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Performance of Concrete with Partial Replacement of Cement by Flyash and Natural Sand by Artificial Sand

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ABSTRACT - Cement Concrete occupies the most important role in the field of Civil Engineering. It mainly consists of Cement, Fine Aggregate and Coarse Aggregate. In the Concrete, the Cement acts as a binding material for Fine Aggregate and Coarse Aggregate. Many investigations have been done on Fly Ash and Artificial Sand individually. The utility of Fly Ash as partial replacement in concrete mixes is rise on these days. 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 of Concrete Mix for 7 days, 28 days, 56 days of Curing Period and Durability Characteristics such as Acid Attack Test, Acid Durability Factor, Acid Attack Factor of Concrete Mix for 30 days, 60 days, 90 days results are analyzed and compared with the Conventional Mix.

KEY WORDS - Concrete, Fly Ash, Artificial Sand, Natural Sand, Coarse Aggregate, H_2SO_4 Solution, Compressive Strength, Acid Attack Test, Acid Durability Factor and Acid Attack Factor.

1. INTRODUCTION - Fly ash is one of the residues generated in coal combustion facilities, and comprises the fine particles that rise with the flue gases. Fly ash is produced by coal-fired electric and steam generating plants. Typically, coal is pulverized and blown with air into the boiler's combustion chamber where it immediately gets ignites, generates heat and produces a molten mineral residue. Boiler tubes extract heat from the boiler, cool the flue gases and cause the molten mineral residue to harden and form ash. Coarse ash particles, called as Bottom Ash or Slag, fall to the bottom of the combustion chamber, and the lighter fine ash particles, termed as Fly Ash, remain suspended in the flue gas. Before exhausting the flue gas, fly ash is removed by particulate emission control devices, such as filter fabric bag houses or electrostatic precipitators.

There are basically two classes of Fly Ash as defined by ASTM C618 as:

1. Class F Fly ash
2. Class C Fly ash

Natural or River sand are weathered and worn out particles of rocks and are of various grades or sizes depending upon the amount of wearing. Now-a-days good sand is not readily available, it is transported from a long distance. Those resources are also exhausting very rapidly. So it is a need of the time to find some substitute to natural river sand. The Artificial Sand produced by proper machines can be a better substitute to River Sand. The sand should be sharp, clean and course. The grains should be of durable material. The sand must be of proper gradation (it should have particles from 150 microns to4.75mm in proper proportion).

2.LITERATURE RIEVIEW –

A.H. L. Swaroop , K. Venkateswara Rao, Prof. P Kodandaramarao (2013) conducted durability studies on concrete with Fly Ash and GGBS with replacing 20% of cement by Fly Ash (FAC1), concrete made by replacing 40% of cement by Fly Ash (FAC2), concrete made by replacing 20% replacement of cement by GGBS (GAC1) and Concrete made by replacing 40% replacement of cement by GGBS (GAC2). The effect of 1% of H2SO4 and Sea Water on these concrete mixes are determined by immersing these cubes for 7days, 28days, 60days in above solutions and the respective changes in both compressive strength and weight reduction had observed and up to a major extent we can conclude concretes made by that Fly Ash and GGBS had good strength and durable properties comparison to conventional aggregate in severe Environment and they recommend that the use of fly ash between 20-40% replacement with cement for better results.

K. Uma Shankar & K. Suganya (2014) conduct Durability Study of structural elements using Fly Ash Aggregates by taking five different cement Fly Ash proportions of R1 (cement 10% and fly ash 90%), R2 (cement 15% and fly ash 85%), R3 (cement 20% and fly ash 80%), R4 (cement 30% and fly ash 70%), R4 (cement 40% and fly ash 60%) and shows that the higher quantity of fly ash in making fly ash aggregate specimens recorded lower weight losses during the Acid Resistance Test.

Nimitha. Vijayaraghavan, Dr. A.S. Wayal (2013) conducted studies on Effect of Manufactured Sand on Durability Properties of Concrete. Three types of replacements were taken i.e., 0%, 50%, 100% of Manufactured Sand by Natural Sand and concluded that The use of manufactured sand in the construction industry helps to prevent unnecessary damages to the environment and provide optimum exploitation of the resources.

Experimental results of M.G. Shaikh et al. suggest that the sharp edges of the particles in artificial sand provide better bond with the cement than the rounded part of the natural sand. Both concrete made using Artificial Sand and Natural Sand are moderate to Chloride Permeability.

3.MATERIALS –

3.1 CEMENT - Ordinary Portland Zurari Cement of 53 grade available in local market of standard brand having Fineness of 6%, Standard consistency of 32%, Specific Gravity of cement 3.1, Initial and Final setting time of 100 min and 170 min respectively was used in the investigation.

3.2 FLYASH – Fly ash having Specific gravity of 2.29 was used.

3.3 FINE AGGREGATE – Fine Aggregate normally consists of Natural, Crushed, or Manufactured Sand. Natural Sand is the usual component for Normal Weight Concrete. The Fine Aggregate having the following physical properties are used.

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

3.4 COARSE AGGREGATE - Coarse Aggregate in concrete occupy 35 to 70% of the volume of the concrete. It may be proper to categories the properties into two groups: exterior features (maximum size, particle shape, textures) and interior quality (strength, density, porosity, hardness, elastic modulus, chemical mineral composition etc.). Coarse Aggregate having properties of Specific Gravity of 2.85, Bulk Density (loose) 1621.77 kg/ m^3,Bulk Density (Compacted) 1774.37 kg/ m^3, Fineness 8.62 were used.

3.5 WATER - Water used for Mixing and Curing shall be clean and free from injurious amounts of Oils, Acids, Alkalis, Salts, Sugar, Organic materials or other substances that may be deleterious to concrete. Generally drinking and potable water is considered satisfactory for mixing concrete.

3.6 CONPLAST SP 430 - Conplast SP430 is based on Sulphonated Napthalene Polymers and supplied as a brown liquid instantly dispersible in water of Specific Gravity of 1.20 was used.

3.7 SULPHURIC ACID - Sulphuric acid is a highly corrosive strong mineral acid with the molecular formula H_2SO_4. It is a pungent-ethereal, colorless to slightly yellow viscous liquid which is soluble in water at all concentrations. Sometimes, it is dyed dark brown during production to alert people to its hazards. The historical name of this acid is Oil Of Vitriol. For preparing dilute sulphuric acid always put concentrated acid slowly into water, never vice versa, in order to avoid overheating of the liquid, as this often causes acid droplets to spew out of the vessel in all directions. Sulphuric acid is a very strong Diprotic Acid that forms two series of salts – Sulphates (e.g. Na_2SO_4, $CaSO_4$) and Hydrogen Sulphates (e.g. $NaHSO_4$).

$$H_2SO_4 \longleftrightarrow H^+ + HSO_4^-$$

$$HSO_4 \longleftrightarrow H^+ + SO_4^-$$

4.EXPERIMENTAL INVESTIGATION-Total number of 36 cubes were casted for this experimental work. 18 cubes are for Normal Mix (or) Conventional 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. 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 concrete cube of size 150 mm X 150 mm X 150 mm are prepared for the conventional mix and combined mix. The specimens are cast and 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% sulphuric acid (H_2SO_4) 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.

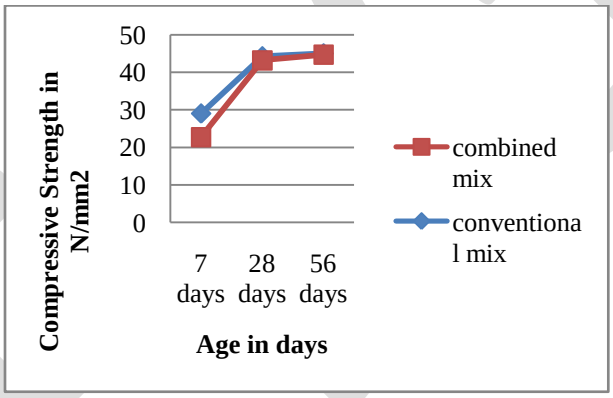
AAF = (Loss in mm on eight corners of each of 2 cubes) / 4

5. RESULTS

5.1 Compressive Strength results

Concrete mixes	7 Days	28 Days	56 Days
Conventional mix	29 N/ mm^2	44.25 N/ mm^2	45.02 N/ mm^2
Combined mix	22.74 N/ mm^2	43.16 N/ mm^2	44.65 N/ mm^2

Compressive Strength results for Conventional and Combined mixes

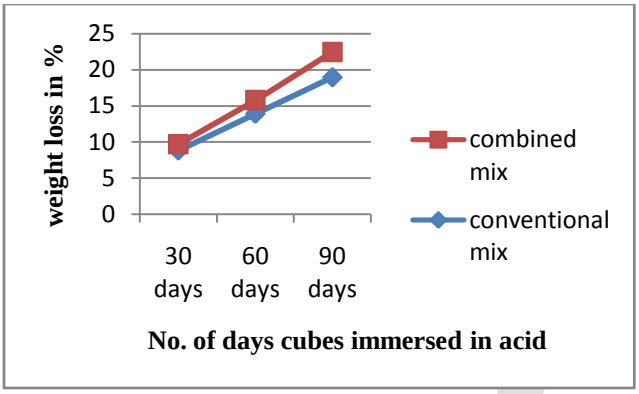


Graph 1 : Variation of Compressive Strength results for Conventional And Combined Mix

5.2 Percentage Weight loss results for conventional and combined mixes

No. of Days	Conventional mix			Combined mix		
	Average weight of cube before immersion in gm	Average weight of cube before immersion in gm	weight loss in %	Average weight of cube after immersion in gm	Average weight of cube after immersion in gm	weight loss in %
30 days	8500	7750	8.8	8550	7720	9.7
60 days	8500	7320	13.89	8550	7200	15.78
90 days	8500	6890	18.94	8550	6630	22.45

% Weight Loss results for both Conventional and Combined mixes

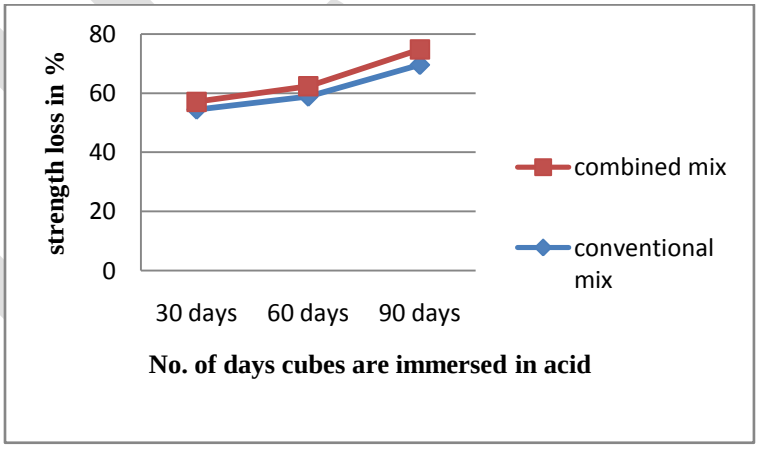


Graph 2 : Variation of Percentage Weight Loss results

5.3 Percentage Strength loss results for conventional and combined mixes

No. of days	Conventional mix			combined mix		
	Average strength of cube before immersion in N/mm^2 w.r.t28 days strength	Average strength of cube after immersion in N/mm^2	strength loss in %	Average strength of cube before immersion in N/mm^2 w.r.t 28 days strength	Average strength of cube after immersion in N/mm^2	strength loss in %
30 days	44.25	20.15	54.46	43.16	18.52	57.08
60 days	44.25	18.22	58.82	43.16	16.26	62.33
90 days	44.25	13.48	69.53	43.16	10.89	74.77

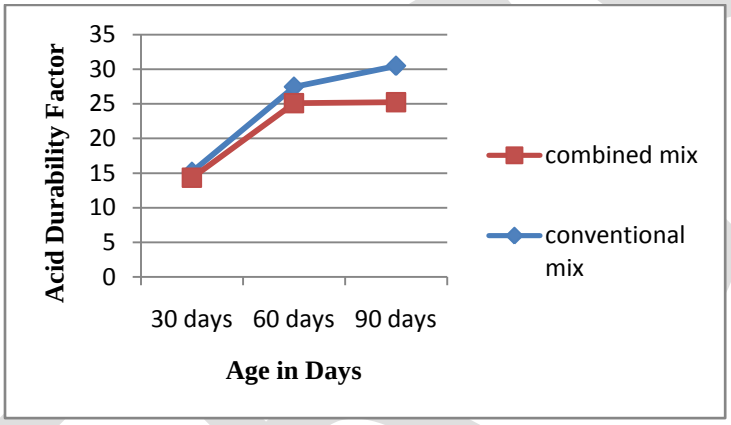
% Strength Loss results for both Conventional and Combined mixes



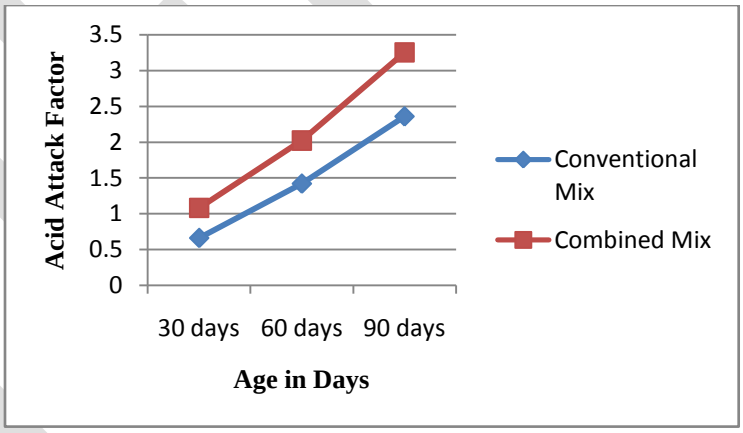
Graph 3 : Variation of percentage Strength Loss results

5.4 Acid Durability Factor and Acid Attack Factor results for conventional and combined mixes

No. of days	Conventional mix					Combined mix				
	Sr	N	M	ADF	AAF	Sr	N	M	ADF	AAF
30 days	45.54	30	90	15.18	0.66	42.92	30	90	14.31	1.08
60 days	41.18	60	90	27.45	1.42	37.67	60	90	25.11	2.02
90 days	30.47	90	90	30.47	2.36	25.23	90	90	25.23	3.25



Graph 4 : Variation of Acid Durability Factor results



Graph 5 : Variation of Acid Attack Factor results

CONCLUSIONS

1. It was observed that the strengths for the combined mix increases gradually as the time of curing period increases.

2. 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 weight loss for combined mix increases by 0.9% ,1.89%, 3.51% at the ages of 30, 60, 90 days respectively.
3. 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 2.62%, 3.51%, 5.24% more as compared to the conventional mix at the ages of 30, 60, 90 days.
4. 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 0.87, 2.34, and 5.24 for 30, 60, 90 days.
5. The Acid Attack Factor for Combined Mix is more as compared to the Conventional Mix. The Acid Attack Factor for Combined Mix raises at the percentages of 0.42, 0.6 and 0.89 for 30, 60, 90 days respectively.
6. 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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