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Application of Energy Conservation and Environmental Protection Measures in Construction of Building Decoration

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In recent years, the environmental problems are getting increasingly prominent with the rapid economic construction and development. As people pay more and more attention to the energy conservation and environmental protection, the energy conservation and environmental protection has become an inevitable trend in the building industry. Decoration, as an important part of the construction engineering, its energy conservation and environmental protection also needs to be strengthened. Hence, this paper explores the detailed application and corresponding problems regarding energy conservation and environmental protection in building decoration, so as to promote the sustainable development of construction resources.

1. Introduction

Decoration, as an important part of construction engineering, usually consumes a lot of energy and leads to a large number of environmental pollution problems during construction process (An et al., 2011). The energy conservation and environmental protection initiatives in architectural decoration works are started late in China. Extensive methods have been adopted by building decoration industry during its development process. However, given the shortage of natural resources in our country, and the concept of environmental protection enjoys popular support, the energy conservation and environmental protection methods are widely used during construction of decoration works (Feng and Zulkiple, 2013; Harrison et al., 2012). In the building decoration works, structural engineer can adopt energy conservation and environmental protection decorative design, new energy conservation and environmental protection materials, advanced construction technology and reasonable construction organization methods to achieve a good energy conservation and environmental protection effect (Hou and Wu, 2016). The realization of energy conservation and environmental protection construction of decoration works is of great significance to build a comfortable living environment, and to achieve the sustainable development of decoration.

The building energy conservation is an important part of China's sustainable development. In 1995, the Ministry of Construction promulgated the *Detailed Rules for Implementation of Energy Conservation in Urban Buildings* (Kephalopoulos et al., 2007; Li, 2015). In 2000, the *Provisions on the Administration of Energy Efficiency in Civil Buildings* were promulgated. In 2007, the *Code for Acceptance of Construction Quality of Building Energy Conservation Project* was issued. These regulations require that new public buildings and residential buildings should reach the 50% energy efficiency standards (Lian, 2014; Mao, 2006). China's building energy efficiency is not only reflected in the building itself, but also reflected in the architectural decoration. Building decoration energy conservation means to satisfy the requirements on energy conservation, materials and environmental protection through the assembly in factory by batch. Energy conservation design in interior decoration requires not only the technical support, but also the artistic assistance. Interior design should be performed according to the following principles: functional principles, aesthetic principles, technical principles, ecological and sustainable principles. Indoor energy conservation design requires designers to follow the aesthetic principles on the premise of creating energy-saving, comfortable, environment-friendly space environment for the people to the largest extend.

This paper analyses China's severe energy shortage situations currently with a large amount of data, and puts forward the urgent need for energy conservation policies. This paper also proposes methods to solve the contradiction between energy conservation and creation of a comfortable indoor environment specific to the

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main problems existing in the interior design of our country at present; and recommends to make full use of solar energy, green lighting design, and green environment-friendly decoration materials, as well as pay attention to furniture selection, and other reasonable and green measures to achieve energy conservation.

2. Three key aspects for energy conservation and emission reduction in building decoration

The use of disposable energy during the construction process is greatly reduced with the introduction of renewable energy technology and the application of advanced equipment; which transforms the parts with a high energy consumption, improves the building energy efficiency (Xu et al., 2013), optimizes conventional energy system, and reduces the use of conventional energy on the basis of satisfying relevant requirements. In the building decoration design, the energy conservation design should be performed based on the energy conservation effect of the buildings and the users' requirement.

2.1 Walls, floors, roofs, doors and windows and other maintenance structures

The tensile strength, thermal conductivity, density and combustion performance of thermal insulation materials should meet the energy conservation requirements. Air tightness, thermal insulation properties, glass shading coefficient and other related performance requirements of exterior walls of the buildings should also meet the energy conservation requirements. In cold areas, other thermal insulation measures should also be taken to save energy. The building energy efficiency can be realized mainly through the renovation of doors, windows and wall insulation. A 60% of energy can be saved if the insulation performance of the doors, windows and walls in buildings is good enough.

In the model shown in Figure 1, we divide the heat transfer channel into 11 sub-channels in parallel to the heat transfer direction; and divide the entire heat transfer plane perpendicular to the heat flow direction into 11 heat transfer sub-surfaces. Among them, sub-channel No. 1 and No.11 refer to the left and right sides of the block 5 mm mortar vertical joints; and sub-channel No. 12 and No. 13 are the blocks, the next two mortar surface.

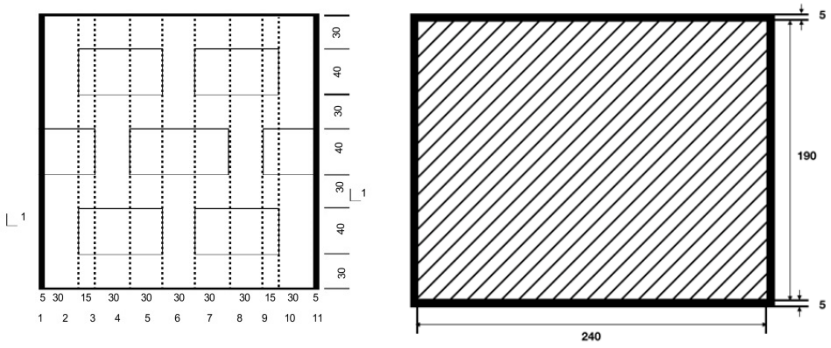

Figure 1: Classification model of heat transfer channel of concrete composite insulation brick

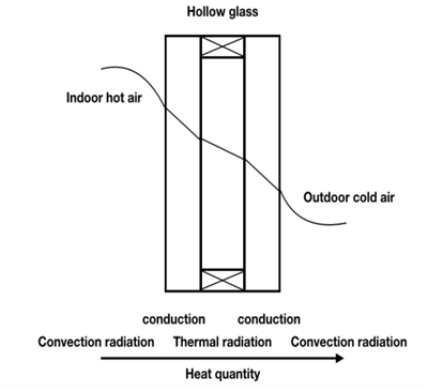

Figure 2: Heat lose channels of hollow glass

In general, the single-layer heat-reflective glass or single-layer Low-E glass can play the energy conservation role to some extent, but their effect is limited. The insulating glass should be a better choice, since it can reduce the flow of convection heat (Figure 2) due to the formation of a confined and isotonic air interlayer

between two layers of glass, which can limit the flow of air and other gas layers. The transfer of heat in the interlayer is realized in two ways: (1) long-wave heat radiation between two glass plates; (2) heat conduction with the air being the medium. Therefore, the insulating glass is transparent and bright, can keep the room warm in winter and cool in summer, and can also reduce the noise level. In 2000, China promulgated and implemented the *Regulations on Energy Management of Civil Buildings* promotion and application.

The hollow glass materials can be used to replace the original single-layer ordinary glass windows during decorative construction process, and they can also be attached to other shade materials outside the window. Thick cloth with good heat insulation effect can be used as the curtain material as well. If the building room and balcony are connected, the insulation layer is needed in the balcony wall to ensure the insulation effect of external structure. The gypsum board insulation material can be installed for top floors to improve the insulation. The timber floors can be installed between the grille and other insulation materials. The manufacturers of decorative materials can add glass wool and other fire insulation materials to improve the insulation performance of housing envelope structures by means of using water and power-saving materials and conducting product design. First of all, the building functions should be realized, since the goal of energy conservation is not to decrease the energy conservation investment and operating costs; even though the energy costs should be recovered in the shortest possible time from the perspective of economic benefits. In addition, with regard to the selection of new energy conservation equipment, their working principle and performance should be understood, economic comparison can conducted as well according to the following principles: namely, realization of the functions of the buildings, good economic returns and the lest energy waste.

Table 1: Relationship between window glasses layers, thickness and heat conduction coefficient

Glasses layers	Thickness	Conduction coefficient ($W/m^2 \cdot K$)
Monolayer	3	6.84
	5	6.72
Double glazing unit	3+6A+3	3.59
	3+12A+3	3.22
Three layers of insulating glass	3+6A+3+6A+3	2.43
	3+12A+3+12A+3	2.11

Note: (1) Normally, the gaps of 9 mm and 12 mm are adopted. K is the measured temperature difference; and the heat flowing through the window in the unit of joule. The greater the K value is, the poorer the window's insulation capacity is, and the more energy it loses

2.2 Distribution and lighting

Energy conservation lighting should be strictly in accordance with the architectural design of the implementation of energy conservation principles. In addition to energy conservation cost recovery, the use of new energy conservation equipment should also be considered, which can be selected after performing the economic and technological comparison of their working principle and performance. Equipment transformation mainly refers to the transformation of lighting devices (see Figure 3), including the installation of energy–saving lamps, sound or light-activate lights in public stairs and other public places. The sampling of low-voltage distribution systems should be conducted strictly to check the cable wire, so as to ensure that the cross-section and conductor resistance value are in line with relevant regulations. The construction department should strictly implement the *Code for Acceptance of Energy Efficient Building Construction*.

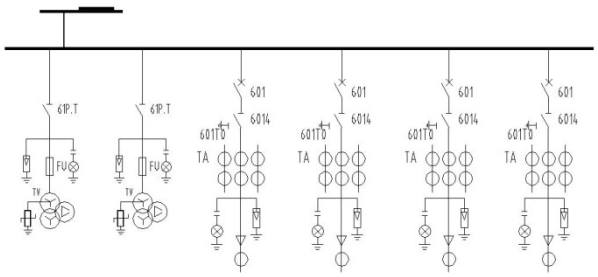

Figure 3: Distribution optimization design of a community

The energy conservation calculation of the energy-saving lamps: conduct a comparison of energy-saving lamps and incandescent lamps; assume a lamp works for 6 hours per day at 0.5 kWh (Chongqing). The switches, connectors and other accessories of energy-saving lamps and incandescent lamps are similar, thus, relevant cost difference is ignored:

1) Annual electric charge of an energy conservation lamp of 8W is: (8 × 6 × 365/1000) × 0.5 = 8.76 yuan

2) Annual electric charge of an ordinary incandescent lamp of 40W is: (40 × 6 × 365/1000) × 0.5 = 43.8 yuan

It can be seen from the above calculation that 35.04 yuan can be saved with an energy-saving lamp than an incandescent lamp. Li Hong, a member of CPPCC National Committee has made the following calculation: replace incandescent lamps of 60W with energy-saving lamps of 10W with similar luminance for 12 households who use lamps for 4 hours a day; the annual saving of power consumption equals the annual power generation capacity of the Three Gorges Project. Hence, it is of great significance to promote the use of energy-saving lamps in China.

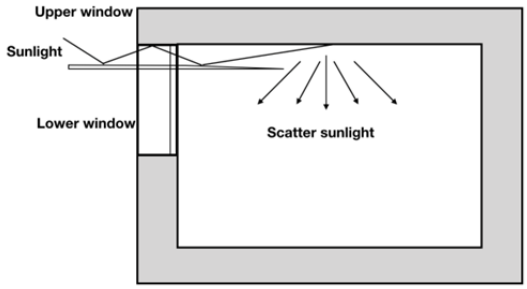

Figure 4: Illumination principle of lighting clapboard

As shown in Figure 4, the lighting baffle is mounted on both outside and inside of the window, which can reflect the light to the ceiling of the room, and block the sun at the same time. The ceiling becomes a secondary light source and illuminates the interior of the room because of the reflection; and the illumination is uniform even far away from the window. In the case of the same window area, the area which is distant from the window is fully illuminated too, and the indoor lighting uniformity and visual comfort are also improved. The light-absorbing partition method can effectively alleviate the non-uniformity of the daylight illumination environment and enhance the light quality.

2.3 Heating and energy conservation

First of all, it should be ensured that the heating system can meet the standard requirements. Secondly, the temperature control devices, calorimeters, hydraulic balance devices and other related equipment can be observed, operated and commissioned easily; and their installation location and direction can meet relevant requirements. Thirdly, the valves, thermometers and meters of cooling equipment should not be replaced, removed or added randomly to ensure complete installation. The energy supply of HVAC system should be optimized by combing local situations. For example, heating with the traditional wall-mounted cast iron heating radiators in winter should be eliminated, which should be replaced by more energy-efficient ground source heat pump central air conditioning systems. The air conditioning refrigeration with energy-saving walls/windows which can save 40% to 60% energy should be used in summer.

Table 2: Annual change chart of urban areas with large central heat supply during 2010-2015

Year	2010	2011	2012	2013	2014	2015
Heat supply area/ billion m^2	3.02	3.35	3.71	3.98	4.14	4.42

Meanwhile, as the people's living standard improves, heating demand is extended from the northern areas to southern areas, with the increased construction area needing heating being over 7 billion m^2 (Table 2). According to estimation, the construction area needing heating in the Yangtze River basin will reach about 5 billion m^2 by 2020. If the central heating mode in northern areas is adopted, an additional 0.6 to 0.8 million tons of standard coal and 400 to 450 billion kWh of electricity will be consumed annually as heating energy according to forecast, which will bring a heavy pressure on energy supply to our country. Based on this development trend, not only the urban construction and energy supply in Yangtze River Basin will be affected the energy shortage deteriorates in China.

The temperature of hot water heated the solar energy is about 30~60 ˚C in general, thus, it is possible to replace the conventional energy with solar energy. As stated before, the indoor temperature can be reduced by 2~3 ℃ as well. According to the relevant information, the indoor temperature can be reduced by 1 ˚C for

each 10% reduction in conventional energy. If the heat meter measurement charge is taken into consideration, another 20% to 30% of energy can be saved as well, promoting the energy efficiency by a considerable margin. The surface color indoor and natural light can also play an important role, especially for the side lighting. Because the depths of the room are mainly from the ceiling and the wall of the reflection, so their reflective coefficient of indoor light has an important role. However, the brightness of the adjacent surfaces should not vary largely, so that the light reflection coefficient should also be taken into account. For example, it is recommended to use light-colored surfaces to improve the reflection coefficient so as to increase the brightness of the room for buildings of a larger area with a greater depth or small windows through repeatedly reflection of the light between the surface of space objects, space walls, ceilings or furniture. The color of the interior surface is closely related to the spectral distribution of light sources; and different light sources have different spectral distributions. When a different light source illuminates a surface with the same color, it may produce a completely different surface color, which is determined by the color of light source.

3. Energy conservation construction

3.1 Enhancement of energy conservation awareness in building management

The enormous energy waste leads to the energy shortage problem in China. In order to solve the problem, the awareness of energy conservation should be strengthened through propaganda, education and other forms, and the energy conservation construction in China should be pushed forward from the source by means of improvement of construction management, reduction in the waste of construction resources, etc. In the decoration construction process, the waste in resources caused by human factors is very common due to poor management.

The energy conservation organizations should be established to take charge of building energy conservation work; and the organization and leadership of such organizations should also be strengthened, so as to create a good situation through joint efforts. The work system on building energy conservation of the leading group should be established and improved gradually, including our daily energy conservation work. For instance, the rework problems caused by unreasonable construction program or improper operation of the construction staff can easily lead to the waste of a large number of construction materials, and bring huge losses to the company.

3.2 Formulation of energy conservation construction technical scheme

Prior to the construction of energy conservation projects the construction departments should, firstly, prepare relevant technical scheme on energy conservation construction and get the approval from the competent construction supervision authorities. According to relevant provisions on energy conservation, the contents related to energy conservation construction should be in listed in the design proposal of each construction project so as to perform planning, organization and guidance of the projects. In addition, professional trainings by experts engaged in construction operations are also necessary. Given all of the above situations, first of all, enterprises should formulate scientific and rational management plans based on their actual situations, and improve their management systems, establish and complement management provisions so as to perform standardized construction.

The construction workers should be encouraged to save energy in their respective working processes through the setup and implementation of the corresponding reward and punishment system, which can lead to the energy conservation of the whole project. The prevalence of energy waste has led to energy shortage in China; therefore, the awareness of energy conservation should be strengthened nationwide in order to solve the energy shortage problem by the ways of publicity, education, etc.

3.3 Energy conservation management of materials

The supervision engineers should perform inspection and acceptance of materials and equipment; keep the quality records at the same time, covering the type, packaging, appearance, specification and technical data; and strictly control the technical indicators and solve the quality problems of equipment and materials, which should be in line with relevant national quality standards as the basis for the energy conservation projects. In order to control the quality of materials and equipment, first of all, relevant standards on materials and equipment should be stipulated in the contract; secondly, the quality standard requirements on materials and equipment should also be satisfied. For some design, equipment involved are not clearly stipulated in the contract, or described in the construction scheme. However, fire resistance is one of the most critical properties of building engineering; moreover, refractory materials in energy conservation engineering have direct impact on the safety of the users; hence specific requirements on fire resistance must be specified, so as to meet the requirements in specifications.

The environment-friendly construction materials should be used and green decorative materials should be adopted. As everyone knows, the decorative materials, including metal, wood and ceramics have very high prices. The forest plays a very prominent role in the control of greenhouse effect; however, the demand of wood in decoration is continuously increasing with the development of industry. Experts pointed out that the reduction in each of 1 cubic meter of decoration wood can reduce the emission of 643 kg of carbon dioxide. The adoption of these materials runs in the opposite direction with sustainable development of the economy, and is not conducive to the healthy development of decoration industry in China either. Nevertheless, many enterprises do not attach importance to the construction of building decoration materials used in environmental protection and energy conservation engineering in order to make more profits. The price paid to the use of wood, metal and other materials is too high, which does not only expedite the exhaustion of all kinds of resources, but also lead to forest deforestation and seriously damage the ecological balance in our country. Taking into consideration all of the above situations, the building decoration companies should raise their awareness, introduce more environment-friendly construction materials, and make efforts to reduce unnecessary waste, so as to ensure the construction quality on one hand, reduce the use of metal, wood and other materials on other hand, and finally realize their long-term development.

4. Conclusions

Building decoration works involve a wide range of complex work, which not only requires reasonable and appropriate arrangement of a lot of manpower and resources, but also a smooth connection between the water-power engineering, main structure and other works. The design and construction can exert a great influence to the environment and energy consumption of the buildings. Therefore, the construction companies at all levels should perform design and construction from the following two aspects to improve their work: namely, the adoption of new and efficient energy conservation environmental technology and integration of technology and management in architectural decoration, so that decoration works can be carried out in a more energy-saving and environment-friendly way.

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