INTERNATIONAL JOURNAL OF ADVANCE RESEARCH, IDEAS AND INNOVATIONS IN TECHNOLOGY

ISSN: 2454-132X
Impact Factor: 6.078
(Volume 7, Issue 3 - V7I3-2233)
Available online at: https://www.ijariit.com

Performance of geopolymer coarse aggregate in 50% replacement with natural coarse aggregate using iron ore tailings

Suchetha R. Murthy
suchethar.96@gmail.com
Dayananda Sagar College of Engineering, Bengaluru, Karnataka

Shiva Kumar G.
iamskg6389@gmail.com
Dayananda Sagar College of Engineering, Bengaluru, Karnataka

ABSTRACT

Concrete contributes a very important role in the construction sector. Aggregates are the basic ingredients in concrete which will contribute about 60-70% of total composition. Due to the highest demand for aggregates it has been resulted in over exploitation of natural resources, hence it is very important to use alternative material. As we know fly ash and IOT are the largest wastes which has been producing in all over India and these are the best suitable alternative materials. In Karnataka state, Kudremukh iron ore company (KIOCL) produce large amount of IOT waste and were deposited in Lakya dam. The present study in under taken to determine the fly ash and IOT characteristics using XRD and SEM analysis and also to determine the strength and durability of concrete made up of geopolymer coarse aggregate for M40 grade of concrete. The cubes of size 75x75x75 are prepared by mixing IOT and fly ash in proportion 70:30 respectively with varying molarity of alkaline activator as 4M, 6M, 8M, 10M & 12M. These cubes are crushed to obtain Geopolymer coarse aggregates and these aggregates are used in RCC structures to check the mechanical behavior and workability of concrete.

Keywords: *Concrete, Iron ore tailing (IOT), Fly ash, Coarse aggregates (CA), Alkaline activator, Compressive strength, Workability.*

1. INTRODUCTION

Steel production has grown dramatically in recent years to satisfy the demands in the building sector. As per the results, massive amounts of iron ore tailing (IOT) are produced and disposed as trash at landfills, quarries, and other locations. IOT is produced in India in millions of tonnes. According to statistics, India produced over 210 million tonnes of IOT in 2017-2018. These tailings not only cause significant environmental concerns but also take up a lot of space in landfills. One method to dispose of these IOT is to use them in the construction sector, where they can be repurposed and reused to create environmentally friendly and sustainable products. It may also minimize the exploitation of natural raw materials and preserve landfill space.

India is a notable producer and exporter in iron ore around the globe. However, the fast increase in output, particularly from large surface mines, has already created an ecological imbalance in their individual locations and has emerged as a major source of environmental risks. Waste/tailings that are ultra-fines or slimes with a diameter of fewer than 150 m aren't helpful and are dumped. Approximately 10–12 million tonnes of mined ore are wasted as tailings in India. For the Indian iron ore industry, the safe disposal or use of such huge mineral riches in the means of ultra-fines or slimes has remained a significant unresolved and demanding problem. Another major waste which is generated in the country is fly ash. For the fusion of lightweight aggregates, fly ash was utilized as a geopolymer, sodium silicate and sodium hydroxide were employed in the appropriate proportions. The mechanical behavior of geopolymer concrete will be determined using these aggregates. This section includes a brief literature review that supports the usage of mining tailings and fly ash. S.V Joshi and colleagues (2012) conducted research and ran a test to find out the "Role of Alkaline Activator in Development of Eco-friendly Fly Ash Based Geo Polymer Concrete." The compressive strength of geo-polymer concrete is shown to increase as the molar concentration rises. At 8M, 10M, and 12M to 14M, there is a notable rise in 28 days common compressive strength. T. I. Ugama and colleagues (2014) conducted a study on “Effect of iron ore tailing on concrete buildings." And also arriving on the test results show that workability decreases when the proportion of IOT increases and that substituting 20% sand with IOT has no perceptible difference from ordinary concrete. Ali Umara Shettima and colleagues (2016) conducted a research on "Evaluation of IOT as a replacement for fine aggregate in concrete" and discovered that adding IOT increased the water demand while lowering the droop value. As a result, as the Iron ore tailing (IOT) increases, the workability of the system declines, as does the compressive power at all ages, the system of concrete containing 25% IOT is

consistently higher than the reference concrete. B. P. Sharath and et al. (2018) investigated and conducted a research on "Sustainable use of IOT as fine aggregates in fly ash-based totally geopolymer mortar," concluding that putting time has been reduced due to the use of IOT within the manufacturing of geopolymer mortar that "the compressive power of geopolymer mortar with the use of IOT has been increased." P. Shubhananda Rao and colleagues (2019) investigated and conducted a brief study on the "use of IOT in infrastructure projects," concluding that the byproducts of an iron ore processing are commonly used in brick production and that pertile waste is also effective as a density controller.

2. MATERIALS

2.1 Fly ash

Fly ash acts as 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 has been 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 /L

2.2 Iron Ore Tailing

Most important iron ores in India are hematite and magnetite. Around 80% Hematite ore has been deposited in eastern sector and around 93% Magnetite ore deposits found in southern sector. Karnataka contributes 72% of magnetite deposit in India. Between these, hematite is that the superior thanks to its higher grade.

IOT 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. IOT Properties

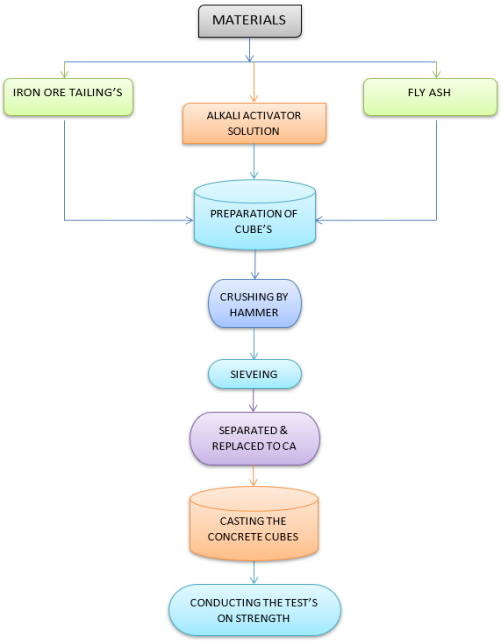
Properties	Values
Water content	1.2%
Specific gravity	2.7
Maximum moisture content	2.08gm/cm^3
Optimum moisture content	14.34%
Coefficient of Permeability	0.011cm/sec
Bulk density	2.38gm/cm^3

2.3 Alkaline Activator Solution

Sodium Hydroxide (NaOH): Sodium hydroxide is an inorganic compound. A metallic base Alkali salts of highly caustic white colour solid materials which are available in flake or granules pellets and which is prepared as different concentration of solution.

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.

3. METHODOLOGY



3.1 Methodology adopted in preparing geopolymer aggregates

Preparing of aggregates is done in 2 phases:

Phase-I: Is to fix the optimum molarity of alkaline activator solution.

Prepared the cubes which is of 75*75*75 mm by using the ash and IOT with the 70:30 proportion respectively with the prepared Alkaline activator solution. Prepared 3 cubes from each molarity of solution and administered the compressive test on the cubes to hunt out the utmost strength among the cubes and respective molarity of solution of the cube with maximum compressive strength is used for the preparation of the Geopolymer coarse aggregate. Here as increasing the molarity of activator solution, the strength also increases simultaneously. The 10M of activator solution is employed for the preparation of geopolymer coarse aggregates.

Figure 1: 75mm cubes of different molarity

Phase-II: Prepare geopolymer aggregates

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 and solution has been mixed with IOT and fly ash. With precautionary measures and proper care mixing was administrated with hand. Prepared slurry was placed to the moulds of 150mm side and therefore the cubes are allowed for the oven curing for 4 hours at 1000 C and demoulded 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 the coarse aggregates. Those aggregates are used in the manufacture of concrete.

Figure 2: Formation of geopolymer Coarse aggregate

4. RESULTS AND DISCUSSION

The Prepared geopolymer coarse aggregates are tested and compared with natural aggregates and the results are reported in the table 3. The water content in the concrete gives the idea about the strength of aggregates and aggregates are more porous as having more water absorption compared to natural aggregates. Outcome of the test 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 CA & Natural CA

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

4.1 Tests on the concrete with 50% 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 casted and cured for the required number of days and has been checked for compressive strength of concrete.

Table 4. Compression Strength values of Concrete cube

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

Table 5. Flexural Strength values of Concrete beam

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

Table 6. Split Tensile Strength values of Concrete cylinder

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

Table 7. Workability results of 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

5. CONCLUSION

- Specific gravity of the IOT is found to be more as compared to 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 has more value compared to IOT. Total dissolved solid of fly ash has more as compared to IOT.
- Mullite and Quartz are the contents present in fly ash with maximum proportion and where IOT has the maximum content of silicon dioxide in the Quartz form.
- Geopolymer coarse aggregates can be synthesized by using fly ash and IOT in proportion of 70:30 respectively. By using the activators NaOH and Na_2SiO_3 in 25% and 5% respectively to the fly ash weight. Aggregates are prepared using the fly ash and IOT 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 for finding the optimum Molarity of the activator solution, where the solution of 10M gives the highest strength.
- Artificial Geopolymer CA absorbs more water as compared with natural CA hence during the mix of concrete, more water is required.
- Geopolymer aggregates have the more workability compared to the natural CA because of flakiness of geopolymer CA. Geopolymer CA has shown the less impact value compared to the conventional aggregates in impact test. As it has more flakiness in the Geopolymer CA, they form the less voids during mix of concrete, hence requirement of fine aggregates is less for the same volume of mix with conventional CA.
- Geopolymer CA are less in weight compared to natural coarse aggregates hence the dead load of structure is less.

6. REFERENCES

[1] Ali Umara Shettima, Mohd Warid Hussin, and et al, (2016) "Evaluation of iron ore tailings as replacement for finer aggregate in concrete", ELSERVIER, Construction and building Materials 120, Pg no. 72 – 79.

[2] B N Skanda Kumar, and et al, (2014) "Utilization of iron ore tailing as the partial replacement for the fine aggregate in the construction of rigid pavements" International journal of research in engineering and technology, Volume: 3.

[3] Chang-long Wang, and et al, (2016) "Properties and Preparation of Autoclaved Aerated Concrete Using Coal Gangue and Iron Ore Tailings", Construction and building materials 104 (2016) 109-115.

[4] K. J Osinubi, and et al, (2015) "Cement modification of tropical black clay using iron ore tailings as admixture". ELSERVIER, Transportation Geotechincs 5, Pg no. 35 – 49.

[5] Khan, M. S. H., Castel, A., Akbarnezhad, A., Foster, S. J., & Smith, M. (2016). "Utilisation of steel furnace slag coarse aggregate in a low calcium fly ash geopolymer concrete". Cement and Concrete Research, 89, 220–229. https://doi.org/10.1016/j.cemconres.2016.09.001

[6] Okoye, F. N., Durgaprasad, J., & Singh, N. B. (2015). "Mechanical properties of alkali activated flyash/Kaolin based geopolymer concrete". Construction and Building Materials, 98, 685–691. Available: https://doi.org/10.1016/j.conbuildmat.2015.08.009

[7] Osinubi, K. J., Yohanna, P, and et al (2015). "Cement modification of tropical black clay using iron ore tailings as admixture". Transportation Geotechnics, 5, 35–49. Available: https://doi.org/10.1016/j.trgeo.2015.10.001

[8] P Shubhananda Rao, and et al, (2019) "use of iron ore tailing in Infrastructure projects" and International journal of Mining and Mineral Engineering, Volume: 10 No. 1.

[9] Ravi Kumar, C. M., Kumar, A., Prashanth, M. H., & Reddy, D. V. (2012). "Experimental studies on Iron-ore tailing based interlocking paver blocks". International Journal of Earth Sciences and Engineering, 5(3), 501–504.

[10] S V Joshi, M.S kadu. (2012) "Role of Alkaline activator in development of eco- friendly fly ash based Geopolymer concrete", international journal of environmental science and development vol.3, no.5, pp.417-421
[11] Sharath, B. P., Shivaprasad, K. N., Athikkal, M. M., & Das, B. B. (2018). "Some Studies on Sustainable Utilization of Iron Ore Tailing (IOT) as Fine Aggregates in Fly Ash Based Geopolymer Mortar". IOP Conference Series: Materials Science and Engineering, 431(9). Available: Available: https://doi.org/10.1088/1757899X/431/9/092010
[12] Sunil C L, Bharath R B, and et al, (2020) "IOT Based on Geopolymer CA using fly ash as Precursor In the construction industry" , International Research Journal of Engineering and Technology , Volume: 7.
[13] T. I Ugama, S. P Ejeh, and D Y Amartey, (2014) "Effect of iron ore tailing on the properties of concrete". And International Institute for science, Technology and Education, Volume: 6 No. 10.
[14] Wang, C. L., Ni, W., Zhang, S. Q., Wang, S., Gai, G. S., & Wang, W. K. (2016). "Preparation and properties of autoclaved aerated concrete using coal gangue and iron ore tailings". Construction and Building Materials, 104, 109–115.
[15] IS:383-1970, "Specification for Coarse Aggregate and Fine Aggregates from Natural Sources for Concrete", Bureau of Indian Standards, New Delhi
[16] IS:456-2000, "Indian Standard Code of Practice for Plain and Reinforced Concrete", Bureau of Indian Standards, New Delhi
[17] IS:10262-2009, "Indian Standard Code for Guidelines of Concrete Mix Proportioning", Bureau of Indian Standards, New Delhi.

