Modeling Optimized Housing Patterns for Rapid Manufacturing Complexes Iran, Tehran

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Abstract Dwelling is an essential need of human being; unfortunately, housing development is the main contributor to the problem of climate change and environmental degradation. Thus, it is important to build more sustainable houses. Today, most of these needs have been resolved by rapid construction. But building a house with a fixed structure and defined style cannot respond to all human needs. Regarding social issues, culture and identity along with economic and environmental issues are very important and will contribute to build a more sustainable house. One of the sustainable models of dwelling, which has been proven over time, is the traditional architecture. Most traditional houses in Iran are constructed with the local wisdom of traditional people in responding to the local climate, use of the local materials and are influenced by their culture. Considering dwelling in old Tehran, we can reach to five pattern plans. The aim of this paper is to take into consideration these patterns based on certain criteria. These criteria are environmental benefits, social benefits, and economic benefits. They could help us reach the new concept of a sustainable house. The house uses a knock-down system and modular construction, and has been incorporated with many sustainable features to make it not only comfortable, but also sustainable and adaptable.

Keywords Rapid Manufacturing, Optimized Housing, Traditional Patterns, Incremental House, Adaptable, Modular Construction, Knock-Down

1. Introduction

The population growth in the world and the need for dwelling is one of the important issues particularly in the third world countries. For responding to it, most of these needs have been resolved by rapid construction. But building a house with a fixed structure and defined style cannot respond to all human needs. Every human being naturally wishes to fulfill all his needs, not only material necessities, but also emotional and spiritual satisfaction. According to Maslow’s hierarchy of needs, there are five basic needs; existential needs, safety, social needs, esteem and self-actualization. [1] Dwelling is important not only to human activities, but also to protect them from natural environment and climate. It accommodates the social and cultural activities, and also a means to self-actualize and gain respect from others. Thus, it is an essential need which can satisfy the five basic needs mentioned above. Due to social and economic differences in the world, criteria of a feasible house differ from one country to another. Schulz did not believe construction is occupation of space. In this case, the most important thing is the spirit of place and the deep connection between earth, structure and sky. [2]

Facing the current environmental problem, global action for sustainability has emerged. In this regard, housing as one of the largest construction industry should be designed in a sustainable way to ensure not only minimum consumption of energy and resources, and minimum environmental impact, but also to enhance human condition and to accommodate their social and cultural needs. There is still lack of knowledge about the importance and the method of building a sustainable house. A house is frequently designed only to accommodate the present needs of its occupants.

Other common issue in housing development is the needs to adapt the house according to the developing needs of its occupants. It is likely that throughout years, the activities and needs of the occupants will change, and thus the house needs some adjustments. Some examples are the needs of an extra room when a baby is born, or when the children have grown and need individual space. Changes, which are not anticipated in the design phase, will cause unplanned renovation cost or even early demolition of the house when it is no longer proper. A sustainable house should take into account the space adaptability and flexibility to prolong the building lifespan. This is aligned with the concept of 4R (reduce, refurbish, reuse and recycle). [3] In Iran, as in other developing countries, people tend to emphasize on the short-term benefits. Thus, most houses are not designed to respond to the changing needs of the owner.

Considering the needs for a more sustainable dwelling; this paper presents a sustainable incremental house to be
implemented in Iran. The research is carried out in several stages; starting with exploration of traditional houses in Iran, the principles coined are integrated with the sustainable strategies to produce a model of incremental house with modular construction and the optimum pattern. The research has involved literature study, case studies, design drawing and proposal modeling.

2. Materials and Methods

Research approach is simulation and modeling. [4] Collecting information method also is library searching and physical studies. All the case studies were taken from the Cultural Heritage, Handicrafts and Tourism of Tehran Province. All of them were analyzed by existing information about traditional houses. The aim of this process was achieving the modular construction. The proposal modular should have both traditional features and modern technology for responding to the needs of modern human.

3. Failed Experiment

Modern world against old world offers different opinions which address the human and rational beliefs. This human-centered attitude has been started since human became axis of all values. Modern architecture as architecture ideology with its theoretical basics, was collected into a book and constructed buildings on basis of modern thought was formed in late nineteenth century. Methods in the modern architects' charter for the design, implementation, and theoretical principles are:

- Using of the steel structure for all structure;
- Showing the structure of the building in façade;
- Not imitating past styles;
- minor using of decoration;
- Using wide window which covers the span between columns entirely. [5]

Nietzsche's criticism of modernity with the changes in Germany began in the late nineteenth century by thinkers such as Heidegger, Freud, Derrida, Deleuze, Lyotard. The philosophy is the spirit of the times and the architecture is the body of the times. Changing of the spirit changes the body. In 1930s, Postmodernism was started as a response to the modernism. Postmodernism was challenged by some criteria of the modernism, such as pure rationalism. From a postmodern perspective, ignoring the problems of today's society such as human dignity, anonymity, cultural crisis, excessive violence, destructive wars, human relations, and finally domination of the technology over human lives have contributed to the conditions of modern life. So, modern human should review the modernity. [6]

Robert Charles Venturi is one of the critics of modern architecture. He doesn't believe in international style and instead believes in regionalism. Namely each building should be based on the cultural, social, historical and physical conditions of the site. It is called local style or native style. [7] Modernist architecture is considered only a technological issue without giving attention to culture, religion, environment and region; therefore, it has failed.

4. Regionalism and Revivalism

A dwelling that is built for human-life could not be devoid of characters, moods, advice, opinions, tastes of occupants that they live in. Twenty to thirty years ago, Iranians made their homes and the utilities were only the drinking water, electricity, and etc. They did not interfere with construction procedure. [8]

In recent years, the number of patterns in modern architecture is rising in comparison with the traditional architecture. The traditional dwelling attended to inside and their aim was to develop the calm in house; so, the building density was low. On the other hand, at the same time, a new dwelling was introduced to the market which paid attention to outer space. Shortage of space for housing and lack of time for the presence of family members at home had caused the western houses to be used in Iran. This type of houses did not fit the culture and cognition of user. Having the three types of open, semi-open, and closed spaces caused a connection between the culture, economy and geography. These are the things that have been emphasized in contemporary Iranian architecture. Recognition of technology in the twentieth century by architects led to freedom of architects from climatic parameters of heat and cold, and moisture. This type of technology could be equipped by some systems, components, and materials in each place and worked by using of fossil fuels and proper systems such as air conditioning and heating systems; While, most of houses in Iran have been perceived with earth and climatic of site for a long time and they did not need using of mechanical energy. They had been using the heat of summer, the cold of winter, and the wind-tower to help different type of ventilation. [9]

Moreover, modern architecture and the world architecture had something new to say by the civil engineering experience in nineteenth-century in Europe. Applications of new materials in Iranian contemporary architecture are dysfunctional actions. New materials have influenced very important after effect on a new face of Iranian architecture, since they involve so many designing details (door, windows, plaster...), architectural elements (column, wall, stair...) and the structures which can create a new shapes and compositions in traditional Iranian architecture. [10] Humans have to be responsible for cultural and environmental issues in: city, residence, design, implementation, planning, collaboration, expanding of architecture culture and development of built environment, particularly in the past thirty years. If they do not attempt to repair these losses, they will face more problems. [11]

5. Shifting to Authentic Innovative Architecture
In every period of history, the form and the concept of the house has appropriately changed based on the conditions of human. This transformation can be found from the house of ancestors in the past until now by the remained samples. This condition can be derived from cultural-social, climatic and economical-financial issues which are more explained in detail in the following.

5.1. Social-Cultural Issues

Successful patterns of ancient houses have been completed with attention to the needs of human by passing the time. So, most of them considered the social and cultural issues such as creating a space hierarchy to preserve the privacy of each room (for example: vestibule, corridor, interior yard and exterior yard, passageway etc.), creating tranquility for residents, adapting the house with needs of users in terms of performance through flexible and extensive spaces.

On the other hand, there was a sense of belonging among the users and the building, because it met all the needs and demands of users. This development and evolution were the result of years of life and experience in those houses. So having a sense of belonging to a place could create an ethnic identity and strength to a group. Thus rehabilitation and updating of patterns and using the flexibility and technology in them will be accepted by the people in Tehran nowadays if the principles and values of the past preserve, because these patterns are rooted in the culture of the people.

5.2. Climatic Issues

Housing has a close connection with nature and the human environment, for example, proper use of materials and natural resources in the region as well as respect for the site. One of the main reasons related to climatic issues is the creation of warming during the cool season and cooling during the hot season by natural resources and construction methods. For example, use of the summer staying places in the cool season and winter staying places in the hot season, the change in the size and number of openings, the use of wind-tower in the summer stay, and use of the vegetation and water in the yard.

When the world is facing the shortage of fossil resources and an increase in environmental pollution, housing as one of the largest energy consumers with keeping its past values and principles, should be able to use the technology and flexibility, and adaptation to meet the user's modern life style.

5.3. Financial-Economical Issues

Sustainable buildings have the greatest impact on decreasing the economic costs such as, providing the energy required by the natural resources, reducing the destruction and increasing the life of building. For increasing the life of building, using the materials with high quality and proper maintenance depends upon the ability to meet the needs of its residents in each time period. For example, by using the light and flexible frame, we can be able to change the room spaces with attention to needs of users. Also, with increasing population and demand for housing, the rapid manufacturing can be very effective in increasing the speed and reducing costs.

6. Case Study

6.1. Case Study Selection

To achieve the new model of traditional house in Tehran; firstly, their strengths must be recognized. Then, they must be combined with the technology for responding to the needs of modern human and aligning with the world. For this purpose, according to information received from the Cultural Heritage, Handicrafts and Tourism Tehran Province, we could achieve five models of traditional houses that need to be discussed.

From exploration of traditional houses in Iran, it is found that most houses have a flexible lay-out. These houses use only limited partitions between rooms, like sash, so that the rooms are easily adjusted according to the needs of the occupants. Some houses are increment; they grow bigger/longer over times to satisfy the addition of the family member. Five traditional houses with adaptability towards functional changes are taken as the case studies to be examined – Italian embassy garden in Farmaniye h, Naseredin Mirza’House, Jalal Al Ahmad’s House, Anis Dole’s House, and Mansion in Nezamiyeh Alley.

6.2. Case Analysis

6.2.1. Italian Embassy Garden in Farmaniye h [12]

Farmaniye garden is located in the Farmaniya neighborhood on the south side of Main Street, The Martyr Doctor Lavasani. Along the North - South Garden is 325 (m), transverse the east – west is 190 (m) and its area is about 61750 (m2) that it is designed with Iranian Garden principles. The Garden Complex includes a main building (exterior) in the garden that has a part of the house containing a piscine and the second house includes a building with a yard in south and one in north; the name of this building is Interior (Figure 1). Around the Interior there is a wall which separates private space of the Interior from the garden space. The rooms include wooden ceiling. Structures and columns built of brick and Plaster are used for surface finishing and decorating. It has a single gable roof.

The main building (Interior) is organized centrally that can be expanded radially (Figure 2). Some spaces can be added without complications for getting natural light and ventilation for previous space and others have been extended (Figure 3). In figure 4 there are some proposed spaces that are shown with blue color. These spaces do not exist now but...
they could be added in the future if the users need more spaces and more rooms for living. Other space that it could be added for that aim is extensive space which is indicated with title of extension in figure 4. Now, this space is porch (outdoor space) but it could change to interior space such as some rooms for living.

Figure 1. Basic Lay-out (Ground floor).
1. Spring house: a part of the house containing a piscina
2. Seven-door
3. Room
4. Kitchen
5. Bath-room & W.C
6. Corridor
7. Porch
8. Stair

Figure 2. Centralized organization.

Figure 3. Developed lay-out (Radial organization).

6.2.2. The House of Naseredin Mirza [12]

The house of Naseredin Mirza is located in No.16, AL. Naseredin Mirza, st. Sor-e-esrafil, st. Naser khosro. It has a dimension of 48 (m) by 21 (m); its area is 1000 (m2). The main building is located on the north of plan and the building on the south of plan is the home of doorkeeper. The area of yard is 480 (m2). The architecture components has been put together particularly; because of Special form of earth or preference of owner. The main building and the guardian home are located in front of each other and it is not common. Frequently, in Qajarid princes' home all the spaces locate around the yard completely figure 5.

Figure 4. The extension and additional spaces in proposed lay-out.

Figure 5. Basic Lay-out (Ground floor).
1. Spring house: a part of the house containing a piscine
2. Room
3. Corridor
4. Yard
5. The home of doorkeeper
7. Stair

There is a space in entrance which is called "Vestibule". Vestibule help us till turning 90° and the people how stand in front of entrance cannot see the inside of home and yard. One of spaces the people can gather to each other is Central hall (spring house). In this place, first floor doesn’t have ceiling. In The two-story buildings like the main building in this home, during religious ceremonies, women and men separated each other; women sat on the second floor and saw ceremonies on the first floor from windows of their rooms.
The construction is made of local hardwoods, adobe, brick and Thatch.

Frequently, this type of home is located in compact context of city. So, its opening such as windows open to the yard and it couldn't expand out of its limits. But with adding new spaces in eastern and western Front, it could respond to needs of its occupants. There are some proposed spaces that are shown with blue color. These spaces could be located in eastern and western front so that it can respond the needs of its occupants. They do not exist now but they could be added in the future (Figure 6). Other space that could be added for that purpose is extended space which is illustrated with title of Extension in figure 6. Now, this space is yard (outdoor space) but it could change to interior space like some rooms for living.

**Figure 6.** The extension and additional spaces in proposed lay-out.

6.2.3. The House of Jalal Al Ahmad [12]

The house of Jalal Al Ahmad is located in No.75, st. Karkon Asasi, st. Khayam. The building includes traditional architecture and classical architecture. It was built during Gajarid era. Since the house had been situated in compact urban texture, the plan does not have a regular geometry. But we could find the same relationship among spaces that existed in traditional houses. This house had two entrances; it might have been changed in the past because of its occupants’ needs. Evidences show that two families had lived in this house and changed the interior spaces for responding to their needs. Figure 7 shows the flexibility of this house. The construction is made of hardwoods, brick and thatch. All of the doors and windows were made of wood.

**Figure 7.** Basic Lay-out (Ground floor).

1. Vestibule: entrance
2. Corridor
3. Reception room
4. Room
5. Hall
6. Terrace
7. Central courtyard
8. Staircase

Most of these types of houses are in city, with limited boundaries. So, it could not expand except toward inside of the plan. Another lay-out can be adjusted with the occupants’ needs by addition of partitions. Figure 8 shows three spaces that are in the house now and are indicated with blue color. This figure shows that each space could be divided to two spaces with partition. So, three rooms could change to six rooms till responding to occupants’ needs.

**Figure 8.** Addition of partitions (Ground floor).

6.2.4. The House of Anis Dole [12]

The House of Aniso Dole is located in opposite of Tehran Mahdiyeh, St. Molavi, and St. Valiasr. It was built during Qajarid era. The final cover is a gable roof. Roofs of another stories covered with diverse materials.

**Figure 9.** Basic Lay-out (Ground floor).
These types of houses are placed in an urban context. Since a central courtyard house cannot extend toward outside and for extending, it should use the methods used in central courtyard house (Figure 9). Whereas, the living spaces could expand around the yard and the form could change to a form of a central courtyard. In figure 10 the blue space is added to the plan. This space is not in the original plan and it could be added for having more rooms and interior spaces in future.

**Figure 10.** The additional spaces in proposed lay-out.

6.2.5. Mansion in Nezamiyah Alley [12]

Mansion is located in No.41, AL. Hasan edalat, AL. Nezamiyah, SQ. Baharestan. It has a dimension of 16m by 12.2m. This building does not have any valuable cultural and historic features. But the important thing about this house is the existence of architectural features of the transition period in Tehran. The construction is made by brick walls, the flat roof with beams of iron (girder is a one of imports during Qajarid era that does not have any value; but now, it define Contemporary architecture in Tehran) and wood. The final cover is a gable roof. Figure 11

**Figure 11.** Basic Lay-out (Ground floor).

1. Room
2. Kitchen
3. Bath room
4. Corridor
5. Entrance and staircase
6. W.C
7. Yard
8. The home of doorkeeper

In this type of building, 60 percent of area is occupied by the building and 40 percent is yard. So, the building has a lot of limitation on expansion and flexibility. This method is newer than other patterns and it is the formal form of plan in constructions Figure 12.

The area that is occupied by building must not be more than 60 percent, so the building could not be expanded toward the yard. Figure 12 shows two rooms that each of them can be divided to two spaces by using partition. So, the number of rooms can be increased.

**Figure 12.** Addition of partitions (Ground floor).

From the study of five houses above, some sustainable items are:

- Pay attention to cultural and religious and create a sense of belonging for occupants.
- Respect for privacy and hierarchy of spaces.
- Preservation of environment by controlling the heat of summer and the cold of winter.
- Efficiency of natural resources by using of natural light, ventilation and etc.
- Incremental house: The space flexibility and adaptability is produced through either addition/adjustment of indoor partitions or addition of a new structure outside the house.
- Use of local materials such as wood, brick and Thatch.

7. Detail Description

7.1. Optimum Pattern
These five houses can be called sustainable; however, not all of their features can be implemented in today’s housing development. Therefore, to design a new model of sustainable house, the sustainable features of these houses are taken and combined with the development of construction industry and the availability of resources at the moment. In the following, all the benefits and positive features are brought for finding optimum pattern.

The final score of patterns can be found in Table 1. The Model 3 is as the optimum pattern among the patterns of traditional houses in Tehran.

### Table 1. Consideration of patterns finding optimum pattern. [Designed by authors.]

<table>
<thead>
<tr>
<th>Positive features</th>
<th>Pattern 5</th>
<th>Pattern 4</th>
<th>Pattern 3</th>
<th>Pattern 2</th>
<th>Pattern 1</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Environmental Benefits</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Efficiency of natural resources by using natural light and ventilation and ext.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overcoming the heat in summer (considering the position of rooms such as Summer stay, use of cooler such as wind-tower, creating the shade on the roof such as dome, creating the shade in open space such as porch)</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Overcoming cold in winter (considering the position of rooms such as winter stay, use of warmer such as stool)</td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Use of courtyard as a cooler in summer (with creation of shade in day and use of vegetable, plant and small pool)</td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Decreasing dust, temperature degree and adverse speed of wind by planting the plants and trees in yard</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td><strong>Total Scores in this part</strong></td>
<td>1</td>
<td>4</td>
<td>5</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td><strong>Social Benefits</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The separation between private and public spaces and their relationship to each other by spaces such as courtyard.</td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Social relationships: use of gathering spaces such as courtyard, porch and spring house (a part of the house containing a piscine).</td>
<td></td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>Creating integral spaces: use of sash instead of rigid material of building for religious ceremonies and family circles.</td>
<td></td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>Keeping privacy: creation of hierarchy (vestibule, takhtgah, kryas, …) and creation of closed, Semi-open and open spaces. (A rotation of 45° or 90°): use of openings with some pores (sash, …), creation of exterior space and interior space</td>
<td></td>
<td></td>
<td>*</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>Putting the routes of access besides main spaces 2</td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Use of Pause spaces Besides the routes of access (the porch besides the courtyard, room besides the corridor)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total Scores in this part</strong></td>
<td>0</td>
<td>4</td>
<td>7</td>
<td>6</td>
<td>3</td>
</tr>
<tr>
<td><strong>Economic Benefits</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Preservation of energy by use of materials with high thermal capacity such as wood, brick and Thatch</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Use of module 3: achieve to appropriate dimension in space, assurance of structure of building and reduction of destruction</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Attention to the internal height (low-rise in winter stay and high in summer staying place)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flexibility and incremental house (increase of life building and decrease of destruction)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total scores in this part</strong></td>
<td>0</td>
<td>3</td>
<td>4</td>
<td>4</td>
<td>3</td>
</tr>
</tbody>
</table>

Total scores for all parts 1 11 16 15 10

1. Like frame of wood which is covered all bout with quilts and blankets, and under which a fire is placed for heating the legs in winter
2. Relationship through putting besides each other is the popular method. This method help that the spaces have the best response in relation to their environment (Ching, 1943: 200). There is it in traditional architecture such as courtyard housing; but the users in Contemporary architecture for getting to privacy spaces such as bedroom must pass through the Reception room and living room, usually.
3. “Pymvn” in Iranian architecture. Element Pymvn means to facilitate the work of all sizes in order to Nyarsh areas. Pymvn an architect makes use of a scale.
7.2. The Modular Construction

The modular construction has grown enormously at the moment, especially in industrialized countries. It is saving in cost and work, since the construction elements are prefabricated in modular sizes and can be easily assembled on site with simple joints.

Some modular constructions use a knock-down system, so that they can be easily assembled and dismantled, which means possibility for refurbishing and reusing. In a knock-down system, the construction flexibility is determined by the flexibility of the joints. Thus, in this house, instead of welded and fixed connections, the structural frames and the secondary members are all joined with bolts.

In designing the house as a modular construction, it is important to find a minimum variation of modular components without limiting the possibility of module combinations.

In Iranian architecture, the size and dimension have played an important role. Pymvn is a unit as criteria and dimensions in Iranian architecture. Architect employed Pymvn in building and used a harmonious proportion to establish proportional spaces. In this type of architecture, use of human proportions in all structure and ornaments was very important. There are two types of Pymvn systems in Iranian architecture: small pymvn and large pymvn. The small Pymvn was usually used to build the dwelling that was the same as the width of the door. The large Pymvn used when the homeowner needed a larger space (home). [13]

Table 2 shows the dimensions in two types of Pymvn systems.

<table>
<thead>
<tr>
<th>Components and Elements</th>
<th>Large Pymvn (cm)</th>
<th>Small Pymvn (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>door and window width</td>
<td>120</td>
<td>93</td>
</tr>
<tr>
<td>width of awning</td>
<td>27</td>
<td>13</td>
</tr>
<tr>
<td>Height of opening</td>
<td>60</td>
<td>60</td>
</tr>
<tr>
<td>Wall thickness</td>
<td>73</td>
<td>60</td>
</tr>
<tr>
<td>Height of Doors</td>
<td>200</td>
<td>186</td>
</tr>
<tr>
<td>Width of the wall</td>
<td>293</td>
<td>213</td>
</tr>
<tr>
<td>Width of the wall</td>
<td>440</td>
<td>320</td>
</tr>
<tr>
<td>Width of the wall</td>
<td>733</td>
<td>533</td>
</tr>
</tbody>
</table>

In following, for example the models three-door and five-door show the using of Pymvn that have been existed in traditional house in Iran. In this analysis was used small Pymvn / 93 (cm). Figure 13 shows the three-door include three doors with width of 93 (cm). Width of three-door room was considered three gazes (equivalent to 3.20 meters) in small Pymvn. According to this Pymvn, door width was 14 nods (approximately 93 cm). The distance between doors was adjusted by cheek with width of two nods and at the junction of door to wall with width of a node. A node equals to 6.6 cm and two nodes are 13.3 cm. Figure 13 is an example of a small pymvn in three-door room. The plan is located in center and the facades of each wall are shown beside them. The walls are prefabricated which are divided into some panels that have determined dimensions. The dimensions of panels are 93*93, 93*186, 6.6*186, and 13.3*186. All of these numbers are in accordance with small pymvn and node. For clarifying this issue, figure 14 shows the three-door rooms in ground floor of Gerami house which are specified with number 18. Figure 15 shows the façades of two three-doors, each room includes three doors that could connect rooms to yard. Figure 16 is a three-dimensional projection of the house.

Three-door is a part of traditional house in Iran that for rapid manufacturing, their walls were turned to some panels with determined dimensions (according to pymvn) in previous section. This process can be implemented to the entire house. Thus, rapid manufacturing houses could be built which are based on the traditional housing patterns in Tehran in order to meet the needs of people today.

To find a proper model of sustainable house, exploration should be carried out towards the local climate, culture and the strength of the local community. Therefore, observation has been done towards several traditional houses in Iran, focusing on the flexibility of a house to respond to the changing needs of its occupants. From the study, it can be seen that some traditional houses are incremental houses with flexible lay-out. Thus, an incremental house is proposed.
Figure 14. Ground floor of Gerami house in Iran. 1- Entrance; 3- Major courtyard; 4- Minor courtyard; 7- porch; 14- Reception hall or talar; 17- Five-door; 18- Three-door; 21- Sash room; 23- Common room; 24- Corridor; 25- wind catcher; 24- Kitchen and storage. [15]

Figure 15. Section A-A from Gerami house. [15]

Figure 16. Tri-dimensional projection of Gerami house. [15]

Modular construction is saving in cost and work, and due to this benefit, it is more likely to be implemented to achieve a sustainable construction. With modular construction, the construction components can be standardized and produced with fabrication and thus the construction becomes faster and cheaper. Moreover, if the joints between modules are not fixed, the construction can be easily dismantled and hence it means an increase in reuse potential of construction materials.

8. Conclusion

Increase of population and entrance of technology to architecture have made a lot of changes in concept of dwelling since nineteenth century. Construct dwelling in similar forms and rapid manufacture without attention to retrospection and regionalism causes some problems; the home does not respond to most of human needs and the dwelling changes into dormitory without identity. For rehabilitation of traditional housing, optimum housing must include positive features of traditional housing like: proportions in each space, proportion among spaces, relation between full space to empty space, a hierarchy, privacy and a lot of positive features which have been mentioned in table 1.

Indeed, there are great contrasts in the method of construction between past and nowadays; For example; using of local hardwoods and thatch for covering roof or using of adobe and brick in structure and walls. That method was a time-consuming process with too much harassment. Whereas, use of natural wood and soil, without any limitation, will damage the site and natural resources.

This paper presents the concept of sustainable incremental house with modular construction. This concept was developed by integrating the sustainability of traditional houses with sustainable design principles and today’s development of the construction industry. The result is an incremental house which can adapt to the changing needs of the occupants, while incorporating sustainable features to reduce the energy and resource usage, and maximize the occupants’ comfort.

Several advantages of this sustainable incremental house are:

- Using of modular construction in designing and construct, and considering Pymvn.
- Using of light steel frame and recycle materials as structure and another materials.
- Using of appropriate insulation against cold, heat and environmental pollutions.
- Using of solar energy collectors.
- Using of solar water heater.
- Using of smart awning and smart glass.

REFERENCES


