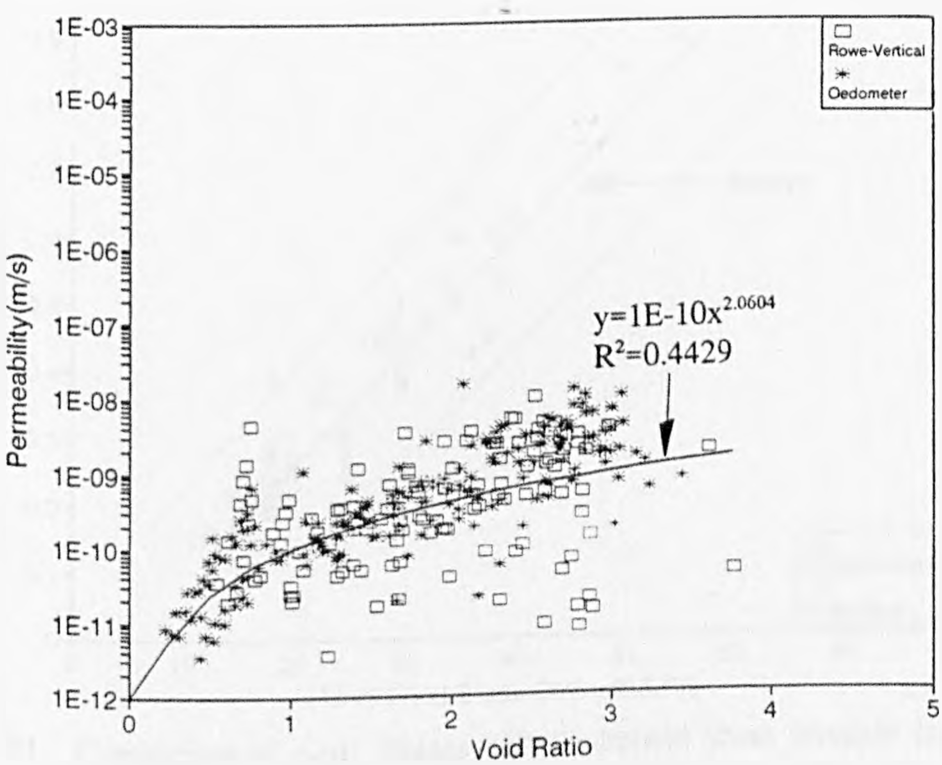


Fig.5.89 : Comparison of Permeability Values with Void Ratio

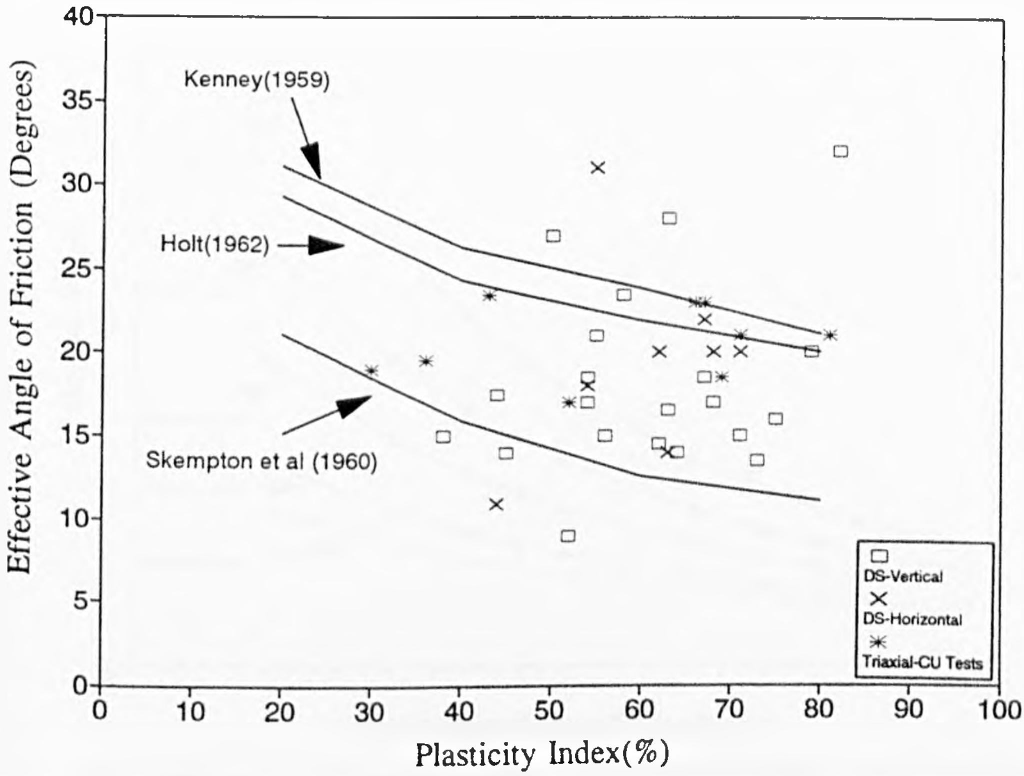


Fig.5.90 : Comparison of Effective Angle of Friction Results with Plasticity Index from Present Study with Data Obtained from Various Researchers

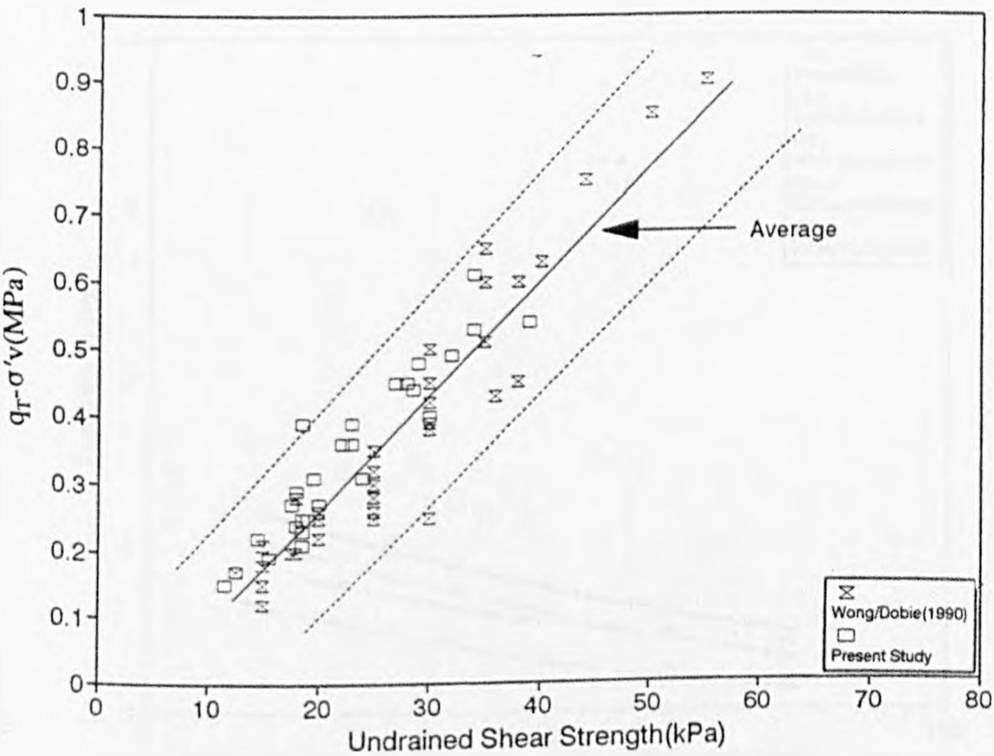


Fig.5.91 : Comparison of q_T-σ'_v Values with Undrained Shear Strength from Field Vane Tests from Present Study with Data Obtained by Dobie and Wong (1990)

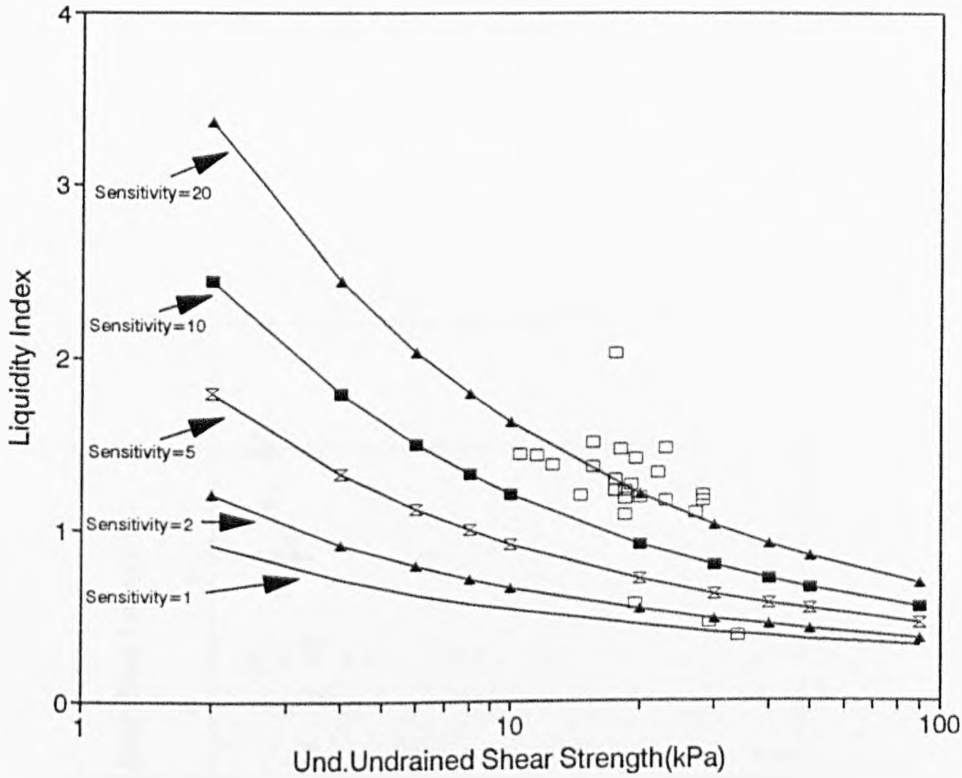


Fig.5.92 : Comparison of Liquidity Index with Undisturbed Undrained Shear Strength Obtained from Present Study with Data Obtained by Leroueil et al (1983b)

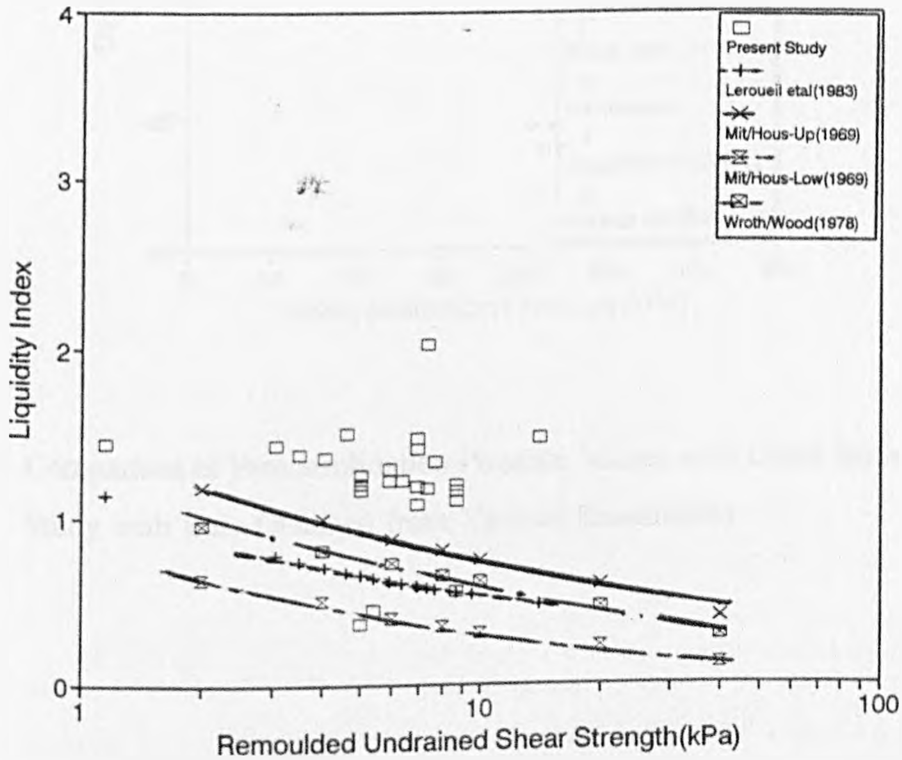


Fig.5.93 : Comparison of Liquidity Index Values with Remoulded Undrained Shear Strength from Present Study with Data Obtained from Various Researchers

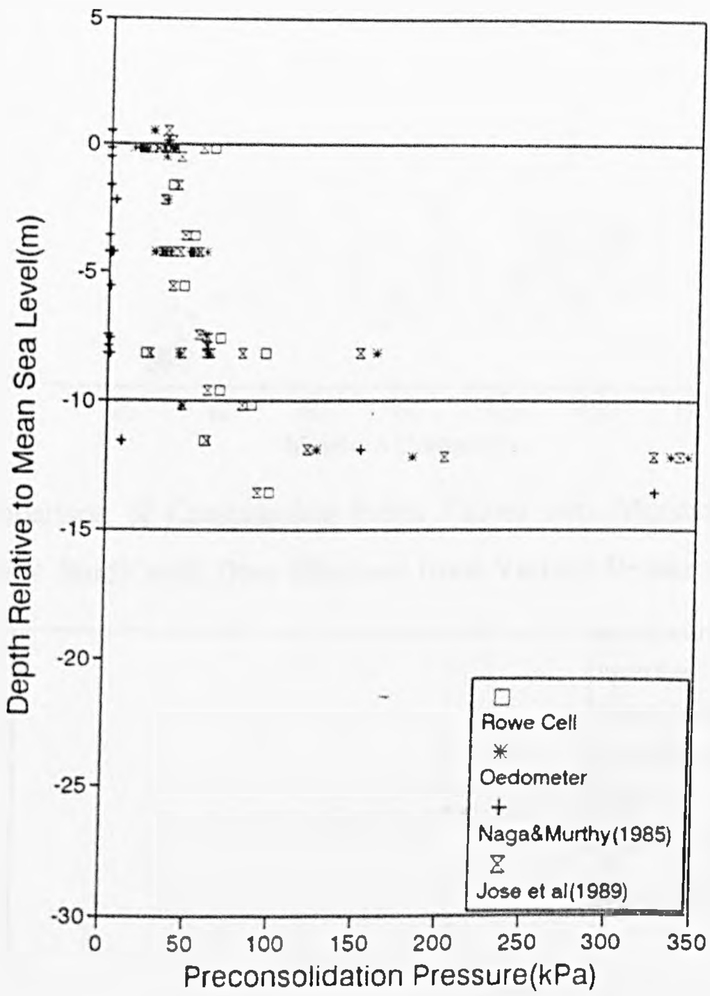


Fig.5.94 : Comparison of Preconsolidation Pressure Values with Depth from Present Study with Data Obtained from Various Researchers

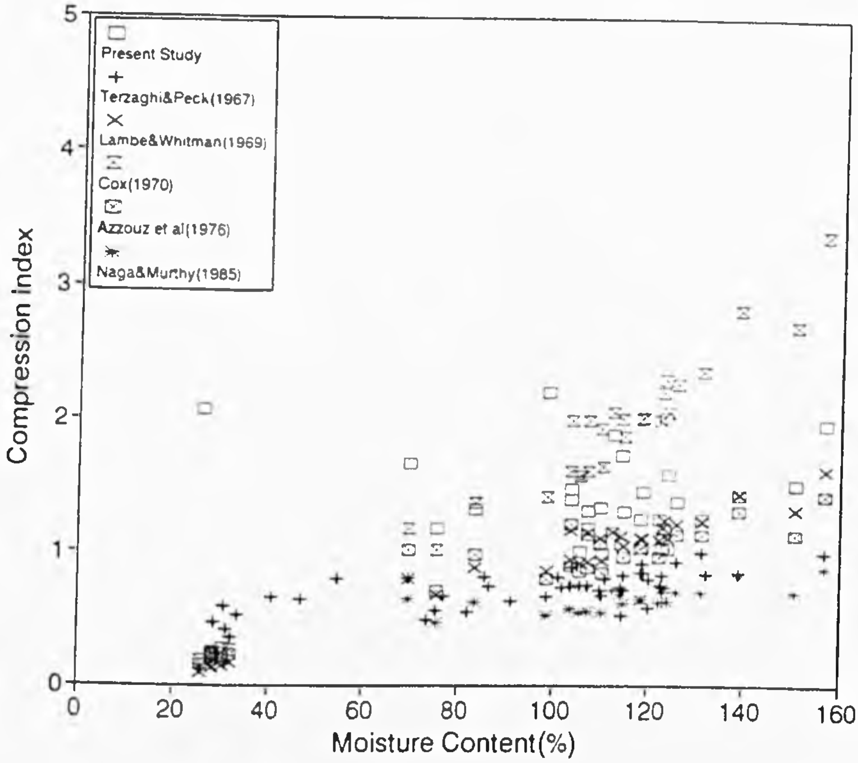


Fig.5.95 : Comparison of Compression Index Values with Moisture Content from Present Study with Data Obtained from Various Researchers

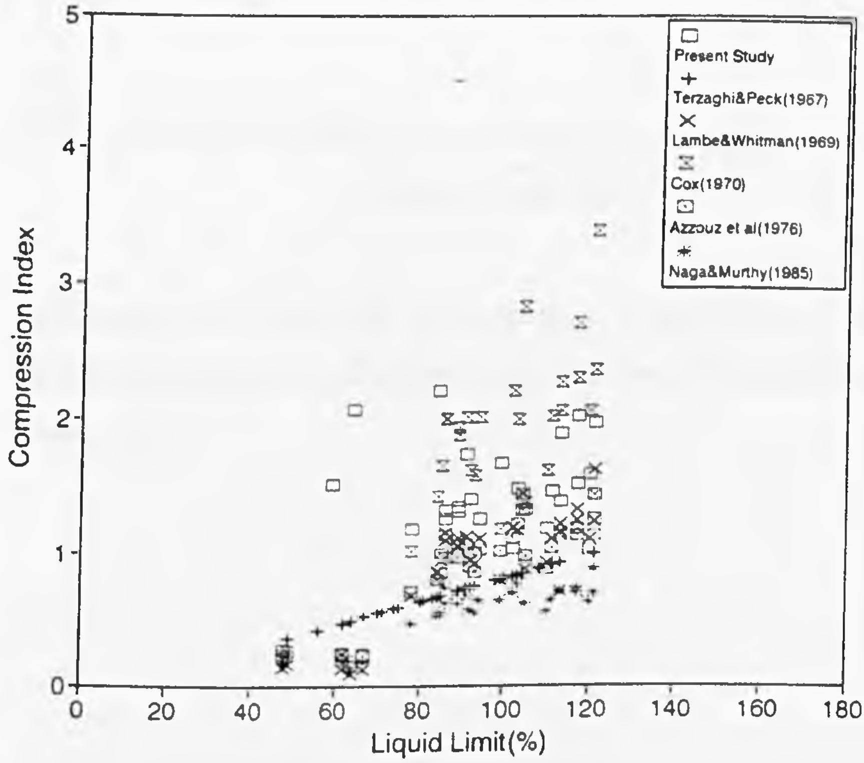


Fig.5.96 : Comparison of Compression Index Values with Liquid Limit from Present Study with Data Obtained from Various Researchers

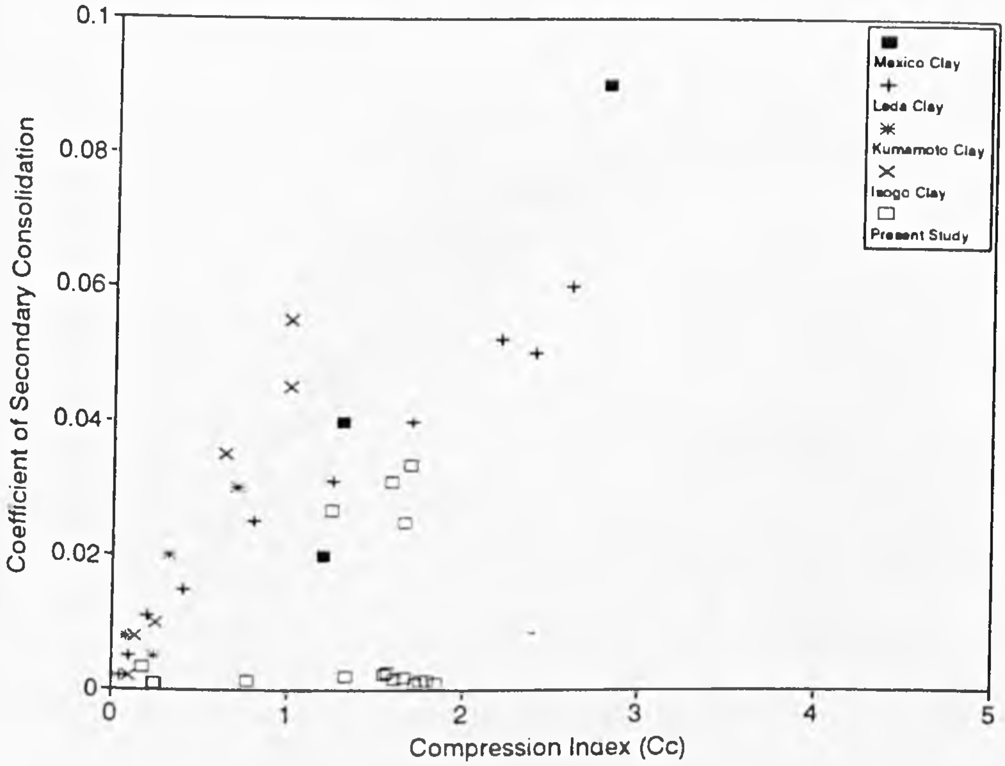


Fig.5.97 : Comparison of Coefficient of Secondary Consolidation Values with Compression Index from Present Study with Data Obtained from Various Researchers

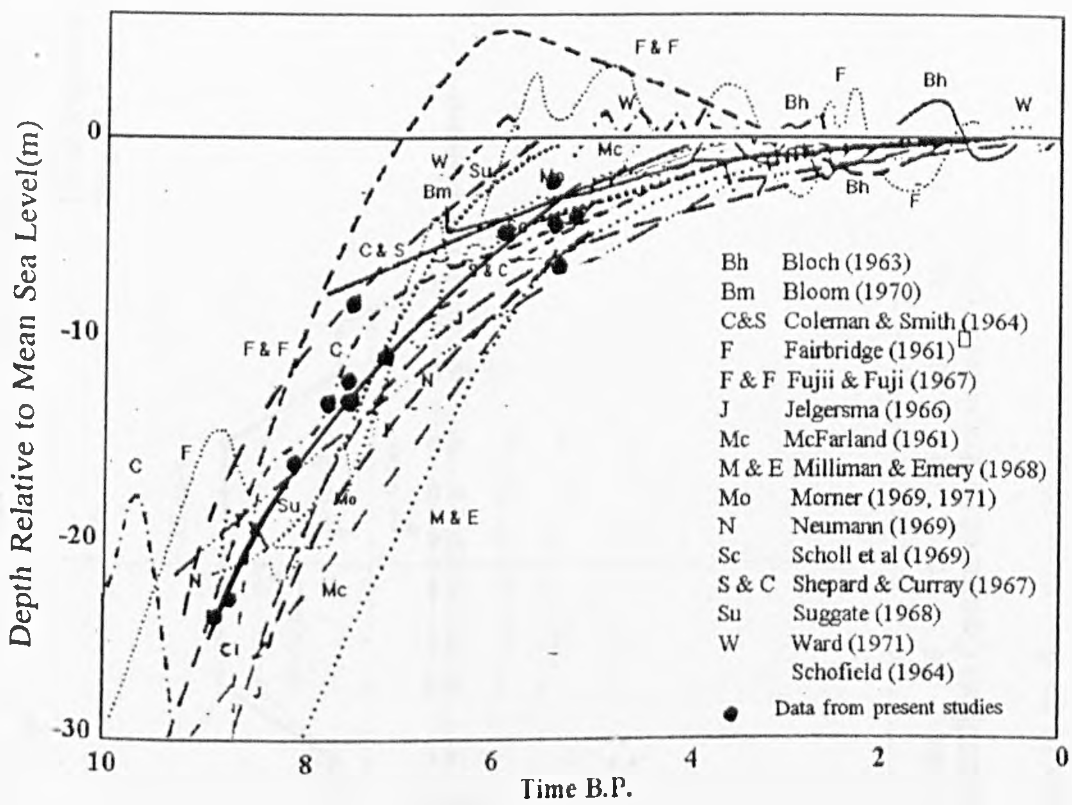


Fig.5.98 : Comparison of Age of Soft Soil Deposits Data from Present Study with Sea Level Changes Hypothesised by Various Researchers for the last 10000 Years B.P.

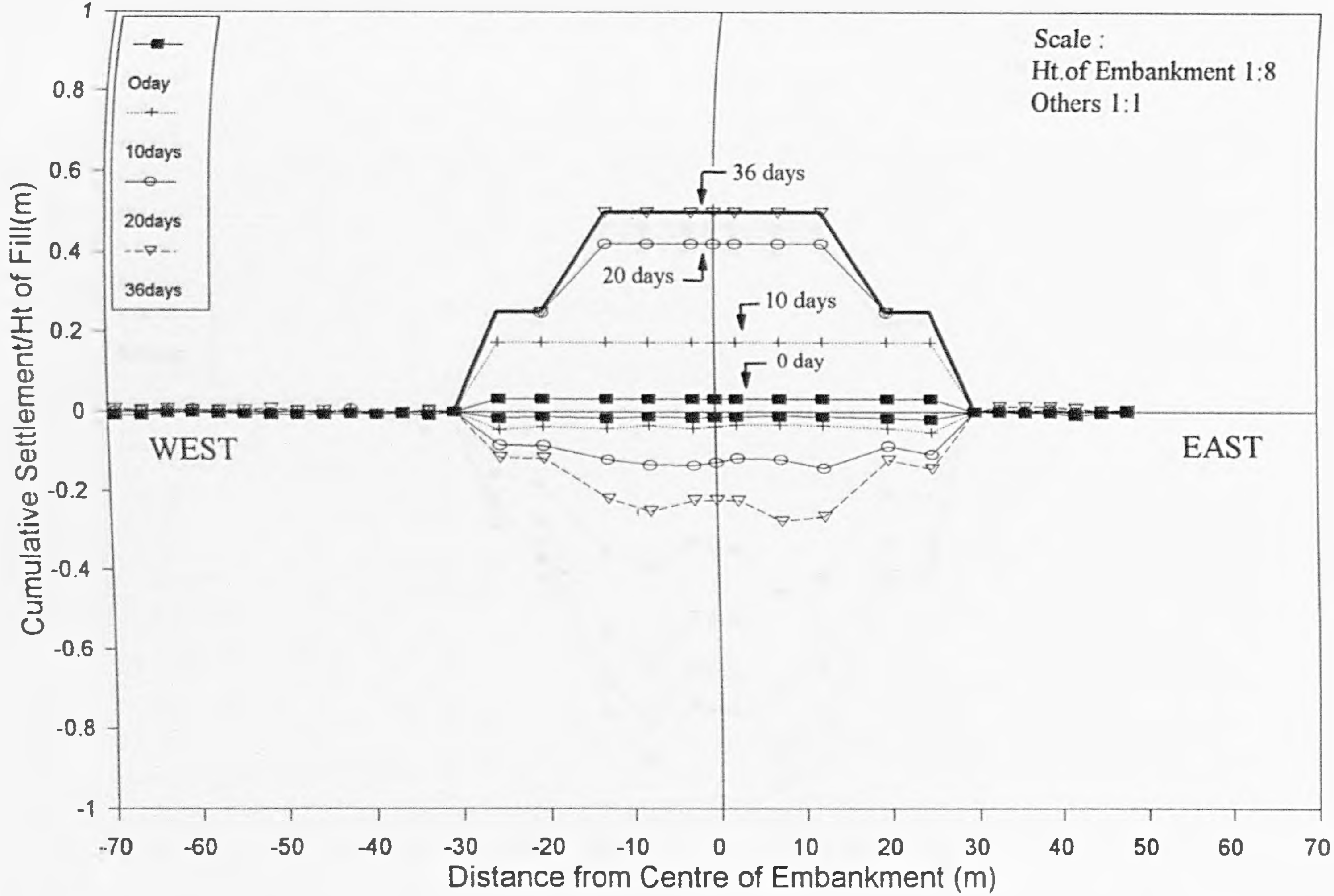


Fig.6.1 : Cumulative Settlement/Heave with Distance in the East-West Direction During the Construction of the Trial Embankment

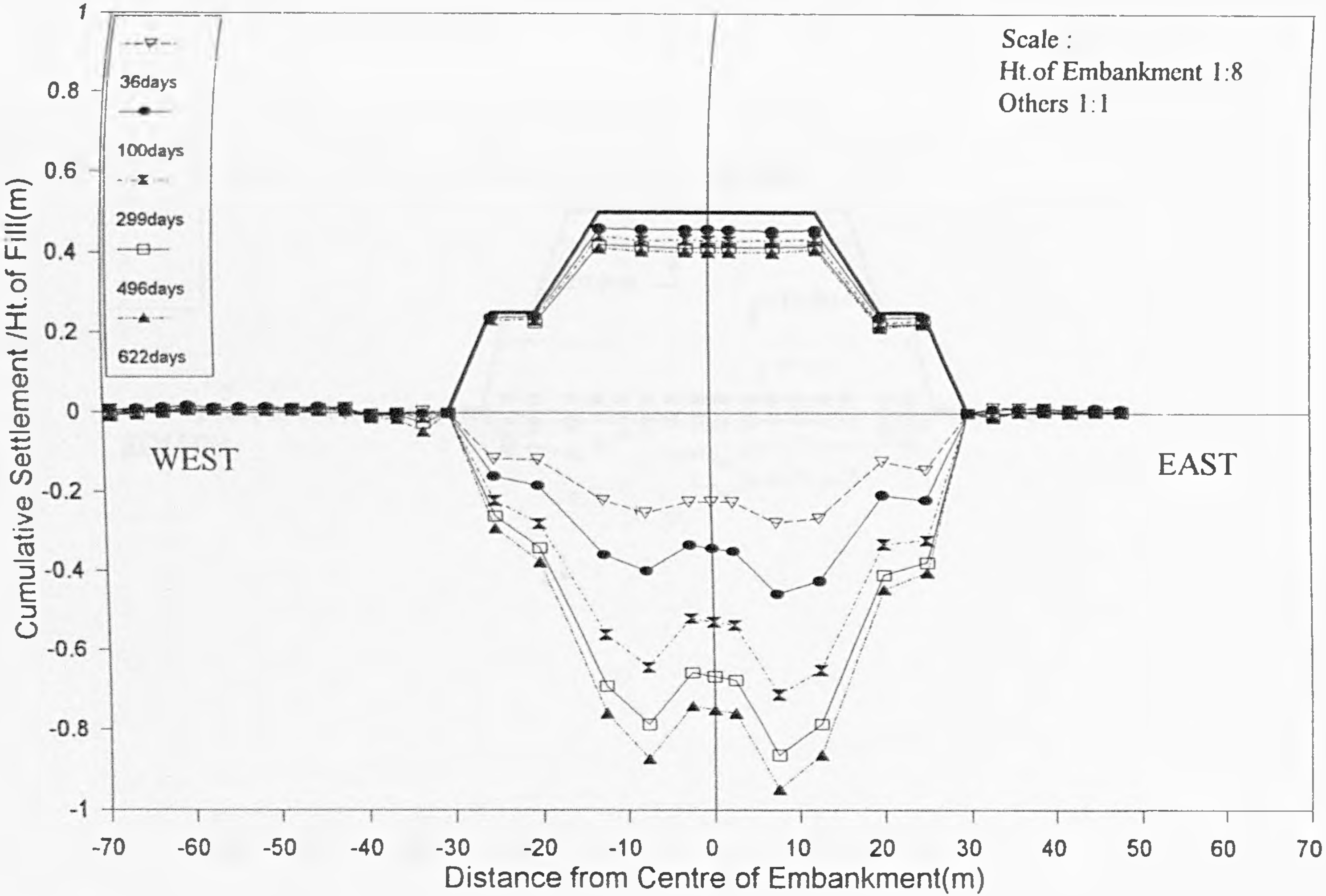


Fig.6.2 : Cumulative Settlement/Heave with Distance in the East-West Direction After the Completion of the Trial Embankment

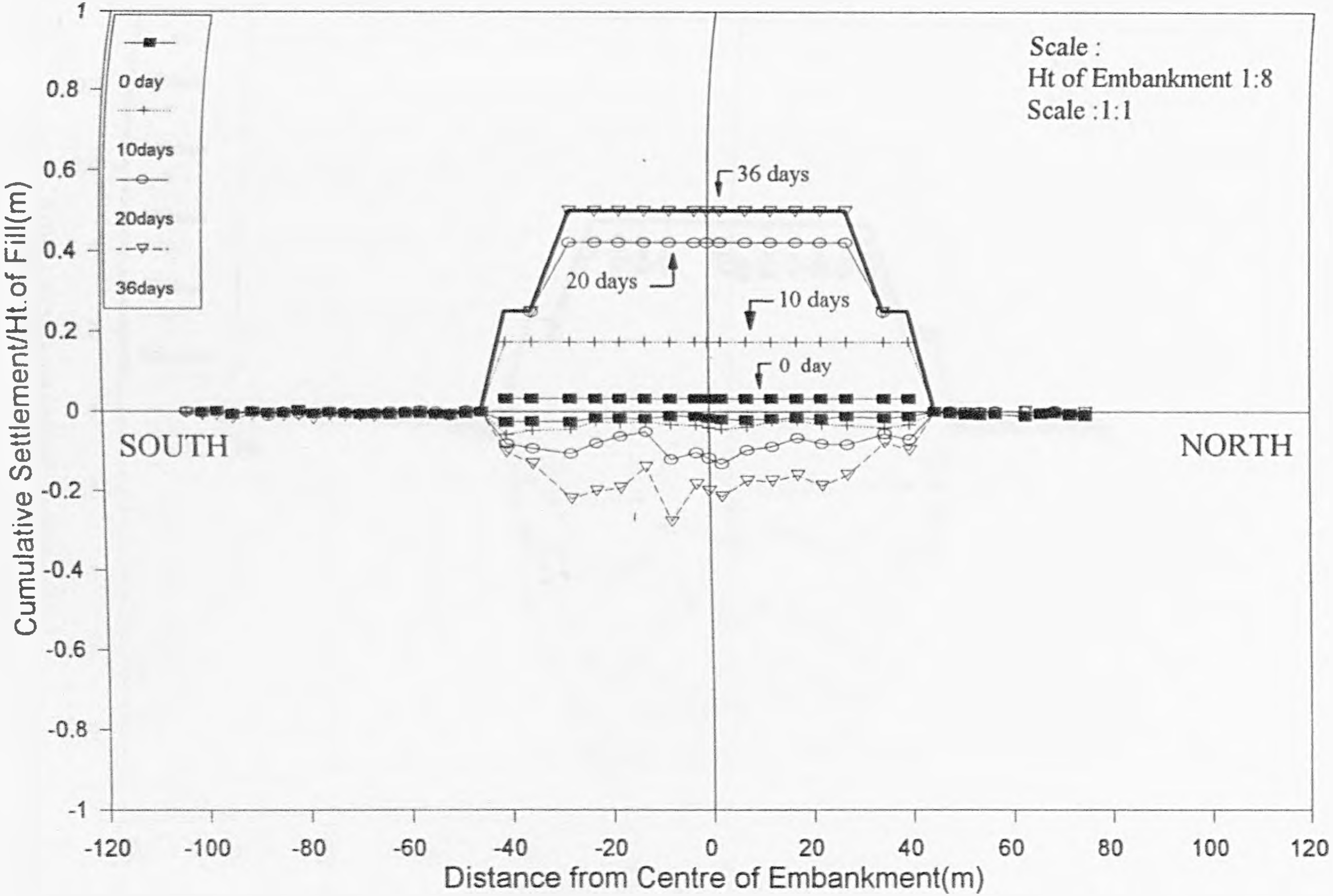


Fig.6.3 : Cumulative Settlement/Heave with Distance in the North-South Direction During the Construction of the Trial Embankment

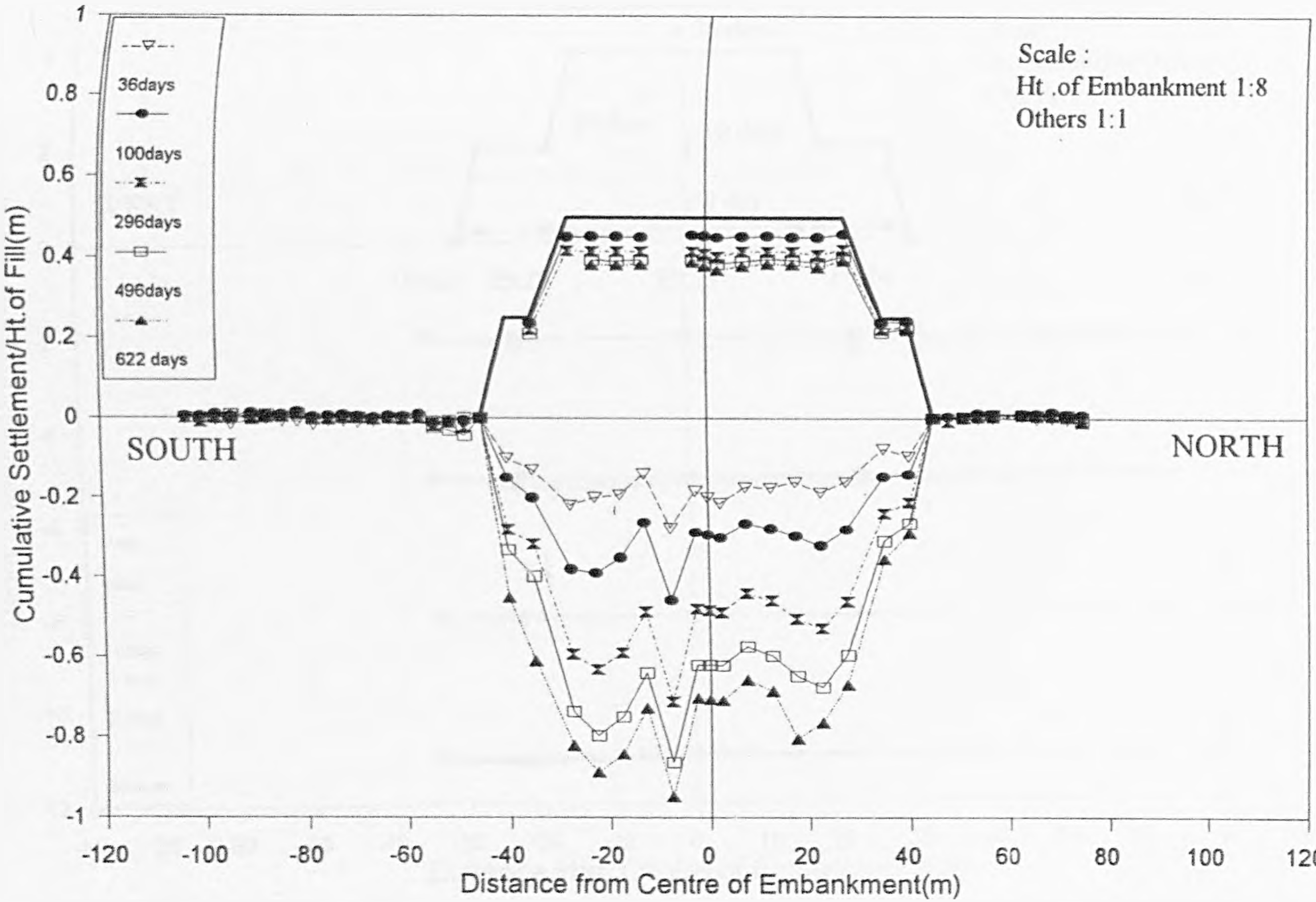


Fig.6.4 : Cumulative Settlement/Heave with Distance in the North-South Direction After the Completion of the Trial Embankment

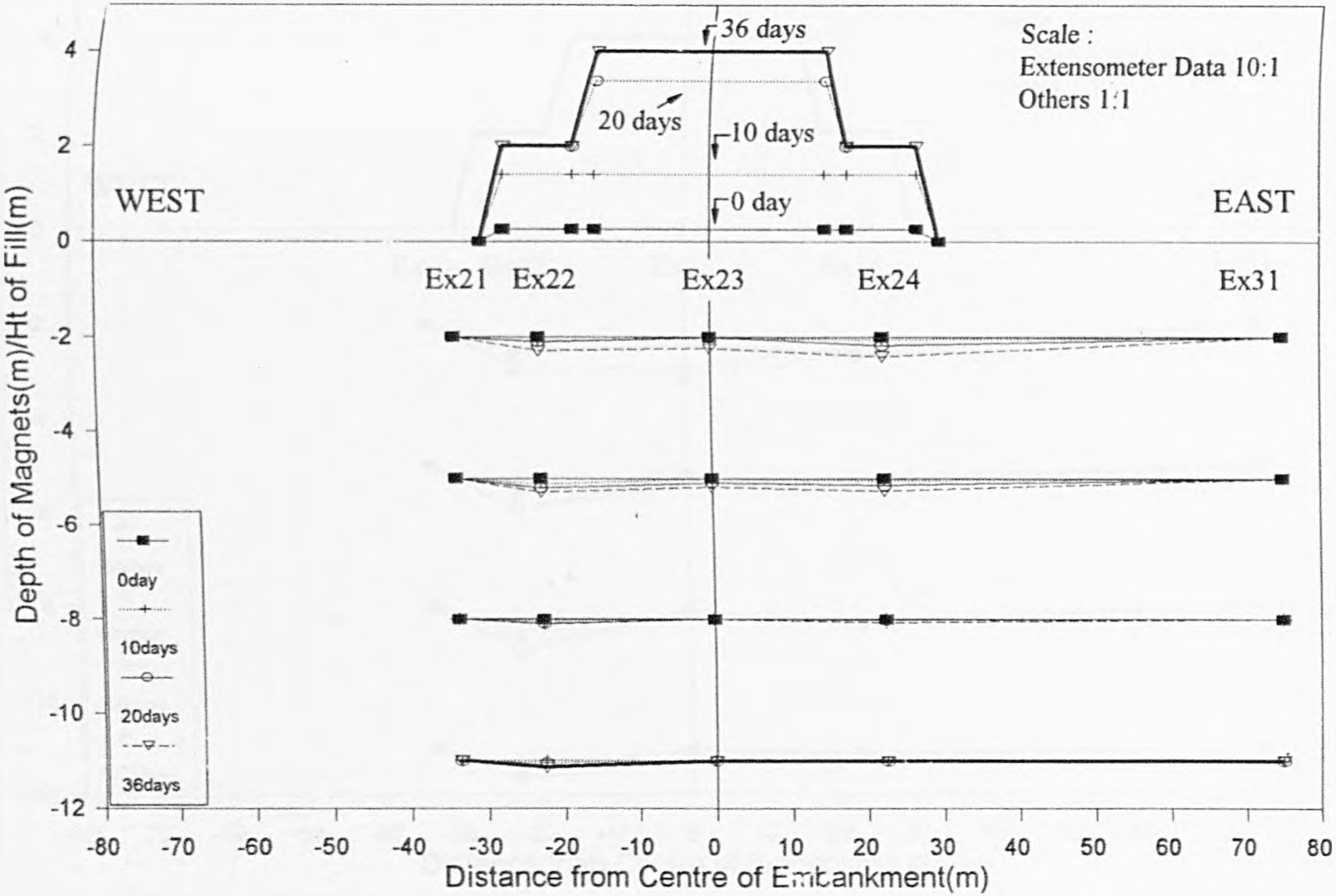


Fig.6.5 : Cumulative Vertical Settlement at Extensometer Locations with Depth in the East-West Direction During the Construction of the Trial Embankment

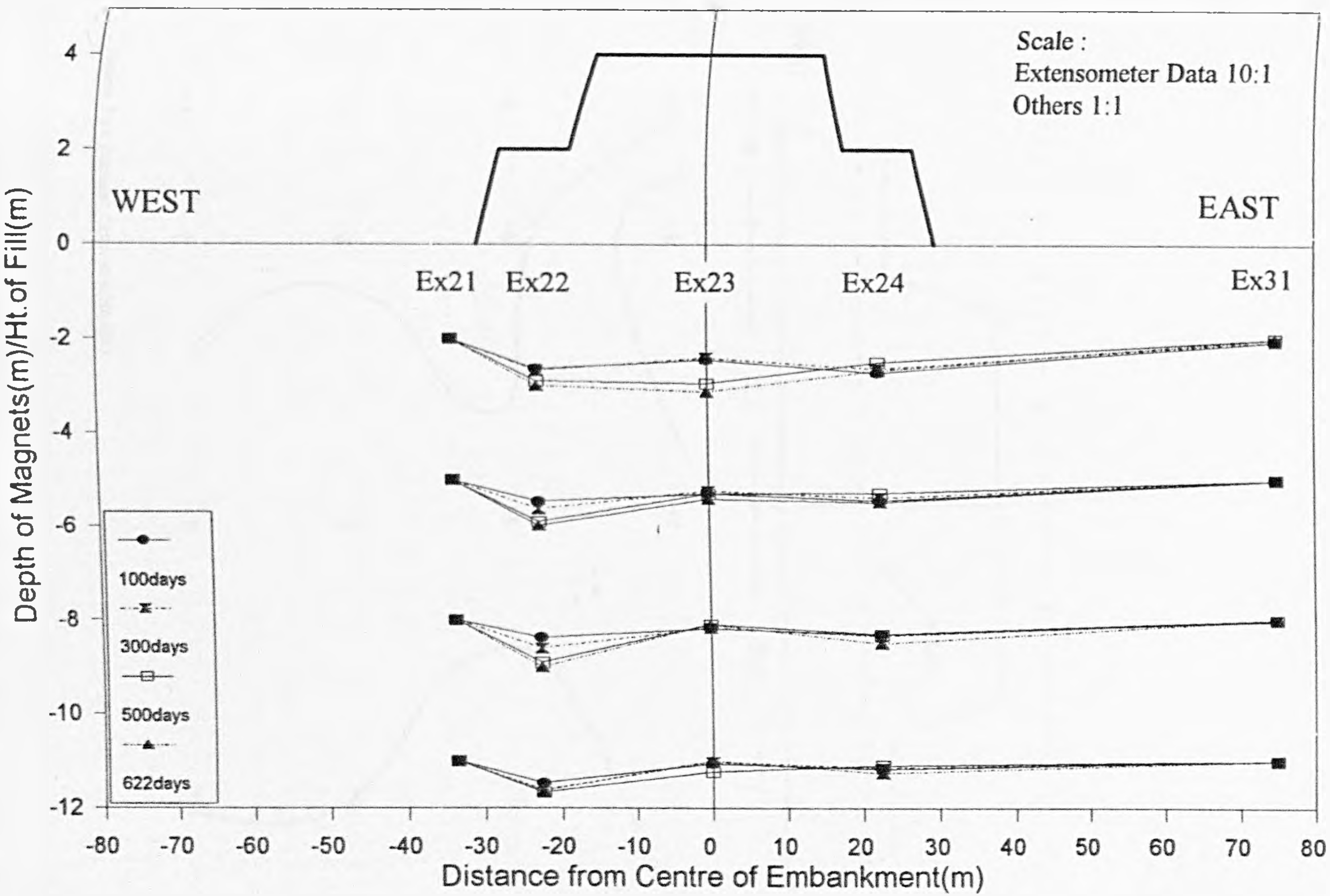
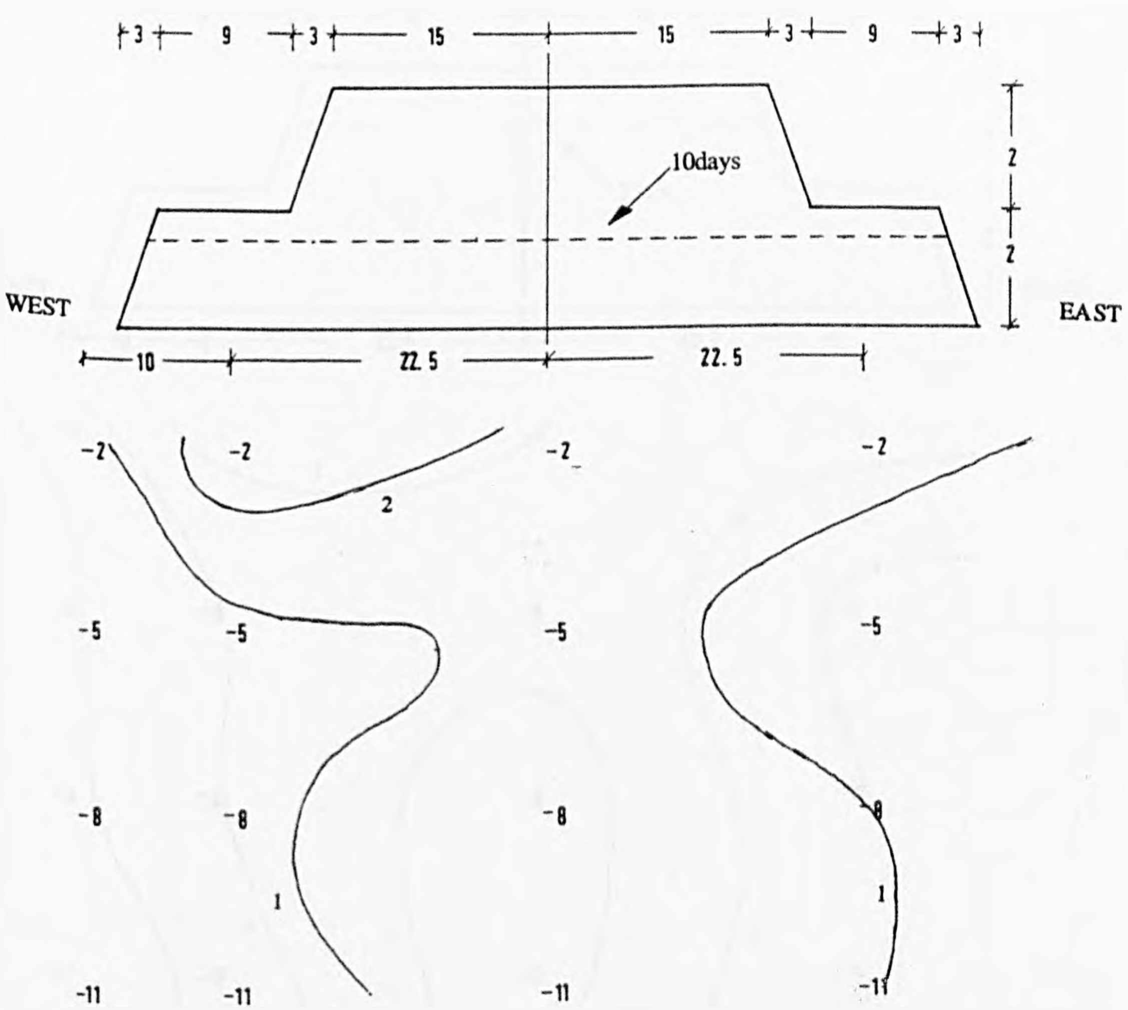


Fig.6.6 : Cumulative Vertical Settlement at Extensometer Locations with Depth in the East-West Direction After the Completion of the Trial Embankment

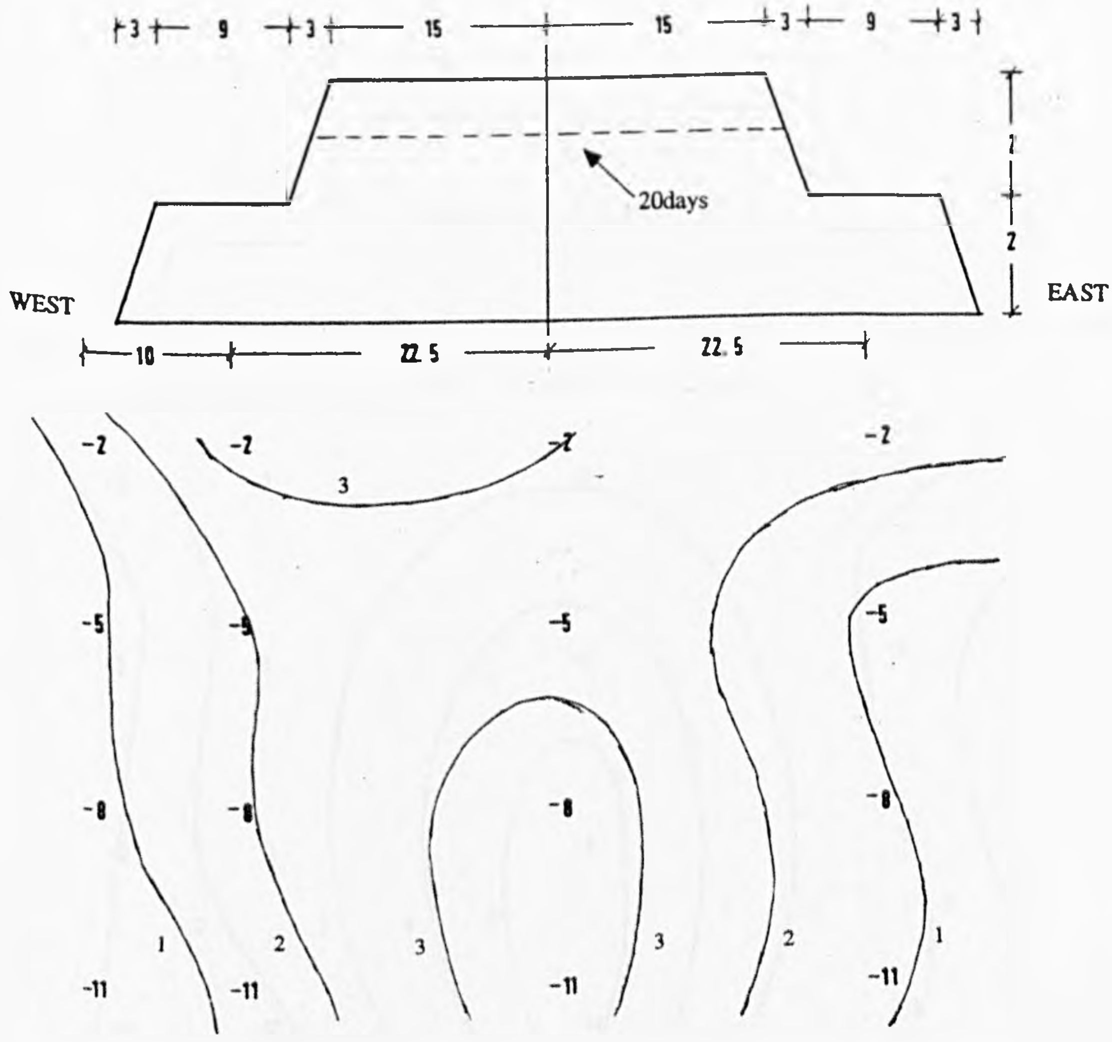
Scale
x axis 1mm : 0.4m
y axis 1mm : 0.1m



Excess Pore Pressure Units in mHd H_2O

Fig.6.7 : Excess Pore Pressure Contours with Time 10 days After the Start of Construction of the Trial Embankment

Scale
x axis 1mm : 0.4m
y axis 1mm : 0.1m



Excess Pore Pressure Units in mHd.H_2O

Fig.6.8 : Excess Pore Pressure Contours with Time 20 days After the Start of Construction of the Trial Embankment

Scale
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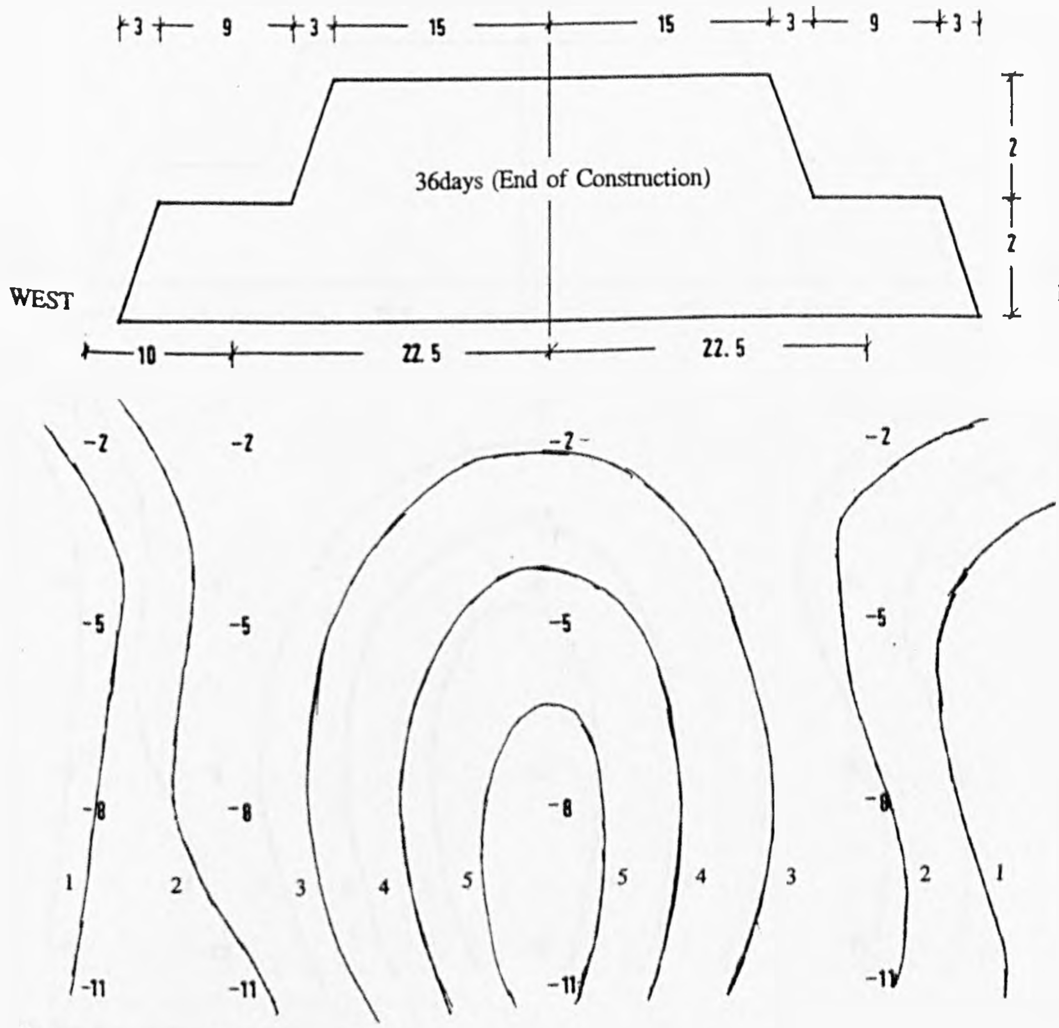
y axis 1mm : 0.1m



Excess Pore Pressure Units in mHd.H_2O

Fig.6.9 : Excess Pore Pressure Contours with Time 36 days After the Start of Construction of the Trial Embankment

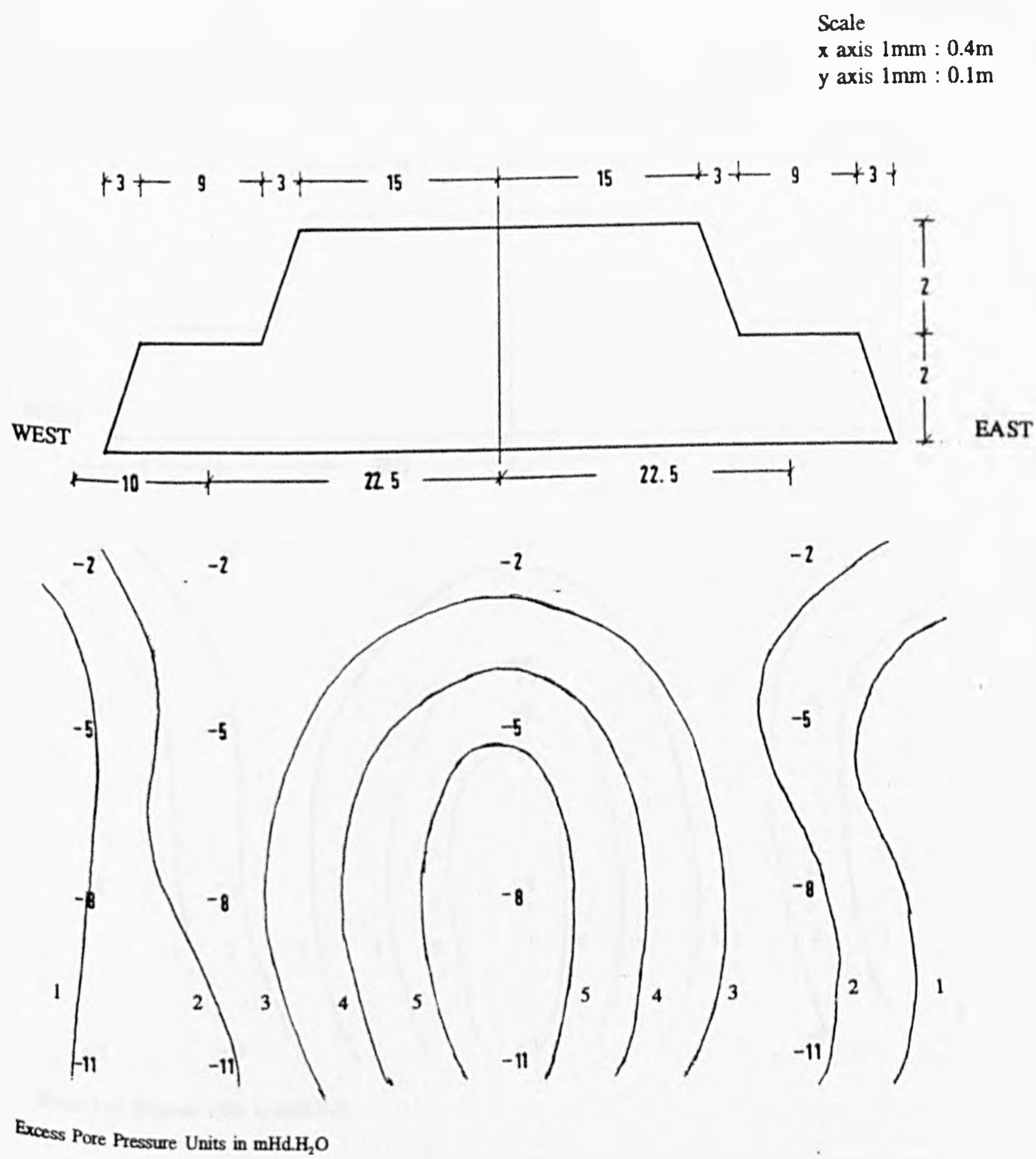


Fig.6.10 : Excess Pore Pressure Contours with Time 100 days After the Start of Construction of the Trial Embankment

Scale
x axis 1mm : 0.4m
y axis 1mm : 0.1m

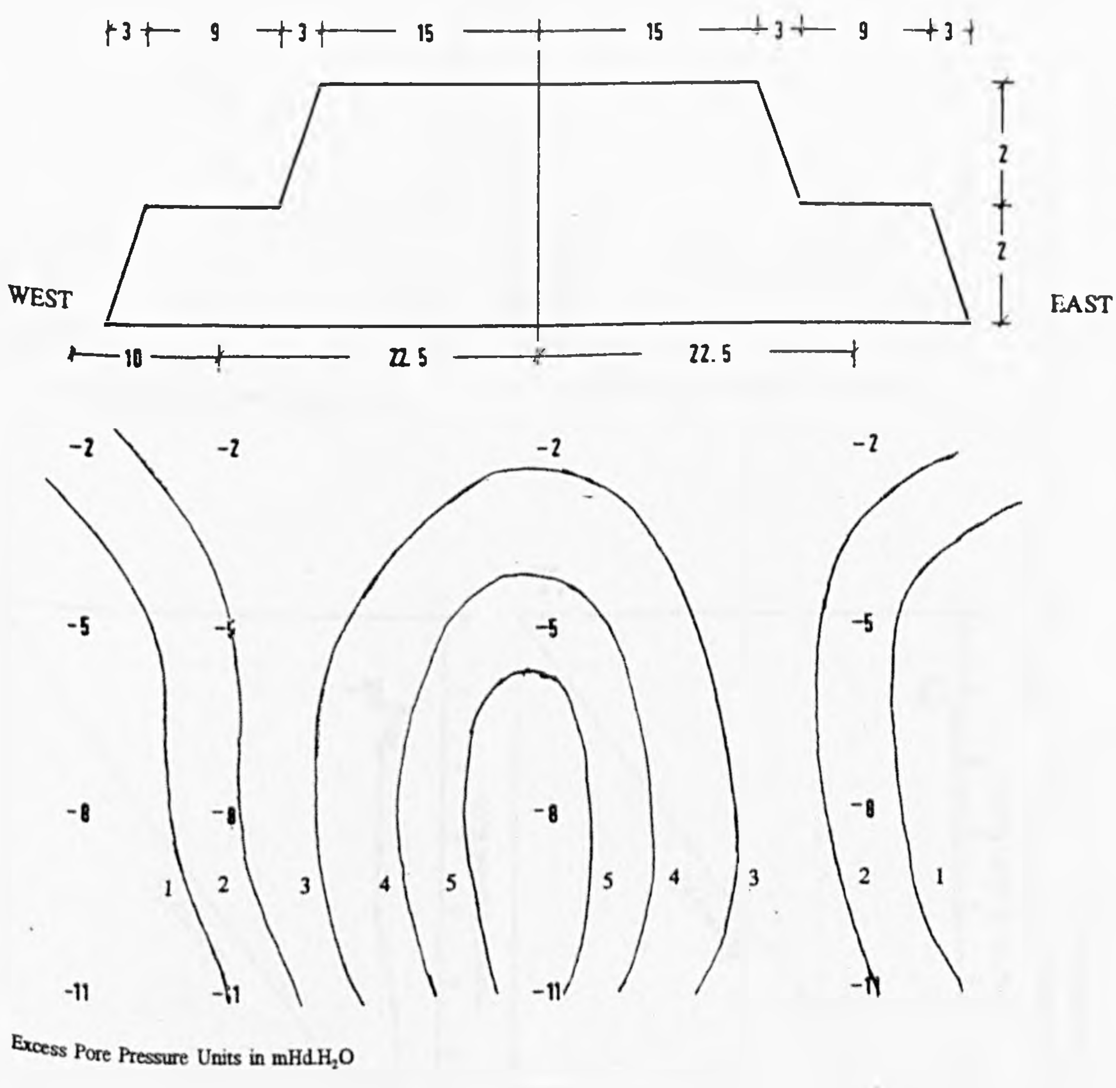


Fig.6.11 : Excess Pore Pressure Contours with Time 300 days After the Start of Construction of the Trial Embankment

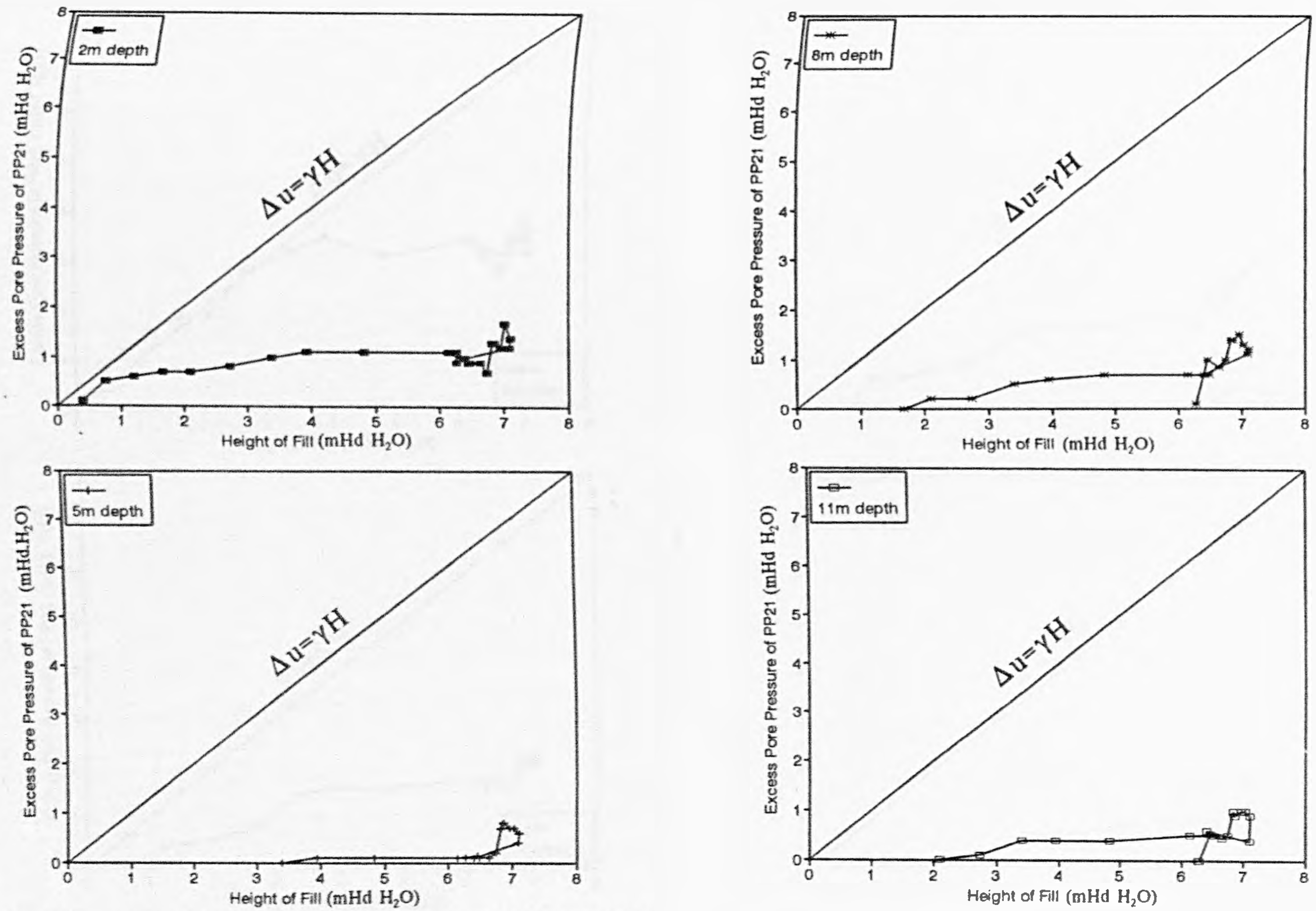


Fig.6.12 : Excess Pore Pressure With Height of Fill for PP21 (2.5m from the Edge of the Embankment) During and After Construction of the Trial Embankment

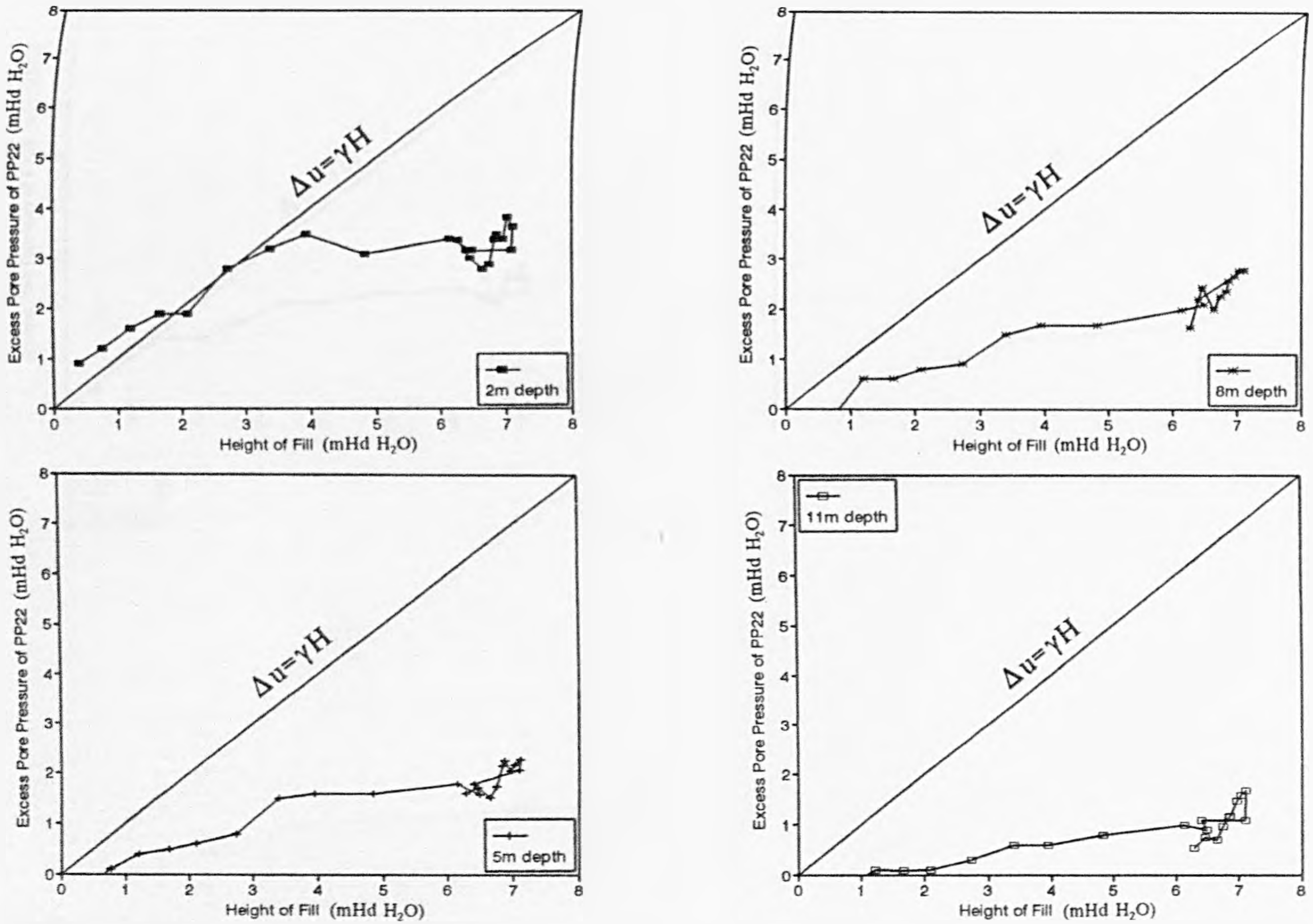


Fig.6.13 : Excess Pore Pressure With Height of Fill for PP22 (22.5m West of the Centre of the Embankment) During and After Construction of the Trial Embankment

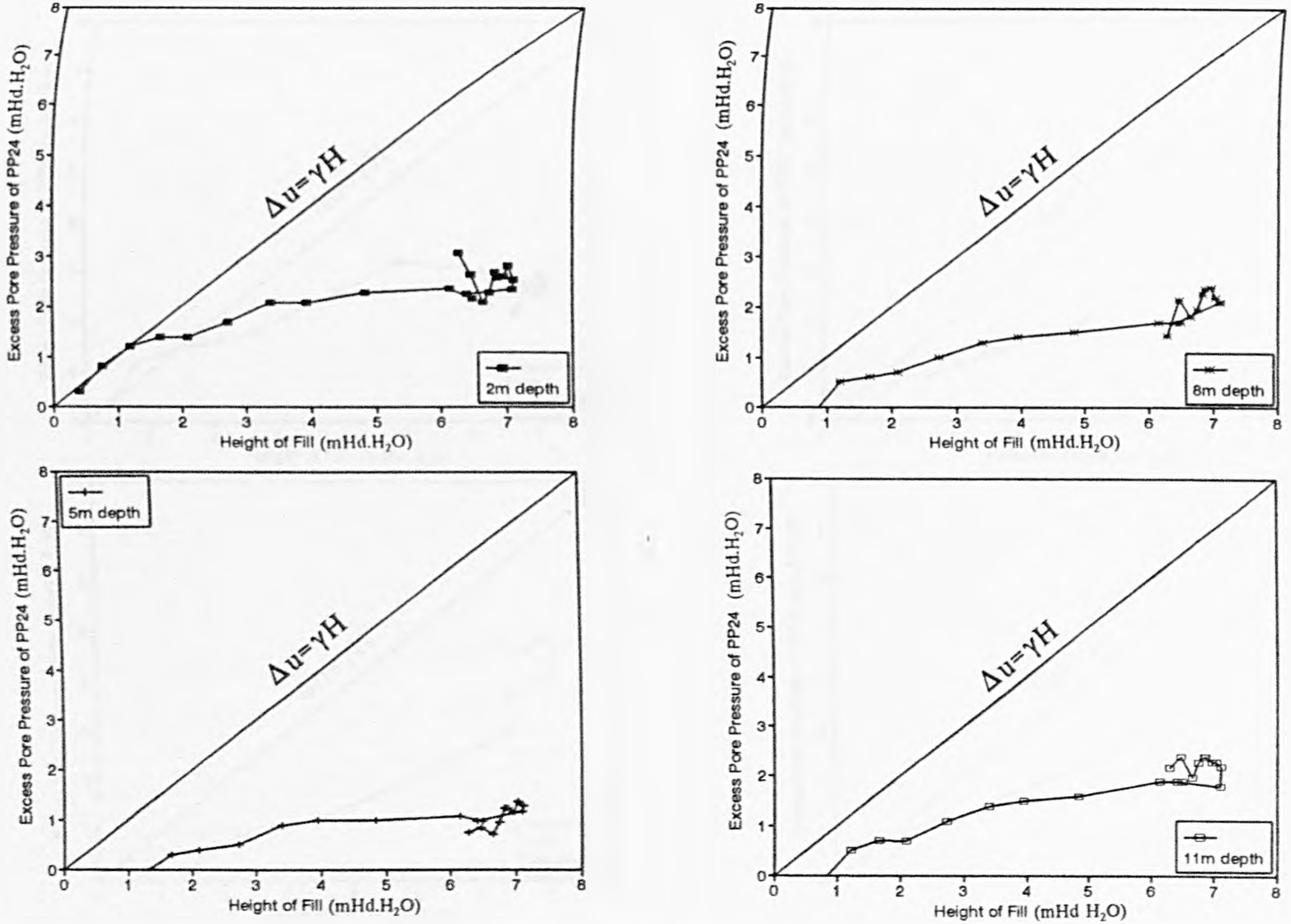


Fig.6.14 : Excess Pore Pressure With Height of Fill for PP24 (22.5m East of the Centre of the Embankment) During and After Construction of the Trial Embankment

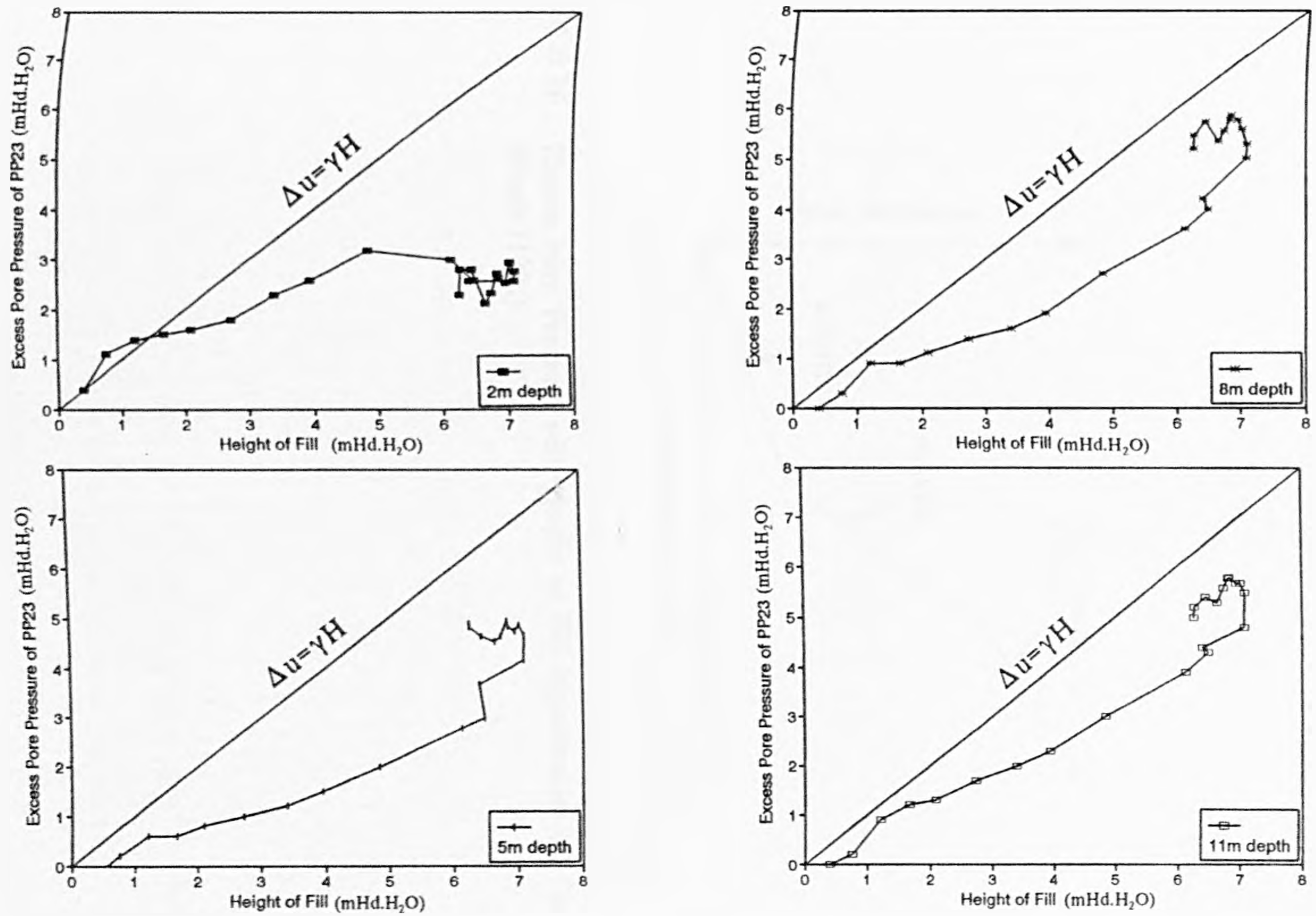


Fig.6.15 : Excess Pore Pressure With Height of Fill for PP23 (The Centre of the Embankment) During and After Construction of the Trial Embankment

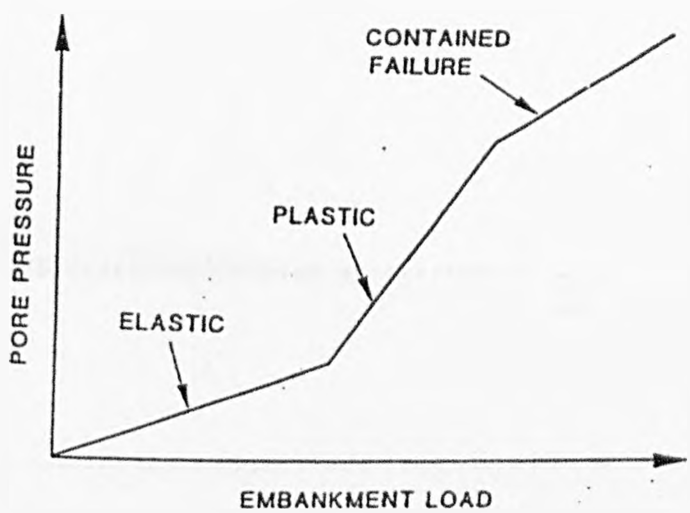


Fig.6.16 : Excess Pore Pressure with Height of Fill hypothesised by Parry and Wroth (1981)

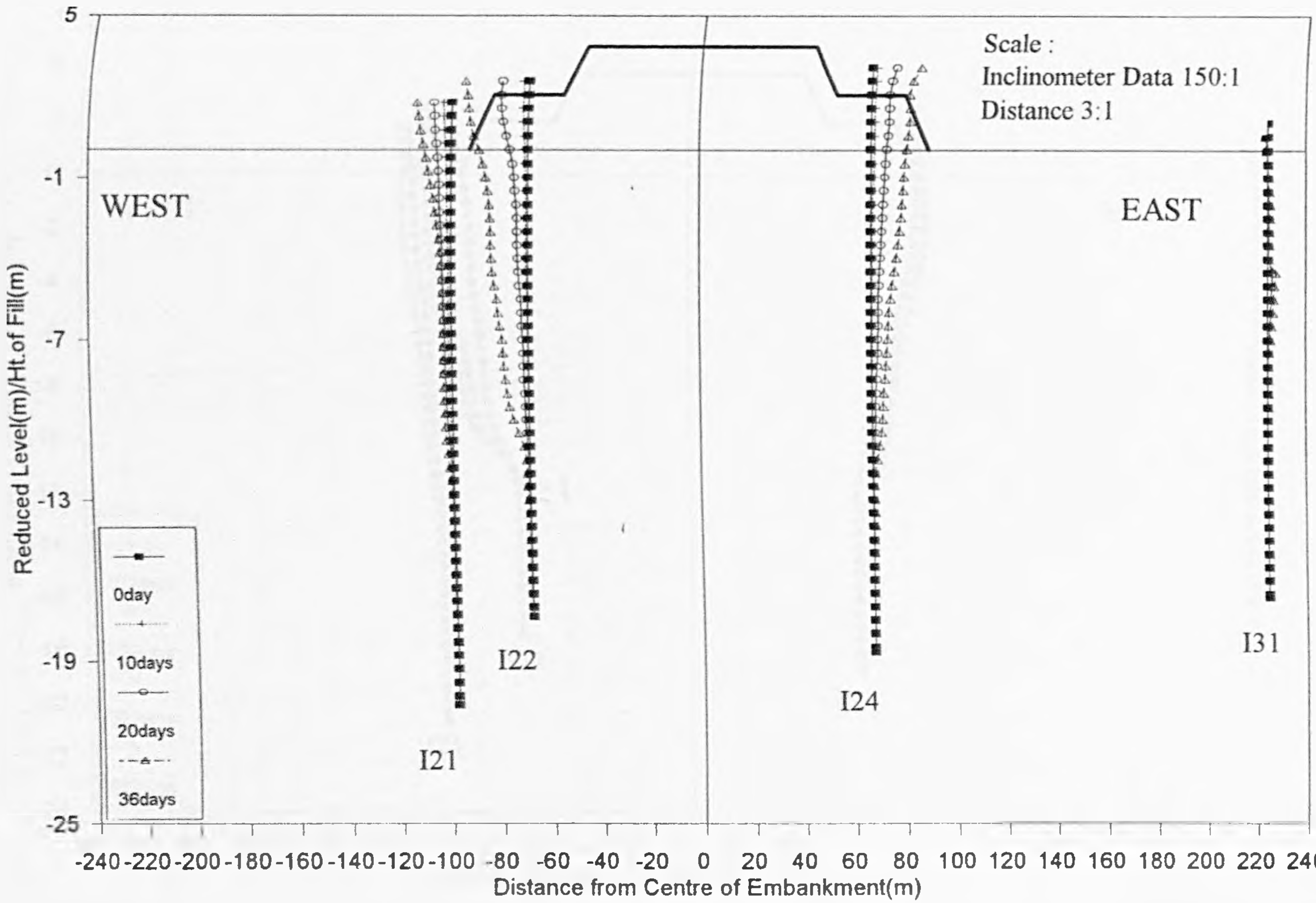


Fig.6.17 : Lateral Displacement with Depth and Time in the East-West Direction During the Construction of the Trial Embankment

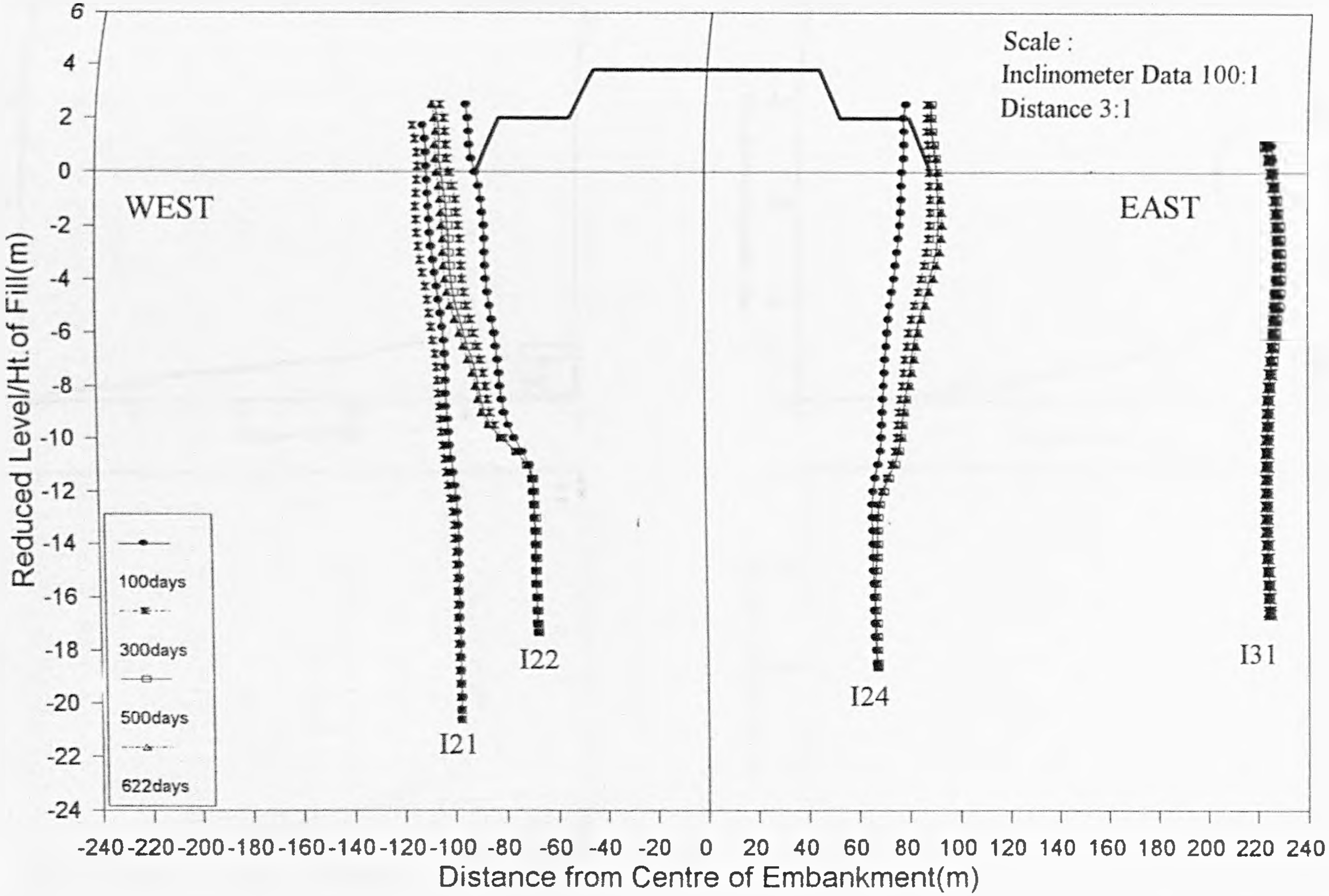


Fig.6.18 : Lateral Displacement with Depth and Time in the East-West Direction After the Completion of the Trial Embankment

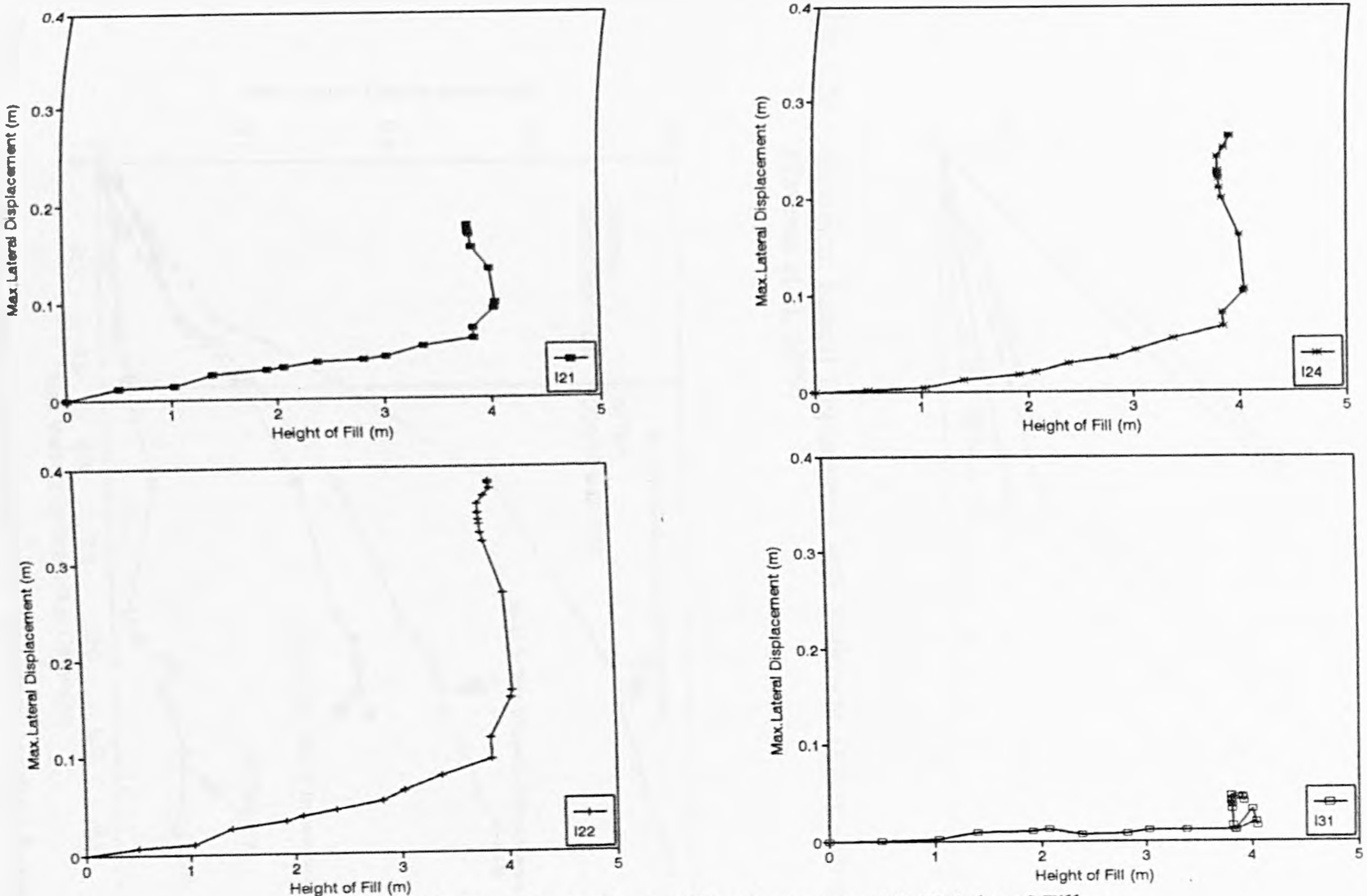


Fig.6.19 : Maximum Lateral Displacement with Height of Fill

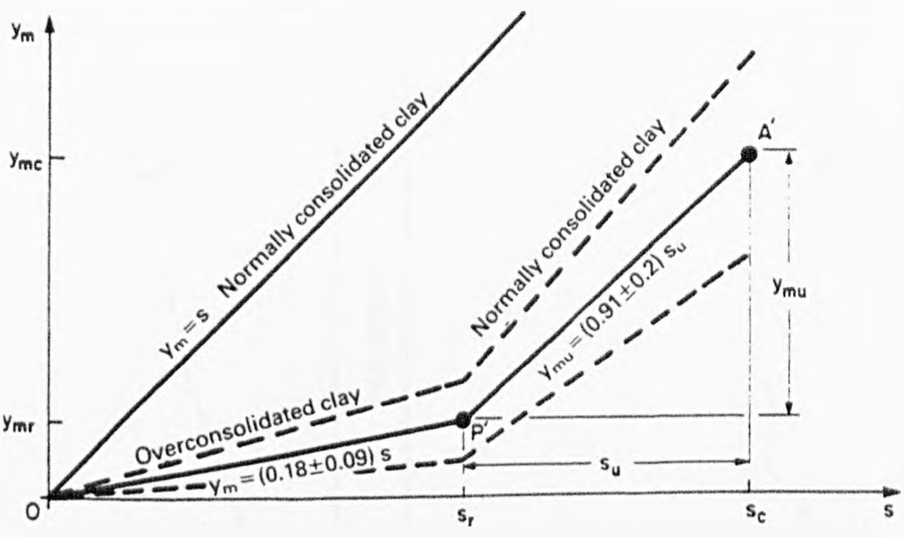


Fig.6.20 : Maximum Lateral Displacement with Settlement During Construction (Tavenas et al, 1979)

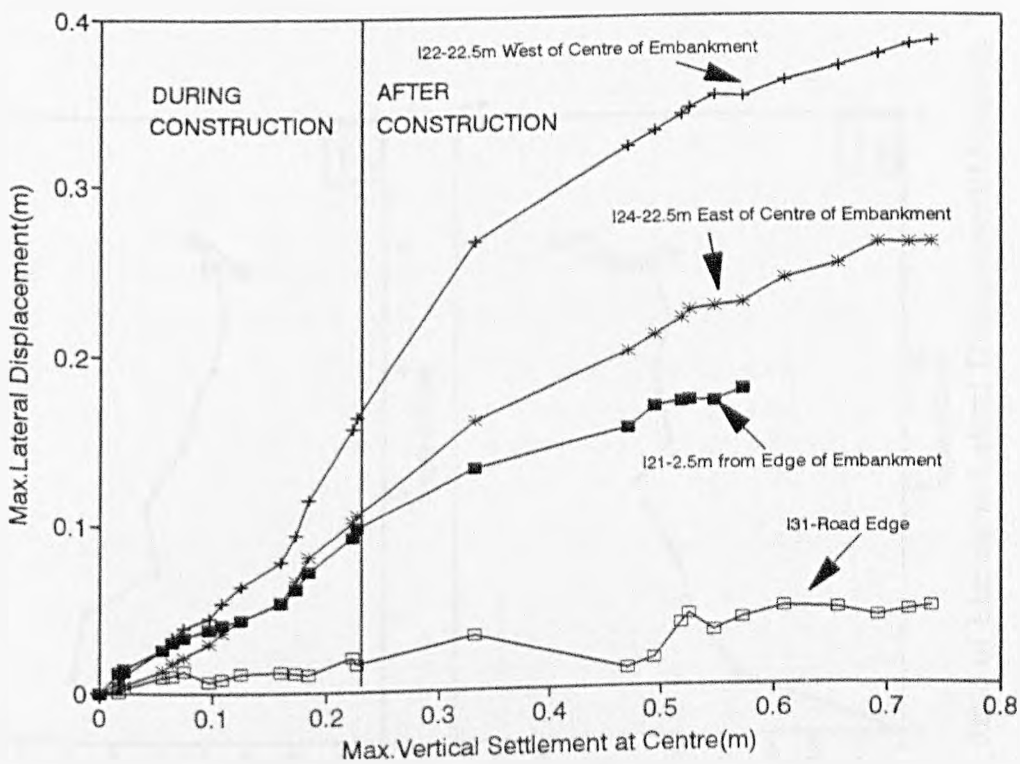


Fig.6.21 : Maximum Lateral Displacement with Maximum Vertical Settlement at Centre of Embankment During and After Construction of the Trial Embankment

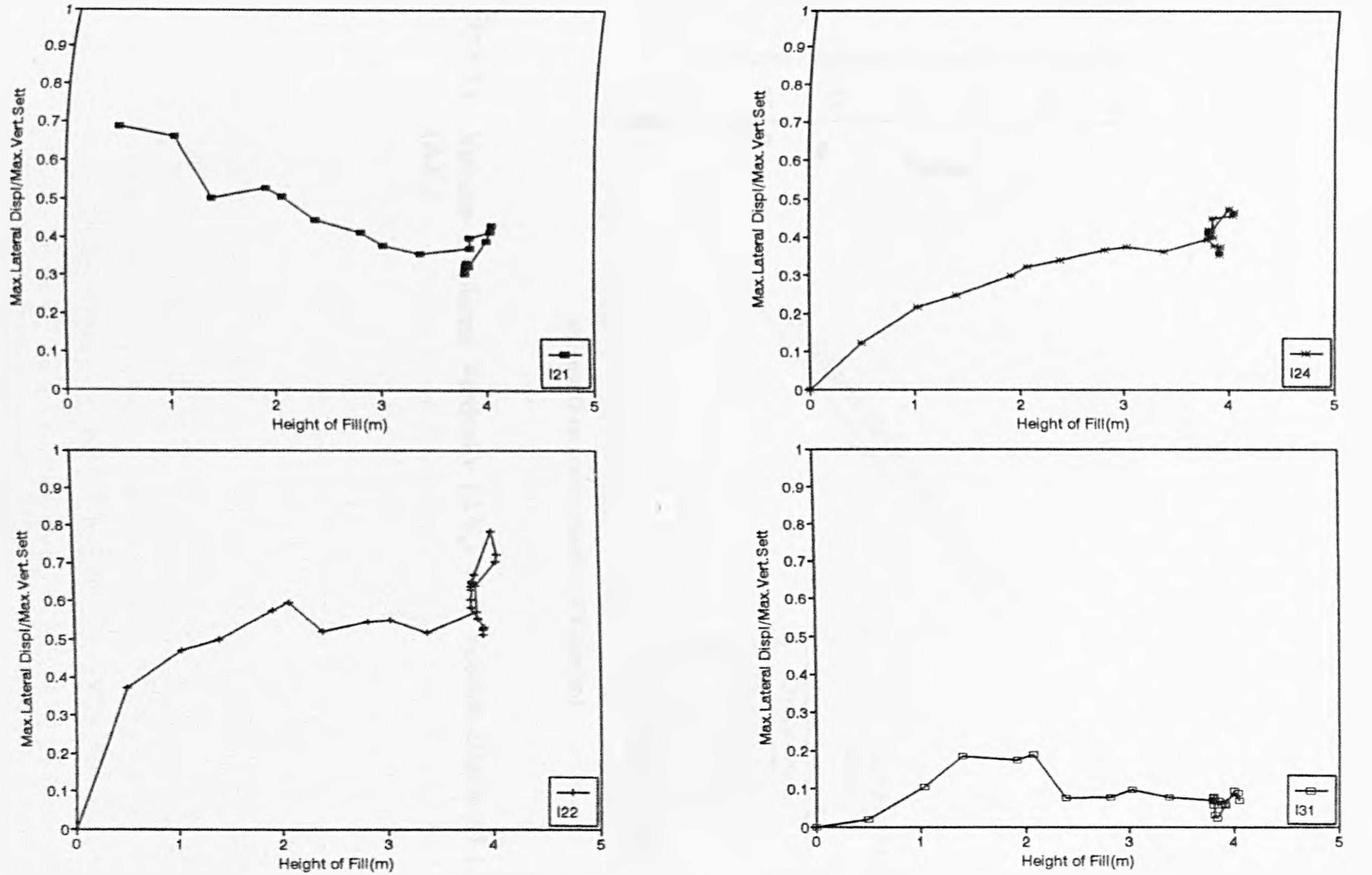


Fig.6.22 : Ratio of Maximum Lateral Displacement/Maximum Vertical Settlement at the Centre of Embankment with Height of Fill

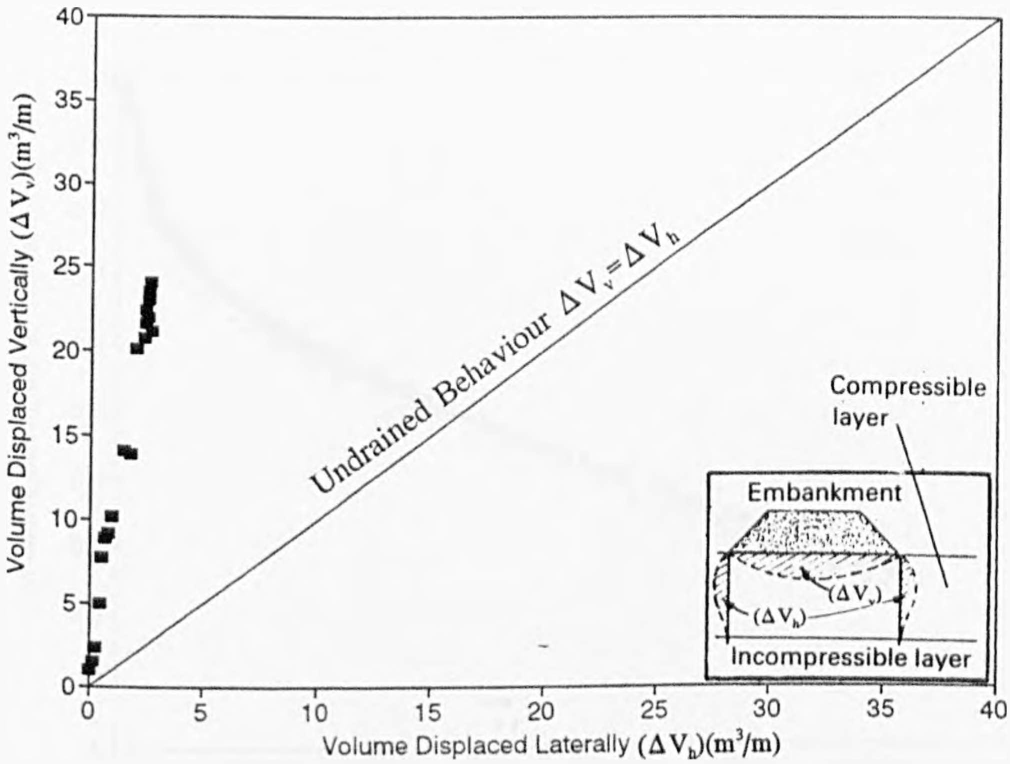


Fig.6.23 : Volume Displaced Vertically (ΔV_v) with Volume Displaced Laterally (ΔV_h)

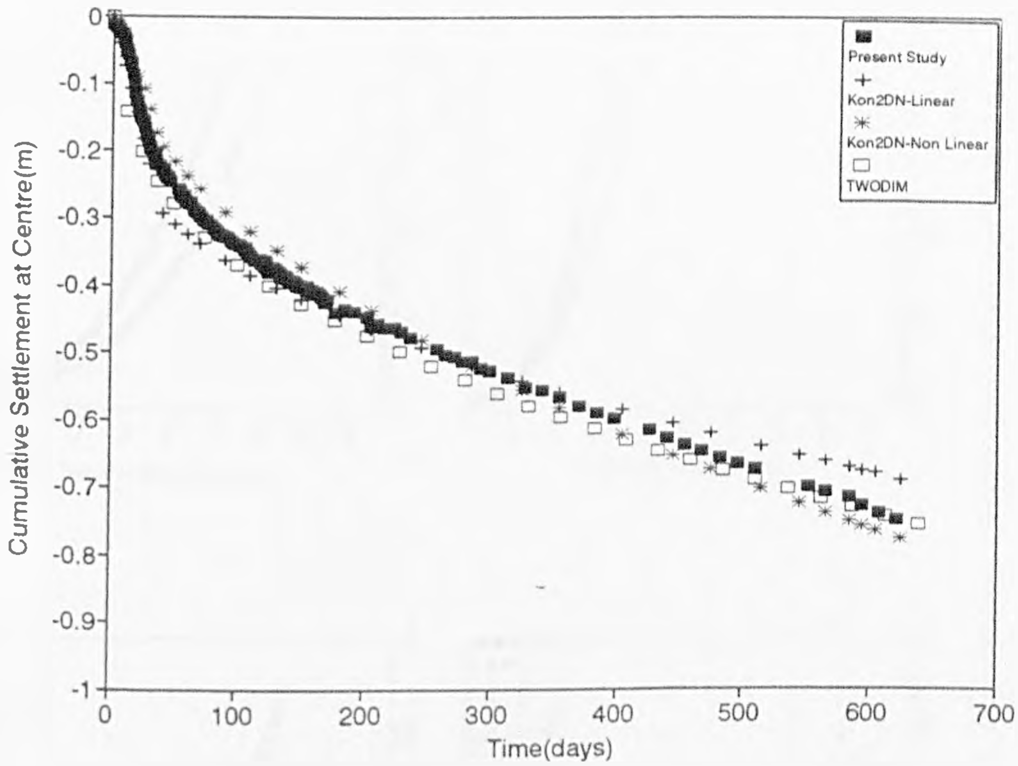


Fig.7.1 : Comparison of Cumulative Settlement with Time from Computer Analysis with Field Data at the Centre of the Embankment

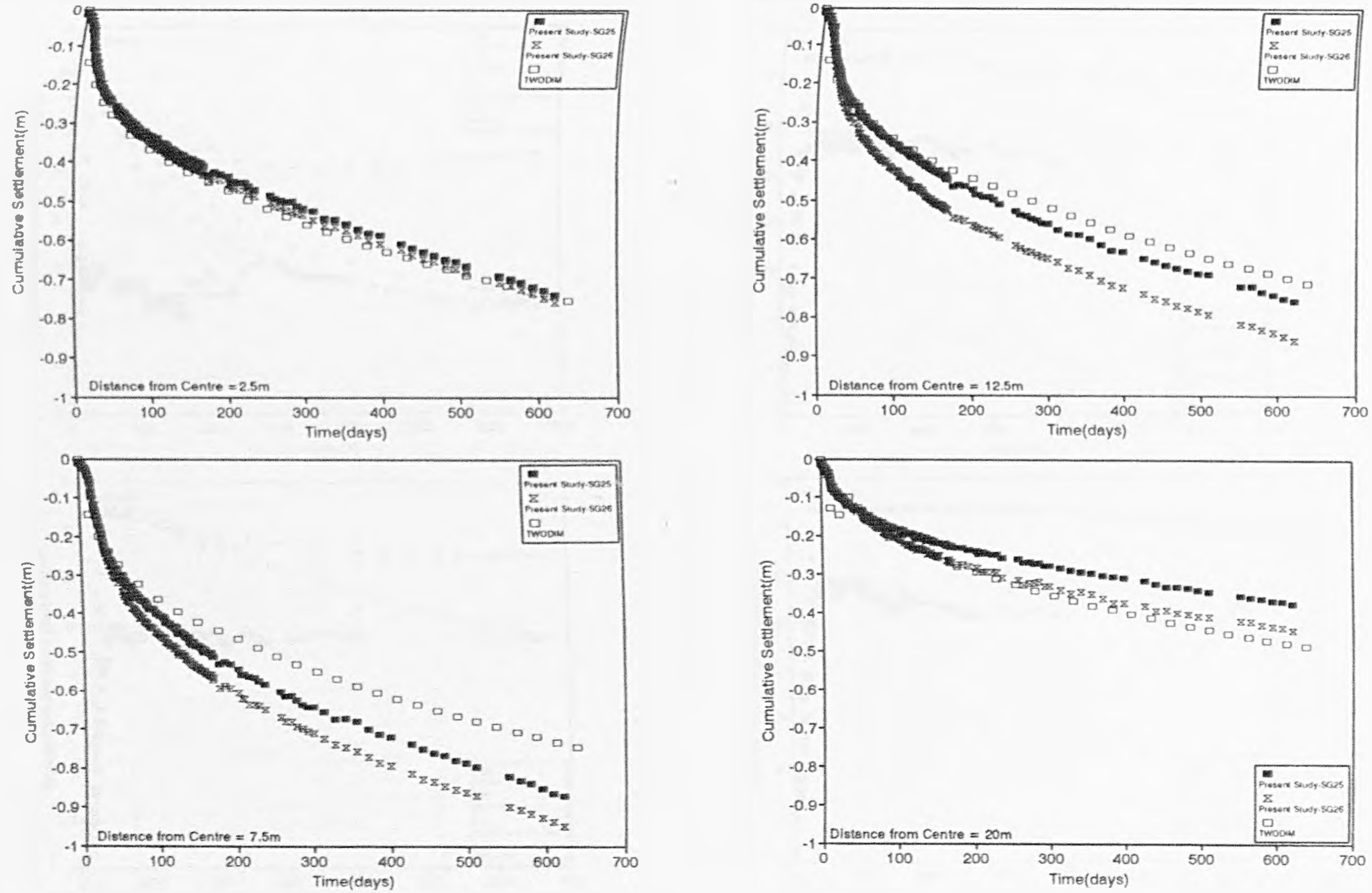


Fig.7.2 : Comparison of Cumulative Settlement with Time between Computer Analysis and Field Data at Other Distances from the Centre of the Embankment

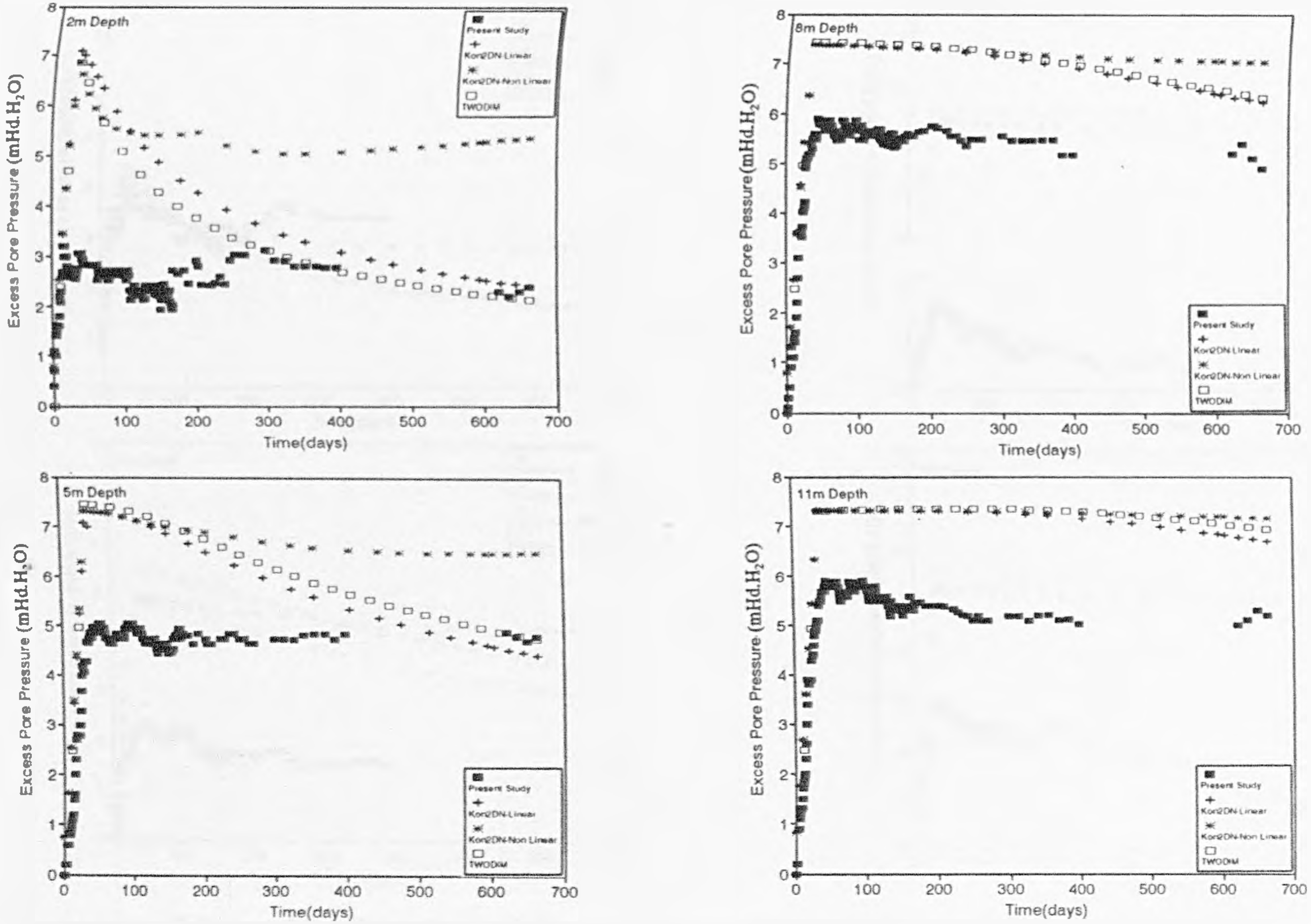


Fig.7.3 : Comparison of Excess Pore Pressures with Time between Computer Analysis and Field Data at the Centre of the Embankment

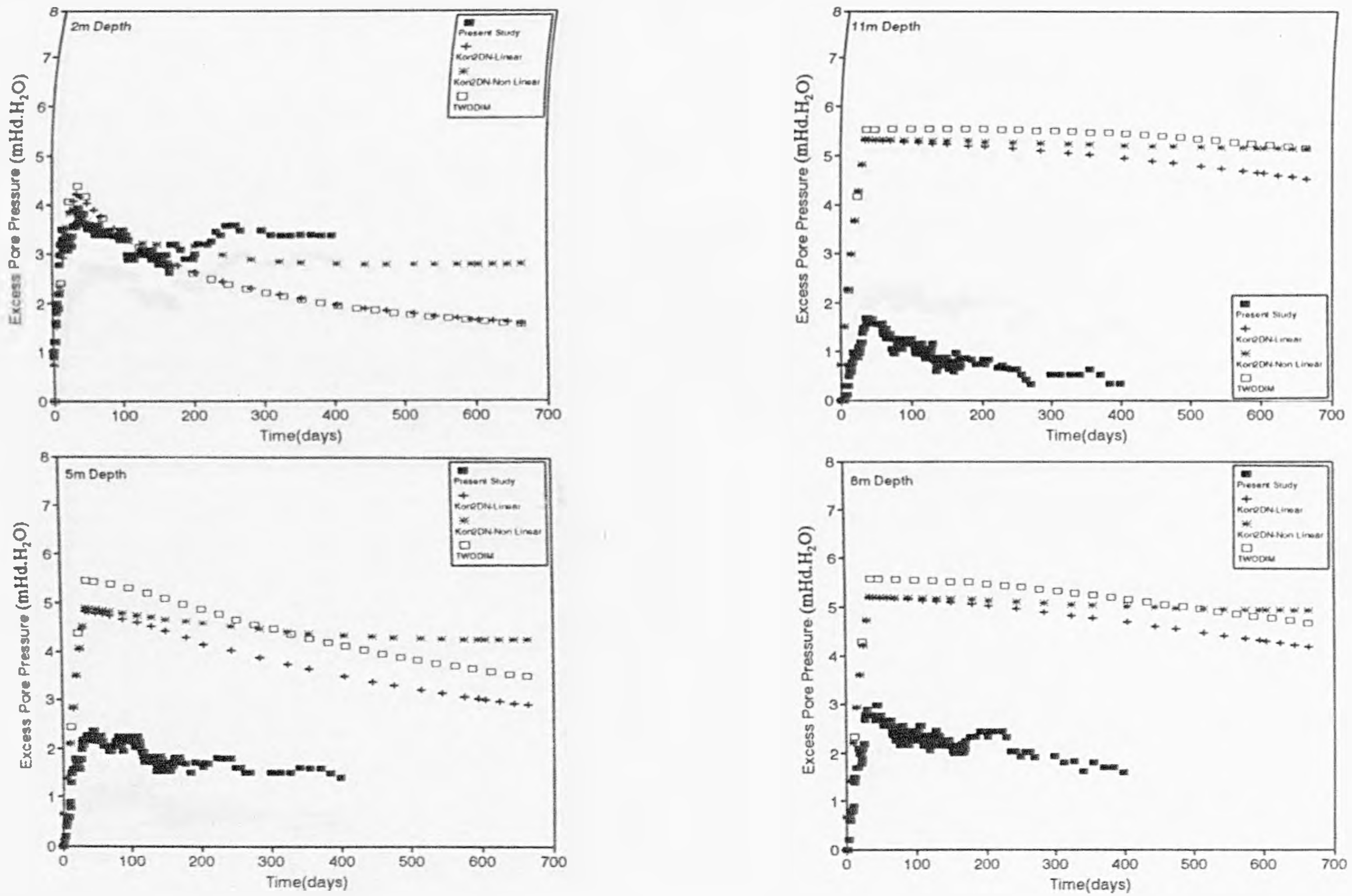


Fig.7.4 : Comparison of Excess Pore Pressures with Time between Computer Analysis and Field Data 22.5m West of the Centre of the Embankment

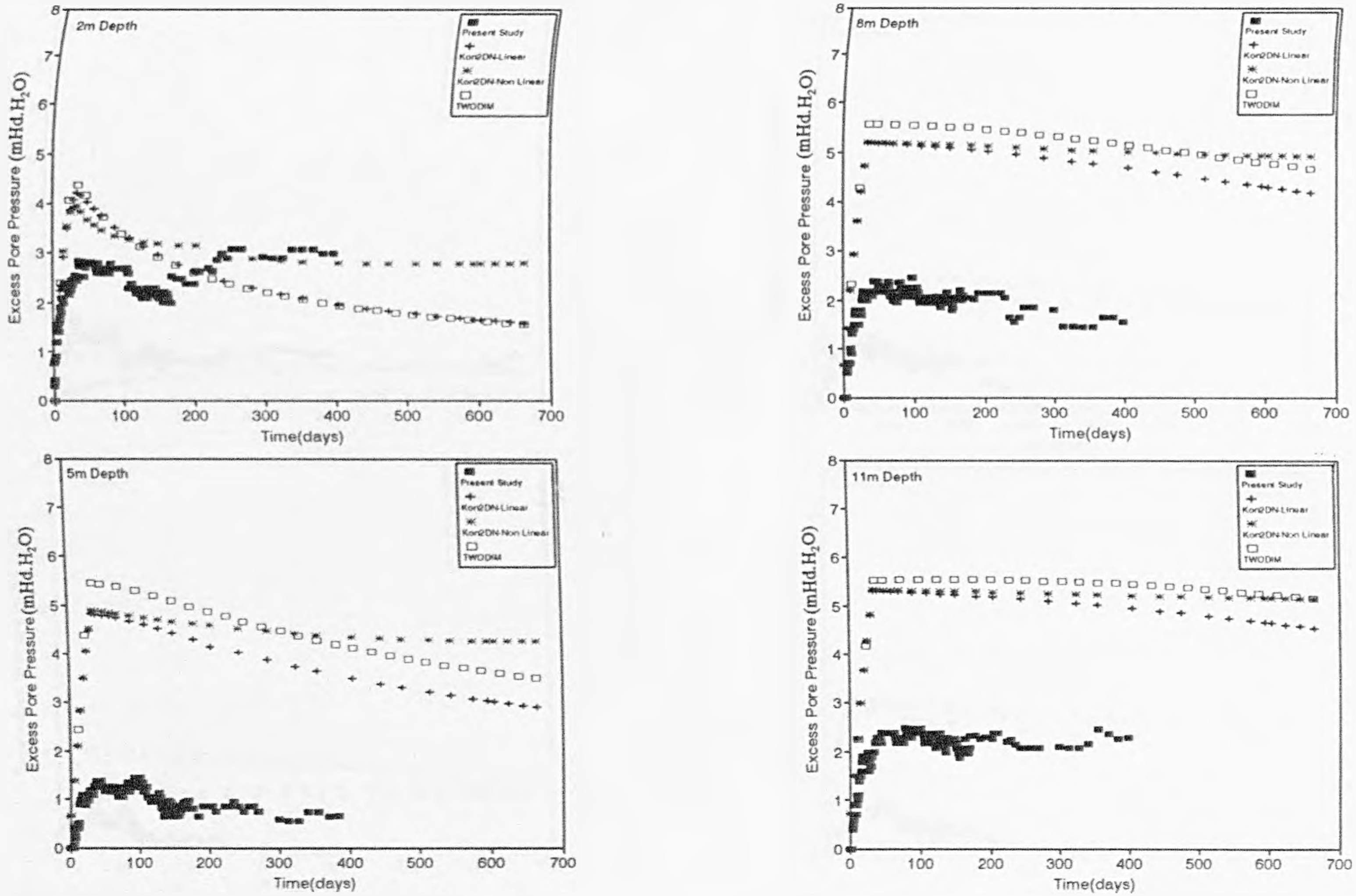


Fig.7.5 : Comparison of Excess Pore Pressures with Time between Computer Analysis and Field Data 22.5m East of the Centre of the Embankment

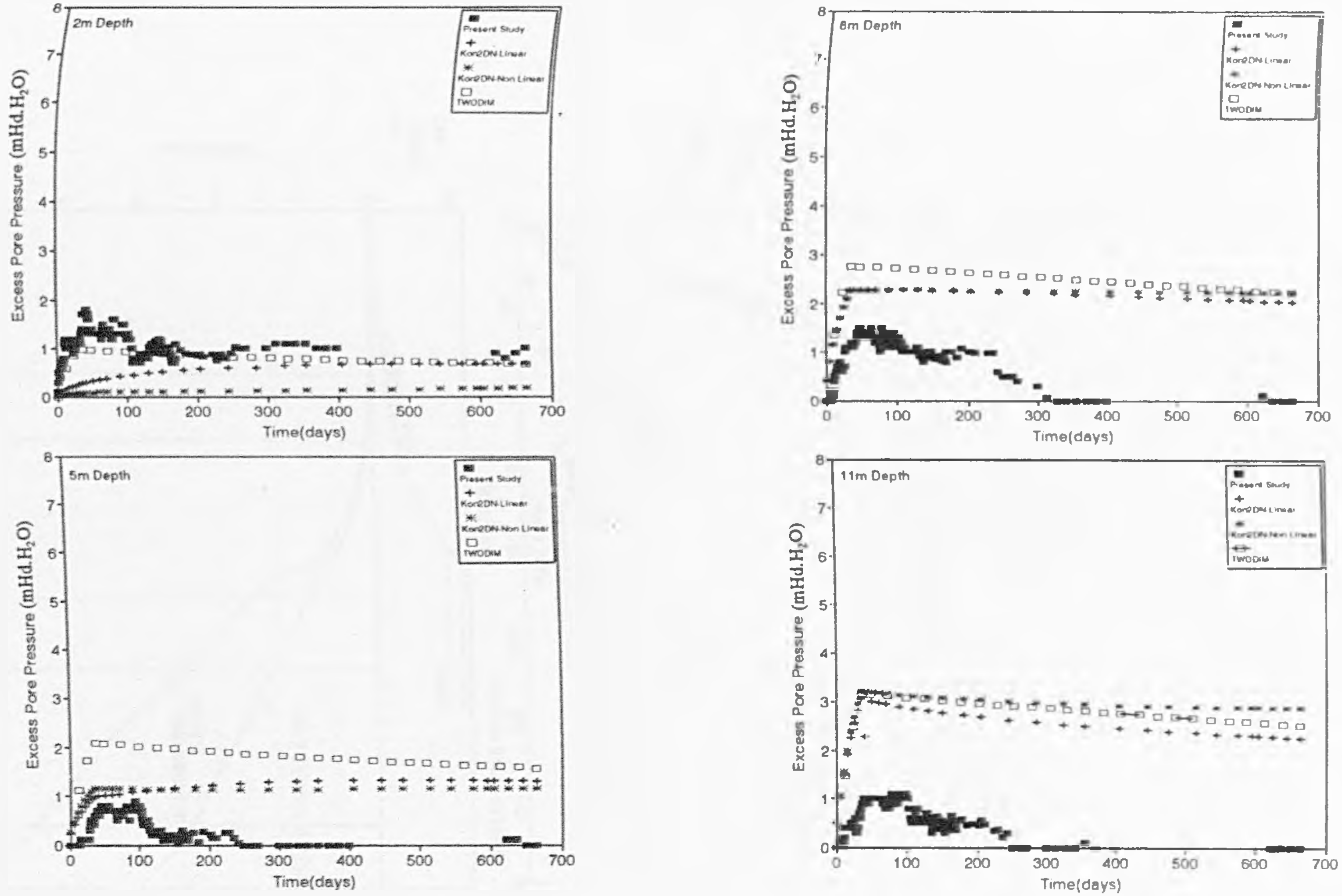


Fig.7.6 : Comparison of Excess Pore Pressures with Time between Computer Analysis and Field Data 32.5m West of the Centre of the Embankment

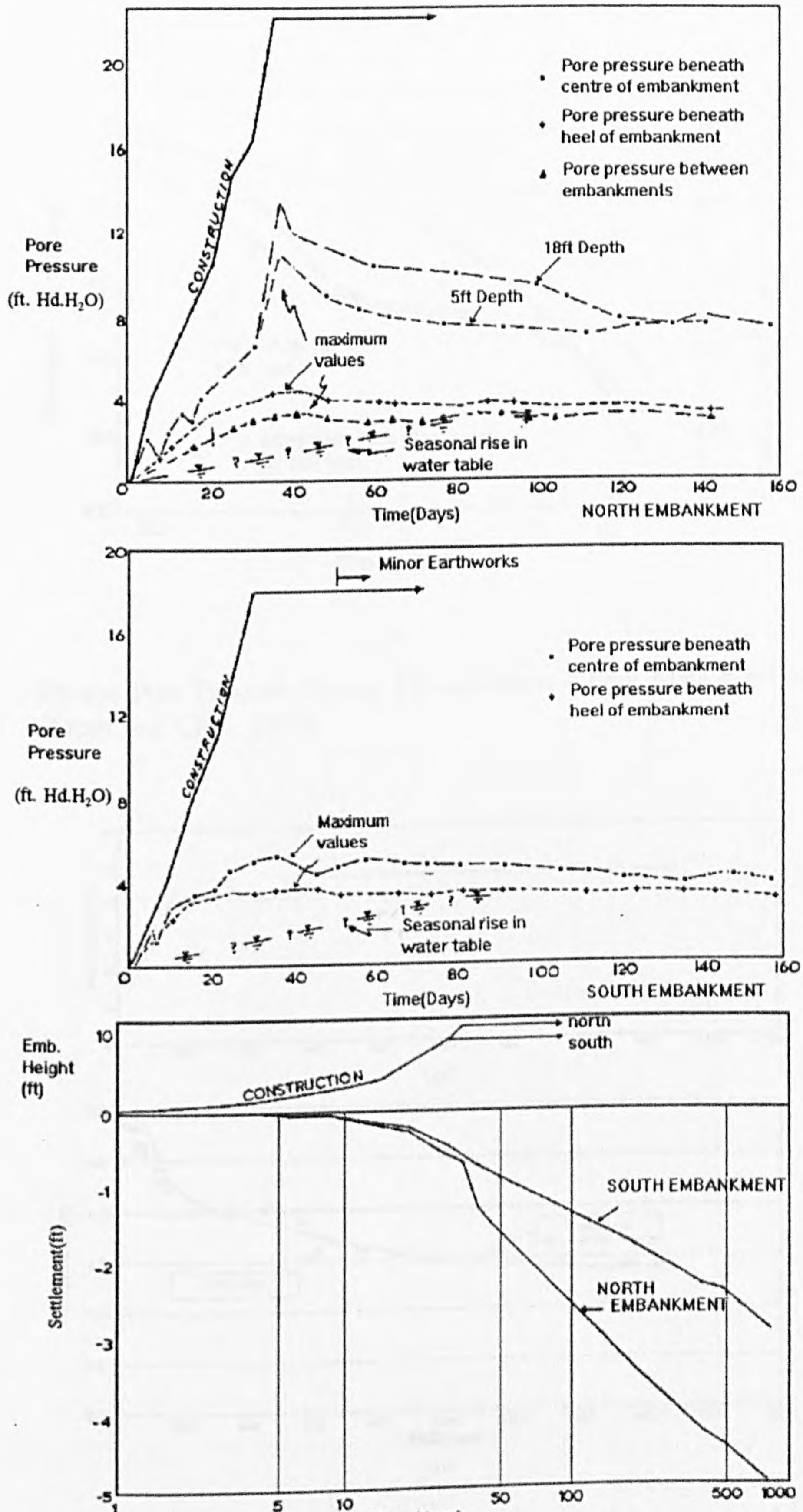


Fig.8.1 : Pore Pressure Dissipation and Settlement of Two Trial Embankments in Kedah, Northwest Peninsular Malaysia (James, 1970)

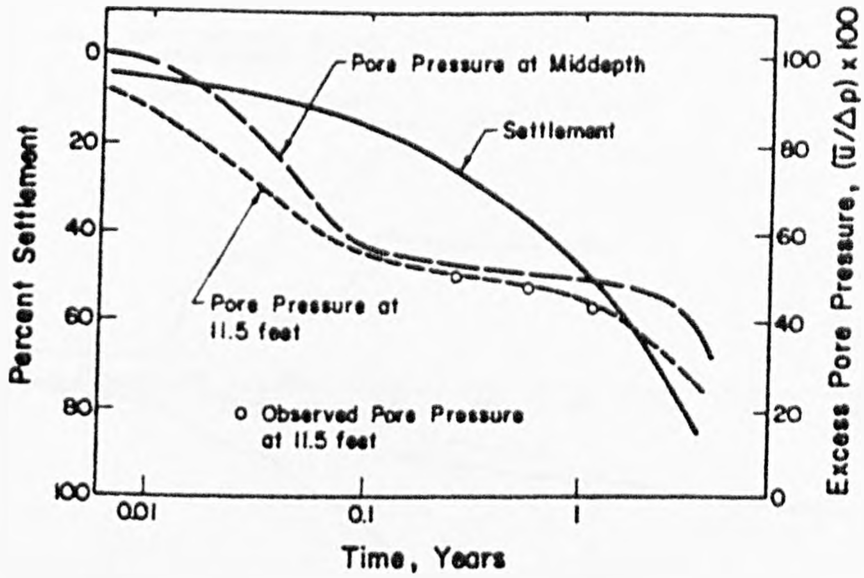


Fig.8.2 : Excess Pore Pressure During Consolidation - Prai, Malaysia Case Study (Mesri and Choi, 1979)

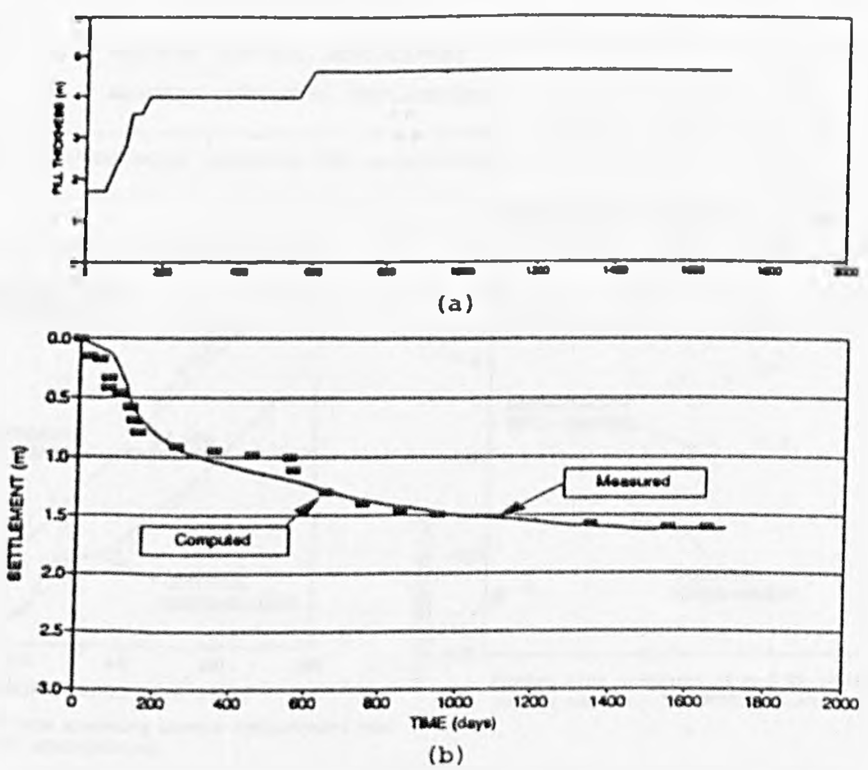
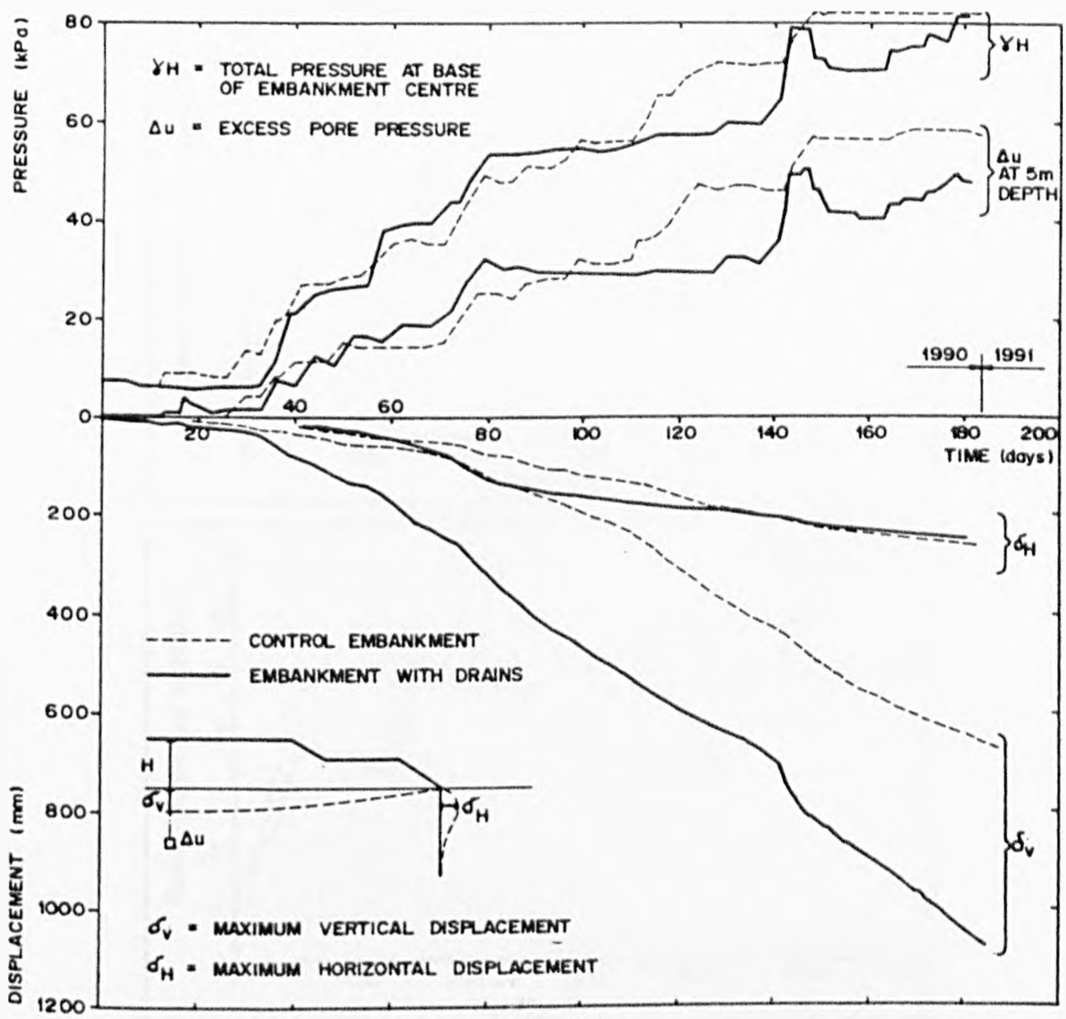
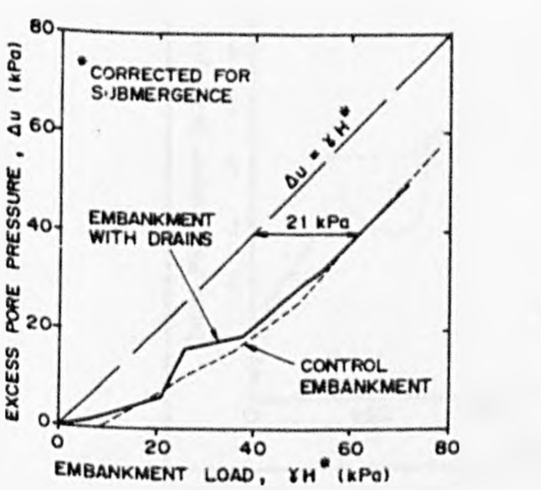


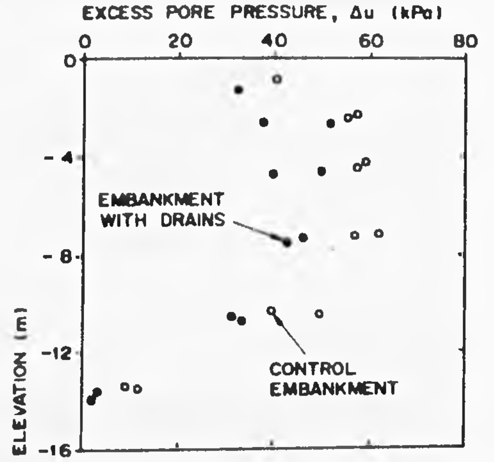
Fig.8.3 : Prediction of Settlement in Penang Using CONSOL Program Using c_v from Oedometer Tests (Wong and Choa, 1991)



Principal instrumentation results for both embankments



Excess pore pressure versus embankment load for both embankments



Excess pore pressure at end of construction versus elevation for both embankments

Fig.8.4 : Perfomance of the Juru Trial Embankment up to the End of Construction (Mohammad et al, 1991)

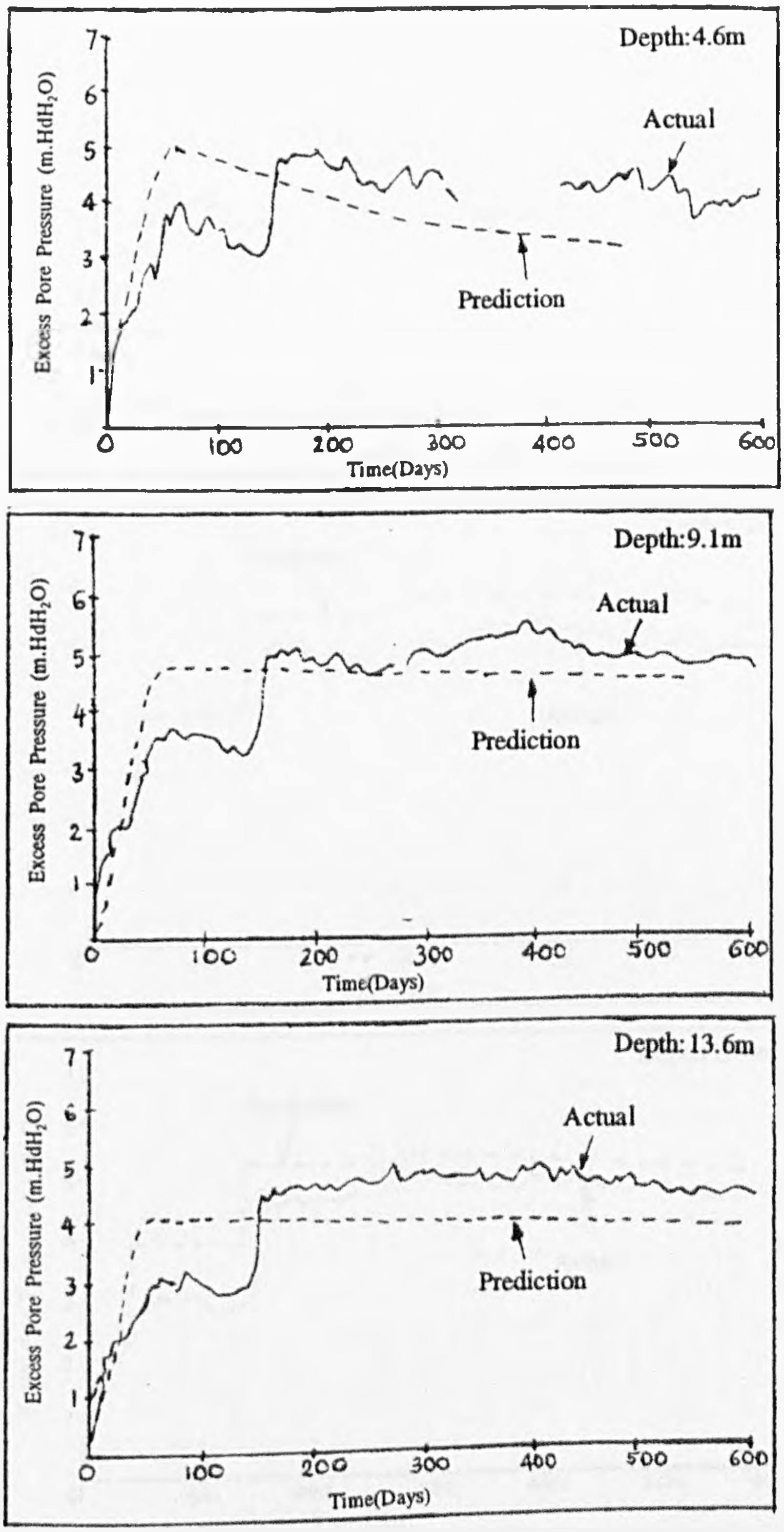


Fig.8.5 : Prediction of the Excess Pore Pressure Dissipation at the centre line of the 3m Control Embankment in Muar Using the Kon2D program (Younger, 1992)

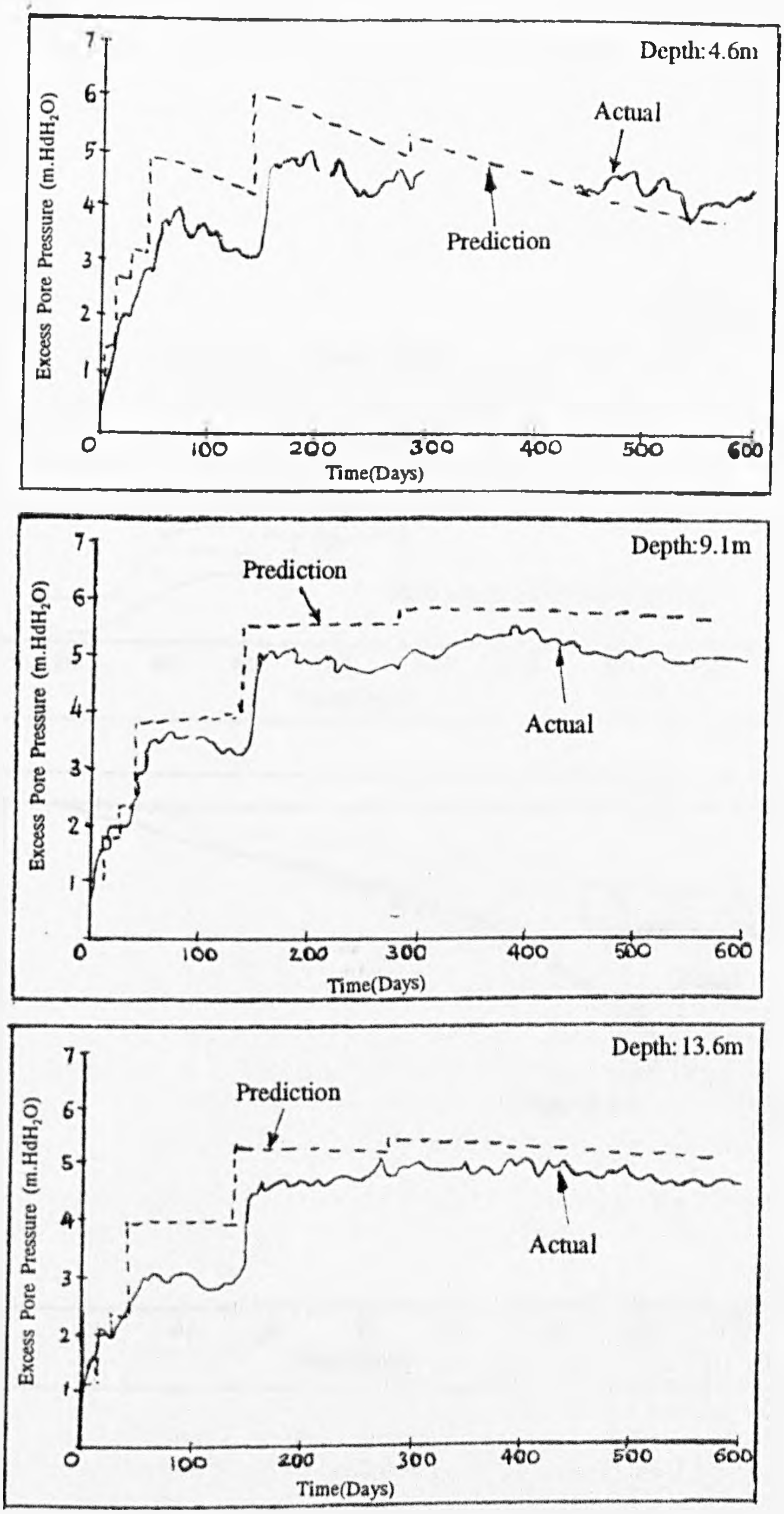


Fig.8.6 : Prediction of the Excess Pore Pressure Dissipation at the centre line of the 3m Control Embankment in Muar Using the Kon2D program with Varying Pore Pressure Coefficient (A) (Younger, 1992)

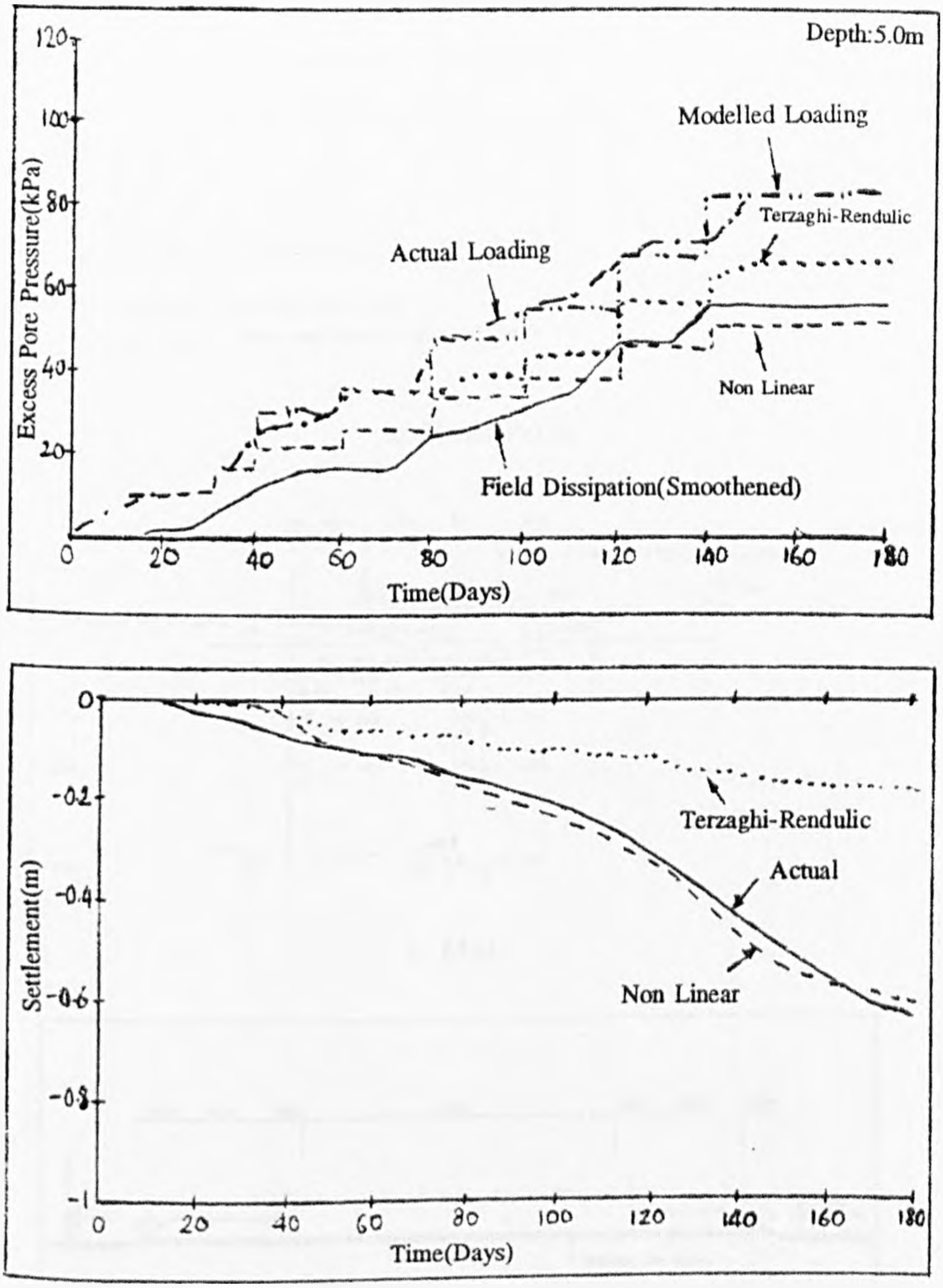
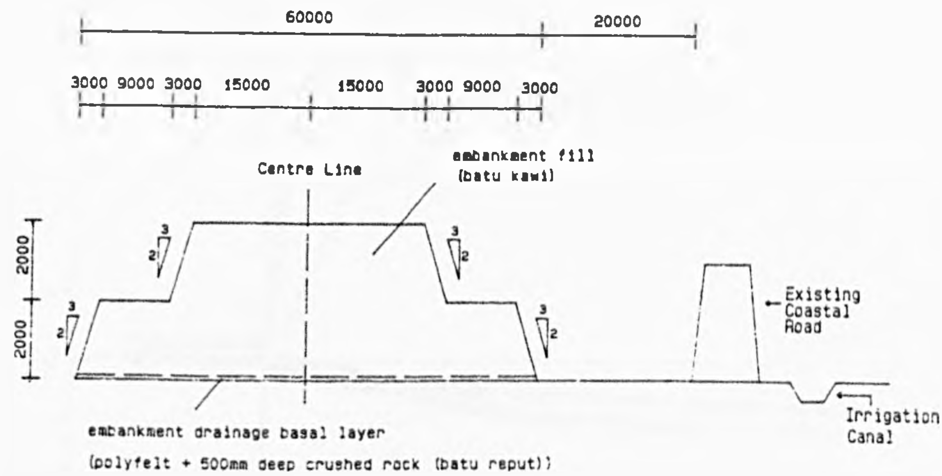
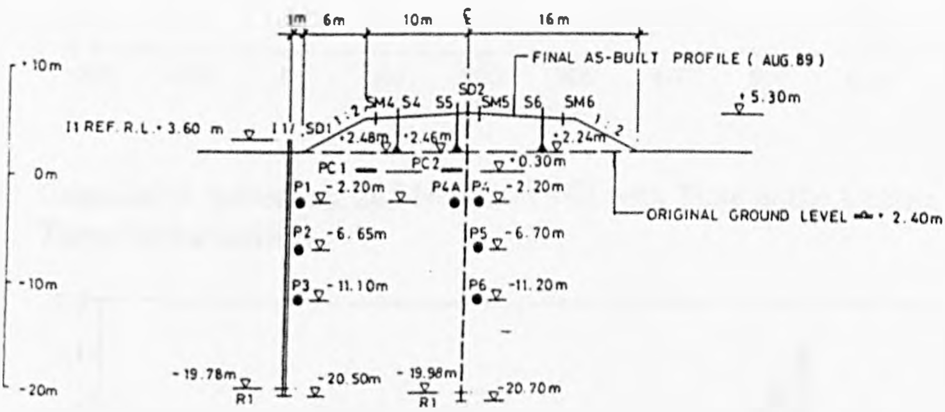


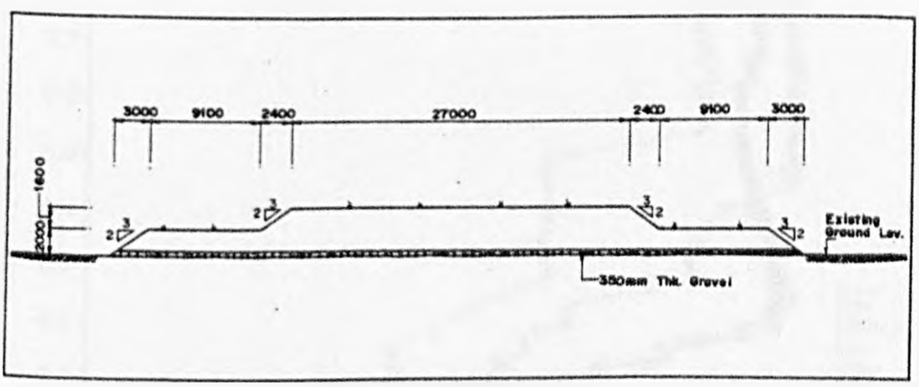
Fig.8.7 : Prediction of the Excess Pore Pressure Dissipation at the centre line of the Juru Trial Embankment Using the Kon2D program with Varying Permeability with Time (Younger, 1992)



a. Kuala Perlis



b. Muar



c. Juru

Fig.8.8 : Details of Cross Section of the Layout of the Three Trial Embankments

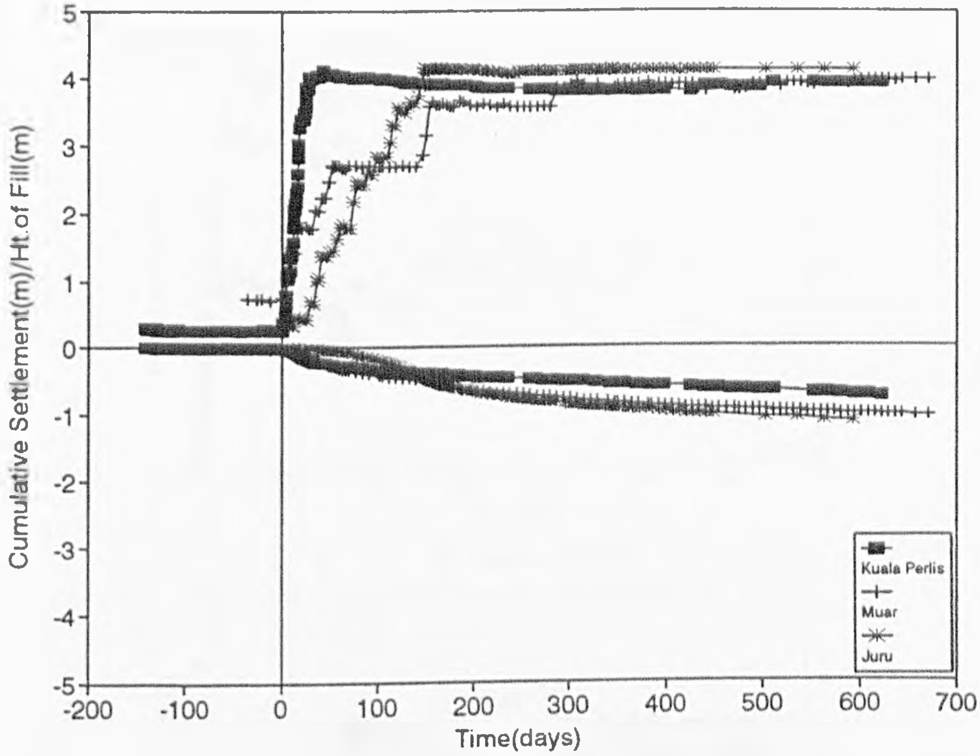


Fig.8.9 : Cumulative Settlement and Height of Fill with Time at the Centres of the Three Embankments

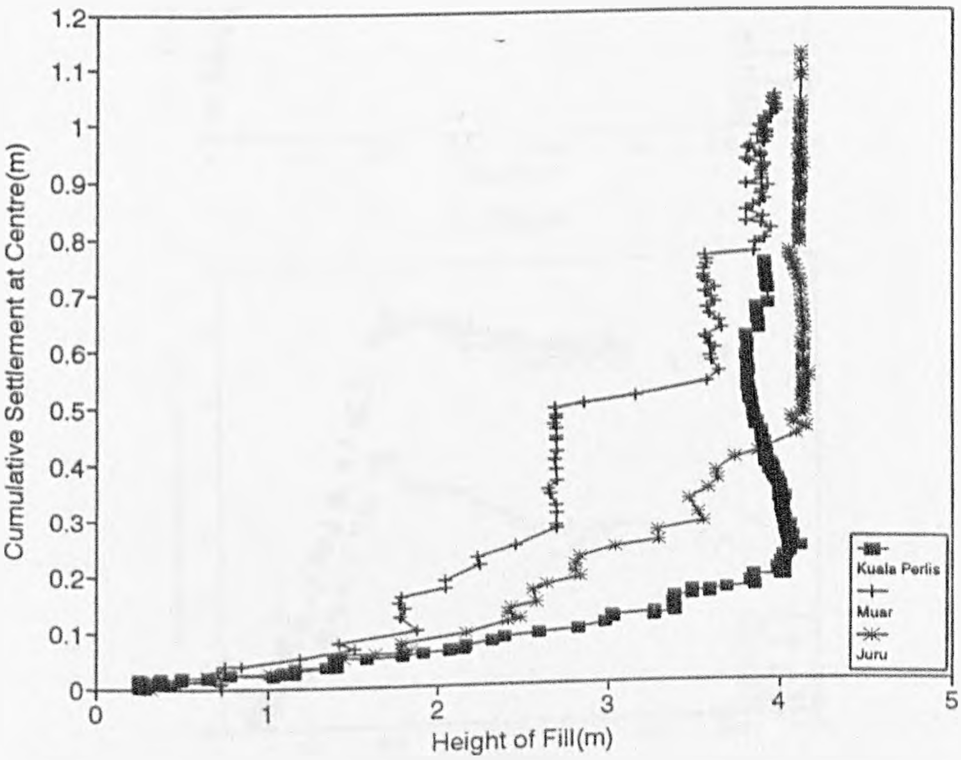
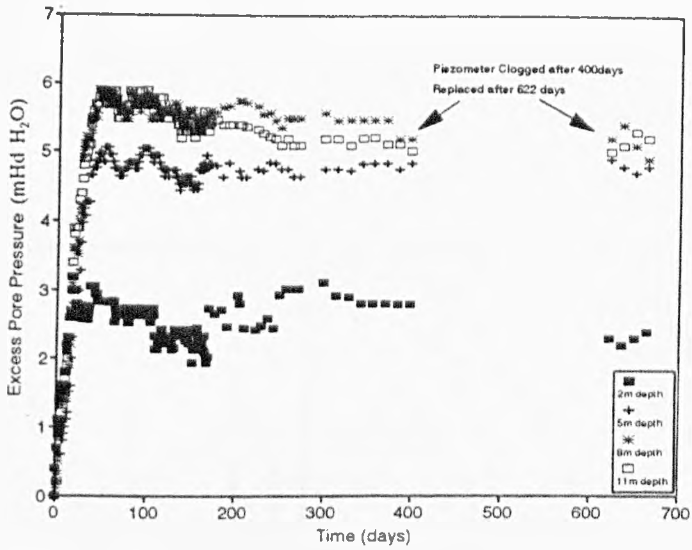
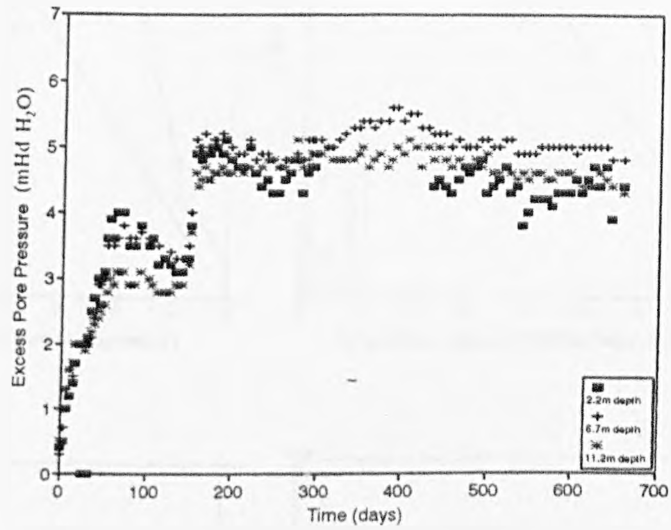


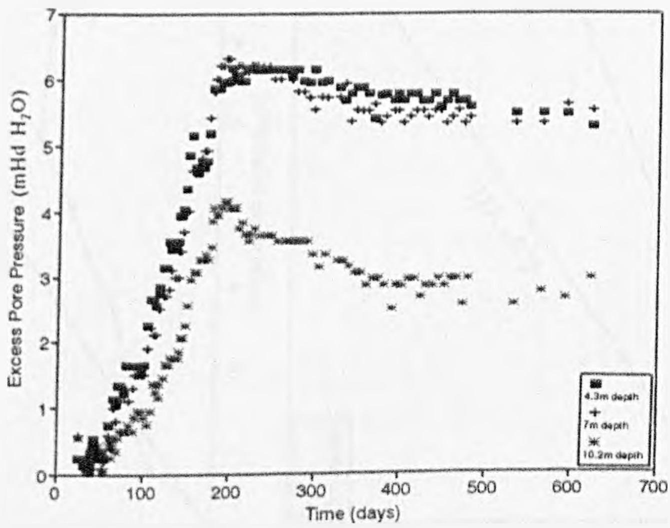
Fig.8.10 : Cumulative Settlement with Height of Fill



a. Kuala Perlis



b. Muar



c. Juru

Fig.8.11 : Excess Pore Pressure with Time

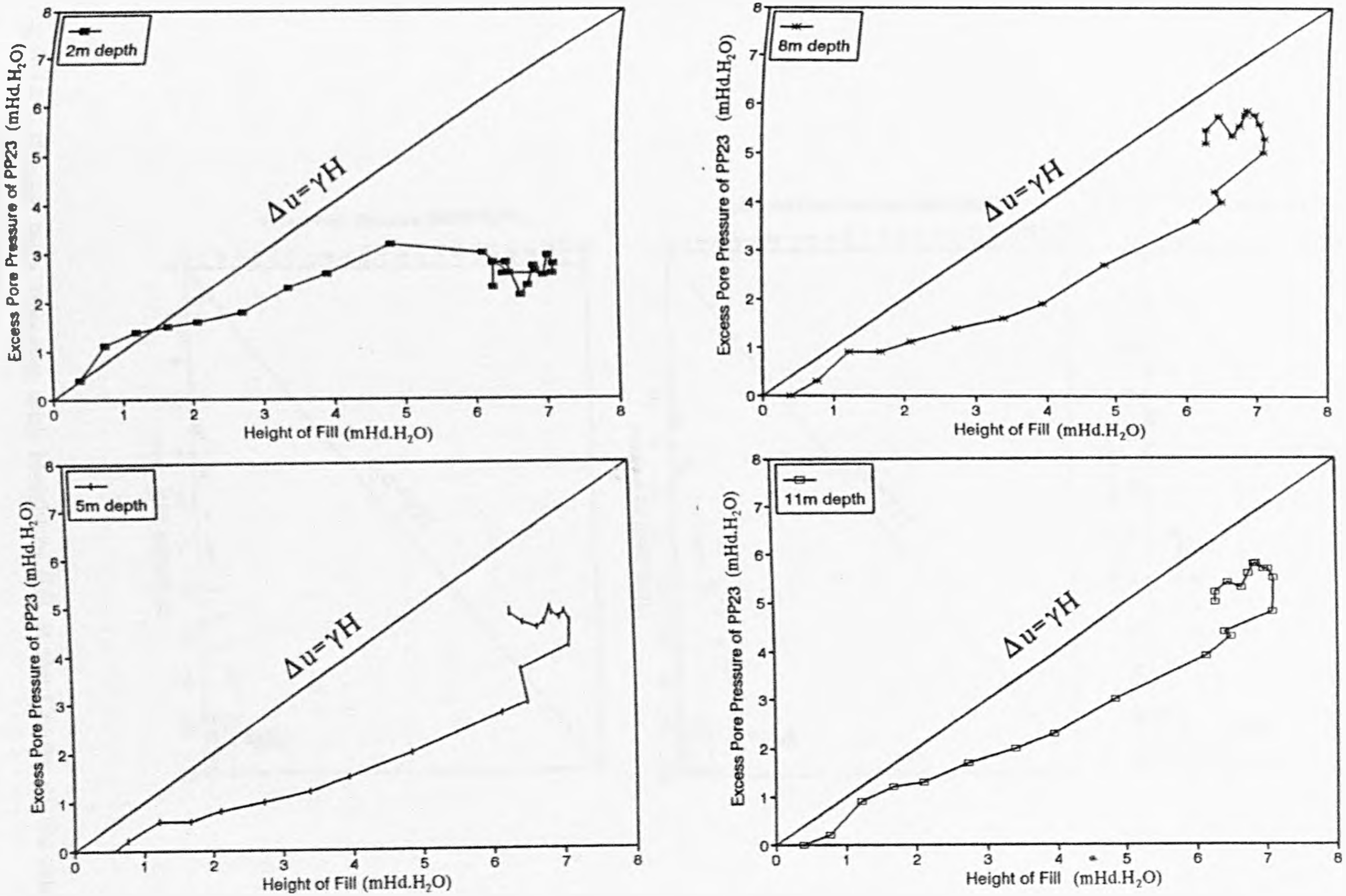


Fig.8.12 : Excess Pore Pressure with Height of Fill at the Centre of the Kuala Perlis Trial Embankment

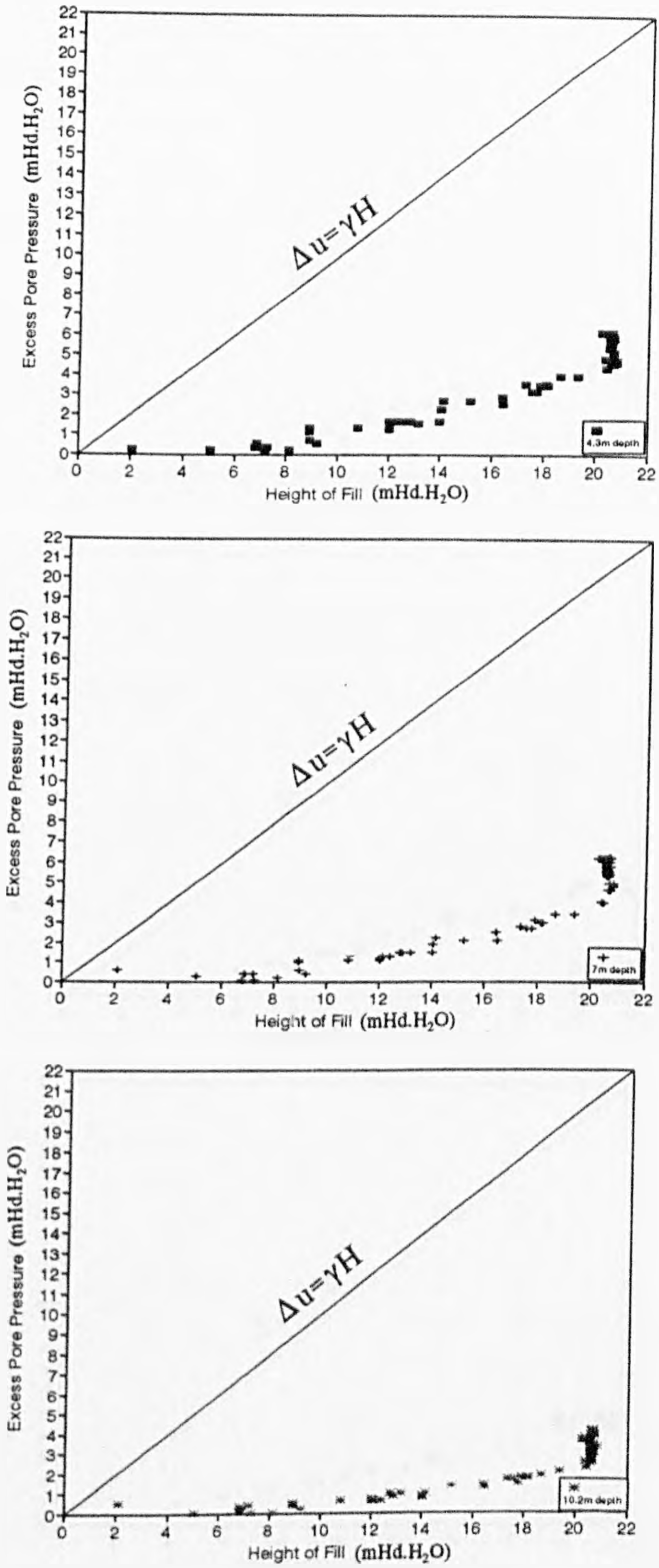


Fig.8.14 : Excess Pore Pressure with Height of Fill at the Centre of the Juru Trial Embankment

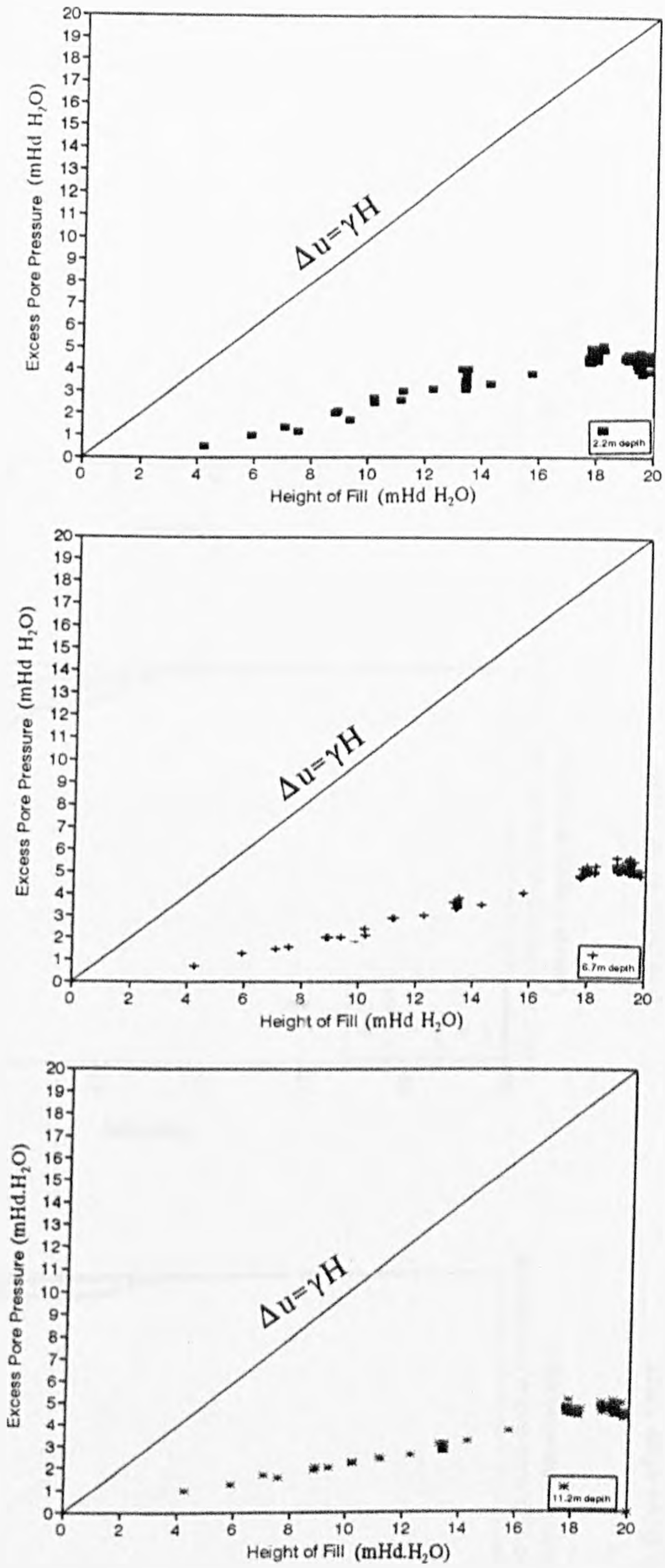
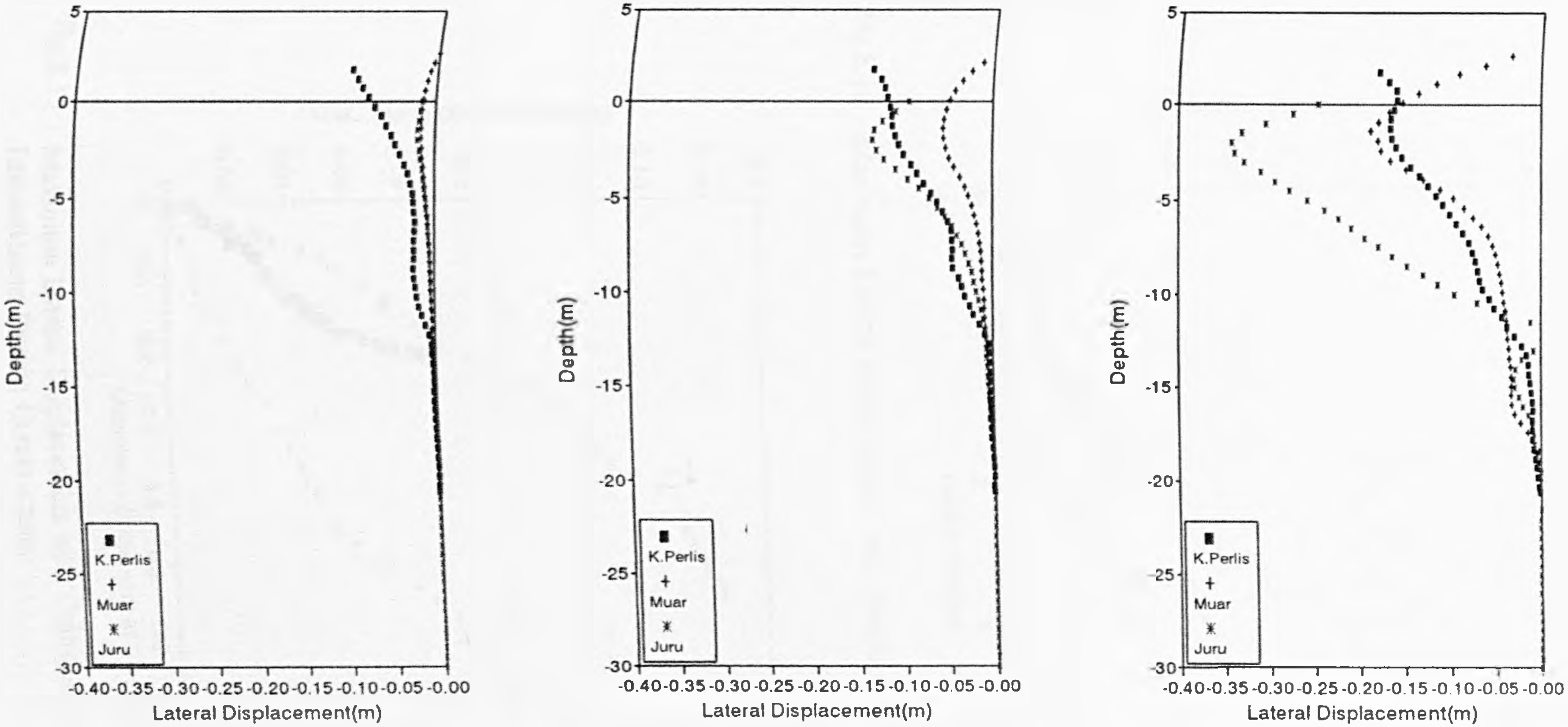


Fig.8.13 : Excess Pore Pressure with Height of Fill at the Centre of the Muar Trial Embankment



36 days after Start of Construction

100 days after Start of Construction

370 days after Start of Construction

Fig.8.15 : Lateral Displacement with Depth and Time for the Three Embankments

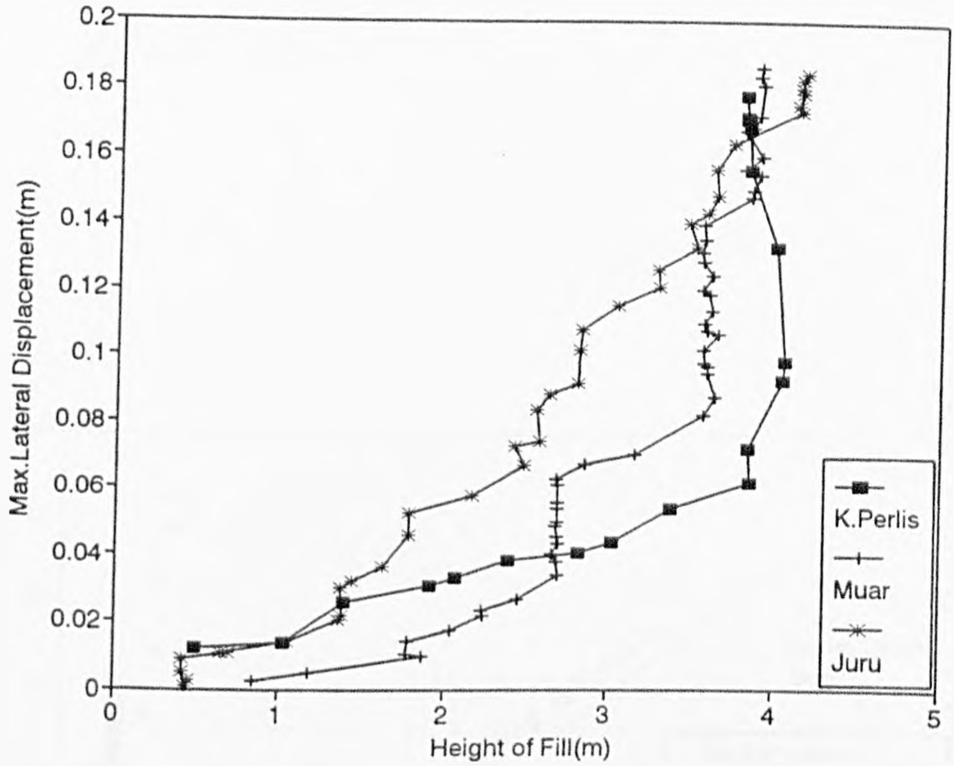


Fig.8.16 : Maximum Lateral Displacement with Height of Fill During Construction

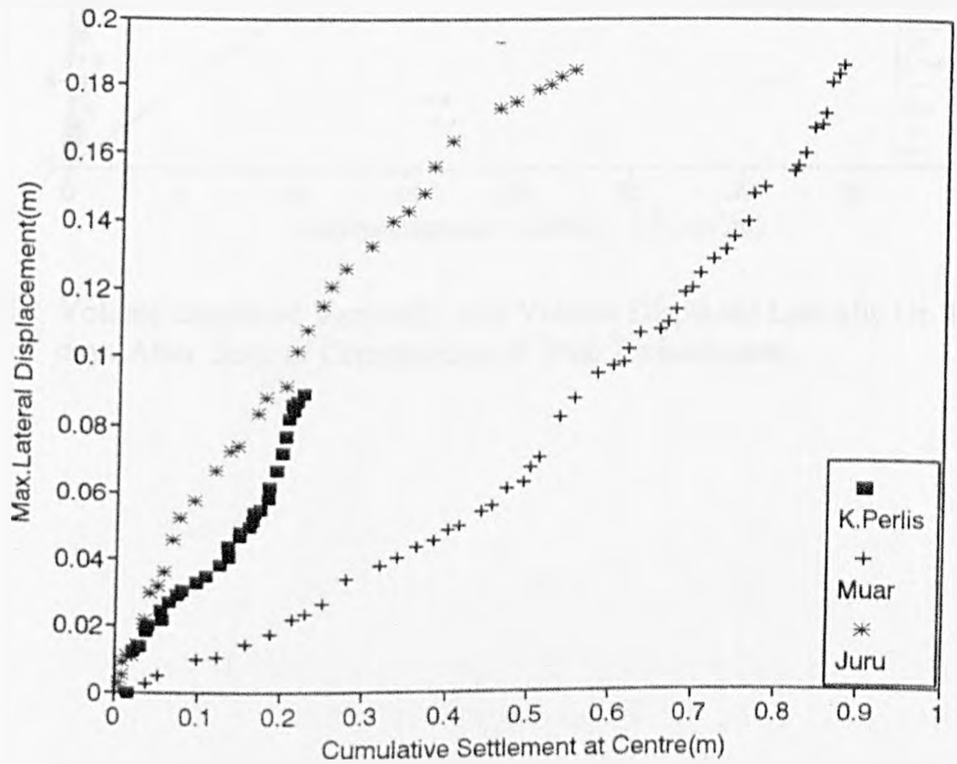


Fig.8.17 : Maximum Lateral Displacement with Cumulative Settlement at Centre of Embankment During Construction

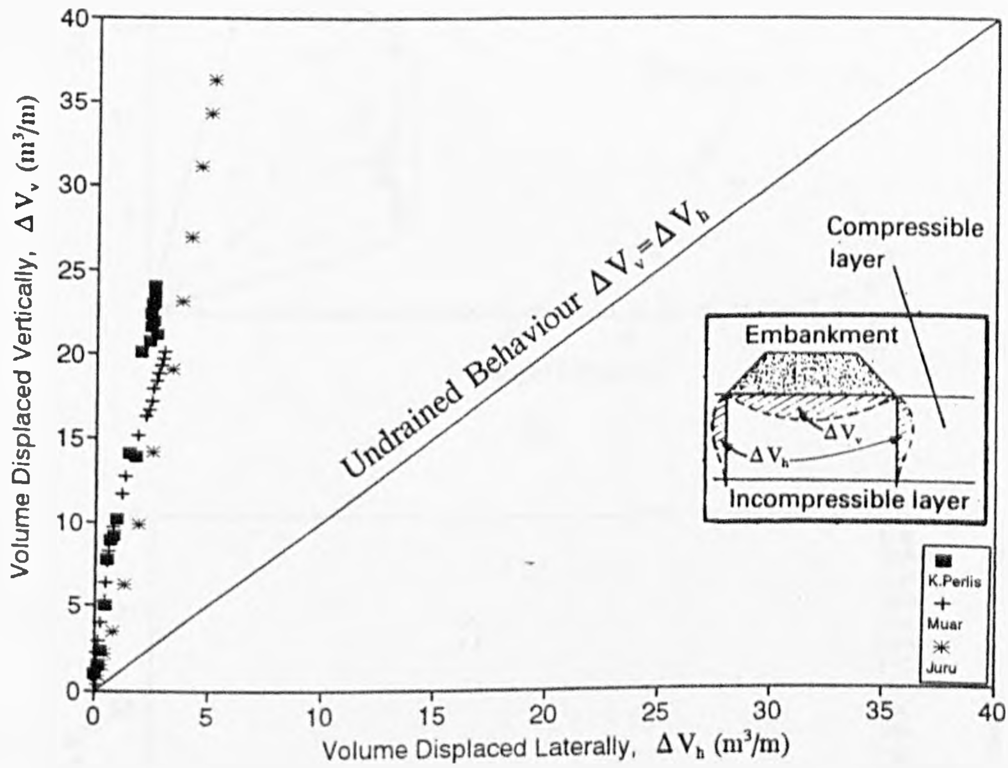
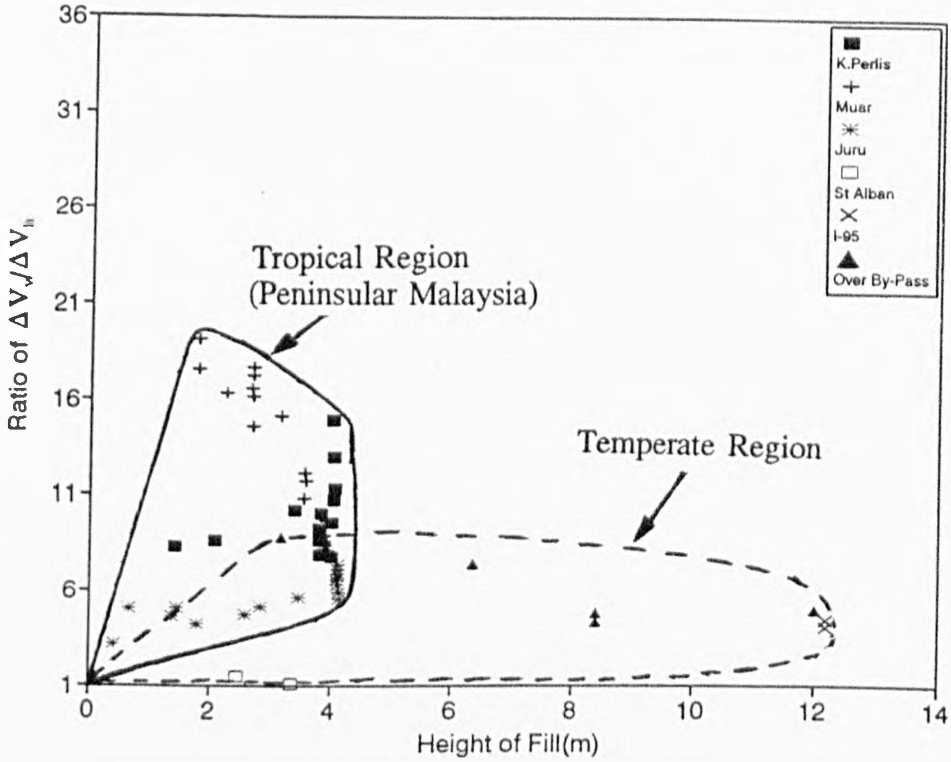
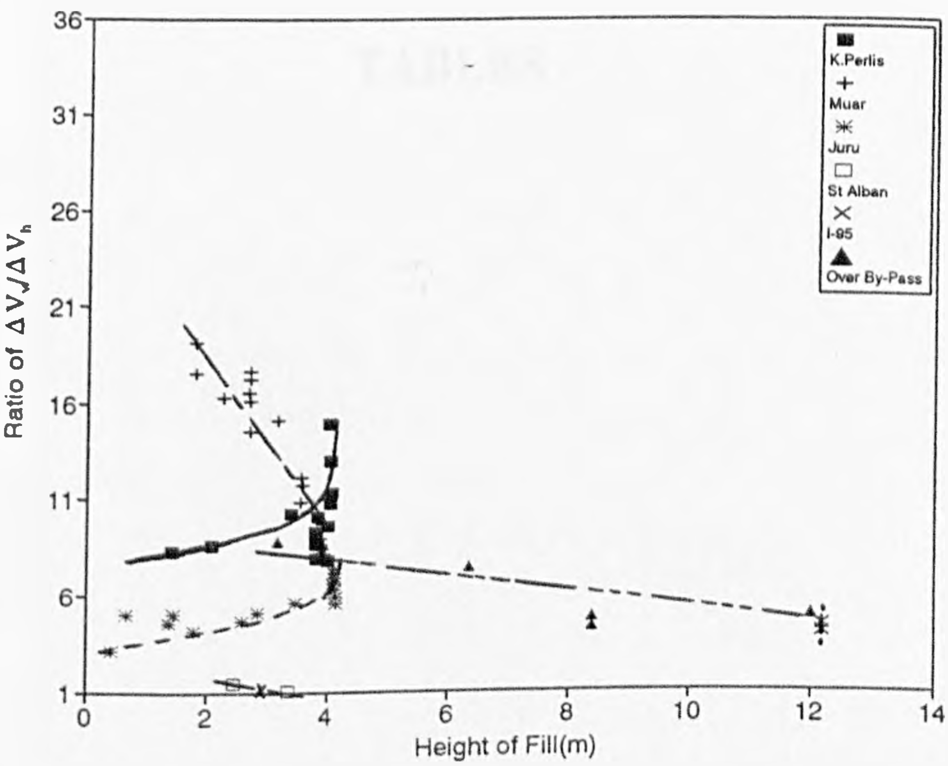


Fig.8.18 : Volume Displaced Vertically with Volume Displaced Laterally Up To 370 days After Start of Construction of Trial Embankment.



(a)



(b)

Fig.8.19 : Ratio of $\Delta V_v/\Delta V_h$ with Height of Fill

TABLES

Quality	Properties That Can Be Determined
Class 1	Classification, Moisture Content, Density, Strength, Deformation and Consolidation Characteristics
Class 2	Classification, Moisture Content, Density
Class 3	Classification, Moisture Content
Class 4	Classification
Class 5	None(Sequence of Strata only)

Table 2.1: Classes of Sample Quality (BS5930:1981)

Area Ratio (%)	Cutting Edge Taper (Degrees)
5	15
10	12
20	9
40	5
80	4

Table 2.2 : Combination of Area Ratio and Cutting Edge Taper from ISSMFE (1965) (Clayton, 1986)

Type of Soil	Length/Diameter Greater Than
Clay (Sensitivity > 30)	20
Clay (Sensitivity 5-30)	12
Clay (Sensitivity < 5)	10
Loose Frictional Soil	12
Medium Loose Frictional Soil	6

Table 2.3 : Length/Diameter Ratios recommendation from ISSMFE (1965) based on Inside Clearance of 0.5-1% (Clayton, 1986)

Skempton and Northey (1952)	Rosenqvist (1953)	Shannon and Wilson (1964)
1.0 : Insensitive	1.0 : Insensitive	< 3 : Low
1-2 : Low	1-2 : Slightly	3-5 : Low to Medium
2-4 : Medium	2-4 : Medium	5-7 : Medium
4-8 : Sensitive	4-8 : Very Sensitive	7-11 : Medium to High
> 8 : Extra Sensitive	8-16 : Slightly Quick	11-14 : High
> 16 : Quick	16-32 : Medium Quick	14-20 : High to Very High
	32-64 : Very Quick	20-40 : Very High
	> 64 : Extra Quick	> 40 : Extremely High

Table 2.4 : Classification of Sensitivity from Various Researchers (Mitchell and Houston, 1969)

Mechanism	Types of Reaction	Limit of Sensitivity	Predominant Soil Types Affected
Metastable Particle Arrangements	Physical	Slightly Quick	All Clays
Silt Skeleton Bond Clay	Physical	Very Sensitive	Clay-Silt-Sand
Cementation	Chemical	Slightly Quick	All Soils Containing Potential Cementation Compounds
Ion Exchange	Physico-Chemical	Slightly Quick	Leached and Weathered Clays
Leaching of Salt	Physico-Chemical	Extra Quick	Glacial and Post Glacial Marine Clays
Weathering	Chemical	< 1 to Medium (Sensitive 1-4)	All Soils Magnitude of Effect Depends on Mineralogy
Thixotropic Hardening	Physico-Chemical	Medium to Sensitive to Slightly Quick	Clays
Dispersing Agent Addition	Physico-Chemical	Extra Quick	Clays-Particularly Organic Bearing or Organic Deposit Associated

Table 2.5 : Mechanisms Affecting Clay Sensitivity (Mitchell and Houston, 1969)

Regression Equation	Correlation Coefficient	No. of Samples	Applicability	Reference
C_c=0.007(LL-7) C_c=1.15(e_o-0.35) C_c=0.256+0.43(e_o-0.84) C_c=0.0046(LL-9) C_c=0.009(LL-10)			Remoulded Clay All Clays Brazilian Clays Brazilian Clays Normally Consolidated Clay	Skempton (1944) Nishida (1956) Cozzolino (1961) Cozzolino (1961) Terzaghi and Peck (1967)
C_c=0.4(e_o-0.25) C_c=0.01(w-5) C_c=0.006(LL-9) C_c=0.37(e_o+0.003LL-0.34) C_c=0.4(e_o+0.001w-0.25) C_c=0.37(e_o+0.003LL+0.004w-0.34)	0.85 0.79 0.59 0.86 0.85 0.86	717 717 678 678 717 678	Clays from Greece and some parts of the United States	Azzouz et al (1976)
C_c=0.21+0.008LL C_c=0.22+0.29e_o C_c=0.2+0.008w C_c=0.2+0.008LL+0.009e_o	0.7 0.77 0.77 0.7	113 113 113 113	Weathered and Soft Bangkok Clay	Adikari (1977)
C_c=0.1882+0.3097e_o C_c=0.1509+0.3401e_o -0.0062e_o^2	0.88 0.9		Soft Bangkok Clay	Sivandran (1979)
C_c=0.575e_o-0.241 C_c=0.0.147w-0.213	0.966 0.963	-	French Clays	Vidalie (1977)
CR=0.0043w CR=0.0045LL			Marine Clays of Southeast Asia	Cox (1968)
CR=0.156e_o+0.0107 (e_o<2)	0.93	230	All Clays	Elnaggar and Krizek (1970)
CR=0.14(e_o+0.007) CR=0.003(w+7) CR=0.002(LL+9)	0.74 0.68 0.53	717 717 678	Clays from Greece and some parts of the United States	Azzouz et al (1976)
CR=0.00566w-0.037 CR=0.0463LL-0.013	0.81 0.63		Bangkok Clays	Balasubramaniam and Brenner (1981)
CR=0.0039w+0.013 (w<100%) CR=0.403logw-0.478	0.86 0.86		French Clays	Viladie (1977)

Table 2.6 : Compression Index and Compression Ratio Relationship with Other Soil Parameters (Balasubramaniam and Brenner, 1981)

$C_\alpha/(1+e_o)$ as a Percentage	Secondary Compressibility Classification
< 0.2	Very Low
0.4	Low
0.8	Medium
1.6	High
3.2	Very High
> 6.4	Extremely High

Table 2.7 : Coefficient of Secondary Consolidation with Compressibility (Mesri, 1973)

Soil Type	C_α/C_c	Reference
Whangamarino Clay	0.03-0.04	Newland and Allely (1960)
Norfolk Organic Silt	0.05	Barber(1961)
Calcareous Organic Silt	0.035-0.06	Wahls (1962)
Amorphous and Fibrous Peat	0.035-0.083	Lea and Brawner (1963)
Canadian Muskeg	0.09-0.1	Adams (1965)
Leda Clay	0.03-0.055	Walker and Raymond (1968)
Leda Clay	0.04-0.06	Walker and Raymond (1969)
Peat	0.075-0.085	Weber (1969)
Post-Glacial Organic Clay	0.05-0.07	Chang (1969)
Soft Blue Clay	0.026	Crawford and Sutherland (1971)
Organic Clays and Silts	0.04-0.06	Ladd (1971)
Portland Sensitive Clay	0.025-0.055	Ladd (1971)
Peat	0.05-0.08	Samson and La Rochelle (1973)
San Francisco Bay Mud	0.04-0.06	Su and Prysock (1972)
New Liskeard Varved Clay	0.03-0.06	Quigley and Ogunbadejo (1972)
Silty Clay C	0.032	Samson and Garneau (1973)
Nearshore Clays and Silts	0.055-0.075	Brown and Rashid (1975)
Fibrous Peat	0.06-0.085	Berry and Vickers (1975)
Mexico City Clay	0.03-0.035	Mesri et al (1975)
Hudson River Silt	0.03-0.06	Mesri, Personal Files
Leda Clay	0.025-0.04	Mesri and Godlewski (1977)
New Haven Organic Clay Silt	0.04-0.075	Mesri and Godlewski (1977)

Table 2.8 : Values of C_α/C_c for Some Natural Soil Deposits (Mesri and Godlewski, 1977)

Description of Compressibility	Coefficient of Volume Compressibility m_v (m^2/MN)	Clay Types
Very High	Above 1.5	Very Organic Alluvial Clays and Peats
High	0.3-1.5	Normally Consolidated Alluvial Clays (e.g. Estuarine Clays)
Medium	0.1-1.3	Fluvio-Glacial Clays, Lake Clays, Upper Blue and Weathered Brown London Clay
Low	0.05-0.1	Boulder Clays, Very Stiff or Hard Blue London Clay
Very Low	Below 0.05	Heavily Overconsolidated Boulder Clays, Stiff Weathered Rocks

Table 2.9 : Typical Values of Coefficient of Volume Compressibility for British Soils (From Head, 1980)

Type of Particles	Description
Dispersed	No Face to Face Association of Clay Particles
Aggregated	Face to Face Association of Several Clay Particles
Flocculated	Edge to Edge or Edge to Face Association
Deflocculated	No Association Between Aggregates

Table 2.10 : Particle Associations in Clay Suspensions (van Olphen, 1963)

Method	Basis	Scale of Observation and Features
Optical Microscope (Polarising)	Direct Observation of Fracture Surfaces or Thin Sections	Individual Particles of Silt Size and Large Clay Particles Groups, Preferred Orientation of Clay, Homogeneity on a Millimeter Scale or Larger
Electron Microsope	Direct Observation of Particle through Soil Sample (Scanning Electron -SEM) Observation of Surface Replicas (Transmission Electron Microscope - TEM)	Resolution to about 100Å,Large Depth of Field with SEM, Direct Observation of Particles, Particle Groups and Pore Space, Details of Microfabric
X-Ray Diffraction	Groups of Parallel Clay Plates produce stronger diffraction than Randomly Oriented Plates	Orientation in Zones Several Square Millimeters Thick, Best in Single Mineral Clays
Pore Size Distribution	i. Forced Intrusion of Non Wetting Fluid (Usually Mercury) ii. Capillary Condensation	i. Pores in Range from 0.01 to > 10 μm ii. 0.1 μm Maximum
Ascoustical Velocity	Particle Alignment Influences Velocity	Anisotropy; Measures Microfabric Averaged over a Volume equal to Sample Size
Dielectric Dispersion and Electrical Conductivity	Variations of Dielectric Constant and Conductivity and Frequency	Assessment of Anisotropy, Flocculation and Deflocculation; Measure Microfabric averaged over a Volume equal to Sample Size
Thermal Conductivity	Particle Orientation Influence Thermal Conductivity	Anisotropy, Measures Microfabric averaged over a Volume equal to Sample Size
Magnetic Susceptibility	Variation in Magnetic Susceptibility with Change of Sample Orientation Relative to Magnetic Field	Anisotropy, Measures Microfabric average over a Volume equal to Sample Size
Mechanical Properties Strength Modulus Permeability Compresshility, Shrinkage Swelling	Properties Reflect Influences of Fabric	Microfabric averaged over a Volume equal to Sample Size, Anisotropy, Macrofabric Features in some cases

Table 2.11: Methods Used in Study of Soil Fabric (Mitchell, 1976)

Calcium Carbonate Content (CaCO3)	Description
0-10%	Clay
10-30%	Marly Clay
30-70%	Marl
70-90%	Chalky Marl
90-100%	Chalk

Table 2.12 : Classification of Carbonate Content by Schon (1965) (From Leroiuel et al (1990))

Percentage of Organic Content	Description
< 3%	Inorganic Soil
3 - 10%	Slightly Organic Soil
10 - 30	Moderately Organic Soil
> 30%	Very Organic Soil

Table 2.13 : Classification of Organic Content (From Leroueil et al, 1990)

Number of space dimensions	Terzaghi-Rendulic pseudo-consolidation theory	Biot theory	Coefficient of consolidation
1	$\dfrac{\partial u_e}{\partial t}=c_1\dfrac{\partial^2 u_e}{\partial z^2}$	$\dfrac{\partial u_e}{\partial t}=c_1\dfrac{\partial^2 u_e}{\partial z^2}$	$c_1=\dfrac{kE\,(1-\upsilon)}{\gamma_w(1+\upsilon)\ (1-2\upsilon)}$
2	$\dfrac{\partial u_e}{\partial t}=c_2\left(\dfrac{\partial^2 u_e}{\partial x^2}+\dfrac{\partial^2 u_e}{\partial z^2}\right)$ or: $\dfrac{\partial u_e}{\partial t}=c_x\dfrac{\partial^2 u_e}{\partial x^2}+c_z\dfrac{\partial^2 u_e}{\partial z^2}$	$\dfrac{\partial u_e}{\partial t}=c_2\left(\dfrac{\partial^2 u_e}{\partial x^2}+\dfrac{\partial^2 u_e}{\partial z^2}\right)+\dfrac{1}{2}\dfrac{\partial(\sigma_x+\sigma_z)}{\partial t}$	$c_2=\dfrac{kE}{2\gamma_w(1-2\upsilon)\ (1+\upsilon)}$
3	$\dfrac{\partial u_e}{\partial t}=c_3\left(\dfrac{\partial^2 u_e}{\partial x^2}+\dfrac{\partial^2 u_e}{\partial y^2}+\dfrac{\partial^2 u_e}{\partial z^2}\right)$ or: $\dfrac{\partial u_e}{\partial t}=c_x\dfrac{\partial^2 u_e}{\partial x^2}+c_y\dfrac{\partial^2 u_e}{\partial y^2}+c_z\dfrac{\partial^2 u_e}{\partial z^2}$	$\dfrac{\partial u_e}{\partial t}=c_3\left(\dfrac{\partial^2 u_e}{\partial x^2}+\dfrac{\partial^2 u_e}{\partial y^2}+\dfrac{\partial^2 u_e}{\partial z^2}\right)+\dfrac{1}{3}\dfrac{\partial(\sigma_x+\sigma_y+\sigma_z)}{\partial t}$	$c_3=\dfrac{kE}{3\gamma_w\,(1-2\upsilon)}$

Notation: υ = Poisson's ratio of soil skeleton, E = Young's modulus of soil skeleton.

σ_x, σ_y, σ_z = total stress increments in x, y and z directions respectively at a point in the soil mass.

c_x, c_y, c_z = one-dimensional coefficients of consolidation in x, y and z directions respectively.

Table 2.14 : Comparisons between 1D, 2D and 3D Consolidation Theory (Murray, 1978)

Name of River	Length (km)	Gradient of Slope from Source to the Coastal Plain
Pahang River	420	1:270
Kelantan River	280	1:250
Perak River	350	1:250
Pontain River	40	1:250
Muar River	110	1:230
Klang River	60	1:30
Bernam River	70	1:15
Kinta River	120	1:45
Kedah River	62	1:66

Table 3.1 : Length of Rivers from Peninsular Malaysia with Gradient of Slope from Source to the Coastal Plain

Source of Data	*Localised Depths (Metres) of Various Sites in Peninsular Malaysia*								
	Perlis	Kedah	Penang	Perak	Selangor	Melaka	Johore	Pahang	Terengganu
Ting and Ooi (1977)	-	-	9-12	-	12	-	14	-	-
Abdullah and Chandra (1987)	5-12	5-12	5-25	-	5-30	-	10-35	3-20	3-10
Malaysian Highway Authority (1989)	-	-	-	-	-	-	-	-	-
Kobayashi et al (1990)	-	-	10-12	-	10-16	12-13	-	-	8-10
Aziz (1993)	6-12	9-16	12-22	11-22	10-23	-	9-18	-	-
Mohamad et al (1994)	-	-	19	-	18.5	-	17-20	-	-
Present Study	13-14	-	-	-	-	-	-	-	-

Table 3.2 : Summary of Localised Depths of Peninsular Malaysia Coastal Soft Soil Deposits from Various Researchers

Names of Formation/Member	Classification
Gula Formation	clay,silt and sand with mminor amount of gravel,shells and corals deposited in amarine environemnt after the most recent major low sea-level
Matang Gelugur Member	sand,gravel,shells and corals deposited in a coastal environment
Bagan Datoh Member	sand,clay and silt deposited in an offshore environment
Teluk Intan Member	sand,clay and silt deposited in an inshore environment
Port Weld Member	clay and silt deposited in a mangrove environment
Beruas Formation	clay,silt,sand,gravel and peat deposited in a terrestrial environment after the most recent major low sea-level
Pengkalan Member	peat formed form an insitu vegetation with minor intercalations of clay and silt deposited in a paludal environment
Simpang Formation	clay,silt,sand,gravel and peat deposited in a terrestrial environment before the most recent major low sea-level
Kempadang Formation	clay,silt and sand deposited in a marine environment before the most recent major low sea-level

Table 3.3 : Sub Division of Peninsular Malaysia Quarternary Sediments by the Geological Society of Malaysia (Bosch, 1988)

Source of Data	Undrained Shear Strength Parameters of Peninsular Malaysia Coastal Soft Soil Deposits		
WEST COAST	Undrained Shear Strength (C_u) (kPa)	Remoulded Shear Strength (kPa)	Sensitivity
Ting and Chan (1971)	-	-	4
Ting and Ooi 1977)	10-60	1-20	2-6
Abdullah and Chandra (1987)	20-40	-	1.5-18
Malaysian Highway Authority (1989)	8-42	2-12	2-8
Kobayashi et al (1990)	-	-	2-10
Nicholls and Ho (1990)	-	-	2-8
Aziz (1993)	10-60	2-20	2-5
Mohamad et al (1994)	8-55	-	2-15
Present Study	10-40	1-13	2-8
EAST COAST			
Abdullah and Chandra (1987)	12-29	-	-

Note : Data obtained from Present Study will be discussed in a later Chapter

Table 3.4 : Summary of Undrained Shear Strength Parameters of Peninsular Malaysia Coastal Soft Soil Deposits from Various Researchers

Source of Data	Classification Properties of Peninsular Malaysia Coastal Soft Soil Deposits							
WEST COAST	Natural Moisture Content (%)	Bulk Density (kN/m³)	Specific Gravity	Particle Size Distribution (%)	Activity	Liquid Limit (%)	Plastic Limit (%)	Liquidity Index
Ting and Ooi (1977)	20-140	-	-	33-65 clay 24-62 silt 1-36 sand	-	40-155	10-45	-
Abdullah and Chandra (1987)	20-175	14.6-15	2.53-2.6	15-55 clay 38-70 silt 7-16 sand	Normal to Active	-	-	0.5-1.2
Malaysian Highway Authority (1989)	20-120	14-17	-	30-70 clay 25-55 silt 1-30 sand	-	40-100	20-40	0.4-2.3
Kobayashi et al (1990)	40-125	14.5-17.5	2.45-2.7	25-85 clay 15-60 silt 0-45 sand	-	50-130	20-70	-
Aziz (1993)	15-130	14-15.5	2.6	27-59 clay 25-64 silt 2-28 sand	Inactive to Active (0.77-4)	40-130	16-53	0.1-1.6
Mohammad et al (1994)	12-175	13-16.5	2.35-2.75	50-60 clay 40-50 silt < 5 sand	Normal to Active (1.04-1.8)	50-150	20-65	-
Present Study	20-160	13-16	2.5-2.8	50-60 clay 20-40 silt 0-25 sand	Inactive to Active (0.5-2.0)	40-125	10-40	0.1-2.1
EAST COAST								
Abdullah and Chandra (1987)	21-107	16.3-17.1	2.5-2.57	31-56 clay 16-49 silt 6-28 sand	-	-	-	-
Kobayashi et al (1994)	70-100	14.5-15.5	2.65-2.7	-	-	-	-	-
Mohamad et al (1994)	-	-	-	-	Inactive to Active (0.64-1.15)	-	-	-

Note : Data Obtained from Present Study will be discussed in a later Chapter

Table 3.5 : Summary of Classification Properties of Peninsular Malaysia Coastal Soft Soil Deposits from Various Researchers

Source of Data	Chemical Properties of Peninsular Malaysia Coastal Soft Soil Deposits					
WEST COAST	Organic Content (%)	Salinity (gm/l)	pH	Chloride Content (%)	Sulphate Content (%)	Carbonate Content (%)
Ting and Ooi (1977)	1-17	20-40		-	-	-
Abdullah and Chandra (1987)	1-22.5	13.7	3-8	-	-	-
Kobayashi et al (1990)	-	-	5.3-8.2	0.05-0.7	0.03-0.9	-
Aziz (1993)	0.3-20	-	4-8.5	0.01-4.5	-	-
Nicholls and Ho (1990)	-	0.01-43	-	-	-	-
Present Study	2-15	24-38	5-9	0.007-0.026	0.1-1.7	13.5-22
EAST COAST						
Abdullah and Chandra (1987)	10	-	-	-	-	-
Kobayashi et al (1990)	-	-	7.5-8.5	-	-	0.14-0.31

Note : Data Obtained from Present Study will be discussed in a later Chapter

Table 3.6 : Summary of Chemical Properties of Peninsular Malaysia Coastal Soft Soil Deposits from Various Researchers

Source of Data	Mineralogy of Peninsular Malaysia Coastal Soft Soil Deposits		
	Montmorillonite (%)	Kaolinite (%)	Illite (%)
Malaysian Highway Authority (1989)	0-60	0-80	2-42
Aziz (1993)	4-45	10-50	5-55
Present Study	5-45	35-65	20-50

Note : Data Obtained from Present Study will be discussed in a later Chapter

Table 3.7: Summary of the Mineralogy of Peninsular Malaysia Coastal Soft Soil Deposits from Various Researchers

Source of Data	Compressibility Characteristics of Peninsular Malaysia Coastal Soft Soil Deposits					
WEST COAST	Compression Index (C_c)	Coefficient of Secondary Consolidation (C_α)	Coefficient of Consolidation (c_v) (m^2/yr)	Preconsolidation Pressure (p_c) (kPa)	Over-consolidation Ratio (OCR)	Initial Void Ratio (e_o)
Ting and Ooi (1977)	-	-	0.61-32	-	0.52-4	-
Abdullah and Chandra (1987)	0.4-1.38	-	-	-	-	-
Malaysian Highway Authority (1989)	0.5-2.35	0.001-0.24	0.7-14.7	20-180	0.4-1.9	1.4-3.2
Kobayashi et al (1990)	0.35-1.8	0.001-0.03		30-250	-	-
Aziz (1993)	1-2	-	0.2-1.5	30-150	1-13	0.9-4.1
Mohamad et al (1994)	0.4-3.2	-	0.2-1.3	20-120	0.5-5.0	0.6-3.5
Present Study	0.6-2.2	0.06-0.35	0.1-25	20-100	1-6.5	2-3.8
EAST COAST						
Abdullah and Chandra (1987)	0.02-0.8	-	-	-	-	-
Kobayashi et al (1990)	0.9-1.2	0.01-0.04	-	-	-	-

Note : Data Obtained from Present Study will be discussed in a later Chapter

Table 3.8 : Summary of Compressibility Characteristics of Peninsular Malaysia Coastal Soft Soil Deposits from Various Researchers

Source of Data	Laboratory Shear Strength Parameters of Peninsular Malaysia Coastal Soft Soil Deposits							
WEST COAST	Consolidated Undrained				Unconsolidated Undrained		Consolidated Drained	
	c'(kPa)	ϕ'(^{o})	C_{cu}(kPa)	ϕ_{cu}(^{o})	C_u(kPa)	ϕ_u(^{o})	c_d(kPa)	ϕ_d(^{o})
Ting and Ooi (1977)	34.5	8-24.5			-	-	0	18-24.5
Abdullah and Chandra (1987)	-	-	2.3-17	1.47-6.1	-	-	-	-
Kobayashi et al (1990)	-	20-27	-	-	-	-	-	-
Present Study	4-12	18-27	-	-	-	-	-	-
EAST COAST								
Abdullah and Chandra (1987)	5.3-12	24-38	5.3-32.7	3-14	17.9-25.5	2.5-4.6	0	24-30

Note : Data Obtained from Present Study will be discussed in a later Chapter

Table 3.9 : Summary of Shear Strength Parameters of Peninsular Malaysia Coastal Soft Soil Deposits from Various Researchers

Source of Data	Type of Soil	e_o	w	γ_d(kN/m^2)	LL	PL	C_c	LI	$\phi'(^0)$	Sensitivity
-	Stiff Clay	0.6	21	17						
	Soft Clay	0.9-1.4	30-50	11.5-14.5						
	Soft Organic Clay	2.5-3.2	90-120	6-8						
-	New Orleans Clay				80	25	0.3			
-	Chicago Clay				60	20	0.4			
Norwegian Geotechnical Institute	Seven Sisters Canada				127	35		0.28	19	
	Lilla Eder Sweden				68	30		1.32	25.5	5
	Gota River Sweden				60	27		1.3	23	12
Bishop and Bjerrum (1960)	Silo, Transcona		50		110	30		0.25	23	12

Table 3.10 : Typical Values of Geotechnical Parameters of Soft Soils (Das, 1990)

Description	Undrained Shear Strength (kPa)
Very Soft	< 20
Soft	20-40
Firm	40-75
Stiff	75-150
Very Stiff or Hard	>150

Table 5.1 : Consistency of Material (BS5930, 1981)

Reduced Level (m)	Insitu Permeability (k_{insitu}) (m/s)
2.169	1.04 E-04
6.169	6.95 E-05
10.169	6.91E-05

Table 5.2 : Insitu Permeability Values Obtained from Falling Head Tests Carried Out in Standpipe Piezometers

Reduced Level (m)	Pressure Head (kPa)	Permeability (k) (m/s)
8.169	40	8.82E-07
8.169	100	1.68E-07

Table 5.3 : Vertical Permeability Values Obtained From Triaxial Tests Using Constant Head

Location	Sample Type	Average Depth below Mean Sea Level(m)	Age of Sample (Years B.P.)
Kuala Perlis	Shells Shells Shells	4.2 5.7 12.3	5130 5950 7120
Sungei Acheh	Organics	13.5	7840
Bagan Datoh	Shells Organics Organics	5.5 23.3 24.3	5330 8700 8990
Port Klang	Shells Shells Organics Organics Organics Organics	5.5 7.5 9.5 12.5 13.5 17.5	2950 5350 7580 7780 7710 8030

Table 5.4 : Age of Kuala Perlis Coastal Soft Soil Deposits

Fill Material	Moisture Content (%)	Particle Size Distribution			Undrained Shear Strength (kPa)
		Sand and Gravel (%)	Silt (%)	Clay (%)	
Type I	3-4	85	12	3	N.A.
Type II	12-15	28-46	28-33	26-28	N.A.

Table 5.5 : Geotechnical Properties of Fill Materials Used in Trial Embankment

Note : This table will be updated from time to time as some data are still not available.

Geotechnical Properties	Undisturbed Undrained Shear Strength (kPa)	Remoulded Undrained Shear Strength (kPa)	Sensitivity
Upper Limit			6
Average m.s..l. 1m m.s.l. 10m m.s.l. 15m m.s.l.	 12 35	 3 10 	3
Lower Limit	-		2

m.s.l. : mean sea level

Table 5.6 : Typical Values of Undrained Shear Strength Parameters from Field Vane Tests

Geotechnical Properties	Moisture Content (%)	Liquid Limit (%)	Plastic Limit (%)	Liquidity Index	Unit Weight (kN/m^3)	Specific Gravity	Particle Size Distribution (%)		
							Clay	Silt	Sand
Upper Limit							80	45	25
m.s.l.									
0-10m m.s.l.	140				14.5				
10m m.s.l.	60								
10-15m m.s.l.	40								
0-15m m.s.l.						2.75			
Average							63	32	5
m.s.l.		105%	35%	1.07					
0-10m m.s.l.	110				14.0				
10m m.s.l.	40								
10-15m m.s.l.	27								
15m m.s.l.		65%	20%	0.15					
0-15m m.s.l.						2.6			
Lower Limit							40	20	0
m.s.l.									
0-10m m.s.l.	80				13.5				
10m m.s.l.	25								
10-15m m.s.l.	12								
0-15m m.s.l.						2.5			

m.s.l. : mean sea level

Table 5.7 : Typical Values of Classification Properties of Kuala Perlis Coastal Soft Soil Deposits

Geotechnical Properties	Preconsolidation Pressure	Overconsolidation Ratio	Compression Index	Initial Void Ratio	Coeff. of Secondary Consolidation
Upper Limit					
0-10m m.s.l.			2.2	3.8	
below 10m m.s.l.			2.0	1.0	
Average					0.003
m.s.l	30	4.1			
0-10m m.s.l.			1.4	3.1	
10m m.s.l.	65	1.4			
below 10m m.s.l.			1.0	0.75	
Lower Limit					
0-10m m.s.l.			0.8	2.4	
below 10m m.s.l.			0.3	0.6	

m.s.l. : mean sea level

Table 5.8 : Typical Values of Compressibility Parameters of Kuala Perlis Coastal Soft Soil Deposits

Soil Properties	Kuala Perlis	Muar	Juru
Liquid Limit(%)	50-120	40-80	40-130
Plastic Limit(%)	20-40	20-40	20-45
Moisture Content(%)	70-130	50-100	60-130
Bulk Density (kN/m^3)	13-17	14-17	14-19
Liquidity Index	0.5-2	1-2	0.5-1.5
Preconsolidation Pressure (P_c)(kPa)	30-70	20-110	20-100
OCR	1-3	0.9-1.9	1.5-5
Void Ratio	2-3	1.4-3	1-3
Compression Index (C_c)	1-2	0.5-2.2	0.5-2.5
Undrained Shear Strength (C_u) (kPa)	10-35	8-30	8-35
Sensitivity	3-5	2-7	3-7

Table 8.1 : Comparison of the Geotechnical Properties of the Three Trial Embankment Sites

Trial Embankment Site	Volume Displaced Laterally as % of Volume Displaced Vertically
Kuala Perlis	3-13%
Muar	0.5-15%
Juru	13-37%

Table 8.2 : Volume Displaced Laterally (ΔV_h) as a Percentage of Volume Displaced Vertically (ΔV_v)

PLATES

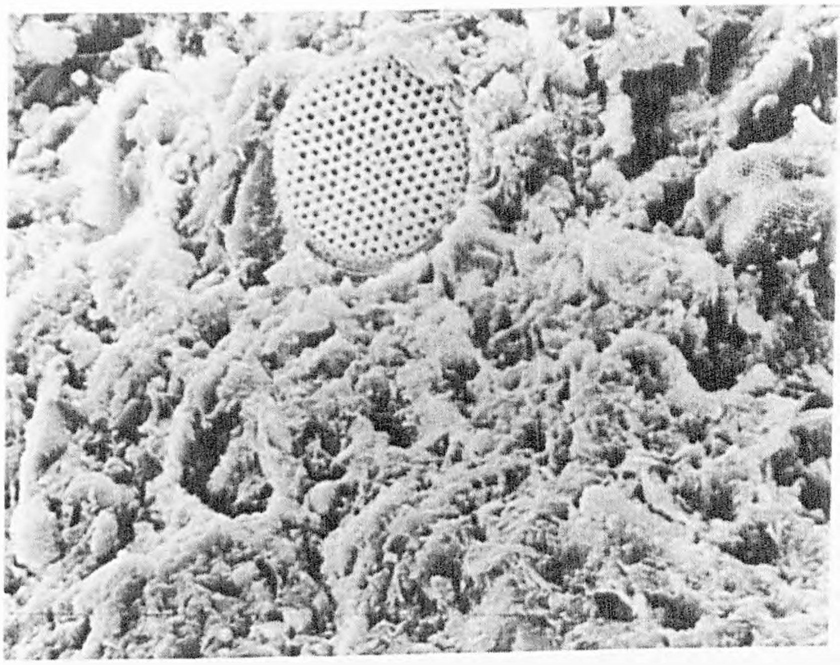


Plate 3.1 : Organic Matter in Peninsular Malaysia Coastal Soft Soil Deposits (Aziz, 1993)

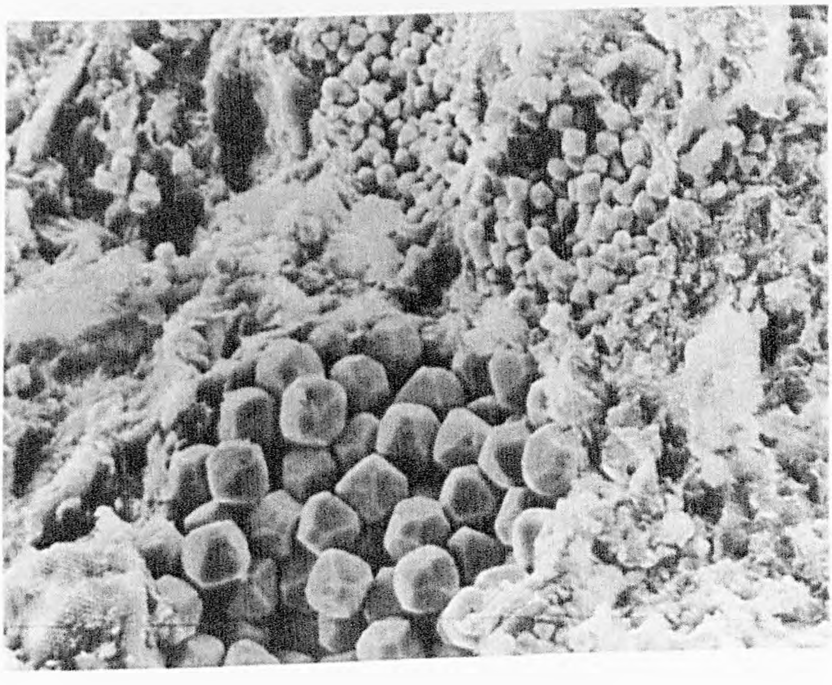


Plate 3.2 : Pyrites in Peninsular Malaysia Coastal Soft Soil Deposits (Aziz, 1993)

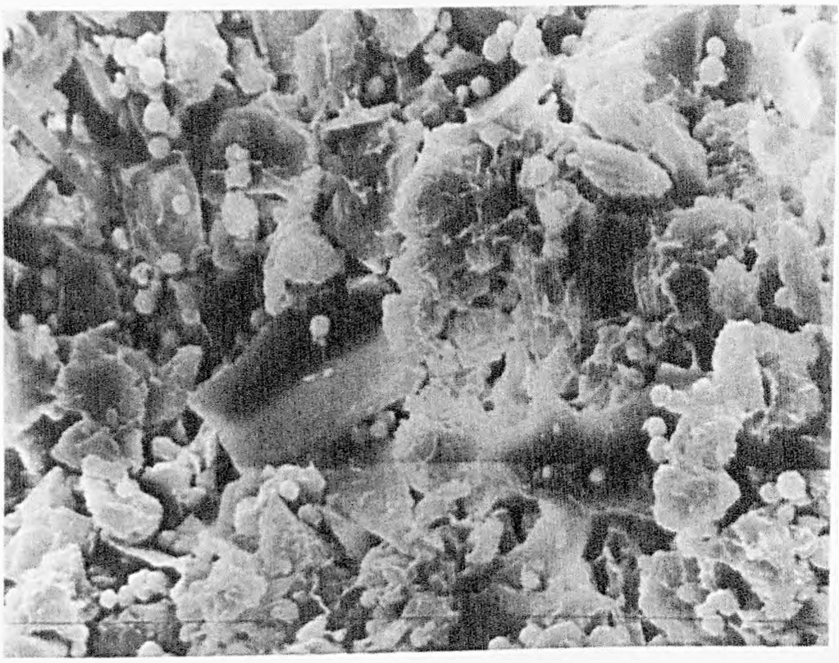


Plate 3.3 : Granular Matrix in Peninsular Malaysia Coastal Soft Soil Deposits (Aziz, 1993)

Plate 4.1 : Surveying of the Trial Embankment Site Prior to Main Site Investigation and Instrumentation Works

Plate 4.2 : Polyfelt Geotextile TS600 used as a Seperator Layer on the Trial Embankment

Plate 4.3 : Pegging the Geotextile by Wooden Stakes

Plate 4.4 : Dumping of Drainage Material by Lorries

Plate 4.5 : Levelling of the Drainage Material by Backpushers

Plate 4.6 : Finished Level of the Drainage Fill Material

Plate 4.7 : Checking for Leakage in Pneumatic Piezometers

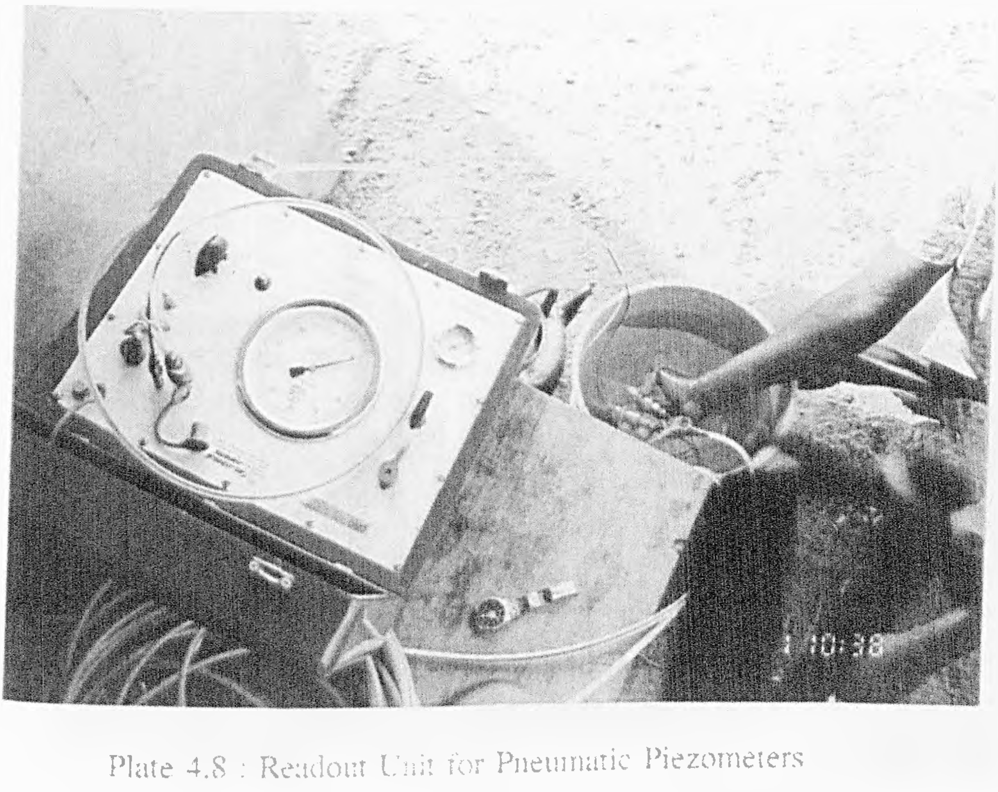


Plate 4.8 : Readout Unit for Pneumatic Piezometers

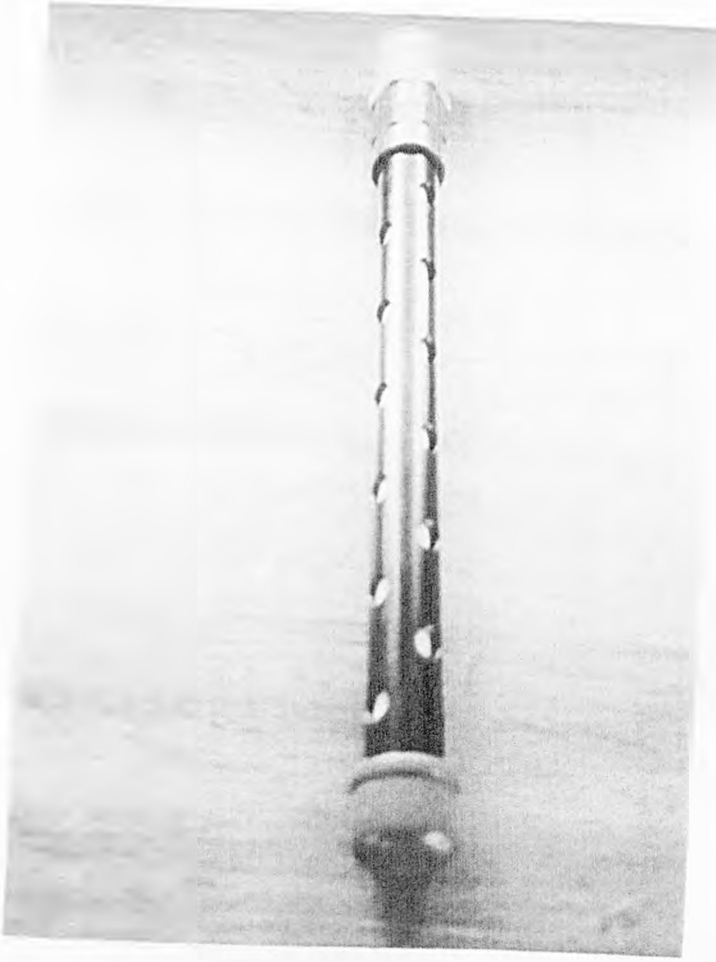


Plate 4.9 : Standpipe Piezometer Tip

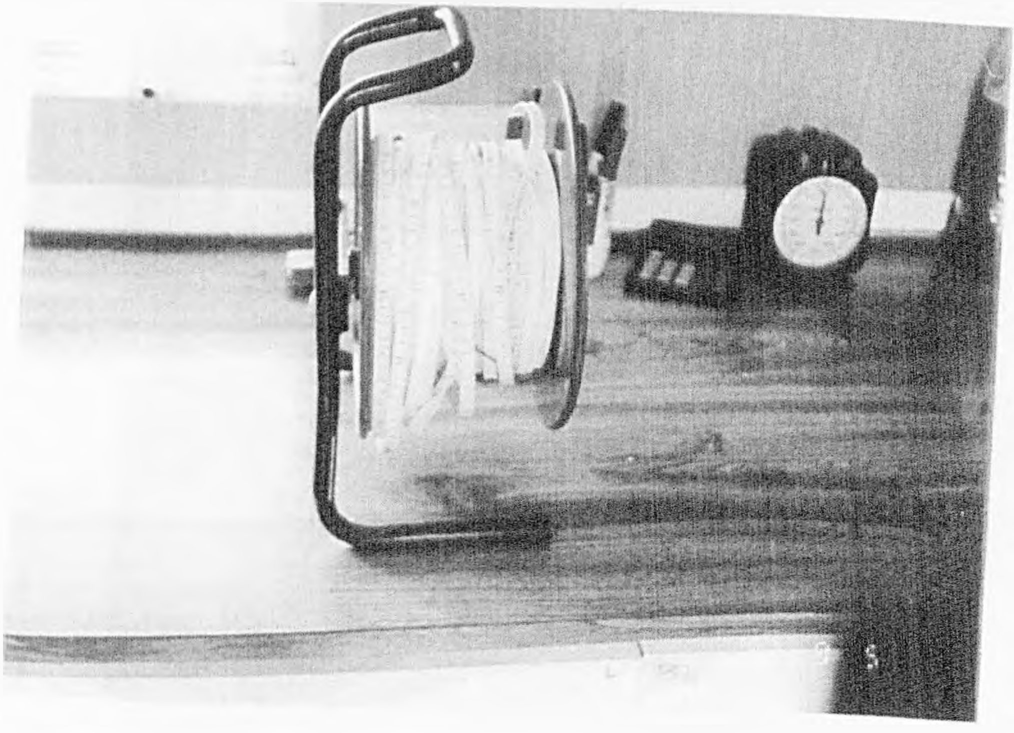


Plate 4.10 : Dipmeter Used for Taking Readings of Standpipe Piezometers

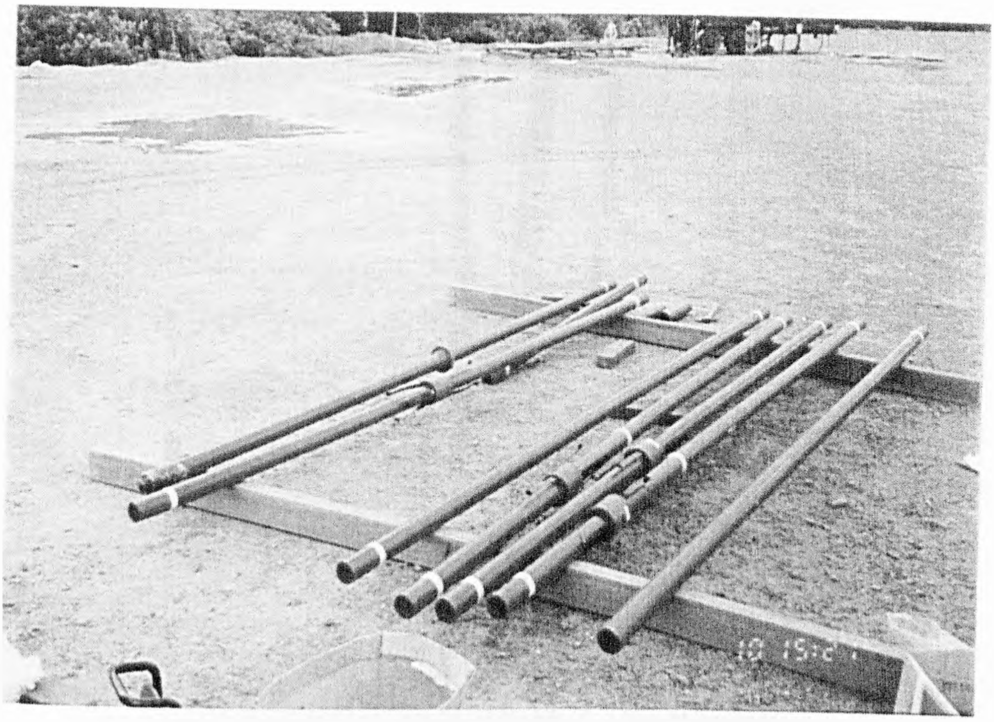


Plate 4.11: Inclinometer/Extensometer Tubes

Plate 4.12 : Insertion of Torpedo Probe to Take Readings of the Inclinometer

Plate 4.13: Spider Magnets Used for the Extensometer

Plate 4.14 : Type of Settlement Plate Used in Trial Embankment

Plate 4.15: Settlement Plate Lowered in Dug Hole

Plate 4.16 : Taking of Reduced Levels of Settlement Plates

Plate 4.17 : Heave Markers Installed Near the South Trial Embankment

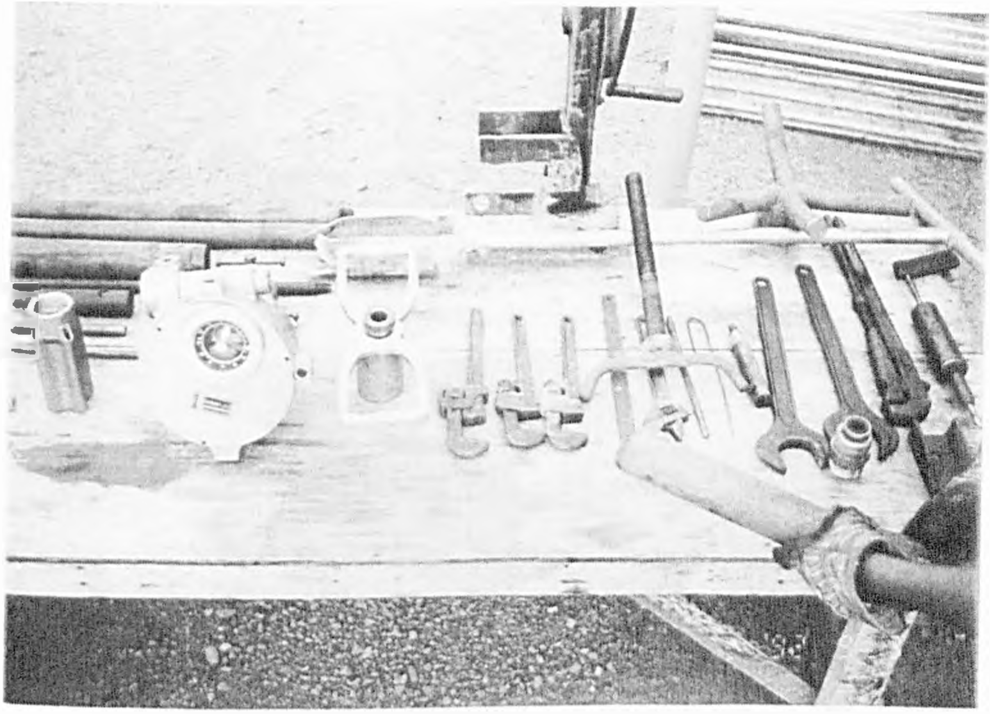


Plate 4.18: Equipment Used for Field Vane Testing

Plate 4.19 : Augering of Hole for Field Vane Testing

Plate 4.20 : Insertion of the Vane Tip for Field Vane Testing

Plate 4.21 Shearing of the Soil During Field Vane Testing

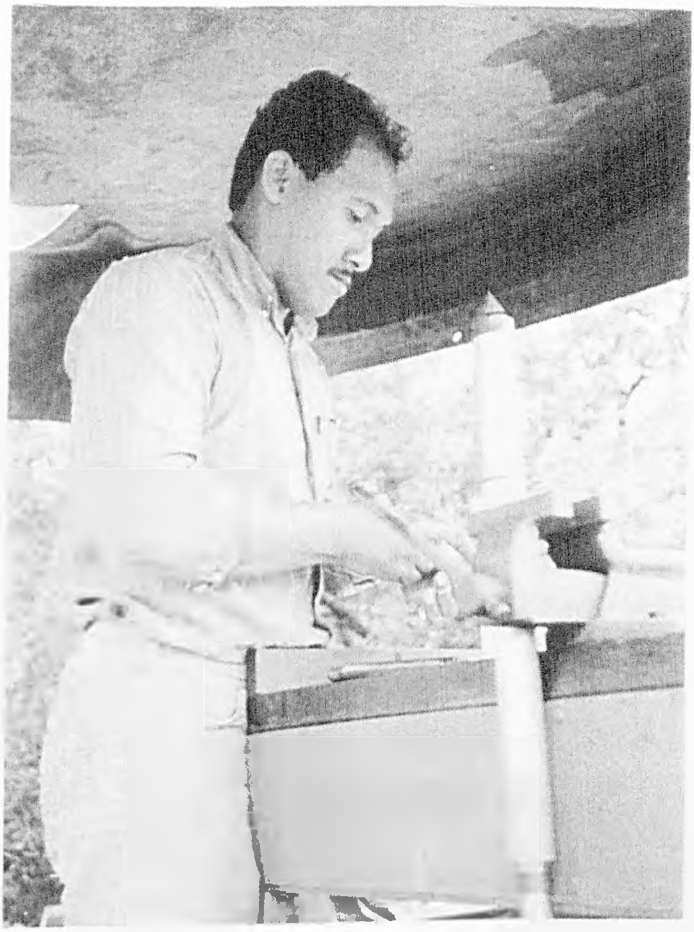


Plate 4.22 : Type of Piezocone Tip Used in the Site Investigation Work of the South Trial Embankment

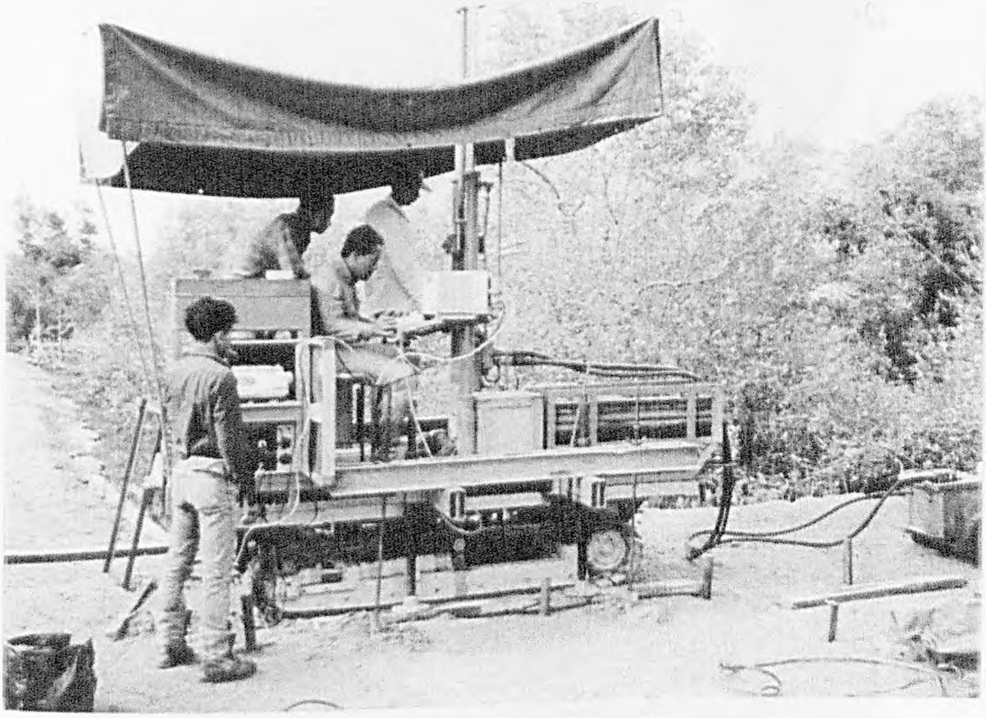


Plate 4.23 : Type of Machinery Used for Piezocone Testing in the South Trial Embankment

Plate 4.24: Hole Dug for Water Replacement Method

Plate 4.25 : Water is Weighed Prior to Filling of Hole

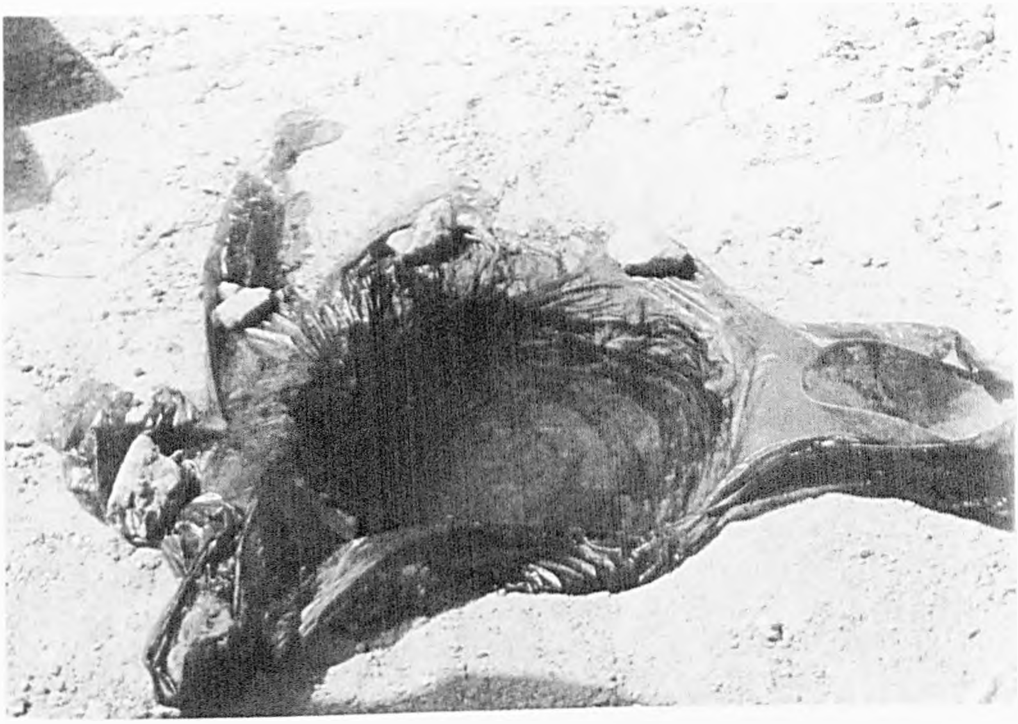


Plate 4.26 : The Hole Being Filled with Water

Plate 4.27 : Samples Stored Horizontally Prior to Testing

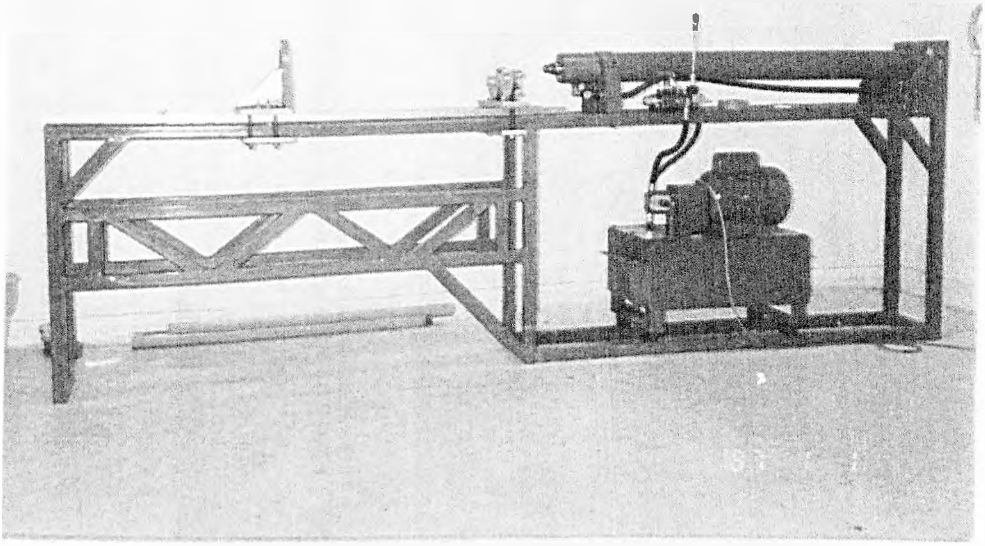


Plate 4.28: The Horizontal Extruder Used for Extrusion of Undisturbed Samples

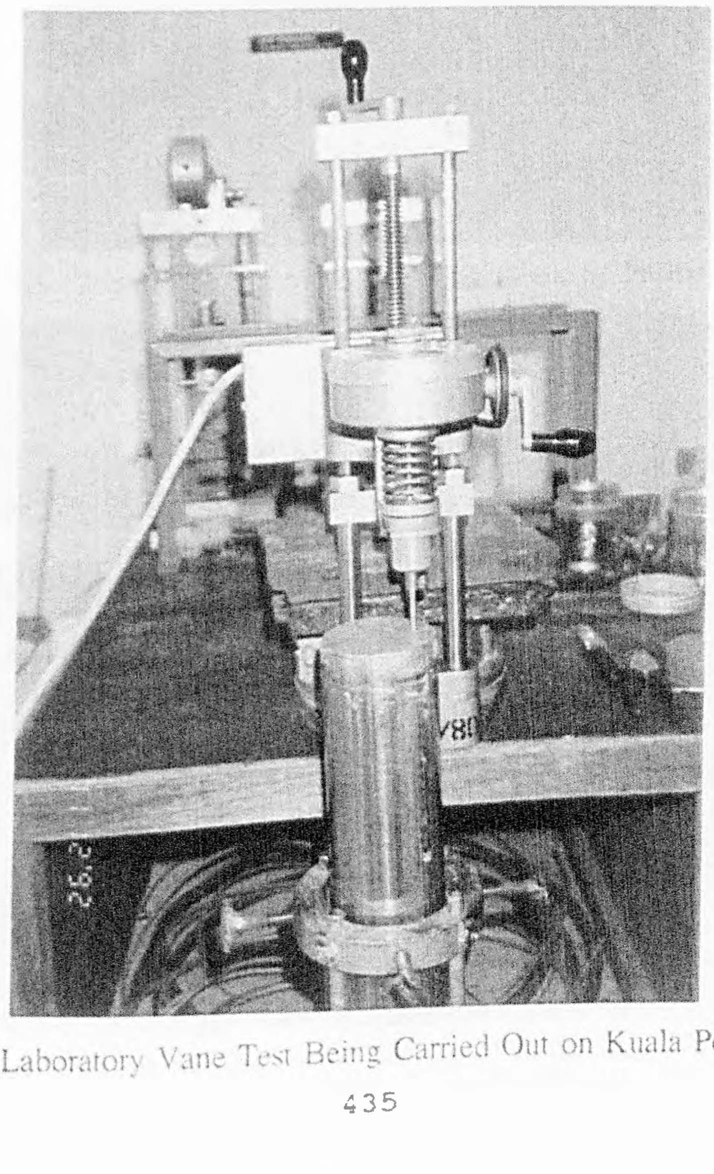


Plate 4.29 : Laboratory Vane Test Being Carried Out on Kuala Perlis Samples

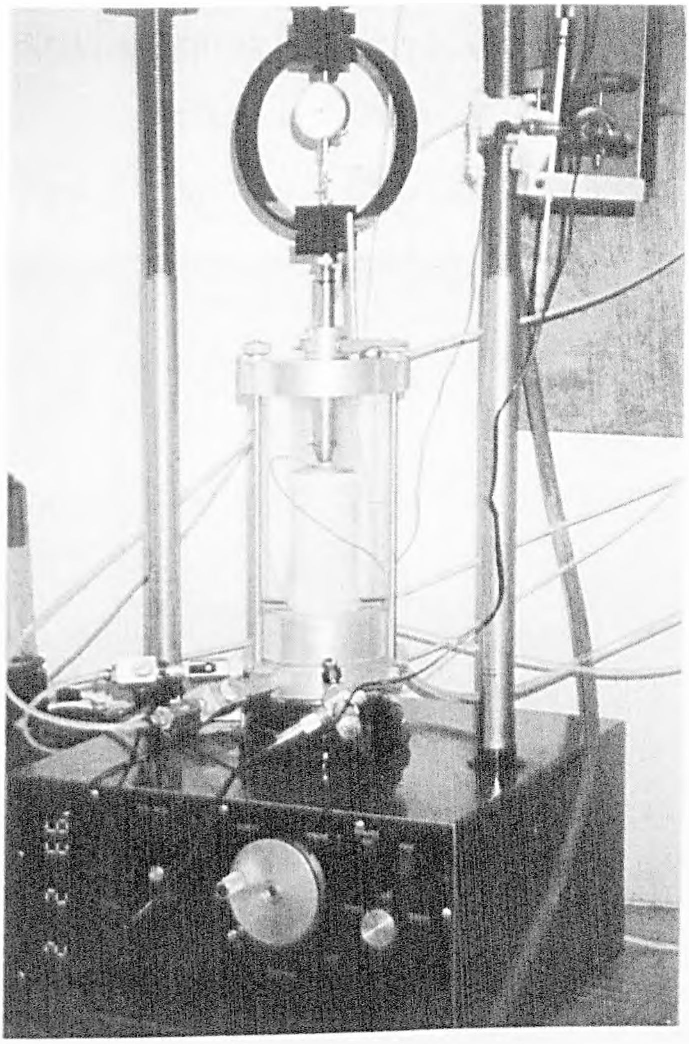


Plate 4.30 : Triaxial Test Setup for Testing of Kuala Perlis Samples

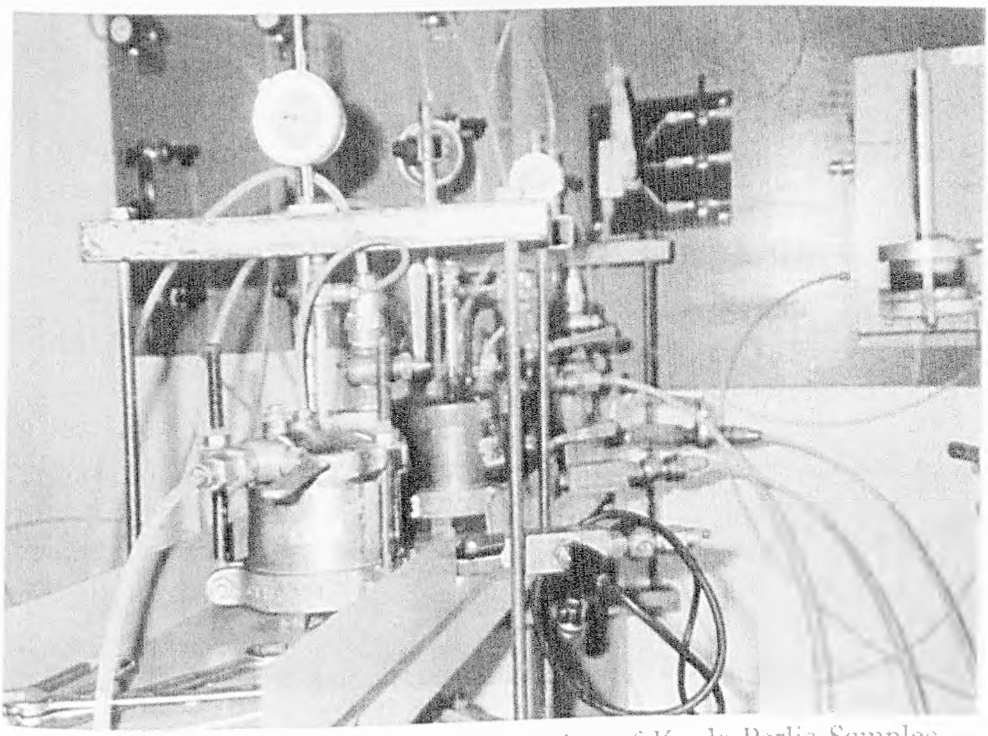


Plate 4.31 : Rowe Cell Setup for Testing of Kuala Perlis Samples

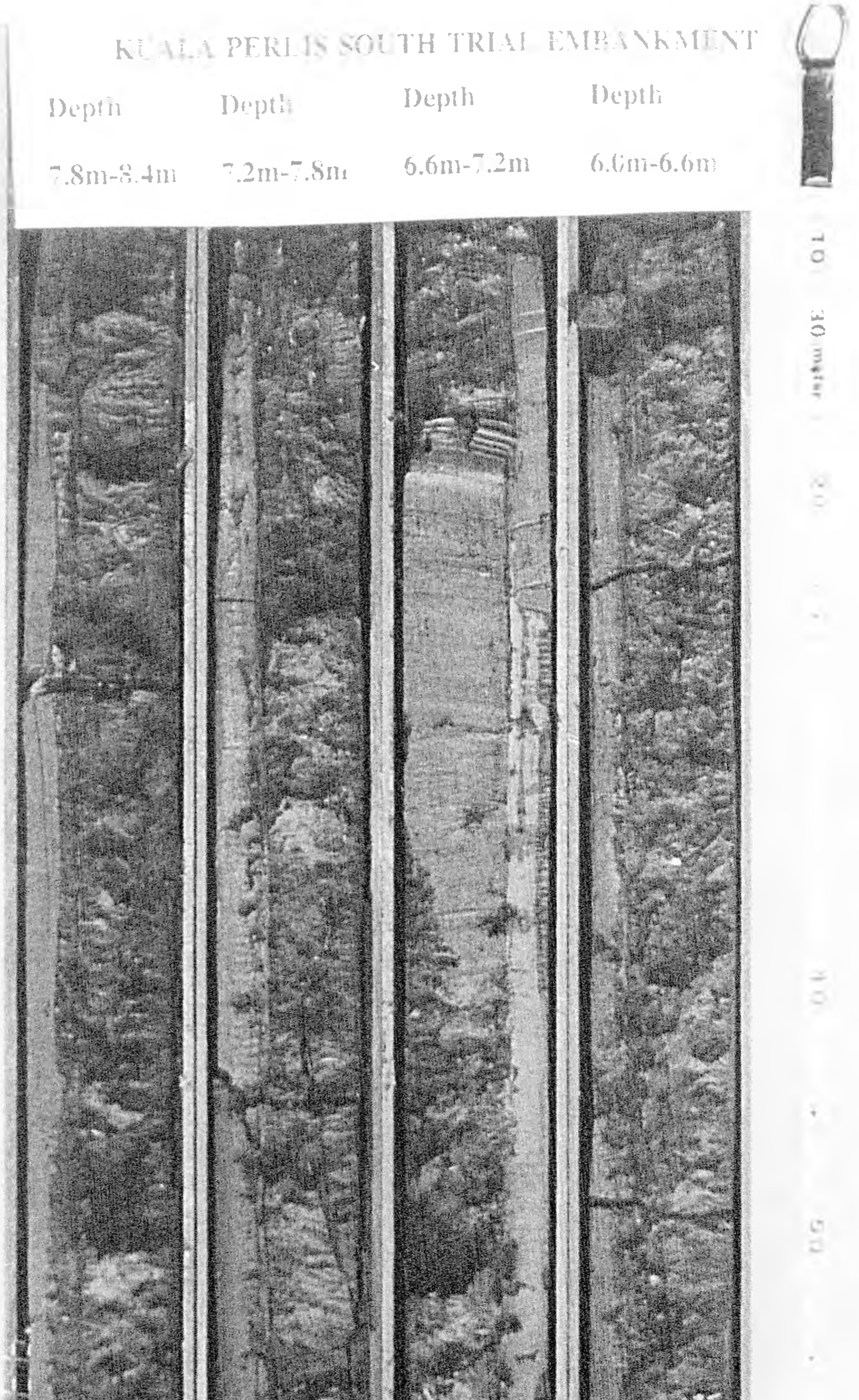


Plate 5.1 :Macrofabric of Kuala Perlis Coastal Soft Soil Deposit (6m to 8.4m)

8.4m-9.0m 9.0m-9.6m 9.6m-10.2m 10.2m-10.8m 10.8m-11.4m 11.4m-12.0m

KUALA PERLIS SOUTH TRIAL EMBANKMENT

Depth	Depth	Depth
13.2m-13.8m	12.6m-13.2m	12.0m-12.6m

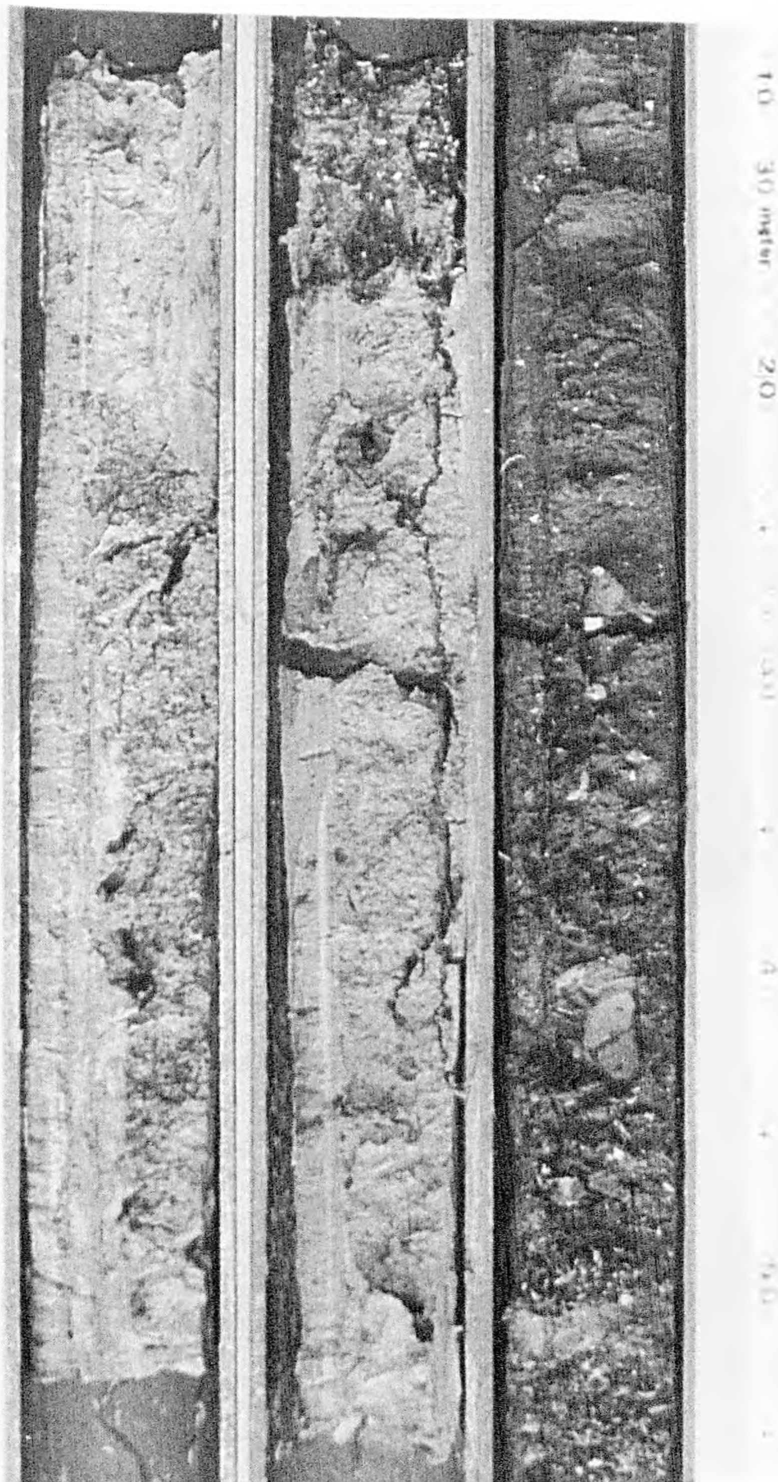


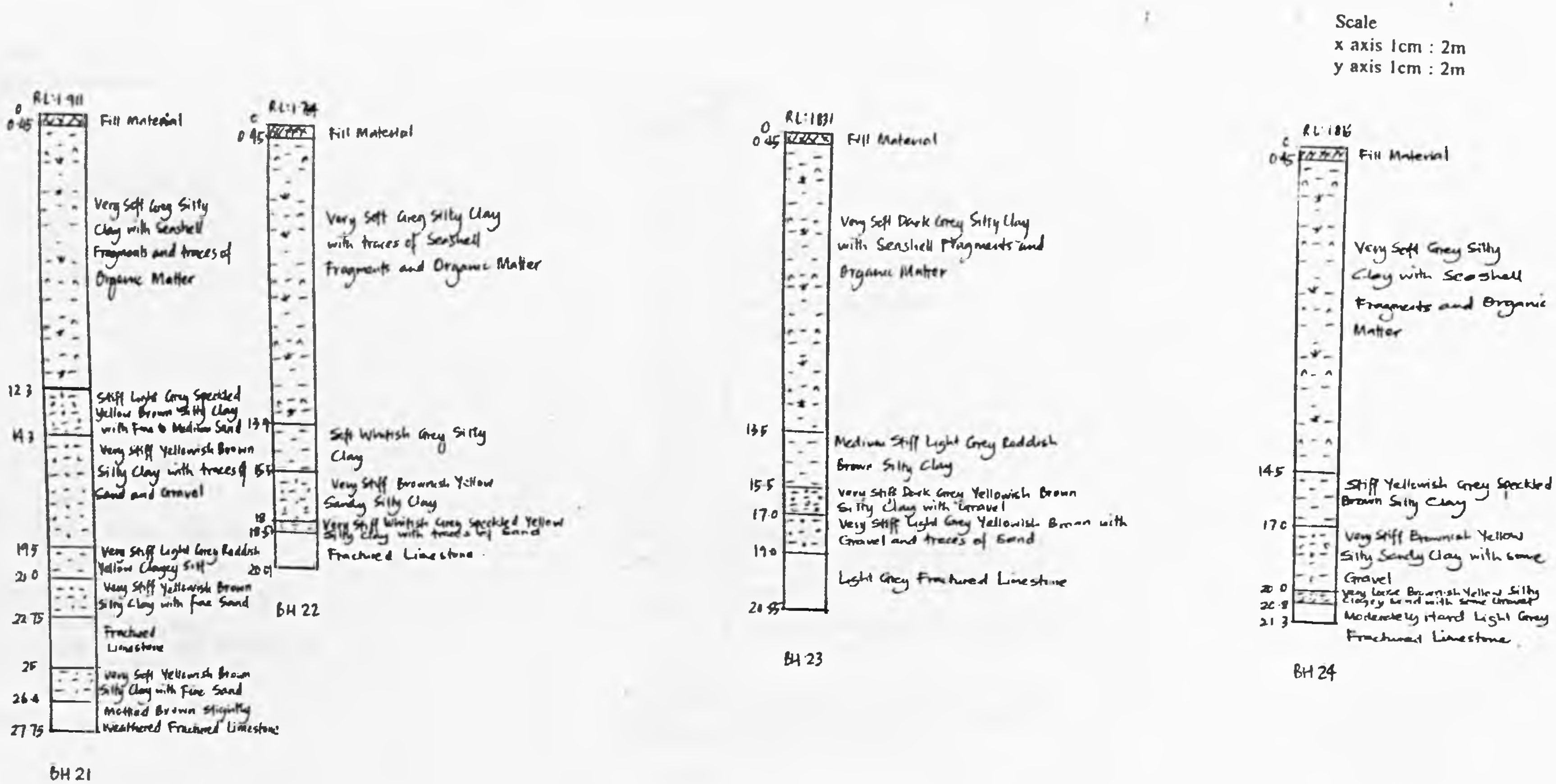
Plate 5.3 : Macrofabric of Kuala Perlis Coastal Soft Soil Deposit (12.0m to 13.8m)

Plate 6.1 : Crack Appearing on the Kuala Perlis South Trial Embankment

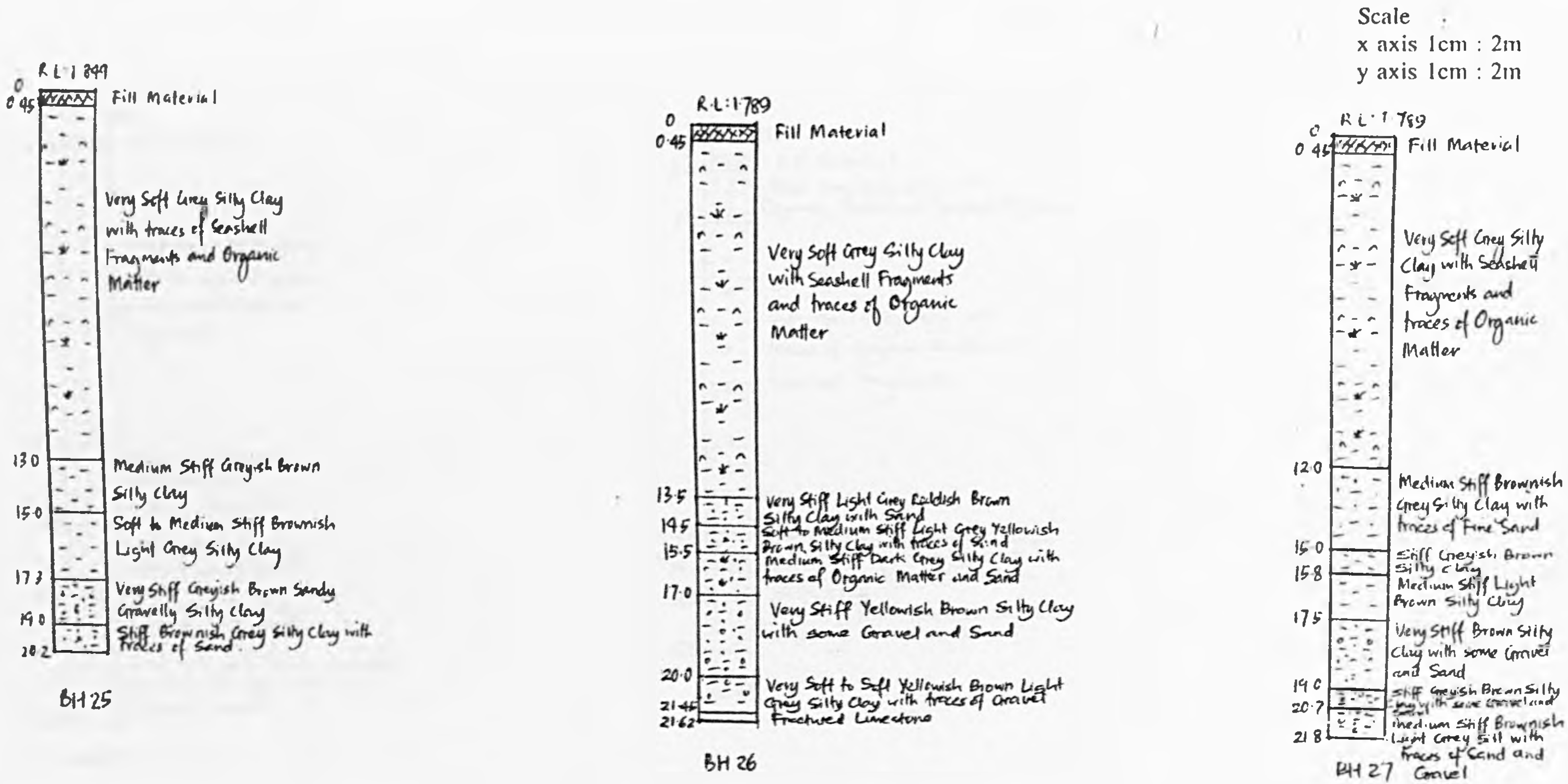
APPENDICES

APPENDIX 5.1

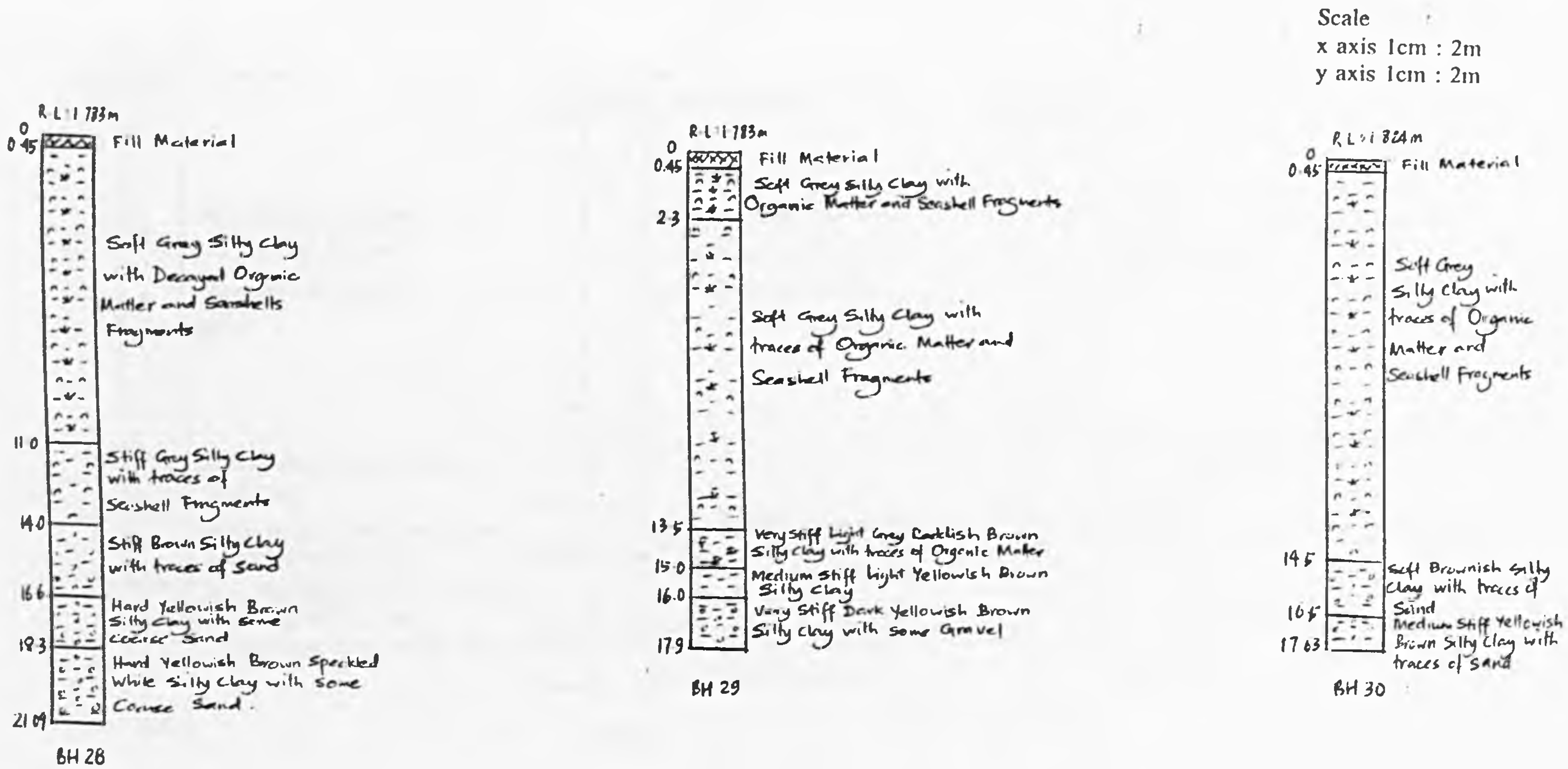
BOREHOLE LOGS OF THE TRIAL SITE BOTH IN THE WEST-EAST AND SOUTH-NORTH DIRECTIONS



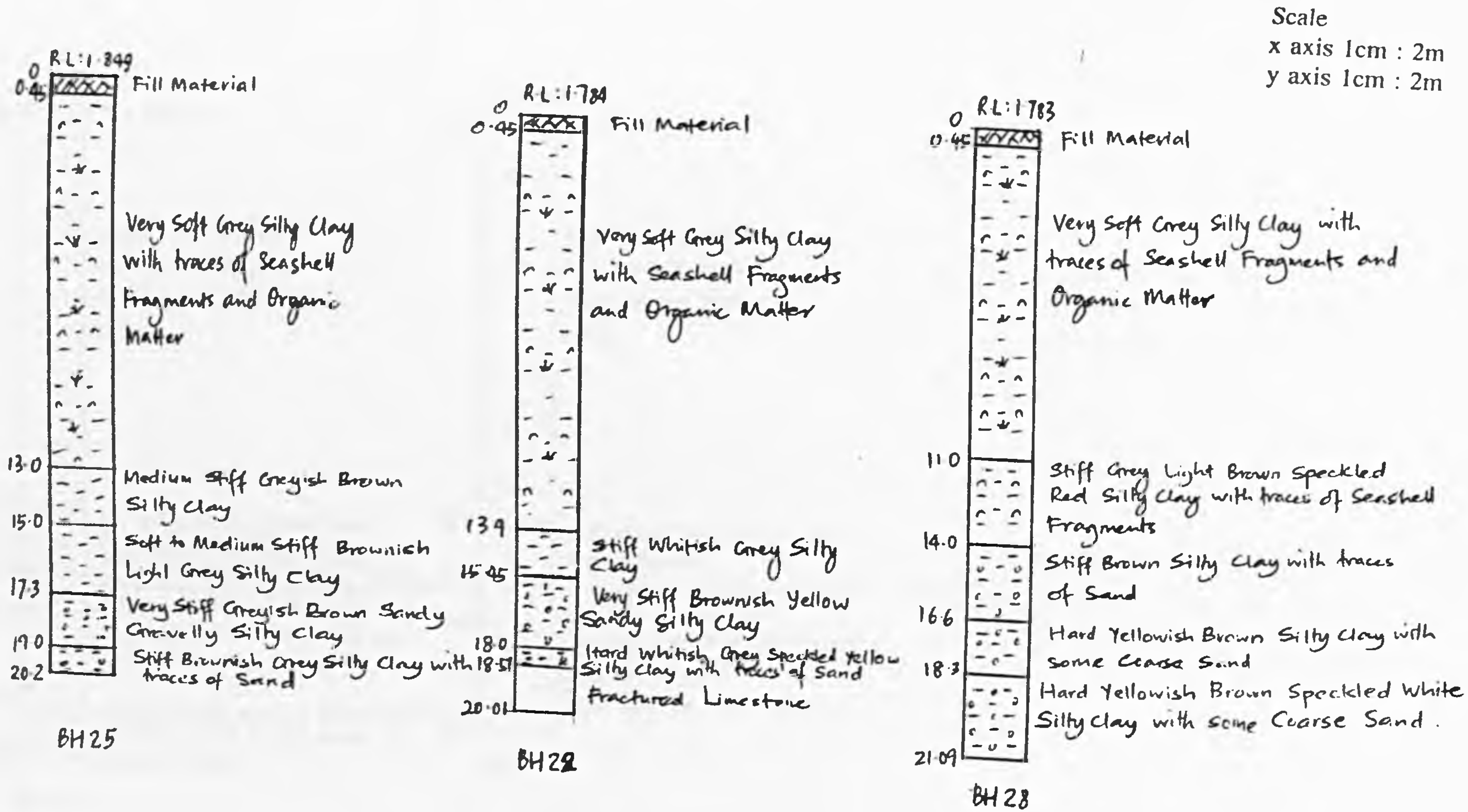
Borehole Logs in the West-East Direction (BH21 to BH24)



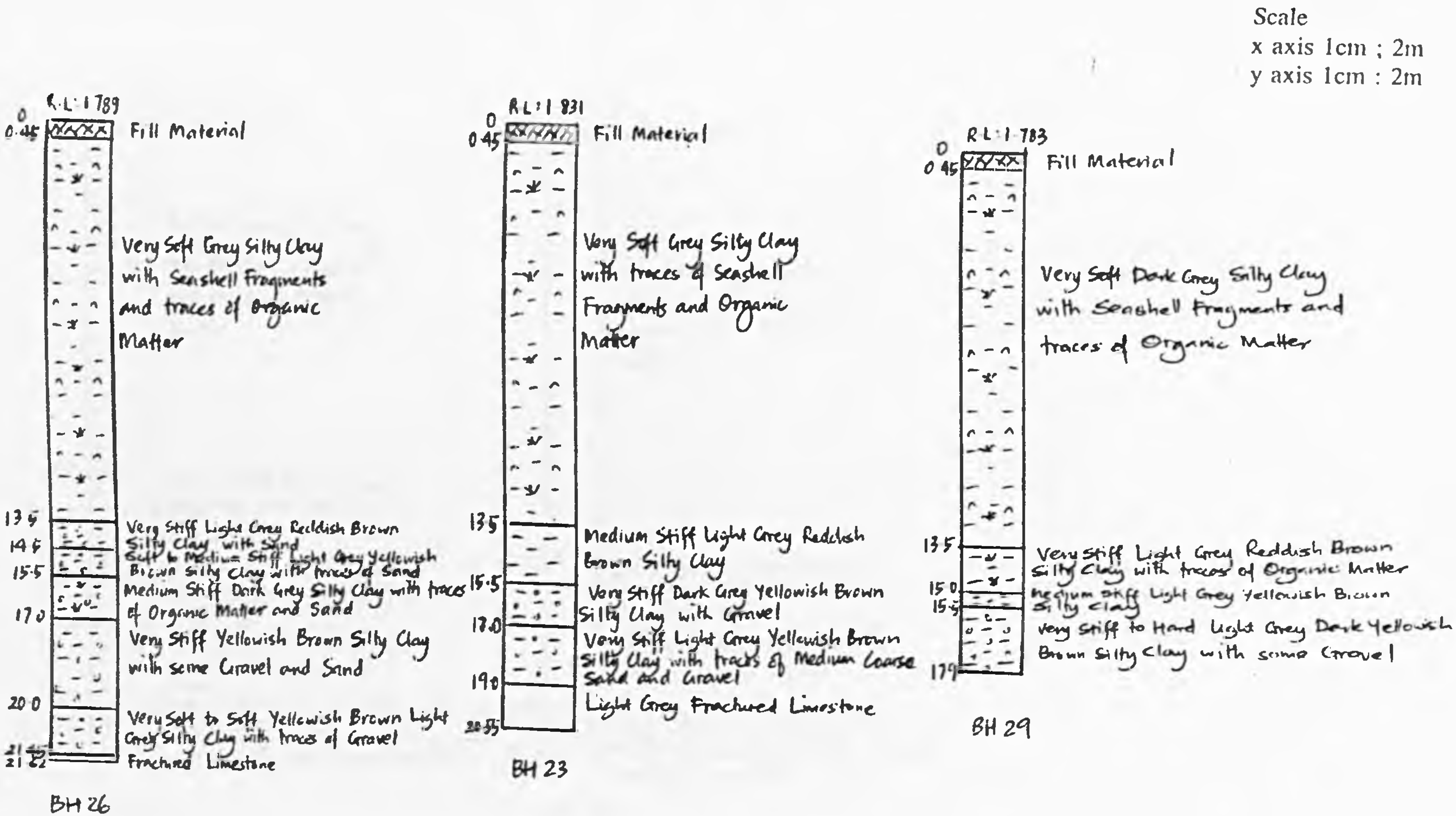
Borehole Logs in the West-East Direction (BH25 to BH27)



Borehole Logs in the West-East Direction (BH28 to BH30)

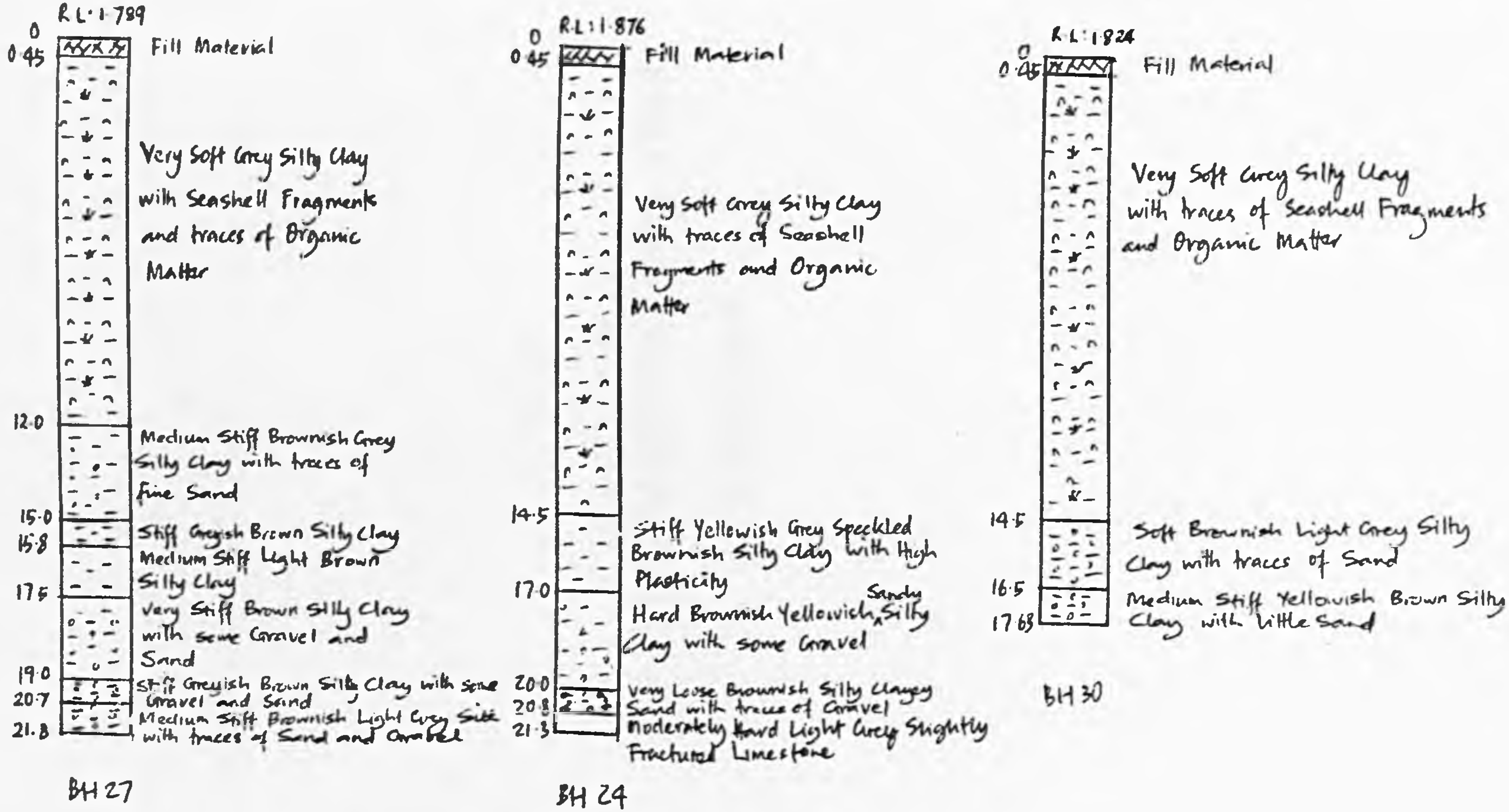


Borehole Logs in the South-North Direction (BH25 to BH28)



Borehole Logs in the South-North Direction (BH26 to BH29)

Scale
x axis 1cm : 2m
y axis 1cm : 2m

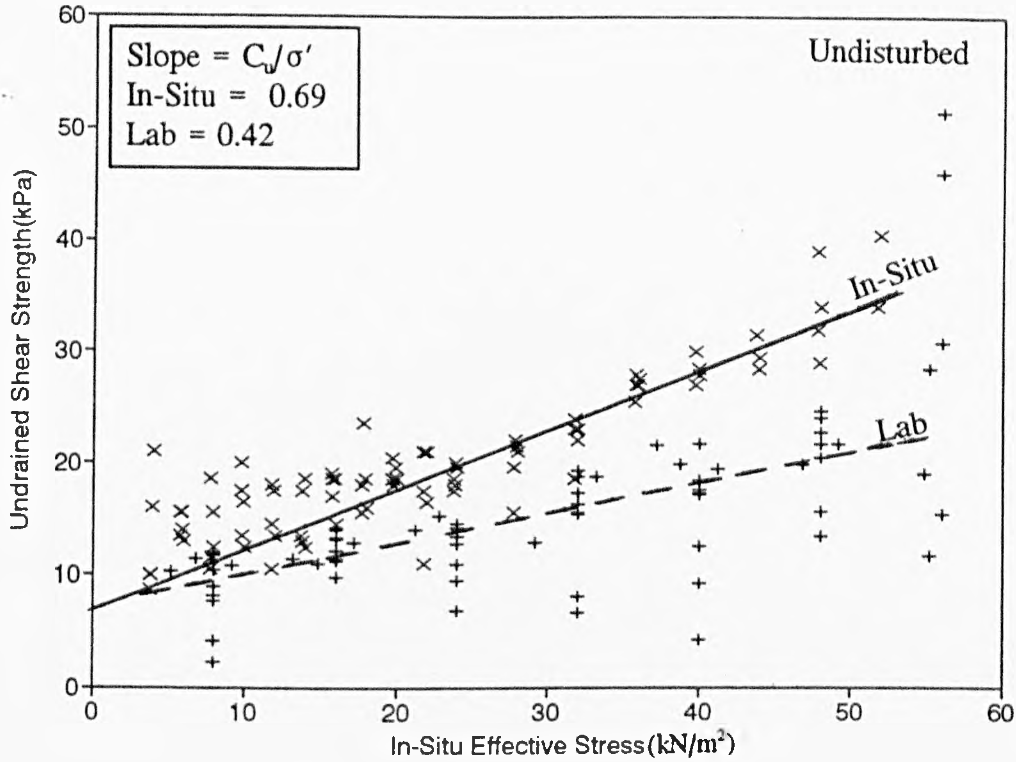


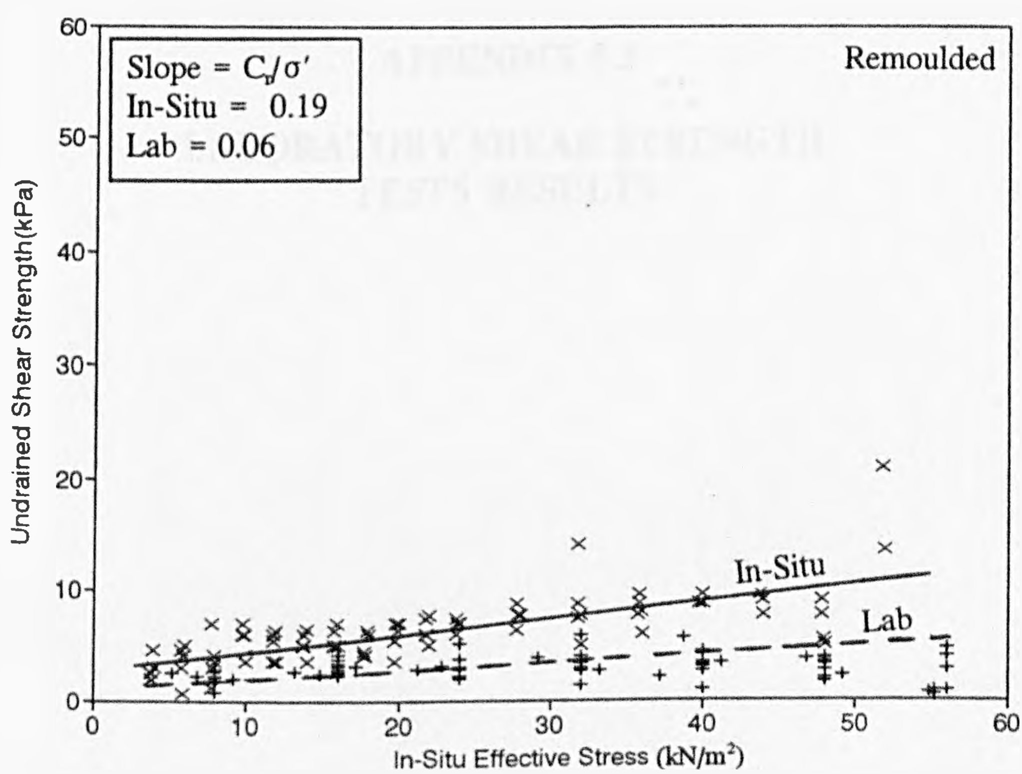
Borehole Logs in the South-North Direction (BH27 to BH30)

APPENDIX 5.2

FIELD VANE AND LABORATORY VANE TESTS RESULTS

(C_u vs σ')


Slope = C_u/σ'
In-Situ = 0.69
Lab = 0.42
Undisturbed
In-Situ
Lab
Undrained Shear Strength(kPa)
In-Situ Effective Stress(kN/m²)
0
10
20
30
40
50
60

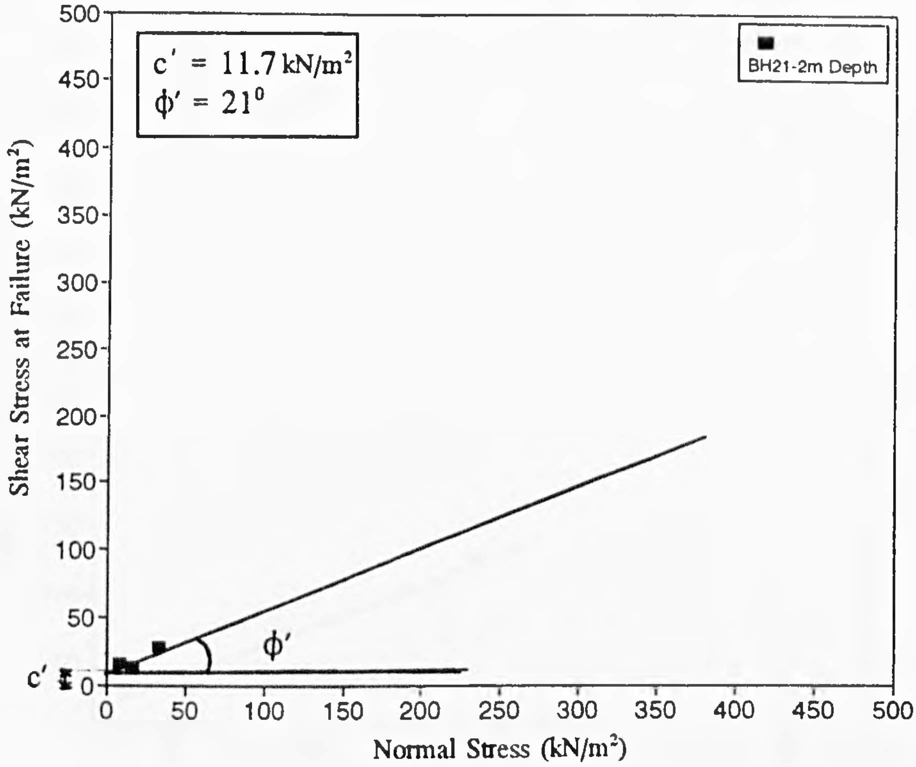

Slope = C_u/σ'
In-Situ = 0.19
Lab = 0.06
Remoulded
In-Situ
Lab
Undrained Shear Strength(kPa)
In-Situ Effective Stress (kN/m²)
0
10
20
30
40
50
60

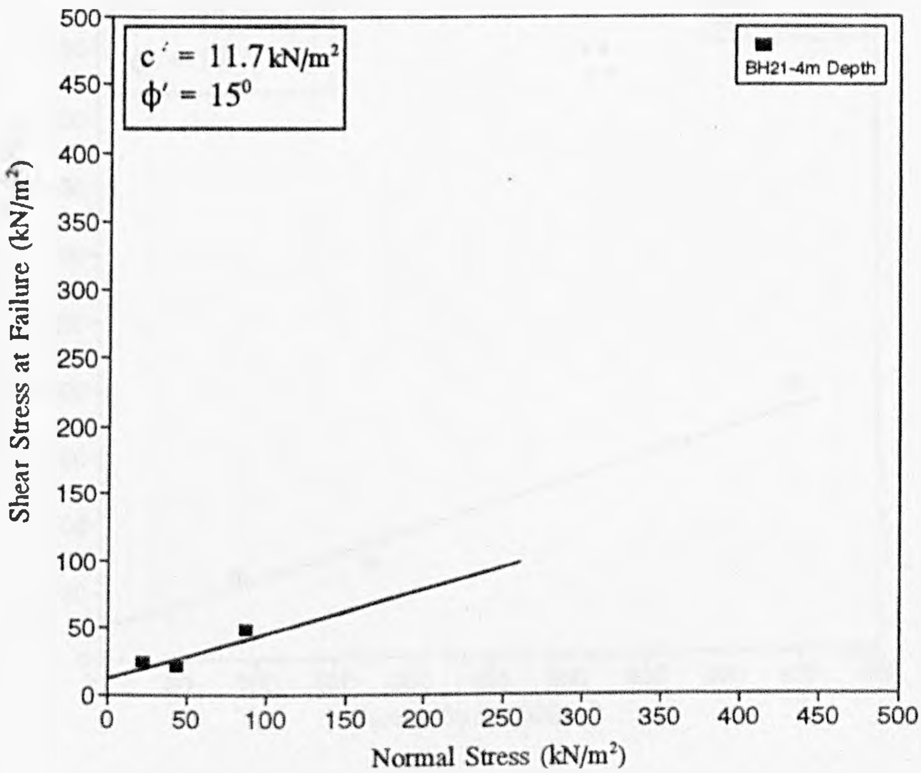
APPENDIX 5.3

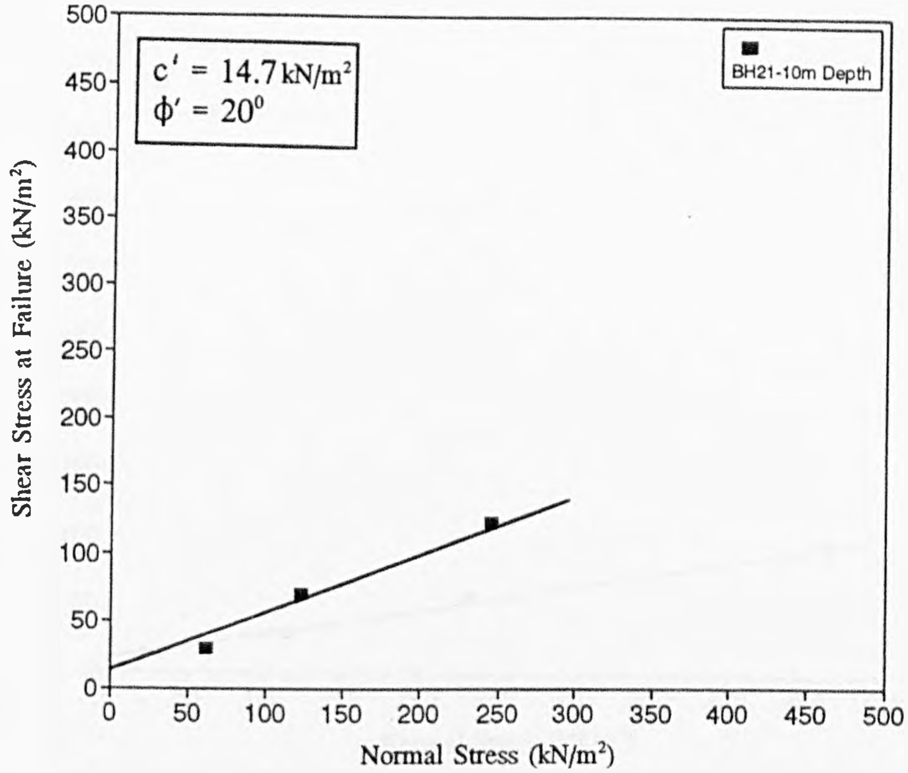
LABORATORY SHEAR STRENGTH TESTS RESULTS

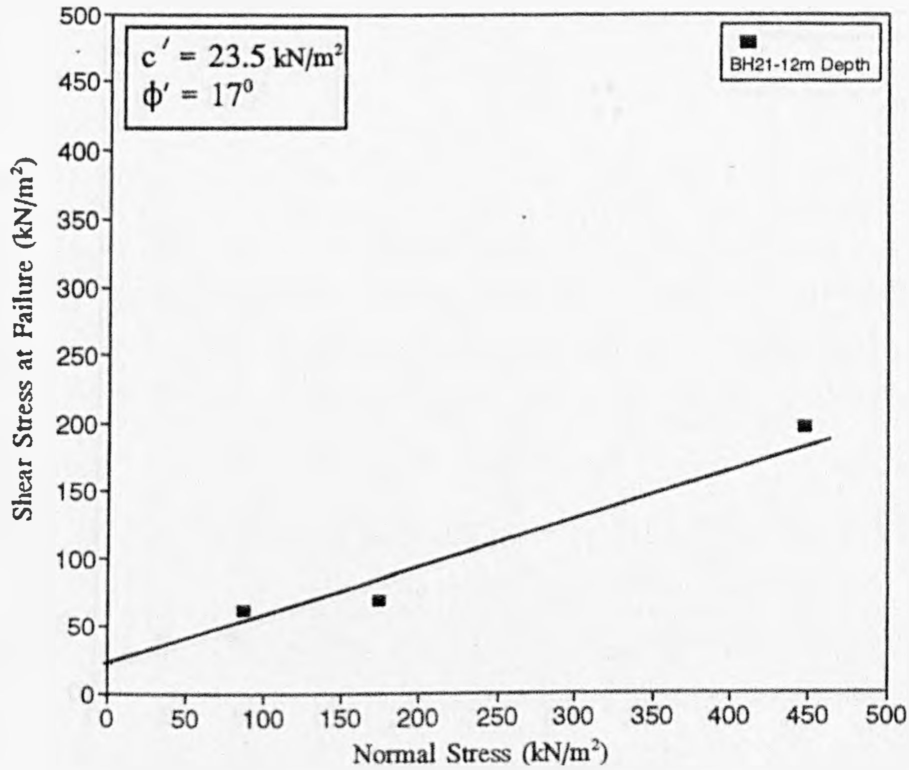
DIRECT SHEAR BOX TESTS

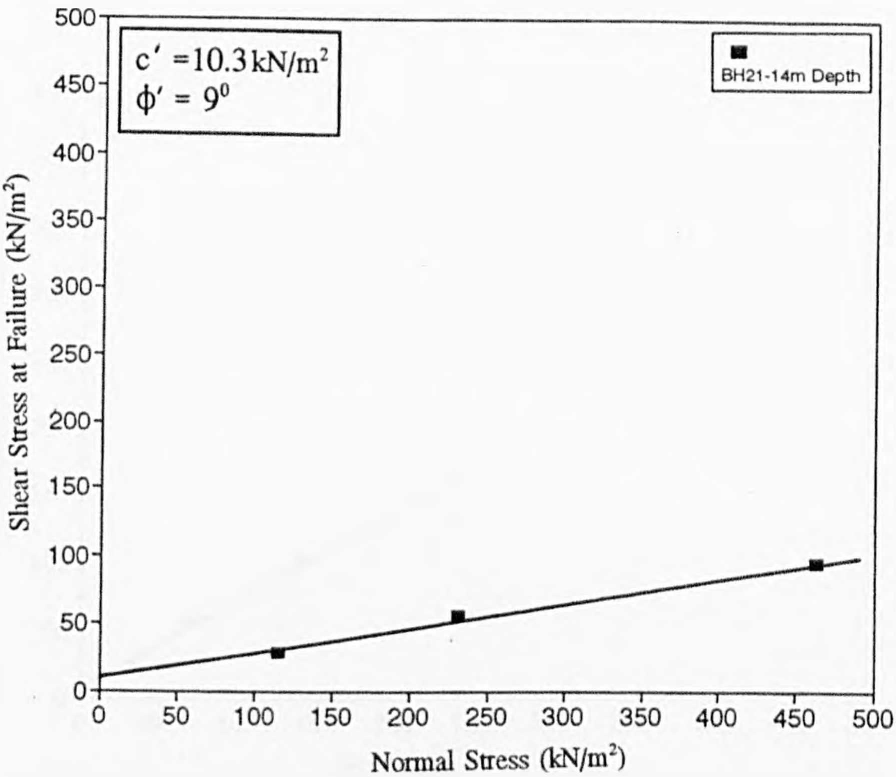
(VERTICAL ALIGNMENT)

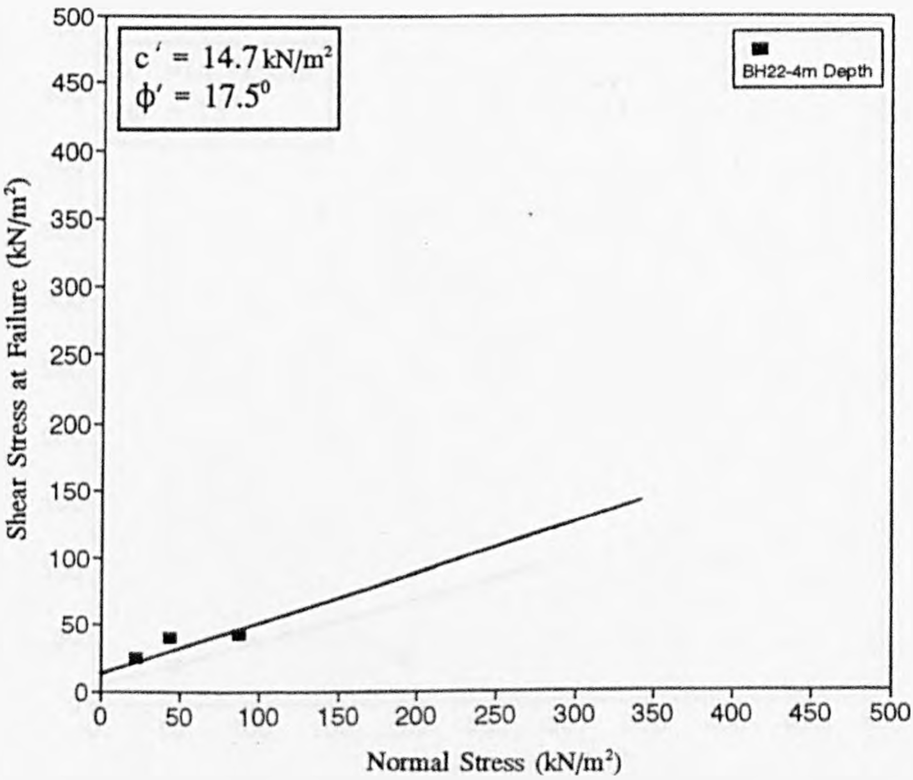

c′ = 11.7 kN/m²
φ′ = 21⁰
BH21-2m Depth
Shear Stress at Failure (kN/m²)
Normal Stress (kN/m²)
φ′
c′
0
50
100
150
200
250
300
350
400
450
500

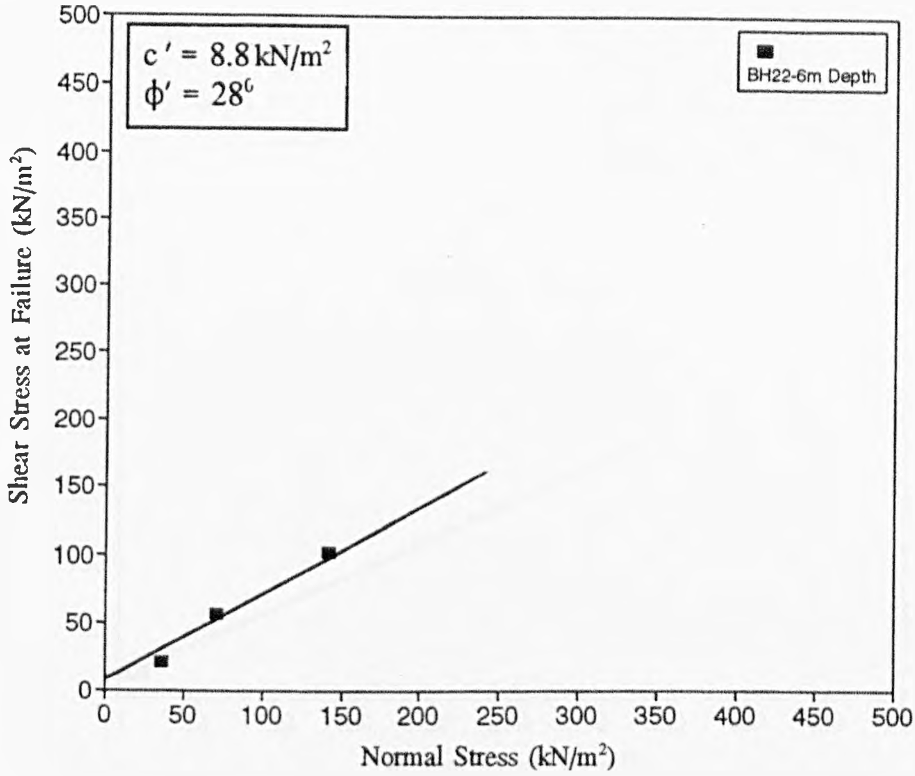

c′ = 11.7 kN/m²
φ′ = 15⁰
BH21-4m Depth
Shear Stress at Failure (kN/m²)
Normal Stress (kN/m²)
0
50
100
150
200
250
300
350
400
450
500

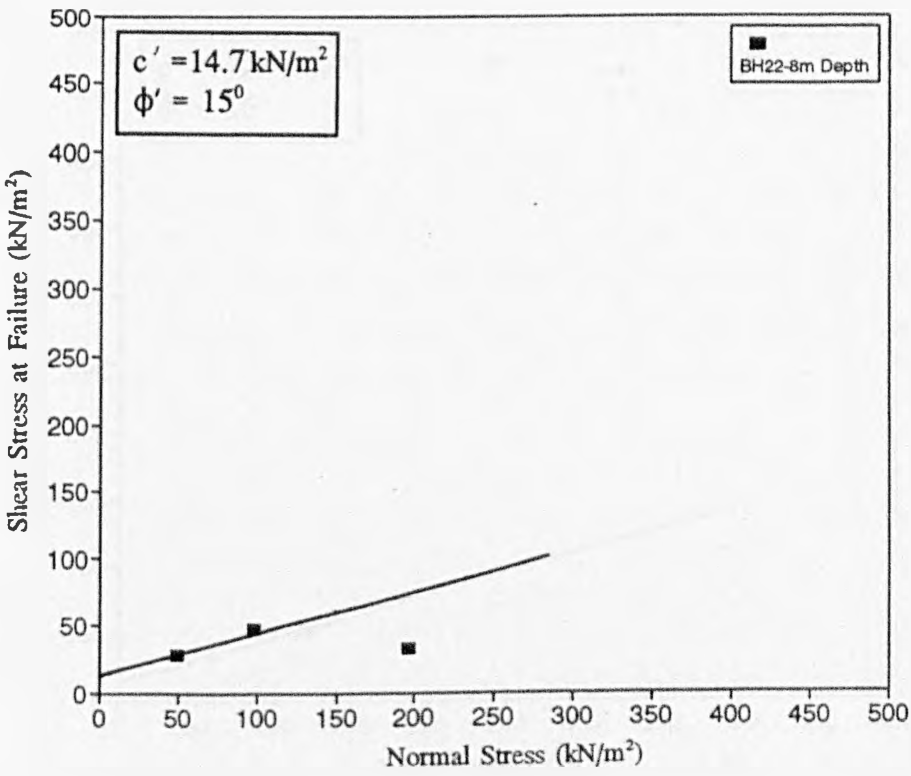

c' = 14.7 kN/m²
φ' = 20°
BH21-10m Depth
Shear Stress at Failure (kN/m²)
Normal Stress (kN/m²)
0
50
100
150
200
250
300
350
400
450
500

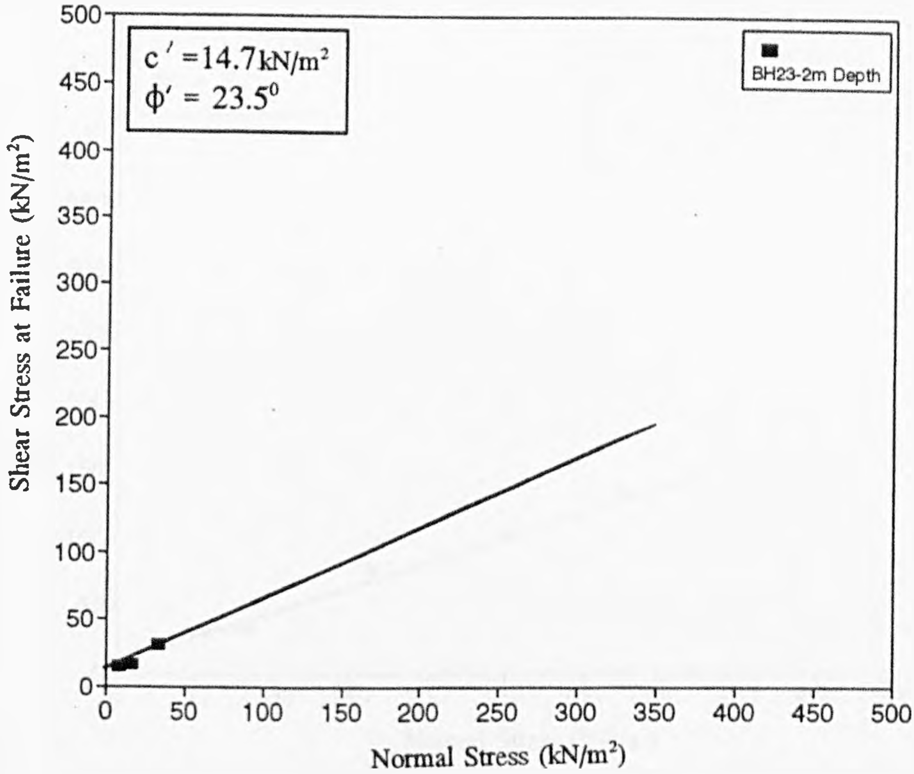

c' = 23.5 kN/m²
φ' = 17°
BH21-12m Depth
Shear Stress at Failure (kN/m²)
Normal Stress (kN/m²)
0
50
100
150
200
250
300
350
400
450
500

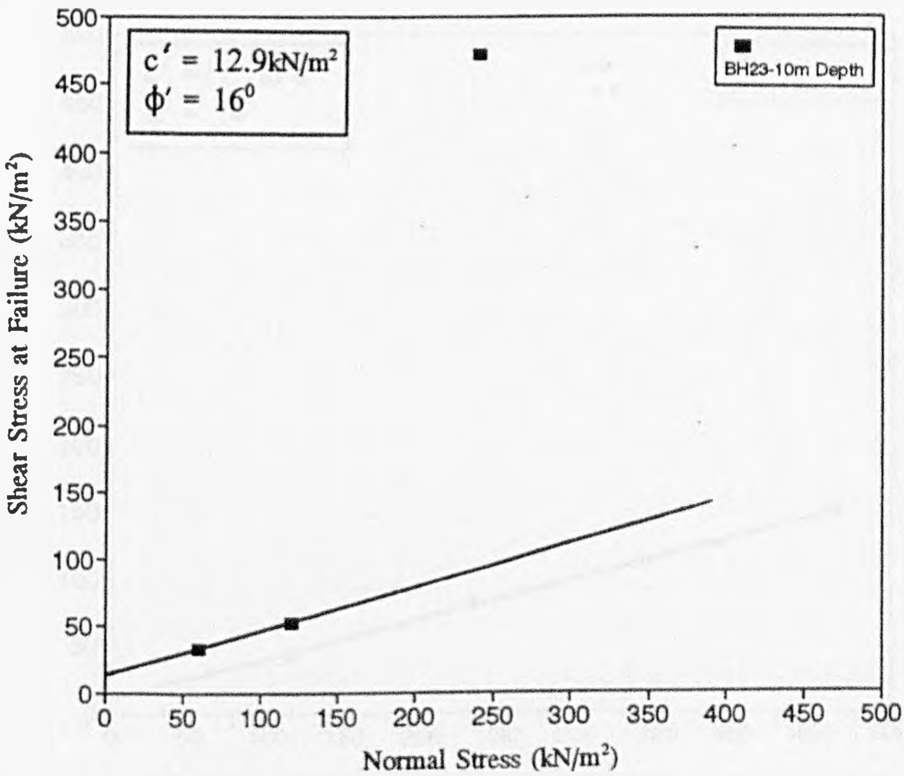

c′ =10.3 kN/m²
ϕ′ = 9⁰
BH21-14m Depth
Shear Stress at Failure (kN/m²)
Normal Stress (kN/m²)
0
50
100
150
200
250
300
350
400
450
500

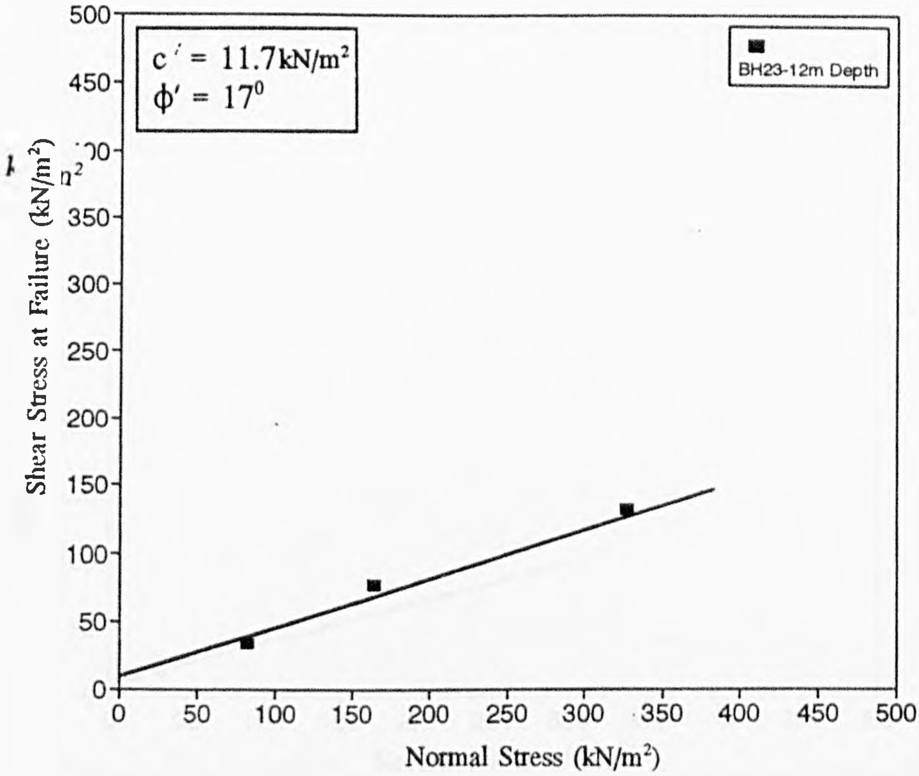

c′ = 14.7 kN/m²
ϕ′ = 17.5⁰
BH22-4m Depth
Shear Stress at Failure (kN/m²)
Normal Stress (kN/m²)
0
50
100
150
200
250
300
350
400
450
500

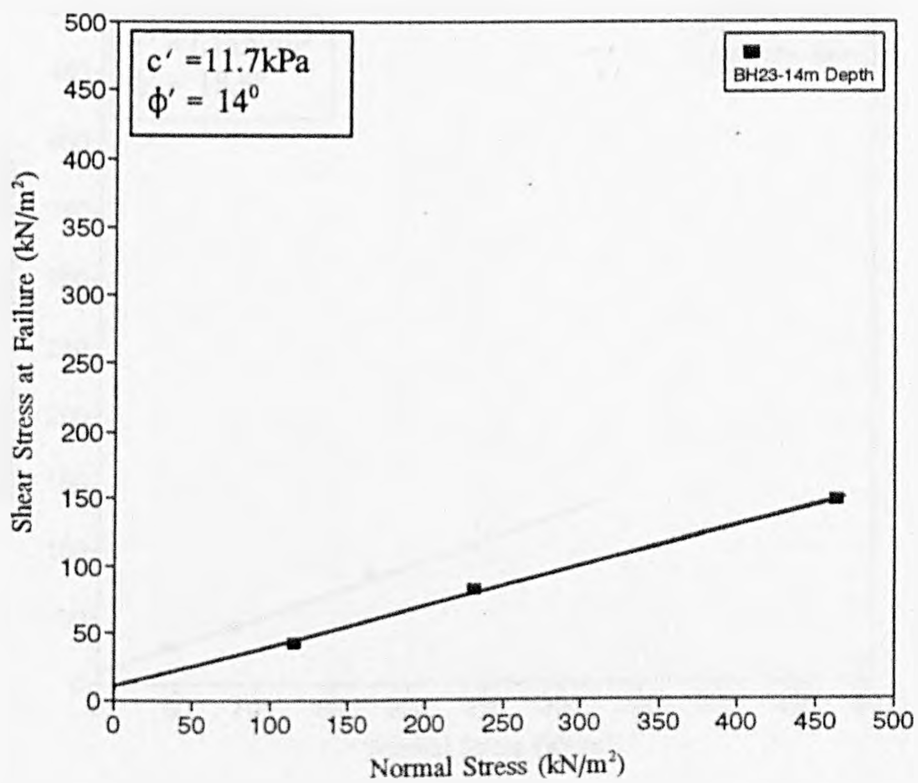

c′ = 8.8 kN/m²
φ′ = 28°
BH22-6m Depth
Shear Stress at Failure (kN/m²)
Normal Stress (kN/m²)
0
50
100
150
200
250
300
350
400
450
500

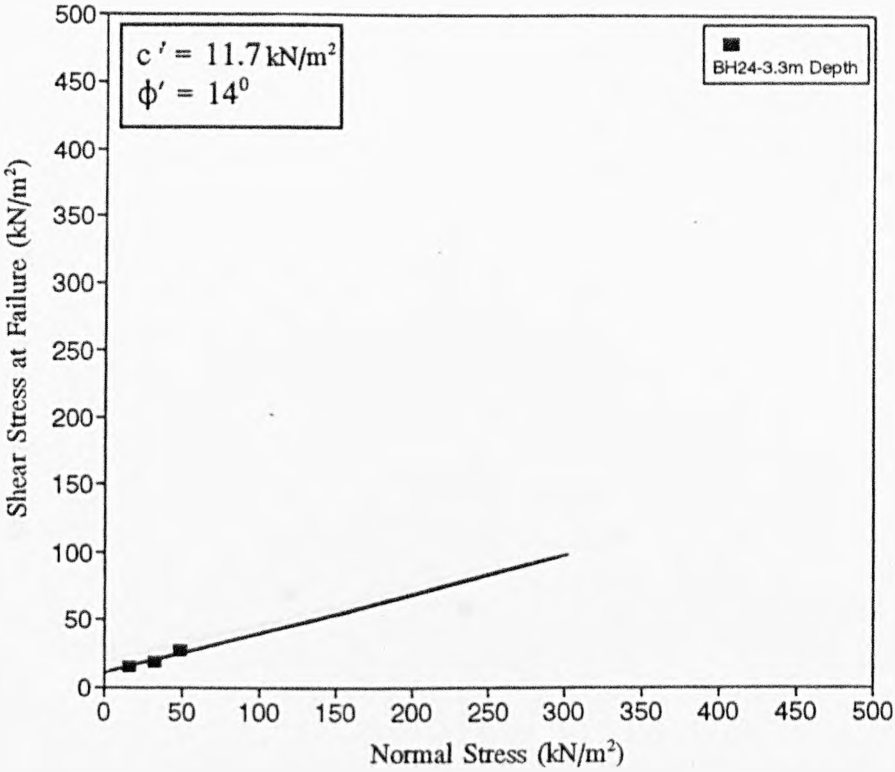

c′ =14.7 kN/m²
φ′ = 15°
BH22-8m Depth
Shear Stress at Failure (kN/m²)
Normal Stress (kN/m²)
0
50
100
150
200
250
300
350
400
450
500

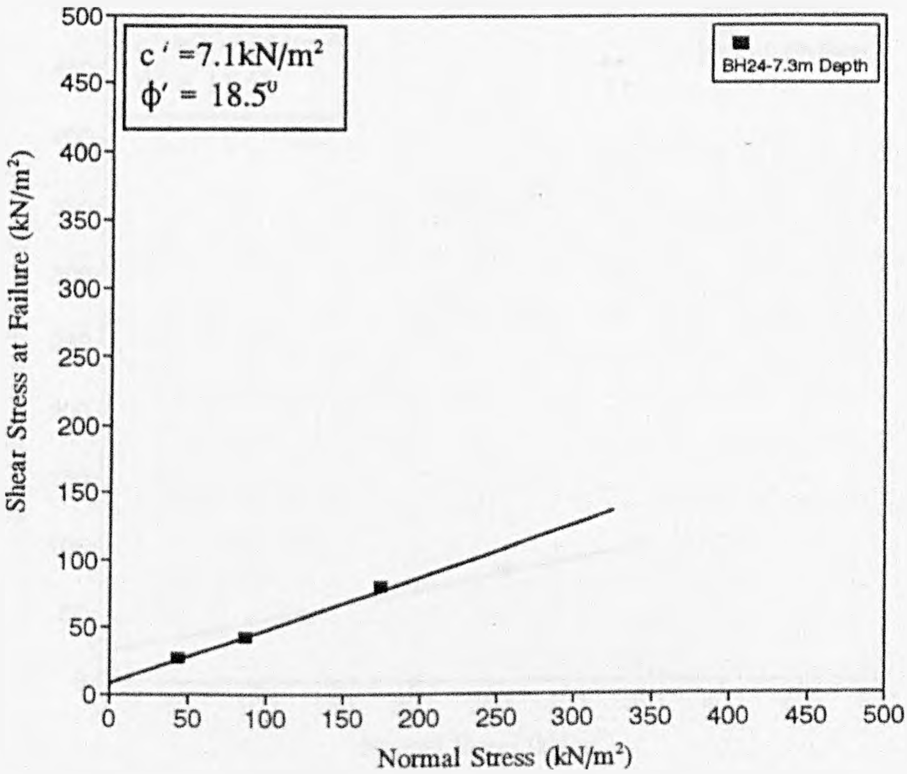

c′ = 14.7kN/m²
φ′ = 23.5°
BH23-2m Depth
Shear Stress at Failure (kN/m²)
Normal Stress (kN/m²)
0
50
100
150
200
250
300
350
400
450
500

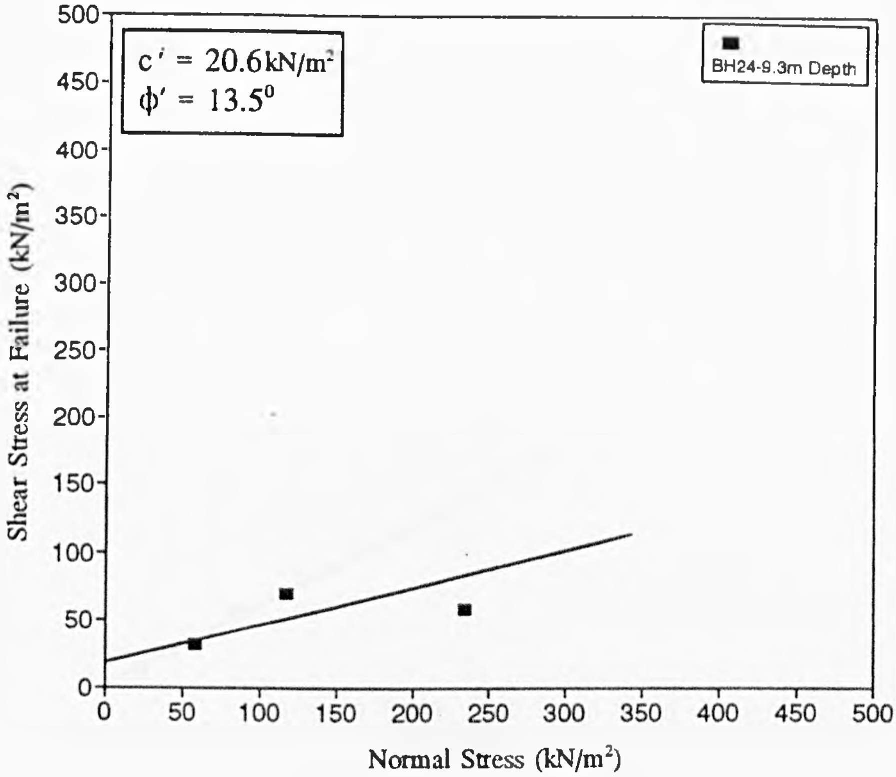

c′ = 12.9kN/m²
φ′ = 16°
BH23-10m Depth
Shear Stress at Failure (kN/m²)
Normal Stress (kN/m²)
0
50
100
150
200
250
300
350
400
450
500

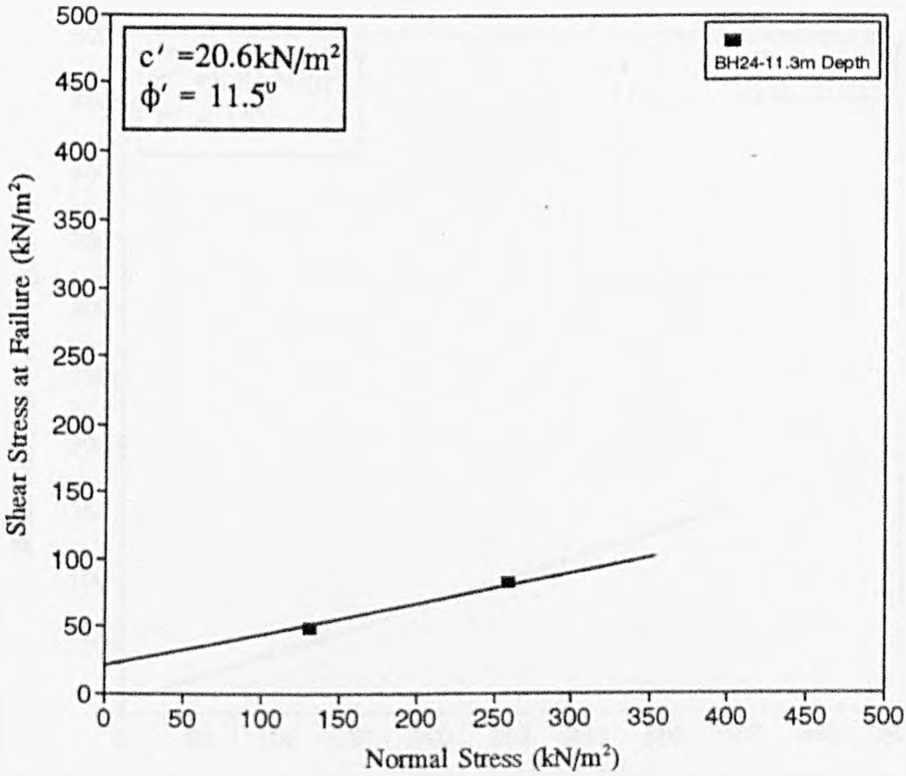

c′ = 11.7kN/m²
ϕ′ = 17⁰
BH23-12m Depth
Shear Stress at Failure (kN/m²)
Normal Stress (kN/m²)

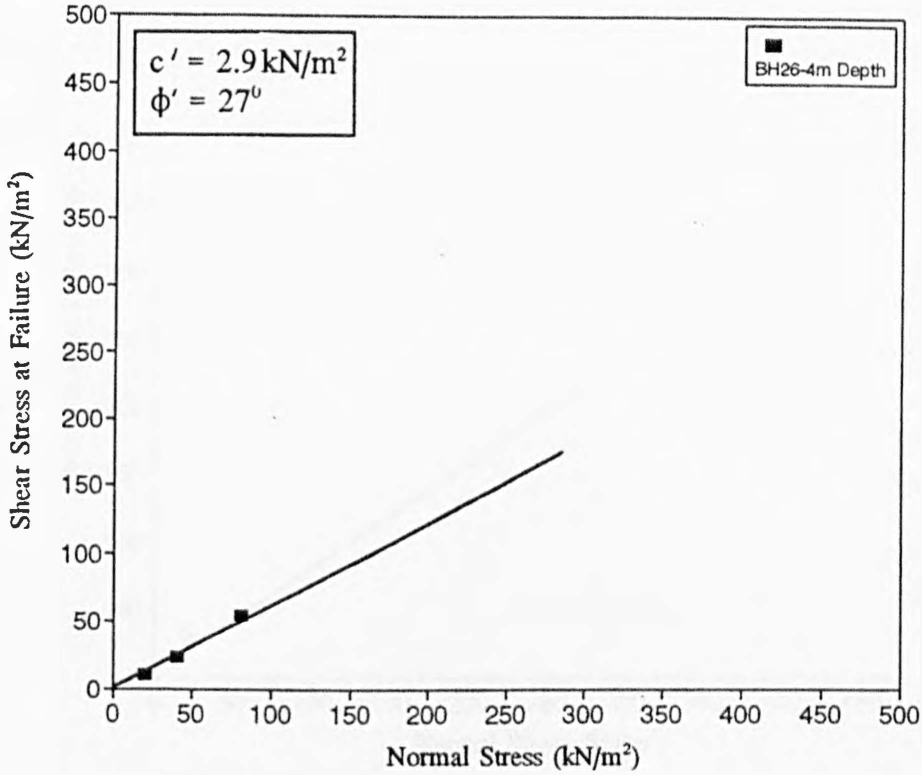

c′ =11.7kPa
ϕ′ = 14⁰
BH23-14m Depth
Shear Stress at Failure (kN/m²)
Normal Stress (kN/m²)


c ′ = 11.7 kN/m^2
ϕ′ = 14^0
BH24-3.3m Depth
Shear Stress at Failure (kN/m^2)
Normal Stress (kN/m^2)
0
50
100
150
200
250
300
350
400
450
500

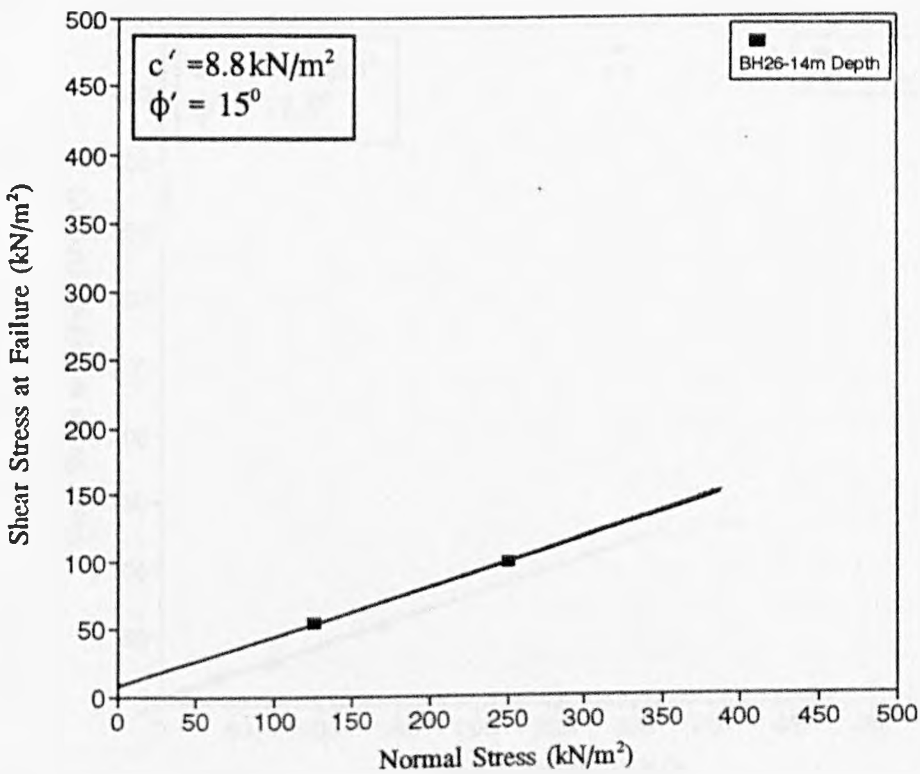

c ′ =7.1kN/m^2
ϕ′ = 18.5^0
BH24-7.3m Depth
Shear Stress at Failure (kN/m^2)
Normal Stress (kN/m^2)
0
50
100
150
200
250
300
350
400
450
500


c′ = 20.6kN/m²
φ′ = 13.5°
BH24-9.3m Depth
Shear Stress at Failure (kN/m²)
Normal Stress (kN/m²)
0
50
100
150
200
250
300
350
400
450
500

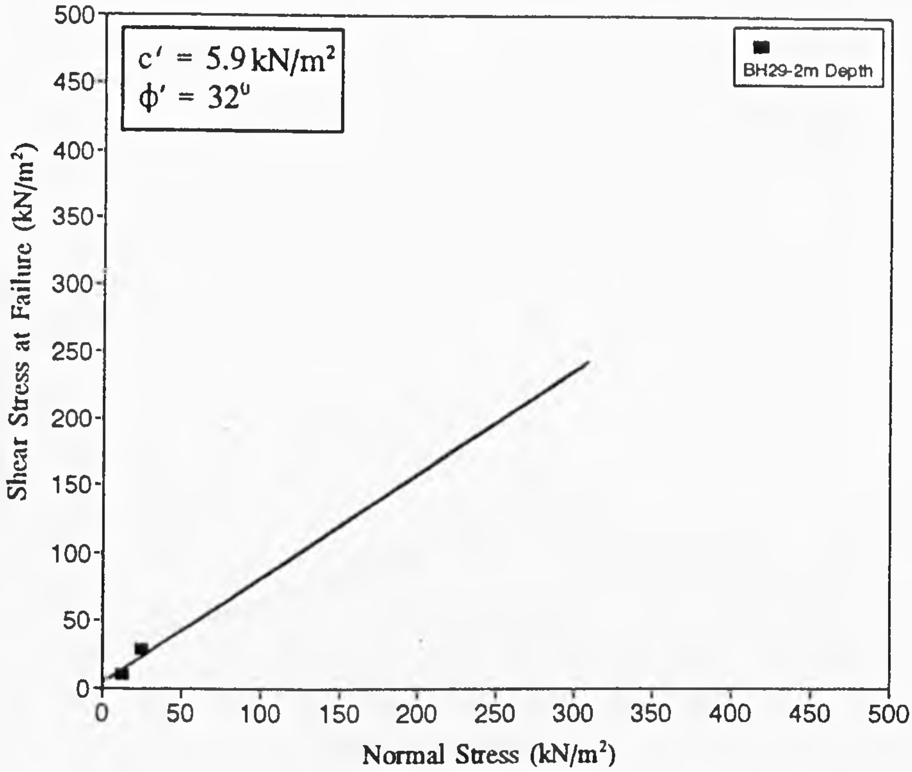

c′ =20.6kN/m²
φ′ = 11.5°
BH24-11.3m Depth
Shear Stress at Failure (kN/m²)
Normal Stress (kN/m²)
0
50
100
150
200
250
300
350
400
450
500

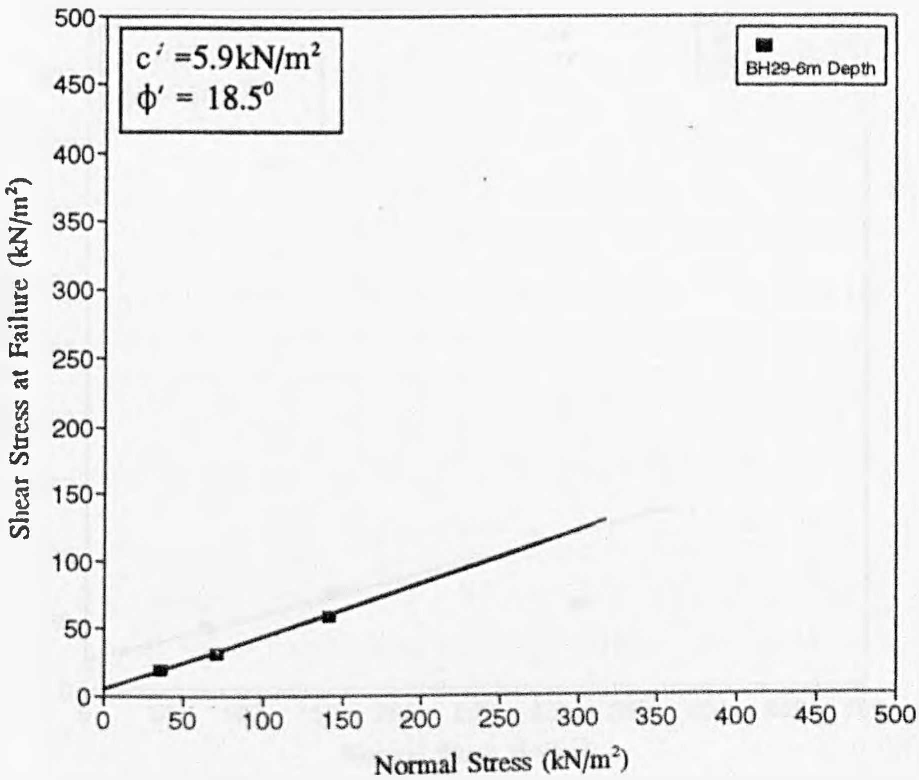


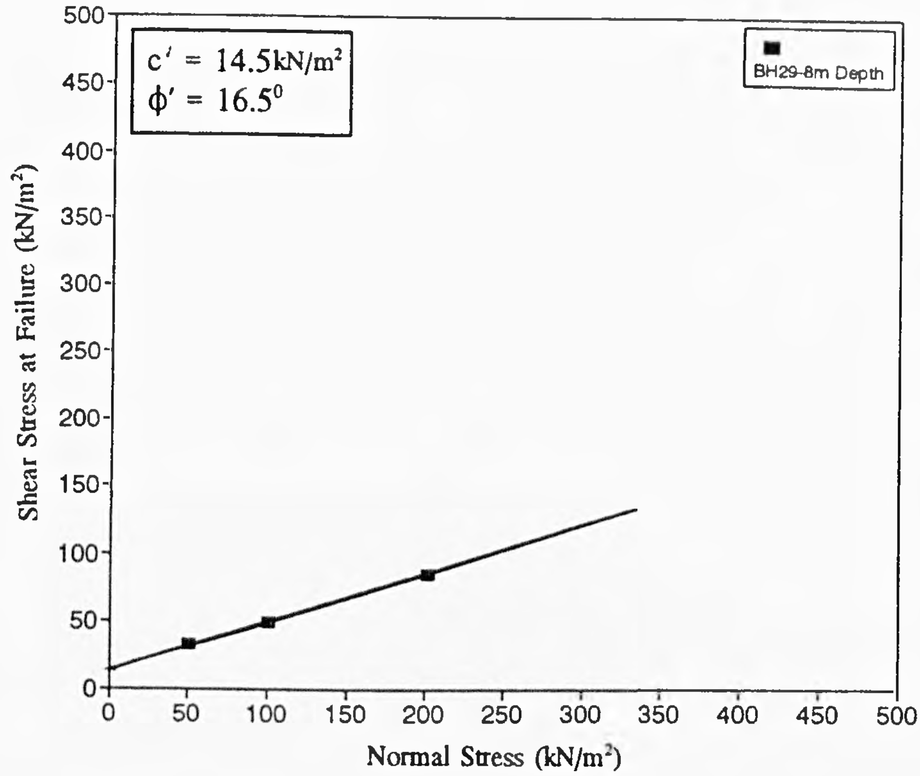
c′ = 2.9 kN/m²
ϕ′ = 27°
BH26-4m Depth
Shear Stress at Failure (kN/m²)
Normal Stress (kN/m²)

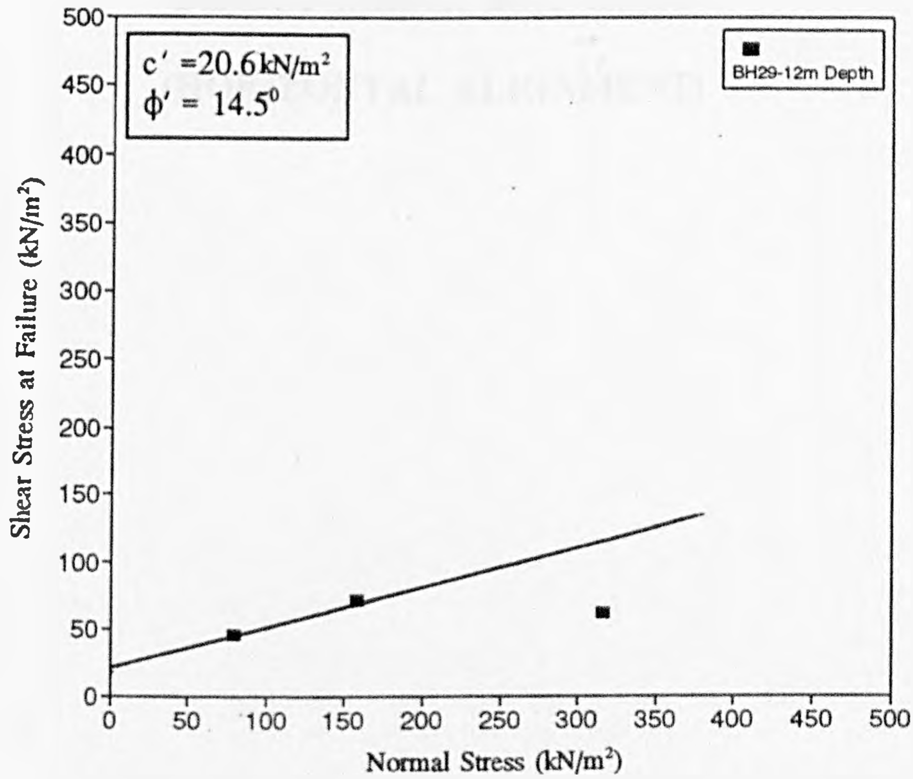


c′ =8.8 kN/m²
ϕ′ = 15°
BH26-14m Depth
Shear Stress at Failure (kN/m²)
Normal Stress (kN/m²)


c′ = 5.9 kN/m²
ϕ′ = 32⁰
BH29-2m Depth
Shear Stress at Failure (kN/m²)
Normal Stress (kN/m²)
0
50
100
150
200
250
300
350
400
450
500

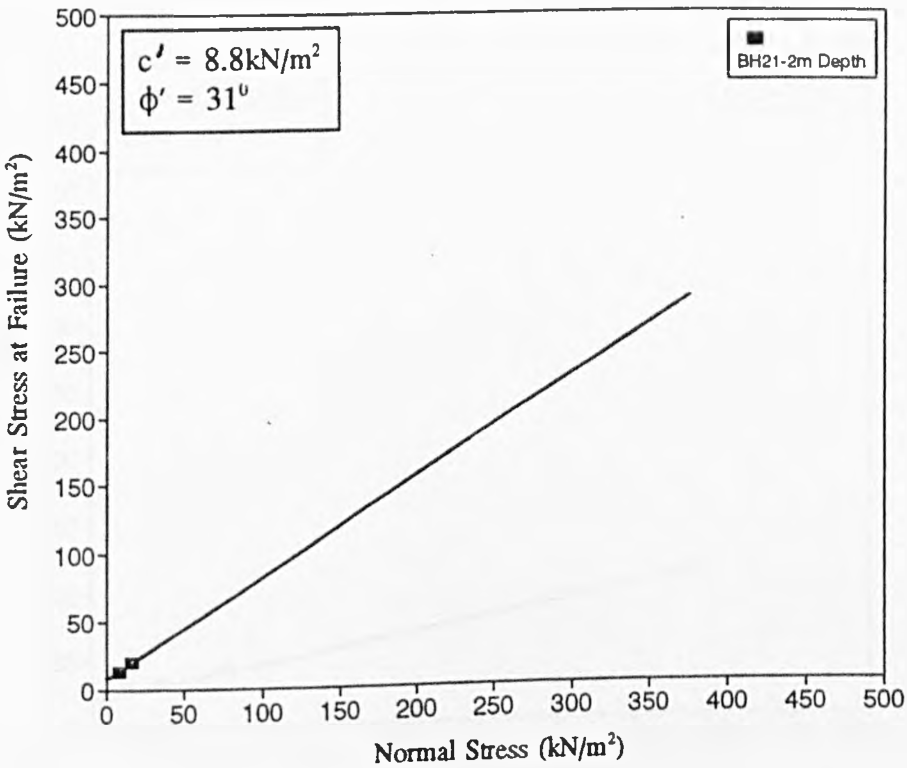

c′ =5.9kN/m²
ϕ′ = 18.5⁰
BH29-6m Depth
Shear Stress at Failure (kN/m²)
Normal Stress (kN/m²)
0
50
100
150
200
250
300
350
400
450
500


c′ = 14.5kN/m²
ϕ′ = 16.5°
BH29-8m Depth
Shear Stress at Failure (kN/m²)
Normal Stress (kN/m²)
0
50
100
150
200
250
300
350
400
450
500

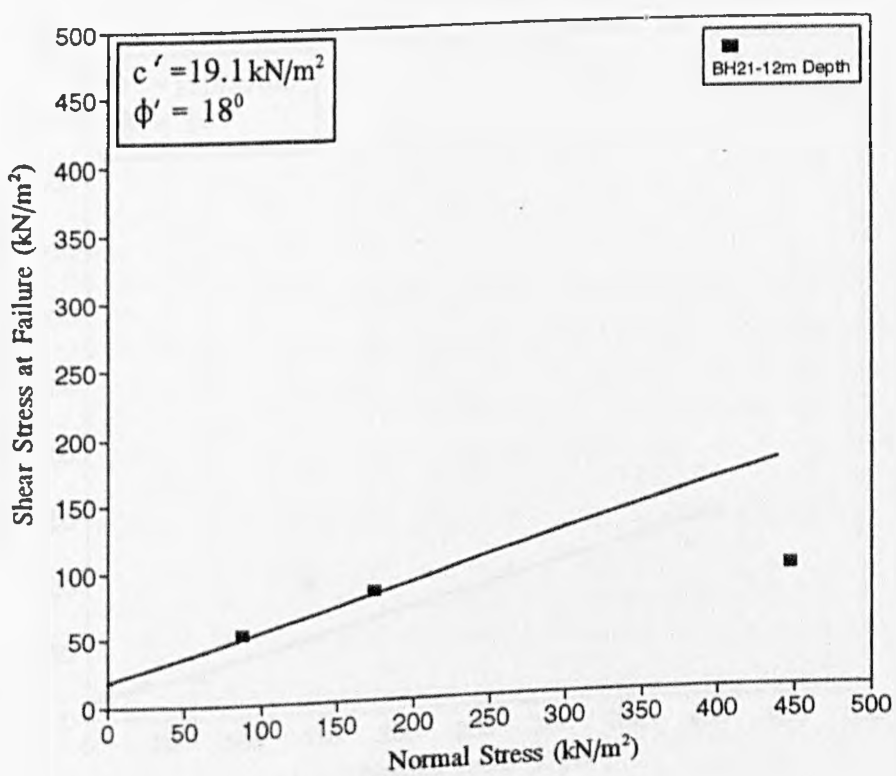

c′ =20.6kN/m²
ϕ′ = 14.5°
BH29-12m Depth
Shear Stress at Failure (kN/m²)
Normal Stress (kN/m²)
0
50
100
150
200
250
300
350
400
450
500

DIRECT SHEAR BOX TESTS

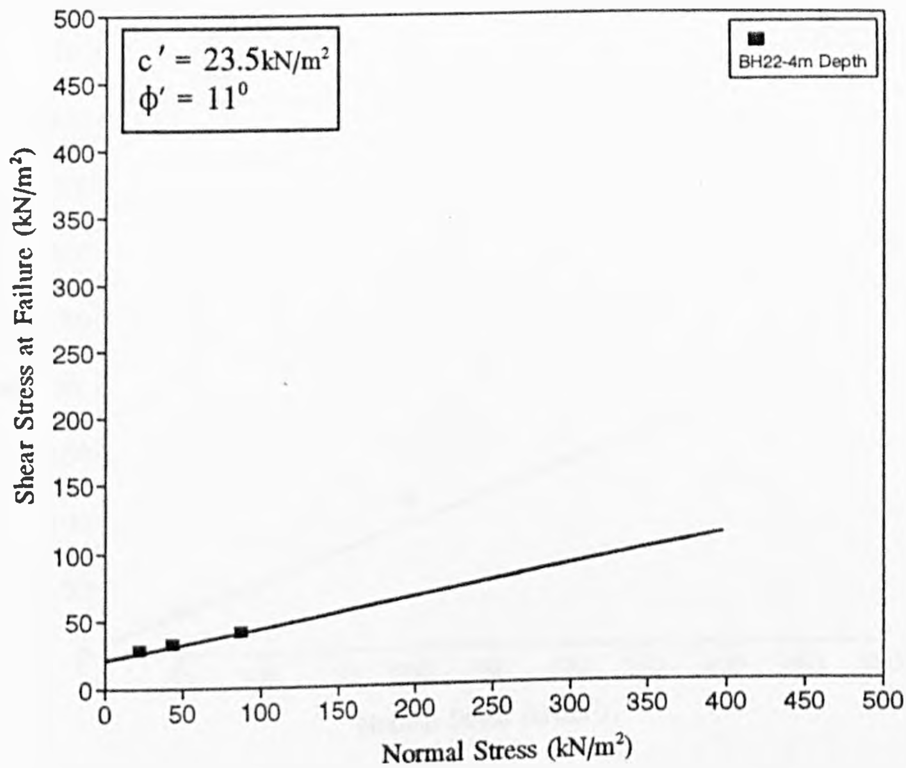
(HORIZONTAL ALIGNMENT)



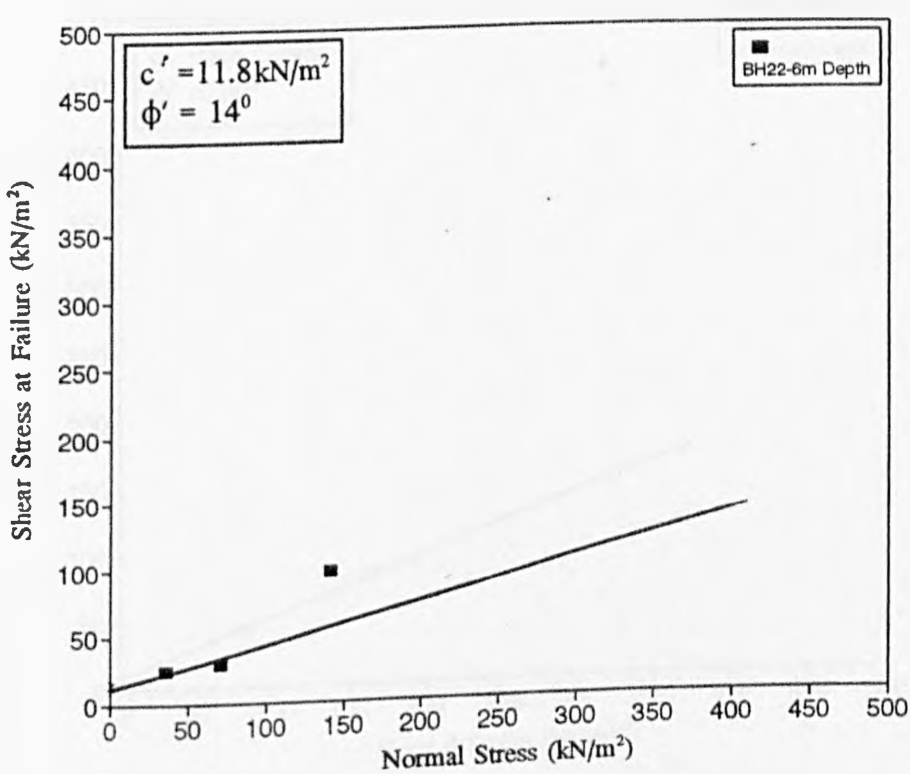
c' = 8.8kN/m²
φ' = 31°
BH21-2m Depth
Shear Stress at Failure (kN/m²)
Normal Stress (kN/m²)
0
50
100
150
200
250
300
350
400
450
500



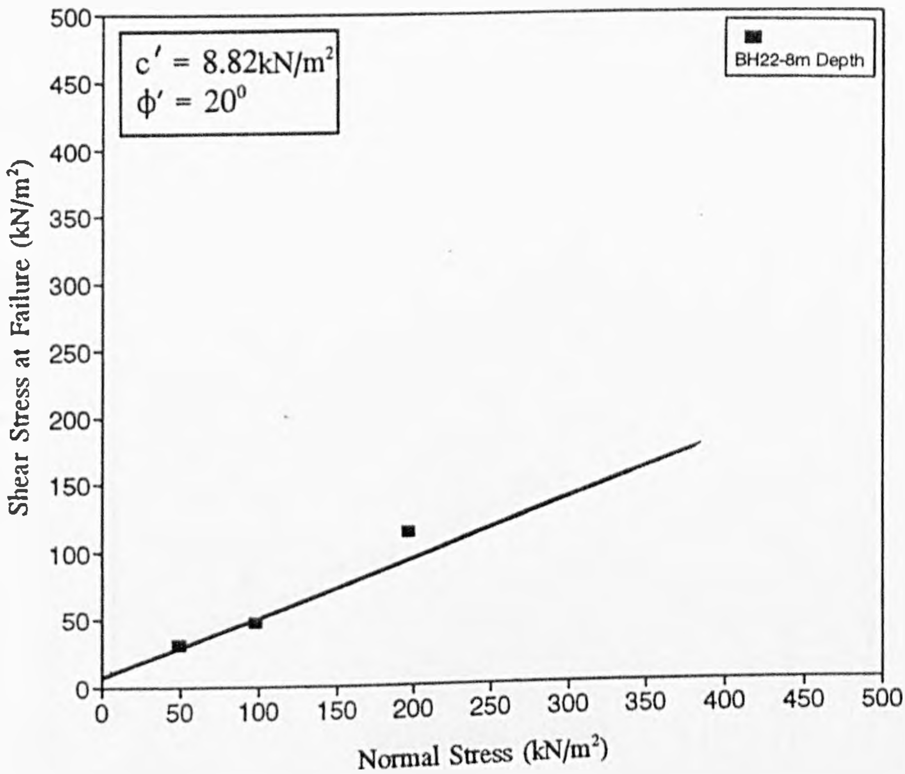
c' =19.1kN/m²
φ' = 18°
BH21-12m Depth
Shear Stress at Failure (kN/m²)
Normal Stress (kN/m²)
0
50
100
150
200
250
300
350
400
450
500



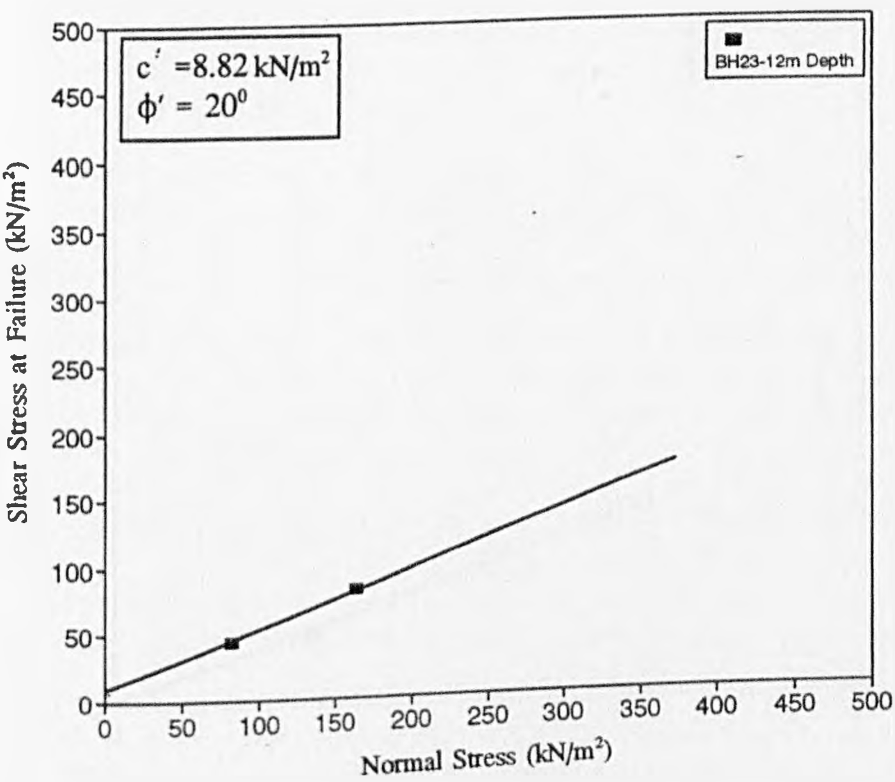
c′ = 23.5kN/m²
ϕ′ = 11⁰
BH22-4m Depth
Shear Stress at Failure (kN/m²)
Normal Stress (kN/m²)
0
50
100
150
200
250
300
350
400
450
500



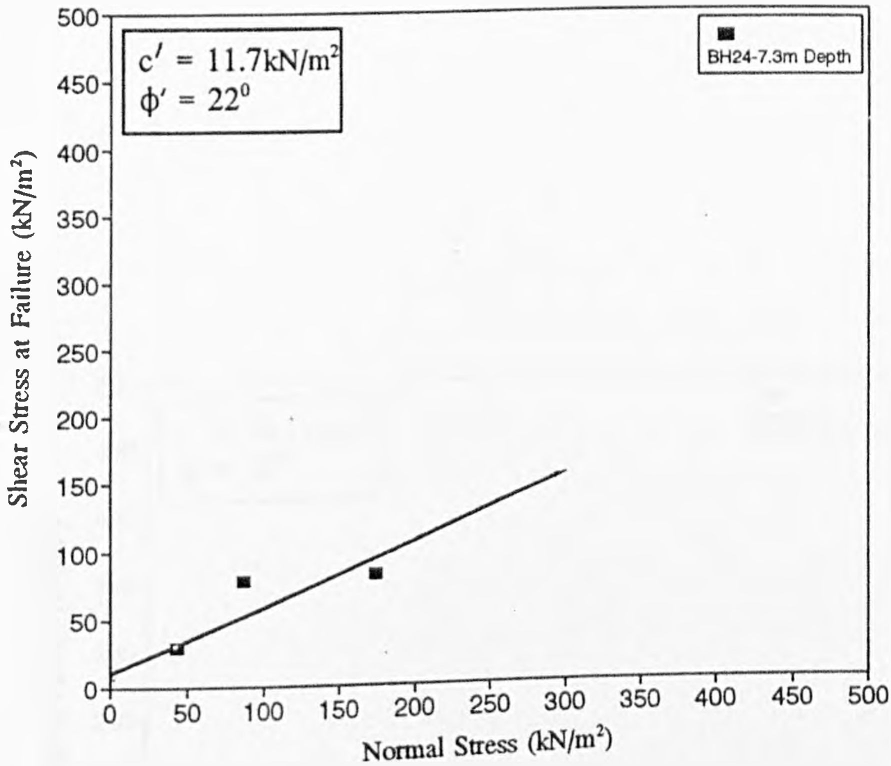
c′ =11.8kN/m²
ϕ′ = 14⁰
BH22-6m Depth
Shear Stress at Failure (kN/m²)
Normal Stress (kN/m²)
0
50
100
150
200
250
300
350
400
450
500

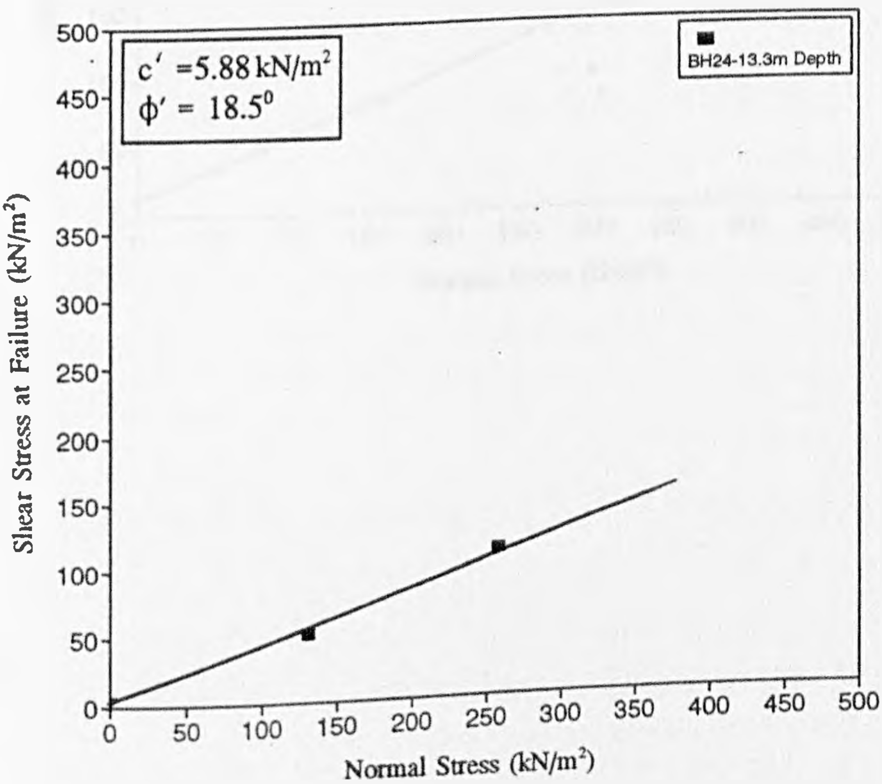


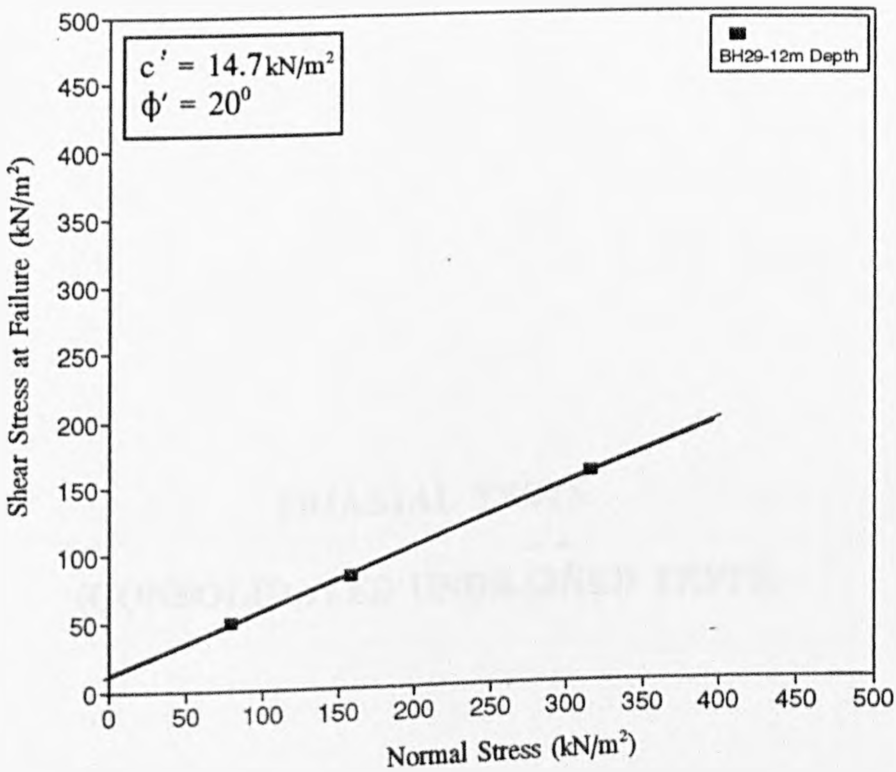
c′ = 8.82kN/m²
ϕ′ = 20⁰
BH22-8m Depth
Shear Stress at Failure (kN/m²)
Normal Stress (kN/m²)
0
50
100
150
200
250
300
350
400
450
500



c′ =8.82 kN/m²
ϕ′ = 20⁰
BH23-12m Depth
Shear Stress at Failure (kN/m²)
Normal Stress (kN/m²)
0
50
100
150
200
250
300
350
400
450
500


c′ = 11.7kN/m²
ϕ′ = 22°
BH24-7.3m Depth
Shear Stress at Failure (kN/m²)
Normal Stress (kN/m²)
0
50
100
150
200
250
300
350
400
450
500

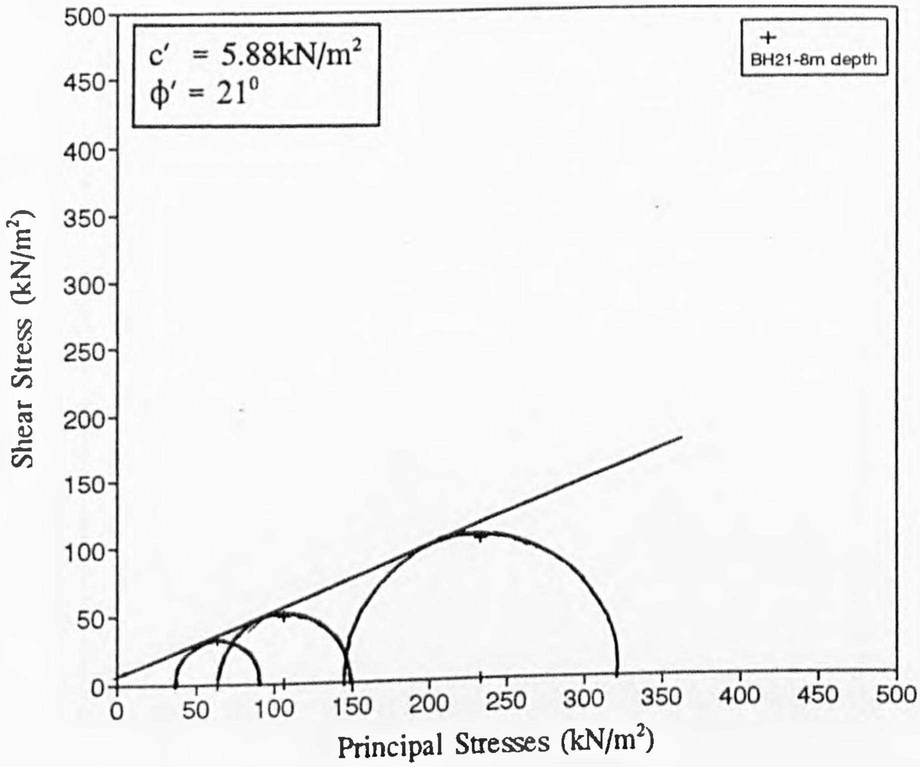

c′ =5.88 kN/m²
ϕ′ = 18.5°
BH24-13.3m Depth
Shear Stress at Failure (kN/m²)
Normal Stress (kN/m²)
0
50
100
150
200
250
300
350
400
450
500

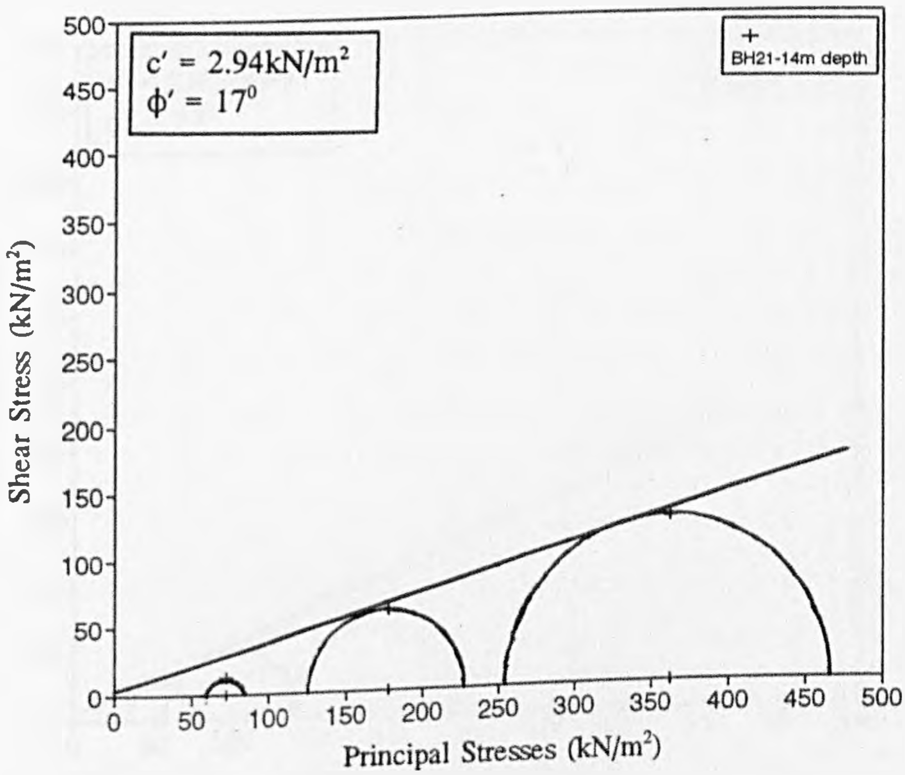


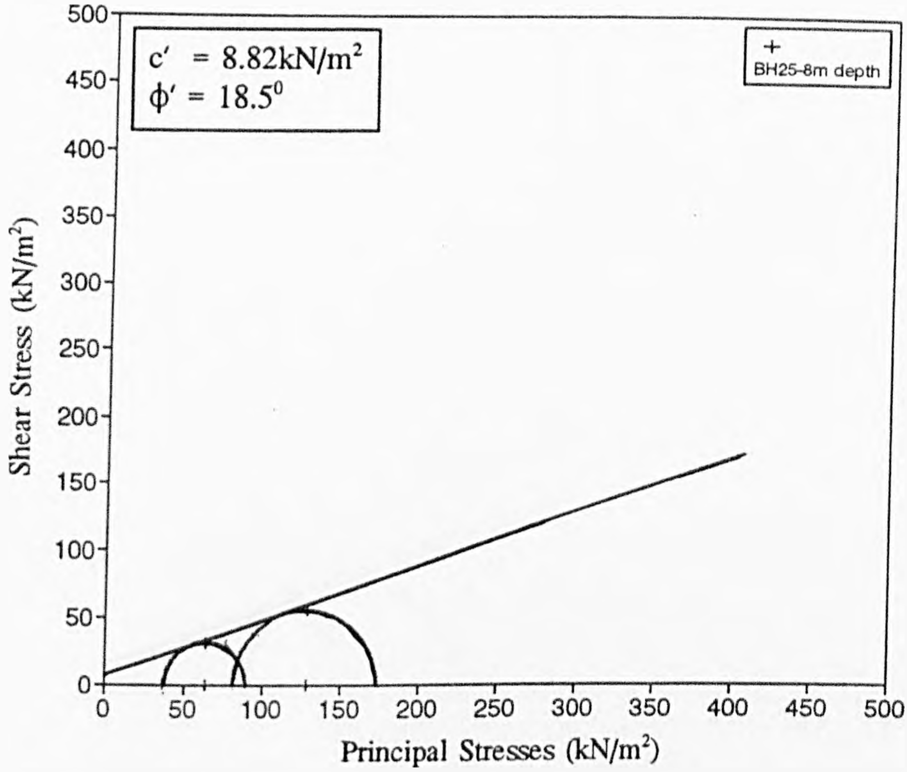
$c' = 14.7 kN/m^2$
$\phi' = 20^0$
BH29-12m Depth
Shear Stress at Failure (kN/m^2)
Normal Stress (kN/m^2)
0
50
100
150
200
250
300
350
400
450
500

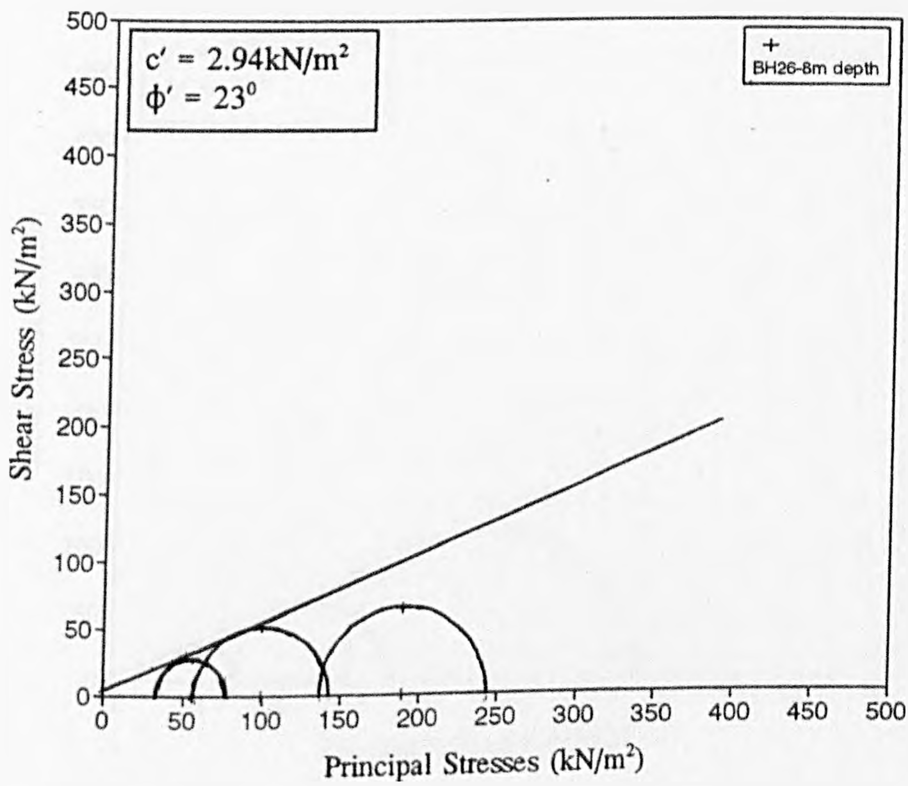
TRIAXIAL TESTS

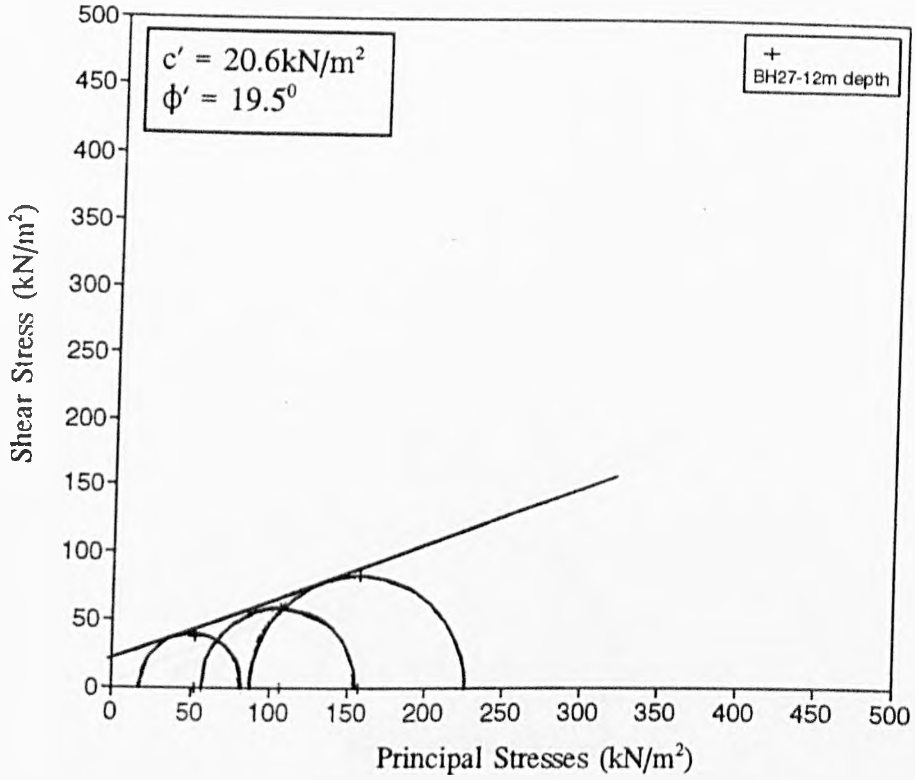
(CONSOLIDATED UNDRAINED TESTS)

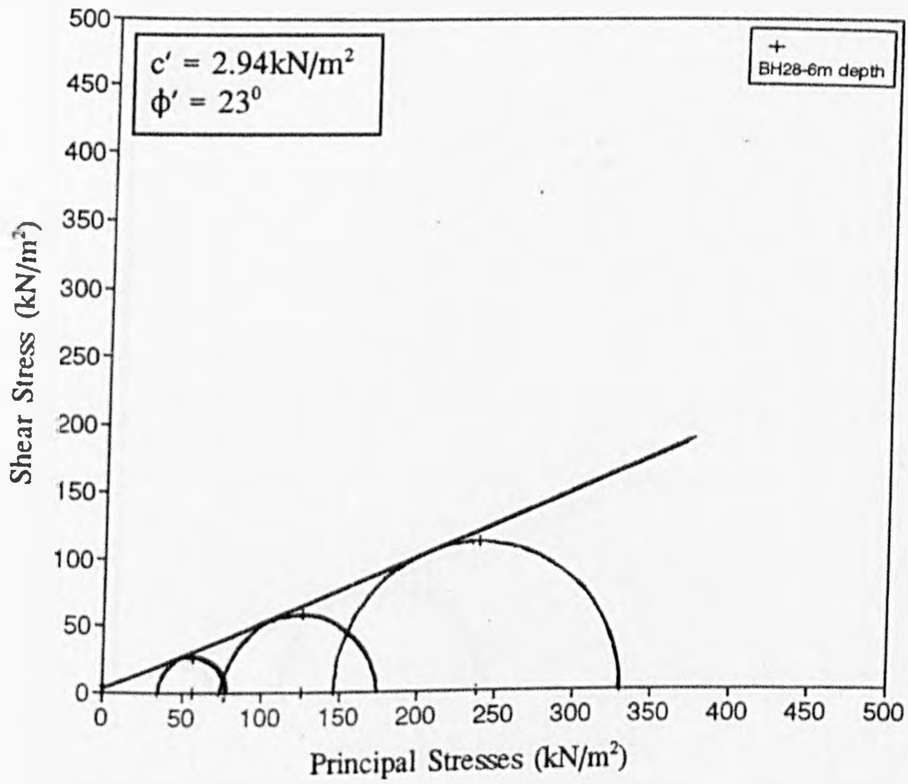

c′ = 5.88kN/m²
ϕ′ = 21⁰
BH21-8m depth
Shear Stress (kN/m²)
Principal Stresses (kN/m²)
0
50
100
150
200
250
300
350
400
450
500

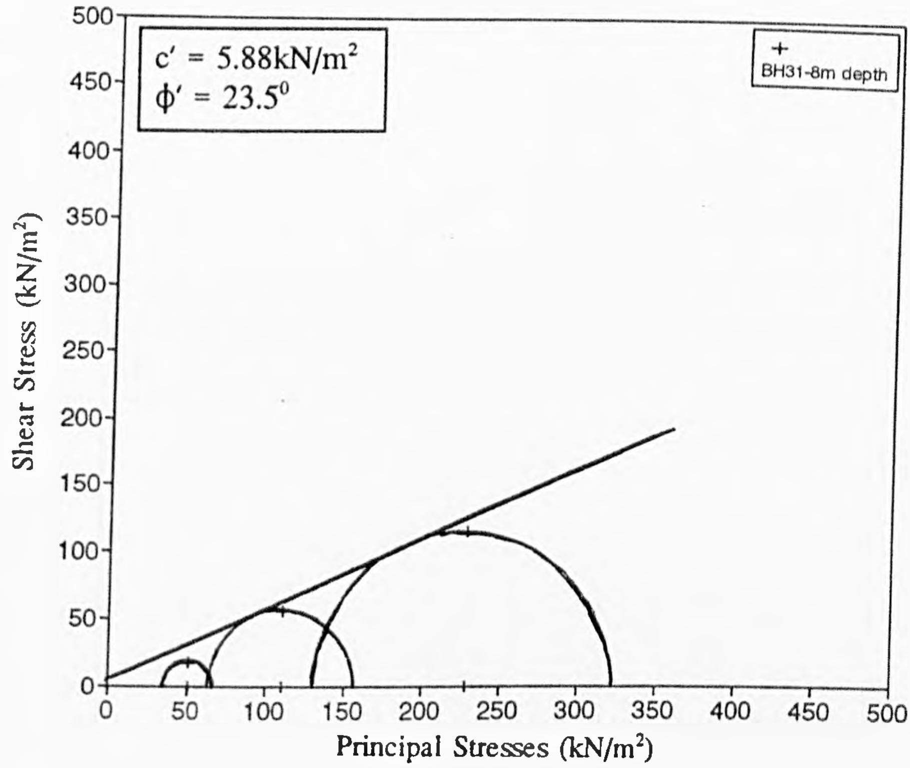

c′ = 2.94kN/m²
ϕ′ = 17⁰
BH21-14m depth
Shear Stress (kN/m²)
Principal Stresses (kN/m²)
0
50
100
150
200
250
300
350
400
450
500


c′ = 8.82kN/m²
φ′ = 18.5⁰
BH25-8m depth
Shear Stress (kN/m²)
Principal Stresses (kN/m²)
0
50
100
150
200
250
300
350
400
450
500

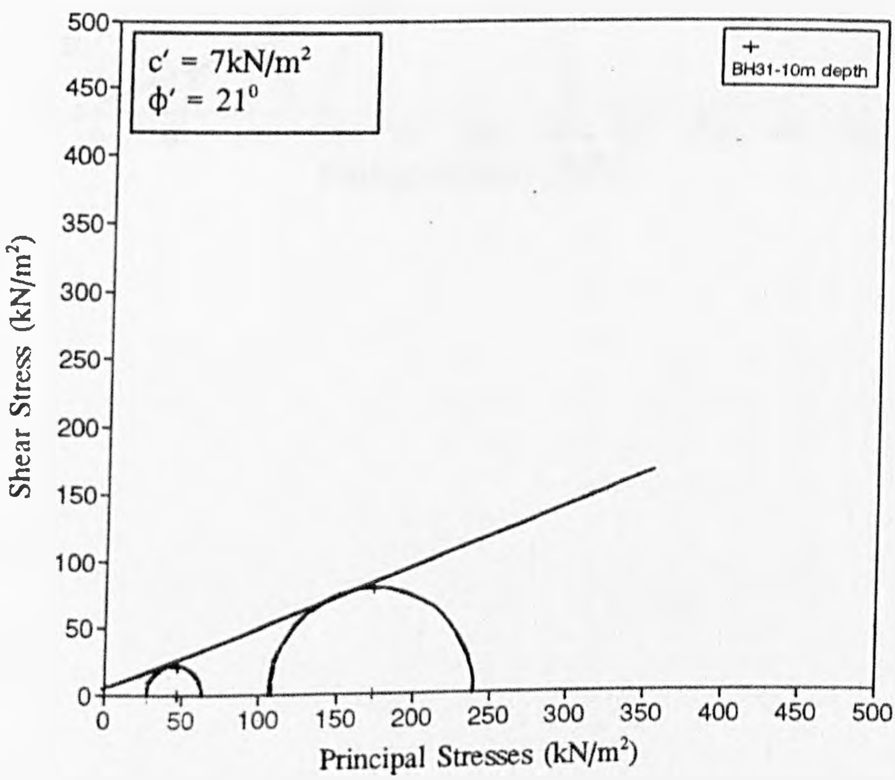

c′ = 2.94kN/m²
φ′ = 23⁰
BH26-8m depth
Shear Stress (kN/m²)
Principal Stresses (kN/m²)
0
50
100
150
200
250
300
350
400
450
500


c′ = 20.6kN/m²
ϕ′ = 19.5⁰
BH27-12m depth
Shear Stress (kN/m²)
Principal Stresses (kN/m²)
0
50
100
150
200
250
300
350
400
450
500

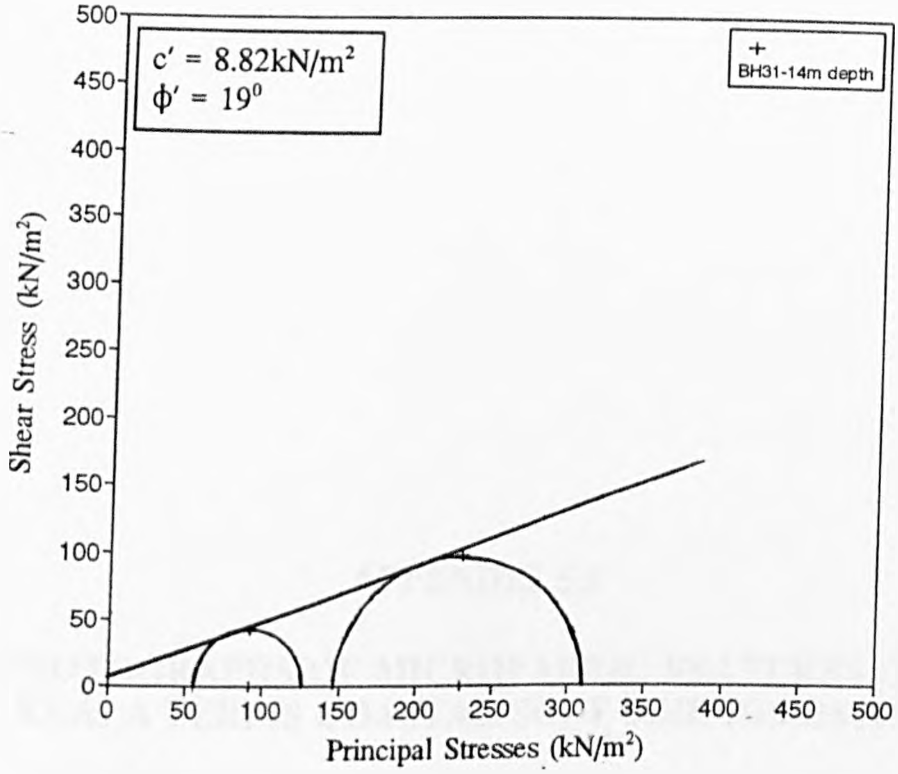

c′ = 2.94kN/m²
ϕ′ = 23⁰
BH28-6m depth
Shear Stress (kN/m²)
Principal Stresses (kN/m²)
0
50
100
150
200
250
300
350
400
450
500



c' = 5.88kN/m²
ϕ' = 23.5⁰
BH31-8m depth
Shear Stress (kN/m²)
Principal Stresses (kN/m²)



c' = 7kN/m²
ϕ' = 21⁰
BH31-10m depth
Shear Stress (kN/m²)
Principal Stresses (kN/m²)


c' = 8.82kN/m²
ϕ' = 19⁰
BH31-14m depth
Shear Stress (kN/m²)
Principal Stresses (kN/m²)
0
50
100
150
200
250
300
350
400
450
500

APPENDIX 5.5

PHOTOGRAPHS OF MICROFABRIC FEATURES OF KUALA PERLIS COASTAL SOFT SOIL DEPOSITS

APPENDIX 5.4

DATA OF MACROFABRIC ANALYSIS OF KUALA PERLIS COASTAL SOFT SOIL DEPOSITS

Macrofabric Data Sheet 1

Site : Kuala Perlis South Trial Embankment
Date Test Done : 3/2/93
Sample No: BH 23AA   Sample Length: 0.3m   Depth: 0.6m to 1.2m   R.L. of Borehole : 1.831m
Orientation of Basic Axis : N.A.
Soil Description : Light to dark greyish clay of high plasticity with traces of organic matter and shell fragments
Observed related or referred features : None
Measurements:

No. of Feature	Nature		Form			Orientation		Spacing
	Feature Type	Soil Classification	Thickness t mm	Continuity Assessment	Surface Geometry	Strike	Dip	S mm
1	Dusting	Sand	0.2	Continuous	Planar	Horizontal		290
2	Dusting	Sand	0.4	Continuous	Planar	Horizontal		-
3	Dusting	Organic	0.5	Continuous	Planar	40		180
4	Lamina	Organic	1	Continuous	Planar	45		-

Macrofabric Data Sheet 2

Site : Kuala Perlis South Trial Embankment
Date Test Done : 3/2/93
Sample No: BH 23AB Sample Length: 0.4m Depth: 1.2m to 1.8m R.L. of Borehole : 1.831m
Orientation of Basic Axis : N.A.
Soil Description : Light to dark greyish clay of high plasticity with traces of organic matter and shell fragments
Observed related or referred features : None
Measurements:

No. of Feature	Nature		Form			Orientation		Spacing
	Feature Type	Soil Classification	Thickness t mm	Continuity Assessment	Surface Geometry	Strike	Dip	S mm
1	Sea Shells	N.A.	0.01	Discontinuous	N.A.	Horizontal		10
2	Sea Shells	N.A.	0.01	Discontinuous	N.A.	Horizontal		25
3	Sea Shells	N.A.	0.02	Discontinuous	N.A.	Horizontal		1825
4	Sea Shells	N.A.	0.03	Discontinuous	N.A.	Horizontal		38
5	Sea Shells	N.A.	0.07	Discontinuous	N.A.	Horizontal		35
6	Sea Shells	N.A.	0.01	Discontinuous	N.A.	Horizontal		10
7	Sea Shells	N.A.	0.01	Discontinuous	N.A.	Horizontal		25
8	Sea Shells	N.A.	0.02	Discontinuous	N.A.	Horizontal		25
9	Sea Shells	N.A.	0.03	Discontinuous	N.A.	Horizontal		38
10	Sea Shells	N.A.	0.07	Discontinuous	N.A.	Horizontal		-

Site : Kuala Perlis South Trial Embankment
Date Test Done : 3/2/93
Sample No: BH 23AB Sample Length: 0.4m Depth: 1.2m to 1.8m R.L. of Borehole : 1.831m
Orientation of Basic Axis : N.A.
Soil Description : Light to dark greyish clay of high plasticity with traces of organic matter and shell fragments
Observed related or referred features : None
Measurements:

No. of Feature	Nature		Form			Orientation		Spacing
	Feature Type	Soil Classification	Thickness tmm	Continuity Assessment	Surface Geometry	Strike	Dip	S mm
11	Dusting	Sand	0.4	Continuous	Planar	Horizontal		70
12	Dusting	Sand	0.3	Continuous	Planar	Horizontal		10
13	Lamina	Sand	1.0	Continuous	Planar	Horizontal		20
14	Dusting	Sand	0.5	Continuous	Planar	Horizontal		40
15	Dusting	Sand	0.2	Continuous	Planar	Horizontal		60
16	Dusting	Sand	0.5	Continuous	Planar	Horizontal		70
17	Lamina	Sand	4	Continuous	Planar	Horizontal		70
18	Lamina	Sand	3	Continuous	Planar	Horizontal		10
19	Lamina	Sand	1	Continuous	Planar	Horizontal		20
20	Dusting	Sand	0.5	Continuous	Planar	Horizontal		40
21	Dusting	Sand	0.2	Continuous	Planar	Horizontal		60
22	Dusting	Sand	0.5	Continuous	Planar	Horizontal		-

Macrofabric Data Sheet 4

Site : Kuala Perlis South Trial Embankment
Date Test Done : 3/2/93
Sample No: BH 23AC Sample Length: 0.4m Depth: 1.8m to 2.4m R.L. of Borehole : 1.831m
Orientation of Basic Axis : N.A.
Soil Description : Light to dark greyish clay of high plasticity with traces of organic matter and shell fragments
Observed related or referred features : None
Measurements:

No. of Feature	Nature		Form			Orientation		Spacing
	Feature Type	Soil Classification	Thickness t mm	Continuity Assessment	Surface Geometry	Strike	Dip	S mm
1	Thin Layer	Organic	10	Continuous	Planar	Horizontal		10
2	Dusting	Organic	0.3	Continuous	Planar	Horizontal		90
3	Thin Layer	Organic	10	Continuous	Planar	Horizontal		15
4	Thin Layer	Organic	10	Continuous	Planar	Horizontal		-
5	Lamina	Sand	0.7	Continuous	Planar	Horizontal		-
6	Thin Layer	Sand	0.5	Continuous	Planar	Horizontal		-
7	Thin Layer	Sand	30	Continuous	Planar	Horizontal		12
8	Thin Layer	Sand	40	Continuous	Planar	Horizontal		-
9	Sea Shells	N.A.	60	Discontinuous	N.A.	Horizontal		-

Macrofabric Data Sheet 5

Site : Kuala Perlis South Trial Embankment
Date Test Done : 3/2/93
Sample No: BH 23AD Sample Length: 0.4m Depth: 2.4m to 3.0m R.L. of Borehole : 1.831m
Orientation of Basic Axis : N.A.
Soil Description : Light to dark greyish clay of high plasticity with traces of organic matter and shell fragments
Observed related or referred features : None
Measurements:

No. of Feature	Nature		Form			Orientation		Spacing
	Feature Type	Soil Classification	Thickness t mm	Continuity Assessment	Surface Geometry	Strike	Dip	S mm
1	Sea Shells	N.A.	1	Discontinuous	N.A.	Horizontal		-
2	Thin Layer	Sand	30	Continuous	Planar	Horizontal		-

Macrofabric Data Sheet 6

Site : Kuala Perlis South Trial Embankment
Date Test Done : 17/5/93
Sample No: BH 23AE   Sample Length: 0.55m   Depth: 3m to 3.6m   R.L. of Borehole : 1.831m
Orientation of Basic Axis : N.A.
Soil Description : Light to dark greyish clay of high plasticity with traces of organic matter and shell fragments
Observed related or referred features : None
Measurements:

No. of Feature	Nature		Form			Orientation		Spacing
	Feature Type	Soil Classification	Thickness t mm	Continuity Assessment	Surface Geometry	Strike	Dip	S mm
1	Lamina	Organic	5	Continuous	Planar	Horizontal		5
2	Lamina	Organic	5	Continuous	Planar	45		5
3	Lamina	Organic	5	Continuous	Planar	Horizontal		40
4	Lamina	Organic	5	Continuous	Planar	Horizontal		20
5	Lamina	Organic	5	Continuous	Planar	Horizontal		-
6	Sea Shells	N.A.	40	Discontinuous	N.A.	Horizontal		-

Macrofabric Data Sheet 7

Site : Kuala Perlis South Trial Embankment
Date Test Done : 17/5/93
Sample No: BH 23AF Sample Length: 0.48m Depth: 3.6m to 4.2m R.L. of Borehole : 1.831m
Orientation of Basic Axis : N.A.
Soil Description : Light to dark greyish clay of high plasticity with traces of organic matter and shell fragments
Observed related or referred features : None
Measurements:

No. of Feature	Nature		Form			Orientation		Spacing
	Feature Type	Soil Classification	Thickness t mm	Continuity Assessment	Surface Geometry	Strike	Dip	S mm
1	Lamina	Organic	2.5	Continuous	Planar	Horizontal		5
2	Lamina	Organic	2.5	Continuous	Planar	Horizontal		70
3	Lamina	Organic	1	Continuous	Planar	Horizontal		10
4	Lamina	Organic	2	Continuous	Planar	Horizontal		70
5	Lamina	Organic	2	Continuous	Planar	Horizontal		80
6	Lamina	Organic	0.6	Continuous	Planar	Horizontal		-
7	Lamina	Sand	10	Continuous	Curved	25	-	20
8	Lamina	Sand	10	Continuous	Planar	45	-	40
9	Lamina	Sand	5	Continuous	Planar	-	45	100
10	Lamina	Sand	5	Continuous	Planar	Horizontal		40
11	Thin Layer	Sand	30	Continuous	Planar	-	45	-
12	Sea Shells	N.A.	20	Discontinuous	N.A.	Horizontal		-

Macrofabric Data Sheet 8

Site : Kuala Perlis South Trial Embankment
Date Test Done : 17/5/93
Sample No: BH 23AG   Sample Length:0.6m   Depth: 4.2m to 4.8m   R.L. of Borehole : 1.831m
Orientation of Basic Axis : N.A.
Soil Description : Light to dark greyish clay of high plasticity with traces of organic matter and shell fragments
Observed related or referred features : None
Measurements:

No. of Feature	Nature		Form			Orientation		Spacing
	Feature Type	Soil Classification	Thickness t mm	Continuity Assessment	Surface Geometry	Strike	Dip	S mm
1	Lamina	Sand	1.5	Continuous	Planar	Horizontal		10
2	Lamina	Sand	1.5	Continuous	Planar	Horizontal		10
3	Dusting	Sand	0.5	Continuous	Planar	Horizontal		10
4	Lamina	Sand	0.65	Continuous	Planar	Horizontal		40
5	Lamina	Sand	2	Continuous	Planar	Horizontal		80
6	Lamina	Sand	1.5	Continuous	Planar	Horizontal		20
7	Thin Layer	Sand	10	Continuous	Planar	Horizontal		20
8	Thin Layer	Sand	20	Continuous	Planar	Horizontal		50
9	Lamina	Sand	2	Continuous	Planar	Horizontal		20
10	Lamina	Sand	2	Continuous	Planar	Horizontal		-
11	Lamina	Organic	2	Continuous	Planar	Horizontal		90
12	Lamina	Organic	2	Discontinuous	Planar	Horizontal		110
13	Thin Layer	Organic	15	Continuous	Planar	-	45	-
13	Sea Shells	N.A.	20	Discontinuous	N.A.	Horizontal		-

Macrofabric Data Sheet 9

Site : Kuala Perlis South Trial Embankment
Date Test Done : 17/5/93
Sample No: BH 23AH Sample Length:0.6m Depth: 4.8m to 5.4m R.L. of Borehole : 1.831m
Orientation of Basic Axis : N.A.
Soil Description : Light to dark greyish clay of high plasticity with traces of organic matter and shell fragments
Observed related or referred features : None
Measurements:

No. of Feature	Nature		Form			Orientation		Spacing
	Feature Type	Soil Classification	Thickness t mm	Continuity Assessment	Surface Geometry	Strike	Dip	S mm
1	Thin Layer	Organic	15	Continuous	Planar	Horizontal		60
2	Thin Layer	Organic	10	Continuous	Planar	Horizontal		230
3	Thin Layer	Organic	25	Continuous	Planar	Horizontal		-
4	Thin Layer	Sand	15	Continuous	Planar	Horizontal		170
5	Lamina	Sand	0.9	Continuous	Planar	Horizontal		40
6	Lamina	Sand	1	Continuous	Planar	Horizontal		-
7	Sea Shells	N.A.	10	Discontinuous	N.A.	Horizontal		60
8	Sea Shells	N.A.	10	Discontinuous	N.A.	Horizontal		10
9	Sea Shells	N.A.	10	Discontinuous	N.A.	Horizontal		5
10	Sea Shells	N.A.	8	Discontinuous	N.A.	Horizontal		80
9	Sea Shells	N.A.	10	Discontinuous	N.A.	Horizontal		-

Macrofabric Data Sheet 10

Site : Kuala Perlis South Trial Embankment
Date Test Done : 17/5/93
Sample No: BH 23AI Sample Length: 0.53m Depth: 5.4m to 6.0m R.L. of Borehole : 1.831m
Orientation of Basic Axis : N.A.
Soil Description : Light to dark greyish clay of high plasticity with traces of organic matter and shell fragments
Observed related or referred features : None
Measurements:

No. of Feature	Nature		Form			Orientation		Spacing
	Feature Type	Soil Classification	Thickness t mm	Continuity Assessment	Surface Geometry	Strike	Dip	S mm
1	Thin Layer	Organic	10	Continuous	Planar	Horizontal		-
2	Sea Shells	Sea Shells	5	Discontinuous	N.A.	Horizontal		10
3	Sea Shells	Sea Shells	10	Discontinuous	N.A.	Horizontal		60
4	Sea Shells	Sea Shells	5	Discontinuous	N.A.	Horizontal		90
5	Sea Shells	Sea Shells	5	Discontinuous	N.A.	Horizontal		40
6	Sea Shells	Sea Shells	5	Discontinuous	N.A.	Horizontal		-
7	Lamina	Sand	0.2	Continuous	Planar	Horizontal		10
8	Lamina	Sand	0.2	Continuous	Planar	Horizontal		-

Macrofabric Data Sheet 11

Site : Kuala Perlis South Trial Embankment
Date Test Done : 17/5/93
Sample No: BH 23AJ   Sample Length:0.55m   Depth: 6.0m to 6.6m   R.L. of Borehole : 1.831m
Orientation of Basic Axis : N.A.
Soil Description : Light to dark greyish clay of high plasticity with traces of organic matter and shell fragments
Observed related or referred features : None
Measurements:

No. of Feature	Nature		Form			Orientation		Spacing
	Feature Type	Soil Classification	Thickness t mm	Continuity Assessment	Surface Geometry	Strike	Dip	S mm
1	Thin Layer	Organic	40	Continuous	Planar	Horizontal		330
2	Thin Layer	Organic	5	Continuous	Planar	Horizontal		30
3	Thin Layer	Organic	5	Continuous	Planar	Horizontal		-
4	Sea Shells	N.A.	5	Discontinuous	N.A.	Horizontal		80
5	Sea Shells	N.A.	5	Discontinuous	N.A.	Horizontal		40
6	Sea Shells	N.A.	5	Discontinuous	N.A.	Horizontal		40
7	Sea Shells	N.A.	10	Discontinuous	N.A.	-	45	-

Macrofabric Data Sheet 14

Site : Kuala Perlis South Trial Embankment
Date Test Done : 19/5/93
Sample No: BH 23AM   Sample Length: 0.57m   Depth: 7.8m to 8.4m   R.L. of Borehole : 1.831m
Orientation of Basic Axis : N.A.
Soil Description : Soft greenish silty clay with traces of organic matter and shell fragments
Observed related or referred features : None
Measurements:

No. of Feature	Nature		Form			Orientation		Spacing
	Feature Type	Soil Classification	Thickness t mm	Continuity Assessment	Surface Geometry	Strike	Dip	S mm
1	Thin Layer	Organic	8	Continuous	Planar	Horizontal		15
2	Thin Layer	Organic	30	Continuous	Planar	Horizontal		180
3	Thin Layer	Organic	5	Continuous	Planar	Horizontal		70
4	Thin Layer	Organic	10	Continuous	Planar	Horizontal		-
5	Sea Shells	N.A.	2	Discontinuous	N.A.	Horizontal		60
6	Sea Shells	N.A.	5	Discontinuous	N.A.	Horizontal		10
7	Lamina	Sand	0.3	Continuous	Planar	Horizontal		150
8	Lamina	Sand	0.5	Continuous	Planar	Horizontal		-

Macrofabric Data Sheet 15

Site : Kuala Perlis South Trial Embankment
Date Test Done : 19/5/93
Sample No: BH 23AN   Sample Length:0.6m   Depth: 8.4m to 9.0m   R.L. of Borehole : 1.831m
Orientation of Basic Axis : N.A.
Soil Description : Soft greenish silty clay with traces of organic matter and shell fragments
Observed related or referred features : None
Measurements:

No. of Feature	Nature		Form			Orientation		Spacing
	Feature Type	Soil Classification	Thickness t mm	Continuity Assessment	Surface Geometry	Strike	Dip	S mm
1	Thin Layer	Organic	5	Continuous	Planar	Horizontal		20
2	Thin Layer	Organic	15	Continuous	Planar	Horizontal		140
3	Thin Layer	Organic	5	Continuous	Planar	Horizontal		120
4	Thin Layer	Organic	5	Continuous	Planar	Horizontal		-
5	Sea Shells	N.A.	20	Discontinuous	N.A.	Horizontal		80
6	Sea Shells	N.A.	5	Discontinuous	N.A.	Horizontal		120
7	Sea Shells	N.A.	7	Discontinuous	N.A.	Horizontal		-

Macrofabric Data Sheet 16

Site : Kuala Perlis South Trial Embankment
Date Test Done : 19/5/93
Sample No: BH 23A0 Sample Length:0.6m Depth: 9.0m to 9.6m R.L. of Borehole : 1.831m
Orientation of Basic Axis : N.A.
Soil Description : Soft greenish silty clay with traces of organic matter and shell fragments
Observed related or referred features : None
Measurements:

No. of Feature	Nature		Form			Orientation		Spacing
	Feature Type	Soil Classification	Thickness t mm	Continuity Assessment	Surface Geometry	Strike	Dip	S mm
1	Thin Layer	Organic	20	Continuous	Planar	Horizontal		110
2	Thin Layer	Organic	6	Continuous	Planar	Horizontal		160
3	Thin Layer	Organic	10	Continuous	Planar	Horizontal		-
4	Sea Shells	N.A.	6	Discontinuous	N.A.	Horizontal		-
5	Lamina	Sand	0.4	Continuous	Planar	Horizontal		-

Macrofabric Data Sheet 17

Site : Kuala Perlis South Trial Embankment
Date Test Done : 19/5/93
Sample No: BH 23AP Sample Length: 0.47m Depth: 9.6m to 10.2m R.L. of Borehole : 1.831m
Orientation of Basic Axis : N.A.
Soil Description : Soft greenish silty clay with traces of organic matter and shell fragments
Observed related or referred features : None
Measurements:

No. of Feature	Nature		Form			Orientation		Spacing
	Feature Type	Soil Classification	Thickness t mm	Continuity Assessment	Surface Geometry	Strike	Dip	S mm
1	Thin Layer	Organic	15	Continuous	Planar	Horizontal		10
2	Thin Layer	Organic	10	Continuous	Planar	Horizontal		150
3	Thin Layer	Organic	6	Continuous	Planar	Horizontal		20
4	Thin Layer	Organic	6	Continuous	Planar	Horizontal		-
5	Sea Shells	N.A.	10	Discontinuous	N.A.	Horizontal		30
6	Sea Shells	N.A.	7	Discontinuous	N.A.	Horizontal		10
7	Sea Shells	N.A.	6	Discontinuous	N.A.	Horizontal		10
8	Sea Shells	N.A.	6	Discontinuous	N.A.	Horizontal		-
9	Laminar	Sand	0.3	Continuous	Planar	Horizontal		-

Macrofabric Data Sheet 18

Site : Kuala Perlis South Trial Embankment
Date Test Done : 19/5/93
Sample No: BH 23AQ   Sample Length: 0.57m   Depth: 10.2m to 10.8m   R.L. of Borehole : 1.831m
Orientation of Basic Axis : N.A.
Soil Description : Soft greenish silty clay with traces of organic matter and shell fragments
Observed related or referred features : None
Measurements:

No. of Feature	Nature		Form			Orientation		Spacing
	Feature Type	Soil Classification	Thickness t mm	Continuity Assessment	Surface Geometry	Strike	Dip	S mm
1	Thin Layer	Organic	10	Continuous	Planar	Horizontal		-
2	Sea Shells	N.A.	10	Discontinuous	N.A.	Horizontal		40
3	Sea Shells	N.A.	5	Discontinuous	N.A.	Horizontal		30
4	Sea Shells	N.A.	5	Discontinuous	N.A.	Horizontal		30
5	Sea Shells	N.A.	10	Discontinuous	N.A.	Horizontal		90
6	Sea Shells	N.A.	10	Discontinuous	N.A.	Horizontal		40
7	Sea Shells	N.A.	10	Continuous	N.A.	Horizontal		-
8	Thin Layer	Sand	40	Continuous	Planar	90		-

Macrofabric Data Sheet 19

Site : Kuala Perlis South Trial Embankment
Date Test Done : 19/5/93
Sample No: BH 23AR   Sample Length:0.46m   Depth: 10.8m to 11.4m   R.L. of Borehole : 1.831m
Orientation of Basic Axis : N.A.
Soil Description : Soft grrenish silty clay with traces of organic matter and shell fragments
Observed related or referred features : None
Measurements:

No. of Feature	Nature		Form			Orientation		Spacing
	Feature Type	Soil Classification	Thickness t mm	Continuity Assessment	Surface Geometry	Strike	Dip	S mm
1	Sea Shells	N.A.	15	Discontinuous	N.A.	Horizontal		30
2	Sea Shells	N.A.	10	Discontinuous	N.A.	Horizontal		30
3	Sea Shells	N.A.	10	Discontinuous	N.A.	Horizontal		40
4	Sea Shells	N.A.	5	Discontinuous	N.A.	Horizontal		50
5	Sea Shells	N.A.	5	Discontinuous	N.A.	Horizontal		-
6	Thin Layer	Organics	5	Continuous	Planar	Horizontal		-

Macrofabric Data Sheet 20

Site : Kuala Perlis South Trial Embankment
Date Test Done : 19/5/93
Sample No: BH 23AT Sample Length:0.46m Depth:12.0m to 12.6m R.L. of Borehole : 1.831m
Orientation of Basic Axis : N.A.
Soil Description : Soft light to dark greenish silty clay with traces of organic matter and shell fragments
Observed related or referred features : None
Measurements:

No. of Feature	Nature		Form			Orientation		Spacing
	Feature Type	Soil Classification	Thickness t mm	Continuity Assessment	Surface Geometry	Strike	Dip	S mm
1	Thin Layer	Organics	20	Continuous	Planar	Horizontal		240
2	Thin Layer	Organics	5	Continuous	Planar	Horizontal		-
3	Dusting	Sand	0.1	Continuous	Planar	Horizontal		200
4	Lamina	Sand	1	Continuous	Planar	Horizontal		-
5	Sea Shells	N.A.	10	Discontinuous	N.A.	Horizontal		60
6	Sea Shells	N.A.	15	Discontinuous	N.A.	Horizontal		50
7	Sea Shells	N.A.	8	Discontinuous	N.A.	Horizontal		10
8	Sea Shells	N.A.	20	Discontinuous	N.A.	Horizontal		50
9	Sea Shells	N.A.	10	Discontinuous	N.A.	Horizontal		-

Macrofabric Data Sheet 21

Site : Kuala Perlis South Trial Embankment
Date Test Done : 20/5/93
Sample No: BH 23AT   Sample Length: 0.46m   Depth: 12.0m to 12.6m   R.L. of Borehole : 1.831m
Orientation of Basic Axis : N.A.
Soil Description : Stiff light greenish clay with traces of organic matter and shell fragments
Observed related or referred features : None
Measurements:

No. of Feature	Nature		Form			Orientation		Spacing
	Feature Type	Soil Classification	Thickness t mm	Continuity Assessment	Surface Geometry	Strike	Dip	S mm
1	Sea Shells	N.A.	15	Discontinuous	Planar	Horizontal		-
2	Thin Layer	Organics	5	Continuous	Planar	Horizontal		10
3	Thin Layer	Organics	5	Continuous	Planar	Horizontal		110
4	Thin Layer	Organics	5	Continuous	Planar	45		-
5	Dusting	Sand	0.05	Continuous	Planar	Horizontal		140
6	Dusting	Sand	0.05	Continuous	Planar	Horizontal		-

Macrofabric Data Sheet 22

Site : Kuala Perlis South Trial Embankment
Date Test Done : 20/5/93
Sample No: BH 23AU Sample Length: 0.46m Depth: 12.6m to 13.2m R.L. of Borehole : 1.831m
Orientation of Basic Axis : N.A.
Soil Description : Stiff mottled light greyish browinish red silty clay with traces of organic matter and shell fragments
Observed related or referred features : None
Measurements:

No. of Feature	Nature		Form			Orientation		Spacing
	Feature Type	Soil Classification	Thickness t mm	Continuity Assessment	Surface Geometry	Strike	Dip	S mm
1	Thin Layer	Organics	5	Continuous	Planar	Horizontal		50
2	Thin Layer	Organics	5	Continuous	Planar	Horizontal		90
3	Thin Layer	Organics	5	Continuous	Planar	Horizontal		-

Macrofabric Data Sheet 12

Site : Kuala Perlis South Trial Embankment
Date Test Done : 17/5/93
Sample No: BH 23AK   Sample Length:0.55m   Depth: 6.6m to 7.2m   R.L. of Borehole : 1.831m
Orientation of Basic Axis : N.A.
Soil Description : Soft greenish silty clay with traces of organic matter and shell fragments
Observed related or referred features : None
Measurements:

No. of Feature	Nature		Form			Orientation		Spacing
	Feature Type	Soil Classification	Thickness t mm	Continuity Assessment	Surface Geometry	Strike	Dip	S mm
1	Thin Layer	Organic	10	Continuous	Planar	Horizontal		40
2	Thin Layer	Organic	5	Continuous	Planar	-	45	210
3	Thin Layer	Organic	5	Continuous	Planar	90	-	20
4	Thin Layer	Organic	8	Continuous	Planar	45		-
5	Sea Shells	N.A.	8	Discontinuous	N.A.	Horizontal		80
6	Sea Shells	N.A.	5	Discontinuous	N.A.	Horizontal		10
7	Sea Shells	N.A.	5	Discontinuous	N.A.	Horizontal		10
8	Sea Shells	N.A.	5	Discontinuous	N.A.	Horizontal		40
9	Sea Shells	N.A.	5	Discontinuous	N.A.	Horizontal		-
10	Thin Layer	Sand	5	Continuous	Planar	Horizontal		60
11	Lamina	Sand	3	Continuous	Planar	Horizontal		-

Macrofabric Data Sheet 13

Site : Kuala Perlis South Trial Embankment
Date Test Done : 18/5/93
Sample No: BH 23AL Sample Length: 0.6m Depth: 7.2m to 7.8m R.L. of Borehole : 1.831m
Orientation of Basic Axis : N.A.
Soil Description : Soft greenish silty clay with traces of organic matter and shell fragments
Observed related or referred features : None
Measurements:

No. of Feature	Nature		Form			Orientation		Spacing
	Feature Type	Soil Classification	Thickness t mm	Continuity Assessment	Surface Geometry	Strike	Dip	S mm
1	Thin Layer	Organic	5	Continuous	Planar	Horizontal		290
2	Thin Layer	Organic	7	Continuous	Planar	Horizontal		-
3	Sea Shells	N.A.	5	Discontinuous	N.A.	45	-	10
4	Sea Shells	N.A.	5	Discontinuous	N.A.	45		10
5	Sea Shells	N.A.	5	Discontinuous	N.A.	45		120
6	Sea Shells	N.A.	5	Discontinuous	N.A.	Horizontal		90
7	Sea Shells	N.A	8	Discontinuous	N.A.	Horizontal		-
8	Lamina	Sand	2	Continuous	Planar	Horizontal		-

Macrofabric Data Sheet 14

Site : Kuala Perlis South Trial Embankment
Date Test Done : 19/5/93
Sample No: BH 23AM   Sample Length: 0.57m   Depth: 7.8m to 8.4m   R.L. of Borehole : 1.831m
Orientation of Basic Axis : N.A.
Soil Description : Soft greenish silty clay with traces of organic matter and shell fragments
Observed related or referred features : None
Measurements:

No. of Feature	Nature		Form			Orientation		Spacing
	Feature Type	Soil Classification	Thickness t mm	Continuity Assessment	Surface Geometry	Strike	Dip	S mm
1	Thin Layer	Organic	8	Continuous	Planar	Horizontal		15
2	Thin Layer	Organic	30	Continuous	Planar	Horizontal		180
3	Thin Layer	Organic	5	Continuous	Planar	Horizontal		70
4	Thin Layer	Organic	10	Continuous	Planar	Horizontal		-
5	Sea Shells	N.A.	2	Discontinuous	N.A.	Horizontal		60
6	Sea Shells	N.A.	5	Discontinuous	N.A.	Horizontal		10
7	Lamina	Sand	0.3	Continuous	Planar	Horizontal		150
8	Lamina	Sand	0.5	Continuous	Planar	Horizontal		-

Macrofabric Data Sheet 15

Site : Kuala Perlis South Trial Embankment
Date Test Done : 19/5/93
Sample No: BH 23AN Sample Length:0.6m Depth: 8.4m to 9.0m R.L. of Borehole : 1.831m
Orientation of Basic Axis : N.A.
Soil Description : Soft greenish silty clay with traces of organic matter and shell fragments
Observed related or referred features : None
Measurements:

No. of Feature	Nature		Form			Orientation		Spacing
	Feature Type	Soil Classification	Thickness t mm	Continuity Assessment	Surface Geometry	Strike	Dip	S mm
1	Thin Layer	Organic	5	Continuous	Planar	Horizontal		20
2	Thin Layer	Organic	15	Continuous	Planar	Horizontal		140
3	Thin Layer	Organic	5	Continuous	Planar	Horizontal		120
4	Thin Layer	Organic	5	Continuous	Planar	Horizontal		-
5	Sea Shells	N.A.	20	Discontinuous	N.A.	Horizontal		80
6	Sea Shells	N.A.	5	Discontinuous	N.A.	Horizontal		120
7	Sea Shells	N.A.	7	Discontinuous	N.A.	Horizontal		-

Macrofabric Data Sheet 16

Site : Kuala Perlis South Trial Embankment
Date Test Done : 19/5/93
Sample No: BH 23A0 Sample Length:0.6m Depth: 9.0m to 9.6m R.L. of Borehole : 1.831m
Orientation of Basic Axis : N.A.
Soil Description : Soft greenish silty clay with traces of organic matter and shell fragments
Observed related or referred features : None
Measurements:

No. of Feature	Nature		Form			Orientation		Spacing
	Feature Type	Soil Classification	Thickness t mm	Continuity Assessment	Surface Geometry	Strike	Dip	S mm
1	Thin Layer	Organic	20	Continuous	Planar	Horizontal		110
2	Thin Layer	Organic	6	Continuous	Planar	Horizontal		160
3	Thin Layer	Organic	10	Continuous	Planar	Horizontal		-
4	Sea Shells	N.A.	6	Discontinuous	N.A.	Horizontal		-
5	Lamina	Sand	0.4	Continuous	Planar	Horizontal		-

Macrofabric Data Sheet 17

Site : Kuala Perlis South Trial Embankment
Date Test Done : 19/5/93
Sample No: BH 23AP Sample Length: 0.47m Depth: 9.6m to 10.2m R.L. of Borehole : 1.831m
Orientation of Basic Axis : N.A.
Soil Description : Soft greenish silty clay with traces of organic matter and shell fragments
Observed related or referred features : None
Measurements:

No. of Feature	Nature		Form			Orientation		Spacing
	Feature Type	Soil Classification	Thickness t mm	Continuity Assessment	Surface Geometry	Strike	Dip	S mm
1	Thin Layer	Organic	15	Continuous	Planar	Horizontal		10
2	Thin Layer	Organic	10	Continuous	Planar	Horizontal		150
3	Thin Layer	Organic	6	Continuous	Planar	Horizontal		20
4	Thin Layer	Organic	6	Continuous	Planar	Horizontal		-
5	Sea Shells	N.A.	10	Discontinuous	N.A.	Horizontal		30
6	Sea Shells	N.A.	7	Discontinuous	N.A.	Horizontal		10
7	Sea Shells	N.A.	6	Discontinuous	N.A.	Horizontal		10
8	Sea Shells	N.A.	6	Discontinuous	N.A.	Horizontal		-
9	Laminar	Sand	0.3	Continuous	Planar	Horizontal		-

Macrofabric Data Sheet 18

Site : Kuala Perlis South Trial Embankment
Date Test Done : 19/5/93
Sample No: BH 23AQ Sample Length: 0.57m Depth: 10.2m to 10.8m R.L. of Borehole : 1.831m
Orientation of Basic Axis : N.A.
Soil Description : Soft greenish silty clay with traces of organic matter and shell fragments
Observed related or referred features : None
Measurements:

No. of Feature	Nature		Form			Orientation		Spacing
	Feature Type	Soil Classification	Thickness t mm	Continuity Assessment	Surface Geometry	Strike	Dip	S mm
1	Thin Layer	Organic	10	Continuous	Planar	Horizontal		-
2	Sea Shells	N.A.	10	Discontinuous	N.A.	Horizontal		40
3	Sea Shells	N.A.	5	Discontinuous	N.A.	Horizontal		30
4	Sea Shells	N.A.	5	Discontinuous	N.A.	Horizontal		30
5	Sea Shells	N.A.	10	Discontinuous	N.A.	Horizontal		90
6	Sea Shells	N.A.	10	Discontinuous	N.A.	Horizontal		40
7	Sea Shells	N.A.	10	Continuous	N.A.	Horizontal		-
8	Thin Layer	Sand	40	Continuous	Planar	90		-

Macrofabric Data Sheet 19

Site : Kuala Perlis South Trial Embankment
Date Test Done : 19/5/93
Sample No: BH 23AR   Sample Length:0.46m   Depth: 10.8m to 11.4m   R.L. of Borehole : 1.831m
Orientation of Basic Axis : N.A.
Soil Description : Soft grrenish silty clay with traces of organic matter and shell fragments
Observed related or referred features : None
Measurements:

No. of Feature	Nature		Form			Orientation		Spacing
	Feature Type	Soil Classification	Thickness t mm	Continuity Assessment	Surface Geometry	Strike	Dip	S mm
1	Sea Shells	N.A.	15	Discontinuous	N.A.	Horizontal		30
2	Sea Shells	N.A.	10	Discontinuous	N.A.	Horizontal		30
3	Sea Shells	N.A.	10	Discontinuous	N.A.	Horizontal		40
4	Sea Shells	N.A.	5	Discontinuous	N.A.	Horizontal		50
5	Sea Shells	N.A.	5	Discontinuous	N.A.	Horizontal		-
6	Thin Layer	Organics	5	Continuous	Planar	Horizontal		-

Macrofabric Data Sheet 20

Site : Kuala Perlis South Trial Embankment
Date Test Done : 19/5/93
Sample No: BH 23AT Sample Length:0.46m Depth:12.0m to 12.6m R.L. of Borehole : 1.831m
Orientation of Basic Axis : N.A.
Soil Description : Soft light to dark greenish silty clay with traces of organic matter and shell fragments
Observed related or referred features : None
Measurements:

No. of Feature	Nature		Form			Orientation		Spacing
	Feature Type	Soil Classification	Thickness t mm	Continuity Assessment	Surface Geometry	Strike	Dip	S mm
1	Thin Layer	Organics	20	Continuous	Planar	Horizontal		240
2	Thin Layer	Organics	5	Continuous	Planar	Horizontal		-
3	Dusting	Sand	0.1	Continuous	Planar	Horizontal		200
4	Lamina	Sand	1	Continuous	Planar	Horizontal		-
5	Sea Shells	N.A.	10	Discontinuous	N.A.	Horizontal		60
6	Sea Shells	N.A.	15	Discontinuous	N.A.	Horizontal		50
7	Sea Shells	N.A.	8	Discontinuous	N.A.	Horizontal		10
8	Sea Shells	N.A.	20	Discontinuous	N.A.	Horizontal		50
9	Sea Shells	N.A.	10	Discontinuous	N.A.	Horizontal		-

Macrofabric Data Sheet 21

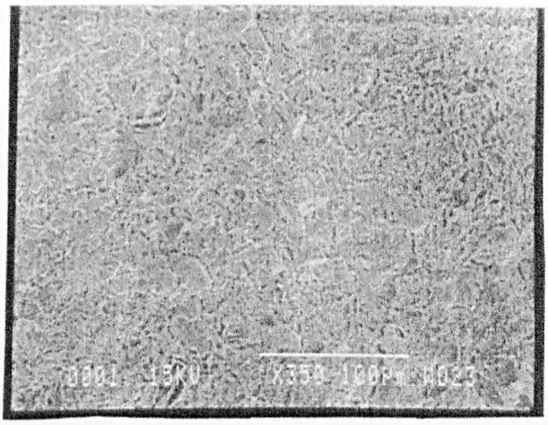
Site : Kuala Perlis South Trial Embankment
Date Test Done : 20/5/93
Sample No: BH 23AT   Sample Length: 0.46m   Depth: 12.0m to 12.6m   R.L. of Borehole : 1.831m
Orientation of Basic Axis : N.A.
Soil Description : Stiff light greenish clay with traces of organic matter and shell fragments
Observed related or referred features : None
Measurements:

No. of Feature	Nature		Form			Orientation		Spacing
	Feature Type	Soil Classification	Thickness t mm	Continuity Assessment	Surface Geometry	Strike	Dip	S mm
1	Sea Shells	N.A.	15	Discontinuous	Planar	Horizontal		-
2	Thin Layer	Organics	5	Continuous	Planar	Horizontal		10
3	Thin Layer	Organics	5	Continuous	Planar	Horizontal		110
4	Thin Layer	Organics	5	Continuous	Planar	45		-
5	Dusting	Sand	0.05	Continuous	Planar	Horizontal		140
6	Dusting	Sand	0.05	Continuous	Planar	Horizontal		-

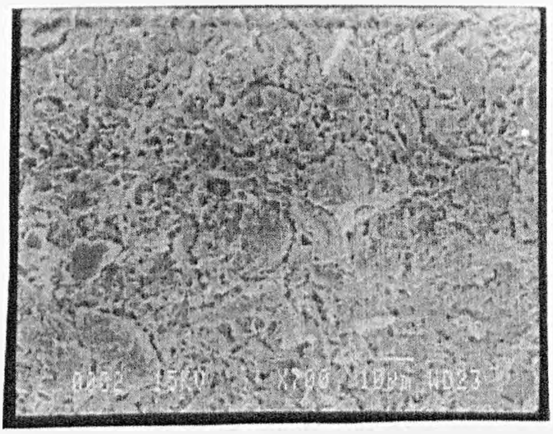
Macrofabric Data Sheet 22

Site : Kuala Perlis South Trial Embankment
Date Test Done : 20/5/93
Sample No: BH 23AU   Sample Length: 0.46m   Depth: 12.6m to 13.2m   R.L. of Borehole : 1.831m
Orientation of Basic Axis : N.A.
Soil Description : Stiff mottled light greyish browinish red silty clay with traces of organic matter and shell fragments
Observed related or referred features : None
Measurements:

No. of Feature	Nature		Form			Orientation		Spacing
	Feature Type	Soil Classification	Thickness t mm	Continuity Assessment	Surface Geometry	Strike	Dip	S mm
1	Thin Layer	Organics	5	Continuous	Planar	Horizontal		50
2	Thin Layer	Organics	5	Continuous	Planar	Horizontal		90
3	Thin Layer	Organics	5	Continuous	Planar	Horizontal		-



Magnification (x350)



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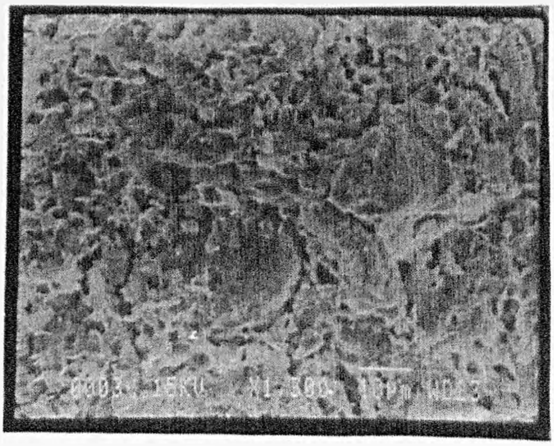
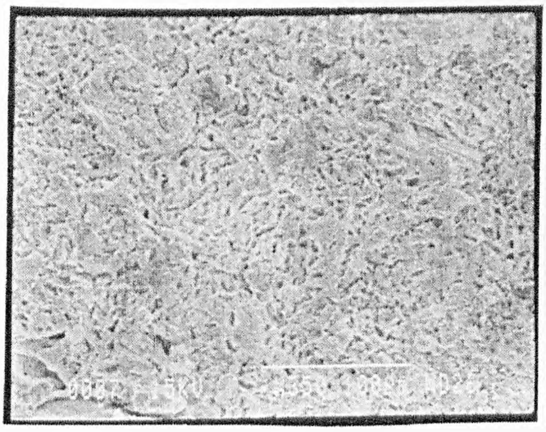


Magnification (x1300)

Microfabric Features of Kuala Perlis Coastal Soft Soil Deposits in Horizontal Alignment at a Depth of 3.7m to 4.3m



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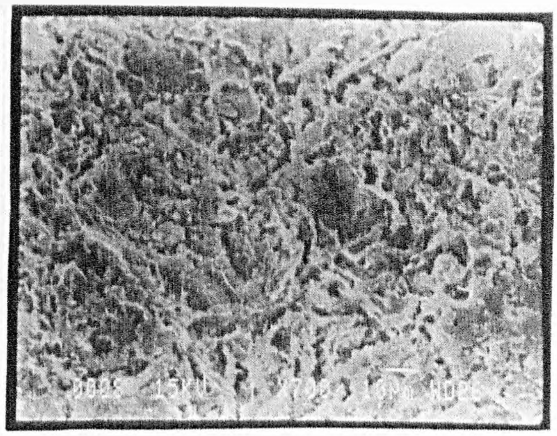
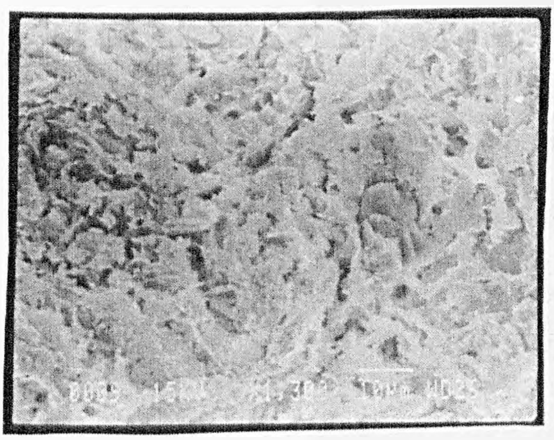
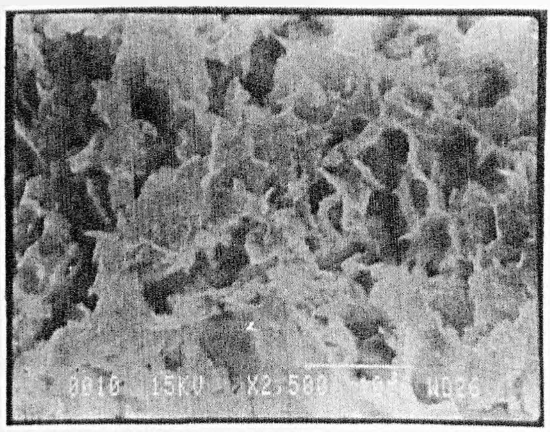


Magnification (x700)

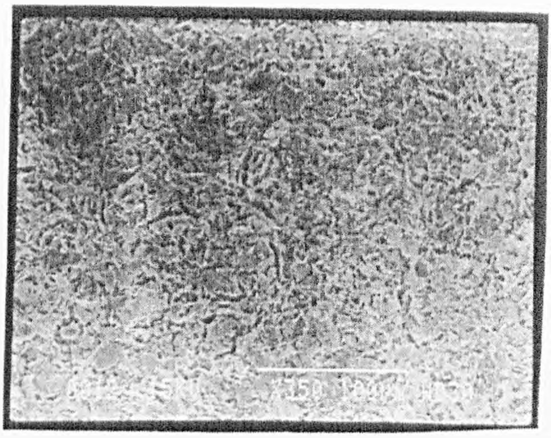


Magnification (x1300)

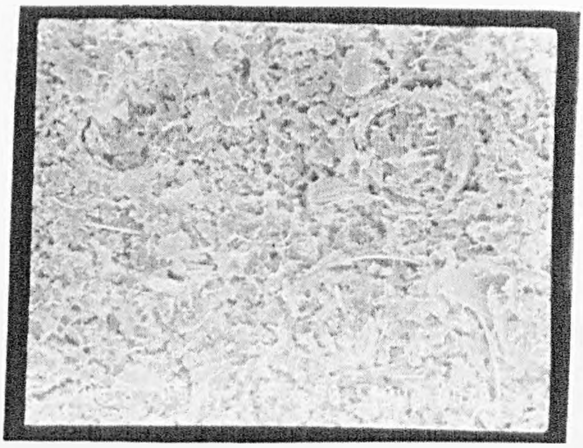


Magnification (x2500)

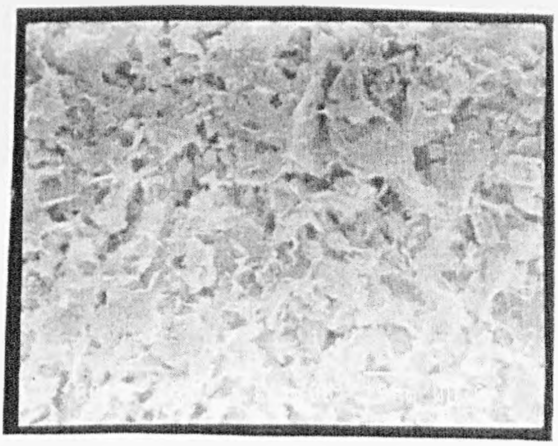
Microfabric Features of Kuala Perlis Coastal Soft Soil Deposits in Vertical Alignment at a Depth of 3.7m to 4.3m



Magnification (x350)

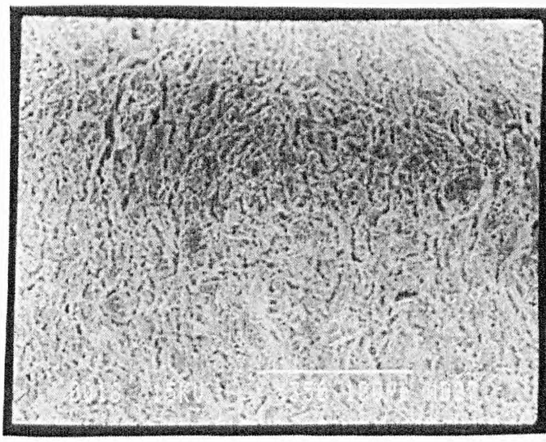


Magnification (x650)

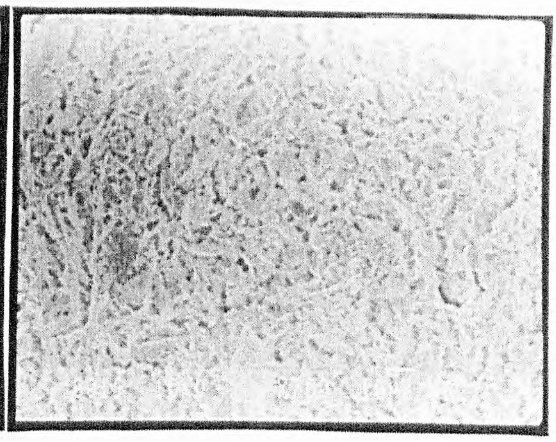


Magnification(x1300)

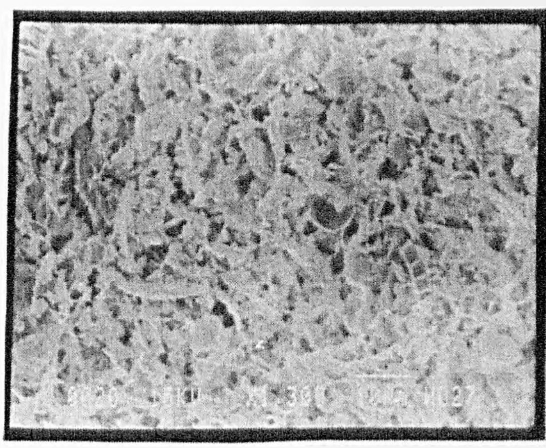
Microfabric Features of Kuala Perlis Coastal Soft Soil Deposits in Horizontal Alignment at a Depth of 5.7m to 6.3m



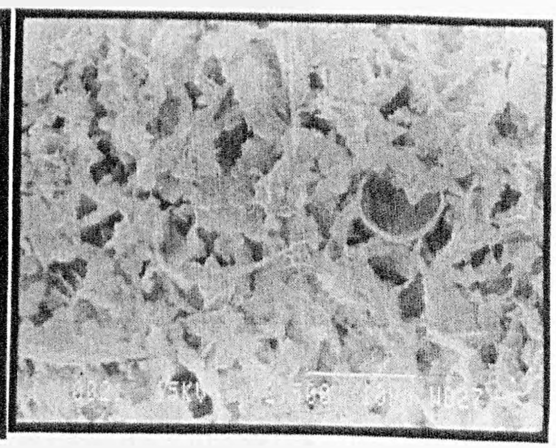
Magnification (x300)



Magnification (x700)

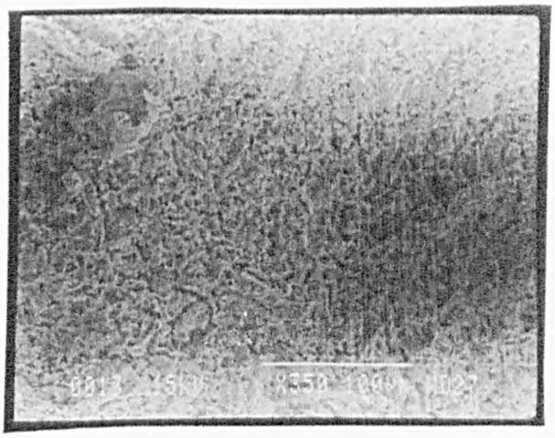


Magnification(x1300)

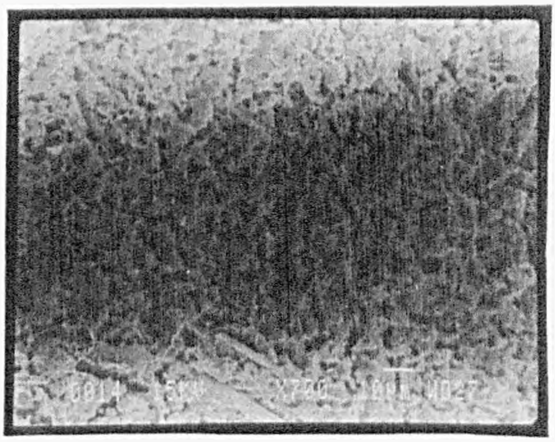


Magnification (x2500)

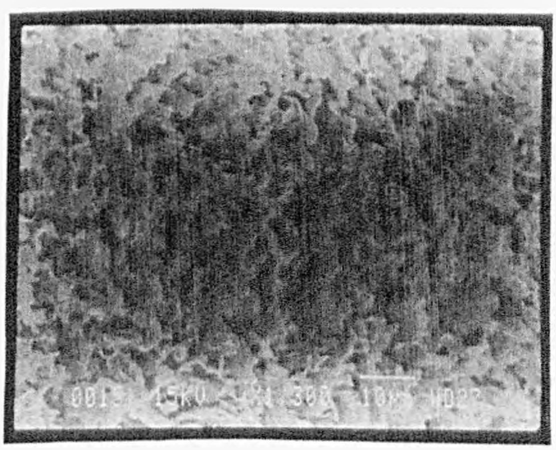
Microfabric Features of Kuala Perlis Coastal Soft Soil Deposits in Vertical Alignment at a Depth of 5.7m to 6.3m



Magnification (x350)

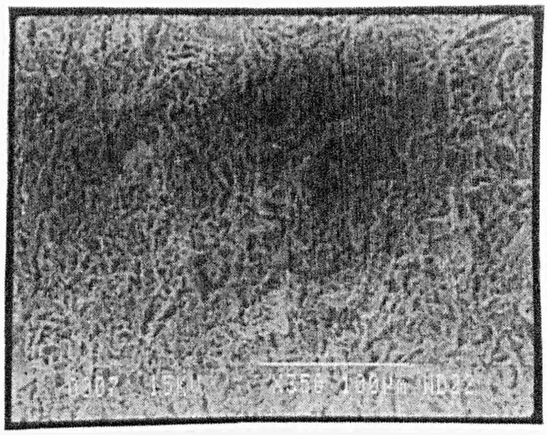


Magnification (x700)

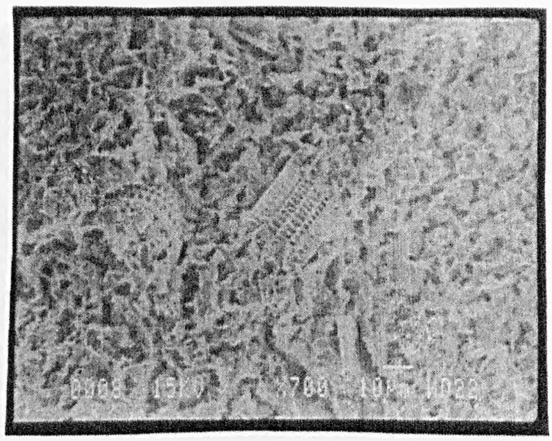


Magnification (x1300)

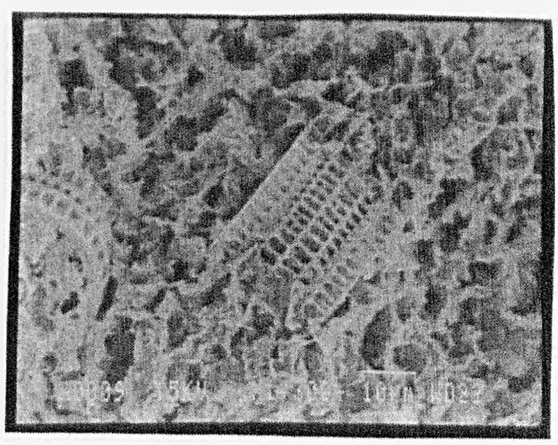
Microfabric Features of Kuala Perlis Coastal Soft Soil Deposits in Horizontal Alignment at a Depth of 7.7m to 8.3m



Magnification (x350)

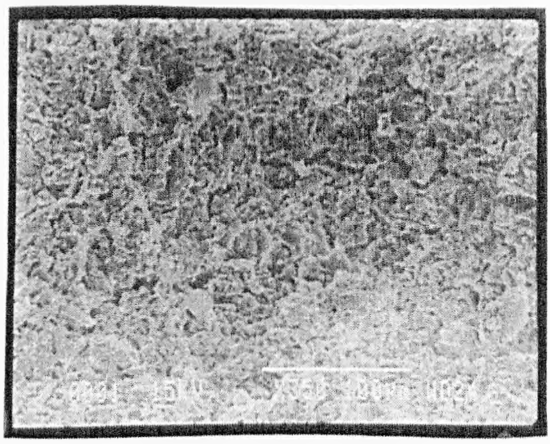


Magnification (x700)

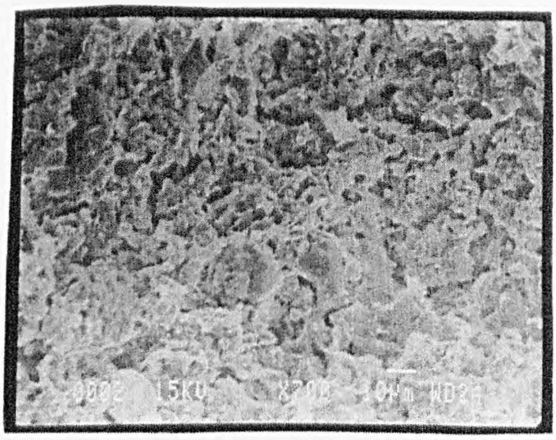


Magnification (x1300)

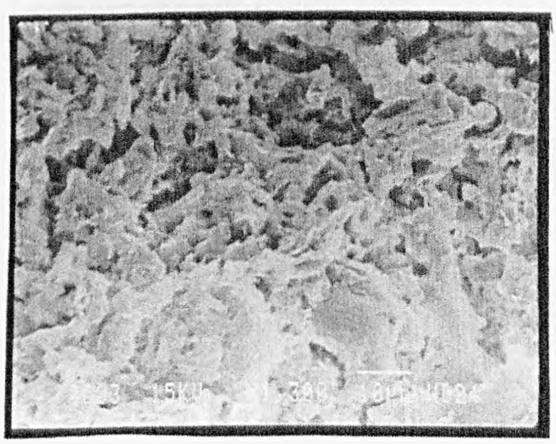
Microfabric Features of Kuala Perlis Coastal Soft Soil Deposits in Vertical Alignment at a Depth of 7.7m to 8.3m



Magnification (x350)

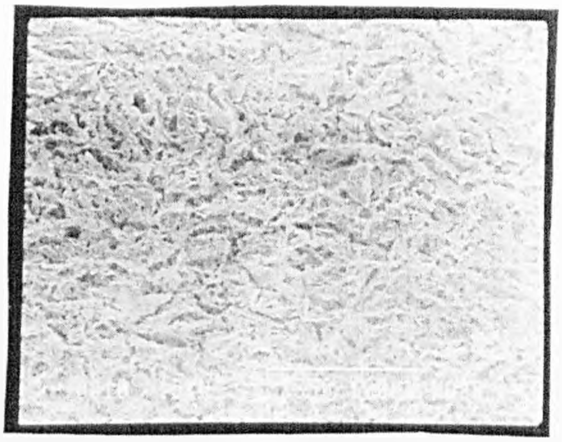


Magnification (x700)

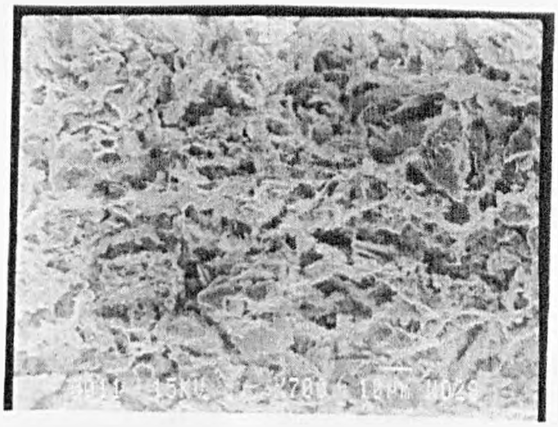


Magnification (x1300)

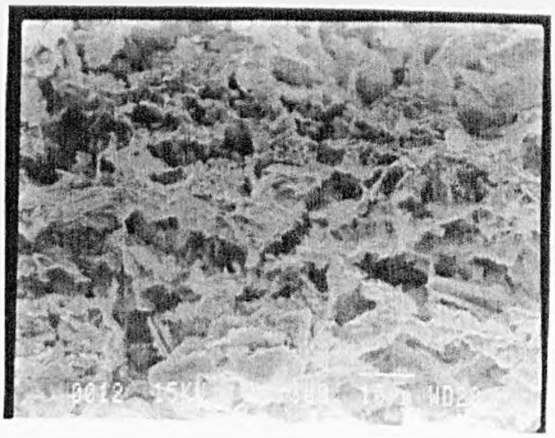
Microfabric Features of Kuala Perlis Coastal Soft Soil Deposits in Horizontal Alignment at a Depth of 11.7m to 12.3m



Magnification (x350)

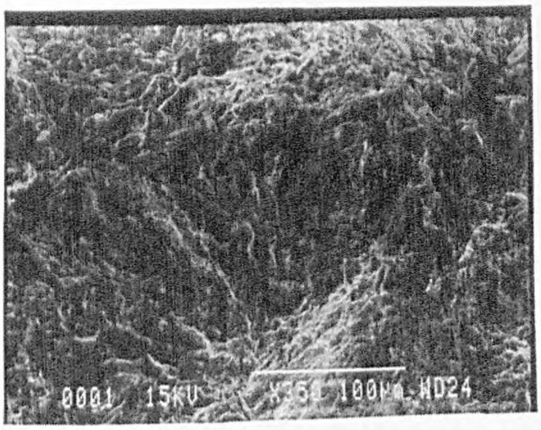


Magnification (x700)

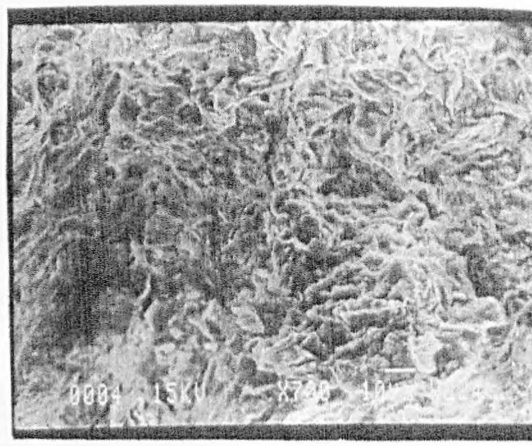


Magnification (x1300)

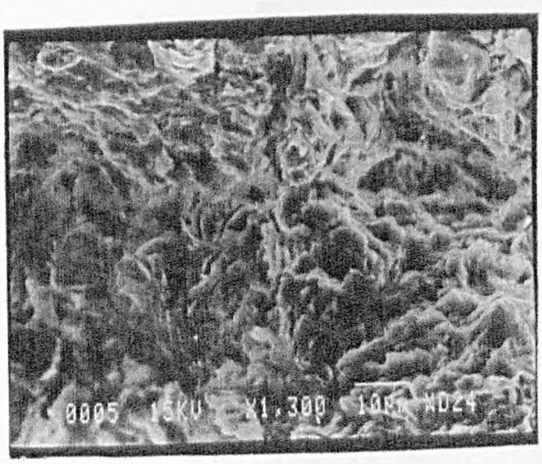
Microfabric Features of Kuala Perlis Coastal Soft Soil Deposits in Vertical Alignment at a Depth of 11.7m to 12.3m



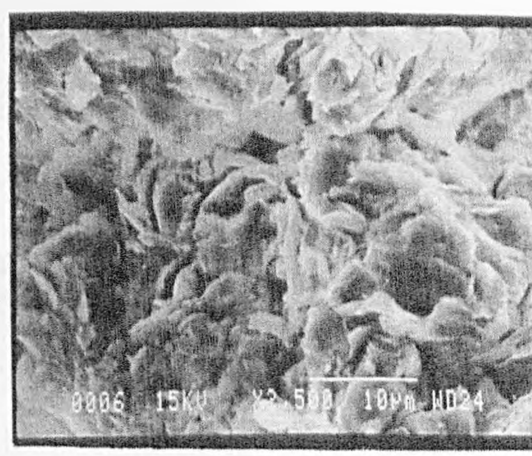
Magnification (x350)



Magnification (x700)

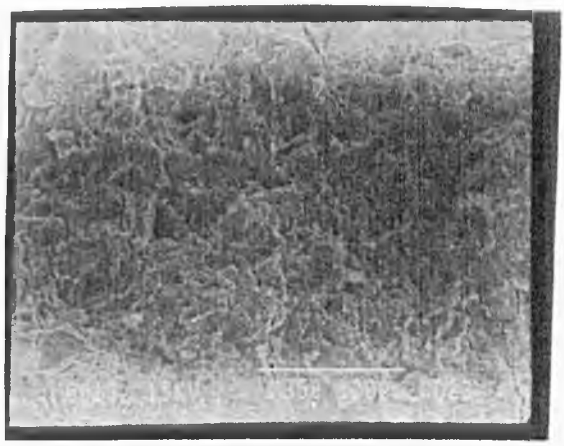


Magnification (x1300)

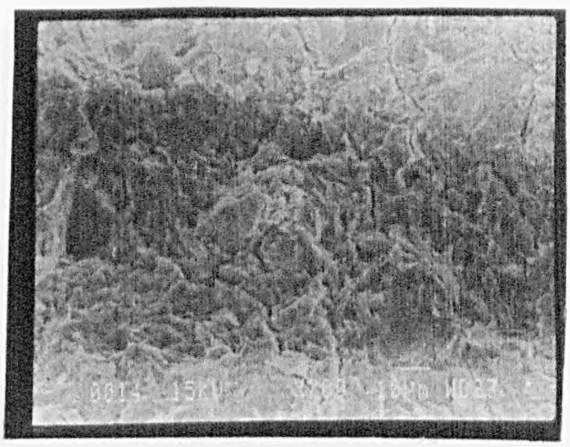


Magnification (x2500)

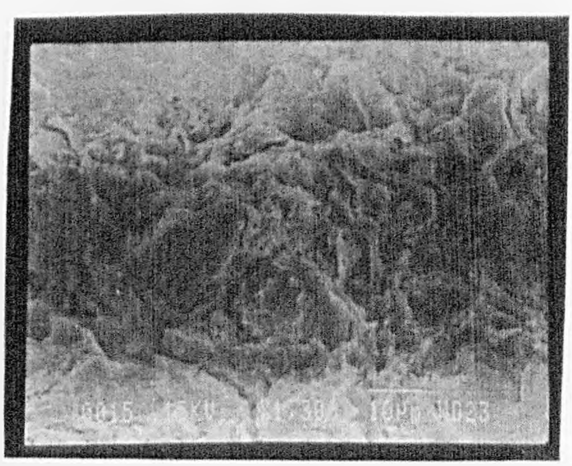
Microfabric Features of Kuala Perlis Coastal Soft Soil Deposits in Horizontal Alignment at a Depth of 13.7m to 14.3m



Magnification (x350)

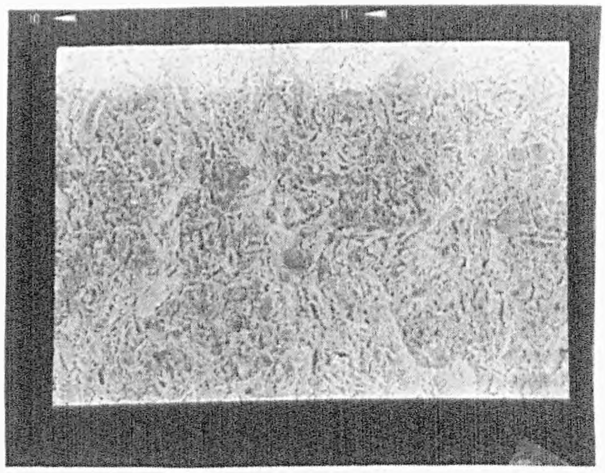


Magnification (x700)

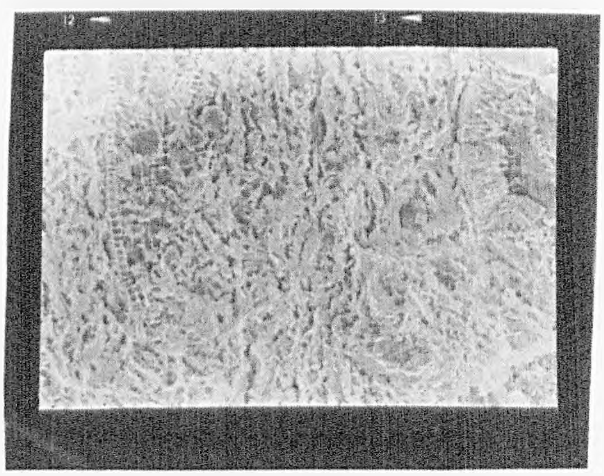


Magnification (x1300)

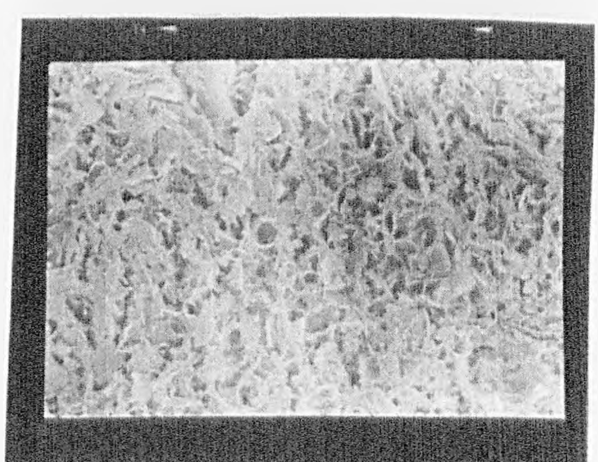
Microfabric Features of Kuala Perlis Coastal Soft Soil Deposits in Vertical Alignment at a Depth of 13.7m to 14.3m



Magnification (x350)

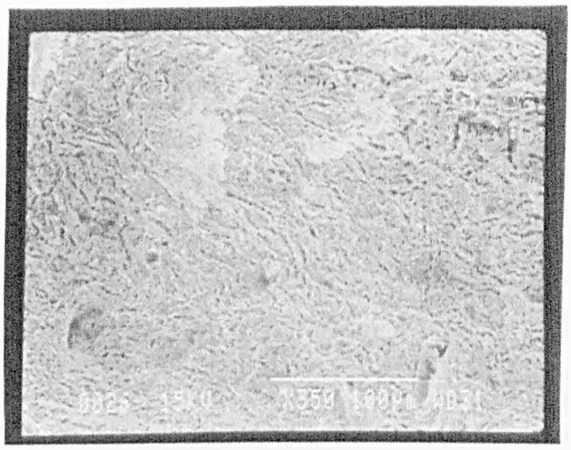


Magnification (x700)

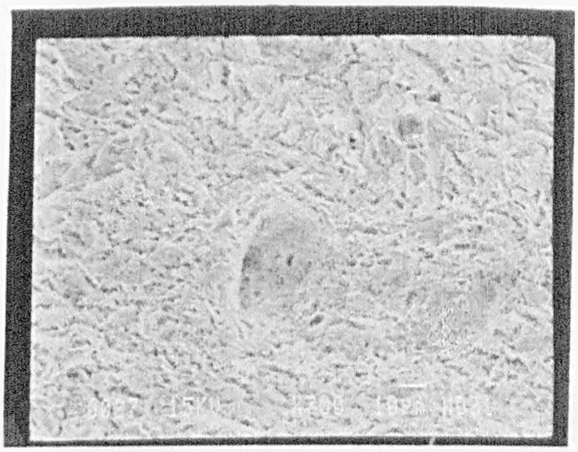


Magnification (x1300)

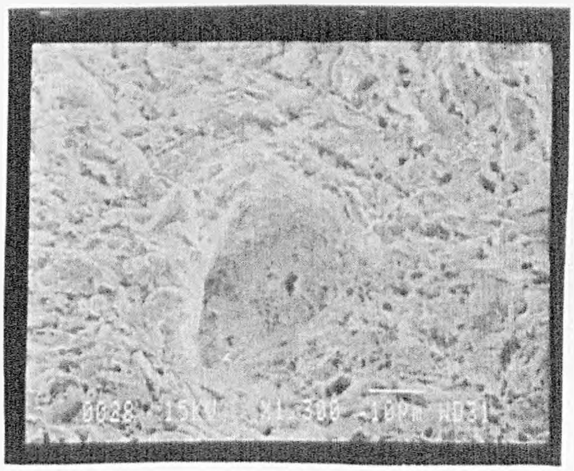
Microfabric Features of Consolidation Kuala Perlis Coastal Soft Soil Deposits in Vertical Alignment at a Depth of 5.7m to 6.3m (Consolidation Pressure=50kPa)



Magnification (x350)

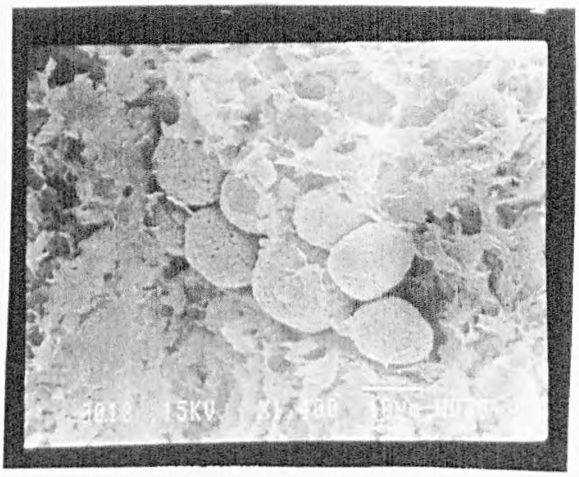


Magnification (x700)

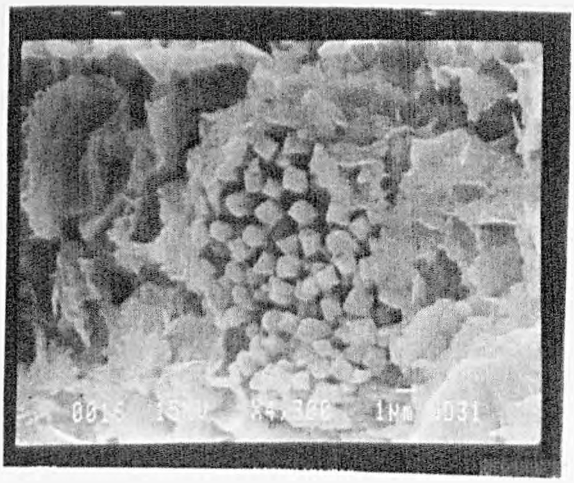


Magnification (x1300)

Microfabric Features of Consolidation Kuala Perlis Coastal Soft Soil Deposits in Horizontal Alignment at a Depth of 5.7m to 6.3m (Consolidation Pressure=50kPa)



a. Pyrites in Cluster Form

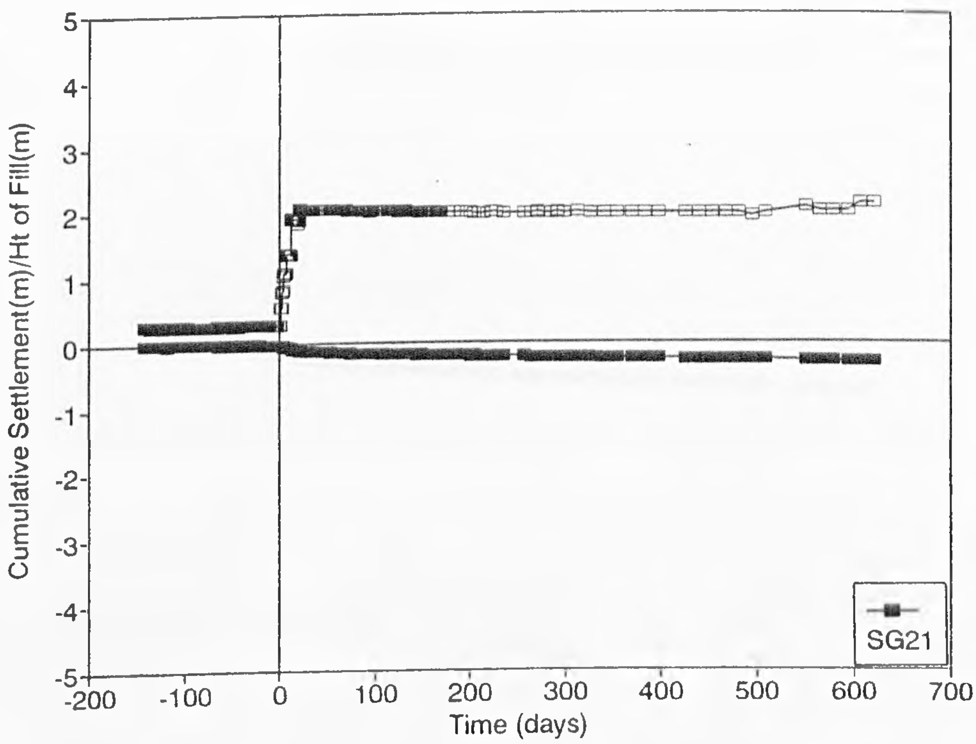


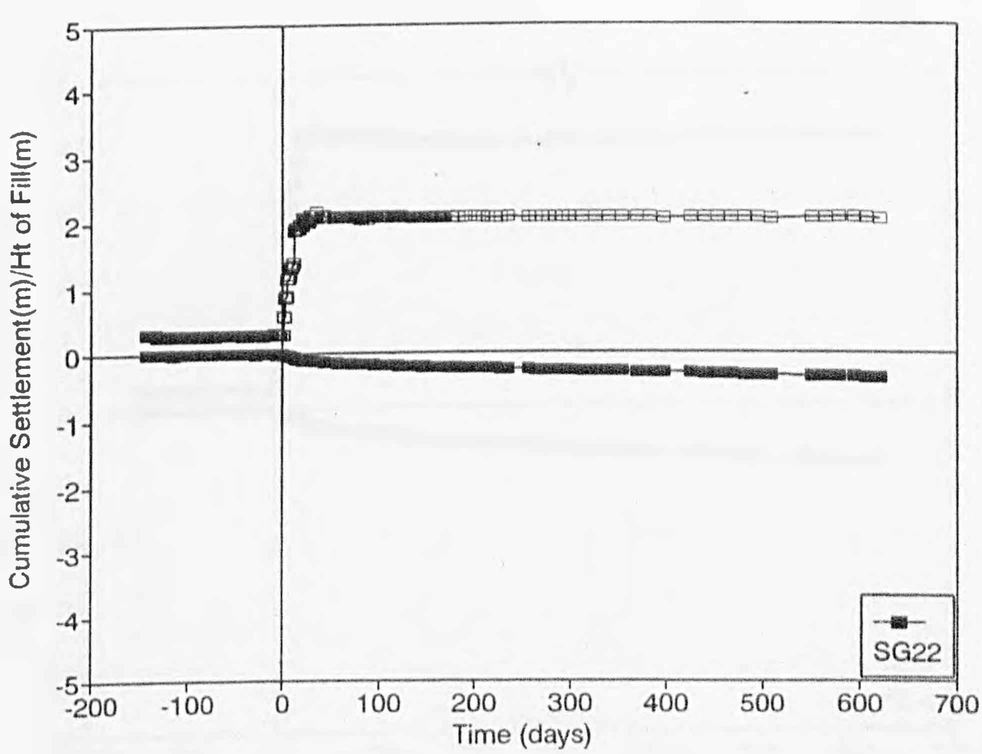
b. Pyrites in Pyritohedral Form

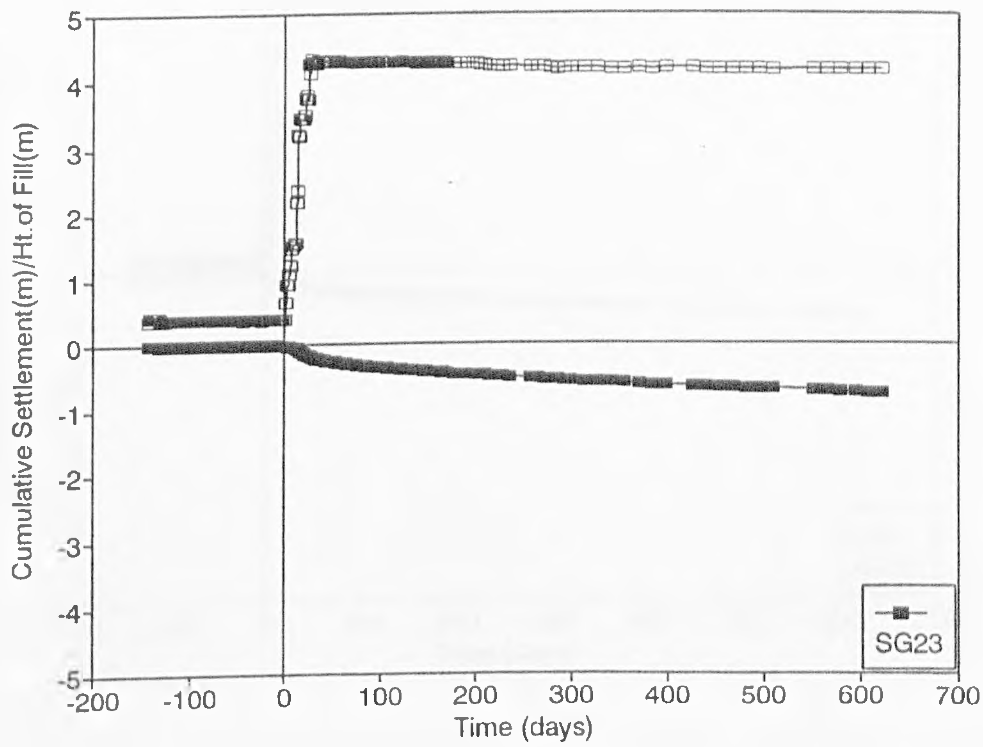
Other Microfabric Features Observed in Kuala Perlis Coastal Soft Soil Deposits

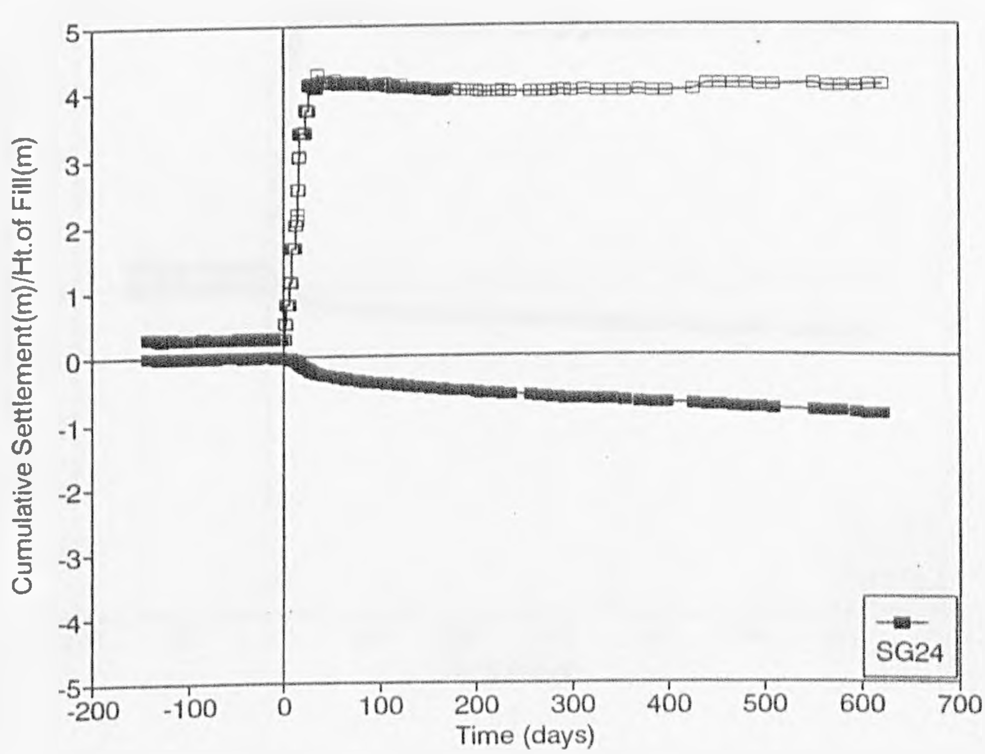
APPENDIX 6.1

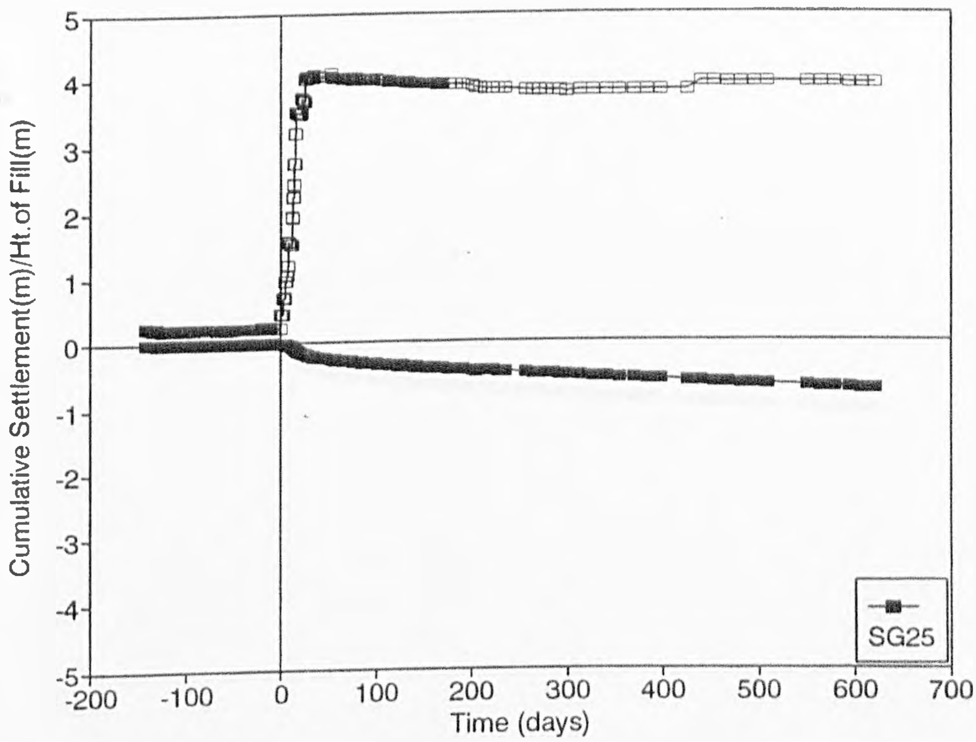
RELATIONSHIP OF CUMULATIVE SETTLEMENT/HEIGHT OF FILL WITH TIME OF SETTLEMENT PLATES (SG21 TO SG30) IN THE EAST-WEST DIRECTION


Cumulative Settlement(m)/Ht of Fill(m)
Time (days)
SG21

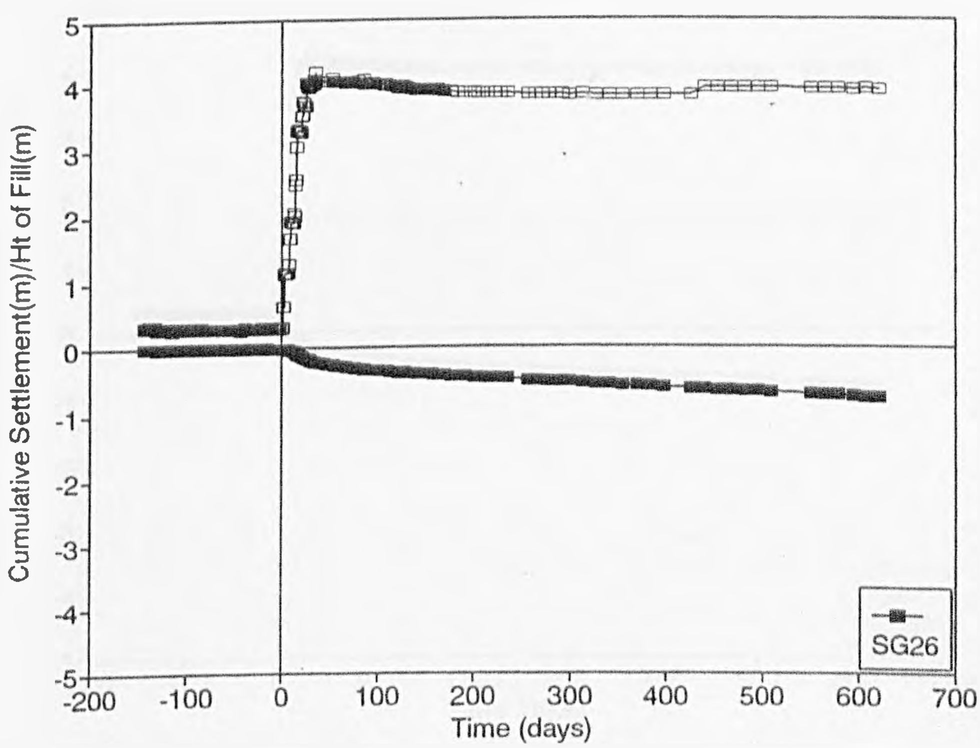

Cumulative Settlement(m)/Ht of Fill(m)
Time (days)
SG22


Cumulative Settlement(m)/Ht.of Fill(m)
Time (days)
SG23

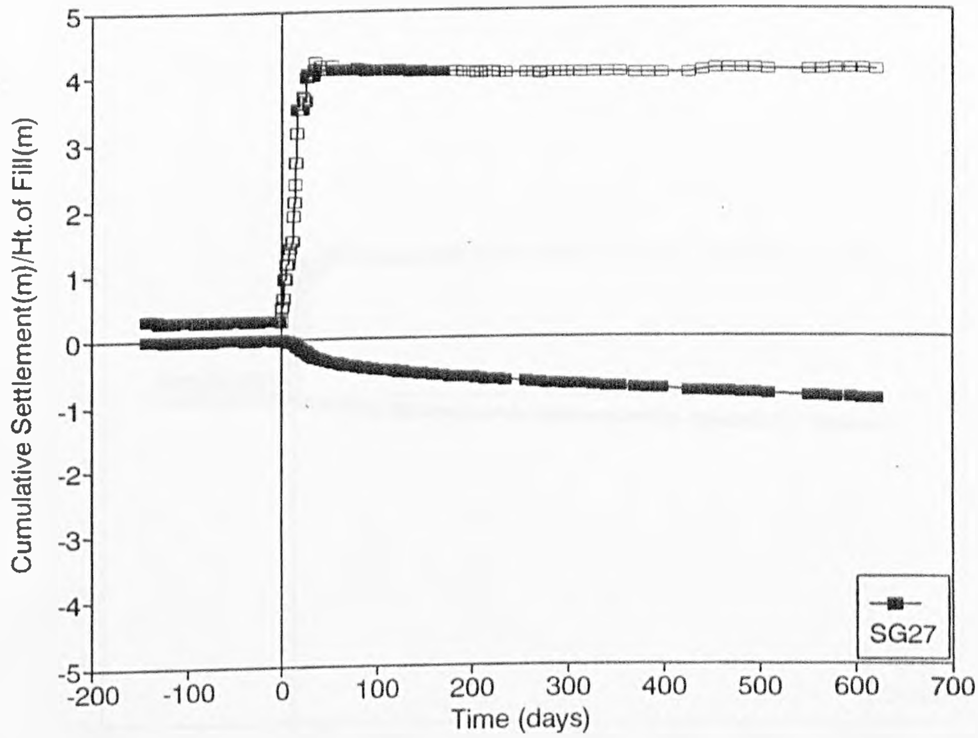

Cumulative Settlement(m)/Ht.of Fill(m)
Time (days)
SG24



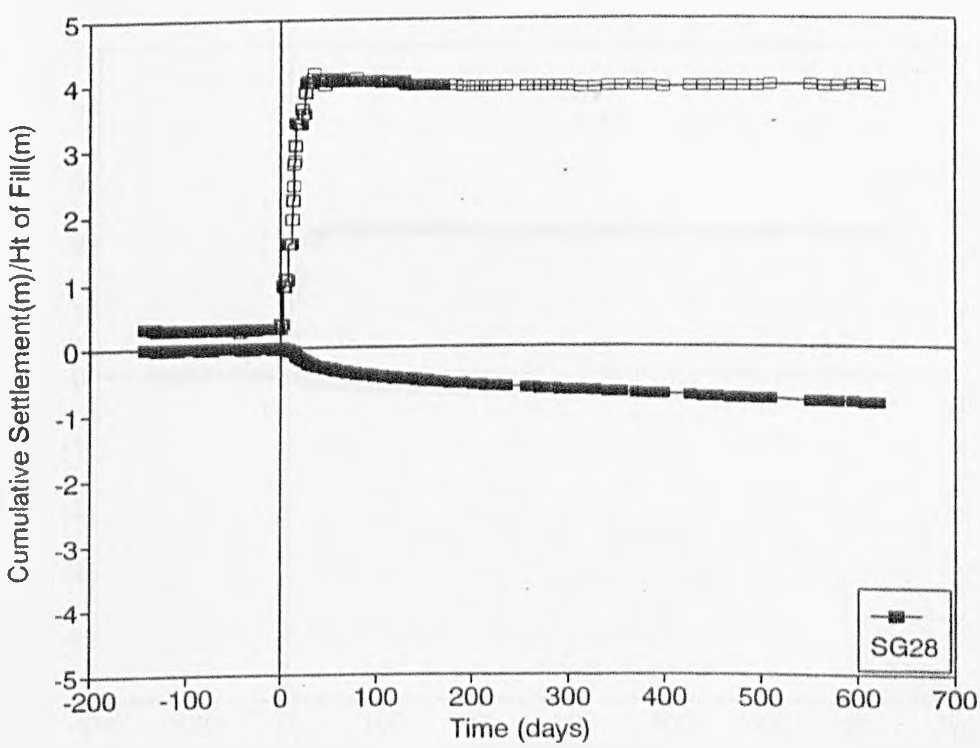
Cumulative Settlement(m)/Ht.of Fill(m)
5
4
3
2
1
0
-1
-2
-3
-4
-5
-200
-100
0
100
200
300
400
500
600
700
Time (days)
SG25



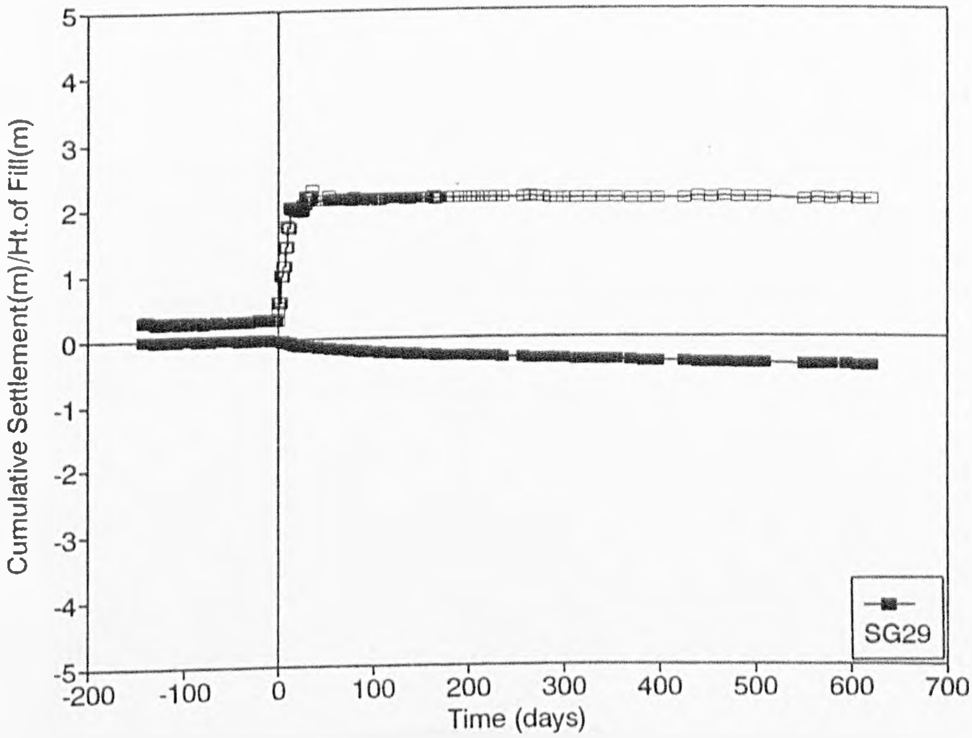
Cumulative Settlement(m)/Ht of Fill(m)
5
4
3
2
1
0
-1
-2
-3
-4
-5
-200
-100
0
100
200
300
400
500
600
700
Time (days)
SG26

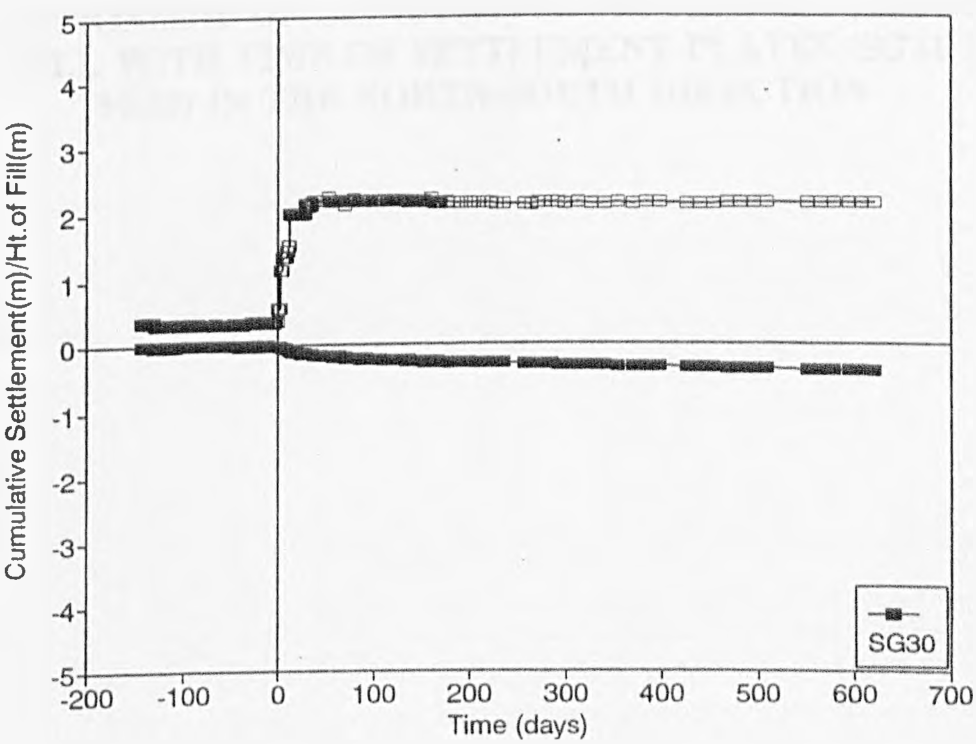


Cumulative Settlement(m)/Ht.of Fill(m)
Time (days)
SG27



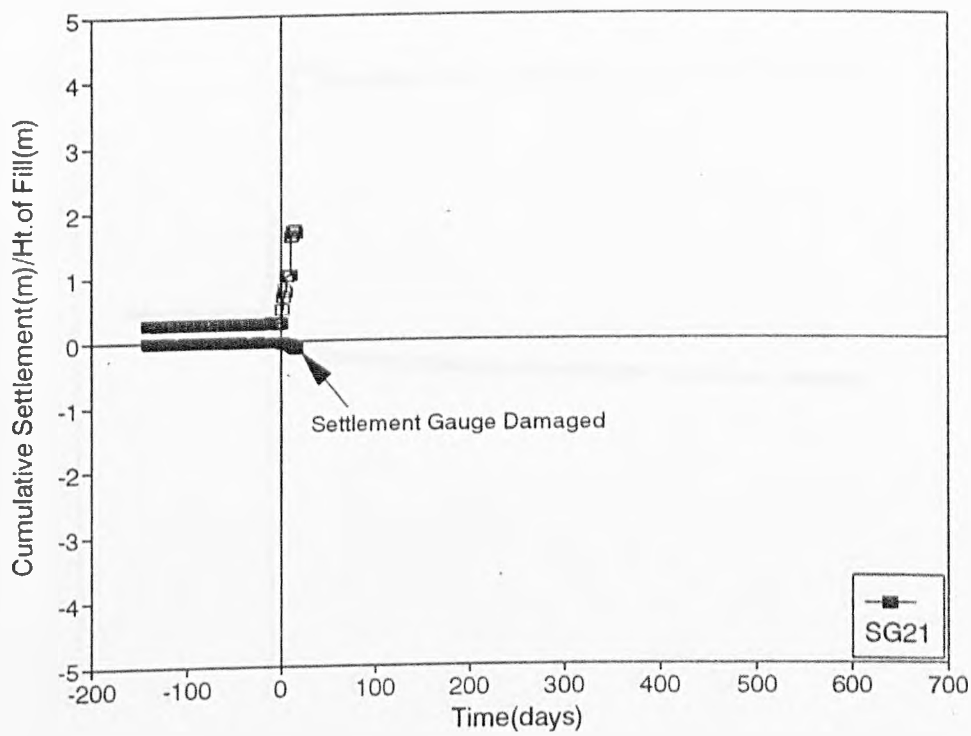
Cumulative Settlement(m)/Ht of Fill(m)
Time (days)
SG28

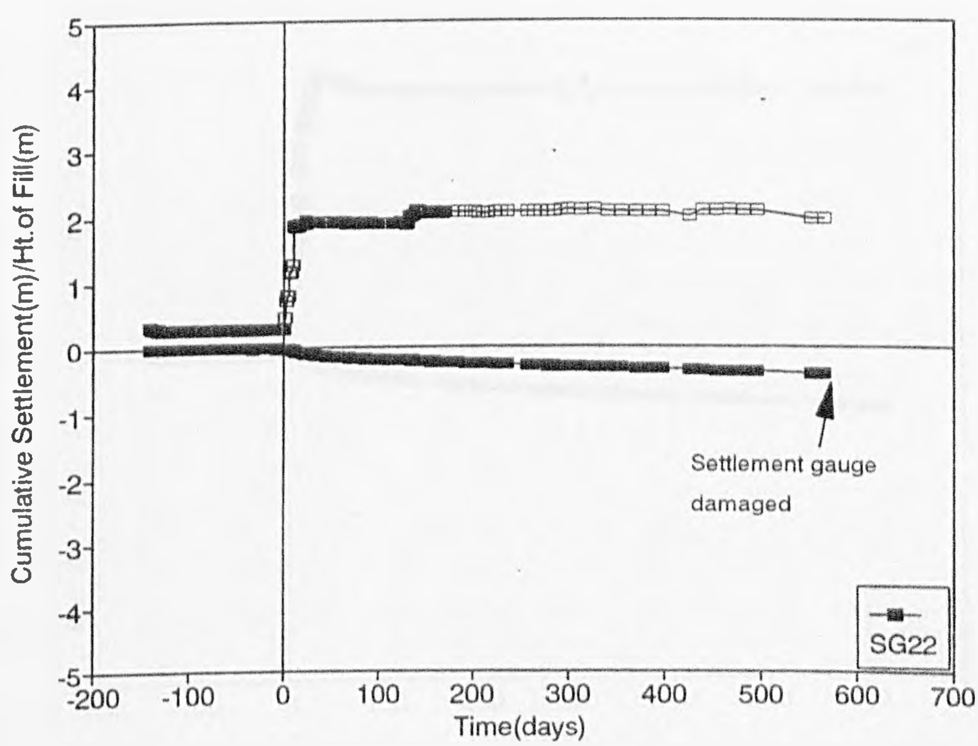

Cumulative Settlement(m)/Ht.of Fill(m)
Time (days)
SG29

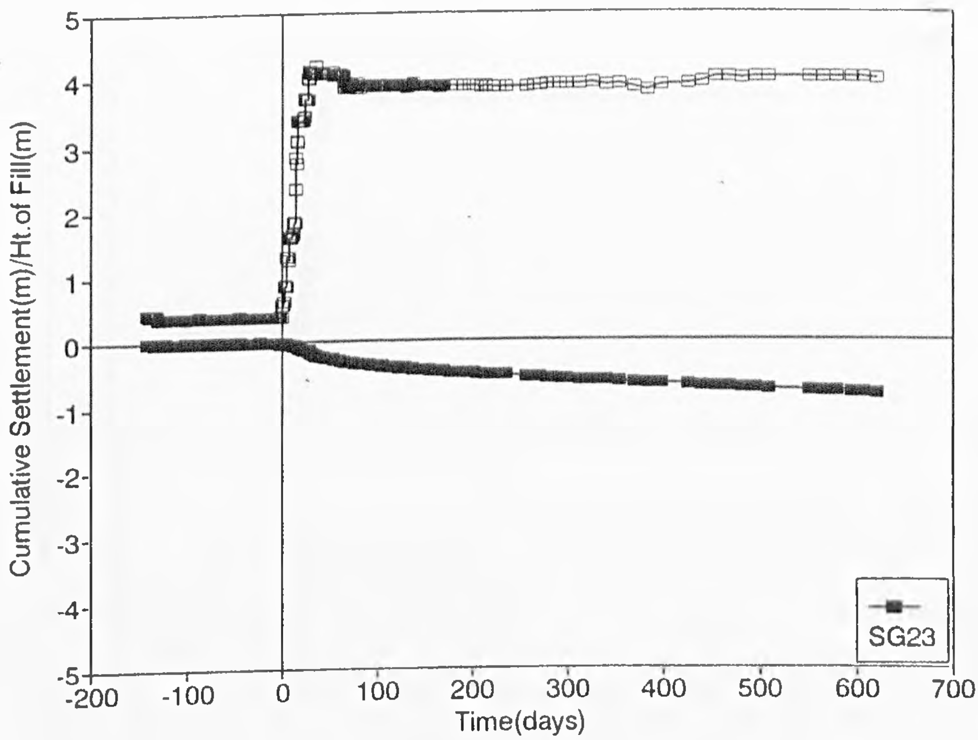

Cumulative Settlement(m)/Ht.of Fill(m)
Time (days)
SG30

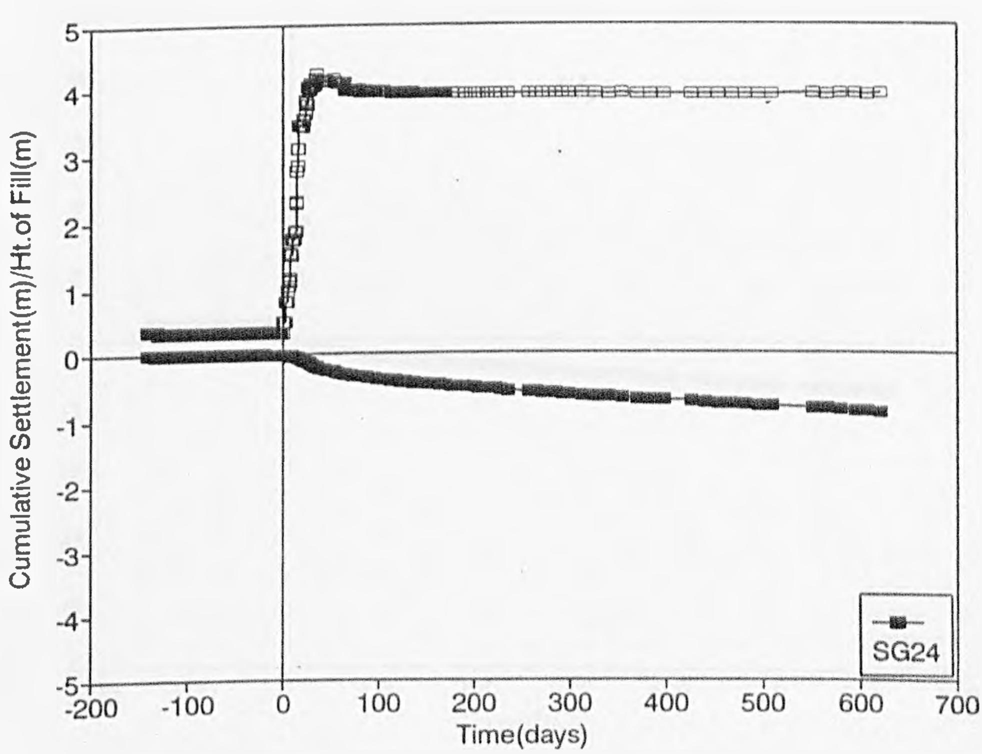
APPENDIX 6.2

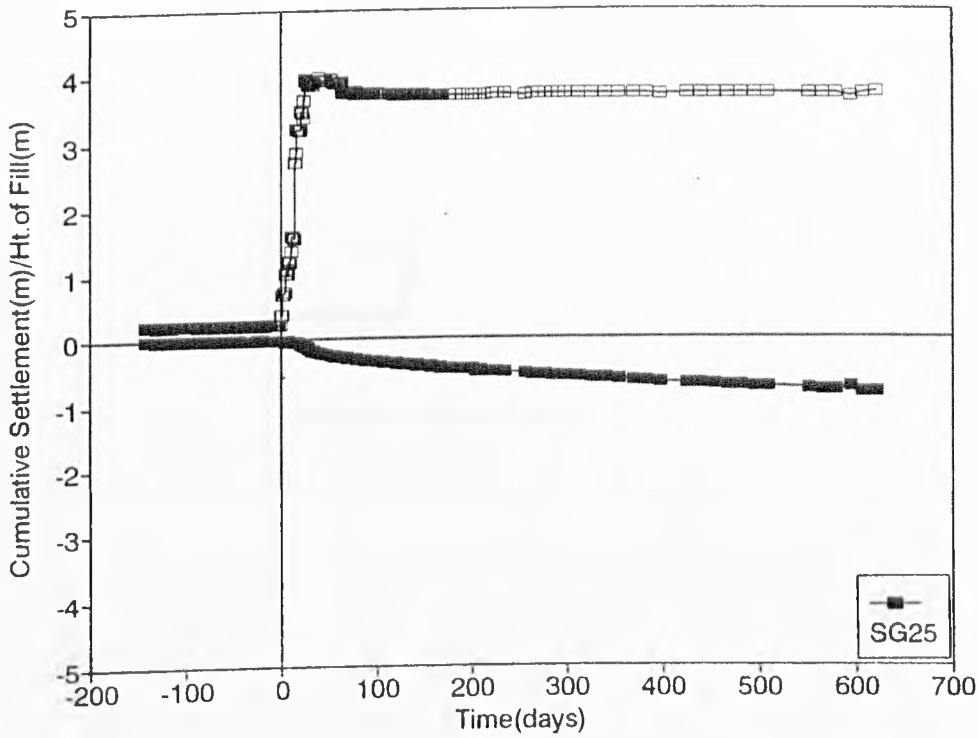
RELATIONSHIP OF CUMULATIVE SETTLEMENT/HEIGHT OF FILL WITH TIME OF SETTLEMENT PLATES (SG21 TO SG36) IN THE NORTH-SOUTH DIRECTION


Cumulative Settlement(m)/Ht.of Fill(m)
Settlement Gauge Damaged
SG21
Time(days)

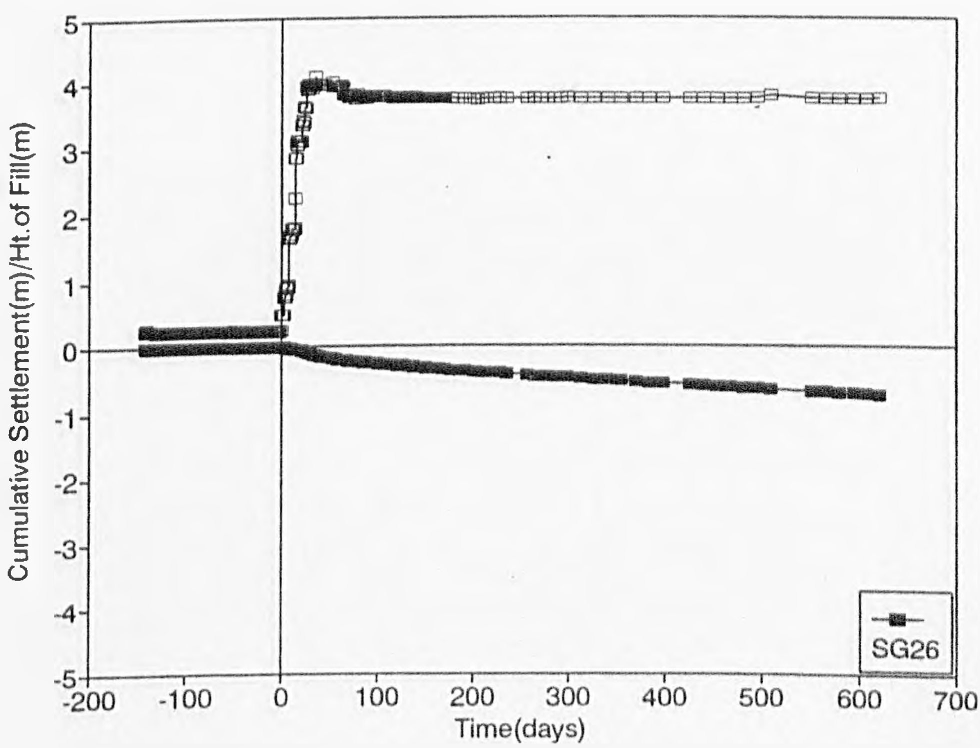

Cumulative Settlement(m)/Ht.of Fill(m)
Settlement gauge
damaged
SG22
Time(days)


Cumulative Settlement(m)/Ht.of Fill(m)
Time(days)
SG23

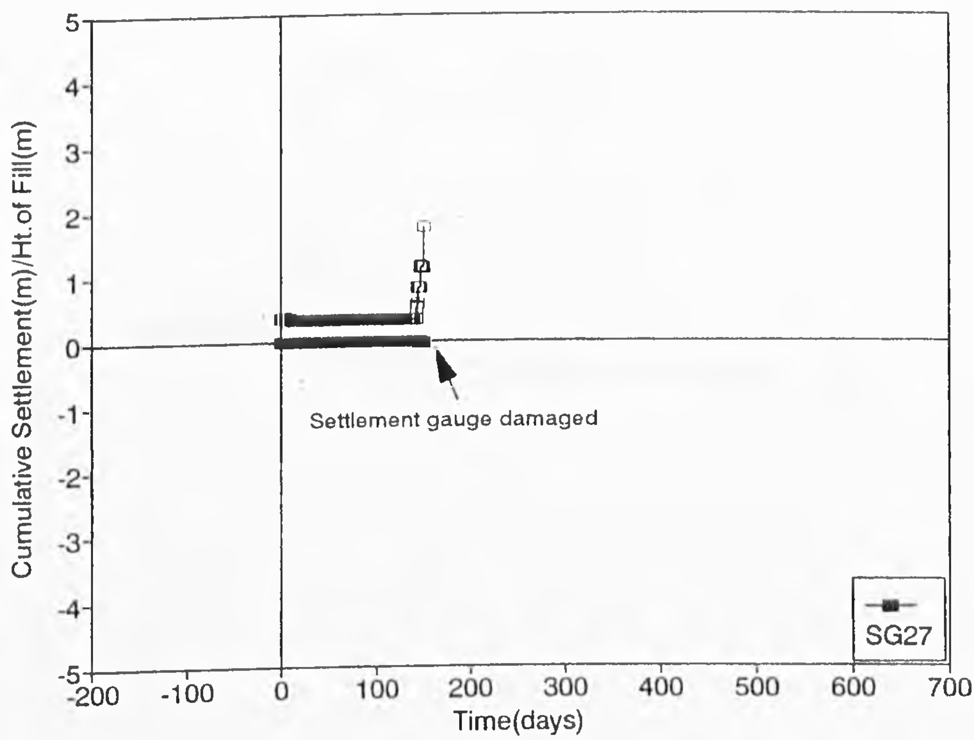

Cumulative Settlement(m)/Ht.of Fill(m)
Time(days)
SG24

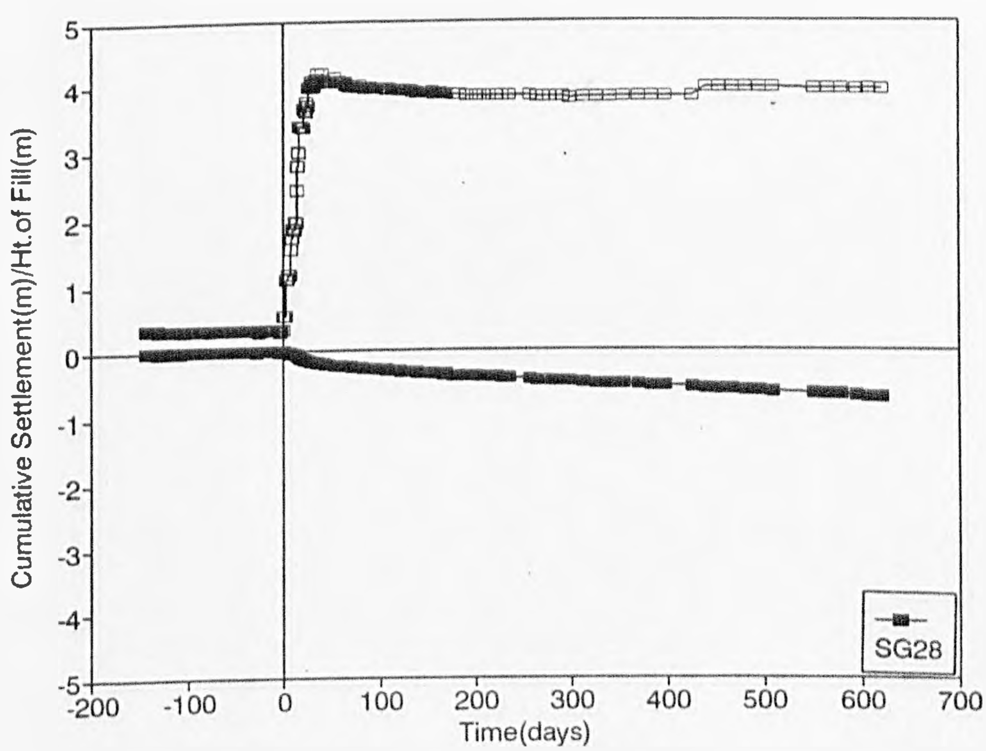


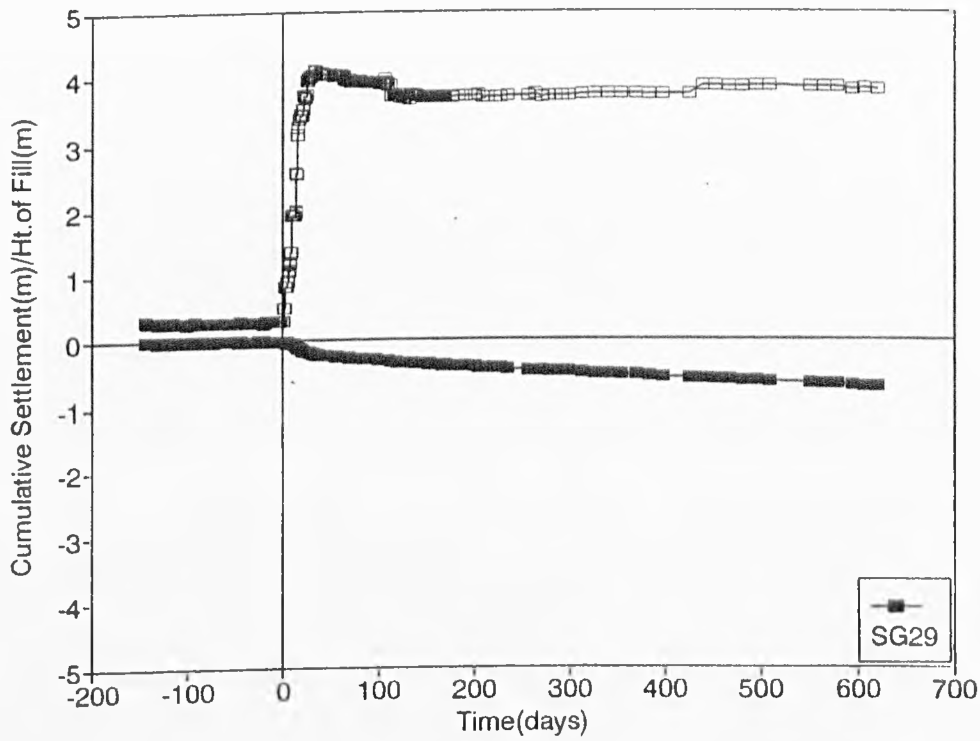
5
4
3
2
1
0
-1
-2
-3
-4
-5
Cumulative Settlement(m)/Ht.of Fill(m)
-200
-100
0
100
200
300
400
500
600
700
Time(days)
SG25



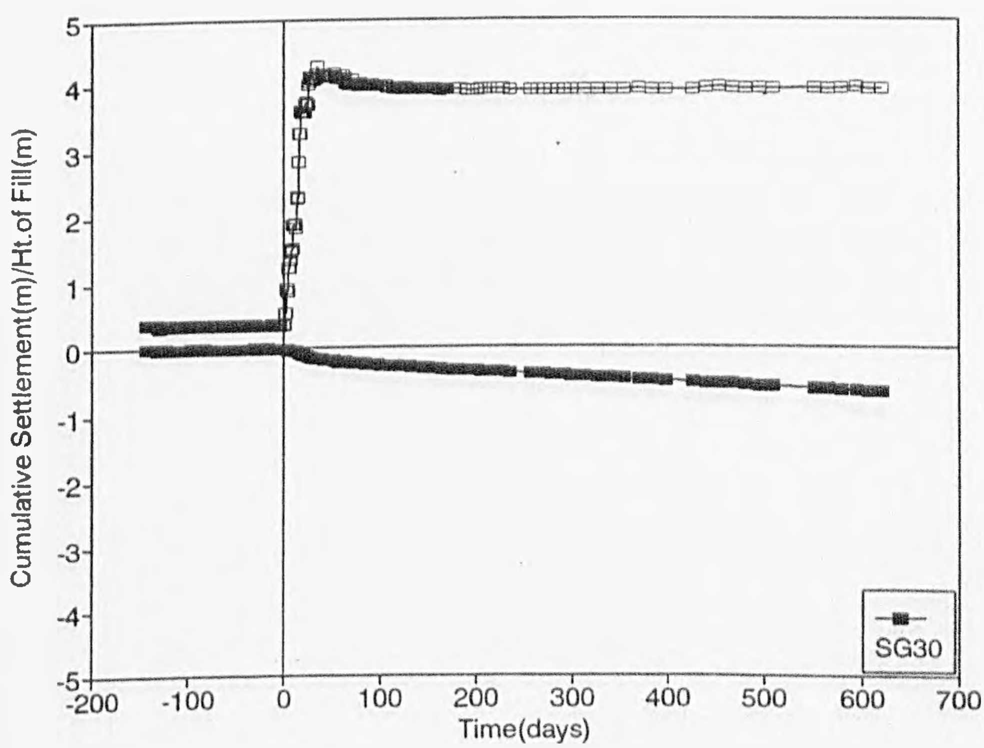
5
4
3
2
1
0
-1
-2
-3
-4
-5
Cumulative Settlement(m)/Ht.of Fill(m)
-200
-100
0
100
200
300
400
500
600
700
Time(days)
SG26


Cumulative Settlement(m)/Ht.of Fill(m)
5
4
3
2
1
0
-1
-2
-3
-4
-5
-200
-100
0
100
200
300
400
500
600
700
Time(days)
Settlement gauge damaged
SG27

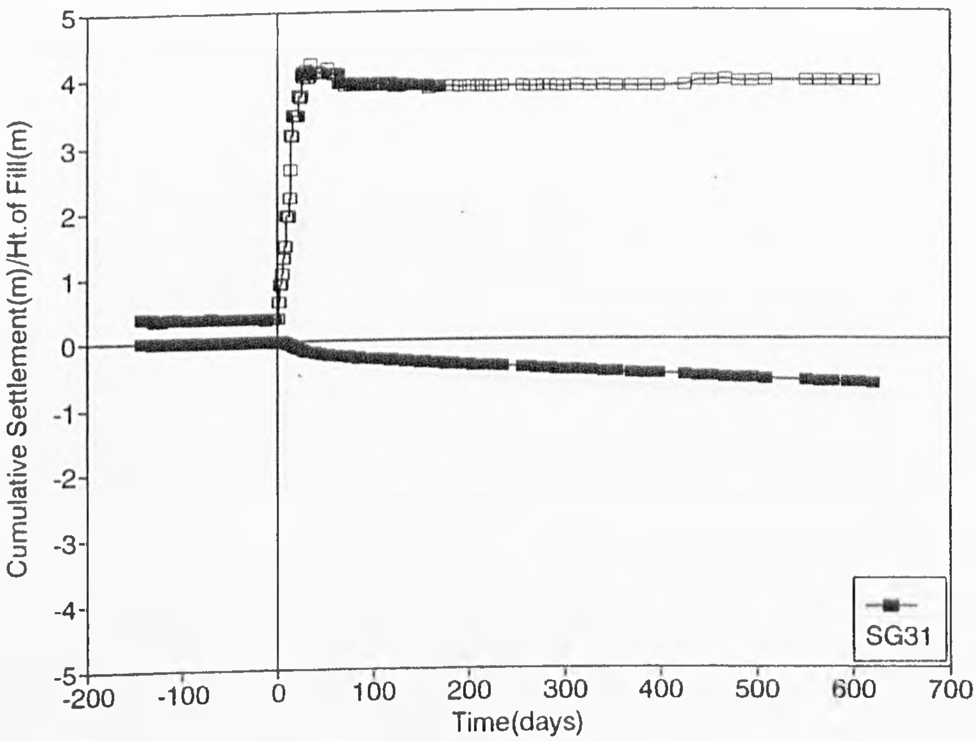

Cumulative Settlement(m)/Ht.of Fill(m)
5
4
3
2
1
0
-1
-2
-3
-4
-5
-200
-100
0
100
200
300
400
500
600
700
Time(days)
SG28



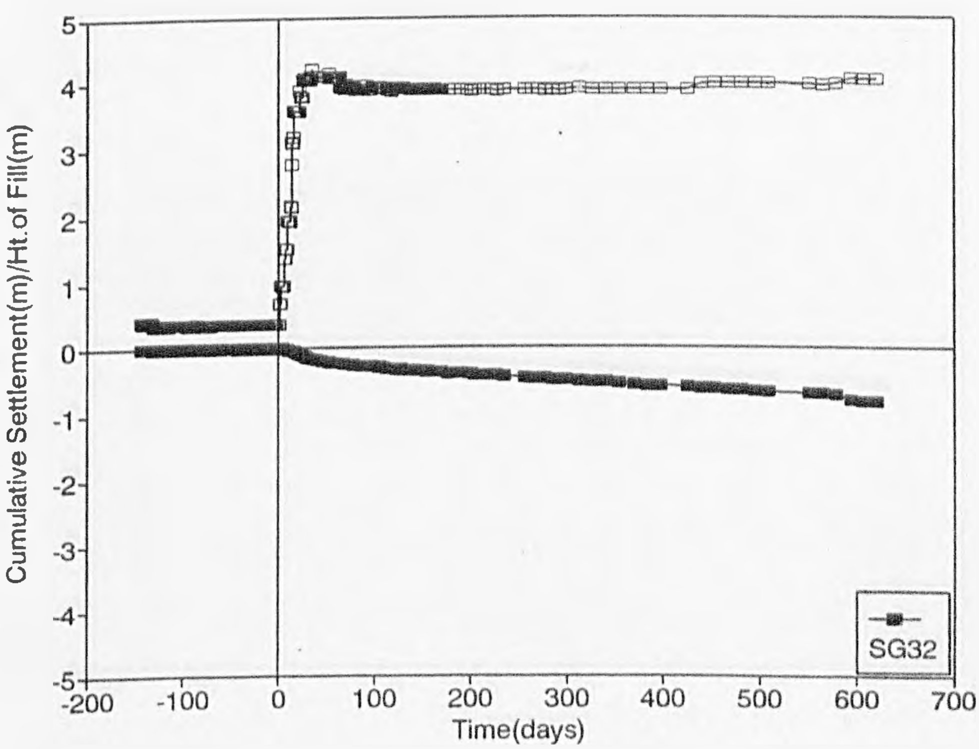
Cumulative Settlement(m)/Ht.of Fill(m)
Time(days)
SG29



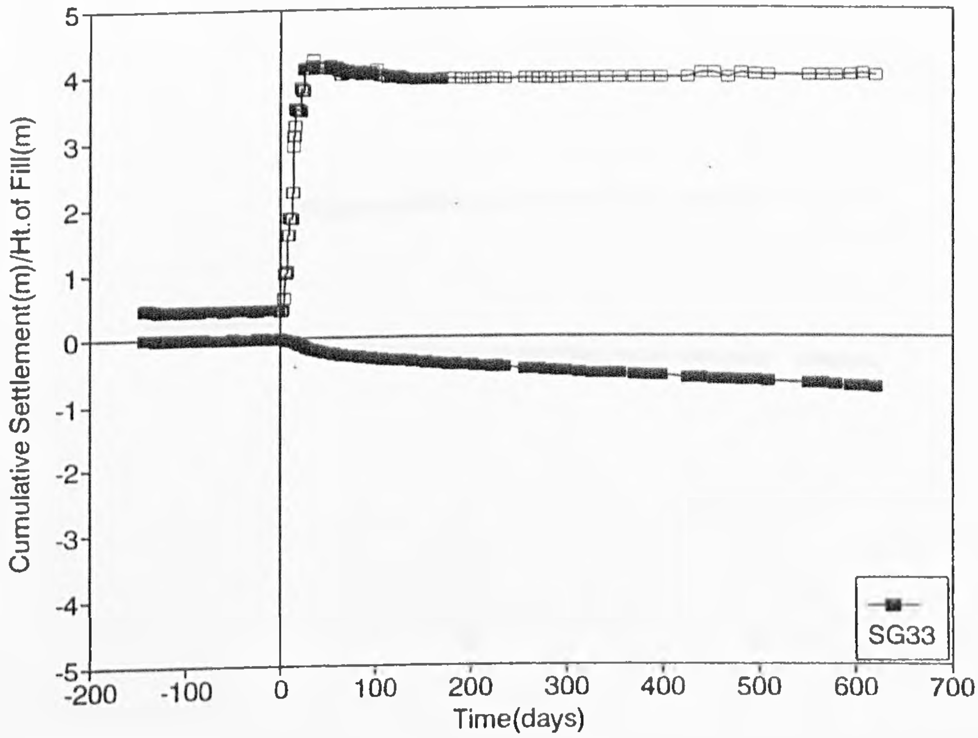
Cumulative Settlement(m)/Ht.of Fill(m)
Time(days)
SG30



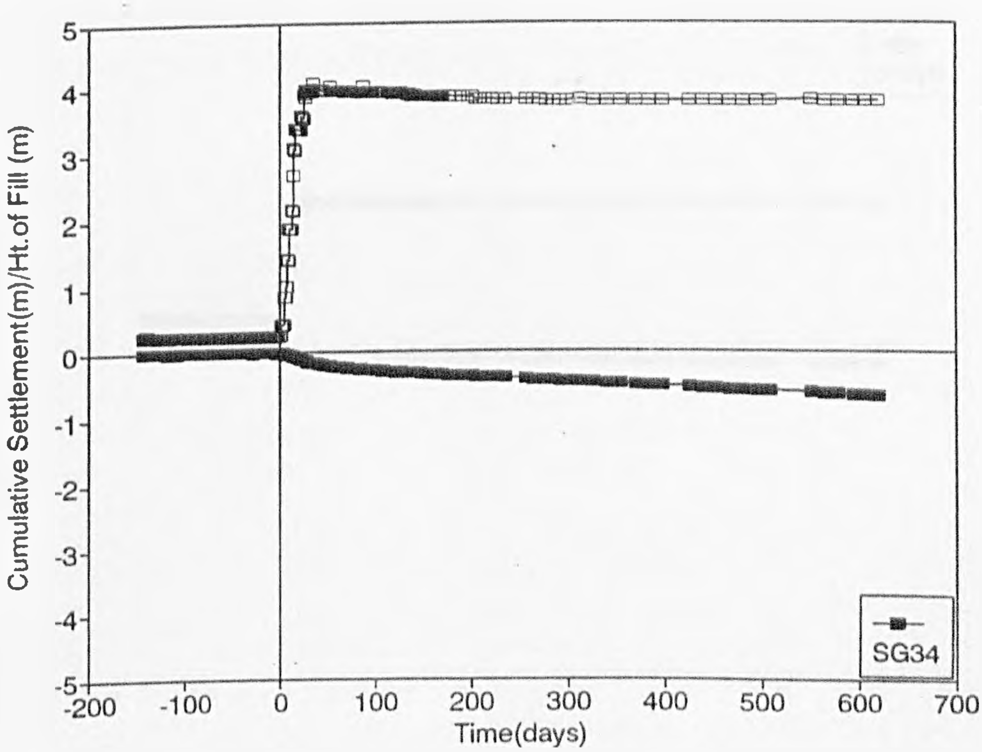
Cumulative Settlement(m)/Ht.of Fill(m)
Time(days)
SG31



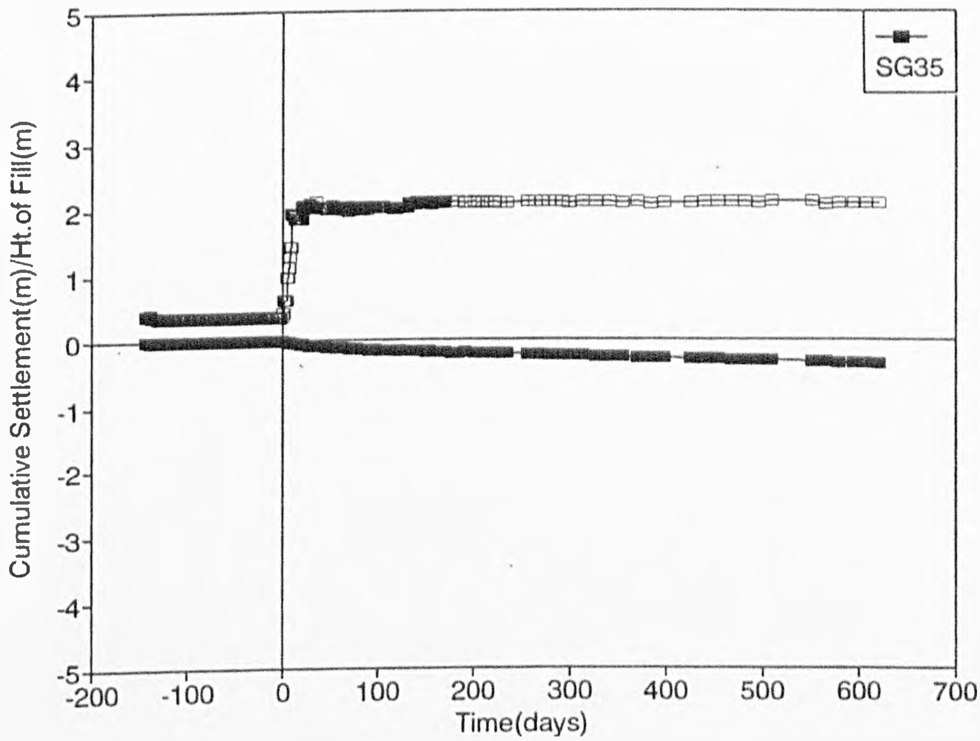
Cumulative Settlement(m)/Ht.of Fill(m)
Time(days)
SG32



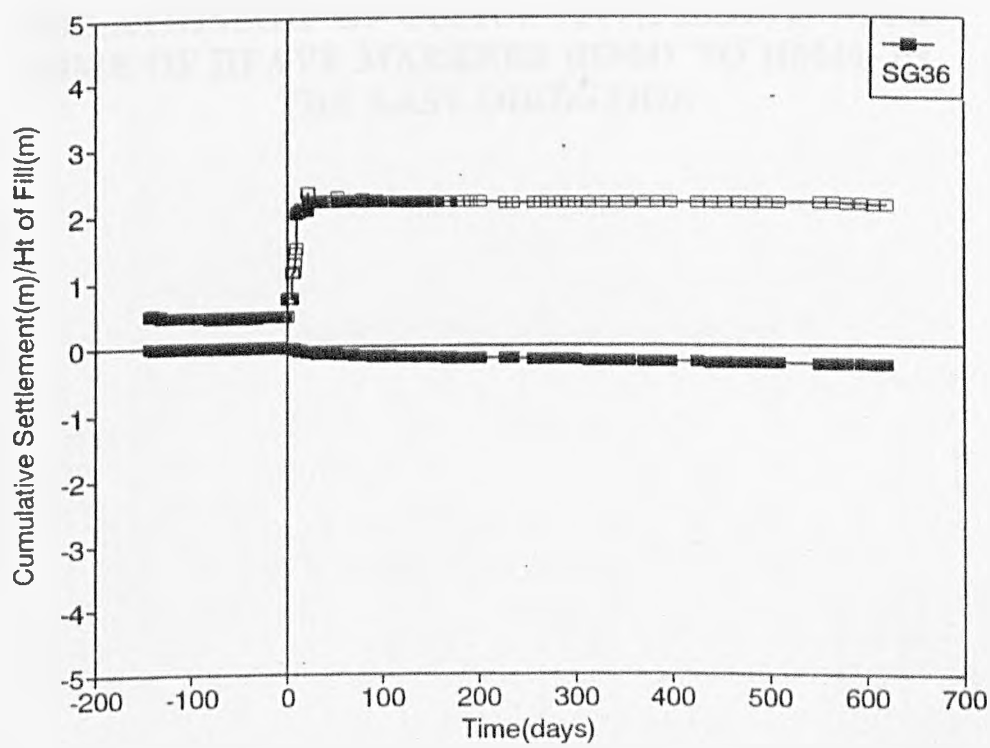
Cumulative Settlement(m)/Ht.of Fill(m)
Time(days)
SG33
5
4
3
2
1
0
-1
-2
-3
-4
-5
-200
-100
0
100
200
300
400
500
600
700



Cumulative Settlement(m)/Ht.of Fill (m)
Time(days)
SG34
5
4
3
2
1
0
-1
-2
-3
-4
-5
-200
-100
0
100
200
300
400
500
600
700



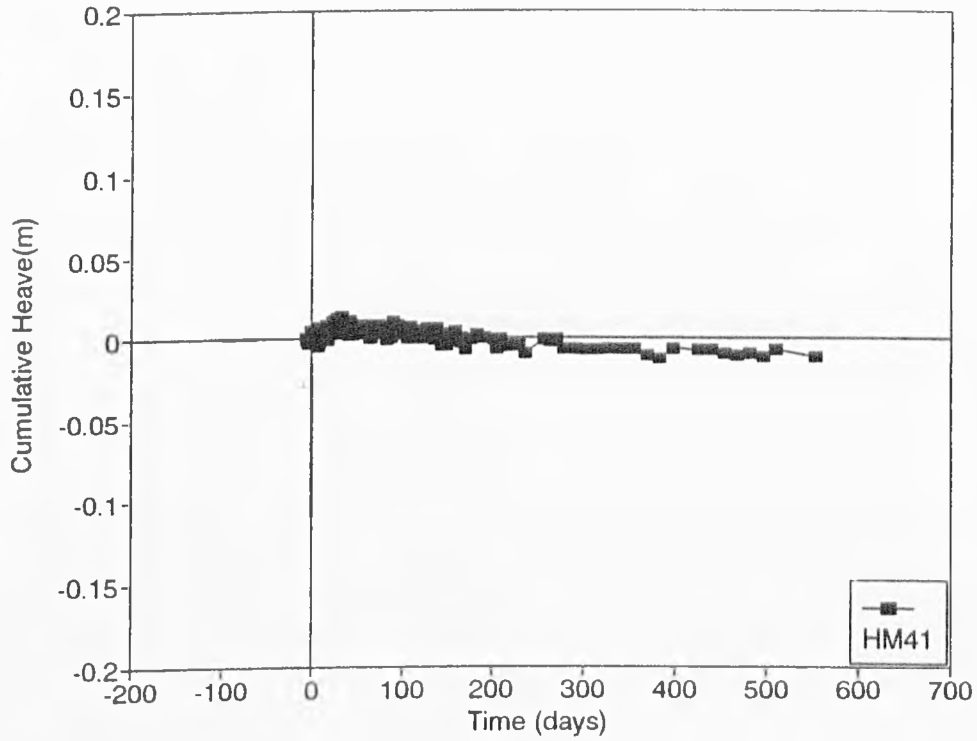
SG35
Cumulative Settlement(m)/Ht.of Fill(m)
Time(days)
5
4
3
2
1
0
-1
-2
-3
-4
-5
-200
-100
0
100
200
300
400
500
600
700



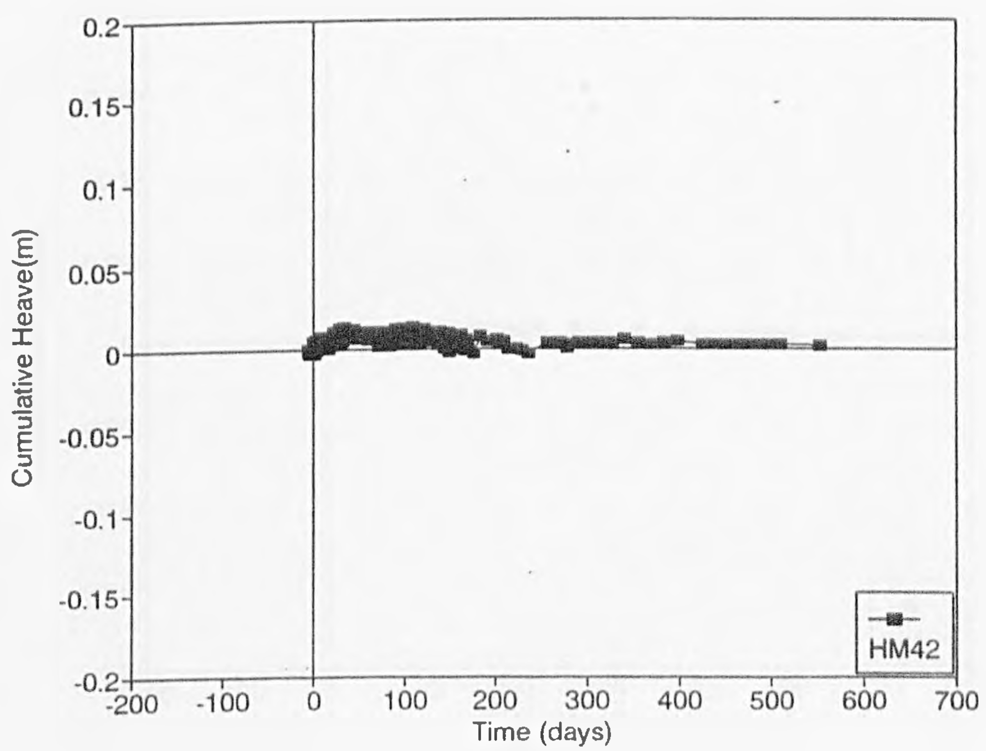
SG36
Cumulative Settlement(m)/Ht of Fill(m)
Time(days)
5
4
3
2
1
0
-1
-2
-3
-4
-5
-200
-100
0
100
200
300
400
500
600
700

APPENDIX 6.3

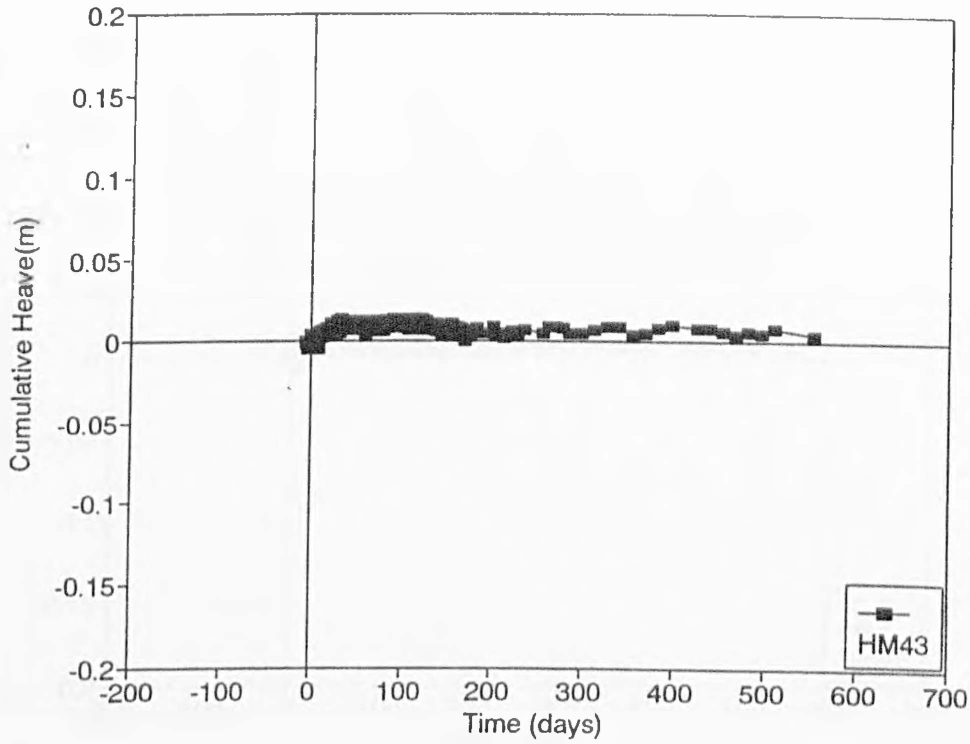
RELATIONSHIP OF CUMULATIVE HEAVE WITH TIME OF HEAVE MARKERS (HM41 TO HM46) IN THE EAST DIRECTION

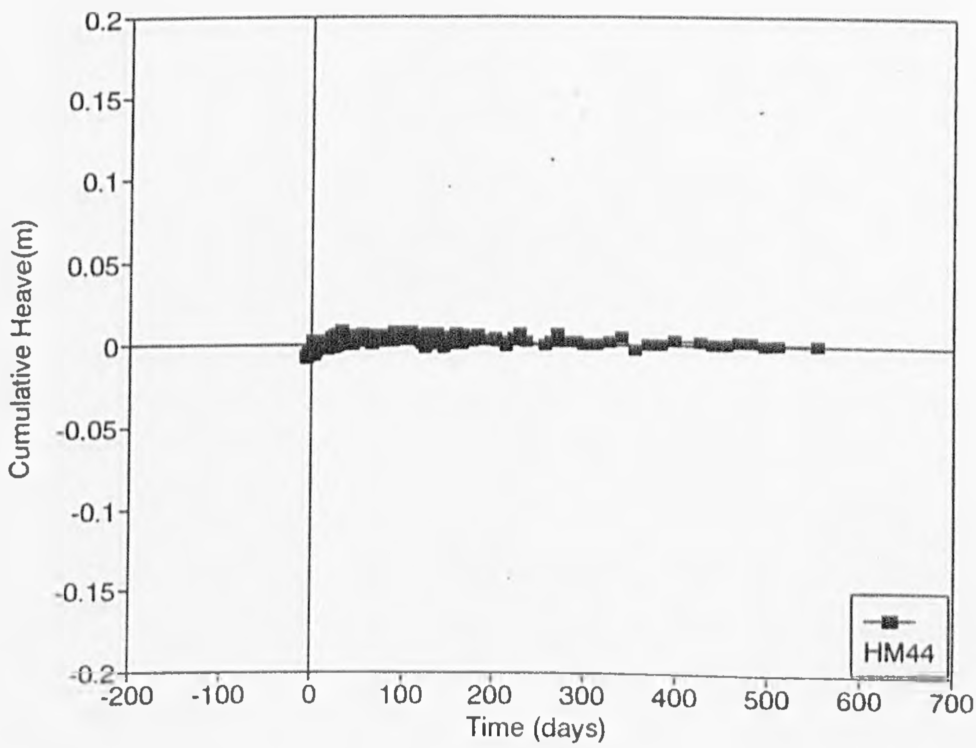


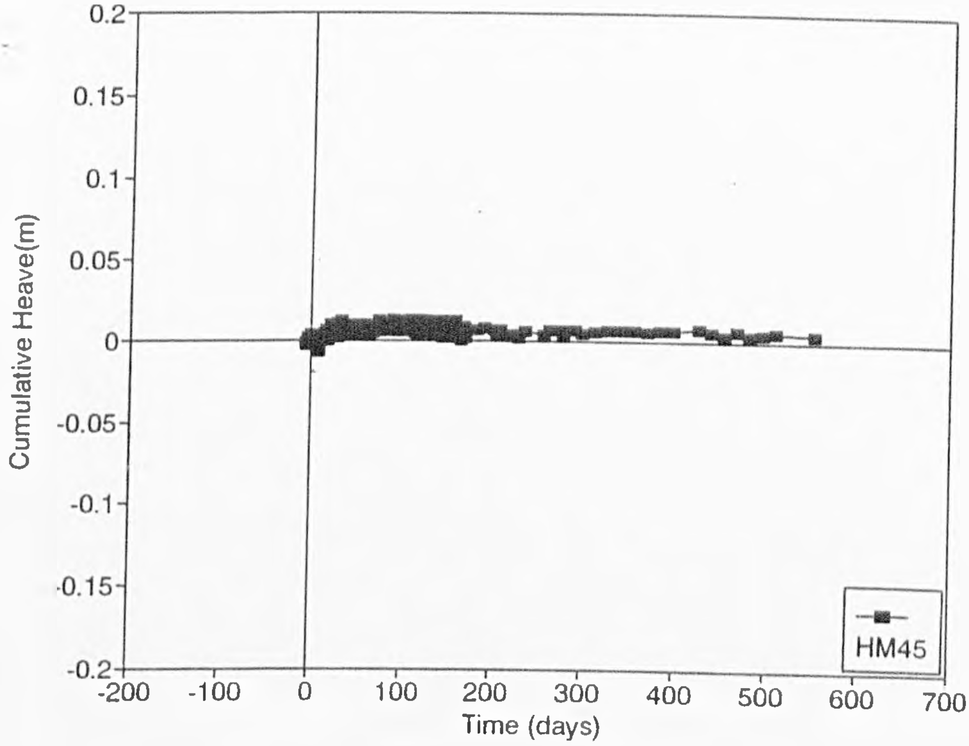
0.2
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
-0.2
Cumulative Heave(m)
-200
-100
0
100
200
300
400
500
600
700
Time (days)
HM41

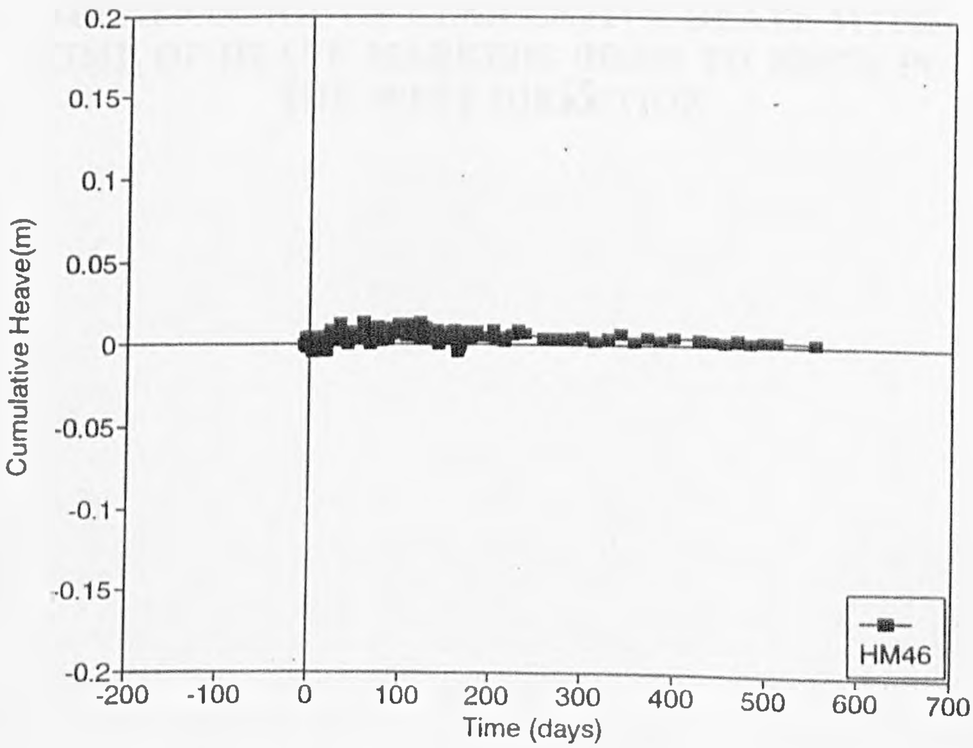


0.2
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
-0.2
Cumulative Heave(m)
-200
-100
0
100
200
300
400
500
600
700
Time (days)
HM42


0.2
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
-0.2
Cumulative Heave(m)
-200
-100
0
100
200
300
400
500
600
700
Time (days)
HM43

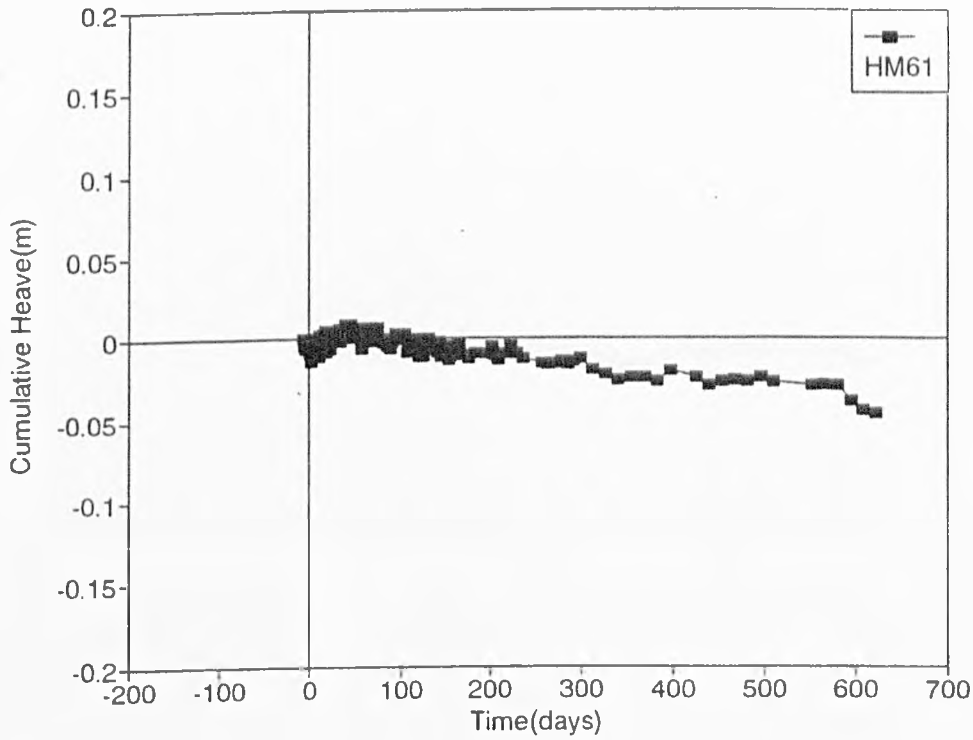

0.2
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
-0.2
Cumulative Heave(m)
-200
-100
0
100
200
300
400
500
600
700
Time (days)
HM44

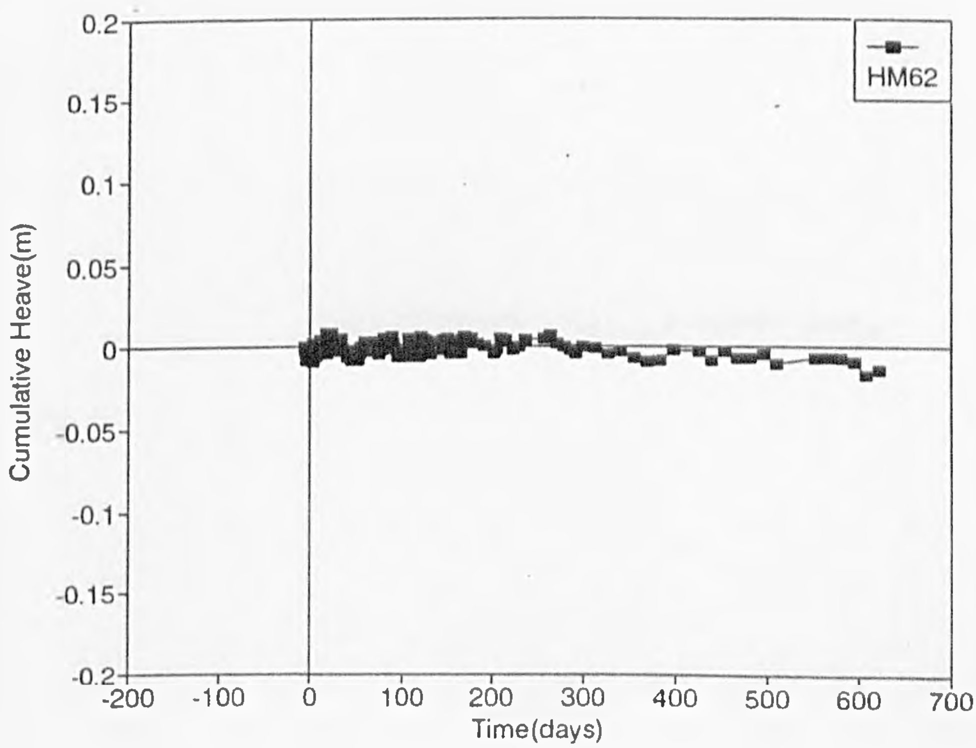

0.2
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
-0.2
Cumulative Heave(m)
-200
-100
0
100
200
300
400
500
600
700
Time (days)
HM45

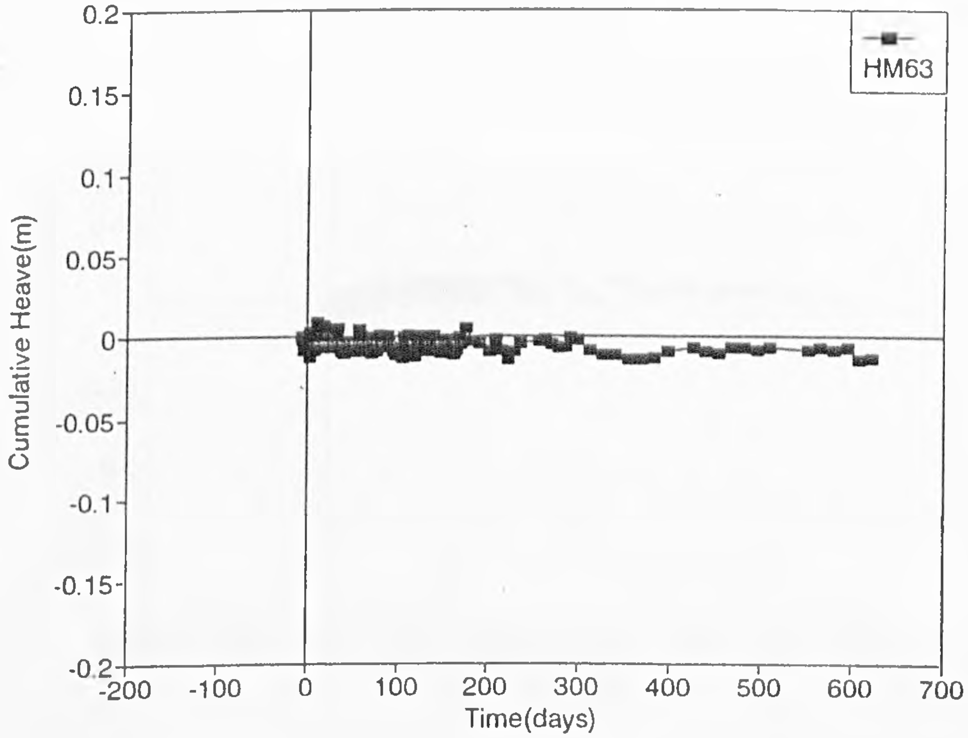

0.2
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
-0.2
Cumulative Heave(m)
-200
-100
0
100
200
300
400
500
600
700
Time (days)
HM46

APPENDIX 6.4

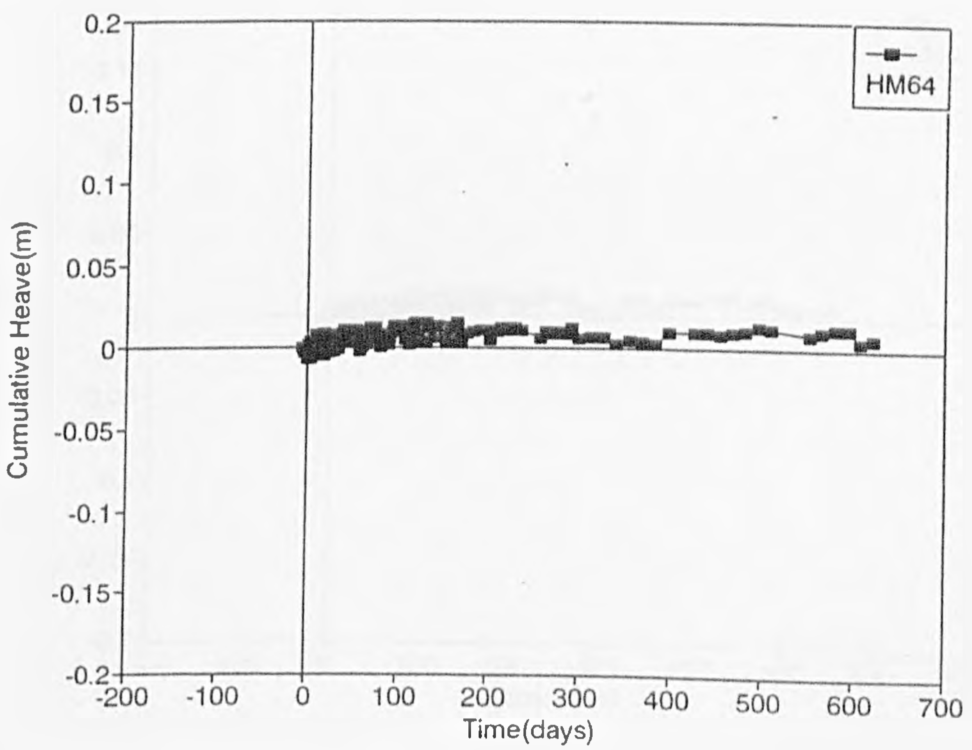
RELATIONSHIP OF CUMULATIVE HEAVE WITH TIME OF HEAVE MARKERS (HM61 TO HM73) IN THE WEST DIRECTION


HM61
Cumulative Heave(m)
0.2
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
-0.2
-200
-100
0
100
200
300
400
500
600
700
Time(days)

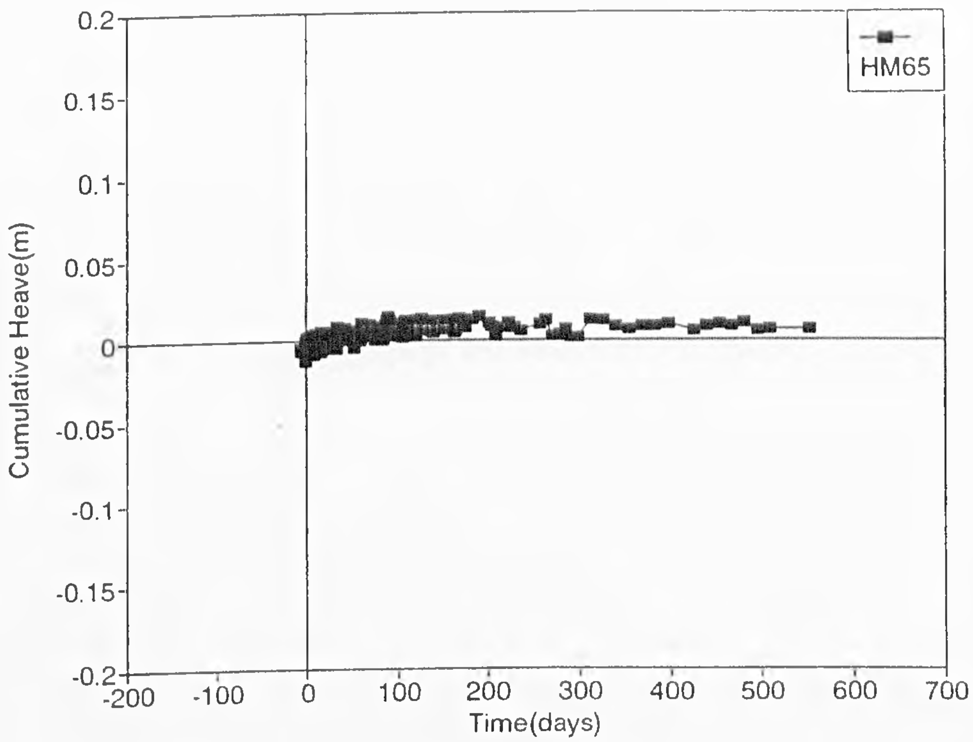

HM62
Cumulative Heave(m)
0.2
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
-0.2
-200
-100
0
100
200
300
400
500
600
700
Time(days)



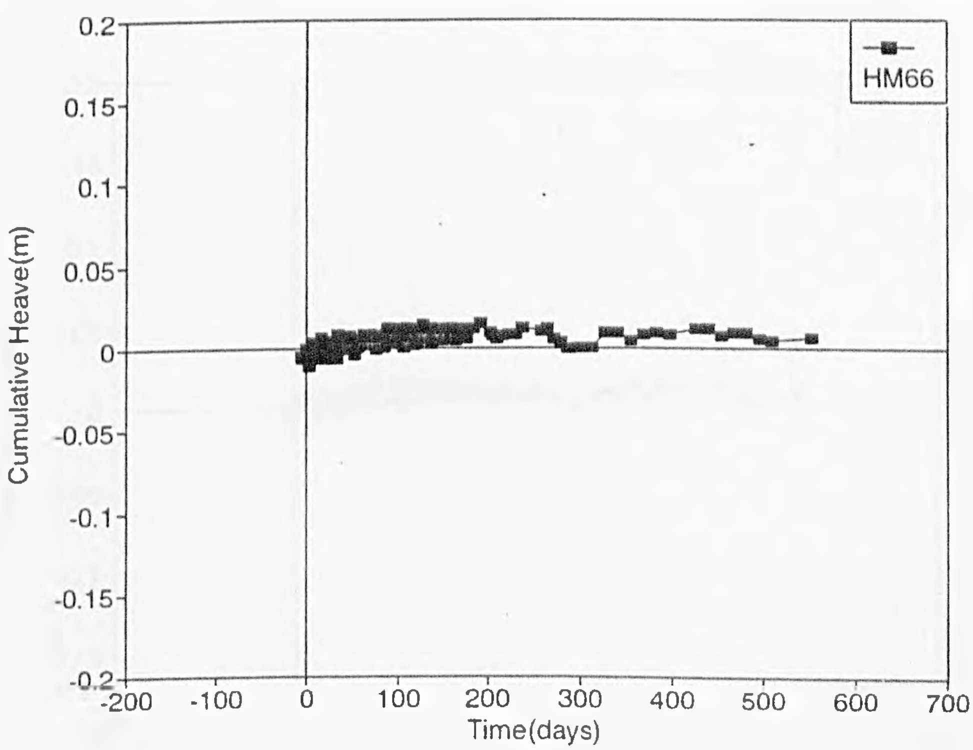
HM63
Cumulative Heave(m)
0.2
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
-0.2
-200
-100
0
100
200
300
400
500
600
700
Time(days)



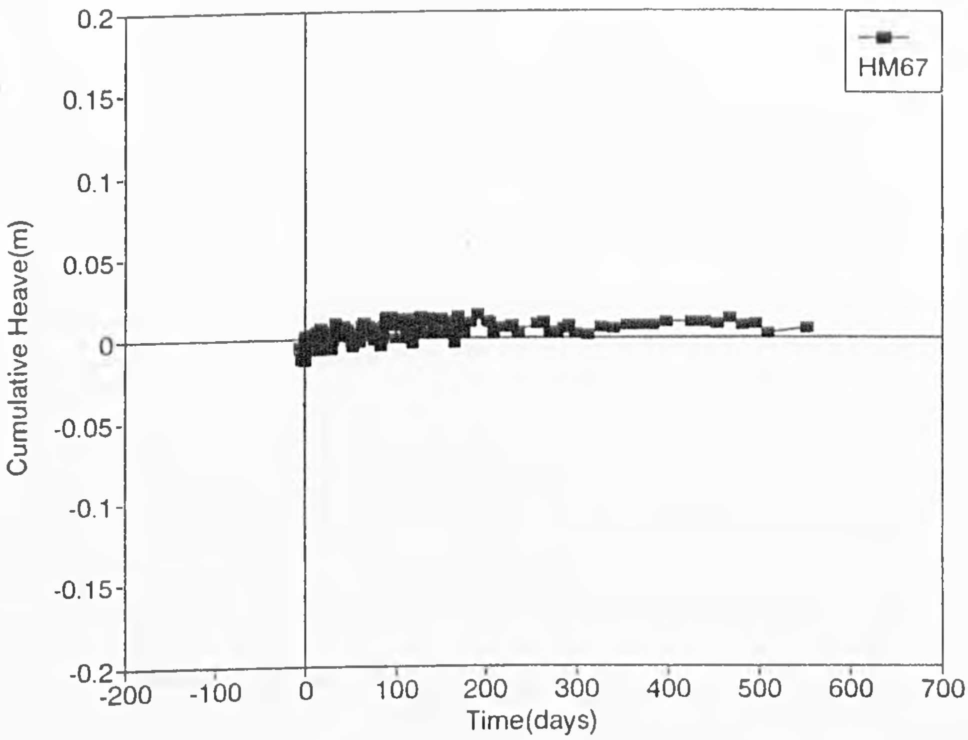
HM64
Cumulative Heave(m)
0.2
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
-0.2
-200
-100
0
100
200
300
400
500
600
700
Time(days)



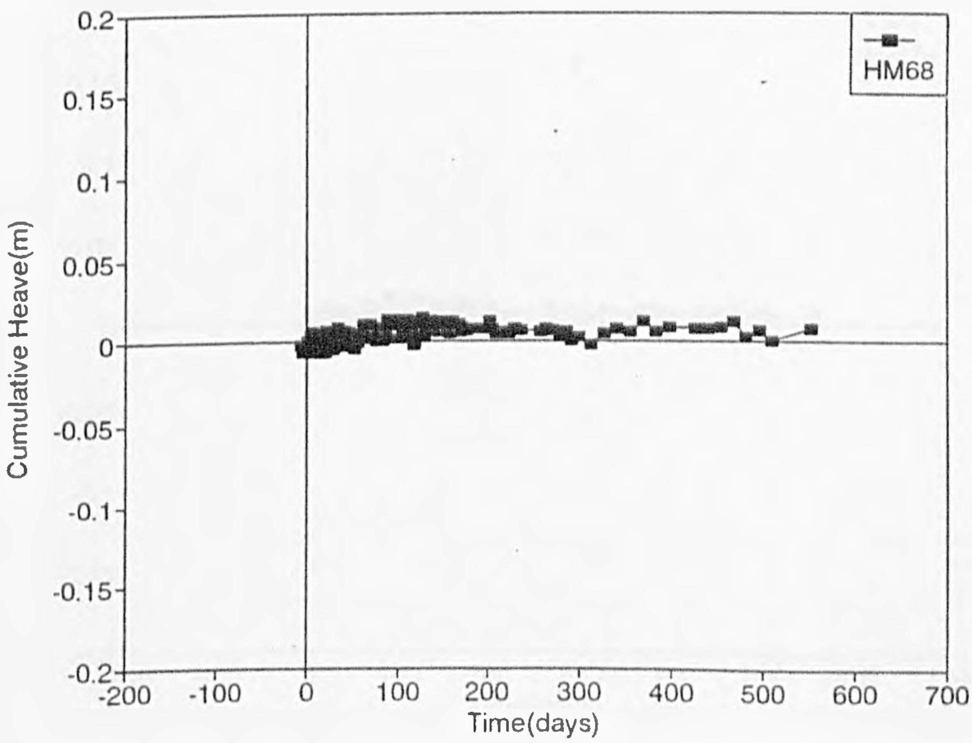
HM65
Cumulative Heave(m)
0.2
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
-0.2
-200
-100
0
100
200
300
400
500
600
700
Time(days)



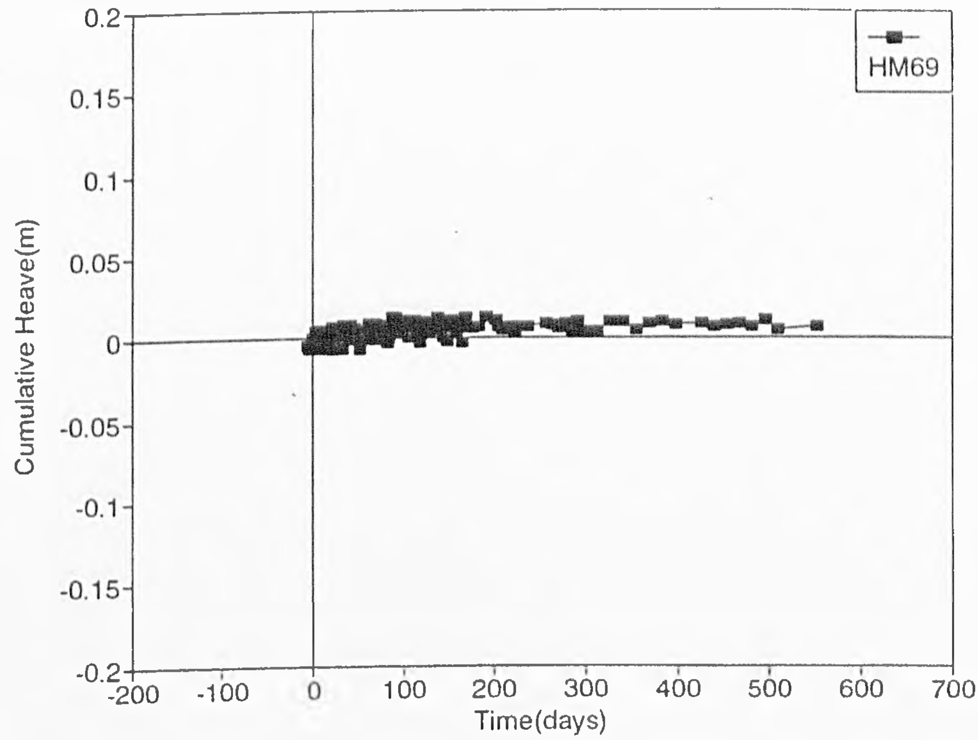
HM66
Cumulative Heave(m)
0.2
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
-0.2
-200
-100
0
100
200
300
400
500
600
700
Time(days)



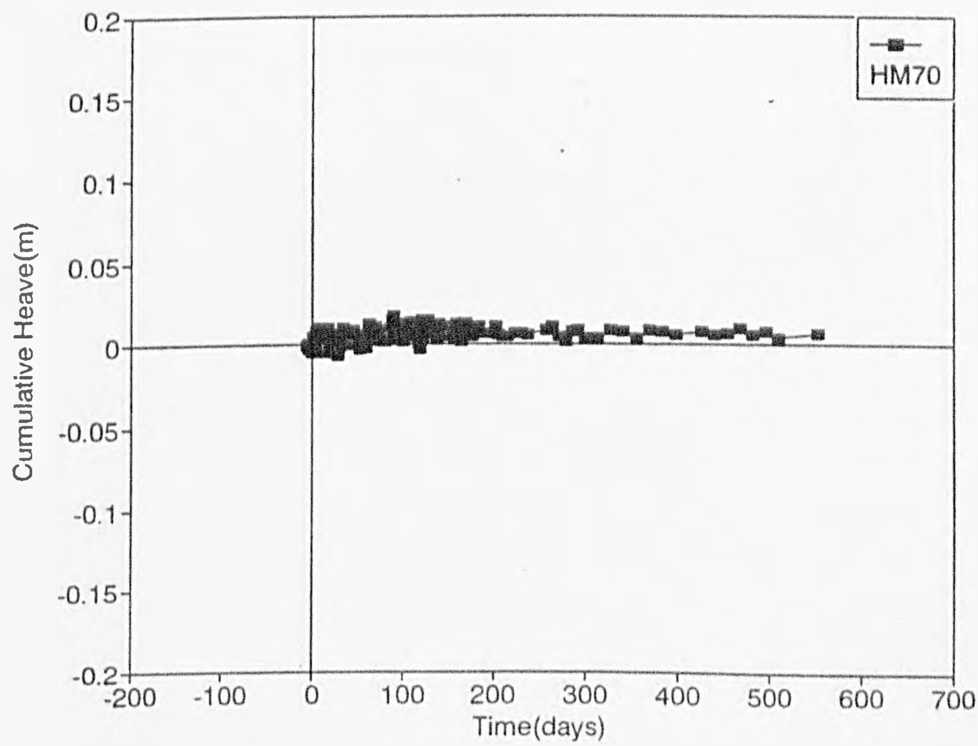
HM67
Cumulative Heave(m)
0.2
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
-0.2
-200
-100
0
100
200
300
400
500
600
700
Time(days)



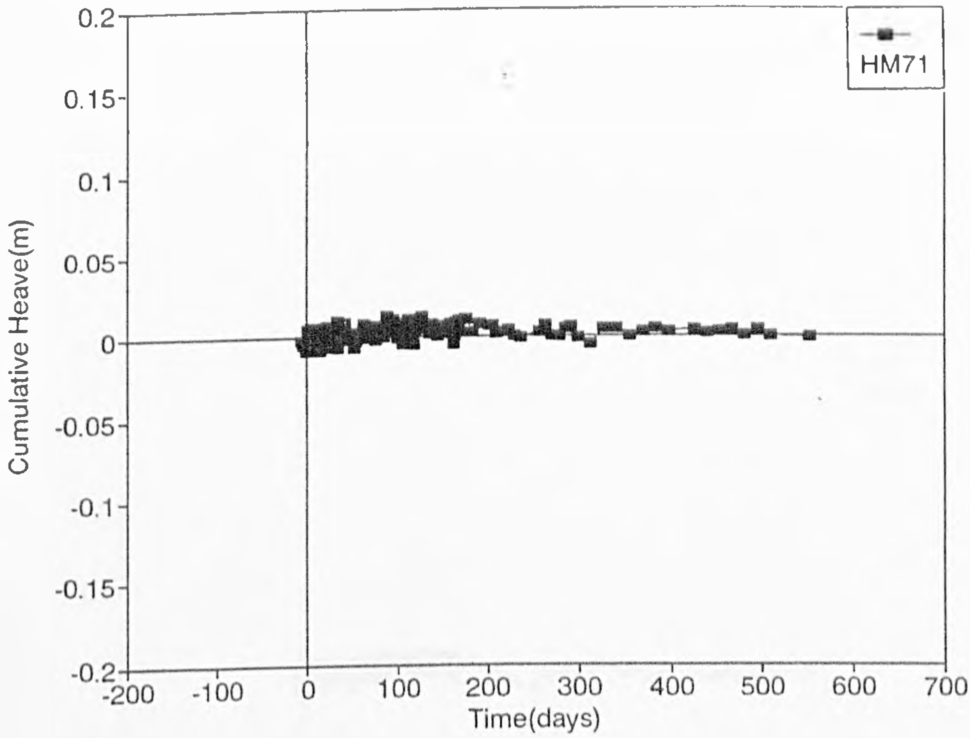
HM68
Cumulative Heave(m)
0.2
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
-0.2
-200
-100
0
100
200
300
400
500
600
700
Time(days)

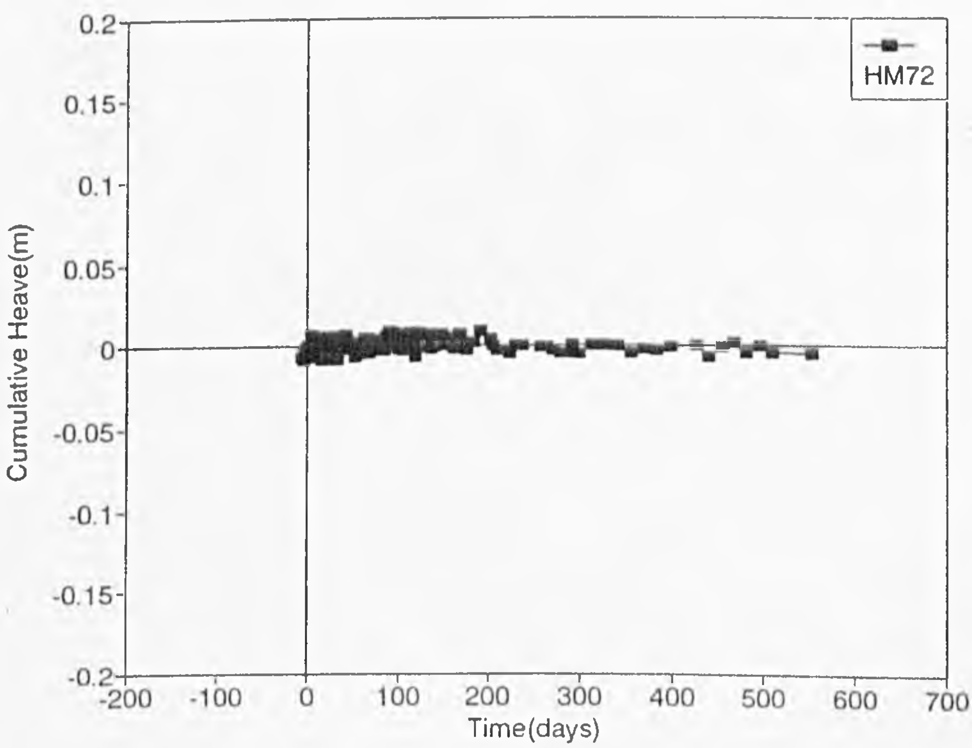


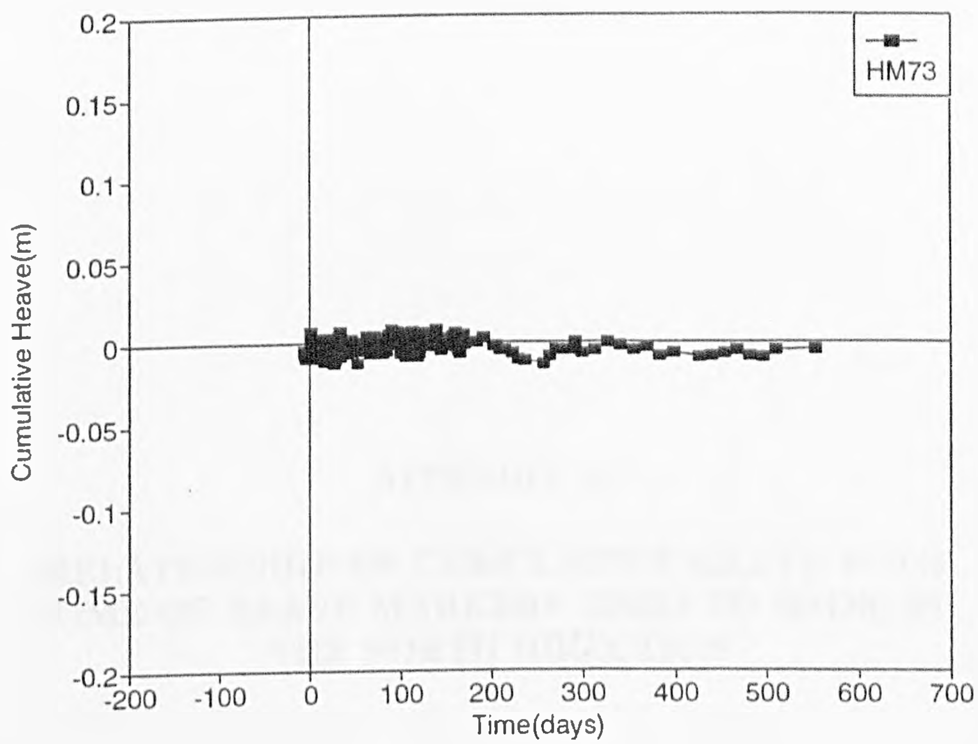
HM69
Cumulative Heave(m)
0.2
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
-0.2
-200
-100
0
100
200
300
400
500
600
700
Time(days)



HM70
Cumulative Heave(m)
0.2
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
-0.2
-200
-100
0
100
200
300
400
500
600
700
Time(days)

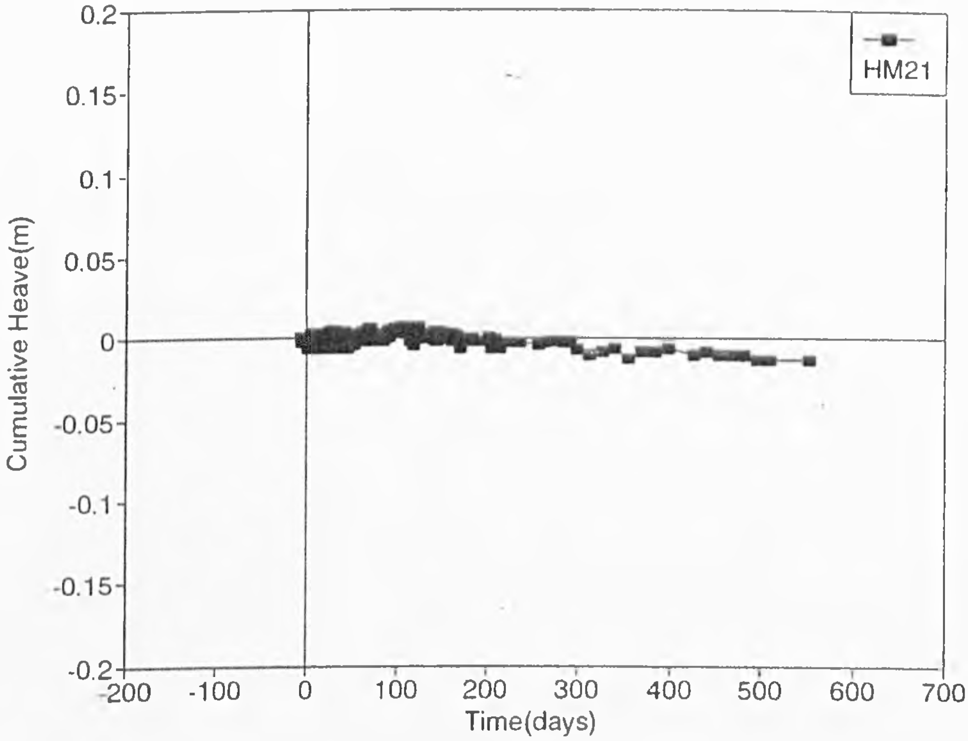

HM71
Cumulative Heave(m)
0.2
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
-0.2
-200
-100
0
100
200
300
400
500
600
700
Time(days)

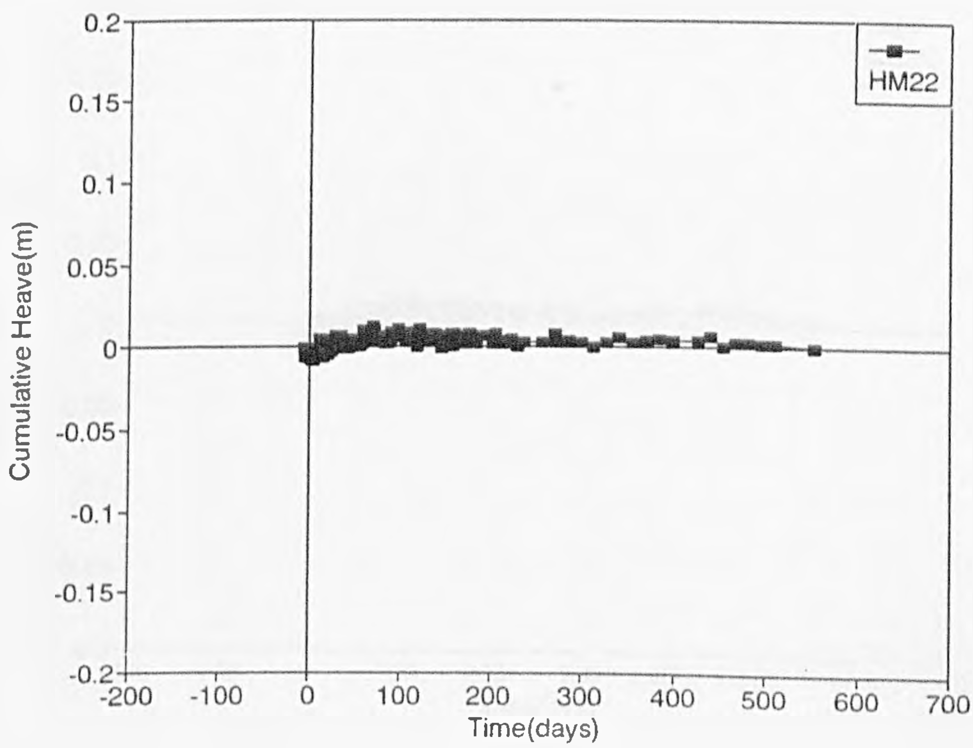

HM72
Cumulative Heave(m)
0.2
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
-0.2
-200
-100
0
100
200
300
400
500
600
700
Time(days)

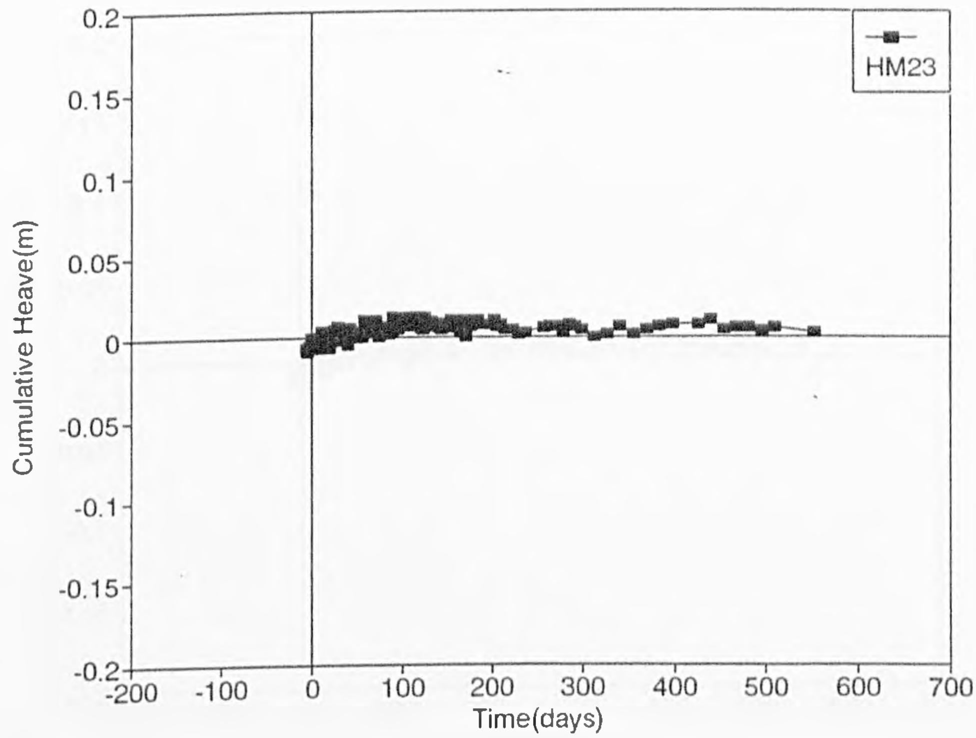

HM73
Cumulative Heave(m)
Time(days)
0.2
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
-0.2
-200
-100
0
100
200
300
400
500
600
700

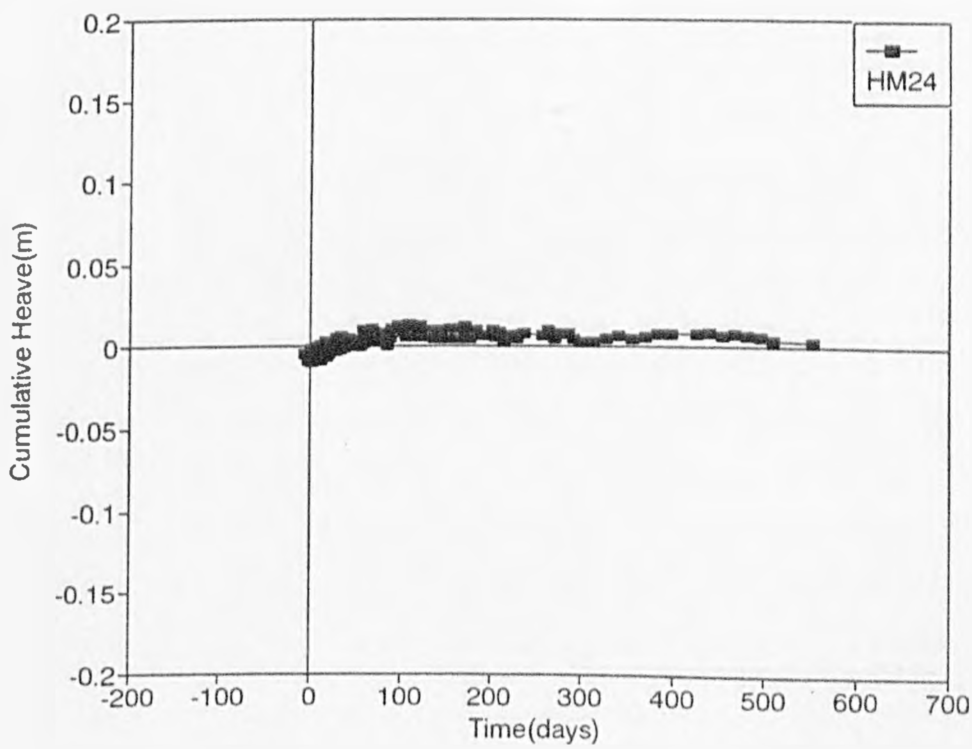
APPENDIX 6.5

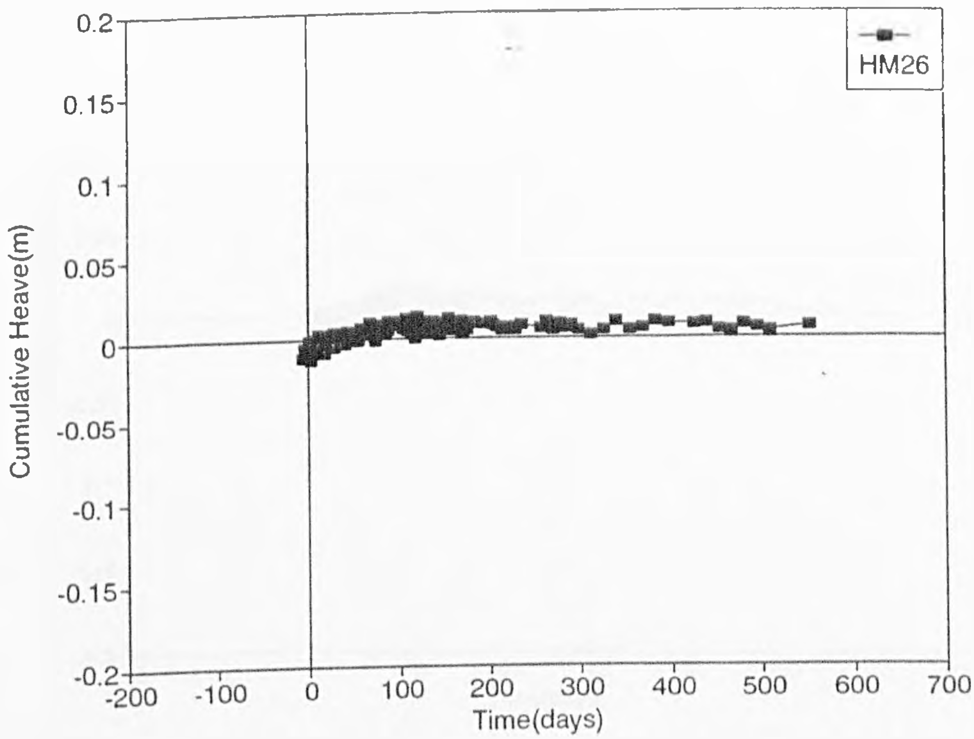
RELATIONSHIP OF CUMULATIVE HEAVE WITH TIME OF HEAVE MARKERS (HM21 TO HM30) IN THE NORTH DIRECTION

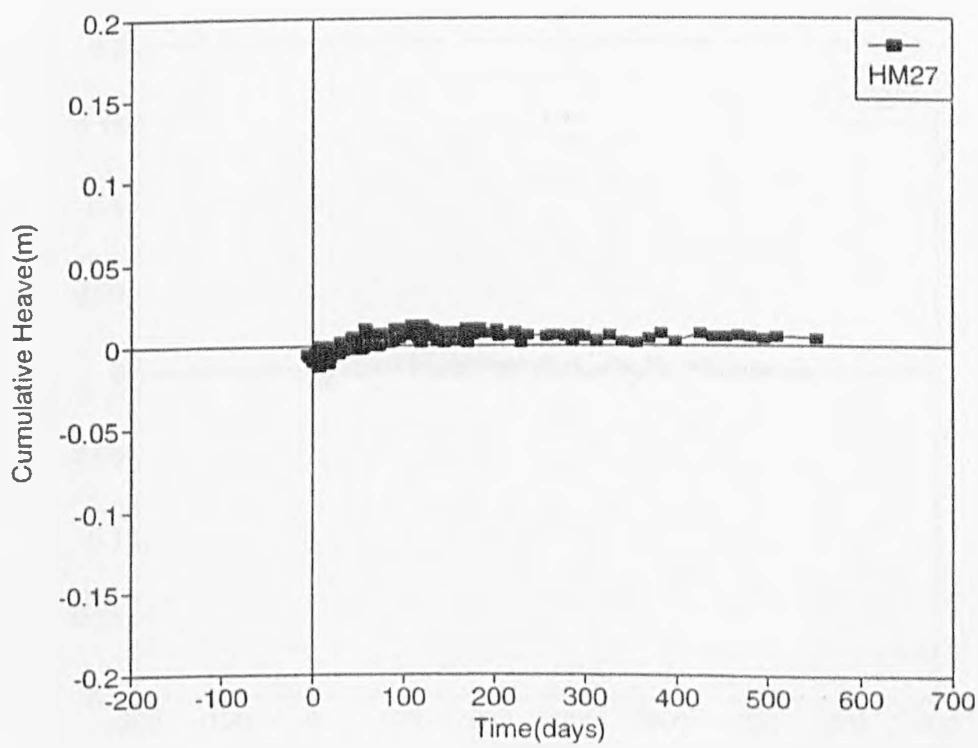

HM21
0.2
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
-0.2
Cumulative Heave(m)
-200
-100
0
100
200
300
400
500
600
700
Time(days)

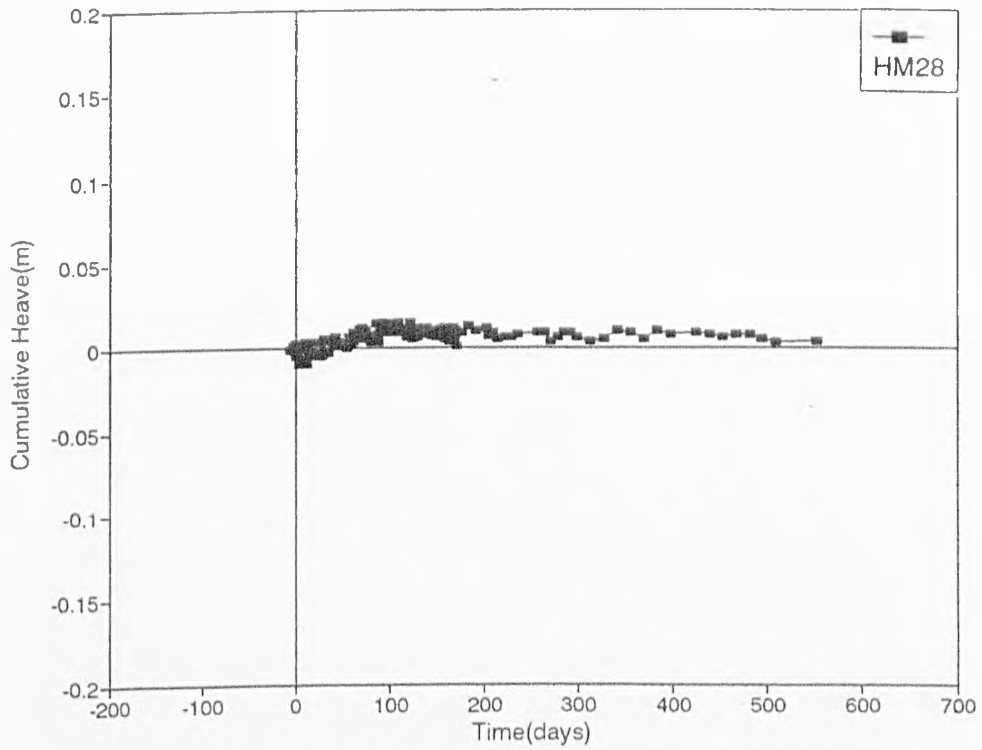

HM22
0.2
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
-0.2
Cumulative Heave(m)
-200
-100
0
100
200
300
400
500
600
700
Time(days)

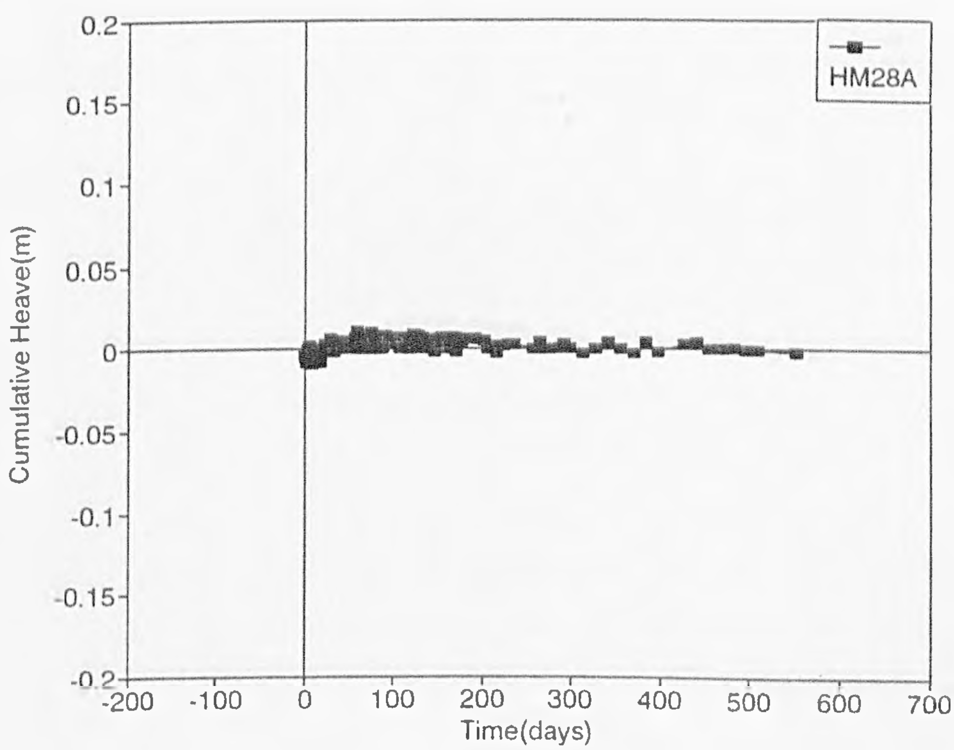

HM23
Cumulative Heave(m)
0.2
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
-0.2
-200
-100
0
100
200
300
400
500
600
700
Time(days)

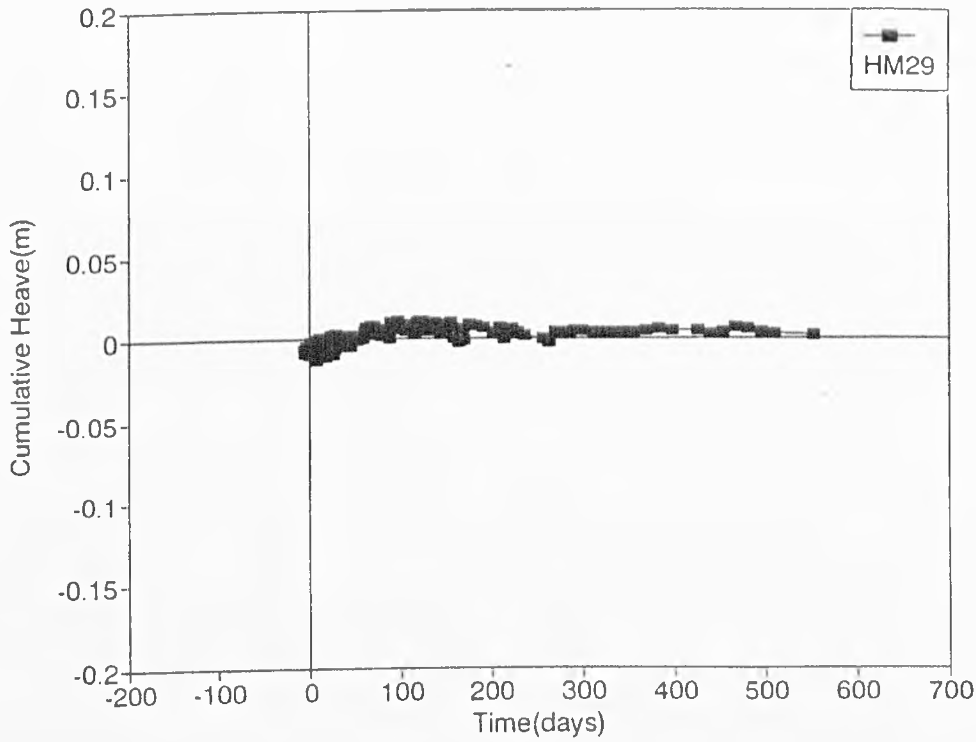

HM24
Cumulative Heave(m)
0.2
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
-0.2
-200
-100
0
100
200
300
400
500
600
700
Time(days)

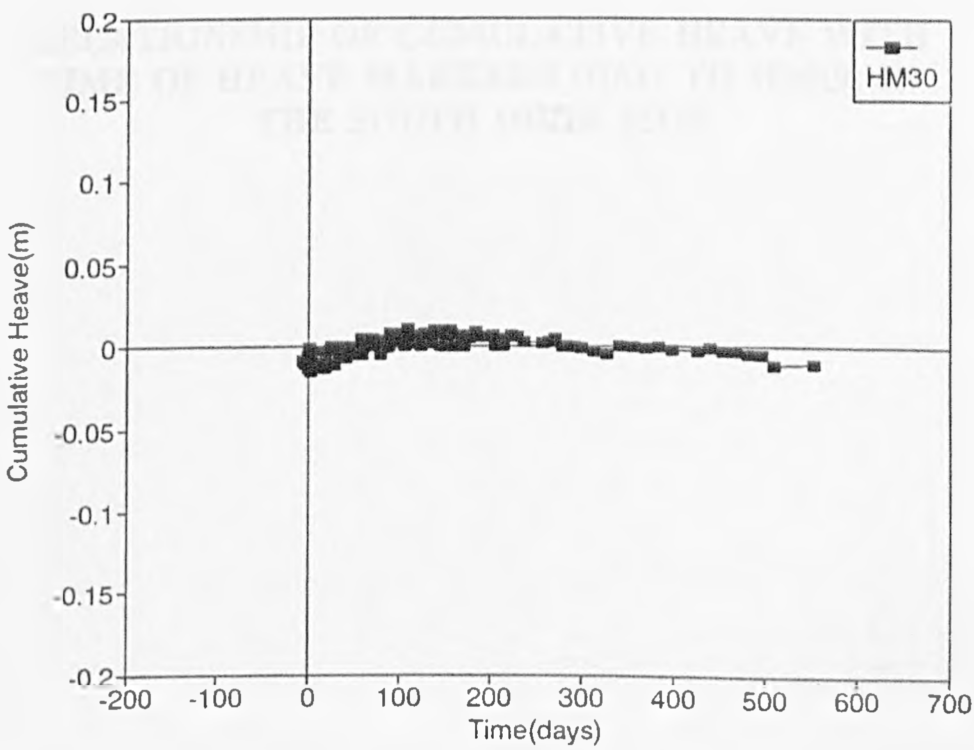

HM26
Cumulative Heave(m)
0.2
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
-0.2
-200
-100
0
100
200
300
400
500
600
700
Time(days)


HM27
Cumulative Heave(m)
0.2
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
-0.2
-200
-100
0
100
200
300
400
500
600
700
Time(days)


HM28
Cumulative Heave(m)
0.2
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
-0.2
-200
-100
0
100
200
300
400
500
600
700
Time(days)

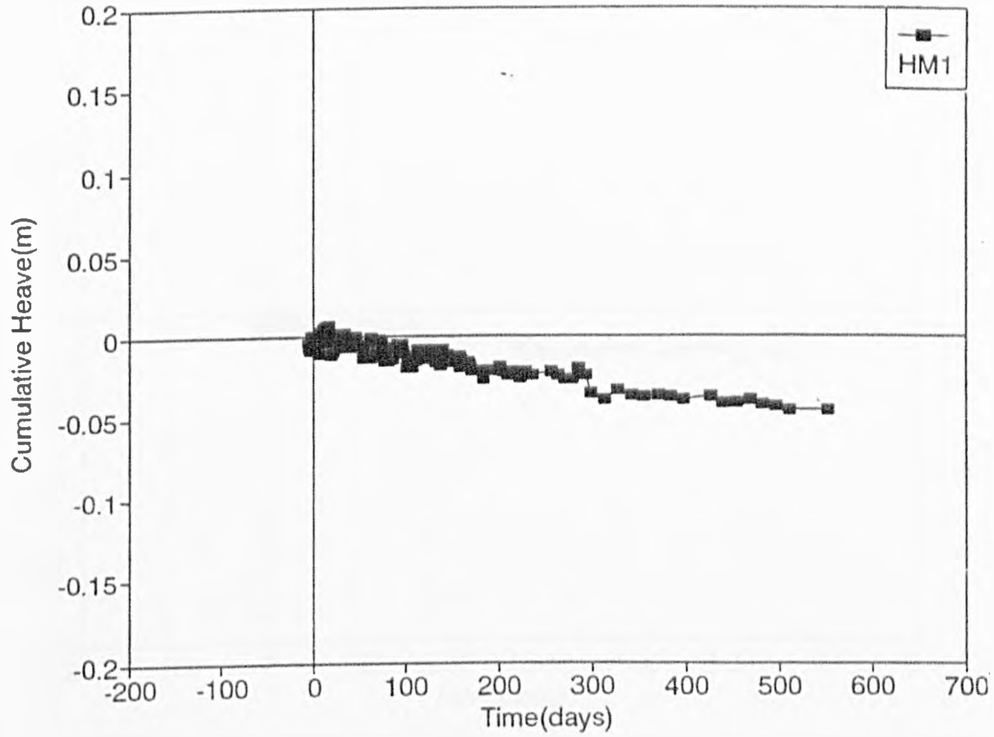

HM28A
Cumulative Heave(m)
0.2
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
-0.2
-200
-100
0
100
200
300
400
500
600
700
Time(days)

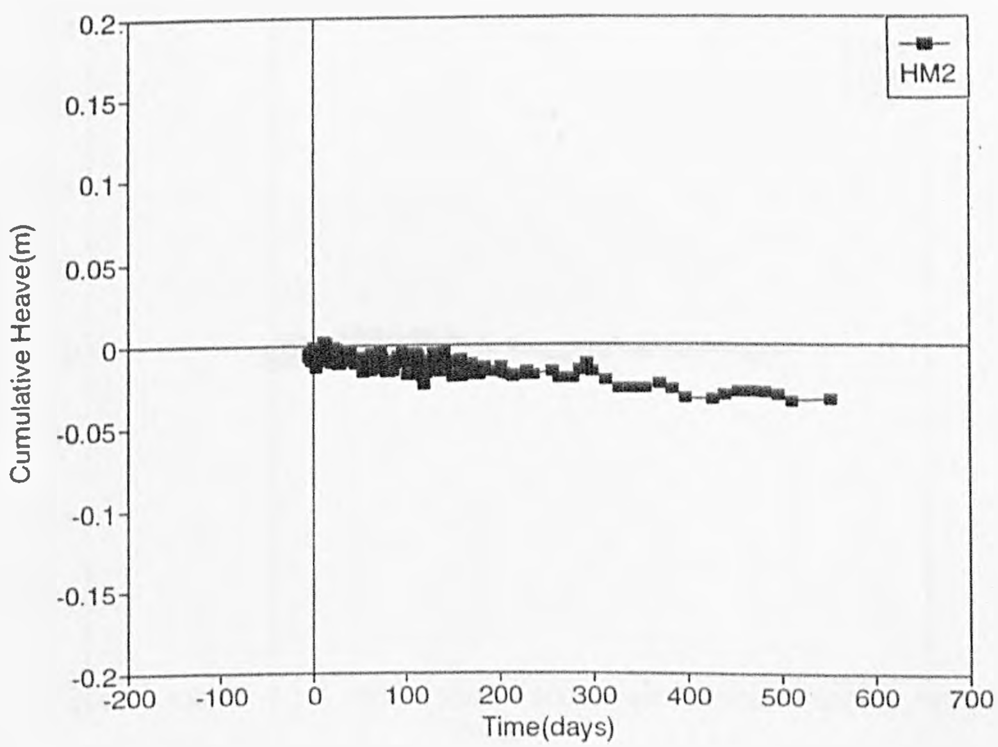

HM29
Cumulative Heave(m)
Time(days)
0.2
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
-0.2
-200
-100
0
100
200
300
400
500
600
700

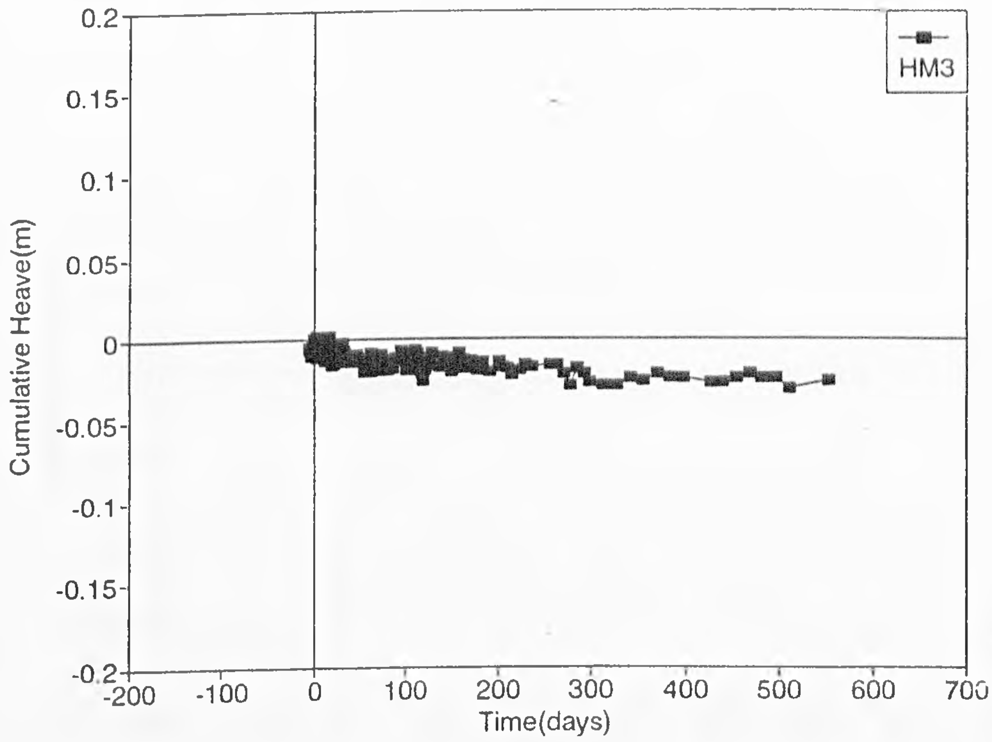

HM30
Cumulative Heave(m)
Time(days)
0.2
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
-0.2
-200
-100
0
100
200
300
400
500
600
700

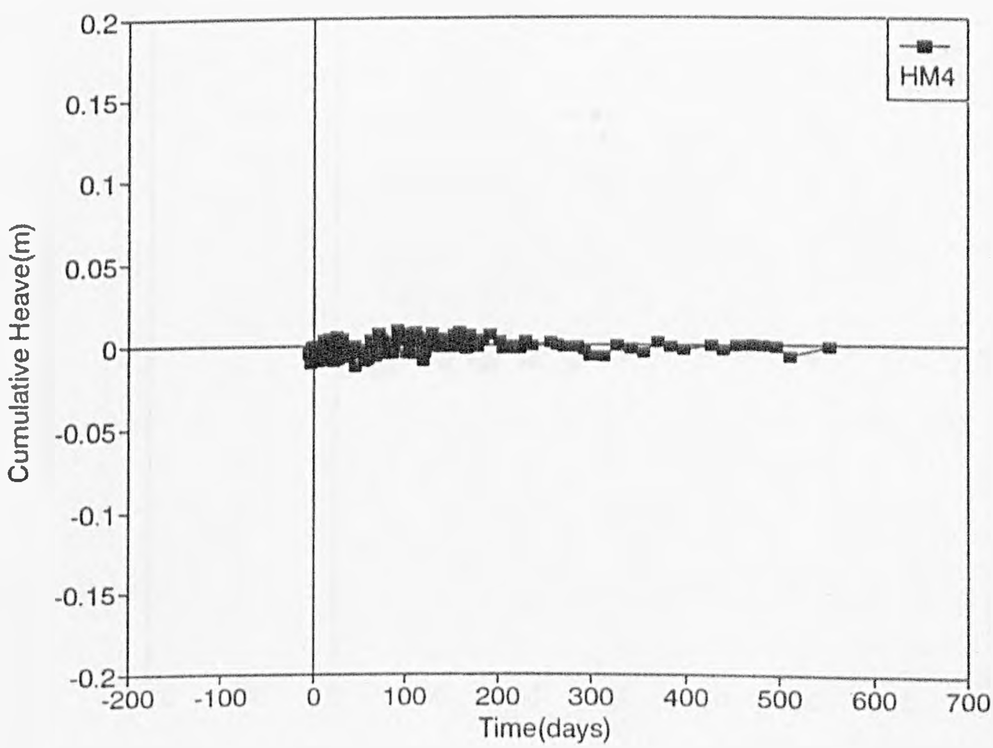
APPENDIX 6.6

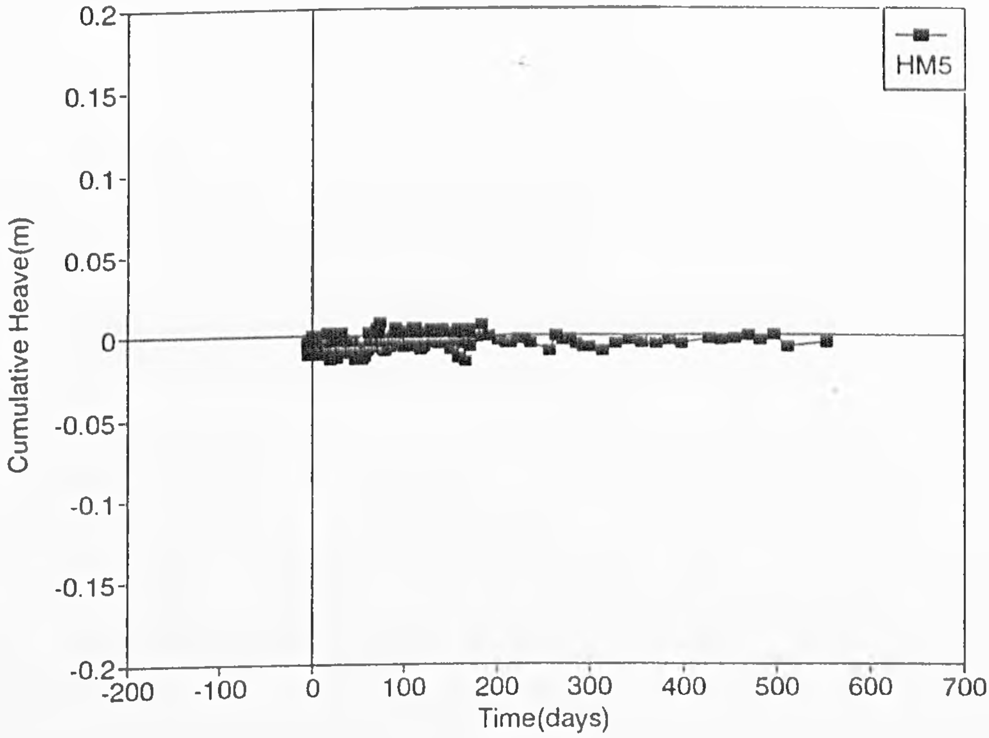
RELATIONSHIP OF CUMULATIVE HEAVE WITH TIME OF HEAVE MARKERS (HM1 TO HM19) IN THE SOUTH DIRECTION

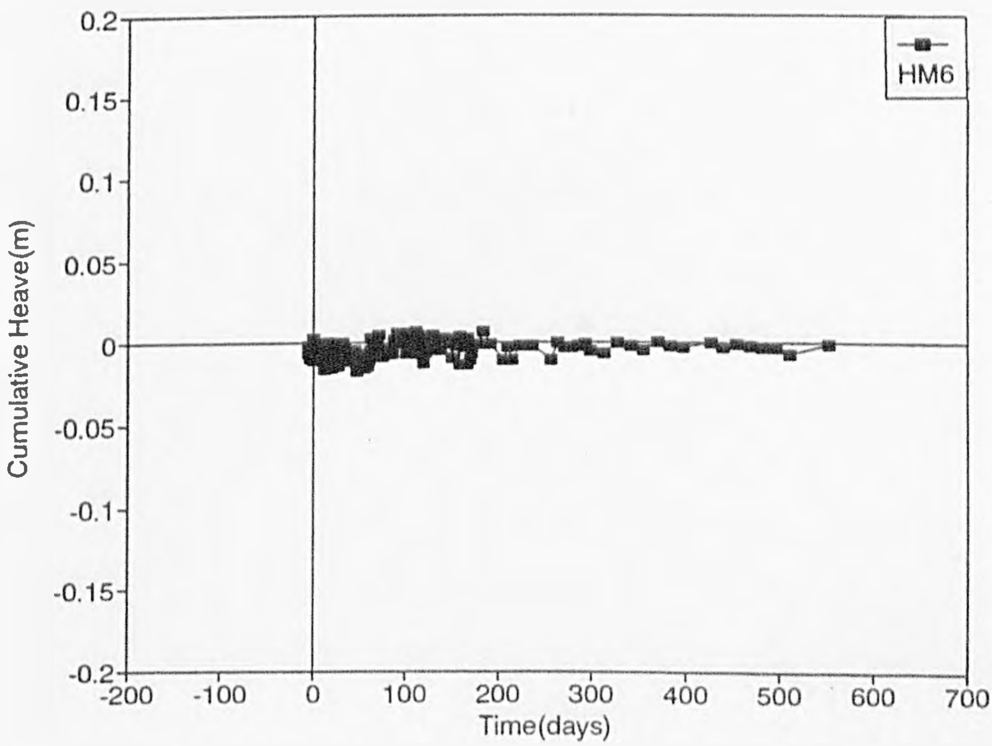

HM1
Cumulative Heave(m)
0.2
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
-0.2
-200
-100
0
100
200
300
400
500
600
700
Time(days)

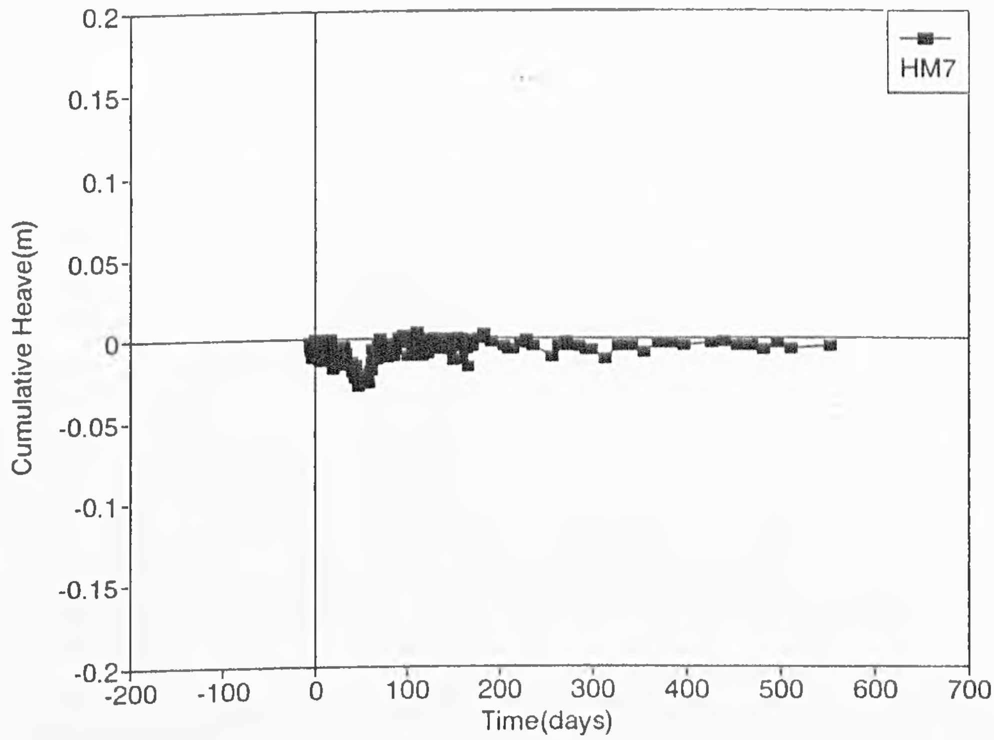

HM2
Cumulative Heave(m)
0.2
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
-0.2
-200
-100
0
100
200
300
400
500
600
700
Time(days)

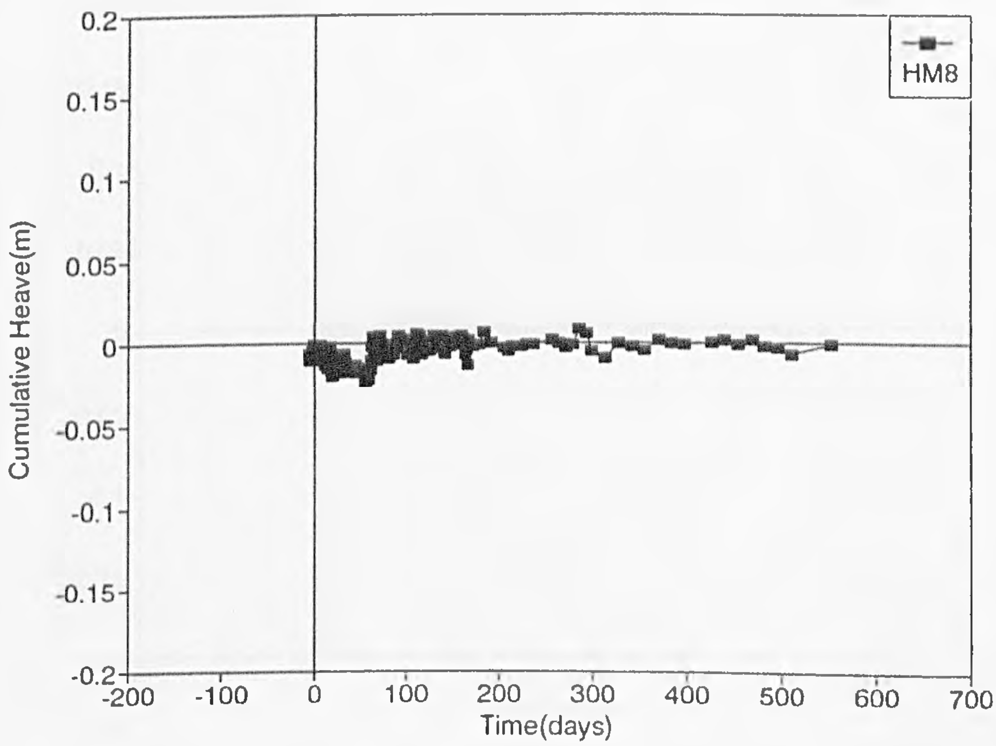

HM3
Cumulative Heave(m)
Time(days)
0.2
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
-0.2
-200
-100
0
100
200
300
400
500
600
700

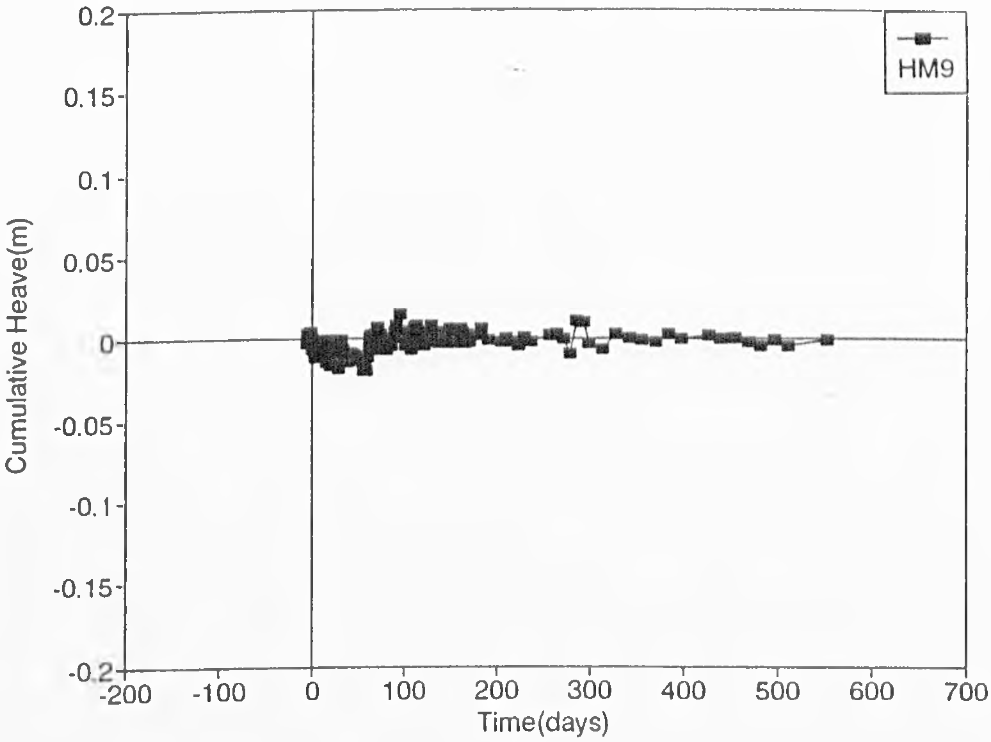

HM4
Cumulative Heave(m)
Time(days)
0.2
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
-0.2
-200
-100
0
100
200
300
400
500
600
700

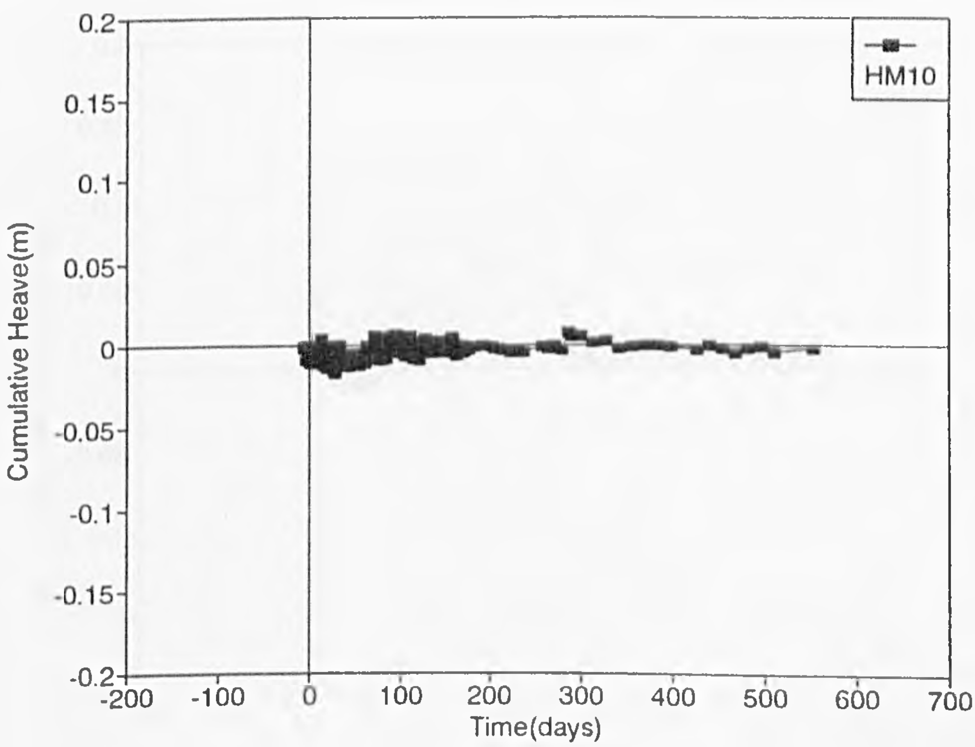

HM5
Cumulative Heave(m)
0.2
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
-0.2
-200
-100
0
100
200
300
400
500
600
700
Time(days)

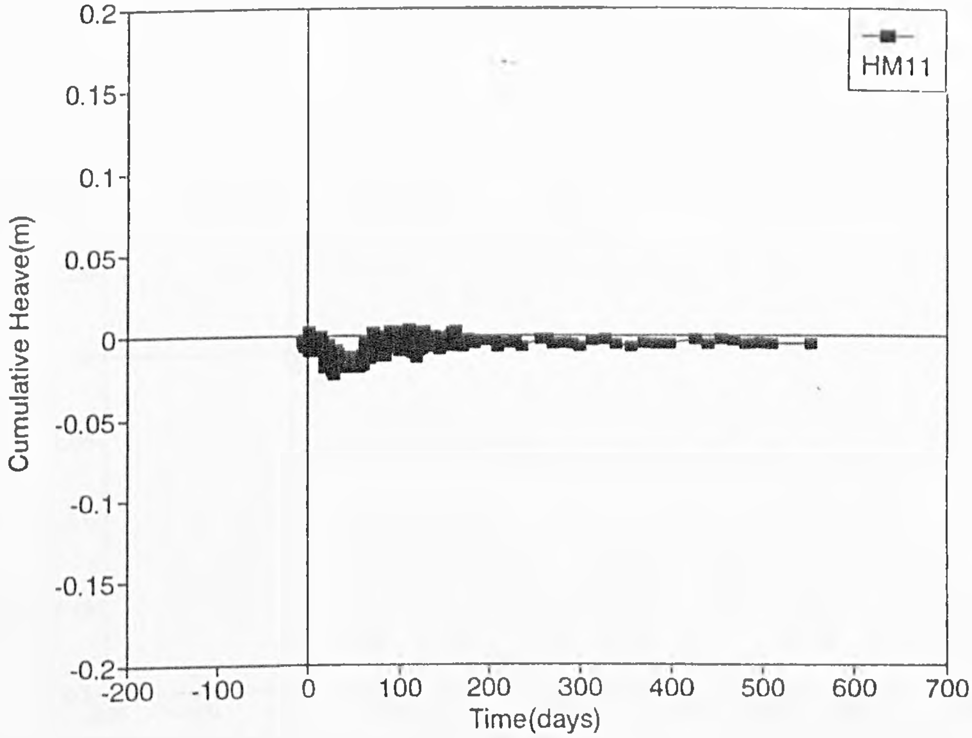

HM6
Cumulative Heave(m)
0.2
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
-0.2
-200
-100
0
100
200
300
400
500
600
700
Time(days)


HM7
Cumulative Heave(m)
Time(days)
0.2
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
-0.2
-200
-100
0
100
200
300
400
500
600
700

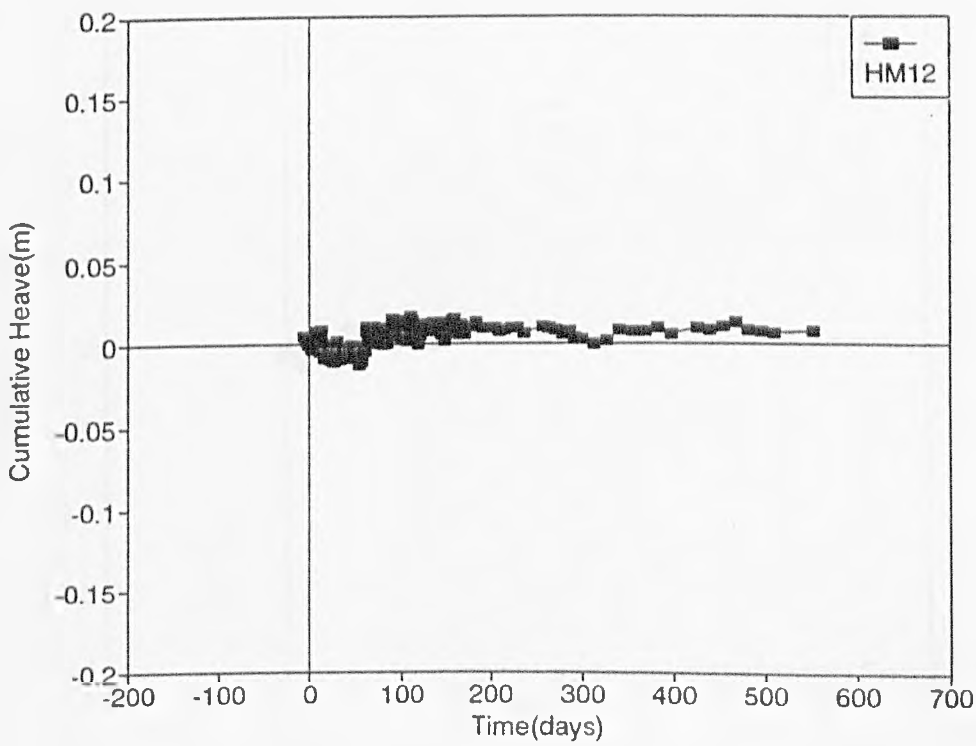

HM8
Cumulative Heave(m)
Time(days)
0.2
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
-0.2
-200
-100
0
100
200
300
400
500
600
700


HM9
Cumulative Heave(m)
0.2
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
-0.2
-200
-100
0
100
200
300
400
500
600
700
Time(days)

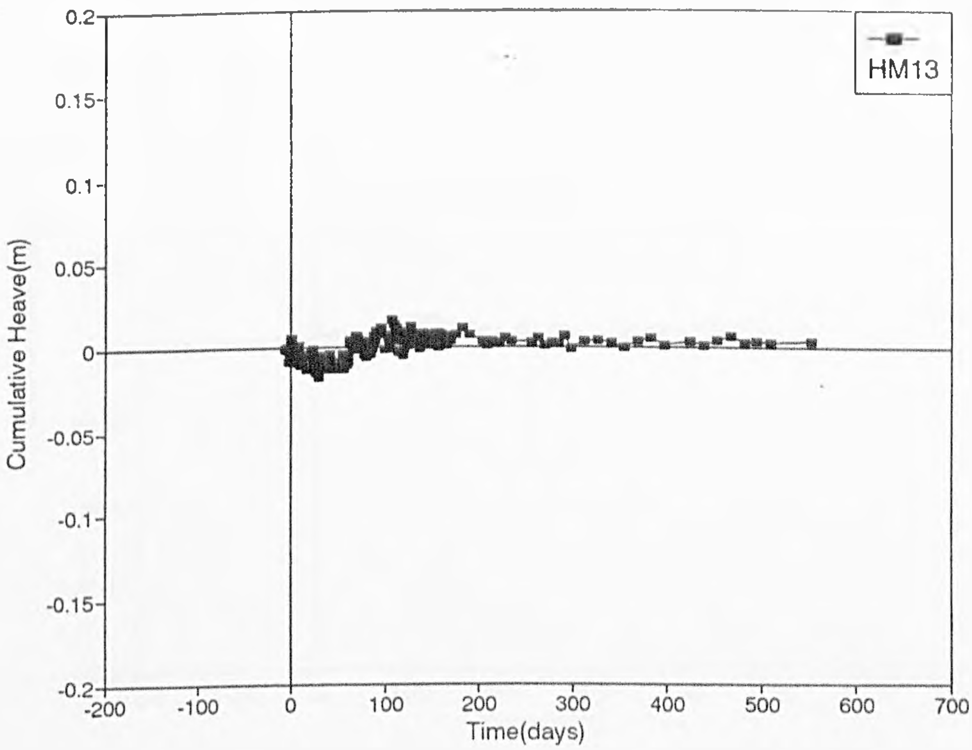

HM10
Cumulative Heave(m)
0.2
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
-0.2
-200
-100
0
100
200
300
400
500
600
700
Time(days)

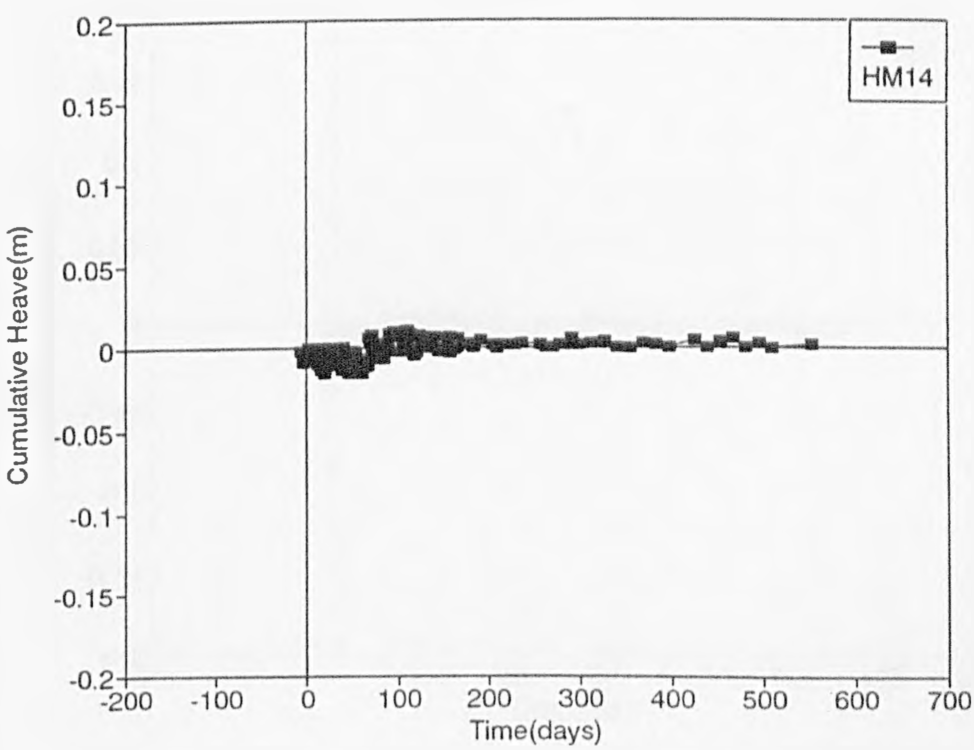


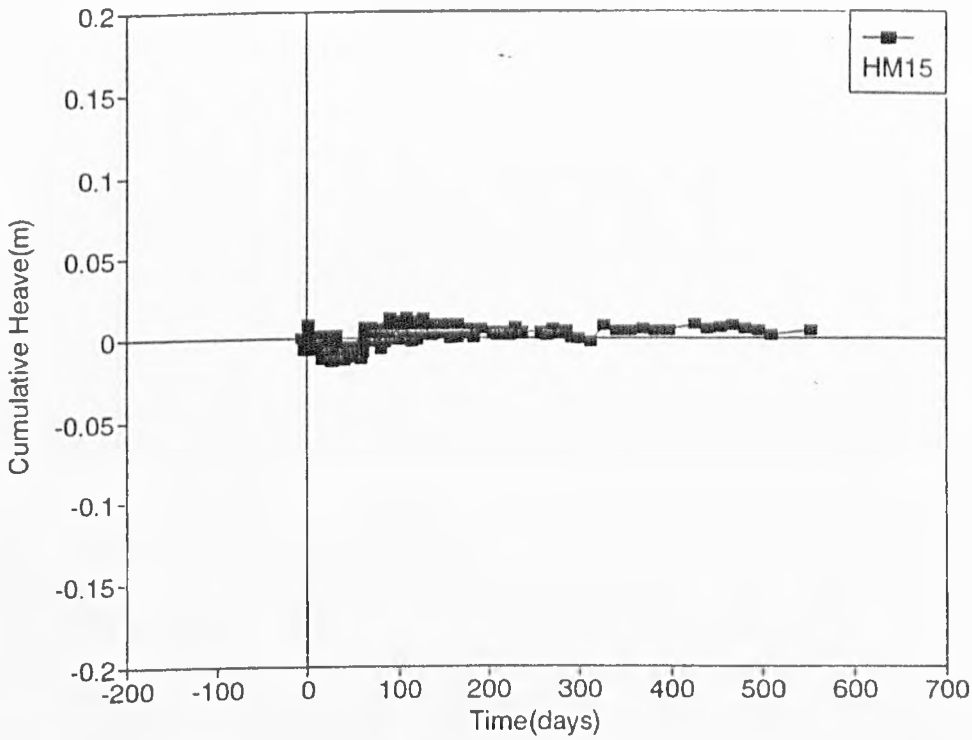
HM11
Cumulative Heave(m)
Time(days)

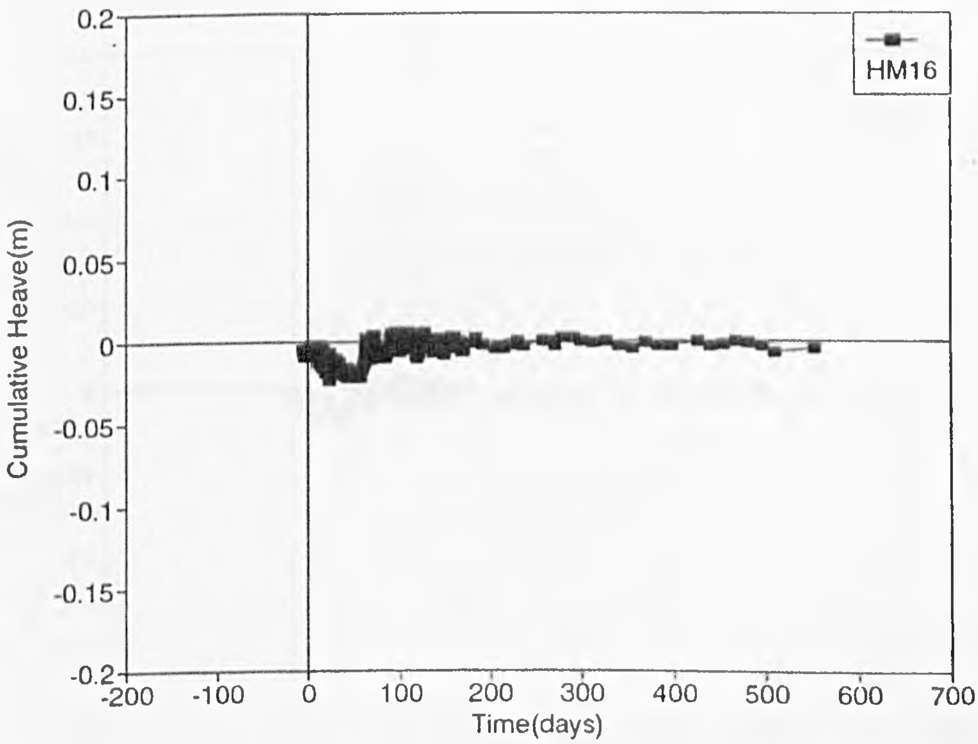


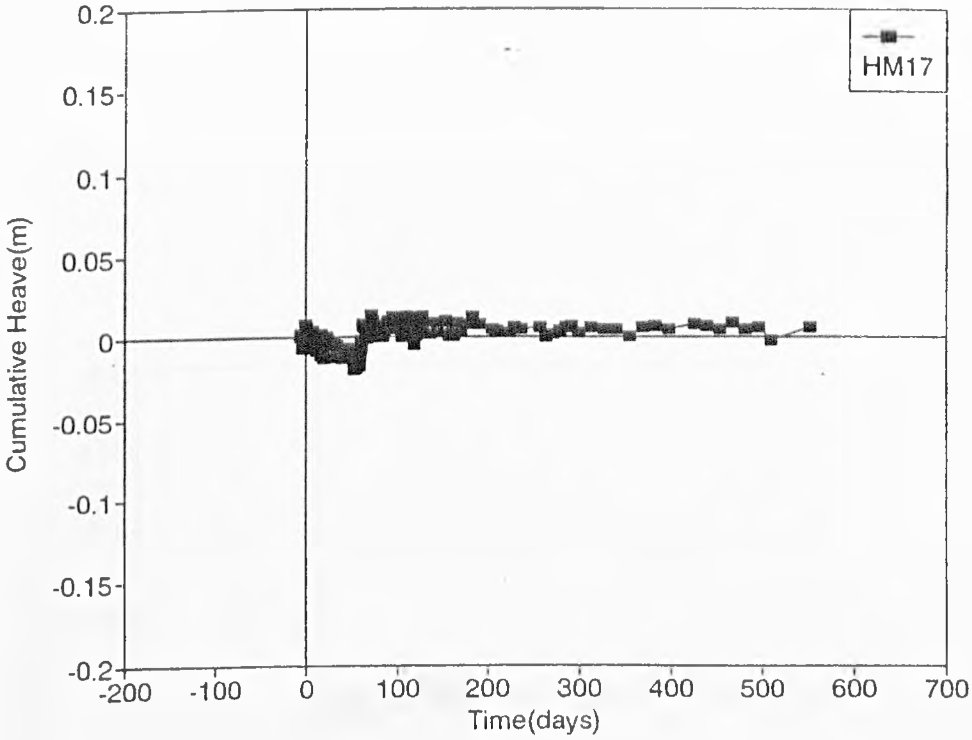
HM12
Cumulative Heave(m)
Time(days)


HM13
Cumulative Heave(m)
0.2
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
-0.2
-200
-100
0
100
200
300
400
500
600
700
Time(days)

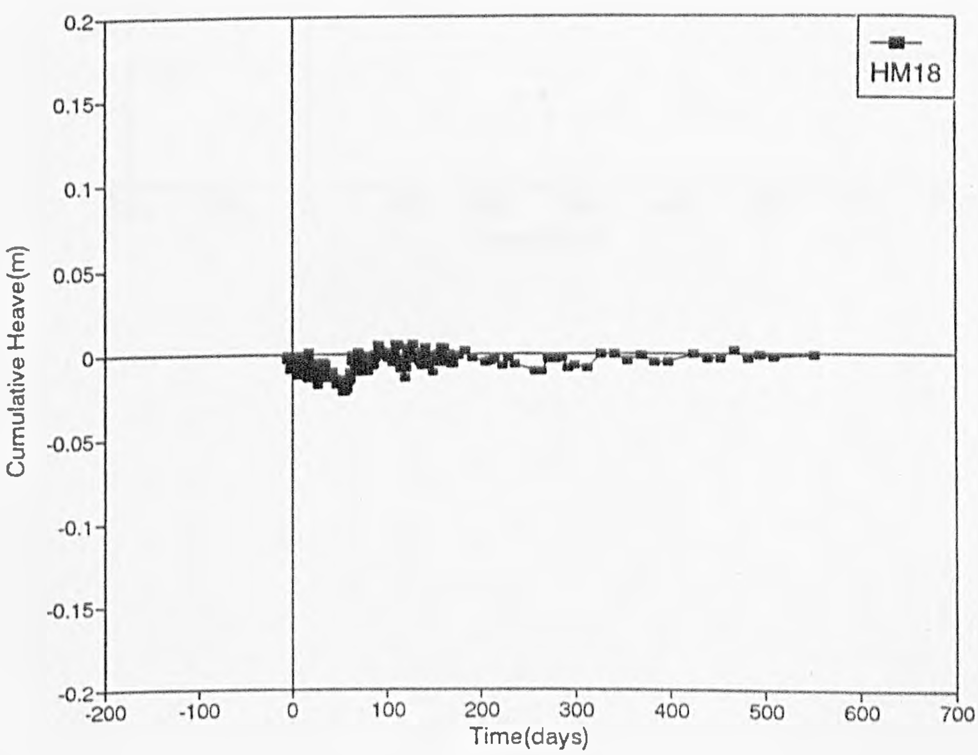

HM14
Cumulative Heave(m)
0.2
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
-0.2
-200
-100
0
100
200
300
400
500
600
700
Time(days)


HM15
Cumulative Heave(m)
0.2
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
-0.2
-200
-100
0
100
200
300
400
500
600
700
Time(days)

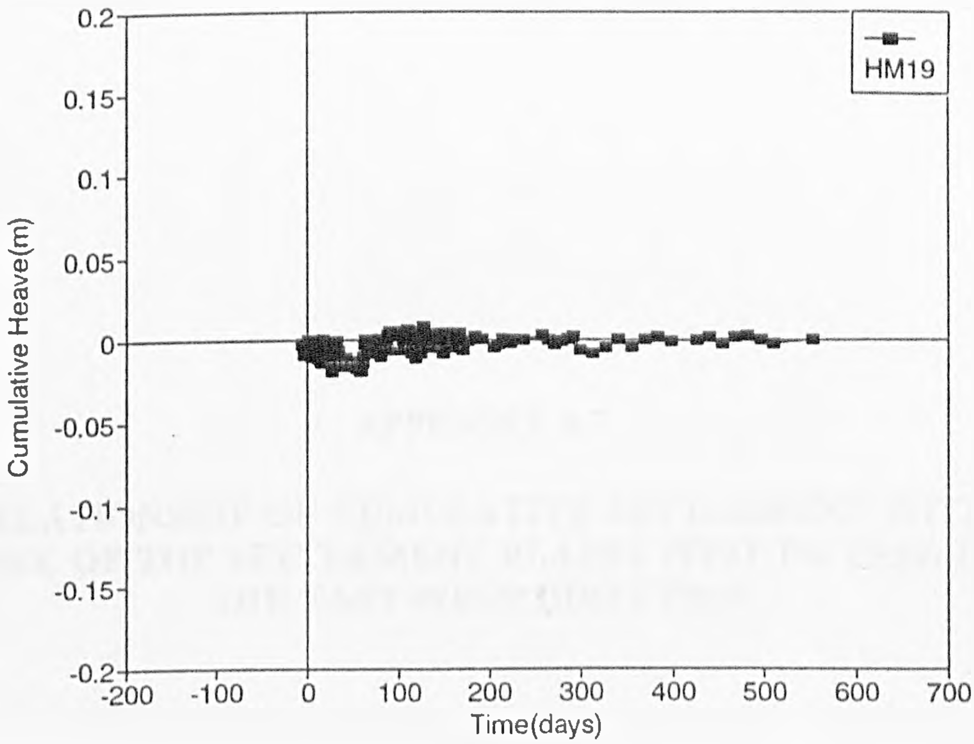

HM16
Cumulative Heave(m)
0.2
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
-0.2
-200
-100
0
100
200
300
400
500
600
700
Time(days)



HM17
Cumulative Heave(m)
0.2
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
-0.2
-200
-100
0
100
200
300
400
500
600
700
Time(days)



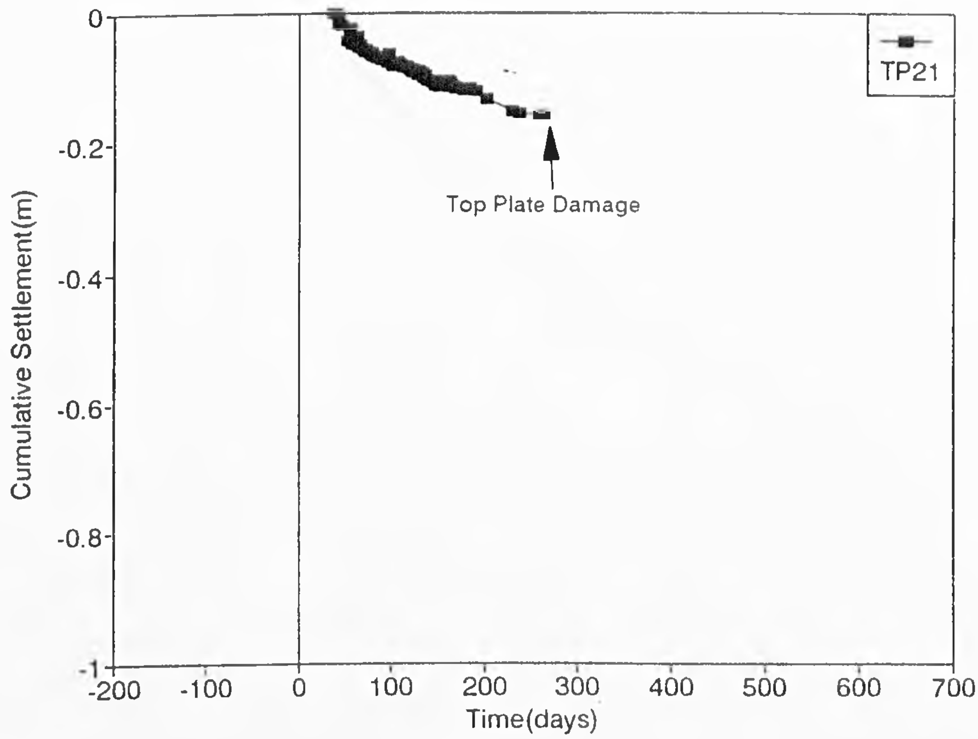
HM18
Cumulative Heave(m)
0.2
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
-0.2
-200
-100
0
100
200
300
400
500
600
700
Time(days)

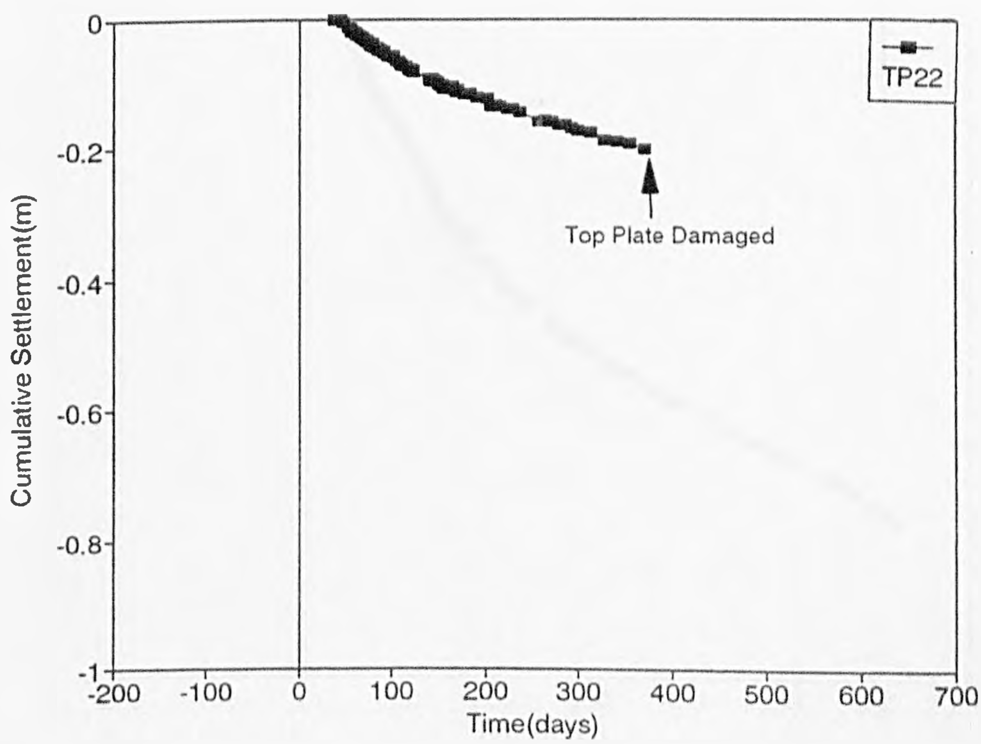


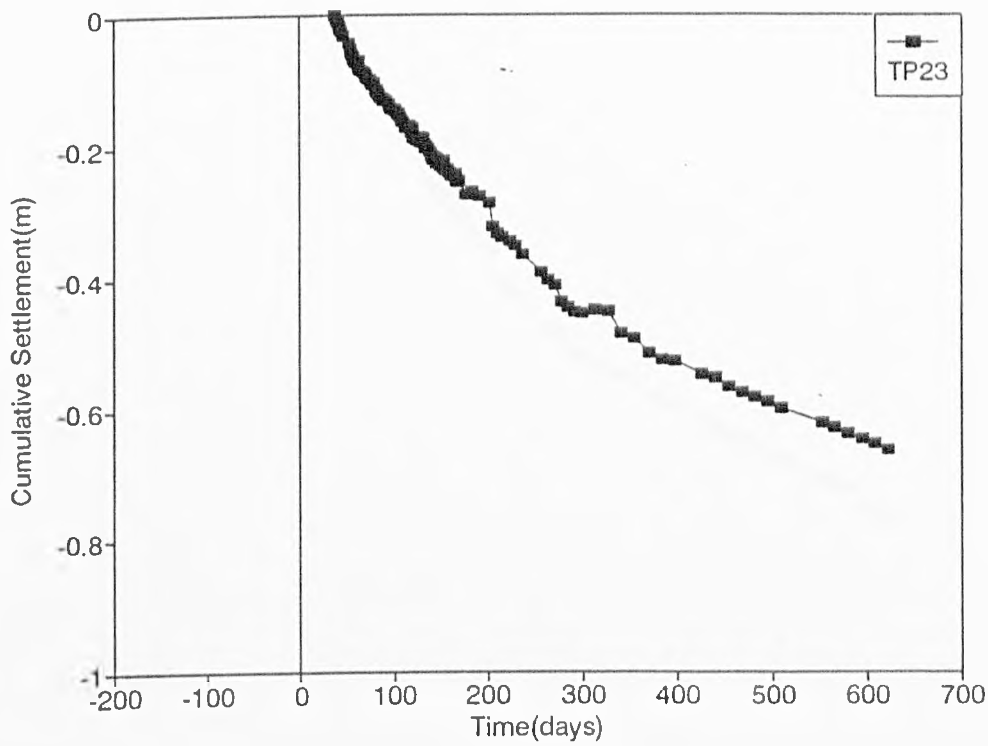
0.2
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
-0.2
Cumulative Heave(m)
-200
-100
0
100
200
300
400
500
600
700
Time(days)
HM19

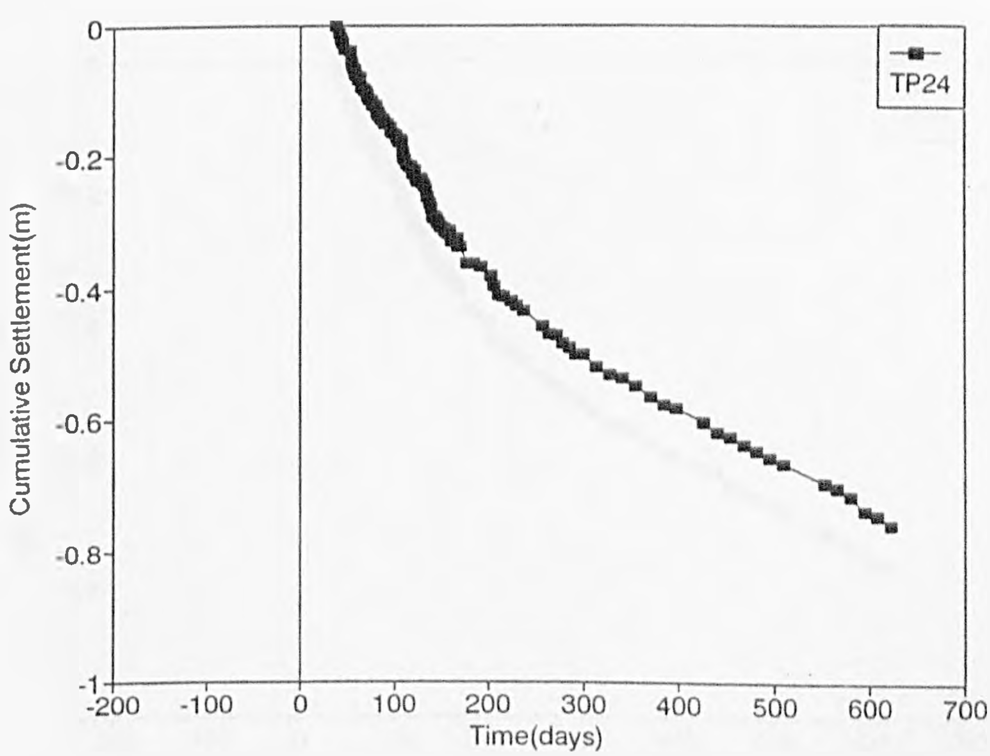
APPENDIX 6.7

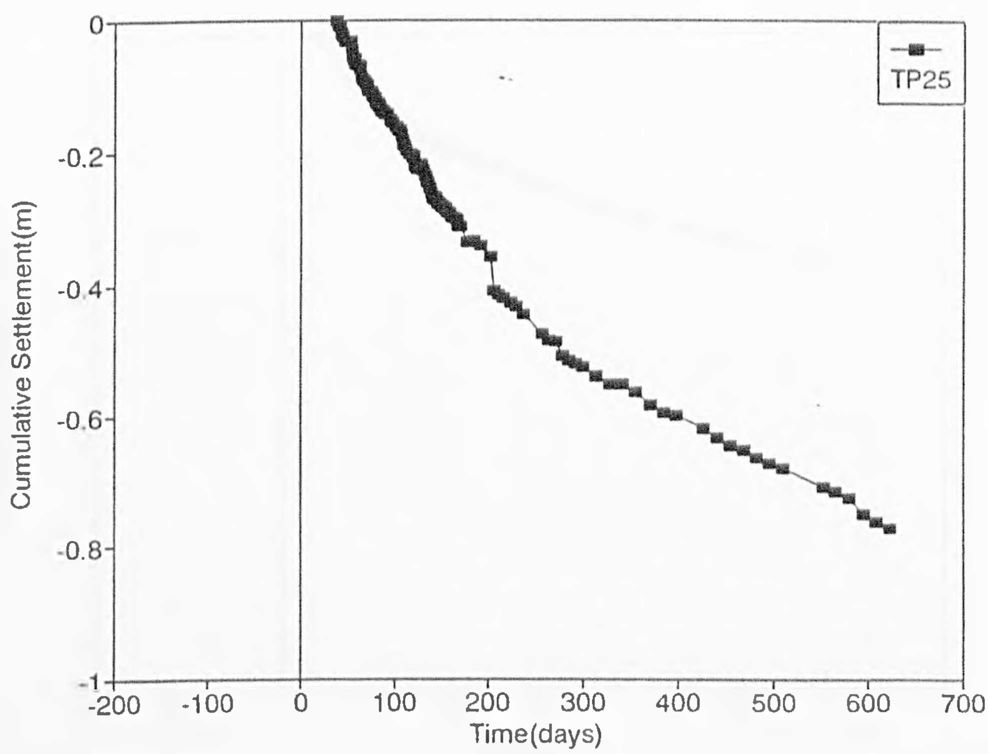
RELATIONSHIP OF CUMULATIVE SETTLEMENT WITH TIME OF TOP SETTLEMENT PLATES (TP21 TO TP30) IN THE EAST-WEST DIRECTION

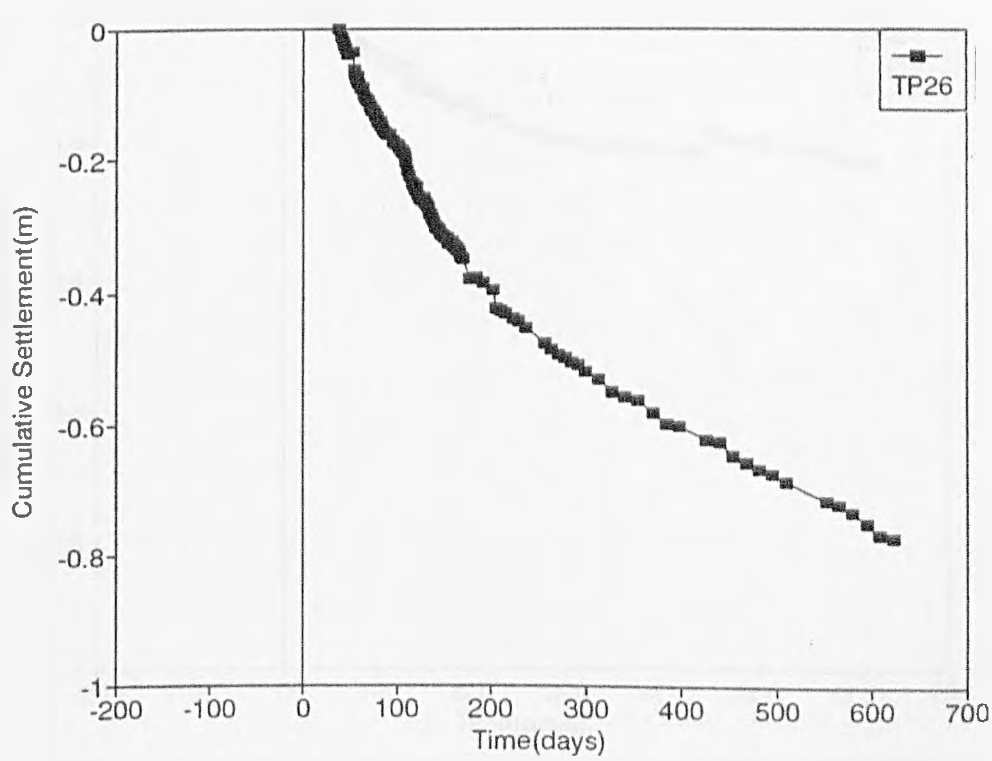

TP21
Top Plate Damage
Cumulative Settlement(m)
0
-0.2
-0.4
-0.6
-0.8
-1
-200
-100
0
100
200
300
400
500
600
700
Time(days)

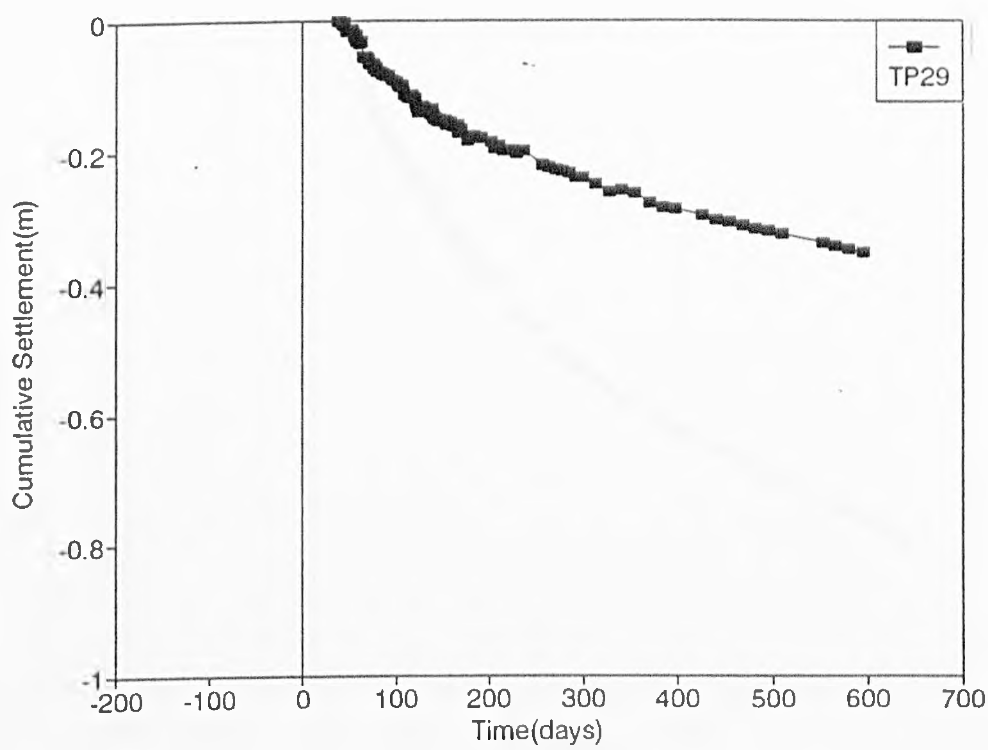

TP22
Top Plate Damaged
Cumulative Settlement(m)
0
-0.2
-0.4
-0.6
-0.8
-1
-200
-100
0
100
200
300
400
500
600
700
Time(days)

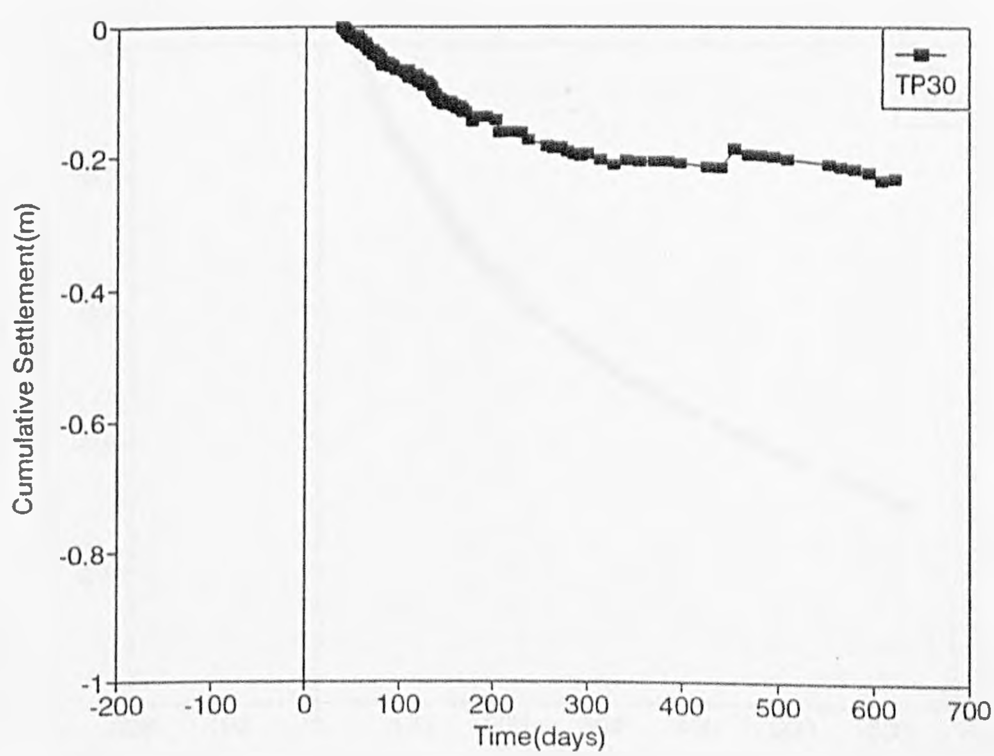

Cumulative Settlement(m)
0
-0.2
-0.4
-0.6
-0.8
-1
-200
-100
0
100
200
300
400
500
600
700
Time(days)
TP23

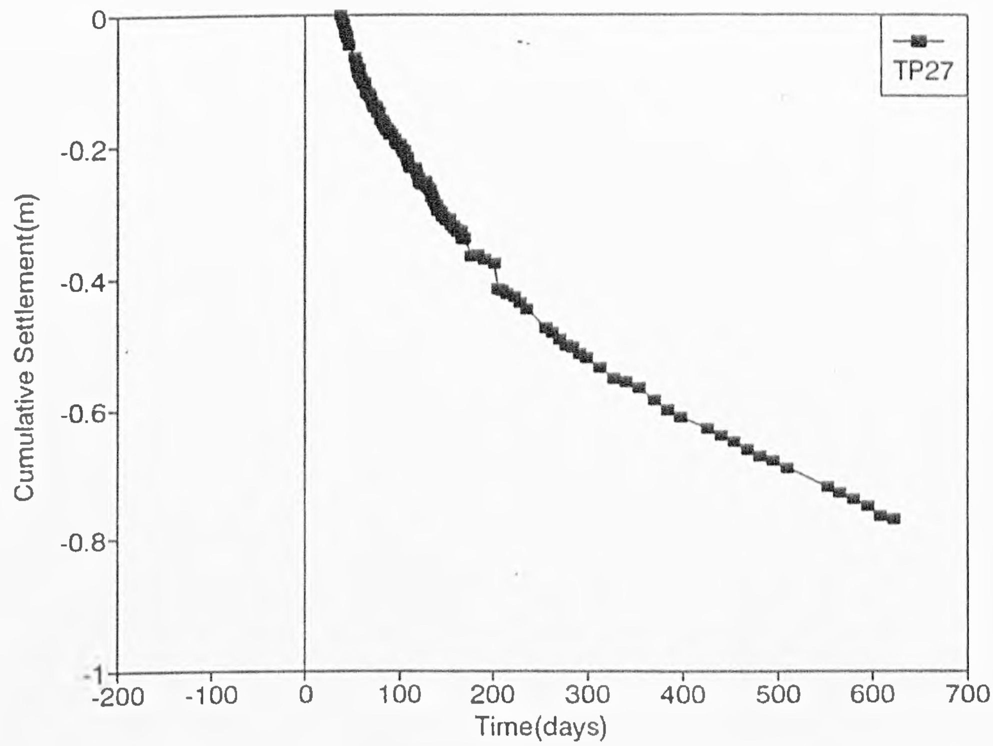

Cumulative Settlement(m)
0
-0.2
-0.4
-0.6
-0.8
-1
-200
-100
0
100
200
300
400
500
600
700
Time(days)
TP24

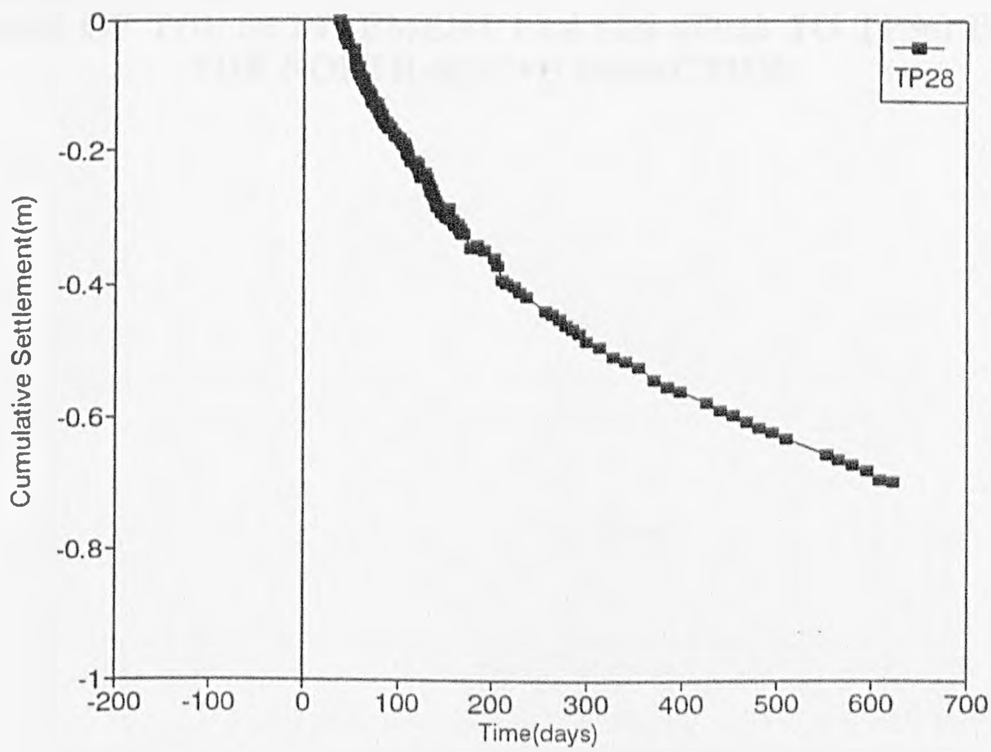

TP25
0
-0.2
-0.4
-0.6
-0.8
-1
Cumulative Settlement(m)
-200 -100 0 100 200 300 400 500 600 700
Time(days)


TP26
0
-0.2
-0.4
-0.6
-0.8
-1
Cumulative Settlement(m)
-200 -100 0 100 200 300 400 500 600 700
Time(days)


TP29
Cumulative Settlement(m)
0
-0.2
-0.4
-0.6
-0.8
-1
-200
-100
0
100
200
300
400
500
600
700
Time(days)

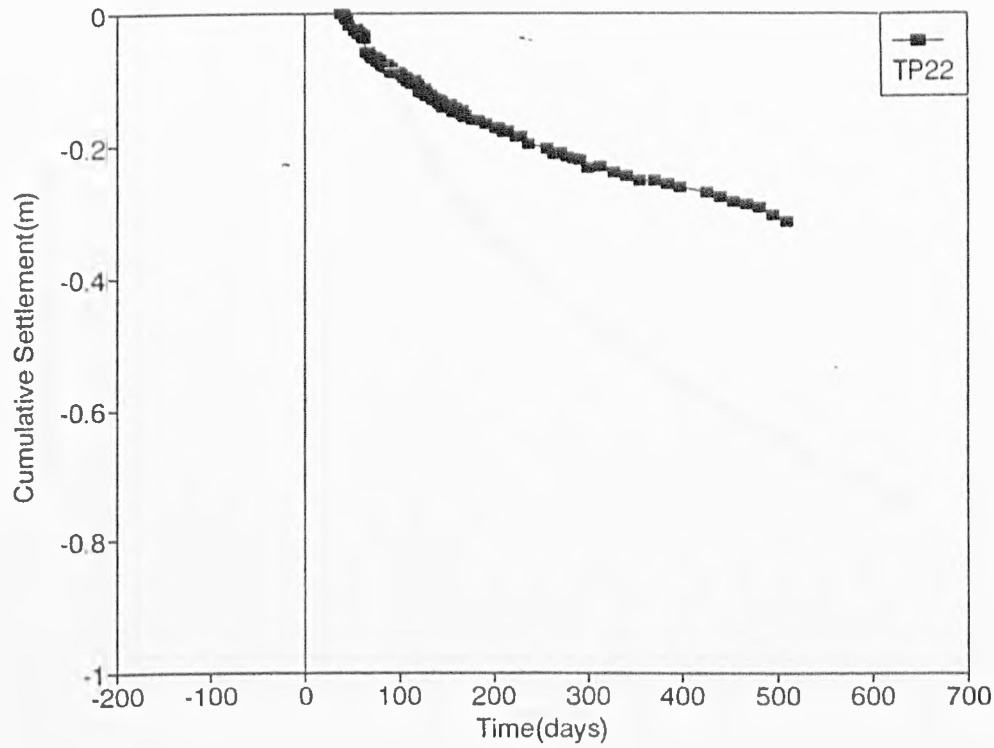

TP30
Cumulative Settlement(m)
0
-0.2
-0.4
-0.6
-0.8
-1
-200
-100
0
100
200
300
400
500
600
700
Time(days)


0
-0.2
-0.4
-0.6
-0.8
-1
Cumulative Settlement(m)
-200
-100
0
100
200
300
400
500
600
700
Time(days)
TP27

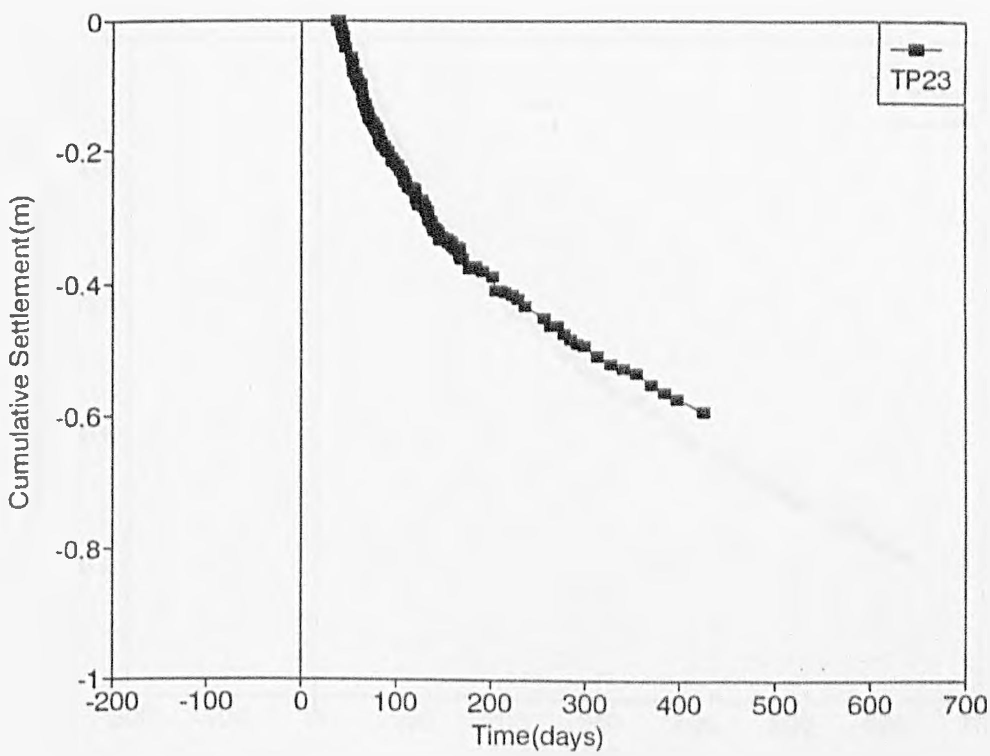

0
-0.2
-0.4
-0.6
-0.8
-1
Cumulative Settlement(m)
-200
-100
0
100
200
300
400
500
600
700
Time(days)
TP28

APPENDIX 6.8

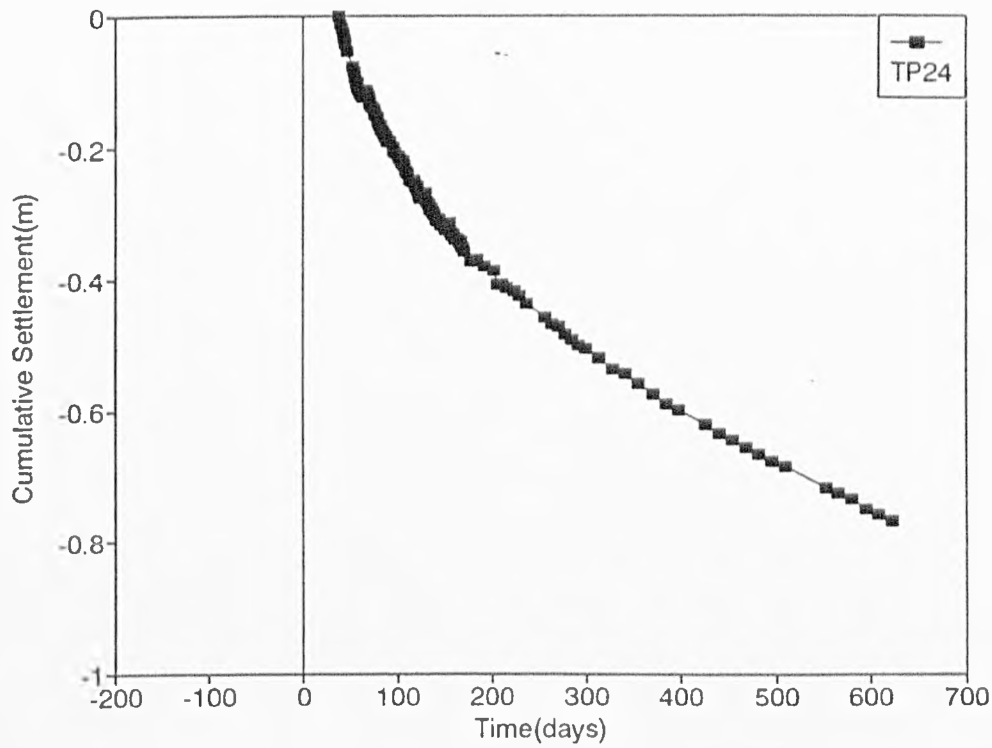
RELATIONSHIP OF CUMULATIVE SETTLEMENT WITH TIME OF TOP SETTLEMENT PLATES (TP22 TO TP36) IN THE NORTH-SOUTH DIRECTION



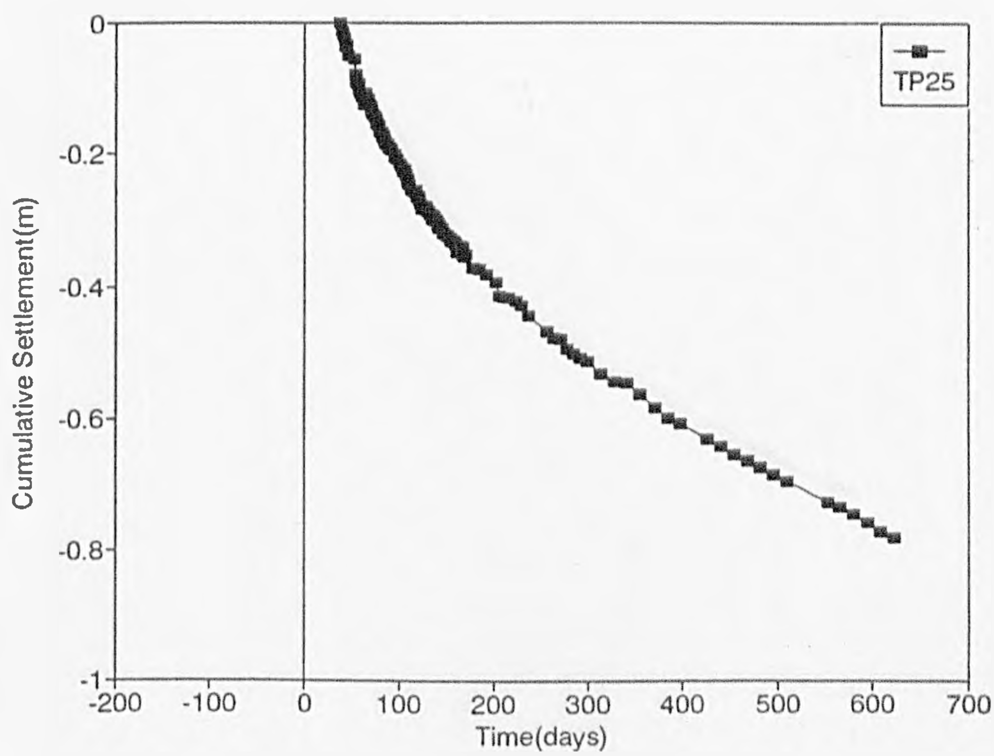
TP22
0
-0.2
-0.4
-0.6
-0.8
-1
Cumulative Settlement(m)
-200
-100
0
100
200
300
400
500
600
700
Time(days)



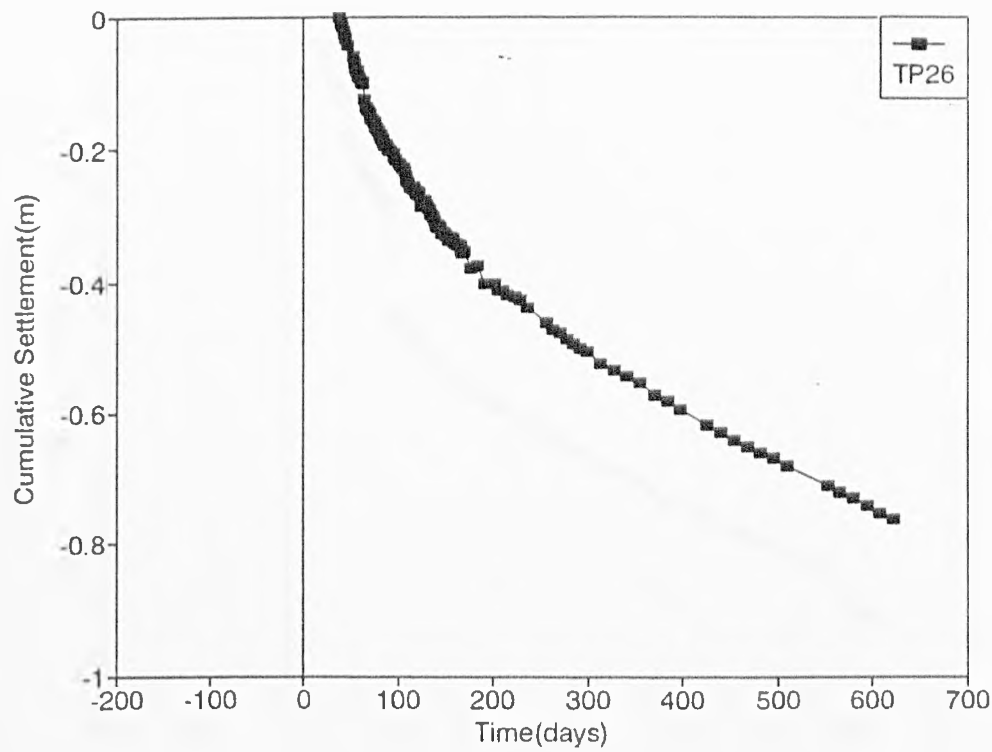
TP23
0
-0.2
-0.4
-0.6
-0.8
-1
Cumulative Settlement(m)
-200
-100
0
100
200
300
400
500
600
700
Time(days)



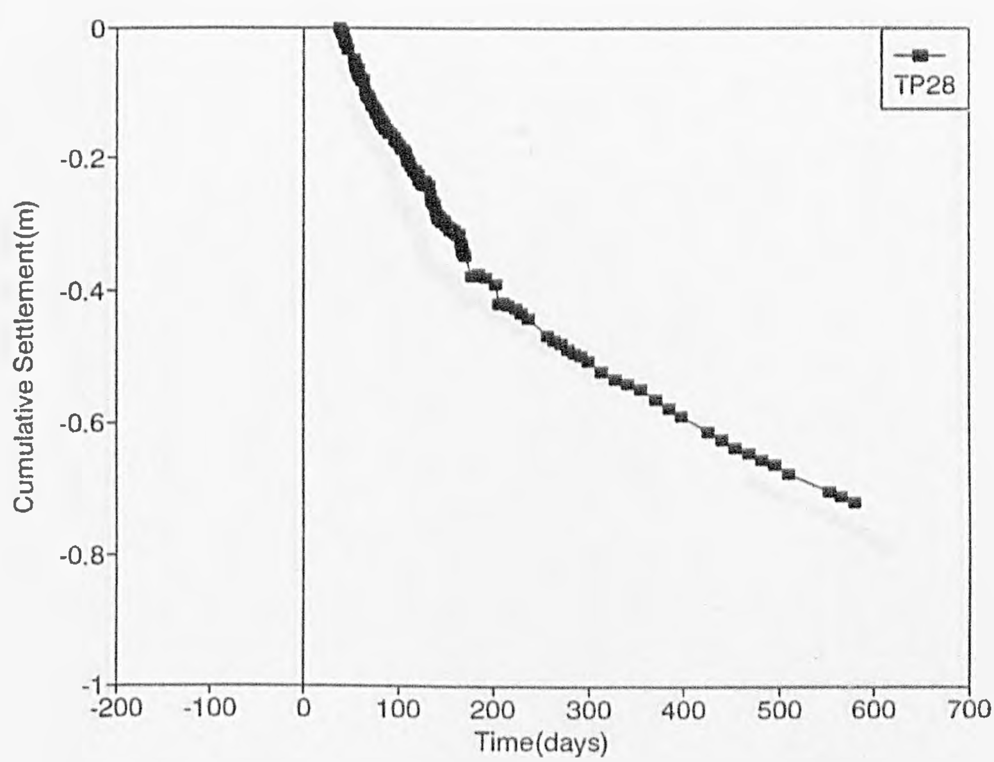
TP24
Cumulative Settlement(m)
0
-0.2
-0.4
-0.6
-0.8
-1
-200
-100
0
100
200
300
400
500
600
700
Time(days)



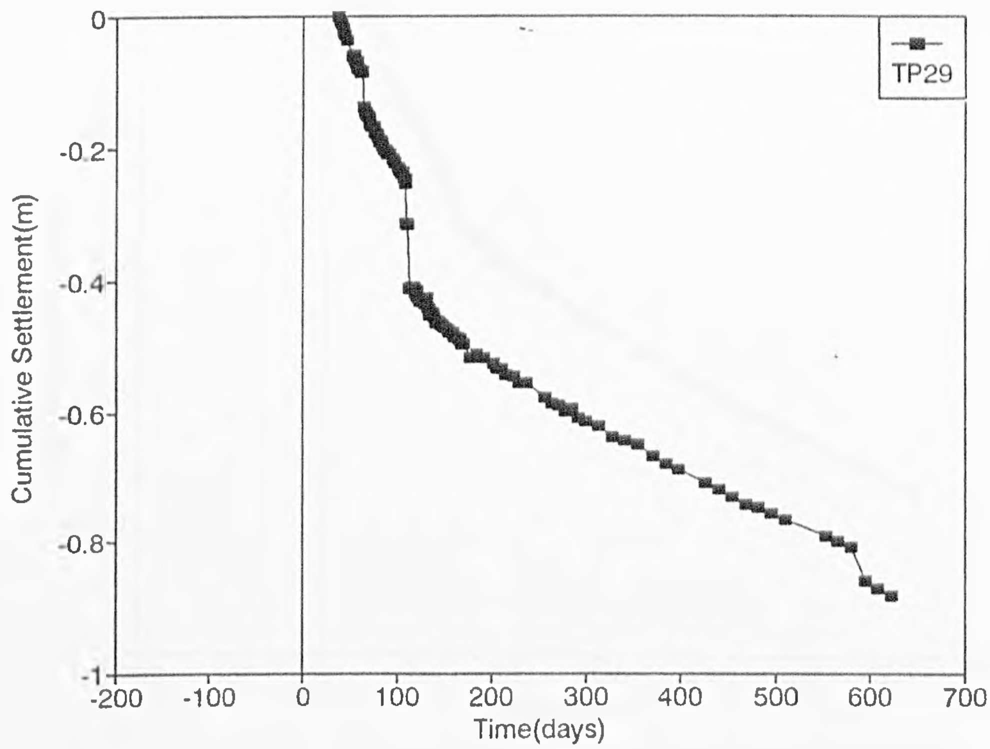
TP25
Cumulative Settlement(m)
0
-0.2
-0.4
-0.6
-0.8
-1
-200
-100
0
100
200
300
400
500
600
700
Time(days)



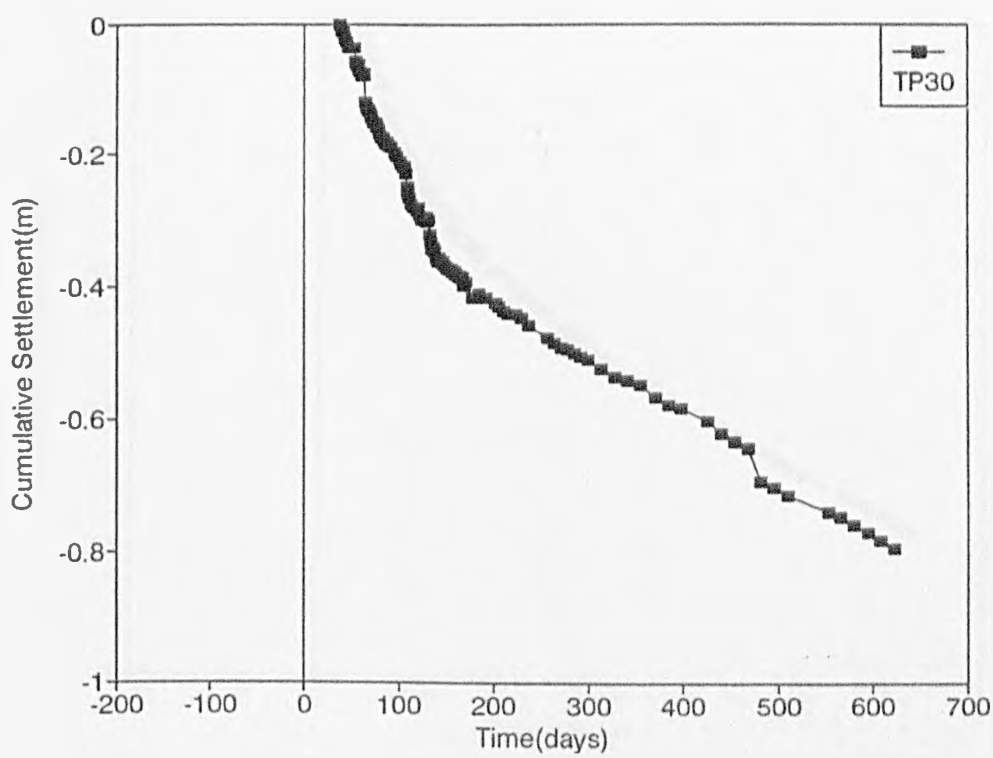
Cumulative Settlement(m)
0
-0.2
-0.4
-0.6
-0.8
-1
-200
-100
0
100
200
300
400
500
600
700
Time(days)
TP26



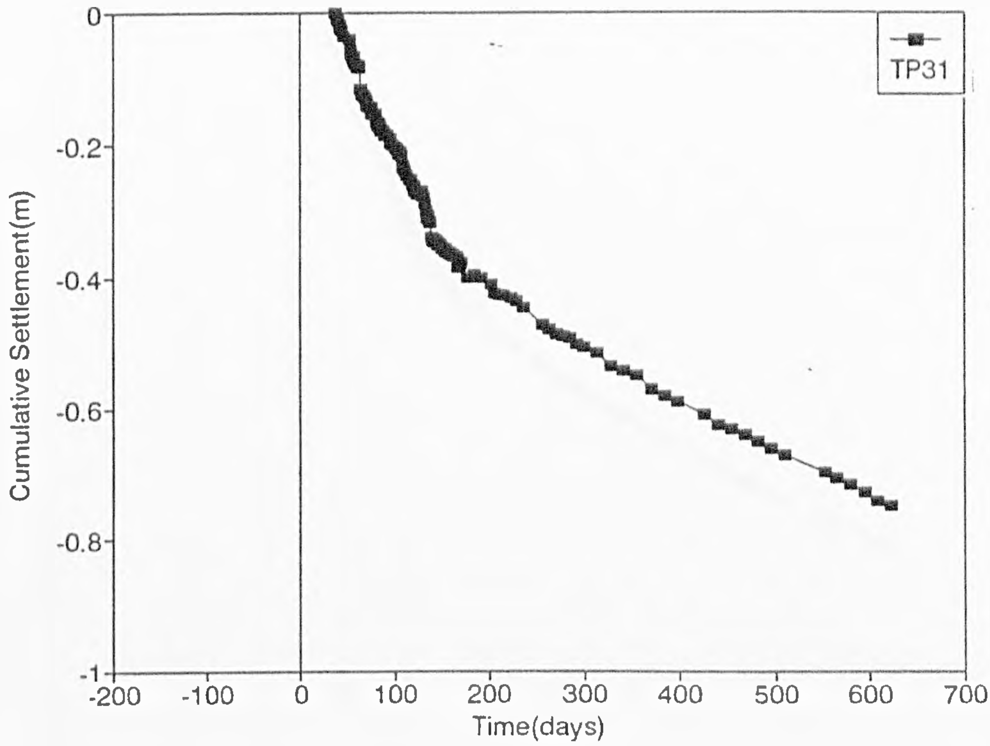
Cumulative Settlement(m)
0
-0.2
-0.4
-0.6
-0.8
-1
-200
-100
0
100
200
300
400
500
600
700
Time(days)
TP28

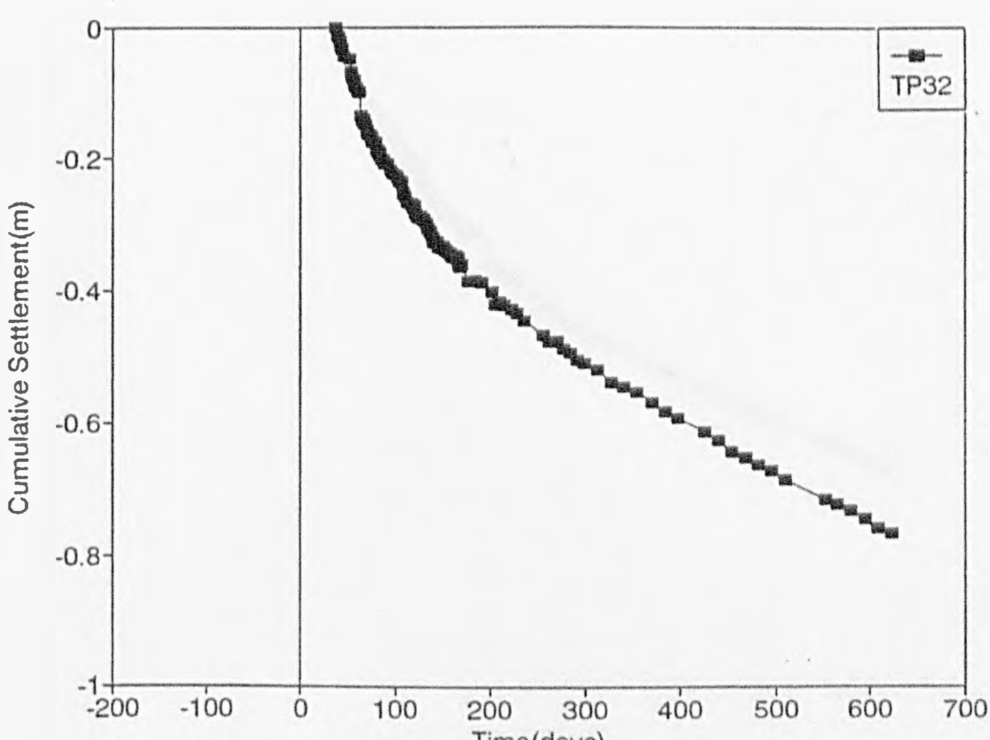


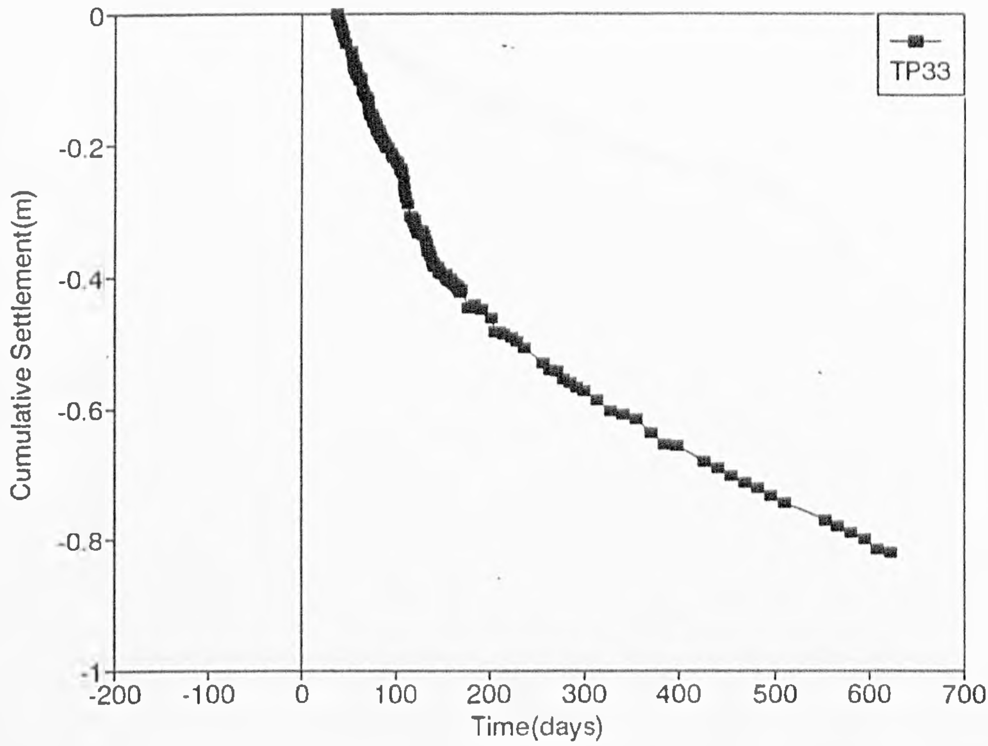
Cumulative Settlement(m)
Time(days)
TP29

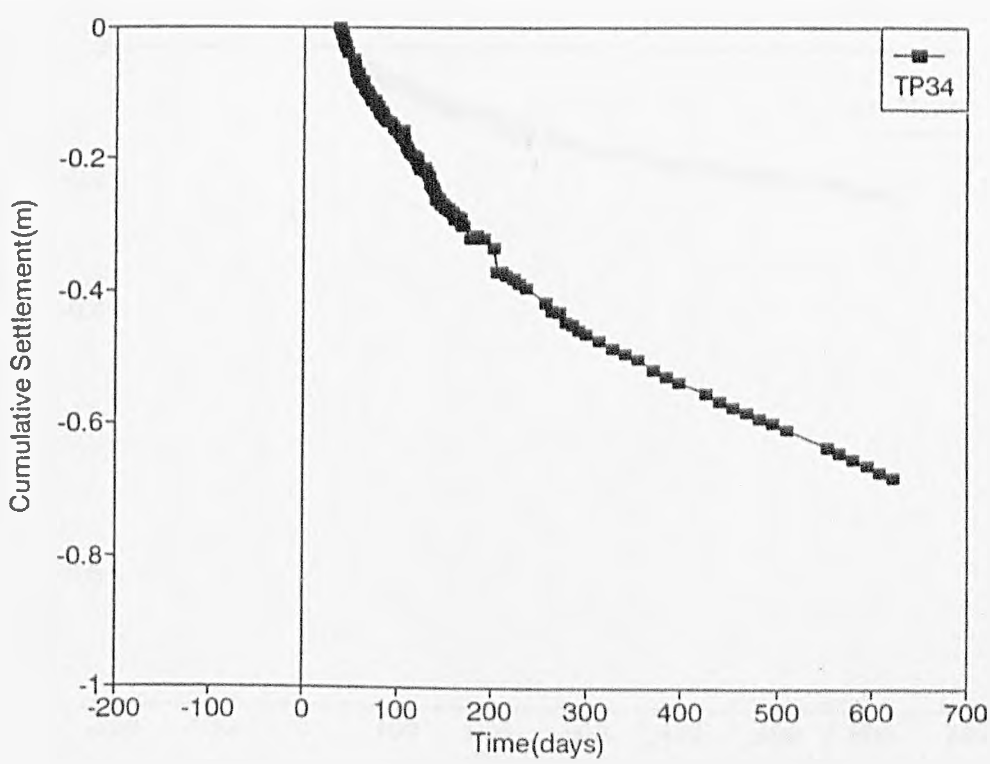


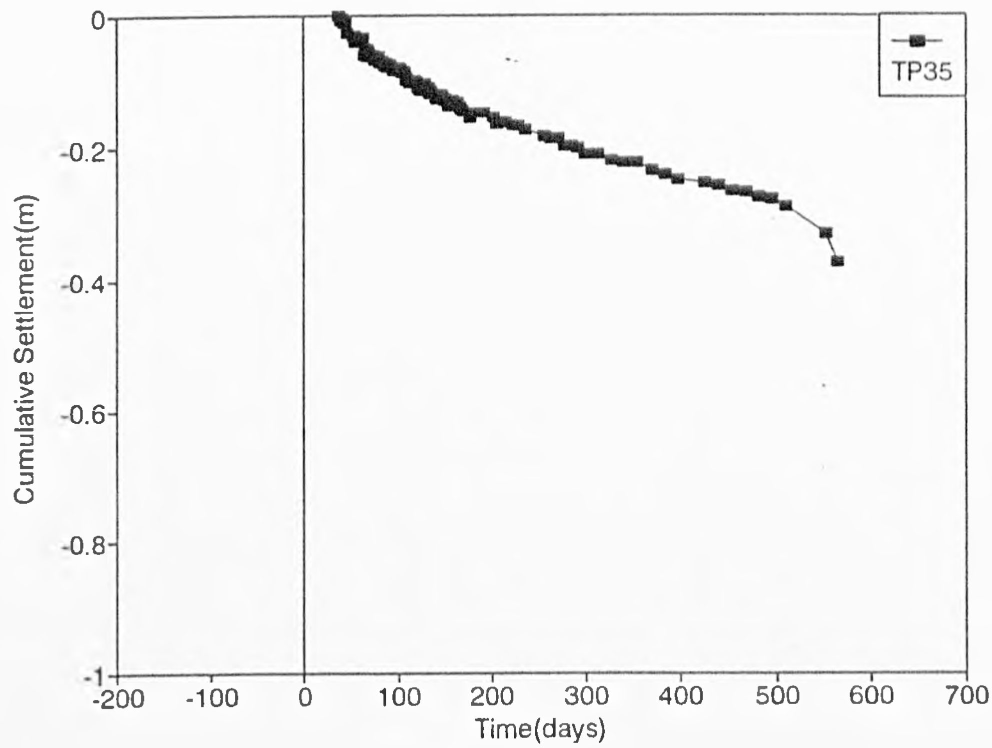
Cumulative Settlement(m)
Time(days)
TP30

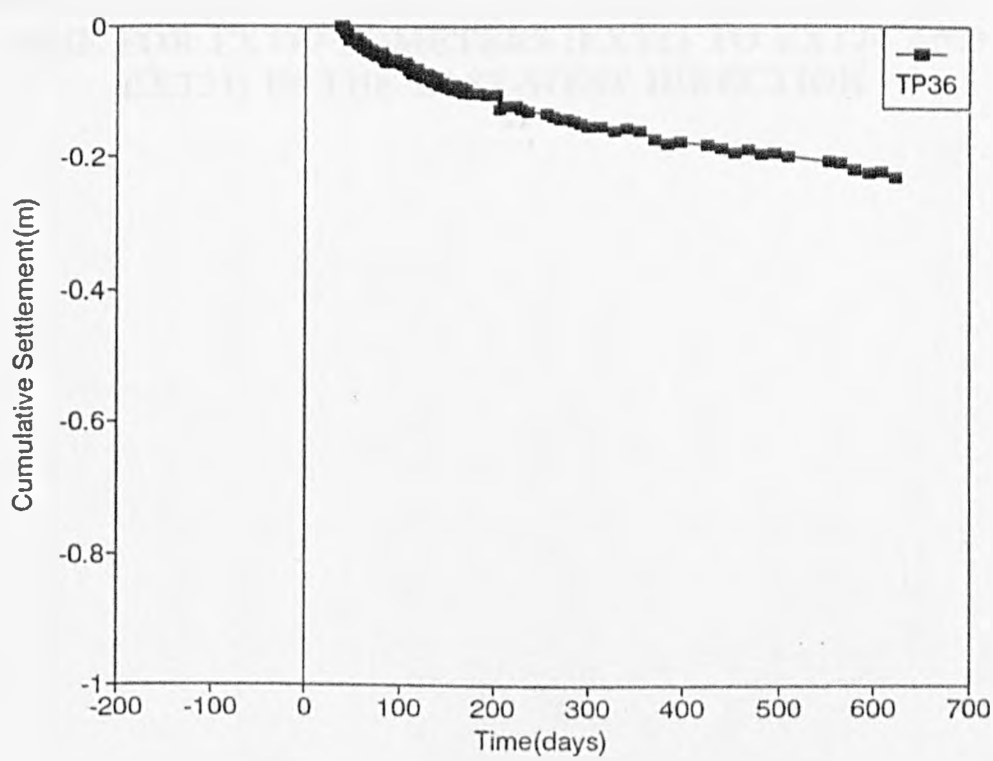

TP31
Cumulative Settlement(m)
0
-0.2
-0.4
-0.6
-0.8
-1
-200
-100
0
100
200
300
400
500
600
700
Time(days)


TP32
Cumulative Settlement(m)
0
-0.2
-0.4
-0.6
-0.8
-1
-200
-100
0
100
200
300
400
500
600
700
Time(days)


TP33
Cumulative Settlement(m)
Time(days)
0
-0.2
-0.4
-0.6
-0.8
-1
-200
-100
0
100
200
300
400
500
600
700

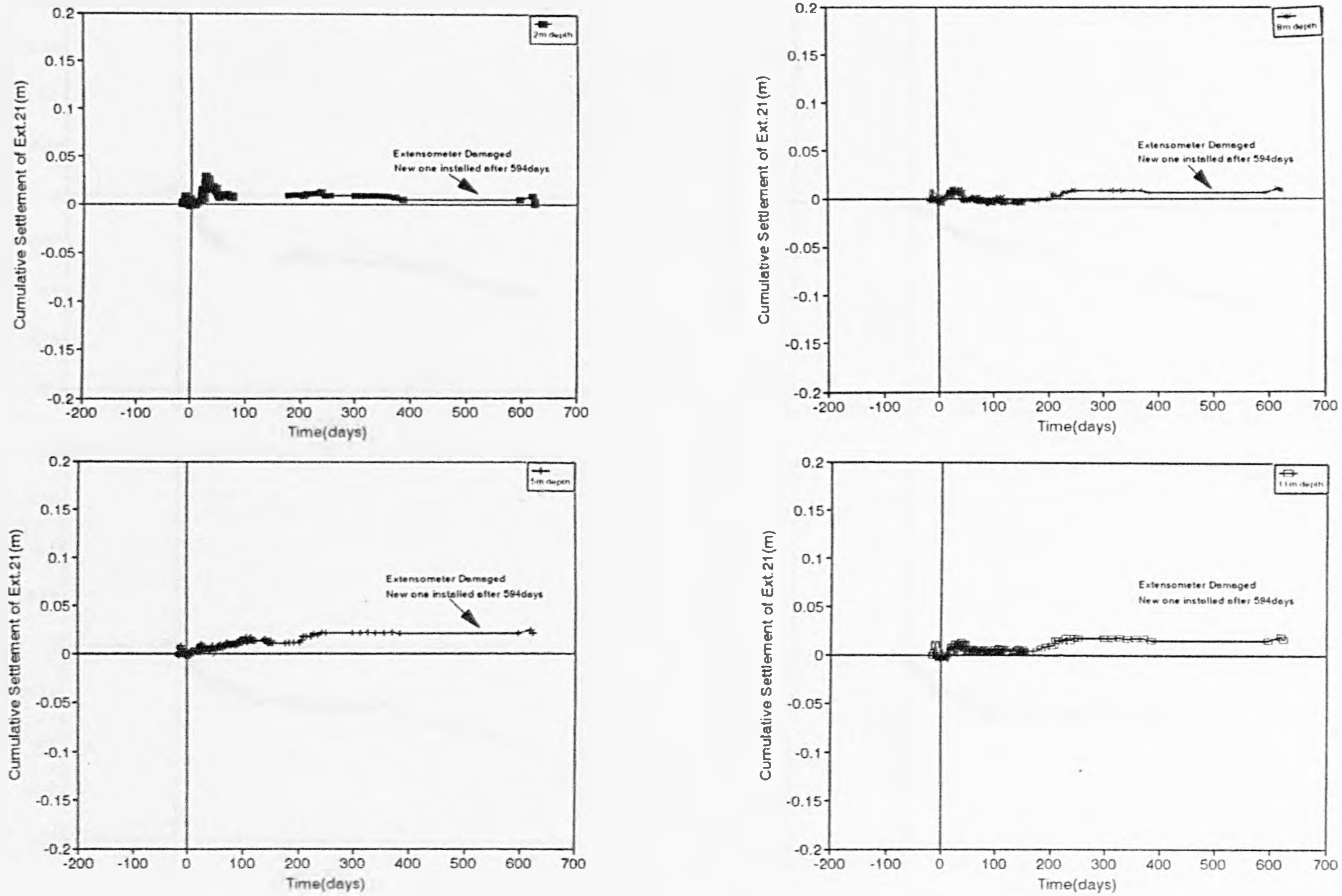

TP34
Cumulative Settlement(m)
Time(days)
0
-0.2
-0.4
-0.6
-0.8
-1
-200
-100
0
100
200
300
400
500
600
700


TP35
Cumulative Settlement(m)
0
-0.2
-0.4
-0.6
-0.8
-1
-200
-100
0
100
200
300
400
500
600
700
Time(days)

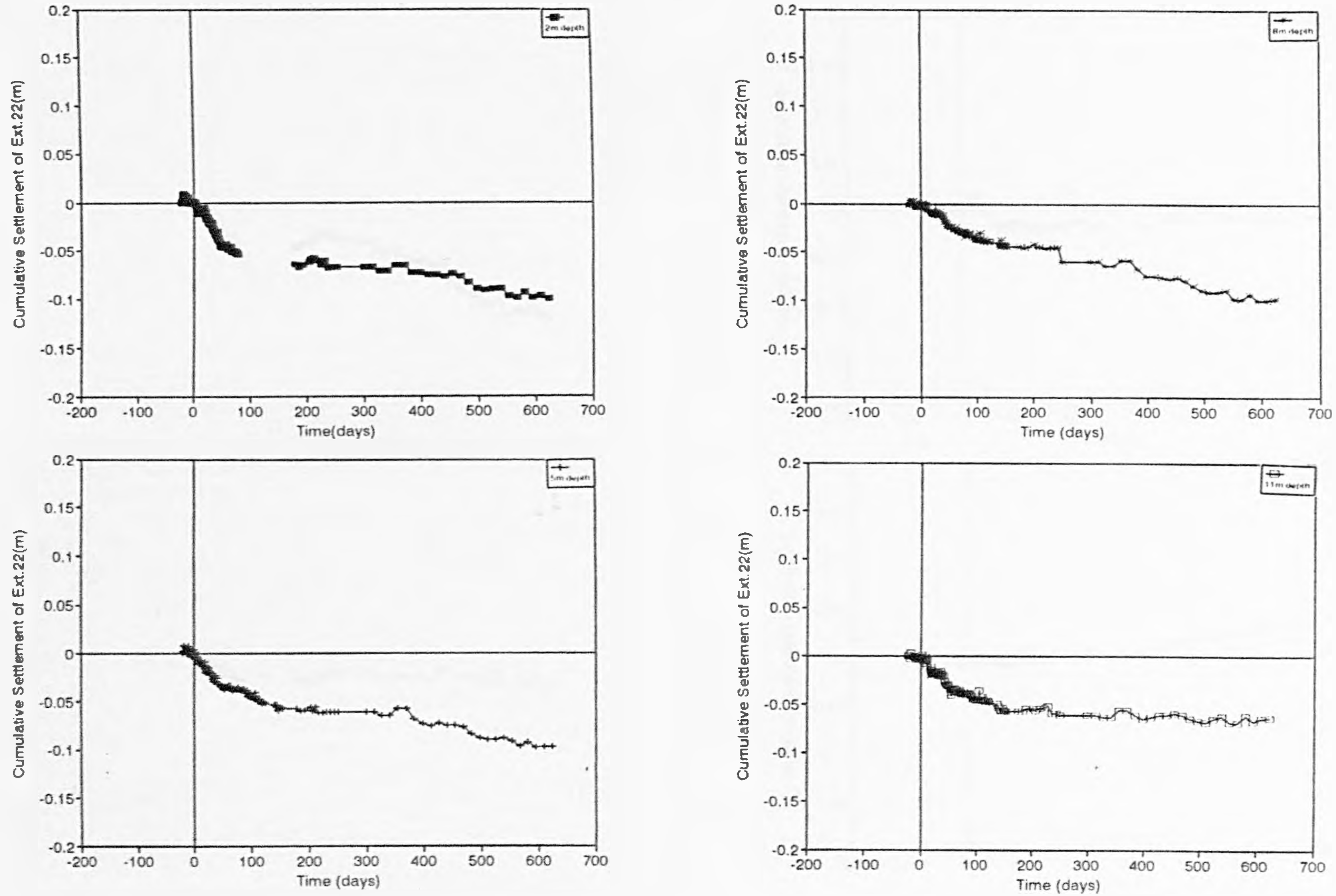

TP36
Cumulative Settlement(m)
0
-0.2
-0.4
-0.6
-0.8
-1
-200
-100
0
100
200
300
400
500
600
700
Time(days)

APPENDIX 6.9

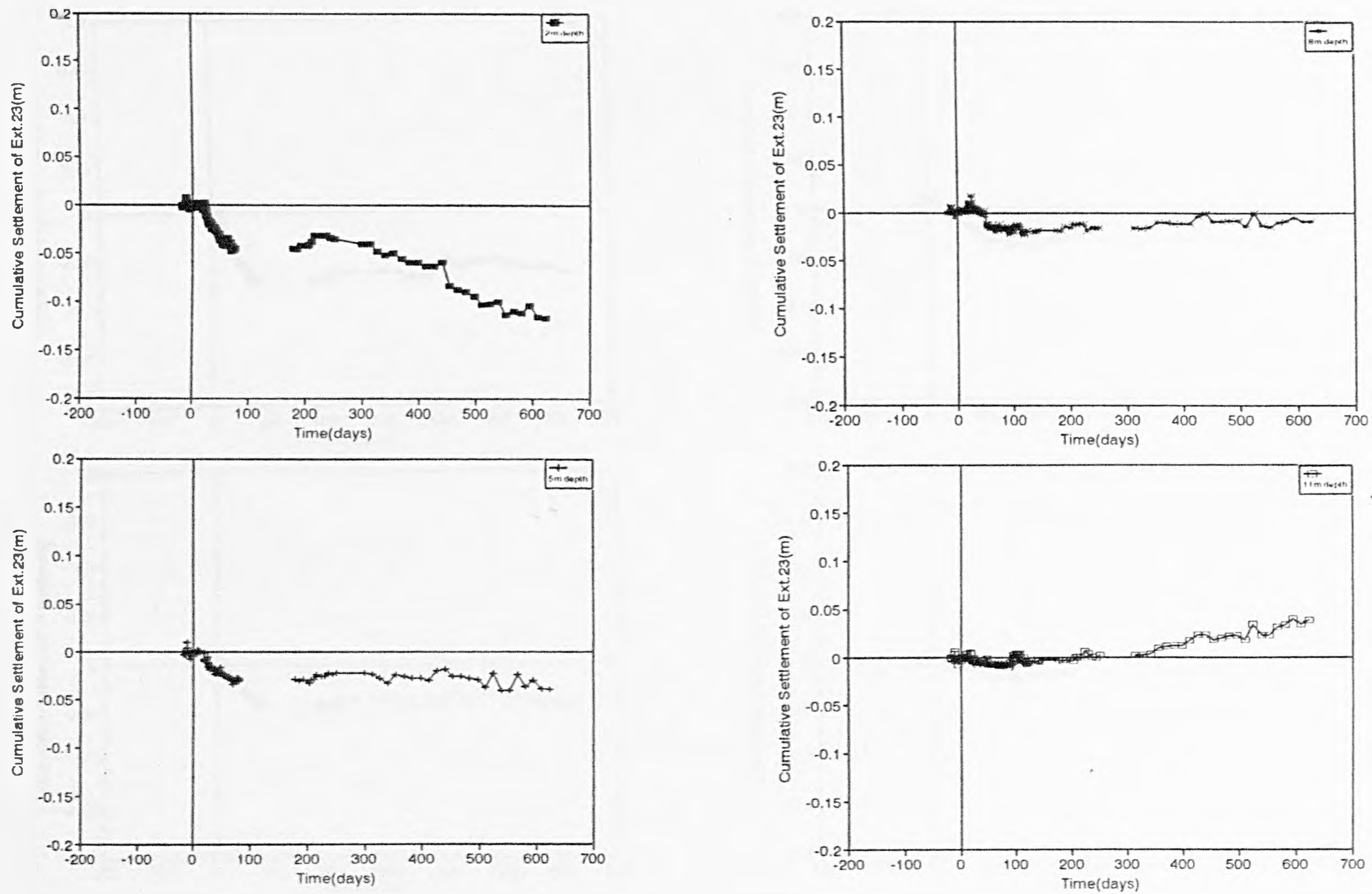
RELATIONSHIP OF CUMULATIVE SETTLEMENT WITH TIME FOR EXTENSOMETERS (EXT21 TO EXT24 AND EXT31) IN THE EAST-WEST DIRECTION



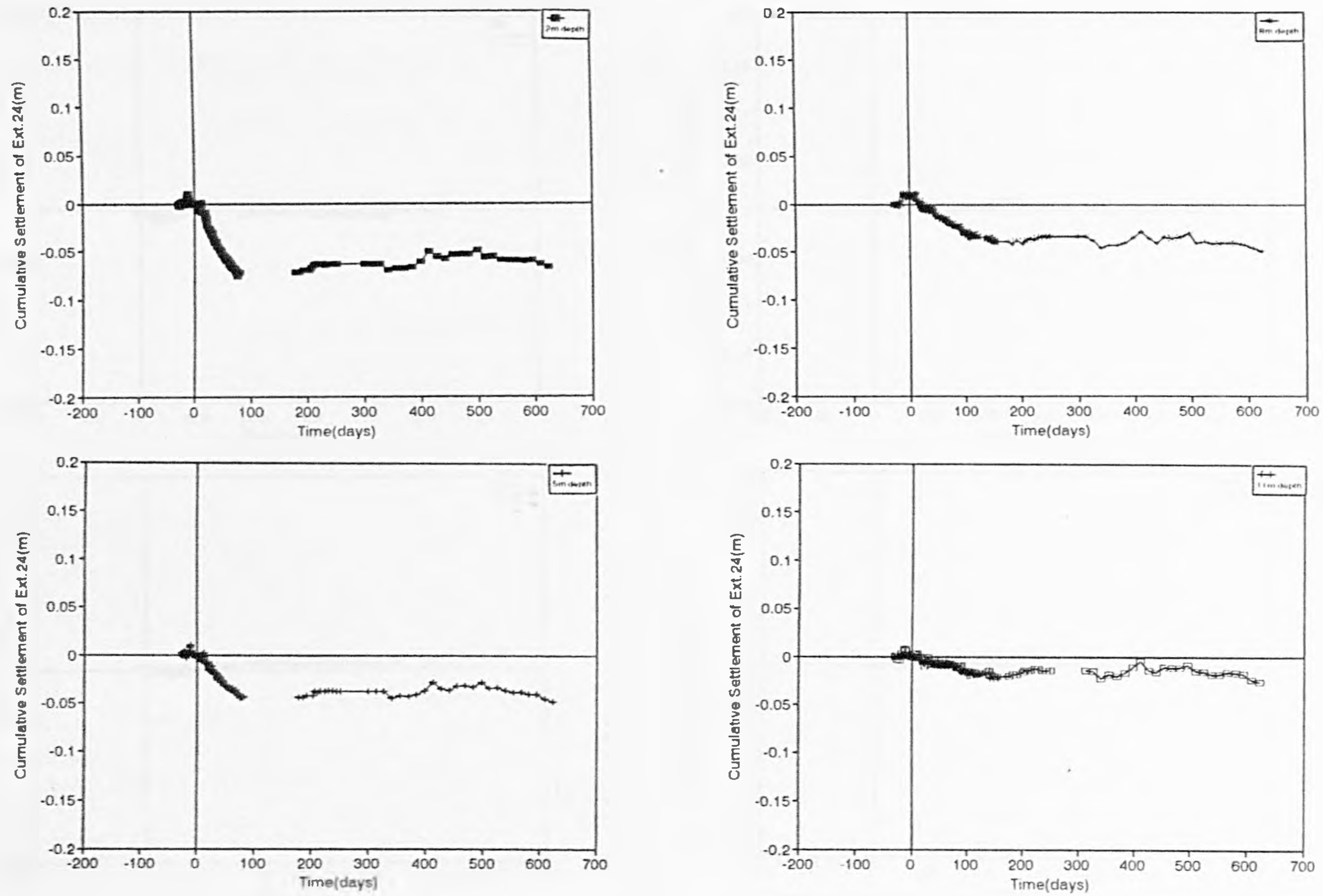
Extensometer 21(2.5m West of Edge of Trial Embankment)



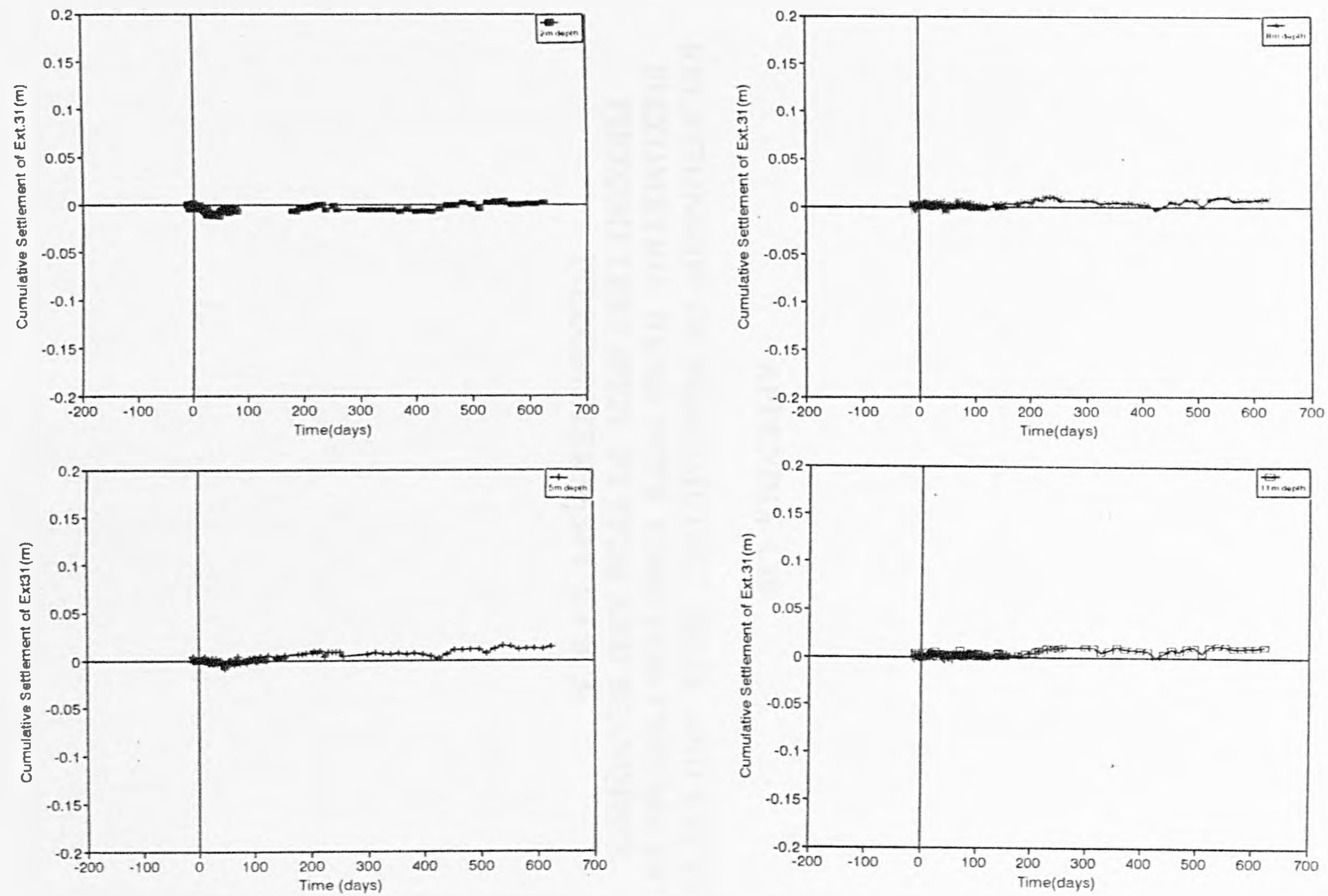
Extensometer 22(22.5m West of Centre of Trial Embankment)



Extensometer 23(Centre of Trial Embankment)



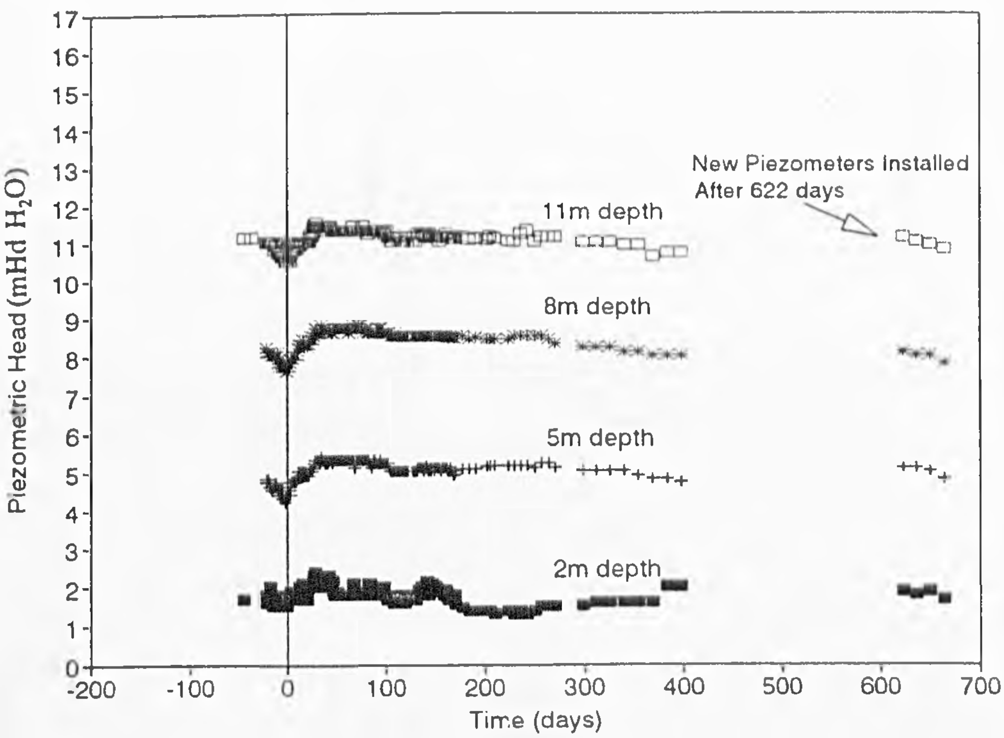
Extensometer 24(22.5m East of Centre of Trial Embankment)



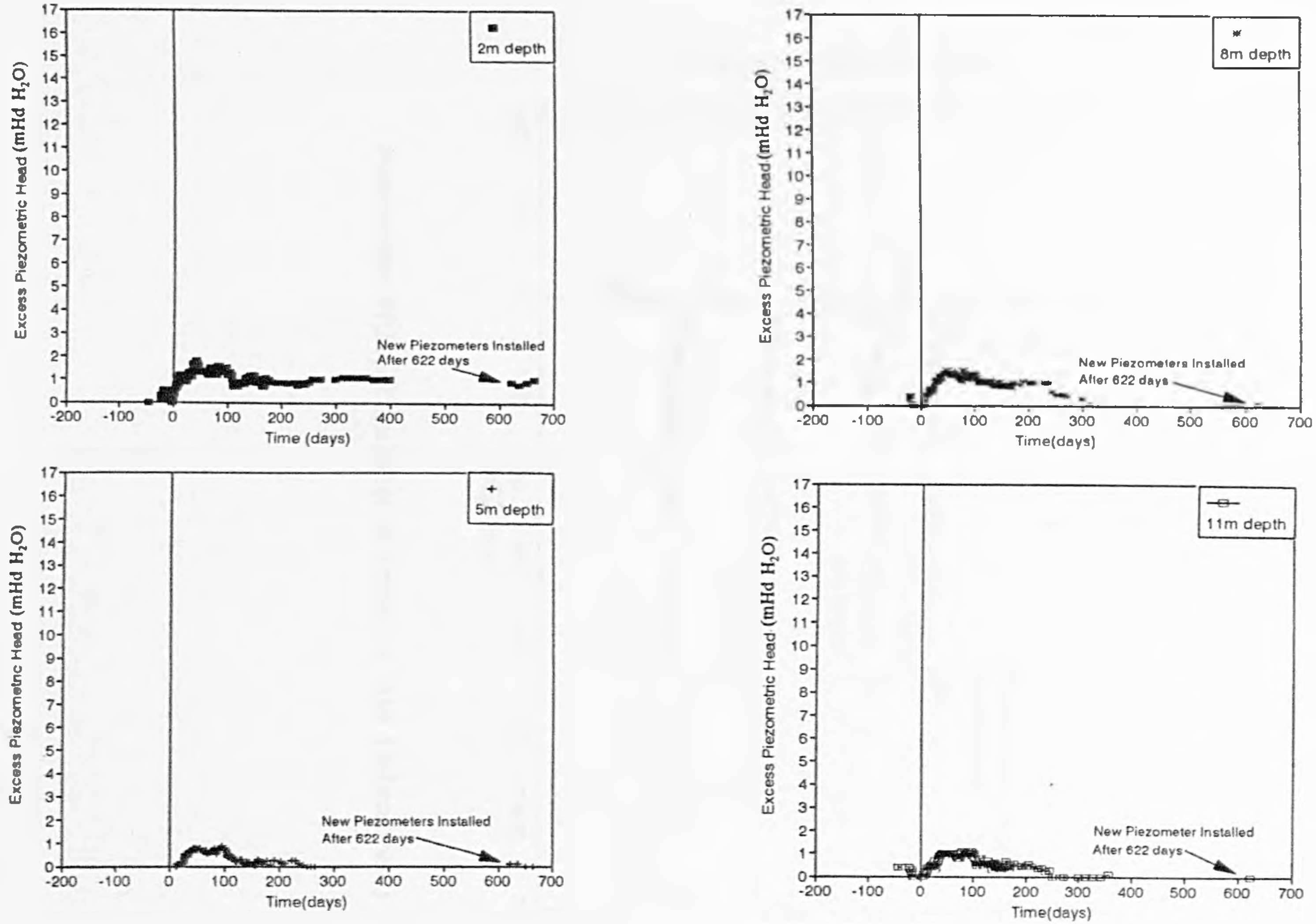
Extensometer 31 (Near the Road Edge)

APPENDIX 6.10

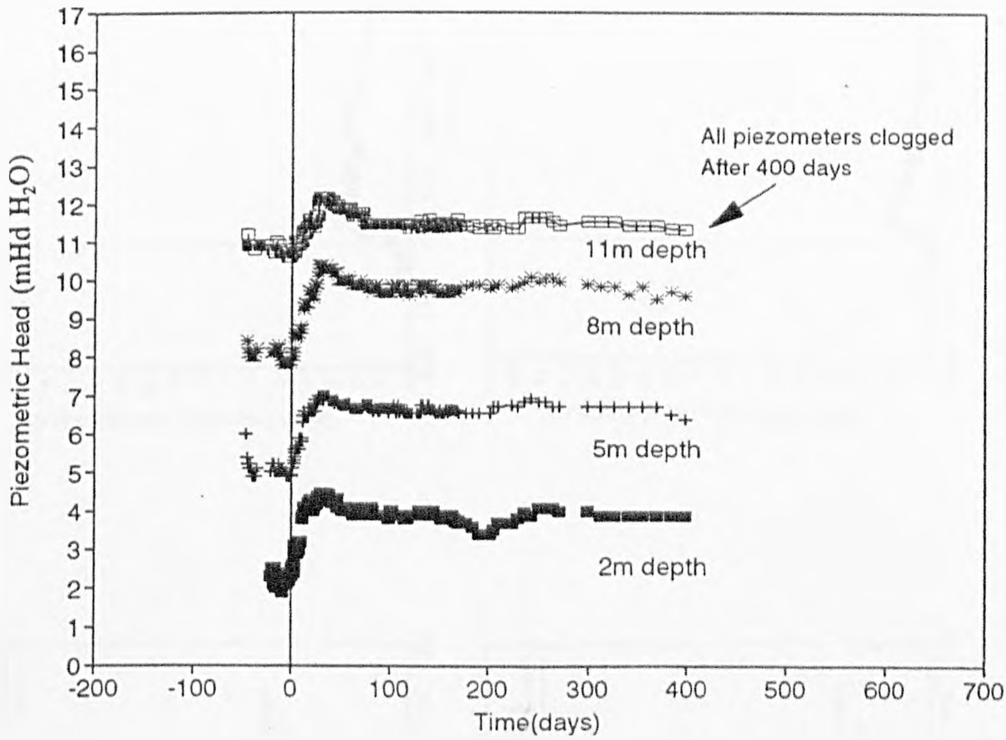
RELATIONSHIP OF PIEZOMETRIC HEAD AND EXCESS PIEZOMETRIC HEAD WITH TIME FOR PNEUMATIC PIEZOMETERS (PP21 TO PP24) AND STANDPIPE PIEZOMETERS (SP1 TO SP3)



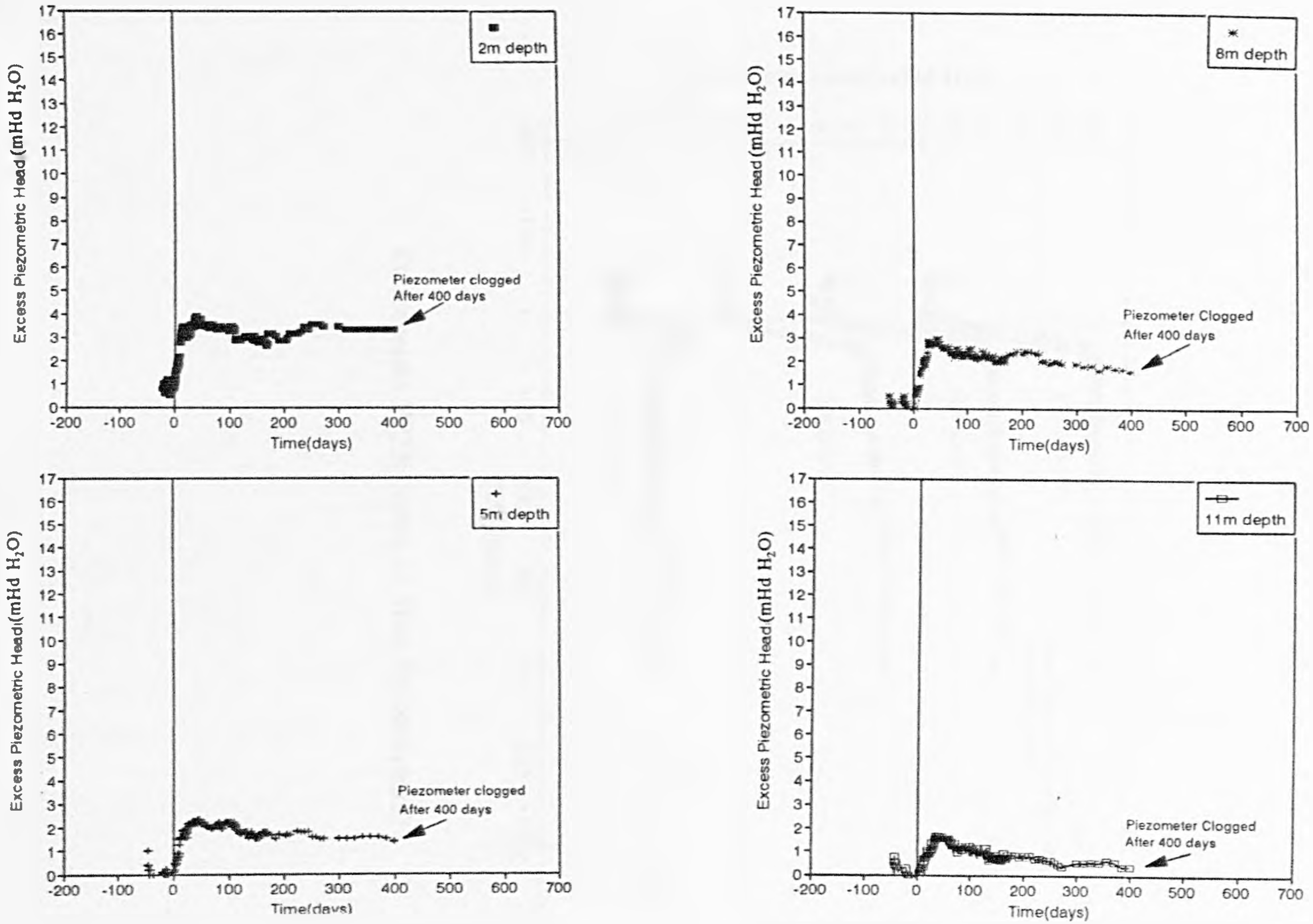
Piezometers PP21(2.5m West of Edge of Trial Embankment)



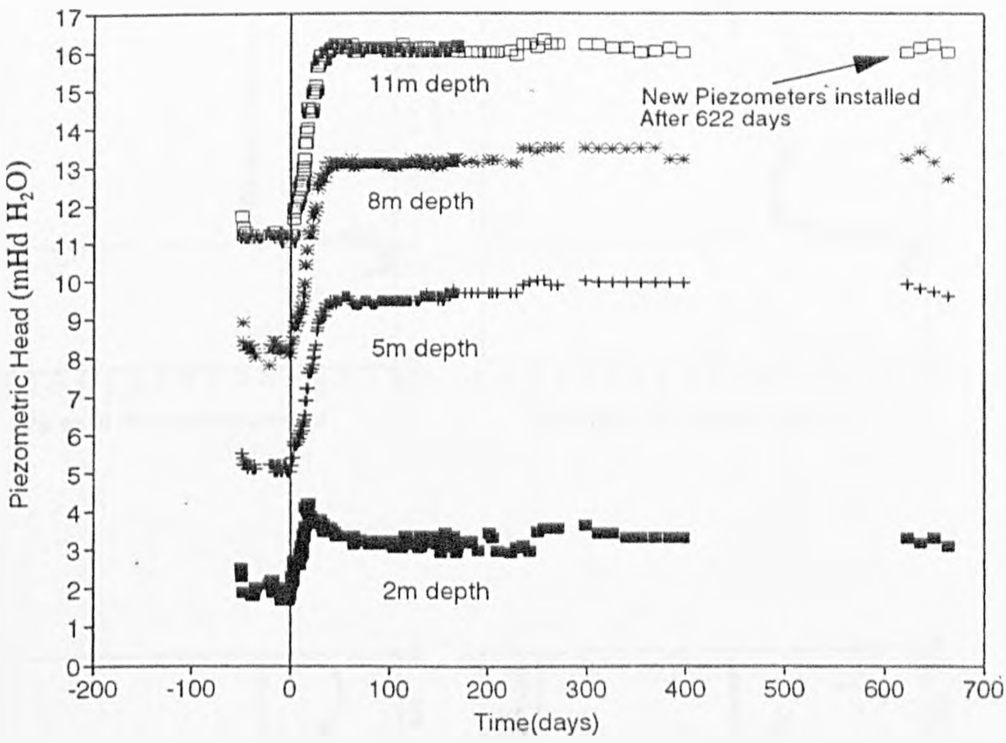
Piezometers PP21(2.5m West of Edge of Trial Embankment)



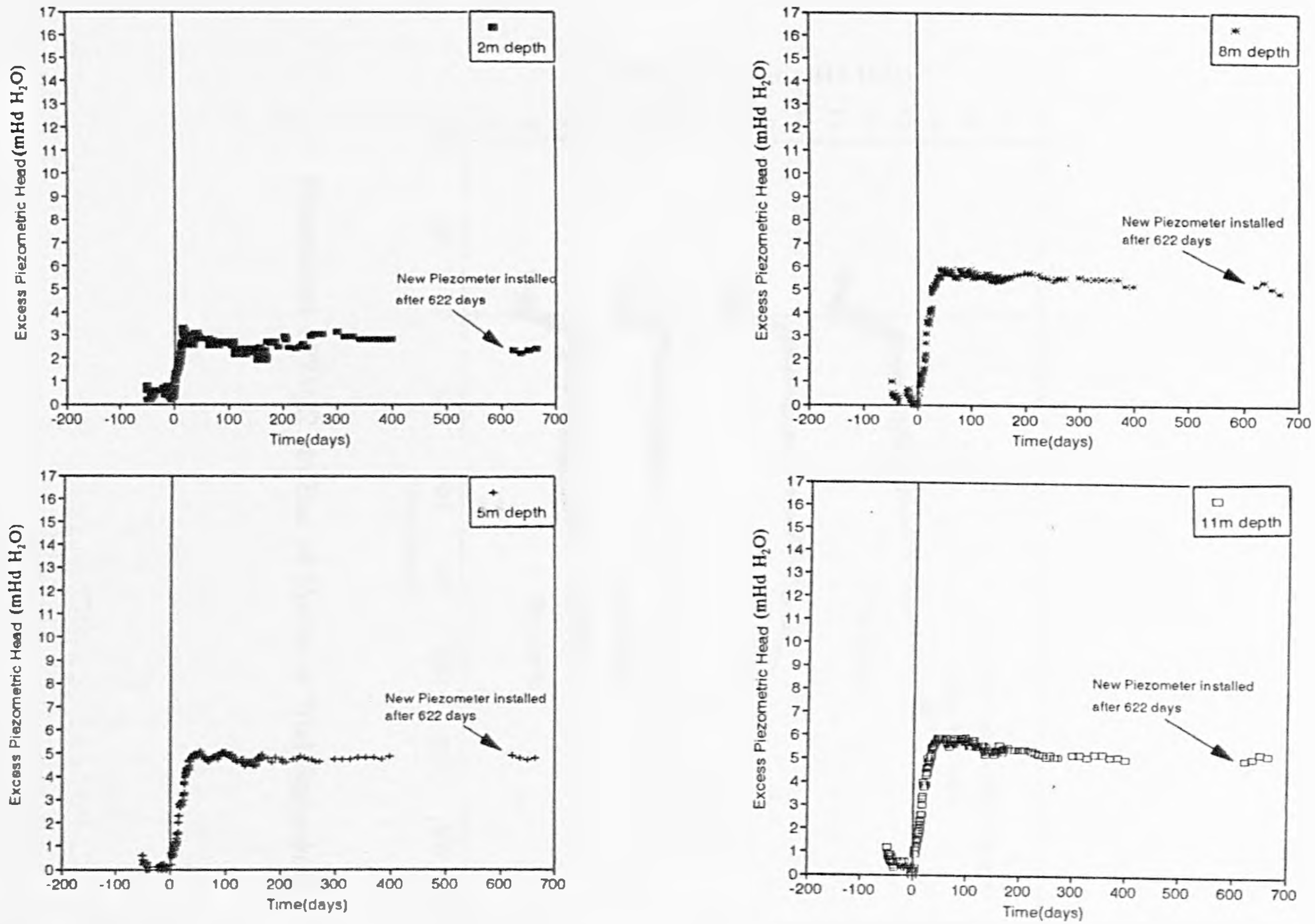
Piezometers PP22(22.5m West of Centre of Trial Embankment)



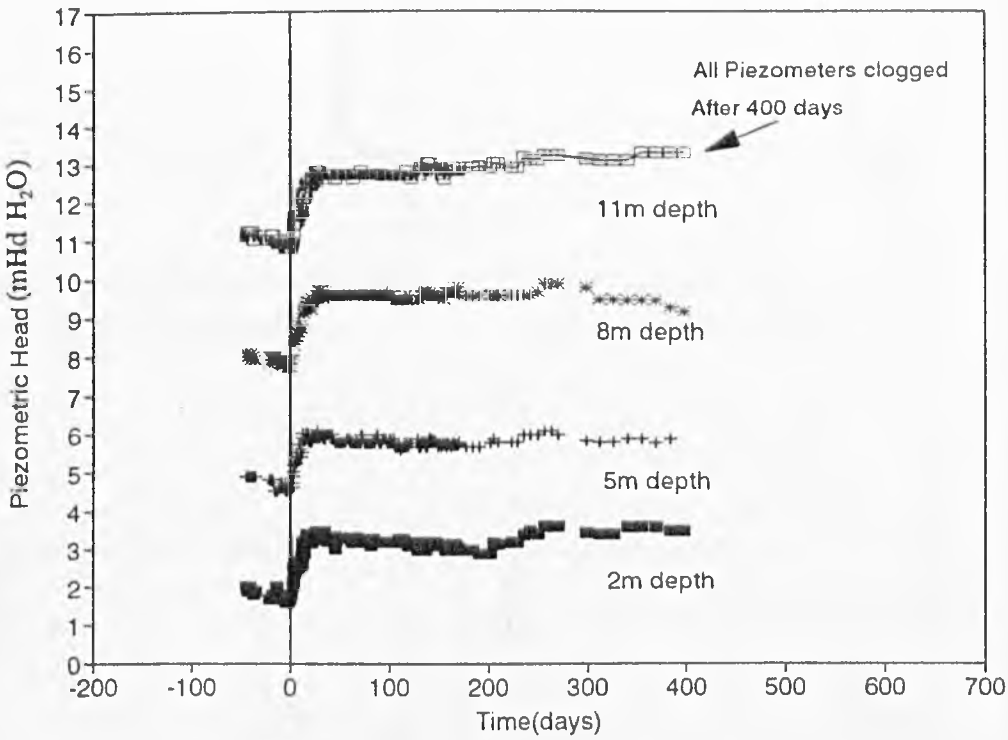
Piezometers PP22(22.5m West of Centre of Trial Embankment)



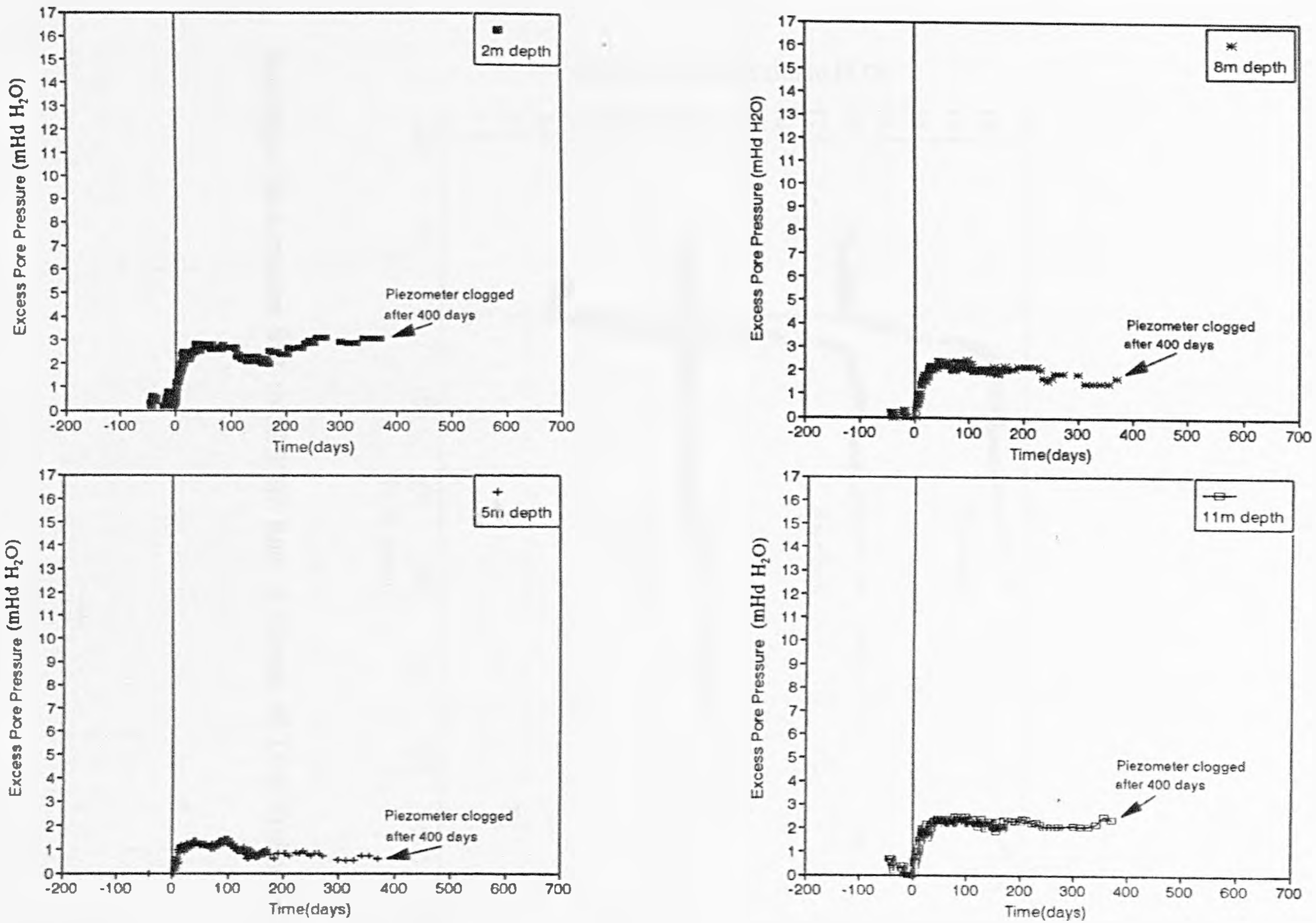
Piezometers PP23(Centre of Trial Embankment)



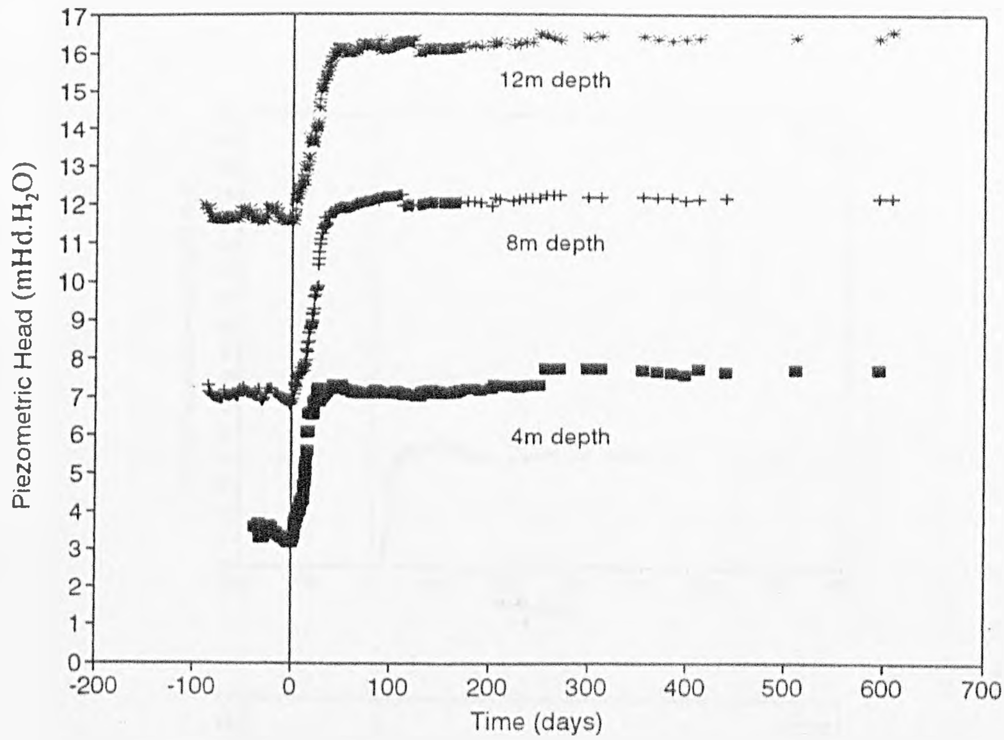
Piezometers PP23(Centre of Trial Embankment)



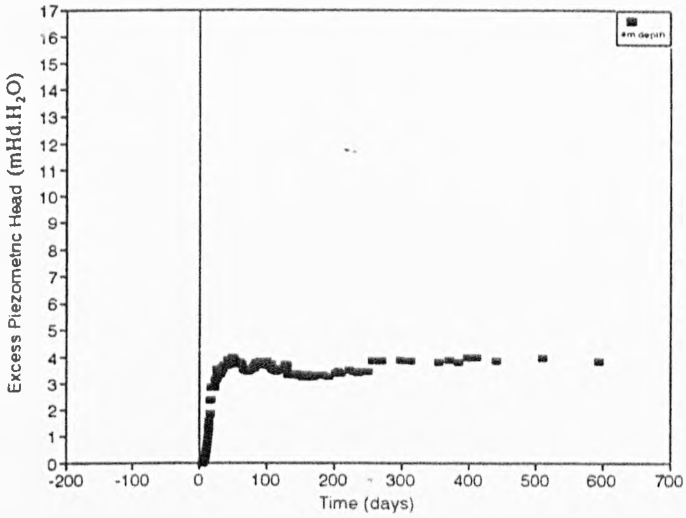
Piezometers PP24(22.5m East of Centre of Trial Embankment)

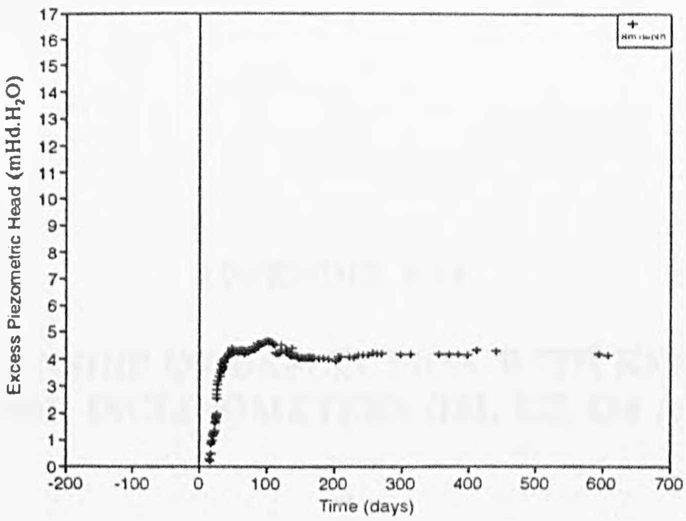


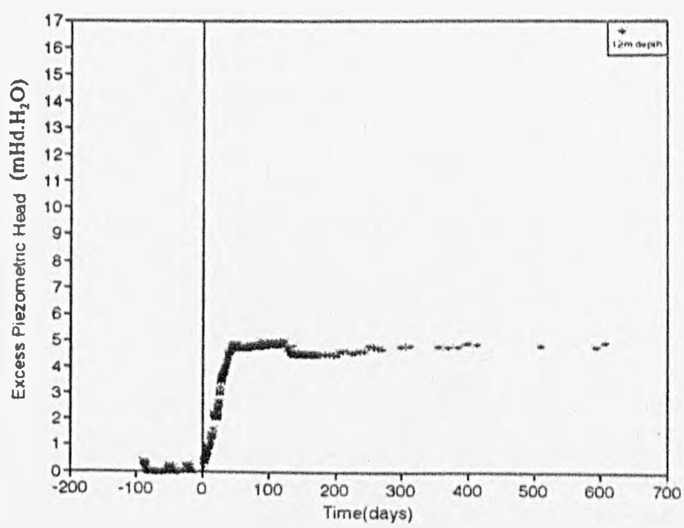
Piezometers PP24(22.5m East of Centre of Trial Embankment)



Standpipe Piezometers SP1 to SP3(5m East of Centre of Trial Embankment)



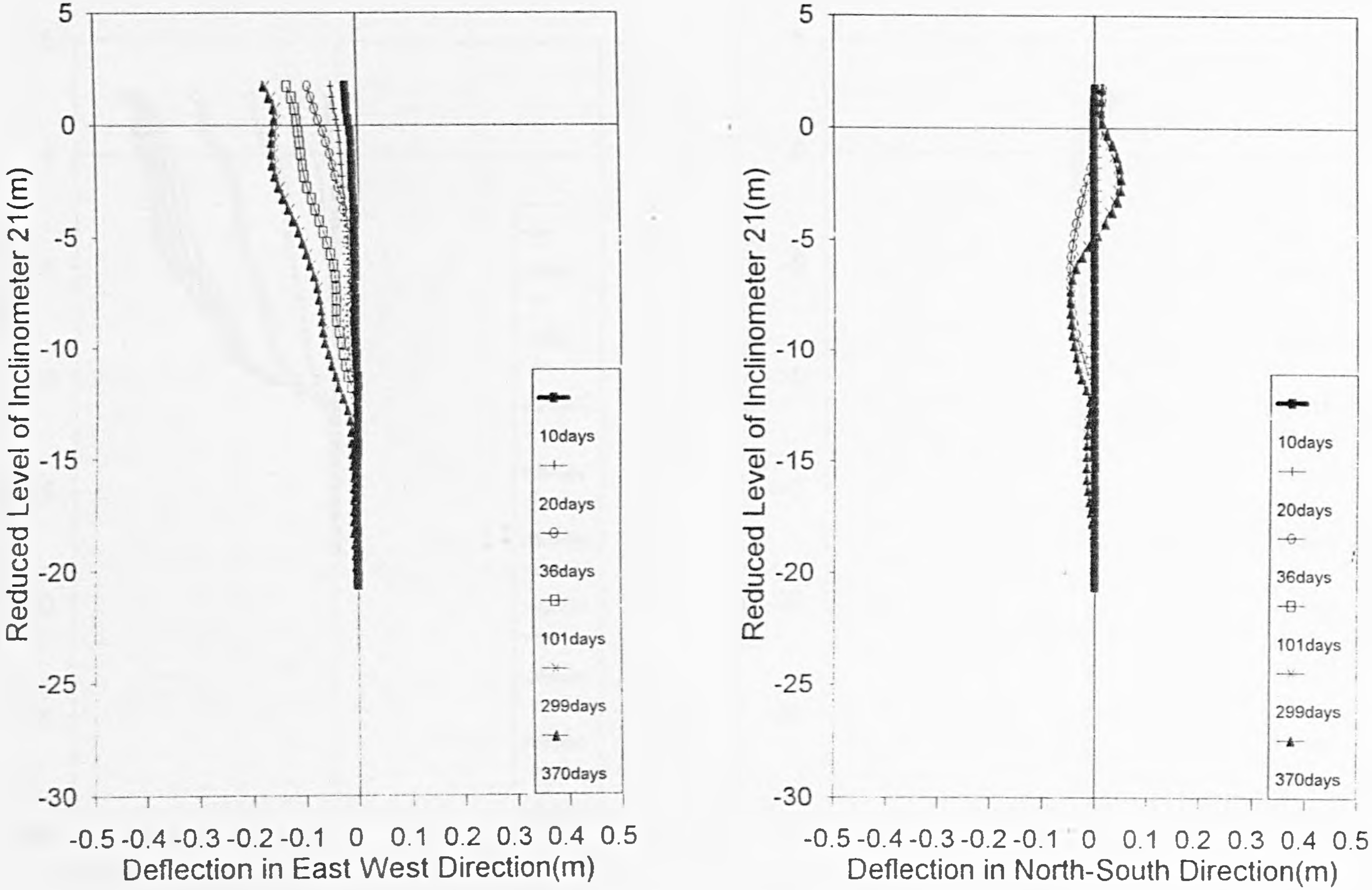




Standpipe Piezometers SP1 to SP3(5m East of Centre of Trial Embankment)

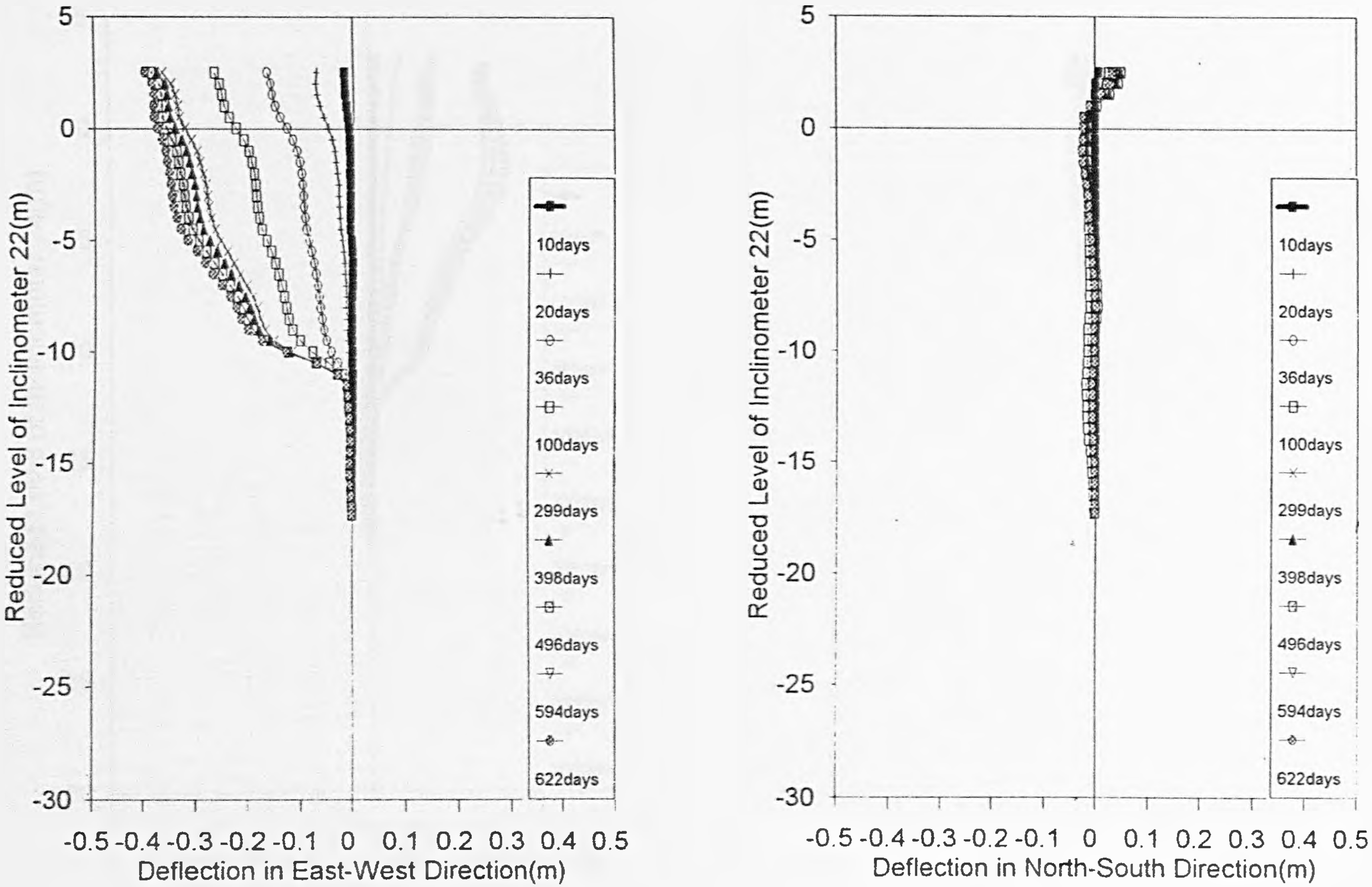
APPENDIX 6.11

RELATIONSHIP OF DEFLECTION WITH REDUCED LEVEL FOR INCLINOMETERS (I21, I22, I24 AND I31)

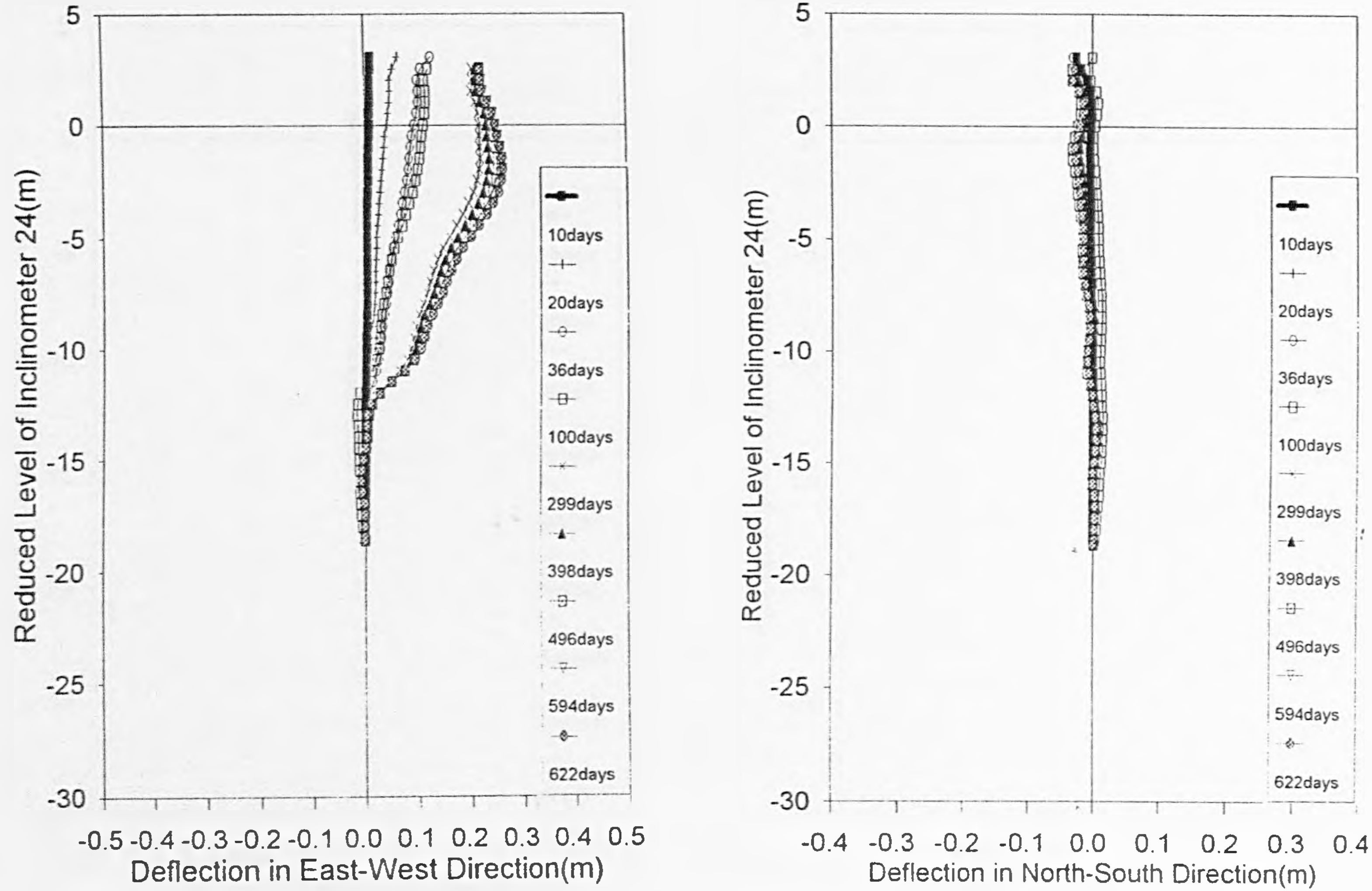


Note : Inclinometer 21 was damaged after 370days

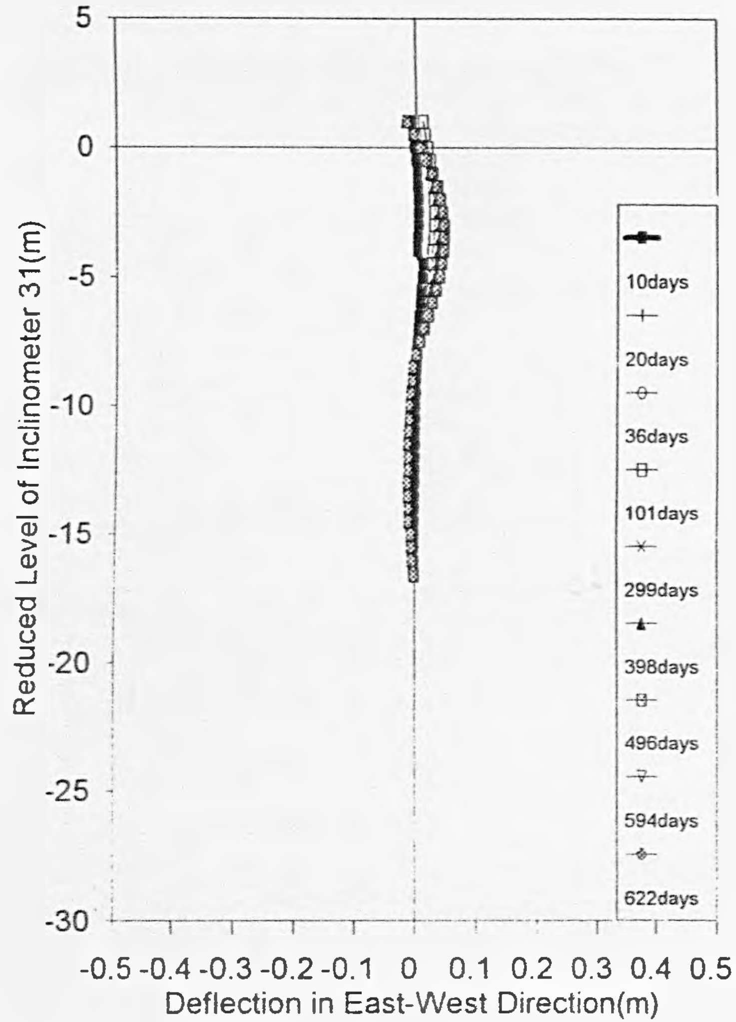
Inclinometer 21

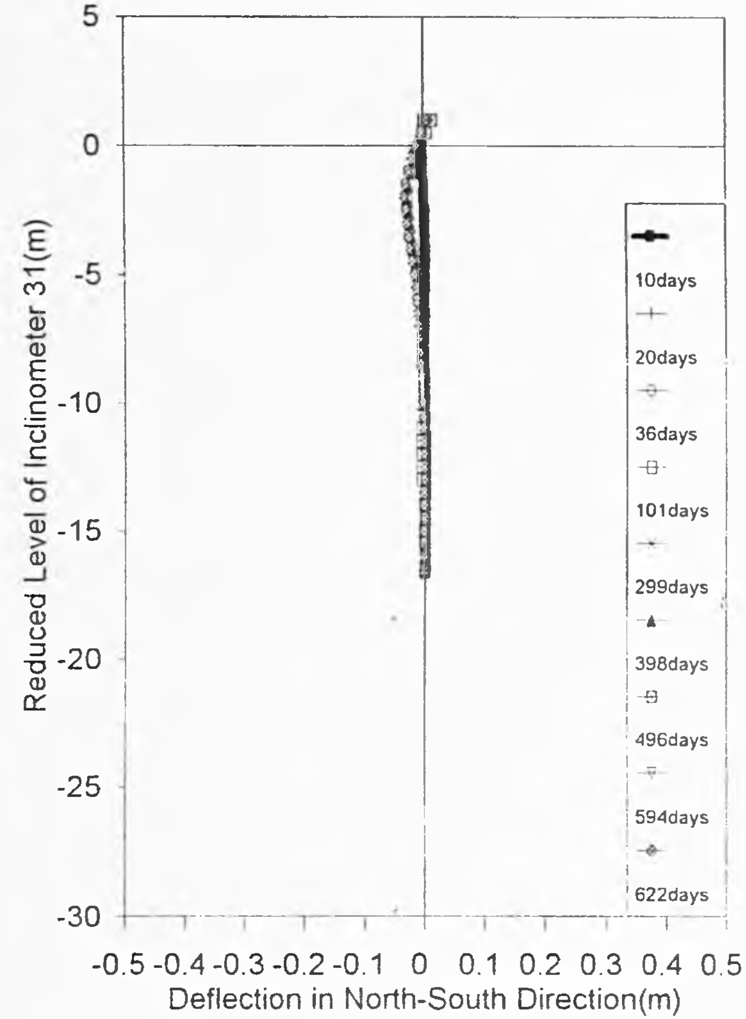


Inclinometer 22



Inclinometer 24





Inclinometer 31

APPENDIX 7.1

INPUT FORMAT AND DATA OF TWODIM CONSOLIDATION PROGRAM

Item	Format	Description of Data	Max.Allowable Value	Units
1	20A4	JOB Name of Job	-	-
2	20A4	Description	-	-
3	15I5	Drainage Boundaries (1 or 2) No of Stages of Construction No.of Layers No.of Nodal Points on Horizontal Axis No.of Nodal Points in Each Layer on Vertical Axis	2 No Limit 10 101 30	- - - - -
4	10I5	No. of Specified Values of Stress and Strain per Layer	10	-
5	10I5	No.of Specified Values of Deviator Stress and Pore Pressure Coefficient `A' per layer	10	-
6	8F10.3	Depths to sucessive boundaries Length of Horizontal Element Base Width of Embankment	- - -	m m m
7	5I5	a. Initial Pore Pressure Data (No data if =0, if 1 read data) b. Lateral Boundary Parameter (O=free, 1=fixed) c. Printout of Stress Data (print inhibited if=0, print if=1) d. Printout of Pore Pressure Data (Values determines intervals between prints) e. Printout of Settlement Data (Values determine intervals between nodal points)	- - - No Limit No Limit	- - - - -

Item	Format	Description of Data	Max.Allowable Value	Units
8	16F5.1	Excess Pore Pressures at Nodal Points if 7(a)=1 (Read in Column Order)	-	kN/m^2
9	10I5	No. of coefficients specified for each layer	-	-
10	8F10.3	Overburden pressures at centres of layers	-	kN/m^2
11	8F10.3	Initial horizontal stresses at centres of layers	-	kN/m^2
12	8F10.3	Elastic settlement per $kN/m^2/m$ in each layer	-	mm
13	3A8	Description of soil in top layer	-	-
14	8F10.3	Values of effective stress corresponding to specified strain	-	kN/m^2
15	8F10.3	Specified values of strain	-	-
16	8F10.3	Values of deviator stress corresponding to specified porewater parameters	-	kN/m^2
17	8F10.3	Specified porewater parameters `A'	-	-
18	8F10.3	Coeffcients of consolidation in vertical direction	-	m^2/yr
19	8F10.3	Coefficient of volume compressibility in vertical direction	-	m^2/MN

Item	Format	Description of Data	Max.Allowable Value	Units
20	8F10.3	Coefficents of consolidation in horizontal direction	-	m^2/yr
21	8F10.3	Coefficients of volume compressibility in horizontal direction	-	m^2/MN
22	8F10.3	Coefficients of secondary consolidation	-	mm/m
23	8F10.3	Range of effective stresses corresponding to coeffcients in Items 18,19 and 22	-	kN/m^2
24	8F10.3	Range of effective stresses corresponding to coefficients given in Items 20 and 21	-	kN/m^2
25	-	Items 13-23 repeated for each layer in the subsoil	-	-
26	2F10.3	Total elapsed time to end of construction Total elapsed time to end of current stage of construction Number of time intervals required for the results of the analysis of this stage	- - No limit	year year -

Item	Format	Description of Data	Max.Allowable Value	Units
27	4F10.3	Increment of embankment height for current stage of construction Side slope of embankment for current stage of construction Unit weight of fill material New width of embankment of terraced or bermed structure otherwise negative value e.g. -10 to indicate side slopes are continuous	- - - -	m kN/m^2 m
28	-	Repeat items 26 and 27 according to number of stages	-	-
29	-	Repeat items 1-28 according to number of cases to be analysed	-	-
30	-	STOP	-	-

```
JOB  KUALA PERLIS SOUTH TRIAL EMBANKMENT
    Coastal Soft Soil Deposit --- 11.83 metre thickness
    1    1    1   15   12
    6
    3
    11.83    2.50      60.0
    0    1    0    1    1    0
    2
    23.67
    23.67
    0.7524
 coastal soft soil deposit
    0.0       18.0      36.0      72.0      143.0      287.0
    0.0      0.002      0.007      0.033      0.049      0.061
    0.0       120.0      287.0
    0.5       1.0        1.0
    8.0       8.0
    3.0       3.0
    8.0       8.0
    3.0       3.0
    0.013    0.013
    0.0       287.0
    0.0       287.0
   0.099       2.0     30
   4.0      0.267      18.0     -10
  STOP
```

APPENDIX 7.2

INPUT FORMAT AND DATA OF KON2DN CONSOLIDATION PROGRAM

(LINEAR VERSION)

PROJECT TITLE : Kuala Perlis South Trial Embankment (Linear Version)

Internal_boundary		: n

Constant Skempton parameter "A"		: n

Number of soil layer		: 1

SOIL LAYER DATA

Soil layer		: 1
Is Soil layer compressible ?		: y
Thickness	meter	= 11.83
Volume weight	KN/m3	= 14.00
Natural water content	%	= 110.00
Young`s modulus	KPa	= 1700
Number of vertical mesh		= 10
Cv	m2/year	= 8.0
Ch	m2/year	= 8.0
Cc		= 1.400
Cr		= 0.140
C_alpha		= 0.013
eo		= 2.900
Pc`	KPa	= 50.00

WATER-TABLE, TIME and HORIZONTAL BOUNDARY DATA

Depth of water table	meter	= 0.00
Time intervals	days	= 5.0
Lateral boundary distance	meter	= 40.0
Number of horizontal mesh		= 20

EMBANKMENT DATA

Initial height of embankment	meter	= 0.45
Initial weight of embankment	KN/m3	= 18.00
Initial half-top width	meter	= 28.31
Half-bottom width	meter	= 30.00
Bulk-weight of embankment	KN/m3	= 18.00
Embankment stage loading		= y
Number of stage loading		= 7

EMBANKMENT STAGE LOADING DATA

Height of fill	meter	=	0.50
Increment at cycle		=	1
Height of fill	meter	=	0.50
Increment at cycle		=	2
Height of fill	meter	=	0.50
Increment at cycle		=	3
Height of fill	meter	=	0.50
Increment at cycle		=	4
Height of fill	meter	=	0.50
Increment at cycle		=	5
Height of fill	meter	=	0.50
Increment at cycle		=	6
Height of fill	meter	=	0.55
Increment at cycle		=	7

BOTTOM BOUNDARY DATA

Permeable Bottom : n

OUTPUT DATA

Offset is needed		:	2
Distance of Offset	meter	=	22.50
Distance of Offset	meter	=	32.50
Vertical point is needed		:	4
Depth of point	meter	=	2.00
Layer of point		=	1
Depth of point	meter	=	5.00
Layer of point		=	1
Depth of point	meter	=	8.00
Layer of point		=	1
Depth of point	meter	=	11.00
Layer of point		=	1

APPENDIX 7.3

INPUT FORMAT AND DATA OF KON2DN CONSOLIDATION PROGRAM

(NON-LINEAR VERSION)

PROJECT TITLE . Kuala Perlis South Trial Embankment (Non-Linear Version)

Data of coeffecient of permeability : N

Constant Skempton parameter "A" : N

Number of soil layer : 2

SOIL LAYER DATA

Soil layer		:	1
Is Soil layer compressible ?		:	Y
Thickness	meter	=	5.83
Volume weight	KN/m3	=	14.00
Natural water content	%	=	110.00
Young`s modulus	KPa	=	1700
Number of vertical mesh		=	10
Cv	m2/year	=	8.0
Ch	m2/year	=	8.0
Cc		=	1.400
Cr		=	0.140
C_alpha		=	0.013
eo		=	2.900
Pc`	KPa	=	50.00
Ck		=	1.450

Soil layer		:	2
Is Soil layer compressible ?		:	Y
Thickness	meter	=	6.00
Volume weight	KN/m3	=	14.00
Natural water content	%	=	110.00
Young`s modulus	KPa	=	1700
Number of vertical mesh		=	10
Cv	m2/year	=	8.0
Ch	m2/year	=	8.0
Cc		=	1.400
Cr		=	0.140
C_alpha		=	0.013
eo		=	2.900
Pc`	KPa	=	50.00
Ck		=	1.450

WATER-TABLE, TIME and HORIZONTAL BOUNDARY DATA

Depth of water table	meter	=	0.00
Time intervals	days	=	5.0
Lateral boundary distance	meter	=	40.0
Number of horizontal mesh		=	20

EMBANKMENT DATA

Initial height of embankment	meter	=	0.45
Initial weight of embankment	KN/m3	=	18.00
Initial half-top width	meter	=	28.31
Half-bottom width	meter	=	30.00
Bulk-weight of embankment	KN/m3	=	18.00
Embankment stage loading		=	Y
Number of stage loading		=	7

EMBANKMENT STAGE LOADING DATA

Height of fill	meter	=	0.50
Increment at cycle		=	1
Height of fill	meter	=	0.50
Increment at cycle		=	2
Height of fill	meter	=	0.50
Increment at cycle		=	3
Height of fill	meter	=	0.50
Increment at cycle		=	4
Height of fill	meter	=	0.50
Increment at cycle		=	5
Height of fill	meter	=	0.50
Increment at cycle		=	6
Height of fill	meter	=	0.55
Increment at cycle		=	7

BOTTOM BOUNDARY DATA

Permeable Bottom : N

OUTPUT DATA

Offset is needed		: 2
Distance of Offset	meter	= 22.50
Distance of Offset	meter	= 32.50
Vertical point is needed		: 4
Depth of point	meter	= 2.00
Layer of point		= 1
Depth of point	meter	= 5.00
Layer of point		= 1
Depth of point	meter	= 8.00
Layer of point		= 2
Depth of point	meter	= 11.00
Layer of point		= 2
