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Research paper

A Flexible Modular Housing System Considering User Preference - Focused on Single-Family Houses for the Elderly-

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Abstract

Background/Objectives: This study aims to propose a flexible modular housing system that takes into account the user preference according to lifestyles and lifecycle of the elderly.
Methods/Statistical Analysis: This study, through the precedent research and theoretical consideration, analyzes the behaviors of the elderly, the characteristics of their housing, and the housing planning technique, especially regarding modular housing, and derives flexible housing planning elements. Analysis of the behavior of the elderly and the characteristics of their housing shows that they have specific preferences for the type of housing flexibility they desire, which can be fulfilled by modular housing.
Findings: Based on the analysis of the characteristics of the elderly and flexible housing plan, a system is configured comprising elements of transformation, addition, and deletion that can be disassembled and recombined according to the behaviors and life types of the elderly. The prototypes are developed for three stages: an independent couple in their sixties, a dependent couple in their seventies, and a dependent single in their eighties, depending on the 10-year lifecycle. In each step, transformation, addition, and deletion are applied separately, and flexible modular housing prototypes are suggested according to the lifestyles and lifecycle of residents. Much research has been published on the topic of elderly housing, but there have been few integrated studies that propose flexible housing plans that adapt to the life types of the elderly. In addition, there is little research on single-family houses, where many elderly people live. This study is distinct from previous studies, as it presented a flexible modular housing system considering user preference according to lifestyles and lifecycle of the elderly.
Improvements/Applications: This study provides a platform upon which the scope of research can be expanded, and prototypes customized for other users, such as young people, will be suggested in the future.

Keywords: *Flexible, Modular, User Preference, Elderly, Single-Family Houses*

1. Introduction

Currently, the elderly population in Korea is increasing rapidly due to improvements in living standards and developments in medical technology. It is expected that Korean society will become a super-aged society from the year 2030. With such changes, there is a need to provide housing with spatial composition informed by the needs and preferences of the elderly. The housing environment is important for elderly people, as it has a large influence on their quality of life. Modular housing, which has recently attracted attention as a solution to these demands, can respond quickly to changes in the lifestyles and lifecycle of elderly people. There has been much research on housing for the elderly, but there have been few integrated studies on flexible housing plans that adapt to their lifestyles, and there is little literature on single-family houses, in which many elderly people live.

The aim of this study is to provide basic data on sustainable housing customized for elderly people. The study focuses on a flexible modular housing system that can adapt to the lifestyles and lifecycle of elderly people, living in single-family houses.

2. Materials and Methods

This study reviews the literature on the behaviors and lifestyles of elderly people to derive a model of flexible housing planning. This is used to propose a flexible modular housing system and prototypes for a single-family house for the elderly, as shown in figure 1.

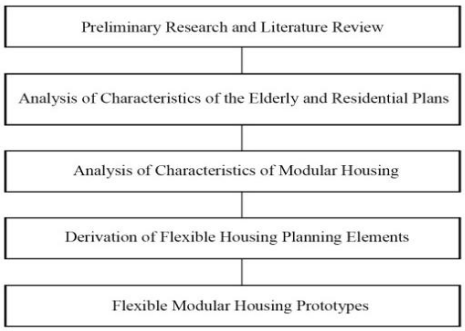

Figure 1: Research methods and process

2.1. Analysis of Characteristics of the Elderly and Residential Plans

2.1.1. Behaviors of the Elderly

The behaviors of elderly people can be classified into three types: complete independence, partial dependence, and complete dependence[1]. The group into which elderly people are classified depends on their ability to complete activities of daily life. This can be measured using scales adapted to a Korean context, such as the K-ADL(Korean Activity of Daily Living), which measures basic daily activities across 7 items and the K-IADL(Korean instrumental Activity of Daily Living),which measures instrumental daily activities across10 items[2]. In this study, complete independence and partial dependence are classified as independence. This is because elderly people who are completely independent will gradually become partially dependent overtime. Those classified as completely dependent are labeled dependent, who are completely dependent on a caregiver for help with activities of daily life, as shown in figure 2.

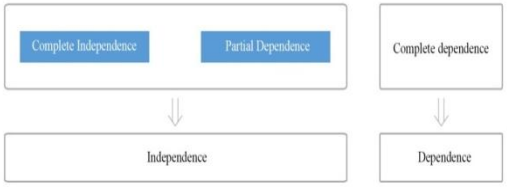

Figure 2: Classification of the behaviors of the elderly

2.1.2. Characteristics of Housing for the Elderly

As shown in table 1, a high proportion of elderly people-42.0% of those in urban areas and 62.7% of those in rural areas-live in single family houses[3]. In figures 3 and 4, although the size of current and preferred residence vary, most elderly people prefer 20–30 pyeong (approximately 66–99 m^2) and 30–40 pyeong (approximately 99–132 m^2) [4]. (1 pyeong = 3.305 ㎡)

Table1: Types of residence occupied by the elderly in urban and rural areas

Unit: person

Category	Single-family house	Apartment	Townhouse	Multi-family housing	Houses in non-residential buildings	Total
The elderly in urban areas	483,110 (42.2%)	473,241 (41.1%)	53,394 (4.7%)	124,798 (10.9%)	15,126 (1.3%)	1,149,669 (100%)
The elderly in rural areas	2,420,382 (62.7%)	1,131,428 (29.3%)	158,612 (4.2%)	99,737 (2.6%)	47,275 (1.2%)	3,857,434 (100%)

Source: Statistics Korea

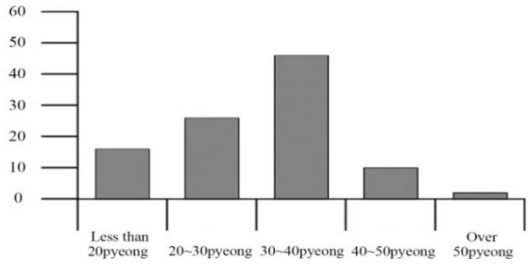

Figure 3: Size of current housing

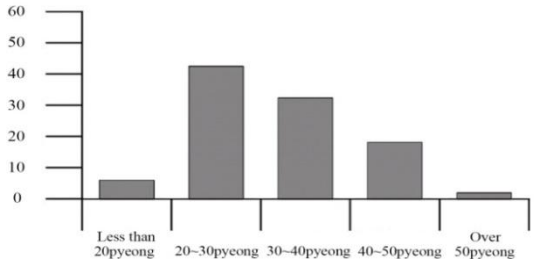

Figure 4: .Size of preferred housing

The most important residential spaces for elderly people are living room (36%), bedroom (22%), kitchen/restaurant (14%), and bathroom (12%)[5]. This is because many elderly people spend a great deal of time in their living rooms and bedrooms. In addition, the living room is the most important regarding space planning, as shown in figure 5, and that elderly people prefer two to three bedrooms and two bathrooms[6]. After a decrease in the number of family members living in the home, spare bedrooms are used for guest or multi-purpose rooms.

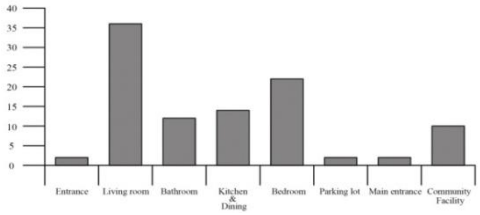

Figure 5: Preference in the residential space

Diverse projects are being conducted to study characteristics of the lives of elderly people and the types of housing most suitable to meet their needs[7]. However, little research has been published showing how housing can adapt to the changing lifestyles and lifecycle of the elderly.

2.2. Analysis of Characteristics of Modular Housing

Modular housing is designed to standardize building members and reflect them in the design. About 80% of the units are manufactured in the factory, and the rest are assembled in the field. Compared to traditional housing, modular housing is more flexible, easier to move, less time-consuming for construction, and more environmentally friendly.

Transportation constraints limit the size of modular housing. The width of the module should be less than 3.0~3.3m, the length should be less than 6.0~ 12.0m depending on the total length of vehicle, and the height should be less than 3.0m considering the height of the trailer and the overpass, referring to figure 6[8].

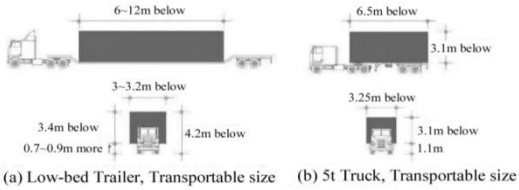

Figure 6: The size of the movable module unit according to the transportation equipment

2.3. Derivation of Flexible Housing Planning Elements

Flexible housing consists of fixed (support) and flexible (infill) elements as shown in figure 7. Fixed elements, such as columns, beams, slabs, and bearing walls, require durability. Flexible elements, such as floors, ceilings, partition walls, are non-structural and can be modified according to the lifestyles and lifecycle of residents[9].

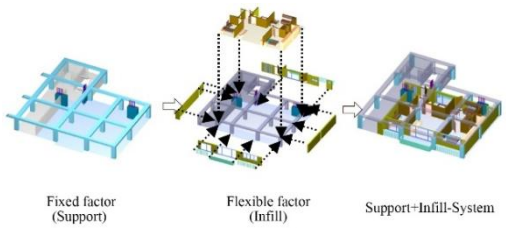

Figure 7: Flexible housing elements

Elderly people prefer the expansion and reduction of the space and the mobility of the partition and the wall as needed, as seen in table 3[5].This may be because elderly people want to change the spatial composition of their houses according to physical, psychological, and family composition changes. Based on the preferences mentioned in table 2, the flexible housing elements according to whether they are independent or dependent are shown in table 3[5].

Table 2.Preference for different types of housing flexibility

Category	Flexible housing elements	Preference
Flexibility	· Installation of height-adjustable bathtub	low
	·Free adjustment of doorway width	low
	· Accessible wall for easy access between bathroom and bedroom	middle
	·Spatial flexibility plan that can be connected to the public space	middle
	·Height-adjustable table and countertop set for physical condition	middle
	· Mobility of partition and wall	high
	·Expansion and reduction of space as needed	high

Table 3: Flexible housing elements according to the elderly types

Characteristic	Type	Flexible housing elements
Flexibility	Independence	·Percentage of bearing wall and column length ·Percentage of drywall in total interior walls in a household ·Easily adjustable method (a method that does not destroy the previous process of floor, wall, ceiling finish) ·Partization of wall materials ·Securing the route of piping and wiring ·Possibility of separation and expansion of architectural plan ·Mobility of partition and wall ·Flexibility in the space where water is used. ·Flexibility of space by using partition walls, storage walls
	Dependence	·Plan to enable integration, separation, flexibility within the household, expansion of households to adapt to changes in family composition, body, and health status of the elderly ·Minimize unnecessary walls, doors, etc. in the space such as living room, to open and share with adjacent space ·Free adjustment of doorway width ·Height-adjustable furniture for user's specific needs

3. Results and Discussion

Based on the analysis of the behaviors of the elderly, flexible housing characteristics, and life type, this study proposes flexible housing prototypes. The proposed system is configured by combining elements that can be transformed, added, and deleted according to the behaviors and life types of the elderly. As shown in figure 8, the behaviors of the elderly are classified into independence and dependence, and life types are classified into lifestyles and lifecycle. The prototypes consist of three basic planes composed of 8, 9, and 12 modules with a 3.0m x3.0m space module for each single-family house, referring to figure 9. This is based on previous research suggesting that elderly people in urban areas are more likely to occupy single-family houses and that the preferred size of residence is 20–40 pyeong (approximately 66–132 m^2). The lifestyles are classified into the single, couple, two generation cohabitation, and three generation cohabitation, and the lifecycle is based on the age group of sixties, seventies, and eighties, depending on the 10-year lifecycle. Table 4 shows the prototype matrix that is made by combining the classification according to the behaviors and life types of the elderly.

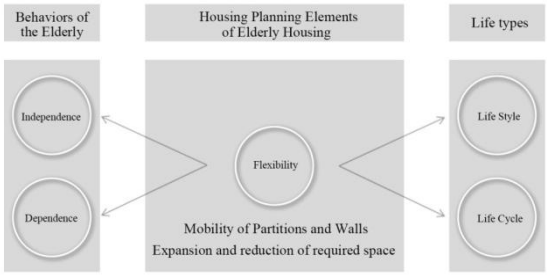

Figure 8: Direction for flexible housing for the elderly

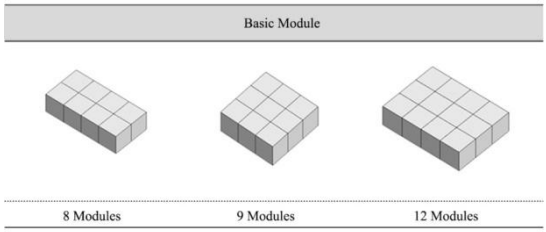

Figure 9: Basic modules

Table 4: Prototype matrix

Life types \ Behaviors of the elderly		Independence	Dependence
Life style	Life cycle		
Single	60s		
	70s		
	80s		8M-3, 9M-3
Couple	60s	8M-1, 9M-1	
	70s		8M-2, 9M-2
	80s		
Two generation cohabitation	60s		
	70s		
	80s		12M-3
Three generation cohabitation	60s	12M-1	
	70s		12M-2
	80s		

As seen in figure 10, the prototypes are developed for three groups: an independent couple in their sixties, a dependent couple in their seventies, and a dependent single person in their eighties, depending on the 10-year lifecycle. Plan elements are modified, added or deleted in each step. In each step, transformation, addition, and deletion of elements are applied separately, and flexible modular housing prototypes are suggested according to the lifestyles and lifecycle of the elderly. Housing spaces are transformed by extending the entrance and bathroom to accommodate wheelchair use and to change a child's room to a guest room. Deletion is used to save energy and reduce maintenance after a child and/or grandchild leave, while addition is used to create a caregiver room or a module that can be used as a terrace or garden for a dependent single person.

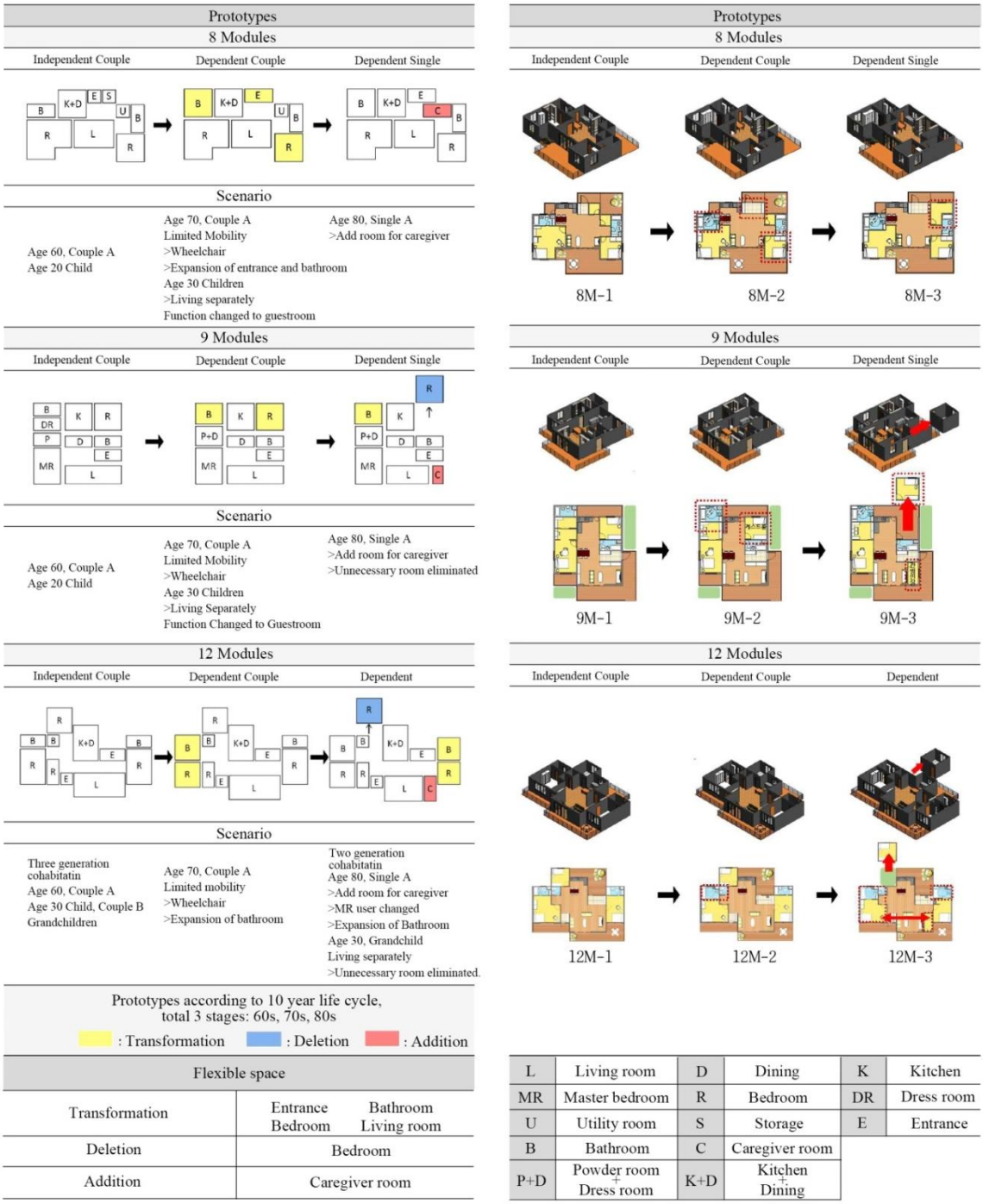

Figure 10: Flexible modular housing prototypes according to the lifestyles and lifecycle of the elderly

4. Conclusion

In order to create a flexible modular housing system that adapts to the lifestyles and lifecycle of the elderly, this study analyzes the behavior of elderly people and the characteristics of their housing. Preferences for different types of flexible housing are identified, and it is shown how modular housing can meet the needs of elderly people in this regard. A system is proposed comprising fixed, flexible, and additional modules that could be disassembled and recombined according to the lifestyles and lifecycle of elderly people. The prototypes are developed for three steps: an independent couple, dependent couple, and a dependent single person, depending on the 10-year lifecycle. In each step, the transformation, addition, and deletion of elements are applied separately, and flexible modular housing prototypes are suggested according to the lifestyles and lifecycle of the elderly.

This study is distinct from previous studies, as it presents a customized modular housing system that changes the housing environment in response to the lifestyles and lifecycle of the elderly. The results of this study provide a platform from which research on this topic can be expanded, and space plans customized for other types of users, such as young people, will be suggested in the future. It is expected that the results of this study will serve as basic data for user-customized residential space planning.

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