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Study on the effect of Compressive Strength of Brick Masonry with Admixed Mortar

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Abstract: In cement mortar, randomly distributed fiber is generally used as Reinforcement to resist propagation of cracks and to improve the ductility behavior. The generally used fibers are coir fiber, jute and mild steel fiber. In the above said material mild steel fiber gives more stability than others it is proved that mild steel added brick work has more post-cracking flexural Stress, Toughness, ductility, compared to plain mortar material. In this project an attempt has been made to study the behavior of brick masonry bonded with mild steel fiber mixed cement mortar and compared with plain cement mortar bonded brick masonry. Water proof chemical also used in cement mortar to minimize corrosion of mild steel fiber.
Keywords: Compressive strength, Brick Masonry, Cement Mortar, MS fiber, Water proof Chemical.

Introduction:

The cement mortar structures are weak in tension and strong in compression. Due to this the structure having low ductility and there are propagation of cracks. To avoid this problem generally narrow steel fibre, mild steel fibre, sugarcane baggas fibres are used in the cement mortar to reinforced it. This will improve the ductility and resist crack formation in the brickwork. However there are some disadvantages in using steel fibre as the reinforcement, it is used widely used in many areas.

The recent studies shows that the fibre reinforced brick work attain its full strength. And also it is proved that the steel fibre added brick work has more capability to withstand more load, and has more crack resistance when compared with other materials added with cement mortar.

This paper attempted to understand mechanisms of bond developed between mortar and brick and conclude that the brick- mortar bond is essentially mechanical in nature. Improve the network of hydration products with the addition of lime, but there is inadequate evidence for bond strength improvement[1]. In this research, 15 different mortars made with sets of combinations of OPC, lime, Condensed silica fume (CSF), and polypropylene fiber (PPF), were used with silt and cement bricks. The compressive strength of masonry prisms, made of one brick long, three bricks high, were studied for each mortar at the age of 28 day, 3 months and one year. The study showed that the behavior of cement brick is superior to the silt brick. Compressive strength of masonry prisms were affected by mortar strength, addition of CSF, the presence of lime and PPF. The strength of cement brick masonry prisms increased with time till the end of testing period while silt brick prism strength

deteriorated after 3 months. The used prism is recommended to be used as a mean of quality control. Wall strength is predicted from its result, and compared with code limit[2]. This paper evaluated the effect of increased bond strength on compressive strength of masonry prisms without altering the brick and mortar characteristics[3]. Brick mortar strength is poor, the prism failure is also accompanied by a failure of the brick mortar bond[4].Attempt has made to study the performance of cement mortar with mild steel fibre at various percentages. The mild steel fibre mixed mortar is used in brick masonry and the behavior is studied and experimentally investigated the increase in the compressive strength for the various percentage of steel fibre added with the various ratio of cement mortar in brickwork at various thickness of mortar between brick layer. They use 6 no of brick to make one brick prism. They made brick cube for 0.5%, 1%, 1.5% of fibre with 1:3, 1:4, 1:6, 1:8, 1:10 ratio of cement mortar for the various thickness of cement mortar between brick layer of 8mm, 10mm, 12mm, 14mm, 18mm.They have concluded that 1.25% of fibre for 12mm mortar thickness gives better result, when compared that other percentage of steel fibre and mortar mix ratios[5]. In this paper investigated the preliminary study of the influence of bond strength on compressive strength of brick masonry. The study showed that the masonry compressive strength is not reduced significantly even when the mortar strength is reduced significantly if the brick mortar bond strength is not altered[6].

Need for the Study:

- To improve the resistance to propagation of cracks in mortar structures.
- To improve the ductility behavior of cement mortar.
- To give more life period to the structure.
- To give more stability while natural disasters like earth quake.
- To avoid structural cracks frequently occurred in the structural masonry wall.

Objectives

The main objective of the present study is to determine the optimum mix percentage to be mixed to obtain maximum compressive strength, and to find the characteristic of brick masonry using cement mortar mixed with the optimum mix percentage of mild steel fibre.

Methodology

Six numbers of bricks are used to determine the compressive strength of brick prisms. Local bricks of size of 225x100x75 mm are used for the test. Bricks are arranged in three layers, each layer has two numbers of brick. Each layer of brick is bonded with the 12 mm thickness of mortar.Mild steel fibre is added with the mortar in weight basis, fibre is partially replaced for “wet mortar weight”. We did only for 12mm of mortar thickness. We made two no of samples for each tee the average value of compressive strength is taken into account we made prisms for 1:4, 1:6, 1:8 ratio of cement mortar, each cement mortar mix prepared for the various percentage steel fibre added (reference (0%), 0.5%, 1%, 1.5%, 2%) and comparatively water proof chemical is also added with cement mortar, without any fibre content, this is help us to identify whether the compressive strength is increase due to the water proof chemical alone. Brick prisms are cured using gunny bags. Compressive strength is determined at 28 days curing time. Compressive stress is determined using “Compression testing machine”

Materials and Methods

Mild steel fibres are used with regular cement mortar. The details regarding the materials and their properties are discussed.

Cement

53 Mega Pascal grade, “Portland pozzolana cement” is used for cement. We used ultratech cement for the project. The properties of cement were determined as per the IS 4031:1968 and results are given in the table.

Table 1. Properties of cement

Properties	Values
Compressive strength	53 M pa
Fineness	5%
Initial setting time	30 minutes
Final setting time	10 hour
Standard consistency	29%
Specific gravity	3.15

Fine Aggregate:

River sand was used as fine aggregate. Properties of natural aggregates. The properties should comply with the norms laid down in IS 38:1970 specifications for fine aggregates from natural sources for concrete. Aggregates should be chemically inert strong, hard, durable of limited porosity free from the properties of the fine aggregates are in table

Table 2. Properties of fine aggregates

Fine Aggregate	Value
Size	Passing through 4.75mmsieve
Fineness modulus	3.5
Specific gravity	2.6

Mild Steel Fibre:

Length and Diameter of fiber used are 40 mm and 0.91mm respectively.

Mix Proportoin

The cement mortar mix used for the experimental study was 1:4, 1:6 and 1:8. The quantity of materials required to make set of two number of brick cube are in the given Table 3.

Table 3 Mix Proportion Details

% of fiber	Sand in Kg	Cement in Kg	Fibre in Kg	Sand in Kg	Cement in Kg	Fibre in Kg	Sand in Kg	Cement in Kg	Fibre in Kg
	1:4			**1:6**			**1:8**		
0%	7.037	1.759	0	7.037	1.759	0	7.037	1.759	0
Chemical	7.037	1.759	0	7.037	1.759	0	7.037	1.759	0
0.5%	7.037	1.759	0.048	7.037	1.172	0.0439	7.037	0.879	0.0417
1%	7.037	1.759	0.096	7.037	1.172	0.0879	7.037	0.879	0.0835
1.5%	7.037	1.759	0.145	7.037	1.172	0.1319	7.037	0.879	0.1253
2%	7.037	1.759	0.193	7.037	1.172	0.1759	7.037	0.879	0.1671

Water Proof Chemical

Setcrete RMV is a brown liquid based on a selected lignosulphonate water proof chemical are used to reduce water absorption and permeability.

Preparation and Testing of Specimens

Casting of Brick Prisms

Six numbers of locally available first class bricks were used to construct masonry of size 225mm x 212mm x 324mm were constructed using cement mortar ratios 1:4, 1:6, 1:8.

The required quantity of sand and cement is calculated previously according to the required cement mortar ratio. Then they mixed properly. Then mild steel fibre is added on the basis of weight of wet cement

mortar. They mixed well, then brick cube prepared.The casted brick prisms were kept under normal atmosphere for next one day. Then it was kept under curing using gunny bags, process for a period of 28 days.The photograph of the specimens of cement mortar prisms shown in Fig 5.

Compressive Strength Test for Brick Prisms

The compressive strength test is the most common test conducted because most of the desirable characteristic properties of mortar and the structural design purpose are quantitatively related to compressive strength. The test was conducted in calibrated compression testing machine of 100 ton capacity as per the specifications given in IS-3495. The prisms were properly held in position such that the load applied gradually till the load is reached. The test specimen with flat face horizontal and mortar filled face facing upward between ply wood, and carefully centered between ply wood were tested for compression by axially applied load at the rate of 5 kN per minute till the failure. The ultimate load was noted. The photograph of the test set up for cube compressive strength in Compression testing Machine is shown in the Fig 7.

Fig. 1 Sample view of M.S Fiber

Fig 2. The water proof chemical

Fig. 3 M.S fibre added Cement Mortar

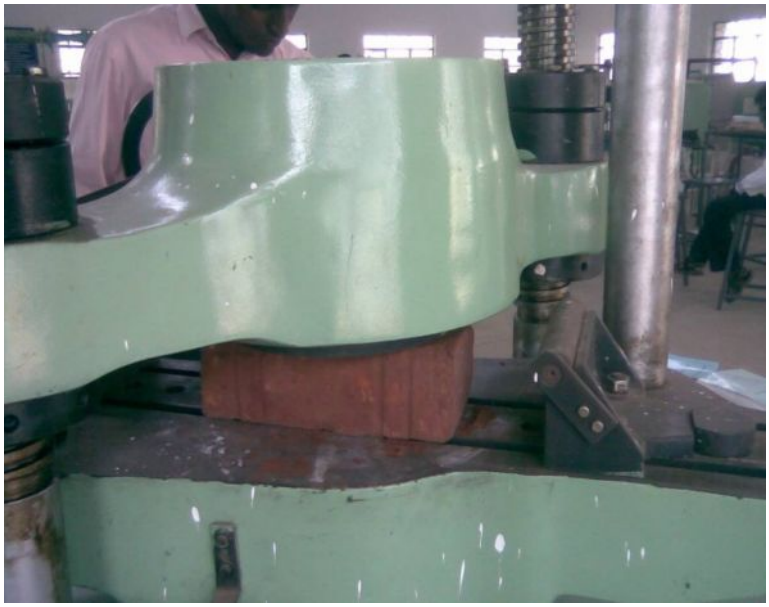

Fig 4. Photograph showing the test setup for brick compressive strength in Universrsal testing machine

Fig 5 Photograph showing the construction of brick prism

Fig 6 Photograph showing curing taken by using gunny bags

Fig 7 Photograph showing the test setup for brick prism compressive strength in compression testing machine

Results and Discussions

General

The investigation was carried out to determine the strength characteristics due to the influence of mild steel fibre mixed cement mortar in brick masonry are discussed. The preliminary investigation includes finding out of aspect ratio of mild steel fibre that can be mixed with cement mortar.

Fibre Length Determination

Aspect ratio is the ratio between length of fibre and diameter of fibre. The aspect ratio approximately fixed as 44. The diameter of mild steel fibre is measured as 0.91mm. so length is determined as 40mm (aspect ratio X diameter of fibre = 44 X 0.91) so the lengthy fibre is cut to 40 mm length by using mechanical cutter, Without no damage to the sharp end of fibre.

Compressive Strength

Bricks to be used for different works should not have compressive strength less than as mentioned in Table 4. The compressive strength testing machine is used for testing the compressive strength of bricks.

Any unevenness observed in the bed faces should be grounded first to have two smooth and parallel faces. The bricks are then immersed in water for 24 hrs at normal temperature. After 24 hrs immersion the bricks should be drained off of surplus water. The frog and other voids if any then should be filled with a mortar of ratio 1:1 with the maximum size of sand not exceeding 3 mm. and should be stored under damp jute bags for 24 hrs followed by immersion in clean water for 3 days . The bricks then should be tested only when the mortar is close to an anticipated strength of brick.

To test the specimens ,bricks are then placed with flat faces horizontal and mortar filled face facing upward between two 3-ply –plywood sheets each of 3 mm thickness and carefully centered between plates of the testing machine. Axial load is applied at a uniform rate of 14 N / mm ^{2} per minute till failure occurs. The load at failure is the maximum load at which specimen fails to produce any further increase in the indicator reading on the testing machine.

Water Absorption:

First class Bricks should not absorb water more than 20%. The bricks to be tested should be dried in an oven at a temperature of 105 to 115^o C till attains constant weight cool the bricks to room temperature and weight (W1). Immerse completely dried and weighed W1 brick in clean water for 24 hrs at a temperature of 27±20 Degree Celsius. Remove the bricks and wipe out any traces of water and weigh immediately (W2).

Water absorption in % by weight = (W2 – W1/W1) x 100

The average of five bricks should be taken. Our bricks absorb 12.114 % of water only, it has less water absorption property.

Efflorescence

Water, if finds access to brick work moves along its pores by capillary action and carries with it dissolved salts. The solution evaporates from exposed surface of the brick work; the salts are left as white deposits on the surface. These white deposits of salts are minor defect relatively. Major out of plasters and spoiling of paints and decorative treatment

Magnesium sulphate is mainly responsible for disintegrating the bricks. Calcium sulpho aluminates hydrate is formed by sulphate attack on cement and lime is also responsible for mortar disintegrations. This does not strictly fall under efflorescence but as the effect is produced due to salt (sulphates), it is also called as efflorescence

There is no perfect remedy for efflorescence, except complete isolation of the construction from water which is very difficult. Water repellent surface treatment may be used for stone as well as brick work. Electro-osmosis and latex silicon injection treatment are claimed to be the perfect method of it. Providing damp –proof –course is one of the methods of preventing rise of the water into the structure and thus preventing efflorescence

Efflorescence traced should be brushed and washed regularly

The test procedure to test the efflorescence is consisting of dipping the ends of bricks in distilled water placed in a dish. The depth of immersion in water being 2.5 cm .then this whole arrangement should be kept in a warm-well-ventilated room temperature of 20-30 ^{0} C until all evaporates. When the water in the dish is absorbed by the brick and surplus water evaporates. When the water is completely absorbed and evaporated place similar quantity of water in dish and allows it to absorb and evaporate as before. Examine the brick after this and find out the percentage of white spots to the surface area of brick.

Total area of brick = 937.5 cm^2

Area covered by white spots = 215 cm^2

Percentage of white spot in the brick = 22.93%

Table 4 Compressive strength of prisms in CM mixed with mild steel fibre

Determination of Compressive Strength of Brick Cube					
S.L no	**Percentage of steel reinforcement**	**Ratio of cement mortar**	**Compressive load in kN**	**Compressive strength in N/mm^2**	**Average Compressive stress N/mm^2**
1	0	1:4	60	1.258	1.520
2	0	1:4	85	1.782	
3	0	1:6	105	2.201	2.201
4	0	1:6	105	2.201	
5	0	1:8	105	2.201	2.201
6	0	1:8	105	2.201	
7	Chemical	1:4	95	1.992	2.306
8	Chemical	1:4	125	2.621	
9	Chemical	1:6	120	2.516	2.463
10	Chemical	1:6	115	2.411	
11	Chemical	1:8	120	2.516	2.411
12	Chemical	1:8	110	2.306	
13	0.5	1:4	115	2.411	2.358
14	0.5	1:4	110	2.306	

15	0.5	1:6	105	2.201	2.254
16	0.5	1:6	110	2.306	
17	0.5	1:8	120	2.516	2.411
18	0.5	1:8	110	2.306	
19	1	1:4	160	3.354	3.512
20	1	1:4	175	3.669	
21	1	1:6	125	2.621	2.516
22	1	1:6	115	2.411	
23	1	1:8	120	2.516	2.411
24	1	1:8	110	2.306	
25	1.5	1:4	125	2.621	2.463
26	1.5	1:4	110	2.306	
27	1.5	1:6	125	2.621	2.516
28	1.5	1:6	115	2.411	
29	1.5	1:8	105	2.201	2.201
30	1.5	1:8	105	2.201	
31	2	1:4	110	2.306	2.254
32	2	1:4	105	2.201	
33	2	1:6	115	2.411	2.463
34	2	1:6	120	2.516	
35	2	1:8	100	2.096	2.149
36	2	1:8	105	2.201	

The addition of mild steel fibre in cement mortar was found to increase the compressive strength of prisms averagely. The water proof chemical added cement mortar compressive strength found to be higher than ordinary cement mortar, for 1:4 ratio cement mortar the compressive strength increases 51.710% higher than ordinary cement mortar,11.90% for 1:6 ratio cement mortar and 9.54% for 1:8 ratio cement mortar.

When 1.0% of mild steel is mixed with cement mortar , the strength was found to be 131.05% higher than ordinary cement mortar for 1:4 ratio cement mortar,14.311% higher for 1:6 ratio cement mortar, and 9.54% for 1:8 ratio cement mortar.

When 1.5% of mild steel fibre is mixed with cement mortar, the strength was found to be 62.03% higher than reference prism for 1:4 ratio C.M, 14.31% for 1:6 ratio cement mortar and 0% for 1:8 ratio cement mortar.

The strength of ordinary plain cement mortar cube (without mild steel fibre) was found to be 1.52 N/mm^2 for 1:4 ratio cement mortar, 2.201 N/mm^2 for 1:6 ratio cement mortar, and 2.201 N/mm^2 for 1:8 ratio cement mortar.

From Table 4, the optimum percentage of mild steel fibre that has to be mixed to get maximum cube compressive was determined as 1.00%

The variation of compressive strength with respect to percentage of mild steel fibre mixed is shown graphically in from Fig. 8- 13.

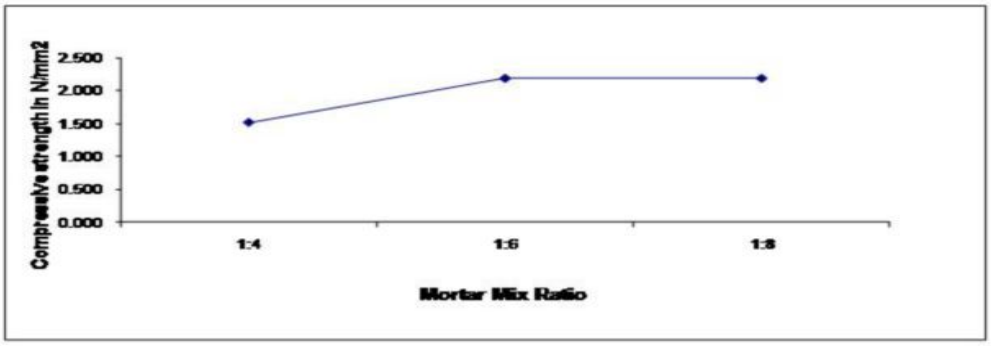

Fig 8. Graph showing Compressive strength of brick cube at 0% of M.S fibre

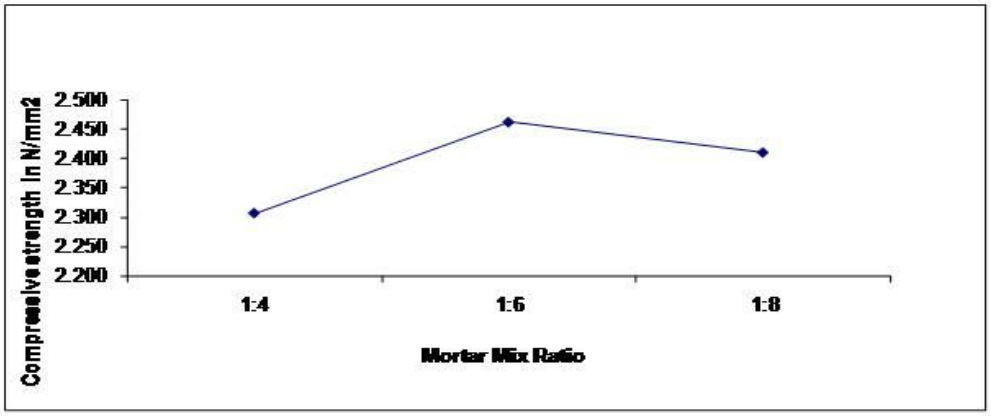

Fig 9. Graph showing Compressive strength of brick using mortar with water proof chemical

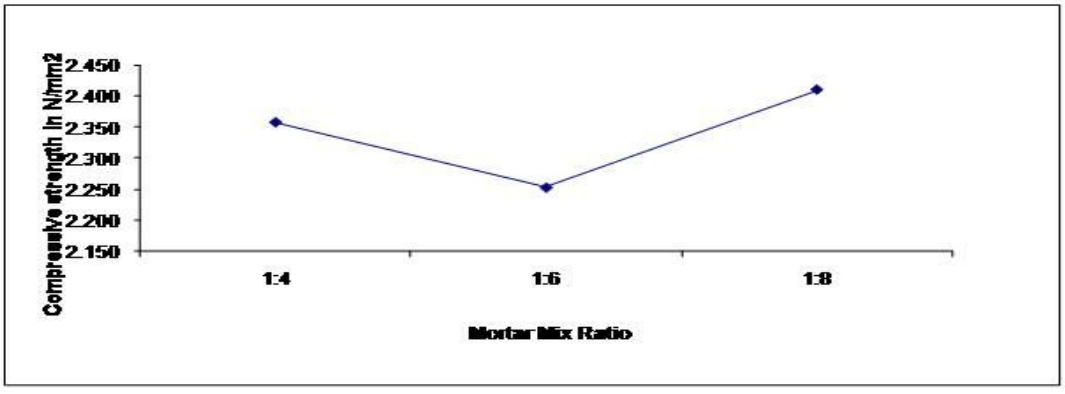

Fig 10. Graph showing Compressive strength of brick cube at 0.5% of M.S fibre

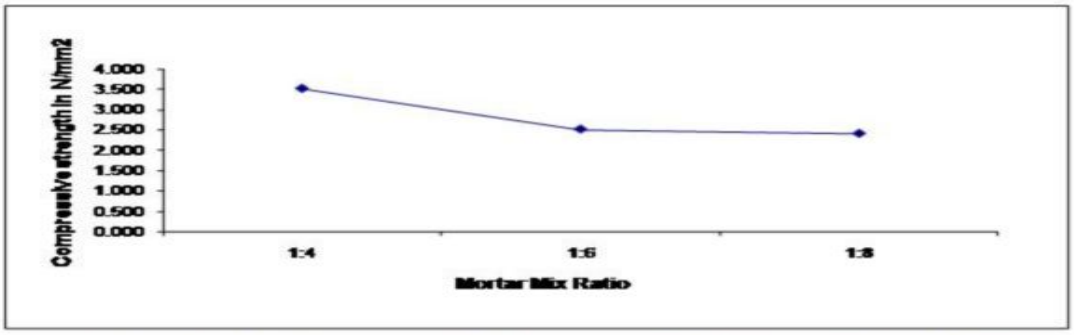

Fig 11. Graph showing Compressive strength of brick cube at 1% of M.S fibre

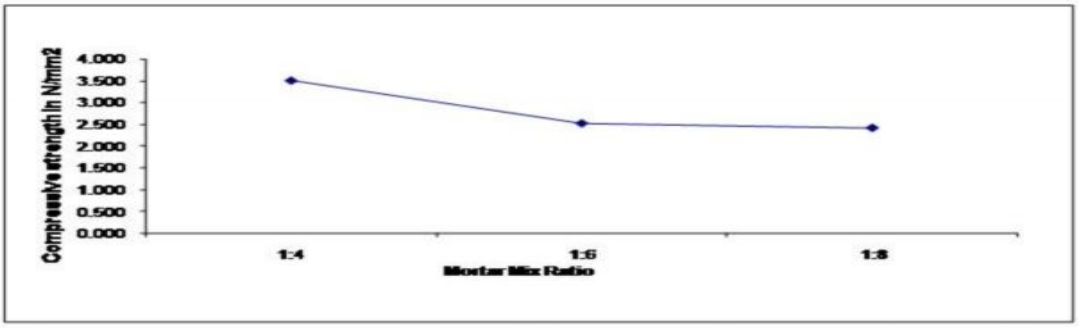

Fig 12. Graph showing Compressive strength of brick cube at 1.5% of M.S fibre

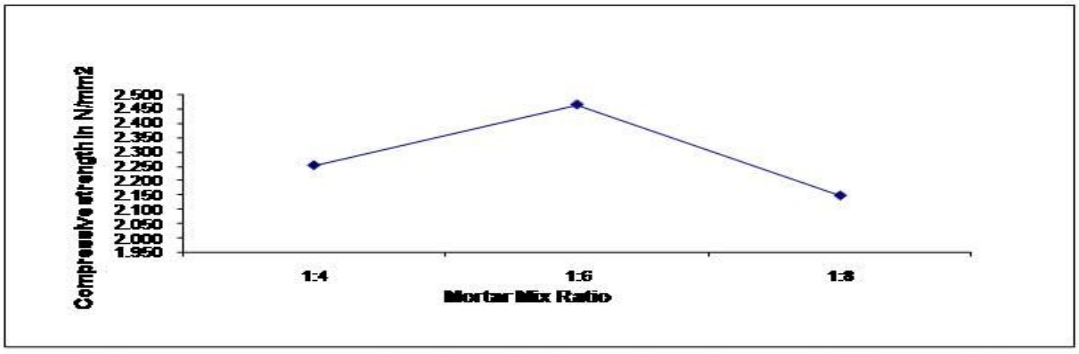

Fig 13. Graph showing Compressive strength of brick cube at 2% of M.S fibre

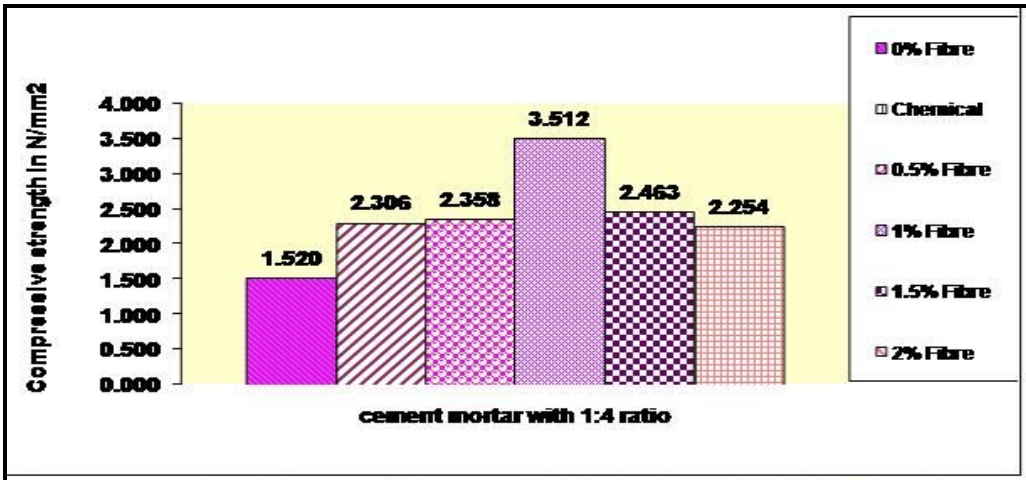

Fig 14. Graph showing the comparison statement of various percentage of fibre added with 1:4 ratio mortar

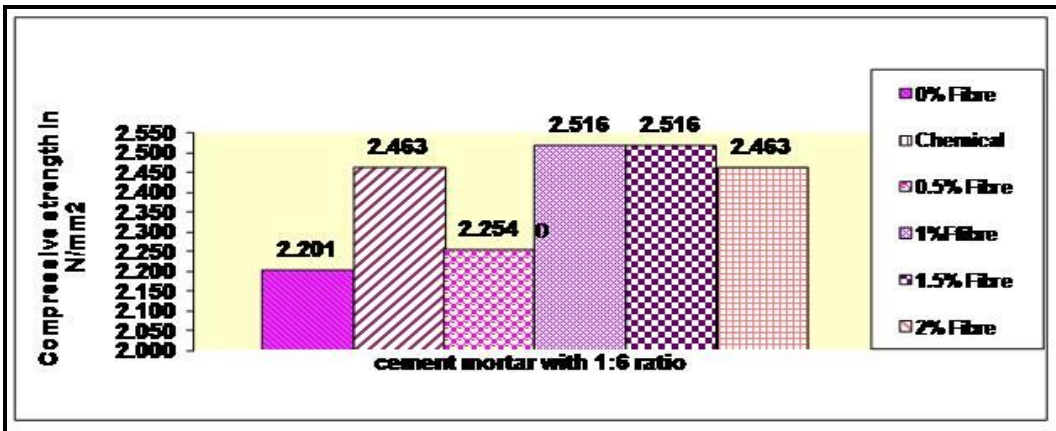

Fig 15. Graph showing the comparison statement of various percentage of fibre added with 1:6 ratio mortar

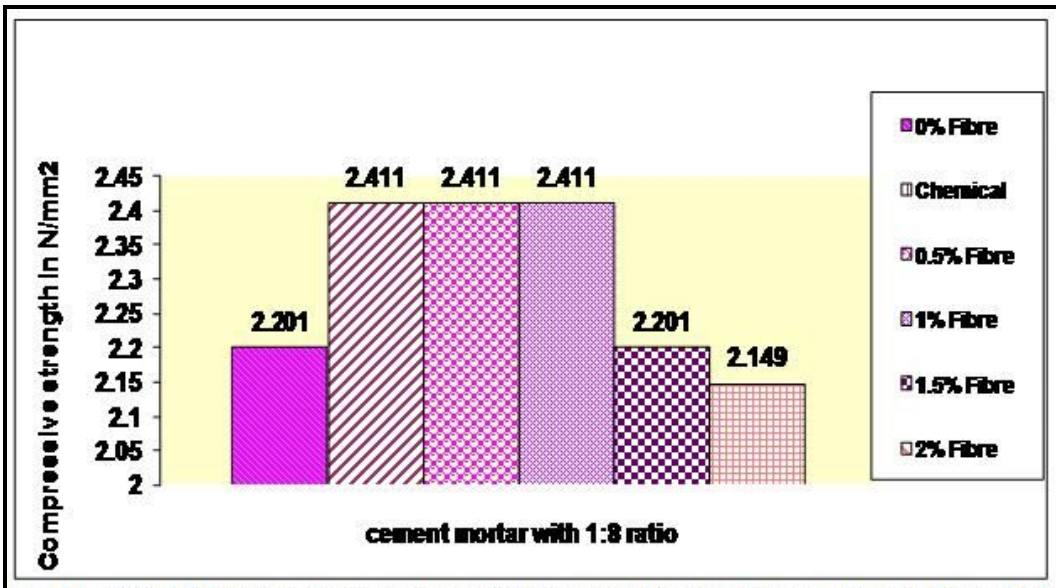

Fig 16. Graph showing the comparison statement of various percentage of fibre added with 1:8 ratio mortar

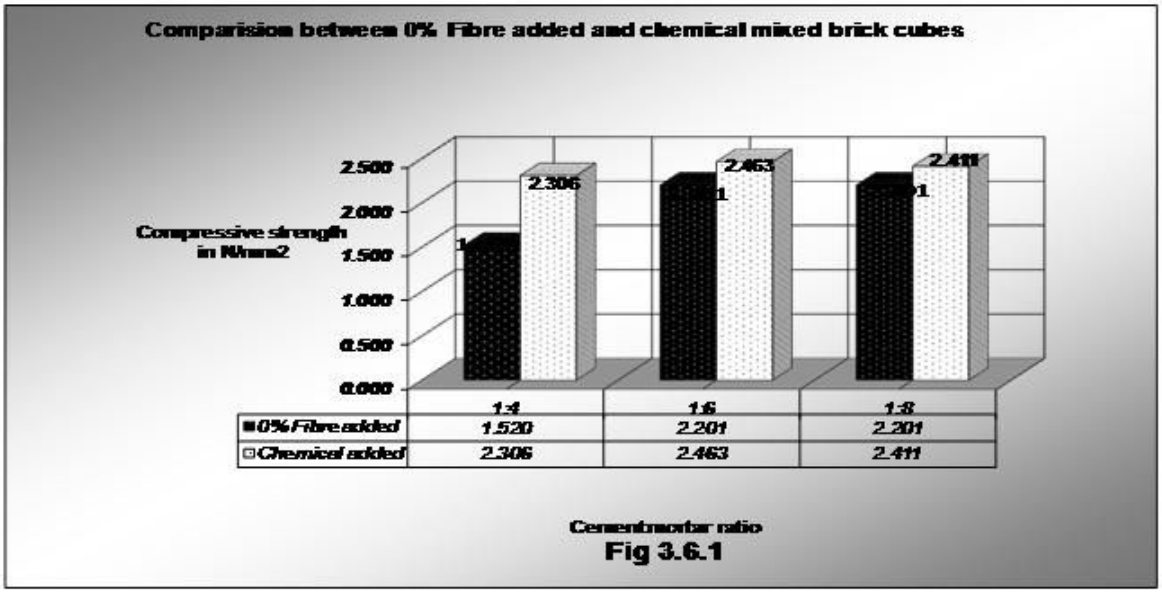

Fig 17. Graphs showing the comparative statement of plain cement mortar brick prism with, water proof chemical added brick prism

Fig 19. Crack formation in the brick prism during compression in compression testing machine

Effect of use of Mild Steel Fibre in CM

The addition of mild steel fibre in cement mortar was found to increase the compressive strength of prisms averagely. The water proof chemical added cement mortar compressive strength found to be higher than ordinary cement mortar, for 1:4 ratio cement mortar the compressive strength increases 51.710% higher than ordinary cement mortar,11.90% for 1:6 ratio cement mortar and 9.54% for 1:8 ratio cement mortar.

When 0.5% of mild steel fibre is mixed with cement mortar ,the strength was found to be 55.13% higher than reference prism for 1:4 ratio C.M, 2.407% for 1:6 ratio cement mortar and 9.54% for 1:8 ratio cement mortar.

When 1.0% of mild steel is mixed with cement mortar , the strength was found to be 131.05% higher than ordinary cement mortar for 1:4 ratio cement mortar,14.311% higher for 1:6 ratio cement mortar, and 9.54% for 1:8 ratio cement mortar.

When 1.5% of mild steel fibre is mixed with cement mortar, the strength was found to be 62.03% higher than reference prism for 1:4 ratio C.M, 14.31% for 1:6 ratio cement mortar and 0% for 1:8 ratio cement mortar.

When 2% of mild steel fibre is mixed with cement mortar, the strength was found to be 48.28% higher than reference prism for 1:4 ratio C.M, 11.903% for 1:6 ratio cement mortar and -2.362% for 1:8 ratio cement mortar. The strength of ordinary plain cement mortar cube (without mild steel fibre) was found to be 1.52 N/mm^2 for 1:4 ratio cement mortar, 2.201 N/mm^2 for 1:6 ratio cement mortar, and 2.201 N/mm^2 for 1:8 ratio cement mortar.

From Table 4, the optimum percentage of mild steel fibre that has to be mixed to get maximum compressive strength was determined as 1.00%

Effect of use of water proof chemical in cement mortar.

We used water proof chemical, to reduce the corrosion of mild steel fibre. Generally mild steel are corrosive nature when it mixed with concrete or with mortar. The water penetrate into the mortar or concrete corrosive it easily, to prevent this problem we added water proof chemical with the cement mortar in the range of 5 to 10 ml per kg of cement, this may reduce the water penetration into the mortar. And a comparative statement is provided for plain cement mortar and water proof chemical added cement mortar. Water proof chemical added mortar gives 51.71 % higher result than 1:4 ratio of plain cement mortar, and 1:6 ratio 11.903%, 1:8 ratio 9.54% higher result.

Conclusion

From the above experimental investigation, the following conclusions were arrived.

The cement mortar containing mild steel fibre found to take more loads in compression than ordinary mortar.

The addition of mild steel fibre in cement mortar was found to increase the compressive strength of prisms gradually. The water proof chemical added cement mortar compressive strength found to be higher than ordinary cement mortar, for 1:4 ratio cement mortar the compressive strength increases 51.710% higher than ordinary cement mortar,11.90% for 1:6 ratio cement mortar and 9.54% for 1:8 ratio cement mortar.

When 1.0% of mild steel is mixed with cement mortar , the strength was found to be 131.05% higher than ordinary cement mortar for 1:4 ratio cement mortar,14.311% higher for 1:6 ratio cement mortar, and 9.54% for 1:8 ratio cement mortar.

The optimum percentage of mild steel fibre that has to be mixed to get maximum cube compressive was determined as 1.00%

It is also noted from the test on brick masonry that, the cracks developed at the masonry in cement mortar with mild steel fibre is beyond the bonding layer of cement mortar, and that at the masonry in cement

mortar without mild steel fibre is through the bonding layer itself. This shows that the crack formation is arrested by mild steel fibre to an extent.

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