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Analysis on the Case of Green Reconstruction of the Existing Buildings

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First of all, both the construction of energy-efficient buildings and green buildings are analyzed on the existing buildings to put forward reconstruction strategies for energy conservation and green building. Optimizing air conditioning, natural ventilation, reducing noise, lighting and other measures are carried out in the case to improve building health comfort degree. For the security of energy-saving renovation of historical buildings, the application of insulation materials is put forward in the case to solve the contradiction between energy-saving renovation of historical buildings and fire prevention. Through the comparison of tested data before and after the reconstruction, the effect of green reconstruction is objectively evaluated to provide reference for the application of technology of green reconstruction of domestic existing buildings.

1. Introduction

At present, the total amount of our country existing buildings is 43 billion m^2, which grows at a speed of 2 billion m^2 per year, and it constitutes the main body of the current urban construction environment. The current existing building amount is about 0.936 billion in shanghai, with the total amount of non-residential buildings of more than 400 million m^2; in addition to the factory buildings, office buildings are the most important part, accounting for 16%~18%, and it is of great significance to carry out green energy-saving renovation to this part of buildings (Yang and Qian, 2015).
For greening reconstruction projects, the performance test before the reconstruction can make us to know about the basic situation of buildings, like "check-up", we can know where there are problems and then "suit the remedy to the case" (Shi et al, 2014). For the actual effect after the reconstruction, the "Post-assessment" work should be paid attention to; and green energy-saving and reconstruction effect is comprehensively evaluated through the data feedback and comparison.

2. Basic Situation of Reconstructed Buildings

The residential building in Shanghai is located in the main city area, built in 1975, and it was reconstructed to 3 seven-storey buildings with basement in 1995. With the construction of the expo site in 2010, the expansion of road made the eastern residential building demolished completely, the east elevation of 3# building in this community along the trunk road was fully opened, a new round of green energy-saving renovation is triggered due to the reason of the building itself and the opportunities brought by environment change (Mostafavi et al, 2015).

2.1 The main body and its function status before the reconstruction

The external environment of this community is not very ideal, as the south of the building is close to six-story residential building and the stories of other floors are poor in the natural lighting except the top two layers. The façade of the building's main body is shabby, the eaves of parts of the windows fall down, outside unit of the air-conditioners are messy, roof insulation boards are damaged seriously, painting on parts of walls fall off and water penetrates, sewage water pipeline is in serious rust and sewage pipeline leaks (Bowers et al, 2014).

2.2 Building enclosure status before the reconstruction

The heat preservation method and relevant performance for the building enclosure before the reconstruction are as shown in Table 1.

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Table 1: Thermal performance of building surrounding structure

Retaining structure parts	1#	2#	3#
Exterior wall	Hollow clay brick wall	Solid clay brick	Hollow clay brick wall
Roof	Ordinary roof	Ordinary roof	Ordinary old roof
Outside the window	Aluminum alloy single-layer glass	Ordinary aluminum alloy window	Aluminum alloy single-layer glass

2.3 Other equipment status before the reconstruction

The air conditioning system adopts the form of water chilling unit and boiler and air-cooled heat pump. Lighting system (Assad et al, 2015): (1) energy-saving tube lamps are used in the corridor, with the power of each energy-saving lamp of 9~12W; (2) energy-saving fluorescent lamps are used in the office; (3) a wide variety of lamps are used in the meeting room, with energy-saving fluorescent lamps, incandescent lamps, shoot lamps, etc.

3. The judgment and idea for energy saving buildings and green buildings

3.1 Judgment basis

According to the standard requirements of Technical Specification for Energy Conservation and Reconstruction of Public Buildings, the need for energy saving reconstruction and the contents are determined in combination with the introduction to the practical situation of this project as well as the judgment principle and method of energy saving and reconstruction of public buildings. According to the goal of green, the building courtyard green building goals are considered comprehensively in terms of the building energy conservation and green building.

3.2 Direction of building energy-saving reconstruction

Energy saving reconstruction of existing public buildings shall be according to the standard requirements of reconstruction specification, the building group enclosure (walls, windows, type system, etc.), HVAC system, lighting system, renewable energy utilization and itemized metering are compared and analysed to obtain the direction of building energy-saving reconstruction (McGinn, 2005).

3.3 Selection of engineering materials

(1) High efficiency, healthy, comfortable- energy-saving reconstruction of public equipment. With healthy, comfortable and efficient office environment as the goal, air conditioners, lighting, noise control, water saving system, etc are reconstructed according to the construction standards of green buildings(Seifert, 2008). Considering the use objects of the buildings, health and comfort are needed to meet on the premise of considering the efficient operation of construction.

(2) Health and comfort- reconstruction of indoor and outdoor environment of buildings. According to the Measures for the Administration of the Control of Indoor Temperature in Public Buildings, the indoor temperature in public buildings is not less than 26℃ in summer, and the indoor temperature shall not be higher than 20℃ in winter. It is shown in relevant researches that the controlling of 5℃indoor and outdoor temperature difference between summer and winter is more beneficial to people's health. In order to reduce indoor and outdoor temperature difference and improve the comfort, cascade temperature control from outdoor to indoor is put forward in this paper.

4. Reconstruction contents for green buildings

After detailed test and analysis, the building facade of this residential building, internal facilities and functions, indoor environment quality, thermal performance of building enclosure all need updating and reconstruction. Through a lot of early stage analysis, based on the regional characteristics of Shanghai, in combination with existing building environment, function, equipment and structure, green reconstruction is carried out with the national green building design and three stars of operation evaluation mark as the target, meanwhile, the construction control and operation management are stressed (Wei et al, 2015).

Through the analysis on the building functional requirements and climate environment characteristics, the architectural function layout and space reconstruction are went over to make it echoing with each other; at the same time, structural design is carried out with materials saving oriented, and the equipment system is reconstructed in combination with the energy saving and space reconstruction to enhance the overall quality of the project in the end. To realize the goal of overall green reconstruction, thirteen green technologies are put forward, such as vertical greening and roof greening, energy saving of enclosure structure, natural ventilation, natural lighting, building shading, unconventional water utilization, air heat recovery, green building materials, lighting energy saving, intelligent buildings, efficient water saving and irrigation methods, solar hot water system, solar photovoltaic power generation system, etc., among them, the effective application of passive energy saving technology is paid special attention to in this project (see Figure 1-a)

Due to limited construction area of the project, the space design in the reconstruction design needs to be stressed. For natural ventilation measures, the design location of the atrium, physical size, performance effect, and the balance between the form design meeting functions and space and the energy saving design passively adapting to climate are explored mainly; in addition, the distance between the south facade of this building and residential building is only 15m, so the building has the problems of sunshine and the sight disturbance, proper atrium size is finally determined and edge division is introduced to improve the quality of indoor air. The proper reduction of well-hole area of atrium can not only satisfy the requirement for use area, the saw tooth set higher than the roof can make the skylight opened to achieve the wind effect, the introduction of edge division can both increase the buffering of the indoor and outdoor transition to avoid the eye directly in the eye, but strengthen the indoor natural lighting effect and also guide air to enter (see Figure 1-b).

This project belongs to the reconstruction of the existing building, therefore, it involves the reconstruction and redesign of structure, and construction space division and structure reinforcement have mutual restriction. After analysing the characteristics of the original structure, its storey is not high, the distance between columns is relatively small, and the space is limited, the building space requirements, the rationality of its own technology and economy are both considered in combination the structure test results, the middle row of pillars are strengthened in traditional way for the open space and four depth space; local space is reinforced with damper, 4.7 m2 net areas for each storey can be increased through the comparison of traditional beams and pillars, and the cooperation facade can be used as structure display element

(a) (b)

Figure 1: Comparison of building exterior before and after reconstruction

5. Reconstruction status of green buildings

5.1 Analysis on the thermal performance of building enclosure structure

In the process of actual reconstruction of buildings, considering the performance and economy and other comprehensive problems, comparison and analysis are made on various schemes to determine the most reasonable scheme of enclosure structure on the premise of referring to relevant national and local standards. Main methods include: determine reasonable ratio of window and wall, select the appropriate thermal insulation materials, determine the feasible structure form, choose suitable outside windows and open doors, and carry out effective integration with function components, etc.

Table 2: Heat transfer coefficient of enclosure structure test results (modified)

The test content	Exterior wall	roof	Overhead floor
Indoor air temperature	17.8	26.8	16.2
Outdoor air temperature	1.8	7.6	0.9
The inner surface temperature	15.2	21	12.4
The surface temperature	3.2	5.8	2.5
Heat flow value	10.6	8.2	7.8

The project is combined with the reconstruction green goals, the same parts before the reconstruction are tested and compared, and the heat transfer coefficient K value of its enclosure structure is far more than the correlative stipulations in the Design Standard of Energy Saving of Public Buildings (see Table 2).

5.2 Analysis on the economic benefit for the reconstruction of green buildings

According to the reconstruction items of building energy saving and green buildings in the section above, the investment recovery status of the building are analysed in building energy saving and green buildings.
(1) Analysis on the economic benefit of energy saving reconstruction of buildings. According to the requirements of building energy saving, the investment costs (incremental cost) for the reconstruction of the internal and external wall thermal insulation of the outer wall of the office building, roof insulation, replacement of windows, intelligent control, green roof, lighting control, natural lighting of the basement and other contents as well as the energy saving effect estimation are shown in the following table 3:

Table 3: Energy saving transformation analysis table

Indicators	Cost estimate /yuan	Energy saving effect /KWh	Save cost /yuan	Carbon reduction /yuan	Payback period /year
Total	26685745	403021	326448	109	738

(2) Analysis on the economic benefit of the reconstruction of green buildings. Green building reconstruction items include rainwater utilization, courtyard greening, landscaping irrigation, hard ground water, water meter measuring, water-saving appliances and green building display platform, etc. Investment costs (incremental cost) and the energy saving effect estimation are shown in the following table 4:

Table 4: Green transformation analysis table

Indicators	Cost estimate /yuan	Energy saving effect /KWh	Save cost /yuan	Carbon reduction /yuan
Total	948300	11500	40250	2.8

(3) Based on the calculation above, the comprehensive carbon reduction of green office buildings is 128t, with a total investment of about 3.7 million Yuan needed; it can reach building energy saving 65% and three star standard for green building after the reconstruction; the payback period of reconstruction is about eight years, with good social and economic benefits.

5.3 Preliminary results

(1) The contents and the status of the building reconstruction at the first stage. Combined with building reinforcement and repair in the courtyard, the project shall start the green reconstruction of courtyard since 2010. At present, the energy saving of 1# building and 3# building, solar hot water system, building item measuring and courtyard greening reconstruction have been completed. The present situation after the reconstruction is as shown in Figure 2.

Figure 2: After transforming appearance

(2) Brief analysis on the energy-saving effect of the courtyard. The building reconstruction effect is analysed after the reconstruction with the method of construction resource audit. The energy-saving reconstruction of existing building at the first phase has had achievements, according to the building energy audit data (normal use) before and after the reconstruction from July 2011 to June 2012, about 305000 kWh energy consumption is saved, with energy consumption dropped by 11.6% (including natural gas and other petrochemical energies, Shown in Figure 3).

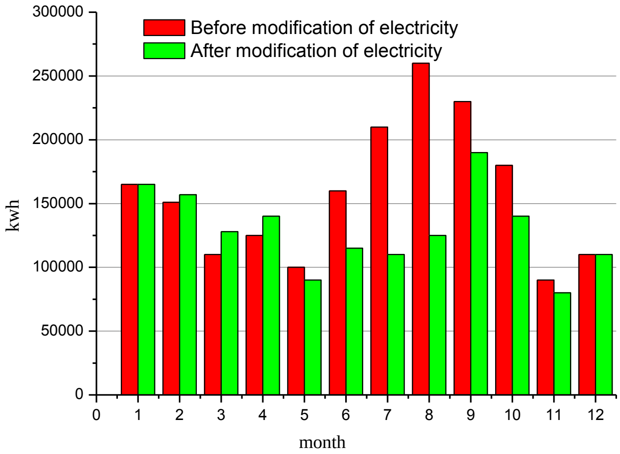

Figure 3: Power consumption comparison before and after modification

(3) Brief analysis on the water saving effect of the courtyard after the reconstruction. Through the replacement of water-saving appliances, water metering, water balance, searching of the leak points and other work, the water consumption is greatly reduced. Consumption of water resources is reduced by about 50%. Monthly water consumption situation is as shown in Figure 4.

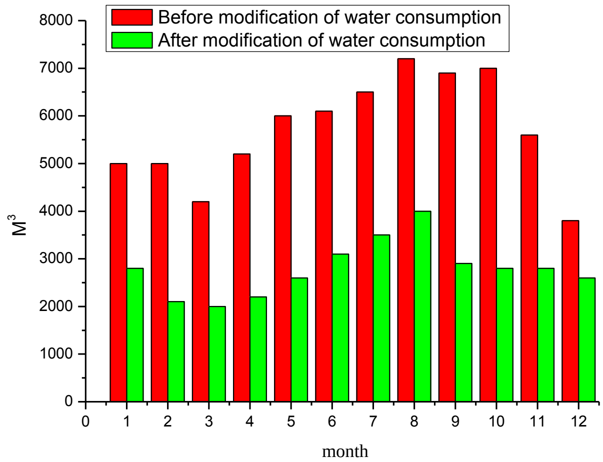

Figure 4: Water consumption comparison before and after modification

(4) Because the project is close to the main road of Tibet south road, noise on site is larger. After the test, the noise level exceeds the standard at the east side and the south side of the base, especially the east side, the on-site noise is 59.0 dB, higher than the indicator stipulated in the standard (55 dB), and therefore, indoor sound insulation performance needs to be focused on. The sound insulation test of separation wall air sound is carried out on the structures of 3 typical walls with different types and uses (including partition structure), the sound insulation test of floor crashing is carried out on the floor slab structure between typical floors (including floor finishing and ventilation ceiling system). Through analysis, the rest can satisfy the requirements of the relevant specification in addition to the glass partition.
(5) After the test, the indoor temperature of the project, relative humidity, wind speed, radon, formaldehyde, benzene, ammonia and others all conform to the relevant provisions, and TVOC is in 0.04 ~ 0.52 mg/m3, which meets the relevant provisions of≤ 0.60 mg/m3 in Indoor Air Quality Standard (see Figure 5). Compared with that before the reconstruction, indoor illumination and lighting effect of this project are improved a lot, take the office of big width on the second floor as an example, average indoor illumination is up to 710.4 lx, higher than 300 lx stipulated in the Building Lighting Design Specification, the average value of indoor lighting coefficient is 2.03%, which meets 2.0% stipulated in Building Lighting Design Standard (see Figure 6).

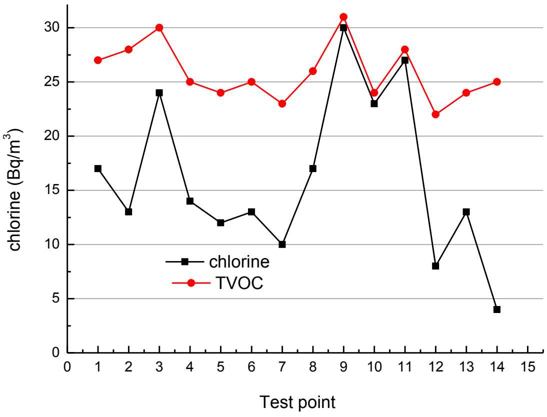

Figure 5: Test result of Radon and TBOC

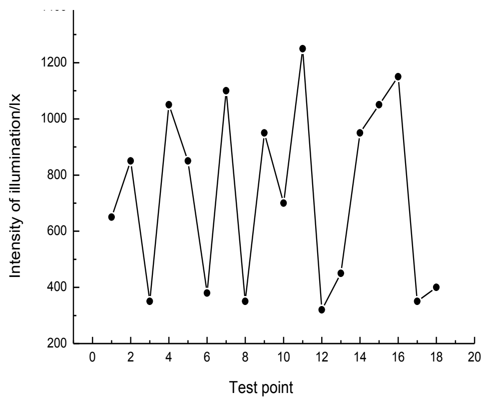

Figure 6: Test results of illumination on 2F

6. Conclusion

Through field investigation and test, the basic building performances of Shanghai SD Building before the reconstruction are mastered, several problems existing in the building and appropriate green energy saving reconstruction scheme is put forward and implemented. Through the performance test after the reconstruction, green energy saving reconstruction effect is objectively judged so as to provide support to a better operation and maintenance of the project through the "post-evaluation" work, and the method can provide reference for the practice of green reconstruction of domestic existing buildings. We get some enlightenment:
(1) Technology should be economic and appropriate. The green reconstruction of the existing office buildings should adopt proper measures to local situations and use proper technologies based on the regional climate characteristics and construction characteristics.
(2) The reconstruction time should be combined with the construction need. Green building reconstruction should be carried out in combination with other reconstructions so as to reduce the cost of green building reconstruction and the impact on the use of building.
(3) Improve display function. The influence of green building demonstration is broadened through the display of green energy saving, safe, environmental protection technologies.

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Reference

Assad M., Hosny O., Elhakeem A., El H.S., 2015, Green building design in Egypt from cost and energy perspectives, Architectural Engineering and Design Management, 11(1): 21-40. Doi: 10.1080/17452007.2013.775100

Bowers T., Ganguly I., Eastin I., 2014, Eco-labeled wood products in the U.S. residential construction industry: Architects' awareness and usage of certified wood and green building programs, 90(5): 605-613.

McGinn T., 2005, Setting fees for profitable green building projects, ASHRAE Journal, 47(4): 17-22.

Mostafavi N., Farzinmoghadam M., Hoque S.i, 2015, Envelope retrofit analysis using eQUEST, IESVE Revit Plug-in and Green Building Studio: a university dormitory case study, International Journal of Sustainable Energy, 34(9): 594-613. Doi: 10.1080/14786451.2013.848207

Seifert B.M., 2008, District of Columbia green building act of 2006 and its implications for sureties, Journal of Professional Issues in Engineering Education and Practice 134(1): 84-86. Doi: 10.1061/(ASCE)1052-3928(2008)134:1(84)

Shi Q., Lai X.D., Xie X., Zuo J., 2014, Assessment of green building policies - A fuzzy impact matrix approach, Renewable and Sustainable Energy Reviews, (36): 203-211.

Wei W.J., Ramalho O., Mandin C., 2015, Indoor air quality requirements in green building certifications, Building and Environment, 92: 10-19.

Yang L., Qian F., 2015, Wind environment in green building design, Nature Environment and Pollution Technology, 14(4): 833-838.