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MECHANICAL PROPERTIES INVESTIGATION OF FINE AGGREGATE REPLACED WITH ROBO SAND IN GEOPOLYMER CONCRETE

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ABSTRACT: Concrete is an essential building material for societal infrastructures throughout the world. In fact, concrete usage around the world is second only to water1). Portland cement is a main component of concrete, however, it is not an environmentally friendly material. The production of Portland cement not only depletes a significant amount of natural resources but also emits a huge quantity of carbon dioxide (CO2) and other greenhouse gases into the atmosphere as a result of decarbonation of limestone and the combustion of fossil fuels. Global warming is caused by the emission of greenhouse gases, such as CO2 into the atmosphere by human activities. Among greenhouse gases, CO2 contributes about 65% of global warming2). The cement industry is responsible for about 6% of all CO2 emissions because the production of one ton of Portland cement emits approximately one ton of CO2 into the atmospher. Due to the production of Portland cement, it is estimated that by the year 2020, CO 2 emissions will rise by about 50% from current levels. Therefore, to preserve the global environment from the impact of cement production, it is imperative to search for and explore new possibilities to develop a concrete material that is more environmentally friendly and yet remain an efficient construction material to replace conventional Portland cement concrete.The aforementioned problems led researchers to investigate for materials with similar properties to be utilized as partially or fully cement replacement materials. Geopolymer concrete is such a one and in the present study, to produce the geo-polymer concrete the Portland cement is fully replaced with fly ash and the fine aggregate is replaced with quarry dust and alkaline liquids are used for the binding of materials. The alkaline liquids used in this study for the polymerization are the solutions of Sodium hydroxide (NaOH) and sodium silicate (Na2Sio3). Different molarities of sodium hydroxide solution i.e. 8M, 10M and 12M are taken to prepare different mixes. And the compressive strength is calculated for each of the mix. The cube specimens are taken of size 150mm x 150mm x 150mm.The Geopolymer concrete specimens are tested for their compressive strength at the age of 7days,mixes of varying sodium hydroxide molarities i.e.8M,10M and 12M are prepared and they are cured by direct sun-light and strengths are calculated for 7 days . The result shows that the strength of Geopolymer concrete is increasing with the increase of the molarity of sodium hydroxide.

KEY WORDS: Geopolymer concrete, Compressive strength, Fly ash

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1. INTRODUCTION

For the construction of any structure, Concrete is the main material. Concrete usage around the world is second only to water. The main ingredient to produce concrete is Portland cement. On the other side global warming and environmental pollution are the biggest menace to the human race on this planet today. The production of cement means the production of pollution because of the emission of CO_2 during its production. There are two different sources of CO_2 emission during cement production. Combustion of fossil fuels to operate the rotary kiln is the largest source and other one is the chemical process of calcining limestone into lime in the cement kiln also produces CO_2.In India about 2,069,738 thousands of metric tons of CO_2 is emitted in the year of 2010. The cement industry contributes about 5% of total global carbon dioxide emissions. And also, the cement is manufactured by using the raw materials such as lime stone, clay and other minerals. Quarrying of these raw materials is also causes environmental degradation. To produce 1 ton of cement, about 1.6 tons of raw materials are required and the time taken to form the lime stone is much longer than the rate at which humans use it. But the demand of concrete is increasing day by day for its ease of preparing and fabricating in all sorts of convenient shapes. So to overcome this problem, the concrete to be used should be environmental friendly.

To produce environmental friendly concrete, we have to replace the cement with some other binders which should not create any bad effect on environment. The use of industrial by products as binders can reduce the problem. In this respect, the new technology geo-polymer concrete is a promising technique. In terms of reducing the global warming, the geo-polymer technology could reduce the CO_2 emission to the atmosphere caused by cement and aggregates industries by about 80% (Davidovits, 1994c). And also the proper usage of industrial wastes can reduce the problem of disposing the waste products into the atmosphere.

GEOPOLYMER

The term geo-polymer was first coined by Davidovits in 1978 to represent a broad range of materials characterized by chains or networks of inorganic molecules. Attempts to reduce OPC usage progressed until the adventure of geopolymer concrete which indeed contains 0% of OPC. The term geopolymer was first coined by Davidovits [8]. Today geopolymer concrete is fabricated by activating pozolaniac properties of industrial by products which are rich of alumina and silica, by alkaline solutions such as NaOH, KOH and Sodium-Silicate etc. It has been estimated that reduction of

CO_2 emission due to the replacement of Portland cement with geopolymer is between 26-45%. The process of geopolymerization includes 3 stages; first the dissolution of mineral oxides (silica and alumina) from the base material, then reorientation of mineral oxides under high alkaline condition and at last forming a 3-D amorphous network with various ratio of Si:Al ; Poly(Sialate) with ratio of Si:Al = 1:1, Poly(Sialate-Siloxo) with ratio of Si:Al = 2:1, Poly(Sialate-disiloxo) with ratio of Si:Al = 3:1 and Sialate Link with ratio of Si:Al > 3:1 [8]. Depending on Si:Al ratio, geopolymers have different applications. Today Poly(Sialate) and Poly(Sialate-Siloxo) are being used as alternatives for OPC, showing strength similar or higher than that of OPC concrete. Geo-polymers are chains or networks of mineral molecules linked with co-valent bonds. Geopolymer is produced by a polymeric reaction of alkaline liquid with source material of geological origin or by product material such as fly ash, rice husk ash, GGBS etc. Because the chemical reaction that takes place in this case is a polymerization process, Davidovitscoined the term 'Geopolymer' to represent these binders.Geo-polymers have the chemical composition similar to Zeolites but they can be formed an amorphous structure. He also suggested the use of the term 'poly(sialate)'for the chemical designation of geopolymers based onsilico-aluminate. Sialate is an abbreviation for silicon- oxo-aluminate.

2.LITERATURE REVIEW

Aleem et. al, (2012) mentioned that, Geopolymer Concrete can be used in the precast industries, so that huge production is possible in short duration and the breakage during transportation shall also be minimized. It shall be effectively used for the beam column junction of reinforced concrete structures and infrastructure works. In addition to that the fly ash shall be effectively used and hence no landfills are required to dump the fly ash.

Anuar et. al, (2011) in this respect, the Geopolymer technology proposed by Davidovits shows considerable promise for application in concrete industry as an alternative binder to the Portland cement. It can be used to produce precast railway sleepers and other pre-stressed concrete building components.

3. MATERIALS

FLY ASH

Fly ash is manufactured by the burning of coal in an electrostatic precipitator, a byproductof industrial coal. The cementitiousproperties of fly ash were discovered in late 19^{th} century and it has been widely used in cement manufacture for over 100 years. InUK , fly ash is supplied as a separate component for concrete and is added at the concrete at the mixer. It generally replaces between 20 and 80 per cent of the normal Portland cement.

Fly ash is a fine, glass-like powder recovered from gases created by coal-fired electric power generation. U.S. power plants produce millions of tons of fly ash annually, which is usually dumped in landfills. Fly ash is an inexpensive replacement for Portland cement used in concrete, while it actually improves strength, segregation, and ease of pumping of the concrete. Fly ash is also used as an ingredient in brick, block, paving, and structural fills.

Fly ash concrete was first used in the U.S. in 1929 for the Hoover Dam, where engineers found that it allowed for less total cement. It is now used across the country. Consisting mostly of silica, alumina and iron, fly ash is a pozzalona substance containing aluminous and siliceous material that forms cement in the presence of water. When mixed with lime and water it forms a compound similar to Portland cement. The spherical shape of the particles reduces internal friction thereby increasing the concrete's consistency and mobility, permitting longer pumping distances. Improved workability means less water is needed, resulting in less segregation of the mixture. Although fly ash cement itself is less dense than Portland cement, the produced concrete is denser and results in a smoother surface with sharper detail.

Class F fly ash, with particles covered in a kind of melted glass, greatly reduces the risk of expansion due to sulfate attack, as may occur in fertilized soils or near coastal areas. It is produced from Eastern coal. Produced from Western coal, Class C fly ash is also resistant to expansion from chemical attack, has a higher percentage of calcium oxide, and is more commonly used for structural concrete.

Although the Federal government has been using the material for decades, smaller and residential contractors are less familiar with fly ash concrete. Competition from Portland cement is one consideration. Because fly ash comes from various operations in different regions, its mineral makeup may not be consistent; This may cause its properties to vary, depending on the quality control of the manufacturer. There are some concerns about freeze/thaw performance and a tendency to efflorescence, especially when used as a complete replacement for Portland cement.

A **thermal station**is a power plant in which the prime movers steam driven. Water is heated, turns into steam and spins a steam turbine which drives an electrical generator. After it passes through the turbine, the steam is condensed in a condenser and recycled to where it was heated; this is known as a Rankine cycle. The greatest variation in the design of thermal power stations is due to the different fossil fuelresources generally used to heat the water. Some prefer to use the term energycenter because such facilities convert forms of heat energy into electrical energy.Certain thermal power plants also are designed to produce heat energy for industrial purposes of district heating , or desalination of water, in addition to generating electrical power. Globally, fossil fueled thermal power plants produce a large part of man-made CO_2 emissions to the atmosphere, and efforts to reduce these are varied and widespread.

Two types of fly ash are commonly used in concrete: Class C and Class F. Class C are often high-calcium fly ashes with carbon content less than 2%; whereas, Class F are generally low-calcium fly ashes with carbon contents less than 5% but sometimes as high as 10%. In general, Class C ashes are produced from burning sub-bituminous or lignite coals and Class F ashes bituminous or anthracite coals. Performance properties between Class C and F ashes vary depending on the chemical and physical properties of the ash and how the ash interacts with cement in the concrete. Many Class C ashes when exposed to water will react and become hard just like cement, but not Class F ashes.

APPLICATIONS OF FLY ASH

Fly ash highly recommended for mass concrete applications. i.e. large mat foundations, dams etc. the hungry horse dam, conyan ferry dam and the Wilson dam, hart well dam and sultan dam in USA, the Lednock dam in UK and sudagin dam in Japan are few examples abroad, LUI center in Vancouver successfully used 50% fly ash for all structural elements in India, some portions of Rihand dam and some part of barrages in Bihar are some examples.

Fly ash can be used for the following

- Filling of mines,
- Replacement of low lying waste land and refuse dumps,
- Replacement of cement mortar,
- Air pollution control,
- Production of ready mix fly ash concrete,
- Laying of roads and construction of embankments,
- Stabilizing soil for road construction using lime- fly ash mixture,
- Construction of rigid pavements using cement-fly ash concrete,
- Production of lime-fly ash cellular concrete,
- Production of precast fly ash building units,
- Making of lean-cement fly ash concrete

NATURAL DEMAND OF SAND

Natural sand is the major constituent of concrete in construction. With increasing population, the need of infrastructures for various purposes also increases. The popularity of use of concrete in constructions has increased the demand of concrete. As a result the demand of natural sand used as fine aggregate is also increasing along with the increase in development activities.Natural sand is generally extracted from river basins. Over-exploitation of natural river sand to meet the increasing demands of construction has been a challenge to the environment. This demand is increasing enormously every year with increasing demands for infrastructural advancements. To meet these demands, the natural river sand has been over exploited resulting in scarcity of sand along with the hiking in price of sand.The collection of 14 crore truckloads of sand every year from river beds, stream beds and pits creates tremendous environmental problems, such as meandering of water courses, denudation of river banks and interference with the natural flow patterns of rivers and streams. The dredging of natural sands has already affected the environment and ecology of many regions of the country. Hence, search for alternative materials for replacement of sand has been carried out. Various alternatives like GGBS, foundry sand, glass powder, quarry dust, etc. as partial replacement of sand has been researched and positive results has been obtained.

QUARRY DUST

Now-a-days the natural river sand has become scarce and very costly. Hence we are forced to think of alternative materials. The Quarry dust may be used in the place of river sand fully. The world wide consumption of fine aggregate in concrete production is very high, and several developing countries have encountered difficulties in meeting the supply of natural fine aggregate in order to satisfy the increasingneeds of infrastructural development in recent years.To overcome the stress and demand for river fineaggregate, researchers and practitioners in the construction industries have identified some alternative materials such asfly ash, slag, limestone powder and siliceous stone powder.In India attempts have been made to replace river sand withquarry dust.The successful utilization of quarry dust as fine aggregate would turn this waste material that causes disposalproblem into a valuable resource. The utilisation will alsoreduce the strain on supply of natural fine aggregate, whichwill also reduce the cost of concrete

A comparatively good strength is expected when sand is replaced fully with or without concrete admixtures. It is proposed to study the possibility of replacing sand with locally available crusher waste without sacrificing the strength and workability of concrete.

Coarse aggregate of 20mm maximum size is used in Reinforced cement concrete work of all types of structures. This is obtained by

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crushing the stone boulders of size 100 to 150mm in the stone crushers. Then it is sieved and the particles passing through 20 mm and retained on 10mm sieve known as course aggregate. The particles passing through 4.75mm sieve are called as quarry dust. The quarry dust is used to sprinkle over the newly laid bituminous road as filler between the bitumen and coarse aggregate and manufacturing of hollow blocks.Based on this experimental investigations, it is found thatquarry dust can be used as an alternative material to thenatural river sand. The physical and chemical properties of quarry dust satisfy the requirements of fine aggregate. It isfound that quarry dust improves its mechanical property of concrete if used along with super plasticizer. Usage of quarrydust it will also reduce the cost of concrete.

5. RESULTS AND DISCUSSIONS

Workability: Workability is defined as the ability of the fresh concrete to fill the mold under proper vibration without reducing the quality. Properties which influence workability are water content, aggregate, cement type, age of concrete and admixtures. Workability increases with increase in water content i.e. more water content results in bleeding and segregation of concrete mix which in turn results in the strength reduction. Chemical admixtures also increase the workability. Concrete mix from undeniable graded aggregate results in harsh mix having low slump which in turn results in low workability.

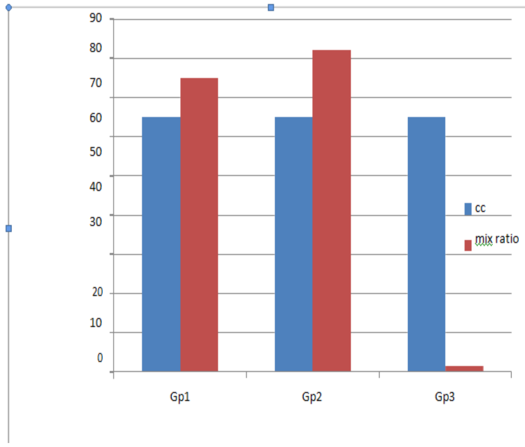

Figure 1 Workbility Test of specimen

COMPRESSIVE STRENGTH:

After 28 days of curing the sample cubes are tested for compressive strength under compressive testing machine. The test samples are taken out from curing tank at least 4 to 5 hours of testing. For one trail at least three specimens are to be tested.

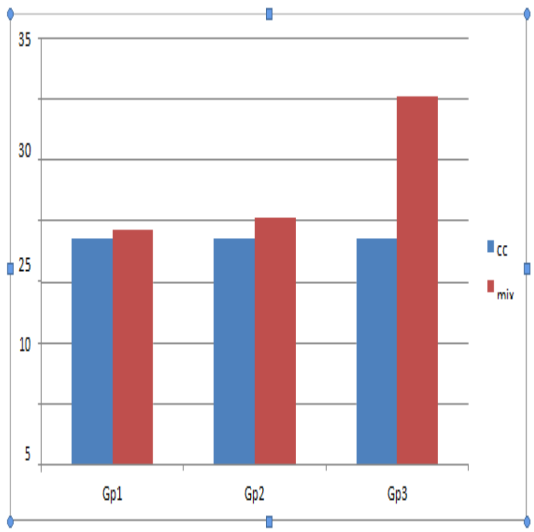

Figure 2 **Compressive strength of specimens at the age of 7**

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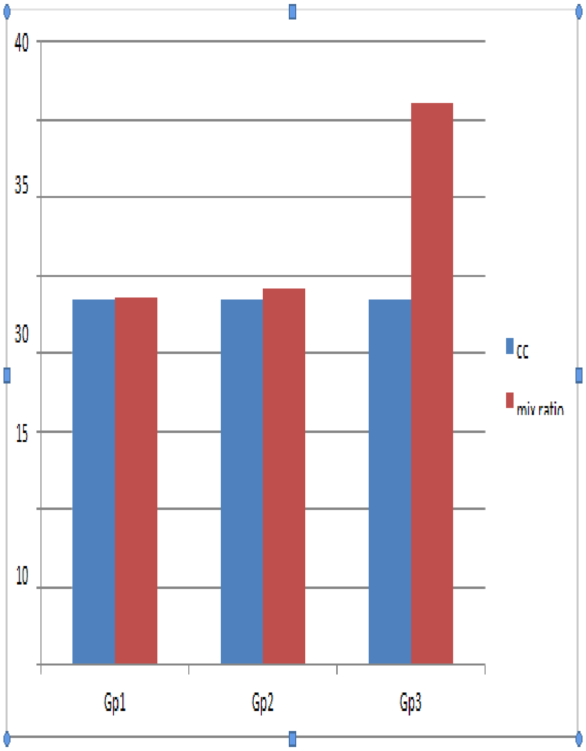

Figure 3 **Compressive strength of specimens at the age of 14 days**

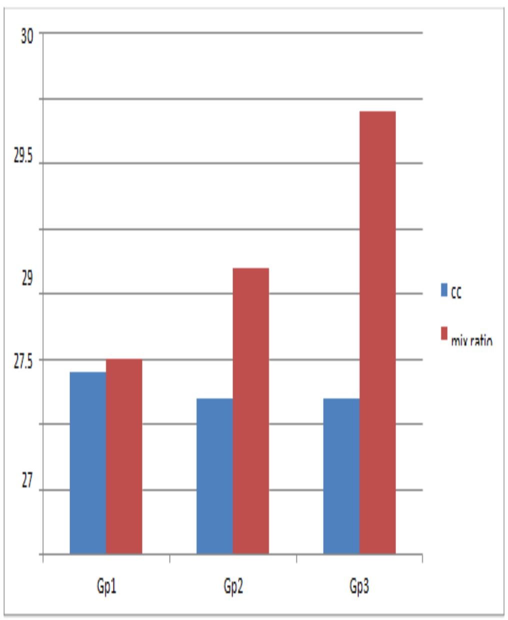

Figure 4 **Compressive strength of specimens at the age of 28 days**

CONCLUSIONS

Based on the experimental work reported in this study, the following conclusions are drawn.

- Higher concentration (in terms of molar) of sodium hydroxide solution results in higher compressive strength of fly ash & quarry dust based geo-polymer concrete.
- Longer curing time, in the range of 4 to 96 hours (4 days), produces higher compressive strength offly ash &quarry dust based geo-polymer concrete. However, the increase in strength beyond 24 hours is not significant.
- The fresh flyash-based geo-polymer concrete is easily handled up to 120 minutes without any sign of setting and without any degradation in the compressive strength.
- The mix GP3 gives higher compressive strength, as it has high molarity of NaOH
- we Observe that the compressive strength is increased with the increase in the molarity of the sodium hydroxide
- After three days of curing the increase the compressive strength is not sufficient
- The geo-polyemer concrete shall be effeviely used for the beam coloumn junction of the reinforced concrete structure
- Geo-polymer concrete shall also be used in the Infrastructure works.
- In addition to that fly ash shall be

effectively used and hence no land fills are required to dump the fly ash

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