Conference Paper

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Publication Date:
2015

Permanent Link:
https://doi.org/10.3929/ethz-a-010578824

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Open Design for Adaptability in Chinese Public Housing

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PAPER ABSTRACT Surveys on public housing in Northern part of China indicated that the common aim of Chinese public housing, which is to provide affordable housing, has been mostly satisfied. However, Critical awareness has been shown that the adaptability of the public housing units was always ignored. More than one fourth (29.9\%) of the public housing units that were investigated were structurally modified by their occupiers for different layouts. This situation indicates that a fixed plan cannot fulfill housing occupiers’ various requirements on spacing layout. This research is proposed to develop and verify a series of design solutions for adaptability in Chinese public housing. Based on the dwelling unit types, dwelling spaces, living modes and demographic conditions of the public housing units investigated, concerning the actual adaptations carried out, this research explores the possible layouts for adaptations and the suitable shape, form, and dimensions of each functional space in different types of Chinese public housing units.

KEYWORDS: Chinese public housing, adaptability, layout

1 Chinese Public Housing

The soaring price of commercial housing makes Chinese government to consider providing public housing for the low-income people, after the housing commercializing reform in 1998. In China, the public housing generally refers to "low-rent housing (Lianzu fang), affordable housing (jingga shiyong fang), and public rental housing (Gongzu fang)\(^1\), which has different target groups. Those eligible lowest income people could apply for low-rent housing units or rent subsidies from the government. Affordable housing are built for those people of certain affordability, and cannot be exchanged in housing market unless the householder make an additional payment to get the whole ownership of the housing unit. Public rental housing, emerged in 2009, aim to benefit the most low-income people through a relatively low rent (compared to common rental housing) and lenient requirements of eligibility (see Fig. 1).

Low-rent housing and affordable housing were the main components of public housing at the initial stage of the housing commercializing reform. They were proved to be effective to curb the soaring commercial housing price. However, the insufficient fund and disorganised management make it hard to resolve the problem totally by Low-rent housing and affordable housing. Drawing on Hong Kong and Singapore’s experience on public housing, Chinese government started to build public rental housing system. Now, Public rental housing is widely believed a new efficient and effective way to meet the needs for a transitional accommodation of low-income people.

Fig. 1. Relationship of three public housing types in China: Public rental housing fill the gap between affordable housing and low-rent housing, also could be accessed by those in waiting lists of the two types

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\(^1\)Wang & Zhao, 2009
According to Chinese “Twelfth five year plan (2011-2015)”, thirty-six million public housing units would be completed and allocated to eligible families. In the government report of 2015, the premier stated that 7.4 million public housing units would be built within 2015. If the number can be achieved, there would be 39 million public housing units built within the five years. It indicates providing more public housing for low-income people is an important duty for Chinese government. In the development of public housing, however, there are still many issues waiting for solutions. In term of building design, the key issue is that the initial design of unit layouts could not satisfy the needs of residents, according to the investigations carried out. That leads to around 30% of residents adapted the internal layouts destructively by themselves based on their diverse needs. To improve residential satisfaction in public housing, providing an open and adaptable interior design might be the solution. It is also an effective method to reduce the constructional waste and save time, money and energy when interior modification is necessarily needed. One more thing need to be pointed out is the Chinese government is national-wide promoting housing industrialisation. For instance, in Shanghai, the local government announced 50% of new buildings in 2015 would be built by prefabricated off-site construction.

Open Building has been widely recognised as a multidisciplinary methodology applied in building design and industrialised construction that support building adaptability according to different requirements.

### 2 Open Building in the Design of Adaptability


Capacity analysis is the demanding practice at the core of design in Open Building. Capacity is defined as the measurable quality of a base building to accommodate a range of variations in floor plan and use within the constraints of a given base building. Capacity analysis explores the degree of Open Building freedom offered by a higher level to a lower level. The dimensions, positions and interface of a lower level should be involved in the analysing process to determine the higher level (see Fig. 2). Investigation on dwelling unit types, dwelling spaces, living modes and demographic conditions is the basis of capacity analysis. For instance, in designing the Support, the possibilities of space and function, zone, and sector should be carefully analysed.

![Fig. 2. Capacity analysis: left, space and function analysis; right, sector analysis (Habraken, 1976, p.82, 85, 88.)](image)

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3 Li, Setoguchi and Huo, 2013


Fig. 3. Principles of Open Building methodology: left: Zones and Margins; middle: Sectors; right: a Sector group (Harbarken, 1976, pp.108-111.)

Fig. 4. The procedure of design for adaptability with Open Building

Open Building method is also characterised by non-structural infill assembled by the occupant in Zones and Margins within a general Support Structure\(^7\). The method systematically divided the Support into spaces designated as Zones, Margins, and Sectors, which are a precise means of delineating territory of similar location and dimension in the infill. Fig. 3 captures the basic principles of Open Building to realise variations.

Summarizing the Open Building method, a diagram (see Fig. 4) showing the procedure of design for adaptability can be presented.

### 3 Investigation

For collecting useful information about Chinese public housing and understanding how residents use and adapt their homes, a survey was conducted within 297 families in Northern China. The dwelling unit types, dwelling spaces, living modes and demographic conditions of the public housing units were investigated, meanwhile concerning the actual adaptations carried out. The socio-geographic attributes were investigated through questionnaires and interviews, and are shown in Table 1. The dwelling unit types and dwelling sizes were measured and sketched by the interviewers and the corrected and redrawn with AutoCAD. In general, one dwelling unit composes of a living room, a kitchen, a bathroom and one or two bedrooms, and all the dwelling units investigated were designed and controlled within 60 m\(^2\) according to the current local regulations. As mentioned, around 30% (80/268) of the internal layouts were adapted by the occupants. These modifications are made mainly based on three reasons. Twenty-nine percent (23/80) of the modifications are to get one more room or space through building a partition in the living room. The new room or the separated space would be used as a bedroom (16/23), or a kitchen (7/23). Around 50% (38/80) of the modifications is to get a wider room by getting rid of inner walls: combining the living room with a kitchen (22/38) is the most popular modification in this group. Fourteen out of eighty families changed the position of inner walls to adjust the size of a certain room.

Most of the visited and recorded housing units (268 /297) were valid to be used for the next step, the internal layout capacity analysis.

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\(^7\) Friedman, 2002, p.34. Originally from Dluhosch, E. 1974.
Table 1. demographic characteristics of the respondents (n=297)

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>n</th>
<th>%</th>
<th>Occupation</th>
<th>n</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Age</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20-29 yr</td>
<td>25</td>
<td>8.4</td>
<td>Worker in state-owned enterprises</td>
<td>23</td>
<td>7.8</td>
</tr>
<tr>
<td>30-39 yr</td>
<td>44</td>
<td>14.8</td>
<td>Worker in private enterprises</td>
<td>47</td>
<td>15.9</td>
</tr>
<tr>
<td>40-49 yr</td>
<td>76</td>
<td>25.6</td>
<td>Civil servant</td>
<td>15</td>
<td>5.1</td>
</tr>
<tr>
<td>50-59 yr</td>
<td>91</td>
<td>30.6</td>
<td>Freelance worker</td>
<td>69</td>
<td>23.3</td>
</tr>
<tr>
<td>60-69 yr</td>
<td>33</td>
<td>11.1</td>
<td>Retired worker</td>
<td>74</td>
<td>25.0</td>
</tr>
<tr>
<td>Over 70 yr</td>
<td>28</td>
<td>9.4</td>
<td>Student</td>
<td>1</td>
<td>0.3</td>
</tr>
<tr>
<td>Total</td>
<td>297</td>
<td></td>
<td></td>
<td>67</td>
<td>22.6</td>
</tr>
<tr>
<td><strong>Family type</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Single person</td>
<td>42</td>
<td>14.1</td>
<td>Educational level</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Couple only</td>
<td>69</td>
<td>23.2</td>
<td>Elementary school certificate</td>
<td>14</td>
<td>4.7</td>
</tr>
<tr>
<td>Couple living with their child(ren)</td>
<td>114</td>
<td>38.4</td>
<td>Middle school certificate</td>
<td>144</td>
<td>48.6</td>
</tr>
<tr>
<td>Lone parent living with his/her child(ren)</td>
<td>28</td>
<td>9.4</td>
<td>High school certificate</td>
<td>70</td>
<td>23.6</td>
</tr>
<tr>
<td>Couple living with their parents and child(ren)</td>
<td>26</td>
<td>8.8</td>
<td>College or university's degree</td>
<td>29</td>
<td>9.8</td>
</tr>
<tr>
<td>Other families</td>
<td>18</td>
<td>6.1</td>
<td>Professional school graduate</td>
<td>24</td>
<td>8.1</td>
</tr>
<tr>
<td>Total</td>
<td>297</td>
<td></td>
<td></td>
<td>15</td>
<td>5.1</td>
</tr>
<tr>
<td><strong>Family size</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 member</td>
<td>32</td>
<td>10.8</td>
<td>Per capita monthly income</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 members</td>
<td>95</td>
<td>32.0</td>
<td>Less than 500 Yuan</td>
<td>77</td>
<td>26.8</td>
</tr>
<tr>
<td>3 members</td>
<td>127</td>
<td>42.8</td>
<td>500-1000 Yuan</td>
<td>63</td>
<td>22.0</td>
</tr>
<tr>
<td>4 members</td>
<td>27</td>
<td>9.1</td>
<td>1000-1500 Yuan</td>
<td>69</td>
<td>24.0</td>
</tr>
<tr>
<td>5 members and more</td>
<td>16</td>
<td>5.4</td>
<td>1500-2000 Yuan</td>
<td>29</td>
<td>10.1</td>
</tr>
<tr>
<td>Total</td>
<td>297</td>
<td></td>
<td></td>
<td>48</td>
<td>16.7</td>
</tr>
</tbody>
</table>

4 Capacity Analysis

The capacity analysis is determined by the dimensions, positions and interface of the spaces and functions. Thus, the housing units investigated were firstly disassembled to individual spaces and functions. Those spaces and functions were measured and compared. Strong patterns can be found, due to the compact shape of each dwelling unit and the tight restriction about the dwelling size, that the similar functional spaces share similar spatial dimensions; meanwhile the width or depth of different functional spaces have a fair chance of overlapping the dimensions. In combination with considering the variable scope of each functional space being of the most commonality, a diagram of spatial dimensions can be presented (Fig. 5. left). Then, because of the requirements of lighting and ventilation, the positions and interface of the functional spaces can be easily determined. The spaces away from the external walls have the worst condition to access natural lighting and ventilation, thus, the area ratio should be reduced and the spaces are usually used as auxiliary functions, such as a bathroom or a kitchen. And if a visual barrier is not necessary, the interface between the auxiliary spaces and the main functions can be ambiguous (Fig. 5. middle). Finally, the dwelling size is basically determined by the width of the dwelling unit. Four types of width dimensions can be distinguished from 3m to 8.1m (Fig. 5. right).

![Fig. 5. Capacity analysis: left, dimensions of functional spaces; middle, disposition along the depth of housing units; right, four types of width dimensions](image-url)
Fig. 6. Prototyping and possible layouts
5 Prototyping and possible layouts

In accordance with the results from capacity analysis, a design procedure can be clearly generated from the axis range, dwelling unit boundary, prototyping, to possible layouts within a boundary. Fig. 6 shows the procedure: the prototypes are designed on the basis of existing typical floor plans and unit combination forms; the possible layouts are proposed based on one of the prototypes, considering the living modes and demographic conditions from the investigation, as well as fulfilling the requirements of pertinence and adaptability for a specific family.

6 Summary

The role of Chinese public housing is to promote and ensure the quality of living for low-income people in China; however, the massive destructive adaptations show the lack of consideration in adaptability. The significance of adaptability has been realized and providing an open and adaptable interior layout to improve the residential satisfaction becomes one of the key tasks in design Chinese public housing. Design for adaptability with Open Building is a rigorous method built on surveys, analysis, and design.

This paper, using Open Building method, developed and verified a procedure of design for adaptability in Chinese public housing. Based on the investigations and capacity analysis, a variety of living modes and demographic conditions can be fitted into the diversity of interior layouts developed from prototyping designs. Based on this research, future studies could be related to undertaking practices, promoting technical services of Infill system, and exploring the possible combination of dwelling units.

Acknowledgement

This work was supported by Dalian University of Technology “the Fundamental Research Funds for the Central Universities” (grant no. DUT15RC(3)013 and DUT14RC(3)138 ) and the Ministry of Housing and Urban-Rural Development of the People’s Republic of China (grant no. 2013-R4-18).

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