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Geopolymer Concrete Subjected to Elevated Temperature: A Review

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***Abstract*--- In this paper will go through the various topics like alkaline activator content, various materials used for the production of geopolymer concrete, durability, mechanical properties, fresh properties and microstructure of the geopolymer concrete. This shows the positive response than normal concrete, so the usability of geopolymer concrete has more impact on coming generation towards greener environment than normal concrete. Because ordinary Portland cement emits high amount of carbon dioxide than geopolymer concrete. During any unpredictable situations like blast, fire , explosion etc. the geopolymer concrete has higher resistance till 4000c shows positive response to the strength compared to normal concrete. Hence the usability of geopolymer concrete may possess higher impact on coming up generation.**

***Keywords*--- Durability, alkaline activator, mechanical properties**

I. INTRODUCTION

Geo as in earth, poly many and myr parts this organic polymer relies on its unique three-dimensional molecular nano-structure for its ultra-high performance. The Mine crafters are going to be familiar with the obsidian. Obsidian is the smooth black material of unequaled strength and blast resistance. The geopolymer obsidian is the number one choice of this generation of Mine craft engineers and architects when it comes to constructing highperformance structures. Geopolymer concrete is also the number one choice of NASA's space engineers who are working with companies such as APUs core to develop robots to 3D print concrete made with lunar regolith and Martian sand in order to construct the first 3D printed space habitations on the moon and mars. This is a building designed by space exploration architects.

From the past years there is a much research was going on the development of the unique high performance geopolymer concrete.

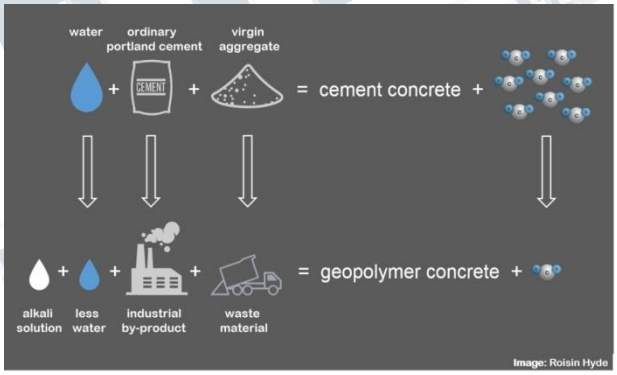

Figure1.1:Difference between geo-polymer concrete and ordinary concrete.

This diagram depicts, the geopolymer concrete is a sustainable concrete and alternative to the normal concrete. Normal concrete is produced by using cement and water to bind virgin aggregate materials such as gravel and sand taken from quarries, riverbeds, and beaches not only this material relies on finite natural resources but this type of production leads to the emission of large volume of carbon-dioxide. On the other hand geopolymer concrete uses the by-products of the industries such as GGBS, Bagasse Ash, quarry dust, agricultural waste and recycle construction aggregates to produce highperformance low impact concrete.

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II. LITERATURE REVIEW

2.1 Fly ash based geopolymer concrete

Badami Bhavin., et.al., [1] explains the impact of cement production on climatic change and environmental pollution. In this study, flash acts as a binder instead of OPC and the aggregates occupy 75 to 80 percent of the volume. There is three trial mix proportion with the varying fly ash, alkaline, and water content in order to obtain the optimum mix. They wrapped vacuum bagging film to minimize the evaporation of water from the concrete. The curing methods adopted are steam curing and dry curing. The GPC concrete shows a higher compressive strength up to 62 MPa whereas the OPC results up to 21.7 MPa. The cost-benefit analysis in the paper presents that for one cubic meter of OPC concrete is Rs 4562 against the GPC concrete which is Rs 3187 proves to be economical and cost-effective by 43 percent of the conventional concrete. Instead, this geopolymer concrete provides good resistance to the corrosive environment like an acid attack.

Sujay Nanavati., et.al., [2] explains the awareness of the alternative binder geopolymer concrete which can be used in precast industries as well as checking the feasibility for the in-situ condition. This paper reviews various materials used for manufacturing concrete such as Fly ash, alkaline liquids, aggregates, superplasticizers. Fly ash plays a good role as an artificial pozzolan, Low calcium fly ash is preferred to use as source material than the high calcium fly ash. The alkaline liquids such as sodium hydroxide and sodium silicate are preferred over potassium hydroxide and potassium silicate in order to be economic. Aggregates comprising of 80% of the volume of concrete which is even the same for the OPC concrete. The super-plasticizers are preferable for better workability. Sunlight curing helped instead of steam curing or over curing. The compressive strength was 1.54 times higher than controlled concrete, the split tensile strength was 1.45 times higher than controlled concrete, the flexural strength was 1.6 times higher than the controlled concrete. The acid resistance of GPC concrete weight reduction was 1.6% decreased in 82 days. The fly ash solves the problem of landfills.

JeetendraAhirwar et.al., [3] explains the waste generated from the demolition in India is about 530 million tones every year, which causes a serious problem of disposing of it. Based on study 3 different mix proportion of geopolymer concrete are considered which yields better results. The impact value of the demolition aggregates was 12.26%, After the casting, the test specimens are heat cured at 80 degrees for 24 hours. From the three different mix proportions, this mix proportion 1:1.5:3 yields the best than the other two mix proportions which are 1:1.75:3.25 and 1:1:1.85. the fly ash-based concrete with 100% replacement decreases the strength of about 5 to 10%, even the split tensile strength also decreases. The fly ash based geopolymer concrete solves the problem of disposal in India and also helps to overcome the environmental pollution.

2.2 Sugarcane Bagasse ash Based geopolymer concrete

ErniSetyowati., et.al., 2014[4] explains the world is facing global climate change due to the pollution caused by the industries mainly the cement production which alone causes 7 percent of the total emissions of CO2viz 930 million tones per annum. Usage of Styrofoam and the bagasse ash in the concrete makes it aerated concrete which has sound insulation property. The silica content in the chemical composition of the bagasse ash sample is 71 percent. The strength of the concrete decreases after 15% replacement. The usage of waste material leads to the economic approach and improves the value of waste eliminating the problem of disposal. The structure can be earthquake resistant because of the reduction in weight which can help in the earthquake zones. The pores in the Styrofoam helps in additional special quality in the concrete which is sound insulation. Hence it solves the problem of waste disposal.

Tony SumanKanth D et.al., [5] explains the universe is facing the environment pollution due to the emission of pollutants from the industries to the atmosphere which one of them is cement production which contributes about 8% of total emissions of CO2 in the world. The 24 specimens cast for the study which are cubes, cylinders and the beams each of size 150mmx150mmx150mm, d-150mm h-300mm and 100mmx100mx500mm respectively. The various controlled factors are taken care such as the heat curing at the rate of 60 degrees for 24 hours, the 12M concentration of NaOH, SSD basis aggregates with varying percentage of bagasse ash and rice husk ash. As the percentage of replacement increases the strength decreases which shows up to 10 percent replacement level the strength was good. The geopolymer concrete gives the early strength of 75% in 7 days which helps in the progress of the work in construction areas. This is preferable for the water shortage area.

Buari T.A et.al., 2015[6] explains the concrete is the second most consumable material after water which leads the circumstance in waste management, the research on sustainable approach can be adopted to solve the issue of

waste. SCBA with varying percentages 5%, 10%, 15%, 20% are considered for the further study, initial and final setting time are 225 minutes and 252 minutes respectively, two types of curing are taken into account which is controlled condition and salt condition are the factors affecting. The SCBA of specific gravity 1.44 and moisture content 0.46 are the preliminary and the chemical composition of the sample with silica of 22 percent. SCBA is a good pozzolanic material which forms the CSH reacting with calcium hydroxide, the pozzolanic activity is favorable in the normal environment and increases with time. The specific gravity is very less than OPC which depicts the greater volume of cementitious material in a huge mass of replacement. The compressive strength at the stake of 10 percent proves a good strength can be used for the construction of masonry wall etc. This solves the problem of waste management and its one way for a sustainable approach to achieve. 2.3 GGBS Based geopolymer concrete.

2.3 GGBS Based geopolymer concrete

Parukutty S. Ambily et.al., [7] explains the ultra-high performance concrete using the wastes such as industrial and agricultural by-products in order to attain efficient and eco-friendly concrete. The GGBS, silica fume and fly ash are the source materials with the silica content 43.4, 94.73 and 62.1 respectively. the curing condition for the specimen is the ambient curing, four mix proportion with steel fibers and one without steel fibers. The mix proportion with steel fibers influences higher strength than the concrete without steel fibers, the highest average compressive strength was 175 MPa with the steel fibers of 1% of 6mm and 2% of 13mm and the highest average compressive strength was 124 MPa without steel fibers. The flexural strength of specimens with and without steel fibers are 13.5 MPa and 9.1 MPa respectively. hence the geopolymer concrete can be ultra high performance, efficient, eco-friendly and sustainable.

Padmanaban M Set.al., [8] explains geopolymer concrete is the alternate way to OPC concrete, which is made by using the source material and alkaline solution. The mix proportion for M30 normal concrete and geopolymer concrete are tabulated. The basic tests such as, sieve analysis, water absorption, specific gravity for the materials such as cement, GGBS, FA, and CA. The specific Gravity for cement, GGBS, FA are 3.15, 2.75, 2.44 respectively with the constant of 8M molarity of NaOH. The water absorption in geopolymer concrete is lesser than the OPC concrete. The compressive strength, split tensile strength and flexural strength of geopolymer concrete are higher than the OPC concrete. The mix proportion with 77% volume of aggregates shows the higher strength with the age, the strength gain in geopolymer concrete is higher at the early age of 7days followed by the decrease in strength as the concrete ages. Geopolymer concrete can be an innovative use of construction material in the industry with benefits such as eco-friendly and economical than the OPC concrete. 2.4 OPC concrete under elevated temperature.

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Tomasz Drzymałaa et.al., [9] explains the behavior of the high-performance concrete under elevated temperatures for different types of HPC such as reference concrete, polypropylene, fiber-reinforced concrete air entrained concrete, and. The thermocouples are placed at the corner, core and to the side surface to measure the temperature inside the furnace. The strength increases up to 400 degrees followed by the decrease in the strength from 450 degrees to 800 degrees up to a maximum loss of 56%. The PFR HPC modulus of elasticity decreases as the temperature increases. After the test specimens exposed to the elevated temperature, the following observations are made the concrete becomes brittle and losses its weight, the color changes, and the fine cracks start after 450 degrees. The air entrained concrete is the alternative solution PRF HPC because of its better resistance to temperature.

NesrineKhodja et.al., [10] explains the behavior of concrete under elevated temperature for HPC with 10% silica fume and the normal concrete. The water-cement ratio of 0.5 for normal concrete and the HPC concrete with a water-binder ratio of 0.32 are maintained throughout, the rate of heating is 7 degrees per minute. The residual compressive strength decreases with increase in temperature, in the range of 600 to 900 degree the decompose of the CSH gel leads to the strength degradation. Due to thermal shock, the mechanical properties were observed in the OPC concrete and HPC concrete which are 81% and 91% respectively. The HPC concrete with a 10% silica fume improved the compressive strength than the OPC concrete at room temperature . Temperature inducing in the specimen changes the composition in concrete which causes cracks. The HPC can have various types of crack such as transangular cracks and the cracks surrounding the concrete.

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2.5 Geopolymer concrete subjected to elevated temperature

Anwar Hosan et.al., [11] explains the effect of various activators such as sodium and potassium based by the change in physical properties and the compressive strength which are subjected to elevated temperatures ranging from 200 to 8000 C after the age of 28 days. The sodium based geopolymer shows the higher compressive strength at the ambient condition further a good resistance up to 400 degrees than the potassium-based geopolymer. At 600 degree the strength of the potassium-based geopolymer is higher than the sodium based geopolymer. The geopolymer with potassium exhibited higher resistance to all the elevated temperature than the sodium based geopolymer. The volume shrinkage of the K-geopolymer is lower than the Na-geopolymer. The K-geopolymer with AAS ratio of 3 shows the maximum residual strength in every elevated temperature than the Na-geopolymer. The k-based geopolymer exhibited minimal cracks on the surface than the Na-based geopolymer.

Faiz Shaikh et.al., 2018[12] explains the study on potassium-activated geopolymer under elevated temperature using the carbon and the basalt fibers by varying the percentage of replacement 0.5, 1 and 1.5%. There are 35 series of the geopolymer specimen where six whereof the additive replacement as described above. The 1% weight of carbon and 1% of basalt fibers improves the stability of the geopolymer, good compressive strength, minimal volume shrinkage and lesser weight loss than the other fiber subjected to elevated temperature. At 800 degree the cracking on 1% weight carbon reinforced geopolymer was less than the basalt based geopolymer. The higher compressive strength, the lower shrinkage volume and the lower weight loss in carbon fiber fly ash geopolymer at the different level of temperature up to 800 degrees have the important role to play as a filler media in the geopolymer. The results indicate that the carbon-based geopolymer has a better bonding in the matrix than the basalt based hence it's preferred to use the carbon-based geopolymer for better resistance geopolymer matrix with good strength and many more advantages. 2.6 Durability of Geopolymer concrete.

2.6 Durability of Geopolymer concrete

R.Venkateshan, K.Pazhani et.al.,[13] study was made on the durability properties of GPC used GGBS as primary binder and black rice husk ash (BRHA) was used as a replacement material for cement upto a proportion of 10 to 30% , conducted tests such as sorptivity, rapid chloride permeability test. Results revealed that strength developed will be reduced beyond the 10% replacement of BRHA and yet strength was well up to 20% replacement levels and durability significantly improved with addition of BRHA with that of reference concrete.

R. Scholar , K. babu et.al.,[14] presents the durability of GPC of fly ash based with sodium hydroxide and sodium sulphate as alkali materials, with varying the content of fly ash from 350 to 550 kg/m3 and alkali activator solution to binder ratio of 0.4 & 0.5. Results revealed that water absorption property is inversely proportional to strength of concrete and fly ash content. Concluded that GPC exhibit the excellent resistance to acid attack with that of normal concrete.

III. CONCLUSION

- Strength developed in geopolymer concrete is high when compared to normal concrete.
- Early strength developed (90% strength will be gain in 3 to 7 days) which helps in removing scaffolding early.
- Resistance to temperature and spalling is high compared to normal concrete.
- Economical in large scale usage.
- Sustainable use of waste materials helps to overcome problem of land filling.
- There is very minimal requirement of water which helps in water sustainability or water conservation.

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