

Factory-Built Housing in Indonesia: Current Practice and Future Challenges¹⁾

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Abstract

Recent earthquake and tsunami in Aceh and North Sumatra has left Indonesia big responsibility in fulfilling housing need for people who lost their homes after this calamity. Use of mass-produced, factory-built systems for housing construction is technology that can be used as a solution to this problem. Factory-built housing can be defined as houses that are partly or all constructed in factory environment, then are transported and erected/ assembled at permanent site. This paper is a summary of recent practices and potential development of factory-built housing in Indonesia by considering several Indonesian National Standard (SNI) which available. The aim of this paper is to explain the possibility of factory-built housing technology in Indonesia. The study synthesises information collected from review and analysis of trade and scientific literatures, a series of site visits to factory-built housing companies in industrialized countries; and discussions with academic institutions and building regulators in Indonesia. Definitions and types of factory-built systems are presented first followed by discussion of practical, regulatory, standards, and scientific issues applicable in Indonesia. Findings are identified as potential research needs in factory-built housing.

Keywords : *Housing construction, factory-built, modular, panellized, knock down.*

Abstrak

Gempa dan tsunami yang baru terjadi di Aceh dan Sumatera Utara mengharuskan pemerintah Indonesia untuk menyediakan perumahan untuk masyarakat yang kehilangan rumah pasca musibah tersebut. Penggunaan sistem produksi massal konstruksi perumahan adalah suatu bentuk teknologi yang dapat dipakai untuk memecahkan masalah. Perumahan fabrikasi didefinisikan sebagai perumahan yang komponen-komponennya diproduksi di pabrik, kemudian dikirim dan dirangkai pada suatu tempat permanen. Makalah ini adalah ringkasan dari kondisi saat ini dan melihat potensi pengembangannya di Indonesia dengan mempertimbangkan SNI yang tersedia. Maksud dari paper ini adalah menjelaskan kebolehhadiah penerapan teknologi perumahan fabrikasi di Indonesia. Studi yang dilakukan merupakan sintesa dari pengumpulan informasi dari kaji ulang dan analisis penerapan maupun kaji pustaka serta hasil kunjungan ke beberapa perusahaan terkait di negara maju, juga diskusi dengan institusi akademik dan regulator di Indonesia. Definisi dan jenis sistem perumahan fabrikasi ditampilkan yang disertai diskusi dari aspek praktis, regulasi, standard dan masalah saintifik di Indonesia. Dari pembahasan yang diberikan, ditemukan beberapa hal yang kiranya dapat menjadi potensi riset tentang topik yang dibahas.

Kata-kata Kunci : *Konstruksi perumahan, produk pabrik, modular, panel, reka bentuk.*

1. Introduction

It has been estimated over more than 150,000 housing units are needed immediately in Aceh and North Sumatra during the re-construction period. There will be big challenges for Indonesian government for providing housing need in a short period of time. Apart from the reconstruction of Aceh and North Sumatra, housing demand in other part of Indonesia also continues to climb. It is estimated that national

housing need in Indonesia has reached more than 1.1 millions unit per year in which sixty percent is purposed for low-income people. Use of mass-produced, factory-built systems can be used to help solving these issues.

In Indonesia 'knock down' system is well-known term rather than factory-built or prefabricated term. Knockdown or factory-built or prefab housing basically have the same principle, in which a house is

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built in a factory and then transported and installed on a permanent site. Knock down system was originated from Bali around 1996 [Dayak Eco Carpentry]. Since then, there have been few manufacturers in Sumatra Selatan, Kalimantan, and Bali itself who produced and exported housing using knock down system [Kompas 8-3-02, Kompas 1-4-05, Kompas 15-4-05]. But, yet their practices have not been widely supported by local and national housing developer, partly because of weak market perception to this technology. After the national occurrence in Aceh and North Sumatra, knock down housing system has begun to emerge due to high need for emergency shelters [ITS]. Since then, the knock down systems used as temporary shelters in Aceh has been adjusted to accommodate permanent shelters. Recent examples of knock down systems that are currently in the process of marketing are: 'Smart Modula' from ATMI and 'RISHA' from PUSLITBANG Bandung [Kompas 1-4-05, Kompas 28-1-05]. This emergence of knock down housing will certainly have significant impact to overcome future housing need in Indonesia and can lead to big opportunity for prefabricated housing export.

This paper discusses factory-built housing system including overview of practices in industrialized nations; practical, technical and scientific challenges; and potential research needs. In the long run, it is expected from this paper that research and development in factory-built housing will be developed to support current practice and ultimately factory-built housing will gain widespread acceptance in Indonesia.

2. Factory-Built Housing

Factory-built or prefabricated systems are not a new technology in housing construction sector. They have been practiced in the North America as early as 1900's. Since then, people in that region began buying factory-built housing out of mail-order catalogues as soon as they could ship the materials cross-country by railroad. The practice has continued until today in which factory-built housing has been used as a means to achieve compressed construction cycle, consistent housing quality, and potential cost savings.

There are some competitive advantages of factory-built systems over stick-built (conventional) construction systems. High quality control can be maintained by in-house inspection throughout the construction processes. From safety and environmental concerns, factory-built housing components or modules can be quickly and easily assembled into a home without generating too much scrap and waste. After delivery to the site, all factory-built housing can be erected/assembled, closed in and occupied in a matter of days leading to efficient use of labour cost during on-site construction.

In general there are four types of factory-built housing construction, listed in order of their completeness of prefabrication: 1) manufactured buildings (formerly known as mobile/mini homes in the US/Canada), 2) modular systems, 3) panellised systems, and 4) pre-engineered/pre-cut systems. The following is the description of the types of factory-built housing system.

2.1 Manufactured (mobile/mini) systems

Of the four types of factory-built housing, manufactured homes are the most completely prefabricated. The homes are typically complete with interior and exterior finishes, plumbing, electrical and mechanical systems. In addition to this, the homes are typically built with an integrated frame that allows them to be transported to site using axles or bogeys and placed on surface mount foundations. This combination creates an affordable housing solution providing there is no major issue on the transportation or shipping. Factory production lines are semi-automated with a typical sequence being: 1) construction of a floor platform, 2) installation of wall panels, 3) installation of roof or ceiling, 4) addition of exterior elements, and 5) interior finishing [Fredonia Group]. In general, housing structure employs 'heavier' construction techniques than equivalent stick-built construction, so that they can resist forces during handling, transportation and erection processes.

2.2 Modular systems

The second type of factory-built housing is modular or sectional homes (**Figure 1**). Like manufactured homes, modular homes may have a steel undercarriage during transportation, but it is generally not a permanent or necessary structural component, and can be removed when the unit is placed on a foundation. Modules can create buildings up to several storeys, with most one-storey houses consisting of 2 to 3 modules and most two-storey houses consist of 4 to 5 modules. Factory production lines are similar to that of manufactured homes.

2.3 Panellized systems

Panellized homes are more labour intensive than manufactured or modular homes because they require more on-site assembly (Figure 2). However, they are more adjustable in term of design flexibility compared to manufactured or modular homes. In panellized systems, panels are usually produced in certain sizes depending on the housing style and configuration. The panels themselves fall into classifications of 'open' or 'closed'. Open panels refers to factory-assembled wall, floor or roof panels that are open on one or both sides to facilitate construction, and installation and regulatory inspection of mechanical, electrical and plumbing services. An exterior open panel wall may



**Figure 1. Typical erection of modular home
(source : Building System Council, USA)**

have sheathing, doors, windows, and siding on the outside and insulation between the studs, but will lack finished materials such as drywall on the inside surface. Closed panels are enclosed on both sides limiting access to onsite inspection. Panel factories are typically part of manufactured or modular homes companies. Due to efficient packaging practices, panellised products are commonly exported overseas by ship.

2.4 Pre-engineered/Pre-cut systems

Pre-engineered or pre-cut homes are the least prefabricated and most expensive type of factory-built housing, and require the most on-site work. However, in some cases skilled do-it-yourself buyers can save labour costs and have the satisfaction of building their own customs. Pre-cut homes can come in variety of styles and packages, including post-and-beam construction, log-homes, and a-frame and geodesic domes. Other system that can be categorized, as pre-cut/pre-engineered system is what people in Indonesia have called 'knock down' system or 'ready-to-assembly' system, in which the building components can be assembled and disassembled according to occupant needs. Originally knock down system was used as temporary shelter for those of people who lost their housing after natural disastrous or other emergency events, such as in Aceh and North Sumatra.

Pre-cut homes can be shipped longer distances more economically than other types of factory-built homes, because there is less to ship and the housing parts or components are more disassembled and compact.

3. Factory-Built Housing in Industrialized Countries

3.1. North America

The majority of housing in the North America is made of wood, which in fact is very suitable for factory-built systems. Traditionally just like in other part of the world, stick-built (conventional) housing construction has been strong in the North America. This is partly due to some societal perceptions of a house as a unique and distinct creation that cannot be highly customized in a factory set-up [US Congress OTA]. Recently, however, many of the distinctions between stick-built and factory-built systems have been disappearing. This has been accelerated by the fact that the North American construction industry has been experiencing a severe shortage of skilled construction labour [Holdridge]. In addition to this, demand for affordable and high quality housing continues to grow both in the US and Canada, with the US Department of Housing and Urban Development and Canada Mortgage Housing Corporation reporting over more than 1.5 millions housing starts needed every year [CMHC]. Factory-built system certainly is favourable use for the North American industry to overcome this problem. In the US alone, modular, pre-cut and panellised housing are forecast to increase 1.7 percent annually through 2007 to 285,000 units, valued at US\$11.8 billion [Fredonia Group].

In the US and Canada, building regulation plays a critical role in characterizing factory-built systems. For example, manufactured and modular homes, while sharing many technological and production-related



Figure 2. Typical erection of panelized home
(source : Bodenhaus, Germany)

characteristics, differ in the manner they are regulated. Modular homes are built in accordance with the state/province, local or regional codes where the homes will be located; while manufacture (mobile/mini) homes are built to the federal/national building code, which can supersede other local or regional codes. The reason for this is due to historical fact that manufactured home is transportable and need to be designed stronger than other housing types.

Distribution or shipping of modular and manufactured homes require good transportation infrastructures, particularly roads. Most of the major roads in North America are wide enough to allow 5-meter wide of modular or manufactured home sections. This is one of the reasons why modular and manufactured homes are the most favourable types of factory-built housing for North American people [Asiz, et. al]. However, pre-cut and panellized systems have currently gained popularity because of high homes quality offered and adjustable to consumer needs.

3.2 Europe

In general, the current situation of housing construction in Europe is quite diverse. Differences in building traditions, consumer requirements, and construction systems make it difficult for Europe to have a unified building regulation. However, factory-built housing has well been known due to its excellent remarks in term of housing quality and affordability.

Factory-built housing in Europe can mean any prefab systems including pre-cut and panellized constructions [Fazio, et. al]. Prefabricated panels often, but not always, have windows, insulation and sometimes internal and external finishes (especially walls) preinstalled. Modular housing composes a small portion of total prefabricated housings in Europe partly due to strict regulation in transportation/shipping.

Rapid construction is a must in Europe. This is the main reason why most of the prefabricated production technique is highly automated, especially those in Sweden, Finland, and Germany [Asiz, et.al]. In Sweden itself, factory-built housing comprises of 90% housing constructions. Wood housing production is heavily factory based with robotic CNC (Computer Numeric Control) cutting notches, wall, floor panels, and roof trusses [Koseter]. Without the CNC machining it would be impossible to count on pieces fitting at the job site. Both CNC technology and onsite cranes are pervasive in Europe even for quite small buildings.

3.3 Japan

There is currently a high level of use of factory-built in Japanese housing sector [Brock, et. al]. One of the main concerns is that because of the construction site waste management regulation. Also, builders are conscious of ease of controlling quality using factory-built system. As illustration for the housing demand,

total housing need in Japan is estimated to be about 1.1 million units per year.

In Japan, factory-built can mean pre-cut framing members, pre-cut framing members with fasteners, prefab panels (wall, floor, and roof) or housing modules (bathroom, kitchen, bedroom). North American modular housing systems have started to gain popularity in Japan, despite of transportation issue related to road infrastructure [Asiz, et. al]. The production plant of modular housing is typical to that found in North America.

4. Practical, Regulatory, and Market Issues in Indonesia

Big challenges will be faced by the industry to achieve housing need target considering the fact that factory-built housing systems in Indonesia has been practiced on very limited basis. Some issues that need to be addressed include fragmentation in the industry, building regulation, and market perception and custom.

4.1 Fragmentation of housing industry

Because the housing industry in Indonesia is so fragmented, individual contractors or developers focus on the protection of their own proprietary design. This approach may be beneficial from the standpoint of competition, but it is not helpful in regard of rapid industry wide adoption of new technology or adaptation to changes in building regulations. There is a need to develop organizations dealing with factory-built housing with the main purpose of giving unified strategies in socialization this technology.

4.2. Building regulations

Other factor that might impede Indonesian factory-built housing construction is building regulation. Currently, every building must conform to the Indonesian National Standard-2000, which is basically derived from standard application of constructions and materials. Since factory-built housing has some advantages over conventional construction, current code could be a major obstacle to factory-built housing industries in achieving efficiency and affordability. There is a need to develop specific regulation about factory-built housing; such as it has been practiced in the US through the Housing and Urban Development Housing Code and in Canada through the Canadian Standard Association for Manufactured Housing [CSA Z-240]. At present, there are about 7 Indonesian National Standard which have direct relation to factory-build housing such as SNI 03-0675-1989; 03-2407-1991 ; 03-2445-1991 ; 03-2449-1991 ; 03-2450-1991 ; 03-3233-1998 and SKBI 4.3.53.1987 [List of INS].

4.3 Market perception and customs

Traditional culture and customs are considered to be the most important factor in shaping people and market perception about factory-built housing. In the short term, there is a need to conduct survey about market need of factory-built housing and to recommend which types of factory-built housing are suitable to Indonesian people both nationally and locally. Currently, intensive surveys have been conducted by few organizations to assess cultural issues in relation to houses for people in Aceh and North Sumatra [PKPU]. The outcome of this survey is expected to give the housing industry thoughts in applying appropriate methods to produce houses that are not only affordable and high quality but also suitable with the custom where the house will be built.

5. Scientific Issues and Research Needs

Development of more factory-built components and systems, greater emphasis on labour efficiencies, and demand for less expensive and high quality materials have challenged the housing industry to understand complex behaviours of housing. Based on field observation and discussion with housing manufacturers, research and development in Indonesia and other countries for the areas including housing materials and components, engineering design, manufacturing technology, and distribution or transportation and erection techniques are key components to achieve affordable and high quality of factory-built housing.

5.1 Housing materials and components

Since materials used in factory-built housing continue to be adjusted with their supply, the housing industry needs to explore innovative materials that specifically exploit the advantages of factory production. Traditionally, wood has been used as the main material for factory-built housing because of its high strength and lightweight that makes wood frame housing is viable to be transported or distributed. Because of recent environmental concerns, use of wood for construction has been limited. Innovative materials such as cold-formed steel, wood and plastic fiber composites, synthetics and polymers, all of which are high strength and light weight, have potential application for housing materials and could be as viable and competitive as wood. Technical and scientific challenges, such as developing viable structural connection systems for these materials, needs to be addressed by the industry and related government agencies as well as academic institutions. The Adhi Karya and WIKA's experience in precast in industry would be valuable to be explore.

5.2 Engineering design

Houses that are produced at the factory are assembled from an incredibly wide range of individual materials, products, and subassemblies. While many of these individual materials and subassemblies may be designed and optimized for their specific functions, finished homes are not. To address this issue, research in engineering design of houses as a system is needed. For example, from the structural perspective buildings with factory-built systems must have structural connections that can develop the necessary force transfers at joints between segments or between modules and foundation. Connectors must be properly selected, adequate in size and number, properly attached or anchored, thus the more detailed SNI could be enriched to fulfill the new requirement in factory built housing.

5.3. Manufacturing technology

Key factor in manufacturing issue is production technology. General methods that can be applied to production systems range from labour-intensive custom handiwork to capital-intensive automated manufacturing. Standardized housing components and systems can be manufactured most efficiently when mass-housing technique is applied to production process. There is a need to do research in finding standardized housing components/systems and efficient factory-production line.

5.4 Transportation and erection methods

Transportation/shipping is a major issue in connection with manufactured and modular homes, especially as some Indonesian provinces have limited capability in transportation infrastructures. Efficient way of transporting or distributing factory-built housing products is by road or by ship depending on the geographic location. Factory-built housing modules must be designed with sufficient resistance to dynamic stresses arising from trucking and installation. There appears to be need for special designs and construction methods and/or optimization of transportation practices, to avoid possibility of transportation damages. Research in this area could help factory-built housing industry in selecting efficient modes of transportation for their products.

Proper on-site installation can preserve the quality of housing built at the factory. Structural damages can occur easily at this construction stage due to major load imposed during lifting housing components. Assembling methods of knock down systems would certainly be different from modular systems. Therefore, there is a need to develop user-friendly installation guides for various factory-built components to allow unskilled workers to put together

a complete home, which meets basic shelter needs for the Indonesian people.

6. Conclusion

Factory-built housing systems are technological areas showing great promise as a way to achieve mass-produced housings and as means to promoting construction that is affordable, environmentally friendly, durable and safe. Basically, there are three important stages in factory-built housing: factory production, transportation or distribution, and on-site erection. Each stage plays a critical role on the overall housing affordability and quality.

Factory-built housing construction in Indonesia will face some challenges if it is to realise its full advantages. Apart from building a strong market perception, development of standardization will play a critical role for expanding capability of the current factory-built housing industry. Multidisciplinary research ranging from housing materials and structures, manufacturing technology, to transportation and assembling methods are crucial to support and upgrade current practices.

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