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STUDY OF GEOPOLYMER CONCRETE USING GRANITE SLURRY AS SAND REPLACEMENT IN BEAM COLUMN JOINT

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Abstract - *The present examination goes for concentrate the properties of geo-polymer concrete (GPC) utilizing granite slurry (GS) as sand supplanting and compare with Geopolymer concrete with 100% sand. In this investigation, River sand was supplanted with various dose of granite slurry (10%, 20%, 30%, 40% and half). Fly ash and Ground granulated blast furnace slag (GGBS) are utilized at 30:70 proportions as geo-polymer covers. Mix of sodium hydroxide and sodium silicate arrangement is utilized as an alkali activator at a molar proportion of 0.56. Compressive quality and split tensile properties were examined following 28 days of restoring at surrounding room temperature. From the outcome we casted beam section joint and tried under half cyclic loading. From the results, it is revealed that the studied mechanical properties were increased with the increasing replacement level of GS up to 30% and decreasing trend of these properties were observed at 50% replacement level. The more dose of granite slurry the less will be strength. It is concluded that optimum replacement level (30%) of Granite Slurry can be used in place of sand and can save the natural resources.*

KeyWords: Geopolymer concrete, granite slurry, compressive strength, splitting tensile strength, load-deflection curve, Stiffness, Half cyclic loading.

1. INTRODUCTION

It is generally realized that the creation of Portland cement devours extensive vitality and in the meantime contributes a vast volume of CO2 to the climate. The cement production is considered in charge of a portion of the CO2 outflows, on the grounds that the generation of one ton of Portland cement discharges around one ton of CO2 into the air. However, Portland cement is still the main binder in concrete construction prompting a search for more environmentally friendly materials. Several efforts are in progress to supplement the use of Portland cement in concrete in order to address the global warming issues. These include the utilization of supplementary cementing materials such as fly ash, silica fume, ground granulated blast furnace slag, rice-husk ash and metakaolin and the development of alternative binders to Portland cement. One conceivable option is the utilization of alkali activated binder and industrial by-product containing silicate materials In 1978, Davidovits (1999) proposed that binders could be produced by a polymeric reaction of alkaline liquids with the silicon and the aluminum in source materials of geological origin or by-product materials such as fly ash, GGBS and rice husk ash. He termed these binders as geopolymers. The most well-known modern results utilized as fastener materials are fly fiery remains (FA) and ground granulated impact heater slag (GGBS). In numerous explores it has been demonstrated that the measure of GGBS can build the quality as that of Portland cement. In some piece of India the measure of sand is diminishing gradually so here we have halfway supplanted with various dose of granite slurry to see about the quality strength picked up.

1.1 Geo polymer

The term Geo-polymer was found by Chelokovski in 1950. Geo-polymer concrete was first made by Davidovits (in 1978) and by using inorganic locks by built structures and with an ill defined microstructure. Alumina-silicate is wealthy in Si and Al. Geo-polymers are the thing that is incredible in association with other Al and Si materials. Al and Si affiliation isn't as much as meeting of solids in geo-polymerisation. The preparing condition of geo polymer concrete is same as regular concrete except the blending operation wherein ordinary concrete we utilize water, in geo polymer concrete we utilize the alkaline solution known as Alkaline Activated Solution (AAS).

1.2 Structural configuration

The shape, estimate, and basic game plan must have a constant load path for transmission of seismic force, which would happen because of the inertia force of particular components to the ground. The section 7 of IS 1893 (section I):2002 and segment 4.4 of IS 4326:1993 enroll the great building setup frameworks. A portion of the past obliterating seismic tremor demonstrated that beam column joint, particularly the outside ones go about as one of the weakest. To examine the conduct of frail beam column joint and to observe the basic parameters between the geopolymer concrete with granite slurry as sand supplanting and geopolymer concrete with sand. Ductility assumes an essential job amid the event of seismic tremors.

2. Research Significance

As we already know day by day the amount of fine aggregate is decreasing so mechanized sand (m-sand) has been made and various researches has also been done. In this investigation an attempt has made to study the mechanical properties of geo-polymer concrete by replacing the fine aggregate using granite slurry at different levels (10%, 20%,30%, 40% and 50%) and along with the result of the compressive strength and tensile strength we have cast 4 beam column joint and we will test it under half cyclic loading. This study is focused on the compressive strength and splitting tensile strength properties of GPC at different curing periods at ambient room temperature. Then we will compare the beam column joint of geo polymer with granite slurry and geo-polymer concrete with river sand by using 2 numbers of LVDT during cyclic loading and compare load deflection behavior, ductility, stiffness degradation with geopolymer concrete with river sand.

3. MATERIALS AND METHODS

Geo Polymer Concrete was comprised of low calcium fly (Class F), GGBS, coarse aggregate, fine aggregate (river sand / granite slurry), basic arrangement (RGL). Crushed granite stones having normal size 20 mm and Natural River sand were utilized as coarse aggregate and fine aggregate respectively. Both the coarse and fine aggregate utilized were adjusting to Zone II of IS 383(1970). The material properties of coarse and fine aggregate are appearing alongside the geo polymer solid we have utilized AAS (RGL1).

Table 1 Parameters of specimens

Parametres	Granite Slurry	Fine Aggregate (River Sand)	Coarse Aggregate
Nominal maximum size	4.75 mm	4.75 mm	20 mm
Specific gravity	2.76	2.36	2.85
Fineness modulus	2.19	4.23	3.07
Water absorption	1.2%	1%	0.24

3.1 FLY ASH

The waste material that we procured from the ignition of pulverized coal, which is gathered by mechanical means from the gases of thermal power plants. We have used the fly ash that is present in CACR laboratory. In this trial work, the fly ash which we have utilized is low calcium based fly ash. This fly ash helps in workability, opposing substance and decrease thermal cracks. The compound arrangement of fly fiery debris is $SiO2$ = 49.45, Al_2O_3 = 29.61, Fe_2O_3 = 10.72, CaO= 3.47, MgO= 1.3, Na_2O= 0.31, K_2O = 0.54, TiO_2 = 1.76, Mn_2O_3 = 0.17, SO_3= 0.27, P_2O_5 = 0.53. The particular gravity of fly powder is 2.1 and the fineness modulus is 8%.

3.2 GGBS (Ground Granulated Blast Furnace Slag)

GGBS ash is replaced with concrete in geo polymer concrete. It gives better workability without an increase in water content and decrease heat of hydration. It is a byproduct of Iron and steel making in the molten stage. The chemical composition of GGBS is SiO_2 = 33.45, Al_2O_3 = 13.46 Fe_2O_3 = 0.31, CaO= 41.7, MgO= 5.99, Na_2O= 0.16, K_2O= 0.29, TiO_2 = 0.84, Mn_2O_3 = 0.40, SO_3 = 2.74. The specific gravity of GGBS is 2.86 and the fineness modulus is 14%.

3.3 ALKALINE LIQUID

It is also known as AAS. AAS content is made by 1:1. For making AAS we need 50% lye (caustic soda) = 1, Na_2Si0_3 (sodium silicate) have molar ratio = 2, which comprises of SiO_2 = 30%, Na_2O = 15%, H_2O = 55%. The final molar ratio Na_2SiO_3/NaOH = 0.56 as the alkaline liquid to activate the source material and those are commercially available.

3.4. FINE AGGREGATE

3.4.1. Sand

Natural river sand is used as fine aggregate. As per IS: 2386 (Part III)-1963, the bulk specific gravity in oven dry condition and water absorption of the sand are 2.36 and 1% respectively. The fineness modulus of sand is 4.23.

3.4.2 Granite slurry

Granite slurry is used as secondary material and in this experiment we are replacing river sand with granite slurry which is collected from granite cutting industry. As per IS: 2386 (Part III)-1963 , the bulk specific gravity in oven dry condition and water absorption of the fine aggregate are 2.76 and 1.2% respectively.

3.5 COARSE AGGREGATE

Crushed granite stones of size 20mm are used as coarse aggregate. As per IS: 2386 (Part III)-1963, the bulk specific gravity in oven dry condition and water absorption of the coarse aggregate are 2.85 and 0.24% respectively. The fineness modulus of 20mm coarse aggregates is 3.07.

4. MIXTURE PROPORTIONS

Here we will take fly ash and GGBS of 30:70 and partial replacement of fine aggregate with granite slurry where we took different dosage of granite slurry of 10%, 20%, 30%, 40%, and 50%. The mix proportion for the geopolymer concrete 0.3:0.7:1.24:2.70:0.425.

5. PREPARATION OF TEST SPECIMEN

We have cast concrete cubes which are of size 150 mm x 150mm x 150 mm and cylinder of size 150 mm x 300 mm. We will mix the specimen according to the mix ratio. The 1st specimen will be having 100% sand with geo-polymer concrete in which the cement has been completely replaced with fly ash and GGBS i.e taken in the ratio of 30:70. Next specimen will be having different dosage of granite slurry with partial replacement of river sand. It was mixed with alkaline activated solution in place of water because this is the difference between geo-polymer concrete with 100% sand and 30% granite slurry.

6. TEST METHODS

We will test all the cubes and cylinder for 28 days under compression and split tensile strength test and after achieving the optimum compressive strength and tensile strength we will cast beam column joint with that mixture and test it under half cyclic loading.

6.1 RESULTS AND DISCUSSION

6.1.1 COMPRESSIVE STRENGTH

Compressive strength values of GPC mixes (100% Sand, 10% GS+ 90% Sand, 20% GS + 80% Sand, 30% GS + 70% Sand, 40% GS + 60% Sand, 50% GS + 50% Sand) at different curing periods are shown.

Table 2 Compressive strength of different geo-polymer concrete mixes

MECHANICAL PROPERTY	**MIX TYPE (28 DAYS)**					
COMPRESSIVE STRENGTH (N/mm^2)	100 % SAND	10% +90%	20% +80%	30% +70%	40% +60%	50% +50%
	50.28	52.71	48.99	57.86	52.88	43.28

From the results, it is observed that compressive strength values of GPC mixes were increased with the increasing replacement levels of GS from 30% at all ages as in the case of 30% GS+70% RS. But these values were decreased at the 50% replacement level of GS as shown.

6.1.2 SPLIT TENSILE STRENGTH

Split tensile strength values of GPC mixes (100% Sand, 10% GS+ 90% Sand, 20% GS + 80% Sand, 30% GS + 70% Sand, 40% GS + 60% Sand, 50% GS + 50% Sand) at different curing periods are shown.

Table 3 Split tensile strength of different geo-polymer concrete mixes

MECHANICAL PROPERTY	MIX TYPE (28 DAYS)					
Split tensile strength (N/mm^2)	100% SAND	10%+90%	20% +80%	30%+70%	40%+60%	50% +50%
	3.3	2.97	3.03	3.52	3.31	1.42

From the results, it is observed that split tensile strength values of GPC mixes were increased with the increasing replacement levels of GS from 30% GS + 70% sand. This is due to the increase in compressive strength. But these values were decreased at the 50% GS + 50% SAND replacement level of GS as shown.

7. DETAILS OF SPECIMEN

The details of the specimen have been taken from the research experiment "Comparative study of geo-polymer concrete with steel fibers in beam column joints". The cross areas of beam column joints are 1000 mm x 150 mm x 150mm and 600mm x 150mm x 150 mm. The column was fortified with 4#12ϕ across high return quality twisted (HYSD) bars and the pillar was furnished with 2#10 ϕ HYSD bars each at top and 2#12 ϕ at the base. HYSD bars of 8 mm diameters were utilized as transverse ties in the segment and stirrups in beams. The general measurements and support points of interest of joint examples are appearing. Geo-polymer concrete with river sand and geo-polymer concrete with partial replacement of river sand with granite slurry joints are assigned as GBRS and GBGS separately. Those beam column joints were demoulded after 24hrs and after that cured under the ambient temperature for 28 day

8. TESTING OF BEAM COLUMN JOINT SPECIMEN

The beam column joint was cured under ambient temperature for 28days. The column was settled in both the end where as the beam go about as a cantilever one. The segment was scored by two steel plates. The beam end was subjected to half cyclic loading utilizing 500 kN hydraulic jack associated with the load cell through the plunger of the jack. The photo of the test setup is has been given in the figure below. In this experiment we tested considerably cyclic loading. Half cyclic loading was connected at the end of the beam which is loaded at first increment and then unloaded and after that again reloaded for the following augmentation of loading which is done for different beam column joint in a similar way. We have augmented the beam for each 1 kN. The dial gauge is utilized to gauge the redirection of the beam where the column was fixed at both the end. The beam was connected 120 mm separate from the free end of the beam. The LVDT's are set 16.5 mm and 12 mm from the free end of the beam. With the assistance of crack detection magnifying lens we can discover the small crack width with a minimum tally of 0.02mm. This strategy was done continuously till the failure of the joints.

Fig 1 Reinforcement and casted Beam column joint

Fig 2 Test setup

9. RESULTS AND ANALYSIS

The recorded data were plotted and from those data, we will compare the load deflection graph, ductility, stiffness, initial and final cracks i.e. geopolymer concrete with 100% sand and Geopolymer concrete with 30% Granite slurry + 70% sand as it has acquired optimum compressive strength and split tensile strength.

9.1 LOAD DEFLECTION CURVE

Two beam column joint from both geopolymer concrete with 100% sand and partial replacement of sand by 30% Granite slurry are cast and tested under half cyclic load. In the experiment the beam column joints have failed on the last cycles of loading.

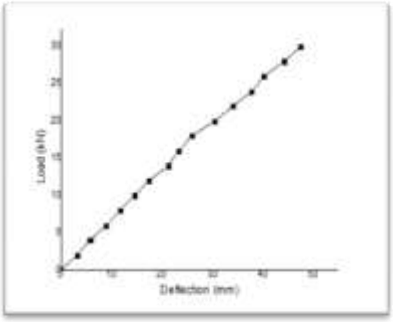

Chart 1 Load deflection curve of GPC with 100% sand

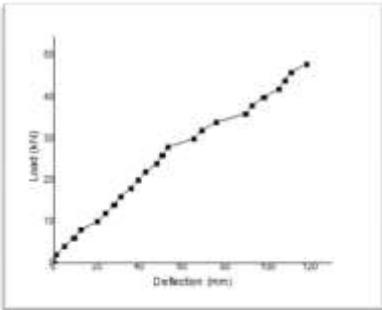

Chart 2 Load deflection curve of GPC with 30% GS +70%sand

9.2 DUCTILITY

A quantitative measure of ductility is calculated from the load deflection curve. The ductility factor is calculated by the horizontal distance between the initial yield point and the ultimate deflection which are from the load deflection curve.

Ductility ratio = ultimate deflection / initial yielding deflection.

In this chart we can see that the Geopolymer concrete is of same materials but in one specimen we have mixed geopolymer materials with granite slurry as partial replacement of river sand. The specimen with highest ductility is with granite slurry of 30% with replacement of river sand.

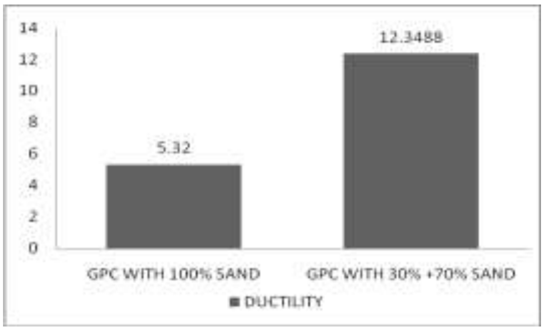

Chart 3 Ductility for all types of specimen

9.3 STIFFNESS

On account of beam column joint, stiffness gets decreased when the joints are subjected to cyclic loading. When the cyclic loading is applied to the concrete or steel materials it will be subjected to repeated, forward, backward. This will result in small micro cracks in the beam column joints. In this way there will be deformed in the joints which is the root cause of the degradation of the stiffness in the beam column joints whenever subjected to cyclic loading. The incline of the line is known as secant stiffness. We will notice that as the numbers of cycles are increasing the stiffness is decreasing gradually. But in the second and third cycle the degradation of stiffness is clearly visible. The procedure selected to determine the degradation of stiffness is described in fig.

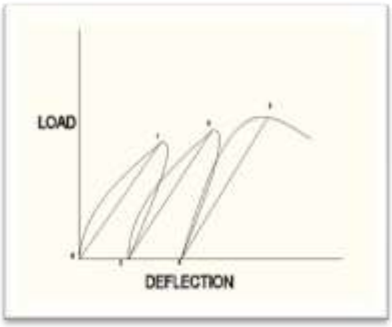

Fig 3 Procedure for calculation of secant stiffness.

Utilization of half cyclic loading on the beam column joint causes degradation of stiffness in the beam column joints. This decrease in stiffness can be evaluated by computing secant stiffness. The stiffness degradation of the examples is given here. Stiffness can be estimated by the proportion of load and deflection. From the Figure it might be noticed that Geopolymer with 100% sand has less stiffness then geopolymer concrete with 30% granite slurry with 70% sand. Here the blue graph line depicts the geopolymer concrete with 30% GS +70% sand and black line depicts geopolymer concrete with 100% sand.

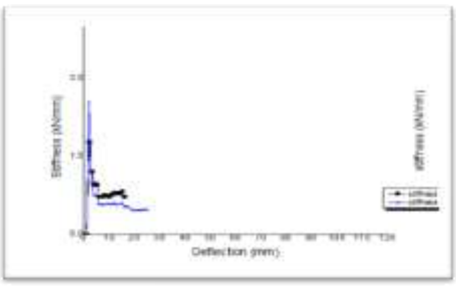

Chart 4 Degradation of stiffness

9.4 INITIAL LOAD AND ULTIMATE LOAD

The First crack load was resolved from the load deflection plot. The initial crack load and final crack load of all the tried examples is given.

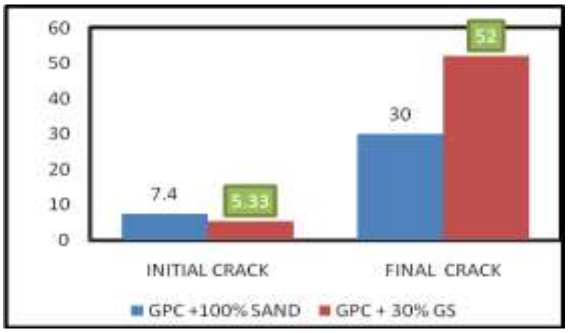

Chart 5 Crack load

10. CONCLUSIONS

Based on the results presented in this investigation the following important conclusions may be observed.

1. It is observed that an increasing trend has been observed in compressive strength of GPC mixes up to 30% replacement level of GS.

2. It is observed that an increasing trend has been observed in splitting tensile strength of GPC mixes up to 30% replacement level of GS.

3. In ductility, the GPC with 30% granite slurry specimen is more ductile than GPC with 100% sand.

4. At the rate of degradation of stiffness the GPC with 30% granite slurry has more stiffness in contrast with GPC with 100% sand.

5. The length of the cantilever beam in a beam - column joint is 600 mm. At 500mm we will put load. In beam column joint the point load is 15 kN as per design load. The ultimate load of GPC with 100% sand beam-column joint is 30 kN. The ultimate load of geopolymer concrete with 30% granite slurry with 70% sand beam column joint is 48 kN.

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