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"A Review on Experimental Investigation ofGeopolymer Concrete"

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Abstract- The Geopolymer or Geopolymerisation or Geopolymer concrete is the best innovative concrete material which is produced by chemical process with industrial waste. General method of Geopolymer concrete is a homogeneous mixer of fly ash or steel waste (GGBS), fine aggregate, course aggregate and alkaline solutions. The industrial combustion waste fly ash and the steel plant waste (GGBS) are the base material for Geopolymer concrete. Alkaline solutions are prepared by mixing of silicate and hydroxide. By Geopolymer process of binding material the requirement of cement is reduced and emission of carbon-di-oxide in atmosphere will reduce. High volume replacement of industrial waste or slag for development of concrete saves a lot of natural resources and energy which reduces the manufacture of Portland cement. In the present work, an attempt has been made to establish the mix proportion to Geopolymer Concrete by flyash with steel waste (GGBS). To study the compressive and tensile strength of Geopolymer Concrete and to prove that the new alternate concrete material is eco-friendly.

Keywords: Geopolymer concrete, Fly ash, GGBS, Alkaline Liquide, Sodium Silicate,

1. INTRODUCTION

The survey shows the total production of fly ash in the world is about 780 million tons per year after 2010. InIndia more than 100 million tons of fly ash is produced annually, out of which 17 – 20 % fly ash is utilized either inconcrete as a part replacement of cement or workability improving admixtures or in stabilization of soil. There areenvironmental benefits in reducing the use of Portland cement in concrete, and using a by-product cementitiousmaterial, such as fly ash, silica fume, ground granulated blast furnace slag, rise husk ash, etc. as a partial substitute.With silicon and aluminum as the main constituents, fly ash has great potential as a cement replacing material inconcrete. The concrete made with such industrial wastes is ecofriendly and hence called as "Green concrete". Somefly ash is utilized in the production of Portland pozzolana cement or part replacement of cement in concrete.

Cement concrete is manmade material which prepared by mixing of cement, water, natural fine and coarse aggregate. The past century developed cement concrete as material for construction work. In 1902 August Perret, first designed building in Paris with structural components beams, slabs and columns. Construction variety of infrastructure and industrial sector by concrete makes it is an essential product. It is widely used manmade material in the globe. It is produced by natural materials; it is reliable material, gives architectural freedom. After water most widely consumed material is concrete as more than ton produced every year for each person in the world. But, the environmental hazard caused by production of concrete material has concerned to make an eco-friendly material for construction. It has been studied that embodied carbon dioxide (ECO2) ranges from 700-800 kg CO2 for a tone of concrete. The embodied carbon dioxide varies depending upon methods and type of mix design.

In cement industry, research has been carried out in collection of latest material and up gradation of technology. In India 93% of cement industry uses dry process technology which is environment friendly. The old dry process technology and semi dry process technology is being used by 7% of cement industry. There is reduction in emission level of CO2 due to the waste heat recovery in cement plant. After steel and aluminium, cement is the next material which produces high energy. It also uses an ample amount of nonrenewable materials, e.g. coal, lime stone etc. About 65% of global warming is caused by CO2. The cement industry is not suitable for sustainable industry since it causes high pollution to the environment. So, there is necessity for alternate material for cement in the concrete which should be eco-friendly, should satisfy mechanical properties and durability characteristics. This new material should be more superior, preferable compared to conventional concrete based on cement.

1.1 GeopolymerConcrete: Geopolymer also known as 'inorganic polymer', has emerged as a 'green' binder with wide potentials for manufacturing sustainable materials for environmental, refractory and construction applications.In 1978, Davidovets proposed that an alkaline liquid can be used to react with sub-product material tocreate binders such as Silicates (C) and Aluminum (AL) as well as. Flyash and GGBS. Geopolimer concrete is anew material in which cement is completely replaced by pozzolanic materials which are rich in silicon (C) andaluminum (Al) fly ash.It is activated by highly alkaline fluids so that the binder can be constructed which binds theset in concrete when subject to high temperatures. Geoplymers were developed as a result of research in heatresistantmaterial after a series of horrific fires. In this research non-combustible and non-combustible geopolymerresins and binders were produced. Bhupolimar is being studied extensively and Portland cement shows promise as agreen alternative for concrete. Research is moving from the domain of chemistry to the commercial applications ofengineering applications and Bhupolimar. It has been found that Geopolymer concrete has good engineeringproperties. The chemical process involved in this case is polymerization. Polymerization process related to achemical reaction between polymerousaluminum-silicon rich minerals like fly ash under highly alkaline conditionsat high elevation temperature, polymerization of C-O-AL-O bond yield. Alkaline fluids are usually sodium orpotassium-based. In our project, we have used potassium hydroxide (KOH) and potassium silicate (K2Sio3). Geopolymer concrete is new material to be developed for use in construction work which should be eco-friendly.

1.2Ground Granulated Blast Furnace Slag: Ground granulated blast furnace slag comprises mainly of calcium oxide, silicon di-oxide, aluminium oxide, magnesium oxide. It has the same main chemical constituents as ordinary portland cement but in different proportions.And the addition of G.G.B.S in Geo-Polymer Concrete increases the strength of the concrete and also curing of Geo-Polymer concrete at room temperature is possible.GGBS (Ground Granulated Blast Slag) is a waste material Generated in iron or Slag Industries have significant impact on Strength and Durability of Geopolymer Concrete.

Ground granulated blast furnace slag is used as main replacement for cement in this geopolymer concrete.

Specific gravity test should be conducted before mixing The specific gravity of GGBS was 2.92

The chemical composition is given below.

Table: 1 Chemical Composition of GGBS.

Sr. no	Characteristics	GGBS (% wt)
1	Aluminium Oxide	7 - 12
2	Calcium Oxide	34 - 43
3	Sulphur	1.0 - 1.9
4	Magnesium Oxide	0.15 - 0.76
5	Silica	27 - 38
6	Manganese Oxide	7 - 15
7	Iron Oxide	0.2 - 1.6

1.3 Fly ash Fly ash, which is rich in silica and alumina, has full potential to use as one of the source material for Geopolymer binder. It is the main solid waste generated from the coal combustion in the power stations. Since the worldwide electric power industry relies heavily on the use of coal as a primary energy source, enormous quantities of fly ash are generated every year. Presently, as per the Indian Ministry of Environmentand Forest figures, only 20% to 30% of fly ash is used in manufacturing cements, construction, concrete, block and tiles and some disposed of in landfills and embankments, but a huge amount of fly ash is unutilized which causes several environmental problems of the air, soils and surface and ground-water pollution.

Recent works on the Geopolymerisation of fly ash, reported production of geopolymeric materials with high mechanical strength, low density, less water absorption, negligible shrinkage and significant fire and chemical resistance. Due to these properties, Geopolymeric materials are viewed as an alternative to Portland cement for certain industrial applications in the areas of construction, transportation, road building, aerospace, mining and metallurgy. Significant research work on geopolymer concrete manufactured from fly ash in combination with sodium silicate and sodium hydroxidesolution.It was a waste product hich was formed by industries and from other sources The specific gravity of fly ash is 2.133.

The chemical composition of fly ash is given below

Table: 2 Chemical Composition of Fly Ash

Sr. no	Characteristics	Fly ash (% wt)
1	Silica	55-65
2	Aluminium oxide	22-25
3	Iron oxide	5-7
4	Calcium oxide	5-7
5	Magnesium oxide	<1
6	Titanium oxide	<1
7	Phosphorous	<1
8	Sulphates	0.1
9	Alkali oxide	<1
10	Loss of ignition	1-1.5

1.4 Alkaline Liquid The alkaline liquid used was a combination of sodium silicate solution and sodium hydroxide solution. The sodium silicate solution (Na2O= 13.7%, SiO2=29.4%, and water=55.9% by mass) was purchased from a local supplier in bulk. The sodium hydroxide (NaOH) in flakes or pellets from with 97%-98% purity was also purchased from a local supplier in bulk. The NaOH solids were dissolved in water to make the solution.

2. OBJECTIVE

The main target of this study is to reduce the carbon-di-oxide emission in the environment and to reduce the demand of cement an alternative product of binding material by recycling of industrial waste is created Geopolymer concrete.

3. LITERATURE SURVEY

J.GuruJawahar. [1]The compressive strength, weight and ultrasonic pulse velocity (UPV) values of GPC mixes (FA100-GGBS0; FA50-GGBS50; FA0-GGBS100) were determined after 28 days of immersion in 3% sulphuric acid (H2SO4). In this study, sodium silicate (Na2SiO3) and sodium hydroxide (NaOH) solution is used as alkaline activator. Specimens were cast and cured for different curing periods at ambient room temperature and then studied the performance of GPC in acid environment. Test results revealed that the increased level of GGBS increased the compressive strength and ultrasonic pulse velocity values of GPC at all curing periods. The percentage of reduction in weight, compressive strength and pulse velocity values is decreased with the increased replacement of GGBS.

P Abhilash at el. [2]By using this type of industrial by-products in concrete industry as a replacement for cement we can reduce the usage of cement which results in minimizing the emission of greenhouses gases into the atmosphere and also savings in cost. This project mainly aims at the study of effect of fly ash (FA) and ground granulated blast furnace slag (GGBS) on the mechanical properties of geo polymer concrete (GPC) when they were replaced for cement at different replacement levels (FA50-GGBS50,FA75-GGBS25, FA100-GGBS0) using Sodium silicate (Na2SiO3) and sodium hydroxide (NaOH) solutions as alkaline activators. Specimens were casted and cured for different curing periods like 7, 14, 28, 56 and 112 days at ambient room temperature to determine the mechanical properties of geo-polymer concrete. Test results shows that as the percentage of GGBS in the mix is increasing, mechanical properties such as compressive strength, split tensile strength and flexural strength were increasing.

K.Prasannaat el. [3] In this present study the main limitations of fly ash based geopolymer concrete are eliminated by addition of Ground Granulated Blast Furnace Slag (GGBS) powder which shows considerable gain in strength utilizing Alkaline liquids for the polymerization process are sodium hydroxide (NaoH) and sodium silicate (Na2Sio3) solutions. Concrete is the most abundant manmade material in the world. However, the production of cement is responsible for approximately 5%-8% of the world's carbon dioxide emissions. In order to create a more sustainable world, a green building materialis essential thus the engineers and scientists found out Geopolymer concrete which is much more durable that ordinary concrete due to its resistance to corrosion. It is also much stronger than ordinary concrete. Geopolymer concrete is a revolutionary sustainable building material that will pave the way for green building.

Paras S.Pithadiya at el. [4] The objective of the present work is to study the effect of GGBS in fly ash based geopolymer concrete and to study the Effect of Oven Curing and Ambient room temperature curing on them. And by replacing fly ash from 0 to 100% with GGBS and inspecting the Fresh Properties and Hardened Concrete properties at 7

days. The casted cube will be cured at normal room temperature and at 700C Oven heat provision for 24 hours and to ascertain the behaviour of concrete mixed with GGBS, thereby examining the changes of properties like Strength and Durability**.**

P.Vignesh at el. [5] In order to create a more sustainable world, engineers and scientists must develop and put into use a green building material. Geopolymer concrete is also much more durable that ordinary concrete due to its resistance to corrosion. It is also much stronger than ordinary concrete. Geopolymer concrete is a revolutionary sustainable building material that will pave the way for green building. In this paper an attempt is made to study strength properties of geopolymer concrete using low calcium fly ash replacing with slag in 5 different percentages. Sodium silicate (103 kg/m3) and sodium hydroxide of 8 molarity (41kg/m3) solutions were used as alkaline solution in all 5 different mixes. The investigations are to be carried for the Compressive strength, Split tensile strength, Flexural strength test on the concrete specimens. Hopefully one day in the near future geopolymer concrete will replace ordinary Portland cement as the most abundant man-made material on earth.

RohitZende at el. [6] One of the methods for replacing concrete constituents is the use of geo-polymer which helps in using very less quantity of cement in concrete. This project represents study on the mechanical properties of geopolymer concrete with various mixes. In this study, Geopolymer concrete is produced with fly ash and sodium hydroxide and sodium silicate is used as a binder. Fly ash is replaced by GGBS in proportions of 25%, 50% and 75% to enhance various properties of concrete. For this project, the mix design is carried out for 11M and 13M concentration of sodium hydroxide. Alkaline activator solution ratio of 2.5 and alkaline liquid to fly ash ratio 0.40 is selected for this investigation. The specimen of size 150x150x150mm cubes, 150x300mm cylinders and 500x100x100mm prisms were casted and the specimens of geo-polymer concrete are cured at ambient temperature for 7 days and 28 days. The cured specimens were then tested for compressive strength, split tensile strength and flexural strength respectively.

N.Manojkumarat el. [7]Manufacturing of cement also releases carbon dioxide. In the present study an attempt been made on concrete and also an experimental investigation on the concrete using by replacing cement with Fly ash and GGBS to decrease the usage of cement as well as emission of concrete.Experimental studies were performed on plain cement concrete and replacement of cement with Fly ash is done. In this study the concrete mix were prepared by using flyash,sodium silicate, sodium hydroxide. A comparative analysis has been carried out for concrete to the geopolymer concrete in relation to their compressive strength, split tension strength, acid resistance and water absorption. The concrete made with fly ash performed well in terms of compressive strength, split tension strength acid resistance and water absorption showed higher performance at the age of 7,14,28 days than conventional concrete. And also two different types of acid attack isdone to determine the and compressive strength both on conventional concrete and geo polymeric concrete.

Ajay Kumar Singh. [8]Geopolymer concrete is environment friendly which has less carbon emission than the Portland cement. The production of Portland cement contributes 13.5 billion ton carbon dioxide per year (0.87ton carbon dioxide for each ton of Portland cement). Geopolymer is combination of waste material like flyash, GGBS therefore does not have an industry which could cause carbon dioxide emission. When Portland cement was produced a mixture of raw materials required heating more than 1400◦ C to obtain cement powder and its corresponding high use of fuels. For preserving our natural resources. It can be used. I have performed following test such as compressive strength, split tensile strength and acid resistance by replacing flyash and GGBSover cement. Low calcium Class F flyash has been used.

Banda RohitRajanat el. [9]The properties of geopolymeric binder prepared using the source materials such as Fly Ash and Ground Granulated Blast Furnace Slag (GGBS) without using any conventional cement have been investigated. The individual properties of the mortar such as setting time, normal consistency, slump test, compressive strength, were determined as per relevant Indian and ASTM standards. The different parameters considered in this study are the proportion of binder components, the ratio of Na2SiO3 / NaOH and the alkaline liquid to binder ratio. The various combinations of fly ash and GGBS considered are 90% & 10%, 80% & 20%, 70% & 30%. The ratio of Na2SiO3 /NaOH is taken as 2 and 2.5 and the alkaline liquid to binder ratio as 0.45. The test results reveal that the geopolymer mortar develops the strength even at ambient conditions. Compressive strength increases with an increase in the quantity of GGBS. It was also found that geopolymer mortars made with Na2SiO3 /NaOH ratio as 2.5 & alkaline liquid to binder ratio as 0.45 produces higher strength. It can be concluded that the results of geopolymer mortars are high when compared with conventional mortars in terms of strength.

Seethalakshmi Tat el. [10]Geopolymer Concrete (GPCs) is a new class of concrete based on an inorganic alumino-silicate binder system compared to the hydrated calcium silicate binder system of concrete. It possesses the advantages of rapid strength gain, elimination of water curing, good mechanical and durability properties and are ecofriendly and sustainable alternative to Ordinary Portland Cement (OPC) based concrete. In the construction industry mainly the production of Portland cement causes the emission of air pollutants which results in environmental pollution. This paper presents the details of the studies carried out on development of strength for various grades of geopolymer concrete with

varying molarity. The alkaline liquids used in this study for the geopolymerization are sodium hydroxide (NaOH) and sodium silicate (Na2SiO3). Different molarities of sodium hydroxide solution (8M,10M and 12M) are taken to prepare different mixtures. The test specimens were 100 x 100 x 100 mm cubes, 100 x 200mm cylinders prepared and oven cured at 75ºC. The geopolymer concrete specimens are tested for their compressive strength at the age of 7,14 and 28 days. GPC mix formulations with compressive strength ranging from 12.33 to 82.10MPa have been developed. The test results indicate that the combination of fly ash and ground granulated furnace slag (GGBS) can be used for development of Geopolymer concrete.

S.Senthilkumarat el. [11]To reduce the carbon-di-oxide emission in the environment and to reduce the demand of cement an alternative product of binding material by recycling of industrial waste is created called Geopolymer. The Geopolymer or Geopolymerisation or Geopolymer concrete is the best innovative concrete material which is produced by chemical process with industrial waste. General method of Geopolymer concrete is a homogeneous mixer of fly ash or steel waste (GGBS), fine aggregate, course aggregate and alkaline solutions. The industrial combustion waste fly ash and the steel plant waste (GGBS) are the base material for Geopolymer concrete. Alkaline solutions are prepared by mixing of silicate and hydroxide. By Geopolymer process of binding material the requirement of cement is reduced and emission of carbon-di-oxide in atmosphere will reduce. High volume replacement of industrial waste or slag for development of concrete saves a lot of natural resources and energy which reduces the manufacture of Portland cement. In the present work, an attempt has been made to establish the mix proportion to Geopolymer Concrete by flyash with steel waste (GGBS). To study the compressive and tensile strength of Geopolymer Concrete and to prove that the new alternate concrete material is eco-friendly.

Er. Irfat Bashirat el. [12]Geopolymer, also known as inorganic polymer, is an alternative binder that uses by-product material such as fly ash instead of cement. Recent research has shown that fly ash-based geopolymer concrete has suitable properties for its use as a construction material. Since the strength development mechanism of geopolymer is different from that of OPC, it is necessary to obtain a suitable constitutive model for geopolymer concrete. The demand of concrete is increasing day by day and cement is used for satisfying the need of development of infrastructure facilities, 1 tone cement production generates 1 tone CO2, which adversely affect the environment. In order to reduce the use of OPC and CO2 generation, the new generation concrete has been developed such as geopolymer concrete. It uses fly ash and alkaline solution as their Binding Materials. Geopolymer requires oven curing in the varying range of 60”C to 100”C for a period of 24 to 96 hours. In this present study the main limitations of fly ash based geopolymer concrete are slow setting of concrete at ambient temperature and the necessity of heat curing are eliminated by addition of Ground Granulated Blast Furnace Slag (GGBS) powder which shows considerable gain in strength.

4. CONCLUSION

From this literature survey, it was found thatGeopolymer Concrete is Alternative to OPC concrete. Geopolymer concrete is a special type of concrete that is manufacture using industrial waste like Fly ash, GGBS which are considered as a more eco-friendly. Keeping in view of savings in natural resources, sustainability, environment, production cost, maintenance cost and all other GPC properties, it can be recommended as an innovative construction material at low cost for the use of constructions.

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