1. INTRODUCTION

1.1. Background and Objective

Among variable infill systems used for Skeleton and Infill (SI) housing, movable storage furniture has been considered as an important element which can compose a residential space corresponding to a resident’s need in Japan. Generally, most of the movable storage furniture is moved by specialists because it is complex to assemble by non-specialists. Considering variable infill systems, it is difficult to claim movable storage furniture can be moved by a resident as a grant (1).

On the other hand, according to the several studies on the living style in the SI housing with variable infill systems, the studies reported that although the rearrangements of the movable storage furniture by residents were not expected, the residents created variable plans by themselves and gained flexibility in their living style. Because of the mechanism behind the infill system, movable storage furniture was simple enough to move by residents (2).

With technical improvements on the movable storage furniture, it starts to appear that more residents are moving their furniture. So in terms of giving various alternatives, it is very important for a resident to explore the possibility of moving the furniture. Therefore, in our previous study (Yi and et al., 2007), we investigated rearranging slim movable storage furniture with casters by a non-specialist such as a graduate student to create various layouts. This previous study was to investigate whether residents could create various residential spaces by moving the movable storage furniture when there is a need for a big-scale modification on a plan due to a change in a lifestyle or life stage. However, big-scale modification does not appear frequently, and it is not highly expected that the residents will need to make a big change by them. On the other hand small-scale modification is highly necessary for the resident to modify the small space plan in a short time corresponding to a temporary need such as large number of short term visitors.

For that reason it is highly desirable to expect both a big and small-scale modification for the SI housing. Specially, in these days, to respond to the various needs due to diverse life and work styles, the significance of a small-scale modification is very high (3).

This study focused on technical aspects of movable storage furniture as one part of the SI system. The study is to investigate and validate possibilities whether a non-specialist (e.g. graduate student) can easily make a small-scale modification by using movable storage furniture.

The objectives of the study are 1) investigation of the possible types and the layout method of the movable storage furniture for the non-specialist (e.g. graduate student), and 2) its validation. This investigation will overview a technical aspect of movable storage furniture and allows for modifying and improving movable storage furniture, not only for the large-scale but also for the small-scale modification.

1.2. Recent development in the field

Recent technical developments in setting and moving variable infill system include the movable storage furniture. Some researches (Fukao, 2003; Shimize, 2003; and Nagau, 2004) suggested technique of interior construction, which take advantages of two different installation methods, known as “partition first raised floor last” and “raised floor first partition last.” Yoshiro (2004) clarified the relationship between the infill and the skeleton in order to mobilize the infill system and made a series of studies. The studies include developing a floor system and inspecting its construction qualities. Endoh (2003) developed and evaluated the interior parts of infill for the improvement in production qualities of interior construction in apartment houses. However, most of these studies were focused on a big-
scale modification done by a specialist, and rarely these studies were focused on the temporary small-scale modification done by a resident who is a non-specialist.

1.3. Outline of the experiment
The study selects a house unit in a renovated building called KYUDOAKUSHA as a case for this study[4]. KYUDOAKUSHA is a three-story dormitory with Reinforced Concrete (RC) structure. Initially, the building was designed by Takeda Goichi who is the first professor in the department of architecture at Kyoto University, and it was completed in 1926 at Hongo, Tokyo, Japan. The building was renovated as an SI house building in 2006. Among the renovated units, the study selects a house unit number called 301 as a study unit. This house unit has a 57.76m² floor area with the ceiling height of 3050mm, which is a typical unit in the building. The selected house unit was renovated to create a residential space to utilize movable storage furniture. The water facilities were placed in the north where there used to be a hallway, and the south area which used to have four rooms was merged into one space (figure 1). The study unit was usually used as a second house as a temporary resident, a Small Office Home Office (SOHO), a laboratory, a cottage in town for researchers or an examination base for a graduate student. The movable storage furniture investigated for this study was originally made as a dividing partition for creating closed space. So it is soundproof, opaque, and earthquake-proof which gives a structural high quality. Moreover its slimness and great mobility (with installed casters) makes it a suitable choice for the study.

The furniture types with casters are T series (T1 and T2) and without casters are B series (B1 and B2). For size, types T1, B1 and B2 have the same depth of 300mm, and T2 has a depth of 600mm. Type T1, T2 and B1 have a width of 860mm except B2 (300mm). The height of the four types is 2500mm. A wardrobe type, a TV rack type, and a shelf type are used depending on their functions. Also small scale furniture B2 (300*300mm) is used as a book shelf[5]

The procedure of dismantling movable storage furniture dismantled, 2) the furniture is disconnected from the system, and 3) the casters are attached. Once the furniture is moved to another location, 1) the casters are stored, 2) the furniture is located, and then 3) the finishing panel and the prop stick are placed. (figure 2)

1.4. Methodology
It is generally accepted that non-closed space can be more easily adapted to temporary actions and effectively respond to the diverse lifestyles in the aspect of architectural planning.[7]

The island type of layout has a characteristic that it needs less number of movable storage furniture connections and it is separate from the wall, in which easy to layout the non-closed room (space). For this reasons the study...
investigate small-scale modification based on Plan C (island type layout) (table 1).
The island type of layout has a characteristic that it needs a smaller number of movable storage furniture connections and it is separate from the wall, which makes it easy to lay out the non-closed room (space).

Moreover, based on our previous study (Yi and et al., 2007), among three different layout plans, the Plan C (island-type) has an advantage when a non-specialist (graduate student) undertakes large-scale modification.

For this reason the study investigates small-scale modification based on Plan C (island type layout) (table 1) which can give us the in-depth information for both large and small-scale modifications.

Investigating furnishing alone in the unit is considered to be efficient enough to understand the resident’s lifestyle, but it is difficult to capture (inspect) the occupant’s behavior (situation of living). For that reason the study undertakes observation to understand the temporary needs for a modification. The study observed the living situation in plan C based on photographs and an interview with the occupants.

Also the study undertook a technical investigation of movable storage furniture related to the small-scale modifications. This investigation explored the construction qualities of furniture after the modification by the non-specialist. The experiment of a short-term living in the plan C was conducted from August 1st 2006, to July 15th 2007. Technical inspection of the furniture was conducted by five specialists including the two in charge of developing the furniture on May 23rd 2007. The experiment of moving the furniture was conducted by two graduate students (men) and a resident (woman) who are non-specialists from July 15th to 16th in 2007 (figure 4).

2. SELECTION OF MOVABLE STORAGE FURNITURE FOR A SMALL-SCALE MODIFICATION

To find the best movable storage furniture for the study, the researcher focused on six movable storage furniture pieces that are being manufactured presently by four major infill manufacturers (PK, DK, DS, IT) in Japan.

The documents and plan drawings were collected to understand their detail. Based on the specifications, the study examined the movable storage furniture by focusing on the “size of the furniture,” “whether there is a device for fixing and moving,” and “modular coordination.” These factors are considered to be the most influential on the construction qualities after moving the furniture. (table 2)

The furniture PK-1, DK-1, and DS-1 are 2400mm high, which equals to the ceiling height, 850-890mm wide, and 600mm in depth. There are jacks for fixing and casters for moving.

The furniture PK-2 and DK-2 are 1900-200mm high, which is lower than the ceiling height, 850-890mm wide, and 600mm in depth.

Table 1. Three layout plans of movable storage furniture

<table>
<thead>
<tr>
<th>Connected type</th>
<th>Contact type</th>
<th>In-phase</th>
<th>L-shape</th>
</tr>
</thead>
<tbody>
<tr>
<td>A SOHO</td>
<td>basic</td>
<td>![Diagram A SOHO]</td>
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<tr>
<td>basic</td>
<td>independent</td>
<td>![Diagram A SOHO]</td>
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<tr>
<td>basic</td>
<td>dependent</td>
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<tr>
<td>basic</td>
<td>independent</td>
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<td>expansion</td>
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<tr>
<td>expansion</td>
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<td>C Cottage in town</td>
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<td>![Diagram C Cottage in town]</td>
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*numbers in [ ] shows the number for movable storage furniture applied.
**reference to the layout type in fig3

Figure 3. Examination on living form and layout of movable storage furniture

Figure 4. Schedule of experiment on moving and the short-term living
and 620-800mm in depth. Modular coordination is single grid. There are panels against tumbling for fixing and casters for moving. Modular coordination is single grid.

IT-1 is 2470mm high, which equals to the ceiling height, 860mm wide, and 300mm in depth. Modular coordination is double grid.

Among the movable storage furniture, the small size, including the device for fixing and moving, and double grid which allows users to fix furniture without opening or closing doors is highly suitable for the study and IT-1, which is slim and has a double grid with a device for fixing and moving, were selected for the experiment. Moreover, based on makers’ reports (The variable infill study group in KYUGA KUSHA renovation housing, 2007), IT-1 passed the minimum performance requirement of the Japanese Industrial Standards (JIS) on insulation of sound, light and impact.

3. LAYOUT PLAN DESIGN FOR THE “PLAN C”

Living styles and the furniture layouts were pre-investigated to design a layout plan for the study unit. Following sections describe how the layout plan for the study was developed.

3.1. Living style investigation
Conditions for planning the unit layout, six living forms (styles) were suggested by the researchers in our previous study. These were a SOHO, a house with a staying room, a shared house, a laboratory, a party place, and a cottage in a town.

Based on the expected number of residents and attributes of each resident, the previous study focused on a SOHO, a laboratory, and a cottage in town, among the six suggestions. These three selections have a different characteristic of the living form (style). Among these three living forms (styles), a cottage in town, in which a family stays for a short-term on a weekend or a vacation, was selected for the research and Plan C was assumed as a living form (figure.3).

Additionally, in the process of planning the layout, an examination was undertaken on a residential space corresponding to each situation of a living form. Concerning actions, the ones which are necessary (sleeping, having a meal, watching TV, etc.) are shown in the table of movable storage furniture.

Table 2. Comparison of movable storage furniture

<table>
<thead>
<tr>
<th>maker</th>
<th>PK-1</th>
<th>DK-1</th>
<th>DS-1</th>
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</thead>
<tbody>
<tr>
<td>Plan</td>
<td>[Diagram]</td>
<td>[Diagram]</td>
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<tr>
<td>Elev.</td>
<td>[Diagram]</td>
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<tr>
<td>Detail</td>
<td>[Diagram]</td>
<td>[Diagram]</td>
<td>[Diagram]</td>
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<tr>
<td>Height</td>
<td>2400mm</td>
<td>2400mm</td>
<td>2524mm</td>
</tr>
<tr>
<td>Size Width</td>
<td>850mm</td>
<td>850mm</td>
<td>850mm</td>
</tr>
<tr>
<td>Depth</td>
<td>600mm</td>
<td>600mm</td>
<td>600mm</td>
</tr>
<tr>
<td>Fixed</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>caster</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Modular Coordination</td>
<td>Single grid</td>
<td>Single grid</td>
<td>Single grid</td>
</tr>
<tr>
<td>maker</td>
<td>PK-2</td>
<td>DK-2</td>
<td>IT-1</td>
</tr>
<tr>
<td>product</td>
<td>[Diagram]</td>
<td>[Diagram]</td>
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</tr>
<tr>
<td>Plan</td>
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<td>Elev.</td>
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<td>Detail</td>
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</tr>
<tr>
<td>Height</td>
<td>1500mm</td>
<td>2000mm</td>
<td>2470mm</td>
</tr>
<tr>
<td>Size Width</td>
<td>1230mm</td>
<td>800mm</td>
<td>860mm</td>
</tr>
<tr>
<td>Depth</td>
<td>800mm</td>
<td>620mm</td>
<td>300mm</td>
</tr>
<tr>
<td>Fixed</td>
<td>Y</td>
<td>Y</td>
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</tr>
<tr>
<td>caster</td>
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<td>Y</td>
</tr>
<tr>
<td>Modular Coordination</td>
<td>Single grid</td>
<td>Single grid</td>
<td>Double grid</td>
</tr>
</tbody>
</table>
meal), the ones which restrict a resident (working, associating with coworkers), and the ones which are free (having a conversation, associating, taking a break) became the subject for the study (NHK, 2006).

3.2. Examination of layout
Examining the layout of the movable storage furniture, the study focused on the connection between each piece of the furniture and the contact between the furniture and skeleton. Concerning the connection between each piece of furniture: there are an I-shape type (two pieces of movable storage furniture) and an L-shape type (three pieces of movable storage furniture) as basic units. Also we classify a connection between less than three pieces into “a basic type” and a connection between more than three pieces into “an expansion type.”

Concerning the contact between the furniture and skeleton: there are four types of contact depending on whether touching the skeleton or not, the number of sides touching the skeleton, and whether the side touching is long or short. We classify the pattern in which no side or the short side is touching into “an independent type” and others into “a dependent type” (figure 3). In the plan C, the layout of an island type, which frequently contains a basic type and an independent type, was selected as the planning condition.

3.3. Designing floor plan
The study conducted four studies in February 2006 (table.3) to set the living form and the furniture layout for the floor plan. In the first and the second study, a drawing of the floor plan was used for study and in the third and the fourth study Computer Graphic (CG) was used for the study.

1) Sleeping space: We placed a sleeping space in the west side of the room in the first study but expected a necessity in the east side also, and placed 600mm depth wardrobe in both of the west and the east sides in the second study. However, the east side was considered not to be used usually, so in the third study we placed two 600mm depth wardrobes as a partition on the west side. In addition, considering about a separate sleeping space, we divided the sleeping space with 300 mm depth wardrobe of an L-shape type.

2) Dining space: We placed it on the west side and separated it from the sleeping space in the back. The first time it was separated from an association space on the east side as well by 300 mm depth wardrobe of an L-shape type, but a wasted space was created around the 300 mm depth wardrobe, so we removed it in the second study. However, a 300 mm depth wardrobe of an S-shape type that separated the sleeping space made the dining space smaller, so we used 300 mm depth wardrobe of an L-shape type to separate from the association space in the third study. In the fourth study, we placed this 300 mm depth wardrobe diagonally and let the space in the back of the 300mm depth wardrobe be used more as a rest space.

3) Conversation and the association space: In the initial study we placed the conversation and the association space on the east side. Considering about the sleeping, we put cushions to sit on in the second study. In the third study, considering about the change in the placement of furniture, we placed a sofa and an L-shape type for separating from the dining space. However, a wasted space was created on the south of the L-shape type, so we placed it diagonally to save a space for a rest.

4. TEMPORARY NEED FOR MODIFICATION ON PLAN C
4.1. Selecting the event situations for the test
In this section, in order to understand the need for a small-scale modification on the plan, the study developed the two different situations, one in which a large number of people visit the room, causing a need to change a size of space temporarily and another situation, in which some visitors sleep in the room, causing a need to change a privacy level (table 4).

For the first situation of many visitors, we set up a New Year party (Jan. 1st, 2007) and a meeting for a study group (May 23rd, 2007). For the second situation of some visitors sleeping, we set up a day when four people, a family of a researcher, stayed in the unit (Jan. 3rd-4th, 2007, and Aug. 8th-10th, 2007), and a day when a researcher and visitors stayed in the unit (May 11th-12th, 2007).

4.2. The situation of many visitors
A New Year party was held with ten people. A rest space on the south of an L-shape type which cannot be seen was used for placing belongings of the guests. Food was placed on a table on the west and people in several groups helped themselves. People were sitting on the sofa at the east of the L-shape type, standing near a kitchen counter at the north of the L-shape type, and sitting on a bench in the back of the kitchen counter. These spaces were separated moderately by the L-shape type and each member of the group had a meal changing a seat gradually.

A meeting for a study group was held with eight people (seven in a meeting) around the sofa. Before the meeting, there was a lecture using a wall on the east side as a screen. For saving a space for a projector, two people were listening to the lecture in front of the kitchen counter. A space in front of the kitchen counter was separated from a space around the sofa, but participants could see through each space, so they were able to attend the lecture. However, in the discussion about the lecture, eye contact was not possible between each of the participants, so there seemed to be a need to change the angle of the layout of the L-shape type.

4.3. A situation of some visitors sleeping
On the day, three of the family members of the researcher (husband and wife in their fifties and an older daughter in her twenties) stayed in the unit; a lady in her fifties and a lady in her twenties slept in the beds in the west side of the room; and a man in his fifties put the sofas on the east together and spread out the futon on them to sleep on it.

On the day the researcher (a man in fifties) and the visitor (a man in sixties) stayed, the researcher slept in the south bed in the west side of the room, and the outsider spread out the futon on the floor around the sofas and slept on it. On the day the four of the family of the researcher (husband and wife in fifties, an older daughter and a younger daughter in her twenties) stayed, husband and wife slept in the beds on the west side of the room, and two daughters arranged the sofas in the east and took out the support for the back to sleep on the sofas.

4.4. Consideration on temporary need for modification on plan C
It can be said that when a large number of people visited the room, a space around the sofas and a space in front of the kitchen counter were able to be used as one space since people could see through each space in spite of the L-shape type separating the two spaces. However, in the discussion about the lecture, eye contact was not possible between each of the participants, so there seemed to be a need to change the angle of the layout of the L-shape type.

In the situations of sleeping, it can be said that the room was used well with the sofas in the east being arranged and used as a bed when many people stayed. However, when the outsider stayed, he slept around the sofas in the east because of privacy although one of the beds in the west was available. Like the sofas, there seemed to be a need

<table>
<thead>
<tr>
<th>Table 4. Situation of living in plan C</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Jan. 3rd, 2007</strong></td>
</tr>
<tr>
<td>10 people (a New Year party)</td>
</tr>
<tr>
<td>7 people (meeting)</td>
</tr>
</tbody>
</table>

| **Jan. 3rd-4th, 2007** | **May 11th-12th, 2007** | **Aug. 8th-10th, 2007** |
| 3 people, a family of a researcher | a researcher and an outsider | 4 people, a family of a researcher |
for the beds in the sleeping space to be changed temporarily into single or double beds as well depending on a situation.

5. EXAMINATION OF MOVING METHOD OF MOVABLE STORAGE FURNITURE

A technical study was undertaken for a moving method for movable storage furniture in the layout of an island type layout, which would enable a small-scale modification (figure 5). The study for a moving method of the furniture was conducted on May 23rd 2007 by a committee (The experimental workshop of variable infill in KYUDO-GA-KUSA residence). The meeting included two people in charge of developing the furniture. In the study, three moving methods were studied.

1) Study plan 1 suggested moving movable storage furniture which was already discon nected from each other in the first place. Concerning the construction qualities, some said “the quality would probably be high since there is no need to connect each other,” and others said “it is considered to be difficult to arrange them neatly.” Concerning the safety against tumbling (discussed in more detail later), some said “single movable storage furniture can stand by itself,” and concerning the shading qualities, some said “there is a possibility of a light leakage.”

2) Study plan 2 suggested moving the movable storage furniture without the box on the top and the prop stick. Concerning the construction qualities, some said “the quality will probably be high since there is no prop stick,” and concerning the safety, “the lower height causes the center of gravity to drop, and that will probably enable an L-shape type to stand by itself,” and others said “it cannot stand by itself during a big earthquake.”

3) Study plan 3 suggested attaching casters and then moving movable storage furniture which is connected to another in the first place. Concerning the construction qualities, some said “the quality will probably be high since there is no need to disconnect or connect each other,” and concerning the safety, some said “it seems to be hard to attach casters without tilting the furniture which is connected to each other and to move it,” and others said “it is probably ok since there are few connected units.”

The committee selected the study plan 3, which suggests moving the movable storage furniture connected to each other already, because both the construction qualities and the safety were considered to be high.

6. EXPERIMENTS ON MOVING MOVABLE STORAGE FURNITURE

6.1. Assumption of small-scale modification on plan C

In order to inspect if the selected moving method corresponds to the temporary need for the modification in the plan, we had an assumption of the small modification on the plan C (figure 6).

1) In order to change the combination of the beds in a sleeping space temporarily, we moved movable storage furniture 4, 5, and 9 (4, 5, and 9, hereinafter) to examine the plan 1, in which a space around the single bed in the south would be larger, and moved 6 and 7 and rotated a table to examine the plan 2, in which a dining space would be larger, and moved 4, 5, and 9 to the north wall to examine the plan 3, in which the beds could be used as a double bed. We did not plan to examine the plan 4, but it was decided to be added during the experiment.

2) In order to change the location of the L-shape temporarily to let visibility go through and change the size of a conversation and an association spaces, we moved 1, 2, 8, 3, and the sofa to examine the plan 5, in which a conversation and an association space would be larger. However, we replaced 1 and 2 with 4 and 5 since there were no casters attached to them.

6.2. Outline of experiment on moving

The experiment was done by one woman and two men in their twenties on July 16th. The modifications into each plan were done by two of them, and the modification into the plan 1 was done by three of them. Also, in our previous study, we have found out that a finishing panel had to be dismantled since it could not stretch and shrink corresponding to the vertical movement of movable storage furniture and that had an influence on the construction qualities. Therefore, in this experiment, on July 15th, we replaced them with improved finishing panels which can stretch and shrink corresponding to the vertical movement of movable storage furniture.

In order to evaluate the construction qualities, a man-hour analysis was made. In “Recommended Practice for Method Improvement on Construction Work” by Architectural Institute of Japan, a work is classified into “a main work,” “an incidental work,” “an external work,” “a margin,” and “a non-work.” In this experiment, because movable storage furniture in the dwelling is being focused and a certain work is being repeated again and again, we classified a work directly concerning movable storage furniture into “a main work,” and a work not directly concerning movable storage furniture into “a non-work.” A main work has to do with “dismantling,” “moving,” and
“fixing” of movable storage furniture and a non-work has to do with “an incidental work” and “an external work” of the furniture. We classified a work before the movement of the furniture into “dismantling,” a movement of the furniture into “moving,” a work fixing the furniture after the movement into “fixing,” a preparation, an arrangement, and a movement of other furniture into “an incidental work,” and taking in and out of things in the furniture into “an external work.” Also, in this analysis, we used a work sampling method at regular intervals in which a work is recorded every 30 seconds (0.5 min.).

6.3. Analysis of construction qualities of the experiment

1) Temporary modification on combination of beds
In the plan 1 in which 4, 5, and 9 are moved, the plan 2 in which 6 and 7 are moved, and the plan 3 in which 4, 5, and 9 are moved to the north wall, movable storage furniture units were already connected to each other while being moved. Single movable storage furniture was planned to move vertically, so casters were attached while workers moved the connected furniture vertically maintaining their rotation numbers equal. Since there was no need to dismantle a finishing panel or to disconnect the furniture, taking in and out of things in the furniture was also not needed. The man-hour of the modification into the plan 1 was 32 man*min, the man-hour of the modification into the plan 2 was 34 man*min, and the man-hour of the modification into the plan 3 was 33.5 man*min.

On the other hand, because this experimental residence was renovated making use of the existent skeleton, there was distortion from the beginning and that caused a gap of 10cm between the wall and movable storage furniture 4, 5, and 9 in the plan 3. Therefore, considering the safety against tumbling and the design, we decided to add a plan 4, in which 4, 5, and 9 were disconnected then 4 and 5 were connected with 6 instead of 9. For that reason, in the modification into the plan 4, the man-hour of dismantling (26 man*min) and the man-hour of fixing (78 man*min) were high and the total man-hour was 117 man*min.

2) Temporary modification on layout of the L-shape
In a modification into the plan 5, in which a conversation and an association spaces became larger by rotating 4, 5, 8, and 3, B2 (300*300), movable storage furniture 8 which played a role of connection, was not able to move vertically and caused a load on other connected furniture, and the furniture could not be rotated because casters only in the front were loaded. As a result, we disconnected 1, 2, 8, and 3 and then moved them, letting the things inside the furniture taken in and out. In the modification into the plan 5, the man-hour of dismantling (16.5 man*min), the man-hour of fixing (22 man*min), and the man-hour of an external work (37.5 man*hour) were high and the total man-hour was 112.5 man*min.

7. CONCLUSION
The study considered the temporary need for the modification on the floor plan of the house unit in the renovated building KYUDOGAKUSHA. The study examined the technical aspect of the movable storage relation to a small-scale modification, and found the following:

1) Examination of movable storage furniture and layout: the study investigated the movable storage furniture that is slim and has a double grid modular coordination with the device for fixing and moving. The selected furniture was expected to be utilized for a small-scale modification by a resident. Regarding the furniture layout, the study was able to find that the island type did not create a closed space and it was easy enough for the non-specialists to make the small-scale modification.

2) Concerning technical aspect of the movable storage furniture:
The plan type C (island type layout) which was utilized for a small-scale modification by a resident shows that unit’s space and resident’s action respond to each other depending on a situation. The study shows a reduction of
temporary blind spots and a rearrangement of beds as residents modify layout of the furniture to adjust to temporary demands.

To adjust movable storage furniture for the small-scale modification, the study found technical problems of the furniture. The furniture B2 (300*300mm) which played a role of connecting other furniture caused a problem of generating load to the other connected furniture. Unlike other movable storage furniture’s horizontal moving, rotating the B2 caused a different load to its two casters which are located on the front side of the furniture; this needs an improvement.

Regarding the man-hours of the modification, the plan 1, 2, and 3, in which movable storage furniture is already connected to each other, have shorter time of the modification than plan 4 and 5. Because unlike plan 4 and 5, in which movable storage furniture is moved in a conventional way, the plan 1 and 2 did not need disconnecting or fixing the furniture or taking in and out of things inside the furniture. This shows the possibility for the improvement in construction qualities of moving the connected furniture.

From the analysis above, in the island plan, the study shows that a movement of connected movable storage furniture can apply to a small-scale modification although the study shows there is still room for improvement.

ACKNOWLEDGMENT

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REFERENCES


Endoh Junko and other four (2003) “Research and Development on Housing Components for the KSI Housing System : Research and Development of the Floor material for interior finishing to be used as Floor preceeding construction method, part 1.” Summaries of technical papers of annual meeting in Architectural Institute of Japan, 743-744

Fukao Seiichi (Nov. 1998) “Considering a durability of houses.” Housing, 2-4


Hatsumi Manabu and other four (Sep. 2000) “Concerning Kitakata Houjing(Takahashi, Sejima)(1).” Summaries of technical papers of annual meeting in Architectural Institute of Japan, 101-102


Nishido Hirotaka and other four (Sep. 2001) “Change the room arrangement in rental housing units with variable infill.” Summaries of technical papers of annual meeting in Architectural Institute of Japan, 1175-1176


Saito Hiroko and another (2000) “Supplying and managing problems of variable infill which correspond to apartment houses of skeleton-type on lease.” Urban Housing Sciences, 29:70-77


Shinohara Satoko, other two, and a lifestyle workshop (Jul. 2003) “A changing family and a changing residence.” Shokokusha publishing, 105

Sone Yoko (Feb. 2002) “Secular Change of Residents and Dwelling Unit Floor Plans in ‘Pilot House.’” Journal of architecture,planning and environmental engineering, Transactions of AJJ, 540:89-96


Ushiyama Mio and other four (2003) “Research and Development on Housing Components for the KSI Housing System : Research and Development of the Floor material for interior finishing to be used as Floor preceeding construction method, part 2.” Summaries of technical papers of annual meeting in Architectural Institute of Japan, 745-746
The variable infill study group in KYUDOGAKUSHA renovation housing (Jun. 2007) “Research on the utilization of movable storage furniture through regeneration of existing apartment house.”

Yi Yongkyu and other two (Sep. 2006) “An Examination of a change in the way of living in Flex Court Yoshida in which movable storage furniture is used.” Urban Housing Sciences, 55:87-88.


ENDNOTES

*1) According to the report of Saito and others (2000), among 17 research cases of variable infill in SI house, “Hi-Town Kitagata” and “Flex Court Yoshida” have a facilitative modification quality of movable storage furniture, and according to the research report concerning variable apartment houses(BRI, 2001), among 40 cases of variable infill in SI house distilled from Architectural Institute of Japan, Association of Urban Housing Sciences, Architectural and House magazines, documents from institutes, etc., there were four cases which admitted the movement of movable storage furniture by a resident.

*2) Because the mechanism of movable storage furniture is complicated and is for specialists, the cost is high and there are few cases in which the furniture is moved or fixed (Saito, 2000; Sone, 2002; Iwahista1, 992), but we found out that a resident can move and fix the furniture by himself if the mechanism is simple, and also there are reported facts that there is a latent need for moving and fixing the furniture by oneself (Nishido, 2001; Kawamura, 1997) and that there are various ways of layout of the furniture for the resident. (Hatsumi, 2000; Yi, 2006)

*3) Hirohara(2002) pointed out that with a change in a form of family, a rearrangement possibility of space making by a selection by a resident is important. Also, Shinohara(2003) and Kazehiro(2000) claimed the importance of a variability of a relation and a sense of distance of a family with various structure and importance of not only reorganizing but also not restricting a corresponding relation between space and living are pointed out as problems of living in the future.

*4) Noshiro(2003) pointed out that the technological development through new architectures of open buildings is the main cause for infill not to be popularized, and although existent buildings were the main subject for open building and its way of thinking, the technological development for loosening a physical restriction caused by a shape of skeleton has not been seen yet. Also, Fukao(1998) claimed that houses built in the 1950’s and the 1960’s are in such low qualities that they are inevitable to be demolished and are something like milk teeth in Japanese urban houses, and houses like permanent teeth, built after 1975, would keep standing for a long time, and also insisted on importance of regeneration and utilization of existent residences which can maintain a quality to a certain extent. Residences in high qualities are expected to be regenerated as SI residences, and infill is considered to play bigger role than skeleton.

*5) Kurosawa(2005) made a residential examination focusing on university students (29 people) living alone from 1993 to 1994 and made an analysis of the average volume of personal belongings. With individualization in family and the change in a form of family standing out in recent years, it can be considered to be appropriate to set a storage quantity of an individual, who lives alone and can move in and out easily, as criteria for judgment in this experimental residence which is used as a second house. Therefore, considering the storage of the kitchen (shoes box, linen, and food) and the storage under the stairs (large things), we set a total volume (3.22m^3) of bed clothes, clothes, and books as a standard, and used two wardrobe with a depth of 600mm and 7 book shelves (6.20 m^3) with a depth of 300mm.

*6) This movable storage furniture was developed on the premise to make a private room in new apartment houses, and the use of the prop stick in a room with a tall height was studied later. Also, the safety is guaranteed in an earthquake-proof experiment by the manufacturer (The variable-infill study group in KYUDOGAKUSHA renovation housing, 2007).

*7) Suzuki(1974) explained that there are “a territorial thought” and “a space unit thought” in architecture, and the territorial thought has an intention of reconsidering the way of modern architecture. Concerning living and territory, N. J. Habraken(1998) mentions that living was not primarily based on a private room with a function but territory, and that architecture need to get back to a space opened to living. Also, Shinohara(2003) mention that there should not always be a private room separated from others for an individual in a small area, but there needs to be a simple, variable device which creates territory in the small area.

*8) In this study, to focus on how skilled a worker is, we classify a person who has not fixed or moved movable storage furniture into a non-specialist. Also, in this residence, which is used as a training center at university, a SOHO, or a cottage in town, movement by a graduate student and a family of a researcher can be expected.

*9) In all of the four times, three T1 (two storage, one TV rack), two T2 (wardrobe), two B1 (sideboard), two B2 were used. In the first and the second time, we assumed two sofa beds, two tables, and four chairs would be used as other furniture. In the third and the fourth time, we assumed two beds, one table, two sofas for two people, one sofa for one person, and six chairs would be used as other furniture.

*10) Considering a variety in a form of family and living, an examination by a woman, an elderly, and a child is also important. In the modification into the plan 1, we had an examination with a woman participating and got a result of high construction qualities as well as the modification into the plan 2 and 3. A worker per work is shown in the table below.

<table>
<thead>
<tr>
<th>modification</th>
<th>24 year-old woman</th>
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<th>23 year-old man B</th>
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(Data of Submission : 2008. 8. 3)