
A REVIEW OF PREFAB HOME AND RELEVANT ISSUES

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ABSTRACT

Having an easily built house has been always one of human wishes. Prefabricated home makes this wish come true because of its affordability and fast completion. This paper gives an overview of different types of prefab home and its terminology. This review sheds light on the characterisation of prefab home, which takes the aspects of off-site technology, mass customisation, and sustainability into consideration. This paper is confined to general review of prefab home without going through different systems utilised in off-site technology. In spite of the fact that prefab home has many advantages, which are discussed in this review, it suffers from a few drawbacks which should be considered by designers. Various exploitations in this field may merit further research in future, including finding the optimum prefabricated systems among the existing systems such as roof, wall, and floor systems for different applications of prefab homes. Nevertheless, there is still a universal design and practice code for prefab homes that emphasize on green technology and sustainability yet to be discovered.

Keywords: Prefab home, modular home, manufactured home, off-site technology

REZUMAT

A avea o casă ușor de construit a reprezentat întotdeauna una dintre dorințele omenesci. Casele prefabricate îndeplinesc această dorință, datorită prețului scăzut și al execuției rapide. Articolul prezintă o trecere în revistă ale diferitelor tipuri de case prefabricate și a terminologiei aferente. Sunt caracterizate casele prefabricate, sub aspectul tehnologiilor industrializate, al adaptării pe scară largă și al sustenabilității. Articolul este focalizat asupra analizei generale a caselor prefabricate, fără a aborda diferitele sisteme utilizate în tehnologiile industrializate. Deși casele prefabricate au multe avantaje, care sunt discutate, ele au câteva neajunsuri, care trebuie luate în considerare de către proiectanți. Diferite aplicații din acest domeniu ar merita o investigație mai atentă pe viitor, inclusiv identificarea soluțiilor prefabricate optime, printre cele existente pentru acoperiș, pereți și planșee. De asemenea, este necesară realizarea unui cod universal de proiectare și de practică pentru clădiri prefabricate, care să pună accent pe tehnologii ecologice și pe sustenabilitate.

Cuvinte cheie: casă prefabricată, casă modulară, casă manufacturată, tehnologii industrializate

1. INTRODUCTION

Housing is an important part of human life, and plays a key role in development economics. In the new global economy, affordable housing has become a serious issue. Recent developments in housing technology have heightened the need for prefab homes because of its affordability. The history of prefab dates back to sixteenth century. It may be historically divided into three main sub-groups regarding World War II. These groups are before wartime, wartime, and post-war. One of the most important events before wartime was manufacturing some parts of building for fishing village of Cap Anne where

is located in Massachusetts now. During the wartime, much effort was made to develop the Fordist mass production of kit houses. It had brought innovation to the technology of building which was shifted from on-site to off-site. After World War II had started, market demand for prefabricated homes for soldiers increased. The U.S. federal government decided to produce 850,000 prefabricated houses in less than two years by giving mandate. This decision sparked much effort in architectural design of post-war housing. Since year 2000, many researchers in the world have been working on different types of manufactured homes from different perspectives. Nevertheless, the past decade has

seen the rapid development of prefab home design from different aspects such as sustainability and cost-effectiveness as well as energy and time saving [1-10].

However, these rapid changes are having a few serious issues, like off-site technology, mass customisation and digital production, which are reviewed in this paper. Off-site is related to the structures that are built in different locations than the location of use. This technique saves the process time of construction. Personalisation of mass production with taking into account of customers' individual demands regarding to price and quality is called mass customisation. The significance of digital production brings about today's process of production, which implies both design and fabrication with computer-aided design and computer-aided manufacturing systems [4, 6].

This paper has been divided into three main parts. Firstly, it gives a brief overview of the history of prefab homes and related terminology. The most common terms used for this topic are prefabrication, mobile home, manufactured home, and modular home. Secondly, it sheds light on the application of different types of prefab homes from different perspectives as well as the contribution of countries in off-site technology.

Finally, advantages and drawbacks of prefab homes are described. There have been no controlled studies which compare characteristics of eco-home and prefab home in order to find a feasible method for shifting the eco-home conventional technology to prefab home new technology according to green material. Far too little attention has been paid to universal design and practice code for prefab homes.

2. THE HISTORY OF PREFAB HOMES

2.1. Before wartime

The history of prefabrication started in the United States of America simultaneously with Great Britain's colonisation effort. In the sixteenth and seventeenth centuries, prompt building process was needed for settlements in

New Zealand, Australia, Africa, Middle East, South Africa, Canada, and United States. Since the British were not familiar with available building materials in these countries, components of building were manufactured in England and shipped to these countries by boats. The first case of these manufactured parts of building was produced in 1624 and sent to the fishing village of Cap Anne where is located in Massachusetts now [7, 11]. England started working on prefabricated structures for Australians in late 1700s and early 1800s. In 1790, England assembled many prefabricated storehouse, cottage, and hospital, with shipping their parts to Sydney, which were considered as shelters. These shelters had timber panel floors, walls, and roofs. After English colonised South Africa in 1820, a committee was sent to South Africa accompanied by three-room wooden shelter to evaluate this shelter for mass production based on South Africa environment. In 1833, the invention of the balloon frame in the implementation of Mary's Church was suggested by Augustine Taylor in Fort Dearborn near Chicago. The light frames, including balloon frame and platform frame were designed by researchers because of two factors: availability of wood in the new countries as well as rapid development of industrial economy with mass-production of lumber mills and iron nails. Balloon frame design was developed promptly to some parts of the world such as Chicago. Before the fire of 1871, Chicago was almost completely constructed of balloon frames. A manning prefabricated colonial cottage, which was designed by British for emigrants, is shown in Figure 1. It was an iron prefabricated system which was developed rapidly in New Zealand and South Africa during the nineteenth century [4, 7, 12-14].

2.2. Wartime

In 1906s, Kit houses were produced with pre-cut pieces of trees by Aladdin Read. In 1908 Sears Roebuck designed prefab houses by a special program and 100,000 units of them were sold until his technique demise in

1940. During the wartime, much effort was made to develop the Fordist mass production of kit houses. That was the time of innovation, when the technology of building shifted from on-site to off-site. During the 1920s and 1930s, there was an economic downturn that caused the decline of mass production. This period of time was not marked for large mass-housing technology but there were some off-site prototypical experiment houses to test the Fordist mass production by using ship building and automobile technology [13, 14].

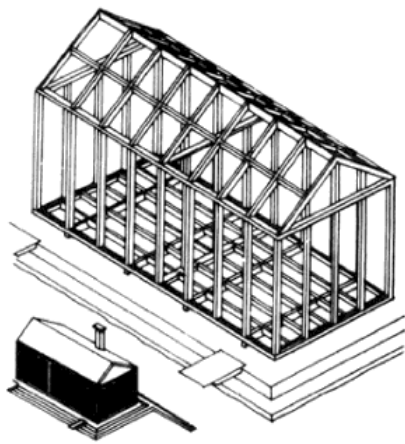


Fig. 1. Iron Prefab [15]

However, there are some unsuccessful experiences about prefabricated homes. As an example, builder George Fred Keck designed both the “Crystal House” and “House of Tomorrow” for the fair in Chicago in 1933. They were made of prefabricated steel frame and glass infill walls. Based on the reports, more than 750,000 people visited these prefab homes within one year for exhibition, but none of them were sold. The reasons for this unsuccessful fair can be discussed from different perspectives such as culture, price, and design. However, in spite of these unsuccessful experiences for prefab home, the research about prefab home was continued [14, 16, 17].

In 1936, Frank Lloyd Wright designed a system of standardised details and modular dimension for prefab home. He could produce more than 100 units over the years but this quantity of production was not still enough as a mass production. Hence, William Levitt started working on high-volume assembly

method to produce mass prefab homes in 1945. By 1948 he could produce 150 prefab homes per week [15, 18].

2.3. Postwar

Since World War II had started, market demand for prefabricated homes for soldiers increased. The U.S. federal government decided to produce 850,000 prefabricated houses in less than two years by giving mandate. This decision sparked much effort for architectures in post-war housing. Lustron Corporation started producing all-steel prefabricated houses in the airplane factories. The houses were simple and traditional in form. The innovation of these prefab homes was related to their construction with complete enamel steel on the interior and exterior. In 1930, Carl Strandlund who was an industrialist suggested the concept of automobile process with metal sandwich panel technology. This method was fashioned after automobile manufacturing. At the beginning, the size of manufactured sheet metals did not fit to each other which caused many wasted materials. Thus, the cost of these prefab homes was very high and the company, stopped working after only 2500 hours working on it, in 1950 [16, 17, 19]. In 1974, the U.S. Department of Housing and Urban Development (HUD) was set up as the government agency to supervise the federal manufacturing housing.



Fig. 2. A Mobile Home with Flanking, Built Based on HUD Code [15]

In 1976, the standards changed by distinguishing permanent homes, which were

being designed based on standard codes such as International Building Code (IBC), and mobile homes according to HUD code. Today, the HUD code have changed the name of these houses from mobile home to manufacture home which is related to the terminology of this topic. A mobile home with flanking near Salt Lake City, Utah, built based on HUD code in late 1970s is shown in Figure 2.

The first balloon-panel frame prefab house was designed and produced by Mark and Peter Anderson on Fox Island, Washington in 1993. In 1996, mass-market retailer IKEA introduced its traditional style prefab homes in Sweden. In 2002, Allison Arieff and Bryan Burkhart published a book about the first survey of contemporary prefabricated houses [20]. Since 2000, many researchers in the world have been working on different types of manufactured homes from different perspectives. Development of technology for prefab homes in last decade brought some new topics in this field of research such as green and sustainable prefab homes as well as off-site work, time saving, energy saving, and low cost prefab homes. Among these, affordability of prefab home is the most important issue. In 2006, Ray Kappe who is a leading modern architect and the founder of the southern California institute of architecture followed the leadership and environmental design (LEED) to produce and assemble the prefab homes. In August 2006, his first model home was awarded a LEED platinum rating in Santa Monica [21-23].

3. TERMINOLOGY USED FOR PRE-MADE HOMES

Generally, the term of prefabricated home is used for those pre-made homes, which their components are fabricated in the factory and transported to the site for assembly. According to the literature, another term is “modular home” which is used in local zoning and building codes. Manufactured home is the other term which HUD code has been used. Hence, different terms are used for different categories of these homes. which are given in more details in the later part.

3.1. Prefabrication

Prefabrication is generally used to explain any manufacturing process in the controlled environment like the factory. The term of “prefab” is commonly used as slang instead of prefabrication. Prefab home is a dwelling made of manufactured off-site components [2, 10, 15, 16, 24].

3.2. Mobile home

Mobile home is produced in the factory and then transported to the site. The location of site can be either permanent or temporary. This type of home is usually hooked up at the site to provide the utilities. It is called house trailer in the United States. However, some authors call it static caravan. It is usually transported by trailer-tractor with being pulled behind it [7, 25-27].

3.3. Manufactured housing

This factory-made home is produced for a fixed location site. Like the other homes, its foundation must be prepared in advance. It is legally classified as a real property assembled in factory to be sent to the site for permanent installation. Since July 15, 1976, a shield in red colour must be installed on all manufactured components of this home as a sign to certify the manufacturer have considered and followed HUD code [11, 18, 21].

3.4. Modular home

This is a dwelling unit made of prefabricated components in factory. The manufacturer of this structure must follow local zoning and building codes. It is a sectional prefabricated home that includes multiple modules which are produced with remote facilities [3, 5].

4. OFF-SITE TECHNOLOGY

Off-site is related to the structures that are built in different locations than the location of use. This technique saves the process time for construction compared to the in situ constructions. It reduces the workload, which would help to cut the cost of labour, particularly when it refers to the mass construction in factory. Hence, with this technique, a large quantity of material can be purchased once by factory with lower price compared to the single home materials. Because of the accuracy of the process in factory, the higher level of sustainability can be achieved in factory for green prefab homes. Rural location sites that are not usually large area can benefit from off-site technology, which does not need large space of site for building. Besides, off-site construction provides both building quality and speed. Modular building components can be built in factory as well as foundation can be prepared simultaneously. Hence, the time and money can be saved in this process [28].

Off-site fabrication has different parts for design such as dimensional coordination, modular size, and tolerances. Building regulations vary according to the country, so it can have different effects on the off-site technology for home producing [29-31]. The history of off-site technology indicates that United States makes more contribution in this technology compared to the other countries [32]. The contribution of countries in this technology is shown in Figure 3.

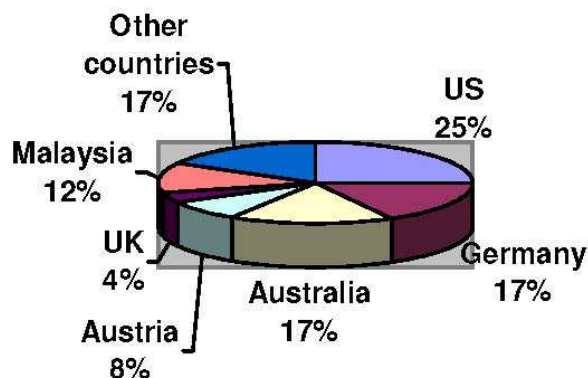


Fig. 3. Contribution of Different Countries in Off-site Technology [32]

5. SUMMARY OF PREFAB HOME ADVANTAGES

Considering the cost price, prefab home has its benefit. They usually cost less than site-built homes. Quality control is another advantage because 70 to 90 percent of prefab home is completed in factory. The manufactured components of prefab home can be controlled with restricted quality control standards in factory. Faster project completion is also one of the benefits. Manufactured homes can usually be installed during one or two days, but in situ building usually takes three to six months to be completed. Reduction of site labour, minimal wastage, less site material, cleaner environment, and safer construction site are briefly the other advantages of prefab homes [11, 16].

6. A FEW DRAWBACKS OF PREFAB HOMES

A few disadvantages of prefab home which have not been paid attentions to should be given emphasis among designers. There has always been stereotype about factory-built home due to its lower cost and tendency for depreciation compared to site-built home. There is another issue about proprietary systems which cannot be matched with mass housing. Mark and Peter Anderson's research as cited by Smith (2011), shows that proprietary systems due to their single-source components are costly to be developed for mass productions [15]. Some people believe that transporting manufactured home would cause the instability of the whole prefab structure. Moreover, manufactured homes cannot be refinanced if only one segment cannot be placed on a permanent foundation. The major issue about disadvantages of prefab homes is safety factor. The history has shown that mobile home, manufactured home, and home trailer could be lethal place during tornado. Harold Edward Brooks is an American meteorologist whose researches are in the field of storms and tornadoes states that 640 of 1641 tornado deaths happened in mobile homes in Norman, Oklahoma since 1975. However, recent developments in the

field of prefab homes have led to a renewed interest in design of more stable prefab home against storm and flood. Mobile homes which became death trap after the tornados at the East Brook in Evansville are illustrated in Figure 4.



Fig. 4. Mobile Home Park in Evansville after the tornado [27]

With the rising cost of land in many countries, it has usually main portion in entirely price of site-built houses. Hence, the price of land has usually main portion in entirely price of site-built houses. Many builders divide the land into many parts to build up many in situ houses. Thus, they sell property and structure at one price, but modular homebuyers pay for only the structure of home and the cost of land will be added. Hence, it can be difficult for modular homebuyers to find one stand-alone land for modular home to be placed on [1, 33].

Another problem is the payment for modular home. For site-built homes, the builders are paid as work is completed over several months. Most of process for modular home is done off-site, but the builders expect to receive most of the payment for home before sending to the site. It may make an issue between buyer and seller because of buyers' preference for making payment after home installation on site.

7. FURTHER DEVELOPMENT

Computer integrated construction and intelligent building are the recent innovations in building technologies. There are some studies about use of robots in manufacturing of building components [34]. Intelligent or smart

building has been defined in different ways. However, it should be precisely defined as the building which adopts its condition according to the surrounding changes [29, 34]. As an example, transformer prefab home which shifts based on climate changes is shown in Figure 5.

The idea for this prefab home emerged from sundial by a group of designers from London in early 2011. This prefab home has the ability to be adjusted according to temperature changes by transforming into different shapes. It is situated on curved shaped rails which can pivot. The parts of house can be moved around and set up in different positions [35]. It is designed and developed as an ecologically sensitive house in Sweden and Lapland. However, researchers are trying to change this single designed prefab home to the mass production. To achieve this, they focus on its moving parts, tracks, and connections in their researches [24].



Fig. 5. Transformer House Shape-shifts [24]

8. CONCLUSION

This review draws an enlightenment on the types of prefab home and its development from past to recent years. It also gives some insights into the production and utilisation of prefab homes. Further, terminology of prefab home is reviewed. The purpose of the current review is to determine the advantages and disadvantages of prefab home with considering off-site technology and

sustainability. In spite of the fact that prefab home has many advantages including reduction of site labour, minimal wastage, less site material, cleaner environment, controlled quality, safer construction site, lower cost, and faster project completion, it suffers from few drawbacks which should be considered by designers as mentioned in the following. It should be noted that prefab home has been stereotyped among the people due to its lower price compared to in situ building. Instability of prefab home compared to in situ home due to the transportation of its segments to the site is another issue. Based on some experiences from the past, proprietary system cannot be matched with mass housing. Prefab home cannot be refinanced if only one segment does not fit to be placed on a permanent foundation. Safety factor is also one of the issues about this home due to the history which shows prefab home were lethal place during the tornadoes. Finding one-stand land for prefab home with proper location and position is also another drawback which the buyers are facing nowadays.

The current paper is confined to the general review of prefab home without considering different prefabricated systems utilised in off-site technology. Various exploitations in this field may merit further research in future, including finding the optimum prefabricated systems among the existing systems for different applications of prefab homes. There is still a universal design and practice code for prefab homes considering green technology and sustainability yet to be discovered.

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