THERMAL INSULATION OF LIGHT WEIGHT COCRETE

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ABSTRACT- *isaimed at efficient and affordable means ofproviding insulation on the roofs of buildings inducing an appreciable temperature reduction thereby making comfortable stay even during peak summer. Insulation of roof tops is becoming an increasingly potential criterion in the present scenario of high thermal radiations in the buildings. So we are trying to develop a thermally insulated material to be provided on roof top in the form of a tile which not only satisfies the desired strength requirements but also keeps the inner surface of the buildings cooler as compared to the exposed surface. Thus in the hunt for developing a suitable mix for tile design we tested various trial mixes for strength, physical properties and thermal conductivities with cement, sand and aluminum powder as basic materials, in the process the unsuitable material mix were rejected and other mix proportions were experimented for more accurate results. Thus the analytical and experimental methods implemented led to a suitable mix satisfying the requirements. This would definitely satisfy the high value insulation requirements of the buildings in the near future.*

Keywords: Aluminium powder, cement blocks, compressivestrength, density, water cement ratio ,thermal insulation

1. INTRODUCTION

1.1. A. Light weight concrete

Light weight concrete can be defined as a type of concrete which includes an expanding agent which increases the volume of mixture while reducing the dead weight. It is lighter than conventional concrete with a dry density below 2000 Kg/m3.

The main specialties of the light weight concrete are the low density and low thermal conductivity. There are many types of light weight concrete which can be produced either by using light weight aggregate or by using an air entraining agent. In this research, aluminium powder has been used as the air entraining agent. The fine powder of aluminium reacts with the calcium hydroxide in the cementatious system produces hydrogen gas. This hydrogen gas in the mix gives the cellular structure and makes the concrete lighter than the conventional concrete.

1.2. Aerated (Gas) concrete

Aerated concrete is obtained by a chemical reaction generating a gas in fresh mortar, so that when it sets it contains a large number of gas bubbles. Finely divided aluminium powder in various percentages by weight of cement is used for producing aerated concrete. The reaction of aluminium powder with a hydroxide of calcium or alkali from the cement liberates hydrogen, which forms bubbles in the wet mix. The bubbles expand the cement paste and concrete rises. The mix hardens with the voids left by the bubbles intact.

1.3.Thermal Insulation

Thermal insulation is a material or combination of materials, that, when properly applied, retard the rate of heat flow by conduction, convection, and radiation. It retards heat flow into or out of a building due to its high thermal resistance

1.4. Thermal Conductivity

Thermal conductivity is the time rate of steady state heat flow (W) through a unit area of 1 m thick homogeneous material in a direction perpendicular to isothermal planes, induced by a unit (1 K) temperature difference across the sample . Thermal conductivity, k-value, is expressed in W/m-K (Btu/h-ft-F or Btu-in/hr-ft 2 -F). It is a function of material mean temperature and moisture content. Thermal conductivity is a measure of the effectiveness of a material in conducting heat.

1.5. USE:

1) An insulating layer in the form of tiles and mass concrete is laid over the roof top.

2) It protects the roof top against rapid moisture penetration and roof damping.

3) Due to its low unit weight it does not supplement any form additional dead load on roof slab without hampering its own strength.

4) Instead of using expensive electronics gadget or instruments we can go for the provision of thermally insulated tiles which is not only efficient but also economical and permanent solution to thermal penetration.

1.6. Objectives .

The objectives of this study are:

1. To develop a light weight concrete with aluminium powder
2. To study the properties of light weight building blocks using light weight concrete.

1.7. Scope of the project

1. This study is limited to the performance based only on a single brand of super grade Portland slag cement (IS455).

2. This study is confined to a single air entraining agent from a single manufacturer that is aluminium powder.

3. The study is done for single cement: sand ratio (1:3).The influence of using aluminium powder as a partial replacement of cement in other ratios is not covered in the present study.

4. The percentage replacement of aluminium powder is limited to six categories that are 0.5, 1, 1.5, 2, 2.5, up to 7% replacement of cement.

5. Water was taken 84 ml. And it is used in motar mix.

6. Study is restricted to a particular type of superplastizier.

2. MATERIALS

2.1. A.Cement

Cement is the most important ingredient of concrete which acts as a binding agent between the aggregate and enhances the strength. Inthis study, Portland Slag Cement (IS455) was used.

2.2.Fine aggregate

In this research, slit free sand is used as fine aggregate

i.e- grade -1,2,3

2.3. Aluminium powder

Fine, uniform, smooth metallic powder free from aggregates available from market is used in this research and it has an atomic weight of 26.98.

2.4. Equipments used

Compressive testing machine ,Lee's apparatus, Thermometers ,volt meter.

3. EXPERIMENTAL WORKS

A concrete mix having the proportions of (1:3) by weight of cement and sand with water 84ml is used throughout the tests of mortar mix and 16 proportions of aluminium powder (0.5 ,1 ,1.5 ,2 , 2.5 upto 7%) by weight of cement are used for partial replacement of cement. For making concrete blocks 1:3 proportion of cement: sand are used with constant water 84ml and the percentage replacement of aluminium powder are (0.5 to 7%) by weight of cement. The dry cement and sand are mixed for one minute in a mixer. 80% of water is then added and mixing is continued for another one minute. Remaining 20% of water is then added. The aluminium powder is then added to the mixed concrete just before pouring in to the mold. Before pouring to the mould. The use of aluminium powder caused the expansion of concrete which led to irregular shapes and dimensions. The expanded layers were cut to form the
leveled surface. The cast cubes and blocks are tested for compressive strength at 3, 7 and 28 days.

3.1. METHODS TO DETERMINE THERMAL CONDUCTIVITY OF CONCRETE.

Available methods to determine thermal conductivity of any material:

1. Searle's method
2. Lee's method
3. Spherical shell method
4. Cylindrical shell method

So for the determination of thermal conductivity of insulating layer,adopting "Lee's method".

3.1.1. Lee'sdisc apparatus:

Here, the specimen rests on a brass base plate and a steam chest is placed on top. Steam is passed through the chest and the temperature of the base plate and the base of the steam chest are measured. The thermometers are set in good thermal conductors and therefore the temperatures that they measure are effectively those of the faces of the specimen.

When a steady state has been reached the temperatures θ1 and θ2 are recorded. The rate of loss of heat from the base plate being by radiation and convection, the base plate is polished so that radiation losses are small and Newton's law of cooling can be applied. We can assume that the heat lost from the sides of the specimen itself is negligible.

$$K=\{w*(dT/dt)T=T2*d\}/\{(T2-T1)*A\}$$

Where,

K= co-efficient of thermal conductivity in kW/m.

w=water equivalent=m*C

m=mass of lower cylinder in kgs

C=specific heat of the substance in kJ/K

dT/dt=slope of temperature(T) vs time(t) curve at T=T2

A=areaofthespecimen in m2

T1=temperature in thermometer 1

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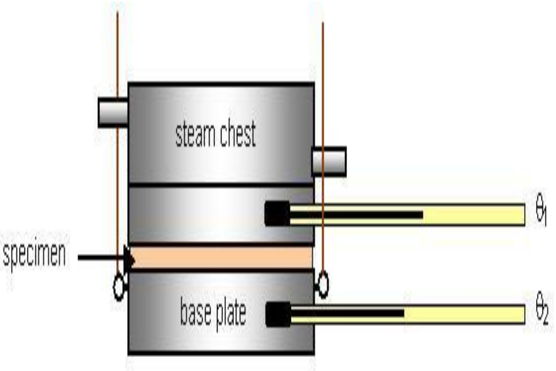
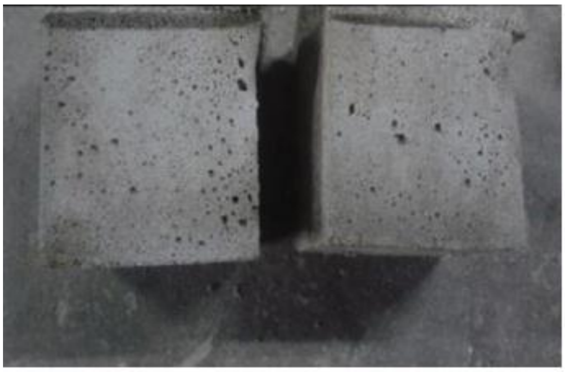
T2= temperature in thermometer 2

d=diameter of the specimen in m





4. ANALYSIS OF RESULTS AND DISCUSSIONS:

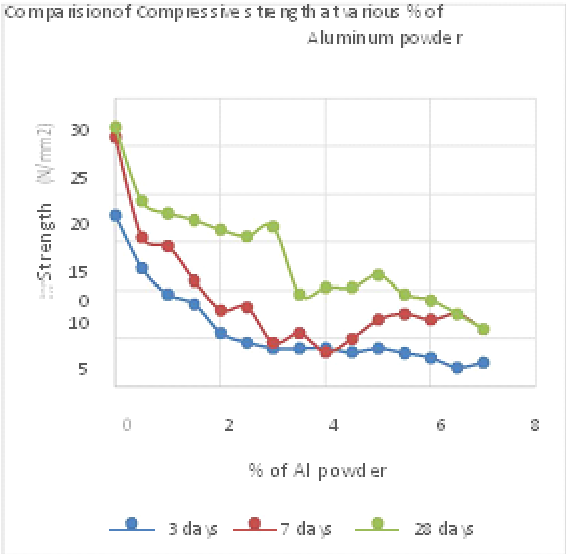
Compressive strength of normal concrete (1;3)

Sl	3 day strength (N/mm2)	7 day strength (N/mm2)	28 day strength (N/mm2)
1	18	24	24
2	18	28	28
3	17.5	26	29
Average	17.8	26	27

Compressive strength of concrete with aluminum powder (1:3)

Water = 84 ml, temperature of mixing = 22°C

% of Al powder	3 days	7 days	28 days
0	17.8	26	27
0.5	12.3	15.5	19.3
1	9.6	14.6	18
1.5	8.6	11	17.3
2	5.6	8	16.3
2.5	4.6	8.3	15.6
3	4	4.6	16.6
3.5	4	5.6	9.6
4	4	3.6	10.3
4.5	3.6	5	10.3
5	4	7	11.6
5.5	3.5	7.6	9.6
6	3	7	9
6.5	2	7.6	7.6
7	2.5	6	6



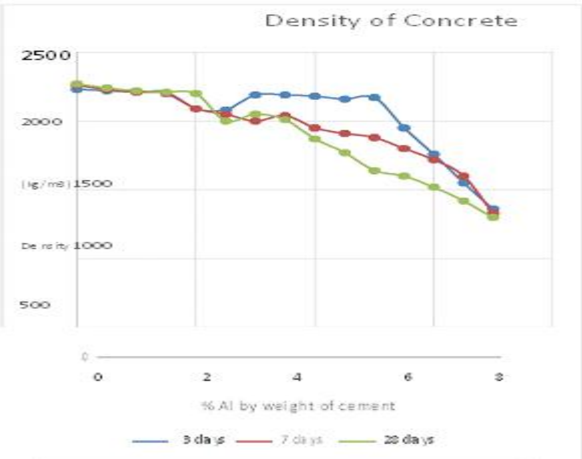
4.1. Density

Table 3,4 shows the values of density for the mortar specimens which produced by without aluminum powder and by using aluminum powder at different percentage results shows that the decrease in densities with increase in aluminum powder.

Sl	3 days density (kg/m3)	7 days density (kg/m3)	28 days density (kg/m3)
1	2240	2260	2280
2	2240	2260	2260
3	2230	2260	2270

Density of concrete with aluminum powder (For 1:3)

% of Al powder	3 days	7 days	28 days
0	2230	2260	2270
0.5	2220	2230	2240
1	2210	2210	2220
1.5	2210	2200	2210
2	2090	2090	2200
2.5	2080	2050	2000
3	2190	2000	2050
3.5	2190	2040	2010
4	2180	1950	1870
4.5	2160	1910	1770
5	2170	1880	1640
5.5	1950	1800	1600
6	1760	1720	1520
6.5	1550	1600	1420
7	1360	1330	1300



Thermal conductivity of mix

Lee's Test Results For(1:3) mix:

1	0	65	-0.01667
2	30	64.5	-0.01667
3	60	64	-0.01667
4	90	63.5	-0.01667
5	120	63	-0.01667
6	150	62.5	-0.01667
7	180	62	-0.01667
8	210	61.5	-0.01667
9	240	61	-0.01667
10	270	60.5	-0.01667
11	300	60	-0.00833
12	330	60	-0.00833
13	360	59.5	-0.01667
14	390	59	-0.01667
15	420	58.5	-0.01667
16	450	58	-0.01667
17	480	57.5	-0.01667
18	510	57	-0.01667
19	540	56.5	-0.01667
20	570	56	-0.00833
21	600	56	-0.00833
22	630	55.5	-0.01667
23	660	55	-0.00833
24	690	55	-0.00833
25	720	54.5	-0.01667
26	750	54	-0.01667
27	780	53.5	-0.01667
28	810	53	-0.01667
29	840	52.5	-0.00833
30	870	52.5	-0.00833
31	900	52	-0.01667
32	930	51.5	-0.00833
33	960	51.5	-0.00833

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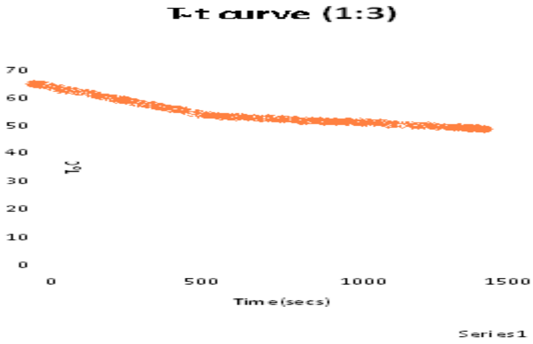


Sl. No.	Time (t) in secs	Temperature(T) in ºC	dT/dt
1	0	59	-0.01667
2	30	58.5	-0.01667
3	60	58	-0.01667
4	90	57.5	-0.01667
5	120	57	-0.00833
6	150	57	-0.00833
7	180	56.5	-0.01667
8	210	56	-0.01667
9	240	55.5	-0.01667
10	270	55	-0.01667
11	300	54.5	-0.01667
12	330	54	-0.01667
13	360	53.5	-0.01667
14	390	53	-0.01667
15	420	52.5	-0.025
16	450	51.5	-0.01667
17	480	51.5	-0.00833
18	510	51	-0.01667
19	540	50.5	-0.01667
20	570	50	-0.01667
21	600	49.5	-0.01667
22	630	49	-0.01667
23	660	48.5	-0.01667
24	690	48	-0.01667
25	720	47.5	-0.025
26	750	46.5	-0.01667
27	780	46.5	-0.00833
28			

Determination of K:

$_1$ = 99º = 372

$_2$ = 54º = 327

= 0.010386 ^{2}

= 0.115= 0.01667 / ( )

= 1.2

= 0.377 / .

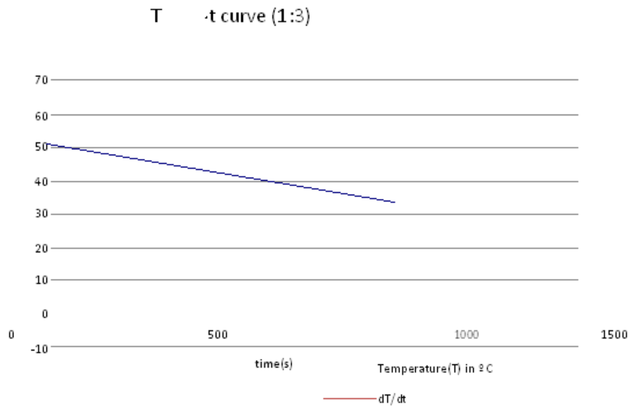
= × = 0.4524 / = 452.4 /

$$\frac{\;}{2-1}_{=2} = \frac{452.4 * 0.01667 * 0.115}{372 - 327 * 0.010386} = 1.855 \;.$$

28	810	46		-0.01667
29	840	45.5		-0.01667
30	870	45		-0.01667
31	900	44.5		-0.01667
32	930	44		-0.01667
33	960	43.5		-0.01667
34	990	43		-0.01667
35	1020	42.5		-0.01667
36	1050	42		-0.01667

Hence, the coefficient of thermal conductivity of 1:3 sample was found to be 1.855 W/m.K.

Lee's Test Results For (1:3) mix: (Using Aluminium Powder)



Calculation:

Test results:

$T1=99^0C=372K$

$T2=48^0C=321K$

d=11.2cm

A=98.52cm2

W=M*C =1.2*0.377 =45

$K=\{W*(dT/dt)_{T=T2}\}/\{(T_1-T_2)*(A/d)\}$

$=(452.4*0.01667*0.112)/\{(372-321)*(9.852*10_{-3})\}$

=1.68

W/mK

5. CONCLUSION:

From the experimental investigation described in this paper, it can be concluded that

1. Aerated concrete of density 2060-1300 Kg/m 3 can be produced by using aluminium powder.
2. The density of aerated concrete decreases with the increase in the percentage of aluminium powder. The percentage of reduction in density is done when the percentage of aluminium powder is varied between 0.5-7% by weight of cement.
3. Compressive strength of aerated concrete also decreases with the increase in aluminium powder percentage.
4. The compressive strength of aerated concrete blocks is observed to be more than that of commercially available cement blocks

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