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The Replacing of Cement with Pozzolanic Materials and Checking its Strength without Superplasticizer

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ABSTRACT - *The use of concrete in this Planet is increasing day by day. The cement which is used in concrete consumes large amount of energy and is responsible for the emission of greenhouse gas. So it becomes necessary to find some alternatives i.e. ecofriendly with environment. Fly ash is a powder material of burned coal from thermal power stations which produces cementitious and pozzolanic material. Commonly use of fly ash in concrete for building construction contributes conducive environmental and also reduces the effect of pollutant in site project. Therefore, this study was conducted to investigate the use of fly ash as partial replacement of cement in concrete as a mean of producing more environmental friendly concrete. The content of fly ash as partial replacement of ordinary Portland cement(OPC) is investigated by weight accordingly in range 30%, 40% ,50% ,60% and 70% for grade 20. The mix proportion of concrete was determine using mix design method according to British Standard. The workability of the fresh concrete mixture was evaluated using slump test while compressive strength of cubes concrete was evaluated at 3, 7, 14, 28 days. A total of 12 cubes for each ratio of concrete with size 150mmx150mmx150mm were made. The optimum compressive strength at 28 days of testing was obtained at 30% replacement. With this percentage of replacement, prism of size 100mmx100x500mm was casted and tested under three-point loading system to study the strength characteristics. This test results indicate that workability decreased with an increased in replacement percentage of fly ash. So, fly ash as pozzolanic materials can be used to partially replace ordinary Portland cement in production of concrete.*

Keywords: Fly Ash, Portland cement, Compressive Strength.

1.INTRODUCTION

Concrete is a widely used construction material composed of a mixture of cement, water, aggregates (such as sand, gravel, or crushed stone), and sometimes admixtures. The cement acts as the binding agent, which, when mixed with water, undergoes a chemical reaction called hydration. This reaction causes the mixture to harden and form a strong, stone-like mass. Aggregates make up the bulk of the concrete, providing structural integrity and strength. Fine aggregates, like sand, fill in the gaps between coarse aggregates, such as gravel or crushed stone, creating a dense and stable mixture. The proportion of water in the mix is crucial, as it affects both the workability and strength of the final product; too much water can weaken the concrete, while too little can make it difficult to mix and place. Concrete is known for its compressive strength, making it ideal for structures like buildings, bridges, roads, and dams. However, it has low tensile strength, which is why steel reinforcement is often added to concrete structures to handle tensile forces. Concrete's durability, versatility, and ability to be molded into various shapes make it one of the most essential materials in modern construction.

1.1 CEMENT

Cement is one of the special binding materials used in construction. It is a powder, usually made of calcium and silicon oxides, that hardens when it come in contact with water. Cement is produced by roasting limestone and clay at high temperature in a kiln to produce clinker. this clinker is ground into a fine powder and blended with small percentages of gypsum to form cement. Cement is the chief binding element that is used in concrete to bind the aggregates.

Fig -1: Cement

1.2 FLY ASH

Fly ash is a spherical, powdery byproduct created during the combustion of pulverized coal at thermal power plants. It primarily consists of silica, alumina and iron oxides and is gathered from the flue gases produced by coal-fired boilers prior to exiting into the environment. Fly

ash has reinvented itself from once being a disposal material to presently having immense value in the construction domain as a partial substitute of Portland cement in concrete. The pozzolanic characteristic of fly ash and ability to react with calcium hydroxide in presence of water forming compounds having cementitious properties makes it a suitable cement substitute. In addition to improving the strength and durability of concrete, this reduces its environmental impact by decreasing carbon dioxide released during cement production. The use of fly ash in concrete produces greater work-ability and also minimizes the heat of hydration, that is why it suits better for large pours and mass concrete structures. The quality of fly ash can vary depending on the coal source and combustion method thus requiring careful selection & testing for specific applications. In concrete, it is used instead of virgin materials and thus a part of more sustainable construction such as the use of industrial waste

Fig -2: Fly Ash

1.3 FINE AGGREGATE

Fine aggregate is a one of the important components of concrete and mortar, consisting of small debris that fill the areas between larger aggregates, like gravel or crushed stone, to create a dense and compact mixture.

Typically, first-rate combination is herbal sand, however it may also include beaten stone sand, synthetic sand, or other similar materials. The particle length of satisfactory combination is normally less than 4.75 mm, with the majority of particles being smaller than 2.36 mm. The role of best fine aggregate in concrete is to provide bulk, enhance workability, and make contributions to the electricity and sturdiness of the very last product. By filling the voids among coarse aggregates, great mixture guarantees a clean and plausible mix, making it less complicated to pour and end the concrete.

Additionally, first-class aggregates help to reduce shrinkage and prevent segregation of the concrete blend.

Fig -3: Fine Aggregate

1.4 COARSE AGGREGATE

Coarse Aggregate is a main component of Concrete consisting of large inert particles. Typically size of coarse aggregate ranging from 4.75mm to 38mm. Coarse aggregate occupies about 60-75% of the concrete mix. The quality and characteristics of coarse aggregate significantly affect the performance of concrete. The shape, size, and texture of the aggregate influence the workability, strength, and durability of the concrete. The selection of coarse aggregate depends on the type of construction, the load bearing requirements, and environmental factors. For instance, high-strength concrete used in structural applications may require aggregates with specific properties, such as low absorption and high resistance to weathering. The durability of concrete is also influenced by the mineral composition and cleanliness of the aggregate, as impurities like clay or organic materials can weaken the bond between the cement paste and aggregate, compromising the concrete's integrity over time.

Fig -4: Coarse Aggregate

1.5 WATER

Water is primary applied in the mixing of concrete, mortar, and plaster, where it activates the cement, initiating the chemical reaction known as hydration. This process is crucial for the hardening and strength development of these materials, making water indispensable in creating strong and durable structures. Beyond mixing, water is vital for curing concrete. After concrete is poured, it needs to be kept moist for a specified period to ensure proper hydration and to prevent cracking or shrinking.

Proper curing enhances the strength, durability, and overall quality of the concrete, ensuring the longevity of the structure. Water is also used in the compaction of soil and aggregates, helping to achieve the desired density and stability of foundations and earthworks. In addition, it is employed in dust suppression during construction activities, minimizing airborne particles and improving site safety. Moreover, water is necessary for cleaning tools, equipment, and surfaces, as well as for maintaining hygiene and sanitation on construction sites. However, managing water use efficiently is crucial to avoid wastage, prevent water logging, and ensure sustainable construction practices.

Fig -5: Water

2. METHODOLOGY

In this work partial replacement of cement with Fly ash, Experimental investigation is carried out to find the strength characteristics fly ash-based concrete. The cement is replaced by Fly ash in the range of 30%, 40%, 50%,60% and 70% by weight of cement for M20 grade mix. Concrete cubes were casted and tested after 3 days, 7days and 28 days curing for compressive strength and compared with normal concrete specimens. So that percentage of Fly ash is to be determined which give high strength when fixed with cement. By taking that percentage of fly-ash.

MIX DESIGN

The M20 grade concrete is adopted for the present work. Detailed mix proportion is obtained as per code

IS 10262-2009

Table -1: Calculation of quantity of Materials

Mix Id	Fly Ash (%)	Cement (%)	Quantity (Kg)				
			Sand	Aggregate	Cement	Fly Ash	Water
FA0	0	100	28.718	57.431	14.84	0	7.42
FA30	30	70	28.718	57.431	10.39	6.81	8.6
FA40	40	60	28.718	57.431	8.91	9.07	8.991
FA50	50	50	28.718	57.431	7.422	11.339	9.38
FA60	60	40	28.718	57.431	5.937	13.607	9.772
FA70	70	30	28.718	57.431	4.45	15.875	10.162

RESULTS AND DISCUSSIONS COMPRESSIVE STRENGTH

All the fly ash based concrete cubes are tested in compression testing machine to determine the compressive strength at 3, 7, 14 and 28 days as shown in Table 5.5 and fig 5.2. From the test it is clear that the ratio FA30 shows the high strength in which 30% fly ash is used & 70% cement is used.

Table -2: Compressive Strength test

Mix	Compressive Strength at 3 days (N/mm^2)	Compressive Strength at 7 days (N/mm^2)	Compressive Strength at 14 days (N/mm^2)	Compressive Strength at 28 days (N/mm^2)
FA0	7.55	15	16.33	20.86
FA30	5.55	6.33	7.77	13.78
FA40	5	5.55	6.67	10.74
FA50	2.44	4.88	6.11	9.53
FA60	2.33	3.33	3.77	8.26
FA70	2	2.44	3	5.912

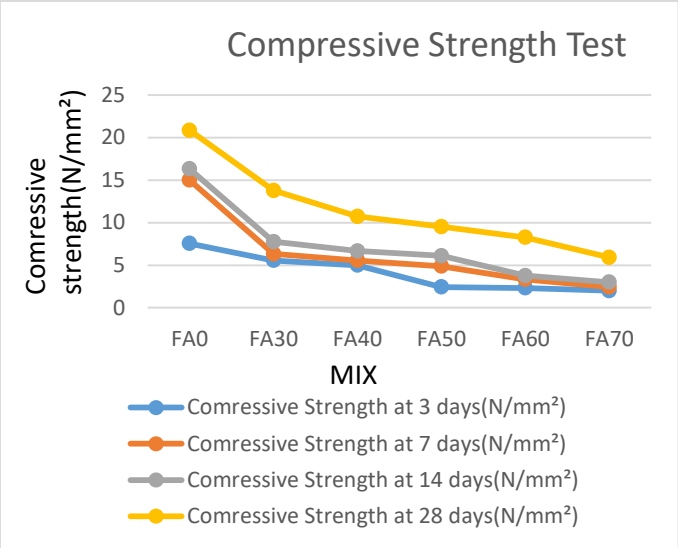

Fig -6: Compressive Strength at 3, 7, 14 & 28 days

Fig-7: Compressive strength test

SPLIT TENSILE STRENGTH

All cylinders were tested in CTM with reference of IS: 516-1959 after 28 days to determine tensile strength of fiber fly ash-based concrete. The split tensile strength is checked for FA30 (i.e. 30% fly ash & 70% cement).

Table -3: Split Tensile Strength at 28 days

S.No	Mix	Split Tensile Strength (N/mm^2)
1	FA30C.1	1.11
2	FA30C.2	0.91
3	FA30C.3	1.18

Fig-8: Split tensile strength

SLUMP TEST

The slump test is a simple, practical measure of concrete workability or consistency.

The slump value of our experiment was 110mm (High) which describe high workability and may not respond to well vibration.

Fig-9: Slump test

FLEXURAL STRENGTH

Ten prisms for different fiber percentage were casted to test the flexural strength in UTM (Universal Testing Machine) by applying two-point load to understand the pure bending behavior. The test was conducted after 28 days of curing and results are shown in Table -4.

Table -4: Flexural Strength at 28 days

S.No	Mix	Split Tensile Strength (N/mm^2)
1	FA30B.1	0.211
2	FA30B.2	0.492
3	FA30B.3	0.164

Fig-10: Flexural strength test

COMPARISION OF TEST RESULTS

The test results obtained from FA30 was compared with the results obtained from the 100% cement concrete, which shows that replacing the 30% cement by fly ash, the 28 days' strength of concrete will be reduced by 33.94%.

COST ANALYSIS

The cost of the size of cube decreases by 12.2% when 30% cement is replaced by fly ash.

CONCLUSION

Based on experimental work, the following conclusions are drawn:

★ Experiments on different times suggest that the compressive strength of concrete mixes decrease with increase percentage of Fly Ash. It should be kept in mind that the optimum limit of mixing of Fly Ash is 40 % and more than that may not be safe for different concrete mixes.

★ Depending upon the percentage of Fly Ash as well as time of curing, the strength of concrete will be varied.

★ By the use of pozzolanic material fly ash, the usage of cement can be reduced which will reduce the cost of concrete to certain extent.

★ It is possible to produce workable concretes with addition of pozzolanic materials like fly ash which have high economical and environmental benefits.

★ The cost analysis indicates that percent cement reduction decreases cost of concrete, but at the same time strength also decreases.

★ The strength of fly ash-based concrete is less than cement concrete, these can be used in low load bearing structures and in construction of rural road and dams.

★ The slump value from experiment is high which describe high workability and may not respond well to vibration.

RECOMMENDATION FOR FURTHUR STUDIES

Our study was based on checking strength of concrete with replacement of cement by fly ash without using superplasticizer, we use Coarse Aggregate of size passing from sieve 12mm and no chemical test of fly ash was conducted, we recommended to other researcher to study about strength behavior of concrete with using superplasticizer and do chemical test of fly ash.

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