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Impact of M Sand and Olivine Sand in Assessment of Mechanical Properties of Geo Polymer Concrete at High Temperature

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Abstract- Geopolymer Concrete is a type of concrete that is made by reacting aluminate and silicate bearing materials with a caustic activator. Commonly, waste materials such as fly ash or slag from iron and metal production are used, which helps lead to a cleaner environment. This is because the waste material is actually encapsulated within the concrete and it also does not have to be disposed of as it is being used. This paper focuses on varying the proportions of M sand and Olivine sand (50:50, 60:40, 70:30) in geopolymer concrete and evaluating its strength characteristics at extreme temperature by adding fibres at different proportions with 0.2%,0.4%,0.6%,0.8%,1.0%. The alkaline activator solution used is a mixture of 10 molar Sodium hydroxide and Sodium silicate in the ratio 1:2. The specimens are cured using oven at 60°C.The mechanical strength properties such as compressive strength, split tensile strength and flexural strength tests are conducted at its 28 day. The test results revealed that very high early age strength was achieved in all the proportions, noticeably in 70:30 proportions with 0.8% addition of fibres.

Keywords- GGBS-Ground Granulated Blast Slag, GPC-Geopolymer Concrete, FA-Flyash, QRD-Quarry Rock Dust, M-Sand-Manufacture Sand, O-Sand-Olivine Sand.

I. INTRODUCTION

Geopolymer concrete does not require heat to make it and it does not produce carbon dioxide. Standard Portland Cement based concrete requires both heat + CO2. The greenhouse gas emissions are about 1.35 billion tons annually which is about 7% of the total greenhouse gas emissions. Moreover, cement production also consumes significant amount of natural resources. Also, Ordinary Portland Cement (OPC) is traditionally used as a binder for the fine and coarse aggregates. Therefore, to reduce the pollution, it is necessary to reduce or replace the cement from concrete by other cementitious materials like fly ash and GGBS.

The main motive is to make the geo-polymer concrete greener by using ambient curing conditions by mixing ground granulated blast furnace slag (GGBS) with Fly ash as a binder for the exorbitant increase in strength in the concrete. Since water plays a major role in any concrete and ineptly water is liberated during the polymerization process in geo-polymer concrete, it is necessary to develop a new mix design procedure for geo-polymer concrete to achieve the desired strength and benedictory workability. Hence, geo-polymer concrete mix design procedure is proposed on the basis of quantity of water to achieve required degree of workability, grading of fine aggregate, solution to fly ash ratio by 0.35, water to geo-polymer binder ratio of 0.35, sodium silicate to sodium hydroxide ratio by 2, and tested after ambient curing for 24 hours and tested for the compressive, split tensile and flexural strengths after 28 days.

II. MATERIALS USED

Flyash

Fly ash is a by-product from burning pulverized coal in electric power generating plants. During combustion, mineral impurities in the coal (clay, feldspar, quartz, and shale) fuse in suspension and float out of the combustion chamber with the exhaust gases. As the fused material rises, it cools and solidifies into spherical glassy particles called fly ash. Fly ash is collected from the exhaust gases by electrostatic precipitators or bag filters. Two types of fly ash are commonly used in concrete. Class C and Class F. Class C are often high-calcium fly ashes with carbon content less than 2%; whereas, Class F are generally low-calcium fly ashes with carbon contents less than 5% but sometimes as high as 10%. In general, Class C ashes are produced from burning sub-bituminous or lignite coals and Class F ashes bituminous or anthracitic coals.

Sodium Hydroxide

It is highly soluble in water, and readily absorbs moisture and carbon dioxide from the air. It forms a series of hydrates $NaOH \cdot nH_2O$. The monohydrate $NaOH.H_2O$ crystallizes from water solutions between 12.3 and 61.8 °C. The commercially available "sodium hydroxide" is often this monohydrate, and published data may refer to it instead of the anhydrous compound.

Sodium Silicate Solution

Sodium silicate is also the technical and common name for a mixture of such compounds, chiefly the metasilicate, also called water glass, water glass, or liquid glass. The product has a wide variety of uses, including the formulation of cements, passive fire protection, textile and lumber processing, manufacture of refractory ceramics, as adhesives, and in the production of silica gel. The commercial product, available in water solution or in solid form, is often greenish or blue owing to the presence of iron-containing impurities.

Olivine Sand

Olivine gemstones are called peridot and chrysolite. Olivine rock is usually harder than surrounding rock and stands out as distinct ridges in the terrain. These ridges are often dry with little soil. The Nominal Specific gravity of Olivine sand is 3.2 to 3.4 and the bulk density is 1.45 to 1.75 g/cm3 . Olivine is named for its typically olive-green color, thought to be a result of traces of nickel, though it may alter to a reddish color from the oxidation of iron. Olivine occurs in both mafic and ultramafic igneous rocks and as a primary mineral in certain metamorphic rocks.

M-Sand

Manufactured sand (M-Sand) is a substitute of river sand for concrete construction. Manufactured sand is produced from hard granite stone by crushing. The size of manufactured sand (M-Sand) is less than 4.75mm. Manufactured sand is an alternative for river sand. Due to fast growing construction industry, the demand for sand has increased tremendously, causing deficiency of suitable river sand in most part of the word. Due to the depletion of good quality river sand for the use of construction, the use of manufactured sand has been increased. Another reason for use of M-Sand is its availability and transportation cost. Specific gravity of M sand nominal value is 2.4 to 2.9 as per IS 383-1970. The Fineness modulus nominal value is 2.2 to 3.2 as per IS 383-1970.

III. SPECIMEN PREPERATION AND TESTING

Geopolymer concrete specimen were prepared by mixing the dry materials in a pan mix for M30 grade of concrete. The dry materials were mixed for about 1 minute and alkaline activator solutions were added in the pan and mixed for about 2 minutes until the mixture combined well and became homogeneous. Basic material properties test like specific gravity, sieve analysis, water absorption test was conducted on olivine sand, M-sand, Coarse aggregate and flyash. Compressive strength and split tensile strength tests were conducted for all the mixes 28 days. All the test specimens were kept at extreme temperature in oven at 60°C.Cubical specimen of size 150 x 150 x 150 mm was casted and tested for compressive strength. A cylinder size 100 x 200 mm was casted and its split tensile strength was evaluated.

IV. PRERPERATION OF ALKALINE ACTIVATOR SOLUTION

Sodium hydroxide pellets are dissolved in distilled water to produce 10M of Sodium hydroxide solution. Then Sodium hydroxide solution in mixed with Sodium silicate solution to form the Alkaline activator solution. The Alkaline activator solution is prepared one day before mixing the concrete. After dry mixing of M-Sand and Olivine Sand, coarse aggregate and fly ash. Polypropylene fibres are added in different proportions as 0.2%,0.4%,0.6%,0.8% and 1%. Alkaline activator solution was added to it. After that wet mixing was done for 5 minutes. Add 5% to 10%extra water for getting workable GPC.

V. COMPRESSIVE STRENGTH TEST

The aim of these experimental tests is to determine the maximum load carrying capacity of test specimen. Mix proportions with 50 : 50, 60 : 40, 70 : 30 in addition of polypropylene fibres in different percentage are added into the mix and tested after subjected to oven curing at 60°C. The load was applied in uniform rate until the sample gets failed then the load at failure has been noted.
Compressive strength = Failure load / Cross sectional area of the cube.

VI. SPLIT TENSILE STRENGTH TEST

It is the standard to determine the tensile strength of concrete in an indirect way. This test could be performed in accordance with IS: 5816-1970. A standard test cylinder of concrete specimen is placed horizontally between the loading surfaces of compression testing machine. Concrete cylinders split in to two halves along the vertical plane due to indirect tensile stresses generated by Poisson's effect.

The load was applied in uniform rate until the sample gets failed then the load at failure has been noted.
Tsp = 2p / πDL Where,
p = Breaking load, N
D = Diameter of specimen, mm
L = Length of the specimen, mm
8.. FLEXURAL STRENGTH TEST

The load was applied to the upper most surface by two point bending in UTM of 4000KN capacity. The axis of the specimen was carefully aligned with the axis of the loading device. The load was applied without shock and increasing continuously at a rate of 1800N/min. The load was increased until the specimen got failed, and the maximum load applied to the specimen during the test was recorded.

The flexural strength of the specimen was calculated using the equation

fr = PL/BD2

where,
fr = flexural strength
P = maximum load applied to the specimen
L = Supported length of the specimen
B = width of the specimen
D = depth of the specimen

VII. RESULTS AND DISCUSSION

Table.1. 28th day Mechanical Strength Results of 50%MS and 50%OS

SI.No	Percentage of PF	Compressive Strength at 28 days (MPa)	Split Tensile Strength at 28 days (MPa)	Flexural Strength at 28 days (MPa)
1	0.2	40.67	4.28	5.92
2	0.4	43.02	4.45	6.27
3	0.6	46.70	4.78	7.24
4	0.8	47.91	4.81	7.90
5	1.0	45.23	4.63	7.15

Table.2. 28th day Mechanical Strength Results of 60%MS and 40%OS

Sl.No	Percentage of PF	Compressive Strength at 28 days (MPa)	Split Tensile Strength at 28 days (MPa)	Flexural Strength at 28 days (MPa)
1	0.2	41.32	4.56	6.02
2	0.4	44.62	4.62	6.87
3	0.6	47.81	4.88	7.44
4	0.8	48.06	4.94	8.16
5	1.0	46.13	4.70	7.23

Table.3. 28th day Mechanical Strength Results of 70%MS and 30%OS

Sl.No	Percentage of PF	Compressive Strength at 28 days (MPa)	Split Tensile Strength at 28 days	Flexural Strength at 28 days (MPa)
1	0.2	42.39	4.86	6.11
2	0.4	44.95	4.79	6.96
3	0.6	48.11	4.98	7.57
4	0.8	49.18	5.01	8.46
5	1.0	46.77	4.81	7.35

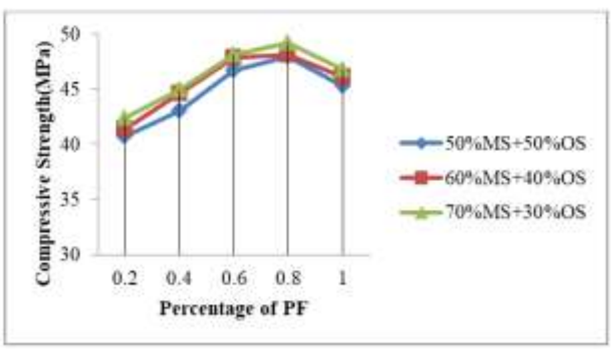

Fig.1 Compressive Strength with different proportions of PF,MS &OS

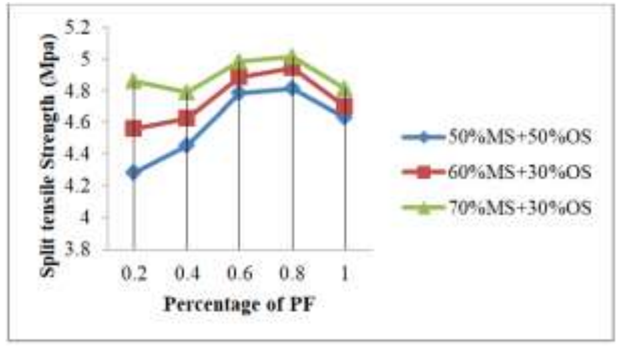

Fig.2 Split Tensile Strength with different proportions of PF,MS &OS

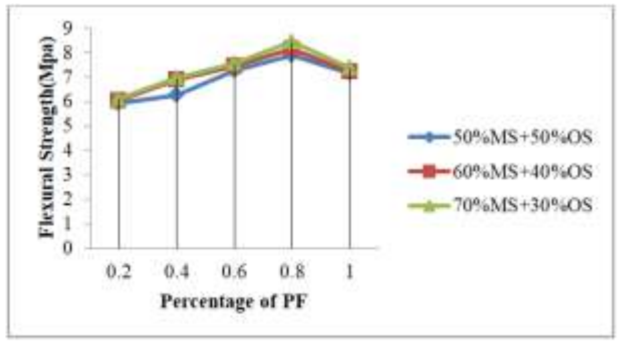

Fig.3 Split Tensile Strength with different proportions of PF,MS &OS

VIII. CONCLUSION

It has been observed that by increasing the M Sand content the strength values tend to increase. High strength is achieved at 10M itself with 1:2 ratio of Sodium hydroxide to Sodium silicate solution. Hence from the results, mix ratio of 70% and 30% of M sand and Olivine sand is concluded as exhibiting better mechanical strength results with 0.8% addition of polypropylene fibres compared to all other fibre fractions. While comparing to three proportions 70% MS+30%OS shows better results compared to other combinations at extreme temperature compared to ambient temperature.

REFERENCES

1. Rangan, BV 2008, 'Fly ash based geopolymer concrete', Research Report GC4Curtin University of Technology Perth, Australia, pp. 1-12.
2. Joseph Davidovits2013, 'Geopolymer Cement A Review', pp. 1-11.

3. VijayaRangan, B 2010, 'Fly ash-based geopolymer concrete', Proceedings of the International Workshop on Geopolymer Cement and Concrete, pp. 68-106.
4. Davidovits, J 1991, 'Geopolymers: Inorganic polymeric new materials", Journal of Thermal Analysis, pp.1633-1656.
5. Anupam Bhowmick & Somnath Ghosh 2012, 'Effect of synthesizing parameters on workability and compressive strength of fly ash based geopolymer mortar', International Journal of Civil and Structural Engineering, vol. 3, no. 1, pp. 168-177.
6. Hardjito, D, Wallah, SE, Sumajouw, DMJ &Rangan, BV 2005, 'Introducing flyash-based geopolymer concrete', Manufacture and Engineering Properties, 30th Conference on our world in Concrete & Structures, Singapore, pp. 1-9.
7. Djwantoro Hardjito, Steenie E Wallah, Dody M Sumajouw & VijayaRangan, B 2014, 'On the development of fly ash-based geopolymer concrete', ACI materials Journal, vol. 101, no. 6, pp. 467-471.
8. Wallah, SE &Rangan, BV 2006, 'Low-calcium flyash-based geopolymer concrete': Long-term properties', pp. 1-97.
9. Ilangovan, R, Mahendran, N &Nagamani, K 2008, 'Strength and durability properties of concrete containing quarry rock dust as fine aggregate', ARPN Journal of Engineering and Applied Sciences, vol. 3, no. 5, pp. 20-26.
10. Valeria Corinaldesi & GiacomoMoriconi 2009,'Influence of mineral additions on the performance of 100% recycled aggregate concrete', Construction and Building Materials, vol.23, no. 8, pp. 2869-2876.
11. Aaron DariousVaz, Donal Nixon D Souza, Noothan Kaliveer, Abdul Aleem, MI & Arumairaj, PD 2012, 'Optimum mix for the geopolymer concrete', Indian Journal of Science and Technology, vol. 5, no. 3,pp. 2299-2301.
12. Abhishek.C, Ayachiti Pranav.B, Nikam, Siddharth.N PISE, Akash.D Shah &Vinayak H Pawar 2016, 'Mix design of fly-ash based geopolymer concrete', International Journal of Scientific and Research Publications, vol. 6, no. 2, pp. 381-385.
13. Jonathan Tailby, Kenneth, JD & Mackenzie 2010, 'Structure and mechanical properties of alumino silicate geopolymer composites with portland cement and its constituent minerals', Cement and Concrete Research, vol. 40, no. 05, pp. 787-794.
14. Parthiban, K &Saravana Raja Mohan, K 2014, 'Effect of sodium hydroxide concentration and alkaline ratio on the compressive strength of slag based geopolymer concrete', International Journal of ChemTech Research, vol. 6, no.4, pp. 2446-2450.
15. Shi-Cong Kou, Chi-sun Poon & Francisco Agrela 2011, 'Comparisons of natural and recycled aggregate concretes prepared with the addition of different mineral admixtures', Cement and Concrete Composites, vol. 33, no. 8, pp. 788-795.
16. Kavipriya S 2019,'Mechanical Strength Properties of Geo Polymer Concrete incorporating Quarry Rock Dust and Recycled Coarse Aggregate', International Journal of Recent Technology and Engineering, vol.8,no.4,pp.8414-8419.
17. Kavipriya S Kannan S Gowtham S 2020, 'Evaluating Optimum Strength of Geopolymer Concrete using Quarry Rock Dust with inclusion of Natural and Hybrid Fibers Under Ambient Curing', International Journal of Engineering and Advanced Technology, vol.9, no.6, pp.1-5.