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An Experimental Investigation on Strength Properties of Concrete by Partial Replacement of Cement with Fly Ash and Fine Aggregate with Stone Dust

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Abstract: ***Cement production leads to CO2 emissions generated during calcinations of CaCO3 and by burning of fuel, is responsible for about 5% of the CO2 emissions in the world. This can be reduced if the pozzolanic materials such as a flyash replacecement within the limits. Now-a-days river sand availability is also reduced and becomes difficult to find due to which there was a need to find an effective alternative. Stone dust, is found as an economic substitute material for river sand as it is a waste material which is obtained from the crusher plants. It can be used to replace river sand partially in concrete. In the present investigation, we have investigated the strength properties of the concrete made with stone dust as partial replacement of fine aggregate in concrete and fly ash as cement. M30 grade mix design is developed using IS design for conventional concrete and replaced mix. Cube specimens (150mm X 150mm) were prepared for both conventional and 30%, 60%, 100% replacement with quarry dust which were further modified by partially replacing cement with 10%, 20%, 30% and 40% of low calcium fly ash. Tests carried on specimens after 3days, 7days, 28days, 56days and 90 days curing to attain its maximum compressive strength. Graphs were drawn and results are compared with the controlled concrete.***

Index Terms: ***Compressive Strength, Flexural Strength, Replacement and Split Tensile Strength.***

I. INTRODUCTION

Cement industries are already facing the shortage of good quality raw materials to produce cement. Many industries are producing unmanageable amounts of wastes as by-products. A variety of these unwanted materials can be used as mineral admixture in concrete. Though, huge volume of natural mineral admixtures is to be used as ingredients for cement, concrete etc. So, continuous investigations are require to be carried out to utilize these greater amounts of by-products as natural mineral admixtures in cement and concrete. Concrete is widely used in making foundations, pavements, bridges, architectural structures, motorways, dams, reservoirs, pipes, fences and poles. The present day concrete demands high performance with economy. Concrete is a material with which any shape can be cast. It is very hard to find other construction materials like concrete.

The concrete properties mainly depend on its constituents. The main important materials used in making concrete are coarse aggregate, cement and fine aggregate. The properties of cement, sand, stone dust and water effects the concrete quality. After hardening, the strength and stability remains the same even under water. The most important area of application is therefore the mortar and concrete production.

The formation of these compounds is not simultaneous. Tricalcium silicate is responsible for imparting strength to cement in early period of setting. Dicalcium silicate is responsible for later strength development.

II. MATERIALS

Different tests on the materials used in this present study is done and the material properties is mentioned below in the following sub-sections.

2.1 Cement

Initial experiments like standard consistency, final and initial setting time, specific gravity, soundness and fineness of cement were conducted on Ordinary Portland Cement. Hence, OPC was used in the present investigation. The chemical composition of the OPC was analyzed as per the standard procedures mentioned in IS 4032:1968. The results of the analysis of the Ordinary Portland cement are presented in 2.1 Table

Table 2.1 Physical Properties of Cement

Sl. No.	Property	Result
1	Standard consistency	30%
2	Specific Gravity	3.12
3	Setting times (minutes) a) Initial b) Final	 90 min 650 min

2.2 Sand

The sand used in the whole investigation was obtained from the Swarnamukhi river near Tirupati, Chittoor district. The properties of sand were analysed as per the procedures mentioned in IS 2386: 1963 and were represented in 2.2 table.

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Table 2.2 Properties of Sand

Sl. No.	Properties	Unit	Results
1	Specific gravity	-	2.56
2	Bulk density	kN/m^3	15.54
3	Fineness modulus before sieving	-	2.6
4	Zone of sand	-	Zone-II

2.3 Stone dust

The stone dust used in the present investigation is obtained from a stone quarry which is in chandragiri, near Tirupati, Andhra Pradesh. The properties were tested and tabulated in 2.3 table.

Table 2.3 Properties of Quarry Dust

SI.No	Property	Values
1	Specific Gravity	2.55
2	Fineness Modulus	3.3
3	Grading of Sand	Zone – I

2.4 Coarse aggregate

The coarse aggregate used for the present investigation is obtained from the quarry which is at chandragiri, tirupathi, Andhra pradesh. Aggregate should be dense, durable, hard, strong, and clean

Table 2.4 Properties of Coarse aggregate

Sl. No.	Properties	Units	Results
1	Specific gravity	-	2.67
2	Bulk density	kN/m^3	15.54
3	Fineness modulus	-	2.72

2.5 Fly ash

Fly ash used is obtained from Rayalaseema thermal power station, proddatur. The properties of fly ash are shown in 2.5 table respectively.

Table 2.5 Properties of Fly Ash

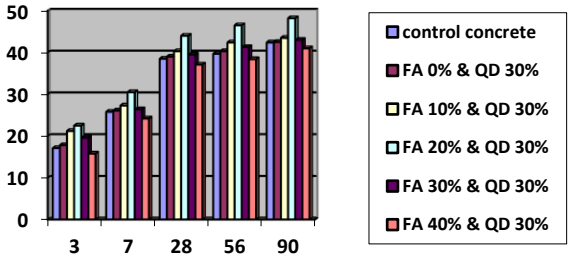
Sl. No.	Properties	Results
1	Specific gravity	2.4
2	Colour	Grey
3	Physical State	Powder

III. RESULTS AND DISCUSSIONS

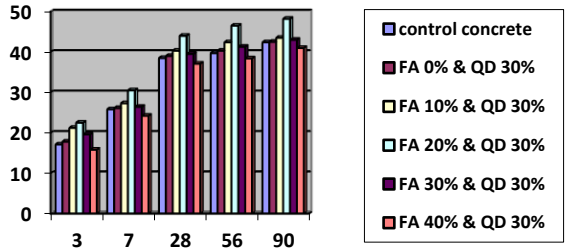
The results obtained in the tests are discussed here. The properties like compressive, flexural and splitting tensile strength of M30 concrete and with different substitute levels of OPC (Ultra tech cement 53 grade) with fly ash, and the sand with stone dust.

3.1 Compressive Strength

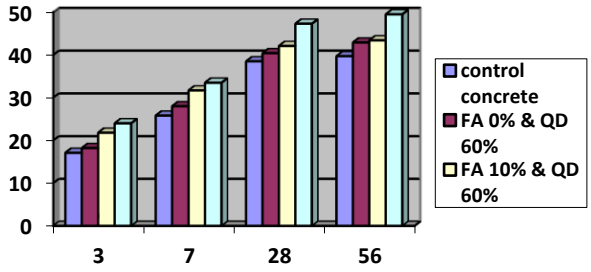
The M30 grade concrete's compressive strength variation with different percentages of stone dust as fine aggregate and fly ash as cement is presented in Figure 3.1.
The compressive strength of concrete prepared using fly ash and stone dust exhibits more strength than the control concrete up to 60% replacement of quarry dust and up to 30% fly ash, with further increase in stone dust and fly ash as cement the compressive strength decreases.



Different Percentages of Quarry Dust



30% Quarry Dust



iii 60% Quarry Dust

Fig. 3.1 Compressive Strength

3.2 Split Tensile Strength:

The variation of M30 grade concrete's split tensile strength with different percentages of Stone Dust and Fly Ash is shown in Figure 3.2.

Strength of concrete increased initially up to 20% of Fly Ash for the various percentage of Quarry Dust and later it decreases with increase in Fly Ash. It can also be observed that at 20% Fly Ash and 60% Quarry Dust combination gives maximum split tensile strength as shown in the figure.

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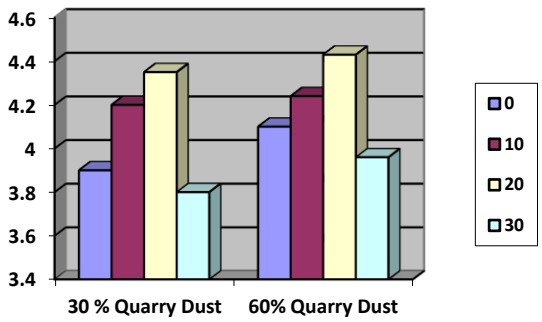

Fig 3.2 Split Tensile Strength

3.3 Flexural Strength:

Flexural strength of M30 grade concrete with different percentages of Quarry Dust and Fly Ash is shown in Figure 3.3.

Flexural strength of concrete increases initially up to 10% Fly Ash for different percentage of Quarry Dust and then with further increase in the Fly Ash it decreases. Maximum split tensile strength is attained at 20% Fly Ash and 60% Quarry Dust.

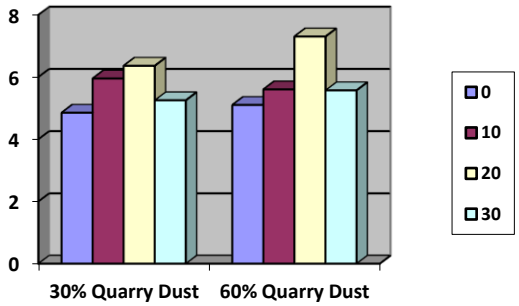

Fig 3.3 Flexural Strength

IV. CONCLUSIONS

The results of the present investigation shows that the combination of stone dust as fine aggregate and Fly Ash as Ordinary Portland cement replacement for concrete preparation.

1. The results of the present investigation indicates the combined application of stone dust and Fly Ash can be adopted as natural sand and Ordinary Portland cement replacement.
2. Using the test results, it can be concluded that with increase in percentage of Fly Ash the various strength characteristics of concrete increased up to 20%, with further increase in Fly Ash leads to decrease in strength for various percentages of stone dust.
3. For a given Quarry Dust content the addition of Fly Ash increases the strength of concrete upto 20% and then decreases. The optimum results were obtained at 60% of stone dust and 20% of Fly Ash.

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