EXPERIMENTAL STUDY ON COIR FIBRE REINFORCED FLY ASH BASED GEOPOLYMER CONCRETE WITH 12M MOLAR ACTIVATOR

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Abstract: Concrete is the widely used construction material that makes best foundations, architectural structures, bridges, roads, block walls, fences and poles. The production of one ton of Portland cement emits approximately one ton of CO2 into the atmosphere. Among the greenhouse gases, CO2 contributes about 65% of global warming. The contribution of ordinary Portland cement (OPC) production worldwide to greenhouse gas emissions is estimated to be approximately 1.35 billion tons annually or approximately 7% of the total greenhouse gas emissions to the earth's atmosphere. After thermal power plants and the iron and steel sector, the Indian cement industry is the third largest user of coal in the country. The industry's capacity at the beginning of the year 2008-09 was about 198 million tones. The cement demand in India is expected to grow at 10% annually in the medium term buoyed by housing, infrastructure and corporate capital expenditures. Considering an expected production and consumption growth of 9 to 10 percent, the demand-supply position of the cement industry is expected to improve from 2008-09 onwards.
Keyword: Geopolymer, Fiber reinforced concrete

I. INTRODUCTION

The trading of carbon dioxide (CO2) emissions is a critical factor for the industries, including the cement industries, as the greenhouse effect created by the emissions is considered to produce an increase in the global temperature that may result in climate changes. The 'tradeable emissions' refers to the economic mechanisms that are expected to help the countries worldwide to meet the emission reduction targetsestablished by the 1997 Kyoto Protocol. Speculation has arisen that one ton ofemissions can have a trading value about US$10.The climate change is attributed to not only the global warming, but also to theparadoxical global dimming due to the pollution in the atmosphere. Global dimming is associated with the reduction of the amount of sunlight reaching the earth due topollution particles in the air blocking the sunlight. With the effort to reduce the airpollution that has been taken into implementation, the effect of global dimming maybe reduced, however it will increase the effect of global warming. Inthis view, the global warming phenomenon should be considered more seriously, andany action to reduce the effect should be given more attention and effort.The production of cement is increasing about 3% annually. Theproduction of one ton of cement liberates about one ton of CO2 to the atmosphere, asthe result of de-carbonation of limestone in the kiln during manufacturing of cementand the combustion of fossil fuels. The contribution of Portland cement production worldwide to the greenhouse gasemission is estimated to be about 1.35 billion tons annually or about 7% of the totalgreenhouse gas emissions to the earth's atmosphere. Cement is alsoamong the most energy-intensive construction materials, after aluminium and steel.Furthermore, it has been reported that the durability of ordinary Portland cement (OPC) concrete is under examination, as many concrete structures, especially those built in corrosive environments, start to deteriorate after 20 to 30 years, even thoughthey have been designed for more than 50 years of service life.

THE USE OF FLY ASH IN CONCRETE

One of the efforts to produce more environmentally friendly concrete is to reduce the use of OPC by partially replacing the amount of cement in concrete with by-productsmaterials such as fly ash. As a cement replacement, fly ash plays the role of anartificial pozzolan, where its silicon dioxide content reacts with the calciumhydroxide from the cement hydration process to form the calcium silicate hydrate (CS-H) gel. The spherical shape of fly ash often helps to improve the workability of thefresh concrete, while its small particle size also plays as filler of voids in theconcrete, hence to produce dense and durable concrete. Generally, the effective amount of cement that can be replaced by fly ash is not more than 30%.An important achievement in the use of fly ash in concrete is the development ofhigh volume fly ash (HVFA) concrete that successfully replaces the use of OPC inconcrete up to 60% and yet possesses excellent mechanical properties with enhanceddurability performance. HVFA concrete has been proved to be more durable andresource-efficient than the OPC concrete. The HVFA technologyhas been put into practice, for example the construction of roads in India, whichimplemented 50% OPC replacement by the fly ash.Activation of fly ash with alkaline solutions enables this by-product material to be acement-like construction material. In this case, concrete binder can be producedwithout using any OPC; in other words, the role of OPC can be totally replaced bythe activated fly ash. Palomo et al (1999) described two different models of theactivation of fly ash or other by-product materials. For the first model, the silicon andthe calcium in the material is activated by a low to mild concentration of alkalinesolution. The main product of the reaction is believed to be a calcium silicate hydrate (C-S-H) that results from the hydration process. On the contrary, the material used inthe second model contains mostly silicon and aluminium, and is activated by a highlyalkaline solution. The chemical process in this case is polymerisation.A well-known example of the first model is the activation of blast furnace slag that has a long history in the former Soviet Union, Scandinavia and Eastern Europe. On the other hand, studies on the second model are limited.

II. METHODOLOGIES

The binder in geo-polymer concrete is fly-ash. Fly-ash binds the coarse aggregate, fine aggregate to form geo-polymerization. Coir dust and pith is to be separated from coir fiber and 25mm of length to be considered. The chopped coir fibre is soaked in solution which is prepared by combination of water and sodium hydroxide. For the preparation of soaking solution for one liter of water we have added sodium hydroxide of 5%. This soaking is allowed for 48 hours so that the coir fibre is to mercerization. After 48hrs coir fibre is washed repeatedly with distilled water and allowed to dry for 24hrs. Now the coir is soaked in latex compound which is combination of 70% of rubber latex, 10% of NaOH solution and 20% of distilled water for 15min and dried for 24hrs. In this research 20% of metakaolin is added to the amount of powder content for the purpose of one day setting only not for strength parameters.

In this work, low-calcium (ASTM Class F) fly ash-based geopolymer is used as the binder, instead of Portland or other hydraulic cement paste, to produce concrete. The fly ash-based geopolymer paste binds the loose coarse aggregates, fine aggregates and other un-reacted materials together to form the geopolymer concrete, with the presence of admixtures Geopolymer concrete can be manufactured by using the low-calcium (ASTM Class F) fly ash obtained from coal-burning power stations. Most of the fly ash available globally is low-calcium fly ash formed as a by-product of burning anthracte or bituminous coal. Coir pith and other undesirable materials are separated from the coir fiber. It is then chopped to about different length of 25mm subjected to chemical treatments. Coir fibers are soaked in sodium hydroxide solution for 48 hours. Fiberwere taken out, repeatedly washed with water and dried in the air. Latex compound is prepared by mixing 70% of natural rubberlatex and 10% of sodium hydroxide solution and 20% of water. The latex compound and the resign solution were agitated to achieve homogenization. Then the coir fiber is dipped in the mixture about 15minutes and dried.

2.1 SOURCE MATERIALS

The combustion of ground or powdered coal which results the residue of finely divided particle is known as fly ash. The combination of oxides ofCalcium (CaO), Aluminum (Al_2O_3), Silicon (SiO_2), and Iron (Fe_2O_3), are the chemical compositions, where the percentage of Titanium,Sodium, andMagnesium, Potassium,Sulphur are present in lesser amount. Fly ash is preferred is Low-calcium (ASTM Class F). The fly ash used in this study was obtained from Ennore Thermal power plant. It falls in the category of class F grade and its chemical composition was given in Table 2.1, The physical properties of fly ash were determined as per IS: 1727-1967 and given in Table.

Component	Bituminous	Subbituminous	Lignite
SiO_2 (%)	20-60	40-60	15-45
Al_2O_3 (%)	5-35	20-30	20-25
Fe_2O_3 (%)	10-40	4-10	4-15
CaO (%)	1-12	5-30	15-40
LOI (%)	0-15	0-3	0-5

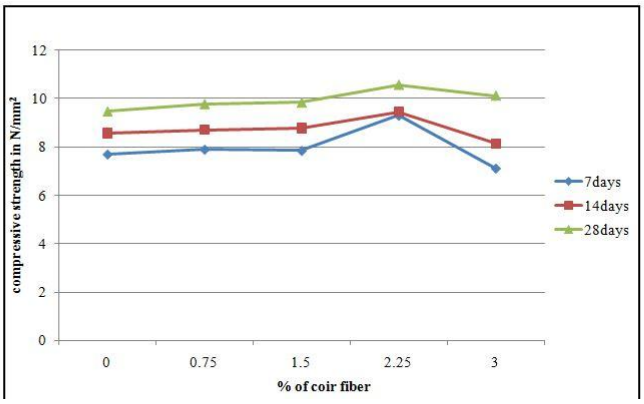
2.2 Ratio of Alkaline solution to flyash

The effect of alkaline solution to fly ash ratio on compressive strength of geopolymer concrete specimens were given in Table 4.4 and shown in Figures 4.1 to 4.3. The alkaline solution to fly ash ratio by mass was varied as 0.35, 0.40 & 0.45. The alkaline solution to fly ash ratio by mass has considerable effect on the compressive strength of geopolymer concrete. Increase in compressive strength at alkaline solution to fly ash ratio of 0.40 and 0.45 was about 22% and 35% with respect to 0.35 respectively. Increase in the alkaline solution to fly ash ratio, increased the compressive strength of concrete irrespective of other factors. The reason for increase in compressive strength was concluded by previous researchers as, in lower alkaline solution to fly ash ratios, only the glassy phases in fly ash were the source of Al and Si to form alumino- silicate gel and also the reaction product was quickly formed that engulfs the fly ash particle and slowing down the further activation of the fly ash particles, thus resulting in only low to moderate degrees of reaction. However, in a higher alkaline solution to fly ash ratios the quartz and mullite phases in fly ash were completely dissolve and increases the amounts of reaction product formation thereby increases the compressive strength.

III. RESULTS

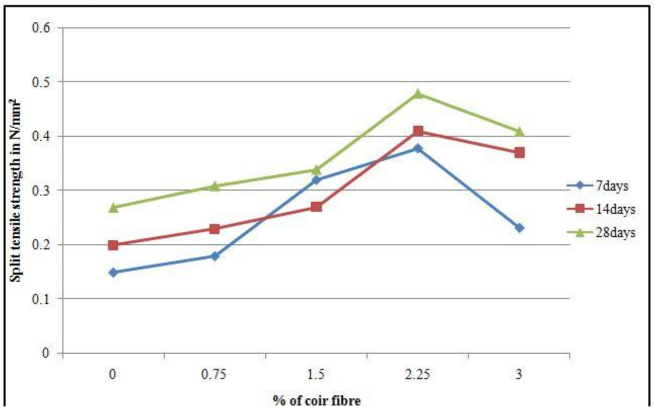
COMPRESSIVE TEST:

The compressive strength test on hardened fly ash based geopolymer concrete was performed on standard compression testing machine of 3000kN Capacity, as per IS: 516-1959. Totally 81 number of cubical specimens of size 100mm x 100mm x 100mm was casted and tested for the compressive strength at the age of 7days, 14days and 28days. The compressive strength test was performed as shown in Figure 3.6. Each of the compressive strength test data corresponds to the mean value of the compressive strength of three test concretecubes. The graph 1 shows that the strength of the specimen increases upto a level and then the strength falls down. For 7 days the maximum strength obtained is 7.3 N/mm2. For 14 days 9.45 N/mm2 is the maximum strength. And for 28 days 10.58 N/mm2 is the maximum strength. This shows that optimum percentage of coir fiber is 2.25 for all.



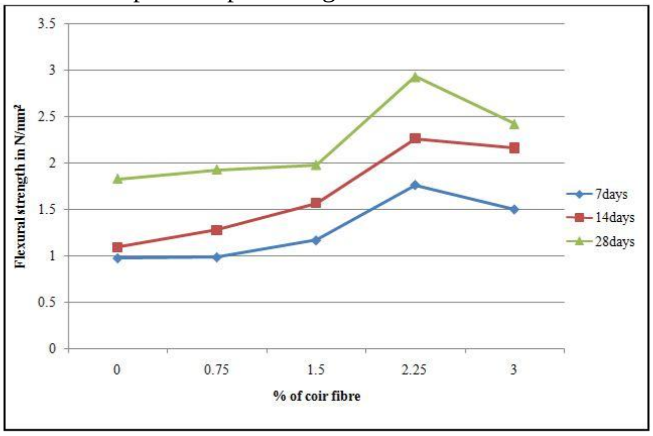
SPLIT TENSILE TEST:

Split Tensile strength is defined as resistance of concrete to radial loading. Cylinders wereplaced in Universal Testing Machine (U.T.M), and load was applied. The readings on dial gaugewere recorded and tensile strength was calculated. The graph 2 shows that the strength of the specimen increases upto a level and then the strength falls down. For 7 days the maximum strength obtained is 0.378 N/mm2. For 14 days 0.41 N/mm2 is the maximum strength. And for 28 days 0.48 N/mm2 is the maximum strength. This shows that optimum percentage of coir fiber is 2.25 for all.



FLEXURAL STRENGHT:

The graph 3 shows that the strength of the specimen increases up to a level and then the strength falls down. For 7 days the maximum strength obtained is 1.76 N/mm^2. For 14 days 2.26 N/mm^2 is the maximum strength. And for 28 days 2.93 N/mm^2 is the maximum strength. This shows that optimum percentage of coir fiber is 2.25 for all.



IV. CONCLUSIONS

The propagation micro cracks are resisted.Fly ash-based geopolymer concrete cured in the laboratory ambient conditions gains compressive strength withage.Optimum percentage of coir fiber is 2.25 in this research.Increase in coir fiber percentage the strength parameters are also increase up to optimum and then strength decreases.For 28 days 2.25% of coir fiber the compressive strength is 11.65% more comparing to 0% of coir fiber.For 28 days 2.25% of coir fiber the split tensile strength is 41.65% more comparing to 0% of coir fiber. For 28 days 2.25% of coir fiber the flexural strength is 37.9% more comparing to 0% of coir fiber.

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