The History of Developments toward Open Building in Japan

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ABSTRACT
Developments toward Open Building began in Japan at the beginning of the 1970s. In this paper, the author describes the history of these developments, discussing mainly developments in which the author was directly involved. In 1971, the idea of systems building was introduced from the USA and UK, referring to the result of famous systems such as SCSD in California. The experience introducing such systems building was utilized in the development for residential buildings in Japan. The KEP project executed by the Japan Housing Corporation was the first trial toward Open Building in the field of residential buildings in Japan. Century Housing System and other trials followed it. The experimental-housing project NEXT21 was constructed in 1993. Then, the SI house concept spread rapidly at the end of the 1990s, and the KSI system was developed. Today, many construction firms and real-estate companies put the name - the SI house - to their housing projects,

Keyword: Open Building, History, Systems building, Japan

1. Characteristics of residential buildings in Japan

The history of open building in Japan has different characteristics from those of other countries. Until about 85 years ago, most residential buildings in Japan were made of wood and there were almost no apartment buildings except row houses or terrace houses. The construction of apartment buildings began immediately after the Great Earthquake in 1923, when reinforced concrete began to be used for buildings, and apartment buildings named Dojunkai were built under the influence of social housing activities in Europe. However, it was still a special case in the context of building production in Japan.

Apartment buildings became popular in Japan after the World War II. In 1955, the Japan Housing Corporation was established as the world's largest organization for supplying residential buildings. Figure 1 shows Harumi Apartment Building, which was built by the Japan Housing Corporation in 1958. It has a reinforced concrete column and beams structure, constructed with the latest building technology at that time. However, the interior construction was designed employing the conventional production organization at that time - namely, a traditional Japanese wooden house was built in a reinforced concrete skeleton (Fig. 2). There were sliding doors, called Fusuma, consisting of a wood frame and paper, to divide rooms. The interiors could be remodeled but actually were not before the building was destroyed in 1997, because the Housing Corporation built the building as rental housing.

The building was thus constructed with the support and the infill being physically separated, although its management and decision-making system was not divided for the support and the infill.

Figure 1 Harumi Apartment Building

Figure 2 Interior of Harumi Project

2. The early development of apartment buildings

In the 1960s the construction of reinforced concrete apartment buildings dramatically increased in number in Japan. In accordance with this increase, organizations specialized in infill for apartment buildings were created, which made the interior of apartment buildings and that of wooden houses more different.

Most skeleton systems had reinforced concrete structures, which were made by concrete in situ, although a construction method using large precast concrete panels was also developed, introducing European systems to respond to mass housing production demands. At first, the Ministry of Construction and the Japan Housing Corporation led the development. However, as the technologies of major general contractors and other private sectors progressed, the Ministry held a competition called the Pilot House Technology Development Competition in 1970. It was a project influenced by Operation Breakthrough held in the United States.

Major general contractors joined the competition and built apartment buildings of ambitious designs as a trial. The floor plans of the constructed buildings are shown in Figs. 3 and 4. In the planning, they proposed to have a large space in the skeleton and divide the space freely with partition panels or storage units. At that time, there were already a considerable number of architects and engineers in Japan who were trying to design various types of room layouts in apartment buildings with movable partitions.

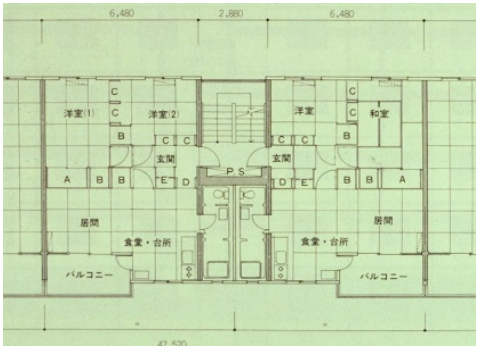

Figure 3 Pilot house (Tokyu)

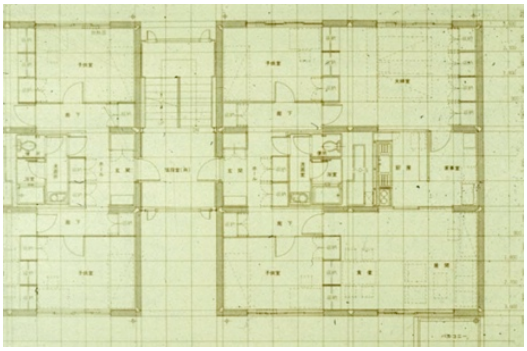

Figure 4 Pilot house (Shimz)

3. KEP system

In 1971, SCSD, a school construction system in the US, was introduced to Japan. This was the first introduction of the idea of systems building. After that, Japanese manufacturers were encouraged to develop building subsystems based on predetermined performance specifications. Yositika Utida, professor of the University of Tokyo, and others played a central role in the promotion of the system. In 1973, the Ministry of Construction established the Housing Components Development Center to develop the interior systems.

Figure 5 KEP experimental Skeleton

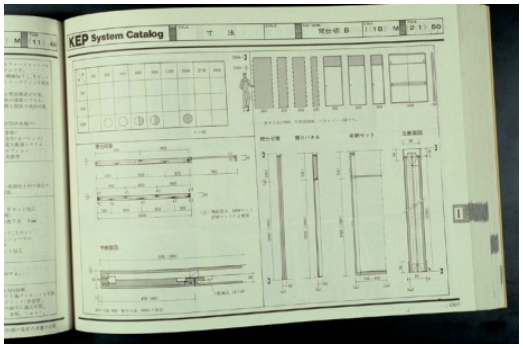

Figure 6 KEP system catalogue

Associated with this movement, the Japan Housing Corporation shifted its focus from technological development, in particular the development of building structures using large precast concrete panels, to the

development of housing components. In 1974, the Corporation started to develop the Kodan Experimental Project (KEP) system, under the supervision of chairperson Professor Utida. The KEP system consisted of four subsystems. The first was a system for external walls, called a shelter. The second was an interior system, the third a system for sanitary facilities, and the fourth a system for ventilation and air conditioning. Performance specifications were set for each of the subsystems and manufacturers developed their products according to the performance specifications. Panasonic, Bridgestone and other manufacturers participated in the development of the infill system, developed various components, and performed assembly tests in the research center of the Japan Housing Corporation (Fig. 5).

The developed components were described in catalogues written in the same format (Fig. 6).

As part of the KEP Development, project staff members visited Europe in 1976 and 1977 to visit a number of projects based on the study of SAR and had discussions with Professor Age van Randen at the Technical University Delft.

Figure 7 JHC Estate Tsurumaki

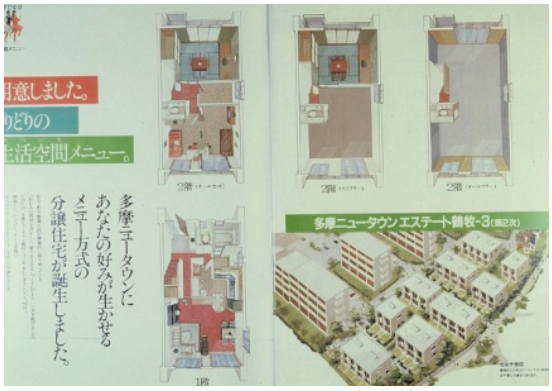

Figure 8 JHC Town Estate Tsurumaki

The research results of KEP were applied to actual apartment buildings starting in 1980, introducing partition panels and storage units in large spaces of the skeleton (Fig. 7: Estate Tsurumaki in Tama Newtown). Japan Housing Corporation sold the apartments under the name “Menu System,” which allowed dwellers to choose their room layouts. Figure 8 is a terrace house with the Menu System. While its room layout on the first floor was fixed, that on the upper floor could be chosen from “no interior finishing at all,” “no interior finishing but a single Japanese style room prepared,” and “completely finished interior prepared by the Corporation.”

Figure 9 JHC Free Space

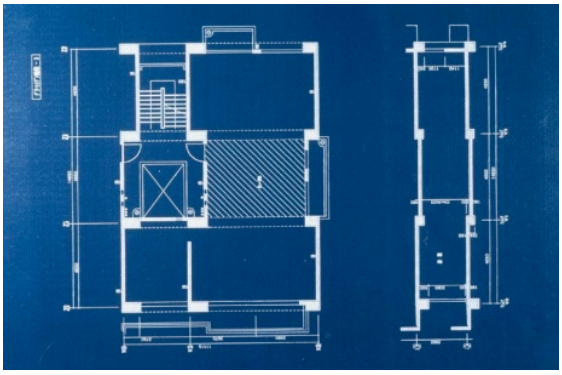

Figure 10 Free Space (plan & section)

Figure 11 presents an apartment building called Free Space, designed by Kudan Architect office at the request of the Japan Housing Corporation. The building has three spaces on the north, center and south sides, and the reinforced concrete floor slab in the center space is 200 mm lower than the north and south spaces. The floor finishing panel is placed 300 mm higher than the upper surface of the slab, allowing free layout of drain and water-supply pipes in the space between the floor panels and the slab. Also there is a light well, where vertical plumbing is set up. Since there are no shared pipes running vertically in each apartment, the apartment rooms as

well as sanitary zones can be freely remodeled. This residential building system was epoch making in 1983 (Figs. 12-14).

Figure 11 Free Space (skeleton)

Figure 12 Free Space (center zone)

4. Other projects

Around the same time, Professor Kazuo Tatsumi and Professor Mitsuo Takada, at Kyoto University, developed the two-step housing supply system. The first building was called Senri Momoyamadai, supplied by the Osaka Prefectural Housing Corporation. In this two-step housing project, the Corporation first provided the building skeleton and dwellers determined the room layout except sanitary facilities, which were fixed in the plan (Figs. 13 and 14).

Figure 13 Senri Momoyamadai Project

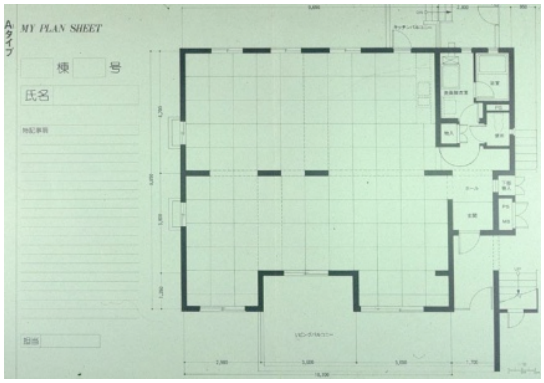

Figure 14 two-step housing (plan)

In addition to these actual pilot projects, in 1980 the Ministry of Construction launched a project called the Century Housing System (CHS).

This study aimed to realize longer life of entire apartment buildings and examined the possibility of independent development of building components of different durability. It determined the expected durability of various types of components and set interface rules for each type. The project also made a rule not to install vertical common plumbing in the center of apartments. Architects offices and general contractors actually designed several apartment buildings according to the rules designated by the project. Figure 15 and 16 show the building named Teradamachi Apartment supplied by Osaka City Housing Corporation, where the apartment unit has a recessed water facility zone as shown in Figure 16.

Figure 15 CHS Teradamachi Apartment

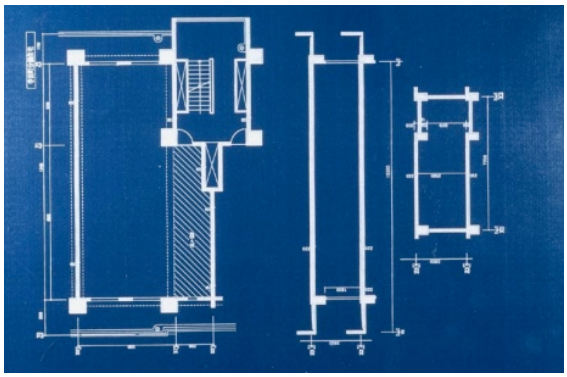

Figure 16 CHS Teradamachi Apartment

In 1986, the Japan Housing Corporation built an apartment building called “Free Plan Rental Apartment house” in Hikarigaoka, Nerima-ku, Tokyo (Fig. 17). The building skeleton (Support) belonged to the Corporation, but the infill, including facilities of kitchen, bathroom and toilet, was owned by dwellers. Dwellers were allowed to freely design the infill according to the planning grid and could realize their room layout according to their own wishes. The residents purchased the infill paying several million yen when they moved in, but the rent was cheaper than other typical apartments by fifty thousand yen or more per month. It was a groundbreaking example of open building at that time (Fig. 18).

Figure 17 Hikarigaoka Free Plan Rental

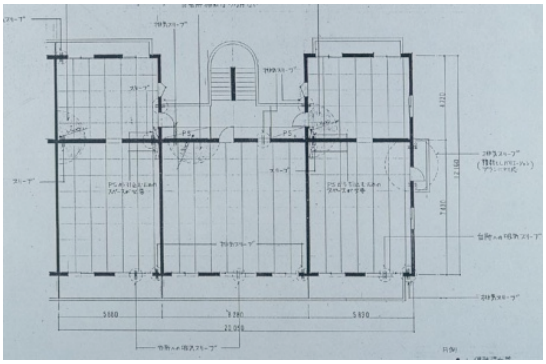

Figure 18 Free Plan Rental (plan)

Dwellers sometimes work together to build condominiums. Such condominiums are usually called cooperative houses in Japan. Cooperative houses have been constructed since the 1970s. Green Village Utsukidai is an open building cooperative housing project constructed in 1992 coordinated by Japan Housing Corporation (Fig. 19). The building has a large void in the center of each unit, which is used as a space for vertical plumbing. As shown in Fig. 20, the central slab of the apartments adjacent to the void is recessed to create a space for horizontal plumbing. The planning and design of about 100 apartments was done by many architects, and the apartments have different room layouts and different finishes. The dwellers are very satisfied with the apartments and have maintained a good community spirit.

Figure 19 Green Village Utsukidai

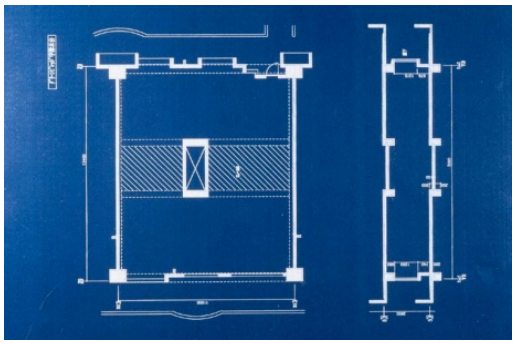

Figure 20 Green Village Utsukidai

5. Experimental Housing NEXT21

Construction of open buildings has thus been tried mostly for public apartments. In 1990, a major city gas supplier, Osaka Gas, planned to develop an experimental near-future-type apartment building, and asked Professors Yositika Utida and Kazuo Tatsumi to carry out the project. As a result, the well-known experimental housing NEXT21 was built. The author was a member of the developing group. NEXT21 is an eco-friendly open building apartment building constructed with the systems building method (Fig. 21).

Figure 21 NEXT21

Figure 22 conventional wooden house

The design of its characteristic external walls is the result of detailed studies. For NEXT21, dimensional coordination was used, with multiple integrated grids. The position of the external walls was determined according to the grid to realize a systematic configuration. The unique exterior of a muted rainbow color was made with the aim shown below.

Traditional Japanese wooden houses are designed based on a 900 mm grid, which allows residents to be involved easily to the determination of room layout. Japanese houses maintain a high level of customer satisfaction since carpenters can build the houses reflecting the requests of the residents. One of the reasons why there have been many open building projects in Japan is due to this characteristic of conventional Japanese wooden houses (Fig. 22). One aim of the open building projects is to enhance the customer satisfaction level and therefore it is easy for Japanese to understand the theory of open building.

However, in designing such traditional houses, owners, architects and carpenters do not closely examine the elevation of the houses, but just focus on the room layout. The elevation is determined as a result of making a floor plan. For this reason, the cityscapes of Japan began to lose their traditional beauty after the World War II.

For NEXT21, each dwelling unit was designed by a different architect, independently. Each architect designed the external walls and window layout of each apartment, resulting in a wide variety of apartments. However, this spoiled the overall design of the building. So, for NEXT21, an external wall system was developed to create a sense of unity in the elevation of the entire building irrespective of the random arrangement of the windows. In the system, stainless siding boards of five colors were put on the wall according to computer-generated random numbers to redirect people's eyes from the randomly located windows to the stripe pattern of the boards. It was an experiment aiming to harmonize the degree of freedom of each apartment and the sense of unity of the entire building.

Another experiment was conducted for NEXT21 to move the position of the external walls (Figs. 23-25). By comparing the circumstances, before and after the wall was moved, the intention of the development, as noted before, is revealed.

Figure 23 NEXT21 before remodeling

Figure 24 NEXT21 after remodeling

Figure 25 NEXT21 cladding

Figure 26 dormitory of medical school Leuven

For the dormitory of a medical school at the University of Leuven, designed by Lucien Kroll and constructed in 1974, students were invited to decide on the façade from catalogues of window units (Fig. 26). The apparently random window layout was in fact the result of careful coordination by the architect Kroll
When architecture is divided into support and infill, it is not clear whether the external walls of an apartment building are classified as support or infill. Normally, the external walls are classified as part of the support. It is normally thought that when the building is considered as a social asset, the elevation of external walls should not depend on the decision-making of residents in the apartments. However these experiments were significant in indicating the possible diversity of the layout of external walls in Japanese residential buildings. The issue of the external walls of open buildings requires more discussion in the future.

5. Conclusion

NEXT21 has produced a substantial reaction in Japan, triggering widespread circulation of the idea of skeleton infill separation. The concept emphasizes physical separation of apartment building components by their duration years, rather than by the method of decision-making or by the form of ownership. The term “SI” has been frequently used in projects such as “House Japan” or “Next-Generation Vision of Town,” started in 1995 by the Ministry of Economy, Trade and Industry. This “I” stands for infill and “S” for skeleton, not for support.

In 2000, Takenaka Corporation and others constructed an experimental SI residential building Flexsus 22 in Aichi Prefecture in the House Japan Project (Fig. 34). They employed a seismic-isolated structure, eliminating beams, to realize the building frame with a high degree of freedom (Fig. 27). The shared pipe shafts were installed on the north side of the corridor and there was a horizontal plumbing zone above the slab of the corridor (Fig. 28).

Figure 27 Flexsus House 22

Figure 28 Flexsus House 22 (corridor)

In this situation, the Housing and Urban Development Corporation (Japan Housing Corporation) developed a concept of open building called KSI where the skeleton and infill are treated separately. In 1997, the Corporation built an experimental residential building in Hachioji City and conducted various experiments (Fig. 27). An electric wiring system that can be mounted directly onto the ceiling's concrete slab was developed and implemented (Fig. 28). Super high-rise apartment buildings developed by the Corporation have been constructed according to the principle of SI separation.

Figure 29 KSI experimental building

Figure 30 KSI electric wiring

The notion of SI separation has been employed not only for public apartment buildings but also for private condominiums. The name "SI house" is now familiar in Japan and more than one million sites are hit if browsed on the Internet using this keyword.

5. References

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