INFLUENCE OF FIBER REINFORCED MORTAR ON THE BEHAVIOUR OF MASONRY WALLS MADE OUT OF LOW STRENGTH BRICKS

MOHAMED H. MATTHANA, AHMED M. TAHWIA & A.H. ABDEL-REHEEM
Assistant Professor Assistant Professor Professor
Structural Engineering Department, Faculty of Engineering,
EL-Mansoura University, Egypt

ABSTRACT

The present paper investigates the effect of fiber reinforced mortar on the behaviour of brick masonry walls made out of low strength bricks. Both experimental and analytical investigations have been carried out. The experimental study has been carried out on five groups of walls. In four groups, all mortar joints are provided with four various amounts of fiber. The walls of the fifth group are constructed with plain mortar joints for the purpose of comparison. Walls have not been provided with any type of plastering. All walls are subjected to concentrated compressive loading and the cracking patterns and both cracking and ultimate loads are reported. The vertical and lateral strains are also measured at the centerlines of walls. Walls are then taken up for detailed finite element analysis where the various types of stresses in bricks and mortar joints are obtained. The study shows that the reinforced fiber mortar joints increase the load carrying capacity of the wall. The values of both lateral and vertical deformations are slightly increased while; the cracking patterns did not changed.

INTRODUCTION

Brick masonry walls have been in use for at least 5000 years. The early use of brick masonry was mostly a matter of experience and empirical knowledge. As the knowledge of structural engineering developed, experimental and theoretical studies on masonry were taken up all over the world [1&2]. The bricks used in the developed countries generally have a higher modulus of elasticity compared to the modulus of mortar. However, developing countries often use low modulus bricks while the

Manuscript received from Dr. Mohamed H. Matthana
Accepted on : 5 / 6 / 2002
Engineering Research Journal Vol 25,No 3, 2002 Minufiya University, Faculty Of Engineering , Shebien El-Kom , Egypt , ISSN 1110-1180

mortar can have a modulus, which could be an order of magnitude more than that of brick [3]. In both cases, the modular ratio of the two constituents, bricks and mortar, plays a very significant role in the behaviour of the brick masonry [1-5]. In case of low strength bricks, the higher value of the modulus of elasticity of mortar than that of bricks causes lateral tensile stresses in the mortar bed joints [5]. The higher the modular ratios between mortar in bed joints and bricks, the higher are the values of the developed tensile stresses. As the tensile strength of mortar in bed joints is very small compared to its compressive strength, the developed lateral stresses cause vertical cracks in mortar bed joints and that continues in the brick units till the failure of the wall by the propagation of vertical cracks [5]. The use of mortar bed joints with relatively higher values of the tensile strength is, then, needed to arrest the developed tensile cracks and consequently increase the load carrying capacity of the wall. Among of the available alternatives to increase the tensile strength of the mortar bed joints are the use of light reinforcement in the bed joints and the use of fiber reinforced mortar. Matthana [6] has studied the role of reinforced mortar bed joints on the behaviour of masonry walls made out of low strength bricks.

In the present paper an attempt has been made to study the effect of fiber reinforced mortar on the behaviour of masonry walls constructed out of low-strength bricks. An experimental study is carried out on a number of wall specimens with mortar joints provided with various amounts of fiber. One group of the wall specimens constructed with plain mortar has also been tested for the purpose of comparison. All walls are subjected to compressive concentrated loads. The cracking patterns and both cracking and ultimate loads are reported. Both vertical and lateral strains at the centerlines of walls are also measured. The walls are then taken up for detailed finite element analysis where bricks and mortar joints are modeled separately. The various types of stresses in bricks and mortar joints are then obtained.

DETAILS OF THE EXPERIMENTAL STUDY

Details of the Test Specimens

The test specimens, used in the experimental study, include five groups of walls, each of two specimens. All specimens have the same dimensions of 93.0 cm length, 72.0 cm height and 10.5 cm thickness. These dimensions are equivalent to, four bricks and three head joints in length, ten bricks and nine bed joints, in height in addition to 1cm mortar seat at both top and bottom of the wall. The 10.5-cm thickness of the wall is the same width of one brick unit. All mortar joints in all walls had the same thickness of 1.0 cm. In four groups of walls, the mortar joints are provided with four various amounts of fiber. The walls of the fifth group are constructed out of plain mortar for the purpose of comparison. The considered fiber ratios are 0%, 1%, 2%, 3%, and 4% of the weight of the cement content in each mix. It should be noted here that, in each wall, the same fiber ratio is used in all mortar joints including both bed and head joints. Walls have not been provided with any type of plastering. The details of various groups of walls are given in Table 1. Figure 1 shows the configurations of the tested specimens while; Plate 1 shows a photograph for such walls at testing.

Table 1. Details of the Tested Walls

Group No.	No. of Specimens	L x H (cm x cm)	Percentage of Fiber (ρ)
Wall A	2	93.0 x 72.0	0.0 %
Wall B	2	93.0 x 72.0	1.0 %
Wall C	2	93.0 x 72.0	2.0 %
Wall D	2	93.0 x 72.0	3.0 %
Wall E	2	93.0 x 72.0	4.0 %

ρ = (Weight of Fiber / Weight of Cement) x 100

Materials

Hand molded perforated (hollow) burnt bricks of average dimensions of 22.5 x 10.5 x 6.0 cm and dry density of 1.37 gm/cm^3 are used. The brick units are tested for the water absorption, the compressive strength and the stress-strain behaviour where the value of Young's modulus is measured. Six specimens are examined in each test. The values of vertical strains are measured using the 200mm Demec gauge. The American Standards for Testing materials, ASTM-C67 [7] are followed. An average value of the compressive strength of 66.9 kg/cm^2 is obtained for the considered bricks while, the water absorption of such bricks is found to be 10.1 %. The bricks exhibited a secant Young's modulus at 25 % of its ultimate strength of 4900 kg/cm^2. The bricks have been kept in water for 20 minutes before casting, to allow for the partial saturation of bricks, which leads to better bonding between the bricks and the mortar bed joints [8&9]. The stress strain relationship of bricks is shown in Fig. 2 while their properties are summarized in Table 2.

Table 2. Properties of the Used Burnt Bricks

Dry Density (g/cm^3)			Water Absorption (%)			C. Strength (Kg/cm^2)			Young's Modulus (Kg/cm^2)
M.V.	S.D.	C.O.V.	M.V.	S.D.	C.O.V.	M.V.	S.D.	C.O.V.	
1.37	0.021	1.51 %	10.1	0.27	2.69 %	66.9	4.57	6.83 %	4900

The cement-lime-sand mortar with mix proportions 1:1:6 is used in the construction of walls. The same ordinary Portland cement is used along with the same lime and the same well-graded fine sand and potable water. In four groups of walls, the same 1:1:6 mortar is provided with four various amounts of fiber while, the walls in the fifth group are constructed out of plain 1:1:6 mortar. As described above, the fiber is added to mortar as a percentage ratio of the cement content in the mix. The considered percentage ratios are 0%, 1%, 2%, 3% and 4%. Alkali resistance chopped stand fiber produced from 100% fiberglass coated is used (The commercial label is CF-140). This type of fibers has 12.0-mm length, 17.0-micron diameter and surface area of about 225.0 m^2/ kg. The used mortars have been mixed manually and the water-cement ratio of 1.3 is kept constant for all mixes in all specimens. The 28-days compressive strength of mortar is determined for the 10x10 cm cubes while the 15x30 cm cylinders are used for the stress-strain behaviour and the measurements of the values of Young's modulus. Six specimens are examined for each mix and each test.

The standard compressometer is used for the measurements of the vertical deformations. The stress strain relationships of mortar with various fiber ratios are shown in Fig. 2 while their properties are summarized in Table 3. All mortar joints in all walls had the same thickness of 1.0 cm. All wall specimens are kept under damp jute bags for 28 days for curing. Before Testing, the walls were also kept under damp sacks for three days.

Table 3. Properties of Various Mortars with Various Fiber Ratios

Mix No.	% of Fiber (ρ)	C. Strength (Kg/cm^2)			T. Strength (Kg/cm^2)			Young's Modulus (Kg/cm^2)
		M.V.	S.D.	C.O.V.	M.V.	S.D.	C.O.V.	
Mix. No. A	0.0 %	75.5	1.52	2.01 %	9.55	0.164	1.72 %	41643
Mix. No. B	1.0 %	72.1	1.43	1.98 %	10.54	0.169	1.60 %	39767
Mix. No. C	2.0 %	68.8	1.46	2.12 %	11.36	0.172	1.51 %	37947
Mix. No. D	3.0 %	64.5	1.59	2.47 %	11.53	0.176	1.53 %	35574
Mix. No. E	4.0 %	62.1	1.61	2.59 %	10.04	0.183	1.82 %	34244

* M.V.=Mean Value, S.D.=Standard Deviation, and C.O.V.=Coefficient of Variation.

Test Procedure

All walls were tested in a loading frame under concentrated compressive loading. A concentrated load from a hydraulic jack was transferred through the upper loading plate of 15.0-cm length to the wall. A wooden plate of 10.5-cm width and 15.0 cm length is used to transfer the load from the loading plate to the wall. The configurations of the loading system and the complete experimental set-up are shown in Plate 1. Two sets of Demec points were fixed in the body of the wall to allow for the measurements of both vertical and lateral strains using the 200-mm Demec gauge. The positions of these Demec points are shown schematically in Fig. 1. At the beginning of loading, small fractions of the expected failure loads of various specimens were applied slowly and then removed in order to exercise the strain instrument. Load is then applied in small increments and all the strain readings are recorded at the end of each load increment. The initiation and propagation of cracks were marked and the mode of failure was noted after final collapse.

DETAILS OF THE FINITE ELEMENT STUDY

As shown in Fig. 2, the considered bricks exhibit, nearly, linear stress-strain relationship while the same relation is linear in some portion only for mortar with various fiber ratios, then the elasto-plastic behaviour starts. Since the entire masonry wall fails in tension before the compressive stresses in the materials reach the nonlinear portion [5], it is considered enough to predict the internal stresses in the wall using a linear-elastic analysis. In the present study, a linear-elastic finite element analysis is employed to study the stress distribution within the body of masonry walls with various fiber ratios in mortar. Both bricks and mortar joints are modeled separately. The four-nodded plane-stress isoparametric quadrilateral element is used in modeling the body of the wall. Utilizing the symmetry of wall, about the vertical axis, only one half of the wall has been considered for analysis. Due to the complicated geometric arrangement of brick units and mortar joints and the relatively high modular ratios between brick and mortar, sudden changes in stresses, from one zone to another one in the wall, were expected. Hence, a relatively fine mesh was used. The configurations of the used mesh are shown in Fig. 3. The analysis has been carried out on a number of walls with various percentages of fiber and consequently with different modular ratios between bricks and mortar. All walls have been subjected to a unit value of compressive stresses in the region of the applied concentrated load (1.0 kg/cm^2 arranged along a central distance of 15.0 cm). The stress distributions in the bodies of various walls have been presented with reference to different sections in the wall. The locations of these sections are shown schematically in Fig. 3. The material properties of brick and mortar with various fiber ratios, obtained experimentally, are used in the analysis. The value of Poisson's ratio of bricks is assumed to be 0.1 while the value of 0.20 is assigned to mortar with various fiber ratios. The thickness of both bed and head joints is kept constant at 1.0 cm for all walls.

RESULTS, DISCUSSIONS, AND MAJOR OBSERVATIONS

Effect of Fiber on the Behaviour of Mortar

As shown in Table 3, the addition of fiber enhances the tensile strength of mortar. The enhancement of the tensile strength of mortar increases with an increase in the percentage of fiber in the mix. This happened for all fiber ratios less than 3%. When the percentage of fiber is increased to be 4 % of the cement content, the tensile strength has reduced. On the other hand, The experimental results show that masonry mortars with various fiber ratios had lower values of both compressive strength and Young's modulus than the values of plain mortar. The reduction in the values of both compressive strength and Young's modulus increases with the increase in the percentage of fiber. Although the slight reduction in the compressive strength may be considered as a defect for using such fibers, the fiber still have the two very important advantages of the higher values of tensile strength and the lower modular ratio between the fiber mortar and bricks. The two advantages help very much in increasing the load carrying capacity of the wall. The variations of both the tensile and the compressive strengths of mortar with the percentage of fiber are shown in Figs. 4 & 5.

Cracking Patterns, Cracking Loads, and Ultimate Loads of Various Walls

Table 4 summarizes the final experimental results of various wall groups while; the typical mode of failure of various wall groups is shown in Plate 2. Each of the reported values, of the cracking and ultimate loads, is calculated as the mean value of two specimens. As shown in Table 4, the fiber reinforced mortar joints increase both the cracking and ultimate loads of the wall. In more details, the wall with plain mortar in joints developed vertical cracks at a load of 10.29 ton. The same wall failed by the propagation of vertical cracks at a load of 12.28 ton. When the wall is provided with fiber reinforced mortar joints with fiber ratio, (ρ), 1 % (group B), the wall developed vertical cracks at a load of 11.43 ton while it failed by the propagation of those cracks at a load of 14.00 ton. Comparing between the two cases of walls A & B, one can find that the introduction of 1% fiber to the mortar in joints increased the cracking load to 111.08 % of that of the same wall without fiber. On the other hand, the ultimate load is enhanced to be 114.01 % of the value of the wall with plain mortar. Again, when the percentage of fiber is increased to 2% of the cement content (group C), both the cracking and ultimate loads of the wall are increased to be 124.98 % and 130.29% of the values of the wall with plain mortar in joints. A further increase in the percentage of fiber to be 3% (group D) has increased the cracking and ultimate loads of the wall to 13.14 ton and 16.57 ton, respectively. Those values are equivalent to 127.7 % and 134.93 % of the cracking and ultimate loads of the wall without fiber in mortar. The increase in the percentage of fiber to 4%, (group E), increased both the cracking and ultimate loads of the wall to 116.62 % and 123.29 % of the values of the wall with plain mortar. However, the wall, in this case, had lower values of both cracking and ultimate loads than the values of the previous case with 3 % fiber (group D). This is may be attributed mainly to the reduction in the tensile strength of mortar in the case of 4% fiber. The variations of both cracking and ultimate loads of various walls with various fiber ratios are plotted in Fig. 6. Referring to Table 4 it is noticed that, for all walls, the introduction of fiber to the mortar in joints reduces the percentage ratio between the cracking and ultimate loads of the same group of walls. Moreover, this reduction increases with the increase in the percentage of fiber. This is may be understood as an increase in the ductility of the wall, which is slightly enhanced with the increase in the percentage of fiber in the mortar joints. It is also noticed that, for all walls, the wall had local crushing failure in the brick under load.

Table 4. Experimental Test Results of Various Wall Groups

Wall Group	% of Fiber (ρ)	P_{CR} (ton)	$P_{CR} / P_{CR(A)}$ %	P_U (ton)	P_{CR} / P_U %	$P_U / P_{U(A)}$ %
Wall A	0.0 %	10.29	100.00	12.28	83.79	100.00
Wall B	1.0 %	11.43	111.08	14.00	81.64	114.01
Wall C	2.0 %	12.86	124.98	16.00	80.38	130.29
Wall D	3.0 %	13.14	127.70	16.57	79.30	134.93
Wall E	4.0 %	12.00	116.62	15.14	79.26	123.29

Variation of Strains of Walls with Various Fiber Ratios

Figures 7 and 8 show the variation of both lateral and vertical strains with the applied load for various wall groups. As shown in the figures, the values of both lateral and vertical strains increase with the increase in the percentage of fiber in mortar. In general, the values of both lateral and vertical strains, of a brick masonry wall, are affected by the elastic properties of both bricks and mortar. As given in Table 3 and plotted in Fig. 2, the introduction of fiber reduces the modulus of elasticity of mortar and this reduction increases with the increase in the percentage of fiber. Consequently, the increase in the values of both lateral and vertical strains is then expected. The increase in both strains of the wall with an increase in the percentage of fiber gives an indication for the enhancement in the ductility of the wall in case of fiber mortars. It is also noticed that, the relationship between both lateral and vertical strains and the applied load is almost linear for all of the examined walls.

Effect of the Fiber Ratio on the Various Stresses in Masonry Walls

Figure 9 shows contour lines for both vertical and lateral stresses of walls with plain mortar in joints under the effect of the applied concentrated load. Figure 9-a shows a contour map for the vertical stress distribution in the body of the wall. It is noticed that, the vertical stresses are concentrated mainly in the vertical mortar joints to the extent that, from this figure of contour lines, one can recognize the arrangement of brick units and mortar joints in the wall without seeing the details of these arrangements. The concentration of vertical stresses is also noticed below the applied concentrated load. The concentration of vertical stresses in vertical mortar joints stems mainly because of the relatively higher value of Young's modulus of mortar in vertical joints compared to that of bricks. With the concentration of vertical compressive stresses in the vertical joints each brick receives two concentrated (self-equilibrating) loads at the center, one acting above and the other below. This leads to a splitting tensile stress at the middle of the brick. In Fig. 9-b, the contour lines of lateral stresses in the body of the same wall are plotted. As can be seen from this figure, the lateral stresses are concentrated mainly in mortar bed joints especially at their junctions with the vertical mortar joints. The mortar in bed joints had tensile lateral stresses.

Figures 10 & 11 show the vertical stress distributions along sections A-A & B-B, which pass through the centerline of brick units and central mortar bed joint respectively. It can be noticed from the two figures that, the vertical stresses are not uniformly distributed along the length of the wall. Wherever the sections intersect a vertical mortar joint, the vertical stresses attain, suddenly, high values due to the higher modulus of mortar. It is also noticed that the percentage of fiber in mortar joints, (ρ), has a minor effect on the value of vertical stresses developed in both bricks and mortar except for the region of vertical joint. At this region the vertical stresses reduces with the increase in the percentage of fiber. This stems mainly because of the reduction in the modulus of elasticity of mortar. The reduction increases with the increase in fiber ratio. On the other hand, the vertical stresses on the rest of each of the two sections are slightly increased with an increase in the % of fiber.

The lateral stress distributions along sections A-A and B-B are shown in Figs. 12 & 13 respectively. From Fig. 12, one can notice that, the lateral stresses in bricks change from compression to tension and vice visa as one moves along the wall length. The brick experiences a small value of lateral tension in the middle while the rest of the brick is subjected to lateral compression. The lateral tension increases in the region near the line of action of the applied load. The lateral compression increases as the vertical joint is approached and reaches a high value in the joint itself. A comparison between Fig. 10 and Fig. 12 makes it clear that, the presence of a large vertical compression at the vertical joint causes a lateral (splitting) tension in the brick below the joint. For walls with fiber in mortar joints, the lateral compressive stresses in bricks reduce with an increase in the percentage of fiber, (ρ). Figure 13 shows the distribution of lateral stresses on section B-B, which passes through the mortar bed joint at the mid-height of the wall. For all walls, the lateral stresses are mainly tensile and their jump to higher values at the vertical joints is also noticed. The values of the tensile lateral stresses reduce with an increase in the fiber ratio. This may be considered as a reason for the increase in both the cracking and ultimate loads of the wall.

COCLUSIONS

Based on the present investigation, the following conclusions can be drawn:

1. The addition of fiber to masonry mortars enhances the tensile strength of mortar. The enhancement increases with the increase in the percentage of fiber so some extent. The considered mortar developed its maximum tensile strength at a fiber ratio of 3%. Beyond this ratio, the strength is again reduced.
2. The addition of fiber to masonry mortars, slightly, reduces both the compressive strength and the modulus of elasticity of the mortar. The reduction in both the strength and the modulus of elasticity increases with an increase in the percentage of fiber.
3. The addition of fiber to mortar increases the cracking load of the wall. The wall with plain mortar in joints developed a vertical crack at a load of 10.29 ton. When the mortar in joints is provided with 1% fiber, the vertical crack occurred at a load of 11.43 ton, which is about 111 % of that of the wall with plain mortar. When the percentages of fiber are increased to 2 and 3% of the cement content, the cracking loads are increased to about 125 % and 128%, respectively, of the value of the plain wall. The wall with 4% fiber developed vertical cracks at 12.0 ton, which is about 117 % only of the cracking load of the plain wall.
4. The addition of fiber to mortar increases the load carrying capacity of masonry walls made out of low strength bricks and such fiber mortars. For the examined walls, the addition of 1% fiber to mortar in joints increased the ultimate load of the wall to about 114 % of that of the wall without fiber. When the percentage of fiber is increased to 2% of the cement content, the ultimate load is, also, increased to about 130 % of that of the plain wall. A further increase in the percentage of fiber to 3 % increased the ultimate load to about 135 % of the load of the plain wall. When the fiber ratio is again increased to 4 %, the wall developed an ultimate load, which is about 123 % only of that of the plain wall.
5. The addition of fiber to mortar in joints reduces the tensile lateral stresses developed in the mortar bed joints as an effect of the high modular ratio between mortar and low strength bricks. The reduction in the developed tensile lateral stresses increases with an increase in the percentage of fiber in mortar joints.
6. The addition of fiber to masonry mortars leads to lesser values of the ratio between cracking and ultimate loads of the wall. This is understood an enhancement in the ductility of the wall. The enhancement in the ductility of the wall increases with the increase in the percentage of finer in mortar in joints.
7. The addition of fiber to mortar in joints increases the values of both lateral and vertical strains of the wall. The increase in both strains increases with an increase in the percentage of fiber in mortar joints. This is, again, one more indication for the enhancement in the ductility of the wall with fiber mortars.

REFERENCES

[1] Sahlin, S. "Structural Masonry", Prentice Hall Inc., Englewood Cliffs, New Jersey, 290 pp., 1971.

[2] Hendry, A. W., "Structural Masonry", Macmillan Education LTD., 284 pp., 1990.

[3] Matthana, M. H., and Jagadish, K. S., "Strength and Elasticity of Burnt Bricks", Proceedings of the 3rd Asia-Pacific Conference on Structural Engineering and Construction (APSEC'96), pp. 295-310, Johor Bahru, Malaysia, 17-19 June, 1996.

[4] Drysdale R. G., Hamid, A. A., and Baker, L. R., "Masonry Structures Behavior and Design", Prentice Hall Inc. A Simon & Schuster Company, Englewood Cliffs, New Jersey 07632, 784 pp., 1992.

[5] Lenczner D., "Elements of Load Bearing Brick Work", Pergamon Press. 113 pp., 1972.

[6] Matthana, M. H., "The Role of Reinforced Mortar Bed Joints In the Behaviour of Brick Walls Made out of Low Strength Bricks", Proceedings of the Fourth International Conference on Civil and Architectural Engineering, the Military Technical College, Cairo, Egypt, 14-16 May, 2002.

[7] American Society for Testing Materials, "Standard Test Method of Sampling and Testing Brick and Structural Clay Tile", ASTM-C67, ASTM, Philadelphia, 1990.

[8] Sinha, B. P., "Factors Affecting the Brick / Mortar Interface Bond Strength", International Journal of Masonry Construction, Vol. 3, No. 1, pp. 14 –18, 1983.

[9] Matthana, M. H, and Tahwia, A. M., "Effect of Suction Rate of Low Strength Bricks on the Bond Strength at the Brick/Mortar Interface", Proceedings of the Second Minia International Conference for Advanced Trends in Engineering (MICATE'2002), EL-Minia, Egypt 16-18 March, Paper No. CIE-47, 2002.

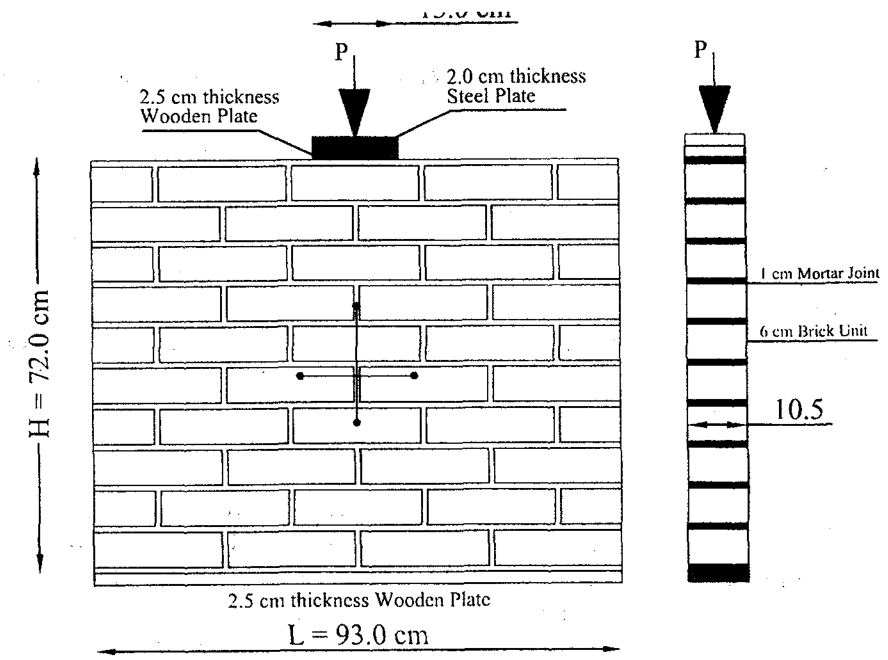


Fig. 1. Details of the Experimental Test Specimens

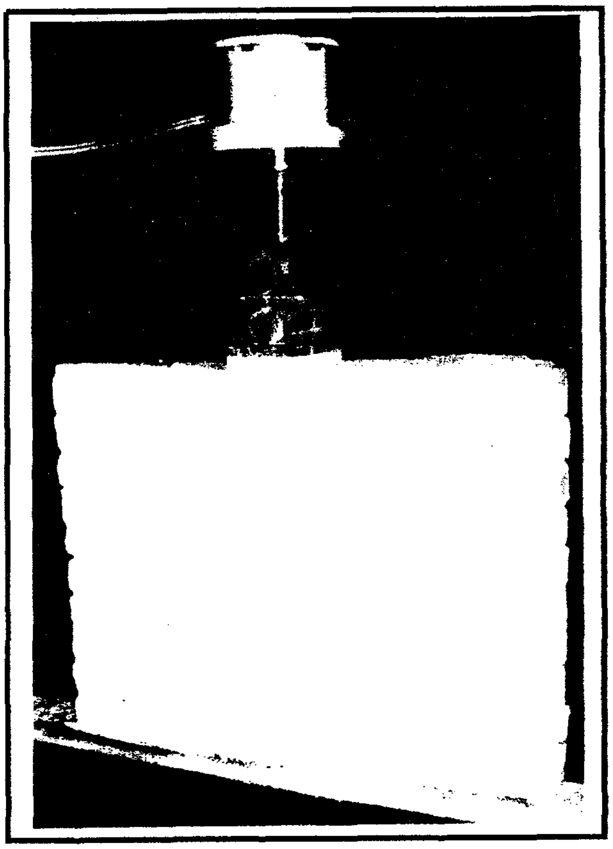


Plate 1. Experimental Test Set-Up

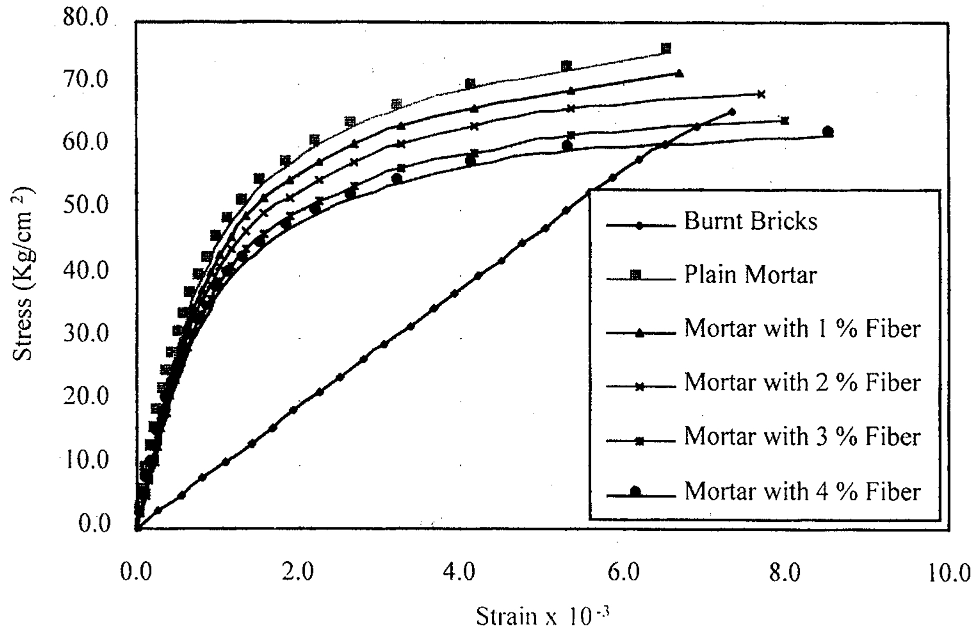


Fig. 2. Stress-Strain Relationships of Bricks and Mortar

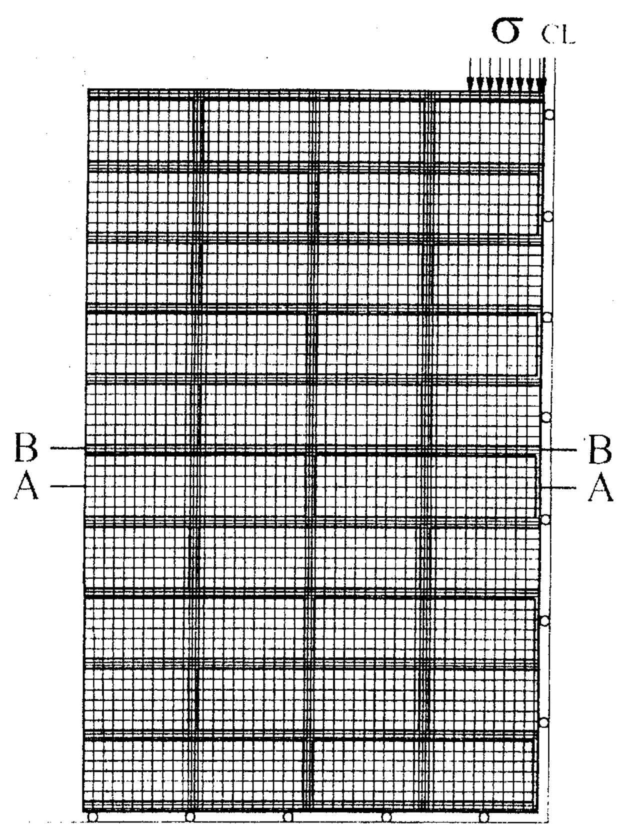


Fig. 3. Configurations of the Finite Element Mesh

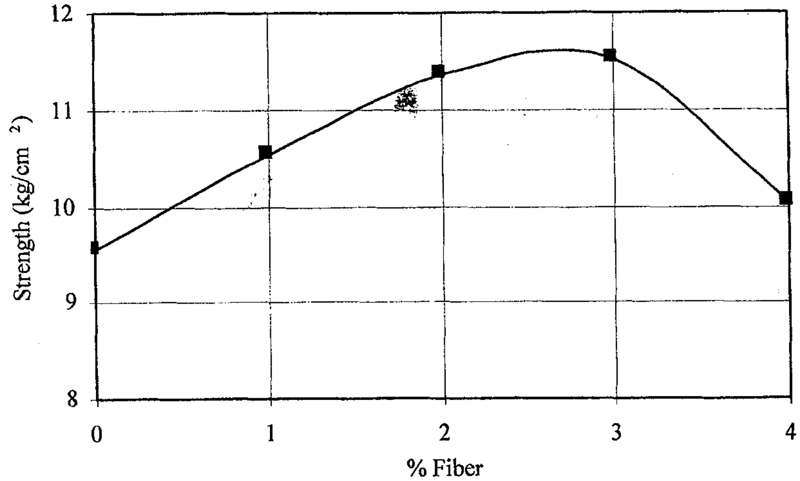


Fig. 4. Variation of the Tensile Strength of Mortar with Various % of Fiber

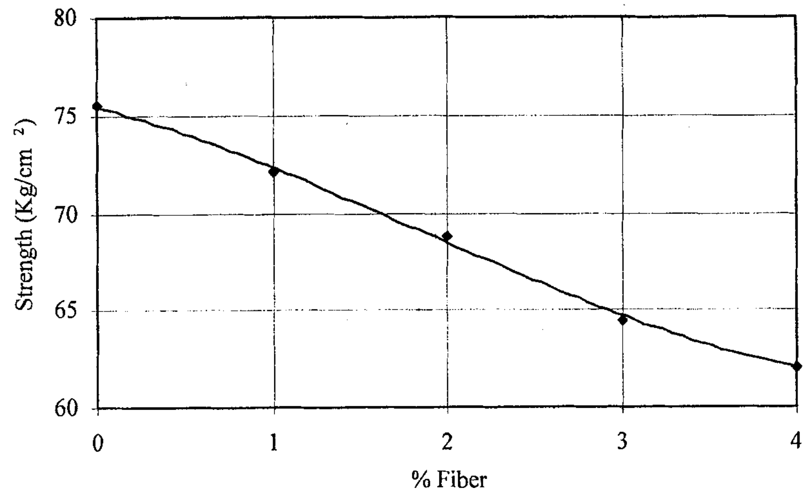


Fig. 5. Variation of the Comp. Strength of Mortar with Various % of Fiber

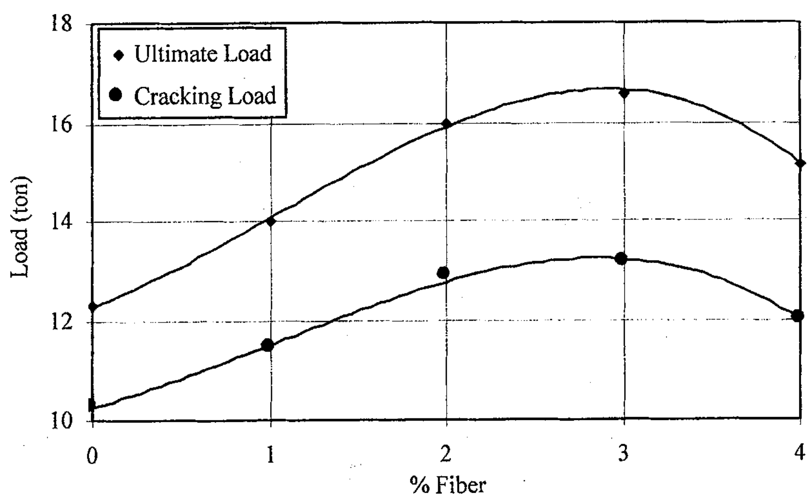
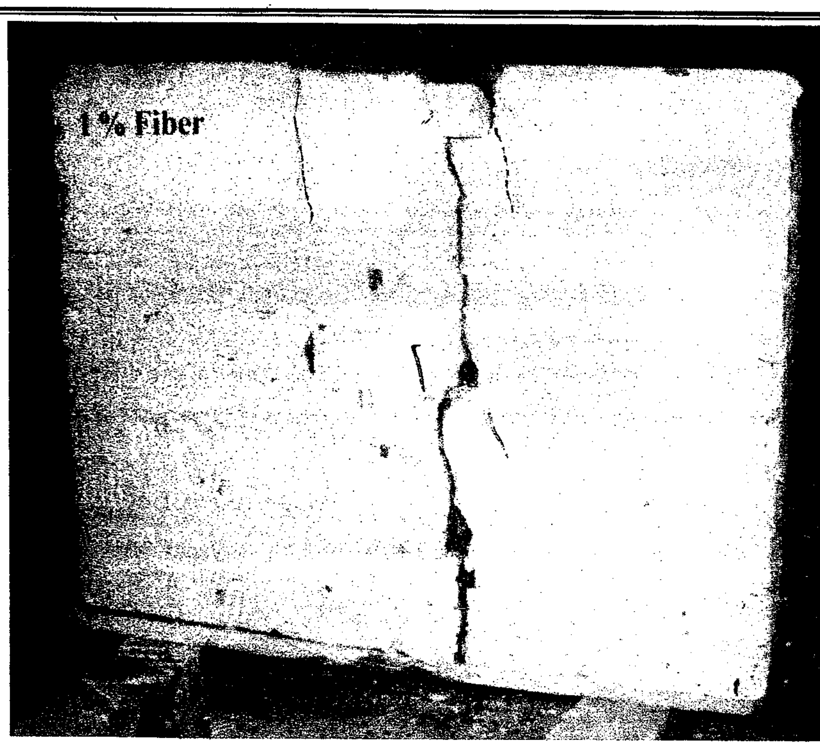
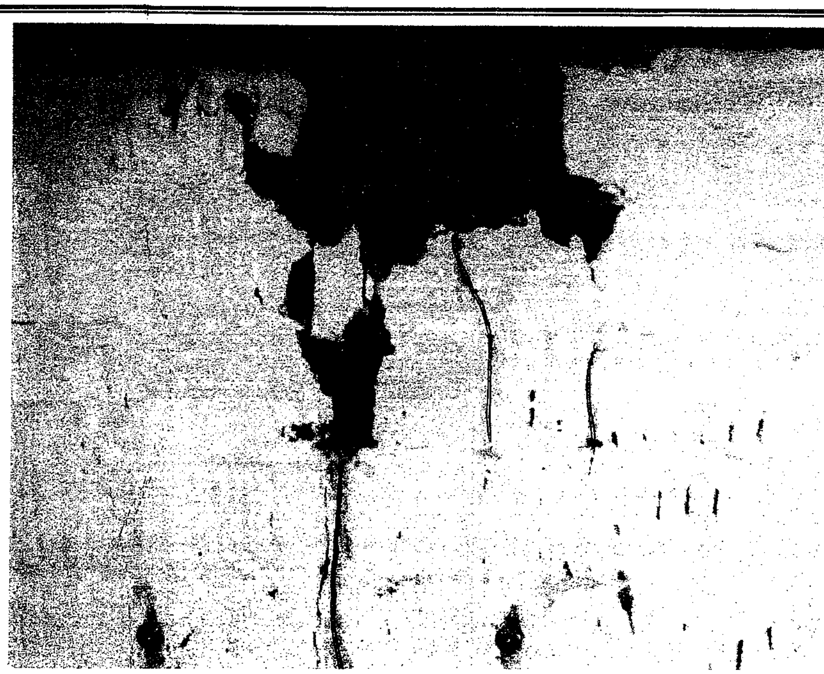


Fig. 6. Variation of Both Cracking and Ultimate Loads of Walls with Various % of Fiber



Typical Mode of Failure of Walls



Close-up View for the Cracking Pattern of Walls (Near Failure)

Plate 2; Cracking Patterns of Masonry Walls Subjected to Concentrated Load

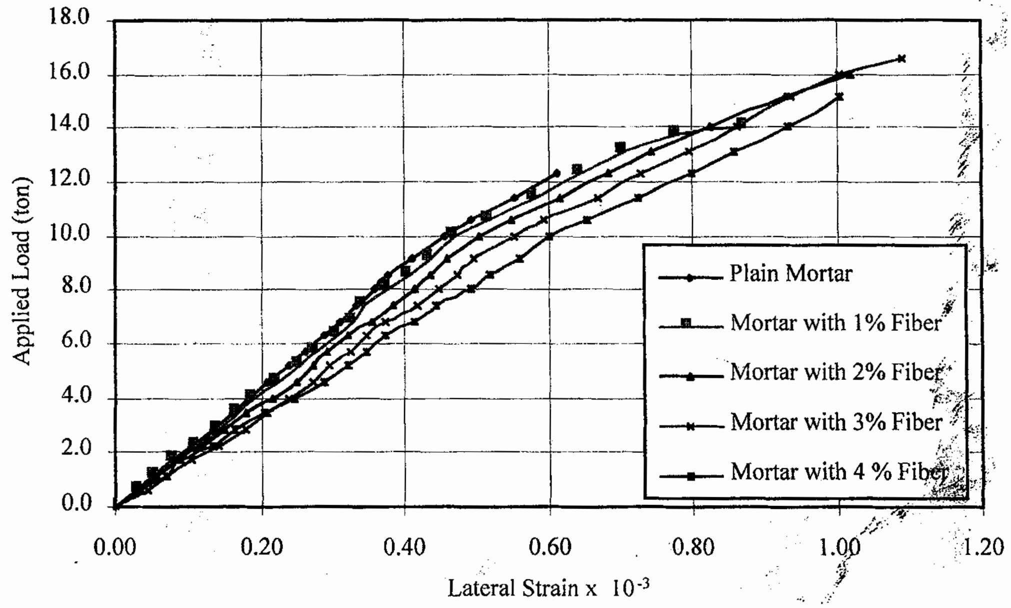


Fig. 7. Variation of Lateral Strains of Walls with Various % of Fiber

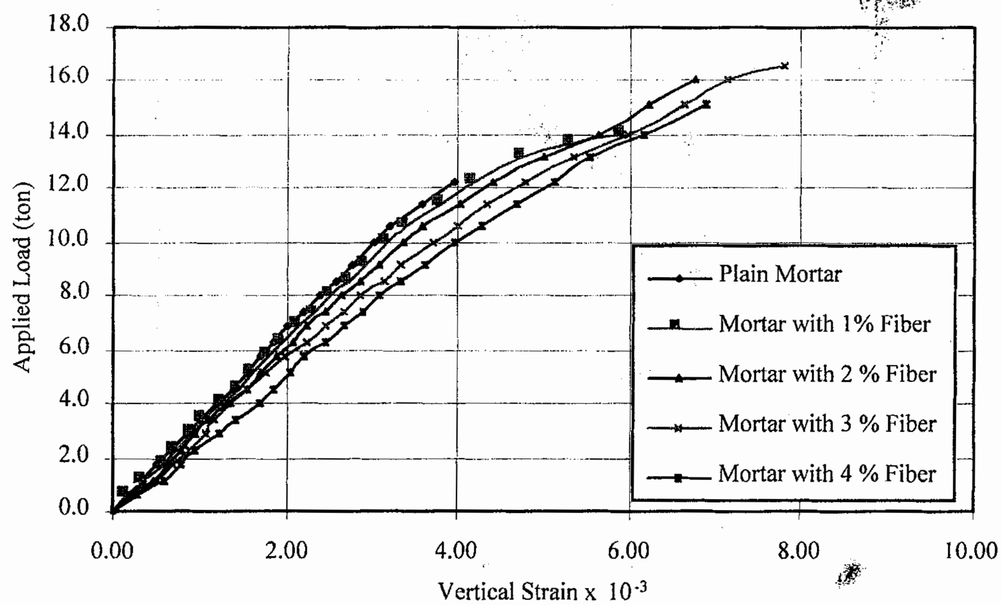
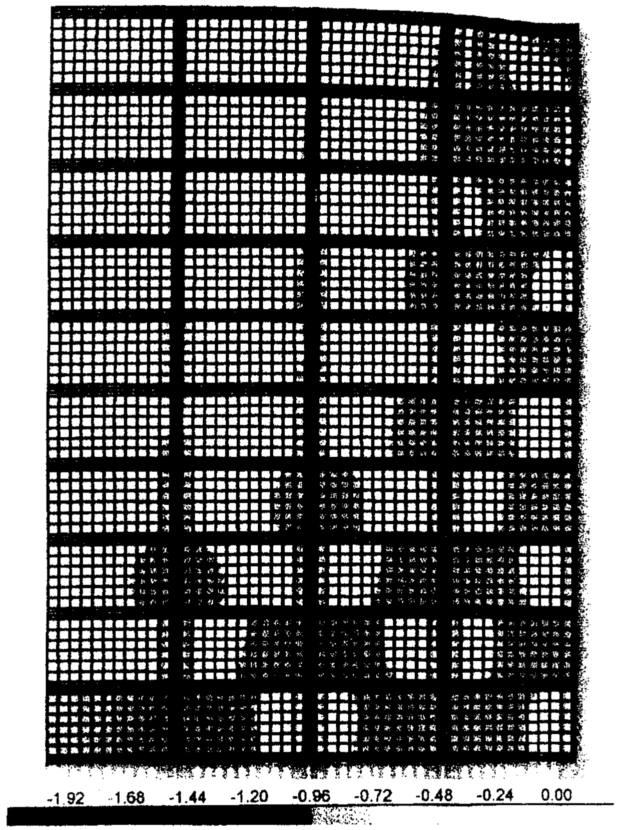
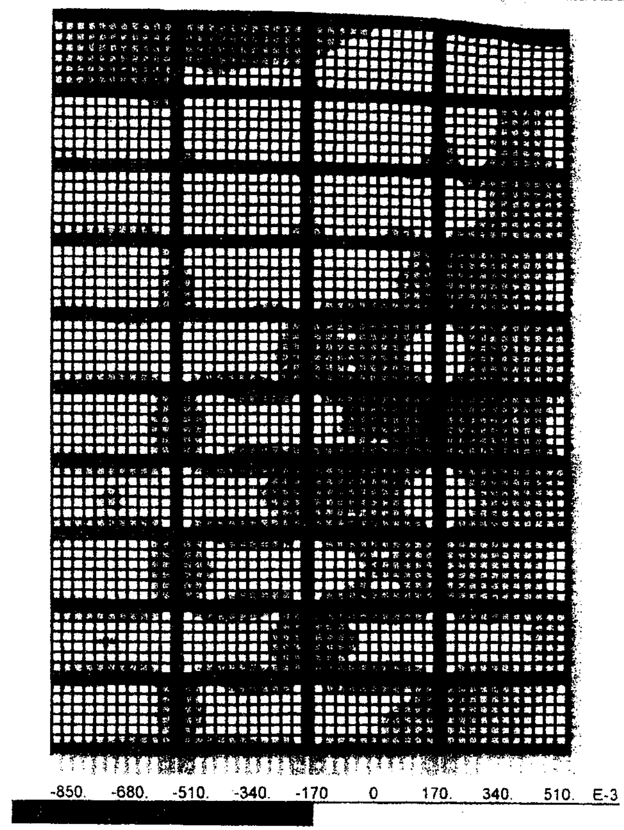


Fig. 8. Variation of Vertical Strains of Walls with Various % of Fiber



(a) Vertical Stresses in Masonry Walls with 0 % Fiber



(b) Lateral Stresses in Masonry Walls with 0 % Fiber

Fig. 9. Contour Lines for Vertical and Lateral Stresses in Masonry Walls Subjected to Concentrated Load

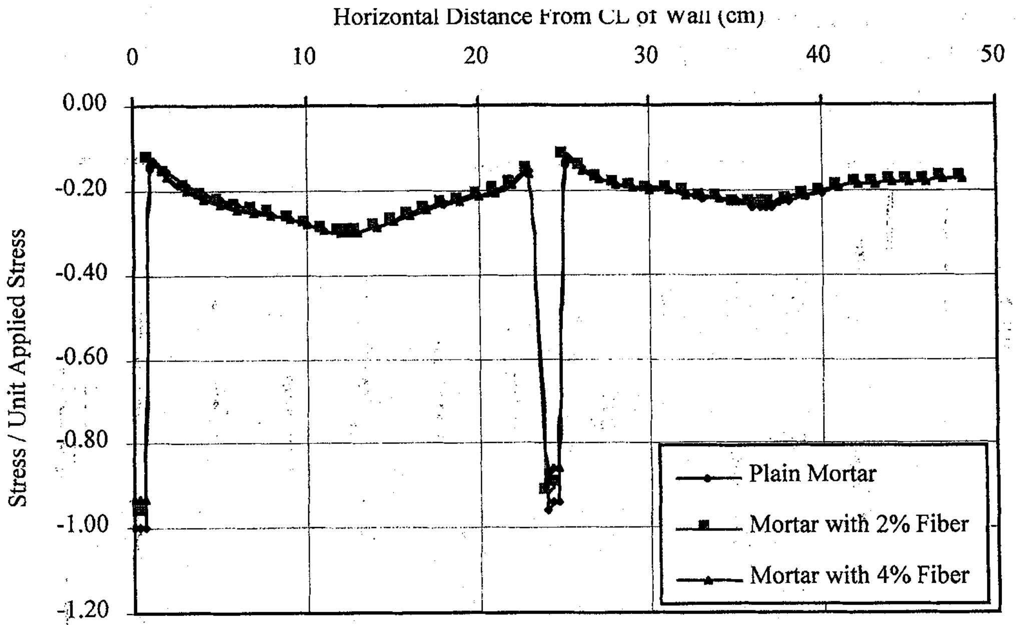


Fig. 10. Variation of Vertical Stresses in Bricks along the Walls Length (Section A-A) For Various Mortars with Various % of Fiber

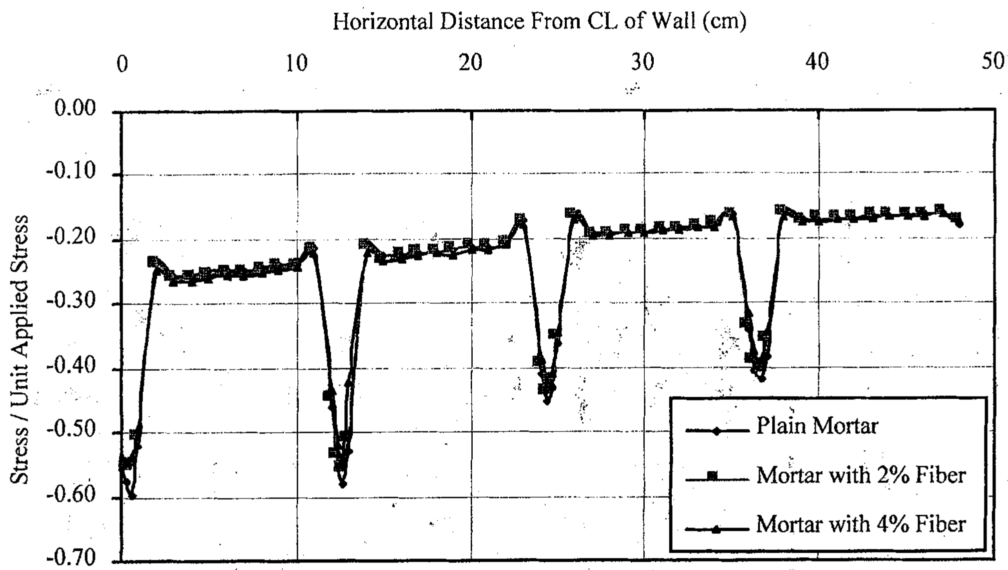
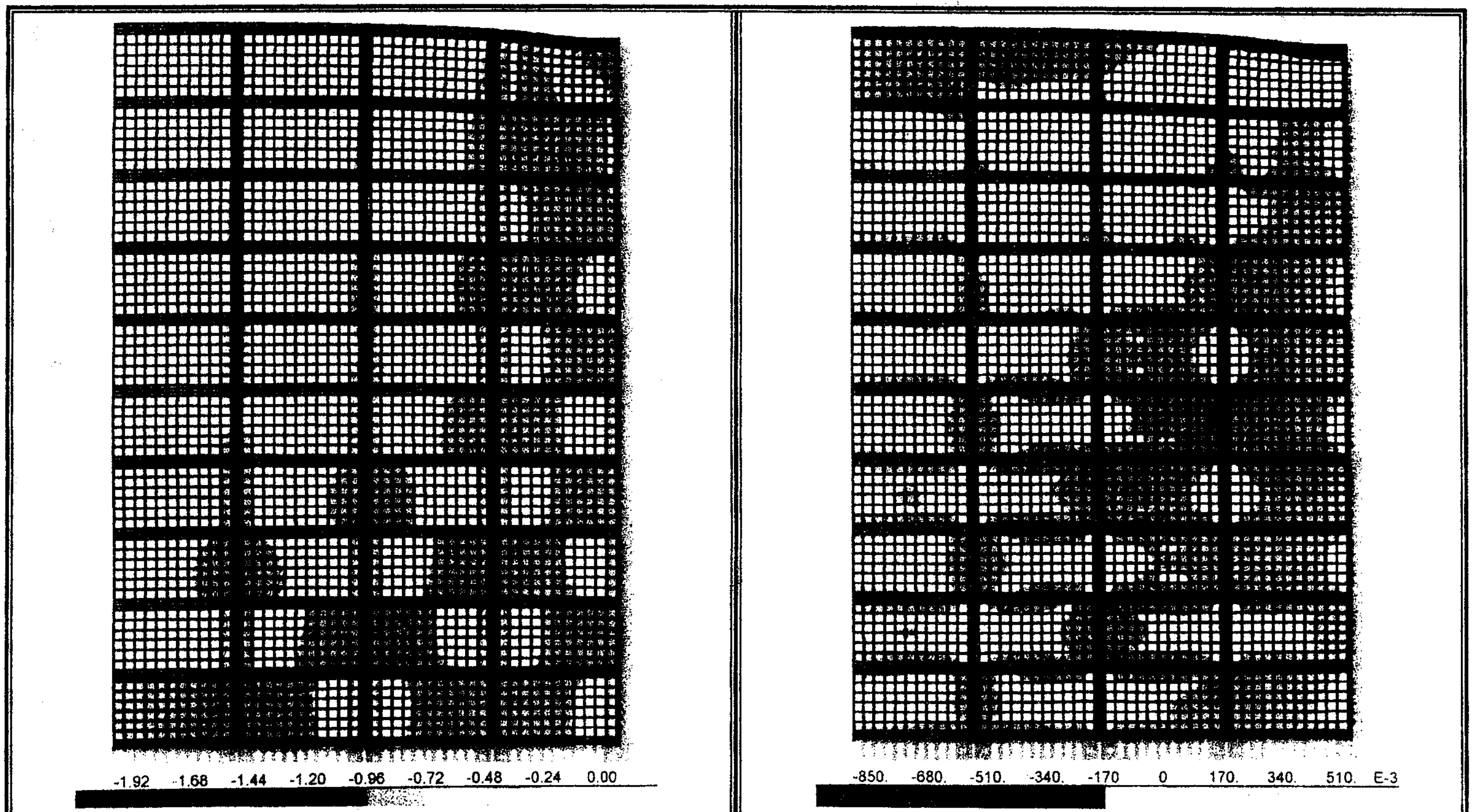


Fig. 11. Variation of Vertical Stresses in Mortar along the Walls Length (Section B-B) For Various Mortars with Various % of Fiber



(a) Vertical Stresses in Masonry Walls with 0 % Fiber

(b) Lateral Stresses in Masonry Walls with 0 % Fiber

Fig. 9. Contour Lines for Vertical and Lateral Stresses in Masonry Walls Subjected to Concentrated Load

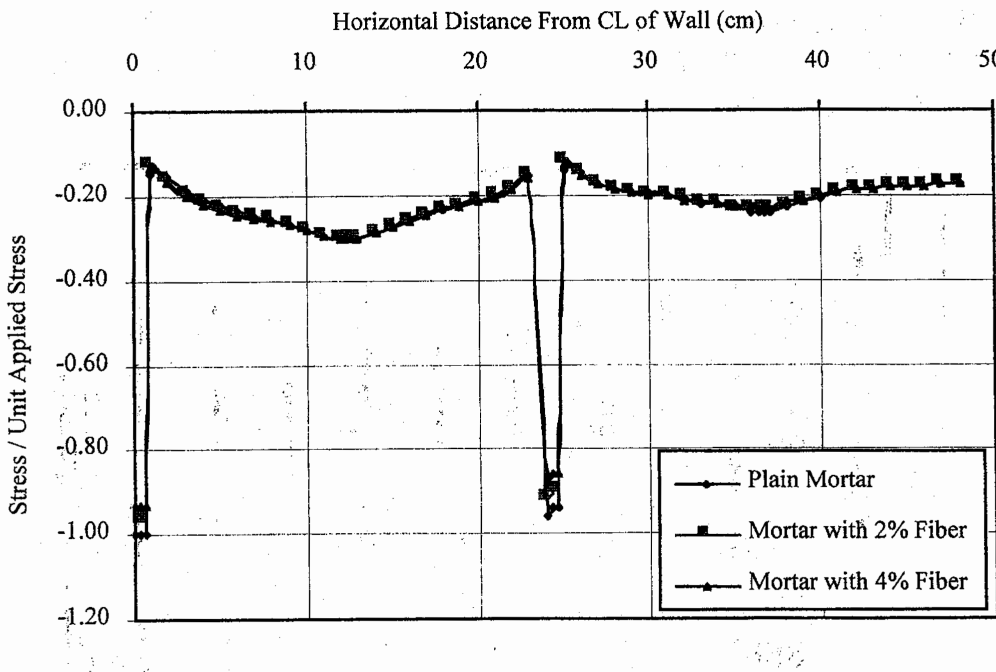


Fig. 10. Variation of Vertical Stresses in Bricks along the Walls Length (Section A-A) For Various Mortars with Various % of Fiber

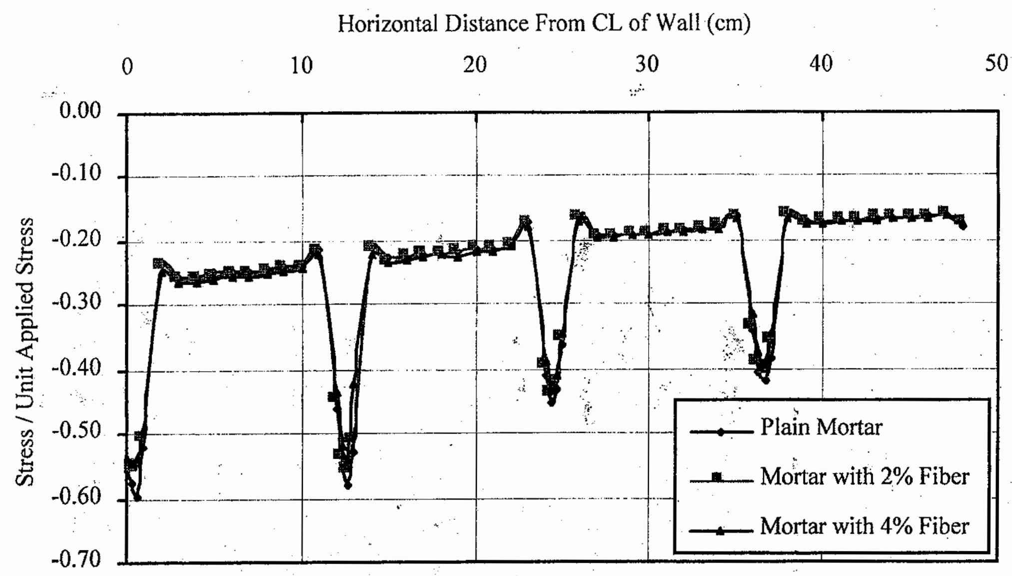


Fig. 11. Variation of Vertical Stresses in Mortar along the Walls Length (Section B-B) For Various Mortars with Various % of Fiber

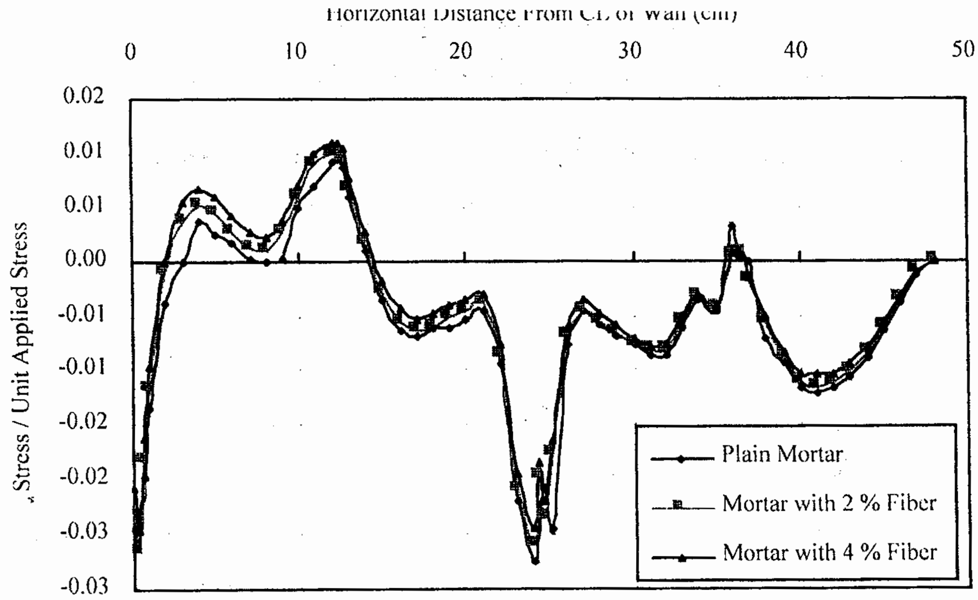


Fig. 12. Variation of Lateral Stresses in Bricks along the Walls Length (Section A-A) For Various Mortars with Various % of Fiber

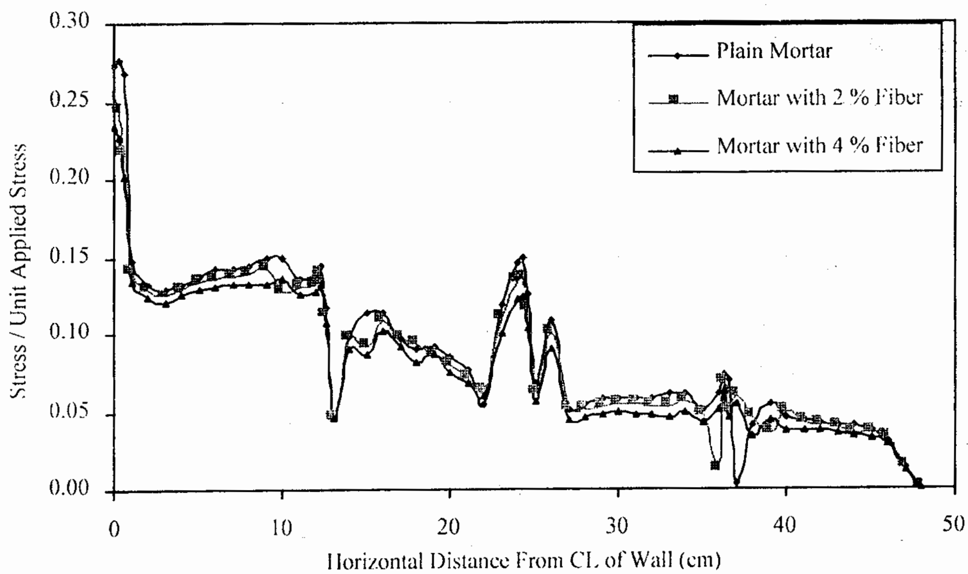


Fig. 13. Variation of Lateral Stresses in Mortar along the Walls Length (Section B-B) For Various Mortars with Various % of Fiber

تأثير المونة المسلحة بالألياف
على سلوك حوائط الطوب المبنية من طوب منخفض المقاومة

د/ محمد حافظ مطحنة　د/ أحمد محمد طهوية　أ.د./ أحمد حسنين عبد الرحيم

قسم الهندسة الإنشائية – كلية الهندسة – جامعة المنصورة

يتناول هذا البحث دراسة تأثير المونة المسلحة بالألياف الزجاجية على سلوك حوائط الطوب المبنية بالطوب منخفض المقاومة. والدراسة تشتمل على شقين أحدهما معملي و الأخر تحليلي. بالنسبة للشق العملي من الدراسة فقد تم اختبار خمس مجموعات مختلفة من الحوائط, في أربعة منها تم تزويد المونة المستخدمة في البناء بأربعة نسب مختلفة من الألياف الزجاجية بينما حوائط المجموعة الخامسة تم بناؤها باستخدام مونة عادية خالية من الألياف لتكون أساسا للمقارنة. وقد تم اختبار الحوائط تحت تأثير أحمال ضغط مركزة حيث تم قياس الانفعالات العرضية والطولية للحائط عند مراحل التحميل المختلفة وذلك عند نقط محددة تم تثبيتها على الحائط. كما تم أيضا تدوين قيم أحمال التشرخ و الأحمال القصوى لكل حائط وكذلك أشكال الانهيار للحوائط المختلفة. بعد ذلك تم عمل تحليل لجميع الحوائط باستخدام طريقة العناصر المحددة حيث أمكن الحصول على أشكال توزيعات الاجهادات المختلفة داخل الحوائط وفى كل من المونة ووحدات الطوب وذلك للحالات المختلفة من نسب خلط الألياف الزجاجية مع مونة المباني.

وقد أوضحت نتائج كل من الشقين العملي والتحليلي من الدراسة أن استخدام المونة المسلحة بالألياف الزجاجية يؤدى إلى زيادة كل من أحمال التشرخ والأحمال القصوى للحوائط وذلك بسبب زيادة مقاومة الشد لهذه المونة وانخفاض النسبة بين معاير مرونتها ومعاير مرونة الطوب المستخدم مما يؤدى إلى انخفاض اجهادات الشد الداخلية المتولدة في المونة وبالتالي فان ذلك يؤدى إلى زيادة مقاومة الحوائط. كما وجد أن استخدام المونة المقواة بالألياف يؤدى إلى زيادة التشكلات العرضية والطولية للحوائط وكذلك التحسن في ممطوليتها بينما لم يتغير الشكل النهائي للانهيار.