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Experimental Study on Geopolymer Concrete

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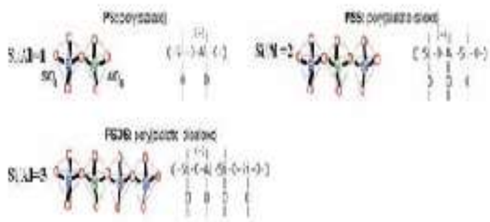
Abstract:
The need for enviro friendly construction materials for sustainable development is currently an important environmental issue in the construction industry. The concrete industry is said to be one of the contributors to global warming. This fact is due to the use of Portland cement as the main component in the production of concrete and other cement-based construction materials. The cement industry is responsible for about 6% of the Carbon-di-oxide (CO2) emission worldwide. However, the use of concrete and cement-based composites, as the most widely used construction materials, are still unavoidable in the foreseeable future. The recent years have seen a great development in a new type of inorganic cementitious binder called “geopolymer binder”. This prompted its application in concrete, which improves the greenness of normal concrete and at the same time maintains comparable and even better properties. This thesis focuses on sustainable development ensuring harmonious balance between people needs and earth resources, mitigating the emission of greenhouse gases, conserving natural resources and converting industrial effluent as an alternate for construction material viz fly ash, GGBS. Geopolymer is a relatively new binder which can be a sustainable and economical binding material as it is produced from alkaline liquids replacing 100% of cement in concrete. Industrial by-products such as fly ash and GGBS had been used as binding material in Geopolymer concrete. It is pragmatically considered that Geopolymer concrete, a construction material that neither be neglected nor avoided. With the mix of 60% of fly ash and 40% of GGBS and other alkali solutions are used to replace the cement. Casted 3 different mix sample specimens out of which 2 are geopolymer concrete samples of 6M and 8M and one sample is conventional concrete. Total 9cubes,6 cylinders,6 beams and 6 sorptivity moulds of each sample are casted and kept in the room temperature for curing to find the mechanical properties of concrete like compressive strength, split tensile strength and flexural strength, quality grade of the concrete and durable properties like water absorption and sorptivity. The test results of Geopolymer concrete were compared with conventional concrete. Keywords: Fly ash, GGBS, Alkali activators (NaOH, Na2SiO3)

INTRODUCTION:

General

Cement is considered to be one of the most vital building materials being used for the production of concrete and now, it plays a pivotal role in developing the infrastructure across the world. Global cement production is expected to increase from 3.27 billion metric tons in 2010 to 4.83 billion metric tons in 2030.The present statistics report reveal that China currently produces over half of the world's cement by which China becomes the top leader in the global production of the cement. It is estimated that China has produced an amount of 2.41 billion metric tons in 2016. It is estimated that India's cement production will reach more than 280 million metric tons by 2017. India is the second largest producer of cement in the world. From the above statistics reports, it clearly shows that cement is one of the integral parts used for the construction and it play significant role to develop infrastructure across the world. The use of concrete around the world is considered as a second commodity after water. The environmental issues associated with the production of Ordinary Portland Cement (OPC) are well studied. The amount of the carbon dioxide released during the manufacture of OPC due to the calcination of limestone and combustion of fossil fuel is in the order of one ton for every ton of OPC produced. It is estimated that the production of CO_2 is approximately half from the calcination and other half from the combustion processes. The cement industry thus contributes conservatively 5-8% of global carbon dioxide (CO_2) emissions, mainly through decomposition of limestone and combustion of fossil fuels during cement production. Grinding the ingredients of cement and their transport to the production site are also significant contributors to the environmental footprint of the cement industry. This emission of greenhouse gas into the atmosphere is the prime reason for global warming. Replacing Portland (cement), either partially or entirely, with alternative cements is also being investigated as an approach for tackling concrete's CO_2 emissions. Dumping and disposal of industrial wastes and by products, which are more toxic and hazardous, are very serious issues. The industrial wastes are dumped in open space and nearby water sources by which, they can deteriorate air quality and water quality over a location and they affect natural resources. Amongst 2 industrial by products of solid wastes, the most prominent materials are Fly Ash (FA), Ground Granulated Blast Furnace Slag (GGBS), Copper Slag (CS), Rice Husk and Silica Fume which can be used as excellent binding materials for making concrete. Being copper slag as an economic alternative to sand, it can reduce the environmental pollution and in addition, it can make way for avoiding the ill effects of uncontrolled exploitation of natural resources. Thus, a new science of concrete has been developed after realizing the use of industrial waste to make the eco-friendly green and smart concrete which can reduce global warming. This demands an innovative science and technology for the development of admixtures and the use of sophisticated scientific apparatus to observe concrete microstructure and even nanostructure. It is expected to produce innovative new binding materials to make ecofriendly superior concrete in the forth coming days. Geopolymer Concrete is one of the clear-cut substitutes used for the reduction of greenhouse gases and it is environmentally friendly.



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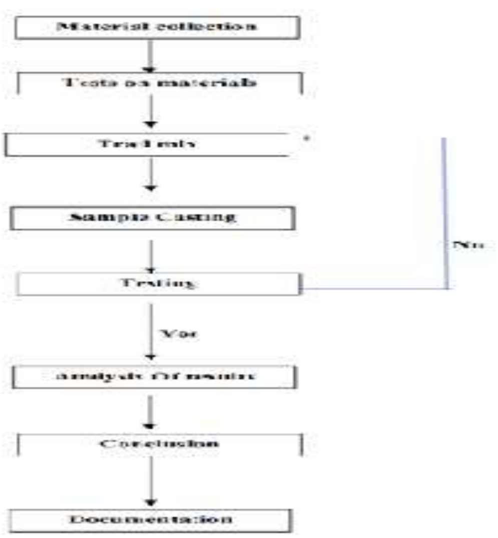
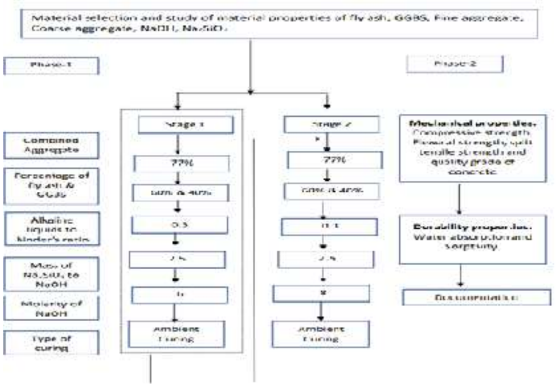
OBJECTIVE:

The main objective of this research work is to investigate the strength and durability properties of Fly Ash (FA) and Ground Granulate Blast Furnace Slag (GGBS) based Geopolymer concrete. The individual objective is framed as follows • To investigate the mechanical properties of Geopolymer concrete like compressive strength, split tensile strength, flexural strength and quality grade of concrete. • To examine the durability properties of Geopolymer concrete in by conducting water absorption and sorptivity tests.

METHODOLOGY:





General

The materials used for making Fly Ash based Geopolymer Concrete mix specimens are low calcium fly ash and GGBS as source material, fine and coarse aggregates as fillers, and activators such as sodium hydroxide solution (NaOH), sodium silicate (Na2SiO3) solution as binders, and superplasticizer as workability agents. This chapter deals with the properties of used materials, trial mix proportions derived and the mechanical properties of the geopolymer concrete mixes. 3.4 Materials The materials required for the preparation of NMC and gpc are mentioned in Table

Table : Composition of materials of conventional concrete and gpc

Type of concrete	Materials present
Conventional Concrete	Cement, fine aggregate, coarse aggregate, water and admixtures
Geopolymer concrete (gpc)	Fly ash, GGBS, fine aggregates, coarse aggregates, water, Alkali activators and super-plasticizer.

3.4.1. Ordinary Portland cement Ordinary Portland Cement (OPC) of 53 grade is used in this study. OPC 53 grade cement is required to conform to BIS specification IS:12269-1987 with a designed strength for28 days being a minimum of 53 MPa. Ordinary Portland cement is generally available in market in different grades such as 33 grades, 43 grade and 53grade for this study we have used 53 grade cement. In general, we can carry on this study with 43 grade cement also but to obtain accurate results we have used 53 grade cement. The physical properties of the cement are given in Table

S.No.	Property	Test method as per IS code	Test result	Permissible value as per IS code
1	Fineness	Sieve test on sieve no.9 (90 micron) (IS 403-part 4)	7% residue	10% IS: 12269: 2013
2	Specific gravity	Specific gravity bottle (IS: 4031-Part 11)	3.15	-
3	Normal consistency	Vicat apparatus (IS: 4031-Part4)	30%	
4	Initial setting time	Vicat apparatus (IS: 4031-Part5)	42 minutes	30-60 minutes IS: 12269-2013
5	Final setting time	Vicat apparatus (IS: 4031 Part5)	470 minutes	600 minutes IS: 12269 2013

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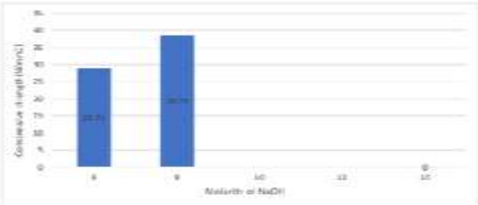
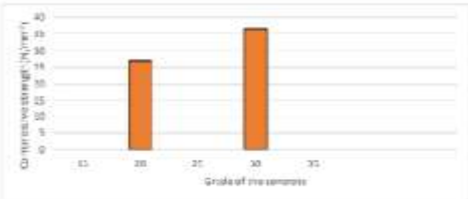
RESULTS:

Hardened Concrete Results Mechanical properties of hardened concrete like compressive strength, split tensile strength, flexural strength was found by destructive testing and results obtained are as follows. 4.2.1. Compressive Strength Cube specimens are tested for compressive strength confirming to IS: 516 - 1959. The specimens are tested for compression in compression testing machine. Table 4.3- Compressive strength results of Geopolymer concrete

S. No.	Mix id of the specimen	Weight of the specimen (kg)	Load (KN)	Compressive strength(N/mm²)	Average compressive strength(N/mm²)	Percentage increase in compressive strength
1)	GPC 6M	8.120	643.95	28.62	28.74	0
		8.140	649.06	28.4		
		8.140	657.12	29.2		
2)	GPC 8M	8.170	852.57	37.39	38.39	83.04%
		8.150	885.6	39.36		
		8.320	886.95	39.42		



S. No.	Mix id	Weight of the specimen (kg)	Load (KN)	Compressive strength(N/mm²)	Average compressive strength(N/mm²)
1)	M20	7.630	596.220	26.5	27.01
		7.660	616.95	27.42	
		7.950	610.425	27.13	
2)	M30	7.130	814.500	36.2	36.65
		8.060	828.900	36.84	
		7.650	830.925	36.93	



➢ The Table shows that the compressive strength of concrete is increased, while increasing the Molarity of Sodium hydroxide. It shows a massive increase in % of compressive strength by just increasing 2M of NaOH.

➢ The target compressive strength of GPC is higher than that of conventional concrete when compared with both M20 and M30 grades of concrete. So, it suggests that GPC achieves higher target strength than that of conventional concrete.

CONCLUSION:

The experiments carried out in the present thesis have given the following conclusion Compressive strength

• The optimum compressive strength obtained is 38.39 N/mm2 at 60% fly ash, 40% GGBS as replacement of binding material and molarity of NaOH is 8M. It shows that the compressive strength increases to the maximum of 83.04%, when molarity of NaOH is increased from 6M to 8M.

• The compressive strength of concrete has increased, while increasing the molarity of NaOH for the same mix proportions.

• Geopolymer concrete has excellent compressive strength, when the presence of GGBS and fly as filler materials and sodium hydroxide and sodium silicate as alkali activators. Geopolymer concrete has a greater advantage that for the same mix proportions by changing the Molarities of solutions we can achieve better strength of concrete. Split tensile strength

• The optimum split tensile strength obtained is 4.496 N/mm2 at 60 % flyash, 40%GGBS as replacement of binding material and molarity of NaOH is 8M. It shows that the split tensile strength increases to the maximum of 38.33%, when molarity of NaOH is increased from 6M to 8M.

• When compared the split tensile strength results of Geopolymer concrete with the Conventional concrete we found that the split tensile strength of Geopolymer concrete is higher than that of conventional concrete for the same compressive strength. Flexural strength

• The optimum flexural strength obtained is 5.416 N/mm2 at 60 % fly ash, 40%GGBS as replacement of binding material and molarity of NaOH is 8M. It shows that the split tensile strength increases to the maximum of 30.19%, when molarity of NaOH is increased from 6M to 8M. 50

• When compared the flexural strength results of Geopolymer concrete with the Conventional concrete we found that the flexural strength of Geopolymer concrete is higher than that of conventional concrete for the same compressive strength.

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