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A REVIEW ON GEOPOLYMER CONCRETE

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Abstract
Geopolymers are in the family of mineral polymers, in which their chemical combinations are similar to zeolite materials, whereas their microscopic structure is amorphous rather than crystalline. The use of polymers such as concrete adhesives result in the production of geopolymer concrete (GPC) that can be a suitable substitute for OPC. To understand the behavior of traditional concrete various literatures related to different geopolymers are studied and reviewed in this paper. From the review it is concluded that to create geo-polymer concrete with improved performance, a range of combinations of GGBS, silica fumes, metakaolin, and rice husk ash as substitute cementitious materials and M-sand as a partial fine aggregate substitute are to be explored.

Keywords: Cement concrete, Geopolymer concrete, Fly ash, Metakaolin, Silica fumes.

I. Introduction
Throughout the world, Portland cement-based concrete is the most widely utilized building material. When normal stresses and impact loads are applied, concrete is a rather inelastic material. Considering the high consumption of concrete and the increasing necessity for cement production, high attention to the environmental degradation effects of this substance is needed. These effects include 7% of CO_2 emission and the considerable consumption of energy such as electricity and fossil fuels. Hence the provision of alternative products in order to move towards sustainable development is essential. Therefore, the use of an eco-friendly concrete enables the reduction of consumption of ordinary Portland cement (OPC) with activated pozzolanic binders as a replacement, leading to lower emission of CO_2 in the atmosphere. Geopolymers are in the family of mineral polymers, in which their chemical combinations are similar to zeolite materials, whereas their microscopic structure is amorphous rather than crystalline. The use of polymers such as concrete adhesives result in the production of geopolymer concrete (GPC) that can be a suitable substitute for OPC.

Figure 1: Examples of Geopolymer Concrete

II. Literature
To understand the behavior of traditional concrete various literatures related to different geopolymers are studied and reviewed in this paper.
Abhinav Shyam et al. (2017) – Carried out a literature review to concentrate on substitution of cement with silica fume, which involves existing and potential research patterns. The reduction of quartz with

coal in an electric arc furnace in the manufacture of silicon or ferrosilicon alloy results in the development of silica fume.More than 90% of the components of chemicals present in silica fume are silicon dioxide. Carbon, sulphur, aluminium oxides, iron, calcium, magnesium, sodium, and potassium are other constituents. They used silica fume which was having a dia ranges from 0.1 to 0.2 microns, has a surface area of 30,000 m^2/kg, and a density of 150 to 700 kg/m3.An analysis of the literature on replacing cement partially by using silica-fume content reveals a significant improvement in all concrete strength properties. Flexural, compressive, and also split tensile laboratory tests were done to find out the outcomes for different concrete grades. They discovered that the best possible % of silica fume (SF) varies from 5 percent to 15 percent according to literature review. All parameters have increased as a result of this percentage replacement. In previous research, silica fume concretes were also detected to have superior durability properties. [1].
Anurag Jain et al. (2015) –The results of compression data on 4 to 6-year-old cores collected from well-documented field tests are performed in this research. Using an accelerated impressed voltage-testing unit, they investigated the effectiveness of silica-fume concrete for resisting damage caused by corrosion in embedded steel. They also looked at the physical properties of high-strength silica-fume concretes, as well as their susceptibility to curing methods, and compared them to portland cement concretes. The experimental program included six stages of silica-fume material, with super-plasticizer and without having super-plasticizer, on replacing the cement in partial form by weight at 0% control mix, 5 percent, 10 percent, 15 percent, 20 percent, and 25 percent, with and without super-plasticizer. It also have 2 types of mixes in which 15% silica-fume was used with cement in regular concrete. They put silica-fume mortar to the test in a variety of chemical conditions, including sulphate compounds, ammonium nitrate, calcium chloride, and various acids. When the silica-fume content was optimized, concrete strength increased significantly. A literature review on the behaviour of silica-fume concrete is made in this article. Also, compression findings found on concrete cores taken after 4 years from an experimental basis made with a very high-strength concrete demonstrated that there is no strength loss in silica-fume concretes. The silica-fume concrete observed to be stronger than both references concretes. The intensity of the SF concrete was much greater than reference concrete after just one day, implying that the SF has a positive impact even after only one day [2].
Atishay Lahri et al. (2015) –This analysis investigates the impact of various replacements that will be used in concrete to partly replace cement product. According to various researchers, only one alternative can offer all of the benefits that cement does. Instead, suitable variations of those constituents are often combined into concrete to produce properties that are almost identical to or better than portland cement concrete. This thesis aimed to conduct a literature review on various concrete alternatives to cement. Fly ash, silica fume, metakaolin, and the ground granulated blast-furnace slag are all instances of this. Cement is often partially replaced by one or a combination of these all the alternatives, or by a grouping of them. By using fly-ash it increases the concrete's compression, tension, and flexural strength. Lower strength gain increased air-entraining, and slump loss increased is the most significant drawbacks of using the fly-ash. The use of silica-fume boosts concrete strength by 10–15 percent while still providing strong early strength. On adding the silica-fume it has the additional benefits, including a lower water-cement ratio, frost resistance, and chemical impact [3].
Jayalakshmi Sasidharan Nair et al. (2016) –The study aims to see how different amounts of recycled materials affect the hardened and fresh characteristics of concrete. The materials used in this analysis were recycled ground granulated blast-furnace slag and also recycled aggregates. Cement is partly replaced with GGBS, coarse and also fine aggregates were substituted by recycled aggregates in different percentage. The mix concept was created to get a grade M-40 concrete mix (control-mix). They used recycling aggregates to substitute 40, 50, and 60 percent of the standard coarse and fine aggregates in mixes. Workability checks were done and given the results satisfactory. It also performs well in terms of compression and stress.As 40, 50, and 60% of the cement is replaced with GGBS in

concrete mixes and 50 RFA and 50 RCA, the compressive strength is improved. Although the results are lesser than those of CM, they meet the M40 grade concrete requirements [4].

Khushhalpreet Singh et al. (2018) –This research aims to minimize cement use by incorporating silica fume into cement concrete. For replacing the cement partially with silica-fume, the strength parameters of concrete there already been tested. Industries are having difficulty properly disposing of their by-products.This study addresses two issues: one is proper disposal, and the other is cement lessening. The material silica fume is used to substitute from 0% to 20% of the cement by weight at a 5% increase in the cubes and the cylinder. Silica fume affects largely on the compression and also tensile strength. The concrete strength increases steadily as silica fume (SF) rises, reaching a maximum value of compressive strength at 15% replacement.It starts to decrease after 15 percent under a uniform load condition of 4 KN, and also split tensile strength raised 15% before starting to decrease. This research suggests that silica fume may be utilized as an admixture in cement concrete, potentially lowering cement costs in the building industry [5].

Muhammad Rizwan Akram et al. (2015) –Evaluated the efficiency of ordinary Portland concrete with the ternary and the binary replacement with supplementary cementitious materials (SCM). The concrete characteristics were prepared for having constant 0.3 water-binder ratio for this reason.Some experiments involving the types and quantities of supplementary cementitious materials (SCMs) like silica fume and GGBS were performed. For Portland cement replacement, silica fume (SF) upto the 7.5 % also GGBS up to 50 percent were be used.The mechanical characteristics and permeability tests were used to investigate physical properties.

From the observations of this research following conclusions are drawn: The use of SCM in various concrete mixes has lower initial strength. After that, it was either more or equal to the ordinary portland cement of 100 percentspecimen.The compression observed was having adverse effect by replacing OPC with both the replacing materials considered in every stages for 56 days, with the water-binder ratio remaining stable at 0.3 [6].

Osama Ahmed Mohamed (2019) –This study looks at how low water-to-binder (w/b) ratio (SCC) self-consolidated concrete made compression when 90 percent of the cement is replaced with industrial by-products including GGBS, fly ash, and silica fume. The visual stability index (VSI) and also the t50 time fresh-properties were calculated for water/binder ratio of 0.27.The compressive strength parameters were evaluated after 3, 7, 28, and 56 days of curing. The compressive intensity of the control mix produced with 100 percent OPC having 55 MPa after three days to 76.75 MPa after 56 days (curing at Normal temperature in water). After curing (3 days), sustainable SCC containing 10% OPC produced strength ranging from 31 MPa to 56.4 MPa after 56 days of curing.In comparison to samples cured using chemicals continuously cured underwater for 28 days, samples cured for three days underwater and then air-dried for 25 days had the highest compressive pressure.According to the findings, SCC can achieve compressive strength sufficient for many practical applications by combining high amount of SCM (GGBS, fly ash, Silica fume) with 10% OPC and 90% supplementary cementitious composites (GGBS, fly ash, Silica fume). Furthermore, compared to water curing for 28 days or membrane curing, air-curing test samples at a relatively high temperature (after three days of water curing) produces a higher 28-day compressive intensity [7].

Priyanka Lohiya et al. (2020) –This research looked at the literature to see whether silica fume can be used to substitute cement partially in concrete. The study discovered that Silica Fume concrete had lower strength in the beginning but strengthened over time. The workability of Silica Fume concrete is reduced as no. of substitutes has increased.Silica Fume is a cost-effective alternative to cement since it contains no waste. Water permeability, chloride ion resistance, corrosion in steel, resistance to sulphate assault to marine life, and other durability tests with silica-fume are essential. For systematic chemical analysis of the steel-slag or silica-fume the presence of alkalis that will badly affect the relationship between binder matrix and aggregate is suggested [8].

Ram Kumar et al. (2016) –This research project was undertaken to evaluate the output of silica-fume used as an admixture in concrete, in light of the raising market value for cement which has resulted in environmental issues and also reduction/depletion of natural resources on 1 hand, and rising prices to the other hand. To solve this dilemma, researchers looked into the use of industrial by-products and waste. In this dissertation, the partial substitution or replacement of silica-fume and its influences were investigated using the M-35 concrete mix.The leading parameter evaluated in research work is M-35 concrete-mixes replacing partially by silica fume at 0, 5, 9, 12, and 15% by cement weight. From the results it is observed that utilizing silica-fume in concrete improved the strength and toughness. As a result, using silica fume reduces the amount of cement added in buildings, and also its use should be encouraged for improved efficiency and environmental sustainability [9].

Yushi Liu et al. (2018) – The outcome of silica-fume (SF) and ground granulated blast-furnace slag (GGBS) on the frost resistance of ECC with a high volume of FA was investigated in this research work. They tested four ECC mixtures: ECC (50 percent FA), ECC (70 percent FA), ECC (30 percent FA + 40 percent SL), and ECC (65 percent FA + 5 percent SF) using freezing-thawing cycles up to 200 times in the sodium-chloride solution and tap water. The relative dynamic elastic-modulus and mass loss of ECC in sodium chloride solution are greater in freeze-thaw cycles than in tap water.Since the ECC (30% FA + 40% SL) has a lower relative dynamic elastic-modulus and also the mass lessthan the other materials, its deflection in a four-point bending test is smaller before and after freeze-thaw cycles.In comparison, ECC (65% FA + 5% SF) exhibits a major deflection increase with a higher first cracking load, and toughness increases sharply after freeze-thaw cycles, indicating that ECC has strong toughness properties [10].

Abdul Aleem et al. (2012) - Looked at the components of geo-polymer concrete, as well as its strength and uses. They concluded from the reviews that user-friendly geo-polymer concrete may be employed in similar settings to typical portland cement concrete.These Geo-polymer Concrete essentials must be blended with a lower alkali activating solution and cure in an acceptable amount of time under ambient circumstances. The manufacturing of adaptable, cost-effective geo-polymer concrete is almost same to the Portland cement in terms of mixing and hardening.In repairs and rehabilitation projects, geo-polymer concrete will be employed. Geo-polymer Concrete will be used efficiently in the precast industries due to its high early strength, allowing for large production in short period and reducing breaking during transportation. A RC structure's beam-column connection should be efficiently utilised using Geo-polymer Concrete. In addition, geo-polymer concrete will be employed in infrastructure projects. Furthermore, because the fly ash would be successfully employed, there will be no need to deposit it in landfills [11].

Vemundla Ramesh et al. (2020) -Investigated advances in geo-polymer concrete mix design and mechanical qualities. After evaluating various articles, they came to the conclusion that geo-polymer concrete is the most cost-effective and environmentally beneficial approach to replace ordinary concrete.Geo-polymer concrete is highly suited for high-strength and high-performance concrete, as well as chemical resistance. In place of fly-ash one can use GGBS to increase concrete's compressive strength under any curing environment, although workability and setting will be diminished.When compared to other ratios, sodium silicate to sodium hydroxide ratio of 2.5 produces good results. Past data must be used to create a suitable code of practice [12].

Hamid Khan et al. (2016) – They compare the compressive strength, durability, and further also geo-polymer concrete to that of portland cement. Fly ash, ground granulated blast furnace slag (GGBS), chemicals (Sodium hydroxide, Sodium silicate), and aggregates are employed in this investigation (Fine aggregates and Coarse aggregates).As the alkaline liquid, a mixture of the solution of alkaline-silicate and also alkaline hydroxide solution was chosen. Because solutions based on sodium were cheaper as compared to potassium-based solutions, they were chosen. To analyse the comparative changes in concrete, the compressive-strength, Split tensile-strength, and Flexural-strength tests are used. The following results are observed from the experimental investigation: The optimal level of fly ash replacement by GGBS in GPC will be determined. The water absorption property of the concrete is lesser than the nominal concrete. When a percentage of geo-polymer having fly-ash is used to replace cement with the same w/c-ratio the slump value increases [13].

III. Conclusion

Reviews of the literature by a number of academics show that no single substitute can provide all of the benefits that cement does. Alternatively, an appropriate mix of all the above items can be added to the concrete to give properties similar to or superior to those of portland cement concrete. To create geo-polymer concrete with improved performance, a range of combinations of GGBS, silica fumes, metakaolin, and rice husk ash as substitute cementitious materials and M-sand as a partial fine aggregate substitute are to be explored.

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