

Retraction

Retracted: Application of Energy Saving and Environmental Protection Materials in Architectural Design

Advances in Materials Science and Engineering

Received 26 December 2023; Accepted 26 December 2023; Published 29 December 2023

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This article has been retracted by Hindawi, as publisher, following an investigation undertaken by the publisher [1]. This investigation has uncovered evidence of systematic manipulation of the publication and peer-review process. We cannot, therefore, vouch for the reliability or integrity of this article.

Please note that this notice is intended solely to alert readers that the peer-review process of this article has been compromised.

Wiley and Hindawi regret that the usual quality checks did not identify these issues before publication and have since put additional measures in place to safeguard research integrity.

We wish to credit our Research Integrity and Research Publishing teams and anonymous and named external researchers and research integrity experts for contributing to this investigation.

The corresponding author, as the representative of all authors, has been given the opportunity to register their agreement or disagreement to this retraction. We have kept a record of any response received.

References

- [1] Z. Yan, "Application of Energy Saving and Environmental Protection Materials in Architectural Design," *Advances in Materials Science and Engineering*, vol. 2022, Article ID 1358251, 12 pages, 2022.

Research Article

Application of Energy Saving and Environmental Protection Materials in Architectural Design

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Received 10 June 2022; Revised 1 August 2022; Accepted 3 August 2022; Published 7 September 2022

Academic Editor: Haichang Zhang

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With the improvement of the living standards of the Chinese people, the construction of the economic system will change from one that meets the needs of the people to one that is perfect. Under the current environment of building a resource-saving socialist harmonious society, it is very necessary for architectural design practitioners to return to the original architectural design and pay attention to the design and use of building materials during construction. The purpose of this paper is to explore and analyze the application of energy saving and environmentally friendly materials in architectural design. This paper firstly analyzes the building's energy consumption and building's energy efficiency. Every major achievement in building energy efficiency will be an important means of mitigating the Earth's energy. Building energy saving has become a major trend of global development, and then the optimal design of reinforcement selection for reinforced concrete beams based on a multiobjective genetic algorithm is discussed. The area of reinforcement required for the member control section is obtained according to the structural analysis program, the main purpose of reinforcement selection is to select safe, economical, and reasonable reinforcement on the premise of meeting the provisions of the code and the requirements of reinforcement structure. Finally, this paper conducts experimental research on the application of phase change energy storage building material SP28 in building energy conservation. The experimental results in this paper show that when the mass ratio of the phase change energy storage material in the wall is less than 15%, there is no wetting and leakage phenomenon. However, when the mass ratio of the phase change energy storage material contained in the wall is greater than 15%, the phenomenon of wetting and leakage will occur, which will cause greater losses when added to the wall. Therefore, it is not suitable for application and building walls. Regardless of leakage, wetting, or economic considerations, the mass ratio of phase change material of 10% is the most suitable for use in walls. It not only has no wetting and no leakage but also has a good energy storage effect and can effectively adjust the ambient temperature.

1. Introduction

Energy is the cornerstone on which people live and thrive. Due to the continuous development of socialism and the development of the market economy, the material conditions of people's living are getting better and better, which directly or indirectly increases people's increasing demand for energy. Regrettably, in practice, the utilization rate of energy by human beings is not very high, and they are faced with huge waste, which leads to an increasing shortage of energy supply. Therefore, researchers in the field of materials in China have begun to focus on how to improve the utilization rate of energy. In order to fully improve the utilization effect of energy, we can also store unused energy

temporarily and release it automatically after the required time. Therefore, controlling the absorption and release of energy by new materials through effective means is an important way to save energy.

The development of the times is accompanied by the arrival of opportunities, and the emergence of phase change energy storage materials meets the requirements of energy saving energy storage. It can rationally utilize resources and release energy when needed. It automatically absorbs heat and stores it when not needed. This can not only improve the utilization of energy but also reduce the change in indoor temperature. Moreover, this method is both environmentally friendly and economical, which meets the sustainable development strategy advocated by China. The phase change

material is added to the building wall in the form of a medium, which can reduce the fluctuation of the indoor ambient temperature. It avoids the use of heating appliances and the like. At the same time, it can reduce the thickness of the envelope structure. It increases the living space of the house and has wide application prospects. Therefore, developing new materials and utilizing them in the building envelope with maximum efficiency can greatly alleviate the current building energy consumption. This paper aims to explore and analyze the application of energy-saving and environmental protection materials in architectural design in order to find more energy-saving and environmental protection materials in architectural design and make a certain contribution to the cause of energy conservation and environmental protection in the society.

The innovation of this paper is as follows: (1) this paper analyzes the building energy consumption and building energy conservation. Building energy conservation has become the general trend of global development; (2) based on a multiobjective genetic algorithm, this paper studies and discusses the optimal design of reinforcement selection of reinforced concrete beams. The main purpose of reinforcement selection is to select safe, economical, and reasonable reinforcement; (3) in this paper, the application of phase change energy storage building material sp28 in building energy conservation is experimentally explored.

2. Related Work

According to the research progress in foreign countries, different researchers have also conducted corresponding cooperative research on energy-saving and environmental protection materials. Yue et al. took wooden buildings as the research object. He evaluated building energy consumption and CO₂ emissions with the concept of the whole life cycle. By comparing and analyzing brick-concrete structures with equivalent thermal performance, he obtained the comparative ecological advantages of wood-structured buildings [1]. Wang et al. proposed that rare Earth standards can guide the development of the rare Earth industry, and the upgrading of the rare Earth industry can promote rare Earth standards. He further studied the indirect impact of the rare Earth standard system on the environment [2]. Zhou et al. prepared a nanoscale sepiolite/Cu₂O/Cu ternary composite anode for lithium-ion batteries using natural clay sepiolite. Compared with Cu₂O and sepiolite, the environmentally friendly sepiolite/Cu₂O/Cu anode prepared by him showed excellent electrochemical performance [3]. As it describes the effects of temperature (85°C) and relative humidity (RH) (85%) on the structure and material properties of environmentally friendly Sn-3.0Ag-0.5Cu. He can carry out more detailed microstructural characterization through scanning electron microscopy with EDS analysis, X-ray diffraction, electron backscatter diffraction, and transmission electron microscopy [4]. Hassan et al. aimed to study the performance of the cement produced by adding different ratios of synthetic zeolite catalysts. He investigated the mechanical and physical properties expressed by compressive strength, fineness, and setting time of five zeolite-

mixed cement clinker samples prepared using different proportions (1–10% by weight) of synthetic zeolite catalysts [5]. Gutierrez et al. have upgraded these wastes by using wet-laid technology in combination with different thermoplastic binder fibers from natural and synthetic sources. After the wet-laid process, the veil or nonwoven fabric he obtains goes through different processes: the thermoforming process or the continuous lamination process [6]. However, these scholars did not analyze and discuss the application of energy-saving and environmentally friendly materials in architectural design but only discussed its significance unilaterally.

3. Application of Energy-Saving and Environmentally Friendly Materials in Architectural Design

3.1. Building Energy Consumption and Building Energy Efficiency. Building consumption is a major aspect of energy consumption. It generally includes many aspects, such as air conditioning, heating, electrical lighting, water supply, and so on. According to statistics, about 30% of the world's electricity is consumed in construction. It also refers to the whole process of energy consumption from building material manufacturing and building construction to building use. An oil crisis in the 1970s made the cause of building energy conservation for the first time in the world, and developed countries such as Europe and the United States also launched research on building energy conservation at this time. Therefore, it is important to understand in detail where buildings consume energy and how to take measures [7]. China's building energy consumption has reached about 30%, and there is a trend of increasing year by year. In addition, China's low utilization rate of energy and unreasonable energy conversion have left a lot of room for building energy conservation. Therefore, building energy conservation has become China's three major application areas after transportation energy conservation and manufacturing energy conservation, as shown in Figure 1 [8]. The overall and external environmental design of the building is based on the analysis of the climate and environmental conditions around the building. Through the design of site selection, planning, external environment, and body orientation, the building can obtain a good external microclimate environment and achieve the purpose of energy conservation.

At present, China's land area is about 40 billion square meters. More than 90% of buildings are high-energy-consumption buildings, and the energy consumption per unit area is about three times that of countries and regions with similar climatic conditions. With the deepening of China's urbanization process, the scale of residential construction is also increasing, and the proportion of building energy consumption in the total consumption of living fuels is also increasing. It has increased from 10 percent in the late 1970s to 27.6 percent now. The total energy consumed by its heating accounts for about 60% of the national building energy consumption [9]. In addition, according to relevant data, it is expected that by 2030, the national urban

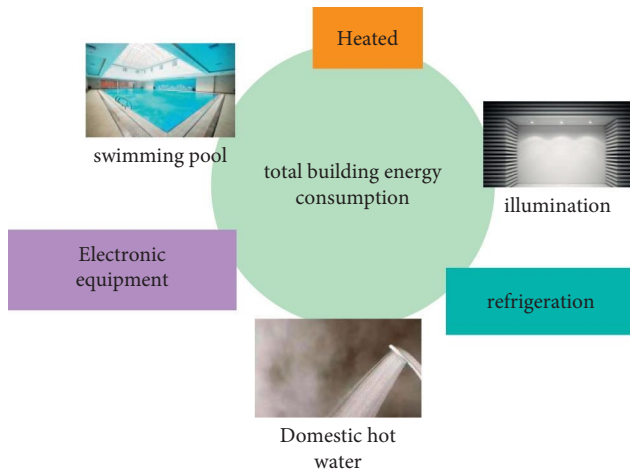


FIGURE 1: Overall composition of building energy consumption.

population will increase to more than 60% of the total population. With the continuous development of society, the urban population will continue to increase, so the buildings and building energy consumption will also increase geometrically. The ratio of construction costs to total energy consumption is also increasing. Therefore, the current research on building energy efficiency is of great significance. Building energy conservation refers to reducing energy consumption as much as possible in the production of building materials and the construction and use of buildings and structures. Every major achievement in building energy conservation will be a key means to solving the problem of global energy consumption. At present, building energy conservation has become a major trend in global development [10]. Figure 2 shows the energy-saving control system for building equipment. The ideal energy-saving building should meet the following three points with minimum energy consumption. First, it can control and receive or prevent solar radiation in different seasons and regions; second, it can maintain indoor comfort in different seasons; third, it can realize the necessary ventilation in the room.

3.2. Optimal Design of Reinforcement Selection for Reinforced Concrete Beams Based on the Multiobjective Genetic Algorithm. After using structural analysis software to analyze the engineering structure, the automatic selection of reinforced concrete members in this paper has become an important link before the engineering structure CAD software draws construction drawings [11]. The area of reinforcement required for the member control section is obtained according to the structural analysis program, and the main task of reinforcement selection is to select safe, economical, and reasonable reinforcement on the premise of meeting the provisions of the code and the requirements of reinforcement structure [12]. The results of reinforcement selection not only directly affect the efficiency and quality of design but also affect the economic and technical indexes of buildings.

3.2.1. Establishment of Beam Section Selection Database. In the engineering design of a frame structure, it is a very tedious work to know the maximum scattering section length of the steel bar and control the reinforcement area of the section during load design, as well as how to select the best reinforcement form. If there is no scientific reinforcement method, it will not be able to accurately reflect the provisions of the design specification. It may also add a lot of complicated trial calculation processes to the designer, and the result of selecting reinforcement is not necessarily the most economical or even unfeasible [13]. Among them, some structural design software has proposed specific drawing templates. However, the choice of reinforcement is faced with the question of how to be economical and reasonable. Therefore, as a key part of the spatial structure optimization design of large-scale medium and high-rise buildings, it is necessary to carry out more in-depth and systematic research on the optimization of reinforcement selection. After a deep understanding of the design specifications and conditions, this paper fully considers the feasibility and convenience of the design and construction process. Based on the previous engineering design experience and specification, this paper presents the reinforcement selection template for the scattering section of the beam. It builds a reinforcement selection database for scattering sections and selects the optimal prediction reinforcement form for beams [14].

The common ones are the diameter of longitudinal reinforcement (14, 16, 18, 20, 22, 25, 28, 32) and the diameter of the stirrup (6, 8, 10, 12, 14). After concretely measuring the basic parameters in the section reinforcement selection module, it obtains the beam member section reinforcement selection database as required in Table 1. More than 2,000 structures can be formed by the steel bars hooped on the limbs [15]. The database not only includes the specific form of reinforcement on one side of the structure but also gives the amount of longitudinal reinforcement and stirrup diameter on one side. It lays a foundation for the estimation of structural construction costs.

3.2.2. Fuzzy Evaluation Target System of Bar Selection Results. As shown in Figure 3, the selection of beams actually includes four parts: negative reinforcement at the support, midspan bottom longitudinal reinforcement, erection reinforcement, and stirrup, which are separated in form but actually affect each other. The reason why it is said that it is separated in form but actually affects each other is that the selection of reinforcement must meet the respective specifications and structural requirements of stirrups, support longitudinal reinforcement, and beam bottom longitudinal reinforcement. It also considers the correlation between parameters such as the number of stirrup legs, the number of longitudinal reinforcements, the diameter of longitudinal reinforcements, the clear distance of reinforcements, and geometric symmetry. At the same time, it is necessary to make the design drawings have good constructability characteristics [16]. Economy is also important. The cost of reinforcement is an important part of the beam cost. It has become an important index for the design institute and the owner to evaluate the design quality.

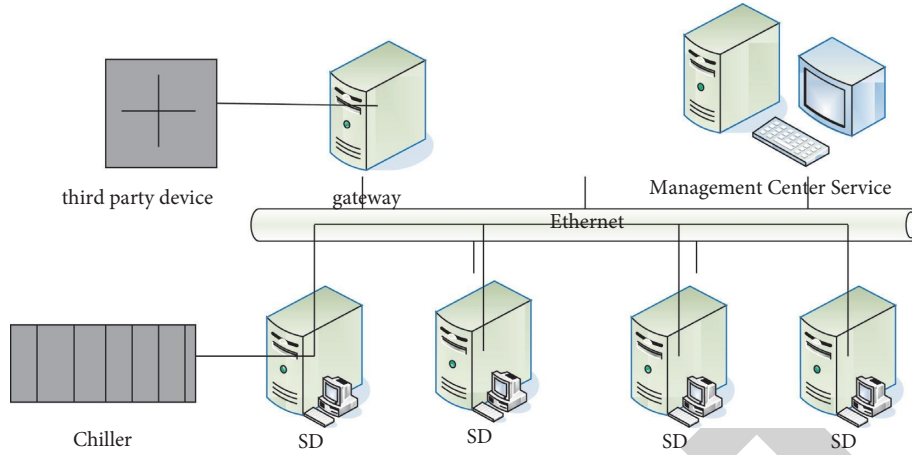


FIGURE 2: Building equipment energy conservation control system.

TABLE 1: Beam selection database.

Serial number	Y	K	T	P
1	250	300	14	2
2	250	300	16	2
⋮	⋮	⋮	⋮	⋮
305	250	650	14	2
306	250	650	16	2
...

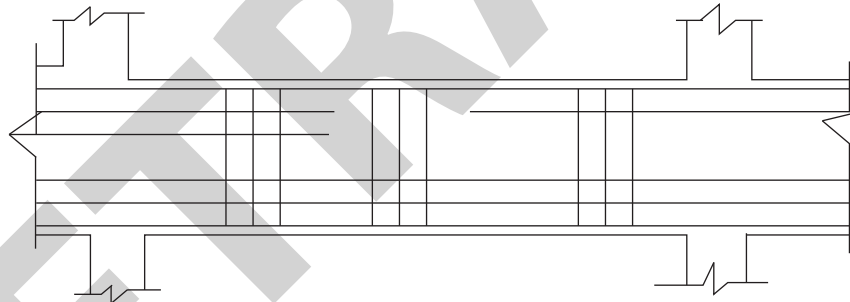


FIGURE 3: Model of beam reinforcement.

It can be seen that the evaluation of the selection results should not be based solely on the merits of a certain parameter in the selection process. It adopts the method of fuzzy comprehensive evaluation and takes into account the requirements of various indicators, which is more accurate and applicable [17]. Therefore, according to the specification requirements, standard Atlas, and design experience, this paper defines the fuzzy evaluation target system for beam selection as shown in Figure 4.

3.2.3. Fuzzy Multiobjective Decision-Making Model for Beam Selection. It sets p decision schemes to form a scheme set $G = \{g_1, g_2, \dots, g_p\}$, and each scheme has q targets, forming a target set $D = \{d_1, d_2, \dots, d_q\}$, and the importance of each target is represented by R , which constitutes the weight vector $R = \{r_1, r_2, \dots, r_q\}$. R satisfies the normalization

condition, $\sum_h^q r_h = 1, r_h > 0$, then the target decision matrix A can be formed as follows:

$$A = \begin{pmatrix} a_{11} & a_{12} & \cdots & a_{1p} \\ a_{21} & a_{22} & \cdots & a_{2p} \\ \cdots & \cdots & \cdots & \cdots \\ a_{q1} & a_{q2} & \cdots & a_{qp} \end{pmatrix} \quad (1)$$

a_{mn} is the attribute value $n = 1, 2, \dots, q; m = 1, 2, \dots, p$ of scheme n target m .

The ultimate purpose of fuzzy comprehensive evaluation is to compare the comparative advantages between the universe of discourse and p methods and select the corresponding optimal prediction method. This preference has nothing to do with methods other than those in the field. Through the relativity of this preference, the corresponding degree of membership of each evaluation method and the

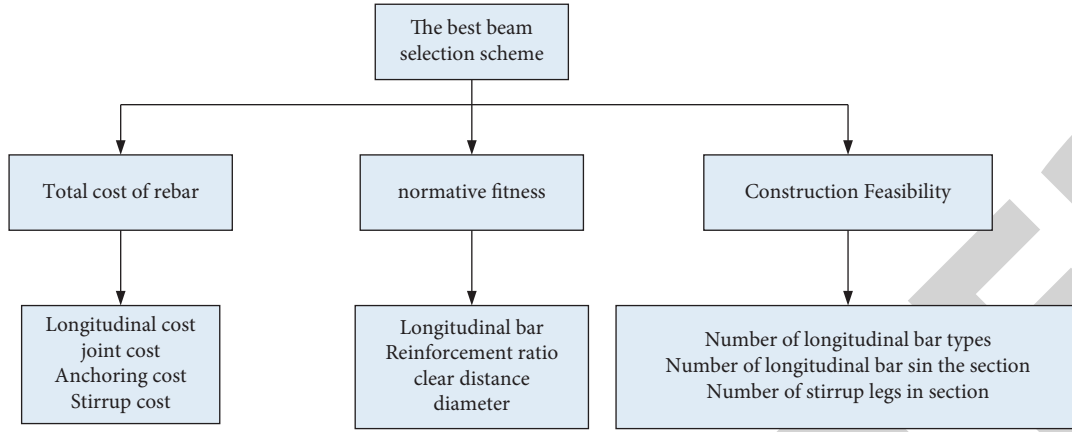


FIGURE 4: Target evaluation system for beam selection.

overall goal can be judged, as well as the corresponding superior program design and corresponding inferior program design in the field [18]. Figure 5 shows the fuzzy comprehensive evaluation method.

In order to establish a fuzzy evaluation matrix with the relative membership degree of each evaluation target to reduce the dimensional impact on each evaluation target and make the model more flexible, the target decision matrix A needs to be standardized as follows:

The standardized processing formula for the bigger and better index can be taken as

$$t_{mn} = \frac{a_{mn}}{a_{m \min} + a_{m \max}} \quad (2)$$

The standardized processing formula for the smaller the better index can be taken as

$$t_{mn} = \frac{a_{h \min} + a_{h \max} - a_{mn}}{a_{m \min} + a_{m \max}} \quad (3)$$

The standardized processing formula for the index can be taken as

$$t_{mn} = \frac{a_{mn}}{a_{m \text{mid}} + a_{m \min}} \quad a_{m \min} \leq a_{mn} \leq a_{m \text{mid}} \quad (4)$$

$$t_{mn} = \frac{a_{h \min} + a_{h \max} - a_{mn}}{a_{m \min} + a_{m \max}} \quad a_{m \min} \leq a_{mn} \leq a_{m \max}$$

In the formula: $a_{m \min}$, $a_{m \max}$, and $a_{m \text{mid}}$ are the minimum, maximum, and intermediate optimum values of the m th index in the scheme set, respectively. t_{mn} is the standardized evaluation target value, that is, the n th evaluation index of the m th scheme is subordinate to the relative membership degree value $n = 1, 2, \dots, q; m = 1, 2, \dots, p$ of excellent. The fuzzy evaluation matrix T of the evaluation target can be formed by using these t_{mn} values as elements.

$$T = \begin{pmatrix} \varphi_{11} & \varphi_{12} & \cdots & \varphi_{1p} \\ \varphi_{21} & \varphi_{22} & \cdots & \varphi_{2p} \\ \cdots & \cdots & \cdots & \cdots \\ \varphi_{q1} & \varphi_{q2} & \cdots & \varphi_{qp} \end{pmatrix} \quad (5)$$

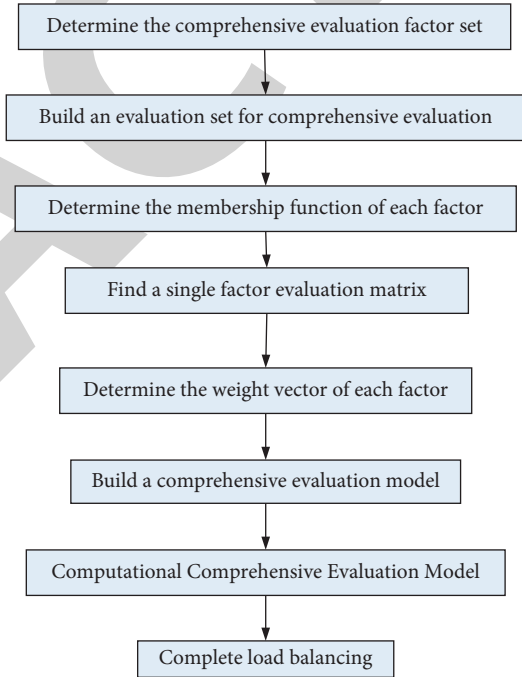


FIGURE 5: Fuzzy comprehensive evaluation method.

In the case of a multiobjective strategy, weights are data describing the relative importance of the objectives. Weight often reflects the degree of managers' understanding of the issues involved in decision-making. It is a comprehensive reflection of managers' professional knowledge, experience, personal preferences, and wishes. Therefore, the setting of weights is also the key to dealing with more target decision-making problems [19]. We use the ordered binary comparison method. For the convenience of description, the relevant contents are summarized as follows:

It has the target set to be compared as $U = u_1, u_2, \dots, u_q$. In this paper, the binary comparison method is used to rank the importance of all the targets in the target set U , and the order of the importance of the q targets that conform to the ranking consistency can be obtained. It may be set to

$u_1 > u_2 > \dots, u_q$, “ $X > Y$ ” means “ X is more important or equally important than Y ,” and the ordered binary comparison matrix of the importance of the target can be obtained:

$$\alpha = \begin{pmatrix} \alpha_{11} & \alpha_{12} & \dots & \alpha_{1p} \\ \alpha_{21} & \alpha_{22} & \dots & \alpha_{2p} \\ \dots & \dots & \dots & \dots \\ \alpha_{q1} & \alpha_{q2} & \dots & \alpha_{qp} \end{pmatrix} = (\alpha_{qp}). \quad (6)$$

Among them, when u_h is more important than u_n , $0.5 < \alpha_{hn} \leq 1$; when u_n is more important than u_h , $0 < \alpha_{nh} \leq 0.5$, and $\alpha_{nm} = 1 - \alpha_{nh}$. When u_h and u_n are equally important, $\alpha_{hn} = 0.5$, obviously $\alpha_{hh} = 0.5$; and α_{hm} is the fuzzy scale value of the relative importance of target u_h to u_n .

The above formula is a matrix of order $q * q$, whose diagonal elements are all 0.5, and divides the matrix into two left and right triangles. The element value in the upper triangle starts from the diagonalizable element value of 0.5, the element value of each row increases from left to right, and the element value of each column decreases from top to bottom [20], namely

$$\left. \begin{array}{l} 0.5 = \alpha_{11} \leq \alpha_{12} \leq \alpha_{13} \leq \dots \leq \alpha_{1p} < 1 \\ 0.5 = \alpha_{22} \leq \alpha_{23} \leq \dots \leq \alpha_{2p} < 1 \\ \dots \dots \dots \\ 0.5 = \alpha_{qp} < 1 \end{array} \right\}. \quad (7)$$

The α_{nm} value here can be obtained by looking up Table 2 according to the tone factor that the target u_h is more important than u_n given by the decision maker.

For the known importance ranking $u_1 > u_2 > \dots, u_q$ and the corresponding adjacent target relative importance fuzzy scale value $\alpha_{12}, \alpha_{23}, \dots, \alpha_{q-1,q}$, according to the principle of relative superiority, the unnormalized weight of the target can be set as

$$e^i = (e_1^i, e_2^i, \dots, e_q^i). \quad (8)$$

$e_1^i \geq e_2^i \geq \dots \geq e_q^i$, the phase sum matrix is constructed from the ordered binary comparison matrix α :

$$\delta = \begin{pmatrix} 1 & \frac{\alpha_{12}}{\alpha_{21}} & \dots & \frac{\alpha_{1q}}{\alpha_{q1}} \\ \frac{\alpha_{21}}{\alpha_{12}} & 1 & \dots & \frac{\alpha_{2q}}{\alpha_{q2}} \\ \dots & \dots & \dots & \dots \\ \frac{\alpha_{q1}}{\alpha_{1q}} & \frac{\alpha_{q2}}{\alpha_{2q}} & \dots & 1 \end{pmatrix}. \quad (9)$$

Comparing the elements of the first column of a matrix:

$$\delta^* = (\delta_1, \delta_2, \dots, \delta_q)^R = \left(1, \frac{\alpha_{21}}{\alpha_{12}}, \dots, \frac{\alpha_{q1}}{\alpha_{1q}}\right)^R. \quad (10)$$

TABLE 2: Corresponding relationship.

Tone operator	Same	Slightly	A little	Relatively	Obvious	Significant
Fuzzy scale	0.5	0.55	0.6	0.65	0.7	0.75

It is the unnormalized weight of each target in the object set $U = \{u_1, u_2, \dots, u_q\}$, namely

$$e^i = (e_1^i, e_2^i, \dots, e_q^i)^R = \left(1, \frac{\alpha_{21}}{\alpha_{12}}, \dots, \frac{\alpha_{q1}}{\alpha_{1q}}\right)^R. \quad (11)$$

Normalizing e_h^i :

$$e_h = \frac{e_h^i}{\sum_{m=1}^q e_h^i} \quad (h = 1, 2, \dots, q). \quad (12)$$

Thus, the target weight vector is obtained, which is expressed as follows:

$$e = (e_1, e_2, \dots, e_q). \quad (13)$$

The most ideal method for beam reinforcement selection is an optimal solution of design, and its various methods and objectives satisfy the optimal predicted value of each alternative method. At the same time, it can also be designed as a worst-case scenario. Its options and goals satisfy the minimum of the alternatives. In order to obtain the relative membership degree r_n of the scheme n to the superior, set the generalized Euclidean weighted distances c_{nf} of the scheme and superior and inferior to be and c_{nl} , respectively, namely:

$$c_{nl} = \left[\sum_{m=1}^q (e_{nm} t_{nm})^2 \right]^{1/2}. \quad (14)$$

According to the complementary set theory of fuzzy sets, the relative membership degree of scheme n to inferior is $r_n^k = 1 - r_n$. In fuzzy set theory, membership degree can be considered as weight, so the weight distance between scheme n and the superior and inferior schemes is B_{nf} and B_{nl} , respectively, there are

$$B_{nl} = r_n^k c_{nl}. \quad (15)$$

In order to solve the relative membership of scheme n to the superior, if the criterion of the shortest distance is followed, that is, the sum of the squares of the weighted distance from the superior and the square of the weighted distance from the inferior is the smallest. Then, the objective function is

$$\begin{aligned} \min G_N &= B_{NF}^2 + B_{NL}^2 = r_n^2 \sum_{m=1}^q [e_{nm} (1 - t_{nm})]^2 \\ &+ (1 - r_n)^2 \sum_{m=1}^q (e_{nm} t_{nm})^2. \end{aligned} \quad (16)$$

Let $\partial G_N / \partial r_n = 0$, the fuzzy optimization model expressed by Euclidean distance is obtained as

$$r_n = \frac{1}{1 + \left(\frac{\sum_{m=1}^q [e_{nm}(1-t_{nm})]^2}{\sum_{m=1}^q (e_{nm}t_{nm})^2} \right)} = \frac{1}{1 + (c_{nf}/c_{nl})}. \quad (17)$$

For different schemes, the relative membership degree of each scheme to the best can be obtained through the process. Finally, the relative membership degree vector obtained is $r = (r_1, r_2, \dots, r_p)$, and the largest one is the best solution.

4. Experimental Results of Application of Energy-Saving and Environmentally Friendly Materials in Architectural Design

Due to the unique heat storage properties of phase change materials, more and more scientists and scholars are interested in them. It has also led to further in-depth research and development of phase change materials in recent years, and its wider use value has been gradually discovered by researchers. At present, the application of phase change materials is more in the field of construction. The most typical one is to add phase change materials into building materials to manufacture various phase change thermal insulation boards, phase change walls of enclosure structures, and phase change heating floors. The combination of phase change, energy storage materials, and traditional building walls can improve the comfort of the indoor environment and reduce the consumption of electricity for home heating. It is a hot issue in the current research in the field of energy conservation. Regarding the research on the arrangement of phase change materials, this paper finds that when the interior environment requires wall insulation, the phase change energy storage should be arranged on the outside of the building wall. When the indoor environment requires the wall to absorb heat, the phase change energy storage material should be arranged on the inner side of the building wall.

In this study, an inorganic composite phase-change energy storage material SP-28 was encapsulated in expanded perlite by a porous-based material adsorption method and then made into a phase-change building wall, and its energy-saving effect was measured. According to the principle of similarity, we will set the properties to be basically similar to the actual building, make it smaller in scale, and keep all other conditions the same as the actual building. The main purpose of this experiment is to detect how the building wall after adding the phase change material SP-28 affects the surrounding temperature and how much is the best.

4.1. Experimental Method. This experiment first builds a common room similar to a residential house. In order to save materials, the house is not large, and its size is 3.5 m × 3.5 m × 3 m. The walls are all made of ordinary concrete, and the surroundings and roof of the walls are the same as those of the residential house, which has a similar simulation effect and is used for later experiments.

4.1.1. Experimental Materials and Experimental Instruments. The experimental materials are vitrified microbeads, putty, water, and phase change material (SP-28). Because its phase transition temperature is within the optimum temperature accepted by humans and its latent heat of phase transition is also high, it is more suitable for use in building walls. The experimental instruments include a differential calorimetry scanner, an electric heating constant air blast drying oven, a self-made mold, shovel, and mortar mixer.

4.1.2. Preparation of Samples. In this experiment, the phase change energy storage material will be inhaled into the expanded perlite with the porous medium as the matrix. It is then mixed with vitrified microbeads, putty, and water. The first does not add phase change material. It mixed 1000 g of vitrified microbeads, 1666 g of glue ash, and 1789 g of water, poured it into the prepared mold, and made a total of two thermal conductivity test blocks. Then, according to the precalculated mass ratio, add 5%, 10%, 15%, and 20% to the prepared mold so that it is evenly mixed and integrated. After the module was made, it was placed indoors for curing, and the curing period was 28 days. The physical parameters of the wall model are shown in Table 3.

In this experiment, five kinds of wall test blocks were produced, and the size of each test block was 300 mm × 300 mm × 30 mm. The wall sample table is shown in Table 4.

For solid-liquid phase change materials, leakage problems usually occur once the material is melted by heat. The content of the phase change material added will also affect the leakage degree of the phase change wall. After five groups of samples were heated on one side of the wall, the leakage phenomenon appeared on the other side of the wall. Among them, sample 5 has obvious leakage, the humidity of the wall is too high, and the material will overflow the wall for a long time. Sample 4 was obviously wet, and the wall was slightly wet, but no material leaked out. From the second and third samples, it can be seen that there is no leakage, and the surface is smoother and denser. It shows that when the mass ratio of the phase change storage material SP-28 in such samples exceeds 15%, the phase transition occurs in the wall with the increase of the external temperature. The phase change material is converted into liquid and leaks out, causing a lot of waste, so it is not suitable for application and building walls. On the contrary, there is no leakage phenomenon, and it can be integrated with the building substrate to form a phase change energy storage building wall. There is no phase change material added to the sample, and no leakage will occur. Therefore, only the first four groups of samples will be considered in the following experiments.

4.2. Experimental Process. Before the experiment, an ordinary room similar to a resident's was built. The direction of the room is facing south, which can ensure sunlight in the east in the morning and the west in the afternoon. On the east and west walls of the room, four square holes with a side length of 300 mm were left out. Then, it inserts the samples 1, 2, 3, and 4 made in sequence and records the serial number.

TABLE 3: Physical and thermal properties of each material.

Material		Specific heat (kJ/kg°C)	Thermal conductivity (W/m·K)	Density (kg/m ³)
Wall materials		940	0.64	2490
Phase transition	Solid	2390	0.85	1300
Material	Liquid	2210	0.69	1270

TABLE 4: Wall specimens.

Sample number	1	2	3	4	5
Mass ratio of phase change material	0%	5%	10%	15%	20%

The environment around the room (ventilation and lighting conditions) is the same as that of ordinary residential rooms, with an initial temperature of 22°C and a maximum temperature of 38°C. The temperature and heat change of the inner wall are collected with thermocouples inside the indoor wall and recorded on a computer.

4.3. Experimental Results. During the experiment, it pays attention to recording the data and sorting out the experimental results. We need to record the temperature of the low temperature side of the phase change wall at different times and then find the average value of the temperature inside each sample, as well as draw the temperature change diagram of each sample at different times. The temperature change of the inner surface of the wall is mainly divided into two stages: the endothermic stage and the exothermic stage, as shown in Figure 6.

During the heat absorption stage of the outer surface of the east wall, the temperature of the inner surface changes.

It can be seen from the mentioned wall surface temperature data that when the temperature of the outside of the wall increases, the heat of the wall is transferred to the inner surface through the interior. However, due to the addition of phase-change energy storage materials to the wall, the transfer of heat is hindered. Therefore, the inner temperature of the phase change wall rises more slowly than that of the ordinary wall. Sample 1 is an ordinary wall, and its temperature changes rapidly, while the temperature changes from sample 2 to sample 4 become slower and slower. It shows that the rising trend of the wall temperature curve after adding the phase change material is more stable. As the proportion of the phase change material is added, the curve changes more gently.

Compared with the common wall sample 1, the temperature reduction of sample 2 is the maximum of 1.55°C and the minimum of 0.01°C at the same time. The maximum temperature decrease of sample three is 3.03°C, and the minimum decrease is 0.04°C. The maximum temperature decrease of sample 4 is 4.68°C, and the minimum decrease is 0.07°C. It shows that the longer the time and the higher the temperature, the greater the temperature reduction at the same time. At the same time, the greater the proportion of phase change material, the greater the temperature reduction of the wall at the same time.

In summary, the addition of phase change materials to ordinary building materials can delay the heat transfer from

outdoors to indoors. Within a certain amount of phase change material, the higher the proportion of the phase change material at any time, the smaller the temperature change. If the final temperature can be controlled at the comfortable temperature of the human body, the use of air conditioning and heating can be avoided. It not only improves thermal comfort but also has a significant energy saving effect.

During the exothermic stage of the outer surface of the east wall, the temperature change of the inner surface is shown in Figure 7:

After noon, the sun gradually sets in the west. At this time, the east wall will not receive direct sunlight, and the temperature will gradually drop. However, due to the solidification and exothermal condition of the phase change material, the temperature of the wall will rise for a short time and then drop, as shown in Figure 7. Since no phase change material was added to the sample 1, its temperature did not rise but dropped directly. Samples 2, 3, and 4 all had different increases in temperature. As the proportion of the phase change material is higher, the temperature of this part increases more. With the passage of time, the temperature of the wall of sample 4 is the highest, which is kept at 24.88°C, and the temperature of other samples decreases successively. It shows that the greater the proportion of phase change material, the better the heat release effect and the smaller the temperature change maintained by the wall.

The temperature of the inner side of the west wall changes as the outside temperature changes, as shown in Figures 8 and 9.

As can be seen from Figure 9, the temperature change law of the west wall is basically the same as that of the east wall. Because the west wall receives direct sunlight after noon, the temperature of the west wall does not change much in the morning. Its temperature rose sharply until after noon, reached a peak at about 14 hours, and then gradually decreased. After 14 h, there is also a short-term temperature rise process, and then it falls again. The changing trend of the whole process is similar to that of the east.

5. Discussion

By heating the samples, it was found that when the mass ratio of the phase change energy storage material contained in the wall was greater than 15%, wetting and leakage occurred. It is easy to cause large losses by adding it to the wall, so it is not suitable for application and building walls. When

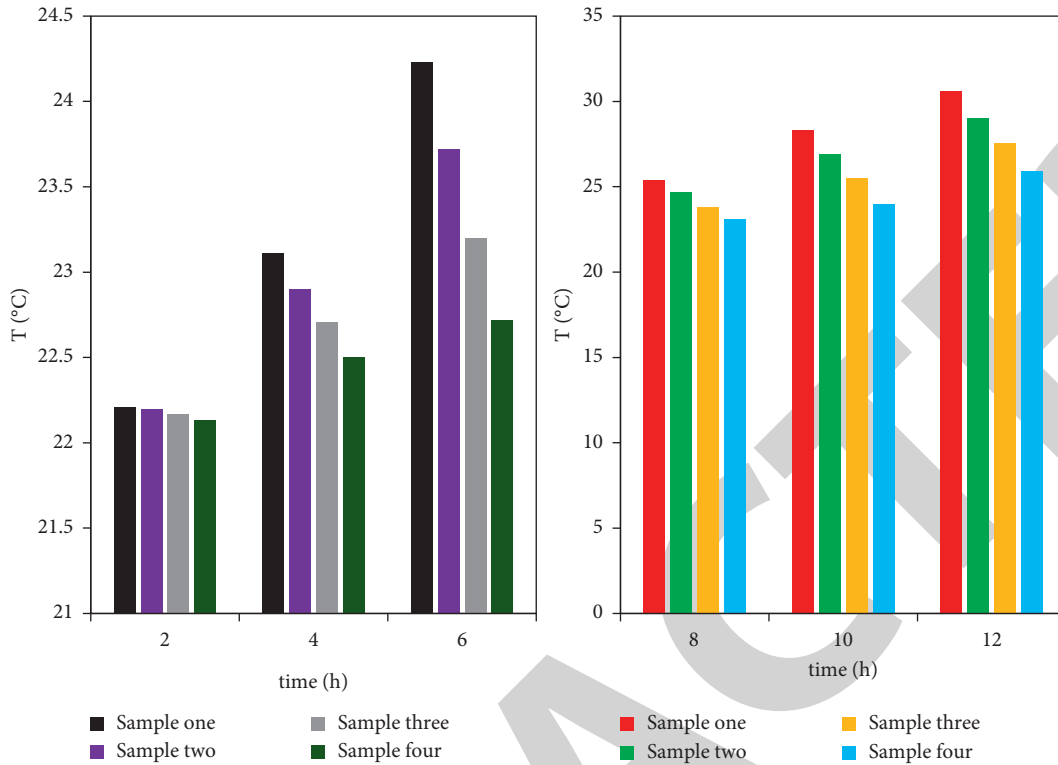


FIGURE 6: The temperature change diagram of the low temperature side when the east wall samples with different ratios absorb heat.

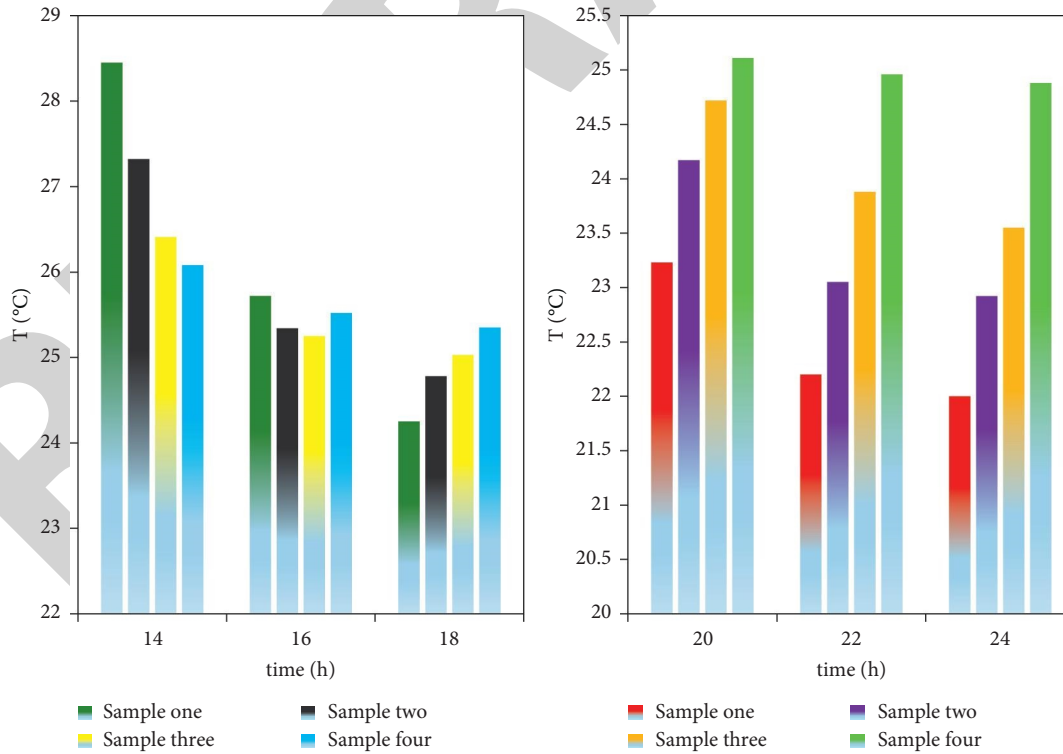


FIGURE 7: The temperature change diagram of the low temperature side when the samples of the east wall with different ratios release heat.

the mass ratio of the phase change energy storage material in the wall is less than 15%, there is no wetting and no leakage, the energy storage effect is good, and the ambient

temperature can be effectively adjusted. When one side of the wall is heated, the temperature on the other side of the wall is lower than that of the ordinary wall due to the heat

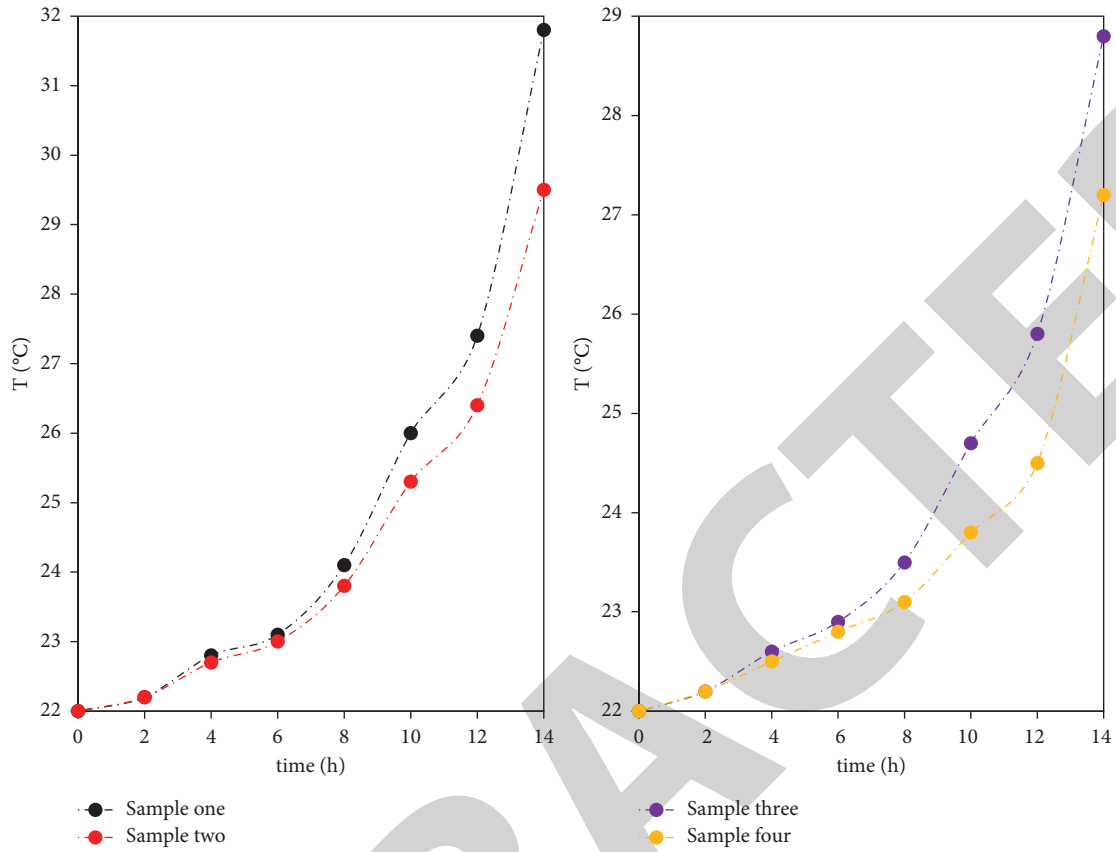


FIGURE 8: The temperature change diagram of the low temperature side when the western wall samples with different ratios absorb heat.

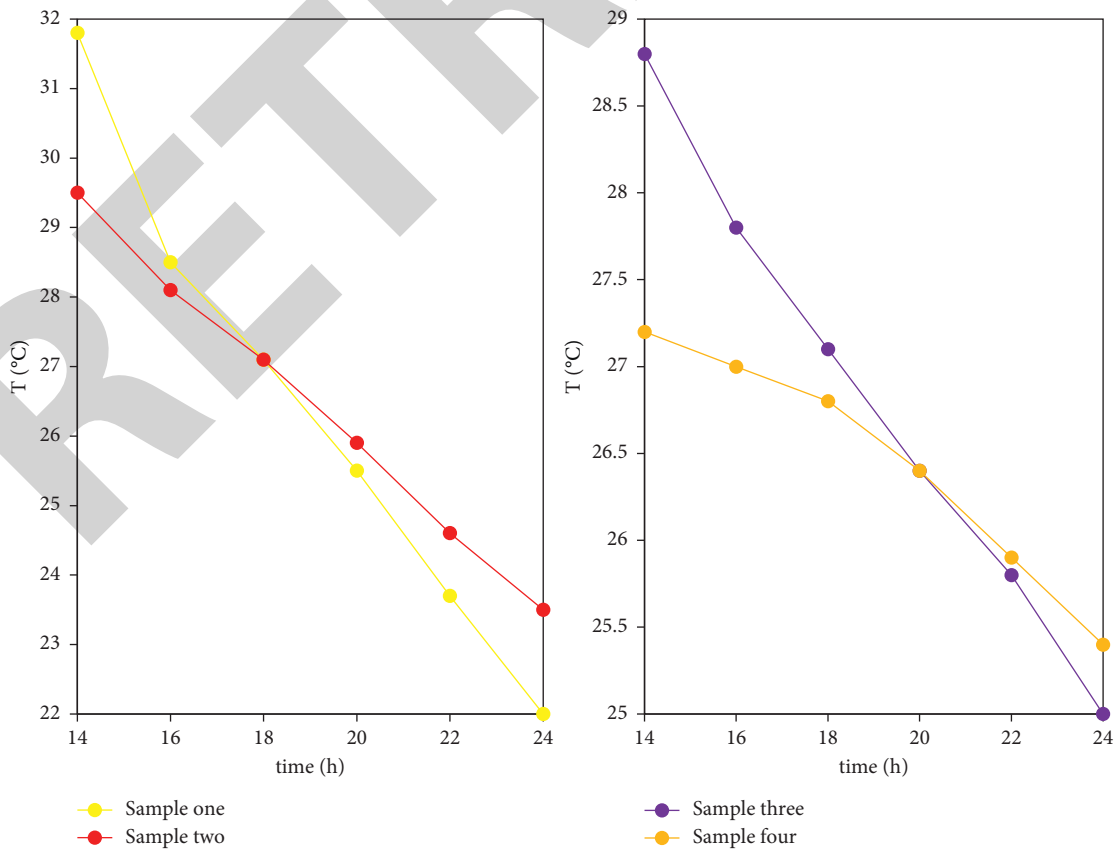


FIGURE 9: The temperature change diagram of the low temperature side when the samples of the west wall with different ratios are exothermic.

storage capacity of the phase change material. As the content of the phase change material in the wall increases, the delayed heat transfer effect is better. When one side of the wall is cooled, the room temperature of the general wall decreases rapidly. However, due to its solidification and exothermic characteristics, the room temperature on the phase change wall surface decreases slowly. As the content of the phase change material increases, the temperature decreases more gradually. Considering the leakage, wetting, and economy, when the mass ratio of phase change material is 10%, it is the most suitable to be used in the wall. The addition of phase change materials can significantly improve the thermal comfort of the surrounding room.

6. Conclusion

In exploring the application of phase change materials in building energy conservation, five kinds of phase change walls were formulated in this paper. The mass ratios of the phase change material added are 0%, 5%, 10%, 15%, and 20%, respectively. By testing the leakage of the wall, it is found that 20% of the phase change walls have obvious leakage, which is not suitable for adding building materials. When 15% phase change was added, the wall had obvious wetting, but no leakage occurred. Others are free of wetting and leakage. During the heating stage of the wall, it was found that the quality of the wall with the addition of phase change material increased more slowly than that of the general wall at room temperature. However, due to the higher mass ratio of the phase change material, the room temperature increases more slowly. In the cooling stage of the wall, it is found that the temperature of the ordinary wall decreases faster than that of the phase change wall, and because the quality of the phase change material is relatively high, the temperature decreases more slowly. It shows that the phase change material can delay and slow down the temperature transition at room temperature, which is beneficial to the stability of the ambient temperature. The application of phase change energy storage materials in building materials has been studied for more than 20 years. Its development is to further screen low-cost, environmentally friendly, and energy-saving phase change materials so as to further improve the ecological energy-saving significance of phase change energy storage building materials.

Data Availability

No data were used to support this study.

Conflicts of Interest

The author declares no conflicts of interest.

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