RESEARCH ARTICLE OPEN ACCESS

A Study on properties of Compressive strength, Sorptivity, Acid resistance and Alkalinity on M25 Grade of concrete

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ABSTRACT
Fly ash is used as fine granulates becomes suitable for partially obstructing voids in addition to pores .At later ages, the concrete mix which is replaced with fly ash exhibit greater strength development than control mix as the relative strength continues to increase with curing times. There is a significant reduction in comparative strength, with greater and consistent reduction at higher replacement levels of fly ash content. There is a important reduction in relative strength, with greater and consistent reduction at higher replacement levels of fly ash content. At later ages, the concrete mix replaced with fly ash leads to decrease in coulombs charge passed, due to higher amount of pozzolano and proper particle size distribution resulting in lower permeability.
The permeability is an indicator of concrete`s ability to transport water extra precisely with both mechanism that is controlling the up- take and transport of water in addition to gaseous substances into cementitious material. Uptake of water by unsaturated, hardened concrete may be characterized by the sorptivity.
Sorptivity is materials ability to absorb moreover transmit water through it by capillary suction .When excess water in concrete evaporates, it leaves voids inside the concrete element creating capillaries which are directly related to concrete porosity and permeability. In this experimental study the concrete mix prepared by partial replacement of cement by flyash and evaluate the results of compressive strength, sorptivity in addition to some of durability tests were conducted on each of the mixes. The concrete specimens were initially cured in water for 28 days and after that the specimens were immersed in 2% Hcl of the total volume of water for determination of acid resistance and 2% NaOH for alkalinity test separately for another 28 days of curing to evaluate the strength of concrete.
Keywords - capillary suction, compressive strength, fly ash, porosity , sorptivity, acid resistance & alkalinity.

Date Of Submission: 25-07-2019 Date Of Acceptance: 06-08-2019

I. INTRODUCTION

In brief and in order to produce concrete-based materials that are sustainable, the use of cement replacement materials and recycled products is necessary. Cement replacement materials are necessary, including coal fly ash, ground granulated blast furnace slag, silica fume, ground glass natural pozzolans or calcined clay (eg. metakolin). Recycled and waste materials can be used to replace aggregates, materials such as recycled glass, brick and concrete and incineration bottom ash. The use of replacement materials is an efficient way of reducing the burden on the environment because of construction activities. They would reduce the embodied energy and improve the durability of construction materials, thus contributing towards the sustainability of our environment.

Concrete has to function in different types of environments, some of which are aggressive otherwise degrading to the concrete quality. Typical aggressive environments are: Seawater (or close to sea), Polluted soils (due to industrial or agricultural effluents), Freezing conditions, to forename a few. Design of concrete for these environments has to take into consideration the alteration that cement paste (or concrete) may undergo upon interaction with the environment.

A durable concrete is one that performs satisfactorily in the functioning environment during its anticipated exposure condition during service(IS 456-2000)

Durability of concrete is correlated to its performance in the service environment. Concrete is subjected to a swarm of durability problems, which typically result in:

- Progressive loss of mass from the surface
- Progressive loss of strength
- Volume changes, which can be of three types: (1) both paste and aggregate expand, (2) the

paste expands, while the aggregate is inert, or (3) only the aggregate expands.

It is now recognized that the strength of concrete alone is not sufficient, but also the degree of harshness of the environmental condition to which concrete is exposed over its entire life is equally important.

Fly ash or flue ash also known as pulverized fuel ash is a coal combustion product that is composed of the particulates that are driven out of coal fired boilers together with the flue gases. The use of small percentages of fly ash in a variety of civil engineering works is being carried out mainly for economical reasons. Fly ash, being available used in a costly construction raw material with the aim to solve the problem of disposal of fly ash in environment and cost reduction in construction.

In 1957 John Philip introduced the term **sorptivity** and defined it as a measure of the capacity of the medium to absorb or desorbs liquid by capillarity.[12]

According to C Hall and W D Hoff, the sorptivity expresses the tendency of a material to absorb and transmit water and other liquids by capillarity.[10] The test method is used to determine the rate of absorption (sorptivity) of water by hydraulic cement concrete by measuring the increase in the mass of a specimen resulting from absorption of water as a function of time when only one surface of the specimen is exposed to water.

II. OBJECTIVES OF STUDY

The objectives of the experimental investigation are

- To achieve good compressive strength at optimum usage of flyash in concrete with affordable sorptivity
- To attain relation between sorptivity and compressive strength
- To evaluate sorptivity with accordance of time.
- To evaluate compressive strength with respect to acid resistance and alkalinity

III. METHODOLOGY

In this study the materials were collected locally and laboratory tests were conducted on cement fine aggregate and coarse aggregate. After completion of laboratory tests on the materials the mix design was prepared for M25 grade concrete using the referential codes of IS 10262-2009 and IS 456-2000.Based on the mix design the cube as well as cylindrical specimens for determining compressive strength and sorptivity were prepared for 7 and 28 days of curing period. The sizes of cube specimens were 150mmX150mmX150mm and cylindrical specimens of 150mmx100mm. Fly ash is used in different percentages as a partial replacement of cement. The measurement of workability carried out by slump test in addition to compaction factor test and the strength tests were conducted on hardened concrete after 7and 28days curing period. The average strength of three cube specimen results was taken in each mix for strength and sorptivity evaluation. From the final results we had done discussions and finally concluded this work. The project followe the following flow chart for entire work.

IV. EXPERIMENTAL PROGRAM

The materials were procured from locallyavailable sources and laboratory experiments were conducted for determination of their properties. The OPC 53 grade cement (RAMCO), locally available sand having specific gravity of 2.76, coarse aggregate of size 20mm and 16mm were used in this work. Flyash collected from nearby Boyapalem, Visakhapatnam used as partial replacement material in place of cement for preparation of concrete. Water cement ratio 0.46 maintained throughout the work and hand mixing done in the preparation of concrete.

Cement was partially replaced by flyash as 10%, 15% and 20% in different mixes. The cube and cylindrical specimens were casted of size 150mm×150mm×150mm and 100mm diameter 150mm height respectively. After demoulding the cylindrical specimens ,each specimen cut into three pieces (each one 50mm thickness) and the specimens are put into water for curing period of 7 and 28 days. After curing period the cube and cylindrical specimens were tested for compressive strength and sorptivity. Compressive strength conducted as per IS 516 and sorptivity test was conducted with reference to ASTM C1585-13.

$S = I/t^{1/2.}$

Here S= sorptivity in mm,

t = elapsed time in mintues $I = \Delta w/Ad$

Δw = change in weight = W2-W1

W1 = Oven dry weight of cylinder in grams

W2 = Weight of cylinder after30 minutes capillary suction of water in grams

A = surface area of the specimen through which water penetrated.

d= density of water

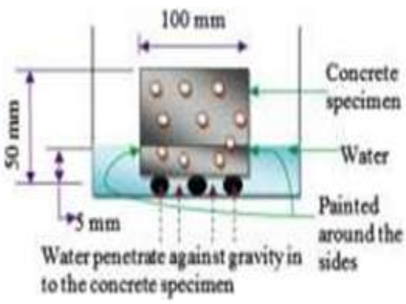

Figure 1 Schematic diagram for sorptivity test
Source:

https://www.google.com/search?q=sorptivity+test&source=lnms&tbm=isch&sa=X&ved=0ahUKEwiTz8zj3rvhAhX6#imgrc=IFY0EuQl-Y0I7M:

Figure 2 sorptivity test

Figure 3 weighing of specimens

Acid Resistance

Cubes of sizes 150mm were cast and cured for 28 days in water.After 28 days curing cubes were taken out and allowed for drying for 24 hours and weights were taken. Take 2 % Hydrochloric acid by weight of water and the cubes were to be immersed in acid(Hcl) solution for required period of time. The concentration(pH) is to be maintained throughout this period. After curing period, the specimens were taken from acid solution and the surface of specimen was cleaned and weight of each cube specimen was measured. The specimen was tested in the compression testing machine under a uniform rate of loading 140Kg/cm^2 as per IS 516. The mass loss and strength of specimen due to acid attack was determined.

Figure 4 curing of cube specimens in acid solution

Figure 5 cube specimens after curing in Hcl solution

ALKALINITY

To determine the resistance of various concrete mixtures to alkaline attack, the residual compressive strength of concrete mixtures of cubes immersed in alkaline water having 5% of sodium hydroxide (NaOH) by weight of water was found.The concrete cubes which were cured in water for 28 days were removed from the curing tank as well as allowed to dry for one day.The weights of concrete cube specimen were taken. Then the cubes were immersed in alkaline water continuously for required number of days.The pH of solution was maintained same throughout the test period. After curing period, the concrete cubes were taken out of alkaline water. The cubes were wiped and dried of minimum time as well as weighed the cubes for evaluation of weight loss. The cubes were tested for compressive strength as per IS 516.The resistance of concrete to alkaline attack was found by the % loss of weight of specimen and the % loss of compressive strength on immersion of concrete cubes in alkaline water.

V. RESULTS AND DISCUSSION

A. RESULTS

From the laboratory tests the following results were obtained

S.No	Name of property	Result	Standard limits
1	Specific gravity of Coarse aggregate	3.10	2.5-2.9 (IS:383-Table 2)
2	Water absorption of coarse aggregate	1.11%	0-2% (IS:383-2016)

Table 1 Tests results of Coarse aggregate

S.No.	Name of property	Result	Standard limits
1	Fineness modulus of fine aggregate	2.75	2.6-2.9 (IS:383-Table 4)
2	water absorption of fine aggregate	0.917 %	0.3-2.5% (IS:383-2016)
3	Specific gravity of fine aggregate	2.765	2.5-2.9 (IS:383-2016)

Table 2 Tests results of Fine aggregate

		Time in minutes					
S.No	Mix	60	240	360	480	600	740
1	Mix-P10	0.333	0.994	0.994	0.994	0.995	0.995
2	Mix-P15	1.050	1.050	1.050	1.051	1.051	1.051
3	Mix-P20	1.029	1.029	1.030	1.030	1.030	1.030

Table 3 sorptivity test results

Table 4 workability test results

S.No.	Mix	Characteristic Compressive strength(N/mm^2) Curing period (days)	
		7	28
1	Control mix	23.83	30.2
2	MIX-P10	24.44	29.81
3	MIX-P15	21.42	27.8
4	MIX-P20	20.5	24.16

Table **5** Compressive strength test results

S.No.	MIX	Workability	
		Slump Value (mm)	Compaction Factor
1.	Control Mix	42	0.92
2.	MIX-P10	30	0.89
3.	MIX-P15	27	0.88
4.	MIX-P20	25	0.83

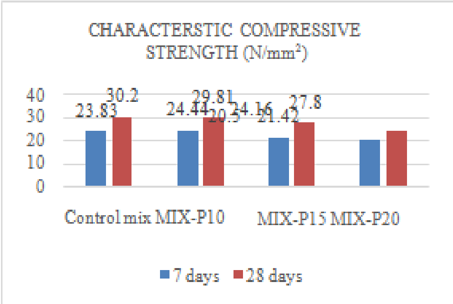

Figure 6 Graphical representation of compressive strength of concrete mixes

Table 6 Percentage weight loss of cube specimens in Acid attack test

S.No.	MIX	Weights(kg) of cube specimens		% loss in weight
		Before curing in acid solution	After curing in acid solution	
1	CM	7.99	7.97	0.48
2	MIX-P10	7.99	7.96	0.48
3	MIX-P15	7.93	7.88	0.63
4	MIX-P20	8.16	8.09	0.85

P-Percentage, C.M-Control Mix

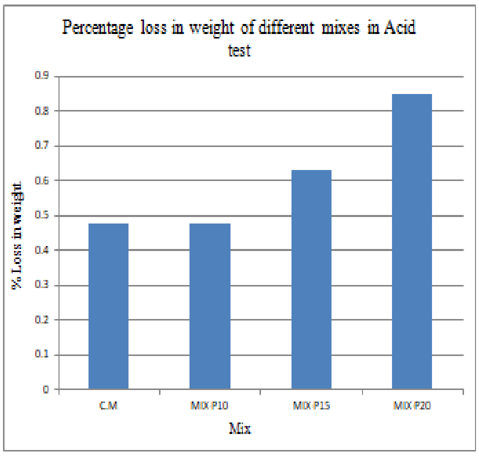

Figure 7 Graphical representation of percentage loss in weight of different mixes in Acid test

Table 7 Strength variation of different mixes after Acid test

S.No	MIX	Compressive Strength (N/mm²)		% loss of Compressive Strength
		Before curing in acid solution	After curing in acid solution	
1	C.M	30.20	30.13	0.23
2	MIX-P10	29.81	29.65	0.54
3	MIX-P15	27.80	27.63	0.61
4	MIX-P20	25.40	25.25	0.59

P-Percentage, C.M-Control Mix

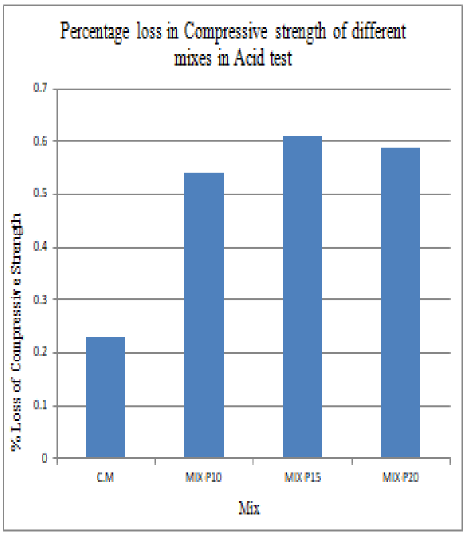

Figure 8 Graphical representation of percentage loss in Compressive strength in Acid test of different mixes

Table 8 Percentage loss in **w**eight of cube specimens in Alkaline test

S.No	MIX	Weight(kg) of cube specimens		% loss in weight
		Before curing in alkaline solution	After curing in alkaline solution	
1	C.M	7.99	7.96	0.38
2	MIX-P10	7.94	7.90	0.50
3	MIX-P15	7.97	7.92	0.62
4	MIX-P20	8.16	8.10	0.73

P-Percentage, C.M-Control Mix

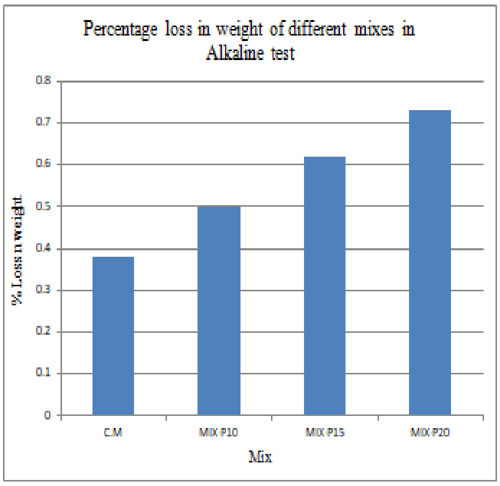

Figure 9 Graphical representation of percentage loss in weight of different mixes in Alkaline test

Table 9 Strength variation of different mixes after Alkalinity test

S.No	MIX	Compressive Strength(N/mm²)		% loss of Compressive Strength
		Before curing in alkaline solution	After curing in alkaline solution	
1	C.M	30.20	30.07	0.44
2	MIX-P10	29.81	29.60	0.70
3	MIX-P15	27.80	27.57	0.83
4	MIX-P20	25.40	25.17	0.91

P-Percentage, C.M-Control Mix

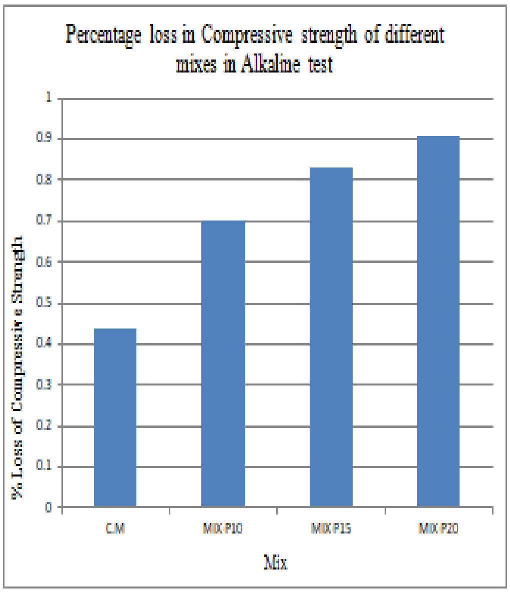

Figure 10 Graphical representation of percentage loss in Compressive strength in Alkaline test of different mixes

B. DISCUSSION

1. The 28 days compressive strength of control specimen is 30.2 N/mm^2.In this attempt the strength difference between obtained value and target mean strength is not exceeded 5% hence good strength is achieved. After replacement of cement by 10% fly ash the compressive strength reached its target strength but for further increment in replacement of cement the strength decreased gradually.
2. Upto 20% replacement of cement with fly ash gave good compressive strength results that is nearly its target strength but not up to mark. These strengths were considerable
3. When fly ash is added in concrete, the reactive silica present in fly ash reacts with calcium hydroxide liberated during cement hydration and forms calcium silicate hydrate (C-S-H) gel. Compact C-S-H gel gives higher strength.
4. The sorptivity value increased with cumulative time period at 10% replacement of cement with fly ash. In MIX-P10, the rate of capillarity of water is increased 0.33% when compared with the initial value at 30 minutes time period.
5. There is no increment in sorptivity after 9 hours of time in MIX-P10 and the values are almost same for further time increment. Compact C-S- H gel gives higher strength and lower permeability and absorption characteristics
6. In MIX-P15 and MIX-P20 the sorptivity values are gradually decreased with minimum cumulative time period when compared to MIX-P10.Because of fineness of flyash ,it occupies remaining pores in the mixes and cause to low permeability and absorbing capacity.
7. The variation in percentage loss in weight when compared to control specimen were 0.48,1.52 and 2.28.The loss in weight was slightly increased at 2% of Hcl added by weight of curing water after 28 days of normal curing was done.
8. The variation in percentage loss of weight in Alkalinity test when compared to control specimen were 0.32,0.63 and 0.92.
9. In Acid resistance,the percentage loss in compressive strength were 1.34,1.65 and 1.56 when compared to control specimen.
10. In Alkalinity test,the percentage loss in compressive strength were 0.59,0.88 and 1.06 when compared to control specimen.
11. Due to reacting of iron from flyash by Hcl, the strength was decreased after 28 days of chemical curing.The reduction in strength may vary by adding increase in concentration of Hcl and Alkalinity.
12. Present investigation shows that the percentage loss in weight and percentage reduction in compressive strength due to acid test are 0.48% to 0.85% and 0.54% to0.59% with replacement of flyash as 10%,15%,20% and similarly in alkalinity test the loss in weight and compressive strengths are 0.58% to 0.73% and 0.70% to 0.91%.
13. There is considerable variation in loss of weight and strength due to acid resistance when compared to alkalinity results.

VI. CONCLUSION

1. The compressive strength increased by 2.5% at 10% replacement of cement with fly ash when compared to control specimen .Hence for obtaining good strength, upto 10% replacement of cement with fly ash in M25 concrete mix is acceptable.
2. In MIX-P10,thesorptivity is high when compared with remaining mixes but it is considerable for ordinary structures.
3. Upto 15% replacement of cement with fly ash the compressive strength and sorptivity values are considerable.
4. Due to acid attack,the percentage loss in compressive strength varies from 0.54 to 0.59 at 10% to 20% replacement of cement with flyash.
5. Due to alkalinity attack,the percentage loss in compressive strength varies from 0.70 to 0.91 at 10% to 20% replacement of cement with flyash.
6. The durability results of weight loss and strength loss for acid attack and alkaline attack increases with increase in the percentage of flyash with partial replacement of cement.

RECOMMENDATION

In the present study the compressive strength and sorptivity tests were done after 28 days of curing period at room temperature and the sorptivity test was conducted at a cumulative time period of 12 hours for each case. The same test will try to do at a long cumulative hours or days with different chemical agents mixing with water for curing at different temperatures and will evaluate the nature of sorptivity.

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M.Hanumanthu" A Study on properties of Compressive strength, Sorptivity, Acid resistance and Alkalinity on M25 Grade of concrete" International Journal of Engineering Research and Applications (IJERA), Vol. 09, No.08, 2019, pp. 71-77