Typical Plan Types of Flexible Housing
Based on the Analysis of Variation Trends

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Abstract: This research aims at suggesting suitable plan types for flexible housing based on the distinctive characteristics of the flexible apartment unit plans in Korea identified through the diachronic analysis of the variation trends. This study performs space analysis using the Space Syntax Model by quantifying the interrelationships among the spatial units each of which are designed to satisfy specific needs of residents. In this paper, 256 flexible unit plans are investigated to analyze the variation trends in flexible housing unit design. This study also identifies typical plan types for flexible housing based on the generalized variation trends.

Keywords: Flexible unit planning, Variation trends, Space Syntax Model, Typical plan types

1. INTRODUCTION

Residential needs frequently change according to the occupants’ life cycles and their various life styles. However, standardized and mass-produced conventional housings are not flexible enough to satisfy residents’ such demands. One of the ways to satisfy dynamic residential needs is to explore a flexible housing concept. Prefabrication may be considered for this purpose. Constructing an entire house through prefabrication is ideal but it practically is not feasible because of high construction cost and increased maintenance efforts. It is therefore necessary to analyze unit plan variation trends to identify multiple resident’s needs to adapt the spaces in a house, accordingly. To identify more economical and rational residential unit plan variations, it is indispensable to know the set of spaces needed to be frequently adapted by the residents.

The major goal of this research is to generalize the direction for the flexible floor planning based on the adaptation tendency in contemporary Korean residential unit plans.

2. RESEARCH SCOPE AND METHOD

Significant numbers of cases are explored to analyze the trends in residential floor plan variations. The flexible apartment housing units studied in this research are limited to the interior spaces designed to be reorganized or the ones having at least more than one spatially controllable area between a bedroom and the other. These spaces are normally constructed with bearing wall structure, bearing wall plus column structure, beam and column structure, or flat slab structure for the division, removal or shifting of spaces with non-bearing wall, sliding door, or furniture-type wall. From the perspective of geographical distribution and construction year (the first year of
actual dwelling), the investigated flexible unit plans have been constructed or will be constructed around Seoul metropolitan area during 1991 - 2005 period. Those housing units selected are introducing various flexible floor-planning features. As a result, total 256 cases are collected for the survey from various sources such as apartment floor plan brochures, catalogues, and web sites of the leading Korean construction companies.

Flexible types, characteristics, and design trends are extracted from the collected cases based on a group of selection criteria such as area, front bay number, and the year of construction. As for area criterion, 60m², 85m², 102m², 135m², 165m², and 180m² or more are considered. This research compared and analyzed the integration values for both before and after the floor plan variations along with the calculations of the frequencies and percentages of such variations. As a consequence, this research was able to produce a set of generalized typical plan types insightful for the flexible housing in the future.

3. OUTCOME OF THE ANALYSIS

3.1. Overview of the Collected Cases

The magnitudes of flexible apartment housing constructions in Korea mapped onto time dimension show that the highest distribution is 34.4% (88 cases) in 2002. Significant portion of the examined cases, 63.7% (163 cases), were constructed during 2001-2003 period. Interestingly, the instances have increased rapidly since 2000 compared to 1990’s and the un-built cases whose points of construction are after the year 2003 will be continuously constructed in the future, therefore, this tendency will likely be maintained.

The frequencies of the collected flexible unit plan cases classified by area are in the decreasing order of 135m²(94 cases), 165m²(71 cases), and 102m²(55 cases). 85.9% (220 cases) of the collected flexible unit plan cases are below 85m² and only small portion of the cases show 180m² or more.

The cross-analysis based on the year of construction and unit area reveals another interesting observation. The apartment units having the area of 165m² and 102m² were dominant compared to the other unit sizes before and after 1994. In the mean time, the units with the area of 135m² have increased rapidly before and after 2002 so that it became the most prevalent apartment unit type followed by the units the sizes of which are 165m² and 102m² as is shown in Figure 1.

Figure 1 Distribution of the Cases Based on Year of Construction and Area
3.2. Characteristic Features of the Surveyed Flexible Unit Plans

Table 1 shows flexible unit plan diagrams obtained from the survey. The diagrams are constructed based on the number and frequencies of variations as well as the bays in which variations are occurred.

<table>
<thead>
<tr>
<th>Number of Variation</th>
<th>Plan Type</th>
<th>Frequency/Bay</th>
<th>Number of Variation</th>
<th>Plan Type</th>
<th>Frequency/Bay</th>
</tr>
</thead>
<tbody>
<tr>
<td>107 cases</td>
<td>&lt;R, L&gt;</td>
<td>2</td>
<td>3 cases appear in 4bays</td>
<td>&lt;R, R, L/R, d, R&gt;</td>
<td></td>
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<tr>
<td>Appearance in 2,3,4 bays</td>
<td>87 cases</td>
<td>&lt;R, R&gt;</td>
<td>1 case appears in 3bays</td>
<td>&lt;L, M&gt;</td>
<td></td>
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<tr>
<td>Appearance in 2,3,4 bays</td>
<td>30 cases</td>
<td>&lt;R, R, L&gt;</td>
<td>2 cases appear in 3bays</td>
<td>&lt;R, L, R&gt;</td>
<td></td>
</tr>
<tr>
<td>Appearance in 2,3 bays</td>
<td>5 cases</td>
<td>&lt;R, K&gt;</td>
<td>1 case appears in 4bays</td>
<td>&lt;R, R, L/R, d&gt;</td>
<td></td>
</tr>
<tr>
<td>Appearance in 3 bays</td>
<td>5 cases</td>
<td>&lt;L, M&gt;</td>
<td>1 case appears in 4bays</td>
<td>&lt;R, L, R/R, K&gt;</td>
<td></td>
</tr>
<tr>
<td>Appearance in 4 bays</td>
<td>5 cases</td>
<td>&lt;R, L/R, d&gt;</td>
<td>1 case appears in 3, 4bays</td>
<td>&lt;R, d&gt;</td>
<td></td>
</tr>
<tr>
<td>Appearance in 5 bays</td>
<td>3 cases</td>
<td>&lt;R, R/R, L&gt;</td>
<td>1 case appears in 3, 4bays</td>
<td>&lt;Examples&gt;</td>
<td></td>
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<td></td>
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<td></td>
<td></td>
<td>R, R</td>
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<td></td>
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<td>R-R</td>
<td></td>
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<td>R-R</td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td>B-Bath Room</td>
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<td></td>
<td>d-Dress Room</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>M-Multi Room</td>
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<td></td>
<td></td>
<td></td>
<td>E- Entrance</td>
<td></td>
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</tbody>
</table>

Variation between Bedroom and Bedroom
Partition between Bedroom and Bedroom
Without Partition between Bedroom and Bedroom
Variation between Bedroom and Bedroom and variation between Bedroom and Living room
3.3. Relational Analysis of the Flexible Floor Types by Area and Bay

One of the characteristic features of the concurrent Korean residential unit plans is that there is a preferred typical unit proportion which usually is a rectangular form whose width is wider than its depth. The reason for this is that the construction companies focus on specific floor plans to attract customers by providing unique apartment units which have many bays (the number of bedrooms or living rooms adjacent to the front balcony) because more bays suggests better view and more daylight from outside. Hence, the preference profile shown by the frequencies for the different number of rooms close to front bay is more distinctive than that differentiated by the area since the major way of performing flexible planning is to transform the rooms adjacent to the front bay in most flexible apartment housing projects investigated (Figure 2).

Figure 2 Flexible Unit Planning Distributions Based on Area (left) and Front Bay (right)

Frequency analysis of the flexible spaces classified by the area shows that the variation between a bedroom and a kitchen or the variation between a bedroom and a living room addresses 4 cases each and those cases appeared mostly as 60m² type. 5 out of 7 cases of 85m² type are coupled with the variation between a bedroom and a living room. Variations happen not just between a bedroom and a living room; they are also performed between a bedroom and a kitchen and are implemented for the design of 3 bedrooms of 3LDK or for making a bedroom larger among a living room, a kitchen, or a dining room of 2LDK.

The variation that happens between a bedroom and a living room addresses 34 (61.8%) out of 55 cases of 102m² type and the variation between a bedroom and another bedroom is represented in 14 cases. As the size of the bedroom adjacent to front area decreases due to a limited front area in 4 LDK, the choice of variation among 4 LDK, a large living room and 3 LDK, or a large bedroom and 3 LDK is occurred.

Each of R, L type and R, R type takes 33 out of 94 cases in 135m² category; R, R, L type takes 21 cases; R, R type takes 31 cases (43.7%); R, L type takes 24 cases; R, R, L type takes 6 among 71 cases that are classified as 165m² type; R, R type and R, L type take 7 among 17 cases of over 180m² type.

For the floor unit plan having more than 135m², it is important to make a large living room, however, it seems that the bedroom size is important matter ensuring more than 3 bedrooms. In general, as the area increases, the variation between a kitchen and a bedroom, the variation between a living room and the bedroom adjacent to the living room, and then the variation between a bedroom and an adjacent bedroom appear. It is found that the variation is directed to primarily control the size of the bedroom (Figure 3).
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As for the relationship between flexible unit types and the number of bays, the flexible planning between a bedroom and a living room generally happens in 3 bays, and the flexible planning between a bedroom and the other bedrooms marks the maximum frequency in 4 bays. There is also a variation among bedrooms and a living room in 4 bays (Figure 4).

3.4. Differentiation of Flexible Spaces Based on Diachronic Flow

Among 14 types of flexible apartment unit plans as are shown in Table 1, the main variation types identified are showing changes between bedroom and living room (R, L type), bedroom and bedroom (R/R type), and bedroom and living room (R, R, L type).

The variation between bedroom and living room is continuously distributed from 1991 to 2005 except 1997 and this type of variation is evenly distributed across all area types, relatively. The same tendency is expected to be continued until 2005 as the flexible planning of bedroom and another bedroom (R, R) has appeared in 165m² since 1999, 135m² since 1995, and 102m² since 2001. It is also expected to be continued until 2005 that the flexible planning among a bedroom, another bedroom, and living room has appeared in 135m² since 2001.

The R, L type unit plan appeared first, followed by R, R type, then R, R, L type has emerged since 2000 which became one of the domineering types in apartment unit design.

Mixed flexible planning has evolved with various flexible planning since 2000 (Figure 5).
If a flexible space is classified in terms of a private space (bedroom, dress room, or study room) and a public space (living room, kitchen, or multi-room), the major variation type is the variation between private and public. The variation is also increased as time passes. The newer types, \(<R,R,L/R,d,R>\), \(<R,R,L/R,d\rangle\), and \(<R,L,R/R,K>\), are developed from the initial types, \(<R,R>\) and \(<R,L>\). Therefore, it can be said that complex types tends to be developed from initial simple variation types, which causes flexible spaces to be increased in number, gradually.

4. INTEGRATION VALUE ANALYSIS BASED ON THE SPACE SYNTAX MODEL

4.1 Flexible Space Analysis Based on Space Syntax

Based on the number of spaces divided by the unit plan variation, integration value change of a varied plan can be derived as follows:

\[
\text{integration value} = \frac{\text{spaces after integration of flexible unit plan} - \text{spaces before integration of flexible unit plan}}{\text{spaces before integration of flexible unit plan}} \times 100\%
\]

As a space changes in flexible apartment unit guided by the formula described above, the results of integration values calculated for various flexible floor plans can be shown as Figure 6. In this figure, R-L-R/R-K indicates that the plan has variations among front side bedroom, living room, and another bedroom plus the variations between rear side bedroom and kitchen. R-L-R/RK is the same as R-L-R/R-K except the one unified space created through removing a non-bearing wall between the bedroom and the kitchen, RK. In this representation, slash (/) signifies the division of a variation case.

As for the apartment units that modify interior partitions, the integration value generally decreases by removing partitions, namely, the residents' approaches to each room or space become easy.

As for the flexible planning characterized by the variation between bedroom and living room which has emerged since 1991, integration value difference is about 5% for most variations between bedroom and living room.

However, as time passes, the partitions among bedroom, living room, and another bedroom were disappearing to enlarge living room and the partition between kitchen and the bedroom next to the kitchen was removed for making the kitchen bigger in type RLR/RK. With this trend, the maximum integration value difference became 20% in flexible unit planning and it has continuously increased until now. As for the relationship between front bay and integration value, front bay makes integration value difference increased.

Similar to the relationship between front bay and flexible space examined above, the more the number of variable bay increases, the more flexible unit planning methods become. Thus, the integration value differences get large.

Generally, integration value has difference based on the number and the types of spaces such as private or public flexible spaces. In other words, the number and type of a flexible space control integration.
As the ways of making flexible plans and the number of spaces that come from such operations increase, it became possible to experience various spatial cognitions even within restricted housing units. At the same time, there has been little change for the integration value differences throughout time dimension while such differences are obvious depending on the changes in flexible unit plan types and the front bay.

4.2 Case Analysis of Flexible Unit Plans through Space Syntax

Figure 7 shows the space analysis value obtained by the Pesh program. It also shows integration values represented by various colors based on the <RLR/RK> type flexible planning and the maximum integration value difference as well. Existing apartment housing unit mainly holds a living in master bedroom and living room.

It is also examined that red and yellow, illustrating high integration value, are master bedroom (R1) and living room (L) in flexible apartment housing unit plan, likewise. Also <RLR/RK> type in Figure 7 shows the maximum integration value difference ranging from 0.699(h) to 0.878(a) which is calculated through the quantitative analysis of Space Syntax.
5. SUMMARY AND CONCLUSION

As one of the outcomes of this research, the characteristics of Korean flexible apartment housing can be described that it is a generally tendency to change interior walls to achieve unit plan variation(s) while maintaining the overall shape of existing apartment unit. It turned out to be that a strong conceptual background for systematic flexible unit planning does not exist. There also is little attention to the un-varied (fixed) spaces. Generally, unit variation is presented as optional space layouts when occupants move into a new apartment house but that cannot fully accommodate the changes and the varieties of life during the entire occupancy period.

1. Based on the survey, 14 types of flexible spaces can be suggested.
2. Based on the frequency analysis, the migration of variation types for the surveyed flexible floor plans can be categorized into the variation from R, L type to R, R type and that from R, R type to R, R, L type.
3. Flexible planning types have a definite configuration in relation with front bay rather than area.
4. Since 2000, diversified types of variable floor plan systems have emerged and they have been developed as complex types which are connected to the back and front of a unit plan. Among these various flexible unit plans and diversified types of spatial organization, the mainstream are the types that have been conceived and evolved from...
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the flexible unit planning operated between private and public spaces such as bedroom and living room.

5. The change of Space Syntax value caused by variable planning shows an increase. As for the tendency of variable planning based on Space Syntax, the integration value was changed by about 5% in the early of 1990 and recently the maximum of the change value for <R, L, R/R, K> type is about 20%.

Based on the result, to correspond to the need for resource saving and to provide various spatial cognitions with residents, a typical flexible plan type tends to have:

1) Variations between private and public spaces
2) Larger number of the spaces affected by the variation
3) Higher integration value difference calculated before and after the variation

For example, in <R, L, R/R, K> type, the number of spaces affected by the variation, placed with non-bearing wall, is two, the variation is the type between private space (bedroom) and public space (living room and kitchen) and the global integration value is the highest of all variation types. Therefore, this type makes it possible to recognize more diversified spatial cognitions than others. Namely, this type could be more desirable to design a flexible unit plan than others in the future.

The research result presents both stimulating and useful information applicable to the other flexible housing unit plan design and construction. We believe the quantitative analysis using Space Syntax Model is also insightful to offer a set of numerical data for the development of better flexible housing unit plans.

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