AN EXPERIMENTAL STUDY ON THE PROPERTIES OF CEMENT CONCRETE MADE BY REPLACING CEMENT BY SILICA FUME AND FINE AGGREGATE BY STONE DUST

Nagaradona Mahaboob Basha[1]
Department of Civil Engineering
JNTU ANANTAPUR

C Rajamallu[2]
Department of Civil Engineering
JNTU ANANTAPUR

Abstract— Natural river sand is expensive due to excessive cost of transportation from natural sources. Also large-scale depletion of these sources creates environmental problems, transportation and other constraints make the availability and use of river sand less attractive, a substitute or replacement product for concrete industry needs to be found. In such a situation the Stone dust can be an economic alternative to the river sand. Stone Dust can be defined as residue, tailing or other non-voluble waste material after the extraction and processing of rocks. Use of Stone dust as a fine aggregate in concrete draws serious attention of researchers and investigators. The use of Silica fume in concrete is desirable because of benefits such as useful disposal of a by-product, increased workability, reduction of cement consumption, increased sulfate resistance, increased resistance to alkali-silica reaction and decreased permeability. However, the use of fly ash leads to a reduction in early strength of concrete. However, the use of stone dust leads to a reduction in the workability of concrete. Therefore, the concurrent use of stone dust and silica fume in concrete will lead to the benefits of using such materials being added and some of the undesirable effects being negated. The decrease in early strength by the addition of silica fume is ameliorated by the addition of stone dust. The decrease in workability by the addition of stone dust is reduced by the addition of fly ash. This dissertation work presents the feasibility of the usage of Stone Dust as hundred percent substitutes for Natural river Sand and silica fume as ten percent substitutes for cement in concrete.

Keywords: Interfacial Transition Zone, Ettringite, Silica fume, Landfills, CSH-Gel.

I. INTRODUCTION

Concrete is a composite material that consists essentially of a binding medium within which are embedded particles of fragments of aggregates. In hydraulic cement concrete, the binder is formed from a mixture of cement and water. Cement is a finely powdered material, which by itself is not a binder, develops binding properties as a result of hydration. Worldwide environmental organizations continuing to increase pressure on the cement and aggregate industries to reduce CO_2 emissions, and reduce the extraction of naturally occurring aggregates, new and innovative solutions are constantly being sought to provide replacement materials which can be substituted for the primary aggregates. Silica fume is a by-product of the manufacture of silicon and ferrosilicon alloys from high purity quartz and coal in a submerged-arc electric furnace. The escaping gaseous SiO oxidized and condensates in the form of extremely fine spherical particles of silica (SiO_2). Silica fume can have over 90% of amorphous silica which is highly reactive. The fineness of the particles speeds up the reaction with calcium hydroxide (produced by the hydration of Portland cement).Silica fume has a diameter ranging between 0.03 and 0.3 μm, making it extremely fine and therefore the specific surface is also very high. This causes an increase in water demand, but also makes the mixtures very stable. The very high fineness also causes the particles to get in between the cement and thus improve packing, but this cannot compensate for the loss in workability. The addition of silica fume is usually around 6.5 to 8% by mass. It must be noted that silica fume is quite expensive. To overcome the stress and demand for river sand, researchers the use of quarry dust to replace river sand was reported by. The use of rock dust as an alternative to natural sand was also reported by. Use of crushed granite fines or crushed rock fines as an alternative to sand in concrete production was also reported. Similarly, stone dust as fine aggregate could be an alternative to natural sand. It is a by product generated from quarrying activities involved in the production of crushed coarse aggregates. Stone dust fine aggregate, which is generally considered as a waste material, causes an environmental load due to disposal problem. Hence, the use of stone dust fine aggregate in concrete mixtures will reduce not only the demand for natural sand but also the environmental burden. Moreover, the incorporation of stone dust fine aggregate will offset the production cost of concrete. In brief, the successful utilization of stone dust fine aggregate will turn this waste material into a valuable resource.

LITERATURE REVIEW

1. Mukesh B. Patel conclusions are drawn from the investigation carried out Crushed Stone dust can be partially used as fine aggregate with conventional river sand in concrete.

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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.

2. Experimental Studies on the Effect of Silica Fume and Quarry Dust in Concrete by U.Vamsi Mohan investigated that on the effective use of Silica Fume and Quarry Dust in concrete mix. The main parameter investigated in this study is M20 grade concrete with partial replacement of cement by silica fume by 0, 10 and 15%and Quarry dust by 20, 30, and 40%.

II. RESEARCH METHOD AND EXPERIMENTAL PROGRAMME

Obviously, the strength of mortar and concrete is intimately related to the strength of the hardened cement paste. The cement hydration products in the form of crystalline matter and gel govern these important properties. Strength of the maturing paste will vary with the type of binder used, with mixture proportions, and with the hydration conditions. The gel helps to maintain continuity in the hardening concrete by filling space between discrete elements on different structural levels. This holds for the crystalline matter on micro-level, as well as for the aggregate grains on meso-level. In preserving continuity, the internal bonding capacity is provided on which strength is relying. Several test methods are in use for the assessment of strength properties, i.e.: Direct test method, indirect test method, and Test method based on wave propagation.

To assess mechanism of cement blending with Silica fume and Stone dust underlying the strength of cement and concrete, it is necessary to determine physic-chemical properties in terms of composition and structure formed during the hardening process. This is complicated and time-consuming. Therefore, the direct method has been selected as major approach to determining strength in this study. Other methods have been used in a supplementary way for illustrating results obtained by the direct approach.

A. Proportioning Details

Mix Designation	Silica fume (%)	Stone dust (%)	Sand (%)
M0	0	0	100
M1	10	50	50
M2	10	80	20
M3	10	100	0

MIX PROPORTIONS

Ingredients	M0	M1	M2	M3
Cement (kg/m3)	400	360	360	360
Silica fume (kg/m3)	-	40	40	40
Stone dust (kg/m3)	-	286.63	458.61	573.27
Fine aggregate (kg/m3)	573.27	286.63	114.66	0
Coarse aggregate (kg/m3)	1213.61	1213.61	1213.61	1213.61
Water (kg/m3)	180	220	220	220

B. MATERIALS INVESTIGATION

Cement: In the present work, ordinary Portland cement of 53 grade Birla Super conforming to IS 12269:1987 has been used. The quantity of Cement is selected as 400 kilogram per cubic meter of Concrete; Fine & Coarse Aggregate: Confirms to the specifications of IS 383: 1970 for graded aggregates and specific gravity; Stone Dust & Silica Fume: Physical properties of Stone Dust as follows.

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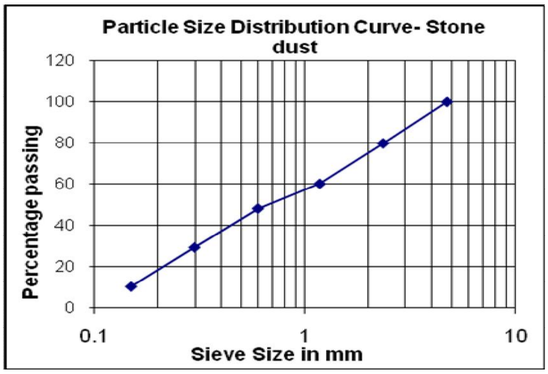


PHYSICAL PROPERTIES OF STONE DUST

PROPERTIES	OBTAINED VALUES
SPECIFIC GRAVITY	2.63
WATER ABSORPTION	0.6 %
A)DRY RODDED BULK	1807 KG/M3
B)LOOSE BULK DENSITY	1628 KG/M3
FINENESS MODULUS	2.72
SPECIFIC GRAVITY	2.63

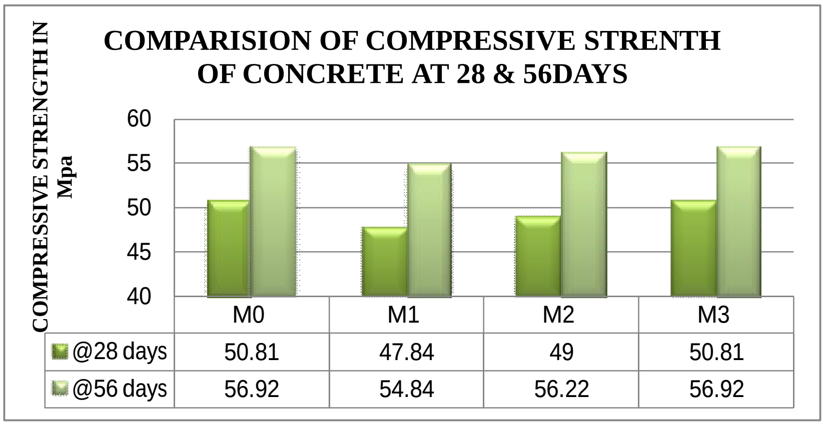
PHYSICAL PROPERTIES OF SILICA FUME

PROPERTIES	OBTAINED VALUES	ASTM-C-1240
LOSS OF IGNITION(LOI)	2.8 %	NOT MORE THAN 6%
MOISTURE	0.4 %	NOT MORE THAN 3 %
POZZ ACTIVITY INDEX	131 %	SHOULD BE MORE THAN
SPECIFIC SURFACE AREA	22 M2/GM	SHOULD BE MORE THAN
BULK DENSITY	590	RANGE BETWEEN 550 TO
+ 45 MICRONS	0.3 %	NOT MORE THAN 3 %

C. RESULTS AND DISCUSSIONS

RESULTS

MIX	AT FRESH STAGE		AT HARDENED STAGE			
	Compaction factor	Slump value(mm)	Compressive strength of Cubes(N/mm^2)		Avg. Flexural Strength of concrete	
			@28 days	@56 days	@28 days	@56 days
M0	91	50	50.81	56.92	2.79	3.8
M1	89	45	47.84	54.84	2.9	3.66
M2	86	37	49.00	56.22	3.01	3.75
M3	85	30	50.81	56.92	3.04	3.57



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DISCUSSIONS

The compressive strength and flexural strength for M20 concrete for both 28 days and 56 days is higher than the other proportions; the compressive strength for M1 concrete is 47.84 N/mm^2 and 54.84 N/mm^2 for 28days and 56 days respectively. The flexural strength for M1 concrete is 3.30 N/mm^2 and 3.66 N/mm^2 for 28days and 56 days respectively; the compressive strength for M2 concrete is 49.00 N/mm^2 and 56.22 N/mm^2 for 28days and 56 days respectively. The flexural strength for M20 concrete is 3.37 N/mm^2 and 3.75 N/mm^2 for 28days and 56 days respectively. This is higher than M10 and M30; the compressive strength for M30 concrete is 43.72 N/mm^2 and 53.53 N/mm^2 for 28 days and 56 days respectively. The flexural strength for M30 concrete is 3.01 N/mm^2 and 3.57 N/mm^2 for 28days and 56 days respectively. The compressive strength of cement mortar with replacement of 10% silica fume got the value of 27.14 N/mm^2 and 32.63 N/mm^2 for 28 days and 56 days respectively.

III. CONCLUSIONS

From the above results, it can be concluded that silica fume and stone dust can be effectively used in concrete, The inclusion of stone dust has desirable effect on concrete mechanical properties which is comparable to normal concrete. The usage of silica fume in concrete as cement replacement materials will lessen the CO2 being emitted during its manufacture and acts as a eco-friendly material reducing the Green house effect, Incorporation of these materials in concrete helps in making it more economical; The cost of stone dust is less compared to natural sand. Thus, it can be concluded that the replacement of natural sand with Stone Dust, as full replacement in concrete is possible. However, it is advisable to carry out trial casting with Stone Dust proposed to be used, in order to arrive at the water content and mix proportion to suit the required workability levels and strength requirement. Finally the Stone dust used as Fine Aggregate replacement enables the large utilisation of waste product, The workability of fresh concrete can be increased by adding suitable admixtures.

IV. REFERENCES

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AUTHORS

Nagradona Mahaboob Basha is from the India. He received the Bachelor in Civil Engineering degree from the JNTUH; He is currently pursuing the M.Tech degree in JNTUA affiliated college. His research interests include Concrete Technology and Framed Structures.

C.Rajamallu is from the India. He currently Head of the Department of Civil Engineering at Bheema Institute of Technology and Sciences, Adoni. He obtained his Masters degree Osmania University of A.P. His research papers very help full for the students who are interested in Concrete. His research interests include Concrete Technology, Reinforced Concrete Designs & Steel Structures.

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