Influence of Strength of Mortar and Thickness of Mortar Joint on Burnt Brick Masonry Prism

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Abstract. Brick masonry remains a fundamental component in construction due to its durability and adaptability. This study examines the effects of varying mortar mix ratios and bed joint thicknesses on the compressive strength of brick masonry prisms. High-quality, hand-moulded clay bricks were used with Portland Pozzolana Cement and locally sourced river sand to prepare prisms with different mortar ratios (1:4, 1:6, 1:8) and joint thicknesses (10mm to 30mm). The prisms were cured for 28 days and tested using a 500 kN servo hydraulic actuator. Results indicate that a 1:4 mortar mix combined with a 15mm joint thickness yields the highest compressive strength. Additionally, the study found that mortar strength significantly influences prism performance, and failure typically occurs through shear or gradual mechanisms. These findings emphasize the importance of optimizing both mix proportions and construction details to enhance masonry strength and performance.

Keywords: Brick masonry, mortar mix ratio, joint thickness, compressive strength, masonry prism, shear failure, structural performance

1. INTRODUCTION

Masonry is one of the oldest building materials known to man and is believed to have been in use for over 6000 years. Construction using masonry remains relatively popular in many parts of the world and is practiced widely even today. Masonry is composed of two different materials namely: the masonry units and the mortar phase. Brick masonry is a highly durable form of construction. It is built by placing bricks in mortar in a systematic manner to construct solid mass that withstand exerted loads The strength of used and, on the mortars, on the other hand, depends on the granulometry, workmanship of the material water /cement ratio. The mortar acts homogeneously in masonry prisms constructed with strong mortar and damage attributable to strain occurs along the joint. The adherence between the masonry unit and the mortar used in wall production affect wall behavior.

2. MATERIALS USED

Bricks: Brick is one of the primary materials used in this study. The clay bricks used are of good quality as per Indian Standard IS 1077:1992 classification. The clay bricks are hand-moulded and have non-modular size. The bricks which are uniform in colour with sharp corners and smooth faces are selected for the study.

Sand:The locally available river sand is used for making mortars conforming to the specifications of Indian Standard IS: 2116:1980.

Cement:Portland Pozzolana Cement is used in the present study for preparing mortar.

Water:Potable drinking water is used in this experiment.

3. METHODOLOGY

In first stage the materials collected which are required for this project and tested the physical properties of Bricks, Sand and Cement as per IS code Recommendations. After finding all the physical properties the selection of Mortar Mix ratio as per IS 1905-1987. The basic tests on Selected mortar ratio as per IS 2250-1981. The test is Consistency of masonry mortar for find W/C ratio and Compressive strength of Mortar.

In second stage the preparation of Masonry prism using materials are Bricks and Cement Mortar, The stacking of bricks one over other with mortar in between. The prisms allowed to Cure for 28 days and tested in Servo Hydraulic Actuator 500KN capacity. By this machine we can Analysis the prisms by taking Load/ Displacement and Stress.

3.1 PREPRATION OF PRISM

Prism specimens were prepared each consisting of five brick units bonded by mortar which was also filled in the holes of the bricks to enhance the bond between bricks units and avoid the failure by separation of the units. prisms were prepared by varying the mortar thickness and mortar ratio.

4. RESULTS AND DISCUSSION

4.1 PROPERTIES OF MATERIALS

4.1.1 PROPERTIES OF SAND

SI. No	Description of test	Results Obtained	BIS Specification	Permissible limit
1	Specific Gravity	2.62	IS 2386-1963(Part-3)	2.6 to 2.75
2	Fineness Modulus	2.4	IS 2386-1963(Part-1)	2.2 to 3.2
3	Bulking of Sand	4%	IS 2386-1963(Part-3)	2% to 5%

Table 4.1 Properties of Sand

4.1.2 PROPERTIES OF CEMENT

Table 4.2 Properties of Cement

SI.	Description of test	Results	BIS Specification	Permissible limit	
No		Obtained			
1	Fineness test	6 .05%	IS 4031-1996 (Part-I)	Not exceed 10%	
2	Normal Consistency	29%	IS 4031-1988 (Part-4)	26% to 33%	
3	Initial Setting Time	140 min	IS 4031-1988 (Part-5)	Not less than 30min	
4	Final Setting Time	230 min	IS 4031-1988 (Part-5)	Not more than 10 hrs.	
5	Specific Gravity	3.12	IS 2720-1980	3.1 to 3.16	

4.1.3 PROPERTIES OF BRICKS

SI. No	Description of test	Results Obtained	BIS Specification	Permissible limit
1	Compressive strength	5.3 N/mm ²	IS 3495-1976(Part-1)	Not less than 3.5
				N/mm^2
2	Size and shape	(215 x 100 x 70) mm	IS 3495-1976	
3	Colour and texture	Uniform	IS 3495-1976	Uniform colour
4	Warpage test	2mm	IS 3495-1976(Part-4)	Not Exceed 2.5mm
5	Water absorption	20.1%	IS 3495-1976(Part-2)	Second class brick

4.1.4 PROPERTIES OF MASONRY MORTAR

Table 4.4 Selection of W/C ratio by Cone Penetration test

Mortar Type	Mortar Ratio	W/C ratio	Penetration in mm	Selected W/C ratio
		0.4	140	
MM 7.5	1:4	0.5	115	0.5
		0.6	90	
	1:6	0.4	165	
MM 2.0		0.5	128	0.6
IVIIVI 3.0		0.6	105	0.0
		0.7	95	
	1:8	0.4	180	
MM 0.7		0.5	145	0.7
		0.6	115	0.7
		0.7	95	

Note: The Selection of W/C the Penetration value in the range (90-130) mm

Mortar Type	Ratio	Trails	Load in Kg	Load in N	Area in mm ²	Comp strength for 28 days in N/mm ²	Average Strength N/mm ²	Minimum strength for 28 days (N/mm ²⁾
	1:4	1	5000	49050		10.1		
MM 7.5		2	4500	44145	4900	9.01	9.34	7.5 and above
		3	4500	44145		9.01		
	1:6	1	2500	24525		5.01		
MM 3.0		2	3000	29430	4900	6.01	5.34	3-5.5
5.0		3	2500	24525		5.01		
	1:8	1	500	4905		1.0		
MM 0.7		2	500	4905	4900	1.0	1	0.7-1.5
		3	500	4905		1.0		

Table 4.5 Mortar Compressive strength test

Note: Above results obtained as per IS 2250-1981 is within limit.

4.2 TESTS RESULTS OF PRISMS

Table 4.6.Test Results of Burnt Brick Masonry Prism

Mortar	Mortar	Prism Peak	Cross	Prism
Mix	Thickness	load(N)	Sectional	Strength(N/mm ²⁾
Ratio	(mm)		Area(mm ²⁾	<u> </u>
1:4	10	25664.61	22000	1.166573
1:4	15	26000.08	22000	1.181822
1:4	20	24439.08	22000	1.110867
1:4	25	19618.31	22000	0.891741
1:4	30	18576.21	22000	0.844373
1:6	10	19741.56	22000	0.897344
1:6	15	23997.06	22000	1.090776
1:6	20	22064.47	22000	1.00293
1:6	25	16931.18	22000	0.769599
1:6	30	16829.4	22000	0.764973
1:8	10	13175.16	22000	0.598871
1:8	15	15099.21	22000	0.686328
1:8	20	12901.44	22000	0.586429
1:8	25	12792.14	22000	0.581461
1:8	30	12638.48	22000	0.574477

Mortar Mix Ratio	Mortar Thickness (mm)	Prism Strength(N/mm ²⁾	Average Brick strength(N/mm ²⁾	Basic Compressive Strength (f ⁴ m In N/mm ²)
1:4	10	1.16657	5.3	0.292
1:4	15	1.18182	5.3	0.295
1:4	20	1.11087	5.3	0.278
1:4	25	0.89174	5.3	0.222
1:4	30	0.84437	5.3	0.211
1:6	10	0.89734	5.3	0.224
1:6	15	1.09078	5.3	0.272
1:6	20	1.00293	5.3	0.25
1:6	25	0.7696	5.3	0.192
1:6	30	0.76497	5.3	0.191
1:8	10	0.59887	5.3	0.149
1:8	15	0.68633	5.3	0.171
1:8	20	0.58643	5.3	0.146
1:8	25	0.58146	5.3	0.145
1:8	30	0.57448	5.3	0.143

Table 4.7.Basic Compressive Strength of Prism

4.3 MASONRY PRISM STRESS V/S STRAIN GRAPH











Graph 4.7.Prism 1:6-15mm

Graph 4.8. Prism 1:6-20mm









Graph 4.11 .Prism 1:8-10mm

Graph 4.12.Prism 1:8-15mm

Graph 4.14.Prism 1:8-25mm



Graph 4.13.Prism 1:8-20mm



Graph 4.15.Prism 1:8-30mm

4.4 LOAD V/S DISPLACEMENT





Graph 4.17. prism 1:4 - 15mm







Graph 4.21. prism 1:6 - 10mm



Graph 4.23. prism 1:6 - 20mm



Graph 4.25. prism 1:6 – 30mm



Graph 4.20. prism 1:4 - 30mm







Graph 4.24. prism 1:6 – 25mm



Graph 4.30. prism 1:8 - 30mm

Displacement, mm

4.5 STRESS COMPARISION TO DIFFERENT MIX RATIO.



Graph 4.31 Prism with 10mm Thick Mortar







Graph 4.34. Prism with 25mm Thick Mortar



Graph 4.33. Prism with 20mm Thick Mortar



Graph 4.35. Prism with 15mm Thick Mortar

4.6 STRENGTH COMPARISION TO DIFFERENT MIX RATIO



Graph 4.36.Compression Strength of Prism with Mortar Mix 1:4



Graph 4.37. Compression Strength of Prism with Mortar Mix 1:6



Graph 4.38. Compression Strength of Prism with Mortar Mix 1:8



Graph 4.39. Comparision of Strength of Prism with Different Mix Ratio

4.7 DISCUSSION OF RESULTS

- From Test Results the Mix Ratio 1:4 give more strength than 1:6 and 1:8.
- The Prism Strength increased with increase in Mortar strength.
- In All Mix Ratio 15mm thick mortar joint give more strength than 10mm, 20mm, 25mm, 30mm.
- The Mortar strength and Brick strength Influences on Prism Strength. If mortar strength is more than strength is more.
- The Failure of Prism Observed that Shear failure and Gradually failure of Prism.
- Minimum Displacement Observed at 14mm in 1:4 Mix of 20mm thick, 11mm in 1:6 Mix of 20mm thick and 10.5mm in 1:8 Mix of 10mm.

CONCLUSIONS

- It is observed that the average Compressive strength of bricks is 5.3 N/mm² and Water absorption of brick is 20.1%. Satisfies the limits mentioned in IS 3495.
- The warpage of bricks 2mm and dimensions of bricks length 4.5m, width 2.1m and Height 1.42m. Satisfies the required limitations.
- Compressive strength of mortar for grade of masonry mortar MM7.5, MM3.0 and MM0.7 are respectively 9.34 N/mm², 5.34 N/mm² and 1 N/mm². Satisfies the limits mentioned in IS 2250.
- There is no Influence of 25and30 mm Mortar thickness on strength of Burnt Brick Masonry Prism.
- The Masonry Mortar Bed thickness of 10mm,15mm and 20mm Influenced more on Strength of prism.
- Among all results the 15mm thick mortar give more strength in all Mortar Mix Ratio.
- MM-7.5 Mortar Mix give more strength than MM-3.0 and MM-0.7.
- The Failure of Prism Observed that Shear failure and Gradually failure of Prism.
- Minimum Displacement Observed at 14mm in 1:4 Mix of 20mm thick,11mm in 1:6 Mix of 20mm thick and 10.5mm in 1:8 Mix of 10mm.
- Maximum Displacement Observed at 22mm in 1:4 Mix of 25mm thick,21mm in 1:6 Mix of 25mm thick and 16mm in 1:8 Mix of 30mm.

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