Effect of Compaction on Compressive Strength of Unfired Clay Blocks

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ABSTRACT

This study investigates the possible use of unfired compacted clay blocks as a substitute of CSEB (Compressed Stabilized Earth Blocks) for the construction of economical houses. Cubes of 150 mm size were cut from the clay blocks which were compacted at various intensities of pressure during the casting. The results show that the compressive strength of the clay cubes increased with the compacting pressure to which the blocks were subjected during casting. The average crushing strength of the cubes, sawed from clay blocks that were subjected to compacting pressure of 7.2 MPa, was found to be 4.4 MPa. This value of compressive strength is about 50% more than that of normal CSEB. This study shows that the compacted clay blocks could be used as economical walling material as replacement of CSEB.

Key Words: **Compacted Clay Blocks, Compressive Strength, Density, Compacting Pressure, Mechanized System.**

1. INTRODUCTION

Generally, the provision of houses to continuously growing population in many developing countries has always remained a challenge due to lack in GNP (Gross National Product) and rise of cost of traditional materials of construction such as cement, aggregates and steel. The solution of this problem lies in technical use of indigenous and low cost materials of construction.

Clay is used as CSEB and rammed earth. Generally, the CSEB consists of 6-10% of OPC (Ordinary Portland Cement), 40-70% of aggregates, 30-60% of natural indigenous clay and about 10% water. After mixing it is compacted to increase its density and is cured for 28 days [1] before using in masonry of walls. In this method, individual units are manufactured and stored to use as low cost material for construction of walls. But rammed earth consists of mixture of clay, silt, sand, organic fiber such as chopped straw and water. Generally, OPC is added as binding material with or without lime. This moist loam mixture is used directly at site in formwork and compacted after casting in the shape of walls. The use of rammed earth is as old as 4000 years and is found in China. Even today, rammed earth houses exist and are in use in Russia, Spain, and England [2].

Both of these types of earthen construction have some drawbacks because they require aggregates and cement which are costly. Since cement is produced industrially and results in the emission of carbon dioxide that can

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affect the environment on one hand and use electricity or fossil fuel for its production on other [3-4]. Since aggregates and cement are costly on one hand and require higher transportation charges to supply them in the plains of the country. Hence, the use of the CSEB is considered to be neither economical nor environmentally friendly. As far as rammed earth is concerned, it is composed of cement as binding material, and aggregates as stabilizer water. Rammed earth walls on drying, may get cracked due to shrinkage causing weakness at several sections [5-19]. The objective of this study is to investigate potential use of compacted clay-pit sand blocks as replacement of CSEB and rammed earth in order to reduce construction cost and promote sustainable construction of houses without losing strength and durability.

2. MATERIALS AND METHOD

Indigenous clay was quarried from the premises of Nawabshah city. The index properties of this local clay [20] are given in Table 1.The pit sand was also quarried locally and it has a moisture content of about 8%. Local clay and pit sand were mixed in a ratio of 70:30 and then 22% of potable water was added by weight [21], the mixture was thoroughly mixed in pan mixture (Fig. 1). This moist clay pit sand mixture was wrapped in plastic sheet for twenty four hours for proper maturing. For casting of clay blocks, the mix was put in layers in the steel mould (Fig. 2). The size of the mould was 150x400x1980 mm. The size of the blocks cast in this mould was 150x300x1980 mm which is comparatively larger than the size of traditional CSEB. The mixture of clay and pit sand placed in the mould was pressed with the help of wooden plunger which was flexibly attached to assembly of four hydraulic jacks in the Mechanized System [22] as shown in Fig. 3.

After casting, the blocks were placed in shade for drying (Fig. 4). During this period of drying, clay blocks were placed on wooden planks. In order to reduce the possibility of cracking at bottom, a finished steel plate and two plastic sheets were provided between moist clay block and wooden plank. These moist clay blocks were covered with plastic sheet in order to control the surface cracking of the blocks due to uncontrolled evaporation of moisture. After drying in shade, the clay blocks, were further dried in sun for 48 hours in order to reduce moisture content. After sun drying of these blocks (Fig. 5), cubes of standard 150 mm size [23] were sawed with the help of disk grinder machine (Fig. 6) and tested in UTM (Universal Testing Machine) (Fig. 7). Eighteen cubes were cut and tested in compression.

3. RESULTS AND DISCUSSION

It was mentioned earlier that 22% of water was added in the clay pit sand mixture in order to make the mix workable

FIG. 1. PAN MIXER USED FOR MIXING OF CLAY PIT SAND AND WATER

TABLE 1. INDEX PROPERTIES OF INDIGENOUS CLAY [20]

Moisture Content (%)	Specific Gravity	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index	Density of Wet Soil (g/cm^3)	Density of Dry Soil (g/cm^3)
12	2.5	44	23	21	1.5	1.3

for casting of blocks. Standard proctor compaction tests were carried out in order to determine the optimum water content of the indigenous clay and pit sand mixture to determine maximum dry density (Fig. 8). It can be observed that the optimum moisture content of the indigenous clay pit sand mixture was found to be 12%. To reduce the added quantity of mixing water, the clay blocks were enveloped in propylene fabric sheet and compacted with the help of plunger of the mechanized system. In this way, the added water in the clay blocks was pressurized to drain out. Consequently, the mixed water was reduced from 22-13% which is close to the optimum water content (i.e. 12%) of the clay pit sand mixture.

The effect of compaction, during casting process of clay blocks, on the compressive strength of cubes of 150 mm size is presented in Fig. 9. It can be observed that, as expected, the compressive strength of clay cubes increased with the increase of intensity of compacting pressure during casting. The increase in compressive strength of clay cubes is associated with the reduction of voids due to expulsion of water from mass of moist clay and as a result, the clay blocks became denser. It is relevant to mention here that the compressive strength of CSEB is generally in the range

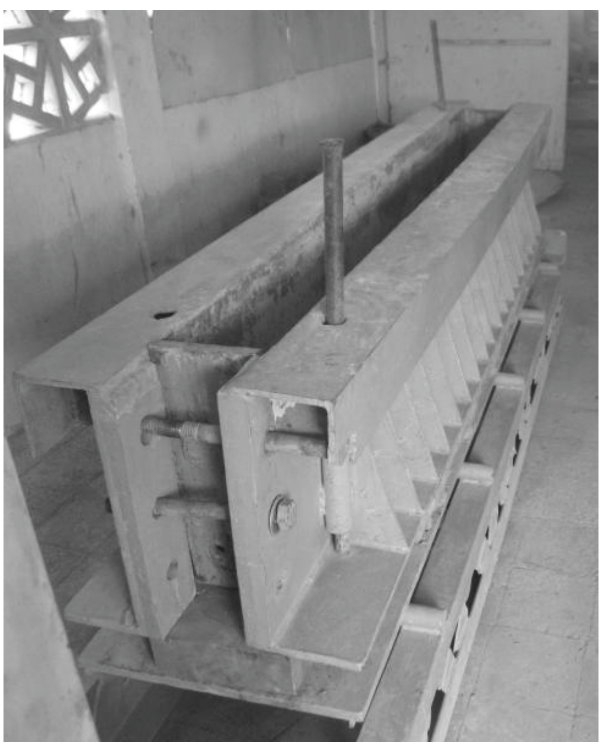

FIG. 2. MOULD FOR CASTING OF CLAY BLOCKS

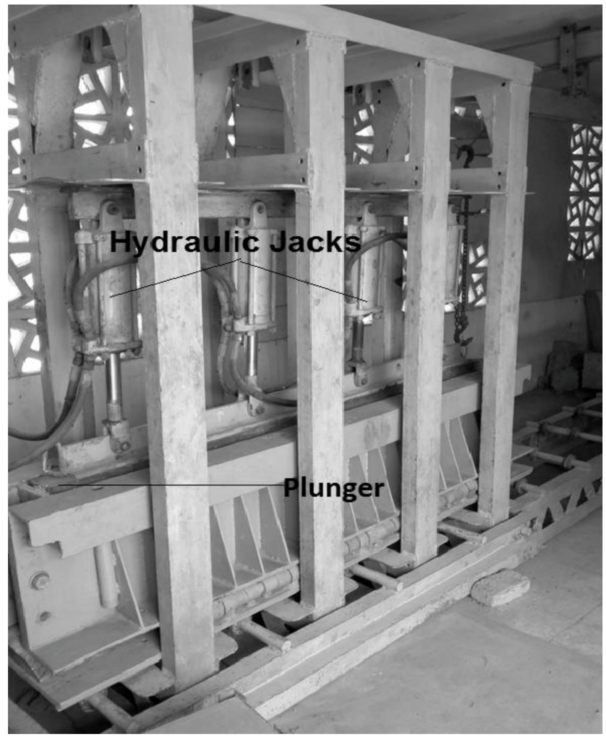

FIG. 3. MOIST CLAY-PIT SAND MIXTURE PLACED IN LAYERS IS BEING COMPACTED WITH THE WOODEN PLUNGER OF THE MECHANIZED SYSTEM

FIG. 4. MOIST CLAY BLOCKS WRAPPED WITH PLASTIC SHEET COVER ARE BEING DRIED IN SHADE

of 2-2.5 MPa [24]. The average compressive strength of clay blocks presented in this study was 4.4 MPa which is about 50% more than that of the CSEB. This implies that the compacted clay blocks can be used as walling material as an alternative to the CSEB for construction of low cost houses.

FIG. 5. A VIEW OF SUN-DRIED CLAY BLOCKS

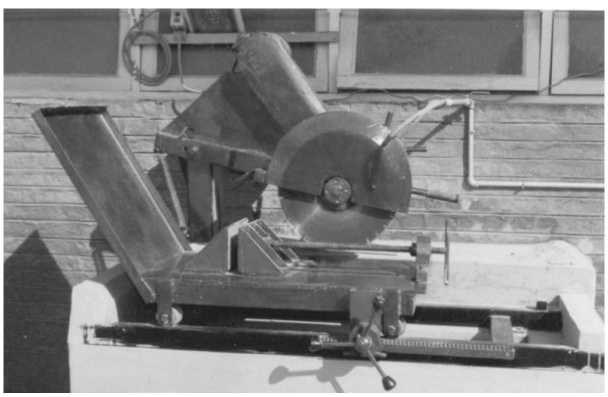

FIG. 6. A VIEW OF DISK GRINDER MACHINE FOR CUTTING CUBES FROM CLAY BEAMS

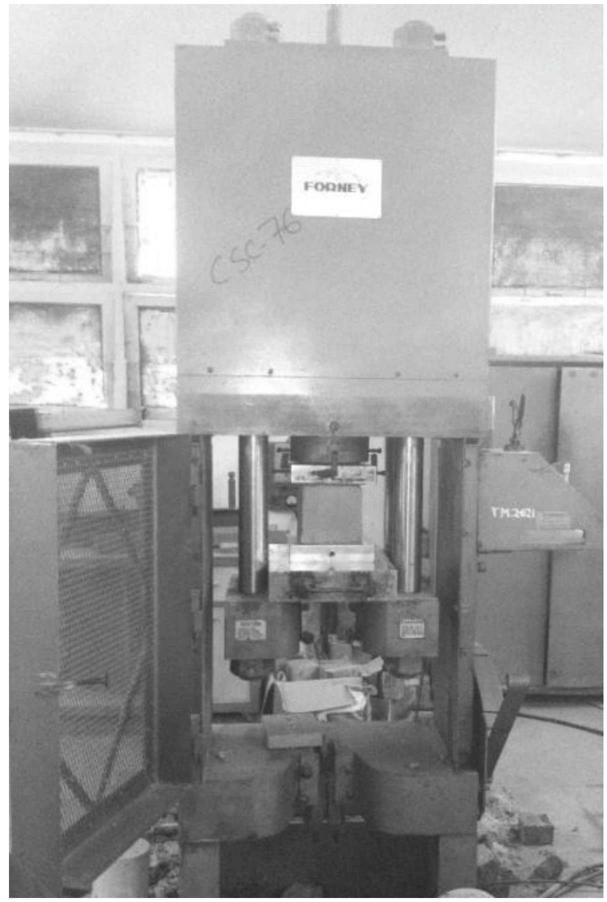

FIG. 7. A VIEW OF COMPACTED CLAY CUBE BEING TESTED IN UNIVERSAL TESTING MACHINE

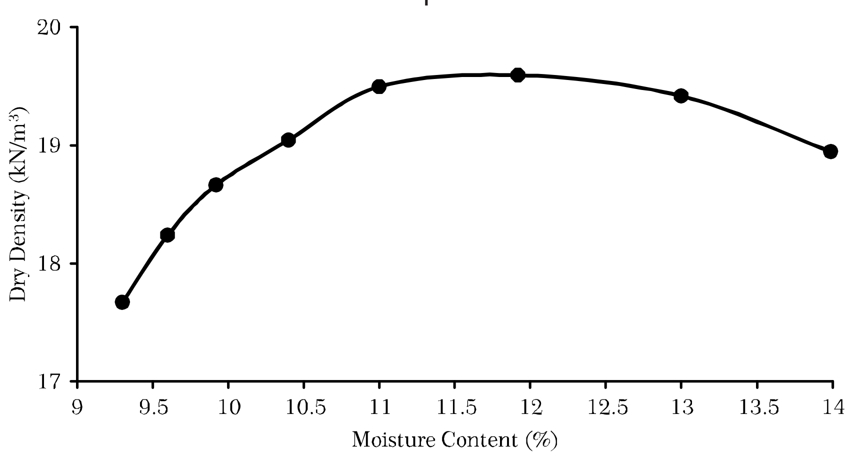

FIG. 8. RELATIONSHIP BETWEEN WATER CONTENT AND DRY DENSITY OF THE INDIGENOUS CLAY USED FOR CASTING OF BLOCKS

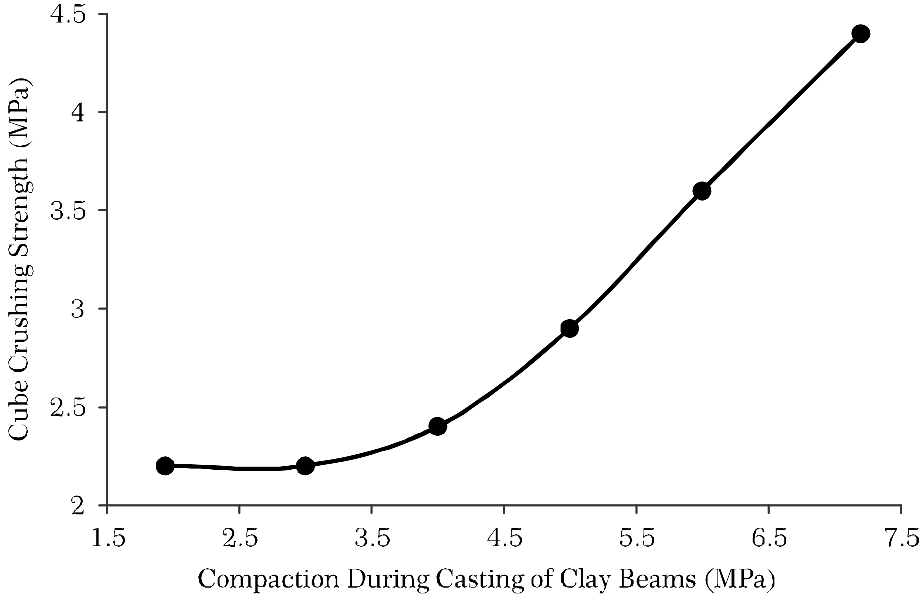

FIG. 9. RELATIONSHIP BETWEEN COMPACTING PRESSURES APPLIED DURING CASTING OF CLAY BLOCKS AND CUBE CRUSHING STRENGTH

4. CONCLUSIONS

In this paper cube crushing strength of unfired clay, which was subjected to varying intensities of compacting pressure during casting process, was investigated. Cubes of 150 mm size were tested for compressive strength. Main conclusions drawn from this study are:

(i) The compressive strength of clay cubes increased with increase of compacting pressure that was applied during the process of casting of the blocks.

(ii) The cubes cut from clay blocks that were compacted at a pressure of 7.2 MPa, showed compressive strength of 4.4 MPa.

(iii) This study shows that the compressive strength of cubes obtained was 50% more than that of the CSEB. This is a significant achievement because by using unfired clay will result in economical construction of houses as compared to the CSEB.

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