Experimental Study on Use of Quarry Dust and Fly Ash with Partial Replacement of Fine Aggregates and Cement in Concrete

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Abstract

Present era is the era of concrete because it is highly demanded material today. The basic raw materials for concrete are cement, sand and coarse aggregate. Due to depletion of natural rivers it is required to use other material than sand being used as fine aggregates. In this experimental study an attempt will be made to find the effect of partial replacement of Fine aggregate by Quarry Dust and Cement by Fly ash. The innovative use of Quarry Dust in concrete formulations as a fine aggregate replacement in the range of 0%, 15%, 30% & 45% by weight for M-40 grade cement (PPC). Fly ash is also used as partial replacement of cement in the same proportion. The specimen is produced and tested as an alternative to traditional concrete in terms of strength and durability aspects. The experimental investigation is concern to know the behavior, mechanical properties and durability aspects of concrete.
Keywords- Concrete, Quarry dust, Fly ash, Compressive strength, Acid Attack test, Sodium chloride test

I. INTRODUCTION

In today's era, Concrete is the widest building material which is used in the whole world. The constituents of concrete are coarse aggregate, fine aggregate, binding material and water. River sand is mostly used as fine aggregate component of concrete, but due to overuse of the material, led to depleting of securable river sand, creates environmental problems and thus increases in the cost of the same. Moreover, to maintain economy without interfering the strength the reuse of waste material has been emphasized. Fly ash (pulverized fuel ash) is also used extensively as a partial replacement of cement. However, though the inclusion of fly ash in concrete gives many benefits, such inclusion causes a significant reduction in early strength due to the relatively slow hydration of fly ash. This paper presents the viability of the usage of Quarry Rock Dust and Fly ash as percent substitutes for Conventional M40 grade Concrete. Mechanical properties such as compressive test, split tensile test and Durability tests such as sodium chloride and acid attack test were performed on cubes and cylinders of concrete in various percentages and compared with conventional concrete.

II. MATERIALS AND METHODS

1) CEMENT**:** Ordinary Portland Cement of 53 grade with specific gravity of 3.15 was used in the present experimental study conforming to IS 12269 – 1987
2) AGGREGATE (NATURAL RIVER FINE AGGREGATE): Locally available river sand having density of 1600 kg/m^3 and fineness Modulus (FM) of 2.88 is used. The specific gravity was found to be 2.67 as per IS 383:1970.
3) COARSE AGGREGATE: Natural granite aggregate having density of 1600 kg/m^3 and fineness modules (FM) of 8.11 was used. The specific gravity was found to be 2.9 and maximum size of aggregate was 20mm.
4) WATER: Potable water was used available in college premises for mixing and curing of concrete cubes.
5) QUARRY DUST: The quarry dust is the by-product which is formed in the processing of the granite stones which broken downs into the coarse aggregates of different sizes. The physical and chemical properties are listed in Table 1 and Table 2

Table 1: Physical Properties of Quarry dust

Property	*Natural Sand*	*Quarry Dust*	*Test Methods*
Specific Gravity	*2.67*	*2.60*	*IS 2386(Part –III,)-1963*
Bulk Relative Density(kg/m^3)	*1600*	*1750*	*IS 2386(Part –III,)-1963*
Absorption (%)	*Nil*	*1.3*	*IS 2386(Part –III,)-1963*

Moisture Content (%)	*1.50*	*Nil*	*IS 2386(Part –III,)-1963*
Sieve Analysis	*Zone III*	*Zone III*	*IS 383-1970*

Table 2: Chemical Properties of Quarry dust

Constituents	*Natural Sand (%)*	*Quarry Dust (%)*	*Test Methods*
SiO_2	*80.75*	*62.48*	*IS 4032-1968*
Al_2O_3	*10.52*	*18.73*	
Fe_2O_3	*1.75*	*6.54*	
CaO	*3.21*	*4.83*	
MgO	*0.77*	*2.56*	
Na_2O	*1.37*	*Nil*	
K_2O	*1.23*	*3.18*	
TiO_2	*Nil*	*1.21*	
Loss on ignition	*0.37*	*0.48*	

FLYASH: Fly ash is the best known and one of the most commonly used "pozzolans". Fly ash from Brick plant in ADIT campus is used. Class F is generally low in lime, usually under 5 per cent and contains of silica, alumina and iron. It improves the cement paste microstructure because of production of C-S-H, and it is reactive.

III. METHODOLOGY

During the present study, 0%, 15%, 30% and 45% of traditional fine aggregate was replaced with quarry dust and similarly cement is replaced with Fly ash. Thirty-six cubes were casted for mechanical properties for checking the compression test and similarly Twenty-four cylinders were prepared for split tensile test. On the other hand, for durability aspects Thirty-six more cubes were casted for acid attack and sodium chloride test respectively.

IV. TEST PROCEDURE

A. Compressive Strength

For compression test, 150 x 150 x 150 mm. sizes of cubes were taken. All the cubes were tested after wiping out the surface moisture. Three cubes for each mix of quarry sand with fine aggregate and cement with fly ash were tested at the age of 28 days curing using universal testing machine. The results of compressive strength of cubes for 7, 14 and 28 days curing are shown in Fig 1.

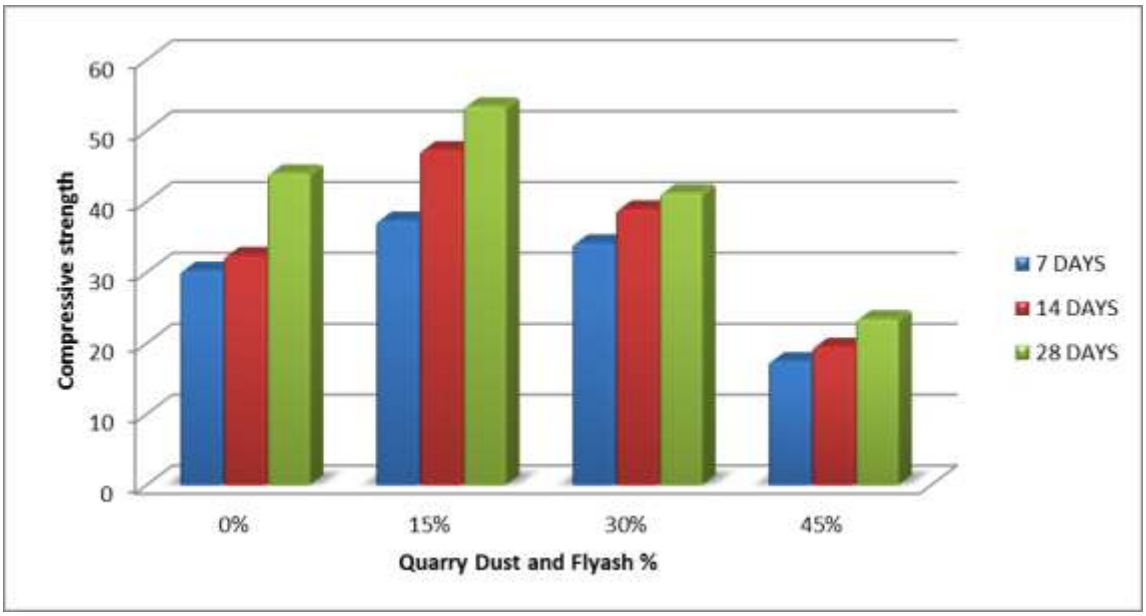

Fig. 1: Compressive Strength of M40 Grade concrete for 0%, 15%, 30% and 45% replacement for 7, 14 and 28 Days

B. Split Tensile Strength

For determining the tensile strength, 150 x 300 mm length cylinder specimen was taken. After 28 days of curing, they are being tested using universal testing machine. The load was applied gradually till the specimens split and readings were noted. The results of split tensile strength of cylinders for 7, 14 and 28 days curing are shown in Fig 2.

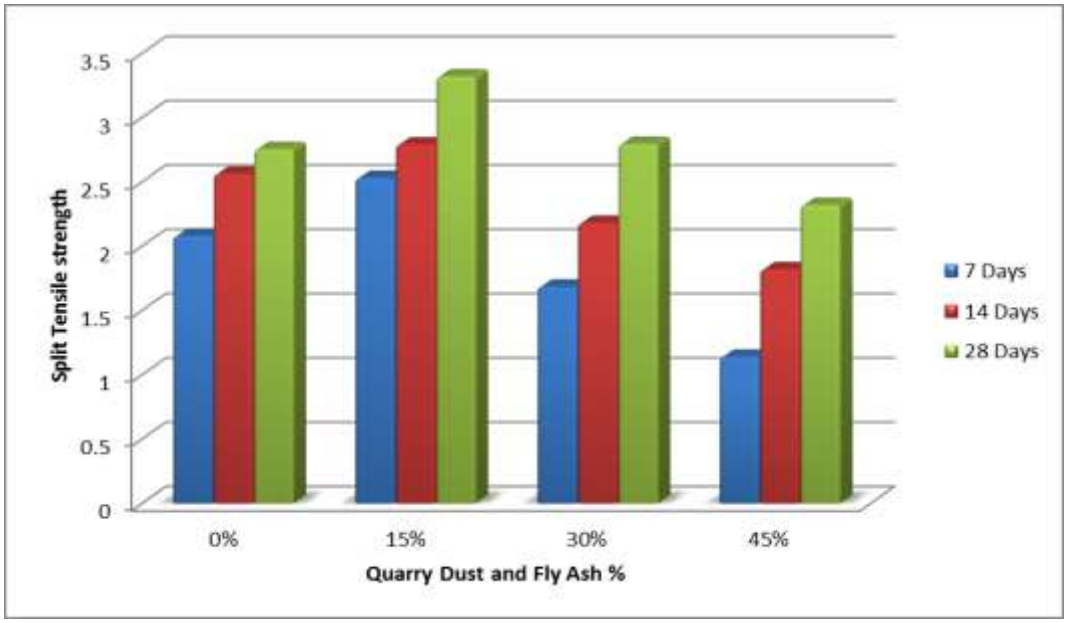

Fig. 2: Split Tensile Strength of M40 Grade concrete for 0%, 15%, 30% and 45% replacement for 7, 14 and 28 Days

C. Sodium Chloride and Acid Attack Test

For these tests, concrete cubes of size 150 x 150 x 150 mm are prepared for various percentages of fly ash and quarry dust. The specimens are casted and cured in mould for 24 hours, after 24 hours, all the specimen are demoulded and kept in curing tank for 28 days. After 28 days the specimens are weighed and immersed in 5% sulphuric acid (H_2SO_4) and in another tank 5% of NaCl solution for 7-14-28 days. After 7-14-28 days of immersing in solution, the specimens are taken out and were washed in running water and kept in atmosphere for 1-day for constant weight. Subsequently the specimens are weighed and loss in weight and hence the percentage loss of weight was calculated as shown in Table 3.

Table 3: weight of cubes before and after 28th days in H_2SO_4 and NaCl

Sr No	*Test performance*	*% of Replacement of Fly ash & Cement*	*Mass of cube before 28th day curing(kg)*	*Mass after 28th day (kg)*
1	*Acid Attack Test(H_2SO_4)*	*0%*	*9.00*	*8.97*
		15%	*8.61*	*8.45*
		30%	*8.65*	*8.47*
		45%	*8.32*	*7.96*
2	*Sodium chloride(NaCl)*	*0%*	*8.61*	*8.54*
		15%	*8.90*	*8.80*
		30%	*8.67*	*8.56*
		45%	*8.55*	*8.30*

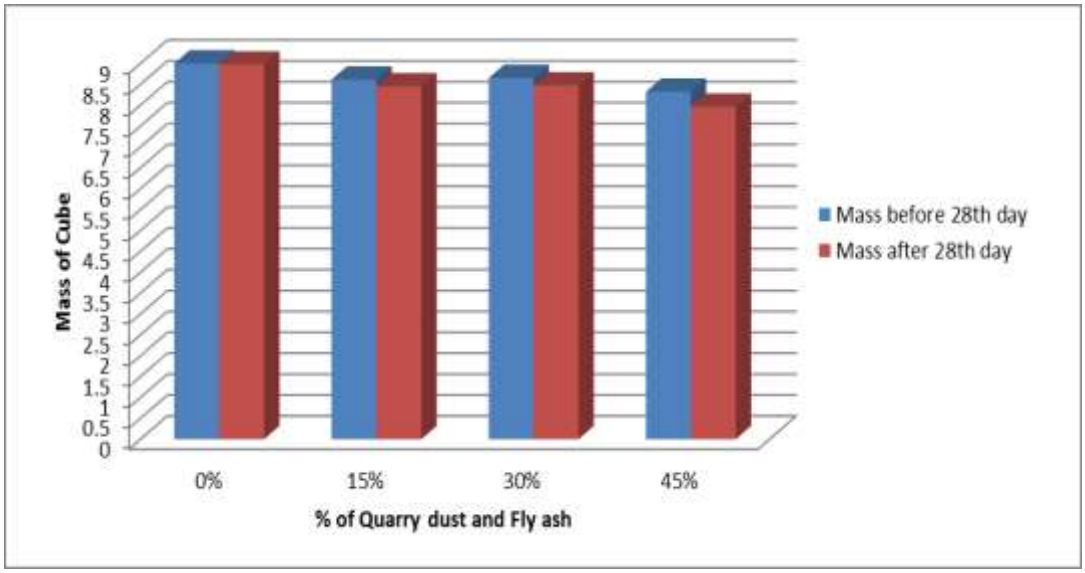

Fig. 3: Mass reduction of concrete cubes when dipped in H_2SO_4 solution

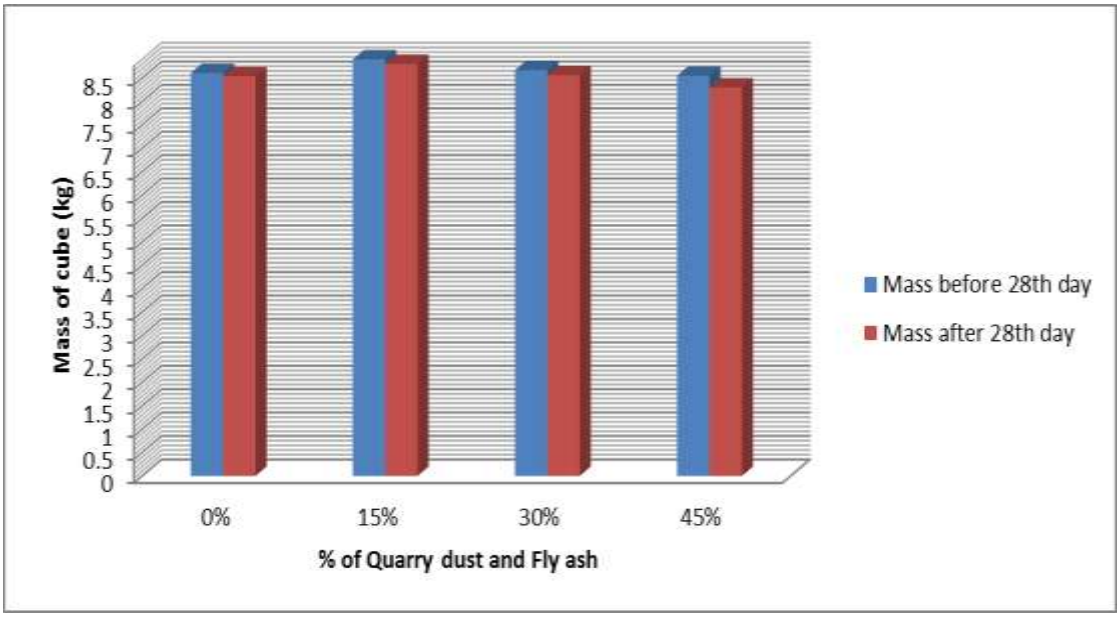

Fig. 4: Mass reduction of concrete cubes when dipped in NaCl solution

V. CONCLUSION

From the results of the experimental study, the following conclusions were drawn on concrete when quarry dust and fly ash are added in different proportions.

1) With the addition of 15% of fly ash and 15% of quarry dust the compressive strength increases to 22% then control mix M40 grade at 28 days. When 30% of fly ash and quarry dust is used, the compressive strength reduces to 20%. Thus for 15% addition of fly ash and quarry dust gives the optimum results.
2) The strength effectiveness was calculated for 28 days; it is found that for split tensile strength same results were obtained, the tensile strength increases at 15% of addition of fly ash and quarry dust, 20% increment is observed. For 30% addition, 15% strength reduction is found as compared to 15%.
3) On durability aspects, after 28 days curing in sulphuric acid and sodium chloride, the percentage of weight loss is minimum for different percentage of fly ash and quarry dust when compared to control mix concrete.
4) As the percentage increases the weight reduction in cubes also increases. For 45% the weight reduction is Sulphuric acid founds to be 4.323 and for Sodium chloride it is 2.928.
5) From study it is concluded that by using fly ash and quarry dust more durable and sustainable concrete can be produced by evaluating optimum content of both.

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