THE ARCHITECTURAL DESIGN PROCESS
and
INDOOR AIR QUALITY

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SUMMARY

Bringing a building into existence that has never been made and used before is a kind of invention which is made by an architect.

Being an architect necessitates the ability to synthesize separated things besides talent. The architect should relate different things such as people's needs and activities, natural features of earth, manufactured products, etc to each other in a systematic way that he or she can produce solutions for design problems and select the most suitable solution to meet people's needs. Thus a building can be imagined as if it physically exists, and as if it is occupied by users.

Although, indoor air quality (IAQ) has been discussed for almost thirty years, it is a new subject for architects from the architectural design point of view. Most of the time, the subject is defined as an engineering problem. However anything related to the building should be recognised by architects, as well, so that they can try to find alternative solutions.

Examining the Architectural Design Process and IAQ together in the whole Building System enables the architect to think about IAQ systematically, and to search design solutions to prevent or reduce possible indoor air pollution before it occurs.

This thesis shows a way of considering IAQ and the building together during the architectural design stage. In this consideration, the building is modelled as a system, the Architectural Design Process is based on The RIBA Plan of Work, IAQ is adapted as a process, the Architectural Design Process and IAQP are examined together, and the Architectural Design Process is evaluated in terms of IAQ.

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Part One : INTRODUCTION

1.1. FACTORS which AFFECT INDOOR AIR QUALITY

Air is a major vital factor to keep human beings alive. The quality of air has a very important role in this. Human metabolism and respiratory needs have been subjected to many researches for a long time. In most of those studies, the relation between air quality and several serious, even fatal, respiratory illnesses has been documented [1-5].

In the past, most studies about air quality were on outdoor air pollution with the exception of workplaces and mines [1,2,6-8]. However, several studies have been done to document the percentage of activities which take place indoors, and the percentage of time that people spend indoors [2,3,6-8]. These studies show that the greater percentage of activities take place indoors, and most people spend the greater percentage of their time indoors and, so, breathe mostly indoor air. Thus, indoor air quality becomes an important issue for people's health.

For almost thirty years, serious health incidents have been recognised indoors, from complaints about irritation of the eye and respiratory system, headache, dizziness, etc.; to deaths because of a bacterium called B. Legionella, lung cancer caused by a natural radioactive gas called radon and a kind of fibre called asbestos, etc. This has led to researches to be done, standards and legislation to be established [2,3,4,9-13].

Many factors causing indoor air pollution have been identified in these indoor air quality related researches [1-3,10-17]. These factors are called sources of indoor air pollutants and, generally, can be classified into two main groups: outdoor sources and indoor sources.

Outdoor air, soil, water, motor vehicle exhaust, industrial activities are some outdoor pollutant sources. Indoor levels of outdoor pollutants are affected by outdoor levels of those pollutants. However, some of these pollutants may be released from an indoor source. For example, the concentration of carbon monoxide, sulphur dioxide and nitrogen dioxide depends on emissions from unvented combustion appliances as well as on emission from outdoor sources [1-3,10-17].

Indoor sources can be grouped under two main headings. These are people themselves as one source of the indoor air pollution, and the building itself as the other.

People generate many of the indoor air pollutants by their biological and physical activities, such as breathing, coughing, sneezing, sweating, etc.; by their household and hobby activities, such as cooking, cleaning, painting, smoking, having pets and plants, etc.; by their office and work activities, such as using photocopying machines, wet processing machines, etc. [1-3,10-17].

The building itself is an important indoor source of indoor air pollutants. Most of the indoor air pollutants are released from building materials, services, furnishings and fittings, office machines and supplies [1-3,10-17]. Besides, construction details and plan of the buildings help indoor air pollution to enter, settle and flow from one space to another space within the buildings.

1.1.1. Building as an Effective Factor to Indoor Air Quality

Building materials give rise to different pollutants in indoor air. Most building materials and the pollutants released from them have been identified in many studies [1-3,10-18]. Concrete, brick, stone and gypsum board contain radon such that its level changes according to the properties of the materials. Panelling, plywood, particle board, ceiling tile, cavity wall insulation materials contain formaldehyde. Asbestos was widely used in thermal and acoustic insulation, decoration, fireproofing, vinyl floor, and cement products. Paints, varnishes, solvents release several kind of volatile organics.

Service systems in buildings can cause pollution. Well water includes radon naturally. Its radon levels vary between low and high level, and radon comes out when the water boils. Therefore, a high radon concentration can result from a well water system (19). Also, ventilating, waste water, and air conditioning systems can produce pollutants such as bacteria, viruses, microorganisms, and can help them to multiply (11). The concentration of some gases can increase because of heating systems such as kerosene and gas space heaters, gas and wood stoves, and open fireplaces. The gases, which are combustion products such as carbon monoxide, nitrogen oxides and sulphur dioxide, enter the indoor air when the heating system is not well designed and maintained (11).

Furnishing materials of the building are another indoor pollutant source. The concentration of some of volatile organics, particulate or gaseous can be due to carpeting type, decoration, fixed and semi-fixed contents of the building. Also, some office machinery such as photocopying machines, and supplies such as adhesives and paper produce certain pollutants such as ozone, ammonia and dust.

Building construction and planning affect indoor air quality by outdoor air infiltration, indoor air exfiltration, volume and location of the space (1-5,14,15).

Outdoor air enters the building by air infiltration through the exterior of the building and by ventilation through openings of the building. Cracks and leaky joints on the exterior walls, around doors, windows and chimneys, are the most common ways for outdoor air infiltration. Also, cracks and leaky joints on the basement walls and foundation, loose-fitting pipes are suitable ways for gas infiltration from the soil. Open windows and doors provide natural ventilation. The influences of outdoor gas infiltration and ventilation on indoor air pollutant concentration have been documented in many studies (20-22). Thus, the poorly designed, constructed or maintained building construction can become a big helper for outdoor air pollutants to enter the building, if the outdoor pollution concentration is high.

The volume of the space effects the level of the indoor pollutant concentration. The concentration of an amount of pollutant released from a source in a smaller space is approximately twice as high as the concentration of same amount of pollutant released from same source in a twice larger space. Therefore, the volume of air contained in the indoor space has been taken into account when the equation is established to describe the relationship between effective factors and the indoor air pollutant concentration [(2)].

Location of the space is important for some kinds of pollutant concentration. For example, basements and lower floors of the building have a higher radon concentration than the upper floors [(19,23,24)].

Air movements within the building help the polluted indoor air to flow from one space to another space. Although, sometimes these movements reduce the pollution concentration in a highly polluted space, they affect the indoor air quality in other spaces within the building.

1.1.2. The Building as an Effective Factor to People's Health

In the late 1960's and the early 1970's, energy-efficiency improvements became one of the main design and use objectives within the buildings. The "Energy Crisis", resulted from the oil embargo in 1973 and encouraged, even sometimes forced, people to design, build and use air tight buildings to reduce the energy cost of heating and cooling their buildings [(5,14,25)].

Stopping draughts by sealing buildings with new insulation materials, using mechanical devices for forced ventilation instead of natural ventilation through windows, reducing ventilation rate in office buildings, bringing recirculated air instead of fresh air were some of the preventive actions of energy conservation (25-27).

However, within a few years serious health complaints from occupants of these new buildings were recognised. The complaints, which are headaches, lethargy, nausea, dizziness, irritation of the eyes and respiratory system, dry throat, dry skin and loss of concentration, have been addressed as building sickness or sick building syndrome (28-30). Although, sick building syndrome was first recognised in some of air tight, mechanically ventilated and air conditioned buildings, researches show that sick building syndrome can, also, occur in naturally ventilated buildings (31-32).

Therefore, a number of factors which cause sick building syndrome have been identified. These factors can be grouped under three main headings which are poor environmental design, poor hardware and poor organisation. Poor lighting, noise, fluctuations of air temperature, poor air quality and inadequate space planning are some examples of poor environmental design. Low standards in construction and services, inappropriate material selection, poor detailing are some results of poor hardware design. Lack of privacy, lack of control over environment, repetitive work, poor maintenance and cleaning are some examples for poor organisation (28-30).

Indoor air quality, as mentioned above, is one of the factors which contributes to sick building syndrome. Also, indoor air quality may have other severe health effects such as long term suffering from lung cancer and death.

It is clearly seen that the building is one of the major factors which affects indoor air quality and contributes to serious health problems.

1.1.3. The Problem from an Architectural Design Point of View

Existence of the building starts with the people's requirements and comes out of the architectural design. During the architectural design, all building related subjects should be considered to achieve better or best solution. If any one of those of subjects is missed, in future the building will have a problem which is related to that point.

Since indoor air quality appeared as a serious problem, scientists, engineers and other professions have been dealing with the subject. Most of the time, avoiding use of certain hazardous materials in the building, increasing ventilation rate were considered the contributions of architects to indoor air quality improvement. In fact, these solutions take place in further stages of the building. Materials selection is done during the specification stage of the architectural design. However, layout, hardware and technical systems of the building are decided before the material specification. Increasing ventilation rate takes place during the use stage of the building. This stage starts when the building construction is completed.

If avoiding the use of certain hazardous materials and increasing ventilation rate are thought to be only contributions of architects, this means indoor air quality is the missing subject in architectural design. Therefore, the architectural design of the building and its designers who are architects have a more active role in indoor air quality than is thought.

Architects' responsibility for indoor air quality is to determine the triangular relationship between indoor air quality, the building itself and its users, and to produce alternative design solutions in terms of indoor air quality.

Some steps should be taken to understand and solve the indoor air quality problem. These steps are:

* identification of indoor air pollutants and their effects on people's health, and the features of the building as sources of pollutants,

* consideration of those indoor air pollutants, their health effects and their building related sources,

* developing remedial design actions to improve indoor air quality, and

* applying those developed design remedies to the building design during the architectural design stage.

These briefed action steps should be followed by architects themselves, as major designers of the building. However, dealing with the subject is not easy for the architects because of these following issues:

* absence of indoor air quality from the existing building system models,

* absence of a systematical thinking of architectural design and indoor air quality together,

* absence of a consideration model of architectural design process and indoor air quality, and

* absence of an evaluation model of architectural design process in terms of indoor air quality.

Approaching indoor air quality problems from the architectural design point of view necessitates these following researches to be done:

* indoor air quality should be placed in the whole building system model as one of the major architectural design objectives,

* architectural design and indoor air quality should be thought together in a systematical way,

* a consideration model of architectural design process and indoor air quality should be developed, and

* an evaluation model of architectural design process in terms of indoor air quality should be developed.

1.2. THE AIMS of THE RESEARCH

First of all, this research is based on three assumptions which lead the research objectives. These assumptions are:

(1) Architectural design decisions of the building affect indoor air quality.

(2) It is possible to develop a systematic model in which architectural design of the building and indoor air quality can be considered.

(3) It is possible to predict the risk of indoor air pollution caused by a building during the architectural design stage by developing an evaluation model of the architectural design process in terms of indoor air quality.

The aims of this research are:

(a) To develop a building system model, and to place architectural design and indoor air quality within the model.

(b) To determine the relationships between architectural design of the building and indoor air quality by considering them together in a systematic model.

(c) To develop an evaluation model of the architectural design process of the building in terms of indoor air quality.

(d) To enable the proposed evaluation model to be applicable to existing buildings.

A case study will be done to show the applicability of the proposed model to existing buildings. The aim of the case study is to apply the consideration model related to indoor air quality and Building System Model to a selected existing building. Although the existing building will be examined in terms of IAQ, it is essential to indicate that the main aim is not to evaluate the existing building. The case study will show the application way of the proposed model and also be a kind of feedback which shows the response of the architect of the selected existing building to the model.

1.3. THE IMPORTANCE of THE RESEARCH

Because, most of the studies about indoor air quality have been done either in science or in engineering, results are, most of the time, either in the form of mathematical models or in the form of technical devices. Sometimes, interpretation of these results into architectural drawing form is difficult. Therefore, they are required to be in a form that architects can apply in their design. The most accepted way is systematic thinking.

Building design has already been introduced as a process [34-36] in the form of systematic thinking. This systematic approach identifies each step that should be taken during design activity. Thus, architects can achieve their design target by following these steps. Also, this systematic approach provides the level and the limit of the relationships between architect and other people such as client, users, contractors, manufacturers, and legislators who are involved in building design.

The first achievement of this research is to introduce indoor air quality as a process within the whole building system and as one of the leading design objectives. In this process, each event stage will be identified. In addition, as two processes, architectural building design and indoor air quality will be considered with a systematic approach. Introducing indoor air quality as a process and considering it with architectural building design will bring systematic thinking on the subject for architects. Therefore, architects will be enabled to interpret their own design solutions into their architectural design to improve indoor air quality. At the same time, they will be enabled to control their design in terms of indoor air quality by using the proposed evaluation model. Also, the applicability of the model on existing buildings will bring more feedback to architects from real cases.

Second achievement of this research is to use the possibility of the whole building system model as a fundamental course setting guide for architectural and building science educators. The educators can place indoor air quality in their teaching area. Thus, architectural students as architects of the future will be aware of the importance of providing a healthy indoor environment for the users during the completion of their architectural education.

The final achievement of this research is to use the possibility of the whole building system model as a policy setting guide for organisational management. Organisational management can evaluate their requirements for their building in terms of indoor air quality. Therefore, they can lead their architects to design healthy buildings. Thereafter, they can apply their building use policy in terms of indoor air quality.

Besides the achievements of the research, examining an existing building in terms of indoor air quality is an important study because it shows how to use the theoretical Indoor Air Quality Process and The Architectural Design Process Model in a practical case. Also, it shows that results of the case study can be used by architects as information resource for a new design.

1.4. THE LIMITATION of THE RESEARCH

As a research subject, indoor air quality covers a wide area. Previously, effective factors to indoor air quality are briefly mentioned as outdoor air, occupants, and the building itself. Also, each factor is the combination of several subfactors which have relationships and dependencies. Each of these factors and subfactors is related to different professional areas, e.g. medicine, chemistry, architecture, engineering, management, etc..

To research each individual factor and its effects and to compile all factors, their effects and relationships, in an indoor air quality study requires a very long research time, and a big research team. Therefore, dividing the subject into determined research areas is convenient for individual researchers in different professions.

The author of this study is an architect. Therefore, the first decision is to choose the building itself as the research area within the whole indoor air quality subject.

The building, as a study area, covers many subjects, e.g. design, construction, use, social and legal aspects. To compile those aspects in the existence and the study of the building requires different groups of people from different professions. Besides, the building as an effective indoor air quality factor affects indoor air quality from different directions because of its combined structure. Also, to identify all effects of the whole building on the indoor air quality requires long study time and team work too.

Second decision which is also related to the researcher's profession is to select architectural design of the building as the effective indoor air quality factor. Although, the other effective indoor air quality factors related to the building are covered in the research, these factors, their effects and relationships are only briefly explained. Mainly, this research is based on the relationship of architectural design of the building to indoor air quality.

Because the building and indoor air quality cover quiet a lot different aspects, as a case study examining an existing building in terms of indoor air quality requires a lot of work to be done too. However, the case study is limited by the structure of the thesis due to the researcher's study area.

1.5. THE STRUCTURE of THE THESIS

In the first part of this thesis, the relationship between indoor air quality and the building is briefly discussed to identify the indoor air quality problem from an architectural point of view. The assumptions on which this research is based, the aims of the research, the importance of the research which identifies achievement of the research and the limitation of the research are, also, identified in this part.

The main structure of the research is firstly to take the subject in whole, and then to proceed to the detailed parts. Thus, the whole building system is modelled in the second part of the thesis. In this model, the architectural design of the building and indoor air quality are placed as two processes of the whole system, and their importance within the whole building system is indicated.

In the third part of the thesis, the architectural design of the building is examined in detail as one of the main activity processes of the whole building system. Indoor air quality is placed as one of the people requirements related to the quality of physical environment within the architectural design process. The examination of the architectural design process is based on The RIBA Plan of Work.

The fourth part of the thesis covers indoor air quality which is detailed as one of the environmental processes of the whole system. The definition of indoor air quality as a process is achieved by a systematic approach.

The architectural design and indoor air quality processes of the building are considered in the fifth part of the thesis. This consideration is based on risk assessment.

The evaluation method for the architectural design process of the building in terms of indoor air quality is developed in the sixth part of the research. Grade systems for hardware and for building environment are established.

In the seventh part of the research, the proposed consideration and evaluation model of the architectural design process and indoor air quality is applied on an existing building. The structure of the case study is based on these two parts:

* the theoretical model which is adopted from the thesis and

* the practical work which includes researcher's observation within the selected existing building and questionnaire which is completed by the user and the architect of the building.

The first step of the application is to examine the existing building in terms of indoor air quality according to the proposed The Building System Model. Objectives, resources, activities, hardware and environment of the existing building are considered with The Building System Model and indoor air quality during this examination. Due to the aim of this case study, the existing building is not considered in detail. There is enough information related to the existing building and indoor air quality to show the connection between The Building System Model, the existing building and indoor air quality.

The second step is to relate the life stages of the existing building with The Architectural Design Process and indoor air quality. Also, The Architectural Design Process and Indoor Air Quality Process Model, feedback chain and risk assessment / risk management model are examined.

The third step of the case study is to examine the evaluation model of The Architectural Design Process and Indoor Air Quality Process.

In last part of the thesis, the research and results of the case study are concluded, and necessary works for further researches are recommended.

Part Two : THE BUILDING SYSTEM

2.1. INTRODUCTION

As an unceasing rule of human existence, people have needs in every situation and stage of their life. They have natural metabolic needs such as breathing, eating, sleeping, etc.; social needs such as communicating, working, entertaining, etc.; health and security needs such as being physically and psychologically healthy, being protected from the effects of natural environment, wild life, other people, etc. Also, people act in their life to meet their needs. They breathe, eat, sleep, etc.; communicate, work, entertain, etc. The things that meet people's needs are either those that naturally exist on the earth (eg air, water, flora and fauna, etc.) or those that are produced by people themselves.

One of the main products is building. People design, pay and use buildings for almost their all needs. Buildings meet either directly or indirectly people's needs. A building itself does not have an edible characteristic, so it does not meet directly people's eating need. But it provides a space for people to have their meal in a good, pleasant condition. Again, the building itself does not do the work of people, but people do their work in spaces within the building.

On the other hand, the building meets directly some of the people's needs with its environmental characteristics. As an artificial environment, a building has internal physical features such as indoor air, temperature, lighting, etc. These environmental features directly meet some needs, such as breathing, visual requirements, heating and cooling. The building, therefore, should have those properties which allow people to perform their activities in the building

As a produced object, a building cannot exist without being designed and constructed. Some people design the building for others. It is defined that the person who designs buildings is called an architect; and the art and science of designing buildings is called architecture [37]. Further, design should meet people's requirements to be considered as an architectural work. If it does not meet the requirements, it has been considered as a sculpture [38].

Also, meeting the requirements is not proof of good architecture. A talented architect is an important factor of good architecture. Besides, other factors such as engineering, site condition, climate, ecology, regulations, finance, outdoor environment, social circumstances, etc. are involved in design of a building [34, 39,40].

It is clear to see that all factors, some of them mentioned above, have close relationships and depend on each other. Also, their individual existence is not enough to achieve the required result. They need to be combined with a systematic approach. Thus, they become interrelated parts of a whole. The whole is the 'Building System'.

2.2. THE SYSTEM

2.2.1. Concept of The System

Different but related definitions of a system have been given in many studies. According to those of general definitions, a system is:

" (.) a set of objects together with relationships between the objects and between their attributes " [41,42],

" (.) a set of interdependent processes " [43],

" (.) 'an accomplishment' of a phenomenon which is necessary to meet needs efficiently " [44],

" (.) an assemblage of components formed to serve specific functions or to meet specific objectives and subject to constraint or restriction " [45].

These definitions emphasize the structure of the system. The structure of the system is mainly based on;

* elements of the system,

* individual action of each element,
* relationships (effectiveness, dependency, etc.) of elements,
* results of these actions and relationships of elements.

Also, the structure of the system is bounded by some main tasks [46,47] which are;

* goals,
* identification and determination of main elements,
* properties of the main elements of the system.

2.2.2. Systems Approach

Systems Approach is the essential part of systems thinking. It can be generally explained as the way of applying the concept of system to solve a problem or to meet people's needs in a responsive environment [38,48]. The main achievements of Systems Approach have been explained in many studies [39,45-48]. Under the guidance of these studies, four main achievement of Systems Approach can be set. These are;

* thought improving,
* problem solving,
* policy setting,
* decision making.

Also, the main characteristics of a system have been determined in studies [44,45,50,54] with the help of Systems Approach. These main system characteristics basically indicate that;

* a system can be designed and developed,
* the elements of the system can be also systems,
* when two or more systems form a new system, those two systems become subsystems of the new system,
* the system is open to optimization,
* only one general system exists,
* time is an important factor at which the system differs from previous

occurrences, therefore, the general system research is never completed (50).

2.2.3. System Modelling

The representation of a system is generally called a 'model' (45). This representation has qualitative and quantitative characteristics, and determines the elements of the system, and shows the conditions and interrelationships of those elements within the system (46,51).

A System Model can be designed in iconic, analogic, or analytic forms (45,52,53). An iconic model is the representative version of a real article. This representation is usually done with the change of scale (miniaturized or enlarged), but sometimes in the real scale. Analogic model is the way of explaining something by using or making a comparison between two things which are expected to produce representative behaviour. Analytic model is the way of using mathematical or logical reasoning about a subject or a problem.

Besides, these three main forms of System Models, another category which is called 'Conceptual Model' is added to the representation of the System Models (53). Conceptual Models are in the form of pictorial or symbolic presentation.

Here, a conceptual model will be taken as a basis on which to build a system model and to apply this model to The Building System. The reason for this choice is that the conceptual model enables the designer to translate the knowledge from an illustrated Building System Model to illustration of a design.

System concepts (elements, their relationships, results) need to be interpreted into a form which is applicable to the illustration of the Conceptual Model of the System. In the most basic conceptual model, this interpretation has been done as inputs - processes - outputs of a system (40,43,46). The basic illustrative presentation of this model is shown below in Figure 1.

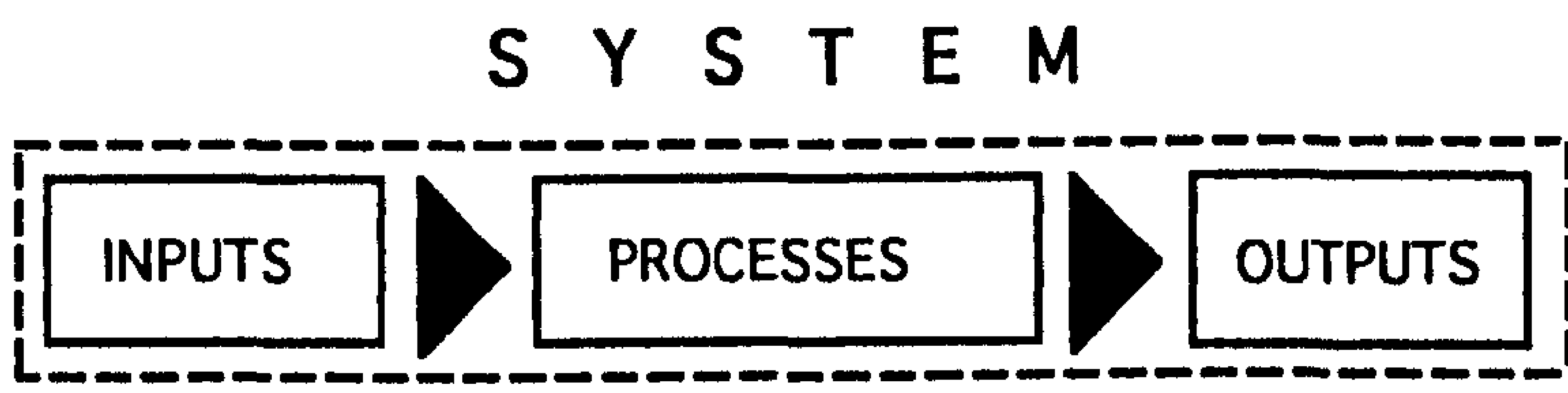


Figure 1. Basic Conceptual Model of A System

The structure and the main tasks of the system enable the system designer to identify inputs, processes, and outputs of the system.

Goals of the system are one of the important tasks of the system. The goals either naturally occur in the creation of the universe, or people's requirements and purposes determine them in the beginning of any activity. These requirements, purposes, and goals are accepted as 'objectives' of the system (44,45,47). Objectives of the system are the first structural elements of the system, and one of the inputs of the system model.

The realisation of those objectives requires existence of many things, eg. materials, tools, knowledge, skill, etc. These things are called 'resources' (54). Resources are the second structural elements of the system, and the other inputs of the system model.

Besides, the realisation of the objectives requires some activities to be done. These activities give new form to the resources, and take place during the processes stage of the system (44,54). Therefore, 'activities' become the third structural elements of the system.

The results of activities, which are targeted to achieve objectives by using resources, are products. These products are called 'objects' of the system, and present two outputs within the system model. One of those outputs is the solid and the formed part which can be called 'hardware' of the object. The other output is 'environment' of the object. The environment of the object covers those parts that identify dimensional, physical, chemical, etc. characteristics of the object.

The existence of the system model is based on those elements, which are objectives, resources, activities, hardware, and environment of the object. Also, the quality and the quantity of each element within the system are dependent on each other. In the absence of any of these elements, the system will probably not work. Even, if it works, the requested result will not be achieved. Therefore, the dependency of each element on the other elements plays an important role within the system model.

Besides, the control of each element and situation within the system is necessary for the achievements of the system. This control can be done with the consideration of each element and the information which is obtained from other elements. Thus, feedback exists within the system, and becomes an important part of the system model.

The translation of these system elements with dependency and feedback features of the system into The Elemental System Model gives that illustrative presentation which is shown in Figure 2.

Each of the system elements, which are objectives, resources, activities, hardware, and environment, also, consists of one or more factors. For example, objectives can be established by either those individuals or those groups of people whose aims are different. But all those different objectives can be targeted at the same time in the same system. Similarly, different resources and many activities can take place within the system. Hardware and environment of the objects can have different, but related features. This combined structure can make each system element occur in independent but related individual systems. Thus, elements of the system can be systems.

In this case, those independent but related elements become subsystems of a main system. Thus, those two levels can be identified as system level and subsystems level of the system model. Also, if several main systems form another system, they become subsystems of the new system, too.

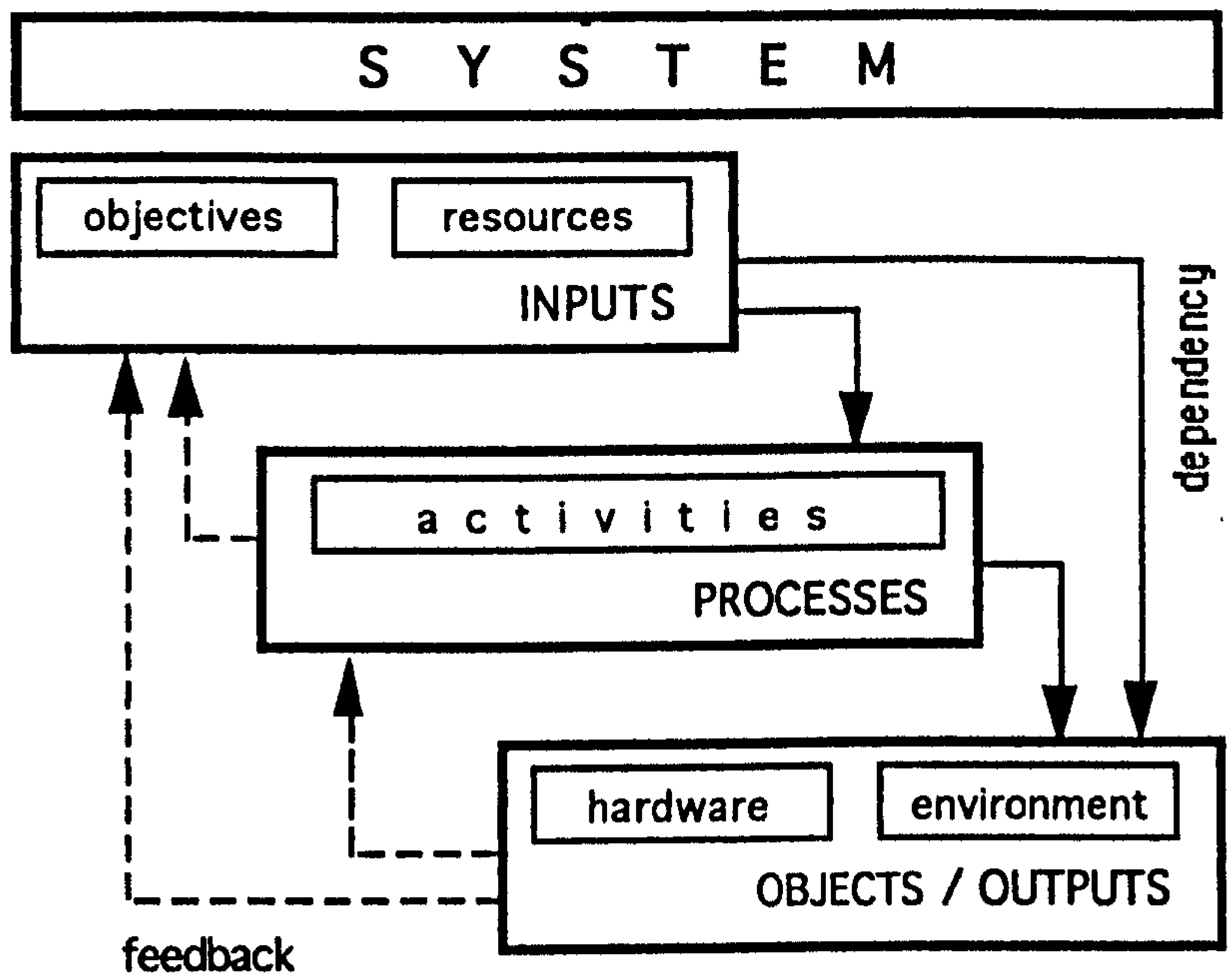


Figure 2. The Elemental Model of The System

The third level of the system model is the processes level. A process is a series of actions which logically occur at different stages of the system (37,54). Two or more processes can act together and complete another process. In this case, those processes which act together become subprocesses of the completed process. All processes within each subsystem are described in that processes level and related subprocesses level which is the fourth level of the system model.

The last level of the system model is the programmes and procedures level. All flow charts within the processes and subprocesses are described in this level.

These five main levels give the hierarchical characteristic of the system model, and are illustrated in Figure 3.

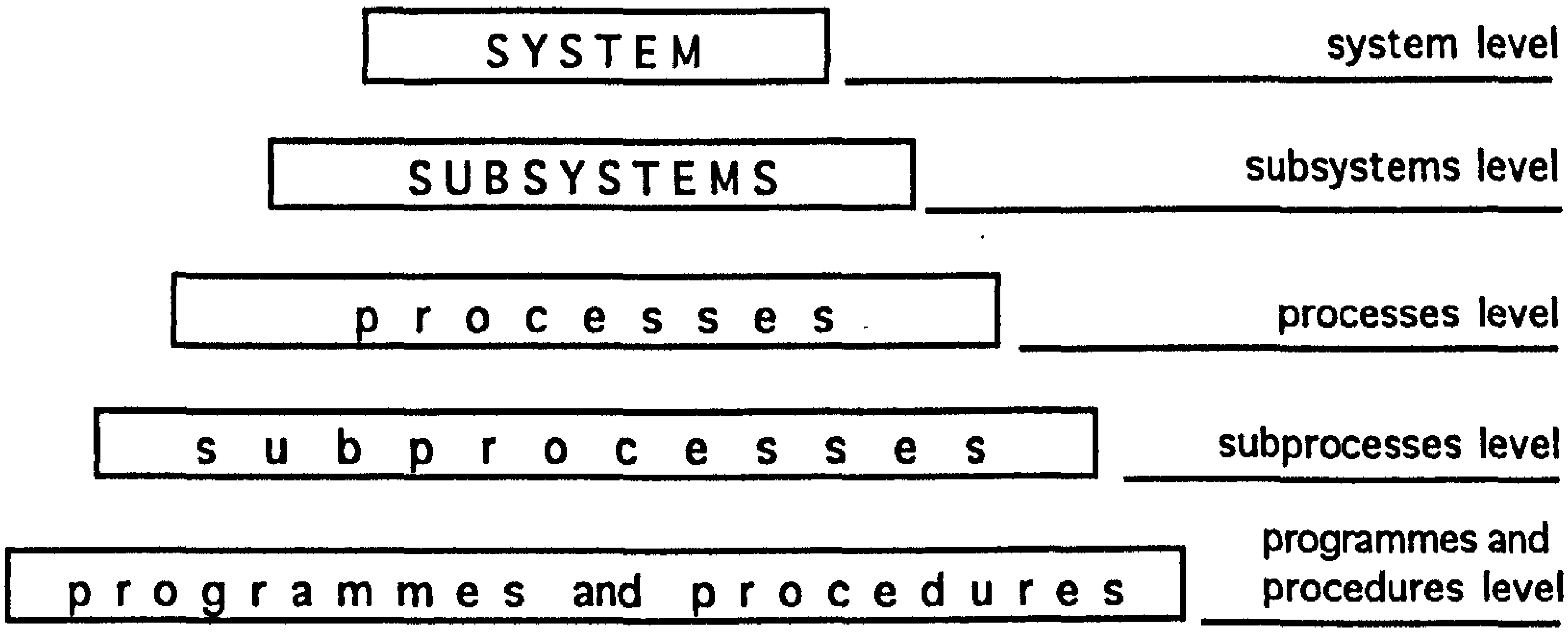


Figure 3. The Hierarchy of The System Model

The hierarchy of the system model can be applied to the elemental system model. This application describes 'the main conceptual system model' which is illustrated in Figure 4.

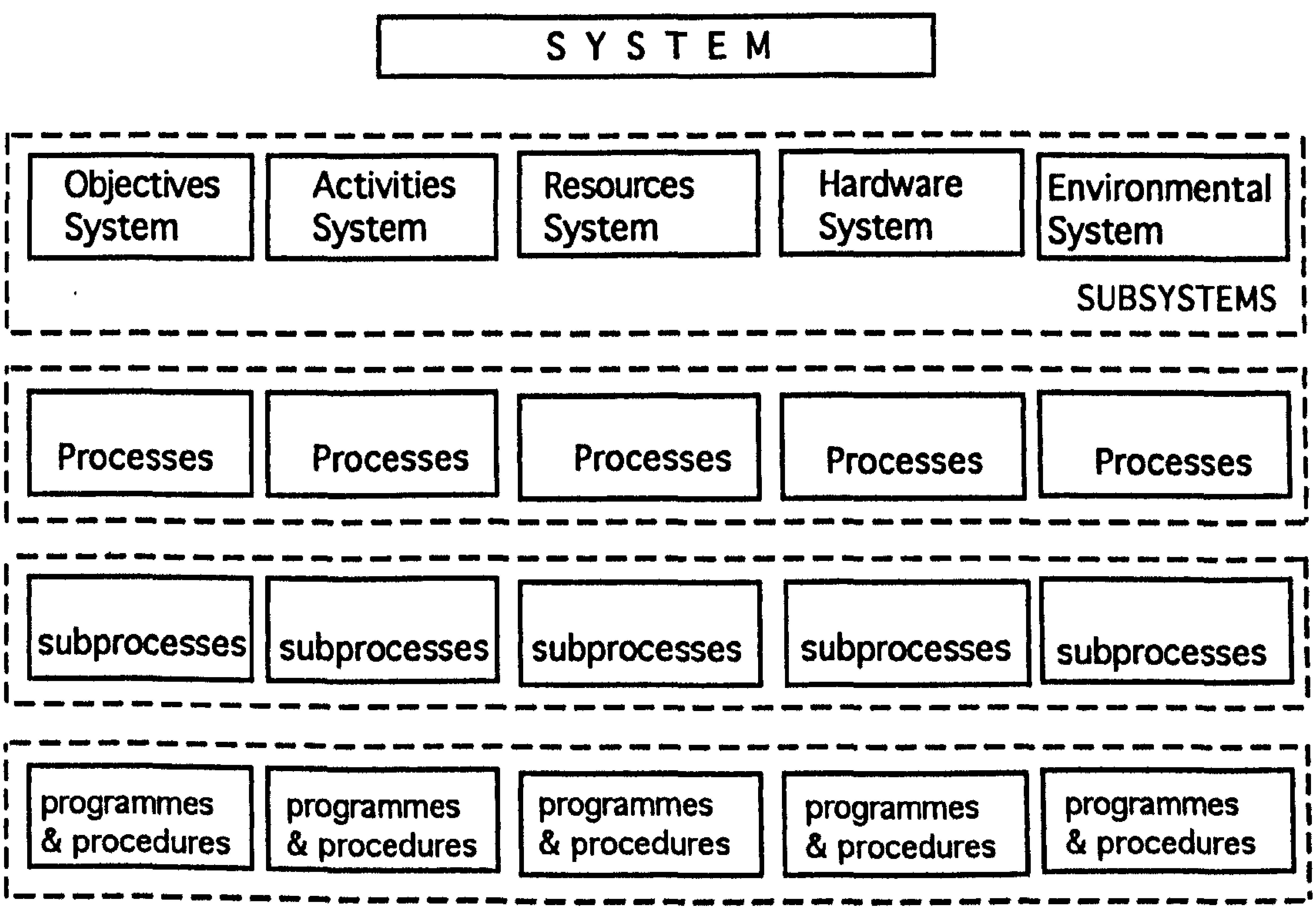


Figure 4. The Main Conceptual System Model

2.3. THE BUILDING SYSTEM

2.3.1. The Building

As a term 'building' has been used to refer two things which are a kind of action and a result of that action. The building which refers to the action has been defined as the art and the practice of putting things together to form and produce a structure (37,55). In this definition, the main matter is the process of production.

In architecture, that formed and produced structure which is the result of that action has also been called as 'building' (37,56). As a structure, a building can be a dwelling house, a theatre, a school, a hospital, and so on. In this case, the main matter is the result which has been referred as a product rather than process (57). Here, as a term, the building will be used mostly to refer to those formed and produced structures, if any additional explanation is not given.

2.3.2. The Life of The Building

The existence of a building starts with the people's requirements. People need different types of buildings to perform their activities within. Therefore, they intend to produce them. The existence of the building in a person's mind is the conceptual beginning of that building.

After identifying their requirements and making their decisions, people act to realise the building. This realisation occurs with design and the construction. Shape and character are given to the building during the design period. In the completion of the design, the building theoretically exists.

But, the real physical existence of the building starts of the beginning of construction period and is completed at the end of this period.

When the building is physically ready to be used, people's occupancy starts within the building. People use the building until end of its life. This is the retirement of the building.

Thus, the building has five main existence stages, and three main existence periods during its whole life. These are:

First stage	: conceptual occurrence of the building; origin for the existence of the building,
First period	: design period of the building,
Second stage	: theoretically existing; designed building,
Second period	: construction period of the building,
Third stage	: physically existing; constructed building,
Fourth stage	: people's occupation of the building; occupied building,
Third period	: use period of the building in which people's occupation continuous,
Fifth stage	: retirement of the building; unoccupied or demolished building.

These stages and periods determine the life of the building and are illustrated as the life cycle of the building in Figure 5.

The term 'the life cycle of the building' has been used mostly in cost analysis of the building [58-60]. In this thesis, the life cycle of the building is time based. The life time of the building has been accepted from the beginning of design to the end of occupancy of the building. Therefore, it covers the design period, the construction period, the use period, and the retirement of the building. It is generally indicated that giving certain time-lengths to those periods in the life of the building is difficult [58-60]. However, in one of the studies [60] the time-length of each period has been suggested. According to this suggestion the design period is sometime between 6 months and 10 years; the construction period is sometime between 6 months and 5 years; the use period is sometime between 6 months and 100 or more years; and the retirement of the building, if it is demolished, is 1 month. Although, these time-lengths are given to periods in the building life, it is indicated that the life of the building is dependent on physical, economic, functional, technological, social, and legal factors (58,60).

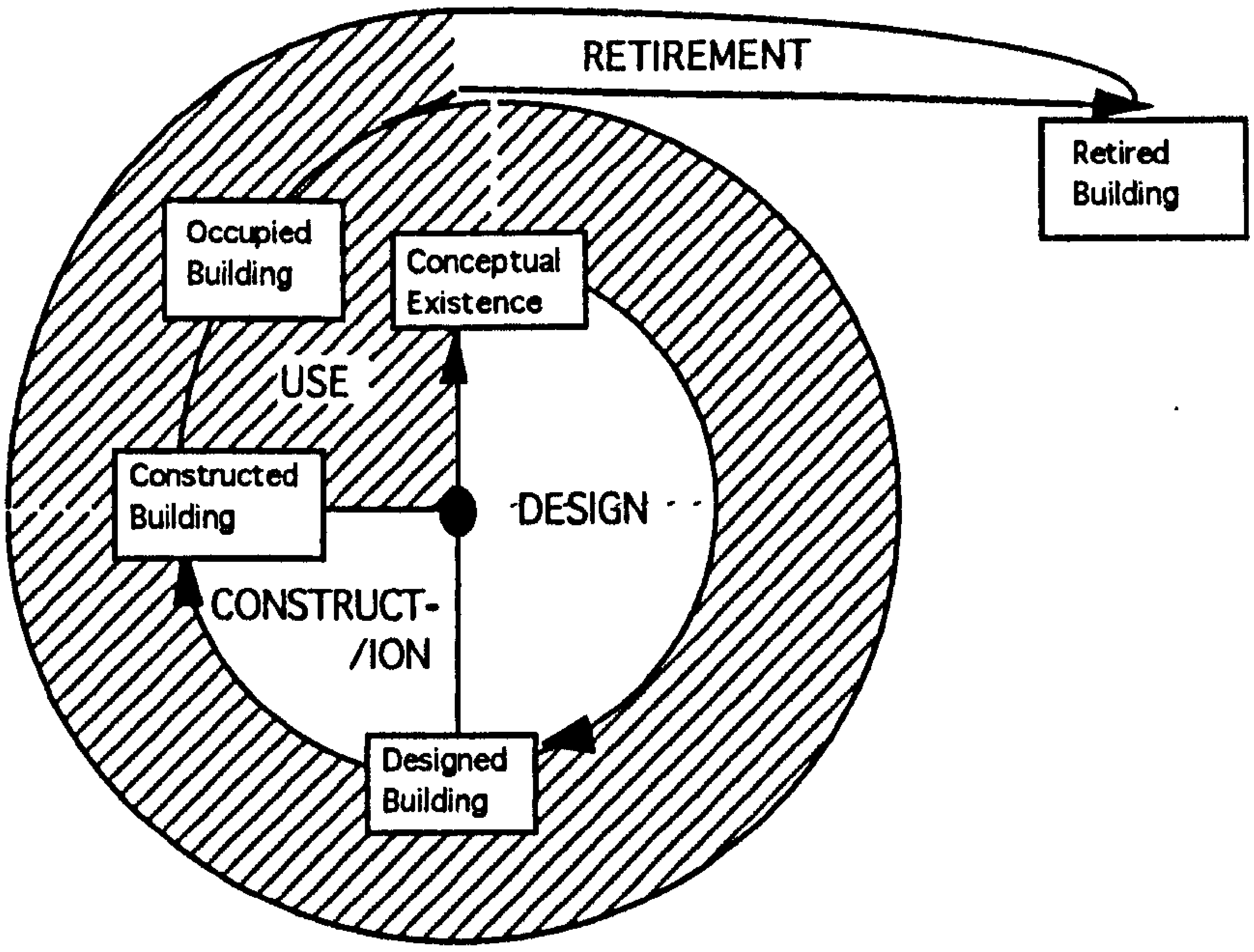


Figure 5. The Life Cycle Of The Building

Although, it is an important factor for building cost analysis, here, time is not mentioned in the illustration of the life cycle of the building, because of the research area of this study.

2.3.2.1. The Existence Stages and Periods of The Building

2.3.2.1.A. The Conceptual Existence Origin of The Building

The existence origin of the building is people's requirements. People require buildings because of their needs.

People need many and different things to maintain their survival and their living standards. Those things are, generally, called human needs in human sciences (61-63), and are related to, both, individual metabolic and social life of people.

The classification of people's needs has been done according to importance and priority of those needs in people's life. The most general classification of people's needs is to divide those needs into two groups which are basic needs and social needs (62). Breathing; eating, drinking; sleeping, waking; excreting; physically and mentally acting are some of those basic needs. Communication, friendship, belongingness, human rights, employment are some of those social needs.

In another classification, people's needs have been grouped under three main categories which are primary, secondary and tertiary levels of needs (63). Physiological needs such as homeostasis, food consumption and sexual behaviour have been accepted as primary needs. Safety needs such as security, stability, dependency, protection, need for law, order; belongingness and love needs such as relationship with other people, belonging to a place; and esteem needs such as achievement adequacy, competence, confidence, independence, reputation, prestige, dominance, attention have been accepted as secondary needs. Finally, self-actualisation which is individual differences; cognitive capacities which are desires to know and to understand; and aesthetic needs which are needs for order, symmetry, closure, system and structure have been grouped in a third level of needs.

Similarly, in another study (61), people's needs have been categorised as deficiency needs, sufficiency needs, and growth needs. The deficiency needs such as breathing, eating, drinking, sleeping, waking, excreting, physically acting are necessary to maintain people's physical survival, and have, also, been accepted as primary needs. Those needs, which are necessary to keep living standards at some level which is beyond the basic survival of people, have been indicated in the sufficiency needs category. The growth needs are those which go beyond sufficient standards and covers people's aspirations for their individual development and enjoyment. Welfare, equity, achievement, participation, appreciation, dignity, etc., have been grouped under these last two categories. The sufficiency and growth needs have, also, been accepted as secondary level of needs.

It is possible to meet other similar classifications of people's needs in other studies. In common, all these studies show that people's life is dependent on the existence of many things. Some of them are vital for people's survival, some of them are necessary for providing some standards in people's life, and some of them are individual's aspirations.

Therefore, people require different things to meet their needs. Things which meet people's needs exist in the earth either naturally or as the results of people's activities.

The planets in space, the earth itself, air, water, flora and fauna, materials, even human beings were created, and naturally exist in the universe. Although, the creation of the whole universe is beyond them, people are aware of the dependency of their existence on these natural things. Those natural things can directly meet people's needs in their original form such as air, water, etc.

However, the existence of these natural things is not enough for people's living standard. People require and produce many other things to meet their needs in the life. For example, eating is vital physical need of people, therefore people require food, and produce it by land cultivation, livestock production, hunting and fishing, etc. Besides, they require supporting products to make their food production easier, and qualitative. Thus, people's needs and requirements become the origins for the existence of many products.

Similarly, the existence of the building starts with the people's needs and requirements. The building as a product meets many different needs of people. For example, people require houses to meet their shelter, security, comfort, socialisation and self-expression and aesthetics needs [64]. Also, other types of buildings such as hospitals, schools, recreation buildings, etc., are required to meet people's health, educational, socio-cultural, etc., needs. As a required product, this is 'the conceptual existence of the building'. .

In Figures 6 Conceptual and Physical Existence Chain of a Product, and in Figure 7 Conceptual and Physical Existence Chain of The Building are illustrated.

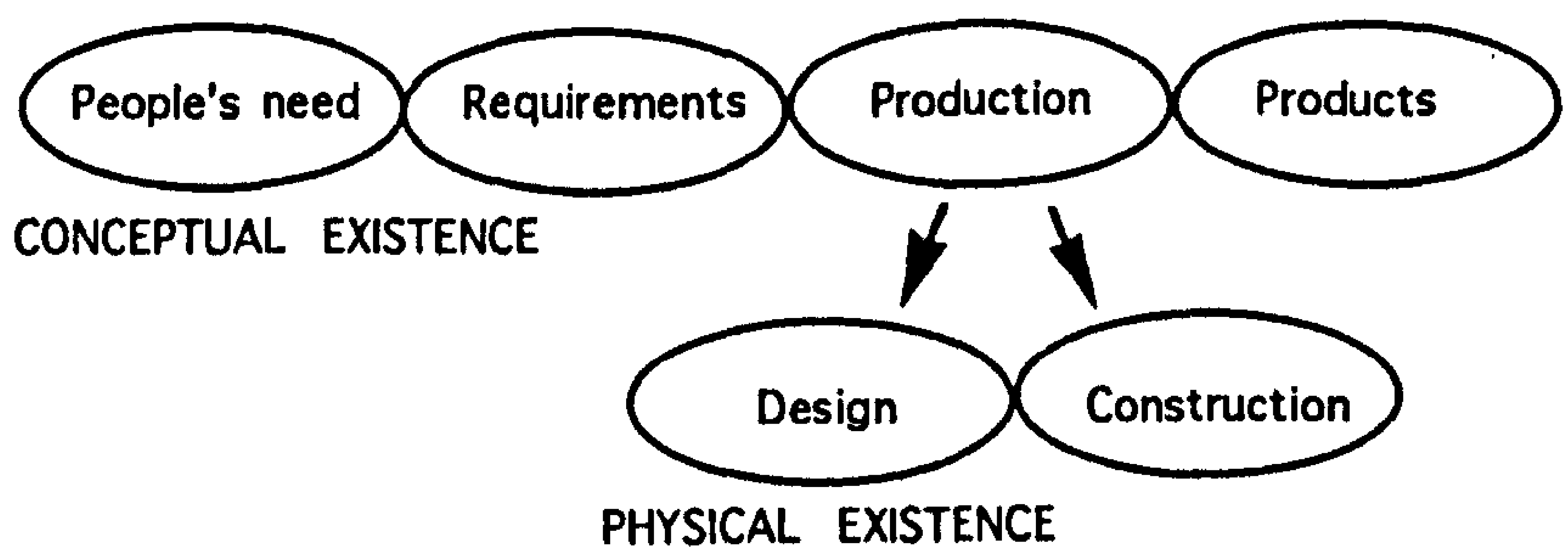


Figure 6. Conceptual and Physical Existence Chain of a Product

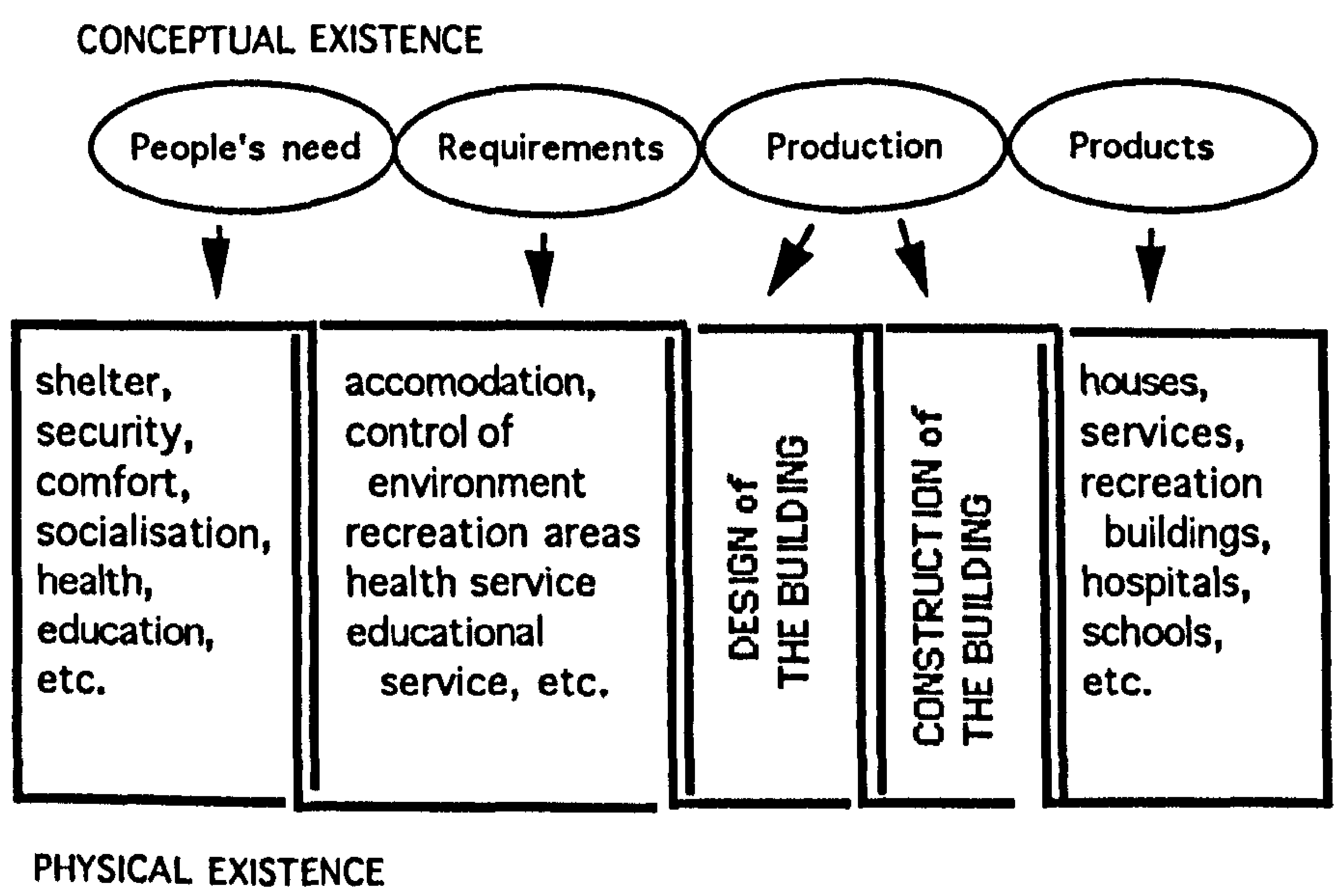


Figure 7. Conceptual and Physical Existence Chain of The Building

2.3.2.1.B. The Design Stage of The Building

As summarised above, people require things to meet their needs. However, requiring those things is not enough for their existence. They need to be produced. Therefore, another link, which is production, is added to the existence chain of those things which are products.

Production which is the act of bringing the products into existence as a result of any process or activity, has two stages which are design and construction of those products (Figure 6).

As one of the major products, the building has both those of stages (Figure 7). In the design stage, physical appearance and other characteristics such as interior environmental features, aesthetic appearance of the building are decided and theoretically given to the building. The qualitative characteristic of the building is mostly dependent on design stage decisions.

From the simple one to the sophisticated one, several definitions of the design have been given in many studies (37,40,43,57,66-68). All these definitions mainly indicate three distinctive ideas about the design. According to the first idea, the design is the creative organisation of information, and the way of assembling that information into a form to solve the problems. In this definition, design has been described as a process (37,66). The second idea indicates that the design is, also, the product of this process (40). Finally, the design has been defined as the control of the environment (43,67).

In this research, the design will be used to describe the creative process which refers to the building design, and the result of this process will be described with the name of the product which is the building itself.

The building design process is the combination of a series of actions. Those actions take place in the design process in an order. The arrangements of those actions have been given in many studies (35,36,40,43,57,69,70). A general presentation of different views about the design process is shown in Table 1.

Most of those studies show the general procedure of the events and the stages of the design process. Also, the whole process covers the conceptual existence, theoretical existence which is design, construction, and use stages of the building.

This general procedure is helpful to set a general working plan for the design and construction team, and the organisation as user of the building. But, this working plan will be abstract, if clear definitions of all actions and stages within the whole process are not done. Therefore, it will be difficult to forecast the problems and to make a division of labour within each stage of the whole existence process of the building.

The RIBA Plan of Work (69) goes further into this general procedure. The purpose of work and decisions, tasks, and participants who are directly involved have been defined for each stages within the whole process.

In this research, design, construction, and use of the building will be based on The RIBA Plan of Work, because it enables the researchers and designers to extend their points to the whole existence process of the building.

Table 1. General Presentation of Design Process

Young's summary of design process (35)		main stages				
		Brief	Analysis	Synthesis	Implementation	Verification
	major events	clarification of requirements	description of problems	solutions to problems	validating the selected solution	preparation of final design; sketch, scheme, and detail design

Chandler's summary of design process (36)		main stages				
		Initation	Preparation	Proposal	Evaluation	Action
	major events	problem identification; inception	analysis; feasibility	synthesis; outline proposals, schematic & detail design	testing and selection of alternatives	implementation; production info., bills, tender, planning, site operation, completion, feed-back.

Frey's summary of design process(40)		Design Development Stages			
		Planning stage	Design stage	Realisation stage	Stage of Use
	major events	analysis	synthesis	construction	modification and maintenance

Markus, et. al 's summary of design process (43)		main stages		
		Analysis	Synthesis	Appraisal
	major events	understanding of the problem	producing a design solution	representation, measurement, evaluation

Burges's summary of design process (57)		main stages		
		Analysis	Synthesis	Evaluation
	major events	defining the problem	developing alternative solutions, and decision making	communicating the decisions

RIBA's Plan of Work (69)		main stages			
		Briefing	Sketch Plans	Working Drawings	Site Operation
	major events	A. Inception	C. Outline Proposals	E. Detail Design	J. Project Planning
				F. Production Information	K. Operations on Site
		B. Feasibilty	D. Scheme Design	G. Bills of Quantities	L. Completion
				H. Tender Action	M. Feed-Back

Swinburn's summary of design process (70)	main design phases						
	Definition	Analysis	Synthesis	Development	Implementation	Operation	Evaluation

2.3.2.1.B1. Consideration of The RIBA Plan of Work and The Existence Stages and Periods of The Building

The first action within the briefing stage of the RIBA Plan of Work is inception. In this stage,clients should state their needs and requirements. As a leader of the design team, the architect should examine all this information, and should prepare first a general brief, which includes the statement of requirements, time, and cost factors. This general brief will be developed in further stages. So, this stage is the first conceptual existence stage of the building.

The second step of the briefing stage is feasibility actions in which the development of organisational statements between the architect and the client continues. Besides, the architectural design, which gives the character and the actual appearance to the building, starts in this stage. Also, engineers such as civil engineers, mechanical and electrical engineers are involved in the design of the building. Therefore, the theoretical existence of the building starts with the feasibility actions.

The sketch plans stage and working drawing stage are the actual architectural, and engineering design stages of the building. The sketch plans stage covers outline proposals and scheme design. The working drawing stage includes detail design, production information, bills of quantities and tender actions. Also, selection of building materials and contents, such as fittings and furniture, makes the manufacturing design to be involved in the design of the building during these stages. In the last step, (tender actions) of the working drawings stage, the designed building as a product of the whole design activities is obtained. The theoretical existence of the building is finished with the completion of these stages.

The fourth stage in the RIBA Plan of Work is site operation in which the actual physical existence of the building starts with the beginning of this stage. This stage is, here, called the construction stage, and is briefly defined in the following section which is C. Construction Stage of the Building.

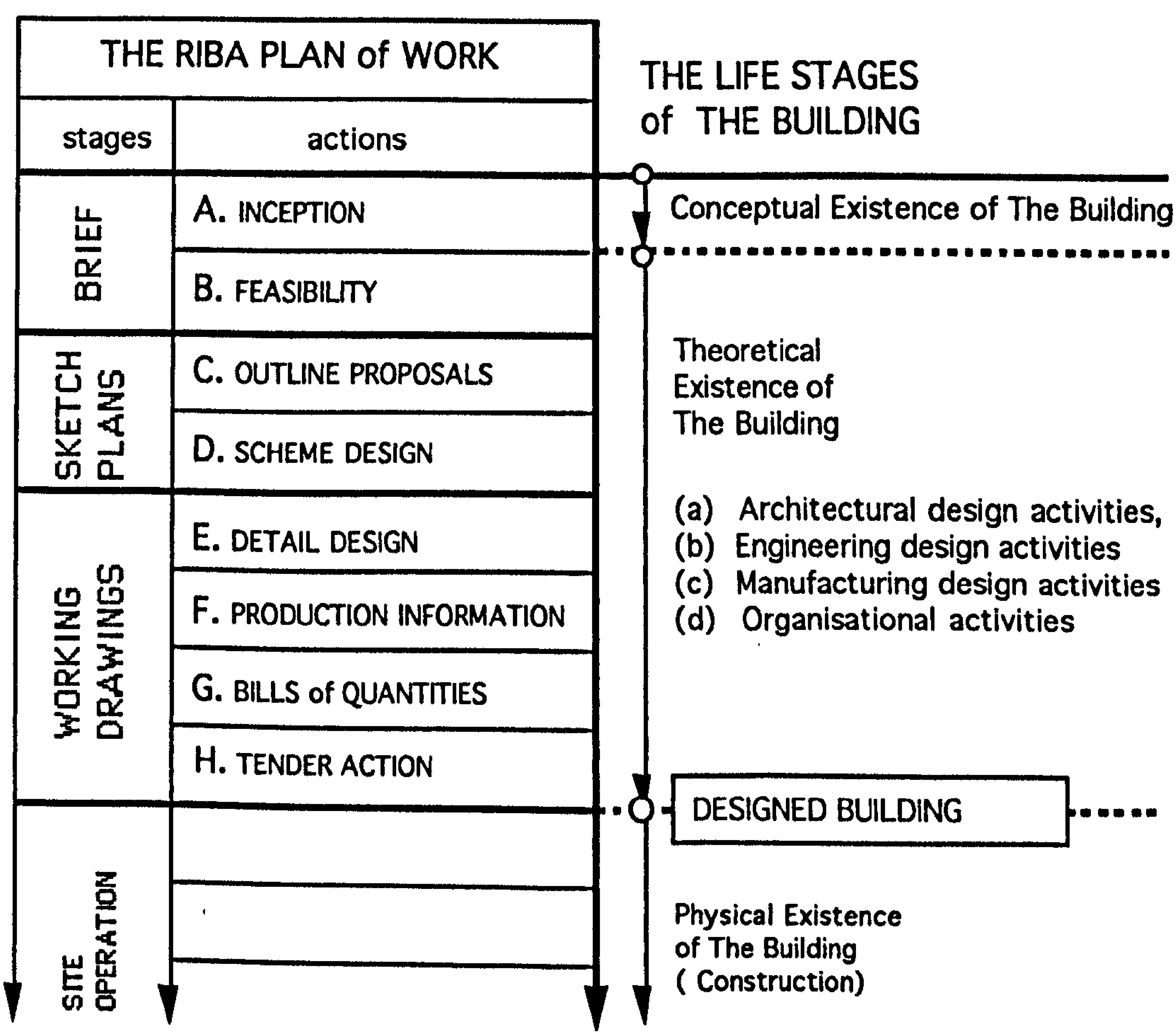
During the design of the building, four main activities take place within the design process. These are:

(a) architectural design activities,
(b) engineering design activities,
(c) manufacturing design activities, and
(d) organisational activities.

In this research the architectural design of the building will be examined in terms of indoor air quality.

In Table 2 the conceptual and theoretical existence periods and stages of the building, and the RIBA Plan of Work are considered.

Table 2 Consideration of The RIBA Plan of Work and
The Conceptual and Theoretical Existence Stages of The Building



2.3.2.1.C. The Construction Stage of The Building

When the design of the building is completed, the construction actions start and bring about the building physical existence. These actions take place in the site area, and are referred under the 'site operation' stage of the building in the RIBA Plan of Work. This stage is, here, called as construction stage of the building.

The first step of the construction stage of the building is the project planning in which organisational arrangements between client, designer, and contractor continue. Besides, three main arrangements take place in the site area before the construction of the building starts (69,71,72). These are: (a) preparation of site teams, job programming; (b) establishing the site area; (c) supplying the building materials and components, and the machinery and tools.

The second step in the construction stage is operations on site area. In this stage the substructure, superstructure, completion elements, finishes, services, installations, fixtures, and loose equipment of the building (71,74) are built according to the design of the building, and the work programme of the site operations.

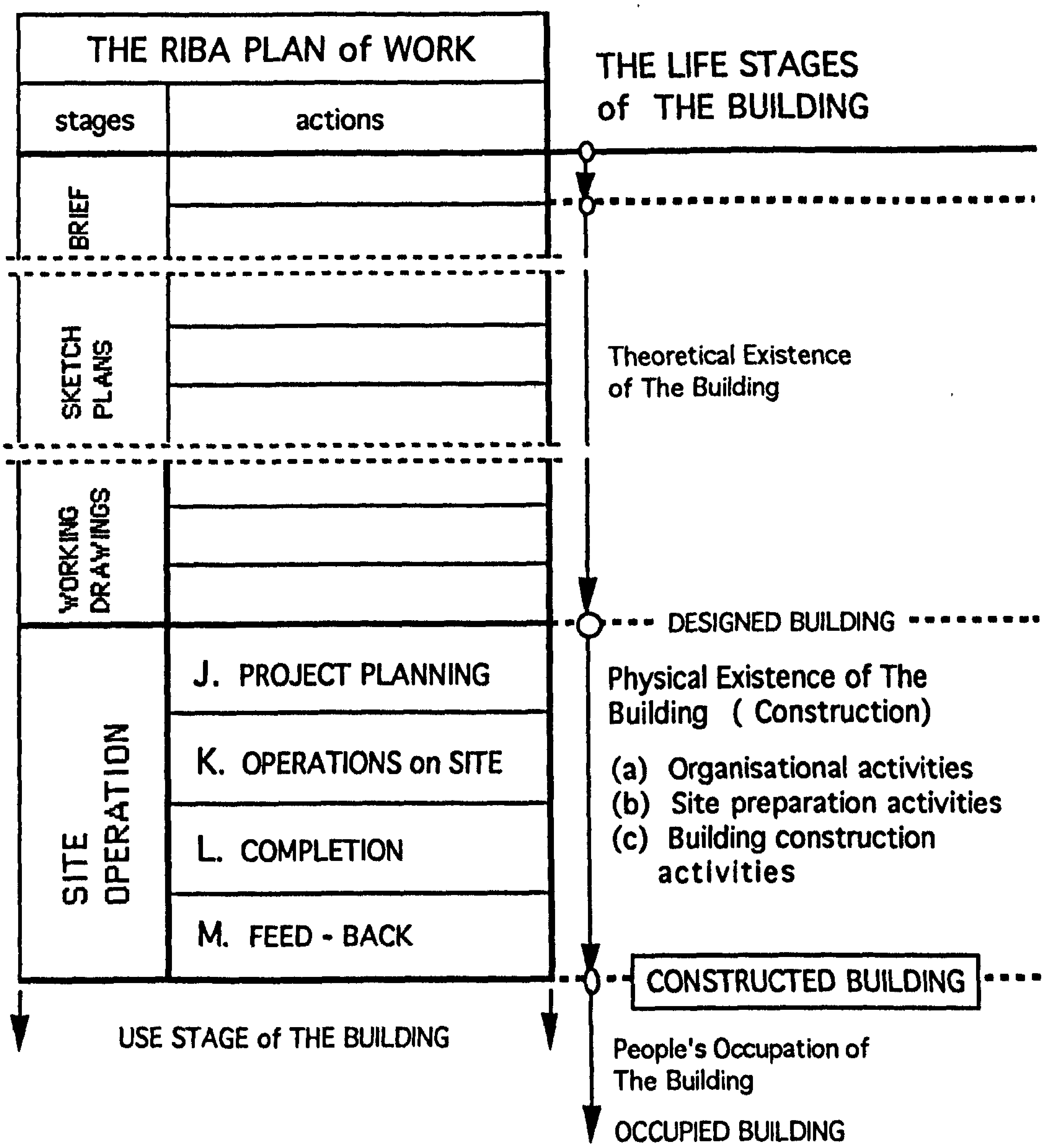
The construction stage of the building finishes with the completion of the site works which includes inspecting the building and site area, completing outstanding works, clearing the site area, arranging the final meetings and handing over the constructed building to the client.

During the construction stage, which is the physical existence period of the building, three main activities take place. These are:

(a) organisational activities,
(b) site preparation activities, and
(c) building construction activities.

The Table 3 shows the consideration of the construction stage of the building and the RIBA Plan of Work.

Table 3. Consideration of The RIBA Plan of Work and The Physical Existence Stage of The Building.



2.3.2.1.D. The Use Stage of The Building

Once the occupants of the building move in, the use stage of the building actively starts. The occupation and the use of the building continue during the whole use period of the building.

The nature of the building occupants can be people, animal, plant, artifact or machine [75]. However, among all these occupants, only the people are the decision makers and the organisers. Therefore, in this research, the terms occupants or users of the building will refer directly to the people, unless there is additional explanation about other occupancy within the building.

The occupant or occupants of the building can be either an individual or a group or an organisation [76]. The group and the organisation will, also, have individuals in their structure. This classification gives the magnitude of the occupants within the building.

People act within the building. These activities can be classified according to their needs, or according to the magnitude of the occupancy. If the classification is based on people's needs, the people's activities can be combined into four groups which are physical activities, psychological activities, social activities, and productive activities. If the classification is done according to the magnitude of the occupants, the activities can be grouped as individual's activities, group activities, and organisational activities which also cover group and individuals activities.

The organisational activities have been identified in many studies [43,77-80]. Here three of those identifications of the organisational activities are summarised. In the first classification [43,77], organisational activities have been grouped as (a) workflow, (b) control, (c) communication, (d) identification, and (e) informal activity.

In the second classification [78], two main activity groups have been identified. These are: (a) planning activities which include forecasting or predicting, planning, and organising or preparing activities; and (b) executive activities which include motivating or commanding, controlling, coordinating activities.

The third classification [79] divides the activities into five main groups which are (a) initiation, (b) organisation or planning, (c) people and facility readiness, (d) start-up, (e) operation.

Although, in the first classification [43], the design of the building has been referred under control activities, here design activities will be separated from the control activities. Because, the control activities are, here, accepted as the part of the use activities which are identified before production of the building but happen after the physical existence and the occupation of the building.

While people are doing their activities within the building, they compare the efficiency of the building with their requirements, expectations and findings. Thus, the use stage becomes the most evaluated and criticised stage of the building. The evaluation and criticism of the building include the design and the construction of the building as well as the management of the building. Besides, they provide useful information for the improvement of the conditions within the building and the other buildings which will be new-designed and constructed. This is, generally, called feed-back which has been referred to as the last step in the RIBA Plan of Work [69].

Due to those classifications which are briefed above, three major statements can be given about the activities and their effective areas within the building. These are :

(a) activities which are related to the profession of the organisation,

(b) activities which are related to the individual user of the building, and

(c) activities which are related to the physical existence of the building.

As results of the evaluation and criticism of the building, the activities which are directly related to the physical existence of the building, and take place during the use period of the building can be united in three major groups [71]. These are : (a) cleaning, (b) maintenance, and (c) refurbishment / modernisation / alterations.

These activities which are cleaning, maintenance, and refurbishment /

modernisation / alterations can happen several time during the use stage of the building. If there is any refurbishment, modernisation or alteration within the building, in this case the design and the construction activities partly take place during the use period of the building.

The consideration of the use stage of the building and The RIBA Plan of Work is shown in Table 4.

2.3.2.1.E. The Retirement of the Building

The retirement of the building is the last stage in the life cycle of the building. The building retires for many reasons. For example:

* The amenities and the facilities within the building become inefficient to meet with the users' requirements,

* The running cost of the building becomes high and unacceptable to keep the building in good condition,

* The failure of the building due to the natural disasters such as flood, and earthquake, etc.; or because of vandalism such as people attack, sabotage, etc.,

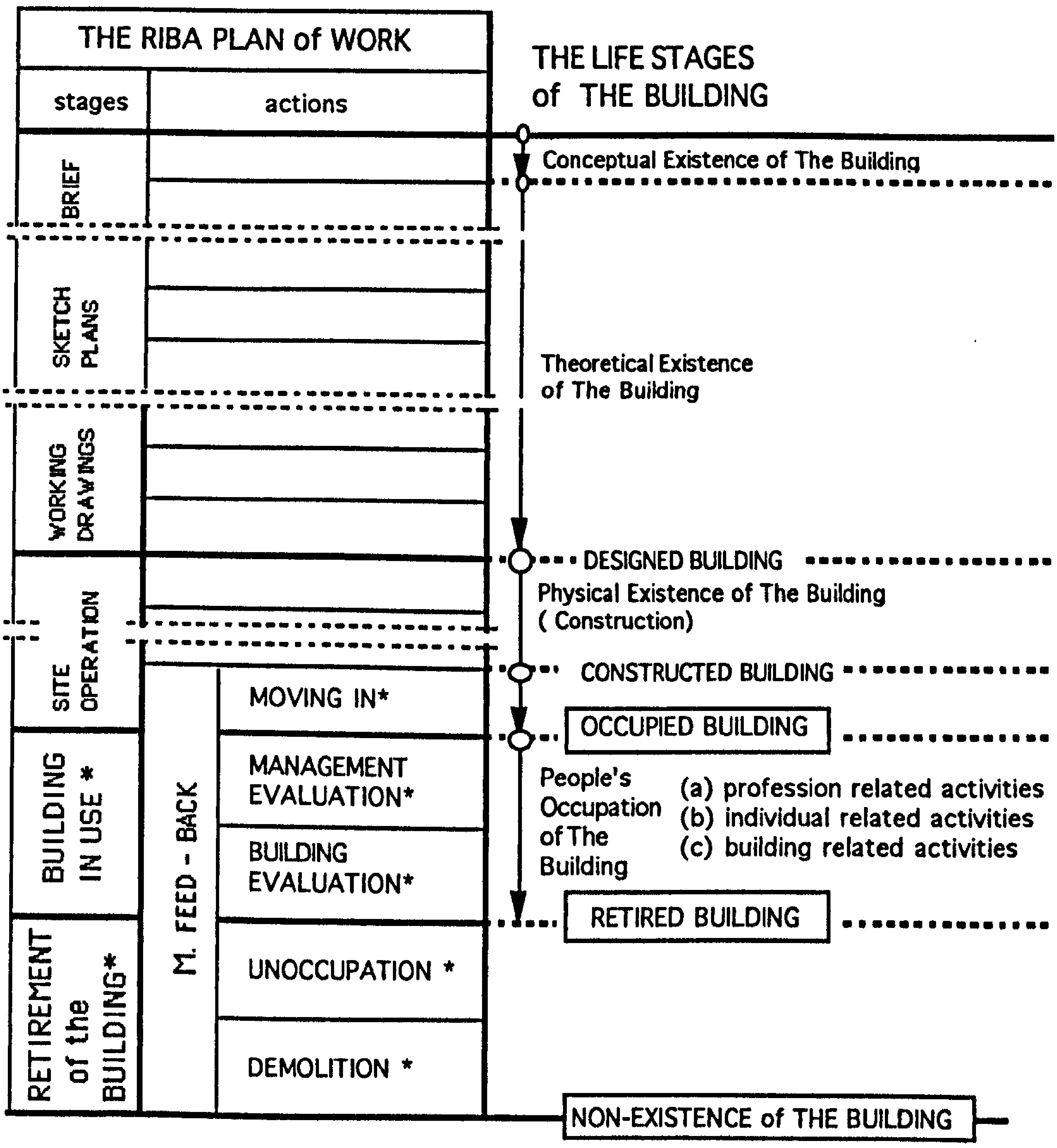
* Although the building can be efficient, people can still empty the building because of their changeable attitudes.

The retirement of the building can happen in two conditions. Firstly, if the building is emptied for any reason, and if it is decided to leave the building as unoccupied for limited or unlimited time, this building can be accepted as a retired building . In this case, the retirement period of the building will continue until the decision is changed and the new occupants move in. During this period, alterations, or modernisation, or refurbishment can be done within the building. Therefore, design and construction activities can, also, take place in retirement period of the building.

The second condition in the retirement stage of the building is the demolition of the building. Once, the building is demolished, this means the building has completed it's life, and does not exist any more.

The consideration of the retirement stage of the building in The RIBA Plan of Work is, also, shown in Table 4.

Table 4. Consideration of The RIBA Plan of Work and The Use Stage and The Retirement of The Building



(* researcher's addition)

2.3.2.2. Effective Features for The Existence of The Building

During the life cycle of the building so many things are involved and gathered to bring the building into existence and to use the building to meet requirements. For example the goals and the acts of bringing the building into physical existence; the physical structure and the environment of the building as the result of those goals and acts; and the supportive features such as knowledge, skill of designing the building, technology and material to design and built the building, rules and standards to control the suitability of the building, etc. These are important and effective features for the existence of the building, and take place in every stage of the building.

These effective features can be grouped in five categories which are (A) objectives, (B) activities, (C) hardware of the building, (D) environment of the building, and (E) resources.

2.3.2.2.A. Objectives for The Existence of The Building

Objectives are the goals of the people who are involved in the existence of the building. Those people have been identified as participants of the design, construction, and use processes of the building [36,39,82,83].

Those people who are involved with the existence of the building can be divided into five main groups. These are:

(a) First group of the participants: These are the people who need the building and finance the whole building project. Clients, users, and developers are in this group of the participants that can be an organisation or an individual.

(b) Second group of the participants: These are the people who design the building and lead the whole building project. Architects, engineers, quantity surveyors are in this group of the participants. This group of the participants is called the design team.

(c) Third group of the participants: These are the people who build the building in the site area. Contractors and subcontractors are in this group of the participants that is called the construction team.

(d) Fourth group of the participants: These are the people who supply the building materials and components; fittings and furnitures; tools and machineries; services such as gas, electricity, water, and telephone. Manufacturers, traders, and public services boards are in this group of the participants.

(e) Fifth group of the participants: These are the people who govern the building design and construction, and set the rules, standards and regulations. Local authorities, town and county planning departments; building control departments, institutes, and establishments; public health and safety departments; etc. are in this group of the participants.

These five groups of people take active and effective role in every life stage and period of the building. However, dominance of their role is changed according to the life stages and periods of the building. For example, decisions of the first group of participants, who are clients, and users, etc., are effective during the identification of the users' requirements and the idealistic existence of the building. But in the design period of the building, effective decisions and activities, which bring the building into theoretical existence, come from the design team. Although, the design team's decisions are effected by clients requirements, the designers bring their own ideas to the design of the building. During the construction period of the building, the contractors' activities are effective, although they act according to the designer's decisions. In the use period of the building, users of the building take their active place. The technical suppliers such as manufacturers, traders, and public service suppliers, and the approving authorities such as local authorities, town planning, and health and safety departments, etc. affect the decisions of clients and users, designers and contractors in all life stages and periods of the building.

Therefore, the objectives of those five groups of participants are matched in the existence of the building (Table 5).

The organisation as the group of users, clients, and developers has some targets to achieve within the building. These targets, which are investment, production, profit, stability, prestige, user well-being, security, morale, durability, flexibility, etc., have been identified as the organisational objectives (36,43,62,77,84). The most referred categorisation of the organisational objectives has been indicated as production, adaptability, morale, and stability (43,77,84).

Table 5. Correlation of The Objectives and The Life Periods of The Building

OBJECTIVES of the PARTICIPANTS → / LIFE PERIODS of the BUILDING ↓	ORGANISATION (Client, users, etc.)	DESIGNERS (Design team)	CONTRACTORS (Construction team)	AUTHORITIES (Institutes, rulers, etc.)	SUPPLIERS (Manufacturers, etc.)
DESIGN PERIOD	◍	●	◍	◍	◍
CONSTRUCTION PERIOD	◍	◍	●	◍	◍
USE PERIOD	●	◍	◍	◍	◍

● Primary Affection
◍ Secondary Affection

The building designers aim to meet the requirements of the organisation, the construction team, and the authorities. Besides, they aim to demonstrate their creativity, and to continue establishing their reputation in architecture (36,85). The goals of the designers are functional suitability and utility of the building, flexibility in the design for possible changes within the building, structural and environmental performance of the whole building. These goals meet with the organisational requirements. Buildability of the building design, repetitive work, availability of the selected building materials are the second group of designers' goals which meet the construction teams' requirements. Meeting the legislation, rules, standards, and achieving the quality in the design of the building are the authority requirements related goals of the building designers.

Quality, continuity and repeat of work, improving site management and organisation of work are some of the construction team's objectives [36].

2.3.2.2.B. Activities During The existence of The Building

During the life periods of the building, which are design, construction, and use, those groups of participants act towards realising their objectives. As briefed in section 2.3.2.1. Existence Stages of The Building, the activities which are taken within the building can be grouped in three main categories. These are:

(a) design activities which include organisational activities, architectural design activities, engineering design activities and manufacturing design activities,

(b) construction activities which include organisational activities, site preparation activities and building construction activities, and

(c) use activities which are mainly organisational activities and include profession related activities, individual related activities and building related activities.

Table 6 shows the correlation of the activities within the building and the life periods of the building.

Table 6 Correlation of The Activities within The Building and The Life Period of The Building

ACTIVITIES within the BUILDING / LIFE PERIODS of the BUILDING	DESIGN ACTIVITIES				CONSTRUCT-ION ACTVS.			USE ACTIVITIES					
										BUILDING RELATED ACTIVITIES			
	ORGANISATIONAL A.	ARCHITECTURAL D. A.	ENGINEERING D. A..	MANUFACTURING D. A.	ORGANISATIONAL A.	SITE PREPARATION A.	BLDG. CONSTR. A.	PROFESSION RLTD. A.	INDIVIDUAL RLTD. A.	CLEANING	MAINTENANCE	REFURBIHSMENT	DEMOLITION
DESIGN PERIOD	●	●	●	●									
CONSTRUCTION PERIOD					●	●	●						
USE PERIOD	●	●	●	●	●	●	●	●	●	●	●	●	
RETIREMENT											●	●	●

● Primary Affection ● Secondary Affection

2.3.2.2.C. Hardware of The Building

Hardware of the building is the shaped, sized and fabricated physical appearance of the building which exists as the result of the building design and construction activities. Hardware of the building can be accepted as the body of the building which covers all its physical parts. Those physical parts of the building have been classified in many studies which are related to the building construction, classifications, standards, rules, etc. The CI/S*f*B Specifications of the building and the building product are the most internationally accepted classifications [73,86-88].

In The CI/S*f*B Specification Table 1, those physical parts of the building have been classified in eight main groups [73,86-88]. These are:

(1-) Substructure; ground, floor beds, foundation and retaining walls, etc., (2-) Superstructure; external and internal walls, floors and galleries, stairs and ladders, roofs, building frames, chimneys, etc.,

(3-) Completion of structure; windows, doors, suspended ceilings, roof lights, and balustrades and barriers, etc.,

(4-) Finishes to structure; wall finishes, floor finishes, ceiling finishes, roof finishes, etc.,

(5-) Services; refuse disposal, drainage, water, gas, refrigeration, heating, ventilation, etc.,

(6-) Installations; power, lighting, communication, transport, security, fire and lightning protection, etc.,

(7-) Fixtures; circulation fixtures, general room fixtures, culinary fixtures, sanitary fixtures, cleaning fixtures, storage fixtures, etc.,

(8-) Loose equipment; circulation loose equipment, general room loose equipment, culinary loose equipment, sanitary loose equipment, cleaning loose equipment, storage loose equipment, etc.

Besides, in the same specification table, these eight groups of building elements have been briefly summarised as substructure; fabric of the building which covers superstructure, completion and finishes; services and installation; and fittings which covers fixtures and loose equipment (86).

Another summary of building elements has been given as constructional elements which covers substructure, superstructure and completion; services which covers all services and installations; and contents which covers finishes, fixtures, and equipments (43).

In this research, The CI/S*f*B Specification is accepted as the basic detailed building elements classification, and all these building elements are summarised as in Table 7.

Table 7. Consideration of Building Hardware Elements and The CI/S*f*B Building Elements Specification

<table>
<tr><th>Building Hardware Elements / CI/S*f*B Specification</th><th>STRUCTURAL ELEMENTS</th><th>SERVICES</th><th>CONTENTS</th></tr>
<tr><td>(1-)Substructure</td><td>(a) Substructure</td><td rowspan="6">(a) Environmental Services
*heating,
*ventilation,
*lighting, etc.

(b) Supply Services
*gas,
*hot & cold water,
*electricity, etc.

(c) Disposal Services
*waste removal,
*drainage, etc.

(d) Central Plant</td><td rowspan="6">(a) Fittings

*all fixture elements</td></tr>
<tr><td>(2-)Superstructure</td><td>(b) superstructure</td></tr>
<tr><td>(3-)Completion</td><td>(c) completion</td></tr>
<tr><td>(4-)Finishes</td><td>(d) finishes</td></tr>
<tr><td colspan="2">(5-)Services</td></tr>
<tr><td colspan="2">(6-)Installations</td></tr>
<tr><td colspan="3">(7-)Fixtures</td><td rowspan="2">(b) Furniture

*all loose equipment</td></tr>
<tr><td colspan="3">(8-)Loose Equipment</td></tr>
</table>

2.3.2.2.D. Environment of The Building

Environment is the particular surroundings in which people and other creatures such as animals and plants live. Also environment is the particular conditions and events which affect the life of people and other creatures [37]. These surroundings, conditions and events exist either naturally or artificially.

The earth itself is the main natural surrounding; outdoor climate, temperature, daylight, darkness, outdoor air, etc. are the natural conditions;

and movements on the earth, wind, rain, snow, etc. are the natural events. Thus the natural environment covers all these aspects even the people and other creatures themselves.

The built surroundings such as cities, urban areas, location, neighbourhood, building, etc. are the artificial surroundings; the built conditions such as indoor climate, temperature, indoor air, lighting, etc. are the artificial conditions. As the main events, people's activities take place within the built surroundings and are affected by the artificial conditions. The built environment covers all man-made surroundings, indoor conditions, and people's activities.

One of the main components of the built environment is the building itself. The environmental characteristics of the building have been described in many studies [43,77,89-93]. According to the research area, these studies cover some particular environmental characteristics of the building.

The studies in applied science and technical research area [43,77,89-93] mostly show two main environmental features of the building. These are the spatial features which are the shape, size, orientation, location, etc. of the building; and the physical features of the building which are indoor temperature, humidity, light, sound, indoor air, etc.

The studies in design and social science [40,93-95] indicate the social characteristics of the internal environment which are related to the people's behaviour, attitude, culture, etc.

Those of spatial, physical, and social characteristics are related to the internal environment of the building.

However, the building, itself, is surrounded by natural and other built surroundings and conditions. Existing buildings around the building, neighbourhood, city, district, flora and fauna, etc. are the outer surroundings of the building. Outdoor climate, public services such as transport, water, electricity, gas, etc. are the outer conditions of the building.

Thus, the environmental characteristic of the building can be classified into two main groups which are indoor environment and outdoor environment of the building.

a. Indoor Environment of The Building

It can be, generally, said that as a built environment the building has three main internal environmental characteristics. These are:

(a_1) The building as a spatial environment,
(a_2) The building as a physical environment,
(a_3) The building as a social environment,

(a_1) The Building as a Spatial Environment

People's needs and requirements which are related to the existence of the building lead the people to produce the building. This is the conceptual existence of the building (Part 2.3.2.1. The Existence Stages and Periods of The Building, Figure 7. The Conceptual Physical Existence Chain of The Building). In this broad flow chart the sequence of actions in the building production are shown in following order:

people's needs → requirements → building.

From this general concept, the sequence of the actions can be detailed to establish the specific areas within the building. In this case, people's requirements lead the people's purposes to be established, and these purposes lead the function of the building to be set. People's requirements, also, set the people's activities within the building, and people's purposes and the function of the building meet those of the activities within the building. This order brings the need of the space(s) within the building, eg space for cooking, space for sleeping, space for working, etc. These spaces form the units within the building, eg kitchen, bedroom, office, etc. The arrangement of these units forms the building, eg house, office building, school, etc.

This detailed sequence of the actions in the conceptual existence of the building is shown in Figure 8.

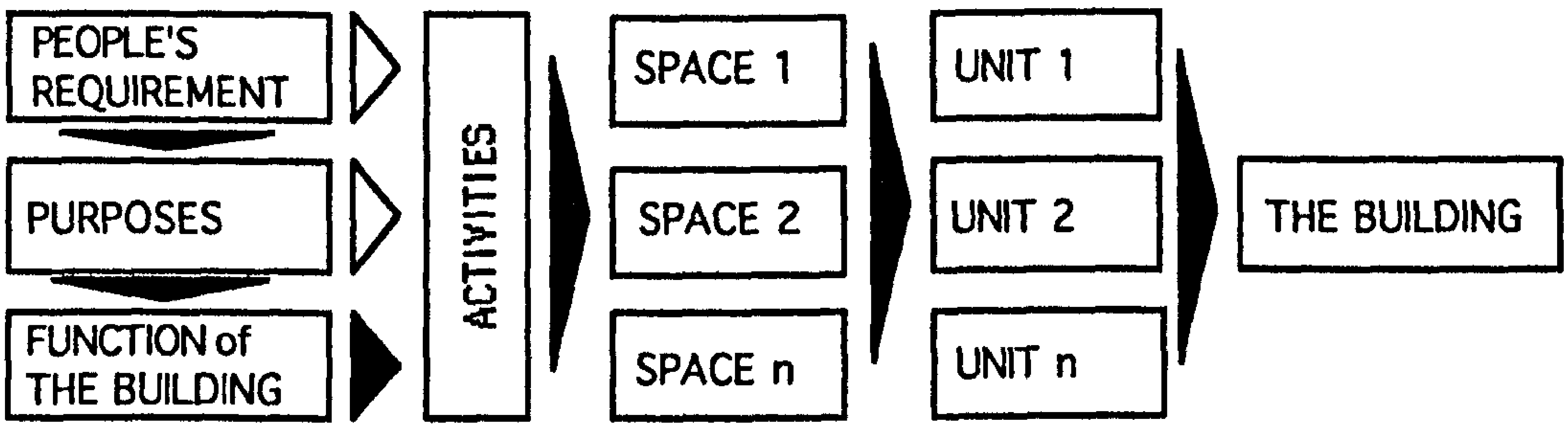


Figure 8. The Sequence of The Actions in The Conceptual Existence of The Building

The space is people's first surrounding within the building, and the unit is the second surrounding. Finally, the building itself is the main surrounding which is formed by units and spaces. These three levels of the surroundings exist by giving dimensions, which are length, width, and height, to the space, unit and the building. Also, arranging their location and deciding their form are important features in their existence.

The spatial existence of the space, unit, and building makes the whole surrounding, which is the building itself, a spatial environment. The building as a spatial environment has some characteristics [35,40,43]. These characteristics have been grouped under four headings which are geometry, form, location, and adaptability of the space [40].

The spatial characteristics of the space, unit and building:

($a_{1.1}$) Dimensional characteristics

. length,
. width,
. height,
. size
. volume

($a_{1.2}$) Formal characteristics

- . shape
- . layout
- . proportion
- . orientation

($a_{1.3}$) Locational characteristics

- . functional connections
- . physical similarities and/or differences
- . dimensional similarities and/or differences
- . formal similarities and/or differences
- . utilisation
- . zones

($a_{1.4}$) Flexibility

- . functional changes
- . adaptability to new utilisation
- . expansion
- . mobility

(a_2) The Building as a Physical Environment

The space(s) and unit(s) within the building, and the building itself have physical conditions such as temperature, humidity, lighting, noise, etc. These conditions differ according to the function and the utilisation of the space, unit and the building.

People respond to the of physical conditions within the space, unit and building. This response occurs with people's sensory systems. People perceive the light, colour, spatial environment, etc. with their eyes, and perceive the sound and noise with their ears. They breath the air, and respond to the odour with their nasal system. They feel the characteristics of the surfaces by touching, and absorb the heat through their skin sensation. Therefore, people's sensory systems are important to classify the physical conditions within the space, unit and building.

In studies which are concerned with the environmental design aspects the classification of these physical environmental conditions has, generally, been done according to people's sensations (43,40,89-93,96). Also, the familiarity of the physical conditions to each other is another important factor for their categorisation. For example, although feeling the temperature is related to the skin sensation, and feeling the air quality is related to the nasal system both of them have been classified in the same group because they are both features of the atmospheric condition within the environment.

The physical features which are related to the environmental conditions of the building can be classified in four main groups. These are:

($a_{2.1}$) Atmospheric features of the physical internal environment

- Thermal Features
  - . temperature,
  - . humidity,
  - . air movement,
- Indoor Air Quality
  - . indoor air pollution
  - . ventilation
- Electromagnetic Radiation

($a_{2.2}$) Visual features of the physical environment

- Lighting
- Reflection, brightness, glare
- Colour

($a_{2.3}$) Auditory Features

- Acoustic
- Sound
- Noise

($a_{2.4}$) Features related to the Sense of Touch

- Texture of the surfaces
- Softness and/or hardness of the surfaces

(a_3) The Building as a Social Environment

People as users act within the building. The nature of people's actions are more than automatic movements which are done in sequence. Although there are general instructions which show how to do different kinds of jobs, and general acceptances that show how to maintain relationships with other people, etc., people's actions show different characteristics due to people's behaviour.

The instructive classification of people's activities is done in Part 2.3.2.2.B Activities During The Existence of The Building as design activities, construction activities, and use activities.

People interact with their surroundings and the conditions as well as they react to them. This communicative situation appears in people's behaviour. The factors which have influence on people's behaviour have been indicated in the studies which are concerned with the people and their environment [91,93-95,97,98,100]. These factors can be defined as personal identification, social characteristics, socio-cultural characteristics, and physical and psychological interaction.

The building should be able to provide the factors to maintain people's relationships between people and their surroundings including other people and things. Therefore the building as a built environment has social characteristics.

The social characteristics of the building:

($a_{3.1}$) User identification

Classification: human based users=people: occupants, non-occupants; non human based users: animals, plants, machinery and equipment.

Categories: individual; group.

Identity: age; sex; health condition / disability.

Occupation: job description; job level; time of occurrence; duration.

($a_{3.2}$) Social characteristics

Privacy

Personal space

Territorial behaviour

Crowding

Community

($a_{3.3}$) Socio-cultural characteristics

Customs

Lifestyle

Traditions

($a_{3.4}$) Physical and psychological interact

Health

Safety

Comfort

Security

Functional appropriateness

Adaptation

Aesthetic / delight

b.Outdoor Environment of The Building

Outdoor factors which limit and control the relationship between the building and the external environment can be classified in four main group (35,40). These are; outdoor spatial features / site; topographic features; outdoor physical features; outdoor services for the building.

(b_1) Outdoor spatial features

size of site

usable area

location

access

neighbourhood / existing buildings

(b_2) Topographic features

geography

seismic area

ground water

soil characteristics / load-bearing

(b_3) Outdoor physical features

($b_{3.1}$) atmospheric features

. temperature

. humidity

. wind

. rain / snow

. sun

. outdoor air quality

. radiation; electromagnetic and radioactive

($b_{3.2}$) flora and fauna / ecological features

. trees, bushes

. wild life / animals

. environmental pollution; soil, water, air pollution

. noise

(b_4) Outdoor services for the building

water

electricity

gas

telephone

sewer

transport; public and private transport, parking etc.

2.3.2.2.E. Resources for The Existence of The Building

Resources are important features of the building. The realisation of the building is dependent on the existence of the resources. Land, materials, tools and machinery, money, time, energy, people themselves, rules and regulations, publications, etc. have been indicated and grouped as the resources of the building and/or design in related studies [36,38,40,101,102].

The resources of the building are, here, classified into four main groups. These are:

(a) People
- (a1) Client, user, developer
- (a2) Design team; architects, engineers, surveyors, etc.
- (a3) Construction team; contractors, workers, etc.
- (a4) Suppliers; manufacturers, traders, services boards, etc.
- (a5) Control authorities; government, local authorities, institutes, etc.

(b) Integrative resources
- (b1) Finance
- (b2) Time
- (b3) Energy
- (b4) Work place
- (b5) Management

(c) Information resources
- (c1) Rules and regulations
- (c2) Science
- (c3) Publications
- (c4) Experience
- (c5) Case studies
- (c6) Evaluation / Feedback

(d) Technology
- (d1) Materials
- (d2) Building components
- (d3) Tools and machinery

2.3.2.3. Evaluation of The Building

During the whole life of the building, people evaluate the building from different points. These evaluations are necessary to make judgments on whether the building meets people's requirements or there is a failure of its quality.

The studies about building evaluation (43,57,59,71,75,76,80,84,86,103-108) indicate the evaluation areas within the building. Technical performance, fitness for purpose, user satisfaction, well-being, costs, and uncertain situations are the areas in which the building is evaluated. These evaluation areas can be classified into three main groups. These are; (a) performance evaluation of the building, (b) cost evaluation of the building, and (c) risk evaluation of the building. The classification of the building evaluation areas is shown below, Figure 9.

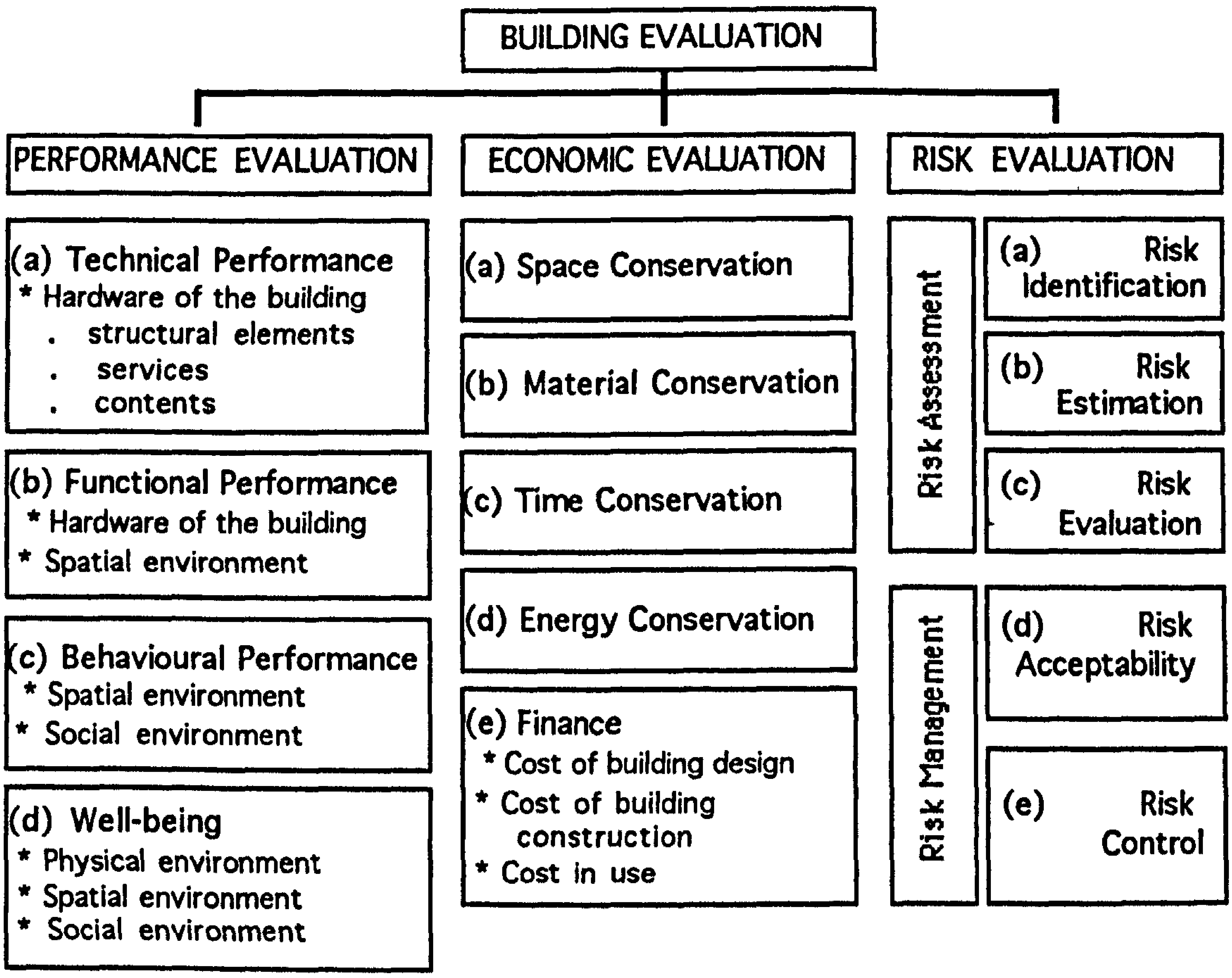


Figure 9. Elements of The Building Evaluation

People's requirements and activities are the main criteria for the building evaluation. Therefore, identification and classification of requirements and activities are important to make a healthy judgement about the building. Also, this identification addresses the features of the building that should be evaluated according to those of classified requirements.

People's requirements related to the technical, functional, behavioural and well-being aspects are the criteria to evaluate the performance of the building (45,76,80).

The technical requirements such as durability, stability, rigidity, maintainability, loads, etc. are the criteria for the evaluation of the technical performance of the building. Technical aspects address the hardware features of the building which are structural elements, services and contents.

The functional performance of the building is measured according to the functional requirements such as fitness for purpose, adequacy, utility, etc. Functional requirements address the hardware and spatial features of the building.

Behavioural expectations such as privacy, community, communication, etc. lead to the evaluation of the social characteristics of the building.

User's well-being, health and safety, psychological comfort and satisfaction are the criteria for the evaluation of mainly physical features of the building. Besides they are used to evaluate spatial and social characteristics of the building.

People evaluate the building according to their economical expectations. These are space conservation, material conservation, time conservation, energy conservation, and finance which covers the design, construction and running costs of the building (57,59,71,75,80).

People's requirements are determined criteria for the performance and economic evaluation of the building. The performance and economic evaluation of the building show the quality of the building.

However, the definition of the quality has been given as " the totality of features of a product or a service that satisfies the stated or implied needs 'meeting agreed requirements' " (104,106,109). From this, the determined and suggested requirements within the building evaluation help to set the performance and economic values of the building. But, still there are possibilities that unpleasant or undesirable things might happen and cause danger within the building. Therefore, those uncertainties within the building should be considered to complete the total qualitative evaluation of the building. This is the risk evaluation of the building.

2.3.2.3.A. Risk Factor in The Evaluation of The Building

The definitions of risk have been given in related studies (106-108,110-112). According to these definitions, risk is;

* the probability of accidental or unexpected losses and damages such as loss of people's life, health, material, and environmental damage, etc. (111), and

* the potential to realise what is likely to happen in an event (107).

In the decision-making, all the losses and the chain of events should be taken into account. Therefore, the consideration of all the facts about the event, and suggesting what is likely happen in the event, are the subjects of a study which is 'Risk Assessment' (106,107,112). Determining the acceptability of estimated risk, and making a judgement or giving an opinion about the position, are the subjects of 'Risk Management' (104,112).

Risk identification, risk estimation and risk evaluation are the elements of the risk assessment (106,107,112). Acceptability and control are the elements of the the risk management (112P). The elements of the risk assessment and risk management are shown in Figure 10.

These elements of risk assessment and risk management, also, give the hazard evolution and the control of the hazard within the building.

In this research, the risk of indoor air pollution within the architectural design of the building will be evaluated. Figure 11 shows the general model of hazard evolution and control chain in the building. This model will be used for consideration of architectural design of the building and indoor air quality.

The performance, economic and risk evaluations within the building are done in all stages which are design, construction and use stages of the building. Results of these evaluations show how the design, construction and use of the building meet people's requirements. These results are important to operate and maintain the building according to user's expectations. Therefore, they provide valuable feed-back to each stage. Also, these results are the informative resources for the new building.

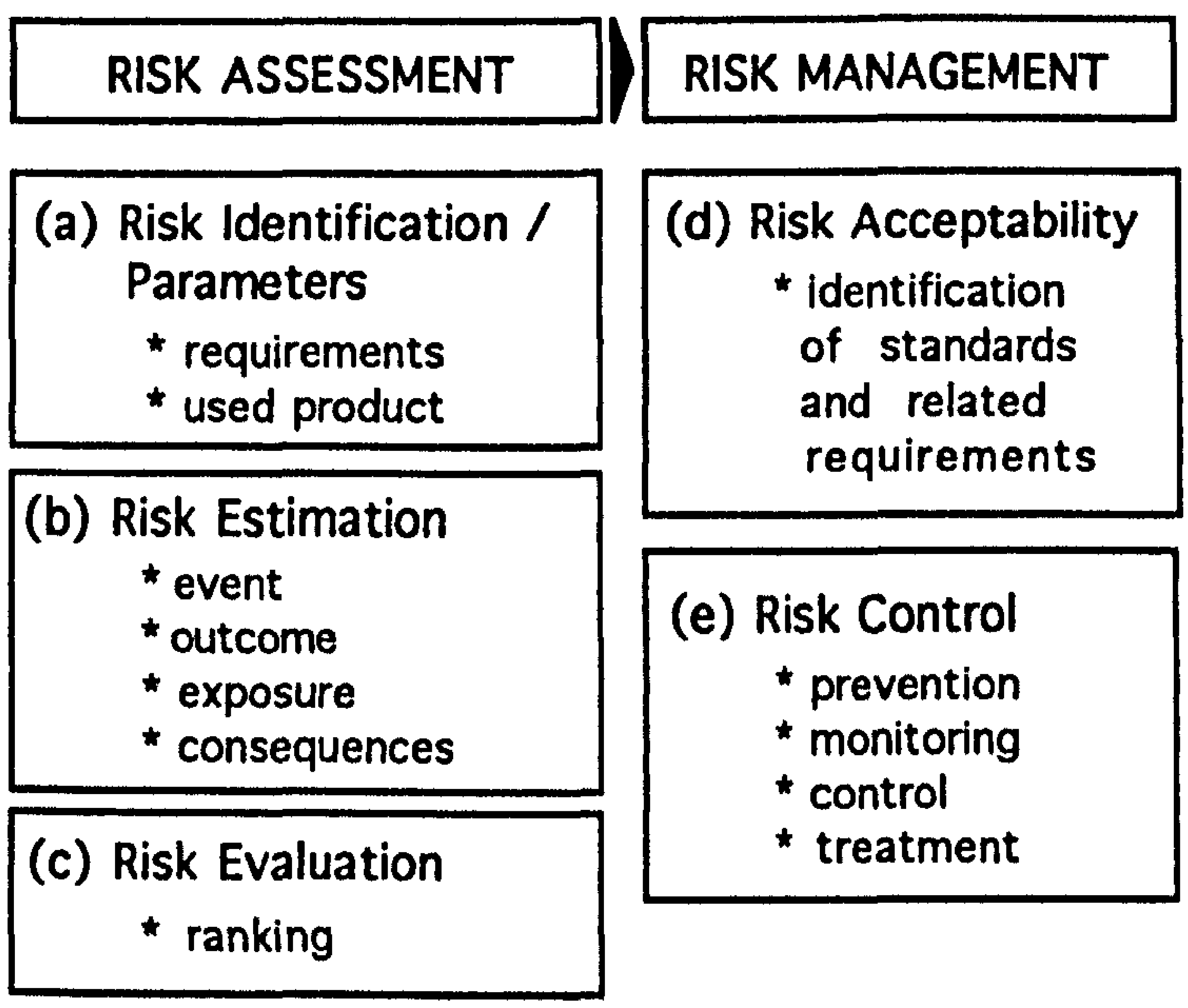


Figure 10. Elements of Risk Assessment / Risk Management

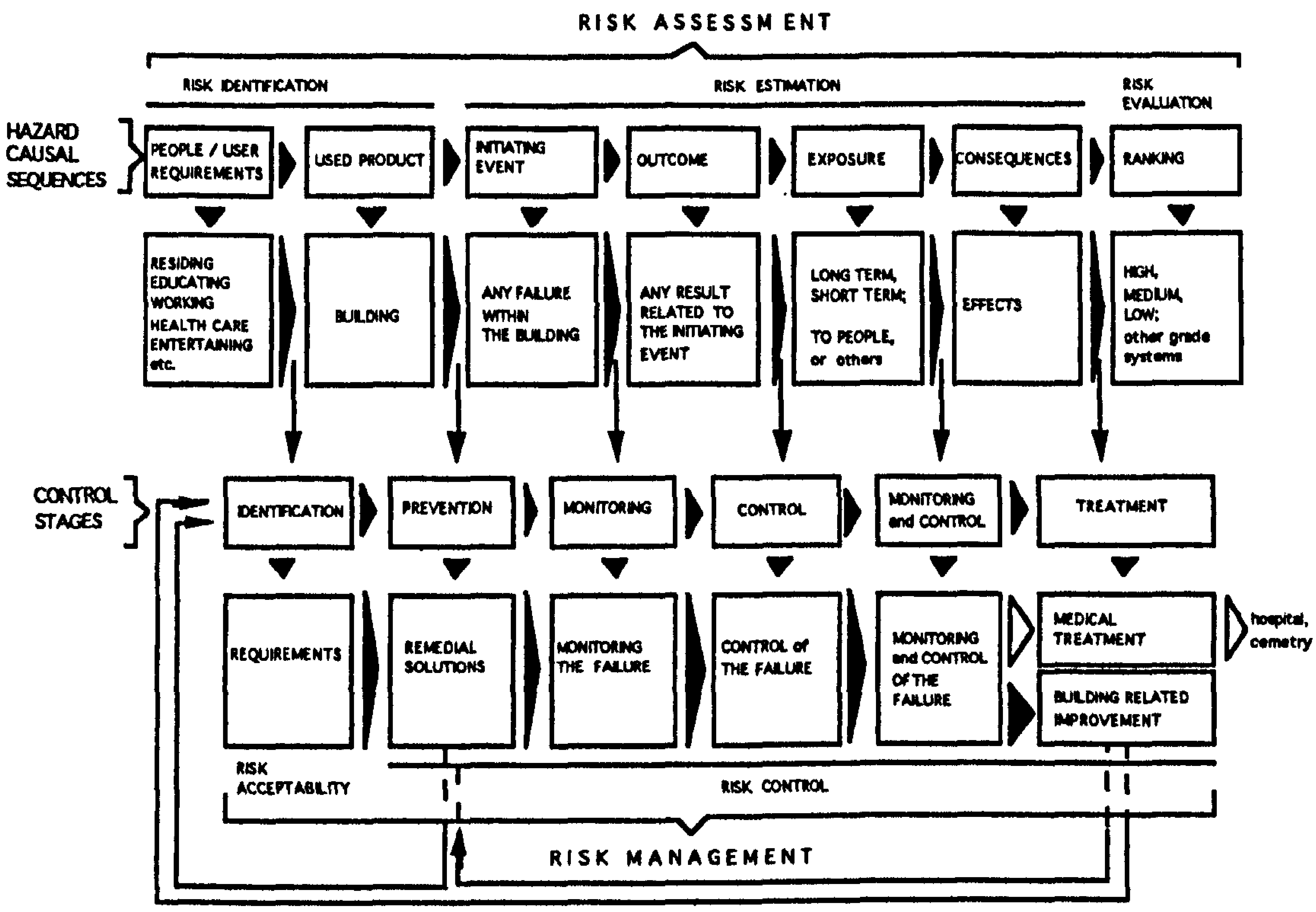


Figure 11. The Hazard Evolution and Control Chain Model for the Building

2.3.3. The Building as a System

Although, as a term, the building is referred to as a formed and produced structure (Part 2.3.1.The Building), it can be clearly seen that the life of this product is full of objects, their relationships, and interdependent processes (Part 2.3.2. The Life of The Building). The systematic arrangement of all these objects, their relationships, and interdependent processes is essential to improve the thought, solve the problems, set the policies, and make the correct decisions within the whole life of the building. This systematic combination of the features of the building brings the idea of accepting the building as a system.

2.3.3.1. The Elements of The Building System

The effective features for the existence of the building are described as objectives, activities, hardware, environment of the building and resources of the building (Part 2.3.2.2. Effective Features for The Existence of The Building). The presence of those of features is important to complete the whole which is the building. There will not be a starting point for the existence of the building if there is no objective. The realisation of the building cannot be achieved without resources. The activities are necessary to turn the objectives and resources into a product. The physical existence of the building becomes impossible without the hardware; and the environment of the building is essential to make the building a usable product for the people. Thus, the individual existence and the inseparable relationships of those of features make them the elements of the whole which is the building system.

From this, the elements of the building system are the objectives, resources, activities, hardware and environment of the building.

Besides, the features of the building have their own instructions which systematically show the parts and the processes of each feature. Hence, each of the building features becomes an individual system which is the subsystem of the whole building system.

The combination of these elements, which are objectives, resources, activities, hardware and environment of the building, and their position within the whole system are shown as the elemental model of the building system in Figure 12.

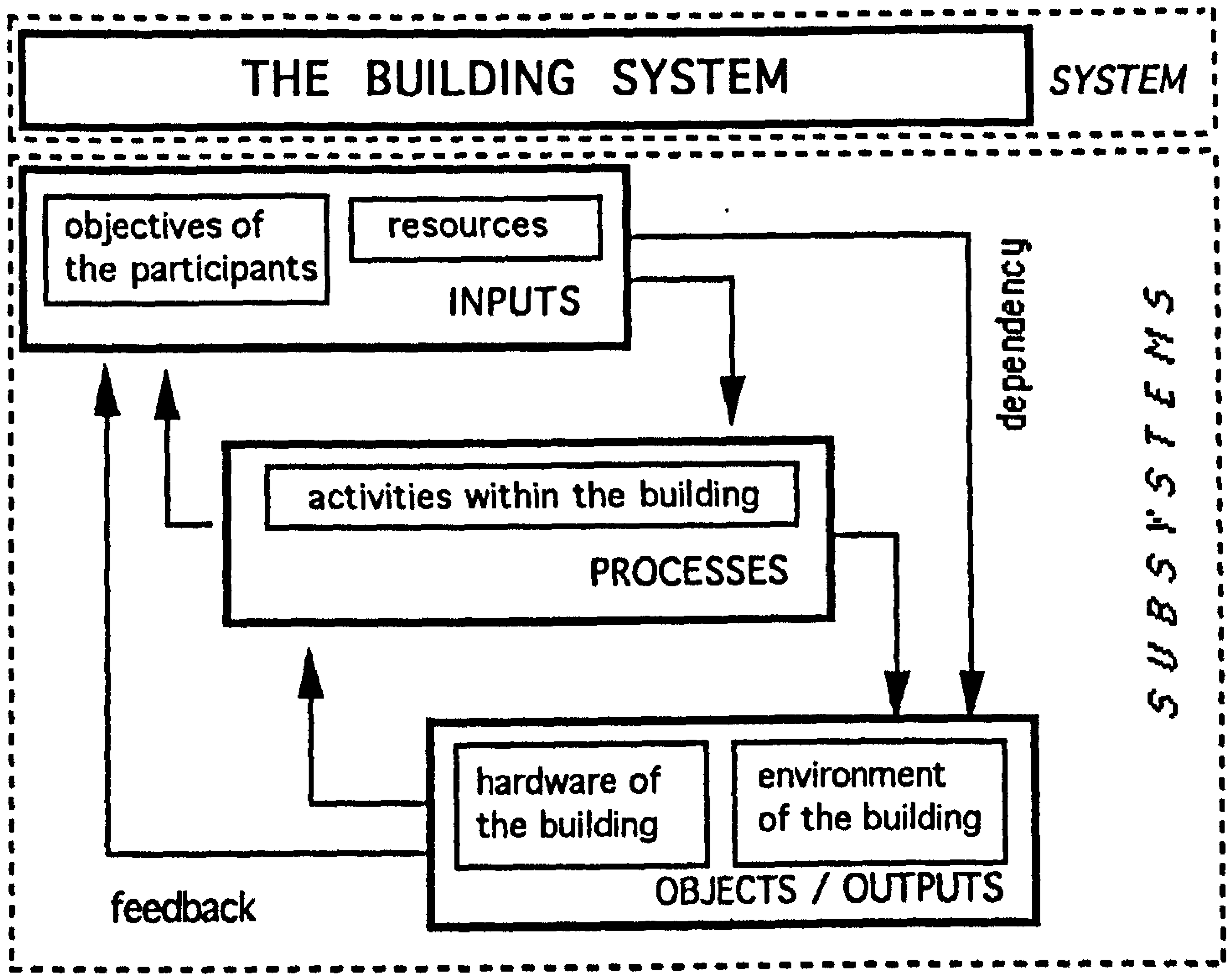


Figure 12. The Elemental Model of The Building System

2.3.3.2. The Building System Model

The elemental model indicates the brief structure of the whole of the building system. From this, conceptualising each element of the building system is necessary to make a pathway that shows the connections between the elements which are the objectives, resources, activities, hardware and environment of the building.

The concepts of the elements, which are, also, subsystems of the building system, are described in Part 2.3.2.2. The Effective Features for The Existence of The Building, are placed in the main conceptual system model which is shown in Figure 4. The Main Conceptual System Model.

From this, the conceptual building system model is obtained as below, Figure 13.

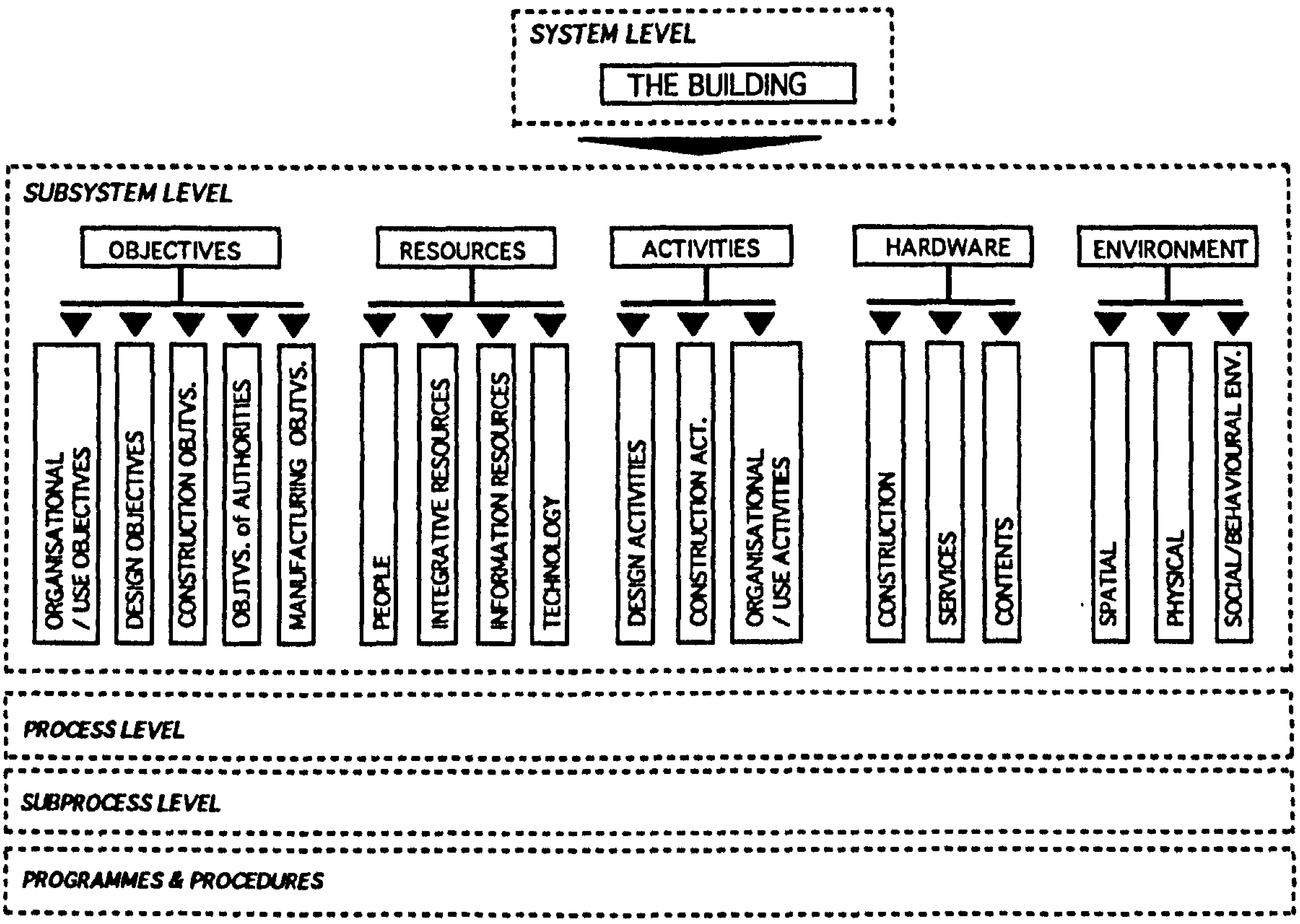


Figure 13. The Conceptual Building System Model

The conceptual openings of process, subprocess and programmes and procedures levels for each subsystem of the building system are separately done in the following section of this part of the research.

2.3.3.2.A. The Objective Subsystem of The Building System

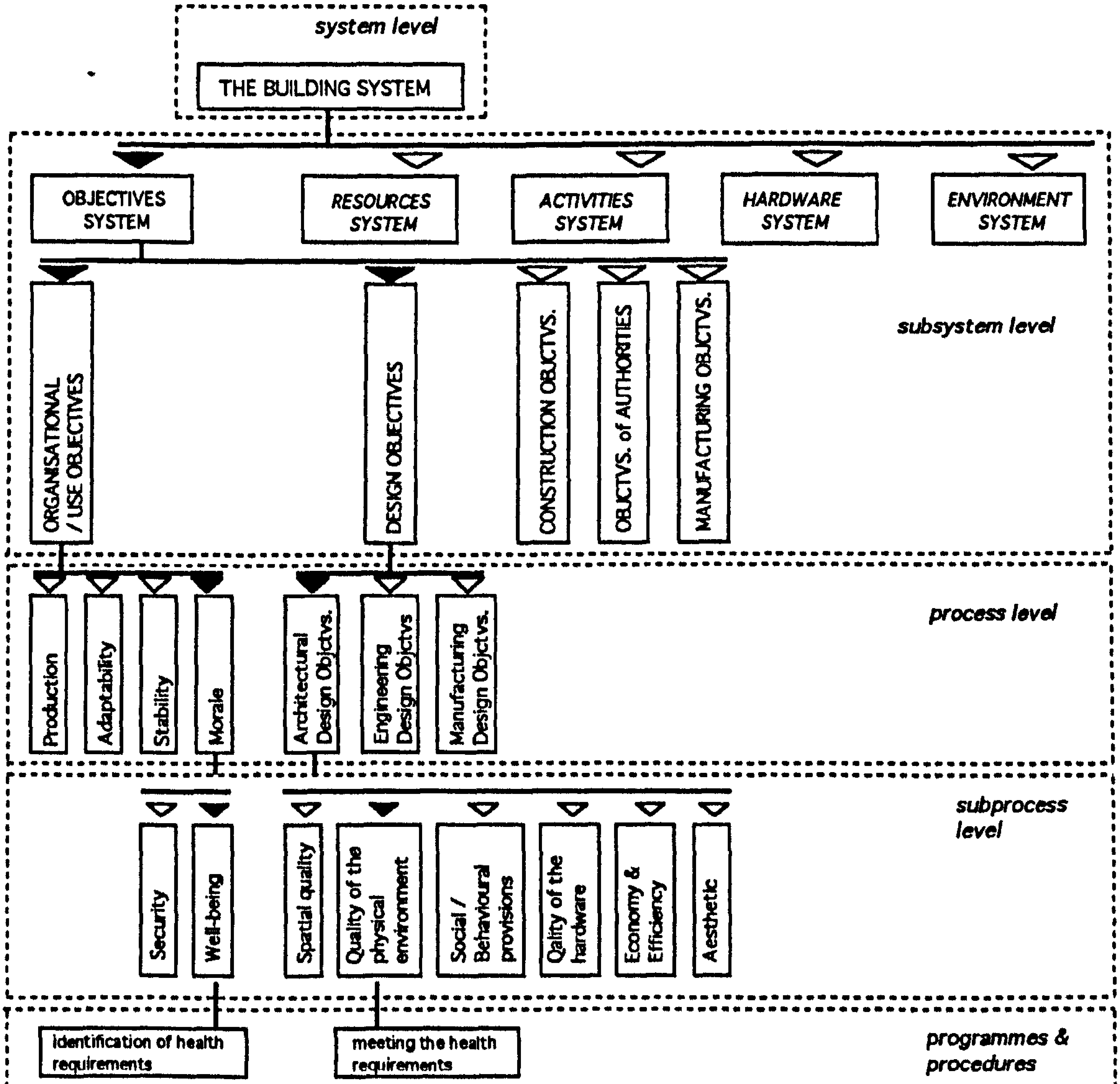


Figure 14. The Concept of The Objective Subsystem of The Building System

2.3.3.2.B. Resources Subsystem of The Building System

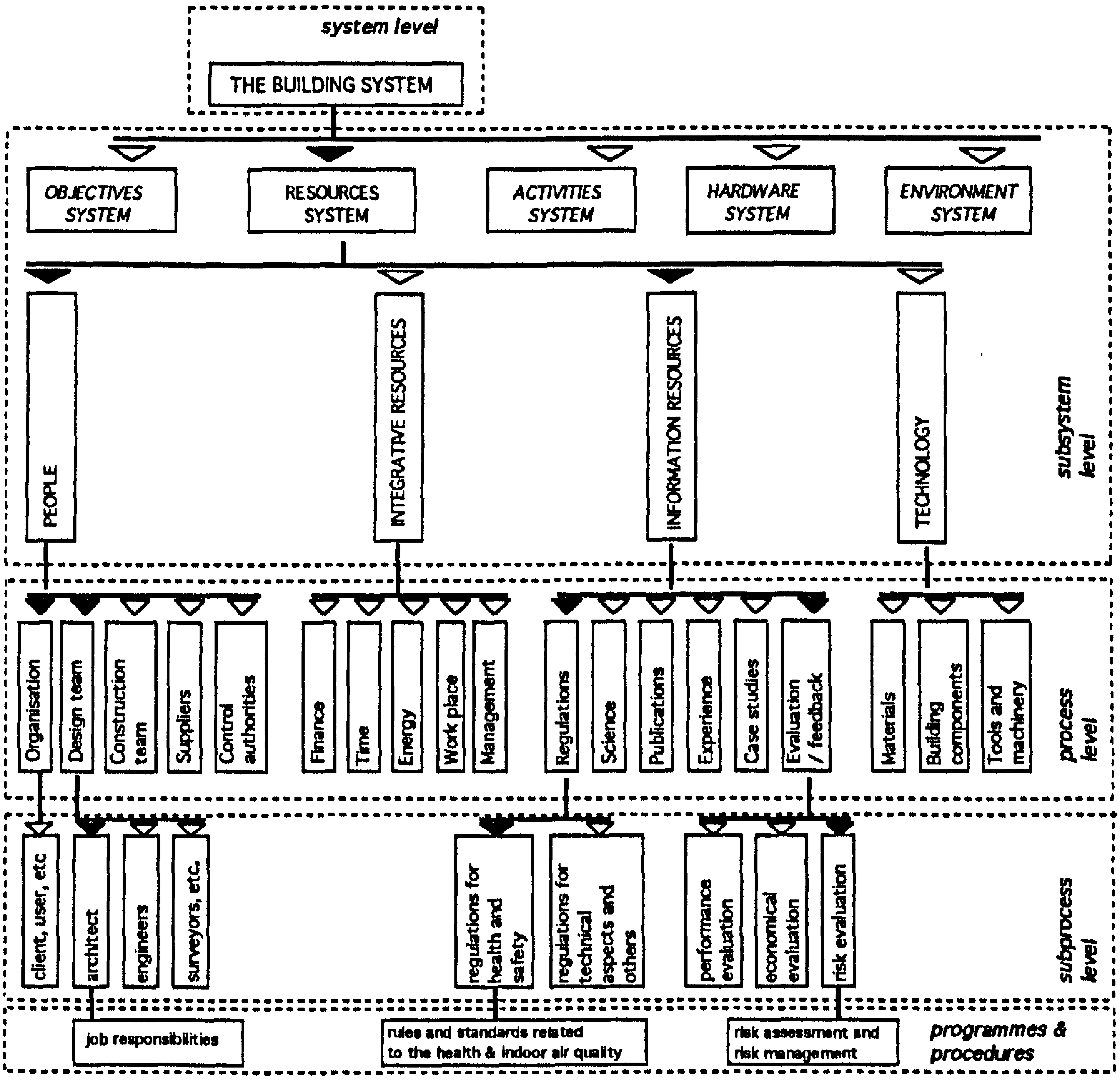


Figure 15. The Concept of The Resources Subsystem of The Building System

2.3.3.2.C. The Activity Subsystem of The Building System

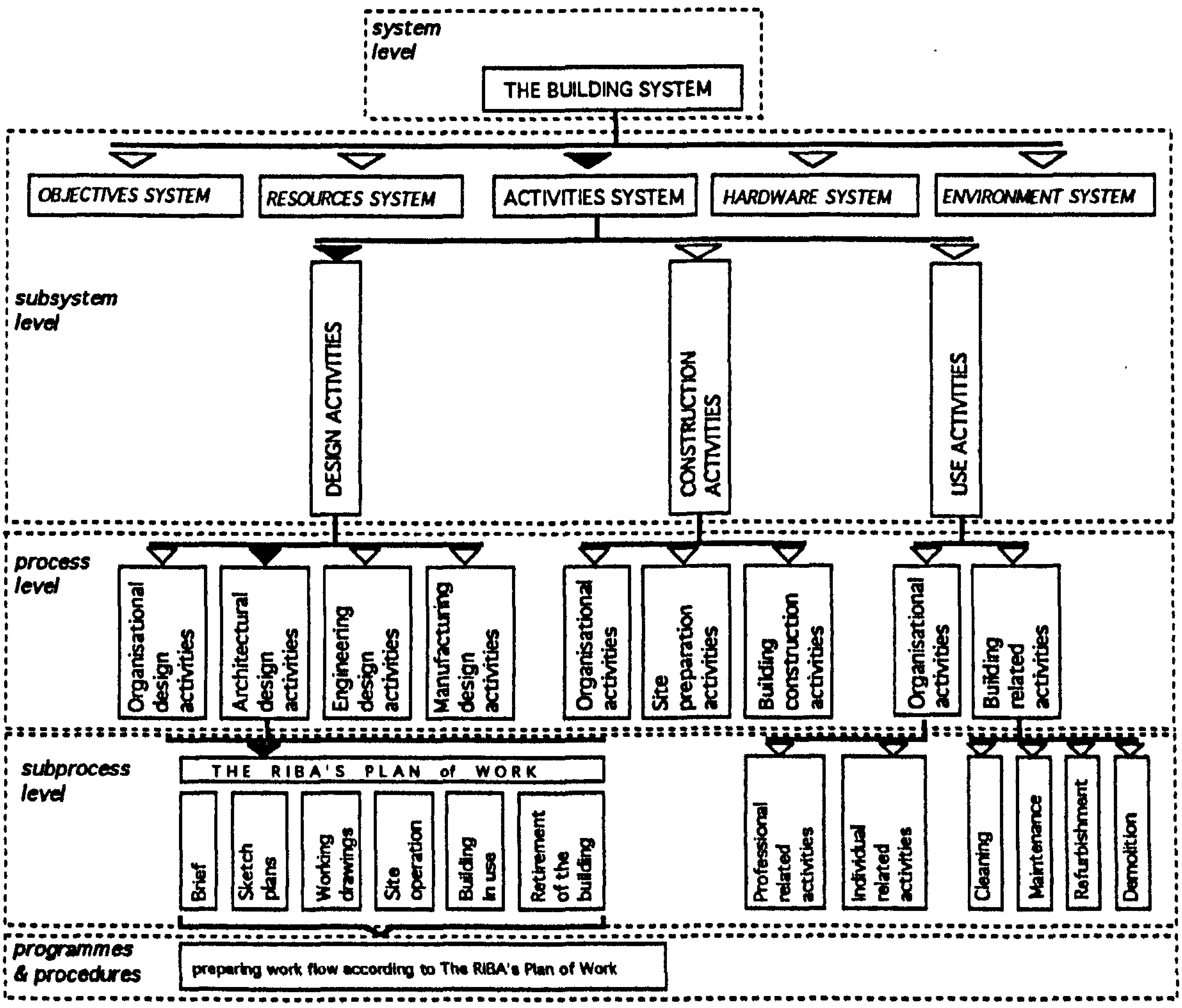


Figure 16. The Concept of The Activity Subsystem of The Building System

2.3.3.2.D. The Hardware Subsystem of The Building System

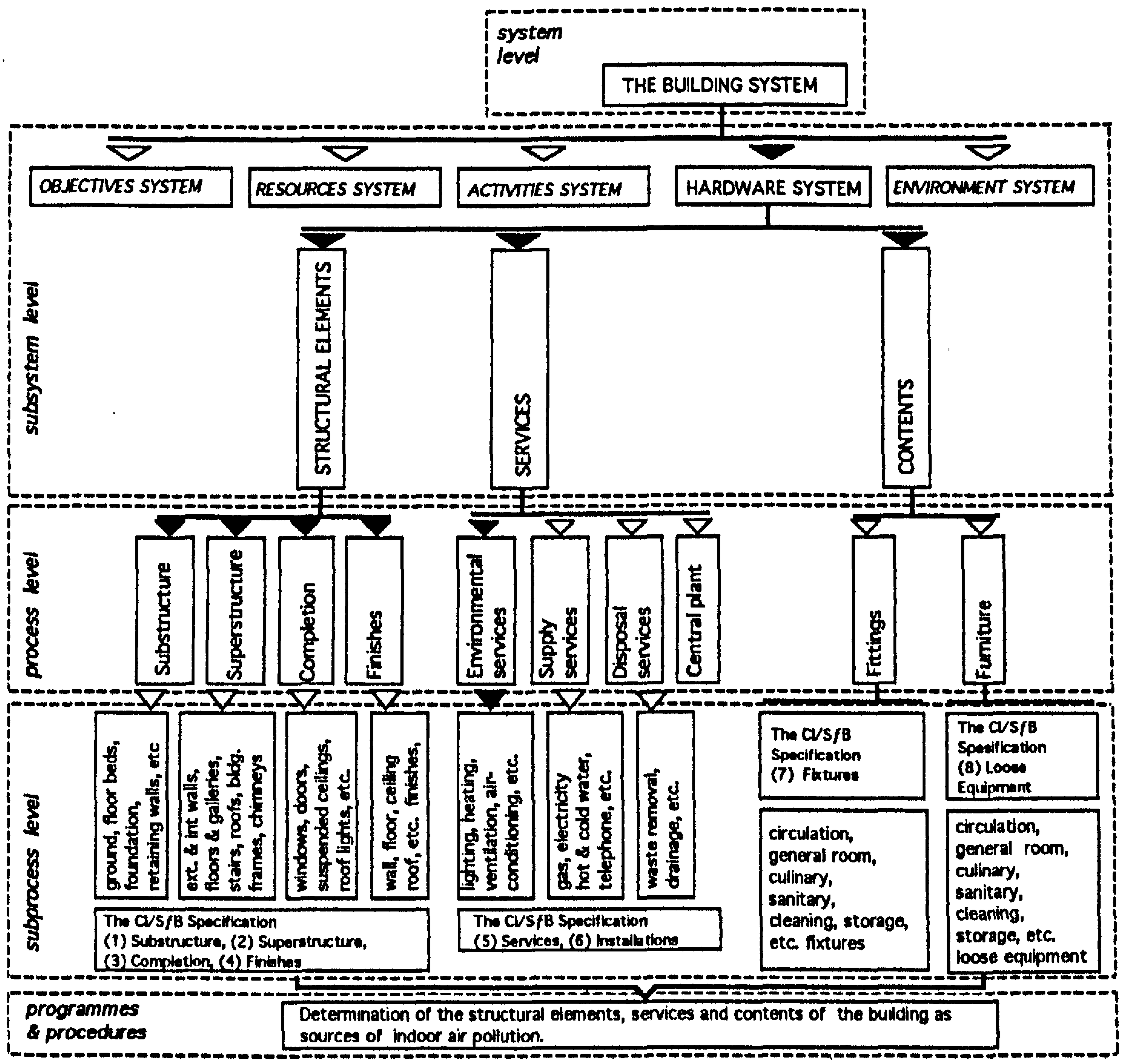


Figure 17. The Concept of The Hardware Subsystem of The Building System

2.3.3.2.E. The Environment Subsystem of The Building System

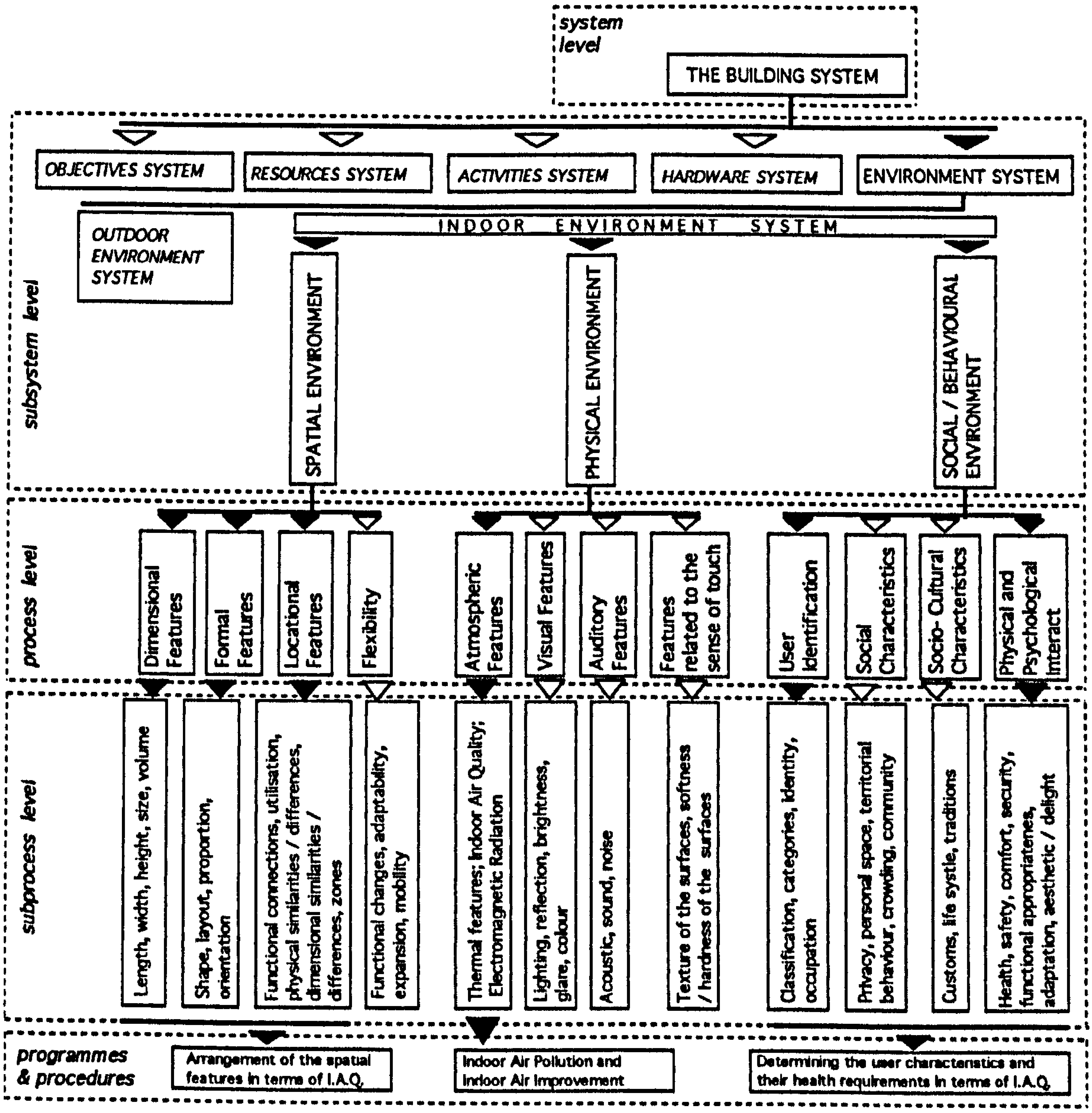


Figure 18.a. The Concept of The Environment Subsystem of The Building System (The Indoor Environment System)

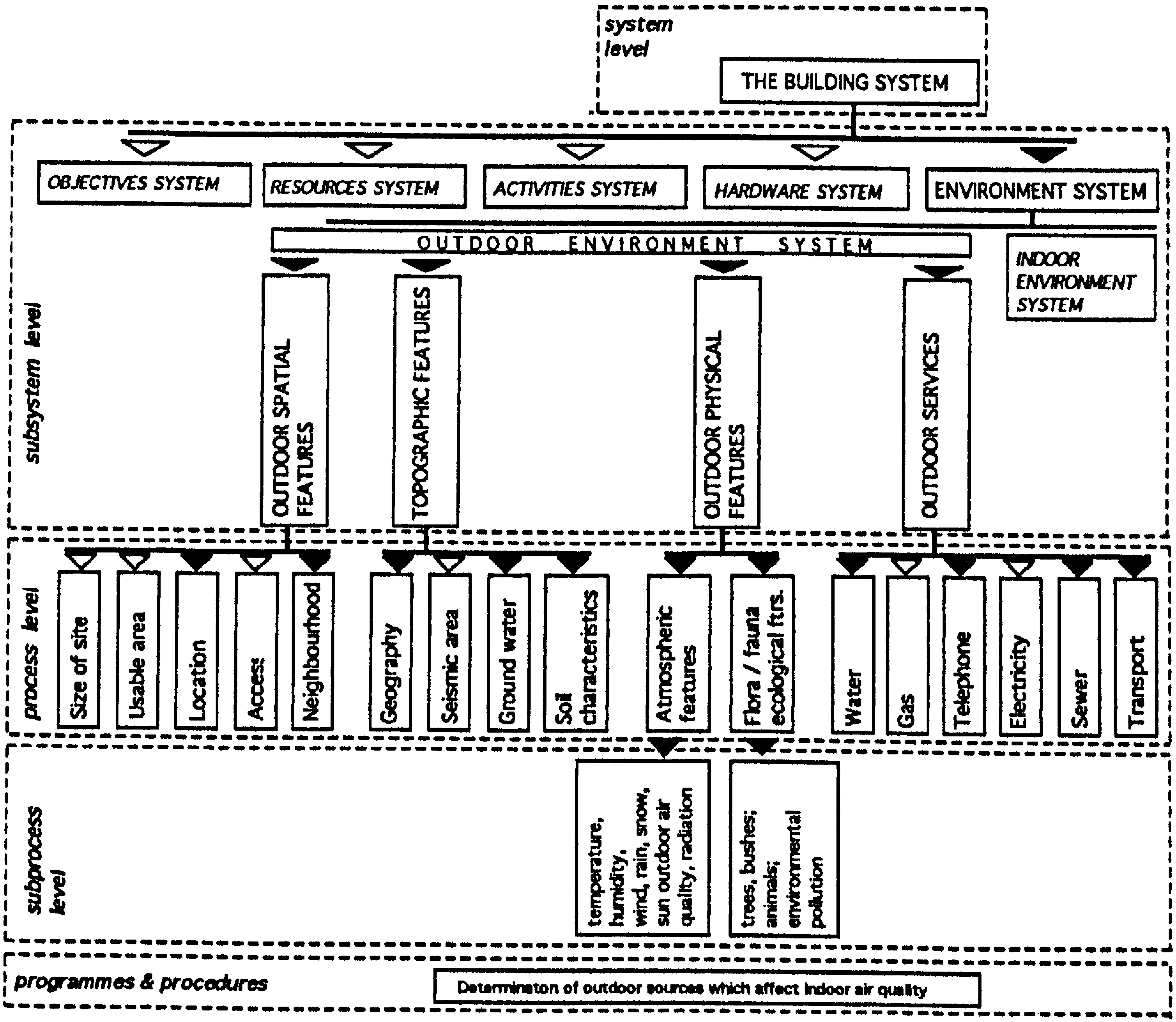


Figure 18.b. The Concept of The Environment Subsystem of The Building System (The Outdoor Environment System)

Part Three : ARCHITECTURAL DESIGN PROCESS

3.1. INTRODUCTION

Building design is the creative process in which a building is produced theoretically. The organisational, architectural, engineering, and manufacturing design activities are involved in the whole building design process. The whole building design process is described as The Design Activity Subsystem of The Building System. Also, the organisational, architectural, engineering, and manufacturing design activities are detailed as the building design processes (Part 2.3.3.2. The Building System Model, Figure 16. The Concept of The Activity Subsystem of The Building System).

The Architectural Design Process is the core of the whole building design. The decisions for the physical appearance of the building and the living conditions within the building are actively taken during the architectural design process. Also, the engineering design processes and the manufacturing design processes take their place within the whole design process according to the architectural design of the building with the assistance of the organisational activities.

The Architectural Design Process of the building is a set of actions. From the elemental model of the building system (Part 2.3.3.1. The Elements of The Building System), the occurrence of these architectural design actions are dependent on the inputs which are objectives and resources. The integration of objectives and resources within the Architectural Design Process is made in a sequence to form the hardware of the building and to determine the environment of the building. The hardware and the environment of the building are the outputs of the Architectural Design Process.

As mentioned in the previous chapter, in this research, the Architectural Design Process of the building will be based on The RIBA Plan of Work. Therefore, in this part, the elements of the Architectural Design Process will be examined according to The RIBA Plan of Work, and the main critical decision points will be identified within the Architectural Design Process.

3.2. THE ELEMENTS of THE ARCHITECTURAL DESIGN PROCESS

3.2.1. The Architectural Design Objectives

During the Architectural Design Process the architects determine their targets to achieve at the end of their work. These targets in the Architectural Design Process have been defined as architectural design goals in related studies (36,40,85). Mainly four issues have been indicated in the architectural design goals (85). These are:

. the functional use which is the utility of the building,
. suitability for the future changes which are the improvisations, functional change and extension,
. avoiding manipulation and designing for others and,
. symbolism and aesthetic.

The use of energy within the building and the cost of the building have been added to those of achievements (36). The environmental provisions of the building, buildability, and the co-operation of the building with the external and internal environment are, also, indicated as the goals of the architects (40).

Here, the objectives of the Architectural Design Process are grouped into six main categories. These are; (a) the spatial quality, (b) quality of the physical environment, (c) social / behavioural provisions, (d) quality of the hardware and buildability, (e) economy and efficiency, and (f) aesthetic. Also, these architectural design objectives are placed within The Building System Model (Figure 14. Concept of The Objective Subsystem of The Building System).

3.2.2. Resources for The Architectural Design

The four main resources of the building system, which are the people, integrative resources, information resources, and technology, are, also, resources for the Architectural Design Process. Resources are involved in the Architectural Design Process according to the stages of the architectural design activities. The concept of the resources are detailed in The Building System Model (Figure 15. Concept of The Resources Subsystem of The Building System).

3.2.3. The Activities of The Architectural Design Process

The architectural design activities are the actions of architects who are the professionally qualified persons to integrate architectural design objectives and resources from the inception of the initial idea to the end of the architectural design process of the building. The architects continue to supervise the completion of the building in the site area, and advise the user during the occupation of the finished building.

As the leader of the design team, the architect acts in two main ways (40,118,119). Firstly the architect needs to communicate with himself / herself, and with the other participants. Secondly, the architect should determine the strategy of the work. Therefore, the architect's activities can be classified into two main groups. These are the communication activities and the decision activities.

3.2.3.1. The Communication Activities

During the Architectural Design Process, the assimilation of the knowledge and the translation of the architect's ideas into visual form is essential for the architect to communicate with himself/herself, and with the other participants. Drawings are the main visual communication devices for this translation (10, 11). At the beginning of the architectural design process, the drawings are essential aids for the architect to develop the ideas and find the solutions. At the end of the Architectural Design Process, the building is described and detailed by drawings. Therefore, two types of drawings are involved in the architectural design. These are sketch drawings and graphic drawings.

(a) The Sketch Drawings

The sketch drawings are the informal ways of 'visual thinking' and 'visual communication' for the architects (118,119). The sketches are the freehand drawings without the use of any instrument. They represent the architect's thought on paper without a lot of details, and are the basis for all further drawings. The general concept of the building is given with the sketch drawings. The proportion is important to give the accurate information, and grid module system, human figures, trees can be used to give scale, depth and natural effect. But the actual size, measurements and small details are not shown at this level of drawing (65,82). At the beginning of the architectural design process, the architect uses more sketches to bring the objectives and knowledge together to develop the idea and alternative solutions.

Diagrams and matrices are used as drawing languages to develop the ideas while the architect is visually thinking with the assistance of sketches.

(a_1). Diagrams

The most common types of diagrams which are used as sketching language in architectural design are the bubble diagrams, circulation diagrams, and area diagrams (65,97,116,118,119).

The bubble diagram is the basic way of showing the functional relationships between spaces. Although, it is very symbolic and abstract, the bubble diagram can be easily modified, rearranged and adapted. Also, new things can be added to the sketched bubble diagram.

The circulation diagram is used to described the traffic flow, distances and routes between the spaces. The circulation diagram is, also, basic drawing which is based on simple lines. It is easy to show the most used traffic routes, private routes and service routes within the building.

The area diagram is the first step to the planning. It is simple freehand drawing which shows the spaces within the building in proportion. The functional relationships between the spaces, the circulation routes and some other information such as orientation of the building, view, relationship with the outdoor environment, etc. are shown in the area diagrams.

(a_2). Matrices

A matrix is a grid in which series of squares are formed by straight lines. It is used to show relationships between things, and to compare things to reach the evaluative decision (65,97,116,118,119). In architectural design, matrices are useful ways to interact the functional use of the spaces and their relationships, relationships between spaces and design issues, the priority of the design issues and spaces. Matrices can be arranged in different forms.

(b). The Graphic Drawings

Once the ideas and alternative architectural design solutions are visualised by sketches, the architect moves to present more intensive drawings for each idea and design solution. This is important to achieve the real appearance of the building. The graphic drawings are used for this intensive visual communication (65, 120-122). The drawing instruments, such as set squares, parallel bar, templates, computer, etc., are used for this type of presentation. The graphic drawings are more detailed and full of accurate information about the building.

Proper dimensioning and actual measurements are important in the graphic drawings. Therefore, the real shape and size of all features and whole building are drawn according to the particular scale. Most common scales for the architectural graphic drawings are 1:500, 1:200, 1:100, 1:50, 1:20, 1:10, and 1:5 (120,122). Also, information about the features which cannot be completely shown in a small scale drawings is given in complete notes and in enlarged scale drawings.

3.2.3.1. The Decision Activities

During the Architectural Design Process, the architect considers these issues:

. the user's requirements and their relationships,

. suitable provisions for those of user's requirements,

. available resources to achieve these provisions, and

. what kind of characteristics these provisions will have and how they will be combined.

While these considerations are taken, various alternatives appear. From the beginning to the end of these considerations, the architect needs to make several decisions which are related to each other. Each decision shows which is the best or most suitable one of various alternatives. This decision-making process is essential to move to the following stage, and to develop the previous decision. Therefore, the Architectural Design Process continues step by step, and the physical and environmental characteristics of the building appear on the papers after decisions.

The design decison-making stages of the Architectural Design Process are examined in related studies (40,118,120). Three main stages, which are the planning stage, design stage and final decision stage, can be pointed in Frey's flow chart of decisions (40).

The planning stage is the initial decision-making stage. The description of user's requirements and available resources, determining abstract principles and forming general ideas about the building are done in the planning stage.

The design stage is the second decision-making stage. Development of the initial ideas, producing and analysing the alternatives, evaluating and synthesising each of the alternatives to achieve the best or most suitable solution are subjects of the design stage.

The final decision stage is the last stage of the design decision-making stages. Deciding the best or most suitable design solution among the other alternatives, working on the details of this solution, completing the whole design of the building, and finally presenting the designed building to the client and contractors are the work to be done in the final decision stage.

These stages have, also, been indicated as an abstraction stage, development and exploration stage, and decision-making stage (118); and schematics, design development, and working drawings stages (120).

Here, the three design decision-making stages are grouped as the conceptual stage, development stage, and final decision and detail stage.

3.2.4. The Objects of The Architectural Design Process

The object of the Architectural Design Process is the designed building which is described and detailed on a set of drawings, and in a list of specifications. Drawings and specifications show the relationships of two inseparable features which are the hardware and the environment of the building. Also, drawings represent the physical appearance of the building.

The features of the hardware of the building, which are the structural elements, services, and contents, are chosen and arranged; the environmental parts of the building, which are the spatial, physical, and social / behavioural features, are characterised and detailed during the Architectural Design Process. Features of the building are conceptually detailed in the Building System Model (Figure 17. The Concept of The Hardware Subsystem of The Building System, and Figures 18.a. and 18.b. The Concept of The Environmental Subsystem of The Building System).

As has been mentioned, the features and the physical appearance of the building are presented with the set of drawings, and specifications.

Therefore, drawings and specifications can be accepted as two main outputs of the architectural design process.

As one of the outputs, architectural drawings have been classified into three main groups. These are location drawings, assembly drawings, and component drawings (65,122). Location drawings are the plans which show the site and floor layout of the building, the sections which show the general construction principles of the building in third dimension, and the elevations which show what the building looks like in terms of physical appearance. The location drawings, also, show where the user's activities will take place within the building. The location drawings are drawn to the scale of 1:500, 1:200, 1:100, and 1:50.

The assembly drawings show the type of the construction of the building, and how the building is put together on site. The sectional plans, vertical sections, and sectional elevations are the assembly drawings. These drawings are drawn to the scale of 1:20, 1:10, 1:5.

The component drawings show the detail of the components of the building, such as doors, windows, floor finishes, roof, etc. These drawings are drawn to the scale of 1:20, 1:10, 1:5, 1:1.

The building specifications are the description of the hardware and the environmental features of the building. Specifications give information about the building materials, components, environmental characteristics of the building, etc. They are related to the architectural drawings, and clearly detailed to tell the contractor how to construct the building on site (120).

3.3. CONSIDERATION of THE ELEMENTS of THE ARCHITECTURAL DESIGN PROCESS and THE RIBA PLAN of WORK

From the consideration of The RIBA Plan of Work and The Existence Stages and Periods of The Building (Part 2.3.2.1.B1), architectural design activities take their place during the conceptual existence and theoretical existence of the building. These two existence stages of the building are equivalent to the briefing, sketch plans and working drawings stages of the RIBA Plan of Work (Table 2. Consideration of The RIBA Plan of Work and The Existence Stages of The Building).

Two critical points have been indicated in The RIBA Plan of Work (113). The first critical point has been stated at the end of the Sketch plans stage which is the second stage of the Plan of Work. It has been indicated that the decisions which are taken at the first stage (Briefing) of the Plan of Work should not be modified after completing the work of the Sketch Plans Stage. The second critical point has been stated in the Working Drawing Stage which is the third stage of the plan of work. The Working Drawing Stage has four substages which are Detail Design, Production Information, Bills of Quantities and Tender Action. It has been indicated that after completing the work of the Detail Design substage, any change in decisions such as change in location, size, shape, or cost of the building will cause abortive work.

The two indicated critical points are general summaries of the decision-making activities. In Table 8 brief consideration of The RIBA Plan of Work and the elements of the Architectural Design Process is shown. Also, the two critical points of the decision-making process are indicated.

However, during the whole design activities there are more decision points than those of two general points. The detailed consideration of elements of the Architectural Design Process and The RIBA Plan of Work gives the additional decision points.

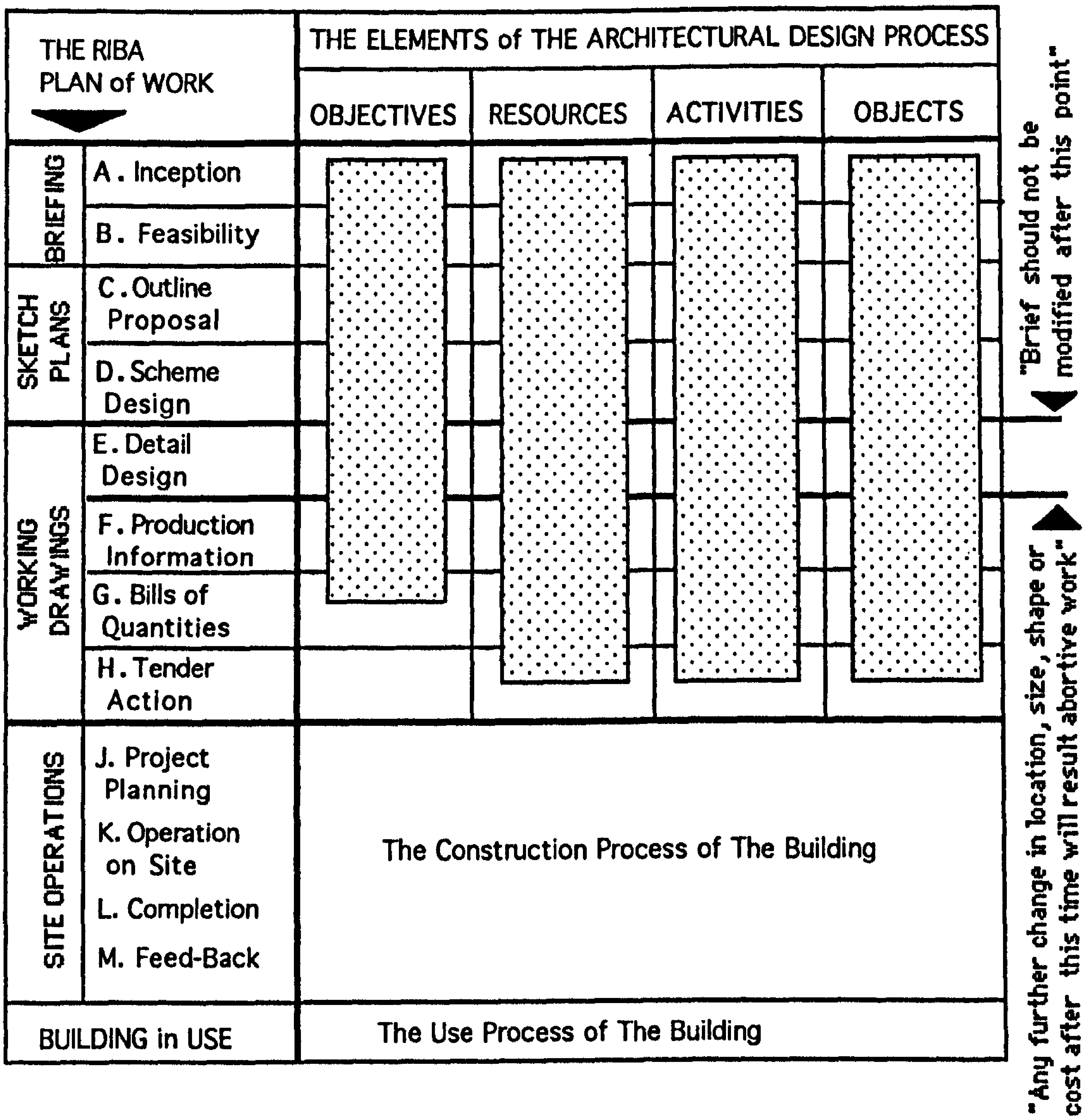


Table 8. Consideration of The RIBA Plan of Work and The Elements of The Architectural Design Process of The Building

3.3.1. The Briefing Stage of The RIBA Plan of Work and The Elements of The Architectural Design Process

The Briefing Stage of The RIBA Plan of Work has two substages, which are A. Inception, and B. Feasibility. Here, these Inception and Feasibility Stages will be considered with the elements of the Architectural Design Process, which are the objectives, resources, activities, and objects.

3.3.1.1. Inception Stage and The Elements of The Architectural Design Process

The actions during the inception stage have been detailed in The RIBA Architect's Job Book (113). Actions are mainly related to the organisational structure of the group working which consists of the design team and client, and the architectural design of the building. However, the determination of the design objectives and resources, and architectural design activities start during the Inception Stage.

Inception - Objectives

The first important step of the architectural design is to determine the design objectives. Two main actions, during the Inception Stage, are directly related to the architectural objectives of the building. These are defining the user's requirements and setting the performance targets. The user requirement study helps the architect to identify the purpose of the building in terms of people's needs and to analyse the effect of these requirements upon the architectural design of the building (113). Also, it helps to identify the performance targets of the building design.

Definition of the user's requirements and performance targets of the building design, lead the architect to identify the objectives of the architectural design. Spatial quality, physical environment quality, social provisions, quality of hardware, economy and efficiency, and aesthetic within the building are the objectives of the Architectural Design Process. During the Inception Stage, determining the starting point of the design strategy is essential to achieve the objectives of the architectural design. Therefore, the architect decides whether the functional objectives, or formal / aesthetic objectives, or environmental objectives will be the starting point as the design strategy (40).

Inception - Resources

Achievement of design objectives depends on making a correct assessment of the resources. The resources of the Architectural Design Process are people resources, integrative resources, information resources, and technology.

During the Inception Stage, the job responsibilities of the people resources which are the organisation, design team, construction team, suppliers, and control authorities are briefly described.

Preparation of schedule of services and fees determines the financial resource which is one of the integrative resources. Details of the site give important information about the constructional work for the building. The other integrative resources which are time, energy, and management are, also, briefly planned during this stage.

Collection of regulations, publications, scientific information, and case studies which are information resources, is started during the Inception Stage.

Design materials and building materials, components, tools and machinery which are the technological resources are, also, briefly considered.

Inception - Design Activities

The architectural design activities which are the visual communication activities and decision activities start with the description of user's requirements. As it is mentioned above, the user requirement study begins during the Inception Stage. Therefore, the inception stage is the beginning of the conceptual decision-making activity of the Architectural Design Process. The conceptual decisions appear on the paper with the sketch drawings which is the initial visual communication.

Inception - Objects

The outputs of the Inception Stage are the specification of the user's requirements and sketch drawings which show the basic idea about the environmental features of the building, such as spaces and their functional relationships, orientation of the building on site , etc.

The detailed consideration of the Inception Stage of The RIBA Plan of Work and the elements of the Architectural Design Process is shown in Table 9.

3.3.1.2. Feasibility Stage and The Elements of The Architectural Design Process

The Feasibility Stage has seven major steps which lead the architect to arrange the organisational and the design activities. These steps have been detailed in The RIBA Architect Job Book (113). Table 9, also, shows the detailed consideration of the Feasibility Stage of The RIBA plan of Work and the elements of the Architectural Design Process.

Feasibility - Objectives
The user requirement study continues during the Feasibility Stage. Briefings about the basic requirements of total project, functional use of the areas and the activities of the users lead the architect to set the architectural design objectives and to decide the design strategy.

Feasibility - Resources
The design team meetings and the report to the client describe the involvement of the people resources in the architectural design. The briefings, surveys, consents, and financial reports cover all the integrative, information and technological resources.

Feasibility - Design Activities
During the Feasibility Stage, conceptual and development design decisions of the architectural design continue, and are visualised by both sketch and graphic drawings. The design team meetings bring the design ideas to discussion. At the first meetings, the conceptual design ideas about the building are presented with the sketch drawings, and the design objectives and those of alternative conceptual solutions are considered. After decisions on suitable or better solutions, these alternative conceptual design solutions are developed and presented with the both sketch and graphic drawings. The interior location drawings show where the user's activities will be performed within the building and the exterior location

drawings show where the building will be placed on the site area (122).

Feasibility - Objects

Two types of outputs are obtained as the objects of the Feasibility Stage. These are specifications and drawings. The specifications of the hardware of the building, which are structural elements, services and contents, are prepared. Also, the environmental characteristics, which are the features of indoor and outdoor environment of the building, are described as the result of user requirement study.

The basic physical appearance of the hardware and the spatial environment of the building are presented with the sketch and graphic drawings. These drawings show locational drawings which are floor plans, sections, and elevations, and the exterior plans of the building. The sketch drawings are not to scale. But the graphic drawings of the building in the feasibility stage are drawn to the scales of 1:500, 1:200, and 1:100 (122).

Table 9. Consideration of BRIEFING STAGE "Inception / Feasibility Stages" of The RIBA Plan of Work and The Elements of The Architectural Design Process

THE RIBA PLAN of WORK / Stages (General)	Stages (Detailed)	THE ELEMENTS of THE ARCHITECTURAL DESIGN PROCESS: OBJECTIVES (Spatial Quality; Quality of Physical Environment; Social Provisions; Quality of Hardware; Economy & Efficiency; Aesthetic)	RESOURCES (People Resources; Integrative Resources; Information Resources; Technology)	ACTIVITIES – Decision - Making: Conceptual / Visual Communication: Sketch Drawings	ACTIVITIES – Decision - Making: Development / Visual Communication: Sketch+Graphic Drawings	ACTIVITIES – Decision - Making: Final Decision &Details / Visual Communication: Graphic Drawings	OBJECTS (Hardware of The Building; Environment of The Building)
BRIEFING – A. INCEPTION	A1.1 Primary Check List A2.1 Exploratory Meetings A3.1 Accept Appointment A3.2, A3.3 Services and Fees A4.1 Performance Target A5.1 Directive for Stage B	User Requirement Study & Determination of Design Strategy	Organisation of Design Team, Information about Client & Site	Functional Analyse of Spaces & Activities; Diagrams & Matrices			List of User Requirmnts Sketch Drawings of Initial Ideas
First Feedback Point : Description of user requirements and available resources; general design ideas, functional relationships							
BRIEFING – B. FEASIBILITY	B1.1 Primary Check List B2.1 Design Team Meetings B3.1 Guide to Briefing B3.2 Briefing / Basic Requirmnts. B3.3 Briefing / Areas, Activities B3.4 Briefing / Building Elements B4.1 Survey: Action Required B4.2 Survey: Context of Project B4.3 Survey: Site / Information B4.4 Survey: Site /Plans, Sections B4.5 Survey: Existing Buildings. B4.6 Survey: Trial Holes B5.1 Consents: B6.1, B6.2 Report to Client B7.1 Directive for Stage C	User Requirement Study : * policy, * operation factors, * general design factors Determinetion of Design Strategy * fuctional strategy, * environmental strategy, * formal strategy	People R.: 1. Client / users, 2.Design Team, 3. Construction Tm., 4. Suppliers, 5. Control Authrts. Integrative R.: 1. Finance, 2. Time, 3. Energy, 4. Work Place, 5. Management Information R.: 1. Regulations, 2. Science, 3. Publications, 4. Experience, 5. Case Studies, 6. Evaluation / Feedback Technology: 1. Materials, 2. Bldng. Compnnts., 3. Tools &machinery		Developing the Conceptual Ideas: sketches; * diagrams. * matrices graphics; * floor plans, * sections, * elevations, * site plans Consideration of Alternative Design Solutions & Design Objectives		Specifictn. of the Hardwr. & Envirnmnt. of the Building Design Solutions developed sketch and graphic drawings *location drawings 1:500, 1:200 1:100
Second Feedback Point : Detailed user requirement study, determination of objectives; obtained resources ; developing the general ideas							

3.3.2. The Sketch Plans Stage of The RIBA Plan of Work and The Elements of The Architectural Design Process

The Sketch Plans Stage of The RIBA Plan of Work has two substages which are C. Outline Proposals and D. Scheme Design.

3.3.2.1. Outline Proposals Stage and The Elements of The Architectural Design Process

The design and organisational activities are continued during the Outline Proposals Stage. These activities have briefly been indicated in two steps which are the primary check list and the directive for stage D. Scheme Design (The RIBA Architect's Job Book) (113).

Outline Proposals - Objectives
The user requirement study continues during the Outline Proposals Stage. Review and consideration of the user requirements and design objectives are done in order to decide whether any changes should be made.

Outline Proposals - Resources
Essential consents and the other information resources which are science, publications, experience, case studies should be considered as the information resources. Evaluation of the studies and design activities provides feedback information to the architect to direct the design development.

Other resources, which are people, integrative resources, and technology, are also considered during the Outline Proposals Stage.

Outline Proposals - Design Activities
The architectural design activities are continued with great intensity during the Outline Proposals Stage. Alternative design solutions are developed and considered to each other and to the design objectives. Therefore, general design approaches are made to eliminate the unsatisfactory design solutions and to concentrate on better solutions. The Outline Proposals

Stage is the design development stage of the decision-making activities of the Architectural Design Process. The whole design work is presented with the sketch and graphic drawings. The drawings are locational drawings which are floor plans, sections, elevations, and exterior plans which show the site condition of the building, and initial assembly drawings which show how the building is put together on site (122).

Outline Proposals - Objects
The detailed specification of the hardware and the environment of the building is one of the outputs of the Outline Proposals Stage.

The other output of Outline Proposals Stage is more detailed location drawings and assembly drawings of the building. Location drawings are drawn to the scale of 1:500, 1:200, 1:100, and 1:50. The initial assembly drawings are constructional drawings which show the sectional plans, vertical sections, and sectional elevations of the building. Initial assembly drawings are drawn to the scale of 1:20, 1:10, 1:5.

The detailed consideration of the Outline Proposals Stage of The RIBA Plan of Work and the elements of the Architectural Design Process is shown in Table 10.

3.3.2.2. Scheme Design Stage and The Elements of The Architectural Design Process

The Scheme Design stage has two steps in which the organisational and design activities are briefly indicated in The RIBA Architect's Job Book (113). Table 10 also shows the detailed consideration of the Scheme Design Stage of the RIBA Plan of Work and the elements of the Architectural Design Process.

Scheme Design - Objectives
The user requirement study, and consideration of those of requirements and the design objectives, are completed during the Scheme Design Stage.

Table 10. Consideration of SKETCH PLAN STAGE "Outline Proposals / Scheme Design Stages" of The RIBA Plan of Work and The Elements of The Architectural Design Process

THE RIBA PLAN of WORK ▼ Stages: General	Detailed	THE ELEMENTS of THE ARCHITECTURAL DESIGN PROCESS ▶ OBJECTIVES (Spatial Quality; Quality of Physical Environment; Social Provisions; Quality of Hardware; Economy & Efficiency; Aesthetic)	RESOURCES (People Resources; Integrative Resources; Information Resources; Technology)	ACTIVITIES: Decision - Making: Conceptual / Visual Communication: Sketch Drawings	ACTIVITIES: Decision - Making: Development / Visual Communication: Sketch + Graphic Drawings	ACTIVITIES: Decision - Making: Final Decision &Details / Visual Communication: Graphic Drawings	OBJECTS (Hardware of The Building; Environment of The Building)
SKETCH PLANS	C. OUTLINE PROPOSALS C1.1 Primary Check List 1. Review of requirements 2. Alternative design solutions 3. Design development 4. General design approaches 5. Essential consents 6. 7. Reports 8. Further instruction, extra fees 9. Consultation of design team 10. Control of actions in Stage C 11., 12. Control of fee accounts C2.1 Directive for Stage D	User Requirement Study Determination of Design Strategy environmental functional formal design strategy	client, design team, ... finance, time, energy, ... regulations, science, ... materials, ...		sketches: diagrams, matrices graphics: floor plans sections elevations site plans		Specifictns. Drawings * developed location drawings * initial assembly drawings
Third Feedback Point: Detailed user requirment study;detailed design strategy; resources; development of design solutions							
SKETCH PLANS	D. SCHEME DESIGN D1.1 Primary Check List 1. Review progress 2. Complete user studies/detail planning solutions development 3. Consulting authorities 4. Full scheme, specifiction.s 5. Distribution of scheme. 6. Engineers' proposals. 7. Final cost plan 9. QS and consultants' reports 10. Full scheme report to client 11. Application of statutory & other consents, client's approval. 12. Control of actions in Stage D. 13. Directive for Stage E. 14. Advising the client 15,16. Control of fee accounts D2.1 Directive for Stage E	Completion of User Requirement Study Determined Design Strategy Determined Design Achievements	client, design team, ... finance, time, energy, ... regulations, science, ... materials, ...		Selection and Development of the most Suitable Design Solution Completion of Location Drawings Development of Assembly Drawings Initial Components Drawing		Specifictns. & Schedls. Drawings * final location drawings * developed assembly drawings *initial compnnts. drawings
" Brief should not be modified after this point " (Indication of The RIBA Plan of Work)							
Fourth Feedback Point : Completed user requirement study, determined objectives; obtained resources ; selected & developed design solution							

This completion is done according to the design strategy of the architect. Therefore, the design strategy which leads the architectural design decision-making activities should be clearly determined in its final form.

Scheme Design - Resources

The people, integrative, information and technological resources are involved in the design activities during the Scheme Design Stage. Also, further required resources for detail design are indicated and obtained.

Scheme Design - Design Activities

The Scheme Design Stage of the RIBA Plan of Work is the beginning of the final decision and details stage of the decision-making activities of the Architectural Design Process. The elimination of the unsatisfactory design solutions should be completed, and the better design solution should be chosen among the alternatives at the beginning of this stage.

The development of that selected design solution is completed with the graphic drawings. The drawings, which are floor plans, sections, elevations and the exterior site plans of the building, should have all required information which shows how the building is put together on site, and how the construction should be formed.

The full scheme of the building specifications is prepared in the Scheme Design Stage. Specifications are important to complete the architectural drawings and to give the detailed information about the features of the building.

Scheme Design - Objects

The clearly stated and detailed building specifications, the final location drawings, which are to scale of 1:500, 1:200, 1:100, 1:50, developed assembly drawings, which are to scale of 1:20, 1:10, 1:5, and initial components drawings, which are to scale of 1:20, 1:10, 1:5, and 1:1, are obtained at the end of the Scheme Design Stage.

3.3.3. The Working Drawings Stage of The RIBA Plan of Work and The Elements of The Architectural Design Process

The Working Drawings Stage of The RIBA Plan of Work has four substages which are E. detail Design, F. Production Information, G. Bills of Quantities, and H. Tender Action.

3.3.3.1. Detail Design Stage and The Elements of The Architectural Design Process

The organisational and architectural actions have been summarised within two steps of the Detail Design Stage in The RIBA's Architect's Job Book (113). Those of steps are E1.1 Primary Check List and E2.1 Directive for Stage F. Production Information.

Detail Design - Objectives

During the Detail Design Stage, the user requirement study is completed. In this completion of user requirement study, there are no strategical changes, but only the final consideration of the user's requirements and design objectives is done.

Detail Design - Resources

The involvement of four main resources of the Architectural Design Process which are people, integrative, information and technological resources continue during the Detail Design Stage.

Detail Design - Activities

During the Detail Design Stage, all conceptual and development design decisions are updated and considered to the design objectives. According to the final design decision the graphic drawings of the floor plans, sections, elevations and site plans of the building are completed. Besides, the final building specifications are done to complete the constructional detail design of the components of the building such as doors, windows, roof, wall finishes, floor finishes, stairs, etc.

Final location, assembly and detail design drawings are presented with the graphic drawings in which the required information about the building for construction on site is shown.

Detail Design - Objects
At the end of the Detail Design Stage, all the listed below graphic drawings are obtained.

* Location drawings

site plans: plot plan, landscape plan, to the scale of 1:500, 1:200,
floor plans, sections and elevations, to the scale of 1:200, 1:100, 1:50.

* Assembly drawings

sectional plans: foundation plan, floor framing plan, roof framing plan, plumbing plan, electrical plan, heating and air-conditioning plan,
vertical structural sections, and elevations, to the scale of 1:50, 1:20, 1:10, 1:5.

* Components drawings

detail drawings of doors, windows, stair, fireplace, elevators, and miscellaneous details, to the scale of 1:20, 1:10, 1:5, 1:1.

Also, specifications of the structural elements of the building such as schedules of doors and windows, are completed, at the end of the Detail Design Stage.

Detailed consideration of the Detail Design Stage and the elements of the Architectural Design Process is shown in Table 11.

3.3.3.2. Production Information Stage and The Elements of The Architectural Design Process

Production Information is the second substage of Working Drawings Stage of The RIBA Plan of Work (113). This stage has seven steps which lead the whole design work towards the preparation of bills of quantities, and tender action. Table 11 also shows the detailed consideration of Production Information Stage and the elements of the Architectural Design Process.

Table 11. Consideration of WORKING DRAWINGS STAGE "Detail Design / Production Information Stages" of The RIBA Plan of Work and The Elements of The Architectural Design Process

THE RIBA PLAN of WORK (General)	Stages	Detailed	OBJECTIVES: Spatial Quality; Quality of Physical Environment; Social Provisions; Quality of Hardware; Economy & Efficiency; Aesthetic	RESOURCES: People Resources; Integrative Resources; Information Resources; Technology	ACTIVITIES (Decision - Making / Visual Communication): Conceptual / Sketch Drawings	Development / Sketch + Graphic Drawings	Final Decision &Details / Graphic Drawings	OBJECTS: Hardware of The Building; Environment of The Building
WORKING DRAWINGS	E. DETAIL DESIGN	E1.1 Primary Check List 1. Review instructions 2. Complete user requirements 3. Detail design&final specifctn. 4. Updating design decisions 5. Engineers' drawings 6. Review cost plan 7. Reviev and confirmation of architectural & engineering dsgn. 8. Review of detail dsign 9. Control of all actions 10. Control of fee accnts E2.1. Directive for Stage F	Final Consideration of User Reqirement Study and Design Objectives	client, design team, ... finance, time, energy, ... regulations, science, ... materials, ...			Final Specifications & Schedules Completion of Assembly& Components Drawings	Specifctn. &Schedules Updated Location Drawings; Completed Assembly &Compnnts. Drawings
	* Any further change in location, size, shape, or cost after this time will result in abortive work * (Indication of The RIBA Plan of Work)							
	Fifth Feedback Point: Updated final design decisions; control of design solutions							
	F. PRODUCTION INFORMATION	F1.1 Primary Check List F2.1 Production Drawings F3.1 Preliminary Tendering F4.1 Register of Contractors F5.1 Information for Tender Documents F6.1 Nominated Subcontartors & Suppliers F7.1 Selection of Nominated Subcontartors & Suppliers F8.1 Directive for Stage G	Final Control of Achievements of Architectural Design	client, design team, ... finance, time, energy, ... regulations, science, ... materials, ...			Final Control &Corrections on All Drawings, Specifcations and Schedules	Specifctn, &schedules All Completed Drawings; location, assembly, components
	Sixth Feedback Point : Control of final corrections and completion of drawings,schedules,specifications							
	G. BILLS of QUANTITIES ; H. TENDER ACTION							

Production Information - Objectives

The Production Information Stage is the final control stage of whole production within the design process. Therefore, during this stage the user requirements and the architectural design strategy are finally considered to ascertain that the determined objectives are achieved during the Architectural Design Process. Also, the achieved design objectives are required as the construction targets.

Production Information - Resources

During this stage besides the design team and client, control authorities, construction team and suppliers are involved in the production action as other people resources. Production drawings and schedules are considered as the information resources for the registration and construction of the building. During the preparation of the drawings and schedules the integrative and technological resources are also considered.

Production Information - Activities

In this stage, only the final control and corrections are done on the whole project. This completion is done according to the final decisions which are taken during the Scheme Design and Detail Design Stages. Therefore, a few final graphic drawings and preparation of the final specifications are jobs which are required to be done.

Production Information - Objects

Two main outputs of the Detail Design Stage, which are all drawings and specifications, are obtained in completed form at the end of this stage. All location, assembly and component drawings, and schedules have been indicated in the previous stage which is Detail Design - Objects.

3.3.3.3. Bills of Quantities Stage and The Elements of The Architectural Design Process

The Bills of Quantities is the third substage of the Working Drawings Stage of The RIBA Plan of Work [113]. The detailed consideration of the Bills of Quantities Stage and the elements of the Architectural Design Process are shown in Table 12.

Bills of Quantities - Objectives
During the Bills of Quantities Stage there is no further user requirement study and the consideration of the user requirements and the design strategy.

Bills of Quantities - Resources
As has been mentioned in the Production Information Stage, the construction team and suppliers are involved in the production action as other people resources to compete in the tender action.

Bills of Quantities - Activities
The design of the building should be completed at the beginning of the Production Information Stage, and final corrections should be finished at the beginning of the Bills of Quantities Stage. Therefore, during the Bills of Quantities Stage, the organisational activities are taken more than the design activities. Organisational activities lead the work towards the tender action.

Bills of Quantities - Objects
The output of this stage is assembled drawings, schedules and specifications which are controlled, completed and corrected during the Detail Design and Production Information Stages.

Table 12. Consideration of WORKING DRAWINGS STAGE "Bills of Quantities / Tender Action Stages" of The RIBA Plan of Work and The Elements of The Architectural Design Process

THE RIBA PLAN of WORK — Stages: General	Stages	Detailed (THE ELEMENTS of THE ARCHITECTURAL DESIGN PROCESS)	OBJECTIVES: Spatial Quality	Quality of Physical Environment	Social Provisions	Quality of Hardware	Economy & Efficiency	Aesthetic	RESOURCES: People Resources	Integrative Resources	Information Resources	Technology	ACTIVITIES (Decision - Making / Visual Communication): Conceptual / Sketch Drawings	Development / Sketch + Graphic Drawings	Final Decision &Details / Graphic Drawings	OBJECTS: Hardware of The Building	Environment of The Building
WORKING DRAWINGS	G. BILLS of QUANTITIES	G1.1 Primary Check List 1. Design team organisstion 2. Update drawings, schedules & specifications 3. Confirm list of tenderers 4. Interview & check site staff 5. Correction of all documents 6. Obtaining outstanding quotations 7. Assemble drawings 8. Prepare draft architect's instruction for changes too late to be included in bills of quantities 9. Advising client 10. Directive for Stage H 11. Control fee accounts							* client, design team, ... * finance, time, energy, ... * regulations, science, ... * materials, ...						Final Corrections on All Drawings, Specifcations and Schedules	Specifctn, &schedules All Corrected Drawings; location, assembly, components	
	Seventh Feedback Point: Final control of all documents for Tender Action ; end of architectural design activities																
	H. TENDER ACTION	H1.1 Primary Check List 1. Client's agreement 2. Procedures to invite tenders 3. Inform all tenderers 4. Arrangement for opening of tenders 5. Check there are no obstructions to the project 6. Client's formal acceptance of tender, notification of results to all tenderers 7. Control of fee account	There is no study related to determination of architectural design objectives and resources; there is no activity related to the architectural design. All activities are organisational to complete the whole design process.														
		H2.1 Issue and Receipt of Tender Documents															
Eight Feedback Point: End of Architectural Design Process:; Result of Tender Action																	
SITE OPERATION and BUILDING in USE		J. PROJECT PLANNING, K. OPERATIONS on SITE, L. COMPLETION, M. FEEDBACK															

3.3.3.4. Tender Action Stage and The Elements of The Architectural Design Process

The Tender Action is the fourth and final substage of the Working Drawings Stage of The RIBA Plan of Work (113). Table 12 also shows the detailed consideration of the Tender Action Stage and the elements of the Architectural Design Process.

During Tender Action there is no study related to the determination of architectural design objectives and resources. Also, there is no design activity in this stage. All activities are organisational likewise in the Bills of Quantities Stage. The outputs of the Tender Action Stage are the received tender documents which are completion of the whole design process of the building.

The Tender Action Stage is also the final stage of the whole design process of the building. After completion of this stage the Site Operation Stage begins to construct the building on the site.

3.3.4. Feedback Points Related to The Architectural Design Process within The RIBA Plan of Work

The RIBA Plan of Work explains the way in which the architect is responsible to manage and supervise a building project both at the design stage and construction stage. The consideration of The RIBA Plan of Work and the elements of the Architectural Design Process shows the division of the architectural design work into stages of The RIBA Plan of Work.

Although in this consideration it appears as if the development of the architectural design work flows in a linear route within the stages of The RIBA Plan of Work, in actual fact a kind of loop occurs within the whole plan of work (40,43,125). When the work within the each stage is completed, the architect should consider all comments and information about this particular work whether it is successful and efficient for the next step, or not. After this partial evaluation, the architect moves to the next working stage. Also, during the development of a new stage, the architect goes back and checks the previous stage, and makes an initial plan for the following stage in order to place new conditions within the whole work. This is the feedback dimension of the work plan (40,43,125).

The results of feedback action are important information for the architect. The architect can reconsider all decisions which are taken in previous stages, and redesign the building project in the present stage. Also, the information can be used as a knowledge resource in future for new projects.

The RIBA Plan of Work indicates two main feedback points which are at the end of D. Scheme Design Stage, and at the end of E. Detail Design Stage. The architect is warned that "the brief should not be modified after the end of D. Scheme Design stage", and "any further change in location, size, shape, or cost after the end of E. Detail Design Stage will result in abortive work" (113).

However, the detailed consideration of The RIBA Plan of Work and the elements of the Architectural Design Process gives eight main feedback points. Review points of design decisions occur at the end of each stage from the beginning of the conceptual existence stage which is A. Inception, to the end of theoretical existence stages which are B. Feasibility, C. Outline Proposals, D. Scheme Design, E. Detail Design, F. Production Information, G. Bills of Quantities, H. tender Action.

The main feedback points and main issues which control the whole process can be summarised as follows (122). Also, the feedback chain within The RIBA Plan of Work is shown in Figure 19.

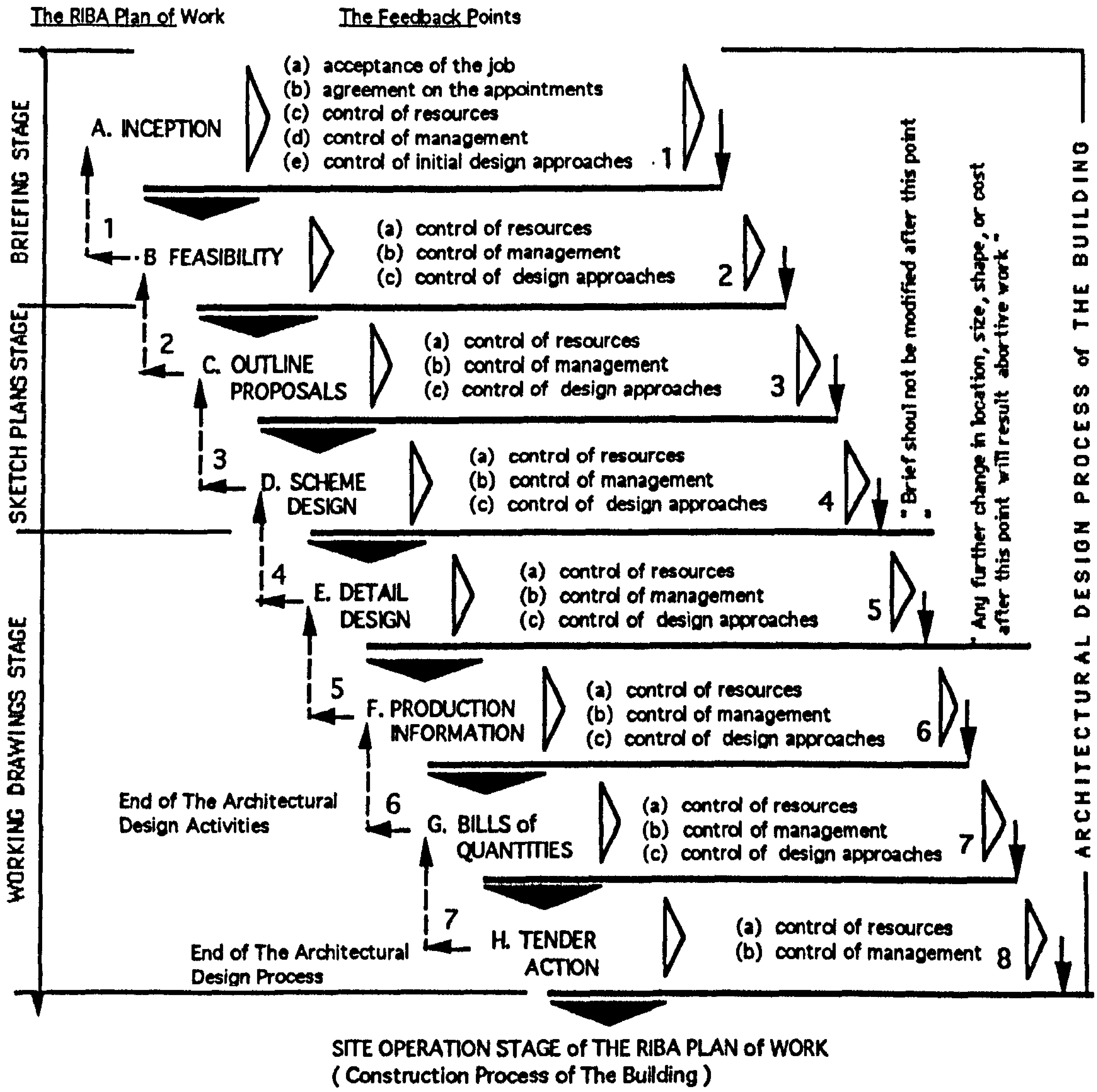


Figure 19. The Feedback Chain Relevant to
The Architectural Design Process within The RIBA Plan of Work

First Feedback Point : A. Inception Stage

Issues, to control:

(a) The acceptance of the job: checking the reliability of client, financial resources to support the project, involvement of other architects, and potential resources of the design team that can meet the client's requirements.

(b) Agreement of the appointments: checking the responsibilities, fees, appointment of the quantity surveyors and other consultants, and the way of communication with people who are involved in the project.

(c) Control of the resources: checking the obtained initial details of client's requirements, details of the site area and other available resources.

(d) Control of management: checking the office procedures, organisational arrangements of job, files, fees and other records.

(e) Control of initial design approaches: checking the initial user requirement study, and determination of the design strategy.

Second Feedback Point : B. Feasibility Stage
Issues, to control:

(a) Control of resources: checking all the initial information which is derived from the Inception Stage, the additional information about user requirements, detailed information about the site area, information from the local authorities and planning department, and cost.

(b) Control of management: checking the progress of job and responsibilities, files, fees and other records.

(c) Control of design approaches: checking the user requirement study, determined design strategy, conceptual design ideas, consideration of design objectives and alternative initial design solutions.

Third Feedback Point : C. Outline Proposals Stage
Issues, to control:

(a) Control of resources: checking the detailed information about the user requirements, the site area, and consents which are derived from the Feasibility Stage, checking the all relevant additional information which are obtained during the Outline Proposals Stage, and cost.

(b) Control of management: considering the experts' such as consultants and engineers advice, checking the progress of job and responsibilities, files, fees and other records.

(c) Control of design approaches: checking the user requirement study, determined design strategy, developed design solutions, consideration of design objectives and developed alternative design solutions, checking the suitability of nominated design solution.

Fourth Feedback Point : D. Scheme Design Stage

" Brief should not be modified after this point "

Issues, to control:

(a) Control of resources: checking all the information which is relevant to the project.

(b) Control of management: checking the communication with consultants and engineers, checking the progress of job and responsibilities, files, fees and other records.

(c) Control of design approaches: checking the completed user requirement study, design strategy, achieved design objectives, and sufficiently detailed selected design solution.

Fifth Feedback Point : E. Detail Design Stage

" Any further change in location, size, shape, or cost after this time will result in abortive work "

Issues, to control:

(a) Control of resources: checking all the information which is relevant to the project.

(b) Control of management: checking the communication with consultants and engineers, checking the progress of job and responsibilities, files, fees and other records.

(c) Control of design approaches: checking the final consideration of user requirement study and achieved design objectives, checking the updated final design decisions, specifications and completion of the whole design of the building.

Sixth Feedback Point : F. Production Information Stage

Issues, to control:

(a) Control of resources: checking all the information which is relevant to the project.

(b) Control of management: checking the communication with consultants, engineers, and contractors, checking the progress of job and responsibilities, files, fees and other records.

(c) Control of design approaches: checking the final corrections on all drawings, specifications and schedules.

Seventh Feedback Point : G. Bills of Quantities Stage
There should not be any architectural design activity after this point
Issues, to control:

(a) Control of resources: checking the all information which are relevant the project.

b) Control of management : checking all the documents for tender action, interview with people who will involved in further stages of the building, final check of files, fees and other records.

(c) Control of design approaches : checking the final corrections on all drawings, specifications and schedules, end of architectural design activities.

Eighth Feedback Point : H. Tender Action Stage
Issues, to control:

(a) Control of resources: checking all the information which is relevant to the tender action.

(b) Control of management : checking the progress of tender action, sending and obtaining tender documents, obtaining client's formal acceptance, final check of files, fees and other records.

Part Four : INDOOR AIR QUALITY PROCESS

4.1. INTRODUCTION

The broad definition of pollution is the process of making water, air, earth and so on dirty and impure. Therefore, contaminated things are not regarded as being of good quality and can be harmful or dangerous to the health and life of people, plant or animal, or can affect property values adversely. In this pollution process, the unpleasant substances are defined as pollutants. The level of pollution depends on emissions, concentrations and combinations of the pollutants, and duration of their existence in the air (37,126-128).

Air pollution has been defined as emissions into the atmosphere and the presence in the atmosphere of one or more air pollutants in enough concentration to be dangerous or hazardous to the life of people, plant or animal, and to the values of property [37,126-128].

Most of the definitions of air pollution were done in terms of outdoor concentrations . However, recently, indoor air pollution has been seriously considered, because the greater percentage of people's activities take place indoors, and most people spend the greater percentage of their time indoors. Indoor air pollution differs from outdoor air pollution in one way in which the concentrations of some of the air pollutants in indoor air are higher than in outdoor air.

The indoor air pollutants are released from several sources. The concentration levels of indoor air pollutants affect indoor air quality. The pollution of indoor air is one of the situations which is related to the indoor air. The other situation is improving a worse condition of indoor air to a better level. The improvement of indoor air is to reduce the emissions of those of indoor air pollutants, and to control their concentration levels by taking preventive actions.

Indoor air pollution and indoor air improvement actions are compilations of a series of individual actions for instance, emissions, concentrations and combinations of pollutants; control of pollutant sources and reducing the pollution level, etc. Indoor air related actions have interrelationships and affect the quality of indoor air. Characteristics of indoor air quality can be described according to the levels of pollution and improvement actions. If the pollution actions outweigh improvement actions then indoor air quality will be described as unhealthy indoor air. If the improvement actions are efficient to reduce indoor pollution then indoor air quality will be described as healthy indoor air.

Thus, indoor air pollution and indoor air improvement become two main parts of indoor air quality. Also, combining a series of indoor air related actions make indoor air quality a process.

The general characteristic of any process is defined as the serial activities of a system (Figure 2. The Elemental Model of The System). As it is indicated, the occurrence of these activities requires some inputs which are objectives and resources. Also, it is briefly mentioned that activities result in some outputs which are hardware and environment related objects.

Here, indoor air quality process will be defined according to this systematic approach. In addition indoor air pollution and indoor air quality improvement actions will be described as subprocesses of the indoor air quality process. During the systematic descriptions, Indoor Air Quality will be abbreviated as IAQ, Indoor Air Pollution Process will be abbreviated as IAPP, Indoor Air Quality Improvement Process will be abbreviated as IAQIP, and Indoor Air Quality Process will be abbreviated as IAQP.

4.2. INDOOR AIR POLLUTION PROCESS / (IAPP)

4.2.1. Objective of IAPP

As a starting point, the objective of IAPP is to make indoor air polluted. Although to pollute indoor air is not a deliberate aim even some natural components and activities cause pollution (126-129). Besides, people's activities and their technological investigations help and encourage pollutants to pollute indoor air and make it an objective for IAPP.

4.2.2. Resources of IAPP

Indoor air pollutants, pollutant sources and polluted spaces are the main resources of IAPP. Identification of these resources is important to determine the nature and the cause of the indoor air pollution, and where the pollution occurs within the building.

4.2.2.1. Indoor Air Pollutants

Air pollutants can be generally classified according to their physical, chemical and adverse health effect properties and their sources (2,13,16,92,126,129-133). Most of air pollutants are the same for indoors and outdoors. But the levels of indoor or outdoor concentrations are important to distinguish them as indoor air pollutants or outdoor air pollutants. Therefore, the general classification of air pollutants can be applied to indoor air pollutants.

Classification of indoor air pollutants:

A- According to the physical properties (13,131,133)

(a_1) gaseous and vapours, and

(a_2) particulates.

B- According to the chemical properties (129,131)

(b_1) organic, and

(b_2) inorganic pollutants.

C- According to the adverse health effect [129,131,132]

(c_1) toxic pollutants,

(c_2) harmful and irritant pollutants,

(c_3) narcotic pollutants,

(c_4) carcinogenic pollutants,

(c_5) mutagenic pollutants, and

(c_6) allergens.

D- According to their sources [2,13,16,92]

(d_1) pollutants from outdoor, and

(d_2) pollutants from indoor.

Some of most common indoor air pollutants are asbestos, benzene, carbon dioxide, carbon monoxide, formaldehyde, lead, nitrogen dioxide, ozone, polynuclear aromatic hydrocarbons, radon, respirable suspended particulates, styrene, toluene, vinyl chloride, and water [1-3,14,17,92,129,133].

4.2.2.2. Sources of Indoor Air Pollutants

Indoor air pollutant sources can be classified into two main groups which are outdoor sources and indoor sources [2,13,16,92].

Outdoors is an important factor for indoor air pollution. If the outdoor environment is polluted it will affect the indoor environment. Outdoor sources which emit air pollutants can be grouped as natural sources and people's outdoor activities. Outdoor air, soil, water, flora and fauna, volcanic movements and wind are examples of the natural sources. Transport, industrial activities, cultivation and waste products are examples of people's outdoor activities which produce air pollutants and affect indoor air [1,5,14,133].

Two main indoor sources are people's activities and the building itself. People's activities can be divided into three main groups which are biological and physical activities, household activities and hobbies, and office activities. The building itself contributes to indoor air pollution directly with its construction materials, contents, and services such as air-conditioning, heating, etc. (1,5,14,133-135). Also, layout and indoor environment of the building help air pollution to stay and spread indoors (136,137).

The sources of indoor air pollutants are shown in Figure 20.

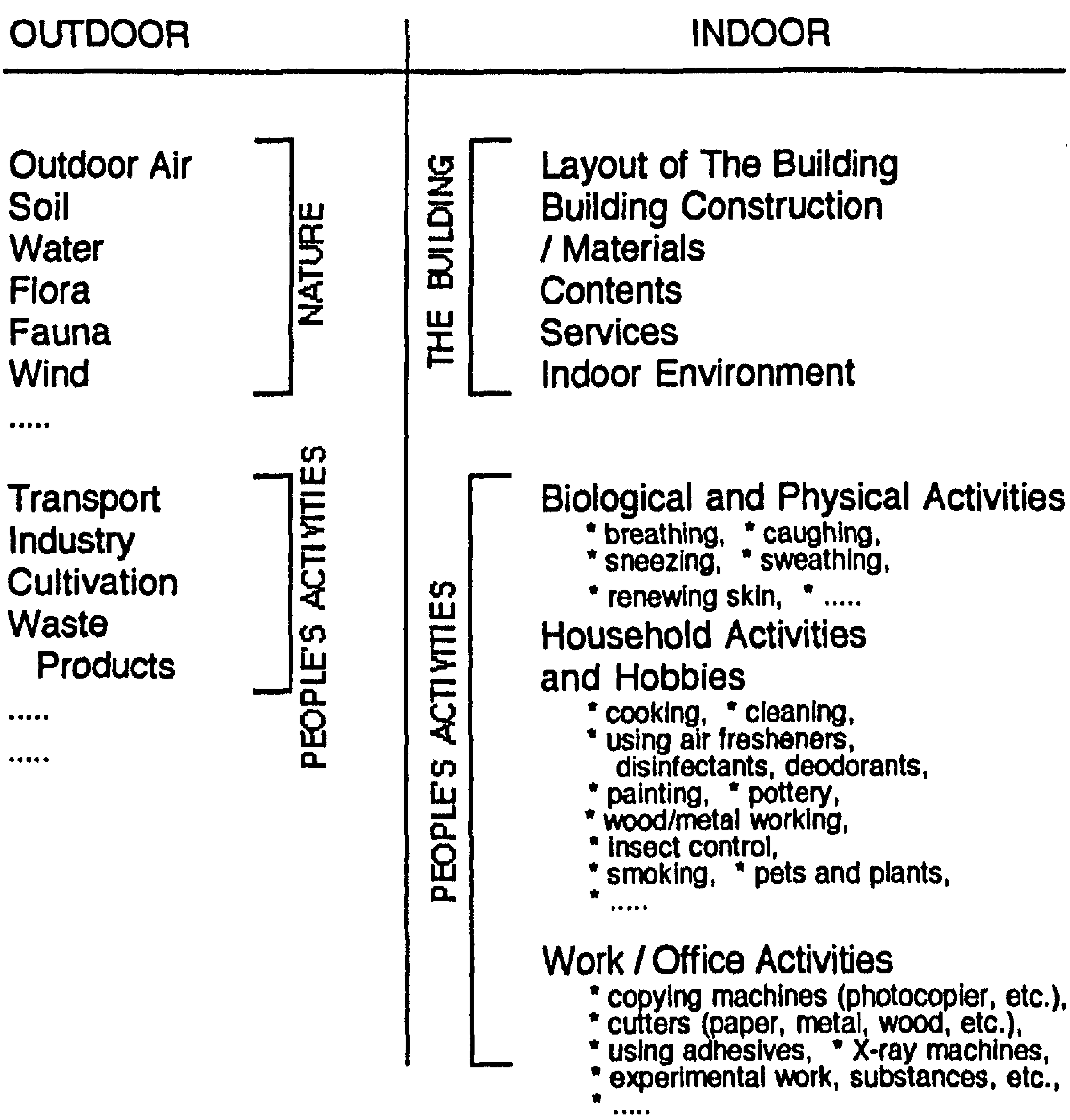


Figure 20. Sources of Indoor Air Pollutants

4.2.2.3. Polluted Spaces within The Building

Spaces within the building are the last resources of the indoor air pollution. The characteristics of spaces are determined according to the activities of the users. For example people need rooms, kitchens, etc. in their houses for their sleeping, cooking activities, etc.

4.2.3. Activities of IAPP

Important actions within the pollution process of indoor air pollutants are their emissions from the sources, concentrations and combinations within indoor air, and their exposure to indoor air (1,126,129,133,138).

All those actions within the IAPP of indoor air pollutants occur at different stages which are early stage, middle stage, and late stage. Besides, the nature of the stages is time and rate based. The time based stages are short term and long term. The rate based stages are high level, medium level, and low level [1,126,129,133,138].

4.2.4. Object of IAPP

The output of the whole IAPP is polluted indoor air which is the object. The type of the indoor air pollution is important in its prevention. Physical properties of the pollutants help to identify the pollution type such as radioactive pollution, gas pollution, odour, dust, etc.

Figure 21 shows a basic systematic combination of elements of IAPP, and Table 13 shows the elements of IAPP and issues which are related these elements.

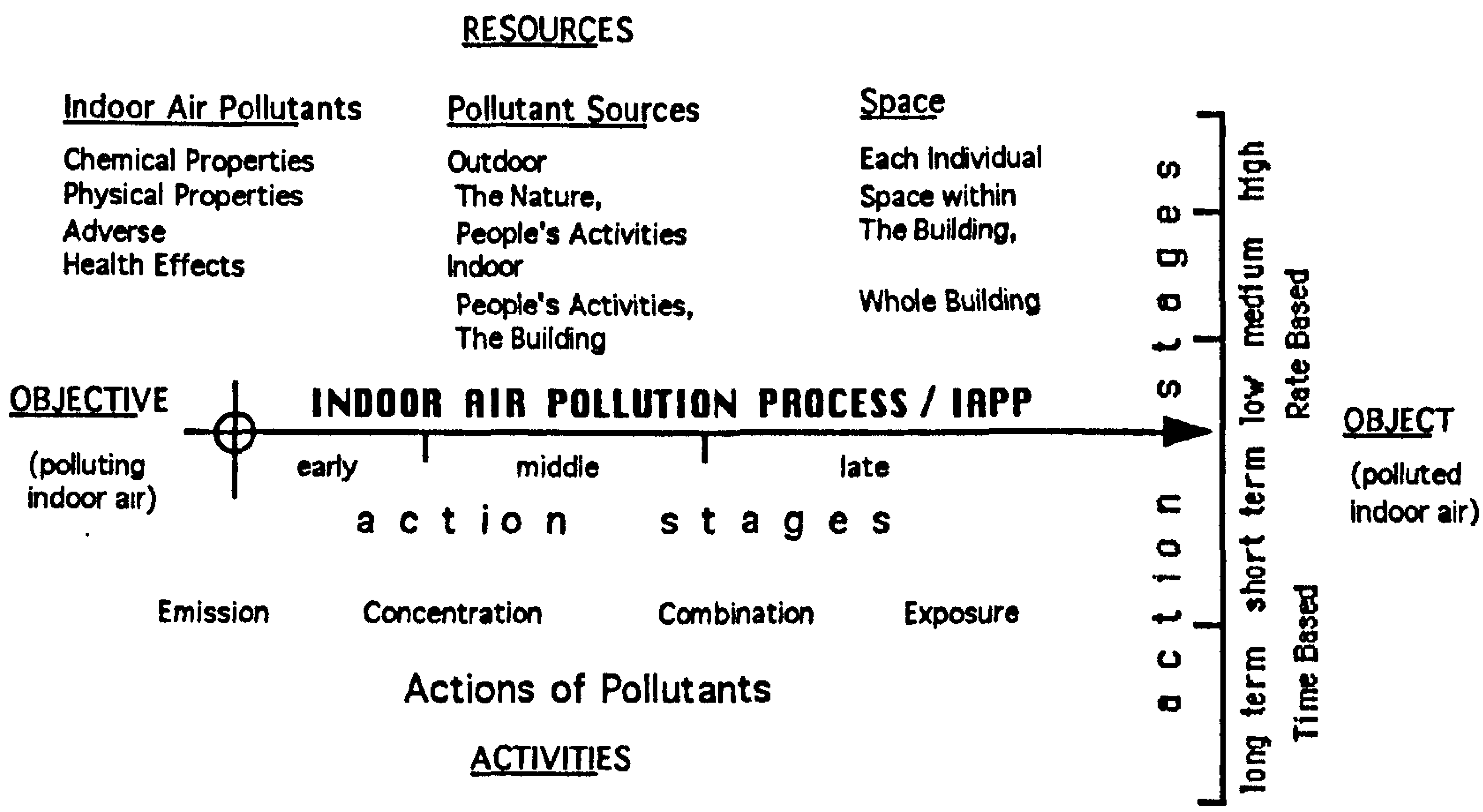


Figure 21. Indoor Air Pollution Process (IAPP)

Table 13. Elements of IAPP and Related Issues

ELEMENTS of IAPP	ISSUES RELATED to ELEMENTS of INDOOR AIR POLLUTION PROCES		
	Identification	Characteristics	Stages
Objective	Polluting Indoor air		Rate Based *Low *Medium *High Time Based *Short/Long Term *Early/Middle/Late
Resources	Indoor Air Pollutants Pollutant Sources Space	Chemical-*Organic *Inorganic Physical- *Gases & Vapours *Particles Adverse Health Effect- *Toxic, etc. Sources- *Outdoor *Indoor	
Activities	Actions of Indoor Air Pollutants	Emission Concentration Combination Exposure	Rate Based *Low *Medium *High Time Based *Short/Long Term *Early/Middle/Late
Object	Polluted Indoor Air	Nature of Indoor Air Pollution *Gas Pollution *Dust *Odour *....	Rate Based *Low *Medium *High Time Based *Short/Long Term *Early/Middle/Late

4.3. INDOOR AIR QUALITY IMPROVEMENT PROCESS /IAQIP

4.3.1.Objectives of IAQIP

The outcome of the IAPP, which is the polluted indoor air, requires some remedial actions to improve the quality of indoor air to reach a better standard. This improvement of the IAQ is essential for the occupants' health.

Therefore, to improve the IAQ and to provide continuity of healthy indoor condition in terms of IAQ for the occupants can be indicated as the two main objectives of IAQIP.

4.3.2. Resources of IAQIP

Resources of IAQIP can be grouped as:

(a) Information resources
(b) Restrictive resources
(c) Scientific and technological resources
(d) Integrative resources

4.3.2.1. Information Resources

Information resources include;

* indoor air pollutants; their characteristics and health effects
* pollutant sources; their characteristics and effectiveness
* polluted indoor spaces; their use function and design
* indoor users; characteristics of occupants, their activities, etc.

Some of the most common indoor air pollutants, pollutant sources and possible polluted indoor spaces are briefly described in Table 14 [1-3,92,129,133].

Table 14. Indoor Air Pollutants, Sources, and Polluted Spaces

POLLUTANTS			POLLUTANT SOURCES	POLLUTED INDOOR SPACE
Name	Characteristics	Health effects	Characteristics	
ASBESTOS	inorganic natural fibrous fire resistant carcinogenic	asbestosis mesothelioma lung cancer	insulation wall board sprayed on steelwork asbestos cement vinyl-asbestos foolr tiles asbestos plasters	any individual space that asbestos products are used whole building
CARBON DIOXIDE (CO_2)	inorganic gasesous inert odourless	headache giddiness suffocation	biological activities of people, heating, tobacco smoke	any individual space basements vaults wells .....
CARBON MONOXIDE (CO)	inorganic gaseous colourless odourless tasteless	cardiovascular neurological fibrinolysis perinatal effects headache dizziness	motor vehicles incomplete combustion heating incinerators tobacco smoke	unvented rooms kitchens garages .....
NITROGEN DIOXIDE (NO_2)	inorganic gaseous miscible with air oxidant	irritation of eye and lung changes in the pulmonary function	motor vehicles unvented gas stoves kerosene heaters unvented gas fired water heaters	unvented rooms kitchens .....
OZONE (O_3)	inorganic gaseous odorous miscible wth air	irritation of eye and lung tissue symptomatic chest and upper respiratory effects	uv light fixtures electrostatic office copying machines	any individual space offices .....
RADON (Rn)	inorganic gaseous radioactive	lung cancer	building materials; stone, brick, concrete, gypsum board soil water	basements first floors unvented rooms .....
BENZENE	organic colourless clear liquid soluble in water miscible with alcohol	carcinogenic effects neuro-toxic symptoms	household solvents and agents tobacco smoking	rooms kitchens .....
FORMAL-DEHYDE	organic gaseous colourless odorous soluble in water	odour detection eye irritation throat irritation biting sesation in nose and eye	particle board plywood textiles consumer products	any individual space

Table 14. Indoor Air Pollutants, Sources, and Polluted Spaces

(continued)

POLLUTANTS			POLLUTANT SOURCES	POLLUTED INDOOR SPACE
Name	Characteristics	Health effects	Characteristics	
POLY-NUCLEAR AROMATIC HYDRO-CARBONS	large group of organic compounds best known is bezo[a]-pyrene	skin cancer lung cancer	incomplete combustion hetaing with coal biomass fuels smoking	buildings without chimneys, kitchens work places .....
STYRENE	organic liquid volatile colourless odorous	respirstory and mucous membranes irritation depression weakness headache, fatigue malaise, tension	vehicle exhaust emission industrial processes combustion incineration recently manufactured plastic products floor covering	newly finished buildings .....
TOLUENE	organic liquid volatile low solubility in water	fatigue, confusion lack of coordination impairment of reaction time sleepiness eye irritation	paints thinners adhesives inks tobacco smoking	any individual space offices .....
VINYL CHLORIDE (VC)	organic gaseous nonirritating colourless generally odourless at low concentrarion	narcotic effects carcinogen loss of consciousness	VC production plants polyvinyl chloride polymerisation facilities smoking floor covering	any individual space
RESPIRABLE SUSPENDED PARTIC-ULATES (RSP)	dust smoke smog bacteria viruses molds fungi spores pollen	allergies eye irritation irritation and infection of respiratory track Legionnaire's disease fever and chills cough	building products furnishings humidifiers ventilation systems air-conditioning water systems combustion people's activities pets plants	any individual space rooms kitchens bathrooms - wc's offices swimming pools .....
WATER	colourless clear liquid evaporable	nasal and sinus infections bronchial problems	biological activities breathing sneezing ..... household activities cooking cleaning washing	any individual space rooms kitchens bathrooms - wc's offices swimming pools .....

Identification of the users of the building is important to evaluate the condition of the indoor environment. Different types of users show a different reaction to the same environment. In this research, users are grouped under two main headings. These are

(a) human based users: occupants such as workers, cleaners, frequent visitors, owners, tenants, etc.; and non-occupants such as owners, financiers, builders, neighbours, public, etc.

(b) non-human based users: animals and plants; and goods, machinery and equipments, etc.

In this research, the term users refers to human based users, and mainly occupants.

The description of characteristics of indoor occupants covers their age, sex, pre-existing health condition, living-working condition. Also the number of occupants and their activities are important to consider whether available space is efficient or not [2,3,92,129,133].

4.3.2.2. Restrictive Resources

Restrictive resources of IAQIP include standards and regulations on health in terms of IAQ, and building regulations in terms of IAQ, such as ventilation rates, standards of building materials.

Some international and national organisations work on IAQ and set the guidelines, standards and regulations which are related to the indoor air pollutants, ventilation rates, technical systems, etc. [10,12,13,17,129,139-143].

Table 15 shows some of the most common indoor air pollutants and their acceptable levels in indoor air [1,129,133].

Table 15. Indoor Air Pollutants and Their Acceptable Levels

POLLUTANT	ACCEPTABLE LEVEL	REFERENCE, STANDARD	POLLUTANT	ACCEPTABLE LEVEL	REFERENCE, STANDARD
ASBESTOS	No safe level	Air Quality Guidelines for Europe-WHO-1987; International Agency for Research on Cancer	RADON (Rn)	100 Bq/m^3 for 1 year; 0.01 WL= 2pCi/L	Air Quality Guidelines for Europe-WHO-1987; ASHRAE 62-1989 (133)
CARBON DIOXIDE (CO_2)	500 ppm for 8 hour	ASHRAE 1982 (1)	BENZENE	No safe level	Air Quality Guidelines for Europe-WHO-1987
CARBON MONOXIDE (CO)	60 mg/m^3 (50 ppm) for 30 minutes; 30 mg/m^3 (25 ppm) for 1 hour 10 mg/m^3 (9-10 ppm) for 8 hour	Air Quality Guidelines for Europe-WHO-1987 (129); US National Ambient Air Quality Standards (NAAQS) (133)	FORMAL-DEHYDE	0.1 mg/m^3 for 30 min.; 120 µg/m^3 continuous	Air Quality Guidelines forEurope-WHO-1987; ASHRAE 62-1989 (133)
NITROGEN DIOXIDE (NO_2)	400 µg/m^3 (0.21 ppm) for 24 hour; 150 µg/m^3 (0.08 ppm) for 1 hour; 100 µg/m^3 (50 ppm) for 1 year	Air Quality Guidelines for Europe-WHO-1987; NAAQS (133)	POLY-NUCLEAR AROMATIC HYDRO-CARBONS	No safe level	Air Quality Guidelines forEurope-WHO-1987
			STYRENE	800 µg/m^3 for 24 hour; 70 µg/m^3 for 30 min.	Air Quality Guidelines forEurope-WHO-1987
OZONE (O_3)	150-200 µg/m^3 (0.076-0.1 ppm) for 1 hour: 100-120 µg/m^3 (0.05_0.06 ppm) for 8 hour	Air Quality Guidelines for Europe-WHO-1987	TOLUENE	7.5 µg/m^3 for 24 hour; 1 µg/m^3 for 30 min.	Air Quality Guidelines forEurope - WHO-1987
			VINYL CHLORIDE (VC)	No safe level	Air Quality Guidelines forEurope - WHO-1987

4.3.2.3. Scientific and Technological Resources

The scientific and technological resources of IAQIP can be grouped under two main headings. These are measurement methods and measurement devices [13,145].

The existence of different kinds of indoor air pollutants necessitate different types of IAQ measurements methods and devices.

Measurement methods of IAQ are systematic ways of researching IAQ and are composed of various components. Measurement methods of IAQ are based on time principles. According to the time principle, IAQ is measured in short-term and long-term periods. Short-time measurement is also defined as real-time measurement. In short-time measurement, results are obtained in a reduced time frame. Long-term monitoring offers the prospect of combining the results of short-term measurements (13,126,131,145).

IAQ measurement devices are used to measure either each individual pollutant concentration such as formaldehyde concentration, or to determine other factors such as air exchange rates, temperature, humidity, etc.

The technical principles of measurement instruments are as follows (13,126,131,145):

* Types of sampling devices: These are personal, portable, and stationary devices. Personal devices are compact, lightweight and carried easily. Portable devices can be carried but are not as convenient as personal devices. Stationary devices are fixed and operated from a permanent location.

* Operating characteristics: These are active or passive in operation. An active device has a power source such as an air pump which is used to force air to a device such as a filter, a collector, or a solution. Active sampling devices are used for short-time measurements. In a passive sampling device, the operating principle is based on diffusion. There is no power source to force air to the device. These devices are used for long-term measurement .

* Output characteristics of sampling devices: Sampling devices can be an analyser or a collector. An analyser device gives a signal and measures when it detects pollutant concentration. If the device is a collector, it collects an air sample which is analysed and measured in a laboratory.

4.3.2.4. Integrative Resources

Integrative resources of IAQIP are finance, energy, time, and working places which are laboratories and buildings themselves.

4.3.3. Activities of IAQIP

Main IAQ improvement actions can be grouped as [13,126,131,145] :

(a) monitoring of IAQ which includes recognition of IAQ and determination of factors which affect IAQ, and

(b) control of IAQ.

4.3.3.1. Monitoring of IAQ

IAQ is recognised by people themselves, and by some devices. Recognition of IAQ by people can be identified as 'perception of IAQ'. This is the process of detecting and judging IAQ. Indoor air pollution can be detected by nasal and visual systems of people [146-148].

Recognition of IAQ by devices is generally identified as 'measurement of IAQ'. Measurement methods and devices are briefly described in section 4.3.2.3. Scientific and Technological Resources.

4.3.3.2. Control of IAQ

A number of remedial actions to control indoor pollution have been recommended [1,3,10,16,33,133]. On the whole, these recommendations can be grouped under four main headings. These are: (a) control of pollutants; (b) control of sources; (c) control of people's activities; and (d) control of building design.

(a) Control of Indoor Air Pollutants

The most commonly recommended and used solution to control indoor air pollutant is dilution of polluted indoor air with fresh air by increasing the ventilation rate within the building [1,12-14,33]. It is generally thought that more air movement with the help of increased ventilation rate and outdoor air infiltration will reduce the concentrations of indoor air pollutants within the building. However, the whole system should be well designed, built, and maintained. Otherwise, increasing air movement alone will not solve the air problem, but will increase costs which are related to the energy consumption [16,25,149].

Another recommended indoor air pollutant control method is sterilization of indoor air [1,12-14,33]. Special filters, collectors and air treatment devices are used to filter indoor air. Sometimes cleaning indoor air with the help of such devices requires advanced technology which increases use costs of the building [13].

(b) Control of Indoor Air Pollution Sources

Removal of all identifiable indoor air pollution sources is the first recommended solution to control indoor air pollution from the sources point of view [12-14,16]. However, in most situations, application of this solution is either impossible or expensive.

Substitution or alteration or sealing of pollution sources are other recommended remedial actions. Also, the applicability of these solutions varies according to conditions within the building.

(c) Control of People's Activities

People's activities within the building can be controlled at two levels. These are control of individual's activities, and control of organisational activities.

Educating and informing people on indoor air quality is one solution to control individual person's activities [13,133].

Providing non-smoking spaces, such as rooms, corridors within the building (3), placing restrictions on use of pollutant sources (12), intending to operate the building according to the original design (16) are recommendations to control organisational activities within the building.

(d) Control of Design

As mentioned earlier, building design does not directly produce indoor air pollution but helps the existence of indoor air pollution within the building. Therefore, control of building design in terms of IAQ becomes very important to reduce the risk of IAQ problems before they happen. Most recommended design solutions related to IAQ are; well designed ventilation system, heating system, and regulating the size and use of spaces (3,10,12).

The achievements of IAQ improvement activities are dependent on several factors which must be considered in relation to each other. On the whole, these factors are:

* identification of indoor air pollutants, pollutant sources, and control methods;
* addressing the responsibilities of people who are involved in design,construction, and use of the building;
* combining the identified factors in a systematic way that aims to achieve correct decisions;
* applying these decisions to achieve the required solutions; and
* evaluating and checking the solutions to see whether they are efficient

Thus, IAQIP has all the general working plan based stages which are analysis, synthesis, realisation, and evaluation of a process.

The resources of IAQIP feed these stages at either the same or a different time. Besides, the level of their effectiveness will be changed according to the active roles of resources within the action stages.

4.3.4. Object of IAQIP

Providing fresh indoor air is the object which is the required achievement of IAQIP. The achievement of clean indoor air is based on levels which are low, medium and high, and based on times which are long term and short term.

Figure 22. shows the basic principle of IAQIP, and Table 16 shows the elements and stages of IAQIP.

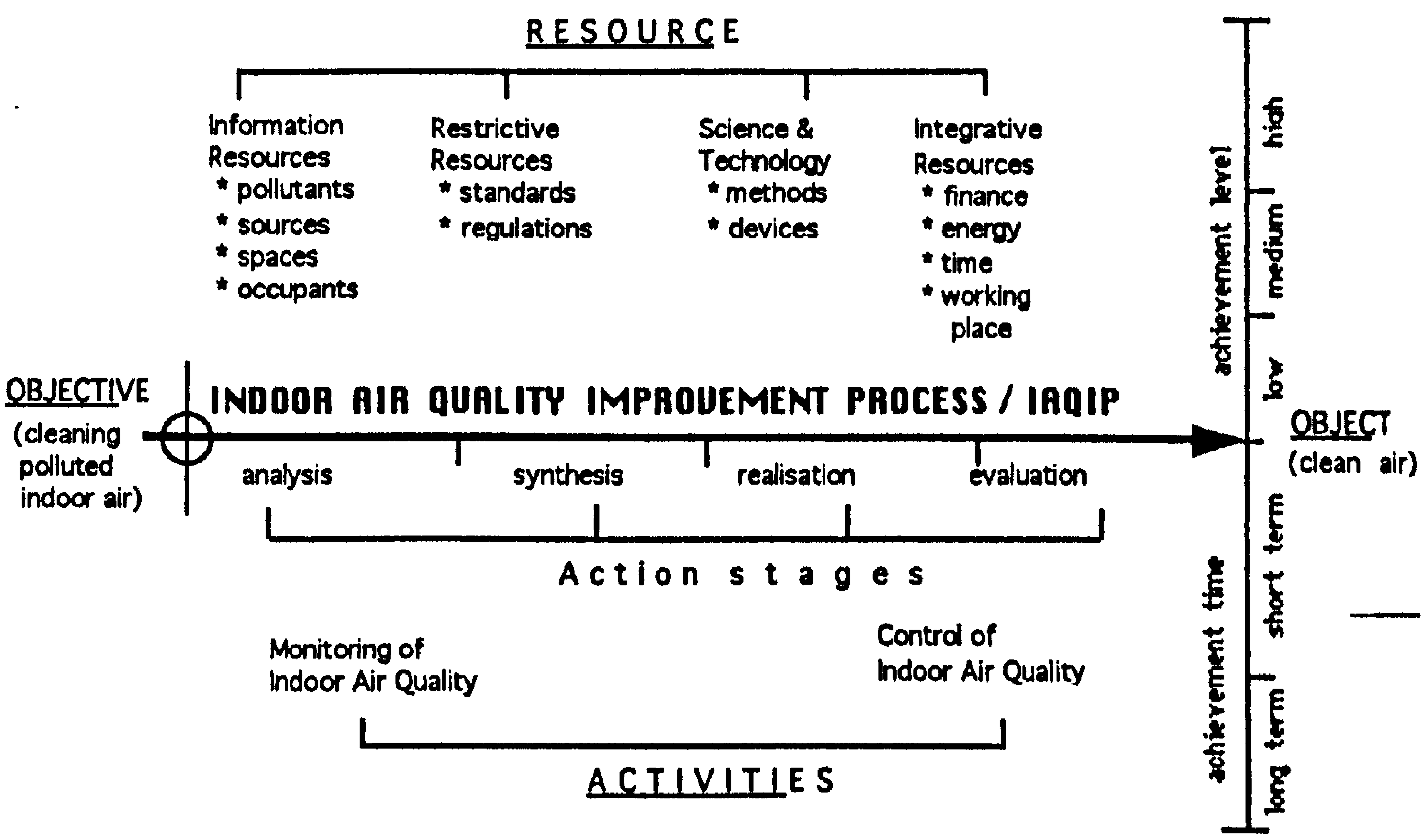


Figure 22. Indoor Air Quality Improvement Process (IAQIP)

Table 16 Elements and Stages of Indoor Air Quality Improvement Process

ELEMENTS of IAQIP	ACTION STAGES OF INDOOR AIR QUALITY IMPROVEMENT PROCESS (IAQIP)			
	ANALYSIS	SYNTHESIS	REALISATION	EVALUATION
OBJECTIVE	Cleaning polluted indoor air			Time Based: short term, long term early, middle, late Rate Based: low, medium, high
RESOURCES Informative Restrictive Science & Technology Integrative	Identification of indoor air pollutants: characteristics, concentrations and health effects Identification of pollutant sources: characteristics, effects on Indoor Air Quality Identification of occupants Identification of polluted indoor spaces Available scientific methods and technologies	Consideration of pollution concentration and standards and regulations Consideration of occupants characteristics and the use function of spaces within the building Consideration of alternative solutions	Involvement of Resources	Efficiency in identification of informative, restrictive, scientific, technological, and integrative resources
ACTIVITIES Monitoring Control	Addressing the responsibilities of people who are involved in design, construction and use of the building Identification of control methods and technologies: characteristics, costs, effectiveness, applicabilities	Monitoring Indoor Air Quality Methods: Perception Measurement Technologies: Devices personal,portable, stationary; operation: active, passive; output: analyzer, collector	Control of Indoor Air Quality: Control of pollutants Control of sources Control of people's activities Control of design Application stages: Time based; long term, short term; early, middle, late	Efficiency in monitoring and control of Indoor Air Quality
OBJECT	Clean indoor air			Achievement Level: low, medium, high Achievement Time : short term, long term; early, middle, late

4.4. INDOOR AIR QUALITY PROCESS / IAQP

As one way of systematic thought, starting from a small point and carrying on through the whole leads IAPP and IAQIP to be combined, because of their basic nature, i.e. both processes are related to indoor air.

Although previous systematic introductions of IAPP and IAQIP show these processes following each other linearly, in fact, it it impossible to separate them from each other. They occur at the same time. The indoor air in a room has been polluted by people, the building itself, and the outdoor environment whether the room is occupied or not. But at the same time, the air has been cleaned on some level by direct or indirect improvement actions, such as opening the windows or the door to enter or to leave the room, putting mechanical ventilation on, etc. Also while polluted air is diluted with fresh air to improve the quality of indoor air by either natural or mechanical ventilation, people, the building, the outdoor environment, etc. carry on to produce pollutants which contaminate indoor air because of the non-stop characteristic of life. Thus, while indoor air is polluted, improvement of the air occurs; and while indoor air is improved, pollution occurs too.

The inseparable characteristics of these processes make them parts of one whole process which is the Indoor Air Quality Process (IAQP). In this case IAPP and IAQIP become subprocesses of IAQP. Domination by one of the subprocesses of the other changes the result of IAQP. For example, if *n* times IAPP is more than *n* times IAQIP the result of IAQP will be below an acceptable level. In the opposite situation, the result will be better or good, etc.

4.4.1. Objectives of IAQP

The objective of the IAQP is to provide more indoor air improvement actions to keep the IAQ at a healthy level for people.

4.4.2. Resources of IAQP

The resources of IAQP are a combination of the resources of IAPP and IAQIP. These resources are grouped as information resources, restrictive resources, scientific and technological resources, and integrative resources. These resources are briefly described in section 4.3.2. Resources of IAQIP.

4.4.3. Activities of IAQP

Activities of IAPP and IAQIP form activities of IAQP. Thus activities of IAQP can be grouped as indoor air pollution activities and indoor air improvement activities as follows:

(a) Indoor air pollution activities: emission, concentration, combination and exposure of indoor air pollutants.

(b) Indoor air improvement activities: monitoring and control of IAQ. Monitoring activities of IAQP are perception and measuring. Control activities of IAQP are control of pollutants, control of sources, control of people's activities, and control of building design.

Both groups of activities are mentioned in sections 4.2.3. Activities of IAPP, and 4.3.3. Activities of IAQIP.

Indoor air pollution and improvement activities take their place in some stages within the whole process. These stages are based on a working plan and the time. The working plan based stages are analysis, synthesis, realisation, and evaluation. The time based stages are early, middle, late stages, and short term and long term stages.

4.4.4. Object of IAQP

The outcome of IAQP is healthy indoor air in terms of people's health requirements.

Figure 23. shows the basic principle of IAQP.

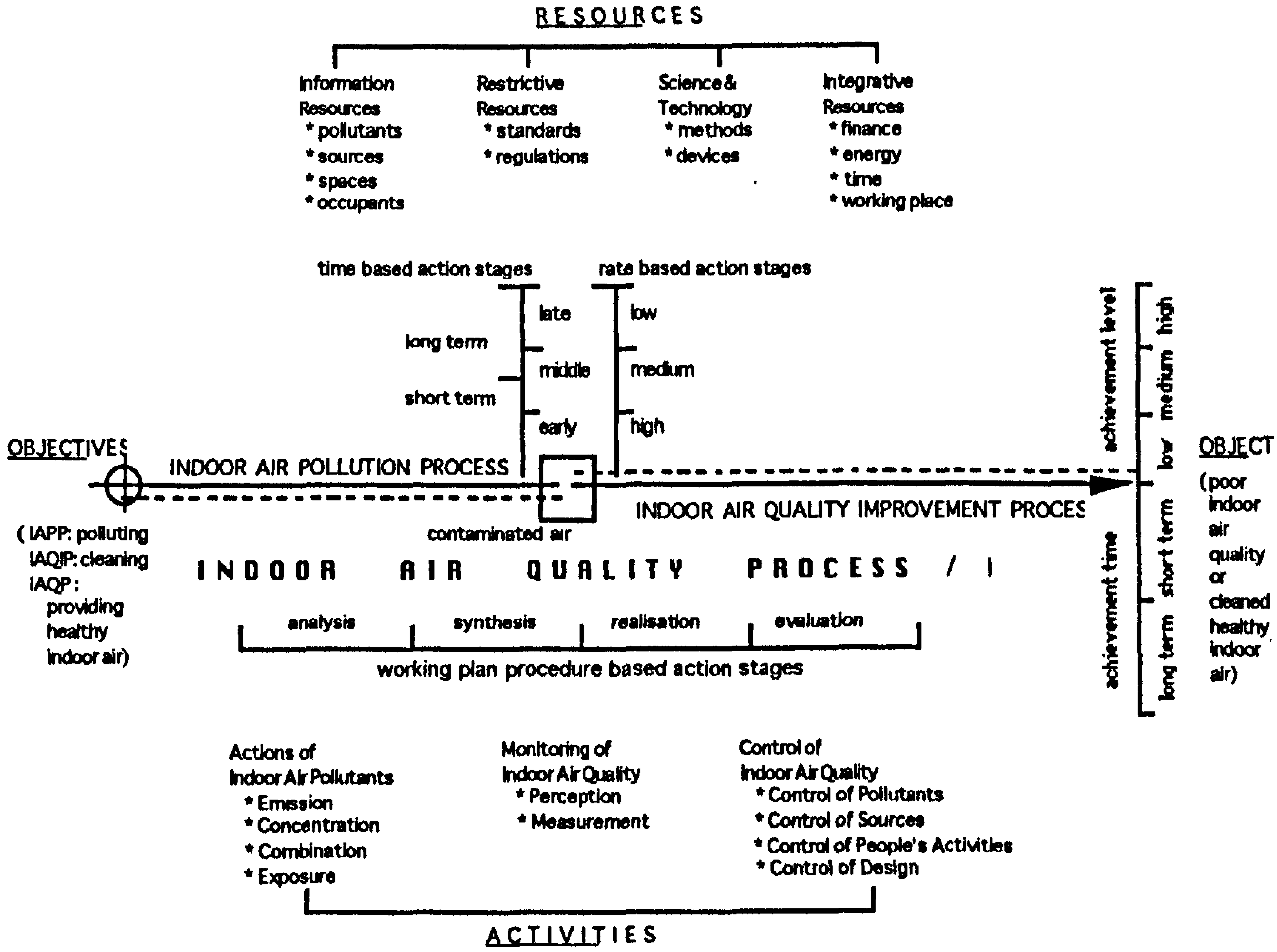


Figure 23. Indoor Air Quality Process (IAQP)

Although, in Figure 23, it appears as if IAQP is a linear flowing series of actions, actually, each stage depends on the others, either on previous stages or on next stages or both. For example, accuracy of synthesis depends on results of analysis; and results of synthesis provides information to realisation. At the same time, synthesis obtains information from resources. Besides, there is a feedback all the time between them. Results of synthesis are checked by results of analysis, etc.

Therefore, the close dependency and feedback interrelationships occur between stages and stages; stages and resources; stages and activities; resources and resources; resources and activities; and activities and activities. Also, their interrelationships affect the output of IAQP.

Figure 24. shows the dependency and feedback levels of IAQP.

OBJECTIVES of IAPP and IAQIP

		IAQIP STAGES				RESOURCES				IAPP & IAQIP ACTIVITIES		
		Analysis	Synthesis	Realisation	Evaluation	Information Resources	Restrictive Resources	Science & Technology	Integrative Resources	Pollutants Activities	Monitoring Activities	Control Activities
IAPP & IAQIP ACTIVITIES	Pollutants Activities	●	●	●	●	●	●	●	●		●	●
	Monitoring Activities	●	●	●	●	●	●	●	●	●		●
	Control Activities	●	●	●	●	●	●	●	●	●	●	
RESOURCES	Information Resources	●	●	●	●		●	●	●			
	Restrictive Resources	●	●	●	●	●		●	●			
	Science & Technology	●	●	●	●	●	●		●			
	Integrative Resources	●	●	●	●	●	●	●				
IAQIP STAGES	Analysis		●	●	●							
	Synthesis	●		●	●							
	Realisation	●	●		●							
	Evaluation	●	●	●								

OBJECT of IAQP

● Dependency and feedback connection

Figure 24. Dependency and Feedback Levels of Indoor Air Quality Process (IAQP)

4.5. STAGES OF INDOOR AIR QUALITY PROCESS

As it is indicated before, a combination of objectives, resources, activities and objects of IAQP occurs in some stages. Such stages are indicated as analysis, synthesis, realisation and evaluation.

Analysis Stage of IAQP
During the analysis stage of IAQP objectives, all resources and activities are identified in detail to understand the problem.

Synthesis Stage of IAQP
Synthesis is the stage of IAQP that objectives, resources and activities of IAQP are examined and considered. While these elements of IAQP are examined and considered, strategies that will be followed to produce alternative solutions for the problem are decided; alternative solutions are developed; and the better solution among them is selected.

Realisation Stage of IAQP
The selected preventive solution is applied to improve IAQ in this stage

Evaluation Stage of IAQP
During this stage the accuracy of resources, the efficiency of activities and the quality of the object are evaluated.

The synthesis and realisation stages of IAQP are affected by the information derived from the analysis stage of IAQ. The information obtained in the analysis stage is limited due to some important issues. These issues are (129,150) :

. comprehensive and conclusive data about indoor air pollutants, their health effects, sources, and affected group of occupants and their characteristics is not always available;

. judgement about the data is not always totally objective because terms such as adverse and sufficient evidence are used to describe some of the data; and

. due to the limited extension and the quality of data, uncertainties occur in IAQ related studies.

Therefore, a risk factor is considered in the evaluation of IAQP [112,150].

Table 17 shows the consideration of the elements and the stages of IAQP.

Table 17. Consideration of The Elements and Stages of Indoor Air Quality Process (IAQP)

STAGES OF IAQP	ELEMENTS OF INDOOR AIR QUALITY PROCESS (IAQP)								
	OBJECTIVES	RESOURCES				ACTIVITIES			OBJECTS
		INFORMATION RESOURCES	RESTRICTIVE RESOURCES	SCIENCE & TECHNOLOGY	INTEGRATIVE RESOURCES	POLLUTION ACTIVITIES	IMPROVEMENT ACTIVITIES		
							MONITORING	CONTROL	
ANALYSIS	To provide more indoor air improvement actions to keep the IAQ in a healthy level for the occupants	DETAILED IDENTIFICATION of : pollutants sources spaces occupants	standards regulations	methods devices	AVAILABILITY of : finance energy time working place	IDENTIFICATION of : emission concentration combination exposure	perception measurement	control of pollutant, source, people's activities and design	data for synthesis stage
SYNTHESIS		integration and consideration of all resources and activities, making strategic decision on solving IAQ problem, development of alternative solutions, selection of suitable/better/best solution							selected solution of IAQ problem
REALISATION		integrations of all resources according to the problem solving strategy				indoor air pollution	application of selected solution to remedy for IAQ problem		healthy indoor air
EVALUATION	RISK ASSESSMENT in IAQP: risk identification, risk estimation, risk evaluation; RISK MANAGEMENT in IAQP: risk acceptability, risk control								

4.6. RISK ASSESSMENT / RISK MANAGEMENT IN THE INDOOR AIR QUALITY PROCESS

Three elements of risk assessment are indicated as risk identification, risk estimation and risk evaluation in Part 2.3.2.3. A. Risk Factor in The Evaluation of The Building. Elements of risk management are grouped as risk acceptability and risk control. Also, the general hazard evolution and control chain model is illustrated in Figure 11.

Here, this general hazard evolution model is modified in terms of IAQ in Figure 25.

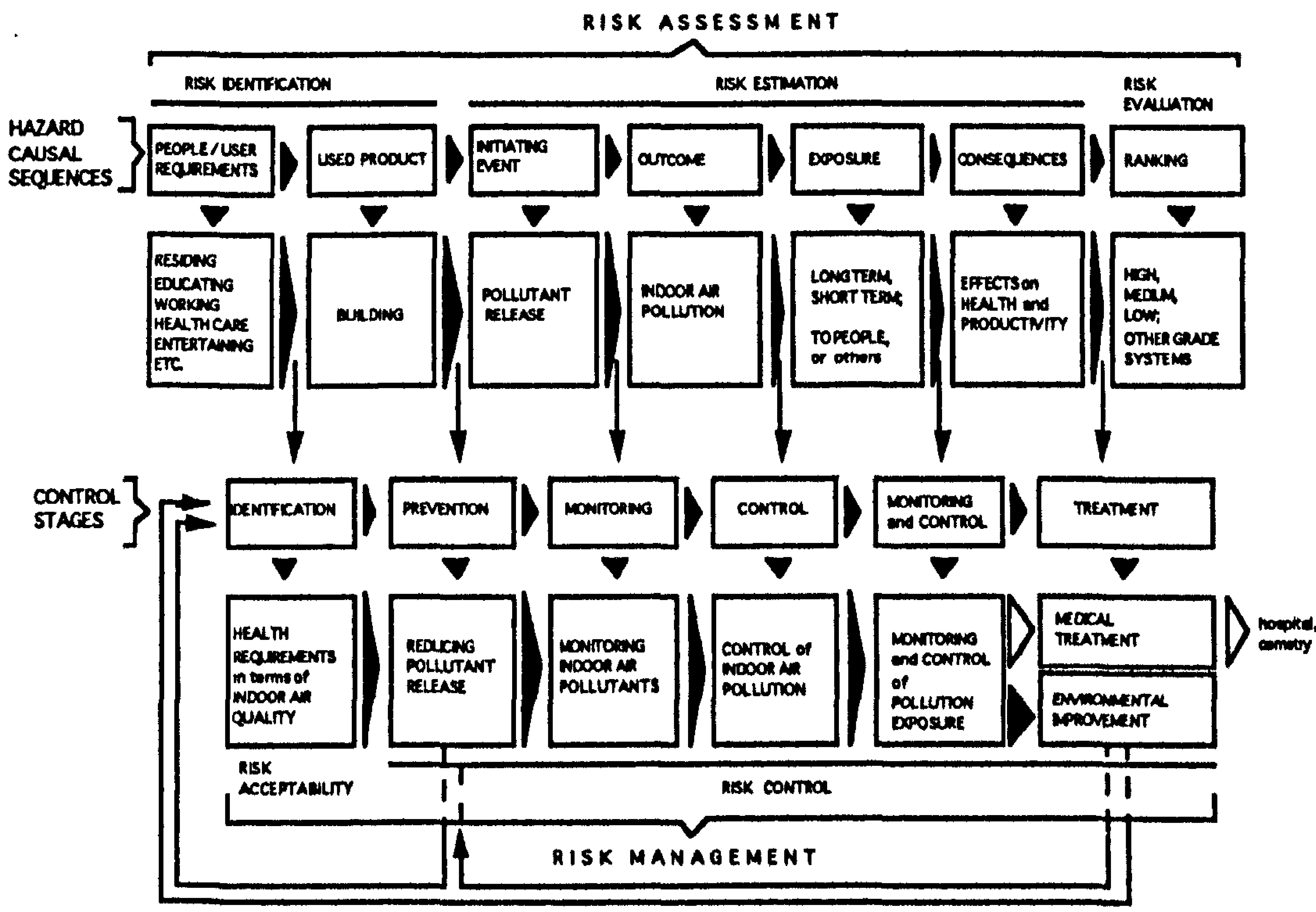


Figure 25. The Hazard Evolution and Control Chain Model for The Building in Terms of IAQP.

4.6.1. Risk Assessment - IAQP

(a) Risk Identification

Risk identification in terms of IAQP determines; whether a monitored or suspected indoor air pollutant causes adverse health effect; which group of occupants will be affected; in which indoor space indoor air pollution possibly occurs; and from which source the pollutant comes out (129,150). During the risk identification these issues are examined in detail..

(b) Risk Estimation

Emission rates of indoor air pollutants, concentration and combination of pollutants in indoor air, occurrence of exposure in long term or short term, and whether the consequence of the pollution affects people's health and productivity, or non-human based occupant's health, or contents of the indoor space are stated or estimated during risk estimation. The difficulties of estimating risk in IAQ can be indicated as (150):

. variety of indoor spaces and their distinctive characteristic show different pollutant concentrations,

. duration of occupancy changes according to activities of each individual occupant and group of occupant within the space,

. existence of many things within the space such as occupants, furniture, machinery, etc. can increase the number of pollutant sources,

Due to these difficulties, before modelling IAQP and the building together, some patterns should be prepared. These patterns are:

(b_1) grouping the spaces according to the occupant's activities; 'functional zones',

(b_2) identification of each space, and grouping the spaces according to the their possible levels of pollution concentrations; 'polluted zones' in term of IAQ within the building,

(b_3) identification of each indoor air pollutant source, and grouping the sources within the space according to their possible priorities in terms of IAQ; 'groups of pollution sources'.

(c) Risk Evaluation

During risk evaluation in IAQP estimated outcome, exposure and consequences of the event, and the event itself are judged by giving ranks to them on some scale. This ranking system is based on various criteria (129,134,151-156). The most accepted criterion in risk evaluation of IAQP is the carcinogenity of an indoor air pollutant [129,150]. However, it is indicated that risk assessment should not be based only carcinogenity [150].

The difficulty in ranking is that all factors in IAQP cannot be measured in the same units. Also, the occurrence of scientific uncertainties in risk estimation affects the scaling system. Therefore, in most ranking systems, the magnitude of risk in IAQP has generally been described in probability of harm terms[129,134,151-156] such as proven adverse health effect, probable adverse health effect, higher probability, lower probability, unclassified, etc. (129).

4.6.2. Risk Management - IAQP

(d) Risk Acceptability

The accepted standards and regulations related to IAQ determine the acceptable levels of emissions, concentrations.and combinations of pollutants.

(e) Risk Control

The prevention, monitoring, control and treatment are the stages of risk control. In IAQP, these stages occur in two conditions. The first one is to control the risk before indoor air pollution incident happens. The second one is to control the risk after the occurrence of indoor air pollution.

Part Five : THE ARCHITECTURAL DESIGN PROCESS and THE INDOOR AIR QUALITY PROCESS

5.1. INTRODUCTION

The building is examined as a whole system (Part 1. The Building System) which consists of objectives, resources, activities, hardware and environment subsystems of the building. Subsystems and their contents are also features of the building. The Architectural Design Process is placed in the activities subsystem, and IAQP is placed in the environment subsystem of the building.

Also, in a previous part of the thesis (Part 4. Indoor Air Quality Process), the building itself is briefly mentioned as one of the indoor air pollutant sources. Before considering the Architectural Design Process and IAQP, the features of the Building System and the features of IAQP need to be examined together in detail to see the effects of the building on IAQ.

In this part of the thesis, firstly, the Building System and its features will be examined as sources of indoor air pollution. Secondly, IAQP will be considered with the life stages of the building. Then the Architectural Design Process and IAQP of the building will be examined according to the RIBA Plan of Work.

5.2. THE BUILDING as an EFFECTIVE POLLUTION SOURCE of THE INDOOR AIR QUALITY PROCESS

Objectives, resources, activities, hardware and environment of the whole building system and IAQP will be considered in the following subparts.

5.2.1. Objectives of The Building System and IAQP

Organisational / Use Objectives - IAQP

The organisational objectives are production, adaptability, stability and morale [43]. The first three objectives are related to the production and alteration activities of an organisation and the stable situation of the organisation. However, the last objective of the organisation, which is morale, is directly related to the people who work and are involved in the organisation.

Morale is the feeling that shows the amount of confidence and optimism of the members of the organisation in the present situation. The happiness and hopefulness of people depend on their security and well-being. To keep people healthy in the organisation should be the main aim of the organisation for the future of people and the organisation.

The objectives of IAQP are grouped as objectives of IAPP and IAQIP. The objectives of IAPP, which are releasing indoor air pollutants and polluting indoor air, are unwanted but, at the same time, unavoidable objectives. However, the objectives of IAQIP, which are decreasing of indoor air pollution and providing healthy conditions in buildings in terms of IAQ for the occupants, are required achievements within the building. Therefore, the improvement objectives of IAQP should be considered while the morale related objectives of the organisation are described.

Design Objectives - IAQP

Design objectives are grouped as architectural design objectives, engineering design objectives and manufacturing design objectives in the building system. Because of the limitation of the thesis, here, architectural design objectives and IAQP will be considered.

Architectural design objectives are briefly mentioned as achieving the environmental and structural quality, economy and aesthetic within the building design. Environmental quality of the building includes features of indoor environment and outdoor environment of the building. Structural quality covers the hardware of the building. Economy within the building represents the minimum use of finance, time and energy resources of the building during design, construction and use periods of the building.

IAQP should be accepted as an important design objective since preventive decisions in terms of IAQ can be taken during the architectural design stage of the building.

In further subparts, the relationships between structural and environmental quality of the building and IAQP will be examined together.

Table 18. shows the correlation between objectives of the Building System and objectives of IAQP.

5.2.2. Resources of The Building System and IAQP

Resources of the building are grouped under four main headings which are people, integrative resources, information resources and technology.

Resources of IAQP are also grouped as information resources, restrictive resources, integrative resources, and science and technology.

People as one of the resource groups of the Building System are linked with information resources of the IAQP. Workers and other associated people within the organisation emit indoor air pollution, and are affected by indoor air pollution. Again, people who are involved in the building try to solve any indoor air pollution problem. Therefore, identification of user and description of job responsibilities of design team members and control authorities are important resources for both Building System and IAQP.

Related integrative resources of the Building System and IAQP are identification of polluted spaces and IAQ management policy, estimating the indoor air pollution period and duration, and the time that preventive actions are taken.

Table 18. Correlation of Objectives of The Building System and IAQP

OBJECTIVES of THE BUILDING SYSTEM ↓ / OBJECTIVES of INDOOR AIR QUALITY PROCESS →			Objectives of Indoor Air Pollution Process	Objectives of Indoor Air Quality Improvement Process
ORGANISATIONAL / USE OBJECTIVES	*Production* *Adaptability* *Stability* MORALE	*Related to the productive activities, altered and stable situation of the organisation.* Related to the users' confidence, optimism, happiness, hopefulness. Security Well-being	pollutant emission; indoor air pollution; hazardous effects on users.	decrease of indoor air pollution; providing healthy condition in the building.
DESIGN OBJECTIVES	ARCHITECTURAL DESIGN OBJECTIVES *Engineering Design Objectives* *Manufacturing Design Objectives*	achievements of; spatial quality, quality of the physical environment, social / behavioral provisions, quality of the hardware, economy & efficiency, aesthetic.	examination of the hardware and the environment of the building and their contribution to indoor air pollution	accepting IAQ as an important design objective; taking preventive actions during the architectural design stage of the building to help improvement of indoor air quality.
CONSTRUCTION OBJECTIVES *OBJECTIVES of AUTHORITIES* *MANUFACTURING OBJECTIVES*			*These objectives are not examined because of the limitation of this thesis.*	

Informative, restrictive and scientific resources of IAQP are linked with information resources of the Building System. Identification of indoor air pollutants, indoor and outdoor sources, acceptable levels of pollutant concentration, health requirements, standards and regulations, and available control methods during the design, construction and use stages of the building provide important information to the design team and other people who are involved in the Building System.

Technological resources of IAQP provide available sampling, and control devices for indoor air pollution control. Also, sampling and control devices can be grouped as tools and machinery of the Building System.

Table 19 shows the consideration of resources of IAQP and resources of the Building System.

Table 19. Resources of The Building System and IAQP

RESOURCES of IAQP ▶	INFORMATION RESOURCES	RESTRICTIVE RESOURCES	INTEGRATIVE RESOURCES	SCIENCE & TECHNOLOGY
RESOURCES of THE BUILDING SYSTEM ▼	Pollutants Sources Spaces Occupants	Standards Regulations	Finance Time Energy Work Place Management	Methods Devices
PEOPLE Organisation, Design Team, Construction Team, Suppliers, Control Authorities,	User (occupant) identification; Identification of job responsibility of design team members at architectural design	Description of job and contribution of control authorities		
INTEGRATIVE RESOURCES Finance Time Energy Work Place Management			Identification of polluted spaces; IAQP management	
INFORMATION RESOURCES Regulations Science Publications Experience Case Studies Evaluation / Feedback	Identification of indoor air pollutants, and indoor / outdoor sources	Identification of acceptable levels of pollutant concentrations, Health requirements, standards, regulations		Available control methods during the design, construction and use of the building
TECHNOLOGY Materials Building Components Tools and Machinery				Available sampling & control devices

5.2.3. Activities of The Building System and IAQP

All activities within the Building System are grouped under three headings which are design activities, construction activities and use activities. Design activities include organisational, architectural, engineering and manufacturing design activities. Construction activities include organisational, site preparation and building construction activities. Use activities within the building are grouped as organisational activities and building related activities. Due to the limitation of this thesis, the RIBA Plan of Work as the base of the Architectural Design Activities and IAQP will be considered in subpart 5.4.

The use activities within the building are results of users' requirements, and the users' requirements are the start of architectural design. Therefore, here architectural design activities and use activities will be considered with IAQP.

Activities within the IAQP are grouped as pollution activities and improvement activities.

Organisational use activities include individual or group profession related activities and individual related activities. Due to the professional and individual related activities of people, some of the indoor air pollutants are released and indoor air pollution occurs The relationship between use activities within the building and activities of IAQP are shown in Table 20.

IAQ improvement activities at the use activities level within the building are:

- * preparing an organisational policy related to IAQ;
- * separating the work activities such as workshop activities and office activities;
- * educating and informing people;
- * restricting some activities of people related to IAQ;
- * cautioning people about the use of some household products;
- * warning people to care about themselves and other people.

Table 20. Organisational Use Activities of The Building System and Activities of IAQP

	USE ACTIVITIES WITHIN THE BUILDING / ACTIVITIES OF INDOOR AIR QUALITY PROCESS	POLLUTION ACTIVITIES	IMPROVEMENT ACTIVITIES
		Pollutants: emission, concentration, combination, exposure	Monitoring, Control
PROFESSION RELATED ACTIVITIES	WORK / OFFICE ACTIVITIES electrostatic copying machines: photocopiers, spirit duplicators, signature machine, blue print copiers, ... cutters: paper, metal, wood, ... use of adhesives, solvents, ... x-ray machines, experimental work: use of chemicals, substances, ... use of chemical cleaning substances: detergent, bleach, ...	ozone, respirable suspended particulates (RSP): dust, bacteria, viruses, molds, fungi, etc), Polynuclear Aromatic Hydrocarbons (PAH) formaldehyde, toluene, benzene alcohol, ammonia, acetylene, water, ...	Organizational policy related to IAQ, seperation of work activities such as workshop activities and office activities informing and educating people, and rectricting some of their activities related to IAQ.
INDIVIDUAL RELATED ACTIVITIES	HOUSEHOLD ACTIVITIES & HOBBIES cooking, cleaning, use of air fresheners: disinfectants, deodorants, ... painting, pottery, wood / metal working, insect control, smoking, pets and plants, ...	RSP, formaldehyde, PAH, toluene, benzene alcohol, ammonia, acetylene, water, carbon monoxide, carbon dioxide nitrogen oxides, ...	Informing and educating people, and cautioning them about the use of some household products which cause indoor air pollution.
	BIOLOGICAL & PHYSICAL ACTIVITIES breathing, coughing, sneezing, sweating, renewing skin, urination / excretion, ...	RSP, PAH, water, carbon dioxide, ...	Informing and educating people, to care about themselves and other people.

It is obvious that if a building is at the design stage, none of the indoor activities in that building can happen including air pollution activities. Therefore, use activities of an existing building, which is functionally similar with the newly designed building, should be examined in terms of IAQ. This examination provides information to the design team so that they can describe the function of the spaces of new building, and group these spaces according to their function and possible pollution level (polluted zones).

Design activities of the Building System and activities of IAQP are considered in Table 21. In this table, all design activities and IAQP activities are briefly considered. In this consideration, it is indicated that previous studies about indoor air pollutants, their sources, and effects of the building on IAQ should be used as feedback information for the new design. Besides, IAQ should be accepted as an important design objective; environmental design strategy should be determined and alternative design solutions should be produced in terms of IAQ.

Table 21. Design Activities of The Building System and Activities of IAQP

<table>
<tr><td colspan="2" rowspan="2">ACTIVITIES OF INDOOR AIR QUALITY PROCESS
DESIGN ACTIVITIES of THE BUILDING SYSTEM</td><td>POLLUTION ACTIVITIES</td><td>IMPROVEMENT ACTIVITIES</td></tr>
<tr><td>Pollutants: emission, concentration, combination, exposure</td><td>Monitoring, Control</td></tr>
<tr><td colspan="2">ORGANISATIONAL DESIGN ACTIVITIES</td><td rowspan="3">Considering previous studies about indoor air pollutants, their sources and effects of the building to indoor air quality as feedback information for the new design.</td><td rowspan="3">Acceptance of IAQP as an important design objective;

determination of environmental design strategy;

producing alternative solutions for the architectural design of the building during design stage .</td></tr>
<tr><td>ARCHITECTURAL DESIGN ACTIVITIES</td><td>Brief,
Sketch Plans,
Working Drawings,
Site Operation,
Building in Use,
Retirement of The Building</td></tr>
<tr><td colspan="2">ENGINEERING DESIGN ACTIVITIES

MANUFACTURING DESIGN ACTIVITIES</td></tr>
</table>

5.2.4. Hardware of The Building System and IAQP

Features of the hardware of the Building System have been classified as structural elements, services, and contents of the building according to the CI/S*f*B specification in Part 2.3.2.2.C Hardware of The Building.

5.2.4.1.Structural Elements of The Hardware and IAQP

The hardware of the building consists of the structural design of elements, and parts and materials of the elements. The structural design of elements is the way in which the elements are designed in a particular shape. In this design all different parts and materials of each element and all elements are assembled to form the structure of the building.

As a process IAQ has two outputs. One of them is polluted air which is the result of IAPP. The second out put is cleaned air which is the result of IAQIP. Also activities of IAQP describes these outputs. Therefore the structural elements of the building are considered with the activities of IAQP.

Table 22 shows the relationships between the structural elements of the building and the activities of IAQP. In this consideration, the structure of the elements are detailed according to the CI/S*f*B specification, and some of the parts and materials of these elements are taken as examples. During the architectural design of the building all structural elements and their parts and materials should be specified for that design.

Table 22. Structural Elements of The Hardware and Activities of IAQP

HARDWARE of THE BUILDING SYSTEM		ACTIVITIES of INDOOR AIR QUALITY PROCESS	POLLUTION ACTIVITIES	IMPROVEMENT ACTIVITIES
	STRUCTURE (Structural Design)	PARTS & MATERIALS	Pollutants: emission, concentration, combination, exposure	Monitoring; Control
STRUCTURAL ELEMENTS	SUBSTRUCTURE ground, floor beds, foundation, retaining walls.	soil, stone, concrete, insulation materials, steel, ...	radon, respirable suspended particulates (RSP), moisture, water, ...	Careful design of details; * details of horizontal surfaces, * details of vertical surfaces, * details of horizontal joints of the surfaces, * details of vertical joints of the surfaces, * details of corner joints of the surfaces, design of good ventilation, careful specification of building materials, correct insulation.
	SUPERSTRUCTURE external walls, internal walls, floors & galleries, stairs, roofs, building frames, chimneys.	partition, plywood, panelling, particle board, fibre board, urea-formaldehyde insulation, brick, concrete, gypsum board, plaster, ...	asbestos, RSP (dust, bacteria, viruses, molds, fungi, etc), formaldehyde, radon, carbon monoxide, nitrogen oxides, water, fibreglass, odour, ...	
	COMPLETION windows, doors, suspended ceilings, roof lights.	window / door frames, timber, metals, mastic, gypsum board, plaster, ...	RSP, formaldehyde, asbestos, radon, odour, ...	
	FINISHES wall, floor, ceiling, roof, stairs finishings	floor coverings; carpet, tiles, parquet,linoleum... wall coverings, plaster, paint, tiles, timber covering, ... ceiling coverings; tiles, plaster, paint, timber, ... glaze, varnish, protective coatings, adhesive, polyvinyl chloride (PVC), ...	asbestos, RSP, formaldehyde, toluene,styrene, vinyl chloride, odour, lead, polyurethane, hydrocarbons, petroleum distillates, ...	

5.2.4.1.A. Substructure - IAQP

The substructure of the hardware of the building is laid on the ground and supports the other structural elements. Basic parts and materials of the substructure are soil itself, stone, concrete, reinforced concrete, steel, insulation materials, and so on. Main pollutants which are emitted from these parts and material are radon, respirable suspended particulates (dust, bacteria, viruses, moulds, fungi, etc.), water, and moisture [134,160,161].

The soil itself contains radon. Some areas on the Earth have been defined as high risk areas where the radon concentration is higher than 50 000 Bq / m^3. Uranium rich alum shales, granites, and uranium mineralisation areas have been grouped as high risk areas. The areas where the radon concentration is below 10 000 Bq / m^3 have been classified as low risk areas. The areas which contain between 10 000 - 50 000 Bq / m^3 radon have been defined as normal risk areas [160]. Also, drinking water and some of the building materials e.g. alum-shale concrete, mill tailing used as concrete ballast, etc. contain radon [3,19, 21,23].

Radon enters the building from the subjacent soil through the cracks, joints, and holes [19, 21, 23]. It has been indicated that radon concentration level is higher in basement and ground floors than other floors such as first and second floors. Also, a high level of radon concentration in bathrooms has been indicated due to the well water. If the water contains radon, the radon is emitted to the air when the water is heated [19].

Besides radon, some of the respirable suspended particulates such as bacteria and moulds enter the building due to the moisture which originates from ground water.

5.2.4.1.B. Superstructure - IAQP

The superstructure of the hardware of the building is like a skeleton which is erected on the substructure. It consists of external walls, internal walls, floors and galleries, stairs, roofs, building frames such as columns and beams, and chimneys. Some of the parts and materials which are used to built the superstructure of the building are partitions, plywood panelling, particle boards, urea-formaldehyde insulation materials, brick, concrete, reinforced concrete, gypsum boards, plasters, etc [18, 92].

Basic pollutants which are released from these materials are asbestos, respirable suspended particulates (dust, bacteria, viruses, moulds, fungi, etc.), radon, water, fibreglass, odour, polynuclear aromatic hydrocarbons, nitrogen oxides. The pollutants are released from the surfaces of the parts and materials of the superstructure. Also, they enter the building from joints, cracks, holes, and openings such as doors and windows [133-135,161].

5.2.4.1.C. Completion - IAQ

Completion is the situation when window, door, suspended ceiling, and roof light related work is finished. In this situation, superstructure work is completed and the building takes on its own physical appearance.

Timber, metals, mastic, glass, gypsum board, plaster are some of the materials which are used to form the window and door frames, suspended ceilings, and roof lights [18].

These materials release indoor air pollutants such as respirable suspended particulates, formaldehyde, radon, asbestos and odour. Also, these pollutants and some other pollutants enter the building through door and window openings, joints, cracks and holes.

5.2.4.1.D. Finishes - IAQP

Finishes are the final work on the structure of the building. Walls, floors, ceilings, roofs, and stairs of the building are finished by coverings such as carpet, tiles, plasters and paint. Also, glaze, varnish, protective coatings, and adhesives are used to finish the surfaces of superstructure elements and completion elements.

Similarly, finishes release pollutants which are respirable e.g. suspended particulates, formaldehyde, radon, asbestos,odour. Additionally toluene, styrene, vinyl chloride, lead, polyurethane, hydrocarbons, petroleum distillates are some of the other indoor air pollutants that are emitted from parts and materials of the finishes (133-135).

5.2.4.2. Services of The Hardware and IAQP

Services of the hardware of the building have been grouped as environmental services, supply services, disposal services and central plant.

5.2.4.2.A. Environmental Services - IAQP

Environmental services include lighting, heating, ventilation and air-conditioning (HVAC) systems (133, 135, 162, 163).

The use of fluorescent lamps in lighting service releases ozone to the air. In addition, the parts and materials of the HVAC Systems emit some indoor air pollutants. Boilers, pipes, breaching insulation, fire proofing, stagnant water, humidifiers, dehumidifiers, cooling towers, drip pans, air intakes, fibreglass insulation, stoves, kerosene heaters and fire places are some of the parts and materials of the HVAC Systems Incomplete combustion in heaters is also an important factor in the emission of indoor air pollutants. These parts and materials release ozone, asbestos, respirable suspended particulates (dust, fibres, bacteria, mould, fungi, viruses, etc.), formaldehyde, nitrogen oxides, carbon monoxide, carbon dioxide, methane, polynuclear aromatic carbons, water, odour, and so on (133, 135, 163).

5.2.4.2.B. Supply Services - IAQP

Gas, electricity, hot and cold water, telephone systems are the supply services of the hardware of the building. Boilers, pipes, breaching insulation, fire proofing, and water are the some of the parts and materials that are used for supply services. Asbestos, respirable suspended particulates, nitrogen oxides, carbon monoxide, carbon dioxide, methane, polynuclear aromatic carbons, radon, water, odour are the indoor air pollutants which are released from parts and materials of the supply services.

5.2.4.2.C. Disposal Services - IAQP

Waste removal services, drainage, and sewerage are the disposal services of the hardware of the building. Pipes and breaching insulation, ducts, waste containers are some of the parts and materials which are used for disposal services. Asbestos, radon, respirable suspended particulates, methane, water, and odour are some of the indoor air pollutants.

5.2.4.2.D. Central Plant - IAQP

The central plant of the building and electrical systems cause electromagnetic pollution within the building. Due to the limitation of this thesis, electromagnetic pollution is not covered.

Table 23 shows the consideration of services and contents of the building system and activities of IAQP. In this consideration, elements of services and contents are examined in two headings which are structural design, and parts and materials of these elements. The structural design of the elements is grouped according to the CI/S*f*B specification, and some of the parts and materials of those of elements are taken as examples.

Table 23. Services and Contents of The Hardware and Activities of IAQP

HARDWARE of THE BUILDING / ACTIVITIES of INDOOR AIR QUALITY PROCESS			POLLUTION ACTIVITIES	IMPROVEMENT ACTIVITIES
	STRUCTURE	PARTS & MATERIALS	Pollutants: emission, concentration, combination, exposure	Monitoring; Control
SERVICES	ENVIRONMENTAL SERVICES lighting; heating, ventilation, air-conditioning (HVAC System)	fluorescent lights; boiler, pipe, and breaching insulation, fire-proofing, stagnant waters, humidifiers, dehumudifiers, cooling towers, drip pans, air intakes, fibreglass insulation. incomplete combustion, stoves, kerosene heaters, fireplaces, ...	ozone, asbestos, respirable suspended particulates (RSP), formaldehyde, nitrogen oxides, carbon monoxide, carbon dioxide, methane, polynuclear aromatic hydrocarbons, moisture, water, odour, ...	Careful design of details; * details of horizontal surfaces, * details of vertical surfaces, * details of horizontal joints of the surfaces, * details of vertical joints of the surfaces, * details of corner joints of the surfaces, design of good ventilation, careful specification of building materials, correct insulation.
SERVICES	SUPPLY SERVICES gas electricity hot & cold water telephone	natural gas supply; boiler, pipe, and breaching insulation, fire-proofing, ...	RSP, asbestos, radon, methane, nitrogen oxides, carbon monoxide, moisture, water, odour, ...	
SERVICES	DISPOSAL SERVICES waste removal drainage sewerage	pipe, and breaching insulation, ducts, waste containers,...	RSP, asbestos, radon, methane, moisture, water, odour, ...	
CONTENTS	FURNITURE circulation, general room, culinary, sanitary, cleaning storage loose equipments	upholstery, textile, varnish, ...	RSP, formaldehyde, polynuclear aromatic hydrocarbons, ...	
CONTENTS	FITTINGS circulation, general room, culinary, sanitary, cleaning storage fixtures .	textile, varnish, shelving, decorative panelling, UV light fixtures, ...	RSP, formaldehyde, polynuclear aromatic hydrocarbons, moisture, water, ozone, ...	

5.2.4.3. Contents of The Hardware and IAQP

Furniture and fittings are the contents within the building. Furniture consists of movable goods such as tables, chairs and beds. Fittings are fixed objects such as sinks, cupboards, wash-basins in some of the spaces within the building. Users within the building need furniture and fittings for their activities.

All loose and fixed equipment within the building release some indoor air pollutants which are respirable suspended particulates, formaldehyde, polynuclear aromatic hydrocarbons, water, ozone, and so on [137, 159]. Table 23 shows the contents of the building and activities of IAQP.

The consideration of the structural elements, services and contents of the hardware of the building plus parts and materials of those hardware elements with the activities of IAQP provides detailed information to the design team such that they can produce alternative solutions and select suitable materials.

IAQ improvement activities which are related to the hardware of the building are:

* careful design of details [95]:
  - details of horizontal surfaces,
  - details of vertical surfaces,
  - details of horizontal joints of the surfaces,
  - details of vertical joints of the surfaces,
  - details of corner joints of the surfaces,
* design of good ventilation,
* careful specification of building materials
* correct insulation.

5.2.5. Environment of The Building System and IAQP

The environment of the building system has been grouped under two headings, indoor environment and outdoor environment of the building, in Part 2.3.3.2.E The Environmental Subsystem of The Building System.

In this part, the indoor and outdoor environments of the building have been examined as features of the environment and characteristics of features. Features of the indoor environment do not produce indoor air pollutants but they help the indoor air pollution to occur and stay inside the building. However, some of the features of the outdoor environment do release indoor air pollutants. Also, they help the pollution to enter the building and to stay inside for a long time.

5.2.5.1. Indoor Environment of The Building and IAQP

The indoor environment of the building consists of the spatial environment, physical environment, and social / behavioural environment.

5.2.5.1.A. Spatial Environment - IAQP

The spatial environment of the building has four main features which are dimensional features, formal features, locational features and flexibility.

Dimensional features cover the length, width, height, are and volume of each space within the building and of the whole building. People need some areas to function and they need some volume of air to support life. Insufficient area and volume of the spaces helps air pollution to occur in a short time.

Shape, layout, proportion, and orientation are the formal features of the spatial environment. Unsuitable shape, such as very narrow angles in the corners, and unsuitable layout, such as the placing of the furniture in the spaces, cause the occurrence of indoor air pollution due to the difficulties in ventilation and cleaning activities. Indoor air pollution activity gains speed due to the unbalanced proportional arrangement of the spaces to each other according to the functional use and the number of users. The orientation of the spaces and of the whole building helps outdoor air pollution enter the building.

Locational features of the spatial environment are functional connections, physical similarities / differences, dimensional similarities / differences, formal similarities / differences, utilisation, and zones. Spaces need to be connected according to their function. Unprotected connections between spaces help the indoor air pollution to flow from polluted spaces to other spaces. Wrong utilisation of the spaces may cause indoor air pollution. Absence of a zonal arrangement of the spaces in terms of IAQ makes the preventive activities difficult.

Flexibility is the final feature of the spatial environment. Functional changes, adaptability, expansion, and mobility are the main characteristics of the flexibility. Unsuitable functional changes, difficulties in adaptability, and unsuitable expansions of the spaces and the whole building can make the indoor air pollutants gain speed in being released from the structural elements of the building.

IAQ improvement activities which are related to the spatial environment of the indoor environment of the building are:

- design of efficient spaces,
- efficient areas and volumes of the spaces,
- suitable shapes and layout for the spaces and the building,
- balanced proportional arrangement of the spaces,
- correct orientation of the building,
- protected connections between the spaces,
- correct utilisation of the spaces,
- arrangement of air polluted indoor zones.

The features of the spatial environment of the building and the activities of IAQP are considered in Table 24 [95, 157, 158].

Table 24. Spatial Environment of the Building and Activities of IAQP

ACTIVITIES of INDOOR AIR QUALITY PROCESS ▶ / INDOOR ENVIRONMENT of THE BUILDING ▼			POLLUTION ACTIVITIES	IMPROVEMENT ACTIVITIES
			Pollutants: emission, concentration, combination, exposure	Monitoring; Control
	FEATURES	CHARACTERISTICS		
SPATIAL ENVIRONMENT	DIMENSIONAL FEATURES	Length, width, height area, volume	Indoor air pollution occurs due to; - unsufficient area and volume, - unsuitable shape and layout, - unbalanced proportion, - careless orientation, - unprotected connections between spaces, - wrong utilisation, - absence of zonal arrangement in terms of indoor air pollution	Design of efficient spaces; efficient areas and volumes, suitable shapes and layout, balanced proportional arrangement, correct orientation, protected connections between spaces, correct utilisation, arrangement of indoor air polluted indoor zones.
	FORMAL FEATURES	shape, layout, proportion, orientation		
	LOCATIONAL FEATURES	functional connections, physical similarities, / differences, dimensional similarities, / differences formal similarities / differences utilisation, zone		
	FLEXIBILITY	functional changes, adaptability, expansion, mobility		

5.2.5.1.B. Physical Environment - IAQP

The physical environment of the building covers the atmospheric features, visual features, auditory features, and features related to the sense of touch. Table 25 shows the consideration of the physical environment of the building and the activities of IAQP.

Table 25. Physical Environment of The Building and Activities of IAQP

INDOOR ENVIRONMENT of THE BUILDING ↓ / ACTIVITIES of INDOOR AIR QUALITY PROCESS →			POLLUTION ACTIVITIES	IMPROVEMENT ACTIVITIES
			Pollutants: emission, concentration, combination, exposure	Monitoring; Control
	FEATURES	CHARACTERISTICS		
PHYSICAL ENVIRONMENT	ATMOSPHERIC FEATURES	Thermal features, heat, coolness, humidy, ... air quality, ventilation, electromagnetic radiation, ...	Moisture, moulds, fungi, bacteria due to the humidity, long term occurence of air pollution due to the poor ventilation,	Structural and environmental design of the building for balanced atmospheric features,
	VISUAL FEATURES	lighting, reflection, brightness, glare, colour, ...	the use of some kinds of lamps in lighting system emits indoor air pollutants,	careful specification of building materials,
	AUDITORY FEATURES	acoustic, sound, noise, ...		
	FEATURES RELATED TO THE SENSE OF TOUCH	texture of the surfaces, softness / hardness of the sufaces, ...	difficulties in cleaning due to the roughness of the surfaces, ...	detailed design of the surfaces for easy cleaning.

Atmospheric features cover the thermal features such as heat, coolness, humidity, ventilation, air quality such as air pollution and improvement, electromagnetic radiation, ventilation, and any other feature which is related to the atmosphere. A high level of the humidity causes moisture. Due to this, moulds, fungi, and bacteria can settle into the spaces. Poor ventilation is one of the effective factors which helps indoor air pollution to stay inside (10, 17, 22, 136).

Visual features are lighting, reflection, brightness, glare, colour, and any other feature which is related to sight. There is no direct connection between the visual features and IAQP. But, the use of some kinds of lamps in the lighting system can cause indoor air pollution.

Acoustic, sound, noise, and any other feature which is related to hearing are the auditory features of the indoor environment of the building. There is no direct connection between auditory features and IAQP, too. However, some kinds of insulation materials which are used in the building to control noise levels release some of the indoor air pollutants.

The texture of the surfaces e.g. smoothness / roughness, softness / hardness, are sense of touch related features of the indoor environment. The texture of the surfaces is an important factor; that is to say, for example, smoothness of the surfaces makes them easily cleaned, roughness of the surfaces helps the air pollutants to stay on the surfaces, and makes the cleaning process difficult. This means using more cleaning detergent and releasing more air pollutant to indoor air.

Improvement activities of IAQP which are related to the physical indoor environment of the building are:

* structural and spatial design of the building for balanced atmospheric features,
* design of good ventilation,
* careful specification of building materials,
* detailed design of surfaces for easy cleaning.

5.2.5.1.C. Social / Behavioural Environment - IAQP

The social / behavioural environment of the building consists of user identification, social characteristics, socio-cultural characteristics, and physical and psychological interaction.

User identification covers classification of users such as human / animal / plant / goods / or substances, categories of users such as individual or group, identity of the users such as sex, health, and disability, and the occupation of the users such as job description, job level, time of occurrence, and duration of occurrence [95]. These identifications are necessary to describe the user as a factor which is both a source of the some of the indoor air pollutants and also a factor which is affected by indoor air pollution.

Social characteristics such as privacy, personal space, territorial behaviour, crowding, and community, and socio-cultural characteristics such as customs, life styles, and traditions of the users provide some useful information so that user's needs and the function of the spaces can be described. This helps to determine the user activities as sources of indoor air pollution.

Physical and psychological interaction include health and safety, comfort, security, functional appropriateness, adaptation, and aesthetic / delight characteristics of the users. Physical and psychological interaction occurs between user and user, and user and building. The level of well-being of the users shows how much the users are satisfied with their building. This means there is a communication between user and building. Identification of the users appropriateness in terms of IAQ within the building determines the achievement level of indoor air quality improvement.

The consideration of the social / behavioural environment of the building and the activities of IAQP is shown in Table 26.

5.2.5.2. Outdoor Environment of The Building and IAQP

The outdoor environment of the building consists of outdoor spatial features, topographic features, outdoor physical features, and outdoor services [92, 95, 164].

All these features of the outdoor environment affect the IAQ in two ways. Firstly, these features cause outdoor air pollution. Buildings are surrounded by this outdoor air. If outdoor air is polluted, indoor air will have

Table 26. Social / Behavioural Environment of The Building and Activities of IAQP

INDOOR ENVIRONMENT of THE BUILDING / ACTIVITIES of INDOOR AIR QUALITY PROCESS			POLLUTION ACTIVITIES	IMPROVEMENT ACTIVITIES
	FEATURES	CHARACTERISTICS	Pollutants: emission, concentration, combination, exposure	Monitoring; Control
SOCIAL / BEHAVIOURAL ENVIRONMENT	USER IDENTIFICATION	Classification of; human / animal / plant / good s/ substance categories; individual / group identity; sex / health / disability occupation job description / job level / time of occurance / duration, ...	User as a source of indoor air pollutants; identification of people's professional related and individual related activities	User as a factor affected by IAQ, identification of user's need, identification of function of spaces, identification of user's appropriateness in terms of IAQ
	SOCIAL CHARACTERISTICS	privacy, personal space, territorial behaviour, crowding, community, ...		
	SOCIO-CULTURAL CHARACTERISTICS	customs, life styles, traditions, ...		
	PHYSICAL AND PSYCHOLOGICAL INTERACT	health, safety, comfort, security, functional appropriateness, adaptation, aesthetic / delight, ...		

poor quality due to the interaction between outdoor and indoor. Secondly some of those of features enter the building and continue to stay there. For example water, gas and sewerage systems in the buildings, and soil and ground water under the foundation of the building. They continue to produce indoor air pollutants if there is no preventive action.

Features of the outdoor services and the activities of IAQP are considered in Table 27.

Table 27. Outdoor Environment of The Building and Activities of IAQP

OUTDOOR ENVIRONMENT of THE BUILDING / ACTIVITIES of INDOOR AIR QUALITY PROCESS			POLLUTION ACTIVITIES Pollutants: emission, concentration, combination, exposure	IMPROVEMENT ACTIVITIES Monitoring; Control
	FEATURES	CHARACTERISTICS		
OUTDOOR SPATIAL FEATURES	SIZE OF THE SITE USABLE AREA LOCATION ACCESS NEIGBOURHOOD	Region, place, surroundings, directions, ... distance from other buildings, function of other buildings, ...	Air pollution due to function of other buildings such as factories, workshops, incinerators, ... carbon monoxide, carbon dioxide, nitrogen oxides, ...	Arrangement of location of the building, examination of neighbourhood, decisions of alternative design solutions for the spatial features
TOPOGRAPHIC FEATURES	GEOGRAPHY SEISMIC AREA GROUND WATER SOIL CHARACTERISTICS	Hilly area, valley, ... movements of the earth's crust, rock, gravel, sand, clay, silt, peat, ...	Respirable suspended particulates (dust, mould, bacteria, virus, ...), moisture, radon, water, ...	Detailed feasibility studies of topographic features, decisions of suitable alternative structures for the building
OUTDOOR PHYSICAL FEATURES	ATMOSPHERIC FEATURES FLORA / FAUNA ECOLOGICAL FEATURES	Air, temperature, humidity, sun, wind, rain, snow, - plants, animals, people, environment, ...	Exposure to the air pollutants due to the wind direction, ... respirable suspended particulates (dust, pollen, bacteria, ...) ...	Decisions of suitable alternative spatial and structural design for the building
OUTDOOR SERVICES	WATER GAS TELEPHONE ELECTRICITY SEWERAGE WASTE REMOVAL TRASPORT	Water supply, natural gas supply, pipe, ducts, waste containers, - vehicles, railway, aircraft, ...	Radon, water, moisture, respirable suspended particulates (dust, mould, bacteria, viruse, ...) methan, carbon dioxide, nitrogen oxides, styrene, ...	Decisions of suitable alternative spatial and structural design for the building

5.2.5.2.A. Outdoor Spatial Features - IAQP

Size of the site, usable area, location, access, and neighbourhood are the outdoor spatial features.

Location and neighbourhood of the building are effective factors for indoor air pollution. Region, place, direction and surroundings determine the situation of the building. Distance from other buildings, functional use of those of neighbour buildings determine the condition of the building.

Use functions of the buildings affects outdoor air quality. For example carbon monoxide, nitrogen oxides and some other air pollutants are released from factories, workshops, incinerators and chimneys of some other buildings such as residential buildings, etc. due to incomplete combustion and releasing smoke without filtration. The occurrence of outdoor air pollution will affect the whole neighbourhood. Location and distance of the affected buildings from those of effective buildings are important to protect the buildings from air pollution.

5.2.5.2.B. Topographic Features - IAQP

Topographic features are geography of the area, seismological characteristics of the area, ground water and characteristics of soil.

The geographical situation of the buildings is important because of the air flow. Hilly areas, valleys, bottom of topographic depressions and other places show different air movement. This difference affects the outdoor air, and the polluted air can either stay for a long time, or move to other places.

Movement of the earths crust, ground water, and soil characteristics such as rocky, sandy, gravelly areas affect the outdoor air. They either release air pollutants or helps them to settle.

Respirable suspended particulates such as dust, mould, bacteria, viruses, radon and moisture are some of the air pollutants that are released due to the topographic features. Preparing detailed feasibility studies of topographic features, discussing suitable alternative structural and spatial design for the building are some of the initial preventive indoor air improvement activities.

5.2.5.2.C. Outdoor Physical Features - IAQP

Atmospheric features, and ecological features (flora and fauna) are the outdoor physical features.

Outdoor temperature, humidity, wind, rain, snow, sun, and other climatic factors affect the outdoor air quality. For example, temperature has an influence on chemical reactions so that air pollution rates tend to increase with temperature. Air pollution is carried by effective wind

Ecological features such as people, plants, animals, solid and liquid substances also release air pollutants such as, water, respirable suspended particulates (dust, pollen, bacteria, virus, etc.), gases, etc.

To protect the indoor air of a building from the direct effects of the physical features of the outdoor environment necessitates carefully considered spatial and structural design of the building.

5.2.5.2.D. Outdoor Services - IAQP

Water, gas, telephone, electricity, sewerage, waste removal, and transport are the outdoor services. Air pollutants are released or carried by parts and material of these services. For example, radon, water, respirable suspended particulates, methane, carbon monoxide, carbon dioxide, nitrogen oxides, styrene are some of the air pollutants which are emitted from pipes, ducts and insulation materials of water and natural gas supplies, waste containers of waste removal system, vehicles, railway, ships, and aircraft which are used for transportation. Considering the spatial and structural design of the building is the first step to protecting the indoor environment of the building from the adverse affect of the outdoor services in terms of air pollution.

5.3. LIFE STAGES of THE BUILDING and INDOOR AIR QUALITY PROCESS

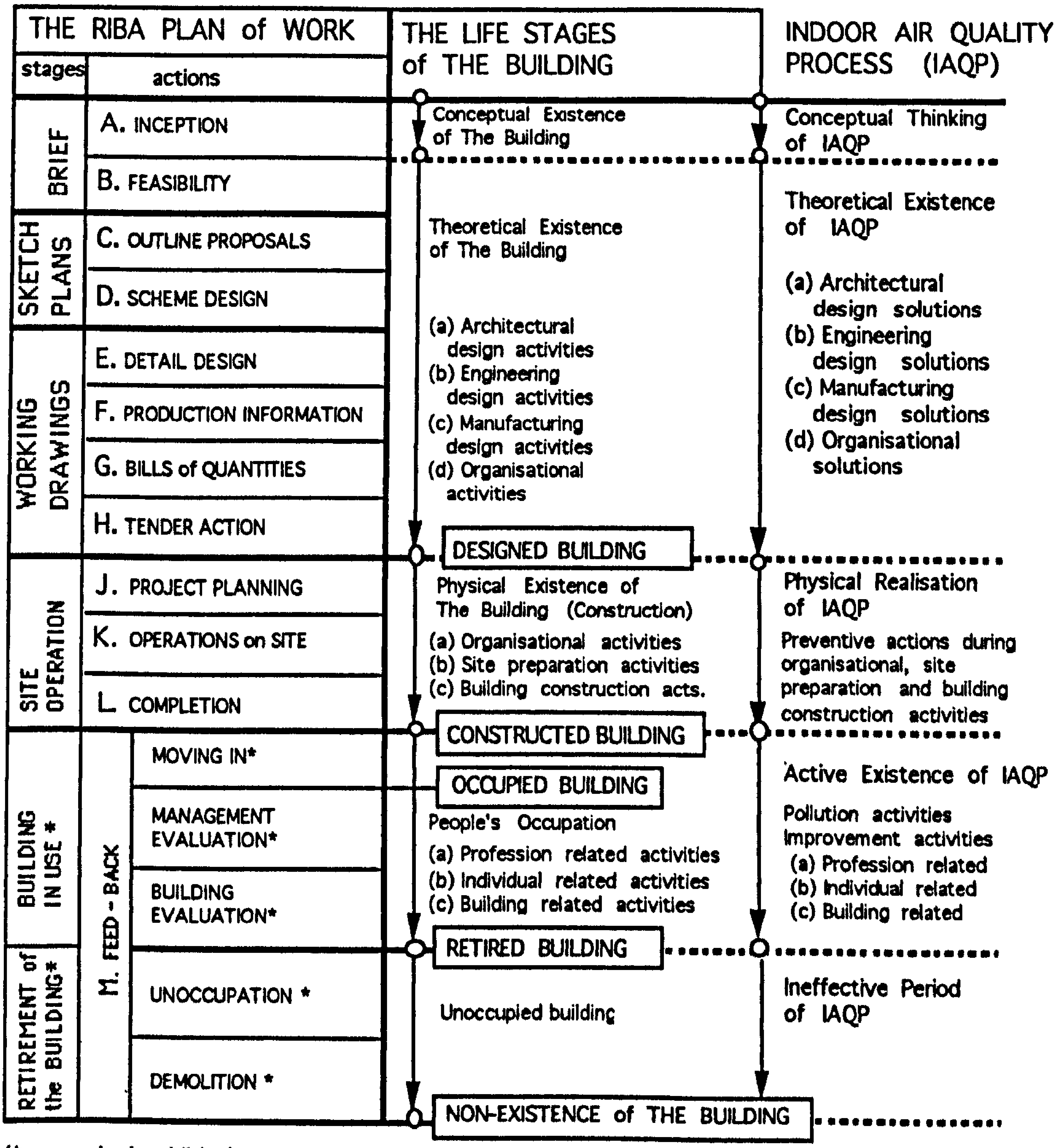
The life stages of the building are considered with The RIBA Plan of Work in Part 2.3.2.1.B. Consideration of The RIBA Plan of Work and The Existence Stages and Periods of The Building. In this consideration, six stages and four periods of the building are indicated. These are:

1. Conceptual existence of the building	- first stage,
2. Theoretical existence of the building	- first period,
3. Designed building	- second stage,
4. Physical existence of the building	- second period,
5. Constructed building	- third stage,
6. Occupied building	- fourth stage,
7. People's occupation	- third period
8. Retired building	- fifth stage
9. Unoccupied building	- fourth period
10. Non-existence of the building	- sixth stage

The stages and periods are also existence stages and periods of IAQP. In Table 28 consideration of IAQP with the life stages of the building and the RIBA Plan of Work is shown.

A statement of the users' requirements is prepared during the inception part of the briefing stage of the RIBA Plan of Work. This is the conceptual existence of the building. When the users' requirements are examined in detail, it is clearly seen that IAQ related health requirements of the users' should be taken account besides other requirements. Thus, the existence of the IAQP begins with the people's requirements in term of IAQ. This is conceptual thinking stage of IAQP.

Table 28. Consideration of IAQP with The Life Stages of The Building and The RIBA Plan of Work



(* researcher's addition)

During the Feasibility part of the Briefing Stage, and all parts of the Sketch Plans and Working Drawings Stages of the RIBA Plan of Work the building theoretically exists due to design activities. All building related decisions are taken to form the building during the theoretical existence period of the building. Therefore, architectural, engineering, manufacturing and organisational solutions which are related to the design of the building are developed. This development should also cover IAQ related solutions so that further IAQ related problems can be reduced from the beginning. Thus, the theoretical existence period of the building becomes the theoretical existence period of IAQ too.

The physical existence (construction) of the building starts with the site operation. This is the fourth stage of the RIBA Plan of Work. The building as an object appears with its structural and environmental features on the site area. This appearance, at the same time, is the physical realisation of IAQP due to the internal environment of the building.

When the building is occupied by its users after the completion of the constructional work of the building, the use period of the building starts. People do their professional, individual, and building related activities within the building. During the use period of the building, indoor air pollution and IAQ improvement activities occur. This is the active existence period of IAQP.

The building is called a retired building when it is empty and not occupied any more by its users. During this period, indoor air pollution continues but it is an ineffective stage and period of IAQP.

The building does not exist anymore, when it is demolished. This is the end of the life of the building. Apart from the ruins of the building, none of the features of the hardware and environment of the building remains. But the data concerning the demolished building is kept for future designs of new buildings as feedback information. The non-existence stage of the building is, also, the non existence stage of IAQP of that building. However, the information about IAQ experience of that demolished building is used for new building design.

5.4. THE ARCHITECTURAL DESIGN PROCESS and THE INDOOR AIR QUALITY PROCESS of THE BUILDING and THE RIBA PLAN of WORK

In this chapter the Architectural Design Process and IAQP of the building and The RIBA Plan of Work will be considered. During these considerations the objectives, resources, activities and objects of the Architectural Design Process and IAQP and the stages of The RIBA Plan of Work will be examined together.

5.4.1. The Architectural Design Process and IAQP, and Briefing Stage of The RIBA Plan of Work

5.4.1.1. Inception Stage - IAQP- The Architectural Design Process

The first consideration of IAQP and the Architectural Design Process should be done during the Inception Stage of The RIBA Plan of Work. Table 29 shows the consideration of IAQP, the Architectural Design process and the Inception - Briefing Stage of The RIBA Plan of Work.

Objectives : Inception Stage - IAQP- The Architectural Design Process
The user requirement study is included in the primary check list which is the first step of the Inception Stage of The RIBA Plan of Work. During the exploratory meetings the representatives of the design team should bring their environmentalist approaches to the design of the building so that the health requirements related to the IAQ of the users can be covered by the agenda.

Table 29. Consideration of IAQP, The Architectural Design Process and The RIBA Plan of Work / Briefing - Inception Stage

THE RIBA PLAN of WORK	THE ELEMENTS of THE ARCHITECTURAL DESIGN PROCESS / THE ELEMENTS of INDOOR AIR QUALITY PROCESS	OBJECTIVES	RESOURCES	ACTIVITIES: Decision - Making: Conceptual / Visual Communication: Sketch Drawings	Development / Sketch+Graphic Drawings	Final Decision &Details / Graphic Drawings	OBJECTS
General / Stages / Detailed	Architectural design process	Spatial Quality; Quality of Physical Environment; Social Provisions; Quality of Hardware; Economy & Efficiency; Aesthetic	People Resources; Integrative Resources; Information Resources; Technology	Conceptual; Sketch Drawings	Development; Sketch+Graphic Drawings	Final Decision &Details; Graphic Drawings	Hardware of The Building; Environment of The Building
	Indoor air quality process	Indoor Air Pollution; Indoor Air Quality Improvement	Restrictive Resources; Integrative Resources; Information Resources; Science & Technology	Indoor Air Pollution Activities; Indoor Air Quality Improvement Activities			Indoor Air Pollution; Indoor Air Quality Improvement
BRIEFING / A. INCEPTION	A1.1 Primary Check List	Environmental approach, User requirement study in terms of IAQ, Environmental - functional design strategy, Acceptance of IAQ as a design objective related to Quality of Physical Environment	User Identification, Design team job description, Environmental consultant, Contribution of authorities, Information about site area and the outdoor environmental characteristics of the site area	Functional analysis of spaces, User activity pattern, Initial design ideas, Functional zones, Indoor air polluted zones, Groups of pollution sources			List of users'health requirements in terms of IAQ, diagrams and matrices showing functional and polluted zones and group of pollution sources
	A2.1 Exploratory Meetings						
	A3.1 Accept Appointment						
	A3.2, Services A3.3 and Fees						
	A4.1 Performance Target						
	A5.1 Directive for Stage B						
	First Feedback Point : Check the IAQ related user requirements, design objectives and strategy, available resources						

When the design team discusses their performance target, they should examine the environmental and the functional design strategies together. Environmental strategy can help the design team to consider the effects of the layout, structure, and outdoor and indoor environment of the building on the health of the users. Then, they can integrate the architectural design of the building and the environmental issues during the design stage. Functional design strategy is important because of the relationship between functional utility of the spaces and the activities of the users as sources of indoor air pollution. Therefore, they can set a strategy that is a combination of the environmental and the functional design strategies. In this case, IAQ will be accepted as a design objective connected to the quality of physical environment of the building. This acceptance will also indicate that IAQ is an important design objective which is directly related to the health of the users.

Resources : Inception Stage IAQP- The Architectural Design Process
Users of the building, members of the design and construction teams, suppliers and authorities are the people resources of the both IAQP and the Architectural Design Process.

Detailed user identification is prepared as a resource related to the people resources. This identification covers all the aspects such as age, sex, health condition, individual, group, occupation, crowding, life style, etc. These aspects are the social characteristics of the building which has been detailed in Part 2, chapter 2.3.2.2.D and section (a_3) Building as a Social Environment. Also, the individual and professional related activities of the users should be identified as a part of the user identification. The relationships between the use activities and IAQP are shown in Table 20.

The job description within the design team is very important. There should be an environmental consultant who is responsible for the quality of the physical environment of the building, and will guide the design team about IAQ. If that environmental consultant is an architect as well, he or she can be considerably helpful to the other members of the design team. Also, the contribution of the authorities should be considered in the job description study too.

Information about the site area and description of the spaces within the building are the parts of integrative resources. Information which covers outdoor spatial, topographic and physical characteristics of the site area, and the outdoor services for the building is obtained during the Inception Stage. These characteristics have been detailed in Part 2, chapter 2.3.2.2.D and the section (b) Outdoor Environment of The Building. Also, identification of possible indoor air pollutant sources, polluted spaces and air pollutants, and searching the possible indoor air pollution control strategies provide important information to the design team. The relationships between the environmental features of the building and IAQ are shown in Tables 24, 25, 26, 27.

Activities : Inception Stage- IAQP- The Architectural Design Process
During the Inception Stage of The RIBA Plan of Work conceptual sketch drawings are done as activities of the Architectural Design Process. Architects, as the designers of the building, should analyse functions of the spaces within the building and the users activity pattern within the spaces in terms of IAQ by using diagrams and matrices.

This space and user activity examination allows the architect to determine the functional zones, indoor air polluted zones and groups of possible pollution sources.

The RIBA's User Requirement Study (165) indicates 12 steps in analysing the user activities and the spaces within the building.
The steps are:

1. Statement: People and purpose,
2. Statement: Function and activities,
3. Investigation: Analysis of activities,
4. Investigation: Analysis of equipment,
5. Interpretation: Analysis of needs: space
6. Interpretation: Analysis of needs: environmental,
7. Recommendation: Plan analysis

(schedules of spaces by activities),
8. Recommendation: Plan analysis
(schedules of space groups),
9. Recommendation: Plan analysis
(schedules of zones),
10. Recommendation: Technical analysis,
11. Recommendation: Analysis of services,
12 Recommendation: Schedules of equipment
(for each space within the building).

While the activities of the users and the functions of the spaces are analysed according to these steps, indoor air pollution sources, polluted zones and IAQ can also be placed in the programme.

The activities of the users within the building can be analysed as one of the major indoor pollution sources in the third step of the user requirement study [95]. Other indoor air pollutant sources related to the building can also be described and grouped while the equipment, the spaces and the services are analysed (4th and 5th, 11th steps), and technological analysis is prepared (10th step). During this description Table 20 Organisational Use Activities of The Building System, Table 22 Structural Elements of The Hardware and Activities of IAQP, Table 23 Services and Contents of The Hardware and Activities of IAQP, Table 24 Spatial Environment of The Building and Activities of IAQP, Table 25 Physical Environment of The Building and Activities of IAQP, Table 26 Social / Behavioural Environment of The Building and Activities of IAQP, and Table 27 Outdoor Environment of The Building and Activities of IAQP can be used to group the pollutant source and to prepare building materials and elements specifications.

IAQ can take its place within the analysis programme at the 6th step which covers the environmental factors of the spaces.

During the plan analysis steps (7th, 8th and 9th) of the user requirement study, indoor air polluted spaces within the building can be grouped according to the possible indoor air pollution levels. The groups of polluted spaces can be defined as indoor air polluted zones [95, 153].

Indoor air polluted zones can be identified according to the users' activities in each space and the required ventilation rates for those spaces. Ventilation rates and standards can be based on internationally accepted standards or existing national standards. For example, ventilation standards for rooms within residences have been defined by ANSI (American National Standards Institute) and ASHRAE (American Society of Heating, Refrigerating and Air-conditioning Engineers) [9, 133, 166]. According to the standards, general living areas and bedrooms should have a minimum 15 cfm/person air exchange rate, and kitchens should have 100 cfm/person air exchange rate with intermittent exhaust capacity and 25 cfm/person air exchange rate with continuous or windows exhaust capacity, toilets and bathrooms should have 50 cfm/person air exchange rate with intermittent exhaust capacity and 25 cfm/person air exchange rate with continuous or windows exhaust capacity, and garages should have 100 cfm/car air exchange rate. The standards help the architect to identify the indoor air polluted zones as;

A. High level indoor air polluted spaces:
   i.e. air exchange rate between 50 - 100 cfm/person,
   and above 100 cfm/person,
B. Medium level indoor air polluted spaces:
   i.e. air exchange rate between 15 - 50 cfm/person, and
C. Low level indoor air polluted spaces:
   i.e. air exchange rate below 15 cfm/person

Also, users' characteristics and their activities within the space can be helpful to form the zoning system. For example, smoking rooms, workshops, and plant rooms will have a higher level of indoor air pollutant concentration, due to the number of users and the way that the spaces are used, than non-smoking rooms, offices, and bedrooms, etc.

Objects : Inception Stage IAQP- The Architectural Design Process

The outputs of the Inception Stage are lists of users' health requirements in terms of IAQ, diagrams and matrices which show the functional and indoor air polluted zones, groups of indoor air pollutant sources, and sketch drawings of initial ideas.

First Feedback Point :
The design team should check the IAQ related user requirements study and design objectives, review the available resources and environmental-functional design strategy at the end of the Inception Stage.

5.4.1.2.Feasibility Stage - IAQP- The Architectural Design Process

Consideration of IAQP and the Architectural Design Process should continue during the Feasibility Stage of The RIBA Plan of Work. Table 30. shows the consideration of IAQP, the Architectural Design Process and the Feasibility - Briefing Stage of The RIBA Plan of Work.

Objectives : Feasibility Stage- IAQP- The Architectural Design Process
Detailed user requirement study continues during the Feasibility Stage. IAQ as a design object is discussed during design team meetings, environmental and functional design strategy is determined in detail. The design strategy of the building will show the design policy of the design team in terms of IAQ.

Resources : Feasibility Stage- IAQP- The Architectural Design Process
Identification of users and their basic requirements, description of job responsibilities within the design team, contribution of the authorities, consents, information about the site, plans and sections of the site, information about the neighbourhood, outdoor environment, specification of building elements and materials, standards, regulations and consents are obtained as resources which are related to IAQ. Other resources are also obtained during the Feasibility Stage.

Table 30. Consideration of IAQP, The Architectural Design Process and The RIBA Plan of Work / Briefing - Feasibility Stage

THE RIBA PLAN of WORK — Stages (General / Detailed)	THE ELEMENTS of THE ARCHITECTURAL DESIGN PROCESS / THE ELEMENTS of INDOOR AIR QUALITY PROCESS	OBJECTIVES	RESOURCES	ACTIVITIES	OBJECTS
	Architectural Design Process	Spatial Quality; Quality of Physical Environment; Social Provisions; Quality of Hardware; Economy & Efficiency; Aesthetic	People Resources; Integrative Resources; Information Resources; Technology	Decision - Making: Conceptual; Development; Final Decision &Details. Visual Communication: Sketch Drawings; Sketch+Graphic Drawings; Graphic Drawings	Hardware of The Building; Environment of The Building
	Indoor Air Quality Process	Indoor Air Pollution; Indoor Air Quality Improvement	Restrictive Resrcs.; Integrative Resrcs.; Information Resrcs.; Science&Technlgy.	Indoor Air Pollution Activities; Indoor Air Quality Improvement Activities	Indoor Air Pollution & Air Quality Improvement
B R I E F I N G / B. FEASIBILITY: B1.1 Primary Check List					
B2.1 Design Team Meetings			IAQ related ;		
B3.1 Guide to Briefing		Detailed user requirement study	Detailed user identification	Consideration of IAQ as initial design ideas	Specification of the materials and elements in terms of IAQ.
B3.2 Briefing / Basic Requirements			Design team job description	Development of alternative design solutions	
B3.3 Brfng / Areas, Acts.		Detailed environmental - functional design strategy	Environmental Consultant	Functional specification of spaces	
B3.4 Brfng / Bldng Elemnts.			Contribution of authorities	Environmental specification of spaces	
B4.1 Survey: Action Required			Plans and sections of site	Preparation of building elementsand materials specification	Sketch and graphic drawings, Location drawings
B4.2 Survey: Context of Project		Design Policy of the Building in terms of IAQ	Information about outdoor environment	Requesting detailed characteristics of the materials in terms of IAQ from manufacturers	
B4.3 Srvy: Site / Informtn			Building materials and elements specification	Floor plans, sections, elevations, site plans	
B4.4 Srvy: Site / Plans, Sections			Standards		
B4.5 Srvy: Existing Bldngs.			Regulations		
B4.6 Survey: Trial Holes			Consents		
B5.1 Consents:					
B6.1, B6.2 Report to Client					
B7.1 Directive for Stage C					

Second Feedback Point : Check IAQ related detailed user requirement study and obtained resources; review design strategy and objectives, examine the developed general design ideas in terms of IAQ.

Activities : Feasibility Stage- IAQP- The Architectural Design Process
IAQ should be considered while the conceptual design ideas and alternative design solutions are being developed. Spatial, physical, social - behavioural and outdoor environmental features of the building should be reflected on the initial sketch and graphic drawings to produce preventive design solutions in terms of IAQ. Functional and environmental specifications of users' activities, possible indoor air pollution sources within the spaces and possible indoor air polluted zones can help the design team during the design solution development. Floor plans of the building will show the functional and environmental relationships of the spaces, sections will show the relationships of the construction and the spaces, and site plans will show the connection of outdoor environment and indoor environment from the IAQ point of view.

Initial building materials and elements specifications are also prepared in this stage. While preparing the specifications, the design team should require the full characteristics of the materials and components in terms of their effects to IAQ from the manufacturers.

Objects : Feasibility Stage- IAQP- The Architectural Design Process
The outputs of the Feasibility Stage are specifications of the materials and the elements, and sketch and graphic drawings of the building.

Tables 22 Structural Elements of Hardware and Activities of IAQP, and 23 Services and Contents of Hardware and Activities of IAQP will be helpful to the design team to prepare the materials and the elements specifications in terms of IAQ.

Arrangements of spaces within the building in terms of IAQ will be developed by the design team, and should be shown on location drawings.

Second Feedback Point :
The design team should check the detailed user requirements study and design objectives in terms of IAQ, review the obtained resources, and develop the general design ideas in terms of the environmental-functional

design strategy.

5.4.2. The Architectural Design Process and IAQP, and Sketch Plans Stage of The RIBA Plan of Work

5.4.2.1. Outline Proposal Stage - IAQP- The Architectural Design Process

The Outline Proposal Stage is the design development stage of the Architectural Design Process. Table 31 shows the consideration of IAQP, the Architectural Design Process and The RIBA Plan of Work / Outline Proposals - Sketch Plans.

Objectives : Outline Proposals Stage- IAQP-
The Architectural Design Process

Detailed user requirement studies in terms of IAQ continue during this stage, as well. Consideration of IAQ as one of the design objects is reviewed during determination of the environmental design strategy.

Resources : Outline Proposals Stage- IAQP-
The Architectural Design Process

The collections of IAQ related essential consents, regulation and standards, detailed information about the users, consultants, available scientific and technological studies, information about the manufactured building products such as materials and elements and other resources continue in the Outline Proposals Stage.

Activities : Outline Proposals Stage- IAQP-
The Architectural Design Process

Alternative design solutions are developed during this stage. General design approaches are reviewed to select the most suitable one. Design approaches related to the IAQ should also be reviewed. Sketches and diagrams which shows the functional and environmental relationships of spaces, and possible indoor air polluted zones, should be reflected in the

Table 31. Consideration of IAQP, The Architectural Design Process and The RIBA Plan of Work / Sketch Plans - Outline Proposals Stage

THE ELEMENTS of THE ARCHITECTURAL DESIGN PROCESS / THE RIBA PLAN of WORK	OBJECTIVES	RESOURCES	ACTIVITIES: Decision - Making: Conceptual	Development	Final Decision &Details	OBJECTS
	Spatial Quality; Quality of Physical Environment; Social Provisions; Quality of Hardware; Economy & Efficiency; Aesthetic	People Resources; Integrative Resources; Information Resources; Technology	Visual Communication: Sketch Drawings	Sketch+Graphic Drawings	Graphic Drawings	Hardware of The Building; Environment of The Building
THE ELEMENTS of INDOOR AIR QUALITY PROCESS	Indoor Air Pollution; Indoor Air Quality Improvement	Restrictive Resrcs.; Integrative Resrcs.; Information Resrcs.; Science&Technlgy.	Indoor Air Pollution Activities / Indoor Air Quality Improvement Activities			Indoor Air Pollution & Air Quality Improvement
Stages: General: SKETCH PLANS; Detailed: C. OUTLINE PROPOSALS						
C1.1 Primary Check List 1. Review of requirements 2. Alternative design solutions 3. Design development 4. General design approaches 5. Essential consents 6. 7. Reports 8. Further instruction, extra fees 9. Consultation of design team 10. Control of actions in Stage C 11., 12. Control of fee accounts	Detailed user requirement study, Review of IAQ as a design object, Review of environmental and functional design strategy	IAQ related consents, standarts, regulations, consultants, authorites, Scientific and technological studies, Information about the manifactured building materials, components and other products.		Development of locational drawings : sketches of functional & environmental relations of spaces, graphic arrangement of layout of spaces on floor plans Initial assembly drawings: sections, details, Material & components specification		Building materials and components specification in terms of IAQ, Developed locational drawings, floor plans, site plans, Initial assembly darwings, sections, details.
C2.1 Directive for Stage D						

Third Feedback Point: Check IAQ related user requirements, design strategy and objectives, resources, and developed design solutions.

graphical location drawings which are floor plans and site plans. While the alternative design solutions in terms of IAQ are produced, preparation of building materials and elements specifications continues. Initial assembly drawings which are structural sections are developed according to the specifications

Objects : Outline Proposals Stage- IAQP-
The Architectural Design Process

Building materials and elements specifications in terms of IAQ, developed locational drawings which show the IAQ related spatial and social characteristics of the spaces within the building, initial assembly drawings which show the general approaches to the detail design of the structure in terms of IAQ are the outputs of Outline Proposals Stage.

Third Feedback Point :

IAQ related user requirement study, obtained resources, environmental-functional design strategy, and developed alternative design solutions should be examined in detail.

5.4.2.2. Scheme Design Stage - IAQP, and The Architectural Design Process

The most suitable design solution is selected and its locational design drawings are completed during the Scheme Design Stage. Table 32 shows the consideration of IAQP, the Architectural Design Process and The RIBA Plan of Work / Scheme Design - Sketch Plans.

Objectives : Scheme Design Stage- IAQP-
The Architectural Design Process

The user requirement study is completed in the Scheme Design Stage. Therefore health requirements of the users in terms of IAQ should be completed too. Besides, the effective environmental and functional design strategy and architectural design achievements in terms of IAQ should also be determined.

Table 32. Consideration of IAQP, The Architectural Design Process and The RIBA Plan of Work / Sketch Plans - Scheme Design Stage

THE RIBA PLAN of WORK / THE ELEMENTS of THE ARCHITECTURAL DESIGN PROCESS	OBJECTIVES	RESOURCES	ACTIVITIES	OBJECTS
THE ELEMENTS of THE ARCHITECTURAL DESIGN PROCESS	Spatial Quality; Quality of Physical Environment; Social Provisions; Quality of Hardware; Economy & Efficiency; Aesthetic	People Resources; Integrative Resources; Information Resources; Technology	Decision - Making: Conceptual, Development, Final Decision &Details; Visual Communication: Sketch Drawings, Sketch+Graphic Drawings, Graphic Drawings	Hardware of The Building; Environment of The Building
THE ELEMENTS of INDOOR AIR QUALITY PROCESS	Indoor Air Pollution; Indoor Air Quality Improvement	Restrictive Resrcs.; Integrative Resrcs.; Information Resrcs.; Science&Technlgy.	Indoor Air Pollution Activities; Indoor Air Quality Improvement Activities	Indoor Air Pollution & Air Quality Improvement
Stages — General: SKETCH PLANS; Detailed: D. SCHEME DESIGN D1.1 Primary Check List 1. Review progress 2. Complete user studies/ detail planning solutions development 3. Consulting authorities 4. Full scheme, specifictions 5. Distribution of scheme 6. Engineers' proposals 7. Final cost plan 9. QS and consultants' reports 10. Full scheme report to client 11. Application of statutory & other consents, client's approval. 12. Control of actions in Stage D. 13. Directive for Stage E. 14. Advising the client 15,16. Control of fee accounts D2.1 Directive for Stage E	Completion of IAQ related user requirement study, Determination of an effective environmental & functional design strategy, and IAQ design policy, Determination of design achievements in terms of IAQ.	All IAQ related essential resources including engineering proposals which cover IAQ related indoor environ-mental implications	Selection and development of the most suitable design solution, Examination of the efficiency of the selected design in terms of IAQ improvement, Completion of location drawings ; floor & site plans, Development of the assembly drawings; structural elements, services, contents, Initial components and details design related to the IAQ improvement.	Completed location drawings, Building materials& components specific-ations, and schedules, Developed assembly drawings, Initial components & detail deisgn.

" Brief should not be modified after this point " (indication of The RIBA Plan of Work)

Fourth Feedback Point : Chect the IAQ related completed user requirement study, design objectives and strategy, resources, and selected and developed design solution.

Resources : Scheme Design Stage- IAQP-

The Architectural Design Process

All essential people, information, integrative and technological resources related to IAQ should be obtained completely in this stage.

Activities : Scheme Design Stage- IAQP-

The Architectural Design Process

The final decision about the most suitable architectural design solution is done during the Scheme Design Stage. In this selection, IAQ should be an effective criterion. After making the final decision, the selected design solution is developed. During this development stage, environmental-functional design strategy should still be effective. Besides, the proposals of engineers, including IAQ related indoor environmental implications, should be obtained and be taken into consideration.

At the end of the Scheme Design Stage locational drawings, which are floor plans and site plans, should be completed. It is indicated in The RIBA Plan of work that the "brief should not be modified after this point". This also means that all IAQ related studies i.e. user requirement study and materials and elements specification in terms of IAQ should be completed and the final decisions should be made.

Assembly drawings, which are sections showing structural and detail design, are developed in guidance of locational design and specifications of materials and elements of the building. During the development of the assembly drawings structural elements, services and contents of the building should be designed according to the design policy which covers IAQ improvement policy too.

In Tables 22 and 23, the relationships between structural elements, services and contents of the building and IAQP are shown. The tables can be useful to develop the detail design.

Objects : Scheme Design Stage- IAQP-

The Architectural Design Process

Final location drawings, complete building materials and elements specification and schedules in terms of IAQ, developed assembly drawings, and initial components and detail drawings are the objects of this stage.

Fourth Feedback Point :
The design team should check the final decisions related to the detailed user requirement study, determined design objectives and design strategy, and selected and developed design solution before moving to the next stage which is the Detail Design Stage.

5.4.3. The Architectural Design Process and IAQP, and Working Drawings Stage of The RIBA Plan of Work

5.4.3.1.Detail Design Stage - IAQP- The Architectural Design Process

The Detail Design Stage is the completion stage of all the drawings and specifications. It is indicated in The RIBA Plan of Work that "any further change in location, size, shape, or cost after this time will result in abortive work". This also means that all IAQ improvement design decisions should be set at this stage and, at the end of this stage, those decisions should be applied on all drawings. Table 33 shows the consideration of IAQP, the Architectural Design Process and The RIBA Plan of Work / Detail Design - Working Drawings Stage.

Objectives : Detail Design Stage - IAQP- The Architectural Design Process
The user requirement study, environmental - functional design strategy, and design achievements are reviewed in terms of IAQ during the Detail Design Stage.

Resources : Detail Design Stage - IAQP - The Architectural Design Process
All IAQ related resources should be obtained, and taken into consideration.

Table 33. Consideration of IAQP, The Architectural Design Process and The RIBA Plan of Work / Working Drawings - Detail Design Stage

THE RIBA PLAN of WORK / THE ELEMENTS of THE ARCHITECTURAL DESIGN PROCESS	OBJECTIVES	RESOURCES	ACTIVITIES: Decision - Making: Conceptual / Visual Communication: Sketch Drawings	ACTIVITIES: Decision - Making: Development / Visual Communication: Sketch+Graphic Drawings	ACTIVITIES: Decision - Making: Final Decision &Details / Visual Communication: Graphic Drawings	OBJECTS
Stages (General / Detailed) / THE ELEMENTS of INDOOR AIR QUALITY PROCESS	Spatial Quality; Quality of Physical Environment; Social Provisions; Quality of Hardware; Economy & Efficiency; Aesthetic	People Resources; Integrative Resources; Information Resources; Technology				Hardware of The Building; Environment of The Building
	Indoor Air Pollution; Indoor Air Quality Improvement	Restrictive Resrcs.; Integrative Resrcs.; Information Resrcs.; Science&Technlgy.	Indoor Air Pollution Activities Indoor Air Quality Improvement Activities			Indoor Air Pollution &; Air Quality Improvement
WORKING DRAWINGS — E. DETAIL DESIGN: E1.1 Primary Check List 1. Review instructions 2. Complete user requirements 3. Detail design&final specifictn. 4. Updating design decisions 5. Engineers' drawings 6. Review cost plan 7. Rewiev and confirmation of architectural & engineering design 8. Review of detail dsign 9. Control of all actions 10. Control of fee accnts	Final consideration of user requirement study in terms of IAQ.	Final consideration of all IAQ related resources.			Consideration of all IAQ related work; Final specifictns. & schedules, Final examination of location drawings, Completion of assembly & components drawings.	IAQ related; specific-ations, schedules, Updated location drawings, Completed assembly& compnnts. drawings.
E2.1. Directive for Stage F						

" Any further change in location, size, shape, or cost after this time will result in abortive work " (indication of The RIBA Plan of Work)

Fifth Feedback Point: Check the updated final design decisions in terms of IAQ, control the architectural design solutions.

Activities : Detail Design Stage - IAQP - The Architectural Design Process
Final considerations of building elements, components, spaces and users' activity specifications and schedules in terms of IAQ are done and assembly and components drawings are completed in this stage. Besides, all completed location drawings should finally be examined so that design achievements related to IAQ can be determined

Objects : Detail Design Stage - IAQP - The Architectural Design Process
IAQ related specifications and schedules of the materials, components, spaces, indoor air polluted zones and users' activities within the building; updated location drawings and completed assembly and components drawings are the outputs of the Detail Design Stage.

Fifth Feedback Point :
Final design decisions related to the users requirements and design strategy should be updated and the design solutions should be checked until the end of this stage.

5.4.3.2. Production Information Stage - IAQP- The Architectural Design Process

The Production Information Stage is the final control and correction stage of all drawings and specifications. Table 34 shows the consideration of IAQP, the Architectural Design Process and The RIBA Plan of Work / Production Information - Working Drawings Stage.

Objectives : Production Information Stage - IAQP-
The Architectural Design Process
Final control of the design achievements and the user requirement study is done in the Production Information Stage.

Resources : Production Information Stage - IAQP-
The Architectural Design Process
During this stage, all IAQ related resources are given final consideration.

Table 34. Consideration of IAQP, The Architectural Design Process and The RIBA Plan of Work / Working Drawings - Production Information Stage

THE RIBA PLAN of WORK / THE ELEMENTS of THE ARCHITECTURAL DESIGN PROCESS	OBJECTIVES	RESOURCES	ACTIVITIES: Decision - Making: Conceptual / Visual Communication: Sketch Drawings	ACTIVITIES: Development / Sketch+Graphic Drawings	ACTIVITIES: Final Decision &Details / Graphic Drawings	OBJECTS
	Spatial Quality; Quality of Physical Environment; Social Provisions; Quality of Hardware; Economy & Efficiency; Aesthetic	People Resources; Integrative Resources; Information Resources; Technology				Hardware of The Building; Environment of The Building
THE ELEMENTS of INDOOR AIR QUALITY PROCESS (Stages: General / Detailed)	Indoor Air Pollution; Indoor Air Quality Improvement	Restrictive Resrcs.; Integrative Resrcs.; Information Resrcs.; Science&Technlgy.	Indoor Air Pollution Activities; Indoor Air Quality Improvement Activities			Indoor Air Pollution &; Air Quality Improvement
WORKING DRAWINGS / F. PRODUCTION INFORMATION: F1.1 Primary Check List	Final control of the achievements of architectural design in terms of IAQ	Final consideration of all IAQ related resources.			Final control and corrections of all drawings, specific-ations, and schedules in terms of IAQ.	IAQ related specific-ations, and schedules, all completed drawings: location, assembly, and compnnts.
F2.1 Production Drawings						
F3.1 Preliminary Tendering						
F4.1 Register of Contractors						
F5.1 Information for Tender Documents						
F6.1 Nominated Subcontartors & Suppliers						
F7.1 Selection of Nominated Subcontartors & Suppliers						
F8.1 Directive for Stage G						

Sixth Feedback Point : Check the final completion and corrections of all drawings, specifications, and schedules.

Activities : Production Information Stage - IAQP-
The Architectural Design Process

Completion of all production drawings i.e. details, sections, etc., and final control and correction of all drawings, specifications and schedules are the activities of Production Information Stage. While this final control is done,

IAQ related architectural design achievements should also be given final consideration.

Objects : Production Information Stage - IAQP-
The Architectural Design Process

All IAQ related specifications and schedules, all completed drawings - location, assembly and components - are the outputs of the Production Information Stage.

Sixth Feedback Point :

At the end of the Production Information Stage, control of final corrections and completions of drawings, schedules and specifications is done.

5.4.3.3. Bills of Quantities Stage - IAQP- The Architectural Design Process

The Bills of Quantities Stage is the final control and correction stage of the all drawings and specifications. Table 35 shows the consideration of IAQP, the Architectural Design Process and The RIBA Plan of Work / Production Information - Working Drawings Stage.

Objectives : Bills of Quantities Stage - IAQP-
The Architectural Design Process

There is no design objective related study in the Bills of Quantities Stage.

Resources : Bills of Quantities Stage - IAQP-
The Architectural Design Process

Final consideration of all IAQ related resources continues during the Bills of

Table 35. Consideration of IAQP, The Architectural Design Process and The RIBA Plan of Work / Working Drawings - Bills of Quantities Stage

THE RIBA PLAN of WORK	THE ELEMENTS of THE ARCHITECTURAL DESIGN PROCESS	OBJECTIVES						RESOURCES				ACTIVITIES			OBJECTS	
		Spatial Quality	Quality of Physical Environment	Social Provisions	Quality of Hardware	Economy & Efficiency	Aesthetic	People Resources	Integrative Resources	Information Resources	Technology	Decision - Making: Conceptual	Development	Final Decision &Details	Hardware of The Building	Environment of The Building
												Visual Communication: Sketch Drawings	Sketch+Graphic Drawings	Graphic Drawings		
Stages: General / Detailed	THE ELEMENTS of INDOOR AIR QUALITY PROCESS	Indoor Air Pollution			Indoor Air Quality Improvement			Restrictive Resrcs.	Integrative Resrcs.	Information Resrcs.	Science&Technlgy.	Indoor Air Pollution Activities Indoor Air Quality Improvement Activities			Indoor Air Pollution &	Air Quality Improvement
WORKING DRAWINGS / G. BILLS of QUANTITIES	G1.1 Primary Check List 1. Design team organisstion 2. Update drawings, schedules & specifications 3. Confirm list of tenderers 4. Interview & check site staff 5. Correction of all documents 6. Obtaining outstanding quotations 7. Assemble drawings 8. Prepare draft architect's instruction for changes too late to be included in bills of quantities 9. Advising client 10. Directive for Stage H 11. Control fee accounts							Final consideration of all IAQ related resources, Request for an environment-alist consultant for construction team.						Final control of all documents for Tender Action, End of architectural design activities.	All specfctns. schedules, corrected drawings, documents for Tender Action.	
Seventh Feedback Point: Check the all documents, specifications, schedules, and drawings for the Tender Action.																

Quantities Stage. This stage is the preparation of the designed building project for the Tender Action. Therefore, an environmental construction policy in terms of IAQ and environmental consultants on the construction team should be requirements for the tenderers.

Activities : Bills of Quantities Stage- IAQP -
The Architectural Design Process

Final corrections of all drawing, specifications and schedules are completed in the Bills of Quantities stage. Also, all IAQ related design solutions, specifications and schedules take their final form. This means, after this stage there is no IAQ related study and work.

Objects : Bills of Quantities Stage- IAQP -
The Architectural Design Process

All completed and corrected drawings, specifications and schedules are the objects of the Bills of Quantities Stage.

Seventh Feedback Point :

Final control of all documents for Tender Action is done, and architectural design activities end at this point.

5.4.3.4. Tender Action Stage - IAQP - The Architectural Design Process

There is no study and work related to the determination of design objectives, resources, and design activities of the building in the Tender Action Stage. All activities are organisational to open and complete the tender action. At the end of this stage, the whole design process is completed and the construction process begins.

Table 36 shows the consideration of IAQP, the Architectural Design Process and The RIBA Plan of Work / Working Drawings - Tender Action Stage.

Table 36. Consideration of IAQP, The Architectural Design Process and The RIBA Plan of Work / Working Drawings - Tender Action Stage

THE RIBA PLAN of WORK / THE ELEMENTS of THE ARCHITECTURAL DESIGN PROCESS	OBJECTIVES						RESOURCES				ACTIVITIES			OBJECTS	
											Decision - Making				
	Spatial Quality	Quality of Physical Environment	Social Provisions	Quality of Hardware	Economy & Efficiency	Aesthetic	People Resources	Integrative Resources	Information Resources	Technology	Conceptual	Development	Final Decision &Details	Hardware of The Building	Environment of The Building
											Visual Communication				
											Sketch Drawings	Sketch+Graphic Drawings	Graphic Drawings		
Stages (General / Detailed) / THE ELEMENTS of INDOOR AIR QUALITY PROCESS	Indoor Air Pollution			Indoor Air Quality Improvement			Restrictive Resrcs.	Integrative Resrcs.	Information Resrcs.	Science&Technlgy.	Indoor Air Pollution Activities Indoor Air Quality Improvement Activities			Indoor Air Pollution &	Air Quality Improvement
WORKING DRAWINGS / H. TENDER ACTION: H1.1 Primary Check List 1. Client's agreement 2. Procedures to invite tenders 3. Inform all tenderers 4. Arrangement for opening of tenders 5. Check there are no obstructions to the project 6. Client's formal acceptance of tender, notification of results to all tenderers 7. Control of fee account	There is no study and work related to the design of the building. All activities are organisational to open and complete the Tender Action.														
H2.1 Issue and Receipt of Tender Documents															

Eight Feedback Point: End of Architectural Design Process; Result of Tender Action

SITE OPERATION and BUILDING in USE — J. PROJECT PLANNING, K. OPERATIONS on SITE, L. COMPLETION, M. FEEDBACK

Eight Feedback Point :
At this point the Architectural Design Process ends and results of tender actions obtained.

5.5. THE FEEDBACK CHAIN of THE ARCHITECTURAL DESIGN PROCESS based on THE RIBA PLAN of WORK in terms of INDOOR AIR QUALITY PROCESS

Eight feedback points were defined in Part 3.3.4. Feedback Points Related to The Architectural Design Process within The RIBA Plan of Work. Also, the feedback points were defined in terms of IAQP in Part 5.4. The Architectural Design Process and The Indoor Air Quality Process of The Building and The RIBA Plan of Work. From these approaches, the feedback chain relevant to the Architectural Design Process based on The RIBA Plan of Work is rearranged in terms of IAQ. This IAQ related feedback chain of the Architectural Design Process is summarised in Figure 26.

5.6. RISK ASSESSMENT / RISK MANAGEMENT, THE ARCHITECTURAL DESIGN PROCESS, INDOOR AIR QUALITY PROCESS and THE RIBA PLAN of WORK

The Risk Assessment / Risk Management model is considered with IAQ in Part 4.6. Risk Assessment / Risk Management in Indoor Air Quality Process. In this consideration, the general hazard evolution and control chain is modelled in terms of IAQ (Figure 25). Here, this model will be applied to The RIBA Plan of Work. Figure 27. shows the consideration of Risk Assessment / Risk Management, IAQ and the Architectural Design Process of the building based on The RIBA Plan of Work.

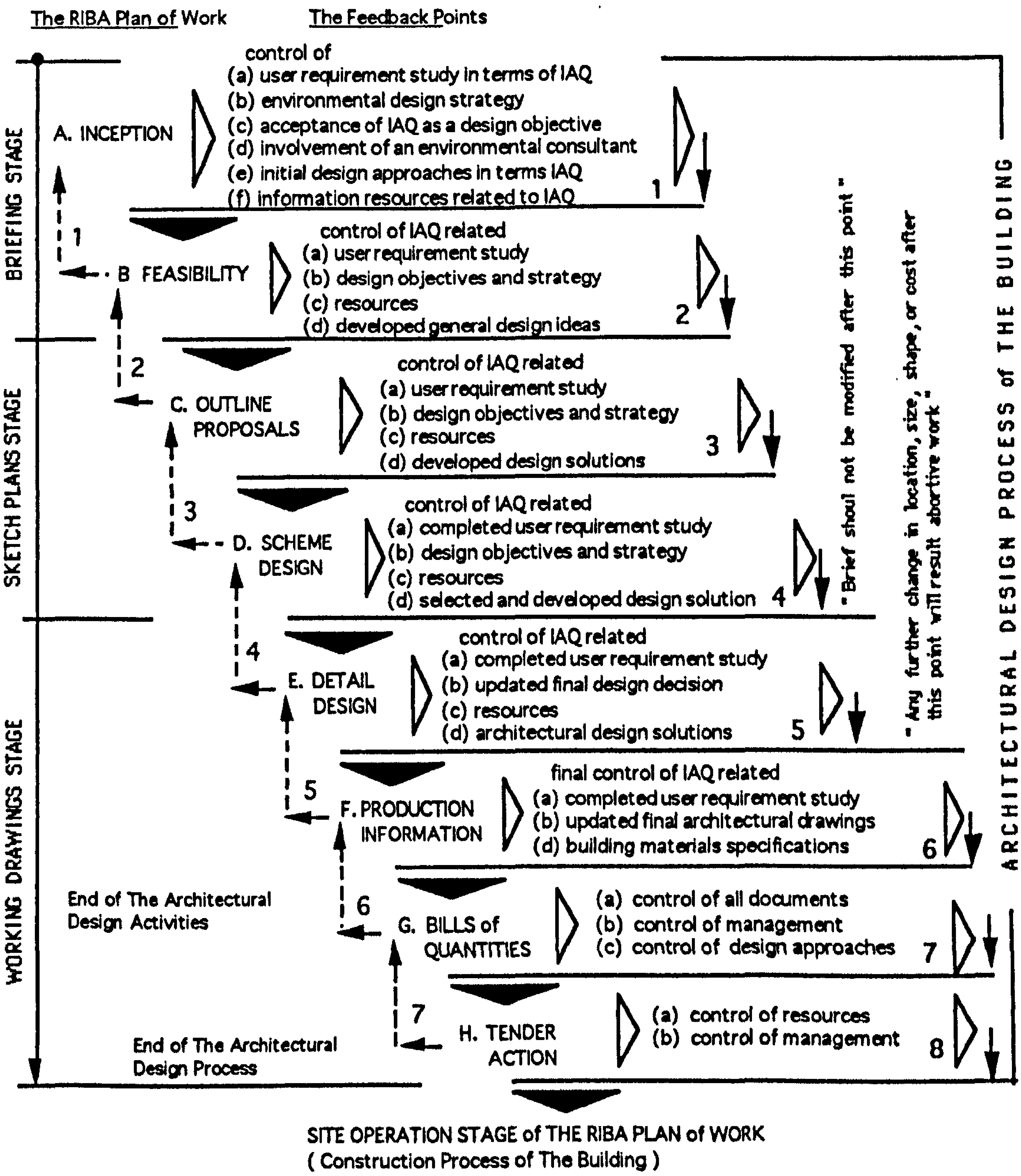
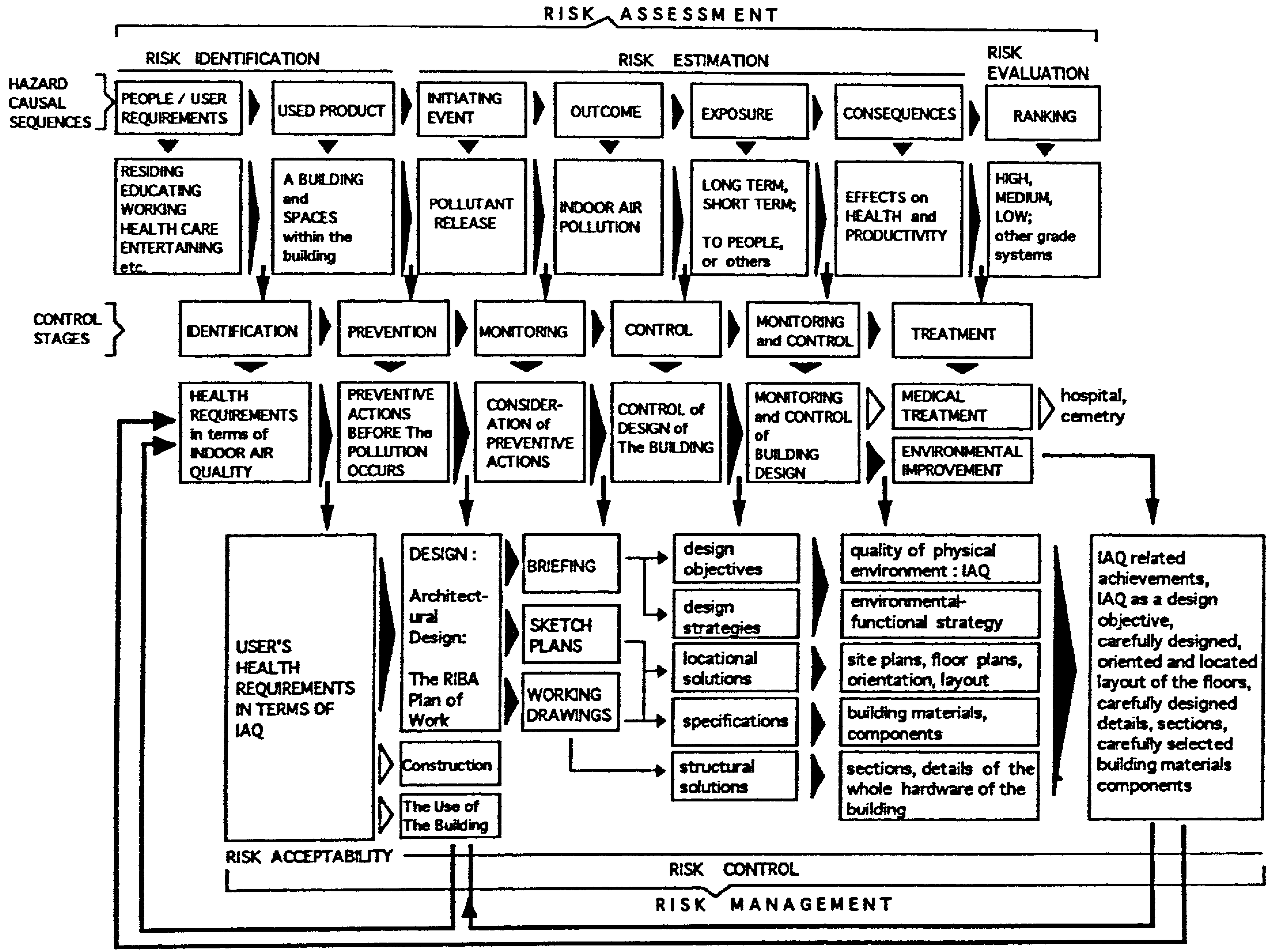


Figure 26. IAQ Related Feedback Chain of The Architectural Design Process Based on The RIBA Plan of Work

Figure 27. Consideration of Risk Assessment / Risk Management and The Architectural Design Process based on The RIBA Plan of Work



5.6.1. Risk Assessment - IAQP - The Architectural Design Process

(a) Risk Identification

People requirements related to the building and the used product (which is the building itself) are examined in this stage for any possible failure related to IAQ occuring. The examination of these hazard causal sequences steps leads to the first two control stages which are identification and prevention.

During the IAQIP health requirements connected to IAQ of the people should be identified. Then, preventive actions should be taken. Those preventive actions can be taken either before or after the indoor air pollution occurs. In this research, it is indicated that preventive design solutions can be produced before the indoor air pollution occurs if IAQ and the architectural design stage are systematically considered. Therefore, the Architectural Design Process of the building is placed in the preventive actions step.

(b) Risk Estimation

Initiating event, outcome, exposure and consequences steps of hazard causal sequences lead to the monitoring and treatment steps of the control stages.

Design objectives, design strategies, locational and structural solutions, specifications are controlled due to the outcome of the initiating event. IAQ as a design objective related to the quality of the physical environment, environmental-functional design strategy, site plans, floor plans, orientation, layout , and other spatial characteristics of the building, sections, details, and whole structural elements of the building, and building materials and components specifications are examined in detail as a result of monitoring and control of the possible exposure. Consequences lead to the monitoring and control steps to produce indoor environmental improvement treatment.

(c) Risk Evaluation

Risk evaluation of the Architectural Design Process in terms of IAQ will be based on the credit system. In the following part (Part 6. Evaluation of The Architectural Design Process in terms of IAQ), each stage of The RIBA Plan of Work will be evaluated and be given credit.

5.6.2. Risk Management - IAQP - The Architectural Design Process

(d) Risk Acceptability
IAQ related consents, regulations and standards will be determined by the selection of building materials, components, and design of services.

(e) Risk Control
The risk control feedback points will be determined as potentiality for risk at the end of each stage of the Architectural Design Process in the following part (Part 6. Evaluation of The Architectural Design Process in terms of IAQ).

In Figure 27, five strategic design approaches have been defined in control of the design of the building in terms of IAQ. These design approaches are definition of design objectives, determination of design strategies, locational design solutions, building materials and components specifications and structural and detail design solutions.

Determination of design objectives and strategies should be completed by the end of the briefing stage. If any IAQ related issue is missed during this stage, it will be difficult to produce the design solutions in terms of IAQ in the following stage.

Locational design solutions, and building materials and components specifications to prevent or reduce possible indoor air pollution should be completed during the sketch design stage. If IAQ is not considered during the preparation of locational design and the building material specification, to produce the structural and detail design, solutions in terms of IAQ will almost be impossible.

If IAQ is not taken into account within the whole design of the building, it is very likely that indoor air pollution within the spaces will occur during the future physical existence of the building.

PART SIX : EVALUATION of THE ARCHITECTURAL DESIGN PROCESS based on THE RIBA PLAN of WORK In terms of INDOOR AIR QUALITY

6.1. INTRODUCTION

Evaluative measurement of the IAQ can be done in two ways [103, 129, 134, 151, 152, 155, 156]. First, there is direct measurement in which the devices are used and numerical results are obtained. This type of measurement can be done only for the actual occurrence of indoor air pollution. The other type of measurement is based on value judgments. Observation of indoor environment, response of people, and available reliable information are used to make a judgement. The judgement about IAQ can be expressed by words such as high, medium or low risk.

Both, the Architectural Design Process and IAQP begin before the building physically exists. The Architectural Design Process practically ends when the building is under construction. But, the real occurrence of IAQP starts during the construction and use stages of the building. Therefore, making quantitative measurement and preparing an absolute numerical scale about the Architectural Design Process in terms of IAQ is impossible. However, relative value judgement can be based on potential indoor air pollution due to the architectural design, detail design and the material specification of the building.

In this part, evaluation of the Architectural Design Process of the building in terms of IAQ will be based on a credit system. In this type of evaluation, the specific targets are identified and stated whether they are achieved or not. This system is based on available information, and can be used to evaluate the design [156].

The five strategic approaches, which are design objectives, design strategies, locational solutions, building materials and components specifications and structural and detail design solutions, will be credited within The RIBA Plan of Work to evaluate the architectural design of the building in terms of IAQ. The strategic approaches were defined in the Risk Assessment / Risk Management model of the Architectural Design Process, IAQP and The RIBA Plan of Work (Figure 27). Also, potential design failure in terms of IAQ due to missing IAQ as a design objective of the Architectural Design Process will be defined at each feedback point.

6.2. EVALUATION of THE ARCHITECTURAL DESIGN PROCESS based on THE RIBA PLAN of WORK in terms of INDOOR AIR QUALITY

6.2.1. Evaluation of The Architectural Design Process in terms of IAQ / Briefing Stage - The RIBA Plan of Work

6.2.1.1. Evaluation of The Inception / Briefing Stage in terms of IAQ

Objectives

Determination of design objectives and design strategy in terms of IAQ are important steps during this stage. Credits will be awarded for the following approaches:

* credit for the acceptance of IAQ as a design objective to improve the quality of physical environment of the building,
* credit for the discussion with the client, user, organisation etc. about their IAQ related health requirements,
* credit for the determination of an environmental-functional design strategy.

Resources

Involvement of an environmental consultant in architectural design will help the design team to consider IAQ as a design objective. This environmental consultant will search the subject, obtain the IAQ related resources, and inform the design team about IAQ during the whole design process.

* credit for the involvement of an environmental consultant in design,
* credit for obtaining IAQ related information, integrative, scientific & technological resources.

Activities

* credit for considering IAQ during examining functional analysis of spaces,
* credit for definition of functional zones, possible indoor air polluted zones, possible sources of indoor air pollutants,
* credit for preparation of user activity pattern in terms of IAQ.

Objects

* credit for prepared list of IAQ related health requirements of users,
* credit for prepared IAQ related diagrams and matrices in which functional zones, indoor air polluted zones, group of pollutant sources, and their connections are shown.

First Feedback Point

* credit for the consideration of IAQ during the Inception Stage.

Potentiality for Risk

* missing the consideration of IAQ during the activities of this stage will cause difficulties in development of design solutions to achieve the quality of physical environment.

In Table 37 IAQ related awarded credits, feedback points, and potentiality for risk of the Inception Stage are briefly shown.

Table 37. IAQ Related Credit System for Inception - Briefing Stage of The RIBA Plan of Work

THE RIBA PLAN of WORK / Stages (General: BRIEFING; Detailed: A. INCEPTION)	OBJECTIVES	RESOURCES	ACTIVITIES: Decision - Making: Conceptual; Visual Communication: Sketch Drawings	Development; Sketch+Graphic Drawings	Final Decision &Details; Graphic Drawings	OBJECTS
THE ELEMENTS of THE ARCHITECTURAL DESIGN PROCESS	Spatial Quality; Quality of Physical Environment; Social Provisions; Quality of Hardware; Economy & Efficiency; Aesthetic	People Resources; Integrative Resources; Information Resources; Technology				Hardware of The Building; Environment of The Building
THE ELEMENTS of INDOOR AIR QUALITY PROCESS	Indoor Air Pollution; Indoor Air Quality Improvement	Restrictive Resources; Integrative Resources; Information Resources; Science & Technology	Indoor Air Pollution Activities Indoor Air Quality Improvement Activities			Indoor Air Pollution; Indoor Air Quality Improvement
A1.1 Primary Check List	Credit : IAQ; design objective, physical quality	Credit : IAQ; information, integrative, restrictive, scientific & technological resources	Credit: IAQ; functional analysis of spaces, user activity pattern, functional zones, indoor air polluted zones, groups of pollution sources			Credit: IAQ; list of users' health requirements, prepared diagrams & matrices; functional & polluted zones, group of pollution sources
A2.1 Exploratory Meetings	Credit : IAQ; discussion with the client, users					
A3.1., A3.2., A3.3						
A4.1 Performance Target	Credit : IAQ; environmental - functional design strategy	Credit : IAQ; environmentalist consultant, design team				
A5.1 Directive for Stage B						

First Feedback Point : Credit : IAQ; *Check the user requirements, design objectives and strategy, available resources*

Potentiality for Risk : Missing IAQ ; Difficulties in development of design solutions to achieve the quality of physical environment

6.2.1.2. Evaluation of The Feasibility / Briefing Stage in terms of IAQ

Objectives

* credit for definition of IAQ as a design objective to improve the quality of physical environment of the building,
* credit for IAQ related user requirement study: consideration of social / behavioural characteristics of the building in terms of IAQ,
* credit for determination of an environmental - functional design strategy and design policy.

Resources

* credit for detailed user identification related to IAQ,
* credit for the involvement of an environmental consultant in design,
* credit for obtaining IAQ related regulations, standards and consents,
* credit for requesting the chemical composition of the building materials from the manufacturer for preparation of building materials and components specifications in terms of IAQ,
* credit for obtaining detailed information about the site area and features of outdoor environment and examining their effects to IAQ related design decisions.

Activities

* credit for consideration of IAQ during producing initial design ideas and alternative design solutions,
* credit for consideration of IAQ during preparation of environmental specifications of spaces, building materials and components,
* credit for consideration of IAQ during arrangement of the spatial indoor features of the building; definition of possible air flow between spaces to see IAQ related connections of the spaces,

* credit for consideration of outdoor spatial, topographic, physical features, and outdoor services during preparation of site plans: examining orientation, location, neighbourhood, etc. of the building in terms of IAQ.

Objects

* credit for prepared building materials and components specifications in terms of IAQ,
* credit for prepared IAQ related alternative design solutions, floor plans and site plans.

Second Feedback Point

* credit for consideration of IAQ during the Feasibility Stage.

Potentiality for Risk

* missing the consideration of IAQ will make almost impossible to develop design solutions to achieve the quality of physical environment.

In Table 38 IAQ related awarded credits, feedback points, and potentiality for risk of the Feasibility Stage are briefly shown.

Table 38. IAQ Related Credit System for Feasibility - Briefing Stage of The RIBA Plan of Work

THE RIBA PLAN of WORK		OBJECTIVES	RESOURCES	ACTIVITIES	OBJECTS
THE ELEMENTS of THE ARCHITECTURAL DESIGN PROCESS		Spatial Quality; Quality of Physical Environment; Social Provisions; Quality of Hardware; Economy & Efficiency; Aesthetic	People Resources; Integrative Resources; Information Resources; Technology	Decision - Making: Conceptual; Development; Final Decision &Details Visual Communication: Sketch Drawings; Sketch+Graphic Drawings; Graphic Drawings	Hardware of The Building; Environment of The Building
Stages	THE ELEMENTS of INDOOR AIR QUALITY PROCESS	Indoor Air Pollution; Indoor Air Quality Improvement	Restrictive Resrcs.; Integrative Resrcs.; Information Resrcs.; Science&Technlgy.	Indoor Air Pollution Activities Indoor Air Quality Improvement Activities	Indoor Air Pollution &; Air Quality Improvement
General	Detailed				
B R I E F I N G	B. FEASIBILITY B1.1 Primary Check List B2.1 Design Team Meetings B3.1 Guide to Briefing B3.2 Briefing / Basic Requirements B3.3 Brfng / Areas, Acts. B3.4 Brfng / Bldng Elemnts. B4.1 Survey: Action Required B4.2 Survey: Context of Project B4.3 Srvy: Site / Informtn B4.4 Srvy: Site / Plans, Sections B4.5 Srvy: Existing Bldngs. B4.6 Survey: Trial Holes B5.1 Consents: B6.1, B6.2 Report to Client B7.1 Directive for Stage C	Credit : IAQ ; design objective, quality of physical environment, Credit : IAQ ; detailed user requirement study, consideration of social / behavioural characteristics of the building, Credit : IAQ ; determination of environmental - functional design strategy and policy	Credit : IAQ ; detailed user identification, Credit : IAQ ; environmentalist consultant, Credit : IAQ ; regulations, standards, consents Credit : IAQ ; detailed information about site area, outdoor environment Credit : IAQ ; requesting the chemical composition of the materials from the manufacturers,	Credit : IAQ ; initial design ideas, alternative design solutions, Credit : IAQ ; environmental specifications of spaces, materials, Credit : IAQ ; layout of the floor plans; consideration of indoor spatial features, possible air flow between spaces, Credit : IAQ ; arrangement of site plans; consideration of outdoor spatial, topographic, physical features, and services.	Credit: IAQ; completed user requirement study Credit: IAQ; specification of the materials & components Credit: IAQ; considered sketch and graphic drawings, alternative location drawings; floor plans, site plans

Second Feedback Point : Credit : IAQ ; *Check detailed user requirement study and obtained resources; review the design strategy and objectives, examine the developed general design ideas in terms of IAQ.*

Potentiality for Risk : Missing IAQ ; Almost impossibility of development of design solutions to achieve the quality of physical environment

6.2.2. Evaluation of The Architectural Design Process in terms of IAQ / Sketch Plans Stage - The RIBA Plan of Work

6.2.2.1. Evaluation of The Outline Proposals / Sketch Plans Stage in terms of IAQ

Objectives

* credit for detailed user requirement study related to IAQ,
* credit for definition of IAQ as a design objective,
* credit for determination of environmental -functional design strategy.

Resources

* credit for obtaining IAQ related regulations, standards and consents,
* credit for the involvement of an environmental consultant, other consultants, and authorities in design of the building,
* credit for obtaining scientific and technological resources related to IAQ,
* credit for building materials, components and other products specifications in terms of IAQ.

Activities

* credit for consideration of indoor and outdoor spatial features in terms of IAQ, during development of locational drawings,
* credit for consideration of IAQ related connections of the spaces during arrangement of layout of floor plans,
* credit for examining structural elements, services and contents of the building in terms of IAQ during preparation of initial assembly drawings: structural sections and details,
* credit for selection of building materials and components in terms of IAQ.

Objects

* credit for selected building materials and components specifications in terms of IAQ,
* credit for developed alternative locational drawings in which IAQ is considered during arrangement of floor plans and site plans,
* credit for selected most suitable locational drawings in terms of IAQ,
* credit for prepared initial assembly drawings.

Third Feedback Point

* credit for consideration of IAQ during the Outline Proposals Stage.

Potentiality for Risk

* missing IAQ will make it impossible to develop locational, structural and detail design solutions, and to prepare building materials and components specifications to achieve the quality of physical environment.

Table 39 briefly shows IAQ related credit system for Outline Proposals Stage.

Table 39. IAQ Related Credit System for Outline Proposals - Sketch Plans Stage of The RIBA Plan of Work

THE ELEMENTS of THE ARCHITECTURAL DESIGN PROCESS / THE RIBA PLAN of WORK	OBJECTIVES	RESOURCES	ACTIVITIES: Decision - Making: Conceptual / Visual Communication: Sketch Drawings	ACTIVITIES: Decision - Making: Development / Visual Communication: Sketch+Graphic Drawings	ACTIVITIES: Decision - Making: Final Decision &Details / Visual Communication: Graphic Drawings	OBJECTS
	Spatial Quality; Quality of Physical Environment; Social Provisions; Quality of Hardware; Economy & Efficiency; Aesthetic	People Resources; Integrative Resources; Information Resources; Technology				Hardware of The Building; Environment of The Building
Stages: General / Detailed; THE ELEMENTS of INDOOR AIR QUALITY PROCESS	Indoor Air Pollution; Indoor Air Quality Improvement	Restrictive Resrcs.; Integrative Resrcs.; Information Resrcs.; Science&Technlgy.	Indoor Air Pollution Activities / Indoor Air Quality Improvement Activities			Indoor Air Pollution & Air Quality Improvement
SKETCH PLANS — C. OUTLINE PROPOSALS: C1.1 Primary Check List 1. Review of requirements 2. Alternative design solutions 3. Design development 4. General design approaches 5. Essential consents 6. 7. Reports 8. Further instruction, extra fees 9. Consultation of design team 10. Control of actions in Stage C 11., 12. Control of fee accounts	Credit : IAQ ; detailed user requirement study, Credit : IAQ ; design objective, quality of physical environment, Credit : IAQ ; environmental - functional design strategy & policy	Credit : IAQ ; consents, standarts, regulations, Credit : IAQ ; consultants, authorites, Credit : IAQ ; scientific and technological studies, Credit : IAQ ; specifications of manifactured building materials, components and other products.		Credit : IAQ ; development of locational drawings : functional & environmental relations of spaces; consideration of indoor & outdoor spatial features Credit : IAQ ; initial assembly drawings: structural elements, services and contents Credit : IAQ ; material & components specifications		Credit: IAQ; building materials and components specifications, Credit: IAQ; developed locational drawings, floor plans, site plans, Credit: IAQ; initial assembly darwings, sections, details.
C2.1 Directive for Stage D						

Third Feedback Point: Credit: IAQ; Check user requirements, design strategy and objectives, resources, and developed design solutions.

Potentiality for Risk : Missing IAQ ; Impossibility of development of structural and detail design solutions, and preparation of the building materials and components specification to achieve the quality of physical environment.

6.2.2.2. Evaluation of The Scheme Design / Sketch Plans Stage in terms of IAQ

Objectives

* credit for IAQ related completed user requirement study,
* credit for determined effective environmental - functional design strategy, and design policy in terms of IAQ,
* credit for IAQ related design achievements.

Resources

* credit for obtaining IAQ related all essential resources,
* credit for IAQ related proposals of engineers,
* credit for IAQ related indoor environmental implications and consultations.

Activities

* credit for consideration of indoor spatial, physical and social / behavioural, and outdoor features of the building in terms of IAQ during the development of the selected design solution,
* credit for completion of location drawings; floor plans and site plans in which IAQ is considered,
* credit for consideration of structural elements, services and contents of the building during the development of the assembly drawings which are structural sections and details: details of horizontal surfaces, details of vertical surfaces, details of horizontal joints of the surfaces, details of vertical joints of the surfaces, details of corner joints of the surfaces.

Objects

* credit for completed location drawings which are suitably designed to prevent, or reduce the possible indoor air pollution in further stages of the building due to architectural design of the building.
* credit for IAQ related building materials and components specifications,

* credit for developed assembly drawings in which IAQ is considered.

Fourth Feedback Point

* credit for consideration of IAQ during the Scheme Design Stage.

Potentiality for Risk

* missing IAQ will make it impossible to develop locational, structural and detail design solutions and to prepare building materials and components specification to achieve the quality of physical environment of the building.

Table 40 briefly shows the credit system and potentiality for risk of the Scheme Design Stage.

Table 40. IAQ Related Credit System for Scheme Design - Sketch Plans Stage of The RIBA Plan of Work

THE RIBA PLAN of WORK / THE ELEMENTS of THE ARCHITECTURAL DESIGN PROCESS	OBJECTIVES	RESOURCES	ACTIVITIES	OBJECTS
	Spatial Quality; Quality of Physical Environment; Social Provisions; Quality of Hardware; Economy & Efficiency; Aesthetic	People Resources; Integrative Resources; Information Resources; Technology	Decision - Making: Conceptual; Development; Final Decision &Details Visual Communication: Sketch Drawings; Sketch+Graphic Drawings; Graphic Drawings	Hardware of The Building; Environment of The Building
Stages (General / Detailed) — THE ELEMENTS of INDOOR AIR QUALITY PROCESS	Indoor Air Pollution; Indoor Air Quality Improvement	Restrictive Resrcs.; Integrative Resrcs.; Information Resrcs.; Science&Technlgy.	Indoor Air Pollution Activities Indoor Air Quality Improvement Activities	Indoor Air Pollution &; Air Quality Improvement
S K E T C H P L A N S — D. SCHEME DESIGN D1.1 Primary Check List 1. Review progress 2. Complete user studies/ detail planning solutions development 3. Consulting authorities 4. Full scheme, specifictions 5. Distribution of scheme 6. Engineers' proposals 7. Final cost plan 9. QS and consultants' reports 10. Full scheme report to client 11. Application of statutory & other consents, client's approval. 12. Control of actions in Stage D. 13. Directive for Stage E. 14. Advising the client 15,16. Control of fee accounts D2.1 Directive for Stage E	Credit : IAQ ; Completed user requirement study, Credit : IAQ ; Determined effective environmental - functional design strategy, and design policy, Credit : IAQ ; Determined design achievements	Credit: IAQ; all essential resources Credit: IAQ; engineering proposals Credit: IAQ; indoor environmental implications and consultation	Credit : IAQ ; selected and developed most suitable design solution; consideration of outdoor and indoor environmental features, Credit : IAQ ; completion of location drawings ; floor & site plans, Credit : IAQ ; development of the assembly drawings; consideration of structural elements, services, contents, initial components and details design	Credit: IAQ; completed location drawings, Credit: IAQ; materials& components specific-ations, and schedules, Credit: IAQ; developed assembly drawings, initial detail deisgn.

* Brief should not be modified after this point * (indication of The RIBA Plan of Work)

Fourth Feedback Point : Credit : IAQ ;*Checkthe IAQ related completed user requirement study, design objectives and strategy, resources, and selected and developed design solution.*

Potentiality for Risk : Missing IAQ ; Impossibility of development of structural and detail design solutions, and preparation of the building materials and components specification to achieve the quality of physical environment.

6.2.3. Evaluation of The Architectural Design Process in terms of IAQ / Working Drawings Stage - The RIBA Plan of Work

6.2.3.1. Evaluation of The Detail Design / Working Drawings Stage in terms of IAQ

Objectives

* credit for IAQ related completed user requirement study,
* credit for IAQ related determined environmental -functional design strategy and policy.

Resources

* credit for consideration of all resources in terms of IAQ,
* credit for consideration of IAQ during the preparation of engineering drawings,
* credit for consultation with the design team about detail and services design related to IAQ.

Activities

* credit for completion of building materials and components specifications, further working schedules in terms of IAQ,
* credit for examination of IAQ related location drawings,
* credit for completion of assembly and components drawings in which IAQ is considered.

Objects

* credit for completed building materials and components specifications, further working schedules in terms of IAQ,
* credit for completed location drawings in terms of IAQ,
* credit for completed assembly and components drawings in which IAQ is considered.

<u>Fifth Feedback Point</u>

* credit for consideration of IAQ during the Detail Design Stage.

Potentiality for Risk

* missing IAQ will make it impossible to develop structural and detail design, and to prepare building materials and components specifications to achieve the quality of physical environment.

Table 41 briefly shows the credit system and potentiality for risk of the Detail Design Stage.

Table 41. IAQ Related Credit System for Detail Design - Working Drawings Stage of The RIBA Plan of Work

THE RIBA PLAN of WORK / THE ELEMENTS of THE ARCHITECTURAL DESIGN PROCESS / THE ELEMENTS of INDOOR AIR QUALITY PROCESS	OBJECTIVES: Spatial Quality, Quality of Physical Environment, Social Provisions, Quality of Hardware, Economy & Efficiency, Aesthetic / Indoor Air Pollution, Indoor Air Quality Improvement	RESOURCES: People Resources, Integrative Resources, Information Resources, Technology / Restrictive Resrcs., Integrative Resrcs., Information Resrcs., Science&Technlgy.	ACTIVITIES: Decision - Making: Conceptual / Visual Communication: Sketch Drawings	ACTIVITIES: Decision - Making: Development / Visual Communication: Sketch+Graphic Drawings	ACTIVITIES: Decision - Making: Final Decision &Details / Visual Communication: Graphic Drawings	OBJECTS: Hardware of The Building, Environment of The Building / Indoor Air Pollution & Air Quality Improvement
Stages: General: WORKING DRAWINGS; Detailed: E. DETAIL DESIGN E1.1 Primary Check List 1. Review instructions 2. Complete user requirements 3. Detail design&final specifictn. 4. Updating design decisions 5. Engineers' drawings 6. Review cost plan 7. Reviewand confirmation of architectural & engineering design 8. Review of detail dsign 9. Control of all actions 10. Control of fee accunts E2.1. Directive for Stage F	Credit : IAQ ; completed user requirement study, Credit : IAQ ; determined environmental - functional design strategy & policy	Credit : IAQ ; considered all resources Credit : IAQ ; engineering drawings Credit : IAQ ; consultation			Credit: IAQ ; completed specifications. & schedules Credit: IAQ ; examined location drawings Credit: IAQ ; Completed assembly & components drawings	Credit : IAQ ; completed specifications & schedules Credit : IAQ ; updated location drawings Credit : IAQ ; completed assembly& components drawings

" Any further change in location, size, shape, or cost after this time will result in abortive work " (indication of The RIBA Plan of Work)

Fifth Feedback Point: Credit : IAQ ; *Check the updated final design decisions, control the architectural design solutions.*

Potentiality for Risk : Missing IAQ ; Impossibility of development of structural and detail design solutions, and preparation of the building materials and components specification to achieve the quality of physical environment.

6.2.3.2. Evaluation of The Production Information / Working Drawings Stage in terms of IAQ

Objectives

* credit for examination of architectural design achievements in terms of IAQ.

Resources

* credit for examination of all IAQ related resources.

Activities

* credit for control and correction of all drawings, specifications, and schedules in terms of IAQ.

Objects

* credit for completed all drawings, specifications, and schedules related to IAQ.

Sixth Feedback Point

* credit for consideration of IAQ during the Production Information Stage.

Potentiality for Risk

* missing IAQ will cause unavoidable potential indoor air pollution within the spaces of the building in the construction stage and use stage of the building,
* missing IAQ will cause potential hazardous effect of indoor air pollution to users' health.

In Table 42 the credit system and potentiality for risk of the Production Information Stage are briefly shown.

Table 42. IAQ Related Credit System for Production Information - Working Drawings Stage of The RIBA Plan of Work

THE RIBA PLAN of WORK / THE ELEMENTS of THE ARCHITECTURAL DESIGN PROCESS / THE ELEMENTS of INDOOR AIR QUALITY PROCESS	OBJECTIVES	RESOURCES	ACTIVITIES: Decision - Making: Conceptual; Visual Communication: Sketch Drawings	Development; Sketch+Graphic Drawings	Final Decision &Details; Graphic Drawings	OBJECTS
	Spatial Quality; Quality of Physical Environment; Social Provisions; Quality of Hardware; Economy & Efficiency; Aesthetic	People Resources; Integrative Resources; Information Resources; Technology				Hardware of The Building; Environment of The Building
Stages: General / Detailed	Indoor Air Pollution; Indoor Air Quality Improvement	Restrictive Resrcs.; Integrative Resrcs.; Information Resrcs.; Science&Technlgy.	Indoor Air Pollution Activities / Indoor Air Quality Improvement Activities			Indoor Air Pollution & Air Quality Improvement
WORKING DRAWINGS — F. PRODUCTION INFORMATION: F1.1 Primary Check List	Credit : IAQ ; considered architectural design achievements	Credit: IAQ ; considered all resources.			Credit: IAQ; controlled and corrected all drawings, specific-ations, and schedules	Credit : IAQ; completed specifications, and schedules, Credit : IAQ ; all completed drawings: location, assembly, and components drawings
F2.1 Production Drawings						
F3.1 Preliminary Tendering						
F4.1 Register of Contractors						
F5.1 Information for Tender Documents						
F6.1 Nominated Subcontartors & Suppliers						
F7.1 Selection of Nominated Subcontartors & Suppliers						
F8.1 Directive for Stage G						

Sixth Feedback Point : Credit : IAQ ; *Check the final completion and corrections of all drawings, specifications, and schedules.*

Potentiality for Risk : Missing IAQ ; Unavoidable potential indoor air pollution within the spaces of the building in further life stages which are the costruction stage and the use stage of the building; Unavoidable potential hazardous effect of indoor air pollution to the users' health.

6.2.3.3. Evaluation of The Bills of Quantities / Working Drawings Stage in terms of IAQ

Objectives

There is no study related to the architectural design objectives during this stage.

Resources

* credit for final consideration of IAQ related all resources,
* credit for requesting for an environmental consultant for the construction team.

Activities

* credit for IAQ related final control of all documents for tender action.

Objects

* credit for all documents in which IAQ is considered for tender action..

Seventh Feedback Point

* credit for consideration of IAQ during the Bills of Quantities Stage.

Potentiality for Risk

* missing IAQ will cause unavoidable potential indoor air pollution within the spaces of the building in the construction stage and use stage of the building,
* missing IAQ will cause potential hazardous effect of indoor air pollution to users' health.

Table 43 shows the credit system and potentiality for risk of the Bills of Quantities Stage.

Table 43. IAQ Related Credit System for Bills of Quantities - Working Drawings Stage of The RIBA Plan of Work

THE RIBA PLAN of WORK / THE ELEMENTS of THE ARCHITECTURAL DESIGN PROCESS		OBJECTIVES: Spatial Quality	Quality of Physical Environment	Social Provisions	Quality of Hardware	Economy & Efficiency	Aesthetic	RESOURCES: People Resources	Integrative Resources	Information Resources	Technology	ACTIVITIES: Decision - Making: Conceptual / Visual Communication: Sketch Drawings	Development / Sketch+Graphic Drawings	Final Decision &Details / Graphic Drawings	OBJECTS: Hardware of The Building	Environment of The Building
Stages: General	Detailed / THE ELEMENTS of INDOOR AIR QUALITY PROCESS	Indoor Air Pollution			Indoor Air Quality Improvement			Restrictive Resrcs.	Integrative Resrcs.	Information Resrcs.	Science&Technlgy.	Indoor Air Pollution Activities Indoor Air Quality Improvement Activities			Indoor Air Pollution &	Air Quality Improvement
WORKING DRAWINGS	G. BILLS of QUANTITIES G1.1 Primary Check List 1. Design team organisation 2. Update drawings, schedules & specifications 3. Confirm list of tenderers 4. Interview & check site staff 5. Correction of all documents 6. Obtaining outstanding quotations 7. Assemble drawings 8. Prepare draft architect's instruction for changes too late to be included in bills of quantities 9. Advising client 10. Directive for Stage H 11. Control fee accounts							Credit: IAQ; final consideration of all IAQ related resources, Credit: IAQ; request for an environmental consultant for the construction team.						Credit: IAQ; final control of all documents for Tender Action, end of architectural design activities.	Credit: IAQ; all specific-ations, schedules, corrected drawings, documents for Tender Action.	

Seventh Feedback Point: Credit: IAQ; *Check the all documents, specifications, schedules, and drawings for the Tender Action.*

Potentiality for Risk : Missing IAQ ; Unavoidable potential indoor air pollution within the spaces of the building in the construction stage and the use stage of the building;
Unavoidable potential hazardous effect of indoor air pollution to the users' health.

6.2.3.4. Evaluation of The Tender Action / Working Drawings Stage in terms of IAQ

There is no study and work related to the design of the building. All activities are organisational to open and complete the tender action.

Eight Feedback Point

* Credit for selecting and environmental construction team among the tenderers.

Potentiality for Risk

* missing IAQ will cause unavoidable potential indoor air pollution within the spaces of the building in the construction stage and use stage of the building,
* missing IAQ will cause potential hazardous effect of indoor air pollution to users' health.

Table 44 shows the credit system and potentiality for risk of the Tender Action Stage.

Table 44. IAQ Related Credit System for Tender Action - Working Drawings Stage of The RIBA Plan of Work

THE ELEMENTS of THE ARCHITECTURAL DESIGN PROCESS ▶ / THE RIBA PLAN of WORK ▼	OBJECTIVES						RESOURCES				ACTIVITIES			OBJECTS	
											Decision - Making				
											Conceptual	Development	Final Decision &Details		
											Visual Communication				
	Spatial Quality	Quality of Physical Environment	Social Provisions	Quality of Hardware	Economy & Efficiency	Aesthetic	People Resources	Integrative Resources	Information Resources	Technology	Sketch Drawings	Sketch+Graphic Drawings	Graphic Drawings	Hardware of The Building	Environment of The Building
Stages: General / Detailed — THE ELEMENTS of INDOOR AIR QUALITY PROCESS ▶	Indoor Air Pollution			Indoor Air Quality Improvement			Restrictive Resrcs.	Integrative Resrcs.	Information Resrcs.	Science&Technlgy.	Indoor Air Pollution Activities Indoor Air Quality Improvement Activities			Indoor Air Pollution &	Air Quality Improvement
WORKING DRAWINGS — H. TENDER ACTION: H1.1 Primary Check List 1. Client's agreement 2. Procedures to invite tenders 3. Inform all tenderers 4. Arrangement for opening of tenders 5. Check there are no obstructions to the project 6. Client's formal acceptance of tender, notification of results to all tenderers 7. Control of fee account	There is no study and work related to the design of the building. All activities are organisational to open and complete the Tender Action. Credit : IAQ ; Selecting an environmentalist costruction team among tenderers. Potentiality for Risk : Missing IAQ ; Unavoidable potential indoor air pollution within the spaces of the building in the construction stage and the use stage of the building; Unavoidable potential hazardous effect of indoor air pollution to the users' health.														
H2.1 Issue and Receipt of Tender Documents															
Eight Feedback Point: End of Architectural Design Process: Result of Tender Action															
SITE OPERATION and BUILDING in USE	J. PROJECT PLANNING, K. OPERATIONS on SITE, L. COMPLETION, M. FEEDBACK														

6.3. CONTROL LOOPS of THE ARCHITECTURAL DESIGN PROCESS based on THE RIBA PLAN WORK in terms of INDOOR AIR QUALITY

The credit system for evaluating the Architectural Design Process based on The RIBA Plan of Work gives a set of instructions in which design objectives, resources, activities and objects are examined in terms of IAQ. These instructions can be arranged in such a way that the design team can control their approach in every stage of the Architectural Design Process. Then, they can move to the next stage or return to the previous stage to complete the required design approach to produce the preventive solutions for possible indoor air pollution in further life stages of the building.

The arrangement of the instructions provides a kind of loop that is applied to each stage of The RIBA Plan of Work. The following figures show the control loops of the Architectural Design Process based on The RIBA Plan of Work in terms of IAQ.

Figure 28. Control Loop of The Inception - Briefing Stage of The RIBA Plan of Work,
Figure 29. Control Loop of The Feasibility - Briefing Stage of The RIBA Plan of Work,
Figure 30. Control Loop of The Outline Proposals - Sketch Plans Stage of The RIBA Plan of Work,
Figure 31. Control Loop of TheScheme Design - Sketch Plans Stage of The RIBA Plan of Work,
Figure 32. Control Loop of The Detail Design - Working Drawings Stage of The RIBA Plan of Work,
Figure 33. Control Loop of The Production Information - Working Drawings Stage of The RIBA Plan of Work,
Figure 34. Control Loop of The Bills of Quantities - Working Drawings Stage of The RIBA Plan of Work,
Figure 35. Control Loop of The Tender Action - Working Drawings Stage of The RIBA Plan of Work.

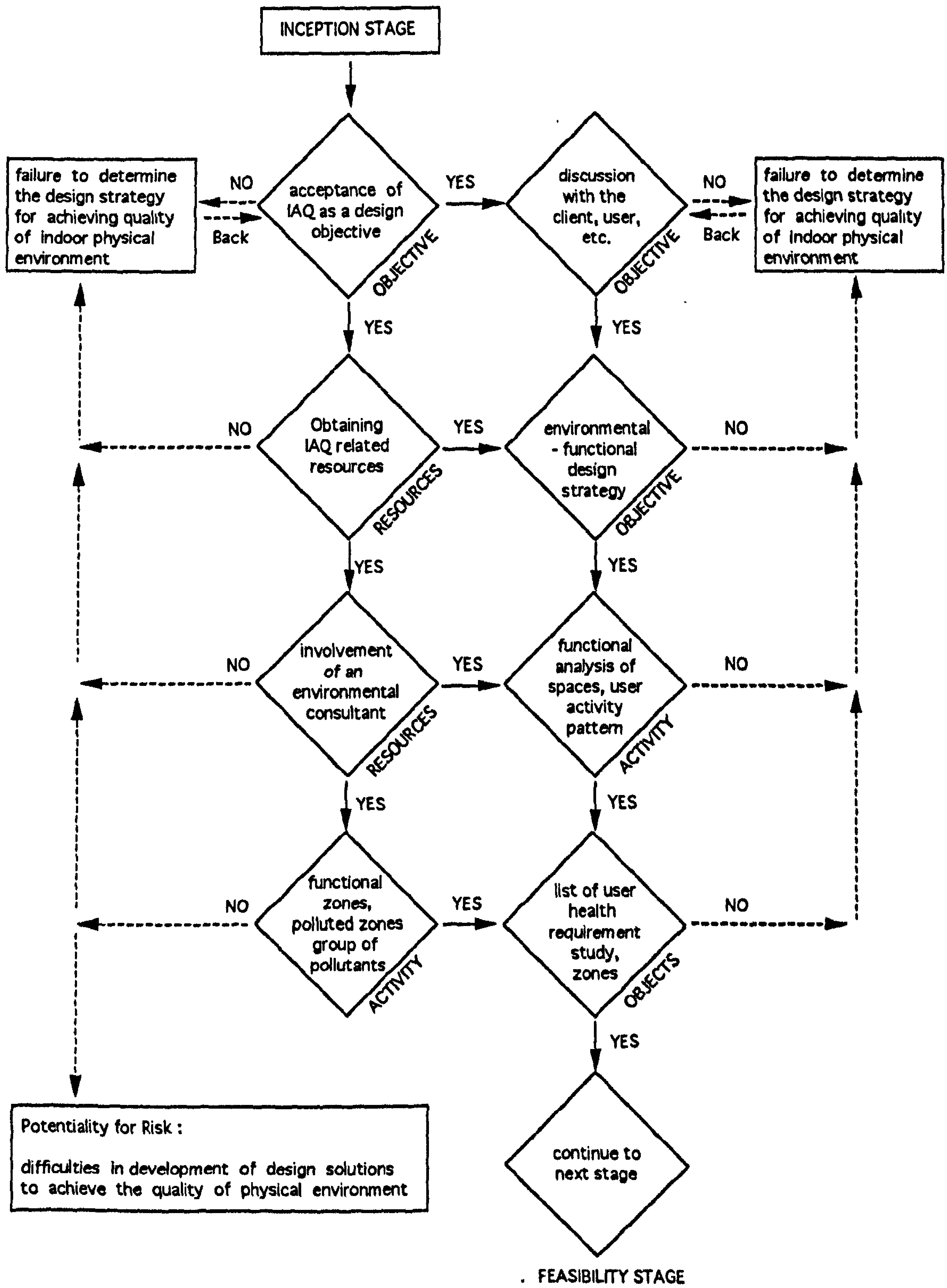


Figure 28. Control Loop of The Inception - Briefing Stage of The RIBA Plan of Work

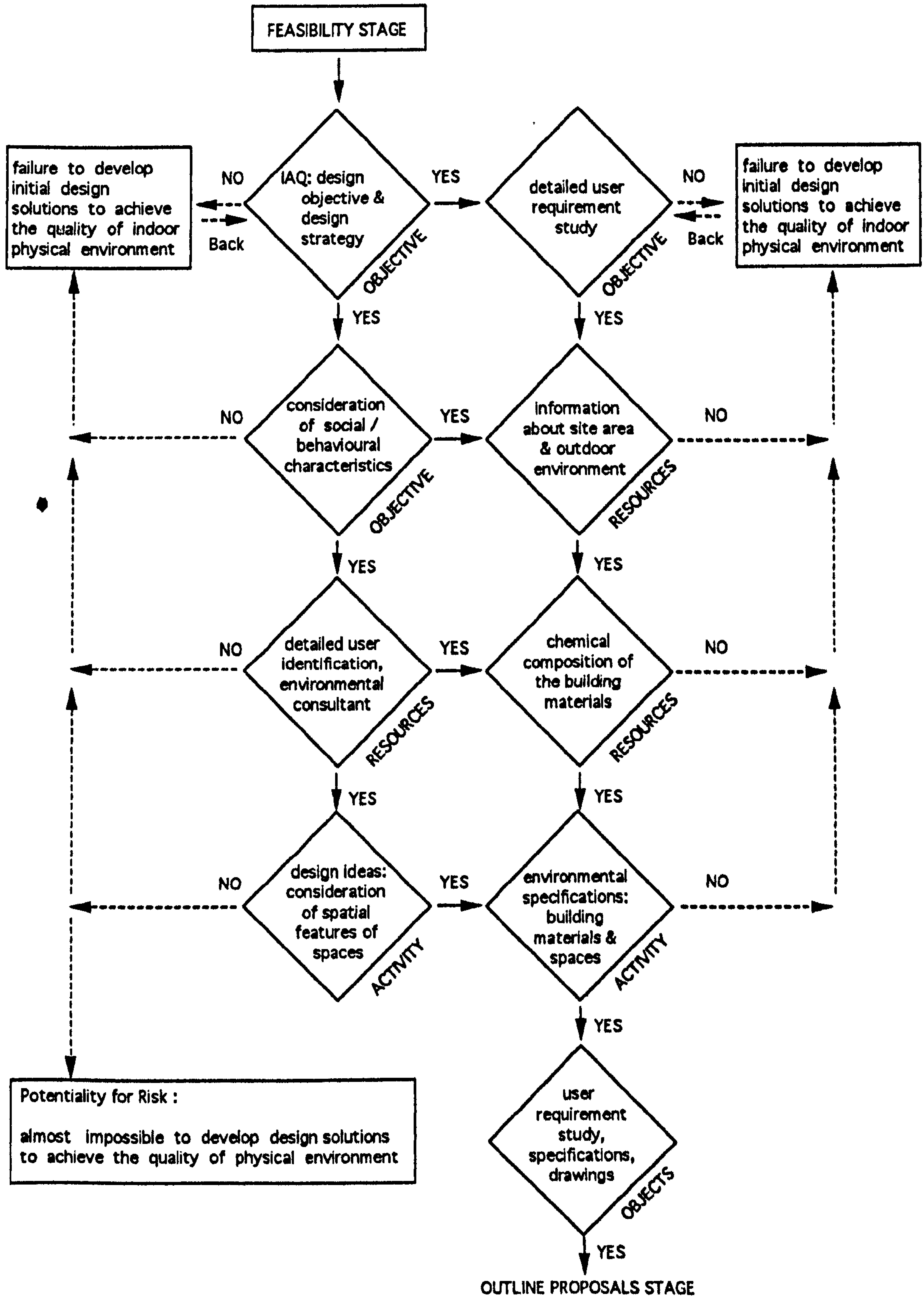


Figure 29. Control Loop of The Feasibility - Briefing Stage of The RIBA Plan of Work

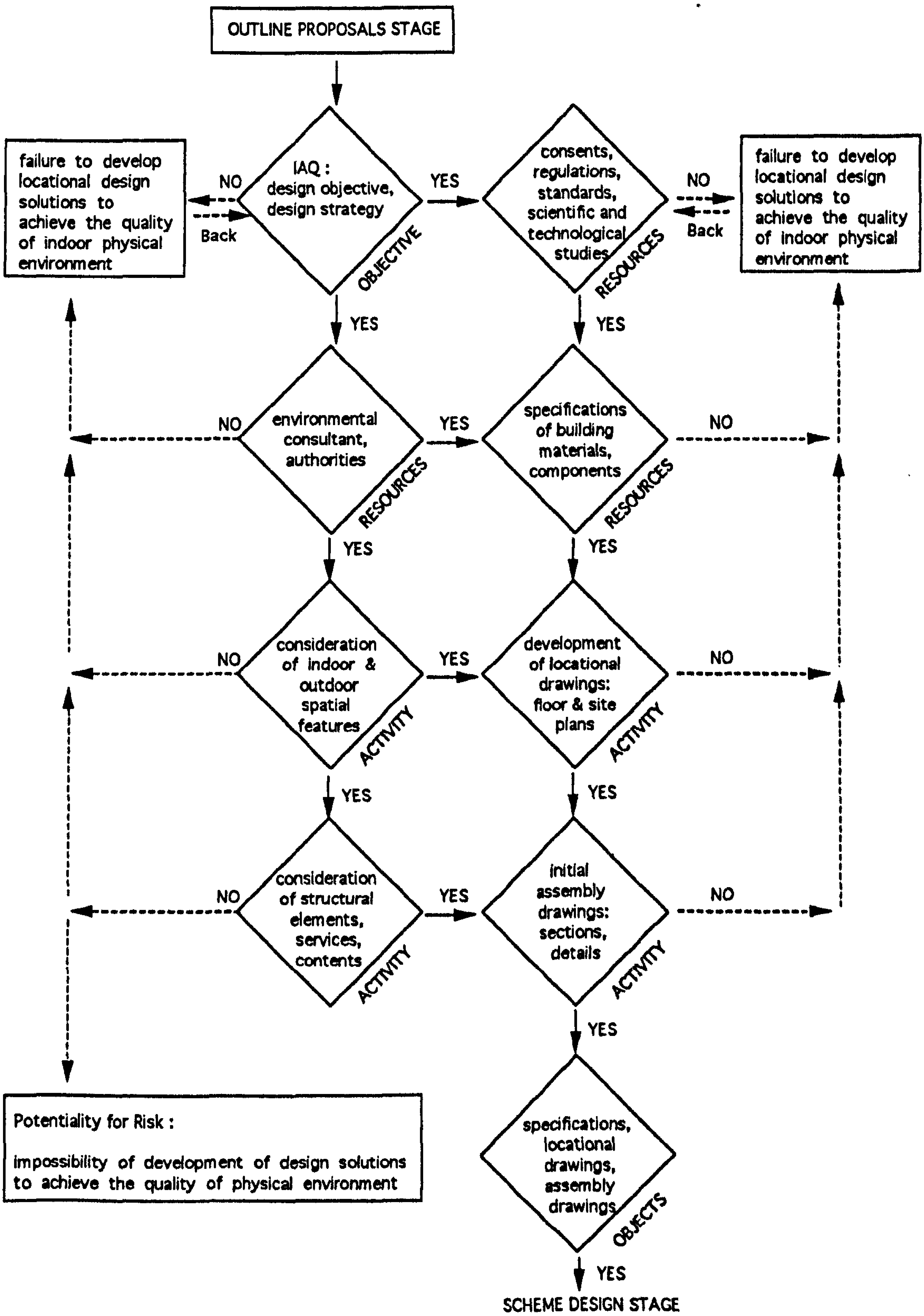


Figure 30. Control Loop of The Outline Proposals - Sketch Plans Stage of The RIBA Plan of Work

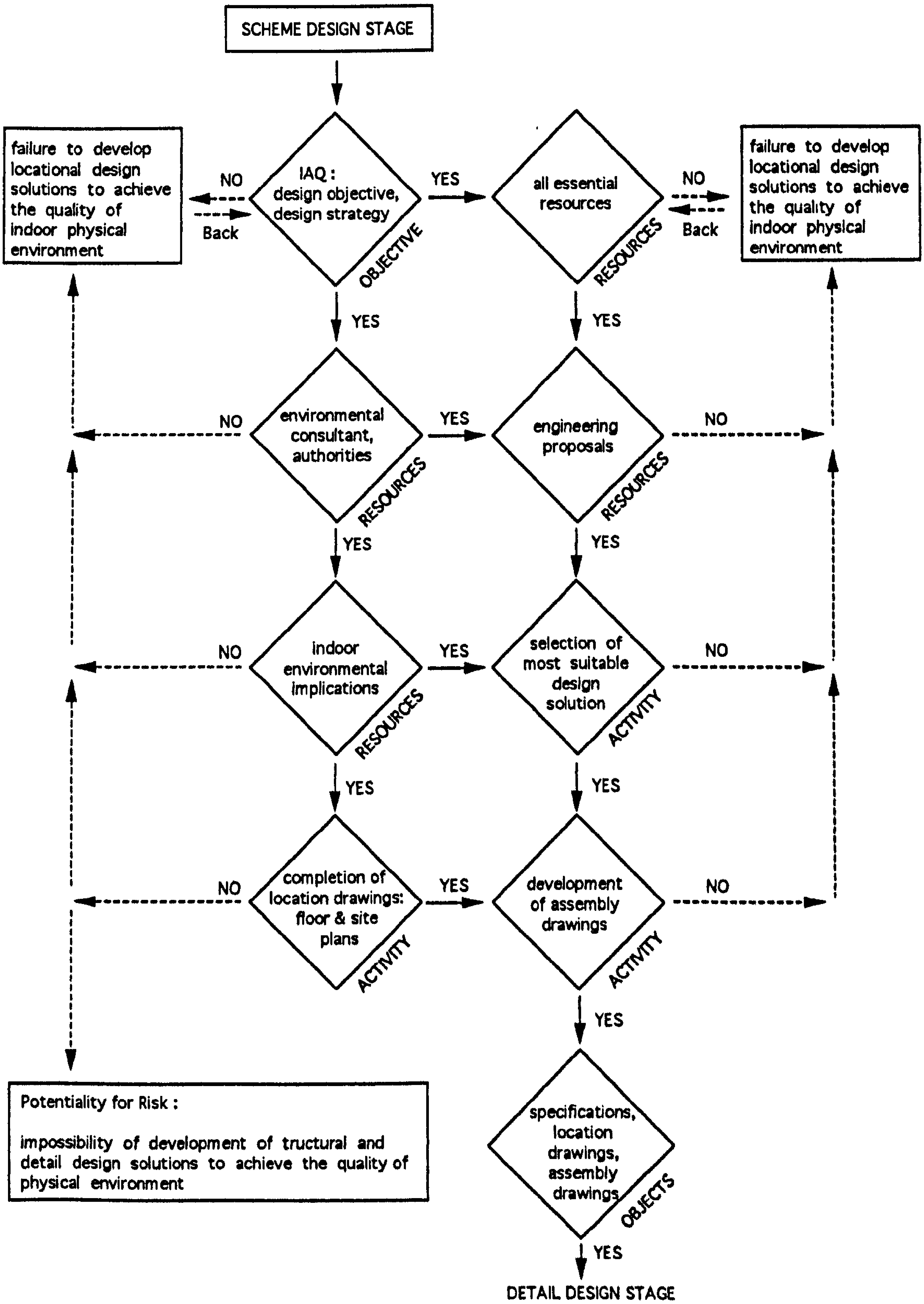


Figure 31. Control Loop of The Scheme Design -
Sketch Plans Stage of The RIBA Plan of Work

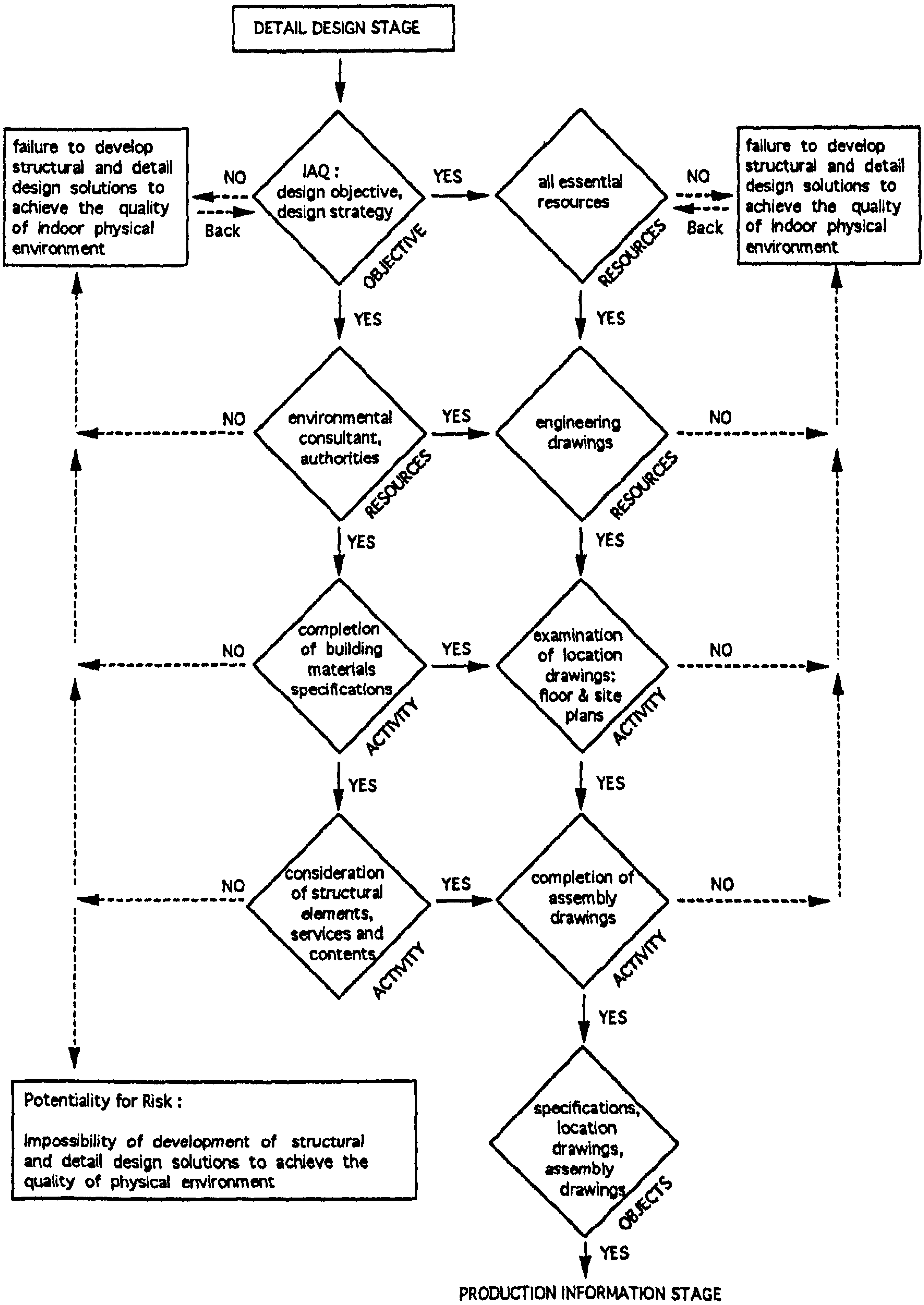


Figure 32. Control Loop of The Detail Design - Working Drawings Stage of The RIBA Plan of Work

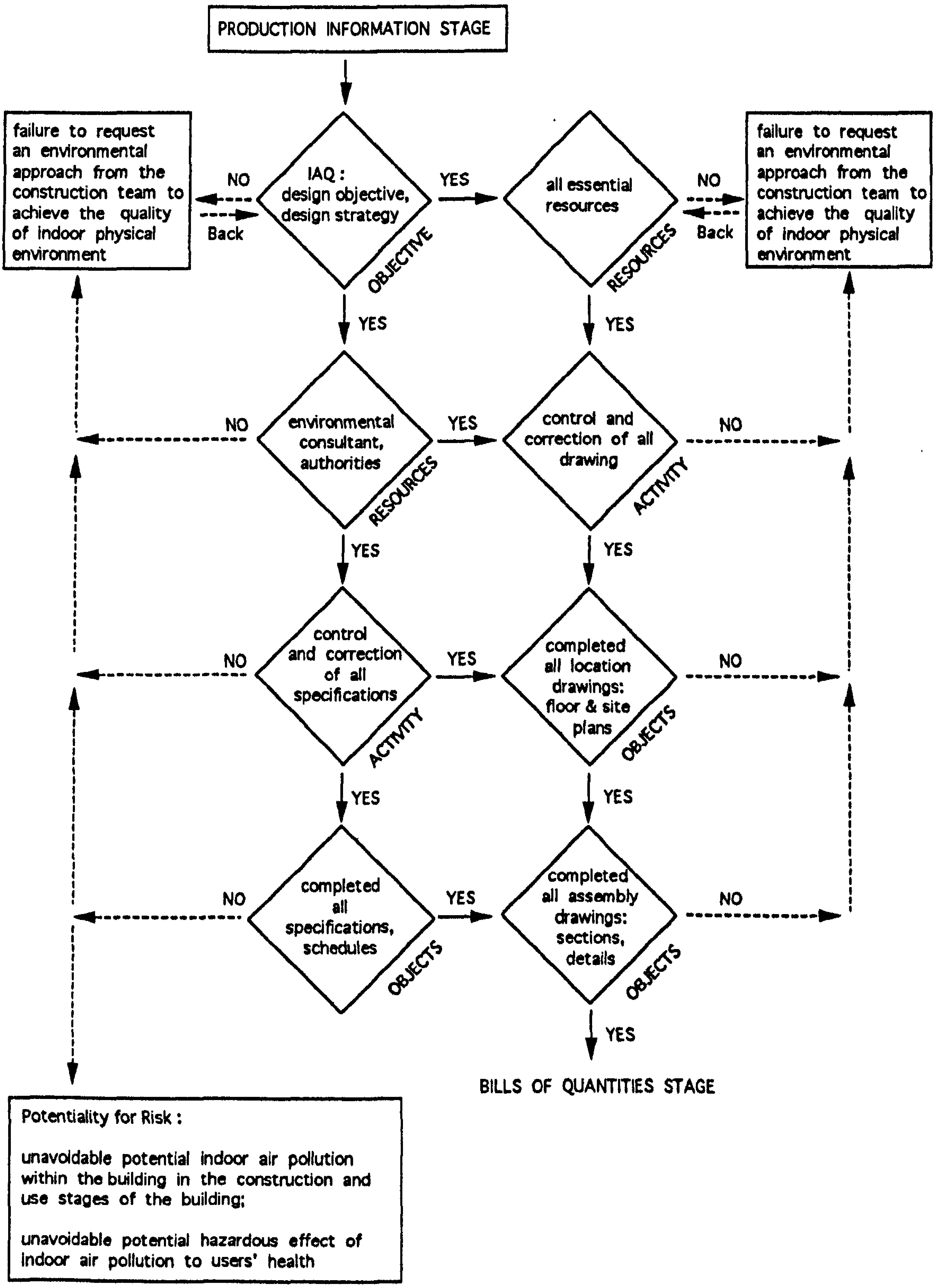


Figure 33. Control Loop of The Production Information - Working Drawings Stage of The RIBA Plan of Work

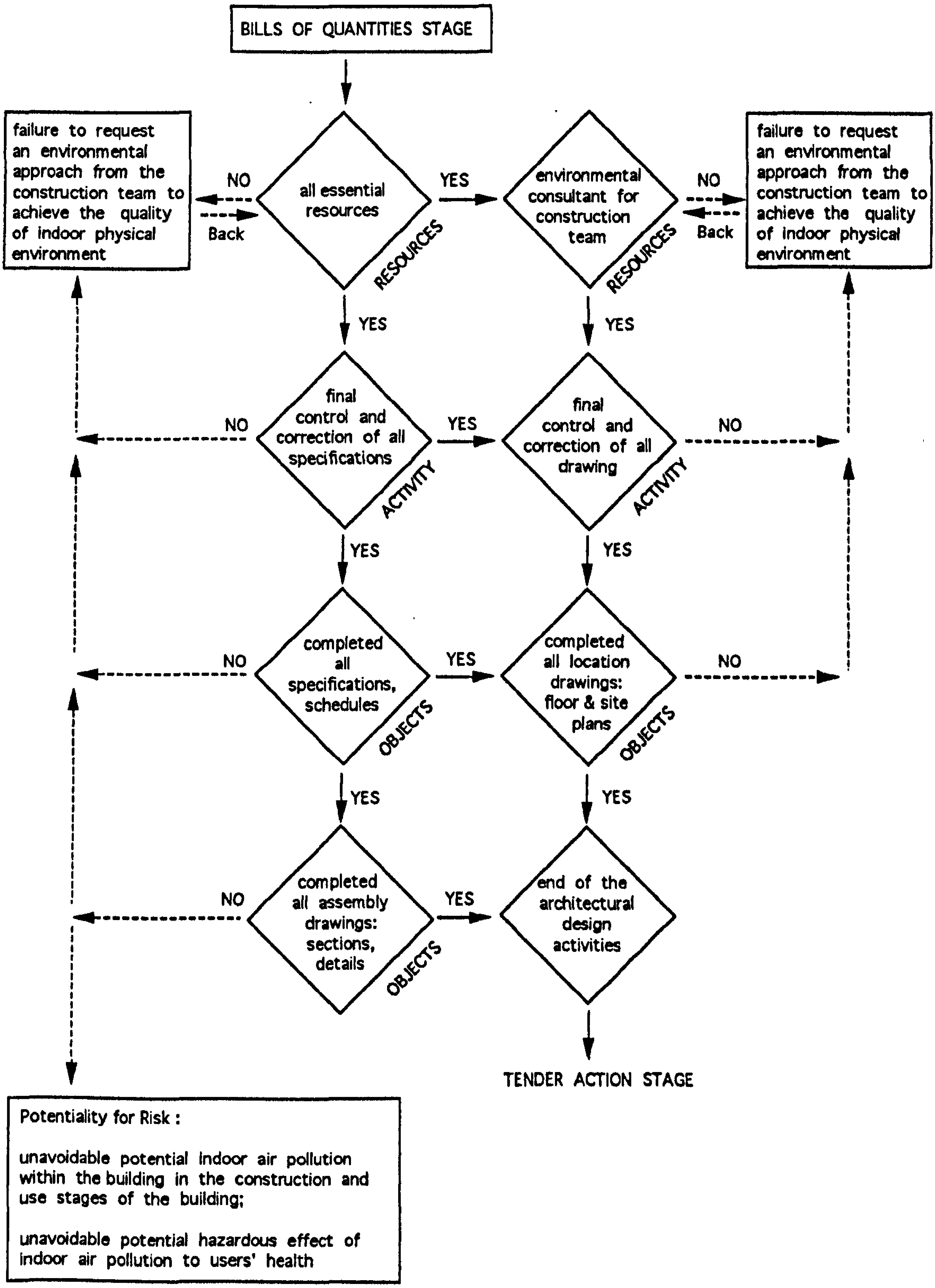


Figure 34. Control Loop of The Bills of Quantities - Working Drawings Stage of The RIBA Plan of Work

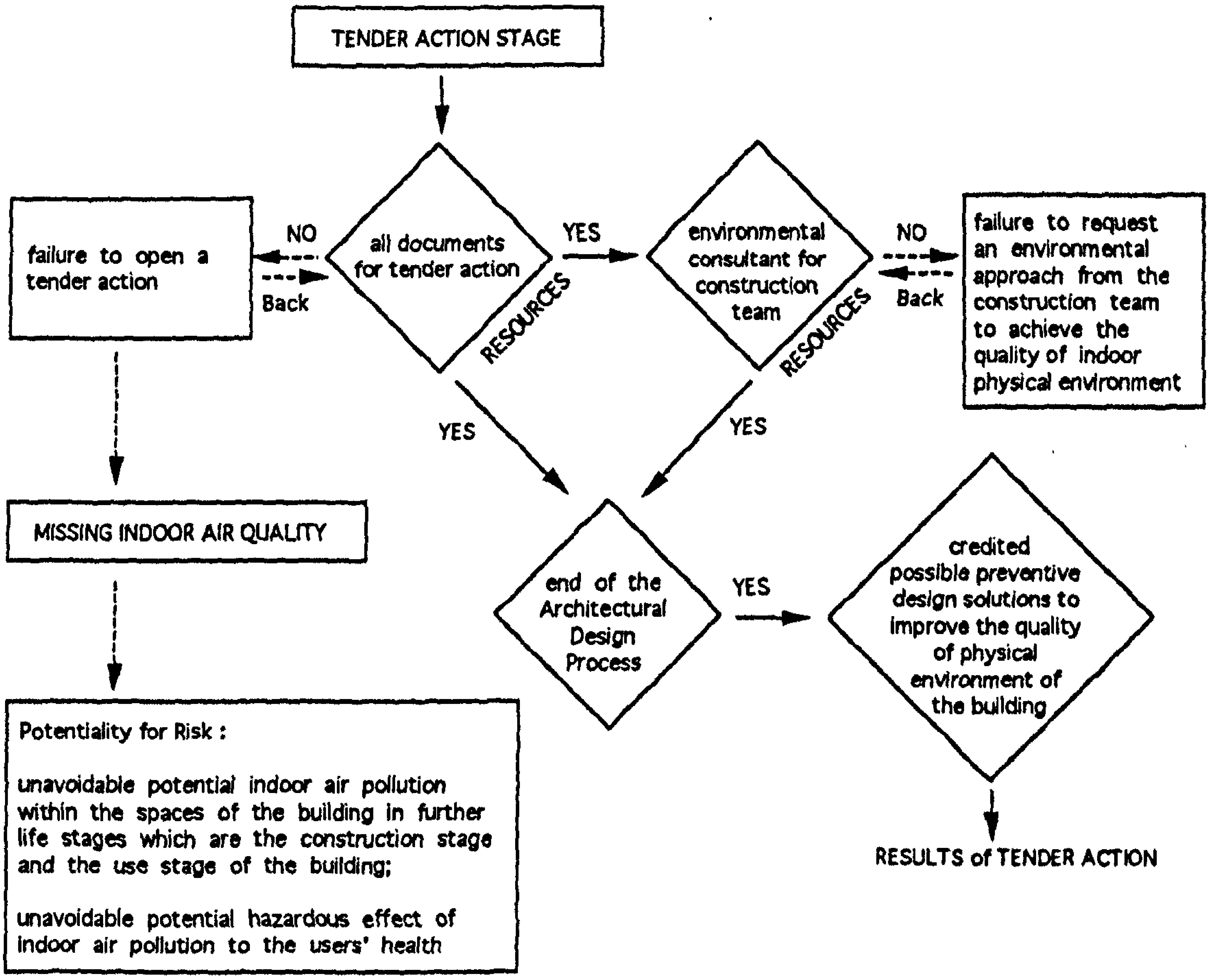


Figure 35. Control Loop of The Tender Action -
Working Drawings Stage of The RIBA Plan of Work

Part Seven : CASE STUDY : The APPLICATION of THE ARCHITECTURAL DESIGN PROCESS-INDOOR AIR QUALITY PROCESS MODEL to an EXISTING BUILDING

7.1. INTRODUCTION

The Architectural Design Process and IAQP were examined in a systematic model in the Part Five. The model shows a consideration way of IAQP and the building during the architectural design stage. It also provides an evaluation way of The Architectural Design Process in terms of IAQ (Part Six).

The consideration model of IAQP and the building can be applied on any existing building to examine it in terms of IAQ. This examination enables architects to evaluate their architectural design solutions to state their IAQ related achievements.

In this case study the proposed consideration model related to IAQ and Building System Model was applied to a selected existing building. The existing building which is selected for this case study is a new office building. Due to the requests of the architects of the building and the managers of the organisation within the building the official name of the building is not mentioned in the study. The building is named as The Existing X Building.

The Existing X Building is occupied by approximately 1700 members of staff who are doing mainly clerical work. Also, other types of work such as restaurant / kitchen, nursery, cleaning, etc. are done within the building as supplementary work.

7.2. CONSIDERATION of THE EXISTING X BUILDING and INDOOR AIR QUALITY - THE BUILDING SYSTEM MODEL

7.2.1. Objectives of The Existing X Building and IAQ

7.2.1.1. Organisational - Use Objectives of The Existing X Building and IAQ

Users' morale related use objectives of the organisation within The Existing X Building and IAQ are correlated in the Table 45 which is produced by the modification of the Table 18 according to The Building System Model.

Organisational-Use Objectives of The Existing X Building and IAQ related questionnaire was done with the coordinator of The Existing X Building. The results of the questionnaire and the statement are also shown in the Table 45.

Organisational-Use Objectives and IAQ related questionnaire is given as Questionnaire 1a Organisational / Use Objectives - Indoor Air Quality in the Appendixes.

7.2.1.2. Architectural Design Objectives of The Existing X Building and IAQ

Architectural Design Objectives of The Existing X Building and IAQ are correlated in the Table 46 which is produced by the modification of the Table 18 according to The Building System Model.

Architectural Design Objectives of The Existing X Building and IAQ related questionnaire was done with one of the architects of the design team of The Existing X Building. The results of the questionnaire and the statement are also shown in the Table 46.

Architectural Design Objectives and IAQ related questionnaire is given as Questionnaire 1b Architectural Design Objectives - Indoor Air Quality in the Appendixes.

Table 45. Correlation of Organisational-Use Objectives of both The Building System Model and The Existing X Building in terms of Indoor Air Quality

ORGANISATIONAL -USE OBJECTIVES /THE BUILDING SYSTEM MODEL	(The Case Study) ORGANISATIONAL - USE OBJECTIVES of THE EXISTING X BUILDING	CORRELATION of BOTH ORGANISATIONAL - USE OBJECTIVES in terms of INDOOR AIR QUALITY
Production *Adaptability* *Stability*	*Related to the production activities, altered and stable situation of the organisation*	
MORALE Related to the users' * confidence * optimism * happiness * hopefulness * security * well-being	Pleasant and efficient working environment ([*The Existing X Building*], *The Project Brief, The Guide To Requirements, Part 3.1*)(167)	Provision of a healthy indoor environment to meet the users' objectives related to their MORALE (confidence, optimism, happiness, hopefulness, security, well-being) Examination of the pollutant emission; indoor air pollution; hazardous effects on users *Decreasing indoor air* pollution to provide healthy condition in the building in terms of IAQ
RESULTS of THE QUESTIONNAIRE -USER/THE COORDINATOR of THE EXISTING X BUILDING		
EVALUATION of ORGANISATIONAL -USE OBJECTIVES /THE BUILDING SYSTEM MODEL	EVALUATION of ORGANISATIONAL - USE OBJECTIVES of THE EXISTING X BUILDING	EVALUATION of BOTH ORGANISATIONAL - USE OBJECTIVES in terms of INDOOR AIR QUALITY
This classification represents the general organ-isational-use objectives for any organisation.	This correlation represents the relationship between general organisational-use objectives and specific organisational-use objectives for The Existing X Building.	This correlation represents the relationship between both organisational-use objectives (The Building System - The Existing X Building) and IAQ.
THE STATEMENT		
IAQ can be accepted as an important environmental feature of a building in terms of providing a healthy indoor environment to meet the users' morale related objectives.		

Table 46. Correlation of Architectural Design Objectives of both The Building System Model and The Existing X Building in terms of Indoor Air Quality

ARCHITECTURAL DESIGN OBJECTIVES /THE BUILDING SYSTEM MODEL	(The Case Study) ARCHITECTURAL DESIGN OBJECTIVES of THE EXISTING X BUILDING	CORRELATION of BOTH ARCHITECTURAL DESIGN OBJECTIVES in terms of INDOOR AIR QUALITY
Achievement of Spatial Quality Social/Behavioural Provisions	Pleasant and efficient working environment ([*The Existing X Building*], *The Project Brief, The Guide To Requirements, Part 3.1*)(167)	Provision of a healthy indoor environment in terms of IAQ to meet the users' objectives related to their MORALE
Quality of The Physical Environment	Pleasant and efficient working environment (167) Minimise the use of air conditioning within the building; Avoidance of the use of CFC blown insulating materials; The use of the traditional materials which will contribute to the quality of the environment (167)(Parts 3.2, 3.3) Identification of the key environmental issues; Investigation of the nature and significance of these issues; Establishing areas of sensitivity in order that the development of the design may minimise any adverse environmental impact; Preparation of an Environmental Statement which will: * highlight measures incorporated into the project's design to avoid potentially significant environmental impacts, * identify and evaluate environmental impacts not mitigated by design modifications, * recommend other ameliorative options which may be appropriate (*Environmental Assessment, The Existing X Building, Part: Objectives*) (168)	Examination of the indoor / outdoor environment and hardware of the building, and their contribution to indoor air pollution Accepting IAQ as an design objective; Taking preventive actions during the architectural design stage of the building to help improvement of IAQ
Quality of The Hardware Aesthetic	High standard of design and visual appearance (168)(Part: *Design Parameters*)	
Economy and Efficiency	*Because the evaluation of the architectural design process in terms of IAQ is based on the risk factor these objectives are not examined*	

Table 46. Correlation of Architectural Design Objectives of both The Building System Model and The Existing X Building in terms of Indoor Air Quality (continued)

ARCHITECTURAL DESIGN OBJECTIVES /THE BUILDING SYSTEM MODEL	(The Case Study) ARCHITECTURAL DESIGN OBJECTIVES of THE EXISTING X BUILDING	CORRELATION of BOTH ARCHITECTURAL DESIGN OBJECTIVES in terms of INDOOR AIR QUALITY
RESULTS of THE QUESTIONNAIRE -THE ARCHITECT of THE EXISTING X BUILDING		
EVALUATION of ARCHITECTURAL DESIGN OBJECTIVES /THE BUILDING SYSTEM MODEL	EVALUATION of ARCHITECTURAL DESIGN OBJECTIVES of THE EXISTING X BUILDING	EVALUATION of BOTH ARCHITECTURAL DESIGN OBJECTIVES in terms of INDOOR AIR QUALITY
This classification represents the general architectural design objectives for any building design.	This correlation represents the relationship between general architectural design objectives and specific architectural design objectives for The Existing X Building.	This correlation represents the relationship between both architectural design objectives (The Building System - The Existing X Building) and IAQ.
THE STATEMENT		
IAQ can be accepted as an architectural design objective in terms of achieving the quality of physical environment of a building.		

7.2.2. Resources of The Existing X Building and IAQ

Resources of The Existing X Building and IAQ are correlated in the Table 47 which is produced by the modification of the Table 19.

Resources of The Existing X Building and IAQ related questionnaire was done with both the coordinator and architect of The Existing X Building. The results of the questionnaire and the statements are also shown in the Table 47.

Resources and IAQ related questionnaires are given as Questionnaire 2a and Questionnaire 2b Resources - Indoor Air Quality in the Appendixes.

Table 47. Correlation of Resources of both The Building System Model and The Existing X Building in terms of Indoor Air Quality

	RESOURCES / THE BUILDING SYSTEM MODEL	(The Case Study) RESOURCES of THE EXISTING X BUILDING	CORRELATION of BOTH RESOURCES in terms of INDOOR AIR QUALITY
PEOPLE	Organisation Design Team *Construction Team, Suppliers* Control Authorities	User Identification: Office Workers, ... Job Responsibility (168)(Appendix B): Project managers : (...) analysis and recommendation of design options Design team leaders (architects) : (...) to obtain all necessary consents to enable the works to be executed Mechanical & electrical engineers : (...) to examine, make recommendations on and design appropriate environmental controls etc. ... Consultees : East Kilbride Development Corp., (...) Strathclyde Regional Council Department of Roads, Sewage and Planning (Regional Archaeologist) (...)	Clients requirements related to IAQ in terms of providing a healthy environment for users Identification of the job responsibility of the environmental consultant in terms of IAQ Description of the job and contribution of control authorities and other related professions
INTEGRATIVE RES.	Management *Finance* *Time* *Energy* *Work Place*	Environmental Management Environmental Assessment, Proposed Office Development (167); The Project Brief The Guide to Requirements, Part 2 Section 3 Environment and Energy Conservation (170)	Identification of air polluted indoor spaces. IAQ policy IAQ management: consulting the design team.
INFORMATION RESOURCES	Regulations Science Publications *Experience* *Case Studies* *Evaluation / Feedback*	British Standards & Code of Practice The Clean Air Act BREEAM, Version 1/93 Health and Safety Executive Environmental Health Department Technical Standards, The Scottish Office, The Building Standards (Scotland) Regulations, 1990 ...	Identification of indoor air pollutants and sources Obtaining available standards, regulations and health requirements in terms of IAQ
TECHNOLOGY	Materials and Building Components *Tools and Machinery*	The use of following materials is expressly prohibited: Materials (or processes) emitting environmentally damaging gases where alternatives less damaging to the environment are readily available; Equatorial hardwoods (from a non-renewable source); High alumina cement; Additives for concrete containing calcium choloride; Asbestos or asbestos based products; ...	Available IAQ control methods during the design of the building: *design solutions, *specifications of building materials and components

Table 47. Correlation of Resources of both The Building System Model and The Existing X Building in terms of Indoor Air Quality (continued)

RESOURCES / THE BUILDING SYSTEM MODEL	(The Case Study) RESOURCES of THE EXISTING X BUILDING	CORRELATION of BOTH RESOURCES in terms of INDOOR AIR QUALITY
RESULTS of THE QUESTIONNAIRE -USER/THE COORDINATOR of THE EXISTING X BUILDING		
EVALUATION of RESOURCES /THE BUILDING SYSTEM MODEL	EVALUATION of RESOURCES of THE EXISTING X BUILDING	EVALUATION of BOTH RESOURCES in terms of INDOOR AIR QUALITY
An organisation can be accepted as one of the resources of a building.	This correlation represents the relationship between general people resources and specific organisation within The Existing X Building.	This correlation represents the relationship between both people-organisation resources (The Building System -The Existing X Building) and IAQ.
RESULTS of THE QUESTIONNAIRE -THE ARCHITECT of THE EXISTING X BUILDING		
This classification represents the general resources for any building design.	This correlation represents the relationship between general resources and specific resources for The Existing X Building.	This correlation represents the relationship between both resources (The Building System - The Existing X Building) and IAQ.
THE STATEMENTS		
IAQ related requirements of an organisation can be accepted as an important resource of a building in terms of providing a healthy indoor environment for the user. IAQ related information can be considered as an important resource for the architectural design of a building in terms of achieving the quality of physical environment of the building.		

7.2.3. Activities of The Existing X Building and IAQ

7.2.3.1. Organisational - Use Activities within The Existing X Building and IAQ

Organisational-Use Activities within the Existing X Building and IAQ are correlated in the Table 48 according to the Building System Model. The Table 48 is produced by the modification of the Table 20.

Organisational-Use Activities within The Existing X Building and IAQ related questionnaire was done with the coordinator of The Existing X Building. The results of the questionnaire and the statement are also shown in the Table 48.

Organisational-Use Activities and IAQ related questionnaire is given as Questionnaire 3a Organisational / Use Activities - Indoor Air Quality in the Appendixes.

7.2.3.2. Architectural Design Activities of The Existing X Building and IAQ

Architectural Design Activities of the Existing X Building and IAQ are correlated in the Table 49 according to the Building System Model. The Table 49 is produced by the modification of the Table 21.

Architectural Design Activities of The Existing X Building and IAQ related questionnaire was done with the architect of The Existing X Building. The results of the questionnaire and the statement are also shown in the Table 49.

Architectural Design Activities and IAQ related questionnaire is given as Questionnaire 3b Architectural Design Activities - Indoor Air Quality in the Appendixes.

Table 48. Correlation of Organisational - Use Activities of both The Building System Model and The Existing X Building in terms of Indoor Air Quality

	ORGANISATIONAL USE ACTIVITIES / THE BUILDING SYSTEM MODEL	(The Case Study) ORGANISATIONAL USE ACTIVITIES within THE EXISTING X BUILDING	CORRELATION of BOTH USE ACTIVITIES in terms of INDOOR AIR QUALITY (IAQ)	
			pollution	improvement
PROFESSION RELATED ACTIVITIES	WORK / OFFICE ACTIVITIES electrostatic copying machines: *photocopiers, *spirit duplicators, *signature machine, *blue print copiers, ... cutters: *paper, metal, wood, ... use of adhesives, solvents, ... x-ray machines, experimental work: *use of chemicals, *substances, ... use of chemical cleaning substances: *detergent, bleach, ...	Work / Office Activities clerical work, VDU work, ... Administration photocopier Publishing/Reprographics use of chemicals PABX Room equipment generates considerable heat some form of air conditioning or forced ventilation will have to be provided Equipment room computers: air conditioning Conference rooms meetings of 25 members of staff ...	ozone, respirable suspended particulates (RSP): *dust, bacteria, viruses, molds, fungi, etc, Polynuclear Aromatic Hydrocarbons (PAH) formaldehyde, toluene, benzene alcohol, ammonia, acetylene, water, ...	Organizational policy related to IAQ, seperation of work activities such as workshop activities and office activities informing and educating people, and restricting some of their activities related to IAQ such as smoking
PROFESSION RELATED ACTIVITIES / INDIVIDUAL RELATED ACTIVITIES	HOUSEHOLD ACTIVITIES & HOBBIES cooking, cleaning, use of air fresheners: *disinfectants, deodorants, ... painting, pottery, wood / metal working, insect control, smoking, pets and plants, ...	Restaurant/Club/Kitchen cooking : disposables, chemicals, waste disposal, sundries, ... Nursery / Kitchen cooking Smokers' Lounge smoking Cleaning Activities within The Building use of detergents, disinfectants, ...	RSP, formaldehyde, PAH, toluene, benzene alcohol, ammonia, acetylene, water, carbon monoxide, carbon dioxide nitrogen oxides, ...	Informing and educating people, and cautioning them about the use of some household products which cause indoor air pollution.
INDIVIDUAL RELATED ACTIVITIES	BIOLOGICAL & PHYSICAL ACTIVITIES breathing, coughing, sneezing, sweating, renewing skin, urination / excretion, ...	Toilets Showers Fitness room sweating, ... Nursery baby changing, ... Individual's biological and physical activities	RSP, PAH, water, carbon dioxide, ...	Informing and educating people to care about themselves and other people.

Table 48. Correlation of Organisational - Use Activities of both The Building System Model and The Existing X Building in terms of Indoor Air Quality (continued)

ORGANISATIONAL USE ACTIVITIES / THE BUILDING SYSTEM MODEL	(The Case Study) ORGANISATIONAL USE ACTIVITIES within THE EXISTING X BUILDING	CORRELATION of BOTH USE ACTIVITIES in terms of INDOOR AIR QUALITY (IAQ)
RESULTS of THE QUESTIONNAIRE -USER/THE COORDINATOR of THE EXISTING X BUILDING		
EVALUATION of ORGANISATIONAL USE ACTIVITIES /THE BUILDING SYSTEM MODEL	EVALUATION of ORGANISATIONAL USE ACTIVITIES of THE EXISTING X BUILDING	EVALUATION of BOTH ORGANISATIONAL USE ACTIVITIES in terms of INDOOR AIR QUALITY
This classification represents the general organisational use activities for any building design.	This correlation represents the relationship between general organisational use activities and specific organisational use activities within The Existing X Building.	This correlation represents the relationship between both organisational use activities (The Building System - The Existing X Building) and IAQ.
THE STATEMENTS		
Organisational Use Activities can be accepted as an important source of indoor air pollutants within a building. An organisation can make a policy to improve IAQ within the building in terms of providing healthy environment for the users. IAQ can be discussed with architects during Briefing Stage of any building design to provide healthy environment for future users of the building.		

Table 49. Correlation of Architectural Design Activities of both The Building System Model and The Existing X Building in terms of Indoor Air Quality

DESIGN ACTIVITIES / THE BUILDING SYSTEM MODEL	(The Case Study) ARCHITECTURAL DESIGN ACTIVITIES of THE EXISTING X BUILDING	CORRELATION of BOTH ARCHITECTURAL DESIGN ACTIVITIES in terms of INDOOR AIR QUALITY
ORGANISATIONAL DESIGN ACTIVITIES ARCHITECTURAL DESIGN ACTIVITIES: Brief, Sketch Plans, Working Drawings, *Site Operation, Building in Use, Retirement of The Building*	Brief The design must take fill cognizance of environmental issues and it is envisaged that (..), maximising natural/cross ventilation (..), using environmentally friendly materials (...) Specification / Contract Items: * Copies of commissioning results for all air handling or air conditioning equipment providing full details of measured air quantity, pressures, temperatures relative humidities etc. as appropriate. * List of principal materials used in construction (...) * A list of any hazardous materials used in construction or services. ... Sketch Plans Stage D Report, (...) design development is reflected on drawing no. (0-) A004 1.0 site layout 2.0 outline schedule of areas 3.0 internal planning relationships 4.0 space planning 5.0 fire strategy 6.0 security strategy 7.0 approvals-statutory authorities 8.0 specialist requirements 9.0 project sponsor 10.0 outline specification 11.0 drawing list Plans: location, site, floors Sections Elevations Space planning Sub-divisions	Considering previous studies about indoor air pollutants, their sources and effects of the building to indoor air quality as feedback information for the new design. Acceptance of IAQ as an important design obective; determination of environmental design strategy; producing alternative solutions for the architectural design of the building during design stage .
ENGINEERING DESIGN ACTIVITIES *MANUFACTURING DESIGN ACTIVITIES*		

Table 49. Correlation of Architectural Design Activities of both The Building System Model and The Existing X Building in terms of Indoor Air Quality (continued)

ARCHITECTURAL DESIGN ACTIVITIES / THE BUILDING SYSTEM MODEL	(The Case Study) ARCHITECTURAL DESIGN ACTIVITIES of THE EXISTING X BUILDING	CORRELATION of BOTH ARCHITECTURAL DESIGN ACTIVITIES in terms of INDOOR AIR QUALITY (IAQ)
RESULTS of THE QUESTIONNAIRE -THE ARCHITECT of THE EXISTING X BUILDING		
EVALUATION of ARCHITECTURAL DESIGN ACTIVITIES /THE BUILDING SYSTEM MODEL	EVALUATION of ARCHITECTURAL DESIGN ACTIVITIES of THE EXISTING X BUILDING	EVALUATION of BOTH ARCHITECTURAL DESIGN ACTIVITIES in terms of INDOOR AIR QUALITY
This classification represents the general architectural design activities for any building design.	This correlation represents the relationship between general architectural design activities and specific architectural design activities of The Existing X Building.	This correlation represents the relationship between both architectural design activities (The Building System - The Existing X Building) and IAQ.
THE STATEMENT		
IAQ can be considered during the Architectural Design Process of any building in terms of producing alternative design solutions to achieve the environmental quality within the building.		

7.2.4. Hardware of The Existing X Building and IAQ

7.2.4.1. Structural Elements of The Hardware and IAQ

Before considering Structural Elements of the hardware of The Existing X Building and IAQ together, the correlation of the hardware of a building and CI/SfB Building Elements Specification was examined with the architect. During this examination the Table 7 Correlation of Hardware of a Building and CI/SfB Building Elements Specification was used. The result of the examination is as follow:

> 'The classification which is shown in the Table 7 Correlation of Hardware of a Building and CI/SfB Building Elements Specification represents the general features of a hardware of any building'.

Structural Elements of the hardware of The Existing X Building and IAQ are correlated in the Table 50 according to The Building System Model. The Table 50 is produced by the modification of the Table 22.

Structural Elements of the hardware of The Existing X Building and IAQ related questionnaire was done with the architect of The Existing X Building. The results of the questionnaire and the statement are also shown in the Table 50.

Structural Elements of the hardware and IAQ related questionnaire is given as Questionnaire 4 Hardware / Structural Elements - Indoor Air Quality in the Appendixes.

Table 50. Correlation of Hardware of both The Building System Model and The Existing X Building in terms of Indoor Air Quality (Hardware/Structural Elements)

<table>
<tr><th colspan="3">HARDWARE
/THE BUILDING SYSTEM MODEL</th><th rowspan="2">(The Case Study)

THE HARDWARE of
THE EXISTING X BULDING</th><th colspan="2">CORRELATION of BOTH
HARDWARE in terms of
INDOOR AIR QUALITY (IAQ)</th></tr>
<tr><th></th><th>STRUCTURE
(Structural
Design)</th><th>PARTS &
MATERIALS</th><th>pollution</th><th>improvement</th></tr>
<tr><td rowspan="4">STRUCTURAL ELEMENTS</td><td>SUBSTRUCTURE
ground,
floor beds,
foundation,
retaining walls.</td><td>soil,
stone,
concrete,
insulation
materials,
steel, ...</td><td>Foundation: shallow reinforced concrete pad and strip footings
Concrete ground floor slabs
Reinforced concrete retaining walls</td><td>radon,
respirable
suspended
particulates
(RSP),
moisture,
water, ...</td><td rowspan="4">Careful design of details;
* details of horizontal surfaces,
* details of vertical surfaces,
* details of horizontal joints of the surfaces,
* details of vertical joints of the surfaces,
* details of corner joints of the surfaces

design of good ventilation

careful specification of building materials

correct insulation</td></tr>
<tr><td>SUPER-
STRUCTURE
external walls,
internal walls,
floors
& galleries,
stairs,
roofs,
building frames,
chimneys.</td><td>partition,
plywood,
panelling,
particle board,
fibre board,
urea-
formaldehyde
insulation,
brick,
concrete,
gypsum board,
plaster, ...</td><td>Frame: (...) predominantly structural steel work
External walls: brickwork and blockwork (BS)
Internal walls: metal studs; fireline board and plasterboard;
specific areas (...) concrete blockwork
Floors: composite profiled metal decking and cocrete slab construction
Stairs: prefabricated steel (...)
Roofs: pitched; flat
...</td><td>asbestos,
RSP (dust,
bacteria,
viruses, molds,
fungi, etc),
formaldehyde,
radon,
carbon
monoxide,
nitrogen
oxides,
water,
odour, ...</td></tr>
<tr><td>COMPLETION
windows,
doors,
suspended
ceilings,
roof lights.</td><td>window / door
frames,
timber,
metals,
mastic,
gypsum board,
plaster,
...</td><td>Windows : aluminium sections;
polyester powder coating on surfaces;
windows shall be designed to provide adequate ventilation (...)
Curtain walling : aluminium frame
external doors : glass; stainless steel
Internal doors : hardwood veneered doors; glazed vision panels, ss. steel
...</td><td>RSP,
formaldehyde,
asbestos,
radon,
odour, ...</td></tr>
<tr><td>FINISHES
wall,
floor,
ceiling,
roof,
stairs
finishings</td><td>floor
coverings;
carpet, tiles,
parquet,
linoleum
...
wall;
plaster, paint,
tiles, timber
...
ceiling;
tiles, plaster,
paint, timber,
...
glaze, varnish,
protective
coatings,
adhesive,
polyvinyl
chloride (PVC),
...</td><td>Floors: carpet tiles; vinyl tiles; beech flooring; porcelain ceramic; granite floor tiles; BAL "BAL FLEX" or similar adhesive; epoxy resin based coating; ceramic tiles; ...
An anti-dust sealant should be applied to self finished concrete floors
Plant and switch rooms: floors should receive a sealant to reduce dusting
Walls: vinyl matt emulsion coating; laminate IPS system, solid laminate panels; seramic glazed tiles; moisture resistant plasterboard; jointless (...) polyurethane finish; ...
Stairs : Terrazo or granolithic finish
Roofs:
flat roof areas: asphalt
pitched roofs: bituminus felt;
polyurethane insulating board
...</td><td>asbestos,
RSP,
formaldehyde,
toluene,
styrene,
vinyl chloride,
odour, lead,
polyurethane,
hydrocarbons,
petroleum
distillates, ...</td></tr>
</table>

Table 50. Correlation of Hardware of both The Building System Model and The Existing X Building in terms of Indoor Air Quality (Hardware/Structural Elements) . (continued)

HARDWARE /THE BUILDING SYSTEM MODEL	(The Case Study) THE HARDWARE of THE EXISTING X BULDING	CORRELATION of BOTH HARDWARE in terms of INDOOR AIR QUALITY (IAQ)
RESULTS of THE QUESTIONNAIRE -THE ARCHITECT of THE EXISTING X BUILDING		
EVALUATION of HARDWARE /THE BUILDING SYSTEM MODEL Structure (Structural Design) / Parts and Materials	EVALUATION of HARDWARE / STRUCTURAL ELEMENTS of THE EXISTING X BUILDING	EVALUATION of BOTH HARDWARE / STRUCTURAL ELEMENTS in terms of INDOOR AIR QUALITY
This classification represents the general hardware / structural elements of any building.	This correlation represents the relationship between general hardware / structural elements and specific hardware / structural elements of The Existing X Building.	This correlation represents the relationship between both hardware / structural elements (The Building System - The Existing X Building) and IAQ.
THE STATEMENT		
Hardware / Structural Elements can be considered during the Architectural Design Process of any building to produce alternative design solutions to achieve the environmental quality in terms of IAQ within the building.		

7.2.4.2. Services of The Hardware and IAQ

Services of the hardware of The Existing X Building and IAQ are correlated in the Table 51 according to The Building System Model. The Table 51 is produced by the modification of the Table 23.

Services of the hardware of The Existing X Building and IAQ related questionnaire was done with the architect of The Existing X Building. The results of the questionnaire and the statement are also shown in the Table 51.

Services of the hardware and IAQ related questionnaire is given as Questionnaire 5 Hardware / Services and Contents - Indoor Air Quality in the Appendixes.

7.2.4.3. Contents of The Hardware and IAQ

Contents of the hardware of The Existing X Building and IAQ are correlated in the Table 52 according to The Building System Model. The Table 52 is produced by the modification of the Table 23.

Contents of the hardware of The Existing X Building and IAQ related questionnaire was done with the architect of The Existing X Building. The results of the questionnaire and the statement are also shown in the Table 52.

Contents of the hardware and IAQ related questionnaire is given as Questionnaire 5 Hardware / Services and Contents - Indoor Air Quality in the Appendixes.

Table 51. Correlation of Hardware of both The Building System Model and The Existing X Building in terms of Indoor Air Quality (Hardware/Services)

HARDWARE /THE BUILDING SYSTEM MODEL			(The Case Study) THE HARDWARE of THE EXISTING X BULDING	CORRELATION of BOTH HARDWARE in terms of INDOOR AIR QUALITY (IAQ)	
	STRUCTURE	PARTS & MATERIALS		pollution	improvement
SERVICES	ENVIRONMENTAL SERVICES lighting; heating, ventilation, air-conditioning (HVAC System)	fluorescent lights; boiler, pipe, & breaching insulation, fire-proofing, stagnan waters, humidifiers, dehumudifiers, cooling towers, drip pans, air intakes, fibreglass insulation. incomplete combustion, stoves, kerosen heaters, fireplaces, ...	Lighting: (...) tubular fluorescent lamps will be used. Use of tungsten filament will be avoided. Heating The flue and chimney must be selected and designed to match the boiler required maximum combustion efficiency to provide sufficient suction or draught (...) Ventilation / air conditioning: The main determinant (...) to provide an environment suitable for the use for which it is designed whilst minimising (...) the effect on the environment. (...) openable windows with local mechanical ventilation for cooling as required. The overriding consideration in the decision will be that the most affective method of achieving control of the building environment taking the building design as an integrated package is achieved. ...	ozone, asbestos, respirable suspended particulates (RSP), formaldehyde, nitrogen oxides, carbon monoxide, carbon dioxide, methane, polynuclear aromatic hydrocarbons, moisture, water, odour, ...	Careful design of details; * details of horizontal surfaces, * details of vertical surfaces, * details of horizontal joints of the surfaces, * details of vertical joints of the surfaces, * details of corner joints of the surfaces
	SUPPLY SERVICES gas electricity hot & cold water telephone	natural gas supply; boiler, pipe, & breaching insulation, fire-proofing, ...	Gas: (...) a gas installation as required (...) fully in compliance with all regulations for safety and identification. Hot cold water: Hot / cold water systems should be designed so that there is a minimum deterioration in water quality, ensuring no risk to public health. The cold water service will be designed and installed to the requirements and recommendations of all relevant codes of practice for the prevention of legionella in domestic water services. (...) spray taps will not be employed to minimise the risk of legionella transmission. ...	RSP, asbestos, radon, methane, nitrogen oxides, carbon monoxide, moisture, water, odour, ...	design of good ventilation careful specification of building materials correct insulation
	DISPOSAL SERVICES waste removal drainage sewerage	pipe, and breaching insulation, ducts, waste containers,...	Waste disposal: Waste disposal facilities adequate for, and suited to the purpose should be provided (...). Care should be given to the location and design of waste disposal facilities (...). Disposal service: Drainage systems should comprise the minimum of pipework necessary to carry away foul water from a building quickly, quietly, free from nuisance or risk of injury to health and without escape of foul air into the building. ...	RSP, asbestos, radon, methane, moisture, water, odour, ...	

Table 51. Correlation of Hardware of both The Building System Model and The Existing X Building in terms of Indoor Air Quality (Hardware/Services) (continued)

HARDWARE /THE BUILDING SYSTEM MODEL	(The Case Study) THE HARDWARE of THE EXISTING X BULDING	CORRELATION of BOTH HARDWARE in terms of INDOOR AIR QUALITY (IAQ)
RESULTS of THE QUESTIONNAIRE -THE ARCHITECT of THE EXISTING X BUILDING		
EVALUATION of HARDWARE /THE BUILDING SYSTEM MODEL Structure (Structural Design) / Parts and Materials	EVALUATION of HARDWARE / SERVICES of THE EXISTING X BUILDING	EVALUATION of BOTH HARDWARE / SERVICES in terms of INDOOR AIR QUALITY
This classification represents the general hardware / services of any building.	This correlation represents the relationship between general hardware / services and specific hardware / services of The Existing X Building.	This correlation represents the relationship between both hardware / services (The Building System - The Existing X Building) and IAQ.
THE STATEMENT		
Hardware / Services can be considered during the Architectural Design Process of any building to produce alternative design solutions to achieve the environmental quality in terms of IAQ within the building.		

Table 52. Correlation of Hardware of both The Building System Model and The Existing X Building in terms of Indoor Air Quality (Hardware/Contents)

HARDWARE /THE BUILDING SYSTEM MODEL			(The Case Study) THE HARDWARE of THE EXISTING X BUILDING	CORRELATION of BOTH HARDWARE in terms of INDOOR AIR QUALITY (IAQ)	
	STRUCTURE	PARTS & MATERIALS		pollution	improvement
CONTENTS	FURNITURE circulation, general room, culinary, sanitary, cleaning storage loose equipments	upholstery, textile, varnish, ...	Fittings and furnishings : Kitchen layout and equipment specification, including wall and floor finishes will be the responsibility of a specialist consultant (...). Servery layout and equipment: (...) consultation with the architect. Nursery layout and equipment: (...) specialist consultant. Sanitary appliances : Wall hung wc suites, urinals, and washbasins to high quality glazed vitreous china. Taps and fittings: chrome plate, Towel dispensers, warm air & hand driers: (...) stainless steel (...) To prevent air from the drainage system entering the building, there should be a trap having an adequate water seal on each sanitary appliance and on all points of discharge into the system ...	RSP, formaldehyde, polynuclear aromatic hydrocarbons, ...	Careful design of details; * details of horizontal surfaces, * details of vertical surfaces, * details of horizontal joints of the surfaces, * details of vertical joints of the surfaces, * details of corner joints of the surfaces design of good ventilation careful specification of building materials
	FITTINGS circulation, general room, culinary, sanitary, cleaning storage fixtures	textile, varnish, shelving, decorative panelling, UV light fixtures, ...		RSP, formaldehyde, polynuclear aromatic hydrocarbons, moisture, water, ozone, ...	

RESULTS of THE QUESTIONNAIRE -THE ARCHITECT of THE EXISTING X BUILDING

EVALUATION of HARDWARE /THE BUILDING SYSTEM MODEL	EVALUATION of HARDWARE / CONTENTS of THE EXISTING X BUILDING	EVALUATION of BOTH HARDWARE / CONTENTS in terms of INDOOR AIR QUALITY
Structure (Structural Design) / Parts and Materials		
This classification represents the general hardware / contents of any building.	This correlation represents the relationship between general hardware / contents and specific hardware / contents of The Existing X Building.	This correlation represents the relationship between both hardware / contents (The Building System - The Existing X Building) and IAQ.

THE STATEMENT

Hardware / Contents can be considered during the Architectural Design Process of any building to produce alternative design solutions to achieve the environmental quality in terms of IAQ within the building.

7.2.5. Environment of The Existing X Building and IAQ

Before considering environment of The Existing X Building and IAQ together, The Environment Subsystem of The Building System was examined with the architect. In this examination the Figure 18a and Figure 18b The Concept of The Environment Subsystem of The Building System were used. In this conceptual model environments of a building are grouped as indoor environment and outdoor environment.

The statement of this examination is;
'The classification which is proposed in the thesis represents the general environments of any building.'

7.2.5.1. Indoor Environment of The Existing X Building and IAQ

A. Indoor Spatial Environment of The Existing X Building and IAQ

Indoor Spatial Environment of The Existing X Building and IAQ are correlated in the Table 53 according to The Building System Model. The Table 53 is produced by the modification of the Table 24.

Indoor Spatial Environment of The Existing X Building and IAQ related questionnaire was done with the architect of The Existing X Building. The results of the questionnaire and the statement are also shown in the Table 53.

Indoor Spatial Environment and IAQ related questionnaire is given as Questionnaire 6 Indoor Spatial Environment - Indoor Air Quality in the Appendixes.

Table 53. Correlation of Indoor Spatial Environment of both The Building System Model and The Existing X Building in terms of Indoor Air Quality

INDOOR ENVIRONMENT /THE BUILDING SYSTEM MODEL		(The Case Study) INDOOR ENVIRONMENT of THE EXISTING X BUILDING	CORRELATION of BOTH INDOOR SPATIAL ENVIRONMENTS in terms of INDOOR AIR QUALITY (IAQ)	
	FEATURES and CHARACTERISTICS		Pollution	Improvement
SPATIAL ENVIRONMENT	DIMENSIONAL FEATURES Length, width, height area, volume	<u>Principal internal dimensions</u> : The prefferred internal widths, window to window, for offices are as tabled, and should be provided on that basis: 12.00 m max. for cellular layout 14.00 m to 16.00 m optimum for mixedlayout Provide a clear height finished floor to underside of lowest point of ceiling, or beam soffit if downstand beams penetrate the ceiling, of 2.70 m min. Corridors are to be 1.80 m wide.	Indoor air pollution occurs due to; - unsufficient area and volume, - unsuitable shape and layout, - unbalanced proportion, - careless orientation, - unprotected connections between spaces, - wrong utilisation, - absence of zonal arrangement in terms of indoor air pollution	Design of efficient spaces; efficient areas and volumes,
	FORMAL FEATURES shape, layout, proportion, orientation	<u>Open plan offices</u>: The proportion should be sensible and the space regular in shape. (...) Height to depth ratios shoud be reasonable and avoid the "tunnel" effect. <u>Cellular offices</u> : (...) regular shape with proportions (...).		suitable shapes and layout, balanced proportional arrangement,
	LOCATIONAL FEATURES functional connections, physical similarities, / differences, dimensional similarities, / differences formal similarities / differences utilisation, zone	Particular attention should be paid to the location of any serviced areas within the office areas, eg. tea-points, equipment rooms etc. Access between floors (...) staircases and lifts. <u>Schedule of accommodation</u> : (Zones) *open plan / cellular offices* meeting rooms conference rooms staff restaurant associated kitchen and ancillary accommodation a nursery facility social club a fitness area postroom security accommodation storage plant rooms toilets / stairs circulation smoking lounge ...		correct orientation, protected connections between spaces, correct utilisation, arrangement of indoor air polluted indoor zones.
	FLEXIBILITY functional changes, adaptability, expansion, mobility	(...) a flexible building form is required which could either be expanded or split into smaller sections (...). (...) flexible and reusable office accommodation (...). (...) regular open plan areas capable of sub-division (...) ...		

Table 53. Correlation of Indoor Spatial Environment of both The Building System Model and The Existing X Building in terms of Indoor Air Quality (continued)

INDOOR ENVIRONMENT /THE BUILDING SYSTEM MODEL	(The Case Study) INDOOR ENVIRONMENT of THE EXISTING X BUILDING	CORRELATION of BOTH INDOOR SPATIAL ENVIRONMENTS in terms of INDOOR AIR QUALITY (IAQ)
RESULTS of THE QUESTIONNAIRE -THE ARCHITECT of THE EXISTING X BUILDING		
EVALUATION of INDOOR SPATIAL ENVIRONMENT /THE BUILDING SYSTEM MODEL	EVALUATION of INDOOR SPATIAL ENVIRONMENT of THE EXISTING X BUILDING	EVALUATION of BOTH INDOOR SPATIAL ENVIRONMENTS in terms of INDOOR AIR QUALITY
This classification represents the general indoor spatial environment of any building.	This correlation represents the relationship between general indoor spatial environment and specific indoor spatial environment of The Existing X Building.	This correlation represents the relationship between both indoor spatial environment (The Building System - The Existing X Building) and IAQ.
THE STATEMENT		
Indoor Spatial Environment can be considered during the Architectural Design Process of any building to produce alternative design solutions to achieve the environmental quality in terms of IAQ within the building.		

B. Indoor Physical Environment of The Existing X Building and IAQ

Indoor Physical Environment of The Existing X Building and IAQ are correlated in the Table 54 according to The Building System Model. The Table 54 is produced by the modification of the Table 25.

Indoor Physical Environment of The Existing X Building and IAQ related questionnaire was done with the architect of The Existing X Building. The results of the questionnaire and the statement are also shown in the Table 54.

Indoor Physical Environment and IAQ related questionnaire is given as Questionnaire 7 Indoor Physical Environment - Indoor Air Quality in the Appendixes.

C. Indoor Social / Behavioural Environment of The Existing X Building and IAQ

Indoor Social / Behavioural Environment of The Existing X Building and IAQ are correlated in the Table 55 according to The Building System Model. The Table 55 is produced by the modification of the Table 26.

Indoor Social / Behavioural Environment of The Existing X Building and IAQ related questionnaire was done with the architect of The Existing X Building. The results of the questionnaire and the statement are also shown in the Table 55.

Indoor Social / Behavioural Environment and IAQ related questionnaire is given as Questionnaire 8 Indoor Social / Behavioural Environment - Indoor Air Quality in the Appendixes.

Table 54. Correlation of Indoor Physical Environment of both The Building System Model and The Existing X Building in terms of Indoor Air Quality

INDOOR ENVIRONMENT /THE BUILDING SYSTEM MODEL		(The Case Study) INDOOR ENVIRONMENT of THE EXISTING X BUILDING	CORRELATION of BOTH INDOOR PHYSICAL ENVIRONMENTS in terms of INDOOR AIR QUALITY	
	FEATURES and CHARACTERISTICS		Pollution	Improvement
PHYSICAL ENVIRONMENT	ATMOSPHERIC FEATURES thermal features, heat, coolness, humidy, ... air quality, ventilation, electromagnetic radiation, ...	Environmental aims: (...) minimise air pollution (...) avoid legionnaires disease (...) (...) avoid the sick building syndrome Natural Ventilation (...) openable windows for people adjacent to the perimeter of the building and a mechanically or electrically controlled top hopper window at high level (...). This is incorporated to maximise the penetration of infiltrating air in summer to naturally ventilate enclosed offices from a single side and to provide high level cross ventilation in open plan offices to remove internal heat gains. Ventilation systems: (...) it is proposed to provide a mechanical ventilation system to ensure both adequate fresh air ventilation is introduced in winter (...) and sufficient ventilation air is provided in summer (...). Conference rooms: (...) consideration should be given to the provision for ventilation / air conditioning (...) Toilets / staff: mechanical ventilation should be provided in all toilets (...) Staff restaurant: (...) the following items should be taken into account and addressed: (...) ventilation ductwork (...) (...) air treatment (...) RH control: All offices, conference and meeting rooms will have a minimum relative humidity (RH) control to 30-35 % RH. Other low limits of RH for equipment will be met. ...	Moisture, moulds, fungi, bacteria due to the humidity, long term occurence of air pollution due to the poor ventilation,	Structural and environmental design of the building for balanced atmospheric features, careful specification of building materials, detailed design of the surfaces for easy cleaning.
	VISUAL FEATURES lighting, reflection, brightness, glare, colour, ...	(...) tubular fluorescent lamp (for) interior lighting; (...) Tungsten filament lamps are avoided (...)	the use of some kinds of lamps in lighting system emits indoor air pollutants,	
	AUDITORY FEATURES acoustic, sound, noise, ...	...		
	FEATURES RELATED TO THE SENSE OF TOUCH texture of the surfaces, softness / hardness of the sufaces, ...	(...) An anti-dust sealant should be applied to self finished concrete floors. ...	difficulties in cleaning due to the roughness of the surfaces, ...	

Table 54. Correlation of Indoor Physical Environment of both The Building System Model and The Existing X Building in terms of Indoor Air Quality (continued)

INDOOR ENVIRONMENT /THE BUILDING SYSTEM MODEL	(The Case Study) INDOOR ENVIRONMENT of THE EXISTING X BUILDING	CORRELATION of BOTH INDOOR PHYSICAL ENVIRONMENTS in terms of INDOOR AIR QUALITY (IAQ)
RESULTS of THE QUESTIONNAIRE -THE ARCHITECT of THE EXISTING X BUILDING		
EVALUATION of INDOOR PHYSICAL /THE BUILDING SYSTEM MODEL	EVALUATION of INDOOR PHYSICAL ENVIRONMENT of THE EXISTING X BUILDING	EVALUATION of BOTH INDOOR PHYSICAL ENVIRONMENTS in terms of INDOOR AIR QUALITY
This classification represents the general indoor physical environment of any building.	This correlation represents the relationship between general indoor physical environment and specific indoor physical environment of The Existing X Building.	This correlation represents the relationship between both indoor physical environments (The Building System - The Existing X Building) and IAQ.
THE STATEMENT		
Indoor Physical Environment can be considered during the Architectural Design Process of any building to produce alternative design solutions to achieve the environmental quality in terms of IAQ within the building.		

Table 55. Correlation of Indoor Social-Behavioural Environment of both The Building System Model and The Existing X Building in terms of Indoor Air Quality

INDOOR ENVIRONMENT /THE BUILDING SYSTEM MODEL		(The Case Study) INDOOR ENVIRONMENT of THE EXISTING X BUILDING	CORRELATION of BOTH INDOOR SOCIAL ENVIRONMENTS in terms of INDOOR AIR QUALITY	
	FEATURES and CHARACTERISTICS		Pollution	Improvement
SOCIAL / BEHAVIOURAL ENVIRONMENT	USER IDENTIFICATION Classification of; human / animal /plant / goods / substance categories; individual / group identity; sex / health / disability occupation job description / job level / time of occurance / duration, ...	1700 people, Individual and group working, Male and female staff, Disable staff, Mainly clerical work at different levels: eg. managers - typists, Staff for the restaurant / kitchen, Staff for the nursery Approximately 40 children in the nursery, Cleaning / security staff, Visitors, ... Working hours: 7.30 - 18.30 Working term: all working days in a year, ...	User as a source of indoor air pollutants;	User as a factor affected by IAQ, Identification of user's need,
	SOCIAL CHARACTERISTICS privacy, personal space, territorial behaviour, crowding, community, ...	Open plan working, Meeting rooms, Conference rooms; for 25 people Crowding: (...) on average 100 members of staff will occupy an area of approximately 100 sq. meters. Nursery: (...) up to 40 children. Staff restaurant: (...) 250 people. ...	identification of people's professional related and individual related activities	identification of function of spaces, identification of user's appropriateness in terms of IAQ
	SOCIO-CULTURAL CHARACTERISTICS customs, life styles, traditions, ...	The building should be as sociable as possible, with areas where people could meet, by chance, others from different departments. The majority of the 1700 staff should be housed in open plan areas, where again, social contact could be made.		
	PHYSICAL AND PSYCHOLOGICAL INTERACT health, safety, comfort, security, functional appropriateness, adaptation, aesthetic / delight, ...	The image desired by (... [the client]) is one of being sympathic to the surrounding area (...). (...) pleasant surroundings, (...) a pleasant working environment and surroundings for (...) employees.		

Table 55. Correlation of Indoor Social-Behavioural Environment of both The Building System Model and The Existing X Building in terms of Indoor Air Quality (continued)

INDOOR ENVIRONMENT /THE BUILDING SYSTEM MODEL	(The Case Study) INDOOR ENVIRONMENT of THE EXISTING X BUILDING	CORRELATION of BOTH INDOOR SOCIAL / BEHAVIOURAL ENVIRONMENTS in terms of INDOOR AIR QUALITY (IAQ)
RESULTS of THE QUESTIONNAIRE -THE ARCHITECT of THE EXISTING X BUILDING		
EVALUATION of INDOOR SOCIAL / BEHAVIOURAL /THE BUILDING SYSTEM MODEL	EVALUATION of INDOOR SOCIAL / BEHAVIOURAL ENVIRONMENT of THE EXISTING X BUILDING	EVALUATION of BOTH INDOOR SOCIAL / BEHAVIOURAL ENVIRONMENTS in terms of INDOOR AIR QUALITY
This classification represents the general indoor social / behavioural environment of any building.	This correlation represents the relationship between general indoor social / behavioural environment and specific indoor social / behavioural environment of The Existing X Building.	This correlation represents the relationship between both indoor social / behavioural environments (The Building System - The Existing X Building) and IAQ.
THE STATEMENT		
Indoor Social / Behavioural Environment can be considered during the Architectural Design Process of any building to produce alternative design solutions to achieve the environmental quality in terms of IAQ within the building.		

7.2.5.2. Outdoor Environment of The Existing X Building and IAQ

Outdoor Environment of The Existing X Building and IAQ are correlated in the Table 56 which is produced by the modification of the Table 27.

Outdoor Environment of The Existing X Building and IAQ related questionnaire was done with the architect of The Existing X Building. The results of the questionnaire and the statement are also in the Table 56.

Outdoor Environment and IAQ related questionnaire is given as Questionnaire 9 Outdoor Environment - Indoor Air Quality in the Appendixes.

Table 56. Correlation of Outdoor Environment of both The Building System Model and The Existing X Building in terms of Indoor Air Quality

OUTDOOR ENVIRONMENT /THE BUILDING SYSTEM MODEL		(The Case Study) OUTDOOR ENVIRONMENT of THE EXISTING X BUILDING	CORRELATION of BOTH OUTDOOR ENVIRONMENT in terms of INDOOR AIR QUALITY	
	FEATURES and CHARACTERISTICS		Pollution	Improvement
OUTDOOR SPATIAL FEATURES	SIZE OF THE SITE USABLE AREA LOCATION ACCESS NEIGBOURHOOD Region, place, surroundings, directions, ... distance from and function of other buildings, ...	South: the A726 (Queensway) West: Northern Distributor Road (Stewardfieldway) North and East: (...) well wooded valley sides of the (...) and a wooded tributary valley to the south east. Further east: industrial area (...) ...	Air pollution due to function of other buildings such as factories, workshops, incinerators, ... carbon monoxide, carbon dioxide, nitrogen oxides, ...	Arrangement of location of the building, examination of neighbourhood, decisions of alternative design solutions for the spatial features
TOPOGRAPHIC FEATURES	GEOGRAPHY SEISMIC AREA GROUND WATER SOIL CHARACTERISTICS Hilly area, valley, ... movements of the earth's crust, ... rock, gravel, sand, clay, silt, peat, ...	(...) Water (...) already substantially polluted (...). (...) There will be no significant residual negative impacts on surface or groundwaters. Potential problems associated with fill material include leachates polluting ground and surface water, and the production of methane gas from organic waste decomposition. Environmental aims: (...) avoid radon contamination. ...	Respirable suspended particulates (RSP) (dust, mould, bacteria, viruse, ...), moisture, radon, water, ...	Detailed feasibility studies of topographic features, decisions of suitable alternative structures for the building
OUTDOOR PHYSICAL FEATURES	ATMOSPHERIC FEATURES FLORA / FAUNA ECOLOGICAL FEATURES Air, temperature, humidity, sun, wind, rain, snow, ... plants, animals, people, environment, ...	The wooded escarpment of the (...) and the smaller tributary valley (...), (...) local nature conservation, (...) pleasant surroundings, No fauna were observed on site, which is unlikely to harbour many species. The adjacent woodland was observed to contain an abundant woodland bird population. ...	Exposure to the air pollutans due to the wind direction, ... RSP (dust, pollen, bacteria, ...) ...	Decisions of suitable alternative spatial and structural design for the building
OUTDOOR SERVICES	WATER GAS TELEPHONE ELECTRICITY SEWERAGE WASTE REMOVAL TRASPORT Water supply, natural gas supply, pipe, ducts, waste containers, ... vehicles, railway, aircraft, ...	Water: (...) the incoming water main is to be routed across site to enter the building to rise to the tank room and to serve any immediate drinking water demands. A cold water down service will distribute water from the tank to the riser position to serve all sanitary fittings. Gas: The installation will be in full compliance with current safety and gas industry regulations. Sewerage : The (...) Water is the receiving water for any discharges off-site (...) Traffic : Air Quality: (...) the incremental effect of the traffic from the developmentwill be virtually imperceptible (...). (Air pollution) increases will be extremely small, (...) levels will remain with appropriate air quality criteria. ...	Radon, water, moisture, RSP (dust, mould, bacteria, viruse, ...) methan, carbon dioxide, nitrogen oxides, styrene, ...	Decisions of suitable alternative spatial and structural design for the building

Table 56. Correlation of Outdoor Environment of both The Building System Model and The Existing X Building in terms of Indoor Air Quality (continued)

OUTDOOR ENVIRONMENT /THE BUILDING SYSTEM MODEL	(The Case Study) OUTDOOR ENVIRONMENT of THE EXISTING X BUILDING	CORRELATION of BOTH OUTDOOR ENVIRONMENTS in terms of INDOOR AIR QUALITY (IAQ)
RESULTS of THE QUESTIONNAIRE -THE ARCHITECT of THE EXISTING X BUILDING		
EVALUATION of OUTDOOR ENVIRONMENT /THE BUILDING SYSTEM MODEL	EVALUATION of OUTDOOR ENVIRONMENT of THE EXISTING X BUILDING	EVALUATION of BOTH OUTDOOR ENVIRONMENTS in terms of INDOOR AIR QUALITY
This classification represents the general outdoor environment of any building.	This correlation represents the relationship between general outdoor environment and specific outdoor environment of The Existing X Building.	This correlation represents the relationship between both outdoor environments (The Building System - The Existing X Building) and IAQ.
THE STATEMENT		
Outdoor Environment can be considered during the Architectural Design Process of any building to produce alternative design solutions to achieve the environmental quality in terms of IAQ within the building.		

7.3. LIFE STAGES of THE EXISTING X BUILDING and INDOOR AIR QUALITY

Life stages of a building and IAQ, as a process (IAQP), are considered with The RIBA Plan of Work in the thesis. Also, the design team of The Existing X Building followed The RIBA Plan of Work during the design and the completion of the building. Therefore, the Table 28 was used to consider the life stages of The Existing X Building and IAQ. This consideration, results of the questionnaire and the statements are shown in the Table 57.

The life stages of the Existing X Building and IAQ related questionnaire was done with the architect of the building, and is given as Questionnaire 10 Life stages of The Building and Indoor Air Quality in the Appendixes.

Table 57. Correlation of The Life Stages of both The Building System Model and The Existing X Building and Indoor Air Quality based on The RIBA Plan of Work

THE RIBA PLAN of WORK	(The Case Study) THE LIFE STAGES of THE BUILDING /The Building System Model and The Existing X Building	CONSIDERATION of BOTH THE LIFE STAGES of THE BUILDING and THE RIBA PLAN of WORK in terms of INDOOR AIR QUALITY
RESULTS of THE QUESTIONNAIRE -THE ARCHITECT of THE EXISTING X BUILDING		
EVALUATION of THE RIBA PLAN of WORK	EVALUATION of THE LIFE STAGES of THE BUILDING /The Building System Model and The Existing X Building	EVALUATION of BOTH THE LIFE STAGES of THE BUILDING and THE RIBA PLAN of WORK in terms of INDOOR AIR QUALITY
This plan of work represents the general working plan for any building design.	This correlation represents the relationship between life stages of any and specific Existing X Building and any accepted plan of work related to the building design, construction and occupation.	This consideration represents the relationship between life stages of any and specific Existing X Building (The Building System - The Existing X Building) and IAQ.
THE STATEMENTS		
IAQ can be conceptually thought during the conceptual existence stage "Inception Stage" of a building to develop the ideas in further design stages in terms of providing healthy environment within the building . IAQ can be considered during the theoretical existence stage of a building "Brief, Sketch Plans and Working Drawing Stages" in terms of achieving architectural design solutions to provide healthy environment within the building.		

7.4. THE ARCHITECTURAL DESIGN PROCESS of THE EXISTING X BUILDING based on THE RIBA PLAN OF WORK and INDOOR AIR QUALITY

During the consideration of The Architectural Design Process of The Existing X Building and IAQ, the tables below were examined with the architect of the building.

Briefing - Inception : Table 29,
Briefing - Feasibility : Table 30
Sketch Plans - Outline Proposals : Table 31,

Sketch Plans - Scheme Design : Table 32,
Working Drawings - Detail Design : Table 33,
Working Drawings - Production Information : Table 34,
Working Drawings - Bills of Quantities : Table 35,
Working Drawings - Tender Action :Table 36,

Results of The Architectural Design Process of The Existing X Building and IAQ related questionnaire and the statements are given in the Table 58. Also, The Architectural Design Process of The Existing X Building and IAQ related questionnaire is given as Questionnaire 11 The Architectural Design Process of The Building and Indoor Air Quality in the Appendixes.

In the consideration model of The Building System, IAQ and The Architectural Design Process, it is suggested that the determination of indoor air polluted zones according to users' activities within spaces and required ventilation rates for those of spaces will be helpful for the architect to produce design solutions in terms of IAQ. From this, spaces within The Existing X Building were classified as indoor air polluted zones according to the schedule of design criteria for The Existing X Building. Also, researcher's visual observation and the sense of smell were used to classified those of spaces in terms of odour and smoke pollution.

Suggested grades for those of spaces within The Existing X Building are indicated as A: high, B: medium, C: low level of indoor air polluted zones, and determined according to the required fresh air allowances which are adopted from the schedule of design criteria for The Existing X Building and present conditions which were observed by the researcher.

Suggested indoor air polluted zones within The Existing X Building, the result of the questionnaire which was done with the architect and the statement are shown in the Table 59.

Indoor air polluted zones within The Existing X Building related questions were placed in Questionnaire 11 The Architectural Design Process of The Building - Indoor Air Quality.

Table 58. Evaluation of The Architectural Design Process of both The Building System Model and The Existing X Building and Indoor Air Quality based on The RIBA Plan of Work

THE RIBA PLAN of WORK	(The Case Study) THE ARCHITECTURAL DESIGN PROCESS of THE BUILDING /The Building System Model and The Existing X Building	CONSIDERATION of BOTH THE ARCHITECTURAL DESIGN PROCESS of THE BUILDING and THE RIBA PLAN of WORK in terms of INDOOR AIR QUALITY
RESULTS of THE QUESTIONNAIRE -THE ARCHITECT of THE EXISTING X BUILDING		
EVALUATION of THE RIBA PLAN of WORK	EVALUATION of THE ARCHITECTURAL DESIGN PROCESS of THE BUILDING /The Building System Model and The Existing X Building	EVALUATION of BOTH THE ARCHITECTURAL DESIGN PROCESS of THE BUILDING and THE RIBA PLAN of WORK in terms of INDOOR AIR QUALITY
This plan of work represents the general architectural design process for any building design.	This correlation represents the relationship between The Architectural Design Process of any and the Existing X Building and any accepted plan of work related to the building design, construction and occupation.	This consideration represents the relationship between The Architectural Design Process of any and the Existing X Building (The Building System - The Existing X Building) and IAQ.
THE STATEMENTS		

IAQ can be conceptually thought during the Inception Stage of The Architectural Design Process of a building. In this conceptual decision-making,

* environmental approach,
* environmental-functional design strategy, and
* user requirement study in terms of IAQ

can be determined by the design team / architects/, and

* IAQ can be accepted as a design objective.

Those of conceptual decisions can visually appear as sketch drawings;

* functional analysis of spaces,
* initial design ideas,
* indoor air polluted zones, and
* user activity pattern,
* functional zones,
* group of indoor air pollution sources.

During the Feasibility, Outline Proposals Stages of The Architectural Design Process alternative design solutions can be produced and developed; during the Scheme Design, Detail Design and Production Information Stages of The Architectural Design Process most suitable design solution can be selected, developed and detailed in terms of IAQ.

This proposed consideration way of The Building System, IAQ and The Architectural Design Process can lead architects to take IAQ into account during the The Architectural Design Process in terms of achieving the physical quality within the building.

Table 59. Determination of Indoor Air Polluted Zones within The Existing X Building

SPACES within THE EXISTING X BUILDING	FRESH AIR ALLOWANCE Lit./Sec./Person	INDOOR AIR POLLUTED ZONE	RESEARCHER'S OBSERVATION (Present Condition)
Open Plan Office	16	B	No noticeable odour and smoke.
Cellular Plan Office	16	B	No noticeable odour and smoke.
Conference / meeting Room	20	A	No noticeable odour and smoke.
Toilets	8 Ach^{-1} (vent	C	No noticeable odour and smoke.
Reception	20	A	No noticeable odour and smoke.
Restaurant / Club	20	A	Areas close to the kitchen: noticeable smell of food
Kitchen	20 Ach^{-1} (vent	A	Noticeable smell of food
Fitness Room	24	A	No noticeable odour and smoke.
Storage Area	no indication	(C)	No noticeable odour and smoke.
Computer Equipment Room	no indication	(C)	No noticeable odour and smoke.
Loading Bay, Waste	no indication	(C)	No noticeable odour and smoke.
Recreation Facilities	24	A	No noticeable odour and smoke.
(Publishing / Reprographics)	no indication	(A)	Noticeable smell of chemicals.
(Smoking Lounge)	no indication	(A)	Noticeable smell and smoke of tobacco.
(Nursery / Changing Room)	no indication	(C)	No noticeable odour and smoke.
...			

RESULT of THE QUESTIONNAIRE -THE ARCHITECT of THE EXISTING X BUILDING

This kind of classification can be helpful for architects to achieve design solutions to provide healthy indoor environment in terms of IAQ for users of the building.

THE STATEMENT

Architects can determine possible indoor air polluted spaces within a building during The Architectural Design Processs of the building.

A - High Level; B - Medium Level; C - Low Level
Grades which are given in brackets are suggested according to the present conditions; other grades are suggested according to the schedule of design criteria for The Existing X Building.

7.5. FEEDBACK CHAIN of THE ARCHITECTURAL DESIGN PROCESS of THE BUILDING in terms of INDOOR AIR QUALITY / THE BUILDING SYSTEM MODEL

IAQ related feedback chain of The Architectural Design Process of The Building System Model was examined with the architect of The Existing X Building. In this examination the Figure 26 IAQ Related Feedback Chain of The Architectural Design Process based on The RIBA Plan of Work was used.

The result of the examination and the statement are shown in the Table 60.

7.6. RISK ASSESSMENT / RISK MANAGEMENT in THE ARCHITECTURAL DESIGN PROCESS of THE BUILDING in terms of INDOOR AIR QUALITY / THE BUILDING SYSTEM MODEL

IAQ related Risk Assessment / Risk Management in The Architectural Design Process of a building was examined with the architect of The Existing X Building. In this examination the Figure 27 Consideration of Risk Assessment / Risk Management and The Architectural Design Process based on The RIBA Plan of Work was used.

The result of the examination and the statement are shown in the Table 61.

Feedback chain and Risk Assessment / Risk Management related questionnaire is given as Questionnaire 12 Feedback Chain and Risk Assessment / Risk Management of The Architectural Design Process - Indoor Air Quality in the Appendixes.

Table 60. Evaluation of The IAQ Related Feedback Chain of The Architectural Design Process

(The Case Study) EVALUATION of THE IAQ RELATED FEEDBACK CHAIN of THE ARCHITECTURAL DESIGN PROCESS based on THE RIBA PLAN of WORK /THE BUILDING SYSTEM MODEL
RESULT of THE EXAMINATION -THE ARCHITECT of THE EXISTING X BUILDING
This feedback chain represents the conceptual thinking process of IAQ and The Architectural Design Process of any building.
THE STATEMENT
Preparation of an IAQ related feedback chain at the begining of The Architectural Design Process of a building can be helpful for architects to see the possible further stages and to receive the necessary information from the previous stage in terms of achieving the quality of the physical environment within the building.

Table 61. Evaluation of The Risk Assessment / Risk Management Model in The Architectural Design Process

(The Case Study) EVALUATION of THE RISK ASSESSMENT / RISK MANAGEMENT MODEL in THE ARCHITECTURAL DESIGN PROCESS in terms of INDOOR AIR QUALITY /THE BUILDING SYSTEM MODEL
RESULTS of THE QUESTIONNAIRE -THE ARCHITECT of THE EXISTING X BUILDING
This Risk Assessment / Risk Management model represents the conceptual risk sequence of IAQ in The Architectural Design Process of a building.
THE STATEMENTS
Preparation of a risk sequence chain in terms of IAQ within the Risk Assessment / Risk Management model during The Architectural Design Process of a building can be helpful for architects, * to determine the risky conditions and stages within the design process, and * to address the responsibilty of the design team, client, construction team authorities, manufacturers and other professions related to the building and IAQ.

7.7. EVALUATION of THE ARCHITECTURAL DESIGN PROCESS of THE BUILDING based on THE RIBA PLAN of WORK in terms of INDOOR AIR QUALITY / THE BUILDING SYSTEM MODEL

The proposed evaluation method of The Architectural Design Process in terms of IAQ is based on the credit system (Part Six. Evaluation of The Architectural Design Process based on The RIBA Plan of Work in terms of IAQ). Also, according to this credit system set of IAQ related instructions are arranged as control loops. It is suggested that architects can control their design approaches in terms of IAQ in every stage of The Architectural Design Process by using these control loops.

This evaluation method was examined with the architect of The Existing X Building which is subject to this case study. In this examination Figures 28 to 35 Control Loops of The Architectural Design Process were used. During the examination, it is explained to the architect that each "YES" line in these control loops represents the awarded credit which is the base for the evaluation method.

Results of the examination of the control loops and the statements are shown in the Table 62.

The evaluation method of The Architectural Design Process in terms of IAQ related questionnaire is given as Questionnaire 13 Evaluation of The Architectural Design Process - Indoor Air Quality in the Appendixes.

Table 62. Evaluation of The Architectural Design Process based on The RIBA Plan of Work in Terms of Indoor Air Quality / The Building System Model

(The Case Study)

EVALUATION of THE ARCHITECTURAL DESIGN PROCESS
in terms of INDOOR AIR QUALITY / THE BUILDING SYSTEM MODEL

INCEPTION STAGE: RESULT of THE EXAMINATION -THE ARCHITECT of THE EXISTING X BUILDING

This control loop conceptually represents IAQ related design activities during the Inception Stage of The Architectural Design Process of any building.

THE STATEMENT

Consideration of IAQ can prevent the possible failure to determine the design strategy, and potentiality for risk in design solutions in terms of achieving the quality of indoor physical environment.

FEASIBILITY STAGE: RESULT of THE EXAMINATION

This control loop conceptually represents IAQ related design activities during the Feasibility Stage of The Architectural Design Process of any building.

THE STATEMENT

Consideration of IAQ can prevent the possible failure during the development of initial design solutions in terms of achieving the quality of indoor physical environment, and potentiality for risk in design solutions in further stages of The Architectural Design Process.

OUTLINE PROPOSALS STAGE: RESULT of THE EXAMINATION

This control loop conceptually represents IAQ related design activities during the Outline Proposals Stage of The Architectural Design Process of any building.

THE STATEMENT

Consideration of IAQ can prevent the possible failure to develop locational design solutions in terms of achieving the quality of indoor physical environment, and potentiality for risk in design solutions in further stages of The Architectural Design Process.

SCHEME DESIGN STAGE: RESULT of THE EXAMINATION

This control loop conceptually represents IAQ related design activities during the Scheme Design Stage of The Architectural Design Process of any building.

THE STATEMENT

Consideration of IAQ can prevent the possible failure to develop locational design solutions in terms of achieving the quality of indoor physical environment, and potentiality for risk in structural and detail design solutions in further stages of The Architectural Design Process.

Table 62. Evaluation of The Architectural Design Process based on The RIBA Plan of Work in Terms of Indoor Air Quality / The Building System Model (continued)

(The Case Study)

EVALUATION of THE ARCHITECTURAL DESIGN PROCESS
in terms of INDOOR AIR QUALITY / THE BUILDING SYSTEM MODEL

DETAIL DESIGN STAGE:RESULT of THE EXAMINATION-THE ARCHITECT of THE EXISTING X BUILDING

This control loop conceptually represents IAQ related design activities during the Detail Design Stage of The Architectural Design Process of any building.

THE STATEMENT

Consideration of IAQ can prevent the possible failure to develop structural and detail design solutions in terms of achieving the quality of indoor physical environment, and potentiality for risk in IAQ due to structural and detail design solutions in further stages of The Architectural Design Process.

PRODUCTION INFORMATION STAGERESULT of THE EXAMINATION

This control loop conceptually represents IAQ related design activities during the Production Information Stage of The Architectural Design Process of any building.

THE STATEMENT

Consideration of IAQ can prevent the possible failure in requesting environmental approach from the construction team in terms of achieving the quality of indoor physical environment, and potentiality for risk in IAQ due to arhitectural design of the building in further life stages of the building.

BILLS of QUANTITIES: RESULT of THE EXAMINATION

This control loop conceptually represents IAQ related design activities during the Bills of Quantities Stage of The Architectural Design Process of any building.

THE STATEMENT

Consideration of IAQ can prevent the possible failure in requesting environmental approach from the construction team in terms of achieving the quality of indoor physical environment, and potentialaty for risk in IAQ due to arhitectural design of the building in further life stages of the building.

TENDER ACTION STAGE:RESULT of THE EXAMINATION

This control loop conceptually represents IAQ related design activities during the Tender Action Stage of The Architectural Design Process of any building.

THE STATEMENT

Consideration of IAQ can prevent the possible failure in requesting environmental approach from the construction team in terms of achieving the quality of indoor physical environment, and potentiality for risk in IAQ due to arhitectural design of the building in further life stages of the building.

CREDIT SYSTEM: RESULT of THE EXAMINATION

Each "YES" line in these control loops represents the awarded credit to evaluate the design achievements in terms of IAQ and the provision of quality of physical environment within the building.

THE STATEMENT

Architects can evaluate their own architectural design achievements in terms of IAQ during The Architectural Design Process by using the credit system.

Part Eight :CONCLUSIONS and RECOMMENDATIONS

8.1. CONCLUSIONS

8.1.1. The Building System

The existence of the building is dependent on necessary features which are the objectives, resources, activities, hardware and environment. These features are structured by many interrelated parts which actively take their place within certain periods of the whole life of the building.

There are three main periods in the whole life of the building which are the design period, construction period and use period. The existence stages of the building within these periods are the conceptual existence which is the required building; the theoretical existence which is the designed building; the physical existence which is the constructed building; the stage that people move in and use the building which is the occupied building; and the retirement stage which is the unoccupied or demolished building.

The sequence of the events and the role of the features systematically occur within the building. Therefore, all the features and life stages and periods of the building make the Building a System. From this, those features, which are the objectives, resources, activities, hardware and environment, become the subsystems of the building system.

The modelling the Building System is essential to see the connections of the subsystems and their details. The building system is conceptually modelled in Part 2.3.3. The Building as a System, and the subsystems are detailed in their processes, subprocesses and programmes and procedures levels within the whole model.

This detailed conceptual model of the building system provides some convenience to the participants who are involved in producing and using the building as follows:

(a) The model itself enables the participants to place their work and research within the whole concept.

(b) The participants can apply the most accepted work flows and specifications, which are related to their professions, to the related subsystems of the model, likewise The RIBA Plan of Work and The CI/SfB Specifications are placed as subprocesses of the Architectural Design Process within the Building System Model.

8.1.2. Architectural Design Process

The RIBA Plan of Work is accepted as the base of the Architectural Design Process. The Architectural Design Process has four elements which are objectives, resources, hardware and environment of the building.

Consideration of the elements of the Architectural Design Process and the RIBA Plan of Work gives eight feedback points. Two of the feedback points are already indicated in The RIBA Plan of Work. These points are placed at the end of the D. Scheme Design and E. Detail Design stages. Other points are placed at the end of each stage of The RIBA Plan of Work

The feedback points are shown in Figure 19. Indication of the feedback points provides a systematic control mechanism to the design team. The design team can check the design approaches at the end of each stage before moving to the next stage.

8.1.3. Indoor Air Quality Process / IAQP

Indoor Air Quality (IAQ) is identified as a process(IAQP) in Part 4. It is examined in detail which shows the subprocesses of IAQP. The subprocesses are Indoor Air Pollution Process (IAPP) and Indoor Air Quality Improvement Process (IAQIP). Accepting IAQ as a process will make professionals to think about IAQ systematically due to its systematic structure.

Elements and stages of IAQP are considered in Figure 23 and Table 17. Researchers who study IAQ can develop this consideration and can place their study within the whole IAQP.

8.1.4.The Architectural Design Process and The Indoor Air Quality Process

The elements of the Building System and the elements of IAQP can be examined together. This examination determines the relationships between the building and IAQ.

The IAQ improvement objectives of IAQP match the architectural design objectives related to the quality of the physical environment. This gives the first conclusion that IAQ is an important design objective which must be considered during the Architectural Design Process.

The resources of IAQP provide informative, restrictive, integrative,scientific and technological information to the resources of the building system. Therefore, during the consideration of the resources of the Architectural Design Process, the resources of IAQP should be taken into account. This consideration necessitates an environmental consultant being involved in the architectural design of the building.

First consideration of IAQ improvement activities can be done during the Architectural Design Process which is based on The RIBA Plan of Work. This consideration leads the design team to produce their own design solutions related to IAQ.

Structural elements, services and contents of the hardware of the building affect IAQ by their detail design and the material and components specification. Also, the features of indoor and outdoor environments of the building help indoor air pollution to occur and flow within the building from one space to other. The hardware and environment related features should be examined in detail in terms of IAQ during the detail design of the features and the materials and components specifications.

The life of IAQP is determined by the life of the building. The conceptual existence of the building leads to the conceptual thinking of IAQP. This is the first appearance of IAQP in people's mind. The theoretical existence of the building is determined by the design of the building. This stage is also the theoretical existence of IAQP. The physical existence (construction) of the building means the physical realisation of IAQP. During the occupation of the building, activities of IAQP occur in reality. The retirement period of the building is the ineffective period of IAQP.

The Architectural Design Process, IAQP and The RIBA Plan of Work can be considered together. In Part 5.4. this consideration has been done in detail. The tables show interconnections of the three important aspects within the life of the building to each other. Also, eight feedback points within the Architectural Design Process have been defined in terms of IAQ. The design team can check their approaches and design solutions in terms of IAQ according to the feedback points.

Although The Architectural Design Process is based on The RIBA Plan of Work in the consideration model, it is indicated that the model itself allows the researcher to place another accepted plan of work instead of The RIBA Plan of Work.

If IAQP is considered during the Architectural Design Process of the building, preventive design solutions can be produced to reduce the effects of an indoor air pollution event before it occurs.

8.1.5. Evaluation of The Architectural Design Process based on The RIBA Plan of Work in terms of Indoor Air Quality

The Architectural Design Process based on The RIBA Plan of Work can be evaluated in terms of IAQ. A credit system can be used during the evaluation. Design objectives, design strategies, locational design solutions, building materials and components specifications, and structural and detail design solutions are considered within the design stages in detail.

Also, a set of IAQ achievement control loops can be arranged for checking whether IAQ is considered during the each stage of the Architectural Design Process.

From these approaches, which are credit systems and control loops, the stages of the Architectural Design Process can be define in terms of IAQ as follows:

A INCEPTION - Briefing Stage of The RIBA Plan of Work
This is the stage to determine IAQ as a base for setting design objectives and strategies.

Lack of consideration of IAQ during this stage will cause failure in determining the design objectives and the design strategies to improve the quality of the physical environment of the spaces. Also, it will cause difficulties in making decisions to produce design solutions in terms of IAQ in next the stage.

B. FEASIBILITY - Briefing Stage of The RIBA Plan of Work
The Feasibility Stage is the consideration stage of the social / behavioural characteristics of the building and outdoor features of the site area in terms of IAQ, and obtaining information about the building materials as to whether they release any harmful indoor air pollutants

Lack of consideration of these tasks will cause a failure to prepare initial design solutions during this stage. Also it will make it almost impossible to develop design solutions in further stages to improve the quality of the physical environment.

C. OUTLINE PROPOSALS - Sketch Plans Stage of The RIBA Plan of Work
During this stage all IAQ related restrictive resources are obtained. Preparation of building material specifications and consideration of all indoor / outdoor spatial features are done in terms of IAQ to produce locational design solutions.

Lack of consideration of IAQ related resources, specifications, and features during the Outline Proposals Stage will cause failure to develop alternative locational design solutions to improve the quality of the physical environment of the spaces. Besides it will make it impossible to select and develop a design solution in terms of IAQ in following stage.

D. SCHEME DESIGN - Sketch Plans Stage of The RIBA Plan of Work
This is the stage to select and develop the most suitable design solution in terms of IAQ. By the end of this stage all locational drawings of the selected design solution are completed. The assembly drawings, structural sections and details, are developed.

Lack of consideration of IAQ related tasks during the Scheme Design Stage will cause failure to develop locational design solutions to improve the quality of the physical environment of the spaces in terms of IAQ. Also, lack of consideration of all structural elements, services and contents of the building will make it impossible to develop structural and detail design solutions from IAQ point of view.

E. DETAIL DESIGN - Working Drawings Stage of The RIBA Plan of Work
The Detail Design Stage is the completion stage of the assembly drawings. It is too late to change any design decision during this stage. Structural elements, services, and contents of the building are considered, and structural sections and details are completed according to the location drawings.

Lack of consideration of structural elements, services, and contents of the building in terms of IAQ will cause failure during the development of the assembly drawings. Therefore, to achieve the quality of the physical environment of the building in terms of IAQ by developing structural and detail design solutions becomes impossible

F. PRODUCTION INFORMATION - Working Drawings Stage of The RIBA Plan of Work
During the Production Information Stage, all control and corrections of the drawings, specification and schedules are done in terms of IAQ.

Lack of consideration of IAQ during this stage will cause failure to request an environmental approach from the potential construction team to improve the quality of the physical environment of the spaces during the construction stage of the building. Also, lack of consideration of IAQ until this stage will cause unavoidable potential indoor air pollution within the spaces in further life stages of the building, and will cause unavoidable potential hazardous effects of indoor air pollution on users' health.

G. BILLS of QUANTITIES - Working Drawings Stage
of The RIBA Plan of Work

The architectural design activities end during this stage. The only design activity is the final correction of all documents.

Lack of consideration of IAQ during this stage, and until this stage, will cause the same results as for the Production Information Stage.

H. TENDER ACTION - Working Drawings Stage
of The RIBA Plan of Work

There is no activity related to the design of the building. All activities are organisational and related to the preparation of the Tender Action.

Failure to complete the documents will cause failure to open a tender action. Also, lack of consideration of IAQ during this stage, and until this stage will cause the same results as for the Production Information Stage.

8.1.6. The Case Study

8.1.6.1. Discussion on Statements

The Building System Model allows researchers to place any subject related to the building in it. During the placement of a subject, it should be considered according to objectives, resources, activities, hardware and environment of the building.

IAQ was placed within The Building System Model in the thesis. The case study shows that the placement of IAQ in the model gives the systematic thinking way of IAQ, the building and The Architectural Design Process together.

IAQ as an OBJECTIVE

IAQ should be accepted as an important environmental feature of a building by users, and as an architectural design objective by architects of the building in terms of achieving the environmental quality and providing a healthy indoor environment for the users. Therefore, IAQ is the target of both users and architects of the building.

IAQ as a RESOURCE

IAQ related people, integrative, information and technological resources are important for architects to direct their architectural design process. IAQ requirements of an organisation within the building are the starting point, and IAQ related information should be considered to produce better design solutions in terms of a healthy indoor environment during The Architectural Design Process.

IAQ as an ACTIVITY

Organisational Use Activities within the building are important sources for the indoor air pollution. Therefore, the organisation should make a policy to improve IAQ within the building, and IAQ should be discussed with architects at the beginning of the design stage.

Architects should place IAQ related improvement activities in their design activities. This placement can be done at conceptual level during the first stage (Inception) of The Architectural Design Process. Consideration of previous studies and obtaining information related to IAQ, determination of an environmental design strategy and acceptance of IAQ as a design objective are the activities which should take place in this stage.

In further stages (Feasibility, Outline Proposals, Scheme Design, Detail Design and Production Information), design activities are done in detail. During the production and development of alternative design solutions, ideas related to the improvement of IAQ should be reflected on the design solutions. Then, most suitable design solution in terms of achieving IAQ within the building can be selected and detailed.

IAQ - HARDWARE

Hardware (structural elements, services and contents) of the building has strong effect on IAQ. Design, parts and materials of hardware are main sources of indoor air pollution. Therefore, hardware should be considered during The Architectural Design Process in terms of producing alternative structural design solutions to improve IAQ within the building.

IAQ as a feature of The Indoor ENVIRONMENT

IAQ is one of the main features of the indoor environment of the building. It is bordered by the spatial environment, identified by the physical environment and affected by the social / behavioural environment of the building. It is also affected by the outdoor environment of the building. Therefore, the consideration of indoor environment (spatial, physical and social / behavioural) and outdoor environment (spatial, topographic, physical and services) during The Architectural Design Process will be helpful for architects to achieve the environmental quality within the building in terms of IAQ.

THE LIFE of IAQ

The life of IAQ starts with the conceptual existence of the building. Whenever people require a building, IAQ conceptually exists. It takes a shape during the design stage, comes into real existence during the construction stage and acts during the occupancy stage of the building. The life of IAQ ends with the demolition of the building. If the importance of IAQ is missed during any stage of this life sequence, the quality of physical environment within the building cannot reach the required level.

Architects deal with the building from the beginning of its life. Therefore, they should take IAQ into account from the first stage to the last stage of The Architectural Design Process and produce better design solutions in terms of providing a healthy environment for future users of the building.

IAQ in THE ARCHITECTURAL DESIGN PROCESS

All the above statements lead architects to consider IAQ during The

Architectural Design Process. IAQ should be an important factor in decision making, and IAQ related solutions should be reflected on architectural design of the building.

IAQ - FEEDBACK and RISK ASSESSMENT / RISK MANAGEMENT
While the programme of the working plan of The Architectural Design Process is organised, feedback points at the end of each stage can be determined, and a feedback chain can be prepared in terms of IAQ. This feedback chain will be helpful for architects to receive essential data from the previous stage, to organise the present stage, and to prepare the necessary information for further stage. Then the possibility of missing a point can be reduced.

Because it affects directly people's health, IAQ should be taken as a risky factor. Missing its importance can cause hazardous effects from headache to death of a person. Therefore, IAQ should be covered by Risk Assessment / Risk Management work. This kind of work will show where and when a risky condition can appear, and who will be responsible for it.

IAQ - EVALUATION of THE ARCHITECTURAL DESIGN PROCESS
Each positive activity in terms of improving IAQ during The Architectural Design Process can be credited. This credit system will be helpful for architects to evaluate their own design. The evaluation of the design of the building means the evaluation of The Architectural Design Process whether it is proceeded in productive way or wasted in chaotic way. It also helps architects to identify the problematic points. If the failure in design in terms of IAQ is caused by their approach, they can determine a new strategy. If it is because of the lack of information which is provided by other professions related to the building and IAQ, they can require the essential work from those of professions.

8.1.6.2. Discussion on Questionnaires

The structure of the questions in questionnaires were based on to identify

* if the proposed model represents the relationships between The

Building System Model and IAQ in general, and The Existing X Building and IAQ in specific,

* if it leads architects to think about IAQ and their own building which is designed by them, and

* if it can be helpful to evaluate a building in terms of IAQ.

The results of the questionnaire show that these aspects were achieved in the proposed model. However, opinion of the architect about the research is also valuable. During the examination of the model, these following issues were indicated by the architect and researcher.

* The architect and researcher agreed that the proposed model is the conceptual thinking way of IAQ and the building together during The Architectural Design Process.
* The architect indicated that the model is informative and leads the architect to consider IAQ during the design stage.
* However, the architect required more specific check list which shows all "do's and don'ts" in terms of architectural design solutions and IAQ.
* The researcher's explanation for this was preparations of these kinds of check lists are the future studies to be done, which are recommended in the thesis.
* It was also indicated by the researcher that preparations of these kinds of check lists are partly the job of the environmental consultant whose involvement in the design of the building is recommended in the thesis.

8.1.7. Summary

Architecture is a kind of invention. It is bringing a building into existence that has never been made and used before. Buildings may look like each other but each of them is different to the others. This invention is made by an architect.

Although being an architect requires talent, it also necessitates a good education so that students can learn to synthesise separated things. Typical building design solutions are not taught to the students, or students do not memorise hundreds of detail designs during their architectural education. Awareness of people's need, relating different things such as natural features of earth, manufactured products, people's activities, etc. to each other, and to think about all those of aspects are taught. Thus a building can be imagined as if it physically exists, and as if it is occupied by users.

Systematic thinking of the problems, combining them in a systematic model, searching for the possible solutions and selecting the most suitable solution to meet the problem are the main tasks that are given to the students. Because every thing changes with time, architectural education is never completed. After graduating from university, architects learn many things during their professional work period. Their ability to think about the problems helps them to produce solutions for the problems.

Although, IAQ has been discussed for almost thirty years, it is a new subject for architects from the architectural design point of view. Most of the time, the subject is defined as an engineering problem. However anything related to the building should be recognised by architects, as well, so that they can try to find alternative solutions.

Examining the Architectural Design Process and IAQP together in the whole building system enables the architect to think about indoor air quality systematically, and to search design solutions to prevent or reduce possible indoor air pollution before it occurs.

The building system model allows the building related professions to place their research within the whole system. Examining the Architectural Design Process according to The RIBA Plan of Work provides systematic movement step by step within the whole process. Thinking of IAQ as a process makes the architect consider IAQ from its conceptual existence to its actual occurrence.

To think of indoor air pollution before it occurs necessitates that IAQ should be thought before the physical existence of the building. This means whenever the building conceptually occurs in people's mind, consideration of IAQ should be started. The consideration of IAQ can be done by following The RIBA Plan of Work. This consideration enables the architect to connect the IAQ to the Architectural Design Process.

The achievements to improve the quality of the indoor physical environment of the building in terms of IAQ can be evaluated. This evaluation is also a criticism of the Architectural Design Process. The architect can control and evaluate the architectural design solutions in terms of IAQ by using a credit system. Each feedback point gives the architect a chance to see the achievements, to search if IAQ has been missed during the whole stage and to define what kind of potentiality for risk occurs.

This thesis shows how IAQ can be considered during the architectural design stage and how the architectural design stage can be examined in terms of IAQ. It does not give any architectural design for any building because the researcher thinks that architecture is an invention and that every architect can produce better design solutions as long as they can approach the problem systematically.

8.2. RECOMMENDATIONS

In this research, IAQ is adapted as a process and considered with the Architectural Design Process based on The RIBA Plan of Work. Because this thesis provides only a way of thinking about IAQ and the Architectural Design Process together, it is limited from many points of view.

The subjects, the building system, the architectural design process, and IAQ, are examined in their general structure. Almost all those architectural design and IAQ related aspects are covered in conceptual models. Although the detailed considerations such as all relationships between location of the building on the site area and IAQ; relationships between suspended ceilings and IAQ, relationships between socio-cultural characteristics of people and IAQ, etc. were not done, the content of the thesis contains enough information to make the relationships between IAQP and the Architectural Design Process possible to understand.

However, the subject should not be kept at this level. Further studies will provide more information to architects. Each feature of the whole building systém and IAQ should be examined in detail. The following steps are recommended to produce more accurate design solutions in terms of IAQ.

* Because IAQ is directly related to people's health, the subject should be placed in the architectural education programme.

IAQ is an important feature of the physical indoor environment of the building. It should be placed in a building science study programme which covers the physical environmental aspects of the building and the effects of those aspects on people's health.

Although a building is not a living thing in reality, it is alive as long as it is occupied and used by people. Besides, its indoor air has biological and psychological effects on people's health, e.g. allergy, lung cancer, stress. Therefore, IAQ can be placed in a building science study that can be called 'Building Biology', and covers the physical environmental aspects of the building and the effects of those of aspects on people's health.

* Because buildings exist in reality as results of the professional architectural work, architects should deal with IAQ.

Architects should approach the subject systematically. They can follow the way of thinking , which is examined in this thesis, of IAQP and the Architectural Design Process together. Then they can concentrate on more specific subjects that can be placed in the Building System Model.

As architects design artificial environments, if some architects have qualifications as environmental consultants, they can help the design team to produce more accurate design solutions in terms of IAQ.

* Indoor Air Pollution occurs due to the services of the building as well. Therefore architects and engineers should be in continuous communication.

Both the architects and the engineers can place their IAQ related research subjects within the Building System Model, and consider them in relation to each other by following The RIBA Plan of Work.

* Building materials and components have a strong influence on IAQ. Due to this, specifications should show all chemical characteristics of building materials and components.

Architects should request manufacturers to give efficient information about their products. Manufacturers should test their products as to whether they have adverse health effect or not, before they put them in the market. Scientists should work on the effects of the materials. Authorities should keep the use of the materials under control.

* IAQ is affected by users' activities and functional changes within the building. Therefore, architects should be more involved in the management of buildings during the use stage.

Architects as designers of buildings know the nature of hardware and environments of the building more than the other people who are involved in the design, construction and use of it. They design the buildings for certain purposes. However, most of the time the buildings are changed either in big scale or small scale by users due to their requirements. During these changes architects should advise the users whether the changes will affect environmental quality of the building or not.

* Because IAQ was not examined for a long time from the architectural design point of view, lack of information makes the subject difficult for architects to produce design solutions.

The IAQP model enables the researchers to classify their IAQ related study as to whether they are objectives, resources, activities or objects of IAQP.

This classification will provide systematic information for the others. So that scientists, engineers, architects, manufacturers and other professions can have shared communication in terms of IAQ.

* As a first step of examining IAQ from the architectural design point of view, this study shows the conceptual approach to the subject. However, specific check lists are helpful for architects to see the critical situation in design. Therefore objectives, resources, activities, hardware and environments of the building system and IAQ should be considered in detail. Also, feedback points and credit system in the proposed evaluation model of The Architectural Design Process in terms of IAQ should be developed.

* IAQ is not a local issue. Architects from different countries should deal the subject and be in communication.

Although the proposed model is based on The RIBA Plan of Work, it is possible to adapt the model to another accepted plan of work. The adaptation of the model to different plan of work will make the subject widely known by architects who do not follow The RIBA Plan of Work during their design activities.

* It is essential to reach information on time for architects to control the situations and make the preventive decisions in terms of reducing the risk of indoor air pollution. Computers are main tools to store, rearrange and retrieve information.Therefore, IAQ related studies should be placed in a computer programme.

The logic of prosed consideration and evaluation model of IAQP and The Architectural Design Process has a similarity to the logic of computer programming. Especially the control loops of the evaluation model are developed according to the basic principles of computer programming. This characteristic of the model shows that it is possible to place the proposed model in a computer programme. Computerising IAQ studies will provide very useful database, and will enable architects to reach the essential information on time, and control the design decisions.

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APPENDICES

QUESTIONNAIRES

QUESTIONNAIRE 1 a

ORGANISATIONAL / USE OBJECTIVES - INDOOR AIR QUALITY

USER / THE COORDINATOR of THE EXISTING X BUILDING

(Please examine the Table 45 Correlation of Organisational - Use Objectives /The Building System Model and Organisational - Use Objectives of The Existing X Building in terms of Indoor Air Quality [IAQ])

1. In The Building System Model Organisational - Use Objectives were grouped as:

- Objectives related to the productive activities, altered and stable situation of the organisation: * Production * Adaptability * Stability

- Objectives related to the users;

* Morale

(confidence, optimism, happiness, hopefulness, security, well-being)

Does this classification represent the general Organisational - Use Objectives for any organisation? <u>YES</u> NO

2. Your users' morale related Organisational - Use Objectives for The Existing X Building were grouped and correlated with general Organisational - Use objectives in the Table 45.

Does this correlation represent the relationship between the general Organisational - Use Objectives and your specific Organisational - Use Objectives for The Existing X Building? <u>YES</u> NO

3. Both Organisational - Use Objectives (The Building System Model - The Existing X Building) were correlated in terms of Indoor Air Quality (IAQ) in the Table 45.

Does this correlation represent the relationship between both Organisational - Use Objectives (The Building System Model - The Existing X Building) and IAQ? <u>YES</u> NO

4. **Can IAQ be accepted as an important environmental feature of a building in terms of providing a healthy indoor environment to meet the users' morale related objectives?** <u>YES</u> NO

(If any of the answers is "NO", please explain the reason:

)

QUESTIONNAIRE 1 b

ARCHITECTURAL DESIGN OBJECTIVES - INDOOR AIR QUALITY

DESIGNER / THE ARCHITECT of THE EXISTING X BUILDING

(Please examine the Table 46 Correlation of Architectural Design Objectives / The Building System Model and Architectural Design Objectives of The Existing X Building in terms of Indoor Air Quality [IAQ])

1. In The Building System Model Architectural Design Objectives were grouped as:

* Achievement of Spatial Quality (dimensional, formal and locational features and flexibility)
* Social/Behavioural Provisions (user identification, social and socio-cultural characteristics, physical and psychological interact)
* Quality of The Physical Environment (atmospheric, visual and auditory features, and features related to the sense of touch)
* Quality of Hardware (structural elements, services and contents)
* Aesthetic
* Economy and Efficiency

Does this classification represent the general Architectural Design Objectives for any building design? YES NO

2. Your environmental quality related Architectural Design Objectives for The Existing X Building were grouped and correlated with the general Architectural Design Objectives in the Table 46.

Does this correlation represent the relationship between the general Architectural Design Objectives and your specific Architectural Design Objectives for The Existing X Building? YES NO

3. Both Architectural Design Objectives (The Building System Model - The Existing X Building) were correlated in terms of Indoor Air Quality (IAQ) in the Table 46.

Does this correlation represent the relationship between both Architectural Design Objectives (The Building System Model - The Existing Building) and IAQ? YES NO

4. **Can IAQ be accepted as a design objective in terms of achieving the quality of physical environment of a building?** YES NO

(If any of the answers is "NO", please explain the reason:

)

QUESTIONNAIRE 2 a

RESOURCES of THE BUILDING - INDOOR AIR QUALITY

USER / THE COORDINATOR of THE EXISTING X BUILDING

(Please examine the Table 47 Correlation of Resources / The Building System Model - Resources of The Existing X Building in Terms of Indoor Air Quality [IAQ].)

1. Organisation was described as one of the resources related to people who are involved in production of a building in The Building System Model (Table 47). (Organisation represents both groups and individuals)

Can an organisation be accepted as one of the resources of a building?

YES NO

2. Both People Resources (The Building System Model - The Existing X Building) were correlated in terms of IAQ in the Table 47.

Does this correlation represent the relationship between both People Resources (The Building System Model - The Existing X Building) and IAQ?

YES NO

3. **Can IAQ related requirements of an organisation be accepted as an important resource of a building in terms of providing a healthy indoor environment for the user?**

YES NO

(If any of the answers is "NO", please explain the reason:

)

QUESTIONNAIRE 2b

RESOURCES of THE BUILDING - INDOOR AIR QUALITY

DESIGNER / THE ARCHITECT of THE EXISTING X BUILDING

(Please examine the Table 47 Correlation of Resources / The Building System Model - Resources of The Existing X Building in terms of Indoor Air Quality [IAQ].)

1. In The Building System Model, Resources of a building were grouped as:

* People (organisation, design team, construction team, suppliers and authorities. Organisation represents both groups and individuals)
* Integrative Resources (management, finance, time, energy, work place)
* Information Resources (regulations, science, publications, experience, case studies, evaluation / feedback)
* Technology (materials and building components, tools and machinery)

Does this classification represent the general Resources for any building? <u>YES</u> NO

2. Your environmental quality related resources for The Existing X Building were grouped and correlated with the general Resources in the Table 47.

Does this correlation represent the relationship between the general Resources and your specific Resources for The Existing X Building?

<u>YES</u> NO

3. Both Resources (The Building System Model - The Existing X Building) were correlated in terms of Indoor Air Quality (IAQ) in the Table 47.

Does this correlation represent the relationship between both Resources (The Building System Model - The Existing X Building) and IAQ?

<u>YES</u> NO

4. **Can IAQ related information be considered as an important resource in terms of achieving the quality of physical environment of a building?**

<u>YES</u> NO

(If any of the answers is "NO", please explain the reason:

)

QUESTIONNAIRE 3 a

ORGANISATIONAL / USE ACTIVITIES - INDOOR AIR QUALITY

USER / THE COORDINATOR of THE EXISTING X BUILDING

(Please examine the Table 48. Correlation of Organisational / Use Activities - The Building System Model - Organisational / Use Activities within The Existing X Building in terms of Indoor Air Quality [IAQ].)

1 .In The Building System Model, Organisational / Use activities were described as

* Profession Related Activities (work/office activities, household activities and hobbies)
* Individual Related Activities (household activities and hobbies, biological and physical activities)

Does this classification represent the general Organisational / Use Activities for any organisation? YES NO

2 . Your Organisational / Use Activities within The Existing X Building were grouped and correlated with the general Organisational / Use Activities in the Table 48.

Does this correlation represent the relationship between the general Organisational / Use Activities and your specific Organisational Use Activities within The Existing X Building? YES NO

3 . Both Organisational / Use Activities (The Building System Model - Existing X Building) were correlated in terms of IAQ in the Table 48.

Does this correlation represent the relationship between both Organisational Use Activities (The Building System Model - The Existing X Building) and IAQ? YES NO

4 . **Can Organisational / Use Activities be accepted as an important indoor air pollutant source within a building?** YES NO

5. **Can an organisation make a policy to improve IAQ within the building in terms of providing healthy environment for the users?**

YES NO

6. **Can IAQ be discussed with the designers / architects/ during the Briefing Stage of any building design to provide healthy environment for future users of the building?** YES NO

(If any of the answers is "NO", please explain the reason:

)

QUESTIONNAIRE 3b

ARCHITECTURAL DESIGN ACTIVITIES - INDOOR AIR QUALITY

DESIGNER / THE ARCHITECT of THE EXISTING X BUILDING

(Please examine the Table 49. Correlation of Architectural Design Activities / The Building System Model and Architectural Design Activities within The Existing X Building in terms of Indoor Air Quality [IAQ].)

1 .In The Building System Model, Architectural Design Activities were based on The RIBA Plan of Work?

Does this classification represent the general Architectural Design Activities for any building design? <u>YES</u> NO

2. Your Architectural Design Activities for The Existing X Building were correlated with The RIBA Plan of Work in the Table 49.

Does this correlation represent the relationship between The RIBA Plan of Work and your specific Architectural Design Activities for The Existing X Building? <u>YES</u> NO

3 . Both Architectural Design Activities (The Building System Model - The Existing X Building) were correlated in terms of IAQ in the Table 49.

Does this correlation represent the relationship between both Architectural Design Activities (The Building System Model - The Existing X Building) and IAQ? <u>YES</u> NO

4 . Can IAQ be considered during the Architectural Design Process of any building in terms of producing alternative design solutions to achieve the environmental quality within the building?

<u>YES</u> NO

(If any of the answers is "NO", please explain the reason:

)

QUESTIONNAIRE 4

HARDWARE / STRUCTURAL ELEMENTS - INDOOR AIR QUALITY

DESIGNER / THE ARCHITECT of THE EXISTING X BUILDING

(Please examine the Table 7 Correlation of Hardware of a Building and CI/SfB Building Elements Specification)

1 .In The Building System Model, Hardware of a building were grouped as

- * Structural Elements (substructure, superstructure, completion and finishes)
- * Services (environmental, supply and disposal services)
- * Contents (furniture and fittings)

(Based on CI/SfB Building Elements Specification)

Does this classification represent the general features of a hardware of any building? YES NO

(Please examine the Table 50 Correlation of Hardware / Structural Elements / The Building System Model and Hardware of The Existing X Building in terms of Indoor Air Quality [IAQ].)

2. Structural Elements of The Existing X Building were correlated with Hardware/ Structural Elements / The Building System Model in the Table 50.

Does this correlation represent the relationship between the general Hardware /Structural Elements / The Building System Model and specific Structural Elements of The Existing X Building?

YES NO

3. Both Structural Elements (The Building System Model - Inland Revenue Building) were correlated in terms of IAQ in the Table 50.

Does this correlation represent the relationship between both Structural Elements (The Building System Model - The Existing X Building) and IAQ? YES NO

4. Can Structural Elements be considered during the Architectural Design Process of any building to produce alternative design solutions to achieve the environmental quality in terms of IAQ within the building?

YES NO

(If any of the answers is "NO", please explain the reason:

)

QUESTIONNAIRE 5

HARDWARE / SERVICES AND CONTENTS - INDOOR AIR QUALITY

DESIGNER / THE ARCHITECT of THE EXISTING X BUILDING

(Please examine the Table 51 Correlation of Hardware / Services and the Table 52 Correlation of Hardware / Contents / The Building System Model and Hardware /Services and Contents of The Existing X Building in terms of Indoor Air Quality [IAQ].)

1. Services and Contents of The Existing X Building were correlated with Hardware / Services and Contents / The Building System Model in the Table 51 and Table 52 .

Do these correlations represent the relationship between the general Services and Contents / The Building System Model and specific Services and Contents of The Existing X Building? YES NO

2. Both Services and Contents (The Building System Model - The Existing X Building) were correlated in terms of IAQ in the Table 51 and Table 52.

Do these correlation represent the relationship between both Services and Contents (The Building System Model - The Existing X Building) and IAQ? YES NO

3. Can Services and Contents be considered during the Architectural Design Process of any building to produce alternative design solutions to achieve the environmental quality in terms of IAQ within the building?

YES NO

(If any of the answers is "NO", please explain the reason:

)

QUESTIONNAIRE 6

INDOOR SPATIAL ENVIRONMENT - INDOOR AIR QUALITY

DESIGNER / THE ARCHITECT of THE EXISTING X BUILDING

1 .In The Building System Model, Environments of a building were grouped as
* Indoor Environment
(spatial environment: dimensional, formal and locational features and flexibility; physical environment: atmospheric, visual, auditory and sense of touch related features; social/behavioural environment:user identification, social and socio-cultural characteristics and physical and psychological interact)
* Outdoor Environment
(outdoor spatial, topographic, physical features and services)

Does this classification represent general environments of any building?
YES NO

(Please examine the Table 53 Correlation of Indoor Spatial Environment / The Building System Model and Indoor Spatial Environment of The Existing X Building in terms of Indoor Air Quality [IAQ].)

2. Features of Indoor Spatial Environment of The Existing X Building were correlated with Features of Indoor Spatial Environment / The Building System Model in the Table 53.

Does this correlation represent the relationship between the general Indoor Spatial Environment / The Building System Model and specific Indoor Spatial Environment of The Existing X Building?
YES NO

3. Both Indoor Spatial Environments (The Building System Model - The Existing X Building) were correlated in terms of IAQ in the Table 53.

Does this correlation represent the relationship between both Indoor Spatial Environments (The Building System Model - The Existing Building) and IAQ? YES NO

4. Can Indoor Spatial Environment be considered during the Architectural Design Process of any building to produce alternative design solutions to achieve the environmental quality in terms of IAQ within the building? YES NO

(If any of the answers is "NO", please explain the reason:

)

QUESTIONNAIRE 7

INDOOR PHYSICAL ENVIRONMENT - INDOOR AIR QUALITY

DESIGNER / THE ARCHITECT of THE EXISTING X BUILDING

(Please examine the Table 54 Correlation of Indoor Physical Environment / The Building System Model and Indoor Physical Environment of The Existing X Building in terms of Indoor Air Quality [IAQ].)

1. Features of Indoor Physical Environment of The Existing X Building were correlated with Features of Indoor Physical Environment / The Building System Model in the Table 54.

Does this correlation represent the relationship between the general Indoor Physical Environment / The Building System Model and specific Indoor Physical Environment of The Existing X Building?

YES NO

2. Both Indoor Physical Environments (The Building System Model - The Existing X Building) were correlated in terms of IAQ in the Table 54.

Does this correlation represent the relationship between both Indoor Physical Environments (The Building System Model - The Existing X Building) and IAQ? YES NO

3. Can Indoor Physical Environment be considered during the Architectural Design Process of any building to produce alternative design solutions to achieve the environmental quality in terms of IAQ within the building?

YES NO

(If any of the answers is "NO", please explain the reason:

)

QUESTIONNAIRE 8

INDOOR SOCIAL / BEHAVIOURAL ENVIRONMENT -

INDOOR AIR QUALITY

DESIGNER / THE ARCHITECT of THE EXISTING X BUILDING

(Please examine the Table 55 Correlation of Indoor Social Environment / The Building System Model and Indoor Social Environment of The Existing X Building in terms of Indoor Air Quality [IAQ].)

1. Features of Indoor Social / Behavioural Environment of The Existing X Building were correlated with Features of Indoor Social / Behavioural Environment / The Building System Model in the Table 55.

Does this correlation represent the relationship between the general Indoor Social / Behavioural Environment / The Building System Model and specific Indoor Social Environment of The Existing X Building?

YES NO

2. Both Indoor Social / Behavioural Environments (The Building System Model - The Existing X Building) were correlated in terms of IAQ in the Table 55.

Does this correlation represent the relationship between both Indoor Social / Behavioural Environments (The Building System Model - The Existing X Building) and IAQ? YES NO

3. **Can Indoor Social / Behavioural Environment be considered during the Architectural Design Process of any building to produce alternative design solutions to achieve the environmental quality in terms of IAQ within the building?**

YES NO

(If any of the answers is "NO", please explain the reason:

)

QUESTIONNAIRE 9

OUTDOOR ENVIRONMENT - INDOOR AIR QUALITY

DESIGNER / THE ARCHITECT of THE EXISTING X BUILDING

(Please examine the Table 56 Correlation of Outdoor Environment / The Building System Model and Outdoor Environment of The Existing X Building in terms of Indoor Air Quality [IAQ].)

1. Features of Outdoor Environment of The Existing X Building were correlated with Features of Outdoor Environment / The Building System Model in the Table 56.

Does this correlation represent the relationship between the general Outdoor Environment / The Building System Model and specific Outdoor Environment of The Existing X Building?

YES NO

2. Both Outdoor Environments (The Building System Model - The Existing X Building) were correlated in terms of IAQ in the Table 56.

Does this correlation represent the relationship between both Outdoor Environments (The Building System Model - The Existing X Building) and IAQ?

YES NO

3. Can Outdoor Environment be considered during the Architectural Design Process of any building to produce alternative design solutions to achieve the environmental quality in terms of IAQ within the building?

YES NO

(If any of the answers is "NO", please explain the reason:

)

QUESTIONNAIRE 1 0

LIFE STAGES of THE BUILDING - INDOOR AIR QUALITY

DESIGNER / THE ARCHITECT of THE EXISTING X BUILDING

(Please examine the Table 28 Correlation of The Life Stages of The Building / The Building System Model - The Existing X Building based on The RIBA Plan of Work and Indoor Air Quality [IAQ].)

1. The life stages of a building and The RIBA Plan of Work / The Building System Model were correlated in the Table 28.

Does this correlation represent the relationships between life stages of any building and any accepted plan of work related to the design, construction and occupation of the building?

YES NO

2. IAQ was also considered with the life stages of a building and The RIBA Plan of Work / The Building System Mode in the Table 28.

Does this consideration represent the relationships between the life of a building and the specific Existing X Building (The Building System Model - The Existing X Building) and IAQ?

YES NO

3. **Can IAQ be conceptually thought during the conceptual existence stage (Inception stage of The Architectural Design Process) of any building to produce initial design ideas to achieve the environmental quality within the building?**

YES NO

4. **Can IAQ be considered during the theoretical existence stage (Feasibility, Outline Proposals, Scheme Design, Detail Design, Production Information, Bills of Quantities, Tender Action stages of The Architectural Design Process) of any building to achieve design solutions in terms of providing a healthy environment within the building?**

YES NO

(If any of the answers is "NO", please explain the reason:

)

QUESTIONNAIRE 11

THE ARCHITECTURAL DESIGN PROCESS of THE BUILDING - INDOOR AIR QUALITY

DESIGNER / THE ARCHITECT of THE EXISTING X BUILDING

(Please examine the Tables 29, 30, 31, 32, 33, 346, 35 and 36 Consideration of IAQ, The Architectural Design Process and The RIBA Plan of Work (The Building System Model - The Existing X Building.)

1. IAQ, The Architectural Design Process and The RIBA Plan of Work (Briefing, Sketch Plans and Working Drawing Stages) / The Building System Model - were considered in the Tables 29, 30, 31, 32, 33, 346, 35 and 36.

Do these considerations represent the relationships between IAQ, The Architectural Design Process and The RIBA Plan of Work or any accepted plan of work related to the design, construction and occupation of the building? YES NO

In the Questionnaire 10 it was indicated that IAQ can be considered during The Architectural Design Process.

2.Can these following issues be determined by architects during the consideration of IAQ in The Architectural Design Process?

* environmental approach
* environmental - functional design strategy
* user requirement study in terms of IAQ
* IAQ as a design objective YES NO

3.Can those of conceptual decisions be reflected on drawings as below?

* functional analysis of spaces
* user activity pattern
* initial and developed design solutions
* functional zones
* indoor air polluted zones
* group of indoor air pollution sources YES NO

(Please examine the Table 59 Determination of Indoor Air Polluted Zones within The Existing X Building.)

Determination of indoor air polluted zones was proposed in the consideration model. Spaces within The Existing X Building were classified as indoor air polluted zones according to your schedule of design criteria. Also, researcher's observation was used for this classification.

4. Does this kind of classification help architects to achieve design solutions to provide a healthy indoor environment within the building for users in terms of IAQ? YES NO

(If any of the answers is "NO", please explain the reason:

)

QUESTIONNAIRE 1 2

FEEDBACK CHAIN, RISK ASSESSMENT / RISK MANAGEMENT - INDOOR AIR QUALITY

DESIGNER / THE ARCHITECT of THE EXISTING X BUILDING

(Please examine the Table 26 IAQ Related Feedback Chain of The Architectural Design Process and the Table 27 Consideration of Risk Assessment / Risk Management and The Architectural Design Process based on the RIBA Plan of Work / The Building System Model.)

1. IAQ related feedback chain of The Architectural Design Process based on The RIBA Plan of Work is shown in the Table 26.

Does this feedback chain represent the conceptual thinking process of IAQ and The Architectural Design Process of a building?

YES NO

Does this kind of feedback chain help architects to see possible further stages and to receive the necessary information from the previous stage in terms of achieving IAQ within the building?

YES NO

2. IAQ related Risk Assessment / Risk Management in The Architectural Design Process based on The RIBA Plan of Work is shown in the Table 27.

Does this Risk Assessment / Risk Management model represents the conceptual risk sequence of IAQ and The Architectural Design Process of a building?

YES NO

Does this kind of Risk Assessment / Risk Management model help architects to see possible risky stages in terms of IAQ within the building design?

YES NO

(If any of the answers is "NO", please explain the reason:

)

QUESTIONNAIRE 1 3

EVALUATION of THE ARCHITECTURAL DESIGN PROCESS - INDOOR AIR QUALITY

DESIGNER / THE ARCHITECT of THE EXISTING X BUILDING

(Please examine the Tables 28, 29, 30, 31, 32, 33, 34, 35 Control Loops of The Architectural Design Process based on the RIBA Plan of Work in terms of IAQ / The Building System Model.)

1. IAQ related control loops of The Architectural Design Process based on The RIBA Plan of Work are shown in the Tables 28, 29, 30, 31, 32, 33, 34, 35.

Do these control loops conceptually represent the IAQ related design activities during The Architectural Design Process of a building?

YES NO

Does the consideration of IAQ during the all stages of The Architectural Design Process prevent the possible failure in design solutions of a building in term of IAQ?

YES NO

2. In these control loops each "YES" line represent the awarded credit in terms of achieving the design solution to improve the IAQ within the building .

Can The Architectural Design Process be evaluated in this credit system in terms of IAQ?

YES NO

Can this kind of evaluation be helpful for architects to see their design achievements in terms of IAQ and providing a healthy indoor environment within the building?

YES NO

(If any of the answers is "NO", please explain the reason:

)