PREFABRICATED BUILDING METHOD IN SRI LANKA AND USER ATTITUDE

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ABSTRACT

During the development of construction industry, people looked forward on building their houses by using less time and cost consuming methods. Prefabricated building methods were introduced as the outcome of this developmental process.

In conventional building method, both total fabrication and erection were carried out in the site, which was a highly labour intensive work and also it was difficult to control the wastages and quality. In such rough working environment, labours refused working, where it became very difficult to arrange skill labours to these work sites. High scarcity of resources, daily rising cost of raw materials, controlling of wastage become much more important.

Prefabricated building method grab considerable market share in developed countries like United States, Japan, china and United Kingdom. From early 1960s prefabricated housing projects were lunched in Sri Lanka. But this method could not grab significant market share in Housing industry of Sri Lanka.

Prefabricated housing projects that previously carried out in various parts of Sri Lanka, selected as the case study and carried out user responsive survey and using personal observation prepare the conclusion and recommendations. Visiting the prefabricated model manufactures and analysis the pros and cons of their models and found out the reasons behind their models, why that those poorly attract the market.

After analysis of all the information, found that major reasons for not grabbing considerable market share as that this prefabricated housing method did not considering the local customs and believes, local climatic conditions, lack of space and expandable ability within these housing units and poor marketing of model manufactures. Then considering these conclusion and prepare the recommendation as the guide line on launching of prefabricated housing projects, where these steps will give good opportunity to grab considerable market shear for prefabricated housing in housing industry.

Key words: Prefabricated building, Conventional building

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RVDB - River Valley Development Board

NERD - National Engineering Research and Development center

NHDA - National Housing Development Authority

ICC - International Construction Consortium (pvt) ltd

1. INTRODUCTION

1.1. Background

Buildings exist to meet one of the primary physical human needs that are shelters. When men who lived in the forests became civilized, their livelihood depended upon agriculture and they felt the requirements of more sophisticated places for accommodation. At the inception, since they led a life shifting from place to place, they did not have any requirement of permanent living places.

But, with the development of technologies, their day-to-day needs and requirements were also changed. Simultaneously, their life styles, attitudes and aspirations were also changed. Eventually, they learned to build their residences applying different improved methods and techniques. When their lives became more civilized, they wished to lead a lifestyle unique for their own existence. Not only their languages, religions, foods, and clothing they were stimulated to prepare but also their residences unique to them as well. Therefore, the *'house'* became a very important feature in the human society. In Sri Lanka, this could be observed very clearly compared to other countries in the world.

The conventional traditional building methods and materials were used by Sri Lankans since the selection of a site to build their houses step by step and finally in residing in their houses are very specific and unique. It is evident in the societies in which they live, their social status, beliefs, and religions.

Under these circumstances, the method of construction of houses by assembling the building components or elements fully produced in a factory by different manufacturers is still an unfamiliar and alienate things for most of the people in Sri Lankan society.

However, the rapid urbanization and industrialization have generated many problems in Sri Lanka such as the scarcity of resources and facilities, higher prices of lands,

deficiency in lands and labourers and higher prices for conventional building materials. To overcome these bottlenecks, it was found essential to introduce new construction methods for house building cheaply and easily within a shorter time and within a limited space.

Nevertheless, both the Engineers and Developers encountered many problems from the clients, when suggesting improved and modern technologies such as prefabrications methods, new materials, and the cost effective methods for erecting houses by assembling the building components or elements fully produced in a factory, especially for housing constructions; as most clients were unwilling and did not accept the application of these modern and cost effective methods; not even for the construction of their own houses. Though this method of prefabrication technology was implemented in Sri Lanka since 1964, compared to the other countries in the world, it has not been absorbed by the housing industry in Sri Lanka. However, when the country encountered unprecedented heavy floods and landslides and the devastation prevailed as a result of Tsunami, these methods of prefabrication of building methods were highly recognized as paramount importance and gained popularity in Sri Lanka considering the scarcity of resources and facilities, higher prices of lands, deficiency in lands and labourers and higher prices of conventional building materials.

1.2. Research Questions

Though the modern technologies, prefabrications methods and new materials were introduced in Sri Lanka since 1964, regrettably, Sri Lankans have failed to realize and observe these modern building methods and grab, encourage and attract a significant market share in building construction industry in Sri Lanka. Therefore, the main research question of this study is formed as,

> "Why this prefabricated building method does not grab significant market share in housing construction industry in Sri Lanka?"

1.3. Objectives

- To identify issues behind the less popularity of prefabricated building methods in Sri Lanka.
- To propose best strategies to improve popularity of prefabricated building industry in Sri Lanka

1.4. Research Justification

Prefabricated building projects were launched in Sri Lanka from 1964. Even though, the importance of prefabricated building projects have been understood for many construction projects that are undertaking all around the country, a lesser number of companies are trying to implement this type of building methods at present. Thus, it seems that these prefabricated building projects are still not popular within the country. Considering this fact, this research aims at conducting a sound analysis about the prefabricated building projects in Sri Lanka and their level of real world applications.

1.5. Research Methodology

Initially, a literature review was carried out about the previous projects, which used prefabricated building methods; where the author found some major issues in those methods. A detailed literature review has been carried out to find the level of prefabricated building methods applied in the world and to find out prefabricated housing projects launched in Sri Lanka. The author visited the previous prefabricated housing projects in Sri Lanka to carry out a user-response-survey to gather personal information as well as to conduct some series of observations. Based on the data analysis of survey details and personal observations, conclusions and recommendations of the research have been made and presented in the latter sections.

1.6. Scope and Limitations of the Research

For the purpose of this study, the whole research area was narrowed down to a kind of residential buildings, which were constructed for permanent residential purposes using the prefabricated building methods. Those residential buildings were

further categorized as individual houses and community scheme-houses, which are presently occupied, and research level models and prototype houses were built by many organizations and developers. Then main scope of this research is the study of these residential units and to gather personal observations and feedback from all the interviews within the individual houses and community scheme-house categorization. Besides that, temporary huts, semi-permanent structures like site offices and quarters are not included for this study. Finally, the main limitations related to this research is residential units.

1.7. Structure of the Dissertation

This dissertation has five chapters.

Chapter 1 provides an overall view of the research and addresses the background, research questions and objectives, research justifications, research methodology and the scope and limitations of the research.

The chapter 2 of the dissertation will review the literatures related to the evolution of building construction with changing social needs of the people with the introduction of modern building construction methods, their advantages, important features and their usage in many ways in the world.

The chapter 3 of the dissertation will discuss the research methodology including literature reviews, data collection methods, data analysis methods and the method of preparation of conclusions and recommendations.

Chapter 4 of the dissertation will consist of data analysis, discussion related to main determinants and modifying factors for housing, and their periodic changes due to the industrialization and urbanization. It will also explain the manner in which these socio-economic factors, users' attitudes, their organizations, religions, aspirations, expectations, economic status, customs & beliefs and aesthetic aspects which influences the housing All the discussed facts are further illustrated using

both foreign and local examples as much as possible to a greater extent. This chapter also will contain the data analysis of user responsive surveys and personal observations of prefabricated housing projects in Sri Lanka in various regions, various societies, various families and communities.

Chapter 5 will consist of the conclusions and the recommendations with guidelines for the implementation of prefabricated housing projects.

2. LITERATURE REVIEW

2.1. Building Construction and the Needs of Shelter

Building construction is the technique and the industry is involved in the assembly and erection of structures, primarily those used to provide shelter. Also it is an ancient human activity that began with the purely functional need for a controlled environment to moderate the effects of climate. Building construction today plays a significant part of industrial culture, a manifestation of its diversity and complexity and a measure of its mastery of natural forces could produce a widely varied built environment to serve the diverse needs of the society.

As a prelude for the overall discussion, this chapter initially traces the history of building construction in brief with the evolution pattern of contemporary building construction methods and techniques and then surveys its' developments so far.

2.2. Historical Development of Building Constructions

Human shelters were, at first, very simple and perhaps lasted only a few days or months. Over the time however, even temporary structures evolved into such highly refined forms as the "Igloo" (Fig.2-1). Gradually more durable structures began to appear, particularly after the advent of agriculture, when people began to stay in one place for a long period of time. The first shelters were dwellings, but later other functions, such as food storage and ceremony, were held in separate buildings.

Figure 2-1: An ancient Iron–Age hut made of clay and wood
(Source: www.solohq.solopassion.com)

According to the related literature, it could be identified that the history of the building is marked by a number of trends from time to time as;

1. The increasing durability of the materials used. Earlier building materials were perishable, such as leaves, branches, and animal hides. Later more durable natural materials such as clay, stone, timber and synthetic materials such as brick, concrete, metals, and plastic were used.
2. A quest for building of ever greater height and span; these were made possible by the development of stronger materials and by the knowledge of how materials behave and how to exploit them to greater advantage (Fig.2-2).
3. The degree of control exercised over the interior environment of building increase precise regulation of air temperature, light and sound levels, humidity, air speed, and other factors that affect human comfort has been possible.
4. The change in energy available to the construction processes, starting with human muscle power and developing toward the powerful machinery and equipment used today.

Figure 2-2: The Parthenon at Greece constructed in 5th century BC
(Source: https://en.wikipedia.org/wiki/Parthenon)

The present state of building construction is complex and there is a wide range of building types, building products and systems. The design process is highly

organized and draws upon research establishments that study material properties and performance, code officials who adopt and enforce safety standards, and design professionals who determine user needs and design a building to meet those needs.

The construction process is also highly organized. It includes the manufacturers of building products and systems, the craftsmen who assemble them on the building site, the contractors who employ and coordinate the work of the craftsmen, and the consultants who specialize in such aspects as construction management, quality control and insurance.

2.3. Socio-economic Context of Contemporary Building Methods

Construction has always been a reflection of the technological and ethical values of a specific society and its value at any given moment of time. Some structures began to have symbolic as well as functional values, marking the beginning of the distinction between Engineering and building (Fig.2-3 & 2-4).

Figure 2-3: Disney Concert hall
(Source*:* www.laphil.com/philpedia/about-walt-disney-consert-hall)

Figure 2-4: Beijing National stadium– Bird nest
(Source: www.designbuild-network.com/projects/national-stadium)

The use of building material such as wood leaves behind a lot of residual waste.

Carpentering, further treatment, installations resulting in lot of waste that cannot be reused in most cases. But use of materials like steel components suffers from no such disadvantages. For example, available at an affordable price, steel building components need no further treatment and can also be reused, hence saving time, money and labour. Yet another advantage which those kinds of materials enjoy over other materials is that building Components could be pre-fabricated in the factory itself and thereby reduce labour cost and installation cost in site. On the other hand, buildings like all economics products, command a range of unit prices based on their cost of production and their value to the consumer. Building construction today is a significant part of the industrial culture, a manifestation of its diversity and complexity and a measure of its mastery of natural forces could produce a widely varied built environment to serve the diverse needs of the society.

2.4. Development of Building Constructions

With the development of the building construction as an industry, it also developed as a recognized profession. Therefore, there are a number of ways of building

methods those could be identified in the world and those are categorized as follows and briefly described further:

1. Traditional building
2. Post-traditional (Conventional) building
3. Rationalized building
4. System building
5. Component building

2.4.1. Traditional buildings

This construction method has been developed to for the use of form construction evolved by the traditional building crafts, bricklaying, carpentry, plastering, tiling and slating. The important feature of this method is the skilled labour requirements were fairly high and nearly two third of the construction work was skill craft work (Fig.2-5 & Fig.2-6).

Figure 2-5: Taj Mahal at Agra, India
(Source: http://en.wikipedia.org/wiki/Taj-Mahal)

The buildings were constructed for specific requirements, also on specific sites. A considerable amount of fabrication as well as assembly of parts take place on site (in-situ). In this traditional building construction, the craftsmen were not only familiar with the content and order of operations in their own work or skill but most of the craftsmen carried out their work with minimum detailed information. Because of the limited range of materials and forms constructions they were aware with the other works of the construction (multi-skilled). Also the work of the craftsmen was

much more readily and inexpensive than the methods based on highly mechanized factory productions.

Figure 2-6: Royal palace of Polonnarwa
(Source: ofhttps://en.wikipedia.org/wiki/Architecture_of_ancient_Sri Lanka)

The traditional craft-based building method was very flexible and able to meet variations in the demand of the market. The builder operated the construction work on this basis with less expenditure, minimum losses and less capital investments. This method was commonly adopted by small firms with a little capital enabled them to carry over a slack periods in demand and was reduced with the time, after the introduction of pre-fabricated building methods.

2.4.2. Post-traditional (Conventional) building

With the growth of the world, traditional building methods have always been in a state of changes from time to time with new materials and developing techniques. Most significant changes occurred with the discovery of cement and steel.

New feasible forms of constructions, new materials and technologies and long span structures came into the field with this growth. (Fig.2-7 & 2-8).

Post-traditional or conventional building methods were a mixture of old traditional and new form of construction (old crafts, new materials and techniques). New techniques of casting mass concrete in in-situ in form work are similar to traditional cob and pies wall constructions.

Figure 2-7: Usage of ready mix concrete
(Source: stallionreadymix.co.za)

Figure 2-8 : Steel structure for long spans
(Source: alibaba.com)

Especially, reinforced concrete and steel was identified as pre-formed and off-site fabricating materials. Skeleton frames were introduced for prefabrication and for assembly on site by operatives with specialized skills. But, this method was found less flexible than the traditional building method and also found labour intensive and tied up with the mechanical plants.

Besides that, greater attention needed for planning, organization of scale of work, use of plants and equipment, systematic supply and assembly of materials and also for whole construction process to produce specific buildings.

2.4.3. Rationalized building

Rationalized building takes place further than post traditional building methods, but it could be applied to constructions carried out by craft processes with traditional materials. This is the method of building in which organization techniques used in manufacturing industries and are applied to the erection processes without involving a radical change in form of construction (Fig.2-9).

Figure 2-9: Beginning stage of Altair twin tower

The main feature of this method is the increase of the demand, size and complexity of all type of buildings resulting in a more complex construction processes which needed to economize in labour and material cost. The whole construction process is ensured with proper flow of labour and materials through a proper organization.

A proper planning and organization and a proper integration of designs and production to be proceeded with the construction work as a continuous process.

Design and organization is developed with a view of continuity of operations and economy of labour. Also more standardization methods are used to maintain the continuity in all production operations and mechanical plants as well in view of those features in this method, the productivity were high and the products were cheap.

2.4.4. System building

System building method is mostly based on forms of construction in which the component parts of building fabric are wholly factory products and site assembled. Those components relate as parts of an integrated system of construction related to specific building types like houses, schools, factories, warehouses etc.

Most of the system building methods are based on skeletal structures in steel, concrete or timber and load baring walls manufactured by pre-cast concrete panels (Fig.2-10). This includes factory produced roofs, bathroom units, room size units, garages, kitchens etc. As the main disadvantage, those do not fit with the components of other systems of different manufacturers. It is therefore called as "Closed System" building method.

The prominent feature of this method is to reduce the amount of skilled labourers to a larger extent. On the other hand, higher overheads for factory productions and higher charges for factory to the site could be seen in this method. Economic success of this method depends on efficient organizational system of fabrication of parts and components.

Figure 2-10: Assembling of prefabricated wall panel
(Source: greenbuildingadvisor.com)

Today, most industrialized buildings often apply this method for rapid construction. On the other hand, this method is economically feasible only for large scale production with large scale market supply.

2.4.5. Component building

Similar to the previous methods, component parts of the building fabric are wholly factory produced and site assembled in this building methods. Those components could be used freely in conjunction with the parts of the fabric constructed on traditional lines such as brick walls, block work and roof tiling. This building method differs from the system building method because of the production of the components is not limited to one manufacturer and each component is inter-changeable with other manufacturers' products. Therefore, this method is called as "Open System" building method.

Figure 2-11: Fully factory produced residential unit at a rural area
(Source: blogs.move.com)

Components are produced for both frame and load bearing wall construction of different materials and all could be used separately or together to produce economic solutions to a wide range of problems. It uses inter related factory produced components from variety of materials for construction.
Economic advantages of mass production may be combined with greatest possible freedom to design to meet user and site requirements more precisely. This could be used for wider range of building types and varieties within acceptable limits of mass production as well.

2.5. Introduction to 'Element Building' Methods

According to the section 2.4 categorization, system building method and the component building method are the most recent and important construction techniques adopted at present. Both these methods are based on forms of construction in which the component parts of building fabric are wholly factory produced and site assembled.

When considering the common features of both the system building and component building, all the building products of those methods are typically based on the following:

- Panels : Including ready-made walls, floors and roofs
- Modules : Ready-made rooms, which could be pieced together to construct a whole house or flat but are used most frequently for Bath rooms and/or kitchens, where all the fittings are added in factory.

In view of the both these methods use prefabricated 'building elements' to erect buildings, hereinafter those will be mentioned as *'Element building methods'* in this dissertation as an umbrella term that covers the terms of *'Modular buildings'*, *Package buildings'* as well as *'Prefabricated buildings'*. In fact, the use of elementary element building methods goes back to over fifty years. The end of World War II caused the modular market to truly explode and greatly evolve and all the returning soldiers came back to America looking forward to purchase a house and start a family quickly.

,

Figure 2-12: Assembling of wholly factory produced modular houses for returning soldiers in USA in1960s
(Source: capsyscorp.com)

This demand for homes was greater than the market place could meet and handle with the traditional building processes. This led people to look for solutions to increase efficiency and lower the cost of new house construction (Fig.2-12).

The element building processes answered both these needs. Besides, these kind of prefabricated buildings provide the luxury of deciding upon the design and style of the buildings beforehand at the present times. Fig. 2-13 represent the Nakagin capsule tower at Tokyo, Japan. It constructed using pre-fabricated components which fully equipped luxury room size capsules.

Figure 2-13: Nakagin capsule tower at Tokyo, Japan.
(Source: www.arcspace.com)

When we consider European and Japanese level of these elementary building methods, we observe that it's far beyond our domestic level. European countries like

Germany have 15%, Austria has 33% and France has 5% market share. In Japan, prefabricated housing companies build more than 150,000 units per annum. (Thomas linner & Thomas bock, 2012).

2.6.Present Situation of Building Constructions in Sri Lanka

Figure 2-14: Future view of Port City project
(Source: colomboportcity.lk)

With the industrial developments of the other countries of the world, most of the government and private developers in Sri Lanka are in the track of using modern building construction methods and technologies for their present construction projects. Although the conventional construction methods were embraced by all construction industries, currently it switched on to use steel and prefabricated components for many construction purposes all over in the country.

A number of huge multi-story apartments, shopping complexes, factories, transport terminals and large residential scheme projects were completed in recent times in many regions in Sri Lanka. Port City project will be the future of construction industry of Sri Lanka and very advanced modern construction methods will be adopted for this project. (See Fig. 2-14).

On the other hand, it was evident that a great deal of new building methods was adopted during the construction of re-development projects at the occasion of Tsunami disaster. However, it is observed that Sri Lanka is not in a comfortable situation to recognize and adopt new building technologies, especially for housing projects to compete with the other developing countries in the world.
It should be realized that at the time of Tsunami disaster, these kinds of new, low-cost and quick construction methods for dwellings and other buildings for refugees were in dire need and required within a very short period of time. But regrettably, the Central Government and Private Sector organizations were mostly unsuccessful and failed to benefit while adopting these methods. (See Fig. 2-15)

Therefore, performing more and more researches and developments on novel technologies and methods of the current building industry has become important and compulsory. In each and every occasion of discussions, new building methods, the time, cost, materials, technology and the economic factors have been the foremost topics. However, in many building projects, especially in housing, we failed to recognize these important factors and turned a blind eye and ignored the social background of the user, environmental issues and the cultural influences for buildings.

Figure 2-15: Temporary huts in a Tsunami refugee camp at Ulle, Sri Lanka
(Source: rotary.madison-mayodan.org)

Generally, a country like Sri Lanka which has outstanding precedence of cultural and social influences for buildings, especially for housing, this phenomenon should be treated as very important. Without identifying the inherent characters of those dominant factors, any attempt to discuss regarding the building construction of that context becomes a futile effort. Therefore, those cultural and social influences and their impacts on buildings, especially housing will be elaborated in detail in the following chapter.

2.7. Concept of Housing

Figure 2-16: Housing – As a basic need of the society
(Source: www.flicker.com)

Housing is a fundamental need for civilized living in any kind of a society (Fig.2-16). The provision of shelter, and the steps taken by the human societies to fulfill their housing needs, has changed through thousands of years of history. Furthermore, the concepts of housing have been parallel to the gradual development of civilization and culture in any country and the population increase, urbanization, planning, controls and vastly the changing expectations of people produce pressure for changes in housing designs and erection methods from time to time. Though philosophers build many concepts and express many opinions, when considering the present situations in the world, it is questionable and is a practical problem as to

what extent they could be solved. Under the circumstances, it is very important to understand these concepts.

2.8. Main Determinant and Modifying Factors

The differences of houses are merely not as the result of physical forces which are always in harmony with its surrounding context. Based on the available literature, the following could be identified as the main determinant and modifying factors for housing in the surrounding context.

1. Climatic conditions
2. Socio-cultural settings
3. Materials, construction & technology
4. Economic conditions

Those factors are widely changed by region to region and by country to country of the world. But it is much complicated to consider the important and dominant factor for housing at the present times.

2.8.1. Climatic conditions

Figure 2-17: Eskimo House at Alaska
(Source: archives.sundayobserver.lk)

The use of characteristics of local climate in housing is not a new innovation. Since the beginning of time, the first humans have been affected by climate and its influence on earth which compelled them to build their houses to protect

themselves especially from the weather elements. Because, a house is a space where a micro-climate is created which is acceptable to inhabitants, response to climate is a vital factor within the various functions that are performed in the house.

Figure 2-18: A typical house at Galle, Sri Lanka
(Source: www.booking.com)

The very first evidence of a house design with climate interests in mind dates back to the fourth century B.C. Each of the region's climatic assets and liabilities could be accommodated by simple design changes such as setting, orientation, wall construction and even placement of openings. (Eskimo houses at Alaska (Fig.2-17) and traditional vernacular houses in Sri Lanka (Fig.2-18) are some examples of houses which were constructed with designs making use of the surrounding climate and its natural effects.

Figure 2-19: A typical open house at Iquitos, Peru.
(Source: davestravelcorner.com)

Under normal circumstances, in Sri Lanka vernacular houses, verandah with eaves around the house and small windows kept the hot sun away and the interior of the house to ensure it is cool and comfortable to live in the hot climatic region. Also the typical communal houses in Iquitos, in the bank of Amazon River, constructed generally as an open structure suitable for the hot and humid climate in the surrounding (Fig.2-19). Furthermore, all those examples suggest the idea of "form follows climate".

2.8.2. Socio-cultural settings

Figure 2-20: The traditional African house at Mali.
(Source: pinterest.com)

The socio-cultural standing in any country or a region performing as a unique feature while creating a shelter for occupant was a product of long time experience, which embodied the traditional life patterns and environment of the particular realm.

The socio-cultural factors which are unique to particular regions like organizations, religions, customs and beliefs, attitudes, ideologies, techno-economic systems, laws and political issues define and modify the houses form and internal space making on inhabitants. This is the main rationale for existence of various kinds of houses with a

variety of forms, shapes, materials, sizes and colours in every nook and corner of the world.

Because of the ”expressions” and “identities” it could be seen in different house designs, with the changes of social and cultural attitudes not only from country to country but also within the boundaries of a country. Fig. 2-20 represent the traditional African house at Mali, It was colured with mud painting and the style of the thatch roofs expresses their socio-cultural influences. For an example, it is interesting to note that a “provincial identity” in traditional housing types in Sri Lanka has been preserved even today due to the socio-cultural acceptance of those plans and forms by the inhabitants.

In some occasions, people with very different attitudes and ideologies respond to varied physical environment by their “way of life” parallel to the basic needs, family and the need for privacy. Those responses may vary from place to place because of changes and a difference to this phenomenon one’s own house reflects his values, aspirations and future expectations as each person’s attitudes and socio-cultural identity.

Figure 2-21: “Tatami” mats used traditional Japanese house.
(Source: crookslog.weebly.com)

For instance, when designing the traditional Japanese houses, they as a first step begin drawing up plans for the house and determine how many “Tatami” mats will

be needed to cover the floor. By designing different layouts, the final configuration of the mats will determine the shape and size of the house (Fig. 2-21).

Parallel to this, when constructing traditional houses in Sri Lanka, it was linked up with a series of rituals like *'Pada Bedeema', 'Gini Kathura', 'Poro Pada'*, etc. for shaping the plan, placement of openings, placement of the well and even placement of the toilet. That brought confidence and hope in the minds of the inhabitants on prosperity. Furthermore, this brought in a spiritual entity to the new house, religious beliefs and practices and confidence and divine blessings to the occupants in the traditional form (Fig.2-22).

Figure 2-22: Religious activities and rituals for digging foundation for a new house. (Source: www.aia.org)

Also, in the Sri Lankan context, even the "ownership" or "possession" of a house is considered as a "symbol of status" in the society. This is the prominent dissimilarity in the Sri Lankan society when comparing with other Western countries in the world.

As the very important matter when describing the relationships between the man and the house, obviously it should satisfy the users' desire for mental and spiritual satisfaction from their cultural and socio-economic environment.

2.8.3. Material, construction and technology

Materials, construction and related technologies are generally treated as ‘modifying’ factors, rather than determinants because they decide neither what is to be built nor its form. Also it could play a vital role in the type of house to be built. It could be identified that the different social and functional attributes, attitudes and aspirations of the users are the guiding factors in the selection of building materials and methods.

There are many models that could be seen in many parts of the world in relation to this matter. In houses in south of Island-Iceland, people use turf roofs according to the concept of “mother nature’s roof” based on their legend of the history (Fig.2-23).

Figure 2-23: Turf roof houses at south of Island, Iceland
(Source: http://litscapeart.com/Artist/172/Chris_Kober)

Figure 2-24: A Bedouin tent at Arab desert areas
(Source: pinterest.com)

The traditional Bedouin tent which is woven from goats' hair was designed to suit the people's life patterns in deserts (Fig.2-24). When it rains, the weave contracts and does not allow water to get inside the tent. In the heat of summer the outside of the tent feels very hot to the touch or feel while the inside remaining blissfully cool.

Figure 2-25: **T**raditional Sri Lankan house constructed using natural materials
(Source: exploresrilanka.lk)

The traditional Sri Lankan tradition has been a part and parcel of nature as well as the materials were borrowed from the nature and returned to the nature (Fig.2-25). Most of traditional houses were constructed by using materials found in the immediate vicinity using techniques developed over previous generations.

Today the world is flooded with new housing materials with vastly improved technologies. It is clear that some of the profound changes associated with the disruption of the traditional building processes and related unique concepts like the Traditional Sri Lankan house constructed using natural materials have been in the field of various building materials and their associated technologies since the industrial revolution.

2.8.4. Economic conditions

Today, the economy affects as the main determining factor of personal life patterns in many social groups rather than the prefabrications new building technologies, due to the rapid industrialization and urbanization. All the socio-cultural concepts related to housing are affected inversely due to the impact of this rapid industrialization and urbanization. Consequently, the problems arise even on the

beliefs, views, attitudes, and commonly in the behaviors and expectations of people.

With the developments in the world around, the basic needs and aspirations of the people also widened and developed with advance technologies. Simultaneously, with the evolutions of industrial revolution and urbanization, even the simple living patterns of the society have changed and we observe we are leaving behind us many of the useful indigenous design concepts for housing constructions.

Figure 2-26: Low income houses at the Colombo municipal region
(Sources: lankabusinessonline.com)

Especially the financial capability of the people is often expected to govern the house form and character to a very great degree and such an expectation does not appear to be much valid in reality.

Most of the people migrated to urban areas which resulted in increase in land values and individual dwelling units. This has been the main reason for the establishment of large housing schemes, modular housing, low cost housing, multi-storied apartments and even unauthorized housing etc. and most of them are unable to fulfill both physical and mental satisfaction of its users (Fig. 2-26).

Figure 2-27: Most developers considered only the number of houses, without thinking about the user.
(Source: www.cartoonstock.com)

On the other hand, man however has considerably lost this ability in the process of those tasks and it becomes a specialized work to be handled by other personnel such as Engineers, Building manufacturers, Property developers etc. Despite it had many positive aspects in the point of view of user responsive actions, there were many negative results observed. The worst impact was that "house" has become a marketable exchangeable item.

In traditional vernacular housing process it is generally accepted that the action of the people and the forces of personalization lead to harmonize living cultures. Every house has given a definite role and character which emphasize its users. But at present it is common to observe some developers advertise for houses which have become merely a "location" of house, and could be changed in every two or three years with little or no regrets (Fig: 2-27).

Besides, the commercial interests have led them to completely ignore the significance in the relationship between user and the house as well as the socio-cultural aspects and their deeply rooted concepts. These are in some occasions, become subordinate and are easily measurable in terms of money value only.

Social and cultural factors are usually the last to be considered by most of the builders, manufacturers and even designers. The attempts of them are very less and

unimportant while understanding the aspirations and attitudes of the user for whom they are building or how this might be translated into built form.

3. RESEARCH METHODOLOGY

3.1. Case study

As a first initial step, carry out the literature review to identify the development of housing industry in Sri Lanka as well as in other countries. Also deeply concentrate and study the practices of prefabricated and elementary building methods in Sri Lanka as well as other countries practices previous researches, text books, journals, and various statistical data. During literature review, mainly collect the details about the previously carried out prefabricated housing projects in Sri Lanka which were identified in background study. Also before starting the research, author himself should carry out site visits and briefly identify the main issues in RVDB colony houses. Then identify projects for background study and other project studies during literature review for the case study for this research.

3.2. Preparation of Questionnaire

Questionnaire is mainly prepared using issues identified in the initial site visits carried in RVDB colony houses in Udawalawe and Morakatiya. These issues are;

- Visual impression.
- Use of materials and technology.
- Flexibility of spaces and changes.
- Economic value of investment.
- Physical comfort level.
- Tally with local customs and beliefs.

During these visits it should be identified that whether all these issues had direct relations to the size of the family, occupation, nature of previous residencies. On completion of the issues, ten questions are prepared to obtain the details and other questions relating to the main problems encountered. In order to get satisfactory results, always try to ensure to minimize the direct questions in the questionnaire. Altogether there are thirty one questions which are given in appendices 1 and are included in this questionnaire.

3.3. Interview and personal observations

After the preparation of the questionnaire, author again to visited these projects and perfect the questionnaire asking questions from randomly selected users. All the questions are to be asked from the users and recorded by the author himself. Due to lack of time availability one day is allocated for one project questionnaire survey. Number of interviewers will be taken depending on the availability of the users and time. A minimum two users are planned to be used for user response survey and all site visits will be planned to take place during day time only.

The author initially visits the government building research institutions for review of the developed prefabricated model houses by them and gather further details about the methods adopted. On completion of the review, other private sector prefabricated housing model manufactures will also visited and details gathered about their systems and applications.

During the site visits to previous projects and model manufactures, author will identify issues and such issues will be recorded as personal observations and will be considered for the data analysis.

3.4. Ways of Carrying out Data Analysis

Firstly, introductory statements to be prepared from personal observation and from the initial site visit. After that the questionnaire data to be summarized for six main problem categories to tally with local customs and beliefs, physical comfort level, economic value of investment, flexibility to spaces and changes, use of material and technology and visual impression. Using these results and personal observations, pros and cons of methods used for these projects are considered in data analysis. Problems encountered in the site visits of model manufactures and from personal observations found in project visits will also be analyzed in the data analysis.

3.5. Ways of Preparing Conclusions

Main findings of data analysis are presented in the conclusion with discussion on practical issues and recommendations and will include as guidelines for implementing prefabricated projects in the future.

4. DATA ANALYSIS

4.1. Introduction to Data Analysis

Since the first step of this study, all the key aspects and aims were based on one main issue of users' attitudes and socio-economic factors on housing which performs as non-facilitators to disseminate the prefabricated building methods for housing in Sri Lanka. Accordingly, the main key issues to disclose in accordance with this are as follows:

- What are the negative and positive aspects of those kinds of houses with regard to users' attitudes or in their point of view?
- Hove those negative aspects actually caused the users' dissatisfaction or their refusal of those houses?
- Can the positive aspects of those housing designs be used to develop a more user satisfying production to meet flexibility and variability of building components?
- Are there any other reasons arising as non-facilitator other than the users' attitudes or dissatisfactions and refusal?

First, discuss the selected case studies for the application of prefabricated building methods for housing in the local context and then critically analyze. All the selected examples will be reviewed more specifically in relation to the idea given by the particular users and the responsible personal about their own dwellings and prototypes. Personal observation and the interpreting feedback from the user responsive survey will be done by author himself.

4.2. Application of the Prefabricated Building Method for Housing in Sri Lanka

The selected case studies discussed which were from various regions, various societies, families and communities in Sri Lanka are basically categorized into occupied houses, research models and built prototypes. Furthermore, building elements and components manufactured by different manufacturers which are relevant to this study, will also be discussed separately.

4.2.1. The colony houses erected by the River Valley Development Board at Udawalawe and Embilipitiya.

These houses were originally developed by the River Valley Development Board (RVDB) in 1964 parallel to the development of Walawe river basin. The initial houses at Udawalawe were erected using prefabricated building elements and they were constructed mainly for the RVDB workers who were involved in various infrastructure development projects in that region.

Figure 4-1: External view of RVDB workers' house at Udawalawe

Figure 4-2: Front view of RVDB workers' houses At Udawalawe

Although it seems like "shanty" dwellings, in fact, those houses were wholly constructed using prefabricated building elements (Fig.4-1 & 4-2). All the external envelope and the roof consist of the timber structure, 16 gauge aluminum corrugated sheets, and factory produced steel doors and windows. It is no doubt that the purpose of an improved housing technology would be to erect houses with minimum time and at low costs. Those houses very well fulfilled these requirements. But it was

completely ignored the very important factor that the ‘user’ who will be living in those houses will be from different regions in Sri Lanka with different social standings. Therefore, the attitudes towards those houses of the people not only who lives in those at the present, but also those who live in normal houses in the surroundings are not suitable for them by all means.

On the other hand, after five years in 1969, the RVDB commenced another housing project with a further improved technology and could be seen at Moraketiya village near Embilipitiya even today. Each house was constructed within a floor area of 450 square feet with two bed rooms, living and dining spaces and a kitchen, using prefabricated concrete wall panels and columns as main building elements which do not require plastering. For the production purposes, a well-equipped fabrication yard was established at Embilipitiya town at that time.

Figure 4-3: External view of a RVDB house at Morakatiya.

The construction of those houses was basically just an assembly of all the panels, ring beams, trusses and purling were bottled together at the site and completed within 7-8 days. Generally, all the building elements were delivered to the site as a complete package (Figure 4-3).

Figure 4-4: Frame structure of RVDB house at Morakatiya

Figure 4-5: Only frame structure is prefabricated RVDB house at Morakatiya.

The roof was either corrugated asbestos or Calicut tiles according to the customers' requirements. But the user was not allowed to change the major layout of the designs as they wish. Those who wished to change the major layout, as an alternative method, only the concrete columns and the roof structures were provided and they were allowed to construct the rest and complete on their own. (Figure 4-4 & Figure 4-5). However, the dwellers' attitudes proved that this housing construction method was comparatively successful. 90% of the dwellers of the region were farmers and generally majority of them had low income. Even at present, they guarantee the conventional housing construction systems, traditional customs and beliefs.

The most prominent thing is, due to the appearance and technology used, the people in this region fashioned those houses with some interesting names as 'Poottu Gewal' and 'Kanu Pita Gewal' etc.

4.2.2. Rukmalgama housing scheme at Athurugiriya (Colombo District)

Figure 4-6: The smallest and the simple house type of Rukmalgama housing community (Type A)

Figure 4-7: External view of the largest house type of Rukmalgama housing community (Type C)

Rukmalgama community housing scheme is one of the first large scale semi-urban housing schemes implemented by the government of Sri Lanka under hundred thousand housing programmed in early 1980s. Unlike the RVDB colony houses, the construction of houses of this scheme were done by bottling of prefabricated sand-cement mixed 4 inch-thick complete wall panels with door window holes which were produced in a nearby workshop. There were 501 houses with four different varieties with the sizes of 400 ft2, 800 ft2, 1200 ft2 including different facilities (Figure 4-6 & Figure 4-7).

Dissimilar to the previous examples, 90% of the dwellers of the Rukmalgama housing scheme were well educated and majority of them work in the government or

private sector organizations. Some of them have migrated to this scheme for their occupations and various economic necessities. It is clear that because of this majority of the dwellers look at the appearance and the quality of those houses much more based on the economic point of view. Unlike in the RVDB houses, it is clear that the attitudes and thoughts of the users in this scheme are based on economic conditions. Also because this scheme is placed in a semi-urban area, the basic needs and requirements of the dwellers of this housing scheme changed rapidly.

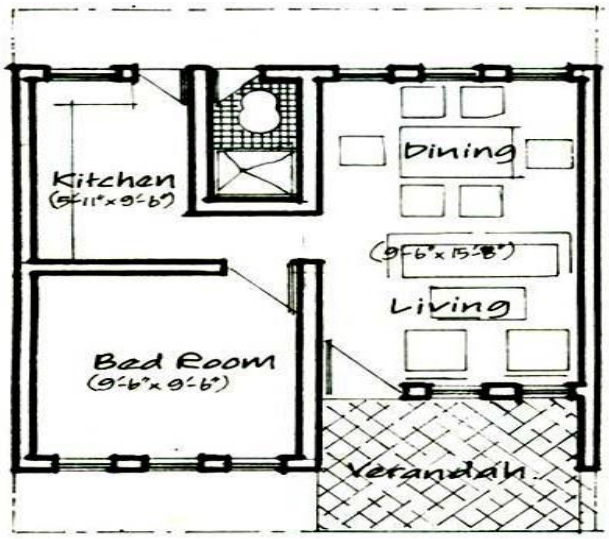

Figure 4-8: Repetitive layout of the house type A and the twin type house (type B)

The shortcomings in the flexibility of spaces of those houses and repetitiveness of layouts have to be discussed later (Figure 4-8). The manner in which they could be minimized and how the flexibility of spaces could be used with maximum efficiency in the plan form have to be considered.

The alternatives that could be taken to effect this prefabricated element technology will also be discussed in detail in the conclusion.

4.2.3. Tsunami kit-houses at Thelwatta (Galle District)

When comparing with the RVDB houses and Rukmalgama housing scheme, the nature of these kit-houses and their dwellers are much different in many ways. The

first thing was that the previously mentioned houses and their elements were totally produced in Sri Lanka and the complete kit-houses were a totally foreign, Spanish products, imported to Sri Lanka in 2005 after the Tsunami disaster in December 2004.

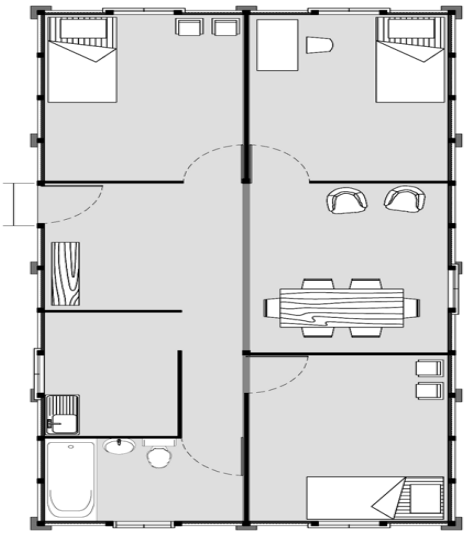

Figure 4-9: Internal layout of the prefabricated kit-house unit at Thelwatha

Figure 4-10: External view of the prefabricated kit-house unit at Thelwatha

Figure 4-11: Placement of the kit-house on the foundation of destroyed house.

Also since those prefabricated house units were made as fully complete units, their compatibility with the local materials, products and conventional methods were very less. Accordingly, these houses fall under "System building". Originally, those kit houses were imported as two-piece packages and fixed properly at the site sheathing of the joints smoothly. Also, many of these houses were placed in the old building foundations (Fig.4-11).

One kit house consists of 3 bed rooms, a kitchen, a bathroom and spaces for living and dining (Figure 4-9). All the internal partitions and ceilings were made of thick plywood boards.

The prominent features of these houses were the less flexibility of the layout. Also the ability to change the appearance, extend of space or replace the original components with the local products is very less. On the other hand, if such changes were possible, the owners were not provided with any knowledge required on this from the organization which granted these houses.

90% of the present owners of those kit-houses were living in different types of good as well as spacious houses before the tragic event of Tsunami. These houses in which they live in now were distributed among them free of charge.

But the overall character, external-internal appearance and finishing of the kit-house were highly appreciated by the dwellers (Figure 4-10). Therefore the attitudes of the

dwellers towards these kit-houses were somewhat positive. Furthermore, there were 25-30 kit-houses in that region and they were obviously contrasted among the other Post-Tsunami houses that were constructed according to conventional methods.

4.2.4. The prefabricated model houses built by the NERD Center at Ekala

Figure 4-12: Assembling of the prefabricated model house, NERD center - Ekala.

This single story prefabricated model houses were introduced by the National Engineering Research and Development center (NERD Center) at Ekala as a solution for the present day problems in housing construction in Sri Lanka. The main building elements of the houses were fully factory produced wall panels and column beam structures (Figure 4-12 & Figure 4-13).

Figure 4-13: External view of the NERD model house before finishing.

According to their experiments, these should be fully completed within 14 days and within an affordable price margin. But it was found really hard to do a house design

of this kind without knowing the exact users who will be living in these houses, their attitudes and needs, their social status and aspirations.

Figure 4-14: External view of NERD model house after finishing.

On the other hand, this was found further difficult in the case of a model house. If a product is introduced as a new product some of its special features have to be specially focused into consideration by actual users. This would mean, the external and internal views, finishing and the overall character of the prototypes should reflect itself the strength and stability, durability of the materials used as well as a "precious look" (Figure 4-14).

The provisions for future changes, extensions, developments and pavement of tiles or light fittings and decorating parts should be enabled.

The major reasons for discontinuing these model houses at the initial level and the negative attitudes towards these methods were found to be the lack of the future changes.

These were carried out as a part of the research and after its completion, researcher was transferred to another country. Also in this model house they have used precast light weight wall panel and to get the light weight, they have entered air bubbles into this concrete. This technology was not available in Sri Lanka as cost of this operation was much higher.

4.2.5. The prefabricated prototype house done by the NHDA at Maligawatta:

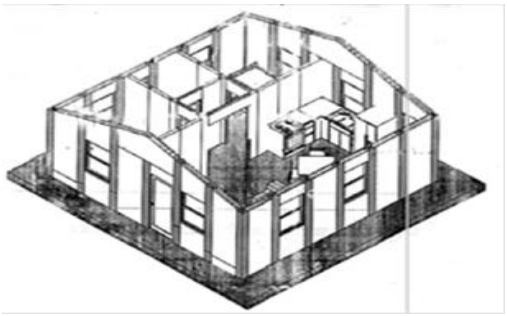

Figure 4-15: Isomeric view of model house of NHDA

With their various housing development and research programs, the National Housing Development Authority (NHDA) at Maligawatta branch also had built a prototype house by using prefabricated building elements with the help of a foreign organization.

The main building elements used for this were 4’ x 4’ foam panel similar to Regiform (Figure 4-15). Specially, the roof also been assembled and finished using those panels. It is clear that if the facts considered in the NERD model were taken into consideration for this housing type, this prototype house would have advanced and placed forward.

Figure 4-16: External view of the finish model house, NHDA - Maligawatta

Figure 4-17: External view of a wall coloured model house, NHDA - Maligawatha

This house facilitates all the factors as:
The 8" thick walls and the overall finishes which reflect durability, strength and a precious and more 'solid' look by the external appearance (Figure 4-16 & Figure 4-17).

The ability to make use of any colour painting, textures and decorative items like moldings and carvings.

The ability to use any kind of tiles and extra components for walls and the floors.

The research personnel who have been engaged on this have been able to take the appearance of this model house much similar to the appearance of a house constructed by conventional building methods.

But some of the important factors about the technology used in the construction of this model house, exact details about the materials or adhesives etc. We are not provided to the local authorities and due to the reasons and problems in the management, this construction was stopped.

Especially, though this prototype house includes most of the properties which are required for a positive attitude of the user towards this kind of a prototype such as internal and external appearance, finishing, the ability to use different materials and

decorative elements, looks ‘strong’ by sight, this project was found to be unproductive due to other reasons which goes beyond the impact of user attitudes and their thoughts.

4.2.6. Involvement of local building product manufacturers and developers

Figure 4-18: Kit form house product of ICC- Piliyandala.

Figure 4-19: Prefabricated wall panels produced by the ICC – Piliyandala

Apart from the NERD and NHDA models taken from various regions in Sri Lanka, there were several building components and materials manufacturers and developers involved in the production of prefabricated building elements for housing. Especially, the local manufacturers and developers in both the private and the

government sector were mostly involved in finding new technologies, new materials and to perform some experiments for improved methods for housing constructions. Parallel to this, some of those manufacturers started to develop some user responsive researches prior to marketing their products for house designs.

But when considered as a whole, some of the limitations given by some of those building product manufacturers and the procedures they have forced to take on the particular products influenced greatly the design freedom of the Engineer, Architecture and the Designer. That means some of the limitations of planning layouts reduced the ability of handling the spaces according to the user requirements. In such cases Engineers, Architecture and Designers needed to go for other alternatives.

Nevertheless, it is clear that the key factor for finding new technologies for house construction, their existence, their popularity and rejection is the users' attitude and their acceptance.

Further discussions about these methods are given under impacts of user attitude.

Figure 4-20: Fully factory produced and site assembled steel house at Bolgoda, ABS (pvt) ltd- Kaduwela.

Figure 4-21: A residential container conversion, Mclerence Logistics Pvt. Ltd.-Walissara.

4.3. Result of User Response Surveys

The author analysis with user response survey and personal observations. Quaternary is prepared to cover all the below mentioned main categories.

- Visual impression of housing units
- Use of material and technology of housing units
- Flexibility to spaces and changes in housing units
- Economic value of investment of housing units
- Physical comfort level of housing units
- Tally with local customs and beliefs in housing units

Prepared quaternary sheet is given with methodology and received data summarized and tabulated in Table 4-1:

Table 4-1: Result of user responsive survey

Location	Visual impression	Use of Material & technology	Flexibility to spaces & changes	Economic value of Investment	Physical comfort level	Tally with local customs & beliefs
Tsunami kit houses at Thelwatha	OK	NOT	NOT	NOT	NOT	OK
	OK	NOT	NOT	NOT	NOT	OK
RVDB	NOT	NOT	NOT	NOT	NOT	NOT

Morakatiya	NOT	NOT	NOT	NOT	NOT	NOT
	OK	OK	OK	OK	OK	NOT
	NOT	NOT	OK	OK	OK	NOT
RVDB colony houses	NOT	NOT	NOT	NOT	NOT	NOT
	NOT	NOT	NOT	NOT	NOT	NOT
Rukmalgama housing scheme	NOT	NOT	OK	NOT	OK	NOT

4.4. Impacts of Users' Attitudes

Generally, when reviewing the facts discussed so far in the selected case studies, some of them basically provide a glimpse of some kind of mismatch between the attitudes of the people generated based on their socio-cultural standings and the various improved technologies identified according to the changing needs and economic background of them. But this should be properly proved before conducting any further discussions. Furthermore, many of these are identified in the initial site visits of the author and the data analysis mainly carried out based on these categories.

4.5. Visual Impression of housing units

Data received from user responsive survey about visual impression is shown in Figure 4-22.

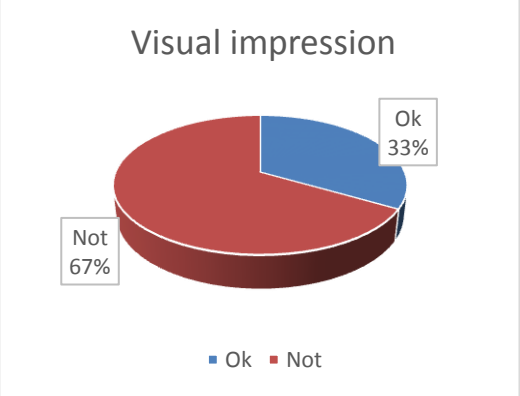

Figure 4-22: Visual impression

According to these details, it is observed that majority of users experience bad visual impression in these case studies. This reflects main negative attitude or ‘image’ of 72% of the people on these prefabricated buildings that they are just ‘unsteady and impermanent’ houses (Figure 4-23).

Figure 4-23: “Impermanent” or unsteady quality, RVDB houses - Morakatiya.

According to the case studies, it is proved that this is mainly because of the materials that are used for the construction, the thickness of walls, and the internal and external appearance of the houses. This is further proved by the words that are used by the people, including the dwellers to describe these houses such as *‘Tent Gewal’, ‘Poottu Gewal’ or ‘Kanu Pita Gewal’* in Sinhala terms.

Mostly the colony dwellers in RVDB houses at Morakatiya and Udawalawe still remain with those attitudes. Indeed, it is justified by the people’s thinking in that manner when one looks at those houses. This was the prominent problem identified during the practical application of those kinds of houses to the society.

Figure 4-24: Visual impression does not reflect a “prestige” or “Durable” look, RVDB houses – Morakatiya

When conserving situations, Most of the people try to understand the worth, strength or suitability to live in these houses by the actual **visual impression** of those type of houses, by its attractive external and internal appearance and by comparing the functionality of the new products with the existing conventional buildings.

But, according to the personal observations, it was clear that fixing, detailing, strength, stability and durability of those houses were not in very bad conditions. Not only in that occupied houses but also in the majority of prototype houses mentioned in the previous parts are well in the strength of the structure, durability of the materials and components used according to the affirmations given by the engineers and other specialized personnel. But the actual visual impression of the house did not reflect the qualities or the ‘prestigious look’ of the actual products (Figure 4-24).

Figure 4-25: Three Inch thick partition wall, model house - NERD center.

For example, if the wall thickness is about two or three inches, although it has a fairly good strength and durability, due to mentioned issues it is very difficult to draw the genuine consent of the user for the use of these types of elements (See

Figure 4-25). 67% of the people expect more ‘solid’ looking walls for their own dwelling.

The previous chapter generated some important facts for discussion. The absence of a fine, reliable communication to the user about the actual quality of the house or the elements used is the serious matter. This has occurred because in most cases the manufacturer or the designer considers only the technical aspects, qualities of the materials and the cost of production. But, whatever the technology or materials that were used, if the design is done in a manner which is visually pleasurable and have the ability to draw the desires of the user about the aesthetic aspects of the house such as appearance and finishing, successful results could be obtained.

Figure 4-26: Interior finish at entrance, Tsunami Kit-house - Thelwatta

Figure 4-27: Interior finish in rooms, Tsunami kit-house - Thelwatha.

As an example, Tsunami kit-houses at Thelwatta came with a difference with good external characters, acceptable appearance, well designed finishes and components both the interior and exterior and it was well accepted by majority of the users (Figure 4-26 & Figure 4-27).

Inversely, if those kit-houses seemed like a mere shipping container or like attached boxes on skills without the finished quality, the reaction of the users could have been negative.

It is therefore, users' satisfaction is the prominent factor. This 'satisfaction' usually came through a comparison of those houses with the contemporary houses in the surrounding which were constructed using conventional building methods. Therefore, the very important factor which can be taken into consideration is that an acceptable house design with prefabricated elements and components is the one which does not look as though it is prefabricated or a mere assembled object with different elements. Further, though it is constructed with a low-cost, the house should not have a 'low-cost' appearance.

In other words, if the actual production or the engineering design really emphasizes those intangible qualities like strength, durability or 'prestige' look of its elements or materials by their finishes, shapes, sizes or the overall 'character' of the house, it is a must for the light of the mentioned issue.

4.6. Use of materials and technology in housing units

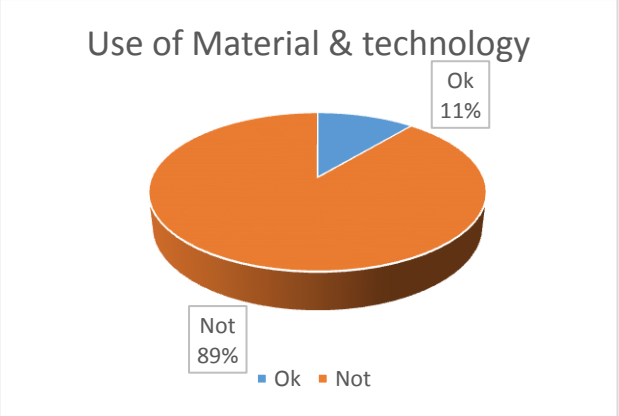

Figure 4-28: Use of material and technology

Data received from user responsive survey are presented in Figure 4-28. This clearly indicates that use of material and technology is not accepted by majority of the users. Unlike the conventional and typical construction methods or materials like bricks, blocks or concrete, it is no doubt that the user thoroughly consider about the durability, strength and stability, availability and as well as the quality when he prepares to select new materials or technologies for his own residence.

But, if the main elements of a house such as internal and external walls or the roof produced using unaccustomed materials like straw, regiform boards or card board panels, it is fairly hard to get the acceptability of the user as the conventional attitudes of the people towards those kinds of materials are commonly 'unstable', 'weak in strength' or 'not suitable' for their social status as well as the economic status within the background of the society they living in.

Commonly, 66% of the people did not understand properly the strength or any intangible qualities of those novel materials or components; even though those were properly treated or strengthened by using various technologies, because of the plus points of the production such as the overall shapes, finishes and sizes of the elements were actually not fairly communicated.

For example, materials like straw-fiber panels or re-usable components were regarded as 'poor materials' by most of the people. This was because they were expected to have the visual attributes of conventional materials like concrete or bricks which were considered the only really 'modern' or 'rich-look' materials.

Further, using re-usable shipping containers as elements for housing is an innovative idea. But common attitude of the people about using these containers is also in the negative and not in a satisfactory situation.

Most of the people decide about the suitability of it for their own houses on the basis of what they have heard before, what they have seen before and what they have experienced before. ‘Not permanent’ or ‘Disposable’ are the main ‘images’ towards those kinds of products.

The major reason for this situation is, even though different types of new materials and technologies are used in housing construction, the user is not provided with the necessary details about them. Especially, some of those methods are more complicated to be understood than the conventional methods and people face many problems in regular maintenances or alterations to their houses. One of the other major issues identified are the limitations or difficulties for changes or alterations of materials for aesthetic purposes, laying conduits and drainage lines, laying floor tiles or wall tiles, fixing sanitary appliances etc.

Figure 4-29: some users’ idea about alteration to the existing prefabricated house.

Some users are thinking to alter their houses without doing any damage to existing prefabricated house (Figure 4-29)

In the case of Tsunami kit-houses at Thelwatta, since the users did not know the exact methods of maintenance or protect those houses by environmental impacts, they used some uncommon methods as solutions. Sometimes it is a surprising to see them as genuine users’ attitudes and ideas.

One of the suitable solutions that could be suggested are the use of those improved technologies only for the essential parts such as external structures like structural

columns and beams or for the 'core' of the house, without doing the whole construction with prefabricated building elements.

Figure 4-30: A RVDB house at Moraketiya, finished using conventional materials

In such event, the rest of the house could be completed by using the conventional methods those are well known by the users. Some of the RVDB colony houses at Moraketiya are good examples for this (Figure 4-30).

4.7. Flexibility to spaces and changes in housing units.

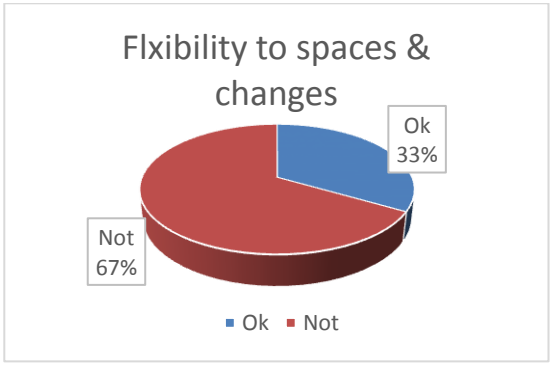

Figure 4-31: Flexibility to spaces and changes

Data received from user responsive survey is illustrated in Figure 4-31. According to that flexibility to spaces and changes were not in accepted levels, for majority of the users.

All users were required to extend or change the spaces of their own houses parallel to the changing basic needs of the family. But in some houses erected with

prefabricated building elements, are willingly or unwillingly ignored that phenomena. For example, some spaces like bedrooms, living and kitchens cannot be reached the acceptable space requirements by even expanding the sizes of them in the future, wholly due to the materials and the technology used.

When a house is constructed with prefabricated elements in a small land area, building materials and technology should be selected in such a manner that it is possible to extend the house vertically by adding more floors, without extending the ground floor. But in the model houses built by the NERD center, even an upper floor cannot be constructed without doing some substantial changes of the materials and the technology. Actually this issue will be tackled by the research personnel in the future but those kinds of things directly influence to generate bad attitudes of 'cannot be changed, alter or extended at all' among the people at the very first step of the experiment.

Figure 4-32: A twin type house at Rukmalagama converted to a two-story one while the original walls remain same.

Besides that in the houses built at Rukmalgama housing scheme, 90% of the small houses have changed to two or three storied houses at present. The important factor is that the element building method by which those houses were erected was not an obstruction for extensions in most cases. That means users have been able to do many more changes, having those strong durable prefab walls as they were without breaking down the whole house using any kind of a construction method or materials (Figure 4-32).

There is a need for a more integrated approach to the planning of spaces within houses with the help of the features of those improved technologies. Flexibility, in particular, between common spaces and activity spaces, needs to be addressed. Mainly, on the occasions like funerals, alms giving, weddings or any other special functions, this would be appropriate. This is a must if the house that is being constructed is small. Therefore, it is vital that the user should be given more opportunities at the beginning to make any alterations or changes in the designs, as per his aspirations. Further, another successful solution will be the suggestion of minimizing permanent walls and using moveable partition with lightweight elements for houses having internal layout with small spaces ensuring flexible spaces that could be changed by the dwellers whenever they liked.

4.8. Economic Value of the Investment of housing units.

Data received from the user responsive survey is illustrated in Figure 4-33. According to this survey, majority of the users are thinking that economic value of investment is at low levels.

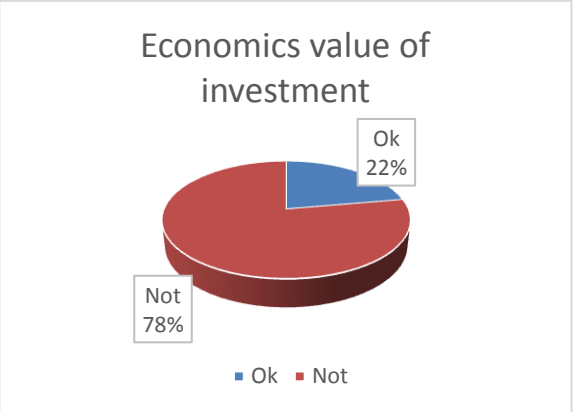

Figure 4-33: Economic value of investment

Regardless of the other social factors, Most of the users are concerned of their economic investments in those houses which were constructed using some novel technology or materials. That means 78% of the people are doubtful even at present

whether those types of house has the actual value compared to what they or donors have spent on it.

If a two-storied normal house could be constructed in the conventional methods using the money that expended to a normal one-storied house by prefabricated elements, usage of that construction method is considered a problem.

Further, due to the external appearance and the lack of basic facilities in a prefabricated house, 78% of the people have the questions whether that can be sold to the same price that they expended on that or they will have to get a lesser value than the noticed price of the house. A lot of this resistance can be explained by the perception that it will affect the resale value and mortgage ability.

Figure 4-34: A rich looking two storied house at Rukmalgama housing scheme built by completely removing the smallest type of house.

Some of the dwellers at Rukmalgama housing scheme, who bought those low cost, poor looking, poor status houses had a different kind of attitude at the beginning of the scheme and demolished them completely after a certain period of time, and erected a new house with a 'prestige look' using conventional materials (Figure 4-34). The massage which came with this is a vital point to think. Therefore, it could be stated that a prefabricated house should have appearance and facilities similar to normal conventional house or should have much more than that.

This means, the particular prefab house should be at a higher stage that user can demand for his house. However, the new method may be far more expensive than conventional methods, which function demands, but 'status' requires more qualities.

Initially, those types of new building methods like prefabrication may be expensive. But, with the development of improved methods suited to local conditions, and fulfillment of pre-requisites for adaptation of those methods, it will be possible to make prefabricated houses economical.

4.9. Traditional Local Customs and Beliefs of housing units

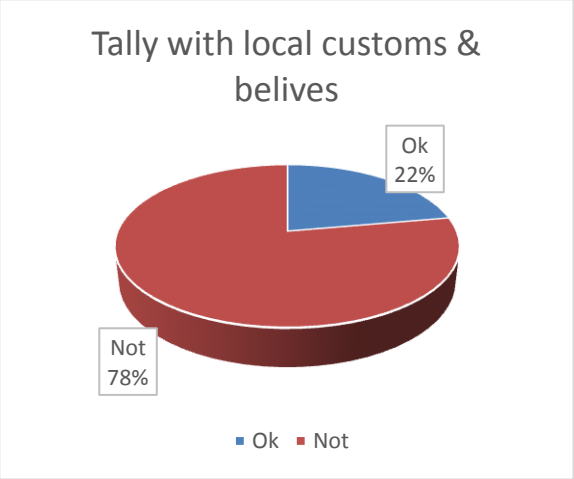

Figure 4-35: Tally with local customs and beliefs.

Data received from user responsive survey is illustrated in Figure 4-35. It is observed that majority of the housing units are constructed without considering that large number of users highly believe in these customs and beliefs.

The construction of a house in a traditional form was linked up with series of rituals that creates confidence and hope in the mind of the occupant on prosperity. This brought in a spiritual entity to the new house, religious beliefs and practices brought confidence and blessings to the occupant in the traditional form. In 78% of the cases of using those new building elements, due to their spans, standard fixed lengths that

are required for wall panels, columns and beams, are merely ignored the rituals and concepts like ‘Pada’. In view of this, many individuals tend to think and conclude that these types of houses are inauspicious and will bring them misfortune.

To overcome this negative attitude to some extent, the users could be offered arranging flexibility on spatial terms as well as an opportunity to take part in design decisions involving spatial arrangement of the dwelling.

The best example is the RVDB colony houses at Moraketiya. When some of the users were allowed to construct the rest of the house after assembling the core structure, the first task they have done was the removal of one prefabricated column among the nine-columns of the outer structure. The mere reason for that was their thinking that ‘nine’ is inauspicious! (Figure 4-36).

Figure 4-36: The removed column by the user thinking that 9 columns are inauspicious

It is to be understood that there is no special advantage at all times in refusing or ignoring the cultural and traditional standings of the user. Therefore, Engineer or the designer should come out with a proposal for alternative technical solutions that are not contradictory to those traditional concepts.

4.10. The Physical Comfort Level of housing units.

Data received from user responsive survey is illustrated in Figure 4-37. It is observed that physical comfort levels of these units are not in acceptable level for 67% of the users.

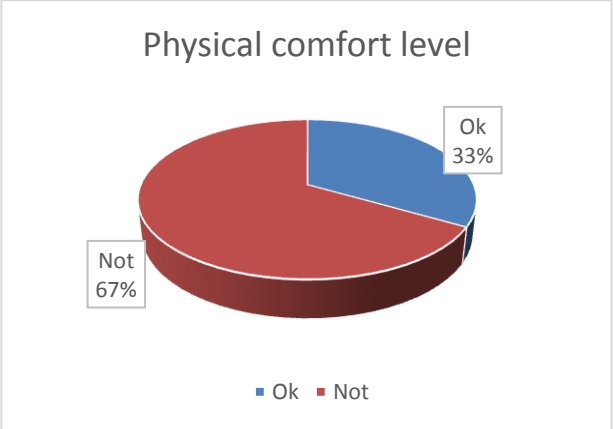

Figure 4-37: Physical comfort level

The physical comfort of a particular house, whether it is a prefabricated or conventional one, is one of the most important factors due to the reason that loss of the physical comfort of the house definitely cause the loss of psychological comfort of the user. Especially, in a country like Sri Lanka, any kind of a new material or a new technology for a house should be selected by considering this factor.

It is common to notice that people expose different attitudes towards some building materials and technologies and about the comfort level of the house, through the things they always see or by their experience.

Figure 4-38: The user gets uncomfortable due to environmental impact.

In 67% cases it could be seen that some of the materials and technologies used for those houses were not adapted to the local climatic conditions (Figure 4-38). This

has in its turn caused severe and unsolved technical problems, especially in the hot, humid areas. For comfort, sometimes they rely on even air-conditioning.

Figure 4-39: Materials are selected without considering the local climatic conditions

A major reason is that some of those products were taken ‘off the shelf’ of a factory in an industrialized country with a temperature, climate and used without any adaptation to local climate. Basic local problems have been neglected, probably because they do not occur in the country of manufacture (Figure 4-39).

Using merely different types of materials and just assembling them is not suitable at all for Sri Lanka. Building elements should be composed in such a manner that they are well suited to the local climate and environmental conditions, better orientation and ventilation could be obtained.

Existing knowledge about designs for local climate must be utilized and much better spaces could be created. In reality, well composing is much better than mere assembling. The most significant factor that needs attention is the correct selection of suitable elements and technologies for the design or for the production.

4.11. Lack of Quality Local Models and Prototypes

The major factor that makes a new technology or a new creation disseminate among the people is the quality precedents about them.

Figure 4-40: Prototype house done by the NERD Center using prefab cement panels

Though different local institutes, research centers and manufacturers have introduced many building materials, technologies or products for housing to the market, even at present there exist lack of good quality prototypes or models that could be used to introduce them to the users. Though there is such a precedence, they are unable to draw the attention or the attraction of the users (See Figure 4-40).

Besides that, when foreign examples are considered, they are much advanced in the case of user attraction levels. The following selected foreign examples give evidence for them.

Figure 4-41: The ‘Magic Box’ at Los Angeles
(Source: www.magicboxincusa.com)

This unique fully prefabricated design is called as ‘Magic Box’ which is a creation of Magic Box Inc. Ltd, at USA (Figure 4-41). In fact, this is a versatile 'box' that changes the stereotypes of prefabricated houses and extension rooms by having qualities such as transparency and simplistic form with high versatility.

Figure 4-42: Exterior view of ‘Magic Box’ at Los Angeles
(Source: www.magicboxincusa.com)

The concept of the Magic Box is based on 'fusion' of art and architecture. It creates unique, innovative environment and the user is free to drive his imagination into transforming this box into his own working space or space for his hobbies as well. Further, this has unique features not found in typical prefabs. Available options include electrical conduits and circuitry, ventilation system (HVAC), plumbing, and window shading (Figure 4-42 & Figure 4-43).

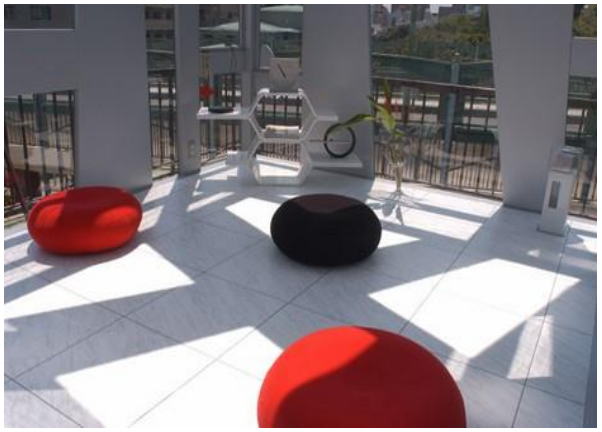

Figure 4-43: Attractive interior view of the ‘Magic Box’ at Los Angeles
(Source: www.magicboxincusa.com)

Although this is a foreign product, it shows some important points to consider. The most significant thing is that it first attracts the user for the prototype or model and

then instructs the user about the rest. The other one is that the precedence should have some kind of a specialty to change the negative attitudes of the user.

Therefore it can be obtained that what should be done is not to imitate but to re-interpret the special design concepts and innovative aesthetic features on those, with a local identity that matches to the local conditions and traditions.

Finally, it should be stated that if houses created using those new methods are low in quality and visual appeal than houses built using conventional materials and methods, and if they do not offer anything innovative in terms of space, economic value, construction time etc. and achieve nothing positive in terms of physical and mental comfort of the user, chances are that such buildings will be received in a negative manner and result in even rejection by the users. These faults and shortcomings were observed and therefore should be rectified as much as possible and to a greater extent.

As a whole, reasons fall under discussed factors could be influenced and controlled by an Engineer, Architect or by a Designer to a certain degree. But, there could be some other factors like political and administrative issues which an Engineer, Architect or Designer will not be able to control in any manner. Therefore, the long distance between the Engineers, Architectures, Manufacturers, Administrative personnel, and also the users must be compensated by a very thorough and accurate design process.

5. CONCLUSION

5.1. Introduction to Conclusion

Case study based research was carried out on finding the answer for "Why this prefabricated building method does not grab significant market share in housing construction industry in Sri Lanka?" For this purpose, several literatures were reviewed and carried out user responsive survey in selected areas where this types of projects previously done in Sri Lanka. Using the results of this survey and personal observations of the author, this data analysis and conclusions are prepared.

5.2. Findings

Findings of data analysis carried out in this case study are;

- Many houses looked very cheap in appearance and the users were not willing to live in these houses.
- RVDB workers' houses and Tsunami kit-houses have main issues in construction materials as these materials do not match with the environmental condition in that area.
- Large number of houses encountered space problems during special occasions like funerals, weddings and arms giving etc. which created large problems to users.
- Alterations were found to be very difficult in 66% of the houses. Some users have completely demolished the prefabricated houses and built new houses using traditional building materials.
- It was the unshakable belief of the users that if they were to be given the opportunity to involve in the design work, good suggestions and valuable good ideas would have emerged to the benefit of both parties.
- Many users faced problems in the maintenance work which resulted in special craftsmen's skill and involvement in carrying out such maintenance work. In addition, these special craftsmen were not available at the area after the completion of these projects.

- Re-selling prices of these houses were found to be difficult and well below than the traditional building methods used same size houses. This method in some occasions didn't give the money value to users.
- All the projects were carried out without giving due consideration to local customs and beliefs of the users and therefore it became a huge problem for users.

Considering the model manufactures of prefabricated building methods, data analysis also revealed the following issues:

- Many of these methods were not cost effective compared with the traditional building methods.
- Some technologies used for models are not available in our country.
- Some models are not exposed to market.
- Heavy machineries are required to install the elements in some of these methods.
- Some models have been discontinued after research level.

5.3.Conclusion

According to the personal observations and questionnaire data analysis, author concluded on following findings. However, some of the findings could not accomplish in larger housing projects as described below:

- Arranging the prestigious look for internal and external finishing of the units.
- Arranging more spaces.
- Involvement of users in design stages.

Everyone needs the prestigious look. When we consider the requirement of prestigious look, it is always combined with price and has to be changed according to their investments. More space means more investments and therefore it cannot be provided in large projects. But due to low cost of this building methods compared to traditional methods, space arrangement of final output will be higher than the traditional methods used houses.

Though in single house construction work, it is possible to involve user in design stages, it will be impossible to involve many users in large projects. In this case the author suggests designs with lot of options enabling the users to change their designs.

When considering findings and practical issues, Author prepare the conclusion as below,

- Housing unit are not with attractive look, flexible in spaces and expandable ability.
- Construction material are not tally with environmental condition and not consider local customs and believes in designing.
- Poor marketing of model manufactures.

Then it is clear that due to above mentioned issues, prefabricated housing method does not grab considerable market share in House construction industry of Sri Lanka.

5.4. Constraints

User responsive survey and personal observation is the main data collection method for this dissertation. Due to lack of time availability, author has carried out these site visits in day time. Therefore, 77% of the interviewed users/people were women house wives or retired persons. But the results of the data collection would have been different or subject to changes if the ideas of other people and users were obtained.

5.5. Recommendations

According to the findings and conclusion author has mentioned a lot of issues about prefabricated housing project lunched in Sri Lanka. It is evident that our prefabricated housing industry is well below the expected levels and as such the usage of the below mentioned recommendations could extend good contributions and support to uplift this industry.

Considering all these findings, recommendations to this type of housing project are:

- Developers, Engineers and Architectures have to consider the internal and external appearance of housing unit. It should have attractive look according to their investment.
- Arrange design proposals with more options for the selection by users in large project and involve user for design stage in individual house construction works.
- It is recommended to build partition wall as removable partitions.
- Material used for units should have to match with the environmental condition of project area.
- Layout should have to match our local customs and beliefs as much as possible.
- Should have awareness programs on the execution of maintenance work and should make available the contact details of maintenance contractors.
- Method of construction should allow future alterations.
- These units should give money value compared to traditional building methods.

Findings, recommendations could be considered as guidelines for prefabricated building projects and following these points and factors will increase the user satisfaction of these units.

When considering model builders of prefabricated building methods, it is important to develop more models for users. Technology should be made available in our country and after the research level the outcome should be presented to the industry with their guidance. These methods should have cost and time advantage compared to other traditional methods.

5.6. Future works

Some of the modern prefabrication methods do not embrace good cost advantages and therefore researches have to be carried out for finding low cost prefabricated

methods. Also lot of material used for these models are not tally with environmental condition of Sri Lanka. Then it is good research area. In this research we interviewed only one member or user from each family and there is no shadow of doubt that the feedback and responses will vary and benefit the interviewer if we interview all the family members.

Comparing with other housing methods, researches on cost and benefits of prefabricated building methods to be conducted from time to time for future developments of this prefabricated building method.

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Appendices

Questionnaire for uses

1. House owners name :
2. Annual household income :
3. Family members :

Relationship	Age	Occupation	Place of work

Information of the previous residence (If applicable):

4. Where did you reside before occupying this house / housing scheme?

5. What about the nature of your previous residence?

6. What is the reasons/reason for leaving from previous residence?

7. What is the reasons/reason for selecting a new house/housing scheme?

8. What are the reason/reasons for selecting this particular type of house? (Applicable for housing scheme dwellers only)

Information of the particular house:

9. What are the special benefits you gain from living in this type of a house?
10. What are your disadvantages you have living in this type of house?
11. What are the advantages you gain from the present space arrangement of the house?
12. What are the disadvantages you have due to the present spatial arrangement of the housing unit?

13. Are there any special design considerations which directly related to the construction methods, materials or components used for the house?
Yes / No
If Yes, what are those?

14. Are you satisfied with those construction methods, materials or components used for the house?
Yes / No
If No, why?

15. Are the layout/plan/spaces of the house already fixed (fixed dimensions of the plan / fixed level changes) by the manufacturer?
Yes / No

16. Did you participate in the design/construction of the house? Or was the construction done according to your requirements?
Yes / No

17. Do you intend to do some extensions or alterations to any part of your house unit?
Yes / No
If Yes, what are those parts?

18. Can you change or alter any building materials, components (such as doors, windows etc.) and finishes (such as textures or colors) as you wish in the exterior or interior of your house unit without any problem?
Yes / No
If No, why?

19. Are you satisfied with the each and every space size and the relationship of plan by functions?
Yes / No
If No, why?

20. Are the layout of individual spaces (such as kitchen, bedrooms etc.) flexible for the arrangement of furniture?

    Yes / No

    If No, why?

21. Did you face any difficulties due to the spatial arrangement, during a special function (funeral/wedding/alms giving etc.) of your house/ house unit?

    Yes / No

    If Yes, what are those?

22. Do you believe in the traditional astrological relationships or any rituals influence your religion for the house construction process?

    Yes / No

    If yes, what are those?

23. According to your knowledge, was the layout and construction of your house done accordance for those rituals and beliefs?

    Yes / No

    If No, what are those?

24. According to your knowledge, is the layout and composition of the house fit to the site / location?

    Yes / No

    If No, why?