Experimental Study on Partial Replacement of Copper Slag and Flyash for Fine Aggregate and Cement and PVA Fiber As Reinforcement in Concrete

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Abstract - **This study presents the experimental behaviour of concrete with partial and fully replacement of copper slag and partial replacement of cement by Fly Ash and its compare with controlled cubes. Fine Aggregates are replaced by copper slag for various percentages 20%, 40%, 60%, 80% and 100% and cement with additionally used material of Fly Ash for various percentage 25%, 50%, 75% and 100% and PVA Fibre for ratio 0.8%, 1.0%, 1.2%, 1.4%, 1.6% is to be used in combination and the strength is to be determined. The compressive strength and Flexural strength of hardened concrete with various replacements is to be done. It is expected that the strength of cubes for various replacements will not have any adverse effect on strength and there might be slight improvement in strength. It would be an economical or a cost effective technique in concreting for the future. The aim of this project is to utilize the PVA fiber as an reinforcement material instead of using steel elements in the structure. It is used in light weight structures and small structures.**

Keywords: Partial Replacement, copper slag, fly ash, Strength of concrete.

I. INTRODUCTION

This concrete developed in the last decade, may contribute to safer, more durable, and sustainable concrete infra-structure that is cost-effective and constructed with conventional construction equipment. With two percent by volume of short fibers, it has been prepared in ready-mix plants and transported to construction sites using conventional ready-mix trucks. The mix can be placed with-out the need for vibration due to its self-consolidating characteristics. It is ductile in nature. Under flexure, normal concrete fractures in a brittle manner. In contrast, very high curvature can be achieved for this concrete at increasingly higher loads, much like a ductile metal plate yielding this inelastic deformation, although different from dislocation movement, is analogous to plastic yielding in ductile metals such that the material undergoes distributed damage throughout the yield zone. The tensile strain capacity can reach 3-5%, compared to 0.01% for normal concrete. Structural designers have found the damage tolerance and inherent tight crack width control of attractive in recent full-scale structural applications. The compressive strength of similar to that of normal to high strength concrete Normal concrete is brittle in nature while this concrete ductile in nature, due to this property; it has wide applications & wide future scope in various fields.

Replacement:

- Fly Ash - 0%,25%,50%,75%,100%
- Copper slag -20%, 40%, 60%, 80%,100%

II. SCOPE & BACKGROUND

More flexible than traditional concrete, Traditional concrete is considered a ceramic, brittle and rigid. It can suffer catastrophic failure when strained in an earthquake or by routine overuse. It is studded with specially-coated reinforcing that hold it together. This concrete remains intact and safe to use at tensile strains up to 5%. Traditional concrete fractures and can't carry a load at 0.01 % tensile strain. Today, builders reinforce concrete structures with steel bars to keep cracks as small as possible. But they're not small enough to heal, so water and deicing salts can penetrate to the steel, causing corrosion that further weakens the structure. Li's self-healing concrete needs no steel reinforcement to keep crack width tight, so it eliminates corrosion.

III. OBJECTIVE

1. To check the ductile behavior of the concrete.
2. To check the behavior of bendable concrete under compression & Flexure.
3. To investigate the effect of sand, copper slag super plasticizer & PVA fibers on the behavior of our concrete.

IV. INGREDIENTS OF CONCRETE

The concrete composed of cement, sand, fly ash, water, small amount of SP and an optimal amount of fibers. In the mix coarse aggregates are deliberately not used because property of Concrete is formation of micro cracks with large deflection. Coarse aggregates increases crack width which is contradictory to the property of Concrete.

4.1. CEMENT

Cement used is Ordinary Portland cement. Numerous organic compounds used for adhering, or fastening materials, are called cements, but these are classified as adhesives, and the term cement alone means a construction material. Blast furnace slag may also be used in some cements and the cement is called Portland slag cement (PSC). The color of the cement is due chiefly to iron oxide. In the absence of impurities, the color would be white, but neither the color nor the specific gravity is a test of quality. Ordinary Portland cement (OPC) – 53 grade (Ultra tech Cement) was use.

4.2. SAND [FINE AGGREGATE]

Fine aggregate / natural sand is an accumulation of grains of mineral matter derived from the disintegration of rocks. It is distinguished from gravel only by the size of the grains or particles, but is distinct from clays which contain organic materials. Sands that have been sorted out and separated from the organic material by the action of currents of water or by winds across arid lands are generally quite uniform in size of grains. Usually commercial sand is obtained from river beds or from sand dunes originally formed by the action of winds. The most useful commercially are silica sands, often above 98% pure. Beach sands usually have smooth, spherical to ovoid particles from the abrasive action of waves and tides and are free of organic matter. The white beach sands are largely silica but may also be of zircon, monazite, garnet, and other minerals, and are used for extracting various elements. Sand is used for making mortar and concrete and for polishing and sandblasting. Sands containing a little clay are used for making molds in foundries. Clear sands are employed for filtering water. Sand is sold by the cubic yard (0.76 m3) or ton (0.91 metric ton) but is always shipped by weight. The weight varies from 1,538 to 1,842 kg/m3, depending on the composition and size of grain. The fine aggregate was passing through 4.75 mm sieve and had a specific gravity of 2.68. The grading zone of fine aggregate was zone III as per Indian Standards.

4.3. SUPER PLASTICIZER

Super plasticizer used is Melamine Formaldehyde Sulphonate. This is used to control rheological properties of fresh concrete. Super plasticizers are additives to fresh concrete which help in dispersing the cement uniformly in the mix. This is achieved by their deflocculating action on cement agglomerates by which water entrapped in the groups of cement grains is released and it is available for workability. Typically super plasticizer increase slump from say 5cm to about 18-20cm without addition of water. When used to achieve reduction in mixing water they can reduce water up to 15-20% and hence decrease W/C ratio by same amount. This results in increase in strength and other properties like density, water tightness. Where thin sections are to be cast super plasticizer can increase workability to pump able level and almost no compaction is required. This help in avoiding honeycombing. The permeability of concrete is a guide to its durability. Gross porosity is usually due to continuous passage in the concrete due to poor compaction or cracks which can be minimized by the use of super plasticizer, the incorporation of which provides increased workability maintaining low w/c ratio. It is reported that coefficient of permeability of cement paste reduces considerably with the reduction in w/c ratio. Thus super plasticizer can be used effectively to improve the properties of concrete and avoid defect. Melamine based Super plasticizer are used to assess their effectiveness in improving durability. Melamine based super plasticizer are reported to be the best and hence chosen for the research work.

4.4. FLY ASH

In RCC construction use of fly ash has been successful in reducing heat generation without loss of strength, increasing ultimate strength beyond 180 days, and providing additional fines for compaction. Replacement levels of primary class fly ash have ranged from 30-75% by solid volume of cementitious material. In proportioning mixes for minimum paste volumes one principal function of a fly ash is to occupy void space which would otherwise be occupied by cement or water. To occupy void space with water would obviously result in reduction in concrete strength. The fact is that even a small amount of free lime liberated from cement is sufficient to react with large volume of fly ash. The huge amount of fly ash is produce in the thermal power stations .Class F fly ash is utilized so the acquisition cost is reduced. Only transportation cost is estimated.

4.5. PVA FIBERS

PVA fiber has suitable characteristics as reinforcing materials for cementitious composites. High modulus of elasticity, durability, tensile strength and bonding strength with concrete matrix are some of its desirable properties. PVA fiber has high strength and modulus of elasticity (25 to 40GPa) compared to other general organic fiber which widely used for cement reinforcing. Fiber elongation is about 6-10%. The tensile strength of fiber is 880-1600MPa. One of the remarkable characteristics of PVA fiber is strong bonding with cement matrix. The layer of $Ca(OH)_2$ called ITZ(Interfacial transition zone) round PVA fiber is formed as white part, and in case of PP, this layer is not observed. It is known that PVA is easy to make complex cluster with metal hydroxide. It is assumed that Ca^+ and OH^- ions in cement slurry are attracted by PVA and makes $Ca(OH)_2$layer. It seems reasonable to think that $Ca(OH)_2$ layer plays important role for bonding strength.

4.6. WATER

Water fit for drinking is generally considered fit for making concrete. Water should be free from acids, oils, alkalis, vegetables or other organic Impurities. Soft waters also produce weaker concrete. Water has two functions in a concrete mix. Firstly, it reacts chemically with the cement to form a cement paste in which the inert aggregates are held in suspension until the cement paste has hardened. Secondly, it serves as a vehicle or lubricant in the mixture of fine aggregates and cement.

V. TEST RESULTS

- ✓ Specific Gravity test of copper slag is =**3.66**
- ✓ Specific Gravity test of PVA fiber is =**1.29**
- ✓ Specific Gravity test of cement is =**3.15**
- ✓ Specific Gravity test of fine aggregate is=**2.66**
- ✓ Water Absorption test of fine aggregate is=**0.7%**
- ✓ Water Absorption test of copper slag is=**0.3%**

VI. TESTING OF CONCRETE

This deals with Tests and testing procedure for fresh & hardened concrete specimen. Investigations are carried out by testing cubes, beams, slabs and cylinders for 7, 14, 28 days. Cubes were tested on Compression Testing Machine (CTM) and beams were tested on Universal Testing Machine (UTM).

6.1. WORKABILITY TEST OF FRESH CONCRETE

Sabaa & Ravindrarajah (1999) had mentioned that workability is a very important property of concrete which will affect the rate of placement & the degree of compaction of concrete. Cement Association of Canada (2003) stated that the workability is the ease of placing, combining & finishing freshly concrete mixed & the degree to which it resists segregation.

6.2. SLUMP TEST.

Slump test is used to determine the workability of fresh concrete. The test is simple and cheap. It is suitable to use in the laboratory and also at site. Although the test is simple, but the testing has to be done carefully. Due to a huge slump may obtain if there is any disturbance in the process. Logic sphere mentioned that the slump test will give a reasonable indication of how easily a mix can be places although it does not directly measure the work needed to compact the concrete. It also mentioned that a slump less than 25mm will indicate a very stiff concrete and a slump that more than 125mm will indicates a very runny concrete. The apparatus & equipment used for the slump test & the procedure of the test according to IS 7320-1974.

SLUMP VALUES

Slump value for copper slag and fly ash

Replacement in percentage	Slump value(mm)
Normal Concrete	23
20%C.S & 0%F.A	24
40%C.S & 25%F.A	24
60%C.S & 50%F.A	25
80%C.S & 75%F.A	26
100%C.S & 100%F.A	27

VII. TESTING ON HARDENED CONCRETE SPECIMENS

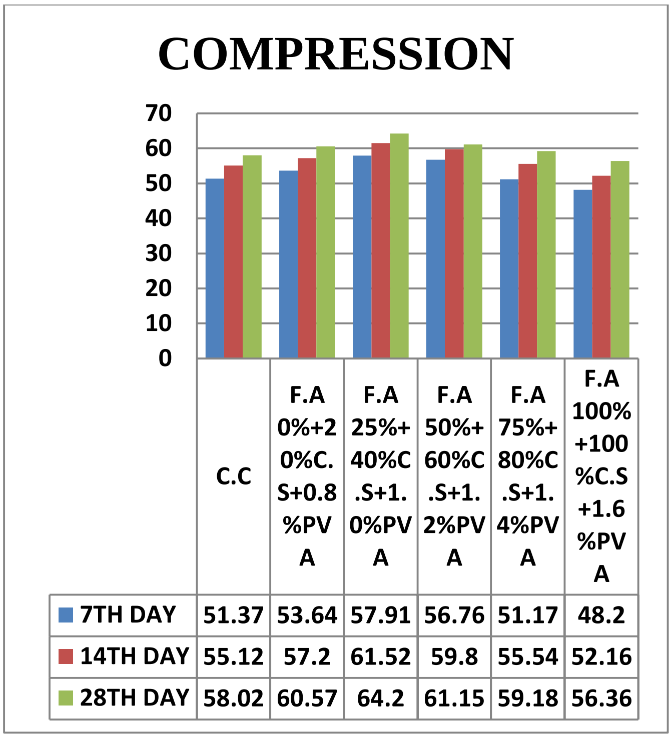
Concrete is combination of Portland cement, water and aggregate that consists of rocks and sand. Normally, concrete is strong in compression but weak in tension. There are many ways that we can used to indicate the strength of concrete. The testing for the strength if concrete is very important in the civil works. This chapter consists of two types of hardened concrete testing. They are compression test and split tensile test. All the procedure used was according to the Indian Standard Code.

7.1. CRUSHING TEST- [TEST ON CUBES]

According to cement association of India (2003), compressive strength of concrete can be defined as the measured maximum resistance of concrete to axial loading. Compression test is the most common test used to test the hardened concrete specimens because the testing is easy to make. The specimens used in compression test were the cube of 150×150×150 mm. The procedure is as below: The testing for the specimens should be carried out as soon as possible after taking out from the curing rank.The axis of specimen is aligned with the centre of thrust of the seated plate. Plate is lowered until the uniform bearing is obtained. The force is applied and increased continuously at a rate equivalent to 20 MPa compressive stresses per minute until the specimen failed. Record the maximum force from the testing machine.

RESULTS FOR COMPRESSION TEST

PARTICULARS	7TH DAY	14TH DAY	28TH DAY
C.C	51.37	55.12	58.02
F.A 0%+20%C.S+ 0.8%PVA	53.64	57.20	60.57
F.A 25%+40%C.S+ 1.0%PVA	57.91	61.52	64.20
F.A 50%+60%C.S+ 1.2%PVA	56.76	59.80	61.15
F.A 75%+80%C.S+ 1.4%PVA	51.17	55.54	59.18
F.A 100%+100%C.S+ 1.6%PVA	48.20	52.16	56.36

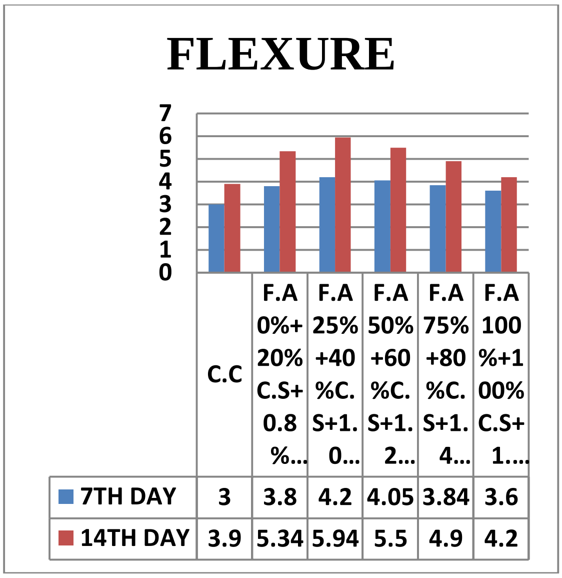


7.2FLEXURE TEST- [TEST ON BEAMS]

Concrete is quite strong in compression and weak in tension. Hence in most of the design of concrete structures its tensile strength is ignored. However at certain situations like water retaining and pre stressed concrete structures the tensile strength of concrete is essential requirement. A direct application of pure tensile stress is difficult. An indirect way is adopted by measuring the flexure strength of beam. Three specimens shall be tested each at the end of three and seven days. The dimension of each specimen should be noted before the testing. The specimen shall then be placed in a machine in such a manner that the load shall be applied to the uppermost surface as cast in the mould. The specimen shall be supported on 38 mm diameter roller with 600 mm span for 150 mm size specimen and 400 mm span for 100 mm size specimen. The load shall be applied through two similar rollers mounted at the third points of the supporting span that is spaced at 200 mm or 133 mm c/c. The spacing of the two load application points at top of specimen is 200 mm for a specimen size of 150 mm x150 mm x 700 mm and or 130 mm for 100 mm x 100 mm x 500 mm. The loading arrangement employed for the test. The axis of the specimen shall be carefully aligned with the axis of loading device. The load shall be increased until the specimen fails and the maximum load applied to the specimen during the test shall be recorded.

RESULTS FOR FLEXURE TEST

PARTICULARS	7TH DAY	28TH DAY
C.C	3	3.9
F.A 0%+20%C.S+0.8%PVA	3.8	5.34
F.A 25%+40%C.S+1.0%PVA	4.2	5.94
F.A 50%+60%C.S+1.2%PVA	4.05	5.5
F.A 75%+80%C.S+1.4%PVA	3.84	4.9
F.A 100%+100%C.S+1.6%PVA	3.6	4.2



VIII. RESULTS

The compressive strength of the cube is attained in the proportion of 125% of fly ash, and 40% replacement of copper slag and 1.0% PVA fiber and it shows the overall strength of the cube at 28 days is more than the conventional concrete 64.20%, while the normal concrete is about 58.02 only. While in case of flexural strength 5.94 is attained and this is greater than the conventional concrete is about 3.9.

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