© January 2024| IJIRT | Volume 10 Issue 8 | ISSN: 2349-6002

An Experimental Study on Geopolymer Concrete with Partial Replacement of Fine Aggregate using Iron Steel Slag

P. Logeshwari[1], Dr.P. Senthamilselvi[2]
[1]*PG Student, M.E Structural Engineering, Government College of Engineering, Salem.*
[2]*Associate Professor, Dept. of Civil Engineering, Government College of Engineering, Salem*

***Abstract*— This research work aims to study further sustainability to the cement less geopolymer concrete by partially replacing fine aggregate by iron Steel slag. Geopolymer concrete is one of the building materials that has become more popular in recent years because it is significantly more environmentally friendly than standard concrete. Geopolymer concrete usually includes fly ash, fine aggregate and coarse aggregate activated by means of alkaline liquids like sodium silicate and sodium hydroxide which is effective in oven curing. Further the Steel slag which is a byproduct obtained from Steel manufacturing industry can be used as a replacement to fine aggregate. By using this for construction purposes, it reduces environmental pollution. Geopolymer concrete of grade M25 with Steel slag as a partial replacement to fine aggregate was studied for its compressive behavior and compared with conventional cement concrete. The study derived that in all stages, the performance of the geopolymer beam with Steel slag was marginally better than the conventional beam with fine aggregate. This investigation work encourages the use of Steel aggregate ash in concrete with its inherent structural advantage, easy availability.**

Key words: Geopolymer, Steel slag, sodium hydroxide (NaOH), sodium silicate (Na2SiO3), fine aggregate, coarse aggregate.

I. INTRODUCTION

Environmental issues resulting from cement production have become a major concern today. To develop a sustainable future, it is encouraged to limit the use of this construction material that can affect the environment. Cement replacement material was proposed to partially replace cement portion in concrete. Geopolymer is the best solution to reduce the use of cement inconcrete. Geopolymer is a hardened cementitious paste made from fly ash, alkaline solution and geological source material. The development of fly ash and steel slag as the source material for geopolymer concrete was studied through the observation of the hardened specimen strength and durability properties. Steel slag is a byproduct of steel making, is produced during the separation of the molten steel from impurities in steel making furnaces. The slag occurs as a molten liquid melt and is a complex solution of silicates and oxides that solidifies upon cooling. The Steel slag produced during the primary stage of steel production is referred to as furnace slag or tap slag.

II. MATERIAL PROPERTIES

A. FLY ASH

Low calcium fly ash (Class F) is one of the deposits produced in the burning of coal. In this work, Class F fly ash is to be used which was collected from Mettur Thermal Power Station, Salem. Generally, Class F fly ash providesgood pozzolanic activity and it contains less than 10% of lime (CaO).

Table. 1 Properties of fly ash

DESCRIPTION	VALUE
CONSISTENCY	29%
INTIALSETTING TIME	50min
FINENESS	8%
SPECIFIC GRAVITY	2.2

B. GGBS

Ground Granulated Blast Furnace Slag which is a by-product of iron manufacturing industry is an accepted mineral admixture for use in concrete. This granulated material when further ground to less than 45micron is called Ground Granulated Blast Furnace Slag (GGBS).

Table.2 Properties of GGBS

DESCRIPTION	VALUE
CONSISTENCY	32%
INTIALSETTING TIME	50min
FINENESS	6%
SPECIFIC GRAVITY	2.45

C. STEEL SLAG

Steel slag is a byproduct generated during the steel making process. It is produced when impurities present in the raw materials used in steel production, such as iron ore, coke and limestone are oxidized and form a molten slag. This slag is a complex mixture of silicates and oxides that floats on the surface of the molten steel. The cost of slag is almost 50% of that of natural aggregate also it is economical to use the steel industrial waste product.

Table.3 Properties of Steel slag

DESCRIPTION	VALUE
BULK DENSITY	1260 kg/m3
WATER ABSORPTION	1.2%
FINENESS	8%
SPECIFIC GRAVITY	2.63

D.FINE AGGREGATE: The fine aggregates used is manufactured aggregates (M- Sand) with a uniform grade. The fine aggregates with particle size 20 mm are generally employed.

Table.4 Properties of Fine aggregate

DESCRIPTION	VALUE
BULK DENSITY	1573 kg/m3
WATER ABSORPTION	1.5%
FINENESS	10%
SPECIFIC GRAVITY	2.53

E. COARSE AGGREGATE: The size of the aggregates used is 20mm.Well graded aggregates either round or cubical shape are a best choice. The Coarse aggregate used was 20mm size crushed granite stone.

Table.5 Properties of Coarse aggregate

DESCRIPTION	VALUE
BULK DENSITY	1370 kg/m3
WATER ABSORPTION	0.8%
IMPACT VALUE	19.6%
SPECIFIC GRAVITY	2.78
CRUSHING VALUE	19.6%

III MIX PROPORTION

The mix calculations per unit volume of concrete shall be as follows:

a) Volume of concrete =1m^3

b) Volume of fly ash = (372/(2.2x1000)) = 0.1690 m^3

c)Volume of alkaline liquid = 0.18658m^3

c) Volume of all aggregates = [a-(b+c)] = [1-(0.1690+0.18658)] = 0.6454m^3

d) Mass of coarse aggregate = d x vol of CA x specific gravity of CA x 1000 = 0.6454 x 0.62x 2.78 x 1000 = 1111.72 kg

e) Mass of fine aggregate = d x vol of FA x specific gravity of FA x 1000 =0.6454x0.38x2.53x1000 =620.48 kg

Fly ash = 372 kg/m^3

Alkaline liquid =186 kg/m^3

Fine aggregate =620.48 kg/m^3

Coarse aggregate = 1111.72 kg/m^3

Alkaline liquid–fly ash ratio =0.5

IV. EXPERIMENTAL INVESTIGATION

This chapter deals with the strength test on the specimen were found by the trial mixes and the control mix was selected. In compressive strength, the optimum percentage of Steel slag was found by replacing the fine Aggregate by 0%, 5%,10%, 15% and 20% of steel slag in geopolymer concrete.

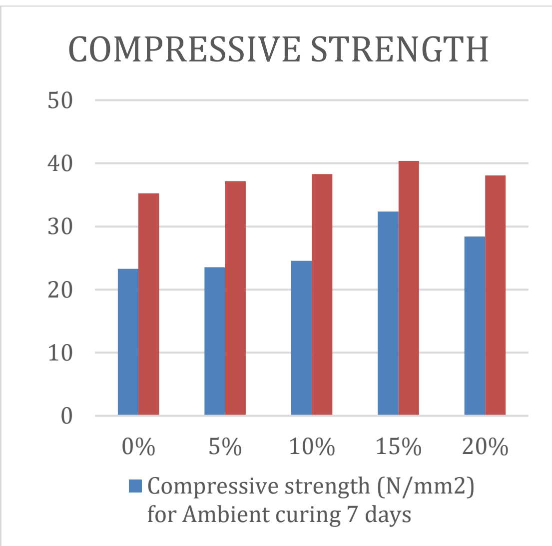
COMPRESSIVE STRENGTH

An important property of hardened concrete is the compressive strength. It is determined by a compression test on specially produced specimens. The main factors influencing compressive strength are the type of fly ash, alkaline liquid ratio and the degree of hydration which is affected mainly by the curing time and method. High early strength means the compressive strength of the concrete in the first 24 hours after production. High early strength is often very important for precast structures, since it means earlier striking, faster turn aroundof the formwork, earlier handling of the precast structures, more economic useof cement, less heat energy. The cubes with 100 mm sizes are used. Moulds be water-proof and non-absorbent; Joints may be sealed with suitable material; Calibrated moulds should of steel or cast iron. The laboratory arrangement to conduct compression test.

The compression test result is the average of three standard cube strength specimens from the same concrete sample and tested at the same age. After cleaning the bearing surface of the compression testing machine, the axis of the specimen was carefully aligned with the centre of thrust of the plate. The load was then gradually applied at a rate of 140 kg/m² per minute until the resistance of specimen to increasing load. The compressive strength was calculated in N/mm^2 from the maximum load sustained by the cube before failure.

Then the compressive stress is ultimate load by area exposed to load and stress value is obtained in N/mm^2.

PERCENTAGE OF REPLACEMENT OF STEEL SLAG	COMPRESSIVE STRENGTH (N/mm2) 7 days	COMPRESSIVE STRENGTH (N/mm2) 28 days
0%	23.54	37.27
5%	23.05	35.31
10%	32.35	38.29
15%	23.54	40.36
20%	21.10	38.07



SPLIT TENSILE STRENGTH TEST

This method consists of applying a diametric compressive force along thelength of the cylindrical specimen. This loading induces tensile stresses on the plane containing the applied load. Tensile failure occurs rather than compressive failure. Plywood strips are used so that load is applied uniformly along thelength of the cylinder. The maximum load is divided by appropriate geometrical factors to obtain the splitting tensile strength. A diametric compressive load is then applied along the length of the cylinder until it fails because PCC is much weaker in tension than compression, the cylinder will typically fail due to horizontal tension and not vertical compression.

Test has been conducted on the specimen of size 100 mm in diameter and200mm in length after the curing period of 28 days.

Proportion	Tensile strength for 7 days(N/mm^2)
0%	2.46
15%	3.27

From the above results show that tensile strength of Geopolymer concrete increases about 32.9% when compared to conventional geopolymer concrete with fly ash.

V.CONCLUSION

1.Geopolymer concrete properties can be enhanced by considering the replacement of fine aggregate with steel slag.

2.The use of GGBS and steel slag as the cementitious material with fly ash could be a better alternative for the insitu applications.

3.From the various percentage of addition of steel slag by the volume of fine aggregate, 15% addition of steel slag by the volume of fine aggregate was found to be optimum value.

4.The compressive strength test results of 15% addition of steel slag are more than the control specimen.

5.This gives the scope that the Geopolymer concrete with fine aggregate in proportion with steel slag be employed in construction for better achievement of strength and durability characteristics.

REFERENCES

[1] B.Singh etal, (2015) “Geopolymer concrete a review of some recent developments”

[2] PrakashR.Voraetal, (2013) “Parametric Studies on Compressive Strength of Geopolymer Concrete”

[3] Ahmad L.Almutairietal, (2021) “Potential applications of geopolymer concrete in construction”

[4] K.A.Olonade et al, (2015) “Performance Of Steel Slag As Fine Aggregate In Structural Concrete”

[5] Kexian Zuo et al, (2019) “Utilization unprocessed steel slag as fine aggregate in normal and high strength concrete”

[6] Yongchang Guo et al, (2018) “Effects of steel slag as fine aggregate on static and impact behaviours of concrete”

[7]Ammar Motorwala, Vineet Shah, Ravishankar

Kammula, PraveenaNannapaneni, Prof.D.B.Raijiwala (2013) “Alkali Activated fly-ash Based Geopolymer Concrete”, International Journal of Emerging Technology and Advanced Engineering:3(1)
[8]Bakharev.T (2005) “Durability of geopolymer materials in sodium and magnesium sulphate solutions”, Cement and Concrete Research, 35, 1233-1246.
[9]Reference code : IS 10262-2019,IS 456 -2000, IS 13311(part 1 and part 2).
[10]Concrete-techgroup. (2008). “Fly ash concrete: Classification”.
[11]Davidovits, J. (1991)"Geopolymers: Inorganic Polymeric New Materials" Journal of Thermal Analysis 37: 1633-1656.
[12]Davidovits.J (1994) “Global warming impact on the cement and aggregates industries”, World Resource Review, 6, 263-273.
[13]Davidovits, J. (1999). “Chemistry of Geopolymeric Systems, Terminology”. Geopolymer 99th International Conference, France. Chemical Science Review and Letters ISSN 2278-6783 Chem Sci Rev Lett 2014, 3(10), 288-294 Article CS092043CN 294.
[14]Fernández-Jiménez.A, Palomo.A and Criado.M (2005) “Microstructure development of alkali-activated fly ash cement: adescriptive model”, Cement and Concrete Research, 35, 1204-1209.
[15]Gonc¸ alves, M. R. F., & Bergmann, C. P. (2007) “Thermal insulators made with rice husk ashes: Production and correlation between properties and microstructure”, Construction and Building Materials.