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AN EXPERIMENTAL STUDY ON GEOPOLYMER CONCRETE BY USING AUTOMOBILES WASTE PRODUCT

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ABSTRACT

Due to their potential impact on the environment, it is absolutely necessary to increase the utilization of a variety of industrial wastes and decrease cement consumption. Promoting geopolymer concrete, which is cement-free concrete made from industrial waste rich in aluminosilicates and alkaline activators, can help accomplish this. It is common knowledge that fly ash contains a lot of aluminosilicates, so using it as a binder would be a big step toward the green revolution. Hence, endeavors are made in this review to create geopolymer concrete by utilizing fly debris as folio material and Potassium hydroxide (KOH) and Potassium silicates (K2SiO3) as basic activators. For alkaline activator solution (AAS) to binder solids (BS) ratios ranging from 0.4 to 0.8, fly ash-based geopolymer concrete has been developed. The current paper conducts an experimental investigation into the effects of various activator/fly ash ratios and concentrations of potassium hydroxide solution (10M, 12M, and 14M). The workability of GP is influenced by the alkaline activator. Characteristics: At 7, 14, and 28 days, the specimens' compressive strength, flexural test, and spilt tensile strength were compared to 10M, 12M, and 14M. From a compressive strength standpoint, geopolymer concrete is cheaper than regular concrete, but alkaline liquid is more expensive.

INTRODUCTION

The industrial sector and urban population have both experienced rapid growth over the past few decades or so worldwide. CO2 emissions into the atmosphere are dramatically rising as a result of these developmental activities, particularly the burning of fossil fuels, the production of cement, deforestation, and other activities. By raising CO2 levels, these emissions caused by humans have shifted the balance of the atmosphere. These man-made sources of emission have upset the natural balance of CO2 in the atmosphere, resulting in 87% of all human-caused emissions. The construction industry and, as a result, cement consumption are directly impacted by this rapid industrialization and urbanization.

As a result, cement consumption has skyrocketed, resulting in the release of a significant amount of carbon dioxide into the atmosphere. According to Neville (2014), the reaction of materials and the consumption of fuel for cement production result in the emission of approximately 1 ton of CO2 during the production of one ton of cement. According to the Intergovernmental Panel on Climate Change (IPCC), the cement production process is the most significant source of global carbon dioxide emissions from non-energy industrial processes. Global cement production currently stands at 4.2 billion tonnes per year and is growing at a rate of 3-4% per year (USGS Report, 2015). According to the Cement Sustainability Initiative (CSI), cement production contributes approximately 5% of all industrial and energy CO2 emissions worldwide. According to CIF (2015), a cement plant's primary sources of greenhouse gas emissions are the chemical transformation of the raw materials, the burning of fossil fuels to provide the thermal energy necessary for chemical action, and the grinding and transporting of materials. Figure depicts the one percent contribution made by the various activities. 1. However, due to its aesthetic value in comparison to that of other building materials, cement cannot be completely avoided in construction. Therefore, the best course of action might be to investigate the alternative to OPC concrete. In this respects "geopolymer concrete" which can be grown essentially involving modern squanders rich in aluminosilicates like fly debris, red mud, slag, and so forth. Enables not only a reduction in one's carbon footprint by completely avoiding the use of cement, but also a reduction in the pollution of the environment caused by the disposal of these activities.

MATERIALS AND ITS PROPERTIES

Materials used for the experiment includes ordinary Portland cement of grade 43, Fly ash, Steel slag, Rubber tyre aggregate, fine aggregate of size less than 4.75 mm, coarse aggregate of size less than 20 mm and alkaline solution (Potassium permanganate and Potassium silicate)

I. Cement

Cement is a binding material in concrete with adhesive and strong properties. The cement used was Ordinary Portland Cement grade 53 conforming to Indian Standard Specifications (BIS 269-1987 & BIS 1987). The choice of brand and type of cement is the most important to produce a good quality of concrete. The type of cement affects the rate of hydration, so that the strengths at early ages can be considerably influenced by the particular cement used. The properties of the cement is tabulated in table 1.1

II. Coarse aggregate

20 mm passing,16 mm passing,12.5 mm passing,10mm passing and 4.7 mm passing are the coarse aggregate used in this project in different proportions (refer fig. 8). The coarse aggregate is tested for specific gravity and fineness modulus in accordance with IS: 2386:1963 standards and is found to be 2.68. The properties of coarse aggregate as observed from the laboratory tests are presented in Table 1.2

III. Fine aggregate

The M-sand was obtained from nearby site is used as fine aggregate in this project. It is free from clay matter, silt and organic impurities etc. The M-sand is tested for specific gravity and fineness modulus in accordance with Indian standards and is found to be 2.65. The sand conforms to zone II. The properties of fine aggregate as observed from the laboratory tests are presented in Table 1.3

IV. Steel slag

Steel slag, a by-product of steel making, is produced during the separation of the molten steel from impurities in steel-making furnaces. Steel slag aggregates are highly angular in shape and have rough surface texture. They have high bulk specific gravity and moderate water absorption (less than 3 percent). It was sieved under 90 microns. The properties of the steel slag is tabulated in table 1.4

V. Rubber tyre aggregate

Rubber Tyre aggregate is the waste product which can be obtained from automobile waste tyre parts. Tyre aggregate from discarded tyre rubber in maximum size is 20mm. According to the council of cement concrete organization, the recycled tyre aggregate concrete can be used for pavements, concrete shoulder, sidewalks curbs and residential driveway and structural fills. The properties of the aggregate is tabulated in table 1.5

VI. Alkaline solution

It has been identified that the type of alkaline liquid also plays an important role in the polymerization process. The most common alkaline liquid used in geopolymerization is a combination of Potassium Hydroxide (KOH) along with Potassium Silicate (K_2SiO_3).

Potassium Silicate is also known as Water glass or liquid glass, available in gel form. KOH pellets considered are 99% pure, with specific gravity varying from 1.28 to1.38 depending on the molarity. The properties of the both KOH and Potassium silicate is tabulated in table 1.6 & 1.7

Table1.1: Properties of cement.

Sl. No	Physical properties	Values
1.	Specific gravity	2.68
2.	Fineness	5%
3.	Initial setting time	35 minutes
4.	Final setting time	320 minutes
5.	Consistency	0.32

Table 1.2: Properties of Coarse Aggregate.

Sl.no	Physical properties	Values
1.	Specific gravity	2.68
2.	Water Absorption	0.5
3.	Fineness modulus	7.65
4.	Bulk density	1540

Table 1.3: Properties of Fine Aggregate.

Sl.no	Physical Properties	Values
1.	Specific gravity	2.65
2.	Water Absorption	2.1%
3.	Fineness Modulus	2.59
3.	Bulk density	1260

Table 1.4: Properties of Steel slag

Sl.no	Physical properties	Values
1.	Specific gravity	2.9
2.	Water absorption	NIL
3.	Fineness modulus	4.087
4.	Bulk density	1447.58

Table 1.5: Properties of Rubber tyre aggregate

Sl.no	Physical properties	Values
1.	Specific gravity	1.15
2.	Fineness modulus	5.34

Table 1.6: Properties of KOH

Sl.no	Physical properties	Values
1.	Physical state	Solid
2.	Color	White
3.	Molecular weight	56.1

Table 1.7: Properties of Potassium silicate

Sl.no	Physical properties	Values
1.	Solids content	29%
2.	Organic content	1.4%
3.	pH value	10.9

MIXTURE PROPORTION AND TEST PREPARATION

a. Mix design proportion

The mix ratios identified are used to prepare geopolymer mortar in the laboratory. Firstly, ratio M40 is verified and materials were taken as per calculated weights respectively. Fly ash and Steel slag are dry mixed for 4min. The alkaline solution is then prepared by mixing potassium silicate and potassium hydroxide in the ratios 2.5, where potassium hydroxide is prepared for 1lit of solution and kept stored for 24 hours with different molarities like 10M,12M and 14M. Preparation of the solution is done just before the time of casting and it can be used 36 hours from the time of mixing. The alkaline solution is added to the dry mix of Fly ash and steel slag in calculated quantity as per mix design. It is then well mixed to make fresh geopolymer mortar and then it is cast into moulds of dimension 150×150×150mm. Similarly, the cube was cast for the ratio M40 for the varying molarities of potassium hydroxide with alkaline ratio. The cubes are casted and then demoulded and curing by sun drying method.

b. Workability test

To determine the workability of concrete mix by slump test conducted by as per IS 1199-1959. The mix ratios identified are used to prepare geo-polymer mortar in the laboratory. Firstly, ratio M40 is verified and materials were taken as per calculated weights respectively. The alkaline solution is then prepared by mixing potassium silicate and potassium hydroxide in the ratios 2.5, where potassium hydroxide is prepared for 1lit of solution and kept stored for 24 hours with different molarities like 10M,12M and 14M. Preparation of the solution is done just before the time of casting and it can be used 36 hours from the time of mixing. The alkaline solution is added to the dry mix of Fly ash and steel slag in calculated quantity as per mix design. It is then well mixed to make fresh geopolymer mortar and then it is cast into moulds of dimension 150×150×150mm.

c. Compressive Strength

The important property of mortar is its strength in compression. As per IS: 3812-1 (2003): Specification of pulverized fuel ash, Part 1: For use of pozzolana in cement, cement mortar and concrete. Compression test is the most common test conducted on hardened mortar. The strength development of mortar cubes was found using two binders such as Fly-ash and Steel slag in different proportion. Cubes of size 150mm×150mm×150mm were casted and the specimen was made to cure after 7,14 and 28 days for various curing methods.

d. Flexural Strength

Flexural strength test was carried for 100mmX100mmX500mm prism specimen using 100-ton capacity Universal testing machine by subjecting the specimen to single point loading to determine the flexural strength as per IS 5161959 and loading is applied gradually and failure load is noted. The flexural strength represents the highest stress experienced within the material at its moment of rupture. The test was as per IS 516-2002 code provision. For this study, experimental work involves casting of concrete beams of size 50cm x 10cm x 10cm for determination of flexural strength for 7 days, 14 days and 28 days curing. The concrete for designed mix is mixed homogeneously by means of hand mixing. Before casting the beam the entire mould is oiled.

e. Split Tensile Strength

The test is carried out by placing cylindrical specimen horizontally between the loading surface of a compression testing machine and the load applied until failure of cylinder, along the vertical diameter. The test should be carried out as per codal provision IS:5161959.the average spilt tensile strength test result for 7 days,14 days and 28 days testing is noted.

TEST RESULTS

a. Compressive Strength of Concrete:

The test results are tabulated below in 1.8

MIX	COMPRESSIVE STRENGTH (N/mm^2)		
	7^{TH} Day	14^{TH} Day	28^{TH} Day
M1	34.6	48.5	44.80
M2	36.80	40.3	47.67
M3	37.11	43.40	46.86
AVG	**36.11**	**40.74**	**46.44**

b. Flexural Strength of concrete:

The test results are tabulated below in 1.9

MIX	COMPRESSIVE STRENGTH (N/mm^2)		
	7^{TH} Day	14^{TH} Day	28^{TH} Day
M1	4.05	5.45	6.12
M2	4.34	5.97	6.61
M3	4.86	5.23	6.92
AVG	**4.41**	**5.55**	**6.56**

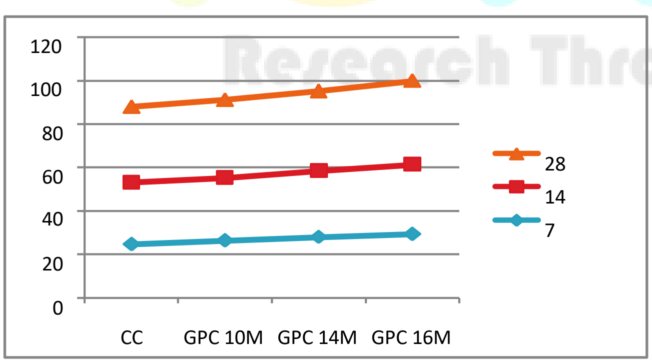
c. Split tensile Strength of concrete:

The test results are tabulated below in 1.10

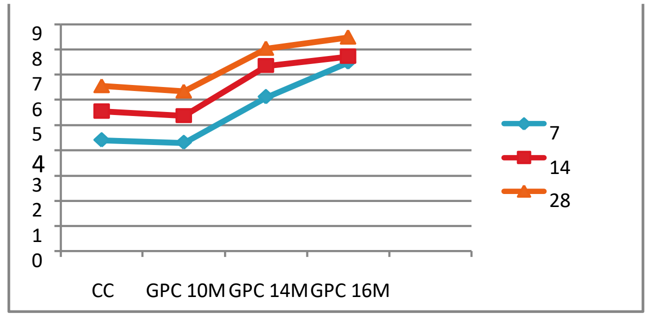
MIX	COMPRESSIVE STRENGTH (N/mm^2)		
	7^{TH} Day	14^{TH} Day	28^{TH} Day
M1	1.40	2.16	2.56
M2	1.46	2.26	2.67
M3	1.60	2.36	2.70
AVG	**1.48**	**2.26**	**2.64**

COMPARISON OF SPECIMENS

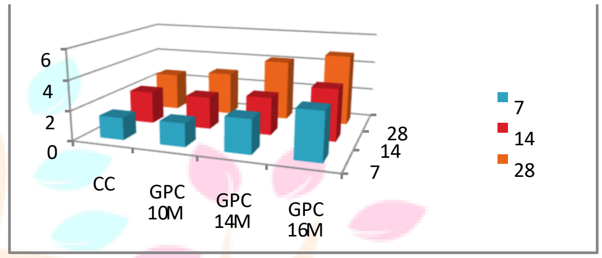
The various aspects such as compressive strength, flexural strength and split tensile strength are represented below, the diffrences between the resultant concrete and the conventional concrete is produced clearly:



Compressive strength of concrete



Flexural strength of concrete



Split tensile strength of concrete

DISCUSSION

Manufacturing of precast structural elements such as decks for bridges, pavers and slabs for pavements, sewer pipes and other non-structural applications. Because of its high resistance to chemical attack, reinforced geopolymer concrete can be used in aggressive marine environment and sewer pipes. Geopolymer concrete can act as a suitable alternative in development of acid resistant due to their strong resistant to acidic environment when compared to OPC concrete.

CONCLUSION

The maximum compressive strength of geopolymer concrete is 48.63 N/mm^2 at 28 days for 12M while comparing to other molarity like 10M, 14M. The spilt tensile strength of geopolymer concrete was high strength compared to conventional concrete at 7days, 14days and 28 days. While high molarity of NaOH was increased with strength of specimen also increased. The maximum flexural strength of geopolymer concrete is 7.49 N/mm^2 at 28 days for 14M while comparing to other molarity like 10M, 12M. Geopolymer concrete strength will be get good result at 28 days because we compared to other strength of specimen result value. Spilt tensile strength of geopolymer concrete is gradually increased with respect to molarity. The strength of specimen is increased while aging of the specimen. Geopolymer concrete is a promising construction material due to its low carbon di oxide emission. Low calcium fly ash based geopolymer concrete has excellent compressive strength and is suitable for structural appliances. Low calcium fly ash based geopolymer concrete has excellent properties within both acid and salt environment. High early strength, low creep and shrinkage, acid resistance, fire resistance makes it better in usage than OPC. Wide spread application in precast industries due to its huge production in short duration and less breakage during transportation. Enhanced research along with acceptance required to make it great advantages to the library. Based on the observation from the literature review, the binder to steel slag ratio is identified. For conventional concrete, OPC 53 grade concrete was used in this project and M40 mix design was used. For preparation of alkaline solution, Potassium hydroxide flakes and potassium silicate gel have been used for bonding purpose. In these experimental shows, flexural and spilt tensile strength was gave better strength but compressive strength is not gave better strength compared to other two strength. Alkaline molarity is identified from the optimization process and molarity 14M gives better strength.

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