TEMPERATURE STUDIES ON FLY ASH BASED CONCRETE

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ABSTRACT: The present work focuses on M20 to M50 grades of concrete with partial replacement of cement using Fly ash (FA = 25%). The cubes are casted and tested for compressive strength at the age of 28 days and 56 days. For the same specimens after curing period both ordinary and fly ash concretes cubes were subjected to thermal cycles of 28 and 56 at a temperature of 1000C in an electric oven then they were also tested for compression. From the above studies it is observed that the compressive strength of concrete with partial replacement of cement with fly ash is shows the more strength than the ordinary concrete. The compressive strength of fly ash concrete for thermal cycles of 28 and 56 shows the more strength than the ordinary concrete after exposing to 1000C for 8hrs duration.Thus, the resistance to adverse effect of thermal cycles is found to be more for fly ash based concrete when compared to ordinary concrete.
KEYWORDS: Temperature studies, Fly ash, thermal cycles, concrete, Compressive Strength.

I. INTRODUCTION

Now a days the use of concrete in infra- structural activity is on the rise and with cement being the most important but costly component of concrete, effort to lessen the cost by partial replacement of cement with accompanying cementitious materials has gained momentum and is even made as a government regulation. However, the production of concrete is not environmentally friendly. In this scenario, the use of conventional waste materials, such fly ash, Rice husk ash, Ground granulated blast furnace slag, silica fume, sugarcane bagasse ash etc. as a replacement for Portland cement in concrete presents one viable solution with multiple benefits for the sustainable development of the concrete industry. Currently, industrial waste such as Fly Ash (FA) is being used as supplementary cement replacement material. Therefore, a great potential exists to reduce the concrete industry`s contributions to greenhouse gases through reduction in cement consumption. The various elements of the structure like columns, outer walls and roof of slab were subjected to solar heat throughout the life. The rise in temperature is from sunrise to a maximum of four times the ambient temperature. In many parts of the world and in India, the peak temperature during summer goes beyond 40^0C and in such conditions the structural will be subjected to 80^0C and 90^0C.the humidity also influence the temperature within the exposed elements due to solar heat. Hence all the elements of the structure which are exposed to solar radiation are said to be experience one thermal cycle in a day. Concrete is the extensive material used for making all the structural elements necessitates the study of behavior of concrete subjected to temperature variations.

The present experimental work was carried out on the concrete by partial replacement of cement with fly ash by 25% for all the grades of concrete subjected to thermal cycles of 28 and 56 per 8 hrs duration in a day at a temperature of 100^0C in an electric oven. The mix design of M20 to M50 grades of concrete were designed as per the method specified in IS 10262-2009.

II. MATERIALS

A brief description about the materials used in this work is given below:

CEMENT:

Cement is a well-known building material and has occupied an indispensable place in construction works. There is a variety of cements available in the market and each type is used under certain conditions due to its special properties. The cement commonly used is Portland cement, and the fine and coarse aggregates used are those that are usually obtainable, from nearby sand, gravel or rock deposits. In order to obtain a strong, durable and economical concrete mix, it is necessary to understand the characteristics and behavior of the ingredients. In this work Ordinary Portland cement (OPC) confirming to IS-12269 (53 Grade) having specific gravity of 3.14.

AGGREGATES:

Aggregates are generally cheaper than cement and impart greater volume stability and durability to concrete. The aggregate is used primarily for the purpose of providing bulk to the concrete. To increase the density of the resulting mix, the aggregate is frequently used in two or more sizes. The aggregates provide about 75% of the body of the concrete and hence its influence is extremely important. Aggregate was originally viewed as an inert, inexpensive material dispersed throughout the cement paste so as to produce a large volume of concrete. In fact, aggregate is not truly inert because it’s physical, thermal and, sometimes, chemical properties influence the performance of concrete, for example, by improving its volume stability and durability over that of the cement paste. From the economic viewpoint, it is advantageous to use a mix with as much aggregate and as little cement as possible, but the cost benefit has to be balanced against the desired properties of concrete in its fresh and hardened state.

In this work sand conforming to Grading zone II of IS: 383 1970 having specific gravity of 2.6 and fineness modulus 2.47 was used as fine aggregate.

Crushed angular metal of 12 mm size having specific gravity of 2.78 and fineness modulus of 6.92 was used as coarse aggregate.

WATER:
Generally, cement requires about 3/10 of its weight of water for hydration. Hence the minimum water-cement ratio required is 0.35. But the concrete containing water in this proportion will be very harsh and difficult to place. Additional water is required to lubricate the mix, which makes the concrete workable. This additional water must be kept to the minimum, since too much water reduces the strength of concrete.
In this work Potable clean water was used.

FLY ASH:
Fly ash is finely divided ash resulting from the burning of pulverised coal or lignite in boilers. The fly ash obtained from lignite is considered superior to that obtained from coal because of its higher lime content. Fly ash is a waste product, and today, it is easily available on all parts of India. The fineness and presence of objectionable ash should be checked in the field by mixing the fly ash in a bucket of full of water and passing the resulting slurry through an IS sieve 150 microns. No residue should be left on the sieve in case of a good sample of fly ash.

III. METHODOLOGY

The scope of present research is to study and evaluate "the effect of thermal cycles on compressive strength of M20 to M50 grades of ordinary concrete and fly ash concretes". Cubes of standard size 100mmx100mmx100mm (length x width x depth) were cast tested for 28 days and 56 days compressive strength. After completion of the normal curing period of 28 days and 56 days the specimens were tested for compression and then the specimens were kept in the electric oven for thermal cycles of 28 days and 56 days at a temperature of 1000C for about 8 hours daily and also specimens were tested for compression.
In this chapter the methods that are adopted and tests that are conducted are explained briefly. The method adopted to obtain the design mixes for M20 to M50 grades of concrete are done according to IS: 10262-2009. For fresh concrete the slump cone test, compaction factor test and vee-bee time has been conducted and for hardened concrete the tests like compressive strength for cubes of size 100mm x 100mm x 100mm has been conducted.
OBJECTIVES:
The work reported in this study, Fly ash obtained from the Dr Narla Tata Rao Thermal Power Plant which is located in Vijayawada is used as a cement replacement material in concrete mix. The final focus of this work is to ascertain the performance of concrete mix containing fly ash and compare with plain concrete mix. This is expected to provide:-
1. To partially replace cement content with fly ash in concrete as it directly influences economy in construction.
2. To evaluate the workability characteristics in terms of slump, compaction factor and vee-bee time on addition of fly ash only (25%).
3. To design and proportion the concrete mix for M20 to M50 grades concrete, as per the recommendation of IS: 10262:2009.
4. To find the Volume proportions of the concrete mixes by partially replacing Cement by fly ash.
5. To evaluate the M20 to M50 grades of ordinary concrete and fly ash concretes for the compressive strengths at 28 days and 56 days of normal curing by replacing cement with fly ash in proportion of 0% and 25%.
6. To evaluate the M20 to M50 grades of ordinary concrete and fly ash concretes for the compressive strengths at 28 days and 56 days thermal cycles at a temperature of 1000C by replacing cement with fly ash in proportion of 0% and 25%.
TEST PROGRAMME:
To evaluate the strength characteristics in terms of compressive strength a total of 4 mixes were tried with different percentages of fly ash (0% & 25%).In all mixes the same type of aggregate i.e. crushed granite aggregate, fine aggregate, fly ash are used. The relative proportions of cement, coarse aggregate, sand and water are obtained by IS - Code method. M20 to M50 are considered as the reference mixes.(Appendix-I)

The parameters are
- For M20 design mix, the percentage of cement replaced with fly ash is in proportion of 0% and 25%.
- For M30 design mix, the percentage of cement replaced with fly ash is in proportion of 0% and 25%.
- For M40 design mix, the percentage of cement replaced with fly ash is in proportion of 0% and 25%.
- For M50 design mix, the percentage of cement replaced with fly ash is in proportion of 0% and 25%.

A total no. of 96 cubes of size 100mm x 100mm x 100 mm were casted and tested for each percentage of partial replacement of cement. A sample calculation for determination of weight and volumes is presented in Appendix- II. The test programmed consisted of conducting compressive strength test on cubes at 28days and 56 days of normal curing and 28 days and 56 days thermal cycles at temperature of 1000 C.
EFFECT OF TEMPERATURE ON CONCRETE:
Due the elevated temperatures, the effects in concrete are
- Spalling of concrete
- Loss of compressive strength
- Loss of weight/mass
- Change in colour

The method adopted to obtain the design mixes for M20 to M50 grades of concrete are done according to IS: 10262-2009. Similarly for all the grades of concrete we replaced the cement with by fly ash is 25%. For fresh concrete the slump cone test, compacting factor and vee-bee time tests have been conducted and for hardened concrete the tests like compressive strength for cubes of size 100mm x 100mm x 100mm has been conducted.

THERMAL CYCLE PROCEDURE:
Thermal cycle includes the heating of specimens at100oC for

a period of 8 hours. Then remove the specimens from oven and kept at room temperature for a period of 16 hours which completes one thermal cycle. Like this the specimens after 28 days and 56 days of normal curing will be kept in oven for 28 and 56 thermal cycles. After 28 days and 56 days the concrete trial specimens of grades M20 to M50 with and without fly ash are exposed to temperature 100oC in an electric oven. The duration of exposure is 8 hours at 1000C temperature. After exposing the specimens for specified durations the specimens gradually cooled in air. Then the specimens are tested for compressive strength as specified by IS: 516-1959. The Electric oven is shown in fig 1.

Fig 1. Electric oven with specimens kept for thermal cycles

IV. RESULTS & DISCUSSION

COMPRESSIVE STRENGTH: The compressive strength of concrete trial mixes of different grades from M20 to M50 without fly ash and with 25% replacement of cement with fly ash were tested after 28 days and 56 days of normal curing. Similarly another set of specimens were also tested after 28 and 56 thermal cycles.

Compressive Strength of Concrete trial mixes with and without Fly ash at Zero Thermal Cycles: Compressive strength of concrete trial specimens with fly ash and without fly ash of different grades are tested at the age of 28 days which varies from 28.67 to 54 N/mm2 and for fly ash blended concrete from 29.66 to 56.03 N/mm2. From the figure 3 it was observed that fly ash concrete gives more compressive strength than ordinary concrete.

Compressive strength of concrete trial specimens with fly ash and without fly ash of different grades are tested at the age of 56 days which varies from 30.67 to 56.70 N/mm2 and for fly ash blended concrete from 31.73 to 57.71 N/mm2. From the figure 6.9 it was observed that fly ash concrete gives more compressive strength than ordinary concrete.

Compressive Strength of Concrete trial mixes with and without Fly ash at 28 Thermal Cycles: Compressive strength of concrete trial specimens with fly ash and without fly ash of different grades are tested for thermal cycles of 28 at 1000C temperature. Which varies from 25.80 to 44.28 N/mm2 for ordinary concrete and for fly ash blended concrete from 33.42 to 60.86 N/mm2. From the figures it was observed that at 28 thermal cycles the concrete specimens without fly ash shows a decreasing trend. Where as in fly ash blended concretes increasing trend was observed for the same grade.

Compressive Strength of Concrete trial mixes with and without Fly ash at 56

Thermal Cycles: Compressive strength of concrete trial specimens with fly ash and without fly ash of different grades are tested for thermal cycles of 56 at 1000C temperature, Which varies from 26.37 to 45.36 N/mm2 for ordinary concrete and for fly ash blended concrete from 33.63 to 61.74N/mm2. From the figures 3 and 4, it was observed that at 56 thermal cycles the concrete specimens without fly ash shows a decreasing trend. Where as in fly ash blended concretes increasing trend was observed for the same grade.

From the table 3, decrease of compressive strength from 10 % to 18 % observed in concrete specimens without fly ash for all the grades of concrete. Whereas for fly ash blended concrete specimens an increase of 8.63 % to 15 % was observed. From the table 4, decrease of compressive strength from 14 % to 20% observed in concrete specimens without fly ash for all the grades of concrete. Whereas for fly ash blended concrete specimens an increase of 5.64 % to 8.5% was observed.

Table.1: Compressive strengths

S.NO	GRADE	TYPE OF CONCRETE	AVG.COMPRESSIVE STRENGTH OF CUBES @ 28 DAYS IN N/mm^2
1	M20	Ordinary	28.67
2		25% Fly ash replacement	29.66
3	M30	Ordinary	36.33
4		25% Fly ash replacement	37.80
5	M40	Ordinary	48.30
6		25% Fly ash replacement	50.26
7	M50	Ordinary	54.00
8		25% Fly ash replacement	56.03

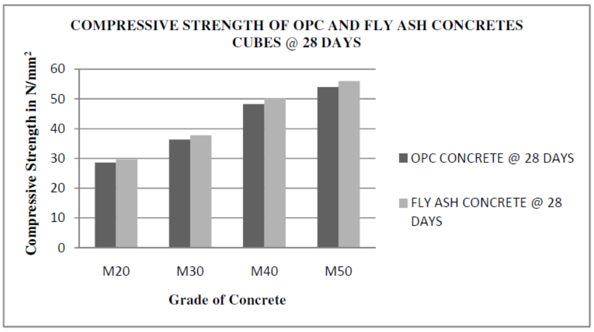

Fig. 2 Compressive strength at 28 days

Table. 2 Compressive Strength of Cubes for M20 to M50 Ordinary Concrete and Fly ash Concretes for Thermal Cycles of 28 and 56 at 1000C temperature.

GRADE	TYPE OF CONCRETE	28 DAYS STRENGTH IN N/mm^2	NO.OF THERMAL CYCLES AT 100^{0}C [28] IN N/mm^2	56 DAYS STREN-GTH IN N/mm^2	NO.OF THERMAL CYCLES AT 100^{0}C [56] IN N/mm^2
M20	Ordinary	28.67	25.80	30.67	26.37
	Fly ash 25%	29.66	33.42	31.73	33.63
M30	Ordinary	36.33	30.66	38.87	32.26
	Fly ash 25%	37.80	41.80	40.44	42.86
M40	Ordinary	48.30	41.87	50.71	43.35
	Fly ash 25%	50.26	57.79	52.00	56.42
M50	Ordinary	54.00	44.28	56.70	45.36
	Fly ash 25%	56.03	60.86	57.71	61.74

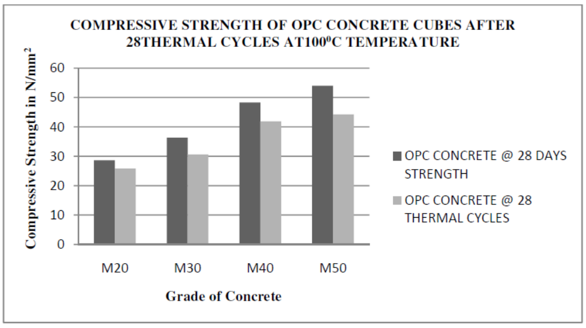

Fig. 3compressive Strength Of Opc Concrete Cubes After 28thermal Cycles At1000c Temperature

Table. 3 Percentage Increase/Decrease of Compressive Strength for M20 toM50 with reference to 28 days strength of Ordinary Concrete and Fly ash Concrete

GRADE	TYPE OF CONCRETE	NO.OF THERMAL CYCLES AT 100^0C [28]
M20	Ordinary	- 10.00 %
	Fly ash 25%	12.68 %
M30	Ordinary	- 15.60 %
	Fly ash 25%	10.80 %
M40	Ordinary	-13.30 %
	Fly ash 25%	15.00 %
M50	Ordinary	-18.00 %
	Fly ash 25%	8.63 %

Table. 4 Compressive Strength of M20 to, M50 Ordinary Concrete and Fly ash Concretes cubes for Thermal Cycles of 56 at 1000C temperature.

GRADE	TYPE OF CONCRETE	56 DAYS STRENGTH IN N/mm^2	NO.OF THERMAL CYCLES AT 100^0C [56] IN N/mm^2
M20	Ordinary	30.67	26.37
	Fly ash 25%	31.73	33.63
M30	Ordinary	38.87	32.26
	Fly ash 25%	40.44	42.86
M40	Ordinary	50.71	43.35
	Fly ash 25%	52.00	56.42
M50	Ordinary	56.70	45.36
	Fly ash 25%	57.71	61.74

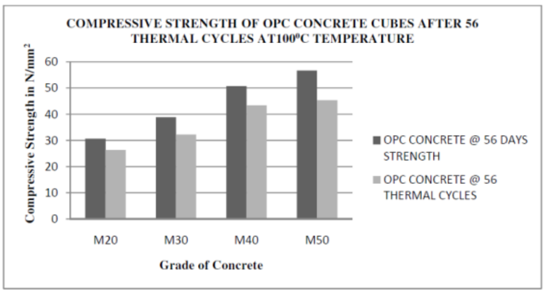

Fig. 4 Variation of Compressive Strength of M20 to M50 Ordinary Concrete for 56 Thermal Cycles at 1000C temperature.

V. CONCLUSIONS

1. The concrete trial specimens, irrespective of the grade of without fly ash content a decreasing trend ranging from 10 % to 18 % of compressive strength was observed for 28 thermal cycles.
2. The concrete trial specimens, irrespective of the grade of with fly ash content a increasing trend ranging from 8.63 % to 15 % of compressive strength was observed for 28 thermal cycles.
3. The concrete trial specimens, irrespective of the grade of without fly ash content a decreasing trend ranging from 14 % to 20 % of compressive strength was observed for 56 thermal cycles.
4. The concrete trial specimens, irrespective of the grade of with fly ash content a increasing trend ranging from 5.64 % to 8.5 % of compressive strength was observed for 56 thermal cycles.
5. From the test results an increasing of compressive strength was observed from 28 days to 56 days in case of fly ash blended cement concrete.
6. Based on the experimental investigations fly ash blended cement concretes resists better than ordinary concrete in case of high temperatures

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