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EFFECT OF SILICA FUME AND PARTIAL REPLACEMENT OF INGREDIENTS ON FLEXURAL AND SPLIT TENSILE STRENGTH OF CONCRETE

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ABSTRACT

Now-days, all over the world, construction activities are taking place on huge scale. Due to this there is great increase in cost of construction. Natural river sand is one of the key ingredients of concrete, is becoming expensive due to excessive cost of transportation from sources. Also large scale depletion of sources creates environmental problems. Unfortunately, production of cement also involves large amount of carbon dioxide gas into the atmosphere, a major contributor for green house effect and the global warming. To overcome these problems there is a need of cost effective, alternative and innovative materials. These materials are stone quarry dust, fly ash, silica fume, rice husk, recycled waste aggregate etc. some of them are industrial by products and are substantially available. In this paper a comprehensive effort is made to partially replace the natural river sand by stone quarry dust and cement by fly ash as an alternative in combination with mineral admixture, for concrete ingredients which shall lead to global sustainable development and lowest possible environmental impact and will also reduce cost of construction as well.

1. Introduction

Continues research efforts have established concrete as a versatile material; concrete required for extensive construction activity can be made available, since all the ingredients of concrete are of geological origin. In the production of concrete, granite/basalt stone and river sand are used as course and fine aggregate, respectively although these materials are usually available, at some places it is economical to substitute these materials by locally available once. River sand which is most commonly used as fine aggregate in the production of concrete and mortar possesses the problem of acute shortage and degradation problems in many areas. At the same time increasing quantity of crushed stone dust is available from crushers as waste. The disposal of this is a serious environmental problem. If it is possible to use this crushed stone dust in making concrete and mortar by partial/full replacement of natural river sand, then this will not only save the cost of construction but at the same time it will solve the problem of disposal of this dust. Engineers are continually pushing the limits to improve its performance with the help of innovative chemical admixtures and supplementary cementitious materials. Nowadays, most concrete mixture contains supplementary cementitious material which forms part of the cementitious component. These materials are majority byproducts from other processes. The main benefits of SCM's are their ability to replace certain amount of cement and still able to display cementitious property, thus reducing the cost of using Portland cement. The fast growth in industrialization has resulted in tons and tons of byproduct or waste materials, which can be used as SCMs such as fly ash, silica fume, ground granulated blast furnace slag, steel slag etc. The use of these byproducts not only helps to utilize these waste materials but also enhances the properties of concrete in fresh and hydrated states. In present study, fly ash is used as SCM to replace cement partially, from 0% to 40 % at the increment of 10%.And silica fume is used as admixture to further enhance the properties of concrete.

Fly ash is major by product as waste material generated by thermal power plant. It is finely divided residue from the combustion of pulverized Bituminous coal or Sub-Bituminous coal (Lignite) in thermal power plants. Silica fume is the byproduct resulted during manufacturing of Silicon or ferrosilicon, having very fine particles .The fineness of Silica fume improves the properties of concrete. NADGIR AND BHAVIKATTI(1), Studied addition of silica fume and stone quarry dust for conventional concrete with no plasticizer fixing one suitable proportion for addition of silica fume, the placement of stone quarry dust is varied from 0 to 60%. The compressive strength of concrete cubes increase with increase in curing ages for all combinations of stone quarry dust percentage for selected concrete mix M15 and M20. Compressive strength of concrete found highest for replacement of sand for 40%, with stone quarry dust. SAHU, SUNIL KUMAR AND SACHAN (2) Studied the suitability of crushed stone dust waste as fine aggregate for concrete which has been assessed by comparing its basic properties with that of conventional concrete. To achieve M20 and M30 grade concrete, the equivalent mixes were obtained by replacing natural sand by stone dust partially and fully. Test result indicate that crushed stone dust waste can be used effectively to replace natural sand in concrete. Concrete made with this replacement can attain the same compressive strength, comparable tensile strength etc. YILMAZ KOCAK (4), studied mutual influence of fly ash and silica fume with Portland cement. The ternary use of fly ash and silica fumes provided the best performance for compressive strength properties of mortar

2. Experimental Program

2.1 Materials and Properties

2.1.1 Fine aggregate

a) Sand: Penganga river sand was used as fine aggregate. The size of sand used is 4.75 mm and down size. The properties of fine aggregate investigated are presented in table no.1. The specific gravity of sand is 2.66.

b) Crushed stone dust: Crushed stone dust used in the laboratory investigations was procured from a local crushing plant at Pusad.The specific gravity of stone dust is 3.00. The properties of fine aggregate investigated are presented in table no. 2. The size of stone dust used is 300µ to 4.75mm.

2.1.2 Coarse Aggregate

The coarse aggregates were available at college site from local quarry. The size of coarse aggregate used is 20 mm and down size.

2.1.3 Binding Materials

a) Cement: Pozzolana Portland cement (PPC) of brand, Ambuja Cement is used. The standard tests were conducted and all the results were found satisfactory as per IS code.

b) Fly ash: The fly ash was whitish Grey coloured and procured from Thermal power plant situated at Paras near Akola (MS). Fineness of fly ash used is 11%

2.1.4 Admixture (Mineral)

a) Silica fume: Silica fume used is a product from Oriental Trexim Private Ltd. Mumbai. It is a byproduct resulting from reduction of high purity quartz with coal or coke and wood chips in an electric arc furnace during the production of silicon metal or Ferro silicon alloys. The specific gravity of silica fume is 2.2.It consist of 0.1 to 1 micron sized fine ,smooth spherical glassy particles with fineness of 20m² /gm.

2.1.5 Water

Water used is potable water available at the college.

Table no.1 Physical Properties of Crushed Stone Dust

Sr. No.	Property	Average
1	Specific Gravity	3.0
2	Fineness Modulus	2.67
3	Water Absorption	0.5 %
4	Surface Texture	Rough
5	Particle Shape	Angular

Table No.2 Physical Properties of Sand

Sr. No.	Property	Average
1	Specific Gravity	2.66
2	Fineness Modulus	3.1
3	Water Absorption	1.62%
4	Surface Texture	Smooth
5	Particle Shape	Rounded

Table No.3 Physical Properties of Coarse Aggregate

Sr. No.	Property	Average
1	Specific Gravity	2.95
2	Fineness Modulus	7.69
3	Water Absorption	0.60%
4	Particle shape	Angular
5	Crushing value	17.40
6	Impact Value	12.50

2.2 Preparation of Specimens

The measurement of materials was done by weight by using electronic weighing machine. Water was measured by volume. Hand mixing was adopted throughout the experiment. Concrete was placed into moulds in layers; hand compaction was done using tamping rod and then vibrated on table vibrator to remove air bubbles. Surface was leveled by trowel to a proper finish. Specimens were kept for curing after demoulding, in water for 27 days. The specimens were numbered before placing them in water tank for curing.

a) Constant Parameters

- Mix proportion of concrete selected - 1:1.5:3
- Type of cement- PPC
- Type of Coarse aggregate
  I) Sand < 4.75mm
  II) Crushed Stone Dust size < 4.75mm
  III) Coarse Aggregates < 20mm
- Period of curing: is 7, 28 days for flexure test and 7, 15,28 days for split tensile test
- Silica fume 2% (Admixture)

b) Variable Parameters

- Fly ash replacing cement by 0% to 40% at the increment of 10%.

4. Mix selection

The grade of concrete adopted for investigation is M 20. The mix proportion used is 1:1.5:3 with water cement ratio 0.45 .the details of mix designations and specimens used in experimental program are given in Table No.4

Table No.4 Details of mix designations

	Mix Designation	Binding materials		Fine aggregate		Coarse aggregate
		Cement	Fly ash	Sand	Crushed Stone dust	
1	F00	100%	--	60%	40%	100%
2	F10	90%	10%	60%	40%	100%
3	F20	80%	20%	60%	40%	100%
4	F30	70%	30%	60%	40%	100%
5	F40	60%	40%	60%	40%	100%

5. Test

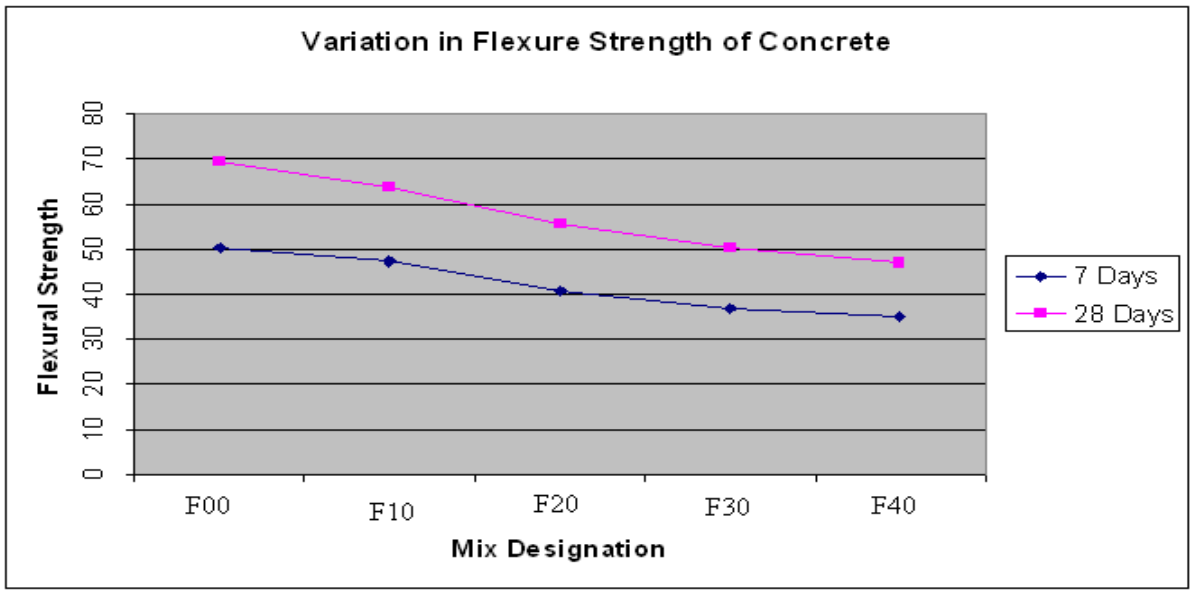
For each batch of concrete, three prisms of 100mm x 100mm x 500mm size were tested to determine flexure strength of concrete and three cylinder of length 300mm x 150mm diameter were tested to determine split tensile strength of concrete.

6. Result and Discussion

Comparing the properties presented in Table No.1 and Table No.2 it is observed that the specific gravity stone quarry dust is higher than sand. The water absorption of stone quarry dust is higher than that of sand.

Due to rough texture and angular shape of Crushed Stone dust the concrete becomes low workable, but on the other hand there is good bonding among the ingredients as compare to conventional concrete ingredients. Figure No.1and 2 shows details of variation of flexure strength and split tensile strength of concrete for various replacement levels of cement with fly ash respectively.

It is observed that the flexure strength and split tensile strength for mix designations F00 (100% cement & 0%fly ash) is about 35-40 % higher than the conventional concrete. The increase in replacement of cement with fly ash results in gradual decrease in the strength of concrete.



Note- Flexure Strength of concrete is given in kg/sq.cm

Figure No. 1

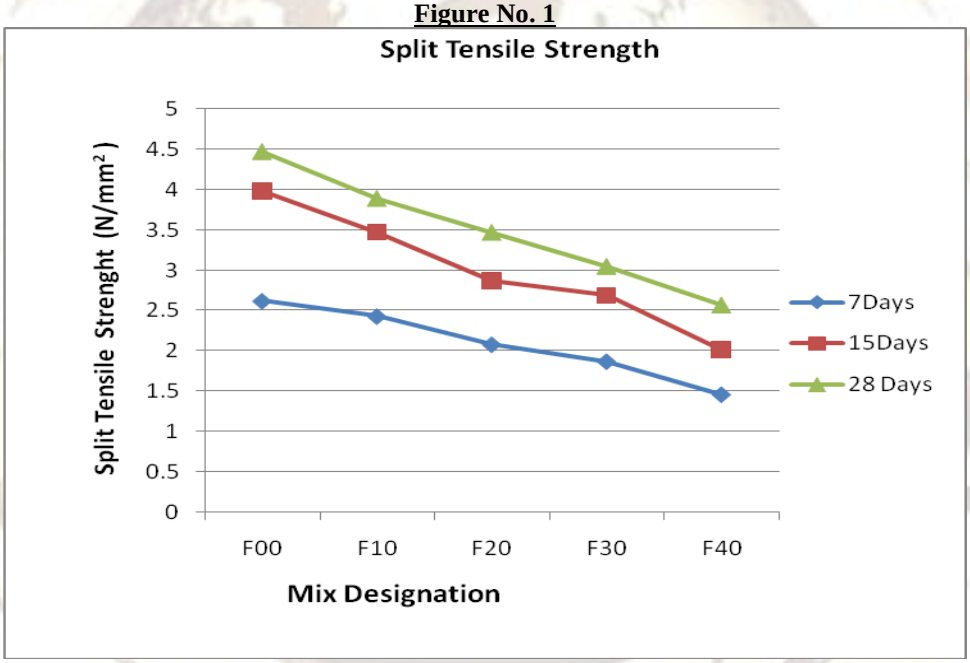


Figure No. 2

7. Conclusion

The following conclusions are drawn from the present investigation carried out

- Crushed Stone dust can be partially used as fine aggregate with conventional river sand in concrete.
- Replacement of even PPC cement with fly ash is possible up to 30%.
- Combination of Silica fume and fly ash makes the concrete more cohesive and dense, thus reduces the permeability. This makes the concrete more durable.
- There will be a good reduction in the cost of concrete by the usage of fly ash.

8. References

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