DEPARTMENT OF CIVIL ENGINEERING

TEAM C-HELIX

EXHIBITION

ULTRA ADAPTIVE TROMBE WALL

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Constructed by: Bhavna and Shruti

ABSTRACT:

A Trombe wall is a classical passive solar heating system used in buildings. Solar energy utilization for covering the heating loads of buildings is an innovative and clean way to reduce electricity consumption. Storage capacity of PCMs can improve indoor air thermal circulation and decrease indoor air temperature fluctuations. In addition, the effectiveness of PCMs in providing protection from overheating, and improving the efficiency of the energy management process and energy saving of Trombe walls is demonstrated

OBJECTIVES:

- To fully utilize the energy available all around us to replace conventional systems.
- To improve the effectiveness of Trombe walls with new technology of PCMs.

EXECUTION:

- Thermal energy storage is an innovation that stores thermal energy by heating or cooling a storage medium to ensure that the stored energy can be utilized at a later time for heating and cooling purposes. Such systems include three principle steps, namely, thermal charging, storing, and discharging.
- The use of PCMs is an alternative way to properly manage incident solar irradiation and lessen building loads.
- Phase change materials (PCMs) absorb and release thermal energy to transform from one phase to another by applying the latent heat storage principle. PCMs can be classified into four types based on the physical phases engaged in the phase change, namely, solid-liquid, solid-gas, liquid-gas, and solid-solid.
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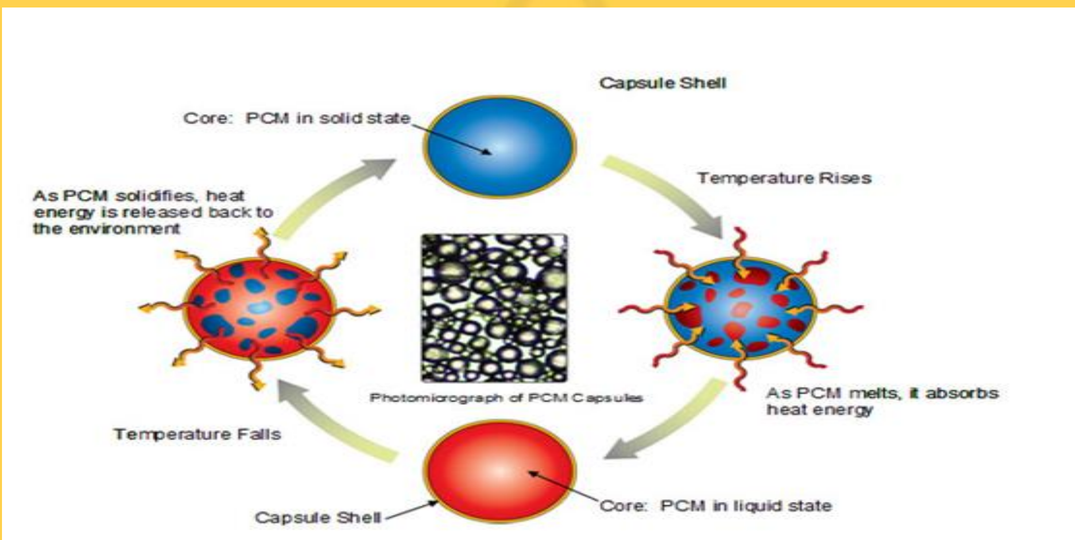


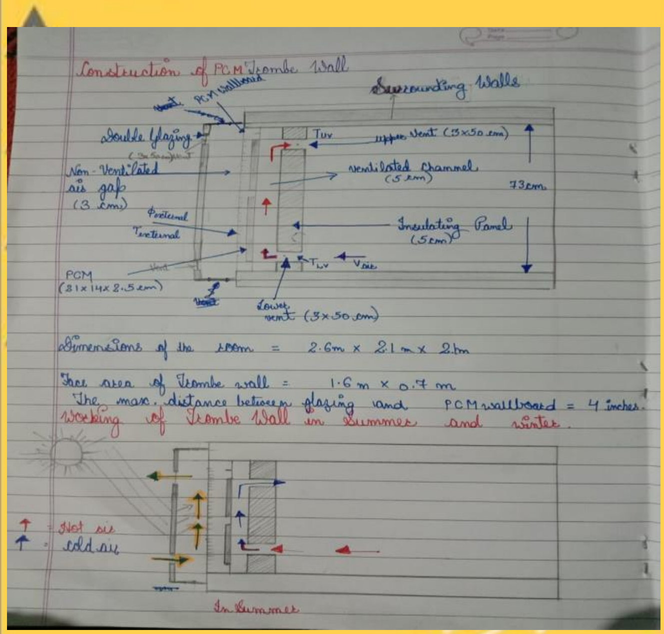
- Classical Trombe walls rely on sensible heat storage, but because of the potential of PCMs for storing high thermal energy per unit mass, the PCMs with Trombe walls is an attractive concept for increasing the thermal storage of the traditional Trombe walls. A Trombe wall filled with PCMs is constructed on the south side of a house. The wall is heated during the day by incoming solar radiation, thereby melting the PCM. At night, the heat is released to warm the house by hardening of PCM at low temperature. The PCM units require less space than mass Trombe walls for a given amount of heat storage and are much lighter in weight.
- Double glazing will help in the minimization of heat loss.
- In this, we are using $CaCl_2 6H_2O$ and paraffin wax (n-eicosane) because this PCM will give less temperature fluctuation and improve the indoor thermal comfort.
- Compound Melting Point (in C) Heat of Fusion (KJ/kg)

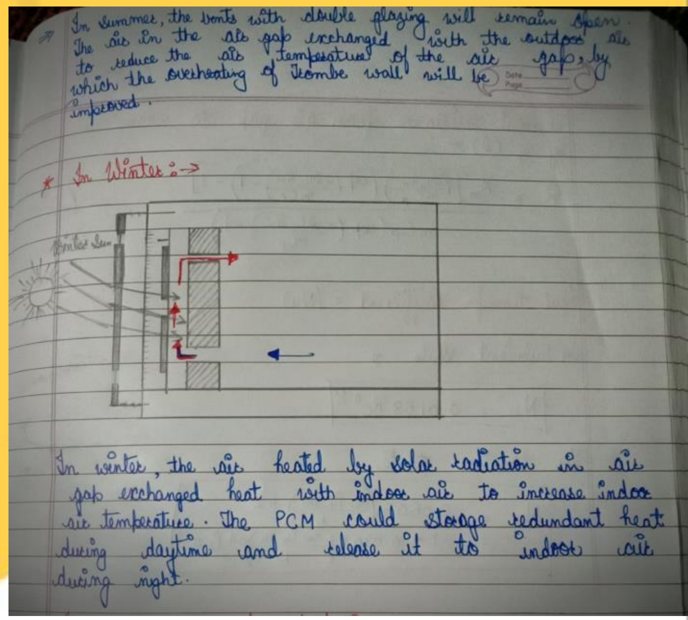
Material	Thickness (m)	Density (kg/m^3)	Conductivity (W/m·K)	Capacity (J/kg·K)
Plaster	0.015	2000	1.38	1000
Concrete	0.240	2400	2.1	800
Insulation	0.020	200	0.04	1400

n-

eicosane($CaCl_2.6H_2O$[66.6%]+Paraffin wax [33.4%]) 46.7 209

This type of PCM is also called **DOUBLE LAYERED PCM.** In the PCM WALLBOARD, outer layer is of Paraffin Wax and inner layer is of inorganic salt ($CaCl_2.6H_2O$).





LEARNING OUTCOMES:

- PCM Trombe wall can improve indoor overheating in summer, and reduce indoor temperature fluctuations in winter.
- These walls also useful in reducing the building loads and will work for prolonged period.
- PCM Trombe walls will maintain the concept of sustainability and zero energy building.

SOCIAL BENEFITS:

- The PCM-Trombe wall shows higher savings in total energy consumption compared with a conventional Trombe wall.
- The PCM-Trombe wall can improve solar energy gain, daily overall efficiency, and solar transmittance during the heating period.
- Environmental impacts can be reduced if PCMs are applied to Trombe walls.
- The PCM Trombe wall can improve indoor thermal comfort and reduce cooling/heating load in the whole year compared with the traditional Trombe wall.

COMPARISON WITH CONVENTIONAL TROMBE WALL:

CONVENTIONAL TROMBE WALL	MODERN TROMBE WALL
• The walls here were bulky and heavy and covered a large space • This Trombe wall leads to large temperature fluctuations • This Trombe wall may lead to overheating in certain cases • The material used here may get worn out with time which reduces the lifespan of the walls as well	• Because of the use of PCM which are very light in weight, the space occupied by the wall is also less • The material used here is one of the best PCM which will reduce the temperature fluctuations to minimum • This Trombe wall solves the overheating problems as well • The PCM material is long lasting; hence, walls can last up to several years

ADVANTAGES OVER EXISTING TECHNOLOGY:

- The PCM-Trombe wall shows higher savings in total energy consumption compared with a conventional Trombe wall.
- The PCM-Trombe wall can improve solar energy gain, daily overall efficiency, and solar transmittance during the heating period.
- PCM-Trombe walls indicate effective prevention of overheating problems in summer and satisfactory heating effects in winter
- The use of PCMs in the Trombe wall could maintain the indoor thermal comfort for prolonged periods

DISADVANTAGES:

- It can be costly to install Trombe walls.
- It has to be carefully designed.

FUTURE ASPECTS:

Major portion of the total primary energy consumed by today's buildings is used in heating, ventilating, and air-conditioning (HVAC). Conventional heating and cooling systems are having an impact on operational cost, energy requirement and carbon dioxide emission. In this regard, Trombe walls are receiving considerable attention because of their potential ability for addressing the environmental and energy crisis. In order to overcome future environmental challenges, passive, low-cost systems that require almost no energy should be promoted. The PCM Trombe wall discussed over here has a great potential for meeting the steadily increasing energy demands without increasing carbon emissions. PCMs can play a significant role in storing high amounts of energy, which is linked with the latent heat of phase change. To ensure better and more cost-effective PCM performance in Trombe walls and hence energy storage applications, the available information should be consolidated to provide better facilities to end-users. However, future research should focus on techniques to improve and optimize the heat transfer of PCMs and the development of these kind of walls. PCM Trombe walls can provide substantial economic benefits, and their advantages outweigh their few negligible disadvantages.

Simulation results created with Ansys SOFTWARE:

Summer simulation results:

From the simulation results, it could be seen that the indoor air temperature in reference room was 34.04°C in maximal, 31.61°C in minimal, and 32.81°C in average; the indoor air temperature in PCM room was 30.31°C in maximal, 28.90°C in minimal, and 29.56°C in average. The average temperature in PCM room was 3.25°C lower than that in reference room, and overheating had improved. When the room temperature was higher than 30°C, the external PCM began to melt and heat was stored in the PCM to prevent heat from entering the room. When the indoor temperature below 30°C at night, the PCM solidified and released heat. Since the thermal resistance of thermal insulation material was far greater than the thermal resistance of the external layer, the heat stored in the wall was mostly convectively transferred into the air gap and followed the air flow to outdoors. Therefore, the room temperature in PCM room was lower than that in reference room.

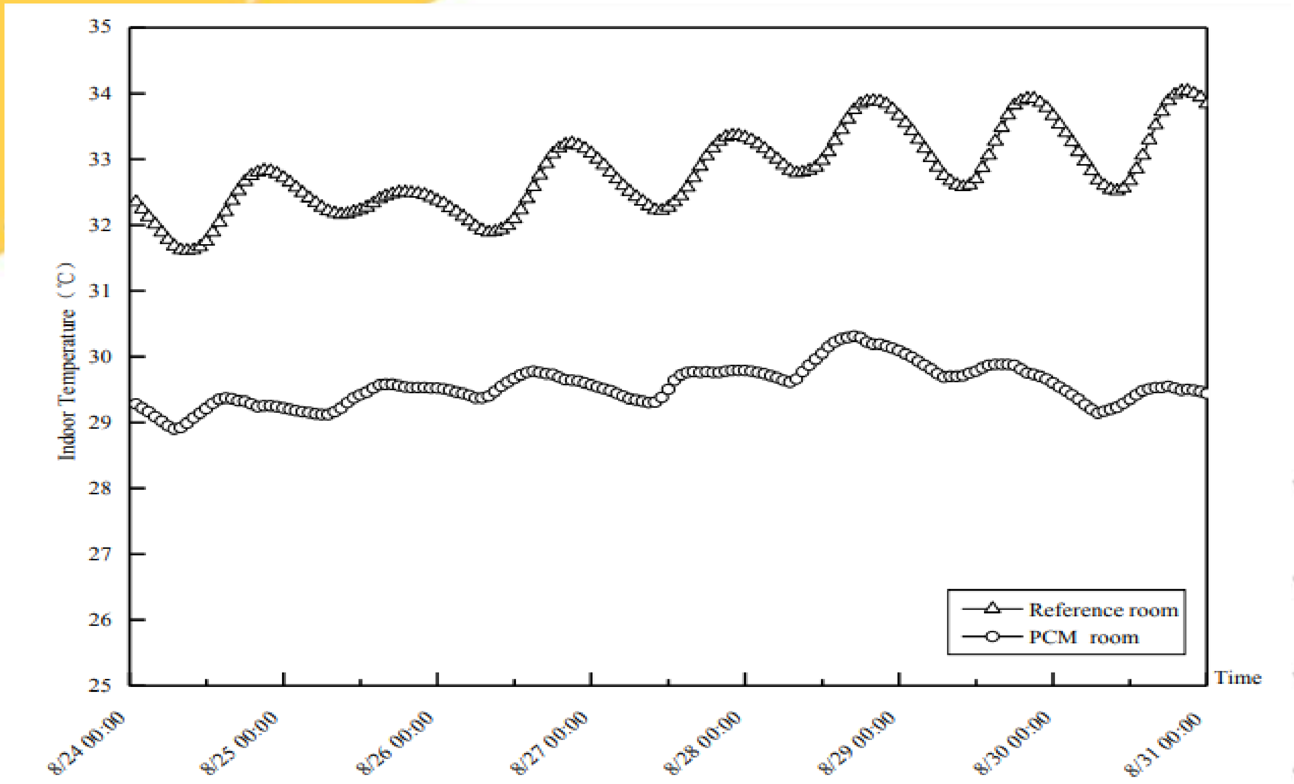


Fig.1- INDOOR TEMPERATURE IN SUMMER

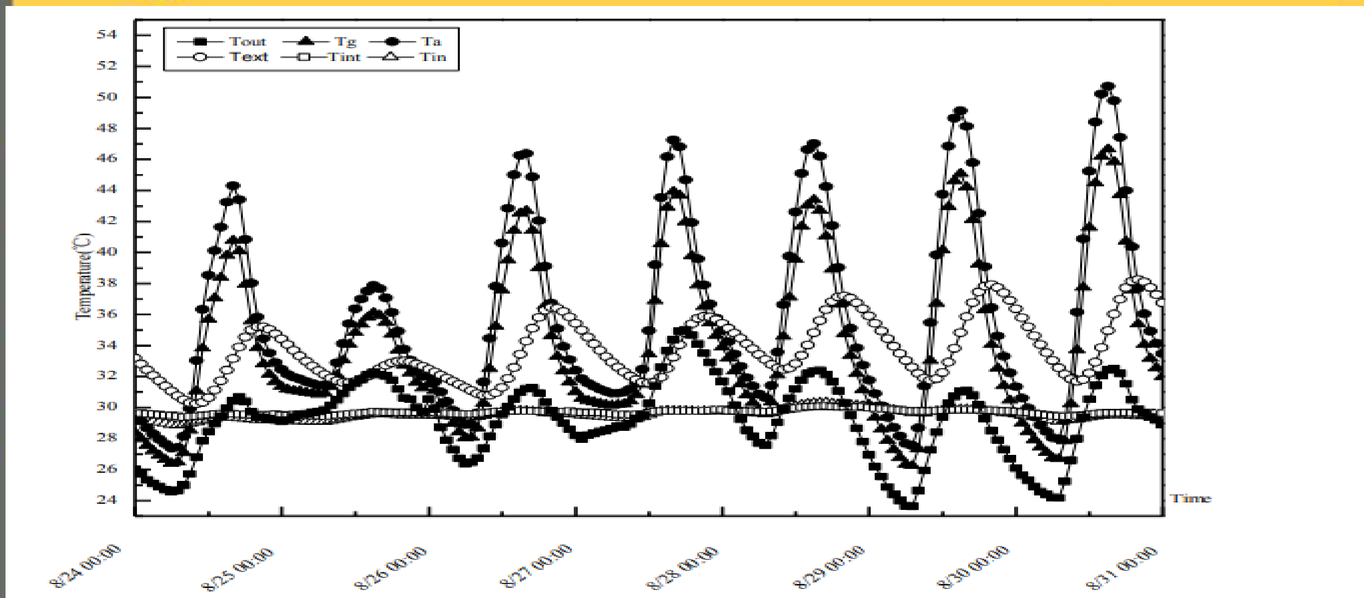
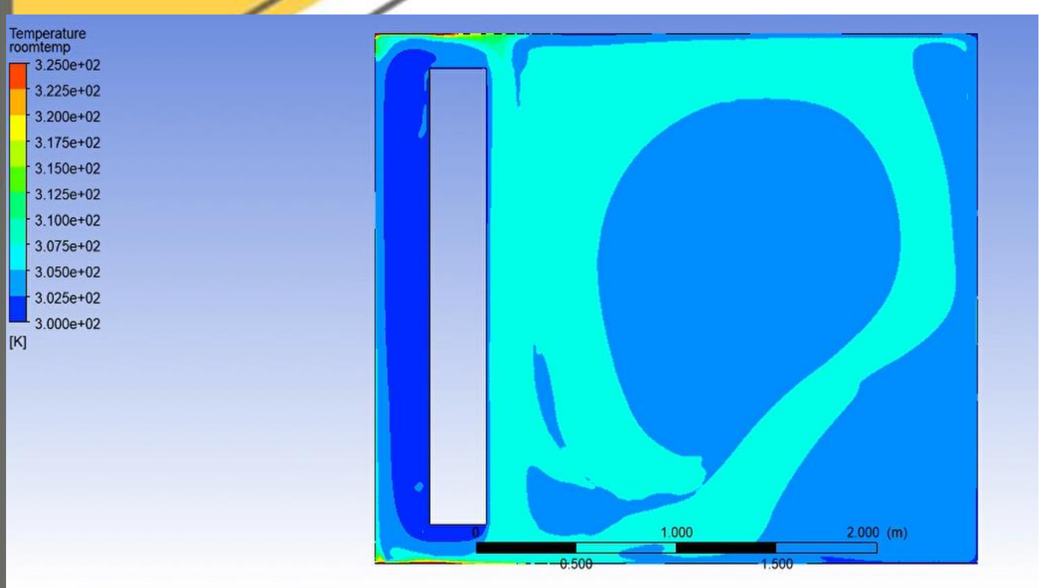
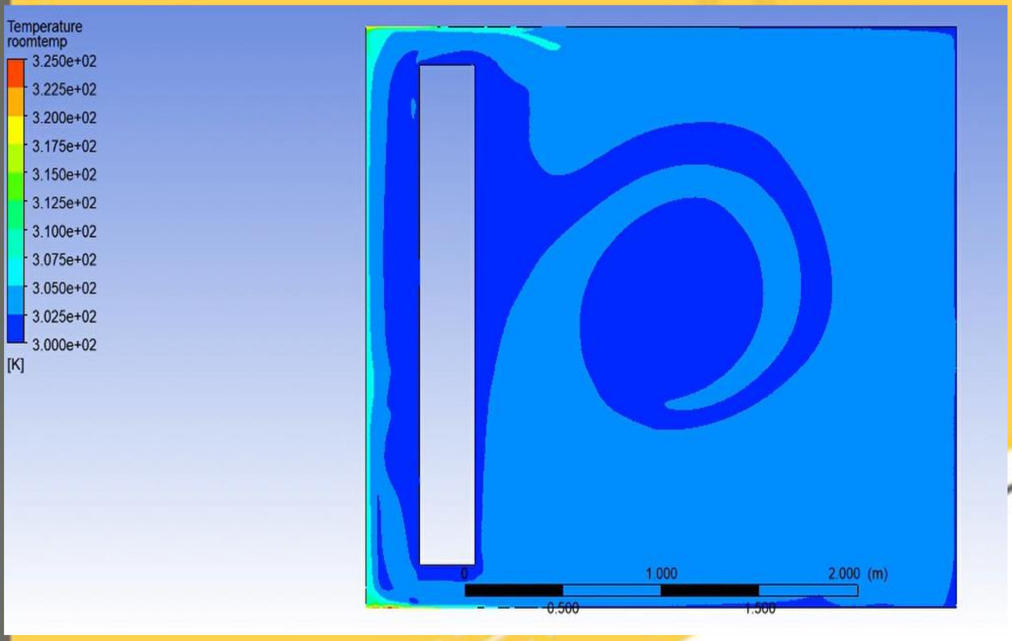


Fig 2:Temperatures in PCM Trome wall in Summer

It could be seen from the figure 2 that the air temperature Ta in the air gap varied the most, followed by the glass temperature Tg and the external pcm layer temperature Text. Ta, Tg and Text were all higher than the outer air gap temperature and had a large fluctuation range. The indoor temperature and insulating wall surface temperature in PCM Trombe room fluctuated around the phase change temperature of 30° C, which was more stable than other temperatures.



Temperature Of room during daytime (12:00 PM)in summer



Temperature Of room during night time (11:00 PM) in summer

Winter simulation results

The phase change temperature of external PCM was 30°C, and the phase change temperature of the inner phase change material was 18°C. From the simulation results, it could be seen that the indoor air temperature in reference room was 24.70°C in maximal, 11.80°C in minimal, and 17.15°C in average. And the indoor air temperature in PCM room was 23.25°C in maximal, 12.15°C in minimal, and 17.09°C in average; The average temperature of PCM room and reference room was basically the same, but the temperature fluctuations in PCM Trombe wall room were obviously smaller than that in reference Trombe wall room.

The air in air gap exchange heat with the indoor air, and the solar radiation obtained in the air gap was all transferred into the room. In the winter, the external PCM was in solid state and was not active. It was mainly caused by the inner PCM. During the day, solar radiation entered the room through the air flow, and the room temperature raised rapidly. When the room temperature was higher than 18°C, the inner PCM began to melt and the excess heat in the room was stored in it. When the solar radiation weakened, the room temperature dropped. And when the temperature was lower than 18°C, the PCM changed from a liquid state to a solid state and released heat. Since there was a thermal insulation layer outside the inner PCM, the thermal resistance of the outward heat transfer was far greater than the inward temperature. Because of this, the heat stored by the PCM was basically all passed into the room. As a result, the room temperature fluctuations in the PCM Trombe wall room were smaller than that in the reference Trombe wall room.

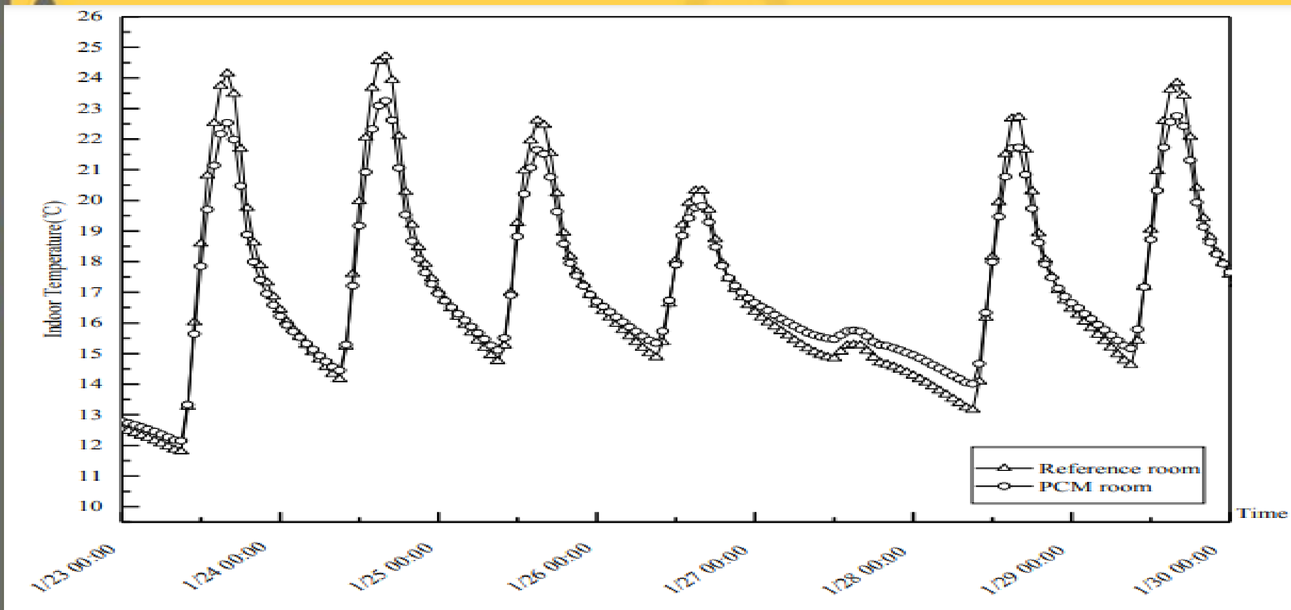


Fig-3: Indoor Temperature in Winter

The temperature comparisons in PCM Trombe wall room shown in Fig.4. It could be seen from the figure that the air temperature Ta in the air gap between the PCM Wall and Insulating wall had the largest variation range, followed by the temperature of the glass Ta and tout (air temperature in the air gap b/w PCM and glazing). Ta, Tg, and Tout were all higher than the outdoor temperature and had a large fluctuation range. The indoor temperature and the wall surface temperature of the room fluctuated around the phase-change temperature of 18° C, which was more stable than other temperatures.

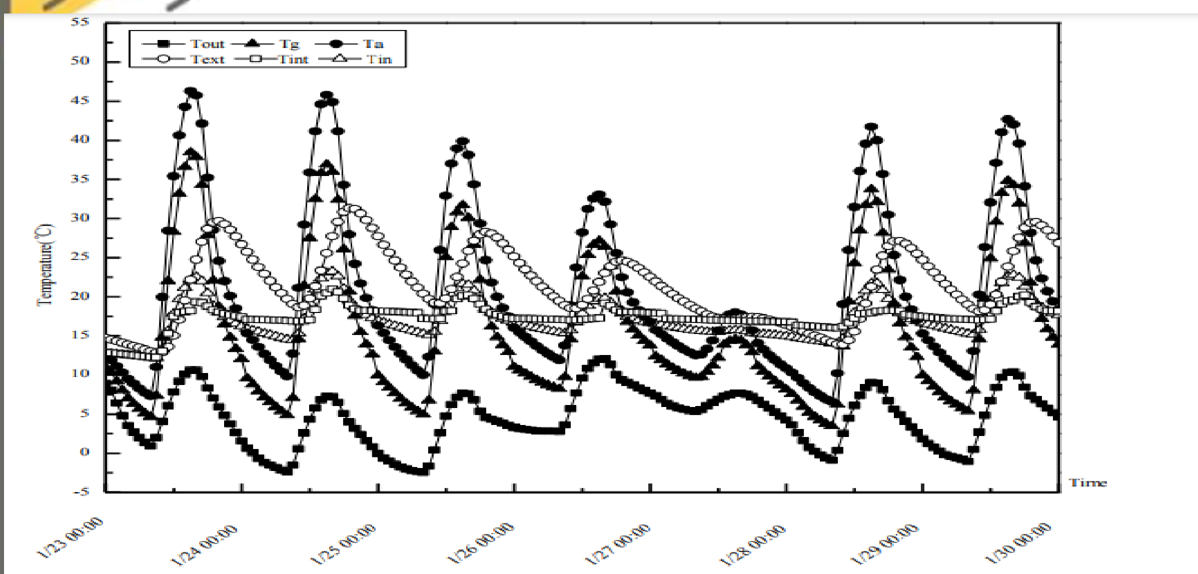
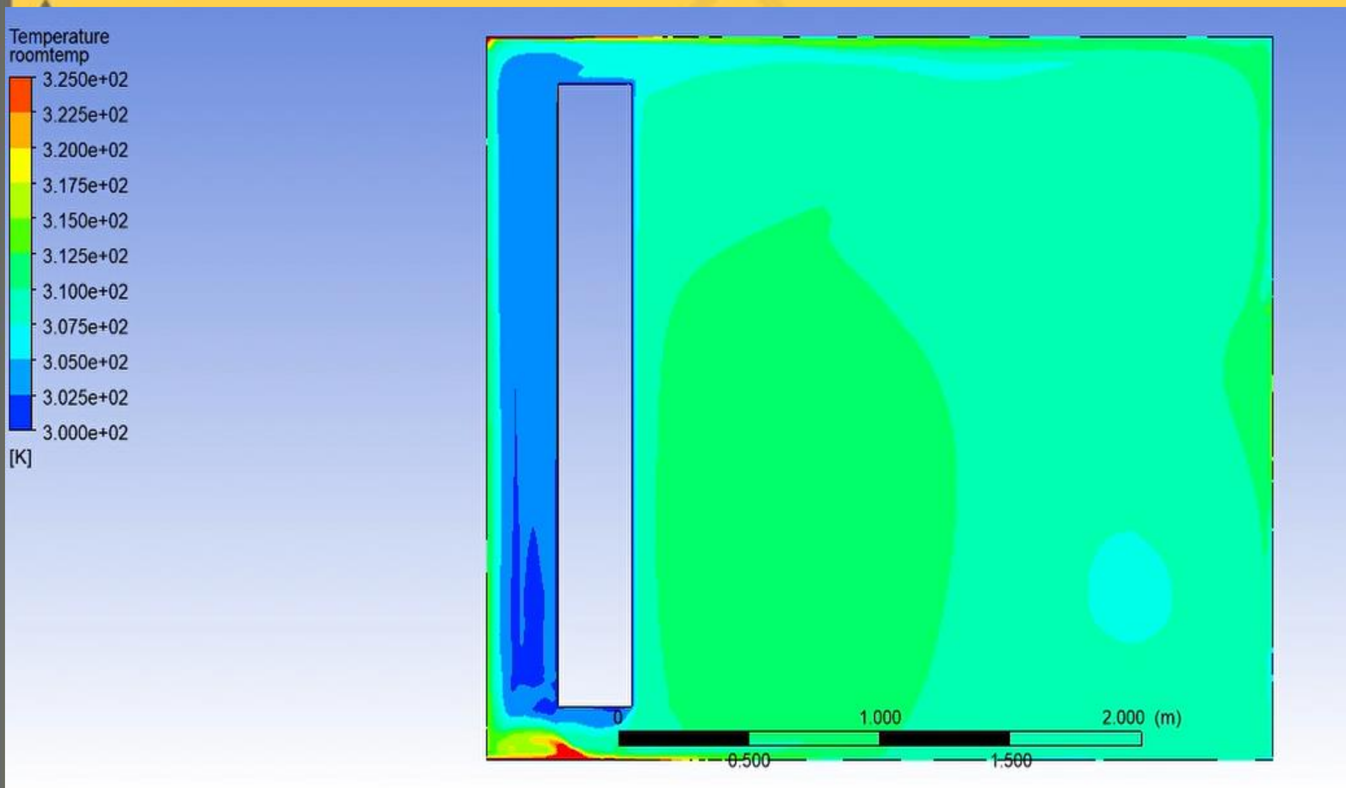
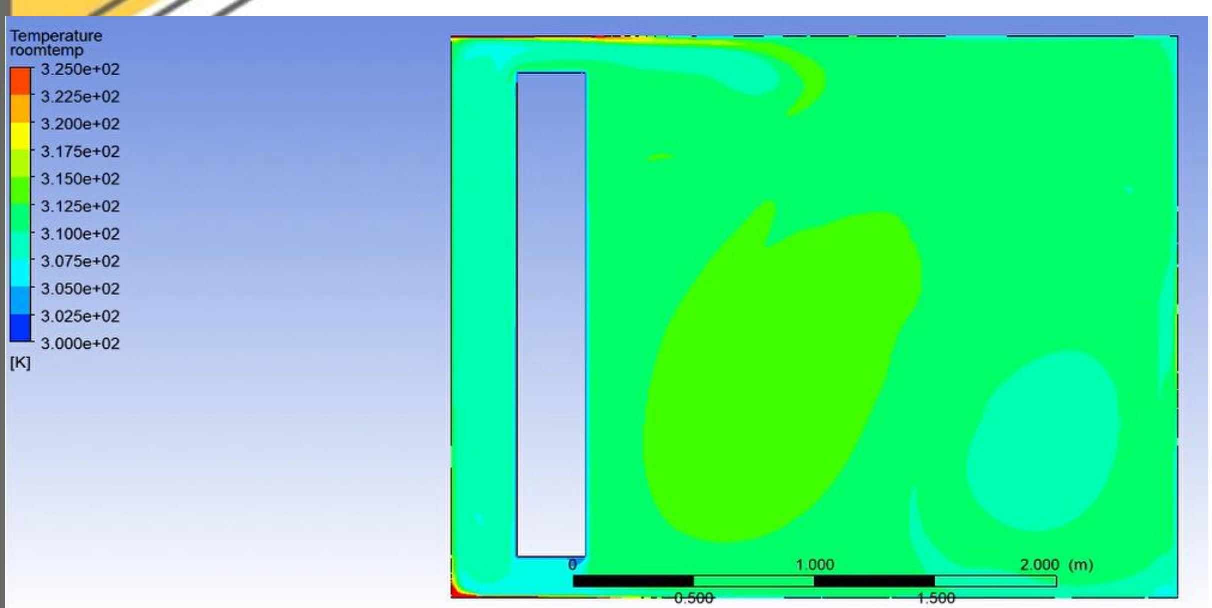


Fig: 4 TEMPERATURES IN PCM TROMBE WALL IN WINTER



Temperature Of room during daytime (12:00 PM) in winters



Temperature Of room during night time (11:00 PM) in winters