Review on Geopolymer Concrete Incorporated With Steel Fiber

P. Devprakas[1], Dr.D. Shoba Rajkumar[2]
[1]Dept of Civil Engineering
[2]Professor& Head, Dept of Civil Engineering
[1, 2] Government College of Engineering, Salem, India

Abstract- *In this Research, fly ash and alkaline activators and different amount of steel fiber were used for preparing geopolymer concrete. Geopolymer concrete are reporting as the greener construction technology compared to conventional concrete that made up of ordinary Portland cement. It's an innovative construction material that utilized fly ash as one of waste material in coal combustion industry as a replacement for carbon dioxide emission to the atmosphere. Alkaline liquid to fly ash ratio varies from 0.4 to 0.45. Ratio of sodium silicate to sodium hydroxide solution was varies from 1 to 2.5. FRGPC contains fly ash, alkaline liquids, fine aggregate, coarse aggregate and steel fiber. Fly ash is rich in silica and alumina reacted with alkaline solution produced aluminosilicate gel that acted as the binding material for the concrete.*

Keywords- Geopolymer concrete, Fly ash, Alkaline activators, Steel fiber

I. INTRODUCTION

Concrete is one of the most commonly used building materials. It's a composite material made from several readily available constituents (cement, sand, aggregate, water). Geopolymer is a new inorganic polymeric material that has undergone a marked development in the past years. The geopolymer term was first used by Davidovits. The utilization of fly ash as waste material also improved and overcome a major problem for disposal.Geopolymer is formed from the reaction of a source material that is rich in silica and alumina with alkaline liquid.If geopolymer is compared with OPC, geopolymers show many advantages. It generally consists of covalent bonds and has such advantages as being excellent in volume stability, light in weight, fire resistant, and low in density, all of which arouse much attention from researchers. Fiber reinforced concrete (FRC) is a composite material made with Portland cement, aggregates and incorporating discrete discontinuous fibres. Plain and unreinforced concrete is known as a brittle material with a low tensile strength and a low strain capacity. The bond between the concrete and the reinforcing steel fibers is a significant mechanism for the performance of reinforced geopolymer concrete as a composite material. However, plain cement concrete faced various imperfection such as brittleness, fracture resistance. Hence, the addition of steel fibers is an alternative to promote these problems such as toughness, flexural strength, and energy absorption improved.

II. LITERATURE SURVEY

a) A. Suriyaprakash, G. Senthil kumar (2015), Steel fibre was added to the wet mix in different proportions such as 0.5%, 1.0%, and 1.5% by the volume of the concrete. . The increase in compressive strength was about 8.2% and 25.9% for GPC1 and GPC2 respectively with respect to GPC mix and decrease in compressive strength was about 18.1% GPC3 respectively with respect to GPC2 mix. The increase in split tensile strength was about 26.9% and 57.4% for GPC1 and GPC2 respectively with respect to GPC mix and decrease in split tensile strength was about 44.2% for GPC3 respectively with respect to GPC2 mix. Compressive strength of 1% steel fiber geopolymer concrete has found to be 5% increase in strength, when compared to that of conventional concrete. Split tensile strength of 1% steel fiber geopolymer concrete has found to be 5% increase in strength, when compared to that of conventional concrete. Hence 1% concentration of steel fibers is found to be the optimum dosage for his project work.

b) Hai-yan Zhang, Venkatesh Kodurb, Liang Cao, Shu-liang Qi (2014), MK-based geopolymers without carbon fibers (GP00-0) develop serious cracks, and is highly prone to rupture even under smaller loads. However, no noticeable cracks develop in the specimens with 2% carbon fibers (GP00-2). MK-based geopolymers (0% FA) possess higher bending strength at ambient temperature, but lower compressive strength as compared with MK-FA based geopolymers (20%, 50% and 75% FA). High bending and compressive strength are both achieved in MK-FA based geopolymers (20%, 50% and 75% FA), while FA-based geopolymers (100% FA) exhibit the lowest bending and compressive strength at ambient temperature. geopolymers made with 50% metakaolin and 50% fly ash and reinforced by 2% carbon fibers exhibit favourable bending and compressive strength both at ambient temperature and after high temperature exposure, thus it is suitable for structural members required for good fire performance.

c) M M A B Abdullah et al 2017, With ratio of 2.0 for solid to liquid ratio, fly ash and fine aggregates together with respective percentage of short steel fiber are initially mixed together. Different Quantity of fibers is used such as 0kg/m^3,26kg/m^3,78kg/m^3,130kg/m^3, 182kg/m^3. The maximum slump value recorded is at 0 wt% of fiber content which is 100 mm and the lowest slump value recorded is 32 mm with the highest fiber content. The fiber content is increases more than 7 wt% the compressive strength and flexural strength of geopolymer concrete is impossible to increases as the slump value continue to decrease. The maximum density of the geopolymer concrete can reach up to 2500 kg/m3 when the percentage of addition steel fiber is at 7 wt%.the water absorption of geopolymer concrete with addition of steel fiber is lower than the 0 wt% (control concrete) which is the lowest reading is at 7 wt% (2.7%).The maximum increase in compressive strength is recorded when the percentage of short steel fiber is at the highest which is 69.80 MPa. Meanwhile, the lowest compressive strength is recorded at 1 wt% of addition steel fiber which is 45.40 MPa. compressive strength of geopolymer concrete reinforced with short steel fiber, the highest addition of steel fiber is chosen which is 7 wt% for the reason that it possessed the highest value of compressive strength which is up to 69.80 MPa. The increasing trending flexural strength for all samples is observed and the highest flexural strength value is up to 5.94 MPa at maximum fiber content which is 7 wt%. Meanwhile, the lowest fiber content in geopolymer concrete mixture has 1.45 MPa of flexural strength value. m the results obtained 7 wt% of short steel fiber content in geopolymer concrete structure shows maximum value of various strength which are compressive strength and flexural strength. The maximum value in compressive strength and flexural strength can achieved up to 69.80 MPa and 5.94 MPa respectively.

d) N. Ganesan, P.V. Indiraa&Anjana santhakumar, Sand having a fineness modulus of 2.83 and specific gravity of 2.50 was used. The maximum size of coarse aggregate was 20 mm with a fineness modulus of 7.69 and specific gravity of 2.72. In order to improve the workability of concrete a naphthalene-based superplasticizer (Conplast SP 430) was employed during mixing operations. Crimped steel fibres (Fig. 2) having a length of 30 mm, diameter of 0.45 mm and an ultimate tensile strength of 800 MPa with an aspect ratio of 66 were used for the present study. the compressive strength development of SFRGPC with various volume fractions of fibres. The compressive strength (fc) of GPC was 45.37 MPa and that of SFRGPC shows an improvement at each volume fraction. The percentage increase in compressive strength was represented as strength gain. For SFRGPC this value ranged from 3.22% up to 8.51% as the volume fraction increases from 0.25% up to 1%.The increase in splitting tensile strength of GPC for various volume fractions of fibres. It may be strength increases from 23.26% for 0.25% volume fraction up to 61.63% for 1% volume fraction of fibres. Indicates that the value increases from 9.4% for 0.25% fibre volume, up to 24% for 1% of fibre volume fraction. The compressive strength of GPC improves slightly with the addition of steel fibres at various volume fractions. The strength increases from 3.22% for 0.25% volume fraction of fibres up to 8.51% for 1% volume fraction. The splitting tensile strength, modulus of rupture, modulus of elasticity and Poisson"s ratio of SFRGPC increases significantly with increase in fibre volume fraction. The splitting tensile strength varied from 23.26% up to 61.63% for the increase in fibre volume fractions from 0.25% up to 1 %. The modulus of rupture varied from 9.4% up to 24%, the modulus of elasticity varied from 13.70% up to 64.92% and Poisson"s ratio varied from 14.28% to 50%.

e) Prakash R. Vora, Urmil V. Dave(2013) , he concludes The ratio of alkaline liquid to fly ash, by mass does not affect the compressive strength of the geopolymer concrete. The sodium silicate to sodium hydroxide ratio by mass equal to 2 has resulted into the higher compressive strength as compared to the ratio of 2.5 for the geopolymer concrete. The compressive strength of the geopolymer concrete increases with increase of concentration in terms of molarities of sodium hydroxide. The compressive strength of the geopolymer concrete increases with increase in the curing time. However, the increase in strength beyond 24 hours is not much significant. Workability of the geopolymer concrete mix increases with the addition of superplasticiser up to 4% of fly ash by mass. Minor reduction of compressive strength of the geopolymer concrete is observed when the superplasticiser dosage used is greater than 2%. 1 day rest period increases the compressive strength of the geopolymer concrete as compared to that for the concrete without the rest period. Compressive strength of the geopolymer concrete decreases with increase in the ratio of water to geopolymer solids by mass. The workability of the geopolymer concrete in fresh state increases with the increase of extra water added to the mix. With increase in the curing temperature in the range of 600C to 900C, the compressive strength of the geopolymerconcrete also increases.

f) F.N. okoe, J. Durgaprasad, N.B Singh, in researches The alkali activators used were solutions of sodium hydroxide, potassium hydroxide and sodium silicate. Solutions of sodium and potassium hydroxides (14 M each) were prepared separately. The solu- tions prepared were left for 24 h before mixing with sodium silicate. The mixtures of sodium hydroxide/potassium hydroxide and sodium silicate solutions were left for one day and then used for geopolymerisation process. the ratio of sodium silicate to sodium hydroxide solution was kept 2.5. The Compressive strength of concrete in 3days, 7days, 14days and 28 days are kaoh solution and NaoH solution was gave higher compressive strength in using NaoHsolution mix. n order to compare the effectiveness of different superplasticizers on compressive strength of geopolymer concrete, different doses of superplasticizers (Naphthalene sulphonate, Malamine-formaldehyde and Polycarboxylate ester-based superplasticizers) were added separately. As well as compressive strength of Napthaline sulphonate gaves higher compressive strength then others. Compressive strength of 100% flyash was give more strength compared then 100% kaolin but 100% OPC gives more strength then 100% flyash.

g) Pradip Nath, Prabir Kumar Sarker, Vijaya B Rangan, Mixtures F00is the control mixture which contained no additive with fly ash and mixtures S10, P08 and C02 contained 10%GGBFS, 8% OPC and 2% CH of total binder (fly ash + additives) respectively. Alkaline liquid was used as 40% ofthe total binder. The ratio of sodium silicate to sodium hydroxide solutions was constant at 2.5. The concentration of sodium hydroxide was 14 Molar in all the mixtures. the control geopolymer paste F00 required morethan 24 hours to set. When the additives were incorporated in the mixture, setting time of geopolymer pastes reducedsignificantly to the comparable value of OPC pastes. Both initial and final setting time decreased for themixes blended with an additive. The mixtures having 10% GGBFS and 8% OPC showed the initial setting time of203 min and 110 min respectively, while mixture having 2% CH achieved initial setting at 607 min. At age of as early as one day, the mortar mixturesS10, P08 and C02 gained 10.5, 8.0 and 3.6 MPa respectively. Compressive strength of these mixtures exceeded 17MPa at 3 days, in contrast of the strength of control mixture (F00) which was negligible at the same age. At 28 days,the geopolymer mixtures blended with the additives showed slightly higher compressive strength than that of F00.However strength after 90 days was almost similar for all the mixtures.

h) M M A B Abdullah *et al* 2017, sodium hydroxide (NaOH) is in the flakes form and sodium silicate (Na2SiO3) solution is used as alkaline activators. The concentration of sodium hydroxide isfixed at 12M also the ratio of NaOH/Na2SiO3 at 2.5. The ratio of fine and coarse aggregates is also included with fly ashratio because they are considered solid constituent in the geopolymer concrete as fly ash/fineaggregates/coarse aggregates is 1:1:1.5 in ratio respectively. The steel fiber used in this study is short type of steel and with range of 0.03 mm to 0.06 mm length. Short steel fibers are used with aspect weight ratio of 0 wt%, 1 wt%, 3 wt%, 5 wt%, and 7 wt%. the fiber content is increases more than 7 wt% the compressivestrength and flexural strength of geopolymer concrete is impossible to increases as the slump valuecontinue to decrease workability. The maximum density of the geopolymer concrete can reach up to 2500 kg/m3 when the percentage of addition steel fiber is at 7 wt%. GPC mix is recorded the lowest density of geopolymer concrete which is 2443 kg/m3when there is no steel fiber is added and considered to be reference point in this study. the waterabsorption of geopolymer concrete with addition of steel fiber is lower than the 0 wt% (controlconcrete) which is the lowest reading is at 7 wt% (2.7%).Compressive strength of geopolymer concrete increases with respectto short steel fiber content in the mixture. The maximum increase in compressive strength is recordedwhen the percentage of short steel fiber is at the highest which is 69.80 MPa. Meanwhile, the lowestcompressive strength is recorded at 1 wt% of addition steel fiber which is 45.40 MPa. The increasing trending flexural strength for all samples is observed and the highest flexural strength value is up to 5.94 MPa at maximum fiber content which is 7 wt%. Meanwhile, the lowest fibercontent in geopolymer concrete mixture has 1.45 MPa of flexural strength value. The maximum value incompressive strength and flexural strength can achieved in 7% steel fiber up to 69.80 MPa and 5.94 MPa respectively.

i) Megharima Datta, G. Premkumar, Trial blend 1- 60%: 40%, trial blend 2- 50%:50%, trial blend 3- 40%: 60%, trial blend 4 - 30%: 70%. In the wake of testing, we found thatblend 4 - 30% fly ash and 70% GGBS gives better quality then different blends. Alkaline activator solution ratio is 2%. steel fibers of variousmeasurement 0.75%, 1.5%, 2.5% in both the conventional and geopolymer concrete. The compressive strength, spilt tensile strength are geopolymer concrete for 0.75%, 1% and 1.5% steel fiber higher then onventional concrete of 0.75%, 1%, 1.5% steel fiber. Especially, geopolymer concrete of 1.5% steel fiber gives more strength then 1.5% of conventional concrete. First split load of OPC, GPC and SFRGPC are equivalent and a definitive load limit of OPC and GPC are relatively equivalent though the SFRGPC is having most noteworthy extreme load conveying limit. In ductility the specimen OPC is more bendable than GPC. Be that as it may, when we addedsteel fibers to the SFRGPC achieves more ductility than SFRCC. Based on a definitive load conveying limit SFRGPC has 1.14 times less split width than SFRCC. The GPC specimen has more stiffness compared to CC, SFRCC, SFRGPC.

j) Syed AhsanullahQuadri,Maneeth P. D(2017),GGBFS replaced 30% by flyash, along with additional steel-fibers varies 0.25%, 0.5%, 0.75%, 1%, 1.25% and 1.5% with the Geopolymer concrete(GPC). Maximum strength results were obtained from GPC with 1.25% of steel fiber. The optimum/maximum compressive strength was 42.39 N per mm2 at 7 days and 55.18 N per mm2 at 28 days curing. The increase in optimum compression strength was 25.22% at 7 days curing and 29.56% at 28 days curing when it is compared to GPC without Steel-fibers. The optimum/maximum split tensile strength was 4.09 N per mm2 at 7 days and 4.81 N per mm2 at 28 days curing. Increases of split tensile strength were 64.91% at 7 days curing and 73.64% at 28 days curing when it is compared to GPC without Steel fibers.The optimum/maximum flexure strength was 5.47 N per mm2 at 7 days and 5.93 N per mm2 at 28 days curing.Maximum flexural strength results were also obtained at GPC with 1.25% of steel fibers and the increases optimum flexurestrength was 69.34% at 7 days and 38.87% at 28 days curing. Fiber Reinforced Geopolymer Concrete (FRGPC) mixes and cured at ambient temperature are able to produce the high compressive strength of 40MPa & 50Mpa.Tensile strength and flexural strength of FRGPC marginally increases as a compressive strength. It is clear that there is no need to expose GPC to a high temperature to achieve maximum strength. If 30% of the flyashes is replaced by GGBFS.

III. CONCLUSIONS

From the study the following conclusions are described as follows:

1. Geopolymerconcrete strength increases with increased volume fraction (V_f).
2. The compressive strength highly influenced by the amount of CaO content in the Fly ash.
3. Compressive strength of the Geopolymer concrete increases with increases of concentration in terms of molarities of sodium hydroxide.
4. Workability of the Geopolymer concrete mix increase with the addition of Super plasticiser.
5. Increase Rest period with Increase the compressive strength.
6. compressive strength and Density increased with fiber content increasing while workability and water absorption decreased.
7. Using 7% steel fibers are given higher compressive strength and low workability, low water absorbtion.
8. While using 0%, 1% and 1.5% steel fiber, 1% steel fiber gives 5% increase in compressive and spilt tensile strength.Hence 1% concentration of steel fibers is found to be the optimum dosage for his project work.
9. geopolymers made with 50% metakaolin and 50% fly ash and reinforced by 2% carbon fibers exhibit favourable bending and compressive strength both at ambient temperature and after high temperature exposure, thus it is suitable for structural members required for good fire performance.
10. The volume fraction of 1% is gives more compressive strength and spilt tensile strength.
11. Compressive strength of the geopolymer concrete decreases with increase in the ratio of water to geopolymer solids by mass.
12. The workability of the geopolymer concrete in fresh state increases with the increase of extra water added to the mix.
13. Compressive strength of 100% flyash was give more strength compared then 100% kaolin but 100% OPC gives more strength then 100% flyash.
14. when we added steel fibers to the SFRGPC achieves more ductility than SFRCC. Based on a definitive load conveying limit SFRGPC has 1.14 times less split width than SFRCC. The GPC specimen has more stiffness compared to CC, SFRCC, SFRGPC.

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