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## **Prefabricated House-Building Systems in Japan**

### **Systeme und Produktion von japanischen Fertighäusern**

### **Sistemi e produzione di case prefabbricate giapponese**

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# Prefabricated House-Building Systems in Japan

## 1 Introduction

About 1.2 million housing units have been newly built in Japan every year although new house-building market in Japan has gradually declined after the end of "Bubble Economy Period" in early 90s. It means that 9 to 10 housing units per 1000 inhabitants have been newly built every year. This number is still much more than other advanced countries such as 6 in USA, 4 to 5 in Germany and France, 3 in UK etc.

This huge market can be divided into two parts. A half is occupied with detached houses built by large prefabricated house manufacturers as well as rather small local builders. Another half is occupied with multi-family dwellings built by general contractors. This paper's focus is on the former half, namely detached house-building market in Japan.

The composition of the detached house-building market is:

A little less than 20 % occupied with prefabricated house manufacturers, a little less than 10 % with North American timber frame house builders, a little less than 70% with conventional wooden house builders and the rest with other kinds. While order-made houses are mainly built in each of these three categories, prefabrication and industrialization have advanced in each category so far. In this paper the state-of-the-art of such prefabrication and industrialization in detached house-building market is made clear.

## 2 The Characteristics of the House-Building Market in Japan

The first uniqueness in the Japanese house-building market lies in its size and density. (Fig. 1) The total investment of building in 2002 was 29,173 billion yen and the house-building investment occupied 64.1% of it, which means 3.7% of GDP. Allocating the building market function-wise, there is no doubt that the house-building market is the largest.

The high percentage of the market is due to the short life-span of houses; if there are 50 million houses in existence now and 1.2 million of them are rebuilt every year, a simple calculation can show that eventually after forty-two years all houses will be rebuilt, thus creating an extraordinary dense market of four new houses in each square kilometer every year.

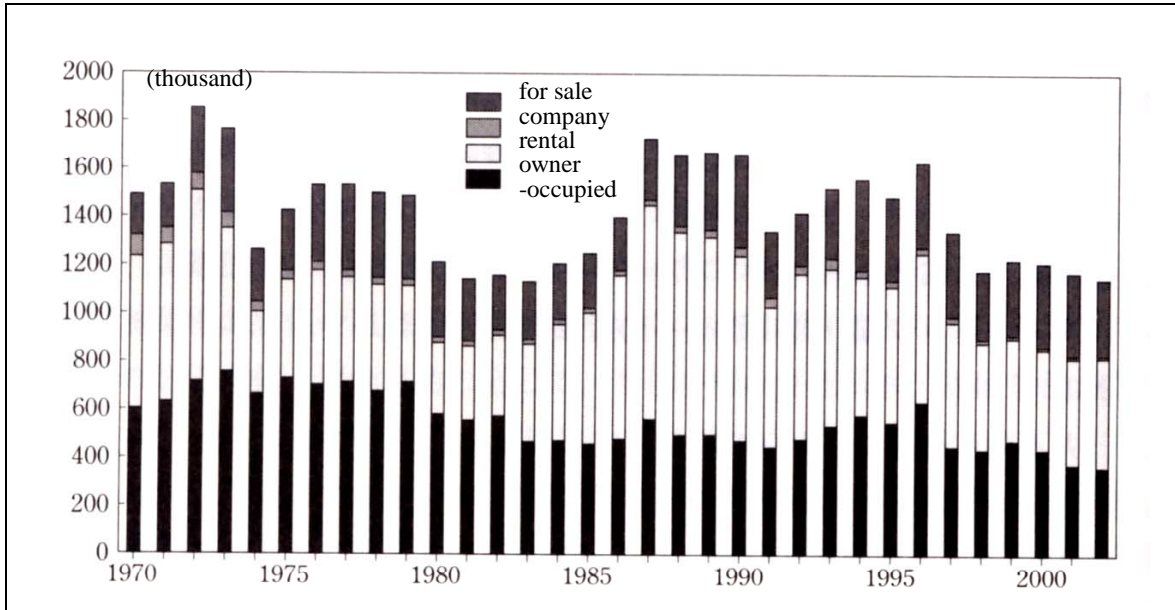


Figure 1: The Number of Newly-built Housing Units during 1970-2002 (\*4)

As for the tenure of the newly-built housing units today, a half of them are owner-occupied or condominiums for sale and another half are rental. Another typical tendency of the composition of newly-built housing units in these years is the decrease of single-family dwellings namely detached houses and the increase of multi-family dwellings.

Fig. 2 shows the composition of the house-building market during Apr.1996 – Mar.1997. Mainly from this graph the characteristics in the house-building market in Japan can be understood as follows.

- The market can be divided into single-family dwellings, namely detached houses, and multi-family dwellings; the two are nearly equal in the number of housing units
- Most of the single-family dwellings are conventional wooden houses designed and built by local builders. Those builders range from those who build only a few new houses a year to those who build a few thousand houses a year, but at any scale most of them are house-building specialists
- Most of the multi-family dwellings are made of RC, SRC or steel structures and the general contractors who design and build them do not usually build detached houses. There are some housing specialists but not so many
- Prefabricated house manufacturers who produce detached houses and low-rise apartment houses play an important role
- The proportion of public housing sectors such as local governments and former Japan Housing & Urban Development Corporation (today's Urban Renaissance Agency) is not so big as in 1960s or 1970s

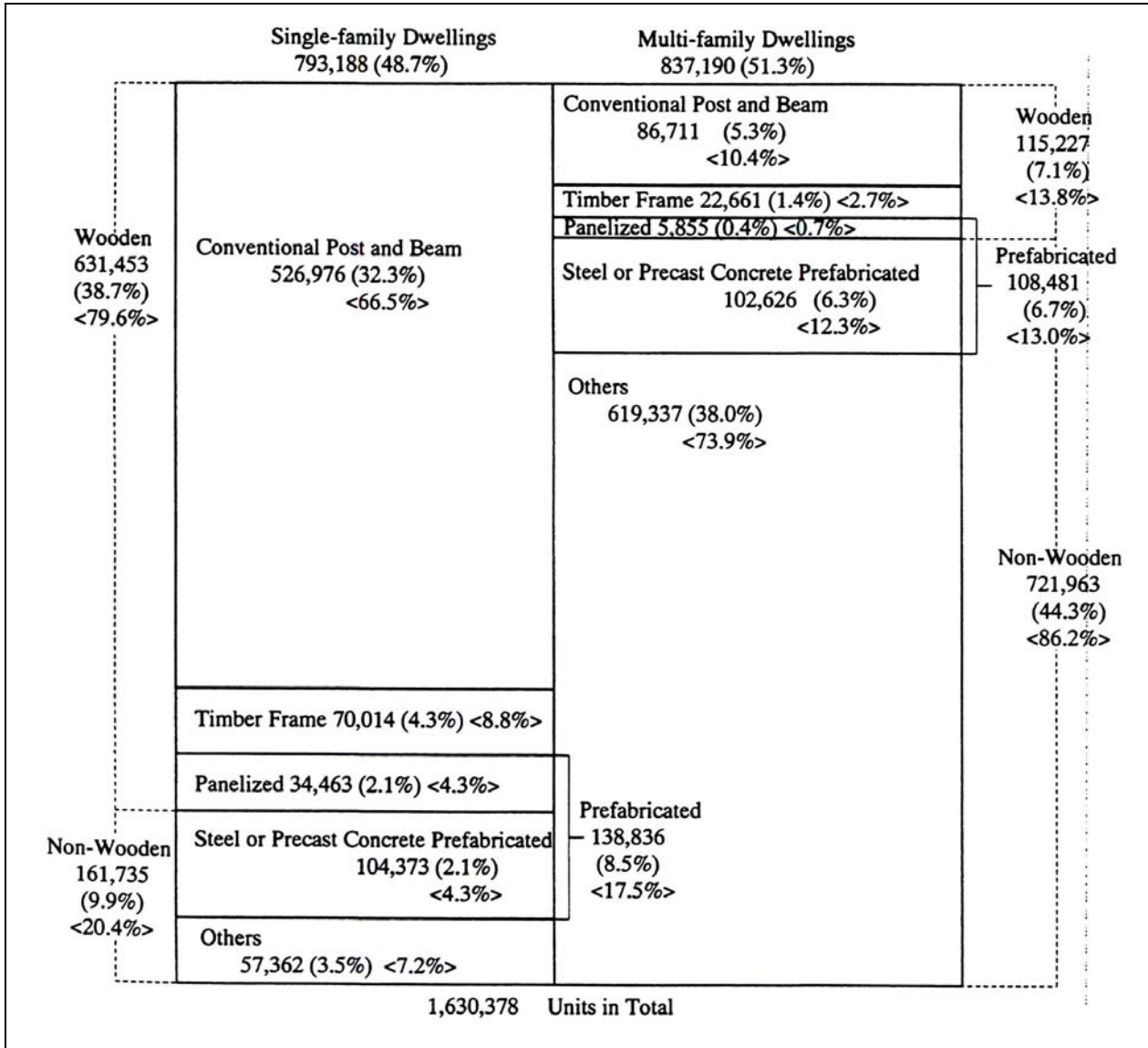


Figure 2: The Composition of Newly-built Housing Units (Apr.1996-Mar.1997) (\*4)

### 3 Prefabricated Houses Manufacturers

Until 1960, almost detached houses are built by carpenters or small builders using conventional wooden post and beam structures. This stable condition of the market began to change in around 1960 when prefabricated house manufacturers appeared. Many of large prefabricated manufacturers came from other industries such as chemical, steel and home electric appliances.

Most of the prefabricated houses market has been occupied with steel structures such as steel frame panel construction as well as steel frame modular construction. Wooden structures has been in the market such as wooden panel construction as well as timber frame modular construction. Although precast concrete structures has been too, the size of their manufacturers has been rather small. (Fig. 3)



3. 1 Conventional Wooden



3. 2 Timber frame



3. 3 Wooden Panel



3. 4 Steel Panel



3. 5 Steel Modular



3. 6 Concrete Panel

Figure 3: Typical Building Systems for Detached Houses in Japan (\*3)

The market conditions since 1960 were in their favor in the following manners:

- The high economic growth in 1960s increased the demand for house-building rapidly and developed a very dense market as previously mentioned
- The construction of detached houses was formerly supported by carpenters or local builders who had some personal relationship with their clients and the production was done within the local district. However the population growth in the city and the increase of nuclear families gave rise to what is called suspended clients who are not in relation with local builders

Therefore, after the rapid growth during the high economic growth period until 1973, they became essential players in the market. As several of them design and build more than ten thousand housing units annually they can invest much capital and human resources into research and development activities of production technologies and so on.

It is in their merchandise development process that most of their research and development activities occur. Generally speaking each manufacturer sell many types of merchandises at the same time and a few new merchandises are always on the development process. Each merchandise is designed for each target defined according to clients' income level, family type, generation and so on. (Fig. 4)

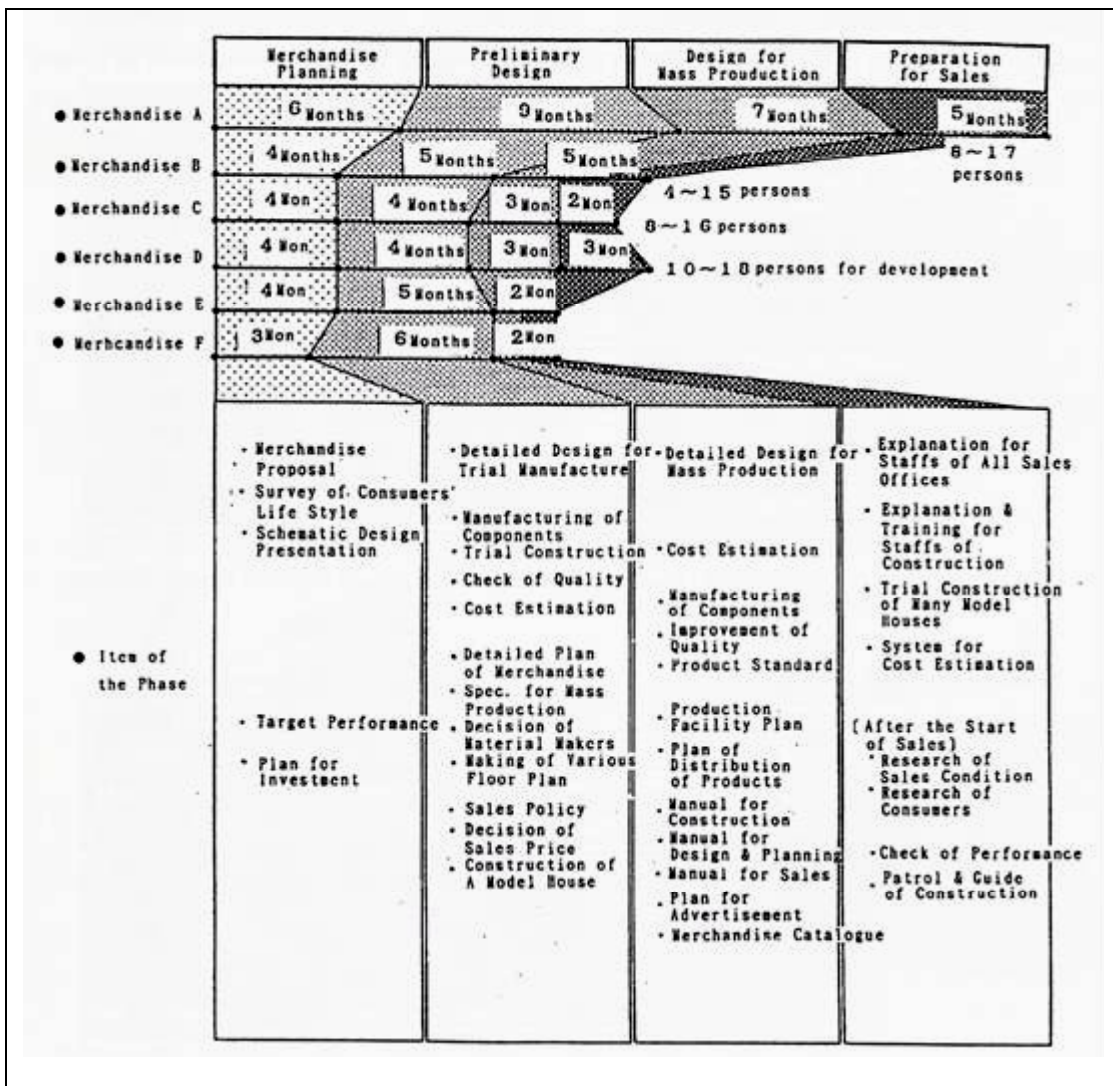


Figure 4: Six Examples of Merchandise Development Process

Each merchandise is not a prototype, the floor plan and the exterior/interior design of which are completely fixed, but what is called a design and production system which has an exterior/interior image, a fixed price level per square meter, a well prepared component system and a planning rule. Hundreds of sales offices nation-widely allocated design and build each house fit to each client's needs using these merchandises, namely design and production systems. Such customization systems lead to high satisfaction rate of clients, which is always more than 80% in many manufacturers' cases.

Such satisfactory customization systems couldn't be realized without their flexible manufacturing systems. Taking the largest manufacturer's example, it controls the production and distribution of more than two million kinds of components in order to realize its order-made prefabricated houses. As it cannot stock so many kinds of components, it produces most kinds of components according to each order from its clients. And such an order-entry manufacturing and delivery system could be established with various application of IT technologies in its design and production process.

## 4 Rationalization of Conventional Wooden House Production

Although in 1980s they said that prefabricated houses would gradually replace conventional wooden houses, their market shares have not changed so much so far. One reason can be said that continuous rationalization of conventional wooden house production has made them competitive since 1980s.

The core technology of such rationalization was what is called the "precut system". (Fig. 5) The system development started with the inventions of the machines which could cut and shape wooden posts, sills and beams in the latter half of 1970s. After the application of CAD-CAM in the middle of 1980s, those structural components for conventional wooden houses became to be automatically cut and shaped according to each order of clients only with the input of post and beam layout plans. (Fig. 6) Such CAD-CAM systems dramatically reduced the necessary carpenters' works for wooden house production.

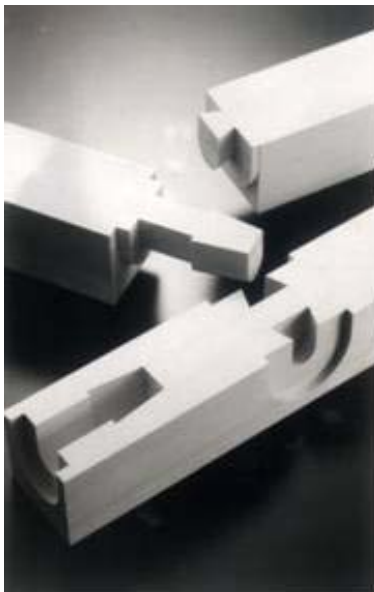


Figure 5: Precut Shapes and An Example of Precut Factories





Figure 6: An Example of CAD-CAM Precut System

On the other hand, in 1980s many builders had been confronted with drastic decrease of carpenters. According to the national census, the number of carpenters in 1990 was 710 thousand while that in 1980 had been 930 thousand. It meant annual decrease by about twenty thousand in average. As its reason was the drastic decrease of the young people who wanted to be carpenters, the average age of carpenters has rapidly risen in the decade. It was such crucial situation that forced many builders to utilize the precut system.

Nowadays there are more than eight hundred “precut factories” which can work for local builders all over Japan and they say that almost seventy percent of conventional wooden houses are built with the precut system.

As a result of the rapid spread of the precut system, local builders and their relating agents have become conscious of other kinds of rationalization and implemented several rationalized methods such as panelizing floors, walls and roofs, the use of engineered woods, the procurement through shorter distribution root of lumbers, the partial application of performance-based design, etc..

## 5 The Actual Position of Prefabricated Houses and Conventional Wooden Houses

As far as conventional wooden houses by small builders are concerned, they are seldom in severe competition with prefabricated houses by large manufacturers, while there are severe competitions among houses of any building system by large firms.

Fig. 7 and 8 clearly show such a condition of the market. Judging from these figures, prefabricated houses or timber frame houses by large firms mainly correspond to comparatively high income clients, while conventional wooden houses by small builders mainly do to comparatively low income ones. From this fact it can be recognized that prefabricated houses could be successful in the market thanks to other characteristics than price competitiveness in Japan although the merits of prefabrication and industrialization has been said cost and price reduction. (Fig. 9)

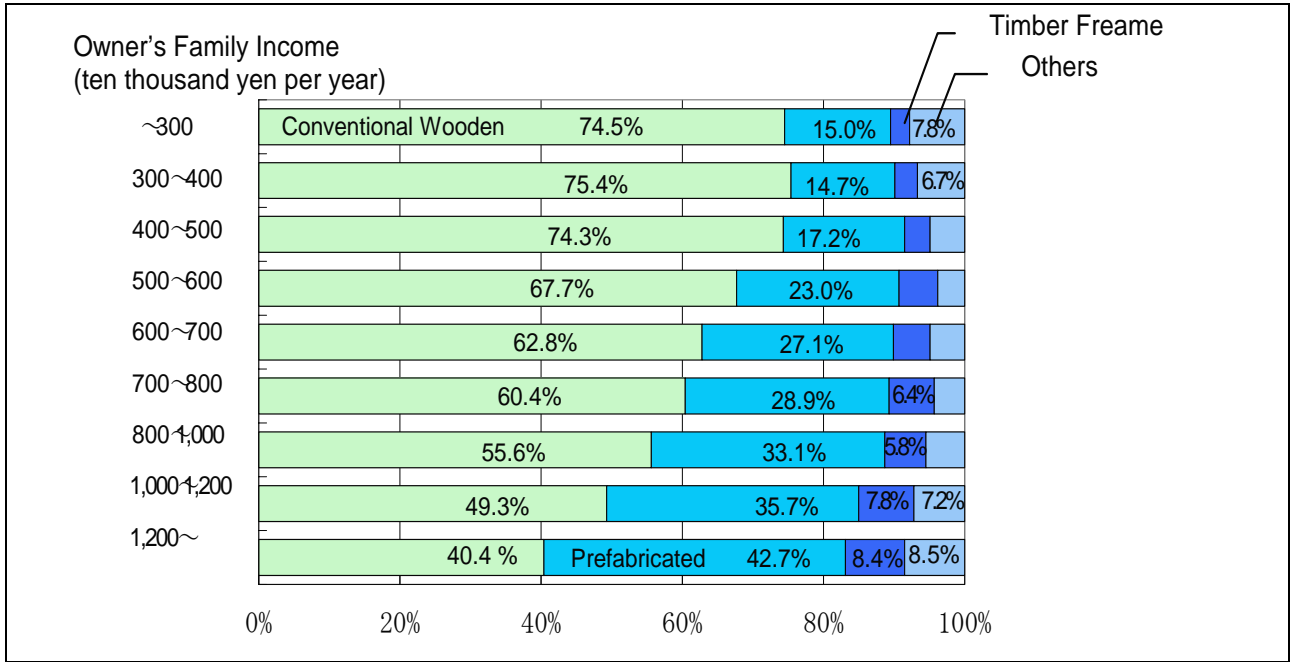


Figure 7: Proportion of Newly-built Detached Houses in Each Client's Family Income Level by Construction Type in 1992 (\*3)

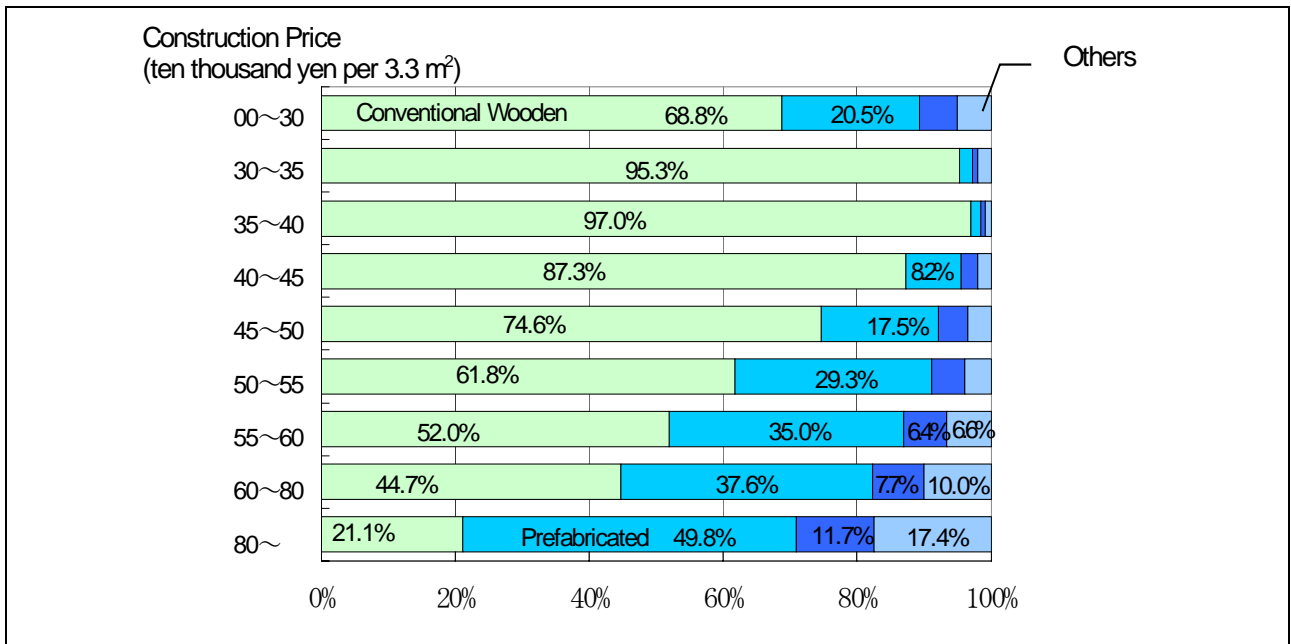


Figure 8: Proportion of Newly-built Detached Houses in Each Construction Price Level by Construction Type in 1992 (\*3)

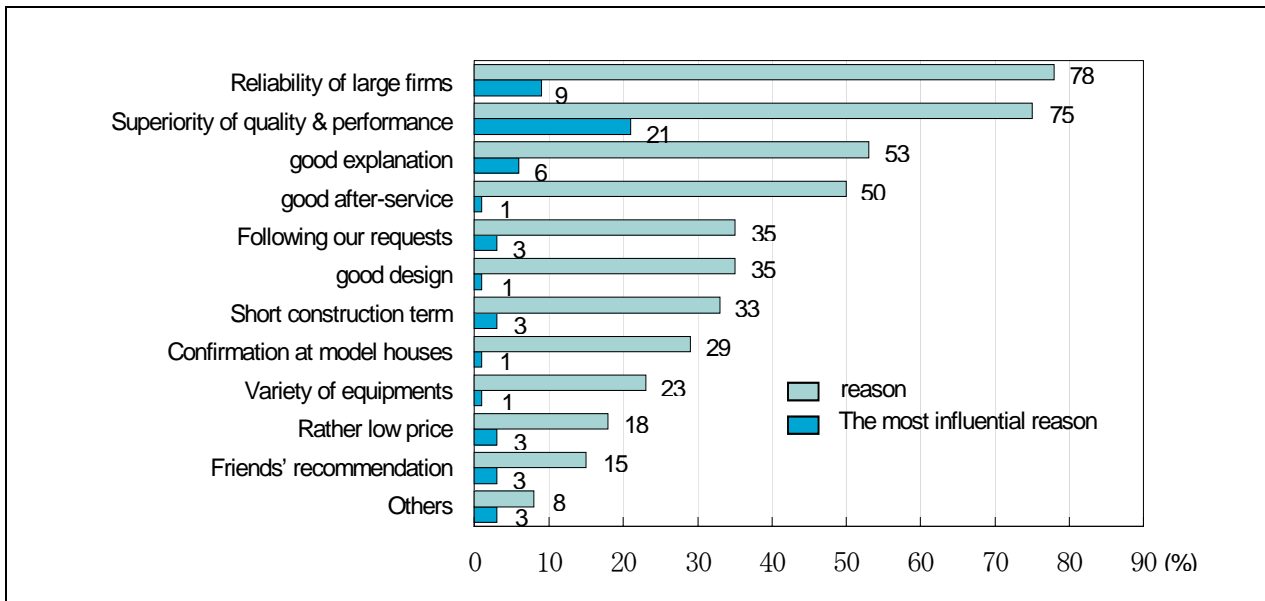


Figure 9: The Reason Why Clients Chose A Prefabricated House (2001, \*5)

## 6 Conclusion

As a result of the enlarging market until the beginning of 1990s, there appeared various kinds of building systems as well as suppliers for order-made detached house production in Japan. Although the market has gradually declined during this decade, the coexistence of various kinds can still be found in the actual market. It is because each agent has continuously made efforts to be competitive each other. Their efforts since 1990s can be said mostly related to rationalization with the application of IT technologies such as flexible manufacturing systems of prefabricated houses and the precut system of conventional wooden houses.

Consequently those different building systems will become more and more similar from the viewpoints of the appearance as well as the performance of houses. Then diversity for customers will decrease in spite of the coexistence of various building systems and suppliers. So the most important question to be answered in near future can be "What is each system's or each type of supplier's uniqueness in the house-building market?"

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