A Study on the Open Building System for Multi-Storey Housing in Indonesia

Fela Warouw*1, Hideki Kobayashi2 and Jiyoung Jung3

1 Graduate Student, Chiba University, Japan
2 Professor, Graduate School and Faculty of Engineering, Chiba University, Japan
3 Assistant Professor, Graduate School and Faculty of Engineering, Chiba University, Japan

Abstract
This paper explores the concept of adaptability through a study of customization work on Indonesian multi-storey housing. Significant differences in interior plans and renovation, modification and customization methods in public rumah susun and private apartments enable small-scale post-occupancy adaptability using low-level industrialized building techniques. This study reveals the importance of the building system for enhancing building service life by differentiating building components according to users, decision control and customization method. The findings suggest two adaptability concepts for infill housing for rumah susun and apartments: adaptable design and affordable production.

Keywords: multi-storey housing; open building; adaptability; customization works; renovation

I. Introduction
In metropolitan Jakarta, multi-storey housing is the dominant criterion in the search for appropriate urban residential upgrading schemes, with accessibility to workplace as the main alternative. Since the 1980s, the Indonesian government has built public housing called rumah susun (RS), with the following technical specifications: walk-up flats with typical layout arrangements for small-size dwelling units which are habitable with low-cost interior components.

After 30 years of mass public housing development in Jakarta, many buildings are now deteriorating. A recent analysis of public RS construction from 1980 to 2005 (Ministry of Public Housing, 2006) revealed physical problems, such as pipe corrosion, lack of installations, dirty exterior walls, porous bathrooms and kitchens, and changes in building façades, that led to the degradation of building performance quality.

Similarly, a survey conducted at a public RS in the Jakarta area after 10 years of occupation demonstrated changes in interior finishing and exterior façades, that residents needed to upgrade stairs, walls, doors and windows.

To live comfortably in a limited space with mediocre interiors, residents need to repair the interior components—walls, floors, sashes, bathrooms, and kitchens—and make dwelling room extensions beyond the boundary walls. Nonetheless, both the designs and methods of the changes are initiated by residents without guidelines or building management control.

As a consequence, such work interferes with the structural form and exterior façade of the building. The process of upgrading and repairing an old building to an acceptable condition is referred to as renovation. In private apartments, residents want to change the standard floor plan and the standard interior components. This modification work is allowed just before move-in and during occupation. This reveals the importance of adaptability in multi-storey housing design to provide occupants with forms and means that facilitate their home space needs before or after move-in. Adaptability also means giving occupants the means of changing their homes as their families grow or their lifestyles evolve.

In the production of mass housing, adaptability must incorporate methods and building systems that permit occupants to personalize and adapt units to their space needs or budgets. Residents, as consumers of housing products, can customize or modify interior components according to individual requirements or personal specifications. The important aspect of customization is that it gives residents more choices and they have an influence on the appearance and quality of their own homes before move-in. Thus, the purpose of this paper is to look at interior plans and modifications, both in public and private housing, in the Jakarta area and to examine customization methods in order to define the adaptability concept and to propose a building system under the open building approach.

2. Literature Review
2.1. Adaptability Form and Open Building System
Friedman (2002) identified four main areas of intervention to achieve adaptability in a dwelling: the
Table 1. Characteristic of Multi-storey Housing in Indonesia

| Categories | Flat 11) | Rusunawa 12) | Rusunami 13) | Apartment 14) |
|------------|----------|-------------|-------------|--------------|
| Location/ | East Jakarta/ | East Jakarta/ | North Jakarta/ | South Jakarta/ |
| Ownership type | Ownership | Rent | Ownership | Ownership |
| Completion/ | 1980/ | 2005/ | 2010/ | On construction/ |
| Developer/ | Perumnas | Local Government | Agung Podomoro Group | Agung Podomoro Group |
| Prices/ | Unknown/ | *400-600 thousand Rp/ | 88,144 million Rp/ | 511-1833 million Rp/ |
| Management | Resident Association | Local Government | Building Management | Building Management |
| Number of | 4 stories/30m/2 | 6 stories/30m/2 | 17-19 stories/21m:/24.5 m²; 35m²/Fixed bedroom, bathroom, kitchen | 35 stories/33m/42m²; 53m²; 100m²/Fixed bedroom, bathroom, kitchen |
| stories/Unit | Fixed bedroom, toilet, kitchen | Fixed bedroom, toilet and kitchen | Reinforced concrete, Lightweight brick | Reinforced concrete, Lightweight brick |
| type/Floor plan system | | | Concrete panel, Brick | Concrete panel, Brick |
| Structure & | Pre-cast concrete, | Concrete panel, | Reinforced concrete, | Reinforced concrete, |
| Exterior | Brick | Lightweight brick | Lightweight brick | Prefabricated panel |
| Interior Finishing & | Concrete counter kitchen | Concrete counter kitchen | **Kitchen sink, | Option kitchen set, |
| Equipment | plus sink, Toilet, Bare | plus sink, Toilet, Bare | bathroom, Ceramic floor, | Bathroom, Painting wall, |
| | finishing wall and floor | finishing wall and | Painting wall, Gypsum | Ceramic & Marble floor, |
| | | floor 10);11) | wall, Fire protection. | Fire protection, Security |
| | | | | system. |

* Price from Rusunawa Marunda, develop by local government of Jakarta; ** Resident can install appliances and equipment after moving-in

manipulation of volume (e.g., alteration of the building envelopes), spatial arrangement (e.g., modified layout), growth and division (e.g., expansion beyond the dwelling or growth into space within the perimeter of the original volume), and the manipulation of subcomponents (e.g., fitted interior elements which are repaired or upgraded) 9).

Habraken (1961) proposed an adaptability concept for mass housing design by separating structure and services (supports) and the enclosures forming the dwellings (infill), which is known as the 'open building' approach 10). Infill typically comprises all components specific to the dwelling unit that can be transformed to meet the occupants’ changing requirements or preferences and cyclical need for technical upgrades. These individual changes must leave the support unaffected 11).

Through this open building approach, the Japan Housing and Urban Development Corporation (HUDC) developed the building system for skeleton infill housing. Skeleton refers to the framework of a building and is a durable structural body. Infill refers to the floor plan and interior finishing. There are three important aspects that are used to determine the skeleton and infill parts, namely: the use of space (common versus private), lifespan (long versus short) and decision-making (community versus private). Furthermore, in considering these aspects, building components are divided into four categories: the skeleton (e.g., structural frames, foundation, and slabs), supporting elements (e.g., cladding for roof and walls, and common service), boundary elements (e.g., windows, balconies, and adaptable walls), and infill (e.g., interior finishing and private services) 12).

Significantly, Japanese housing manufacturers are playing a role in advancing the industrialized production of infill systems. The application of new design and production approaches, called mass customization, is related to the mass production of housing ‘components’, and the combination of these components enables customers to customize their new homes in response to individual demand 13).

2.2 Indonesia Multi-storey Housing: rumah susun and apartments

The regulation of multi-storey housing (Rumah Susun Law No. 16/1985) states that "Rumah susun are multi-level buildings that are built in a structured environment whose functionality is divided, both horizontally and vertically. Each part of this structured environment is owned and used separately, particularly for residences, and is facilitated by shared equities, assets and land". The unit room set (sarunsun) comprises a living room and/or a bedroom, a bathroom, a kitchen and a balcony. Shared equities are the community-owned parts that serve multiple units; for instance, structural construction, boundary walls/floors, exterior walls, roofs, common spaces (stairs, elevators and corridors) and common services (running water, electricity, phone lines, gas, drainage, and piping). Assets are common properties, such as social facilities and playgrounds, which are separated structurally from the building 14).
The early stage of mass public housing, from 1974 to 1984, provided 9,028 units\(^1\). A state-owned housing company established in 1974, Perumnas, designed the standard layout plan for single and family units (e.g., 18, 36, or 54 m\(^2\)) arranged with radial or linear patterns within four-storey flat housing\(^2\). From 1985 to 2000, the local government and private sector worked together with Perumnas to advance mass public housing development and supplied about 17,943 units. The term *rumah susun* is used and recognized as a five-storey building consisting of standardized design for single (e.g., 18, 21 or 27 m\(^2\)) and/or family units (e.g., 30 or 36 m\(^2\)) that are arranged in rows with galleries and/or corridor access. Later, the terms for a low-cost flat, *rumah susun sederhana*, a low-cost rental flat for people with fixed or irregular wages, *rusunawa*, and a low-cost ownership flat aimed at fixed-income people, *rusunani*, came into wide use\(^3\). When the Indonesian government announced the construction of 1000-unit tower-type housing (2007) containing both resident-owned and rental units\(^4\), *rusunani* was recognized as eight- to 20-storey buildings that offer standard layout plan designs for single and family units (e.g., 21, 24.5 or 35 m\(^2\))\(^5\). Another term for a private RS is an apartment and/or condominium, which refers to high-cost multi-storey housing for people with high income. Table 1 shows the characteristics from each term for multi-storey housing in Indonesia, which differ in developer, price, number of stories, unit type, floor plan system, and interior and finishing equipment.

### 3. Study Objective and Method

The objective of this paper is divided into 5 parts. First, layout-plan types are investigated, focusing on interior components standard before residents move in. Second, transformation of interior components during occupation is examined. Third, choices for design and production are examined when residents modify components. Fourth, the adaptability concept for RS and apartments is defined with respect to the standard plan, transformation and interior component modification. Finally, the above findings are applied to the development of a building system.

The first three objectives listed above are achieved through surveys conducted on RS and apartments in metropolitan Jakarta in April and September 2007. Table 2 lists case studies including building names (locations) and basic information about tenure, construction year, design, developer and number of units. Seven public RS housing projects were chosen to represent the mass public housing planning from 1980 to 2005 in the Jakarta area. Flat housing located at Tanah Abang (R1) and Klender (R2) have early RS building designs (1980s), whereas Tipar Cakung (R6) and Jatirawasari (R7) have more recent designs (2000s). For case studies of buildings located within Jakarta and constructed during the 1990s, Kemayoran (R3), Bendungan Hilir (R4) and Pasar Jumat (R5) were used. To elucidate the general condition of multi-storey housing design, private apartments with interior modifications were investigated with the help of real estate agents (Century 21 Casablanca) in the Jakarta area and on the Internet. After surveying and collecting data on apartments, 4 buildings constructed in different years between 1995 and 2006 were chosen as case studies.

Using qualitative research methods, observations on site were conducted focusing on interior components, such as kitchens, bathrooms, walls, floors and balconies, in order to find all adjustments or alterations of dwelling rooms or interior adaptation. Every finding was recorded by camera and in writing. An interview of resident associations and property managers was also conducted to collect information about adaptation work. The two sheets comprised the following items in Table 3. below.

### Table 3. Interview Sheet Content

| Sheet 1 | Sheet 2 |
|---------|---------|
| Name, Location, Developer, Construction year, Tenure, Number of stories, Income level, Structure, Unit rooms type, Layout plan type (fixed, half-free or open), Customization stage (pre- or post-occupancy), Renovation system (developer, interior company or resident), Adaptation method (remodeling, renovation and on-site work), Adaptation method (ready-made or on-site work), Finishing specification, Customized interior component categories, Production type, Adaptation method. |
| Standard component type, Production type, Layout plan type, Structure, Unit rooms type, Number of stories, Income level, Interior assembly, Production type, Customized interior component categories, Production type, Production type, Customization stage (pre- or post-occupancy), Renovation system (developer, interior company or resident), Adaptation method (remodeling, renovation and on-site work), Adaptation method (ready-made or on-site work), Finishing specification, Customized interior component categories, Production type, Adaptation method. |

### Table 2. Case Study

| Categories | Case Name/Tenure | Completion Year | Construction/Stories/ Room Type (m²) | Developer/ Management | Number of Observation |
|------------|------------------|-----------------|--------------------------------------|-----------------------|-----------------------|
| Public (R) Rumah Susun | R1. Tanah Abang/Ownership | 1980 | Pre-cast/4th/2 BR (36) | P/R | 3 UR |
| | R2. Klender/Ownership | 1982 | Pre-cast/4th/2 BR (36) | P/R | 3 UR |
| | R3. Kemayoran/Rent | 1990 | Conventional/5th/Studio (18) | P/P | 2 UR |
| | R4. Bendungan Hilir/Ownership | 1994 | Conventional/5th/Studio (18) | LG/R | 2 UR |
| | R5. Pasar Jumat/Rent | 1996 | Conv, pre-cast/10th/Studio (21) | P, JICA/P | 3 UR |
| | R6. Tipar Cakung/Rent | 1995 | Conv, pre-cast/10th/Studio (21) | PJICA/P | 3 UR |
| | R7. Jatirawasari/Rent | 2003 | Pre-cast/6th/2BR (35) | LG/LG | 1 UR |
| Private (A) Apartment | A1. Batavia/Ownership | 1995 | Pre-cast/34th/Studio (48) | Private/BM | 1 UR |
| | A2. Ambasador/Ownership | 1997 | Pre-cast/25th/3BR (118) | Private/BM | 1 UR |
| | A3. Mediterranean B/Ownership | 2002 | Pre-cast/34th/2BR (90) | Private/BM | 2 UR |
| | A4. Ambasador II/Ownership | 2006 | Pre-cast/33th/2BR (44.7) | Private/BM | 1 UR |

\(\text{RA: Resident association; P: Perumnas; LG: Local Government; BM: Building Management; UR: Unit Room}\)
4. Study on Customization Work
4.1 Standard Interior Plan

The interior plan for rental/ownership RS (1984-2005) design is standardized both in layout plan and component finishing/fittings. In order to reduce production cost and rent/purchase price, the floor plans and interior finishing from each case study were compared using as parameters the specification standard from the developer and the stage at which the resident modified the interior component. The differences observed in surface finishing (e.g., walls and floors) and fitting plans (e.g., walls, kitchen, and toilet) can be divided into four types (Fig.1.) as follows.

1). Unfinished interior plan. Interior walls and floors are exposed without finishing (e.g., paint) and some of the units are open space without walls between rooms. Thus, residents can personalize bathrooms (e.g., basins) and kitchens (e.g., cabinets and ceramics) and install interior walls after move-in.

2). Half-finished interior plan. Interior surfaces and bathroom fixtures are well equipped, except for in the kitchen area. Some developers offer standard equipment, such as counter concrete plus sink or kitchen space plus sink for residents to personalize just before move-in.

3). Ready-made interior plan. The interior plan includes all equipment and appliances as part of a standard plan and uses high quality materials or fittings (e.g., built-in kitchen sets and imported marble). Residents do not need to personalize before move-in, but they can make modifications during occupation.

4). Order-made interior plan. The standard layout plan can be modified; for example, by merging two small units (e.g., a studio type and a one-two bedroom type) during the construction stage. Residents can order a new interior plan from the developer before move-in.

4.2 Interior Modification Works

In public RS, residents have to deal with low-cost material finishing, and no fit-out rules are maintained. In the open building approach, fit-out refers to the process or action of installing building infill in making habitable space in a base building\(^5\). Moreover, residents are not allowed to modify the interior layout and finishing without legal permission from the tenants association\(^22\). In private apartments, the procedure for modifying interior components is prepared by the building management to anticipate any renovation work done during occupation\(^8\). The fit-out rules in apartments consist of an explanation of prohibited interior/exterior components for individual changes.
and material specifications for modifications\textsuperscript{7}.

Obviously, interior modification by residents can be used to indicate the forms of adaptability in multi-storey housing design. Renovation and fit-out work from case studies R1 to A4 were organized by interior component and type of adaptation work (Table 4). We found that the adaptation work could be categorized into three intervention areas for achieving adaptability in a dwelling (Fig. 2.), as follows.

1). Manipulation of subcomponents

Interior components are manipulated according to a standard interior plan and fit-out rules. Fit-out (F) refers to fitting interior components into an unfinished or a half-finished interior plan. Upgrading (U) refers to replacing standard interior components that were installed as part of the ready-made interior plan. There are four categories of manipulated components: walls and floors (a); kitchens (b); bathrooms/toilets (c); balconies (d); sashes (s).

Fit-out and upgrade work in public RS can be described as tiling, painting, installing toilet basins and kitchen cabinets, installing sashes onto balconies and replacing windows and doors. With less detailed regulation and bare finishing surfaces, residents in public RS have greater freedom to do such adaptation work than residents of apartments. Standard interior plans in apartments also allow fit-out and upgrade work such as installing kitchen equipment, tiling, painting and replacing fittings.

2). Spatial arrangement

Modification of floor plans in both public RS and apartments is done for the purpose of accommodating the needs and lifestyle changes of residents. Table 4. shows that floor plans were adjusted and interior components were modified in three ways: partition wall installation (PW1); partition wall demolition (PWD) and kitchen space modification (KSM).

In public RS, residents enlarge their living rooms by demolishing the small kitchen and then constructing a new kitchen counter on the balcony after enclosing or enlarging the balcony space. For private apartments, we found that bedroom and bathroom spaces were enlarged by demolishing interior walls.

3). Growth and Division

Living in limited space with few fit-out regulations encourages residents in public RS to add space beyond the boundary wall as well as to install walls or floors inside the unit. This adaptation work is only found in resident-owned RS and consists of two types: horizontal expansion (HE) and vertical expansion (VE). Small-scale horizontal expansion was accompanied by boundary wall replacement, whereas large-scale expansion was identified as open-room construction on ground-floor units. Upstairs units also erected walls and laid floors for expanding balcony space. The top floor units had the benefit of attic space with gable roofs. After enclosing the ceilings, residents erected floors in attic areas, put in small stairs and enjoyed the new floor space inside their units.

4.3 Interior Customization Method

Interior customization can be defined as interior component modification according to a resident’s individual requirements. The observed characteristics of adaptation work reveal that residents have control over interior component design and the customization method used. Most manipulated components use on-site production, such as brick-laying a wall, pouring concrete or laying brick for a kitchen counter and pouring a concrete floor. This on-site work component can be designed by residents or planned by a designer or craftsman. The fabrication and assembly process can be in-place (e.g., self-built, do-it-yourself) or off-site (e.g., craftsmanship, order-made). Only a few interior components are defined as industrialized products, such as sashes (e.g., windows and doors) and built-in kitchen sets. These off-site work components are either mass-produced (standard, no choice) or custom-produced (customized standard, with choices).

Analysis of the customization methods considered both design type and production method. Manipulated
interior components from case studies A1 to R4 were organized and classified into three customization methods (Table 5).

1). Select-Option type (SO). Mass-produced components with standardized design such as kitchen cabinets, bathroom fixtures, doors and windows offer limited options.

2). Order-Made type (OM). Made-to-order components with custom design such as kitchen cabinets, bathroom fixtures, doors and windows and material for surface finishing offer many choices of design and materials used for production. These components are produced by a combination of mechanized plants and manual finishing in place. Customers work with experts to design a particular component, and then an interior company or craftsman will produce the component off-site and/or on-site.

3). Self-Made type (SM). Self-made components with original design produced from raw materials include kitchen cabinets, bathroom fixtures, doors and windows, and finishing on walls, floors and balconies. Customers can work alone or with the help of craftsmen to produce these components on site.

5. Adaptability Concept in Multi-storey Housing Design: Rumah Susun and Apartments

The concept of post-occupancy adaptability, which means that occupants can modify units after move-in, is well-established in interior design in multi-storey housing. Adaptation work is characterized as small-scale adaptability, because the degree of change is low, comprising minor improvements of surfaces, upgrading of fittings and minor extensions.

The manipulated components of RS and private apartments are related to small-scale adaptability and customization methods, such as those described in Fig.3. The figure reveals the trend in customization methods that enable many forms of adaptability. Interior adaptability in public RS is used to add self- and order-made components. Obviously, the many forms of interior adaptability in public RS take advantage of the unfinished interior plan, which enables residents to personalize interior components according to their needs and budgets. Interior

Table 5. Interior Customization Method

| Code Name | Wall & Floor (a) | Kitchen (b) | Bathroom (c) | Balcony (d) | Sash (s) |
|-----------|-----------------|-------------|--------------|-------------|---------|
| SO OM SM  | SO OM SM        | SO OM SM    | SO OM SM     | SO OM SM    | SO OM SM |
| R1 x x O  | x x O           | x x O       | x x O        | x x O       | O O O   |
| R2 x x O  | x x O           | x x O       | x x O        | x x O       | O O O   |
| R3 x x O  | x x O           | x x O       | x x O        | x x O       | x O O   |
| R4 x x O  | x x O           | x x O       | x x O        | x x O       | O O O   |
| R5 x x O  | x x O           | x x O       | x x O        | x x O       | O O O   |
| R6 x x O  | x x O           | x x O       | x x O        | x x O       | O O x   |
| R7 x x O  | x x O           | x x O       | x x O        | x x O       | x O x   |
| A1 x O x  | x x x           | x x x       | x x x        | x x x       | O x x   |
| A2 x O x  | x x x           | x x x       | x x x        | x x x       | O x x   |
| A3 x O x  | x x x           | x x x       | x x x        | x x x       | O x x   |
| A4 x O x  | x x x           | x x x       | x x x        | x x x       | O x x   |

O = Found; x = Not Found; SO: Select-Option; OM: Order-Made; SM: Self-Made
adaptable in private apartments is used to order- made and select-option type. The half-finished and ready-made interior plans limit the choices of residents to personalize interior components.

The figure also reveals that interior components manufactured in Indonesia are products of low- level industrialized building techniques which do not support interior customization in multi-storey housing. Mass-produced components do not offer many choices for customers; hence, they are only used for limited types of adaptation work. The self- and order-made components are widely used in many forms of adaptation work because of their customer-based design and budget.

5.1 Adaptable Design for Infill Housing

Based on the above findings, the adaptability approach for infill modification in multi-storey housing must consider residents' needs and lifestyle; thus, there are two adaptable designs:

1. Self-Order Design for Public Rumah Susun

During the occupancy stage, residents can customize infill components using self-made and order-made production. At the design stage, the developer arranges a standard plan with a minimum requirement approach, such as an open plan, with few internal walls, bare finishing surfaces, and unfitted bathrooms and kitchens, and including an optional balcony plan. Management associations must prepare some type of 'do-it-yourself' (DIY) guideline for self-assembly, self-finishing and fitting interior components.

2. Select-Order Design for Private Apartments

Before and after move-in, residents in private apartments can customize infill using the select-option design and order-made components. At the design stage, the developer arranges a standard plan, infill components and an infill customization plan. This customization plan can vary from an open plan, an optional plan or a menu selection. Exterior modification is not included in the customization plan; for example, those proposed for public RS. The open plan refers to free internal walls, free arrangement, fixed wet areas (bathrooms, kitchens), unfitted components and bare finishing surfaces, while the optional plan offers choices for partition wall arrangement and room necessities. Menu selection offers a choice of surface finishing and fitting fixtures. During occupancy, the management association must prepare a legal covenant that is suitable for each customization plan.

5.2 Affordable Production for Infill Housing

Adaptable design for infill housing must support various production methods that are affordable both with respect to customer budget and household income. Affordable production can be achieved if manufacturing methods and decision control are taken into account (see Fig.4.). Manufacturing methods are divided into off-site work and on-site work, while decision control for customization design is divided among the developer, interior companies and craftsmen and residents/users.

In low-level manufacturing, the developer provides standard design components and enables component customization by residents, with the help of craftsmen and interior designers, of both design and production. By providing many types of customization methods, both residents and developers gain an advantage. In public RS, residents can customize the interior according to household income and the developer can reduce the housing cost of interior finishing. In private apartments, residents can choose the customization method that suits their budget. The developer can offer many options taking into consideration the residents' lifestyles and budgets, from middle- to high-cost.

Interior design companies and craftsmen can cooperate with the developer to prepare customization plans for option design and order design. The assembly design and self design must be authorized and be supported by a DIY guideline from the developer or management association. Moreover, this situation will become a catalyst for infill manufacturing development, from low-level to middle-level industrialized building techniques.

![Fig.3. Relation between Customization method and Scale of Adaptability compared by Adaptation Works](image-url)

![Fig.4. Manufacturing method and Decision Control for Affordable Infill Housing](image-url)
### Table 6. The Open Building System for Multi-storey Housing in Indonesia

| Building Parts                  | Public Rumah Susun | Private Apartment |
|---------------------------------|--------------------|-------------------|
|                                 | Decision Control   | Customize Method  |
| Base Building (I)               | Management, Resident Association | Standard Design |
| structural, access (corridor, stair, elevator), etc | Management, Resident Association | Standard Design |
| Common Components (II)          | Management, Resident Association | Select-Option Design |
| boundary wall, exterior façade, roof, balcony, piping and service line, social facilities, etc | Management, Resident Association | Standard Design |
| Individual Components (III)     | Resident           | Self Design, Order Design |
| floor plan (open plan, zone), finishing (wall, floor), fitting (kitchen, bathroom, sash), services, etc | Resident | Select-Option Design |

#### 5.3 Three Categories of Building Parts

This study on customization work summarizes the different levels of multi-storey housing design to be considered for the open building system (Table 6): user (public rumah susun and private apartments), decision control (developers, management and residents) and customization method (standard, order-design and self-design). The building components for rumah susun can be classified into three categories:

**I. Base building.** Parts under the decision control of the developer and management, comprising several shared equities, such as access corridors, stairs and elevators. These components are for long-term use, with a service life of 50 years or more.

**II. Common components.** Parts under the decision control of the developer and management, comprising some components of shared equities, such as boundary walls, exterior façades, balconies, piping and service lines, as well as assets, including social facilities and the exterior landscape. These components are for middle-to short-term use and can be modified according to community demand.

**III. Individual components.** Parts under the decision control of individual residents. These include the set of all interior components of a rumah susun, such as floor plan, interior finishing, interior fittings, and private services. These components are for middle-to short-term use and are easily changed according to individual preferences and requirements.

#### 6. Conclusion

To ensure that the industrialization of housing components is advancing in Indonesia, the small-scale adaptability of multi-storey housing must be maintained with a proper building system. Minimum standard fittings, such as unfinished and half-finished interior plans, enable residents to customize interior components. Self-order design is the most suitable method for interior customization using low-level industrialization building techniques. Finally, this study also reveals that the open building concept is directed at realizing adaptable design for infill at public RS and private apartments, and providing an affordable production method.

### References

1. Maruhum, B. and Hidhehiko, T. (2002) An Application of the AHP to Urban Residential Upgrading in Jakarta. Journal of Asian Architecture and Building Engineering, 1 (1), pp.253-259.
2. Indonesia Architecture Magazine. (2007) Rumah Susun. Jakarta: PT Grasindo Mediatama (in Indonesian).
3. Kementrian Negara Pekerjaan Rakyat. (2007) Peraturan Menteri PU No.05/PRT/M/2007: Pedoman Teknis Pembangunan Rumah Susun Di Kawasan Perkotaan Tahun 2007-2011. (in Indonesian).
4. Government of Indonesia Decree no.4/1988, section 16,20,21.
5. Majalah IDEA. (2008) Apartment Bercorak Kuning Flat di Jakarta. Jakarta: PT Samindra Utama. (in Indonesian).
6. Noguchi, M. (2003) The Effect of the quality-oriented production approach on the delivery of prefabricated homes in Japan. Journal of Housing and the Built Environment, 18, 353-364.
7. Majalah IDE. (2008) Apartment Bercorak Kuning Flat di Jakarta. Jakarta: PT Samindra Utama. (in Indonesian).
8. Menteri Pekerjaan Rakyat. (2007) Peraturan Menteri PU No.06/PRT/M/2007: Pedoman Teknis Pembangunan Rumah Susun Sederhana Bertingkat Tinggi. Jakarta. (in Indonesian).
9. Indonesia Apartment (2007) Design Concept Lifestyle. Jakarta: PT Grasindo Mediatama (in Indonesian).
10. Tenant Association. (2008) Kebon Kacang Flat (in Indonesian).
11. Tenant Association. (2008) Kebon Kacang Flat (in Indonesian).
12. Tenant Association. (2008) Kebon Kacang Flat (in Indonesian).
13. Tenant Association. (2008) Kebon Kacang Flat (in Indonesian).
14. Tenant Association. (2008) Kebon Kacang Flat (in Indonesian).
15. Tenant Association. (2008) Kebon Kacang Flat (in Indonesian).
16. Tenant Association. (2008) Kebon Kacang Flat (in Indonesian).
17. Tenant Association. (2008) Kebon Kacang Flat (in Indonesian).
18. Tenant Association. (2008) Kebon Kacang Flat (in Indonesian).
19. Tenant Association. (2008) Kebon Kacang Flat (in Indonesian).
20. Tenant Association. (2008) Kebon Kacang Flat (in Indonesian).
21. Tenant Association. (2008) Kebon Kacang Flat (in Indonesian).
22. Tenant Association. (2008) Kebon Kacang Flat (in Indonesian).

### Notes

- Renovation: resident adaptation work addressing inadequate low-quality interior components after move-in
- Modification: resident adaptation work performed to accommodate lifestyle changes
- Adaptability: building forms and systems that enable adaptation work by residents before and after move-in
- Small scale adaptability: small changes of interior surface components, fitting parts and structural modifications.
- Customization: design and production systems that enable residents to change interior components according to space needs and budget
- Affordable: a customization method that fits within the resident's income and budget for interior component production
- DIY: resident handmade infill components in their own unit rooms

### References

1. Maruhum, B. and Hidhehiko, T. (2002) An Application of the AHP to Urban Residential Upgrading in Jakarta. Journal of Asian Architecture and Building Engineering, 1 (1), pp.253-259.
2. Indonesia Architecture Magazine. (2007) Rumah Susun. Jakarta: PT Grasindo Mediatama (in Indonesian).
3. Kementrian Negara Pekerjaan Rakyat. (2007) Peraturan Menteri PU No.05/PRT/M/2007: Pedoman Teknis Pembangunan Rumah Susun Di Kawasan Perkotaan Tahun 2007-2011. (in Indonesian).
4. Government of Indonesia Decree no.4/1988, section 16,20,21.
5. Majalah IDEA. (2008) Apartment Bercorak Kuning Flat di Jakarta. Jakarta: PT Samindra Utama. (in Indonesian).
6. Noguchi, M. (2003) The Effect of the quality-oriented production approach on the delivery of prefabricated homes in Japan. Journal of Housing and the Built Environment, 18, 353-364.
7. Majalah IDE. (2008) Apartment Bercorak Kuning Flat di Jakarta. Jakarta: PT Samindra Utama. (in Indonesian).
8. Menteri Pekerjaan Rakyat. (2007) Peraturan Menteri PU No.06/PRT/M/2007: Pedoman Teknis Pembangunan Rumah Susun Sederhana Bertingkat Tinggi. Jakarta. (in Indonesian).
9. Indonesia Apartment (2007) Design Concept Lifestyle. Jakarta: PT Grasindo Mediatama (in Indonesian).
10. Tenant Association. (2008) Kebon Kacang Flat (in Indonesian).
11. Tenant Association. (2008) Kebon Kacang Flat (in Indonesian).
12. Tenant Association. (2008) Kebon Kacang Flat (in Indonesian).
13. Tenant Association. (2008) Kebon Kacang Flat (in Indonesian).
14. Tenant Association. (2008) Kebon Kacang Flat (in Indonesian).
15. Tenant Association. (2008) Kebon Kacang Flat (in Indonesian).
16. Tenant Association. (2008) Kebon Kacang Flat (in Indonesian).
17. Tenant Association. (2008) Kebon Kacang Flat (in Indonesian).
18. Tenant Association. (2008) Kebon Kacang Flat (in Indonesian).
19. Tenant Association. (2008) Kebon Kacang Flat (in Indonesian).
20. Tenant Association. (2008) Kebon Kacang Flat (in Indonesian).
21. Tenant Association. (2008) Kebon Kacang Flat (in Indonesian).
22. Tenant Association. (2008) Kebon Kacang Flat (in Indonesian).

### Notes

- Renovation: resident adaptation work addressing inadequate low-quality interior components after move-in
- Modification: resident adaptation work performed to accommodate lifestyle changes
- Adaptability: building forms and systems that enable adaptation work by residents before and after move-in
- Small scale adaptability: small changes of interior surface components, fitting parts and structural modifications.
- Customization: design and production systems that enable residents to change interior components according to space needs and budget
- Affordable: a customization method that fits within the resident's income and budget for interior component production
- DIY: resident handmade infill components in their own unit rooms