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STUDY AND INVESTIGATION IN DEVELOPING LOW-COST CONCRETE BY USING FLY ASH AND QUARRY STONE DUST

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ABSTRACT
The increased emphasis on the life-cycle cost analysis for building project requires that new attention to be focused on service life and durability of concrete structures. Durability is the ability to resist weathering action, chemical attack or any other process of deterioration. Concrete's great versatility and relative economy in filling wide range needs has made it a competitive building material. This high demand for concrete in construction lead to the increase in the release of carbon dioxide in cement production and also to the scarcity of natural river sand. So there is an urge to replace the conventional concrete materials. Materials like Fly-ash and Quarry dust (QD) are chosen based on the criteria of cost and mechanical properties. This project is concerned with the evaluation of changes in compressive strength in different mixes of M25 Grade concrete which include conventional aggregate concrete, concrete with 25% replacement of cement by fly ash and fine aggregates with varying percentages of 0%, 25%, 50%, 75% & 100% by Quarry Dust (QD). We can conclude that concretes made by Fly ash and Quarry Sand Dust have given good strength and durable properties when compared to conventional concrete in severe environment.

Keywords: Fly ash, Quarry dust (QD), M25 Grade concrete.

1. INTRODUCTION

1.1 General

Concrete is a composite material consisting of coarse and fine aggregate which bonded with cement. In concrete, the Portland cement is the most common material in making of concrete. The requirements of construction materials are escalating and so that the demand and cost for cement and other raw materials are increasing day by day. To overcome these issues in construction the usage of alternative construction materials in construction fields is highly preferred and suggested.

Fly ash is the common and well-known alternative material, which can be used for making concrete in construction. Fly ash is a by-product of coal combustion, and it is combination of fine particles from the boiler with fuel gases. These are the substitute material for the portland cement. Fly ash is improving the workability of concrete and applicable for concrete structures and also for the brickworks, wall constructions etc., Quarry dust is another building material, which generated from finely crushed rock. It can be used as a fine aggregate in concrete. The ingredients of concrete may partially replaced with fly ash and quarry dust using some determined quantity. The previous research outcome shows that if fly ash and quarry dust are used to partially replace the concrete materials maximum of 50%, it improves the strength of the concrete and also this is one of the ways to reduce the problems in construction due to lack of raw materials.

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Hence, in this project, the fly ash (class F) and quarry dust have been considered as an alternative for cement and fine aggregate, respectively. This study aims to examine the effect of replacing both cement and fine aggregate with fly ash (25%) quarry dust (25%, 50%, 75% and 100%) in various predetermined proportions. The structural properties like compressive and split tensile strength of hardened concretes were determined and compared with controlled concrete with proper design mix at 28 days curing.

Igneous and metamorphic rocks cover about 90-95% of the earth's surface. In earth's crust, most abundantly available type of rock is igneous and due to its wide range of physical and chemical properties, enables its use in all different sectors of construction purposes. Most of the high rise mountains, hills, plateaus and surface of the earth, even in oceanic crust consist of igneous rock. The leading manner of extracting rock or stone is through digging, quarrying and blasting. In India, most of the rocks are extracted through quarrying. Quarrying is the process of extracting rock using explosives. 15 The pieces of rock or stone obtained in quarrying are used in either stone masonry or aggregate in building or road construction. In this blasting process of rock, numerous small or fine particles of stones are transformed into dust particles in the atmosphere. These dust particles surround the environment throughout the quarry and get settled on the leaves and bark of trees, thereby killing the tissues of the tree. Hence to reduce air pollution, this quarry dust is used for construction purposes. It is used as a substitute for fine aggregate in concrete either partially or fully. As it is originated from rock, it offers better strength when compared with sand as fine aggregate in concrete. It can also be used in road construction and manufacturing of bricks and tiles. It is the cheap and best material available in the market for construction purposes.

2. LITERATURE REVIEW

Abdullah Anwar *et al*., (2014) 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 days 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.

Rai *et al.,* (2014) investigated the effect of fly ash with quarry dust as fine aggregate on mortar mixtures. The findings showed for a given water to cement ratio, an increase in fly ash content caused the drop in compressive strength of the mortar. While by the addition of fly ash, the decrease in early strength was enhanced by the increase of quarry dust. Thus from the

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investigation, it can be justify that quarry dust could improve the performance of mortar mixtures incorporated with fly ash in the form of compressive strength.

Krishnamoorthi and Kumar, (2013) studied the properties of concrete mixture by simultaneous utilize of fly ash and quarry dust. They produced the concrete replacing cement of 10%, 15% and 20% by fly ash while using quarry dust as fine aggregate to compare with the conventional concrete. They had found that the increase in quarry dust resulted in decrease of slump values. Meanwhile, the decrease in workability by the addition of quarry dust is reduced by the addition of fly ash.

Suresh chandra *et al.,* (2014) studied the effect of replacement of sand by quarry dust in hollow concrete block for different mix proportions. The objective of the study is to indicate the properties of hollow concrete blocks produced by the quarry dust as sand replacement. The results showed the hollow concrete blocks sand production can be replaced partially by 50% by quarry dust instead of complete replacement. It seemed that the blocks with 50% replacement performs better than blocks which are conventionally prepared using natural sand. Moreover, the hollow concrete blocks can be used in load bearing masonry structures as other option in construction industry.

Shruti *et al.,* (2016) the mechanical behaviour of M20 grade concrete was studied with quarry dust as sand replacement by 25%, 50%, 75% and 100%, ground granulated blast furnace slag (GGBS) as cement replacement by 20%, 30%, 40%, 50% and 60% with plain cement concrete. The optimum replacement of sand by quarry dust recorded from the findings was at 50%. The split tensile strength carried out on specimen with 50% quarry dust replacement on sand and 60% GGBS replacement of cement gave an increase value linearly. Besides, the flexural strength conducted with the same proportion showed an increase value but it did not show the linear value of increased. From the outcome, the 50% or quarry dust and 60% of GGBS by replacement were selected to be incorporated in the concrete in order to achieve maximum mechanical properties.

3. OBJECTIVE AND METHODOLOGY

3.1 Objective

The present study deals with the replacement of cement by 25% Fly ash and replacement of fine aggregates with varying percentages (0, 25, 50, 75, 100%) by Quarry stone Dust for M25 grade of concrete.

i) To study the effect of replacement of different percentages (0, 25, 50, 75, 100%) in fine aggregates by quarry dust and 25% cement by Fly ash in the concrete.
ii) To determine the workability of freshly prepared concrete by Slump test & compaction factor test.
iii) To determine the compressive strength of cubes at 7, 14, 28 days curing

3.2 Methodology

1. The fly-ash and quarry dust were collected from different sources.
2. Sieved the quarry dust with IS Sieve 4.75mm to IS Sieve 75microns. The passed from 4.75mm and retained on 75microns was used for this study.
3. Physical properties of all materials were tested (mentioned in chapter4).

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4. Design mic design of M25 grade concrete was for this study. The partial replacement of 25% cement with fly ash and 10%, 20%, 30%, 40% & 50% of river sand with quarry dust.
5. The fresh properties of concrete are tested by using slump and compressive strength.
6. The harden properties of concrete is tested by using compressive strength test.
7. Based on the test results, the conclusion will drawn.

4. EXPERIMENTAL WORK

Experimental work carried out including properties of various materials used and their mix proportions. The details of method of casting of specimens and their testing procedures are explained.

Materials used:

- Ordinary Portland cement (53Grade),
- Fly ash
- Quarry dust,
- Fine & Coarse Aggregates,
- Super plasticizer (Conplast SP-430)
- Water.

Table. 1: Design proportions of materials for M25 grade concrete.

Item name	**As per mixed Design (kg/m^3)**
Cement	438.13
Fine aggregates	612.58
Coarse aggregates	1109.27
water	197.16

4.1 Mix Proportions

M25 grade of concrete is considered. Natural sand is replaced with Quarry-dust with various percentages 0, 25, 50, 75, 100%. Cement is replaced with Fly ash by 25%. The mix design for concrete is carried out as per IS 10262-2019. Details of mix proportion for M25 concrete given below:

Volume of the cube = 1.1 X $(0.15)^3$ = 3.7125 X 10^{-3}

Table. 2: Mix proportions for 1cube preparation.

MIX	FLYASH – QD	CEMENT	FLYASH	FA	QD	CA	WATER (lit)
1	0-0	1.626	0	2.27	0	4.12	0.732
2	25-0	1.22	0.4065	2.27	0		
3	25-25			1.703	0.567		
4	25-50			1.135	1.135		

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5	25-75			0.567	1.703		
6	25-100			0	2.27		

4.2 Sample Production

The cement, fine and coarse aggregates were weighted according to mix proportion of M_{25}. All are mixed together in a bay until mixed properly and water was added at a ratio of 0.45. The water was added gradually and mixed until homogeneity is achieved. Any lumping or balling found at any stage was taken out, loosened and again added to the mix.

For the second series of the mixture, the Quarry dust was added at 25%, 50%, 75% and 100% by weight of fine aggregates and the Fly ash was added 25% by the weight of cement. Immediately after mixing, slump test and compaction factor were carried out for all the concrete series mixture. A standard 150×150×150mm cube specimens were casted.

The samples were then stripped after 24hours of casting and are then be ponded in a water curing. As casted, a total of (54) 150×150×150mm cubes and were produced.

4.3 Curing

The method of curing adopted was the ponding method of curing and produced samples were cured for cubes at 7days, 14days, 28days.

4.4 Test for Fresh Properties of Concrete (Workability Test)

4.4.1 Slump Test

Which can be employed either in laboratory or at site of work. It is not a suitable method for very wet or very dry concrete. It does not measure all factors contributing to workability, nor is it always representative of the placability of the concrete. It is not a suitable method for very wet or very dry concrete. It does not measure all factor contributing to workability. The slump test was carried in accordance with B.S:1882 PART2:1970.

4.5 Testing

4.5.1 Compressive Strength of Concrete

The compression test was conducted according to IS 516-1959. This test helps us in determining the compressive strength of the concrete cubes. The obtained value of compressive strength can then be used to assess whether the given batch of that concrete cube will meet the required compressive strength requirements or not. For the compression test, the specimen's cubes of 15 cm x 15 cm x 15 cm were prepared by using hwa concrete as explained earlier. These specimens were tested under universal testing machine after 7 days, 14 days and 28 days of curing. Load was applied gradually at the rate of 140kg/cm^2 per minute till the specimens failed. Load at the failure was divided by area of specimen and this gave us the compressive strength of concrete for the given sample.

5. RESULTS AND DISCUSSIONS

As per experimental programme results for different experiments were obtained. They are shown in table format or graph, which is to be presented in this chapter.

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5.1 Workability Test

5.1.1 Slump Test

The Slump test was performed on the Fly ash - QD concrete to check the workability of it at different replacements viz. 25 %, 50 %, 75% and 100% the following results were obtained below table.

Table. 3: Results of slump test.

Mix	Fly ash (%)	% of Quarry dust	Slump value (mm)
M1	0	0	150
M2	25	0	156
M3		25	170
M4		50	184
M5		75	190
M6		100	197

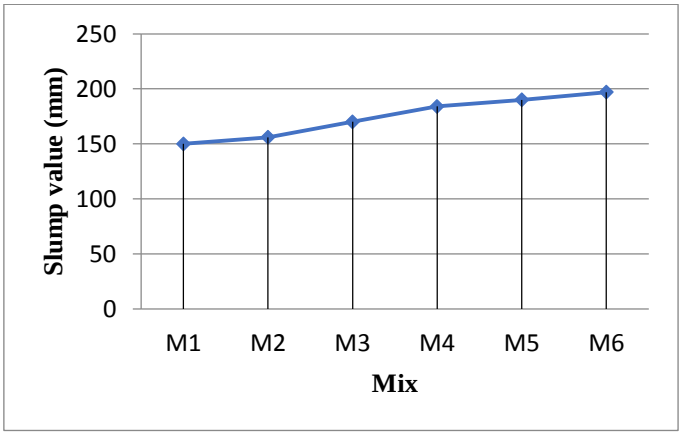

Fig. 1: Slump test results.

The above fig. 1 shows the slump results. It was observed that, the slumps increased as the Fly ash – QD content were increased in the mix. It was suitable for medium Workability mixes.

5.2 Compressive Strength Test

The Compressive strength generally a gradual increase up to a particular proportion of Quarry dust at constant Fly ash proportion. But a gradual increase in the QD% leads to the gradual increase in the Compressive strength upto 50% after decreases the compressive strength and optimum values are obtained at 25% fly ash +50% QD for water curing.

Table. 4: Results of average compressive strength (N/mm^2).

Mix	Fly ash (%)	% of Quarry dust	7days	14days	28days
M1	0	0	15.12	22	25.2
M2	25	0	16	22.5	26.9
M3		25	16.3	22.8	27.3
M4		50	16.5	23.2	27.5
M5		75	16	22.8	27
M6		100	15.8	22.3	25.4

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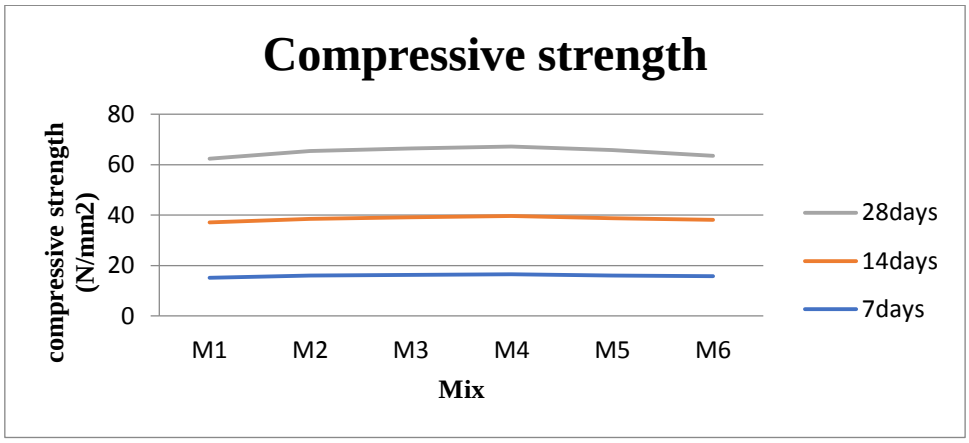

Fig. 2: Compressive strength v/s % of Flyash & QD mix.

From the above results it was observed that with the increase in percentage of flya sh (25%) & QD from 0% to 50% in concrete the compressive strength increases after that decreases.

6. CONCLUSIONS

In this project work, elaborate testing were carried out and the obtained results were analyzed critically based on the previous research works available in literatures. The project outcomes are summarized as conclusions for the prime properties of concrete, such as, compressive strength and workability properties.

The concrete can be successfully replaced with 25 % Fly ash with cement and 25%, 50%, 75%, 100% replacement Quarry dust and of its weight.

- As the % replacement increases the strength decreases after the Fly ash(25%)-QD(50%) mix proportion (hence the present study is limited to Fly ash(25%)-QD(10%) of replacement).
- The weight loss & residual strength of the Fly ash & quarry dust concrete is observed more than that of normal aggregate and cement based conventional concrete.
- The maximum compressive strength for 7, 14 and 28 days curing at after Fly ash(25%)-QD(50%) mix proportion.
- For all types of mixes considered always an increase in strength up to a certain level is seen for both 7, 14 & 28days curing.
- Also, they reduce the cost of construction when compared to conventional aggregate based concrete.

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