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ASSESSING THE CORRELATION BETWEEN THE MECHANICAL PROPERTIES OF CLAY BRICK SPECIMENS

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Abstract: This research article presents a detailed case study on the mechanical properties of clay bricks, specifically examining their density, compressive strength, and flexural strength. The study involves collecting clay brick samples and conducting laboratory tests to measure these properties. The primary objective is to assess the quality of the clay bricks by analysing the correlations between density, compressive strength, and flexural strength. The results of this study provide insights into the strength characteristics of clay bricks, enabling a comprehensive evaluation of their quality and classification.

Index Terms - Clay brick samples, density, Compressive strength and flexural strength.

I. INTRODUCTION

Bricks are fundamental construction materials in the structural field, and their quality directly determines the strength and durability of the structures they comprise. Poor-quality bricks can compromise the integrity of a structure, leading to potential damage and failure. Therefore, assessing the quality of bricks before their use in construction is crucial.

The quality of bricks is determined by their properties, which are influenced by factors such as mineralogical composition, manufacturing processes, and firing temperatures. Physical properties provide a quantitative characterization of a brick's behaviour under external influences and are critical as they significantly impact the brick's performance and strength in structural applications. Mechanical properties, which describe a material's response to externally applied loads, include resistance to deformation, distortion, and overall strength.

This study focuses on clay brick samples collected from the Manimutharu river bed areas in the Cuddalore district of Tamil Nadu. Five sample locations, designated S_1, S_2, S_3, S_4, and S_5, were selected for this research. The aim is to evaluate the strength of these clay bricks by correlating their physical and mechanical properties. Density, compressive strength, and flexural strength were measured to establish this correlation. The results, which provide insights into the strength and classification of clay bricks from different locations, are detailed in the following sections and summarized in the accompanying tables. This study not only enhances the understanding of clay brick properties but also aims to increase the value and utility of clay brick products.

II. MATERIAL AND METHODS

Samples of clay bricks were collected from various locations in the Manimutharu river bed in the Cuddalore district. Five samples, identified as S_1, S_2, S_3, S_4, and S_5, were used in this study. The bricks are handmade, burnt clay bricks of uniform shape and size, with dimensions of 22 x 9 x 8 cm, measured using a measuring scale. The objective of this research was to analyse and investigate the physical and mechanical properties of these clay brick samples (5).

2.1 DENSITY

Fire clay bricks were selected to determine their density. The bricks were oven-dried at a temperature of 103°C until a constant weight was achieved. Their volumes were measured, and densities were calculated using the following formula: (6)

$$\text{Density}(\rho) = \frac{\text{Mass of the brick}(M)}{\text{Volume of the brick}(V)}\ \text{g/cm}^3 \quad (1)$$

Where,

ρ is the density,
M is the mass, and
V is the volume of the brick.

2.2 COMPRESSIVE STRENGTH

The compressive strength of the bricks was determined using a compressive strength testing machine. The dimensions of the bricks were measured, and the area was calculated using the formula:

$$\text{Area} = L \times B \quad (2)$$

Where, L is the length and B is the breadth of the brick. The brick samples were placed in the testing machine, and a gradual load was applied until the bricks failed. The compressive strength was then calculated using:

$$\text{Compressive strength}(f_c) = \frac{F}{A}\ \text{N/mm}^2 \quad (3)$$

Where, fc is the compressive strength, F is the maximum force at failure, and A is the cross-sectional area where the force was applied.

2.3 FLEXURAL STRENGTH

For the flexural strength test, a three-point bending test was conducted. An increasing load was applied at the center of the sample until it broke or permanently bent. The flexural strength was calculated using the following formula:

$$S_f = \frac{3FL}{2wd^2}\ \text{N/mm}^2 \quad (4)$$

Where, S_f is the flexural strength, F means the maximum force applied, L is the length of the sample, W is the width of the sample and D is the depth of the sample

III. RESULTS AND DISCUSSIONS

The results for the density, compressive strength and flexural strength of clay bricks from different locations were tabulated and presented in the table given below.

Table.1. Mechanical test results from some selected clay brick samples (Manimutharu River bed)

Sl.no	Sample identifications	Density ($g.cm^{-3}$)	Compressive Strength (N / mm^2)	Flexural Strength (N/mm^2)	Bricks Criteria
1	S_1	1.69	12.02	3.04	1st Class
2	S_2	1.78	12.64	3.46	1st Class
3	S_3	1.80	13.07	3.89	1st Class
4	S_4	2.02	14.09	4.57	1st Class
5	S_5	1.96	13.13	4.15	1st Class

3.1 DENSITY OF RED CLAY BRICKS

Density of a clay brick depends on specific gravity of clay, method of manufacture and degree of burning. Density of burned bricks made with clay usually exceeds 1.6 g/cm^3, averaging 2.0 g/cm^3 (10). The density affects a number of properties of building bricks but probably the most important effect is on its strength From Table 1 sample (S_1) showed the lowest density 1.69g/cm^3 while sample (S_4) showed the highest 2.02 g/cm^3. In this study, density of a brick decrease, it's strength also decrease. The estimated results of all five clay brick samples in the range of 1.69 to 2.02 g/cm^3.

3.2 COMPRESSIVE STRENGTH

Bricks are mainly used in construction, so it has a good compressive strength to support the construction weight [L. Zhang (2013)]. higher firing temperature affects to improve the compressive strength. The decrease in the compressive strength of fired bricks can be explained by the cause of the porous defect in a brick structure. The pore defect is weak bond compaction, where it is more easily broken. Compressive strength of clay product was highly affected by the one of the following factors, firing temperature, method of production, physical, mechanical and mineralogical properties to the raw material (11).

The compression test is the most important test for assuring the engineering quality of the building material (brick). In Cauvery River bed, theTable1 and Fig1, Shows the high level of compressive strength in location (S_4) (14.09 N/mm^2) and the lowest strength (12.02 N/mm^2) is produced by the location (S_1)

Fig 1 indicates that the brick is to have the higher density has the greatest compressive strength (14.09 N/mm^2). The bricks with the high density seem to be correlated with high compressive strength as shown in the Fig 1. The compressive strength of a materials is strongly influenced by the characteristics of the raw materials used and by the production process.

In general, it is believed that the red clay bricks have expected high density can have the high mechanical strength. The fig2 shows the results of estimated compressive strength of the collected five clay brick samples from different locations of Manimutharu River bed. It is clear that from the Fig. among the tested brick samples of (S_1 – S_5), S_4 is shown the highest compressive strength of about of 14.09 N/mm^2.

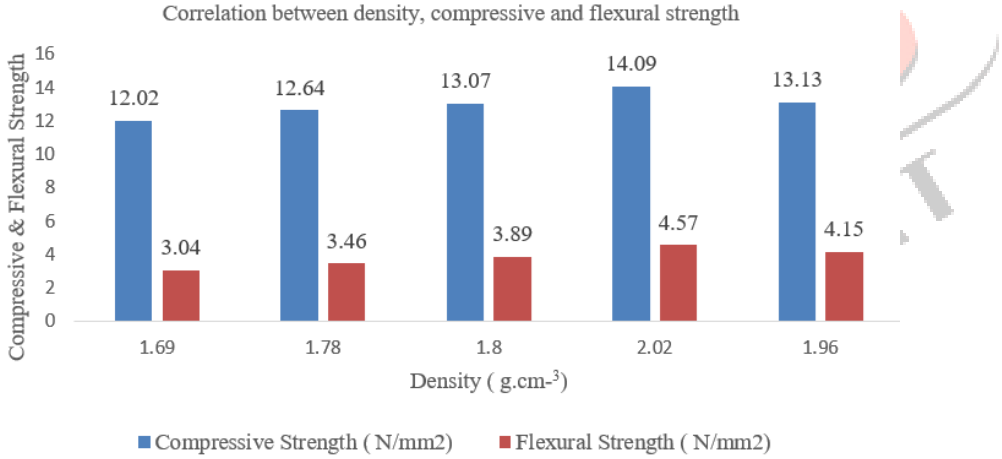

Fig.1 Density verses Compressive and flexural Strength Correlations of Clay Brick Samples collected from Manimutharu riverbed areas (S_1-S_5).

From the present study sample S_4 is assume to be high compressive strength value than that of other brick sample. Although the remaining of other 4 brick samples have the compressive strength values in the range of 12.2 – 13.13 N/mm^2 respectively.

Furthermore, there is a good significant correlation between density, compressive strength and flexural strength of all analyzed clay bricks. Both the compressive and flexural strength of brick samples are found to increase with increasing the density as depicted in the figure2. These results are mostly supported by the Facts the high-density value observed for the brick samples is directly related to their height compressive and flexural strength with high particle packing in the brick bodies.

3.3 FLEXURAL STRENGTHS

From a scientific point of view, flexural strength informs about the resistance of a material against deformation, i.e, flexural strength indicates how much force is required to break a test sample of a defined diameter. The higher value, the more impactive forces the material is able to withstand. The change of Modulus of rupture (MOR) values varies with respect to different locations of the clay brick specimens (S_1 to

S_5) are given in table (Table.1). The obtained results from the table indicate the increase of densities (2.02 g cm^{-3}) lead to the increase of MOR values (4.57 N/mm^2). The Fig. (1) shows the flexural strength for the clay bricks along with their different locations, it shows that the highest flexural strength (S_4) as compare to other types of bricks.

This will attain the maximum flexural strength of the clay brick. In the case of sample (S1), the lowest value of (3.04 N/mm^2), with decrease of density. There is a good significant correlation were found between the modulus of rupture, density there is a critical relation between the flexural strength and density of the clay bricks has crush hold density approaches. Flexural strength gradually increases indicating the density is limiting factor are flexural strength development in the presence study all the clay bricks can have the nearest standard value of flexural strength meet in the first criteria (Table.1) and it suitable for building construction purpose. The different values of the modulus of rupture of the clay specimens with difference locations as shown in the graph Fig.2. The flexural strength of clay bricks exhibited the similar trend to the top compressive strength. From the result it is evident that clay brick can withstand higher flexural load in the sample (S_4). This is the major fact for the durability of bricks.

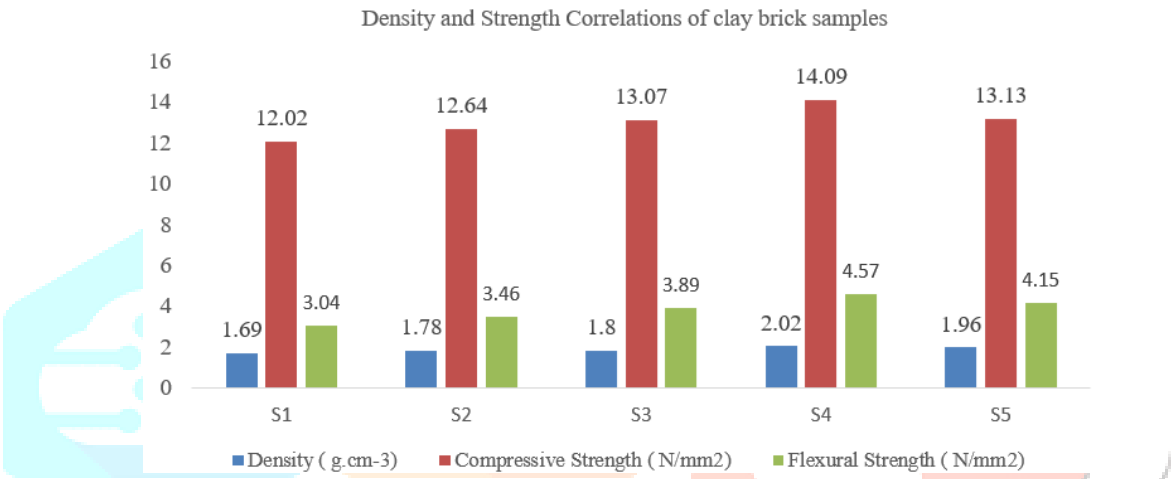

Fig.2. Physical (Density) and Mechanical Strength Correlations of Clay Brick Samples collected from Manimutharu riverbed areas (S_1-S_5).

IV. CONCLUSIONS

The present research work was focused to the study the physical and mechanical properties of five clay bricks of Manimutharu River bed for their quality assessment using the standard brick criteria and the following the conclusions are drawn from the above results and are discussed.

1. It is found a good corelation between the density, compressive and flexural strength properties was found for the five clay bricks samples of Manimutharu River bed of different locations (S_1-S_5).
2. The high-density values which are responsible for their high compressive and flexural strength and vice versa and hence this will increase to improve to the mechanical properties of the bricks.

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