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Experimental Study on Partial Replacement of Cement by Fly Ash, Silica Fume and Sand with Quarry Dust

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Abstract: ***Concrete is the most widely used construction material due to its good compressive strength and durability. Conventional concrete need water curing for a minimum of 28 days to achieve its target strength. The aim of the investigation is to evaluate the use Fly ash and silica fume in replacement of cement. Concrete of M30 grade were cast by replacing fine aggregate with 50% quarry dust and by varying quantity of fly ash and silica fume by 5%, 10%, 15%, 20%,25%. In this study, compressive strength, split tensile strength concrete with optimum. Compression strength of concrete is tested on cubes at different replacements of fly ash and silica fume for 28days increased. Split tensile strength of concrete is tested on cylinders at different replacements of fly ash and silica fume for 28 days increased.***

Keywords: Flyash, Silica Fume, Quarry Dust, compressive strength, split tensile strength

1. Introduction

In recent years, tremendous efforts have been taken in the area of concrete engineering and technology to research and study the utilisation of by-products an waste materials in the production of concrete. The successful utilisation of these materials will result in the reduction of environmental load, waste management cost and concrete production cost, besides enhancing the properties of concrete in both fresh and hardened state. Efforts in this area have been focused in identifying and optimising the benefits of different types of cement replacement materials as well as identifying alternative materials as aggregates in concrete.

1.1 Silica Fume

Condensed Silica fume, also known as micro silica, is a dry amorphous powder which, when added with standard cements will increase the durability and strength of the concrete as well as reducing permeability and improving abrasion-erosion resistance. It may also be used in many applications where high strength is required. The addition of silica fume produces concrete with reduced permeability resulting in increased water tightness enhanced chemical resistance and reduced corrosion of reinforcing steel. Silica fume has a bulk density of approximately 610kg/m³.

1.2 Fly Ash

Fly ash, an artificial pozzolanna is the unburned residue resulting, from combustion of pulverized coal or lignite. It is collected by mechanical or electrostatic separators called hoppers from flue gasses of power plants where powdered coal is used as fuel. This material, once considered as a by-product finding difficulty to dispose off, has now become a material of considerable value when used in conjunction with concrete as an admixture.

1.3 Quarry Dust

The reduction in the sources of natural sand and the requirement for reduction in the cost of concrete production has resulted in the increased need to identify substitute material to constituent materials as aggregates in the production of concretes. Several types of materials have been investigated for this purpose both in developing and developed countries and the outcome of success has been varying. The materials usually researched for this purpose are either by-product materials or even sometimes manufactured aggregates. Manufactured aggregates are mostly used to produce concretes to meet specific purposes such concrete with superior properties or structural lightweight concrete. On the other hand, the advantages of utilization of by-products or aggregates obtained as waste materials are pronounced in the aspects of reduction in environmental load and waste management cost, reduction concrete production cost and enhancement in some properties of concrete. Quarry dust, a by-product from the crushing process during quarrying activities is one of those materials being studied, especially as substitute material to sand as fine aggregates. Quarry dust have been used for different activities in the construction industry such as for road construction and manufacture of building materials such as lightweight aggregates, bricks, tiles and autoclave blocks It is noted that there are numerous publications available in the area of utilisation of by-product and waste materials as well as different types manufactured aggregates in concrete mixes.

2. Scope of the work

- The aim of this investigation is to evaluate the use of industrial waste in concrete
- In this study the physical properties of concrete different percentages of fly ash and silica fume will be evaluated with conventional concrete specimen
- To determine the effect of mineral admixtures (Silica Fume,

Fly Ash, quarry dust) on the Compressive Strength of concrete.

- To determine the effect on the split tensile,Compressive Strength of concrete.

3. Literature Review

Abdullah Anwar et al. [1] studied the Compressive Strength of Concrete by Partial Replacement of Cement with High Volume Fly Ash and presented a brief review with mixtures containing 10%, 20%, 30% and 40% Fly Ash by the bulk of the cementitious material (OPC) for M30 and M40 grade of concrete. The test result indicates that the compressive strength of mix with 10%, 20% and 30% replaced with fly ash were more as compared with conventional concrete thus enhancing the durability of structures. When the percentage of replacement is increased the water/ binder ratio gets reduced, thereby, increasing the compressive strength. Also, it is observed that the compressive strength of concrete having more than 40% replacement of cement by fly ash suffers adverse effects though water/ binder ratio is gradually lost weight. The compressive strength of the concrete mix with 40% replacement with fly ash was lesser than the conventional concrete at 28 days. The result obtained for 28-day compressive strength confirms that the optimal percentage for replacement of cement with fly ash is about 30%. Yet, in reality approximately 50% of the Fly Ash produced throughout the world is stockpiled/land filled as a wasteland.

Balamurugan and Perumal [2] studied the behaviour of concrete by replacing sand by quarry dust. They reported that the variation in the strength of concrete when replacing sand by quarry dust from 0% to 100% in steps of 10%. M20 and M25grades of concrete are taken for their study keeping a constant slump of 60mm. From their test results it is found that the maximum compressive strength, split tensile strength and flexural strength are obtained only at 50% replacement. So, they concluded that quarry dust can be utilized in concrete mixtures as a good substitute for natural river sand at 50% replacement with additional strength than control concrete.

Chandana Sukesh et al. [3] carried out a work on partial replacement of sand with quarry dust in concrete. The work mainly focus on the properties of concrete and to investigate some properties of quarry dust, the suitability of those properties to enable them to be used as partial replacement materials for sand in concrete. They concluded that the replacement of sand with quarry dust shows an improved in the compressive strength of the concrete and the ideal percentage of the replacement of sand with quarry dust is 55% to 75% in case of compressive strength. The further increasing the percentage of replacement can be made useful by adding the fly ash along with the quarry dust so that 100% replacement of sand can be achieved.

4. Experimental Program

4.1mix Design For M30 Grade Concrete

Table 1.1: Mix Details of M30 Grade Concrete

C	F.A	C.A	W/C
1	1.672	2.779	0.45

4.2 Materials:

Cement: An ordinary Portland cement OPC 53 grade was used.

Fly Ash: In the present work, fly ash brought from Bhupalpally, KTPP is used.

Natural Sand: Natural river sand passing through 4.75mm was used as fine aggregate and was tested following IS: 383-1970. The sand conformed to zone II

Coarse Aggregate: The aggregates were selected based on the limitation of IS 881 and 882 of 20mm size

Quarry Dust: Quarry dust is collected from local stone crushing units. The physical properties of quarry dust obtained by testing the sample as per IS standard. The sand conformed to zone II**.**

5. Testing

Two types of specimens namely cubes and cylinders were cast. Cubes were used for compression strength test and cylinders for split tensile strength test.

Test for compressive strength:
The specimens were removed from the curing tank and its surfaces are cleaned with cotton waste. They were tested in wet condition in a Compression Testing Machine. The rate of loading was maintained at 140 kg/cm Minute as per the requirements given in the code of practice (IS: 516-1969). Three specimens of 150mm cubes were tested for required age and the average value of compressive strength was calculated. The results of compressive strength test were tabulated in table

Table 1: Compression strength with replacement of fly Ash

Sl.No	Percentage of cement replaced with fly ash	Compression strength N/mm^2
1	5	43.55
2	10	41.11
3	15	40.66
4	20	38.33
5	25	37.44

Table 2: Split tensile Strength replacement of Fly Ash

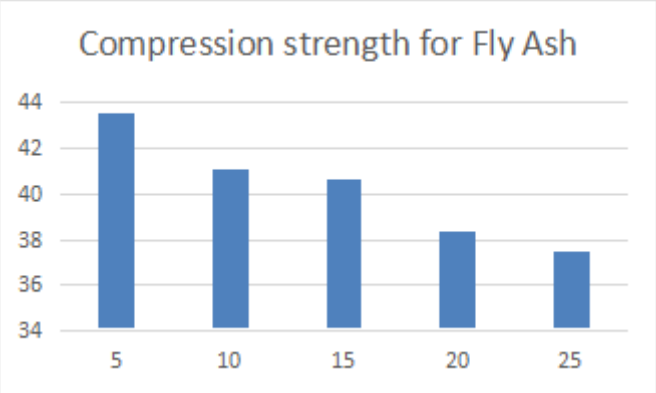
Sl.No	Percentage of cement replaced with fly ash	Split tensile strength N/mm^2
1	5	2.694
2	10	2.509
3	15	2.336
4	20	2.238
5	25	2.058

Table 3: Compression Strength replacement of silica fume

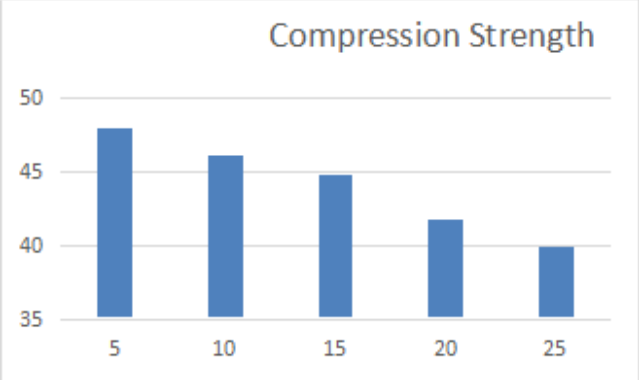
Sl.No	Percentage of cement replaced with Silica fume	Compression strength N/mm^2
1	5	48
2	10	46.22
3	15	44.88
4	20	41.77
5	25	40

Table 4: Split tensile Strength replacement of Silica Fume

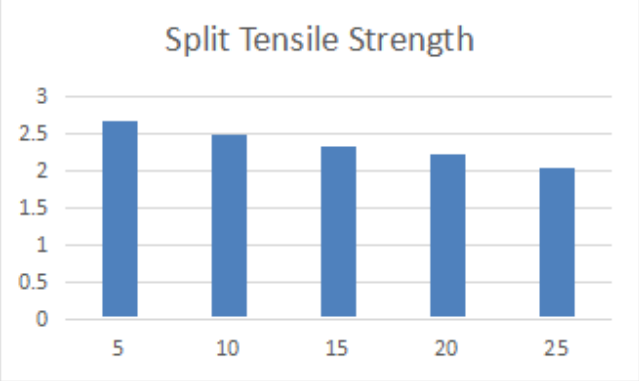
Sl.No	Percentage of cement replaced with Silica fume	Split tensile strength N/mm^2
1	5	2.830
2	10	2.689
3	15	2.547
4	20	2.406
5	25	2.123



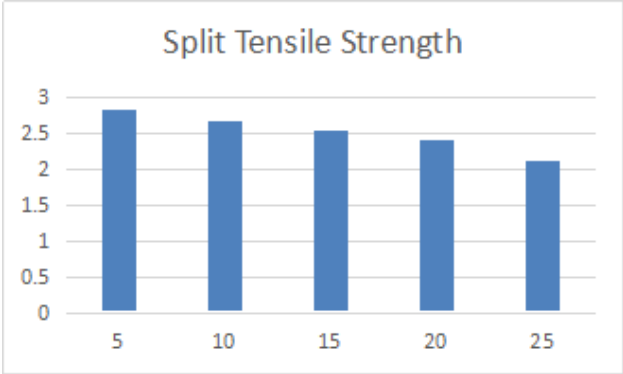
Graph 1: Compression strength with replacement of Fly Ash



Graph 2: Compression Strength replacement of Silica fume



Graph 3: Split Tensile Strength replacement of Fly Ash



Graph 4: Split Tensile Strength replacement of Silica Fume

6. Conclusions

- Compression strength of concrete tested on cubes at different replacements of fly ash for 28days has highest strength at 5%
- Compression strength of concrete tested on cubes at different replacements of silica fume for 28days has highest strength at 5%
- Split tensile strength of concrete test on cylinders at different replacements of fly ash for 28 days has highest strength at 10%
- Split tensile strength of concrete test on cylinders at different replacements of silica fume for 28 days has highest strength at 5%
- Compare to fly ash the silica fume has more compression strength.
- As the replacement of cement with fly ash has meet more than the target strength the optimum percentage can be used upto 15%
- As the replacement of cement with silica fume has meet more than the target strength the optimum percentage can be used upto 25%.

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