FLEXIBILITY IN THE DESIGN OF BUILDINGS

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To The Memory of
Mr. Rashed Nijaidi Al-Jassim (1922-83),
My Father.

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DECLARATION

1. The candidate, Hazim R. Al-Nijaidi, while registered for the degree of Doctor of Philosophy, was not registered for another award of the CNAA or of a university during the research programme.

2. The candidate, Hazim R. Al-Nijaidi, while registered for the degree of Doctor of Philosophy, did undertake and complete advanced studies in connection with the programme of research in partial fulfilment of the requirements of the degree.

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ABSTRACT

FLEXIBILITY IN THE DESIGN OF BUILDINGS

Hazim Al-Nijaidi

The study investigated the relationship between design and flexibility. Proposals by designers on how to incorporate the ability of buildings to accommodate changes in the requirements of the activities to be housed in buildings over time has led to a diversity of ideas regarding the relationship between suggested design variables and the achieved flexibility. Though a number of studies have been made on specific organisations and buildings, there has been no overall investigation of the general relationship between design and flexibility. To investigate this relationship it was necessary to:

1. Propose a system of measurement by which the extent of incorporation of the design variables in design proposals could be assessed (Chapters II and III).

2. Propose a system of measurement by which the extent of flexibility of buildings in use could be assessed (Chapter IV).

3. Assess the extent of flexibility achieved by the incorporation of design variables in design proposals by a study of actual buildings in use (Chapters V, VI, VII, and VIII).

The study has largely achieved these objectives. It provided methods to enable objective comparison to be made between alternative design proposals in terms of the incorporation of design variables. It provided methods to enable objective comparison to be made between buildings in terms of their flexibility in use. It became apparent that the flexibility of buildings in use was related to only certain aspects of design variables or even to only certain parts of buildings.

The study demonstrated that the flexibility of buildings in use is largely predictable from knowledge about their design. It showed that current ideas on flexible designs contain many factors that are redundant to flexibility. It recommends that future proposals of designing for flexibility need to be more refined than those at the present and that will enhance the effectiveness of manipulating the potential flexibility of buildings at the design stage. The main area of further research to emerge was concerned with the operationalisation of other design variables and their testing in various building types utilising the methods defined in this study.

CHAPTER I

INTRODUCTION

FLEXIBILITY IN THE DESIGN OF BUILDINGS

1.1. Introduction:

This study examines a number of problems concerning the relationship between the design of buildings and their flexibility in use. Interest in designing for flexibility has been growing as a result both of the increasing need to incorporate the potential for change in housing activities in buildings and to meet the problems that have already arisen. Though a wide diversity of ideas and solutions about designing for flexibility have been put forward in the literature, there nevertheless exists a number of real problems, the solutions to which constitute the objectives of this study.

The aim of this chapter is to identify the problems that are to be dealt with in this study. Background studies concerned with change are reviewed in order to set the context within which the study will be carried out. The relevant main areas in the literature are identified and they include: the empirical evidence of change; the problems of change; the solutions to the problems resulting from change, and a further exploration of a specific group of solutions concerned with preventive actions in buildings by using flexible designs. Finally the problems of flexible designs will be outlined followed by proposals to deal with these problems.

1.2. Background Studies of Change:

Most of the previous studies that were concerned with change in buildings' use over time have tended to concentrate upon two main issues. The first was to provide empirical evidence to demonstrate the fact that buildings and the organizations housed in them change over time. The second was to put forward solutions to the problems which might arise from such changes over time. Studies providing empirical evidence were originated by Cowan in the beginning of the sixties whilst studies of the solutions have on the whole been made since then.

1.2.1. Empirical Evidence of Change:

Prior to studies which provided empirical evidence of change little regarding the size of the problems of change had been recognized.(1) Accordingly, in the empirical studies, the objective was to demonstrate in a measurable way the fact of change and to explore its problems.(2) Though only. limited numbers of studies have been carried out, their findings have received considerable attention. These studies were carried out principally by Cowan and others in hospitals(3) and offices(4), and by the Laboratory Investigation Unit in teaching laboratories.(5) Such studies were a description of the development of organizations and the buildings they occupied over time. Measuring such developments was done by noting by how much certain characteristics of the organizations or their buildings had changed over the years. The characteristics of organizations measured included some that are common to most building types and others that are quite specific. One common characteristic, for example, is the number of people accommodated, which can change in the whole organization or in its various parts, and occurs in almost any organization.(6) On the other hand change in the number of hours taught, for example, is a characteristic specific to organizations such as laboratories or polytechnics.(7) The development of buildings was often examined in relation to their areas.(8) Perhaps one measure of the change of buildings is change in these areas. In these earlier studies, the point was made that change in the characteristics of organizations would reflect complex factors that change over time due to a variety of reasons.(9) Change in the organization over time would then, it was argued, be accompanied by change in its requirements for accommodation, and thus the buildings occupied were also measured.(10) Measuring change in the area of buildings was carried out to support the assumption that change in the organization results in changes in the accommodation required.

In addition to the supposition that change is virtually inevitable over time(11), empirical studies also revealed some other relevant findings regarding the developments of organizations and their demand for accommodation over time. In hospitals, for example, it was shown that though the majority of departments in a hospital change over time, the rates with which they change differed, depending upon their functions or size.(12) In offices, it was shown that the development of office activity normally follows a cycle of birth-growth-decline-death and this cycle is normally reflected in its requirements for accommodation.(13) In addition, various conclusions were drawn regarding the trend of the increase in the use of information technology(14) with predictions that appeared to have been largely supported in the years that followed.(15) In short, empirical studies of change have succeeded on the whole in demonstrating the occurrence of change and in drawing attention to various other issues specifically related to the type of organizations examined. Most of these studies have one thing in common, that is, whole organizations were examined. The records, including information about the whole organizations were examined either to identify changes in them, or some of the buildings were looked at in order to show that organizations had undergone change.(16)

1.2.2. <u>The Problems of Change</u>:

The problems resulting from change in the organizations occupying buildings, and in their requirements for accommodation, are the undesirable but inevitable consequences that follow such changes.(17) They may be brought about by the increasing inappropriateness of buildings to the organizations housed.(18) In systematic examinations, the problems resulting from change in organizations are only one part of the many problems that occur over time with respect to the interaction between organizations and the units of accommodation they occupy.(19) Such problems were examined in relation to the state of fit between organizations and their accommodation.(20) The state of fit was the basic criterion against which the relationship between the social and physical organizations was examined. In such studies, it was argued that organizations generally require resources of three types. They demand financial, material or information, and accommodation resources. The point was made that organizations relate to the accommodation they occupy through their demand for the resources of accommodation.

The resources of accommodation demanded by organizations fall into two types, first for buildings, and second for a specific location. The demand for buildings includes all the physical characteristics of buildings, such as their size, layout, and services. The demand for location includes consideration of characteristics such as the transport available, surrounding amenities and so on.(21) Each organization is different from another in terms of the uniqueness of its demands for accommodation, that is the type of building or location it considers appropriate.(22) The extent to which organizations find their accommodation appropriate is determined by the extent to which the resources provided by their accommodation meet those resources demanded by them.(23) Absolute matching between the resources provided and those demanded is rarely possible, and organizations generally tolerate certain degrees of mismatch.(24) The extent of matching between the resources demanded and those provided is referred to as the state of fit, which indicates the appropriateness of units of accommodation to the organizations housed. It is this tolerable state of fit which organizations aim to maintain in order to function. Examination of the state of fit is the context in which any imbalance is examined. An appropriate state of fit can only be maintained if the resources provided are within a tolerable degree of mismatch with those demanded.(25) Often, such an appropriate state of fit cannot be maintained due to an imbalance occurring between the resources of accommodation demanded by organizations and those actually provided by the units of accommodation they occupy. The reasons for such imbalance occurring in the equation of fit can be a change in either or any combination of three factors. These are i) the demand, ii) the provision, and iii) the standards of allocation. The resources demanded may change as the organizations themselves undergo change over time. The resources provided also may change due to deterioration in the characteristics of accommodation over time, such as the physical deterioration of buildings or environmental decay of the location and its surroundings. Finally, the imbalance may occur due to a change in standards of accommodating organizations. Changes occur in social and other values, that is changes occur in the criteria which determine the appropriateness of units of accommodation to the organizations housed.(26) Thus, the problems associated with change in the organizations can be seen in a context of the deterioration of fit over time, and change in the organizations is only one of many reasons causing mismatch.

In other approaches, emphasis was placed upon buildings rather than organizations, and these were looked at in relation to time. Any deterioration in their usefulness over time is referred to as their obsolescence.(27) If obsolescence occurs as a result of the deterioration in the physical conditions of buildings, then it is referred to as the physical obsolescence of buildings. Obsolescence could also occur due to deterioration in the characteristics of location in which case it is referred to as the location obsolescence. In addition, obsolescence may occur due to the ineffectiveness of a building in providing resources different from those demanded by the organization occupying it and is referred to as <u>functional obsolescence</u>.(28) Thus, clearly, there are some types of obsolescence which occur inevitably, irrespective of the organizations housed, such as physical obsolescence. Other types of obsolescence such as functional obsolescence can only be discussed in relation to the type of organization housed.(29)

Accordingly, it is clear that regardless of whether the area of interest is the organization housed in buildings or the buildings themselves, the undesirable consequences of change were examined within the context of the deterioration of fit between organizations and their accommodation. For the problem of deterioration of fit, over the years, many solutions have been suggested.

1.2.3. <u>Solutions to the Deterioration of Fit</u>:

The problems of the deterioration of fit were approached by past writers from various stand-points and various solutions were proposed. These solutions have received varying degrees of emphasis in the literature accordingly to the discipline to which they relate most.(30) They have been categorized by Nutt et.al. according to two criteria.(31) First, they were looked at according to whether their time of implementation was before or after the occurrence of the deterioration of fit. The resultant actions were referred to as preventative (i.e. to prevent deterioration of fit before it occurred) or corrective (i.e. to correct after deterioration of fit) actions respectively. Second, actions were looked at in terms of the context in which they were implemented - the organization or its units of accommodation.

Accordingly the resultant actions could be: i) preventative in organizations, ii) corrective in organizations, iii) corrective in buildings, and iv) preventative in buildings. Each of the four types of actions has its own limitations and balance of fit is maintained by various combinations of these actions.(32)

(i) Preventative Actions in Organizations:

These have been examined in a very few cases, mainly by Aylward.(33) He discussed a number of what he called "tactics"(34) based on an analogical approach with the tactics he proposed to be implemented in buildings. Basically these tactics describe what office and manufacturing organizations need to do, initially, to reduce the problems arising from possible changes in their work, such as, for example, the employment of multi-specialized users to avoid the need for employing extra users in cases of growth, thus reducing the amount of accommodation that would be required otherwise.(35) However, Aylward's approach has not been investigated further in the studies of change that followed.

(ii) Corrective Actions in Organizations:

These have received greater attention than preventive actions. They centre around the modification of people's activities to fit any mismatch between the resources they demand and those already provided by their accommodation, that is they depend upon the inherent potential of tolerance people generally possess.(36) Discussion of corrective actions in organizations appear always related to investigations of space utilization, mainly in universities(37) or hospitals.(38) Space utilization studies examined the scope and methods of increasing the use and usefulness of buildings by re-organization of the activities taking place in them.(39) In other cases, studies of space utilization have been referred to as the study of the multi-use of space in hospitals(40) or the shared-use of space in polytechnics.(41)

Most of such studies resulted in more specific and short term actions depending upon the type of organization examined.(42) In schools, for example, the size of groups and timetables were examined in order to present timetables which fitted existing buildings rather than the need for extra accommodation.(43) In other words, the aim was to restructure activities so that total utilization of the accommodation became possible.(44) In hospitals many studies were made to examine the pattern of temporal occupancy of each of the rooms in the buildings.(45) The results tended to show that many areas of the hospital examined were under-utilized, that is they were either not occupied for most of the time at which they were available, or even when occupied, a large proportion of their area was not used.(46) Thus this demonstrated the need to increase the occupancy of rooms for more time and to utilize more of the space, in order to meet changing sizes of groups using them or changes in work patterns.

(iii) Corrective Actions in Buildings:

These have related to both the management of the process of adaptation and to the building's technology. Studies that concentrated upon the management of adaptation have taken specific buildings as case studies and explored the problems which the organization housed in them had during the period studied.(47) These noted the timing and tactics used in the re-organization of activities within buildings and their re-allocation into temporary accommodation. Studies that concentrated upon building technology have looked at the physical characteristics of materials and the tactics used in their maintenance.(48) In some cases, the topics in such studies overlapped with those regarding the modernization and saving of old buildings.(49)

(iv) Preventative Actions in Buildings:

These have received more attention in architectural literature. Such studies emphasized certain design properties to be incorporated in buildings, and these were thought to facilitate the maintenance of an appropriate state of fit as the organizations changed over time. The designs including these properties are often called flexible or adaptable designs.(50)

1.2.4. Flexible Designs:

It would be true to say that preventive actions to tackle the problems of the deterioration of fit was the solution most often reported in the architectural literature. This literature is, in fact, in no way short of ideas on such designs. However, among the various ideas, some have received more attention in the general literature(51) as well as in that which was concerned with certain building types.(52)

Studies of flexible design often included implicit assumptions about the relationship between the design properties advocated and the achieved flexibility in use. The proposals for flexible designs often differed from each other in relation to (i) the type of change with which they were concerned most, (ii) the case of adaptation involved, (iii) the part of a building in which design decisions were emphasized, or even in (iv) the type of design decisions themselves.

(i) For the type of change, some ideas of flexible designs were concerned mostly with facilitating the accommodation of relatively small scale changes in the requirements of organizations for accommodation.(53) Others were mostly related to relatively larger scales of change.(54)

(ii) For adaptation, the emphasis in some was placed upon the accommodation of change with adaptation;(55) in others the emphasis was placed upon the accommodation of change without adaptation.(56)

(iii) For the parts of buildings, some ideas were concerned most with the layout of buildings incorporating rooms subdivision(57) and circulation pattern(58) while others placed the emphasis upon the services(59) or the structure(60) of a building.

(iv) Finally, for the type of design decisions themselves at each of the parts of buildings, the differences between ideas can be illustrated by, for example different approaches to the subdivision of rooms. Here, some ideas have argued for greater similarity among rooms in a building(61) and others argued in favour of greater variety.(62)

1.2.5. Properties of Flexible Designs:

From the introduction above, it is clear that ideas on flexible designs have differed in many respects. However, despite such variations there can be identified some common properties which have been advocated. Flexible designs are often characterized by (i) the way in which the layout is sub-divided, (ii) the type of circulation pattern, (iii) the type of structure, (iv) the type of relationships between the components of buildings that differ in their life span and finally (v) the general consideration of being capable of expansion.

(i) Sub-division of Layout: There can be identified the tendency to increase zoning of rooms(63) and to increase(64) or decrease(65) the similarity between rooms. For zoning, many studies argued for the zoning together of rooms that provide special services or accommodate special functions which have a different rate of change in requirements from those in other rooms.(66) A zoning of this sort will, it was argued, reduce the disruption to other rooms in the building in the case of change thus facilitating flexibility. For the similarity between rooms, while the majority of studies argued for increasing this similarity, only a few of them concentrated upon reducing it as a way of facilitating flexibility. Increasing similarity was regarded as appropriate when small scale changes can be catered for without adaptation to the buildings.(67) Reducing similarity was taken as a condition for initially providing rooms in the building that could be useful in the future.(68)

(ii) Circulation Pattern: Most studies argued for one where changes in patterns of communication between users in various rooms in a building can be catered for without corresponding changes in the building itself.(69) That was thought to be achieved by having circulation patterns that are similar throughout the buildings and do not reflect the particularity of the patterns of communication between users in the various rooms.(70)

(iii) The Relationship Between Elements of Buildings: For the relationships between the elements of a building, many studies argued in favour of decreasing the dependency between those that are likely to be changed in the short term and those that are not.(72) This again was seen to facilitate flexibility by easing adaptation(73) and reducing disturbance to users in other parts of a building.(74)

(iv) Structure: Regarding the building structure, studies argued generally in favour of reducing the supporting points by using wide span skeletons(75) while at the same time increasing the extent of standardization.(76)

(v) The Consideration of Expansion: For the consideration of extensions to buildings, the studies looked at many aspects of buildings including the structure, circulation pattern, services, and the building envelope. Standardisation in the structure was thought relevant to facilitating of extensions to buildings.(77) Having a main open corridor system and a standard units of envelope together with a clearly identified main outlets of services would all contribute to designs of buildings that can be extended easily.(78)

However, it should be noted that not all the proposals of flexible designs can be characterized by all of these factors for differences often arise between them in terms of the number of factors being considered in each. Nevertheless, regardless of the design properties or factors emphasised, it was clear that previous studies implied or assumed relationships between them and the achieved flexibility in use. Their mention in the literature was a consequence of the realization of the need to enhance the flexibility of buildings, by means of their design. However, in addition, there were in the literature some studies which discussed some of these design ideas in relation to temporary accommodation, but these were less frequent.(79)

1.3. The Design and Flexibility of Buildings:

From the foregoing, it is clear that architectural literature is not short of studies concerned with diverse ideas on designing for flexibility. However, it was similarly apparent that most of the studies contained implicit assumptions regarding the relationships between a number of design variables and the flexibility of buildings in use.

Though there is a wide diversity of ideas, nevertheless little has been done to assess the extent to which the achieved flexibility of buildings in use is actually related to the incorporation of the design variables advocated. The resultant lack of knowledge about the relationship between the design of buildings and their flexibility in use appears to be due to two reasons, and these are;

(i) The inadequacy of available methods of assessing the potential flexibility of buildings.

(ii) The insufficiency of evidence available in empirical studies of organizations and the buildings that housed them over certain time.

1.3.1. Inadequacy of Assessment Methods:

The inadequacy of existing methods of assessing the potential flexibility of buildings according to their design appears to reflect the paucity of knowledge available. Four main methods were noted in the literature, and these were put forward by Fawcett(80), Moharram(81), Moss and Anderson(82) and Phillips and Vickery.(83) Fawcett equated the adaptability of a building with the probability that the areas of its rooms match those required by various activities. Moharram indicated the flexibility of a multi-storey housing building by comparing its layout with some pre-defined layout prototypes, subjectively assumed to provide for flexibility. Moss and Anderson illustrated the flexibility of a layout in out-patient departments of a hospital by the freedom with which the grouping of consultation/examination rooms in it allowed for different requirements of consultation and examination sessions. Phillips and Vickery proposed a 'theoretical expression for predicting the cost communication of an organization', by measuring the resistance of buildings to the pattern of communication of the organizations housed in them. However, each of these methods were deficient either singly or in a combination of three factors:

(i) The particularity of the design variables examined, (ii) The particularity of the meaning of flexibility adopted, and (iii) The lack of empirical evidence concerning the relationship between design and flexibility.

(i) The Particularity of the Design Variables Examined.

None of the four studies outlined above identified the main design variables that were commonly advocated in past studies of flexible designs. Moharram and Moss and Anderson emphasised design variables that were relevant to certain building types only, while the proposals of both Fawcett and Phillips and Vickery did not actually concentrate upon a particular design variable. Rather they measured the relationship between room layout and the requirements for rooms or for communication between them. Moss and Anderson in this respect, concentrated upon the arrangement of consultation/examination rooms in out-patient departments in hospitals, though they provided objective measures that illustrated variations between hospitals in relation to these arrangements.(84) Moharram had identified design variables that are relevant mainly to multi-storey housing buildings, and these were subjectively assumed to enhance flexibility to a differing degree. The comparisons between buildings were made upon the basis of accumulating their rank order scores with respect to a group of design variables.(85) In short, it is clear that these methods of assessing the potential flexibility of buildings, did not contain any examination of the main design variables common in the majority of other past studies on flexible designs, and in some cases only subjective measurements were utilized.

(ii) The Particularity of the Meaning of Flexibility Adopted:

None of the four studies of methods of assessing the potential flexibility of buildings had adopted a comprehensive interpretation of flexibility which could cover the use made of the term by the majority of other studies. This point can be illustrated with respect to the methods proposed by Moss and Anderson as well as with respect to those suggested by Fawcett or by Phillips and Vickery. Moss and Anderson's proposal was clearly limited to problems in out-patient departments, as they reduced the flexibility of a layout to cover only the 'number of different time-tables' of consultation/examination sessions, a department can accommodate.(86) In Fawcett's methods, the meaning of flexibility, 'adaptability' in his words, was again limited, but not in relation to a specific building type. Fawcett had divided previous literature into the historical, the design and the methodological approaches, and argued in favour of the latter.(87) Such a categorization of the literature itself has problems. The historical approach was divided from the others, because its studies involved case studies of the history of selected organizations and their buildings. The design approach was separable because its studies involved introductions and explorations of design ideas. Finally, the methodological approach was separable because of the methods of probability it used in predicting future requirements of activities and the future performance of buildings.

This type of categorization is not of great utility since none of the approaches is clearly differentiated from the others. The studies in each complement knowledge in the others and provide evidence and exploration of various aspects of the process of change. Evidence of the occurrence of change and how its undesirable consequences may be eliminated through design decisions together with ways of predicting the future performance of buildings was provided. The meaning of flexibility adopted by Fawcett embodies the partiality of the study from which it originated.(88) It says hardly anything about aspects of change such as its types, magnitude and specific consequences. In addition, the study concentrated upon measuring the future flexibility of a building rather than its past real flexibility.(89) As a result certain assumptions about the future standards of allocating activities were implied, but these themselves could change with time. Further, the study concentrated upon only one aspect of adaptability,(90) that is looseness of fit, and only discussed room layout.(91) It overlooked other aspects of layout that are also relevant to looseness of fit and only concentrated upon one characteristic of rooms, that is area.(92) Accordingly, the study did not examine the potential adaptability of buildings if adaptation was also a consideration. For Phillips and Vickery, the proposal was limited to only one aspect of organizations, that is communication, and was not related to the wider interpretation of flexibility.

In short, the meanings of flexibility adopted in these three past studies of assessing the potential flexibility of buildings were very limited and lacked comprehensiveness.

(iii) The lack of Empirical Evidence: Despite the point that previous studies of methods of assessing the potential flexibility of buildings were greatly limited in both the design variables examined and the meanings of flexibility adopted, they also suffered from the lack of sufficient empirical evidence regarding the relationship between design and flexibility. For Moharam's proposal, the evidence necessary was not available at all, as she explicitly stated that the method was subjective in assuming that certain properties of design would enhance flexibility. With respect to Fawcett's, Moss and Anderson's and Phillips and Vickery proposals, which were relevant to predicting the future flexibility of buildings, the studies did not contain any case studies of past changes in organizations or of adaptations in buildings. The studies, in measuring the extent of certain properties of design did not show how the varying degrees of incorporation of design variables related to the extent of the achieved flexibility.

To summarize, the four methods of assessing the potential flexibility available in the literature are inadequate in describing the relationship between the design of buildings and their flexibility in use. They were selective in the properties of design examined; they were limited in the interpretation of flexibility adopted, and finally, they lacked any empirical evidence concerning the history of some organizations and the buildings housing them. There existed, however, in the literature, another group of studies which may be utilised in describing the general relationship between design and flexibility. This group of studies, which concentrated upon examining the development of some organizations in relation to that of the buildings housing them, will now be examined.

1.3.2. Insufficiency of Empirical Studies:

In attempting to describe the relationship between the design of buildings and their flexibility, use may be made of past studies that described the development of certain organizations and their buildings over time. Such studies, though they did not specifically aim at measuring this relationship contained examinations of some properties of buildings and/or in describing the developments of organizations indicated changes in them over time, and the adaptations needed. However, these studies did not provide an adequate assessment of the relationship between the design of buildings and their flexibility for three reasons, each related to one of three groups of studies.

(i) The first group of studies, mainly those by Cowan and others, concentrated upon the general relationship between organizations and buildings over time in an aim to quantify changes in either.(93) Such studies being the earliest in the field did not examine the relationship between any specific design variable and the changes that were accommodated in the buildings examined. They, by quantifying change, illustrated the need to consider flexibility in the design of buildings, and in some cases emphasised flexibility in relation to subdivision, and the availability of space.(94)

(ii) In the second group of studies, a degree of emphasis has been placed on the design of the buildings examined in relation to the amount of change that occurred in the organizations housed.(95) The problems about these studies are two-fold. First, they did not provide measures of general applicability of both the properties of design examined and of the amount of change that had taken place. Second, they included only one case study, i.e. one organization and the building it occupied. In restricting the investigation to one case study, an assessment of the relationship between the extent of incorporating the design variable in the building and the extent of its flexibility cannot be made. Such design variables are incorporated in any building, but to differing degrees. Similarly, every building can accommodate change, but some do more than others. Accordingly, it was not clear whether the amount of change that was accommodated in relation to the amount of adaptation, was particularly high, considering the extent to which the design variables were incorporated in the building. To be able to assess the relationship between the design of buildings and their flexibility, a wider sample of buildings must be examined. Only then, can the extent of incorporation of the design variables be related to the amount of change or adaptation taken place.

(iii) In the third group, a study of direct relevance was carried out in seven hospitals.(96) In it, buildings were compared in relation to their initial cost and that of the potential subsequent adaptations with respect to selected types of conversion, e.g. a conversion of an out-patient department into wards.(97) Yet there were some problems with this study. It looked at the structure of the buildings examined as nominal types of structural systems, but did not isolate any specific variable concerning the structure, and had not measured its extent in the buildings.(98) In addition, it concentrated on only those changes in activities that have been accommodated by adaptation; thus it was limited to this particular aspect of flexibility. Accordingly, the study related the extent of this limited aspect of flexibility to the cost of buildings rather than to the extent to which a specific design variable is incorporated in them. The study, however, provided some valuable methodological points with respect to the measurement of change in the servicing levels of rooms in a building.(99)

To summarize, there were many problems with the studies that examined certain specific organizations and their buildings over time, despite their apparent relevance to the assessment of the relationship between the design of buildings and their flexibility. These problems, together with those that emerged with the studies that looked at proposals for measuring the potential flexibility of buildings, reflect the paucity of knowledge available concerning the extent to which the achieved flexibility is related to the incorporation of design variables in building. It is clear therefore that there has been no overall investigation of the general relationship between the design of buildings and their flexibility in use.

1.4. The Research Problem:

It has become clear that previous studies of flexibility do not provide an adequate assessment of the relationship between the incorporation of design variables in design proposals and the achieved flexibility of buildings in use. To overcome this problem it is necessary to:-

1.4.1. Propose a system of measurement by which the extent of incorporation of design variables in design proposals can be assessed. This will enable an objective comparison to be made between alternative design proposals in terms of the extent of incorporation of design variables. However, there is a need to identify and categorize the main design variables advocated in past studies of flexible designs in order to establish the general applicability of the system of measurement to be proposed.

1.4.2. Propose a system of measurement by which the extent of flexibility of buildings in use can be assessed. This will enable an objective comparison to be made between buildings in terms of the extent of their flexibility in use. In order to arrive at a system of measurement, a more comprehensive interpretation of flexibility need to be adopted so as the measures proposed will not be confined to any one particular building type.

1.4.3. Assess the extent of flexibility achieved by the incorporation of design variables in design proposals, by a study of actual buildings in use. To achieve this a number of buildings need to be examined.

1.5. Summary:

This chapter has been concerned with summarizing the existing information on the relationship between the design of buildings and their flexibility in use, leading to an identification of the research problem and what is considered necessary to do, in order to solve this problem. The chapter started with an identification of the main areas of emphasis in past studies concerned with change in the use of buildings over time. These were the provision of empirical evidence about the occurrence of change and the various actions that may be taken to tackle the undesirable consequences resulting from it. The chapter then included a more detailed examination of one group of these actions, that is flexible designs. Studies of flexible designs contained implicit assumptions about the relationship between the design variables advocated in them and the achieved flexibility of buildings in use. It has been shown that there is insufficient knowledge about the relationship between the achieved flexibility of buildings in use and the incorporation of design variables in design proposals. To investigate this relationship it is necessary to propose three objectives, to be pursued over the next seven chapters of this study.

The first research objective, i.e. proposing measures of design variables will be dealt with in Chapters II and III. Chapter II will aim to identify, categorize and define the main and common design variables emphasised in past studies of flexible designs. Chapter III will include the measures proposed for most of these variables.

The second objective, i.e. proposing measures of the flexibility of buildings in use, will be dealt with in Chapter IV.

The third objective, i.e. assessing the relationship between the achieved flexibility of buildings and the design variables will be dealt with in Chapters V to VIII. Chapter V describes the research design of the empirical work needed to assess the relationship between the flexibility of buildings in use and two selected design variables. Chapter VI will concentrate on a comparison of the buildings examined in terms of the extent, within them, of the two design variables selected. Chapter VII will aim to present a comparison between the buildings examined in terms of their flexibility in use. Chapter VIII will present a general assessment of the relationship between the extent of incorporation of the two design variables and the flexibility of buildings in use. Finally, Chapter IX will include a general discussion of the conclusions and the need for further research that can be deduced from this study.

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CHAPTER II

FLEXIBLE DESIGNS

2.1. Introduction:

This and the following chapter deals with the first research objective of the study, that is the proposal of a system of measurement by which the extent of incorporation of design variables in design proposals can be assessed. The aim in this chapter is to identify the main and common design variables that have been advocated in past studies of flexible designs. Measures of most of these variables will be proposed in the following chapter. The need for an identification of design variables stems from the diversity of terminology used to describe properties of buildings, as well as from the unavailability of definitions and from the overlap between the concepts of flexible designs that were discussed separately in past studies. The following sections will discuss the possible criteria for the categorization of flexible designs.

2.2. Criteria for Categorization:

For the main design variables to be identified, criteria, as a basis for the analysis of flexible designs, are needed. Though many criteria may be used, there are problems with most of them. However, an attempt will be made to examine the various possible criteria, and the least problematic will be used as a basis for the analysis of flexible designs and the categorization of their main properties. The criteria that may be used are: i) the building type in which the designs were proposed, ii) the parts of buildings which have been studied in the various ideas put forward on flexible designs, iii) the types of change and iv) the ways in which flexible designs were thought to accommodate change in the activities to be housed in the resultant buildings.

2.2.1. Building Types:

The context in which flexible designs were proposed presents problems if used as criteria for the categorization of concepts from various studies. The problems relate to the existence of certain concepts in some studies that do not coincide with those in other studies, though there exists some scope for common ground between these studies.

The properties of circulation patterns provide a general degree of common agreement. Both Lynch on the general level(1), and Weeks in hospitals(2), argued for circulation patterns that are loosely tailored to the patterns of communication between the different parts of the institutions to be housed in buildings, as predicted at the initial design. Such circulation patterns, it was argued, would allow changes in patterns of communication to occur, without corresponding changes in the buildings. In studies of different building types, common ground is evident in relation to the distinction observed between buildings' elements. Distinctions have resulted in a general categorization of elements into those that are time-independent and those that are time-dependent.(3) Respectively, there were the concepts of 'shell-scenery' in offices(4); 'hard-soft elements' in hospitals(5); and 'basic-supplementary parts' in laboratories.(6) However, despite this common ground, there are also some problems that relate to specific building types and the activities housed.

The problems arising from using concepts in one study to illuminate those in others are evident in instances where studies belonging to different building types are to be related to each other. It could be observed that studies of different building types contained concepts that do not coincide with those in others. The existence of different concepts in studies of different building types often stems from the particularity of the problems of change in different building types. In many cases, there are some unique problems of change in certain building types. For example, emphasis was placed in studies of hospitals upon the independent access for growth for each hospital department(7), since each was observed to have varied patterns of growth over time.(8) Such emphasis has resulted in frequent discussions of types of circulation patterns such as the 'communication grid'(9) and the 'hospital spine'(10) in hospitals with no corresponding concepts in schools or offices. Thus, despite the common ground, the existence of such concepts does not always help the application of studies of one building type to illuminate concepts in studies of other building types.

2.2.2. The Parts of Buildings:

The parts of buildings to which previous concepts of flexible designs have been related have some problems if used as criteria for categorization. Concepts of flexible designs differ in relation to whether previous studies have mainly discussed them individually or in relation to some other concepts. There can be isolated two groups of concepts. The first group include those concepts that have been discussed almost individually such as the 'duffle coat' concept.(11) The second group, however, include those concepts where their distinction from other concepts is what have been emphasized in previous studies, such as the 'shell'(12), 'basic parts'(13) and the 'hard elements'(14) which have been distinguished from the 'scenery', 'supplementary parts' and the 'soft elements' respectively. It is the existence in the literature of the second group of concepts that poses difficulty in using the parts of buildings as criteria for categorization. The difficulty, in particular, is that the parts of buildings that have been assigned to one of the concepts in a particular study can not be fully isolated from those assigned to the other concept. This will cause difficulty in relating concepts in one study to those in other studies in relating the parts of buildings relevant to them. This point could be illustrated in relation to the distinction between the parts relating to each of the 'shell' and the 'scenery' concepts in studies of offices.

The 'shell' and the 'scenery' are concepts that refer to certain parts of a building. Previous studies have emphasized the distinction between them as a condition to facilitate the accommodation of changing organizations.(15) On the one hand, the 'shell' refers to the parts of a building that relate to long-term design decisions, i.e. those that need not change frequently due to changes in the requirements of the activities housed in a building. On the other hand, the 'scenery' refers to the parts of a building that relate to the short-term design decisions, i.e. those that need to be changed more frequently than those parts relating to the 'shell'.(16) Previous studies have attributed various parts of a building to either the 'shell' or the 'scenery'. Among these are; the structure, main circulation routes and access points in respect of the 'shell'; and partitions and local circulation areas in respect of the 'scenery'.(17) The parts of a building assigned to each of the 'shell' and the 'scenery' can be categorized in more than one view of identifying buildings as systems. The problem thus is that while the parts assigned to the 'shell', for example, can be distinguished from those assigned to the 'scenery' if one of the views of identifying buildings is adopted, they cannot be as clearly divided if another view of identifying buildings is adopted.

Buildings, generally, can be seen either as a building system or as an environmental system. In the building system identification, buildings were seen as an assembly of components, i.e. 'the stuff of which the building is made, the bricks-and-mortar, components, service installations and so on, compromise the building system'.(18) The building system was categorized into three subsystems; the constructional, the services and the content. According to the environmental system identification, and in particular the environmental spatial system, buildings were seen as an assembly of environmental subsystems, and these are related to the 'dimensional and geometrical properties of single spaces and to the spatial relationships between them' without reference to the materials involved in these subsystems(19).

With these ways of identification, the parts of a building assigned to the 'shell' can be distinguished from those assigned to the 'scenery' only if the building system view is adopted and not the spatial system view. That is according to the building system view, the structure of a building, as relating to the 'shell' can be distinguished from the partitions as relating to the 'scenery' in respect of the life span of these elements. Such distinctions can be applicable to most building types. However, according to the spatial system view, the parts assigned to both the 'shell' and the 'scenery' are sometimes parts of one spatial subsystem, such as the circulation pattern. In this subsystem, the main circulation routes are assigned to the 'shell', while the local circulation areas are assigned to the 'scenery'. Distinctions between the main and the local circulation areas whilst generally possible to identify within the context of a particular building type nevertheless do not fit alternative ideas which define the distinction in other building types. Distinctions between the parts assigned to the 'shell' and those assigned to the 'scenery' if they are to be applied to comparable concepts in other building type, such as 'hard and soft elements', may only be made in relation to the building system view of buildings. In such a case, the distinctions may be seen as inadequate, since many of the parts which were assigned to both the 'shell' and the 'scenery' were defined in general terms in relation to the spatial system view of buildings. To summarize, the parts of buildings if used as criteria for the categorization of concepts of flexible designs cannot be adequate. They result either in partial similarity between concepts in studies of different building types, or define some unique concepts within each building type, with little applicability to other building types.

2.2.3. <u>The Types of Change</u>:

Each of the concepts of flexible designs has been discussed in relation to the problems of a particular type of change. In using types of change as criteria for categorizing concepts, there are still some problems, although the scope for using them is greater than for those of the previous criteria. These problems are twofold. These are (i), that studies of flexible designs of different building types have often included concepts which related to types of change that differ greatly from those in other studies, and (ii), that the criteria for categorizing the types of change relevant to the various concepts of flexible designs within a particular study were in many cases not consistent.

For (i), studies of different building types have often approached the typology of change from different stand points, depending upon the particularity of the building type in question. In offices, for example, the 'shell-scenery' concepts as a whole addressed two types of change. Those were changes within one institution over time and changes in the allocation of different institutions in one building.(20) In laboratories, the 'basic-supplementary' parts concepts have been related to types of change according to their predicted frequency and the levels of the institution upon which they are occurring-in the whole institution, departments, groups of researchers and the individual research worker.(21) Thus, the types of change in the way they were presented in different studies are not directly accessible for categorization, unless they are to be analysed in terms of a common criterion.

For (ii), there exist some studies that have introduced many concepts. The types of change that have been discussed in relation to these concepts were often not categorized in relation to specific criteria. For example, in the study by Lynch(22), there was no common criterion that differentiated among the types of change that were discussed in relation to the concepts being introduced, such as 'variety', 'communication substitutes' and 'growth forms'. In that study, whilst what distinguished 'variety' from 'communication substitutes' was the type of requirements in which change may occur, (being the requirements for rooms or for circulation patterns), 'growth forms' seem to have been distinguished in relation to growth as opposed to change. Yet growth as a part of change, i.e. change in the quantity of some thing, may occur in relation to both the requirements for rooms or circulation pattern. Thus, again the types of change attached to the concepts of flexible designs, even within individual studies, appear to overlap.

In short, the attempt to overcome overlaps between concepts of flexible design and categorize them in relation to the relevant types of change is not fully reliable, since the types of change themselves suffer from a great extent of overlap. However with more case studies of change in institutions of different building types, certain types of change may be identified and can be taken as the underlying background to identifying concepts of flexible designs.

2.2.4. <u>The Accommodation of Change</u>:

The final criteria for the analysis and the categorization of concepts of flexible designs seem to be the least problematic. They are the ways in which buildings resulting from concepts of flexible designs were thought to accommodate change after use. In most previous studies, concepts were discussed in relation to either of two ways of accommodating change, i.e. with and without the use of buildings' adaptation. This criteria will be examined in more detail in the following section with the aim of identifying exclusive concepts or variables of flexible designs.

2.3. The Ways of Accommodating Change:

The two ways of accommodating change have been discussed in various concepts of flexible designs, and the concepts, as such, can be categorized according to which of the ways they advocate. However, these two ways differ greatly and each has certain limitations. In principle, the case in which change is to be accommodated without adaptation is that in which the resultant building will continue to be appropriate to the activities housed as they change, where its characteristics during this process remain as in the initial design. When change is to be catered for with adaptation, the building will continue to be appropriate to the activities housed as they change by having its characteristics changed from those defined at the initial design. Change in the characteristics of buildings by adaptation can only be made by removal, modification or insertion of elements of buildings.(23) Depending on the elements of buildings considered, adaptations will vary considerably along a continuum in relation to reversibility. At one end they are easily reversible, such as changes in furniture and movable partitions, while at the other end they are relatively irreversible, such as change in walls or in the structure of buildings.

How well do the resultant buildings accommodate change? In either case, to say that change can be accommodated, means that the building is continually considered as appropriate to the institutions housed as they change over time. As the appropriateness of buildings to the institutions housed can be examined in relation to the match between the resources of accommodation demanded by the institutions and those provided by the units of accommodation, the accommodation of change means that an appropriate state of fit between demand and provision is to be maintained. The appropriateness of the accommodation provided at a particular point in time varies from case to case depending upon the size of difference between the resources demanded and those provided. At one extreme, the resources demanded are to a large extent similar to those provided; there is a close match resulting in a great extent of appropriateness of the buildings to the institutions they house. As the size of difference between the resources demanded and those provided increases, i.e. resulting in lesser match, a lower appropriateness of buildings to the institutions they occupy follows. The size of difference between the resources demanded and those provided describes the state of fit. If there is a smaller difference then possibly the mismatch may be considered as tolerable. For higher differences, the extent of mismatch may be regarded as intolerable.(24) The degrees of mismatch has resulted in various terminologies to describe the state of fit concerned. If none or very little mismatch exists between the resources demanded and those provided, the state of fit is described as optimum.(25) In some cases of difference the state of fit is referred to as 'loose fit' where the difference is not too large and tolerable(26) and 'misfit' where the difference is great and thus intolerable.(27) However, the term of 'loose fit' is generally considered in relation to the provision of more resources rather than less than those demanded.

The two ways of accommodating change relate to these various terminology regarding the state of fit. The state of 'loose fit' applies to instances when change is to be accommodated without adaptation, while 'optimum fit' is related to the cases where change would have to be accommodated by adaptation. The first way of accommodating change relies upon no change in the buildings occupied but upon the tolerance and adaptability that people have in tolerating differences between the optimum accommodation they demand and that actually provided.(28) Of course, there are always limits to how adaptable people can be; the size of difference between demand and provision could increase beyond tolerance, i.e. resulting in cases of misfit. From such situations comes the second way of accommodating change by adaptation of buildings. In this case once the adaptation of people to mismatch in the state of fit with their units of accommodation is no longer feasible, actions turn to the adaptation of the accommodation, to transform it into a different state presenting different accommodation resources, so as to match or to be within a tolerable difference from those demanded by the institution after undergoing change. Accordingly, the state of fit obtained after the accommodation of change through adaptation will be closely related to 'optimum fit'.

To summarize, the ways of accommodating change, i.e. ways of maintaining appropriate state of fit as described in studies concerning flexible designs have been identified as being with or without the use of buildings' adaptation by the reliance upon human's adaptation to mismatch between the accommodation demanded and that provided. But many buildings can accommodate change in demand without any adaptation and almost every building can be adapted and thus accommodate more change. So what was novel in flexible designs? Every building is flexible to the extent that it enables the accommodation of some change without adaptation and if adapted would be more able to accommodate more changes.

2.4. Categorisation of Flexible Design Properties:

Studies of flexible design have attempted to identify properties of design that increase the ability of a building to facilitate these two ways of accommodating change rather than provide a new concept that is not already available in buildings. Every design is flexible to some extent as it contains a certain potential to facilitate the two ways of accommodating change in the resultant buildings, and flexible designs are those that incorporate some intentional decisions to increase their ability in facilitating the accommodation of change in the buildings that result from them.

There can be isolated two distinct groups of decisions. Each is relevant to one of the ways of accommodating change. These result in, design decisions that facilitate the accommodation of change without adaptation, and those that facilitate the accommodation of change with adaptation. The first group aims at increasing the potential of buildings to allow a loose state of fit to be maintained over time while the second group aims at increasing the potential of building to enable ease in subsequent adaptation. So what were the concepts that were thought to facilitate these potentials? In other words, how have these design decisions been translated into properties of design?

2.5. Looseness of Fit:

Design decisions related to looseness of fit, though basically centering upon the relationship between institutions and buildings, have in many cases concentrated on certain properties of buildings. There cannot be any building, with certain properties, which can be loosely fitted to all institutions. Properties of buildings that make them a loose fit to certain groups of institutions cannot make them so for others. Whatever the properties being advocated, the resultant buildings could be just exactly what was required by a certain group of institutions. Thus, on the basic level, it should be emphasized that though ideas of design on looseness of fit concentrated upon the relationship between buildings and institutions, nevertheless if properties of buildings are being advocated, they have a theoretical limitation, i.e. the buildings resulting from them cannot be loose fit for all activities.

Ideas of flexible designs related to looseness of fit can be grouped into two interrelated approaches. Both, basically, do not specify properties of buildings; rather they suggest the way in which buildings relate to the activities to be housed in them, so a loose state of fit is attained. However, out of the second approach, some properties of buildings, often relevant to the layout design, have been emphasized in previous studies, and have received a dominant importance.

The first approach advocates the provision of more resources in buildings than those optimistically demanded by the activities in them. The second approach advocates the provision of resources that are not specific to the resources demanded by the activities in them.

2.5.1. The First Approach: Over-capacity:

The first approach could be exemplified by a specific concept often referred to as 'over-capacity', and has been introduced in a study that was not related to any particular building type(29). It refers generally to the provision of more resources in buildings than are actually demanded by the institutions to be housed in them. Regardless of the amount of resources demanded, the provision should, according to this concept, be greater. Thus the extent of over-capacity is a statement explicit to the relationship between demand and provision rather than describing the provision itself. Over-capacity has been discussed in relation to aspects of buildings such as area or services.(30) However, measurements of over-capacity can only be made if the amount of resources demanded are known and that is in addition to knowledge about the amount of resources actually provided. The amount of resources demanded can be identified by referring to what has been agreed as space standards in allocating activities to spaces and taking this as a measure of demand. Space standards are generally available for public institutions rather than for private requirements. However, despite this (limited) possibility of measurements, there has been no specific study that measured over-capacity.

The main argument for over-capacity centres around the assumption that an extra provision would prove useful if the requirements of activities housed in rooms increase over time. The amount of over-capacity, of course, will be limited to the availability of resources, and to a lesser extent, to the limits to which individuals tolerate over-provision of resources. However, Lynch pointed to the financial penalties of over-capacity and argued for emphasis on examination of whether the extra provision is justified financially.(31) In addition, he pointed to the fact that if justifiable, over-capacity would only prove useful if the future requirements are similar to their prediction. Future requirements may be less than present ones and thus the whole exercise could prove unfounded. Such limitations seem to have been well acknowledged by various writers and that has led to emphasis on other strategies.(32) Yet, because of a general tendency to growth, the idea has survived to some extent. To sum up, over-capacity as a suggested way of increasing looseness of fit, though it could be measured, is not a variable of buildings, nor does it result in some properties of buildings which can be guaranteed relevant to even some institutions. There are implicit assumptions in it which could prove irrelevant in the future, and thus there are clear limitations.

2.5.2. The Second Approach: Neutrality:

The second approach is covered in a wide range of studies, all of which advocate a general idea which could be referred to as neutrality. The idea of neutrality is a direct translation of the concept of looseness of fit. It centers around arguments that looseness of fit can be achieved by designing buildings not specifically tailored to the institutions in them. Thus previous studies in implying neutrality, have concentrated more upon the relationship between buildings and the institutions in them rather than upon the buildings directly. The idea of neutrality is best described by the hypothesis that was originated by Cowan.(33)

Cowan has hypothesized that buildings vary in the degree of specialization of the activities they can accommodate along a scale. At one end of the scale, there are buildings capable of accommodating a wide range of activity types, for example offices and factories. At the other end, there are those that could only house a limited number of activities, for example concert halls. Similarly, activities vary in the extent to which their requirements are specialized along a similar scale. At one end, there are activities whose demands for space may be rather specific and specialized while at the other end are those whose demands are more general. However, Cowan's hypothesis has touched upon the essence of looseness of fit in relating activities to spaces, and has associated that with the degree to which buildings are specialized to a particular purpose. Nevertheless, though the extent of specialization has not been measured, it is clear that looseness of fit has been discussed in relation to a relative interpretation of generality and specialization. It follows from Cowan's hypothesis that there are some buildings which could provide great flexibility at the present since they are appropriate to various activities. Future flexibility of these buildings would follow accordingly, since the way future requirements differ from present requirements for buildings of a particular institution are analogous to how present requirements of one institution differ from those of another.

In practice, previous studies on looseness of fit in relation to neutrality have emphasized a specific property of buildings that can be referred to as uniformity. Uniformity of buildings, however, cannot be claimed relevant to the looseness of fit of all institutions, but it is the property argued for in most studies. Its essence is the uniformity of room size or sizes (and/or attributes) within a given building. Uniformity is not neutrality, but it is the property of buildings that resulted from an examination of neutrality, and it is claimed to be relevant to the majority of institutions. The dominant property of flexible designs shown in past studies was uniformity. Accordingly, this study will concentrate upon uniformity rather than upon the general and theoretical ideas of neutrality.

The argument in favour of uniformity as an aspect of neutrality in practice involves various assertions. First, that neutrality of a building results from the neutrality of each of the rooms in it. Second, that the neutrality of each room results from the usually generous mismatch between the resources it provides and those demanded by the activities housed in it. Third, that activities in different rooms normally demand different types of accommodation resources. Fourth, if these activities are accommodated in rooms that are generally uniform in the resources of accommodation provided, then there will be a great chance of having mismatch in some of the rooms if not in them all. The total sum of mismatch in these rooms may be a measure of the neutrality of the building in question and so uniformity then relates to looseness of fit. Of course if all activities require similar resources of accommodation and being accommodated in uniform rooms, then uniformity will not produce looseness of fit. Rather, the case is best described as optimum fit. However, such situations are not the norm in relation to large and complex organizations such as public institutions.

Past recommendations related to uniformity are of two approaches. They advocate either the increase or the decrease in the extent of uniformity, though this majority of studies have argued for the former case. The majority of studies will be examined under the heading of uniformity. Those that argued for decreasing the extent of uniformity in buildings will be examined under the heading of variety.

2.6. Uniformity:

Uniformity is the property of buildings' layout that describes the similarity between the various parts of a building. The argument for uniformity concentrates upon two aspects of layout, the subdivision into rooms and the ways in which rooms relate to each other. Accordingly, the idea of uniformity can be divided into the uniformity of rooms and the uniformity of circulation pattern.

2.6.1. Uniformity of Rooms:

A number of studies advocated uniformity or similarity of rooms in a building as a property that would provide potential flexibility. On the general level Lynch argued for 'unspecialized Forms' based upon analogies with biological concepts.(34) He noted arguments that complexity hinders adaptability and which mention how a simple house can survive various tenants' requirements. His argument was that complexity and specialization would enhance adaptability if it has a purpose. His analogy with biology was that the most complex species are the ones which survive changes in their environment better. Of course, in addition to the fact that analogies always have problems(35), the theory on which the analogy is based has not been fully explored. However, though he advocated forms that are as general as possible and do not reflect the particularity of the activities in them, he concentrated upon uniformity as relevant to flexibility, that is regardless of whether it was associated with complexity or simplicity. Similar arguments were cited by Aylward.(36) The quest for uniformity between spaces or rooms in a building has not followed the line that all rooms should be exactly the same. In fact it seems that fewer types of rooms is what has been advocated rather than complete unification, and this is true of studies of specific building types.

In more specific examples of building types, such as hospitals, the idea of uniformity of rooms in a building has been most strongly and clearly advocated. Weeks, in his approach towards 'indeterminate hospitals' has implied uniformity of rooms in a building as illustrated by the 'Duffle Coat' concept.(37) As the name implies, the idea was an analogy with the coats which are of three sizes, but fit the whole navy personal rather loosely. Weeks has emphasized that individual activities in separate rooms in a hospital are always under continuous change in their requirements.(38) His suggestion was that rooms should not fit closely the requirements of the individual constituents of institutions at the time of design. Rather they should be loosely fitted to the routines they accommodate.(39) Thus some rooms are larger than optimally needed while others could be smaller. However, he pointed out that neither the degree of waste nor the degree of pinch would hinder the activities carried out in them if the requirements were studied carefully.(40) If such a tolerance was considered possible and necessary tó accommodate small scale and frequent changes then, he argued, the rooms in a building should not have unique characteristics, rather they should to a large extent be similar. Each, he said, should represent the common denominator of the various requirements for facilities containing most of the services required but within limits. Some could resemble over or under capacity rather than perfect capacity.

The argument for similarity of rooms has incorporated another dimension. Similarity of rooms has been argued for not to attempt the unification of room types in a building but to ensure the limitation of these types. Weeks argued for limited types of rooms to cover various requirements in a way similar to the limited sizes of coats sailors use. The concept of the 'duffle coat', has been frequently advocated in many other studies, though referred to in other terms, such as the 'multi-strategic space'.(41)

A further point is that the idea of limitation of room types in buildings has been encouraged by reasons other than the need to cater for continuous small scale changes within the parts of an institution or the need to locate different institutions in speculative buildings. These reasons are to do with the increasing trend towards standardization of building construction in terms of structural, subdivision or service components.(42) To sum up, the idea of uniformity of rooms though advocated by analogy to differing concepts, has clear and consistent attributes. These are the similarity between rooms in a building and the tendency to minimize room types rather than to unify them.

2.6.2. Uniformity of Circulation Pattern:

Uniformity of circulation pattern is the variable of building layout that reflects the common ground among studies that advocated the similarity between the ways in which rooms relate to one another in a building. On the general level, the basic attributes of this design variable have been outlined by Lynch in his discussion of 'communication substitutes'.(43) He described them as a system of communication patterns that allow 'changes in patterns of interaction without corresponding changes in physical setting'.(44) The system would allow the different parts in buildings to be connected in a variety of ways. The initial characteristics of the circulation network are not specifically tailored to the requirements for communication of the institutions that occupy the various parts of the building. He finally described them as 'a high-level neutral and perhaps finely netted circulation and communication system'.(45) The basic analogies Lynch used were to do with both the biological systems and with communication patterns upon the urban scale. In short, his solution to the problems of change in communication pattern between parts of an organization was the provision of a high level of accessibility and a neutral circulation pattern, which reflect a high level of similarity throughout and are not specifically dependent upon the patterns of communication at a particular point in time.

In hospitals, for example, corresponding ideas were suggested regarding circulation patterns in outlining the main characteristics of 'indeterminate' hospitals(46), and the 'multi strategy buildings'.(47) Weeks and Best argued for a '...communication system which has high accessibility characteristics and which serves all parts of the complex equally'.(48) Weeks also noted that '...the high accessibility characteristics of the communication lattice network minimizes the difference between different parts of the complex'.(49) Weeks and Best, in suggesting such a concept, have criticized the detailed analysis of the communication pattern of a medical organization in terms of traffic of people, information and goods as a basis of design.(50) While attempts are normally made to represent such communications by a diagram or a matrix, they are all too easily converted into corridors, mechanical channels and sometimes door openings.(51) The criticism was based on the view that the resulting building will very likely become functionally obsolete for its initial purpose because the diagram or matrixes underlying its initial design are basically '...a detailed picture of the communication pattern of a medical organization at the point in time when the diagram was constructed. ...The problem lies in the use of detailed time-dependent descriptions of an organization as a basis for physical design'.(52) In another article, Weeks noted that the shape of this system is 'predetermined from the outset' and it 'may get longer but its characteristic form will not alter, since it does not result from but dictates the overall form of the organization'.(53) In describing such patterns of circulation, Weeks emphasized that the system should also be capable of expansion.(54) Expansion was discussed in relation to various parts of the circulation. The circulation network included the internal street system which could be on many levels, and the departmental corridors.(55) The potential for expansion was emphasized in relation to both the main corridor and the departments. Expansion of the main corridor was to allow both the connection of new departments which could be built along it as a consequence of overall institution growth, and, in the construction period, to comply with the policy of building individual buildings along it independently of each other in terms of dates of completion. Expansion of the departmental corridors connecting departments was to provide a potential for differential rates of growth among the various departments in hospitals. On parallel lines similar notions on circulation patterns were pointed out in various studies of other building types.(56) However, these notions have not been examined in the same amount of detail as Weeks gave to his studies.

To summarise, the uniformity of circulation as a variable of buildings has some clear and identifiable characteristics. It refers to the similarity of the relationships between various parts of the building, and in some cases includes other characteristics such as the potential for expansion. Two main variables thus emerge from studies that attempted to tackle the problems of change by increasing the potential of looseness of fit. These are the uniformity of rooms and the uniformity of circulation pattern in buildings. The uniformity of rooms refers to the similarity between rooms in a building and to the minimization rather than unification of room types. The uniformity of circulation refers to the similarity of ways by which parts or rooms in a building relate to each other.

2.7. Variety:

Variety is a variable of layout that is conceptually the reverse of uniformity. It relates to reducing the extent of similarity between the parts of a building. Reducing similarity, i.e. increasing variety in a building has been considered as a condition relevant to increasing the potential flexibility. Arguments for variety were first introduced by Lynch who used analogies.(57) He noted that, '...by analogy, one might conclude that a certain amount of variation in an environment would enhance its future adaptability'.(58) In this analogy Lynch referred to Simpson's argument that genetic variation in a population relates to its survival chances. The argument for variety considers that buildings may contain some parts that are not fully suited to the present requirements of activities. These parts could, in the future, be useful after change. However, in discussing the idea of variety, Lynch criticized its relevance to future adaptability though accepted its advantages for present flexibility. His criticism was based upon two points. First, that environmental features that vary from the norm at present can not be analogous to living creatures in that they cannot breed and multiply so such features will serve only a small percentage of the population in the future. Second, variety of environmental features will only be relevant if future requirements resemble the resources provided by the small percentage of features that are different from the norm at present. Similar arguments have also been put forward by Aylward.(59) Variety is another proposition to enhance potential looseness of fit, but it has many limitations, and that seems the reason for its small popularity compared with uniformity.

2.8. Looseness of Fit: Summary:

The potential for looseness of fit suggested in previous studies centres upon the way buildings relate to institutions housed in them, and that in relation to the concepts of over-capacity and neutrality. Neither of these concepts refer to design variables that can be measured in buildings irrespective of the activities to be housed in them, so there will be no need to propose measures for neutrality and over-capacity. However, out of the concept of neutrality there resulted some variables of buildings which were considered, in practical terms, relevant to the majority of cases rather than to them all. These variables are conceptually the reverse of each other. They are to maximize or minimize similarity between the parts of buildings. Maximizing similarity related to uniformity, whilst minimizing it related to variety. However, the ideas of uniformity have been more frequent than those regarding variety. Moreover, the arguments for increasing similarity have not only been discussed in relation to the similarity between rooms in buildings, but also in relation to the ways rooms relate to each other, thus resulting in two design variables; uniformity of rooms and uniformity of circulation pattern.

2.9. Ease of Adaptation:

The remaining concepts introduced in studies of flexible designs considered accommodating change by adaptation, and are thus concerned with the potential of designs to increase their ease of adaptation. The various studies differ in context and in terminology, but centre upon some properties of the layout of buildings. Layout has always been discussed in relation to the problems of adaptation as a factor that can facilitate the flexibility of buildings in accommodating change. The various studies, in suggesting ways of dealing with change, concentrated upon certain properties of building layout which can be manipulated at the initial design stage to enhance the potential flexibility. These properties can be grouped under the headings of concentration and modularity of structure, zoning of areas of special provision and independence between buildings' elements. These are the basic variables of layout, and will be discussed in more detail below.

2.9.1. Concentration and Modularity of Structure:

Concentration and modularity of structure are two inter-related variables of layout which describe the structural systems of buildings that were thought to facilitate their flexibility. Generally, concentration of structure means limiting or reducing the number of supporting points of the structure of buildings, while modularity means the repetition of the dimensional properties of the structural system throughout the building. Though concentration and modularity of structure have been emphasized in considering flexibility, other factors also played a significant role.

The idea of concentration of structure has resulted from the introduction of modern systems of construction, which often ceased to use load bearing walls to support floors and roofs. They simply relied upon the use of grids of columns with the use of reinforced concrete or steel sections, especially in high rise buildings.(60) Even in low rise buildings, though load bearing walls are used, the tendency has been to limit those walls so cost may be reduced as well as adaptation facilitated.(61) Standardisation in buildings has been heavily associated with the use of limited supporting points.(62) Lynch, in considering flexibility in buildings , generally noted that it may be achieved 'in a building by concentrating structural support at a few widely-separated points, leaving wide spans where future changes will not affect the fabric of the building'.(63)

Though concentration of structure has been continually emphasized for many specific building types, it has often been discussed in relation to the specific dimensions of the structural grid that were thought appropriate to the type of activities housed. In hospitals, for example, concentration of structure was an important facet of the design of 'multi-strategy buildings', though Weeks noted some reservations, in relation to the high cost which could be paid for flexibility.(64) In offices, concentration of structure forms the basis of the concepts of the 'shell-scenery'.(65) Detailed analyses were made of the extent to which columns were spaced in accordance with variations in the depth of office space required. Office space could be categorized as shallow, medium and deep in its depth in relation to the type of subdivision needed.(66) For each depth of space, certain dimensions of the structural grids were sought in accordance with other planning considerations such as the location of circulation routes.

Concomitant with the notion of concentration of structure is that of modularity, which describes the repetition of the structural grid. Columns were not always on a repetitive modular grid throughout buildings. Buildings could be found with various degrees of concentration of the vertical structural supports accompanied by various grids at which these support points were distributed. Modularity of structure is a direct consequence of standardization of building construction, and is particularly evident in most system buildings of prefabricated construction.(67) It embodied assumptions regarding the reduction in the cost of construction in standardized buildings. In addition to these assumptions in favour of modularity of structure were the proposed advantages concerning flexibility of buildings. In the later respect, writers dealt with modularity both on the general level and in respect of some building types.

On the general level, the notion of modularity of structure is analogous to that of the 'lattices' in what Lynch has described as 'additive structure' as a policy for flexibility in city planning.(68) 'The flexibility lies in the myriad ways in which the constellation of units may be patterned, and in the interchangeability of parts'.(69) Though the word structure has different meanings in 'additive structures' and modularity of structure, there are many connections. In 'additive structure', it has a general use and a meaning referring to the spatial pattern of cities as a framework within which 'the details are fixed while the total pattern is unspecified'.(70) The connections are in the descriptions of the 'modules' and 'lattices' as different kinds of 'additive structure'. 'The former refers to standardised parts of one or more sizes, which may be linked together in a set way, but can in some form very irregular total patterns ...The lattice, on the other hand, is a repeating plane or solid regular grid of dimensions, within which parts must fit'.(71) The grid in the lattice is thus analogous to that of the structure. The main reservation regarding the lattice is that the whole grid may become obsolete if its component parts, i.e. the modules become so. Accordingly the suggestion was made that the system, 'must be a highly generalized one, neutral in quality, or performing a very simple function which is highly likely to persist'.(72) This general notion of the lattice brings together the other ideas suggested by Lynch regarding 'unspecialized forms' and thus uniformity of building. Such a connection between modularity of structure and uniformity is much evident in studies of specific building types.

In hospitals, for example, the notion of modularity of structure has been linked with the overall modular patterns of planning layouts. Weeks noted that 'the dimensional characteristics of the modular planning element must be such that it is suitable for a very wide range of functions'.(73) The modules suggested were 7.20 meters x 3.60 meters for research and diagnostic areas and 9.60 meters x 3.60 meters for large group teaching laboratories. The basic width grids of 3.60 meters was considered relevant not only to the structure and partitions but also to the vertical distribution of services. In other words the modular grid is the denominator of the dimensional properties of the various elements of buildings. In offices, dimensional co-ordination of the structural grid was a necessary condition for multi-storey buildings based upon the isolation of 'strategic' from 'tactical' design decisions.(74) In research laboratories, the modularity of structure was an evident aspect of the design of laboratories discussed by the Nuffield Foundation(75), and more specifically in relation to change by the laboratories Investigation Unit(76). In most of these studies, while modularity of structure has been considered a basic priority for the accommodation of change, it has also been part of an overall modular approach towards planning layouts, thus including services and subdivision.

To sum up, it is clear that while concentration and modularity of structure are considerably inter-related they both are part of an overall modular planning approach including other elements of buildings. However, they describe different facets of buildings' structure thought relevant to flexibility. Concentration of structure refers to the extent of minimization of vertical supports in the plan, and modularity refers to the extent of similarity, co-ordination and repetition of the grids upon which the vertical structural points are distributed.

2.9.2. Zoning of Areas of Special Provision:

Zoning of areas of special provision is the variable of building layouts that describes parts of a building according to a particular criterion. Zoning in previous studies could be isolated in relation to two inter-related criteria; the characteristics of the activities housed in the different parts of the building and the characteristics of the elements or the parts of buildings themselves.

The general principles of zoning are parallel to those discussed by Lynch in whole buildings and on the city level, in 'zoning and concentration of structure' and 'growth forms' concepts.(77) His main emphasis was on zoning according to the characteristics of activities in relation to their degree of specialization or likelihood to change. His arguments centres around the point that activities of different types or of different patterns of change may be isolated from each other. Activities of specialized requirements of accommodation may be grouped together in certain areas in the building away from those whose requirements are less specialized. Similarly, activities that are expected to change in faster rates than others may be grouped together in special areas, away from those that are less likely to change in their requirements. The assumption that zoning would increase the potential flexibility of buildings relates to future adaptation and particularly the expansion of buildings. Adaptation, is argued, would become easier and with less problems to the majority of activities in the building, if it is limited to only those areas that are occupied by activities undergoing change. When there is a need to grow, there, claimed, will always be an open access for the expansion of a building available. Such an arrangement would reduce disturbance, resulting from the adaptation, to the majority of activities in a building.

The separation of activities in different parts of a building has also some problems. Lynch argued that such a differentiation between the parts of a building accommodating different activities would only be relevant to future flexibility if future changes occur within each of the differentiating activities. Had future changes required more interrelationships between the differentiated activities, such an arrangement would hinder flexibility. The general arguments Lynch used have been echoed in various studies of specific building types. In housing, for example, the idea of zoning is evident in various studies that sought flexibility of housing units, particularly in multi-storey buildings.(78) Because of the nature and limited number of activities generally carried out in houses, the two criteria for zoning have largely overlapped. In most studies, bathrooms and kitchens have formed a separate zone which clearly differentiated from other areas of the house. Their zoning has been based upon the characteristics of activities occurring in them as well as the characteristics of the servicing requirements of these activities. In other building types, such as offices, zoning again is clearly evident in designs proposed to facilitate flexibility. Designs according to concepts of the 'shell' and 'scenery' embodied the two criteria for zoning.(79) In zoning according to the characteristics of activities, attempts have been made to isolate groups of certain activities from others. These activities could be either highly specialized, for example, involving computer processes and/or of a higher likelihood to change. The zoned activities are often differentiated from others because of their specialized demand for services, environmental features or privacy.(80) Zoning could also be observed in offices in the grouping of services into vertical shafts, or under-floors or false ceilings.(81) Similar ideas about zoning could be found in other building types particularly hospitals(82) and laboratories.(83)

To summarise, zoning in buildings refers to the differentiation between parts of a building according to the special characteristics of activities housed in them , or their likelihood to change, as well as according to the special characteristics of the parts of a building. Its claimed relevance to the potential flexibility of buildings relates to the claimed relationship with the ease of adaptation and the reduction of disruption to other areas.

2.9.3. Independence of Buildings' Elements:

Independence of building elements is a variable of building layouts that incorporates many design ideas about flexibility in relation to some specific building types. Buildings if examined as a building system, i.e. as an assembly of material elements, are the products of a varied set of inter-related elements.(84) These elements are often of differing material substances, and consequently of a different physical life span. The elements relate differently to the activities housed. The characteristics of some are a direct indication of the characteristics of the activities housed in buildings, while those of others indicate the characteristics of activities to a lesser extent, and relate differently to changes in the activities housed in buildings. Some elements reflect these changes more than others, and need to be changed during the life span of buildings.(85) This need coupled with variation in their physical life spans, i.e. their rate of physical deterioration over time, has stimulated interest in increasing their independence.

Therefore a number of design concepts have been introduced, such as the 'shell-scenery' in offices(86), 'hand-soft elements' in hospitals(87) and 'basic-supplementary parts' in laboratories.(88) However, though the elements distinguished from each other in these concepts of design largely resemble independence between buildings' elements, they do not always coincide fully with the theoretical categorizing of buildings' properties. Nevertheless, underlying all these concepts, there exists a reasonably identified variable of building layout dealing with the distinction between two groups of building elements. In fact design decisions relating to each of these groups of elements have also been grouped in two groups. The first, often referred to as 'strategic' decisions, related to the elements of buildings that need not change with frequent changes in the activities to be housed. The second, referred to as 'tactical' decisions related to the characteristics of buildings that reflect the activities to be accommodated and need to be changed with changes in them.(89)

To summarise, the independence of building elements is a variable of building layout identified as being important in studies of flexibility because of the varying physical life spans of the elements in buildings and the differing frequency of changing them in relation to changes in the activities housed.(90) It is basically an idea that aims at reducing the problems encountered with the adaptation of buildings.

2.10. Ease of Adaptation: Summary:

The potential of designs to increase the ease of subsequent adaptations in the resultant buildings has been argued in relation to a number of variables associated with buildings' layouts. These variables often are common to many building types; they at the same time reflect general principles. The variables identified were concentration and modularity of structure, zoning of areas of special provision, and the independence of buildings' elements.

2.11. Design Variables: Summary:

The aim in this chapter was the identification of the design variables that underlie general and specific ideas about designs for flexibility in buildings. The identification of these variables involved a discussion of the criteria that may be used for the analysis and categorization of flexible designs. Analysis of flexible designs was made in relation to the ways of accommodating change. Two basic ways of accommodating change were discussed in the studies investigated. These were the accommodation of change with or without adaptation. Flexible designs then were seen to aim at increasing the potential of buildings in relation to these two ways. Neither of them is novel, but buildings vary in the extent of their possible accommodation of change by each principle. The properties of flexible designs relevant to each are already available in any building but to a differing extent. Thus flexible designs were identified as those designs in which deliberate decisions were taken to increase these properties in order to increase the potential of the resulting buildings to accommodate change with respect to each of the two ways described. The predominant design variables were either to increase the potential of looseness of fit or the ease of adaptation. The former design variables included uniformity of buildings (in relation to rooms or circulation patterns) and variety of rooms. The latter included concentration and modularity of structure, zoning of areas of special provision and the independence of building elements. In the following chapter an attempt will be made to propose measures of most of these design variables.

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CHAPTER III

MEASURES OF DESIGN VARIABLES

3.1. Introduction:

The aim of this chapter is to propose measures of the design variables identified in the previous chapter, and this constitutes the first research objective of this study. Design variables are the main and common properties of buildings; they cover the various ideas of flexible designs. They fell into two groups; the first relevant to looseness of fit, the second relevant to the ease of adaptation. The first group resulted in uniformity of rooms, uniformity of circulation pattern and variety of rooms. The second group included concentration and modularity of structure, zoning of areas of special provision and the independence of building elements. These variables have been defined in general terms in the previous chapter. In this chapter the aim is to give definitions in more detail, and identify measures.

However, the following sections will not include measures of variety and the independence of building elements. Variety is conceptually the reverse of uniformity of rooms, so measures of the latter will be used to indicate inversely its extent in a building. Independence of building elements is the extent to which the elements of a building can be adapted independently of each other, and for that no measures have been achieved in this study. There are some common characteristics in the design variables which are relevant to the development of measures, as each in one way or another relates to the whole building and each is present in any building, but to a differing extent. The measures to be proposed should be capable of indicating the extent to which each variable is present in a building.

3.2. Criteria of Measures:

There are various criteria to be satisfied. They include first validity, reliability, sensitivity of measures, and second applicability of measures to the drawings of buildings.

3.2.1. Validity, Reliability and Sensitivity:

The measures generally have to satisfy criteria such as validity, reliability and sensitivity. The validity of measures in its broad sense is judged by the extent to which the thing measured actually resembles or is, in fact, the thing which is to be measured. The reliability of measures can be evaluated by looking at definitions and the exclusiveness of the categories identified to illustrate variations of a variable in a population. Reliability of measures involves the consistency between results obtained from measurements reported by different people or at different times but in comparable conditions. Interrelated with validity and reliability is the sensitivity of measures. The sensitivity of measures is the degree to which the categories of the characteristics or variables to be measured allow even small variations to be noticed among a population of cases.(1)

3.2.2. Applicability to Drawings of Buildings:

The proposed measures should be capable of being measured from the drawings of buildings; they need not involve a survey of actual buildings nor do they need to depend upon analysis of users' responses to a particular question. They are to be used before the construction of buildings, i.e. in the process of assessing design proposals, and are to aid the comparison between alternative proposals. To sum up, measures of design variables are expected to be valid, reliable, sensitive enough to indicate small variations between buildings and capable of being applied to the drawings of buildings. In the following sections an attempt will be made to present, along these criteria, measures for the variables identified earlier.

3.3. Uniformity of Rooms:

Uniformity of rooms refers to the extent of similarity between rooms in a building. Uniformity of rooms as one of the main variables of flexible designs is a conceptually simple idea despite the diversity of terminology and contexts in which it has been discussed. The measures to be developed for assessing uniformity should provide a formula into which data about rooms in a building could be put to obtain a score. The score should be a measure of the extent of similarity between the rooms in the building examined. There are various stages in obtaining the measure. Initially, the characteristics of rooms in relation to which uniformity is to be examined should be identified. It would then become possible to compare rooms in buildings. The extent of similarity between rooms in a building could thus be examined with respect to each identified characteristic of a room. Uniformity of rooms therefore is a general variable that may be broken down into a number of parallel sub-variables. Each of the sub-variables is concerned with one of the characteristics of the rooms considered.

3.3.1. The Characteristics of Rooms:

In empirical studies concerned with the survey of buildings, room characteristics were put into a number of groups. The majority of studies agreed upon four basic groups of characteristics.(2) These were physical, servicing and fixed-equipment, environmental and temporal. Physical characteristics relate to the spatial environmental subsystem which refers to the dimensional and geometrical properties of rooms and the spatial relationship between them.(3) They include characteristics such as area or accessibility. Servicing characteristics refer to the services outlets available in each room, such as electricity, water or gas,(4) while fixed-equipment are generally those that are fixed in their location because of their connections to the services outlets. Environmental characteristics refer to the properties of the environmental conditions, such as noise level or day light.(5) Finally, temporal characteristics refer to the use patterns of rooms in terms of the type of functions housed or the time of their use in relation to the total time for which they are available.(6) The characteristics within some of the groups can be measured from the drawings of buildings, while the characteristics within other groups can only be measured from actual buildings. The physical and servicing and fixed-equipment characteristics of any room can be obtained from the plan, sections and detailed drawings of the building, whereas environmental and temporal characteristics are only possible to measure in buildings after use. Evaluation of environmental characteristics tends to be subjective, and relates to how people feel about the ambient conditions of rooms. Thus they can only be fully assessed if the assessor actually occupies the room concerned. Temporal characteristics, by definition, relate to the occupancy of rooms and can only be assessed after use.

All the characteristics of rooms can be examined in relation to uniformity when assessment is to be made of buildings and not design proposals. However, for the purpose of this study, that is to allow comparisons to be made in design proposals, uniformity will only be examined in relation to some of these characteristics. Given variations between the groups of room characteristics, it is apparent that certain groups are relatively more accessible than others for examination in this study, which depends upon the availability of previous drawings of buildings. Initially, it is only physical and servicing characteristics that are accessible, since they are the only groups that are available for measurements from the drawings of buildings. However, it is not always possible to find past drawings of buildings containing services. Thus for the purpose of this examination physical characteristics will be examined as examples of room characteristics. This is in order to allow the measures to be proposed to be illustrated in terms of some worked examples. It may be concluded that examination of uniformity of rooms at the initial design can only be made in relation to certain groups of rooms' characteristics, and out of these, the physical characteristics are the most accessible for examination in this study.

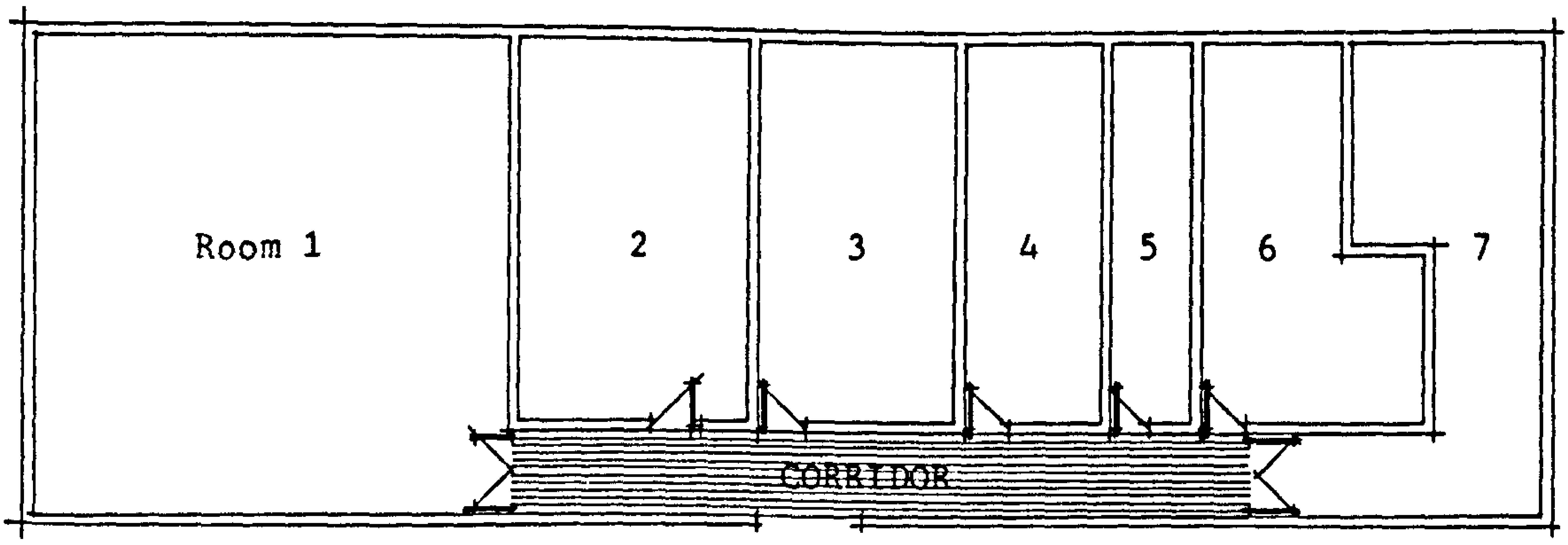
3.3.2. Selected Physical Characteristics of Rooms:

There are various physical characteristics of rooms that have been examined in past studies, and which have a general applicability and relevance to various building types. Area, height and shape have often been noted.(7) However, there are other characteristics of rooms which are also very relevant to the rooms' layout in buildings.(8) These include relationship to building envelope, location of doors, number of rooms directly accessible, accessibility of rooms and their relationship to corridors. Rooms in a building differ in their properties with respect to each of these characteristics thus providing various room types. An attempt will be made to illustrate the types of rooms in relation to these characteristics.

(a) Area: The area of a room can be measured straightforwardly if its plan is geometrical. For rooms that are not geometrical in their plans, the plan of each room will be sub-divided into geometrical segments and their areas will be summed up to obtain the area of a room.

(b) Height: Height can be measured from section drawings of buildings in a straightforward way.

(c) Shape: The shape of a room can be classified as one of a number of pre-identified shape types. Shape types have been grouped by the Unit for Architectural Studies into rectangular, L-shaped and other.(9) Rectangular and L-shaped groups were classified by the ratio between the longest and shortest dimensions of rooms in the plan. Taking this classification as a basis, seven shape types have been identified and are illustrated on Figure-1.



Type One:	Rectangular. L:S = 1. eg. Room1.
Type Two:	Rectangular. L:S = Greater than 1 and equal or less than 1.4. eg. Room2.
Type Three:	Rectangular. L:S = Greater than 1.4 and equal or less than 2. eg. Room3.
Type Four:	Rectangular. L:S = Greater than 2 and equal or less than 4. eg. Room4.
Type Five:	Rectangular. L:S = Greater than 4. eg. Room5.
Type Six:	L-Shape. (L1:L2) and (S1:S2) = Equal or greater than 0.25 and Equal or less than 0.75. eg. Room6.
Type Seven:	Others. eg. Room7.

Notes:

L =	Longest wall of a room.
S =	Shortest wall of a room.
L1, L2 =	Longest walls of segments making the L-Shape.
S1, S2 =	Shortest walls of segments making the L-Shape.

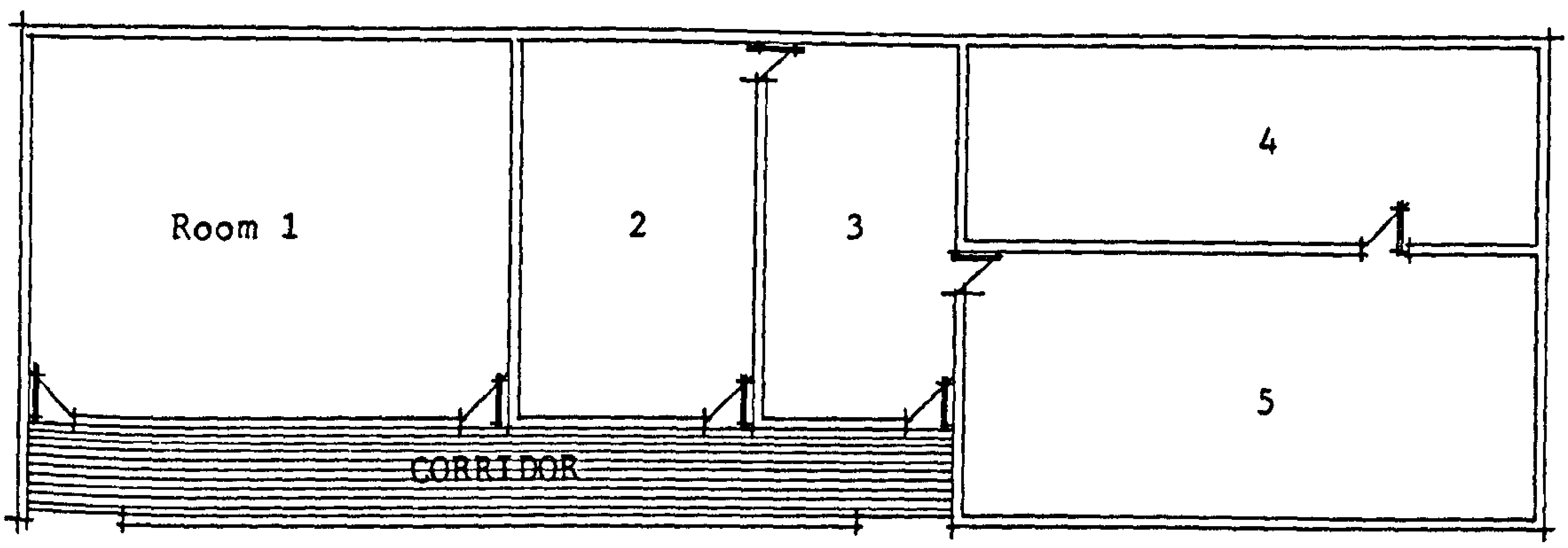
Figure-1
Types of Shape of Rooms

(d) Relationship of rooms to building envelope: Rooms can be adjacent or not adjacent to building envelope. Adjacent rooms are those where part of one or more of their walls form part of the building envelope.

(e) Location of doors: Rooms also differ in the number of the walls on which doors are available. Doors can be available on one wall (Type One) or two walls (Type Two) or three or more walls (Type Three).

(f) Number of rooms accessible: Rooms differ in relation to the number of rooms directly accessible to them through doors. A room could have only one room directly accessible to it (Type One), or two rooms (Type Two) and so forth.

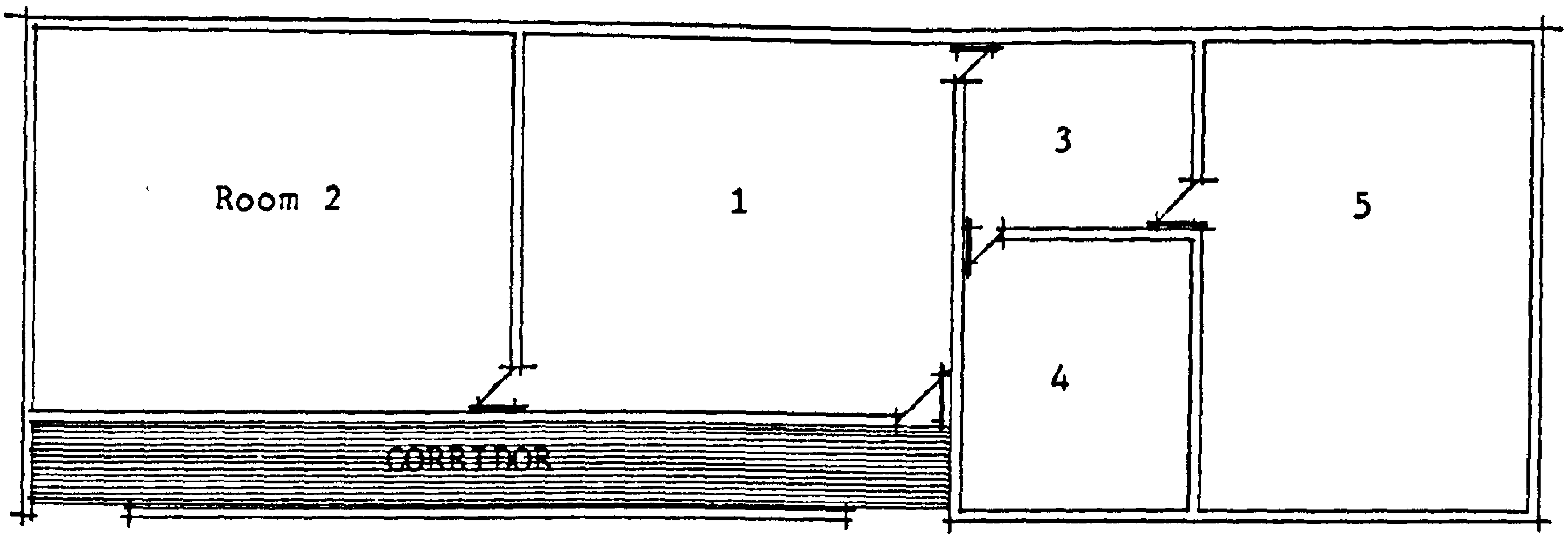
(g) Accessibility: Accessibility of a room can be assessed as to whether its doors open into other rooms or a corridor. The types of rooms according to their accessibility are illustrated on Figure-2.



Type One:	Where all doors of a room open onto a corridor. eg. Room1.
Type Two:	Where some doors open onto a corridor while the remaining doors open onto another room. eg. Room2.
Type Three:	Where some doors of a room open onto a corridor while the other doors open onto two or more rooms. eg. Room3.
Type Four:	Where all doors of a room open onto one room. eg. Room4.
Type Five:	Where all doors of a room open onto two or more rooms. eg. Room5.

Figure -2-
Types of Accessibility of Rooms

(h) The relationship of rooms to corridors: The relationship of rooms to corridors can be assessed in terms of the separation of a room from a corridor. The resulting types of rooms are illustrated on Figure-3.



Type One:	Where the room has direct access to the corridor. eg. Room1.
Type Two:	Where the room is adjacent to the corridor, but its access to it is through another room. eg. Room2.
Type Three:	Where the room is not adjacent to the corridor, but its access to it is through another room. eg. Room3.
Type Four:	Where the room is adjacent to the corridor, but its access to it is through two or more rooms. eg. Room4.
Type Five:	Where the room is not adjacent to the corridor, but its access to it is through two or more rooms. eg. Room5.

Figure -3-
Types of the Relationship of Rooms to Corridors

Having identified some of the main physical characteristics of rooms an attempt will be made now to explore means of measuring uniformity to arrive at an assessment of it in a building in relation to each of the room characteristics.

3.3.3. Measures of Uniformity of Rooms:

The characteristics of rooms have been illustrated, and some were selected as examples with respect to which uniformity of rooms will be examined. The next stage is to derive a measure of uniformity of rooms with respect to each of these characteristics. Uniformity of rooms is stated as the extent of similarity between rooms in a building with respect to the room characteristics mentioned. The measure of the extent of uniformity in a building relates to the approach taken in the interpretation of similarity between rooms. Basically, the similarity between rooms can be looked at in either of two ways depending upon the characteristics of rooms examined. In this respect, room characteristics can be looked at in two broad groupings: The first include shape, relationship of room to building envelope, location of doors, number of rooms accessible, accessibility, and the relationship of a room to corridors. The second group include area and height. The two groups of characteristics differ in two main respects. First, the number of room types resulting in a building if each of the characteristics is taken as a criterion for the typology of rooms, and second, the amount of information available regarding how much each of the rooms or the room types differ from the rest in relation to the characteristic selected.

The first group of characteristics results in only a limited number of room types, while those resulting from the second group are often significantly more. There are only two room types resulting from using the relationship of rooms to building envelope, for example, as a criterion for the typology of rooms in a building, while all the rooms in a building could be different in their areas thus resulting in greater number of room types which could approach the total number of rooms in a building.

Information regarding how much each of the rooms or the room types differ from the rest is far less in relation to characteristics of the first group than in relation to those of the second. Differences between rooms or room types with respect to characteristics of the first group can only be measured on nominal, ordinal or discrete continuous scales of measurements, while those with respect to characteristics of the second group can be measured on an interval continuous scale of measurement.(10)

It is these differences between the characteristics of rooms that causes measures of the similarity of rooms to be interpreted in two different ways, depending upon the characteristics examined. Measuring the extent of similarity between rooms with respect to characteristics of the first group can be approached in relation to the number of room types in a building and the distribution of rooms between them.

Measuring uniformity with respect to characteristics of the second group will concentrate upon the actual differences between rooms or between room types. The following sections will introduce the measures in relation to each of the two groups of characteristics. Those relating to the first group of characteristics will be examined under the heading of: Uniformity of rooms - General characteristics. Those relating to the second group of characteristics will be examined under the heading of: Uniformity of rooms - Area.

3.3.4. Uniformity of Rooms - General Characteristics:

Similarity of rooms in a building, i.e. their uniformity, relates basically to the number of room types in it, and in some detail, to the distribution of rooms between the room types. There are two attributes of uniformity of rooms in a building, and each concentrates upon one of these aspects of the similarity. The first is a basic attribute which relates to the minimization of room types in a building. The second is relatively a more detailed attribute, which relates to the variation in the distribution of rooms between the room types. These two measures rely upon the availability of certain data concerning the rooms in a building. Such data include the total number of rooms in a building; the number of room types in relation to the characteristic of rooms examined; and finally the number of rooms in each of these room types.

(i) The Basic Attribute - Minimization of Room Types: Indicator One.

The minimization of room types in a building as the basic attribute of uniformity of rooms is based upon the assumption that the fewer the number of room types in a building the more similar the rooms will be. The extent of minimization of room types in a building could be indicated as a ratio between the number of rooms and the number of room types. If all rooms in a building are similar in their type, then the building is of a maximum extent of uniformity, and its score on this ratio is equivalent to the number of rooms in a building. If each of the rooms differs in its type from other rooms, then there is a minimum extent of uniformity and its score on this ratio is equivalent to one. The score of a building that indicates its extent of uniformity will range between a minimum value of one and a maximum value of a number equivalent to the number of rooms in it.

However, buildings generally differ in both the number of rooms in them as well as in the number of room types. A simple ratio as indicated above, if applied to buildings of different numbers of rooms, will result in scores that are confusing in terms of the comparison. In cases, for example, when all the rooms in each of the buildings to be compared are of a similar room type, but the buildings differ in the numbers of rooms in them, then their scores on this ratio differ although all are of a maximum extent of uniformity. The extent of uniformity in a building should be indicated in proportion to its maximum extent of uniformity according to the number of rooms in it. It is only then that the comparison of buildings will become meaningful. Accordingly a formula has been developed to indicate the extent of minimization as a percentage of the maximum extent of minimization of room types in a building. In other words, it shows the simple ratio in a building but only as a percentage of the maximum score this ratio takes. This ratio is referred to as Indicator One.

Indicator One = 100*(X-Y)/(XY-Y) where;
X = The number of rooms in a building.
Y = The number of room types in a building.

However, buildings could be similar in their scores on this basic indicator of uniformity but still have differences between them in relation to more detailed aspects of uniformity. Uniformity does not only depend on the number of room types in relation to the number of rooms in a building, but also on the numbers of rooms within each type. So if the scores obtained from indicator one are identical, it does not necessarily mean that the buildings compared are equally uniform.

(ii) The Detailed Attribute - Variation Between Room Types: Indicators Two, Three, Four and Five:

The distribution of rooms between room types is a more specific attribute of uniformity, and the need to examine it arises when the buildings to be compared score similarly on indicator one concerning the basic attribute of uniformity. The distribution of rooms between room types varies from one building to another. In some buildings, room types contain similar numbers of room, i.e. the rooms in a building are evenly distributed between the room types. In other buildings, rooms are clustered at some room types more than at others. It is this variation in the distribution of rooms between the room types that is being considered as directly relevant to uniformity, and necessitates the derivation of formulas to measure its extent in different buildings.

If rooms are similar, then their number in a particular room type increases, leaving other room types with smaller numbers of rooms. There then will be a wider difference between the room types in terms of the number of room in them, if the rooms are clustered in certain room types more than in others. Accordingly, with wider variation between the room types, there will be more clustering at certain room types, and thus more rooms that are similar, i.e. more uniformity. If rooms are evenly distributed between the room types then there exist fewer percentages of rooms of any one room type, and thus lesser uniformity. The relationship between the extent of variation between room types in a building and its extent of uniformity is thus a positive relationship. Higher extent of variation is associated with higher extent of uniformity and vice versa. As a result, measurement of the extent of variation between room types will inversely indicate the extent of uniformity in a building in some detail. However, there are various ways of indicating the extent of variation of the distribution of rooms. Each of the ways captures certain characteristics of the distribution more than others. A detailed assessment of the extent of variation in the distribution of rooms would involve measurements by these various ways. Such variations can be indicated by first, the highest percentage of rooms at any room type, second, directly by measuring variation statistically and third, indirectly, by measuring the evenness of the distribution.

First: The Highest Percentage of Rooms - Indicator Two.

Consideration of the highest percentage of rooms at any room type will give a general account of the extent of variation between room types, and thus it is largely limited. The highest percentage of rooms at any room type differs between different building. The greater this percentage in a building, the greater is the extent of variation between room types, and thus, the greater is the extent of uniformity. Increases in the percentage of rooms at a particular room type in a building mean a decrease in the percentages of rooms at one or more of the remaining room types. The highest percentage of rooms at any room type is referred to as Indicator Two. This general indicator of variation has clear limitations. Buildings could be similar in the highest percentage of rooms at any room type, but differ in the distribution of rooms at the remaining room types.

Second: Direct Measures - Indicators Three and Four.

Variations between the room types in a building in terms of the number of rooms in them can directly be indicated by using some of the statistical measures of dispersion.(11) There are two basic measures of dispersion, the range and the coefficient of variation, though the latter is generally considered more reliable. The range describes the difference between the maximum and the minimum values of a set of data - in this case, the set represents the numbers of rooms at the room types. The range can be divided by the mean of the datum and indicated as a percentage. The percentage resulting will be a figure representing the amount of difference between the maximum and the minimum numbers of rooms at the room types, as a percentage of the mean of these numbers at all the room types. The higher this percentage in a building, the higher the extent of variation between the room types, and thus, the higher the extent of uniformity. This percentage will be referred to as Indicator Three.

However, a more reliable measure of variation is the coefficient of variation between the numbers of rooms at all the room types. It takes into account the numbers of rooms at all the room types and not only those that contain the maximum and the minimum numbers of rooms. It measure the average of deviations of the numbers of rooms in all the room types from the mean of these numbers and shows it as a percentage of the mean. The greater the value of the coefficient of variation, the greater the extent of variation between the room types in terms of the number of rooms in them, and thus, the greater the extent of uniformity. The coefficient of variation is referred to as Indicator Four. Both indicators three and four require comparisons to be made between buildings that do not differ greatly in the number of room types in them, since they depend upon the extent of variation between the room types and the mean number of rooms at them. The mean number of rooms could be great when few room types are available. Thus, even with a high extent of variation between the room types the final scores of these indicators in some buildings can be lower than those in buildings with similar variation between room types but with many room types, while the latter represent buildings of lower uniformity. Measurement of variations between room types can more reliably be illustrated indirectly by measuring the evenness of the distribution of rooms at the room types.

Third: Indirect Measures - Indicator Five.

Indirect measurement of variation between room types in terms of the numbers of rooms in them can be made by measuring the evenness of the distribution of rooms between the room types. The higher the extent of evenness of the distribution, the lower the extent of variation, and thus the lower that of the uniformity of a building. Higher evenness in the distribution means a similar number of rooms in room types, and thus there are fewer percentages of rooms at the room types, resulting in a lesser similarity, i.e. lesser uniformity. Lower evenness means greater variation between room types and higher uniformity.

The need to measure the evenness of the distribution arises from the problems in other measures of variation, i.e. the highest percentage, the range and the coefficient of variation. The highest percentage considers one room type only and ignores the distribution of rooms at the other room types in a building. The range considers differences in the numbers of rooms between two room types only. The coefficient of variation, though it considers all the room types, does not give clear results when the the number of room types is relatively small, e.g. two room types. The need thus is for a formula that indicates the extent of evenness and thus, inversely indicates the extent of variation between the room types in a building.

Such a formula has been derived in this study. It is a ratio and its outcome is a score describing the extent of evenness. The maximum extent of evenness in the distribution of rooms is known for any building, in advance, according to this ratio. It is equivalent to the number of room types in it. The maximum extent of evenness is the minimum extent of variation and thus the minimum extent uniformity in a building is also known. Thus, as the score of a building departs further from a number equivalent to the number of room types in it, the distribution departs further from the absolute evenness and the uniformity increases. The best way to illustrate this formula is by a worked example. The example is a group of three buildings A, B, and C. All have similar numbers of rooms and room types. The rooms, however, are distributed differently between the room types in each building.

Assuming that the buildings contain 20 rooms each, distributed between four room types:

X = Number of rooms in a building. (20 in this example).
Y = Number of room types in a building. (4 in this example).
xy= Number of rooms at room type y. (y = 1, 2, 3 ...etc.).

E (Extent of Evenness) = [Sum(1/xy)]/(Y/X).

The rooms are distributed between the room types as follows:

	Building A	Building B	Building C
x1	5	5	1
x2	5	5	1
x3	5	1	1
x4	5	9	17

The scores of buildings A, B, and C on this indicator are 4.00, 7.55 and 15.29 respectively. The scores indicate that the extent of evenness is considerably higher in building A than in B or than in C. Thus A is the least uniform while the highest extent of uniformity is in C. This example included buildings with similar numbers of room types. However, there exist situations where the buildings to be compared do not differ only in the extent of evenness of the distribution of rooms between the room types in them, but also in the number of room types. In such situations, assessing evenness by the ratio E presents some problems. The score of a building in relation to the ratio E is dependent upon both the extent of the evenness of the distribution of rooms between the room types and the number of room types in it. Accordingly, buildings with a similar extent of evenness but of different numbers of room types will score differently with respect to E. The score of a building in relation to E, in order to be meaningful, needs to be assessed in relation to its maximum value in a building, i.e. in accordance with the number of room types in it. This can be done by showing the maximum extent of evenness (i.e. the number of room types in it (Y)), as a percentage of its score on E.

The formula describing this percentage will be referred as Indicator Five.

Indicator Five = (Y/E) * 100 = 100*(Y*Y)/[X(Sum 1/xy)].

The score of a building with a maximum extent of evenness, that is minimum uniformity, will take the value of 100.00 as a percentage, irrespective of the number of room types in it. The score will decrease with decreases in the extent of evenness, i.e. with increases in the extent of uniformity. Indicating the extent of evenness by indicator five will thus allow a detailed comparison to be made between buildings of differing extent of uniformity which may contain different numbers of rooms and different numbers of room types.

3.3.5. Uniformity of Rooms - General Characteristics: Summary:

Measures of the extent of uniformity of rooms as far as the general characteristics of rooms have been identified. The input to these measures is data concerning the total number of rooms, the number of room types, and the number of rooms in each of the room types in the building. There are two measures. The first is general and relates to the minimization of room types in a building. The second is more detailed and relates to variations in the distribution of rooms between the room types in a building. The extent of variation in the distribution will be indicated in general terms using the highest percentage of rooms in any room type, or directly by the range and the coefficient of variation between the numbers of rooms at the various room types, and finally indirectly by a formula which indicates the extent of evenness of the distribution of rooms between the room types. The latter formula contains less problems than the first two ways of measuring detailed variations between room types.

3.3.6. Uniformity of Rooms - Specific Characteristics (Area):

Up to now, uniformity of rooms has been considered in relation to room types, e.g. seven categories of shape or five of accessibility, to arrive at a series of simple measures of uniformity of rooms in a building. Measurements have been made in relation to what was referred to as the general characteristics of rooms. Measuring area however, gives a much finer assessment of the uniformity of rooms, as in theory there could be an almost infinite number of room types of small differences in area taken to represent different types of rooms. Where the most basic measures of uniformity in relation to the general characteristics of rooms fail to provide a satisfactory answer regarding the comparison of buildings, finer measures may be considered for other characteristics of rooms. The area of rooms should then be taken into account, particularly if consideration of the room types does not indicate appreciable similarity or variation between rooms in real terms. For example, a room of area of 10 sq.m. is different in its type from that of 11 sq.m. as well as from that of 50 sq.m., but surely the extent of difference, and thus of similarity between it and either of the other two rooms is not comparable with the other. Similarly, two buildings with ten rooms in each, distributed evenly between five room types, defined by their areas, could score similarly on the measures of minimization but still could be significantly different. The areas of the ten rooms in the first building could range from 20.00 sq.m. to 25.00 sq.m., while those in the second building could range from 20.00 sq.m. to 150.00 sq.m. Surely, in real terms, the extent of similarity between rooms in the first building differs from that in the second, though both score similarly on the measures of uniformity relevant to the general characteristics of rooms. Such inconsistency between the score of a building in terms of its uniformity of rooms with respect to room characteristics such as area, measured by measures that are specifically relevant to their general characteristics, and the extent of similarity between rooms in it in real terms, would justify the need for modifications of measures to make them appropriate to the specific characteristics of rooms, by considering their differences from the general characteristics. These differences are, in part, due to the nature of the data concerning the characteristics of rooms, which in the case of the more basic measure are nominal, ordinal and discrete continuous, whereas characteristics such as area are, of course, continuous interval data.

Measures of uniformity that are relevant to nominal or ordinal characteristics of rooms are, however, not capable of utilizing the extra information about differences between room types available inherently in interval characteristics. These measures concentrate on differences between room types rather than on how greater these differences are. The loss of information available in interval characteristics reduces the potential use of measures in the comparison of buildings. It masks certain differences between buildings, thus resulting in comparisons that are less reliable. What is needed are, some measures that measure uniformity of rooms with interval characteristics which, while measuring the real extent of uniformity, are capable of utilizing the extra information available in characteristics that are interval in their scale of measurement.

(i) <u>Uniformity of Area - All rooms</u>:

The main lesson to be drawn is that where more information about uniformity is needed, emphasis should be placed upon the amount by which each room type differs from the rest, rather than upon the basic measures of uniformity. In other words, the extent of uniformity of rooms of a particular building could be indicated in more detail by considering the extent to which the areas of rooms are similar. The extent of similarity of area can be indicated by measuring the extent of variation. The greater the similarity, the less the extent of variation. Thus, if a group of buildings are to be compared with each other, those with the highest extent of variation between the areas of their rooms are those with the lowest extent of similarity, and thus lowest uniformity. There are a number of ways to measure variation statistically, often referred to as measures of dispersion.(12) Of these measures, one has been considered particularly reliable, that is, the coefficient of variation. It is the coefficient of variation which can be used to indicate, inversely, similarity of rooms in a building in terms of their areas, and thus their uniformity. The data needed for this measure is the area of each of the rooms in a building.

If the areas of all the rooms in a building are measured by the coefficient of variation, then the resulting score will give an indication of the extent of similarity between all rooms in the building. This, however, does not really get at the essence of the variable of uniformity. Absolute Uniformity has not been advocated in past studies. Rather, they have argued for buildings whose rooms are distributed within a limited number of different room types.(13) Such studies have accepted that there is a need for rooms of different sizes, but have argued that the number of these sizes should be limited. This limited number of sizes should cover the requirements of most activities that could occur in a building. Each of the recommended sizes cover the requirements of a particular group of these activities. Each of the activities in the group may have a loose state of fit with the room it occupies, if it is assigned to one of the room sizes recommended.

(ii) Uniformity of Area - Groups of Rooms:

The argument against having buildings with all rooms of a similar area was made to avoid choosing a particular area which could either be considerably greater or smaller than most activities would require. If many rooms are considerably bigger than needed a great amount of waste space would result, which would not in most cases be economically feasible. If many rooms are considerably smaller than needed, then the state of fit could be far from tolerable, since there are always limits to how much people can adapt to losses in what they consider as a necessary condition for accommodation. Thus, the argument was made for providing rooms of a limited number of different areas which while being economically feasible, are also appropriate for a tolerable but reasonably loose state of fit with the activities housed. According to this, the extent of similarity between rooms in a building will not be indicated by the extent to which each room differs from a specific area considered appropriate. Rather, it will be the extent to which each room belonging to a particular group of rooms differs from the specific area considered appropriate to that group. In short, instead of applying the coefficient of variation formula to all rooms in a building once, it will be applied several times, each time to one of the groups of rooms whose areas could be substituted by one specific area. The resulting score of uniformity of rooms in a building will not be only one but a number of scores, each relevant to a particular group of rooms, which latter may be averaged to give the one final score of uniformity. However, since the groups normally contain different numbers of rooms and are of a different total area, a simple mean of the coefficient of variation can not be used. Accordingly, the coefficient of variation for each group of rooms will be multiplied by a weight factor. There are two weight factors; the number of rooms in the group as a percentage of the total number of rooms in a building and the area of rooms in the group as a percentage of the area of all rooms in a building. There thus result two coefficients of variations by multiplying the original coefficient of variation for the group by these two weight factors. The mean of the two resulting coefficients of variation will be taken as a representative of the extent of variation in the areas of rooms in the group, and those for all the groups can be averaged to indicate the overall extent of variation in the areas of rooms in a building.

The grouping of rooms by area can be made by matching the area of each room with a number of pre-defined intervals of area. Each interval represents the range of areas which can be substituted for by a specific area. Rooms of different areas falling into each range can be substituted for by rooms of the same area, economically feasible, and providing a tolerable but loose state of fit with the activities that required the optimum and differing areas within the range. For example, if it is considered that certain activities require rooms of areas ranging from 20.00 sq.m. to 40.00 sq.m. can be housed in rooms of one size, that is 30.00 sq.m., then 20.00 to 40.00 is the interval of area that has been considered appropriate on grounds that relate to the economic feasibility as well as to the inherent limitation of human adaptability. Thus for the measurement of uniformity of rooms that fall within this range (20.00-40.00 sq.m.) in different buildings what will be measured is the average extent of variation in area of those rooms from their mean (30.00 sq.m.) i.e. the area which could be substituted for their areas. Buildings vary in this extent of variation. In some buildings, all the activities that require rooms of areas ranging from 20.00 sq.m. to 40.00 sq.m. have been provided with rooms of 30.00 sq.m. area. In other buildings, each of the activities that require rooms of areas ranging from 20.00 sq.m. to 40.00 sq.m. has been provided by its specific required area, 20.00 or 40.00 or even 23.00, 29.00 or 35.00 sq.m. In the buildings mentioned earlier, there is no difference between the areas of rooms and their possible substitutes, i.e. greater uniformity, while in those mentioned latter, the difference is greater, i.e. lesser uniformity.

(iii) Proposed Groupings of Rooms:

The question is how to identify these specific areas that can be substituted for certain ranges of area? There is no clear-cut answer since there is no test to identify these specific areas. However, there has been some relevant empirical work in identifying the specific areas which may fit most activities. This measures the area of rooms in some buildings and subjectively speculates upon the number of activities that could fit them. Cowan, making the first study(14), has identified the area beyond which increases in the amount of area would not correspond to a similar rate of increase in the number of activities that could be housed. Such studies, however, did not recommend other specific areas that could substitute certain ranges or intervals of area with respect to various numbers of activities. An attempt will be made to propose a method for the identification of the areas that could substitute for others, and since the emphasis is placed upon the method rather that upon the areas themselves, those resulting and adopted in this study will only be considered as possible alternatives, rather than firm recommendations.

The area that could substitute for others could be the mid-point of a range of area, i.e. of an interval. The interval may be identified by a rule defining how its maximum point relates to its minimum point, i.e. the maximum and the minimum area of the interval. Other rules may be suggested, depending upon the availability of relevant empirical evidence. With the unavailability of evidence according to which intervals were established, different rules need to be tried. Two basic rules have been adopted in this study. The ratios between the maximum area of an interval and its minimum area according to the first and the second of these rules are 1.50 and 2.0 respectively. For a minimum area of an interval of 20.00 sq.m., for example, the intervals resulting are 20.00-30.00 sq.m. and 20.00-40.00 sq.m. according to the first and the second rules respectively. The specific areas that could substitute for all areas within these intervals as the mid-points of these intervals would be 25.00 sq.m. and 30.00 sq.m. respectively. According to these rules, intervals of area can be defined for each building. However, the other main question that needs to be answered is where does the first interval start, i.e. what would be the minimum or the maximum area of the first interval to be defined. Two approaches have been adopted in this study. The first approach identifies intervals that are applicable to all buildings, while the second identifies specific intervals with respect to each building examined.

For the first approach, predefined intervals are to be generated. The minimum area of the first interval is identified as 0.90 sq.m., the reasonable minimum area of rooms in buildings. The first interval, thus, finishes at 1.35 sq.m. and 1.80 sq.m. respectively according to the first and second rules of defining intervals. The minimum area of the second interval according to the first and second rules is more than 1.35 sq.m. and 1.80 sq.m. respectively and less or equal to 2.02 sq.m. and 3.60 sq.m. respectively. Other intervals follow similarly. The membership of rooms in each of the resulting intervals could be decided by arranging the areas of rooms in a building in an ascending order, like the scale of the theoretical intervals defined above.

For the second approach, intervals are to be defined for each building independently. The first interval is defined either by a) starting from the smallest room in the building, or b) starting from the largest room in the building. For a) the minimum area of the first interval will be that of the smallest room and its maximum area will be 1.50 or 2.00 of its minimum area (i.e. according to the first or the second rule). The minimum area of the second interval will be the area of the room that follows the maximum area of the first interval, and its maximum area will again be 1.50 or 2.00 of its minimum. The minimum area of the third interval follows similarly. Intervals will be established until the maximum area in the building has been covered. For b) the first interval will be that whose maximum area is the maximum area in the building, and the minimum area of the first interval will be 0.66 or 0.50 of the maximum area. The maximum area of the second interval will be that of the room which follows (i.e. less than) the minimum area of the first interval and its minimum area will be that of 0.66 or 0.50 of its maximum area. The maximum area of the third interval will similarly be defined as the area of the room that follows the minimum area of the second interval and so on. Intervals will continually be established until the minimum area in a building is covered. The idea in the second approach is to incorporate the particularity of use in buildings.(Appendix-C2)

Though the second approach is relatively more relevant to uniformity, the first is meant to enable connections with other studies to be made. The second approach has not been used in past studies and is directly relevant to the real uniformity. It allows the extent of uniformity of a building to be assessed in connection with the reality of its use, i.e. by taking into account the particularity of the requirements of activities in it. Consideration of uniformity in relation to actual activities is analogous to the assessment of uniformity of design proposals. Design proposals may be assessed in relation to the requirements of some activities that are known at the initial design stage. Design proposals are seldom assessed in relation to any activity. Accordingly, uniformity will be assessed in this study in relation to how buildings are actually used, i.e. taking into account the requirements of the activities in them. In short, the second approach enables the assessment of uniformity in buildings practically in relation to some activities, rather than theoretically in relation to any activity. The first approach is apparently less relevant to the assessment of real uniformity, since it does not consider the particular requirements of activities in buildings. It has been considered to explore the theoretical uniformity of buildings. It provides a finer assessment of uniformity. Establishing standard intervals allows connections to be made with other studies. It is analogous to that used by Cowan in establishing intervals of area, and measuring the frequency of their occurrence in different buildings. However, Cowan's intervals, aimed for a different objective, have apparently been specified for easing statistical analysis by arranging the areas of rooms into intervals of hundreds square feet (100, 200, 300...etc.). Intervals in this study have considered the areas resulting from the dimensions mentioned in studies concerned with the modular planning of buildings.(15)

From these two approaches there result six different ways of defining intervals, thus six different ways of grouping rooms in buildings. All these ways will be used in this study. These six ways result in different sizes of intervals in each building, and thus the scores of uniformity will differ for each building according to the way used for grouping its rooms. Buildings generally are expected to score less when smaller intervals are considered than in the case of wider intervals. The number of rooms included in an interval generally increases with increases in the range of the interval. Accordingly, the smaller the range of intervals, the more critically uniformity is to be assessed. In addition, buildings are generally expected to score higher on uniformity when the second approach is adopted than the first. The differing scores of uniformity are needed in this study since it aims at exploring methods rather than resulting in final assessment of some buildings.

3.3.7. Uniformity of Rooms - Area: Summary:

The basic measure of uniformity of rooms in relation to specific characteristics such as area has been identified as the coefficient of variation between rooms, grouped or not. The coefficient of variation for all rooms together indicates the extent of theoretical uniformity. The average coefficient of variation considering groups of rooms indicates the extent of practical uniformity. Various rules can be adopted to define the membership of rooms in each group.

3.4. Uniformity of Circulation Pattern:

Uniformity of circulation pattern refers to the similarity between rooms in a building in terms of their relationships to other rooms. Since there have been no reported measures of uniformity as a characteristics of circulation pattern, studies that examined other characteristics of circulation pattern provide some useful connections.

The usefulness of such studies relates to the representation of circulation pattern rather than to its uniformity. The following sections will describe the characteristics of circulation pattern that have been examined in past studies, and identify the ways in which circulation pattern has been represented.

3.4.1. Circulation Pattern - Efficiency and Uniformity:

Most studies of circulation patterns have concentrated upon their efficiency.(16) According to the arguments of the efficiency of the circulation pattern, the cost of journeys between rooms in a building is to be minimized.(17) The cost of journeys for the whole building is the sum of the costs of journeys from all the rooms in it.(18) The cost of journeys from each room is the sum of all those of individuals in it. The cost of journeys for each individual is the sum of those of all his/her journeys. The cost of each journey is the multiplication of its distance by its frequency by a cost factor representing the relative importance of the time spent by the individual making the journey.(19) Often the cost factor relates to salaries of individuals in the institution which occupies the building examined, in relation to their total hours of work.(20) The distance is often substituted for by time taken in order to enable the measurement of the cost of journeys horizontally or vertically by lifts or stairs.(21) The cost of journeys for a particular institution is compared between various layout proposals. The layout of the least cost will be considered the most efficient in its circulation pattern. In such a layout, the individuals who undertake costly journeys, i.e. most frequent and/or higher in cost factor, will be allocated rooms that are close to each other. Individuals whose journeys are less frequent or have a relatively lower cost factor, can be allocated rooms that are far away from each other. There are many ways for the generation of efficient layouts of buildings in relation to the special requirements of different institutions.(22)

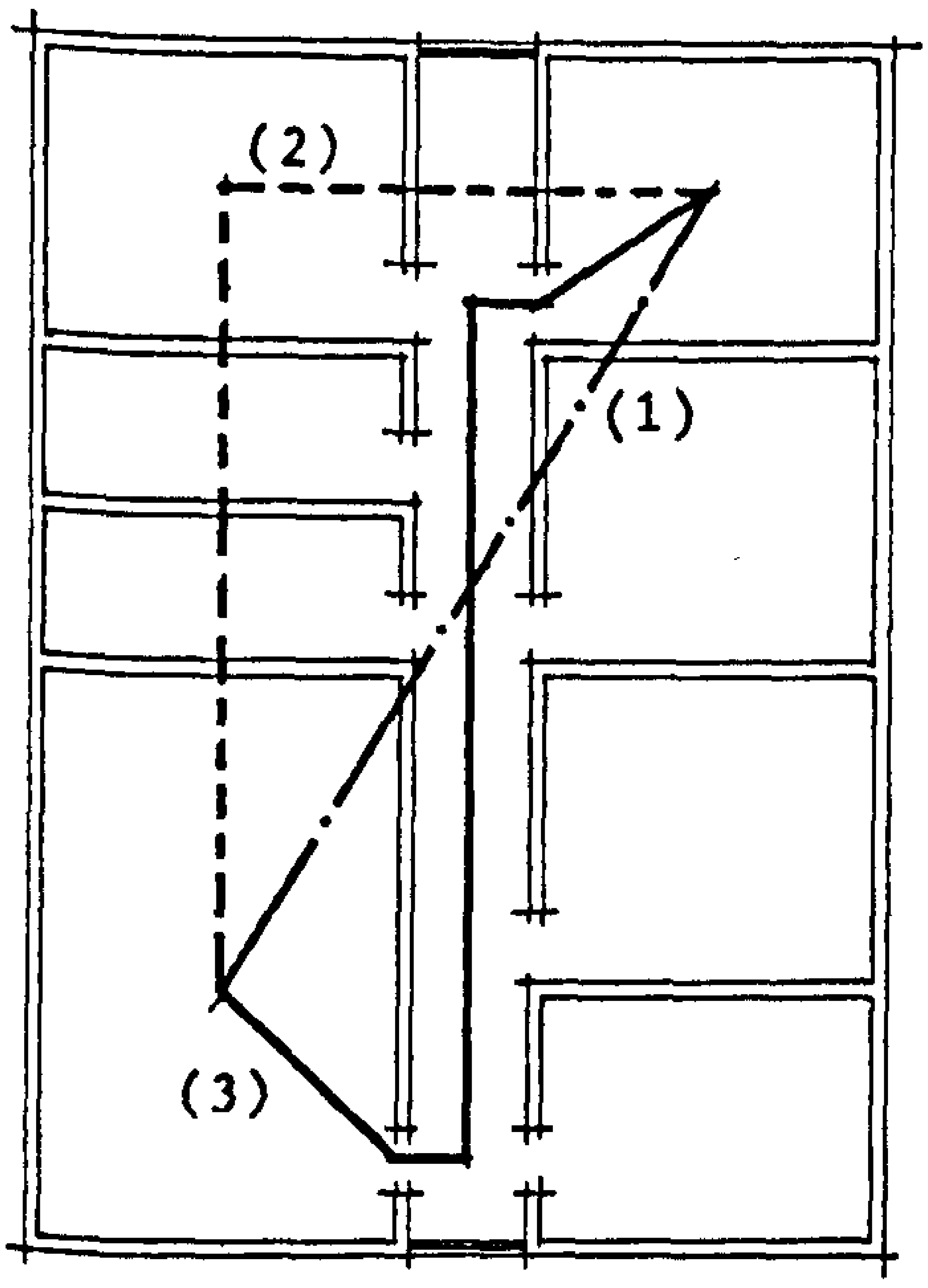
However, efficiency and uniformity are characteristics of circulation pattern that differ fundamentally from each other. In discussing efficiency, the aim is to identify circulation patterns that are specifically tailored to the patterns of communication between individuals in the institutions to be housed in buildings. The optimisation of buildings to the requirements of the institutions to be housed in them is concerned most with the provision of an optimum state of fit, while in contrast, uniformity is aimed at the provision of a loose state of fit.(23) A consequence of the concentration upon efficiency is that the location of each room in a building is unique in its relation to other rooms, and that is calculated in accordance with the cost of journeys from it. By contrast, concentrating upon uniformity means that rooms in a building are generally similar in their locations in relation to other rooms, and that is irrespective of the cost of journeys from them. It is by contrast with the ideas of providing time-independent buildings for time-dependent requirements that the ideas of uniformity of circulation have been proposed, yet there are many important and relevant methods and points in studies of efficiency that can be utilized in relation to the development of measures of uniformity of circulation. Assessing the efficiency of circulation patterns in buildings, unlike uniformity, requires a detailed knowledge about journeys between all rooms as well as some measurements of the physical relationships between rooms. It is in relation to the ways adopted in the measurement of the physical relationships between rooms, i.e. the representation of circulation pattern, that studies of efficiency assist in proposing measures of uniformity.

3.4.2. The Representation of Circulation Pattern:

The circulation pattern has been discussed with respect to the relationship between rooms in a building. There are at least two aspects to the relationship between any two rooms on the same floor in buildings. These are proximity and adjacency.(24) Previous studies of efficiency have emphasized proximity rather than adjacency. Proximity, refers to the distance between the centroids of any two rooms. The distances have been measured by three ways, thus resulting in three types of distances. These types are direct, rectangular and actual, and the actual distance approximates actual journeys of pedestrians better than the other distances, and can be used to represent the proximity between any two rooms (Figure-4).(25)

Adjacency refers to type of spatial relationship between any two rooms in a building. The spatial relationship can be discussed in relation to the accessibility between rooms, considering whether rooms share walls between them, or have direct access to and relationships with corridors.(26) Previous studies regarded any two rooms as adjacent if they shared any part of any of their walls. However such studies had only identified limited types of adjacency relationships between rooms. Yet many relationships, which can be isolated as eight types of adjacency, can be found in buildings (Figure-5).(27)

To summarize, from previous examinations of circulation patterns the methods of presenting a circulation pattern has been noted and modified. They described the relationships between rooms in a building. The relationship between any two rooms could be looked at with respect to proximity or adjacency. Both proximity and adjacency need to be discussed in assessing the relationship between any two rooms. They focus upon different characteristics of layout and relate to different aspects of journeys. Proximity relates to the length of journeys, while adjacency considers the ease of routes of journeys. Both thus relate to the time taken by individuals and accordingly the frequency of journeys as well as the choice of routes in making journeys. In short, they relate to the characteristics of the layout which determine its appropriateness to the institutions to be housed in the resultant building.

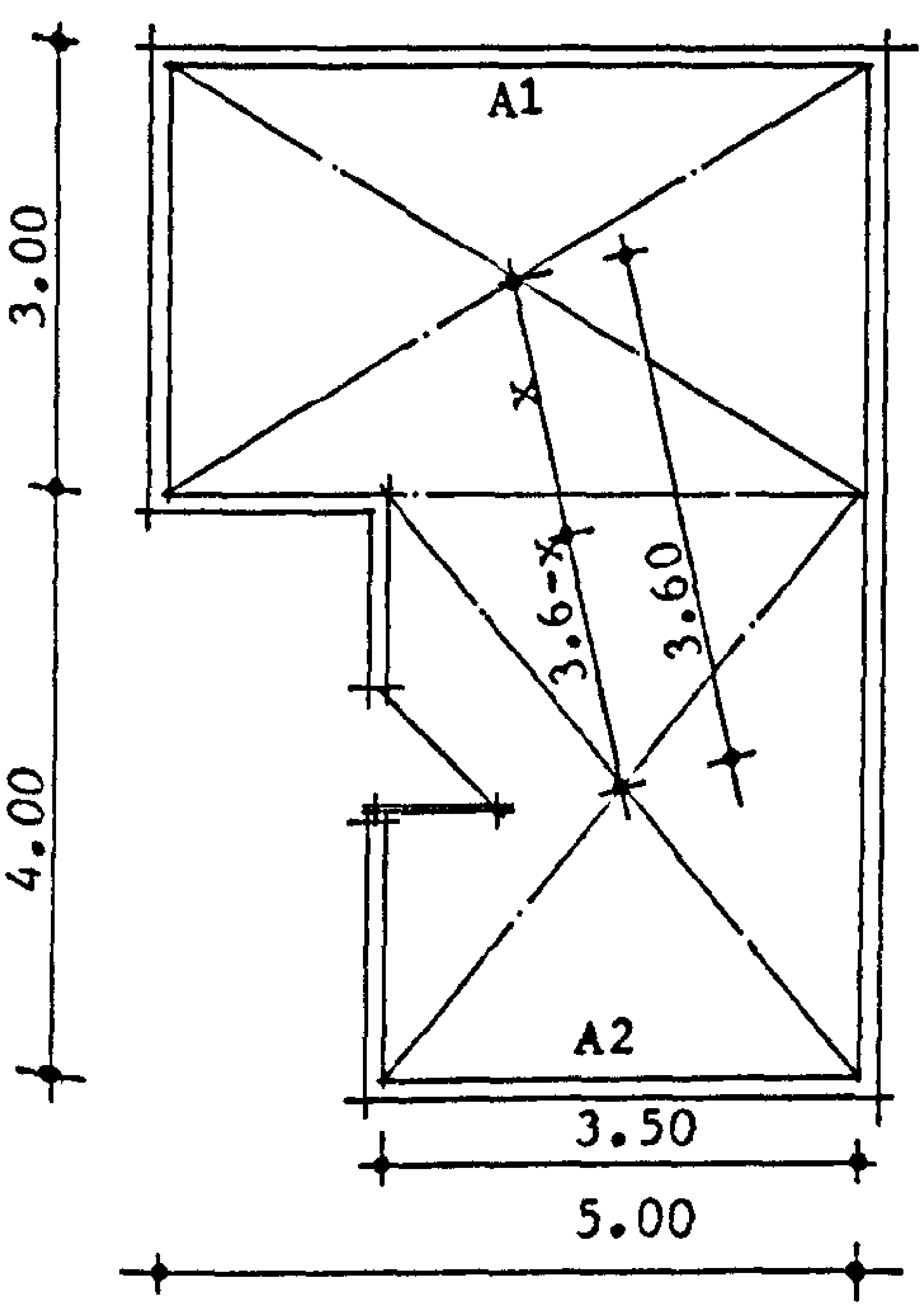


a) Types of Distances between Rooms:

1. Direct Distance:
The straight line between the centroids of two rooms.

2. Rectangular Distance:
The distance of the two right-angles intersected lines that are drawn from the centroids of the two rooms and are parallel to the building envelope.

3. Actual Distance:
The shortest distance from the centroid of a room to the central point of its door, to a point on the central line of the corridor in front of its door, along the central line of the corridor to the center of the other room's door, then to the centroid of the other room.



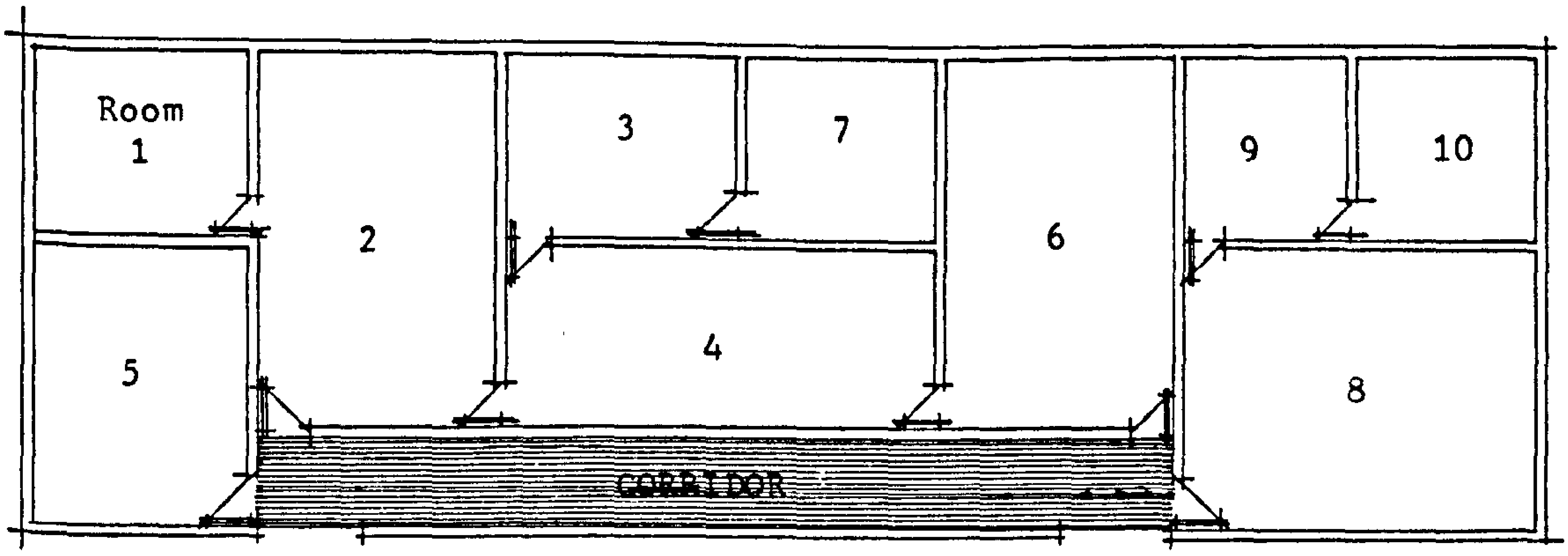
b) The Centroids of Rooms:

The centroids of rooms can be identified directly for rooms of geometrical shape plans as the geometrical central point of the shape. For non-geometrical shapes, the room will be divided into a number of geometrical shapes whose centroids are known. Later the centroid will be identified for any two geometrical shapes to begin with and then with each of the remaining shapes. The centroid point of any two geometrical shapes, however, is a point on the line connecting their centroids. This point is a way from each of the centers of the two shapes in a distance propotional to the area of that shape if compared with that of the other shape, out of the total length of the line.

$$Area(A1)/Area(A2) = (X)/(3.6-X)$$

$$X = 1.86$$

Figure -4-
Proximity Relationships between Rooms



Type One: Where the two rooms are adjacent and have a direct access between them. eg. Rooms1, 2.
Type Two: Where the two rooms are adjacent, but the access between them is through another room. eg. Rooms2, 3.
Type Three: Where the two rooms are not adjacent, but the access between them is through another room. eg. Rooms1, 4.
Type Four: Where the two rooms are adjacent, and the access between them is through a corridor. eg. Rooms5, 2.
Type Five: Where the two rooms are not adjacent, but the access between them is through a corridor. eg. Rooms5, 4.
Type Six: Where the two rooms are adjacent but the access between them is through another room and a corridor. eg. Rooms6, 9.
Type Seven: Where the two rooms are not adjacent, but the access between them is through another room and a corridor. eg. Rooms6, 1.
Type Eight: Where the two rooms are adjacent or not adjacent but the access between them is through more than one room or even both more than one room and a corridor. eg. Rooms2, 7 or Rooms6, 10.

Figure -5-
Types of Adjacency Relationships between Rooms

3.4.3. The Measures of Uniformity of Circulation Pattern:

A measure of uniformity of circulation pattern is aimed at giving a score to a building indicating the extent of similarity between rooms in it in terms of their relationships to other rooms. Giving such a score is involved with three stages: (i) The identification of proximity and adjacency relationships between each room and all other rooms in the building. (ii) Taking each room and summarizing, preferably numerically, its relationships to all other rooms in the building. Finally, (iii) measuring the extent of similarity between rooms in a building in terms of the summaries of the relationships of each to all other rooms.

(*i*) The relationships between each room and other rooms in a building can be identified by measurements of its plan in relation to both of proximity and adjacency. For proximity, actual distances are measured between the centroids of each two rooms. For adjacency, the type of adjacency relationship between any two rooms is identified as one of the eight types of adjacency mentioned earlier.

(*ii*) For each room, the relationships to other rooms will be summarized in relation to proximity and adjacency as follow: For proximity, the relationships of each room to all other rooms can be summarized by finding the average (mean and median) of its distances to other rooms. Accordingly for each room in the building there will be two scores (the mean and the median) summarizing its proximity relationships to all other rooms. However, the mean and the median indicate different aspects of the distances between a room and other rooms. The mean simply gives an account of all the distances, while the median concentrates upon the most frequent of these distances. The median thus summarizes the majority of the distances and not them all. The mean and the median are appropriate in different circumstances. In a layout where all the distances are relatively similar the mean needs to be applied. In layouts where there exist only a few distances that differ greatly from the majority of distances, then the median is more appropriate since it avoids presenting a figure that is more markedly affected by the longest or shortest distances. For adjacency, the relationships of each room to all other rooms in a building may be summarized by finding the percentages of rooms that relate to it in each of the eight types of adjacency relationship. Accordingly, for each room in a building, there will be eight percentages. Each is the percentage of the number of rooms in one of the eight types of adjacency relationships. Thus, the relationships of each room to all other rooms in a building can be summarized and indicated by either of two scores in relation to proximity, and by eight scores in relation to adjacency. Once such scores are available for each room in the building, the next stage will be measuring the extent of similarity between all rooms in it in relation to each of these scores.

(iii) Measuring similarity between rooms: The extent of similarity between rooms, in relation to the scores summarizing their proximity and adjacency relationships to other rooms, can be indicated, inversely, by actually measuring variation using statistical measures of dispersion.

For proximity, the extent of similarity between rooms in terms of the scores summarizing their proximity relationships to all other rooms can be indicated by measuring the extent of variation using the coefficient of variation or the range being shown as a percentage of the mean or the median. The coefficient of variation measures differences in the average distances of all the rooms in a building, while the range takes into account only the longest and the shortest of these distances. If the average distances found in (ii) above, differ greatly from each other, then the coefficient needs to be measured as it captures the differences wholly. If the average distances differ slightly then measurement of the range will suffice, since it resembles the coefficient of variation for such differences in distance. The coefficient of variation and the range when measured in relation to the mean and the median of the distances result in four alternative ways of indicating similarity between rooms and thus the extent of uniformity of circulation. Deciding upon which alternatives to consider can not be done at the outset, because it depends upon the resulting measurement of distances. However, in comparing buildings in terms of their uniformity of circulation, it may not be appropriate to measure different alternatives in different buildings, as that might increases the subjective element in the assessment. Accordingly measurements of all the alternatives are needed and then an assessment of buildings in terms of their rank order could be one way of comparing them. The four alternatives to the measurement of uniformity of circulation as far as proximity is concerned, thus, are:

<u>Indicator One</u> = The coefficient of variation between rooms in terms of the mean of their distances to all other rooms.
<u>Indicator Two</u> = The coefficient of variation between rooms in terms of the median of their distances to all other rooms.
<u>Indicator Three</u> = (Maximum mean of the distances between a room and all the rooms - Minimum mean)*100/ The mean of means.
<u>Indicator Four</u> = (Maximum median - Minimum median)*100/ The median of medians.

The extent of similarity between rooms in their adjacency relationships to all other rooms can be indicated inversely by measuring the extent of variation of the percentages of the number of rooms in each of the eight types of adjacency relationships. Uniformity of circulation for adjacency is to be measured and indicated for each of the types of adjacency relationships. There will be eight parallel scores each indicating the extent of uniformity of adjacency within a particular type of adjacency. Each of these scores represents the extent of similarity between rooms in relation to the percentages of rooms in a particular type of adjacency relationship. A building in which all rooms have similar percentages of rooms in type three adjacency relationships, for example, would have a high extent of uniformity in type three of adjacency relationships. The extent of uniformity may vary in a building with respect to the eight types of adjacency relationships, depending upon the extent of similarity in the respective percentages. If the overall extent of uniformity with respect to all the eight types of adjacent relationships is needed, then it would seem sensible to average the resulting eight scores and their mean could be used. However the mean itself has been found unsatisfactory after these measures were tried in a pilot study.(Appendix-A2) It was found that the values of the eight scores differ considerably and a simple mean would not be fully representative. It was found that the adjacency types that contain fewer relationships always score low, i.e. the value of the coefficient of variation is considerably greater than those in other types.

Such variation between adjacency types in relation to the values of their respective scores of uniformity would distort the overall extent of uniformity if averaged directly, since the overall score would be greatly affected by the scores of types containing relatively fewer relationships, rather than by the scores of types of adjacency containing the majority of relationships. Accordingly, it was thought that if the score of each adjacency type was multiplied by a factor representing its weight among the remaining eight types, then the overall measure of uniformity would reflect more accurately the extent of similarity between rooms in a building, since it would be affected by the extent of similarity in types of the majority of relationships more than by that of the less frequent relationships. The weight factor for each type for this purpose is the proportion of relationships falling within the type concerned out of all the relationships in the building, i.e. those distributed between the eight adjacency types. This, of course, could be achieved by counting the relationships for each type for all rooms, rather than for each room individually. Accordingly, the overall extent of uniformity would be the mean of the extent of uniformity of the eight types after they have been multiplied by their weight factors. The types with fewer relationships and higher scores would have their scores reduced proportionally to the number of their relationships. There would then be one score for each building indicating the extent of its uniformity of circulation with respect to adjacency. This single score, incorporating those of the various adjacency types, is used in the comparison of buildings in which the majority of relationships differ from each other. It does not only distinguish buildings in which relationships are clustered in a particular adjacency type and vary in the extent of uniformity, but also between buildings which vary in the type of adjacency in which the relationships are clustered and in the uniformity within each type.

To summarize, measuring the extent of uniformity of circulation in a building involves first, identifying adjacency relationships and distances between each room and all other rooms in it, second, summarizing for each room the average relationship to other rooms in terms of the mean or median distance (proximity), and the percentage of rooms relating to it in each adjacency type (adjacency), and thirdly, measuring the extent of variation between rooms in relation to the summaries of their relationships to other rooms.

3.5. Concentration and Modularity of Structure:

Concentration and modularity of structure are two interrelated variables in the layout of buildings. In general terms, concentration of structure relates to the reduction in the supporting points of the structure. Modularity of structure refers to the extent of similarity of the structural modules. Both of these variables are generally shown on the plans and the section drawings of the buildings.

3.5.1. Concentration of Structure:

Concentration of structure is the extent of the reduction in the supporting points of the structure, either in terms of the number of supporting verticals or their cross-sectional area. Buildings can be compared in relation to both the reduction in the number of their structural verticals and the area of these verticals in the plan. Comparisons with respect to the number of verticals can be made in relation to the ratio between the number of supporting points and the area of the building. The resulting ratio can be shown as a percentage, i.e. indicating the number of supporting points for each 100 sq.m. of area. The lower this percentage, the greater the extent of concentration. This percentage will be referred to as Indicator One. With respect to the reduction in the area of the vertical supports, buildings can be compared in relation to the percentage of the total area taken by the vertical supports. The lower this percentage, the greater the extent of centralisation of the structure. This percentage will be referred to as Indicator Two. Both of these indicators need to be considered together in the comparison of buildings, as each is a partial indicator of the extent of concentration of structure. The concentration of structure means reducing the effect of factors that hinder the freedom with which a layout may be sub-divided. Both the number of supporting points and their area act together since they, together with other factors, relate to the amount of the structure needed. Accordingly, increases in the amount of either means a reduction in the amount of the other. Buildings with fewer supporting elements are not necessarily high on the extent of centralisation as these supporting elements could occupy a greater proportion of the total area.

3.5.2. Modularity of Structure:

Modularity of structure refers to the extent of similarity or repetition between the structural modules in the plans of buildings in relation to their dimensions and areas. The dimensions and area of the structural modules vary between buildings, and the less the variation in either the more the extent of modularity. Both area and the dimensions need to be considered to allow for the differing extent of modularity to be assessed. Variation between modules in a building, as with the room uniformity will be measured by the coefficient of variation.

3.6. Zoning of Area of Special Provision:

Certain parts of buildings are zoned because of requirements for special provision. In almost every building there are some rooms that differ significantly from the rest in their characteristics, particularly in terms of their servicing and environmental conditions, e.g. operating theatres in hospitals. The location of such specialized rooms in relation to other rooms differs between buildings.

In some, they are distributed randomly or where they are needed in the various parts of the building. In other buildings, there have been certain design decisions to cluster or group these rooms together. It is this grouping of rooms that is to be examined as representative of the ideas that suggested the zoning of areas of special provision. At the same time, it is the extent of this grouping that needs to be measured.

However, before attempting to propose measures for this the criteria which distinguish rooms of special provision, i.e. those to be grouped, from other rooms must be identified. The criteria can be any of the characteristics of rooms. Each of these characteristics could be used to identify various room types. In many studies zoning has been examined in relation to services.(28) The level of services provided was the criterion to illustrate the difference between areas of special provision and others.(29) The differentiation between intensive supply and other is an unexplored matter, which could vary enormously between building types. Bathrooms in housing are more specialized than other rooms, while in hospitals they are too low in their extent of specialization of services compared with operating theatres. Yet, while accepting this diversity among building types, it would always be possible to agree upon certain guidelines with respect to each. A useful tool for this differentiation between rooms in buildings could be the use of the scale of service levels developed by Llewelyn-Davis et.al.(30). In this eight servicing levels were identified, covering all room types in hospitals, classified according to the number of different service outlets present in them. Thus, taking this scale of servicing as the criterion to be used to differentiate between the various room types in buildings, certain judgements still need to be used to distinguish the rooms of specialized provision from other rooms.

The extent of zoning or grouping of rooms of special provision is discussed in relation to the extent to which these rooms are related to each other in their location. The more closely located are such rooms the more the extent of zoning. The location relationships between such rooms need to be indicated in relation to the location relationships between all rooms in the building. The location relationships will be illustrated by both the proximity and adjacency between rooms.

3.6.1. Zoning and Proximity:

The extent of zoning of rooms of special provision in relation to proximity is indicated by the extent to which these rooms are close to each other compared with how close other rooms are to them. The extent of zoning is indicated in a ratio of the average distance between specialized rooms and that between all rooms in the building to be shown as a percentage. To obtain such a percentage the distances between each room and all other rooms in the building should be measured. The nominator of this ratio is the mean of the mean distances between each specialized room and all other specialised rooms. The denominator of the ratio is the mean of the mean distances between each room and all other rooms in a building. The smaller this ratio, the more the gap between distances between specialized rooms and those between all rooms, thus the more the extent of zoning.

3.6.2. Zoning and Adjacency:

The extent of zoning of rooms of special provision could be indicated in relation to the types of adjacency relationships between specialized rooms if compared with those between all rooms in a building. The types of adjacency relationships have been identified as eight in an earlier discussion of uniformity of circulation. These types could be reduced to fewer types to indicate the extent of grouping of rooms of special provision and thus their zoning. When considering circulation, adjacency took into account grouping and accessibility. Zoning does not need to take accessibility into account. Thus, the eight types of adjacency are not needed. What is required is only two types that illustrate grouping - adjacent and not adjacent. This is much the same as proximity, but what the two types of adjacency add is an indication of a greater (adjacent) or lesser (not-adjacent) degree of zoning. In buildings with higher extent of zoning of rooms of special provision, the percentage of relationships between rooms that are adjacent should be higher between specialized rooms than between all rooms in a building. Accordingly buildings may be compared in relation to the ratio between the percentage of adjacent relationships between specialized rooms and that between all rooms in a building. To sum up, the extent of zoning of areas of special provision, will be indicated as a ratio of the proximity and adjacency between specialized rooms and between all rooms in the building.

3.7. Measures of Design Variables - Summary:

The aim of this chapter was to propose measures for the design variables that have been identified in Chapter II as factors that contribute to the flexibility of buildings. These are variables describing the whole layout of buildings and are present in every building but to a differing extent. To measure them, certain criteria need to be satisfied, including validity, reliability, sensitivity and applicability to the drawings of the buildings. The variables identified for measurement were: i) Uniformity of rooms; ii) Uniformity of circulation pattern; iii) Concentration and modularity of structure and iv) Zoning of areas of special provision. However, the measures of both the uniformity of rooms and the uniformity of circulation pattern have been developed and tested in some pilot case studies. (Appendix-A)

(i) Uniformity of rooms has been broken down into a number of parallel sub-variables, each relevant to one of the characteristics of rooms by which uniformity is measured. The measures of uniformity need to be modified when applied to different characteristics, since these differ in their scale of measurements. Uniformity of rooms was indicated in relation to the general characteristics by the extent of minimization of room types and by variation in the distribution of rooms between room types. In relation to some specific characteristics such as area, uniformity of rooms was indicated by the extent of variation between room areas, with or without the grouping of rooms.

(ii) Uniformity of of circulation has been related to previous studies that represented circulation patterns. Its extent was illustrated in relation to proximity and adjacency between rooms.

(iii) Concentration and modularity of structure are largely interrelated. Concentration can be measured by the extent to which the number and the areas of vertical structural supports are minimized in relation to the area of buildings. Modularity can be measured by the extent of similarity between the structural modules in relation to their dimensions and areas.

(iv) Zoning of areas of special provision can be measured by the extent to which specialized rooms are close to each other compared with how close are all rooms to each other, and that is in terms of proximity and adjacency.

The measures proposed constituted the first research objective of this study. The following chapter will deal with the second research objective of the study, that is the proposal of a system of measurement by which the extent of flexibility of buildings in use could be assessed.

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CHAPTER IV

THE FLEXIBILITY OF BUILDINGS IN USE

4.1. Introduction:

The previous two chapters were concerned with the first objective of this study, that is the proposal of a system of measurement by which the extent of incorporation of some selected design variables in design proposals could be assessed. This chapter deals with the second research objective. The aim is to propose a system of measurement by which the extent of flexibility of buildings in use could be assessed.(p.19)

Only a limited number of proposals for directly measuring the flexibility of buildings have been made but these produce many problems.(p.12) In order to find indicators with fewer problems, literature concerned with the definitions of flexibility will be reviewed to isolate the basic attributes of flexibility. Indicators of flexibility then will be reduced to the measurement of these attributes. Past attempts to measure these attributes will be examined and their problems noted. Finally, the indicators of flexibility will be outlined and the research tool for obtaining the relevant data, that is a questionnaire, will be given. The chapter will conclude with the identification of two types of indicators of the flexibility of buildings in use. Neither of these types provide an abstract assessment of the extent of flexibility in each building. Rather, each enables assessments to be made of a particular building only in relation to some other buildings.

4.2. The Meaning of Flexibility:

'Flexibility would appear to be regarded as a highly desirable characteristic without any clear definition of term having been arrived at', stated Moss and Anderson.(1) Previous studies of the meaning of flexibility are of two types. In some, a single definition of flexibility was used, while a number of definitions were utilized in others. The general meaning of flexibility can be extracted from studies that used one definition, while more detailed meanings relevant to the classes of flexibility can be obtained from studies where many definitions were proposed.

4.2.1. <u>The General Meaning of Flexibility</u>:

The definitions in most studies have three points in common; i) They treat flexibility as a capacity of buildings, ii) they state the objectives that buildings are to fulfill according to this capacity, and iii) they state the means by which buildings can achieve these objectives. Examples of these definitions include those by Pye(2), Lynch(3), Turan(4). However in many studies the term adaptability was used rather than flexibility.(5) Pye noted that flexibility was defined as 'the ability to be adapted to changing circumstances'.(6) Lynch defined adaptability as 'the generalized adjustability of an environment or artifact with minimum effort to future change of use'.(7) Turan referred to it as 'the capacity to provide re-arrangement, re-organization and expansion...'.(8)

The objectives of flexibility are concerned with the accommodation of change. The means, i.e. the accommodation of change can be made with or without the use of building adaptation. The general meaning of flexibility thus is the ability of a building to cater for future change either with or without adaptation. As such, flexibility is inherent in any building but to a differing extent. In this respect, Moss and Anderson noted that 'it would be anathema...to say that the design is not flexible even when it can have only restricted uses. What this usually means is that the design allows for a range of uses and/or management patterns in addition to those set down in the brief'.(9) All buildings can cater for change, but to differing degrees. All buildings can be adapted, but some can be adapted more easily than others.

In discussing flexibility, previous studies, though they explicitly referred to it as the capacity of buildings, implicitly spoke of the need to increase its extent in buildings. In measuring the extent of flexibility in buildings, past studies provided a general idea of what its main attributes are. The extent of flexibility can be assessed in relation to the amount of change to be catered for and the amount of adaptation necessary. Greater extent of flexibility has often been equated with on the one hand increasing the range of objectives, and on the other, decreasing the necessary resources of means. Increasing the range of objectives has been referred to in terms of new conditions(10), more freedom of choice(11), more uses(12), more change(13) and so on. Decreasing the necessary resources has been in terms of no adaptation(14), minimum effort(15) and so on. Statements were frequent in the literature though not formulated in terms of a comprehensive system of measurement. However, the important point to be emphasized is that in most of these studies a description of flexibility appears to be a statement about both the objectives and the means, i.e. about the amount of change in relation to the amount of adaptation. This is the main point in the qualification of flexibility. In order to be able to quantify the two attributes of flexibility, that is change and adaptation, an examination of its specific meanings is needed. Specific definitions were made in relation to classes of flexibility. Such classes often implied differences in the extent of flexibility.

4.2.2. Specific Meanings of Flexibility:

In other studies, many definitions of flexibility were proposed. The definitions reflected the general meaning of flexibility although each referred to a particular class of it. The analysis will focus upon the main criteria used by previous writers to distinguish between the classes of flexibility they identified. Generally, the classes of flexibility within each of the previous studies were identified in relation to either or both the objectives of flexibility and the means of achieving them. Within the general objective of flexibility - catering for future change - classes have been identified in relation to the types of change to be accommodated. Similarly, within the whole spectrum of means of achieving the objectives of flexibility - that is with or without adaptation - classes have been isolated from each other depending on which of the cases of adaptation is involved.(16)

The classes of flexibility which resulted present many problems. These problems exist whether either or both of the objectives or means have been used as criteria of classification. If either is used, the problems are limited to those concerned with the overlap between the classes of flexibility that resulted and with the limited number of classes actually being identified. If both objectives and means are used for classification, then the problems are concerned with the validity of the resultant definitions. However, while the problems occurring when either the objectives or the means are used may be sorted out by further clarification of them as criteria for classification, those which resulted when both are used cannot be dealt with unless empirical evidence is provided. Where both the objectives and means were used, the resultant classes were based upon certain assumptions about the relationship between them. It would be justifiable, as a matter of definition, to give a word to a class of flexibility in relation to a particular type of change or a particular case of adaptation. It is hardly justifiable to give a word to a class of flexibility referring to a particular type of change with the assumption that this type of change is to be catered for by a particular case of adaptation, if evidence is not available. Since such evidence was not available it is not clear how classes of flexibility, including specific types of change and specific cases of adaptation, can be defined. Accordingly an attempt will be made to explore the classification of flexibility only in relation to either of the objectives (i.e. the types of change) or the means (i.e. the case of adaptation).

(i) Objectives of Flexibility:

Examination of the classes of flexibility in relation to the types of change helps with the clarification of criteria to measure the extent of flexibility in a building. The classes of flexibility have been identified in relation to different types of change. The types of change attached to these classes differed in two main ways. In some studies, the types of change differed because they referred to differing phenomena in which change occurs, such as one function or many functions as used by Pena.(17) In other studies, the types of change differed in relation to some attributes of change considered as criteria for their classification.(18)

The classes of flexibility where the types of change differed because of the phenomena in which change occurs are not necessary, since the types of change are not actually different. Most types of change result in a change in the activity demand for space - a main cause for the deterioration of fit between activities and the spaces occupied. The resultant classes of flexibility often overlap, as in the classification of flexibility into expansibility, convertibility and versatility by Pena et.al.(19) Convertability is distinguished from versatility according to the number of activities in which change occurs, and is to be catered for. Convertability thus caters for one activity while many activities are attached to versatility. But the accommodation of change in one activity or in different activities is not critically different, since the consequences of both these changes are similar, that is, change in the demand for space of the activity to be accommodated. In addition, while expansibility is attached to the accommodation of growth, in contrast to both convertibility and versitility which cater for change, it could be part of convertibility or versatility and not a distinct class. This is so because growth is not different from change but a class of it, as it is by definition a change in size or magnitude of a specific property of a particular phenomena.(20) If the phenomena to be considered is the demand of activity for space then growth in the area required for example is only a change in the amount of area required. Furthermore, it could also be observed that the criterion used to distinguish between the three classes of flexibility in this example, is not the same. While the criterion was the number of 'functions' to be catered for, as the distinction was made between convertability and versatility, the criterion which distinguished expansibility from both was the nature of change and not the number of activities in which change occurs. Thus expansibility was defined as catering for growth as opposed to other terms which are relevant to the accommodation of change.

Where the classes of flexibility have been isolated in relation to types of change being identified according to the attributes of change, though theoretically only limited classes were identified, some of the attributes are particularly relevant to the measurement of flexibility. An example of this is the classification suggested by the OECD.(21) The OECD has attached the objective of catering for small magnitude-high frequency changes to the concept of flexibility, while the objective of catering for large magnitude-low frequency changes was attached to adaptability. It is evident that the OECD categorization of change is based on the attributes of magnitude and frequency of change. However, the OECD in isolating the two types of change and attaching each to one of the two classes of flexibility had not only overlooked other types of change (that is Large magnitude-high frequency changes and Small magnitude-low frequency changes), but also had not considered another main attribute of change, that is uncertainty, in relation to the classes of flexibility. Accordingly, there is no account of how either flexibility or adaptability caters for other types of change resulting from considering magnitude, frequency and uncertainty of change as criteria for the categorization. From such classification, the resultant types of change in relation to the magnitude of change are useful. They enable the assessment of flexibility in a building after the occurrence of change. Buildings could be compared in relation to the amount of change that has occurred in them.

To summarize, the relevance of examining the classification of flexibility in relation to the types of change considered (i.e. objectives) to the measurement of flexibility are twofold; first, the class of flexibility that covers the rest is identified as that concerned with change in the demand of the activities housed in buildings for the resources of accommodation, and second, that the classes that differ in the extent of flexibility can be indicated by reference to the types of change catered for in relation to the magnitude of change.

(ii) Means of Flexibility:

Past classifications of flexibility in relation to the means (i.e. adaptation) are a useful basis for illustrating the extent of flexibility in relation to the extent of adaptation. The extent of flexibility relates inversely to the extent of adaptation. The majority of the relevant classes of flexibility concern the accommodation of change by reference to the presence or absence of adaptation and its differing extent. The highest extent of flexibility exists when adaptation is not needed. Once adaptation is considered, then the extent of flexibility decreases as the extent of adaptation increases. This is the general theme in most studies of flexibility in relation to adaptation, though many studies are not clear enough about the meaning of adaptation, thus resulting in an overlap between the classes of flexibility they sought to identify.

Previous studies generally treated adaptation as any major change in buildings' elements, such as re-allocation of partitions, or structural alterations.(22) Accordingly, accommodating change with adaptation covered the changes in some buildings' elements rather than in others. Changes in the latter covered the case without adaptation. But, especially with modern systems of construction, pre-fabrication and integrated furniture systems, the classification of buildings' elements becomes more difficult. Lines cannot be drawn clearly between the different elements. This resulted in overlap between the cases with and without adaptation. The classes of flexibility which catered for change with adaptation overlapped with those which catered for change without adaptation. It could also be noted that in previous interpretations of the case of 'without adaptation', the term has included two different cases. The first is that in which change occurred only in certain building' elements such as moveable partitions and furniture, while the second case is that in which no changes whatsoever happened to any of the building' elements.

Most design ideas on increasing the extent of potential flexibility can broadly be grouped into those that increase the ease with which adaptation can be made irrespective of the buildings' elements in which adaptation is made, and those that increase the extent of looseness of fit, i.e. the accommodation of change without any adaptation whatsoever.(p.36) Design decisions to increase the ease of adaptation relate to technical matters concerning the elements of buildings.(p.47) Design decisions to increase the extent of looseness of fit concentrate upon activities and upon how much people can tolerate mismatch between the accommodation demanded and that actually provided.

In view of this sharp distinction between the cases where changes are made in one or more of the buildings' elements and those cases where no changes whatsoever are made, it is not clear how previous studies justify their distinction between the cases of with and without adaptation. They misleadingly included the cases of no change whatsoever and of changes in some elements in the same category (called 'without adaptation') and the cases where changes are made in other elements in the other category (called 'with adaptation'). In short, it is not clear why closely interrelated changes in various buildings' elements were separated into two categories with and without adaptation, nor is it clear how essentially different situations (without any change and with change in some elements) can be classified under one category (without adaptation). It would be better to interpret adaptation in terms of changes in any of the buildings' elements, whether furniture, partitions or structure are concerned. It would be possible to describe the degree of such changes (adaptation) as on a continuum. At one end they are reversible, and at the other, much less reversible. Reversible changes in buildings' elements are exemplified by re-arrangement of furniture and moveable partitions, while irreversible changes are exemplified by structural alterations. The case of accommodating change with adaptation then covers changes in buildings' elements at both ends of the continuum. The case of accommodating change without adaptation refers to that in which no changes whatsoever are made to any of the building elements. The two casesare widely different from each other in essence. Thus, it is possible to arrive at distinct classes of flexibility, one referring to the case of change in any element (with adaptation) while the other refers to the case where no change is made in any element (without adaptation).

To summarize, the meaning of flexibility can be stated in some detail in relation to the types of change to be catered for and the case of adaptation involved. The classes of flexibility imply variation of its extent depending upon the amount of change to be catered for and the extent of adaptation needed. Greater flexibility relates to greater change and smaller adaptation. A statement about the flexibility of a building can not be made unless both the amount of change accommodated and the level of adaptation required are described. Accordingly, the term flexibility in this study will be used to refer to the capacity of a building to accommodate change in the demand of the activities housed in it for resources of accommodation without adaptation or with varying levels of adaptation.

4.3. Outlining the Measures of Flexibility:

The flexibility of various buildings ranges along a continuum depending upon the amount of change that can be accommodated in them in relation to the amount of adaptation necessary. This is the main issue concerning flexibility in buildings; it can not be described in relation only to change or only to adaptation. It is a statement about both, i.e. about the relationship between change and adaptation. Thus, buildings may be compared in relation to their flexibility in accordance with the amount of change being accommodated for each amount of adaptation, or in accordance with the extent of adaptation necessary for certain amounts of change. There were various proposals for the measurement of change and adaptation in the literature, and these may be utilized in measuring flexibility itself. An attempt will be made to explore these proposals.

4.3.1. Indicators of Change in the Demand:

Change in the demand for space is indirect and may be measured once the states of demand at at least two points in time are known. At any particular point in time, the demand of activities for space reflects various interrelated properties of these activities and their allocation in buildings. There are various factors that can be used to indicate change in the demand of an activity for resources of space. These include:

(i) Change in space standards.

(ii) Change in room usage.

(iii) Change in buildings.

(iv) Change in users.

(v) Change in activities.

In the following sections, an attempt will be made to explore the the appropriateness of these indicators with respect to indicating change in the demand of the activities housed in a building over time. The indicators will be examined in relation to some empirical exercises carried out on certain buildings and departments of the Oxford Polytechnic. (Appendix-B) The exercises were aimed at determining the availability of data on past activities and use, and at testing whether the data available could provide an adequate assessment of change in demand.

(i) Change in Space Standards:

In theory, change in space standards can be used to indicate change in the demand of activities housed in a building for space. For activities in buildings, an assessment of their demand for space at any point in time can be made by considering space standards with some supporting data describing such activities. Thus assessing in this way the demand at two points in time would enable measurements to be made of the amount to which it has changed over the period of time examined. Despite this possibility in theory, change in space standards cannot often be used in practice for four main reasons:

a) Space standards for the allocation of activities in buildings may not be available for all types of institutions and for all dates in the past. b) Even if past space standards are available, there is no assurance that the past allocation of the institution examined has been made in accordance with these standards. In such a case, an examination of published standards for the time in the past considered would become irrelevant in indicating the past demand for the institution examined. c) Even if past standards are available, they may not be usefully utilized if the necessary supporting data about activities in the past are not available. To establish the state of demand considering space standards, detailed information about past activities is needed in regard to the nature of activities, the number of people involved, patterns of rooms occupancy and so on. Finally d), even if detailed data about past activities are available together with past space standards, they may not be useful since most of the standards relate to only the most basic aspects of demand such as area.(23) However, if standards determine area, utilization of them is possible since they can be averaged for each part of the building examined. With respect to other aspects of demand, such as services and the accessibility of rooms, overall estimates of requirements of activities for selected parts of a building can not be similarly averaged.

These problems have emerged from an exercise involving examination of space standards, to obtain the previous demand of some activities housed in some buildings of an academic institution - The Oxford Polytechnic. Two buildings which were occupied by parts of the departments of Construction and Architecture have been examined. The exercise aimed at identifying the state of demand of the activities housed in these buildings about five years earlier. Examination of published national space standards for polytechnics for past years has been made.(24) At the Polytechnic, information about past room usages has been sought, but no precise data existed, apart from general information that relied upon some individuals' memories about use in the whole buildings. In addition, not enough data about activities has been found. Although total numbers of students in each academic department were available, those students concerned specifically with the parts of buildings examined were unknown. In short, although some space standards were available for this particular case study, they were of no great help without the necessary supporting data.

To summarize, space standards are often not a reliable means in identifying the previous state of demand. They may not be available, or the allocation of activities into buildings may not have been made in accordance with standards. If available, they need to be complemented with knowledge about the previous characteristics of activities which often are not recorded for the parts of the institution housed in the buildings examined. Thus, in practice, change in space standards is not a reliable indicator of change in the demand for space.

(ii) Change in Room Usage

There are certain advantages if change in the rooms' usage is considered as an indicator of change in the demand. If change of rooms' usage is to be measured, then the previous uses of each room need to be known. The usage of a room at any particular point in time can be identified within a number of types of use. Each of these represents a general statement about the purposes for which rooms are used. Various typologies of rooms' usages have been suggested in different studies, although it is often not clear what the criteria were that have been used to distinguish between different types of rooms usage.(25) Nevertheless, the general criteria included the nature of activities carried out in each room, the number and specific characteristics of users, the patterns of temporal occupancy, and in some cases the characteristics of rooms themselves, being physical, servicing ...etc.

Change in the usage of rooms can be measured by preparing a list of the types of use in all rooms in the building over a set period of time. By considering the beginning and the finishing years of the period, a use pattern can be identified. The use pattern of a building in each year is the number and the area of rooms that fall into each of the types of room' usage identified shown as percentages of the total number of rooms in a building and its total area. Change in the rooms' usages of a building over a particular period of time will be indicated by the difference between the percentages of both the number and the area of rooms for each use type between the beginning and the finishing years of the period examined. The resulting differences will indicate the extent of change in each of the types of use.

The basic advantage of using change in the usages of rooms as an indicator of change in the demand is the availability and the retrievability of the data that describe use patterns at a particular point in time. Data describing present use patterns can be gained from a survey of the building concerned. Data describing past use patterns can be gained from interviews with users who have used the building over the period of time in question. The control of the data available is related to the fact that they are concerned with rooms and do not involve any detailed analysis of activities. To assess the advantage of using change in rooms' usage as an indicator of change in the demand an exercise was carried out in relation to some of the Oxford Polytechnic buildings. (Appendix-B2) The aim was to indicate the extent of change in the demand of the activities housed in these buildings over a three years time.

The exercise involved various tasks. a) The plans of three buildings were updated from a survey of rooms to show their present sub-division and modified to show previous sub-divisions. b) An attempt was made to identify a typology of rooms' usage as expected in buildings of higher education institutions. That was carried out by reviewing previous proposals in this respect. These included those proposed by UNESCO(26), the Department of the Environment(27), the Unit for Architectural Studies(28), the Cambridge Centre for Land Use and Built Form Studies(29), the Laboratory Investigation Unit(30), and some others (31). c) In accordance with the types of rooms' usage which emerged, the usage of each room in the three buildings was identified for the beginning and finishing dates of the period examined. Finally, d) an attempt was made to indicate the amount of change in use in each building in terms of the percentages of rooms and their areas relevant to each of the use types. However, the resulting data was not very useful, because in the period examined only a few of the rooms had their usages changed. In addition, since the total areas of the three buildings has remained constant over the period examined, it was not possible to arrive at an overall estimate of change in each building by averaging the extent of change with respect to the various use types. Such an approach may have proved more useful, had relatively longer periods of time, and larger buildings been examined, allowing both the occurrence of more change in the usage of rooms and in the total area of buildings.

There is still a further problem with room usage as an indicator of demand, and that concerns subjectivity. The types of use that could be identified before the investigation of the buildings were not clearly distinguishable from each other. In most of the proposals for the typology of room usage, various implicit and subjective assessments were used in the literature in differentiating a particular use type from another. The identified types in any study often overlapped in criteria which haven't been spelt out explicitly nor defined operationally. Often the resulting types have differed in relation to the nature of activities carried out, the size of groups housed in rooms and the characteristics of people involved or even the characteristics of rooms themselves without this being made clear. The method is to a great extent limited to the measurement of change in buildings belonging to a similar building type. Most of the proposals for the typology of rooms' usage suggested in past studies are relevant to a particular building type. This is, in itself, a consequence of the absence of any operationally defined criteria for the typology. Proposals of the typology of rooms' usage in hospitals(32) or laboratories(33) are often unique and applicable only to those building types.

There are many other problems in treating change of use as an indicator of change in demand. Just as the description of the usages of rooms incorporates the characteristics of activities, users, or buildings, change of use will most likely overlook changes in these various aspects. A change in the type of a room usage could be a change in the number of people occupying it, their pattern of temporal occupancy, the purposes of use or the activities carried out in it, or even any adaptation made to the facilities within it. All such changes are overlooked by referring only to changes in the inadequately defined types of use. A further limitation of using change of room usage as an indicator of change in the demand, is that it is related only to demand for the facilities within rooms and says nothing about change in the demand for the location of rooms in terms of changes in patterns of communication between users in different rooms.

To summarize, the use of a room is so general a statement about what is carried out in it or by whom or even about its physical characteristics, that change in rooms' usage is far from conveying precisely the change in demand of the activities in buildings. This is coupled with the fact that most proposals of the typology of rooms' usage are inadequately defined and relevant to specific building types.

(iii) Change in Buildings:

The argument for indicating change in demand by change in the buildings occupied is based upon the assumption that the demand of activities housed in buildings at any point in time is reflected by the characteristics of the building itself at the time concerned.(34) The problems with this argument relate to problems in this assumption and in the requirement to examine only those buildings whose total areas have changed over time.

The assumption that the plans of a building represent the demand of the activities housed does not hold true in many cases. The demand of the activities housed may change in various ways but still without any corresponding changes in the buildings occupied. People, normally, do not need to have their buildings changed with respect to every change in their activities inside these buildings, since they can tolerate a certain extent of mismatch between their optimum demand and what is actually provided. It is when the extent of mismatch becomes intolerable that decisions to adapt buildings are normally taken.(35) Accordingly, the examination of change in buildings over time is likely to reflect only a proportion of the change in the demand that has occurred previously. Changes of demand that are reflected in changes in buildings are normally those of a relatively large scale, i.e. when adaptation of buildings is needed. Thus, an examination of change in buildings as an indicator of change in demand and then the flexibility of buildings would only be relevant if the hypotheses to be tested are between the flexibility and design variables concerned with increasing the ease of adaptation. In this study, emphasis is placed upon the testing of hypotheses about the relationship between flexibility and design variables concerned with the accommodation of change without adaptation by increasing the potential looseness of fit. Therefore, for the purpose of this study, measurement of change in demand in this way is of limited use. Moreover, there are further problems.

For example, the length of the period examined is also relevant to the adoption of change in buildings as an indicator of change in the demand. It is often only over relatively longer periods of time that change in buildings, i.e. adaptation occurs. Examination of longer periods of time is normally limited by many other factors such as the availability of data and past records. The use of change in buildings as an indicator of change in demand is limited also by the need to examine only buildings whose areas have changed over time. Most past studies have produced graphs representing change in the total area of the buildings examined.(36) If buildings whose total areas have not changed over time are to be examined, then this approach is not applicable. Buildings, whether they have changed in area or not, are the object of this study. The emphasis is upon design variables other than the total area. An alternative could be the examination of changes in the areas of individual rooms rather than of the whole building at once. Again, this would soon prove limited, as normally, though the subdivision among rooms in a building may vary over time, the number of rooms in most cases does not change greatly. Consequently, averaging the extent of change in the area of each room, for example, to give an overall extent of change in the whole building, would always approach the value of zero, thus posing a difficulty in the comparison of a group of buildings.

To summarize, there are various limitations to the use of change in buildings as an indicator of change in the demand of the activities housed in them over time. It does not convey enough information about various aspects of change and it limits the selection of buildings and the periods of time over which they may be examined.

(iv) Change in Users:

A further indication of change in the demand could arguably be achieved by examining changes in the characteristics of the users of buildings over a set period of time. The relationships between the users and their demand for accommodation is largely interrelated with the nature of their activities. However, the argument for examining the users is largely based upon the assumption that even similar activities, performed by different users of buildings may need different resources of space. A support for this argument may be found in different sources, for example, a Ph.D. thesis in which the relationship between the status of individuals within an organization and their requirements for space has been examined in relation to offices.(37) Members of an organization may require different provision of space with respect to generally similar tasks being performed, according to their status.

The characteristics of users in which change may occur vary widely. The choice of characteristics for examination is often affected by the availability of records or other sources of information regarding the previous characteristics of users in buildings. This may be seen in the limited characteristics examined in previous studies that looked at the history of certain institutions and their buildings. Most of these studies concentrated upon the numbers of users over a set period of time.(38) What helped determine such a choice was that past studies often examined change in whole institutions. The numbers of users in the institutions examined as a whole and in their basic functional divisions are often available in past records such as pay-slips. In situations where the object of interest is not whole institutions or their basic divisions, but those sub-sections of them that occupied certain buildings, the relevant numbers of users can not normally be obtained from records. This is the disadvantage of using this to indicate change in the demand of activities housed in certain buildings over time.

Such a problem was encountered in an exercise to find out about the data available concerning the previous characteristics of users of three buildings of the Oxford Polytechnic. The most detailed records found were relevant only to whole departments of this educational institution. To summarize, change in the characteristics of users while in theory a reasonable indicator, in practice is difficult to use because of lack of data.

(v) Change in Activities:

Change in activities can be directly related to change in their demand for space, but its use as a measure is limited again by problems in methods of collecting the relevant data. The measure of change in activities depends upon the availability of data describing the activity pattern that was performed in a particular building at the beginning and end of the period of time to be examined. The data that may describe activity patterns, however, are very diverse. Such diversity relates to the meaning of activities and to their various dimensions. In exploring the meaning of 'activities', Farbstein has stressed that there is no universally accepted definition of 'activity pattern', and referred to it generally 'as a description of the typical make-up or flow of activities for a population group, a class or an organization'.(39) The activity pattern of a particular organization, he noted, 'consists of the highly interdependent activity routines of the people who compose that organization'.(40) An activity is treated as 'an abstraction of human behaviour'.(41)

Change in activities can be indicated by the difference between the data describing the types of activities at a particular time and that at another. Data describing activities at any time depend upon the dimensions of activities examined and thus relate to the approach taken in the categorization of activities. In this respect, Farbstein classified past studies concerned with the categorization of activities in accordance with the approach they used into three groups. Each of the groups had considered categorization in relation to either of three dimensions of activities. These are: 'the nature of the activity, or what is done; the actors, or those who take part; and the time patterns through which activities occur'.(42) The aim of categorizing activities was to partition the continuous stream of human behaviour 'into more or less discrete 'episodes' which can form the elements or units of analysis'.(43) The categorization of activities in various studies has often resulted in a large list of activity types. These lists are often shortened by the grouping of the resultant activity types, and that depends upon the object of interest in each study and the methods used in the analysis of the collected data. The process of this grouping of activity types is often referred as the aggregation of activities.(44)

When the nature of an activity is used as a criterion of categorization, 'most studies do not fully explain how and why they have chosen the descriptors and classes they use'.(45) In general terms, only observable actions of individuals or groups have been considered. The types which resulted from such studies are often unique in their nature, based on the context of the study. Some studies have made the categorization not only in relation to the nature of an activity, but also in relation to its location. A particular example of this is Cowan et.al. study of university activities.(46) Consideration of the location of activities in addition to their nature allows an understanding to be made concerning the appropriateness of a building in terms of the appropriateness of the facilities within each of the rooms in it as well as that of their locations. Such an understanding is to be made in connection with the requirements of institutions considering the nature of their activities in different rooms as well as the pattern of communication between them.

The categorization of activities has been carried out in relation to the individual actor or groups of actors. In both cases, 'the choice of descriptors used for the population is usually found to be intimately bound up with the initial selection of a place or a population to study'.(47) In the categorization of activities by individuals, the underlying object is to explain who does what, perhaps 'allowing us to predict the activity distribution of a population simply by knowing its composition'.(48) In this respect, Farbstein noted that such indicators are not sufficiently powerful in explaining or predicting what people do, because of the relevance of other factors such as the technology used by organizations.(49) For the categorization of activities by groups, consideration is given to any change in the composition of the population involved which might change the nature of the activity.

With respect to the time patterns, 'activities are distinguished and described according to temporal criteria which define the meshes of the sieves we use to filter them out of the continuous stream of behaviour'.(50) Activities are classified by when they start and how long they last and in what order as well as with what frequency, using 'time budgeting' techniques. Such techniques 'can be used to show how population classes divide their time among activities'.(51)

To summarize, activity patterns may be analysed in relation to a particular population in accordance to their nature and location, the characteristics of people involved and the patterns of time at which they occur. It is clear that a more detailed description of activity patterns needs to consider all these dimensions together. However, there was an important characteristic common between studies that categorized activities with respect to their various dimensions; most studies had categorized activity patterns of certain populations by using data describing these patterns at the time of carrying out the studies. The recording of such data was often made by the participants in the activities themselves, using 'activity diaries'(52), or else by observers.(53) Although in most of these studies the aim was to predict future activity patterns according to knowledge available at the time of surveys, little was done to describe past activity patterns. In this point previous activity studies fall short, and cannot be used to assist in describing change in activities over time to indicate change in the demand. Despite their value in pointing out the various dimensions of activities, their methods of collecting data are only partially useful for application to past activity patterns.

However, there are other groups of studies which aimed specifically at measuring changes in activities over time. These are often very selective in the attributes of activities they looked at. Those selected are determined by the availability of records. An example of these studies is the work carried out by the Laboratory Investigation Unit who reported change in the number of hours taught and the number of students in whole academic departments.(54) Relying upon past records restricts the attributes of activities that can be examined, and requires the examination of whole institutions only, rather than any part of them being housed in a particular building as the object of study.

An exercise was carried out to explore the availability of records that describe past activity patterns in a teaching institution, that is the Oxford Polytechnic. From an earlier exploration, it was found that past records of activities were mostly unavailable for activities in all rooms. Nevertheless, for a specific group of rooms, that is 'pooled rooms'(55), some records were available for the last few years. (Appendix-B1) Such records contain information about the groups of users who used such rooms, including the identification of the group, the purpose of using the room, the size of groups and in some cases information about the use of audio-visual materials. These facts were obtained from records of the pooled rooms committee, the registry, the modular time-tables office and the educational methods unit. Pooled rooms records were examined over a three year period with respect to one of the buildings of the polytechnic which contained a relatively higher number of such rooms compared with other buildings. Complete information for each hour for each day for the three years was not found. Since the occupancy of rooms is more consistent within the weeks of a single term, those relevant to the second week each term were taken as representative. In addition it was observed that within each week rooms' occupancy varied. Rooms were frequently occupied for most hours on Thursdays, and Thursdays were taken as most representative of week days. Change in activities was examined in the activities carried out in rooms on Thursdays of the second week of terms over three terms. The activity patterns of each for each room were recorded in terms of a code of the nature of teaching carried out-tutorial, seminar, lecture or project work, a code describing the group using it, a code of the size of the group, and finally a code for the hour of the day it was used. The analysis of such data provided little indication of change in the whole building because of the short period examined and the limited number of pooled rooms in it. Further, the whole area of the building had not changed nor had the number of pooled rooms in it.

However, a further attempt was made to use data concerning pooled rooms to indicate the demand of the four activity types with respect to the area of rooms used. It aimed to find out how much area was allocated for lecture, seminar, tutorial or project work in each of the terms examined. Such area was measured by grouping the rooms used for each of these activities, together with the size of teaching groups in them, and then finding the average area required by each student each term. Change in the demand then was shown as the difference between such averages of area expressed as a percentage of that of the first term examined. What emerged was that each of these activities was accommodated in rooms of different sizes as expected but depending upon the size of the teaching group rather than the nature of the activity. In this respect most of the activities appeared to be similar in their demand. In most cases a marginally smaller room than needed was provided, but where a larger room than demanded was provided, it tended to be very much larger. This simply relates to the types of rooms available and the average size of groups using them. The requirements of smaller groups were frequent and are accommodated by the majority of small rooms, except for one or two large rooms, which for all routine activities are going to be too large. Variations in the allocations of activities to rooms could assist in establishing the extent of the tolerable looseness of fit depending upon the amount of mismatch and its frequency. These observations are useful in two ways. First, they could provide a reliable indication of change, had the records been available for longer periods of time and for various types of activities or various room usages and not only for pooled rooms. The data, however, are very dispersed between records and are not complete in most cases. Second, they could assist in the measurements of design proposals. Assessing the extent of tolerable mismatch relates to the identification of the range of intervals needed in the measurement of uniformity of rooms in relation to some specific room characteristics such as area.

To summarize, an attempt was made to examine the applicability of past activity studies to the measurement of change in activities over time. Most of the activity studies provide useful insights into the attributes of activities being examined at present, but fell short of useful application to the descriptions of past activity patterns. Few of the studies aimed at describing past activity patterns are limited to specific aspects of the activity examined and they rely upon the records of whole institutions. However, examinations of present and past activity patterns in relation to the rooms occupied could assist in establishing the tolerable extent of looseness of fit, and thus aid the measurement of design variables such as uniformity of rooms. An exercise was also carried out to explore these conclusions.

4.3.2. Indicators of Change in the Demand - Summary:

An attempt was made to explore the validity and reliability of various indicators of the past activity demand for space, so that change in it could be measured. These indicators included standards, room usage, buildings, users, and activities. The methods used by previous studies to report such changes were outlined. None of the indicators used were found to be comprehensive and reliable in indicating change, and each had its own specific problem. Most indicators were partial if considered alone, and relied upon different methods of collecting the relevant data. The methods in many cases were not adequately reliable if applied to measurements of past activity demand rather than to present demand. There is a clear need to consider all the indicators together. Measuring them all needs to be considered with respect to an alternative method of data collection. This alternative method should not be dependent upon the availability of past records, nor is to be relevant only to a particular type of activities.

The following section will be concerned with measurements of the second attribute of flexibility - the adaptation of buildings.

4.3.3. Indicators of Adaptation:

Adaptation of buildings is relatively easy to measure compared with change in demand, though again its measurement depends upon the availability of past records. Many studies have equated the extent of adaptation to its cost.(56) Cost would provide a reliable indicator, but depends entirely upon the availability of past records. Such records may, at times, be available for all buildings occupied by a particular institution, but not for each of its buildings or for each part of each of its buildings. It falls short of use for the objective of this study, in which the adaptations to selected parts is what needs to be measured. An exploratory exercise to test the soundness of this conclusion was carried out, with respect to adaptations of some of the buildings of the Oxford Polytechnic. From discussions with the building officer and technicians in various departmental workshops, it emerged that many adaptations were carried out by the Polytechnic's own technicians and not by outside firms, and records of their cost were not available. In addition, many of the adaptations have not been entered on plans of buildings. This increased the difficulty in obtaining relevant data. Accordingly, an attempt was made to look for further indicators of adaptations.

Past studies have classified the extent of adaptation by various criteria. These included the craftsmen involved in carrying out the adaptation(57), and the element of buildings in which adaptations were made.(58) Though neither of these was an entirely satisfactory indicator, they held true for many cases. If adaptation is complex then always there is a need for a specialized firm to carry it out. Similarly, if it involves changing constructional elements of buildings, its extent is higher than that of moving demountable partitions. Adaptation can also be looked at in terms of the disturbance to other users in the building.(59) The more they are affected, the more its probable extent. These ideas relating to adaptation can be used to overcome the problem of un-availability of data on the cost of adaptation. However, as adaptation ranges widely over a continuum, many of the changes in building elements are reversible and might not have been reported on the plans or on other records.

4.4. Alternative Indicators of Flexibility:

The previous section was concerned with exploring the various indicators of change in the activity demand for space and the adaptation of buildings. The main problem common between change in the demand and adaptation was with the methods of obtaining data. Change in the demand, in particular, encounters a difficulty with the lack of comprehensiveness of the indicators used in past studies.

The alternative measure of flexibility proposed did not suffer from the partiality of indicators because it used them all. Data was to be collected through the use of questionnaire, about the various indicators. A questionnaire provided the opportunity of gaining data about activities in the specific part of a building occupied by a particular institution. Thus it could provide more relevant data for the specific objective of comparing buildings in terms of their past change of activities and past adaptation. A questionnaires ensured that most of the necessary data was available for all the buildings to be compared. A further advantage of the questionnaire was that data was collected for most of the relevant indicators and not only for those for which records were available. There were also some specific advantages regarding change in activity demand and adaptation. With respect to change in activities, the questionnaire provided data giving an account of small scale changes in the activities of a sample population and often not reported in records. An important example of this is past communication patterns between members of an institution. Even more, a questionnaire left open access for data to be reported by respondents. In the adaptation of buildings, a questionnaire enabled the reporting of the various extent of adaptation which are often reversible and not reported in the plans of the buildings. In addition, it allowed an assessment to be made of users' responses to the adaptations made to their buildings. Further, the questionnaire was a valuable tool in comparing buildings of different types, just as the measures of design variables can be applied to different buildings. Of course, if buildings belonging to one particular building type are to be compared with each other, there will still be the possibility of adding more specific questions relevant to the activities normally associated with the building type examined. Nevertheless there were also some disadvantages of the questionnaire.

It is not a perfect tool, but its disadvantages are less than those of other methods. Its basic disadvantage is that it provides what generally could be described as soft rather than hard data. However, in view of the comprehensiveness of the collected data such a disadvantage may be accepted. Further, a questionnaire is always affected by the sample size and response rate. To overcome this, an attempt was made to survey the whole population who had used a particular building over a set period of time and not just a sample of this group. Another disadvantage of using questionnaires to get data concerning past events is that the period examined will always be restricted by the memory of the respondents of details. This problem could prove vital for relatively long periods of time where many adaptations were made. But for the objective of this study it would have less effect, since changes over shorter periods of time were examined because of the types of design variables studied. These variables concern the accommodation of small scale changes without the need for adaptation of buildings and these changes are what occur over shorter periods of time, for which the questionnaire is a reliable alternative.

There is no general rule defining the length of time to be examined, and thus the appropriateness of the questionnaire. Examination of buildings over long periods of time has to assess flexibility in relation to the ease with which adaptation was made. With a greater number of adaptations, detailed responses from individuals are difficult to obtain and thus the questionnaire would be inadequate.

Alternatively an assessment of whole buildings only can be made to ensure the availability of past records on the cost of adaptation. In the examination of buildings over a shorter period the emphasis is to be placed upon change in demand rather than adaptation, for which the questionnaire is relevant. There exists still the problem of defining what is meant by short or long periods. This can only be assessed in relation to the buildings examined. Change in the allocation of activities into rooms in buildings differs depending upon the type of institutions examined. In some, such as educational institutions, there are more frequent changes in the allocation of activities than in other institutions such as hospitals. In educational institutions the activities allocated to rooms differ daily, weekly, every term if not yearly. Thus a period of one year in an educational institution would normally involve more changes than in a hospital, and this restricts the accuracy of data obtained by a questionnaire. In this study, a three year period in an academic institution was considered as appropriate taking into consideration nine main different allocations of activities to rooms based on nine academic terms. In short, the appropriateness of the questionnaire to assess flexibility depends upon the length of time considered reasonable, and that depends upon the type of institution examined and the amount of adaptation made.

The responses provided the data about the state of activity patterns and buildings both at particular points in the past and changes that occurred over a period of time. Further, the questionnaire allowed the examination of activity patterns in relation to two broad groupings - those in rooms and in corridors. There were questions, in the questionnaire, about the two groupings of activity patterns at any point in time, and about any change in them over time. This allowed an assessment to be made of changes in what is done in rooms as well as in the patterns of communication between users in different rooms. The questions included those about the characteristics of users of buildings, room occupancy, the activities carried out and changes in them, satisfaction with rooms, relocation from rooms, adaptations of rooms and a detailed account of the journeys each respondent made from his/her room to all other rooms, pointing out for each journey the purpose of visit, the frequency and the length of stay at the room of destination.

The extent of flexibility of a building was indicated by the amount of change reported in relation to the amount of adaptation. The amount of change reported was indicated by the percentage of respondents reporting each type of change and by the amount of change in the numbers and the distances of journeys travelled weekly between rooms. This is done by combining data describing users' response to the questionnaire with data obtained from measurements of the plans of buildings in the beginning and finishing dates of the period examined.

The amount of adaptation reported was indicated by the percentage of respondents reporting each type of adaptation. Two basic indicators of the extent of flexibility in a building resulted - composite and single indicators. Composite indicators gave an assessment of flexibility by considering both change and adaptation together as flexibility is a statement about both. Single indicators gave an assessment of flexibility in relation only to change in demand or adaptation. Single indicators are useful in situations where the buildings to be compared in relation to flexibility are similar with respect to change or adaptation. Further, they may be used to give a detailed account of either of change or adaptation if required.

4.5. Flexibility of Buildings in Use - Summary:

The aim of this chapter was to propose a system of measurement by which the extent of flexibility of buildings in use could be assessed, and that is the second research objective of this study. In order to identify such measures, the meaning of flexibility was identified and its basic attributes defined. The chapter included then a review of previous methods of measuring these attributes and pointed out their problems. Finally, an attempt was made to outline an alternative method of measuring flexibility which could encompass most previous indicators and still not depend on the availability of records - a questionnaire. The basic advantages and disadvantages of the questionnaire used in this study were reported. Two types of indicators were used to measure the extent of flexibility of a building over a particular period of time. These were called composite and single indicators. In the following chapters an attempt will be made to examine the third research objective of this study.

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52. Tomlinson, J. et.al. "A Model of Students' Daily Activity Patterns". Environment and Planning, Vol. 5. 1973. pp. 231-266.

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55. Pooled Rooms: Rooms used for different purposes by all members of the Oxford Polytechnic, but mainly for teaching, e.g. tutorial, seminar...etc. Booking of Pooled Rooms is controlled centrally by the pooled rooms office. This differentiates them from rooms used and controlled by only one, or a limited number of departments.

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CHAPTER V

RESEARCH DESIGN

5.1. Introduction:

This thesis has argued that there were a number of different design variables connected with the layout of a building which affect its flexibility in use. Three objectives were stated for this study, two of which have been dealt with in the previous chapters. The first objective, which was concerned with proposing a system of measurement by which the incorporation of design variables in design proposals could be assessed, has been dealt with in Chapters II and III. The second objective, which was concerned with proposing a system of measurement by which the extent of flexibility of buildings in use could be assessed, has been dealt with in Chapter IV. The third objective of this study is to assess the extent of flexibility achieved by the incorporation of design variables in a study of actual buildings in use. This remaining objective will be dealt with in this and the following three chapters. This chapter outlines the research design of the empirical work needed to satisfy the third objective by posing a number of propositions and indicating how they will be tested. In it; i) the variables, ii) the relationships between them, iii) the propositions, iv) the sample of buildings, and v) the ways in which variables will be measured, will be outlined.

5.2. The Variables:

The relationship between the design variables associated with the layout of a building and its flexibility is hypothetical and untested. In order to test the relationship the variables involved need to be identified and propositions that can be tested put forward. Design variables related to the flexibility of buildings are numerous. Two of these variables have been selected for testing; i) the uniformity of rooms, and ii) the uniformity of circulation. These are the independent variables in the hypothetical relationship, while the dependent variable is the flexibility of buildings in use.

5.2.1. Independent Variables:

Both of the independent variables were measured from the plans of buildings. Their definitions and measures were as follows:

(i) Uniformity of Rooms:

Uniformity of rooms is the extent of similarity between rooms in a building. It can be measured with respect to the general characteristics of rooms, such as shape or accessibility, as well as with respect to the area of rooms. Measuring uniformity in relation to the general characteristics of rooms takes into account a basic and a detailed attribute of uniformity. The basic attribute is the minimization of room types in a building and can be measured by a formula referred to as Indicator One.(p.72) The detailed attribute of uniformity considers variation in the distribution of rooms between room types in a building, and can be measured by the extent to which rooms are clustered in any room type - Indicator Two (p.74), and by statistical measures of dispersion - Indicators Three and Four (p.74), or indirectly, by measuring the evenness of the distribution of rooms - Indicator Five (p.78). However, it is possible to arrive at an overall assessment of uniformity of rooms with respect to all the indicators for each general characteristics, by using the mean of rank order of scores of a building on all separate measures. Assessing uniformity with respect to a number of general characteristics of rooms can be assessed by using the mean of the scores of a building on each indicator for all the characteristics of rooms. Measuring uniformity in relation to the area of rooms can be done by using the coefficient of variation between the areas of all rooms in a building or for groupings of rooms in it. Groupings of rooms can be achieved by using intervals of area, and there are six ways of defining intervals.(p.83) An overall assessment of uniformity considering all the groups of rooms in a building can be achieved by using the mean of the coefficient of variation for these groups, after being multiplied by a weight factor. The weight factor is the number of rooms and their areas in a group shown as a percentage of the total number and the total area of rooms in a building.

(ii) Uniformity of Circulation Pattern:

Uniformity of circulation pattern is the extent of similarity between rooms in a building in terms of their relationships to all other rooms. There are two aspects of uniformity of circulation. Those are proximity and adjacency. The concept of proximity requires the consideration of the distance between the centre (more accurately centroid) of a room and that of another. Adjacency takes into account whether rooms are next to or removed from other rooms, and whether or not they are accessible to each other. Measuring uniformity of circulation is made by summarizing, for each room in a building, the proximity and adjacency relationships to all other rooms, and then measuring variation between rooms in relation to the summaries of their relationships to other rooms. To analyze these variations is to give an assessment of the uniformity of circulation.

5.2.2. Dependent Variables:

Flexibility of buildings as the only dependent variable can be indicated by the amount of change that has been accommodated in a building in relation to the amount of adaptation made to cater for any such changes. It was argued that, the extent of flexibility of a building can be indicated by the analysis of responses of the users in it to a questionnaire about changes in their work and their account of adaptations made. Such responses can be analysed in two ways, which would result in composite or single indicators of flexibility. Composite indicators give a direct assessment of flexibility by considering change and adaptation, while single indicators need to be analysed individually, either for change or for adaptation. However, unlike composite indicators, single indicators allow specific aspects of flexibility according to, for example, the type of change to be investigated, rather than giving the general assessment of all types of change. These indicators are outlined below.

(i) Composite Indicators:

The overall extent of flexibility is an assessment of three composite indicators. Each of these indicators represents the percentage of respondents reporting change with respect to certain conditions of adaptation and the re-allocation from the rooms used over time. Composite Indicator One: This is the percentage of respondents who reported a change in their activities, or demand for rooms, but who have neither requested to move from their rooms nor made requests to adapt them. Change in activities may occur, for example in relation to a change in the type of information, materials handled or the type or the number of people with whom such information or materials may be handled. Change in the demand for rooms may occur in relation to the demand for the facilities within rooms or the location of rooms. Composite Indicator Two: This indicator is similar to Indicator One, but involves the reponses of only those users who did not actually move nor adapt their rooms. Composite Indicator Three: This is the percentage of users who moved from their rooms and needed to adapt their new rooms. This percentage is the average of the percentages of those who moved because their work has changed or those who moved because of a major re-allocation of users within the building. In each case, the percentage of respondents who moved is broken down by the various levels of adaptation actually made in the new rooms.

(ii) Single Indicators:

Single indicators measure the various types of change or the extent of adaptation. If buildings have similar levels of adaptation made to them, then variation in the amount of change in the demand would indicate the degree of flexibility. If change in demand is reasonably constant, then any variation in the level of adaptations made, also indicates flexibility. If buildings are similar both in the amount of change and of adaptation, then no assessment of their flexibility can be made since these indicators of flexibility are relative between buildings and do not indicate the absolute extent of flexibility in each. But where there are differences in both change and adaptation, then these can be interpreted to give a general assessment of their variations in flexibility. However, there are two basic types of demand in relation to rooms; a) demand for the facilities within rooms, b) the demand for the location of rooms. Single indicators measure changes in both of them.

(a) The facilities within rooms: Change in the demand for the facilities within rooms takes into account; 1) change in users' characteristics, e.g. status, occupation or sharing rooms; 2) the types and number of activity types carried out by them in their rooms; 3) the general and specific characteristics of their activities, e.g. the type of information or materials handled and for specific characteristics of teaching, the courses and the number of hours taught; and 4) the levels of satisfaction with the facilities in their rooms.

(b) The location of rooms: Change in the demand for the location of rooms is indicated in two ways. The First is a measure of users' perception of change, taking into account; 1) the level of satisfaction with the location of their rooms, the number or type of people with whom communication is made; 2) the journeys they made to other rooms; and 3) their direct conception about the location of rooms. The Second is change in the nature of journeys between rooms. This includes the number, average distance and average total distance of journeys of various types. The types of journeys are identified according to a number of criteria. These criteria include, the beginning or destination rooms of journeys, purpose, number of purposes, frequency, length of stay at rooms of destination and finally the types of adjacency relationships between the beginning and destination rooms of each journey.

5.3. Design Variables and Flexibility:

Relationships between design variables (uniformity of rooms and uniformity of circulation) and a building's flexibility in use can be operationalized by considering relationships between the various indicators used to measure them. However, since flexibility can be indicated by either composite or single indicators, its relationships with each of the design variables were examined in two stages. The first was where composite indicators were used while the second was relevant to the use of single indicators of flexibility. Relationships of each of the design variables with flexibility are as follows:

5.3.1. Uniformity of Rooms and Flexibility:

The relationship between uniformity of rooms and flexibility can be examined in various stages depending upon which of the characteristics of rooms are measured in relation to uniformity, and upon how flexibility is indicated. This relationship can be examined when uniformity is measured in relation to the general characteristics of rooms or their area, and even that with or without the grouping of rooms. In each case, uniformity of rooms can be related to flexibility whether indicated by composite or single indicators. Uniformity of rooms can, however, be related to each of the three composite indicators, as well as to each of the two single indicators - i.e. change and adaptation. When single indicators are used to indicate flexibility, such as those concerned with change in the demand, uniformity of rooms can be related to change in the demand for the facilities within rooms, or the demand for the location of rooms. In the case of the demand for the location of rooms, uniformity of rooms can be related to users' conception of change or the change in the nature of journeys made between rooms. In short, the relationship between uniformity of rooms and flexibility can be broken down into a number of specific relationships between certain aspects of uniformity and some of flexibility, in order to allow for a detailed assessment to be made of the propositions to be tested.(Figure-6)

5.3.2. Uniformity of Circulation Pattern and Flexibility:

Similar to the case of uniformity of rooms, there are many specific relationships between the uniformity of circulation pattern and the flexibility of buildings. These specific relationships depend upon the aspect of circulation examined in relation to uniformity, being proximity or adjacency, and the way of indicating flexibility. Basically, uniformity of circulation can be divided into uniformity of proximity and that of adjacency, and each of these can be related to flexibility. Flexibility, for its part, can be indicated by each of the three composite indicators (One, Two and Three), or by either of the single indicators (change or adaptation). However, when single indicators about change are used, only those relating to change in the demand for the location of rooms are required. Change in the demand for the location of rooms, however, can be indicated by users' conception of change or by change in the nature of journeys made between rooms. In short, there can be identified many specific relationships explaining how the uniformity of circulation pattern relates to the flexibility of buildings. (Figure-7)

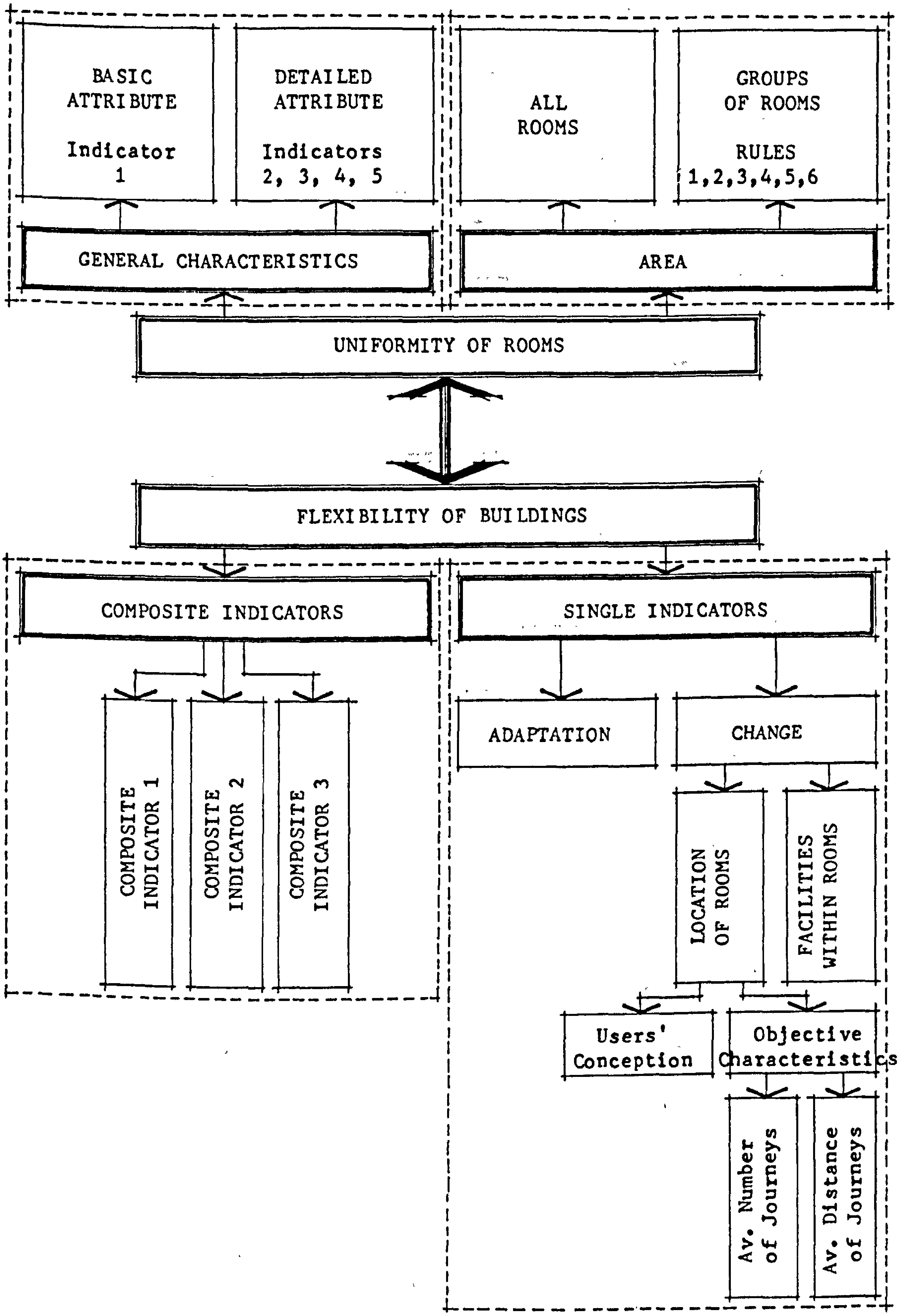


Figure-6
Uniformity of Rooms and Flexibility

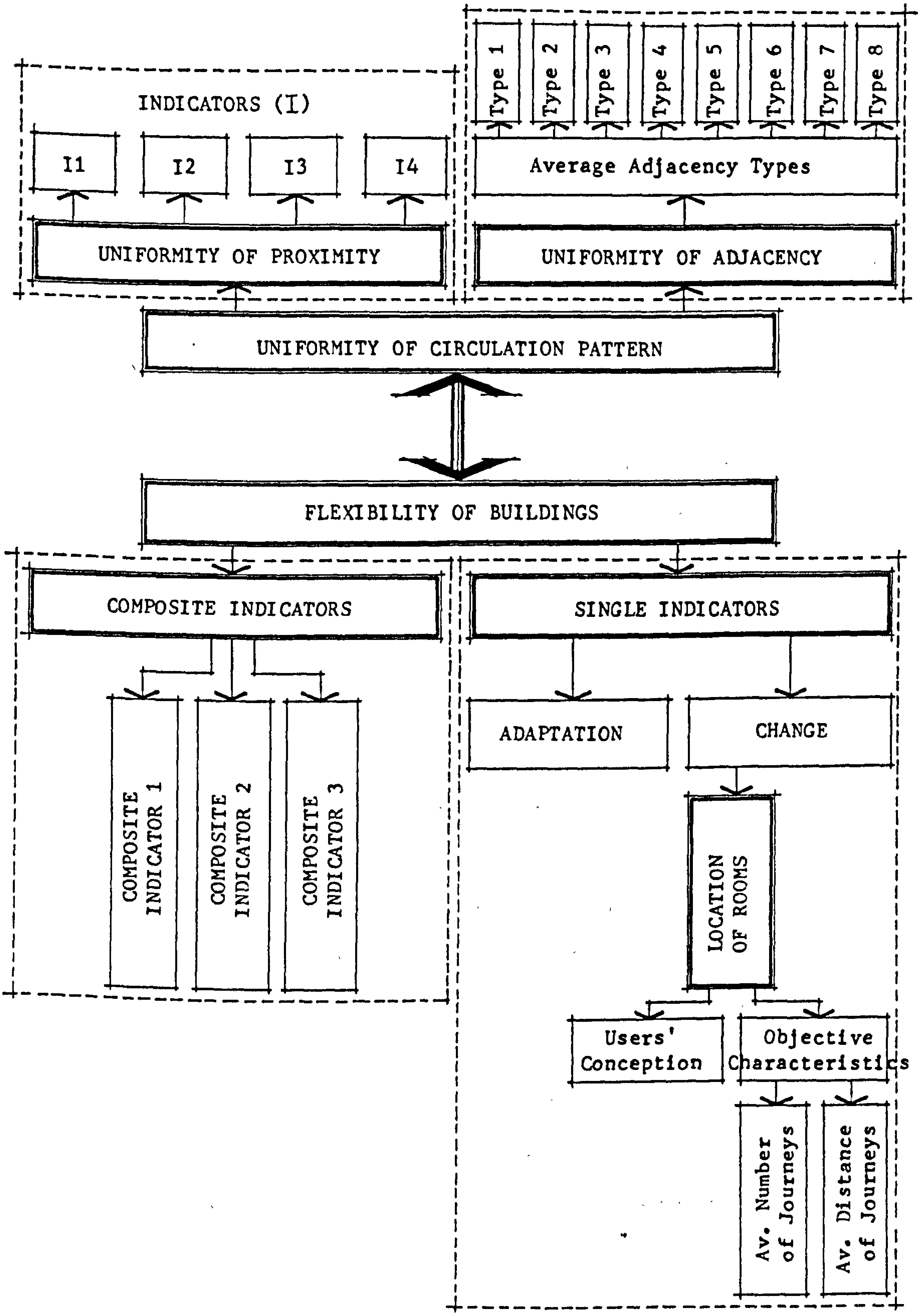


Figure-7
Uniformity of Circulation Pattern and Flexibility

5.4. The Propositions:

The propositions to be tested concern all the specific relationships above. All the propositions are formulated in terms of relationships between the extent of design variables and that of flexibility. By and large, all the propositions suggest that design variables relate to flexibility, and there is a direction to this relationship, often positive. These propositions are stated for each of uniformity of rooms and uniformity of circulation.

5.4.1. Uniformity of Rooms and Flexibility:

There were three propositions about the relationships between uniformity of rooms and flexibility. (i) Null proposition: That uniformity of rooms of a building does not relate to its flexibility. (ii) Main Propositions: That uniformity of rooms of a building relates positively to its flexibility. (iii) Rival Proposition: That uniformity of rooms of a building relates negatively to its flexibility.

5.4.2. Uniformity of Circulation Pattern and Flexibility:

Similar to the case of uniformity of rooms, there were three propositions to be tested about the relationship between uniformity of circulation pattern and the flexibility of buildings. (i) Null proposition: That uniformity of circulation pattern of a building does not relate to its flexibility. (ii) The Main Proposition: That uniformity of circulation pattern of a building relates positively to its flexibility. (iii) The Rival Proposition: That uniformity of circulation pattern of a building relates negatively to its flexibility.

5.5. The Buildings:

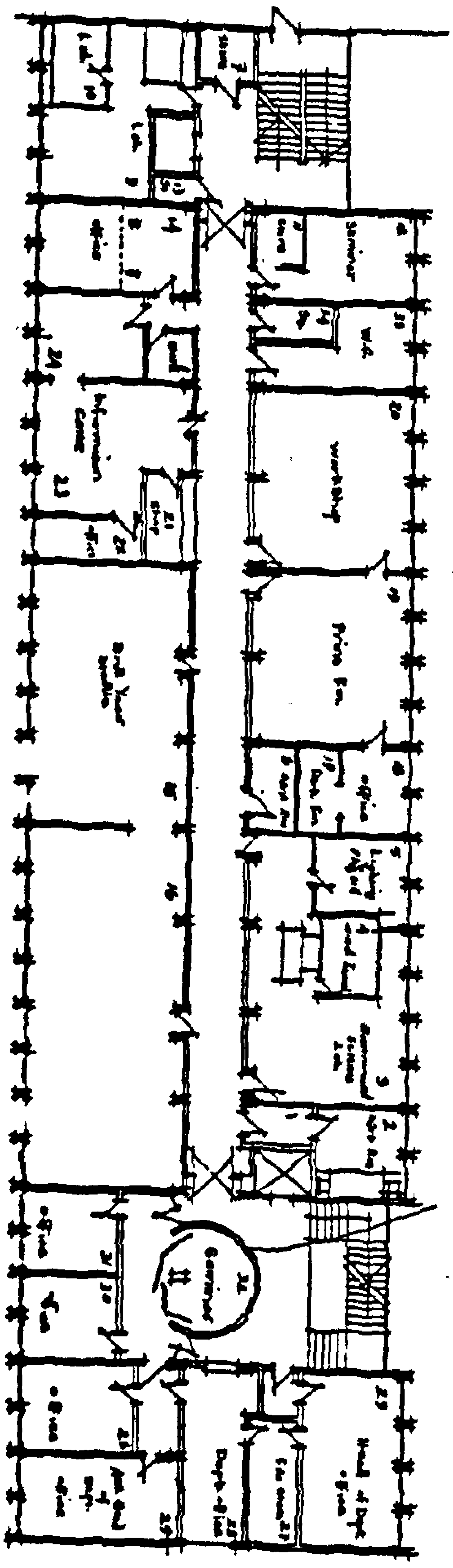
Once the variables and their measures are identified and propositions about relationships between them are set out, the next step is to find cases in which these propositions could be tested. The search is for buildings rather than for institutions. It is in these buildings where variations in flexibility (the dependant variable), are to be examined in relation to variations in the design variables (the independent variables). The buildings to be selected should be largely similar in most of their characteristics other than those related to the design variables, which should differ greatly. In this way the effect of any intervening variable could be controlled enabling variation in flexibility to be explained by variation in the design variables. However, absolute similarity in all characteristics other than in the independent variables is something that may be found only in theory. In practice some compromise must be made. Therefore the selection of buildings is to be based primarily upon variation in the design variables, while allowing some minor variation in the other characteristics.

To ensure some similarity in factors other than the chosen design variables between the buildings to be selected for the case study, characteristics such as their physical form and the activities housed in them needed to be considered. For physical form, the buildings should, at least, be comparable in size and in the number of rooms in each. For the activities housed, it was considered that buildings belonging to a particular institution would be appropriate, since the activities housed in them would be controlled in a comparable way, by factors related to policy and expenditure. Further, the more rooms of similar uses in the buildings, the more likely the activities in them are to be similar.

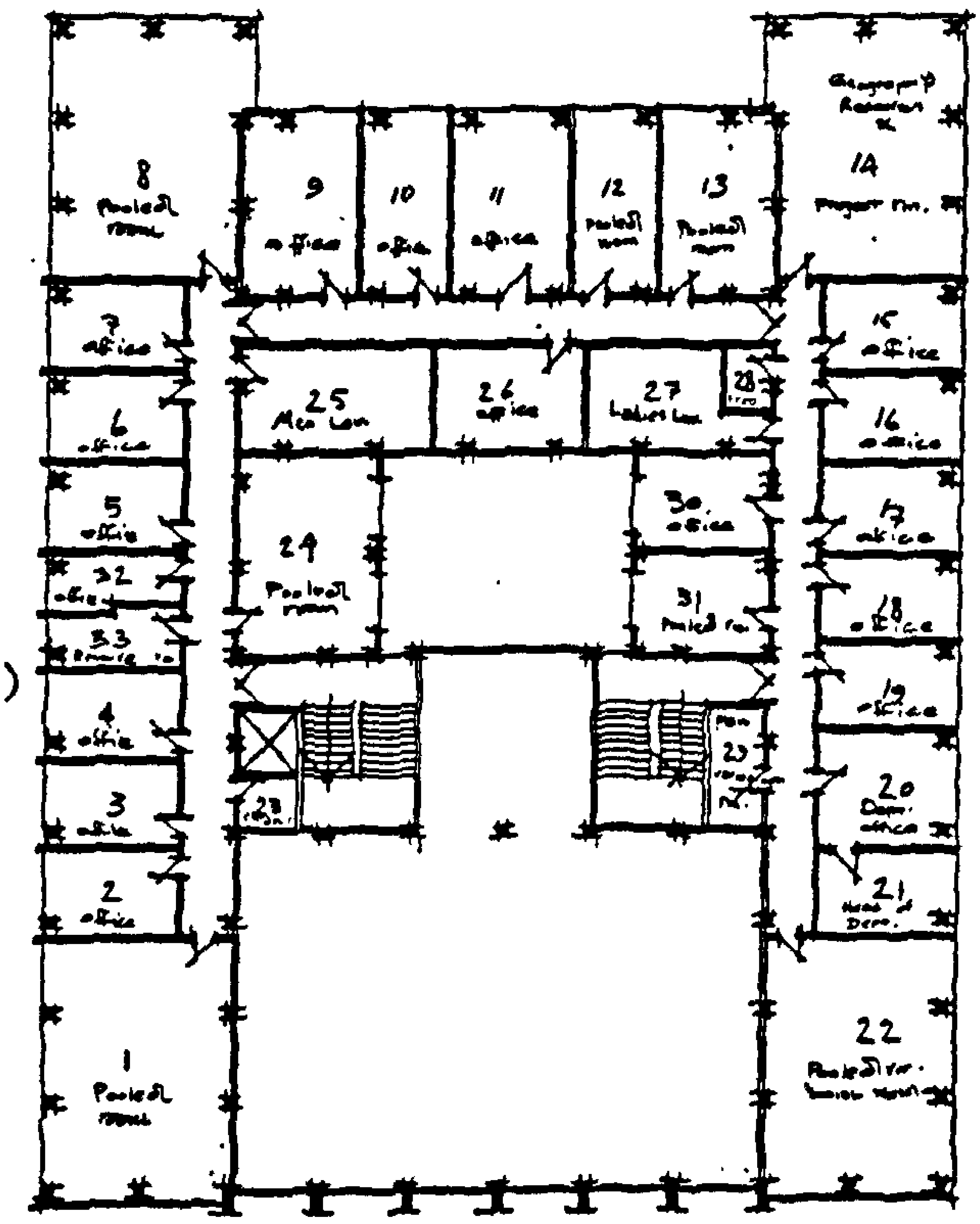
To ensure variation between the buildings in terms of their design variables, a relatively large number of buildings needed to be measured in terms of their design variables and then a few of them selected for a detailed measurement of both design variables and flexibility. The few buildings to be selected are to possess relatively the highest and lowest extent of design variables.

In accordance with the above criteria, a sample of three buildings were selected. These were part of nine buildings belonging to the Oxford Polytechnic. They were largely similar in most factors other than design variables. For the organizational factors, all are part of one institution. All are used for teaching. Each is occupied mainly, if not exclusively, by one department. Each, again, is the main part of the accommodation for the department concerned. In each, the majority of staff offices, heads of department and the departmental offices are allocated. The buildings were also comparable in the number of rooms in each and their construction. However, the buildings differed in the types of courses taught and their requirements, for example the need for dark rooms, laboratories or pooled rooms. They also differed with respect to some other factors, such as being on the ground floor or on other floors, or whether they are part of a multi-storey building or not. One of them is a one-storey building while the other two are on the third and fourth floors respectively of other buildings. However, such variations were not emphasized since they relate to some of the other design variables which have not been tested in the case study. Examples of these variables are the independence of buildings' elements, modularity and concentration of structure and zoning for areas of special provision, which generally concern the adaptation of buildings.

The buildings in the sample will be referred to as buildings A, B and C. Building A is the third floor of a teaching block. It is occupied by an architecture department. It contains a variety of uses, staff offices, laboratories, workshops and studios. There are 31 rooms in all. Rooms are generally located on both sides of a central corridor. Building B is the fourth floor of a teaching block. It is occupied mainly by a department of social studies. Uses of rooms in it are limited to staff rooms or pooled rooms. There are 31 rooms in all. It is planned around a court with a U-shaped corridor and rooms on both sides of the corridor. Building C is part of a one-storey building. It is occupied by a department of construction. Uses of rooms in it are diverse. They include staff rooms, pooled rooms, laboratories and others. There are 34 rooms in all. It is a deep-plan building. The corridor divides the building asymmetrically. Rooms in it differ greatly in size. There are skylight windows in its barrel vaulted ceiling.(Figures-8)



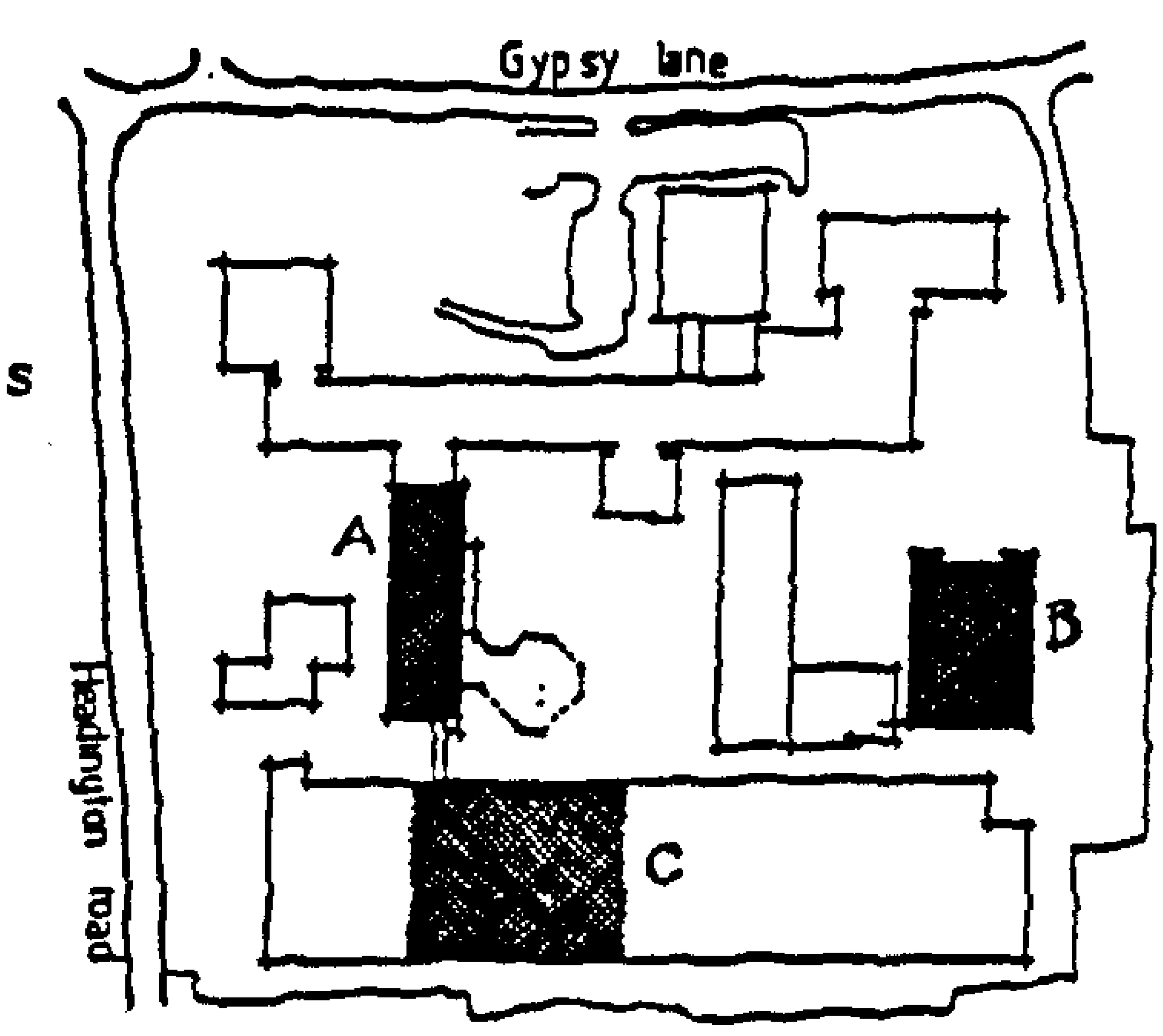
(A)



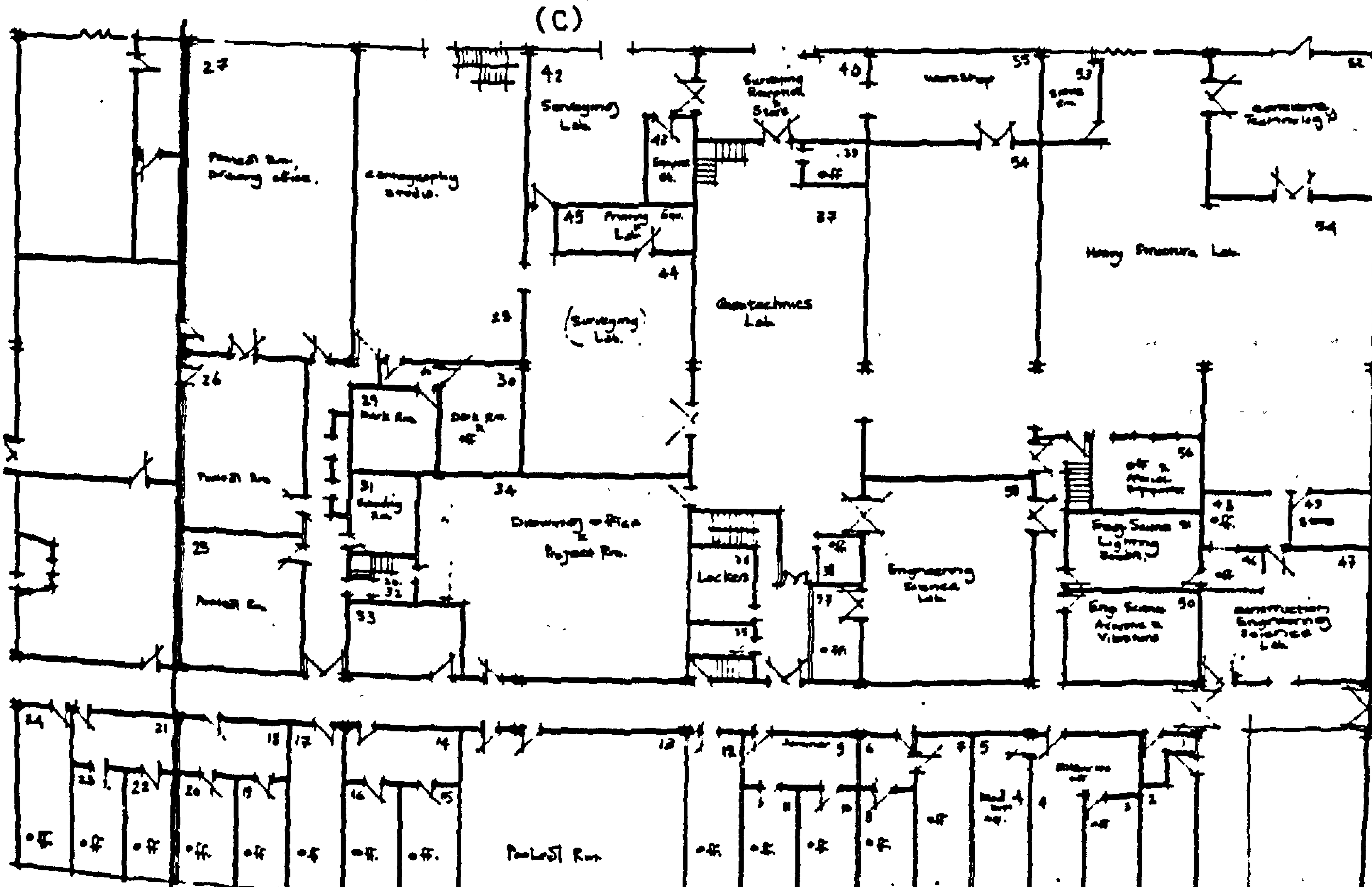
(B)

Figure-8 -

Plans of Buildings A, B and C



(C)



5.6. The Period of Time Examined:

Clearly the longer the period of time for which flexibility of buildings was to be examined, the greater the changes in activities and the more adaptation was likely to be reported. However, the time period to an extent depends on the type of design variables investigated. Some of the variables of design, such as modularity and concentration of structure and the independence of a buildings' elements require longer periods of examination to find out about flexibility. Previous studies have suggested relationships between these variables and the aspect of flexibility related mainly to adaptations on a major scale. Such adaptations, in most cases, occurred at intervals of 10-20 years or more. Other variables of design flexibility, in fact those that are examined in this study, can be studied over much shorter periods of time. Previous studies have suggested relationships between these variables, and flexibility, as they are concerned with looseness of fit, that is to say, the accommodation of small scale changes with minimum adaptation.(p.36)

Now the aim was to examine flexibility over a relatively short span of time. For that, three factors have specifically affected the length of the period examined. First, the availability of plans to be measured. Though some plans of the three buildings since they were constructed were available, they were not in many cases for selected certain dates. Accordingly, plans were updated at specified dates by reference to the key personnel (the building officer, departmental chief technicians and other senior staff) to assertain how rooms were sub-divided and what their main characteristics were. This exercise was not really feasible for periods longer than 3-5 years in duration. Second, the availability of the same users who used the buildings continually over the period. Ideally, flexibility of a building was more accurately described if all users who occupied it over the years gave their account of the changes in their work and the adaptations made. But in longer periods of examination many of the users may have moved to a different building in the Oxford Polytechnic or even moved out of the Polytechnic. Third, the method used to indicate flexibility. Since flexibility of a building is to be indicated by users' responses to a questionnaire about the changes they experienced, the extent to which changes are reported will be directly affected by the memory of users. The longer the period on which users are asked to report, the less is the extent of accuracy.

Accordingly, the period was limited to 11 academic terms between Sept.1980 and Feb.1984. Such a period was considered reasonably appropriate to the design variables, i.e. those concerned with looseness of fit, as it represented a period of many changes in the overall development of the institution, a period where plans for starting dates can be checked with reasonable accuracy, a period where the majority of users still occupy the same building, though may have moved from their rooms, and finally a period where memory does not lapse greatly.

5.7. Measuring Design Variables:

Uniformity of rooms and uniformity of circulation were measured from the plans of buildings at the start of the period examined, i.e. Sept.1980. The plans of buildings were already available. They were checked for accuracy with key personnel in buildings and, where necessary, corresponding alterations were made.(Appendix-C1) From these plans, data relevant to the indicators of uniformity of rooms (Appendix-C2) and uniformity of circulation (Appendix-C3) were collected for each of the rooms in the buildings. These data were analysed by SPSS (Statistical Package for the Social Sciences)(1) to obtain the scores of each building with respect to each of the indicators.

5.8. Measuring Flexibility:

Flexibility was indicated by the analysis of users' responses to the questionnaire they were given about any change and adaptations to their buildings experienced during the period Sept.1980 to Feb.1984. The analysis was done by using SPSS. However, a further exercise was also carried out. It was a survey of the rooms in the three buildings as they were in Oct.1983. (Appendix-D) The survey provided a background against which the plans of 1980 could be assessed in relation to their design variables, in order first, to understand the extent of adaptation made in each building so single indicators of flexibility about change in the demand in each building could be carefully assessed and second, to obtain measurements of distances and adjacency relationships between rooms in 1983/84 in order to compare them with those of 1980/81, to indicate changes in the nature of journeys made between rooms. This is relevant to the part of single indicators of flexibility that is concerned with change in the demand for the location of rooms.

5.8.1. The Questionnaire:

The questionnaire included two types of questions. These were questions that describe certain conditions in the academic years 1980/81 or 1983/84, and questions that describe any changes or adaptation during the period 1980/81 - 1983/84. The main part of the questionnaire included questions about many aspects of activities. There is a supplementary part which is devoted specifically to the journeys made between rooms. (Appendix-E)

The main part contained questions about: i) The general descriptions of users. These included the date when they started using the building, the departments by which they were employed, the mode of employment, occupation, the location of their rooms, an assessment of the difference between their current and previous rooms, the patterns of rooms' occupancy and finally the activities carried out in their rooms. ii) Change in activities. These were about change in any aspect of teaching (addressed to teaching staff only), change in any of the components of activities, change in the activities according to their location whether inside rooms or between rooms, the predictability of these changes and finally change in the demand for rooms. iii) The levels of satisfaction with the facilities within rooms or with the location of rooms. iv) Any requests made to move from, or to adapt rooms. They were about reasons for placing such requests and the fulfilment of them. v) Change in the allocation of users into rooms. They were about reasons for moving to a different room, the adaptations made in the rooms users moved to, to make them suitable and finally the reasons for not moving from rooms. vi) Adaptation. They included reasons for carrying out the adaptation, the people who carried them out, the effect of adaptation and finally the frequency of adaptation for each component of buildings. vii) An assessment of users' conception of buildings flexibility. Users were asked to estimate from the plans attached to the questionnaire the number of rooms to which they could move, without affecting their work.

The supplementary part about journeys included a record of all journeys made by users from their rooms to all other rooms in the building in 1980/81 and in 1983/84. Users were asked to indicate for each journey between any two rooms, the purpose of visiting rooms, the frequency of journeys weekly and the average length of stay at destination.

5.8.2. <u>The respondents</u>:

The questionnaire was to be answered by all staff who used the buildings regularly for any length of time during the period Sept.1980 to Feb.1984. The identity of users of the building who moved out prior to the date of distributing the questionnaire could not be known accurately. However such users are, by and large, from the same departments which occupied the buildings during this period and not from other academic or administrative parts of the polytechnic. Accordingly, the questionnaire was distributed to i) all staff using the buildings at the time of distribution and ii) the majority of staff in the departments who occupied the buildings for any time during the period Sept.1980 to Feb.1984. The aim was to obtain responses from the whole population who used the buildings and not a sample of this population. The number of users in each building at the time of distributing the questionnaire ranged from 20 to 35 approximately. The questionnaire was delivered to respondents through their departmental offices, and checks were made to ensure reception of it. Collection was made directly and again through, departmental offices a week after distribution. Reminders were sent to staff who had not responded and those who had not returned the questionnaire after six weeks were not asked any more.(Appendix-E)

The numbers of users at the time of distribution were 26, 32 and 24 for buildings A, B and C respectively. The total numbers of questionnaires distributed in these buildings were 59, 72 and 42 respectively. These numbers included questionnaires that were given to the staff who occupied the buildings during the period of time examined. The numbers of questionnaires returned were 36, 32 and 28 respectively in the three buildings. Those which were fully completed were 21, 27 and 18 respectively. The differences between the numbers of questionnaires returned and the numbers of users in the three buildings at the time of distribution account for both those still using the building who failed to return it completed, and those who returned the questionnaire but were not using the building at the time of distribution. The latter completed it for the period they stayed in the building prior to Feb.1984. Accordingly, if an assessment is to be made of the response rate based upon the number of questionnaires completed and the numbers of users at the time of distribution alone, it may be argued that the returned questionnaires provide a fairly comprehensive assessment of flexibility in the three buildings with response rates of 81%, 84% and 75% for buildings A, B and C respectively.

The remaining part of this study will be devoted to an analysis of the data gained from the case study regarding the design variables and the flexibility of the three buildings in order to test the propositions outlined in this chapter. Comparison of buildings in terms of design variables will be introduced in the following chapter, i.e. Chapter VI. Chapter VII will give a comparison of buildings in terms of their flexibility. The relationships between design variables and flexibility will be discussed in Chapter VIII. The final chapter, i.e. Chapter IX will be concerned with any general conclusions that may be drawn from this study.

5.9. References:

1. Nie, N. H. et.al. SPSS Statistical Package for the Social Sciences. Second Edition. New York, Mc.Graw-Hill. 1975.

CHAPTER VI

DESIGN VARIABLES: COMPARISON OF BUILDINGS

The purpose of this chapter is to compare the buildings examined in relation to two main design variables; these are the uniformity of rooms and the uniformity of circulation pattern.

6.1. Uniformity of Rooms:

The first of the design variables to be examined is the uniformity of rooms, that is the extent of similarity between rooms in a building. It could be examined in relation to a number of variables associated with uniformity, each being relevant to one of the characteristics of rooms. The measures of these associated variables in a building differ depending upon the characteristics of rooms being examined. In chapter three two groups of measures were identified as relevant to the associated variables.(p.78) In the first group, uniformity of rooms was examined in relation to general characteristics of rooms such as shape, accessibility or the number of rooms directly accessible to each room. In the second group, uniformity of rooms was examined in relation to the area of rooms. The first and the second of these groups of variables will be examined in relation to the general characteristics of rooms and the area of rooms respectively.

6.1.1. Uniformity of Rooms - General Characteristics:

Uniformity of rooms refers to the extent of similarity between rooms in a building with respect to each of seven general characteristics selected. These characteristics are:

i) Shape of Rooms.

i) Relationship of rooms to building envelope.

iii) Number of Doors in Rooms.

iv) Location of Doors in Rooms.

v) Number of Rooms Directly Accessible to each room.

vi) Relationship of Rooms to Corridor.

vii) Accessibility of Rooms.

The extent of uniformity relating to these characteristics can be measured with respect to the first or both of two attributes. The first is a basic attribute and relates to the minimization of room types in a building. It can be measured by a formula, developed in this study, involving the number of rooms in a building and the number of room types in it (Indicator One). The second is a detailed attribute and relates to the distribution of rooms between the room types. Differences between the room types with respect to the number of rooms in them can be measured by; First, the extent of clustering of rooms, shown by the percentage of rooms in any of the room types in a building (Indicator Two), and second, differences can be measured, directly or indirectly, by considering variation between room types in each building. Directly, these can be measured by some of the statistical measures of dispersion, such as the range shown as a percentage of the mean (Indicator Three) and the coefficient of variation (Indicator Four). Indirectly, the variation may be shown by measuring the extent of evenness of the distribution of rooms between the room types by a formula developed in this study (Indicator Five). The following sections describe how the three polytechnic buildings that have been examined in a case study differed in their uniformity in respect of each of the characteristics of rooms measured. These buildings are referred to as A, B and C.

(i) Shape of Rooms:

The three buildings examined are generally low in their extent of uniformity of shape, though B is slightly higher than C and A. The generally low extent of uniformity and the differences between the three buildings can be illustrated by their scores on the basic and the detailed attributes of uniformity, that is the minimization of room types and variation between them in a building.(Table-1)

(a) The Minimization of Room Types:
(Indicator One).

Indicator One illustrates uniformity by considering the extent to which the room types in a building are minimized. The three buildings are generally similar with a low extent of uniformity. This relates to the large number of room types distributed within the three buildings. There are six out of the seven possible room types which are defined by their shape. The three buildings have the same number of room types in them (i.e. 6) with a largely similar number of rooms in them (31, 31, and 34 for buildings A, B, C respectively). Uniformity is measured by a formula involving the number of rooms and the number of room types in a building. The result is that building C is slightly more uniform than either building A or B, since C contains a few more rooms (34 rooms) than the other two (31 rooms), while all the buildings have the same number of room types (6 room types). As the three buildings are generally similar in their uniformity according to this attribute, then the detailed attribute of uniformity needs to be examined to show whether there are more detailed differences between them.

(b) Variation between Room Types:
(Indicators Two, Three, Four and Five).

The second indicator identifies the detailed differences between buildings by considering the distribution of rooms within the room types in each of them. Room distribution is measured by; first, the extent to which the rooms are clustered in any room type (Indicator Two), second, directly by statistical measures of dispersion

(Indicators Three and Four), and third, indirectly by measuring the evenness of the distribution of rooms (Indicator Five). On these measures, building B is the most uniform. First: Clustering of rooms: Indicator Two. How rooms are clustered in any room type is indicated by the percentage of rooms in the various room types in a building. The highest percentage is greater in building B than in either building A or C. These differences mean that there are more rooms that are similar in their shape type in building B than in buildings A and C. In other words building B is more uniform than the other two. Second: Direct Measures:- Indicators Three and Four. Variations in the room types in each building are greater in building B than in either building A or C, meaning that building B is the more uniform. Such variations are measured statistically using the range and the coefficient of variation. The range of the numbers of rooms in the room types is higher in building B than in buildings C or A. When the range is shown as a percentage of the mean of these numbers, a similar pattern emerges (Indicator Three). This pattern indicates that there are more differences in the room types in building B than in the other two buildings as a result of a greater clustering of rooms in building B. Building B is more uniform than buildings A or C. The coefficient of variation is a more representative statistical measure of variation than the range, and using this, building B is higher in its uniformity than the other two buildings (Indicator Four). Third: Indirect Measures: Indicator Five. Indirectly, variation in the room types is illustrated with respect to the evenness of the distribution of rooms. The less even the distribution of rooms within the room types in a building, the more the extent of uniformity. The distribution is least even in building B compared with those in buildings A and C (Indicator Five). There are wider differences between the room types in building B than in buildings A or C. Building B has more rooms that are similar and are clustered within room types and is, therefore, more uniform.

To summarize, for the detailed attribute of uniformity, although the three buildings are relatively low in uniformity, building B is more uniform than buildings A or C.

Thus, despite the differences between the three buildings, they show a relatively low extent of uniformity in relation to both the basic and the detailed attributes of uniformity. These two attributes, however, need to be examined together to give an overall assessment of uniformity. Building C was more uniform than the other two on the basic attribute, while building B was more uniform than the other two on the detailed attribute. It might be thought that a calculation of the average rank order of each building in relation to the various measures would provide the answer, but this has not proved successful. The rank order calculation distorts the overall differences between the buildings since the sample is small, and there are always two buildings largely similar on either attribute. Alternatively, a general assessment of the scores of buildings has been sought. Accordingly, it can be concluded that building B has a higher higher extent of uniformity than the other two, although building C scored relatively higher on the basic attribute of uniformity. This is because the differences between the score of building B and those of the other buildings are significantly greater on the detailed attribute than differences between the score of building C and those of the other buildings on the basic attribute.

Table-1
Shape of Rooms

1. Number of rooms in in each of the room types classified according to the shape of rooms.

ROOM TYPES	BUILDING A		BUILDING B		BUILDING C	
	NO.	PCT.	NO.	PCT.	NO.	PCT.
SQUARE	2	6.50	1	03.20	1	03.90
RECTANGULAR(1:1.4)	8	25.80	5	16.10	6	17.60
RECTANGULAR(1.4-2.0)	10	32.30	19	61.30	12	35.30
RECTANGULAR(2.0-4.0)	4	12.90	3	9.70	6	17.60
RECTANGULAR(4.0)	-	-	-	-	-	-
L-SHAPE	1	3.20	1	3.20	3	8.80
OTHERS	6	19.40	2	6.50	6	17.60
TOTAL	31		31		34	

2. The scores of buildings on the five indicators of uniformity.

INDICATORS	BUILDINGS (A)	(B)	(C)
INDICATOR ONE	13.88	13.88	14.14
INDICATOR TWO	32.20	61.30	35.30
INDICATOR THREE	174.19	348.38	194.11
INDICATOR FOUR	67.00	134.00	65.00
INDICATOR FIVE	54.24	37.64	55.24

(ii) Relationship of Rooms to Building's Envelope:

The aim in this section is to illustrate how the three buildings examined differ in their uniformity, with respect to the relationship of a room to the building envelope. Rooms can either be part of the building envelope or not, resulting in two room types in this respect. The three buildings examined are largely similar with respect to the basic attribute, but differ greatly with respect to the detailed attribute, resulting in building B being the most uniform.(Table-2)

(a) Minimization of Room Types:
(Indicator One).

The basic attribute of uniformity illustrates the extent to which room types in a building are minimized. The three buildings are generally similar, with a reasonably high extent of uniformity, as shown by their scores on Indicator One. The similar extent of uniformity relates to the similarity of the buildings in the number of rooms and that of room types in them. Rooms in all the buildings are of two types. However, in the examination of uniformity with respect to characteristics of rooms with this limited number of types (2 in this case), an analysis of the detailed attribute of uniformity becomes more relevant. It is rare to find all rooms of the same type in a building, and having only two room types in each building is a reasonably high extent of minimization. Nevertheless, the distribution of rooms between these two room types differs greatly between the buildings.

(b) Variation Between Room Types:
(Indicators Two, Three, Four and Five).

The majority of rooms in building B are part of the building envelope, while in buildings A and C, there are many rooms of both room types, though differences between the room types in A are greater than those in C. Three ways can demonstrate how the buildings differ in the detailed attribute of uniformity. First: Clustering of Rooms: (Indicator Two). There is a significantly greater percentage of rooms of similar type in B than in A or C, though least in C. In other words, there is greater variation between the room types in B than in A or in C and thus a correspondingly similar variation in uniformity. Second: Direct Measures: (Indicators Three and Four). By statistically measuring variation, using the range and the coefficient of variation, the extent of variation is significantly greater between room types in B than in A or C. This illustrates, again, the extent to which rooms in B are clustered within one room type, i.e. B is more uniform than A or C. Such differences between buildings are shown by their scores on Indicators Three and Four with respect to the range and the coefficient of variation respectively. Third: Indirect Measures: (Indicator Five). Indirectly variation between room types can be illustrated by measuring the evenness of the distribution of rooms in them. Building B is again considerably more uniform than either A or

C. The distribution of rooms between the room types in building B is least even, compared with a higher extent of evenness in buildings A and C, as shown by the scores of buildings on Indicator Five. The distribution of rooms between room types in building C is least even, as there are broadly similar numbers of rooms (15 and 19) in the two room types. In short, according to all indicators of the detailed attribute of uniformity, building B is considerably more uniform than A and C, though C is least in its uniformity. The three buildings are largely similar on the basic attribute of uniformity, but differ greatly on the detailed attribute, with building B being the most uniform.

Table-2
The Relationship of Rooms to Building's Envelope.

1. The number and the percentage of rooms in each of the room types classified according to the relationship of rooms to the envelope of buildings, in buildings A, B and C.

ROOM TYPES	BUILDING A		BUILDING B		BUILDING C	
	NO.	PCT.	NO.	PCT.	NO.	PCT.
NOT ON ENVELOPE	10	32.30	3	9.70	19	55.90
ON ENVELOPE	21	67.70	28	90.30	15	44.10
TOTAL	31		31		34	

2. The scores of buildings on the five indicators of Uniformity.

INDICATORS	BUILDINGS		
	(A)	(B)	(C)
INDICATOR ONE	48.33	48.33	48.48
INDICATOR TWO	67.70	90.30	55.90
INDICATOR THREE	70.96	161.29	23.52
INDICATOR FOUR	35.00	80.00	11.00
INDICATOR FIVE	87.71	34.96	99.00

(iii) Number of Doors in Rooms:

How do the buildings differ with respect to their uniformity of rooms in terms of the number of doors in rooms? The three buildings differ greatly in this respect. Building B is the most uniform and C is least. Such differences can be illustrated with respect to the scores of buildings on both the basic and the detailed attributes of uniformity.(Table-3)

(a) <u>Minimization of Room Types:</u>
(Indicator One).

Building B is considerably more uniform than either A or C with respect to the basic attribute of uniformity. Since the three buildings contain largely similar numbers of rooms, differences between the buildings in relation to the extent of minimization relate to differences in the number of room types in them. There are only two room types in B, compared with five in each of A and C. However, there is even greater detailed differences between the buildings with respect to variation in the distribution of rooms between the room types within each.

(b) <u>Variation Between Room Types:</u>
(Indicators Two, Three, Four and Five).

Building B is again more uniform with respect to doors than A or C. In B, not only there were fewer room types, but the majority of rooms were in one of these types. In both A C, though there are types that contain over 50% of the rooms, other room types in each building still contain a relatively large number of rooms. Variation between the buildings examined can be indicated by; First: Clustering of Rooms: (<u>Indicator Two</u>). The highest percentage of rooms of the same type is significantly greater in building B than in A or C, though least in C. Second: Direct Measures:- (<u>Indicators Three and Four</u>). The statistical measures of variation indicate differences between the buildings though they fail to show the higher extent of variation between the room types in building B. Since B contains only two room types, then the average number in these types is greater than those in A or C. Thus, even if variations between room types are large, they result in smaller scores if shown as a percentage of the mean. This is a typical situation where the statistical measures fail to show differences in the extent of uniformity of buildings if the number of room types differs greatly between them. However, they clearly show differences between buildings A and C, as A is more uniform than C. Third: Indirect Measures: (Indicator Five). Indirectly, variation between room types in each building can be indicated by the extent of evenness of the distribution of rooms in each. There is a significantly lower extent of evenness in B than in A or C, and again lowest in C. In B, there is a great difference between the numbers of rooms in one type and those in the other types. Differences between room types in buildings A and C are far less, leading to higher evenness and lesser uniformity. In short, building B is more uniform than A or C with respect to the detailed as well as the basic attributes of uniformity, though C is least.

Table-3
Number of Doors in Rooms.

1. Number and the percentage of rooms in buildings A, B and C in each of the room types.

ROOM TYPES	BUILDING A		BUILDING B		BUILDING C	
	NO.	PCT.	NO.	PCT.	NO.	PCT.
ONE DOOR	16	51.60	30	96.80	19	55.90
TWO DOORS	10	32.30	1	3.20	7	20.60
THREE DOORS	1	3.20	-	-	3	8.80
FOUR DOORS	3	9.70	-	-	2	5.90
FIVE DOORS	1	3.20	-	-	1	2.90
SIX DOORS	-	-	-	-	2	5.90
TOTAL	31		31	-	34	

2. The scores of buildings A, B and C on the indicators of uniformity in relation to the number of doors in rooms.

INDICATORS	BUILDINGS (A)	BUILDINGS (B)	BUILDINGS (C)
INDICATOR ONE	17.33	48.33	14.14
INDICATOR TWO	51.60	96.80	55.90
INDICATOR THREE	241.93	187.09	317.64
INDICATOR FOUR	106.00	93.00	121.00
INDICATOR FIVE	32.32	12.49	41.87

(iv) Location of Doors in Rooms:

The aim in this section is to indicate which of the buildings is most and which is least uniform in relation to their uniformity of rooms with respect to the location of doors on the walls of rooms.

Doors in some rooms, are located on one wall, in others on two or more walls, thus resulting in various room types according to the number of walls containing doors. There are great differences between the three buildings with building B being the more uniform than A or C, and C is least. These differences can be indicated with respect to the minimization of room types and the variation between room types.(Table-4)

(a) <u>Minimization of Room Types:
(Indicator One)</u>.

The extent to which the room types are minimized is greater in building B than in buildings A or C, leaving B as the most uniform. The minimization of room types depends upon the number of rooms in a building in relation to the number of room types. Building B is higher than A or C, because it contains a lesser number of room types, though the extent to which it is higher than C is smaller than that with respect to A, since C contains slightly more rooms than A or C. Differences between the buildings can be shown by their scores on <u>Indicator One</u>. B is more uniform than A and C, and A is least. However, there are more detailed differences between the buildings.

(b) <u>Variation Between Room Types:
(Indicators Two, Three, Four and Five)</u>.

With respect to the detailed attribute of uniformity, there are even greater differences between the three buildings. B is again considerably more uniform than A or C though C is the least uniform. These differences can be illustrated with respect to: First: Clustering of Rooms: (<u>Indicator Two</u>). The highest percentage of rooms of any one type is greater in B than in A or C. Nearly all rooms in B have doors on one wall while only around 50 percent of the rooms in A or C are of the same type. Second: Direct Measures: (<u>Indicators Three and Four</u>). The difference between the room types in each building can more reliably be indicated by using statistical measures of dispersion, since the buildings do not differ greatly in the number of room types in them. The scores show greater variation in B than in A or C, and least in C. Third: Indirect Measures: (Indicator Five). Differences between the buildings can further be illustrated by measuring the evenness of the distribution of rooms in each of them. The distribution is less even in B than in A or C, and highest in C. In short, the buildings differed with respect to both the detailed as well as the basic attributes of uniformity, though on the detailed attribute the buildings differed greatly. Building B is the most uniform, C is the least with respect to the location of doors.

Table-4
Location of Doors in Rooms

1. Number and percentage of rooms in each of the room types in buildings A, B and C.

ROOM TYPES	BUILDING A		BUILDING B		BUILDING C	
	NO.	PCT.	NO.	PCT.	NO.	PCT.
DOORS ON ONE WALL	19	61.30	30	96.80	19	55.90
DOORS ON TWO WALLS	7	22.00	1	3.20	6	17.60
DOORS ON MANY WALLS	5	16.10	-	-	9	26.50
TOTAL	31		31		34	

2. The scores of buildings A, B and C on the indicators of uniformity in relation to the location of doors.

INDICATORS	BUILDINGS (A)	(B)	(C)
INDICATOR ONE	31.11	48.33	31.31
INDICATOR TWO	61.30	96.80	55.90
INDICATOR THREE	135.48	187.09	114.70
INDICATOR FOUR	59.00	93.00	49.00
INDICATOR FIVE	73.52	12.49	80.21

(v) Number of Rooms Directly Accessible to each Room.

How do the buildings differ in their uniformity with respect to the number of rooms directly accessible to each room in them? Rooms in a building differ in terms of the number of rooms directly accessible to them, thus resulting in various room types. There are rooms with no other room directly accessible to them as well as rooms with one or more rooms directly accessible. The three buildings differ greatly in their uniformity with respect to both the basic and the detailed attributes of uniformity. Building B is again significantly more uniform than A or C, which are largely similar.(Table-5)

(a) Minimization of Room Types: (Indicator One).

The extent to which room types are minimized is greater in B than in A or C, which are relatively similar and C is the least. Rooms in building B are distributed between only two room types while those in A and C are distributed between five room types. In relating the numbers of room types characterized by the number of rooms accessible to them, to the numbers of rooms in each building, the extent of minimization is illustrated on Indicator One. However, there are also some detailed differences between the buildings.

(b) Variation Between Room Types: (Indicators Two, Three, Four and Five).

The buildings differ greatly with respect to the detailed attribute of uniformity, leaving building B as the most uniform. Differences between buildings can be illustrated in three ways: First: Clustering of Rooms: (Indicator Two). The highest percentage of rooms in B is greater than those in A or C. In B, not only are there only two room types, but also rooms are clustered predominantly in one of these types. In both A and C the percentage of similar rooms is relatively small, both because of the large number of room types and the distribution of rooms between room types. Differences between room types can further be indicated. Second: Direct Measures: (Indicators Three and Four). Building B failed to score higher than the others on the direct measures of variation, leaving that for A. This instance is another example of a case where the statistical measures of dispersion fail to illustrate real variation between room types within each building, if the number of room types is small, however great the extent of variation between them. However, when the number of room types is similar, as in the case of A and C, such indicators may be adopted. They show that A is more uniform than C. Examination of the evenness of the distribution is thus more needed, since it will illustrate how B differs from both A and C, as well as further testify to the difference between A and C. Third: Indirect Measures: (Indicator Five). Variation between room types is lastly indicated indirectly by the evenness of the distribution of rooms between room types in the buildings. The distribution is least even in B though slightly more even in C than in A. This means greater variation and thus greater uniformity in B than in A or C. However, this indicator supported the general assessment made according to Indicator Two, and supported that which was made according to Indicators Three and Four. For indicators Three and Four, which incidently were only relevant to A and C, the pattern remained similar. To summarize, Building B is the most uniform in the basic as well as in the detailed attributes of uniformity with respect to the number of rooms having access to each room. B not only contains fewer room types, but the rooms in it are also of the same type. Building C is often least in uniformity.

Table-5
Number of Rooms Directly Accessible

1. Number and percentage of rooms in buildings A, B and C in each of the room types.

ROOM TYPES	BUILDING A		BUILDING B		BUILDING C	
	NO.	PCT.	NO.	PCT.	NO.	PCT.
NO ROOMS	7	22.60	29	93.50	9	26.50
ONE ROOM	15	48.40	2	6.50	15	44.10
TWO ROOMS	6	19.40	-	-	6	17.60
THREE ROOMS	2	6.50	-	-	3	8.80
FOUR ROOMS	1	3.20	-	-	-	-
FIVE ROOMS	-	-	-	-	1	2.90
TOTAL	31		31		34	

2. The scores of buildings A, B and C on the indicators of uniformity.

INDICATORS	BUILDINGS (A)	(B)	(C)
INDICATOR ONE	17.33	48.33	17.57
INDICATOR TWO	48.40	93.50	44.10
INDICATOR THREE	225.80	174.19	205.88
INDICATOR FOUR	89.00	87.00	80.00
INDICATOR FIVE	42.99	24.15	43.85

(vi) Relationship of Rooms to Corridor.

How do the buildings examined differ in terms of their uniformity of rooms with respect to the relationship of a room to the corridor in buildings? Rooms in a building relate to the corridor of it in either of five ways; thus there are five room types classified according to the relationship of rooms to corridor in buildings. The three buildings differ in a way similar to that which resulted when uniformity was examined in relation to the number of rooms directly accessible to each room. Building B is considerably more uniform than either A or C with respect to the detailed as well as the basic attributes of uniformity. Rooms in B are not only distributed between only two room types, but also concentrated in one of these types. Rooms in both A and C are distributed between five room types, and the extent to which rooms in each are clustered in any one type is greatly less than in B. The differences between buildings in terms of their extent of uniformity are illustrated by their scores on the indicator of the minimization of room types and by those on indicators of variation between room types.(Table-6)

(a) Minimization of Room Types:
(Indicator One).

The extent of the minimization of room types is significantly greater in B than in A and C, since B contains a lesser number of room types, while all contain largely similar numbers of rooms. C, however is slightly more uniform than A, though both contain similar number of room types, since it contains slightly more rooms.

(b) Variation Between Room Types:
(Indicators Two, Three, Four and Five).

The highest percentage of similar rooms in any type is significantly greater in B than in A or C. This is shown by Indicator Two. The statistical measures, i.e. Indicators Three and Four, again failed to show B as most uniform, because of the small numbers of room types in it. They showed, however, that C is more uniform than A. Finally, Indicator Five concerning the evenness of the distribution summed up differences between buildings. It shows that the distribution in B is least even, though the extent of evenness is greater in A. Thus building B is more uniform than A or C, A is least. To summarize, there was a consistency between the rank order of buildings on both the basic and the detailed attributes of uniformity. B is more uniform than A and C, and A is least.

Table-6
Relationship of Rooms to Corridor

1. Number and percentage of rooms in buildings A, B and C in each of the room types.

ROOM TYPES	BUILDING A		BUILDING B		BUILDING C	
	NO.	PCT.	NO.	PCT.	NO.	PCT.
TYPE ONE	15	48.40	30	96.80	19	55.90
TYPE TWO	3	9.70	1	3.20	4	11.80
TYPE THREE	8	25.80	-	-	8	23.50
TYPE FOUR	2	6.50	-	-	1	2.90
TYPE FIVE	3	9.70	-	-	2	5.90
TOTAL	31		31		34	

2. The scores of buildings A, B and C on the indicators of uniformity.

INDICATORS	BUILDINGS		
	(A)	(B)	(C)
INDICATOR ONE	17.33	48.33	17.57
INDICATOR TWO	48.40	96.80	55.90
INDICATOR THREE	112.90	187.09	264.70
INDICATOR FOUR	87.00	93.00	107.00
INDICATOR FIVE	59.38	12.49	38.16

(vii) Accessibility of Rooms:

How do the buildings examined differ in relation to their uniformity with respect to the accessibility of rooms? Rooms in a building differ in terms of where they can be entered from - i.e. from other rooms, corridor or both, resulting in five main types of rooms classified according to accessibility. The buildings examined differ in their uniformity of rooms with respect to accessibility, in a way similar to how they differed in terms of their uniformity with respect to the majority of the characteristics of rooms examined earlier. B is significantly more uniform than A and C on both the basic and the detailed attributes of uniformity. The higher extent of uniformity in B is a consequence of a fewer number of room types and a greater proportion of rooms being of a similar type. The differences between buildings can be illustrated with respect to indicators of the basic and detailed attributes of uniformity.(Table-7)

(a) Minimization of Room Types: (Indicator One).

There is a greater extent of minimization of room types in terms of accessibility in B than in A or C. B is higher than A, although both contain similar numbers of rooms, because B contains fewer room types. B is higher than C, because B contains fewer room types, which if considered in relation to the numbers of rooms in B and C will still produce a differing extent of minimization. However, C is slightly more uniform than A, since it contains more rooms, although both have similar number of room types.

(b) Variation Between Room Types: (Indicators Two, Three, Four and Five).

The buildings differ, in detail, in a way similar to how they differed in relation to the basic attribute of uniformity. There is greater variation in the number of rooms between the room types in B than those in A or C. Rooms in B are not only distributed between fewer room types, but are also concentrated in one of these types. In A and C there are many rooms in most room types. Differences between buildings can be illustrated in three ways. First: Clustering of Rooms: (Indicator Two). The highest percentage of rooms in any room type in each building, is significantly higher in B than in A or C. 93.50% of the rooms in B are similar, while this percentage drops to 35.50% and 35.30% in buildings A and C respectively. Second: Direct Measures: (Indicators Three and Four). By examining differences in the number of rooms between room types in each building, using statistical measures of dispersion, similar patterns emerge. More variations are in B than in A or C, and these are indicated by the range and the coefficient of variation. Third: Indirect Measures: (Indicator Five). By examination of the extent of evenness in the distribution of rooms in each building, similar patterns emerge. The distribution is considerably less even in B than in A or C, though highest in evenness in A. This means that within the room types in each building, there are more comparable numbers of rooms in room types in A and C than in B, thus leaving B as the most uniform. To summarize, there are clear differences between the uniformity of rooms as far as accessibility is concerned in the three buildings examined. These differences are of a similar pattern with respect to both the basic and the detailed attributes of uniformity. Building B is considerably more uniform than A or C and it is least in uniformity.

Table-7
Accessibility of Rooms

1. Number and percentage of rooms in buildings A, B and C in each of the room types.

ROOM TYPES	BUILDING A		BUILDING B		BUILDING C	
	NO.	PCT.	NO.	PCT.	NO.	PCT.
TYPE ONE	7	22.60	29	93.50	9	26.50
TYPE TWO	4	12.90	1	3.20	4	11.80
TYPE THREE	4	12.90	-	-	6	17.60
TYPE FOUR	11	35.50	1	3.20	12	35.30
TYPE FIVE	5	16.10	-	-	3	8.80
TOTAL	31		31		34	

2. The scores of buildings A, B and C on the indicators of uniformity.

INDICATORS	BUILDINGS		
	(A)	(B)	(C)
INDICATOR ONE	17.33	31.11	17.57
INDICATOR TWO	35.50	93.50	35.30
INDICATOR THREE	112.90	270.96	132.35
INDICATOR FOUR	47.00	93.00	54.00
INDICATOR FIVE	86.50	14.27	77.88

6.1.2. Uniformity of Rooms - General Characteristics: Summary.

Uniformity of rooms, with respect to each of seven selected characteristics of rooms, has been examined in three buildings in relation to two attributes. The first is a basic attribute and concentrates upon the minimization of room types in buildings. This attribute has been indicated by Indicator One. The second is a more detailed attribute and relates to the variation in the distribution of rooms between room types within each building. This detailed attribute has been indicated by four indicators (Indicators Two, Three, Four and

Five). From the analysis of the scores of buildings on each of these indicators with respect to each of the selected characteristics, some general points emerge.

(i): Although four indicators have been used to illustrate the extent of the detailed attribute of uniformity in a building, that is the variation between room types, only one of the indicators could be deemed sufficient, and that is Indicator Five. It is more comprehensive and more reliable. It is more comprehensive than both Indicators Two and Three since it takes into account the total number of rooms, the number of room types and the number of rooms in each room type in a building. It is more reliable than Indicator four, since the latter works better only when there are no great differences between buildings in terms of the number of room types in them. The greater comprehensibility and reliability in Indicator Five has been demonstrated from the analysis made in the previous sections. Its score in a building always resembled the overall trend of variation between room types, as measured by the other indicators. It also, unlike Indicator Four, resembled this trend in situations where there exist similar as well as different numbers of room types in the buildings compared. Accordingly, the extent of uniformity of a building can be illustrated on the basic level by Indicator One, and by Indicator Five only on the detailed level. However, from the examination of the scores of buildings on these two indicators, some other comments can be made.

(ii): There is a clear pattern between the extent of uniformity of a building with respect to the majority of the general characteristics of rooms examined, and that is evident in relation to the basic as well as the detailed attributes of uniformity. Building B is always considerably more uniform than both A and C with respect to the majority of the characteristics. To arrive at an overall assessment of uniformity in a building, the average of its scores on indicators of the basic or the detailed attribute with respect to the selected characteristics of rooms can be used. The average score of each building with respect to its actual scores on each indicator for all the characteristics of rooms examined demonstrates clearly the pattern between the uniformity of a building in relation to the various characteristics of rooms. This can be shown by considering the average of scores with respect to the minimization of room types (Indicator One) and the variation between room types (Indicator Five).

For the minimization of room types, the average of the scores of each building with respect to its uniformity in relation to the seven characteristics is greater in B than in A or C. The average scores are 23.23, 40.94 and 22.96 for buildings A, B and C respectively. These averages resemble the seven actual scores in each building. The coefficients of variation between the seven scores are 49.30, 30.64 and 51.08 in buildings A, B, and C respectively. Such figures indicate that there is a great consistency between the score of a building on Indicator One with respect to a particular characteristic of rooms, and those with respect to other characteristics.

For the variation between room types, indicated by Indicator Five, similar patterns exist. The average of the seven scores of a building on this indicator is higher in B than in A or C. The average scores are 62.38, 21.21, and 62.31 for buildings A, B and C respectively. The coefficients of variation between the seven scores are 31.49, 48.59 and 34.83 for buildings A, B and C respectively. These figures show that there is no great discrepancy between the scores of a building on the detailed attribute of uniformity when different characteristics of rooms are examined. A consequence of the emergence of this pattern could be a reduction in the necessary measurements to establish the extent of uniformity of a building. Measuring uniformity with respect to only a limited number of general characteristics of rooms appears to be sufficient.

(iii): Although in theory, a building that is more uniform than others on the basic attribute of uniformity still could be lower on the detailed attribute, this was not found so. Buildings that were, on average, higher or lower than the rest on the basic attribute were similarly so on the detailed attribute of uniformity. The average score of building B on the basic attribute (40.93) is higher than those of A and C (23.23 and 22.96 respectively). Similar is the case with respect to the detailed attribute, as the average scores of buildings B, A and C are 21.21, 62.38 and 62.31 respectively. These scores show that both A and C, while largely similar, are lower in their uniformity than B. This demonstrates that when design decisions were taken to increase uniformity, they have been done so on many counts of uniformity. However, the smaller the differences between the scores of buildings on either attribute, the less accurate are predictions about their rank order on the other attribute. The average score of A was slightly higher than that of C on the basic attribute, but marginally lower on the detailed attribute.

An assessment of uniformity in a building considering both the basic and the detailed attributes can be made either subjectively in general terms or by examining the rank order of buildings. Examination of the rank order results, sometimes, in a confusing result if the number of buildings compared is small. In this example the overall assessment of uniformity results in B being the most uniform. A and C are very similar.

6.1.3. Uniformity of Rooms - Specific Characteristics: Area:

In the following sections an attempt will be made to arrive at a finer assessment of uniformity of rooms in the buildings examined, by considering the areas of rooms. Uniformity of rooms according to area has been measured by the coefficient of variation between the areas of rooms in a building. Measurement of the coefficient of variation has been made for all rooms in a building together, and for groupings of rooms, i.e. without and with the use of area intervals.

Without the grouping of rooms, there will only be one score for each building to indicate its uniformity. With the groupings of rooms, there will be many scores for each building; each score is relevant to one of the groups of rooms in it. These scores can be averaged to give an overall assessment of uniformity. However, since six ways of grouping rooms in a building have been used, the final scores of a building resulting from each way can again be averaged to indicate uniformity of area. Obtaining a measure of the uniformity of rooms with respect to area of rooms in a building according to each way of grouping rooms in it involved a number of measurements. First, the intervals of area that define each group of rooms in a building have been identified. Second, the rooms of a building that fall into each group have been identified, and the coefficient of variation between their areas measured. Third, to give an average of the coefficient of variation for all the groups of rooms in a building a simple mean of the coefficients of variation for all groups cannot be used. The coefficient of variation in each group relates to rooms that vary in terms of their number and area within the total number and area of all rooms in the building. The coefficient of variation for each group has been multiplied by a weight factor. There were two weight factors - the number of rooms in each group as a percentage of the total number of rooms in a building, and the area of rooms in the group as a percentage of the total area of rooms in the building. Accordingly, for each group of rooms, there resulted two scores indicating the coefficient of variation between rooms in it, but the first resulted from considering the number of rooms while the second considered the area of rooms out of that of all rooms. The mean of these two scores for a group of rooms has been used to indicate the uniformity of area of rooms within the group. The resulting scores for all groups of rooms in a building have been averaged to give an overall assessment of uniformity of rooms with respect to area of rooms in a building. This process has been repeated six times, using the six ways of defining grouping of rooms in buildings.(Appendix-C2)

Examination of the scores of buildings resulted from the measurements outlined above will be utilized in two ways. First, to illustrate how the buildings examined differ in their uniformity of area to allow testing of the propositions concerned with the flexibility of buildings, and second, to explore how the scores of a building vary in relation to the way of grouping rooms in it. The three buildings examined differ in their uniformity of area of rooms, whether groupings of rooms have been used or not. Differences between buildings however when groupings are used vary from those when they are not. Without the grouping of rooms, the buildings differ in a way similar to how they differed in relation to uniformity of rooms when the general characteristics of rooms were examined. With the grouping of rooms, differences between the buildings examined depend upon the way used to define the grouping.

(i) Area: All Rooms:

Without the grouping of rooms, variations between buildings in their uniformity of rooms with respect to area is largely similar to those when the general characteristics of rooms have been examined. Building B is significantly more uniform than A or C which are also largely similar. The coefficient of variation between the areas of rooms in buildings B, C and A are 68.82%, 123.51% and 128.93% respectively. The majority of rooms in B are comparable in their areas, while rooms in A or C differ greatly from each other. However, such variation in the scores of buildings will significantly change when uniformity of rooms is measured in relation to grouping of rooms.

(ii) Area: Grouping of Rooms.

With the grouping of rooms, variation between buildings depend not only upon variations between the areas of rooms in them, but also upon ways used to group rooms within each.(Table-8) Each way of grouping rooms resulted in different numbers of groups of rooms in each building, dependent upon the range of the interval used to define the group. With many rooms in a group, due to a wider range of interval, the extent of variation between the areas of rooms in the group is possibly greater, compared with that when fewer rooms in a group are included. Moreover, since the coefficient of variation of each group is multiplied by the percentages of the number and the area of rooms in it out of those of all rooms in the building, the overall coefficient of variation in a building depends upon the extent of variation between rooms as well as upon these percentages. From the measurement, building A emerged as the most uniform, B the least. The mean of the scores of buildings considering the six ways of grouping rooms within them are 1.62, 2.35 and 2.17 for buildings A, B and C respectively.

These scores suggest that the amount of variation between the areas of rooms considered in relation to the proportion of rooms in which these variations exist is least in A. This pattern results from considering both the number of rooms within each group and their areas as a weight factor. The pattern is similar to that when only area of rooms in a group is considered as a weight factor, since buildings A, B and C score 1.38, 2.26 and 2.23 respectively. However, when only the number of rooms in each group is taken as a weight factor a similar rank order of buildings results, though the difference between A on the one hand and B and C on the other decreases, while the difference between B and C increases. Building B is far less uniform than A or C, and A remains the most uniform. The scores of A, B and C when only the numbers of rooms are taken as a weight factor are 1.85, 2.44 and 2.11 respectively. These scores indicate that the three buildings differ in not only the extent of variation between the areas of rooms, but also in the proportion of rooms at which such variation exists. The scores of B and A are greatly affected by the large number of rooms that differ in area, while that of C is affected by the large proportion of areas of rooms that differ out of the total area of the building.

The score of a building differs in relation to whether the grouping of rooms in it is standard or specific. It is always lower, i.e. high uniformity, when standard intervals are used. The mean scores of buildings A, B and C with respect to the standard intervals are 1.51, 1.54 and 1.92, compared with 1.88, 3.14 and 2.69 when the other four ways of grouping have been used. This pattern is applicable, as well, to the scores of buildings when only the number of rooms or only the area of rooms of each group was used as a weight factor. These differences relate to variation in the number of groups of rooms made in each building according to standard or specific intervals. It is higher when standard rather than specific intervals are used. With many groups, the number of rooms in each group decreases and so does the coefficient of variation between their areas, resulting in higher uniformity.

The scores of buildings also differ with respect to the four ways of defining specific intervals. The scores differ in relation to either or both the ratio between the minimum and maximum limits of intervals, and the starting point of intervals. For the ratio between the maximum and minimum ends of an interval, the uniformity of a building is always lower when the ratio is 1.5 compared with that of 2.0. With a ratio of 2.0 the range of interval is greater than that of a 1.5 ratio, i.e. including more rooms and, thus, possibly more variation between them compared with those in the case of 1.5 ratio. The uniformity of a building is always less if intervals are drawn up starting with the largest room in a building, rather than with its smallest. This is related to the increase in the range of intervals, and thus of the increase in the number of rooms in each group, and possibly their variation within groups if intervals start at the largest room.

The various ways of defining intervals have illustrated that the uniformity of rooms in a building with respect to area can be assessed with varying degrees of precision. Uniformity can be assessed more critically if small ranges of intervals are used. This allows the exploration of variation between buildings at different levels. If the assessment of uniformity fails to show appreciable differences between buildings, then the range of intervals can be increased until clear differences between buildings emerge. In the buildings examined the average of the scores according to the six ways of grouping rooms showed a difference between them, with building A being more uniform than B or C. As C and B appeared largely similar, their differences can be examined in relation to either standard or specific intervals. With standard intervals C is least uniform, while with specific intervals B is the least uniform, as the average of their scores are 1.54, 1.92 for B and C on the standard and 3.14 and 2.69 on the specific intervals respectively. This shows that in general terms, building B is more uniform, but with respect to the particularity of each building, C is more uniform. Such differences can be further discussed, differentiating the scores of uniformity in each group of rooms from others. For example, when intervals are defined starting from the smallest room in a building, C is the least uniform, and B is the least uniform when intervals are defined starting from the largest room in a building. Most rooms in B are relatively similar, compared with greater diversity of rooms in C. Accordingly, more rooms are grouped in most groups of rooms in B, when intervals are defined starting from the largest room. Differences between buildings, at the end, need to be assessed with respect to certain judgements about the most appropriate method of grouping rooms and defining intervals.

These judgements have to be subjective. In this study, all the six ways adopted have shown differences between the buildings examined. In short, with the grouping of rooms according to their area, A is more uniform than C or B, though B, in many cases, is least.

Table-8
Indicators of the Uniformity of Rooms: Area
With and Without Grouping of Rooms
Using Six Rules of Grouping
BUILDINGS A, B and C

I = All rooms.

I33 = Average of those of groups.

I3N = Average of those of groups - In each group, the cofficient of variation is multiplied by the number of rooms in the group as a percentage of the total number of rooms in a building.

I3A = Average of those of groups - In each group, the cofficient of variation is multiplied by the area of rooms in the group as a percentage of the total area of all rooms in a building.

I3NA = Average of those of groups - In each group, I3NA = (I3N+I3A)/2

The six rules of defining intervals can be identified in terms of; the types of intervals resulting, being standard or specific, the ratio between the minimum and maximum areas of the reslting intervals, and the starting point of the intervals being the minimum or the maximum area.

RULE1: Standard Intervals with 2.0 Ratio.

RULE2: Standard Intervals with 1.5 Ratio.

RULE3: Specific Intervals with 2.0 Ratio - Starting from Minimum area.

RULE4: Specific Intervals with 1.5 Ratio - Starting from Minimum area.

RULE5: Specific Intervals with 2.0 Ratio - Starting from Maximum area.

RULE6: Specific Intervals with 1.5 Ratio - Starting from Maximum area.

INDICATOR	BUILDING A	BUILDING B	BUILDING C
I	128.93	68.82	123.51
I33			
RULE1	14.14	6.41	18.70
RULE2	6.99	4.18	8.09
RULE3	13.42	9.28	21.82
RULE4	8.13	4.21	12.67
RULE5	12.42	12.82	21.37
RULE6	8.45	5.00	12.67
AVERAGE	10.05	6.48	14.68
I3N			
RULE1	2.69	2.36	2.83
RULE2	0.94	0.90	0.89
RULE3	2.66	3.70	3.47
RULE4	1.30	1.59	1.71
RULE5	3.18	5.73	3.41
RULE6	1.35	1.86	1.71
AVERAGE	1.85	2.44	2.11
I3A			
RULE1	1.68	2.03	3.30
RULE2	0.71	0.87	0.68
RULE3	1.68	3.22	3.96
RULE4	0.99	1.21	1.53
RULE5	2.84	6.21	4.23
RULE6	1.04	1.57	1.53
AVERAGE	1.38	2.26	2.23
I3NA			
RULE1	2.19	2.20	3.07
RULE2	0.83	0.88	0.78
RULE3	2.17	3.46	3.71
RULE4	1.14	1.40	1.62
RULE5	3.01	6.00	3.82
RULE6	1.20	1.72	1.62
AVERAGE	1.62	2.35	2.17

6.2. Uniformity of Circulation Pattern:

The second of the design variables to be measured in the buildings examined is the uniformity of circulation. It is the extent of similarity between rooms in a building in terms of their relationship to other rooms. There are two aspects of uniformity of circulation, proximity and adjacency. Proximity considers the distances between rooms (p.91), while adjacency takes into account whether rooms are next to, or removed from other rooms, and how they are accessible to each other.(p.92) Eight types of adjacency relationships between rooms have been identified. Measuring the extent of uniformity of circulation in a building, involves; First, identifying distances and adjacency relationships between each room and all other rooms in it.(Appendix-C3. Tables-38 and 39) Second, summarizing for each room, the average relationship to other rooms, by using the mean or the median distance for proximity, and also the percentage of rooms relating to it in each adjacency type for adjacency. (Appendix-C3. Tables-40 and 41) Finally, measuring the extent of variation between rooms with respect to the summaries of their relationships to other rooms. For each building, there will be a number of scores indicating its extent of uniformity. For the uniformity of circulation proximity, there will be four scores resulting from considering two ways of summarizing distances (mean and median), and two ways of measuring variation (the coefficient of variation and the range). For the uniformity of circulation adjacency, there will be eight scores with respect to the eight adjacency types, which can be summarized by one score. The three buildings examined differ in their uniformity of circulation, with respect to both proximity and adjacency.

6.2.1. Uniformity of Circulation - Proximity:

For proximity, the extent of uniformity is higher in A than in either B or C. Differences between the three buildings can be illustrated by their scores on the four indicators of proximity.(Table-9)

Table-9
Uniformity of Circulation Pattern - Proximity
Buildings A, B and C

INDICATORS	BUILDINGS A	B	C
INDICATOR ONE (CV. OF MEANS)	11.26	17.33	18.41
INDICATOR TWO (CV. OF MEDIANS)	14.74	19.80	20.66
INDICATOR THREE (RANGE OF MEANS)	50.91	65.71	61.99
INDICATOR FOUR (RANGE OF MEDIANS)	66.40	76.56	69.81

However, the extent to which the buildings differ from each other varies, depending upon how variations between rooms are measured, as well as on how the average distances between rooms are summarized. When variations are measured by the coefficient of variation (i.e. Indicators One and Two), the extent of uniformity of all buildings is high, and building A is much more uniform than the other two buildings, with C being the least uniform. If variations are measured by the range (i.e. Indicators Three and Four), all buildings score low, with small differences between A on the one hand and both B and C on the other, but with B being the least uniform. Such differences between the indicators show a number of points. First, that the majority of distances in each of the three buildings are largely similar, though differing to an extent between buildings. Low coefficient of variation indicates greater similarity, and that is established by considering the average distances of all rooms. Second, that in each building, the maximum average distance differs greatly from the minimum average distance, indicating that there are few rooms in each building located far away from the majority of rooms, though this differs between buildings. Third, that differences between the three buildings are greater when all average distances are considered compared with considering only their maximum and minimum distances.

Further, the uniformity of buildings differs more when the mean is used to summarize distances for each room (Indicators One and Three), than when the median is used (Indicators Two and Four). The extent of uniformity is always greater in the case of the median. This indicates that the extent of variation is greater between the most frequent distances (not including the minimum and maximum distances) than between all distances (not including the minimum and maximum distances). In short, the buildings differ from each other in relation to the extent to which all their distances, their most frequent distances and the extremes of their distances vary between rooms in each.

To arrive at an overall assessment of uniformity of circulation proximity, the scores of buildings on the four indicators need to be considered. From all the indicators, and considering all distances in it, building A emerged as more uniform than B or C. Each of B or C is higher than the other in its uniformity with respect to a certain group of distances between rooms. B is higher than C when all distances are considered. C is more uniform only if the minimum and maximum average distances are considered. A general assessment of uniformity in buildings B and C, would conclude that building B is more uniform, since more weight needs to be placed upon all distances in a building than upon their extremes.

However, there are some general points that can be drawn regarding relationships between the extent of variation between the average distances of rooms, i.e. extent of uniformity of proximity, and some of the characteristics of corridors in buildings. Corridors are relevant in this respect, since most distances between rooms are measured along them. The length of corridors and their location in relation to the whole layout seem to affect the uniformity of circulation proximity. There are some differences between the three buildings examined in relation to the location of corridors and their length. In A, the corridor is in the central line of the layout i.e. divides the layout symmetrically, and is shorter than the corridors in building B or C. In B, the corridor is again in the central line of the layout but much longer than that in A and C. In C, the corridor is not in the central line of the layout, but is shorter than that in B. The location of the corridor seems to affect the uniformity of proximity as measured by the coefficient of variation. Greater uniformity emerged when the corridor was on the central line of the layout. Both A and B, whose corridors are on the central line, scored more than C on Indicators One and Two. The length of the corridor seems to affect uniformity of proximity as measured mainly by the range as a percentage of the mean. Greater uniformity emerged when corridors were short. Both buildings A and C, which have shorter corridors than B, scored higher on Indicators Three and Four. Relationships between some clear characteristics of layout and scores of uniformity resulting from accumulative detailed measurements of distances, are particularly useful in arriving at an overall assessment of uniformity from the outset. Certainly, there exist more characteristics that could affect the final scores of uniformity, but these need to be identified and explored in a greater number of case studies. The accumulation of information on such characteristics would mean that the rank order of buildings, if not their actual scores, is to some extent predictable. A manipulation of such characteristics would enable an overall and desirable extent of uniformity to be achieved more easily at the initial design.

6.2.2. Uniformity of Circulation - Adjacency:

The extent of uniformity of circulation with respect to adjacency in a building can be inversely shown by the extent of variation between rooms in it, expressed as the percentages of rooms relating to each in each of the eight types of adjacency. There will be eight scores, according to the eight adjacency types, but these can be averaged, resulting in one final score.

The buildings examined differ in many respects, leading to clear differences between their final scores of uniformity. The buildings differ not only in the number of types of adjacency relationships between rooms in each, but also in the types of the majority of relationships.(Table-10) The relationships between rooms in building B are distributed between five out of eight types of adjacency, while those in each of buildings A and C are distributed between eight types. Moreover, there are clear differences between the buildings in terms of the distribution of relationships between the adjacency types. Most of the relationships reported between rooms in building B, (85.42%) are clustered in one type (Type 5). In building A the majority of the relationships are clustered in two out of the eight types, as there are 30.80% and 37.25% in Types 7 and 8 respectively. In C, most of the relationships are clustered in three types, as there are 25.95%, 35.04% and 24.90% in Types 5, 7 and 8 respectively. These percentages show that there are clear differences between the three buildings in relation to their circulation pattern with respect to adjacency.

Table-10
Number and Percentage of Adjacency Relationships
Buildings A, B and C

Adjacency Types	BUILDING A		BUILDING B		BUILDING C	
	NO.	PCT.	NO.	PCT.	NO.	PCT.
TYPE0	031	03.22	031	03.22	034	02.90
TYPE1	030	03.12	002	00.02	038	03.26
TYPE2	006	00.62	000	00.00	016	01.37
TYPE3	022	02.28	000	00.00	022	01.90
TYPE4	022	02.28	049	05.12	036	03.11
TYPE5	188	09.15	821	85.42	300	25.95
TYPE6	008	00.83	002	00.20	014	01.20
TYPE7	296	30.80	056	05.80	405	35.04
TYPE8	358	37.25	000	00.00	288	24.90

However, in addition to these differences, the buildings also differ in the extent of uniformity of circulation patterns in them.(Table-11) Differences in the uniformity of adjacency between the three buildings can be shown by differences in their uniformity with respect to each of the adjacency types or by considering them all together. Since the buildings differ in the types of adjacency of the majority of their relationships, an assessment of all types in each building is more relevant, because the score in each type will be affected by the percentage of relationships in it, as well as by the variation between rooms. As the percentages differ, the score of uniformity would become meaningless with respect to types of differing percentages. There is no common type of adjacency in the three buildings, which have comparably large percentages of relationships.

According to the overall scores of uniformity, building B is considerably more uniform than A and C; the scores of A, B and C are 8.20, 3.99 and 8.23 respectively. These scores give an overall accumulation of the extent of variation between rooms with respect to each of the eight types of adjacency, taken in relation to the percentage of relationship in each type out of the total number of relationship in each building.

Table-11
Uniformity of Circulation - Adjacency
Buildings A, B and C

ADJACENCY TYPES	BUILDINGS A	B	C
TYPE0	00.00	00.00	00.00
TYPE1	02.56	00.86	02.96
TYPE2	01.31	00.00	01.79
TYPE3	03.22	00.00	03.41
TYPE4	02.90	02.45	03.23
TYPE5	20.59	16.00	23.50
TYPE6	02.09	00.00	02.18
TYPE7	15.04	15.37	14.38
TYPE8	26.11	00.00	22.61
ALL TYPES	08.20	03.99	08.23

However, since A and C are largely similar, they may further be compared in relation to the scores of uniformity in the types of comparable numbers of relationships in them. These are Types 8 and 7 in buildings A and C respectively. Building A contains 37.25% of its relationships in Type 8 while building C contains 35.04% of its relationships in Type 7. Thus differences between their scores of uniformity in these types indicate mainly their uniformity rather than the uniformity plus that proportion of variation due to differences in the percentage of rooms. Building A scored 26.11 in Type 8 while building C scored 14.38 in Type 7. This indicates that building C is more uniform than A with respect to the types of adjacency containing a large proportion of relationships (35.04% - 37.25%). Moreover, if A is compared with C, again considering variation in Type 7 in A and Type 5 in C, A is more uniform. A contains 30.80% of the relationships in

Type 7 while C contains 25.95% of the relationships in Type 5. A, however, scored 15.04 in Type 7 while C scored 23.05 in Type 5. Considering differences between the percentages of relationships in Types 5 and 7 compared with the scores in these respective types, where the score of C would be more uniform had it contained exactly similar percentages of relationships, A is nevertheless more uniform.

6.3. Comparison of Buildings - SUMMARY:

The aim of this chapter was to compare the three buildings examined in a case study in relation to the extent of incorporation of two specific design variables concerned with the flexibility of buildings in use. These variables were the uniformity of rooms and the uniformity of circulation pattern. For the uniformity of rooms, the buildings were compared with respect to some selected general characteristics of rooms as well as with respect to the area of rooms. With respect to the general characteristics of rooms, uniformity was shown by measuring the minimization of room types and the variation between room types. With respect to the area of rooms, uniformity was indicated by measuring variation between the areas of rooms in a building for all rooms taken together, and for groupings of rooms, and these were defined in six ways. For the uniformity of circulation pattern, the buildings were compared in relation to both proximity, by measuring variation between rooms in terms of their average distances to other rooms, and adjacency, by measuring variation between rooms in terms of the percentages of rooms relating to each in each of the adjacency types. The comparison has resulted in some clear differences between the buildings examined.

For the uniformity of rooms with respect to the general characteristics of rooms, analysis of the scores of buildings examined enabled three general conclusions to be drawn. First, that only one of the four indicators of the detailed attribute of uniformity, that is Indicator Five concerning variation in the distribution of rooms between room types, can be considered sufficient. It can be reasonably relied upon because it resembles the scores of other indicators. Thus, uniformity of rooms can be indicated by only two indicators, Indicators One and Five, which are relevant to the basic and the detailed attributes of uniformity respectively. Second, that there is a clear pattern between the scores of a building on either the basic or the detailed attributes of uniformity with respect to most of the general characteristics of rooms examined. Building B was always considerably more uniform than A or C with respect to most of the characteristics examined. Finally, there is also a similar pattern between the scores of a building on both the basic and the detailed attributes of uniformity, though in theory such scores may differ. Building B was more uniform than A or C with respect to the basic as well as with respect to the detailed attribute of uniformity.

For the uniformity of rooms with respect to area of rooms, the way buildings differ from each other varies when uniformity is measured for all rooms taken together compared with measuring it for groupings of rooms within a building. Without the grouping of rooms the buildings differ in a way similar to how they differed in relation to the general characteristics of rooms. When rooms are grouped, their scores depend upon the overall extent of variation in the areas of rooms in each group as well as upon the ways of defining groups of rooms. Considering the six alternative ways of grouping of rooms in buildings, building A is more uniform than B and C, and B is the least uniform. Measurements of uniformity of rooms suggest that it is generally a total variable of layout with respect to most of the characteristics of rooms. However, when the pattern of scores in relation to area differed with the grouping of rooms, it was largely to be expected, since detailed measurements of area which clearly had not been done at the initial design of the buildings compared were involved. However, in general terms, uniformity does seem to have been considered at the design stage.

For uniformity of circulation, the pattern of the scores of buildings differed in the case of adjacency from that of proximity. With respect to adjacency, the pattern is largely similar to that resulting from measuring uniformity of rooms with respect to their general characteristics. With respect to proximity, the pattern largely resembles that resulting from measuring the uniformity of rooms with respect to their area, where groupings of rooms have been made prior to comparisons being undertaken.

CHAPTER VII

FLEXIBILITY - COMPARISON OF BUILDINGS

7.1. Introduction:

The aim in this chapter is to identify the flexibility of the buildings that have been examined in a case study. The flexibility of a building was argued, in chapter four, to be a statement about the amount of change in the demand of activities housed in it for accommodation in relation to the amount of adaptation necessary. The more change in the demand that can be catered for, the more is the extent of flexibility. With respect to adaptation, the less the extent of adaptation to be carried out in order to cater for certain changes in the demand, the more is the extent of flexibility. The flexibility of a building can be measured in two main ways, and these are referred to as i) single indicators and ii) composite indicators. Single indicators of flexibility will be examined first. These two ways of measuring flexibility will be used to measure the flexibility of each of the three buildings that are examined in a case study. These were referred to as buildings A, B and C.

7.2. Single Indicators of Flexibility:

There are two single indicators of flexibility. They measure either change in the demand of activities for accommodation or adaptation, independently of each other. Single indicators allow a detailed examination to be made of each of the two basic factors involved in flexibility. They, thus enable a comparison to be made between buildings that are similar with respect to either the amount of change or that of adaptation.

7.3. Change in the Demand:

Change in activities normally relates to either or both of the components of demand, that is, the facilities within rooms or the location of rooms.

7.4. The Demand for the Facilities within Rooms:

By and large, changes in the demand for the facilities within rooms is related to most aspects of the activities housed in rooms. It usually occurs because of two main reasons. The occupiers of each room may have, over time, some change in the activities they carry out, or new occupiers may be brought to rooms, who may carry out different activities from those carried out by their predecessors. Change in the demand of activities for the facilities within rooms in each building can be indicated by changes in; i) users, ii) types of activities, iii) characteristics of activities, and finally, iv) satisfaction with the facilities within rooms.

7.4.1. Change of Users:

There are some aspects related to the users of each building which if changed would indicate change in the demand of their activities for rooms, and thus if related to adaptation would indicate the flexibility of buildings. These aspects are: a) mode of employment being full or part time (Table-12), b) occupation, including the full range of teaching and non-teaching occupation (Table-13) and c) the way rooms are shared, being solely for individual staff, by group of staff, or staff and students and so on.(Table-14)

There are differences between the three buildings with respect to all these aspects, but to a differing extent in the case of occupation and mode of employment than in the case of rooms occupancy. Such differences can be examined in relation to starting year of investigation (1980/81) and in relation to the period from 1980/81 to 1983/84. In the starting year, the majority of users in the three buildings have reported similar types of occupation, that is principal lecturer and similar mode of employment, that is full time, but the percentages of these users are always greater in B than in C than in A. For rooms occupancy, there are many types of occupancy being reported by many users in each building. The majority of users in both B and C have reported sharing rooms with a group of staff, while those in A have reported sharing with students, and to a lesser extent with groups of staff. Such differences would indicate two things, first that there is greater similarity of the characteristics of users in the buildings in terms of occupation and mode of employment, though to a greater extent in B than in A or C, and second, that despite this similarity, room occupancy differed between the buildings. The three buildings differed in terms of the academic department occupying them and that could explain differences in room occupancy, which could relate to the requirements of courses taught in each academic department.

For the period of investigation, fewer changes have occurred with respect to modes of employment and occupation compared with those in room occupancy. For the mode of employment more changes, though few, were reported in B than in A or C, while for the occupation changes were largely similar, though least in C. Such changes can be indicated by the percentages of respondents who reported different mode of employment and different occupation in the finishing year of investigation from that in the starting year. For room occupancy, the buildings differed greatly in the amount of change in them as well as in the directions of such changes. More users have reported different room occupancy in both B and C (48% and 44% respectively) than in A (19%). This would indicate that there were greater re-allocation of users into rooms in both B and C, compared with users of A who mainly have retained their rooms over the years. The directions of change, however, also differ between the buildings. There is a greater tendency towards rooms are occupied by one staff member in C, but towards rooms occupied by groups of staff in both A and B. In short, there were many changes in the three buildings and particularly if room occupancy was examined. Changes were greater in both buildings B and C than in A.

Table-12
Mode of Employment

Employment	BUILDING (A) 80/81	BUILDING (A) 83/84	BUILDING (B) 80/81	BUILDING (B) 83/84	BUILDING (C) 80/81	BUILDING (C) 83/84
FULL TIME	78.90	76.20	91.70	91.30	82.40	83.30
P.TIME 1 DAY	---	---	---	---	05.90	---
P.TIME 3 DAYS	---	---	04.20	04.30	---	05.60
P.TIME 4 DAYS	---	04.80	---	---	---	---
P.TIME 5 DAYS	21.10	19.00	04.20	04.30	11.80	11.10

Table-13
Types of Occupation

OCCUPATION	BUILDING (A) 80/81	BUILDING (A) 83/83	BUILDING (B) 80/81	BUILDING (B) 83/84	BUILDING (C) 80/81	BUILDING (C) 83/84
T. HEAD	11.10	10.00	08.00	12.50	05.90	11.80
T. PRINCIPAL	44.40	35.00	68.00	66.70	52.90	41.20
T. LECTURER	---	---	12.00	08.30	11.80	11.80
T. RESEARCH	---	---	---	04.20	05.90	05.90
T. OTHER	---	05.00	---	---	---	---
N. CLERICAL	22.20	20.00	08.00	04.20	11.80	11.80
N. TECHNICAL	22.20	25.00	04.00	04.20	11.80	17.60
N. PRINCIPAL	---	05.00	---	---	---	---

Table-14
Room Occupancy

OCCUPANCY	BUILDING (A) 80/81	BUILDING (A) 83/83	BUILDING (B) 80/81	BUILDING (B) 83/84	BUILDING (C) 80/81	BUILDING (C) 83/84
ONE STAFF	16.70	10.00	13.60	10.00	15.40	40.00
GROUP STAFF	27.80	45.00	77.30	85.00	61.50	40.00
ONE STAFF-STUDENTS	44.40	35.00	04.50	05.00	07.70	06.70
GROUP F,P/T STAFF	11.10	10.00	04.50	---	07.70	06.70
OTHERS	---	---	---	---	07.70	06.70

7.4.2. Types of Activities:

The types of activities carried out by each user in his/her room was clearly a direct indication of rooms usage and thus any change in them will be more directly related to change in demand. Respondents were asked to indicate whether they carried out any of eight types of activities in their rooms in 1980/81 and 1983/84 (Teaching, study, experimental, preparation, discussion, administrative, relaxation and storing).(Table-15) Their responses were analysed to show differences in the activities carried out in the three buildings in both the starting and finishing dates of the period examined as well as any changes that occurred during this period. By and large, for the starting date of investigation the buildings differed in relation to the type of activity carried out by the majority of users in each, and that is relevant to differences between the academic departments occupying each building. In building B four types of activities were most frequently carried out by the majority of users. These were teaching, research, discussion and administrative tasks. Rooms in building B were used as staff offices in which administrative tasks and tutorials were carried out. In building A most activity types have been carried out. This may be explained by the rooms in building A having been used for a variety of purposes where for example, teaching and preparation were carried out simultaneously in laboratories, dark rooms or information centres. In building C again most activities have been carried out, though there was no significatnly large percentage in any of the types.

In addition, there were some differences between the three buildings in the starting date of investigation with respect to the number of activity types carried out by respondents in their rooms.(Table-16) Though respondents of all buildings have reported many activity types being carried out in their rooms (6, 4 and 5 in A, B and C respectively) many respondents in C reported few activity types while others reported many. This would show that the uses of rooms in C were more diverse than in A or B. The buildings also differed in the extent and the direction of change in these types over the period examined. There were more changes in B than in C and least changes in A, and that is shown by the percentage of respondents who did not report in 1983/84 the same activity types nor the same number of activity types as in

1980/81. For the activity types such as teaching, for example, 40% of the respondents in B have not reported it in either the starting and the finishing dates of investigation. This percentage drops to 0% and 17% in buildings A and C respectively. Similarly, the percentages of respondents who reported in 1983/84 a different number of activity types from that in 1980/81 were greater in B (44%) than in C (22%) than in A (14%). The directions of change also differed. There was a clear tendency in B towards carrying out a lesser number of activity types at the finishing date of investigation compared with that at the starting date. In C the pattern was in reverse, while it is not very clear in A. This would mean that the buildings did not only differ in the activities carried out in them at the starting date of investigation, but also in the extent and direction of change over the period examined. Building B is characterized by the largest amount of change, and that towards fewer numbers of activity types in rooms. Building C is of less change, but towards larger numbers of activity types in rooms. Building A is of the least change with no clear direction of change.

Table-15
Types of Activities in Rooms (%)

ACTIVITIES	BUILDING (A)		BUILDING (B)		BUILDING (C)	
	80/81	83/83	80/81	83/84	80/81	83/84
TEACHING	61.90	61.90	74.10	70.40	38.90	44.40
STUDY-RESEARCH	57.10	61.90	63.00	59.30	50.00	55.60
EXPERIMENTAL	33.30	28.60	03.70	03.70	22.20	27.80
PREPARATION	52.40	52.40	37.00	37.00	38.90	50.00
DISCUSSION	52.40	52.40	70.40	66.70	44.40	61.10
ADMINISTRATIVE	71.40	71.40	81.50	74.10	55.60	61.10
RELAXATION	42.90	42.90	33.30	25.90	22.20	16.70
STORING	04.80	04.80	11.10	11.10	---	---

Table-16

Number of Activity Types Carried Out in Rooms (%)

NUMBER	BUILDING (A) 80/81	BUILDING (A) 83/83	BUILDING (B) 80/81	BUILDING (B) 83/84	BUILDING (C) 80/81	BUILDING (C) 83/84
0 ACTIVITIES	14.30	04.80	18.50	25.90	22.20	05.60
1 ACTIVITY	04.80	09.50	07.40	29.60	22.20	16.70
2 ACTIVITIES	09.50	14.30	---	---	05.60	05.60
3 ACTIVITIES	09.50	14.30	---	03.70	05.60	11.10
4 ACTIVITIES	19.00	19.00	29.60	25.90	11.10	22.20
5 ACTIVITIES	09.50	09.50	25.90	22.20	27.80	33.30
6 ACTIVITIES	33.30	28.60	14.80	14.80	---	---
7 ACTIVITIES	---	---	03.70	03.70	05.60	05.60

7.4.3. The Characteristics of Activities:

Change in the characteristics of activities is again one of the most relevant indicators of change in the demand, and thus if related to adaptation would indicate the extent of flexibility. Respondents were asked to indicate any change they experienced in their activities in relation to; i) the general, and ii) the specific characteristics of activities.

(i) For the general characteristics of activities, respondents were asked to report the extent of change in; the information or materials handled and the ways of handling such information or materials. While very few (5-6%) respondents reported complete change, many reported some changes in the materials or information handled in all the buildings. This varied between the buildings, as most changes occurred in buildings C (83%) and least in A (55%). For change in the ways of handling such information or materials, the pattern is largely similar to that of change in the information or materials handled. However, here buildings A and B were largely similar, though A could be regarded as having more change. In short, there were many changes in all the buildings, though more change in building C than in either A or B, and the aspects of activities that have changed reflect differences between the academic departments in the three buildings. In C and A there were changes in both the information or materials and the ways of handling them, since the activities were diverse any way at the beginning date of investigation and there were many laboratories and offices. In B more changes in the information or materials handled than in the ways of handling them relate to the usages of rooms for teaching but for different courses or modules.

(ii) The <u>specific characteristics of activities</u> which were directly related to the type of institution examined included; the number of teaching hours, number of students taught, courses or modules taught, year of course and finally, the extent of use of illustrative and demonstration materials and equipment.(Table-17) By and large, there was a clear difference between the buildings in relation to change in teaching activities. There were more changes in building C than in building B and this in turn had more changes than building A. This pattern differed to some extent in relation only to the subjects and the courses or modules taught. With change in the subjects taught, both building A and B were largely similar in terms of the percentages of users reporting such changes, though these percentages were relatively too low if compared with those in building C. With respect to change in the courses/modules being taught, there were no respondents reporting such a change in A, while the percentages in both buildings B and C were identical. A further issue may be examined, that is the aspects of their teaching activity in which respondents reported change.(Table-18) This differed in the buildings examined. In building C many respondents reported change in five or six aspects of their teaching activities. In both buildings B and A, though all respondents have reported change in, at the most, four aspects of activities, the percentages of respondents who reported change in various numbers of teaching aspects was higher in most cases in building B than in building A. To sum up, again there were more specific changes in teaching activities in C than in B, which in turn had more change than building A.

Table-17
Change in Aspects of Teaching (%)

	BUILDING (A)	BUILDING (B)	BUILDING (C)
NO. OF HOURS TAUGHT	19.00	29.60	38.90
NO. OF STUDENTS	23.80	29.60	44.40
SUBJECTS TAUGHT	14.30	14.80	33.30
COURSES-MODULES TAUGHT	---	33.30	33.30
YEAR OF COURSE	28.60	03.70	27.80
USE OF ILLUSTRATIVE EQUP.	19.00	33.30	38.90

Table-18
Number of Teaching Aspects in Which Change Occurred (%)

	BUILDING (A)	BUILDING (B)	BUILDING (C)
ZERO ASPECTS	57.10	44.40	38.90
ONE ASPECT	09.50	11.10	11.10
TWO ASPECTS	09.50	14.80	05.60
THREE ASPECTS	19.00	14.80	16.70
FOUR ASPECTS	04.80	14.80	---
FIVE ASPECTS	---	---	11.10
SIX ASPECTS	---	---	16.70

7.4.4. Satisfaction with the Facilities within Rooms:

Change in respondents' level of satisfaction with the facilities within their rooms is an indirect indicator of changes in the demand. There was some difference in the extent to which respondents in the three buildings were satisfied with their rooms in 1980/81.(Table-19) The majority of respondents (60%) were satisfied in building C, and 43% were satisfied in building A, but in building B the majority were dissatisfied (76%). In spite of this variation in the extent of satisfaction in 1980/81, the three buildings were similar in the trend towards higher levels of satisfaction in 1983/84. Yet they differed to some extent in relation to the rate of improvements in the levels of satisfaction. The rate of this improvement was higher in building C than in building B and minimal in building A. In building C while none of the respondents reported a very satisfactory level in 1980/81, 18% of them did so in 1983/84. This was in addition to an increase in the percentages of respondents who reported satisfaction and to a decrease in the percentages of respondents who reported dissatisfaction. In B, the trend is exemplified by the increase in the percentages of respondents who reported satisfaction and the decrease in those of the respondents who reported dissatisfaction. All of this is in addition to the emergence of 10% who reported in 1983/84 neither satisfaction nor dissatisfaction. In A, the percentages in all levels of satisfaction have changed very little. The three buildings also significantly differed in relation to the percentages of respondents who reported in 1983/4 different levels of satisfaction from those in 1980/81. Buildings B and C were largely similar in this aspect and the percentages in them were much higher than those in building A. These percentages covered all levels of satisfaction and were 63%, 61% and 38% in buildings B, C and A respectively.

Table-19

Satisfaction with the facilities within rooms

	BUILDING (A)		BUILDING (B)		BUILDING (C)	
	80/81	83/84	80/81	83/84	80/81	83/84
VERY SATISFACTORY	05.60	04.80	09.10	05.00	---	17.60
SATISFACTORY	38.90	42.90	13.60	20.00	60.00	70.60
NEITHER NOR	33.30	28.60	---	10.00	26.70	05.90
UN-SATISFACTORY	11.10	14.30	54.50	40.00	13.30	---
VERY UN-SATISFACTORY	11.10	09.50	22.70	25.00	---	05.90

To sum up the various indicators of change in the demand for rooms all showed some differences between the three buildings in the amount and the directions of change over the period examined. The amount of change if related to adaptation is what is important here, since it allows a comparison between buildings in terms of their flexibility. For this purpose, it could be noted that there were, on average, many changes in all the buildings, though least in building A. Each of buildings B and C is higher than the other on certain aspects of change.

7.5. The demand for the Location of Rooms:

Change in the demand for the location of rooms is directly related to changes in the pattern of communication between users in a building. Such a change occurs basically as a consequence of changes in the characteristics of users and their activities over time as well as to their re-allocation within buildings. The extent to which the buildings differed in changes in the patterns of communication may be indicated by; i) how much the users in each building have perceived changes, and ii) by examining how much changes have occurred in the journeys within each.

7.5.1. Users' Perception of Change:

The extent to which the demand for the location of rooms has changed over time may be indicated by examining; i) the satisfaction with the location of rooms in 1980/81 and 1983/84, and ii) change in the journeys users made between rooms.

(i) Satisfaction with the Location of Rooms: The three buildings differed in relation to both the percentages of users who reported each level of satisfaction in 1980/81 or 1983/84 and in the change in the levels of satisfaction reported over the period examined.(Table-20) In both 1980/81 and 1983/84 more people were satisfied in building B than in either building A or C. The buildings also differed in the amount of change in the levels of satisfaction, though all were largely similar in the trend towards higher levels of satisfaction with greater rate of improvement in B. More changes have occurred in B than in C and much more than in A. These were reflected by the percentages of respondents who reported in 1983/84 different levels of satisfaction from those reported in 1980/81. These percentages were 59%, 44% and 19% for buildings B, C and A respectively. In view of these variations it could be concluded that there were generally more changes in building B than in building C or than in A and where there were more changes, they were towards more improvements in satisfaction.

Table-20
Satisfaction with the Location of Rooms (%)

	BUILDING (A)		BUILDING (B)		BUILDING (C)	
	80/81	83/84	80/81	83/84	80/81	83/84
VERY SATISFACTORY	15.80	09.50	18.20	20.00	20.00	29.40
SATISFACTORY	47.40	57.10	54.50	60.00	46.70	58.80
NEITHER NOR	26.30	19.00	13.60	10.00	20.00	11.80
UN-SATISFACTORY	05.30	04.80	13.60	10.00	06.70	---
VERY UN-SATISFACTORY	05.30	09.50	---	---	06.70	---

(ii) Change in Journeys: With respect to respondents' perception of the change in the journeys they made from their rooms, again there were some differences between the three buildings. These differences could be indicated in relation to: a) Change in the number/type of people with whom information or materials may be handled, and b) Change in the journeys made to and from rooms. For (a), the buildings differed in relation to the percentages of respondents reporting each extent of change. There were more changes in building C than in either buildings A or B, although both were largely similar. Not only was the percentage of respondents who reported no change significantly lower in building C but, as a consequence, more people reported some or complete change. For (b), i.e. changes in the journeys made between rooms, more changes were reported in building C than in A in which, in turn, there were more changes than in building B. The percentages of respondents reporting a change in the journeys they made were 44%, 33% and 22% in buildings C, A and B respectively. The percentage of respondents reporting a change in the number/type of people visiting them was again higher in building C 56% than in the other two, though higher in building B (41%) than in A (33%). In short, building C is where the most changes have occurred compared with both buildings A and B. Such differences if considered together with change in the levels of satisfaction with the location of rooms would enable a general assessment to be arrived at. It could be concluded in the light of differences between B and C on the change in the levels of satisfaction and on change in journeys, that both B and C were higher than A with respect to the amount of change in the demand for the location of rooms according to users' conception of change. Change in the demand for the locations of rooms can, however, be more reliably indicated by considering change in objective characteristics of journeys between rooms over the period examined.

7.5.2. Objective Characteristics of Journeys:

The unit of analysis in this section is not the individual respondents who filled the questionnaire, rather, it is the journeys made by the respondents. Respondents were asked to report the journeys they made from their rooms to all other rooms in the building they used, for the years 1980/81 and 1983/84. For each journey, they were asked to indicate its purpose, frequency and length of stay at the room of destination. Journeys were then classified in relation to various criteria, which included; the rooms from which journeys started, purpose, number of purposes, frequency, length of stay at the room of destination and finally the type of adjacency relationship between the beginning and destination rooms. These criteria can be seen as alternatives for the typology of journeys in buildings. Each results in various types. All journeys in each building belonging to each of these types were then summarized for the years of the beginning and end of the period examined in relation to the percentage of journeys in each type out of all journeys, average distance (measured from plans) and finally their weekly average total distance. The resulting data described the journeys, and thus the pattern of communication in each building in each year. Change in the pattern of communication over the period examined for each type of journey was indicated by changes in the summaries of journeys, i.e. the percentage, average distance and average total distance of journeys. The extent of change for each type could be indicated by a simple subtraction of the summaries of journeys in 1983/84 from those of 1980/81. However since the emphasis is placed upon the magnitude of change rather than upon its direction, i.e. increase or decrease in the summaries of journeys, the positive or negative values resulting from the subtraction were treated in absolute terms, i.e. their signs (+,-) were ignored. Further, since flexibility was to be examined for the period following 1980/81, and since the buildings vary in their size and population, the extent of change in the summaries of journeys was indicated as a percentage of the summaries in 1980/81. However, to arrive at an overall average of change considering all types of journeys in relation to each criterion of typology, the extent of change in each type will be multiplied by a weight factor. The weight factor for each type of journey is the percentage of journeys that fall into it, out of all journeys in a building. The average of the extent of change for all types of journeys after being multiplied by the weight factor represents the overall change in journeys in each building. For each building, there will be three scores representing the overall change in journeys with respect to the percentage of journeys, average distance and average total distance. These three scores will be available six time, i.e. for the six criteria used for their typology in buildings.

In analyzing the resulting data some clear differences between the three buildings emerged in relation to the changes in them. Building B had a higher extent of change than either buildings A or C. The overall extent of change with respect to the percentage of journeys, average distance and average total distance for the three buildings is shown in a table form. Initially, there were three tables available indicating the extent of change in journeys with respect to the types of journeys resulting from using each of six criteria typology, i.e. the beginning and destination rooms; purposes; number of purposes; frequency; length of stay at destination rooms and the adjacency relationships between the beginning and destination rooms of journeys.

However, the following sections will not include analysis of all these tables.

Analysis of changes of journeys when classified according only to their purposes, number of purposes, frequency, and the length of stay at the destination rooms would be more representative. Moreover, only the percentages and the average distances of journeys at each type, would be sufficient. These points have emerged from taking the mean and the coefficient of variation of the overall extent of change in journeys with respect to all the criteria of journeys examined and with respect to the three ways of summarizing them.(Table-21, 22, and 23) The reason for this limitation is that the coefficient of variation in the scores within each building is more comparable between the three buildings than if all these aspects of journeys and all these ways of summarizing them are considered. For example, the coefficients of variation between the overall extent of change with respect to all criteria of typology were 54%, 86% and 28% for buildings A, B and C when the percentages of journeys were considered. Apparently the data resultant from measuring the summaries of journeys differed with respect to the criteria considered in the typology. The data concerning some of the criteria, such as the adjacency relationship between rooms of each journey, were largely dependent upon the size of the sample. For the ways of summarizing journeys, the average total distances of journeys weekly presents similar problems. Again this seems to be affected by the frequency of journeys as well as their average distance and the changes in them. Measurements of change in journeys classified by their frequency can be done separately together with the purposes and number of purposes of journeys. The final comparison between buildings will be presented with respect to changes in journeys classified in only four alternative ways in relation to; i) purpose, ii) number of purposes, iii) frequency and iv) the length of stay at the room of destination. With respect to each of these aspects, journeys will be summarized using; first, their percentages and second, their average distances at each type of journeys. The comparison, in short, shows that building B is highest in its changes with respect to both the percentages and average distances of journeys, A is least and C in the middle. C is largely similar to B in relation to change in the percentages of journeys and largely similar to A with respect to change in the average distance of journeys. The buildings will be compared with respect to changes in journeys classified according to each of the four aspects of journeys at a time.

Table-21
Overall Extent of Change - Percentages of Journeys (%)

	BUILDING (A)	BUILDING (B)	BUILDING (C)
ROOMS	1.67	0.12	4.32
PURPOSE	2.92	4.20	6.05
NO. OF PURPOSES	4.40	9.87	3.15
FREQUENCY	6.16	2.62	6.63
PERIOD OF STAY	1.18	4.09	4.66
ADJACENCY	2.48	1.10	7.74
MEAN	3.13	3.66	5.42
CV.	53.99	85.67	28.34

For only; Purpose, number of purposes, frequency and destination stay, the mean and the coefficient of variation (CV.) are as follows:

MEAN	3.66	5.19	5.12
CV.	50.11	53.32	26.25

Table-22
Overall Extent of Change - Average Distances of Journeys (%)

	A	B	C
ROOMS	0.55	0.42	0.51
PURPOSE	1.56	3.01	1.97
NO. OF PURPOSES	1.80	8.99	1.53
FREQUENCY	2.57	11.28	5.14
PERIOD OF STAY	2.03	2.86	2.68
ADJACENCY	0.64	2.86	2.68
MEAN	1.52	4.81	2.06
CV.	47.57	81.13	76.22

For only the purpose, number of purposes, frequency and period of stay at room of destination, the mean and the coefficient of variation (CV.) are as follows:

MEAN	1.99	6.53	2.83
CV.	18.78	56.46	49.30

Table-23
Overall Extent of Change - Average Total Distances

	BUILDING (A)	BUILDING (B)	BUILDING (C)
ROOMS	1.95	1.50	0.14
PURPOSE	2.37	6.32	4.10
NO. OF PURPOSES	5.30	9.59	1.90
PERIOD OF STAY	7.96	6.77	5.04
ADJACENCY	2.73	10.96	3.07
MEAN	4.06	7.02	2.85
CV.	55.94	46.39	60.06

For only the purpose, number of purposes, and the period of stay at destination, the mean and the coefficiet of variation (CV.) are as follows:

MEAN	5.21	7.56	3.68
CV.	53.66	23.44	43.79

(i) Purpose of Journeys:

The purpose for which journeys are made could be one of any combination of the following purposes; teaching, study/research, experimental tasks, preparation tasks, discussion, administrative tasks, relaxation/socializing and miscellaneous purposes. Journeys in each building and for each of the years 1980/81 and 1983/84 were classified by these purposes. Change in the purposes of journeys in each building was shown by changes in the journeys that were relevant to each purpose in each building. Change in the journeys relevant to each purpose was shown by changes in the percentage of all journeys in a building and in their average distance. By and large there seem to be more changes in building B than in either C or A, though the extent of change in building A is less than that in C. Such variation will be discussed in relation to first, the percentage number and second, the average distance of journeys.

First for the number of journeys, the three buildings differed in relation to the percentages of journeys for each purpose in 1980/81 as well as in relation to the extent of change in these percentages over the period examined.(Table-24) In 1980/81 the buildings not only differed in the purposes for which the majority of journeys were made in them, but also in the purposes that were dominant on all journeys. The highest percentages of journeys in buildings A and B were reported for administrative tasks (43% and 40% respectively), and in building C for discussion (49%). Thus, the buildings differed in relation to the distribution of the journeys between the various purposes, and accordingly indicating differences between the activities carried out in them. Again, there was more diversity of room usages in building C, compared with more specific usages in B, and to a lesser extent in A. However, coupled with this diversity, clear changes have occurred over the period examined. The extent of change in the percentages of journeys for each purpose was higher for less usual purposes of journeys and that is true for all three buildings. For purposes scoring the lowest percentages, such as experimental tasks, study/research and miscellaneous in buildings A, B and C respectively, the relevant extent of change was 9.0%, 140.00% and 62.00% respectively. For purposes with the highest percentages, such as administrative tasks in both A and B and discussion in C, the relevant extent of change was 18.00%, 13.00% and 3.00% respectively. This discrepancy between the extent of change in all purposes can be averaged, considering the percentages of journeys in each type, in order to arrive at an overall indication of change in the percentages of journeys. The resulting overall extent of change in buildings C, B and A was 6.05, 4.20 and 2.92 respectively. These scores indicated that there were more changes in the percentages of journey for various purposes in building C than in either B or A, though A is less than B.

Table-24
The Percentages of Journeys - Purpose

A) The percentages of journeys made for various purposes.

	BUILDING (A)		BUILDING (B)		BUILDING (C)	
	80/81	83/83	80/81	83/84	80/81	83/84
TEACHING	11.40	11.90	22.20	16.90	29.60	12.80
STUDY/RESEARCH	05.10	04.10	03.00	07.20	18.40	16.10
EXPERIMENTAL	03.40	03.10	01.00	00.00	22.40	15.40
PREPARATION	22.90	22.30	05.10	15.70	21.60	19.10
DISCUSSION	27.40	16.60	30.30	37.30	49.60	48.00
ADMINISTRATIVE	42.90	50.80	40.40	45.80	29.60	38.60
RELAXATION	03.40	03.10	15.20	20.50	---	09.10
OTHERS	06.90	04.70	11.10	15.70	05.60	09.10

B) The extent of change in the percentage of journeys.

	BUILDING (A)	BUILDING (B)	BUILDING (C)
TEACHING	04.38	23.87	56.75
STUDY/RESEARCH	19.60	140.00	12.00
EXPERIMENTAL	09.00	100.00	31.00
PREPARATION	03.00	20.80	12.00
DISCUSSION	39.00	23.00	03.00
ADMINISTRATIVE	18.00	13.00	30.00
RELAXATION	09.00	35.00	---
OTHERS	32.00	41.00	62.00

Second, for the average distance of journeys, the buildings differed in relation to the average distances of journeys for various purposes in 1980/81, as well as in relation to the extent to which the average distances of journeys for various purposes have changed over the period examined.(Table-25) In 1980/81 the average distances of journeys were longer in both buildings C and A than in building B. With respect to the extent of change in the average distances of journeys for various purposes, the buildings differed in relation to the purposes considered, leading to differences in the overall extent of change. Differences in the extent of change, however, were largely evident for those purposes which covered a higher percentage of journeys, such as administrative tasks where percentages of journeys in the three buildings were largely similar. The average distance of journeys for the various purposes have changed significantly more in building B than in either building C or A. The means of the overall extent of change were 3.01, 1.97 and 1.56 for buildings B, C and A respectively. To sum up, in the variation of the buildings in relation to the percentages and the average distances of journeys, there were more changes in building B than in A or C and least in building A as far as the distances of journeys are concerned, though there were more changes in building C than in B or A, (with A being the least always), with respect to the percentages of journeys made for various purposes.

Table-25
Average Distances of Journeys - Purpose

A) The average distances of journeys (m.) classified by their purpose.

	BUILDING (A)		BUILDING (B)		BUILDING (C)	
	80/81	83/83	80/81	83/84	80/81	83/84
TEACHING	31.29	27.52	29.06	33.65	33.41	40.07
STUDY/RESEARCH	33.24	38.35	18.20	20.40	38.53	39.25
EXPERIMENTAL	27.50	23.73	26.40	00.00	40.10	42.37
PREPARATION	38.03	32.89	23.20	21.35	32.06	34.55
DISCUSSION	34.05	30.76	29.60	26.10	36.85	35.65
ADMINISTRATION	35.74	36.11	33.21	40.98	34.71	34.41
RELAXATION	32.20	18.00	35.08	22.91	00.00	33.40
OTHERS	37.00	25.93	17.01	17.78	25.91	38.35

B) The extent of change in the average distances of journeys classified by their purpose.

	BUILDING (A)	BUILDING (B)	BUILDING (C)
TEACHING	12.00	16.00	20.00
STUDY/RESEARCH	15.00	12.00	02.00
EXPERIMENTAL	14.00	100.00	06.00
PREPARATION	14.00	08.00	08.00
DISCUSSION	10.00	12.00	03.00
ADMINISTRATIVE	01.00	23.00	01.00
RELAXATION	44.00	35.00	---
OTHERS	30.00	05.00	48.00

(ii)Number of Purposes:

The purpose of a journey could be one or any combination of the purposes identified in the previous section. Thus, the number of purposes for a journey could be any number of 1-8 inclusive. However, the majority of journeys in both years 1980/81 and 1983/84 and in all the buildings examined have been made for not more than three purposes per journey. Changes in journeys will be examined with respect to first, percentage of journeys and second their average distances. By and large the extent of change is higher in buildings B than in either A or C.

First; for the percentages of journeys at various numbers of purposes, the buildings differed in relation to the percentages of journeys for each number of purposes in 1980/81 as well as with respect to the extent of change in these percentages over the years examined.(Table-26) In 1980/81, the buildings differed in relation to the distribution of journeys at the various numbers of simultaneous different purposes. Journeys in both buildings A and B were made for four different simultaneous purposes, and in building C journeys were made for six different simultaneous purposes. However, though the maximum percentage of journeys in each building were for one purpose, the percentage of such journeys in buildings A and B differed greatly from that in building C. In short, the distribution of journeys between the various numbers of purposes was largely similar in both buildings A and B and differed from that in C. However, as in the previous section on the purpose of journeys, the buildings differed in the changes that occurred in them. Change in the percentages of journeys of simultaneous purposes in the three buildings differed with respect to the specific number of purposes and totally with respect to the overall extent of change. For one purpose, for example, which is the number of purposes for the majority of journeys, there was more change in building B than in either building A or C. The extent of change in buildings B, A and C was 25.00%, 9.00% and 6.00% respectively. The overall extent of change in the percentages of journeys for the various simultaneous number of purposes was significantly higher in building B than in either A or C, and least in C. The average overall extent of change for building B, A and C was 9.87%, 4.40% and 3.15% respectively.

Table-26
The Percentages of Journeys - Number of Purposes

A) The percentages of journeys at types classified by the number of purposes of a journey.

	BUILDING (A)		BUILDING (B)		BUILDING (C)	
	80/81	83/84	80/81	83/84	80/81	83/84
ONE PURPOSE	81.10	88.80	81.60	61.30	58.50	62.00
TWO PURPOSES	15.40	06.40	13.30	23.80	24.40	19.70
THREE PURPOSES	02.30	02.70	02.00	10.00	07.30	12.50
FOUR PURPOSES	01.10	02.10	00.00	01.30	01.60	02.40
FIVE PURPOSES	00.00	00.00	03.10	02.50	04.90	02.00
SIX PURPOSES	00.00	00.00	00.00	00.00	03.30	01.40
SEVEN PURPOSES	00.00	00.00	00.00	01.30	00.00	00.00

B) The extent of change in the percentages of journeys made classified by the number of purposes of a journey.

	BUILDING (A)	BUILDING (B)	BUILDING (C)
1 PURPOSE	09.00	25.00	06.00
2 PURPOSES	58.00	79.00	19.00
3 PURPOSES	17.00	400.00	71.00
4 PURPOSES	91.00	---	50.00
5 PURPOSES	---	19.00	59.00
6 PURPOSES	---	---	58.00
7 PURPOSES	---	---	---

Second, for the average distance of journeys, the three buildings differed in relation to the average distance of journeys for the various simultaneous purposes in 1980/81 as well as in relation to the extent of change in the average distance for all the numbers of simultaneous purposes.(Table-27) In 1980/81, the buildings differed in their average distances for numbers of simultaneous purposes of the majority as well as for those of the minority of journeys in each. The majority of journeys in all buildings, for example were for one purpose, and their average distances were shorter in building B than in the other two. These distances were 29.81m, 34.68m and 36.13m for buildings B, C and A. For the extent of change in the average distances for the various numbers of simultaneous purposes, there were significantly more changes in building B than in either buildings A or C. This higher extent of change was evident in the numbers of purposes of the majority as well as with respect to the overall extent of change. The overall extent of change for the various numbers of simultaneous purposes in buildings B, A and C was 8.99%, 1.80% and 1.53% respectively. To summarize, it is clear that the buildings have differed not only in their journeys in 1980/81, but also in the extent of change in these journeys in the period that followed. Building B again had significantly more change in the number as well as in the average distances of journeys than either A or C, and the least changes were in C.

Table-27

Average Distances of Journeys - Number of Purposes

A) The average distances of journeys classified by the number of purposes of a journey.

	BUILDING (A)		BUILDING (B)		BUILDING (C)	
	80/81	83/84	80/81	83/84	80/81	83/84
1 PURPOSE	36.13	35.24	29.81	38.33	34.68	36.68
2 PURPOSES	37.74	28.31	40.16	21.05	32.44	36.58
3 PURPOSES	28.80	27.00	10.60	30.10	36.86	35.96
4 PURPOSES	06.10	15.50	00.00	15.00	42.40	42.20
5 PURPOSES	00.00	00.00	18.20	31.40	40.03	47.10
6 PURPOSES	00.00	00.00	00.00	00.00	36.80	19.70
7 PURPOSES	00.00	00.00	00.00	12.00	00.00	00.00

B) The extent of change in the average distances of journeys classified by the number of purposes of a journey.

	BUILDING (A)	BUILDING (B)	BUILDING (C)
1 PURPOSE	02.00	29.00	06.00
2 PURPOSES	25.00	48.00	13.00
3 PURPOSES	06.00	184.00	02.00
4 PURPOSES	148.00	---	00.00
5 PURPOSES	---	73.00	18.00
6 PURPOSES	---	---	46.00
7 PURPOSES	---	---	---

(iii) Frequency of Journeys:

Changes in the pattern of communication in a building may be examined in relation to a further aspect of journeys, that is their frequency. The frequency of a journey could be usefully classified as follows: 1-5 times/week, 6-10 times/week, 11-15 times/week, or 16 or over times/week. Changes were indicated by changes in first the percentages and second the average distances of journeys of each frequency over the years. By and large, building B was significantly lower in its extent of change than either building A or C in relation to change in the percentages of journeys and significantly higher than these two in relation to change in the distances of journeys.

First, for the percentages of journeys at the various types of frequency, the buildings differed to some extent in 1980/81, and significantly in relation to the extent of change in these percentages over the years.(Table-28) In 1980/81, though in all buildings there were journeys of all the frequency types, the majority of journeys were of the minimum frequency i.e. 1-5 times a week. The buildings differed mainly in relation to the type of frequency of the highest percentage of journeys among the remaining types of frequency. However, while the majority of journeys were of relatively low frequencies in all buildings in 1980/81, there was also a considerable percentage of journeys of a much higher frequency in building C. For the extent of change in the percentages of journeys of the various frequencies, there were far few changes in building B than in either building A or C. The overall extent of change was 2.62%, 6.16% and 6.64% for buildings B, A and C respectively.

Table-28
The Percentage of Journeys - Frequency

A) The percentages of journeys in the types of journeys classified by the frequency of journeys.

	BUILDING (A)		BUILDING (B)		BUILDING (C)	
	80/81	83/84	80/81	83/84	80/81	83/84
1-5 TIMES	52.10	64.20	66.00	60.80	55.40	66.00
6-10 TIMES	30.20	18.70	15.50	19.00	12.00	05.10
11-15 TIMES	08.30	08.60	09.30	10.10	03.30	05.90
16 TIMES OR OVER	09.50	08.60	09.30	10.10	29.30	22.90

B) The extent of change in the percentages of journeys classified by the frequency of journeys.

	BUILDING (A)	BUILDING (B)	BUILDING (C)
1-5 TIMES	23.00	08.00	19.00
6-10 TIMES	38.00	23.00	58.00
11-15 TIMES	04.00	09.00	79.00
16 TIMES OR OVER	09.00	09.00	22.00

Second, for the average distance of journeys of the various types of frequency, the buildings differed in relation to both the average distances of journeys at the various frequencies in the beginning year of investigation, and in relation to the extent of change in these distances over the period examined.(Table-29) In 1980/81, the average distance of journeys differed between the buildings in relation to all frequencies. In fact, there was no clear pattern about how these distances have differed. However, the distances for higher frequencies were shorter than those for lower frequencies in all buildings, though to a lower extent in building C. A further point may be observed; the average distances of journeys in building C were longer than those in buildings A and B for most of the frequencies, while the average distances in building A were longer than those in building B for all the frequencies. For the extent of change in the average distances of journeys at the various frequencies there were significantly more changes in building B than in building C in which in turn, there were more changes than in building A. This general pattern emerged mainly from the consideration of both the percentages of journeys at the most common frequencies, and at the overall extent of change. For more frequent journeys, presumably in low frequencies such as 6-10 times a week the pattern held, in that changes in building B were significantly more than those in building C, in which again more changes than in building A. Variations may be indicated by the overall extent of change in the average distances in the three buildings. This was 11.28%, 5.14% and 2.57% for buildings B, C and A respectively. To sum up, the three buildings differed in the characteristics of their journeys for the various frequencies in 1980/81 as well as in relation to changes in these characteristics. The extent of change in the percentages of journeys at the various frequencies was significantly lower in building B than in buildings A or C, while the extent of change in the average distances of journeys was greater in building B than in either A or C, though least in A.

Table-29
Average Distances of Journeys - Frequency

A) The average distances of journeys classified by the frequency of a journey.

	BUILDING (A)		BUILDING (B)		BUILDING (C)	
	80/81	83/84	80/81	83/84	80/81	83/84
1-5 TIMES	38.90	36.94	33.95	27.83	30.97	38.30
6-10 TIMES	35.79	30.72	20.10	57.69	40.23	24.81
11-15 TIMES	36.15	30.55	36.06	26.72	47.93	42.42
16 TIMES OR OVER	23.53	20.82	19.97	23.95	35.21	32.44

B) The extent of change in the average distances of journeys classified by their frequency.

	BUILDING (A)	BUILDING (B)	BUILDING (C)
1-5 TIMES	05.00	18.00	24.00
6-10 TIMES	14.00	187.00	38.00
11-15 TIMES	15.00	26.00	11.00
16 TIMES OR OVER	12.00	20.00	08.00

(iv) Length of Stay at Room of Destination:

Change in the pattern of communication in a building could also be illustrated with respect to yet another aspect of journeys, that is the length of time respondents stay at the room of destination of their journeys. The length of stay was classified into the following periods: 0-10 minutes, 11-59 minutes, 1-3 hours and over 3 hours. Changes in the journeys made in each building could be indicated by changes in first, the percentage and second, the average distance of journeys with various periods of stay at the room of destination. By and large, the buildings differed greatly in relation to the extent of change in the percentages of journeys, and to a lesser extent with respect to the distances of journey.

First, for the percentages of journeys with various periods of stay, the buildings differed to a small extent in relation to the distribution of journeys with various periods of stay in 1980/81, and to a greater extent in relation to changes in these percentages.(Table-30) In 1980/81, though the buildings were similar in that journeys in them were of every period of stay and the majority of journeys in them were for short periods of stay, they differed with respect to the percentages of journeys at these various periods of stay. But there was a pattern in that the percentages of journeys with the various periods of stay decreased as the period of stay increased. In building A, for example, the percentages of journeys with the four periods of stay were 75%, 18%, 5% and 2% respectively. In the three buildings in 1980/81 the majority of journeys were for shorter periods of stay, though many journeys were also made in building C for longer periods of stay. This in fact would indicate that the uses of rooms in building C were more diversified than those in either building A or B. For the extent of change in the percentages of journeys with the various periods of stay over the years examined there were significantly less changes in building A than in either building B or

C. This pattern was applicable to the extent of change with respect to all periods of stay except the shortest. However, variation between the buildings in relation to their overall extent of change may be explained by their variations in both the percentages of journeys with various periods of stay and the extent of change in these percentages. Such variation may be examined in relation to any two buildings at a time. Buildings B and C, for example were largely similar in their overall extent of change, but each was higher than the other with respect to either the percentages of journeys or the extent of change in the various periods of stay. For the period of 0-10 minutes for example, which in B had a higher percentage of journeys than C, C was higher in its extent of change. In short, though the three buildings differed slightly in their percentage of journeys with the various periods of stay at the room of destination, the extent of change in these percentages was less in building A, than in either building B or C, though highest in C. The overall extent of change was 1.18, 4.09, 4.6 for buildings A, B and C respectively.

Table-30
The Percentages of Journeys
Period of Stay at Room of Destination

A) The percentages of journeys at the various types classified by the period of stay at the room of destination of a journey.

	BUILDING (A)		BUILDING (B)		BUILDING (C)	
	80/81	83/84	80/81	83/84	80/81	83/84
0-10 MINUTES	75.30	77.80	67.10	65.00	52.20	59.00
11-59 MINUTES	17.60	17.20	26.00	21.30	31.50	33.50
1-3 HOURS	05.30	03.30	05.50	13.80	12.00	05.40
OVER 3 HOURS	01.80	01.70	01.40	00.00	04.30	01.40

B) The extent of change in the percentages of journeys classified by the period of stay at the room of destination of a journey.

	BUILDING (A)	BUILDING (B)	BUILDING (C)
1-10 MINUTES	03.00	03.00	14.00
11-59 MINUTES	02.00	18.00	06.00
1-3 HOURS	38.00	151.00	55.00
OVER 3 HOURS	06.00	100.00	67.00

Second for the average distances of journeys at the various periods of stay, the buildings were to some extent different in relation to both their distances in the various periods in 1980/81, and their overall extent of change.(Table-31) In 1980/81, there was no clear relationship between the average distance of journeys and the length of stay at the room of destination in any of the three buildings. The average distances in all periods of stay and in all buildings ranged from 10.40m to 38.66m, though the majority of average distances were over 30.00m. In the shortest period of stay, i.e. 0-10 minutes, the average distances in buildings B, C and A were 31.02m, 35.25m and 36.57m respectively, while in the longest period of stay, they were 10.40m, 35.65m and 38.66m. However, it may be observed that the average distances in building A were longer than those in building B or C, and those in B were generally shortest. This pattern was applicable to the periods of stay of the highest as well as the lowest percentages of journeys. In short, the average distances of journeys in 1980/81, while not clearly related to the length of stay were generally shorter in buildings B and C than in building A. For the extent of change in the average distances of journey with the various periods of stay, the three buildings were largely similar in their overall extent of change, though the change was highest in B, and least in A. Building B was highest in its extent of change in the periods of stay of the highest percentage of journeys. Building A was higher than the other two, in relation to the period of the second highest percentage of journeys. Building C, however was significantly highest in relation to the two other periods of the lowest percentages of journeys. Accordingly, it was through the combination of the percentages of journeys and the extent of change at the various periods of stay that the total overall extent of change at each of the buildings was established. The overall extent of change was 2.03%, 2.68% and 2.86% for buildings A, C and B respectively. In short, though the buildings were relatively comparable in their average distances in 1980/81 and in their overall extent of change, the journeys were relatively shorter in building B than in the other two, and have been undergoing more changes as well.

Table-31
Average Distances of Journeys
Period of Stay at Room of Destination

A) The average distances of journeys classified by the period of stay at the room of destination.

	BUILDING (A) 80/81	BUILDING (A) 83/84	BUILDING (B) 80/81	BUILDING (B) 83/84	BUILDING (C) 80/81	BUILDING (C) 83/84
0-10 MINUTES	36.57	35.64	31.02	34.60	35.25	37.36
11-59 MINUTES	35.26	24.23	27.08	23.87	32.12	34.59
1-3 HOURS	31.82	29.46	35.35	33.56	13.83	40.55
OVER 3 HOURS	38.66	38.06	10.40	10.40	35.65	20.46

B) The extent of change in the average distances of journeys classified according to the period of stay at the room of destination of journeys.

	BUILDING (A)	BUILDING (B)	BUILDING (C)
1-10 MINUTES	03.00	12.00	06.00
11-59 MINUTES	31.00	12.00	08.00
1-3 HOURS	07.00	05.00	27.00
OVER 3 HOURS	02.00	00.00	43.00

7.5.3. Objective Characteristics of Journeys - Summary:

The previous sections showed alternative bases for the comparison of buildings in relation to the extent of change in their patterns of communication over time considering objective changes in journeys. Each section has concentrated on a particular aspect of journeys which was used as a criterion of their classification. The extent of change in the journeys of each of the types resulting was summarized in relation to the average percentage and the average distance. The comparison of buildings has revealed that there were more changes in building B than in either building C or A, and least in A.

The mean of the overall extent of change resultant from consideration of the purposes, number of purposes, frequency and length of stay at destination room, was used to give a general assessment of change in journeys in each building. The means of the overall extent of change with respect to the percentages of journeys were 5.19, 5.12 and 3.66 for buildings B, C and A respectively. The means of the overall extent of change with respect to the average distances of journeys were 6.53, 2.83 and 1.99 for buildings B, C and A respectively. This would indicate that there were most changes in the average distances and in the percentages of journeys in B and least in A. C, however, was nearly similar to B when the percentages were considered while nearly similar to A when the average distances were considered.

How do these variations explain differences in the overall change in the three buildings? A key factor in the interpretation is identifying which of the types of change related to changes in the percentages of journeys and which related to changes in the average distances of journeys. Changes in the percentages of journeys indicate, mainly, changes in the pattern of communication between users in a building regardless of their allocation to rooms. Such changes may be brought about by changes in the population occupying the building and/or changes in their work patterns. Changes in the distances of journeys, however, indicate both changes in the pattern of communication between users in a building and/or changes in their allocation to rooms. The pattern of communication between users in a building may not change, if neither the population nor their work changes, but still some changes in the average distances of their journeys could occur as a result of allocation in the building. Thus, if variation between the buildings in relation to their extent of change in the percentages of journeys or their distance was examined against this background it may be concluded that in building A, there were few changes in the pattern of communication and in the re-allocation of users within the building over the years, in building C there were more changes in the pattern of communication than in the allocation of users within the building and finally, in building B there were more changes in the pattern of communication than in the other two buildings, and also significantly more changes in the allocation of users within the building. If these changes can be used to indicate change in the demand it may be concluded that it was least in A and more in C and significantly more in B.

7.5.4. The Demand for the Location of Rooms - Summary:

Two ways have been used for assessing change in the demand for the location of rooms. The first concentrated on indicators relevant to users' subjective assessment of change while the second considered change in the objective properties of journeys. According to the subjective assessment both B and C were higher than A in the amount of change. According to the objectives measurements, B had more change than C and significantly more than A. It is clear that there was a great similarity between the patterns that emerged from the two ways of assessing change in the demand for the location of rooms. It could be concluded that B sustained its higher level of change and A had least change, while C was in the middle between the two.

7.6. The Demand for Rooms - Summary: Location and Facilities:

A general assessment of change in the demand for the facilities within rooms revealed that though changes had occurred in all the buildings they were always higher in both B and C than in A. A comparable assessment of change in the demand for the location of rooms indicated that they were highest in B and least in A. There was again a clear pattern between the amount of change that occurred in the demand for the facilities within rooms and for their location. B had the most changes, while A had the least. The amount of change in C was more than in A and less than in B.

7.7. Adaptation of Buildings:

Adaptation is the controlling criterion against which variations between buildings in terms of change in demand may be interpreted to indicate variation in their extent of flexibility. This section is a univariate descriptive account of the extent of adaptation that occurred in the three buildings during the period 1980-1984. At a quick glance, the buildings seem to differ greatly in the amount of adaptation that was made in them. Building C has had large scale adaptation compared with either B or A. Both buildings B and A were largely similar in the minimal extent of adaptation. In fact, only one room in building A has been sub-divided into two other small rooms, and in B, two rooms were sub-divided into two each. This superficial variation in the amount of adaptation may be examined in more detail with respect to various aspects of adaptation. However, before this examination is made, the reasons for which adaptations were made in the three buildings will be discussed.

7.7.1. Reasons for Adaptation:

The percentages of respondents reporting various reasons for adaptations in the three buildings indicated, clearly, how low the extent of adaptation was in both buildings A and B compared with that in C.(Table-32) In all buildings, the most frequently reported reason for adaptation was the accommodation of new equipment. 56%, 33% and 11% were the percentages of respondents reporting such a reason in buildings C, A and B respectively. For other reasons, again significantly more respondents in building C have reported adaptation to increase/decrease the area of rooms or to improve standards, than in either of A or B. Thus variation between buildings in terms of the percentages of respondents reporting different reasons would indicate variation in the extent of adaptation as well as variation in the types of change in activities encountered. In building A, most adaptations were made mainly to accommodate new equipment, while in building C, other reasons were also important.

Table-32
Reasons for Adaptation (%)

	BUILDING (A)	BUILDING (B)	BUILDING (C)
To accommodate new equipment	33.30	11.10	55.60
To increase or decrease area	04.80	03.70	27.80
To improve or maintain standards	09.50	11.10	38.90
To allow for new communication patterns	04.80	---	---
To make provision for privacy	---	---	05.60

7.7.2. The Extent of Adaptation:

The extent of adaptation may be indicated by (i) the level of craftsmanship involved in carrying out the adaptation, and (ii) the components of buildings in which adaptations were made.

(i) Level of Craftsmanship:

The users were asked to indicate who carried out the adaptations in their rooms. Adaptations may be carried out by individual users, group users, departmental or polytechnic central workshops, outside firms and specialized outside firms. The buildings differed with respect to; first the percentages of users reporting adaptation at each of the levels of craftsmanship and second, with respect to the level of craftsmanship at which most adaptations were made in each building.(Table-33) In the percentages of respondents reporting various levels of adaptation, the buildings differed in the average percentage for all levels, as well as more remarkably at certain specific levels. More adaptations in relation to all levels on average were carried out in building C than in building A in which in turn had more adaptations than building B. This pattern was relevant to the adaptations made by group users and to a lesser extent with respect to those made by outside firms. With respect to individual users and departmental workshops, the pattern differed. Here, more adaptations were made in building A, though in itself this percentage was small. With respect to adaptations made by the polytechnic central workshop, the highest percentage was in building B. This may be accounted for by the fact that there were no departmental workshops in the departments using building B. In short, there were many more respondents reporting adaptations in building C than in A, in which in turn more respondents reported adaptations than in B. For the level of craftsmanship at which most adaptations were made, there were again large differences between the three buildings. There were high percentages at most levels in building C and the percentage of respondents reporting adaptations by outside and specialized firms were significantly higher than in buildings A or B. Most responses about the adaptations in building A were about departmental workshops adaptations. Considering that there was no departmental workshop in building B, it may be concluded that there were more adaptations of higher levels of craftsmanship in building C than in buildings A or B, though in A there were more adaptations than in B.

Table-33
Craftsmanship Involved in Adaptations (%)

	BUILDING (A)	BUILDING (B)	BUILDING (C)
INDIVIDUAL USERS	09.50	---	---
GROUP USERS	04.80	03.70	16.70
DEPARTMENTAL WORKSHOPS	33.30	---	16.70
CENTRAL WORKSHOPS	04.80	22.20	---
OUT-SIDE FIRM	04.80	03.70	50.00
SPECIALIZED FIRM	---	---	16.70

(ii) Buildings Components and Frequency:

Examination of components of buildings in which adaptations were made indicate the extent of adaptation. Implicitly assumed is that certain components are associated with higher levels of adaptation than others. However, this is not always the case; it is largely dependent upon the construction of buildings. But all the three buildings examined were of a comparable construction. The ease with which adaptations were made with respect to each component of buildings may be seen to be associated with the frequency of adaptations in each. The components of buildings were moveable furniture, fixed furniture, services, environmental fixtures, false-ceilings, finishes, doors and finally walls or partitions. The frequency with which each may be adapted was less than once a year, once a year, once a term, and finally more than once a term. Examination of responses indicated that the buildings differed in two main aspects. They differed in relation to the frequency of adaptation in the various components and in relation to the components in which many adaptations were made.

For variation in the frequency in which adaptations were made, building B had the least number of components in which adaptations were made once or more a year, while building C had the maximum number of components. In six components, adaptations were made less than once a year in building B, while the number was four in building A and three in C. For the types of components in which adaptations were made once or more a year, adaptations were made more frequently in different buildings in each component. For example, for moveable furniture most of the adaptations in buildings A were made more than once a term, and in building C, once a term, while in B less than once a term; for walls least frequently in B, and more frequently in A and C. Many respondents in them have reported adaptations of walls once a term. The percentages of respondents in the buildings who reported adaptations in certain components of a similar frequency differed according to the component examined. By and large, building C had the maximum percentages. In moveable furniture, for example, there were more respondents in C who reported adaptations once a year and once a term than in either A or B. With fixed furniture, there were more respondents who reported adaptations once a year in building B, than in C or in A. With services, adaptations, made once a year, were reported more in building A than in C which in turn had more than B. With doors, adaptations of once a year have only been reported in building C. In short, the buildings differed in relation to the frequency of adaptations made in the various components, the components in which many adaptations were made and finally in relation to the percentages of respondents who reported each frequency of adaptations at each component. By and large, more adaptations were made in building C than in A in which in turn had more adaptations than in building B.

To sum up, the examination of the various indicators of adaptation has largely confirmed the superficial conclusion about variation between buildings in their extent of adaptation. It may be concluded, accordingly, that in building C there were more adaptations than in either A or B, though B had slightly fewer adaptations than A. This variation in the extent of adaptation if used in relation to variation in the extent of change in demand would give a general assessment of flexibility in the three buildings.

7.8. Single Indicators of Flexibility - Summary:

The purpose of examining both the change in the demand for rooms and the adaptation made in buildings over a certain period of time was to arrive at an assessment of their flexibility in use. If the buildings were similar in the amount of change in the demand for rooms and in adaptation, then they were similar in flexibility. If they were similar in the amount of change only, then those with the least adaptations were the most flexible. If buildings were similar in adaptation only, then those of the largest amount of change were the most flexible. If buildings differed in both change and adaptation, then their flexibility will be assessed by considering the amount of difference between them in change in relation to that in adaptation, and that can be done for every two buildings at a time.

The three buildings differed in relation to both change in the demand for rooms and the adaptation made in them. There were more adaptations in C than in either A or B, though least in B. There were more overall changes in the demand for rooms in B than in C than in A. From these differences, B appeared to be the most flexible since it contained more change and least adaptation. It was more flexible than C, mainly because the latter contained significantly more adaptation. B was more flexible than A mainly because it contained significantly more changes. Differences in flexibility between A and C were less clear, since C contained more change while A contained less adaptation. The comparison between C and A can be facilitated by examining composite indicators of flexibility. Finally, a detailed assessment of differences between the flexibility of building B on the one hand and either A or C on the other can be made by an examination of the specific aspects of change, i.e. change in the demand for the facilities within rooms or change in the demand for the location of rooms. For the flexibility of buildings in relation to change in the demand for the facilities within rooms, B was more flexible than C, since it contained less adaptation, while more flexible than A since it contained more change. For the flexibility of buildings with respect to change in the demand for the location of rooms, B was far more flexible than C because it contained more change and less adaptation, and only greater than A since it contained more change.

7.9. Composite Indicators of Flexibility:

Composite indicators of flexibility seek to measure change in the demand for rooms and adaptation both considered together and in relation to other criteria. They were measured by the percentage of users who reported various types of change by the varying extent of adaptation. There were three basic composite indicators of flexibility; i) the percentage of users who reported change in their work but have neither requested to move nor to adapt their rooms, ii) the percentage of users who reported change in their work but have not, actually moved from nor adapted their rooms, and iii) the percentage of respondents who moved from their rooms and accordingly, needed to adapt their new rooms for their requirements.

7.9.1. Composite Indicator One - Change of Work: No Request to Move from or to Adapt Rooms:

If people have experienced change in their work, and have neither requested to move from their rooms nor to adapt them, then this would be explained, in many cases by the extent of change in the requirements of accommodation being tolerable in relation to the available accommodation. This may be seen to give an indication of the extent of flexibility available in the accommodation. Of course, when many changes occur, but with no adaptation being requested, then the building would be of a significantly higher flexibility in relation to the case of minimum adaptation. The higher the percentage of respondents reporting change in their work without even requesting to move from or to adapt their rooms, the higher the extent of flexibility of their buildings. This indicator may be examined in relation to various types of change. Basically, respondents were asked to indicate change in their activities and in their demand for accommodation.

(i) Activities:

Change in activities may be indicated by changes in either (a) the general or (b) the specific characteristics of activities.

(a) General Characteristics of Activities:

Change in the general characteristics of activities may be looked at in relation to the components of activities or their location. The components of activities in which change may occur included the information or materials handled, the number/type of people with whom such information may be handled and finally, the ways in which such information or materials were handled. In change in the information or materials handled, the buildings differed greatly in relation to the percentages of respondents reporting such a change in each. The buildings also differed though to a varying extent in relation to the percentages of respondents reporting various amounts of change. With some change in the information or materials handled, the percentages of respondents in the three buildings were to some extent similar to each other. These were 64%, 72% and 60% for buildings A, B and C respectively. With respect to complete change in the information or materials handled, there was a great difference between the three buildings. In building C, more respondents have reported such a change compared with those in either buildings A or B. All respondents who have neither requested to move from nor to adapt their rooms in building C have reported complete change in the information or materials handled. With respect to the location of activities, activities could be seen as those that took place in rooms or outside rooms. Change may occur in what was done in rooms, or in the journeys made by respondents from their rooms as well as in those made by other staff towards respondents' rooms. The percentages of respondents who reported change in what they did in their rooms were of a similar pattern to those concerning change in the information handled in the three buildings. To sum up, it was in building C that the maximum extent of change in general characteristics of activities has occurred, while it was less in buildings A or B.

(b) Specific Characteristics of Activities:

Specific characteristics of activities were those that basically related to the building type examined. In teaching institutions, these included; the number of teaching hours, the number of students taught, the subjects taught, courses of modules taught, years of course and the extent of using illustrative and demonstration materials. A measurement of change in these teaching aspects was obtained by analyzing the responses of teaching staff only. In all buildings, there was a change in teaching aspects, though to differing degrees. There were more changes reported in building C than in either building A or B. For example with respect to the number of teaching hours, all respondents in building C reported such a change, while the percentages of those in buildings A and B was 75%. For the subjects taught, the percentages of respondents who reported change in all buildings were largely similar to those concerning the number of hours of teaching. These percentages were 100%, 67% and 56% for buildings C, A and B respectively. Another example is the change in the number of students taught and the extent of use of illustrative materials. Here though building C had the highest percentage of respondents reporting such a change without requesting to move from or adapt their rooms, the extent of change in building A was much lower than in building B. The percentages of respondents in buildings, C, B and A were 86%, 67% and 25% respectively, for change in the number of students taught, and 80%, 50% and 25% for change in the extent of use of illustrative materials. Also, with respect to change in the year of courses taught, building C maintained its largest percentage, none of the respondents in building B reported such a change. Finally, with respect to changes in the courses or modules taught, the pattern was very different. Now it was building B which had the highest extent of change. All respondents in building B reported such a change, while this percentage in buildings C was 75% and in building A none of the respondents reported such a change.

To sum up, the percentages of respondents who reported change in aspects of teaching activities were higher in building C than in either A or B, and in a pattern similar to the percentage of respondents who reported change in the general characteristics of activities. The main difference here was that the rank order of buildings A or B to the other was largely related to the aspect of teaching examined.

(ii) <u>The Demand of Activities:</u>

The buildings differed in relation to the percentages of respondents reporting change in their activities and who neither requested to move from or to adapt their rooms; do they differ in relation to the percentages of users who thought that changes in their activities have affected their demand for rooms? Of course, these percentages of change in demand are more directly relevant to the indication of flexibility. People are expected to make requests about moving from or adapting their rooms, if they think that changes in their activities have affected their requirements for rooms. If such requests have not been made, it may be assumed that although change in activities have caused change in the demand, this change is still tolerable within the existing accommodation. As previously mentioned, there were two basic aspects of the demand for rooms. These are the demand for the facilities within rooms and that for the location of rooms. By and large, there was a clear difference between the three buildings in terms of the percentages of respondents who reported change in their demand for rooms and have neither requested to move from nor to adapt rooms. However, these percentages in the three buildings exhibited a pattern that differed to some extent from that in change in activities. What was clear was that for both aspects of demand, the rank order of each building to the other two was identical. The highest percentage of respondents was in building B, the lowest was in A. For change in the demand for the facilities within rooms, for example, these percentages were 75%, 57% and 43% for buildings B, C and A respectively. These percentages, seem to show a correspondence existing between the rank order of buildings with respect to change in the demand and that in relation to change in activities. Building A was always lowest, and buildings B and C were relatively higher. To sum up, there seems to be a pattern about the rank order of each building in relation to the change in the general as well as the specific characteristics of activities and the demand of activities for accommodation. In conclusion, it may be assumed that building A is the least flexible and probably B is the most, with C possibly as flexible as B.

7.9.2. Composite Indicator Two - Change of Work: No Change of Location, No Adaptation of Rooms:

Now a less severe indicator of flexibility. This is when people experience change in their activities or demand but actually remain in their rooms and do not make any adaptations to them. Some of these people may have complained about the appropriateness of their rooms, but their inappropriateness was not at all extreme, i.e. they remained in their rooms but with a diminished extent of satisfaction. However, because of the small number of users, the percentages of those reporting change who neither moved from nor adapted their rooms will not be sub-divided with respect to various levels of satisfaction. This composite indicator indicated some variations between buildings in terms of their flexibility. The way in which the buildings differed was largely similar with respect to various types of change examined, i.e. change in the general or the specific characteristics of activities, or even according to the demand of activities. By and large, for all types of change, the buildings differed similarly to the differences with respect to Composite Indicator One.

(i) Activities:

Change in activities may be looked at in relation to (a) the general or (b) the specific characteristics of activities.

(a) General Characteristics of Activities:

For the general characteristics, change may be examined in relation to the components of activities or their location. For the components of activities; Change could occur in the information or materials handled, ways of handling them and the number/type of people with whom such information may be handled. Variations between the three buildings in relation to the percentages of respondents who reported change in any of these aspects of activities and have neither moved from nor adapted their rooms, were largely similar. In building B, there was always a significantly higher percentage of respondents reporting such a change than in either building A or C. In building C, the percentage of respondents reporting such a change was always lowest. For change in the information or materials handled for example, the percentages of respondents in buildings B, A and C were 83%, 56% and 40% respectively. From these percentages, it may be concluded that building B was significantly higher in its extent of flexibility than either building A or C. Activities of users in a building could also be seen as those which take place in rooms or those outside rooms, i.e. journeys between rooms. For changes in what respondents did in their rooms and in the journeys made, building B again was distinguishable from the rest. All respondents in it have reported that the changes they experienced were to do with what they did in their rooms and with the journeys they made from their rooms. In building A, however, the percentages of respondents who reported such changes was lowest. For changes in the number/type of people visiting respondents' rooms, the pattern was slightly different, in that it was in building C that all the respondents have reported such a change and not in building B. Building A maintained its lowest percentage of respondents reporting such a change. In short, in all the buildings there were relatively high percentages of respondents reporting changes in what they did in their rooms as well as in the journeys made between rooms. Building A had the lowest percentage always, and building B and C were largely similar on average.

(b) <u>Specific Characteristics of Activities</u>:

Variations between buildings, in terms of the percentages of respondents in each who reported change in various specific aspects of teaching, exhibited a less consistent pattern. However, in all the buildings, most percentages were relatively high. With respect to the number of students taught and the extent of using illustrative materials, for example, it was in building B that the highest percentage was reported, and in A the lowest. For the change in subjects taught and the year of course, though building B maintained its relatively high percentage of respondents, it was in building A where identical percentages of respondents have also reported such changes. This of course left building C with the lowest percentage, though in itself was relatively high -67% for changes in both these aspects. With respect to the hours of teaching and the modules or courses being taught, the pattern was different. The least percentage of respondents reported in B, and slightly more in building A leaving building C with the highest percentage. On average, building A was lower in its flexibility than B and C. This variation between buildings seemed to relate to or indicate variations between the types of use in them. In building B for example, where module teaching predominated, there was a greater possibility of change in the number of students taught as well as in the number of teaching hours. In building C, however, where a variety of changes have taken place, the percentages of respondents who reported change in the various aspects of teaching were largely similar. In building A, lower percentages of respondents have reported changes in various aspects of teaching because the pattern of use in the building was more stable.

(ii) <u>The Demand of Activities</u>:

The pattern in which the buildings differed in relation to the percentages of respondents who reported change in their demand for rooms was largely similar to that with respect to change in activities. Both buildings B and C, on average, have much higher percentages than building A, though in B, in most cases the percentage was higher than in C. For the change in the demand for facilities with rooms, the percentages in the three buildings differed to some extent. The percentages were highest in building B and lowest in A. For the location of rooms, the buildings were similar, in that all respondents who reported change in their requirements have neither moved from nor adapted their rooms. In short, variation in the percentages of respondents who reported change in demand were basically related to the demand for the facilities within rooms. These variations could indicate the extent of flexibility in the three buildings. The extent of flexibility seemed to be of a decreasing order for buildings B, C and A.

7.9.3. Composite Indicator Three - Change of Work: Location Changed, Adaptation Made to Rooms:

The previous two composite indicators were basically about the extent of inertia, i.e. respondents staying in the same room and experiencing change but not requesting or actually moving from or adapting rooms. There is another aspect of flexibility, i.e. when users move from their rooms. When users move from their rooms, the main criteria which indicated the extent of flexibility was the decrease in the extent of adaptation that needs to be made to the new rooms, in order to suit the requirements of its new occupiers. The less adaptation is needed in the new rooms the more flexible the building, since it allows for re-allocation of users into the other rooms. However, the reasons for which users move to different rooms needed to be examined, as they defined the interpretation of the percentage of users who changed location. If users move because of inappropriateness of their rooms to their changing requirements, then the more users move, the less the extent of flexibility. However, once users have moved from their rooms because of considerable changes in their work, the main criteria becomes the decrease in the level of adaptation needed in the new rooms. Once the extent of flexibility was controlled by the level of adaptation, then the percentage of respondents who move rooms and adapt their new rooms may be interpreted more clearly. Thus, if similar percentages of respondents move from their rooms, then the measurement of the extent of flexibility will be the percentages in each level of adaptation. If the reason which made people move from their rooms is nothing to do with change in their work, but rather because of a major re-allocation of users within the building, by then the criteria which define the extent of flexibility will be the decrease in the level of adaptation in the new rooms. In the following paragraphs an examination will be made of the percentages of respondents who moved to other rooms grouped according to their reasons for moving.

(i) Change of Work:

There were some clear differences between the buildings in relation to the percentages of users who moved from their rooms because of a change in their work. None of the respondents who reported change in their work moved to a different room in building B. In building C, only 29% of those who reported change in their work have moved to a different room. In building A however, 40% of those who moved to a different room did so because of change in their work. This clearly indicates that building B was higher in its flexibility than either A or C, since none of the respondents in it who experienced a change needed to change their location. Examination of these percentages in relation to the levels of adaptation needed thus will be made for only buildings A and C. For moveable furniture, the minimum level of adaptation, the percentage of those who needed to move were 50% and 25% for buildings A and C respectively. For fixed furniture, again 50% in A needed to do this adaptation, while none in C. Variation between buildings A and C with respect to these percentages were meant to indicate in which building the least adaptation has been made, though in building A there was a relatively high proportion of respondents who moved from their rooms because their work changed. This is to say that building A may be considered lowest in its extent of actual flexibility. Thus, this reinforced the previous conclusion that was made with respect to the percentages of respondents who retained their locations. To sum up, there were no respondents in building B who needed to move from their rooms because their work changed, and the maximum percentage was in building A. In addition, for buildings A and C if the percentages of those who moved to different rooms were related to the level of adaptation needed, again building A is that in which more adaptations were made. In conclusions, it was building B, that seemed to be significantly higher in its extent of flexibility, according to this indicator, than either buildings A or C, though C seemed to be slightly more flexible than A.

(ii) Re-allocation:

The three buildings differed in terms of the percentages of respondents who moved because of a major re-allocation within the buildings. The percentages of those who moved to a different room in buildings B, C and A were 74%, 41% and 24% respectively. Out of these, the percentages of those who moved because of re-allocation were 85%, 71% and 40% respectively. There were more changes in the location of rooms in building B than in C and in turn than in A. These percentages may be used to indicate flexibility if looked at in relation to the percentages of those who reported each of the levels of adaptation. By and large, it might be misleading to use these percentages literally since the number of respondents involved with the various levels of adaptation was relatively too small. However, from these percentages tentatively may be drawn the conclusion that B was the most flexible and A was the least.

7.10 Composite Indicators of Flexibility - Summary:

Three composite indicators have been used to indicate the flexibility of the buildings examined. They all have shown clear differences between the buildings. The first composite indicator, which considered the percentage of respondents who reported change in their work but had not requested to move from nor to adapt their rooms, has shown that building A was the least flexible and possibly B was the most flexible. The second composite indicator which considered the percentage of respondents who reported change in their work but actually had not moved from nor adapted their rooms has shown that flexibility was higher in B than in C and in C than in A. The third which considered change in the allocation of users into rooms has shown that the flexibility was higher in B than in C, and slightly more in C than in A. A general assessment of the flexibility of buildings according to all such indicators can be concluded in that building B was the most flexible compared with A and C, though C was slightly more flexible than A.

7.11. Single and Composite Indicators - Summary:

This chapter was an analysis of users' responses to a questionnaire about changes in their activities and their account of the adaptation made in their building in order to indicate variations between the three buildings examined in terms of their flexibility. Flexibility of a building was indicated by the amount of change in the demand for rooms in relation to the amount of adaptation made in them to cater for such a change. To arrive at an overall assessment of the extent of flexibility in each building, the amount of two types of indicators were examined, single and composite indicators. Each of the single indicators showed either the extent of change in demand for rooms or that of adaptation and to indicate flexibility in a building both main single indicators need to be considered together. Each composite indicator showed directly the extent of flexibility in a building, because it encapsulated at the same time variations in the extent of change in relation to those of adaptation. Examination of both single and composite indicators has many advantages. They enable a more reliable assessment of flexibility to be arrived at, as both are alternative ways of examining flexibility. If either way fails in illustrating differences between the buildings examined, the other might do. Single indicators were particularly useful in arriving at an assessment of flexibility in relation to specific aspects of change or those of adaptation.

Measurements of both single and composite indicators have resulted in a clear pattern about differences between the buildings examined in terms of flexibility. Building B was more flexible than either building A and C on both of these indicators. Single indicators did not enable a clear comparison between buildings A and C, and thus composite indicators could be utilized for this purpose. Building C emerged as slightly more flexible than A on composite indicators, and thus they were the only way available for comparison. In overall comparisons, and by considering the extremes of the scale of flexibility covering all buildings, both composite and single indicators have shown that B can be located at one end of this extreme while A and C are at the other. Noting such differences, and those which emerged in Chapter VI, the following chapter will be concerned with examining the relationship between the flexibility of buildings in use and their design.

CHAPTER VIII

DESIGN VARIABLES AND THE FLEXIBILITY OF BUILDINGS

8.1. Introduction:

The aim of this chapter is to examine the relationship between the design of buildings and their flexibility. The examination will concentrate on two specific design variables, namely the uniformity of rooms and the uniformity of circulation pattern. The relationships will be investigated in accordance with empirical evidence from the case study which involved three buildings. The three buildings have been compared with each other in terms of specific design variables and their flexibility in chapters VI and VII respectively. Investigation of the relationship in this chapter will be based upon the findings in both these chapters, and that will constitute the third research objective of this study.

The relationship between the design of buildings and their flexibility is hypothetical and untested. It underlies the variety of proposals of flexible designs. There were various aspects or variables of design which were claimed to be relevant to the flexibility of buildings in use and thus the relationship between the design of buildings and their flexibility can be broken down into a number of parallel relationships, each relevant to a particular design variable. This study, however, concentrated on the relationships with respect to two specific design variables. Each of these variables is present in every building but to a differing extent. All buildings are flexible but some are more flexible than others. Accordingly the relationship between the design variables of buildings and their flexibility was formulated in terms of the degree to which the variables were incorporated in buildings and the degree to which buildings were flexible.

Testing the relationships between these design variables and the flexibility of buildings involved testing three propositions; the main, rival and null propositions. The main proposition suggested that the flexibility of buildings relates positively to the design variables. The rival proposition stated that the flexibility of buildings relates negatively to the design variables. Finally, the null proposition stated that there is no relationship between the flexibility of buildings and the design variables. Testing these propositions was in a way comparing the relationships that emerged from the case study with those predicted by these three propositions. Tests of these propositions, however, are of a general nature in this study, and concrete verifications will not be attempted because of the small size of the sample of buildings examined. Because of this small size, statistical measures of relationships can not be used, since they would be affected greatly by the extreme values of some buildings, rather than represent the overall trend of relationships. The fewer the number of buildings, the less confidence can be placed upon these statistical measures, and thus the less reliable the generalizations that can be made from them.

There will always be scope for possible variations in the interpretations of relationships when specific statistical measures are not used. Nevertheless, wherever possible, a number of guidelines were made use of which included: (a) If the scores of buildings with respect to flexibility neither corresponded in any pattern of rank order nor with respect to differences between them in their scores of design variables, then no relationships were assumed to exist. (b) If all the scores of buildings with respect to flexibility corresponded in both the rank order and the differences between them to those with respect to design variables, then a perfect relationship was assumed. Its direction was determined by the similarity of the direction of the rank orders of buildings with respect to flexibility with that with respect to design variables. If similar directions were observed then positive correlation was assumed, and negative correlation with different directions. (c) If the building of the highest or lowest rank order in flexibility sustained its rank order in design variables while the other two had their rank orders changed, then a relationship was assumed. Its strength depended upon the difference between the scores of the building sustained in rank order and those that have changed. The larger the difference, the stronger the relationships were assumed to be, and vice versa. The various combinations of these cases were discussed when they arose in the sections relevant to discussing relationships.

The following sections present the relationships between, on the one hand, the uniformity of rooms and the uniformity of circulation and on the other, the flexibility of buildings. However, the relationship between each design variable and the flexibility of buildings involved various specific relationships. These were found by considering different characteristics of rooms or of circulation pattern in relation to the design variable as well as by considering different ways of measuring the flexibility of buildings.

8.2. Findings:

By and large, strong relationships emerged between the design variables and the flexibility of buildings. These relationships were often as predicted by the main proposition, i.e. the flexibility of buildings related positively to the extent of incorporation of design variables. However, in some cases no relationships were found and that was particularly important, as it represented specific areas in which past ideas on flexible design were shown to be unfounded. These findings will be presented with respect to the relationship of the flexibility of buildings with first, the uniformity of rooms, and second, the uniformity of circulation pattern.

8.2.1. Uniformity of Rooms and Flexibility:

The flexibility of the buildings examined related by and large positively to the uniformity of rooms, except when measured in relation to the area of rooms when rooms were grouped.(Figure-9) The uniformity of rooms was examined in relation to some general characteristics of rooms such as accessibility as well as in relation to some specific characteristics, such as the area of rooms. With respect to all these characteristics, uniformity was highest in building B.(p.194) However, when uniformity of rooms was examined in relation to area considered with the grouping of rooms, different patterns emerged, and these patterns differed in accordance with the way the rooms were grouped. On average, i.e. by considering six ways of grouping rooms in the measurement of uniformity, building A was the most uniform compared with B or C, and B the least uniform.(p.195) With respect to flexibility, there were clear differences between the buildings examined and these were evident in all ways of measuring flexibility. Flexibility was measured by single and composite indicators. In both these ways of measuring flexibility, building B appeared to be the more flexible than either A or C. On single indicators, B was more flexible than A, since B contained more change while both had similar amounts of adaptation, and B was more flexible than C since though it contained slightly more change, the adaptations in it were considerably less than those in C.(p.233) On composite indicators, again building B was more flexible than either A or C with respect to each of the three composite indicators, though C was largely similar to B on two of these three indicators.(p.244)

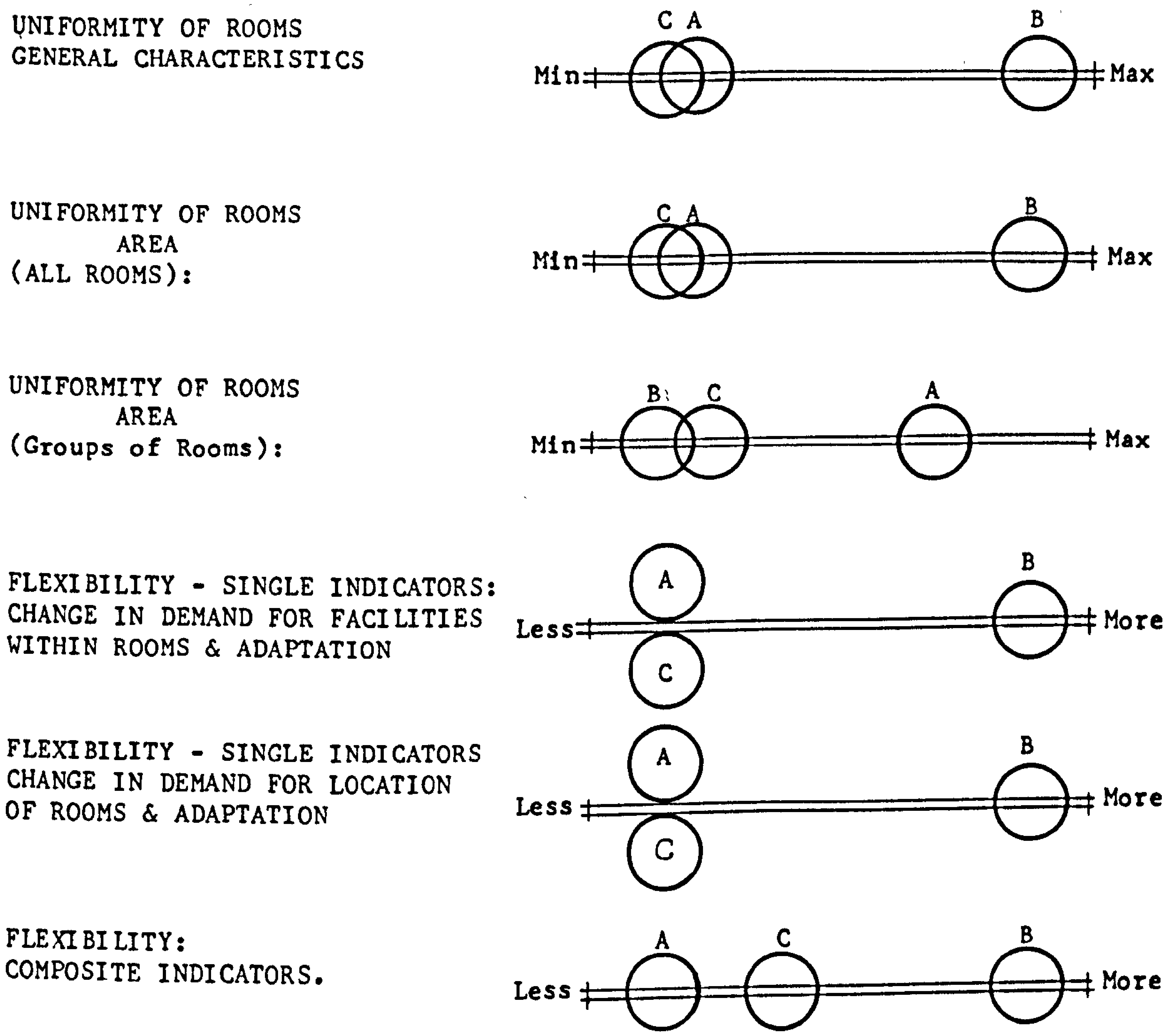


Figure-9
The Relationship between the
Uniformity of Rooms and Flexibility

In accordance with such variations between three buildings with respect to both the uniformity of rooms and their flexibility, some general assessment of the relationship between the design of buildings and their flexibility can be made. The relationship was strong and positive in most cases. Building B, while emerging as the most uniform, also emerged to be more flexible than either A or C. Differences between buildings A and C with respect to the design variables and flexibility cannot reliably be used to test the relationship for two reasons. First, with respect to the uniformity of rooms, the two buildings were largely similar, and second, an assessment of their relative flexibility cannot be made fully, as with respect to single indicators, one (A) was lower in adaptation while the other (C) is higher in change.(p.233) But, of course, the flexibility of either A or C can be compared with that of B, since B was only similar to either A or C in either adaptation or change. It was similar to A in adaptation but higher in change, and similar to C in change but lower in adaptation. According to these difference, the flexibility of buildings related positively to the uniformity of rooms. This general assessment can further be testified to because similar relationships exist between the uniformity of rooms and some specific aspects of flexibility, according to the specific class of change, such as the flexibility of buildings with respect to change in the demand for the facilities within rooms.

However, the positively strong relationship between the uniformity of rooms and the flexibility of buildings was not found when the uniformity was measured in relation to area where groupings of rooms were considered. Building B, while the most flexible(p.246), emerged as the least uniform in area if rooms were grouped.(p.195) This in a way would suggest that there was a negative relationship between the uniformity of rooms and flexibility, but closer examination indicated that this relationship was rather weak for two main reasons. First, that on uniformity of rooms, the range of buildings' scores as whole was relatively too small(p.186) compared with that established when uniformity of area was measured without the grouping of rooms(p.182), and second, the small range of scores of buildings on uniformity did not correspond with the wide differences in flexibility between building B on the one hand and either A or C on the other. B and C while largely similar on uniformity were widely different in flexibility. In short it could be concluded that there was a weaker but still negative relationship between the flexibility of buildings and the uniformity of the area of rooms in them, measured after grouping. This relationship and that which emerged when uniformity was measured with respect to all the general characteristics and ungrouped areas would enable some conclusions to be drawn.

The general pattern was that increasing similarity between rooms ensured an increase in the flexibility of a building. This goes in line with the majority of past studies which argued for uniformity as a necessary condition for flexibility. This has been supported with respect to all ways of measuring flexibility, thus indicating a certain degree of reliability in the measures used. Against this background, it was clear that the relationship between flexibility and uniformity depended on how uniformity rather than flexibility was measured. As uniformity, when measured in relation to area of grouped rooms related weakly and negatively to flexibility, this could be seen an important aspect of this examination. Such uniformity as an aspect of design appears to be not quite relevant to flexibility. Of course it could be argued that it was the way of grouping rooms that produced this relationship, but this was not the case, since six ways were used for grouping and the final scores of buildings were an average of their scores on each of these ways.

Accordingly, it could be concluded that a higher uniformity of rooms in relation to their areas measured after grouping, could not be used to predict flexibility. In other words greater similarity between the areas of rooms within each group is largely irrelevant if compared with greater similarity of the areas of all rooms in the building. Similarity on the overall level, when all rooms in a building were considered, was more relevant to flexibility than similarity on the detailed level, i.e. within each group of rooms. The most flexible building (i.e. B in this case), had greater similarity on the overall level (all rooms) rather than on the detailed level (within groups of rooms). However, it could still be possible to have buildings where similarity on the overall level corresponds with that on the detailed level, but with the former related most to flexibility. Such a conclusion has a consequence for the validity of past claims concerning the relationship between uniformity of rooms and flexibility.

The case study supported past ideas on the value of increasing uniformity rather than the variety of rooms. However, since greater similarity on the detailed level, i.e. with respect to the areas of rooms being grouped, did not correspond to increases in flexibility, then this demonstrates that previous ideas on designing for uniformity were not wholly valid in relation to flexibility. Greater similarity on the detailed level appeared to be a condition that was not fully appreciated or at least seen to be relevant to users' conception of flexibility, and thus it was not crucial to the changing requirements of their activities. This, in a way, would further support the relevance of looseness of fit, where smaller differences on the detailed level are not crucial to the accommodation of change. A consequence of this is that the idea of minimizing types of rooms according to area rather than unifying them was not the best recommendation in relation to flexibility. Similarity of all rooms in a building in relation to one specific size was what correlated most with flexibility.

Perhaps this was largely related to users' conceptions of the extent of similarity of their rooms and above all, to those of people concerned with making decisions upon the allocation of users into rooms and of assessing their requirements for accommodation. A consequence of this was that ideas, such as "duffle coat"(1) or "multi strategy spaces"(2) did not survive the test wholly. These ideas argued for limiting the types of rooms in a building, i.e. increasing similarity of rooms belonging to each group of rooms in a building. However, it was only the general principles of "duffle coat" or "multi strategy spaces", that is increasing the similarity between all rooms in a building, which have shown to be related to flexibility. These ideas were not foreseen at the outset of this study, as it was generally assumed that similarity on the detailed level is what accounts to flexibility.

A further point of interest was the extra support to Cowan's hypothesis(3) provided by this case study. Accepting Cowan's findings that there is a specific area of room relevant to most activities, the consequence is that idea of the "duffle coat", i.e. having a number of room types each appropriate to a particular group of activities, is not the best. The strong relationship between the overall similarity between rooms and the flexibility of buildings supports Cowan's hypothesis rather than those arguing for limitation rather than unification of room types. Greater similarity between all rooms means few differences between rooms and their single substitute, i.e. the area of the majority of the activities. This support to Cowan's hypothesis was less expected than that support to hypotheses on the limitation of room types, shown in the cases of the "duffle coat" idea. In short, the case study, although it demonstrated the validity of claims concerning the relevance of similarity between rooms in a building to its flexibility, also pointed out that the previous emphasis on similarity was not wholly justified.

The recommendations to designers for uniformity of rooms, need to be acknowledged as tentative, since they are based on only a limited case study. On the general level, architects may continue considering the uniformity of rooms as a necessary condition for the flexibility of buildings. However, what is different is the need to consider uniformity only on this overall level, rather than on the detailed level, i.e. within groupings of rooms. This is easier said in theory than done in practice. In no circumstances should all rooms in a building be similar in size, though they may be designed to be similar with respect to some other characteristics, such as the shape of rooms.

The argument for not having all rooms in a building of a similar area relates to human tolerance and economy. The argument for human tolerance may be catered for by providing more generous accommodation; but the argument for economy might conflict with this. It is often not possible to provide much extra capacity in buildings just to ensure similarity in order to provide future flexibility to deal with changes in use that may never occur. The argument for economy often outweighs that for flexibility in practice. Thus, greater and overall similarity is often unattainable. This is the main problem with designing for flexibility and here compromise must be made.

The compromise can be made by weighing the value of the overall similarity between rooms against that of their cost. One compromise is to exclude the most extreme areas and ensure similarity with respect to the majority of areas required in a building. This is best left to decisions concerning the particularity of design problems. This conclusion would go back to the idea of limiting the sizes of rooms rather than unifying them. Yet this conclusion is unlike previous views which argued for emphasis upon similarity within all groups of rooms. Once again the recommendation to architects concerning the relationship between uniformity and flexibility has proved to be rather flexible itself. The following section will consider the relationship of another design variable, that is the uniformity of circulation to the flexibility of buildings.

8.2.2. Uniformity of Circulation Pattern and Flexibility:

The flexibility of the buildings examined related strongly and positively to uniformity of their circulation pattern but in relation to only one of the two aspects of circulation.(Figure-10) This points to a serious defect in past claims about the relevance of uniformity of circulation to the flexibility of buildings. Past claims about the relationship between the uniformity of circulation pattern and the flexibility of buildings were stated in general terms, and circulation itself was not defined operationally. In attempting to test these claims, this study operationalized the term uniformity and defined circulation in terms of both proximity and adjacency of rooms in a building. Two parallel design variables resulted. They were the uniformity of proximity and the uniformity of adjacency. Propositions on the relationships of each of these variables and the flexibility of buildings were tested in the case study. Their testing was based on how the three buildings examined in the case study scored on flexibility in comparison with how they would have scored according to their scores on the uniformity of circulation.

For uniformity of circulation there were clear variations between the three buildings, though the buildings varied differently in the case of uniformity of adjacency from the case of proximity. In uniformity of adjacency, building B emerged considerably more uniform than either building A or C, and C was least.(p.192) In uniformity of proximity, though the range of scores of the three buildings was smaller than that in the case of adjacency, it was building A which emerged more uniform than B or C, and again C was the least uniform.(p.191) In the flexibility of buildings the buildings also differed considerably, with building B being more flexible than either A or C. Such differences emerged from the composite indicators, which considered change and adaptation simultaneously, as well as, from the single indicators which enabled a detailed account of change in the demand for the location of rooms to be made in relation to adaptation. Change in the demand for the location of rooms is the aspect of flexibility that is most relevant to the uniformity of circulation pattern. In arguing for the uniformity of circulation pattern, the object of past studies was to enable the accommodation of change in the demand for the location of rooms without the need for their adaptation.(p.43) The emphasis was upon allowing a change in the pattern of communication between users of a building, to be catered for without a corresponding physical change.

Changes in the pattern of communication were reflected by changes in the type of people with whom information or materials were handled or in the type of information or materials themselves, as well as by changes in the journeys made between rooms. For change in the type of people handling information or materials, as well as in the type of information or materials handled, differences between the buildings were best illustrated by composite indicators. For change in the journeys between rooms, a detailed account of flexibility was made by examining single indicators of flexibility concerned with change in the demand for the location of rooms in relation to change in the objective characteristics of journeys (number and average weekly distance). For the number of journeys made between rooms, there were significantly more changes in B and C than in A.(p.226) These if related to adaptation would leave B as more flexible than A and C, since it contained less adaptation than C and more changes than A. For change in the average distances of journeys, there were considerably more changes in B than in either A or C.(p.227) Accordingly B was the most flexible, since it contained more change and less adaptation than C, and only more changes than A. These overall and detailed differences between the flexibility of the three buildings (i.e. with respect to composite and single indicators respectively) compared with differences between them in relation to uniformity of circulation allowed a testing of the relationship between flexibility and uniformity to be made.

For the relationship between the uniformity of adjacency and the flexibility of buildings, the relationship was found to be as predicted by the main proposition, i.e. strong and positive. Building B was considerably more uniform and more flexible than either A or C. For the relationship between the uniformity of proximity and the flexibility of buildings, the relationship was much weaker and tended to have a negative direction, i.e. as predicted by the null and the rival propositions to a little extent. Building B while being the most flexible, was less uniform than A and slightly more than C. A, while being the most uniform, was much less flexible than B. C, however, while slightly less uniform than B, was much less flexible than B. A general assessment of this relationship would result in no clear pattern. The relationship cannot be assumed fully negative according to the scores of A, since B maintained its upper rank order than C. In short, the uniformity of circulation pattern related differently to the flexibility of buildings when considered in relation to both adjacency and proximity. The uniformity of adjacency related strongly and positively to flexibility, while the uniformity of proximity related weakly and to some extent negatively to flexibility.

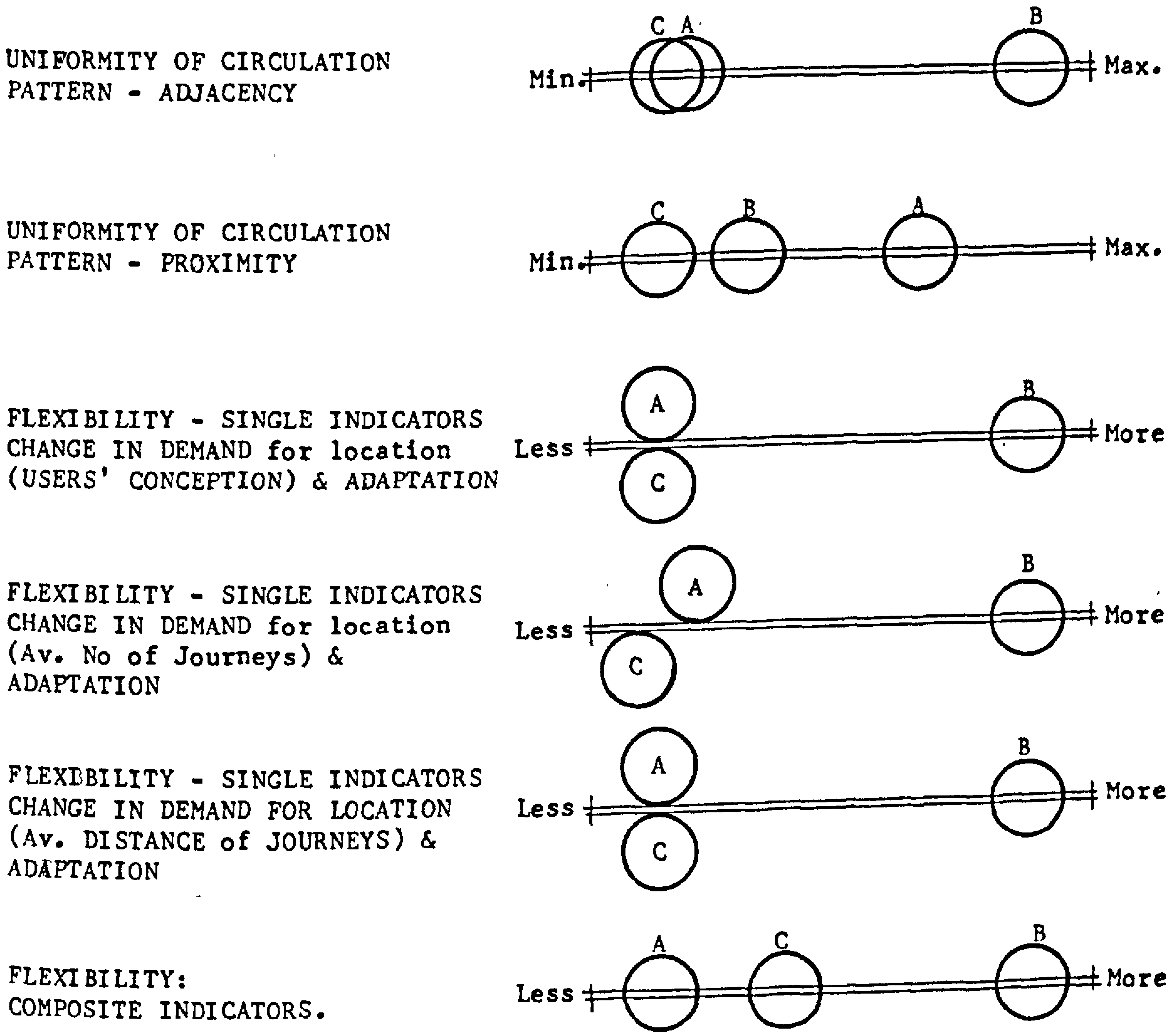


Figure-10
The Relationship between the
Uniformity of Circulation Pattern and Flexibility

Accordingly, it could be concluded that the relationship between the uniformity of circulation and the flexibility of buildings depended upon the aspect of circulation examined. It is only adjacency which related to flexibility. A greater flexibility can be achieved by increasing similarity between rooms in a building with respect to their adjacency relationships to other rooms rather than with respect to both adjacency and proximity relationships. The emergence of such differences between the two aspects of circulation pattern was not expected from previous claims of the relevance of uniformity of circulation to flexibility. Past studies did not demonstrate any limitations on the aspects of circulation pattern or the extent to which uniformity relates to flexibility - another example where the general claims of past studies of the relationship between the design of buildings and their flexibility appear not to be wholly correct.

The differing relationships between, on the one hand uniformity of adjacency and proximity, and on the other, the flexibility of buildings was not expected in the light of the continuing emphasis on proximity in past studies of circulation. Most past studies of circulation examined proximity rather than adjacency in relation to the efficiency of circulation. Proximity relates to the time spent by users in making journeys within a building, and that affects efficiency, since efficiency is defined by the cost of journeys. The cost of journeys depends, by definition, upon the time spent and the cost factor (assessed in accordance with their salaries) of individuals making journeys. The emerging importance of adjacency in uniformity in relation to flexibility would mean that priorities in assessing the efficiency of circulation pattern may need to be reviewed to emphasize adjacency rather than proximity.

Adjacency in the past has been examined in general terms, by isolating only two main types of adjacency relationships between rooms; adjacent and non-adjacent. This study has examined a wider range of adjacency types, and these types have proved to be relevant to flexibility. In the light of the emergence of the importance of adjacency to the flexibility of buildings, conclusions could be drawn that adjacency could be relevant to other variables of buildings associated with their use, such as efficiency. The importance of adjacency may be looked at in terms of its relationship to the choice of routes people normally take in moving between rooms in a building. The choice of routes may be seen to be related to the subjective assessment of the closeness of rooms to which journeys are made. The subjective assessment of closeness of rooms appears to be related to adjacency more than to proximity. People can probably subjectively assess closeness by examining how rooms are to be accessed rather than how far they are removed from them. In other words, it could be argued that comparing alternative routes of journeys is easier and more immediate when people compare alternative adjacency relationships in terms of access, rather than when they compare alternative proximity relationships, i.e. in terms of distance. The following section will consider what implications this limited case study has on designing for flexibility.

Designing for flexibility needs to be extended to designing for an increase in the uniformity of circulation pattern. What has been demonstrated by this limited case study, is that designing to increase the uniformity of circulation pattern in order to improve flexibility, needs to concentrate on the uniformity of adjacency rather than upon the uniformity of both adjacency and proximity. This has two specific consequences. First, that the freedom with which architects design layouts of buildings will increase, if only the uniformity of adjacency needs to be considered. Achieving greater uniformity of proximity relates to many properties of corridors in buildings such as their length or their location in relation to the envelope of buildings.(p.190) Second, increasing the uniformity of adjacency is a process that is more easily carried out compared with that of proximity during the development of design alternatives. Increasing the uniformity of adjacency can easily be observed visually since it relates to the characteristics of rooms that are mainly nominal or ordinal in their scales of measurement. By contrast, to obtain an increase in the uniformity of circulation with respect to both proximity and adjacency not only both the characteristics of rooms and corridor properties need to be considered, but also a detailed measurement and analysis of distances needs to be made. To summarize, the case study shows that the uniformity of adjacency only is what affects flexibility, not that of both adjacency and proximity.

8.3. Conclusions:

The aim of this chapter was to test propositions about the relationship between the design of buildings and their flexibility, using data from a case study involving three buildings. This relationship was examined in relation to two specific design variables generally considered to be associated with the flexibility of buildings; the uniformity of rooms and the uniformity of circulation pattern. The case study demonstrated that the design of buildings actually relates to their flexibility, but not exactly as predicted by previous studies concerned with the two design variables examined. The uniformity of rooms related positively and strongly to flexibility and that held for all the characteristics of rooms examined. The only exception in which a rather weak and a negative relationship emerged was when the uniformity of area of rooms was measured after groupings of rooms. For the uniformity of circulation positive and strong relationships were found in the case of adjacency of circulation only rather than in relation to both adjacency and proximity.

The main conclusion to emerge from such a limited case study is that the claims made in past studies though valid on the general level need to be more refined because they contained assumptions redundant to flexibility. This point means that the flexibility of buildings is still largely predictable from knowledge about their initial designs, but this prediction can more reliably be made with respect to only some rather than all the aspects of design incorporated in the claims of past studies. This would be of some value to designers. To go further and put forward some recommendations concerning the design for flexibility in the light of evidence from the case study specific points can be made in relation to both the uniformity of rooms and the uniformity of circulation. For the uniformity of rooms, an increase in the similarity between all rooms in a building can contribute to flexibility, rather than an emphasis upon similarity after grouping of rooms. The outcome depends on the financial penalties that can be tolerated, but departures from this similarity could be minimized. For the uniformity of circulation, increasing similarity between rooms in relation to their adjacency relationships to other rooms alone rather than in relation to both adjacency and proximity is a condition appropriate to ensuring greater flexibility. Further support to Cowan's hypothesis about the appropriate size of rooms, and about the importance of adjacency if compared with the proximity of circulation in promoting flexibility arise from this study.

8.4. References:

1. Weeks, J. "Planning for Growth and Change". Architect's Journal. Vol. 132, No. 3403. July 7 1960. PP.20-22.

2. Weeks, J. "Multi-strategy Buildings". Architectural Design. 10/1969. p.537.

3. Cowan, P. "Studies in the Growth, Change and Ageing of Buildings". Bartlett Society Transactions. Vol. 1. 1962-63. PP.53-84.

CHAPTER IX

CONCLUSIONS

This chapter is concerned with the general conclusions that can be drawn from this study. It will however, include a reminder of the problem area and its background leading to an identification of the research objectives considered necessary for investigating the problem, what has been done in this study with respect to these objectives, what conclusions can be drawn from the way in which these objectives have been dealt with, and finally what areas of further research have been defined.

9.1. Background, Problem and Objectives:

This study examined the flexibility of buildings in relation to their design. Growing interest in designing for flexibility has been largely a result of the need to incorporate, at the initial design stage of buildings, the potential to accommodate change in the requirements of organizations housed in them over time. The consideration of flexibility, at the initial design stage, as a preventive measure, was one of four groups of actions considered relevant to illuminating the undesirable consequences of change, that is the deterioration in the appropriateness of fit between organizations and the buildings housing them over time.(p.6) The growing interest in flexibility had resulted in studies containing a wide diversity of proposals and ideas of design.(p.9) However, despite this diversity, the studies commonly concentrated on selected design variables.(p.10) It was argued that the studies have implicitly assumed that the incorporation of such design variables in design proposals would enhance the achieved flexibility in the resultant buildings in use. However, though a number of studies have been made of specific organizations and buildings(p.16), there is insufficient knowledge of the extent to which the achieved flexibility of buildings in use is related to the incorporation of the advocated design variables.(p.18) There has been no overall investigation of the general relationship between design and flexibility. To investigate this relationship it was necessary to achieve three objectives:

(i) Propose a system of measurement by which the extent of incorporation of the design variables in design proposals could be assessed.

(ii) Propose a system of measurement by which the extent of flexibility of buildings in use could be assessed.

(iii) Assess the extent of flexibility achieved by the incorporation of design variables in design proposals by a study of actual buildings in use.(p.19)

9.2. The Study:

The study has largely achieved the three research objectives stated. The first objective was dealt with in Chapters II and III. The second objective was dealt with in Chapter IV. The third objective was dealt with in Chapters V to VIII.

9.2.1. The First Objective:

A system of measurement of some selected design variables was proposed in Chapter III after they have been categorized and defined in Chapter II. In Chapter II, the design variables were grouped into:

(i) Those claimed to enhance the potential of buildings to accommodate change without adaptation (looseness of fit), which included over-capacity and neutrality.(p.37) Neutrality, however, has resulted in uniformity of rooms and uniformity of circulation pattern and also in variety of rooms.(p.41) (ii)Those claimed to enhance the potential of buildings to accommodate change with adaptation, by claiming to ease subsequent adaptations in buildings.(p.33) These included; concentration and modularity of structure, the zoning of areas of special provision and the independence of buildings' elements.(p.47)

The derivation of measures for over-capacity and variety was not found necessary. Over-capacity is not a variable of buildings, rather it relates to the relationship between buildings and the activities in them.(p.47) Variety is conceptually the reverse of uniformity, and for it the same measures could be used to indicate its extent in a building inversely.(p.47)

In Chapter III measures were achieved for all the remaining variables, but not the independence of buildings elements.(p.101) Measures of the uniformity of rooms and the uniformity of circulation pattern were tested in a pilot study and necessary modifications were made.(Appendix-A)

9.2.2. The Second Objective:

A system of measurement by which the extent of flexibility of buildings in use was proposed in Chapter IV. A more comprehensive interpretation of flexibility was defined in relation to the isolation of its objectives (the accommodation of change) and its means (the adaptation necessary). All buildings were seen as flexible but to a differing extent and the more flexibility the more the change accommodated, and the more the flexibility the less adaptation necessary.(p.114) In measuring flexibility of a building over a given period of time, both change and adaptation needed to be assessed. Past indicators of change and adaptation were seen to be either partial or have some methodological problems, and an alternative method was suggested which included most of past indicators.(p.131) The method enables objective comparison to be made between buildings in terms of their relative extent of flexibility in use.

9.2.3. The Third Objective:

Assessment of the relationship between the flexibility of buildings in use and their design was made in a case study with respect to two main design variables; the uniformity of rooms and the uniformity of circulation pattern. The case study investigated three buildings (Chapter IV) and these were compared in terms of the extent of their incorporation of the two design variables and of their flexibility in use in Chapters VI and VII respectively. A general assessment of the relationship was made in Chapter VIII, in order to test propositions that the flexibility of buildings in use is related to their extent of incorporation of design variables. The case study has shown varying degrees of support to these propositions and they were dependent upon the aspect of the design variables examined.

Uniformity of rooms was found to be strongly and positively related to the flexibility of buildings when considered in relation to most of the characteristics of rooms.(p.250) However, when uniformity of rooms was measured in relation to area, and groupings of rooms were considered, weaker and negative relationships were found.(p.252) The proposition that uniformity of rooms related positively to the flexibility of buildings was strongly supported with respect to all the characteristics of rooms, but not to areas measured after groupings of rooms.

For uniformity of circulation, the results differed in that support to the proposition of its relationship to the flexibility of buildings was dependent upon the aspect of the circulation pattern considered. When uniformity of circulation was considered in relation to the adjacency of circulation, the proposition that it related positively to flexibility was strongly supported.(p.256) When uniformity of circulation was considered in relation to the proximity of circulation, a weaker but negative relationship with flexibility was found.(p.258)

9.3. Conclusions:

The conclusions that can be drawn from this study concern both the systems of measurements that were proposed with respect to the design variables and the flexibility of buildings in use, as well as the findings from the case study with respect to the relationship between design and flexibility.

9.3.1. The Design Variables:

The main design variables advocated in past studies as relevant to the flexibility of buildings have been defined and measured. Previously they were stated in general terms only. The measures provided will enable objective comparisons to be made between alternative design proposals in terms of the incorporation of design variables. Now that measures have been developed for most of the design variables examined in this study there seems no reason why other, perhaps not yet established properties, cannot become measurable too. The resulting measures should provide a more reliable interpretation of differences between buildings or between alternative design proposals. This would thus facilitate a more objective approach to the design of buildings in general. The proposed system of measurements should be of assistance to both practicing architects and researchers in the field of study.

During the design process a continuous measurement of change in the scores of a design proposal in relation to selected design variables would indicate whether modifications are leading to greater or less incorporation of the design variables being advocated. There could thus be a score made for each design proposal with respect to each design variable, and this score would change with any change in the characteristics of buildings that are associated with it. The characteristics of the buildings could be modified in order to obtain differing scores for the design variables, and according to these scores, modifications could be regulated. The measures proposed should also be of assistance in providing a basis for testing the relationships between the design of buildings and their flexibility. The more detailed the measures, the more accurate the relationships described.

9.3.2. The Flexibility of Buildings:

As has been argued earlier, there has been no comprehensive measure of the flexibility of buildings in use in the literature.(p.14) The system of measurement proposed in the study demonstrated the complexity of flexibility with reference to the past performance of buildings. Assessing this performance is a quantification of the extent to which its objectives can be achieved in relation to the amount of resources used as means. Therefore the relative importance of the objectives and means to indicate flexibility could only be assessed in general terms, and this was because of the absence of some units of measurement common between the two. Adding to the complexity of measuring flexibility is the diversity of indicators used to reflect the amount of both change and adaptation. Accordingly, it could be concluded that the comprehensive approach to measuring flexibility will encounter many problems if buildings are to be examined over long periods of time in use. In other words, it must be expected that measurement of flexibility in real case studies will need to make compromises on the length of period examined and/or the numbers of factors involved with flexibility. There is an important consequence resulting from this difficulty, and that is related to the way in which future flexible designs should be proposed. Such proposals need to be limited in the number of properties of buildings, if claims about such properties are to be tested. To suggest design proposals specifying a wide diversity of buildings' properties without being able to test their relationship to flexibility would not be wholly helpful for advancing objective knowledge about the role of design in the future performance of buildings.

9.3.3. Flexibility and Design of Buildings:

There was insufficient knowledge in the literature, about the general relationship between the design of buildings and the achieved flexibility in use. This resulted mainly from the lack of systems of measurements of the design variables and the flexibility of buildings in use as well as from the absence of an adequate empirical investigation. This study, in utilizing the systems of measurements proposed and in adopting them in a case study, provided some knowledge about this relationship. The flexibility of buildings in use was found to relate strongly to their design, but only in relation to certain aspects of the design variables that were advocated in general terms in past studies. This has two main consequences:

(i) The study had provided evidence verifying the general claims that the flexibility of buildings is related to their design. This is important because it means that flexibility as a desirable property of buildings concerning their future performance is to some extent predictable from knowledge about their initial design. The value of this is that there is scope for dealing with the problems of change in the use of buildings, though change itself is unpredictable. To be able to deal with the undesirable consequences of change will be of great utility for the organizations to be housed in buildings. Thus the possibility of achieving greater flexibility means maintaining a more appropriate level of fit with their buildings. This state of fit is the most basic consideration in the resources that organizations need in order to function over time, and can be seen as the ultimate object of design, in providing accommodation which fits the requirements of those occupying it. Increasing the flexibility of buildings is a task that has many desirable outcomes, and to be able to achieve it by manipulating the initial design should prove useful in most cases. Any further positive empirical evidence of the relationship between the design of buildings and their flexibility would ease attempts to find more specific ways of increasing flexibility. This would result in further advantages to those to be housed in buildings as well as to those who build them. Thus, the main value of the case study is that it demonstrated objectively the validity of the claim that the flexibility of buildings relates in certain ways to their initial design.

(ii) The design variables that have been advocated in past studies of flexible designs, though relating to the flexibility of buildings in use on the overall level, do not do so fully on the detailed level. This would suggest that current ideas on designing for flexibility contain many factors that are actually redundant to flexibility. A greater degree of redundancy could perhaps be found in those ideas on design variables concerned with the ease of adaptation, since the range of factors involved is much greater. Demonstrating the redundancy in current ideas on flexible designs has some relevance to both practicing architects and researchers in the field.

For practicing architects, there will thus be more freedom in designing the layouts of buildings, since they need not fully follow the implications of current ideas on flexible designs. They could, perhaps, concentrate on only those aspects of the design variables found relevant to flexibility, without any loss in the extent of potential flexibility of their design proposals. This would most probably limit the design considerations that architects need to have in respect of flexibility, thus enabling them to place greater emphasis on factors related to other variables concerned with the performance of buildings.

For researchers in the field this study not only demonstrated that the manipulation of the potential flexibility of buildings could become more effective at the design stage, but also pointed out the directions with which this enhancement of manipulation could be made. In making the manipulation of flexibility more effective, emphasis needs to be placed on only certain aspects of design variables. In pointing out the directions of increasing the effectiveness of manipulation, it was shown that this can be done by pursuing a more limited approach towards the design ideas advocated in the literature. Future proposals for flexible design are recommended to concentrate on limiting the aspects of the design variables advocated as well as on illustrating how differently these variables perform with respect to the different aspects of buildings that are involved.

9.4. Areas of Further Research:

This study illustrates the need for further research in a number of areas:

(i) On the most immediate level, further research is needed to propose measures for the remaining design variables(p.62) and to refine the measures of flexibility of buildings in use.(p.132) A consequent extension of such inquiry into measures would be a further test of the relationship between the design of buildings and their flexibility, concentrating on design variables associated with easing the adaptation of buildings. Such an examination would aim at narrowing and defining the implications of the use of each design variable with respect to various building types.

(ii) On establishing the relative relevance of certain parts of a building, generally considered together, to the requirements of organizations that are housed in buildings. For example, the circulation patterns in buildings are commonly discussed in relation to proximity and adjacency, but this study has demonstrated that it is only adjacency that appears to be related to the flexibility as an aspect of performance. This could be linked with research into exploring any mismatch between the objective properties of design and users conception of these properties.

(iii) On the wider level, the study demonstrated the pressing need for refinement of definitions and scrutiny of concepts concerned with the social aspects of the performance of buildings in use. There was often in the literature reference to vague concepts such as rooms' usage, activity, demand or flexibility. The operationalism of concepts associated with the design and use of buildings is necessary to observe changes in them accurately and to examine relationships between them. The relationship between the design and the performance of buildings, especially if discussed in relation to flexibility is still novel in this area of empirical research.

9.5. Immediate and Wider Implications:

It is the object of this study to be of use to both practicing architects and researchers in the field.

For practicing architects, the study provided a method that could enable architects to arrive at objective assessments of the design proposals in terms of the extent to which design variables, associated with flexibility, are incorporated. Thus, in concentrating on those aspects of the design variables that were found relevant to flexibility of buildings in use, they should be able to arrive at an identification of the most potentially flexible design proposal among those assessed.

For researchers in the field, the study should be of value in two respects. First, it provided and tested a method for measuring the flexibility of buildings in use, which can be used in relation to other problems concerning the performance of buildings. Second, it provided some insights into the role of design in the flexibility of buildings in use. It demonstrated empirically that the flexibility of buildings in use is related to certain aspects of their design. It showed that current ideas on designing for flexibility, through flexible designs, do contain many factors that are redundant to flexibility. Finally, the study showed that the manipulation of the potential flexibility of buildings could become more effective at the initial design stage, and recommended that future ideas on flexible designs should be far more refined and explicit in the aspects of design variables involved or the parts of buildings associated with them than past studies have proposed.

APPENDICES

APPENDIX -A-
Pilot Study: Design Variables

This appendix contains some of the initial empirical work carried out in a pilot study in order to develop a system of measurement by which the extent of incorporation of some design variables in design proposals could be assessed. This appendix is divided into two sections (Appendix-A1 and Appendix-A2).

Appendix-A1 deals with the pilot study of the uniformity of rooms.

Appendix-A2 deals with the pilot study of the uniformity circulation pattern.

Appendix-A1
Uniformity of Rooms

This appendix describes the buildings which have been examined in a pilot study concerned with developing measures of the uniformity of rooms with respect to their areas. The proposed measures were tried out on some buildings belonging to the Oxford Polytechnic.

A number of indicators were used to demonstrate the uniformity of rooms in a building with respect to their areas. The indicators measured the minimization of room types according to the areas of rooms and the variation between the areas of rooms. Both of these attributes were tried also with the grouping of rooms according to intervals of area. Four basic indicators have been measured. These are:

i) I1: Minimization of room types. This indicator was measured by:
I1 = (Sum(1/J))/(K/L). where;
J = Number of rooms in each room type of area.
K = Number of room types in a building.
L = Number of rooms in a building.

ii) I2: Variation between the areas of rooms. This indicator has been measured by the Coefficient of Variation (I21) and the Inter Quartile Ratio (I22) between the areas of room in a building.

iii) I3: Extent of variation between the room types in a building with respect to the number of rooms in them. The extent of variation has been measured by the Coefficient of Variation.

iv) I4: Minimization of room types in relation to the number of area intervals in a building. This indicator has been measured by:
I4 = (Sum(1/T))/(N/R). Where:
T = Number of room types in an interval.
N = Number of intervals in a building.
R = Number of room types in a building.

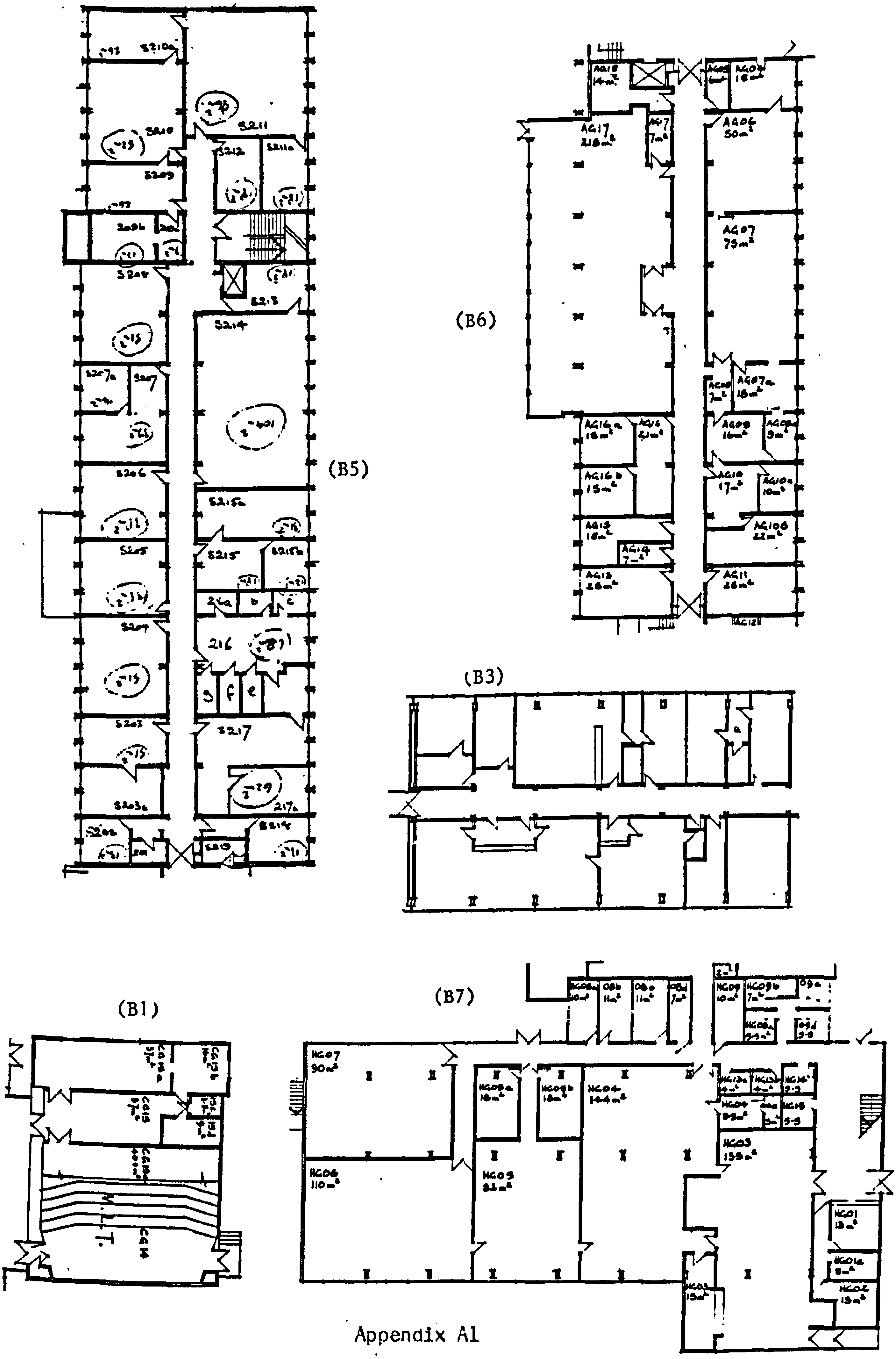
The results of the pilot study demonstrated the need to emphasize the measurement of variation between the areas of rooms rather than the minimization of room types. This appendix contains:

Table-34 which shows the scores of some of the buildings with respect to the indicators above.

Figures 11 and 12 which show the plans of the buildings examined.

Table-34
Pilot Study
Uniformity of Rooms - The Scores of Buildings

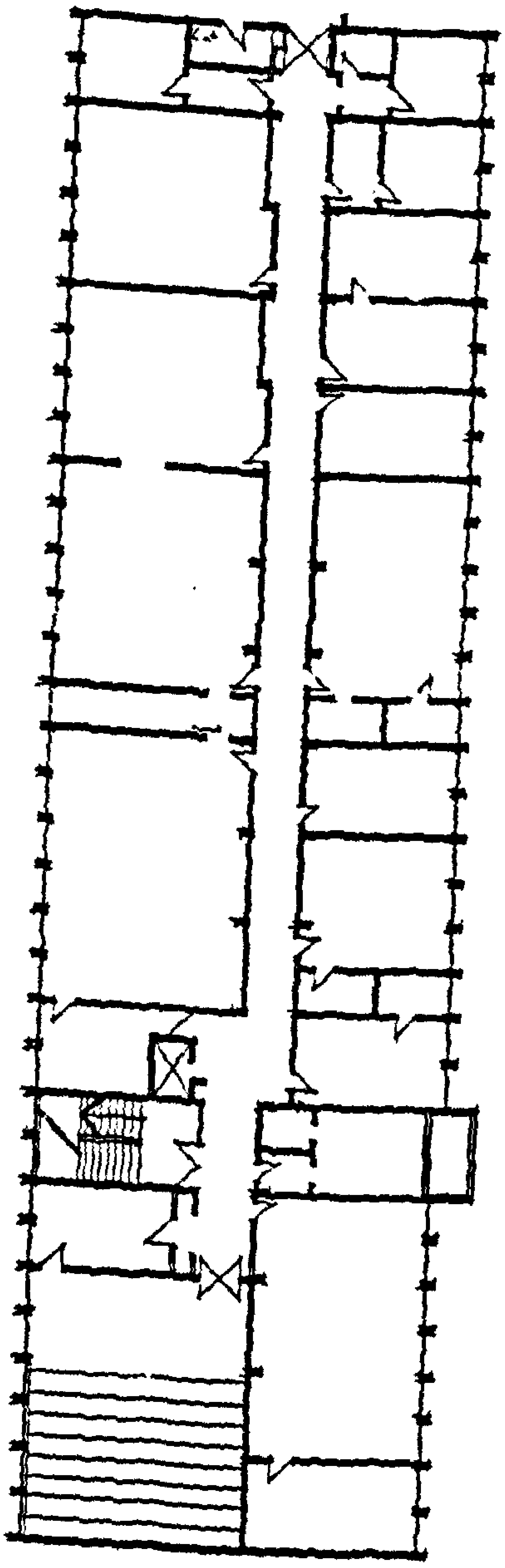
BUILDINGS	INDICATORS OF UNIFORMITY I1	I21	I22	I3	I4
B1	5.60	1.75	1.13	0.71	3.50
B2	13.09	0.77	0.45	2.30	1.62
B3	14.50	1.07	0.88	1.33	3.84
B4	16.85	1.96	0.92	2.75	3.23
B5	22.87	1.64	0.95	2.66	3.72



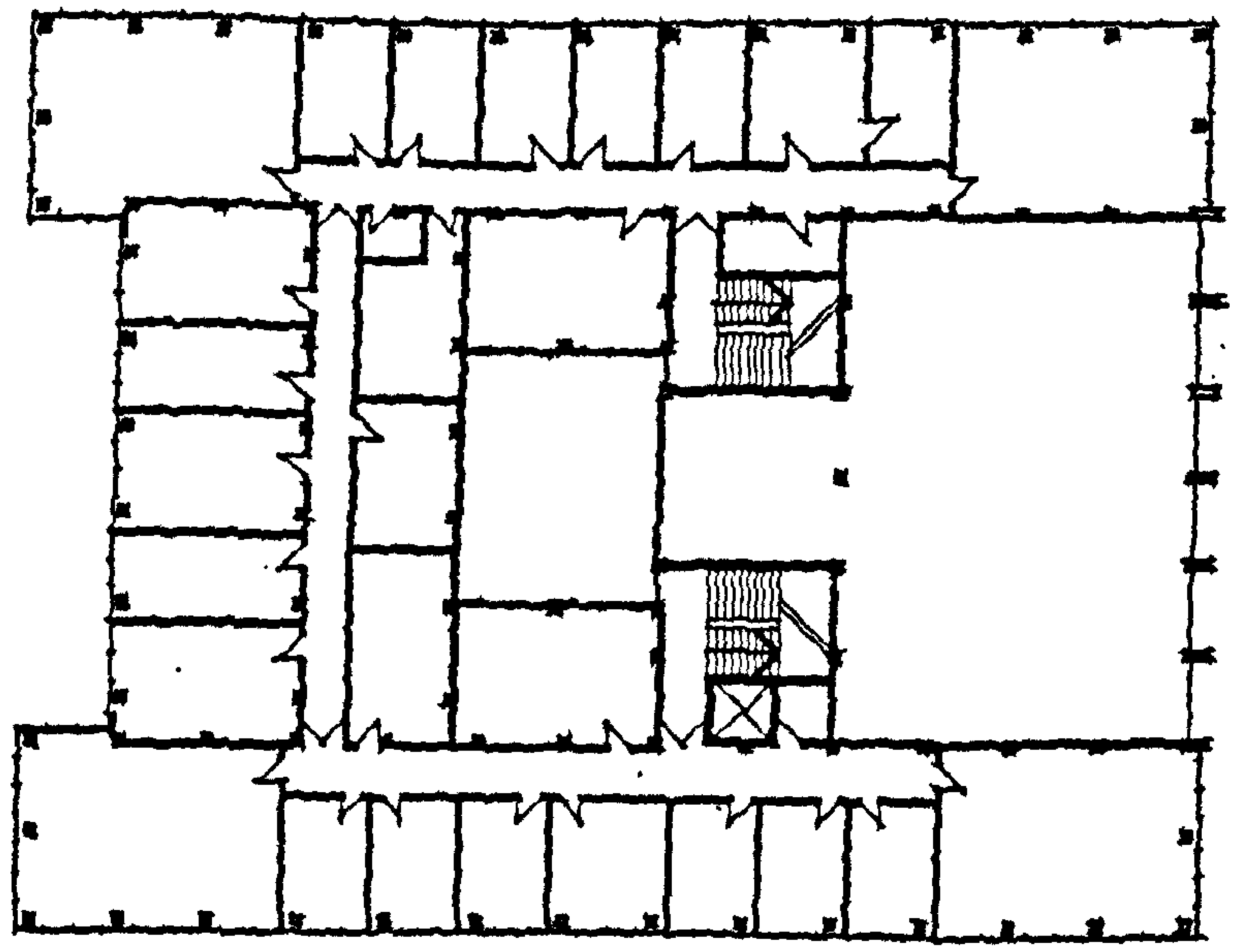
Appendix A1

Figure - 11 -
Pilot study: Uniformity of Rooms - Buildings 1, 3, 5, 6 and 7.

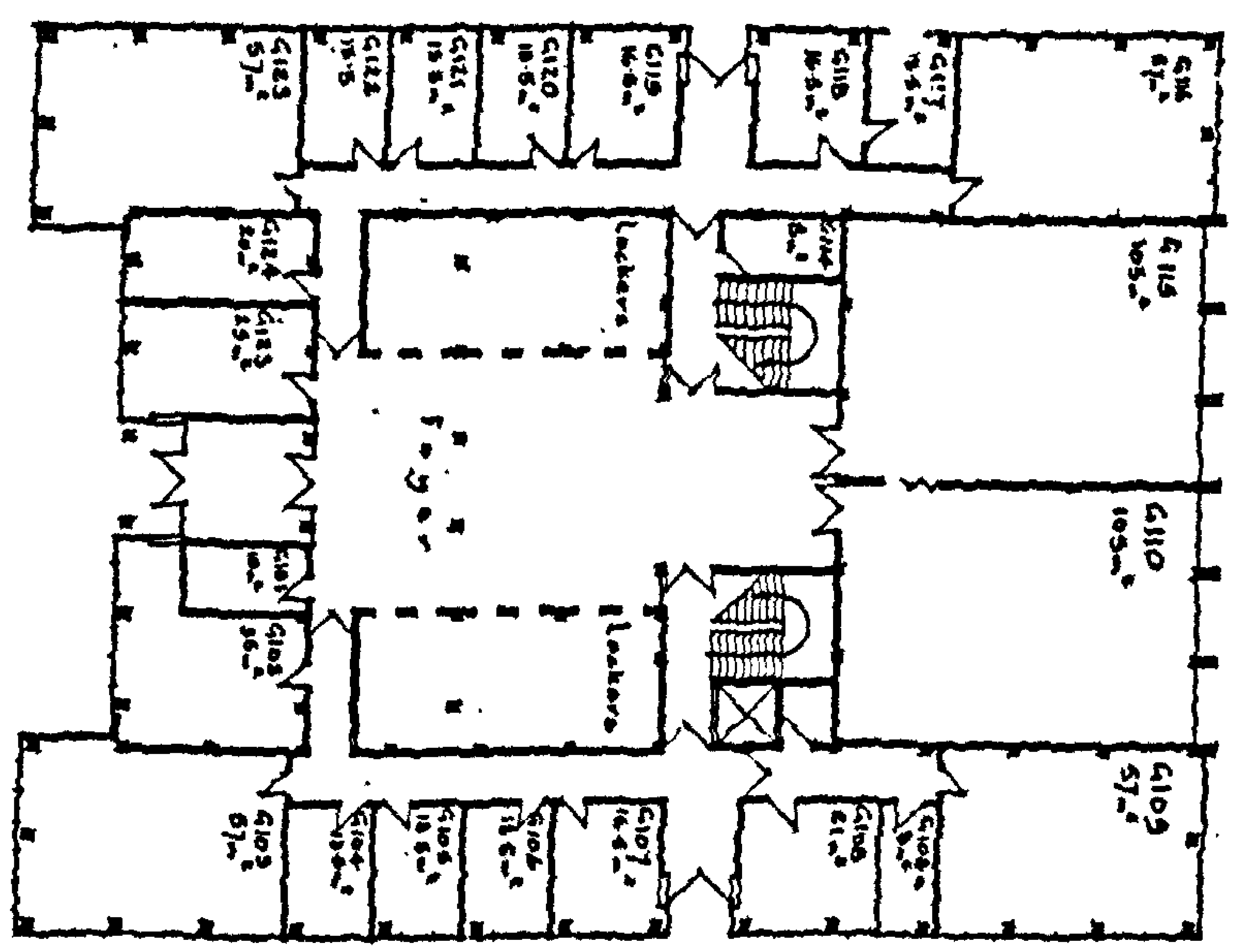
(B8)

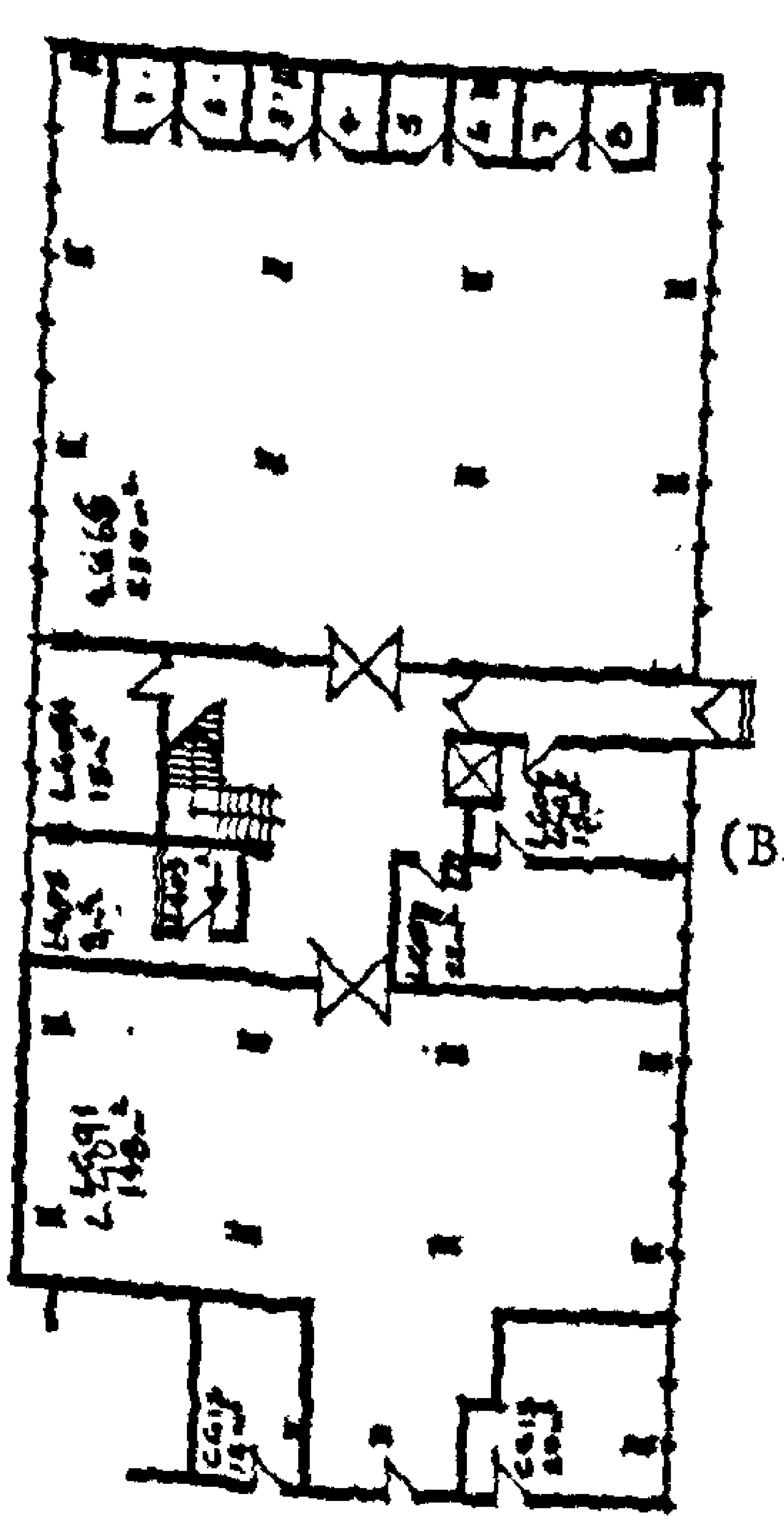


(B4)



(B9)





(B2)

Appendix A1

Figure - 12 -
Pilot study: Uniformity of Rooms; Buildings 2, 4, 8 and 9.

Appendix-A2
Pilot Study
Uniformity of Circulation Pattern

This appendix describes some of the empirical work carried out in a pilot study to develop measures of the uniformity of circulation pattern. The measures have been tried on six buildings. Four of these buildings were part of the Oxford Polytechnic building complex. The remaining two buildings were selected from the literature and these are part of the Northwick Park Hospital. Their plans were available in a book on hospitals. (Stone, P. ed. British Hospitals and Health-Care Buildings: Design and Appraisals. London. The Architectural Press. 1980. pp.148-149) The appendix includes; the plans of the buildings examined, their scores and some of the analysis made on the scores of these buildings.

There were four scores of uniformity of circulation pattern in each building with respect to four indicators (I1, I2, I3 and I4). I1 concerns the proximity between rooms. I2 concerns the adjacency between rooms. I3 concern the proximity between rooms and corridors. Finally, I4 concerns the adjacency between rooms and corridors. However, indicators I1 and I2 have both been modified when they were applied to the three buildings that have been examined in a case study. I3 has been included in the examination of the uniformity of rooms. I4 has been dropped from the analysis.

The analysis presented in this appendix concentrates upon I2. It describes the relationship between the extent of uniformity of circulation with respect to each adjacency type and the number of rooms that relate to other rooms in the adjacency types. Initially, it was thought that an assessment of the uniformity of circulation in a building could be achieved by averaging the scores of uniformity with respect to the various adjacency types. It emerged from the pilot study that this can not be done, since there resulted a large discrepancy between the scores of uniformity of the various types. The scores related not only to the extent of variation between rooms but also to the percentage of rooms in each adjacency type. This meant that the scores in adjacency types need to be multiplied by some weight factor, and that was numbers of relationships in these types shown as percentages of the total number of relationships at all types. The pilot study has resulted in a further modification to the measures. Eight rather than seven adjacency types needed to be identified.

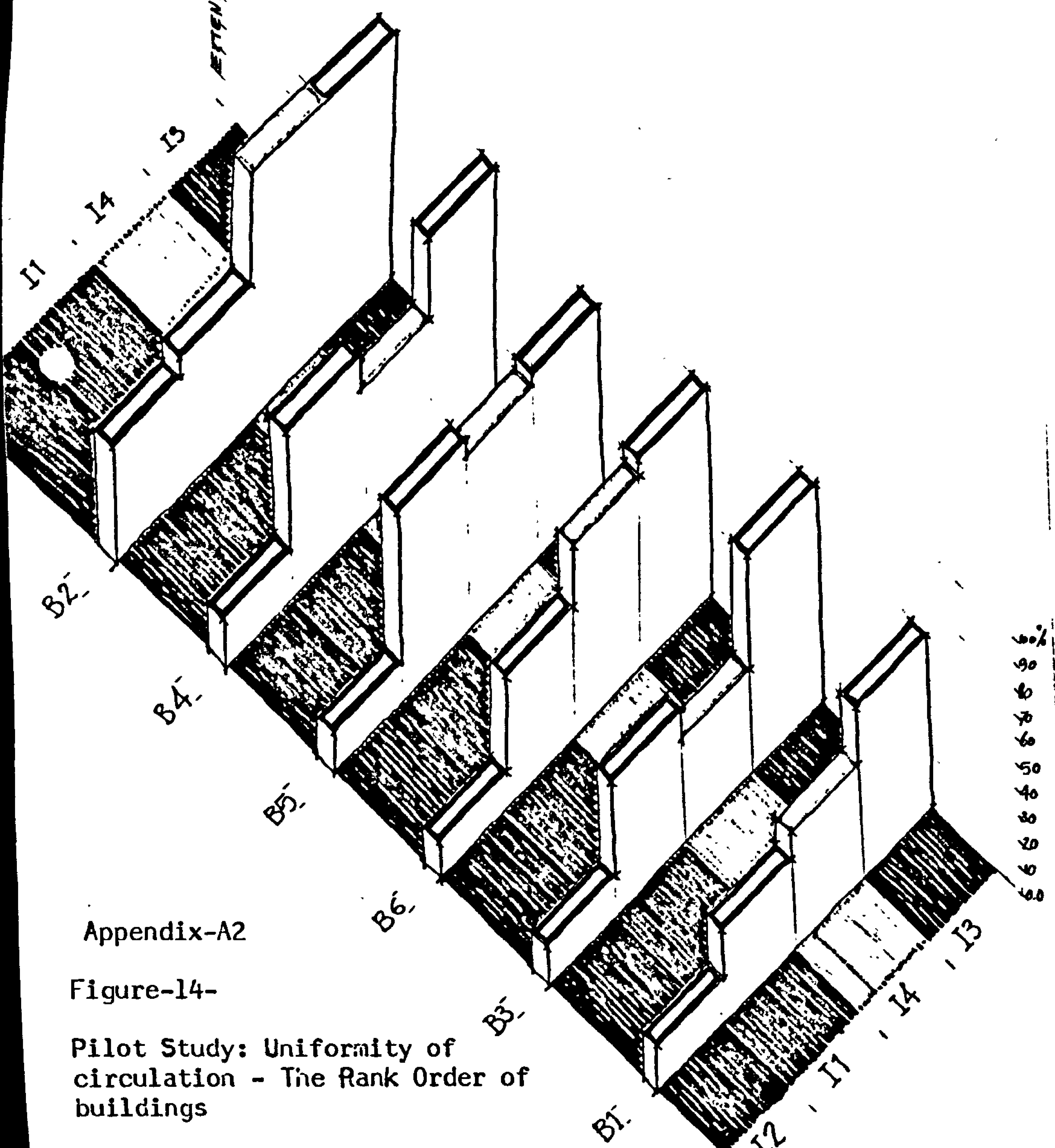
The appendix includes:

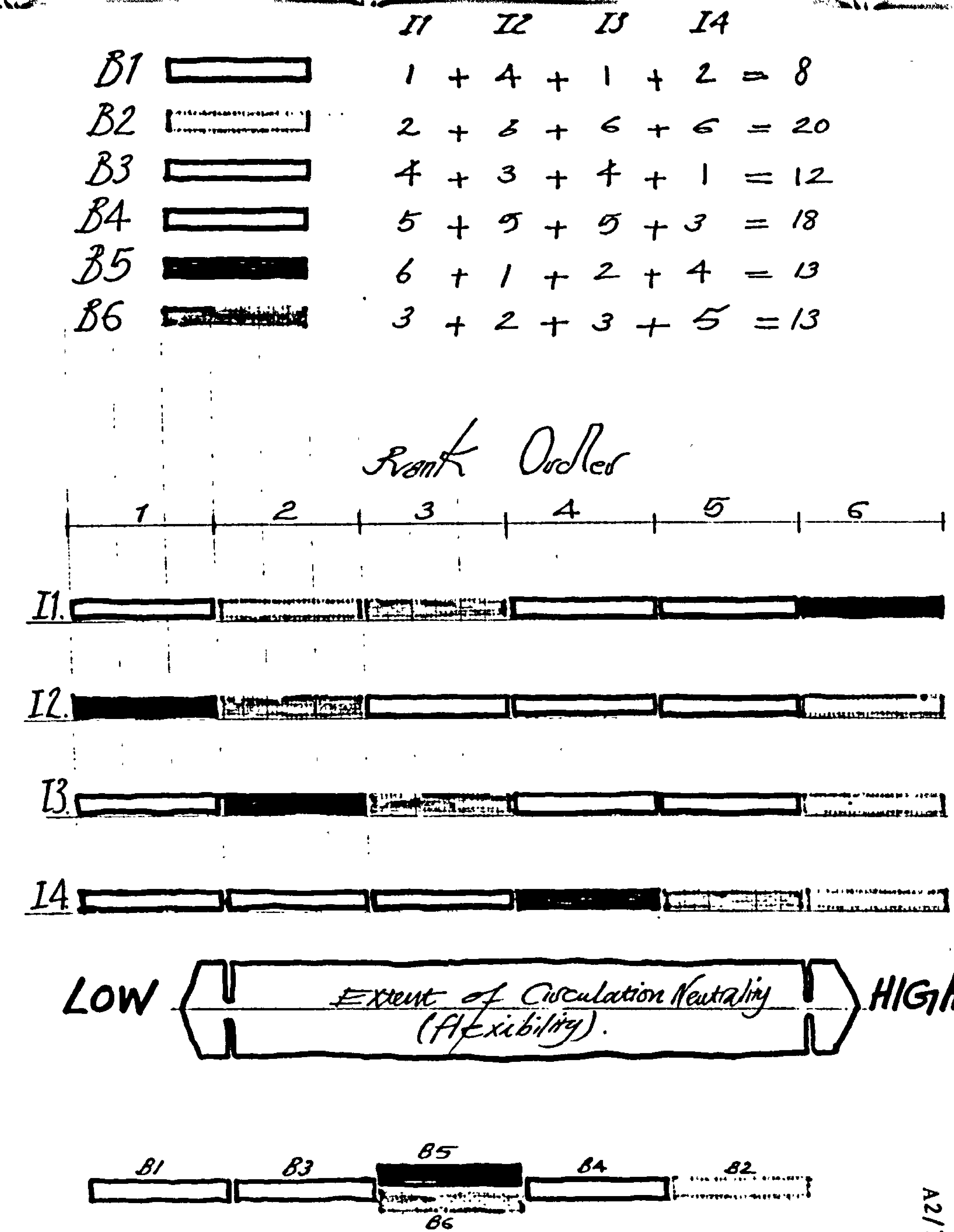
Figure-13: This shows the plans of the buildings examined in the pilot study.

Figure-14: This is a graphic representation of differences between the buildings examined with respect to their scores on the four indicators of uniformity of circulation.

Figure-15: This shows the relationship between the scores of buildings on indicator I2 (concerning adjacency relationships between rooms) with respect to various adjacency types and the percentage of rooms that relate to other rooms in these types. It shows that the types that contain fewer relationships have large scores on this indicator.

Figure-13-
Pilot Study: Uniformity of circulation - Plans of Building

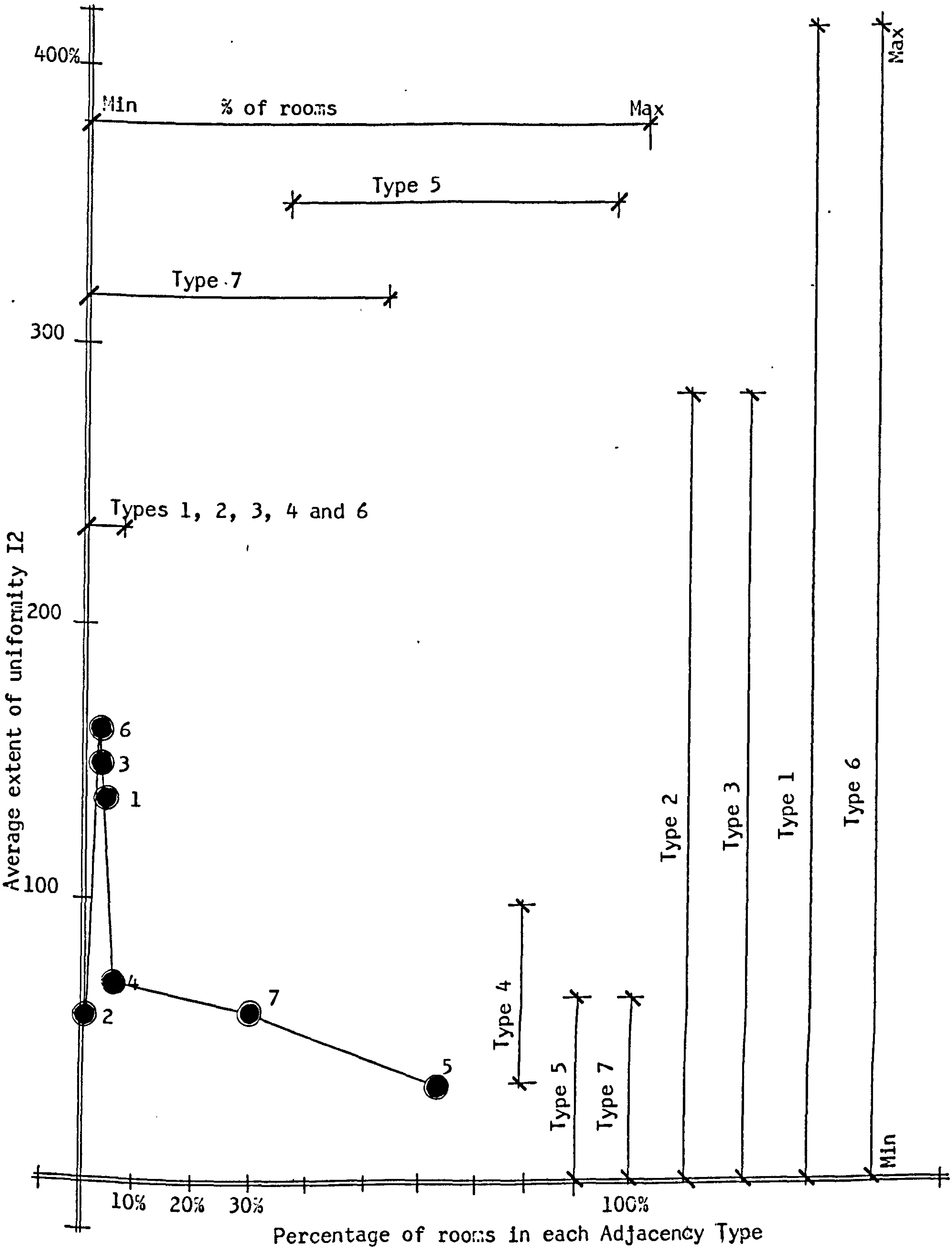




Appendix-A2

Figure-14-

Pilot Study: Uniformity of circulation - The Rank Order of buildings



Appendix-A2

Figure- 15
The Uniformity of Adjacency and the percentage of rooms in the seven types of Adjacency

APPENDIX-B
Pilot Study
Measures of Flexibility

This appendix describes some of the empirical work carried out, in a pilot study, in order to propose a system of measurement by which the extent of flexibility of buildings in-use could be assessed. It is divided into two sections, and these are referred to as: Appendix-B1 and Appendix-B2.

Appendix-B1 is a sample of the analysis of data about Pooled Rooms.

Appendix-B2 is a sample of the analysis of data about Room Usage.

Appendix-B1
Pilot Study
Pooled Rooms

This appendix contains a sample of the analyses carried out on data available in the Oxford Polytechnic records about the use of pooled rooms. The use of each room was recorded, by the pooled rooms committee for each hour of the day at which rooms have been booked. The records contained the type of teaching activities carried out (being lecture, seminar, tutorial, project work) the types of users (for teaching, they were classified by the courses or modules number), the size of groups using rooms, and finally any special audio-visual equipment used. Some analyses have been made concerning the categorization of these data entries in order to identify the demand of certain activities for area. The allocations of each type of activity in different rooms have been recorded in order to identify the average requirements of each student for area according to the type of activity in question. These averages have then been compared with the actual areas of the rooms at which activities have been allocated, and mismatch measured. The whole exercise did not prove entirely useful either because of the lack of relevant data, or the small scale of change being recorded.

This appendix is a sample of the tabulation of data on pooled rooms in one of the Polytechnic buildings together with the plan of that building in 1982/83. The tabulation has been made according to:

i) Hour: The hour of the day at which rooms were used. The hours are coded as follows:
1. 9 -10. 2. 10-11. 3. 11-12. and so on.

ii) Users: Rooms have generally been booked for modular courses, and the module number is what has been kept in records. The module number was used identify the user groups.

iii) Number of Users: In many cases the number of users of rooms has also been kept on records. This number, however, does not represent the actual number of users in each room. Rather these numbers are figures given to the Pooled Rooms Committee prior to the occupation of rooms.

iv) Purpose: Rooms are generally booked for teaching, and this is classified into lecture, seminar, project work, tutorials or others. These types of teaching activities were not always reported in Pooled Rooms records. They, for certain courses, have been extracted from the Modular Courses Time-table.

v) Room Number: Number of rooms on the door.

vi) Term: Academic terms classified as 1, 2 and 3 for each academic year.

vii) Year: The years of investigation were coded as:
1. 1980/81. 2. 1981/82. 3. 1982/83. 4. 1983/84.

Appendix B1

File: POOLED
Report: POOLED
Selection: USER DES. begins with 2

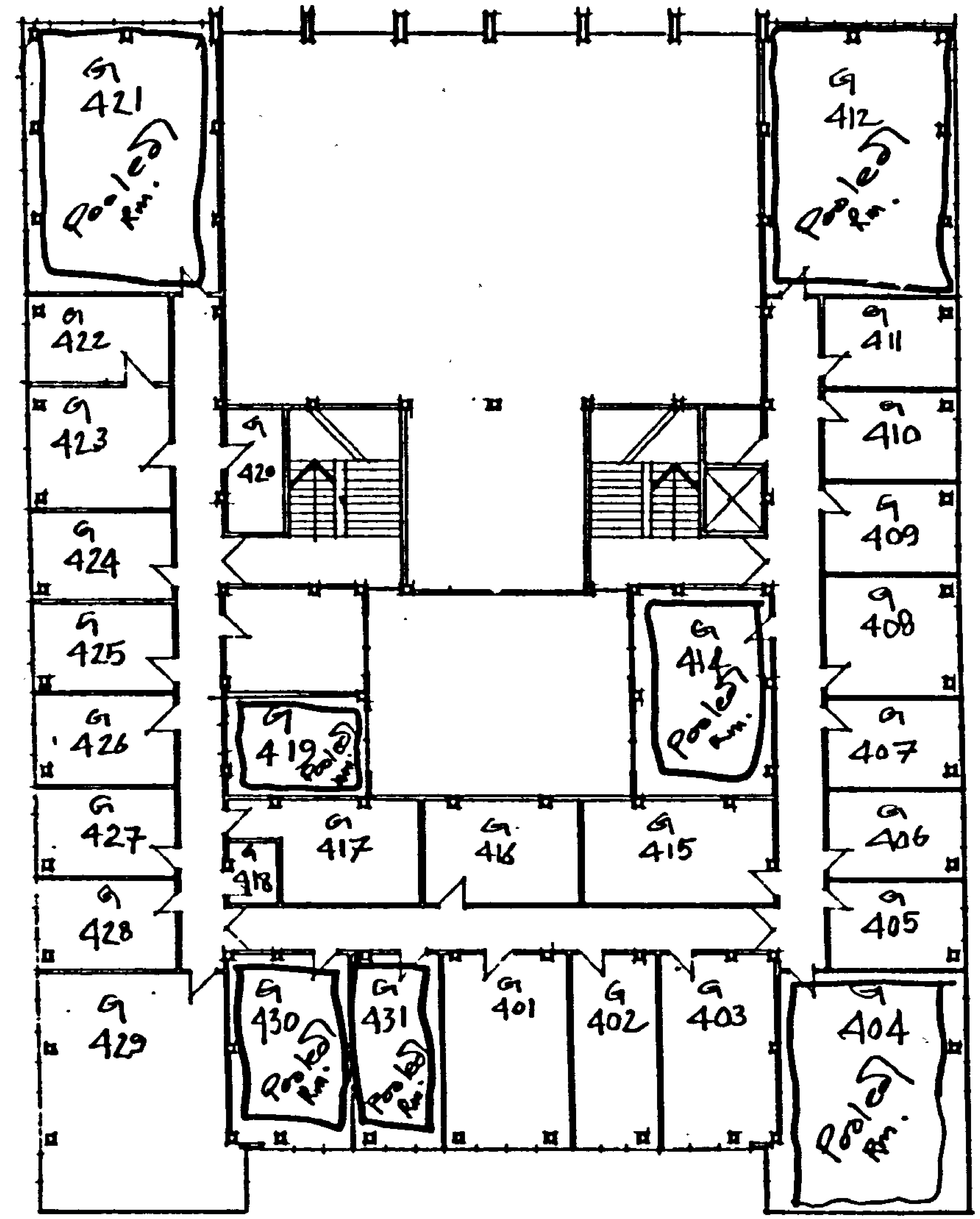
Page
17 NOV.

HOUR NO.	USER DES.	NO. OF USERS	PURPOSE	ROOM NO.	TERM	YEAR	MIS.
2	2423		S	G404	1	3	
2	2100	15	L	G414	1	3	
3	2260	20	L	G414	1	3	
8	2113	18	S	G414	1	3	
1	2161	7		G419	1	3	NOT SHOWN
4	2601	10	S	G419	1	3	
6	2120	10	(L)	G419	1	3	
4	2601	10	S	G430	1	3	
6	2219	13	L	G430	1	3	
7	2202	15	S	G430	1	3	
2	2401	12	S	G431	1	3	
4	2460	12	S	G431	1	3	
3	2610	20	L	G404	2	3	
4	2421	15	L	G404	2	3	
6	2362	15	S	G404	2	3	
2	2100	15		G414	2	3	
3	2314	12	S	G414	2	3	
8	2113	20		G414	2	3	
9	2170	15		G414	2	3	
2	2410	13	S	G419	2	3	
7	2407	12	S	G419	2	3	
2	2631	30	L	G421	2	3	
3	2106	30	S	G421	2	3	
4	2631	12	S	G421	2	3	
7	2610	12	S	G421	2	3	
8	2413	25	L	G421	2	3	
2	2410	13	S	G430	2	3	
3	2631	15	S	G430	2	3	
4	2621	13	S	G430	2	3	
6	2219	13	L	G430	2	3	
3	2314	12	S	G431	2	3	
4	2405	12	S	G431	2	3	
9	2637	10	S	G431	2	3	
1	2130	12		G404	3	3	
3	2610	20	S	G404	3	3	
3	2412	10	S	G412	3	3	
4	2412	10	S	G412	3	3	
2	2100	15		G414	3	3	
3	2314	12	S	G414	3	3	
8	2113	20		G414	3	3	
9	2304	15	S	G414	3	3	
2	2410	13	S	G419	3	3	2410 IN G430
4	2344	8	(L)	G419	3	3	2344 IN G301
6	2121	10		G419	3	3	
7	2610	12	S	G421	3	3	
8	2413	25	L	G421	3	3	
2	2410	13	S	G430	3	3	
3	2304	15	S	G430	3	3	
4	2621	13	S	G430	3	3	

File: POOLED
Report: POOLED
Selection: HOUR NO. equals 2
and ROOM NO. contains G419

Page 1
17 NOV.83

HOUR NO.	USER DES.	NO. OF USERS	PURPOSE	ROOM NO.	TERM	YEAR	MIS.
2	7344	10		G419	1	3	NOT SHOWN
2	2410	13	S	G419	2	3	
2	2410	13	S	G419	3	3	2410 IN G430



Appendix-B2
Pilot Study
Room Usage

This appendix is a tabulation of the types of room usage in three buildings belonging to the Oxford Polytechnic examined in a pilot study.

The purpose of examining room usage was to enable an assessment to be made of the demand of activities for space, and eventually change in the demand. The usage of each room in three buildings of the Oxford Polytechnic were identified from the survey of those buildings. The recorded room usages, though stated generally, were latter grouped into some usage categories. Such categories were based on past proposal of typology of room usage in literature on educational buildings. The number and area of rooms belonging to each usage category were shown as percentages of the total number and total area of all rooms in a building respectively, and that was done for two academic years. The difference between these percentages were shown as percentages of those percentages at the beginning year of examination. The resultant changes were too small to allow a reliable comparison of the buildings examined. The examination of room usage did not help much in indicating change in the demand.

The categories of room usage and the percentage of rooms in them in the three buildings examined are shown on Table-35 below.

Table-35
Pilot Study - Measures of Flexibility
Percentage of Rooms in Each Category of Room Usage

Types of Room Usage	BUILDINGS (A)	(B)	(C)
1. Office and Administration.	26.47	57.57	35.84
2. General Teaching.	5.88	21.21	7.54
3. Specialized Teaching.	17.64	3.03	26.41
4. Supporting Areas.	41.17	12.12	18.86
5. General Use.	5.88	6.06	7.54
6. Others.	0.00	0.00	3.77

1. Office and Administration.	-Offices.
2. General Teaching.	-Classrooms.
3. Specialized Teaching.	-Studios. -Laboratories. -Special Functions.
4. Supporting Areas.	-Print and Dark Rooms. -Information Centres. -Workshops. -Departmental Shops. -Stores.
5. General Use.	-Common Rooms. -W.C. -Access.
6. Others.	

APPENDIX-C
Case Study
Measuring Design Variables

This appendix contains the plans of the three buildings examined in the case study (A, B and C), together with a sample of the data extracted from them regarding the uniformity of rooms and the uniformity of circulation pattern. The appendix is divided into three sections, and these are referred to as; Appendix-C1, Appendix-C2 and Appendix-C3.

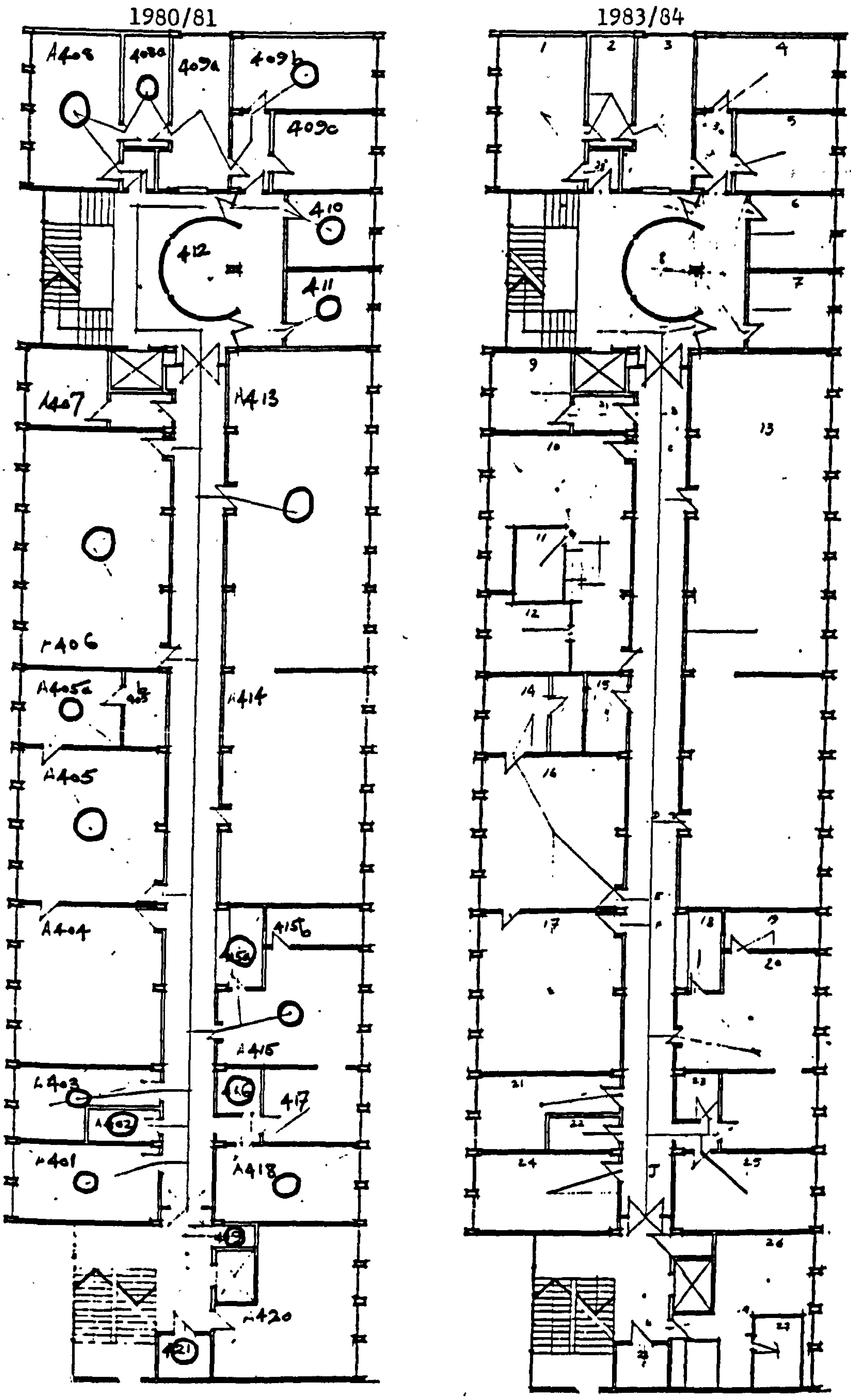
Appendix-C1 shows the plans of the buildings examined.

Appendix-C2 includes a sample of the data on the uniformity of rooms.

Appendix-C3 includes a sample of the data on the uniformity of circulation pattern.

Appendix-C1
Case Study
Plans of Buildings A, B and C

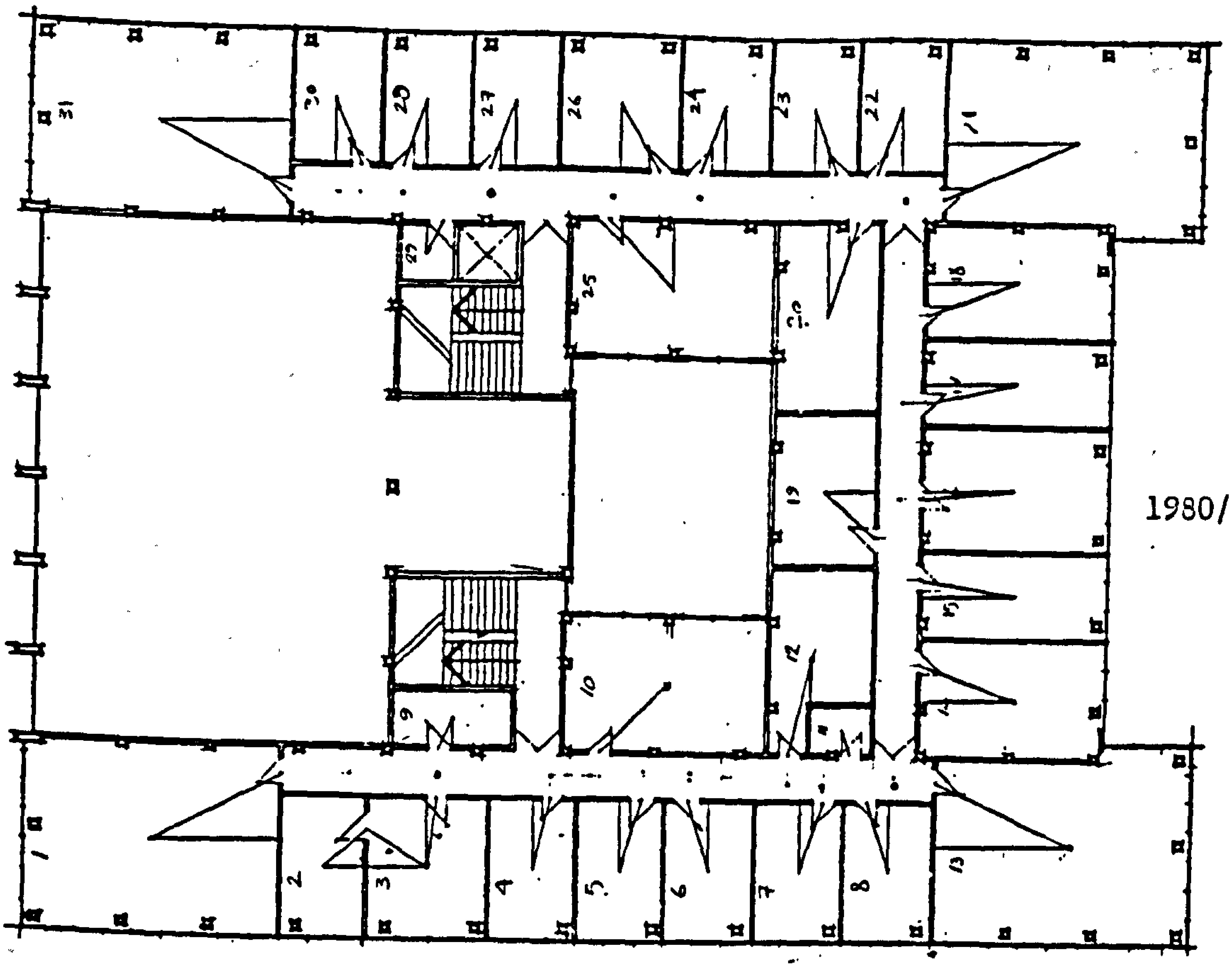
This appendix contains the plans of buildings A, B and C, as they were in 1980/81 and in 1983/84. On the plans the lines of the actual distances between rooms (proximity) are shown. The actual distance between any two rooms has been measured along corridors from the centroid of one room to that of an other.



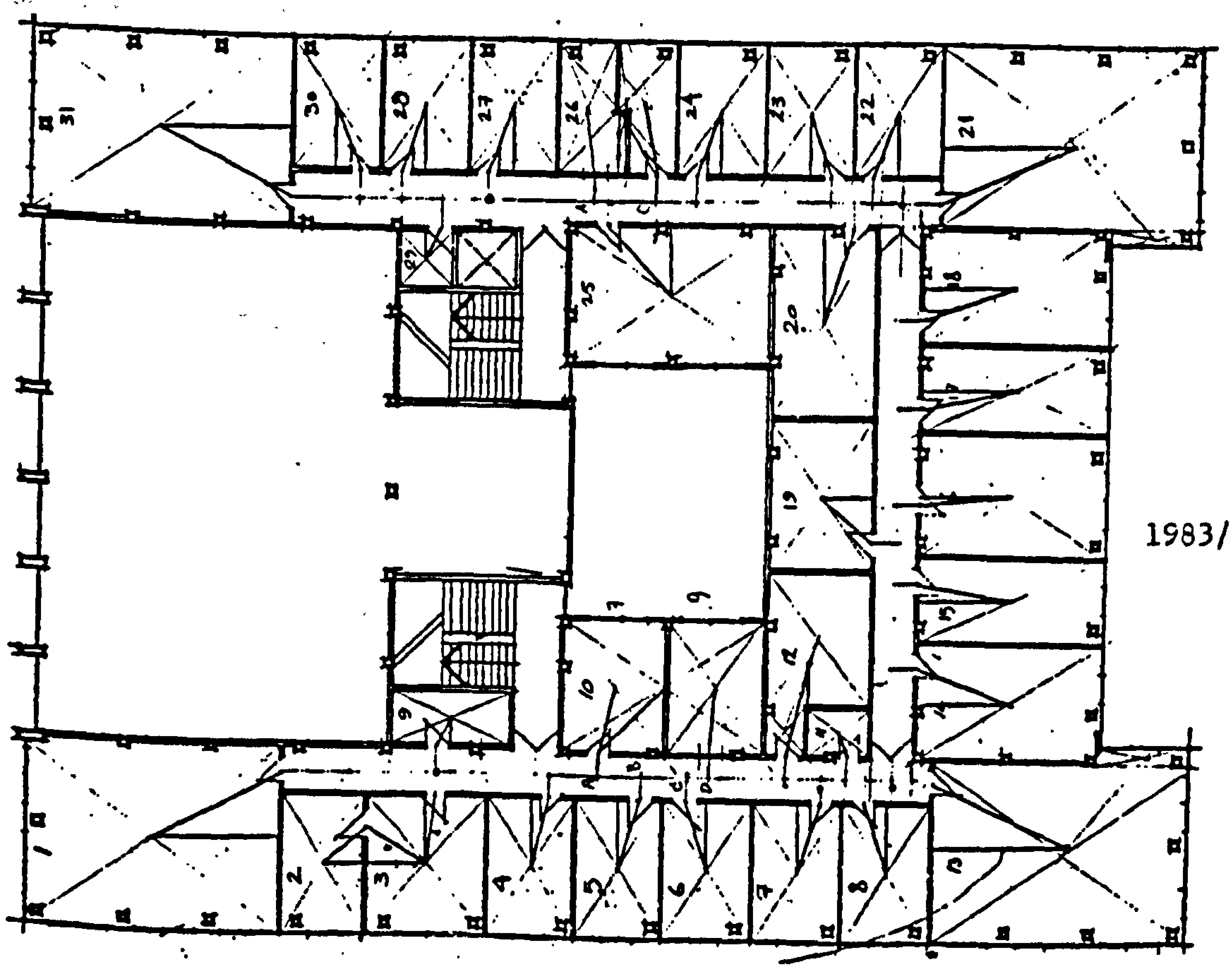
Appendix C1

Figure-16

Plans of Building A - 1980/81 and 1983/84



1980/81

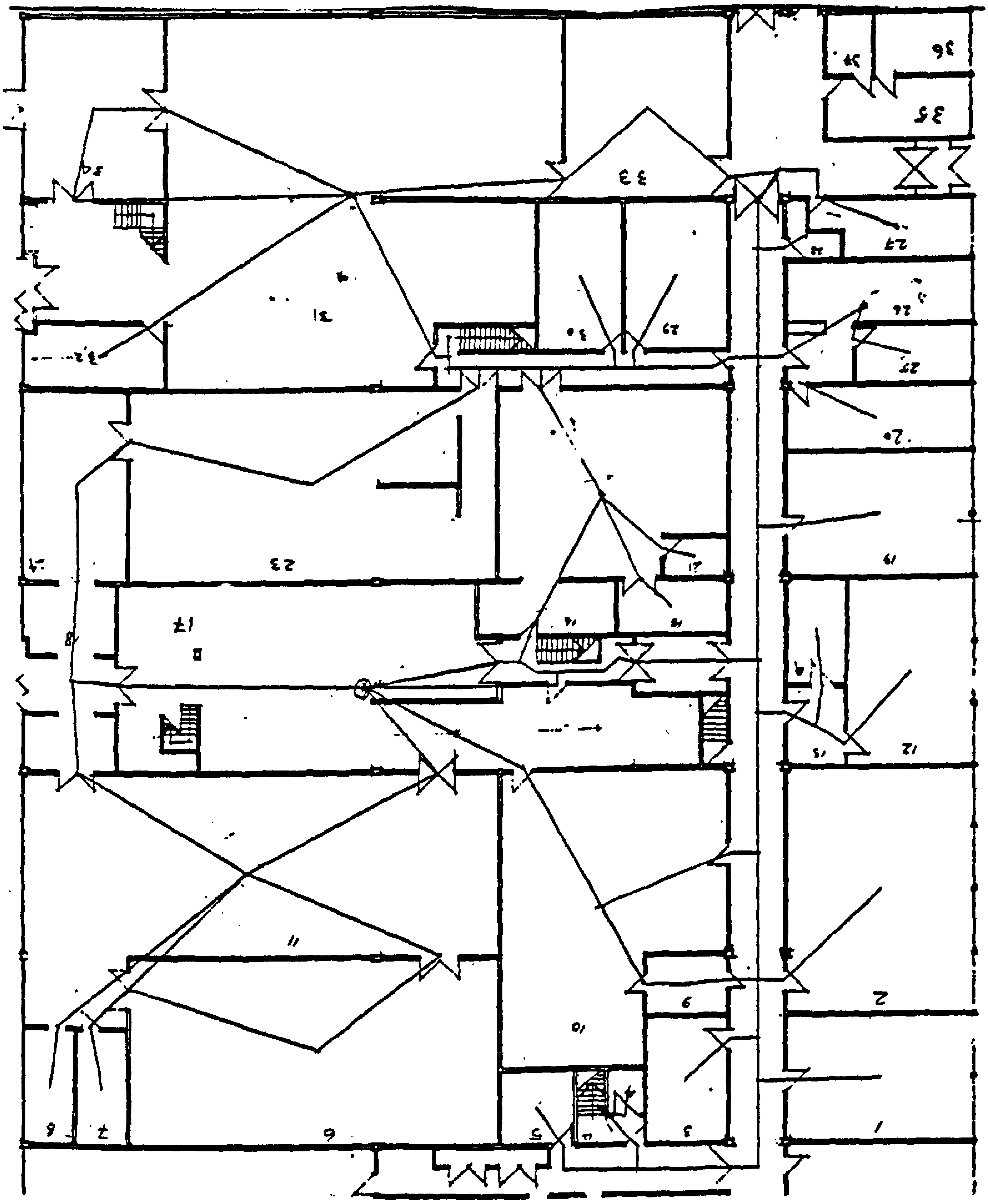


1983/84

Appendix C1

Figure- 17

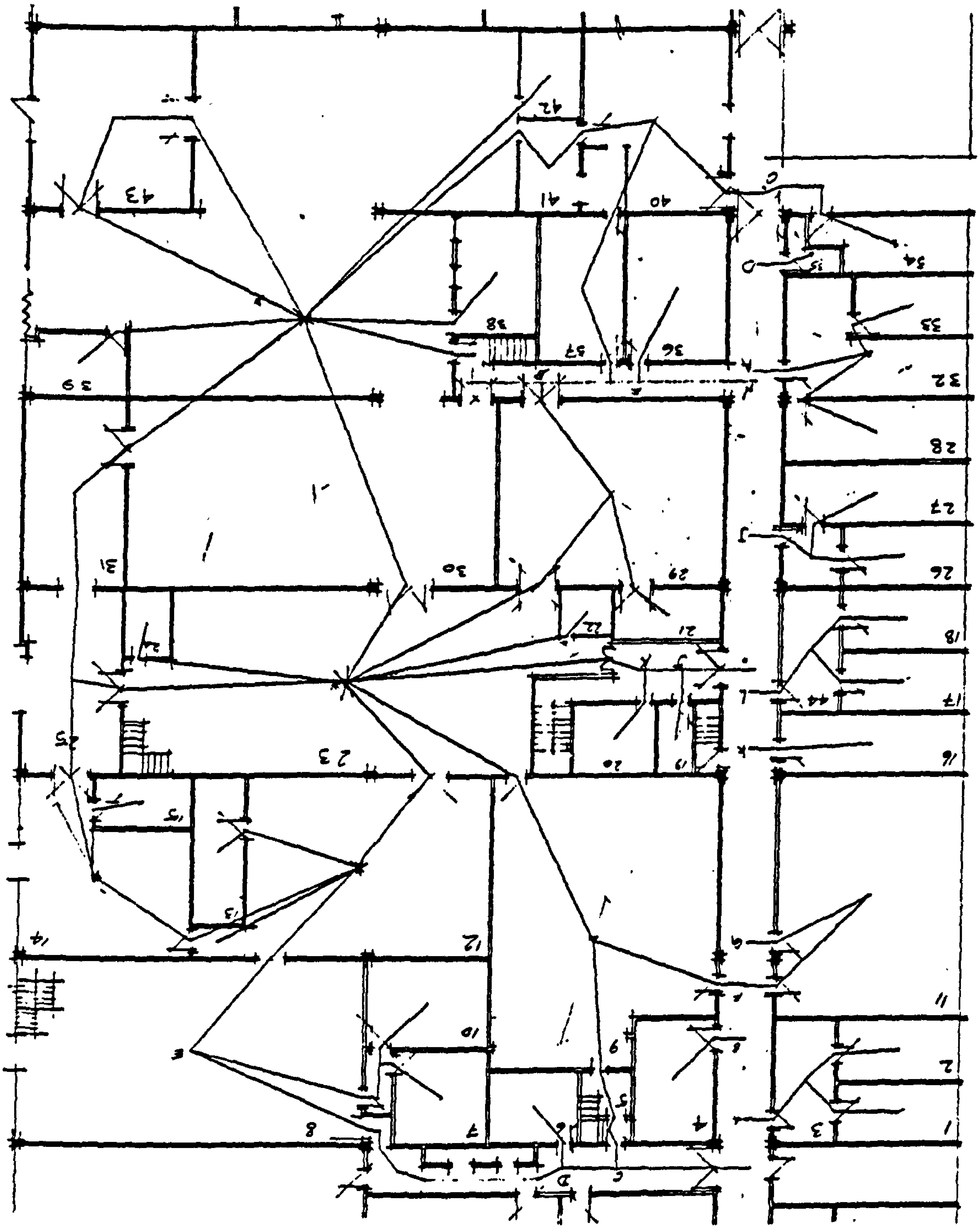
Plans of Building B - 1980/81 and 1983/84



Appendix C1

Figure-18

Plan of Building C - 1980/81



Appendix C1

Figure 19

Plan of Building C - 1983/84

Appendix-C2
Case Study
Uniformity of Rooms

This appendix contains a sample of the data concerning the measurements of uniformity of rooms with respect to their area in the three buildings examined in the case study. The appendix contains tables about the rooms included in each interval of area according to six rules of defining intervals (two of which resulted in standard intervals while the remaining four concerned specific intervals). The number and the area of rooms in each interval of area are shown as percentages of the total number and total area of rooms in the building, together with the coefficient of variation (I33) between the areas of rooms in each interval. The coefficient of variation in each group of rooms was multiplied by the the relevant percentages of rooms in the group to represent alternative ways of indicating the extent of uniformity between rooms in each group. These alternative coefficients can be averaged for each group and eventually for all groups of rooms in a building. This appendix contains:

Table-36 which shows the distribution of rooms between groups in one of the buildings examined (A) according to standard intervals.

Table-37 which shows the distribution of rooms between groups in building (A) according to specific intervals.

APPENDIX - C2 -
Table - 36
Standard Intervals of Area: Building - A

Total number of rooms in the building = 31
Total area of rooms in the building = 722.26 sq.m.
PCT.No. = Number of of rooms in each interval as a percentage of total number of rooms in the building.
PCT.AREA = Area of rooms in each interval as a percentage of the total area of rooms in the building.
I33 = The coefficient of variation between the areas of rooms in each interval.

INTERVALS	PCT. NO.	PCT.AREA	I33
RULE 1:			
(1) 000.60-001.20	-	-	-
(2) 001.20-002.40	-	-	-
(3) 002.40-004.80	9.67	1.52	27.91
(4) 004.80-009.60	25.80	7.37	17.74
(5) 009.60-019.20	25.80	15.98	16.43
(6) 019.20-038.40	22.58	24.83	17.97
(7) 038.40-076.80	12.90	27.44	4.78
(8) 076.80-153.60	-	-	-
(9) 153.60-307.20	3.22	22.85	0.00
(10)307.20-614.40	-	-	-
RULE 2:			
(1) 000.60-000.90	-	-	-
(2) 000.90-001.35	-	-	-
(3) 001.35-002.02	-	-	-
(4) 002.02-003.03	3.22	0.34	0.0
(5) 003.03-004.55	5.45	1.17	8.0
(6) 004.55-006.83	9.67	2.21	12.49
(7) 006.83-010.25	16.12	5.15	4.64
(8) 010.25-015.37	16.12	8.94	11.48
(9) 015.37-023.06	16.12	12.95	13.64
(10)023.06-034.59	16.12	18.91	15.81
(11)034.59-051.89	9.67	20.20	3.82
(12)051.89-077.84	3.22	7.23	0.0
(13)077.84-116.77	-	-	-
(14)116.77-175.15	3.22	22.84	0.0
(15)175.15-262.73	-	-	-
(16)262.73-394.10	-	-	-
(17)394.10-591.15	-	-	-
(18)591.15-886.73	-	-	-

APPENDIX - C2 -

Table 37

Specific Intervals of Area: Building - A

Total number of rooms in the building = 31
Total area of rooms in the building = 722.26 sq.m.
PCT.No. = Number of of rooms in each interval as a percentage of total number of rooms in the building.
PCT.AREA = Area of rooms in each interval as a percentage of the total area of rooms in the building.
I33 = The coefficient of variation between the areas of rooms in each interval.

INTERVALS	PCT.NO.	PCT.AREA	I33
RULE 3:			
(1)002.52-005.04	12.90	2.18	25.52
(2)005.12-010.24	22.58	6.70	14.22
(3)010.40-020.80	29.03	18.80	19.63
(4)022.44-044.88	19.35	22.01	16.40
(5)046.64-093.28	12.90	27.44	4.78
(6)165.00-330.00	3.22	22.85	0.0
RULE 4:			
(1)002.52-003.78	3.22	0.34	0.0
(2)004.00-006.00	12.90	2.54	10.38
(3)006.08-009.12	19.35	5.99	8.83
(4)010.40-015.60	16.12	8.94	11.48
(5)016.56-024.84	22.58	19.53	15.99
(6)025.70-038.55	9.67	12.33	13.58
(7)046.64-069.96	12.90	27.44	4.78
(8)165.00-247.50	3.22	22.84	0.0
RULE 5:			
(1)165.00-082.50	3.22	22.84	0.0
(2)052.28-026.14	19.35	36.21	21.79
(3)025.70-012.85	38.70	30.60	24.92
(4)010.40-005.20	22.58	7.43	17.24
(5)005.12-002.56	12.90	2.54	10.38
(6)002.52-001.26	3.22	0.34	0.0
RULE 6:			
(1)165.00-108.90	3.22	22.84	0.0
(2)052.28-034.50	12.90	27.44	4.78
(3)033.76-022.28	19.35	22.01	16.40
(4)020.32-013.41	19.35	13.72	14.31
(5)013.28-008.76	9.67	5.01	12.92
(6)007.92-005.22	19.35	5.99	8.83
(7)005.12-003.37	12.90	2.54	10.38
(8)002.52-001.66	3.22	0.34	0.0

Appendix-C3
Case Study
Uniformity of Circulation Pattern

This appendix contains a sample of the data concerning measurements of the uniformity of circulation pattern in the three buildings examined in the case study (A), (B) and (C). The data is about the proximity and adjacency relationships between rooms in buildings. Measuring the uniformity of circulation pattern with respect to each of proximity and adjacency involves three stages.

First, the proximity and adjacency relationships of each room in a building to all other rooms is identified from measurements of its plan.

Second, for each room all the proximity and adjacency relationships to other rooms are summarized in a few scores. Summarizing proximity, which resulted in two scores, was made by measuring the mean and the median of the distances between one room and other rooms. Summarizing adjacency relationships of each room, which resulted in eight scores, was made by measuring the percentage of rooms that relate to it in each of the eight types of adjacency relationships.

Third, for each building the extent of variation between rooms in it is measured with respect to each of the scores that resulted from summarizing relationships of each room to other rooms. For proximity the coefficient of variation between the means or the median of distances represents the extent of uniformity of proximity. For adjacency the coefficient of variation between rooms with respect to each of the percentages of rooms relating to them in each adjacency type represents the extent of uniformity of adjacency with respect to each type in question. The extent of uniformity of adjacency of a building considering all adjacency types can be obtained by averaging the eight scores of the eight types. Before the eight scores were averaged, they were multiplied by a weight factor. The weight factor for each adjacency type is the number of relationships in it shown as a percentage of the total number of relationships in the building.

This appendix contains the following four tables:

Table-38 which shows a sample of the proximity relationships between rooms a building (Building A - 1980/81).

Table-39 which shows a sample of adjacency relationships between rooms in a building (Building A - 1980/81).

Table-40 which shows the summaries of proximity relationships for each room in buildings A, B and C.

Table-41 which shows a sample of the summaries of adjacency relationships between rooms in a building (Building A 1980/81).

PART (A). VARIABLE (CN.). INDICATOR ( ).

Appendix - C3
Table-38
Proximity in A - 1980/81

ROOMS

ROOMS	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1		4.40	7.80	16.40	15.20	19.40	19.40	13.20	25.00	26.20	28.20	33.40	31.00	53.40	52.20	47.20
2	4.40		3.20	11.80	10.60	18.60	18.60	12.80	29.60	30.80	32.80	38.00	35.60	58.00	61.80	51.80
3	7.80	3.20		8.60	7.40	15.40	15.40	9.60	23.40	24.60	26.60	31.80	34.00	56.40	60.20	50.20
4	16.40	11.80	8.60		8.40	16.80	16.80	10.60	25.00	26.20	28.20	33.40	31.00	53.40	57.20	47.20
5	15.20	10.60	7.40	8.40		15.80	15.80	9.60	23.80	25.00	27.00	32.20	29.80	52.20	56.00	46.00
6	19.40	18.60	15.40	15.80	15.80		12.40	6.20	20.40	21.60	23.60	28.80	26.40	48.80	52.60	42.60
7	19.40	18.60	15.40	16.80	15.80	12.40		6.20	20.40	21.60	23.60	28.80	26.40	48.80	52.60	42.60
8	13.20	12.80	9.60	10.60	9.60	6.20	6.20		14.20	15.40	17.40	22.60	20.20	42.60	46.40	36.40
9	25.00	29.60	23.40	25.00	23.80	20.40	20.40	14.20		14.00	16.00	21.20	18.80	41.20	45.00	35.00
10	26.20	30.80	24.60	26.20	25.00	21.60	21.60	15.40	14.00		2.00	7.00	16.60	43.20	47.00	37.00
11	28.20	32.80	26.60	28.20	27.00	23.60	23.60	17.40	16.00	2.00		9.00	18.60	45.20	49.00	39.00
12	33.40	38.00	31.80	33.40	32.20	28.80	28.80	22.60	21.20	7.00	9.00		23.60	50.20	54.00	44.00
13	31.00	35.60	34.00	31.00	29.80	26.40	26.40	20.20	18.80	16.60	18.60	23.60		26.60	30.40	20.40
14	53.40	58.00	56.40	53.40	52.20	48.80	48.80	42.60	41.20	43.20	45.20	50.20	26.60		3.80	6.20
15	57.20	61.80	60.20	57.20	56.00	52.60	52.60	46.40	45.00	47.00	49.00	54.00	30.40	3.80		10.00
16	47.20	51.80	50.20	47.20	46.00	42.60	42.60	36.40	35.00	37.00	39.00	44.00	20.40	6.20	10.00	
17	48.40	53.00	51.40	48.40	47.20	43.80	43.80	37.60	36.20	38.20	40.20	45.20	21.60	14.80	18.60	8.40
18	58.80	63.40	61.80	58.80	57.60	54.20	54.20	48.00	46.60	48.60	50.60	55.60	32.00	30.00	33.80	23.80
19	59.40	64.00	62.40	59.40	58.20	54.80	54.80	48.60	47.20	49.20	51.20	56.20	32.60	30.60	34.40	24.40
20	52.80	57.40	55.80	52.80	51.60	48.20	48.20	42.00	40.60	42.60	44.60	49.60	26.00	24.00	27.80	17.80
21	55.40	70.00	68.40	55.40	54.20	50.80	50.80	44.60	43.20	45.20	47.20	52.20	28.60	26.60	30.40	20.40
22	55.00	59.60	58.00	55.00	53.80	50.40	50.40	44.20	42.80	44.80	46.80	51.80	28.20	26.20	30.00	20.00
23	57.00	61.60	60.00	57.00	55.80	52.40	52.40	46.20	44.80	46.80	48.80	53.80	30.20	28.20	32.00	22.00
24	58.80	63.40	61.80	58.80	57.60	54.20	54.20	48.00	46.60	48.60	50.60	55.60	32.00	30.00	33.80	23.80
25	58.60	63.20	61.60	58.60	57.40	54.00	54.00	47.80	46.40	48.40	50.40	55.40	31.80	29.80	33.60	23.60
26	66.60	71.20	69.6	66.60	65.40	62.00	62.00	55.80	54.40	56.40	58.40	63.40	39.80	37.80	41.60	31.60
27	69.40	74.00	72.40	69.40	68.20	64.80	64.80	58.60	57.20	59.20	61.20	66.20	42.60	40.60	44.40	34.40
28	63.40	68.00	66.40	63.40	62.20	58.80	58.80	52.60	51.20	53.20	55.20	60.20	36.60	34.60	38.40	28.40
29	4.40	9.00	7.40	19.00	18.40	15.00	15.00	8.60	20.40	21.80	23.80	28.80	26.40	48.80	52.60	42.60
30	11.60	7.00	3.80	4.80	3.60	12.00	12.00	5.80	19.80	21.20	23.20	28.20	25.80	48.20	52.00	42.00
31	21.40	26.00	24.40	21.40	20.20	16.80	16.80	10.60	3.60	10.60	12.60	17.60	15.20	37.60	41.40	31.40
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ROOMS	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38
1	48.40	58.80	59.40	52.80	55.40	55.00	57.00	58.80	58.60	66.60	69.40	63.40	4.40	11.60	21.40							
2	53.00	63.40	64.00	57.40	70.00	59.60	61.60	63.40	63.20	71.20	74.00	68.00	9.00	7.00	26.00							
3	51.40	61.80	62.40	55.80	68.40	58.00	60.00	61.80	61.60	69.60	72.40	66.40	7.40	3.80	24.40							
4	48.40	58.80	59.40	52.80	55.40	55.00	57.00	58.80	58.60	66.60	69.40	63.40	19.00	4.80	21.40							
5	47.20	57.60	58.20	51.60	54.20	53.80	55.80	57.60	57.40	65.90	68.20	62.20	18.40	3.60	20.20							
6	43.80	54.20	54.80	48.20	50.80	50.40	52.40	54.20	54.00	62.00	64.80	58.80	15.00	12.00	16.80							
7	43.80	54.20	54.80	48.20	50.80	50.40	52.40	54.20	54.00	62.00	64.80	58.80	15.00	12.00	16.80							
8	37.60	48.00	48.60	42.00	44.60	44.20	46.20	48.00	47.80	55.80	58.60	52.60	8.60	5.80	10.60							
9	36.20	46.60	47.20	40.60	43.20	41.80	44.80	46.60	46.40	54.40	57.20	51.20	20.40	19.80	3.60							
10	38.20	48.60	49.20	42.60	45.20	44.80	46.80	48.60	48.40	56.40	59.20	53.20	21.80	21.20	10.60							
11	40.20	50.60	51.20	44.60	47.20	46.80	48.80	50.60	50.40	58.40	61.20	55.20	23.80	23.20	12.60							
12	45.20	55.60	56.20	49.60	52.20	51.80	53.80	55.60	55.40	63.40	66.20	60.20	28.80	28.20	17.60							
13	21.60	32.00	32.60	26.00	28.60	28.20	30.20	32.00	31.80	39.80	42.60	36.60	26.40	25.80	15.20							
14	14.80	30.00	30.60	24.00	26.60	26.20	28.20	30.00	29.80	37.80	40.60	34.60	48.80	48.20	37.60							
15	18.60	33.80	34.40	27.80	30.40	30.00	32.00	33.80	33.60	41.60	44.40	38.40	52.60	52.00	41.40							
16	8.40	23.80	24.40	17.80	20.40	20.00	22.00	23.80	23.60	31.60	34.40	28.40	42.60	42.00	31.40							
17		25.00	25.60	19.00	21.60	21.20	23.20	25.00	24.80	32.80	35.60	29.60	44.00	43.40	32.80							
18	25.00		12.60	6.00	18.80	16.60	12.40	19.80	14.60	27.60	30.60	24.40	54.20	53.60	43.00							
19	25.60	12.60		6.80	19.60	17.40	13.20	20.60	15.40	28.40	31.40	25.20	55.00	54.40	43.80							
20	19.00	6.00	6.80		13.60	11.40	7.20	14.60	9.40	22.40	25.40	19.20	49.00	48.40	37.80							
21	21.60	18.80	19.60	13.60		12.20	14.20	16.00	15.80	23.80	26.60	20.60	52.80	52.20	41.60							
22	21.20	16.60	17.40	11.40	12.20		10.40	12.20	12.00	20.00	22.80	16.80	52.80	52.20	41.60							
23	23.20	12.40	13.20	7.20	14.20	10.40		13.80	6.00	21.60	24.40	18.40	54.40	53.80	43.20							
24	25.00	19.80	20.60	14.60	16.00	12.20	13.80		13.00	20.00	22.80	16.80	56.40	55.80	45.20							
25	24.80	14.60	15.40	9.40	15.80	12.00	6.00	13.00		20.60	23.60	17.40	56.00	55.40	44.80							
26	32.80	27.60	28.40	22.40	23.80	20.00	21.60	20.00	20.60		3.00	6.80	64.00	63.40	52.80							
27	35.60	30.60	31.40	25.40	26.60	22.80	24.40	22.80	23.60	3.00		9.80	67.00	66.40	55.80							
28	29.60	24.40	25.20	19.20	20.60	16.80	18.40	16.80	17.40	6.80	9.80		60.80	60.20	49.60							
29	44.00	54.20	55.00	49.00	52.80	52.80	54.40	56.40	56.00	64.00	67.00	60.80		14.60	17.20							
30	43.40	53.60	54.40	48.40	52.20	52.20	53.80	55.80	55.40	63.40	66.40	60.20	14.60		16.40							
31	32.80	43.00	43.80	37.80	41.60	41.60	43.20	45.80	44.80	52.80	55.80	49.60	17.20	16.40								
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PART (A) VARIABLE (CN.) INDICATOR ( )

Appendix - C3
Table 39
Adjacency in A - 1980/81

ROOMS

ROOMS	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38
1		1	3	8	8	8	8	7	8	7	8	8	7	8	8	7	7	8	8	7	7	7	7	7	7	7	8	7	1	8	7							
2	1		1	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8							
3	3	1		2	3	8	8	3	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8							
4	8	8	3		2	8	8	3	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8							
5	8	8	3	3		8	8	3	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8							
6	8	8	8	8	8		2	1	8	7	8	8	7	8	8	7	7	8	8	7	7	7	7	7	7	7	8	7	7	3	7							
7	8	8	8	8	8	2		1	8	7	8	8	6	8	8	7	7	8	8	7	7	7	7	7	7	7	8	7	7	3	7							
8	7	8	3	3	3	1	1		7	5	7	7	4	7	8	5	5	7	7	5	5	5	5	5	5	5	7	5	5	1	5							
9	8	8	8	8	8	8	8	7		4	8	8	7	8	8	7	7	8	8	7	7	7	7	7	7	7	8	7	7	8	1							
10	7	8	8	8	8	7	7	5	4		1	1	5	6	8	5	5	7	7	5	5	5	5	5	5	5	7	5	5	7	4							
11	8	8	8	8	8	8	8	7	8	1		2	7	8	8	7	7	8	8	7	7	7	7	7	7	7	8	7	7	8	7							
12	8	8	8	8	8	8	8	7	8	1	2		7	8	8	7	7	8	8	7	7	7	7	7	7	7	8	7	7	8	7							
13	7	8	8	8	8	7	6	4	7	5	7	7		7	8	5	5	6	6	5	5	5	5	5	5	5	7	5	5	7	5							
14	8	8	8	8	8	8	8	7	8	6	8	8	7		1	1	3	8	8	7	7	7	7	7	7	7	8	7	7	8	7							
15	8	8	8	8	8	8	8	8	8	8	8	8	8	1		3	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8							
16	7	8	8	8	8	7	7	5	7	5	7	7	5	1	3		1	7	7	5	5	5	5	5	5	5	7	5	5	7	5							
17	7	8	8	8	8	7	7	5	7	5	7	7	5	3	8	1		7	7	5	4	5	5	5	5	5	7	5	5	7	5							
18	8	8	8	8	8	8	8	7	8	7	8	8	6	8	8	7	7		3	1	7	7	7	7	7	7	8	7	7	8	7							
19	8	8	8	8	8	8	8	7	8	7	8	8	6	8	8	7	7	3		1	7	7	7	7	7	7	8	7	7	8	7							
20	7	8	8	8	8	7	7	5	7	5	7	7	5	7	8	5	5	1	1		5	5	4	5	4	5	7	5	5	7	5							
21	7	8	8	8	8	7	7	5	7	5	7	7	5	7	8	5	4	7	7	5		4	5	4	5	5	7	5	5	7	5							
22	7	8	8	8	8	7	7	5	7	5	7	7	5	7	8	5	5	7	7	5	4		5	4	5	5	7	5	5	7	5							
23	7	8	8	8	8	7	7	5	7	5	7	7	5	7	8	5	5	7	7	4	5	5		5	5	5	7	5	5	7	5							
24	7	8	8	8	8	7	7	5	7	5	7	7	5	7	8	5	5	7	7	5	4	4	5		5	5	7	5	5	7	5							
25	7	8	8	8	8	7	7	5	7	5	7	7	5	7	8	5	5	7	7	4	5	5	5	5		4	7	5	5	7	5							
26	7	8	8	8	8	7	7	5	7	5	7	7	5	7	8	5	5	7	7	5	5	5	5	5	4		1	4	5	7	5							
27	8	8	8	8	8	8	8	7	8	7	8	8	7	8	8	7	7	8	8	7	7	7	7	7	7	1		7	7	8	7							
28	7	8	8	8	8	7	7	5	7	5	7	7	5	7	8	5	5	7	7	5	5	5	5	5	5	4	7		5	7	5							
29	1	8	8	8	8	7	7	5	7	5	7	7	5	7	8	5	5	7	7	5	5	5	5	5	5	5	7	5		7	5							
30	8	8	8	8	8	3	3	1	8	7	8	8	7	8	8	7	7	8	8	7	7	7	7	7	7	7	8	7	7		7							
31	7	8	8	8	8	7	7	5	1	4	7	7	5	7	8	5	5	7	7	5	5	5	5	5	5	5	7	5	5	7								
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Appendix -C3-

Table 40

The Summaries of Proximity Relationships - A, B and C

	BUILDING A		BUILDING B		BUILDING C	
ROOM	MEAN	MEDIAN	MEAN	MEDIAN	MEAN	MEDIAN
01	36.40	33.40	39.19	37.20	42.60	46.50
02	39.65	38.00	36.11	34.20	40.72	43.50
03	37.41	34.00	32.25	29.80	40.08	43.10
04	36.76	33.40	29.54	26.40	49.64	55.10
05	35.68	32.20	27.63	23.40	50.94	56.50
06	34.24	28.80	26.76	22.20	53.42	54.50
07	34.24	28.80	24.60	22.40	49.55	50.70
08	28.46	22.60	24.19	21.20	50.55	51.70
09	31.42	29.60	31.49	28.80	34.67	36.30
10	32.03	30.80	29.31	25.20	34.58	34.70
11	33.90	32.80	22.67	20.00	38.02	38.30
12	38.63	38.00	25.89	23.60	35.26	34.40
13	27.05	28.20	26.82	25.00	29.80	28.60
14	36.05	37.80	24.08	24.60	33.72	32.80
15	39.61	41.60	23.56	22.80	34.52	35.10
16	30.65	31.60	23.41	23.60	28.90	29.10
17	32.25	32.85	23.77	23.20	34.42	36.50
18	36.67	33.80	24.54	25.40	42.60	41.90
19	37.31	34.40	22.76	21.60	32.89	31.70
20	31.35	27.80	26.54	24.60	38.37	37.10
21	35.25	30.40	27.28	26.60	33.57	34.20
22	33.43	30.00	25.07	23.80	47.65	53.30
23	34.36	32.00	25.54	22.60	37.74	34.50
24	36.46	33.80	27.85	27.40	43.01	41.70
25	35.59	33.60	30.44	29.60	34.93	33.30
26	42.25	41.60	28.92	29.00	31.68	34.50
27	44.92	44.40	32.56	32.40	39.68	38.90
28	39.58	38.40	34.55	35.40	32.38	30.70
29	34.20	28.80	32.36	32.80	32.78	32.10
30	32.61	28.20	35.81	36.60	33.15	32.70
31	28.81	26.00	41.47	40.80	40.82	37.90
32	-	-	-	-	52.61	50.10
33	-	-	-	-	37.78	37.10
34	-	-	-	-	51.98	49.70
MEAN 35.08		MEAN 35.25	MEAN 28.61	MEAN 27.28	MEAN 39.56	MEAN 37.76

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Table 41

Adjacency Relationships Between Rooms in Building (A)

Summary

RM	TYPE0 NO	TYPE0 PCT	TYPE1 NO	TYPE1 PCT	TYPE2 NO	TYPE2 PCT	TYPE3 NO	TYPE3 PCT	TYPE4 NO	TYPE4 PCT	TYPE5 NO	TYPE5 PCT	TYPE6 NO	TYPE6 PCT	TYPE7 NO	TYPE7 PCT	TYPE8 NO	TYPE8 PCT
01	01	03.2	02	06.5	00	00.0	01	03.2	00	00.0	00	00.0	00	00.0	14	45.2	13	41.9
02	01	03.2	02	06.5	00	00.0	00	00.0	00	00.0	00	00.0	00	00.0	00	00.0	28	90.3
03	01	03.2	01	03.2	00	00.0	04	12.9	00	00.0	00	00.0	00	00.0	00	00.0	25	80.6
04	01	03.2	00	00.0	01	03.2	02	06.5	00	00.0	00	00.0	00	00.0	00	00.0	27	87.1
05	01	03.2	00	00.0	01	03.2	02	06.5	00	00.0	00	00.0	00	00.0	00	00.0	27	87.1
06	01	03.2	01	03.2	01	03.2	01	03.2	00	00.0	00	00.0	00	00.0	14	45.2	13	41.9
07	01	03.2	01	03.2	01	03.2	01	03.2	00	00.0	00	00.0	01	03.2	13	41.9	13	41.9
08	01	03.2	03	09.7	00	00.0	03	09.7	01	03.2	13	41.9	00	00.0	08	25.8	02	06.5
09	01	03.2	01	03.2	00	00.0	00	00.0	01	03.2	00	00.0	00	00.0	13	41.9	15	48.4
10	01	03.2	02	06.5	00	00.0	00	00.0	02	06.5	13	41.9	01	03.2	07	22.6	05	16.1
11	01	03.2	01	03.2	01	03.2	00	00.0	00	00.0	00	00.0	00	00.0	14	45.2	14	45.2
12	01	03.2	01	03.2	01	03.2	00	00.0	00	00.0	00	00.0	00	00.0	14	45.2	14	45.2
13	01	03.2	00	00.0	00	00.0	00	00.0	01	03.2	13	41.9	03	09.7	087	25.8	05	16.1
14	01	03.2	02	06.5	00	00.0	01	03.2	00	00.0	00	00.0	01	03.2	12	38.7	14	45.2
15	01	03.2	01	03.2	00	00.0	01	03.2	00	00.0	00	00.0	00	00.0	00	00.0	28	90.3
16	01	03.2	02	06.5	00	00.0	01	03.2	00	00.0	13	41.9	00	00.0	10	32.37	04	12.9
18	01	03.2	01	03.2	00	00.0	01	03.2	00	00.0	00	00.0	01	03.2	13	41.9	14	45.2
19	017	03.2	01	03.2	00	00.0	01	03.2	00	00.0	00	00.0	01	03.2	13	41.9	14	45.2
20	01	03.2	02	06.5	00	00.0	00	00.0	02	06.5	12	38.7	00	00.0	09	29.0	05	16.1
21	01	03.2	00	00.0	00	00.0	00	00.0	03	09.7	11	35.5	00	00.0	11	35.5	05	16.1
22	01	03.2	00	00.0	00	00.0	007	00.0	02	06.5	12	38.7	00	00.0	11	35.5	05	16.1
23	01	03.27	00	00.0	00	00.0	00	00.0	01	03.2	13	41.9	00	00.0	11	35.5	05	16.1
24	01	03.2	00	00.0	00	00.0	00	00.0	02	06.5	12	38.7	00	00.0	11	35.5	05	16.1
25	01	03.2	00	00.0	00	00.0	00	00.0	02	06.5	12	38.7	00	00.0	11	35.5	05	16.1
26	01	03.2	01	03.2	00	00.0	00	00.0	02	06.5	12	38.7	00	00.0	10	32.3	05	16.1
27	01	03.2	01	03.2	00	00.0	00	00.0	00	00.0	00	00.0	00	00.0	14	45.2	15	48.4
28	01	03.2	00	00.0	00	00.0	00	00.0	01	03.2	13	41.9	00	00.0	11	35.5	05	16.1
29	01	03.2	01	03.2	00	00.0	00	00.0	00	00.0	14	45.2	00	00.0	10	32.3	05	16.1
30	01	03.2	01	03.2	00	00.0	02	06.5	00	00.0	00	00.0	00	00.0	14	45.2	13	41.9
31	01	03.2	01	03.2	00	00.0	00	00.0	01	03.2	13	41.9	00	00.0	10	32.2	05	16.1

APPENDIX-D
Case Study
Survey of Rooms - A Sample of Data Sheets

This appendix is a sample of the data sheets used to record data during the survey of rooms in the three buildings. Data was collected about various characteristics of rooms, and these are grouped into: identification of rooms; adaptation; physical characteristics; environmental characteristics; servicing characteristics; furniture and equipment; and finally use characteristics.

Appendix - D -

Room Code Number	Identification of Rooms: Name on the Door	Number on the Door	Number on the Plan	Level of Building (1,2,3,4,5)	Adoptation: Adaptation on progress	Adaptation is to start this term.	Previous adaptations were on...
A17	office Visual aids equipmed photographic		A405 a	4			✓
A18	office visual aids equipment photographic	A3/12	A405 a	4			
A19	print workshop. Room	3/11	A405	4			
A20	Workshop	3/10	A404	4			
A21	Shop		A415 a	4			
A22	office Information Resource Technician	3/7	A415 b	4			
A23	Information Centre, & photocopying		A415	4			
A24	Slide Tech. Maps Samples	3/8	A417	4			

Room Code Number	Physical Characteristics							
	Dimensions of room	Area	Height	Number of the Category of shape	Number of Doors	Number of Usable Doors	Distance between centroid of room and Doors	
A17	3.60 x 1.60	5.76	full		1	1		
A18	3.60 x 2.60	9.36	full		2	2		
A19	7.20 x 6.60	47.52	full		3	2		
A20	7.50 x 6.60	49.50	full		2	1		
A21	3.80 x 1.80	6.84	full		1	1		Window op on corrid for sales
A22	1.80 x 4.40	7.92	full		1	1		
8.8 A23	2.00 x 4.40 + 6.60 x 3.60	32.56	full		4	4		
A24	3.60 x 4.40	15.84	full		1	0		

Appendix - D -
cont.

Room Code Number	Environmental Characteristics												
	Out look.	Daylight	Ordinary lights.	Special lights.	Natural Ventilation (windows)	Natural Ventilation	Artificial Ventilation	No Ventilation	Central heating	Local heating	No heating	Double Glazing	Black Out Provision
A17			✓	✓		✓	✓				✓		✓
A18	✓	✓	✓		✓	✓ Green House					✓		
A19	✓	✓	✓		✓				✓				✓
A20	✓	✓	✓						✓				
A21	✓	✓	✓		Through Door						✓		
A22	✓	✓	✓		✓						✓		
A23	✓	✓	✓		✓				✓				
A24	✓	✓	✓		✓						✓		

Room Code Number	Servicing Characteristics								
	Cold water & Drainge	Hot water	Special drainge	Special Voltage	Gas	Vacuum	Compressed air	Running Through Ducts	
A17	✓	✓							
A18	✓	✓						Pipes Horizontally & a special pipe	
A19									
A20				✓	✓				
A21									
A22									
A23									
A24									

Appendix - D -
cont.

Room Code Number	Furniture						Equipments.				
	Number of types of Movable furniture	Fixed Furniture	percentage of floor area occupied by Fixed Furniture	Number of movable partitions	Number of integrated partition furniture units.	Number of Work Stations	Self supported equipments	Movable equipments	Fixed equipments	Fixed Furniture Integrated Equipments	
A17	1 Stools	✓	All area within 1.50x2.50			3		4			
A18	3 Chair desk Draw	✓ Bench grav Hour Drawer	.6X.120 1.0X1.20 .6X1.00			1		✓			
A19	3 Desk Stools Cabinet	✓	1.00X length bothside			12	3	7			
A20	~~5~~ Desk Chair Stool Bench Shelves	✓	along corridor			10	3	✓			
A21	2 Chair & drawer	✓	.60X2.5 & shelves			2		✓			
A22	3 Desk Chair Cabinet	✓	No only shelves			2					
A23	4 Chair desk Shelves ~~[illegible]~~ cupboard	✓	No only shelves			>9	✓	✓			
A24	5 Desk Chair Cabinet maps Shelves	✓	Shelves on wall			2	...				

Appendix - D -
cont.

Room Code Number	Room Usage									
	Single Users Room	Multiple Users Room	Bookable	Un Bookable	Use by one Department	Use by different Departments	Staff Use only	Usable all the Time	Number of Users	Description of the Category users.
A17		✓	✓		✓				3	
A18	✓			✓	✓		✓	✓	1	Tech.
A19		✓		✓	✗			✓	12	Students, Tech. Staff.
A20	~~✓~~	~~✓~~		✓	✓			✓		
A21	✓			✓	✓		✓	✓	1	Staff Lecture
A22	✓				✓		✓	✓	2-3	Staff Tech.
A23		✓		✗	✗	✗		✓	10	Students
A24		✓		✓	✗	✗		✓	Varies	Staff, Students (information

Appendix-E
Case Study
The Questionnaire

This appendix is about the questionnaire used to get responses of users in buildings to the assess the flexibility of these buildings in use. In the beginning of this appendix copies of the letters sent in connection with the questionnaire are included. There are two letters; the first introduced respondents to the questionnaire and the second reminded late respondents to return the questionnaire.

oxford polytechnic

Headington Oxford OX3 0BP Tel (0865) 64777 Director B L Tonge BSc PhD CChem FRSC MBIM

Department of Architecture
Buildings Research Team
Dr R J Newman MA DipSoc DPhil FRSA
M Jenks DipArch RegArch (Research Fellow)

I am undertaking a research project for a Ph.D. degree, which involves a study of changes in Polytechnic buildings over time. Part of this study involves finding out how the buildings are, and have been, used. I would, therefore, very much appreciate it if you could answer some questions about how you use a specific part of the Polytechnic building.

The attached questionnaire aims to provide information about the way in which a sample of buildings in the Polytechnic have accommodated changes in use over a set period of time. This information will be compared with the ideas and design features included at the initial design stage which were intended to facilitate changes in future use, and conclusions drawn about design for future changes. The questions I should like you to answer are about the rooms you may have used since 1980, the purposes for which they are now used and how those purposes have changed.

I should stress that your answers will be treated in the strictest confidence. The questions, will require about 20 minutes to answer, I will call to collect the questionnaire in a few days.

I am most grateful, in anticipation, for your help and cooperation.

Yours very sincerely

Hazim Al-Nijaidi
Postgraduate Research School
Department of Architecture
Oxford POlytechnic

oxford polytechnic

Headington Oxford OX3 0BP Tel (0865) 64777 Director B L Tonge BSc PhD CChem FRSC MBIM

Department of Architecture
Post Graduate Research School
Reader: Dr R J Newman MA DipSoc DPhil FRSA

20 March 1984

Dear

I sent you a questionnaire a few weeks ago but as yet have not received a reply. I am sure that you were busy during this period, or may be the questionnaire was not applicable to you. Nevertheless, I would be most grateful if you could spare some time to complete the questionnaire so that I can include your reply with those of the many other members of staff who have already responded.

I hope that you will be able to spare the time and would be grateful if you could leave the completed questionnaire with your departmental office.

I will call in on Monday, 26 March 1984 to collect it.

Thank you again

Yours sincerely

Hazim Al Nijaidi

SOME NOTES,

1 This questionnaire is about ONLY PART A of the Polytechnic buildings shown on the Master Plan below.

2 The detailed plans of PART A of the Polytechnic buildings as it was and is in the academic Years 1980/81 and 1983/84 are illustrated on Pages 13 and 14 respectively.

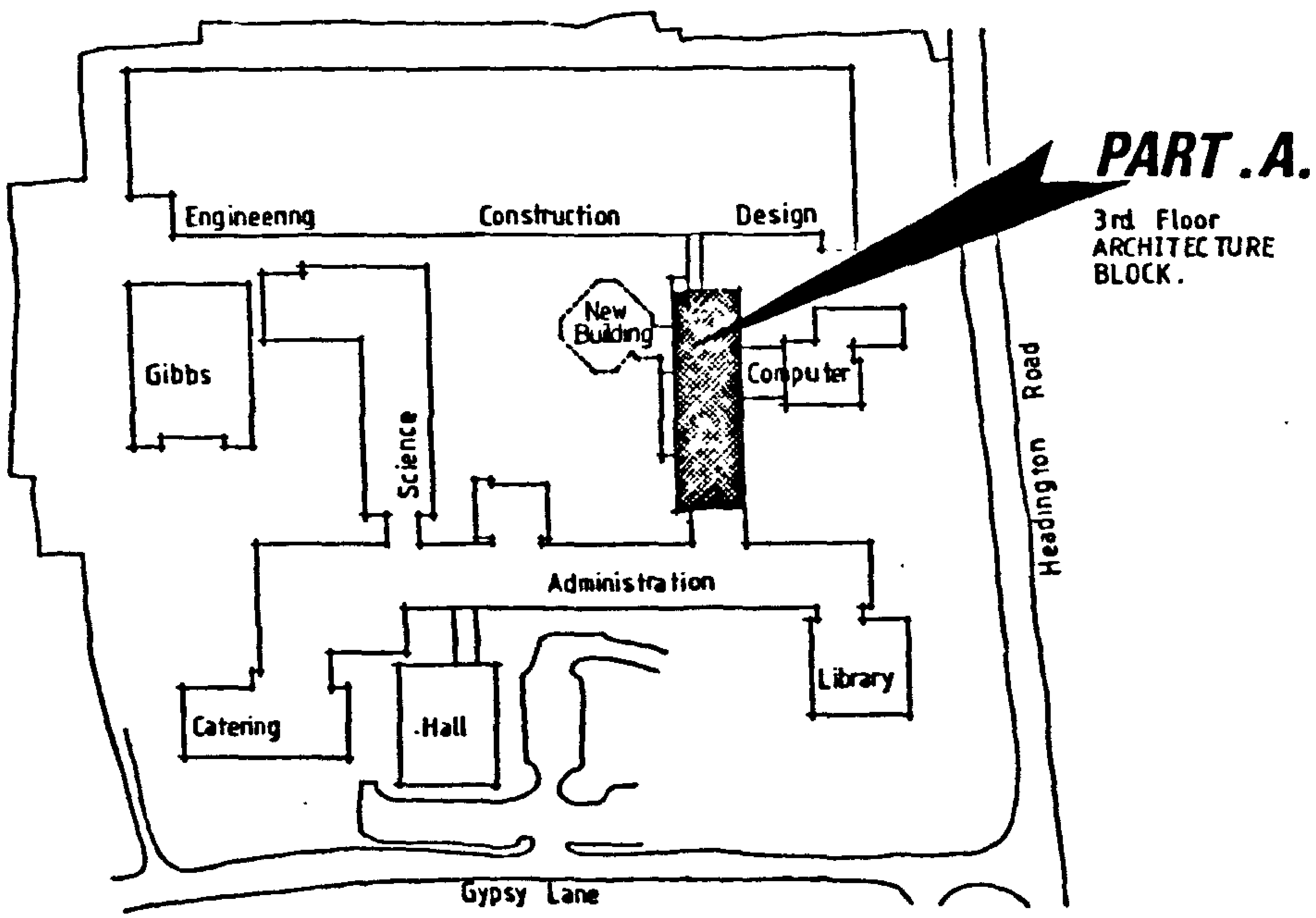
3 Please answer the questionnaire unless, there was NO ROOM in PART A OF THE Polytechnic buildings which could be described, for any length of time, since October 1980 as:

- A room in which you had or have one or more of the following:
  - Your own desk, chair (and) cabinet, or a working bench and a stool.
  - A desk or a bench which you shared with other staff.
- AND/OR as a room:
  - You kept the keys for.
  - Where you stayed the majority of time spent at the Polytechnic.
  - Where other staff assumed you can be found or contacted.
  - Housing a special activity, with which you are strongly involved.

IF NONE of these conditions apply, please do not fill in the questionnaire.

4 Please note, that PART A of the Polytechnic buildings will be referred to in the questionnaire as THE BUILDING.

5 PLEASE USE TICKS [✓] IN ANSWERING THE QUESTIONNAIRE.



INITIALLY, SOME BACKGROUND QUESTIONS: **Appendix - E**

1 Have you used THE BUILDING regularly since October 1980?

(please tick)

Yes	
No	

IF YES, Please go to Question 2

IF NO, Please state below the date when you first used THE BUILDING, and then go to Question 2.

> NOTE: As most of the following questions ask about your activities in both 1980/81 and 1983/84, please, answer the questions about 1980/81 in relation to the date you stated above.

2 What were (are) the names of the departments, for which you used THE BUILDING, for both academic years 1980/81 and 1983/84? (Please write below).

In 1980/81: ....

In 1983/84: ....

3 Are you employed full-time or part-time at the department(s) you named in Question 2?

(please tick)

	1980/81	1983/84
Full-time		
Part-time		

If Full-time, please go to Question 4

If Part-time, please write in the number of days per week you worked in 1980/81 and 1983/84

	1980/81	1983/84
Number of days		

4 What was your occupation in 1980/81 and 1983/84?

e.g. TEACHING STAFF: Head or Acting Head of Department; Reader; Principal or Senior Lecturer; Lecturer I or II; Research Assistant; or Others.

NON-TEACHING STAFF: Principal or Senior Officer/Administrative or Professional; Clerical; Technical; Manual and Miscellaneous; or Others .

(Please write your occupation below):

At 1980/81: ....

At 1983/84: ....

SOME NOTES,

1 This questionnaire is about ONLY PART ***B*** of the Polytechnic buildings shown on the Master Plan below.

2 The detailed plans of PART ***B*** of the Polytechnic buildings as it was and is in the academic Years 1980/81 and 1983/84 are illustrated on Pages 13 and 14 respectively.

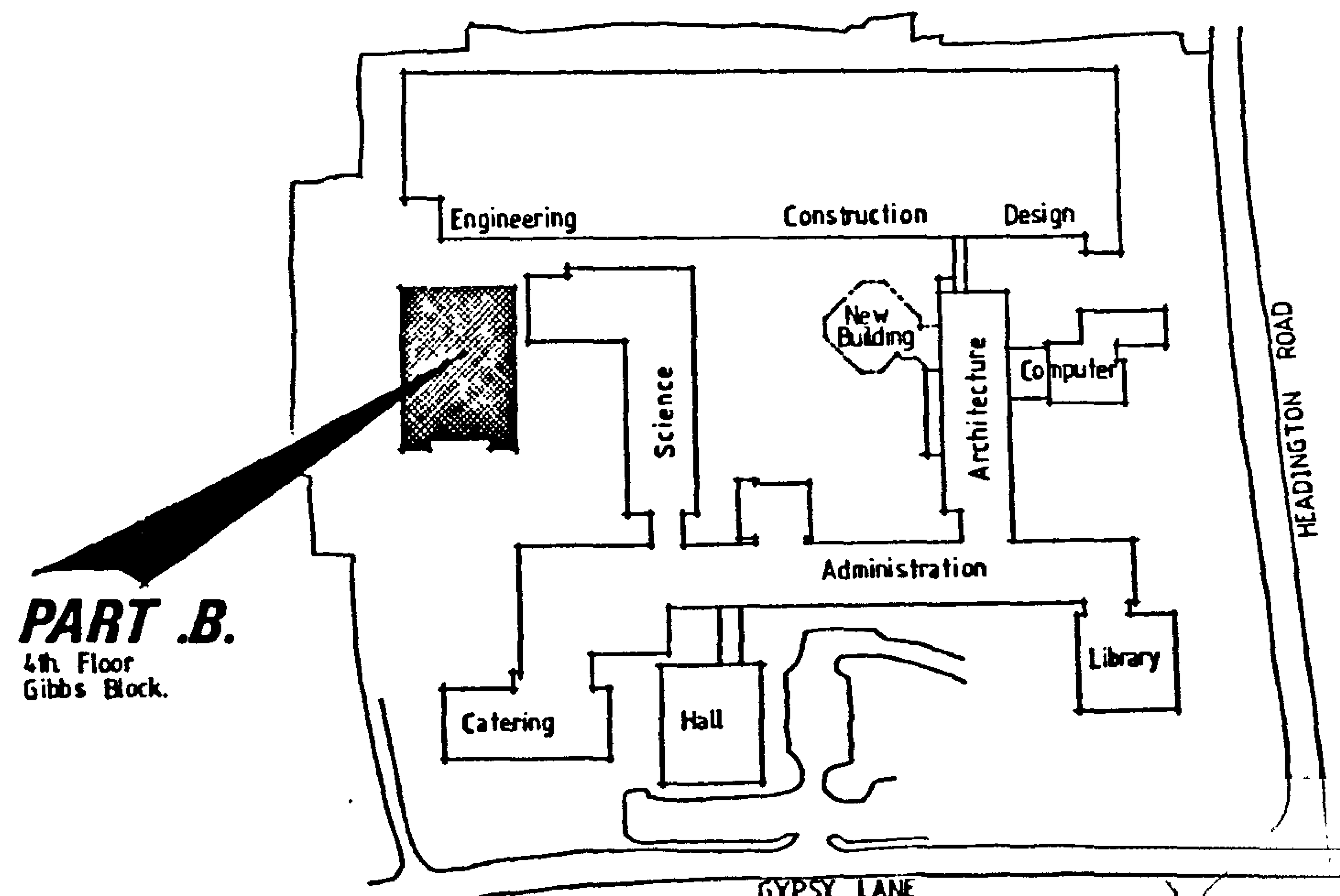
3 Please answer the questionnaire unless, there was NO ROOM in PART ***B*** OF THE Polytechnic buildings which could be described, for any length of time, since October 1980 as:

- A room in which you had or have one or more of the following:
  - Your own desk, chair (and) cabinet, or a working bench and a stool.
  - A desk or a bench which you shared with other staff.
- AND/OR as a room:
  - You kept the keys for.
  - Where you stayed the majority of time spent at the Polytechnic.
  - Where other staff assumed you can be found or contacted.
  - Housing a special activity, with which you are strongly involved.

IF NONE of these conditions apply, please do not fill in the questionnaire.

4 Please note, that PART ***B*** of the Polytechnic buildings will be referred to in the questionnaire as THE BUILDING.

5 PLEASE USE TICKS [✓] IN ANSWERING THE QUESTIONNAIRE.



SOME NOTES,

1 This questionnaire is about ONLY PART ***C*** of the Polytechnic buildings shown on the Master Plan below.

2 The detailed plans of PART ***C*** of the Polytechnic buildings as it was and is in the academic Years 1980/81 and 1983/84 are illustrated on Pages 13 and 14 respectively.

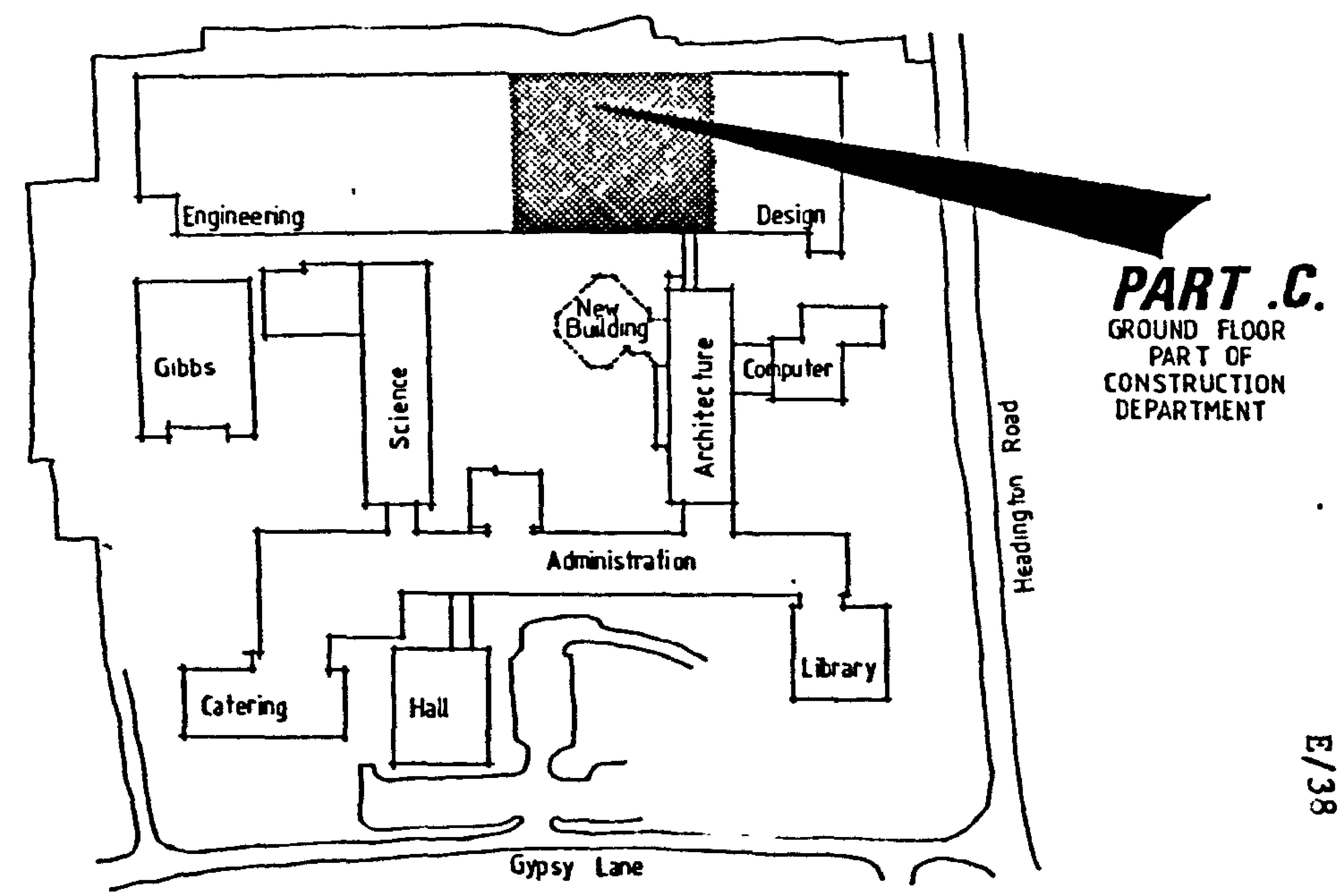
3 Please answer the questionnaire unless, there was NO ROOM in PART ***C*** OF THE Polytechnic buildings which could be described, for any length of time, since October 1980 as:

- A room in which you had or have one or more of the following:
  - Your own desk, chair (and) cabinet, or a working bench and a stool.
  - A desk or a bench which you shared with other staff.
- AND/OR as a room:
  - You kept the keys for.
  - Where you stayed the majority of time spent at the Polytechnic.
  - Where other staff assumed you can be found or contacted.
  - Housing a special activity, with which you are strongly involved.

IF NONE of these conditions apply, please do not fill in the questionnaire.

4 Please note, that PART ***C*** of the Polytechnic buildings will be referred to in the questionnaire as THE BUILDING.

5 PLEASE USE TICKS [✓] IN ANSWERING THE QUESTIONNAIRE.



NOW SOME QUESTIONS ABOUT YOUR MAIN ROOM

5 Out of all rooms, which are shown on the plans of THE BUILDING in 1980/81 and 1983/84, which of them do you consider to be your main room?

(Please write below the number of the room as shown on the Plans on pages 13 & 14).

For 1980/81:

For 1983/84:

Please NOTE, that the rooms, whose numbers you wrote above, will be referred to in the following questions as YOUR ROOM.

6 Can you describe what was contained in YOUR ROOM in 1980/81, compared with what is contained in YOUR ROOM in 1983/84?

(please tick where applicable)

	Less	The Same	More
Amount of moveable furniture			
Amount of fixed furniture			
Amount of moveable equipment			
Amount of place-fixed equipment			
Height of room			
Amount of windows			
Blackout provision			
Power points			
Cold/hot water provision			
Other special services (please specify)			

7 How was (is) YOUR ROOM occupied in 1980/81 and 1983/84?

(please tick)

was (is) it occupied by:	1980/81	1983/84
Yourself only (full-time or part-time)		
Yourself and other staff at the same time		
Yourself and other staff but not at the same time		
Yourself and groups of students occasionally		
Others (please specify)		

NEXT SOME QUESTIONS ABOUT THE ACTIVITIES CARRIED OUT BY YOU AND ANY CHANGES IN THEM:

PLEASE NOTE: That some of the following questions ask about your activities in YOUR ROOM, while other questions ask about your activities in THE BUILDING (i.e. the whole building).

8 Which of the following activities were (are) carried out by you in YOUR ROOM in 1980/81 and 1983/84,

(please tick)

	1980/81	1983/84
Teaching		
Study / Research		
Experiments (involving equipment)		
Preparation and maintenance (materials and equipment)		
Discussion with colleagues		
Administrative tasks		
Relaxation and / or socialising		
Others (please specify)		

9 (This question need only be answered by Teaching Staff).

Has the teaching carried out by you in THE BUILDING changed since 1980/81, in any of the following aspects?

(please tick)

Aspects of teaching	Yes	No
Average number of hours of teaching (including all teaching methods eg. lectures, seminars, private tutorials, projects)		
Average number of students taught at a time		
Subjects you teach		
Courses/Modules you teach		
Year of course you teach		
Extent of using illustrative & demonstration materials/equip.		
Others (please specify)		

10 (All staff should answer this and the *following questions*).
Considering all the activities you carried out in THE BUILDING since 1980/81, could you please tick the box that best describes the extent of change in any of the following aspects?

(please tick)

	No Change	Some Change	Complete Change
The information, materials and equipment handled			
The number and/or the type of people, with whom information, materials or equipment are handled			
The ways of handling such information, materials or equipment			
Others (please specify)			

11 Have any changes which occurred in your activities in THE BUILDING since 1980/81, resulted in a change in any of the following aspects?

(please tick)

What you do in your room	
The journeys you make from your room to other rooms in THE BUILDING on an average week	
The number/type of people who visit your room on an average week	
Others (please specify)	

12 Were the changes which occurred in your activities in THE BUILDING since 1980/81 at all predictable?

(please tick)

Yes	
No	

IF NO, Please go to Question 13
IF YES, Please answer Question 12 a) below and then go to Question 13.

12 a) IF the changes in your activities were predictable, were they:

(please tick)

Very easy to plan ahead	
Easy to plan ahead	
Neither easy nor difficult to plan ahead	
Difficult to plan ahead	
Very difficult to plan ahead	

NOW A QUESTION ABOUT THE EFFECT OF CHANGES IN YOUR ACTIVITIES, UPON YOUR REQUIREMENTS FOR ACCOMMODATION:

13 Have the changes in the activities performed by you in THE BUILDING, affected your requirements for any of the following?

(please tick)

The facilities within a room	
The location of a room	
Others (please specify)	

THE NEXT FOUR QUESTIONS ARE ABOUT HOW SATISFACTORY YOU FIND YOUR ROOM:

14 How satisfactory were (and are) the facilities within YOUR ROOM in relation to your work?

(please tick)

	1980/81	1983/84
Very satisfactory		
Satisfactory		
Neither satisfactory nor unsatisfactory		
Unsatisfactory		
Very unsatisfactory		

15 How satisfactory was (and is) the location of YOUR ROOM, in relation to the journeys you made (make) to other rooms within THE BUILDING?

(please tick)

	1980/81	1983/84
Very satisfactory		
Satisfactory		
Neither satisfactory nor unsatisfactory		
Unsatisfactory		
Very unsatisfactory		

16 Have you requested to move from your room since 1980/81?

(please tick)

Yes	
No	

IF NO, please go to Question 17

IF YES, please answer Questions 16(a) and 16 (b) below, and then go to Question 17.

16 a) were the requests made, because of the unsuitability of any of the following characteristics of your room, to your work?

(please tick)

Area of room	
Visual and/or accoustic privacy	
Services (eg. water, high voltage, etc.)	
Environmental condition (eg. blackout, lighting, etc.)	
Furniture/equipment	
Relationship of room to other rooms	
Others (please specify)	

b) Have any of your requests, been fulfilled?

(please tick)

All requests have been fulfilled	
Some of the requests have been fulfilled	
None of the requests have been fulfilled	

17 Have you requested any adaptation to YOUR ROOM since 1980/81?

(please tick)

Yes	
No	

IF NO, please go to Question 18.

IF YES, please answer questions 17(a) & 17(b) below and then go on to Question 18.

17 a) Were the requests made because of the unsuitability of any of the following characteristics of your room to your work?

(please tick)

Area of room	
Visual and/or accoustic privacy	
Services (eg. water, high voltage, etc.)	
Environmental condition (eg. blackout, lighting, etc.)	
Furniture/equipment	
Relationship of room to other rooms	
Others (please specify)	

17 b) Have any of your requests been fulfilled?

(please tick)

All requests have been fulfilled	
Some of the requests have been fulfilled	
None of the requests have been fulfilled	

NOW SOME QUESTIONS ABOUT CHANGE IN THE LOCATION OF YOUR ROOM

18 Has the location of YOUR ROOM changed since 1980/81, or since first you used THE BUILDING?

(please tick)

Yes	
No	

IF NO, Please go to Question 19

IF YES, Please answer questions 18(a) & 18(b) and then go to Question 20.

18 a) What was the reason which made you move to a different room?

(please tick)

Your work has changed	
A major reallocation of rooms within the Department	
Affected by building's alteration/adaptation	
Structural failure/collapse of part of the building	
Other reasons (please specify)	

18 b) What adaptations were made to the new room you moved to, so as to be suitable for your work requirements?

	(please tick)
Moveable furniture changed/provided	
Fixed furniture installed/removed	
Some services(water, electricity, etc.) *changed/provided*	
Some Environmental Conditions(eg. blackout, *lights, etc.)changed*	
False ceiling installed/removed	
Fixed walls or moveable partitions installed/removed	
Finishes changed	
Door openings provided/blocked	
No adaptation whatsoever	
Others (please specify)	

19 IF the Location of YOUR ROOM <u>HAS NOT CHANGED</u>, could you tick the box below that best describes the reason?

	(please tick)
Your work has not changed	
Your work has changed, but your accommodation requirements have not.	
Your work & accommodation requirements have changed but an alternative room is not available yet	
Other reasons (please specify)	

<u>NOW SOME QUESTIONS ABOUT ANY ALTERATIONS OR ADAPTATIONS THAT WERE MADE TO THE ROOMS YOU OCCUPIED:</u>

20 Have any adaptations been made since 1980/81 to YOUR ROOM?

	(please tick)
Yes	
No	

IF <u>NO</u>, please go to Question 25.
IF <u>YES</u>, please continue through (ie. go to Question 21).

21 *What was the reason for carrying out the adaptations or alterations?*

	(please tick)
To accommodate new equipment	
To increase/decrease area of YOUR ROOM	
To improve/maintain standards of accommodation	
To allow for new patterns of communication with others	
To made provision for privacy of work stations	
Other reasons (please specify)	

22 Who carried out the adaptations or alterations?

	(please tick)
Yourself only	
You and other staff (possibly students) using the room	
Departmental workshop technicians	
The *Polytechnic central workshop technicians*	
Local outside firm	
Specialised outside firm	
Others (please specify)	

23 Has your work been affected by the adaptations or alterations which were made to YOUR ROOM?

	(please tick)
Greatly affected	
Affected a little	
Not affected	
Not at all affected	

24 How frequently have the adaptations/alterations been made to YOUR ROOM? (please tick)

	Less than once a Year	Once a Year	Once a Term	More than once a Term
Moveable furniture changed/provided				
Fixed furniture installed/removed				
Some services changed/provided				
Some environmental conditions changed				
False ceilings installed/removed				
Walls or partitions installed/removed				
Finishes changed				
Door openings provided/blocked				
Others (please specify)				

NOW ONE HYPOTHETICAL QUESTION ABOUT THE OVERALL APPROPRIATENESS OF OTHER ROOMS IN THE BUILDING TO YOUR WORK:

25 If you were to consider moving from your room to any of the rooms in THE BUILDING, firstly as THE BUILDING was in 1980/81 and secondly as it is now in 1983/84 (please see plans on pages 13 & 14), how many of the rooms on the plans do you think would be suitable to your work requirements, providing that:

- Your work will not be seriously affected.
- You may assume that moveable furniture can be provided easily.

(please tick)

No. of Rooms suitable to your work	1980/81	1983/84
0		
1 - 5		
6 - 10		
11 - 15		
16 - 20		
21 - 25		
26 and more		

The final few questions (26, 27, 28 and 29) ask you to give an approximate account of your movements within THE BUILDING from YOUR ROOM in an average week in 1980/81 (this may require a feat of memory on your part, but please try to fill it in with the help of the attached plans) and also in 1983/84.

THE QUESTIONS:

26 (a & b)
Could you please tick the rooms you normally have visited in 1980/81 or visit in 1983/84 on an average week, as journeys made from YOUR ROOM.

27 (a & b)
For each of the rooms you ticked in question 26, please tick the box that indicates the purpose of the majority of times you visited (visit) each for.

28 (a & b)
For each of the rooms you ticked in question 26, please tick the box that indicates the number of times you visited (visit) each on an average week.

29 (a & b)
For each of the rooms you ticked in question 26, please tick the box that indicates the average length of time you spent (spend) in each room every time you visited (visit) them.

Attached are two A3 sheets of paper referred to as page 13 and page 14. Page 13 is to be used to answer questions 26a, 27a, 28a and 29a (about 1980/81) while page 14 is to be used to answer questions 26b, 27b, 28b and 29b (about 1983/84).

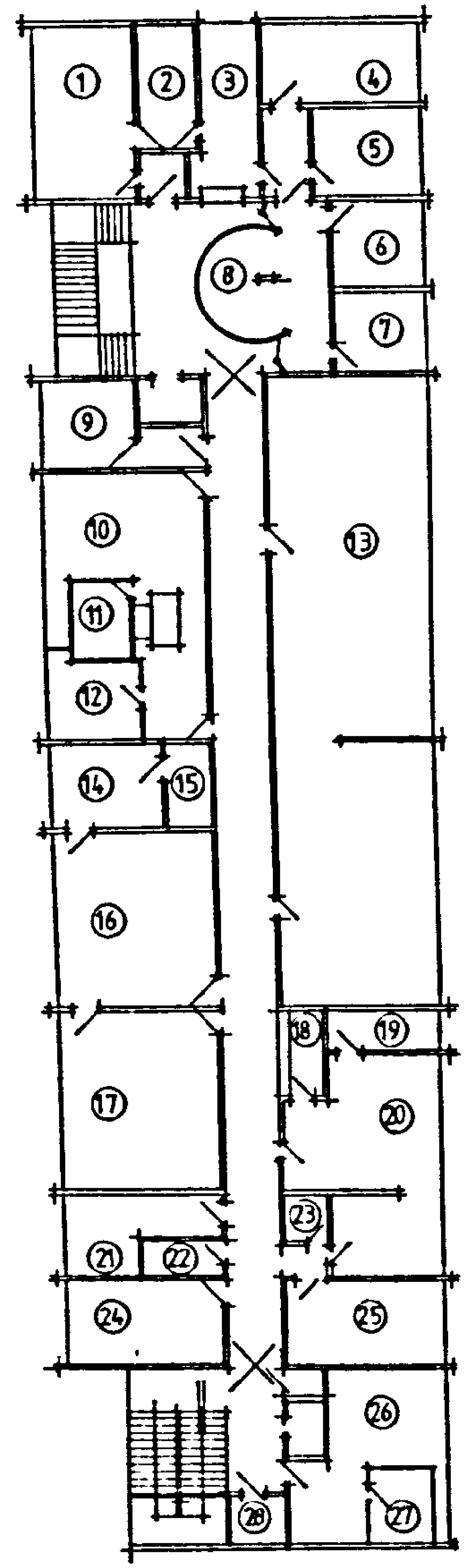
Each of pages 13 and 14 contains (in addition to the plan of THE BUILDING in 1980/81 or 1983/84) the following:

- A circle in the top left corner.
- A list of the numbers by which all the rooms shown on relevant plan can be identified. This list is located on the left-hand side column.
- Boxes of the possible answers for the four questions below. These boxes are located on the top row.

NOTE: For each of pages 13 and 14, Could you please:
Firstly, identify YOUR ROOM, and put its number in the circle on the top left corner, and
Secondly, for each of the rooms you visit, tick the box that best describes your answer to any of the questions above.

E/44

1980/81
PART .A.
[3rd. FLOOR _ ARCHITECTURE BLOCK]



Could you put in the circle above the number of the room of your WORK STATION

QUESTIONS

ROOMS	Q26a	Q27a								Q28a				Q29a			
		PURPOSE OF VISIT								NO OF VISITS				LENGTH OF STAY			
	ROOMS VISITED	Teaching	Study & Research	Expermental	Preparation Maintenance	Discussion	Administrative Tasks.	Relaxation Socializing	Others	1_5	6_10	11_15	16 or over	0_9 minutes	10_59 minutes	1_3 hours	over 3 hours
1																	
2																	
3																	
4																	
5																	
6																	
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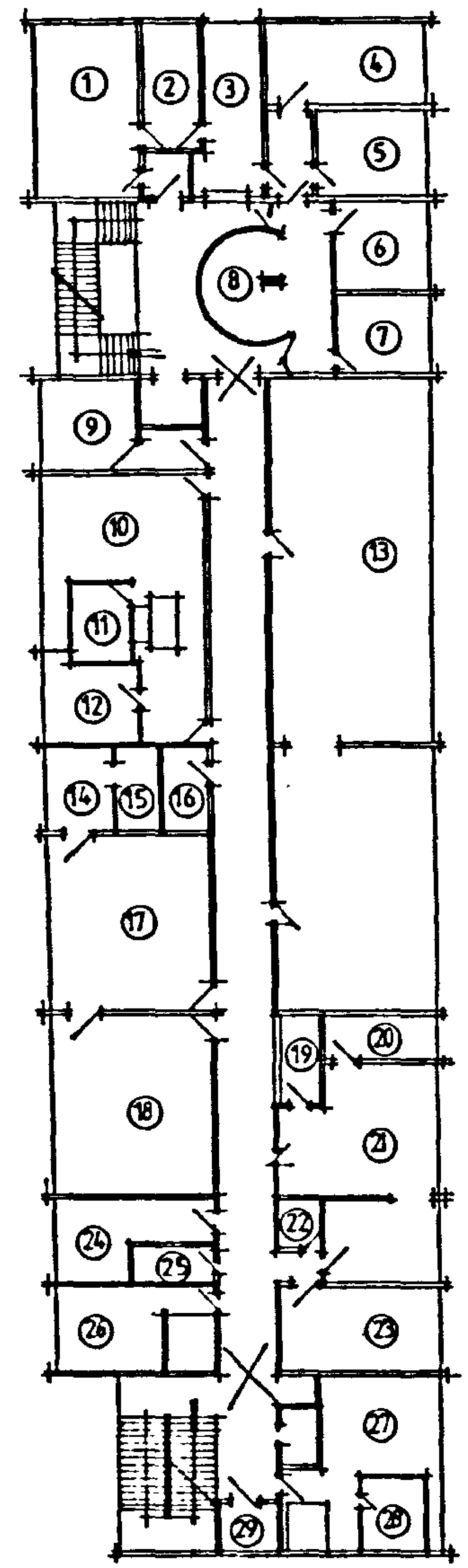
26																	
27																	
28																	

Could you put in the circle above the number of the room of your WORK STATION

QUESTIONS

ROOMS		Q26b ROOMS VISITED	Q27b PURPOSE OF VISIT: Teaching	Study & Research	Expermental	Preparation Maintenance	Discussion	Administrative Tasks	Relaxation Sociolizing	Others	Q28b NO. OF VISITS: 1-5	6-10	11-15	16 or over	Q29b LENGTH OF STAY: 0-9 minutes	10-59 minutes	1-3 hours	over 3 hours
Head of Dept.	1																	
Store & Photocopy	2																	
Dept. Office	3																	
Associate Head of Dept.	4																	
Office	5																	
Office	6																	
Office	7																	
Seminar rm.	8																	
Dark rm.	9																	
Env. Science Lab.	10																	
Wind Tunnel	11																	
Lighting Lab.	12																	
Studiou	13																	
Office	14																	
Dark rm.	15																	
Dark rm.	16																	
Print rm.	17																	
Workshop	18																	
Shop	19																	
Office	20																	
Information Center	21																	
Store	22																	
Office	23																	
Women Toilet	24																	
Cleaner's Store	25																	
Seminar rm.	26																	
Lab.	27																	
Lab.	28																	
Store	29																	

1983/4
PART 'A'
[ARCHITECTURE BLOCK - 3rd FLOOR]



PLEASE NOTE, THAT ROOMS NUMBERS MAY BE DIFFERENT FROM THOSE ON THE PLAN OF 1980/81.

Could you put in the circle above the number of the room of your WORK STATION

QUESTIONS

ROOMS	Q26a ROOMS VISITED	Q27a PURPOSE OF VISIT: Teaching	Study & Research	Expermental	Preparation Maintenance	Discussion	Administrative Tasks.	Relaxation Sociolizing	Others	Q28a NO. OF VISITS: 1-5	6-10	11-15	16 or over	Q29a LENGTH OF STAY: 0-9 minutes	10-59 minutes	1-3 hours	over 3 hours
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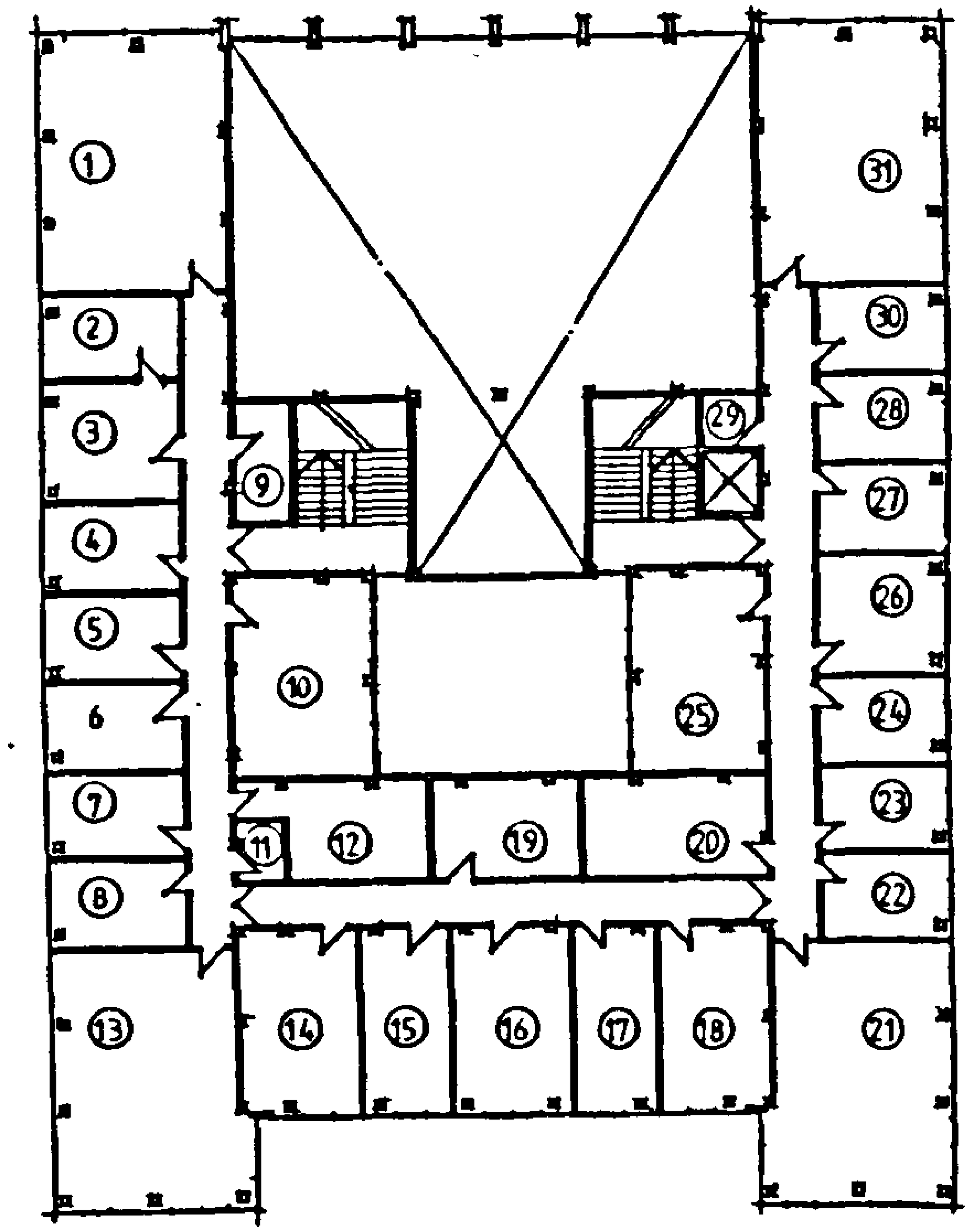
1980/81
PART .B.
[4th FLOOR _ GIBBS BLOCK]



E/46

PLEASE TICK

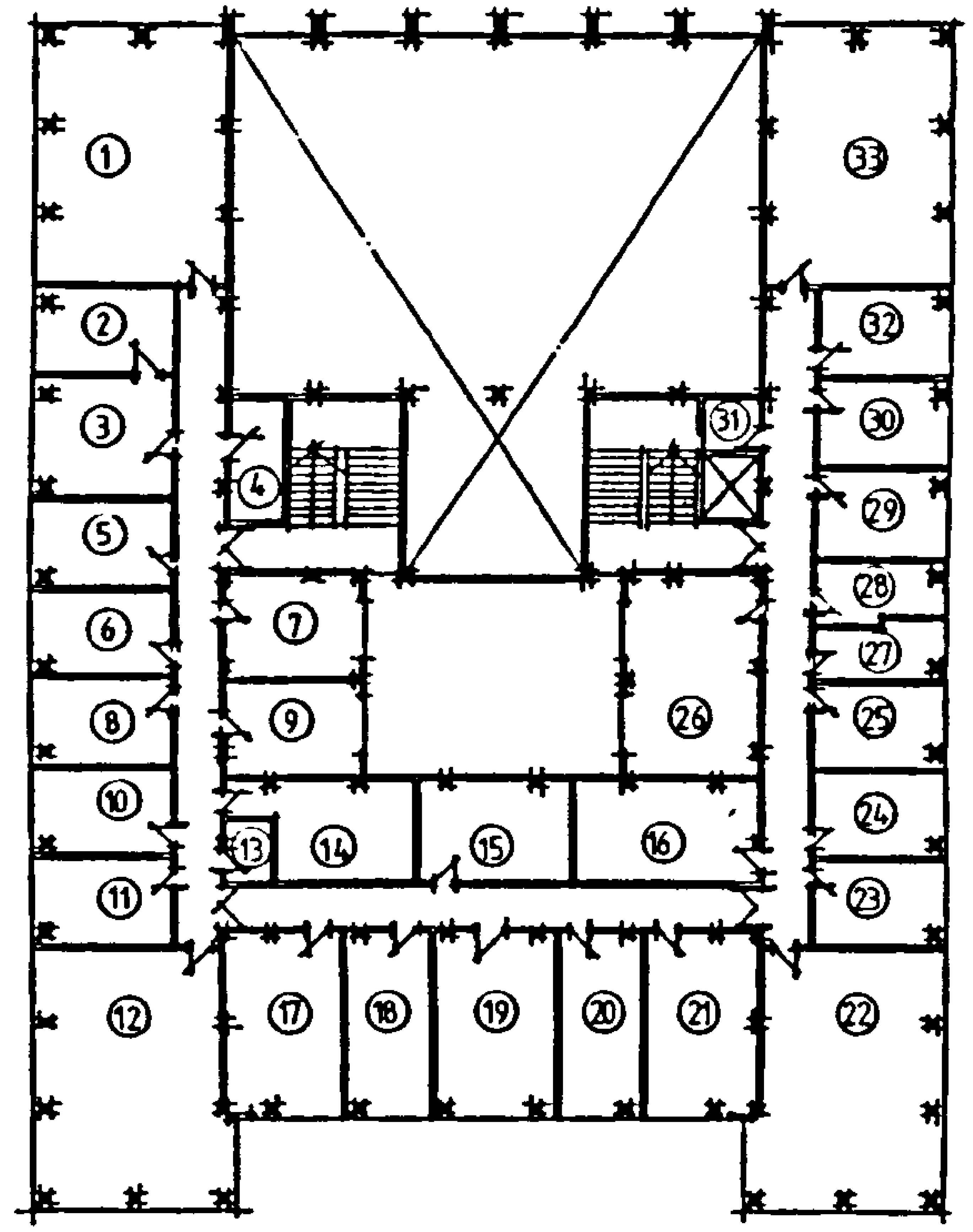
QUESTIONS

Could you put in the circle above the number of the room of your WORK STATION

ROOMS		Q26b ROOMS VISITED	Q27b PURPOSE OF VISIT: Teaching	Study & Research	Expermental	Preparation Muinterance	Discussion	Administra-tive Tasks.	Relaxation Socializing	Others	Q28b NO. OF VISITS: 1-5	6-10	11-15	16 or over	Q29b LENGTH OF STAY: 0-9 minutes	10-59 minutes	1-3 hours	over 3 hours
Poold rm. (Soc.Work)	1																	
Head of Dept.	2																	
Dept. Office	3																	
Variogriograph rm.	4																	
Office	5																	
Office	6																	
Pooled rm.	7																	
Office	8																	
Office	9																	
Office	10																	
Office	11																	
Geography Reso	12																	
Photocopy	13																	
Women Toilet	14																	
Office	15																	
Men Toilet	16																	
Pooled rm.	17																	
Pooled rm	18																	
Office	19																	
Office	20																	
Office	21																	
Poold rm.	22																	
Office	23																	
Office	24																	
Office	25																	
Poold rm.	26																	
Office	27																	
Resourses rm.	28																	
Office	29																	
Office	30																	
Cleaner's Store	31																	
Office	32																	
Pooled rm.	33																	

1983/84
PART .B.

[4th. FLOOR. GIBBS BLOCK]



PLEASE NOTE THAT ROOMS' NUMBERS MAY BE DIFFERENT FROM THOSE ON THE PLAN OF 1980/81.

Could you put in the circle above the number of the room of your WORK STATION

QUESTIONS

ROOMS	Q26a ROOMS VISITED	Q27a PURPOSE OF VISIT: Teaching	Study & Research	Expermental	Preparation Maintenance	Discussion	Administra-tive Tasks.	Relaxation	Socializing	Others	Q28a NO OF VISITS: 1_5	6_10	11_15	16 of over	Q29a LENGTH OF STAY: 0_9 minutes	10_59 minutes	1_3 hours	over 3 hours
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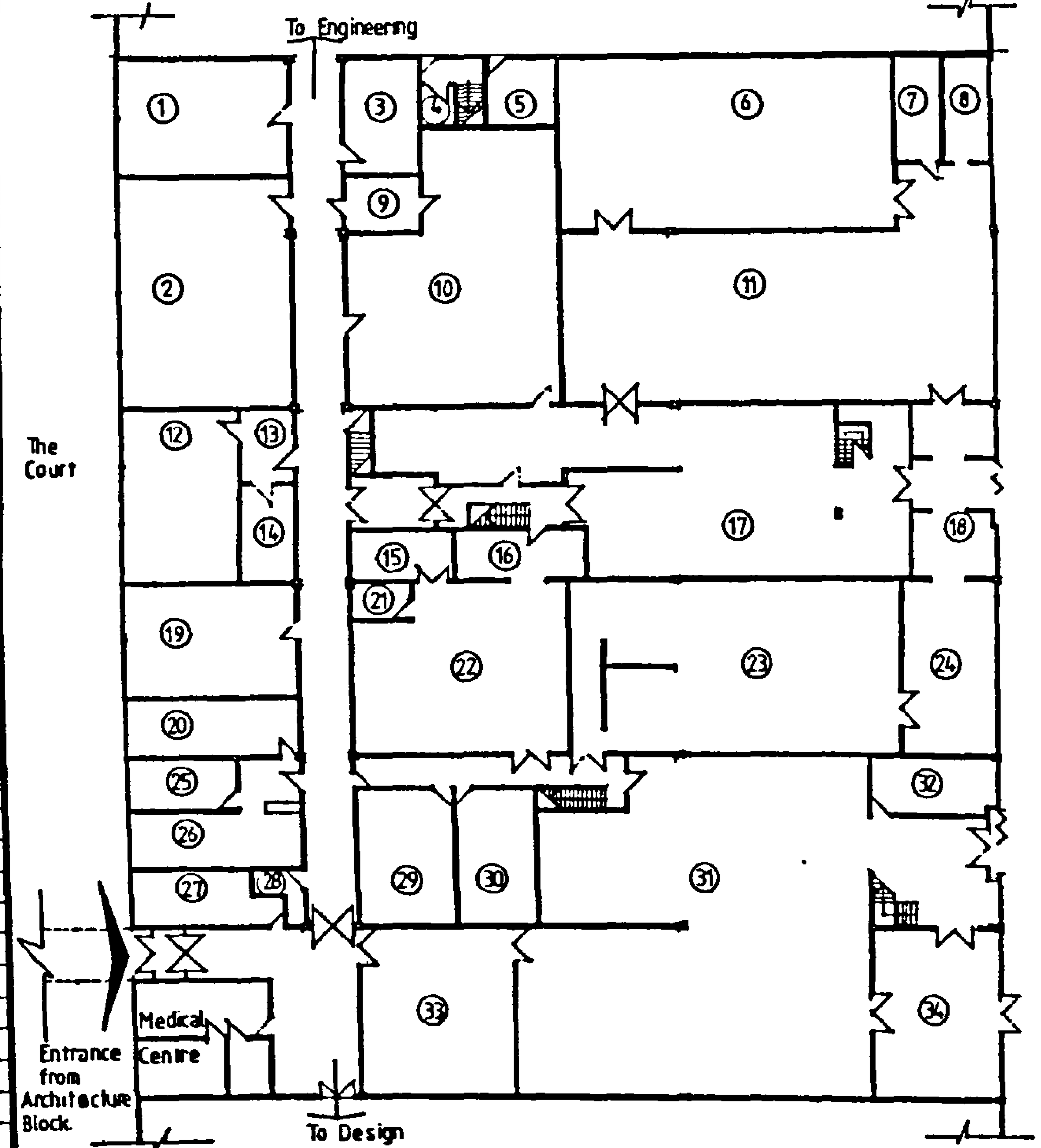
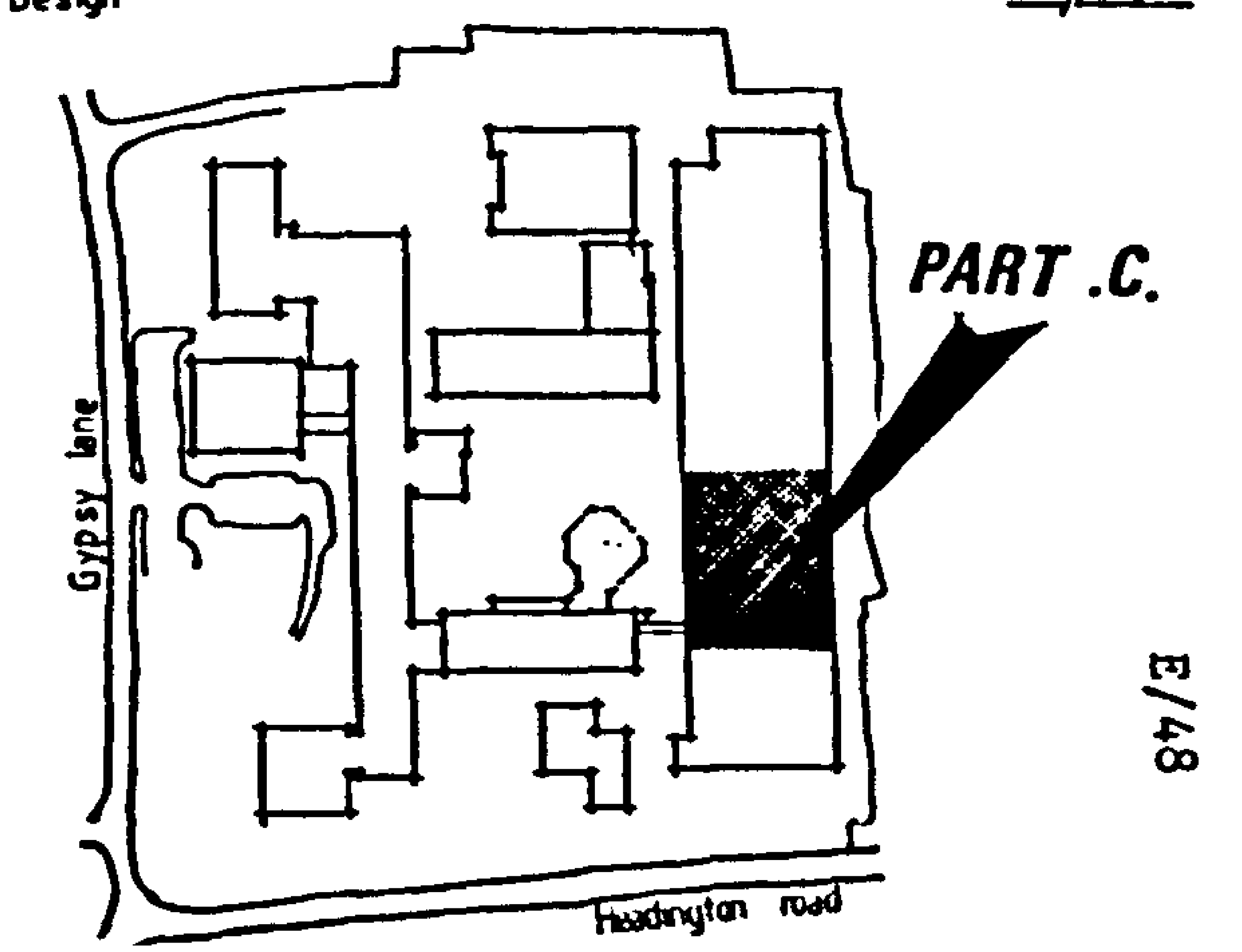
PART .C.

[GROUND FLOOR _ CONSTRUCTION DEPT.]





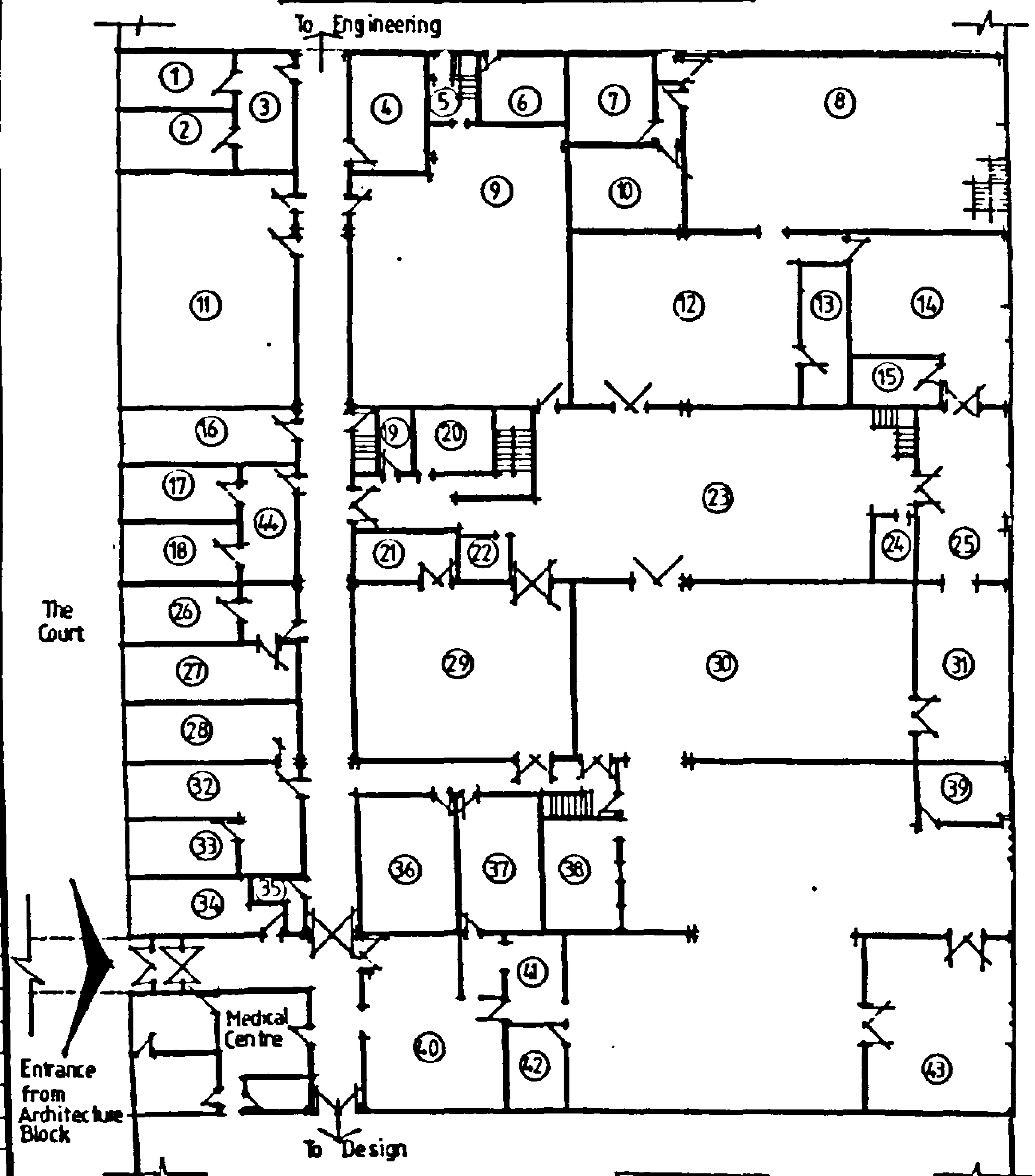
Could you put in the circle above the number of the room of your WORK STATION

QUESTIONS

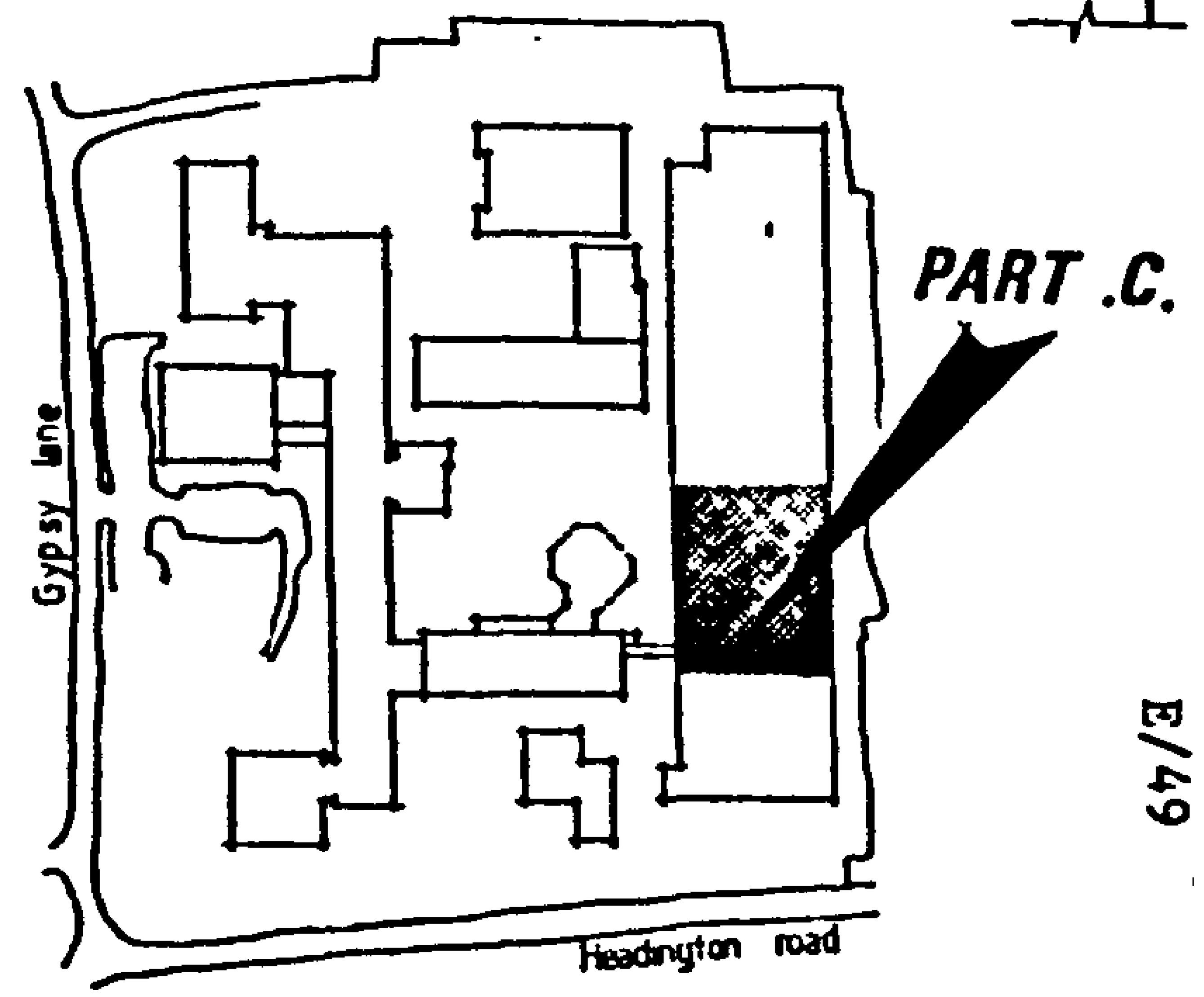
ROOMS		Q26b ROOMS VISITED	Q27b PURPOSE OF VISIT: Teaching	Study & Research	Expermental	Preparation Maintenance	Discussion	Administrative Tasks.	Relaxation Socializing	Others	Q28b NO. OF VISITS: 1_5	6_10	11_15	16 or over	Q29b LENGTH OF STAY: 0_9 minutes	10_59 minutes	1_3 hours	over 3 hours
Office	1																	
Office	2																	
Corridor	3																	
Plant rm.	4																	
Store	5																	
Concrete Humidity rm.	6																	
Dark rm.	7																	
Cartography Studio	8																	
Drawing rm.	9																	
Dark rm & Office	10																	
Pooled rm	11																	
Surveying	12																	
Surveying	13																	
Surveyng Lab	14																	
Store	15																	
Office	16																	
Office	17																	
Office	18																	
Store	19																	
Lockers	20																	
Office	21																	
Office	22																	
Geotechnics Lab	23																	
Office	24																	
Surveyng Store	25																	
Office	26																	
Office	27																	
Head of Dept	28																	
Eng. Science Lab	29																	
Heavy Structure Lab	30																	
Workshop	31																	
Department Office	32																	
Associat Head of Dept.	33																	
Women Toilet	34																	
Cleaner's Store	35																	
Accoustic Lab	36																	
Lighting Lab	37																	
Office & Equip.	38																	
Sieve rm.	39																	
Eng Science Lab	40																	
Office	41																	
Store	42																	
Concrete Technology	43																	
Corridor	44																	

PART .C.

GROUND FLOOR _ CONSTRUCTION DEPT



Please Note;
That rooms numbers on the plan above may be different from those on the plan of 1980/81 .



APPENDIX - F
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