Application of High Strength Sound Insulation Decorative Board in Soundproof Wall of Hotel Rooms——A Case Study of Guangzhou Kempinski Garden Hotel

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Abstract: The article based on acoustic insulation performance test of high strength sound insulation decorative board, the design, construction technology and operation key points of the room partition wall are discussed. Examples show that application of high strength sound insulation decorative board in sound insulation is feasible and good, this material could be used for a reference for similar sound insulation construction.

1. Introduction

The sound insulation decorative board, also known as High strength sound insulation decorative board, is a new high-strength lightweight plate[1], which has been researched and tested for many years, and has been specially designed and made of various inorganic materials. With 100mm dual panel dual main joist and the thickness of 50mm substantia proprigia layer which has glass wool, rock wool, sound-absorbing cotton, it takes fireproof plasterboard, cement fiberboard and high strength sound insulation decorative board for comparison (Table 1): the three kinds of building materials as measured insulation product specifications are: 48dB, 51dB and 52dB, the sound insulation effect of high strength sound insulation decorative board is better; on mechanical properties, the strength of high strength sound insulation decorative board is about 6Mpa, slightly lower than the fiber cement board, and is twice as strong as fireproof plasterboard board; on toughness it has 1130N, which is much higher than the other two, and could not easily fragile when bending, water resistance and thermal properties is also good; on environmental safety high strength, high strength sound insulation decorative board has excellent performance, the limit of radionuclides shows in class A, no benzene, E1 index reaches less than 0.1. The surface of high strength sound insulation decorative board can be advanced with the technology of any different three-dimensional relief, glazed, plastic and metal finishes, UV surface coating to reach a variety of realistic decorative perfect effect, without printing, coating process design, it saves the cost, shorten the construction period, which is the perfect combination of value and effect decorates material, currently it was widely used in large public buildings or civil building.

Table 1 Performance comparison of common board in building room

| Item                              | Fireproof plasterboard | Cement fiberboard | High strength sound insulation decorative board |
|-----------------------------------|------------------------|-------------------|-----------------------------------------------|
|                                   |                        |                   |                                               |

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2. Test section
The raw material of the test selects one high strength sound insulation decorative board which from Guangdong Meisui Industrial Development CO., LTD. The specification is GS000 (1200*2400*12) mm, which commissioned by the national building materials testing centre to inspect the airborne sound insulation, centre testing number is WT2014B03A01201, according to Rating standard Of sound insulation in buildings GB/T 50121-2005, test result is 30dB (see Table 2 and figure 1). This data is in line with the range of A-level noise allowed at night of the hotel rooms.

Table 2 Air sound transmission loss diagram

| Center frequency, Hz | 100 | 125 | 160 | 200 | 250 | 315 | 400 | 500 | 630 |
|----------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| Sound transmission loss, dB | 20.7 | 29.8 | 23.4 | 23.9 | 30.2 | 31.7 | 28.9 | 31.8 | 27.7 |
| Center frequency, Hz | 800 | 1000 | 1250 | 1600 | 2000 | 2500 | 3150 | 4000 | 5000 |
| Sound transmission loss, dB | 29.5 | 30.4 | 30 | 33.3 | 29.1 | 26.4 | 31.3 | 34.1 | 36.3 |
| Weighted Sound transmission loss, RW | RW (C1; C2) =30(0; -1)dB |
3. Structural design of high strength sound insulation decorative board in the hotel room

Guangzhou Kempinski Garden Hotel has 215 rooms, the construction model site of the hotel room is in the sixth and seventh layers, the design organization is Guangdong Meisui Industrial Development CO., LTD., construction organization is Gold Mantis Construction Decoration and Shenzhen Great Wall decoration group CO., LTD. The hotel room uses the above tested high strength sound insulation decorative board.

3.1 Structural design of high strength sound insulation decorative board in the hotel room

The wall in the construction model site of the hotel room selects dual panel dual main joist five layer structure, sound insulation board layer structure of the television background wall is as follows (see Figure 2): The first layer is 12mm high strength sound insulation decorative board; the second layer is 12+3mm high strength sound insulation decorative board; increasing 75mm vertical main joist between second and third layers; the third layer is the 12mm high strength sound insulation decorative board; increasing 75mm vertical main joist between third and fourth layers; the fourth layer is the 12+3mm high strength sound insulation decorative board; the fifth layer is 12mm high strength sound insulation decorative board; and in the vertical main joist put two 50 square steel pipe as the fixed structure of TV rack. In order to strengthen the prominence of the TV parts, the spacing of the vertical main joist of TV background sound insulation wall is set to 200mm, which is an encrypt area, also it is helpful to increase the weight bearing capacity of the structure.
The structure of the bedside background wall (see Figure 3) has a main joist which all built with red glass wool and on surface are full spread cushioning pads. For the better effect of sound insulation performance has been considered in the construction process, compared to the installation method of general cement fiber board, wooden board on the market, specially reinforced with internal stiffeners in the air layer wall, changed the surface contact into line contact among the brords, which is to effectively reduce solid-borne sound transmission passageway of high strength sound insulation decorative board, air layer makes the wall retains inherent sound insulation and produce additional sound transmission loss.

![Figure 3 The transverse section of bedside background wall](image)

According to the comparison of the sound insulation performance of several light-weight walls in the following figure[2] (see Fig. 4), in this case, the wall is divided into two layers using an 18mm thickness air layer (see Figure 5) After the wall penetrates, incident sound passes through the air layer to the second layer of the wall, then the air layer plays the role of the elastic layer of the flexible cushion, thus consuming the acoustic energy. At the same time, the sound waves are reflected when they pass through different media surfaces in turn, and the multiple reflections of the sound waves also gradually attenuate the sound energy. In the construction process also pay attention to:

1. Where there is a fall-edge board (12mm thick high strength sound insulation decorative board) is required to use professional caulk with special GRG powder batch sewing.
2. Where there is no decline edge board (containing 3mm thick tendons in 12mm thick high strength sound insulation decorative board), all the stitching required GRG powder grafting.
3. All horizontal, vertical high strength sound insulation decorative board need staggered joints installation.
Figure 4 Comparison of Several Lightweight Wall Sound Insulation Properties

1. 12mm gypsum plaster board (25dB)
2. 12mm gypsum plaster board, 80mm hollow (35dB)
3. 12mm gypsum plaster board, 80mm hollow, filled with mineral wool

1. 50mm honeycomb sandwich laminates with plywood surface (30dB)
2. 50mm honeycomb sandwich laminates + 56mm air layer + 30mm honeycomb sandwich laminates (35,5dB)
3. 50mm honeycomb sandwich laminates + 56mm air layer + 30mm honeycomb sandwich laminates, filled with mineral wool (44dB)
Figure 5 Partition wall horizontal section of air layer

3.2 Construction technology of shock absorption

Damping pad is a flexible material, can reduce the impact of sound bridges, improve the sound insulation value. When the sound waves incident on the damping pad, the damping vibration overcomes the friction within high strength sound insulation decorative board, vibration reduction while consuming acoustic energy, to achieve the unloading function. The thicker damping pad has a good effect on reducing the low-frequency solid sound, the thickness of the damping pad attached main joist should more than 5mm (see Figure 6).

Figure 6 Damping pad construction drawings

The elastic parts can increase the sound insulation significantly, and the additional elastic parts between the main joist and the plasterboard can effectively improve the sound insulation[3]. The sound absorption material in the partition wall is very important to the sound insulation, and the weighted sound reduction index ($R_W$) will increase[4]. The engineering practice has proved that the noise can be
effectively reduced by using the sound absorption board with inner filling sound absorption cotton\(^5\). So, in the hotel room of this case, in order to achieve good sound insulation effect, selecting the red glass sound-absorbing cotton into the structural design.

Placed 50mm red glass sound-absorbing cotton during the main joist (weight: 50kg / m\(^3\)) to absorb sound, thereby increasing the amount of sound transmission loss. When the sound waves incident on the glass sound-absorbing cotton, in addition to its own internal porous structure and bubbles friction with the air, making part of the sound energy can be consumed, but also consider the adiabatic air compression heat generated by the exchange, the sound energy changed into heat, which is to further weaken the sound absorption, and to achieve the function of sound absorption and noise reduction. At the same time, the main raw material of glass sound-absorbing cotton meets the requirements of environmental protection and is not easily disturbed by external factors such as precipitation, high temperature and sunlight, and maintains its own sound-proofing and chemical properties. The low-density and light weight structure is favorable for construction operation, also good hermeticity improve hotel room comfort.

3.3 Hole construction process
Hole process designing: an integral molding soundproof box to reduce the formation of a gap → fire rubber mud blocking perforation department → anti-corrosion paint processing nail cracks → special GRG powder caulk.

According to the ratio of open porosity and sound insulation diagram\(^6\) (see Figure 7), hole sound is the key link of sound insulation. According to the theoretical value, when the opening area of the envelope is more than 1%, the sound transmission loss after the opening of the envelope is reduced from 60dB to less than 20dB, and in the hotel room it is unavoidable to install the cable box. In order to get better sound insulation from the accumulated construction experience and to further reduce the sound leakage of open wall holes, it must be considered the combination of the installation technology and architectural acoustics. In this case, the holes are fully considered in the design process. The presence of gaps makes the sealing performance deteriorate, resulting in poor sound insulation of the whole rooms. Therefore, it is necessary to handle the holes of the plug-in box in the wall of the guest room.

![Relation diagram of opening rate and sound insulation quantity](image)

Figure 7 Relation diagram of opening rate and sound insulation quantity

Besides, according to the sound quality insulation law, the sound transmission loss is directly proportional to the logarithm of the mass (mass plane density) of the unit area of the sound insulation structure, and the sound transmission loss increases by 6dB when the mass surface density increases by 1 time. In order to avoid the resonance effect caused by the plate, room insulation method in this
case is using a 24mm thick soundproof box that made of same material of plate as wiring box bottom box, soundproof box integral preformed, then it will reduce the gap when small plates assembled, and then filling, shaping into a whole, thereby weakening the plug wire holes influences the sound transmission loss on the structure (see Figure 8).

![Soundproof box structure diagram](image)

**Figure 8 Soundproof box structure diagram**

Soundproof box perforation process is embedded into the flexible rubber mud which is fire retardant and corrosion resistant to plugging, and the bolt will be fixed on the insulation plug wire then tin on the bottom box, also use the GRG powder dressing (see Figure 9), which can effectively buffer the sound and vibration to spread, meeting the requirement of sound transmission loss standard.

![Figure 9 details of pore handling in a sound insulation box](image)
All those nail holes at the plate (see Figure 10) must be used anti-corrosion paint processing, and then paint in the patch hole on special GRG powder, thereby reducing the effects of water and dust.

![Figure 10 Board screw spacing diagram](image)

According to *Code for design of sound insulation of civil buildings GB50118-2010* in China, the sound insulation standards of hotel buildings for guest rooms of special-class, first-class, second-class have the following provisions for walls, floors, corridors and exterior walls (see Table 3).

| Structure type                  | Single-number quantity of air-borne sound insulation + spectrum adaptation term | Special-class (dB) | First-class (dB) | Second-class (dB) |
|--------------------------------|---------------------------------------------------------------------------------|--------------------|-----------------|------------------|
| The partition and floor between the rooms | weighted sound reduction index + Pink noise spectrum adaptation term $R_w + C$ | >50                | >45             | >40              |
| The partition between the guest room and the corridor | weighted sound reduction index + Pink noise spectrum adaptation term $R_w + C$ | >45                | >45             | >40              |
| Exterior walls of the room (including windows) | weighted sound reduction index + Pink noise spectrum adaptation term $R_w + C$ | >40                | >35             | >30              |

From table 3, it is known that the special-class sound insulation standard of the five star hotel of the partition wall in the guest room is greater than 50dB, and partition wall thickness is not more than 200mm. The construction model site in the sixth layer and seventh rooms of the Guangzhou Kempinski Garden Hotel selects dual panel dual main joist five layer sound insulation structure, also sound insulation wall thickness control in less than 200mm, and the sound insulation capacity of 59dB reached the five star room noise standards, which shows a good effect.
3.4 Conclusion
(1) The partitions of the hotel room selects dual panel dual main joist five layer structure which is helpful for increasing the weight bearing capacity and meeting the contract requirements, while the air layer and the damping pad make the sound insulation effect improved significantly.
(2) Adding flexible material can increase the sound insulation and reduce the cost.
(3) An integral molding soundproof box and GRG special powder can effectively reduce the gap area and improve the sound insulation of the wall.

4. Application prospect of high strength sound insulation decorative board
Through the good feedback of this case, the application of high strength sound insulation decorative board can be extended to the industry field with special requirements for acoustics in new and old buildings. With design creativity, this construction material can meet the advantages of functional and artistic modeling. It will also usher in a larger space for development and become a popular lightweight, high-strength and environment-friendly building material, and has a broader market.

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