Application of Energy Saving Construction in Construction and Civil Engineering

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Abstract

Energy-intensive and highly polluting construction and civil engineering have long been serving as the economic support of the country and causing serious environmental pollution and energy shortage at the same time. To achieve harmony between harmony between mankind and nature as well as sustainable development of social economy, energy saving construction should be applied in construction and civil engineering to change that dilemma. This paper gives an overview about energy saving construction, defines optimization method of it and discusses its specific application in construction and civil engineering.

Keywords: Energy Saving Construction, Construction Engineering, Civil Engineering, Technology Application.

1. RESEARCH BACKGROUND

1.1 Literature review

In recent years, natural resources shortage and environmental pollution seriously affected national economy, and energy-intensive and highly polluting construction and civil engineering just made things worse, which posed great threats to the sustainable development of social economy as well as environmental protection of mankind, of which, greenhouse gas emission alone already caused a lot of natural disasters and huge economic loss to the country (Hu, 2016). Considering that, only the R&D and application of energy saving construction in construction and civil engineering could benefit environmental protection by improving the energy-intensive and highly polluting development and reducing natural resources wastage, which made the increasingly significant research on energy saving construction an important subject on the sustainable development of national economy (Deng, 2016).At present, a large number of domestic scholars and technicians carried out deep research into energy saving construction and made great achievements in the application of renewable energies including solar energy, wind energy and geothermal energy. As was proved by many practices, the application of solar energy, wind energy and geothermal energy in construction and civil engineering could cause great reduction in energy loss and contribute to environmental protection as well as economic development.

1.2 Research purpose

This paper aims at a wide application of energy saving construction in construction and civil engineering based on a deep understanding of energy saving construction theory gained from a research on its specific application in construction and civil engineering (Mu, 2016). This paper discusses the application value of energy saving construction in construction and civil engineering by giving an overview about the status quo, principles and comprehensive evaluation method of the application of energy saving construction and making a deep analysis of its optimization method as well as the applications of wall energy saving construction, door and window energy saving construction, solar energy and wind energy in construction and civil engineering. As is known, social economic system reform has greatly improved the structure of productive forces, and similarly, the application of energy saving construction will contribute a lot to the rapid and sustainable development of social economy.

2. AN OVERVIEW OF ENERGY SAVING CONSTRUCTION

2.1 The status quo of the application of energy saving construction in construction and civil engineering

The development of urbanization in our country has greatly increased the number of construction and civil engineering projects which are energy-intensive and highly polluting. However, there is a big gap in the application of energy saving construction between China and developed countries. According to the statistics, by the end of 2015, of all the 60 billion square meters floor space of buildings, only one billion square meters used energy saving construction, accounting for only 1.7% (Cheng, 2016). Besides, due to extensive management in construction and civil engineering, the energy saving construction is narrowly applied with low standards and energy efficiency. As a result, it is imperative to apply energy saving construction in construction and civil engineering with no delay.

2.2 The principles of energy saving construction application

As the limits in energy saving construction greatly constrain its application in construction and civil engineering (Li, 2016), certain principles should be followed in energy saving construction application. First, energy saving materials should be scientifically selected for use. Second, operational process should be followed during the construction. Third, safety should be guaranteed during the construction. Fourth, pollutants and garbage should be carefully dealt with according to relevant law and regulations to improve resources recycle.

2.3 The comprehensive evaluation method of energy saving construction

The effects of energy saving construction application in construction and civil engineering directly relate to energy efficiency and even the sustainable development of national economy, which makes it necessary to make a comprehensive evaluation on energy saving construction application so as to select the optimal one (Wang and Jiang, 2016). Generally speaking, there are five comprehensive evaluation methods, including analytic hierarchy process (AHP), fuzzy comprehensive evaluation method (FCE), TOPSIS evaluation method, grey correlation method and principal component analysis(PCA)(Liu, 2017).Developed by Thomas L. Saaty in the 1970s, the analytic hierarchy process (AHP) is a comprehensive evaluation method based on mathematics that essentially reflects a person's way of thinking. Users of the AHP first decompose the complex problem into a hierarchy of more easily comprehended sub-problems, and then evaluate its various elements by comparing them to each other two at a time, with respect to their impact on an element above them in the hierarchy, so as to discover the nature of the problem. The widely used and mature fuzzy comprehensive evaluation method makes a comprehensive evaluation about different technology solutions by composing the fuzzy relations of various elements in the solutions with fuzzy mathematics and quantifying elements with fuzzy boundaries (Liu, 2016). Figure 1 shows the schematic diagram of fuzzy comprehensive evaluation method.

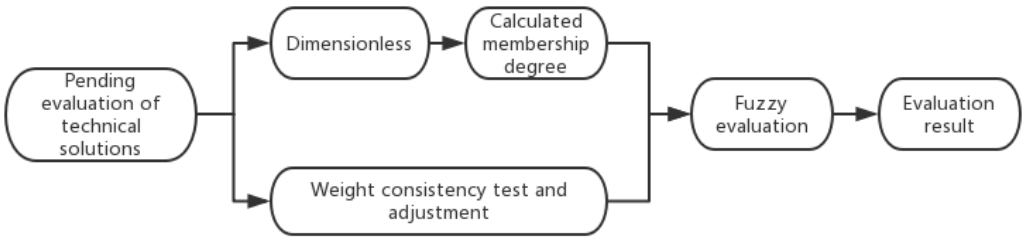

Figure 1. Schematic Diagram of Fuzzy Comprehensive EvaluationMethod

Raised in the 1980s, TOPSIS evaluation method aims at finding the approximation between the solution to be evaluated and the optimal one by calculating and evaluating the distance between the best and worst solutions discovered in the original matrix (Zhu and Shi, 2017).Deriving from the grey system theory and raised by Professor Deng Julong in the 1980s, grey correlation method first analyses the grey correlations of different solutions which can be judged from the approximation of geometric shapes of statistical series curves and then draws conclusion from comparing and ranking the approximations between various solutions and the best one according to their correlations (Li, 2017). In accordance with dimension reduction theory, PCA converts a set of observations of possibly correlated variables into a set of values of linearly uncorrelated variables before ranking the variables in the way that the first principal component has the largest possible variance and each succeeding component in turn has the highest variance possible under the constraint that it is orthogonal to the preceding components and then classifies and names the principal components so as to get the explanatory variables (Jia and Li, 2017).

3. THE OPTIMIZATION OF ENERGY SAVING CONSTRUCTION SOLUTIONS

Previous evaluation methods usually optimized solutions by detailing, grading and weighted accumulating the index, which, though simple and operational, in certain cases, could not make an absolute evaluation about a value but only describe the evaluation result with approximation, thus easily leading to information loss and optimization inaccuracy. While fuzzy comprehensive evaluation method can make a comprehensive evaluation about technical solutions by describing the performance characteristics of their index with fuzzy sets and getting the evaluation result in vector form, which guarantees the accuracy of solution optimization. Therefore, this paper analyses the optimization of energy saving construction with this method.

3.1 The establishment of index set and evaluation set

Users of fuzzy comprehensive evaluation method for energy saving construction solution optimization should first establish an index set of all the index of the energy saving construction solution$M=\{m_1, m_2, m_3, \ldots, m_j, \ldots, m_n\}$. If there is more than one layer of index in the solution, then divide them into different layers. After that, establish an evaluation set of the evaluation index, namely$V=\{v_1, v_2, v_3, v_4\}$, according to the index system of energy saving construction. The evaluations include excellent, good, medium and poor which are graded as$\{1, 0.8, 0.5, 0.2\}$. At last, affirm the optimization matrix D of each alternative solution according to the experts' grading, and then normalize these matrixes (Wang, 2015).

$$D=\begin{bmatrix} d_{11} & d_{12} & d_{13} & \ldots & d_{1m} \\ d_{21} & d_{22} & d_{23} & \ldots & d_{2m} \\ \ldots & \ldots & \ldots & \ldots & \ldots \\ d_{n1} & d_{n2} & \ldots & \ldots & d_{nm} \end{bmatrix}, (k=1,2,3,4,\ldots,n, l=1,2,3,4,\ldots,m) \quad (1)$$

In this formula, d_{kl} $(0\leq d_{kl}\leq 1, k=1, 2, \ldots, n, l=1, 2, \ldots, m)$represents the membership of the k^{th} evaluation index to thel^{th} judgement level, or the rationality of evaluation index$m$ in the energy saving construction solution being evaluated asd_k.

3.2 The determination of the optimal energy saving construction solution

The model $S=D\times C$ can be used in fuzzy comprehensive evaluation method to determine the optimal energy saving construction solution based on the evaluation matrix D and judgement index weight C of every energy-saving construction solution. In the model$S=D\times C$, C represents the weight vector of sincerity price index. c_k in formula $C=(c_k)_{1\times k}$, $c_k\in[0, 1]$, $\sum_{k=1}^{n} c_k = 1$represents the weight of the k^{th} evaluation factor in the general goal F, and s in the model $S=D\times C$is the optimal vector of the energy saving construction solution. After that, rank the priorities of alternative solutions according to the multiplication results gained by multiplying the optimal vectors of all the alternative energy saving construction solutions with relevant grades in evaluation set, and the one with the highest grade will be optimal.

4. THE APPLICATION OF ENERGY SAVING CONSTRUCTION IN CONSTRUCTION AND CIVIL ENGINEERING

4.1 The application of door and window energy saving construction in construction and civil engineering

As is known, door and window energy saving construction has an important role in construction and civil engineering. With the requirements for daylighting of the living environment increasing, more and more building area is reserved for doors and windows in construction and civil engineering, which greatly adds to the difficulty of construction, in that designers should adopt many methods in door and window construction to guarantee best insulation and daylighting, which will effectively reduce energy loss during the heating period.Three aspects should be taken into consideration when using door and window energy saving construction. First, energy efficient heat preservation materials of good quality should be used for qualified glass radiation to guarantee comfortable daylighting and temperature indoor. Second, the size of doors and windows should be scientifically designed in accordance with the area and height of the house to guarantee good heat preservation and daylighting at the same time, in that good at daylighting as large doors and windows are, they are poor at heat preservation with heat running away from their apertures. Third, good airtightness of doors and windows should be assured by filling the apertures between the wall and doors and windows with foam and

plastic seal trips so as to reduce heat loss indoor. Figure 2 shows the operation flow chart of door and window energy saving construction.

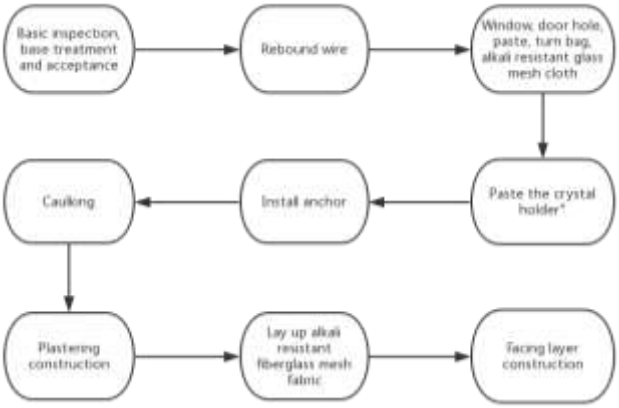

Figure 2. Operation Flow Chart of Door and Window Energy Saving Construction

4.2 The application of roof energy saving construction in construction and civil engineering

Energy saving construction can also be applied in roof construction which can not only guarantee good heat preservation, but also reduce the adverse impacts on the building from solar radiation (Gong, 2015). It requires constructors to strictly select construction materials and test their abilities to resist radiation when applying roof energy saving construction. In addition, the most environmentally friendly roof energy saving construction is to plant green plants on the roof, which not only raises energy efficiency but also improves the greening rate of the building and is thus worth promoting.

4.3 The application of wind energy in construction and civil engineering

Renewable wind energy is green and easily accessible, which offers a new choice to energy saving construction in construction and civil engineering, in that it can be transformed for reuse with certain equipment. Complementary with solar energy, wind energy can be transformed into electricity in rainy days and solar energy on sunny days, which can greatly lower cost and guarantee good quality of the construction and civil engineering.

4.4 The application of solar energy in construction and civil engineering

The application of solar energy in construction and civil engineering can greatly reduce energy loss. However, as solar energy is, to a large extent, limited by the differences in illumination time caused by geological differences, it is necessary to take the environment and other factors of the building into consideration so as to make full use of solar energy which can be transformed into electricity by solar panels.

4.5 The application of ground source heat pump technology (GSHP) in construction and civil engineering

GSHP is an important technology that can heat or cool the building through the underground shallow layer in the way that it makes use of the constancy of underground shallow layer temperature and transfers heat betweenthe low-temperature heat source and the high-temperature heat source (Cui and Fu, 2015). That is to say, during the heating period, the ground source heat pump can extract the heat from the underground shallow layer and warm it up to heat the building; and in summer, the pump will transfer the heat of the building to underground shallow layer so as to maintain indoor temperature constancy of the building.

4.6 The application of outer wall energy saving construction in construction and civil engineering

The outer wall energy saving construction is also important in construction and civil engineering. As is known, the out wall of the building has the largest contact area with external environment, making it easy for heat loss, yet the application of outer wall energy saving construction can provide proof for the out wall with

environmental composite insulation materials that are good at both heat preservation and thermal insulation. It is necessary to carefully check the density, US-FMVSS, heat conductivity coefficient and compressive strength of the insulation materials in accordance with national regulations, so as to make sure all the environmental composite insulation materials are qualified.

5. CONCLUSIONS

In conclusion, the application of energy saving construction in construction and civil engineering has become the tendency as well as a must in sustainable social development and environment protection. Therefore, the stakeholders of construction and civil engineering should pay more attention to the promotion of energy saving construction application and advocacy of green construction philosophy, which can lower energy and resource loss while guarantee construction quality at the same time. Only in that way can the goal of maintaining sustainable social development and harmonious relationship between mankind and nature be achieved.

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