# ADAPTABILITY

# OF COMMERCIAL FLEXIBLE PARTITION SYSTEMS

# TO RESIDENTIAL APPLICATIONS

# IN NORTH AMERICA

A Thesis Submitted

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To my mother, who rains and shines with me...

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## ABSTRACT

The flexible partition, one of the main components of the flexible housing schemes in West European countries exhibited a comparative technological lack. This research investigated the adaptability of selected commercial flexible partitions available in the North American market to residences since the most realistic way to influence the technological process was to start from the known products and developing them in an innovative direction. The consequences of the proposed sectoral transfer were seen as immediate and long term effects and categorized into three groups of constraints: legal, technological and marketing constraints. The context of evaluation was drawn, and the performance concept was used to form a set of evaluation criteria. Fifty partition systems were reviewed, characterized and mismatched portions were screened out. The analysis with thirteen selected partition systems suggested that the performances of most of them were above the level required for dwelling. The study showed that most of them were economically more feasible as compared to fixed gyproc partitions if life-cycle costs were considered. Since the study showed that the partitions were sound in technical terms, it recommended further studies to look into the matter of modifying them by introducing new materials which would cut down the unnecessary performances and might reduce the initial cost as well.



## RÉSUMÉ

Une des principales forces composantes de l'habitat pré-fabriqué en Europe du Nord, les cloisons amovibles, démontre un défaut technologique. Cette étude cherche à démontrer l'adaptabilité des cloisons commerciales disponibles sur le marché nord-américain au secteur résidentiel puisque la façon la plus réaliste d'influencer le procédé technologique est de commencer par les produits connus et de les développer dans une nouvelle direction. Les conséquences du transfert de ces cloisons ont été perçues comme ayant des effets immédiats mais également plus éloignés et catégorisées en groupes de contraintes: les contraintes légales; les contraintes technologiques; les contraintes de marché. Des évaluations ont été faites et un concept de performances utilisé afin de dresser une liste de critères d'évaluation. 50 systèmes de cloisons ont été caractérisés et ceux qui ne répondaient pas aux critères retirés. L'analyse de 13 systèmes a démontré que leurs performances ont été bien supérieures au niveau requis. L'étude a démontré également que la plupart de ses systèmes sont économiquement profitables comparés aux cloisons de gyproc fixes, si l'on considère les bénéfices à long terme. L'étude indiquant que ces systèmes de cloisons sont technologiquement sans défaut, il est recommandé d'approfondir la possibilité de les modifier en introduisant de nouveaux matériaux qui diminueraient les performances inutiles et en même temps réduiraient le coût initial.

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# CHAPTER ONE

# INTRODUCTION

This opening chapter is intended to present to the reader the background and the research design of the study under consideration. The chapter is divided into two sections. The first section introduces general ideas in the field of flexible houses that have particular relevance to the research, provides a clear statement of the research problem by identifying problem areas in this field, and outlines the objectives of the research along with its scope and limitations. The second section illustrates the approach, methods and techniques that were chosen to address the research problem adequately. The background information presented in this chapter is derived, as indicated in the text, from various related literature.

## 1.1 Background Information on the Study

### 1.1.1 Introducing the Concepts of Flexibility in Housing: General Principles of Support and Infill:

The vitality and diversity of human content along with the meaningful interaction of individual and environment in the act of dwelling had, in general, missed the attention of the professionals engaged in this field. The production of homes through traditional process ignored the possibility of ***personalization***[1] of the home. The

1 Rabeneck et al (1974) define personalization as "the guarantee of a private domain in which personal choice may be exercised."

householder or the occupant had long been excluded from such a process and thus privacy of individual life-style seemed to disappear from his own dwelling. The desire of man to "identify himself" and "recognize him" in his dwelling tends to fade away in the monotony of rigid, impersonal and uniform houses which, in fact, negate certain necessary dimensions of human being (Habraken, 1985).

It is in this context that the concept of ***flexibility***[2] in dwellings tends to revolutionize contemporary architectural thoughts in general, and in the field of housing in particular. The futility of traditional housing process to address such fundamental issues has, in fact, led the way to new housing strategies which would allow people to make decisions about their life-style and assume responsibility for their home. The concept of ***flexibility in housing***[3] is a product of such an innovative strategy, the strategy of support and infill, a term first coined and used by N.J. Habraken, a Dutch architect, in 1962.

The support and infill concept suggests a strategy to restore the natural relationship between individual and his dwelling and attempts to re-establish the householder or the occupant as an active participant in the process of housing in both individual and communal spheres of decision making. The SAR (Stitching Architecten Research) methodology, based on the concept of support and infill and developed during the year 1965, considers that a dwelling is mainly a result of two spheres of decision making: one for the architect, builder and the local authority, and the other for the industrial designer, manufacturing industries and the occupant. In this way, the dwelling consists of two technical assembly

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2 Dluhosch (1974) defines **flexibility** as "the ability to achieve a change in conditions without changing the basic system as such." Thus, it refers primarily to adaptations to change and relates to transformational elements of a given building system without affecting the basic system (or, the structural support).

3 The author defines **flexibility in housing** as a system in which the internal space of a dwelling could easily be altered through multiple or interchangeable use of space primarily to ensure personalization and further to extend opportunities for choice as circumstances change (after Rabeneck et al, 1973).

patterns: the support or the structure, and the infill system of detachable units. As shown in Fig. 1.1, the support is considered to be the social part of the dwelling which belongs to a larger infrastructure about which an individual can not decide alone. On the other hand, the infill system of detachable units which includes non-load-bearing partition systems, is considered to be the individual part that remains clearly within the realm of the individual dweller who can shape, change and adapt it according to his own choice, needs, requirements and affordability.

Thus, this housing strategy ensures the separation of the commissioning client (i.e., the developer or, the local authority) and the user client (i.e., the householder or, the occupant) and diminishes the problem of the present housing process in which client with whom the architect deals is rarely a person who would occupy the house he designs. It intends to bring back the individual, who had long been excluded in the traditional housing production system, to participate actively in the process on the basis of the fundamental principle of self-determination of his dwelling unit.

It is worth mentioning here that, as shown in Fig. 1.2, in an ideal situation the support should be produced and supplied by a developer or a local authority as building components in the building production channel, whereas the infill of detachable units should be produced and supplied by manufacturing industries as industrial products through normal marketing channels, and acquired by each household as private goods.

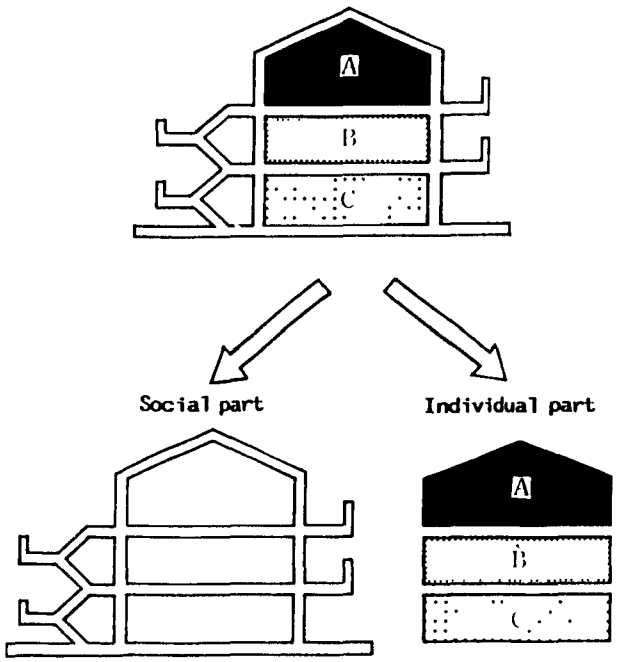


*Fig. 1.1* : Support and Infill Concept: The Social and Individual Parts of a Dwelling (after Tatsumi et al, 1987)

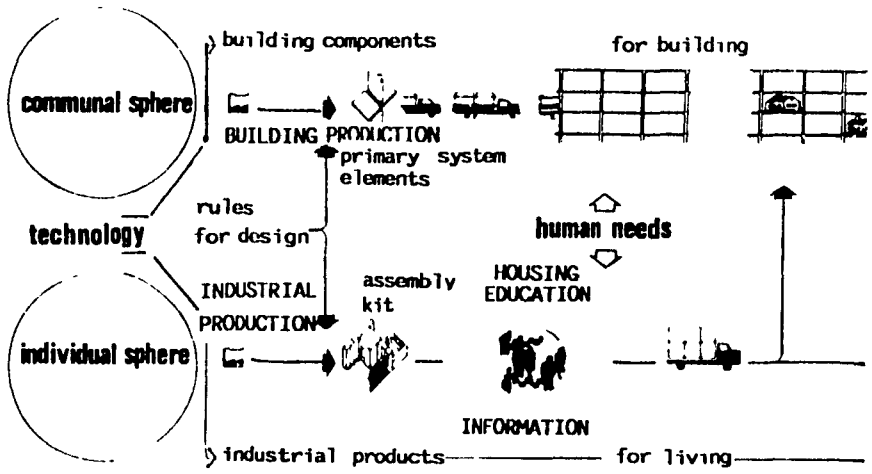


*Fig. 1.2* : Separation of Production of Support and Manufacturing of Infill (after Hamdi, 1971)

### 1.1.2 General Problem Area: Inadequacy of Flexible Partition Systems:

Although the concept of support and infill has been translated into projects in reality in different countries like the Netherlands, Germany, England, Sweden, France, Switzerland and Japan during the last two decades, it is interesting to note that, in most of the cases, the separation of support and infill could not be realized in the production. In general, both support and infill had a common production process and obviously detachable partitions, one of the most important components of the infill package, failed to achieve its full potential (Worthington, 1973).

As a matter of fact, in Europe, where a considerable number of flexible housing schemes were implemented, a "comparative lack of the technology" of the internal partitions is observed in spite of the fact that "their designers had carefully considered the general design of the shell (or, the support) for flexibility" (Rabeneck et al, 1973). Most of the internal flexible partitions used in these schemes exhibit a very disappointing picture in which bad workmanship, poor accoustical performance, sloppy installation techniques and unacceptable visual quality were the most common symptoms.

One of the main reasons for this is the fact that the manufacturing industries have not been producing flexible partition systems for residential applications mainly due to the absence of a steady market although they have long been producing a wide range of such systems for a steady market that prevails for commercial applications. It should be noted at this point that ***commercial flexible partition systems***[4] are

4 The author defines **commercial flexible partition system** as a non load bearing internal partition system which could be relocated without changing the basic structural system of a building as such, and which is intended to be installed in response to the requirements set by the commercial, administrative and institutional buildings (Derived from information provided in several manufacturers' catalogues).

profusively and successfully used in office buildings, schools, gymnasiums and stores all over in Europe and North America.

### 1.1.3 Statement of the Research Problem:

Since a large variety of commercial flexible partition systems are readily available in the present North American market and since they are being used successfully and efficiently in offices, institutional buildings, schools, stores, gymnasiums and other commercial services, it would be very much appropriate to pose the following clear and simple research question:

**Could commercial flexible partition system be *adaptable*[5] to residential applications?**

### 1.1.4 Rationale of the Study:

The relevance and importance of the concept of flexibility in housing could hardly be denied in the present context with the increasing rate of social and economic changes in the life-cycle of an individual. However, one of the most important components of such a house, the flexible partitions, proved to be inadequate in practical applications as demonstrated in most of the realized schemes. **Therefore, the whole area of partition systems as infill components in flexible housing schemes is in need of concentrated research and development. Significant progress in the support and infill approach to new housing construction would primarily depend on the progress of development of such vital infill components as partition systems.** Therefore, it follows that great

5 **The author** defines **adaptability** as suitability or fitness to perform efficiently with respect to a set of intended functions and economic considerations. (after **Parker**, 1970)

advantages might be gained if appropriate flexible partition systems could be developed for this purpose. Investigation of practical possibilities of doing it easily and at reasonable cost still stands as one of the most important lines or directions of research in this field (Hellinghausen et al, 1987). Since the most realistic way to influence the evolutionary process of the building products seems to be to start from known products and develop them in innovative directions, it further follows that before taking a step forward to manufacture flexible partition systems exclusively for housing purposes, it would be wise, and perhaps the best approach, to examine the possible adaptability of presently available commercial flexible partition systems to residential applications. It is expected that such an investigation would not only explore the possibility of applying some of them to residences, but also ensure a better understanding of the problem by reducing the information gap that stands in the way of formulating manufacturing guidelines for such a building component.

### 1.1.5 Objectives of the Study:

The ultimate goal of the research is, as indicated in the statement of the research problem, to examine the possible adaptability of commercial flexible systems to residential applications.

The objectives are as follows:

a. To review relevant literature and document important aspects, research, and works in the field of flexibility in housing in general and in relation to the partition systems as infills in particular.

b. **To identify major obstacles and problem areas, if any, in transferring commercial building products to the residential market.**

c. **To form a set of evaluation criteria which could be used to examine the adaptability of commercial partition systems to residential applications.**

d. **To demonstrate selected commercial partition systems and examine their aforesaid adaptability with the help of the set of evaluation criteria formed for this particular purpose.**

e. **To analyse and synthesize the findings of the study in relation to the research problem in a summarized form and make concluding remarks and recommendations derived from them.**

### 1.1.6 Scope and Limitation

Flexibility in housing is a vast and diversified field. In a broader sense it includes an innovative participatory process for a better means of personalization of the home and a carefully worked out design of the support (or, shell) to incorporate infill systems with a considerable degree of variations. However, it was beyond the scope of the research to focus on each and every aspect of the subject matter due to time-budget-personnel constraints. It was rather intended to concentrate on one of its infill components, the flexible partition system, and examine in detail the potentials of selected commercial flexible partitions in residential uses.

For such examinations, the author basically relied on the manufacturers' product literature. And for obvious reasons, as clearly stated in the next section, it was beyond the scope of the present study

to question the validity and authenticity of various tests and their results that appear in the product catalogues. It was, therefore, realistically assumed that the manufacturers undertook rational approach and prescribed methodology to come up with such results.

Evaluation of any building product is context dependent. The context (or, the parameters) of such an evaluation, and the process of selecting partition systems (or, the screening mechanism) from a large number of available variety are presented in chapters four and five respectively in the same sequential order as they appeared to be necessary in course of the study.

## 1.2 Research Design:

The following subsections describe the research design that was carefully formulated to carry the research out efficiently and systematically.

### 1.2.1 Research Assumption

The basic research assumption was, as indicated earlier, that some commercial flexible partition systems available in the North American market could be efficiently and successfully applied to residences. It was further assumed that there might be some problem areas or obstacles other than those of functional and economic aspects, that stand in the way of transferring commercial building products to residential uses.

### 1.2.2 Selection of an Appropriate Approach to Address the Research Problem

Not many methods were available to the researcher to address the research problem which was clearly spelled out earlier. One possibility

could be putting each of the selected partition systems into practical applications (i.e., putting them in model house) and monitoring their suitability in the new residential context in the course of time. Such a practical approach of incorporating commercial flexible partition systems in some of the dwellings in housing projects would require extensive field work. Moreover, time required to monitor results made the approach beyond the scope of the present research.

Another approach could be conducting simulative experiments aimed particularly at testing the performance of the systems that is to be expected in use. This approach called for fairly extensive laboratory tests and investigations at quite high expense. Such an approach was also beyond the scope of the research due to time-personnel-budget constraints.

A suitable, and in fact, the only realistic approach available to the researcher within such constraints was to form a set of ***criteria***[6] through which it would be possible to make an ***evaluation***[7] of suitability of the selected partition systems to residential applications. It was quite obvious that an acceptable assessment of their appropriateness in a new context would primarily depend on the success of rational, logical and sensitive formation of a set of ***evaluation criteria***[8]. Chapter four deals with the method of forming such criteria in detail.

### 1.2.3 Methods and Stages of Data Collection and Organization of the Report

Information required for the research was collected from primary

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6 **Rosen** (1979) defines **criteria** as "a quantitative statement of the desired performance."

7 **Parker** (1970) defines **evaluation** as "an unbiased assessment of the suitability of particular products to particular building situations."

8 **The author** defines **evaluation criteria** as a set of quantitative statements of the desired performance in order to make an unbiased assessment of the suitability of particular product to particular building situations. (after **Rosen**, 1979, and **Parker**, 1970)

and secondary sources. To fulfill each of the objectives of the study possible sources were identified and methods to be adopted in order to collect required information were determined. The whole research was conceived as a continuous process containing six different stages. The information gathered in each stage was organized, edited and presented in written forms that constituted different chapters of this report. Thus, this report is organized in six different chapters each dealing with different stages and thus, different objectives of the study. Following is a brief description of these stages along with the indication of the methods that were adopted in each stage:

a. Stage I: Establishment of the Basis of the Research:
Chapter One:

The first step was to establish the background to the research itself on the basis of the research literature. In this stage the concept of the research was formed, statement of the research problem was spelled out, its objectives, scope and limitations were framed, and finally, methods of collecting data were determined. Chapter One contains extracts of this stage. It establishes the background of the research and presents the methods that were adopted to address the research problem.

b. Stage II: Review of Literature for Specific Information:
Chapter Two:

At this stage an exhaustive search of related literature was made with the help of standard library facilities and eventually a bibliography was prepared, which is presented at the end of this report. Relevant information was extracted from the available literature which is documented in chapter two in the form of a literature review. The chapter highlights the aspects, research and works that have been done

in the field of flexibility in housing.

c. **Stage III: Collection of Basic Information on Transferring Commercial Building Product to Residential Market: Chapter Three:**

At this stage several methods were adopted to collect basic information required to understand the possible consequences of transferring commercial building products to the residential market. Firstly, structured interviews were conducted with selected architects, developers and officials related to manufacturing and marketing of flexible partition systems to get their views, ideas, comments, and reactions on the particular topic. This helped the author to identify problem areas and obstacles in transferring commercial building products to residential uses. The persons interviewed were selected on the basis of their relation to the subject matter and also their availability. Structure of such an interview is presented in Appendix 1 whereas the list of the persons interviewed is provided in Appendix 2. **The findings of this stage of investigations are presented in Chapter three. This chapter mainly identifies the problem areas and obstacles that stand in the way of transferring commercial building product to residential market.**

d. **Stage IV: Formation of a Suitable Tool for Evaluating Commercial Flexible Partitions for Residential Applications: Chapter Four:**

At this stage, a set of evaluation criteria was formed with the help of which the adaptability of commercial flexible partition systems could be examined. Relevant and exhaustive information on existing evaluation process of building products was collected, the basic principles of such evaluations were reviewed and used to achieve a methodical approach. **Chapter four describes such logical and rational approach in forming the evaluation criteria and an evaluation system.**

e. **Stage V: Evaluation of Commercial Flexible Partitions: Chapter Five:**

At this stage, firstly, a comprehensive list of the manufacturers in this field was prepared with the help of Canadian Trade Index, Fraser's Canadian Trade Directory, and Company Index in order to collect catalogues of their products and specific information that seemed to be necessary. List of the manufacturers of flexible partition systems is incorporated in Appendix 3. Correspondence was made with them by mail and by telephone wherever it appeared easier. Appendix 4 documents of the letter that was sent to all of them along with one of the many replies that was received by the author. Secondly, references were collected from Sweets Canadian Construction Catalogue File, and Thomas American Construction Catalogue File. A screening mechanism to select partition systems for examining their assumed adaptability was then developed, and partitions were selected with that mechanism and evaluated. **Chapter Five presents the screening mechanism, demonstrates and evaluates selected partition system, and documents the findings for each of them.**

f. **Stage VI: Interpretation of Analysis: Addressing the Research Question, and Summarizing the Study: Chapter Six:**

In this final stage, the findings of the evaluation were interpreted in relation to the research problem. Conclusions, recommendations and immediate reflections were derived from the interpretations and the study was summarized in its entirety. **Thus Chapter Six accomodates the sum and substance of the study.**

### 1.2.4 Search for Literature

Now that the background and the methods of the research have already been presented, it is necessary to provide the reader with the state of the art in the field of flexibility in housing as it stands today. This introductory chapter will, therefore, be followed by a literature review which would gather all relevant information on the subject matter more specifically, and try to establish a possible link between the present study and the valuable works of the main stream researchers in this field.

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# CHAPTER TWO

# LITERATURE REVIEW

This chapter is aimed at bringing back some of the scholarly resources of available research literature on the topic of flexibility in housing to the reader. A number of critical and analytical comments made by the author is incorporated in the text wherever it appeared to be necessary. The text is organized in two sections illuminating two sides of the 'flexibility-coin': the theory and its subsequent applications in different West European countries. Thus, it tends to document the state of art in its entirety.

## 2.1 Theoretical Background of Flexibility in Housing

This section contains a brief pen-sketch of the development of the support-and-infill concept, an outline of the methods prescribed by its initiators to bring the concept into reality, and an overview of its potentials, advantages and disadvantages as revealed by the researchers engaged in this field. Such an analytical study of the existing theory, which is primarily not a technical or a functional solution, was considered to be an integral part of the research itself since it allows to lay the base for a common understanding of the problems and a common base for dealing with them. A historical background was also considered to be as important as its physical interpretation as well as its practical applications.

### 2.1.1 A Brief Historical Account

The concept of flexibility, as defined in chapter one, has its design and technological roots imbedded in the history of architecture. Weber (1976) rightly stated that the introduction of the arch into Roman architecture was primarily intended to provide a secondary screening element (or, an infill element) with columns still acting as structural supports. In fact, it was only later in the early Christian buildings that the arch was used as a structural element as such. He further pointed out that throughout the history of architecture, conversion of old, unused and obsolete structures to new uses by introducing new infill elements was not very uncommon. He cited an interesting example demonstrated in Yugoslavia, where a palace of a Roman ruler in split becomes a house (city) for thousands of its citizens in the present time. However, such conversion of buildings over time, often at high expense, could only be possible due to the inherent characteristics of the traditional post-and-lintel construction system although they were not designed to accommodate changes that ensure flexibility through the provision of transformable space.

The idea of designed transformable space in housing was first put forward by the famous architects like Mies van der Rohe, Adolf Rading, Le Corbusier and Jeanneret, as early as in 1927, during the Weissenhufsiedlung exhibition at Struttgart, West Germany. According to Rabeneck et al's (1973) opinion, this exhibition enabled 'the most advanced architects of the time' to put their 'revolutionary ideas into practice'. Mies Van Der Rohe's steel framed apartment dominated the projects in the exhibition which contained 'internal partitions which could be disposed according to the likings of the tenants, in whatever manners they choose' (Giedion, 1972). The house by Adolf Rading displayed in the exhibition was characterized by the interior planned as a single living space which could be subdivided by means of sliding and folding

partitions running on tracks in the ceiling and floor. The 'double house' designed by Le Corbusier exemplified the possibilities of flexible housing in which space could be transformed for day and night use. Le Corbusier remained interested in such an idea for quite long and implemented it in two of his projects in reality: 'projet immeuble locatif' and 'Maisons Loucheur', in subsequent years (Rabeneck et al, Op.cit.).

Although the idea of flexibility in housing introduced by the notable architects received general attention and instantaneous appreciation of all concerned, it was not before the early sixties that the concept was meaningfully conceived as a housing strategy to address contemporary context of some of the problems that evolved out of the post-war housing production system. After World War II there was a pressing need for housing as the 'cities had been decimated, entire populations were relocating and a baby boom was under way' (Lukez, 1986). Since then the talent of the housing professionals has been almost solely devoted for meeting the high production quota by solving two problems: the problem of providing 'optimum accommodation for the smallest sum of money', and the problem of providing 'maximum accommodation for a given sum' (Collins, 1965). The solution to these problems, as prescribed by the *behaviourists*[1], led to the mass application of prototype housing units under highly centralized controls. Consequently, quantity had replaced quality in the production process of housing and the opportunity to incorporate any personal or community identity in the dwellings tended to fade away in the characteristic oppressive uniformity, formal rigidity and impersonal appearance of these so called mass housing blocks. And in these 'perfect barracks', as Habraken (1972) calls them, man no longer houses himself, he is rather helplessly housed.

1 Pawley (1971) termed the advocates of 'tight-fit-functionalism' as behaviourists.

It is, in fact, the recognition of the futility of mass housing by the *libertarian*[2] architects, led by Habraken, that laid the foundations for the new housing strategy, the strategy of support-and-infill, that aims at establishing a framework within which responsibilities can be distributed in the act of dwelling, general principles of which have already been introduced in chapter one.

### 2.1.2 Physical Interpretation of the *Support*[3] and *Infill*[4]: The *SAR*[5] Methods

The timely arrival of the concept of support and infill paved the way for the establishment of the research organization SAR following a number of intensified and politicized discussions among the participants in the housing process in the Netherlands. SAR devoted its initial years for developing physical interpretations of the *levels*[6] of the new housing strategy, i.e. support and infill, and offer methods and design tools that would generally benefit all in this field. Following is a brief description of the interpretations, methods and tools as derived from some of the SAR publications which are refined further by the researchers who have still been working on them since then.

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2 **Pawley**, (Ibid) termed the researchers and architects who have taken account of the inadequacies of mass housing and proposed approaches that allow people to assume responsibility for their homes as **libertarians**.

3 **Support**, as interpreted by **Kendall et al** (1986), is a completed phase of construction fixed in great many aspects which leaves open a number of alternatives in the distribution of functional spaces.

4 **Infill**, as interpreted by **Kendall et al** (Ibid), 'is the co-ordinated material system which when combined with the support, make a house that can be lived in'.

5 **SAR** stands for **Stichting Architecten Research** which means the Foundation for Architects Research. It was founded in 1964 with Habraken as its first director. It is funded by contributions from architects, builders, developers and a yearly grant from the government

6 In 1973, a third **level** of planning was added to the two levels mentioned above, i.e. **the tissue**. While support land infill concern the building itself, the **tissue** concerns 'the arrangement of buildings in their relationship to each other and to their surrounding space' (Carp, 1978).

Support, in its simplest form, includes the structural skeleton of dwellings whereas infill may contain, as indicated by Kendall et al (1986), any combination of partition, drain, waste, ventilation, water supply, heating, electrical, data and communication network, equipment, fixtures, wall, floor, cabinet and ceiling systems. However, according to Lukez (1986), it would not be useful to make two water-tight compartments and assign each of the building systems or components to the class of support and infill since the physical definition and division primarily depend on the context particular to each locale. Nevertheless, it would be useful to identify general characteristics of support and infill. Support is characterized by 'its longer life' span, it is more 'rooted to local conventions, climate, regulations and streetscape' whereas the infill usually 'has a shorter life, is not so rooted to local trends, is independent by and large from external environment, and is not so fully regulated by local jurisdictions' (Kendall et al, 1986). Based on these general characteristics and the local context, it would be possible to classify building elements, components and systems into the categories of support and infill for individual schemes before SAR Method could be used to design supports.

The SAR Method is a dynamic design process of the support that aims at generating design variations and evaluating them against design requirements (Bao, 1984). It divides the support into spaces called zones, margins and sectors that are means of delineating territory of similar location and dimension in a support. Fig. 2.1 shows such schematic division of a support. Each zone can be designated for different uses in relation to their functional and locational suitability. The margins (i.e. spaces with smaller dimensions between two adjacent zones) could be used if a space requires greater depth provided it has not already been assigned another use. A sector, on the other hand, is a designated area that contains one or more zones and margins which could eventually be planned and evaluated (Lukez, 1986).

Room types and their dimensions can be tested against the assigned dimensions of a zone and, if needed, zones and margins could be redefined, or room size be altered. In turn, several room combinations could be tested and evaluated against sectors already defined and designated by the designer. Sectors meeting different design objectives could eventually be combined with other sectors to form sector groups that would provide the basis for defining dwelling layouts. The relationship of several functions in a sector group, usually notated by simply writing such relationships in respective zone locations, leads to a basic variation as shown in Fig. 2.2. By analyzing the type and number of basic variations, the capacity of the support to meet design criteria could be understood, and if needed, adjustments should be made in the design of the support (Habraken, 1976).

To prevent the conflict of different human and physical activities in the support a method of co-ordinating space and material known as ***modular co-ordination***[7] was developed by SAR. It is based on the tartan grid which allows for free placement of materials and spaces in alternating 10/20 cm (i.e. 4/8 inches) bands as shown in fig. 2.3. In this way it is possible to designate two types of bands: build bands for the allocation of material, and the space bands for human or physical systems whose positions may be unknown in the earlier stage of the design. Once a space band is set up, the possibility of intrusion of unwanted objects is removed and conflicts between systems is minimized.

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7 **Modular co-ordination**, in its general terms, as defined by Turner et al (1972) is 'the specific application of standardization in the construction industry, so that the building materials and components are designed to be made more interchangeable by having their key dimensions comform to full multiples of an agreed-upon measurement (or, module recommended by many as 4 inches or 10 mm). Bemis, A.F. of U.S.A. first put forth the concept of such base module as a means of rationalizing the building industry in 1936 prior to World War II.

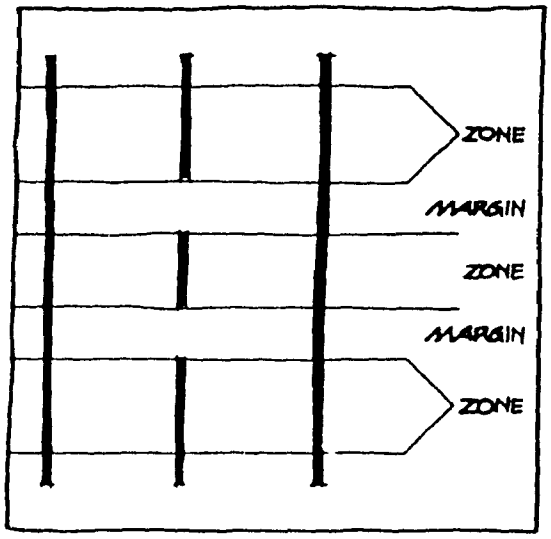
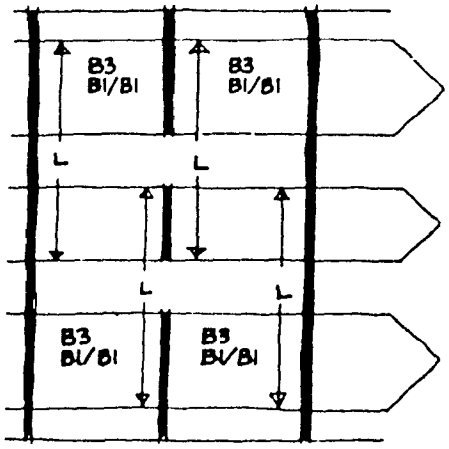



*Fig. 2.1 : Schematic Division of a Support*
(after Lukez, 1986)




$B_1$, $B_2$, $B_3$ indicates different bedrooms.

*Fig. 2.2: Basic Variations*
(After Lukez, Ibid)

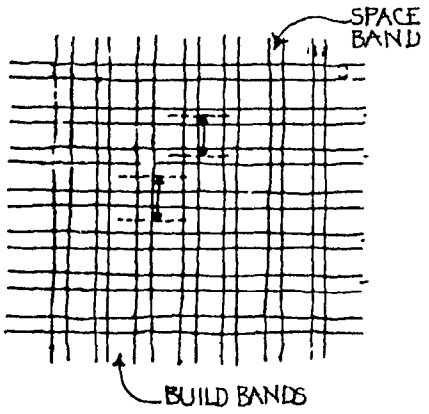



*Fig. 2.3: Tartan Grid*
(After Lukez, Ibid)

### 2.1.3 Advantages and Disadvantages of the Concept of Support and Infill:

The main advantage of the concept of support and infill is its capacity to ensure an efficient channel for flexibility in housing to meet diversified and dynamic needs of individual households in addition to its basic aim to remove the inequality and inadequacy of the present decision making process in housing. Dluhosch (1974) identifies two basic classes of needs which may be linked with the concept of flexibility: differing needs that are primarily space dependents, (e.g., need for differing dwelling types based on differing interaction patterns, life-styles, income distribution, consumption patterns), and changing needs that are largely time dependent (e.g. formation of family, child rearing, death, divorce, change of family status). A carefully detailed multi-family housing involves offering variable dwelling-cell areas to match the differing needs of the future occupants. Another advantage offered by such a scheme is the freedom of choice concerning internal arrangements according to the occupants' needs prior to move in. And thirdly, the option of moving the partitions following the occupants' adds another dimension to its potential advantages whims or the evolution of his changing needs (Martel et al, 1974). The ability of the house to adapt to the users' various requirements increases the saleability and renders a marketing bonus to its developer. And it is in this way that Ritter (1962) suggested, 'the very best selling points' are imbedded in such schemes.

Secondly, the new concept opens the way for variation in housing consistent with the principles of ***industrialization***[8] and indicates a new

8 Turner et al (1972) define **industrialization** as the process whereby products are manufactured in larger quantities which usually imply standardization in the final product, specialization in labour, a concentration of production, purchasing and marketing, and mechanization of production process.

horizon in which the contradiction between ***standardization***[9] and variation in housing tends to be removed (Bao, op.cit). In addition, the new design method (i.e., the SAR method) provides the possibility of scientific design of housing units with its capacity to translate the terms of zones, margins and sectors into computer language and make special programs to analyze and compare results (Bao, Ibid.).

However, Rabeneck et al (1973) holds that the design methods prescribed by its initiators in terms of zones, margins and detachable units preserve 'an implicit control over the occupant' and lead to the fallacy of 'freedom through control' Arsene-Henri (1972) believes that the occupants' freedom must include the right to make 'mistakes' and 'bad plans' without inhibiting the freedom of others.

Weber (Op.cit), on the other hand, sees the disadvantage of the method as a by product of its advantages. By making the present system somewhat more flexible, the method may actually be used for exploitation by those pursuing their own selfish interests, without relinquishing their control over the process of planning and design. In that sense, he considers, it tends to postpone the needed reform in the decision making process of housing.

And finally, the most important disadvantage of the flexible living units that allow users to manipulate their own environment is that they are generally considered more expensive than that of the traditional ones. In an era of shortages, most of the opponents of this concept argue, it is more important to provide housing than to be concerned with the luxury of flexibility. However, studies on ***life-cycle analysis***[10] reveal that high

9 Turner et al (Ibid) define **standardization** as 'the process whereby parts or products are manufactured similar enough to be interchangeable within an accepted or established range of walls for size, weight, quality, strength.'

10 **AIA** (1974) defines **Life Cycle Cost Analysis** as a 'technique which allows assessment of a given solution on the basis of considering all relevant economic consequences over a given period of time (or, a life-cycle)'.

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The project contains 36 dwellings with minimum supports, as shown in fig. 2.4, allowing maximum freedom in the arrangement of internal partitions based on a 90 cm (3") planning grid.

**The partitions, in contrast to the expensive and high quality long-span structure, are crude being the cheapest available. The panels are 2500mm x 900mm, 35mm thick veneered hollow-core chipboard with cover strips. They are held in place by friction screws. Skirtings and trims are in moulded plywood.**

In spite of the fact that the flexibility in housing turned out to be constrained for several reasons (e.g., fixed size of the dwelling units), a study of the internal arrangements of the apartment showed that the inhabitants of the experimental building used the freedom provided by the flexible partitions resulting in significant variations compared to the plans suggested by architects. However, the study further reveals that quality of the flexible partitions did not correspond to the expectations of the occupants (Martel et al, Op.cit; Rabeneck et al, Op.cit).

### 2.2.2 Great Britain

**Name of the Project:** **Adelaide Road Estate**
**Location:** **Borough of Camden, London**
**Architect:** **Hamdi, N., Wilkinson, N., Greater London Council**

It is one of the first support-infill projects based on SAR principles that was built outside the Netherlands. The architects developed the PSSHAK method (The Primary Support Structure and Housing Assembly Kit) with the aim of allowing tenants to choose plan before moving in, allowing the layout to be adapted to family's changing needs, and to subsequent tenants, and providing long term adaptation of the basic structure to different mixes of dwelling sizes.

The estate consists of eight three storey buildings, located in an existing urban fabric which is largely residential in character. The primary structure used concrete piers and slabs which were positioned, so as to provide ample freedom for residents to design the interior to match their present as well as future needs. Fig. 2.5a shows possible positions of partition systems.

A complete set of industrially produced detachable units (or, the assembly kits) was provided by a Dutch firm (Brunyzel) in compliance to the need and choice of the individual tenants following a couple of revisions made by the architect and the representatives of the firm. The partition system, which was employed in this scheme was innovated and first used in Scandinavia. It has no fasteners to walls, floors and ceilings and held in position by pressure screws (i.e. spring loaded jack) as shown in fig. 2.5b.

The greatest obstacles that the architects encountered, however, did not concern the technical considerations of building but evolved out of the procedures and standards of the public agencies (Hamdi, 1978; Hamdi et al, 1971; Lukez, Op.cit.).

### 2.2.3 The Netherlands

| | |
|---|---|
| **Name of the Project:** | **Molenvliet** |
| **Location:** | **Pappendrecht** |
| **Architect:** | **Werf, F.V.d, Group Kokon** |

This project, an outcome of a competition, was the first support project realized from the ideas and methods developed by SAR. It consists of 122 dwelling units organized around courtyards as shown in fig. 2.6 for over three hundred residents. The support contains carefully placed concrete piers spaced at 4.37 m (i.e., 15 ft.) interval to accommodate various different dwelling plans. The piers and slabs are constructed by

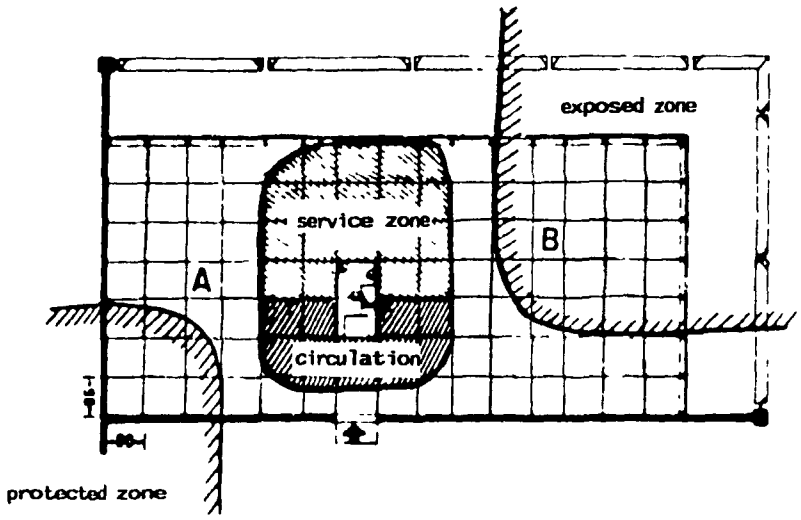



*Fig. 2.4:* Plan, Montereau Research Project, France (After Martel et al, 1974)

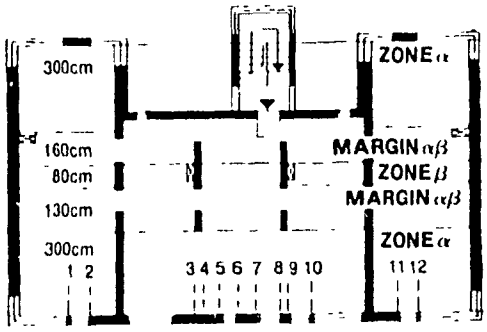
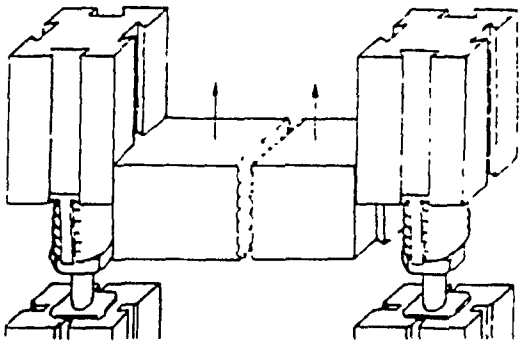



*Fig. 2.5a:* Position of Partition System PSSHAK (After Hamdi, 1978)



Infill Components Pressure Screws Securing the Infill Panel to the Floor and Ceiling

*Fig. 2.5b:* Detail of PSSHAK Partition System (After Hamdi, Ibid)

using *tunnel form*[17], a new construction technique.

The infill, laid out and controlled by the households, included partitions, interior doors, kitchen and bathroom elements, electrical and mechanical systems, closets and some of the facade elements. The technique used to hold the partitions in position was the same as Adelaide Road project as described earlier.

The conventional building approval process proved to be cumbersome as the authorities required detail designs of the dwellings in the place of the drawings showing the free plan support only (Lukez, Op.cit.).

### 2.2.4 Sweden

| | |
|---|---|
| **Name of the Project** | **Tensta** |
| **Location:** | **Near Stockholm** |
| **Architect:** | **Unknown** |

The project contains 650 flats on a difficult sloping site. Although flats were completed to plan-types, occupants had the option of modifying or re-planning them according to their choices prior to move-in at no extra cost.

The structure is built using the Skarne system of construction, which is characterized by large concrete panels with load bearing external cross-walls and an intermediate row of columns to form a relatively unobstructured floor area to each flat (Fig. 2.7).

The partitions are 70mm thick made of timber subframe and vinyl covered facing sheet of 13mm glass reinforced gypsum. The standard panel

---

11 A tunnel form is a volume in the size of the structural bay it will form. The hollow forms are properly positioned, concrete is poured for the walls and the slabs, it can then be slipped out of the bay and repositioned for a new bay if needed allowing builders to work rapidly and efficiently (after Lukez, Op.cit.).

size is 600mm which weighs 39 kg for 2.5m high panel. The panels are placed over the floor finish and a 70mm wide batten is placed on the ceiling with groves in both sides to accept plastic skirtings which mask electrical installation. The batten is routed to receive the bolt head of a spring loaded fixing device which keeps both batten and partition in place. The partition had gained 1/2 hour fire rating and 30 db acoustic insulation (Rabeneck et al, Op.cit.).

### 2.2.5 Switzerland

| | |
|---|---|
| Name of the Project: | Casa Patriziale di Carasso TI |
| Location: | Carasso |
| Architect: | Snozzi, L., Vacchini, L. |

This project contains twelve flats and a polyvalent hall for 300 persons. The flats standardized for 4 1/2 and 6 1/2 room flats and are freely grouped around the service core, as shown in fig. 2.8, location of which is determined with considerable attention to provide a degree of flexibility. The hall is situated on the basement level and extends up to the entrance level with windows opening up in that level. The facades of the flats are completely glazed and a covered parking site goes with the house.

It is the only project, to the best of the author's knowledge, where commercial flexible partition system was adapted to residential application. Steel faced partitions, manufactured by Strafor-Hawerman Ltd., with self-evident joints finished in a uniform color were adjusted as desired on a grid of 95 cm. Steel finished internal doors and partitions were erected after the carpet had been laid throughout the whole flat. Steel finish allowed simple hanging of pictures, often with the use of magnets. No attempt by occupants to wallpaper or paint over the baked on matt acrylic finish was recorded in the post-occupancy studies indicating the apparent acceptance and thus success of such adaptation (Rabenick et al, Op.cit., Werk, 1970).

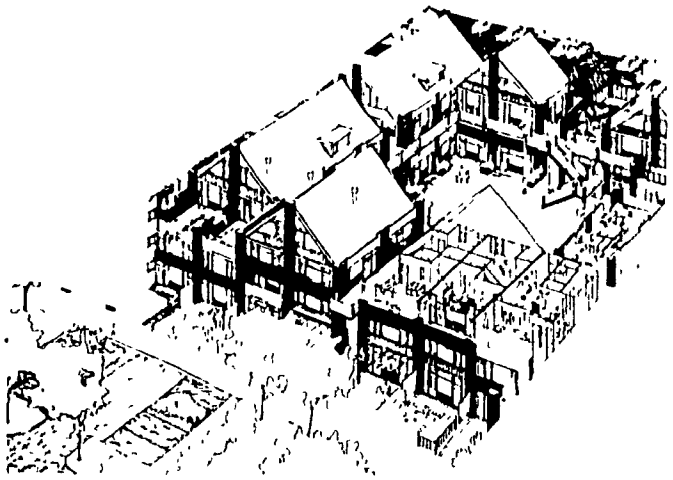


*Fig. 2.6*: Molenvliet, The Netherlands
(After Lukez, 1986)

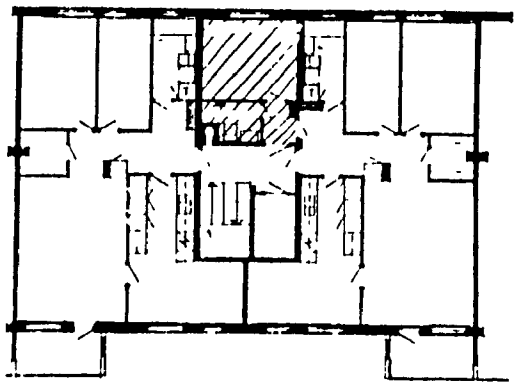


*Fig. 2.7*: Planning of Tensta, Sweden
(After Rabeneck et al, 1973)

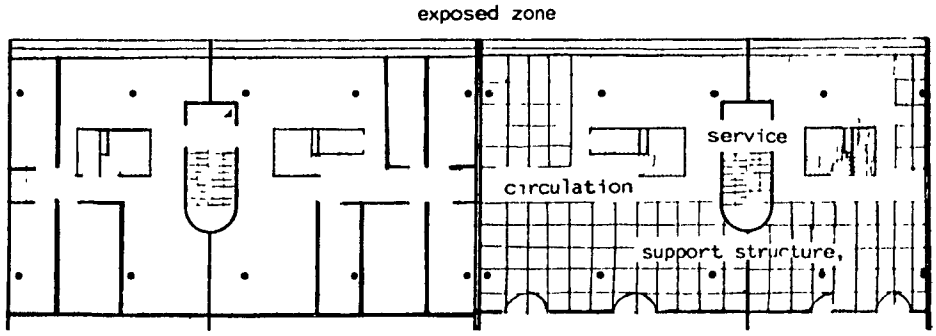



*Fig. 2.8*: Casa Patriziale di Carasso TI, Switzerland
(After Rabeneck et al, Ibid)

### 2.2.6 Identification of General Problems Related to Flexible Partitions: Lessons from the Past Experience

The problems of flexible partitions, as identified by the author from available feedback studies, could be categorized in the following groups:

a. **Functional Problems:** Although the designers, in most of the cases, considered general design of the support for flexibility, the projects in reality display a comparative lack about appropriate technology in relation to the residential partitions as required by the functions of habitability and practicability. The occupants tend to use whatever partitions are readily available at the expense of cumbersome electrical distribution, low acoustic performance and sloppy installation techniques. The problem, therefore, lies in bringing simplicity, function and flexibility together in the most cost-effective way.

b. **Aesthetic Problem:** The feedback studies show that in most of the cases, poor finishing of the partitions create aesthetically unpleasant and unacceptable indoor environment. They also reveal that the most successful applications of flexible partitions were those in which there were no external signs that they were unconventional. The problem, therefore, lies in getting the appearance of a fixed wall and still making it flexible.

c. **Management Problem:** Problems of management as revealed by feedback studies are generally context dependent and more relevant to a renting situation. Rearrangement of the partitions on moving, storing of unused and new partition components and their general maintenance appeared to be very critical in some of the projects. However, this category of problem has the least bearing on the present study since

its context, as described in chapter four, concentrates on the housing ownership market and clearly spells out the managerial responsibilities of the parties concerned in each of its major options.

### 2.2.7 Obstacles and Roadblocks to Adapt Commercial Flexible Partitions to Residences

Although commercial flexible partition system was adapted to a public housing scheme in Switzerland as described earlier, no information about the obstacles and roadblocks as encountered by its initiators in relation to the idea of transferring a sophisticated product from one market to another was available in any of the possible sources. However, it is important to identify such problem areas with respect to the proposed sectoral transfer of commercial flexible partition systems before evaluating the adaptability of their functional, economic and aesthetic performance in a new context. The next chapter (chapter three) discusses such issues at length in a North American context.

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# CHAPTER THREE

# TRANSFERRING COMMERCIAL BUILDING PRODUCT TO A RESIDENTIAL MARKET

This chapter explores the possible obstacles and necessary tasks associated with the notion of putting an established commercial building product in residential uses. The commercial flexible partition system in order to be applied successfully and adequately in residences needs to be investigated in two different yet interrelated areas: one is the subject of transferring it to residential market, and the other one is the matter of its adaptability in a new context to fulfill the needs of the related decision making participants. It would be a mistake to think that once established, adaptability of commercial flexible partition systems would automatically lead it to adequate applications in reality. In the course of the research this point struck the author as particularly important and as requiring a thorough investigation. Findings of such investigations through interviews with selected representatives of building product manufacturers, architects, developers and economists are further strengthened by relevant literature, and documented in two sections. Section one establishes the meaning of such sectoral transfer. Section two points out its consequences and looks for strategies open to overcome them.

## 3.1 Meaning of Transferring Commercial Flexible Partition System to Residential Market

For a complete understanding of the meaning of sectoral transfer of commercial flexible partitions in relation to the manufacturing and the home building industries, it was necessary to collect information on the production and marketing channels of building components, and their relationships with the activities of the home-builders. The search for information gradually revealed the existing scenario that follows in this section.

### 3.1.1 Manufacturing Channels of Building Product:

The manufacturing channel of building product generally follows a standard route in North America. The flow of activities related to the manufacturing of a new building product could best be perceived by a diagram (Fig. 3.1). The process starts with an assumption made on the potential market demand of a particular building product. Such an assumption is often verified by a market study done by ***marketing***[1] experts as a part of the ***marketing research***[2] program of a particular industry, which eventually serves as a basis for making ***production decisions.***[3]

Once market demand is ascertained through such a study, a team generally consisting of industrial and mechanical engineers aided by other professionals begins the design process. When a satisfactory solution for a specific set of requirements is achieved in the form of drawings,

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1 **Massie** (1964) defines **marketing** as 'the performance of business activities that direct the flow of goods and services from producer to the consumer and includes selling, buying, storage, standardization, financing and risk taking.'

2 **Massie** (Ibid) defines **marketing research** as the 'systematic gathering, recording and analyzing of data about problems relating to the distributing and sale of goods'.

3 **Production decision** mainly includes decisions on location of the plant, number and capacity of the machines required to meet the market demand, working conditions within the industry and materials handling.

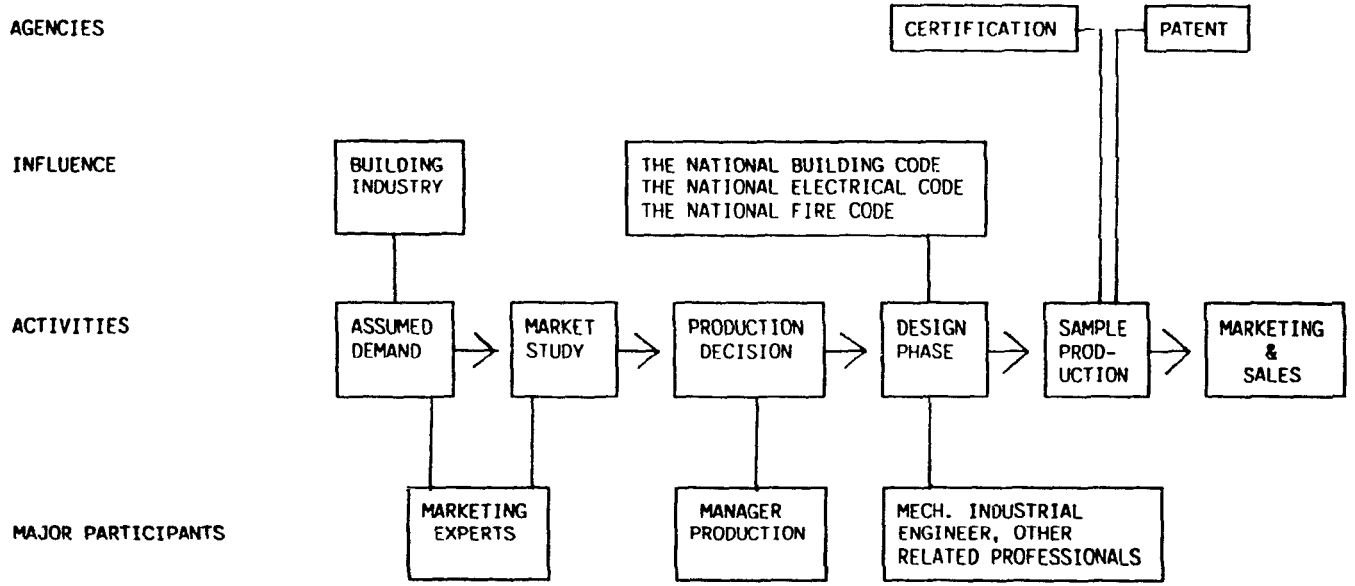



*Fig. 3.1*: **The Production Cycle**
**(Based on Information Collected During the Study)**

specifications and other technical information, it is followed by a sample production.

The sample product along with the design documents (i.e., drawings, specifications, calculations if any) are then submitted to the concerned agencies for the purpose of certification. Such a certification is not mandatory unless and until it is required by government regulations. However, generally a building product should meet the provisions of certain codes which varies with the occupancy characteristics of the buildings in which it is intended to be used or installed. For example, in case of the commercial flexible partition system, in absence of any set standards, provisions set by The National Building Code, The National Fire Code, and The National Electrical Code with respect to the ***business and personal services occupancy***[4] must be met. Depending on the existence and availability of required evaluative tests, such certification is provided by private agencies in Canada (e.g. Canadian Standard Association, Underwriters Laboratories of Canada). Generally, it takes four to eight weeks to obtain such certification after submitting the design documents and the sample product. After obtaining the certification, production takes place according to the marketing strategies taken by the manufacturer.

### 3.1.2 Marketing Activities of Building Product Manufacturers:

Within the scope of the marketing program of a building product manufacturer, its marketing activities are spreaded over the entire period of the production phase, and in some cases, extended up to the point of delivery of the product to the customers. All the activities under this program are integrated and balanced in terms of what is 'the best' for the

4 According to **The National Building code of Canada** (1985, p.4) '**business and personal services occupancy** means the occupancy or use of a building or part thereof for the transaction of business or the rendering or receiving of professional or personal services.'

manufacturer in the market place with special attention paid to the interests of the customers. **Three main elements of such marketing activities that bear significance in the context of the present analysis are pricing, channels of distribution, and product promotion.**

**Pricing** means translation of the value of a particular product into quantitative term (i.e. in dollars and cents) for customers at a point in time (Massie, 1964). The pricing decisions are, therefore, the most important tasks for a manufacturer since prices generate its prime source of current revenue. The decision maker is required to make valid judgments concerning customers' income and competitive markets. In case of the commercial flexible partition system, it is only obvious that such pricing is targeted towards a capital intensive building industry (i.e. the commercial building industry).

**Channels of distribution** is the second major aspect for the present concern. It is the route that a particular product follows in its passage from the manufacturer to the customer. For a building product this route could either be very simple or be very complex depending mainly on the nature of the product, nature and location of the market, and the availability of middlemen to handle the product. The manufacturer is free to select one or more than one distribution channels from the following alternatives:

a. **General or Intensive Distribution Channel** whereby the manufacturer seeks to obtain the widest possible distribution for its product by allowing it to be sold by anyone willing to stock it.
b. **Selective Distribution Channel** whereby the manufacturer chooses only those outlets that are best suited to serve his needs.
c. **Exclusive Dealership Channel** which allows only one middleman to stock and sell the product in a given market.

d. **The Leasing Distribution** under which the manufacturer gives possession and use of the equipment to a party but the title remains with him.

In general, the commercial flexible partition systems are channelled to the customers through exclusive dealers chosen by the manufacturers in strategic locations with respect to the potential market demand.

**Product promotion** represents the third set of marketing activities of a manufacturer, which refers to its nonprice selling deeds directed towards assisting the salesman in making his efforts more productive. The following two are the most widely accepted and used techniques of such product promotion:

a. **Advertising** which refers to any paid form of nonpersonal presentation of a product to appeal to the mass.
b. **Personal Selling** which refers to the process of assisting and persuading to buy a product in a face to face situation. Sales force is hired and trained by the marketing manager and directed either to the middlemen or to the ultimate consumer.

The marketing activities of the building product manufactures, as outlined in the previous paragraphs, interact with the main events in the building industry in a definite way. It would, therefore, be prudent at this stage to grasp the model of the present North American home-building industry before any consequences of transferring the commercial flexible partition system to residences could be traced with a reasonable degree of accuracy.

### 3.1.3 Home Building Industry vs. Building Product Manufacturer:

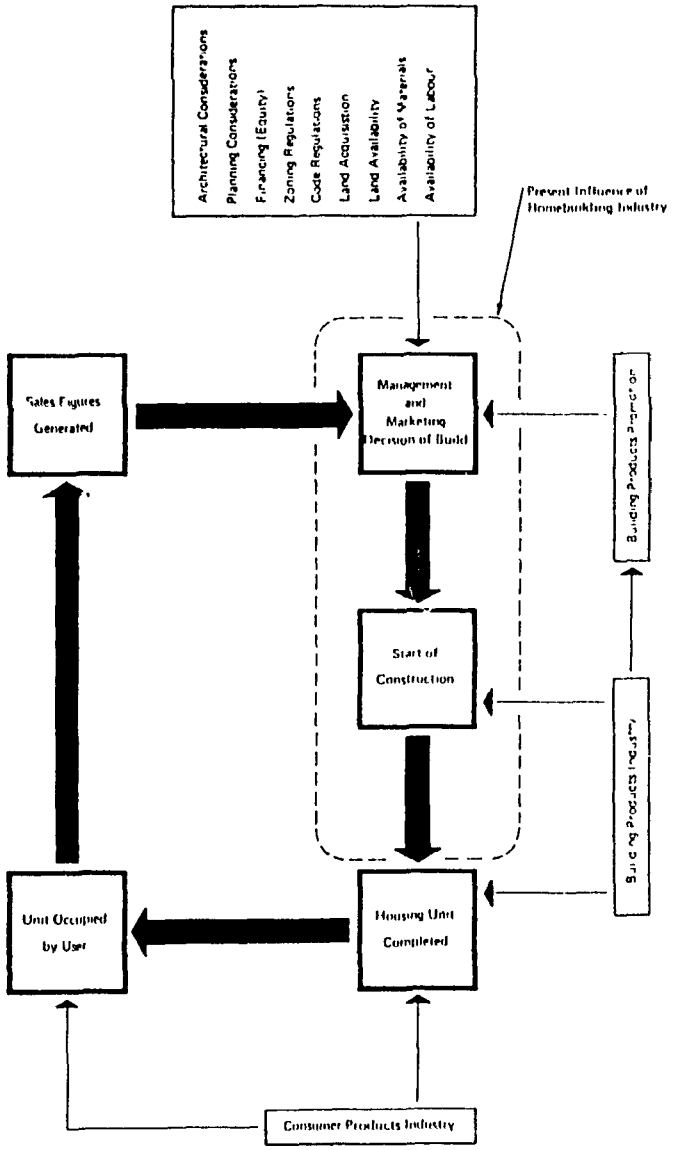
The activities of the home-builders in North America are streamlined to a point at which they permit great efficiency of the

activities themselves. The main events in the home building industry along with the related participants and external influences which bear upon the cycle are clearly shown in figure 3.2. In brief, the decision to build on the part of the home-builder is followed by start of construction, the completion of the home and occupancy. Sales figures that are generated by selling of homes are fedback into the management and marketing part of the process where they become the most important influences in relation to the next decision to build (Roberts, 1970).

There are two kinds of external influence that bear upon the building process: the industry norms (e.g., architectural and planning considerations, zoning and code regulations), and the influences of the building product industry. The first set of influences remains constant over a long period of time, whereas the second set tends to change with the introduction of new building materials and products. Such changes depend heavily on the product promotion activities of the concerned building product industry. In the present context, as shown in fig. 3.2, the building product industry and its promotional activities interact directly with the builders, and no direct link between them and the user of the dwelling unit (i.e., the occupant) exist to time that now is. In an attempt to identify consequences of transferring the commercial flexible partition system to residential uses that follows in the next section, this particular point would bear importance and significance.

## 3.2 Consequences of Transferring the Commercial Flexible Partition Systems to Residential Market and Possible Strategies to Overcome the Constraints

Now that the essential perspectives of the building product industry and the home-building industry have been drawn to a reasonable clarity in the last section, it is possible to understand the consequences of transferring the commercial flexible partition system to residential market in terms of the problem areas and the obstacles that might occur.




KEY

Events in the 'Closed System'

Industrial Norms

Activities in the Closed System

Other Links to the Closed System

*Fig. 3.2:* The Decision Making Participants in the Home-Building Industry (After Roberts, 1970)

The search for information also revealed the tasks and strategies to overcome them.

### 3.2.1 Consequences

Consequences of sectoral transfer of commercial flexible partitions could be seen as immediate and far fetched effects, and categorized into three groups of constraints as follows:

a. **Legal constraints:**

Although no permission is required to transfer the commercial flexible partition system to residential market, each of the systems must conform to the provisions of The National Building Code, The National Electrical Code and The National Fire Code with respect to ***residential occupancy***.[5]

For non-load bearing partitions in particular, nothing much is provided in the National Building, Electrical and Fire Codes of Canada (Op.cit.). Mentions of partitions or requirements related to partitions could only be traced in the documents mentioned above as the following:

**Table 9.10.3.A**
Forming Part of Articles 9.10.3.1. 9.11.2.1. and 9.11.2.2.

| Type of Wall | No. | Description | Finish on Each Side [1] | *Fire Resistance Rating* h | Sound Rating [2] |
|---|---|---|---|---|---|
| Non *loadbearing* steel stud | 25 | 90 mm steel studs spaced up to 600 mm o.c. | C | ¾ | III |
| | 26 | Same as 25 | D | 1 | III |
| | 27 | Same as 25 with mineral fibre filling cavity | C | 1 | II |
| | 28 | Same as 25 with mineral fibre filling cavity | D | 1[4] | II |
| Column 1 | 2 | 3 | 4 | 5 | 6 |

**Addendum to Table 9.10.3.A**

[1] The finishes designated by letter refer to the following:
A = 12.7 mm gypsum board taped joints
B = 12.7 mm gypsum sand plaster
C = 15.9 mm special fire resistant Type X gypsum board conforming to CSA A82.27 Gypsum Board Products and
D = 19 mm gypsum sand plaster on 9.5 mm gypsum lath or metal lath

5 As specified by **The National Building Code of Canada** (1985), **residential occupancy** means 'the occupancy and use of a building or part thereof by persons for whom sleeping accommodation is provided but who are not harboured or detained to receive medical care or treatment or are not involuntarily detained.'

**SUBSECTION 9.10.11. FIREWALLS**

Firewalls

**9.10.11.1.** Except as provided in Article 9.10.11.2., a *party wall* on a property line shall be constructed as a *firewall*

Party walls between dwelling units

**9.10.11.2.** In a *building* of *residential occupancy* in which there is no *dwelling unit* above another *dwelling unit*, a *party wall* on a property line between *dwelling units* need not be constructed as a *firewall* provided it is constructed as a *fire separation* having not less than a 1 h *fire-resistance rating*. Such wall shall provide continuous protection from the top of the footings to the underside of the roof deck. Any space between the top of such wall and the roof deck shall be tightly sealed by caulking with mineral wool or *noncombustible* material

**b. Technology Constraints:**

It was mentioned earlier that the number and the capacity of the machines and other facilities required to manufacture a particular building product are set as essential parts of the production decisions at the managerial level. These decisions are made on the basis of the marketing research that is conducted in the initial stage of the production cycle. Accordingly the number and the capacity of the machines are kept to an optimum level. However, in most of the cases, the manufacturers hold excess capacity to cope with incidental situations that might occur during the production phase.

The transfer of the commercial flexible partitions to residences would mean opening of a new market and consequently an additional demand which might start to interfere with the productive arrangements of the manufacturers concerned. Increasing capacity means introduction of more machines that would incur an added fixed cost to the manufacturer. Most of the manufactures would not take such financial risks unless and until they are assured of a steady market. However, the study assumes the option of adapting existing production methods for the time being without starting a new one right away.

**c. Marketing Constraints:**

The present marketing techniques of the commercial flexible partition system present the third set of constraints in their adequate and successful transfer to residences. Firstly, high prices of such systems in comparison with the widely used fixed gyproc wall stand as the most significant obstacle. The pricing policy of these systems, as discussed earlier, are targeted towards the commercial building industry which is characterized by a high level of economic prosperity. In absence of pertinent information on the potential life cycle cost savings by using these systems in the residences the home-builders as well as the dwellers, would be reluctant to incorporate them in their schemes.

Secondly, the concept of support and infill, as discussed at length in chapter two, requires that in an ideal condition the infill system would be procured by the dwellers themselves according to their choice, need and affordability. The marketing channel of the partition systems which does not have any link with the dwellers presently has to be modified to let the new housing system work to its utmost efficiency.

### 3.2.2 Strategies Open to Overcome the Constraints:

The legal constraints in relation to the transfer do not necessitate any strategy that has to be undertaken. Any deviation from the code regulation for any of the partition systems would simply mean that it would not be transferrable since it would neither be possible to modify the system nor be permissable to change the code.

However, to overcome the rest of the constraints as outlined in the last section, the following tasks and strategies are open to the builders and the manufacturers:

a. **Gradual Introduction of the Partitions**

The builders could gradually introduce flexibility in housing in their schemes. They could give options to the dwellers for flexibility in a limited number of units and inform the prospective buyers about their merits and a possible life-cycle cost savings in installing the flexible partition systems. This gradual introduction would enable the manufacturer to handle the demand with the excess capacity of the technology which they presently hold.

b. **Extensive Marketing Strategies**

The manufactures could reconsider their pricing policies for a new competitive market. As an essential strategy, they could turn to the concept of ***third degree price discrimination***[6] which occurs when manufacturers charge different prices in different markets for the same product. (e.g., different prices for the same telephone services for commercial and residential uses). If efficiently done, a reduced price coupled with the adequate information on the associated life cycle cost saving could open up a new market which would maximize their market share over the total industry sale.

Secondly, to penetrate into a new market, the manufacturers could diversify their marketing channels (e.g. pushing the product directly to the prospective buyers and builders simultaneously through dealers as well as personal sales).

And finally, the manufacturers could further intensify their product promotion activities through leaflets, advertisements and enjoy their greatest opportunity to stimulate market demand. Certainly these promotional activities mean 'cost' to them and these have to be

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6 **Clarkson, K.W., et al** (1982) define **third degree price discrimination** as 'the sale of technically similar goods at prices disproportional to their marginal cost, taking full account of manufacture, sale, delivery and also risk and uncertainty.'

justified in terms of increased sales and profits.

### 3.2.3 The Adaptability Question:

It was clearly stated in the beginning of this chapter that acceptability of builders and dwellers to install the flexible partition system in residences would depend heavily on their adaptability in a new context. Within the scope of the present study, a set of evaluation criteria is required to examine such adaptability accurately. The following chapter stipulates a rational approach in forming a set of an appropriate evaluation for the aforesaid purposes.

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# CHAPTER FOUR

# FORMING EVALUATION CRITERIA

# AND

# DEVELOPING EVALUATION SYSTEM

This chapter stipulates a rational method in forming a set of evaluation criteria and developing an appropriate evaluation system which could be used to examine the adaptability of the presently available commercial flexible partition systems to residential applications in North America. As the research progressed it was understood that neither a host of information on each of the partition systems by itself, nor its organized documentation was able to give a satisfactory answer to the research question. A tool was essentially needed with the help of which it would be possible to evaluate whether the commercial flexible partition systems which were designed and marketed to meet a particular set of requirements could satisfy another set of requirements or not. This chapter is organized in three sections. Section one prepares the ground to an appropriate approach in forming the required set of criteria. Section two forms them in a logical order while section three developes an evaluation system suitable for the particular purpose.

## 4.1 Preparing the Ground for an Appropriate Approach: Towards Forming the Required Evaluation Criteria:

### 4.1.1 Construction of a Conceptual Framework: The Context of The Evaluation: The Parameters of the Investigation

To accomplish the objective of forming a tool, it was necessary to construct a conceptual framework within the boundaries of which the partition systems would be evaluated. Following paragraphs describe such boundary conditions.

At the inception in North America the concept of support and infill, as outlined in chapter two, is likely to bear significant appeal and seems to be more meaningful in the area of ownership housing market. As multi-family housing has already started to drift more and more away from rental to condominium ownership, the buyers would certainly want to personalize their dwelling units and would like to be willing to pay the price to do so. In other words, it would be quite logical to perceive that they would gladly pay the premium, if any, for this freedom of initial organization and potentials for future change (Wasserman, 1981). It would, therefore, be realistic to propose that the partition system under present investigations would be incorporated in various standardized and neutral building envelopes (i.e., the support variations) developed for 'condominiums for sale' situations in particular. However, in the existing North American housing scenario, even in the presence of the technology required, it might necessitate yet another research to identify flexible dimensional systems by using SAR methodology that would accommodate a large number of unforeseeable uses of the internal space. However, multi-unit housing in the present North American market, generally characterized by column and slab construction, could easily be built or adapted as support. It is, therefore, assumed that such adaptation could be possible without disrupting or changing the present system. It is further proposed that the flexible partitions under consideration would not be meant for being installed throughout a dwelling unit. For obvious reasons, wet cores like kitchen and toilet would have

fixed partitions.

As far as the nature of occupant participation is concerned, it is assumed that his intervention may take place at the conceptual level involving planning of his dwelling units, at the level of the execution of work related to the installation of the partition system or, at both levels. The possible options could, therefore, be combined in multiple ways depending on the local conditions, and occupant's interests and skills. The possible scenarios in which a developer could interact with an occupant within this conceptual framework are illustrated in fig. 4.1 while the major options are described in clearer terms in the following paragraphs.

One of the major scenarios, as shown in fig. 4.1, implies that the developer sells the support (or, the shell) with an incorporated heating system and sanitary appliances; the occupant plans his unit by himself with or without the help of a planning guide provided by the developer; he chooses the partition system according to his need, taste and budget within the choice provided by the developer. The developer installs the partitions (may be through a contractor) and adjusts the price according to the quantity and type of the system specified by the occupant.

The other major option, also shown in fig. 4.1, implies that the developer sells the support (or, the shell) with an incorporated heating system and sanitary appliance, the occupant plans his dwelling unit by himself with or without the help of a planning guide provided by the developer; he selects and buys partition system on the open market according to his need, choice and resources; installs the partitions by himself exercising his skills and putting his labor. However, in both the major options the partition system would belong to the occupant and he is supposed to maintain a reasonable stock of variable components (or, a storage) and tools that might be used or interchanged in case of future

transformations of the internal space of his dwelling unit which would most probably be associated with possible additions, omissions or relocations of the partitions.

It is further assumed that any additions, omissions or relocations of the partition system under consideration would take place in response to the changing needs of the occupant, as outlined in Chapter Two, and thus would only relate to the long range internal transformations, as shown in Fig. 4.2, as opposed to day to day, or day to night transformations of the internal spece of the dwelling unit. It is wise to make this assumption since feedback studies on flexible housing projects realized in western Europe reveal that although the mere knowledge that the layout can be altered, if so desired, has a positive effect on occupants' satisfaction and although the occupants value this opportunity most highly, transformation of the internal space in practice was rarely a day to day hobby of the occupants. Changes made after move-in only took place in relation to the necessity that emerged at different stages of the occupants' life cycle at reasonably lengthy intervals (Rabeneck, A., et al, 1974).

And lastly, it is important to note that the proposed context permits but does not require a change in the occupants' present role in the housing process in which his partitipation is limited to choosing a complete housing unit. This implies that the concept of support and infill should preferably be introduced gradually instead of trying to bring it in by disrupting the fibre of the existing housing process entirely by overnight.

### 4.1.2 Evaluation Approaches in Practice:

Bounded by the limits set by the context outlined in the last section, the quest for an appropriate approach in forming the required set

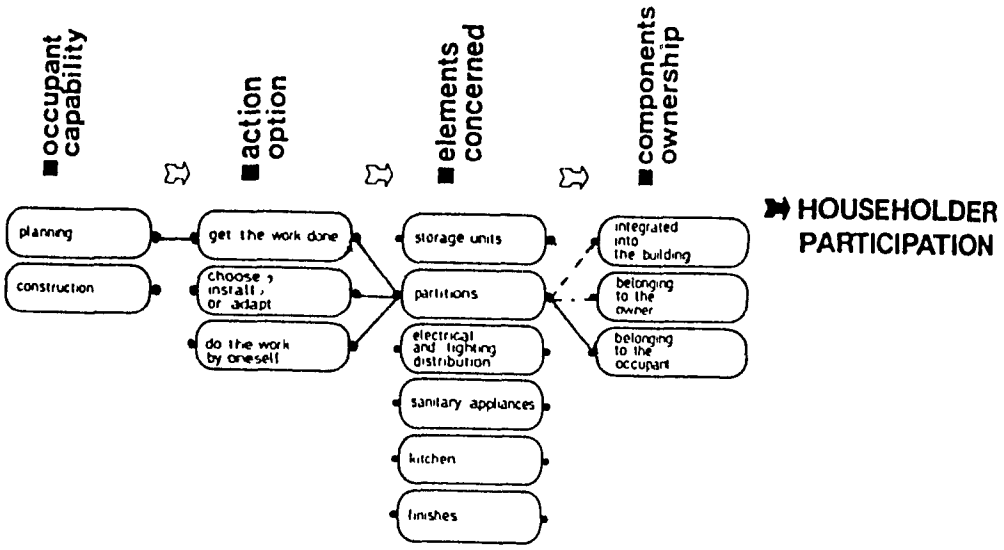


*Fig. 4.1*: Model of Developers and Householders Participation (After Warshaw, 1974)

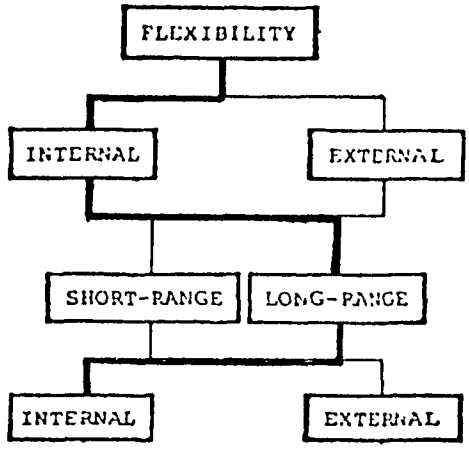


*Fig. 4.2*: Short and Long Range Flexibility and the Proposed Context
(After Dluhosch, 1974)

of evaluation criteria could set about. In order to formulate a rational approach, it was necessary to take lessons from the past experience on different evaluation systems that have been devised in several countries for assessing building products and materials. Two main streams of approaches were identified, as described in the following paragraphs, from a handful of evaluation schemes that were reviewed by the author from the available literature on this topic.

The first stream of approaches, as represented by the ER (Egenska predovisioning) system which has been developed in Sweden, is more concerned with general properties of a product or material rather than its use in some specific and defined way. The ER council, an organization founded for this purpose, publishes ER sheets containing complete and reliable information about the properties of products or materials based on extensive laboratory tests conducted uniformly for each of them by approved agencies. Similarly, the council publishes ER surveys which provide guidance on how to interpret the properties of products and materials. Thus, the ER sheets and the ER surveys provide a common framework for the project designer, product manufacturer, building contractor and building owner (The Editors of Industrialization Forum, 1970). This type of evaluation of general properties of building products and materials on the basis of laboratory tests by approved agencies is, in fact, not very uncommon in evaluation schemes in other countries. In North America, laboratory tests are generally conducted by approved agencies (e.g., Underwriters' Laboratory of Canada) and results are often incorporated with the related certification documents. However, keeping aside the impossibility of testing the properties of each and every commercial flexible partitions within the limited scope of the present study, this approach seems not to be logically pertinent for the present purpose since it is based on the statements of facts validated by the ER procedures, and not on statements of suitability of particular product in particular building situation.

The other stream of evaluation approaches as represented by The Method of Assessment and Testing (MOAT) devised in the United Kingdom, is based on the suitability of particular products or materials for particular building situations. A board called the Agrément Board has been formed in response to the need for a neutral organization which would provide unbiased and independent assessments of single proprietary products in specified uses. Therefore, in this system of evaluation, if a particular product or material claims more than one kind of use, then each needs to be considered separately. Since it is impossible to deduce the ***performance***[1] in use of a product or a material from its basic physical, chemical and mechanical properties alone, the provision of information sheets containing technical data is not the point of concern in this case. The Agrément Certificate issued by the Board is rather an evaluation of a material or a product based on fairly elaborate process of testing the levels of performance which the product or the material must demonstrate if it is to work satisfactorily in a specified building situation (Parker, 1970). Although the tests and the simulative experiments required for this method of evaluation, often at high expense, restrict the possibility of applying it directly to the present purpose, the underlying principle of performance in use seems to be useful and relevant. However, the fundamental principles of the concept of performance needs amplification to demonstrate how it is applied in evaluating existing profucts or materials before a systematic approach to fulfill the present objective could be developed.

### 4.1.3 Essentials of the Performance Concept

The concept of performance is, in fact, indispensable to evaluate

1 According to **Bennett** (1979), **the performance** of a material or a product is its "inherent capability to meet requirements set forth by the user. It is the product's ability to respond to user needs and environment impact."

an existing product or material in terms of ***user needs***[2] (Camous, R., 1972). It considers that the ***building process***[3] starts with user needs (or, participant needs) and ends up with a physical solution (i.e., the building itself) as shown in Fig. 4.3a. In simple terms, the physical solution is considered as 'good' if it corresponds to the needs of the participants that had been identified at the initial stage of the building process.

Verification of this correspondence or match necessitates an intermediate stage where the ***performance requirements***[4] (or performance attributes), i.e., the requirements that a particular solution is supposed to satisfy, are described without prejudging the means that would be used to achieve the physical solution. Each of the performance requirements or attributes could eventually be transformed into a ***measurable***[5] whole or parts which is termed as performance variables. Thus each of the performance requirements or attributes is made up of one or more performance variables (Mathur, 1980). For example, thermal comfort is one of the performance requirements of a building. The thermal comfort of a building has, in turn, temperature, air exchange per unit time, air speed and humidity as its constituent parts, each of which is a performance variable by itself.

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2 According to **Bennett** (Ibid) '**user needs** are requirements in building design that should provide an environment that supports, shelters and stimulates the users of a facility'.

**Rosen et al** (1979) defines **user needs** as 'identifiable human needs (physiological, sociological, psychological) resulting from the performance of daily living or working activities.'

3 According to **Mathur**, (1980) the **building process** involves two distinct acts: one is the design process which is the process of making proposals as how the physical solution in response to the user needs will be achieved; and the other is the production process which is the process of carrying out the proposals in order to achieve the physical solution.

4 **Rosen et al** (Op.cit.) define **performance requirements** (or, attributes) as 'statements developed from identified user needs and objectives that indicate an expected level of performance in order to fulfill a given function.'

5 **Blachère** (1970, pp. 3-8) holds that the **performance variables** could either be **quantifiable** or **non-quantifiable. Quantifiable variables** are the variables which could be expressed in numerical values. **Non-quantifiable variables** are the variables which could only be expressed in descriptive terms. If variables to be measured are non physical (e.g., pleasure, satisfaction), it is still possible to 'measure' (not in the physical sense) it by a subjective scale, a scale which can vary from one person to another.

Each of these performance variables must achieve certain performance levels to exhibit the desired requirements or attributes (e.g., thermal comfort) as per user needs. The performance level required of a variable, or the limit set on the performance level of a variable as per user needs, or, in some cases, as per statues (i.e. by-laws, codes, standards) is called a performance criterion (or, an evaluation criterion) which has already been defined in chapter one. Performance criteria could be set for each of the variables that bear significance on the final performance of a physical solution fo fulfill a specified function even before the solution is developed or available.

On the other hand, once the physical solution is developed and available, ***performance characteristics***[6] of each of its variables could be obtained from field observation or laboratory tests or simulative experiments. With criterion set for each of the variables, evaluation, as defined in chapter one, of the physical solution would consist in comparing the levels of the performance characteristics under each variable (i.e., the level obtained, or measured) against the respective criterion, (i.e., the level required) as shown in Fig. 4.3b. It is in this way that a physical solution could be evaluated, by comparing numbers where the variables could be expressed in numbers or by comparing phrases where it would not be possible to quantify them in a similar way. However, the hierarchy and the relationships of the constituent levels of a physical solution (or, a building) must be understood before an evaluation at the level of a building product could be done efficiently and analyzed meaningfully.

It is, therefore, very important to recognize that a building is an accumulation of interrelated components. The building products (e.g.,

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6 **The author** defines **performance characteristics** as 'the observed or measured level of performance of a variable obtained in reality after the first solution has been developed and made available, which might differ from its anticipated or projected level of performance'. (after Camous, 1972)

the flexible commercial partitions) which are offered on the market place by manufacturers are, in fact, components. The components which a building is composed of are numerous and can be simple or complex ranging from a floor tile, a window, a partition to a prefabricated kitchen or bathroom. These components are made from certain materials. In order to better comprehend what evaluation would mean at the level of components, an intermediate level, i.e., the level of functional element, should be introduced (as diagramically shown in Fig. 4.3c) between the level of building and component.

Functional element is a set of functions combined in a particular way in the building as a whole (Camous, Op.cit.). Some of the functions of a functional element can occur in another functional element, but a particular combination of each of them is unique. The internal subdivisions of a building are, for example, functional elements which have the general function of defining spaces in relation to different kinds of indoor human activities. The main components of internal subdivisions are: partitions, doors, ceiling system, floor tiles. The concept of functional element allows to pass from the level of components to the level of a building and makes it possible to describe the required performance at each level. It must be understood here that performances required at one level is dependent on the requirements at the level immediately above it. For example, performances required of a partition would depend on the type of internal subdivision it would eventually enclose.

On the other hand, unlike performance requirements, performance characteristics at any level would depend on the level immediately below it. For example, performance characteristics of wooden partitions are effectively different from those of a metal partition since properties of these materials which they are made of are different.

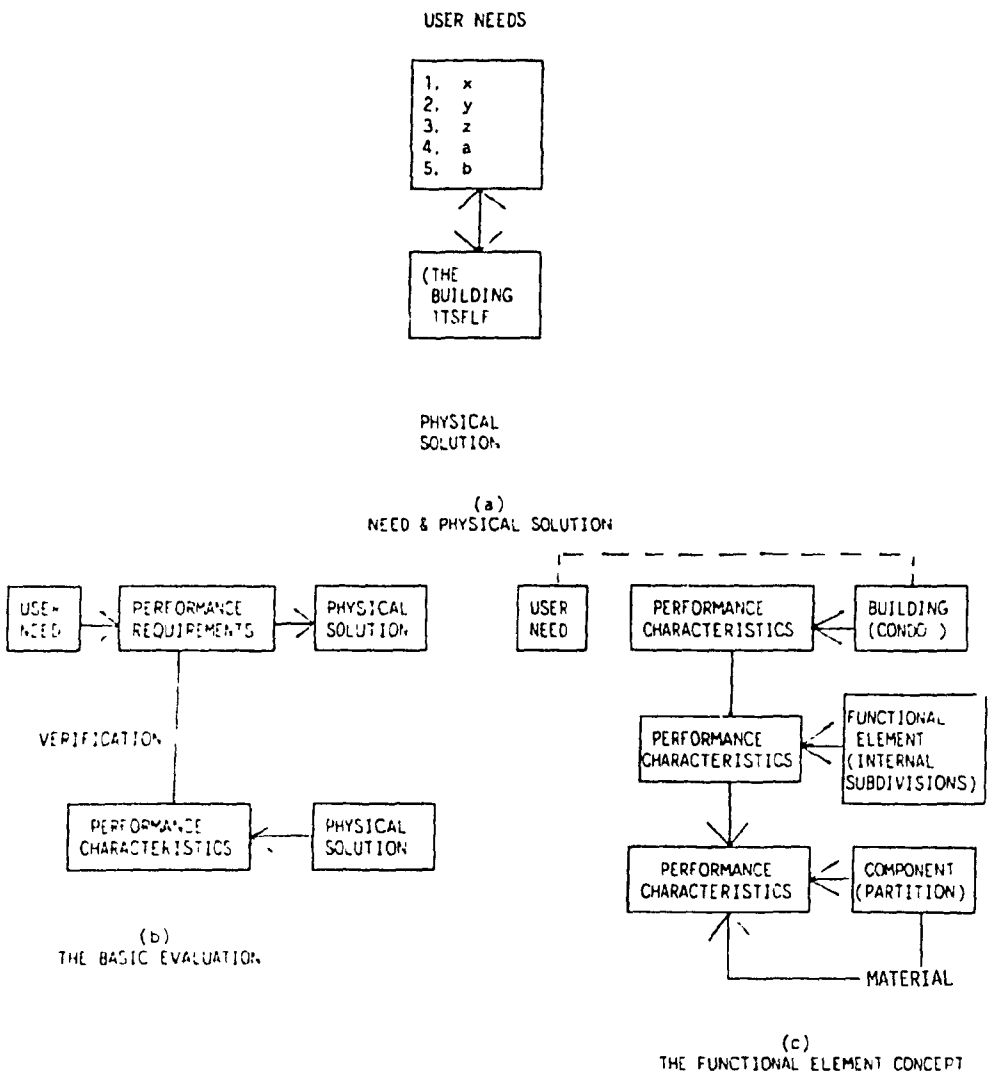


*Fig 4 3.* The Essentials of Performance Concept (after Camous, 1972)

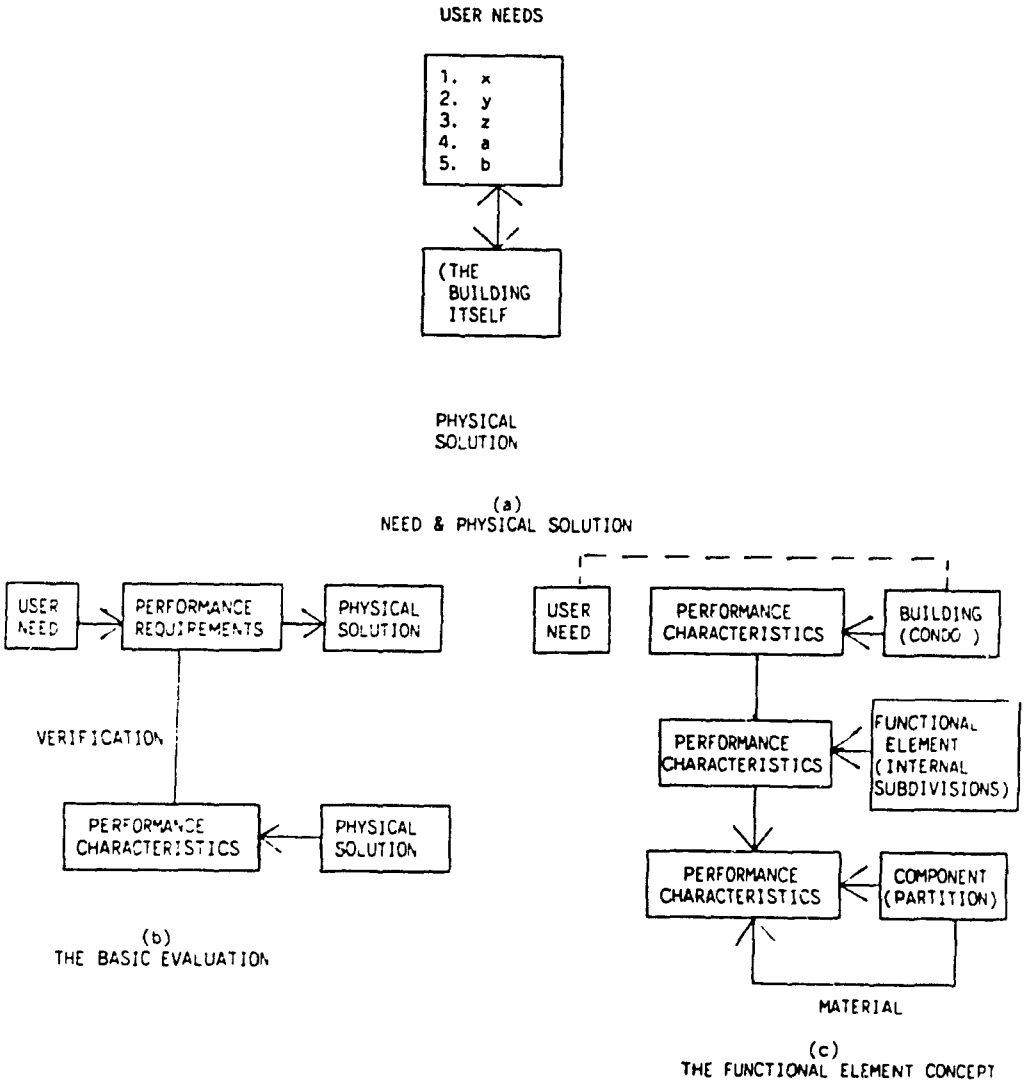


*Fig. 4.3*: The Essentials of Performance Concept (after Camous, 1972)

Keeping in mind the essentials of the performance concept described herein, it would be appropriate at this point to start to identify related participants in the housing process.

### 4.1.4 Identification of User: Relevant Participants in the Housing Process

It is important to point out the relevant participants in the housing process on the basis of whose needs, goals, and aspirations the performance requirements for the flexible partition system for free plan condominiums in North America would be set. Participants associated with the housing process in North America can be identified and their area of responsibility and involvement pinpointed in the following categories:

a) **Building Materials and Products Manufacturer:** The party who develops and markets building materials or building products.

b) **Design Decision Makers:** The design professionals (e.g., architects, engineers) who usually select building materials and products for a project.

c) **Developers (or, Builders):** The party (e.g., construction manager, contractor, sub-contractor) involved in the production phase of a project who generally make recommendations on building materials and products to bring a project in at the construction cost estimate.

d) **Householders (Or, Occupants):** The individuals who eventually occupy dwelling units generally after completion of the construction phase. In rare cases, they are allowed to select certain products and appliances as per their choice, needs and affordability.

Since commercial flexible partition systems, subject to the present evaluation, have already been manufactured and made available in the

market, the part of the manufacturer's objectives, needs and aspirations seems to diminish although the present study might initiate a process of developing a new system exclusively for residences.

The model of householders participation within the conceptual framework of the evaluation set in the beginning of this chapter makes the role of the design decision makers insignificant. It is, therefore, only justifiable not to include the needs of the manufacturers and the design decision makers separately in formulating the required set of criteria.

However, within the context set for the evaluation, successful adaptation of the commercial flexible partitions to domestic uses would primarily depend on the acceptance of the developers and the householders. Therefore, it would be logical to formulate the set of criteria on the basis of their needs and aspirations. It is well understood that there might be points of conflicts between the needs and aspirations of developers and those of householders but it is assumed and expected that, even from the developers' point of view, marketing potentials of dwelling units would largely depend on the needs and aspirations of the householders. Therefore, it would not be unjustifiable to consider only the common needs of these participants under different need categories.

### 4.1.5 Categories of User Needs:

User needs can be sorted into three categories: ***The Sociological Needs***[7] (or, **The Social Needs**), ***The Physiological Needs***[8] and ***The Psychological Needs***[9] (Rosen et al, Op.cit.; Blachère, 1970; Parson, 1972).

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7 **Bennett** (1979) defines **The Sociological Needs** as 'the basic human requirements that are produced by political, economical and cultural standards of society'.

8 **Bennett** (Ibid) defines **The Physiological Needs** as 'the basic physical requirements that are generated by survival and daily living'.

9 **Bennett** (Ibid) defines **The Psychological Needs** as 'the perceived human requirements generated by social pressures, reactions to the environment, and mental attitudes and states of mind.'

A step by step procedure could be followed to derive relevant performance requirements along with their variables from the grass root level of these three categories of needs and criterion for each of them could eventually be set.

## 4.2 Formulation of Evaluation Criteria

### 4.2.1 Evaluation Criteria from Sociological Needs

The sociological needs of the developers and the householders in relation to the incorporation of flexible partition system to dwelling units in condominiums would center around the word 'economy' (according to social scientists, economic aspect is a function of sociological order). Economic constraints placed on the developers and the householders must be evaluated since success with economic aspects is a quality on the same plane as success with the physical and other aspects of a building component. There is, therefore, no difference between economic and other performance requirements (Blachère, Op.cit.). It should also be noted here that in many cases the decision making participants in the housing process are restricted more by economics than by any other performance criteria (Rosen, Op.cit.). A step by step process of formulating evaluation criteria from the basic sociological need of 'economy' has been presented sequentially in a tabular form (Table 4.1). The table is followed by necessary explanatory notes to illustrate how acceptable levels of performance (or, the evaluation criteria) were assigned to each of the variables.

*Table 4.1:* **Sequential Presentation of Forming Evaluation Criteria in a Step by Step Procedure on the Basis of Sociological Need Common to Developers and Householders.**

| Sociological Need Common to Developers and Householders | Performance Requirements or attributes: | Performance Variables under such Performance Requirements | Evaluation or Performance Criteria Assigned to each of the variables (quantifiable or non-quantifiable) |
|---|---|---|---|
| Economic Needs | o Economy: should be compatible with the traditional fixed partitions in terms of cost and benefit | a. Cost ($ per l.ft)<br>i Cost of components<br>ii Cost of installation<br>iii Installated cost (i + ii) | The installated cost should not exceed $188 per linear feet (L.ft) |
| | o Durability:* The performance should continue to maintain its initial characteristics for a desirable length of time inspite of normal wear and tear | b. Useful life (years) | The useful life should be minimum 50 years |
| | o Maintainability:* should have a possibility for easy maintenance compatibles with normal domestic activities | c. Mode of cleaning operation | Should have provisions for cleaning with ordinary light wt. domestic cleaning appliances, and soft detergent without the help of machineries, washing liquids, equipments with special chemicals. |

* Although the developers are not directly concerned with durability and maintainability of the partitions, their interests in these two attributes are quite obvious since they would eventually add to the marketing potentials of these flexible partitions.

a) Cost: It is a difficult task to assign an appropriate cost criterion for flexible partition systems in residential applications. The concept of support and infill (or, flexibility in housing) is not designed primarily to reduce the cost of housing per se, but rather to match the dwelling accommodation to the budget of the householder and his short and/or long term needs. Nevertheless, both the developer and the householder would obviously be interested in the effect of introducing flexibility in housing on the cost of the dwelling units in terms of economics.

Intensive studies on economics of support consistently agree that there are great potentials for cost reductions in the new concept which could be classified into three categories: ***Short Term Benefits***[10], ***Integral Cost Benefits***[11] and ***Benefits Related to Depreciation and Finance***[12]. Additional costs, if any, in spite of the cost reductions should further be weighted against easy maketing potentials of the flexible dwelling units. It is, therefore, realistic to assume that the cost of flexibility in housing (or, the cost of the support structure) is compatible to that of conventional housing on the basis of the findings of several studies, one of which clearly states, 'given substantial quantitative benefits inherent in adaptable experiments in comparison to inflexible one; the study provides clear evidence that flexibility can be afforded' (Hartkopf, 1974).

The context set for the present evaluation implies that the

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10 **Lukez** (1986) defines **Short Term Benefits** as 'savings due to improved construction and building methods using off site production techniques, not necessarily by the same contractor.'

11 **Lukez** (Ibid) defines **Integral Cost Benefits** as 'savings which can be determined by understanding and controlling life-cycle costs over the life of a building.'

12 **Lukez** (Ibid) defines **Benefits Related to Depreciation and Finance** as savings by the households and the capital market consequent to the finance according to the life time of the components instead of life time of the entire building which make more money to be available in the capital market.

household, being assured that the cost of the support is compatible to that of the traditional dwellings, would be more concerned with the possible long term benefits of the flexible partitions since additional cost, if any, would be borne by them according to what they specify as per their taste and requirements. It would not be justifiable to assign cost per unit of conventional fixed partition as the acceptable figure for the flexible partitions since the flexible partitions offer additional future benefits to the households. These future benefits which are inherent to the flexible character of the partitions must be taken into accounts before arriving at a workable cost criterion. In other words, it would be a gross mistake to disregard flexible partitions only because of their higher initial costs as compared to those of conventional fixed partitions. **Thus, it necessitates a *life cycle costing*[13] instead of a simple costing to arrive at a meaningful cost criterion which would deal with the potential use rather than concentrating on the immediate use of the flexible partition itself.**

Now, it is necessary to deal with two different aspects of the problem to be able to solve for the cost criterion on the basis of life cycle costing. Firstly, varying tasks and their respective costs associated with conventional and flexible partition system in relation to the phenomenon of relocating them must be identified correctly. Table 4.2 shows all possible tasks in relation to a single relocation (Friedman, 1987). Secondly, the number of relocations of a particular partition over the ***life cycle***[14] must be

13 **Dell'Isola et al** (1981) defines **Life Cycle Costing** as "an economic assessment of an item, area, system, or facility and competing design alternatives considering all significant costs of ownership over the economic life, expressed in terms of equivalent dollars.

14 The **AIA** (1977) defines **life cycle** as "the period of time between the baseline date and the time horizon, over which the future costs relating to the decision or alternative under study will be incurred."

*Table 4.2*: **Tasks and Costs Associated with 'Conventional' and 'flexibility' Alternatives**
(after Friedman, 1987)

| Alternative Relocate wall between adjacent bedrooms | | | |
|---|---|---|---|
| CONVENTIONAL | | FLEXIBILITY | |
| TASKS | Cost[1] | TASKS[2] | Cost[1] |
| 1 Remove gypsum boards | C1 | 1 Unscrew boards | C1 |
| 2 Detach service lines (if exist) | C2 | 2 Detach service lines (if exist) | C2 |
| 3 Remove studs | C3 | 3 Unscrew studs | C3 |
| 4 Fix ceiling and floor | C4 | 4 Install the same studs in a new location | C4 |
| 5 Re-install new studs | C5 | 5 Install the same wall boards in a new location | C5 |
| 6 Re-connect service lines | C6 | | |
| 7 Cover studs with gypsum boards | C7 | | |
| 8 Plaster gypsum boards | C8 | | |
| 9 Clean up debris | C9 | | |
| 10 Paint | C10 | | |
| Cost (Conventional) | Cnc | Cost (Flexible) | Cnf |

predicted with a reasonable degree of accuracy. Studies on family growth consider a time span of fifty years as a realistic life-cycle period and reveal as shown in Fig. 4.3, that within this cycle there are six possible instants with respect to a ***base line date***[15] and a ***time horizon***[16] which might necessitate relocations of partitions including the initial arrangements as per needs, choice and affordability of households prior to move in (Tatsumi et al, 1987). It could, therefore, be assumed that households would relocate one particular partition at least three times (or, take advantage of the flexibility on fifty percent of the probable relocation occasions). If same number of relocations over the same time horizon is considered for conventional fixed partition and flexible partitions side by side, it would take the form as shown in Table 4.3. Contemporary prices indicate that total costs to install a solid fixed partition with gyproc on both sides of wooden studs with standard electrical provisions would be $35.00 per L.ft. The price for demolishing such a solid partition, on the other hand, would be $15.00 per L.ft as shown in Table 4.3.

15 The **AIA** (Ibid) defines **baseline date** as 'the starting point for the life cycle cost analysis, beyond which decisions deal with future courses of action'. It is the 'today' in the analysis. May be referred to as the baseline year (or analysis year 0).

16 The **AIA** (Ibid) defines **time horizon** as 'the ending point of the life cycle cost analysis. The cutoff, or last year, of the analysis.

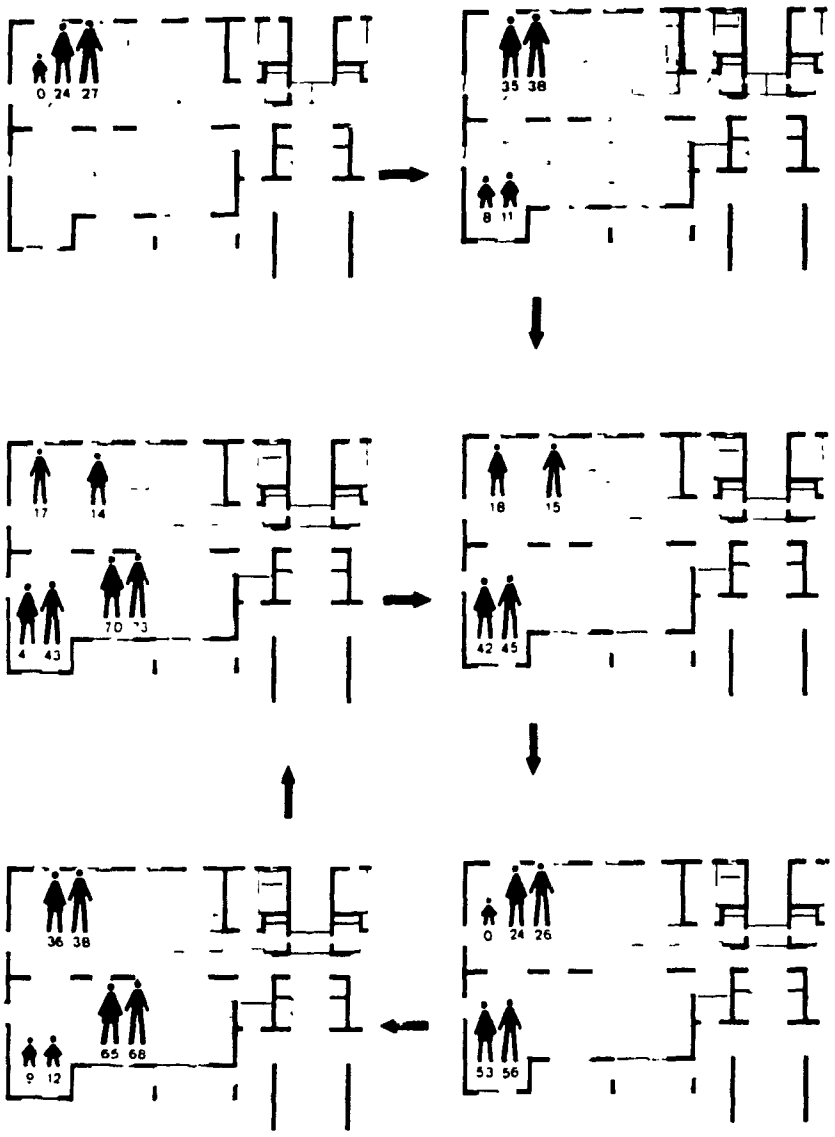



*Fig. 4.4*: Family Dynamics: Life-Cycle and Possible Instants of Relocating the Partitions (after Tatsumi et al, 1987)

***Table 4.3*: Cost of Conventional and Flexible Partitions**

| INSTANT IN TIME HORIZON | COST FOR CONVENTIONAL FIXED PARTITION (includes Service & Demolition Cost) | COST OF FLEXIBLE PARTITION |
|---|---|---|
| Base Line Date (Analysis Year 0) | $CC_I$ = Initial Cost of Conventional Partition ($35.50 per L.ft) | $CF_I$ = Initial Cost of flexible Partition |
| First Probable Relocation (Analysis Year 11) | $CC_1$ = Cost of First Relocation of conventional Partition ($51.00 per L.ft) | $CF_1$ = Cost of First Relocation of Flexible Partition |
| Second Probable Relocation (Analysis Year 29) | $CC_2$ = Cost of Second Relocation of conventional Partition (Identical with $CC_1$) | $CF_3$ = Cost of Second Relocation of Flexible Partition |
| Third Probable Relocation (Analysis Year 46) | $CC_3$ = Cost of Third Relocation of conventional Partition (Identical with $CC_1$) | $CF_3$ = Cost of Third Relocation of Flexible Partition |
| TOTAL | $CC_T = C_I + C_1 + C_2 + C_3$ | $CF_T = C_I + CF_1 + CF_2 + CF_3$ |

Now, life cycle cost saving or total saving over the life cycle of a household by incorporating flexible partition as against conventional fixed partition alternative takes the following mathematical expression:

$$LCS = \sum_{t=o}^{t=n} fn\ (CC_T - CF_T)$$

Where LCS = Life Cycle Cost Saving

fn = Multiplier Combining Time of Frequency of occurrence including Present Value Discount and Inflation Escalation.

$CC_T$ = Total Cost of Conventional Partition
$CF_T$ = Total Cost of Flexible Partition

It is possible to fix any combinations of the variables in the equation and solve for the unknown one. However, a ***Break-Even Analysis***[17] will be required to solve for the cost of flexible

17 The **AIA** (Ibid) defines **Break-Even Analysis** as 'a procedure for evaluating alternatives in terms of a common unknown variable. It involves solving for the value of the variable which will make the cost equations for the alternatives equivalent; this value is the break-even point'.

partition that would be compatible to its conventional counterpart. Allowing no life cycle cost saving (i.e. LCS=0) and substituting the value for $CC_T$ from Table 4.4, the break-even cost for flexible partition becomes $188 per L.ft. (For detail calculations refer to Appendix 5). It means that this is the amount that the two alternatives will be equivalent over a life cycle of fifty years allowing three relocations. If the unit cost of any flexible partition exceeds this amount, it will not be economically feasible as compared to fixed conventional partitions. Otherwise, if the unit cost of any flexible partition happens to be lower than this amount, there would be a cost saving (i.e., a life cycle cost saving) with respect to its conventional counterpart.

Therefore, this amount could be used as the upper limit of the cost criterion for flexible partitions most appropriately considering three relocations.

b) **Useful Life**[18]: The requirements for durability imply that the performance of the flexible partition system should continue to be satisfied for a specified period of time. **The criterion for useful life should obviously be identical to the life cycle of a household which is clearly indicated in Fig. 4.4, as fifty years.** Within this period no partition is expected to be replaced by the new ones.

c) **Mode of Cleaning Operations:** The requirements for maintainability are non-quantifiable, but yet criterion could be set with the help of simple, understandable and meaningful phrases. The context outlined in the beginning implies that the partitions would be

18 **Dell'esola** (op.cit.) defines **Useful Life** as 'the period of time over which a building element may be expected to give service'.

personal properties of the households and maintained by them. Easy mode of cleaning operation would help the households to maintain them from time to time, whenever necessary, over the entire life cycle. Therefore, it would be justifiable to set the following criterion: **The flexible partition should have provisions for cleaning with ordinary domestic cleaning appliances like light wt. mop using soft detergent, without the help of any heavy machineries or equipments that need special chemicals.**

### 4.2.2 Evaluation Criteria from Physiological Needs:

The physiological needs in relation to the incorporation of flexible partition common to the developer and the households could be identified as fitness for habitation (or, functional needs), fitness for manageable operation, and conformity with governing regulations. Table 4.5 illustrates the step by step formulation of evaluation criteria in relation to these physiological needs which will be followed by explanatory notes on the logic of assigning a criterion against each variable.

*Table 4.4:* **Sequential Presentation of Forming Physiological Criteria in a Step by Step Procedure on the Basis of Physiological Need Common to Developers and Households**

| Physiological Needs common to Developers and Householders | Performance Requirements or attributes derived from relevant physiological need common to developers and householders. | Performance Variables under each performance | Evaluation or Performance Criteria Assigned to each of the variables (quantifiable or non-quantifiable) |
|---|---|---|---|
| Fitness for habitation (i.e. functional needs) | Habitability:<br>o Should ensure a physical separation between functional spaces, either visually separated or, visually connected. | a. Transparency | Should offer the option between opaque and transparent materials. (Either Entirely Opaque or Entirely gazed) |
| | o Electrical network should easily be incorporated into the partition. | b. Electrical provisions | Should be able to incorporate electrical network and/or relocate the outlets without dismantling the system entirely by dismantling the acces panel and related panels only. |
| | o Should provide with hanging provisions for domestic decoration and functional elements. | c. Hanging provisions | Should have the provision for hanging or attaching lightweight decorative and/or functional elements at fixed locations only. |
| | o Should allow a choice of location of doors. | d. Door location and Type | Should provide a choice of interchangeable at any desired position, hinged door with opaque material. |
| Conformity with governing regulations. | Code acceptability:<br>o Should conform to the building code in relation to residential occupancies (i.e. it should meet the minimum level of fire resistance capacity, and interior sound level.) | e. Fire resisting capacity | Minimum 3/4 hr; minimum 1 hr for party wall. |
| | | f. Interior sound level (STC) | 30 |

*Table 4.4:* **Sequential Presentation of Forming Physiological Criteria in a Step by Step Procedure on the Basis of Physiological Need Common to Developers and Households**

Continued

| Physiological Needs common to Developers and Householders | Performance Requirements or attributes derived from relevant physiological need common to developers and householders. | Performance Variables under each performance | Evaluation or Performance Criteria Assigned to each of the variables (quantifiable or non-quantifiable) |
|---|---|---|---|
| Fitness for application | Practicability:<br>∘ Should be available to the developers or householders. | g. Availability | Should be available (or, delivered) to the households within 28 days after placing the order. |
| | ∘ Fixing conditions should correspond to the ceiling and floor construction techniques generally used in housing | h. Fixing conditions | Should be able to be fixed without provisions of double floor and/or suspended ceiling. |
| | ∘ Should easily be handled manually. | i. Panel dimension | Width: 1215 mm (4 ft.) |
| | | j. Panel weight | Weight range 44 - 65 kg/ (8' x 4') |
| | ∘ Should quickly be installed into the support. | k. Installation time | Range 2.5 man hr. - 2.9 man hr. per panel (8' x 4') |
| | ∘ Should require simple installation tools. | l. Installation tools | Installation should be possible with a set of lightweight tools with 1 electrical light wt. equipment. |

a) **Transparency:** Privacy and contact must balance in a residence. People need privacy in certain parts of a dwelling where they can concentrate on the activities like sleeping, relaxing, thinking or planning that compose a significant part of their domestic life. There might be certain parts of the dwelling, depending on individual choice, where a complete visual shutoff could not be desirable, rather a visual connection might appear to be more interesting in spite of a physical separation. On the basis of his realistic assumption the following criterion is set: **The flexible partition should offer an option between opaque and transparent materials.**

b) **Electrical Provisions:** It could be realistically assumed from the context of evaluation outlined in the beginning that the location of electrical outlets would be determined by the households in relation to the plans made by them which might change their positions during the life-cycle. Therefore, the partition system should possess an easy-to-manage electrical network (i.e., cabling, outlet sockets) which generates the following criterion: **The flexible partition should be able to incorporate electrical network and/or relocate the outlets by dismantling the access and related panels only without dismantling the system entirely.**

c) **Hanging Provisions:** The purpose of a partition is to physically separate two functional spaces which might or might not be identical. Although a partition is, generally common to two functional spaces, its characteristics in two sides might change in relation to the space it encloses. For example, characteristics of a partition which divides a living room and a bedroom might vary on the two sides of it. In fact, lightweight functional elements and/or decorative pieces attached to or hung from the partition bring this characteristic change. Therefore, to bring these characteristic and subtle changes in the partition, attachment and hanging provisions should exist which necessitates the following criterion: **The flexible partition should have the provision for hanging or attaching lightweight decorative and/or functional elements at least at fixed locations.**

d) **Door Locations and Type:** The context of evaluation implies that the households would plan their own dwelling unit according to their needs, choice and affordability. Therefore, the partition system should provide the possibility of locating different types of door at any desirable position which might be interchanged during the life-cycle. This necessitates the following criterion:

**The flexible partition should provide a choice of interchangeable door locations (hinged and opaque type) at any desired locations as per requirements of the households.**

e) **Fire Resisting Capacity:** According to **The National Building Code of Canada** for safety reasons, **the partition system should have the fire resisting capacity of 3/4 hr. to be used as an internal partition, and the fire resistance capacity of 1 hr. to be used as a partition between two adjacent dwelling units.**
**(refer to Appendix 6)**

f) **Interior Sound Level:** Overall sound insulation should be provided by the partition system to ensure acoustical privacy within a dwelling and also in between two adjacent dwelling units. A study of The National Building Code of Canada reveals that the minimum sound levels for party walls must have a STC of 40. Feedbacks from already realized flexible projects, as described in chapter two, indicate that **such levels could be a minimum of STC 30 for internal partitions.**

g) **Availability:** The partition system should be readily available as per requirements of the developers and/or households. It is expected that after selecting the partitions neither the developer nor the households would wait too long for its delivery It is assumed by the author that both the parties could wait maximum 28 days after placing the order for the partitions. The criterion therefore reads: **The flexible partition system should be available (~~ delivered) to the developers or the households within maximum 28 days after placing the order.**

h) **Fixing Conditions:** Fixing conditions of the flexible partition system should correspond to ceiling and floor construction techniques generally used in housing. The partition system which

requires any special conditions (e.g., suspended ceiling, double floor) would not be adaptable to dwellings. Therefore, the following criterion is set: **The flexible partition should be able to be fixed without provisions of a double floor or a suspended ceiling at floor and ceiling levels respectively.**

i) **Panel Dimension:** The width of the panel should preferably be capable of being handled by a single person. **Study of standards reveal that a maximum width for easy handling by a single person should be 1200 mm (4 ft.).** However, variations in the panel width especially smaller width would be more preferable to suit to different internal dimensions.

j) **Panel Weight:** It is revealed from the feedback studies on the realized flexible projects, as described in chapter two, **that weight of each panel (8' x 4') should preferably be in the range of 44 kg. - 65 kg. to ensure easy handling and installation.** The lower limit (i.e., 44 kg.) is for a single person handling, while the upper limit (i.e., 65 kg.) indicates two-man handling.

k) **Installation Time:** It is expected that a rearrangement of the internal space of a dwelling unit would take place during the off time of the households, i.e., during weekends or holidays. As shown in Table 4.6, mode of manipulation for different types of objects in flexible housing scheme varies with their hiearachy of flexibility. Thus, partitions require two or more persons to manipulate (Dluhosch, 1974). **This knowledge coupled with the experience from already realized projects in Europe, as reviewed in chapter two, indicate that the maximum acceptable range to install a single panel (8' x 4') should be 2.5 man hr. - 2.9 man hr.**

***Table 4.5*: Hierarchy of Flexibility and Different Mode of Manipulation**

(After Dluhosch, 1974)

| Type of Object | Mode of Manipulation |
|---|---|
| Small use objects including hand tools gadgets and implements | Easily manipulated by hand by a single person (note difference levels by age and health) |
| Non attached medium size objects furniture tools implements etc | Capable of manipulation by exertion of a whole body |
| Semi attached and detachable objects components or sub assemblies including partitions | Require two or more persons to move or manipulate or minor mechanical aid |
| Units assemblies etc | Capable of manipulation by mechanical means only |

1) **Installation Tools:** The partition, as specified in the context, would be installed by the developer or by someone appointed by the householder, or self installed by the householder. In any case, it would be desirable by all parties, that tools required for the installation should be simple and easily manageable. The following criterion is, therefore, set: **Installation of the partition should be possible with a set of light weight tools allowing maximum one piece of light weight electro-mechanical equipment.**

### 4.2.3 Evaluation Criteria from The Psychological Needs:

**The psychological needs of the developers and the households in relation to the flexible partition represent one of the most important yet very obscure area.** Psychological needs tend to vary from person to person as opposed to physiological needs which tends to be shared. However, needs common to developers and households could be generalized under the term 'aesthetic needs'. Logical formation of Psychological Criteria follows in Table 4.7 with explanations that follow.

*Table 4.6:* Sequential Presentation of Forming Psychological Criteria in a Step by Step Procedure on the Basis of Psychological Needs Common to Developers and Households

| Physiological Needs common to Developers and Householders | Performance Requirements or attributes derived from relevant physiological need common to developers and householders. | Performance Variables under each performance | Evaluation or Performance Criteria Assigned to each of the variables (quantifiable or non-quantifiable) |
|---|---|---|---|
| Aesthetic Needs | Appearance:<br>• The appearance of the flexible partition should blend into the residential character of the dwellings. | a. Modular characteristics | Should be non-modular in appearance with no visible vertical batten. |
| | | b. Color | There should be at least eight different colors available from which the developer or the households would choose. |

a) **Modular Characteristics:** As described in Chapter Two, the households tend not to prefer the modular appearance (i.e., strong visual lines between the panel or any visual element which indicates its flexible character) in the internal partitions of their dwelling units. The following criterion is, therefore, set: **The flexible partition should be non-modular in appearance with no visible vertical battens.**

b) **Color:** Reactions to color are highly individual. Color preferences of people are personal and revealing which gradually grow from experiences and cultural associations. Color creates perceptions about light since there is no color without light. There should at least be a range of colors from darker to lighter shades to allow the households select according to their choice Studies reveal that people generally prefer eight different color shades for the finished surface of the interior of their dwellings. The following criterion is, therefore, assigned: **There should be at least a range of eight different colors of the finished surface of the partition system from which the households can select.**

## 4.3 Developing Appropriate Evaluation System:

### 4.3.1 General Considerations: Some Important Clarifications:

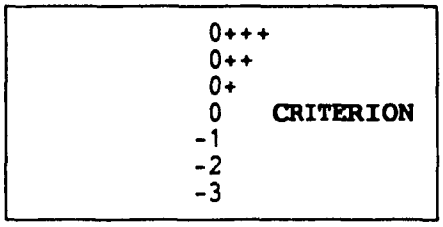
For an easy understanding and comparison of performances of different variables of a particular flexible partition system, a numerical rating (or, grading) scale would be useful. However, it would not be justifiable to rank order the variables since relative importance of user needs is a function of individual priority. Moreover it would be misleading to attempt to summarize evaluations under each requirement in a single comprehensive assessment. In other words, it would be meaningless to make a weighted summation of all the ratings for a

particular partition. If a common scale for rewarding extra performance and for penalizing missing performances are set, it would be arbitrary. Mixing performances of many variables being completely uninformed as to the proportion of people who are more sensitive to what, would therefore, not be desirable. Individuals would be capable of making the synthesis of the evaluation corresponding to the performance of the variables as per their preferences. The significance of a method which helps with quality evaluation is that it makes the evaluation of each aspect explicit, and not that it provides a comprehensive single numerical evaluation (Blachère, Op.cit.).

### 4.3.2 Performance Rating Scale

A simple numerical rating scale is necessary for an easy understanding, comparison and analysis of performances of different variables of a particular flexible partition. To construct such a scale, generally, minimum or maximum acceptable levels of performance of a variable (i.e., the criterion) are rated as '0', and bonus points are awarded for additional performances up to a limit, above or below which additional performance yields no additional benefit (Parsons, Op.cit.). It is beyond the scope of the present study to derive such limits for each variable since it requires extensive information on performance and benefit in relation to the user. Moreover, it is perceived at this point that if performance of a variable of a particular commercial flexible partition system exceeds the criteria formulated herein, it does not make it 'better' for residences. It is obviously 'worse' if it does not meet them. Therefore, the following rating procedure is undertaken: The rating 0 for any variable would mean that it meets the criterion. Any negative value from -1 to -3 would mean that the measured performance of that variable is deficient in meeting the criterion. While, on the other hand, if the observed performance exceeds the criterion, it would be denoted as 0+, or 0++ or 0+++ depending on the degree by which it exceeds

the criterion. Thus, the performance of each variables are grouped under seven grading categories as follows:




Details of such categorizations for the performance of variables are properly placed in the next chapter, (i.e., chapter five) along with the evaluation of flexible partitions.

### 4.3.3 Evaluation of Commercial Flexible Partition System

Being equipped with a set of evaluation criteria and an evaluation system, it is possible to select a number of commercial flexible partition system and put them under evaluation to examine their adaptability to residential applications. The next chapter (i.e., chapter five) deals with such selections and evaluations.

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## 5.1 A Brief Introduction to Commercial Flexible Partition System: Their Classification:

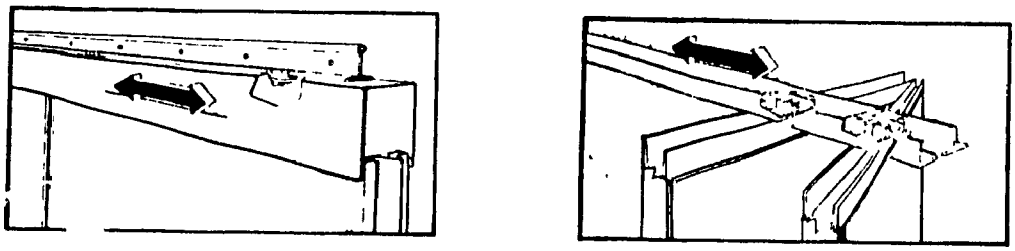
A commercial edifice is generally considered to be a constantly changing environment since its management, personnel and policy change from time to time. Such a changing environment often requires reconfiguration of its internal space. Commercial flexible partition system, as already defined in chapter one, makes such configurations in little time, and with minimum disruption to commercial activities. Unlike fixed drywall, these partitions are engineered to precision in order to eliminate demolition and thus safeguarding data, communication and electrical network, equipment and furniture from construction hazards. Most of them are able to meet the most sophisticated layout requirements of commercial edifices. Since inception, commercial flexible partition systems are available in various kinds differing in technology, standards, constituent materials, visual quality and nature of flexibility.

The range of choices for commercial flexible partition systems available in the North American market include three distinct types that could be categorized under three broad headings and characterized as follows:

a. **Mobile or Operable Partition System:** This type of partition system is generally composed of a series of panels generally suspended on wheels which are capable of moving along the tracks and trolleys provided by the system. The panels are either manually handled or electrically operated. There are two different kinds of mobile partitions: sliding type, and folding type. Sliding type partitions generally have panels which could be slided, if desired, and stacked on the stacking end of the partition as shown in fig. 5.1a. On the other hand, folding type partitions offer a series

of panels connected by hinges in most of the cases, which could be folded and stacked at the end, if desired, as shown in fig.5.1b. Mobile or operable partitions are available in a wide range of finishes from vinyl to genuine wood and plastic laminate. They are generally used in spaces where a quick transformation (i.e., day to day, or day to night) is required (e.g., in restaurants, or in gymnasiums).

b. **Demountable Partition System:** This type of partition system is generally composed of wallboards installed parallel to each side of metal studs placed at specified intervals. The panels are held in place by ceiling or floor tracks and the studs as shown in fig. 5.2. Demountable partitions could be relocated, if desired, since they are made of interchangeable and reusable panels. They are generally adaptable to virtually any plan, or to the client's changing requirements. In most of the cases, relocation costs are claimed to be fractions of the expense of changing a fixed partition. They are usually used in commercial spaces where transformation of space is required but not everyday, that is to say, at reasonable intervals (e.g., in office buildings).



(a)
Sliding Type

(b)
Folding Type

Fig. 5.1: Mobile or Operable Partition

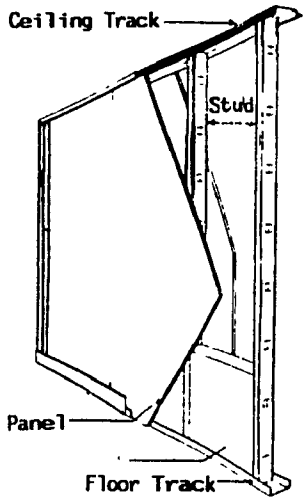



Fig. 5.2: Demountable Partition

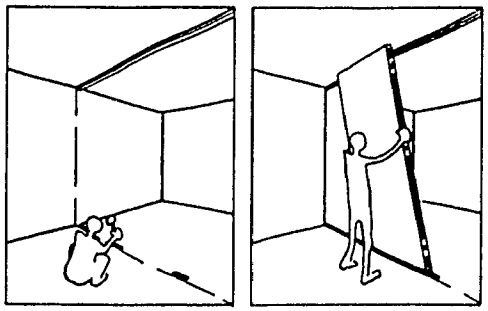


Fig. 5.3: Portable Partition

c. **Portable Partition System:** This type of partition is generally composed of prefabricated and self-contained wallboards held in position by metal channels at floor and/or ceiling levels as illustrated in Fig. 5.3. The panels are often made of honeycomb coreboards with face layers of wallboards laminated with adhesives. The panels are interlocking and generally no stud is required for their erection. These partitions can also be adapted to any plan or client's requirements. They are extensively used in offices, industrial and institutional buildings where clients are beset with space alterations frequently.

## 5.2 Screening Mechanism: Meticulous Selection of the Partitions for Evaluations:

With the classifications of partition systems made in the last section, it is very important to screen out or eliminate certain portions of them from the evaluating process which do not match the context of the study to avoid unnecessary work.

In the first consideration, all the partition systems that fall under the category of mobile or operable system could be eliminated since they have successfully been applied in residences since architects like Le Corbusier and Adolf Rading had displayed their potential use in residences long ago as described in Chapter Two. Therefore, there is no valid reason to pose a question once again on their adaptability in residences. Moreover, the context of the present study clearly indicates its main focus, i.e., the long term trans-formation of internal space as opposed to its instantaneous transformation, in which the mobile or operable system seems to bear a little significance.

In the second consideration, all the partial height partitions could also be eliminated from the process since their use in residences are most unlikely. Partial height partitions for commercial toilets could

also be eliminated for the same reasons.

And lastly, all the flexible partition systems meant for any special applications (e.g., clean air partitions for hospitals, bullet proof partitions for high-risk areas), are excluded from the process since their use in residences could hardly be justifiable.

Therefore, it follows that only full height partitions meant for normal applications and fall within the categories of Demountable and Portable options could be selected for the present evaluations. However, from the partitions selected thus, only those on which complete and relevant data were available would finally be advanced to the evaluating stage.

## 5.3 Source of Data:

Data presented in this chapter is based on the following sources:

a. Technical literature (i.e., product catalogues) published by manufacturers.

b. Personal Interviews with sales representatives of all the manufacturers whose products are being evaluated in this study.

c. Structured conversation over the telephone with representatives of selected manufacturers, several contractors and personnels involved with the construction industry.

## 5.4 Organization and Presentation of Relevant Data: Documentation of Evaluations:

Becoming acquainted with a product is considered to be the first step in putting it to work. Therefore, it seemed to be very important to familiarize the readers with each of the partition systems before evaluation with respect to their residential adaptability could be

meaningfully communicated to him. Moreover, it is expected that a brief introductory information on each of them might enable the reader to find out data which could be important to him for any particular reason.

For each of the selected partitions relevant information and subsequent evaluations are organized in three parts one following the other. The first part (i.e., Part A) briefly introduces the partition system under study, the second part (i.e., Part B) puts it into evaluation, while the third part (i.e., Part C) addresses the research question and subsequently derives conclusions. All the data and evaluation for each partition are presented in suitable and self explanatory formats with broad comprehensive headings. The following sections accomodate such information and evaluations preceded by a performance rating scale common to all of them.

## 5.5 Performance Rating Scale Common to Partitions under Evaluations

As indicated in the last chapter, the following table presents the performance rating scale that has been constructed to assess the performance of different attributes of each of the selected partitions numerically with respect to their respective criteria:

**Table 5.1: Performance Rating Scale**

| Performance Variables | Rating Scale |
|---|---|
| a. Cost | 0+++ Life Cycle Cost $165 per L.ft and less<br>0++ Life Cycle Cost $166 per L.ft-$176 per L.ft<br>0+ Life Cycle Cost $177 per L.ft-$187 per L.ft<br>0 Life Cycle Cost $188 per L.ft<br>-1 Life Cycle Cost $189 per L.ft-$199 per L.ft<br>-2 Life Cycle Cost $200 per L.ft-$210 per L.ft<br>-3 Life Cycle Cost $211 per L.ft and above |
| b. Useful Life | 0+++ 61 years - above<br>0++ 56 years - 60 years<br>0+ 51 years - 55 years<br>0 50 years<br>-1 45 years - 49 years<br>-2 40 years - 44 years<br>-3 39 years and less |
| c. Mode of Cleaning Operation | 0+++ Without machineries with a piece of dry cloth or brush<br>0++ Without machineries with water & piece of cloth or spunge<br>0+ Without machineries with water and light weight mop<br>0 Without machineries with soft detergent and a light weight mop<br>-1 With light equipment and detergent<br>-2 With heavy machinery and detergent<br>-3 Factory cleaning upon dismantling only |
| d. Transparency | 0+++ Opaque, Option of glazing at any desired positions<br>0++ Opaque, Option of glazing at more than 1 fixed positions<br>0+ Opaque, Option of glazing at 1 fixed positions<br>0 Entirely Opaque, or Entirely Transparent<br>-1 Opaque only, no choice<br>-2 Transparent only, no choice<br>-3 With punches, see through only |
| e. Electrical Provisions | 0+++ Possible by removing the baseboard or post cover only<br>0++ Possible by removing battens, baseboards, trims, postcovers.<br>0+ Possible by removing only one particular panel involved<br>0 Possible without dismantling the partition as a whole, dismantling the access panel and related panels only<br>-1 Possible by dismantling the partitions (1 side only)<br>-2 Possible by completely dismantling the partitions (all sides)<br>-3 Not possible at all |

**Performance Rating Scale (Continued)**

| Performance Variables | Rating Scale |
|---|---|
| f. Hanging Provisions | 0+++ Possibility of hanging and/or attaching light heavy wt. functional or decorative elements at any desired location (with reinforced backing).<br>0++ Possibility of hanging and/or attaching moderate wt. functional or decorative elements at any desired location (with reinforced backing).<br>0+ Possibility of hanging and/or attaching moderate wt. functional or decorative elements at fixed locations only.<br>0 Possibility of hanging and/or attaching light wt. functional or decorative elements at fixed locations only.<br>-1 Possibility of adhesive type light wt. hangers only.<br>-2 Possibility of pasting paper type decorations only.<br>-3 No possibility of pasting or hanging anything at all. |
| g. Door Location and Type | 0+++ Interchangeable door position at any desired location, any type hinged or sliding; any material - opaque or glazed.<br>0++ Interchangeable door position at any desired location, any type - hinged or sliding, opaque material.<br>0+ Interchangeable door location at any desired position, hingered type, opaque or glazed material.<br>0 Interchangeable door locations at any desired position, hinged door with opaque materials<br>-1 Interchangeable door locations at 3 fixed positions only.<br>-2 Interchangeable door locations at 2 fixed positions only.<br>-3 Interchangeable door locations at 1 fixed position only. |
| h. Fire Resisting Capacity | 0+++ 3 1/2 hr. - 4 hr.<br>0++ 2 1/h hr. - 3 hr.<br>0+ 1 1/2 hr. - 2 hr.<br>0 3/4 hr. - 1 hr.<br>-1 30 min. - 44 min.<br>-2 15 min. - 29 min.<br>-3 1 min. - 14 min. |

**Performance Rating Scale (Continued)**

| Performance Variables | Rating Scale |
|---|---|
| i. Interior Sound Level (STC) | 0+++ 41 - above<br>0++ 36 - 40<br>0+ 31 - 35<br>0 30<br>-1 25 - 29<br>-2 20 - 24<br>-3 19 and less |
| j. Availability | 0+++ Available in 13 days, or less.<br>0++ Available within 14 days - 20 days after placing the order.<br>0+ Available within 21 days - 27 days after placing the order.<br>0 Available in 28 days after placing the order.<br>-1 Available within 29 days - 35 days after placing the order.<br>-2 Available within 36 days - 42 days after placing the order.<br>-3 Available within 43 days - and more. |
| k. Fixing Conditions | 0+++ -<br>0++ -<br>0+ -<br>0 Double floor/suspended ceiling not required<br>-1 Suspended ceiling required.<br>-2 Double floor required.<br>-3 Double floor and suspended ceiling both required. |
| l. Panel Dimension | Width<br><br>0+++ Any width as desired<br>0++ 3'-8" - less<br>0+ 3'-6" - 3'-11"<br>0 4'-0"<br>-1 4'-1" - 4'-6"<br>-2 4'-7" - 5'-0"<br>-3 5'-0" - above |
| m. Panel Weight | 0+++ 25 kg. and less<br>0++ 24 kg. - 33 kg.<br>0+ 34 kg. - 43 kg.<br>0 44 kg. - 65 kg. per panel (8' x 4')<br>-1 66 kg. - 75 kg.<br>-2 76 kg. - 85 kg.<br>-3 85 kg. and above |

**Performance Rating Scale (Continued)**

| Performance Variables | Rating Scale |
|---|---|
| n. Installation Time | 0+++ 1.0 man hr. and less<br>0++ 1.5 man hr. - 1.9 man hr.<br>0+ 2.0 man hr. - 2.4 man hr.<br>0 2.5 man hr. - 2.9 man hr.<br>-1 3.0 man hr. - 3.4 man hr.<br>-2 3.5 man hr. - 3.9 man hr.<br>-3 4.0 man hr. and above |
| o. Installation Tools | 0+++ Light wt. tools only.<br>0++ Light wt. tools with 1 special light wt. equipment.<br>0+ Light wt. tools with more than 1 special light wt. equipment.<br>0 Light wt. tools with 1 electrical light wt. equipment.<br>-1 Light wt. tools with more than 1 electrical light wt. equipment.<br>-2 Heavy tools with 1 electrical equipment.<br>-3 Heavy tools with more than 1 electrical equipment. |
| p. Modular Characteristics | 0+++ Monolithic single piece.<br>0++ Almost invisible hairlines.<br>0+ Visible vertical grooves only.<br>0 No vertical battens.<br>-1 Embedded visible vertical battens.<br>-2 Light visible vertical batten.<br>-3 Strong visible vertical batten. |
| q. Color | 0+++ Any color (could be printed).<br>0++ 12 - more.<br>0+ 9 - 11 Colors.<br>0 8 Different Colors.<br>-1 5 - 7 Colors.<br>-2 2 - 4 Colors.<br>-3 Single Choice. |

## 5.6 Evaluations of Selected Commercial Flexible Partition Systems (In Alphabetic Orders)

### 5.6.1 Dampa(R) Mova-Wall Partition System

Part A: General Data

Manufacturer: Dampa Inc.

Category: Demountable Partitions, Non-Progressive or Progressive Type

Features: Variety of colors of Aluminium Trims and PVC Vinyl Trim to complement many Vinyl Board colors.
Available in 4 different thicknesses offering varying degree of acoustical privacy.
Battenless construction possible with special fasteners called Skru-It Concealed Fasteners.

Main Properties:

1. Thickness: 4 options, 89 mm (3½") 95 mm (3 3/4"), 117 mm (4 5/8") and 124 mm (4 7/8")
2. Weight per Panel (8'x4'): 64 kg (140 lbs) and 80 kg (176 lbs) (depending on thickness)
3. Fire Rating: 1 hr
4. Sound Rating (STC): 35-51 depending on thickness and Batten or Battenless options

Major Components:

1. Steel Stud 64 mm (2½") or 92 mm (3 5/8")
2. Steel Top Track and Floor Track
3. Gypsum Board with Vinyl covers
4. Skru-It Fasteners
5. Miscellaneous Trims

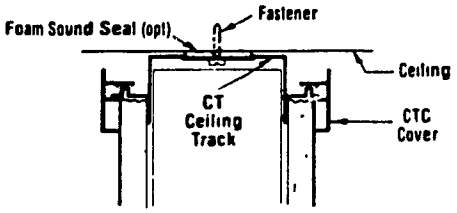
Installation Details:

1. Setting of Steel Studs into Steel Tracks at floor and ceiling.
2. Installation of services in the partition cavity and incorporation of acoustic insulation if required (R8 fibreglass)
3. Installation of Progressive or Non Progressive Panels. For Battenless surface, E-Clip Concealed Fasteners used.
4. Installation of Trims.

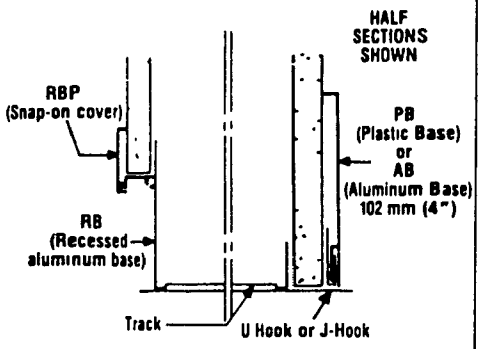
## Dampa(R) Mova-Wall Partition System (cont.)

Part A: General Data (cont.)

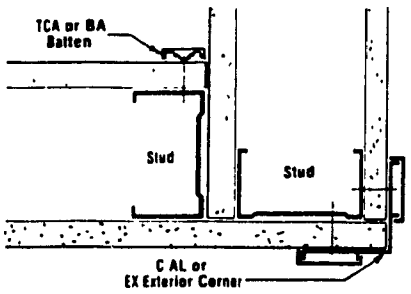
Pictorial Presentation of Technical Details



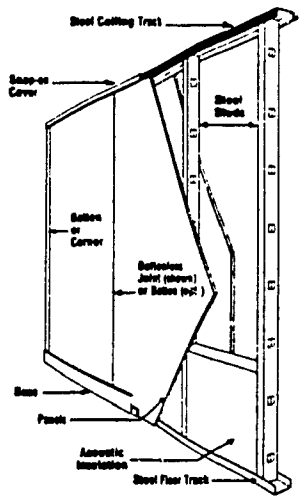

Section at Ceiling Level




Section at Floor Level




Standard Exterior Corner



Sectional Perspective of Basic System

## Dampa(R) Mova-Wall Partition System (cont.)

Part B: Evaluations:

| Attributes | Performance Variables | Performance Criteria | Observed Performance | Performance Rating |
|---|---|---|---|---|
| Economy | a. Cost | | | |
| | i)Cost of Components | - | $ 60 per L.ft. | |
| | ii)Cost of Install-ation | - | $ 30 per L.ft. * | |
| | iii)Installed Cost | - | $ 90 per L.ft. | |
| | iv)Life Cycle Cost | $188 per L.ft. (height 8') | $180 per L.ft. | 0+ |
| Durability | b. Useful Life | 50 years (min.) | 50 years | 0 |
| Maintain-ability | c. Mode of cleaning | Should have provisions for cleaning without machineries with soft detergent and a light wt. mop. | Without machi-neries, with soft detergent and light wt. mop. | 0 |
| Habitab-ility | d. Transparency | Should at least be of entirely opaque or en-tirely transparent ma-terials (2 options). | Option of glazing at any desired positions. | 0+++ |
| | e. Electrical Provisions | Should be able to in-corporate electrial network and/or relocate the outlets without dismantling the systems entirely. | Possible by removing 1 par-ticular panel involved. | 0+ |
| | f. Hanging Provisions | Should have the pro-vision for hanging or attaching light wt. functional and/or decorative elements. | Moderate wt. functional/dec-orative elements at fixed loca-tions. | 0+ |
| | g. Door Location & Type | Should offer choice of interchangeable door location at any desired position, normal hinged type, with opaque mate-rial. | At any desired position, hinged, opaque. | 0 |

*includes the costs for minor patching of the marks, lines or patterns, if any, of the floor and the ceiling (for all the partition systems reviewed in this report)

## Dampa(R) Mova-Wall Partition System (cont.)

Part B: Evaluations (Cont.)

| Attributes | Performance Variables | Performance Criteria | Observed Performance | Performance Rating |
|---|---|---|---|---|
| Code Acceptability (i.e., conformity with governing regulations) | h. Fire Resisting Capacity | 3/4 hr. - 1 hr. | 1 hr. | 0 |
| | i. Interior Sound Level (STC) | 30 (min.) | 35 - 52 (depending on different thickness) | 0+++ |
| Practicability | j. Availability | Should be available in 28 days after placing the order. | 7 days | 0++ |
| | k. Fixing Conditions | Should be able to be fixed without provisions of double floor and/or suspended ceiling. | Double floor suspended ceiling not required | 0 |
| | l. Panel Dimension | Width: 4' (max.) | 2' - 6" - 4' - 0" | 0+++ |
| | m. Panel Weight | Weight Range 14 kg. - 65 kg. per panel. (8' x 4') | 64 kg per panel | 0 |
| | n. Installation Time | 2.5 man hr. per panel (8' x 4') | 2.5 man hr. per panel | 0 |
| | o. Installation Tool | Installation should be possible with a set of light wt. tools with max. 1 electrically operated light weight. | Light wt. tools with 1 electrical equipment | 0 |
| Appearance | p. Modular Characteristics | Should be non-modular in appearance with no visible vertical battens. | Option of battenless construction | 0 |
| | q. Color | There should be at least eight different colors available from which the developer or the householder would choose. | 12 colours in vinyl | 0++ |

## Dampa(R) Mova-Wall Partition System (cont.)

Part C: Observations and Findings

1. In spite of the higher initial installed costs, Dampa(R) Mova-Wall partitions could be adaptable to residences as it is, since all the criteria are met.
2. It would be economically more feasible than its fixed gyproc counterpart if life cycle benefits are considered.
3. The system offers more than the performance required (criterion) for residential applications in variables Life Cycle Cost, Transparency, Electrical Provisions, Hanging Provisions, Interior Sound Level, Availability, Panel Dimension and Choice of Colors. Although no modification is required to use it in residences, excess performances in these variables do not make it 'better' for residences. Therefore, excess performance could be cut down to the required level by changing at material level which might in turn cut down its higher initial costs.

## 5.6.2 Environwall System

Part A: General Data

Manufacturer: Environwall Partition Systems Ltd.

Category: Demountable Partitions, Non-Progressive or Progressive Type

Features: Unique design provides ease of installation, removal, replacement and additions. Cornice height or full height solid or glazed. Compatible with wall supported furniture. Customized curved plexiglass corners. Custom color of co-ordinating trims. Option of progressive or non-progressive battenless construction. Electrical and communication cables easily accomodated in stud raceways.

Main Properties:

1. Thickness: 76.2 mm (3")
2. Weight per panel (8'x4'): 60 kg (132 lbs)
3. Fire Rating: 3/4 hr.
4. Sound Rating (STC): 35 (no insulation)
   50 (cavity insulation)

Major Components:

1. Steel Stud 64 mm (2½")
2. Steel Top Track and Floor Track
3. Gypsum Board pre-decorated 12.7 mm (½") with vinyl covering
4. Panel Clips fastened to the back of Gypsum Panels
5. Extruded Aluminium or PVC Base and Head

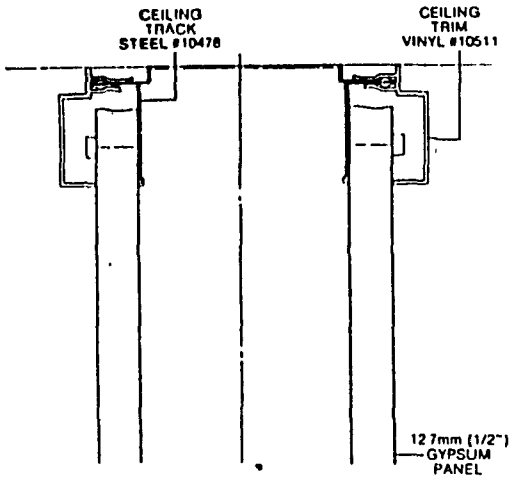
Installation Details:

1. Setting of Steel Studs into Steel Tracks at floor and ceiling
2. Installation of services in the stud raceways
3. Installation of Progressive or Non-Progressive Panels, battenless or with battens
4. Installation of Top and Base Trims

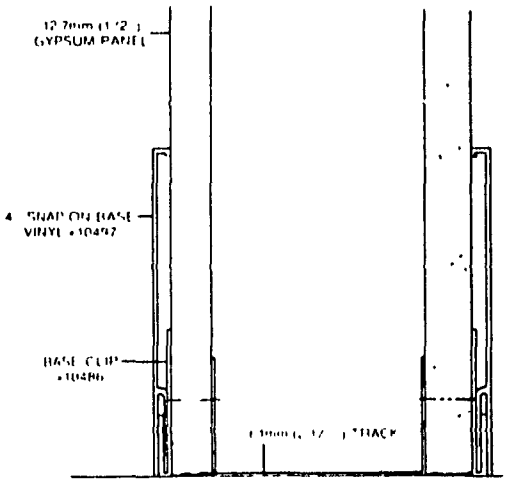
## Environwall System (Cont.)

Part A: General Data (Cont.)

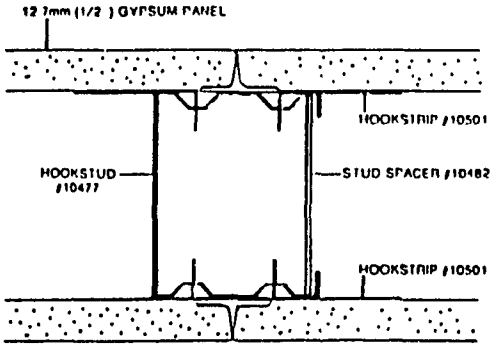
Pictorial Presentation of Technical Details



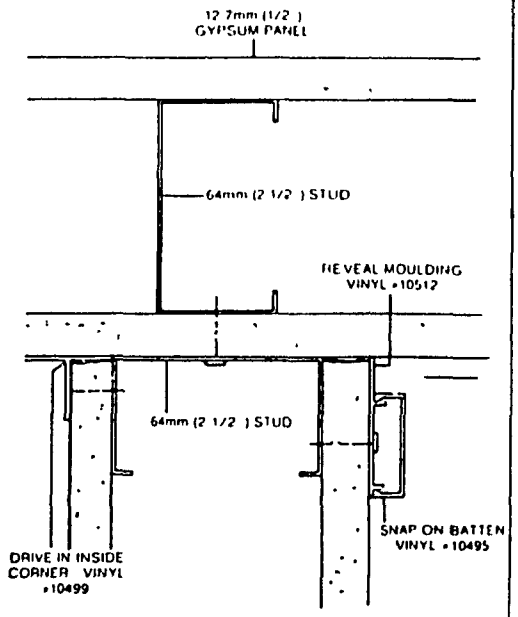

Section at Ceiling Level




Section at Floor Level




Standard Panel to Panel Joints




Section at Intersection of Panels

## Environwall System (Cont.)

Part B: Evaluations

| Attributes | Performance Variables | Performance Criteria | Observed Performance | Performance Rating |
|---|---|---|---|---|
| Economy | a. Cost | | | |
| | i)Cost of Components | - | $ 24.00 per L.ft. | |
| | ii)Cost of Installation | - | $ 16.00 per L.ft. | |
| | iii)Installed Cost | - | $ 40.00 per L.ft. | |
| | iv)Life Cycle Cost | $188 per L.ft. (Height 8') | $ 88.00 per L.ft. | 0+++ |
| Durability | b. Useful Life | 50 years (min.) | 25 years | -3 |
| Maintainability | c. Mode of cleaning | Should have provisions for cleaning without machineries with soft detergent and a light wt. mop. | Without machineries, with soft detergent and light wt. mop. | 0 |
| Habitability | d. Transparency | Should offer the option between opaque & transparent materials. | Option of glazing at any desired positions. | 0+++ |
| | e. Electrical Provisions | Should be able to incorporate electrial network and/or relocate the outlets without dismantling the system entirely. | Possible by removing 1 particular panel involved. | 0+ |
| | f. Hanging Provisions | Should have the provision for hanging or attaching light wt. functional and/or decorative elements. | With reinforced backing, hang/ attach moderate wt. func./dec. elements, anywhere. | 0++ |
| | g. Door Location & Type | Should offer choice of interchangeable door location at any desired position, normal hinged type, with opaque material. | At any desired position, hinged, opaque. | 0 |

## Environwall System (Cont.)

Part B: Evaluations (Cont.)

| Attributes | Performance Variables | Performance Criteria | Observed Performance | Performance Rating |
|---|---|---|---|---|
| Code Acceptability (i.e., conformity with governing regulations) | h. Fire Resisting Capacity | 3/4 hr. - 1 hr. | 3/4 hr. | 0 |
| | i. Interior Sound Level (STC) | 30 (min.) | 35 - 50 (depending on different thickness) | 0+++ |
| Practicability | j. Availability | Should be available in 28 days after placing the order. | 2 days | 0+++ |
| | k. Fixing Conditions | Should be able to be fixed without provisions of double floor and/or suspended ceiling. | Double floor/ suspended ceiling not required | 0 |
| | l. Panel Dimension | Width: 4' (max.) | 4' (standard panel) | 0 |
| | m. Panel Weight | Weight Range 44 kg. - 65 kg. per panel. (8' x 4') | 60 kg per panel | 0 |
| | n. Installation Time | 2.5 man hr. per panel (8' x 4') | 1.4 man hr. | 0+++ |
| | o. Installation Tool | Installation should be possible with a set of light wt. tools with max. 1 electrically operated light weight. | Light wt. tools with 1 electrical equipment | 0 |
| Appearance | p. Modular Characteristics | Should be non-modular in appearance with no visible vertical battens. | Option of battenless construction | 0 |
| | q. Color | There should be at least eight different colors available from which the developer or the householder would choose. | Any customized color | 0+++ |

## Environwall System (Cont.)

Part C: Observations and Findings

1. In spite of the low durability level, Environwall Partition System could be adaptable to residential applications because of its lower installed costs. Even if the system is replaced once during the life-cycle of the support (or, the building envelope), the life cycle costs do not exceed the required level (inflation taken care of).

2. The lower cost of components indicates that, if installed by the householder all by himself putting his own labor, the system becomes economically feasible to the developer and householder instantaneously, keeping aside the issue of life-cycle benefits.

3. Modifications at materials level could be made to cut down the observed additional performances required for its residential applications.

## 5.6.3 High Performance Partition System

Part A: General Data

Manufacturer: Donn Products Ltd.

Category: Demountable Partitions, Non-Progressive or Progressive Type

Features: Hairline joints between panels offer the appearance almost similar to fixed partitions. Easy access to service cables. High fire resistant capacity. Rapid installation techniques.

Main Properties:

1. Thickness: 89 mm (3½")
2. Weight per Panel (8'x4'): 70 kg (154 lbs)
3. Fire Rating: 2 hr.
4. Sound Rating (STC): 40

Major Components:

1. Steel Stud 64 mm (2½")
2. Steel Top Track and Floor Track
3. Gypsum Board with Vinyl Facing
4. Panel Clips
5. Miscellaneous Trims

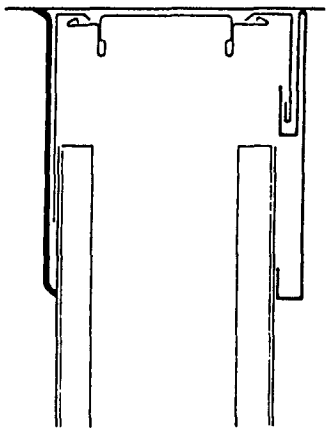
Installation Details:

1. Setting of Steel Studs into Steel Tracks at floor and ceiling level
2. Installation of services
3. Installation of Progressive or Non-Progressive Panels, with or without battens
4. Installation of miscellaneous trims

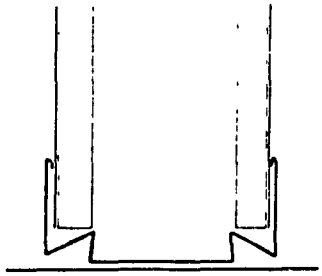
## High Performance Partition System (Cont.)

Part A: General Data (Cont.)

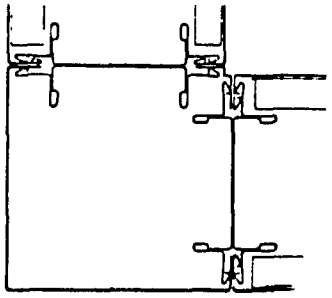
Pictorial Presentation of Technical Details



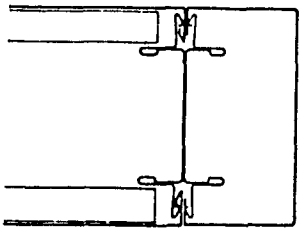
Section at Ceiling Level



Section at Floor Level



Corner Details



End Condition

## High Performance Partition System (Cont.)

Part B: Evaluations

| Attributes | Performance Variables | Performance Criteria | Observed Performance | Performance Rating |
|---|---|---|---|---|
| Economy | a. Cost | | | |
| | i) Cost of Components | - | $ 30.00 per L.ft. | |
| | ii) Cost of Installation | - | $ 25.00 per L.ft. | |
| | iii) Installed Cost | - | $ 55.00 per L.ft. | |
| | iv) Life Cycle Cost | $188 per L.ft. (Height 8') | $130.00 per L.ft. | 0+++ |
| Durability | b. Useful Life | 50 years (min.) | 30 years | -3 |
| Maintainability | c. Mode of cleaning | Should have provisions for cleaning without machineries with soft detergent and a light wt. mop. | Without machineries, with soft detergent and a light wt. mop. | 0 |
| Habitability | d. Transparency | Should offer the option between opaque & transparent materials. | Option of glazing at any desired positions. | 0+++ |
| | e. Electrical Provisions | Should be able to incorporate electrial network and/or relocate the outlets without dismantling the system entirely. | Possible by removing 1 particular panel involved. | 0+ |
| | f. Hanging Provisions | Should have the provision for hanging or attaching light wt. functional and/or decorative elements. | With reinforced backing, hang/attach moderate wt. func./dec. elements, anywhere. | 0++ |
| | g. Door Location & Type | Should offer choice of interchangeable door location at any desired position, normal hinged type, with opaque material. | At any desired position, hinged, opaque. | 0 |

## High Performance Partition System (Cont.)

Part B: Evaluations (Cont.)

| Attributes | Performance Variables | Performance Criteria | Observed Performance | Performance Rating |
|---|---|---|---|---|
| Code Acceptability (i.e., conformity with governing regulations) | h. Fire Resisting Capacity | 3/4 hr. - 1 hr. | 2 hr. | 0+ |
| | i. Interior Sound Level (STC) | 30 (min.) | 40 | 0++ |
| Practicability | j. Availability | Should be available in 28 days after placing the order. | 28 days | 0 |
| | k. Fixing Conditions | Should be able to be fixed without provisions of double floor and/or suspended ceiling. | Double floor/ suspended ceiling not required | 0 |
| | l. Panel Dimension | Width: 4' (max.) | 4' (standard panel) | 0 |
| | m. Panel Weight | Weight Range 44 kg. - 65 kg. per panel. (8' x 4') | 70 kg (154 lbs) | -1 |
| | n. Installation Time | 2.5 man hr. per panel (8' x 4') | 2.0 man hr. | 0+ |
| | o. Installation Tool | Installation should be possible with a set of light wt. tools with max. 1 electrically operated light weight. | Light wt. tools with 1 electrical equipment | 0 |
| Appearance | p. Modular Characteristics | Should be non-modular in appearance with no visible vertical battens. | Almost invisible hairline - joints | 0++ |
| | q. Color | There should be at least eight different colors available from which the developer or the householder would choose. | Any color | 0+++ |

## High Performance Partition System (Cont.)

Part C: Observations and Findings

1. The low durability level does not restrict the possible adaptability of High Performance Systems to residences since its lower installed cost would allow 1 replacement during the life-cycle of the support (or, the building envelope).

2. The lower cost of components makes the system compete with its gyproc counterpart, if self-installation is considered, i.e., if the householders isntall the system putting his own labor, the initial costs could be cut down remarkably.

3. However, weight of 8' x 4' panel might restrict easy installation, relocation, addition and omission of partitions by the limited man power of an average household. Excess performances of other variables could be cut down by modifying the system at the material level.

## 5.6.4 InnerSpace Partition System

Part A: General Data

Manufacturer: National Partitions and Interiors Inc.

Category: Demountable Partitions, Non-Progressive or Progressive Type

Features: Three feet wide doors with full edge trim, pre-hung with mortised hinges. Sturdy post system of aluminium extrusions for strength and replacements of panels which also serves as raceways for service cables. Maintenance free exclusive diamond coat vinyl facings in wide range of woodgrains and designer color. Steelfacings also available.

Main Properties:

1. Thickness: 76 mm (3")
2. Weight per Panel (8'x4'): 85 kg (187 lbs)
3. Fire Rating: 1 hr.
4. Sound Rating (STC): 35

Major Components:

1. Steel Top Track and Floor Track
2. Honey-comb core gypsum face panels
3. Aluminium extruded post with cover

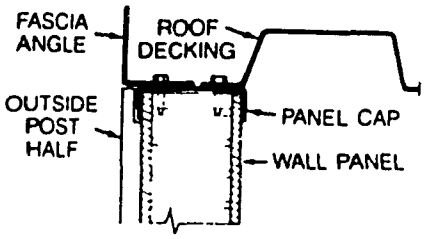
Installation Details:

1. Installation of Steel Tracks at floor and ceiling
2. Placing of panels in the channels
3. Placing of posts in between two adjacent panels and incorporation of service cables through the post as required
4. Placing of spring-held vinyl-clad strips on the posts to match the interior panel facings

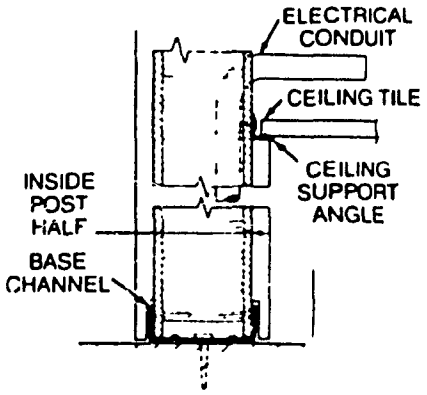
## InnerSpace Partition System (Cont.)

Part A: General Data (Cont.)

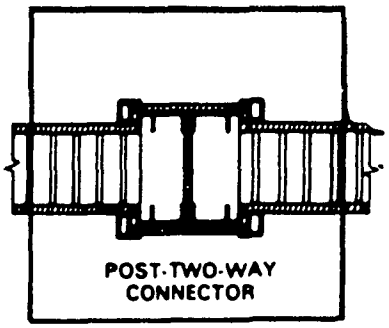
Pictorial Presentation of Technical Details



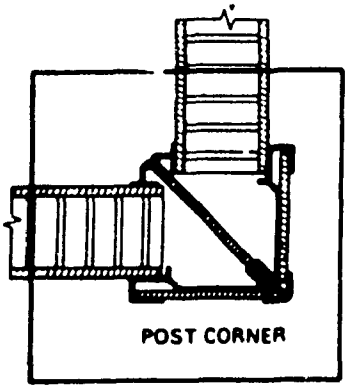

Section at Ceiling Level




Section at Floor Level




Two Way Connections with Posts




Post Corner

## InnerSpace Partition System

Part B: Evaluations

| Attributes | Performance Variables | Performance Criteria | Observed Performance | Performance Rating |
|---|---|---|---|---|
| Economy | a. Cost | | | |
| | i)Cost of Components | - | $ 80.00 per L.ft. | |
| | ii)Cost of Install-ation | - | $ 10.00 per L.ft. | |
| | iii)Installed Cost | - | $ 90.00 per L.ft. | |
| | iv)Life Cycle Cost | $188 per L.ft. (Height 8') | $120.00 per L.ft. | 0+++ |
| Durability | b. Useful Life | 50 years (min.) | 30 years | -3 |
| Maintain-ability | c. Mode of cleaning | Should have provisions for cleaning without machineries with soft detergent and a light wt. mop. | Without machi-neries with soft detergent and a light wt. mop. | 0 |
| Habitab-ility | d. Transparency | Should offer the op-tion between opaque & transparent mate-rials. | Option of glazing at any desired positions. | 0+++ |
| | e. Electrical Provisions | Should be able to in-corporate electrial network and/or relocate the outlets without dismantling the system entirely. | Possible by removing post cover. | 0+++ |
| | f. Hanging Provisions | Should have the pro-vision for hanging or attaching light wt. functional and/or decorative elements. | Possibility of hanging moderate wt. func./dec. element at fixed positions. | 0+++ |
| | g. Door Location & Type | Should offer choice of interchangeable door location at any desired position, normal hinged type, with opaque mate-rial. | At any desired location, hinged, opaque material. | 0 |

## InnerSpace Partition System (Cont.)

Part B: Evaluations (Cont.)

| Attributes | Performance Variables | Performance Criteria | Observed Performance | Performance Rating |
|---|---|---|---|---|
| Code Acceptability (i.e., conformity with governing regulations) | h. Fire Resisting Capacity | 3/4 hr. - 1 hr. | 1 hr. | 0 |
| | i. Interior Sound Level (STC) | 30 (min.) | 35 | 0+ |
| Practicability | j. Availability | Should be available in 28 days after placing the order. | 28 days | 0 |
| | k. Fixing Conditions | Should be able to be fixed without provisions of double floor and/or suspended ceiling. | Double floor/ suspended ceiling not required | 0 |
| | l. Panel Dimension | Width: 4' (max.) | Any width | 0+++ |
| | m. Panel Weight | Weight Range 44 kg. - 65 kg. per panel. (8' x 4') | 85 kg (187 lbs) | -2 |
| | n. Installation Time | 2.5 man hr. per panel (8' x 4') | 2.5 man hr. | 0 |
| | o. Installation Tool | Installation should be possible with a set of light wt. tools with max. 1 electrically operated light weight. | Light wt. tools with 1 electrical equipment | 0 |
| Appearance | p. Modular Characteristics | Should be non-modular in appearance with no visible vertical battens. | Embedded vertical lines | -1 |
| | q. Color | There should be at least eight different colors available from which the developer or the householder would choose. | Any color | 0+++ |

## InnerSpace Partition System (Cont.)

Part C: Observations and Findings

1. Higher cost of components coupled with low level of durability makes InnerSpace Partition System difficult to be adapted to residences with respect to economical consideration. With 1 replacement during the life-cycle of the building envelope, the life-cycle cost exceeds the allowable limits.

2. Higher weight of the panels makes the system unmanageable in terms of self installation, relocation, addition or ommissions of panels during its life-cycle.

3. The embedded vertical lines would generate a surface quality more closer to commercial environ. as opposed to a residential character in its appearance.

4. All other criteria are met for applying it to residences, some of which exceeds the required level.

## 5.6.5 KnollWall System

Part A: General Data

Manufacturer: Knoll Office International, Inc.

Category: Portable Partitions, Non-Progressive Type

Features: Completely non-progressive and modular partition system. Total re-usability and no material loss by providing interchangeability of solid sections, glazed sections, door and door frame assemblies on the same module. Shop fabricated panels available in baked enamely, vinyl, fabric, wall coverings, wood veneers or glass. Non permanent fastening with ceiling by Twist Clips, and with floor by Hook Tapes.

Main Properties:

1. Thickness: 57.15 mm ($2\frac{1}{4}$")
2. Weight per Panel (8'x4'): 72 kg (158.4 lbs)
3. Fire Rating: - (No flammable materials used)
4. Sound Rating (STC): 38

Major Components:

1. Steel (18 gauge) Top Track
2. Steel (20 gauge) Floor Track
3. 57.15 mm ($2\frac{1}{4}$") shop-fabricated panels (22 gauge furniture steel in both faces packed with fibreglass)
4. Vertical Posts attached with Panels (16 gauge steel)
5. Post Covers

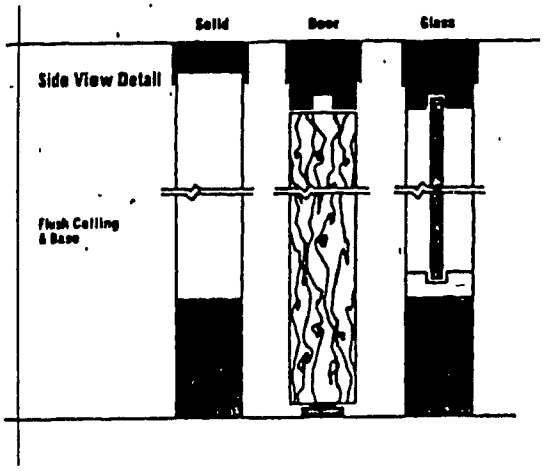
Installation Details:

1. Installation of ceiling and floor channels, adjustable saddlers are used to compensate floor level variations
2. Erection of prefinished unitized panels and glazing wherever specified
3. Installation of service cables in the cavity of vertical post cover and ceiling and floor channels.
4. Base and post covers snapped into place.

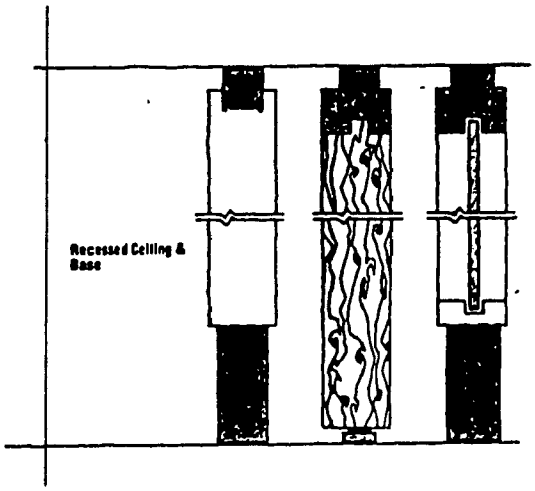
## KnollWall System (Cont.)

Part A: General Data (Cont.)

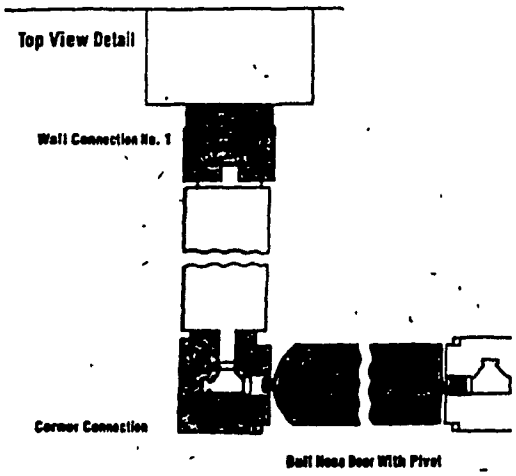
Pictorial Presentation of Technical Details




Side View Detail (Flush Ceiling and Base)




Side View Detail (Recessed Ceiling and Base)




Corner Connection Detail

## KnollWall System (Cont.)

Part B: Evaluations

| Attributes | Performance Variables | Performance Criteria | Observed Performance | Performance Rating |
|---|---|---|---|---|
| Economy | a. Cost | | | |
| | i)Cost of Components | - | $111 per L.ft. | |
| | ii)Cost of Installation | - | $ 30 per L.ft. | |
| | iii)Installed Cost | - | $144 per L.ft. | |
| | iv)Life Cycle Cost | $188 per L.ft. (Height 8') | $120 per L.ft. | -3 |
| Durability | b. Useful Life | 50 years (min.) | 60 years | 0++ |
| Maintainability | c. Mode of cleaning | Should have provisions for cleaning without machineries with soft detergent and a light wt. mop. | Without machineries with soft detergent, light wt. mop. | 0 |
| Habitability | d. Transparency | Should offer the option between opaque & transparent materials. | Option of glazing at any desired position. | 0+++ |
| | e. Electrical Provisions | Should be able to incorporate electrial network and/or relocate the outlets without dismantling the system entirely. | Possible by removing post covers and base boards. | 0++ |
| | f. Hanging Provisions | Should have the provision for hanging or attaching light wt. functional and/or decorative elements. | Possibility of hanging moderate wt. func./dec. element at any desired positions. | 0++ |
| | g. Door Location & Type | Should offer choice of interchangeable door location at any desired position, normal hinged type, with opaque material. | Any desired location, hinged type, opaque material. | 0 |

## KnollWall System (Cont.)

| Part B: Evaluations (Cont.) | | | | |
|---|---|---|---|---|
| Attributes | Performance Variables | Performance Criteria | Observed Performance | Performance Rating |
| Code Acceptability (i.e., conformity with governing regulations) | h. Fire Resisting Capacity | 3/4 hr. - 1 hr. | Not Available | - |
| | i. Interior Sound Level (STC) | 30 (min.) | 38 | 0++ |
| Practicability | j. Availability | Should be available in 28 days after placing the order. | 70 days | -3 |
| | k. Fixing Conditions | Should be able to be fixed without provisions of double floor and/or suspended ceiling. | Double floor/ suspended ceiling not required | 0 |
| | l. Panel Dimension | Width: 4' (max.) | 4' and 5' | 0 |
| | m. Panel Weight | Weight Range 44 kg. - 65 kg. per panel. (8' x 4') | 100 kg | -3 |
| | n. Installation Time | 2.5 man hr. per panel (8' x 4') | 1.8 man hr. | 0++ |
| | o. Installation Tool | Installation should be possible with a set of light wt. tools with max. 1 electrically operated light weight. | Only light wt. tools required | 0+++ |
| Appearance | p. Modular Characteristics | Should be non-modular in appearance with no visible vertical battens. | Embedded visible vertical battens | -1 |
| | q. Color | There should be at least eight different colors available from which the developer or the householder would choose. | 8 different colors | 0 |

**KnollWall System (Cont.)**

Part C: Observations and Findings

1. Higher installed costs would restrict the application of KnollWall System in residences. It not be economically feasible to install the system even if its life cycle cost is considered.
2. Time required to get the system in site after placing the order is too long, which would be a problem area in incorporating this system in residences. It would be most unlikely that the households or developers would wait that long to fulfill their needs.
3. Higher weight per panel would diminish the ease of handling.
4. And finally embedded visible vertical battens tend to create commercial environment.
4. All other criteria are met for applying it to residences, some of which exceeds the required level.

## 5.6.6 Mobilflex Portable Walls

Part A: General Data

Manufacturer: Quebec Architectural Products Inc.

Category: Portable Partitions, Progressive Type

Features: Designed to be easily carried, stored or relocated. High acoustical performance. Low installed costs. Each panel has two adjustable mechanisms at the bottom to accomodate floor level irregularities.

Main Properties:

1. Thickness: 92 mm (3 5/8")
2. Weight per Panel (8'x4'): 145 kg (319 lbs)
3. Fire Rating: 6 3/4 hr. (if fire rated gypsum is used)
4. Sound Rating (STC): 48

Major Components:

1. Aluminium Top Track and Floor Track
2. 92 mm (3 5/8") shop fabricated panels with inner steel frame with 62.4 mm ($\frac{1}{2}$") gypsum
3. Trims

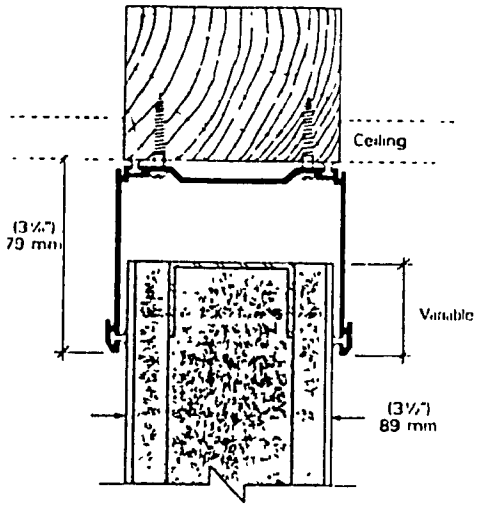
Installation Details:

1. Installation of ceiling and floor tracks as per lay-out plan
2. Erection of prefinished panels into the tracks
3. Setting of Base and Top Trims in position.

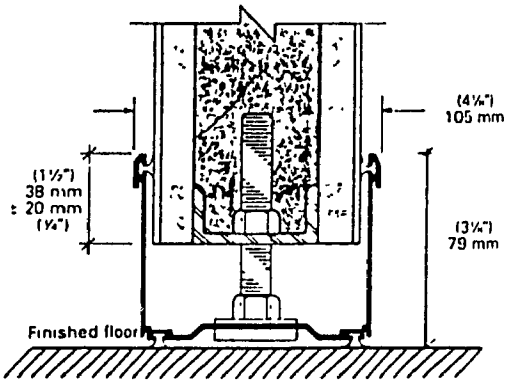
## Mobilflex Portable Walls (Cont.)

Part A: General Data (Cont.)

Pictorial Presentation of Technical Details




Section at Ceiling Level




Section at Floor Level

## Mobilflex Portable Walls (Cont.)

Part B: Evaluations

| Attributes | Performance Variables | Performance Criteria | Observed Performance | Performance Rating |
|---|---|---|---|---|
| Economy | a. Cost | | | |
| | i)Cost of Components | - | $ 40 per L.ft. | |
| | ii)Cost of Install-ation | - | $ 10 per L.ft. | |
| | iii)Installed Cost | - | $ 50 per L.ft. | |
| | iv)Life Cycle Cost | $188 per L.ft. (Height 8') | $ 80 per L.ft. | O+++ |
| Durability | b. Useful Life | 50 years (min.) | 20 years | -3 |
| Maintain-ability | c. Mode of cleaning | Should have provisions for cleaning without machineries with soft detergent and a light wt. mop. | Without machi-neries, with soft detergent, light wt. mop. | 0 |
| Habitab-ility | d. Transparency | Should offer the op-tion between opaque & transparent mate-rials. | Opaque only | -1 |
| | e. Electrical Provisions | Should be able to in-corporate electrial network and/or relocate the outlets without dismantling the system entirely. | Not possible at all | -3 |
| | f. Hanging Provisions | Should have the pro-vision for hanging or attaching light wt. functional and/or decorative elements. | Possibility of hanging/attaching light wt. dec./ func. elements at fixed location. | 0 |
| | g. Door Location & Type | Should offer choice of interchangeable door location at any desired position, normal hinged type, with opaque mate-rial. | Any desired location, hinged type, opaque material. | 0 |

## Mobilflex Portable Walls (Cont.)

Part B: Evaluations (Cont.)

| Attributes | Performance Variables | Performance Criteria | Observed Performance | Performance Rating |
|---|---|---|---|---|
| Code Acceptability (i.e., conformity with governing regulations) | h. Fire Resisting Capacity | 3/4 hr. - 1 hr. | 3/4 hr. (if fire rated gypsum is used) | 0 |
| | i. Interior Sound Level (STC) | 30 (min.) | 48 | 0+++ |
| Practicability | j. Availability | Should be available in 28 days after placing the order. | 42 days | -2 |
| | k. Fixing Conditions | Should be able to be fixed without provisions of double floor and/or suspended ceiling. | Double floor/ suspended ceiling not required | 0 |
| | l. Panel Dimension | Width: 4' (max.) | 4' | 0 |
| | m. Panel Weight | Weight Range 44 kg. - 65 kg. per panel. (8' x 4') | 145 kg | -3 |
| | n. Installation Time | 2.5 man hr. per panel (8' x 4') | 2 man hr. | 0+ |
| | o. Installation Tool | Installation should be possible with a set of light wt. tools with max. 1 electrically operated light weight. | Light wt. tools and 2 elect. equipment | -1 |
| Appearance | p. Modular Characteristics | Should be non-modular in appearance with no visible vertical battens. | Almost invisible hairlines | 0++ |
| | q. Color | There should be at least eight different colors available from which the developer or the householder would choose. | 40 | 0+++ |

## Mobilflex Portable Wall (Cont.)

Part C: Observations and Findings

1. The life-cycle cost of Mobilflex Portable Wall is lower and even with 1 replacement within the life-cycle of the support (i.e., building envelope) it is economically feasible.

2. As far as habitability and practicability are concerned, it would not be adaptable to residences easily. The non existence of electrical provisions in the partitions poses the most serious problem in terms of residential habitability. Long availability time and high panel wt. pose practical problems in terms of management and handling of the system.

3. However, other performances fulfill the criteria.

4. All other criteria are met for applying it to residences, some of which exceeds the required level.

## 5.6.7 PC 350(R) Gravity Lock Wall System

Part A: General Data

Manufacturer: Partition Components International Ltd.

Category: Demountable, Non-Progressive or Progressive Type

Features: Gravity Lock Panel Clips installed at the back of the panels fits into three rows of horizontal reinforcing channels which pull panels tight to studs but allow horizontal movement for tighter butt joints. Electricals installed at any time. Non progressive panels easily removed for relocation or replacement. Wall hung furniture reinforcing. Excellent privacy rating - visual and acoustical. Readily available from the stock.

Main Properties:

1. Thickness: 92 mm (3 5/8")
2. Weight per Panel (8'x4'): 58 kg (127.6 lbs)
3. Fire Rating: 1 hr.
4. Sound Rating (STC): 45 (with R8 Fibre Glass Insulation)

Major Components:

1. Metal Top Track and Floor Track
2. 64 mm ($2\frac{1}{2}$") metal stud
3. 38 mm x 19 mm ($1\frac{1}{2}$" x 3/4") horizontal clip retainer channel
4. 12.7 mm ($\frac{1}{2}$") pre-finished vinyl covered gypsum
5. Trims

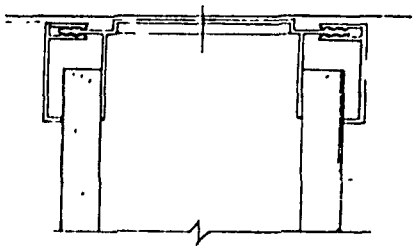
Installation Details:

1. Installation of ceiling and floor tracks as per lay-out plan
2. Placement of metal stud into the tracks
3. Placement of 3 rows of horizontal clip retainer channels
4. Setting of panels with special clips at the back. Panels are hung from metal framing system. Electrical or communication cables are held in the cavity. If required insulation is also put in the cavity.
5. Setting of trims.

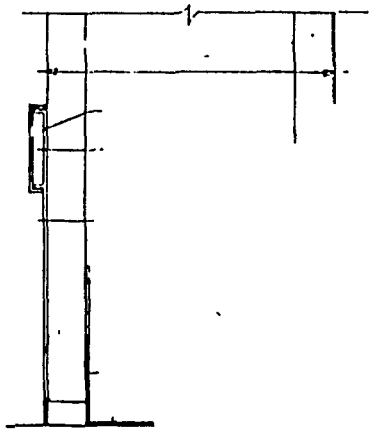
# PC 350(R) Gravity Lock Wall System (Cont.)

Part A: General Data (Cont.)

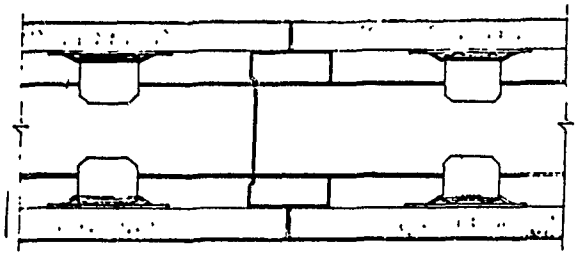
Pictorial Presentation of Technical Details



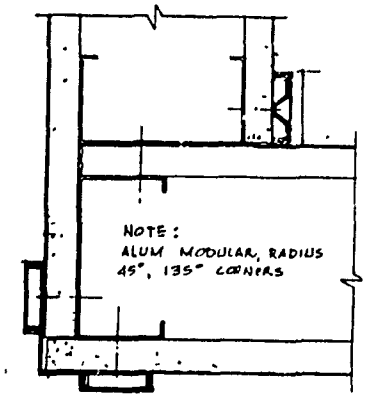
Section at Ceiling Level



Section at Floor Level



Typical Panel to Panel Joint




Exterior Corner Detail

## PC 350(R) Gravity Lock Wall System

| Part B: Evaluations | | | | |
|---|---|---|---|---|
| Attributes | Performance Variables | Performance Criteria | Observed Performance | Performance Rating |
| Economy | a. Cost | | | |
| | i)Cost of Components | - | $ 30 per L.ft. | |
| | ii)Cost of Installation | - | $ 25 per L.ft. | |
| | iii)Installed Cost | - | $ 55 per L.ft. | |
| | iv)Life Cycle Cost | $188 per L.ft. (Height 8') | $130 per L.ft. | 0+++ |
| Durability | b. Useful Life | 50 years (min.) | 50 years | 0 |
| Maintainability | c. Mode of cleaning | Should have provisions for cleaning without machineries with soft detergent and a light wt. mop. | Without machineries, with water and cloth. | 0++ |
| Habitability | d. Transparency | Should offer the option between opaque & transparent materials. | Option of glazing at any desired position. | 0+++ |
| | e. Electrical Provisions | Should be able to incorporate electrial network and/or relocate the outlets without dismantling the system entirely. | Possible by removing 1 particular panel involved. | 0+ |
| | f. Hanging Provisions | Should have the provision for hanging or attaching light wt. functional and/or decorative elements. | Light Heavy wt. furniture by using furniture reinforcing channels. | 0+++ |
| | g. Door Location & Type | Should offer choice of interchangeable door location at any desired position, normal hinged type, with opaque material. | Any desired location hinged, opaque or glazed | 0+ |

## PC 350(R) Gravity Lock Wall System

Part B: Evaluations (Cont.)

| Attributes | Performance Variables | Performance Criteria | Observed Performance | Performance Rating |
|---|---|---|---|---|
| Code Acceptability (i.e., conformity with governing regulations) | h. Fire Resisting Capacity | 3/4 hr. - 1 hr. | 1 hr. | 0 |
| | i. Interior Sound Level (STC) | 30 (min.) | 45 (with R8 fibre glass insulation) | 0+++ |
| Practicability | j. Availability | Should be available in 28 days after placing the order. | 14 days | 0++ |
| | k. Fixing Conditions | Should be able to be fixed without provisions of double floor and/or suspended ceiling. | Double floor/ suspended ceiling not required | 0 |
| | l. Panel Dimension | Width: 4' (max.) | 4' | 0 |
| | m. Panel Weight | Weight Range 44 kg. - 65 kg. per panel. (8' x 4') | 58 kg | 0 |
| | n. Installation Time | 2.5 man hr. per panel (8' x 4') | 1.6 man hr. | 0++ |
| | o. Installation Tool | Installation should be possible with a set of light wt. tools with max. 1 electrically operated light weight. | Light wt. tools with 1 electrical equipment | 0 |
| Appearance | p. Modular Characteristics | Should be non-modular in appearance with no visible vertical battens. | Hairlines | 0++ |
| | q. Color | There should be at least eight different colors available from which the developer or the householder would choose. | 20 colors | 0++ |

## PC 350(R) Gravity Lock Wall System (Cont.)

Part C: Observations and Findings

1. PC 350(R) Gravity Lock Wall System is readily adaptable to residences since performance of all the variables of the system satisfy respective criterion.
2. Self-installation by the householders remove the obstacle of the initial cost involvements and makes it compatible with its fixed gyproc counterpart, even if the life cycle costs are not considered.
3. Performances of most of the attributes exceed the required level. The extra performances do not add to the adaptability of the system into residential application. Modifications at the materials level could be made to cut these additional performances down to the required level.
4. All other criteria are met for applying it to residences, some of which exceeds the required level.

## 5.6.8 SpaceSetter 204 Partition System

Part A: General Data

Manufacturer: Modernfold, An American Standard Company

Category: Portable Partitions, Non-Progressive Type

Features: Panels are spring-loaded to ceiling. Easily installed, relocated, added or omitted. Service cables could be accomodated at the bottom raceways of the panels. Moderate wt. cabinets and other furniture could be hung from the panels. Wide range of colors.

Main Properties:

1. Thickness: 57.15 mm (2¼")
2. Weight per Panel (8'x4'): 77.2 kg (160 lbs)
3. Fire Rating: Not Available (not combustible materials)
4. Sound Rating (STC): 35

Major Components:

1. Steel Top Track and Floor Track
2. Gypsum panels in steel frame waffles, vinyl facings
3. Trims

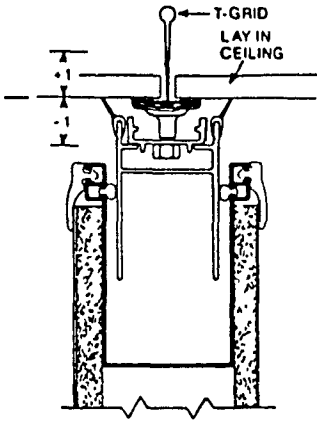
Installation Details:

1. Installation of Ceiling and Floor Tracks as per lay-out requirements
2. Installation of service cables in the built-in raceways at the bottom
3. Setting of spring-loaded pre-finished panels into the Tracks
4. Placing of miscellaneous Trims

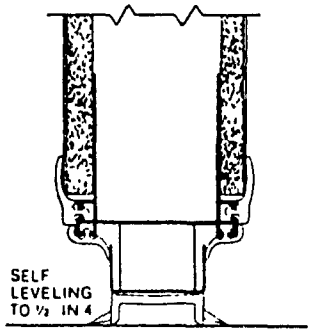
# SpaceSetter 204 Partition System

Part A: General Data (Cont.)

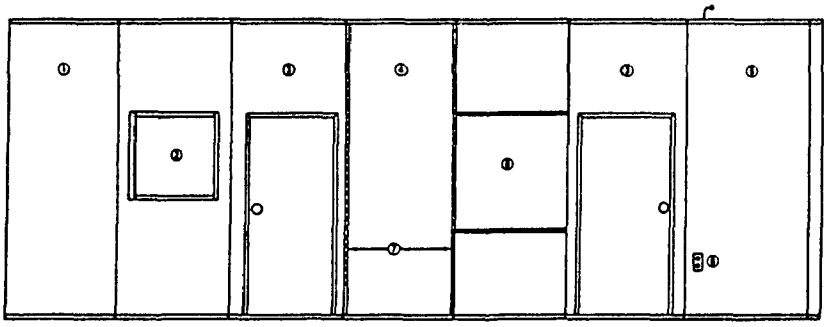
Pictorial Presentation of Technical Details




Section at Ceiling Level




Section at Floor Level



1. Starter Panel
2. Glazed window panel, 3' × 3'
3. Standard pass door panel
4. Intermediate panel – self plumbing
5. Expandable finish panel
6. Electrical outlet with "pigtail" connection
7. K-V slotting, accepts hang on accessories and shelving
8. Chalkboard or tackboard, 4' × 4' or full height

Elevation Showing Different Options Available

## SpaceSetter 204 Partition System (Cont.)

Part B: Evaluations

| Attributes | Performance Variables | Performance Criteria | Observed Performance | Performance Rating |
|---|---|---|---|---|
| Economy | a. Cost | | | |
| | i)Cost of Components | - | $ 25 per L.ft. | |
| | ii)Cost of Installation | - | $ 15 per L.ft. | |
| | iii)Installed Cost | - | $ 40 per L.ft. | |
| | iv)Life Cycle Cost | $188 per L.ft. (Height 8') | $ 85 per L.ft. | 0+++ |
| Durability | b. Useful Life | 50 years (min.) | 25 years | -3 |
| Maintainability | c. Mode of cleaning | Should have provisions for cleaning without machineries with soft detergent and a light wt. mop. | Without machineries, with dry brush. | 0+++ |
| Habitability | d. Transparency | Should offer the option between opaque & transparent materials. | Option of glazing at any desired position. | 0+++ |
| | e. Electrical Provisions | Should be able to incorporate electrial network and/or relocate the outlets without dismantling the system entirely. | Possible by removing related panels. | 0 |
| | f. Hanging Provisions | Should have the provision for hanging or attaching light wt. functional and/or decorative elements. | Moderate wt. func./dec. elements at fixed locations. | 0+ |
| | g. Door Location & Type | Should offer choice of interchangeable door location at any desired position, normal hinged type, with opaque material. | Any desired location, hinged, opaque. | 0 |

## SpaceSetter 204 Partition System (Cont.)

Part B: Evaluations (Cont.)

| Attributes | Performance Variables | Performance Criteria | Observed Performance | Performance Rating |
|---|---|---|---|---|
| Code Acceptability (i.e., conformity with governing regulations) | h. Fire Resisting Capacity | 3/4 hr. - 1 hr. | Not Available (Non-combustible material) | - |
| | i. Interior Sound Level (STC) | 30 (min.) | 35<br>tion) | O+ |
| Practicability | j. Availability | Should be available in 28 days after placing the order. | 42 days | -2 |
| | k. Fixing Conditions | Should be able to be fixed without provisions of double floor and/or suspended ceiling. | Double floor/ suspended ceiling not required. | O |
| | l. Panel Dimension | Width: 4' (max.) | 3' and 4' | O++ |
| | m. Panel Weight | Weight Range 44 kg. - 65 kg. per panel. (8' x 4') | 77.2 kg | -2 |
| | n. Installation Time | 2.5 man hr. per panel (8' x 4') | .5 man hr. | O+++ |
| | o. Installation Tool | Installation should be possible with a set of light wt. tools with max. 1 electrically operated light weight. | Light wt. tools | O+++ |
| Appearance | p. Modular Characteristics | Should be non-modular in appearance with no visible vertical battens. | No vertical battens | O |
| | q. Color | There should be at least eight different colors available from which the developer or the householder would choose. | 24 colors | O++ |

## SpaceSetter 204 Partition System (Cont.)

Part C: Observations and Findings

1. Although the durability level is lower, low installed cost makes SpaceSetter 204 Partition System economically feasible for residential applications with 1 replacement during the life-cycle of the shell (i.e., the building envelope).

2. The system is deficient in the practicability aspects. The weight per panel is higher than the limit suitable for handling by two persons. The availability time after placing order is also an obstacle for applying it to residences.

3. The fact that the system has no fire rating does not restrict it from applying it to residences as internal partitions. However, it restricts its use as party walls since to be used as party walls the code requires at least 1 hr. fire rating.

## 5.6.9 System 40 Partitions

Part A: General Data

Manufacturer: Provincial Partitions Inc.

Category: Demountable Partitions, Non-Progressive Type

Features: Unlimited sizes and layout possibilities. Panel can be cut to any customized size to suit even the most critical dimensions. The filler panels can also be removed and reused. Heights from 5'-6" to 20'-0". Any combination of glass, vinyl clad or metal clad possible.

Main Properties:

1. Thickness: 72.6 mm (3")
2. Weight per Panel (8'x4'): 100 kg (220 lbs)
3. Fire Rating: $\frac{1}{2}$ hr.
4. Sound Rating (STC): 30

Major Components:

1. Steel Top Track and Floor Track
2. Metal Studs
3. Pre-finished vinyl covered gypsum panels
4. Trims

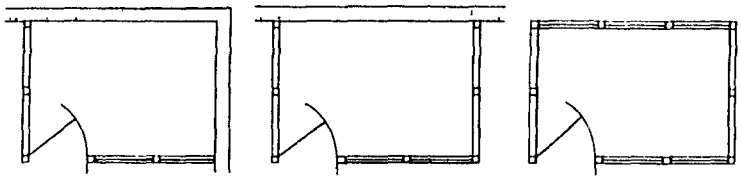
Installation Details:

1. Installation of Ceiling Tracks and Floor Tracks as per lay-out plans
2. Setting of metal stud into the Floor and Ceiling Tracks
3. Setting of Panels into the Tracks after inserting service cables in the cavity.
4. Setting of Battens and Trims

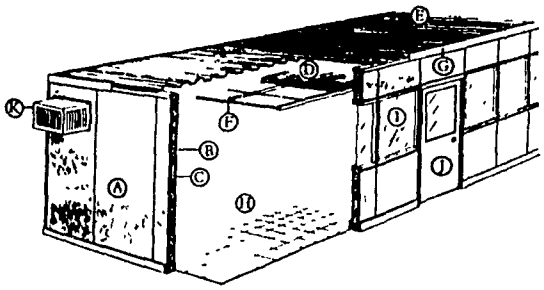
## System 40 Partitions (Cont.)

Part A: General Data (Cont.)

Pictorial Presentation of Technical Details



Two Wall, Three Wall and Four Wall Constructions




**All Full System 40 Modules Are Totally Interchangeable**

A **Metal Clad Exterior** — 24 gauge precoated steel is easily washable, highly resistant to abrasion, impact and most common chemicals

B **Vinyl Clad Interior** — Low maintenance, washable, prefinished vinyl covered gypsum panels create a warm working atmosphere

C **Wall Insulation** — 2" wall cavities may be filled with fiberglass insulation to provide sound and privacy control

D **Ceiling Insulation** — 6" fiberglass insulation may be installed between metal roof deck and acoustical drop ceiling.

E **Metal Roof Deck** — Allows unit to become sealed for dust and noise resistance

F **Ceiling Grid** — 2' x 4' suspended grid accepts light fixtures and acoustical tile

G **Facia Trim** — To conceal roof deck corrugations and foam closers

H **Flooring** — Tile or carpet available. Others upon request

I **Windows** — Types and thicknesses selected to best suit customer's application

J **Door And Frame** — 3' x 7' steel door and frame c/w 1½ pr. mortise butt hinges, cylindrical lockset and dome type floor stop. (Special hardware available upon request.)

K **Air Conditioning Units** — Wall mounted air conditioners from 5,000 BTU's and up (to suit your requirements).

Sectional Perspective Showing All Possible Constituents

**System 40 Partitions (Cont.)**

Part B: Evaluations

| Attributes | Performance Variables | Performance Criteria | Observed Performance | Performance Rating |
|---|---|---|---|---|
| Economy | a. Cost | | | |
| | i)Cost of Components | - | $ 35 per L.ft. | |
| | ii)Cost of Install-ation | - | $ 20 per L.ft. | |
| | iii)Installed Cost | - | $ 55 per L.ft. | |
| | iv)Life Cycle Cost | $188 per L.ft. (Height 8') | $115 per L.ft. | 0+++ |
| Durability | b. Useful Life | 50 years (min ) | 50 years | 0 |
| Maintain-ability | c. Mode of cleaning | Should have provisions for cleaning without machineries with soft detergent and a light wt. mop. | Without machi-neries, with water and a piece of cloth. | 0++ |
| Habitab-ility | d. Transparency | Should offer the op-tion between opaque & transparent mate-rials. | Option of glazing at any desired position. | 0+++ |
| | e. Electrical Provisions | Should be able to in-corporate electrial network and/or relocate the outlets without dismantling the system entirely. | Possible without dismantling as a whole. | 0 |
| | f. Hanging Provisions | Should have the pro-vision for hanging or attaching light wt. functional and/or decorative elements. | Moderate wt. func./dec. ele-ments at any de-sired position (with rein. backing). | 0++ |
| | g. Door Location & Type | Should offer choice of interchangeable door location at any desired position, normal hinged type, with opaque mate-rial. | Any desired lo-cation, hinged, opaque or glazed. | 0+ |

**System 40 Partitions (Cont.)**

Part B: Evaluations (Cont.)

| Attributes | Performance Variables | Performance Criteria | Observed Performance | Performance Rating |
|---|---|---|---|---|
| Code Acceptability (i.e., conformity with governing regulations) | h. Fire Resisting Capacity | 3/4 hr. - 1 hr. | ½ hr. | -1 |
| | i. Interior Sound Level (STC) | 30 (min.) | 30 | 0 |
| Practicability | j. Availability | Should be available in 28 days after placing the order. | 14 days | 0++ |
| | k. Fixing Conditions | Should be able to be fixed without provisions of double floor and/or suspended ceiling. | Double floor/ suspended ceiling not required | 0 |
| | l. Panel Dimension | Width: 4' (max.) | 3'-4" | 0++ |
| | m. Panel Weight | Weight Range 44 kg. - 65 kg. per panel. (8' x 4') | 100 kg | -3 |
| | n. Installation Time | 2.5 man hr. per panel (8' x 4') | 1.6 man hr. | 0++ |
| | o. Installation Tool | Installation should be possible with a set of light wt. tools with max. 1 electrically operated light weight. | Light wt. tools with 1 electrical equipment | -2 |
| Appearance | p. Modular Characteristics | Should be non-modular in appearance with no visible vertical battens. | Light visible vertical batten | -2 |
| | q. Color | There should be at least eight different colors available from which the developer or the householder would choose. | 4 colors | -2 |

## System 40 Partitions (Cont.)

Part C: Observations and Findings

1. System 40 Partitions are economically feasible to be applied into residences.
2. Lower Fire Rating restricts the system not to be used in party wall since code would not permit that.
3. Panel weight is high for easy handling by 2 persons.
4. The modular appearance of the surface and limited available color would tend to restrict mass acceptance of the householders to apply it in residences.

## 5.6.10 Treco Fabrication Partition System

Part A: General Data

Manufacturer: Treco Fabrication

Category. Portable Partition, Non Progressive Type

Features: Rapid and simple installation technique. Suitable for new construction as well as renovations. Simple service cable installations. Adjustments could be made to compensate floor level variations.

Main Properties:

1. Thickness: 76.2 mm (3")
2. Weight per Panel (8'x4'): 75 kg (165 lbs)
3. Fire Rating: 1 hr.
4. Sound Rating (STC): 40

Major Components:

1. Steel Top Track and Floor Track
2. Metal facing Honeycomb core panels
3. Rivets
4. Miscellaneous Trims

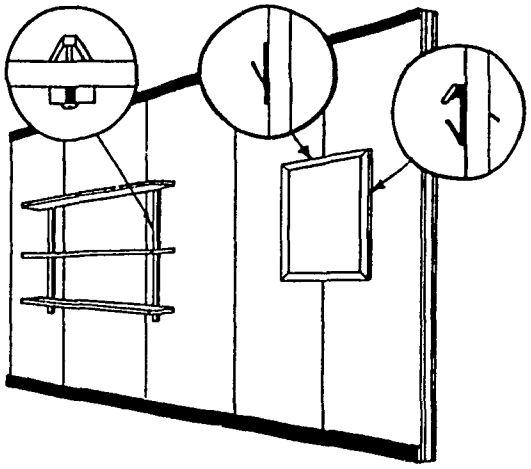
Installation Details:

1. Installation of Floor and Ceiling Tracks with adjustable saddlers to compensate floor level variations.
2. Erection of pre-finished panels with glazing wherever specified.
3. Installation of service cables at the bottom of the panels.
4. Setting of miscellaneous Trims.

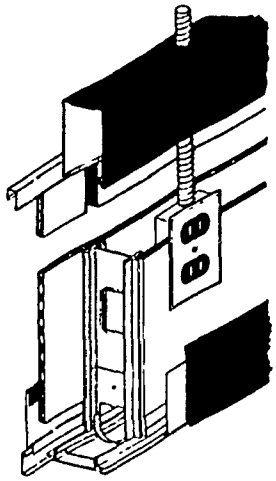
## Treco Fabrication Partition System

Part A: General Data (Cont.)

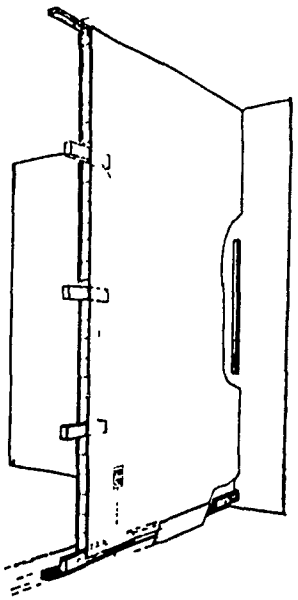
Pictorial Presentation of Technical Details



Perspective Showing Glazing and Shelf Details



Perspective Showing Top Track & Ceiling Track with Service Cables Details



Sectional Perspective Showing Overall Components

## Treco Fabrication (Cont.)

Part B: Evaluations

| Attributes | Performance Variables | Performance Criteria | Observed Performance | Performance Rating |
|---|---|---|---|---|
| Economy | a. Cost | | | |
| | i)Cost of Components | - | $100 per L.ft. | |
| | ii)Cost of Install-ation | - | $ 20 per L.ft. | |
| | iii)Installed Cost | - | $120 per L.ft. | |
| | iv)Life Cycle Cost | $188 per L.ft. (Height 8') | $180 per L.ft. | 0+ |
| Durability | b. Useful Life | 50 years (min.) | 60 years | 0++ |
| Maintain-ability | c. Mode of cleaning | Should have provisions for cleaning without machineries with soft detergent and a light wt. mop. | Without machi-neries, with a piece of cloth. | 0+++ |
| Habitab-ility | d. Transparency | Should offer the op-tion between opaque & transparent mate-rials. | Glazing at more than 1 fixed position . | 0++ |
| | e. Electrical Provisions | Should be able to in-corporate electrial network and/or relocate the outlets without dismantling the system entirely. | Possible without dismantling as a whole. | 0 |
| | f. Hanging Provisions | Should have the pro-vision for hanging or attaching light wt. functional and/or decorative elements. | Moderate wt. at func./dec. ele-ments at fixed locations. | 0+ |
| | g. Door Location & Type | Should offer choice of interchangeable door location at any desired position, normal hinged type, with opaque mate-rial. | Any desired lo-cation, hinged and opaque. | 0 |

## Treco Fabrication (Cont.)

Part B: Evaluations (Cont.)

| Attributes | Performance Variables | Performance Criteria | Observed Performance | Performance Rating |
|---|---|---|---|---|
| Code Acceptability (i.e., conformity with governing regulations) | h. Fire Resisting Capacity | 3/4 hr. - 1 hr. | 1 hr. | 0 |
| | i. Interior Sound Level (STC) | 30 (min.) | 40 | 0++ |
| Practicability | j. Availability | Should be available in 28 days after placing the order. | 28 days | 0 |
| | k. Fixing Conditions | Should be able to be fixed without provisions of double floor and/or suspended ceiling. | Double floor/ suspended ceiling not required | 0 |
| | l. Panel Dimension | Width: 4' (max.) | 4' | 0 |
| | m. Panel Weight | Weight Range 44 kg. - 65 kg. per panel. (8' x 4') | 75 kg | -1 |
| | n. Installation Time | 2.5 man hr. per panel (8' x 4') | 1.8 man hr. | 0++ |
| | o. Installation Tool | Installation should be possible with a set of light wt. tools with max. 1 electrically operated light weight. | Light wt. tools | 0+++ |
| Appearance | p. Modular Characteristics | Should be non-modular in appearance with no visible vertical battens. | Almost invisible hairlines | 0++ |
| | q. Color | There should be at least eight different colors available from which the developer or the householder would choose. | 8 colors | 0 |

## Treco Fabrication (Cont.)

Part C: Observations and Findings

1. Treco Fabrication Partition System could be applied to residences as it is since most of its performances meet the requirements including economic considerations.
2. The only problem area is its weight which might restrict easy handling by the limited man power that a household might possess.
3. The system offers performances more than the required levels as far as most of its variables are concerned. This unnecessary performance might be cut down by modifying the system at material levels.

## 5.6.11 UltraWall Partition System

Part A: General Data

Manufacturer: United States Gypsum, Building America

Category: Demountable Partition, Progressive Type

Features: Engineered for quick change, aesthetic versatility. Permits ceiling height upto 12 ft. Ample chase space of 1 7/8 inch. for wiring, standard size boxes and sound control. Erection on both sides or only one side possible to suit future tenant needs.

Main Properties:

1. Thickness: 85.6 mm (3 3/8 inch)
2. Weight per Panel (8'x4'): 80 kg (176 lbs)
3. Fire Rating: 1 hr. and 2 hr. (depending on combustion)
4. Sound Rating (STC): 40,42,46,47,48,50 (depending on construction)

Major Components:

1. Electro-galvanized steel Runners
2. Extruded Aluminium Ceiling Runners
3. Gypsum Panel 3/4 inch.
4. Clips
5. Trims

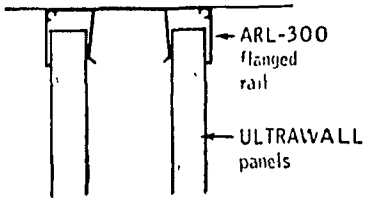
Installation Details:

1. Attachment of Floor and Ceiling Runners as per lay-out.
2. Placement of Steel Studs as per specifications.
3. Installation of Gypsum Panels after service cable installations.

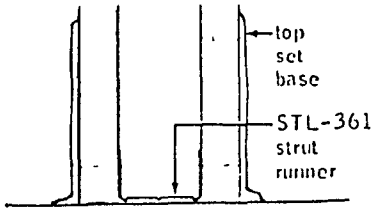
## UltraWall Partition System (Cont.)

Part A: General Data (Cont.)

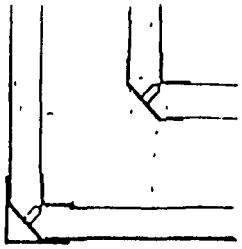
Pictorial Presentation of Technical Details



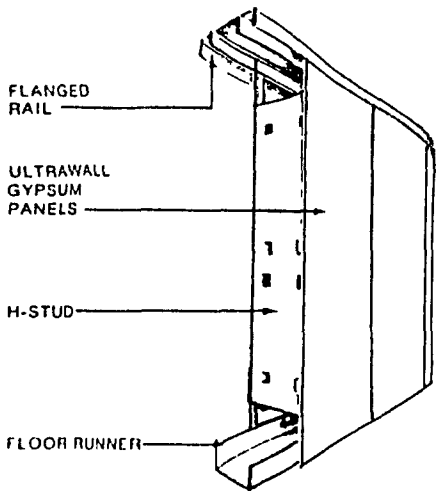

Section at Ceiling Level




Section at Floor Level



Standard Corner Detail




Sectional Perspective

## UltraWall Partition System (Cont.)

Part B: Evaluations

| Attributes | Performance Variables | Performance Criteria | Observed Performance | Performance Rating |
|---|---|---|---|---|
| Economy | a. Cost | | | |
| | i)Cost of Components | - | $ 25 per L.ft. | |
| | ii)Cost of Install-ation | - | $ 20 per L.ft. | |
| | iii)Installed Cost | - | $ 45 per L.ft. | |
| | iv)Life Cycle Cost | $188 per L.ft. (Height 8') | $105 per L.ft. | 0+++ |
| Durability | b. Useful Life | 50 years (min.) | 30 years | -3 |
| Maintain-ability | c. Mode of cleaning | Should have provisions for cleaning without machineries with soft detergent and a light wt. mop. | Without machi-neries, with soft detergent and light wt. mop. | 0 |
| Habitab-ility | d. Transparency | Should offer the op-tion between opaque & transparent mate-rials. | Glazing at any desired position. | 0+++ |
| | e. Electrical Provisions | Should be able to in-corporate electrial network and/or relocate the outlets without dismantling the system entirely. | Without dismant-ling the parti-tion as a whole, access panel and others. | 0 |
| | f. Hanging Provisions | Should have the pro-vision for hanging or attaching light wt. functional and/or decorative elements. | Light wt. dec./ fun. elements at fixed loca-tions. | 0 |
| | g. Door Location & Type | Should offer choice of interchangeable door location at any desired position, normal hinged type, with opaque mate-rial. | Any desired lo-cation, hinged, opaque. | 0 |

## UltraWall Partition System (Cont.)

Part B: Evaluations (Cont.)

| Attributes | Performance Variables | Performance Criteria | Observed Performance | Performance Rating |
|---|---|---|---|---|
| Code Acceptability (i.e., conformity with governing regulations) | h. Fire Resisting Capacity | 3/4 hr. - 1 hr. | 1 hr and 2 hr. | 0+ |
| | i. Interior Sound Level (STC) | 30 (min.) | 40, 42, 46, 47, 48, 50 | 0+++ |
| Practicability | j. Availability | Should be available in 28 days after placing the order. | 28 days | 0 |
| | k. Fixing Conditions | Should be able to be fixed without provisions of double floor and/or suspended ceiling. | Double floor/ suspended ceiling not required | 0 |
| | l. Panel Dimension | Width: 4' (max.) | 2' and 2'-6" | 0++ |
| | m. Panel Weight | Weight Range 44 kg. - 65 kg. per panel. (8' x 4') | 80 kg | -2 |
| | n. Installation Time | 2.5 man hr. per panel (8' x 4') | 1.5 man hr. | 0++ |
| | o. Installation Tool | Installation should be possible with a set of light wt. tools with max. 1 electrically operated light weight. | Light wt. tools with 1 electrical equipment | 0 |
| Appearance | p. Modular Characteristics | Should be non-modular in appearance with no visible vertical battens. | Hairline joints | 0++ |
| | q. Color | There should be at least eight different colors available from which the developer or the householder would choose. | 40 colors (if vinyl is used) | 0++ |

## UltraWall Partition System (Cont.)

Part C: Observations and Findings

1. Lower installed cost compensated lower durability level in applying UltraWall Partition System into residences. With 1 replacement of the system during the life-cycle of 50 years, the system still demonstrates economic feasibility.

2. Higher weight would make the system unmanageable for householders to install, relocate, add or ommit the system.

3. There are extra-performances of many variables which do not add to the quality of residential partitions.

## 5.6.12 V-Wall Movable Wall

Part A: General Data

Manufacturer: Herman Miller

Category: Portable Partitions, Progressive Type

Features: Excellent acoustical ratings. Easy accomodation of electrical wires and telecommunication cables. Ability to interchange with systems products. Wide range of panel trim and finish options. Easy to plan, specify and use.

Main Properties:

1. Thickness: 76.2 mm (3")
2. Weight per Panel (8'x4'): 80 kg (176 lbs)
3. Fire Rating: 1 hr.
4. Sound Rating (STC): 38

Major Components:

1. Metallic Top and Floor Runners
2. Gypsum facing panels with core board studs, pre-finished with fabric or vinyl surface finish.
3. Pressure connectors
4. Trims

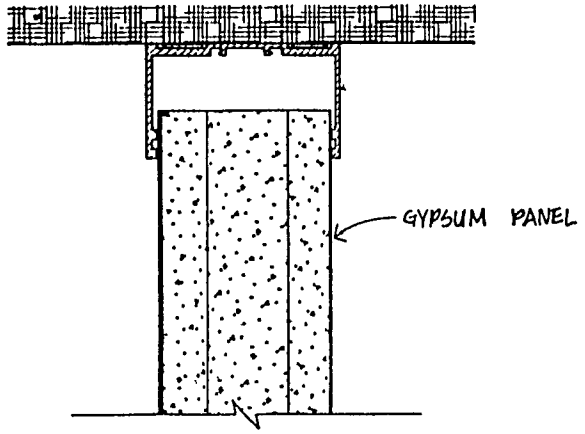
Installation Details:

1. Installation of ceiling and floor runners.
2. Placing of panels into the runners after laying out service cables through the panel cavities.
3. Placing of Trims wherever required.

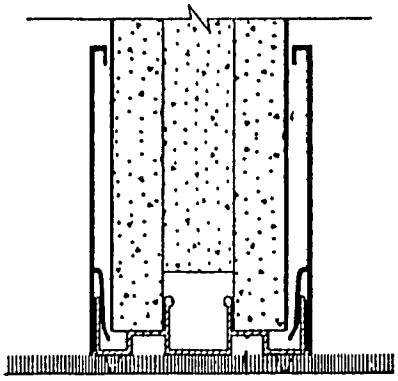
# V-Wall Movable Wall

Part A: General Data (Cont.)

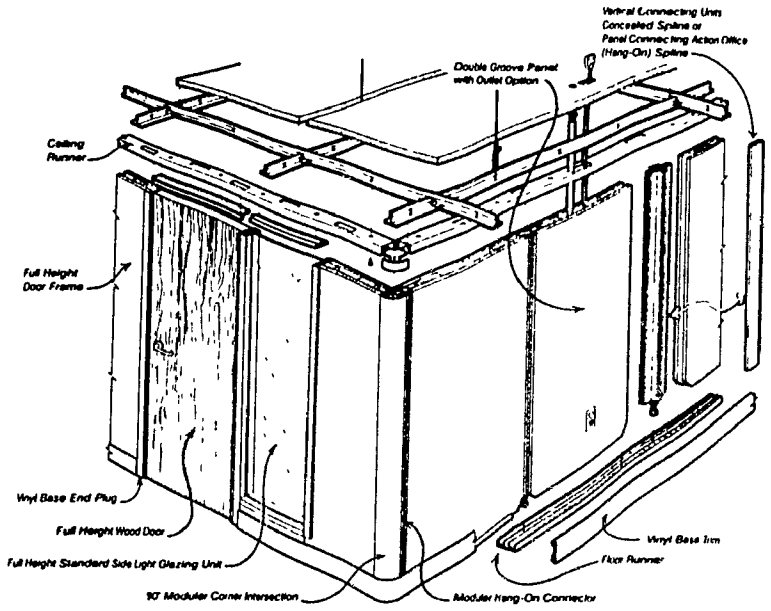
Pictorial Presentation of Technical Details




Section at Ceiling Level



Section at Floor Level




Sectional Perspective

## V-Wall Movable Wall (Cont.)

Part B: Evaluations

| Attributes | Performance Variables | Performance Criteria | Observed Performance | Performance Rating |
|---|---|---|---|---|
| Economy | a. Cost | | | |
| | i)Cost of Components | | $ 60 per L.ft. | |
| | ii)Cost of Install-ation | | $ 35 per L.ft. | |
| | iii)Installed Cost | | $ 95 per L.ft. | |
| | iv)Life Cycle Cost | $188 per L.ft. (Height 8') | $200 per L.ft. | -2 |
| Durability | b. Useful Life | 50 years (min.) | 20 years | -3 |
| Maintain-ability | c. Mode of cleaning | Should have provisions for cleaning without machineries with soft detergent and a light wt. mop. | With water and cloth. | 0++ |
| Habitab-ility | d. Transparency | Should offer the option between opaque & transparent materials. | Glazing at any desired location. | 0+++ |
| | e. Electrical Provisions | Should be able to incorporate electrial network and/or relocate the outlets without dismantling the system entirely. | Without dismantling access panel and a set of panels. | 0 |
| | f. Hanging Provisions | Should have the provision for hanging or attaching light wt. functional and/or decorative elements. | Moderate wt. func./dec. elements at any position. | 0++ |
| | g. Door Location & Type | Should offer choice of interchangeable door location at any desired position, normal hinged type, with opaque material. | Any desired position, hinged, opaque. | 0 |

## V-Wall Movable Wall (Cont.)

Part B: Evaluations (Cont.)

| Attributes | Performance Variables | Performance Criteria | Observed Performance | Performance Rating |
|---|---|---|---|---|
| Code Acceptability (i.e., conformity with governing regulations) | h. Fire Resisting Capacity | 3/4 hr. - 1 hr. | 1 hr. | 0 |
| | i. Interior Sound Level (STC) | 30 (min.) | 38 (depends on surrounding installation) | 0++ |
| Practicability | j. Availability | Should be available in 28 days after placing the order. | 7 days | 0+++ |
| | k. Fixing Conditions | Should be able to be fixed without provisions of double floor and/or suspended ceiling. | No double floor/ suspended ceiling required | 0 |
| | l. Panel Dimension | Width: 4' (max.) | 23" or 29" | 0++ |
| | m. Panel Weight | Weight Range 44 kg. - 65 kg. per panel. (8' x 4') | 80 kg per panel | -2 |
| | n. Installation Time | 2.5 man hr. per panel (8' x 4') | 1.6 man hr. | 0++ |
| | o. Installation Tool | Installation should be possible with a set of light wt. tools with max. 1 electrically operated light weight. | Light wt. tools with more than 1 light wt. electrical equipment | -1 |
| Appearance | p. Modular Characteristics | Should be non-modular in appearance with no visible vertical battens. | Hairline joint | 0++ |
| | q. Color | There should be at least eight different colors available from which the developer or the householder would choose. | 16 colors | 0++ |

## V-Wall Movable Wall

Part C: Observations and Findings

1. Higher installed costs coupled with lower durability make V-Wall Movable wall economically not feasible for residential applications.
2. Panel weight restricts easy installation or handling by the householders during its life-cycle.
3. Installation Tools required for the system put forward another problem area for its application in residences since it is most unlikely that the householders would be interested to possess more than 1 electrical equipments for this purpose.
4. However, most of the other performances are more than the requirements to apply it to the residences.

## 5.6.13 Westroc Modulaire 2 Partition System

Part A: General Data

Manufacturer: Westroc Industries Ltd.

Category: Demountable Partitions, Progressive or Non-Progressive Type

Features: Wide selection of colors and textures, hairline thin joints, hook on base for easy electrical installation, carpet saver tapes for avoiding unsightly holes in the carpet after relocation. Choice of progressive and non-progressive installation.

Main Properties:

1. Thickness: 95 mm (3 3/4")
2. Weight per Panel (8'x4'): 64 kg (140 lbs)
3. Fire Rating: 1 hr.
4. Sound Rating (STC): 40

Major Components:

1. 64 mm. ($2\frac{1}{2}$") steel stud
2. Steel top track
3. Monolithric corner (90°, 135°)
4. NP and Econo Clip
5. Floor Track with carpet saver
6. Vinyl board or Gypsum board
7. Miscellaneous Trims

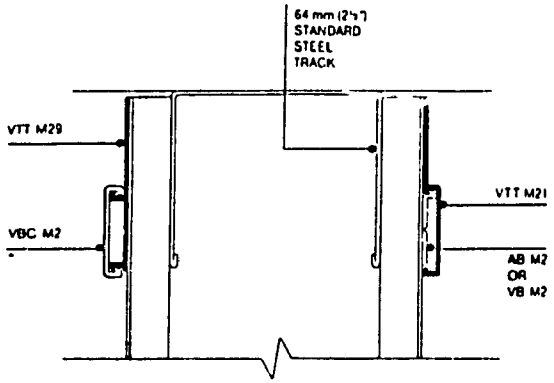
Installation Details:

1. Setting of steel studs spaced 600 mm. (14"0 o.c. into steel tracks at floor and ceiling.
2. Installation of services (electrical or other network) as per specifications on one or both sides of the stud.
3. Installation of vinyl or gypsum board as per specifications with either of the two alternative possibilities: incorporating non progressive battenless system using Westroc NP clip, or progressive battenless system using Westroc Econo clip.
4. Installation of top and base trim and finish according to specifications.

## Westroc Modulaire 2 Partition System (Cont.)

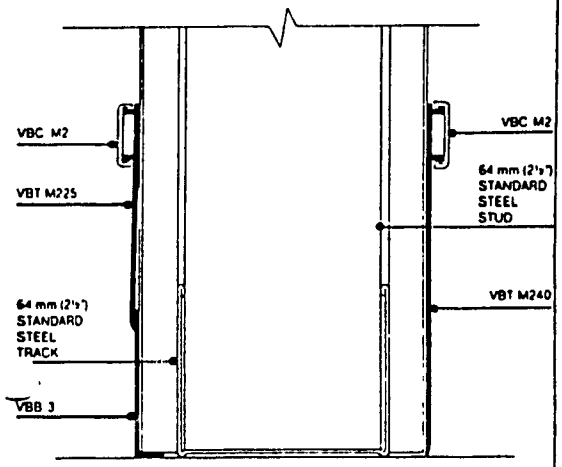
Part A: General Data (Cont.)

Pictorial Presentation of Technical Information



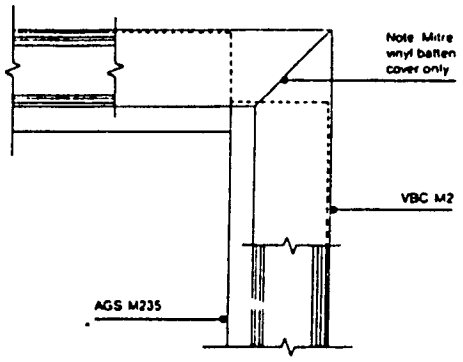

VTT: Vinyl Top Trim
VBC: Vinyl Batten Cover
AB : Aluminium Batten

Section at Ceiling Level

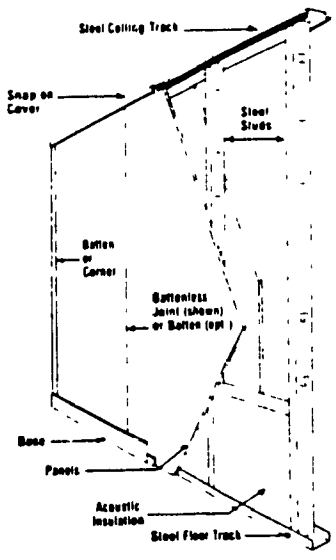



VBC: Vinyl Batten Cover
VBT: Vinyl Batten Trim
VBB: Vinyl Base Backing

Section at Floor Level




Standard Corner Details




Sectional Perspective

**Westroc Modulaire 2 Partition System (Cont.)**

| Part B: Evaluations | | | | |
|---|---|---|---|---|
| Attributes | Performance Variables | Performance Criteria | Observed Performance | Performance Rating |
| Economy | a. Cost | | | |
| | i)Cost of Components | | $ 25.00 per L.ft. | |
| | ii)Cost of Install-ation | | $ 30.00 per L.ft. | |
| | iii)Installed Cost | | $ 55.00 per L.ft. | |
| | iv)Life Cycle Cost | $188 per L.ft. (Height 8') | $145.00 per L.ft. | 0+++ |
| Durability | b. Useful Life | 50 years (min.) | 50 years | 0++ |
| Maintain-ability | c. Mode of cleaning | Should have provisions for cleaning without machineries with soft detergent and a light wt. mop. | Without machi-neries with water, cloth. | 0++ |
| Habitab-ility | d. Transparency | Should offer the op-tion between opaque & transparent mate-rials. | Glazing at any desired position. | 0+++ |
| | e. Electrical Provisions | Should be able to in-corporate electrial network and/or relocate the outlets without dismantling the system entirely. | Possible by removing base board only. | 0+++ |
| | f. Hanging Provisions | Should have the pro-vision for hanging or attaching light wt. functional and/or decorative elements. | Hang and/or attach moderate wt. func./dec. elements at fixed locations. | 0+ |
| | g. Door Location & Type | Should offer choice of interchangeable door location at any desired position, normal hinged type, with opaque mate-rial. | At any desired position, hinged type, opaque material. | 0 |

## Westroc Modulaire 2 Partition System (Cont.)

Part B: Evaluations (Cont.)

| Attributes | Performance Variables | Performance Criteria | Observed Performance | Performance Rating |
|---|---|---|---|---|
| Code Acceptability (i.e., conformity with governing regulations) | h. Fire Resisting Capacity | 3/4 hr. - 1 hr. | 1 hr. | 0 |
| | i. Interior Sound Level (STC) | 30 (min.) | 40 | 0++ |
| Practicability | j. Availability | Should be available in 28 days after placing the order. | 7 days | 0+++ |
| | k. Fixing Conditions | Should be able to be fixed without provisions of double floor and/or suspended ceiling. | Double floor/ suspended ceiling not required | 0 |
| | l. Panel Dimension | Width: 4' (max.) | 4' | 0 |
| | m. Panel Weight | Weight Range 44 kg. - 65 kg. per panel. (8' x 4') | 64 kg | 0 |
| | n. Installation Time | 2.5 man hr. per panel (8' x 4') | 2.5 man hr. | 0 |
| | o. Installation Tool | Installation should be possible with a set of light wt. tools with max. 1 electrically operated light weight. | Light wt. tools with 1 electrical operated equipment | 0 |
| Appearance | p. Modular Characteristics | Should be non-modular in appearance with no visible vertical battens. | Hairline joints | 0++ |
| | q. Color | There should be at least eight different colors available from which the developer or the householder would choose. | Any color (if gypsum is used) | 0+++ |

**Westroc Modulaire 2 Partition System (Cont.)**

Part C: Observations and Findings

1. Higher durability and lower installed cost make Westroc Modulaire 2 Partition System readily adaptable to residences as far as economy is concerned. The cost of components indicate that if self-installation by the householders using their own labor could cut down the cost immediately and bring it to the level of its fixed gyproc counterpart.
2. Most of the other performances not only meet the required level but are in excess.
3. The excess performances could be cut down to the required level by modifying its constituent materials.

## 5.7 Conclusions: Interpretations, Summary and Recommendations

The following chapter interpretes the evaluations, summarizes the findings of the study, makes recommendations in light of the findings, and finally presents reflections of the author in the light of the experience that he gained from the study.

# CHAPTER SIX

# CONCLUSIONS

This chapter presents the final conclusions pertaining to the research undertaken. The chapter is divided into four sections. Section one interprets the findings of the evaluation presented in the last chapter with reference to the research question: Could commercial flexible partition system be adaptable to residential applications? The second section presents the sum and substance of the research in a nutshell. The third section makes relevant recommendations in the light of the experience gained during the study. Finally, the fourth section presents some opinions of the author on the subject as reflections which might tend to go beyond the immediate scope of the present study and place it in a broader perspective.

## 6.1 Interpretation of the Evaluation: Addressing the Research Question

It is worth recalling here that the study gained its initial momentum by focusing on a single and simple pragmatic question on the possible adaptability of commercial flexible partition systems available in the North American market into residential applications. At the end of the long journey in quest of an answer, it seems that in spite of the proven adaptability of most of the systems evaluated herein, it would be quite inadequate to come up with a simple 'yes' as a response. It would, therefore, be logical to grasp the overall view of the evaluations and interpret the most important findings that deserve special mention.

### 6.1.1 Overall View of the Evaluations:

The following table (Table 6.1) provides a clear overall view of the evaluations with the help of an evaluation ***matrix*** [1] rating sheet followed by a comprehensive list of general observations and findings in relation to the research question. However, it was mentioned earlier that there is no valid reason to rank order the variables since relative importance of their needs is a function of individual priority. For the same reasons, weighted summation of variable ratings of each system would not be meaningful in the same way to each and every individuals.

The matrix provided here would make the evaluation of each aspect explicit rather than providing a meaningless single number for each of the systems.

---

1. **Rosen** defines **Matrix Analysis** as 'a form of mathematics that provides a systematic method for the manipulation and solution of systems. The Matrix is a rectangular array of numbers, called elements, arranged in rows and columns'.

Table 5.1: Evaluation Matrix of Selected Commercial Flexible Partition Systems for Residential Applications (In alphabetic order)

| Name of the Partition System and Type | Economy | Durability | Maintainability | Habitability | | | | Code acceptability | | Practicability | | | | | | Appearance | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Life Cycle Cost | Useful Life | Mode of Clean. | Transparency | Elect. Prov. | Hanging Prov. | Door Location & Type | Fire Rating | Sound Rating | Availability | Fixing Cond. | Panel Dimen. | Panel Wt. | Installation Time | Installation Tool | Modular Character | Color |
| Dampa Mova Wall (Demount ) | 0+ | 0 | 0 | 0+++ | 0+ | 0+ | 0 | 0 | 0+++ | 0++ | 0 | 0+++ | 0 | 0 | 0 | 0 | 0++ |
| EnvironWall (Demount.) | 0++ | -3 | 0 | 0+++ | 0+ | 0++ | 0 | 0 | 0+++ | 0+++ | 0 | 0 | 0 | 0+++ | 0 | 0 | 0+++ |
| High Perf. Partitions (Demount.) | 0+++ | -3 | 0 | 0+++ | 0+ | 0++ | 0 | 0+ | 0++ | 0 | 0 | 0 | -1 | 0+ | 0 | 0++ | 0+++ |
| InnerSpace Partitions (Portable) | 0+++ | -3 | 0 | 0+++ | 0+++ | 0+ | 0 | 0 | 0+ | 0 | 0 | 0+++ | -2 | 0 | 0 | -1 | 0+++ |
| KnollWall System (Portable) | -3 | 0++ | 0 | 0+++ | 0++ | 0++ | 0 | - | 0++ | -3 | 0 | 0 | -3 | 0++ | 0+++ | -1 | 0 |
| Mobilflex Portable Wall (Portable) | 0+++ | -3 | 0 | -1 | -3 | 0 | 0 | 0 | 0+++ | -2 | 0 | 0 | -3 | 0+ | -1 | 0++ | 0+++ |
| PC 350(R) Gr. Lock (Demount ) | 0+++ | 0 | 0++ | 0+++ | 0+ | 0+++ | 0+ | 0 | 0+++ | 0++ | 0 | 0 | 0 | 0++ | 0 | 0++ | 0++ |
| SpaceSetter 204 (Portable) | 0+++ | -3 | 0+++ | 0+++ | 0 | 0+ | 0 | - | 0+ | -2 | 0 | 0++ | -2 | 0+++ | 0+++ | 0 | 0++ |
| System 40 (Demount.) | 0+++ | 0 | 0++ | 0+++ | 0 | 0++ | 0+ | -1 | 0 | 0++ | 0 | 0++ | -3 | 0++ | 0 | -2 | -2 |
| Treco Fabrication (Portable) | 0+ | 0++ | 0+++ | 0++ | 0 | 0+ | 0 | 0 | 0+ | 0 | 0 | 0 | -1 | 0++ | 0+++ | 0++ | 0 |
| UltraWall (Demount.) | 0+++ | -3 | 0 | 0+++ | 0 | 0 | 0 | 0+ | 0+++ | 0 | 0 | 0++ | -2 | 0++ | 0 | 0++ | 0++ |
| V-Wall Movable Wall (Portable) | -2 | -3 | 0++ | 0+++ | 0 | 0++ | 0 | 0 | 0++ | 0+++ | 0 | 0++ | -2 | 0++ | -1 | 0++ | 0++ |
| Westroc Modulaire 2 (Demount.) | 0+++ | 0++ | 0++ | 0+++ | 0+++ | 0+ | 0 | 0 | 0++ | 0+++ | 0 | 0 | 0 | 0 | 0 | 0++ | 0+++ |

Note: For Performance Rating Scale please refer to pages 82 and pages 92-95

### 6.1.2 Interpretation of Evaluations with Reference to the Research Question:

From the evaluations made in the last section and from the evaluation matrix provided in Table 6.1 the following interpretations are made:

a. **High Standards of the Partitions:**

Most of the commercial flexible partition systems are simply too good* or too sophisticated to be adapted to residences, since most of the performances of variables of majority of the systems exceed the required levels for residential applications. In simpler terms, overall standards as exhibited in the evaluations are very high, higher than the standard required for the residential applications. However, as indicated in the individual evaluations, these excess measures do not necessarily add to the quality of residential partitions. Therefore, if any modifications of these partitions are to be made for applying it exclusively to residences, it has to do with cutting down unnecessary performances by modifying them at the materials level.

b. **Higher Initital Costs: Self Help Vs. Commercial Flexible Partitions:**

The life-cycle costs of most of the partition systems evaluated here indicate its economic feasibility in long terms. But higher initial costs as compared to their fixed gyproc counterpart could affect the acceptance of the householders as well as the developers since they might be unaware of the life-cycle benefits. Adaptability of some of the systems would be easier, as indicated in individual evaluations, if they are self-installed by the householders putting their own labor. Such self-installation cut down initial costs instantaneously and make them economically

* indicates O+, O++, O+++ rating in most of the attributes of a partition system

feasible, as compared to fixed gyproc wall keeping aside the question of future benefits. However, it should be understood that if the developer is removed from the scene once the support is complete, the households must have a degree of construction skill to install partitions of their own. Excess weight of the partitions might restrict easy handling and self-management since most of the systems offer higher weight per panel as demonstrated in the evaluation matrix. For some of the systems, the manufacturers recommended certified installers for this purpose.

c. **Durability and the Partitions:**

Lower durability level seems not to be a major problem area in the possible adaptation of the systems in the residences since lower installed costs in most of the systems make them economically feasible with one complete replacement of the system during the life-cycle of the support (i.e., the building envelope).

d. **Availability Time and the Partitions:**

Availability time is one of the problem areas as demonstrated by the evaluation matrix. The systems with higher availability time would be less desirable to the developers and the households.

e. **Aesthetics Vs. the Partitions:**

Some of the systems exhibit modular characteristics which seems to be one of the most important barriers in adapting them to residences since strong vertical lines in partitions are psychologically associated with commercial environments. It would most probably be very difficult for the householders to accept such an aesthetic consequence, even if all other performances of a system are efficiently met.

## 6.2 Summary:

The concept of flexibility in housing has been translated into reality in a number of housing projects in Western Europe. Although these projects exhibited a lot of potential in recovering the people's stolen participation in the housing process, a host of technical problems, specially in the area of infill components such as internal partitions, affected the actual need for and ultimate success of such support and infill projects. Assuming that the concept of support and infill would bear significant market demand in North America, it was understood that there was no valid point in making new housing more tractable unless the partition itself becomes sufficiently sound in technical terms and psychologically more acceptable in aesthetic terms. To begin with, the most realistic way seemed to be to start from similar known products, i.e., commercial flexible partition systems, which had long been used successfully in corresponding applications, obviously in a different context. However, as a first step towards the journey to the unknown, it was necessary to understand the implications of transferring a sophisticated product from one market to the other to find out the possible roadblocks that the existing organization of the manufacturing industry and the building industry might pose, and the legal obstacles, if any, related to such sectorial transfer. Secondly, it was necessary to examine the adaptability of commercial flexible partition systems into residential applications. The context of the study was outlined and an attempt was made to develop a set of evaluation criteria with the help of which it would be possible to examine their possible adaptability in residences. Out of context partitions were screened out with a screening mechanism devised exclusively for this purpose and finally, a number of partitions were selected and advanced to the evaluating stage. The study suggests that a major portion of the commercial flexible partitions could be adaptable to residences although they possess performances not required for residences. Higher initial costs might restrict such adaptations and

aesthetic considerations might bear high significance.

## 6.3 Recommendations:

### 6.3.1 On Sectoral Transfer:

The study recommends a gradual introduction of flexibility in housing which would enable the manufacturers to handle the initial demand for the time being with excess capacity of technology that they generally hold and add new machineries as the market demand grows positively and becomes steady.

It recommends to the manufacturers to reconsider their pricing policy for a new competitive market and turn to the concept of third degree prices in different markets for the same product.

It further recommends that the manufacturers should diversify their marketing channels and intensify their product promotion activities to penetrate into the new market.

### 6.3.2 On Modifications of Commercial Partitions:

Although most of the partitions evaluated herein could directly be applied to residences, excess performances not required for residential applications could always be modified. The study recommends such modifications at material level only, since most of them do not pose any technical problems whatsoever.

### 6.3.3 On Further Studies:

Such modifications at material level would require extensive studies on the properties of suitable materials, their availability and

economic aspects. The study strongly recommends such in-depth investigations.

## 6.4 Reflections:

Technological innovation for building materials is an evolutionary process based on gradual introduction of components, materials and assemblies. Steps forward seem to be minor but over time and in aggregation, they tend to continually improve the service rendered to the users. The world of building is marked by great prudence and a certain inertia. It tends to reject too pronounced innovations, too sudden developments. The most realistic way to influence the evolutionary process is to start from known products. Therefore, the study concentrated on such known products, i.e., the commercial flexible partitions systems.

The possibilities for partitioning infill fall into two groups: common building materials and pre-fabricated or pre-assembled 'systems'. The simplest and the most commonly used choice from the first group is the 2 x 4 gyproc board partition. The simplicity and low initial cost lead one to suspect that the higher costs of the various systems do not overweigh their advantages. However, the study shows that with life-cycle benefits, durability and ease of relocation, the most costly systems could become more desirable. Old dry wall becomes scrap, messy to demolish and expensive to dispose of. The days may be numbered for reducing a partition to a heap of rubble when change is desired. If housing conditions are to be improved, obsolete components must be recycled and re used with minimum destruction and waste. Today partitions don't have to be fixed forever. Partitions don't have to cause trouble, waste and expense when the place they are located is no longer the right place.

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## APPENDIX ONE

### Interview Guidelines

Date .....  Time .....

Person Interviewed .....

1. Flexibility in housing in general, your reactions
2. Flexibility in housing, your comments on its prospects in North America in particular
3. Adaptability of commercial flexible partitions to residences, your views
4. Possible functional problem areas that you could foresee to use them in residences
5. Possible aesthetic problem areas that you could foresee to use them in residences
6. Possible legal problems that you could foresee in transferring them for one market to another
7. Possible marketing problems that you could foresee to put them to residential uses
8. Strategies, in your view, to overcome the obstacles, if any, that stand in the way of such sectoral transfer
9. Your suggestions in this matter
10. Any other comments, views, opinions relevant to the topic

## APPENDIX TWO

### List of Representatives of Building Product Manufacturers, Officials and Professionals Interviewed during the Research

Mr. Vince Palermo, Manager Production, Knoll Office Inc., Montreal

Mr. Raymond Daillaire, Manager Production, Rampart Partitions Ltd., Montreal

Mr. Roger Perrier, Sales Representative, Domtar Laminated Products, Montreal

Mr. Fernand Gagnon, Sales Representative, Westroc Industries Ltd., Montreal

Mr. Donahue, Sales Representative, Dampa Building Systems, Montreal

Mrs. Pauline Filion, Secretary-in-charge, Canadian Standard Association, Montreal

Mr. Perron, Underwriters' Laboratories of Canada, Montreal

Professor Nabil Hamdi, professor, Department of Architecture, MIT, Cambridge, Mass., USA

Mr. Roger Richard, Partner Architect, Roger Richard Bruno Arch., Montreal

Professor Guelzar Haider, Department of Architecture, Carlton University, Ottawa

Professor Rafiquzzaman, Department of Economics, Concordia University, Montreal.

Mr. William Smith, Architect and CAD Manager, Minto Developer, Ottawa

## APPENDIX THREE

### List of Major Manufacturers of Commercial Flexible Partition Systems in North America

#### Canada

| Name | Address | Telephone No. |
|---|---|---|
| Arcopel Acoustique Ltd. | 4617 Des Grandes Prairies<br>Montreal H1R 1A5 | (514) 324-6864 |
| C & C Designs Ltd. | 1156 Yonge<br>Toronto M4W 2L9 | (416) 961-6574 |
| Canadian Portable Structures Ltd. | 4400 Corporate Dr.<br>Burlington, Ont. L7L 5R3 | (416) 335-5500 |
| Dampa Inc. | 1285 Morningside Ave.<br>Scarborough, Ont. M1B 3W2 | (416) 286-3020 |
| Donn Products | 735 Fourth Line Road<br>Oakville, Ont. H1C 2L5 | (416) 845-3883 |
| Expanded Metal Corp. | 20 Fasken Dr.<br>Rexdale, Ont. M9W 1K5 | (416) 675-6311 |
| Herman Miller | 2113 Place Bonaventure<br>Montreal, PQ | (514) 871-1871 |
| Hilco Walls & Ceiling Ltd. | 625 Angus<br>Regina, Sask. S4R 3K7 | (306) 525-3369 |
| Knolloffice Inc. | 17400 Trans Canada Hwy<br>Kirkland, PQ H9J 2M5 | (514) 695-9030 |
| Quebec Architectural Products<br>(Rampart Partitions Inc.) | 7365 Chouinard<br>Lasalle, PQ H8N 2L6 | (514) 367-0330 |
| Magi Walls Inc. | 45040 Wilson<br>Montreal, PQ H4A 2V4 | (514) 489-8941 |
| Panelfold Canada Inc. | 90 D'Anvers Parc Ind.<br>St. Augustin, PQ G0A 3E0 | (418) 878-3303 |
| Partition Components Inc. | 150 Ferrier, Unit 14<br>Markham, Ont. L3R 2Z5 | (416) 475-6022 |

**Canada**
(cont.)

| Name | Address | Telephone No. |
|---|---|---|
| Provincial Partitions Ltd. | 1285 Eglinton Ave. E.<br>Mississauga, Ont. L4W 3A6 | (416) 238-0017 |
| Soper's | P.O. Box 227<br>Hamilton, Ont. L8N 3E8 | (416) 528-7936 |
| Trecco Fabrication | 590 Sagard<br>St. Bruno, PQ J5C 1X7 | (514) 653-5657 |
| VIP Office Screen | 1462 Columbia North<br>Vancouver, BC V7J 1A2 | (604) 985-9121 |
| Westroc Industries Ltd. | 2424 Lakeshore Road (W)<br>Mississauga, Ont. L5J 1K4 | (416) 823-9881 |
| | **United States of America** | |
| AR Claridge Products and Equip. | P.O. 910<br>AR, Harrison | - |
| CA A-Z Western Factory Supply | 2170 West Broadway<br>CA Anaheim | - |
| CA American Partitions and Building System | 18335 Mt. Langeley St.<br>Dept. CR<br>CA 92708 | (714) 964-5656 |
| CA Fieldtec Inc. | 3250-T S. Susan St.<br>Santa Ana CA 92704 | (714) 540-4000 |
| CA Simplex Inc. | 8468-T Loma Place<br>Upland CA 91786 | (800) 854-7951 |
| CT Neiss Corp. | PO Box 478<br>Rockville CT 06066 | (203) 872-8528 |
| CT Modular Industries Inc. | PO Box 2040<br>Terryville CT 33266 | - |
| FL National Partitions Inc. | 340-T W 78th Rd.<br>Hialech, FL 33014 | (800) 327-3697 |
| FL Endure-a-Lifetime Inc. | 7500-T Northwest 72 Ave.<br>Miami, FL 33266 | (800) 325-1337 |

## United States of America
(cont.)

| Name | Address | Telephone No. |
|---|---|---|
| FL Panelfold Inc. | 10750-T N.W. 36 Ave.<br>Miami, FL 32288 | - |
| GA United McGill Corp. | 1501 Kalamazoo Dr.<br>Griffin, GA 30224 | (404) 228-9864 |
| IL Cardinal Ind. Inc. | P.O. 24 W 351 Army Trail Rd.<br>Bloomingdale, IL 60108 | (312) 529-2474 |
| IL Opto International | 65E Palatine Rd.<br>Prospect Heights, IL 60208 | (312) 621-2115 |
| MA Deluxe Systems | 3 Strafello Dr.<br>Avon, MA 021820 | - |
| MA Eckel Industries Inc. | 161 Fawcett St.<br>Cambridge, MA 02138 | (617) 491-3221 |
| MI Roberts Movable Walls | PO Box 339<br>Comstock, MI 49041 | (616) 345-2915 |
| NY National Office Product | 641, Sixth Ave.<br>NY, NY 10011 | (212) 924-0662 |
| OH Component System Inc. | 7002 Tr. Granger Rd.<br>Cleveland, OH 44131 | (216) 524-5000 |
| PA General Partitions Mfg. | PO Box 8370-T<br>Erie, PA 16505 | (814) 838-6551 |
| PA Modular Engineering Co. | PO Box 8241<br>Erie, PA 16505 | (814) 837-6813 |
| VA Nomadic Structures Inc. | 7700 South Dr., Ste. 200<br>Springfield, VA 22105 | (800) 336-5019 |
| WI Hough Mfg. Corp. | PO Box 591-B<br>Janesville, WI 53545 | (608) 756-1241 |

## APPENDIX FOUR

**Letter Sent to All Building Product Manufacturers, and One of the Many Replies Received by the Author**

Dear Sir

We are very much interested to get a complete set of relevant information pertaining to all the different movable, portable, and demountable partition systems for offices that you presently manufacture or deal with

It would be highly appreciated if you could send us a complete set of catalogues at your earliest convenience. The information should include installation process, time required to install a single panel, useful life span, cleaning procedures, provision of electrical cables, and outlets, fire and sound ratings, dimension of each panel, tools needed for installation, unit weight of each panel, overall appearance, color options and, if possible, a complete price list

We would further like to know the full address and telephone number of your dealer, if any, in Montreal.

Thanking you, and anticipating a very quick response,

Yours faithfully,

Syed Yamin

**Letter**

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**ENVIROWALL**
PARTITION SYSTEMS LIMITED

November 18, 1988

Mr F Yamin
2520 Quesnel Apt 1
Montreal, Quebec
H3J 1G7

Dear Mr Yamin

Thank you for your inquiry concerning Envirowall Pre-finished wall systems

The enclosed product brochures, specifications and detail sheets will give you some idea of the construction and appearance of our wall system We have also included samples of our stock vinyl finishes At the present time we do not have a representative in the Montreal area However, we would be most happy to have a Toronto representative meet with you if required

We appreciate your interest in Envirowall
If you should require additional information, please do not hesitate to contact us

Yours truly
ENVIROWALL PARTITION SYSTEMS LTD

Beverley Clausen
General Manager

BC/ms

**One of the replies**

## APPENDIX FIVE

**Calculations: Break-Even Analysis for Determining the Allowable Life-Cycle Costs of Commercial Flexible Partitions as compared to that of Fixed Gyproc Partitions:**

(a) Life-cycle cost saving or total saving over the life-cycle of a household by incorporating flexible partition as against conventional fixed partition alternative takes the following mathematical expression (refer to page 70):

$$LCS = \sum_{t=o}^{t=n} fn\,(CC_T - CF_T) \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (i)$$

Where, LCS = Life Cycle Saving

fn = Multiplier combining time frequency of occurance including present value discount and inflation escalation

$CC_T = CC_1 + CC_2 + CC_3$ (for 3 relocations in this case) = Total cost of conventional partitions

$CF_T = CF_1 + CF_2 + CF_3$ (for 3 relocations in this case) = Total cost of flexible alternative

A Break-Even Analysis is required to solve for the upper limit of the allowable cost of flexible partition that would be compatible to the fixed gyproc walls. Break-Even analysis is a procedure for evaluating alternatives (in this case the fixed wall and flexible partitions) in terms of a common unknown variable. It involves solving for the value of the variable which would make the cost equations for the alternatives equivalent, this value is the break-even. If the fixed gyproc wall and the flexible partitions are economically equivalent, there will be no loss or gain in monetary terms if either of them is incorporated in the dwelling. In other words, there will be no life cycle cost savings in this case. (i.e, LCS = 0)

Considering 3 relocations in a life-cycle as assumed in chapter four, and considering a break-even (i.e., LCS = 0) between the conventional and flexible alternatives, using (i), we get,

$$0 = fn\,[(CC_1 - CF_1) + (CC_2 - CF_2) + (CC_3 - CF_3)]$$

$$\therefore\ 0 = fn\,[CC_1 + CC_2 + CC_3 - (CF_1 + CF_2 + CF_3)]$$

$$\therefore\ CF_1 + CF_2 + CF_3 = \$153 \quad \text{(Substituting the values of } CC_1, CC_2 \text{ and } CC_3 \text{ from table 4.3)}$$

For an allowable cost for flexible partition, initial cost of the conventional partition must be added to this.

$\therefore$ Allowable Cost for Flexible Partitions = \$153 + \$35
= \$188 (per L.ft)

(Prices are taken from 1989 price index as provided by the local contractors)

This means that over the life cycle of fifty years with flexible partitions relocated on three occasions, the total cost must not exceed \$188 since it is at this cost that the two alternatives (fixed gyproc wall and flexible partitions) are equivalent. If the life cycle cost is more than \$188, it means the gyproc wall would be economically more feasible while if it is less than this amount there will be a saving (i.e, life cycle saving) as compared to fixed gyproc wall.

(cont.)

(b) It is interesting to note that a majority of the partitions evaluated herein are supposed to generate a potential life-cycle cost saving over a period of fifty years as against fixed gyproc walls. Being unaware of such information the home-owners might be interested to incorporate fixed gyproc wall due to its lower initial costs . The study strongly recommends that the manufacturer should make relevant information on such cost saving readily available to the prospective clients.

(c) It is in the context of this higher initial cost that the flexible partition might be more acceptable in luxury condominiums. However, if self installation is considered, it might bear significance in affordable housing or in accomodations like student dormitories since if self-installed, 55% of such initial cost could be reduced instantaneously.

## APPENDIX SIX

### Some Important Notes on Fire Rating

It should be understood that fire rating data for different partition systems cited in this report are based on the characteristics, properties, performance of materials and systems obtained under controlled installation and test conditions. Proper fire rated flexible partitions for residences would be hard to achieve since it would be difficult to assign the home-owner the responsibility of ensuring that the relocated partition has a proper installation at the top and on the bottom, that the door frame in the partition is properly constructed and that no other mistakes could have crept into the relocation activity. It is assumed that the supports would be fixed and fire rated and for the infill the code would eventually be relaxed.