# Feasibility Studies on Over-Burdened Soil from NLC for Brick Manufacturing

Jagatheeswaran D[1*], Tenuarvinth M[2]
[1]*Professor, Sona College of Technology, Salem, India*
[2]*P.G Student, Sona College of Technology, Salem, India*

**Abstract-Over-burden refers to the unused rock or soil that is produced during mining operations and is deposited within the mine area. Disposing of this waste poses a substantial environmental challenge and incurs extra costs for the mining sector. Opting for Over-burden sand as a substitute for river sand in construction offers several benefits, including reduced environmental impact, increased land resource availability, decreased disposal costs associated with over-burden for the mining industry, and aiding in the preservation of natural river sand in and around Tamil Nadu.**

**Key Words – OB Soil, Brick Manufacturing, Triplet Test, Prism Compression Test, Mining Waste, CARD-NLC.**

## 1. INTRODUCTION

China is currently the world's largest coal producer, followed closely by India, according to power-technology.com. Global coal production in 2018 reached 7,813.3 million tons, with India contributing around 771 million tons, as stated by worldcoal.org. In India, open cast mining is the primary method employed for coal extraction, accounting for approximately 90% of the total, while underground mining makes up the remaining 10% (ICOMS 2019). Open cast mining generates a significant amount of waste rock, which is stored as overburden (OB) dumps (Gupta et al. 2015). The stripping ratio, which indicates the ratio of overburden to coal, is generally around 2.2 in Indian coal mines but may vary depending on the location (source: coal.nic.in). Previous research conducted by Jamal and Sidharth (2008) involved the production of bricks using a mixture of coal overburden, fly ash, and other rocks. The process included crushing the overburden, mixing it with water, allowing it to soak and blend for 8-10 hours, filling the mixture into wooden molds, and drying the molds in the sun for 6-8 days. Several researchers have explored different methods of utilizing waste, including converting coal mine overburden into bricks. However, the current study proposes a more efficient and streamlined process that yields bricks of various sizes. The study aims to investigate the use of coal mine overburden as a substitute for clay materials in brick manufacturing. This approach not only offers a viable alternative but also reduces environmental pollution by minimizing dust and leachate emissions associated with coal mine waste. According to recent data from the official website of the Ministry of Coal (Government of India), NLCIL has reported an overburden production of 2.3 million tonnes for the period of 2021-2022. This project focuses on transforming overburden into a value-added product for the construction industry.

## 2. COLLECTION OF OVER-BURDENED SOIL

I have been authorized by the Centre for Applied Research & Development [CARD] to acquire 150Kg of Over-Burdened (OB) dump from their laboratory storage facility. This OB dump, sourced from the Neyveli Lignite Corporation Limited (NLC), serves as the raw material for our studies. We collaborated with officials from CARD-NLC to locate and gather samples of OB soil that had been accumulated in and around the CARD Laboratories for different research purposes.

## 3. BRICK MANUFACTURING PROCESS

The production of OB Bricks involves a manufacturing process that combines 60% of OB Soil, obtained from the Neyveli Lignite Corporation (NLC), with 40% of traditional red murrum soil. To create these bricks, water is added in an amount equal to 30% of the total weight of the dry mixture of soils.

### 3.1. Soil Extraction:

Obtain the overburdened soil from the designated mining area within NLC. Overburdened soil refers to the top layer of soil that is removed during mining operations. This soil can be utilized for brick manufacturing, reducing waste and promoting sustainability. As Shown in Fig-01 & Fig-02.

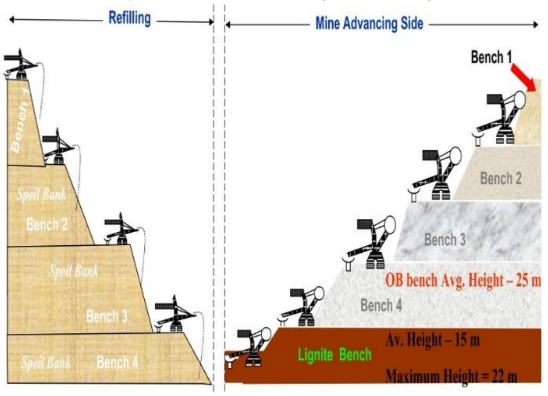


Fig-01.

Fig-02.

3.2. Soil Preparation:

The extracted soil needs to be properly prepared before it can be used for brick production. The soil should be cleared of any impurities such as rocks, debris, organic matter, and large particles. As shown in Fig-03.

Fig-03.

3.3. Mixing:

The prepared soil is mixed with 40 % of red murrum soil to create a suitable brick-making mixture. To improve the strength and binding properties of the bricks. The exact proportions of the ingredients may vary depending on the desired characteristics of the final product. As shown in Fig-04 & Fig-05.

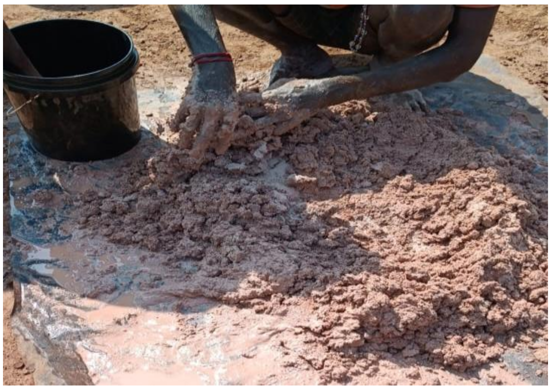

Fig-04.

Fig-05.

3.4. Shaping:

The mixed soil is then shaped into brick forms using a brick-making machine or by hand. The most common shape for bricks is rectangular, and moulds can be used to ensure consistent dimensions. The excess soil is trimmed off, and the bricks are left to dry partially. As shown in Fig-06 & Fig-07.

Fig-06.

Fig-07.

3.5. Drying:

The partially formed bricks are then set aside to dry naturally. This process allows the excess moisture in the bricks to evaporate, strengthening them and reducing the likelihood of cracking during firing. Drying can take several days or even weeks, depending on the ambient conditions. As shown in the Fig-08 & Fig-09.

Fig-08.

Fig-09.

3.6. Firing:

Once the bricks have dried sufficiently, they are ready for firing. Firing is the process of subjecting the bricks to high temperatures in a kiln or oven. This transforms the raw materials into solid, hardened bricks through a process called vitrification. The firing temperature and duration depend on the type of soil used and the desired strength of the bricks. As shown in Fig-10 & Fig-11.

Fig-10.

Fig-11.

3.7. Cooling and Curing:

After the firing process, the bricks are allowed to cool down gradually. Rapid cooling can cause thermal stress and lead to cracks. Once cooled, the bricks undergo a curing period where they are stored in a controlled environment to continue hardening and achieving their full strength. As shown in Fig-12.

Fig-12.

3.8. Utilization:

The manufactured bricks can be used for various construction applications, such as building walls, foundations and other structures. Their utilization in construction projects helps reduce the demand for conventional clay bricks and promotes sustainable building practices. This manufacturing of brick from OB soil also helps reduction of environmental impact in and around of Neyveli.

## 4. MECHANICAL PROPERTIES OF OVER-BURDENED SOIL.

### 4.1. Testing of Mechanical Properties

#### 4.1.1. Triplet Shear Test:

The triplite shear test is an essential procedure employed to assess the structural integrity and shear strength of masonry units. Specifically designed to evaluate the performance of these units under shear loading conditions, this test provides valuable insight into their capacity to withstand lateral forces and resist deformation. By subjecting the masonry unit to controlled forces in multiple directions, the triplite shear test facilitates the collection of crucial data for designing sturdy structures and enhancing construction practices. In this study, we present a comprehensive analysis of the triplite shear test performed on a specific masonry unit with the objective of evaluating its shear strength and providing valuable knowledge to optimize its practical applications. The test yields several outcomes, realistic shear loading conditions and precise measurement of shear strength. The specimen used consists of three bricks made from a mixture of 60% OB and 40% red murram soil, following conventional brick manufacturing methods. The mortar is prepared and applied to the bed side of the unit as depicted in Figure 17. Three specimens are cast without any precompression during the casting process. The dimensions of the casting for the triplet test are 220mm in length, 230mm in width, and 90mm in depth. The test is conducted using a Universal Testing Machine (UTM) and follows the guidelines outlined in the European code book EN - 1052 - Part 3 for determining the initial shear strength of masonry units. There is no specific code book available in Indian Standards (IS) for testing the initial shear strength of masonry units. EN 998 Part 2 provides standards for masonry mortar, which was utilized in this triplite shear test. EN 1052 - Part 3 determines the in-plane initial shear strength of the horizontal bed joint in masonry through shear testing of a specimen. Four different failure modes are considered to obtain valid results. The initial shear strength is determined by the linear regression curve to zero normal stress. The testing process can result in four types of failure:

1) Shear failure in the unit/mortar bond area, either on one or divided between two-unit faces (Figure 13).
2) Shear failure solely in the mortar (Figure 14).
3) Shear failure in the unit (Figure 15).
4) Crushing and/or splitting failure in the unit (Figure 16).

It is recommended to use three specimens for testing and to calculate the initial shear strength of the masonry unit.

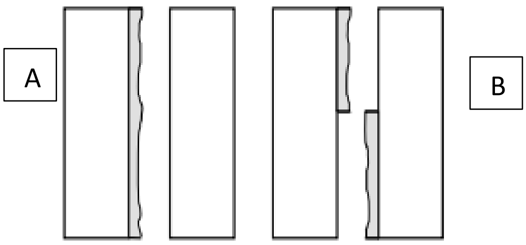


Fig-13.

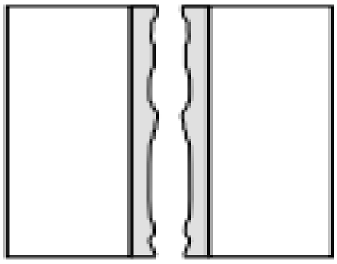

Fig-14.

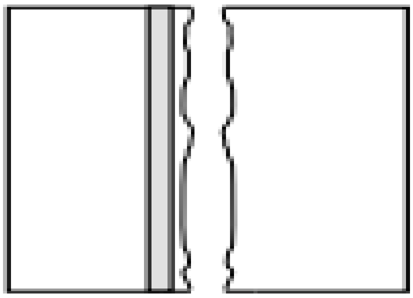

Fig-15.

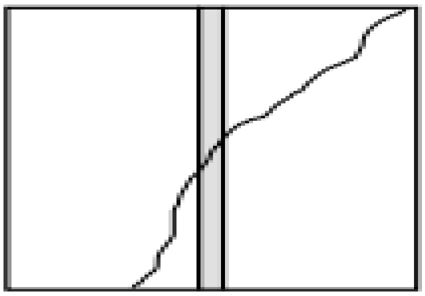

Fig-16.

The specimen is casted to the above said dimensions for initial shear strength. Total three specimen were casted and tested as shown in Fig-17.

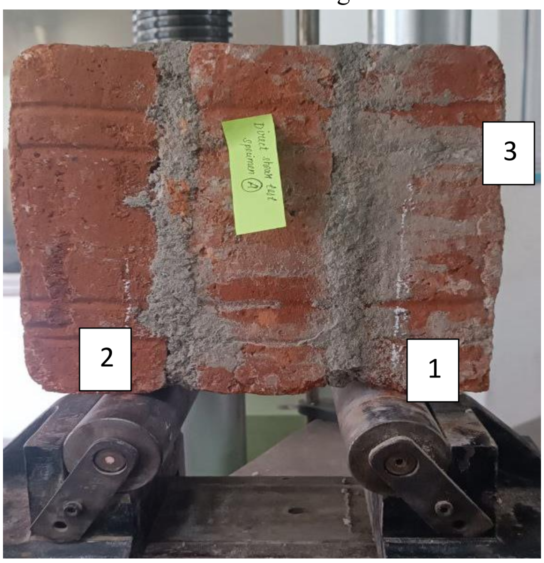


Fig-17.

This is the test set-up for computing initial shear strenght. Brick number 2 is bonded with the mortar with brick 1 & 3. Supports are provided at the eccentricity point of the brick to eleminate the turning moment which is created when load applied on the brick 2. 4 mm thick wooden plate is provied on the top surface befour load is applied for the computing initial shear strength. There may be use of hard are soft capping for the purpose of uniform loading in the brick 2. The moratr thickness is 3mm in the initial shear strength computation.

This is type one failure where the unit gets dis-attach from the mortar as Shown in Fig-13A is the failure pattern of the triplet test. The calculation, we should compute the UTM output and with formula of calculating the initial shear force of masonry unit. Where the shear force is equal to the failure loading divided by the area of joints. There should be calculating of both bed area of the 2nd brick which is 2A.

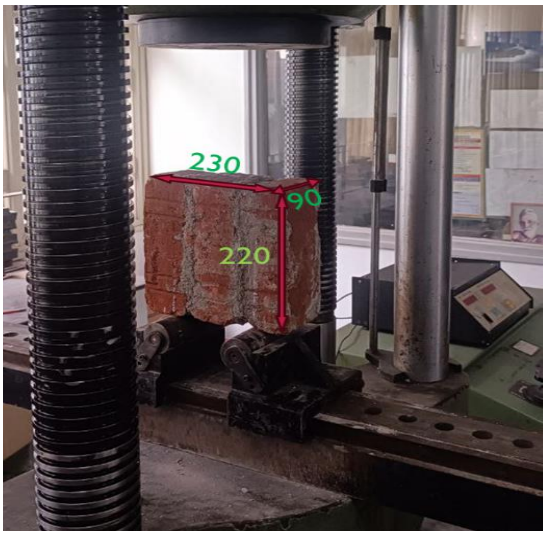


Fig-18.

Fig-19.

$$Sf = \frac{F}{2A}$$

The results and interpretation of the triplet shear test is discussed in chapter 5 clause 5.1.

4.1.2. Prism Compression Test:

The masonry prism compression test serves the purpose of determining the compressive strength and deformation characteristics of masonry units when subjected to axial loading. This test is essential for evaluating the structural integrity and performance of masonry components, ensuring they meet the required standards and design specifications. The procedure for conducting this test is specified in clause 5.4.1 of Appendix B in the IS - 1905 1987 instruction manual, which also provides correction factors for different height-to-thickness ratios of the masonry unit being tested. The test is performed using a Universal Testing Machine (UTM), with the load at the first crack and the load at the collapse of the 4-stack brick prism, as depicted in Figure 23, being recorded. The masonry units are arranged in a stack bond in the stretcher position, aligned and mortared properly, replicating the construction method. The dimensions of the masonry prism match those of the masonry unit in terms of length and width. The mortar and joint thickness, as well as the positioning and alignment of the units during prism preparation, need to accurately represent the actual construction. The prisms can be constructed as solid or hollow, either unrouted or grouted, based on the specific conditions of the structure. Grouting, consolidation, and reconsolidation should all follow the same technique. The failure pattern in the brick prism compression test can be classified into seven types, as illustrated in Figure 21. The specimen is cast at the dimensions of 300 mm in length, 210 mm in breadth, and 210 mm in width for the 4-stack brick prism used in the compression test, as shown in Figure 20.

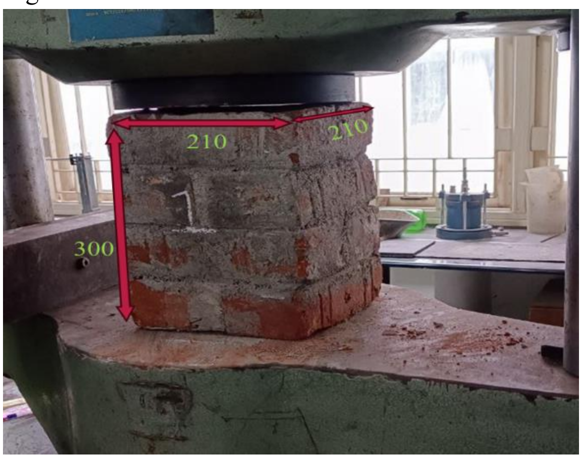


Fig-20.

The 4 – Stack Prism exhibits a failure mode of splitting into two halves at the centre of the prism. The weight of the prism was 27Kg at the time of testing. The total failure pattern is shown in Fig-21. The result is given in chapter 5 clause 5.2.

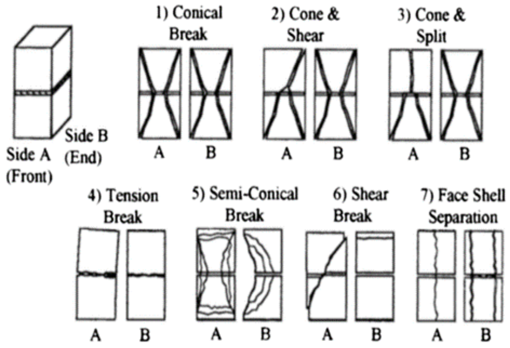


Fig-21.

The failure pattern is as shown in the Fig-23. This failure of the 4 – Stack prism compression is off Face shell Separation failure.

Fig-22.


Fig-23.

Fig-24.

### 4.2. CHEMICAL TEST OF OB-SOIL:

#### 4.2.1. Chemical analysis of OB Soil:

The following report presents the results of a chemical analysis conducted on an overburdened soil sample. The purpose of the analysis was to determine the composition of the soil in terms of various chemical components. The soil sample was collected from a NLCIL-CARD and subjected to a series of tests to assess its elemental composition.

Loss of Ignition:

The purpose of the ignition test, known as the loss of ignition (LOI) test, was to assess the quantity of organic material in the soil. A predetermined weight of the soil sample was subjected to heating in a furnace at a specific temperature (typically approximately 550°C) for a designated period of time. The reduction in weight observed after ignition indicated the presence of organic matter. To determine the elemental composition of the soil, X-ray fluorescence (XRF) analysis was conducted. In this process, the soil sample was bombarded with X-rays using an XRF instrument, which prompted the atoms in the soil to emit characteristic fluorescent X-rays. These emitted X-rays were measured, and based on their intensities, the elemental composition of the soil was determined.

#### 4.2.2. RESULTS AND DISCUSSION OF CHEMICAL ANALYSIS OF OB-SOIL:

Loss of Ignition:

The loss of ignition test revealed that the overburdened soil sample had a loss of ignition of

17.29%. This indicates the presence of organic matter within the soil.

Elemental Composition:

The Chemical analysis indicated the following composition of the soil sample:

Silica ($SiO_2$): 77.50%

Calcium oxide (CaO): 1.35%

Magnesium oxide (MgO): 0.42%

Iron oxide ($Fe_2O_3$): 1.25%

Aluminium oxide ($Al_2O_3$): 1.02%

Sodium oxide ($Na_2O$): 0.15%

These results suggest that the soil primarily consists of silica, with notable amounts of calcium oxide, iron oxide, aluminium oxide, and smaller amounts of magnesium oxide and sodium oxide.

## 5.CONCLUSION

The chemical analysis of the overburdened soil sample revealed a loss of ignition of 17.29%, indicating the presence of organic matter. Additionally, the elemental composition analysis showed the predominant presence of silica (77.50%) in the soil, along with other components such as calcium oxide, magnesium oxide, iron oxide, aluminium oxide, and sodium oxide. These findings contribute to a better understanding of the soil's composition, which can be valuable in assessing its fertility, potential agricultural applications, and environmental implications. Because of the presence of higher number of oxides in the soil which is used for manufacturing of OB-Brick, there could be chances for leaching in the wall which is constructed using OB-Soil with-out proper treatment for the leaching process.

## 6.RESULTS AND DISCUSSION:

6.1Triplet Test:

$$Sf = \frac{F}{2A}$$

The shear for calculation is to divide the loading force by bed area of the brick. The bed area of the brick should be multiplied by two because of the mortar is applied on the both bed side of the brick while the force is applied on the top surface of the brick. The results are consolidated of 3 Initial shear strength specimen test that are conducted.

$$Sf = \frac{Ultimate\ force}{2\ X\ Aread\ of\ the\ bed\ side\ of\ the\ brick}$$

The value of the test was 1.39 N/mm$^2$.

6.2 Prism Compression Test:

The prism test is conducted to find-out the compression strength. A 4-stack Brick prism is subjected to compression load in UTM machine. The is conducted at the provision of IS 1905-1987 (Clause 5.4.1) code book. The failure pattern of the masonry prism test is of total split or triangulation split of the masonry unit. The compression strength of the individual brick should of 3.5 N/mm$^2$. The result of the prism compression test was 10.7 N/mm$^2$. The results are consolidated of 3 prism compression specimen test that are conducted.

## 7.CONCLUSION

The aforementioned study conducted on the manufacturing process of OB bricks from CARD – NLC highlights the significance of two essential tests in assessing the strength of masonry structures. The triplet test is instrumental in evaluating the bond strength between masonry units and mortar, while the masonry prism compression test measures the load-bearing capacity of the entire masonry structure. Because of the presence of higher number of oxides in the soil which is used for manufacturing of OB-Brick, there could be chances for leaching in the wall which is constructed using OB-Soil with-out proper treatment for the leaching process. The results of the study indicate an initial shear force value of 1.39 N/mm2 and a prism compression test result of 10.7 N/mm2 for a 4-stack prism configuration.

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