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UTILIZATION OF IRON ORE TAILINGS IN GEOPOLYMER CONCRETE

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Abstract— *This project deals with the experimental study to determine the properties geopolymer concrete which contains Ground Granulated Blast Furnace Slag (GGBS), Alkaline Activated solution like sodium hydroxide, sodium silicate solution, partially and fully replacement of fine aggregates that is replacement of M-Sand by iron ore tailings. Coarse aggregates. Hardening of geopolymer concrete can be achieved by ambient curing.*

Keywords—Geopolymer, GGBS, Alkaline Activated solution, Ambient curing.

I. INTRODUCTION

1.1 General

There is a lot of environmental impacts of cement on our ecology. One of the major problem is emission of carbon dioxide from the cement industry. The global release of CO_2 from all the sources is found to be 23 billion tons a year , Out of this total carbon dioxide emission 7% of carbon dioxide emission if from Ordinary Portland Cement production industry. As carbon dioxide is harmful for human health and also for the wild life. The cement manufacturing industry is labour intensive and uses large scale and potentially hazardous manufacturing process. The geopolymer concrete was introduced to reduce environmental pollution that causes by production of Portland cement.

In 1978, professor Joseph Davidovits introduced the development of mineral binders with an amorphous structure, named geopolymers. Davidovits (1988, 1994) proposed that an alkaline liquid could be used to react with silicon (Si) and the aluminium (Al) in a source material in by-product materials such as GGBS and rice husk ash to produce binders. The chemical reaction that takes place in this case is a polymerization process, he coined a term "Geopolymer" to represent these binders. This was a class solid material, produced by the reaction of an alumino silicate powder and an alkaline liquid. Geopolymer concrete is an innovative construction material which shall be produced by the chemical action of inorganic molecules. Otherwise geopolymer is an inorganic alumino-hydroxide polymer synthesized from predominantly silicon (Si) and aluminium (Al) materials of geological origin or byproduct materials such as GGBS. The term Geopolymer was introduced to represent the mineral polymers resulting from geochemistry. The process involves a chemical reaction under highly alkaline conditions on Si-O-Al-O bonds in amorphous form. Due to its high mechanical properties combined with substantial chemical resistance, low shrinkage and creep and environmental friendly nature very less amount of carbon dioxide production in comparison with OPC, it is a better construction material for future

Mining activities generally occupy and spoil large tract of land due to generation of a large amount of waste rocks and tailing, which deposited at the surface and becomes a continuous source of metal pollution to the soil air and water resources of the area concerned. A number of conventional destructive.so instead of disposing of this iron ore tailings so better to reuse them as a replacement for fine aggregates

Geopolymer concrete is starting to revolutionize concrete. It is being used more in highway construction projects and offshore applications. Construction is one of the world wide growing fields. As per the present world statics, every year million tons of cement are required. Ordinary Portland Cement is commonly used in concrete. While producing one ton of cement, approximately one ton of carbon dioxide will be emitted to the atmosphere, which causes major problems in environment. Also, huge quantity of energy is also required for the production of cement. Hence it is most essential to find an alternative binder. The industry produces a waste called GGBS which is simply dumped on the earth, occupies large areas. By producing geopolymer concrete all the above mentioned problems are solved. Since geopolymer concrete doesn't use any cement, the production of cement shall be reduced and hence the pollution of atmosphere by the emission of carbon dioxide shall also be minimize

1.2 Aim and Objective of the study

The aim of the research is to evaluate the performance and suitability of iron ore tailings as a alternative for fine aggregates in the production of geopolymer concrete.

To evaluate the compressive strength and split tensile strength of the geopolymer concrete mix with the replacement of fine aggregates by iron ore tailings.

- The objective of this project is to study strength characteristics of geopolymer concrete using GGBS and iron ore tailings with the usage of alkaline activated solution contains sodium hydroxide and sodium silicate solution.

- Fully replacement of M-Sand by iron ore tailings.
- Determining the strength properties of concrete for 7,14,21 days.

II. MATERIALS USED .

A)Ground Granulated Blast Furnace Slag(GGBS).

GGBS is obtained by quenching molten iron slag, (a byproduct of iron and steel making.) from a blast furnace in water or stream to produce a glassy, granular product that is then dried and ground into a fine powder.

TABLE 1. Physical Properties of GGBS

SL NO	Properties	Values
1	Appearance	Fine powder
2	Particle size	25 Microns-Mean
3	Colour	White
4	Odour	Odourless
5	Specific Gravity	2.95

TABLE 2. Chemical Properties of GGBS

Component	Portland cement%	GGBS %
SiO_2	21.07	35.35
Al_2O_3	5.00	14.00
Fe_2O_3	2.92	0.36
CaO	64.40	41.41
MgO	2.07	7.45
K_2O	0.59	-

B) Manufactured-Sand(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 crushed sand is of cubical shape with grounded edges, washed and graded to a construction material. The size of manufactured sand (M-Sand) is less than 4.5mm. The specific gravity of this m-sand is 2.66.

C) Iron ore tailings

Tailings are distinct from overburden, which is the waste rock or other material that overlies an ore or mineral body is displaced during mining without being processed. Tailings are also called mine dumps, slimes, tails, refuse, slickens are the materials left over after the process of separating the valuable fraction from the uneconomic fraction of an ore.

TABLE 3. Properties of Iron ore tailings

SL NO	Properties	Values
1	Specific gravity	2.77

D) Coarse aggregates

Aggregates are the important constituents in concrete. The size of aggregates 4.75mm to 50 mm are classified as coarse aggregates, except for the mass concrete which may contain up to 150mm size aggregates. The aggregates occupy 70 to 80 % of volume of concrete

TABLE 4. Properties of Coarse aggregates

SL NO	Properties	Values
1	Specific gravity	2.65
2	Fineness modulus	6.2
3	Water absorption	0.185
4	Impact value	13.93%

E) Alkaline Activated solution

The solution of sodium hydroxide and sodium silicate are used as alkaline activator solutions in the present study. In this study we are using 5M sodium hydroxide and 5M sodium silicate solution. For 1M sodium solution 40g of sodium hydroxide pellets are dissolved in one liter of water. So, for 5M sodium hydroxide solution 200g is dissolved in one liter of water. For 1M sodium silicate solution 122g of sodium silicate is dissolved in one liter of water so for 5M solution 610g of sodium silicate is dissolved in one liter of water. This sodium silicate solution is prepared before 24hours of the casting of specimen. The chemical composition of this sodium silicate solution was Na_2O=8%, SiO_2=28% and water 64 % by mass. This mixture of solution forms the alkaline activator solution. Both these solutions are mixed together at the time of mixing.

I. MIX DESIGN.

There is no standard mix design are not yet available for geopolymer concrete. While the strength of cement concrete is known to be well related to its water cement ratio, such as simplistic formulation may not holds good for geopolymer concrete.so mix design for this geopolymer mix is done by trial and error method. Djwantoro Hardjito, et al (2004), showed that geopolymer paste binds the coarse aggregates, fine aggregates and other unreacted materials together to form the GPC (Geo Polymer Concrete), and as usual concrete technology methods to produce GPC mixes can be often employed. As in the Portland cement concrete, the aggregates occupy the largest volume (about 75-80% by mass) in GPCs are a new class of construction materials and there is no standard mix design approaches are yet available for GPCs. While GPCs involve more constituents in its binder (GGBS, NaOH, Na_2SiO_3 and water) whose interaction and final structure and chemical composition are under intense research where as the chemistry of Portland cement and its structure and chemical composition (before and after hydration) are well established due to extensive research carried out over more than the century, while strength if cement concrete is known to be well related to its water

cement ratio.so for this geopolymer concrete mix trial and error method was done.

The investigation was done on the proportion 1:1.5:2.7 (GGBS, fine aggregate, coarse aggregates) by replacing the fine aggregate that is M-Sand by iron ore tailings. The percentages of replacement are 0, 20, 40, 60, 80,100 %. For all the proportions the alkaline solution to binder taken is 0.5 kept as constant.

I. CASTING, CURING AND TESTING OF THE SPECIMENS

1.1 Casting of specimens

GGBS, Fine aggregates and coarse aggregates were taken in mix proportion 1:1.7:2.6 which corresponds to M25 grade of concrete. Fine aggregates is replaced by Iron ore tailings. All the ingredients were mixed in dry condition till we get homogeneous mixture. To this dry mix required amount of alkali activated solution of 5M was added and solution to binder ratio is 0.5 and the entire mix is again mixed till we get homogenous mixture. This mixed concrete is poured into the moulds at this time the compaction is done in 3 layers by hand compaction and then it kept on the vibrator for compaction. After the compaction the surface is well levelled and given smooth finishes. After 24 hours the specimens were demoulded.

1.2 Curing of specimens

The demoulded specimens were placed for curing the curing is done by placing the demoulded specimens in atmospheric temperature that is sunlight so this type of curing is called as ambient curing. This type of curing eliminates the heat curing of geo polymer. These specimens are cured for 7, 14, 21 days.

1.3 Testing of specimens

The specimens are tested for compressive strength for cubes of size 150mm x 150mm x 150mm cast iron steel moulds. For each proportion 3 cubed were tested at the age of 7 days, 14 days, 21 days. The specimens are also tested for split tensile strength for cylindrical moulds of size 150mm diameter and 300mm high cast iron moulds. For each proportion 3 cubes were tested at the age of 7 days, 14 days, 21 days.

4.3.1Compressive strength test

The specimens of dimensions 150mm x 150mm x 150mm which was prepared are tested in 2000KN capacity compression testing machine. The compressive strength is calculated by using the equation,

$$F=P/A$$

Where, F= Compressive stress in N/mm^2.
P= Maximum Load in N
A=Cross sectional area in mm^2.

The average compressive strength of various proportions is given in table 5.

Mix proportions	Compressive strength in N/mm^2		
	7th Day	14th Day	28th Day
0%	38.81	38.95	42.22
20%	39.11	41.73	45.32
40%	43.32	45.69	48.66
60%	40.44	42.36	46.29
80%	38.14	40.51	43.48
100%	34.22	36.59	39.56

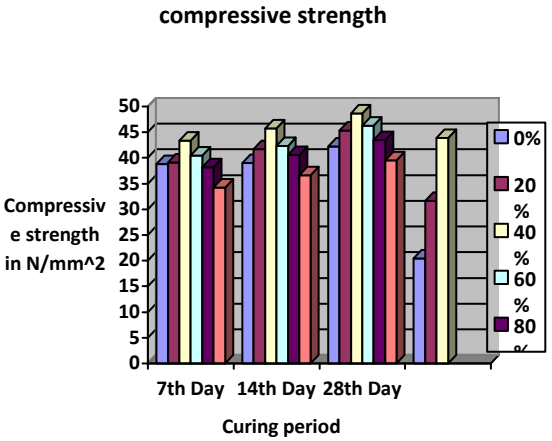

Fig 1. Compressive strength of geopolymer concrete with replacement of fine aggregates by iron ore tailings

4.3.2 Split tensile strength

The cylindrical specimens of dimensions 150mm diameter and 300mm high which was prepared are tested in 2000KN capacity tensile strength testing machine. The split tensile strength is calculated by using the equation,

$$F=2P/(\pi xDxL)$$

Where, F= Split tensile strength in N/mm^2
P= Load at failure in N.
D= Diameter of the cylindrical specimen in mm.
L= Length of the cylindrical specimen in mm.

The average split tensile strength of various proportions is given in table 5.1

TABLE 5.1 The average tensile strength

Mix proportions	**Split tensile strength in N/mm2**		
	7th Day	**14th Day**	**28th Day**
0%	2.49	2.58	3.95
20%	3.08	3.50	4.00
40%	3.81	3.88	4.47
60%	3.43	3.71	4.05
80%	2.87	3.15	3.49
100%	2.47	2.75	3.09

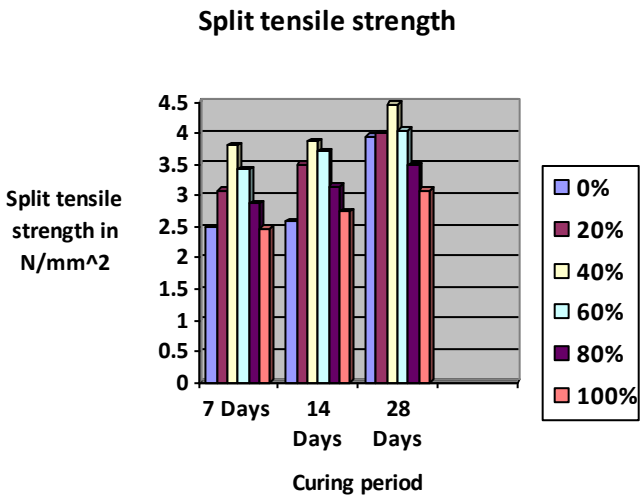

Fig 1.2 Split tensile strength of geopolymer concrete with replacement of fine aggregates by iron ore tailings.

V.RESULTS AND DISCUSSIONS:

On geopolymers, a trial and error method was adopted to develop a process of manufacturing GGBS based geopolymer concrete with the replacement of fine aggregates by iron ore tailings following the technology currently used to manufacture substituent for the Ordinary Portland Cement Concrete.

After some failures in the beginning, the trail and error method yielded successful results. The optimum mix is GGBS: Fine aggragate: Coarse aggregate are 1:1.7:2.6.

The comparison graph shown in Fig.1 and Fig.2 shows that compressive strength of cubes and split tensile strength of cylindricals respectively shows for different percentage of iron ore tailings. For ambient curing of specimens of 40% replacement of iron ore tailings give the maximum strength when compare to other percentages of replacement.The maximum strength achieve within 28 days of curing.

VI. CONCLUSION.

Geopolymer is eco-friendly as it emits low amount of carbon dioxide when compare to Ordinary Portland Cement Concrete This geopolymer concrete with replacement of fine aggregates by iron ore tailings can be mixed with a relatively low-alkali activating solution and it must be cured under ambient curing. The production of cost effective geopolymer concrete can be mixed and hardened like Ordinary Portland Cement Concrete.

- As geopolymer concrete does not use cement but instead it uses GGBS so , geopolymer emits less amount of carbon dioxide when compare to OPC and also it uses less amount of energy when compare to OPC, and it is eco friendly as it uses mining waste that is iron ore tailings.
- At 40% replacement of iron ore tailings the Compressive strength and Split tensile strength will increases.
- From 60% to 100% the compressive strength and split tensile strength decreases.
- The geopolymer concrete can be mixed with a low-alkali activating solution and it must be cured under ambient conditions.

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