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Study on Strength Parameter of Conventional Concrete with Fly Ash and Quarry Dust as a Supplement

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Abstract: Never-ending process of research being done on concrete brings forth the wide variety of concrete that we can put into use today. However, people tend to lean towards items that are easily available, cheap and possessing quality at the same time. Fly ash is a waste product obtained from industries can be used instead of cement at certain levels could be beneficial as it helps in lessening the rate of environmental degradation. In this project, cement has been replaced by fly ash in certain levels such as 40% and 50% and fine aggregate has been replaced by quarry dust as 10% and 20%. Target strength of M30 has been achieved. The characteristic properties of the constituent materials are studied; compressive strength and split tensile strength tests results are reported. These specimens tested for 7, 28 and 56 days. From the results it is seen that in comparison with conventional concrete, the increase in the level of quarry dust resulted in a slight decrease in strength. In this study concrete with 50% fly ash replacement and 10% quarry dust replacement instead of cement and fine aggregate proves to be more beneficial as well as economical.

Keywords: Fly Ash, Quarry Dust, Strength

1. Introduction

Concrete is the most commonly used building material all over the world. It is estimated that a total of 4.3 billion tonnes of cement is produced worldwide annually with a rapid increase in demand [1]. Increasing works requiring concrete leads to large scale production of cement, which emits CO_2 causing global warming. Moreover, due to the increasing prices of sand, people opt for cheaper means without compromising its quality. Also, large numbers of restrictions are present in case of Ordinary Portland Cement. Disposal of industrial waste is a global problem. Additionally, the non-biodegradable nature of these wastes further increases severity of the problem [2]. Utilization of quarry dust in concrete is recommended particularly in regions where sand is not easily available [3].

To overcome these restrictions, fly-ash as percentage replacement in concrete with stone dust as sand supplement is studied in normal conditions to analyse the variation in their properties.

1.1. Significance of the Project

This paper helps us to know, effective use of sand replacement by stone dust along with fly-ash replacement for certain percentage of cement. Also, it helps in the utilization of the waste products taking a step further to reduce global warming effect and for a better environment.

1.2. Objectives

Based on the literature study the following objectives are highlighted:

1. To study the effect of quarry dust as fine aggregate in conventional concrete.
2. To study the strength behaviour of concrete made with different fly ash replacement levels (40% and 50%) and quarry dust replacement levels (10% and 20%).

3. To determine the compressive and split strength characteristics of fly ash concrete and replacement of stone dust combination in conventional concrete.

2. Methodology Followed

2.1. Materials Used

a) Cement

Cement is a binder which sets, hardens and therefore, binds materials together. The cementing action occurs due to the chemical reaction between cement and siliceous soil in the presence of water. Locally available Ordinary Portland Cement (OPC) of grade 43 is used as shown in Figure 1. Tests are conducted on cement to obtain its physical characteristics as per IS: 4031–1999 [2]. The preparation of the concrete specimen is confirmed to the requirements as per IS: 8112-1989 [3].

Figure 1. *View of Ordinary Portland cement of Grade 43.*

b) Fly Ash

Fly Ash is a residue or a by-product obtained from coal combustion. It is also defined as the fine particulate which is collected in the particle removal system of the combustion system. Fly Ash constitutes of elements such as silica, alumina and iron. It blends freely in mixtures and is almost spherical in shape. It solidifies while suspended in exhaust gases and is collected by using electrostatic precipitators. Its size ranges from 0.5 µm to 300 µm. Fly Ash collected from Udupi Power Corporation Limited (UPCL) is shown in Figure 2.

Figure 2. *View of Fly ash Collected from UPCL (Udupi).*

c) Coarse Aggregate

Coarse aggregates are the particles of size greater than 4.75 mm. For general construction purposes, it ranges between 9.5mm and 37.5mm in diameter. It makes up the solid and hard mass of concrete with cement and sand and helps in increasing the crushing strength of concrete. It occupies major volume of the concrete. It can have different shapes, namely, round, angular, flaky or irregular. The type of coarse aggregate shown in Figure 3 is of angular type and nominal size of 20 mm obtained locally in the market. Test results were obtained as per IS 383: 1970 [4].

Figure 3. *View of 20mm down size Coarse Aggregate.*

d) Fine Aggregate

Fine aggregate is basically defined as the sands won from the land or marine environment. It fills up the voids existing in the coarse aggregate and also to reduce shrinkage and cracking of concrete. It helps in hardening of cement by allowing water through its voids.

Figure 4 shows the fine aggregate which is locally available in the market being used for the study purpose. It is well graded and passing through 4.75 mm IS Sieve and retained on 75 micron IS Sieve. Test results were obtained as per IS 383: 1970 [4].

Figure 4. *View of Fine Aggregate.*

e) Quarry Dust

Quarry Dust is obtained from fine crushing of stones in quarries. In this study, it is used to replace fine aggregate at certain percentages. Figure 5 shows view of quarry dusts. Muhit et al. [5] determined that retaining from 100 mm sieve is used as sand replacement.

Figure 5. *View of Quarry Dust.*

f) Water

Water used in concreting plays an important role in mixing, laying, compacting, setting and hardening of concrete. The strength of the concrete directly depends on the quantity and quality of water used in the mix.

2.2. Preparation of Test Specimen

The concrete moulds were prepared with M30 grade of concrete. Mix design was carried out using IS 10262-2009 [6]. Target slump of 75 mm was obtained. In the mixer, dry mix was prepared by mixing sand and coarse aggregate to which cement was added.

Different fly ash replacement levels such as 40% and 50% and quarry dust replacement levels such as 10% and 20% was done as per the weight. Water was added according to the water cement ratio in the design mix and well mixed. 2 ml of commercially available super plasticizer (SP 430) was added per 1 kg of cement to get better workability. Moulds were demoulded after 24 hours and kept for curing. Specimens were tested on 7, 28 and 56 days.

2.3. Test Procedure

a) Preliminary Tests

Specific gravity test on Coarse aggregate, Quarry dust and Fine aggregate, cement and fly ash were conducted. Sieve analysis tests were conducted for coarse, fine and Quarry dust. Normal consistency test and setting time of cement (IS 4031-1988 [2]) and compressive strength of mortar cube were carried out.

b) Compression test

Test is carried out with reference to IS 516-1959 [7]. Test was performed at the age of 7, 28 & 56days with the help of Compressive testing machine (Figure 6). Weight and dimensions of specimens were measured before testing of specimen. Specimens are kept under compression testing machine (maximum capacity of 200 tonnes) so as to apply load on surface other than top and bottom surface. The load was applied without shock and continuously at a rate of approximately 14N/mm^2 until resistance of the specimen to the increasing load breaks and no greater load can be sustained. Total load applied at failure was recorded.

Compressive strength was calculated using the formula,

$$Compressive\,Strength\ (N/mm^2) = \frac{Breaking\ load}{Area}$$

c) Split Tensile Tests

This test is carried out with reference to IS 5816-1999 [8]. Test was performed at the age of 7, 28 & 56days with the help of Compressive testing machine (Figure 7). Diameteral lines were drawn on the two ends of specimen. Specimens were mounted on testing platform of compression testing machine. Two packing strips of plywood 12mm wide and 3mm thick were provided for each specimen. Uniform load was applied continuously until the specimen broke and the reading was noted.

Split Tensile strength was calculated from the formula,

$$Split\ \ Tensile\ \ Strength\ (N/mm^2) = \frac{2P}{\pi \times D \times L}$$

Figure 6. *Compressive Strength test on*

Concrete cube.

Figure 7. *Split Tensile Strength test on concrete cylinder.*

3. Results

3.1. Preliminary Test Results

i) Characteristics test results on coarse aggregate, quarry dust; fine aggregate and cement are represented in Table 1, Table 2, Table 3 and Table 4 & 5.

Table 1. *Characteristic test results on coarse aggregate.*

Sl. No	Particulars	Test Results
1	Specific Gravity	2.75
2	Type of Aggregate	Angular
3	Grade of Aggregate	Well graded
4	Water Absorption	0.5%

Table 2. *Characteristic test results on quarry dust.*

Sl. No	Particulars	Test Results
1	Specific Gravity	2.61
2	Zone of Aggregate	II
3	Grade of Aggregate	Well graded

Table 3. *Characteristic test results on fine aggregate.*

Sl. No	Particulars	Test Results
1	Specific Gravity	2.55
2	Zone of Aggregate	II
3	Grade of Aggregate	Well graded
4	Water Absorption	1%

Table 4. *Characteristic test results on cement.*

Sl. No.	Particulars	Test Results	IS Requirement
1.	Specific gravity	3.1	IS 2386 (Part III) [8]
2.	Normal Consistency	33%	IS 5513-1969 [9]
3.	Initial setting time	90 minutes	30 minutes
4.	Final setting time	280 minutes	600 minutes
5.	Compressive strength cement		
	3 days	25.5	≥23 N/mm^2
	7 days	34.8	≥33 N/mm^2
	28 days	46	≥43 N/mm^2

Table 5. *Specific Gravity test result of Fly ash.*

Sl.No	Particulars	Test Results
1.	Specific Gravity	2.44

ii) Discussions on preliminary test results are explained in Section 4.1.

3.2. Test Results on Conventional Concrete

Bar chart representation of conventional concrete is shown in Figure 8.

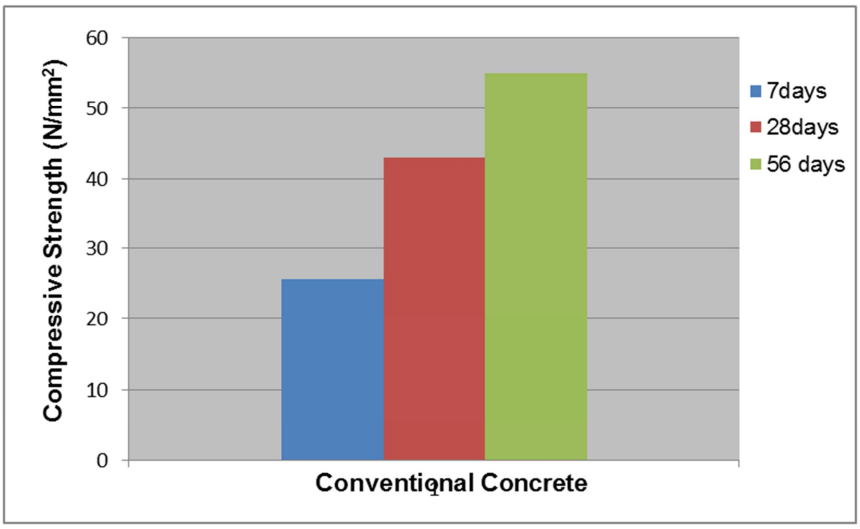

Figure 8. *Compressive Strength of conventional concrete for 7, 28 and 56 days.*

3.3. Test Results on Fly Ash Concrete with Quarry Dust

Different levels of replacement such as 40% and 50% of fly ash and 10% and 20% replacement of quarry dust for compressive strength (Figure 9) and Tensile Strength (Figure 10) is shown below.

a) Compression Test

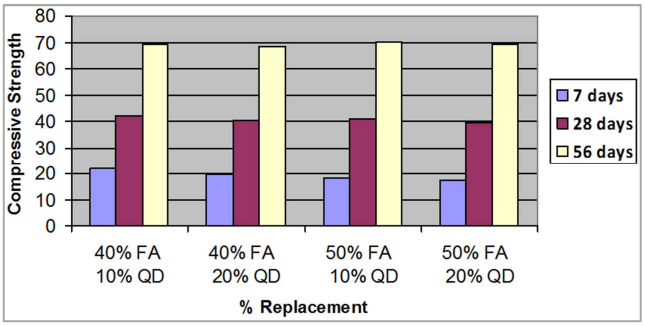

Figure 9. *Compressive Strength against % replacement for 7, 28 and 56 days.*

b) Split Tensile Test

Split Tensile Strength for Fly Ash Concrete with Quarry Dust replacement for 7, 28 and 56 days are shown in Figure 10.

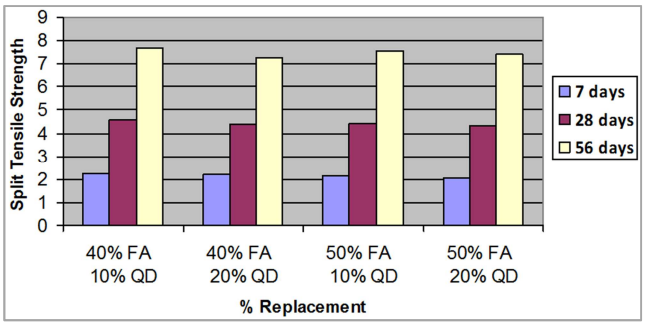

Figure 10. *Split Tensile Strength against % Replacement for 7, 28 and 56 days.*

4. Discussions

4.1. Discussion on Preliminary Test Results

From Table 1 and Table 2 it is observed that water absorption of coarse aggregate is lesser than the RCA, since the absorption capacity will be more in cement pastes coated aggregates.

Upon comparison to the limits provided as per the respective IS Code, the preliminary test results on coarse aggregate, fine aggregate, quarry dust, cement and fly ash were found to be standard and suitable for use in concrete works. Furthermore, the well graded aggregate and use of super plasticizer would result in better workability conditions.

4.2. Discussion on Conventional Concrete and Fly Ash and Quarry Dust Concrete

From the results it is observed that the 56 day compressive strength of fly ash based concrete is more than that of the conventional concrete. The best results are obtained for 50% fly ash and 10% quarry dust replacement levels as seen in Figure 9.

From Figure 10 it is seen that the split tensile strength of the concrete cylinders is almost equal to that of the conventional concrete. For 40% fly ash replacement and 10% quarry dust replacement shows higher value for the split tensile strength.

5. Conclusion

The concept of partial replacement of cement by fly ash and natural fine aggregate by quarry dust highlighted in the present investigation could improve the Based on the experimental investigation and results and discussion following conclusions are drawn.

Compressive strength of 56days fly ash based concrete shows 20% more strength compared to the conventional concrete. Experimental study reveals that effective compressive strength results of 50% fly ash and 10% quarry dust replacement levels are best suitable for the construction purpose. For Split tensile strength 40% fly ash and 10% quarry dust replacement levels shows the higher strength. In this study optimum value of 10% of quarry dust can be effectively replaced as sand replacement in concrete work.

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