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Compressive Strength Studies on Masonry by Bond Strength Improvement

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Abstract

In India, masonry structures are still practiced on major scale. Causalities majorly happens in masonry structures during earthquakes in earthquake prone zones due to less bond strength and non-structured designs. The main aim of afore mentioned paper is to find solution to increase this bond strength, so that practice of masonry structures in rural area can made safe and economic with respect to strength. This study of bond strength can be carried out by analytic approach as well as experimental approach. In analytic approach, finite element method is used for the study, which requires large numbers of properties to model materials, which are not available in literature for the Indian scenario because literature focuses about results not properties. So this bond strength study is carried out by experimental approach to give it more practical and meaningful direction. In mortar, arbitrarily dispersed fibers are generally used for fortification to resist proliferation of crack and also helps to improve strength and ductility behavior which will help the structure to get less damages and to enhance the performance during earthquakes in earthquake prone zones. This will reduce the causalities. The use of recron 3s polyester fibers is economic, easy to practice and effective approach as well. This experimental studies are started by making mortar cubes and ended up with making masonry prism by using recron 3s polyester fibers with different mortar bed thicknesses. To study the bond strength an apparatus was made to carryout wrench test. The studies on brick masonry prism suggests that use of recron 3s polyester fiber in mortar can increase the bond strength to enhance the performance of the masonry structure. Use of 8 mm thick mortar bed gives more convincing results than 12 mm thick mortar bed when compressive strengths of masonry wallettes are compared.

Keywords: Bond strength; Brick masonry; Flow table test; Recron fibers; Wrench test.

Introduction

Brick work is the building of structures from singular units, which are regularly laid in and bound together by mortar; the term brick work can likewise allude to the units themselves. The basic materials of workmanship development are block, building stone, for example, marble, rock, travertine, and limestone, cast stone, solid square, glass piece, and adobe. Brick work is for the most part a profoundly tough type of development. A man who builds stone work is known as an artisan or bricklayer. An unreinforced masonry building (or UMB, URM building) is a type of construction where load bearing walls, non-load bearing walls or other configurations, such as chimneys, are made of brick, cinderblock, tiles, adobe or other masonry material that is not fixed by reinforcing material, such as rebar in a concrete or cinderblock. The term is used in earthquake engineering as a classification of certain structures for earthquake safety purposes, and is subject to minor variation from place to place. URM structures are vulnerable to collapse in an earthquake. One problem is that most mortar used to hold bricks together is not strong enough. Additionally, masonry elements may "peel" from the building, and fall onto occupants or passersby outside. There is a particular cause for concern in regions which can generate strong earthquakes, but only rarely. Failure of masonry mainly depends on the bond strength between mortar and bricks. It should be adequate enough to resist the shocks of

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earthquake to ensure the workability as a safe measure of the building or unit. So, this study is carried out to study this bond strength and to investigate if any strengthening can be done or not?. This study of bond strength can be done by analytic approach or experimental approach as well. In analytic approach, finite element method is used for the study which requires large numbers of properties of masonry to model material, which are not available in literature for the Indian scenario because literature focuses about results not properties. So this study is carried out by experimental approach to give it more practical and meaningful direction. This experimental studies were started by making mortar cube models and ended up with making masonry wall models for the study using recron 3s polyester fibres. In mortar, arbitrarily dispersed fibres are generally used as fortification to resist proliferation of crack and helps to improve strength and ductility behavior [1]. To study the bond strength an apparatus was fabricated to carryout wrench test.

Scope of study

The cement mortar structures are weak in tension and strong in compression. Due to this, the structure will have low ductility and hence more propagation of cracks. To avoid this problem generally narrow steel fiber, mild steel fiber, recron fibers are used in the cement mortar to reinforce. This will improve the ductility and resist crack formation in the brick work. Recent studies show that the recron fibre reinforced brick work attains its full strength and has more crack resistance when compared with other materials added with cement.

Mix design adopted

To find the optimum dosage of Recron 3s fiber, fiber with different percentages of cement are added in the mortar. For the study following mortar mix design is considered.

Mortar and Recron Mix:

1:6 (C: S) + 0% Recron 3s polyester fibre

1:6 (C: S) + 0.15% Recron 3s polyester fibre

1:6 (C: S) + 0.30% Recron 3s polyester fibre

1:6 (C: S) + 0.45% Recron 3s polyester fibre

1:6 (C: S) + 0.60% Recron 3s polyester fibre

Experimental tests conducted and results

Compressive strength of cement mortar

Compressive strength of cement mortar is calculated by making mortar cubes of size 50 mm (Figure 1). Optimum water content f0or cement mortar is found out by flow table test (Figure 2).

Figure 1: Flow table test for cement mortar

Figure 2: Cement mortar cubes

Cement mortar cubes with and without fibres (as mentioned above) are casted and tested under compression by digital compressive testing machine for 28 days strength and the results are tabulated (Table 1).

Table 1: Compressive strength of cement mortar cube

Specimen Size (L×B×H) mm	Trial No.	% of Fibre	Compressive Strength (MPa) (28 Days)	Avg. Compressive Strength (MPa) (28 Days)
50X50X50	1	0	10.12	10.23
	2		12.72	
	3		13.76	
	1	0.15	11.6	10.61
	2		10.04	
	3		10.2	
	1	0.30	10.96	11.84
	2		12.36	
	3		12.2	
	1	0.45	13.2	**12.8**
	2		12.68	
	3		12.52	
	1	0.60	8	8.28
	2		8.48	
	3		8.36	

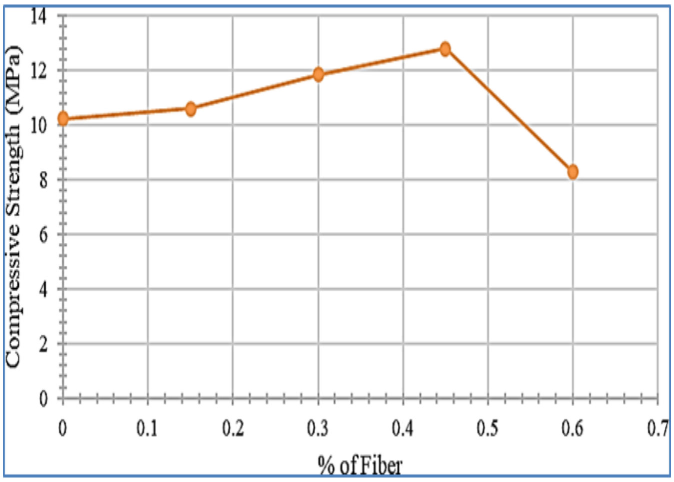

Figure 3: Variation of compressive strength of cement mortar

From the graph of variation of compressive strength of cement mortar (Table 2), it can be seen that, 0.45% of Recron 3s fiber content gives maximum compressive strength. Hence for the further study, mortar with 0.45% Recron 3s fiber is used to cast masonry prisms to evaluate compressive, shear and bond strength.

Compressive strength of masonry

Compressive strength of masonry is calculated by casting masonry wallettes and testing them under compressive load in loading frame apparatus (Figure 4). Mortar thickness of 8 mm and 12 mm are chosen as two types of specimens. Also cement mortar without addition of fibres and with addition of 0.45% fibres(which is the optimum maximum compressive strength of cement mortar cubes) masonry wallettes are tested for compressive strength and the results are tabulated (Table 2).

Figure 4: Compression test set-up for masonry wallette

Table 2: Compression strength of masonry wallette

Mortar Thickness (mm)	Specimen Number	Compressive Strength (MPa)			
		0%		0.45% Fiber	
8 mm	1	4.57	4.59	6.60	6.7
	2	4.47		6.70	
	3	4.72		6.80	
12 mm	1	6.12	6.22	8.12	8.12
	2	6.31		7.91	
	3	6.22		8.34	

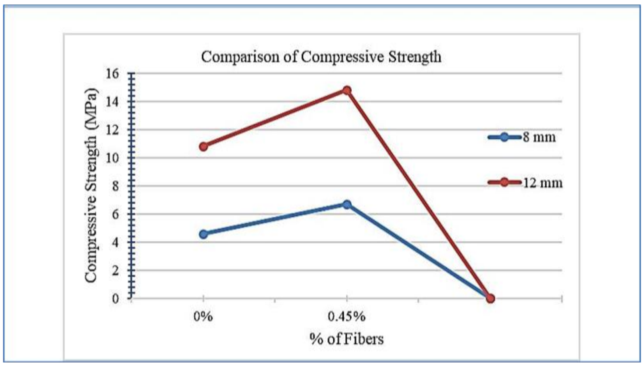

Figure 5: Compressive strength of brick for 8mm and 12mm bed mortar with 0% and 0.45% of fiber mixed

From the graph of variation of compressive strength of brick (Figure 5), it is clear that with addition of fibers, the compressive strength radically increases for 8 mm and 12 mm both the cases. With addition of 0.45% recron fiber compressive strength increases up to 45% for 8 mm thick bed and 30% for 12 mm thick bed.

Shear strength of masonry

Shear strength of masonry is calculated by making masonry triplet specimens and testing them under shear load in Universal Testing Machine and results are tabulated (Table 3).

Table 3: Shear strength values of masonry triplet specimens

Mortar thickness (mm)	Specimen No.	Shear Strength (MPa)			
		0% Fiber		0.45% Fiber	
8 mm	1	0.15	0.16	0.24	0.22
	2	0.16		0.23	
	3	0.17		0.22	
12 mm	1	0.22	0.22	0.18	0.186
	2	0.23		0.20	
	3	0.21		0.18	

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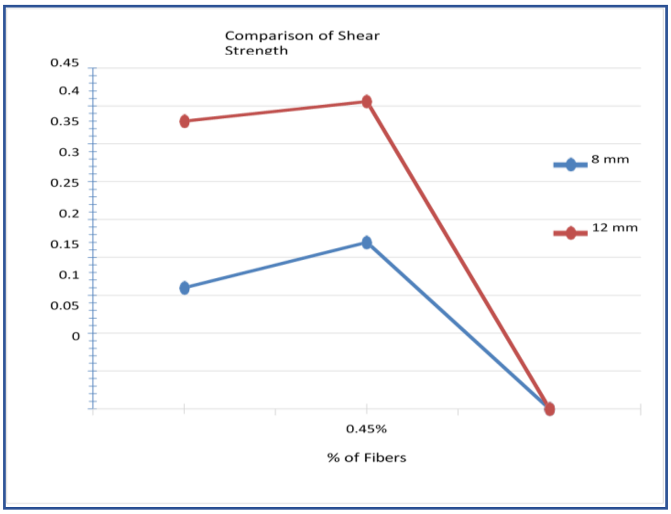

Figure 6: Shear strength of brick masonry triplet for 8mm and 12mm bed mortar with 0% and 0.45% of fiber mixed

From the graph of variation of shear strength of brick masonry triplet specimens (Figure 6), it is clear that with addition of fibers, the shear strength radically increases for 8 mm and decreases for 12 mm bed thickness. With addition of 0.45% recron fiber shear strength increases up to 37% for 8 mm thick bed and decreases up to 15% for 12 mm thick bed. The decrease in shear strength for 12 mm thickness is not much significant when compared, the benefits with respect to other improvements in the property.

Bond strength of masonry

Bond strength of masonry are tested by modified wrench test apparatus. The apparatus is fabricated in the laboratory (Figure 7). The strength values are tabulated (Table 4).

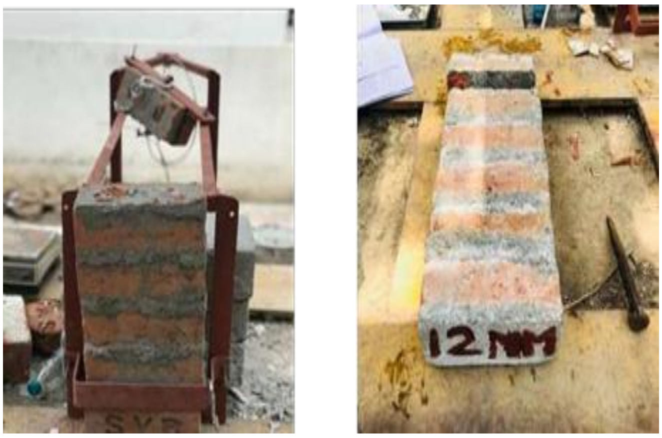

Figure 7: Bond wrench test set-up and failure of bond

Table 4: Bond strength values of masonry

Mortar Thickness (mm)	Specimen Number	Bond Strength (MPa)			
		0% Fiber		0.45% Fiber	
8 mm	1	0.047	0.049	0.101	0.102
	2	0.050		0.105	
	3	0.052		0.100	
12 mm	1	0.063	0.067	0.129	0.127
	2	0.068		0.135	
	3	0.071		0.124	

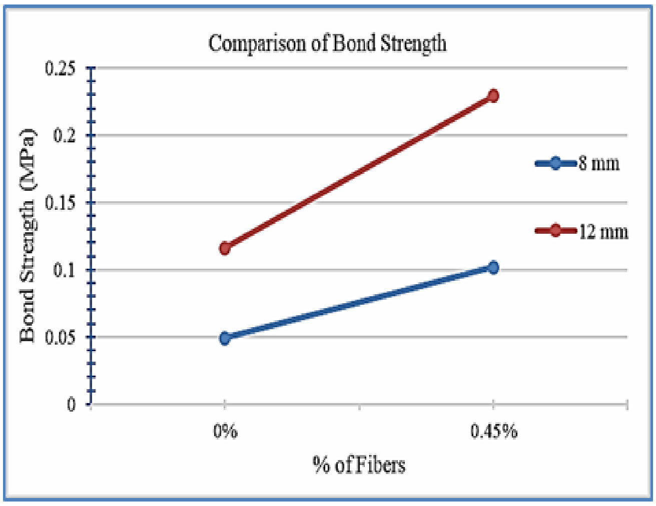

Figure 8: Bond strength of masonry for 8mm and 12mm bed mortar with 0% and 0.45% of fiber mix

From the graph of variation of bond strength of masonry with percentage of fibre mix (Figure 8), it is observed that bond strength increases with addition of 0.45% recron 3s fiber. Addition of recron 3s fiber gives favorable results in both 8 mm as well as 12 mm mortar bed thickness.

Conclusions

1. Addition of fiber, enhances the performance of the masonry.
2. Masonry mainly fails due to low bond strength, by ad ding fiber the bond strength can be improved.
3. The optimum fiber content is found out to be 0.45% by compressive strength studies on cement mortar.
4. 12 mm thick mortar bed with addition of 0.45% fiber, gives optimum compressive strength.
5. 12 mm thick mortar bed without addition of fiber and 8 mm thick mortar bed with 0.45% fiber gives optimum shear strength.
6. 12 mm thick mortar bed with addition of 0.45% fiber, gives optimum bond strength.

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