An Experimental Study on the Thermal Performance of Gypsum Partition Walls

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ABSTRACT

Buildings can use less energy if they finish their walls and ceilings with gypsum board. The construction of homes, businesses, and factories uses this material, which was developed in Australia in the early 1990s and then adopted by othercountries including China and India. Without the need for columns or beams, gypsum walls can be used as slabs and wallsfor structural and aesthetic reasons. A lack of fresh building supplies is a result of India's severe housing deficit. The use of sustainable solutions is always preferable when resources are few. To optimally use gypsum board as building material,methods are needed to reduce mold and condensation that frequently found on the material and inner surface of board. This study compares the thermal efficiency of several gypsum partition walls. The test parameters considered in the wallsincluded with and without filler material on thermal performance. Filler materials considered as EPS sheets. Present study will help to choose the right combination of materials for improving the thermal performance of gypsum partition walled structures.

Keywords: Rapid, Sustainable, Thermal performance

1 Introduction

Reducing the use of energy-intensive construction materials and providing housing units promptly and economically are the two key problems the mass housing sector is currently confronting. There is a sizable demand for building materials including cement, steel, bricks, and water to supply the rising demand for dwellings and other infrastructure. Due to the dearth and rising costs of these materials, alternative low-cost solutions are needed to satisfy the vast housing needs, especially for the Economically Weaker Section (EWS) and Low-Income Group (LIG) sectors. The suggested method promises to provide high-quality dwellings to the general people rapidly and economically while also ensuring sustainability through reduced energy use and the use of recyclable waste as a raw material. Any type of gypsum, including flue gas gypsum, mineral gypsum, phosphogypsum, and marine gypsum, can be used to create gypsum wall panels, with the production process using relatively little energy. A typical building material is gypsum board, sometimes known as plasterboard or plasterboard. It is made of gypsum, a soft sulphate mineral composed primarily of calcium sulphate dihydrate. Gypsum board is widely used to cover the walls or ceilings in residential and commercial structures. It is well known for having a smooth, flat surface that is easy to paint and decorate. In addition to being soundproof and fireproof, gypsum board can also help keep a building's humidity levels under control [4]. Gypsum board is made by pressing gypsum between two layers of paper or fibreglass mats. The finished board is then cut into sheets of various widths and thicknesses, depending on the intended use. Gypsum board assemblies are frequently used as partitions because of their beneficial thermal efficiency and straightforward installation in buildings. In general, the ASTM E-119 furnace test conditions [5] time during which the temperature at the rear side of the un-exposed board reaches to a critical value establishes the fire resistance capabilities of a gypsum board assembly.

Gypsum board can be installed in a number of ways, including by nailing or screwing it to metal or wood studs, adhering it to already-existing walls or ceilings, or both. To polish the surface and create a smooth surface ready for painting or wallpapering, joint compound and tape can be employed. Due to its ease of

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installation and affordability, gypsum board is a flexible and often used building material in both residential and commercial construction.

Building partition walls allows you to divide up a larger area into smaller, independent rooms or zones. They are widely used in houses, workplaces, and other facilities to provide private spaces, storage areas, or simply to divide a large space into smaller, more manageable sections. Partition walls can be made from a variety of materials, including plasterboard, wood, glass, and even metal. The type of material to be used will be determined by the purpose of the partition wall and the ambience that is sought for the space. Partition walls can be permanent or temporary, depending on the needs of the user. Stronger materials are typically used to build permanent walls, which are intended to remain in place for the whole life of the construction. Temporary walls, on the other hand, are often built from lightweight materials and may be rapidly relocated or taken down as needed. Designing partition walls with doors, windows, and other components can improve their adaptability and functionality. For instance, a partition wall could include a window to bring in natural light or a sliding door to make moving between rooms straightforward. Overall, partition walls are a practical and versatile way to divide up a larger room into smaller portions and may be customised to satisfy a range of purposes and interests.

A non-load bearing wall is a wall that does not support any structural weight of a building or structure. It means that this wall is not required to hold up the roof, floors, or any other parts of the building. These types of walls are usually constructed to create separate rooms or areas within a building, or to provide a partition between different sections of a room. They are typically made from materials such as drywall, plaster, or wood framing, and are usually thinner and lighter in weight than load-bearing walls. Since non-load bearing walls do not carry any weight, they can be easily modified or removed without affecting the structural integrity of the building. This makes them an ideal choice for interior walls, as they can be moved or repositioned to accommodate changes in the layout or function of a space. This makes them an ideal choice for interior walls, as they can be moved or repositioned to accommodate changes in the layout or function of a space.

Due to the demands of flexible architectural layouts and the requirement for acoustic absorption materials, it is frequently challenging to expose thermal mass in partition walls, floors and ceilings in office buildings. They consequently frequently encounter abrupt fluctuations in thermal energy load. This results in temperature fluctuations inside, which may lessen occupants' thermal comfort [1]. The aim of the present study is to analyze the effect of an additional EPS sheet to improving thermal resistance. EPS sheet materials are taken into consideration as filler materials. The results of this study will be used to select the best combinations for enhancing the thermal performance of gypsum partition walled constructions.

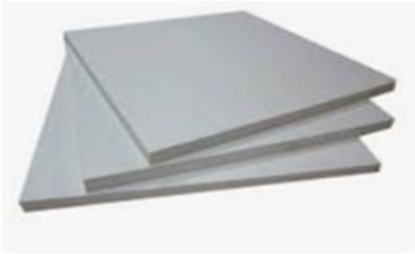

Figure 1: *Gypsum Board*

Most of the research mainly focused on the structural aspects of gypsum walls. The figure 1 shows the gypsum board, it is also fire resistant, sound proof and can help to control humidity level in a building. And the excellent thermal performance and low cost of concrete-sandwich walls have made them widely applied in residential buildings [3]. Limited studies on the thermal performance of gypsum partition wall filled with

EPS sheet layers by experimental methods. The thermal performance of gypsum partition wall evaluated based on time lag and decrement factor [2].

Advantages of using EPS:

- Long life
- Low maintenance, fast
- Excellent insulating and shock absorbingcharacteristics
- Thermal conductivity of EPS core decreases as it density decreases.

Figure 2: *EPS Sheets*

Figure 2 shows EPS sheet can be considered a waste material in certain contexts, particularly when it is discarded after its initial use. EPS is often used in packaging materials, such as foam blocks or trays, that are used to protect products during shipping.

2 Methodology

2.1 Materials And Methods

In this work, the impact of EPS on the real temperature of a gypsum board cubicle is investigated in the field. The test specimen located at field in real temperature.

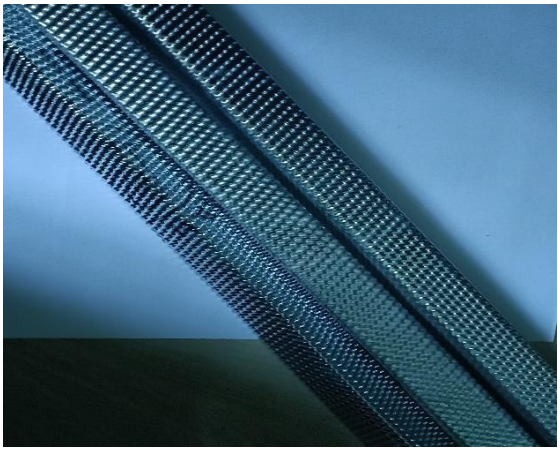

Figure 3: *Vertical studs*

Figure 3 shows vertical stud is made of special high-performance steel that undergoes stringent quality checks and controls to ensure correct and consistent base material for further profiling.

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Figure 4: *Screws*

The cubicle for gypsum board is 1000mm in size. According to fig. 4, the components include gypsum board, vertical studs, and screws. Additionally, the 1000mm by 1000mm by 150mm partition wall in the gypsum board cubicle. The filler elements in the partition wall are thought of as several layers of EPS panel. The EPS sheet was positioned in the middle of the partition wall in the first scenario. In the second situation, two EPS sheets were equally spaced apart and positioned in the partition wall. And in the third situation, three EPS sheets were inserted into the gypsum partition wall.

The sensor is used to measure the inner and outer temperature of the gypsum partition walls. Heat transfer from the outer to inner space of the gypsum partition wall. And then analyzing the temperature curve of six sensors. Three sensors connected in the outer surface of the gypsum partition wall. And other three-sensors connected in the inner surface of the gypsum partition wall. Thermal performance of gypsum partition wall canbe evaluated based on the time lag and decrement factor.

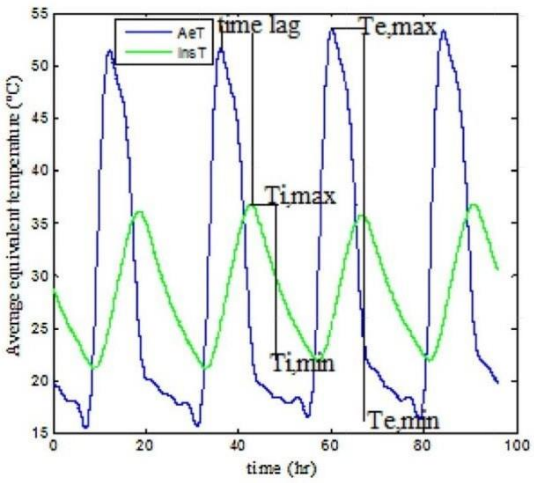

Figure 5: *Time lag and decrement factor (Pape et al.,2017)*

The decrement factor represents how quickly the temperature difference across a material decreases over time. Figure 5 shows lower decrement factor helps to minimize heat loss or gain over time, allowing the interior of a building to maintain a more stable temperature. The amount of time needed for the heat wave to go from the wall's exterior to interior is known as the time lag. The ratio of the heat wave amplitudes at the surfaces of the walls is known as the decrement factor [2].

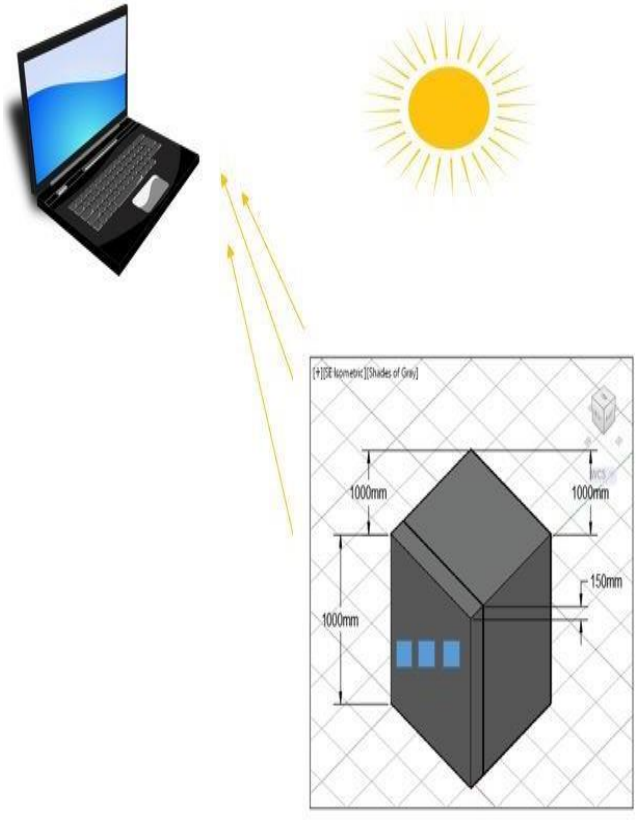

Figure 6: *Schematic diagram of test specimen*

In this work, the impact of filler material at the real temperature of a gypsum partition wall is investigated in the field. The test specimen was located in a field at real temperature. The size of the gypsum board cubicle is 1000mm in figure 6. And the gypsum board cubicle has a partition wall (1000mm×1000mm×150mm).

Table 1: *Scenarios considered during the experimentalwork.*

Scenario	Description
1	Without filler in gypsum partition wall
2	With EPS sheet one layer in the centre of gypsum partition wall
3	With EPS sheets two layer in the gypsum partition wall
4	With EPS sheets three layer in the gypsum partition wall

The first scenario (Scenario 1) was a control case without EPS sheet, only with the gypsum partition wall. In scenario 2,3,4 the EPS panels are filler material by one, two and three layers. The EPS panel having length 1000mm, width 150mm and 2mm thickness.

2.2 Material Characterization

The IS 2542 part (2) recommended the methods of test for gypsum board such as compressive strength test, water absorption test and moisture content. The compressive strength test specimen 200×150×150mm was considered approximate as the same size was recommended in IS 2542 PART (2) to evaluate the compressive strength of gypsum block. The compressivestrength of gypsum block is 0.68 N/mm², which is morethan the minimum compressive strength (i.e 0.5 N/mm²)defined in IS 2849- 1983 was achieved.

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Figure 7: *Test Specimen*

A longer time lag can help to even out temperature fluctuations. It acts as a buffer, slowing down the rate at which heat is transferred, which can result in more stable and comfortable indoor temperatures. To achieve a good thermal performance, materials with high thermal mass and insulation properties are often used. High thermal mass materials, such as concrete or brick, have a longer time lag because they can absorb and store heat energy. Insulation materials, on the other hand, have a lower decrement factor as they impede the transfer of heat. It's worth noting that achieving the optimal thermal performance involves considering various factors such as climate, building design, insulation, ventilation, and thermal mass.

Table 2: *Properties of gypsum board*

Material	**Compression strength (N/mm^2)**	**Water absorption**	**Moisture content**
Gypsum board	0.68	50.2%	15.89%

The moisture content test for gypsum board is used to measure the amount of moisture present in the material. This test helps determine if the gypsum board is at an appropriate moisture level for installation or if it has been affected by excessive moisture.

Figure 8: *Scenario 1- without filler in partition wall*

EPS sheets are lightweight, making them easy to handle and install. Their lightness allows for easy transportation and reduces the structural load on buildings. This characteristic simplifies the installation process and can save time and labour costs during construction.

Figure 9: *Scenario 2 - With EPS sheet -one layer in the centre of gypsum partition wall*

The number of 3-layer EPS sheets used in a gypsum partition wall would depend on various factors such as the desired insulation level, local building codes, and specific project requirements. Typically, EPS insulation is used in combination with other materials in partition walls to enhance thermal performance.

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Figure 10: *Scenario 3 - With EPS sheets- two layer in the centre of gypsum partition wall*

The number of 3-layer EPS sheets used in a gypsum partition wall would depend on various factors such as the desired insulation level, local building codes, and specific project requirements. Typically, EPS insulation is used in combination with other materials in partition walls to enhance thermal performance.

Figure 11: *Scenario 4 - With EPS sheets -three layer in the centre of gypsum partition wall*

The number of 3-layer EPS sheets used in a gypsum partition wall would depend on various factors such as the desired insulation level, local building codes, and specific project requirements. Typically, EPS insulation is used in combination with other materials in partition walls to enhance thermal performance.

3 Results And Discussion

3.1 Real Temperature of Scenario 1

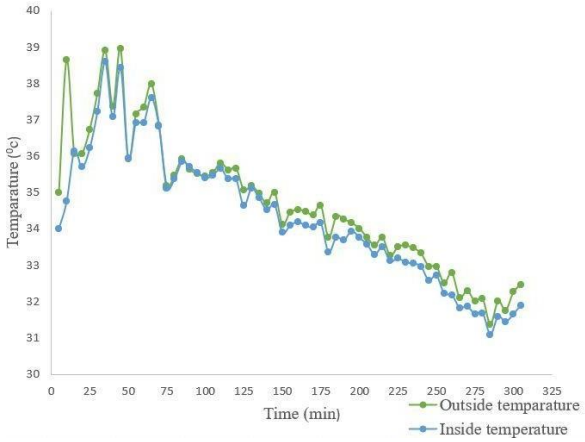

Figure 12: *Comparison graph of Time vs Temperature without filler material*

3.2 Real Temperature of Scenario 2

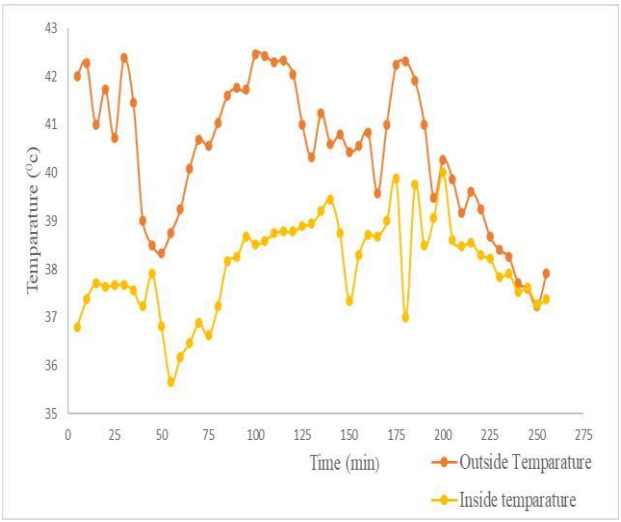

Figure 13: *Comparison graph of Time vs Temperaturewith one layer EPS in the gypsum partition wall*

3.3 Real Temperature of Scenario 3

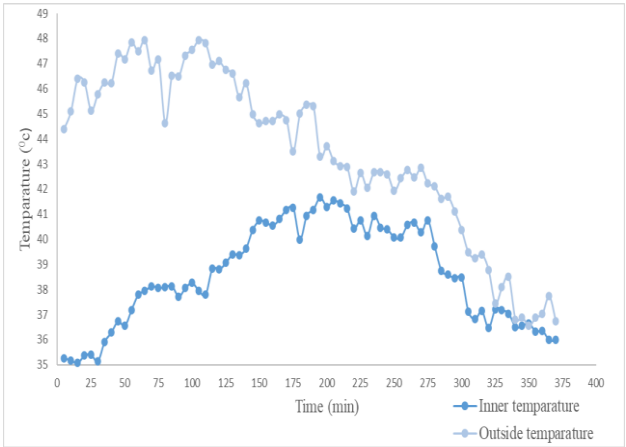

Figure 14: *Comparison graph of Time vs Temperature with two-layer EPS in the gypsum partition wall*

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Table 3: *Time lag and decrement factor values.*

Scenario	Time lag (min)	Decrement factor
1	0	1.008
2	27	0.69
3	38	0.65
4	62	0.42

With varied EPS panel layer arrangements, the delay time and decrement factor are both highly variable. The time lag lengthens and the decrement factor shortens as the number of EPS layers rises. The heat is stored in the envelope throughout the day using these values for the time lag and decrement factor.

3.4 Real Temperature of Scenario 4

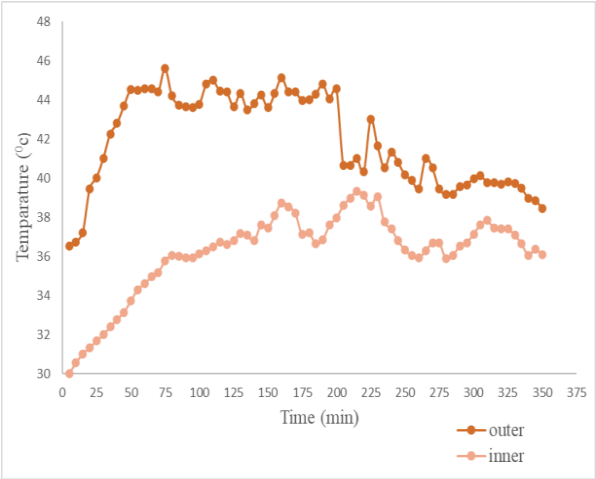

Figure 15: *Comparison graph of Time vs Temperature with three-layer EPS in the gypsum partition wall*

3.5 Time Lag and Decrement Factor

The x-axis could represent time units (minutes), while the y-axis could represent the magnitude of the temperature. The graph could show a decreasing trend where the magnitude of temperature decreases over time.The time lag and decrement factor are calculated using Fig 12, Fig 13, Fig 14 and Fig 15. This curve represents the variation of outside temperature and inside temperature of gypsum partition wall. The value found of time lag and decrement factor are summarized in Table 3.

4 Conclusion

Based on experimental studies conducted, the followingconclusion can be drawn:

- Hence by use of EPS material, it can reduce the inside temperature of gypsum partitionwalls and good thermal performance than without filler in the partition walls
- As the number of EPS layer increases, the time lag increases and the decrement factor decreases.
- This reduces the energy needed to cool the building during warm periods, as fluctuationsin the outside are not felt.
- Scenario 4 is the right combination of materials for improving the thermalperformance of gypsum partition walls.
- It helps to reduce the running cost of thebuildings.

5 Publisher's Note

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How to Cite

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