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Strengthening of Masonry Wall Using Wire Mesh

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***Abstract*: The inherent weakness of masonry in tension has been repeatedly demonstrated in seismic events. The need to overcome seismic deficiency of unreinforced masonry (URM) panels has led to the development of structural walls with different reinforcement patterns. Confined masonry (CM), which consists of an URM masonry panel bordered with slender columns and beams, is one such alternative. Confining elements, tie columns and bond beams, are cast after the construction of the wall. These elements are usually constructed of reinforced concrete, although timber, reinforced masonry, and other materials have been used occasionally. RC frames with unreinforced masonry infill walls are common in developing countries with regions of high seismicity. Masonry is a complex material it is well known that masonry has a good performance when resisting and transmitting compressive loads and a poor performance to resist tensile demands so the wire mesh is infilled in the wall in order to study the behavior of Infill masonry walls under cyclic loading by strengthening with wire mesh , Optimize the size and diameter of the mesh for maximum increase in shear strength and ductility , Anchorage of mesh to the columns , Study behaviour with openings and analyse the result of load bearing capacity and strength attain by the normal masonry wall and the wall infilled with the wire mesh.**

***Keywords*: Concrete, Frame, Masonry, Reinforcement, Strengthening, Wire mesh.**

1. Introduction

The study demonstrates that the use of welded wire mesh with micro-concrete is an effective method for strengthening URM walls. An increase up to seven times in shear strength, and up to twenty-four times in ductility has been observed for reinforcement ratio of 0.29% in both the directions. It is well known that masonry has a good performance when resisting and transmitting compressive loads and a poor performance to resist tensile demands. A modern masonry wall can be reinforced both horizontally and vertically. Reinforcement is usually required in both load-bearing and non-load-bearing walls. The most common horizontal reinforcement for a masonry wall is a galvanized steel wire ladder or truss laid in the mortar between courses of brick or block. In particular, the constituent elements of masonry (bricks and mortar) have a strong non-linear response when subjected to high demand loads and, normally, have an anisotropic behavior. There is also a special issue to define the mechanical behavior of the contact zone between brick and mortar, which is highly non-linear. Moreover, normally earthquake loads demand a non-linear response in buildings and their structural components.

2. Objectives

- Study the behavior of infill masonry walls under cyclic loading by strengthening with wire mesh.
- Optimize the size and diameter of the mesh for maximum increase in shear strength and ductility.
- Anchorage of mesh to the columns.
- Study behaviour with openings.

3. Materials Used

A. Brick

A brick is a block or a single unit of a kneaded clay-bearing soil, sand and lime, or concrete material, fire hardened or air dried, used in masonry construction The bricks are obtained by molding clay in rectangular blocks of uniform size and then by drying and burning these blocks. As bricks are of uniform size, they can be properly arranged and further, as they are light in weight, no lifting appliance is required for them. The bricks do not require dressing and the art of laying bricks is so simple that the brickwork can be carried out even with the help of unskilled laborers. Bricks are produced in many types, sizes, which vary with region and time period, and in bulk quantities.

B. Mortar

Mortar is a workable paste used to bind construction blocks together and fill the gaps between them. Mortar may be used to bind masonry blocks of stone, brick, cinder blocks, etc. Mortar becomes hard when it sets, resulting in a rigid aggregate structure. Modern mortars are typically made from a mixture of sand, a binder such as cement or lime, and water. Mortar can also be used to fix, or point, masonry when the original mortar has washed away.

C. Wire mesh

A mesh is a semi-permeable barrier made of connected strands of metal, fiber, or other flexible/ductile materials. A mesh is similar to a web or a net in that it has many attached or woven strands. ¨Has a safety tension of two times more of a regular construction iron, the use of wire mesh ensures 40% saving from weight compared to regular construction iron.

4. Methodology

Using scaled down bricks of size 63X30X30mm experimental setup has been carried. The compressive strength test for normal size clay brick and scaled down clay bricks have been compared. Water Absorption test is done. In this test bricks are weighed in dry condition and let them immersed in fresh water for 24 hours. After 24 hours of immersion those are taken out from water and wipe out with cloth. Then brick is weighed in wet condition. The difference between weights is the water absorbed by brick. The percentage of water absorption is then calculated. The less water absorbed by brick the greater its quality. Good quality brick doesn't absorb more than 20% water of its own weight. Efflorescence test is done. The presence of alkalies in bricks is harmful and they form a gray or white layer on brick surface by absorbing moisture. To find out the presence of alkalis in bricks this test is performed. In this test a brick is immersed in fresh water for 24 hours and then it's taken out from water and allowed to dry in shade. If the whitish layer is not visible on surface it proofs that absence of alkalis in brick. If the whitish layer visible about 10% of brick surface then the presence of alkalis in acceptable range. If that is about 50% of surface then it is moderate. If the alkalis's presence is over 50% then the brick is severely affected by alkalies.

5. Experimental Investigation

A. Compressive strength test for bricks

This test is used to find the crushing strength of the brick.
Ultimate load on brick = 93195 N
Face area of brick = 24150 mm^2
Compressive strength = load/area
= 93195/24150
= 5.45 N/mm^2

Fig. 1. Compression testing set up

B. Water absorption test

The percentage of water absorption is then calculated. The less water absorbed by brick the greater its quality. Good quality brick doesn't absorb more than 20% water of its own weight.

Table 1
Weight of bricks

	Wt. of brick before immersion (gm)	Wt. of brick after immersion (gm)	Percentage of water absorption %
Sample 1	0.142	0.159	11.9
Sample 2	0.148	0.165	11.4
Sample 3	0.136	0.153	12.5

Fig. 2. Immersion and weighing of brick specimen

C. Efflorescence test

The presence of alkalies in bricks is harmful and they form a gray or white layer on brick surface by absorbing moisture. To find out the presence of alkalis in bricks this test is performed. In this test a brick is immersed in fresh water for 24 hours and then it's taken out from water and allowed to dry in shade.

If the whitish layer is not visible on surface it proofs that absence of alkalis in brick. If the whitish layer visible about 10% of brick surface then the presence of alkalis in acceptable range. If that is about 50% of surface then it is moderate. If the alkalis's presence is over 50% then the brick is severely affected by alkalies.

D. Hardness test

In this test a scratch is made on brick surface with a hard thing. If that doesn't left any impression on brick then that is good quality brick.

E. Size, shape and color test

Fig. 3. Size, shape and color of the brick

F. Structure test and soundness test

Fig. 4. Inner face of broken brick

6. Experimental Results

A. Bare frame

This specimen was designated as the reference frame to compare its performance against retrofitted specimens. Six full displacement cycles were applied to the test specimen. First cracks were observed and corresponding restoring force was measured at 15 KN. The observed maximum cracks with maximum lateral load is measured at 43KN.

B. Infill frame without mesh

This is another reference specimen with infill wall. Twelve full displacement cycles were applied to the test specimen. First damage was observed when the infill wall (open) separated from the beam and corresponding restoring force was measured at27 KN. The observed maximum cracks opening with a maximum lateral load is measured at 80KN, concrete sapling was observed at the bottom ends of columns.

C. Infill frame with mesh

Full displacement cycles were applied to the test specimen. First flexural crack on the beam–column joint was observed and a restoring force of 90kN. The first diagonal crack occurred on the infill wall with chicken mess and the corresponding restoring force 75kN. The observed maximum cracks opening with a maximum lateral load is measured at 133KN.

D. Energy dissipation system

The energy dissipation systems are devices specially designed and tested to dissipate large quantities of energy. The most common energy dissipation systems are the viscous ones (force proportional to the velocity of deformation) and the hysteretic (force proportional to displacement), however there are also the visco-elastic, electro-inductive and by friction damping systems.

Table 2
Energy dissipation table

Cycle	Bare frame	Infill wall without mesh	Infill wall with mesh
1	0.062	0.112	0.1087
2	0.14	0.242	0.458
3	0.267	0.468	1.0310
4	0.331	0.579	1.326
5	0.58	1.015	1.7497
6	0.647	1.132	1.9564

7. Conclusion

- The first crack of the frame without mesh occur at 27 KN where the crack at the frame with mesh occur at 39KN.
- Ultimate load carrying capacity of the frame without mesh occur at 80KN where the frame with mesh occur at 133KN.
- Ultimate load carrying capacity the frame with mesh is about 45% higher than the frame without mesh.
- The energy dissipation capacity of the infill wall frame with mesh is about 45% higher than the infill wall frame without mesh.
- The normal masonry wall's brick and mortar elements exhibit more stress during the cyclic load whereas in case of meshed wall, the major stress is being transferred to the mesh.
- Larger opening size has more Deformation due to Reduction in Stiffness (B3 has 10% higher deformation compare to B2).
- The provision of Reinforcing Mesh in B4(Bare Frame + Brick Infill with open+ Reinforcing Mesh) has greater reduction of 38% of Deformation to B2(Bare Frame + Brick Infill with open).
- The experimental campaign was focused on bond between confined wall with mesh. Comparison of experimental results showed that load carrying capacity increases 30-40% in case of mesh.

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