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An Experimental Study on GeopolymerConcrete with Steel Slag as fine Aggregate

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ABSTRACT:
In this work, the performance of steel slag used as coarse aggregate in geopolymer concrete with low fly ash calcium content is evaluated. GPC contains zero cement at all. This experimental study was done to create GPC by using steel slag in place of the natural coarse aggregate in geopolymer concrete. Laboratory tests of the mechanical properties of the geopolymer concrete were conducted, and the conclusion was drawn based on the findings. These mechanical properties included compressive, tensile, flexural, rebound hammer, and ultrasonic pulse velocity tests. It is discovered that the performance of steel slag in geopolymer concrete is comparable to that of natural coarse aggregate.

I.INTRODUCTION

In geopolymer concrete, silica and alumina-rich pozolanic material that has been alkali activated substitutes the cement binder found in traditional concrete. The importance of this ground-breaking technology to substitute cement in concrete has grown over the past few decades, and it has lately been applied in real-world settings.

Because the manufacture of concrete includes the release of a significant amount of CO2 into the atmosphere, cement replacement is important because it plays a significant role in global warming.

In addition, because natural gravel is utilised as fine aggregate in traditional concrete, which makes up 50–60% of the material, fine aggregate contributes to the loss of natural resources. Each year, 8–12 million tonnes of natural aggregates are used to make concrete.

The volume of industrial trash produced annually increases more quickly globally. Every year, mining and industrial activities in India produce about 960 MT of solid waste.

There are numerous research projects underway to replace the fine aggregate in concrete in order to preserve this quickly dwindling natural resource.

According to Suganya.N and Thirugnanasambandam.S7, steel slag from scrap is chosen for this investigation because its physical and chemical characteristics are comparable to those of natural gravel.

Thus, in this experimental work, scrap steel slag, an industrial waste, is used to replace the natural fine aggregate in cement-free geopolymer concrete.

II. LITERATURE REVIEW

1) Sultan Tarawneh et al (2014)1 studied the effects of using steel slag aggregate on mechanical properties of concrete and reports that steel slag acts as accelerator at early age and 7 days strength of steel slag concrete is higher and at 28 days, the effect is reduced.

2) Mohammed Nadeem, Arun Pofale (2012)2 investigated use of different types of steel slag as coarse in concrete and reports that steel slag absorbs lesser water than brick aggregate. Also the compressive strength of steel slag coarse aggregate concrete is similar to or better than that of conventional aggregate concrete. Heavy weight steel slag yield better compressive strength.

3) N A Lloyd and B V Rangan (2010)3 presents a detailed report on making of geopolymer concrete, its short term and long term properties and suggests that geopolymer is well suitable for precast elements.

4) B. Vijaya Rangan (2008)4 developed low calcium fly ash based geopolymer concrete and reports its material properties, mix design, fresh and hardened properties of concrete. Reports that geopolymer concrete is more durable and undergoes very low creep and shrinkage.

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5) Vinothini.P, Kumaravel. S and Girija. P(2015)5 studied the ambient curing of fly ash based geopolymer concrete with addition of GGBS. Reports that GGBS in geopolymer accelerates its setting time and aids curing at ambient temperature.
6) Pradip Nath et al (2015)6 reports that fly ash based geopolymer shall be made under ambient curing by adding small percentage of GGBS, OPC or CH. Low to moderate strength concrete shall be achieved by this method.

III. GEOPOLYMER

Similar to zeolites, geopolymers are made of a polymeric Si-O-Al framework. Geopolymers are amorphous rather than crystalline, which is the fundamental distinction between them and zeolite.

Depending on the system's SiO2/Al2O3 ratio, the reaction generates SiO4 and AlO4, tetrahedral frameworks joined by a common oxygen as poly(sialates) or poly(sialate-siloxo). long-distance covalent bonds that hold the link together. As a result, the geopolymer structure is seen as a thick amorphous phase made up of a semi-crystalline 3-D alumino-silicate microstructure.

Commercially available geopolymers can be used to make high temperature ceramics, novel binders for fire resistant fibre composites, toxic and radioactive waste encapsulation, new concrete cements, and fire, heat, and adhesive-resistance coatings and adhesives.

IV. METHODOLOGY

Fly ash, fine aggregate, coarse aggregate, alkaline solution, and steel slag are used to create Geopolymer concrete in this study. It is important to research the qualities of each of these materials. The compressive strength of the cast specimens was tested under two different curing conditions (ambient curing and sunshine curing), each of which included a different amount of steel slag and fly ash.

4.1 Fly Ash

Class F type-low calcium fly ash that complies with ASTM C 618 and is obtained from thermal power plants that burn lignite was received in the dry state from Mettur Thermal Power Station (MTP), Salem, Tamil Nadu, and used to make concrete. Fly ash has an approximate specific gravity of 2.27. Table 1 is a list of the fly ash's chemical make-up.

Table1.Chemical properties of fly ash

S. No	Component	Weight%
1	SiO2	61.30
2	Al2O3	29.40
3	K2O3	1.20
4	MgO	0.75
5	CaO	1.21
6	Fe2O3	3.27
7	Fe2O3	0.003
8	TiO2	0.01
9	Na2O	0.73
10	CI	0.04
11	LOI	0.67

4.2. Fine aggregate:

It was confirmed that zone II of IS 383: 1970 was met by using river sand that passed through a 4.75 mm IS sieve. 2.6 and 3.6, respectively, were the fine aggregate's specific gravity and fineness modulus. The uniformity coefficient was 3.33.

4.3 Coarse Aggregate

As coarse aggregate for the investigation, natural stone that had been crushed to a maximum size of 20 mm and had a specific gravity and water absorption of 2.7 and 0.1%, respectively, was employed. The coarse aggregate utilised in this investigation complies with the requirements of IS 383:1970.

4.4Steel Slag

Scarp steel slag from JSW Steel Industry's steel re-rolling factory in Salem, Tamil Nadu, was reduced in size using a mechanical jaw type crusher and graded to a maximum size of 20mm.Table 2 provides a list of the physical characteristics of steel slag.

Table2. Physical properties of steel slag aggregate

S.No	Parameter	Value
1	Bulk Density	1260kg/m3
2	Specific Gravity	3.48
3	Water Absorption	1.5%
4	Fineness Modulus	5.43
5	Crushing value	20.5%
6	Impact value	25.75%

V. MIX DESIGN

For this study's purposes, M20 grade concrete was used. Based on laboratory trials, the binder to solution ratio of 0.45 and the sodium silicate to sodium hydroxide ratio of 2.5 were used to determine the geopolymer mix proportion. Table 3 lists the ingredients' mix proportions.

Table3. Mix Design

S.No	Ingredient	M I(kg/m^3)	M II (kg/m^3)
1	Fly Ash	219	219
2	Activator solution	140	140
3	Sodium hydroxide	40	40
4	Sodium silicate	100	100
5	Fine aggregate	730(sand)	760(steel slag)
6	Coarse aggregate	1250	1250
7	SP	6.32	6.32

5.1 Mixing

Concrete mixing was done according to tradition. A day before manufacturing concrete, sodium hydroxide solution was made. Sodium hydroxide and silicate solutions were combined just prior to the start of the concrete mixing process. To create a homogenous mixture, all the dry components were thoroughly mixed before the solution was added. Sp was included last to achieve the necessary workability.

5.2 Casting

Standard concrete specimens – cube 150mm x 150mm x 150mm, cylinder 150mm dia and 300mm length, prism 100mm x 100mm x500mm were cast. After 24 hours, the specimens were demoulded.

5.3 Curing

Concrete sample underwent ambient curing. The samples were tested after being kept at a temperature of 32°C±2°C for28 days in the lab.

5.4 Testing

Cubes casted were put for compressive strength test (fig.1) and cylinders casted were put for tensile strength test under Universal Testing Machine (UTM) (fig.2).

Fig.1

Fig.2

VI. RESULTSANDDISCUSSION

6.1 Compressive strength test result:

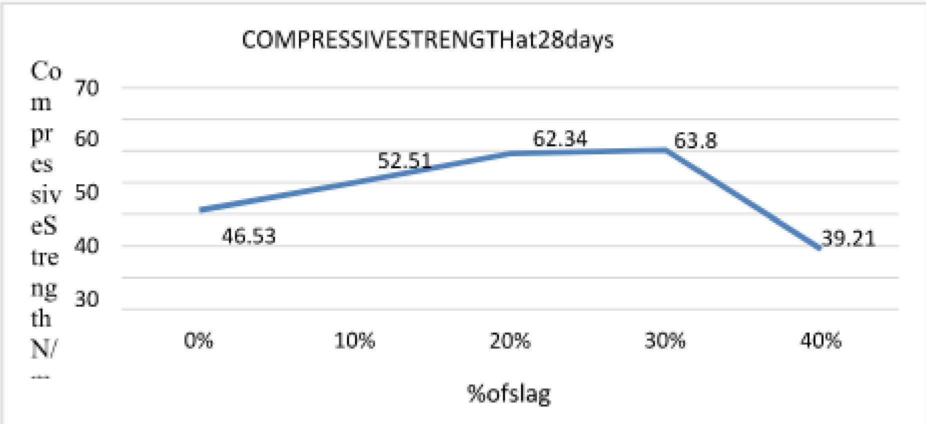

Fig1 Compressive Strength of geopolymer concrete at 28 days

6.2 Split Tensile Strength Test Results:

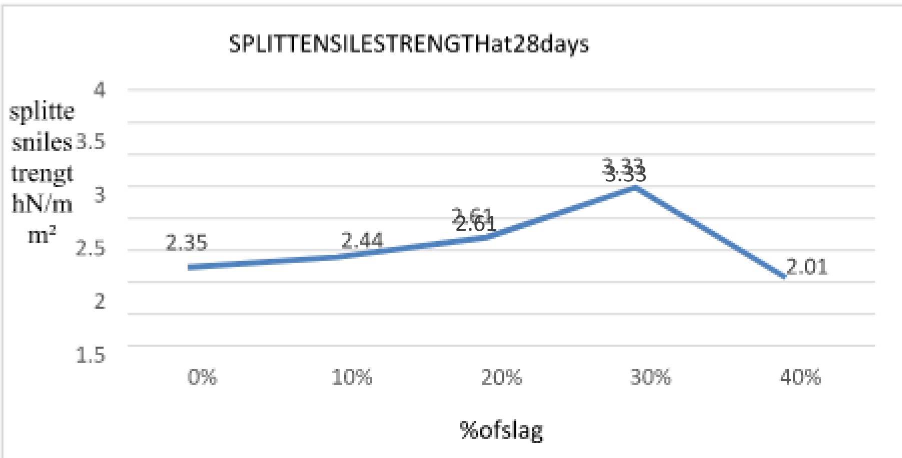

Fig2 SplitTensileStrength of geopolymer concrete at 28days

6.3Flexural Strength Test Results:

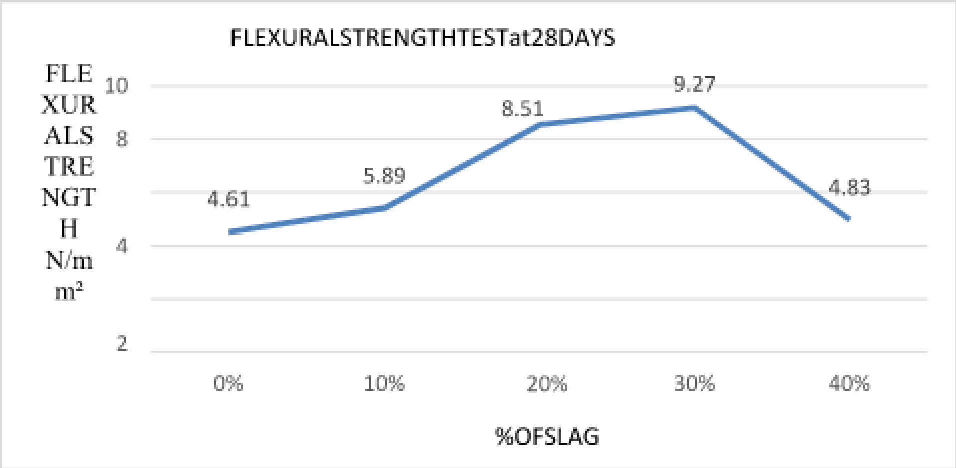

Fig3 Flexural Strength of geopolymer concrete at28days

Table 4. Mechanical properties

S.No	Test Conducted	M I (MPa)	M II (MPa)
1	Compressive Strength	27.25	25.35
2	Tensile Strength	2.85	2.65
3	Flexural Strength	4.58	4.02

VII. CONCLUSION

Our experiment's goal is to ascertain the strength behaviour of concrete made with steel slag in place of some of the fine material in ash-based geopolymer. The results of the tests for compressive, tensile, flexural strength, indicated that roughly 20% of the fine aggregate in geopolymer concrete should be replaced by steel slag**.**

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