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A SYSTEMATIC REVIEW ON POLYPROPYLENE FIBER REINFORCED GEOPOLYMER CONCRETE

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Abstract: *As the construction development rapidly grows around the world, the consumption for Ordinary Portland Cement growing exponentially. As a matter of fact that the creation of one ton concrete discharges around one ton of CO_2 to the environment because of the calcinations of lime stone and the energy required for ignition. The generation of cement based binder is consuming high amount of energy and limited natural resources. The alternative of cement based binder may be the binders that created by polymeric reaction of alkaline fluid with alumino-silicate materials, which is commonly known as geopolymer based binder. Constituent of Geopolymeris same as the conventional concrete in view of fine and coarse aggregate and it produced a strong bond with these aggregate. As a secondary reinforcement the use of polypropylene fiberis a good option to improve the physical property of geopolymer concrete. This paper presents a systematic review on different research works done in the region of polypropylene fiber reinforced geopolymer concrete.*

Keywords: *Geopolymer concrete, polypropylene fiber*

1. GENERAL

The massive requirement of concrete for infrastructure development increases the demand of ordinary Portland cement exponentially. The effect on environment due to production of ordinary Portland cement is very severe, as all we know that production of one ton concrete discharges around one ton of CO_2 to the environment because of the calcinations of lime stone and the energy required for ignition [11].The generation of cement based binder is consuming high amount of energy and limited natural resources. To lessen these issues, it is important to discover an optional material for bonding of constituent of mortar or concrete. As the research is going on to find an alternative material for ordinary Portland cement, Partial substitution of ordinary Portland cement is presented by the material having bonding

properties[9], [10]. In 1978, Davidovits recommended that the alternative of cement based binder can be the binders that created by polymeric reaction of alkaline fluid with alumino-silicate materials, and term these binders as geopolymer based binder. As the geopolymers consumer the minimum natural resource and its mainly utilize the industrial byproducts, which can cause negative impact on the environment when its directly discharged to the environment system, as based on its basic row material the geopolymer binder have get attention as a green material for the construction industries and given weighted as a alternative of ordinary Portland cement. Due to its special property of harden after few hour of placing and other properties over ordinary Portland cement like superior corrosion resistivity, low shrinkage and capacity to resist freeze and thawing effect, given the cutting edge to the geopolymer as a alternative of ordinary Portland cement. The mix design available currently is not suitable for the design of geopolymer concrete due to its special inherent property, so due to this currently mix design for required strength and workability of geopoymer concrete is done by the trial and error method based on the experience and validate by the experimental data available. Geopolymer concrete have advantage over ordinaryportandcment in respect of sustainable material and other high value properties like shrinkage, corrosion resistivity etc, but as the same time it has the requirement to improve the tensile and flexure strength as like in the ordinary Portland cement[11]. The use of polypropylene fiber as a secondary reinforcement is a good option to improve the physical property, ductility, fatigue and impact etc of geopolymer concrete [11], [14].

2. CONCRETE AND ENVIRONMENT

In the 1978 when the devidovits first find the material have the bonding capacity like ordinary porland cement, which is manufactured by the use of any material having the higher alumino-slicate in its constitution and able to form a inorganic molecules network in the alkaline environment. Geopolymers are synthesized by the reaction of a solidaluminosilicate powder with alkali hydroxide/alkali silicate. Under highly alkaline conditions, polymerisation takes place when reactive aluminosilicates are rapidly dissolved and free $[SiO_4]$_and $[AlO_4]$tetrahedral units are released in solution. The tetrahedral units are alternatively linked to polymeric precursor by sharing oxygen atom, thus forming polymeric Si–O–Al–O bonds. The following reactions occur during geopolymerisation. The reaction takes place in the geopolymerisation process is given in Fig.1.

$$(Si_2O_5.Al_2O_2)_n + H_2O + OH^- \rightarrow Si(OH)_4 + Al(OH)^{4-} \quad (1)$$

$$Si(OH)_4 + Al(OH)^{4-} \longrightarrow (\text{-Si-O-Al-O-})_n + 4H_2O \quad (2)$$

Figure 1: Schematic Formation of Geopolymer Concrete [1]

In view of the carbon credit point and the urgent need of the sustainable development the scope of the geopolymer binder is increase significantly, because it use the minimum natural resources and consume the byproducts of the industries which cause deterioration to the environment if discharge to the environment system without process. Geopolymer gives the benefit in two ways first by using minimum natural resources and secondly by utilizing the industrial waste so this technology gives the benefit in the carbon credit system[10].There are two fundamental constituents of geopolymers, to be specific the base material and the alkaline fluids. The base material for geopolymers in view of alumina-silicate ought to be rich in silicon (Si) and aluminum (Al). These could be characteristic minerals, for example, kaolinite, clay, and so forth. On the other hand, waste materials which is produced as a byproduct of some industrial process, for example, red mud, slag, fly ash, rice-husk ash, silica fume and so on could be utilized as base material. The decision of the base material for making geopolymers relies on upon components, for example, accessibility, cost, sort of use, and particular request of the end clients. Zeng s et al. [18] demonstrated that comparative concoction piece in the base material did not create comparative compressive quality and high substance of calcium did not generally prompt high compressive quality. The basic fluids are from dissolvable soluble base metals that are generally sodium or potassium based. The most well-known soluble fluid utilized as a part of geopolymerization is a mix of sodium hydroxide (NaOH) or potassium hydroxide (KOH) and sodium silicate or potassium silicate [10]. The polymerization procedure includes a significantly quick concoction response under antacid condition on Si-Al minerals that outcome in a three dimensional polymeric chain and ring structure comprising of Si-O-Al-O bonds viz;

Mn [-(SiO_2) z–AlO_2] n. wH_2O

where M is a monovalent cation, for example, potassium or Sodium, the image "–" is represented the bond, n is the level of polycondensation or polymerization and z is 1, 2,3 or higher [1].The electrical resistance of new geopolymers stays unaltered in the initial two

hours of the postpone time which was proposed as the presentation time of geopolymerization and significant segment of geopolymerization gets over inside a time of 24h [15]. Like hydration in Portland cement, the geopolymerization of fly ash remains based geopolymer may take longer period on account of the moderate dispersion of receptive particles from the fly slag after quick response period at the early age. Moderate geopolymerization process can devour free particles and lessen porosity in the geopolymer examples [15].

The synthetic response involves stap by step for, Dissolution of Si and Al iotas from the source material through the activity of hydroxide particles, after that Orientation or buildup of antecedent particles into monomers, and at the end Setting or polycondensation or polymerization of monomers into polymeric structures[19].

3. GEOPOLYMER TECHNOLOGY AND ITS REACTION MECHANISM

The essential contrast between the geopolymerbinder and the ordinary Portland cement binder is the binder. The silicon and aluminum oxides in the low-calcium fly ash make polymerization in the presence of alkaline fluid and form a binder which binds the aggregate present in the concrete composition including material other than the aggregate, whereas binder presence in the ordinary Portland cement is bind aggregate and other particle presence in the concrete due to its hydration mechanism which create a strong bond. Rangan et al. [10] proposed the mix plan method for creation of fly ash based geopolymer concrete while Anuradha et al. [4] had introduced changed rules for mix design of geopolymer solid utilizing Indian standard code (IS 10262-2009).As on account of ordinary concrete, the approximate weight of the aggregate in concrete is comprising of around seventh five to eighty percentage, which is the deciding factor for density of concrete, it is observed that density of normal concrete and the density of geopolymer concrete is more an less same due the presence of same amount of aggregate in both of the system and the property like grading, angularity etc is also consider same as in the normal concrete [10].

Studies carried out on fly ash based geopolymer concrete demonstrated that the compressive strength and the workability of geopolymerbinder are affected by the extents and properties of the constituent materials that make the geopolymerbinder.

Patankar et al. and Abhishek et al. [17], [2] proposed the guideline for designing of mix proposition for geopolymer concrete with the guiding factor like water to geopolymer

binder ratio, sodium silicate to sodium hydroxide ratio etc, according to the research water to geopolymer binder ratio is taken as 0.40, with 13M concentration of sodium hydroxide solution. Heat curing is done for this experiment. Outcome of the research have demonstrated the, Higher fineness of fly ash remains brings about higher quality and workability with early length of warming, Compressive strength grow with increment in centralization of sodium hydroxide solution and Compressive strength decreases with increment in water to geopolymer proportion[17].

4. GEOPOLYMER CONCRETE WITH POLYPROPALINE FIBER

Incorporation of fiber into the cementations lattice can upgrade the flexural properties and control the crack propagation and improve other properties including shrinkage [12].

Research with different type of fiber is going on to get desire result with binding matrix, parameter are study with the variation of, amount of fiber, aspect ratio of fiber and orientation of the fiber etc,

The physical parameters of fiber mix matrix are impacted by the extents and properties of the constituent materials that make the composite [16]. Ilamvazhuthi et al. examined essentially on the impacts of polypropylene and glass fiber on the mechanical properties of geopolymercement [20].Polypropylene fiber have advantage over other fiber due to its low cost and superior capacity to improve the tensile and flexure capacity including break resistance [11].Due to the inherent hydrophobic property of the polypropylene the effect of billing is minimize during the mixing. Venugopal et al. and Eswaramoorthi et al. [18], [6] have study the effect of polypropylene fiber on the geopolymer matrix. In the study they have tested geopolymer matrix with and without polypropylene fiber for the compressive strength, split tensile strength and deflection test. Subbiah et al. [16] examined physical and durability properties of geopolymermatrix with polypropylene fiber by mixing polypropylene fiber ingeopolymermatrix and heat curing is applied. Outcome of the experiment state that the workability thorough slump test and compressive strength slightly improvement due to addition of the polypropylene fiber in the geopolymer matrix. Durability experiment is conducted on that matrix and found that the resistance due to acid attack is resisted by the matrix. Patil et al. [14] had done an exploratory program to decide mechanical properties of polypropylene fiber strengthened geopolymer concrete. The impacts of consideration of polypropylene strands on compressive strength, split tensile and flexural quality of solidified

geopolymer solid composite were contemplated. Polypropylene fiber were added to the mix in two distinct lengths of 12mm and 20mm and furthermore the hybridization of both polypropylene fiber was mixed in volume of cement. In light of the test outcomes, it was watched that the polypropylene fiber mixgeopolymer concrete had moderately higher quality than GPC and OPC concrete.

Reed et al. [11] explored the impacts of polypropylene fiber in geopolymermatrix utilizing 0.05 and 0.15 % fiber (by weight) under surrounding curing. Compressive strength and durability were dissected.

Ranjbar et al. [12] assessed the impacts of water absorption, and roughness property of geopolymar with the addition of polypropylene and steel fiber. The fiber used in geopolymermatrix was performed by 0.5, 1, 2, 3 and 4% of the aggregate volume of each sort of filaments. Nisha et al [13] concentrated the impact of mix of steel fiber and polypropylene fiber on the physical properties of geopolymerconcrete under surrounding curing. The result acquired from different reviews demonstrated that the polypropylene and glass fiber have huge impact on the pressure, split ductile and flexural quality. The incorporation of strands not generally brought about an expansion in the quality parameter.

5. CONCLUSION

Based on this literature review, it is concluded that polypropylene fiber mix geopolymermatrix has considerable potential to improve the physical properties of the matrix specially the tensile and flexure strength property. The factor affecting the polypropylene fiber mix geopolymermatrix is percentage of fiber added, orientation of fiber and aspect ratio apart from that the concentration of alkaline fluid, curing condition, and fly ash to alkaline fluid ratio also give impression on the polypropylene fiber mix geopolymermatrix.

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