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RESEARCH ARTICLE

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EFFECT OF REPLACEMENT OF NATURAL SAND BY FLY ASH, GGBS AND STONE CRUSHER DUST ON THE PROPERTIES OF CONCRETE

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ABSTRACT

Concrete is a widely used construction material, which can exhibit better strength and durability characteristics. At present in India, it is estimated that the annual consumption of cement concrete is 400 metric tons. This will definitely cause an equal demand on the materials like sand, aggregates and other materials required to produce huge quantity of cement concrete. This will gradually decrease all the natural resources connected in producing cement concrete every year. Sand is commonly used fine aggregate that is derived from river banks. Now a day's river sand is very costly material because of more constructional activities. Due to this situation, investigate began for alternative material to natural sand. For replacement of river sand some substitute materials have already been used such as fly-ash, bottom ash, quarry dust or limestone and siliceous stone powder, filtered sand, copper slag. The main objective of this experimental investigation is to find out the effect of replacement of natural sand by fly ash, GGBS and quarry dust on the properties of concrete. The percentage substitution of natural sand by (Quarry dust + Fly ash) and (Quarry dust + GGBS) adopted in the experimentation are (5%+5%), (10%+10%), (15%+15%), (20%+20%), (25%+25%), (30%+30%) and (35%+35%). The workability characteristics are studied through slump. The strength characteristics such as compressive, tensile, flexural and shear strengths are studied. The work is carried out for M30 grade of concrete.

Keywords: Concrete, Quarry dust, Fly ash, GGBS, Natural sand

INTRODUCTION

Sustainability is a global concern and hence the goal of human kind should be to create a sustainable world. In order to achieve sustainability, methods that are to be selected are effective utilization of currently available resources for a longer period of time; minimize the wastage of material/ energy and controlling over use, and ensuring that there are reserves kept for future generations without complete debilitation. But the man's greed has influenced his own self to over-utilize, pollute and consume the natural resources around him without giving a thought for future generations or for the existence of other species.

In the construction industry, natural sand (river sand) is used as an important building material, and the world utilization of sand in concrete generation alone is around 1000 million tons per year, making it deficient and limited. The non-scientific method of removing the sand from the river beds has led to sinking of bridge piers and lowering of water table and change in direction of river courses leading to floods. Hence, the current focus of construction industry should be too partially or complete removal of natural sand in concrete by waste material or a material that is obtained through recycling, without compromising the quality of the end product.

The successful utilization of quarry dust as fine aggregate would turn this waste material that causes disposal problem into a valuable resource. The utilization will also reduce the strain on supply of natural fine aggregate, which will also reduce the cost of concrete (2). Fly ash is generally used as replacement of cement, as an admixture in concrete, and in manufacturing of cement. Whereas concrete containing fly ash as partial replacement of cement poses problems of delayed early strength development, concrete containing fly ash as partial replacement of fine aggregate will have no delayed early strength development, but rather will enhance its strength on long-term basis (7).

Objective of the study

Main objective of this experimental investigation is to find out the effect of replacement of natural sand by fly ash, GGBS and quarry dust on the properties of concrete. The percentage substitution of natural sand by (Quarry dust + Fly ash) and (Quarry dust + GGBS) adopted in the experimentation are (5%+5%), (10%+10%), (15%+15%), (20%+20%), (25%+25%), (30%+30%) and (35%+35%). The workability characteristics are studied through slump. The strength characteristics such as compressive strength, tensile strength, flexural strength and shear strengths are studied. The work is carried out for M30 grade of concrete.

Material used

Cement: Ordinary Portland Cement 43 grade conforming to IS: 8112 – 1989 was used.

Sand: Locally obtainable natural sand confirming to zone II of IS: 383–1970 was used for the work.

Coarse aggregate: Locally available crushed aggregates of size 20mm below confirming to IS: 383–1970 was used in this work.

Ground granulated blast furnace slag: In this experimental work, GGBFS obtained from JSW Cement factory, Hospet, India, confirming to IS 3812 (part 1):2003 was used.

Fly ash: In this experimental work, low calcium, class F fly ash obtained from Raichur thermal power plant conforming to IS: 3812 (Part 1) – 2003 was used.

Quarry dust: Quarry dust was obtained from Nelogal, Haveri District.

Water: Potable water was used.

Experimental results

Workability test result

Table1 gives the workability test results of concrete produced by replacing natural sand with the combination of (Quarry dust + Fly ash) and (Quarry dust + GGBS). The variation of slump is shown in fig.1

Table 1: Slump test results

% replacement of natural sand	Slump values (mm) for concrete produced by replacing natural sand by	
	(Quarry dust +Fly ash)	(Quarry dust + GGBS)
0	90	90
(5+5)	74	72
(10+10)	79	76
(15+15)	86	79
(20+20)	89	84
(25+25)	81	88
(30+30)	75	92
(35+35)	68	86

Strength test results

Tables 2, 3, 4 and 5 give the test results of compressive strength, tensile strength, flexural strength and shear strength of concrete produced by replacing natural sand with combination of (Quarry dust + Fly ash) and (Quarry dust + GGBS). Also it gives the percentage increase or decrease of strength with respect to reference mix. The variation of strength is depicted in the form of graph as shown in fig 2, 3, 4 and 5.

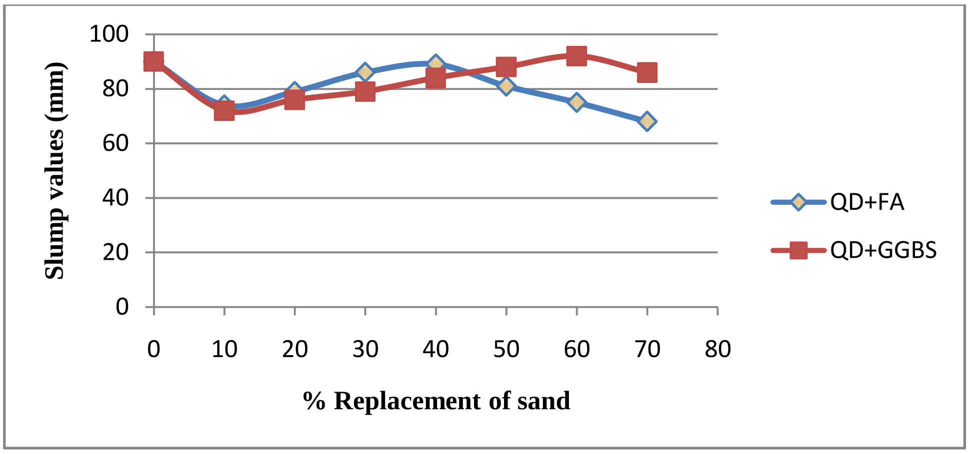

Fig.1: Variation in slump

Table 2: Results of compressive strength

Percentage replacement of natural sand	Compressive strength of concrete by replacing natural sand by (QD+FA) (MPa)	Percentage increase or decrease of compressive strength with respect to reference mix	Compressive strength of concrete by replacing natural sand by (QD+GGBS) (MPa)	Percentage increase or decrease of compressive strength with respect to reference mix
0	30.37	0.00	30.37	0.00
(5+5)	31.85	+4.87	30.81	+1.45
(10+10)	32.15	+5.86	31.26	+2.93
(15+15)	32.89	+8.30	32.00	+5.37
(20+20)	33.33	+9.75	32.89	+8.30
(25+25)	32.00	+5.37	33.63	+10.73
(30+30)	31.11	+2.44	34.37	+13.17
(35+35)	29.63	-2.44	32.74	+7.80

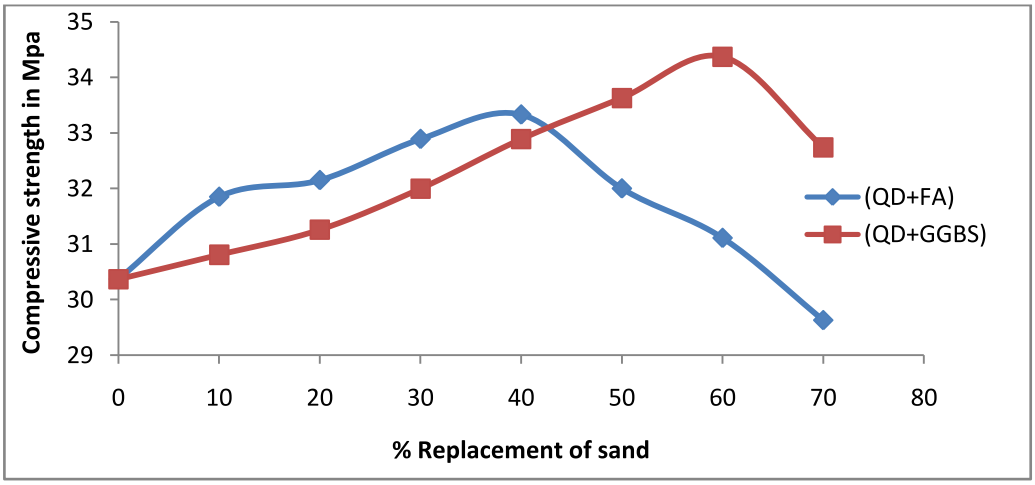

Fig. 2: Variation in compressive strength

Table 3: Results of split tensile strength

Percentage replacement of natural sand	Split tensile strength of concrete by replacing natural sand by (QD+FA) (MPa)	Percentage increase or decrease of Split tensile strength with respect to reference mix	Split tensile strength of concrete by replacing natural sand by (QD+GGBS) (MPa)	Percentage increase or decrease of Split tensile strength with respect to reference mix
0	2.40	0.00	2.40	0.00
(5+5)	2.50	+4.17	2.45	+2.08
(10+10)	2.59	+7.92	2.55	+6.25
(15+15)	2.69	+12.08	2.69	+12.08
(20+20)	2.88	+20.00	2.78	+15.83
(25+25)	2.69	+12.08	2.83	+17.92
(30+30)	2.64	+10.00	2.88	+20.00
(35+35)	2.31	-3.75	2.64	+10.00

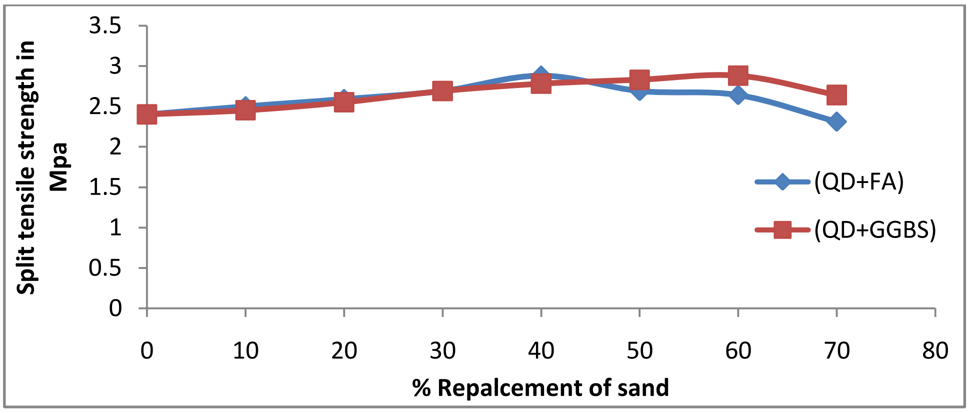

Fig. 1: Variation in split tensile strength

Table 4: Results of flexural strength

Percentage replacement of natural sand	Flexural strength of concrete by replacing natural sand by (QD+FA) (MPa)	Percentage increase or decrease of Flexural strength with respect to reference mix	Flexural strength of concrete by replacing natural sand by (QD+GGBS) (MPa)	Percentage increase or decrease of Flexural strength with respect to reference mix
0	4.73	0.00	4.73	0.00
(5+5)	4.93	+4.23	4.87	+2.96
(10+10)	5.00	+5.71	5.00	+5.71
(15+15)	5.20	+9.94	5.13	+8.46
(20+20)	5.47	+15.64	5.27	+11.42
(25+25)	4.87	+2.96	5.53	+16.91
(30+30)	4.60	-2.75	6.00	+26.85
(35+35)	4.00	-15.43	5.20	+9.94

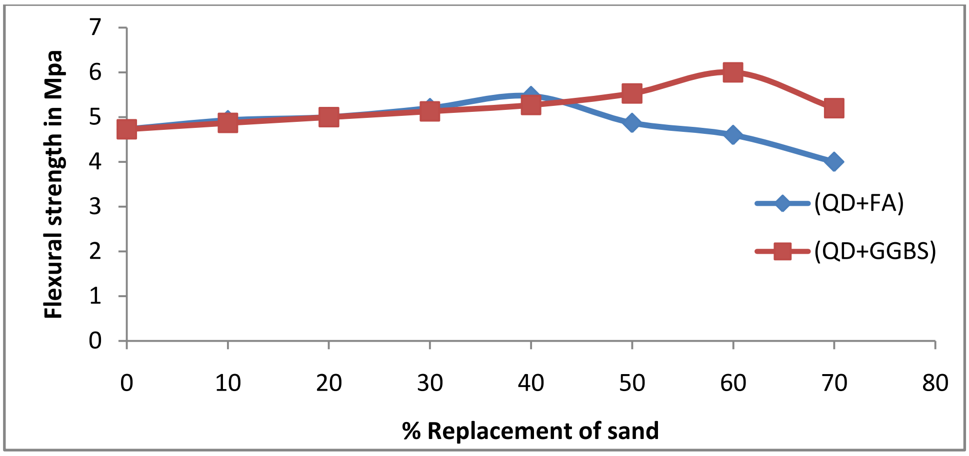

Fig. 4: Variation in flexural strength

Table 5: Results of shear strength

Percentage replacement of natural sand	Shear strength of concrete by replacing natural sand by (QD+FA) (MPa)	Percentage increase or decrease of shear strength with respect to reference mix	Shear strength of concrete by replacing natural sand by (QD+GGBS) (MPa)	Percentage increase or decrease of shear strength with respect to reference mix
0	4.26	0.00	4.26	0.00
(5+5)	4.63	+8.69	4.44	+4.23
(10+10)	4.81	+12.91	4.63	+8.69
(15+15)	5.00	+17.37	5.00	+17.37
(20+20)	5.56	+30.52	5.37	+26.06
(25+25)	4.81	+12.91	5.56	+30.52
(30+30)	4.26	0.00	5.74	+34.74
(35+35)	4.07	-4.46	5.00	+17.37

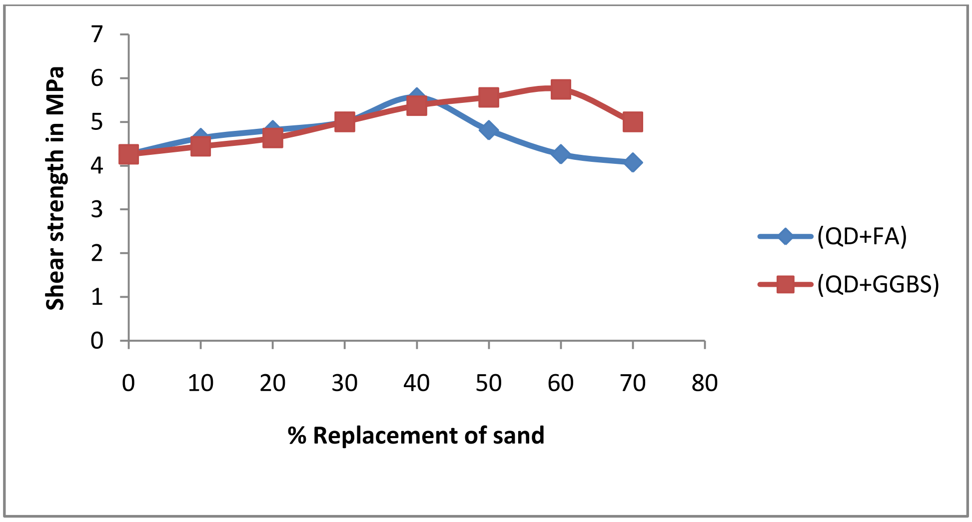

Fig . 2: Variation in shear strength

Observations and discussions

The following observations were made based on the experimentation conducted on the behavior of concrete by replacing natural sand by fly ash, GGBS and quarry dust.

1) It is found that the workability of concrete (as measured from slump) manufactured by replacing natural sand by (quarry dust + fly ash) go on increasing up to 40% substitution of natural sand by (quarry dust + fly ash). Thereafter the workability shows a decreasing trend. Thus the workability reaches the higher value when 40% natural sand is replaced by (quarry dust + fly ash)

Similarly It is found that the workability of concrete (as measured from slump) manufactured by replacing natural sand by (quarry dust + GGBS) go on increasing up to 60% substitution of natural sand by (quarry dust + GGBS).Thereafter the workability shows a decreasing trend. Thus the workability reaches the higher value when 60% natural sand is replaced by (quarry dust + GGBS)

This may be due to the fact that at 40% and 60% substitution levels of natural sand by (quarry dust + fly ash) and (quarry dust + GGBS) concrete respectively. The ball bearing actions of (quarry dust + fly ash) and (quarry dust + GGBS) is high there by inducing the flow characteristics to concrete.

Thus it can be concluded that the workability values reach the higher value when 40% natural sand is replaced (quarry dust + fly ash). Also it can be concluded that the workability values reach the higher value when 60% natural sand is replaced by (quarry dust + GGBS).

2) It is found that the compressive strength of concrete produced by replacing natural sand by (quarry dust + fly ash) go on increasing up to 40% substitution. Thereafter the compressive strength shows a decreasing trend. Thus the compressive strength reaches a higher value when 40% natural sand is replaced by (quarry dust + fly ash). A similar trend is observed when 60% natural sand is replaced by (quarry dust + GGBS).

3) It is found that the tensile strength of concrete manufactured by replacing natural sand by (quarry dust + fly ash) go on increasing up to 40% substitution. Thereafter the tensile strength shows a decreasing trend. Thus the tensile strength reaches a higher value when 40% natural sand is replaced by (quarry dust + fly ash). A similar trend is observed when 60% natural sand is replaced by (quarry dust + GGBS).

4) It is found that the flexural strength of concrete manufactured by replacing natural sand by (quarry dust + fly ash) go on increasing up to 40% substitution. Thereafter the flexural strength shows a decreasing trend. Thus the flexural strength reaches a higher value when 40% natural sand is replaced by (quarry dust + fly ash). A similar trend is observed when 60% natural sand is replaced by (quarry dust + GGBS).

5) It is found that the shear strength of concrete prepared by replacing natural sand by (quarry dust + fly ash) go on increasing up to 40% substitution. Thereafter the shear strength shows a decreasing trend. Thus the shear strength reaches a higher value when 40% natural sand is replaced by (quarry dust + fly ash). A similar trend is observed when 60% natural sand is replaced by (quarry dust + GGBS).

This may be due to the fact that at 40% and 60% substitution levels of natural sand by (quarry dust + fly ash) and (quarry dust + GGBS) concrete respectively. The pozzolinic reaction may be high thereby producing more C-S-H gel which is responsible for higher strength values. This may also be due to the effective pore filling effect.

Thus it can be concluded that the strength of concrete reaches higher value when 40% natural sand is replaced by (quarry dust + fly ash). Also it can be concluded that the strength of concrete reaches the higher value when 60% natural sand is replaced by (quarry dust + GGBS).

Conclusions

Following conclusions may be drawn based on the experimentation conducted on the behavior of concrete produced by replacing natural sand by (quarry dust + fly ash) and (quarry dust + GGBS).

- The workability of concrete as measured from slump is higher when 40% natural sand is replaced by (quarry dust + fly ash). Also the workability is when 60% natural sand is replaced by (quarry dust + GGBS).
- The compressive strength of concrete reaches higher value when 40% natural sand is replaced by (quarry dust + fly ash). Also

the compressive strength of concrete reaches the higher value when 60% natural sand is replaced by (quarry dust + GGBS).

- The tensile strength of concrete reaches higher value when 40% natural sand is replaced by (quarry dust + fly ash). Also the tensile strength of concrete reaches the higher value when 60% natural sand is replaced by (quarry dust + GGBS).
- The flexural strength of concrete reaches higher value when 40% natural sand is replaced by (quarry dust + fly ash). Also the flexural strength of concrete reaches the higher value when 60% natural sand is replaced by (quarry dust + GGBS).
- The shear strength of concrete reaches higher value when 40% natural sand is replaced by (quarry dust + fly ash). Also the shear strength of concrete reaches the higher value when 60% natural sand is replaced by (quarry dust + GGBS).

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