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ASSESSING THE PROPERTIES OF GEOPOLYMER CONCRETE: A REVIEW

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ABSTRACT: Concrete is the most abundant manmade material in the world. The production of ordinary Portland cement contributes 5-7% of total green house gas emission. It also consumes large amount energy .Hence it is essential to find alternative to cement. Geopolymer concrete (GPC) is the best alternative greener material to the existing cement concrete which is most expensive, resource and energy consuming Fly ash is a byproduct of coal obtained from thermal power plant. It is also rich in silica and alumina. Therefore fly ash is used to produce a geopolymer concrete. Geopolymer concrete is totally a cement free concrete. In geopolymer, fly ash act as binder and alkaline solution act as an activator. Fly ash and alkaline activator undergo geo polymerization process to produce alumino silicate gel. Alkaline solution which is used is a combination of sodium hydroxide (NaOH) and sodium silicate (Na_2Sio_3) with ratio 2.5. A grade chosen for the investigation was M-30. The mixes were designed for molarity of 12M, 14M and 16M.. The test results have shown that compressive strength, Flexural strength and split tensile strength increases with increase in molarity.

Key word: **Geopolymer concrete, Strengths, Fly ash, Molarity**

I. INTRODUCTION

Portland cement concrete (PCC) is a versatile material and is used for construction all over the world. The production of Portland cement requires pyro processing of materials at temperatures in the range of 1400°C – 1500°C, which makes it an expensive and energy intensive process. Also, during the manufacture of Portland cement, CO_2, the primary green house gas is released, due to the calcinations of limestone and combustion of fossil fuel, to the atmosphere. Hence, the use of Portland cement concrete should be reduced and an environmental friendly concrete should be used in construction.

The three fundamental elements for supporting an environmentally-friendly concrete technology for sustainable development are the conservation of primary materials, the enhancement of the durability of concrete structures, and a holistic approach to the technology. Regarding the conservation of primary materials, reduction in the consumption of cement, aggregates and water along with the use of waste materials and industrial by-products, are the principal actions to be taken in order to reduce the utilization of non-renewable resources and the negative impact on the environment.

The term Geo polymer was first used by Davidovits in 1970. Geopolymers are inorganic polymeric materials predominantly made from the polymerization of industrial waste materials such as kaolin, metakaolin, fly ash, granulated blast furnace slag and rice husk ash etc. which are rich in silica and alumina. These aluminium-silicate materials transform into a dimensionally stable mass at low temperature through polycondensation. Geo polymerization involves a chemical reaction between the aluminium–silicate material and an alkali solution under highly alkaline conditions yielding amorphous to semi-crystalline three dimensional polymeric structures, which consist of Si–O–Al bonds. Geo polymers, from the family of inorganic polymers, possess excellent mechanical and thermal properties. The rate of strength gain is greater compared to normal concrete. Geo polymer attains 90 % of its strength within 4 hours of the polymerization reaction (Davidovits and Davidovics, 1998).

The formation of Geo polymer is normally a two step process, involving:

• Activation: This refers to dissolution of the silicates and aluminates from the raw materials in the presence of a highly alkaline solution. This is followed by orientation of the molecules and, finally, transportation of the silicates and aluminates to form Si-O-Al bond.

• Polycondensation: Polymerization takes place through application of heat and this leads to the formation of 3D cross linked polysialate structure

Inspired by the geo polymer technology and the fact that fly ash is a waste material abundantly available, we have carried out experimental investigation to study the influence of morality of sodium hydroxide solution on the properties of geopolymer concrete.

II. NECESSITY OF GEOPOLYMER CONCRETE

Construction is one of the fast growing fields worldwide. As per the present world statistics, every year around 260, 00, 00,000 Tons of Cement is required. This quantity will be increased by 25% within a span of another 10 years. Since the Lime stone is the main source material for the ordinary Portland cement an acute shortage of limestone may come after 25 to 50 years.

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More over while producing one ton of cement, approximately one ton of carbon di oxide will be emitted to the atmosphere, which is a major threat for the environment. In addition to the above huge quantity of energy is also required for the production of cement. Hence it is most essential to find an alternative binder. The Cement production generated carbon di oxide, which pollutes the atmosphere. The Thermal Industry produces a waste called flyash which is simply dumped on the earth, occupies larges areas. The waste water from the Chemical Industries is discharged into the ground which contaminates ground water. By producing Geopolymer Concrete all the above mentioned issues shall be solved by rearranging them. Waste Fly Ash from Thermal Industry + Waste water from Chemical Refineries = Geo polymer concrete. Since Geopolymer concrete doesn't use any cement, the production of cement shall be reduced and hence the pollution of atmosphere by the emission of carbon di oxide shall also be minimized.

III. CONTITUENTS OF GEOPOLYMER CONCRETE

The following are the constituents of Geopolymer concrete

- Fly Ash- rich in Silica and Aluminium
- Sodium Hydroxide or Potassium Hydroxide
- Sodium Silicate or Potassium Silicate

IV. PROPERTIES OF GEOPOLYMER CONCRETE

The superior properties of Geopolymer concrete are as follows:-

- Sets at room temperature
- Non-toxic, bleed free
- Long working life before stiffening
- Impermeable
- Higher resistance to heat and resist all inorganic solvents
- Higher compressive strength

V. TABLE 1 CHEMICAL COPOSITION OF FLYASH

From Scientific Reports ISSN2045-2332(online)

Characteristics	**Fly ash (%Wt)**
Silica	55-65
Iron-oxide	5-7
Aluminium oxide	22-25
Calcium oxide	5-7
Magnesium oxide	<1
Titanium oxide	<1
Phosphorous	<1
Sulphate	0.1
Alkali oxide	<1

TABLE 2 PHYSICAL PROPERTIES OF FLY ASH
From Scientific Reports ISSN2045-2332

Physical properties	Properties of Fly ash used
Specific Gravity	2.51
Intial Setting time	120 minute
Final setting time	280 minute
Fineness specific surface m^2/kg min	320
Lime reactivity Avg compressive strength	4

VI. LOCAL AVAILIBILITY OF FLY ASH

Shri Singaji Thermal power plant in Khandwa District Madhya Pradesh

VII.LITERATURE REVIEW

N.L.N. Karan Kumar et al. in 2017 present the study of "Nano silica on the strength properties of different types of geopolymer concrete" has been investigated at ambient temperature curing condition. The dry components of Geopolymer concrete i.e., fine aggregate, coarse aggregate, flyash, GGBS, were mixed. Then the liquid part of the mixture i.e., The NaOH with molar concentration 12M is mixed with NA2SiO3 solution in the proportion of 1:2 (by weight) to make alkali activator fluid. Collodial nano silica with 4%, 6%, 8% and 10% of binder by weight is also added to the fluid. These liquids are mixed another 2 minutes. After mixing, the fresh concrete was the filled into steel moulds into 3 layers and each layer was tamped and vibrated on vibration table. The geopolymer concrete specimens are removed from the mould after 24 h of casting and cured at ambient temperature (27+- 2 degree celcius) the testing, the specimens with geopolymer concrete without nano-silica (FA-NS-0) are cured at 60 temperature for 48 hours only within the hot air oven. 28 days strength properties of only flyash based GPC with Nano silica has a considerable improvement over control GPC mix. Addition of 6% Niño-silica in only Flash based GPC cured at ambient temperature, improves compressive strength of 25.9% over control GPC mix. Similarly split

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tensile and Flexural strength improve 29.02% and 36.80% over respective control GPC strengths. Strength properties of GGBS blended fly ash GPC mix with NanoSilica shows significant improvement over the control GPC mix. It was observed that, addition of 6% Nanosilica in GGBS blended fly ash based GPC cured at ambient temperature improves compressive strength, Split tensile strength and flexural strength of 46.54%, 50.72% and 48.29% over control GPC mix.

P.A. Prabakaran et al. in 2017 gives the "Experimental investigation on flexural behavior of Geopolymer concrete" Eight trial mixes are prepared for M30 grade concrete with 100% replacement of cement with ASTM class F fly ash. In this NaOH of 12M and 14M are used as the alkali activator solutions in four different percentages viz., 0.4%, 0.45%, 0.50% and0.55% of fly ash. Natural River sand and coarse aggregates of 20 mm maximum size are used for all the geopolymer concrete specimens. The optimum percentage of alkali activator solutions is arrived by conducting the tests for compressive strength, split tensile strength and flexural strength on the geopolymer concrete specimens. From the experimental results, it is observed that there is no 13. Significant variation in strength properties of geopolymer concrete mixes when compared to that of the normal concrete. Geopolymer concrete with 0.4% of alkaline solution of 14M is found to be the optimum mix proportion and its compressive strength is improved by 7% than that of conventional concrete specimen. The experimental investigations on the flexural behavior of geopolymer concrete beams are carried out by conducting two point load tests on three beams of size 1000mm × 100mm × 200mm. From the flexural tests, it is observed that there is no significant variation in the flexural behavior of geopolymer and conventional concrete. The compressive and tensile strengths at 7 days of GPC-3, GPC-4 and GPC-8 are comparatively higher than results of conventional mix. This suggests a higher early strength is possible with Geopolymer concrete. For flexural strength GPC-4 and GPC-8 mixes only are used to compare with the conventional concrete mix. Flexural behavior of Geopolymer concrete beams has an increase in the load carrying capacity compared to the conventional M30 mix by 19.2%. From the results it's inferred that using higher percent of fly ash and lower percent of alkali activator solution as a cement replacement can obtain higher strength.

PATEEL ALEKHYA et al. in 2017 gives the "Experimental investigations on Geopolymer concrete" This will explore the areas in which geopolymer concrete outperforms ordinary concrete. Geopolymer concrete uses fly ash and GGBFS, a byproduct created from the burning of coal and iron. The production of geopolymer concrete allows fly ash to be recycled and eliminated from landfills. Geopolymer concrete is also more resistant to damage than standard concrete. There is a need to find some alternative binding material. Any material which contains silicon and aluminum in amorphous state can be a source of binding material in AAC. The experimental work involved development of an alkali activated concrete. As far as possible, the technology and the equipment currently used to manufacture OPC concrete were used in this study to make the alkali activated concrete. Fly ash (Grade I) and GGBFS from Bellary Sathavahana I spat Limited were considered as the source materials. Sodium hydroxide and Sodium silicate were procured commercially from a local vendor. The some property of Alkali activated is discoursed for the different morality of alkali solution (NaOH). alkali earth ions are used to stimulate the pozzolanic reaction or release the latent cementitious properties of finely divided inorganic materials. The materials could be minerals as well as industrial by-products consisting primarily of silicates, alumino silicate and calcium. Numbers of trial mixtures of AAC were prepared, and test specimens in the form of 150 mm cubes or 100x200 mm cylinders were 14 M. The 60 liter capacity pan mixer with rotating drum available in the concrete laboratory for making OPC concrete was used to manufacture the AAC.

A. Gowtham Kumar et al. in 2017 gives the "Experimental Study on Plastic Fiber Reinforced Fly ash based Geopolymer Concrete" In this experimental study, thermal power plants accessible waste material fly ash is used as geopolymer material. Here testing has been done to study the properties of geopolymer concrete using fly ash as the most important binding resource. Due to its Resistance of corrosion ordinary Portland cement is less durable than geopolymer concrete. High calcium fly ash will produce more carbon dioxide emissions to reduce these emissions we have preferred to use low calcium fly ash. In this experimental study, we have used two alkaline liquids as binders, sodium hydroxide (12M) and sodium silicate. These are useful for polymerization process. A mix proportion for geopolymer concrete is different from normal concrete and was designed by assuming the density of geopolymer concrete as 2400 kg/m3. This experimental study describes the effect of polypropylene fibers in geopolymer concrete an experimental work has been carried out on cubes, cylinders and prisms to know the various strengths. The polypropylene fibers were added with five different percentages (0%, 0.75%, 1.5%, 2.25%, and 3%). The strength parameters were determined for various ages of concrete. t. The Na2SiO3 and NaOH are mixed one day before to get polymerization which is perfectly suitable as the binding agent. Powder content (fly ash and GGBS) and aggregate are mixed for one minute and the binding agent is added with small amounts and the mixing is done for 2minutes. Now the fibers are added to the mixture with the slow increment and mixing is done thoroughly All the materials are mixed manually. Curing is done under ambient conditions. GGBS is added for setting, purpose only, not for strength parameter. Tests were conducted for the specimens for various days of 7 and 28 days and tested in compressive strength testing machine. The strengths are decreasing gradually by increasing the percentage of polypropylene fibers. We can reduce the brittle nature of the structure by adding of polypropylene fibers. The strengths are decreasing due to less bonding nature and ratio of alkaline activators.

Rashmi Gopalan et al. in 2017 gives "The Effect of Tensile and Shear Reinforcement on the Flexural Behavior of Reinforced Geopolymer concrete Beams" Geopolymer concrete (GPC) is the best alternative greener material to the existing cement concrete which is most expensive, resource and energy consuming. Geopolymer technology not only has the potential to reduce 15 global greenhouse gas (GHG) emissions caused by ordinary Portland cement (OPC) production, it also has exceptional mechanical and durability properties. With the intention of overcome the limited resource of structural behavior of GPC, this work was proposed to assess the effect of tension reinforcement percentage (1.0, 1.5 & 2.0) and shear span/depth (1.9 & 2.9) on the flexural behaviour of reinforced alkali activated slag concrete beams with ground granulated blast furnace slag (GGBFS) as source material. The properties such as load carrying capacity, flexural strength, moment carrying capacity, deflection and ductility behaviour of six RGPC beams were experimentally evaluated using two-point loading and the results were compared with the existing codal provisions (BS 8110, BIS 456, and ACI 318). From the results obtained from the experiments conducted and the discussions, the following conclusions can be made The ultimate load carried by the beams increases with the increase in the percentage of tensile reinforcement and shear span-to-depth ratios. The first crack load and the load at yielding were observed to be in the range of 29 to 35 %and 79 to 93 % of their ultimate loads. The deflection at ultimate load carrying capacity increases with the increase in the percentage of tensile reinforcement and shear span-to-depth ratio results in improved energy absorption capacity of the beams. The experimental deflections were found to be more than the theoretical deflections prescribed by the codes. The span-to-deflection ratios of all the tested beams were observed to be inside the permissible limits prescribed by the codes. The ductility behaviour improves with the increase in the percentage of tensile reinforcement and shear span-to-depth ratio. The ultimate moment carrying capacity of the beams were observed to be more than the corresponding values prescribed by the codes and found to increase with the reinforcement percentage and shear span-to-depth ratio. The failure of all the beams was found to be due to diagonal tension failure and no shear compression failure, resulting in adequate shear reinforcement.

H Tea Karan Kumar et al. in 2017 gives "Experimental Study on Coir Fibre Reinforced Fly ash Based Geopolymer Concrete With 12M Molar Activator" the behavior of coir fiber as reinforcement in geopolymer concrete. Low-calcium fly ash is used as the production of geopolymer concrete. Before using in concrete coir fiber is treated with latex adhesive solution. Coir fibers of length 25mm with various percentages i.e. 0%, 0.75%, 1.5%, 2.25%, 3% are used. The combination of Na2SiO3 solution &NaOH result was used for fly ash activation. Binding agent to fly ash ratio was 0.45.The morality used was 12M (Molars). Ambient curing is followed for the work. The various strength parameters were tested at various ages i.e.., 7, 14 and 28 days. Coir fiber which is acting as reinforcement added to resist the micro cracks. So this can be 17 applicable where the requirement to resist the micro cracks. 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 fiber 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 fiber is to mercerization. After 48hrs coir fiber 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 met kaolin is added to the amount of powder content for the purpose of one day setting only not for strength parameters The coarse aggregate 10 mm was used The locally available river sand, passing through 4.75 mm was used The particle size of the met kaolin was referred with the help of scanning electron microscope. In powder content 20%is used as met kaolin for the setting purpose only. The coir fiber is chopped to 25mm. The chopped fibers are allowed to soak in sodium hydroxide for 48hours for chemical treatment. After 48hours the treated coir fiber is washed repeatedly and allowed to dry for 24 hours. The dried fibers are then resin with latex compound the combination of 70% of latex, 10% of sodium hydroxide solution and 20% of water to achieve thee homogenization and allowed to dip for 15 minutes and dried for 24 hours. Polymerization is formed by the mixing of Na2SiO3 and NaOH. Sodium hydroxide is in the form of pellets or flakes. To form 12M, the sodium hydroxide flakes of 480 gems are dissolved in water to require the concentration. During the formation of concentration it liberates large amount of heat. To form polymerization the mixed sodium silicate and sodium hydroxide are allowed to keep at room temperature for minimum of 24hrs. This mixed solution acts as a binding agent. The Na2SiO3 and NaOH are mixed one day before to get polymerization which is perfectly suitable as the binding agent. All the materials are mixed manually. Fly ash and aggregate are mixed for one minute and the binding agent is added with small amounts and the mixing is done for 2minutes. Now the treated fibers are added to the mixture with the slow increment and mixing is done thoroughly. For compressive test cube specimens of 150x150x150mm, for split tensile test9 cylindrical specimens of 150mm diameter and 300mm height specimen and for flexural strength beam specimens 100x100x500mm3 were casted. Curing is done under ambient conditions. The propagation micro cracks are resisted. Optimum percentage of coir fiber is 2.25 in this research. Increase in coir fiber percentage the strength 18 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.

Srinivasan K in 2017 gives "The Durability Studies on the Slag Based Geo polymer Concrete Strengthened with Steel Fibers" The studies were conducted to achieve the maximum strength and durability of geo polymer concrete. The influence of binder addition with alkali activators (sodium hydroxide) and accelerators (calcium nitrate and sodium sulphate) on the strength properties of slag geopolymer concrete was methodically tested. The effects of sodium hydroxide concentration of 12M investigated. The concrete was cured in the various curing regime like hot air oven and controlled room temperature.. The steel fibers were added in geopolymer concrete (GC2 and GC5 series) for dosage of 0.5%, 1.0% and 1.5% by the weight of total binder and further as alternate wet and dry test, acid attack, rapid chloride permeability, Evaluation of corrosion, post temperature effect and water permeability test of slag based geopolymer concrete (with and without steel conclusions were made based on all the above test results. Out of all the mixtures, GC22 mix (B/TA=0.22 and FA/CA=0.6 with 1.0% of the steel fibre. The furnace slag used in this study is a by-product of the ferrosilicon industry and is commercially available in the market as Ground Granulated Blast Furnace Slag (GGBS), which is conforming to BS 6699-1992 (British Standard) Fine aggregate (river sand) used in this study was passing through 4.75 mm IS sieve, conforming to grading zone-II. The specific gravity of the fine aggregate was 2.65. Gravel pieces which passed 12.5 mm sieve size, retained on 10mm sieve were used as coarse aggregate for concrete production. The specific gravity of the coarse aggregate was 2.73. Based on the various durability test conducted on geopolymer concrete mixture of GC2(Binder / Total Aggregate - 0.22, Fine Aggregate / Course Aggregate – 0.6) and GC5 (Binder/ Total Aggregate - 0.22, Fine Aggregate / Coarse Aggregate – 0.6) with steel fiber, the GC2mix series (GC21, GC22 and GC23) performed well in acid attack, GC23 mix attains61.6MPa after 180 days of immersion in hydrochloric acid. The specific gravity of slag Performed well in the acid resistance as micro fill in concrete. The steel fiber improves the integrity of concrete in compressive properties. The resistance over temperature by the concrete was also shows the reasonable compressive strength of 28.2MPa (GC23) after removing from 800°C. In RCPT the permeability of chloride was very low in all concrete mixtures, mix GC23 was giving the better protection to rebar and good resistance of corrosion 19

G. Adisekhar et al. in 2017 gives "Effect on Flexural strength of Reinforced Geopolymer concrete Beams by using GGBS, Met kaolin and Alkaline Solution" This paper describes the experimental studies on Flexural behavior reinforced Geopolymer concrete beams (GPC). In the production of Ordinary Portland cement causes pollution to environment by releasing CO2.In the present study ground Granulated Blast Furnace slag (GGBS) and Metakaolin is used to convey Geopolymer concrete. Geopolymer bond is set up by using dissolvable course of action of sodium silicate and sodium hydroxide. This settled extent is 2.5 and the convergence of sodium hydroxide is 8M. The concrete beams of size 150 mm X 150mm X 700 mm with varying percentage of GGBS and Metakaolin are tested in present study. The paper focuses on investigating characteristics of M40 concrete with various proportions of Ground Granulated Blast furnace Slag (GGBS) and Metakaolin. The behavior of studied with reference to ultimate load and mid span deflection was calculated. The fundamental refinement between Geo-polymer bond and others is the clasp. To outline Geo-polymer activator plan used to react with silicon and aluminum oxides which are accessible in Metakaolin and GGBS. This fundamental activator course of action ties coarse aggregate and fine aggregate to outline Geo-polymer mix. The fine and coarse aggregate include around 75% mass of Geo-polymer concrete. The fine aggregate was taken as 36% of total. The thickness of Geopolymer bond is taken 2426 kg/m3.The workability and nature of concrete are affected by properties of materials that make Geopolymer concrete. The mixing is done with 1:2.5 ratios. Material used: 1. GGBS, 2. Metakaolin, 3. Reinforcement, 4. Fine Aggregate, 5.Coarse Aggregate 6.Sodium Silicate, 7. NaOH. The preparation of NaOH solution is done by dissolving the following ingredients in water. A concentration of 8M NaOH is calculated as molecular weight of NaOH is 40 and for 8M we need to calculate NaOH by 8 X 40 = 320 grams and dissolve by adding distilled water to NaOH flakes use the solution of after 24 hours. The soluble activator arrangement is set up before 24 hours of throwing. At first, all dry materials were blended appropriately for three minutes. Soluble activator

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arrangement is added gradually to the blend. Blending is accomplished for 5 minutes to get uniform blend. Based on the experimental and analytical investigations carried out on the reinforced Geopolymer cement concrete beams and conventional Portland cement concrete beams, it can be concluded that the load deflection characteristics of the RCC beams and GPC beams are almost similar. The cracking moment was marginally lower for GPC beams compared to OPC beams. The crack patterns and failure modes observed for GPC beams were found to be 20 similar to the OPC beams. From the test results it is observed that the ultimate load for GPC with more than70% GGBS and 30% MK gives similar results with OPC.

V. Keerthy et al. in 2017 gives the "Experimental studies on proportion of Geo polymer concrete with GGBS and Fly Ash". Its main objective is to manage the quality properties of geopolymer concrete and to make a concrete without using cement. .This helps in lessening of Carbon emanations brought about by traditional concrete. The primary point is to utilize the ground granulated impact heater slag and fly fiery remains setup of common Portland concrete. From this we can look at the properties of geopolymer concrete with bond concrete. The material used in this experiment is Fly ash, chemicals, GGBS, NaOH, Na2SiO3, Aggregates. The Fly ash is taken from the fly fiery debris the waste item got from warm power plants. It is acquired as powder. The Ground granulated impact heater is by-result of iron and steel in impact heater to create a shiny, granular item that is then dried and ground into a fine powder, The Alkaline activators is the combination of Sodium silicate and Sodium Hydroxide are utilized as basic arrangement activators. 10mm size of coarse and fine aggregates are used. In this method the qualities of geopolymer cement is inspected for blends of 8 morality of NaOH. The atomic weight of NaOH is 40. To get ready 8 Morality of arrangement, 320gm of sodium hydroxide chips are weighted and broken up in refined water to frame 1-litre arrangement. In the same manner for 10 morality 400gm of NaOH flakes are weighted and dissolved in 1 liter distilled water. The geopolymer cement is composed according to the aggregate volume involved by fine and coarse totals which are embraced as 70%. The water substance to fly fiery remains and GGBS proportion is taken as 0.45. The proportion of NaOH to Na2SiO3 is taken as 1:2 of morality 8and 10. The casting and curing is done in such a way that at first the fine total and coarse total, fly cinder, GGBS are blended in dry condition and after that the soluble arrangement which is a mixture of NaOH and Na2SiO3 arrangement are added to the dry blend. Water is added to the compendious material. The blending is accomplished for 6-8 minutes. In the wake of blending is done the examples are thrown by giving appropriate compaction in three layers. For the curing, 3D shapes are deformed following 1 day of throwing and they are set in encompassing room temperature for 7 and 28 days. For testing the examples were tried according IS 516-1959 and the qualities were ascertained for 7&28 days .For compressive strength the solid shapes of dimension 150 mm x 150 mm x 150 mm be set up for every blend. Following 24 hours the examples were de-shaped and cured for 7& 28 days. The compressive quality reported is the normal of three results got from three indistinguishable 3D shapes. For 21 Split tensile strength Barrels of an example of the dimension 150 mm x 150 mm x 300 mm be set up for every blend. Following 24hours the examples were deformed and cured for 7& 28 days. The split elasticity reported is the normal of three results got from three indistinguishable chambers. For Flexural strength The bar (examples) of dimension 100mm × 100mm × 500 mm were utilized and are set up for every blend. Following 24 hours the examples were deformed and cured for 7& 28 days. The flexural quality reported is the normal of three results acquired from three indistinguishable hats. Hence The Compressive strength test which is done at the age of 7 days the percentage variation between 8m and 10mare 38.5%, 10.24%, 15.04%, 3.65%. and for 28 days are 26.38% , 9.11%, 9.3% ,11.28% The split tensile strength test which is done at the age of 7 days the percentage variation between 8m and 10m are54.17%, 48.21%, 43.24%, 50.9% for 28 days are 51.11% , 30.%, 47.74% ,60.86% .The flexural strength test which is done at the age of 7days the percentage variation between 8m and 10m are 16.95%, 17.88%, 15.67%, 54.35% for 28 days are 87.64% , 76.02%, 70.25% ,64%.

Balaraman R et al. in 2016 gives the "Comparative study of Geopolymer Concrete in Fly ash with Conventional Concrete". In this research the experimental studies on Geo polymer Concrete has carried out the experiments are conducted by varying morality of Sodium hydroxide solution in Geo Polymer Concrete and the properties such as Compressive Strength, Split tensile Strength, and workability are measured. The experiments are also repeated with GGBS instead of Fly ash on selected samples and the above measured parameters are presented and discussed. An target Compressive Strength in Geo Polymer Concrete is achieved when the morality of Sodium hydroxide solution is 15%.The polymerization process involves a substantially fast chemical reaction under alkaline condition on Si-Al minerals that result in a three dimensional polymeric chain and ring structure consisting of Si-O-Al-O bonds, In this work, low-calcium (ASTM Class F) fly ash-based geo polymer is used as the binder, instead of Portland or other hydraulic cement paste, to produce concrete. The fly ash-based geo polymer paste binds the loose coarse aggregates, fine aggregates to form the geo polymer concrete, with or without the presence of admixtures. The manufacture of geo polymer concrete is carried out using the usual concrete technology methods. As in the case of Ordinary

Portland cement concrete, the aggregates occupy about 74-80% by mass in geo polymer concrete. The silicon and the aluminum in the low-calcium (ASTM Class F) fly ash react with an alkaline liquid that is a combination of sodium silicate and sodium hydroxide solutions to form the geo polymer paste that binds the aggregates. In this the comparison between Geopolymer concrete and 22 Conventional concrete is discussed. The essential deference between the composition of geo polymer concrete and normal concrete lie in formation mechanism and the final end product. The material used in this experimental research Ordinary Portland cement (OPC) of 53 is used, the fly ash was collected in the form of dry powder from the electrostatic precipitators directly. A combination of sodium silicate solution and sodium hydroxide solution was chosen as the alkaline liquid Local aggregates, comprising 20 mm, and less than 20 mm coarse aggregates and fine aggregates, in saturated surface dry condition, were used. The coarse aggregates were crushed granite-type aggregates and the fine aggregate was fine sand. Coarse aggregates were obtained in crushed form majority of the particles were of granite type. The quality is tested using the crushing and impact test. The fine aggregate was obtained from the sand dunes in uncrushed form. The sulphonated naphthalene-formaldehyde (super plasticizer) is used as super plasticizer in the preparation of geo polymer concrete Use of super plasticizer permits the reduction of water to the extent up to 30 percent without reducing workability in contrast to the possible reduction up to 14percent in case of plasticizers. The super plasticizers produce a homogenous, cohesive concrete generally without any tendency for segregation and bleeding. The concrete mix is designed as per IS 10262– 2009, IS 456-2000 for the normal concrete. Finally the super plasticizer, sulphonated naphthalene formaldehyde which is 1% by weight of cement is added to the concrete. The grade of concrete which we adopted is M30 with the water cement ratio of 0.4. Mix proportion and mix design for conventional concrete are shown Mix design for geo-polymer concrete is also shown. The manufacturing of Test specimens and Fresh concrete and casting is done the fly ash and the aggregates were first mixed together for about 3 minutes. The liquid component of the mixture was then added to the dry materials and the mixing continued for further about 4 minutes to manufacture the fresh concrete. The fresh concrete was cast into the 150 mm cube moulds immediately after mixing, in three layers. For compaction of the specimens, each layer was given 60 to 80 manual strokes using a compacting rod. Before the fresh concrete was cast into the moulds, the slump value of the fresh concrete was measured. Slump test is the most commonly used method of measuring consistency of concrete which can be employed either in laboratory or at site. The variation of slump for geo polymer concrete prepared using fly ash and GGBS with morality of sodium hydroxide solution The experimental results shows that the slump value increases with increase in morality of sodium hydroxide solution It is also observed that the increase in slump is about 22.58% for increase of morality from 8 to 16 in fly ash based geo polymer concrete. However, the increase 23 in slump beyond 12M of sodium hydroxide solution is marginal in both the cases. Heat curing method is generally recommended for geo polymer Concrete. The test specimen is cured in hot air oven at 80°C for 24 hours The compressive test on both conventional concrete and geo polymer concrete is carried out in accordance with IS 516- 1999 standards, The test is conducted on concrete specimens of size 150mm x 150mm x 150mm. Geo polymer concrete specimens are cured in oven for 24 hours at 80°c.The specimen is placed at the centre of the compressive testing machine platform, the load is applied gradually till the specimen fails. The experimental set up for the measurement of compressive strengths shown. Hence an experimental study was conducted on both conventional and geo polymer concrete. The influence of morality of sodium hydroxide solution on the properties of geo polymer concrete such as slump, compressive strength, and split tensile strength has-been studied the measured slump, compressive strength and split tensile strength of geo polymer concrete increase with increasing morality of sodium hydroxide solution and follow power relationship. The empirical equations are obtained to predict slump, compressive strength, split tensile strength for any concentration (morality) of sodium hydroxide solution. Increase in morality increases compressive strength of fly ash based geo polymer concrete by approximately 65%. However, the increase in compressive strength is marginal for lower concentration of sodium hydroxide solution (8M-10M). The increase in morality of sodium hydroxide solution also increases compressive strength of GGBS based geo polymer concrete by approximately 82%. However the effect is significant only beyond 14M of sodium hydroxide solution. However any percentage of concentration of sodium hydroxide solution, GGBS based geo polymer concrete gives high compressive strength compare to fly ash based geo polymer concrete. Increase in morality also increases slump and split tensile strength in both categories of geo polymer concrete. The recommended morality of sodium hydroxide solution is 15% in order to achieve optimum compressive strength.

Kolli.Ramujee et al. in 2013 gives research on “On the Development of Mix design for low calcium based Geopolymer concrete in Low, Medium and Higher grades-Indian Scenario” In this research he tells that Geopolymer concrete is a cement less concrete gaining popularity globally towards the sustainable development .It is a type of amorphous alumino-silicate cementitious material which can be synthesized by polycondensation reaction of geopolymeric precursor and alkali polysilicates. Beside fly ash, alkaline solution is utilized to make geopolymer paste which binds the aggregates to form geopolymer concrete In this Research an attempt is made to develop the mix design for Geopolymer concrete in low, medium and higher 24 grades and relative comparison has been made with equivalent mix proportions of grades of OPC Concretes in both heat cured and ambient cured conditions. About 7 different mixes for each grade is casted, tested and optimized The design parameters like alkaline liquid to fly ash ratio and water to Geopolymer solids ratio were proposed to develop the Geopolymer concrete in lower grades. The primary difference between Geopolymer concrete and Portland cement concrete is the binder. The silicon and aluminum oxides in the low –calcium fly ash reacts with the alkaline liquid to from the geopolymer paste that binds the loose coarse and fine aggregates and other unreacted materials to form the geopolymer concrete. As in the case of Portland cement concrete the coarse and fine aggregates occupy about 75% to 80% of the mass of Geopolymer concrete. This component of Geopolymer concrete mixtures can be designed using the tools currently available for Portland cement concrete Based on earlier research conducted in Materials testing lab by the author, the following parameters were maintained constant throughout the Experimental work. The parameters are the ratio of sodium silicate to sodium hydroxide =2.5 he curing Temperature = 600C the curing duration = 24HrsRatio of Fine aggregate to total Aggregate = 0.35The other parameters varies between different grades of concrete. The Concentration of Noah is kept constant i.e. 8M for G20 grade whereas for G40 and G60grade concretes it was maintained as 16M.For G40 & G60 mixes the alkaline solution to fly ash ratio was 0.40 ,whereas for G20 the ratio is limited to 0.35. Compressive strength tests were performed at the age of ,7 and 28 days in accordance with IS:516-1959 under 2000KN Compression testing machine with uniform rate of load application for Geopolymer concrete mixes and control mixes From the investigation it is clear that for Water/binder ratio the governing factors in designing the Geopolymer mix design for various grades. Water/binder ratios of 0.27, 0.21& 0.158&0.35 are suggested for G20, G40 & G60 respectively compressive strength of geopolymer concrete can be achieved by decreasing water binder ratio. The compressive strength attained at 28 days for all grades of Geopolymer concrete under ambient curing is almost equal to compressive strength achieved by Geopolymer concrete at 7days . Because of the slow reactivity of fly ash at ambient temperature, be applied to increase the geo polymerization process. The decrease in water content favors the formation of demands for increase of concentration of Sodium hydroxide and sodium silicate Hence increase in concentration of NaOH results in increase of compressive is recommended 8M, 16M&16M concentrations for Low medium and higher grades respectively. 25

U.R.Kawade et al. in 2014 gives research on “Fly Ash Based Geopolymer concrete” In this paper, fly ash is used to produce a geopolymer concrete. Geopolymer is a material resulting from the reaction of a source material that is rich in silica and alumina with alkaline solution. Geopolymer concrete is totally cement free concrete. In geopolymer, fly ash act as binder and alkaline solution act as an activator. Fly ash and alkaline activator undergo geopolymerization process to produce alumino silicate gel. Alkaline solution used for present study is combination of sodium hydroxide (NaOH) and sodium silicate (Na, Si) with ratio 2.5. A grade chosen for the investigation was M40.The mix was designed for molarity of 12M, 14M and 16M. The test results have shown that compressive strength increases with increase in molarity. Objective of this investigation is to study performance characteristics of source material Study & evaluation of chemical composition & effects of NaOH & sodium silicate on fly ash. Study of polymerization process in Fly ash, NaOH & sodium silicate of the composition that is geopolymer.) Testing of geopolymer by using universal testing machine. Analysis of geopolymer testing & comparison. Material used: Low calcium Class F fly ash, Sodium hydroxide, Sodium silicate solution, Coarse aggregate, Fine aggregate, Distilled water in this investigation, low calcium class f fly ash obtained from Nasik. Sodium silicate is mixed with sodium hydroxide as an activator the ratio of Na_2SiO_3 & NaOH was 2.5 and varying the morality of sodium silicate solution like 12M, 14M, and 16MCuring temperature is kept 60° for 24 hours. In this experimental investigation, only geopolymer concrete cubes are used for testing compressive strength. The construction industry is in demand of eco friendly & greener materials which are durable. As compared to the existing concrete materials, fly ash is advantageous but its uses as tested against strength & durability needs to be confirmed. The present project work emphasized on the research & development activity in construction materials using fly ash with geo polymers. The project work revels with preparation of test samples of fly ash with geo polymers of different morality of sodium silicate solution .The samples are prepared with the different molarities such as 12M, 14M and 16M.Tests for compressive strength are carried out on samples as above for 7 & 28 days, as per prevailing standards for Respective properties. he test results have shown that compressive strength increases with increase in morality.

Girish M.G.et al. in 2017 speaks on “Geopolymer concrete an Eco-Friendly Alternative to Portland Cement Paving Grade Concrete” The current generation of “Sustainable development” demands the new concrete which uses the less natural resources, energy as well as generates less CO_2, without compromising on strength and durability aspects. In this research works on geopolymer concrete prepared from conventional alkali-activator solutions like sodium hydroxide and sodium silicate curable at ambient temperature is gaining momentum now a days. The paste phase and solid phase properties of geopolymer concrete containing quarry dust and sand as fine aggregate, suitable for discussion. The targeted compressive strength of 40Mpa was 16 achieved soon after seven days of curing and maximum strength attained in 28 days is nearly 62 Mpa. Both the compressive strength and flexural strength were within the acceptance limit of paving grade concrete. The NaOH solution was prepared 24 hours before the mixing. Mix M1 and M2 are more or less identical in composition except that, in mix M2, sand is replaced by quarry dust by same amount. Mix M30 also has quarry dust in place of sand as fine aggregate. The quantity of coarse aggregate used in M3 is slightly higher than M1 and M2. Developing a geopolymer concrete suitable for rigid pavement application. The study comprised of examining the fresh and hardened state behavior of three different Mixes of geopolymer concrete. Among the mixes; mix M1 contained sand as fine aggregate, mix M2 had quarry dust as fine aggregate and mix M3 was having more course aggregate content along with quarry dust when compare to other two mixes. The following conclusions are arrived from the studies the fresh state properties of the GPC indicated that the slump and spread values were in the close proximity of assumed standards except for the mix M3. Thus it can be concluded that the developed GPC can be adopted for fixed form paving. The compressive strength of GPC obtained was in the range of 40-60MPa which is more than the target strength. The mixes gained strength gradually over the period of times of curing. This is due to the pozzolanic action of fly ash. All the three mixes acquired a target strength of40MPa in 7 days of curing. Thus it can be concluded the GPC may facilitate the early opening of road to traffic. The complete replacement of sand by quarry dust resulted in a reduction of compressive strength of GPC. Whereas the GPC containing a combination of more quantity of coarse aggregate and the quarry dust produced better compressive strength. The flexural strength of GPC is found to be significantly more than the target strength. Hence, it can be concluded that the GPC can become a practicable alternative to conventional cement concrete pavement.

VIII. APPLICATIONS

In the short term, there is large potential for geopolymer concrete applications for bridges, such as precast structural elements and decks as well as structural retrofits using geopolymer-fiber. Geopolymer technology is most advanced in precast applications due to the relative ease in handling sensitive materials (e.g., high-alkali activating solutions) and the need for a controlled high-temperature curing environment required for many current geopolymer. Other potential near term applications are precast pavers & slabs for paving, bricks and precast pipes.

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