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REVIEW STUDY ON MECHANICAL PROPERTIES OF GEOPOLYMER CONCRETE INCORPORATING FLY ASH AND GGBS

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Abstract:

Cement is the second bulk ingested outcome in the world. Cement production leads to 7% of carbon dioxide emissions globally. Geopolymer concrete is the environmental friendly another to ordinary Portland cement (OPC) established concrete and can be easily prepared by activating (with the help of sodium, potassium silicates, and hydroxides), the waste alkali-activated solids (GGBS, Flyash, Corncobash, Baggaseash, Silica fume, Metakoline, and Rice husk ash, etc). Concrete is a highly versatile construction material that contributes to designing the hardest environment while proceeding with the most motivational forms. Engineers and researchers are continually shoving the curbs to upgrade production with the assist of experimental mineral admixture. Nowadays, most of the concrete mixture constitutes various cementitious materials that make part of the cementitious component. In this review study, our aim is mainly to the confined judgment of mechanical properties of alkali-activated fly ash and GGBS-deployed

geopolymer concrete.

Keywords- Geopolymer, Alkaline Activator, Flyash, Sodium Silicate (Na_2SiO_3), Sodium hydroxide (NaOH), Ground granulated blast furnace slag (GGBS).

Introduction

Geopolymers are manufactured by thermal activation of solid aluminosilicate substances such as fly ash, metakaolin, rice husk ash, granulated blast furnace slag, etc., with an alkali metal hydroxide and silicate solution(Kavipriya,2019). Geopolymer concrete is activated blend that it not requires Portland cement in all, and therefore the "cement" or binding constituent of the concrete is just about carbon-neutral. Sooner than hydrating Portland cement, geopolymer concrete is produced by blending the sand and aggregate with slag or fly ash, and then operating it with the help alkali such as sodium hydroxide (Rabiaa et al.,2020). Although fly ash is presented to concrete that holds ordinary Portland cement, the blend evolves strength over a chains of hydration response by which calcium silicate saturates configurations. Association between Portland cement grist and H_2O starts the responses. Disparate Portland cement hydration, polymerization perhaps reported as a three-state procedure especially started by contact between an aluminosilicate substances and an operating solution with exesses pH (Tempest et al.,2015). These phases include dissolution, reorientation, and hardening. The aluminosilicate substance is assorted in the company of an alkaline operating mix that librates silica and alumina monomers. Extent to which the aluminosilicate substance liquefies is connected to the sensation of the substance, the power of the activating mix, and processing hour. The ground granulated blast furnace slag-(GGBFS) and fly ash deployed geopolymer concrete were recognized as the usual GPC kind that has been pre-owned (Kavipriya,2019). Operating mixtures are generally a union of an alkaline soda, to the same degree NaOH or KOH, and emulsifiable silica, to the same degree sodium silicate. (Tempest et al.,2015). The percentages of these mixes differ and are infrequently disclosed due to their unshared nature. In the company of the greenhouse gases, approximately 65% of global warming is due to emission of CO_2, the cement industry is accountable for approximately 7% of all CO2 emissions (Hardjitoet al., 2004).

Mechanism of polymerization

Geopolymer is a kind of unshaped alumino-silicate cementitious stuff. It can be amalgamated by the polycondensation reaction of the geo polymeric forerunner and alkali poly-silicates well known as a polymerization exercise (Vignesh et al.,2020). Geopolymerization process is a composite procedure accompanied by an heat releasing production, phages of polymerization are demolition to curdling, curdling to precipitation, and precipitation to crystallization. Geopolymer is an aluminosilicate amalgam manufactured as a sequel of inanimate polymerization (Ashwini et al.,2019). Basically, two main phases are carried out to manufacture geopolymer concrete: the first phase incorporates aluminosilicate cessation and evolution types of polymer, the second phase incorporates the extension of polymeric specks through nuclei attain censorious size also crystals begin to fabricate. The cessation phase starts when Si-Al from fresh substances touchs an alkaline solution, to fabricate Si and Al families. Numerous variables impact the emergence of Si and Al families, namely alkaline metal kind (Na+ or K+), alkaline solution attentiveness, rate, and time blending (Tempest et al.,2015). The reorganization phase incorporates Si and Al dispersed into the oligomers after cessation. Oligomers into the aqueous stage form various webs by condensation to gel evolution, clarification of reactive Al and Si families from the fresh substances is occurring at Al+3 and Si+4 disestablishing on the surface of wellspring Si-Al substances are detached. The petrifaction phase includes the generation of a continuous gel incorporating rearranging and reconstitution, three phases, guide to fabricate geopolymer with an amorphous, or partly- crystalline, three-dimensional aluminosilicate, lattice. The Silica and alumina amide start to acknowledge and deliquesce within bigger categories. During the time that the sets form, H_2O molecules are freed. The dissolution stage and the alkalinity of the operating mixture highly impact the fare of reaction. The realignment stages outcome in a ceaseless polymeric lattice of three- dimensional aluminosilicate formations. The specimen may solidify moderately on its self depending on the configuration of the parent substances and the medium conditions. Nevertheless, to obtain notable strength, the substance must be cured with required heat. Number of temperatures has been examined with a fashion of enlarging temperatures (up till [100˚C] 212˚F) that guide to quickened solidifying and strength gain. The temperatures less than (60˚C) 140˚F have normally been found to sequel in inaptly slow reactions when unmodified parent substances are used. The cessation and repositioning stages

overlap to some extent. Beginning of solidifying leads to prevent further more migration of geopolymer forerunners and causes an end to these stargazes. Solidifying may be started separately through a fall in pH, or opportunity of nucleation sites bring about by the existence of calcium or iron in the blend. The outer implementation of heat also set offs solidifying. Cessation and realignment durations of higher than 48 hours look to furnish small developments in substance performance. On realization of hardening, the substance generally shows not less than 80 percentage of its ultimate compressive strength hardening (Tempest et al.,2015).

Physical and Chemical Properties

GGBS- Ground-granulated blast-furnace slag (GGBS) is acquired by smoothing liquefied iron chaff (a spinoff of iron and steel-manufacturing) from a blast forge in steam or water, to fabricate a granular, glassy outcome that is then seared and Pulverized into a sheer talc (Ajay and George,2018).

S.No.	Characteristics Fineness(m^2/Kg)	Ajay and George (2018)	Gautam et al. (2015)	Turker et al.(2016)
1.	Fineness(m_2/kg)	390	395	540
2.	Specific gravity	2.85	2.8	-
3.	Particle size (cumulative %)	97.11	-	92
4.	Loss in ignition	0.27	-	0.00
5.	Moisture Content	0.11	-	-
6.	Chemical Moduli			
	$MgO+ SiO_2 +CaO$	76.01	Sio_2-33.45%	Sio_2-43.08%
	$(CaO+MgO)/SiO_2$	1.30	Al2o3-13.46%	Al203-11.34%
	CaO/SiO_2	1.07	Cao-41.7%	Cao-36.25%

Table.1. Properties of GGBS

Sodium Hydroxide- NaoH is commonly accessible in pellets or flake forms. The cessation of NaOH with H_2O is mostly exothermic and results in heat production.

The price of NaOH is largely varied as claimed by to the morality of the material and the vital of concrete. IS 252:1991 gives the recognition for caustic soda, purity, and technical uses(Ajay and George,2018).

Description	Ajay and George (2018)	Gautam et al. (2015)	Turker et al.(2016)
Colour	Colorless	White	Colorless
Specific gravity	2.13	1.7	-
pH	14	-	-
Assay	96%	-	-
Carbonate(Na_2CO_3)	2%	2.0	≤4
Chloride(Cl)	0.01%	0.01	-
Sulphate(SO_2)	0.05%	0.05	-
Lead(Pb)	0.01%	0.001	≤0.5
Iron(Fe)	0.01%	0.001	≤10
Potassium(K)	0.1%	0.10	-
Zinc	0.02%	0.02	-

Table.2. Properties of sodium hydroxide

Sodium Silicate- Na_2SiO_3 is known by the name of H_2O glass or aqueous glass is generally available in liquid form. Na_2SiO_3 solution plays a big role in the polymerization operation under the high alkaline state when reactive aluminosilicates are quickly break down and free [SiO4] - and [AlO4] - bipyramidal parts are freed in solution and are possibly connected to polymeric parents by sharing oxygen atom. Consequently making Si –O–Al –O covalent bonds (Ajay and George,2018).

Property	Ajay and George (2018)	Gautam et al. (2015)	Turker et al. (2016)
Appearance	Liquid(gel)	Liquid(Gel)	Tempered liquid
Boiling point	102ºC for 40% aqueous solution	102°C for 40% aqueous solution	-
Molecular weight	184.04 Dalton	122.06324g/mol	-

Specific	1.6	1.70	-
Na_2O	15.9%	15.90	8.52
H_2O	52.7%	52.70	-
SiO_2	31.4%	31.40	27.09

Table.3. Properties of Sodium Silicate

Fly Ash- Fly ash is wispy gray talc consisting mainly of spherical, glassy fleck that are manufactured as a spinoff in a coal-fired power station. Flyash has pozzolanic belongings, connotation that it reacts with lime to shape cementitious amalgams (Aleem and Arumairaj,2012).

Properties	Asraar Anjum	Santosh et al.(2016)	Turker et al.(2016)
Specific Gravity	2.4	2.36	2.45
Fineness(m^2/kg)	-	224	425
SiO_2	55-65%	52%	49.45%
Al_2O_3	5-7%	Cao-4%	29.61%
Fe_2O_3	22-25%	Consistency-45%	10.72%

Table.4. Properties of fly ash

Setting Time

It is reported that geopolymer mortar paste has a speedy setting time collate to OPC mortar paste. The main character of Na_2SiO_3 as the impetus can be perceive understandably, the greater quantity of Na_2SiO_3 in the blend gives the speedy final setting time(Risdanareni et al,2015). But then, the growing quantity of silicate within a definite limit could lessen the setting time. Above all the quick setting time of geopolymer results much complication, such as reduces workableness. It was strenuous to cast geopolymer concrete with low workableness and speedy setting time. The appropriate superplasticizer is required to reduce this speedy setting time (Risdanareni et al,2015). Fresh pastes require a certain set time to lose flow ability or plastic consistency for placement and finishing purposes (Shi et

al.,2015). It is described that the slump value of concrete starts increasing as the proportion of GGBS enlarges up to 50% substitution and then starts decreasing (Thakur et al.,2016). A replacement of fly ash with slag can effectively decrease the setting times (Shi et al.,2015).

Workability of Geopolymer concrete

In its fresh condition, the geopolymer concrete has a firm stability. In spite of that the ample contraction was achievable, a development in the workableness was considered as sensible. The incorporation of a high-scale water-Lessing admixture ameliorated the workableness of the firm concrete but has extremely small influence on the compressive strength up to round about 2% of this amalgamation to the quantity of fly ash by mass. (Hardjito et al.,2004)

Mechanical Properties

Compressive Strength- Gpc with 100% ggbs activated with alkaline solution gives maximum compressive strength (Oyebisi et el.,2016), gpc with 100% fly ash shows minimum compressive strength, the optimum value of ggbs and fly ash replacement for better result alkali activated gpc is 60% ggbs and 40% fly ash, further increase in fly ash volume leads to decrease in strength of gpc.GPC with 100% fly ash has 61.1 Mpa and 20%slag and 80% fly ash has 83.7 Mpa strength(Shi et al.,2015). It is reported that the concrete compressive strength with an enlarging percentage of GGBS substitution OPC reduces after 7 days but enlarges after 28 days with the most appropriate percentage of 50% substitution by GGBS(Thakur et al.,2016). It is found that utilizing fly ash deployed geopolymer concrete has numerous goods in idiom of engineering, environment, and wealth above ordinary Portland cement concrete.

Fly Ash deployed Geopolymer concrete is the foremost welshing of Portland cement concrete, i.e. stubby resistance to corrosion and enhance in environmental pollution. (Zerfu and Ekapurti, 2016). It is found that the effect of Sodium hydroxide molarity, Na2SiO3/NaOH ratio, fly ash/alkaline activator ratio and curing temperature are obligatory for attaining the most appropriate strength of geopolymer, the longevity of the fly ash deployed geopolymer is superior to OPC when uncovered to an antagonistic environment. (Bakri et al., 2011).

Split tensile Strength- Gpc with 100% ggbs activated with alkaline solution gives maximum split tensile strength (Oyebisi et el.,2016), gpc with 100% fly ash shows minimum split tensile strength, the optimum value of ggbs and fly ash replacement for better result alkali activated gpc is 60% ggbs and 40% fly ash, further increase in fly ash volume leads to decrease in strength of gpc. It is reported that concrete split tensile strength with an enlarging proportion of GGBS reduces after 7 days but enlarges after 28days with the most appropriate percentage of 60% substitution by GGBS. It exhibits the unhurried rate of reaction of grid by amalgamation of GGBS. At the most appropriate proportion of GGBS the Split tensile strength is 22.58% greater compared to ordinary cement concrete(Thakur et al.,2016).

Flexure strength- Gpc with 100% ggbs activated with alkaline solution gives maximum flexure strength (Oyebisi et el.,2016), gpc with 100% fly ash shows minimum Split tensile strength, the optimum value of ggbs and fly ash replacement for better result alkali activated gpc is 60% ggbs and 40% flyash, remoter increase in flyash volume results to decrease in strength of gpc. , it could be noticed that the concrete flexural strength with an growing proportion of GGBS growes after 28 days with the most appropriate percentage of 50% substitution by GGBS. At this phase with the substitution of cement with GGBS flexural strength is 27.13% greater compared to ordinary cement concrete(Thakur et al.,2016).

Conclusion

1. The geopolymer concrete compressive strength is directly proportional to the concentration of NaOH solution.
2. The geopolymer concrete compressive strength is inversely proportional to the alkaline liquid to Fly ash ratio.
3. Water substitution for sodium silicate exhibits the decrement in the geopolymer concrete compressive strength as an increment in water substitutions well as the workableness of the fresh concrete increases.
4. Geopolymer concrete with 100% GGBS shows maximum mechanical property result.
5. GGBS and fly ash replacement shows goods results in mechanical property up to replacement level of 60% GGBS and 40 % fly ash, further increase in ggbs replacement leads to decrease in mechanical property GPC.

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