Increasing the Thermal Insulating Properties of Cement Plaster Using Conventional Materials to Make Energy Efficient Buildings

[1]Sheikh Mohd Aarif, [2]Er A.A Masoodi, [3]Mohd Shoeb Alam
[1]M.Tech Scholar, [2]Associate Professor, [3]Assistant Professor
[1]Department of Civil Engineering,
[1]Al-Falah University, Faridabad, India

Abstract: Nowadays buildings are the largest consumer of energy because the cement plaster we use has low thermal insulation which leads to consumption of a lot of energy to keep the interiors of the building thermally comfortable. In the areas where the severe temperature fluctuations occur, a lot of energy is consumed in the form of fossil fuels, air conditioners, and other heating and cooling devices to keep the internal environment comfortable. So one of the best ways to reduce the energy demands in buildings is to reduce heat losses through the envelope. Thermal insulating plasters are the important means to face the energy efficiency issues in buildings. Use of Nano technology or aerogel based plasters and phase change material based plasters make a significant contribution to this field, reaching higher level of thermal performance inside the buildings. But these plasters are uneconomical and their cost is approximately 20 times higher than the conventional cement plaster. Thus new plaster solutions have to answer certain specific economical and technical needs to meet the market demand. The present research is an attempt to improve the thermal insulation of conventional cement plaster using conventional materials viz. polystyrene, polymer polypropylene, heated white clay, which otherwise are the wastes with almost zero scrap value. Experimental work was carried out and it was observed that by the addition of these materials the thermal conductivity dropped, making thermally efficient plasters able to meet real market and end users-demand. The present work describes the results of research that is oriented towards the development of low cost thermal insulating plasters by incorporating the conventional materials, which can be mainly due to the blocking of the path of heat transfer either by creating a porous structure as in case of polystyrene and heated clay or by preventing the direct grain to grain contact by incorporating material within the mix possessing high thermal insulation as in case of polymer polypropylene. In this attempt, different samples were prepared by incorporating different proportions. Results showed that thermal conductivity decreased by 84.4%, 58.0%, 92.2% for polystyrene based cement plaster, polypropylene based cement plaster, and heated clay based cement plaster as compared with conventional cement plaster.

Index Terms – Thermal insulating plaster, Polystyrene, Heated white clay, polypropylene, thermal conductivity.

I. INTRODUCTION

Buildings are one of the leading sectors in the energy consumption throughout the world especially in developed countries. The building sector consumes around 40% of the total fossil energy and produces nearly 40% of the total carbon dioxide emissions which are very harmful for existence. It is due to the increase in the living standard and in occupants comfort demands, mainly for heating and cooling. So improving the energy efficiency of buildings will have a significant benefit for energy-saving and emission-reduction on the earth. Nowadays the trend in the commercial buildings is to decrease the wall thickness to reduce the materials consumed, the transport costs, and the construction time. The main disadvantage of these lightweight buildings is the low thermal mass, resulting in large temperature fluctuations through the building envelope. The key to an effective thermal barrier is proper installation of quality insulation products. A house should have a continuous layer of insulation around the entire building envelope. Studies show that improper installation can cut performance by 20% or more. While some types of insulation reduce air leakage, most do not, so always follow the guidelines to limit the air leakage potential as much as possible. Thermal insulating plasters are an important means to tackle the energy efficiency issues in building field. Use of nanotechnology or aerogel based plasters, could make a significant contribution to this field, reaching higher levels of thermal performance. Efficient thermal insulation in buildings helps to reduce the size of heating and cooling systems and the annual energy consumption. The project is being carried out to meet the energy crisis by providing plasters with high thermal insulation, by the use of green conventional materials leading to an efficient and economical way of tackling with the energy issues in the building sector faced throughout the world. The application of the new solutions can be therefore a useful tool not only for new constructions but also for the refurbishment of existing buildings, in order to reduce the heat losses of the envelop. The research aims to improve the insulation performance and decrease the cost of insulation methods which are in use in the current date.
The various types plasters used are:

- Cement plaster
- Gypsum plaster
- Mud plaster

- Lime plaster

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II. MATERIALS AND METHODS

2.1 Materials used and tests

The various materials used include

- Cement
- Sand
- Polystyrene
- Polypropylene
- Heated white clay

The test results on cement and sand are shown in table 1.

Table1. Properties of cement and sand

Material	Test property	Result	Specified limit	Specification
Cement	Consistency	31%	30-35%	IS 4031:1988
	Initial setting time	41 min	Not less than 30 min	
	Final setting time	506 min	Not less than 600 min	
	Specific gravity	3.15	3.10-3.15	
Sand	Fineness modulus	2.90	Grading zone iii	IS2386:1963
	Specific gravity	2.64	2.6-2.8	

2.2 Methodology

The percentage of different components is enlisted in the following tables:

Table 2: details of polystyrene based plaster

	Polystyrene %	Cement sand ratio
Sample 1	20%	1:4
Sample 2	25%	1:4
Sample 3	30%	1:4
Sample 4	35%	1:4
Sample 5	40%	1:4

Table 3: Details of polypropylene based plaster

	Polypropylene %age (by weight)	**Cement sand ratio**
Sample 1	0.25%	1:4
Sample 2	0.5%	1:4
Sample 3	1.0%	1:4
Sample 4	1.5%	1:4

Table 4: Details of heated clay based cement plaster

	Heated clay %	Sand %	Cement sand ratio	Polymer polypropylene %
Sample 1	50%	50%	1:4	0.5%
Sample 2	50%	50%	1:4	1.0%
Sample 3	75%	25%	1:4	0.5%
Sample 4	75%	25%	1:4	1.0%

III. RESULTS AND DISCUSSIONS

The main aim of the project was to observe the relative variation in the thermal conductivity and other properties including compressive strength, tensile strength and water absorption between the conventional cement plaster and the modified cement plasters. The cement sand mix used throughout the work was 1:4. Different tests were performed on conventional cement plaster and results obtained are shown in following tables and figures:

Table5. Properties of conventional plaster

Material	Property	Result
Conventional plaster	Thermal conductivity	0.70 W/mK
	Compressive strength	13.5Mpa
	Tensile strength	2.57Mpa
	Water absorption	16%
	Density	1.90 g/cm^3

Table 6: Results of polystyrene based plaster

Samples	Polystyrene ratio %	Density (g/cm3)	Thermal conductivity (w/mk)	Compressive strength (m/pa)	Tensile strength (m/pa)	Water absorption (%)
Sample 1	20%	1.20	0.351	3.50	1.30	44.00
Sample 2	25%	1.14	0.263	3.10	1.23	42.00
Sample 3	30%	1.11	0.220	2.90	1.20	41.30
Sample 4	35%	1.05	0.195	2.30	1.06	40.00
Sample 5	40%	1.00	0.180	2.10	1.01	38.40

Table 7: Results of polypropylene based plaster

Samples	Polypropylene%	Density (g/cm^3)	Thermal conductivity (w/mk)	Compressive strength (m/pa)	Tensile strength (m/pa)	Water absorption (%)
Sample 1	0.25%	2.30	0.464	12.50	2.47	5.80
Sample 2	0.50%	2.10	0.422	13.24	2.54	6.30
Sample 3	1.0%	1.90	0.330	14.52	2.66	5.40
Sample 4	1.5%	1.80	0.294	13.82	2.60	7.30

Table 8: Results of heated white clay based plaster

Samples	Heated clay	Polypropylene %age	Thermal conductivity (W/mk)	Compressive strength (Mpa)	Tensile strength (Mpa)	Water absorption (%)	Density (g/cm^3)
Sample 1	50%	0.5%	0.096	6.95	1.84	13.37	1.71
Sample 2	50%	1.0%	0.092	9.00	2.10	11.84	1.74
Sample 3	75%	0.5%	0.060	6.00	1.71	19.29	1.64
Sample 4	75%	1.0%	0.054	7.38	1.90	17.20	1.67

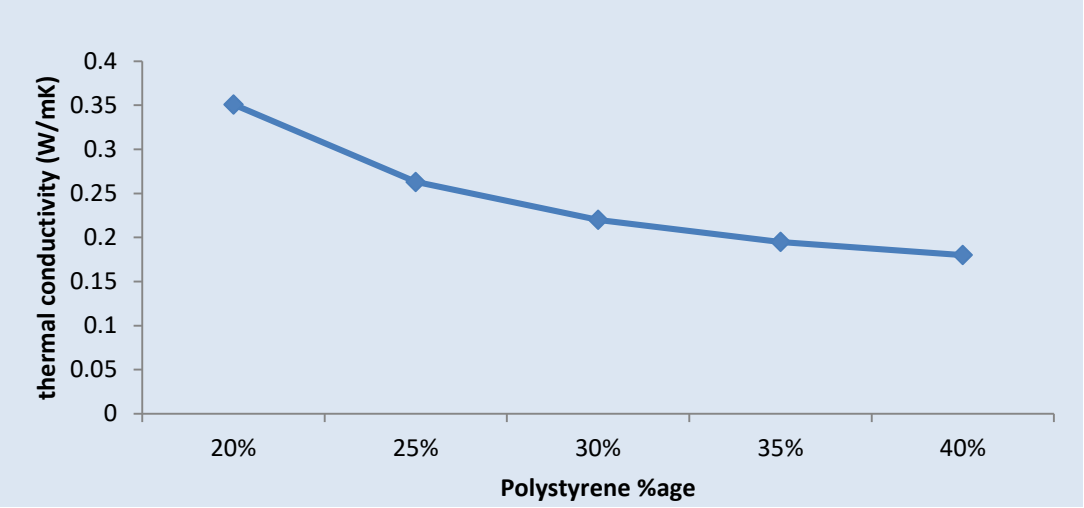

Figure 1.Thermal conductivity variation with polystyrene

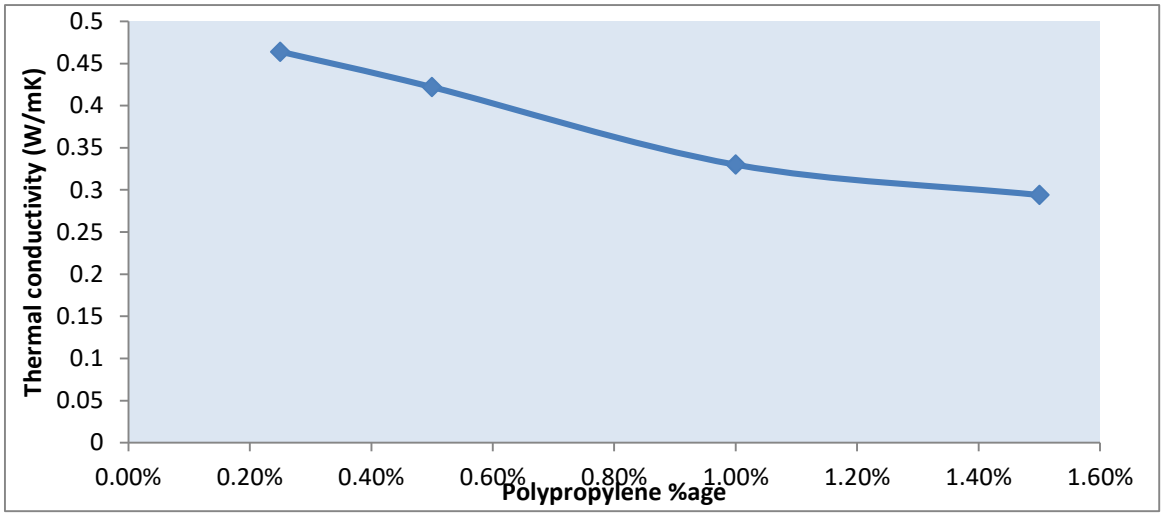

Figure2. Thermal conductivity variation with polypropylene

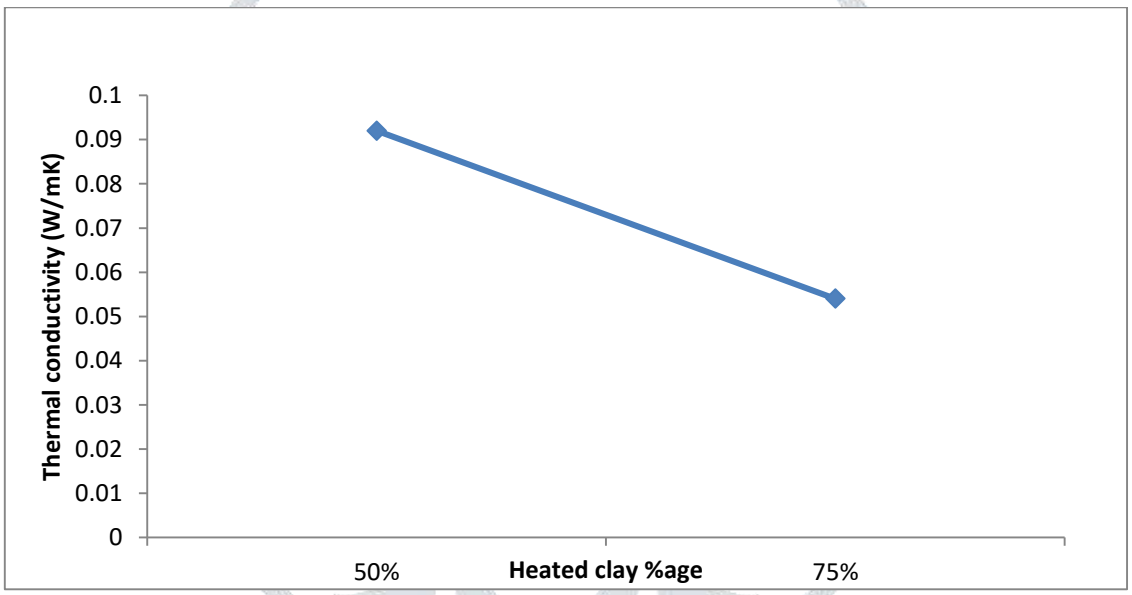

Figure3. Variation of thermal conductivity with heated clay at 1% polypropylene

IV. CONCLUSION

The following results can be concluded based on this experimental study:

- The samples incorporated with different percentages of heated clay showed reduction in thermal conductivity value. A huge reduction of 92.2% in thermal conductivity was observed for 75% heated clay based cement plaster. The strength of the sample was also found to be 7.38Mpa, which is satisfactory for the plaster work. Thus the development and large scale production of heated clay based plasters can improve the spread of new and innovative plasters, also acting sensibly in terms of economy.

- The samples incorporated with different percentages of polystyrene also showed reduction in thermal conductivity value. A large reduction in thermal conductivity by 74.3% was observed for 40% polystyrene based cement plaster.
- In thermal conductivity test, result indicated that samples incorporated with different percentages of polypropylene showed reduction in thermal conductivity value. A significant reduction in thermal conductivity by 58% was observed for 1.5% polystyrene based cement plaster. Moreover there was an adequate increase in the compressive strength at 1% polymer propylene.

- The size of heating and cooling systems can be reduced and thus the annual energy consumption of majority buildings can be brought to a high standard of sustainability by using these thermal efficient plasters.
- Thus environment can be made sustainable by decreasing the emission of CO_2 due to excessive use of fossil fuels and air conditioning devices.

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