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INVESTIGATION OF DIFFERENT METHODS TO MINIMIZE CRACKING IN MASONRY WALLS

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Abstract: Masonry is widely used as a construction material for load bearing structures or as infill walls in reinforced concrete skeleton frame structures. Cracking is one of the most common problems in masonry walls. It would be better to take relevant precautions at the construction stage rather than carrying out rectification work after cracks are formed. Laboratory tests were carried out to investigate the effectiveness of five methods that can be used as remedial measures to prevent cracking near the wall openings. Test wall panels would represent the load bearing brick masonry walls with openings. Five different types of wall panels were constructed in this study, namely, walls with normal lintel above the opening, normal lintel above the opening and walls reinforced with hexagonal wire mesh, normal lintel above the opening and walls reinforced with hexagonal plastic mesh, continuous lintel above the opening and both the continuous lintel above the opening with a continuous beam just below the opening. Loads at which cracks propagate were compared. From the test results it was found that many cracks propagated on walls with normal lintels at low load levels. When walls were reinforced with hexagonal wire mesh or plastic mesh, walls could withstand higher loads before cracking. However, from the results it could be clearly seen that walls having both the continuous lintels above the opening and continuous beams below the openings were the most effective method to control cracking in masonry walls compared to all four other remedial measures considered in this study.

Keywords: brick walls, cracks, hexagonal plastic mesh, hexagonal wire mesh, lintels, openings

1. Introduction

Load bearing brickwork has been used in structures for many centuries and the popularity has been mainly due to its durability, economy, aesthetic appearance, speed of construction and fire resistance.

Cracking is one of the most common problems in masonry walls. If proper precautions are taken, it can be prevented. When cracks are propagated in walls, relevant rectifications should be carried out to maintain its aesthetic appearance, structural adequacy and serviceability. As it is difficult to repair and conceal cracks permanently, maintenance costs will be increased. Therefore, it would be better to take relevant precautions in the construction stage rather than doing rectifications after cracks are formed.

By selecting proper materials, construction me-thods and quality control measures, cracks in masonry walls can be eliminated or minimized. Before selecting a proper method to prevent cracking it would be always better to identify the real reasons for them. It would be due to movements caused as a result of temperature variations, shrinkage and creep deformations, over loading, poor construction techniques, bad design or combination of the above reasons. In most of the cases, type and the magnitude of the cracks will give hints for the causes for cracking (Almherigh, 2014 [1]).

In load bearing structures, it is very common to observe diagonal cracks at the edges of openings. These cracks occur as a result of uneven stress distribution since the brickwork below the opening is stressed to a lesser degree (Jayasinghe, 1997 [2]).

Various techniques used to minimize cracks in load bearing masonry structures are considered in this research study. It is focused to study the behaviour of masonry walls to identify the effectiveness of the length of lintels, provision of beams at sill levels of openings and the use of wire mesh and plastic mesh on strengthening of walls with openings.

2. Objectives

The main objective of this study is to find an effective method to minimize crack propagation near openings of the load bearing masonry walls.

3. Methodology

In this experimental study, different remedial measures that can be used to minimize cracks near openings in brick walls were considered. Laboratory tests were carried out to investigate the effectiveness of these different methods. A brick wall panel having an opening with a normal lintel of 200 mm bearing lengths on either side was considered as the control specimen. The other types of wall panels considered in this study were, (1) wall having normal lintel above opening and wall reinforced with hexagonal wire mesh, (2) wall having normal lintel above opening and wall reinforced with hexagonal plastic mesh, (3) wall with a continuous lintel above the opening, (4) wall with a continuous lintel above the opening and with a continuous beam just below the opening.

3.1 Specimen Preparation

Each wall was 110mm thick, 1400mm wide and 720mm high and consisted of 600mm wide, 240mm high openings. Duplicates were tested for each case considered. The mortar joint thickness was 10mm and the mix proportion used was 1:5 cement: sand. For wall plastering 1:6 cement: sand ratio was used. For lintel 1:2:3 cement: sand: aggregate concrete was used and the 10mm tor steel was used as reinforcement for the lintel. Important properties of materials used were obtained by carrying out standard tests and are listed in Table1.

Table 1: Properties of used materials

Material	Code	Property	Value
Burnt Clay Brick	SLS 39: 1978[4]	Mean compressive strength (N/mm²)	2.35
		Water absorption (% by mass)	22.08
		Dimension	
		Length (mm)	203
		Width (mm)	104
		Height (mm)	53
1:5 mortar-bed joints	BS 4551-Part 1: 1998[5]	Compressive strength (N/mm²)	6.77
1:6 mortar-Plaster	BS 4551-Part 1: 1970[5]	Compressive strength (N/mm²)	5.20
1:2:3 concrete	BS 1881-116:1983[7]	Compressive strength (N/mm²)	21.13
Wall panel	BS 5628-1:1992[6]	Modulus of elasticity (N/mm²) (Drysdale et al.1999 [3])	1000

3.2 Types of Walls Considered

3.2.1 Walls with Normal Lintels (SL)

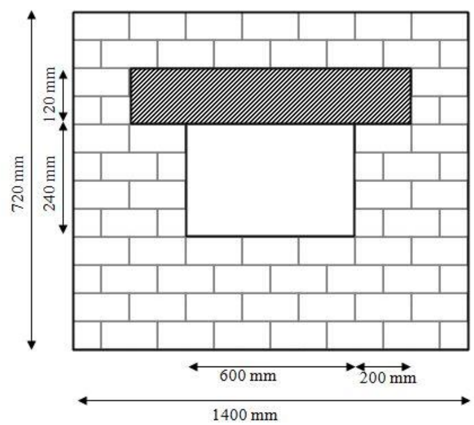

Fig 1: Wall with normal lintel

Normal lintel with 1000mm long, 120mm high and 110mm width was cast above the wall opening. 10 mm tor steel bar was provided as reinforcement.

All sides of the wall were plastered. Dimensions of the wall panel are shown in Figure 1.

3.2.2 Normal Lintel with Wire Mesh (SL+CM)

Normal lintel with 1000mm long, 150mm high and 110mm width was cast above the wall opening. A 10 mm tor steel bar was provided as reinforcement. Both sides of the wall were reinforced with ½″ hexagonal wire mesh (see Figure 2). The wire mesh was carefully fixed to walls using nails, before plastering.

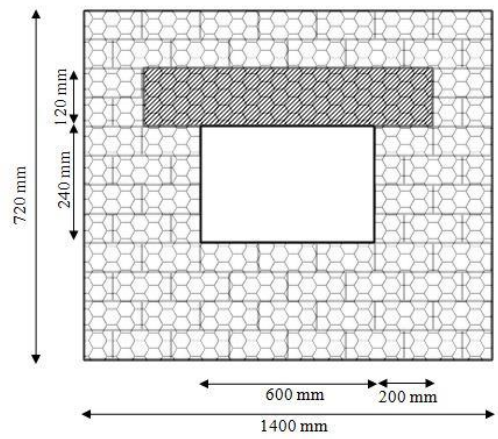

Fig 2: Normal lintel with wire mesh

3.2.3 Short Lintel with Plastic Mesh (SL+PM)

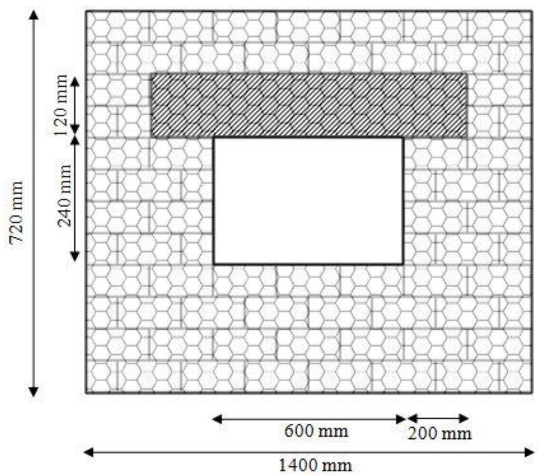

Fig 3: Normal lintel with plastic mesh

Instead of wire mesh, a hexagonal plastic mesh with the same netting shape was used to reinforce the two sides of the wall (see Figure 3). Also, nails were used to fix the mesh to wall panels. Plastering was done after fixing plastic mesh to wall panels.

3.2.4 Walls with Long Lintel (LL)

A continuous lintel throughout the width of the wall was cast above the wall opening as shown in Figure 4. Lintels were 1400mm long, 120mm high and 110mm wide. Reinforcement was provided using 10 mm tor steel bar.

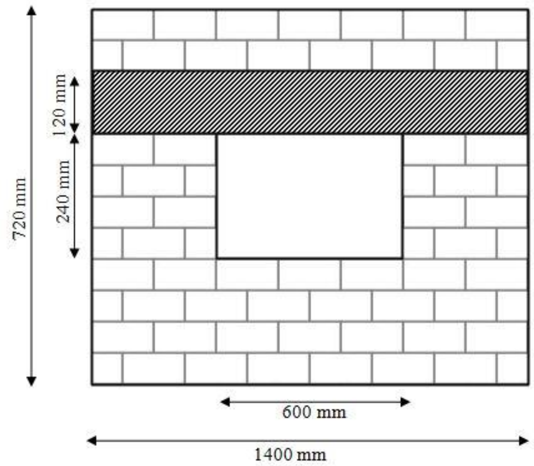

Fig 4: Wall with long lintel

3.2. 5 Continuous Lintel above the opening and a Continuous Beam below the opening (TBLL)

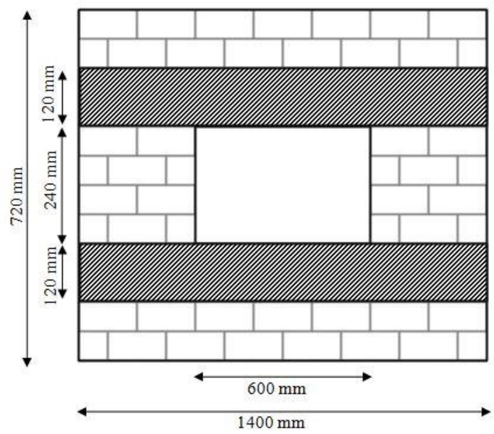

Fig 5: Top lintel and beam just below opening

Continuous lintel above the opening and a continuous beam below the opening were cast as shown in Figure 5. As same as the previous cases, a 10 mm steel bar was used as the reinforcement.

3.3 Laboratory Testing

Figure 6 shows the experimental setup used for testing. Loading was done using 50T hydraulic jack and loading was monitored using 30T proving ring. To apply a uniformly distributed load on walls, steel I section and a steel plate were used. Crack propagation was continuously monitored with applied load. Also, cracks were mapped to get an idea about the crack pattern. For each type of wall, two wall panels were tested for better judgment.

Fig 6: Experimental setup

4. Experimental Results and Analysis

4.1 Comparison of Cracking Loads

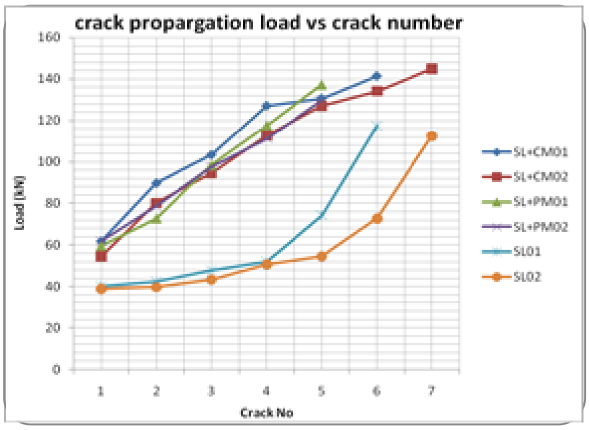

Fig 7: Load Vs crack no plots for SL, SL+CM and SL+PM

The test results of SL, SL+CM and SL+PM wall panels were compared to study the effectiveness of wire mesh and plastic mesh on preventing crack propagation.

Figure 7 shows the load at which each crack developed. It could be clearly seen that the wire mesh and plastic mesh act almost in the same manner. Walls without mesh gave comparably low load at initial cracking. The load difference between two consecutive cracks was higher in walls with wire mesh or plastic mesh than walls without mesh.

Similarly, the cracking loads of SL, LL and TBLL walls are plotted against the crack number for comparison (see Figure 8).

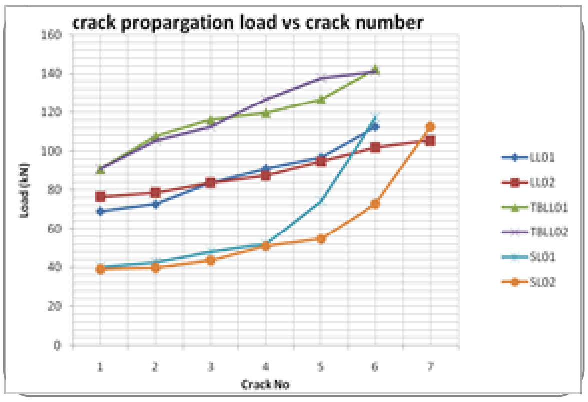

Fig 8: load Vs crack no for SL, LL and TBLL

The highest load for the initial cracking was obtained for walls having continuous lintels with continuous beams below the openings. The lowest initial cracking load was observed in the walls with normal lintels. According to Figure 8; the gradients have no such significant difference at the initial stages as compared to walls reinforced with wire mesh or plastic mesh, as shown in Figure 7. In other words, all the walls without mesh do not show much increase in load between consecutive cracks.

5. Conclusions

By comparing the test results of SL, SL+CM and SL+PM it is clear that when brick wall panels are reinforced with wire mesh or plastic mesh, the initial cracking load can be increased. Also it can be seen that the load increment between two consecutive cracks is higher when the walls are strengthened with wire mesh or plastic mesh.

When comparing the results of SL, LL and TBLL wall panels, it can be seen that the highest load at the initial cracking is resulted in TBLL panel. The lowest initial cracking load is obtained for SL walls. The load increment between consecutive cracks is approximately the same in all three types of walls. In other words, all the walls without any reinforcing mesh, do not show much increase in load between consecutive cracks.

From the results of all the types of wall panels considered in this study, it could be clearly seen that walls having both the continuous lintels above and continuous beams below the openings were the most effective method to control cracking in masonry walls.

Acknowledgement

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