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Research on System Evaluation and Green Transformation Program Design of Public Building

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In this paper, public building reconstruction program was designed as a starting point, combined with public building renovation design content, evaluation, and application features green technology content. Through the intervention of AHP methodology to evaluate the results of rehabilitation programs from the perspective of policy-makers, the research stage the same item multiple (or single) green evaluation rehabilitation programs. Deepening public building reconstruction and transformation program design results matching green evaluation criteria, effective green technology from the design phase to implement the plan and promote. Based on AHP in solving multi-objective, multi-level and multiplicity of decision factors to build and evaluation system features, public buildings transforming was designed for the research object, which corresponds to the green transformation of the target evaluation method. The system constructed public buildings green transformation program design evaluation system and identified at all levels of decision variables and weighting factor evaluation system.

1. Introduction

Around the world are facing a sharp reduction in energy use relates to building construction and operation of a large number of construction site and the creation of buildings lead to a deterioration of regional resources and environment (Hassler, 2014). The endless use of building materials, the global climate change and the strange anomalies Geography and climate projections events and frequency increase, is continually increasing environmental degradation, climate and resources, varying degrees of threat to people's health (Seidel and Janda, 2013). According to EU statistics, the building sector energy consumption accounts for about 42% of the total social energy consumption, is higher than the transportation and industrial sectors (Patel, 2012). To achieve sustainable development goals of the European community, the European Union must be the social energy performance building stock will be improved. In the United States, the construction and use of buildings consume 39% of the country's total energy consumption (Spoth and Redondi, 2013). If we calculate the energy production and transportation of building materials, this proportion will reach 48%. In addition, from the whole building life cycle, including building construction, use and maintenance process, about 40% of the energy consumed by air conditioning (Prashanth, 2014).
Press the architectural design process and the design depth, architectural design can be divided into decision-making (or program) design, preliminary design (Catthoor and Gbanie, 2013). Design costs about 1% of the cost of the total cost, but the impact overall performance targets for the project implementation has reached 70% (Peters, 2016). Final performance of building products is largely determined by the design stage. At this stage, nearly 80 percent architect of decision-making will go directly to the construction or operation and maintenance phase of the construction project environmental impact the final performance of the building. By designing programs to significantly improve the overall performance of the building operability has been minimal. Found in the program design has a crucial impact on the entire construction project (Todd and Underwood, 2013).Green building rating system should be established on the basis of two key aspects. On the one hand, the process of establishing evaluation system must be highly complex collection of system; therefore, this process is bound to need a multi-level cooperation project of the participating parties. Project Evaluation System Requirements government administration, planners, architects, construction units,

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management and operation of the user and other parties to the participants possess concept of sustainable development, and work together to complete the entire construction process. On the other hand, this multi-level partnership is reflected in the program throughout the whole life cycle of the building requires a consensus of environmental awareness, from start to finish through the clear overall environmental performance of building evaluation results. The core of these two factors on the operation of the implementation of green building rating reflects the higher demands, the needs of modern scientific method as an evaluation of its technical support. Thus, in the green building evaluation system development process draws some relatively mature evaluation theory, such as eco data model, full life-cycle theory and other relevant information databases and evaluation methods.

2. Green building design theory

2.1 Building performance simulation tool

Computer simulation of building performance tools appear, so that architects do not have experience or only with simple calculations to evaluate design alternatives (Diallo, 2014). Some suitable for use in the design phase of the program, flexible and easy analysis software for architects in the initial stages of the program can be for a variety of quantitative forecasting performance of buildings. By evaluating simulation tools to distinguish between the overall performances levels of the building can make the environment green building concept no longer stay in any play, blur level, thus ensuring the architectural design goals operability. Effective building performance simulation will analyse the process, material / member data, design standards, design details and other information on the dynamic integration of iterative design process of exploration. Building performance simulation tools as a design tool to evaluate and design combine to become part of the design process. Design phase use building performance simulation tools can improve the design of the built environment to grasp the overall performance, being able to play a guiding role in practice. Compare of main building performance analysis software was shown in Table 1.

Table 1: Compare of main building performance analysis software

Name	Functions	Advantages	Disadvantages
Ecotect	Energy Analysis Thermal condition analysis Lighting and shading analysis Noise environment analysis Cost analysis	Model checking ability The result is saved to a single file Analytical statements is easily to understand Viewing result is fast and precise Can be showed on different mediums With RMS	Analysis step is not much clear Cost too much time Some analysis process makes program unstable
Green Building Studio	Energy Analysis Thermal condition analysis Lighting and shading analysis Cost analysis	Less preparation work quick analysis from Revit model to gbXML LEED Daylight Credit 8.1	File is too large Can't choose analysis type Analysis type is limited Need password
Virtual Environment	Energy Analysis Thermal condition analysis Lighting and shading analysis Cost analysis	With Revit Plugins With similar UI to Revit Less analysis time With Life-Cycle cost analysis LEED Daylight Credit 8.1	The result is not consistent while using different toolkit Limited ability in check models

2.2 Multi-objective multi-attribute decision making theory

Decision program set is X = (x1, x2, ..., xn), DR for decision-making criteria, gj j th constraint, where, j = 1,2, ..., n, fi i th the objective function, i = 1,2, ..., n, then the multi-objective optimization decision-making process is essential:

$$DR\left[f_1(x), f_2(x), \ldots, f_n(x)\right], x \in X \tag{1}$$

$$x \in X = \left[x \middle| g_i\left(x\right) \le 0, j = 1, 2, ..., \mathrm{m} \right] \tag{2}$$

In the scheme set X, according to the decision criteria DR, by the objective function is maximized or minimized optimized way to find the optimal solution. In the multi-objective optimization decision-making process, decision makers and target preference information together determine the decision criteria. Multiple attribute decision making multi-objective was to evaluate the selection, decision-makers by analysing existing data and sample information decision on a finite number of known solutions of comprehensive evaluation and sorting.
Xj is the j-th attribute, ai is the i-th program, uij for the i-th program utility function value in the j-th attribute decision making under, DR of decision criteria, (2) the specific decision-making formula:

$$DR\left[\mathrm{a}_1\left(u\right), \mathrm{a}_2\left(u\right), ..., \mathrm{a}_n\left(u\right) \right], \mathrm{u} \in U \tag{3}$$

$$u \in U = \left[u \middle| u_{ij}\left(x\right) = f\left(\mathrm{a}_i, X_j \right), \mathrm{i} = 1, 2, ..., \mathrm{m}; \mathrm{j} = 1, 2, ..., \mathrm{n} \right] \tag{4}$$

Building products was given a variety of target property functions, environmental, economic, aesthetic, it is a typical multi-objective multi-attribute decision-making system. Aiming decision attributes, namely architectural design parameters, green building design phase of evaluation and decision-making is a limited evaluation of the program known choice.
In the multi-objective multi-attribute decision analysis problems, all the attribute values for each program constituting decision matrix, decision-making information for each program in the index attributes in the form of a matrix intuitive reflection. Decision matrix is the basis for multi-objective multi-attribute decision-making process. m a program attributes constituting the decision matrix, represented by U. Wherein, X = (x1, x2, ..., xn) set for the program, Xi = (x1, x2, ..., xn) represents the i-th program, F = (f1, f2, ..., fn) as a set of attributes, fj represents the j-th index attributes.

$$U = \begin{array}{c} \\ x_1 \\ x_2 \\ \vdots \\ x_n \end{array} \begin{array}{c} \begin{array}{cccc} f_1 & f_2 & \cdots & f_n \end{array} \\ \begin{bmatrix} u_{11} & u_{12} & \cdots & u_{1n} \\ u_{12} & u_{22} & \cdots & u_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ u_{1n} & u_{11} & \cdots & u_{nn} \end{bmatrix} \end{array} \tag{5}$$

As shown in Figure 1 is the highest level decision-making overall objective is the ultimate purpose of the decision, but the overall goal is not clear, it is the overall goal under the m sub-goals, each sub-goal also can be subdivided into n sub-goals until the individual grade target intuitive, concrete, workable so far. Bottom recursive hierarchy represent different attributes of each sub-index corresponds to the target, known as attributes layer or layers factors.

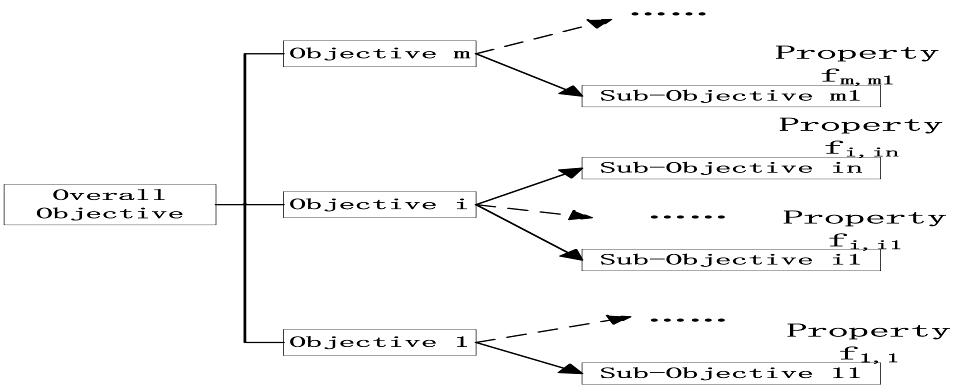

Figure 1: Multi-objective multi-attribute recursive hierarchy

2.3 Evaluation system comparison matrix realization

AHP evaluation system comparison matrix elements for the implementation is already complete construction of "public building renovation design green evaluation system" hierarchical model to transform green design rating of the target layer, layer progressive build different levels of comparison matrix in secondary layer adjacent to the same criteria be between "decision variables" the key factors (or sub-goal rule layer under layer) twenty-two take right. Ultimately, building a complete system-level comparison matrix:

$$A=\begin{Bmatrix} x_{11} & x_{12} & x_{13} & \cdots & x_{1n} \\ x_{21} & x_{22} & x_{23} & \cdots & x_{2n} \\ x_{31} & x_{32} & x_{33} & \cdots & x_{3n} \\ \cdots & \cdots & \cdots & \cdots & \cdots \\ x_{n1} & x_{n2} & x_{n3} & \cdots & x_{nn} \end{Bmatrix} \tag{6}$$

Pairwise comparisons array formula A-- any target layer;
x1 ~ xn - decision variable factor (or elements) of the target layer.
The judgment matrix elements in each column for the normalization process:

$$W_{ij}=\frac{a_{ij}}{\sum_{i=1}^{n}a_{ij}}\left(ij=1,2,3......n\right) \tag{7}$$

Each column will be treated by normalizing judgment matrix rows sum process:

$$W_{ij}=\sum_{i=1}^{n}W_{ij}\left(ij=1,2,3......n\right) \tag{8}$$

3. Experiments and results

3.1 Venues in three-dimensional design green transformation

Building renovation and additional vertical greening: RENOVATION be encouraged additional vertical greening, achieve its main green space in the form of diversification, create wealth building vertical interface, improving the environmental quality of building vertical outdoor function areas, regulating external building microclimate surroundings. The additional vertical green transformation was shown in Figure 2.

Figure 2: The additional vertical green transformation

Renovation and construction of green roofs added: RENOVATION be encouraged additional roof (or air) green, to achieve the transformation of the body building additional vertical green space, create a rich architectural top (or middle) green screen, room for improvement renovation building vertical zone greening the environment and improve the physical microenvironment. Building green roof types include green roofs, sky gardens, sunken courtyards and other forms, and through the roof greening rate control settings to implement.

3.2 Building envelope heat transfer coefficient index

Limit the roof heat transfer coefficient in different climatic zones should satisfy the "public building energy efficiency design standards" GB50189-2005 building roof heat transfer coefficient, as shown in Table 2 public building roof heat transfer coefficient limit tables.

Table 2: Statistic of limit value of roof heat transfer coefficient

climatic province	shape coefficient S	heat transfer coefficient
Cold regions A	⩽0.3	⩽0.35 W/(m2·K)
	0.3<S⩽0.4	⩽0.30 W/(m2·K)
Cold regions B	⩽0.3	⩽0.45 W/(m2·K)
	0.3<S⩽0.4	⩽0.35 W/(m2·K)
Cool areas	⩽0.3	⩽0.55 W/(m2·K)
	0.3<S⩽0.4	⩽0.45 W/(m2·K)
Hot Summer and Cold Winter Zone	——	⩽0.70 W/(m2·K)
Hot Summer and Warm Winter Zone	——	⩽0.90 W/(m2·K)

After building renovation and non-heating room heating room wall heat transfer coefficient transformation control: non-heating room in different climatic zones of heating and limits the room wall heat transfer coefficient should satisfy the "public building energy efficiency design standards" GB50189-2005 on building non-heating room and the heating room wall heat transfer coefficient requirements, as shown in Table 3 public building wall heat transfer coefficient limits.

Table 3: Statistic of limit value of heat transfer coefficient of public buildings partition walls

climatic province	shape coefficient S	heat transfer coefficient
Cold regions A	≤0.3	≤0.6 W/(m2·K)
	0.3<S⩽0.4	≤0.6 W/(m2·K)
Cold regions B	≤0.3	≤0.8 W/(m2·K)
	0.3<S≤0.4	≤0.8 W/(m2·K)
Cool areas	≤0.3	≤1.5 W/(m2·K)
	0.3<S≤0.4	≤1.5 W/(m2·K)

Public buildings green transformation program design of the modified weighting, building renovation design weight of 46%, building physics environmental reconstruction design evaluation index weighting of 21%, building energy-saving design evaluation index weight of 14% (Figure 3).

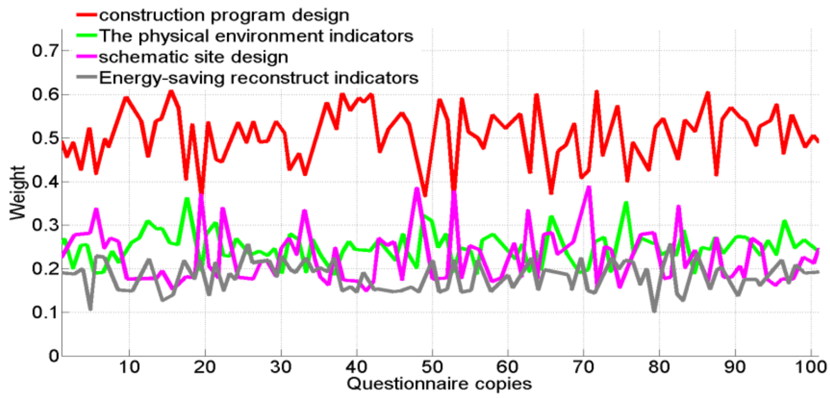

Figure 3: Weight of influential factors of green-renovation of public buildings

4. Conclusions

In this paper, effective green technology from the design phase to implement the plan and promote. Based on AHP in solving multi-objective, multi-level and multiplicity of decision factors to build and Evaluation System features, public buildings transforming the design plan for the research object, which corresponds to the green transformation of the target evaluation method, the system constructed public buildings green transformation program design evaluation system and identified at all levels of decision variables and weighting factor evaluation system. Improve the traditional building renovation program evaluation in response to the evaluation difference transform green design goals to achieve, deepen public buildings green transformation program to determine the basis, to match the design criteria for evaluating the content and provisions related rehabilitation programs, effectively promote the transformation of public buildings green deepened.

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