Application of Open building Principles in Ecological Renovation & Adaptation Design of Modern Historical Buildings in Nanjing, China

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ABSTRACT
Ecological renovation & adaptation design is an important topic for modern historical buildings in Nanjing, China. Principles of Open Building proved to be new opportunities in ecological renovation & adaptation design of these buildings. Zhongnongli project was taken as an example to show how principles of Open Building could help to make the sophisticated job of ecological renovation & adaptation design of modern historical buildings efficient. Simulations of effect of renovation & adaptation design were also given to show the improvement in building performance.

KEYWORDS
Open building Principles, Ecological Renovation & Adaptation Design, Modern Historical Buildings in Nanjing, China

INTRODUCTION OF NANJING AND THE PROJECT
Located in the Yangtze River Delta economic zone, Nanjing has always been one of China’s most important cities. With urban population of over five million (2006), Nanjing is the second largest commercial center in the East China region, after Shanghai. It has been ranked fourth by Forbes magazine in its listing of “2008 Top 100 Business Cities in Mainland China”, also being awarded the title of 2008 Habitat Scroll of Honor of China, Special Award of UN Habitat Scroll of Honor and National Civilized City.

Nanjing used to be the capital of the Republic of China before the Chinese Civil War in 1949, so it is famous for its modern historic buildings. Modern historic buildings in this paper refers to the buildings from 1840 (Opium War) to 1949 (establishment of People’s Republic of China). Development of Modern historic buildings in Nanjing, not only numerous in numbers and types, but also with great cultural and architectural value, is big issue for both Nanjing and China in the rapid development & renovation of Chinese cities. The Zhongnongli project in this paper is very typical in this circumstance.

Zhongnongli block lied in downtown Nanjing. Most of the buildings there were built in Republic of China era. Lacking of maintenance, the modern historic buildings in the block were in poor condition. Residents there were mainly low incomer and elders. In rapid renovation of current Chinese cities, poor building performance and living condition were always major reasons for these buildings and blocks being demolished. Ecological Renovation & Adaptation design was very important to improve the building performance as well as preserve cultural value of these buildings.

Current status of modern historical buildings: great value vs. poor condition
In our detailed field investigation and research on buildings in the Zhongnongli block in both the hottest summer and coldest winter, each with duration of 7 days, we found that most of the old buildings, although with great cultural & Architectural value, were in poor condition. Lack of maintenance, without insulations, high energy consumption and poor interior environment were major problems for the buildings in Zhongnongli. In winter, when the exterior temperature was -2°C (Centigrade), the interior temperature was only 2°C (Centigrade)! Among the residents, 63% think it was intolerable cold in winter and 62% think intolerable hot in summer in their home. While the residents, the elders and the poor, couldn’t offer either heating or air conditioner at home. So we can imagine how terrible the interior environment was.

Gap between construction & materials of old buildings and modern technologies
According to our research, the key reason for poor living condition in modern historical buildings was poor performance of the buildings. This was result of gap between construction & materials when they were built and current technologies as well as lack of maintenance. Most of the modern historic buildings were built without insulations and dampproof treatments. As time went by, the walls got very wet and serious mildewed. Almost half (48%) of the walls and furniture got serious mildewed in Summer and there is still almost 1/3 (31%) got serious mildewy in winter. (Figure 2) In this case, it was almost impossible to further improve performance of these buildings just by ordinary renovation (painting, façade renovation, etc). We need ecological renovation & adaptation to get real improvement of performance of these buildings.
Ecological renovation & adaptation of modern historical buildings was quite sophisticated. There were several characteristics of ecological renovation & adaptation design of these buildings that made it special, especially different for ecological design of new buildings.

- Envelope could not be changed easily due to the need of cultural & architectural value preservation of the buildings.
- Possibilities of spatial change must be considered according to the existing space layout & envelope of the building from the very beginning of renovation design.
- Ecological design methods and technologies easy for new buildings might not be suitable or quite difficult for old buildings.

In research, we found the basic principles of open building: levels of intervention and distributed control, showed to be new opportunities for furthering ecological renovation & adaptation design of modern historical buildings. With the division of buildings into “shell” and “infill”, ecological renovation & adaptation design of modern historical buildings could become very efficient. The very complicated and technical part “shell” renovation & adaptation could be controlled by designer (together with government /developer, etc). They dealt with most challenges of ecological renovation & adaption and providing utmost flexibility. While “infill” adaption design could be controlled by occupants (with help from designer). Yet, for preservation of modern historical buildings, occupants need to obey much more cultural & technological regulations from the very beginning of renovation design. This was a great different between ecological design of modern historical buildings and new buildings in the situation of “control”.

Figure 1: Site plan and photos of Zhongnongli block

Figure 2: Temperature and Mildewy of interior environment of buildings in Zhongnongli block in Nanjing, China

Open Building Principles: New Opportunities in Ecological Renovation & Adaption Design

Ecological renovation & adaptation of modern historical buildings was quite sophisticated. There were several characteristics of ecological renovation & adaptation design of these buildings that made it special, especially different for ecological design of new buildings.
How Open Building Principles could help Ecological Renovation & Adaptation Design

In Zhongnongli project (Figure 3), we made ecological renovation & adaptation design for the pink housings (converted into shops) and the yellow housings (still using as housing). Principles of open building were proved to be efficient way for ecological renovation & adaptation design in the following aspects:

Division of “Shell” and “infill” and ideas of levels of intervention made the sophisticate job of ecological renovation & adaptation design clear and easier.

In the zhongnongli project, “Shell” meant the common part, including envelope, structure system and overall layout, with intervention from municipality, developer and designer. “Infill” meant individual part, with intervention from occupants (with help from designers), mainly the layout of their individual space. By this division, tasks and roles of ecological renovation & adaptation design became very clear.

Ecological renovation & adaptation design included ecological renovation of shell and design of ecological cell: adaption design of overall layout & space, renovation of envelope: addition of insulations and shadings, change of windows, design of PV and roof, updating of structure system, and thermo-bump, etc. Shell was the key point in ecological renovation & adaptation design for the purpose of both cultural value preservation and building performance improvement. While infill, although individual, need to obey much more cultural & technological regulations of the buildings from the very beginning of renovation design.

Ideas on distributed control of different levels and & different roles of different people insured both improvement of building performance and flexibility for occupants' needs.

According to ideas of open building, shell is controlled by designer (together with government /developer/occupants), while infill is controlled by occupant. In the zhongnongli project, this principle proved to be an efficient way to make clear tasks and roles of various participants and make them work together.

The very technical part: ecological renovation of the shell was mainly controlled by designer to ensure cultural value preservation and building performance improvement. Occupant had much control in their individual part. This was especially true for the buildings that would still be used as housing after renovation. Residents could easily express their ideas
and needs and took part in adaption design. While in the buildings that would be converted into shops, developer and designer had much control with consideration to market investigation since the occupants were not clear in design phase. Flexibility was especially focused in this circumstance for different needs of different occupants and different needs of occupants in different time. Further adaption design of the infill would be controlled by occupants when they moved in.

Figure 5 shows the ecological renovation & adaption design and simulation of effect of the changes in building performance after renovation of the shell we made in Zhongnongli project. This building would still be used as housing. First we made adaption design of overall layout & space (together with structure renovation), removing some partitions and, adding individual kitchens and toilets, adding of skylights, etc. We did this according to investigation and consultation with residents. From the difference in simulations of natural day lighting and vitalization before and after renovation, we can see the improvement in building performance. Second, we did ecological renovation & adaption of envelope, adding insulations and shadings, changing windows, designing PV and roof renovation, etc. Then, we designed the ecological cell with application of thermal pump for the whole block.

A SUMMING UP
All in all, due to aims of cultural preservation and building performance improvement, ecological renovation & adaption design of modern historical buildings was very sophisticated. Principles of open buildings: levels of intervention and distributed control showed us an efficient way to simply the design. In Zhongnongli project, by division of “Shell” and “Infill”, designer controlled the “shell” to ensure the design could fulfill the need for cultural preservation and building performance improvement, as well as providing utmost flexibility for occupants (in housing renovation, also consulting with residents). While occupants could control their infill, residents starting from design phase and commercial occupants when they got the key. In this means, principles of open building proved to be new opportunities for efficient ecological renovation & adaption design for modern historical buildings in China.

Figure 5:
Adaption design of overall layout and simulation of the improvement in building performance.
Top four: comparison of housing plans before and after renovation design
Left two: original plans
Right two: renovated plans
Middle four: comparison of lighting status before and after renovation design
Left two: original lighting status
Right two: renovated lighting status
Bottom four: comparison of natural ventilation status before and after renovation design
Left two: original natural ventilation status
Right two: renovated natural ventilation status
Note: in each group, top ones are for first floors and bottom one second floors
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