ANALYSIS ON CONSTRUCTION TECHNOLOGY OF LARGE STEEL STRUCTURE BUILDING THERMAL INSULATION ENGINEERING

by

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In order to solve the need of maintaining temperature in large steel structure buildings, the author proposes a method of applying new materials, this method is used to analyze the properties of exterior insulation materials for steel structure buildings. Combining with the need of heat preservation in large steel structure cold storage, the author puts forward a new construction technology and applies it into practice by combining autoclaved gas technology, the advantages and disadvantages of organic and inorganic materials on heat preservation effect are analyzed, through the value engineering formula of maximum efficiency analysis, the minimum life cycle cost, in the ideal place, time to play the necessary function of the product. Finally, the experimental samples adopted the author's method are compared with the ordinary samples. The experimental results show that the absolute value of indoor and outdoor temperature difference under the construction process is significantly greater than that under the current construction process, the highest temperature reached 29.2° and the lowest was 25.6°. In conclusion, the method adopted by the author can greatly help the current construction technology and reduce the loss of enterprises.

Key words: *large steel building, heat insulation and heat preservation, construction technology, value engineering*

Introduction

The proportion of building energy consumption in the total energy consumption is increasing year by year, and has reached 40% recently, how to reduce energy consumption in the construction field has become an urgent problem to be solved. According to incomplete statistics, if the use of building materials with good thermal insulation performance, the energy consumption of buildings can be reduced by 25-51%. Therefore, the use of building insulation materials can be a good solution the problem of building energy consumption. However, at present, there are still some buildings in the country do not effectively use building insulation materials, resulting in the energy consumption and loss of buildings is very serious. Therefore, innovative research and development of building materials with good thermal insulation performance, it cannot only greatly reduce the energy consumption of buildings, but also improve the thermal insulation ability of indoor residences, which is of great significance to improve people's quality of life and protect the surrounding environment. Generally speaking, the common characteristics of thermal insulation materials are light, loose, porous, low thermal conductivity, by effectively blocking the heat exchange between the building and the outside world to reduce the energy consumption of the building to achieve the purpose of building energy saving. In-

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organic heat insulation insulation material has the characteristics of non-combustion, wide use temperature, good chemical corrosion resistance and so on. Organic heat insulation material has the characteristics of low water absorption and better water impermeability [1].

Literature review

Through the analysis of the characteristics of steel structure space truss, the application status of steel structure space truss construction, the existing problems in steel structure space truss construction and the main construction technologies, Yang *et al*. [2], analyzed how to improve the quality of personnel, strengthen the quality control of component installation and welding, improve the quality of component processing and manufacturing, and strengthen the corrosion control of steel structures. In addition, four quality control measures are put forward: strengthening the fire resistance of steel grid structure, which can provide corresponding reference value for staff in the same industry. At this stage, China's urban population has increased dramatically. In urban planning and construction, mainly high rise buildings, the design form has changed greatly. Yao *et al*. [3] summarized the characteristics of fabricated steel structure construction, and discussed the building assembly from five aspects: component segmentation technology and hoisting scheme design, peripheral integration and green building technology, sandwich panel construction, exterior wall panel construction, and steel column construction. The key construction technology of steel structure is discussed. In recent years, the number of high rise building projects is increasing, making high rise steel structures have been widely used. In order to ensure the quality of buildings, it is necessary to improve the reliability of steel structure installation. Zhang *et al*. [4] mainly analyzed the application of steel structure hoisting construction technology in high rise buildings, aiming to provide technical support for building construction, emphasize the safety and quality of steel structure hoisting, form an integral steel structure system, and promote the good development of high rise building construction.

On the basis of the current research, the authors put forward a new wall material method incorporating autoclaved gas technology. This method is used to analyze the properties of exterior insulation materials for steel structure buildings. The advantages and disadvantages of organic and inorganic materials on heat preservation effect were analyzed, through the value engineering formula of maximum efficiency analysis, the minimum life cycle cost, in the ideal place, time to play the necessary function of the product.

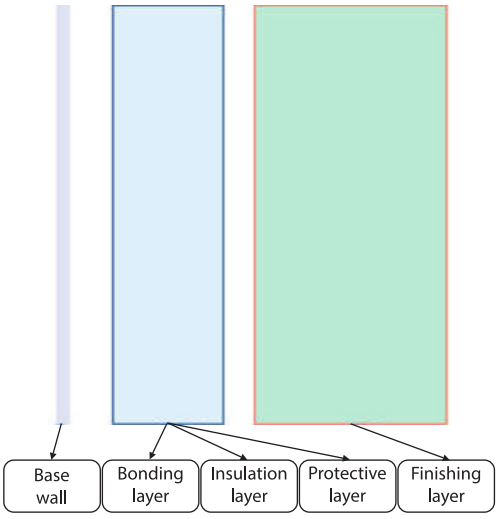

Figure 1. Basic construction diagram of new autoclaved aerating technology wall material

Methods

Selection of energy saving insulation wall materials

In order to further improve the thermal insulation effect of large steel structures, when selecting construction materials, as far as possible, choose energy-saving insulation materials, because the wall has a great influence on the thermal insulation effect and quality of the whole construction, therefore, the author only selected energy-saving insulation materials for the wall [5]. A new type of wall material inte-

grated with autoclaved gas technology is adopted as the wall material in the construction of large steel structure cold storage insulation project, the basic structure of this material is shown in fig. 1. 65% fly ash and quantitative cement were mixed, and an appropriate amount of water was added, and then injected into the corresponding mold after mixing. The energy-saving insulation wall material is divided into four different types according to its different volume density levels, and the corresponding technical indicators of each type are different. See tab. 1 for the technical indexes of four different types of energy-saving insulation wall materials [6].

Table 1. Comparison of material properties of different grades

Level	Strength level	Bulk density/drying shrinkage [kgm^{-3}]	After the frozen strength [mmm^{-1}]	MPa	Coefficient of thermal conductivity [Wm^{-1}K^{-1}]
B003	A1.0	320	0.15	0.7	0.12
B004	A1.5	390	0.25	1.2	0.16
B005	A2.5	450	0.35	2.6	0.16
B006	A7.5	650	0.50	2.8	0.18

In the selection of energy saving insulation wall materials, according to the heat preservation needs of large steel structure cold storage, from the strength level, volume density, thermal conductivity, post-freezing strength and other aspects of the selection of its level, when the process conditions permit, B006 grade energy saving insulation wall materials should be selected as far as possible, which can significantly improve the insulation property of large steel structures [7]. In view of this problem, the author made a comprehensive analysis of it, and replaced the traditional material with cast-in-place steel bearing plate structure, in order to further reduce the construction difficulty and construction cost, the construction period can also be shortened by nearly one month. Figure 2 is a schematic diagram of thermal insulation structure of large steel structure cold storage overhead layer nodes. In fig. 2, A shows the structure of polyurethane sealant material, B represents reinforced concrete structure with a thickness of 150 mm, C is C20 strength concrete protective layer structure with thickness of 45 mm, D stands for SBS waterproof coil material, the thickness is 2.5 mm, E means polyethylene plastic film of 3 mm thickness, F is 0.5 mm extruded insulation board structure, G stands for polystyrene foam board, thickness of 12 mm, H denotes light channel steel structure, whose type is 12$^{\#}$ or 22$^{\#}$, and I stands for heat insulation sandwich [8].

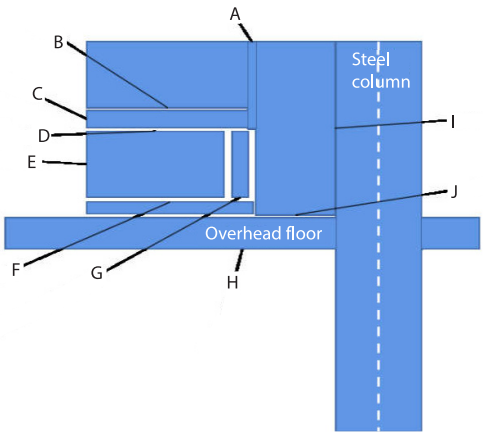

Figure 2. Schematic diagram of thermal insulation structure of large steel structure cold storage overhead layer nodes

Crack treatment of insulation board of steel structure wall

Due to the large steel structure cold storage structure compared with ordinary cold storage structure, the library body is larger, therefore, when the temperature difference between inside and outside is large, it is easy to cause the pressure of the library plate structure to increase, resulting in the deformation of the library plate, and then cause a large number of cracks, affect the thermal insulation performance of cold storage, and cannot be used normally [9]. Therefore, in view of this problem, the author in accordance with the aforementioned construction process to complete the construction, but also need to deal with the cold storage wall insulation board gap. The maximum spacing standard of expansion joints of different kinds of large steel structures is shown in tab. 2 .

Table 2. Maximum spacing standard for expansion joints of different kinds of large steel structures

Structure type	Indoor	In the open air
Shelving steel structure		
Prefabricated	95.5 m	68.5 m
Frame steel construction	54.5 m	43.5 m
Cast-in-site type		
Prefabricated	74.5 m	32.6 m
Shear wall steel structure		
Cast-in-site type	62.5 m	38.2 m
Prefabricated	41.6 m	29.4 m
Retaining steel structure		
Cast-in-site type	40.78 m	28.6 m
Prefabricated	32.6 m	21.3 m

Analysis of external insulation materials for external walls

At present, the external wall insulation materials in the construction market are divided into two categories: organic materials and inorganic materials, the organic insulation materials mainly include polyurethane foam, polystyrene board (EPS), extruded board (XPS), phenolic foam and so on, inorganic thermal insulation materials are mainly rock wool products, inorganic thermal insulation mortar, foam glass, *etc.* The thermal insulation structure of colloidal polystyrene particles is shown in fig. 3. Organic thermal insulation material is better than inorganic thermal insulation material in thermal insulation performance, inorganic thermal insulation material in the fire performance is better than organic thermal insulation material. At present, organic thermal insulation materials are widely used in the application of building external thermal insulation [10].

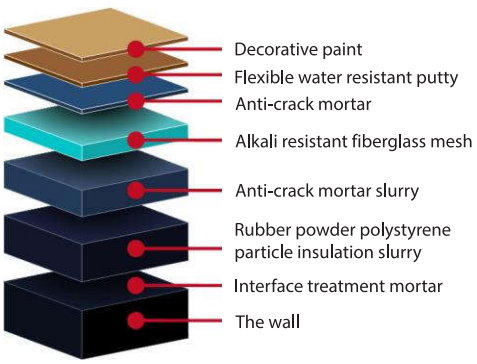

Figure 3. Insulation structure diagram of powdered polystyrene particles

Performance analysis of organic insulation materials

Organic thermal insulation materials have the advantages of good thermal insulation effect, light weight, good waterproof performance, convenient construction, high compactness, but at the same time, there are also the disadvantages of aging resistance, poor stability, large deformation coefficient, poor safety, easy combustion, high engineering cost. The use of organic thermal insulation materials such as polyurethane foam, EPS, XPS, and phenolic foam in Chinese buildings has caused frequent fire accidents, resulting in huge economic losses and human casualties. Once burned, it not only burns very quickly, but also produces a large amount of toxic gas [11].

Performance analysis of inorganic insulation materials

Inorganic thermal insulation materials are mainly rock wool board, foam glass, foam concrete, inorganic thermal insulation mortar and so on. Inorganic insulation material can save energy and waste, the material itself has excellent fire performance, excellent performance of aging resistance and low price. At the same time, inorganic thermal insulation material capacity is significant, thermal insulation efficiency is slightly poor, but fire retardant, deformation coefficient is small, anti-aging, stable performance, low engineering cost, good ecological protection, can cycle production and utilization. Inorganic thermal insulation mortar can be applied to the outer insulation layer of coating or surface brick in the south, and can also be applied to the outer plastering of the large mold built-in thermal insulation board system, for stairwell, household partition wall, kitchen toilet inside heat preservation, enclosed balcony, ceiling and other enclosure structure inside the insulation layer is also very suitable [12]. Due to the thermal performance of inorganic thermal insulation materials, the thermal insulation and fire protection of underground garage roof, the thermal insulation layer of steel structure building, the thermal insulation layer of special-shaped building, the thermal insulation filling of dry hanging stone inner layer, ground thermal insulation, ground heating and thermal insulation are very suitable for the application of inorganic thermal insulation materials [13]:

– Fire resistance

At present, inorganic thermal insulation materials on the construction market have excellent fire performance, the fire requirements can meet the fire requirements, according to the fire department of the material fire performance division, inorganic thermal insulation materials belong to A class, that is, non-combustible materials. Different inorganic thermal insulation materials are also different in terms of fire performance. In the selection of inorganic thermal insulation materials, according to the actual refractory temperature of the material itself, and the actual refractory requirements required by the application, select the appropriate inorganic insulation materials.

– Bulk density, strength and thermal conductivity of inorganic thermal insulation materials

The bulk density, strength and thermal conductivity of inorganic thermal insulation materials are the main indicators to measure material characteristics, the best machine thermal insulation materials can meet the requirements of small bulk density, high strength and low thermal conductivity, but it is difficult to meet in practice, because the bulk density is generally increased to ensure the strength of the material, the bulk density of the material is increased at the same time, and the density of the material is increased, which generally leads to the increase of thermal conductivity. Figure 4 is the relationship curve of bulk density, thermal conductivity and strength of inorganic thermal insulation material. The bulk density, strength and thermal conductivity of inorganic thermal insulation material determine the performance of the materi-

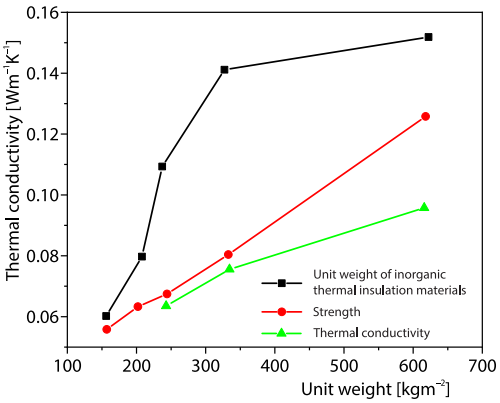

Figure 4. Relation curve of bulk density, thermal conductivity, and strength of inorganic thermal insulation material

al, fig. 4. When selecting the material, it can be selected according to the actual requirements and the material performance index [14].

Water absorption

Water absorption is the main index to measure the performance of inorganic insulation materials. Inorganic thermal insulation material water absorption leads to the improvement of thermal conductivity of the material, this is because the thermal conductivity of water is 20 times of the air in the space of the thermal insulation material, the thermal insulation material water absorption reduces the thermal insulation effect. Especially in the cold areas in the north, if the moisture in the pore of the insulation material will condense into ice after pre-cooling, and even the material cracking will occur, thus damaging the structure of the insulation material [15]. So in the choice of thermal insulation materials, we must try not to use those inorganic thermal insulation materials with large water absorption rate. Elected with absorbent large thermal insulation material, you can take in the material surface to do waterproof treatment or in the internal space of thermal insulation material to add hydrophobic agent. However, this can increase the cost of materials and make it difficult to ensure that the material is waterproof for a long time.

Basic theory of value engineering

Track concept

Value engineering (VE), also known as value analysis (VA), refers to the functional analysis of products or jobs as the core, for the purpose of increasing the value of a product or job, an organized creative activity that seeks to achieve the necessary functions required for the use of a product or job at the lowest life-cycle cost, some people also call it functional cost analysis. The implementation method is to analyze the technical and economic characteristics of the product or operation, and find out the method to reduce the cost and meet the functional requirements through research. In material procurement, the lowest life-cycle cost is reflected, and the necessary function of the product is played at the ideal place and time [16].

The value theory formula is:

$$V = \frac{F}{C} \tag{1}$$

where F is the function, functional importance coefficient, G – the cost, cost factor, and V – the Value, coefficient of functional value.

Function analysis

Functional analysis determines the effectiveness of value engineering and is the core of value engineering. Through the function analysis, cost qualitative analysis and cost quantitative analysis of the product, the mutual relationship between them is determined, the necessary function of the product is found out, and the cost is allocated to achieve the purpose of creating and improving the program. Functional analysis can find out the unreasonable functions, elim-

inate them, and then readjust the ratio between functions, finally, the functional structure of the product is more reasonable [17].

Functional evaluation

Function evaluation is to determine the realistic cost of the function, the target cost, the ratio of the target cost and the realistic cost, the difference between the realistic cost and the target cost, and select the functional field of the value engineering object according to the value coefficient or the aforementioned difference. In the function evaluation, the function cost is calculated by the function of the product. The realistic cost of functionality is assigned to the cost of functionality through the actual cost of the product. The target cost of a function is a measure of the value of the function, that is, the minimum cost required to realize the function. If the target cost is less than the actual cost of the function, the function value is low. If the value is equal to or greater than the realistic cost of the function, the function value is high [18].

Three-stage control theory

The control of the project implementation stage is the most important part of the quality management of the whole anti-corrosion and thermal insulation engineering, this stage can be divided into pre-control, in-process control and post-control in chronological order.

Prior control: Ex ante control refers to predicting possible problems in the construction before the construction starts, mainly including: study the construction environment, carry out training for construction personnel, and formulate construction equipment, technology and technology. The main purpose of ex ante control is to prepare the project before construction, in order to ensure the smooth completion of the project to lay the foundation. The control before construction is mainly for the construction scheme and construction material management.

In-process control: In-process control refers to the control work carried out in the process of engineering construction, mainly the control of all links of anti-corrosion and insulation pipe-line construction, including the anti-corrosion and quality control of 3PE steel pipe, the production and quality control of polyethylene outer protective pipe, the installation and control of waterproof cap*, etc.* For anti-corrosion and insulation engineering construction process management, mainly for the construction technology, construction quality supervision and management.

Post control: Post control is at the end of the project, anti-corrosion insulation pipe has been produced, the use of relevant quality standards, judge whether the whole construction process to meet the requirements, ex post control is mainly to carry out quality inspection, acceptance and evaluation of the project or sequence [19].

Results and discussion

Now the previous construction design of large steel structure cold storage insulation engineering construction technology is applied to the actual cold storage cold storage room plant construction project. The cold storage of the project adopts a single-layer ultra-high steel structure with a plane size of 126.23 m × 52.31 m, the highest position is 42.36 m away from the ground, and the maximum span is 22.35 m. The construction of thermal insulation engineering is completed by using the technology proposed previously, and the results after construction are compared with the existing construction technology of the project. The author chose the indoor and outdoor temperature difference of the cold storage after the construction of the two technologies as the evaluation index, and the experimental results obtained are compared in fig. 5.

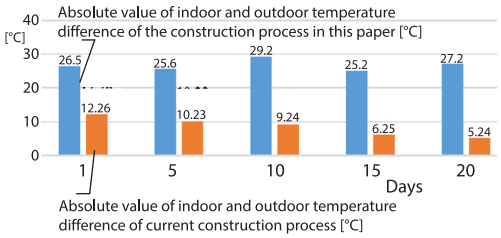

Figure 5. Comparison table of experimental results of two construction technologies

As can be seen from fig. 5, the absolute value of the indoor and outdoor temperature difference of the cold storage under the construction process is significantly larger than that of the current construction process, with a maximum of 29.2° and a minimum of 25.6 °. Because the absolute value of the indoor and outdoor temperature difference is larger, the temperature in the cold storage room meets the storage conditions, and the insulation effect is better. Therefore, through comparative experiments and results, it is concluded that the construction technology of large-scale steel structure cold storage insulation engineering proposed by the author has better insulation effect in practical application [20].

Conclusion

On the basis of the current research, the authors propose a method for the application of new materials. Combining with the need of heat preservation of large steel structure cold storage, a new construction technology is proposed, which is applied into practice by autoclaved gas technology, the advantages and disadvantages of organic and inorganic materials on heat preservation effect are analyzed, through the value engineering formula of maximum efficiency analysis, the minimum life cycle cost, in the ideal place, time to play the necessary function of the product. Through these can reduce the economic loss of enterprises and effectively help enterprises to achieve economic results and strategic goals.

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