International Journal of Engineering Research and General Science Volume 3, Issue 1, January-February, 2015
ISSN 2091-2730

STRENGTH AND DURABILITY STUDIES ON CONCRETE WITH FLYASH AND ARTIFICIAL SAND

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ABSTRACT- Currently India has taken a major initiative on developing the infrastructures such as Express Highways, Power Projects and Industrial Structures etc., to meet the requirements of globalization, in the construction of buildings and other structures. Concrete plays the key role and a large quantum of concrete is being utilized in every construction practices. River Sand, which is one of the constituents used in the production of Conventional Concrete, has become very expensive and also becoming scarce due to depletion of river bed. Quarry dust is a waste obtained during quarrying process. It has very recently gained good attention to be used as an effective filler material instead of Fine Aggregate. An attempt have been made to examine the suitability of replacing the 30% of Fly Ash and 50% of Artificial Sand for a Concrete of grade M35.Examine strength characteristics such as Compressive Strength for 7days, 28days, 56days of Curing Period and Durability Characteristics such as Acid Attack Test, Acid Durability Factor, Acid Attack Factor for 30days, 60days, 90days results are analyzed and compared with the Conventional Mix.

KEY WORDS: Cement, Fly Ash, Natural Sand, Artificial Sand, Coarse Aggregate, HCl Solution, Compressive Strength, Acid Attack Factor, Acid Durability Factor.

1. INTRODUCTION-Artificial sand is a crushed stone dust used as a Fine Aggregate. However, recycled concrete aggregate, Fly Ash, Blast Furnace Slag, Quarry Dust, a by-product from the crushing process during quarrying activities is one of those materials that have recently gained attentions to be used as concreting aggregates, especially as Fine Aggregates. Quarry Dust have been used for different activities in the construction industry, such as Road Construction, and manufacture of building materials, such as light weight Aggregates, Bricks, Tiles and Autoclave Blocks. The Artificial Sand produced by proper machines can be a better substitute to River Sand. The sand must be of proper gradation (it should have particles from 150 microns to 4.75 mm in proper proportion).

Fly Ash is one of the residues generated in the combustion of coal. Fly Ash is generally captured from the chimneys of power generation facilities. Fly Ash consists of fine, powdery particles that are predominantly spherical in shape, either solid or hollow, and mostly glassy (amorphous) in nature. The carbonaceous material in Fly Ash is composed of angular particles. The particle size distribution of most bituminous coal Fly Ashes is generally similar to that of silt (less than a 0.075mm).These ash particles consist of Silica, Alumina, Oxides of Iron, Calcium, and Magnesium and toxic heavy metals like Lead, Arsenic, Cobalt, and Copper. This poses problems in the form of land use, health hazards, and environmental impact.

2.LETERATURE RIEVIEW

Prof R. S. Deotale, Harshavardhan L. Rangari, Prof Swapnil P. Wanjari conducted studies on concrete mix with partial replacement of Cement by suitable Pozzolonic Cementitious Material and Sand by Manufactured Quarry Sand. The present study is aimed at utilizing Quarry sand as fine aggregate replacing natural sand and also the compressive strength of the water cured specimens is measured on the 7, 28, 56 days for M25, M30, M35 grades of concrete and concluded that 50% Replacement of Natural Sand by

Quarry sand would produce higher compressive strength for all grade of concrete M35, M30, M25 Grade of concrete and as per the study of acid attack and concrete show that con. H_2SO_4 affect more on concrete as compare to HCl.

Rajamani. N.P et.al in (2006) studied on this work, a prediction equation was proposed which estimates the 28 days compressive strength of fly ash concrete and can also be used to modify any basic cement concrete mix so that the concretes with and without replacement of fly ash have similar strength. The prediction equation also considers the different levels of replacement of sand and fly ash with fine aggregate at sand replacements of 20, 40, 60 % were prepared. Actual fine aggregate quantity added was varied from 1.0 to 1.6 times the quantity of sand replaced to study the effect of higher quantity of fly ash in concrete. Compressive strength of these mixes was determined at 7, 28 days. They reached their target mean strength and compared with proposed prediction equation.

By Prof. Chandrakant B Shah et.al, their study was aimed in finding the trends due to replacement of Portland cement by processed fly ash of compressive strength of standard 70.7 mm mortar cubes at the ages of 3, 7, 28, 56 and 90 days. The percentage replacements were 40, 45, 50 and 55 respectively. Test showed that although the initial strengths were lower than that for only OPC, for mix at later age, the results were close to that of OPC. The study showed that replacement of OPC 53 grade cement by processed fly ash up to 55 to 60 % would be possible.

P. M. Shanmugavadiv etal. have shown from water permeability test that permeability reduced with increase in proportion of manufactured sand. This may be due to less voids present in concrete with manufactured sand showing better bonding between the aggregate and cement paste. Results of rapid chloride penetration test shows that chloride ion penetrability is high for concrete with natural sand while it is reduced using manufactured sand. They attribute this due to coarser grain size of manufactured sand resulting in better packing of particles. They suggest that 70% of manufactured sand in concrete is the optimum replacement for natural sand for better results.

3.EXPERMENTAL INVESTIGATION- This experimental program consists of the following steps:

- Materials used
- Casting
- Curing
- Testing

3.1 Materials used

Cement- Ordinary Portland Cement of 53 grade available in local market of standard brand was used in the investigation. The Cement used has been tested for various proportions as per IS 4031-1988 and found to be conforming to various specifications of IS 12269-1987. The physical properties of Portland cement are given in below table.

Serial no	Property	Test results
1	Specific gravity	3.12
2	Fineness of cement	6%
3	Normal consistency	32%
4	Initial setting time	100min

5	Final setting time	170min

Table: 1 Physical properties of Ordinary Portland Cement

Fine aggregate-In the present investigation locally available natural Sand and artificial sand was used as Fine Aggregate. The physical properties of Natural Sand and artificial sand are tabulated in below Table.

Property	**Natural Sand**	**Artificial Sand**
Specific Gravity	2.55	3.09
Bulk Density (loose) in kg/ m^3	1547	1592.15
Bulk Density (Compacted) in kg/ m^3	1681	1740.29
Fineness	2.46	2.86

Table 2: Physical Properties Of natural sand and artificial sand

Coarse aggregate-Machine Crushed angular granite metal of 20mm and 10mm size from the local source was used as Coarse Aggregate. The physical properties of Coarse Aggregate are given in below table.

S.NO	Parameter	Test value
1	Specific gravity	
	20 mm	2.85
	10 mm	2.65
2	Fineness modulus	8.62
3	Bulk density(Kg/cu. M.)	
	Loose	1548.14
	compacted	1696.3

Table 3: Physical Properties Of Coarse Aggregate

Fly ash- In the present investigation Class F Fly Ash from Vijayawada Thermal Power Station, Krishna Dist, and Andhra Pradesh was used as cement replacement material. The properties of fly ash are conforming to IS 3812-1981 of Indian Standard Specification for Fly Ash for use as Pozzolana and Admixture. Specific gravity of 2.29 was used.

Water-This is the least expensive but most important ingredient of concrete. The water which is used for making concrete should be clean and free from harmful impurities such as Oil, Alkalities, Acids, etc. In general the water which is fit for drinking should be used for making concrete.

Chemical admixtures-Usually the chemical admixtures used are high range water reducers (Super Plasticizers) and viscosity-modifying agents, which change the rheological properties of concrete. In this project work, super plasticizer CONPLAST SP 430 is used.

Hydrochloric acid- It is formed by the dissolution of gaseous hydrogen chloride in water. It is a strong volatile monoprotic acid that easily liberates acrid gaseous HCl. The maximum concentration of hydrochloric acid is approx. 38% HCl. Its salts are called

chlorides.Hydrogen chloride (HCl) is a monoprotic acid, which means it can dissociate (*i.e.*, ionize) only once to give up one H^+ ion (a single proton). In aqueous hydrochloric acid, the H^+ joins a water molecule to form a hydronium ion, H_3O^+.

$$HCl + H_2O \rightarrow H_3O^+ + Cl^-$$

3.2 Casting-The cast iron moulds are cleaned of dust particles and applied with mineral oil on all sides before concrete is poured in the moulds. The moulds are placed on a level platform. The well mixed green concrete is filled, allowed to flow and settle itself in the moulds. Excess concrete was removed with trowel and top surface is finished level and smooth. 150mm x 150 mm cubes were used. In this paper Total number of 36 cubes were casted.18 cubes are for Normal Mix and the 18 cubes are for Combined mix i.e., for 30 % replacement of flyash for cement and 50% replacement of artificial sand for natural sand.

3.3 Curing-The specimens are cured in mould for 24 hours. After 24 hours, all the specimens are demoulded and kept in curing tank for 28 days. After 28 days all specimens are kept in atmosphere for 1day for constant weight. subsequently, the specimens are weighed and immersed in 5% hydrochloric acid (HCl) solution for 30, 60, 90 days.

3.4 Testing- The specimens are tested by compression testing machine having capacity of 300T after 7, 28, 56 days of curing. Load should be applied gradually at the rate of 140 kg/cm^2 per minute till the Specimens fails. Load at the failure divided by area of specimen gives the compressive strength of concrete. For acid attack test after 28 days all specimens are kept in atmosphere for 1day for constant weight. subsequently, the specimens are weighed and immersed in 5% hydrochloric acid (HCl) solution for 30, 60, 90 days. After completion of age of immersing in acid solution, the specimens are taken out and were washed in running water and kept in atmosphere for 1day for constant weight. Subsequently the specimens are weighed and loss in weight and hence the percentage loss of weight was calculated.

Acid Durability Factor - Are determined directly in terms of relative strengths. The relative strengths are always with respect to the 28 days value (i.e at the start of the test).

Acid Durability Factors (ADF) = Sr (N/M)

where, Sr = relative strength at N days, (%)

N = number of days at which the durability factor is needed.

M = number of days at which the exposure is to be terminated.

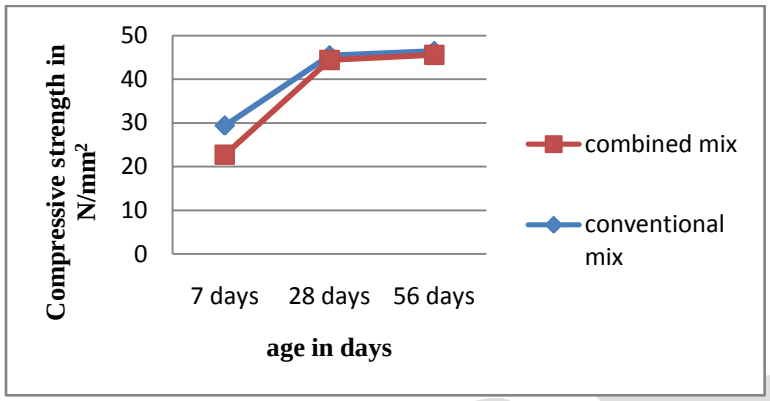
Acid Attack Factor - The extent of deterioration at each corner of the struck face and the opposite face is measured in terms of the solid diagonals (in mm) for each of the two cubes. Acid Attack Factors (AAF) per face is calculated as follows.

AAF = (Loss in mm on eight corners of each of 2 cubes) / 4

4. RESULTS

Compressive Strength results

Concrete mixes	7 days	28 days	56 days
Conventional mix	29.42 N/mm^2	45.48 N/mm^2	46.47 N/mm^2
Combined mix	22.74 N/mm^2	44.39 N/mm^2	45.56 N/mm^2

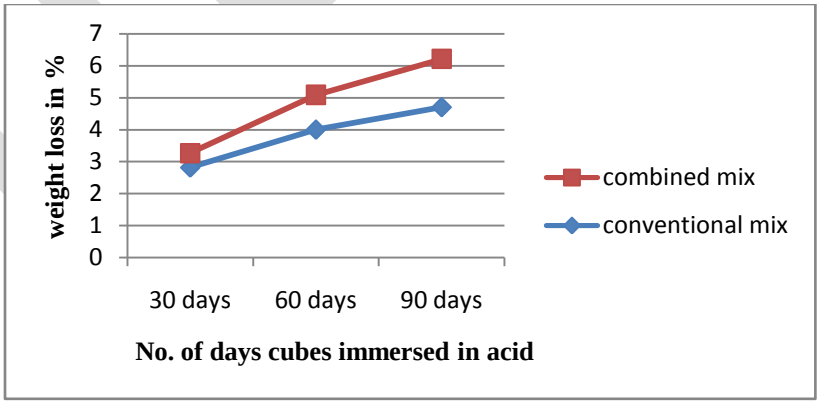


Graph 1: Variation of Compressive Strength with Curing time for two Mixes

Percentage Weight loss results

No. of days	Conventional mix			Combined mix		
	Average weight of cube before immersion in gm	Average weight of cube after immersion in gm	weight loss in %	Average weight of cube before immersion in gm	Average weight of cube after immersion in gm	weight loss in %
30 days	8500	8260	2.82	8550	8270	3.27
60 days	8500	8160	4.0	8550	8115	5.09
90 days	8500	8100	4.7	8550	8020	6.21

Table 4.2 Percentage Weight Loss For Conventional And Combined Mix

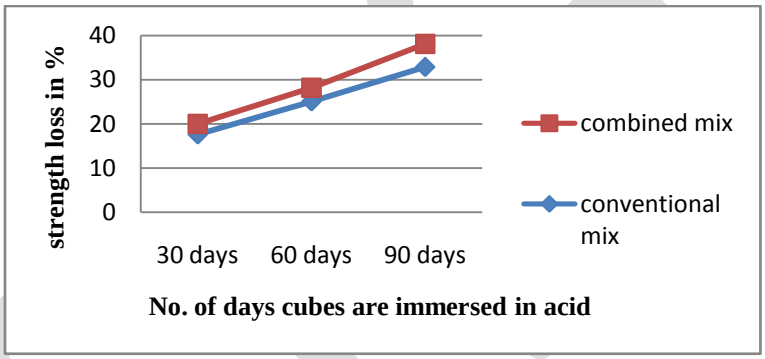


Graph 2: Shows the Percentage Weight Loss for Conventional and Combined mix at the ages of 30, 60, 90 days of Immersion of cubes in Acid (HCl)

Percentage Strength loss results

No. of days	Conventional mix			Combined mix		
	Average strength of cube before immersion in N/mm^2	Average strength of cube after immersion in N/mm^2	strength loss in %	Average strength of cube before immersion in N/mm^2	Average strength of cube after immersion in N/mm^2	strength loss in %
30 days	45.48	37.48	17.59	44.39	35.49	20.00
60 days	45.48	34.07	25.08	44.39	31.89	28.16
90 days	45.48	30.52	32.89	44.39	27.48	38.09

Table 4.3 Percentage Strength loss for conventional and combined mix

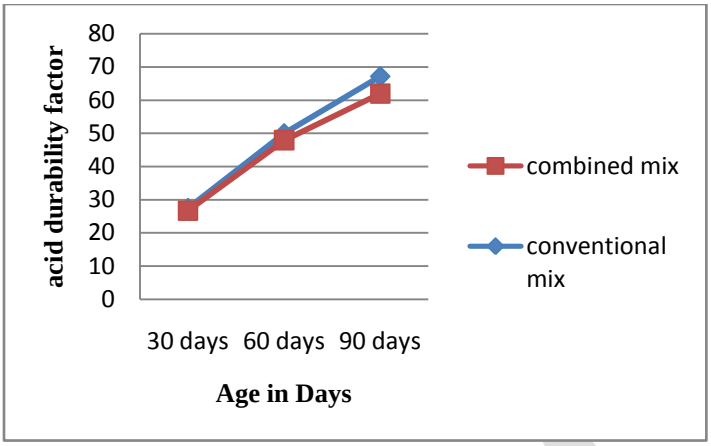


Graph3: shows the Percentage Strength loss for Conventional and Combined mix at the ages of 30, 60, 90 days of immersion of cubes in Acid(HCl)

Acid durability factor

No. of days	Conventional mix				Combined mix			
	Sr	N	M	ADF	Sr	N	M	ADF
30 days	82.41	30	90	27.47	80	30	90	26.66
60 days	74.92	60	90	49.94	71.84	60	90	47.89
90 days	67.11	90	90	67.11	61.91	90	90	61.91

Table 4.4 Acid Durability Factor

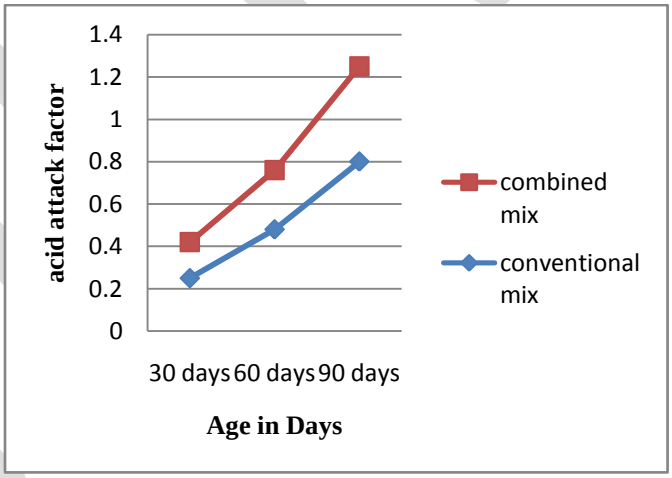


Graph 4: shows the acid durability factor for conventional and combined mix at the ages of 30, 60, 90 days of immersion of cubes in acid(HCl).

Acid attack factor

Age in days	AAF	
	Conventional mix	Combined mix
30 days	0.25	0.42
60 days	0.48	0.73
90 days	0.80	1.25

Table 4.5 Acid Attack Factor



Graph 5: shows the acid attack factor for conventional and combined mix at the ages of 30, 60, 90 days of immersion of cubes in acid(HCl)

CONCLUSIONS-From the results obtained in this investigation, the following conclusions can be drawn:

- The Combined Mix reduces its Compressive Strength by 6.68 N/mm^2 at the age of 7 days, 1.09 N/mm^2 at the age of 28 days and 0.91 N/mm^2 at the age of 56 days.

- The Strengths for the combined mix at the earlier age i.e., at the age of 7 days is very low where as the Strengths at the later ages i.e., at the age of 28, 56 days is high.
- It is observed that the strengths for the combined mix increases gradually as the time of curing period increases.
- The Percentage Weight loss gradually increases as the number of days immersion of cubes in Acid increases. The Percentage weight loss for combined mix is more as compared to the Conventional mix. The Percentage Wt. loss for Combined mix increases by 0.45% , 1.09%, 1.51% at the ages of 30, 60, 90 days respectively.
- The Percentage Strength loss gradually increases as the number of days immersion of cubes in Acid increases. The Percentage Strength loss for combined mix is more as compared to the Conventional mix. The Percentage Strength loss for combined mix is 2.41%, 3.08%, 5.2% more as compared to the Conventional mix at the ages of 30, 60, 90 days.
- The Acid Durability Factor for Combined mix is less as compared to the Conventional mix. The Acid Durability Factor for combined mix reduces at the percentages of 0.81, 2.05, 5.2 for 30, 60, 90 days.
- The Acid Attack Factor for Combined Mix is more as compared to the Conventional Mix. The Acid Attack Factor for Combined Mix is raises at the percentages of 0.17, 0.28 and 0.45 for 30, 60, 90 days respectively.
- The results obtained for combined mix are almost equal to that of the conventional mix, therefore it is recommended that both Fly Ash and Artificial Sand are replaced combined.

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