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Behaviour of Brick Masonry by using Cement Lime Mortar with Chemical Admixture

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Abstract : Cement mortar is normally used as a binding material in masonry units. Mortar is an essential material for making bond between brick units. This paper is focused on evaluation of basic properties in masonry units by applying cement lime mortar with superplasticizer and to compare with conventional mortar. Two types of bricks such as clay and fly ash bricks were used. Two types of ingredients like that cement lime mortar and mortar with superplasticizer were prepared with three mix proportions. Tensile bond strength was determined by testing brick couplets, shear bond strength was determined by testing bricks triplets and flexural strength carried out by testing stack bonded prism. When using chemical admixtures in mortar bond, strength properties are improved than conventional mortar.
Key words : cement lime mortar, superplasticizer, triplet, couplet, tensile bond strength, shear bond strength.

1.0 Introduction

Masonry is a building of structure from individual units laid in and bound together by mortar. Behavior of masonry depends on the characteristics of masonry units, mortar and bond between them. Mortar is a workable paste used in Masonry. Mortar is typically made from a mixture of sand, cement, lime and water. Masonry units are good in compression and weak in tension. Perfect bond between the masonry unit and mortar is essential for the masonry to resist the stresses due to the different type of loading conditions[1]. Bond strength depends upon Mix combinations, water cement ratio, brick surface units, etc. Triplet was used to determine shear bond strength of mortar joints. Couplet was decided to tensile bond strength of mortar joints and flexural strength was found by using stack bonded prism.To make improvement in the bond between the bricks units and reduce the water content in mortar where chemical admixtures used in mortar[2,3].

2.0 Objectives

This investigation study has been aimed at following objectives:

- To determine tensile bond strength of mortar joints with two different types of bricks and three mix combinations.
- To determine shear bond strength of mortar joints with two different types of bricks and three mix combination.
- To determine flexural strength of masonry units by using stack bonded prism.

3.0 Methodology

In order to achieve the above objectives following methodology were adopted.

- Two types of mix with various mortar ratio and two types of bricks were selected for the study to investigate the influence of different types of materials on masonry strength.
- Tensile bond strength was determined by testing brick couplets in accordance with ASTMC 952 – 76[5,6].
- Shear bond strength was determined by testing brick triplets.
- Flexural strength was determined by beam element und Uniformly Distributed Load condition.

Table 1 No of specimens

Test Name	No of Specimens	
	Clay Bricks	Fly Ash Bricks
Couplet	18	18
Triplet	18	18
Stack Bonded Prism	18	18
Total	54	54

4.0 Material Used

4.1 Bricks

4.1.1 Clay bricks

Clay bricks collected from locally available area. Size of clay brick is 280X104X70 mm.

4.1.2 Fly ash bricks

Fly ashbricks collected from nearby area. The size of flyash brick is 230X107X74mm.

4.2 Cement

43 grade of ordinary Portland cement was used. This type of grade cement commonly used in masonry work.

4.3 Sand

Locally available river sand passing through IS sieve 4.75mm was used.

4.4 Lime

Locally available lime powder was used. It is used to obtain strength and hardness for the specimen.

4.5Superplasticizer

To improve the workability of mortar superplasticizer was used.0.8% superplasticizer (PCEs) was used

5.0 Specimen Preparation

Specimen has prepared by hand mixing. Mix proportion were taken from IS specification. Three types of mix proportions are:

- Rich mix(H_1) - 1:1/4:3
- Medium mix(H_2) - 1:1/2:4.5
- Normal mix (M_1) -1:1:6

Two mix combinations were used. These are:

- Cement + lime + sand + water
- Cement +lime+ sand+ 0.8% superplasticizer + water.

Table 2 Properties of brick

Specimen	Mix proportion	Compressive strength N/mm^2 (f_{ck})	Water absorption(%)	Bulk density Kg/m^3
Conventional mortar	1:1/4:3	29.425	3.594	2188.4
	1:1/2:4.5	10.365	5.228	1616.09
	1:1:6	12.372	10.268	1890.43
Mortar with chemical admixture	1:1/4:3	36.781	2.764	2334.02
	1:1/2:4.5	22.403	5.339	2275.28
	1:1:6	22.403	4.941	2269.32

Table 3 Properties of mortar

Property	No of specimen tested	Clay brick	Fly ash brick
Size (mm)	10	228X104X70	230X107X75
Water absorption(%)	6	9.037	4.975
IRA(kg/m^2/minute)	6	0.7	0.169
Compressive(N/mm^2)	6	5.7	7.12
Bulk density(kg/m^3)	6	187.52	1709.42

6.0 Testing of Specimen

6.1 Tensile bond strength of mortar joints

In order to determine the tensile bond strength bricks couplet were tested in accordance with ASTM C 952-76[4,7]. Cross couplet were made with two types of bricks. The mortar thickness 12mm was maintained. Universal testing machine (UTM) of capacity 1000 KN was used for the testing the couplets. Couplet was placed at the center of the loading platform of the UTM. The bond strength of the couplet was calculated based on the failureload and bond area between brick and mortar.

Fig 1 Testing of brick couplets

6.2 Shear bond strength of mortar joints

Shear bond strength was determined by testing brick triplets in accordance with ASTM C 952-76. Three bricks were joined in the long face by mortar. By applying compressive force on the top of the brick shear was created on the bond area[8]. Shear strength was calculated by finding the ratio between load and area parallel to the mortar joint. Shear bond strength of specimens tabulated in table 4.

Fig 2 Cracks in triplets

Fig 3 Failure of triplets

Table 4 shear bond strength of mortar joints

Type of brick	Type of mortar	Mix propotion	Shear strength ($N/mm^{2)}$	f_{vb}/f_{ck}
Clay bricks	Conventional mortar	1:1/4:3	2.9619	0.1006
		1:1/2:4.5	3.4285	0.3307
		1:1:6	1.8571	0.1501
	Mortar with chemical admixture	1:1/4:3	3.5619	0.0968
		1:1/2:4.5	3.8190	0.1423
		1:1:6	2.6381	0.1177
Fly ash bricks	Conventional mortar	1:1/4:3	3.3809	0.1148
		1:1/2:4.5	2.0952	0.2021
		1:1:6	1.7619	0.1424
	Mortar with chemical admixture	1:1/4:3	3.410	0.0927
		1:1/2:4.5	3.1619	0.1411
		1:1:6	2.4667	0.1100

- From the test an approximate relation were arrived for each type of mix between tensile bond strength of masonry specimen and compressive strength of mortar.they were

For H_1 grade -f_{tb}= $0.0140f_{ck}$….(1)
For H_2 grade – f_{tb}=$0.0289f_{ck}$….(2)
For M_1 grade – f_{tb}=$0.0705f_{ck}$….(3)

- By using the above relationship we may easily find the tensile bond strength value of the specimen for various compressive strength of mortar.
- From the table concluded clay bricks carry high shear strength property than fly ash bricks.
- Conventional mortars carry less shear bond strength property in clay and fly ash bricks**.**
- Mortar with chemical admixture attained high shear bond strength.

6.3 Flexural Bond Strength

- Flexural bond strength was determined by stack bonded prism. seven bricks were constructed vertically. 12 mm

- mortar thickness was maintained. Stack bonded prism were placed horizontally on loading platform of UTM. Uniformly distributed load was applied to the stack bonded prism. Flexural strength was calculated by finding the ratio between bending moment and moment of inertia. Flexural bond strength of specimen tabulated in table 6.

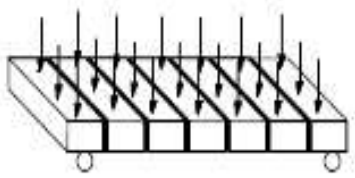

Fig 5 Flexural prism

Fig 6 Failure of prism

Table 5 Tensile bond strength of mortar joints

Type of brick	Type of mortar	Mix proportion	Tensile strength ($N/mm^{2)}$	f_{tb}/f_{ck}
Clay bricks	Conventional mortar	1:1/4:3	0.4777	0.0162
		1:1/2:4.5	0.3852	0.0371
		1:1:6	0.3821	0.0308
	Mortar with chemical admixture	1:1/4:3	0.5301	0.0144
		1:1/2:4.5	0.4407	0.0196
		1:1:6	0.4654	0.2077
Fly ash bricks	Conventional mortar	1:1/4:3	0.4105	0.0139
		1:1/2:4.5	0.3727	0.0359
		1:1:6	0.3494	0.0282
	Mortar with chemical admixture	1:1/4:3	0.4280	0.0116
		1:1/2:4.5	0.3523	0.0233
		1:1:6	0.3494	0.0155

From the table by comparing conventional mortar and mortar with chemical admixture, chemical admixtures improve the strength property.Rich mix (H_1) has higher bond strength compare to the other mix proportions.Clay bricks shows high bond property when compare to the fly ash bricks.In the normal mix 1:1:6 (M_1) has less bond property compared to the other mixes.From the test results similar to equations (1), (2), (3) an approximate relation was arrived for each type of mix between shear bond strength of masonry specimen and compressive strength of the mortar. They were

For H1 grade - $f_{sb}= 0.1012\ f_{ck}$.....(4)
For H2 grade - $f_{sb}= 0.1290\ f_{c}$.....(5)
For M1 grade - $f_{sb}= 0.1300\ f_{ck}$...(6)

By using the above relationship we may easily find the shear bond strength value of the specimen for various compressive strength of mortar.

Table 6 Flexural bond strength of mortar joints

Type of brick	**Type of mortar**	**Mix proportion**	**flexural strength ($N/mm^{2)}$**	**f_{fb}/f_{ck}**
Clay bricks	Conventional mortar	1:1/4:3	16.28	0.901
		1:1/2:4.5	13.02	0.998
		1:1:6	9.910	1.185
	Mortar with chemical admixture	1:1/4:3	17.69	1.150
		1:1/2:4.5	14.15	1.032
		1:1:6	10.61	1.321
Fly ash bricks	Conventional mortar	1:1/4:3	15.59	0.863
		1:1/2:4.5	12.75	0.977
		1:1:6	7.087	0.847
	Mortar with chemical admixture	1:1/4:3	17.00	1.105
		1:1/2:4.5	14.17	1.033
		1:1:6	9.922	1.236

From the table mortar with chemical admixture attain high strength property than conventional mix.Rich mix 1:1/4:3 (H_1) mortar observed high strength property.When compare to the other two mix proportions.While comparing conventional mortar and mortar with chemical.Admixture, it is observed that mortar with chemical admixture shows high strength property.

From the test results similar to equations (1) to (6) an approximate relation was arrived for each type of mix between flexural bond strength of masonry specimen and compressive strength of the mortar. They were

For H1 grade – $f_{fb}= 1.0047\ f_{ck}$....(7)

For H2 grade – $f_{fb}= 1.0101\ f_{ck}$....(8)

For M1 grade – $f_{fb}= 1.1472\ f_{ck}$...(9)

By using the above relationship we may easily find the shear bond strength value of the specimen for various compressive strength of mortar.

7.0 Result and Discussion

The result of the tensile, shear and flexural bond strength for specimen made from clay and fly ashbricks mortar specimen with superplasticizer shows high shear bond strength of mortar joints.

In the rich mix 1:1/4:3 (H_1) obtained maximum shear bond strength when compared to the other two mixes.The strength property of the masonry was mainly influenced by the strength of the mortar.Sand content increased in the mortar it improves the strength. When reduce the sand content it affects the strength property. Mortar with superplasticizer attained high bond strength compared to the conventional mortar.

When compared to clay bricks and fly ash bricks, clay bricks attained high bond property with mortar.Based on the equation 1 to 9, the approximate value for tensile bond strength, shear bond strength and flexural bond strength of masonry can be obtained with respect to the compressive strength of mortar.

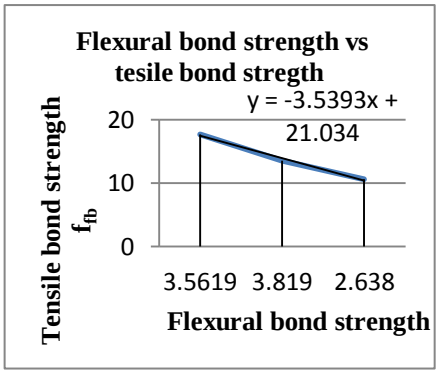

Fig 7 shear vs tensile bond strength

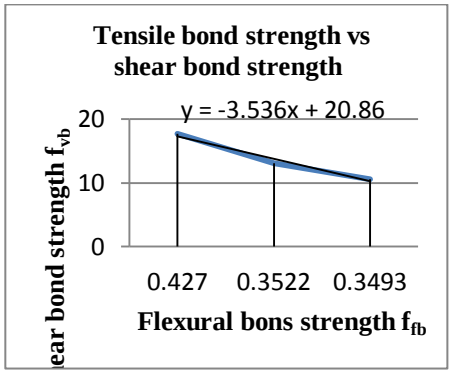

Fig 8tensile vs tensile bond strength

8.0 Conclusion

- By the test result it is commonly observed in all the type of mortar specimen there is a decreasing of strength by increasing the sand content.
- By comparing clay and fly ash bricks,clay brick shows high bonding property.
- Mortar with chemical admixtures shows high strength value.

9.0 References

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