Experimental Investigation on effect of high strengthGeopolymer concrete using GGBS and Copper slag.

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Abstract:

Concrete is the most widely used building material. It has desirable engineering properties, can be moulded into any shape and more importantly is produced with cost effective material. In the engineering industry the improvement of existing materials allows for technological advancement and the construction of more reliable structure without over design. Successful examples of high-rise buildings in the world are obvious evidences that the use of high strength concrete in now day's reality in construction worldwide. Large number of mineral admixtures which are waste products of other industries, are bring beneficially used in making quality of concrete. Growing demand for construction materials necessitated the usage of alternative materials in the production of conventional concrete. Since there is a scarcity of fine aggregate throughout the country it is essential to find a replacement of fine aggregate. Proposed idea is to use copper slag as replacement of fine aggregate. Copper slag is by product material produced during the smelting and refining process of manufacturing of copper. Thus, this material is produced in large quantity asa waste. The objective of this work is to study the strength and durability properties of concrete. In this studyM60 grade of concrete is used. An experimental investigation will be conducted to study the properties of concrete containing copper slag as a partial replacement of fine aggregate and mineral admixture as a partialreplacement of cement in the concrete mix design. Copper slag content has been 40%as a replacement of fine aggregate and silica fume 0 to 20% and GGBS0 to 20% as a replacement of cement. The obtained result will be compared with the conventional concrete there by knowing the change in the properties of concrete containing copper slag as partial replacement of fine aggregate and mineral admixture.

Keywords: High Strength Concrete, Copper Slag, Silica Fume, GGBS

1. INTRODUCTION

Concrete is a composite material composed of fine and coarse aggregate bonded together with a fluid cement that hardens over time. Geopolymer concrete is a type of concrete that is made by reacting aluminates and silicate bearing materials with a caustic activator, such as fly ash or slag from iron and metal production. High-strength strength geopolymer concrete consists of M60 to M80 MPa using geopolymer binders at ambient curing conditions.

2. OBJECTIVES

Designing of HSGC as per IS 10262:2019. To study the Fresh and hard properties of single activator based HSGC. To study the Micro structural properties of single Activator based HSGC. To estimate the cost-efficiency index of HSGC, in comparison with conventional concrete.

3. LITERATURE REVIEW

Almas mevawala explains - Copper slag is mixed with fine aggregate in different proportions and tested for various properties of concrete. And also added polypropylene fiber as admixture for more strength. Compare the result of CBR and UCC strength is increase. Addition of copper slag improve the soil properties. Compare the result of normal concrete with copper slag concrete there is not much effect in its design strength.

Abdullah anwar, syed aqeel ahmad explains - This research paper present a study of strength properties of concrete by partial replacement of fine aggregate with copper slag and cement with silica fume. In the present experimental investigation for M40 grade of concrete, fine aggregate replaced with copper slag 40% and cement was partially

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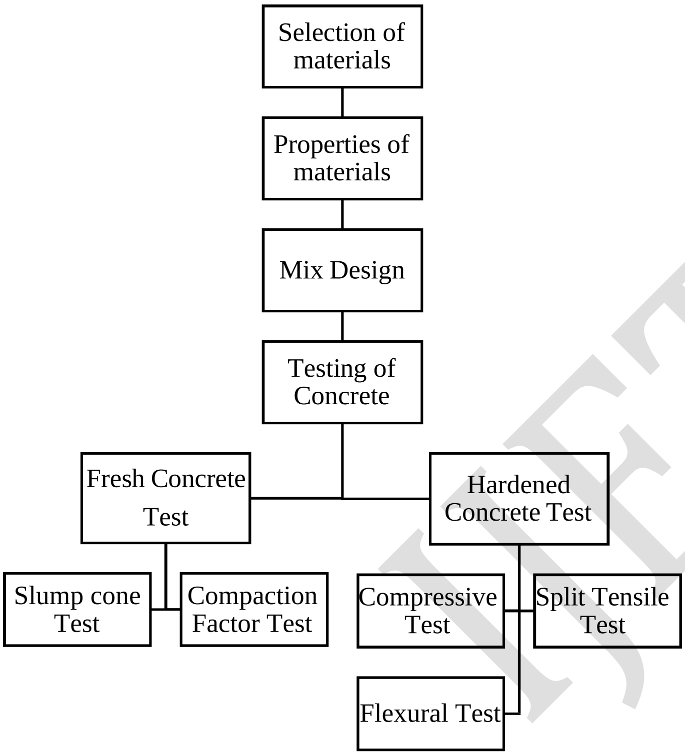
replaced with silica fume from 0 to 15%. The utmost intensity was achieved for 40% replacement of fine aggregate with copper slag. The compressive strength of concrete increase as percentage of copper slag increases with 40%. The flexural strength & split tensile of concrete increase as percentage of copper slag increase with 40%.

4. METHODOLOGY



5. MATERIALS USED

The concrete is a composite mass containing coarse aggregate, fine aggregate, water and cement. The strength and durability of concrete depends mainly on the materials used in it. The behavior of materials would be different based on its nature.

1. GROUND GRANULATED BLAST FURNACESLAG

The chemical composition of a slag varies considerably depending on the composition of the raw materials in the iron production process. Silicate and aluminates impurities from the ore and coke are combined in the blast furnacewith a flux which lowers the viscosity of the slag. In the case of pig iron production the flux consist mostly of a mixture of limestone and forsterite or in some cases dolomite. In the blast furnace the slag floats on top of the iron and is decanted for separation. Slow cooling of slag melts results in an unreactive crystalline material consisting of an assemblage of Ca-Al-Mg silicates. To obtain a good slag reactivity or hydraulicity, the slag melt needs to be rapidly cooled or quenched below 800 °C in order to prevent the crystallization of merwinite and melilite.

Fig1. GGBS

2. FINE AGGREGATE

Manufactured sand (M-Sand) is a substitute of river sand for concrete construction. M- Sand is produced from hard granite stone by crushing. Due to fast growing construction industry, the demand for sand has increased tremendously, causing deficiency of suitable river sand in most part of the word. Due to the depletion of good quality river sand for theuse of construction, the use of M-Sand has been increased. M-Sand is used for availability and transportation cost. The properties of sand will affect the strength of concrete in great manner. The fine aggregates should not have high clay and silt content, since clay will affect the behavior of cement and reduces the strength of concrete. The fine aggregate should also be free from any organic contents. Fineness modulus of sand should be between 2.5 to 3.2.

Fig2. Fine Aggregate

3. COARSE AGGREGATE

Aggregates are the most mined materials in the world. Aggregates are a component of composite material such as concrete. The aggregate serves as reinforcement to add strength to the overall composite material. Due to the relatively high hydraulic conductivity value as compared to most soils, aggregates are widely used in drainage applications such as foundation and French drains, septic drain field, retaining wall drains and road side edge drains. Aggregates are also used as base material under foundations, roads and railroad. In other words aggregates are used as a stable foundation or road/rail base with predictable, uniform properties (e.g. to help prevent differential settling under the road or building). The coarse aggregate is collected from local area. The nominal coarse aggregate size is 20 mm. the texture of the aggregate will have significant effect on properties of concrete.

Fig3. Coarse Aggregate

4. SODIUM HYDROXIDE

Sodium hydroxide is a highly caustic base and alkali that decomposes proteins at ordinary ambient temperatures and may cause severe chemical burns. It is highly soluble in water and readily absorbs moisture and carbon dioxide from the air. It forms a series of hydrates NaOH·nH crystallizes from water solutions between 12.3 and 61.8 °C.

Fig4. Sodium Hydroxide

5. SODIUM SILICATE

Sodium silicate is a generic name for chemical compounds with the formula Na_2xSiO_2+xor $(Na_2O)x\cdot SiO_2$, such as sodium metasilicate Na_2SiO_3, sodium orthosilicate Na_4SiO_4 and sodium pyrosilicate $Na_6Si_2O_7$. The anions are often polymeric. These compounds are generally colorless transparent solids or while powders and soluble in water in various amounts.

Fig5. Sodium Silicate

6.PRELIMINARY TESTS

1. SEIVE ANALYSIS

The sample was brought to an air-dry condition before weighing and sieving. This can be achieved either by drying at room temperature or heating at a temperature of 1000°C to 1100°C. The air-dry sample 1 kg was taken and sieved successively on the appropriate sieves starting with the largest size sieve as stated in the table 5.1. Sieving is carried out on a machine not less than 10 minutes required for each test.

2. SPECIFIC GRAVITY

The test procedure is same as that of specific gravity of fineaggregate and coarse. The Table below shows the observed reading of specific gravity test on fine & coarse aggregate.

7. TEST ON CONCRETE

1. FRESH CONCRETE

Fresh concrete or plastic concrete is a freshly mixed material which can be molded into any shape. The relative quantities of cement, aggregates and water mixed together, control the properties of concrete in the wet stateas well as in hardened state. The following tests are conducted to evaluate the degree of workability.

Slump Value Test

Slump test is used to determine the workability of fresh concrete. Slump test as per IS 1199:1959 is followed. The apparatus used for doing slump test were slump cone and tamping rod. The internal surface of the mould was thoroughly cleaned and freed from superfluous moistureand adherence of any old set concrete before commencing the test. The mould was then filled in four layers, each 1/3 of the height of the mould, each layer being tamped 25 times with a standard tamping rod taking care to distribute the strokes evenly over the cross section. After top layer had been rodded, the concrete was struck off level with a trowel and tamping rod. The mould was removed from the concrete immediately by raising it slowly and carefully in a vertical direction. This allowed concrete to subside. This subsidence was referred as slump of concrete. The difference in level between the height of the mould and that of the highest point of the subsided concrete was measured. This difference in height in mm was taken as slump of concrete. The obtained slump value for controlled concrete was 80 mm.

Fig6. Slump Cone Test

2. HARDENED CONCRETE TEST

One of the purposes of testing hardened concrete is to confirm that the concrete used at site has developed the required strength. Testing of hardened concrete plays an important role in controlling and confirming the quality of cement concrete works. Systematic testing of raw materials, fresh and hardened concrete are inseparable part of anyquality control programmer for concrete, which helps to achieve higher efficiency of the material used and greater assurance of the performance of the concrete with regard to both strength and durability. Thetest methods should be simple, direct and convenient to apply. The controlled concrete is cast and cured for 28 days and the tests for hardened concrete such as compressive strength, split tensile strength, compressive stress and strain behavior are

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done. Compressive Strength Test The compressive trength test for cubes was conducted in compression testing machine as per IS 516:2004. The cubes were tested in compressive testing machine at the rate of 140 kg/cm^2/min and the ultimate loads were recorded. The bearing surface of machine was wiped off clean andthe surface of the specimen was cleaned. Load was applied to opposite sides of the cubes such that casted side of specimen was not top and bottom. The axis of the specimen was carefully aligned at the center of loading frame. The load applied was increased continuously at a constant rate until the resistance of the specimen to the increasing load breaks down. Maximum load applied was recorded. Compressive strength of cubes at 28 days.

Fig7. Compressive Strength Test Split Tensile Test

The split tensile strength test for cylinders was carried outas per IS 516 : 2004. This test was carried out by placing a cylinder specimen horizontally between the loading surfaces of a universal testing machine and the load was applied until failure of the cylinder along the vertical diameter. When the load was applied along the element on the vertical diameter, the cylinder is subjected to a horizontal stress and the split tensile strength was found using subsequent formula.

Fig8. Split Tensile StrengthFlexural Strength Test

Flexural test evaluates the tensile strength of concrete indirectly. It tests the ability of unreinforced concrete beam or slab to withstand failure in bending. The results of flexural test on concrete expressed as a modulus of rupture which denotes as (MR) in MPa or psi. The flexural test on concrete can be conducted using either three point load test (ASTM C78) or center point load test (ASTM C293).

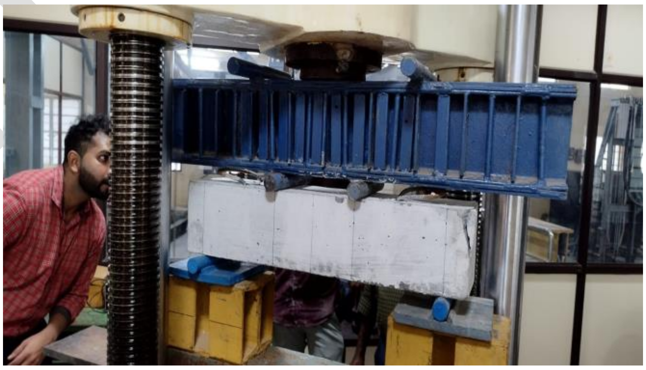

Fig9. Flexural Strength Test

8. RESULTS AND DISSCUSSIONS

Slump cone test

Test	Both Alkaline Solutions	Sodium Hydroxide Solutions	Sodium Silicate Solutions
Slump Value	105mm	96mm	100mm

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Compressive Strength Test

Specimen	Load (P) (10^3N)	Area (A) (mm^2)	Compressive Strength = P/A(Mpa)
1	1477	22500	65.6
2	1413	22500	62.8
3	1494	22500	66.4

Average Compressive Strength of Both Alkaline Solutions28days = 64.95 Mpa

Specimen	Load (P) (10^3N)	Area (A) (mm^2)	Compressive Strength = P/A(Mpa)
1	770	22500	34.22
2	740	22500	32.89
3	725	22500	32.22

Average Compressive Strength of Sodium HydroxideSolutions 28days = 33.11 Mpa

Specimen	Load (P) (10^3N)	Area (A) (mm^2)	Compressive Strength = P/A (Mpa)
1	950	22500	42.22
2	935	22500	41.56
3	905	22500	40.22

Average Compressive Strength of Sodium SilicateSolutions 28days = 41.33 Mpa

Split Tensile Strength

Specimen	Load (P) (10^3N)	Split Tensile Strength (Mpa)
1	290	4.10
2	222	3.11

Average Split Tensile Strength of Both Alkaline Solutions28days = 3.605 Mpa

Flexural Strength Test

Specimen	Flexural Strength (Mpa)
1	5.4

Average Flexural Strength of Both Alkaline Solutions28days = 5.4 Mpa

8. CONCLUSION

The physical and chemical properties of the materials are determined. Mix design is arrived based on the material property. Determined the grading of zone in fine aggregate and Coarse aggregate based on the sieve analysis. The physical properties of the materials are determined and compare to IS Code specification. The chemical composition of the materials is compared with standardvalue. As per IS method (10269-2019) the mix design is made. Then the Fresh and Hardened concrete test are made in that the strength value of both alkaline solutions is comparatively higher than either one of the alkaline solutions and slightly higher than the conventional concrete.

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