Research on the Adaptability Design of Residential Buildings Based on the Upside-down System

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Abstract
Many buildings within age limit have been demolished and reconstructed in this process, which results in waste of resources, environmental pollution and a series of social problems. Open building, as a method of architectural design theory, focuses on the use of the whole life cycle of the building, to provide a new guiding thinking for the future construction of buildings. Theory of open building is not only limited to the transformation of architectural space, but also the change of relationship among time, function and people. This paper takes the upside-down system as the core, and probes respectively two adaptive designs of residential building types in low-rise high density and high-rise high density through several program analyses, to provide references and thoughts for designs of the existing residential building transformation in China.

Keywords: Open building; Residential building; Upside-down system; Adaptability

1. Introduction

For a long time in the development of the history, traditional construction design is based on functionality, different spaces will be set in an eternal fixed position or state due to different need of usage until the whole construction was demolished because of various reasons. This is particularly evident and common in large demolition, rapid development of China. But in a different perspective, as Professor N.J. Habraken said, "to live is to build", buildings should be an act, a platform, not just a form. Open building design concept is a new idea of thinking about people and time and architecture, space and function start to have a different flexibility from the previous at different levels as people have the “interaction” with time and need, start with little tricks, save resources and costs while meeting their new needs, so as to better ensure the use of the building's lifecycle.

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2. The idea of open architecture in the context of the times

2.1 The idea and characteristics of open architecture

Open building concept was first proposed by Dutch architect N.J. Habraken, emphasis on adaptability as a point of view, to improve the different needs of buildings caused by the different environments and different users in the building's lifecycle. The open building has the follow features: (1) Hierarchy: the interior of the building should be divided into different levels, each level is relatively independent and has different timeliness; (2) Participatory: non-professional households or households should have the same decision-making power as professional designers and construction workers, and thus they are more involved in the construction of practical activities, enhancing the interaction between people and architecture; (3) Relevance: there should be a certain correlation between the various systems in the building, for convenience of interlinking and piecing; (4) Flexibility: architecture and the environment is constantly changing, so the design is a gradual and gradual process change with time.

2.2 The development of open architecture and the practice in China

Open building has gone through three major historical stages: 20-30s year of 20th century, modern architects’ flexible attempt on the small residential areas; after World War II, discussion about building components and designs of construction method caused by the large-scale industrial production; in the past 30 years, due to the deepening understanding of the relationship between people and time and architecture, high comfort, low energy consumption concept is widely recognized.

China's open building system and theory began later than Europe and Japan etc., one of the practice cases is the supporting residential house built in the outskirts of Wuxi City by a professor Bao Jiasheng in 1984, later, China's open building research and practice started to develop along the two directions of composition of the development of components and architectural design strategy, the application of Upside-down in the transformation of contemporary China's residential buildings in the third part of the text comes from the teaching practice of open building joint workshop of Beijing University of Civil Engineering and Architecture and China Institute Building Standard Design and Research directed by professor Steven Kendall.

3. Composition and Characteristics of Upside-down (inverted beam system)

3.1 Opening Building’s feature

We divide the different walls of Open Building into three levels, respectively, they are the walls can be never changed (Black Wall), the walls that can be changed by the developers (Grey Wall), and the walls that can be changed by the users (Red Wall) that is internal filled wall. Users can change the internal filling wall of the separation of space according to their own needs to meet the needs of different periods of living, to achieve the vision of a century. And the core technology, Upside-down of the Open Building achieved the separation of infrastructure(Skeleton) and filling structure(Infill).

3.2 An open adaptive system - Upside-down (inverted beam system)

Upside-down is a system of inverted beams, the method of operation is to flip the beam at the floor, and the ceiling, wall, and floor layer in the pipeline system of traditional residential are all collected in the inverted beam system. Then the movement and change of the wall and the ceiling in space make no different to the pipelines, also achieved the variability of the wall. The bathroom is assembled, after determining the infrastructure of the pipeline, the bathroom can be placed in different areas within a certain range depending on the needs of the household.
3.3 Upside-down and the Feasibility of Combining Residential Design

In the 1960s, Professor of the Institute of Architectural Studies in the Netherlands, N.J. Habraken proposed the theory of open building, and applied the Upside-down system (inverted beam system). In recent years, China has also developed on the basis of open architecture for China's national conditions of the SI system. SI system refers to the residential load-bearing structure as a long-term base system (Skeleton), its characteristics need to have a strong durability and can be a hundred years unchanged. But the space building within the building is flexible and variable, adaptive design can be operated according to different needs, the households can also adjust the space based on the changes in its population in a timely manner. This adaptive interior space (Infill) makes the idea of a century building easier to achieve. At the same time, it is also due to the Upside-down (inverted beam system), the internal filling wall can get out from the bondage of pipelines and access to flexibility and meet the residential multi-directional needs.

4. An Experimental Study on the Adaptability Design of Residential Buildings in Upside-down system

4.1 Low-rise High-density Residential Type

4.1.1 Features of Low-rise High-density Residential

Low-rise high-density residential has a low-level, close to the natural advantages of the ground, make it more convenient for the tenants to have independent venues, making people get close to nature more easily, and is especially suitable for the elderly and children. Today, there are more and more people in the city began to yearn for low-rise residential life. However, the early low-rise high-density residential interior piping system is intricate, seriously affecting the use of indoor space, making the indoor space changes become difficult, and cannot meet the needs of households very well.

4.1.2 Prototype Selection and Research

We studied a number of college dormitory as a prototype, and had design of the study. With a view to the building property rights attribution and the actual transformation of the implementation, we finally positioned the design to a college student dormitory. The university dormitory property belongs to school, and because of the development of the times, policy changes and other factors, its initial function will be replaced. For buildings that do not have an open building design concept, such a large functional change has resulted in significant waste of resources, environmental pollution and high costs. We take a certain apartment in a university in Beijing as a prototype to extract the characteristics of its architectural structure, introduce open
architecture and Upside-down (inverted beam system) to adapt to usage needs of the new era of college dormitory.

Fig. 2. An Apartment Floor Plan of a College in Beijing.

4.1.3 Adaptability Design of Low-rise and High-density Residential Buildings - a Case Study of a University Apartment

According to the design principles of open buildings and the structural characteristics of Upside-down (inverted beam system), the building can be divided into the main structure system (frame structure and traffic box), gray wall system (facade and sub-wall), filling system (indoor partition and the whole kitchen, Wei) and furniture four levels, and then develop different needs according to their users, at last develop possible sets of types and the variable built-in system program within the sets.

<table>
<thead>
<tr>
<th>Acreage</th>
<th>34.81 m²</th>
<th>67.38-73.19 m²</th>
<th>99.94 m²</th>
<th>132.44 m²</th>
<th>147.11 m²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type of people</td>
<td>Students, Single young teachers</td>
<td>Students, Young teachers</td>
<td>Young teachers</td>
<td>Young teachers</td>
<td>Young teachers</td>
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<tr>
<td>The number of people</td>
<td>1-4 persons</td>
<td>1-2 persons</td>
<td>2-4 persons</td>
<td>2-6 persons</td>
<td>4-8 persons</td>
</tr>
</tbody>
</table>

Table 1 Adaptive hours type design (Part)

4.2 High-rise High-density Residential Type

4.2.1 High-rise High-density Residential Features
High-rise high-density building is the main building type of the city today, widely used in housing, office, business and so on. This paper discusses how to adapt to the change of population structure and the change of family demand, and provide a reasonable strategy for the future development of residential industry. The design uses an open building Upside-down, which breaks the restraints of various pipelines within the traditional house and provides the flexibility and openness of the internal space to meet the different needs of different people for residential space. This theoretical system is not the innovation of architectural technology, instead it relies on the characteristics of today's times and economy and technology, the change of concept of housing and design, that is, to meet the needs of society, “open” building.

4.2.2 Prototype Selection and Research

The main problem facing Chinese cities is the series of urban diseases caused by infinite spread, but it may be solved by open building that takes the lifecycle of building as a breakthrough. This section takes high-rise high-density residential as the research object, the Upside-down system as the basis, studies the problem of different groups’ requirements of different residential space, and selects a high-rise residential tower as the prototype building.

Fig.3. Beijing High-rise Tower House Floor Plan.

4.2.3 Adaptability Design of High-rise and High-density Residential Buildings - taking a High-rise Residence as an Example

China's demographic changes in the demand for residential space types are very different, such as single people and young families just composed and families with children or elderly families have great differences towards the needs of residential space, thus, the research takes the domestic population structure as the main line to discuss a common family’s features of demands of residential space in different periods.

<table>
<thead>
<tr>
<th>Family Demographic Changes</th>
<th>New stage</th>
<th>Newborns living alone</th>
<th>second children living alone stage</th>
<th>Parental care stage</th>
<th>Pension stage</th>
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<td>New stage</td>
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<td>Pension stage</td>
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5. Conclusion

China’s urban housing is in an increasing demand of adaptability and flexibility in the process of rapid development. While the design concept of open building with the Upside-down system as the core is focused on the future, add the human-time elements to the building in a greater degree, enhance the interaction between people and buildings to meet the different needs of people of different times and provide a new idea for the study of the adaptability of our house playing an important role to promote the healthy development of the housing industry.

After a half-month pilot study of works camps, we found that the adaptability of space has been greatly improved, spatial division is more flexible and more chances and possibilities are provided for residents in their later life according to their own needs after the open architectural concept was applied to residential design.

Acknowledgement

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References