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Compression Behaviour of Prisms with Clay Brick and Flyash Brick

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Abstract
The objective of the present paper is to characterize the compression behavior of masonry prisms. This method is used for the prediction of behavior based on properties of masonry is proposed and typical values of the properties are given for different cases. With regards to laboratory test, compression tests were performed on clay bricks and fly ash brick prisms with different mix proportions of 1:4, 1:5, and 1:6 for finding the compression strength hence, modulus of elasticity. The test has been conducted on 7 days and 28 days with the cured specimens of the all three mix ratio and result were obtained however the result of fly ash with masonry have higher compressive strength and Modulus of elasticity than those obtained from that of clay masonry prisms.
Keywords: *Brick, Flyash, Prism, Mortar, Strength, Stress*

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I. Introduction

Brick masonry is the common construction material in India because of its abundance, low cost good sound insulation properties and availability of skilled labors.

Bricks are obtained by moulding clay in rectangular blocks and then drying and burning them. In places where stones are not easily available bricks are used in construction. These are preferred because of its durability, strength, reliability, low cost etc.

In this project, a study of behavior of bricks in masonry structures with different mix proportions are carried out. Masonry units are of several types such as clay bricks, concrete blocks, line based blocks, stones etc. and generally the choice is governed by local availability, compressive strength, fire resistance, cost case of construction etc.

Fly ash bricks are made from the fly ash which is obtained as a waste material from burning of coal or lignite in various industries, especially in power houses. Lime or cement is also added to give the bricks required strength.

Many factories have come up in India to manufacture fly ash bricks. The Indian government also encourages this use of the waste product by giving concessions in its manufacture.

II. Literature Review

Kaushik et al (2007) proposed nonlinear stress-strain curves for bricks, mortar, and masonry and six "control points" have been identified on the stress-strain curves of masonry, which can also be used to define the performance limit states of the masonry material or member. Using linear regression analysis, a simple analytical model has been proposed for obtaining the stress-strain curves for masonry that can be used in the analysis and design procedures. The model requires only the compressive strengths of bricks and mortar as input data, which can be easily obtained experimentally and also are generally available in codes. Simple relationships have been identified for obtaining the modulus of elasticity of bricks, mortar, and masonry from their corresponding compressive strengths. It was observed that for the strong and stiff bricks and mortar of lesser but comparable strength and stiffness, the stress-strain curves of masonry do not necessarily fall in between those of bricks and mortar.

Characteristics (strength, absorption and durability) of compacted fly ash – lime bricks with and without gypsum additive were examined by Gourav and Reddy (2014). Compressive strength, flexure bond strength and stress strain characteristics of fly ash brick masonry using four types of fly ash bricks and cement-lime mortar were investigated. The results reveal that (1) it is possible to achieve 8 – 10 MPa compressive strength in saturated state, reasonably low values of water absorption, good dimensional stability and durability characteristics for fly ash lime gypsum bricks using 10% lime and 2% gypsum, (2) fly ash bricks of higher density can be produced using fly ash-sand mixture, instead of fly ash alone and (3) fly ash brick masonry shows higher flexure bond strength when compared with that of burnt clay brick masonry.

Sivagnanaprakash et al (2015) carried out comparative study on material properties of clay brick and fly ash brick. Compressive strength, tensile strength, durability, water absorption, impact resistance, and thermal conductivity of QFAC bricks were investigated and compared with conventional clay bricks. The compressive strength of QFAC brick was 15% higher than that of clay bricks. The flexural strength of QFAC brick was found to be twice that of clay brick. The average water absorption of QFAC brick was as low as 10%. The QFAC brick also possessed high impact resistance and high durability. The thermal conductivity of QFAC brick was as low as that of clay bricks. Hence QFAC bricks are a superior replacement and environmentally sustainable material for clay bricks

Ashish et al (2018) evaluated properties of brick having coal ash and explores the possibility of utilization of coal bottom ash and coal fly ash as an alternative raw material in the production of coal ash bricks. Lower cement content was used in the investigations to attain appropriate strength and prohibit high carbon content that is cause of environmental pollution. The samples use up to 7% of cement whereas sand was replaced with bottom ash. Bricks were tested for compressive strength, modulus of rupture, ultrasonic pulse velocity (UPV), water absorption and durability. The results showed mix proportions of bottom ash, fly ash and cement as 1:1:0.15 i.e., M-15 achieved optimum values. The coal ash bricks were well bonded with mortar and could be feasible alternative to conventional bricks thus can contribute towards sustainable development.

In the study by Khan (2014), three types of FAB masonry referred as Type A (conventional masonry in English bond), Type B (odd course of bricks on edge and even course on bed) and Type C (all bricks on edge in Flemish bond) had been considered. Since Type B and C masonry consist of inside cavity that resulted in the saving of number of bricks by 25%. The reduction in the manufacturing cost of fly ash bricks and saving in the number of bricks resulted in the considerable reduction in the overall cost of masonry structure.

III. Materials

3.1.PROPERTIES OF CEMENT

Cement is the most important material on building construction which is available in powder form. When mixed with water it can set to a hard durable mask even under water. The properties of this good cement primarily depends upon the chemical composition, thoroughness of the burning and fineness of grinding. The physical properties of cement used in this study is shown in Table 1.

Table 1 – Cement Properties

Specific Gravity	3.1
Normal Consistency	32%
Initial Setting Time	30mins
Final Setting Time	600mins

3.2.PROPERTIES OF SAND

Fine aggregate of size between 4.75mm and 0.15mm is used in this research. This is used for making concrete, mortars and plasters. For economy in construction as far as possible local sand fit for the perpendicular use, should be used otherwise transport expense will be a major part of the cost of the sand. Soft sand is the ideal material for making mortar and plaster for brick work.

Table 2 – Sand Properties

TESTS	RESULTS
Fineness modulus	2.70
Fine aggregate grading	Zone II
Specific gravity	2.44

3.3.PROPERTIES OF BRICK

The average weight of the clay bricks and fly ash bricks is calculated by taking the three samples for each type and the weight of the fly ash bricks is 20% higher than the clay brick samples as presented in Table 3.

Table 3 - Average Weight Of Bricks

Brick Type	Average Weight (Kg)
Average Weight of Clay brick	2.714 kg
Average Weight of Fly Ash brick	3.031 kg

IV. Experimental Study

4.1. COMPRESSION STRENGTH ON BRICK

The compression testing of the material plays a vital role in finding the strength of the material. The average sizes of bricks are selected in both the cases of clay bricks and fly ash bricks for compressive testing. From the test results, it is seen that compressive strength of fly ash is 28% higher than that of clay bricks which is given in Table 4.

Table 4 - Compressive Strength

Brick Type	Brick Size (mm)	Average Compressive Strength (N/mm^2)
Clay bricks	210 x 100	3.74
Fly Ash Bricks	215 x 110	5.20

4.2.WATER ABSORPTION TEST

The water absorption test was carried out for the clay bricks and fly ash bricks and tabulated in Table 5. Water absorption of flyash bricks was 35% higher than that of clay bricks.

Table 5- Water Absorption

Brick Type	Size (mm)	Average water absorption (%)
Clay bricks	210 x 100	15.76
Fly ash bricks	215 x 110	24.51

4.3.EFFLORESCENCE TEST

The bricks are immersed in water for 24 hours. They are then observed for while (or) gray patches, which are due to the presence of harmful alkalis. The observation is reported as nil for both the types of bricks.

V. Test On Prisms

5.1 Specimen Details

In this experimental study, masonry prisms were cast with clay bricks and fly ash bricks. For each types of bricks, 3 mortar ratios were investigated i.e. 1:4, 1:5 and 1:6. For each mortar ratio, 3 specimens were cast for compressive strength and 3 for modulus of elasicity. The details of the specimens are given in Table 6, the total number comes to 36.

Table 6 – Requirement of Prisms

Type of Bricks	Cement Mortar Ratio	No. of Prisms
Clay bricks	1:4	6
	1:5	6
	1:6	6
Fly ash bricks	1:4	6
	1:5	6
	1:6	6
Total		36

5.2 Compression Test on Masonry Prisms

Test set up was made to determine the compressive strength of masonry prisms with clay bricks and flyash bricks for the mix ratio of CM 1:4, CM 1:5 and CM 1:6 at the end of 7 and 28 days. The dimension of masonry clay brick and flyash brick prisms are 210mm x 210mm x 500mm and fly ash brick prism 215mm x 215mm x 500mm.

The test was carried out at the end of 7 and 28 days of curing. The prisms were placed between the plates of compression testing machine as shown in Figures 1 and 2. The load was applied axially at a uniform rate of until the prisms failure occurred.

To determine the compressive strength of masonry prism, the maximum load at failure stage is noted which is divided by its surface area of masonry prism is expressed in N/mm^2.

Figure 1 Compression Test on Flyash Brick Prisms

Figure 2 Compression Test on Clay Brick Prisms

5.2 Stress Strain Behaviour

The prisms were placed with the frame set up in which a compressometer is fixed at one lateral direction (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. at the centre of prism surface. The load was applied axially by the universal testing machine at a uniform rate and corresponding stress, strain values were noted at equal intervals until the prism failure occurred.

Figure 5 Compression Testing of Brick Masonry

VI. Results And Discussion

6.1 Compressive Strength of Clay and Flyash Bricks

The compression test is carried out for the **7** days and 28 days cured specimen using the universal testing machine for fly ash bricks and clay bricks. From Figure 6 which shows the compressive strength of clay brick prisms, it is understood that prisms with mortar ratio 1:4 possessed the highest compressive strength of 1.17N/mm^{2}at 28 days and the prism with mortar ratio 1:5 has the highest compressive strength of 1.05 N/mm^2 at 7days.

From Figure 7, it is seen that flyash brick prism with mortar ratio 1:4 had the highest compressive strength of 2.73 N/mm^2 at 28days and the prism with mortar ratio 1:6 possessed the highest compressive strength of 1.05 N/mm^{2}at 7days.

While comparing the two types of brick prisms at the end of 7days, clay brick prisms with mortar ratio 1:5 had the higher compressive strength of 1.07 N/mm^2 than flyash brick prisms with a compressive strength of 1.05 N/mm^2 with mortar ratio 1:6. But at 28 days, compressive strength of flyash brick prisms were significantly higher than that of clay brick prisms. Flyash brick prism with mortar ratio of 1:4 had the highest compressive strength of 2.73 N/mm^2 of all the prisms with various mortar ratio and with clay bricks.

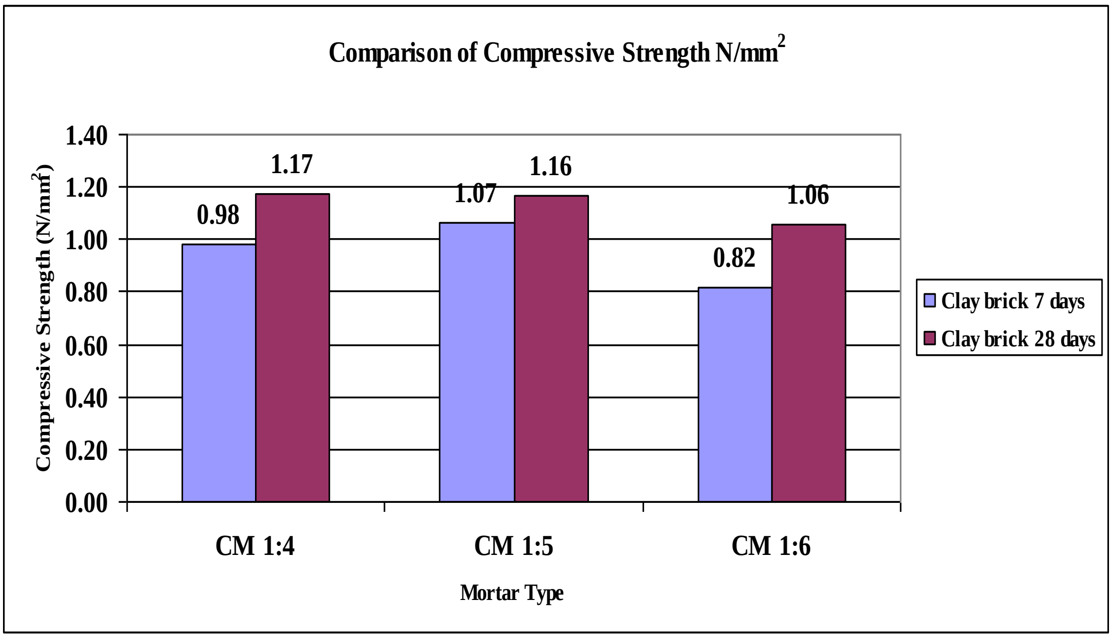

Figure 6 Compressive Strength of Clay Brick Prisms

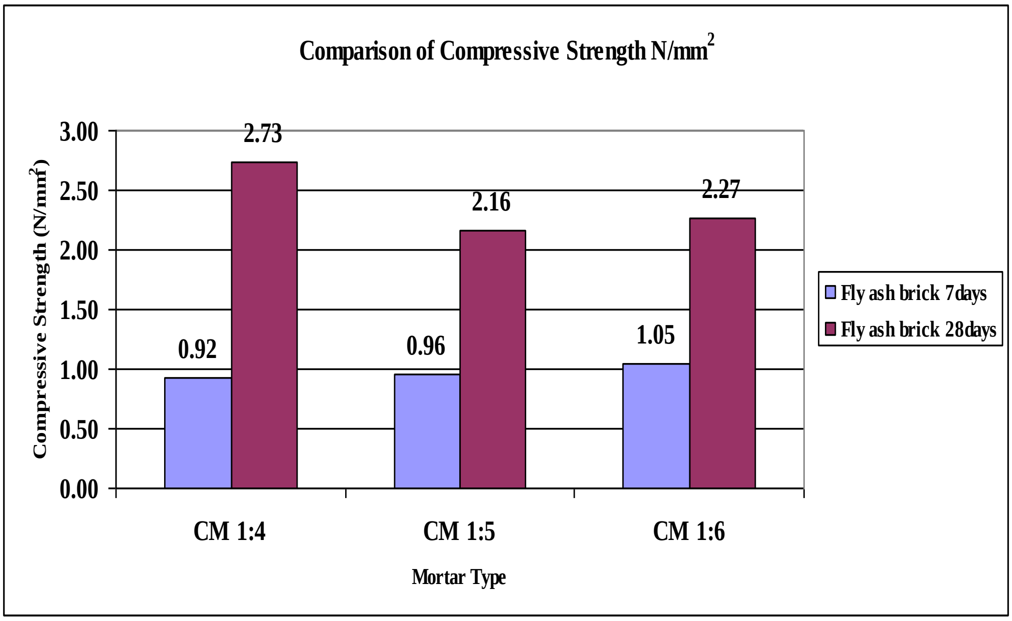

Figure 7 Compressive Strength of Flyash Bricks

6.2 Load-Deflection Behaviour of Clay and Flyash Bricks

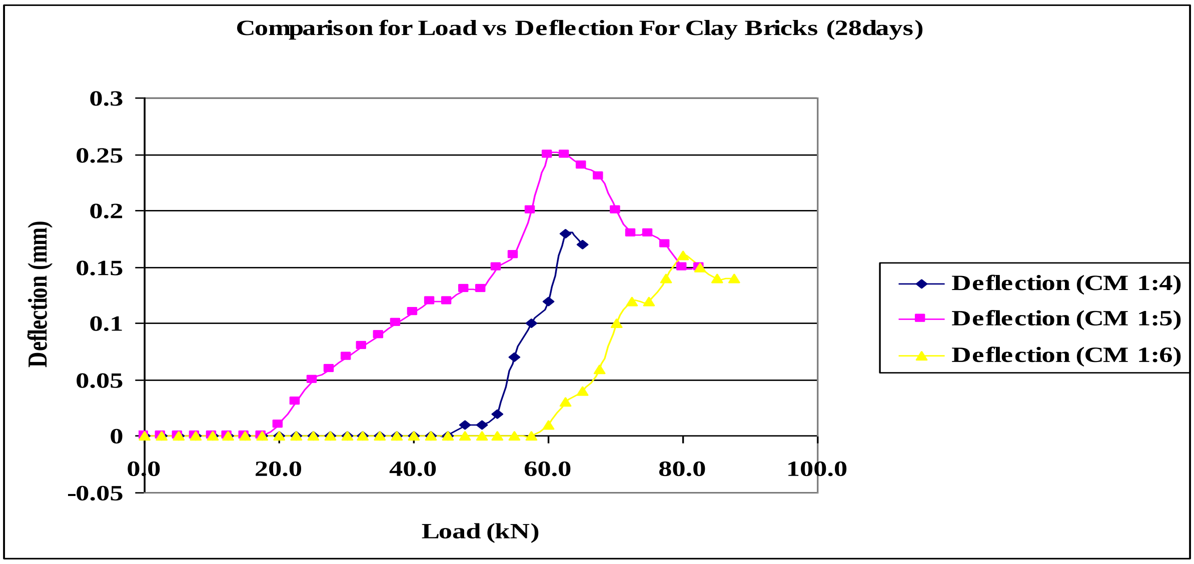

Figure 8 Load-Deflection Curve of Clay Brick Prisms

From the load-deflection curve of clay brick prisms at 28days shown in Figure 8, it is observed that prisms with CM 1:6 reached the maximum load of 88kN with a maximum deflection of 0.15mm. Clay brick prisms with CM 1:4 had the maximum load of 62kN with maximum deflection of 0.17mm. The maximum load and maximum deflection of clay brick prisms with CM 1:5 was observed as 60kN and 0.25mm. The load taken by clay brick prisms with CM 1:6 was higher than that of clay brick prisms with CM 1:4 and 1:5 by 30% and 31% respectively.

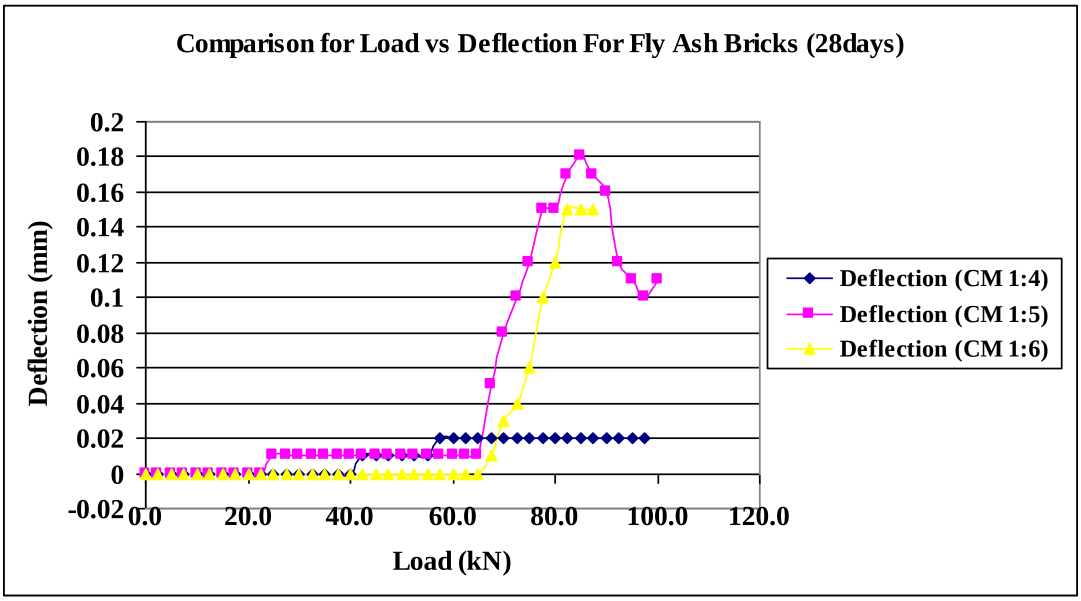

Figure 9 Load-Deflection Curve of Flyash Brick Prisms

Load-deflection of flyash brick prisms with CM 1:4, CM1:5 and CM1:6 are presented in Figure 9. Flyash brick prisms with CM 1:6, had the maximum load and deflection of 84kN and deflection of 0.15mm. The maximum load and deflection of flyash brick prisms with CM 1:5 were 82kN and 0.18mm. The maximum load and deflection of flyash brick prisms with CM 1:4 were observed as 97kN and 0.02mm. The deflection was not varying from 60kN to 97kN which may be due to loss of contact between the specimen and testing machine or accessories. Hence the highest load was taken by flyash brick prisms with CM 1:6 which is 2% higher than that of prisms with 1:4. Maximum deflection was seen in the flyash prisms with CM 1:5 and the value is higher than that prisms of CM 1:4 by 17%.

6.3 Stress-Strain Behaviour

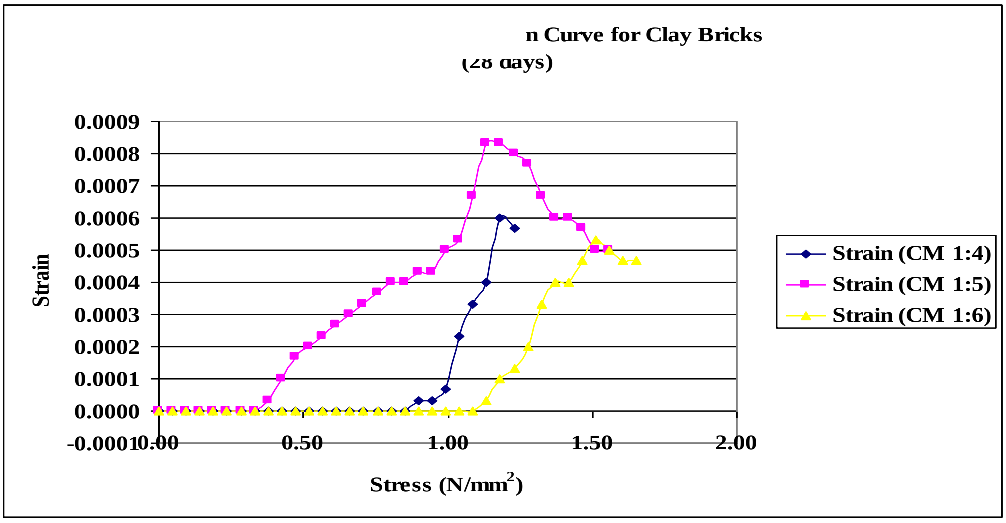

Figure 10 Stress Strain Curve of Claybrick Prisms

Stress strain curves of claybricks and flyash bricks are shown in Figures 10 and 11 respectively. From Figure 10, it is observed that clay brick prisms with CM 1:6 had the highest stress value of 1.7N/mm^2 and it is higher than that of prisms with CM 1:5 and CM 1:4 by 5% and 29% respectively. The highest stress value of clay brick prism with CM 1:6 which is attributed to the higher cement content of the morar.

The largest strain was observed in clay brick prism with CM 1:5 which is 0.00083. It exceeds the strain values of clay brick prisms with CM 1:4 and CM 1:6 by 28% and 41% respectively. Hence clay brick prism with CM 1:5 was found to be more ductile than the other two prisms.

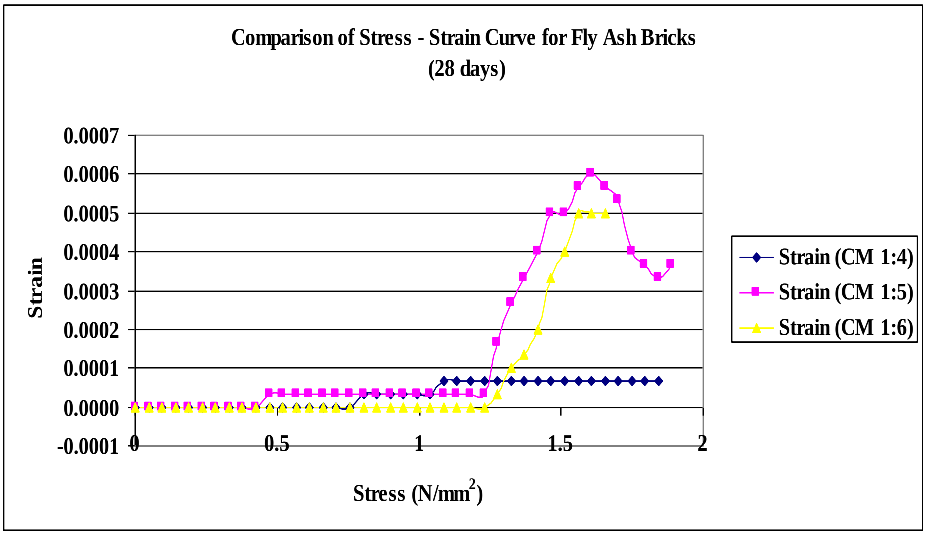

Figure 11 Stress Strain Curve of Flyash Bricks

The highest stress among flyash brick prisms was observed in the one with CM 1:5 with the value of 1.9N/mm^2. This is higher than that of prisms with CM 1:4 and CM 1:6 by 5% and 16% respectively. The highest strain values observed in flyash brick prisms with CM 1:5 and CM1:6 were 0.0005 and 0.0006 respectively. The prism with CM 1:4 did not show increasring trend in strain even at the stress level of 1.9N/mm^2 indicating that may due to loss of contact between the specimen and testing machine or accessories.

VII. Conclusions

From the exeprimental invesitgation carried out on clay and flyash brick prisms, the following conclusions are drawn:

1. Compressive strength of flyash bricks is 39% higher than that of clay bricks. It is mainly contributed by flyash and cement content of the bricks.
2. Water absorption of flyash was 55% higher than that of clay bricks. This may be due to the presence of unburnt clay particles in the flyash.
3. Compressive strength of prisms with CM 1:4 possessed the highest strength at the end of 28 days.
4. Though the 7day compressive strength was higher in clay brick prisms, 28 day compressive strength was higher in fly ash brick prisms which is attributed to the slow rate of hydration of flyash bricks
5. Highest load was taken by flyash and claybrick prisms with CM 1:6 with least maximum deflection indicating the higher stiffness of specimens.
6. Claybrick prisms with CM 1:5 and flyash brick prisms with CM 1:6 were found to have the largest strain value showing ductile behaviour.
7. Stress was higher in flyash and clay brick prisms with CM 1:5.

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