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EXPERIMENTAL EVALUATION OF COMPRESSIVE STRENGTH AND STRESS STRAIN BEHAVIOUR FOR STONE MASONRY PRISM HAVING VARIOUS SIZES

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Abstract — *This paper deals with an experimental investigation on the strength of stone masonry. Stonework is a composite material with stone as the building units and the mortar as the jointing material. When this two element combined to form a stonework unit, the properties of the materials influences the strength of the stonework. To study the behaviour of masonry under compression, the prisms of the stone masonry has been made in different sizes with cement mortar of 1:6. The prisms were tested under the compression and load and deformations were observed. The compressive strength of the masonry unit has been calculated and the stress strain curve plotted. Also the Modulus of elasticity has been calculated. The results of compressive strength show that the strength of the stone masonry increases in P4, P3, P2 with respect to P5. The results of load and the deformation of stone masonry clearly show that deformation capacity of pier is significantly increases in P1, P2, P3, P4 with respect to P5.*

Keywords-*Compressive Strength Test, Modulus of Elasticity, Cement Mortar, Stone Masonry Prism.*

1. INTRODUCTION

Two important properties in any structural element are the compressive strength and the modulus of elasticity. The compressive strength is important because it determines the load carrying capacity of the element; the modulus of elasticity is important because it provides the estimate of deformation of the element under loading.

Masonry has historically been a common and successful means of construction in load bearing structures due to its durability, strength and ease of construction. Today, it constitutes a considerable proportion of buildings worldwide that are often of historic and cultural significance. In developing countries stone masonry is an affordable and cost-effective material; it is used as building material for construction purposes. Masonry is a heterogeneous material with a complex, non-linear, anisotropic behavior (when compared to materials such as concrete or steel) which can be attributed to the different material components and the abundant inter faces. The knowledge of masonry strength and deformation characteristics is important as these determine masonry performance over time and allowable stress and stiffness in design codes for new building. However, information available on the strength characteristics of stone masonry is limited. An experimental evaluation of prediction models for the mechanical behavior of stone masonry under compression is performed. This paper intends to contribute to the understanding of the characteristics of stone masonry.

2. MASONRY PRISMS

2.1 Masonry Prisms (for compression test)

To study the behaviour of masonry under compression, the prisms of the stone masonry has been made in different sizes with cement mortar of 1:6. The prisms were tested under the compression and the load and deformations observed. The compressive strength of the masonry unit has been calculated and with the help of load and deformations. Then the stress strain curve were plotted, the Modulus of elasticity was calculated. The details for the masonry units as follows:

Table 1: Details of Masonry Prisms

S. No.	ID	Length mm	Width mm	Height mm	No. of Course
1	P1	275	100	425	5
2	P2	140	100	330	4
3	P3	125	100	250	3
4	P4	100	100	170	2
5	P5	75	100	85	1

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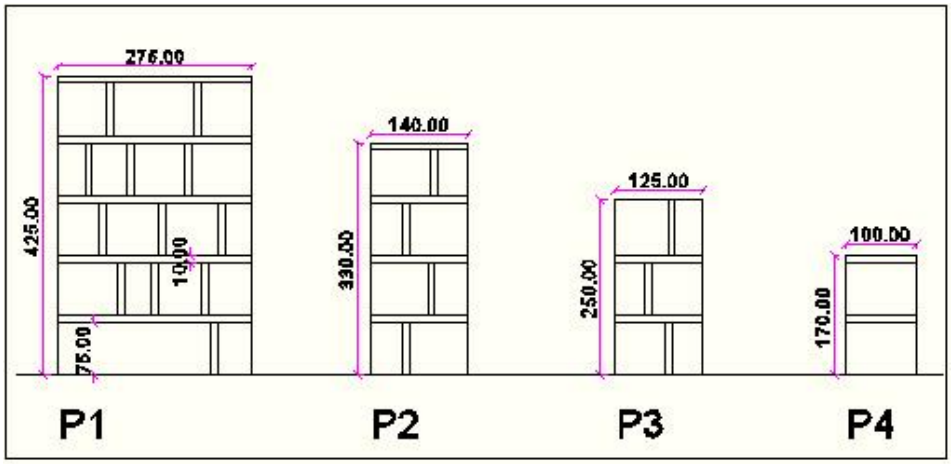

Figure 1: Elevation of the masonry Prisms

3. EXPERIMENTAL INVESTIGATIONS

3.1 Masonry Units under Compression

The different scale down masonry prisms P1, P2, P3, P4 and P5 were placed on the compression testing machine. The dial gauge was installed. The testing of the masonry prisms were done as per the SP 20. The load and the deformations have been recorded during the test. The results obtained are tabulated below:

Table 2: Detailed Observations of Compression Test for Masonry Prism P1

ID : P1 Size : 275X100X425 mm Peak Load : 178 KN Compressive Strength: 6.47 N/ mm^2	
Stress (N/mm^2)	***Strain (X 10^{-3})***
0	0
0.18	0.19
0.36	1.41
0.55	2.47
0.73	3.53
0.91	6.47
1.09	8.00
1.27	8.59
1.45	9.76
1.64	10.82
1.82	11.18
2.00	12.71
2.18	13.29
2.36	13.88
2.55	14.59
2.73	15.88
2.91	16.24
3.09	21.29
3.27	22.00
3.45	22.59
3.64	23.06
3.82	23.53
4.00	23.76
4.18	24.24

Figure 2: View of P1

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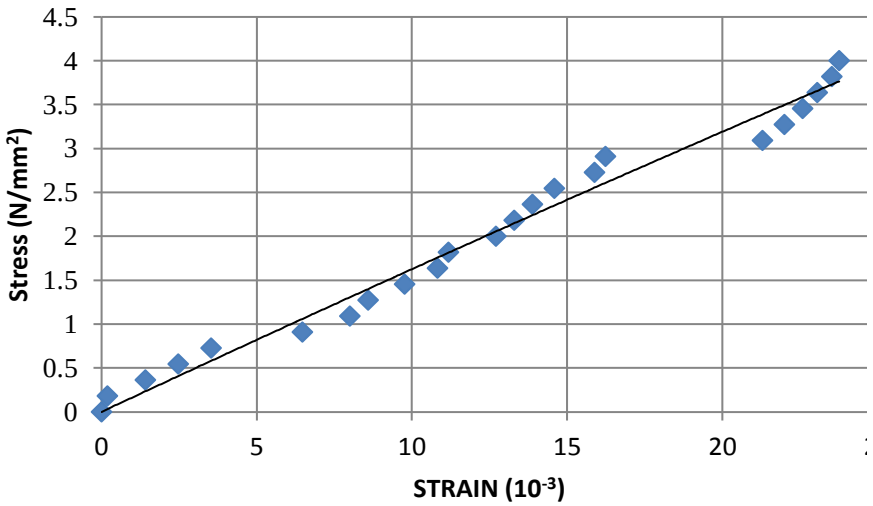

Figure 3: Stress Strain Diagram of P1

Table 3: Detailed Observations of Compression Test for Masonry Prism P2

ID : P2
Size : 140X100X330 mm
Peak Load : 105 KN
Compressive Strength: 7.50 N/ mm^2

Stress (N/mm^2)	*Strain (X10^{-3})*
0	0
0.36	0.91
0.71	2.12
1.07	2.18
1.43	2.30
1.79	2.97
2.14	3.64
2.50	7.12
2.86	9.55
3.21	11.97
3.57	12.88
3.93	13.48
4.29	15.00
4.64	15.45
5.00	15.61

Figure 4: View of Test for P2

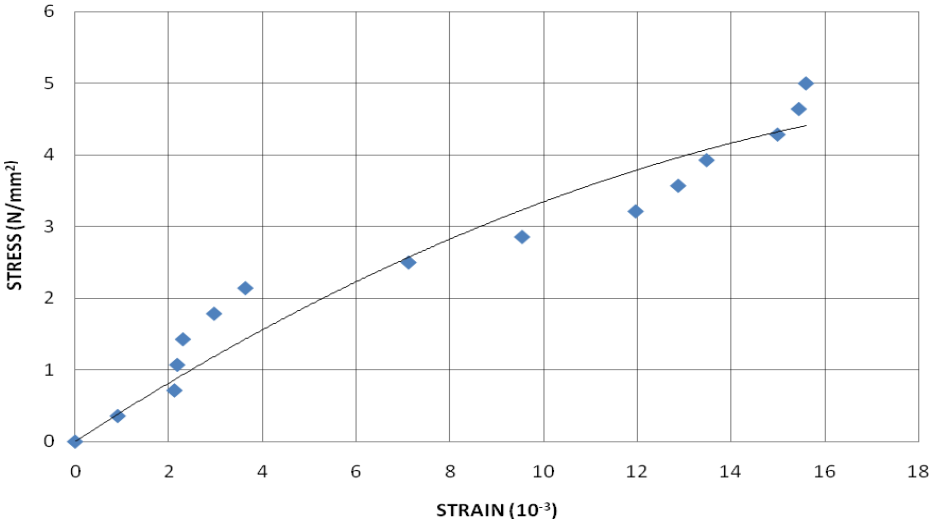

Figure 5: Stress Strain Diagram of P2

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Table 4: Detailed Observations of Compression Test for Masonry Prism P3

ID : P3
Size : 125X100X250 mm
Peak Load : 68 KN
Compressive Strength: 5.4 N/ mm^2

Stress (N/mm^2)	*Strain ($X10^{-3}$)*
0	0
0.40	0.80
0.80	2.20
1.20	5.60
1.60	7.20
2.00	9.60
2.40	10.20
2.80	11.40
3.20	12.20
3.60	12.60

Figure 6: View of Prism P3

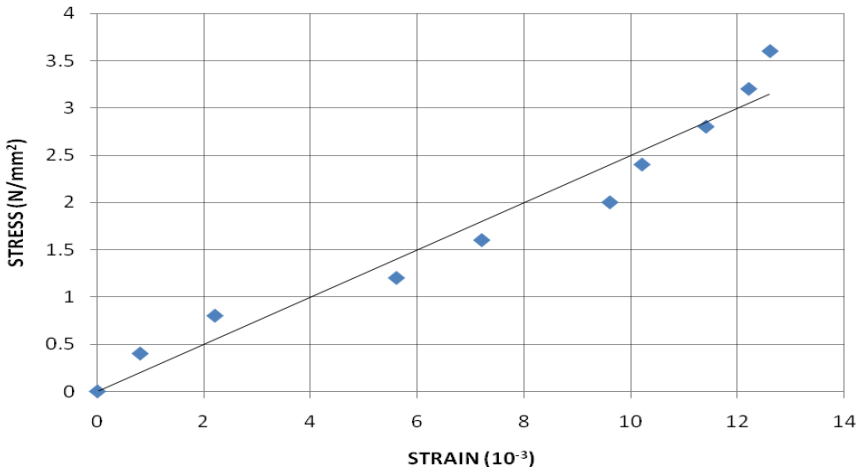

Figure 7: Stress Strain Diagram of P3

Table 5: Detailed Observations of Compression Test for Masonry Prism P4

ID : P4
Size : 100X100X170 mm
Peak Load : 61 KN
Compressive Strength: 6.1 N/ mm^2

Stress (N/mm^2)	*Strain ($X10^{-3}$)*
0	0
0.50	1.18
1.00	5.00
1.50	10.29
2.00	12.35
2.50	15.29
3.00	17.94
3.50	20.29
4.00	21.76

Figure 8: View of Prism P4

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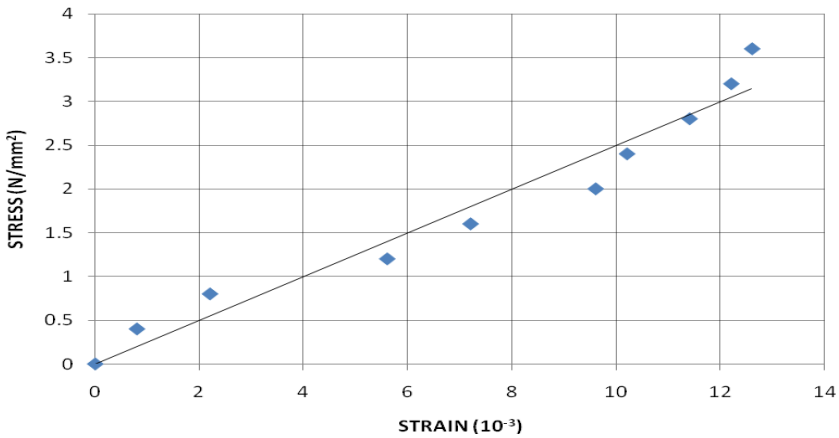

Figure 9: Stress Strain Diagram of P4

Table 6: Detailed Observations of Compression Test for Masonry Prism P5

ID : P5
Size : 75X100X85 mm
Peak Load : 120 KN
Compressive Strength: 16 N/ mm^2
Remarks : **Due to one Coarse, after failure of mortar, load taken be stone piece**

Stress (N/mm^2)	*Strain (X10^{-3})*
0	0
0.67	1.06
1.33	3.29
2.00	5.29
2.67	12.94
3.33	21.76

Figure 10: View of Prism P5

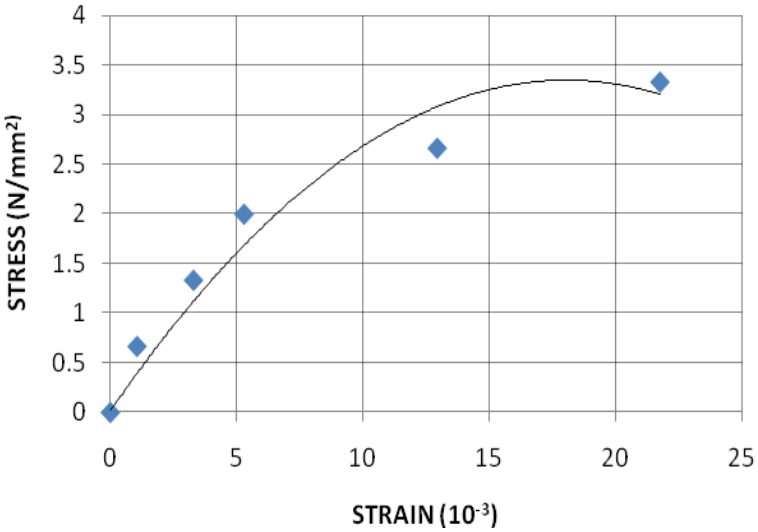

Figure 11: Stress Strain Diagram of P5

4. PERFORMANCE ANALYSIS

On the basis of the results found, comparative study for the variations of the load carrying capacity under compression, development of stress and strain, deformation capacities etc. with respect to the cross sectional size and height for the various models are reported in this section. Comparison of Strength of masonry prism P1, P2, P3, P4 with P5

- The results of compressive strength show that the strength of the stone masonry is increases in P4, P3, P2 with respect to P5.
- The variation in compressive strength ranges from 4% to 48%.

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- The results of compressive strength show that strength of P1 is decreasing in reference to P2.
- The strength of the P2 and P1 is 48% and 28% higher with respect to P5 respectively.
- There is only 4% to 7% increase in the compressive strength for P4 and P3 in comparison to P5.
- The maximum compressive strength of the P4 is 48 N/mm^2.

The variation of the compressive strength for the P1, P2, P3, P4 and P5 is shown in Figure 12 and 13.

Table 7: Comparison of Compressive Strength

ID	Compressive Strength (N/mm^2)	% variation of Compressive Strength with respect to P5
P5	5.07	-
P4	5.25	4
P3	5.44	7
P2	7.50	48
P1	6.47	28

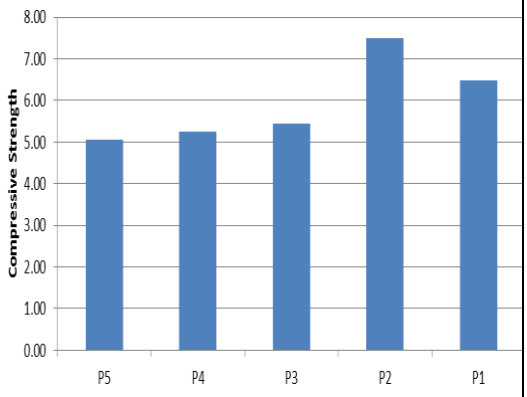

Figure 12: Variation of Compressive Strength (N/mm^2)

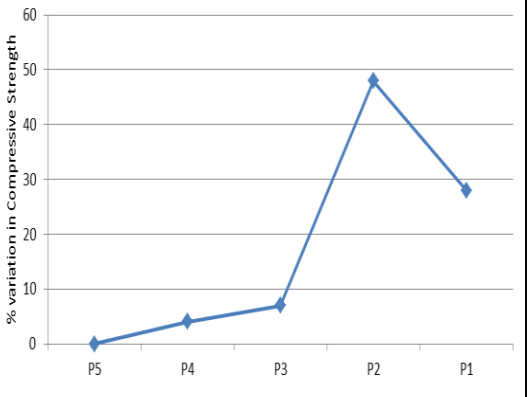

Figure 13: % Variation of Compressive Strength with P5

Stress Strain Behaviour of Stone Masonry Prism

To study strain development phenomena in stone masonry under compression, masonry prisms were made for with different sizes. On the basis of the results found, comparative study for the variations of the load and deformations under compression, development of stress and strain, deformation capacities etc. with respect to the cross sectional size and height for the various models are reported in this section.

Load and deformation of masonry prism P1, P2, P3, P4 with P5

- The results of load and the deformation of stone masonry clearly show that deformation capacity of pier is significantly increases in P1, P2, P3, P4 with respect to P5.
- The load (compressive) is proportional to deformation up to the about 30% to 50% of the maximum load in P1, P2, P3, P4 with respect to P5.
- The variation in strain capacity ranges from -41% to 13 with respect to P5.
- The results show that the maximum deformations is about 235, 181, 73, 100 % more for P1, P2, P3, P4 with respect to P5 respectively.
- The strain varies from about .003 to .013 in P1, P2, P3, P4 and P5 at the level of the same stress level i.e. 2.
- The average modulus of elasticity for the P1, P2, P3, P4 and P5 is 0.031×10^4.
- The Modulus of elasticity for the P3 is found minimum as 0.023×10^4 and maximum as 0.038×10^4 for P2.
- The masonry prism P5 having only one layer of stone with mortar layer at top and bottom. So the stress strain curve is linear for very small range.

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The variation of the compressive strength for the P1, P2, P3, P4 and P5 is shown in Figure 14 and 15.

Table 8: Comparison of Maximum Deformation under Peak Load

ID	Maximum Deformation (mm)	% variation of Maximum Deformation with respect to P5
P5	1.85	-
P4	3.7	100
P3	3.15	70.2
P2	5.15	178.4
P1	10.3	456.8

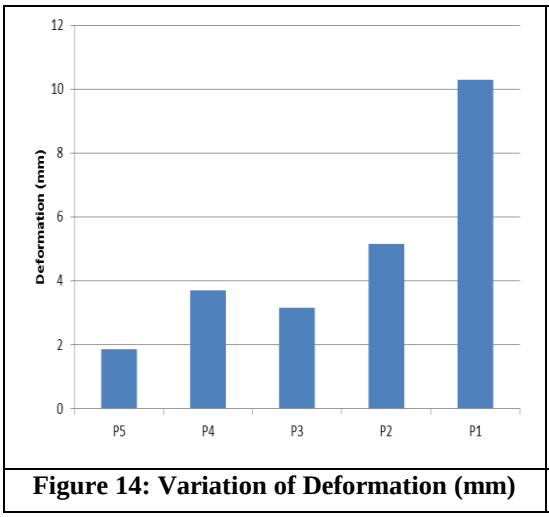

Figure 14: Variation of Deformation (mm)

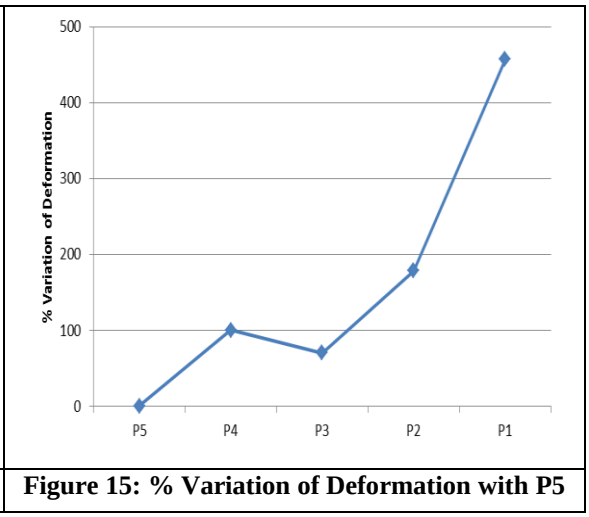

Figure 15: % Variation of Deformation with P5

Table 9: Comparison of Maximum Strain

ID	Strain (10^{-3})	% variation of Strain with respect to P5
P5	21.36	0
P4	21.76	2
P3	12.6	-41
P2	15.61	-27
P1	24.24	13

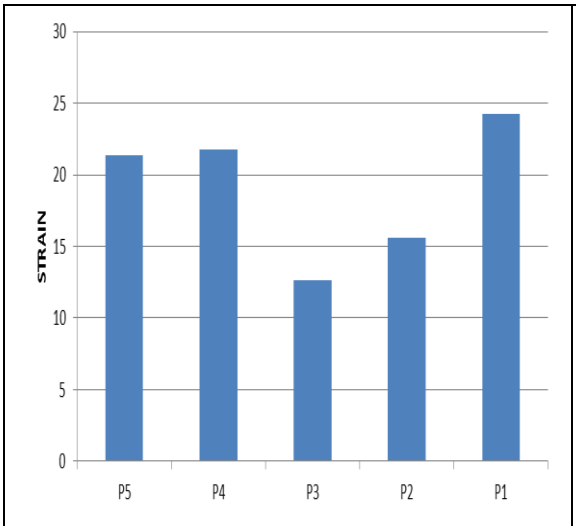

Figure 16: Variation of Strain

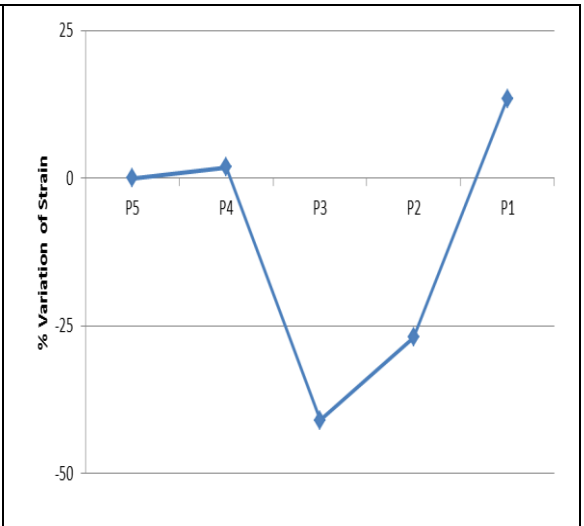

Figure 17: % Variation of Strain with P5

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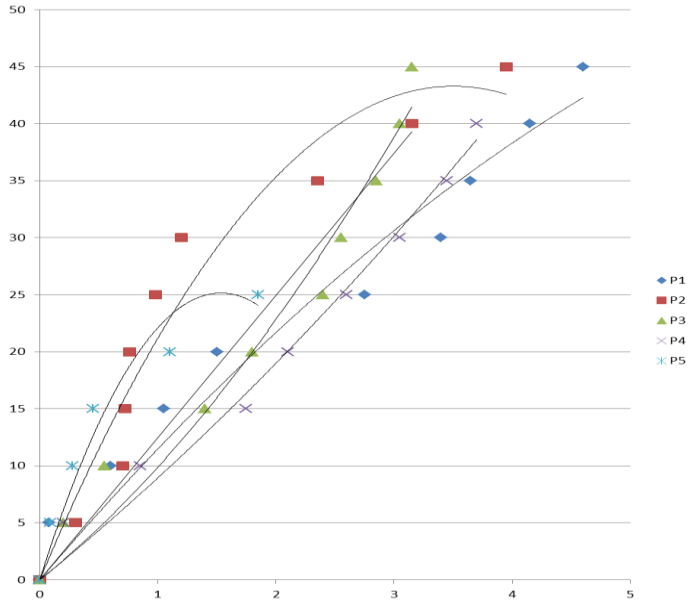

Figure 18: Variation of Stress Strain

CONCLUSIONS

The stone masonry performance under compression loads has been studied by the means of experimental setup on different scale down models of the prisms. The results were obtained and analyzed. Some of the important conclusions: The compressive strength of the stone masonry depends upon the strength of the mortar. The number of layers in stone masonry also affects the strength of construction. The aspect ratio of the stone prisms also shows different failure patterns and the variation in compressive strength.

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