

# Relation between Compressive Strength of Baked Clay Cubes and Cylinders

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## Abstract

Reinforced Baked Clay (RBC) seems to be potential alternative of Reinforced Cement Concrete (RCC) for construction of low cost houses. In order to utilize RBC as a construction material for buildings, it is necessary to understand compression behaviour of baked clay. In this paper, relation between cube crushing strength and cylinder strength of baked clay is presented. For this purpose, clay beams were cast in a mould and compacted at a pressure of 6 MPa. The clay beams were dried and fired in a kiln at a temperature of 900°C. Cubes of 150 mm size were sawed from a baked clay beam. Cylinders of 150 mm diameter and 300 mm height were cut, from another baked clay beam, using core cutter machine. Both the cubes and cylinders were tested for compressive strength in Universal Testing Machine. The results showed that the cube crushing strength of baked clay was 25 MPa and the ratio of the compressive strength of the cylinders and the cubes was found to be 0.6. Suggestions for improvement of compressive strength of baked clay cylinders are also discussed.

## Keywords

Baked Clay, Compressive Strength, Cubes, Cylinders, Low Cost Houses

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## 1. Introduction

Uncontrolled population growth in Pakistan has resulted in tremendous shortfall in housing units [1]. This problem is aggravated due to increase in cost of traditional materials of building construction, *i.e.*, aggregates, cement and steel. This problem of shortage of houses could possibly be resolved by using local materials of building construction. Clay is one of the potential materials of building construction in plains of Pakistan. Clay is

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available in enormous volume in plain regions. Clay can be quarried economically at a shallow depth without need of much specialized machinery and manpower. The proposed idea is to utilize Reinforced Baked Clay (RBC) as a substitute of Reinforced Cement Concrete (RCC) for construction of low cost houses. At this stage, precast panels of clay beams could be cast, fired and post reinforced and could be utilized for construction of low cost houses [2]-[7]. In order to further enhance the use of RBC as a low cost material of building construction, more detailed research is required to be conducted to understand its behaviour.

Since compressive strength of concrete is considered to be an important property because of load carrying capacity, elastic modulus and tensile strength are dependent on it. Generally compressive strength of concrete is determined by testing standard size cubes or cylinders. Up to this stage, the compressive strength of cubes cut from baked clay beams compacted at various intensities of compaction is investigated only [2]-[7]. Previous studies report that the compressive strength of baked clay cubes is comparable to that of normal concrete [2]-[7]. The compressive strength of baked clay cubes depends on compaction at the time of casting [8] and firing temperature [9]-[11].

Up to yet, no work is reported in the literature regarding compressive strength of baked clay cylinders. In codes of practice, generally, compressive strength of cylinders is used for design of various structural members of a building. In order to formulate the codes for use of RBC as a construction material in buildings, it is necessary to investigate the compressive strength of baked clay cylinders and find its relation with corresponding compressive strength of baked clay cubes. Therefore, this study was conducted to determine the relation between cube crushing strength and compressive strength of baked clay cylinders.

## 2. Materials and Methods

### 2.1. Preparation of Clay and Pit Sand Mixture

Clay was obtained locally at a depth of 1200 mm. Clay was ground in a Pulverizer after drying. Forty-two percentage of clay was replaced with pit sand in order to reduce shrinkage. Quantity of water added was 22% of the mixture of clay and pit sand by weight. Mixing of the whole mixture was carried out in a pan mixture for fifteen minutes.

### 2.2. Casting of Baked Clay Beams

Clay beams of dimensions 150 mm × 300 mm × 1980 mm were cast in a steel mould by putting moist mixture of clay and pit sand in five layers. The beams were mechanically pressed at a pressure of 6 MPa using a Mechanized System [12] as shown in **Figure 1**. The beams were then dried and baked in a kiln at a temperature of



**Figure 1.** A clay beam is being cast and compacted in a Mechanized System.

900°C. Cubes of 150 mm size were sawed from a baked clay beam. Cylinders of 150 mm and 300 mm height were cut from another baked clay beam using core cutter machine (**Figure 2**). A view of a baked clay cylinder core is shown in **Figure 3**.

### 2.3. Testing Programme

Both the baked clay cylinders and cubes were tested in Universal Testing Machine (**Figure 4**). The cubes were tested using British Standard BS EN 12390-3 [13] and the cylinders were tested in accordance with ASTM C873 [14] and ASTM C39 [15]. For testing of the cubes and cylinders, the load was applied in a direction perpendicular to the casting layers.



**Figure 2.** A baked clay cylinder is being cut with core cutter machine.



**Figure 3.** A baked clay cylinder core of 150 mm diameter and 300 mm height.



**Figure 4.** Baked clay cubes of 150 mm size are being tested in Universal Testing Machine.

**Table 1.** Compressive strength of baked clay cubes of 150 mm size.

S. No.	Sample ID	Compressive strength (Mpa)
1	C1	25.6
2	C2	26.3
3	C3	25.1
4	C4	26
5	C5	24.5
6	C6	26.9
7	C7	24.7
8	C8	25.3
9	C9	25
10	C10	25.2

### 3. Results and Discussions

#### 3.1. Compressive Strength of Baked Clay Cubes

Ten baked clay cubes were tested in compression. Compressive strength of the cubes is presented in **Table 1**. Average cube crushing strength was found to be 25 MPa. It is to be noted that cube crushing strength of normal concrete is 20 MPa [13]. This implies that compression behaviour of baked clay cubes is as good as normal concrete.

#### 3.2. Compressive Strength of Baked Clay Cylinders

Ten samples of baked clay cylinders were tested in compression in Universal Testing Machine. The compressive strength of the cylinders is presented in **Table 2**. Average compressive strength of the cylinders was found to be 15 MPa. This implies that the compressive strength of baked clay cylinders was found to be 0.6 times the cube crushing strength. This ratio of cylinder strength to cube strength of baked clay seems to be less than that of concrete, which is 0.8 [16]. This may be due to presence of voids and drying cracks in relatively more volume of a cylinder as compared to a baked clay cube. It is to be noted that both the cylinders and cubes were cut from baked clay beams. The beams were cast in five equal layers, each of thickness 60 mm. The cubes contained

**Table 2.** Compressive strength of baked clay cylinders of diameter 150 mm and height 300 mm.

S. No.	Sample ID	Compressive strength (Mpa)
1	S1	15.2
2	S2	14.7
3	S3	15.4
4	S4	15.3
5	S5	14.8
6	S6	14.5
7	S7	14.9
8	S8	15
9	S9	15.6
10	S10	15

maximum of three layers and the cylinders involved all the five layers.

Since the compressive strength of a cylinder is considered to be more realistic for design of structural compression members, it is suggested to conduct further studies to minimize the voids and drying cracks in clay beams in order to achieve compressive strength of baked clay cylinders as high as exhibited by normal concrete.

#### 4. Conclusions

The compressive strength of cubes and cylinders that were obtained from baked clay beams fired at 900°C is described in this paper. Following conclusions can be drawn:

- 1) Average Compressive strength of the cubes was found to be 25 MPa which is 25% more than cube crushing strength of normal concrete.
- 2) Average compressive strength of baked clay cylinders was 15 MPa. This implies that compressive strength of baked clay cylinders is about 0.6 times the cube crushing strength. The ratio of cylinder to cube crushing strength of baked clay is less than that of normal concrete, which is 0.8.
- 3) Future studies are suggested to be carried out to reduce voids and drying cracks in baked clay beams in order to enhance compressive strength of cylinders.

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