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An Experimental Study of Substitute Materials by Partial Replacement of the Constituent Materials of Cement Concrete

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Abstract:

The basic construction materials especially for conventional concrete are sand, metal and water. As their availability is dependent on natural resources, they become scarce and costlier day by day. At the same time the cheap and abundantly available industrial By-products such as Fly-Ash, Building demolition debris, Crusher dust, Plastic waste, scrape etc. Lot of research is going on in order to replace the low cost as well as environmental friendly materials in civil engineering construction. In this project we substitute Fly-ash in place of the cement and the Robo-sand in place of the fine aggregate to some extent at variable percentages are used.

The M_{30} grade of concrete is considered for all replacements and tests. Some percentage of cement is replaced by fly ash, and fine aggregate is replaced by Robo-sand. Concrete mixtures were produced, tested and compared in terms of compressive strength, tensile strength, flexural strength with conventional concrete. By changing the percentage replacement of material, strength equal to the conventional concrete can be found, optimum percentage of Cement or fine aggregate. In this study compressive strength, tensile strength and flexural strength are evaluated. We replace the Fly-Ash to the cement for obtaining the optimum value which is considered as the 25%. Now keeping the fly ash percentage constant and partial replacement of fine aggregate by robo-sand with increasing percentage has been experimented. The compressive test on concrete cubes, tensile test on cylinders and flexure test on beams is taken into account. The curing at 7days, 28 days and 90 days of cubes, cylinders and beams is considered.

Key words: **concrete, fine aggregate, coarse aggregate fly ash, robosand**

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I. INTRODUCTION

The air pollutants like Sulfur Oxides (SO), Nitrogen Oxide (NO2), Carbon monoxide (CO) and the fine dust are effluents of Cement manufacturing plants. Over and over percentage of Nitrogen oxide and Sulfur oxide in the atmosphere may lead to acid rains, thus ground water may be polluted surface water quality may be degraded leading un suitability for drinking and also responsible for various health problems as the Sulfur dioxide in high concentrations and the excess percentage of Carbon monoxide reduces the oxygen percentage in atmosphere, which causes breathing problems and cardiovascular diseases.

Therefore, the time to explore alternatives or substitutes of Cement, Sand, Coarse aggregates is immediate and certain to happen in the present era.

Further high volume of production of industrial wastes posing environmental pollutants but the same are providing a way to find out new solutions for a sustainable development by exploring substitutes to Cement, Sand, Coarse aggregates.

1.1 Fly Ash

Fly ash is the thinly divided mineral residue resulting from the combustion of ground or powdered coal in electric power generating thermal plant. Fly ash is a useful mineral admixture for concrete. It influences many properties of concrete in both fresh and hardened state. Fly ash is a byproduct obtained by burning coal from the thermal power plants. Form the power plants, for every year around 85 million tons of fly ashes producing as a waste product. There is only 10 – 15 % is using for constructions. Some of the brick manufacturing industries are using fly ash. In present days its usage is increased up to some extent. Fly ash is mostly available in two types. They are Class – C fly ash and Class – F fly ash.

curing temperatures.

1.1.1 Manufacturing of Fly Ash

Fly Ash is a result of the combustion of pulverized coal in electric power generation plants. When the powdered coal is ignite in the burning chamber, the carbon and volatile materials are burned off. However, some of the mineral impurities of soil, shale, feldspars, etc., are fused in suspension and carried out of the combustion chamber in the exhaust gases.As the exhaust gases cool, the compound materials solidify into round glassy particles called Fly Ash. Due to the fusion in suspension these Fly Ash particle are mostly minute hard spheres and empty ecospheres with some particles still being Pleura-spheres, which are sphere containing smaller spheres. The size of the Fly Ash particles varies but tends to be similar to some extent larger than Type I Portland cement.

2.2 Properties of Fly Ash:

Some of the important properties of Fly ash are
The spherical shape and particle size distribution of fly ash will increases the flow ability and fluidity. So the amount of water can be reduced, this will helps in producing high strengths. So fly ash can be used as a water reducer.

The drying shrinkage of concrete is directly proportional to the cement paste to aggregate ratio and water content. Due to the increase in drying shrinkage cracks are observed in concrete. So the water reducing property of fly ash reduces the drying shrinkage

1.2 **Robo Sand:** Robo sand is also called as manufactured sand obtained by crushing natural granite stone. Robo sand is defined as a crushed granite aggregate produced by crushing natural granite stone

1.3.1 Properties of robo sand

- Robo-sand is a perfect substitute for Natural sand and it is an environmental friendly product.
- It cannot contain harmful ingredients and organic materials.
- Based on the sieve analysis reports by NCCBM and JNTU, Robo-sand is confirming to Zone – II of IS 383 specifications.
- It is compatible with any type of Cement.

1.3.2 Importance of Robo-Sand

Robo-Sand is important in many aspects because of the following issues

The river sand which is available today is very deficient in many aspects because it containing high amount of silt and fine particles.

Natural sand contains other impurities such as shells, coal, bones, silt and mica. When this sand is used in construction, Decay of these materials occurs due to the weathering effect. This will shorten the service life of a structure.

1.3.3 Applications of Robo-Sand

- Robo-Sand is suitable for all concrete preparations and applicable to all segments such as Independent houses, Ready mix plants, concrete batching plants and Builders.
- Most of the ready mix plants are using Robo-Sand in their mix proportions for overcoming the non availability of natural sand.
- The designers are suggesting manufactured sand along with natural sand to reduce the cost of construction.
- In Hyderabad most of the constructions are undergoing with Robo-Sand because of its availability and advantages.

LITERATURE REVIEW

[1] T.Subramani, K.S.Ramesh(2015)studied the rapid growth in construction activity, the available sources of natural sand are getting exhausted & also, good quality sand may have to be transported from long distance, which adds to the cost of construction. In some cases, natural sand may not be of good quality

[2] Rachana M N, E.RameshBabu July (2014)studiedthe main cause of concern is the nonrenewable nature of natural sand and the corresponding increasing demand of construction industry. River sand which is one of the basic ingredients in the manufacture of concrete has become highly scarce and expensive.

[3] NimithaVijayaraghavan (2013) in his study vast amount of concrete is consumed by the construction industry. About 35% quantity ofconcrete is comprised of sand. A good quality concrete is formed by careful mixing of cement, fine and coarse aggregates, water and admixtures as required to obtain an optimum quality andeconomy

[4] Priyanka A. Jadhav, Dilip K. Kulkarni, (2013) studied the effect of water cement proportion on fresh and hardened properties of concrete with partial replacement of natural sand by means of manufactured sand was investigated. Concrete mix design of M20 (2900 psi) grade was done according to Indian Standard code (IS: 10262).

EXPERIMENTAL MATERIAL

3.1 General

In this experimental program, the first step is selecting of the raw materials. Number of conventional trails is prepared and the mix proportions for M30 grade are selected by changing different water cement ratios. By replacing the cement with fly ash and fine aggregate with robo sand for M30 grades, the strength properties are studied for this grade.

3.2 Description of Materials

Concrete is a composition of three raw materials. Cement, Fine aggregate and Coarse aggregate. These three raw materials play an important role in manufacturing of concrete. By varying the properties and amount of these materials, the properties of concrete will changes. The main raw materials used in this experimental work are Cement, fine aggregate, Coarse aggregate and water.

Definition of OPC

Cement can be defined as a bonding material that has cohesive & adhesive properties which makes it capable to unite with different construction materials in forming a compacted material. It is one of the most widely used type of Portland cement.

The name Portland cement was given by Joseph Aspdin in 1824 due to its color similarity and in quality of hardening capacity like Portland

stone. Portland stone is a white grey limestone which is available in island of Portland, Dorset.

Fly Ash Applications

Fly ash could be use as prime material in blocks, paving or bricks, however, on the most important applications is PCC pavement. PCC pavements utilize a large amount of concrete and using fly ash provide great economic benefits.

Fly Ash Benefits

Fly ash can be a expenses effective substitute for Portland cement in some markets. In addition, fly ash could be known as an environmentally friendly produce, because it is a by-product and has low embodied energy. Fly ash is available in two color, and coloring agents can be added at the job site. Fly ash also requires less water than Portland cement, and it is easier to make use of in cold weather. Other benefits are.

TESTS ON MATERIALS

Tests on Cement

Specific gravity of cement

The method used to calculate specific gravity of cement is Le-chatlier's Flask method. In this cement is tested by using Kerosene. The tested cement specific gravity is of 3.15.

4.1.1 Normal Consistency of Cement

Normal consistency test is conducted as per IS 4031 (part 4) – 1988. The main purpose of conducting Normal consistency is to find the amount of water to be added for producing cement paste of standard consistency. Vicat apparatus is generally used for this test and is confirming to IS 5513 – 1976. The other apparatus are balance, Gauging trowel.

Curing of concrete:

Process of maintaining enough moisture in concrete to maintain the rate of hydration during its early stages - The most important single step in developing concrete strength, after proper mix design - If not properly carried out, affects its strength, water tightness and durability.

curing of cubes in water

TESTING OF SPECIMENS

General

Calculation of Fresh and Hardened properties is the main era in concrete testing. The well cured specimens in curing tank are tested for Compressive strength, split tensile strength and modulus of rupture. By taking out the specimens from the curing tank, the specimens were exposed to sun light for surface drying. After the drying process, the specimens are processed for testing. The specimens are tested for 7 days and 28 days strengths. In this chapter the testing procedures and formulations are discussed and presented as follows.

7.3 Mechanical Properties of concrete

Mechanical properties of concrete are mainly related to the calculation of its strength. The calculation of mechanical properties includes the testing of concrete for its performance in Compressive strength, Split tensile strength and modulus of rupture. The procedures and calculations of these three tests are confirmed by the standard specification IS 516 – 1959.

7.3.1 Compressive Strength

Compressive strength or crushing strength is the main property observed in testing the cubes. Cubes are tested to calculate Compressive strength by applying gradual loading in Compression Testing Machine. The reading of the failure load is occurred on the top of the machine in the indicator.

The Compressive strength has been calculated by the formula

Compressive strength = applied load/cross sectional area

= P/A

= load/area N/mm^2

7.3.2 Split Tensile Strength

Split tensile strength is the most important property of concrete. Concrete generally weak in tension. So to improve tensile behavior of concrete, split tensile strength is important. It is also important in reducing formation of cracks in concrete. Cylinders are casted for calculating split tensile strength. The cylindrical specimens are also tested in compression testing machine. The cylinders are placed in axial direction by facing cylindrical face to the loading surface. Here the cylinder split into the two parts and reading observed on the top of the machine.

The split tensile strength has been calculated by the formula

Split tensile strength = $2P / \pi ld$

P = failure load (applied load)

L = height of the cylinder specimen

D = diameter of mould

7.3.3 Flexural Strength

Most of the beam failures are occurred due to their failure in flexural strength. It is important that prediction of flexural strength by calculating modulus of rupture for reducing failure problems in beams. The calculation of modulus of Rupture in terms of Flexural strength is the main aim in casting beam specimens. In this modulus of rupture is calculated by testing specimens in the universal testing machine. In this line of facture is the main important property in formulating the modulus of rupture.

The modulus of rupture is denoted by "f_{cr}".

The 'f' value is mainly based on the shortest distance of line fracture 'a'

If 110mm < a < 133mm, $f_{cr} = 3PL/bd^2$

If a > 133mm, $f_{cr} = PL/bd^2$

If a < 110mm, the test shall be discarded

RESULTS AND DISCUSSIONS

Conventional	7 days compressive strength (N/mm^2)	28 days compressive strength (N/mm^2)	90 days compressive strength (N/mm^2)
	28.20	39.126	39.20

Split tensile strength

Fly ash	Cement	7days Split tensile strength	28 days split tensile strength	90 days split tensile strength
15%	85%	2.53	3.48	3.49
20%	80%	2.55	3.50	3.52
25%	75%	2.66	3.55	3.57
30%	70%	2.56	3.46	3.47

Flexural Strength

Fly ash	Cement	7days split tensile strength	28 days split tensile strength	90 days split tensile strength
15%	85%	3.54	4.27	4.29
20%	80%	3.58	4.30	4.33
25%	75%	3.73	4.36	4.40
30%	70%	3.59	4.25	4.28

CONCLUSIONS

1. From the above experiment, cement has been replaced by fly ash in 15%,20%,25%,30%.the optimum value of fly ash was determined.

2. The optimum value of fly ash is taken as 25%, now keeping the 25% of fly ash constant. Fine aggregate has been replaced by robo sand in increasing percentage.

3. From the experiment 50% of fine aggregate can be replaced with Robo sand.

4. Robo sand qualifies itself as a substitute for river sand at reasonable cost.

5. Target strength(38 Mpa) is generally used for a wide range of structural uses. From the present study it is concluded that by decreasing the water to cement ratio to 0.43, the above target strength can be achieved through robo sand and fly ash.
6. Generally, fly ash based concrete has the ability to develop strength over prolonged periods of time. So at a long period of run the compressive strength of with 25% fly ash achieves similar strength of conventional concrete.

7. Compressive strength reduces when cement replaced by fly ash, as fly ash percentage increases.
8. Split tensile strength and flexural strength increases slightly.

9. Use of fly ash in concrete can save coal and thermal industry disposal costs.

10. This experimental study concludes that fly ash can be innovative supplementary cemtitious material.

SCOPE OF FURTHER WORK

1. In this project 60% of fine aggregate has been replaced by robo sand, 100% replacement of fine aggregate by robo sand can be done for future work.
2. The cement has been replaced by fly ash partially, GGBS, Slag cement can also be replaced in place of cement partially.
3. In this project normal water curing has been done, sea water curing can also be done.
4. Durability tests can be done.

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