World Journal of Materials Science
ISSN:2960-0146
DOI: https://doi.org/10.61784/wjms3003

STUDY ON THE SOUND INSULATION PERFORMANCE OF SANDWICH LIGHTWEIGHT PARTITION WALL PANELS

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Abstract: In order to create a healthy and comfortable indoor environment, based on the sandwich lightweight partition structure, this article systematically analyzes the impact of factors such as the type of filling material in the partition wall cavity, the thickness of the filling material, the number and quality of panel layers on its sound insulation performance. Through experimental tests, the reverberation chamber method was used to measure the sound insulation amount and the standing wave tube method was used to measure the sound absorption coefficient, and the effects of different filling materials and structural parameters on the sound insulation effect were compared. The results show that filling glass wool or rock wool materials significantly improves the sound insulation of sandwich partition walls, and increasing the thickness of the filling material and the number of panel layers further optimizes the sound insulation performance. The research results provide a theoretical basis for the design of indoor partition walls and help improve indoor acoustic comfort.
Keywords: Sandwich lightweight partition wall panels; Sound insulation performance; Filling material; Number of panel layers; Reverberation chamber method; Standing wave tube method

INTRODUCTION

In modern buildings, indoor acoustic comfort has become one of the important indicators for measuring environmental quality. The control of airborne sound transmission pathways is a key factor in evaluating the acoustic quality of buildings. Optimizing indoor sound insulation performance is of great significance for improving personnel comfort and work efficiency [1,2]. Sandwich lightweight partition wall panels are widely used to separate indoor spaces due to their lightweight and flexible structural features. However, the sound insulation performance of sandwich partition walls is affected by many factors, such as cavity filling material type, filling thickness, number and quality of panel layers, etc. [3,4]. Existing research mainly focuses on the impact of a single factor on sound insulation performance, lacking systematic comprehensive analysis. Therefore, this article aims to systematically evaluate the impact of different structural parameters on the sound insulation performance of sandwich lightweight partition wall panels through experimental research, so as to provide a basis for optimizing its design.

1 MATERIALS AND METHODS

1.1 Sandwich Lightweight Partition Wall Panel Structure

Sandwich lightweight partition wall panels are mainly composed of a keel and multi-layer wall panels installed on both sides of the keel to form a spatial structural unit. There is a cavity in the middle that can be filled with fiber-based sound-absorbing materials. The structural construction method of sandwich lightweight partition wall panels is shown in the figure 1 and figure 2 below. In the sound insulation analysis, the sandwich lightweight partition wall panel can be simplified into two parallel plates, separated by a cavity, and the cavity is filled with fiber-based sound-absorbing materials. The propagation of sound in sandwich lightweight partition wall panels is shown in the figure 1and figure 2 below. In the figure 1, Pi, Pr, Pt, and P2b represent incident, reflected, transmitted sound pressure and bridging sound pressure. Sound is transmitted partly through the cavity and partly through the mechanical connections between the wall panels, the so-called sound bridge. Important parameters of the two panels include their unit area masses m1 and m2, critical frequencies fc1 and fc2, and the sound insulation amounts R1 and R2 of the two panels.

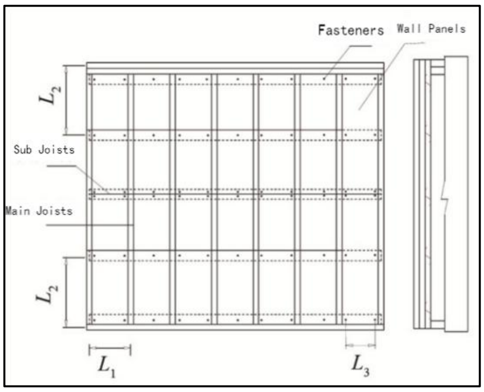

Figure 1 Schematic Diagram of Partition Wall Panel Structure

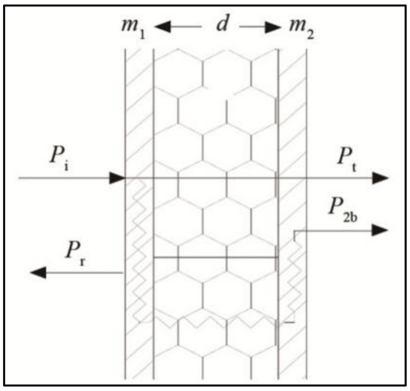

Figure 2 Schematic Diagram of Sound Propagation of Sandwich Lightweight Partition Wall Panels

1.2 Materials and Specifications

Factors considered for sound insulation of sandwich lightweight partition wall panels include: wall cavity size, wall cavity filling material (rock wool, glass wool), wall panels (type, number of layers, thickness, quality), etc. In the test, the main keel spacing was 1200mm and the secondary keel spacing was 400mm; the lightweight wall panel materials used commonly used gypsum board, oriented structural strand board OSB and other boards; the filling materials in the cavity were rock wool and glass wool, with a thickness of 60mm, 90mm, the specific test plan is shown in the table 1 below.

Table 1 Sound Insulation Test Plan for Sandwich Lightweight Partition Wall Panels

Serial No.	Sandwich Lightweight Partition Wall Panel Construction	Code
1	2 layers of 12mm gypsum board + 90mm cavity + 2 layers of 12mm gypsum board	SGB212-KQ90-SGB212
2	2 layers of 12mm gypsum board + 90mm glass wool + 2 layers of 12mm gypsum board	SGB212-BLM90-SGB212
3	(16mm gypsum board + 12mm OSB board) + 60mm glass wool + 2 layers of 16mm gypsum board	SGB16-OSB12-BLM60-SGB216
4	(16mm gypsum board + 12mm OSB board) + 60mm rock wool + 2 layers of 16mm gypsum board	SGB16-OSB12-YM60-SGB216
5	(16mm gypsum board + 12mm OSB board) + 90mm rock wool + 2 layers of 16mm gypsum board	SGB16-OSB12-YM90-SGB216
6	1 layer of 16mm gypsum board + 90mm glass wool + 1 layer of 16mm gypsum board	SGB116-BLM90-SGB116
7	1 layer of 16mm gypsum board + 90mm glass wool + 2 layers of 16mm gypsum board	SGB116-BLM90-SGB216
8	2 layers of 16mm gypsum board + 90mm glass wool + 2 layers of 16mm gypsum board	SGB216-BLM90-SGB216

In the above table 1, 1 layer of 12mm gypsum board represents fire-resistant gypsum board; 2 layers of 12mm gypsum board represents 1 layer of ordinary gypsum board + 1 layer of fire-resistant gypsum board. The test material type, specifications, thickness, density and mass per unit area are shown in the table 2 and table 3 below.

Table 2 Partition Wall Panel Types and Material Properties

Wall Panel Type	Thickness /mm	Density/kg/m³	Unit Area Mass/kg/m²
Gypsum Board	12	593	7.5
Fire-Resistant Gypsum Board	12	721	9.2
Fire-Resistant Gypsum Board	16	721	11.5
OSB Board	12	592	7.2

Table 3 Cavity Filling Materials and Properties

Filling Material Type	Thickness /mm	Densit y/kg/m³	Unit Area Mass /kg/m²	Airflow Resistance /(Pa·s·m⁻²)
Glass Wool	60	10.4	0.6	3600
Glass Wool	90	10.5	1.0	4800
Rock Wool	60	31.3	1.9	11400
Rock Wool	90	52.5	4.7	12700

1.3 Experimental Methods

The sound insulation measurement of sandwich lightweight partition wall panels is based on standards such as GBT19889.3-2005 "Sound Insulation Measurement of Acoustic Buildings and Building Structures" and BS EN ISO 10140-2:2010, using two sound source positions and a rotating microphone to measure the sound insulation effect. , the distance between the microphone position and the interface is 1.5 m. Finally, the weighted sound insulation amount Rw is calculated based on the 1/3 octave center frequency in the 100Hz-5000kHz frequency band. The size of the opening is 3m×2.1m. Considering that the sound insulation of the double-layer lightweight plate partition wall will be affected by the installation conditions in the test opening, the depth of the test opening, the peripheral connection and installation of the partition wall specimen and the test opening, try to eliminate Test losses and deviations caused by structural sound transmission and gaps and gaps caused by structural connections.

2 RESULTS AND ANALYSIS

The figure 3 and figure 4 below compares and analyzes the sound insulation effect of the wall without filling and glass wool in the 90mm cavity (two layers of 12mm gypsum board on both sides). The weighted sound insulation of the wall under the two working conditions is 52dB and 57dB respectively. The sound insulation of the glass wool filling is about 5dB higher than that of the unfilled sandwich wall, and the sound insulation effect is significant. In addition, when glass wool is filled, its sound insulation improvement effect in the low frequency range is not obvious. When the frequency exceeds 100Hz, its sound insulation improvement effect is more prominent. This shows that filling the wall cavity with glass wool or rock wool will increase the attenuation of sound propagation in the cavity. The depth of the cavity and the amount of filling material have a positive effect on sound attenuation.

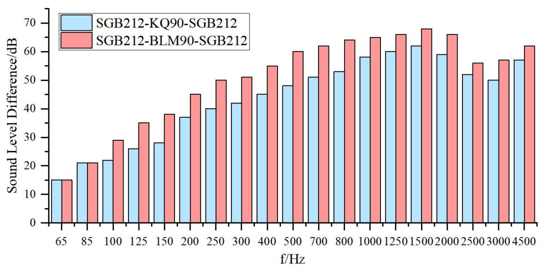

Figure 3 The Impact of Cavity and Glass Wool Filling on Wall Sound Insulation

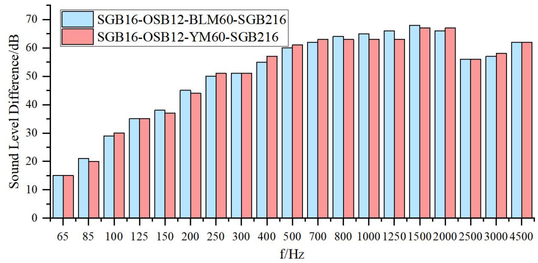

Figure 4 The Impact of Different Filling Materials on Wall Sound Insulation

The figure 3 and figure 4 above compares and analyzes the sound insulation effect of walls filled with 60mm glass wool and 60mm rock wool (one side is 16mm gypsum board + 12mm OSB board; one side is 2 layers of 16mm gypsum board). The results found that the weighted sound insulation of filled glass wool and rock wool were 55.6dB and 54dB respectively, and the former was 1.6dB higher than the latter. In the 125-1000Hz spectrum range, the sound insulation effect of walls filled with glass wool is slightly better than that of walls filled with rock wool. In the low-frequency and high-frequency ranges, the sound insulation of rock wool is better than that of glass wool. Overall, the sound insulation of walls filled with glass wool is 1.1-1.6dB higher than that of walls filled with rock wool. The performance parameters of filling materials, especially the impact of material density, air flow resistance, etc. on wall sound insulation need to be further studied and analyzed.

The figure 5 and figure 6 below compares and analyzes the sound insulation effect of walls filled with 90mm rock wool and 60mm rock wool (one side is 16mm gypsum board + 12mm OSB board; one side is 2 layers of 16mm gypsum board). The weighted sound insulation of the wall is 58dB, 54.4dB, the weighted sound insulation of the former is 3.6dB higher than that of the latter. This shows that the greater the cavity filling thickness, the greater the sound transmission loss in the wall system, and the sound insulation performance is optimized and improved.

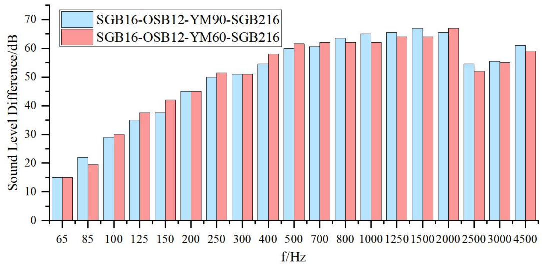

Figure 5 The Impact of Different Thicknesses of Filling Materials on Wall Sound Insulation

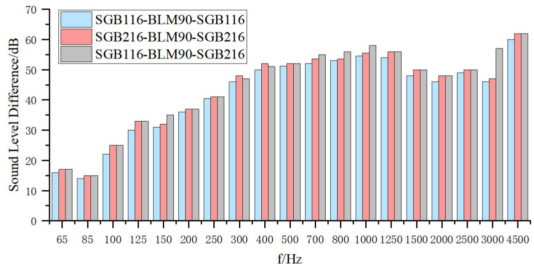

Figure 6 The Impact of the Number of Panel Layers on Wall Sound Insulation

Furthermore, the figure 5 and figure 6 above compares and analyzes the impact of 2, 3, and 4-layer panels on the sound insulation effect of the wall (the panels are all 16mm fire-resistant gypsum boards). The corresponding weighted sound insulation amounts are 47dB, 51.2dB, and 55.3dB respectively. Since the increase in the number of wall panel layers will reduce the energy transmission into the cavity, the number of wall layers increased from 2 to 3 and 4 respectively, and the sound insulation increased by 4.2dB and 8.3dB respectively.

3 CONCLUSION

Based on the above-mentioned research on the sound insulation performance of sandwich lightweight partition wall panels, the impact of the type of filling material, filling material thickness, panel layer number and quality on the sound insulation performance of the partition wall cavity was analyzed. The results found that filling the wall cavity with rock wool or glass wool, increasing the number of panel layers or improving panel quality, and avoiding structural connections has a positive effect on optimizing and improving the sound insulation performance of sandwich lightweight partition wall panels. The research results provide a theoretical basis for optimizing the sound insulation design of sandwich lightweight partition wall panels, which helps to improve the indoor acoustic comfort of buildings.

COMPETING INTERESTS

The authors have no relevant financial or non-financial interests to disclose.

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