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On the Renovation of Energy-saving Technology of Universities Teaching Buildings in the Cold Regions

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Abstract. At present, construction industry march toward energy saving and environmentally friendly. Renovation of energy-saving technology of universities teaching buildings are on the track. However, particular measures should be taken to deal with the unusual natural environment in the cold regions. Based on the paper will mainly study the importance of the Renovation of energy-saving technology of universities teaching buildings discuss, the difficulties during the execution and analyze the specific means.

1. Introduction

China is a country with a vast territory, which leads to the large span from north to south and the distinct altitude. The north and south-western regions are severely cold in winter due to their high altitude. During the Renovation of energy-saving technology of universities teaching buildings, enough attention should be put on the geographical environment. At the same time, we should be well-prepared and apply technical analysis to improve the degree of integration and the pertinence of construction.

2. Importance of Energy-saving Technology Renovation

As one of the important parts of urban public constructions, universities teaching buildings are essential resources for the urbanization process of China. Nonetheless, as a result of legions of teachers and students, the design criteria of teaching buildings are inferior to common buildings in order to meet functional demands. Executing the Renovation can not only reduce waste of public resources but improve the environmental performance per unit yield, accelerating the sustainable development of Energy-saving and Emission Reduction.

Low-temperature heating is usually adopted to avoid pipe burst because universities teaching buildings cover a large area and are always in use. Some universities' inadequate internal management, poor awareness of energy conservation and environmental protection result in 24-hour long-term operation of air conditioning. Other universities' lack of corresponding targeted maintenance and management measures cause that the indoor air environment can't meet the specific requirements of the engineering design, so these universities have to improve the working hours of the fresh air system to improve the indoor environment.

3. Difficulties During the Energy-saving Technology Renovation

Difficulties during the Renovation of energy-saving technology of universities teaching buildings in the cold regions are as follows:



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- In many areas, the winter temperature is below zero. For example, in Changchun, the winter temperature difference between indoor and outdoor can exceed 40°C. In such severe cold, the staff must carry on the integration Renovation to the exterior wall enclosure structure to improve the thermal insulation performance as much as possible.
- The construction time for energy-saving technology Renovation is relatively short due to the long severe cold in these regions. For example, in Changchun, the annual construction time is only from April to September. In October, the temperature is likely to be lower than zero, which will seriously affect not only the quality of the energy-saving technology Renovation project but the construction cost.
- Targeted design varies from region to region. Many universities don't pay enough attention to the climate characteristics of the cold regions during the construction, only consider the energy conservation and environmental protection but ignore the architectural characteristics of the whole teaching buildings, resulting in the weak pertinence of the construction design scheme.

4. Specific measures

This paper takes the energy-saving technology Renovation of a university in Changchun as the example. The overall goal of this university is to reduce the energy consumption of the HVAC system while improving the comfort of teachers and students in the classroom.

4.1 The indoor and outdoor temperature of teaching buildings in different months

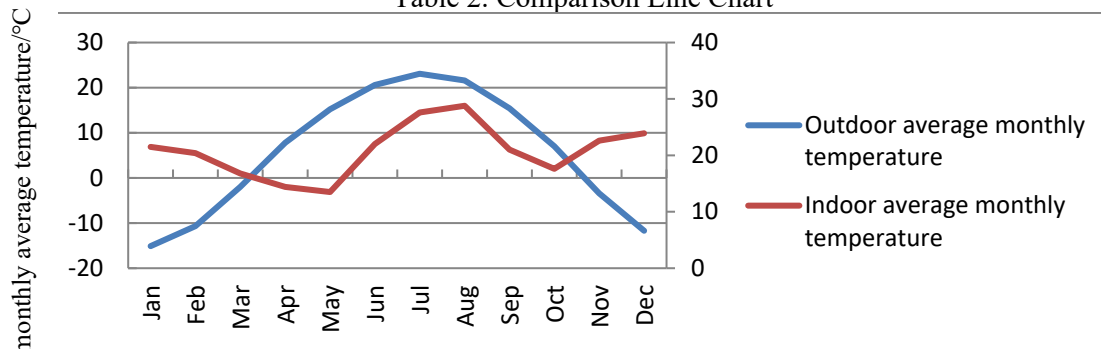
The author inquired the statistical table of the average temperature of Changchun in the past 30 years. The result shows that January is the coldest month, the average monthly temperature is -15.1°C and July is the hottest with the average monthly temperature 23.1°C. The author also combined the school internal data and temperature detection, getting the indoor average temperature of the teaching buildings. The indoor heating in winter starts from late October to early April, and the opening of the air conditioning system in partial rooms in summer starts from mid-June to late August. (as Table 1)

Table 1. The Outdoor and Indoor Average Temperature of Teaching Building

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Outdoor average temperature	-15.1	-10.7	-2	7.8	15.2	20.6	23.1	21.6	15.4	7	-3.4	-11.7
Indoor average temperature	21.5	20.4	16.8	14.4	13.5	22	27.6	28.8	21	17.6	22.6	23.9

The comparison data of the indoor and outdoor temperature of the basic teaching buildings reveals that the indoor and outdoor temperature trends are basically the same in summer, and the indoor and outdoor temperature difference is small; but when heating, the difference becomes wider and the indoor heat transfer coefficient will become larger with the decrease of the external temperature. So conducting the energy-saving Renovation of the external structure of the teaching building in winter is of great significance to save energy and develop environmentally-friendly buildings (as Table 2)

Table 2. Comparison Line Chart



4.2 Measures of energy-saving technology Renovation

According to many guidelines in these technical standards, select the appropriate materials for the Renovation, and comprehensively analyze the thermal performance, water absorption performance, flammability, economic performance etc. of the teaching buildings to optimize the thermal insulation parameters of the materials.

4.2.1 Preparation. According to the relevant principles of the project plans, the constructors optimized the design of the external window glass structure, and selected the appropriate thermal insulation materials through the structural comparison. They selected the 45 mm thick graphene polystyrene board material on the whole, which can perform a good heat preservation even in the range of - 20 °C to 30 °C, isolate 85% cold air and sharply reduce the cold and hot air exchange of indoor and outdoor.

After systematic exploration, the designers found that the external wall thermal insulation structure of the whole buildings is missing, and the single area of the window is more than 20 m². The whole buildings have 26 floors, over 70 meters high. The first floor has four laboratories, 12 meters high. The height of other floors is 3.5m. Through the TWGA model, the designers analyzed that the building's figure coefficient is 0.426, the average window wall ratio is 0.42 and the maximum window wall ratio is 0.83. The heating area is 867800 square meters.

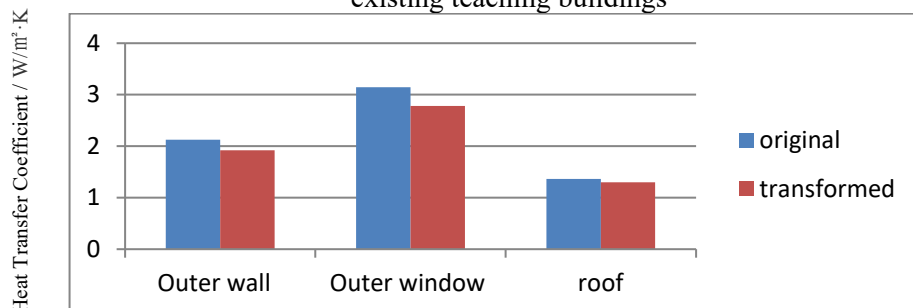
4.2.2 Enclosure performance improvement. The designers first used the instrument measuring the outer wall, outer window and roof structure of the teaching buildings and got the heat transfer coefficient of the buildings, then worked out the average values: 2.124, 3.143, 1.364.

The designers studied the transformed thermal performance of the existing enclosure structure of the buildings:

- The exterior wall is covered with grey ceramic bricks. Plastering plus strong thermal insulation performance. The main construction material is clay hollow bricks, with structural size of 20mm + 370mm + 20mm and heat transfer coefficient of 1.919.
- The outer window adopts plastic steel window made of transparent hollow glass, which is reinforced by grey floor tiles and cement adhesive layer. The overall material is polymer coil material with structure size of 5mm + 9mm + 5mm and heat transfer coefficient of 2.78.
- The whole roof is of levelling layer structure with cement mortar, and the cement mortar structure is levelled by adding cement perlite insulation layer and emulsified asphalt pearl layer. The structure size is 25mm + 1.5mm + 25mm + 120mm + 1mm + 20mm + 200mm, and the heat transfer coefficient is 1.297.

By improving the performance of the enclosure structure, the Heat transfer coefficient of the building exterior wall, exterior window and roof is decreased obviously, especially after the Renovation of the exterior window. This also proves that the Renovation of the enclosure structure for the energy-saving effect of the building itself is very efficient. (as Table 3)

Table 3. Comparison of before and after Renovation Heat transfer coefficient of enclosure structure of existing teaching buildings



4.2.3 External wall thermal insulation performance Renovation. The constructors adopted the technology of thickening the external wall insulation layer to analyze the difference of the annual accumulated heat load. On the whole, the heat transfer coefficient of the universities buildings' structure and external wall can be significantly decreased by increasing the thickness of the insulation layer.

Generally speaking, with the increasing thickness of the external wall insulation layer, the annual accumulated cooling load of the buildings will also increase year by year and the increasing range will be smaller and smaller. Therefore, the constructors set the heat transfer coefficient of the buildings as 0.275 and sequenced the annual cumulative cooling load of the whole buildings by enlarging the thickness of insulation layer by + 20%.

4.2.4 energy-saving Renovation of roof and window. Besides the wall structure, the roof system of the teaching buildings are also transformed:

- Polyaniline resin material with a thickness of 115mm, oxidized resin material with a thickness of 85mm and PUR material with a thickness of 70mm are used to strengthen the building as a whole, further reducing the heat transfer coefficient of the roof.
- The original window to wall ratio of the teaching buildings is 0.79 at most. The constructors adjusted the ratio of a few outer windows to 0.62 by reducing some large windows.
- Fill inert gas (argon) into the hollow glass structure and use the photochromic glass structure to prevent the ultraviolet rays from entering the room while preventing the internal hot air from escaping outwards in the hot days.

5. Material and resource measures during the Renovation

The target is to reduce the consumption of materials and resources during the construction. It is required to make full use of the existing the existing resources.

5.1 Material saving measures

The purpose of material saving measures is to reduce the consumption of materials and resources during the construction. It is required to take effective measures to urge and promote the rational use of materials.:

- Improve the technology and shorten construction time.
- Carry out scientific management on construction materials, master the in-time information of construction materials and well-maintain the turnover materials.
- Recycle waste generated during construction as much as possible.
- Temporary facilities use the original buildings on the site, or use materials easy to dismantle and be reused.
- Compare the consumption of actual construction material and calculated material to improve the material saving rate.

5.2 Resource reuse measures

The purpose is to improve resource reuse rate and save materials and resources to the greatest extent. Use the existing resources to recycle the construction waste as much as possible.

5.2.1 Existing resource utilization measures. It is required to investigate the current situation of the site and analyze the feasibility and economy of reusing the existing buildings and facilities. Reasonably arrange the construction schedule, utilize the proposed roads and buildings and reduce the consumption of resources and energy:

- Make full use of existing or proposed roads on and around the site during construction.
- Make full use of the existing water supply, drainage, heating, power supply, gas, telecommunications and other municipal pipeline works at the site and surrounding areas during the construction.

- Make full use of existing or proposed buildings at the site during construction.

5.2.2 Waste Management. It is required to formulate and implement the construction waste management plan to classify and dispose the site waste, separate the recyclable construction waste and reapply it directly into the construction process, or recycle it through the recycling manufacturer for reprocessing. Calculate the recycling proportion of construction waste according to the formula and evaluate it.

$$\text{Recycle proportion } \beta = \frac{\text{actual recovery amount of construction waste (t)}}{\text{total amount of recyclable construction waste by building volume (t)}} \times 100\%$$

5.3 Obtain raw material locally

This measure intends to take local materials and reduce the energy consumption and environmental impact caused by material transportation. It is required to increase the proportion of locally produced construction materials and products. The proportion of localized materials should be calculated according to the formula, and select the larger one to implement.

$$\text{Proportion of localized materials } \alpha = \frac{\text{amount of construction materials within 500km from production and construction site (t)}}{\text{total amount of construction materials (t)}} \times 100\%$$

6. Conclusion

To sum up, the technicians should comprehensively know about the factors of teaching buildings in severe cold regions on the basis of fully mastering the national energy-saving technical standards. The analysis of this paper reveals that the research on the energy-saving technology Renovation of teaching buildings is conducive to the comprehensive view of the shortcomings in the current energy-saving technology Renovation. Therefore, we should strengthen the material selection, optimize the construction structure and improve the systematical and scientific degree of the energy-saving technology Renovation.

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