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A Study on Partial Replacement of Coarse Aggregate by using Geopolymer Tailing

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Abstract: ***Concrete is that the basic material in all the construction works and coarse aggregate constitutes nearly 60 to 70% of the combination but the procurement and therefore the generation of the natural coarse aggregate is being deficit day by day and that lead to the use of other alternative materials which are naturally available in India. Fly ash and IOT are the best suitable materials for replacement of natural aggregates because of the availability of these huge sources in all over India. The Iron ore tailing is procured for the KIOCL, kudremukh where in the large amount of IOT is available as a waste. This study is taken up to determine the variation of various properties of strength and mainly durability of concrete made by the geopolymer coarse aggregate for M40 grade of concrete. Geopolymer coarse aggregates are prepared by using IOT, fly ash and alkaline activator of variable molarity. XRD and SEM analysis is preferred for determination of physical and chemical properties. The cubes of size 75*75*75 are prepared by mixing flyash and IOT in proportion 70:30 respectively with varying molarity of alkaline activator as 4M,6M, 8M, 10M, 12M. And the compressive strength should be determined to seek out the optimum molarity of Alkaline activator solution and then the cubes are crushed to prepare the coarse aggregates.***
Keywords: Concrete, Iron ore tailing, Fly ash, Coarse aggregates, Alkaline activator, Compressive strength.

I. INTRODUCTION

In recent years, steel production has increased significantly to meet the construction industry demands. This has resulted in the generation of huge amount of iron ore tailings (IOT) which are disposed of as waste in landfills, quarries, etc. India produces millions of tons of IOT. A statistical survey showed that India produces about 210 million tons of IOT in 2017-2018. These tailings pose serious environmental problems besides occupying large area of landfill sites. One way of disposing these IOT is to utilize them in construction industry where they would be recycled and reused to supply green and sustainable product. It might also save landfill space and reduce the extraction of natural raw materials.

India is one among the important iron ore producers and exporter within the world. However, the rapid climb in production, especially from large surface mines, have already caused ecological imbalance in their respective regions and emerge because the source of main environmental hazards. The waste/tailings that are ultra- fines or slimes, having diameter but 150 μm, aren't useful and hence are discarded. In India approximately 10–12 million tons of such mined ore is lost as tailings. The safe disposal or utilization of such vast mineral wealth within the form ultra-fines or slimes has remained a serious unsolved and challenging task for the Indian iron ore industry. Fly ash is also the another largest waste producing in the country. Fly ash as a geopolymer and sodium silicate and sodium hydroxide used with the required proportion for the synthesis of light weight aggregates. Using these aggregates the geopolymer concrete will be prepared for which compressive strength, split tensile strength and flexural strength will be found out.

II. OBJECTIVES

A. To Characterize iron ore tailings and fly ash for physical and chemical properties.
B. To Study the workability of concrete.
C. To recognize the optimal molarity of alkaline activator and optimum mix for manufacture of geopolymer coarse aggregates as per test for coarse and fine aggregates specified in BIS code IS: 383-1970.
D. To compare the various basic properties of Geopolymer coarse aggregate with that of naturally available coarse aggregate.
E. To examine the various strength properties (for 28days) of geopolymer aggregates such as compressive strength, split tensile strength, and flexural strength.

III. LITERATURE

S.V Joshi and et.al (2012) Investigated and administered the take a look at to apprehend the "Role of Alkaline Activator in Development of Eco-friendly Fly Ash Based Geo Polymer Concrete". It is found that compressive power of geo- polymer concrete will increase with growth in molar concentration. Substantial growth in 28 days common compressive power is found at 8M, 10M, &12M to 14M.T. I. Ugama and et.al (2014) administered the take a look at on "impact of iron ore tailing at the houses of concrete". And arrived on the outcomes that workability decreased with growth in IOT percentage, the substitute of 20% sand with the aid of using IOT has no a whole lot distinction then the traditional concrete.

Ali Umara shettima and et.al (2016) administered the take a look at on "Evaluation of iron ore tailings as a substitute for fine aggregate in concrete" and met the end result that addition of IOT multiplied the water call for and reduced the droop value. Thus the workability decreases with growth of IOT, function compressive power of concrete containing 25% of IOT is continuously extra than the reference concrete at all of the age.

B. P. Sharath and et al (2018) Investigated and administered the take a look at on "sustainable usage of iron ore tailing because the fine aggregates in fly ash primarily based totally geopolymer mortar" and concluded that putting time has been decreased because of the usage of iron ore tailing withinside the manufacturing of geopolymer mortar and the compressive power of geopolymer mortar with the herbal sand and the iron ore tailing is degrees from 2.90 to 4.90 Mpa and 3.47 to 8.27 Mpa respectively.

P. Shubhananda Rao, and et al (2019) Investigated and administered take a look at on "use of iron ore tailing in infrastructure projects" and concluded that the produced in iron ore processing are regularly applied in brick making and use of pertile waste additionally confirmed that powerful as a density controller.

IV. MATERIALS

A. *Fly Ash*

Fly ash may be a by-product generated within the process of combustion of the coal within the electronic precipitator of the facility plant. in coal, the combustible elements like carbon, hydrogen, oxygen, Hydrocarbons, and non-combustible minerals impurities of coal chemically recombine and fuse to offer crystalline molten ash in various stages in power plants of coal. Fly ash is collected from the Raichur Thermal Power Station, It is operated by the Karnataka Power Corporation Limited (KPCL) and was the first thermal power plant to be set up in the state.

TABLE 1: Fly ash properties

Property	Result
Specific gravity	2.21
Power of hydrogen (pH)	11.5
Electrical conductivity	729 □S/cm
Total dissolved solids	461 mg/L

B. *Iron Ore Tailing*

Most important iron ores in India are hematite and magnetite. About 79% hematite ore deposit in Eastern Sector (Assam, Bihar, Chhattisgarh, Jharkhand, Odisha & Uttar Pradesh) about 93% magnetite ore deposits found in Southern Sector (Andhra Pradesh, Goa, Karnataka, Kerala & Tamil Nadu). Karnataka contributes 72% of magnetite deposit in India. Between these, haematite is that the superior thanks to its higher grade. Iron ore tailing has collected in Lakhya dam which is generated by Kudremukh ore Company Limited. In the present work ore tailings which is a waste created after extraction of iron metal was explored for generation of development materials. Properties of iron ore tailing has found out.

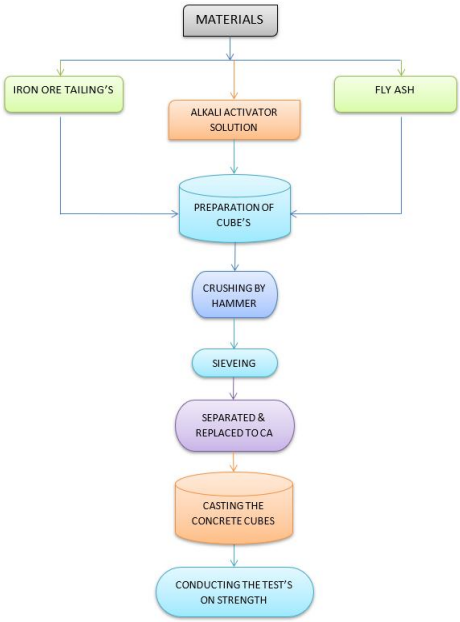
TABLE 2:
Physical properties of iron ore tailing

Sl no	Properties	Values
1	Water content	1.2 %
2	Specific gravity	2.7
3	Maximum dry density	2.08 gm/cm^3
4	Optimum moisturecontent	14.34 %
5	Coefficient of Permeability	0.011 cm/sec
6	Bulk density	2.38 gm/cm^3

C. Alkali Activator Solution.

1) *Sodium Hydroxide (NaOH):* Sodium hydroxide is an inorganic compound. A metallic base Alkali salts of Highly caustic white solid materials available in flake or granules pellets or and which are prepared as different concentration of solution.
2) *Sodium Silicate (Na_2SiO_3):* Sodium silicate is named liquid glass or water glass. It's available in solid form and also in aqueous solution. It's white or colorless.

V. METHODOLOGY



A. Methodology Adopted in Preparing Geopolymer Aggregates

Preparing of aggregates is done in 2 phases:

1) *Phase-I : Is to fix the Optimum Molarity of Alkaline Activator Solution:* Prepared the cubes of 75*75*75 mm by using the ash and ore tailing with the proportion 70:30 respectively. With the prepared Alkaline activator solution. Prepared 3 cubes from each molarity of Alkaline activator. administered the compressive test on the prepared cubes to hunt out out the utmost strength among the cubes. and respectives molarity of alkaline solution of the cube with maximum compressive strength is used to preparation of the Geopolymer coarse aggregate. Here as increasing the molarity of Alkaline activator solution, the strength also increase simultaneously. The 10M of alkaline activator solution is employed for the preparation of geopolymer coarse aggregates.

Fig. 1: 75mm cubes of different molarity

2) *Phase-II: Prepare Geopolymer Aggregate:* Alkaline activator is ready for 10M by mixing of NaOH and Na2SO3 with a water . Required quantity of the fly-ash and ore tailing was weighed. flyash and Iron ore taling has mixed with alkaline activator solution. Mixing was administered by hand with proper care and precaution. Prepared slurry was added to the moulds of 150mm side and therefore the cubes are allowed for the oven curing for 4 hours at 1000 C and demolded later. Those cubes are kept outside for every week to realize the strength during a dry climate then the aggregates prepared by crushing of the cubes after every week. Obtained the varied sizes of coarse aggregates. Those aggregates are used for the preparation of concrete.

Fig. 2: Formation of geopolymer Coarse aggregate

VI. RESULT AND DISCUSSIONS

The Prepared geopolymer coarse aggregates are tested and compared with the natural aggregates and the test results are reported in the table 3. The water absorption gives the idea of the strength of aggregates and aggregates are more porous as having more water absorption compared to natural aggregates. Results shows that geopolymer aggregates has more impact value than natural aggregates. According to IS code the if impact value lies between the 30- 45% those are considered as the good quality aggregates. The crushing values of good quality aggregates should be lie below 30-40 %.

Table 3: Comparison of test results of Geopolymer coarse aggregates and Natural coarse aggregates

Sl. no	Tests conducted	Geopolymer Coarse Aggregates	Natural Coarse Aggregates
1	Specific gravity	1.91	2.73
2	Water absorption	7.08%	0.35%
3	Impact strength	28.32%	15.39%
4	Crushingstrength	23.96%	17.82%
5	Apparent specific gravity	2.05	2.5

A. Tests on the concrete with partial replacement of NCA with GCA

The natural aggregates replaced by the geopolymer aggregates as like 50:50. and the concrete has prepared for the 50:50 proportion of GPA and NA. Cubes are prepared and cured for the required number of days and compressive strength has been checked.

Table 4: Compressive strength values of concrete

Sl.No	GCA:NCA	Age of M40 concrete in Days	Average Compressive Strength (N/mm^2)
1	50:50	7	22.14
		21	29.32
		28	31.60

Table 5: Flexural strength of beam values of concrete

Beam with 50% replacement of NCA and GCA	7th day test result (N/mm2)	28th day test result (N/mm2)
1	2.667	4.000
2	3.200	4.845
3	3.466	5.221
Average	3.111	4.688

Table 6: Split tensile of strength cylinder values of concrete

Cylinder with 50% replacement of NCA and GCA	7th day test result (N/mm2)	28th day test result (N/mm2)
1	1.650	2.600
2	1.750	2.550
3	1.550	2.900
Average	1.650	2.680

Table 7: Comparison test results of Geopolymer concrete and Natural Concrete

SL no	Tests conducted	Geopolymer concrete	Natural concrete
1	Slump (mm)	100	85
2	Compaction Factor	0.86	0.95
2	Vee-Bee Consistency	8	7

VII. CONCLUSIONS

Specific gravity of the iron ore tailing is found more compared to the fly ash. Fly ash has more silt content (74%) and iron ore tailing has sand in high proportion (70%) power of hydrogen of both IOT and fly ash are basic in nature.

Electric conductivity of fly ash is more compared to IOT. Total dissolved solid of fly ash is more compared to IOT.

Mullite and Quartz are the contents present in fly ash in maximum proportion and where IOT has the maximum content of silicon dioxide in the form of the Quartz. Geopolymer coarse aggregates can be synthesized by using the fly ash and IOT in proportion of 70:30 respectively. By using the activators sodium hydroxide and sodium silicate in 25% and 5% respectively to the weight of fly ash. Aggregates are prepared using the IOT and Fly ash which are free of cost. Thus, only labour cost will be applicable for the preparation of aggregates. 4M,6M,8M,10M and 12M of alkaline activator is used to find the optimum Molarity of the alkaline activator solution. where the solution of 10M gives the maximum strength. Artificial Geopolymer coarse aggregates absorbs the water compared to the natural coarse aggregate hence during the mix of concrete, more water is required.

Geopolymer aggregates have the more workability compared to the natural coarse aggregates because of flakiness of geopolymer coarse aggregates. Geopolymer coarse aggregates has shown the less impact value compared to the conventional aggregates in impact test. Due to the more flakiness of the Geopolymer coarse aggregates they form the less voids during mix of concrete, hence the requirement of fine aggregates is less for the same volume of mix with conventional coarse aggregates.

Geopolymer coarse aggregates are less in weight compared to natural coarse aggregates hence the dead load of structure is less.

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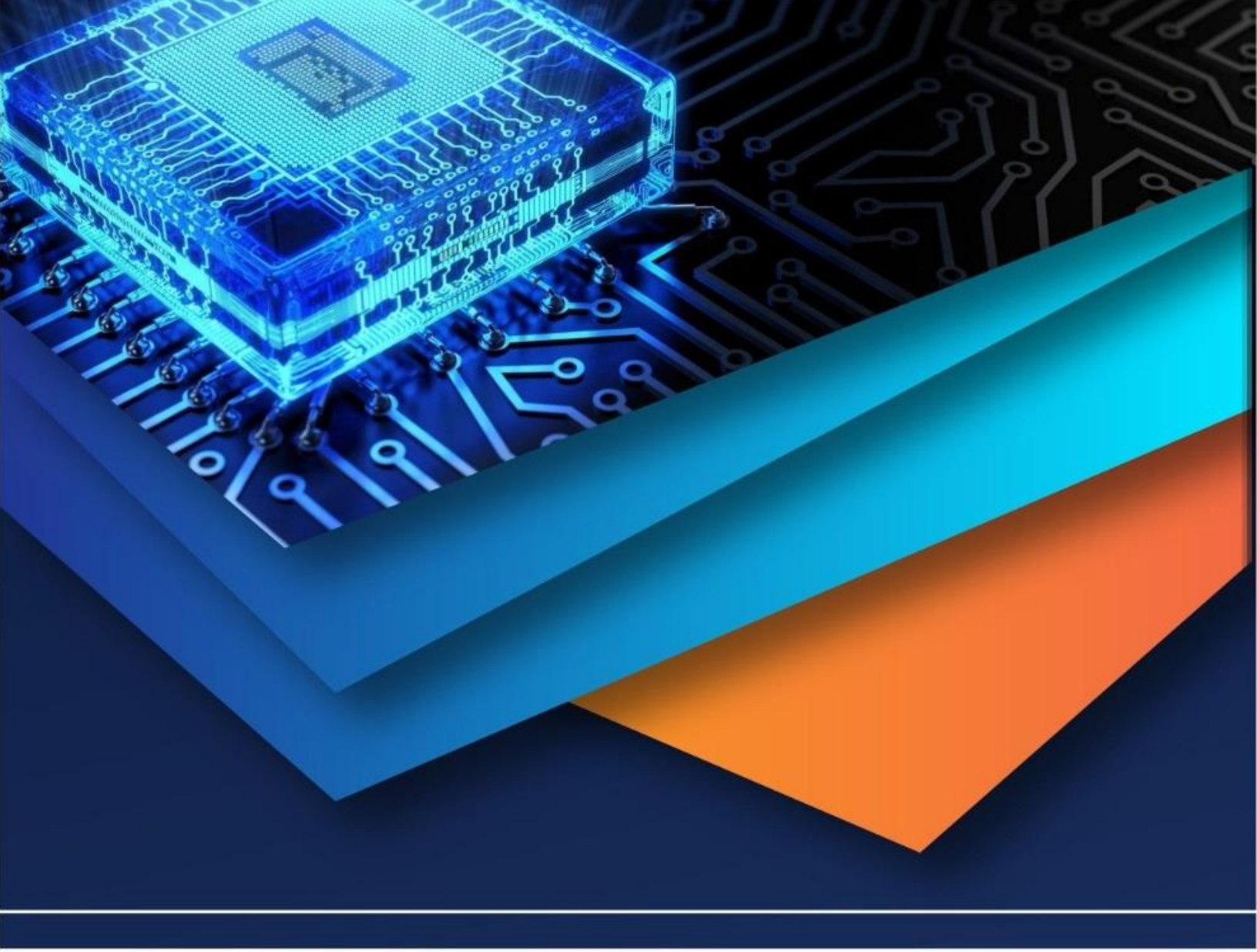

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