International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 07 Issue: 06 | June - 2023 SJIF Rating: 8.176 ISSN: 2582-3930

Development of a Process for Utilization of Mining Wastes with Fly Ash for the Production of Bricks

[1]Smruti Ranjan Behera [1*]Amar Kumar Das

[1] M.Tech Scholar, Dept. of Environmental Engineering, Gandhi Institute For Technology (GIFT), Autonomous, Bhubaneswar

[1*] Associate Professor, Dept. of Mechanical Engineering, Gandhi Institute for Technology (GIFT), Autonomous, Bhubaneswar

Abstract

Sustainable management of iron ore tailings is a high concern to all stakeholders who are into iron ore mining. This study seeks to add value to the tailings by using them as a substitute for bricks for civil manufactory. The iron tailings were mixed in varied proportions with different combinations of cement and fly ash for use in the construction industry. Bricks were made using a variety of compositions of iron tailings, Ordinary Portland cement and fly ash, in cuboid mould(9 ″ X 5 ″ X 3 ″). The bricks were dried for 24 hours. Mechanical features such as water absorption, compressive strength, and efflorescence are tested. The maximum compressive strength order of11.82 N/ mm2 was recorded with rates of 721(Iron trailing, flyash and cement). The properties of the iron ore tailings similar as plasticity, continuity, density, compressive strength, XRF, XRD, SEM tests were conducted. Water absorption for the proposed bricks are lower than that of burnt complexion bricks. The lower capillary cavity can help the formation of efflorescence. This process, with the same parameters, can be changed commercially, and a large number of wastes of iron ore can be used to make bricks. thus, the technological processes linked in this paper can convert large quantities of unsafe waste into the surroundings into value- added products. Iron trailing can be seen as a stable addition to clay soils, its use when confined to making bricks.

Keywords iron ore tailings(IOT), compressive strength, XRF, XRD.

1. Introduction

The mine tailings are generated as the wastes due to exploration, excavation, beneficiation and extraction of mineral ores [1]. India is one of the major iron ore producer and exporter in the world. It was estimated that about 10–15 % of the iron ore mined in India is unutilized, even now, and is discarded as waste/tailings due to lack of cost effective technology in extracting low grade ores [2] . The waste thus created in the form of ultra-fines or slimes has remained a major unsolved and challenging task for the Indian iron-ore industry. Due to the extensive mining activities and increasing low grade ores, there is a generation of mine tailings in large quantities. The common practice of handling the tailings are to store them in tailing dams or as overburden stockpiles near mine sites. The cost of handling and storage of mineral waste represents a financial loss to a company, estimated at around 1.5 to 3.5 % of total cost and depending on the mineral being mined [3].The continuous accumulation of the mine tailings causes problems to the community concerning health issues and sustainability. Some of the problems relate to erosion, development of acid mine drainage (AMD) and dam failures, and high cost of rehabilitation to the mining industries upon mine closures [3]. The problems have created the awareness of sustainability issues, and researchers are therefore focusing on improved ways in which the mine tailings can be managed or recycled effectively. Therefore, comprehensive utilization of waste/tailings is important in saving resources, improving surrounding and for sustainable development. Iron ore tailing, produced from mineral beneficiation process, usually have high contents of SiO2 and Fe2O3, which enables it to be a potential source of silicon and iron. Some researchers have used mine wastes and tailings into different civil applications. Further, building blocks from mine waste are eco-friendly as it utilizes waste and reduces air, land and water pollution. It is energy efficient and also cost effective as reported by various investigators. Behra et al. developed bricks by mixing iron ore tailing and clay in different proportions and found the highest compressive strength (CS) of 25.40 MPa at 950oC in 40:60 proportions of clay and waste, respectively. Further, water absorption (WA) of iron ore bricks was low in comparison to fly ash and clay bricks [4]. A research has been carried out by Rao et al. (2016) to utilize the iron ore tailings from the tailing ponds of Donimalai iron ore mine, India. The tailing sample assayed 49.40% Fe. Initially de sliming of the sample was performed and then hydro cyclone undertow was subjected to magnetic separation [5].

Detailed mineralogical characterization of different ore types has been carried out [6] using transmitted and reflected light microscopy. Scanning electron microscope-energy dispersive spectroscopy (SEMEDS), X-ray diffraction (XRD) and X-ray fluorescence (XRF) have also been used with a view to test the amenability of these ore types for beneficiation requirements. The nature of these ores is responsible for producing large amounts of alumina-rich slime during mining and handling operations. Suitable beneficiation schemes have been recommended for each type based on detailed characterization investigations on these ores [6]. The technological processes identified in this paper utilization of iron ore tailings for brick Manufacture can convert large amounts of hazardous waste into the environment into value-added products. Iron tailing can be seen as a stable addition to clay soils, its use when restricted to making bricks. This research helps to open a new area of research [7].

The study in the paper utilization of iron ore tailings as brick making shows that the iron ore tailings exhibited a good mechanical strength and even in the case of compressive strength, there was an improvement of 11.56% over conventional brick. The indirect tensile strength did not improve against the control mix due high content of fines in the tailings aggregates but showed 4.8% improvement compared with the previous study where the conventional brick material was partially replaced by 20% with iron ore tailings So, the paper aims to study the effective utilization of iron tailing to manufacture alternative bricks and its economical stability as compared to fly ash and conventional burnt bricks.

2. Materials and Methods

2.1 Materials used in brick manufacturing

The following raw materials were used to prepare the sample of brick for the experimental purpose as shown in Figure 1. The iron ore trailing used in the trial is collected from iron ore mines in Joruri Iron ore Mines positioned in Keonjhar district of Orissa. The flyspeck size of the tailings range is in between 10 to 150µm.

Figure 1(a) pulverized form of Iron ore tailings (b) fly ash(c) Portland cement Fly ash of sizes(0- 5 mm), having loss on ignition(LOI) of0.14 which were attained from marketable broker, were mixed and used in the control blend. Ordinary general purpose Portland cement of grade of 43(IS 8112) was used. This was brought in from original request. The cement had a normal thickness of29.5, soundness of0.8 mm with original setting time of0.5 h and maximum final setting time of 10 h. The specific gravity of the cement was 3.1. Chemical composition of OPC indicated(24.98 SiO_2,4.84 Al_2O_3,3.02 Fe_2O_3,61.24 CaO, and1.42 MgO) out of which presence of CaO is about 61 %by weight which leads to a long – term build – up of strength.

2.2 Characterization of brick samples

The characteristics of iron ore tailings vary depending on the specific composition of the chase, as well as the system of brick product. The physical and chemical properties of the iron ore tailings are shown in Table 1 and Table 2 independently. It can be seen from Table 2 that iron oxide, copper oxide, silica, and alumina are the main ingredients of iron ore tailings. Some heavy metals similar Magnesium, Sodium, Manganese and Sulphur is present in veritably small concentrations.

2.3 Characterization of brick samples

The characteristics of iron ore tailings vary depending on the specific composition of the chase, as well as the system of brick product. The physical and chemical properties of the iron ore tailings are shown in Table 1 and Table 2 independently. It can be seen from Table 2 that iron oxide, copper oxide, silica, and alumina are the main ingredients of iron ore tailings. Some heavy metals similar Magnesium, Sodium, Manganese and Sulphur is present in veritably small concentrations.

Table 1 Physical property of iron ore tailings

Property	**Value**
Fines (clay and silt)	6.75%
Sand content	60%
Specific gravity	2.62%
Air dry density	1770 kg/m3
Particle size	< 150 µ

Table 2 XRF study of iron ore tailings

LOI%	SiO2%	Al2O3%	CuO%	MgO%	Na2O%	MnO2%	TiO2%	SO3%	Fe2O3%
0.14	34.80	14.14	16.16	2.70	5.3	0.5	5.3	0.86	24.14

The main crystalline phases detected by X-ray diffraction (XRD) of iron ore tailings are hematite (α-Fe2O3), goethite (α-FeOOH), and quartz (SiO2).41,47,55,56 Kaolinite (Si2Al2O5(OH)4) is a mineral commonly associated with iron ore tailings as well as minor gibbsite (Al(OH)3). A typical XRD profile showing crystalline phases of quartz, hematite, and goethite is shown in Figure 2.

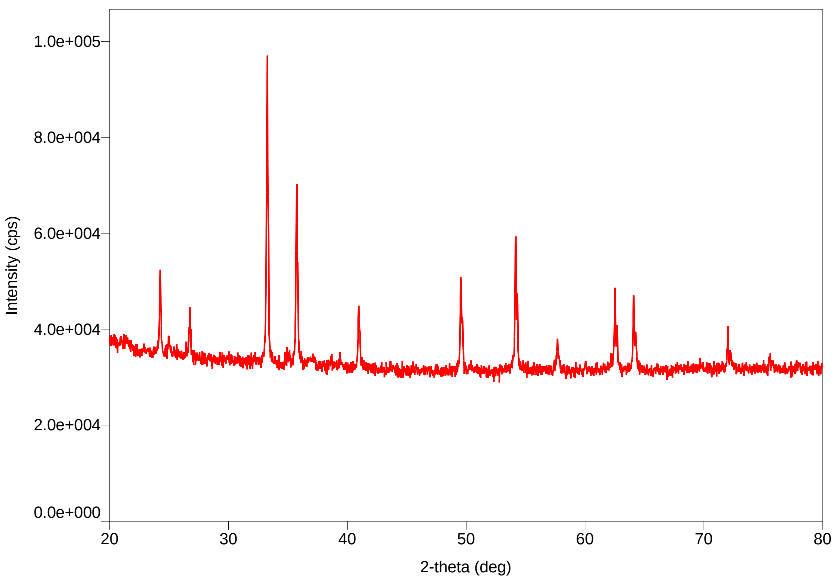

Figure 2 XRF studies of Iron ore tailings

2.4 Preparation techniques

The flow chart of the manufacturing system of bricks is shown in Figure 2. The experimental program is to produce the iron ore trailing bricks for fulfilling the musts of the public and international norms(i.e., IS and ASTM) by using iron ore trailing with a partial relief of fly ash and OPC for brick making. For preparing the bricks, iron ore tailing was taken as a major total in combination with fly ash and cement as minor summations. Livery mixing of constituents should be assured to get correct test results of the instance. The bricks were prepared using cast iron moulds for five different combinations of over said summations by chance of weight. The bricks were of size190mm X 90 mm X(BIS, 1988, 1993, 1989). It was calculated that for a single brick,2.65 kg of admixture is needed and sufficient quantum of water i.e. about 500 ml for each slipup was added while mixing. oil painting was applied to the inner part of the mould and after filling the admixture, load up to 15- 19 kN was applied using contraction testing machine for proper compaction of bricks. The bricks therefore prepared was kept for 24 hours in the mould and also removed and kept under sun for drying with proper curing by scattering water,. Bricks were cured for 7 days, 14 days, 21 days and 28 days and also tested for its compressive strength using compression testing machine.

3. Results and Discussions

The results for the various tests on bricks have been summarized in this section and it has been discussed in detail.

3.1 Bulk density

The bulk density of a brick is one of the crusial parameters in the design of masonry structures [8]. For conventional fired bricks or earthen bricks, the density ranges between 1.8 and 1.9 g/cm^3.

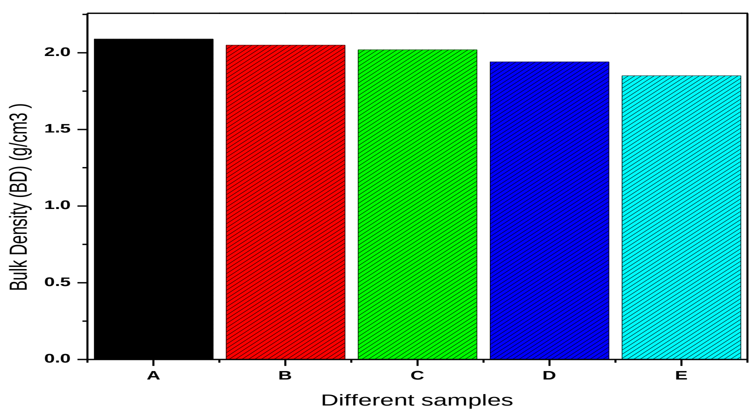

Figure 3 Variation in Bulk densities of samples

However, in the present study, introduction of iron ore tailings exhibited slightly higher density, which was in the range of 2.15 to 2.2 g/cm^3 for various block types. Furthermore, such increase can be attributed to tight packing of fine particles and slightly higher specific gravity of IOT. The BD of different brick samples is presented in Figure 3. The BD exhibited maximum value (2.2 g/cm3) for A and minimum value (1. 88 g/cm3) for E. Present study indicated that the iron tailing percent in different combination ratio increased linearly with BD.

3.2 Compressive strength (CS)

Compressive strength is the main mechanical property of a concrete that is normally specified in supply of concrete .Out of ten bricks five bricks were tested for its compressive strength and five for its water absorption, as per ISRM standards (BIS 1980).

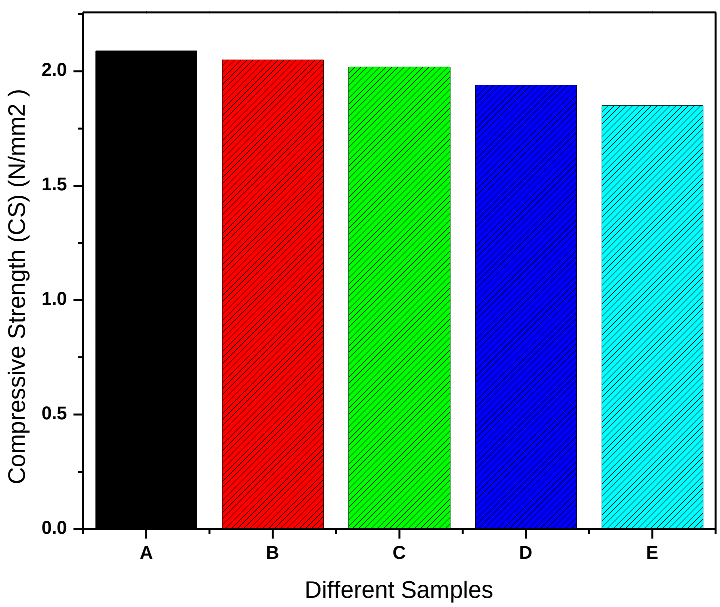

Figure 3 Variation in compressive strength of samples

Figure 4 also gives the results of compressive strength and water absorption for all the five set of bricks of different rate. According to IS norms, the compressive strength of bricks should be minimal 3 MPa, whereas water immersion shouldn't be further than 20 for 24 hr absorption(BIS, 1991; 1992) From Table 4 it can be concluded that the compressive strength of bricks reduces with reduction in chance of cement in admixture. still, with increase in curing period the minimal strength of bricks could be gained. But in all the cases the water immersion is within the admissible limit.

International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 07 Issue: 06 | June - 2023 SJIF Rating: 8.176 ISSN: 2582-3930

3.3 Water absorption (WA)

The WA is an important property of brick to study about mechanical strength and it's showed the permeability of iron trailing bricks and also an index of the degree of the response of fired clay bricks as shown in Figure 4. It's also apparent in geo polymerized bricks, meanwhile increased degree of geo – polymerization results in deceased permeability and porosity. Water absorption test involves immersing the iron ore trailing bricks in water for minimum 24 hours and also assaying the water for presence of dangerous substances**.**

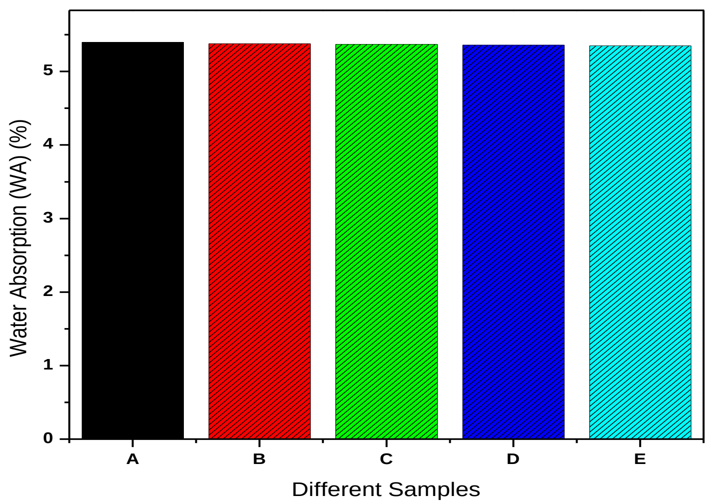

Figure 4 Variation in Water absorption of samples

4.Conclusion

The present study shows that it's viable to use iron trailing wastes to produce standard quality bricks. The experimental results showed the compressive strength is affected by the increase in cement/ sodium silicate percentage, and or increase in the heating duration of the manufactured bricks and were similar with the standard specified for burnt clay bricks(IS 10771992). Likewise, it's possible to manufacture different types of IOT bricks that can safely be used as load – bearing and non – load bearing units by either using varied binding agents along or regulation the heating duration. This system won't only help to reclaim the iron ore wastes but will also produce stronger, energy – effective, and economically feasible indispensable building accoutrements Eventually, this won't only help fulfil the conditions of the accumulating populace of India but will also assist in conserving the ever precious soil resources.

References

[1] Kuranchie, F. A. (2015). Characterisation and applications of iron ore tailings in building and construction projects.

[2] Lamani, S. R., Aruna, M., Vardhan, H., & Shanth, A. T. (2015). Development of value added product using iron ore waste for its effective utilization. *International journal of advanced and applied sciences*, *2*(12), 30-35.

[3] Behera, K., Bose, B. P., & Mondal, M. K. (2019). Production of construction bricks using iron ore tailings and clay. In *Waste Management and Resource Efficiency: Proceedings of 6th IconSWM 2016* (pp. 583-596). Springer Singapore.

[4] Rao, G. V., Markandeya, R., & Sharma, S. K. (2016). Recovery of iron values from iron ore slimes of Donimalai tailing dam. *Transactions of the Indian Institute of Metals*, *69*(1), 143-150.

[5] Roy, S., Das, A., & Venkatesh, A. S. (2007, August). Characterization of Iron Ore from the Jilling Area of Eastern India with a view to Beneficiation, In. In *Iron Ore Conference, Perth* (pp. 20-22).

[6] Kuranchie, F. A., Shukla, S. K., Habibi, D., & Mohyeddin, A. (2015). Utilisation of iron ore tailings as aggregates in concrete. *Cogent Engineering*, *2*(1), 1083137.

[7] Lamani, S. R., Aruna, M., Vardhan, H., & Shanth, A. T. (2015). Development of value added product using iron ore waste for its effective utilization. *International journal of advanced and applied sciences*, *2*(12), 30-35.

[8] Beulah, M., Sudhir, M. R., Mohan, M. K., Gayathri, G., & Jain, D. (2021). Mine waste-based next generation bricks: a case study of iron ore tailings, red mudand ggbs utilization in bricks. *Advances in Materials Science and Engineering*, *2021*, 1-10.

[9] Thejas, H. K., & Hossiney, N. (2022). Alkali-activated bricks made with mining waste iron ore tailings. *Case Studies in Construction Materials*, *16*, e00973.