# Experimental study on Masonry Infill Material Properties

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**Abstract** — Infills walls are constructed using different types of structural blocks such as clay bricks, fly ash bricks, solid concrete blocks, hollow and cellular blocks. Constructions of bricks or blocks with cement mortar are called masonry. Masonry structures are durable in nature and are resistant to severe climatic conditions. They also accommodate minor earthquake disturbances and normally will not lead to failure in differential settlement of foundations. The factors governing the strength of a masonry structure includes brick strength, mortar strength, elasticity, workmanship, brick uniformity and the method used to lay bricks. In this experimental study fly ash brick prism and clay brick prisms of sizes 230 x 230 x 300mm with CM1:4, CM1:5 and CM1:6 mix proportions were used. The compressive strength and modulus of elasticity tests was compared with curing period of 7th and 28th day's specimens of 3 each and of totally 108 prisms. The results of fly ash brick masonry prism proved that it has achieved maximum compressive strength and young's modulus.

**Index Terms** — Brick masonry, Brick prism, Cement mortar, Clay bricks, Compressive strength, Fly ash bricks, Modulus of Elasticity

## 1 INTRODUCTION

Masonry units are of several types such as clay bricks, fly ash bricks, concrete blocks, line based blocks, stones etc. Brick masonry is a common construction material in India because of its abundance, low cost, good sound and heat insulation properties, and availability of skilled labour. Masonry is extensively used in India as infill walls in reinforced concrete buildings. Analysis and design of buildings with masonry require material properties of masonry. [1,2] Bricks are obtained by moulding clay in rectangular shape, dried and burned.

Fly ash bricks are made by fly ash which is obtained as a waste material from burning coal or lignite in varies industries, especially in power stations. Lime or cement is added to give the bricks required strength. These are preferred because of its durability, strength, reliability and cost etc. Generally the choice is governed by local availability, compressive strength, fire resistance, cost case of construction etc. Compressive behaviour of masonry is typically a non elastic, non homogeneous and anisotropic material composed of two materials of quite different properties.

Under lateral loads, masonry does not behave elastically even in the range of small deformations. Masonry is very weak in tension because it is composed of two different materials distributed at regular intervals and the bond between them is very weak. Therefore, masonry is normally provided and expected to resist only the compressive forces. During compression of masonry prisms constructed with stronger and stiffer bricks, mortar of bed joint has a tendency to expand laterally more than the bricks because of lesser stiffness.

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However, mortar is confined laterally at the brick-mortar interface by the bricks because of the bond between them, therefore, shear stresses at the brick – mortar interface result in an internal state of stress which consists of triaxial compression in bricks.[2] Limited experimental research has been carried out in India to determine the stress - strain curves of masonry typically constructed in the Indian industry.[3] In the present study the experimental testing of masonry prisms is performed to obtained the compressive strength and stress - strain curves.

## 2 PROPERTIES OF MATERIALS

The properties of materials were tested as per Indian Standard codes [5-8]

**CEMENT**

| | |
|---|---|
| Specific Gravity | : 3.1 |
| Normal Consistency | : 32% |
| Initial Setting | : 30 minutes |
| Final Setting | : 600 minutes |

**SAND**

| | |
|---|---|
| Fineness Modulus | : 2.70 |
| Fine aggregate grading | : Zone II |
| Specific Gravity, G | : 2 .44 |
| Bulk density | : 1720kg/m$^3$ |

**BRICKS**

**TABLE 1**
**Compressive Strength of bricks**

| Type of Bricks | Brand Name | Brick Size (mm) | Average Compressive Strength (N/ mm$^2$) |
|---|---|---|---|
| Clay Bricks | A C B | 210 x 100 x 75 | 3.746 |
| Fly Ash Bricks | A C B | 215 x 110 x 75 | 5.203 |

**TABLE 2**
**Water Absorption**

| Type of Bricks | Brand Name | Brick Size (mm) | Average Water Absorption (%) |
|---|---|---|---|
| Clay Bricks | A C B | 210 x 100 x 75 | 15.757 |
| Fly Ash Bricks | A C B | 215 x 110 x 75 | 24.510 |

**Weight of Bricks**

Average Weight of Clay brick : 2.714 kg

Average Weight of Fly Ash brick : 3.031 kg

## 3 MIX PROPORTION

In this experimental study, clay bricks and fly ash bricks were used. Total numbers of specimens are mentioned below:

**TABLE 3**
**Total numbers of specimens**

| Type of Bricks | Cement Mortar Ratio | No. of Prisms made |
|---|---|---|
| CLAY BRICKS | 1:4 | 18 |
| | 1:5 | 18 |
| | 1:6 | 18 |
| FLY ASH BRICKS | 1:4 | 18 |
| | 1:5 | 18 |
| | 1:6 | 18 |
| Total | | 108 |

## 4 PRISM CASTING AND CURING

Casting of prisms (Fig.1) were made 230mm x 230mm x 300mm in dimension for using CM 1:4, CM 1:5, and CM 1:6 mix proportions and allowed to curing (Fig.2) of 7 and 28 days with using of gunny bags .

**Fig. 1 Casting of Clay brick and Fly Ash Prisms**

**Fig. 2 Curing of Clay brick Prisms**

## 5 TESTING PROCEDURE

**Compressive Strength Test**

Universal testing machine (UTM) of capacity 1000kN was used for the testing of compressive strength of Prism specimens (Fig.3-6). The prisms were placed at the centre of the loading platform of UTM tested under axial compression without any eccentricity. The load is increased gradually till the crushing of specimens. The load at which the specimen failed was taken as the Ultimate compression strength. Testing procedure were followed as per relevant IS Code of Practices.[9]

**Fig. 3 Test set up for Compressive Strength**


**Fig. 4 Compressive Strength Test for Fly Ash Brick**

**Fig. 5 Compressive Strength Test for Fly Ash Brick**

**Fig. 6 Compressive Strength Test for Clay Brick**

**Young's Modulus Test**

The prisms were placed with the frame set up in which a compressometer (dial gauge) is fixed at one lateral directions ( X or Z) of the frame in which other three faces of the frame is fitted with adjustable screws with pivot rod at centre of the specimen to tighten the frame with masonry prism. The compressometer is centrally pivoted with the prism to observe the lateral movement of prism during axial loading. Set the dial gauge (least count = 0.01) at the centre of prism surface. The load was applied axially at a uniform rate and corresponding readings were noted at equal intervals until the prism failure occurred. The tests were carried out 1000kN capacity Universal testing machine (UTM). The test set up is shown in the Fig.7 &Fig.8

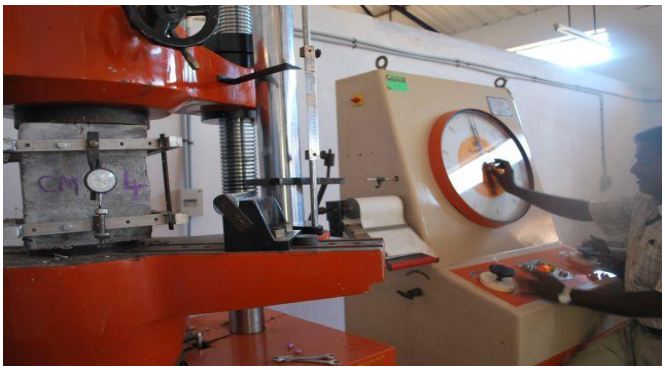

**Fig. 7 Test set up for Modulus of Elasticity**

**Fig. 8 Modulus of Elasticity Test on Fly Ash Brick**

## 6 TEST RESULTS

**Compressive Strength Results**

Compressive strength results (Table 4 & 5) of the masonry prisms represented graphically is shown in the Fig.9 & Fig.10

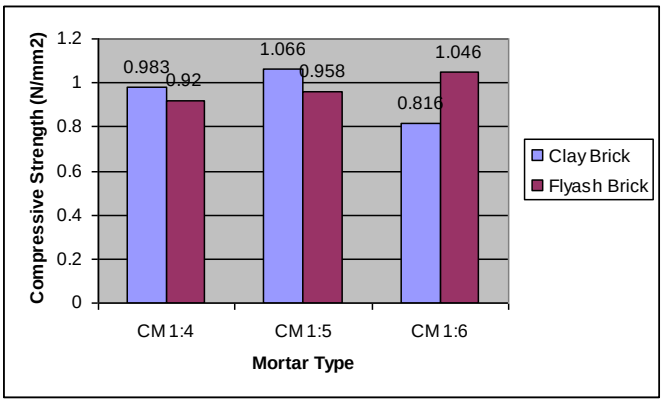


**Fig. 9 Compression Strength for Bricks at 7 days**

**TABLE 4**
**Compressive Strength - Masonry Prism - 7days**

| Brick Type | Specimen Identification | Area (mm²) | Compressive Strength (N/mm²) | | |
|---|---|---|---|---|---|
| | | | CM 1:4 | CM 1:5 | CM 1:6 |
| Clay Brick | ACB 1 | 44100 | 0.862 | 1.043 | 0.816 |
| | ACB 2 | 44100 | 0.907 | 1.020 | 0.726 |
| | ACB 3 | 44100 | 1.179 | 1.134 | 0.907 |
| | | **Average** | 0.983 | 1.066 | 0.816 |
| Fly Ash Brick | ACB 1 | 52900 | 0.832 | 0.945 | 1.059 |
| | ACB 2 | 52900 | 1.002 | 0.983 | 1.040 |
| | ACB 3 | 52900 | 0.926 | 0.945 | 1.040 |
| | | **Average** | 0.920 | 0.958 | 1.046 |

**TABLE 5**
**Compressive Strength - Masonry Prism - 28days**

| Brick Type | Specimen Identification | Area (mm²) | Compressive Strength (N/mm²) | | |
|---|---|---|---|---|---|
| | | | CM 1:4 | CM 1:5 | CM 1:6 |
| Clay Brick | ACB 1 | 44100 | 1.156 | 1.066 | 0.998 |
| | ACB 2 | 44100 | 1.247 | 1.202 | 1.066 |
| | ACB 3 | 44100 | 1.111 | 1.224 | 1.111 |
| | | **Average** | 1.172 | 1.164 | 1.058 |
| Fly Ash Brick | ACB 1 | 52900 | 2.268 | 2.212 | 2.306 |
| | ACB 2 | 52900 | 2.344 | 2.174 | 2.231 |
| | ACB 3 | 52900 | 3.573 | 2.079 | 2.268 |
| | | **Average** | 2.728 | 2.155 | 2.268 |

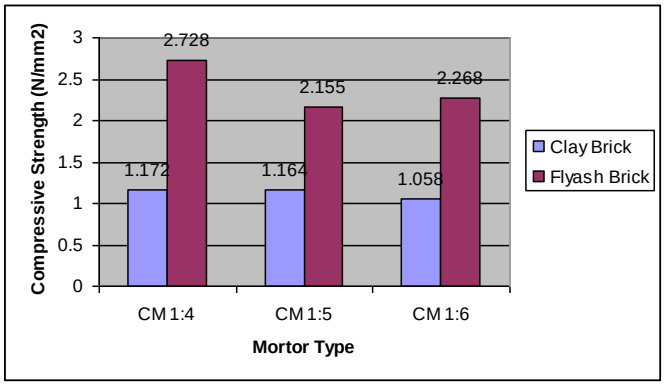


**Fig. 10 Compression Strength for Bricks at 28 days**

**Results for Young's Modulus**

Stress strain curve of the clay bricks and fly ash bricks represented graphically in the Fig.11-14

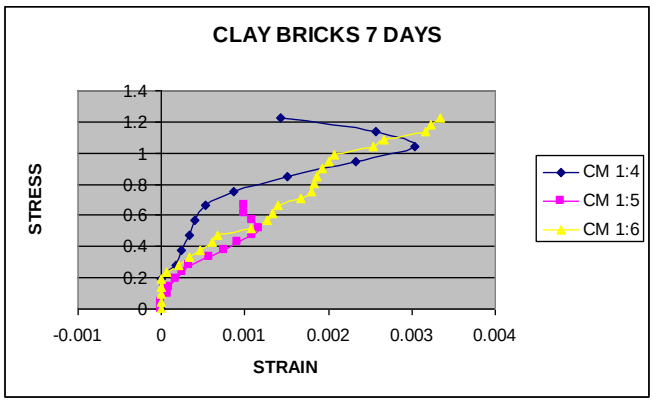


**Fig. 11 Stress Strain for Clay Brick Masonry Prism (7days)**

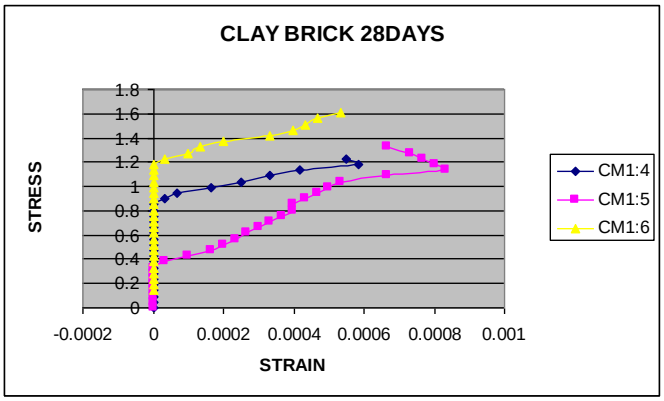


**Fig. 12 Stress Strain for Clay Brick Masonry Prism (28days)**

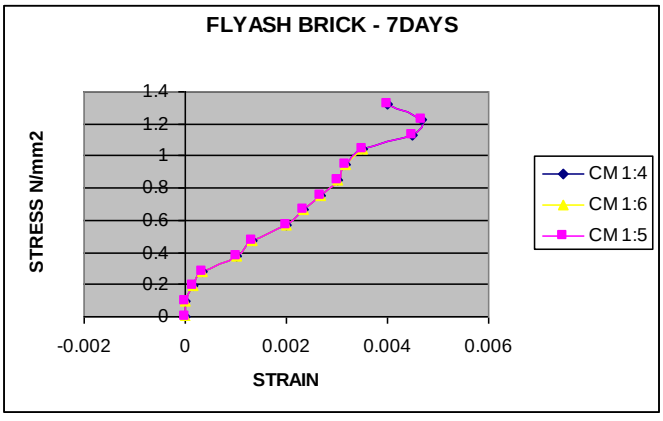


**Fig. 13 Stress Strain for Fly Ash Brick Masonry Prism (7days)**

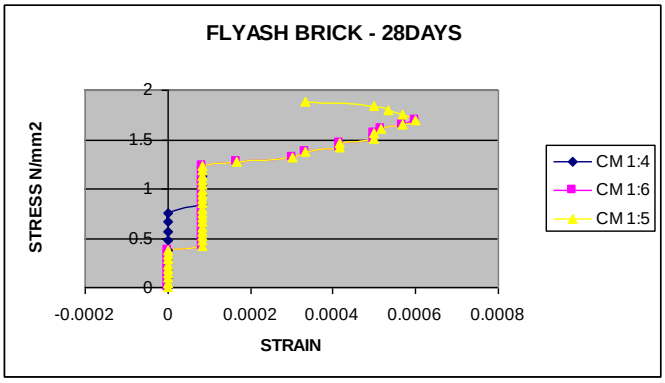


**Fig. 14 Stress Strain for Fly Ash Brick Masonry Prism (28days)**

## 7 RESULT AND DISCUSSIONS

Compressive testing of masonry prisms were conducted using two different bricks and three cement mortar ratios viz. 1:4, 1:5 and 1:6.(Fig.9 and 10) It is found that, the Compressive strength of clay bricks masonry prisms for, 7 days cured were 0.983N/mm², 1.066 N/mm² and 0.816 N/mm² for the ratio of 1:4, 1:5 and 1:6 respectively and the Compressive strength of fly ash bricks masonry prisms for 7 days cured were 0.920N/mm², 0.958 N/mm² and 1.046 N/mm² for the ratio of 1:4, 1;5 and 1:6 respectively. (Table. 4) The Compressive strength of clay bricks masonry prisms for, 28 days cured were 1.172 N/mm², 1.164 N/mm² and 1.058 N/mm² for the ratio of 1:4, 1:5 and 1:6 respectively and the Compressive strength of fly ash bricks masonry prisms for 28 days cured were 2.728 N/mm², 2.155 N/mm² and 2.268 N/mm² for the ratio of 1:4, 1:5 and 1:6 respectively. (Table.5). Based on the test results, it has been observed that, there is a considerable increase in the compressive strength for fly ash bricks than the clay bricks.

Similarly, Young's Modulus value also obtained for clay bricks (Fig.11 and 12) and fly ash bricks (Fig.13 and 14) masonry prism for 7 days and 28 days cured. The graphs drawn based on the young's modulus value obtained for both clay bricks and fly ash bricks masonry prism. It is observed that, the stress strain curve increased linearly gradually for 7 days cured samples and the stress strain curve for 28 days cured samples. It is shown that, for the 28 days cured clay bricks, the stress value of 0.8 N/mm² (CM1:4), 0.4 N/mm² (CM1:5) and 1.1 N/mm² (CM1:6), there was no strain. It has maintained its constancy up to the above mentioned level. It is shown that, for the 28 days cured fly ash bricks, the stress value of 0.8 N/mm²( CM1:4), 0.4 N/mm² and maintained its constancy up to 1.2 N/mm² ( CM1:5) and 1.2 N/mm² (CM1:6), there was no strain. It has maintained its constancy up to the above mentioned level.

## 8 CONCLUSION

Based on the results obtained through graphically and analytically, it is found that, the compressive strength of 28 days cured clay bricks prisms and fly ash bricks prisms were increased significantly than the 7 days cured clay bricks prisms and fly ash bricks prisms. Further, the compressive strength of 28 days cured fly ash bricks prisms of CM ratio 1:4 were found to be increased significantly at the rate of 132% than the clay bricks prisms, the compressive strength of 28 days cured fly ash bricks prisms of CM ratio 1:5 were found to be increased significantly at the rate of 85 % than the clay bricks prisms and the compressive strength of 28 days cured fly ash bricks prisms of CM ratio 1:6 were found to be increased significantly at the rate of 114% than the clay bricks prisms.

The average Young's Modulus of Clay Brick prism of CM 1: 4 were found to be 8463 N/mm² and for Fly ash brick prisms were found to be 13693 N/mm², Clay Brick prism of CM 1: 5 were found to be 2783 N/mm² and for Fly ash brick prisms were found to be 7740 N/mm² and Clay Brick prism of CM 1: 6 were found to be 8675 N/mm² and for Fly ash brick prisms were found to be 10470 N/mm². It is evident that, the young's modulus of fly ash brick prisms of CM ratio of 1:4, 1:5 and 1:6 is found to be higher than the clay brick prisms of similar CM ratios. Based on the experimental study revolves that, the fly ash brick prism were found to give higher compressive strength and higher Young's Modulus when compared to clay Brick prisms.

Further, the fly ash brick prisms will improve the strength of the masonry and also can accommodate the minor earthquake disturbances and resist the all kind of lateral loads considerably.

## 9 REFERENCES

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