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Material Characteristics of Geopolymer Concrete for Different Strength

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Abstract **- Every year 87 to 100 million tonne of fly ash is generated from coal based thermal power stations in India and power is the key to the prosperity and development of a nation and the power generation in India consumes 70% of country's coal production and generates 100 million tonnes ash per tear. The ash generation is projected to increase at least to 175 million tonne per year by 2012. Now, having seen that fly ash is such a wonderful and useful material that it can be used for large number of gainful applications like in building components, cement, construction of embankments, raising, dykes, agriculture and mine fill material, it is successfully accepted for large scale utilization instead of disposing at high handling costs. This article deals with the management of fly ash in utilization based on its quality and value, Quarry dust, 12.5mm coarse aggregate with geoploymer concrete.**

Keywords- **Cement, Fly ash, Quarry dust, Sand, 12.5mm aggregate. Alkaline solution, Geo polymer concrete.**

I. INTRODUCTION

Geo polymer concrete (GPC) is a latest innovation in the construction sector and an environment friendly construction material obtained as a result of polymerization chain reaction of inorganic molecules comprising of readily available materials like low calcium fly-ash and Ground Granulated Blast Furnace Slag (GGBFS). This fly ash is then collected in the dust-collection systems that remove particles from the exhaust gases. The usage of geo polymer concrete not only can reduce the emission of greenhouse gases but it also can achieve early strength compare to using Portland cement.

There is further study related to the behavior of geo polymer concrete to enhance the durability of the concrete so it could use in construction and sustain longer time. Study related to changing the pozzolanic materials, adding admixtures and also shrinkage behavior has been done to improve the durability of geo polymer concrete. Several improvements has been done on the geo polymer concrete throughout the years to make sure the geopolymer concrete can sustain more loads.

II. FLY ASH

Fly ash is a pozzolanic material. It is a finely-divided amorphous alumino- silicate with varying amounts of calcium, which when mixed with Portland cement and water, will react with the calcium hydroxide released by the hydration of Portland cement to produce various calcium - silicate hydrates (C-S-H) and calcium aluminates hydrates. Some fly ashes with higher amounts of calcium will also display cementations behavior by reacting with water to produce hydrates in the absence of a source of calcium hydroxide. These pozzolanic reactions are beneficial to the concrete in that they increase the quantity of the cementations binder phase (C-S-H) and, to a less extent, calcium- aluminates hydrates, improving the long- term strength and reducing the permeability of the system. Both these mechanisms enhance the durability of the concrete.

III. AGGREGATES

Aggregates are inert granular materials such as sand, gravel, or crushed stone that, along with water and Portland cement, are an essential ingredient in concrete. For a good concrete mix, aggregates need to be clean, hard, strong particles free of absorbed chemicals or coatings of clay and other fine materials that could cause the deterioration of concrete.

Aggregates, which account for 60 to 75 percent of the total volume of concrete, are divided into two distinct categories--fine and coarse. Fine aggregates generally consist of natural sand or crushed stone with most particles passing through a 3/8-inch sieve. Coarse aggregates are any particles greater than 0.19 inch, but generally range between 3/8 and 1.5 inches in diameter. Stone Aggregates are processed using high quality raw material and the latest technology under the constant supervision of our skilled experts. Available in 12mm, 20mm and 40mm variants, they are used in various areas

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of Infrastructure industry including construction, roads and railways for supreme strength.

IV. QUARRY DUST

Currently India has taken a major initiative on developing the infrastructures such as express highways, power projects and industrial structures etc., to meet the requirements of globalization, in the construction of buildings and other structures concrete plays the rightful role and a large quantum of concrete is being utilized. This paper presents the feasibility of the usage of Quarry Rock Dust as hundred percent substitutes for Conventional Concrete. Tests were conducted on cubes and beams to study the compressive, flexural strengths of concrete made of Quarry Rock Dust for three different proportions and five different methods. Durability Studies were done for concrete with Quarry Rock Dust and compared with the Conventional Concrete.

V. ALKALINE SOLUTION

The alkaline liquid commonly used in geo poly merisation is a combination of sodium hydroxide (NaOH) or potassium hydroxide (KOH) and sodium silicate or potassium silicate. Xu and van Deventer (2000) observed that the addition of sodium silicate solution to the sodium hydroxide solution as the alkaline liquid enhanced the polymeric reaction.

1. Sodium silicate

Sodium silicate is the common name for a compound sodium meta- silicate, Na2SiO3, also known as water glass or liquid glass. Sodium carbonate and silicon dioxide react to form sodium silicate and carbon dioxide.

2. Sodium hydroxide

Sodium hydroxide, also known as caustic soda, or lye, is an inorganic compound with the chemical formula NaOH. It is a white solid and highly caustic metallic base and alkali salt which is available in pellets, flakes, granules. Sodium hydroxide is soluble in water, ethanol and methanol. Similar to the hydration of sulphuric acid, dissolution of solid sodium hydroxide in water is a highly exothermic reaction in which a large amount of heat is liberated, posing a threat to safety through the possibility of splashing; use of hand gloves is recommended while preparing sodium hydroxide solution. The resulting solution is usually colorless and odorless with slippery feeling upon contact with other alkalis.

VI. FEATURES OF GEOPOLYMER CONCERTE

1. Reduced Heat of Hydration:

The pozzolanic reaction between fly ash and lime generates less heat, resulting in reduced thermal cracking when fly ash is used to replace portland cement.

2. Reduced Alkali Silica Reactivity:

Fly ash combines with alkalis from cement that might otherwise combine with silica from aggregates, causing destructive expansion.

3. Workability:

Concrete is easier to place with less effort, responding better to vibration to fill forms more completely.

4. Ease of Pumping

Pumping requires less energy and longer pumping distances are possible.

5. Improved Finishing:

Sharp, clear architectural definition is easier to achieve, with less worry about in-place integrity.

6. Reduced Bleeding:

Fewer bleed channels decreases porosity and chemical attack. Bleed streaking is reduced for architectural finishes. Improved paste to aggregate contact results in enhanced bond strengths.

7. Reduced Segregation:

Improved cohesiveness of fly ash concrete reduces segregation that can lead to rock pockets and blemishes.

8. Reduced Slump Loss:

More dependable concrete allows for greater working time, especially in hot weather.

VII. CONSTRUCTION PROCEDURES

1. Material Handling and Storage

When fly ash is used as a mineral admixture, the ready-mix producer typically handles fly ash in the same manner as Portland cement, except that fly ash must be stored in a separate silo from the Portland cement.

2. Mixing, Placing, and Compacting

Placement and handling of fly ash concrete is in most respects similar to that of normal concrete. Fly ash concrete using Class F fly ash has a slower setting time than normal concrete hours, depending on the temperature. Placement and finishing, although properly proportioned concrete mixes containing fly ash should benefit workability and finishing.

The concrete mix is placed in layers in standard steel moulds (cube, cylinder and beam) for casting the concrete specimens. The concrete placed was compacted using table vibrator. Before casting a thin coat of oil was applied on the interior faces of the mould to prevent damages to concrete on extraction. Normal procedures for screeding, finishing, edging, and jointing of conventional PCC are also applicable to fly ash concrete

3. Curing

The proper application of a curing compound should retain moisture in the concrete for a sufficient period of time to permit strength development. After 24 hours of casting, the specimens are removed from the mould with

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great care. The surfaces of the specimens are cleaned gently to remove loose particles and are lowered in a curing tank containing clean freshwater. The water in the curing tank was removed after every 10 days and filled with freshwater for curing.

VIII. TEST PROCEDURES

1. Preparation of Test Specimens

The ingredients for the various concrete mixtures were weighed and casting was carried out using a pan mixer. Precautions were taken to ensure uniform mixing of ingredients. The specimens were cast in steel moulds and compacted on a table vibrator by placing the concrete in the moulds in three equal layers and compacting with the table vibrator after placing each layer. The specimens were cured in water on remolding after 24 hours.

2. Mechanical Properties

Compressive strength tests were done on 150 mm cube concrete specimens at different ages as per the procedure specified in IS: 516-1959 [28]. Cylindrical concrete specimens were tested at 21, 28 days. The flexural tests were carried out on beam specimens of size 500 x 100 x100 mm under standard two-point loading, while the split tensile strength was determined by subjecting 150 mm diameter x 300 mm long cylinders to diametric compression.

3. Compressive test

The compressive strength of concrete cubes of the different mixer are found out at the end of 21 and 28 56 days. The concrete cubes are tested for their compressive strength in the compression testing machine as per IS 516-1959 specifications. The rate of loading is applied 140 kg/sq.cm/min until the failure takes places. The ultimate loads of the concrete cubes are recorded.

4. Splitting tensile strength

The splitting tensile strength of concrete cylinders (150 mm dia & 300 mm ht) are tested as per IS 5816-1970 specification. The rate of loading shall be applied without shock increased continuously at rate to produce approximately a splitting tensile stress of approximately 14 to 21 kg/cm2/min until specimen failure be recorded. The splitting tensile strength τ of the specimen shall be calculated from the following formula.

$$\tau = \frac{2P}{\pi dl`}; \quad kg/cm2$$

P = maximum load in kg applied to the specimen.
D = measured diameter in cm of the specimen.
L = measured length in cm of the specimen.

5. Modulus of rapture

The modulus of rapture of the beam (100mm x 100mm x 500mm) is tested in UTM as per IS : 516-1959 specifications. The rate of loading applied 180 kg/sq.cm/min. the shall be increased until the specimens fails, and the maximum load applied (P) to the specimen during the test shall be recorded.

Modulus of rapture $\sigma = \frac{M}{I} = \frac{\sigma}{Y}$;

$$I = bd3/12; \quad Y = D/2$$

Where,

M = Moment

D = measured depth in cm of the specimen at the point of failure.

I = Moment Of Inertia.

P = maximum load in kg applied to the specimen.

IX. CONCLUSION

The alkaline solution selected for the present study is sodium silicate and sodium hydroxide which is relatively cheaper compared to potassium hydroxide based alkaline solution. Morality of sodium hydroxide is fixed based on trials. Basic proportions will be obtained for the materials Mix design of concrete control specimens using ordinary Portland cement concrete is done as per IS: 10262-2009 and mix design for Geo polymer concrete is based on the available literature.

To use 12.5mm coarse aggregates from demolished building of age 8 years are used for the studies. Beams will be cast and subjected to flexural strength test after 28days of curing. For ordinary Portland cement concrete beams, water curing is used. For Geo polymer concrete beams, ambient curing is used. Crack width in beams is measured for ultimate load. Geo polymer concrete cubes incorporated with 12.5mm coarse aggregate and natural coarse aggregate, Quarry dust will be cast and subjected to compression test after 7, 14 and 28 days.

Geopolymer concrete cylinders incorporated with recycled coarse aggregate and natural coarse aggregate will be cast and subjected to Split tensile strength test, RCPT test as per ASTM C 1202 standard and sorptivity test as per ASTM C 1585 standard will be conducted after 28 days.

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