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GPC Filled Corrugated steel tubular column: A Review

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Abstract - Geopolymer is a sustainable binding material having similar binding property to ordinary Portland cement.it can be produced from fly ash, granulated blast furnace slag like aluminosilicate material it can be activated by alkaline solution. Geopolymer concrete having higher mechanical strength than ordinary Portland cement. Alkaline activators can improve strength and durability of geopolymer concrete. The geopolymer concrete technology reduce global carbon dioxide emission.

The Concrete filled corrugated steel tube have the same working mechanism as tube confined concrete columns because of its high lateral stiffness and corrosion resistance of corrugated steel pipe and corrugated steel pipe provide strong confinement effect. Concrete filled corrugated steel tube offers advantages such as ease of construction, high ductility, confinement effect, strong interlocking effect between corrugated steel pipe and concrete and load bearing capacity. So Geopolymer filled corrugated steel tube has benefit of both geopolymer concrete and concrete filled corrugated steel tube.

Key Words: geopolymer concrete, fly ash, alkaline solution, corrugated steel pipe, load bearing capacity.

1. INTRODUCTION

1.1 Geopolymer Concrete

In this world one of the mostly used construction material is concrete, but there is also have some environmental issues because of highly usage of concrete. Main reason is content of Portland cement in concrete, which cause massive production of carbon dioxide emission in environment, it's around 7% of total human induced carbon dioxide emission in every year. For example, for the production of one ton Portland cement around 1.5 tons of raw material needed, for this process leads to elimination of around one ton of carbon dioxide. Constructers are using Geopolymer cements, which producing from GGBS and Fly ash with alkali activator solution [1]. The ordinary Portland cement-based concretes have high internal energy than geopolymer cement. Production of OPC leads to high amount of greenhouse gas in atmosphere. Ordinary Portland cement-based concert are not that much durable in many environmental conditions. In this situation OPC can replace with Geopolymer concrete [2]. and alkaline activators are effect the mechanical properties of the Geopolymer concrete. There have some suitable materials are acknowledge for geopolymer materials such as class F Fly ash (FA), Silica and Alumina composition, even though the problem of generation of the F classs Fly ash based Geopolymer materials can be cured only high temperature. Curing of GPC at surrounding temperature slag is normally added. Mainly ground granulated blast furnace slag is used [3].

Experimental and research shows that substitution of fly ash with GGBS improve the compressive strength of concrete regardless of type of curing. The thing is more alkaline content improves strength of the concrete up to some range. Mix design is process that selecting suitable ingredients used in a particular concrete and identify their relative proportions to reach given target strength and workability. The Binder content, amount of fine and coarse aggregate used in the mix also matter of the strength of GPC. Basically more in the binder content, the compressive strength of GPC also increase [14].

1.2 Concrete Filled Corrugated Column.

Wang et al [5] state that Concrete filled galvanized corrugated steel tubular column is a new composite member to reduce the anticorrosion maintenance cost and improve the corrosion resistance of concrete filled steel tubular structure and it has advantages such as high load bearing capacity, free of maintenance, and good ductility. Corrugated steel pipe are made from cold- formed galvanized steel sheet after the crimping and mechanical pressing. Concrete filled corrugated steel tube fabricated from concrete filled galvanized corrugated steel pipe. Steel is protected by cathodic protection due to Zinc oxide film on the surface of the structure. In addition, cladding layer is difficult to remove which reduces periodic maintenance cost. Anticorrosive pipe used as bridges, rain water pipe, culvert, channel etc. service life of corrugated pipe depend on selection of appropriate coating. Concrete filled corrugated column will perform well under lateral cyclic loading and compression because of strong interlocking effect between concrete and corrugated steel pipe due to corrugation of corrugated steel pipe [5].

Fang et al [6] state that concrete filled corrugated steel tube structure shows excellent local stability and post peak behaviour even it is not configured with transverse reinforcement due to effective confinement provided by the corrugated steel pipe. Test result shows that ductile behaviour of concrete columns is improved due to corrugated steel sleeves. Concrete filled corrugated steel tube column embedded with steel structure have good seismic bearing Capacity. Its construction is easier and economical than or same as that of SRC column. Corrugated steel pipe enhance the confinement of the structural steel and internal concrete, so we get enough bearing capacity and ductility. The Stud on the structural steel do not make significant effect to the axial behaviour of the concrete filled corrugated steel tube. Structural steel ratio and confinement factor help to increasing the axial mechanical performance of the concrete filled corrugated steel tube.

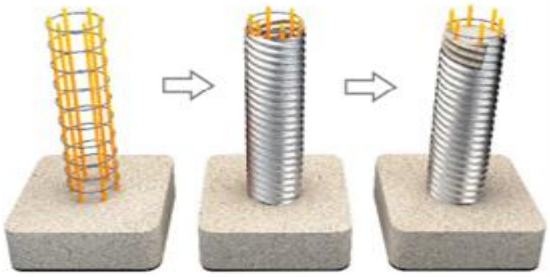

Fig-1: CFCST Column

Che Chou et al [7] state that concrete column confined by FRP frapped spiral corrugated tube have coupled surface between concrete and FRP. Steel tube provide confining effect to the concrete column it help to improving structural performance such as ductility, stiffness. The FRP wrapped spiral corrugated tube provide both confinement and shear strength to the concrete column. Convex surface of the spiral corrugated tube help to increase the interlocking effect of corrugated tube and concrete. Concrete filled GFRP wrapped spiral corrugated tube have good strength and deformation capacity. Concrete column reinforced with FWSCT enhance the seismic performance. The FWSCT prevent the shear crack inside the confinement tube, hence plastic hinge is developed with in the unwrapped region.

Yang et.al [8] state that The Corrugated steel pipe gives strong confinement because of hoop stress. Ductility and load bearing capacity of concrete filled galvanized steel tube is similar to ideal TRC column. The hollow corrugated steel pipe is not good for carrying axial load without in filled concrete and longitudinal bars. No noticeable buckling in CFGCST however little bit vertical crack formed inside the concrete.

2. MATERIAL

Kumar et.al [9] studied the ingredient of Geopolymer concrete are Flyash, GGBS, Fine aggregate, Course aggregate, Alkaline activator Solution. Alkaline activator Solution is combination of Sodium hydroxide, Sodium silicate and water. The Sodium hydroxide solution are made by dissolving sodium hydroxide pellet in to distilled water. Molarity of sodium hydroxide solution depend on concentration of Sodium hydroxide per liter. The sodium hydroxide solution was prepared 24 hour before use, because huge amount of heat generated when sodium hydroxide pellet mix with water. Flyash is collected from combustion of coal in power plant.

Super plasticizer are added in to Geopolymer concrete for attaining good workable concrete. Commonly Naphthalene Sulphonate based Super plasticizer is used for increasing workability of GPC. Excess water can reduce the strength of Geopolymer concrete. Average density of Geopolymer concrete is similar to ordinary Portland cement concrete. Ratio of Flyash and GGBS effect the compressive strength of concrete. Ground Granulated Blast Furnace Slag is a by-product of slag of iron from Blast furnaces.

3. ALKALINE ACTIVATOR SOLUTION

Danda et.al [2] state that ratio of sodium silicate solution to sodium hydroxide solution was varying. Commonly 2.5 ratio are adopted. Commonly 8M, 10M, 12M and 14M concentration of NaoH are prepared for Geopolymer concrete. Sodium hydroxide prepared before 24 hour of casting. At the time of casting both sodium hydroxide solution and sodium silicate solution are mixed.

3.1. Molarity of Sodium Hydroxide solution

The ratio of sodium silicate to sodium hydroxide taken in this study is 2.5.The compressive strength of geopolymer concrete is directly proportional to molarity of sodium hydroxide solution. Fig 3 explain that high molarity sodium hydroxide show higher compressive strength at 28 and 56 day [2].

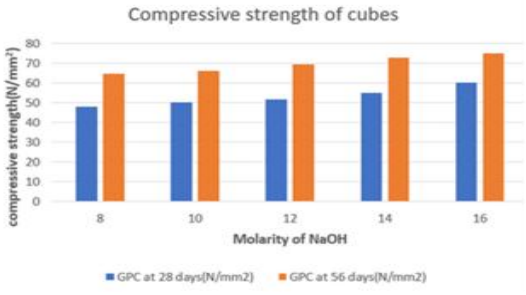

Chart-1: compressive strength of GPC vs. Molarity of NaoH

4. MIXING PROCESS

First put the course aggregate in to mixer and mix with small quantity of water for few minute to reduce dust content. Add specific amount of fine aggregate in to mixer and rotate the mixer for another two minute. Later specific amount of GGBS and fly ash add in to mixer followed by alkaline activator solution with particular amount of super plasticizer. The rotation of mix was allowed to another five minute for thorough mixing of reactive solid and alkaline activator solution. Geopolymer concrete are harsh and stiffer. So extra water and super plasticizer are essential for good workable concrete [11].

5. CASTING OF CONCRETE SPECIMEN

Neupane et.al [12] Studied that Concrete cubes, cylinders and beams with particular dimension were cast to find the property of Geopolymer concrete. 3 specimen were made for each test. After 24 hour of casting, the demolded specimen placed for curing at ambient temperature in laboratory. After 28 days, test were carried out.

6. WORKABILITY OF CONCRETE

Workability of Geopolymer concrete was determined by slump test. Factors depending the workability of Geopolymer concrete are water content, ratio of GGBS and Fly ash, Molarity of alkaline solution, size of aggregate, super plasticizer . Workability of Geopolymer concrete decreases with increase of GGBS content and workability of Geopolymer concrete decreases with increase of Molarity of sodium hydroxide solution. Because high molarity sodium hydroxide solution are high viscous. Appropriate amount of super plasticizer help to improve the workability of the Geopolymer concrete. 21%-30% of OPC replaced by fly ash help to improve the workability of concrete because round shape of Fly ash. Higher percentage of Fly ash based geopolymer concrete have lesser water demand than OPC concrete. Geopolymer concrete showed less segregation [12].

7. CURING

Poloju.et.al [4] studied about ambient and oven cured concrete and its compressive strength of GPC. Oven cured concrete shows higher compressive strength than ambient cured geopolymer concrete. Because of early polymerization in the high temperature curing. Increasing strength of ambient cured GPC by adding GGBS content.

In this method test is carried out in ambient temperature of 210-250C. Demoulded specimen were kept at ambient temperature for 7 or 28 days [10]. In Flyash based Geopolymer concrete, high temperature is necessary for initiate Geopolymerization reaction. The presence of GGBS is essential for ambient cured Geopolymer concrete with sodium hydroxide solution and sodium silicate solution, otherwise heat curing is necessary. GGBS improve mechanical and micro structural property of geopolymer [11].

7. DENSITY OF CONCRETE

Gholampour et.al (2017) studied that less amount of water and air content in geopolymer concrete enhance the density and durability of GPC than OPC concrete. Density of geopolymer increases with GGBS content and size of aggregate effect the density of geopolymer concrete [13].

8. MECHANICAL PROPERTY OF HARDENED CONCRETE

8.1 Compressive Strength

Concrete cubes are used for conducting compressive test. Minimum 3 cubes were made for compressive test. GGBS content in geopolymer concrete enhance the early strength of concrete and compressive strength. Because GGBS consist of higher amount of calcium than fly ash. This leads to mix produce more calcium silicate gel with the alumina silicate. Due to this reason GGBS geopolymer is less workable and stiffer. Method of curing effect the compressive strength of geopolymer concrete. Heat cured specimen have higher compressive strength than ambient cured geopolymer concrete. Fly ash partially replaced by silica fumes increase the compressive strength [11].

Compressive strength increases with GGBS but higher amount of GGBS effect the setting time of geopolymer concrete. Higher amount of GGBS leads to decreasing of setting time. Oven cured slag blended fly ash geopolymer give high early strength. Amount of fine and course aggregate, binder content, molarity of alkaline content also effect the compressive strength [14].

Saranya et.al [15] state that Geopolymer concrete gained 95% of compressive strength within 7 days and OPC concrete attained only 50% of compressive strength with in 7days. Geopolymer attain early strength than OPC.

Bouaissi. et.al [16] State that large amount of GGBS impact negatively on strength development. Compressive strength of fly ash-GGBS based geopolymer paste increases in the beginning and compressive strength decreases with large amount of GGBS replacement. Replacement of GGBS become 40%, the compressive strength reduced with time.

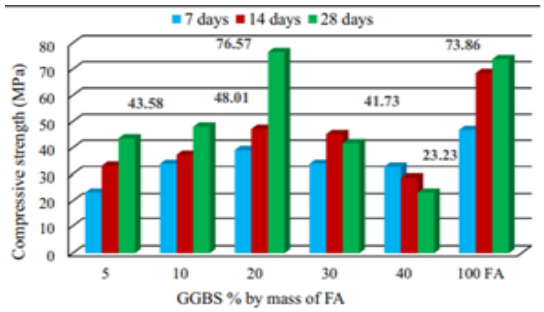

Chart-2: Compressive strength of fly ash GPC paste with varying GGBS replacement (Bouaissi. et.al)

8.2 Split Tensile Strength

Minimum 3 cylinder are used for conducting split tensile strength test. Tensile strength increases with GGBS content and molarity of Sodium hydroxide solution. Combination of silica fumes, fly ash, GGBS shows low tensile strength. Combination of fly ash-GGBS based geopolymer shows high tensile strength than Flyash only geopolymer concrete. Because GGBS make rough surface between paste and aggregate than spherical shape of Flyash component. Alkali activator bind on the aggregate surface on the GPC concrete help to increase bond strength and it help to increase the tensile strength. Alumina -silicate gel precipitation and alkali dissolution in the geopolymer play an important factor to attain good tensile strength. Split tensile strength of GPC concrete is 8%-12% greater than OPC concrete of same grade [11].

8.3 Flexural Strength

Nath et.al [17] state that Flexural strength of both GPC and OPC shows higher value than split tensile strength of GPC and OPC concrete. Flexural strength increases with GGBS or calcium hydroxide blended with fly ash geopolymer concrete.

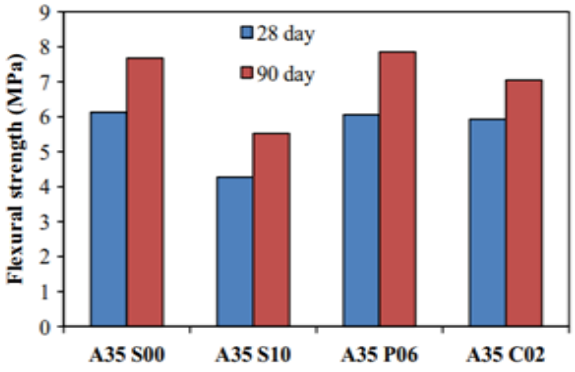

Chart-3: comparison of flexural strength of GPC contain 35% alkaline activator (Nath et.al)

In fig. 2 shows that 35% alkaline activator and different ingredients of mixtures compared. A35 S10 have 30% lower compressive strength than A35 S00 mixture. Because presence of extra water with additive cause negative consequence on flexural strength of GPC concrete. Compressive strength increases with additives but addition of more additives after a certain range effect the rate of tensile strength, when geopolymer cured in ambient condition. Percentage of calcium silicate hydrate gel increases with increase of additive in mixture. So tensile capacity of geopolymer concrete increase. Presence of additional water in the place of alkaline activator solution effect the strength of concrete.

Flexural strength of geopolymer concrete is greater than OPC concrete with same grade. Flexural strength of geo polymer concrete increases with age. Heat cured geopolymer concrete shows higher flexural strength than OPC concrete [18].

9. CONCLUSION

Based on literature review it is concluded that concrete filled corrugated steel tubular column have higher load bearing capacity and confinement effect than ordinary concrete filled tubular column. Geopolymer filled corrugated steel tubular column get advantage of both corrugated steel tubular column and geopolymer concrete. Geopolymer concrete show higher strength than OPC Concrete. Durability of GPC greater than OPC concrete. Oven cured geopolymer concrete have higher strength than ambient cured geopolymer concrete. Tensile and flexural strength of GPC have far better than OPC concrete.

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