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EXPERIMENTAL STUDY ON HEAT TRANSFER PHENOMENON OF A WALL MADE WITH DIFFERENT BRICKS FILLED IN PCM AND OPERATING OUTSIDE TEMPERATURE

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ABSTRACT

Thermal energy storage can be accomplished either by using sensible heat storage or latent heat storage. Sensible heat storage has been used for centuries by builders to store/release passively thermal energy, but a much larger volume of material is required to store the same amount of energy in comparison to latent heat storage. The principle of the phase change material (PCM) use is simple. As the temperature increases, the material changes phase from solid to liquid. The reaction being endothermic, the PCM absorbs heat. Similarly, when the temperature decreases, the material changes phase from liquid to solid.

The reaction being exothermic, the PCM desorbs heat. The integration of PCM in building walls is a way to enhance the storage capacity of building envelop and then to rationalize the use of renewable and non-renewable energies. The integration of PCM in building walls is a way to enhance the storage capacity of building envelop and then to rationalize the use of renewable and non-renewable energies.

Thermal energy storage (TES) systems using phase change material (PCM) have been recognized as one of the most advanced energy technologies in enhancing the energy efficiency and sustainability of buildings.

Keywords: Phase change materials, Sensible and Latent heat, Analysis,

1. INTRODUCTION

The building materials comprise a vast area that itself is significant heat storage and transfer outlet. For this reason, researchers have studied the incorporation of PCM into building construction materials to enhance the thermal properties of the latter.

PCM incorporation into building components like bricks, gypsum boards, concrete, mortars blocks, other materials was extensively studied. PCM can also be incorporated into floors, walls, or ceiling as well.

Phase change material are the material which have property of thermal energy storage, high heat of fusion, melt and solidify at a specific temperature, and are capable of storing and realising thermal energy. Heat energy is absorbed or released when the material change from the solid state to liquid state or vice versa. The heat energy is absorbed during the melting process of phase change material when compared with normal material and a greater amount of energy is absorbed when PCMs melts.

The melting points of PCMs are depending on latent heat of storage of the unique materials. The materials will absorb the heat till it changes its phase. There is a continuation in absorption of heat without a significant rise with temperature until all PCMs materials are transformed to the liquefied phase.

Whenever temperature of the material falls, then the PCMs released the stored latent heat. Growing urbanisation and severe climate change will lead to an increase in the energy consumption of buildings in the near future. According to the International Energy Agency (IEA), over one-third of worldwide final energy consumption and nearly 40% of total direct and indirect CO2 emissions were attributed to the building and construction sector. Indeed, modern lightweight buildings have lower thermal inertia than conventional heavyweight buildings, resulting in high energy consumption and large fluctuations in indoor air temperature.

Today, energy saving is one of the most serious challenges of sustainable development. Hence, integration of energy efficiency measurements and improvement of the energy performance of the building envelope is essential to reduce energy consumption. Innovative technologies such as thermal energy storage (TES) can reduce the peak demand and improve thermal comfort.

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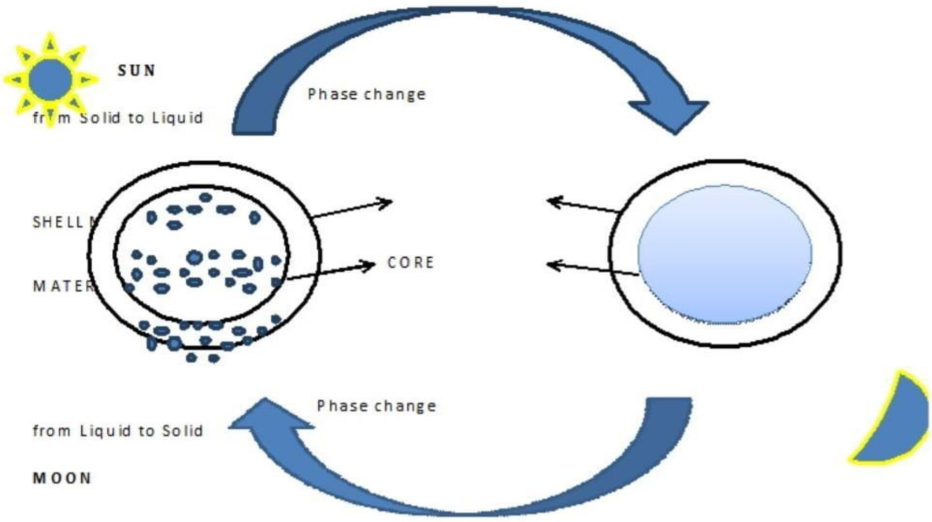

2. METHODOLOGY

- Problems were identified through literature study.
- Design, construction and development of climate test apparatus were carried out with appropriate measuring instrument
- Appropriate building materials were selected and their thermo-physical properties were found.
- Walls were constructed with building materials has 0.36 m^2 surface area .
- Heat transfer performance of building wall with different building materials was studied using climate test apparatus.
- PCMs were mixed with concrete.
- Experiment results of cement hollow bricks and red clay bricks wall were compared.
- All the results of different materials were compared and conclusions were made.

2.1 Components used

1. Phase change material
2. Cement hollow bricks (M1)
3. Red clay bricks (M2)
4. Bundle of Thermocouple
5. Temperature indicator.

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2.2 Sodium thiosulphate

Temperature sensor (Sl. no: 8830)	Name	Pt 100
	Type	2 wire type
	Make	ACE Instruments
	Accuracy	±0.1 ˚C
	Ammeter	0-99.9 A

Temperature Indicator

PCM name	Melting Point (°C)	Latent Heat (kJ\kg)	Density (kg\m3)	Specific Heat (kJ\kg.K)	Thermal Conductivity (W/mK)
Sodium thiosulphate	36-48	201	1670	4.18	0.6035-
pentahydrate					0.7718

PCM Properties

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3. MODELING AND ANALYSIS

Figure 1: Experimental setup.

Wall 1 (Cement Hollow Bricks without PCM)

In this wall, consists of a cement hollow brick with cement concrete plaster only. The wall measurement is 60cm height and length. The thickness of the wall is 10cm. A single cement hollow brick measurement is 20×40 ×10 cm

Wall 2 (Cement Hollow Bricks With PCM)

In this wall consists of a cement hollow brick and Pcm mixed cement concrete plaster. The wall measurement is 60 cm height and length. The thickness of the wall is 10cm. A single cement hollow brick measurement is 20×40 ×10 cm

Wall 3 (Red Clay Bricks without PCM)

In this wall, consists of a red clay brick with cement concrete plaster only. The wall measurement is 60cm height and length. The thickness of the wall is 10cm. A single red clay brick measurement is 20×10 ×10 cm

Wall 4 (Red Clay Bricks with PCM)

In this wall, consists of a red clay brick and Pcm mixed cement concrete plaster The wall measurement is 60cm height and length. The thickness of the wall is 10cm. A single red clay brick measurement is 20×10 ×10 cm

4. RESULTS AND DISCUSSION-TEMPERATURE OBSERVATION

DAY 1

SL NO.	TIME	WALL 1^0C		WALL 2 ^{0}C		WALL 3 ^{0}C		WALL 4 ^{0}C	
		T1	T2	T3	T4	T5	T_6	T_7	T_8
1	10.30	27	26	27	25	27	25	27	24
2	11.30	28	27	28	25.7	28	26.7	28	25
3	12.30	30	29.2	30	27	30	28	30	26
4	1.30	31	30	31	29	31	29	31	28.2
5	2.30	30.5	29.7	30	27.6	30	28.1	30	26.2
6	3.30	30	29	30	27.3	30	28.2	30	26.4

DAY 2

SL NO.	TIME	WALL 1 ^{0}C		WALL 2 ^{0}C		WALL 3 ^{0}C		WALL 4 ^{0}C	
		T1	**T2**	**T3**	**T4**	**T5**	**T6**	**T_7**	**T8**
1	10.30	28	27	28	26.2	28	26	28	25
2	11.30	30	29	30	27.5	30	27.2	30	26.4
3	12.30	31	29.4	31	29.3	31	29	31	26.7
4	1.30	32	31	32	30.1	32	30	32	28
5	2.30	32	31.2	32	30.4	32	29.4	32	28.5
6	3.30	31	30	31	29	31	29.3	31	26.7

DAY 3

SL NO.	TIME	WALL 1 ⁰C		WALL 2 ⁰C		WALL 3 ⁰C		WALL 4 ⁰C	
		T1	T2	T3	T4	T5	T6	T_7	T8
1	10.30	27	26	27	25	27	25	27	24
2	11.30	28	27	28	25.7	28	26.7	28	25
3	12.30	30	29.2	30	27	30	28	30	26
4	1.30	31	30	31	29	31	29	31	28.2
5	2.30	30.5	29.7	30	27.6	30	28.1	30	26.2
6	3.30	30	29	30	27.3	30	28.2	30	26.4

DAY 4

SL NO.	TIME	WALL 1 ⁰C		WALL 2 ⁰C		WALL 3 ⁰C		WALL 4 ⁰C	
		T1	T2	T3	T4	T5	T6	T_7	T8
1	10.30	29	28	29	27.8	29	27	29	26
2	11.30	30	29	30	28	30	28	30	26.4
3	12.30	31	30	31	29	31	29	31	28.5
4	1.30	32	31	32	30.2	32	30.2	32	29
5	2.30	33	32	33	31.4	33	31.5	33	29
6	3.30	32	30	32	30.3	32	30.2	32	29

DAY 5

SL NO.	TIME	WALL 1 ⁰C		WALL 2 ⁰C		WALL 3 ⁰C		WALL 4 ⁰C	
		T1	T2	T3	T4	T5	T6	T_7	T8
1	10.30	30	29	30	28.2	30	28	30	27
2	11.30	31	30	31	29	31	29	31	28
3	12.30	32	31	32	30.4	32	30	32	28.4
4	1.30	32	31	32	30.5	32	30.7	32	28.7
5	2.30	33	32	33	31.3	33	31.4	33	29
6	3.30	33	30	33	31	33	31.2	33	28

5. CALCULATION AND GRAPH

FORMULA

Thermal resistivity (R) =L ÷ K A

Heat transfer (Q) = ▲T/ R

L_1 = Thickness of cement hollow brick (10 cm) L_2 = Thickness of red clay brick (10 cm)K_1 = Thermal conductivity of cement hollow brick K_2 = Thermal conductivity of red clay brickK_3 = Thermal conductivity of sodium thiosulphateT_1 = Wall 1 Outside temperatureT_2 = Wall 1 Inside temperature T_3 = Wall 2 Outside temperature T_4 = Wall 2 Inside temperature T_5 = Wall 3 Outside temperature T_6 = Wall 3 Inside temperature T_7 = Wall 4 Outside temperature T_8 = Wall 4 Inside temperature Wall 1 (Cement Hollow Bricks without PCM) Wall 2 (Cement Hollow Bricks With PCM) Wall 3 (Red Clay Bricks without PCM) Wall 4 (Red Clay Bricks with PCM)

WALL 1 Cement Hollow Bricks without PCM

$T_1 = 31^0C$ $T_2 = 30^0C$ L = 10 cm = 0.1m

R = 1 ÷ (25 × 0.1) = 0.1 ÷ (0.4×0.36) = 0.69 K/W

Q = 1/0.69 = 1.44 W

WALL 2 Cement Hollow Bricks With PCM

$T_3 = 32\ ^0C$ $T_4 = 30\ ^0C$

R = (0.1÷ (0.4×0.36)) + (0.1/(0.77×0.36)) = 0.69+0.36 = 1.05 K/W

Q = 1/1.05 = 0.91 W

Wall 3 Red Clay Bricks without PCM

$T_5 = 32\ ^0C$ $T_6 = 30\ ^0C$

R = 0.1/(0.5*0.36) = 0.55 K/W

Q = 2/0.55 = 3.6 W

Wall 4 Red Clay Bricks with PCM

$T_7 = 32^0C$ $T_8 = 28\ ^0C$ $K_3 = 0.77$

R = (0.1/(0.5*0.36)) + (0.1/(0.77*0.36) = 0.91

Q = 2/0.91 = 2.19 W

GRAPH FOR HEAT TRANSFER AND RESISTIVITY :

6. CONCLUSION

All of the PCM have a good potential for reducing cooling loads by enhancing the storage capacity of the building envelop. However, this storage capacity can be enhanced with an increase of the PCMIBW thermal conductivity.

The major conclusions of this study are listed below

- Sodium thiosulphate has more heat storage capacity than the surrounding air.
- The core material of phase change material which was incorporated in between wall was efficiently working and there is drop in temperature maximum around 3^0C to 5^0C. This helps us to reducing the utilization of air conditioning system.
- Using air conditioners and electric fans to stay cool accounts for nearly 20% of the total electricity used in buildings around the world today. Therefore, by using PCM nearly 20% of electricity can be saved.
- The PCMs work is more effective in summer conditions.

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