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An Experimental study related to affect of different Thermal Insulation Materials on Cement Concrete

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Abstract - *The heat loss across the concrete roof, floor or wall increase the heating or cooling load and hence the energy requirement during winter and summer respectively. However the thermal conductivity of the cement concrete can be reduced by adding the thermal insulation materials within the cement concrete mixture itself; thereby providing better thermal insulation across the building components from the surrounding atmosphere without any considerable reduction in the reliability of the building elements i.e. without any reduction load bearing capacity of the building components .*

Keywords *- Thermal insulation, K factor, Strength, Cement, Water, Sand, Aggregate, Human Hair, Glass Powder, Cotton*

I. INTRODUCTION

The K Factor of Insulation

The K factor of insulation represents the material's thermal conductivity or ability to conduct heat. Usually, insulation materials have a K Factor of less than one. The lower the K factor, the better the insulation. "The time rate of steady heat flow through a unit area of homogeneous material induced by a unit temperature gradient in a direction perpendicular to that unit area."

$Q= k\times A\times(dT/dx)$

There are plenty of cheap and common insulation materials available in the market today. Each of these insulations have their own ups and downs. As a result, when deciding which insulation material to use we should be sure to be aware of which material would work the best in our situation.

II. LITERATURE SURVEHY

Dale P. Bentz, Edward et al. [1] titled as "Effects of cement particle size distribution on performance properties of Portland cement-based materials." done experiment & simulation analysis, they explain the effects of cement particle size distribution on a variety of performance properties are explored via computer simulation & a few experimental studies. Properties examined in modify evolution, & interfacial transition zone microstructure. The computer simulation are conducted using two cement particle size distributions that bound those commonly in use today & three different water-to-cement ratios: 0.5, 0.3 & 0.246. For lower water-t-cement ratio systems, the use of coarser cements may offer equivalent or superior performance, as well as reducing production costs for manufacturer.

Dr S L Patil, J N Kale, S Suman Fly et al. [2] "Fly Ash Concrete: A Technical Analysis For Compressive Strength" done experiment studies. Ash, a waste generated by thermal power plants is as such a big environmental concern. The investigation reported in them paper is carried out to study the utilization of fly ash in cement concrete as a partial replacement of cement as well as an additive so as to provide an environmentally consistent way of its disposal and reuse. This work is a case study for Deep Nagar thermal power plant of Jalgaon District in MS. The cement in concrete matrix is replaced from 5% to 25% by step in steps of 5%. It is observed that replacement of cement in any proportion lowers the compressive strength of concrete as well as delays its hardening. This provides an environmental friendly method of Deep Nagar fly ash disposal.

III. MATERIAL USED FOR ANALYSIS

1. Glass powder

Glass powder is the most common insulation used in modern times. Because of how it is made, by effectively weaving fine strands of glass into an insulation material, Glass powder is able to minimize heat transfer

Glass powder is an excellent non-flammable insulation material, with R-values ranging from R-2.9 to R-3.8 per inch. If we are seeking a cheap insulation this is definitely the way to go, though installing it requires safety precautions. It is mandatory to use eye protection, masks, and gloves when handling this product.

"Figure 1: Glass powder"

2. Cellulose (Cotton)

Cellulose insulation is perhaps one of the most eco-friendly forms of insulation. Cellulose is made from recycled cardboard, paper, and other similar materials and comes in loose form. Cellulose has an R-value between R-3.1 and R-3.7. Some recent studies on cellulose have shown that it might be an excellent product for use in minimizing fire damage. Because of the compactness of the material, cellulose contains next to no oxygen within it. It is also one of the most fire resistant forms of insulation. However, there are certain downsides to this material as well, such as the allergies that some people may have to newspaper dust. Also, finding individuals skilled in using this type of insulation is relatively hard compared to, say, glass powders. Still, cellulose is a cheap and effective means of insulating.

"Figure 2: Cotton"

3. Human Hair: A lock of 100 hairs can withstand 12 tons, if the scalp were strong enough.

"Figure 3: Human Hair"

IV. MAKING OF CEMENT CONCRETE BLOCKS

We compared first without using any external insulating content in concrete blocks & second time we used different insulating material. Both are analysed & compared it's both properties.

STEPS ARE

PROCESS 1: For concrete blocks (without any external insulating content)

"Figure 4: Without using any insulating material"

content of mixing elements for making 3 blocks :
Cement: 4.172 kg
Aggregate: 14.584 kg
Sand: 6.772 kg
Water: 1.8 litres
Ratio of cement/water: 2.267

applying grease film on inner surfaces of the mould

filling the prepared mixture in the moulds

For proper settling of mixture in the mould

Storing the blocks in water reservoir for period of 14 days

Drying the blocks after removing them from water for 24 hours

PROCESS 2: For concrete blocks with glass powder

"Figure 5: Composition of cement concrete mixture after adding glass powder"

Proportion of glass powder:
5% of cement= 228 g/3 blocks
Cement and glass mixture = 4.9 kg
Sand=8.272 kg
Aggregate=16 kg
Water proportion = (mass of cement-glass mixture)/ratio of cement to water
= 2.19 liters

PROCESS 3: For concrete blocks with human hair

"Figure 6: Composition of cement concrete mixture after adding human hair"

Proportion of Human hair: 5% of cement= 228 g/3 blocks
Cement and hair mixture = 4.9 kg
Sand=8.272 kg
Aggregate=16 kg
Water proportion = (mass of cement-hair mixture)/ratio of cement to water
= 2.19 liters

Note: The proportion of cement and water has been maintained constant throughout for all the material blocks. The composition of concrete block with 5% cotton as additive has been kept same as that of the human hair blocks .The compression test of 1 block of each material additive was conducted on compression testing machine at structural department, B.V.M Engineering College. Further the rest of the 2 blocks of each material additive was taken for the thermal conductivity analysis on the experimental setup prepared by us.

V. COMPRESSIVE ANALYSIS OF CONCRETE BLOCKS

The compression test of the plain and insulated concrete blocks was conducted in order to check the effect on compressive load bearing capacity of plain concrete block after addition of the different thermal insulation additives in it.

1) For plain block
Mass of block: 8.631 kg
Maximum compressive load sustained by the block
(Fracture load): 132 t
2) For glass powder block
Mass of block: 8.631 kg
Maximum compressive load sustained by the block
(Fracture load): 118 t
3) For human hair added block
Mass of block: 8.631 kg
Maximum compressive load sustained by the block
(Fracture load): 80 t
4) For cotton added block
Mass of block: 8.631 kg
Maximum compressive load sustained by the block
(Fracture load): 108 T

VI. THERMAL ANALYSIS WITH EXPERIMENTAL SETUP

"Figure 7: putting heater between two blocks"

"Figure 8: putting j-type thrmocouple at outer surface"

"Figure 9: covered with insulating material"

NOTE: All the steps mentioned are performed for each of the test specimen with different thermal insulation additive.

OBSERVATIONS AND RESULTS

Table 1: Simple blocks

SR NO	TIME	INNER TEMP	OUTER TEMP
1	11:30	110	29
2	12:30	110	30
3	1:00	110	34
4	1:30	110	37
5	2:00	110	41
6	2:30	110	44
7	3:00	110	45
8	3:30	110	47
9	4:00	110	49
10	4:30	110	50
11	5:00	110	51
12	5:30	110	51
13	6:00	110	51

Table 2: Blocks with glass powder

SR NO	TIME	INNER TEMP	OUTER TEMP
1	11:30	110	37
2	12:30	110	36
3	1:00	110	38
4	1:30	110	39
5	2:00	110	42
6	2:30	110	44
7	3:00	110	45
8	3:30	110	45
9	4:00	110	46
10	4:30	110	46
11	5:00	110	47
12	5:30	110	48
13	6:00	110	48

Table 3: Blocks with human hair

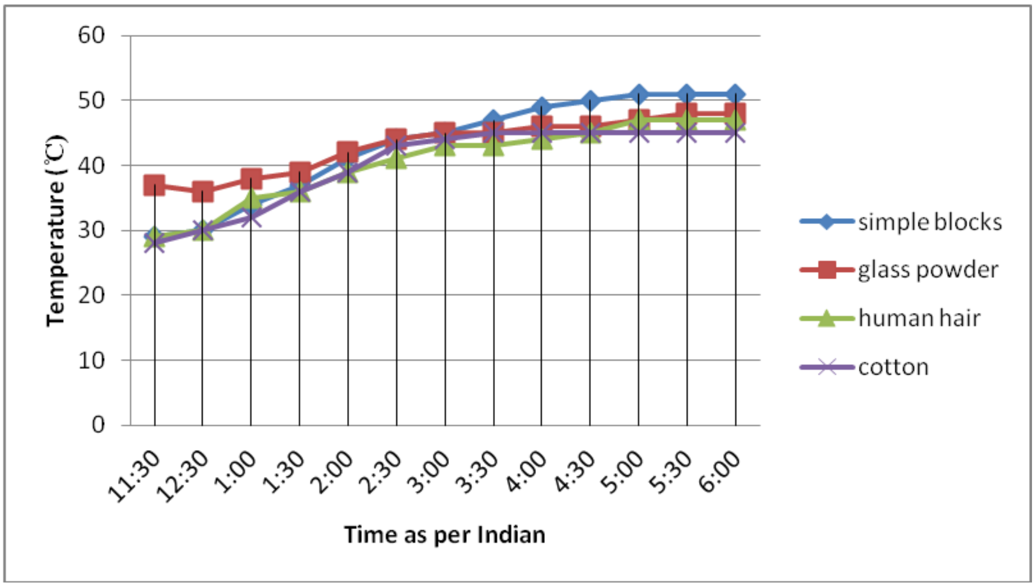
NO	TIME	INNER TEMP	OUTER TEMP
1	11:30	110	29
2	12:30	110	30
3	1:00	110	35
4	1:30	110	36
5	2:00	110	39
6	2:30	110	41
7	3:00	110	43
8	3:30	110	43
9	4:00	110	44
10	4:30	110	45
11	5:00	110	47
12	5:30	110	47
13	6:00	110	47

Table 4: Blocks with cotton

NO	TIME	INNER TEMP	OUTER TEMP
1	11:30	110	28
2	12:30	110	30
3	1:00	110	32
4	1:30	110	36
5	2:00	110	39
6	2:30	110	43
7	3:00	110	44
8	3:30	110	45

9	4:00	110	45
10	4:30	110	45
11	5:00	110	45
12	5:30	110	45
13	6:00	110	45

VII. COMPARISON OF SPECIMENS WITH DIFFERENT INSULATION ADDITIVES



"Figure 10: Analysis of different material used in Concrete"

CALCULATIONS OF THERMAL CONDUCTIVITY:

1. Simple block

Q=VI cos ø
=230*2.9*0.995
=663.665 W
$A=0.15*0.15m^2$
dx=0.15m
k=Qdx/Adt
=663.665*0.15/(0.15*0.15)(110-51)
=74.99 W/m°c
Where,
Q=heat transfer rate in watt
V=supply voltage (V)
I =current (A)
Cos ø = Power factor
A= cross sectional area (m^2)
dx= thickness of the block (m)
dt= temperature gradient (°C)

2. Cotton block

k=Qdx/Adt
=663.665*.15/(.15*.15)(110-45)
=68.068 w/m°c

3. Glass-powder block

k=Qdx/Adt
=663.665*0.15/(0.15*0.15)(110-48)
=71.361 w/m°c

4. Human hair block

k=Qdx/Adt
=663.665*0.15/(0.15*0.15)(110-47)
=70.229 w/m°c

CONCLUSION

- With the addition of thermal insulation additives in cement concrete blocks, it is observed that there is considerable drop in the thermal conductivity of the block as it is observed that the steady state temperature at the outer surface reduces unto 6°C as compared to the plain concrete blocks.
- The maximum drop in outer surface temperature is observed by adding cotton followed by human hair and glass powder.
- The optimum content up to which the additives can be added to the concrete mixture ranges from 5 to 7 %. Beyond that the compressive strength of the block reduces drastically.
- The maximum compressive strength is obtained in case of glass powder additive block followed by cotton and human hair respectively.
- Hence depending on the requirement based on the load bearing capacity and requirement based on minimum heat loss from the building components the above mentioned thermal insulation materials can be put in use as the situation demands.
- The above mentioned materials can supplement the currently emerging and increasingly used Autoclaved Aerated Concrete (AAC) blocks as the availability of the fly ash used in these blocks is a concern at places where thermal power plants are far away.

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