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# Utilization of Abandoned Mine Soil in Making Bricks to Be Used for Construction Activity

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***Abstract: Mining is a process of extraction of valuable minerals or geological substances from the earth; however, mining degrades the ecosystem. Earlier studies have discovered that about 10-15% of the ore mined is not utilized and discarded due to lack of cost-effective extraction technology for low graded ore in India. These soils cause environmental degradation as they do not support the growth of vegetation. Thus, the land becomes abandoned and fits for nothing. These soils have created an unsolved problem in mining industries. Bringing a solution to this issue is a challenging task. And it is necessary due to the presence of heavy metals in them. Concomitantly, there is a substantial demand for the construction materials. Due to increase in the population the need for shelter is increasing day by day. So, it is imperious to use these mining soils in building materials such as bricks, concrete blocks and other products which are of high value in day-to-day life. In the present study we attempt to prepare non modular bricks by using iron tailings or soils and clay soil. Here in this study we prepared different bricks varying their composition with respect to percentage of mine waste viz... 0,20,40,60,80, 100.The bricks made up 20%, 40%, 60% of mine soil replaced with the regular clay soil, attained compressive strength of 10.07MPa, 7.11MPa, 3.95MPa respectively with a water absorption of 14.57%, 15.61%, 18.44% respectively. So, mined soil which is unfertile and useless otherwise can answer sustainability by going for Brick making.***

***Keywords: Mine soil, Bricks, compressive strength, water absorption.***

## I. INTRODUCTION

Abandoned mines can be found in various parts of the world. It is estimated that there are 500, 000 in United States, 50,000 in Australia and 10,000 in Canada [21]. The Bingham canyon mine is considered as the largest mines in the world extracting copper from the earth, the other larger mines around the world are Mirny mine in Russia containing diamond. Grasberg is the largest gold mine and the third largest copper mine in the world [11]. Such that Bellary is considered as the hub for iron ore mining during 2005-06 in Karnataka. Due to excessive demand the extracting process increased leading to the loss of biodiversity near the area and made Bellary a barren land. Sandur is the place in Bellary where the extraction of iron ore and manganese takes place. It is considered as the largest miners of manganese ore in India. Earlier studies have discovered that about 10-15% of the ores mined is not utilized and discarded due to lack of cost-effective extraction technology for low graded ores in India [18] The soils /tailings having equivalent diameter of less than 150 µm is considered as ultra-fines or slimes are discarded as they are not considered as useful. Roughly 10-12million tons of mined ore is discarded as soil or tailings in India. The effective utilization or disposal of such immense mineral soil without further environmental degradation has become a crucial unsolved and a demanding job for Indian ore industry. As estimated about 1.5-3.5% of the total cost is drained on handling and storage these mineral soils which caused financial loss to the company and it depends on the mineral being mined [16]. Therefore, the extensive utilization of the mineral soils or tailings is necessary to restore the resource for sustainable growth. Recently Jayalatha and VeenaKumaraAdi reported Restoration of Physico-Chemical Properties of Zinc Contaminated Soil by Bacterial Biosurfactant [8] It was found that the mine soil was used in backfilling of quarries and in land reclamation, they are also used as subside fill or as aggregates in the construction of roads, embankments, foundations and dams.

Due to growing population the need for construction materials is extending at a dreadful rate. In order to meet the demand new means of new techniques need to be developed. The materials which are consumed in large quantities in manufacturing activities such as bricks, cement, steel and aggregates put stress on the natural resources and demand huge raw materials. Therefore, use of any substitutes for these materials needs to be encouraged and their benefits are to be understood properly. In this way use of mine soils in brick production need to be considered as these tailings can be converted into bricks which might meet the demand for bricks in metropolitan cities in future.

Further, these bricks made from mine soil are cost effective and energy efficient, eco-friendly as they utilize soil and prevent air water and land pollution. The demand for building materials in India is increasing day by day as the population growth and need for shelter. So, it is important to use the soils from mines in the production of bricks, concrete blocks or other products of high value and need [17]. Abandoned mines pose many problems to the ecosystem as they do not support the growth of vegetation. Large mass of soil gets wasted because of this. The objective of this study is to use mine soil for making bricks which has high demand in construction industry. Mine soil was mixed with different proportions of regular clay and studied to check the suitability for construction work.

## II. METHODOLOGY OF BRICK MAKING

For preparing bricks the mine soil was collected from Sandur. It was then mixed with clay. The mixture was made at 4 different proportions by taking percentage of volume as 20%, 40%, 60%, 80%. Here 20% of mine soil is mixed with 80% of clay, 40% of mine soil mixed with 60% of clay soil, 60% of mine soil with 40% clay and then 80% of mine soil with 20% of clay along with this a combination of brick completely made up of clay is also prepared to compare the strength of bricks, the bricks were designated as mentioned in Table 1. However, 100 % mine soil was not considered in the study because soil was not cohesive and did not have plasticity. The bricks of size 230mmx110mmx70mm was prepared according to Bureau of Indian Standards [3]

Initially the mixture of mine soil and clay is prepared. The clay and mine soil mixture were soaked and then mould was prepared, oil was applied to the inner part of the mould initially, precautions were taken to avoid any void spaces and compacted properly. The bricks prepared were kept for 24 hours in the mould. [14]. Which was later removed and dried in shade for a week. Then they were kept for drying for two weeks in sunlight later the bricks were burnt in the conventional way following the procedure adopted for clay bricks Fig.1 shows the bricks kept for drying. The strength of bricks was tested by compressive testing machine and water absorption test is also conducted. Compressive strength of all the bricks were tested by applying load axially at uniform rate of 14 N/mm2 per minute using Compression testing machine till it fails and the maximum load at failure was noted, compressive strength is calculated. [6]

Table 1: Designation of bricks used in the study

| Designation of experimental brick | % of mine soil added |
|---|---|
| A | 0 |
| B | 20 |
| C | 40 |
| D | 60 |
| E | 80 |


Fig1: Bricks kept for drying

### A. *Laboratory Studies*

For the experiments to be carried out the soil sample was collected from Sandur taluk of Ballary district of Karnataka state. The samples were collected from different locations near the co-ordinates N15º6’0” and E76 º33’0”. Tests were conducted on the soil prior to making of bricks to know the composition of the soil, heavy metals were analysed on AAS. The results reveal the presence of various heavy metals. The tests conducted on mine soil are Particle size distribution by sieve analysis, specific gravity test, Moisture content test, liquid limit test. After making of brick, they were tested for compressive strength and water absorption to check their suitability for construction.

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## III. RESULTS AND DISCUSSION

### *A. Analysis of Soil*

Table 2: Test results of soil content

| Sl. No. | Heavy metal Composition | Desired Range of fertile soil* | Values for mine soil |
|---|---|---|---|
| 1 | pH | 5.5-7.5 | 8.4 |
| 2 | Electrical conductivity (EC) (S/m) | <0.1 | 0.20 |
| 3 | Organic carbon (OC) (%) | 0.5-0.75 | 0.6 |
| 4 | Nitrogen (N) (Kg/ha) | 280-560 | - |
| 5 | Phosphorus ($P_{205}$) (Kg/ha) | 10-25 | 117.7 |
| 6 | Potash ($K_2O$) (Kg/ha) | 120-280 | 98.6 |
| 7 | Zinc (Zn) (ppm) | 0.60 | 19.62 |
| 8 | Copper (Cu) (ppm) | 0.20 | 2.905 |
| 9 | Manganese (Mn) (ppm) | 2.00 | 4.69 |
| 10 | Iron (Fe) (ppm) | 4.50 | 9.98 |
| 11 | Boron (B) (ppm) | 0.50 | 0.30 |
| 12 | Sulphur (S) (ppm) | 10.0 | 61.21 |

**note: "Manual on Soil Sample Analysis" Uni of Agri and Horti Sciences, Shivamogga, Karnataka, India.*

The composition of the fertile soil that supports the growth of vegetation is tabulated in Table.2. From the analysis it is clear that the experimental soil has the composition such that it is not suitable for the growth of vegetation. It has pH 8.4 which is alkaline, Nitrogen is nil, phosphorus is 117.7Kg/ha which is very high, potash 98.6 Kg/ha which is very less compared to the desired value. Further the micronutrients required for the growth of vegetation such as zinc, copper, manganese, iron and sulphur are available in very high amount. In such conditions the plants cannot grow as the micro-organisms required for the plant growth cannot survive in such harsh conditions. So, it can be stated that mine soil cannot support growth of vegetation. These composition changes the other properties of soil. So, it is necessary to use this soil for other purposes such that they do not harm the ecosystem and help in sustainable growth.

### *B. Particle size Distribution by Sieve Analysis*

The particle distribution analysis is broadly used in classification of soil. The test is performed to determine the percentage of different sizes of grains present in the soil. It is used to differentiate the coarse, larger particles and small particles contained in the soil. It helps in classifying the soil as the grain sizes effect the engineering properties of the soil. Fig2 shows the particle size distribution test results of the experimental soil, its fineness modulus ranges between 4-6.75 indicating it's a combination of coarse aggregate and fine aggregates [4]

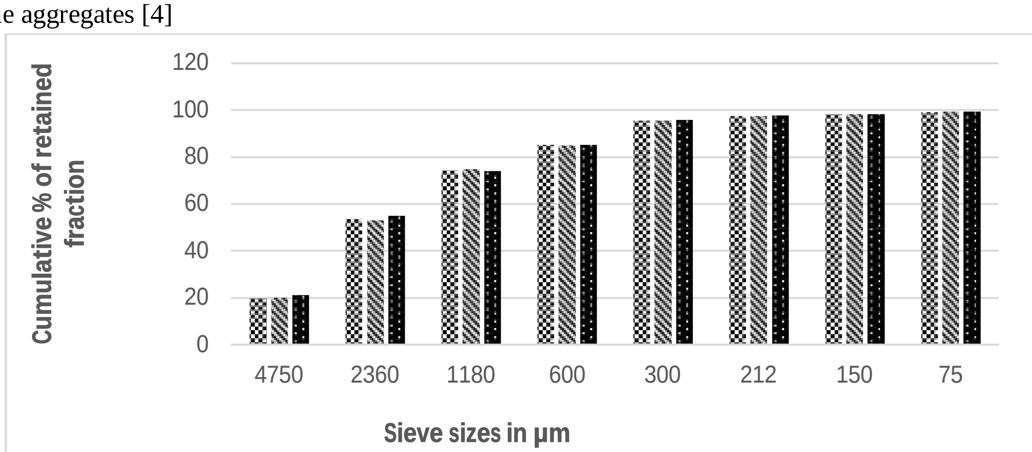


Fig 2: Graph of sieve analysis

*C. Specific Gravity Test*

Specific gravity is defined as the ratio of mass of unit volume of soil at a given temperature to the mass of the same volume of water at given temperature. The density of the minerals which makes up the soil particles influences the specific gravity of the soil.

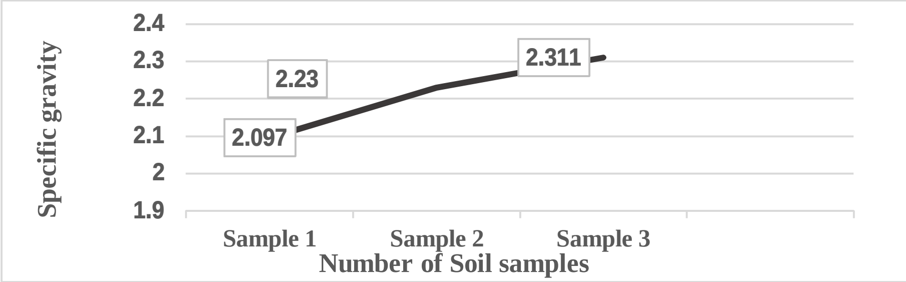


Fig 3: Graph of specific gravity of soil

Fig 3 represents the test results of specific gravity of soil. According to IS: 2720 (Part 4)–1985 the specific gravity ranging 2.00-2.60 indicates the soil is rich in organic content.

*D. Moisture Content Test*

Moisture content of the soil is the ratio of mass of water held in the soil to that of dry soil. the mass of water stored in soil is determined by finding the difference of the mass of the soil before and after drying the soil. Fig 4 shows the test results of moisture content test results which ranges between 14-20 indicating that soil is clayey. Clayey soil has fewer void spaces and are mostly waterlogged.

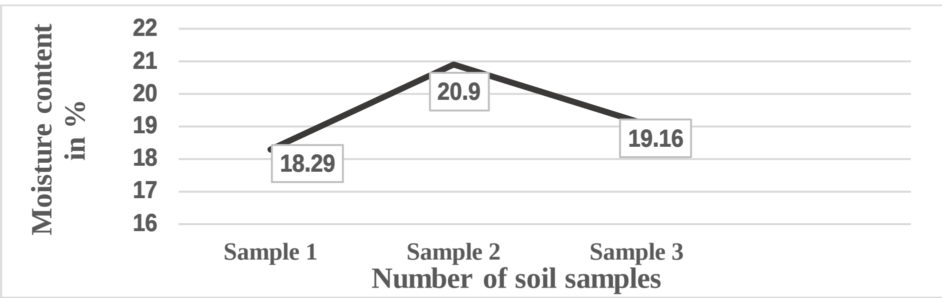


Fig 4: graph of moisture content of soil

*E. Liquid Limit Test*

Liquid limit is defined as the minimum water added to the soil where soil has small shearing strength against the flow when the soil is still being in a liquid state. Liquid limit is the water content at which soil changes from a plastic to viscous fluid state.

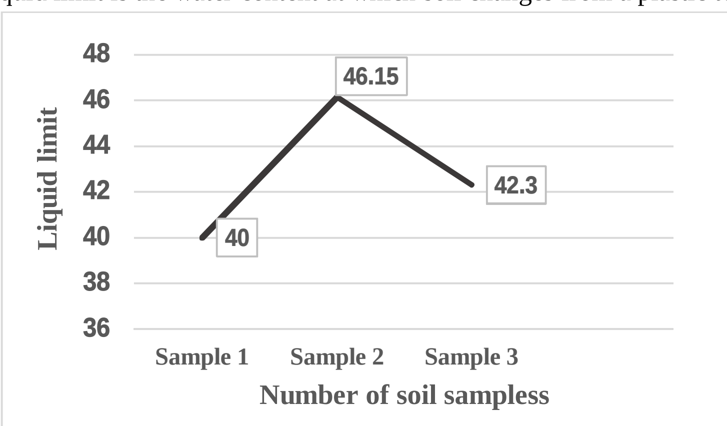


Fig 5: Graph of liquid limit test

Fig 5 shows the test results of liquid limit test. Liquid limit test is conducted to study the consistency of soil. The soil with liquid limit ranging between 40-150 is clayey [5] which is high in plasticity and compressibility.

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### *F. Plastic Limit Test*

Plastic limit is defined as the water content at which the soil begins to crumble when rolled into a thread of 3mm diameter. It is the moisture content below which soil ceases to be plastic. It is the boundary between plastic and semisolid state of the soil.

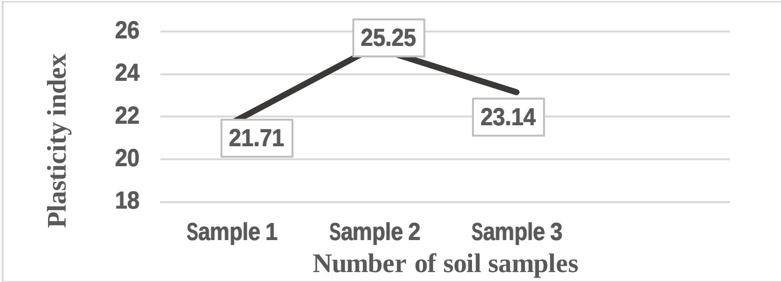


Fig6: graph of plastic limit

Fig 6 represents the plastic limit test results. Plasticity index ranging between 15-100 is clayey [5] and cohesive in nature which can be easily deformed and has low strength.

From the soil analysis it is observed that the mine soil has pH 8.4 which is alkaline and there is no Nitrogen content which is essential for plant growth but it is rich in Phosphorus with 117.7kg/ha, Zinc 19.62ppm, Copper 2.905ppm, Manganese 4.69ppm, Iron 9.98ppm, Sulphur 61.21ppm. These heavy metals do not support the growth of vegetation as there is no microbial activity takes place due to the absence of microbes in such harsh environment. It is also seen that the soil is clayey and has fewer voids and they are mostly waterlogged so it can be stated that the mine soil is not suitable for vegetation. But they need to be treated or should be used for other productive purposes to avoid further environmental degradation.

### *G. Analysis on Bricks*

The preparation, drying and burning of bricks are the steps followed during the making of bricks. The steps followed are adopted according to the conventional method followed for manufacturing of clay bricks in factories. The compressive strength and water absorption test were conducted based on Bureau of Indian Standards IS 3495-Part I: 1992 and IS 3495-Part II: 1992). [6], [7].

### *H. Compressive Strength of Bricks*

Compressive strength of a brick is defined as the capacity of the brick to withstand the compressive stress acted on it when tested under CTM (Compressive strength Testing Machine). It is also the ability of the material to resist failure in the form of cracks.

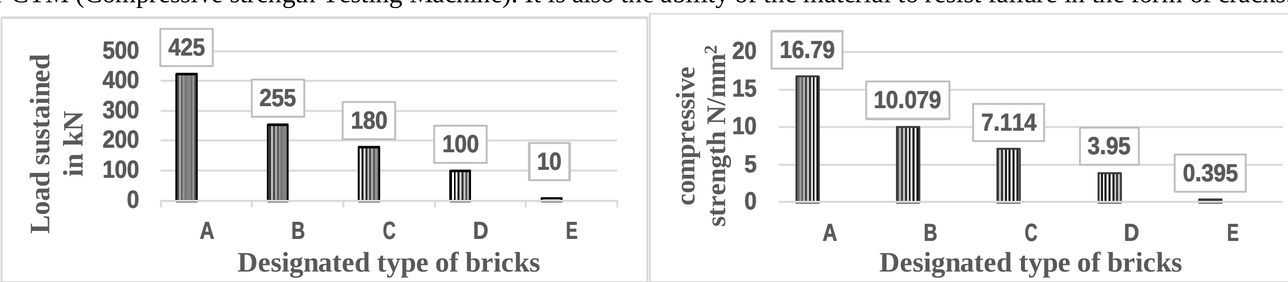


Fig 7: Graph of load sustained and compressive strength of bricks

Fig 8: Compressive strength test conducted on brick

Fig.7 shows the results of load sustained and compressive strength of bricks, Fig. 8 shows the test conduction. Among the 5 combination the bricks made up of 0%, 20%, 40% and 60% of mine soil meet the criteria of BIS.

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The bricks are classified based on their compressive strength (IS: 1077:1992) [3] as tabulated in Table.3 and they are designated as class first, second, third (IS: 1077:1976) [2] as shown in Table.4.

Table3: Classes of bricks according to IS: 1077:1992

| Brick Class designation | Average compressive strength not less than ($N/mm^2$) | Average compressive strength less than ($N/mm^2$) |
|---|---|---|
| 35 | 35 | 40 |
| 30 | 30 | 35 |
| 25 | 25 | 30 |
| 20 | 20 | 25 |
| 17.5 | 17.5 | 20 |
| 15 | 15 | 17.5 |
| 12.5 | 12.5 | 15 |
| 10 | 10 | 12.5 |
| 7.5 | 7.5 | 10 |
| 5 | 5 | 7.5 |
| 3.5 | 3.5 | 5 |

Table 4: classes of bricks according to IS: 1077:1976

| Classes of bricks | Compressive strength ($N/mm^2$) | Results obtained ($N/mm^2$) | Designation of bricks |
|---|---|---|---|
| First class | 10.3 | 16.79 | A |
| Second class | 6.86 | 10.07<br>7.11 | B<br>C |
| Common building bricks | 3.43 | 3.95 | D |
| Sun dried bricks | 1.47-2.45 | --- | |

## I. *Water Absorption Test For Bricks*

It is the test conducted to determine the durability of the bricks for example the degree of burning, quality of the material and weathering behaviour. Increase in the water absorption indicates the presence of pores increase in voids leads to poor quality. Fig 9 shows the conduction of test on bricks.

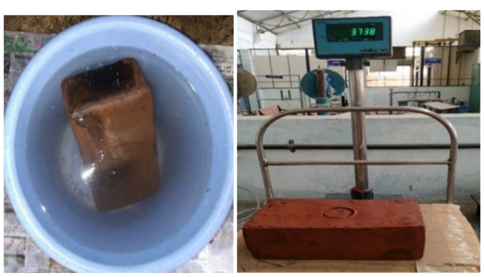

Fig 9: water absorption test conducted on bricks

According to IS standards, the compressive strength of bricks should be minimum $3.5N/mm^2$ (IS 3495-Part I: 1992)[6] whereas water absorption should not be more than 20% for 24hr immersion (IS 3495-Part II: 1992). Considering the results given in the Table 4 all the bricks that is made up of 0%, 20%, 40% and 60% of mine soil achieves the requirement, having compressive strength of 16.79 $N/mm^2$, $10.07N/mm^2$, $7.11N/mm^2$, $3.95N/mm^2$ respectively according to IS standards and also achieves criteria of not absorbing more than 20% after 24hr of soaking in water. Test results of water absorption test is represented in Fig 10, Fig.11 is the shows the effect of water absorption on compressive strength of bricks. It indicates that as the water absorption of the bricks increases their compressive strength decreases.

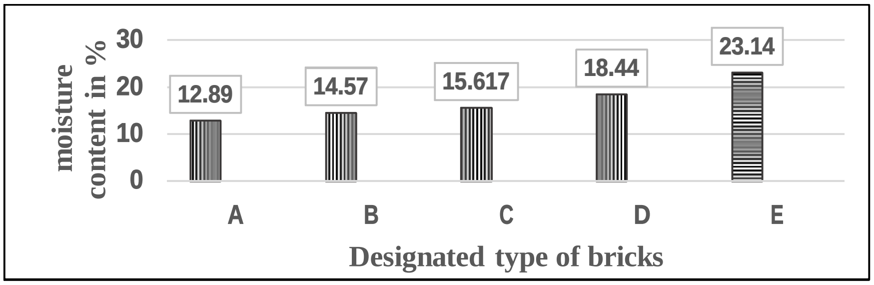


Fig 10: Graph of water absorption by bricks

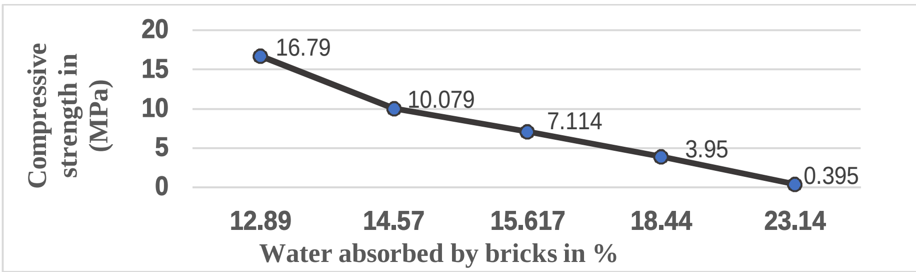


Fig 11: effect of water absorption on compressive strength of brick samples

## IV. CONCLUSION

The study was aimed at producing environmentally friendly bricks made up of mine soils, from the results of compressive strength and water absorption tests it is seen that bricks made up of 100% of clay achieve more strength than other bricks of concern. But the bricks made up of 0%, 20%, 40%, 60% of mine soil having compressive strengths 16.79N/mm$^{2,}$ 10.07N/mm$^2$, 7.11 N/mm$^2$, 3.95 N/mm$^2$ respectively passes through the criteria of Indian Standards (IS: 1077:1992) [3]. They are many studies that have been taken place regarding the efficient usage of mine soil. Amit (2006) [1] reviewed the present status of usage of building materials made from waste. Yongliang et al. (2011) [22] investigated the usage of hematite tailings in production of non-fired bricks. Their investigation showed that non-fired bricks made up of 78% hematite tailings achieved desired compressive strength of 20MPa and water absorption of 15% with curing of 28days in room temperature. Similarly, Chen et al. (2011) [9] attained the compressive strength of up to 15.9 MPa for 20 days curing. Dr. Shivakumara. B et al., (2017) [12] studied the compressive strength of bricks made up of mine soil and quarry dust after 28days of curing and obtained 10.9MPa of compressive strength. Sanjay.Shukla et al., (2016) [19] studies the utilization of iron ore tailings in making of geopolymer bricks where sodium silicate is used as an activator for making geopolymer bricks and attained UCS of 50.53MPa. Hammond et al (1998) [13] studied the utilization of mining and quarrying wastes for construction activities as they pose problem to the environment. Govind R Adhikari et al, (2007) [20] studied the mill tailings that are collected from Kolar gold fields, and bricks were by adding additives to the tailings. Ordinary Portland cement, black cotton soil and red soils were selected as additives. Bricks with 20% of cement and 14days of curing were identified to be suitable. So, the required strength of the bricks for the construction of buildings can be achieved by mixing mine soil with clay and firing it. Here the mine soils can be used for a useful purpose and prevent environmental degradation.

## V. ACKNOWLEDGMENTS

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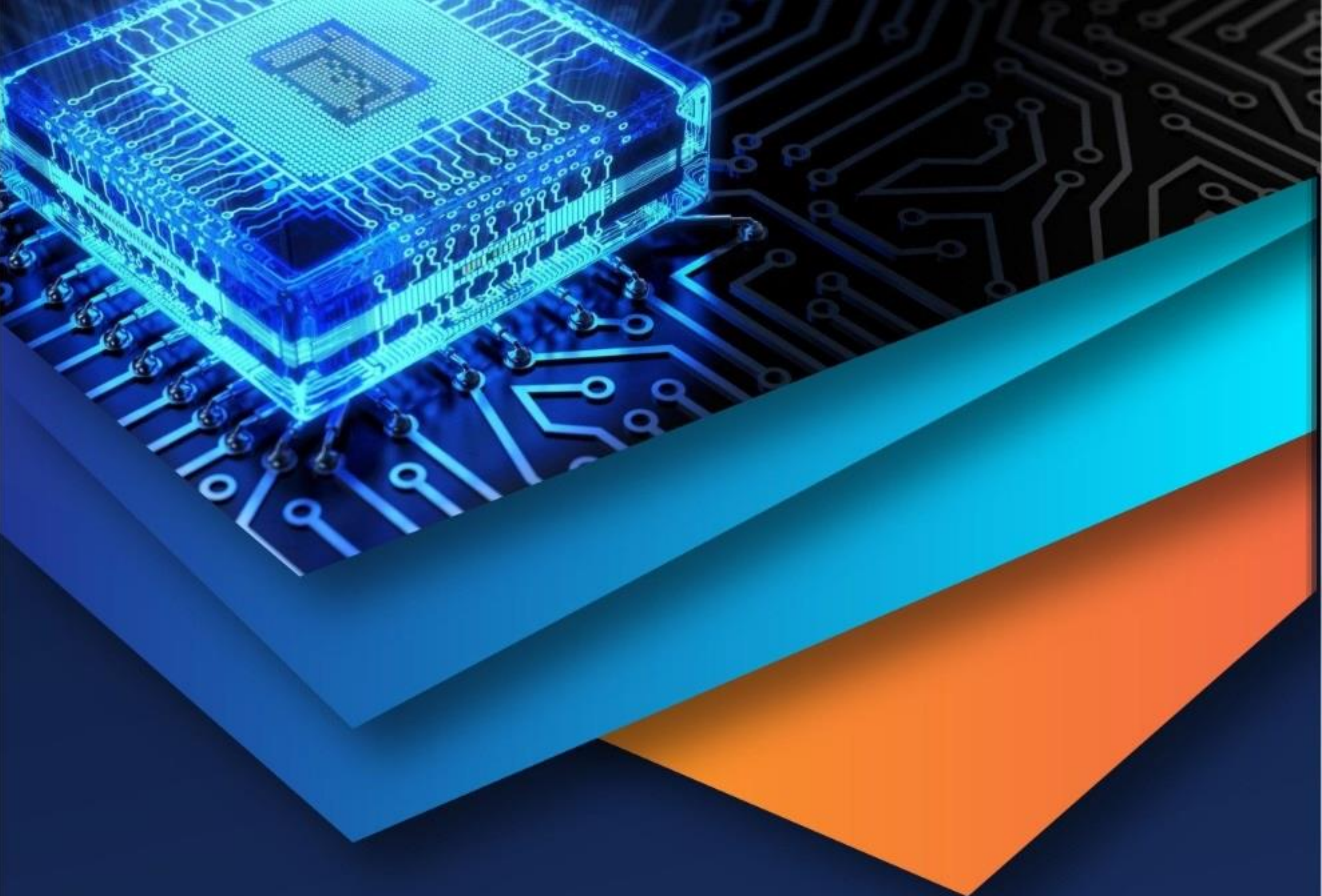
## REFERENCE

[1] Amit, R. and Rao, D. B. N., “Utilization potential of industrial/mining rejects and tailing as building materials”, Management of Environment Quality: An International Journal, 16, PP. 605-614, 2005.
[2] Bureau of Indian Standards (BIS), IS 1077:1976, “Common burnt clay building bricks specification”, 1976.
[3] Bureau of Indian Standards (BIS), IS 1077:1992, “Common burnt clay building bricks specification”, 1992.
[4] Bureau of Indian Standards (BIS), IS 2720 (Part 4)-1985, “Methods of test for soils”, 1985.
[5] Bureau of Indian Standards (BIS), IS 2720 (Part 5)-1985, “Methods of test for soils”, 1985.
[6] Bureau of Indian Standards (BIS), IS 3495- [Part-I]:1976, “Methods of Tests of Burnt Clay Building Bricks" specification”, 1976.
[7] Bureau of Indian Standards (BIS), IS 3495[Part-II]:1976, “Methods of Tests of Burnt Clay Building Bricks" specification”, 1976.

[8] Jayalatha N. A and Veena Kumara Adi (2017). "Restoration of Physico-Chemical Properties of Zinc Contaminated Soil by Bacterial Biosurfactant" in International Journal of Current Trends in Science and Technology, ISSN 0976-9730 Vol. 7, no. 10, pp. 20329-20335. https://doi.org/10.15520/ctst.v7i10.59
[9] Chen, Y. Zang, Y. Chen, T. and Liu, T. "Utilisation of hematite tailings in non-fired bricks production". Fifth International Conference on Informatics and Biomedical Engineering (ICBE), PP.1-4, 2011.
[10] D.B.N. Rao, Amit, R. "Utilization potential of industrial/mining rejects and tailing as building materials", Management of Environment Quality: An International Journal, 16, PP. 605-614, 2005.
[11] David Michaud, "Largest mines in the world", "Mining News", 911 Metallurgist,2013.
[12] Dr. Shivakumara. B, Likith.N.P, Manjunatha, Siddesh.S.S. "Manufacturing of building blocks by utilising of iron ore tailings" International journal of engineering science and computing, volume 7, issue no.5, 2017.
[13] Hammond, A. A. "Mining and quarrying wastes: A critical review", Engineering Geology, 25(1), PP. 17-31. 1998.
[14] Harsha Vardhan, Shreekant R L, And Aruna M, "Utilization of Iron Ore Waste in Brick Making for the Construction Industry", International Journal of Earth Sciences and Engineering ISSN 0974-5904, Vol. 09, No. 02, April, 2016, pp. 450-455
[15] Manual on Soil Sample Analysis" University of Agricultural and Horticultural Sciences, Shivamogga, Karnataka, 2015
[16] Mohanty, M. Dhal, N. Patra, P. Das, B. and Rama Reddy, P., "A novel approach for utilization of iron ore soils", Reviews of Environment Contamination and Technology, 206, PP. 29-47, 2010.
[17] Muduli, S.D. Rout, P. K. Pany, S. Mustakim, S. M. Nayak, B. D. and Mishra, B. K., "Innovative process in manufacturer of cold setting building brick from mining and industrial soils", The Indian Mining Engineering Journal, 49(8), PP. 127-130, 2010. 4-7, 2014.
[18] Rudramuniyappa, M.V., "Iron ore and their impact on environment in Sandur- Hospet region, Bellery district, Karnataka, India", National Metallurgical Laboratory Proceedings, Jameshdpur, PP. 273-278, 1997.
[19] Sanjay K.Shukla, Francis A.Kuranchie, and Daryoush Habibi, "Utilization of iron ore mine tailings for the production of geopolymer bricks", International Journal of Mining, reclamation and environment, vol 30,issue 2, Pg 92-114, 2016.
[20] Surendra Roy, Govind R Adhikari, Rama N Gupta "Use of gold mill tailings in making bricks: a feasibility study", 2007.
[21] Werner, T.T.; Bach, P.M.; Yellishetty, M.; Amirpoorsaeed, F.; Walsh, S.; Miller, A.; Roach, M.; Schnapp, A.; Solly, P.; Tan, Y.; et al. A Geospatial Database for Effective Mine Rehabilitation in Australia. Minerals 2020, 10, 745. [CrossRef]
[22] Youngliang, C. Yamin, Z. Tiejun, C. Yunliang, Z. and Senxu, B., "Preparation of eco-friendly construction bricks from hematite tailings", Construction and Building Materials, 25, PP.2107-2111, 2011.

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