Academic Journal of Science and Technology
ISSN: 2771-3032 | Vol. 10, No. 1, 2024

Research on A Kind of Lightweight Heat-insulating, Sound-insulating and Light-transmitting Concrete Interior Partition Wall Block

Junyan Zou, Kai Zheng, Shanshan Li

Southwest Petroleum University, School of Civil Engineer and Geomatics, Sichuan Chengdu, 610500, China

Abstract: The new composite concrete with both lightweight, thermal insulation, heat insulation and light transmission properties is a new type of building The new composite concrete with both lightweight, thermal insulation, heat insulation and light transmission properties is a new type of building material with energy saving and consumption reduction functions. This paper integrates the research status of scholars in this field at home and abroad, realises the lightweight of blocks by studying the properties of lightweight aggregate concrete and porous concrete, and selects suitable light- transmitting materials, tests the light transmittance and mechanical properties of concrete blocks after adding light-transmitting materials, then analyzes the advantages and disadvantages of the sound insulation effect produced by adding soundproofing materials made from different materials to concrete blocks, and selects the best sound insulation effect by adding soundproofing materials to concrete blocks. concrete blocks, and selects the best soundproofing material for the comprehensive performance. Then we analyze the advantages and disadvantages of Then we analyze the advantages and disadvantages of adding different sound insulation materials into concrete blocks, and select the best sound insulation material with comprehensive performance. the same time of realising the three properties of light weight, sound insulation and light transmittance, we further study the effect of adding different thermal insulation materials on the thermal insulation effect of the blocks, and select the concrete blocks with the best thermal insulation performance.

Keywords: New composite concrete, lightweight, heat preservation, sound insulation, light transmission.

1. Introduction

Concrete is the largest and most widely used bulk material in the world, and the annual output of concrete in China is more than 4 billion m^3 , which is more than half of the world's annual output. In the process of the development of concrete from ordinary concrete, special concrete, high strength concrete to high performance concrete, the wide application of additives has played a great role in promoting, and additives have become the fifth indispensable component in modern concrete. Admixtures can meet the construction requirements of pumping, spraying, self-compacting and other new techniques; they can obtain the superior performance of concrete in terms of fluidity, seepage resistance, freezing resistance, corrosion resistance, impact and abrasion resistance, cracking and shrinkage reduction, etc.; and they can save the use of cementitious materials, reduce the consumption of energy for production and construction, shorten the construction period, improve the quality of construction, reduce the environmental pollution and improve the labour conditions. The use of high-quality additives can achieve remarkable technical, economic and social benefits.

On the basis of previous experimental research, this experiment selects the commonly used externally activated admixtures or organic polymers to improve the strength of concrete, and further researches the concrete internal partition wall with both lightweight, heat preservation, thermal insulation, and light transmittance properties. This internal partition wall also has the advantages of simple structure and no external decoration. This internal partition wall can reduce indoor artificial lighting, save energy, reduce noise, temperature difference and other impacts on the human body, provide a comfortable living environment, the research is significant.

2. Current Status of Domestic and International Research

Modern civil engineering constantly places new demands on the quality of structural elements, energy efficiency and fire safety. The commonly used ordinary concrete, with its high self-weight, low tensile strength, high thermal conductivity, slow hardening and long production cycle, does not meet the requirements of modern civil engineering well. The basic characteristics of lightweight concrete are lower bulk density and better thermal insulation performance, which is an important difference with ordinary concrete. And from the point of view of earthquake resistance, lightweight concrete has the advantage of low self-weight. In addition, lightweight aggregates are usually intumescent materials and are therefore very effective for sound and thermal insulation. Partial or total replacement of normal mass concrete with lightweight concrete can produce considerable benefits by reducing the constant loads on the structure[1] . Research experiments on lightweight concretes are also abundant. Wang Qing[2] et al. experimentally confirmed that the water-cement ratio, glue-sand ratio, fly ash mixing, silica fume mixing, steel fibre mixing, and density grade of ceramic sand added to Ultra High Performance Lightweight Concrete (UHPLC) have a great influence on its workability, mechanical properties, apparent density and specific strength. Tian Tao[3] research confirms that compared with the dry density of ordinary concrete, the dry density of foam lightweight concrete is about 1/5 to 1/8, about 300-1600kg/m^3 , so the use of foam lightweight concrete can help to significantly reduce the structural loads of the building, and effectively avoid or reduce the uneven settlement of the building.

Energy saving in the construction industry Since 2009, energy saving and emission reduction has been established as China's basic national policy, and its significance and importance have been further highlighted, becoming the primary programme to deal with the energy crisis and environmental degradation, and gradually penetrating into all aspects of society. In China, social energy consumption is mainly concentrated in the three major fields of construction, industry and transport, and among them, building energy consumption accounts for more than 30% of the total social energy consumption, and if we add the energy consumption in the production of building materials, the proportion will be more than 40%, so it is of great significance to reduce the energy consumption of buildings. The key to building energy consumption lies in the thermal insulation effect of the building envelope, so it is necessary to study the thermal insulation performance of concrete. Thermal insulation concrete is a new type of green concrete[4] which is mixed with a certain amount of glass beads thermal insulation material during the concrete mixing to make it a new type of green concrete with both thermal insulation and load bearing. Huang Wei[5] and other use of calcium carbonate whiskers and glass beads to prepare recycled thermal insulation concrete, and through experiments to prove: with the increase of calcium carbonate whiskers, the compressive strength of recycled concrete gradually grows, when calcium carbonate whisker mixing 5%, the compressive strength of recycled thermal insulation concrete reaches 19.1 MPa, followed by a gradual decline; recycled thermal conductivity of thermal insulation concrete and the law of change of compressive strength is basically the same, with the increase of compressive strength, thermal conductivity is the same, with the increase of compressive strength, thermal conductivity is the same, with the increase of compressive strength. Compressive strength increases, the thermal conductivity also increases.

With the rapid development of the economy, noise pollution is becoming more and more serious. The existence of noise seriously affects people's daily life, and acoustic concrete comes into being[6] . Zhang Jinhua[7] explores the change rule of sound absorption coefficient at different frequencies and the change rule of comprehensive average sound absorption coefficient of porous concrete under the conditions of different void ratio, different aggregate gradation, different specimen thickness and artificial pores. Comprehensive consideration of the strength of porous concrete and sound absorption factors, summed up the preparation of porous concrete acoustic sound-absorbing concrete blocks good mix design scheme. After the research and test of experts and scholars, it is found that the sound insulation effect of ceramic aerated concrete block[8] , sound insulation mat and cast-in-place concrete composite block[9] , recycled coarse aggregate concrete block[10] is remarkable. Therefore, this study will further investigate the effect of added materials on the sound insulation performance of concrete on the basis of previous studies.

The development trend of green building and construction industrialisation will promote the development of building materials towards functional qualities. The energy consumption of the external walls, roofs and windows of China's residential buildings is 3.4 times higher than that of developed countries. At the same time, the increase in building density and the narrowing of the building spacing will inevitably result in poor lighting conditions inside the building, and can only rely on the increase in artificial lighting to enhance the level of light, which will inevitably lead to an increase in energy consumption. Therefore, through the corresponding measures to make the concrete has a certain degree of light transmission properties, will to a certain extent reduce the lighting energy consumption[11] . Translucent concrete is such a new type of building material with light transmission function, which is formed by compounding materials with light transmission function on the basis of traditional cement substrate. Light-transmitting concrete is made of fine-grained concrete and translucent fabric, which is poured in layers in precast moulds. The light that passes through loses almost no energy, so that light, shadows and even colours can be seen through the concrete even on very thick walls. Light-permeable concrete has a good light transmission effect, which changes the grey and monotonous image of previous concrete products and makes them bright and lively; buildings using light-permeable concrete as external walls can also clearly show the outlines of both indoor and outdoor objects, and can be colourful with the cooperation of lights. Light-conducting concrete not only has a good decorative effect, but also makes the indoor has natural light, play the role of lighting, green, energy saving[12] . Therefore, light-permeable concrete is a new type of building material with good application prospects, and is a research hotspot in the field of cement concrete science[13] .

In summary, based on the previous research, this paper will start from the four properties of light weight, heat preservation, sound insulation, and light transmission, and study the way by which various materials can be combined with concrete blocks, which can make the concrete internal partition wall give full play to the above four properties.

3. Test Materials and Methods

3.1. Raw materials for testing

(1) Selection of lightweight materials

Through literature research, two options of adding shale ceramic granules to traditional concrete materials and adding foaming agent to ordinary concrete were selected to study the apparent density of concrete blocks, compare the performance of lightweight aggregate concrete and porous concrete, and produce concrete blocks with optimum lightweight performance.

(2) Selection of insulation materials

Through preliminary experiments and literature surveys, two options of concrete mixed with expanded perlite bulk and aerated concrete were selected, and the thermal conductivity tester was used to determine the thermal conductivity of the concrete blocks and select the concrete blocks with optimal thermal insulation performance.

(3) Selection of sound insulation materials

Through the literature research, the choice of rubber-plastic sound insulation sponge through the inlay or bonding method and the internal combination of concrete blocks, adding sound-absorbing materials and concrete raw materials fusion of concrete blocks produced by the two programmes, through the measurement of the environmental noise decibel size to choose the best sound insulation performance of the concrete blocks.

(4) Selection of light-transmitting materials

Based on the previous two open-ended experiments on light-transmitting concrete materials and properties, among the three light-transmitting materials, namely resin, optical fibre, and acrylic, acrylic has better light-transmitting properties and is more economical, so it continues to be chosen as the light-transmitting material for this experiment.

3.2. Test methods

(1) Matrix material ratio

In order to ensure the accuracy of the experimental results, the matching ratio of the matrix needs to be strictly controlled, through the review of relevant information, on the basis of the existing data, combined with the specific operation of the laboratory, after adjusting, to obtain four kinds of research on different properties of the material of the better matching ratio.

Table 1. Shale vitrified concrete test block ratios

Material type	Cement/(kg/m^3)	Sand/(kg/m^3)	Water/(kg/m^3)	water-cement ratio	Lightweight shale pellets/(kg/m^3)
	400	540	170	0.43	450

Table 2. Porous concrete test block ratios

Material type	Cement/(kg/m^3)	Sand/(kg/m^3)	Water/(kg/m^3)	Fly ash/(kg/m^3)	Polypropylene fibre blowing agent/(kg/m^3)
	36.5	40	30.6	29.3	0.028

Table 3. Expanded perlite concrete test block ratios

Material type	Cement/(kg/m^3)	Expanded perlite/(kg/m^3)	Water/(kg/m^3)	Fly ash/(kg/m^3)	Water reducing agent/(kg/m^3)
	60	5	45.6	40	0.8

Table 4. Aerated concrete test block mix ratios

Material type	Cement/(kg/m^3)	Quicklime/(kg/m^3)	Water/(kg/m^3)	Fly ash/(kg/m^3)	Gypsum/(kg/m^3)	Magnesium oxide/(kg/m^3)	Aerosol/(kg/m^3)
	57	119.7	400	364.3	28.9	0.45	1.5

(2) Specimen preparation

①Test block size and mould making. The test block used in this experiment is in the form of a board, the size of 150mm * 150mm * 30mm, the board material in the actual construction projects in the panoply of high, and the board material itself is low-cost, can be reused, environmental pollution and other characteristics. Therefore, the choice of composite wood board made of mould material, its internal dimensions of length and width and test block dimensions of the same length and width, height (36mm) slightly higher than the height of the test block, out of the dumping, handling and other processes of cement mortar spilled out of consideration, this design (shown in Figure 1).

Figure 1. Test block size (150× 150× 30 mm)

② Fixing light-transmitting materials. The experiment uses the first planting method to combine the concrete matrix and acrylic. Acrylic if not well fixed, may have an impact on the subsequent compressive strength and other experiments, in order to better avoid the phenomenon of uneven distribution of acrylic, in the process of mould preparation, beforehand, the bottom of the mould will be reserved on the cross-section of light-transmitting materials with the same size of the holes, and did not penetrate the bottom of the mould, the acrylic material inserted into the reserved holes, and then the cement mortar is poured, so that the specimen poured out in the guarantee The specimen poured in this way has strong operability while not affecting the subsequent experiments.

③According to different performance studies, different admixtures or test materials are added to make a cement mortar that meets the requirements.

④Mixing cement mortar. 4 kinds of cement mortar matrix are used small concrete mixer for on-site mixing, in order to ensure the quality of the finished matrix, each time mixing a test block of mortar dosage, the mixer adopts the first slow mixing for 1min, and then fast mixing for 2min, so that all kinds of materials are mixed uniformly, and the end of the finished matrix materials can be obtained.

⑤ Cement mortar pouring and vibration. In order to facilitate the smoothness of mould release, brush the mould with release agent 20min before pouring cement mortar. After mixing the cement mortar, quickly add it into the mould and place it on the concrete vibrating table for vibration, so as to make the concrete compact and combined, in order to eliminate the phenomenon of concrete honeycomb and pockmarked surface.

(vi) Constant temperature curing. Specimen conservation using the existing standard laboratory curing box for constant temperature steam curing (as shown in Figure 2, below), curing temperature control at 20 (± 2) ℃, curing time for 28d.

Figure 2. Constant temperature steam curing box for concrete

Figure 3. Specimen in constant temperature steam curing

(vii) Demoulding and polishing of test blocks. After curing, the test block is demoulded and polished to get the finished concrete test block.

(viii) The performance test was carried out, and the specific test method is shown in Table 5:

Table 5. Performance studies

<table>
<tr><th>performances</th><th>norm</th><th>test equipment</th><th>instructions</th></tr>
<tr><td>compressive strength</td><td>Interfacial bonding strength</td><td>Pressure testing machine</td><td>The compressive strength of the light-transmitting concrete specimens was tested by a pressure tester to analyse the interfacial bond strength between the light-transmitting material and the concrete matrix.</td></tr>
<tr><td>Lightweight performance</td><td>apparent density</td><td>Concrete Strength Tester</td><td><table>
<tr><th>Apparent density (kg/m^3)</th><th>Concrete type</th></tr>
<tr><td>(2800, +∞)</td><td>heavy concrete</td></tr>
<tr><td>[2100,2800]</td><td>Plain concrete</td></tr>
<tr><td>(-∞,2100)</td><td>lightweight concrete</td></tr>
</table></td></tr>
<tr><td>Insulation performance</td><td>thermal conductivity</td><td>Flatbed thermal conductivity meter</td><td>A flat plate thermal conductivity meter was used to determine the thermal conductivity of expanded perlite bulk concrete and aerated concrete, and a low thermal conductivity was selected as the thermal insulation material.</td></tr>
<tr><td>soundproofing</td><td>decibel</td><td>decibel meter</td><td>Acoustic measurement equipment (decibel meter) was used to analyse the sound insulation effect of concrete blocks, mainly for experiments on noise decibels and room sound quality measurements, and to select materials with good sound insulation effect as sound insulation materials.</td></tr>
<tr><td>translucent</td><td>transmittance</td><td>illuminance meter</td><td>Measurement of light transmittance with a light transmission performance test device, illuminance meter as a light transmission detection instrument, test block incident light and outgoing light surface emission brightness, multiple measurements of the test block to take the average value for the light transmittance, selection of light transmittance materials with good light transmission effect.</td></tr>
</table>

4. Results and Discussion

4.1. Compressive strength test

The results of the compressive strength experiments are shown in Table 6 and Figure 4:

Table 6. Experimental results of compressive strength

base material	Experiment No.	Compressive strength (MPa)	Average value (MPa)	Control (MPa)
Plain concrete blocks	1	34.56	34.56	0
Perlite concrete blocks	2-1	25.53	24.46	-10.1
	2-2	24.32		
	2-3	26.54		
aerated concrete block	3-1	26.62	26.31	-8.25
	3-2	25.65		
	3-3	26.66		
Porous concrete blocks	4-1	31.62	31.96	-2.6
	4-2	32.42		
	4-3	31.84		
Shale ceramic concrete blocks	5-1	31.53	30.5	-4.06
	5-2	30.96		
	5-3	29.01		

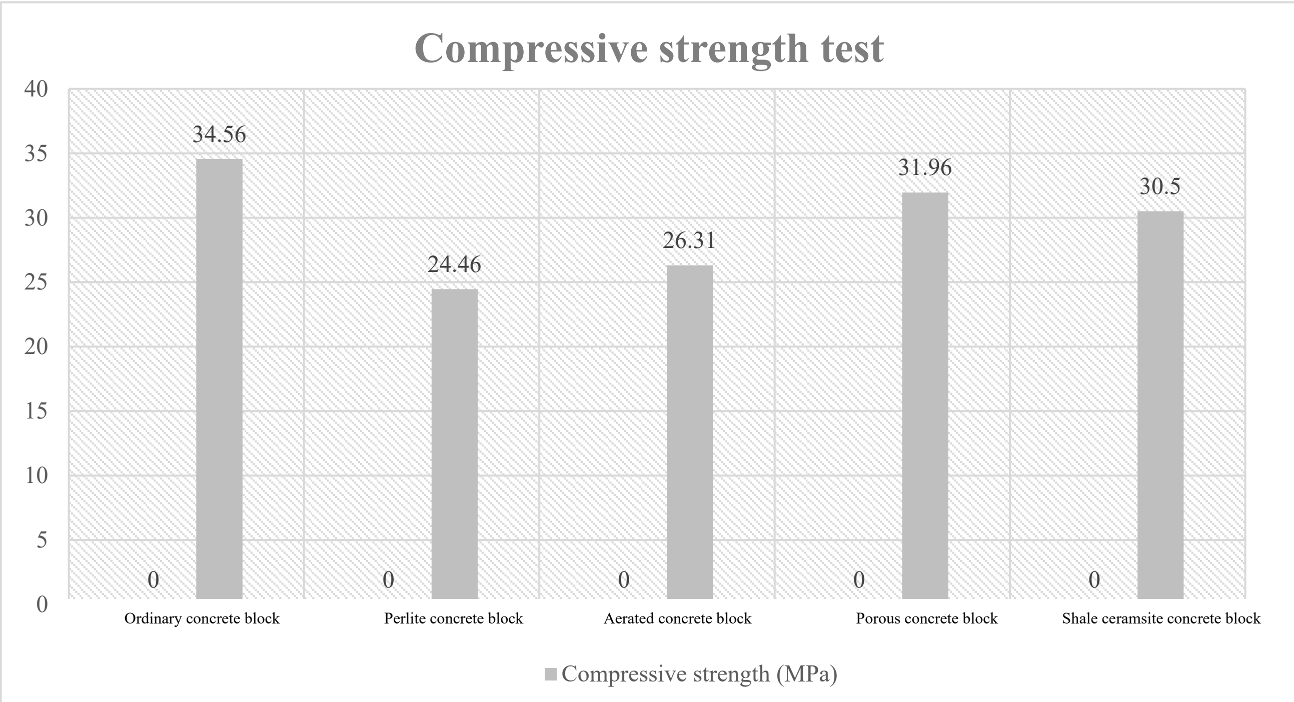

Figure 4. Compressive strength test results

As can be seen from Table 6, there is a significant difference in the compressive strength effect of the different lightweight aggregate concrete blocks selected for this experiment compared to the compressive strength effect of concrete blocks of the same strength. Aerated concrete blocks and perlite concrete blocks have lower compressive strength performance, and the compressive strength of ordinary concrete blocks compared to the compressive strength of 8.25 MPa, 10.1 MPa. shale terra cotta concrete and porous concrete compressive strength effect is better, of which the porous concrete blocks have the best compressive strength performance.

4.2. Lightweight performance experiment

The results of the lightweight performance experiments are shown in Table 7 and Figure 5:

Table 7. Experimental results of lightweight performance

base material	Experiment No.	Block weight (g)	Average weight (g)	Comparative weight (g)
Plain concrete blocks	1	1688.2	1688.2	0
Perlite concrete blocks	2-1	1112.3	1138.4	549.8
	2-2	1126.1		
	2-3	1176.9		
aerated concrete block	3-1	1442.1	1439.3	248.9
	3-2	1398.6		
	3-3	1477.2		
Porous concrete blocks	4-1	1428.7	1407.9	280.3
	4-2	1391.6		
	4-3	1403.5		
Shale ceramic concrete blocks	5-1	963.8	993.6	694.6
	5-2	994.9		
	5-3	1022.1		

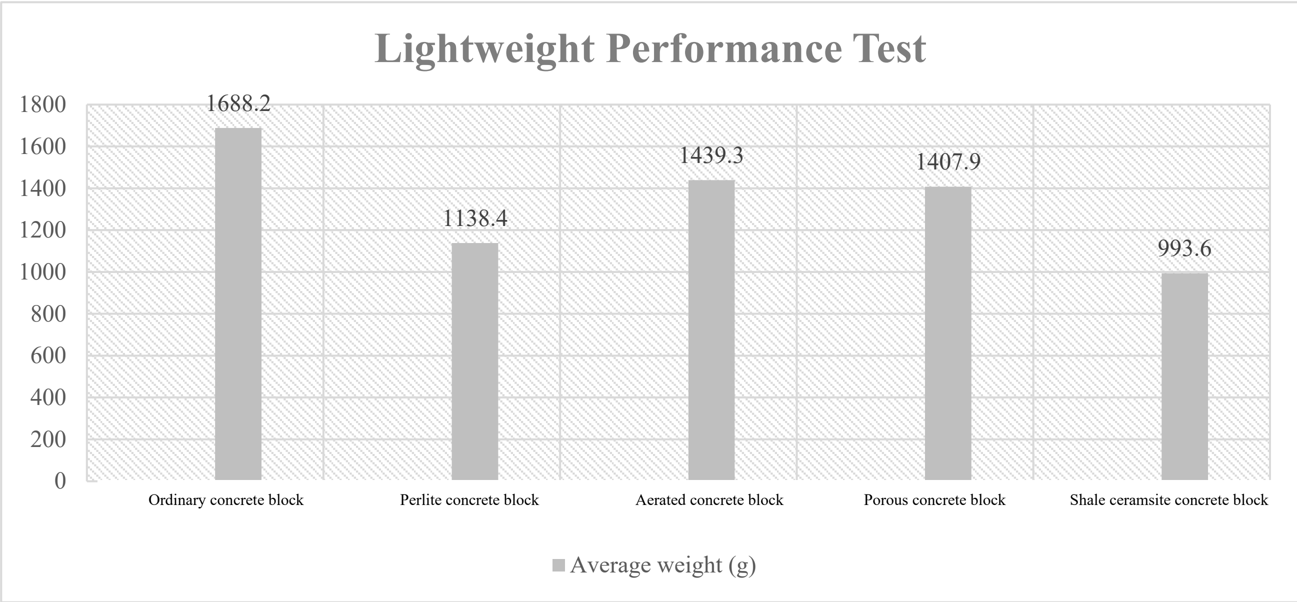

Figure 5. Lightweight performance test results

From Table 7, it can be seen that all the different lightweight aggregate concrete blocks selected for this experiment have a significant lightweight effect compared to the weight of concrete blocks of the same strength. Among them, aerated concrete blocks and porous concrete blocks have lower lightweight performance, reaching a weight reduction of 248.9 g and 280.3 g respectively.Perlite concrete and shale vitrified concrete have better lightweight effect, and shale vitrified concrete blocks have the best lightweight performance, reaching a weight reduction of (against ordinary concrete blocks) 694.6 g.

4.3. Sound insulation performance test

The experimental results of the sound insulation effect are shown in Table 8 and Figure 6:

Table 8. Experimental results of sound insulation performance

base material	Experiment No.	No Soundproofing Volume (DB)	Sound insulation volume (DB)	Ambient volume (DB)	Sound insulation (DB)	Average (DB)
Plain concrete blocks	1	90.2	65.9	50.6	24.3	24.3
Perlite concrete blocks	2-1	91.2	52.2	50.5	39	39.1
	2-2	92.6	53.6		39	
	2-3	92.2	52.9		39.3	
aerated concrete block	3-1	94.2	63.5	49.9	30.7	31.7
	3-2	95.1	62.8		32.8	
	3-3	94.8	63.2		31.6	
Porous concrete blocks	4-1	95.6	57.8	51.1	37.8	37.2
	4-2	95.2	58.2		37	
	4-3	94.9	58.1		36.8	
Shale ceramic concrete blocks	5-1	91.9	61.2	51.6	30.7	29.8
	5-2	92.3	62.3		30	
	5-3	91.6	62.8		28.8	

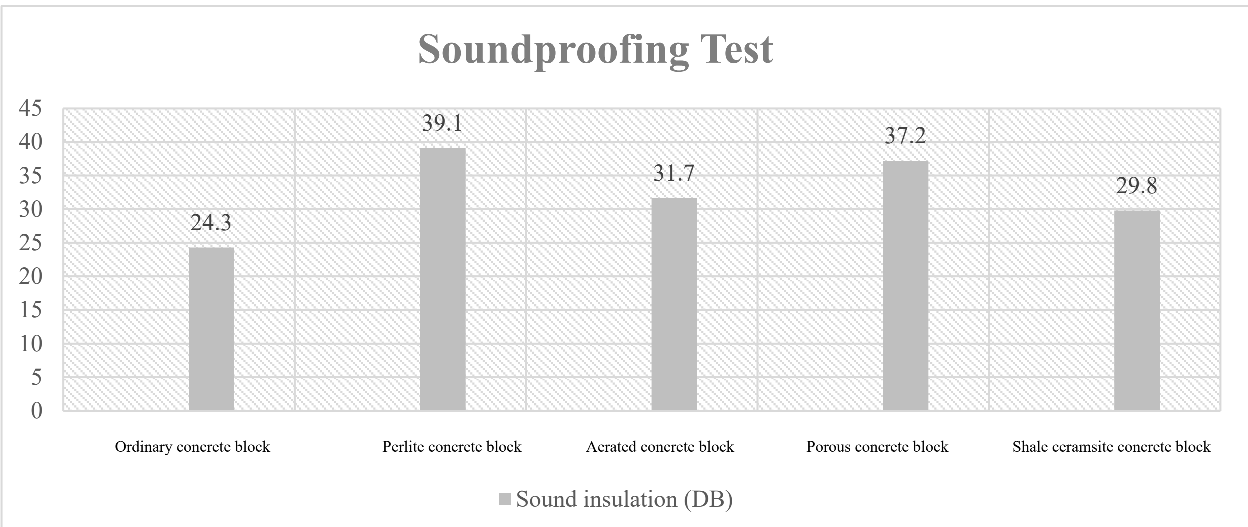

Figure 6. Sound insulation performance test results

From Table 8, it can be seen that all the different lightweight aggregate concrete blocks selected for this experiment have a significant difference in sound insulation performance compared to the sound insulation performance of concrete blocks of the same strength. The sound insulation performance of aerated concrete blocks and shale vitrified concrete blocks is lower, reaching a reduction of decibels 31.7 DB and 29.8 DB, respectively.Perlite concrete and porous concrete have a better sound insulation effect, with expanded perlite concrete blocks having the best sound insulation performance.

4.4. Insulation performance experiment

The experimental results of the insulation effect are shown in Table 9:

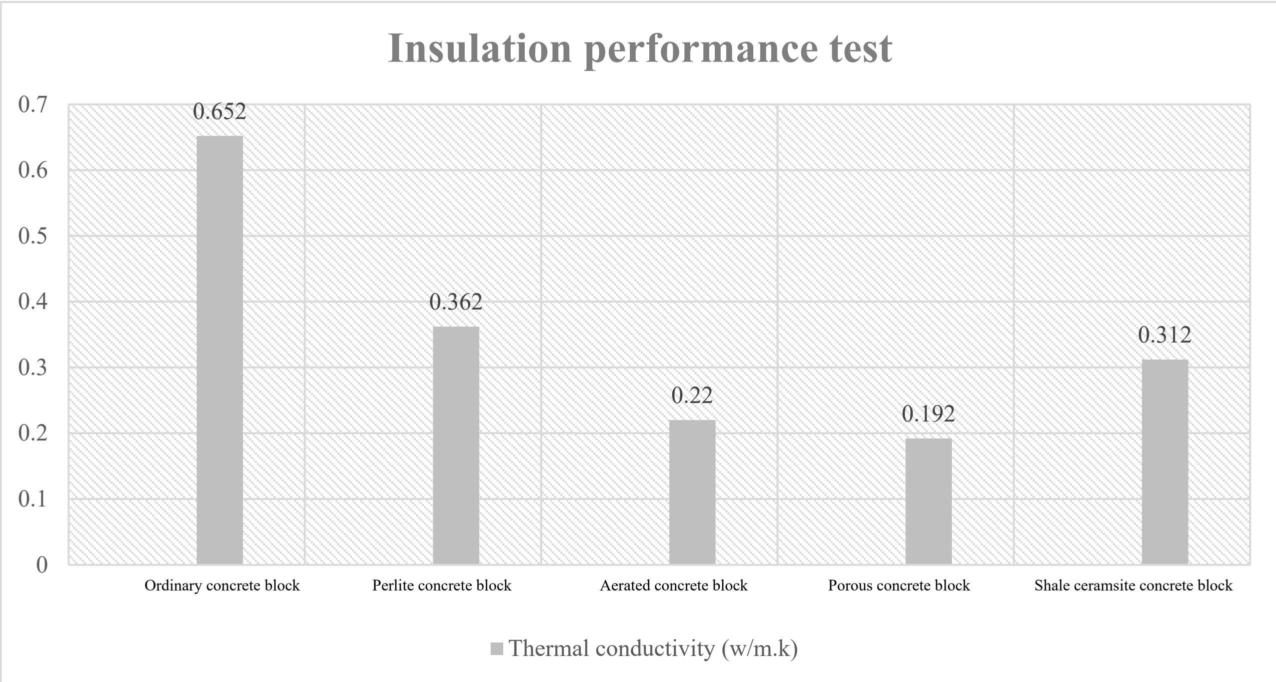

Figure 7. Insulation performance test results

Table 9. Experimental results of thermal insulation performance

base material	Experiment No.	Thickness (mm)	Density (g/cm³)	Thermal conductivity (w/m.k)
Plain concrete blocks	1	30	2.501	0.652
Porous concrete blocks	2	30	2.086	0.362
aerated concrete block	3	30	2.132	0.220
Perlite concrete blocks	4	30	1.686	0.192
Shale ceramic concrete blocks	5	30	1.472	0.312

In this experiment, the thermal insulation performance test was carried out using a flat plate thermal conductivity tester, and the control thickness of all the blocks was 30 mm.After measuring the density of the blocks, the thermal conductivity data obtained are shown in Table 9.The thermal conductivity of porous concrete blocks and shale vitrified concrete blocks is higher, and the thermal conductivity of aerated concrete blocks and perlite concrete blocks is lower. However, compared with ordinary concrete blocks, the thermal conductivity of all material blocks in this experiment is low. The thermal insulation effect is better. The best thermal insulation effect is the expanded perlite blocks.

5. Conclusions and Recommendations

By analysing the results of the compressive strength experiment, lightweight performance experiment, thermal insulation performance experiment and sound insulation performance experiment mentioned above, and comprehensively comparing the performance of light-transmitting concrete based on different matrix materials, the compressive strength of porous concrete blocks is the greatest, and in other performance, it is found that shale terra cotta concrete blocks have the best lightweight performance, and the expanded perlite blocks have the best sound insulation as well as thermal insulation effect, but the compressive strength of expanded perlite is the is the lowest in comparison and needs to be avoided for its use at critical points of the component structure.

At present, translucent concrete, as a new type of building material, has certain aesthetic advantages over traditional materials while possessing energy saving and consumption reduction. By considering the combination between different matrix materials and translucent materials to improve the combining ability and light transmittance between the two, and focusing on the three properties of translucent concrete lightweight, heat preservation, and acoustic insulation on this basis, more high-quality combinations are explored in order to achieve the goal of green building.

Bibliography

[1] CAO Zheng,ZHU Yajing,WU Xiaojun et al. A review of research on the preparation of lightweight concrete[J]. Concrete,2022,No.395(09):184-187+192.

[2] WANG Qing,GAO Shu-chang,GAO Jia-cheng et al. Properties of ultra-high performance lightweight concrete with ceramic sand and its influencing factors[J/OL]. Silicate Bulletin:1-12[2023-04-21].

[3] Tian Tao. The use of foam lightweight concrete in highway embankment disease management[J]. Sichuan Building Materials, 2023, 49(02):18-19.

[4] WANG Wenjing,JIANG Lu,CHEN Yang et al. Image analysis method of recycled insulated concrete insulation aggregate based on the principle of somatoscopy[J]. Concrete, 2017, No.332(06):136-139.

[5] HUANG Wei,FANG Zhangping,GE Jinjin et al. Performance test of calcium carbonate whisker reinforced recycled thermal insulation concrete[J]. Journal of Hunan City College (Natural Science Edition),2022,31(03):13-17.

[6] ZHANG Qingxu,GE Yicheng. Experimental research on sound-insulating concrete [J]. Shanxi Construction, 2018, 44 (29): 129-130.

[7] Zhang Jinhua. Research on the Preparation of Concrete Acoustic and Sound Insulating Blocks[D]. Southeast University, 2006.

[8] ZHANG Long,YANG Jie,XU Hongyi et al. Research on sound insulation and thermal insulation performance of ceramic aerated concrete block [J]. Wall Material Innovation and Building Energy Saving, 2017, No.219(02):39-40.

[9] Liu Qiusheng. Construction technology of sound insulation mat and cast-in-place concrete composite sound insulation floor[J]. Construction Technology, 2008, No.302(07):72-74.

[10] GU Xiaoyu, XIE Jiming, PENG Xiaoqian et al. Research on making acoustic concrete wall with recycled coarse aggregate [J]. Science and technology innovation guide, 2015,12(23):18-19.

[11] CHEN Sijia, XU Xun, WANG Zonghao et al. Research on the interfacial properties of alkali magnesium sulfate cement-based resin translucent concrete[J]. Concrete and Cement Products, 2020, No.288(04):9-13.

[12] ZHOU Zhi, GAO Xipeng, SHEN Juan et al. Research on the preparation of resin translucent concrete products and its energy-saving effect [J]. Functional Materials, 2016, 47(09): 9017-9022.

[13] WANG Shu, WU Yuanyuan, WU Xiong et al. A review of translucent concrete preparation, properties, and applications [J]. Materials Herald,2016,30(S1):467-469+477.