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Spatial Flexibility in Housing: Establishing Conceptual Framework for Adaptive Design Model

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ABSTRACT

This paper presents a comprehensive review of all significant research about flexibility and adaptability in architecture with particular focus on housing design. The aim is to establish a conceptual framework for a sustainable building design model for Adaptable Housing in Brunei Darussalam. In general, flexibility is ability and potential of a building to change, adapt and reorganize itself in response to change. The problems identified are related to sustainable building design and its adaptability and modification throughout the life-cycle of the house. Therefore, the research focuses on the conceptual framework and investigates the constraints of design. Form and function were identified as technological difficulties in the concept of adaptability and flexibility. Adaptability in a broader sense includes innovative participatory processes for a better way to personalise the home. The method used in this study is a logical flow from the preliminary investigation to form a conceptual framework. Data were retrieved from document review as well as project information, interviews, and observations. The findings confirmed that the conceptual framework could contribute for the development of research in Adaptable Housing by formulating an Adaptive Design model. The main contribution of this study is a conceptual framework that is the basis for designing a questionnaire survey for data collection at the next level of research. This framework provides variables for adaptable housing including activities in the house and satisfaction level for dependent and independent space.

1. Introduction

This research project stems from a diverse needs of users to transform, improve and adapt to their habitats. This need confronts the inhability of contemporary architecture to develop profoundly adaptable architectural living environments. Throughout its life, a house will accommodate a series of occupants with varying needs and requirements. Due to the rapidity of social, technological and economic change, spatial flexibility is becoming one of the main qualities to measure the performance of present and future architecture. The concept of flexibility is not a new one. Flexibility can be easily achived in most vernacular, rural, and semi-rural housing. The house always reflected

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the needs and desires of the individual user. However, with the great tension of modern life, and the introduction of mass-housing, people had to adapt to the house instead of the house becoming suitable to needs of the people's.

2. The Nature of Flexibility

The lifestyle and behaviour of the Brunei community towards design standard and user needs depends on various factors such as physical area and the psychological feeling of the internal spaces in the building. Therefore, this study is concerned with the concept of flexibility in housing. The research aims to establish conceptual framework for the ongoing research related to Performance Index of Satisfaction for Adaptable Housing in Brunei Darussalam. In order to achieve that goal, this study examines the concept of flexibility in order to provide a better understanding of its importance and application, as well as its types and meanings. By establishing such a framework, this review works can provide an overview of the current state of knowledge on the adaptability of buildings and identify critical areas towards sustainable building design in Brunei Darussalam.

2.1 Definition of Flexibility

The term flexibility is applied to objects that bend and yield easily. It does not refer to the physical characteristics of materials, but rather to spatial flexibility, that is, the arrangement of space, and the tendency to change in order to suit new conditions, needs and uses. There are four (4) reasons that most likely require moving from one place of residence to another. These reasons are:

i. Changes in family size [1] that require more or less space.
ii. Changes in life style [2] include socio-economic status, values, and aspirations
iii. Changes in equipment, appliances, and furniture [3].
iv. Variable characteristics of family members' activities in the housing unit [4].

In this definition, a flexible house may allow the families to cope with these changes in terms of:

i. The character of spaces by improving their adaptability to alterations of interior design [5,6].
ii. The size of the house through horizontal or vertical extension or reduction, which means that the house can adapt to growth and expansion as well as contraction [7-9].
iii. The function of the space in terms of versatility and interchangeability, which means that the house provides a multi-function of space [10-12].

In fact, spatial flexibility in housing design is achieved when one, or any combination of these types of changes is possible.

2.2 Type of Flexibility

The three (3) basic types of flexibility in housing design can be classified as adaptability, elasticity, and versatility (see Figure 1).

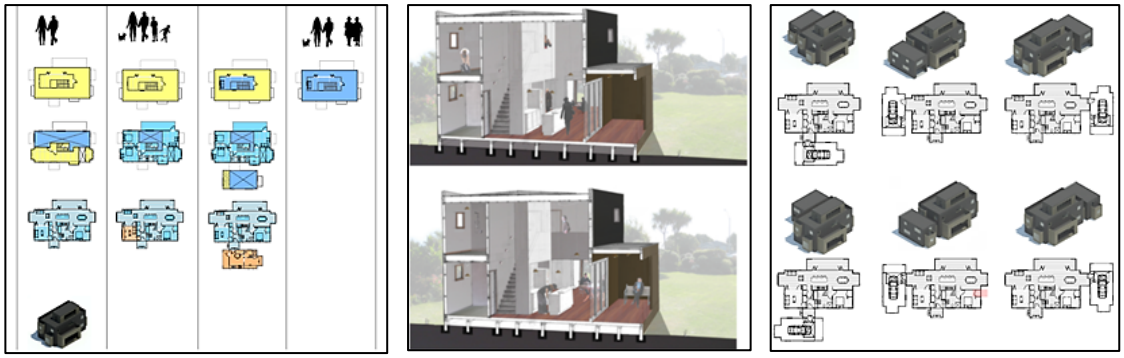

Fig. 1. Adaptability, elasticity and versatility

2.2.1 Adaptability

Adaptability in general is the ability of individual modifications to suit new conditions. The ability to adapt to changing needs by changing internal walls and installation within a dwelling unit while maintaining a constant area may be described as internal variability [13]. Practically, adaptability covers all internal changes, including character changes in both the space availability and the spatial structure [14], subdivision, and the combination of space [15]. In designing adaptable housing, the most effective method is to eliminate the fixed elements of interior design as much as possible. When the position of the kitchen, bathroom, and entrance, for instance, can be determined in advance [16], the remaining space is freed for other functions.

2.2.2 Elasticity

Elasticity is the tendency to return to its normal or previous size or shape after being stretched or stressed. The term, flexible housing, means the ability to accommodate family growth in different stages [17]. In other works, it is the capacity to change the size of the dwelling [15], either to expand it [16,18] or to shrink it. The concept of elasticity is related to the study of changes in floor area, space requirements, and residential form.

The lifespan of flexibility may be classified as either long-term [18], or short-term [19]. The first occurs after a relatively long period of house occupation. Long-term flexibility responds mainly to the need for renovation [20] due to family growth and increased space requirements. On the other hand, short-term flexibility occurs in a relatively short time, due to the need for changing spaces [21,22] for other reasons. Elasticity can be achieved in two (2) ways:

i. Add-on [23]: Add new space to the total space already given, and
ii. Add-in [24]: Add space to the interior of the house without changing the existing area.

In the first case, add-on, which enlarges the actual space, can be the responsibility of the individual owner. It can be implemented by extending a house or terrace. An example of this type is the expansion of row houses, such as “the Growing House” by Avi [23], in which the core of the house, a two-story terrace house, can be extended by adding a single story building next to the existing house. In the second case, add-in means the gain of usable floor space without actually increasing the ground area occupied. This approach is not used in most housing forms, because its application is limited by the actual form, structure, and the existing space of the housing type. Both add-on and add-in approaches are controlled by housing regulation and building codes in terms of the architecture, building construction, height of building, fire zones, accessibility, enclosure requirements, etc.

2.2.3 Versatility

Versatility is the ability to provide multiple uses of spaces. This approach deals with two variables namely space [25] and time [26]. Space may be used either for several functions at the same time, or for different functions at different times [18]. Versatility can be achieved only through neutral plan design, or neutral across equipment and room sizes. The basic components of versatility in space are:

i. Neutral accessibility for rooms [24].
ii. Combine multiple functions in one space and reduce wastage of access area [27].
iii. Appropriate use of access space, which allows functional switching [28].
iv. The neutral external appearance of the building [29].

Versatility may an easy and readily available way to achieve flexible housing, as it only requires functional interchangeability within spaces. This type provides fewer opportunities for freedom and change. However, because it does not require such large open spaces or new technological construction methods, versatility can be applied in the traditional construction systems.

2.3 Level of Flexibility

There are two (2) interdependent levels of flexibility that influence the flexible housing design process, namely the architect's and the user's point of view. To achieve flexible housing, both levels must be considered. The concept of flexibility is based on decisions, on the one hand, that will be made by the architect, on the other hand, made by individual users.

2.3.1 The role of the architect

The role of the architect may be defined in two (2) ways. His first role was that of a professional researcher who developed organizational patterns and new housing design systems that provided potential freedom [30]. His main goal is to make the residence as adaptable as possible to the wishes of the user. These adaptable have two (2) different goals. One of them is the physical arrangement, which means the suitability of a certain space for user activities; the other is psychological order, which means that the modification of space reflects the actual psychological and personal needs of the user [31]. In his second role, the architect serves as an advisor to the individual user, helping him make informed decisions.

2.3.2 The role of the user

Prof. L. Warshaw divided the user's participation into two roles [32]. One, depends on his ability to make decide [33], which is related to his imagination, creativity, judgement, access to information, and intellectual curiosity. The second depends on his own ability to carry out the changes [34] he desires in the given design of the house. This requires attitude and skills, experience, and manual dexterity. In fact, user involvement in the design process falls into one of the following categories:

i. The creation of forms and objects themselves [18].
ii. The arrangement of forms that have been given to him by the architect [35].
iii. The choice between alternative designs [36].

In flexible housing, the actual participation of users is extended to fundamental aspects of the housing units, including planning the interior layout, partitions, doors and openings, storage locations and services, and wall, floor, and ceiling finishes. To some extent, users are also involved in the selection of colors and the treatment of the external facade.

3. Methodology

The methodology reflects the logical flow from the preliminary investigation in initiated the study. It deals with the development of a conceptual framework including an extensive literature review of previous research on flexible and adaptable housing. The review reinforces the need for this research and provides support for the conceptual framework. A series of preliminary interviews with experts in construction industry in Brunei were also conducted to identify the design constraints, and assist the study in identifying issues related to adaptability in housing.

Theoretical triangulation involves using multiple perspectives to interpret a set of data. This method typically involves the use of professionals outside of a specific field of study such as engineers and surveyors. In theory, it is believed that individuals from different disciplines or positions bring different perspectives. Therefore, if each evaluator from the different disciplines interprets the information in the same way, then validity is established.

Preliminary studies investigate design constraints in terms of form and function to identify technological difficulties for adaptability and flexibility in housing. Difficulties in architectural design are classified as the structural methods, and the design of functional requirements for space. The study focuses on two (2) different variables based on the functional impact as follows:

i. Lower Impact: Independent spaces such as living area and bedroom.
ii. Higher Impact: Dependent spaces such as bathroom, kitchen and dining area.

As a result, a conceptual framework was established based on literature review, interviews and observation as a basis for designing a questionnaire survey for data collection in the next stage of the research.

4. Social and Technological Difficulties

Based on the objective of the study, the conceptual framework will provide a solid foundation in establishing a model or hypothesis for research on adaptable architecture. This framework has identified two (2) constraints as social and technological difficulties in achieving adaptability in housing. The factors are building structure and functional requirements of the space.

4.1 Building Structure

The best way to achieve flexibility of space is to avoid obstacles in the interior space as much as the structure permits. The bearing wall structure is, in most cases, built with heavy materials such as brick or masonry. This limits the flexibility of space and, to a certain extent, conflict with the concept of the open plan. For this reason, the bearing wall structure is, in most cases, inefficient in providing flexible space needed. With the development of new materials and technologies, however, such as the use of lightweight material, concrete panels, prefabricated of light brick, have made this type more economical and efficient. On the other hand, the skeleton frame structure, which consists of horizontal beams and vertical supports, seems to be more flexible and adaptable to different building forms. The major categories of the skeleton frame structure are, for example, the two-way cross

frame, parallel cross frame, envelope frame, and frame on polygonal grid. Most of these categories facilitate the designing of the required flexible space. Other types of building structure in housing, such as flat and cantilevered slabs may also provide for adequate possibilities of flexible housing space.

The approach of avoiding obstacles to space, itself creates a number of problems, mainly due to the use of moveable partitions as an alternative to permanent walls. The moveable partitions have proved, until now, unable to meet the space requirements in housing. If partitions are made light enough to be easily moved, they provide sufficient acoustic insulation. On the other hand, if they provide adequate acoustic insulations, they become too heavy to move easily. In the actual manufacture of moveable partitions, the functional requirements of lightness and acoustic insulation are, so far, in clear conflict. Due of this conflict, it is difficult to achieve the desired characteristics that can be summarised as good noise reduction, durability, attractiveness, good quality finish, ease of operation, adequate dimensions and size, and good hardware.

4.2 Functional Requirements of the Space

The second constraint in housing design is the functional requirements of space. Housing unit space may be described as a combination of dependent and independent space.

4.2.1 Dependent space

Spaces whose locations depend upon the locations of other spaces are considered dependent. They may be called dynamic spaces or living spaces. Their characteristics are defined as follows:

i. Continuous: A way to overlap homogenous spaces and save space.
ii. Articulated: A way to differentiate and connect opposite properties of living spaces, such as private/common, day/night, and quiet/noise.
iii. Dynamic: The process by which the fullest meaning of flexibility is achieved.

4.2.2 Independent space

Spaces characterized by their independent location and position are considered as independent. They may be called static spaces or service space (baths, toilets, kitchen and, to some extent, storage areas). Independent spaces provide the necessary environmental conditions and apparatus that allow living spaces to proceed according to a particular program. The most important characteristics of independent spaces are defined as:

i. Integral: A feature that facilitates freedom and efficiency and saves space for other purposes.
ii. Static: A method of achieving total flexibility of space.

The inherent nature of services spaces requires that they be segregated from living spaces, to which, nevertheless, they must also be related. Integral allows for the realization of an adaptable, economical space and provides for greater utilisation of a given area. When the spaces where activity occurs are defined by dependent space and basic supporting functions are supplied by independent space, flexibility of the housing unit space is achieved.

5. Findings and Discussion

The main contribution of this study is a conceptual framework that will be the basis for designing questionnaire survey for data collection at the next level of research. The framework considers all the key findings from the preliminary investigation. Framework is an explicit interpretation of a situation and a description of entities and the relationship between them. This framework provided a sensitising tool to approach Adaptable Housing Design model. In addition, the framework organised concepts such as spaces, activities, construction system, and environment that have been explored indirectly in data collection. The framework orients the study towards inclusion and openness to finding the data to collect rather than setting limits and exclusions on what should be attended or collected.

The finding of the preliminary investigation is a conceptual framework. The framework will guide for the initial stages of the research by identifying what is within the scope of the case study for housing. A conceptual framework has been developed using a factor approach to better understand the relationship between cause and effect, as shows in Figure 2.

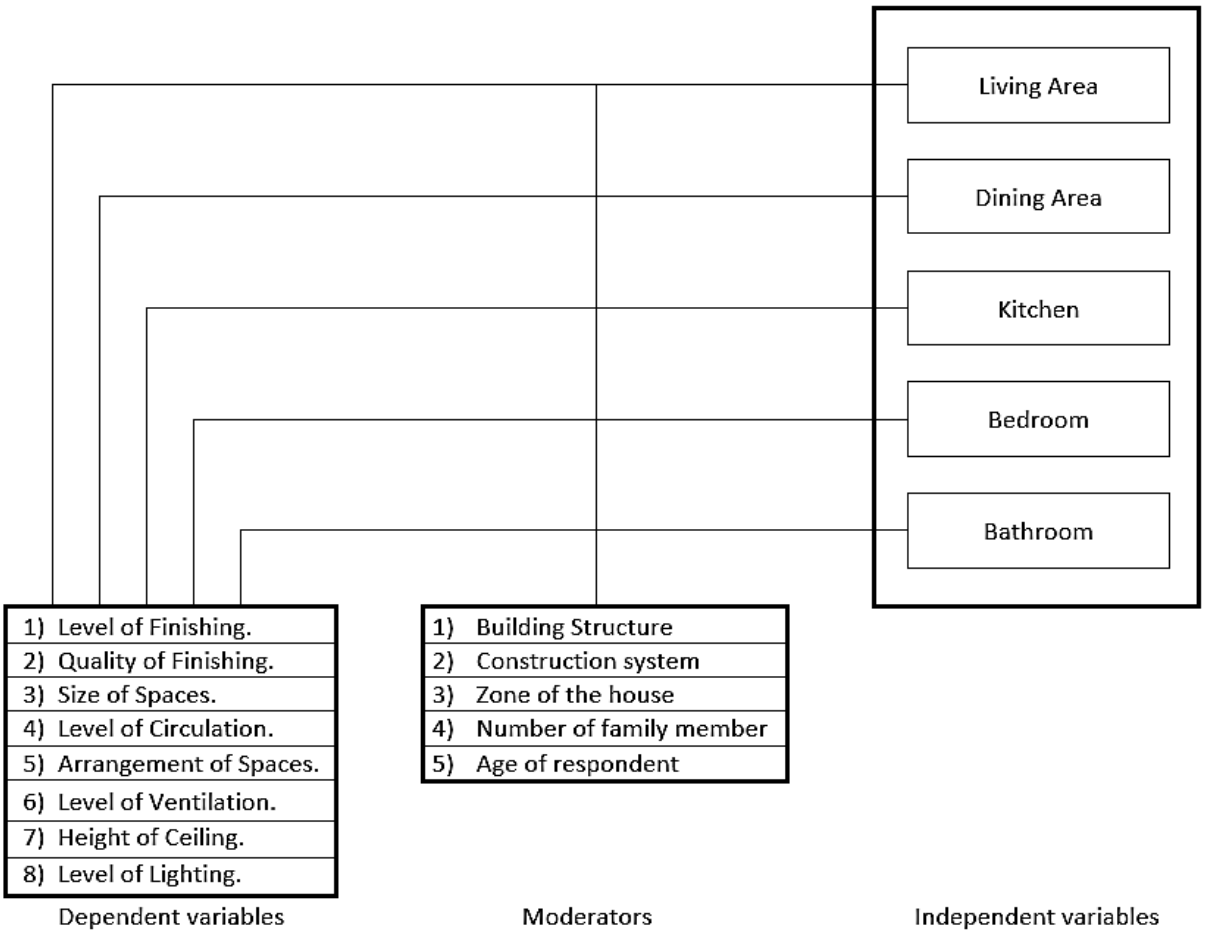

Fig. 2. A conceptual framework of adaptability in housing

The above framework can be used to identify levels and to validate adaptable housing design model. Information about the activities and level of satisfaction of users in the building layout, and the problems that they face in carrying out activities inside the building are summarise as follows:

i. Level of satisfaction:
   (a) Housing layout and its relationship to activities.
   (b) Internal Environmental Quality (IEQ).
   (c) Circulation and accessibility in the house.
   (d) Durability and performance of finishing.
ii. Activities in the house:
   (a) Daily activities of the individual and the family.
   (b) Celebration and occasions such as feast.
   (c) Social activities such as meeting with relatives.

The two levels of flexibility are integrated. One cannot exist without the other. The user may not be able to make the changes he needs in the internal layout of the dwelling without the architect's help in providing him with a dwelling as flexible as possible. Similarly, the process of flexibility will never be completed unless the user participates and responds.

6. Spatial Flexibility for Adaptable Architecture

When trying to summarise the insights into the new possibilities resulting from this study, the larger question of the future of architecture comes into focus. What will be the nature of future architecture? Does the development of the Adaptive Design Model mean that all architecture will be dynamic and adaptive? This question defies an easy answer, as it can be argued that much of today's architecture is already dynamic and adaptive. However, the speed and efficiency of adaptation in today's architecture is still low. The development of an adaptable architecture means that such efficiency can be improved. Therefore, the revolution lies not in adaptable architecture as a mysterious new type of architecture, but in the shift of the mode of perception of any architecture as being complex and adaptive, and designing and using it accordingly.

At the same time, the above statement does not imply that rapid spatial adaptation will necessarily occur everywhere. On the other hand, many scenarios can be imagined where rapid transformation of architecture is not and will not be required, where stability, and continuity of spatial reference is desired. Yet in such cases, a complex adaptive view of architecture retains its validity and relevance. Building maintenance requires as much, if not more, effort as creating a new one. For example, buildings need to be actively repaired and maintained. Therefore, in order to maintain some of their characteristics, many of their parts need to be adapted, so that they can maintain their functionality and usability in the changing world around them.

Adaptable architecture cannot not be reduced to the technical characteristics of the built environment alone. Their awareness must have a profound influence on our culture and society, our way of thinking and our values. Adaptable architecture can provide new ways to relate memories and history with space, and attribute value to architectural systems, which are by definition in a process of perpetual motion.

7. Conclusions

The commonality of all possible adaptable architectural scenarios is the increased role of residents in the formation and transformation of architectural habitats. Beyond doubt, the future of architecture is participatory, focused on enabling people to form and improve the spaces in which they live their lives. To make the spatial flexibility of buildings achievable in Brunei Darussalam, the architectural floor system needs to be reconfigured. The design should focus on standardising the form and dimension of the basic elements of the construction system. The use of building

components composed by dry construction and assembly should be buildable and practicable. Thus, a new adaptable innovative direction for Waffle Slabs floor system design needs to be further developed, based on the conceptual framework of the Adaptive Design Model established in this research.

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