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RESEARCH NOTE

Enhancing Performance of Infill Masonry With Skin reinforcement Subjected To Cyclic Load

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ABSTRACT

Masonry infill has been widely used as building material due to its cost effectiveness and availability. The failure of these masonry infill walls during the past earthquakes have underscored the importance of ensuring the safety of the infill walls when it is subjected to lateral loads. In-plane and out of plane failures have been observed in many reinforced concrete framed building with masonry infill. To prevent the failure of the infill walls researchers have worked on various confinement techniques like, textile reinforced mortar, ferro cement, and diagonal bracings using fiberglass reinforced panels (FRP) etc. In this paper chicken mesh were used as a confinement technique and the experimental investigation is presented for enhancing the in-plane properties of masonry infill walls like diagonal tension and shear thereby improving the in-plane strength of masonry infill wall. For studying the lateral load capacity of the infill wall two specimens are cast namely, i) infill wall without mesh (B2), ii) infill wall with mesh (B3). Single bay, single floor 1:3 scaled down reinforced cement concrete (RCC) frames designed as per codal provisions are cast with scaled down bricks for construction of infill walls and because of incorporation of skin reinforcement for infill walls the ductility, energy dissipation, ultimate loads are improved considerably and reduced the displacements.

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NOMENCLATURE

Δy	Yield displacement	μ	Ductility ratio
Ki	Initial stiffness	*B2*	Infill wall without mesh
Pu	Ultimate loads	B3	Infill wall with mesh
Δu	Ultimate displacement		

1. INTRODUCTION

Infill masonry panels may change drastically the global lateral stiffness and strength of the building structures, the natural frequencies and vibration modes, the energy dissipation capacity and the failure mechanism. The infill panels can modify the global structural behaviour, attracting forces to parts of the structure that are not designed to resist lateral forces, resulting in unexpected behaviour and collapse of the structure. The failure of buildings with masonry infill has been observed in various buildings during the past seismic events. Diagonal cracking in the infill walls due to the in-plane response of walls has been a common failure mechanism as shown in Figure 1.

Researchers have worked on the strengthening of the infill walls with various techniques to increase the in-plane and out-of-plane resistance to lateral load. For unreinforced masonry walls a study on retrofitting methods by Amiraslanzadeh et al. [1] has shown that

Figure 1. Diagonal cracking of infill

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among the various methods available the surface treatment method and centre core technique improves the behaviour of inplane and out of plane significantly. This is because of the low cost and less requirement of skilled labour. Experiments have shown that shotcrete with welded wire fabric is effective in increasing the strength and durability of the unreinforced masonry (URM) walls. However, the weight of the structure was found to increase considerably. Increase of load carrying capacity and deformability was observed when textile-reinforced mortar (TRM) was applied in URM walls subjected to cyclic loading in comparison with FRP [2]. However, the cost of TRM may be high because, it was observed that resin impregnated TRM is more operative in terms of strength, compared to mortar impregnated TRM. Experimental investigation has been done to study the behaviour of infill walls ranging from scaled down specimens to full scale models to predict the exact response to lateral forces.

Recent earthquakes have witnessed the partial or complete collapse of masonry infill walls. Researchers have been working on studying the confinement of masonry infill using various techniques. The concept of reinforced plaster on the surface of masonry infills where, a thin layer of cement plaster is to be applied over high strength steel reinforcement [3, 4] introduced. The steel can be arranged as diagonal bars or as a vertical and horizontal mesh. The reinforced plaster technique improved the in-plane resistance [5]. Confined masonry was studied by many researchers, to mention the earliest work [6-10]. The basic feature of confined masonry structures is the vertical RC or reinforced masonry tie columns, which confine the walls at all corners and wall intersections.

Tie beams and Columns should be connected together along the walls to be effective at floors levels. Some of the important conclusion drawn are, disintegeation has greatly reduced on the addition of the confinement and improves ductility and energy dissipation, but no significant effect on the ultimate load resistance. However, introduction of confinement in masonry is a difficult task.

Post-tensioning masonry has been studied globally in the recent years [11-16]. The forces involved are compressive force and it counteracts the tensile stresses when the cyclic load is applied to masonry wall. Alloy steel is used as a Post-tensioning tendons [8, 15, 17], although mono-strand tendons are common [18-20]. The disadvantage of the tendons are relaxation losses, Corrosion and the strength also lowered when compared with the weight of the alloy. To overcome this diadvantages fiber reinforced plastic presents a promising solution for this problem [12]. The compressive strength is greatly reduced when Anchorage of post-tensioning in masonry is done.

To strengthen the URM walls and to improve the shear capacity, FRP composites was studied by Hashemi and Mosalam [21]. To evaluate the strength of shear capacity, experimental study was performed and the specimens were tested under cyclic load. Ductility is computed from the experimental study with the gradual increase in lateral cyclic loading in the form of hysteretic load deflection curves.

2. EXPERIMENTAL INVESTIGATION

For experimental investigation single bay reinforced concrete frame scaled down to 1:3 ratio were considered. The details on the frame are shown in Figure 2. The infill bricks were also scaled done to cater the thickness of the infill wall. Experimental investigations were done on infill walls to study the in plane behaviour of the wall subjected to lateral load. The lateral displacements at the top and bottom of the test specimens were measured using two linearly varying differential transformers (LVDT's) with a stroke length of ±50mm. Typical instrumentation scheme is shown in Figure 3. The loading sequence for the experiment is presented in Figure 4.

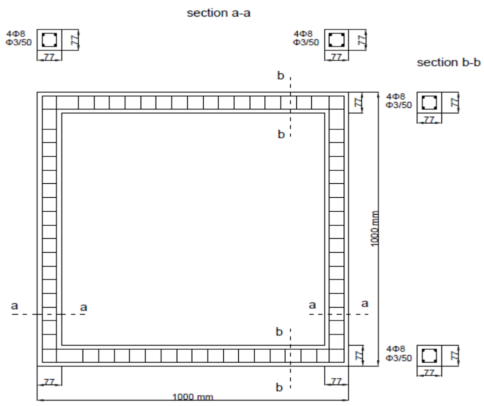

Figure 2. Reinforcement detail of the frame

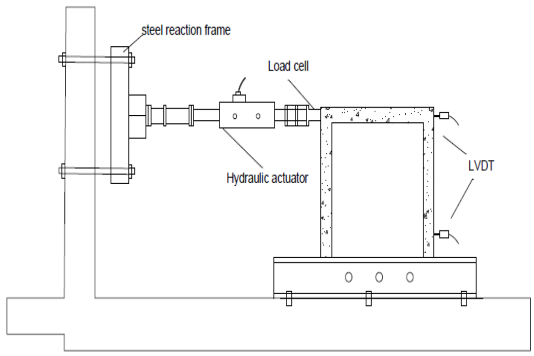

Figure 3. Experimental set-up

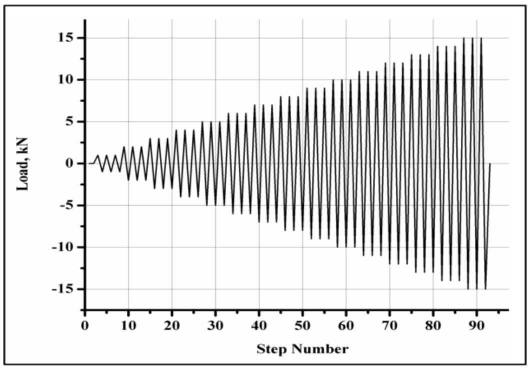

Figure 4. Loading History

Cyclic load (push and pull) was applied in increments of 1kN with three cycles for each increment. Load was applied to the specimens by means of 50kN hydraulic jack and it was measured using load cells. The specimens were fixed to the strong floor through bolts of 20 mm diameter.

Two single-bay, single-storey RC frames of 1:3 reduced-scale were experimentally studied under cyclic load-controlled at the Structural Engineering Laboratory of Karunya Institute of Technology and Sciences, Coimbatore. Frame columns were detailed to yield in flexure before shear failure. The infill masonry of size 1000 × 1000 × 76.67mm were casted in a scale of 1:3 as shown in Figure 5. Burnt clay bricks of size 66.7 x 33.3 x 33.3mm were used for the specimens. The bricks were also scaled to 1:3 to ensure compatibility. The test specimens were (a) frame with infill masonry wall (B2), (b) frame with infill masonry wall with wire mesh (B3).

For the tests conducted, load versus displacemnet hysterisis curves were drawn and on the envelope backbone curves obtained with peak load points on each cycle. The point at which deviation from the linear behaviour occurs is taken as the yield point. The following parameters were estimated from the backbone curve.

I. Yield displacement (Δy): Average displacement of the yield points on the forward and reverse curves

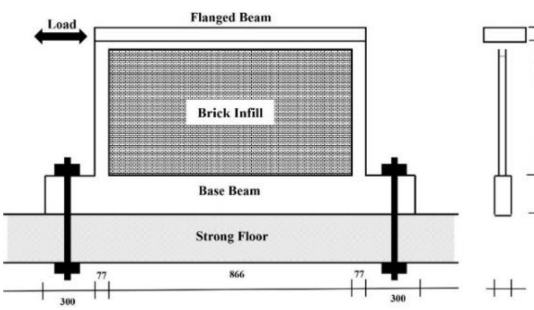

Figure 5. Geometry of Frames tested. All dimensions are in mm

II. Initial stiffness (Ki): Slope of line joining the yield points on the forward and reverse backbone curves

III. Ultimate loads (Pu): Average of maximum loads on the forward and reverse backbone curves

IV. Ultimate displacement(Δu): Average maximum displacement on the forward and reverse backbone curves

V. Ductility ratio (μ): Ratio of Δu and Δy

VI. Cumilative energy dissipation: Area under the load-displacement curve.

3. RESULTS AND DISCUSSIONS

3. 1. Infill Wall without Mesh (B2) Infill wall was constructed with bricks of size 66.7 x 33.3 x 33.3mm. The bricks were laid with cement mortar of 1:3. The walls were plastered using 1:3 mortar. When subjected to cyclic load the first cracks were observed at a load of 34.64 kN in the infill wall at a displacement of 2.09mm (see Figure 6) since the infill wall increase the stiffness of the frame the displacement was less than the bare frame and load carrying capacity was increased. The maximum load carried by the specimen was 104kN at displacement of 30.61mm. Due to the limitations in the loading condition it was unable to load beyond this point and the hysteresis loop was plotted as shown in Figure 7.

Chicken mesh was taken as skin reinforcement [22]. To fix the chicken mesh to the masonry the following procedure was adopted Figure 8

i. 8mm diameter rods were welded to the column reinforcement before casting in the beam column joints corners and was allowed to protrude out of the columns

ii. After removing the formwork for the beams and columns, the frame was cured for 28 days and then the infill wall was constructed

iii. The chicken mesh was attached to the protruding rods on both sides of the wall stretching to the maximum possible level.

Figure 6. Infill Frame (B2)

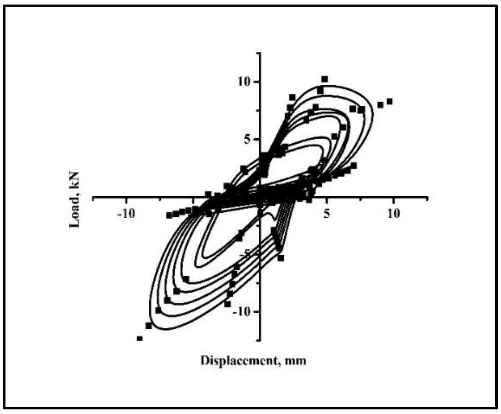

Figure 7. Hysterisis Curve for B2

Figure 8. Infill frame with Mesh

Plastering of wall was done using 1:3 mortar to completely cover the mesh. Since, the thickness of chicken mesh was 1mm the mortar required had thickness of 3mm.

3. 2. Infill Wall with Mesh (B3)

The infill wall with mesh was subjected to cyclic load as shown in Figure 8. The first crack was observed at the load of 3.28 kN and displacement of 1.5mm. The maximum load on the specimen was 164 kN and displacement of 25.36mm and the hysteresis curve was plotted as shown Figure 9. Table 1 presents the comparative results of the frames tested namely B2, and B3. The pre-yield stiffness (Ki), yield displacement (Δy), ultimate displacement (Δu), ultimate load (Pu), ductility (μ) and energy dissipation are calculated from the back bone curve (Figure 10). The following observations were made based on the tabulations

The

i. Pre-yield Stiffness (ki)

pre-yield stiffness for the frame (B3) is found to be 39% higher than the frame (B2). This is due to the fact that the addition of Chicken mesh as a skin reinforcement increases the stiffness.

ii. Yield Displacement (Δy)

Because of the stiffening of the frame by the infill the yield displacement of B2 is reduced, however the load carrying capacity is increased. The addition of mesh in the infill B3 showed a decrease of 42%.

iii. Ultimate displacement (Δu)

The frames were loaded to the extent of the capacity of loading. For comparison of ultimate displacement the load upto which the infill frame (B2) was loaded is considered as the reference and the displacement of B2 and B3 are compared. B3 show a reduction of 30.21% displacement compared to B2.

iv. Ductility (μ)

It can be observed that B3 had ductility 17% more than B2. Hence, the addition of mesh increases the ductility, since the yield displacement is reduced.

v. Energy dissipation

The addition of mesh (B3) in the infill (B2) increase the energy dissipation by 5%.

4. RESULTS AND DISCUSSIONS

It is evidenced that as the stiffness of the specimen increases the displacement reduces and makes the structural system more rigid. The pre-yield stiffness was found to increase by 39% for infill frame with mesh (B3). The yield displacement was found to reduce by 42% and ultimate displacement reduced by 30% comparing specimens B3 and B2.

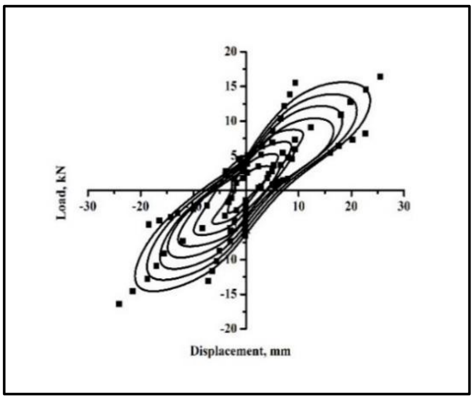

Figure 9. Hysterisis Curve for B3

TABLE 1. Comparitive results of Frame

Specimen	Ki (kN/mm)	Δy (mm)	Δu (mm)	Pu (kN)	μ	Energy dissipation kNm
B2	1.66	2.1	30.6	10.4	14.6	189
B3	2.7	1.2	21.3	16.4	17.6	198

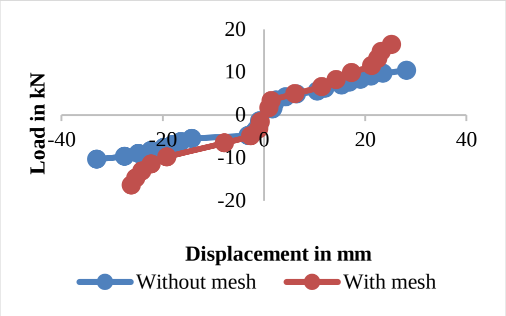

Figure 10. Backbone Curve for B2 and B3

The incorporation of mesh increased the ductility ratio by 16.8 % for specimen B3 compared to B2. The cumulative energy dissipation was estimated as area under the positive curve and the increase in energy dissipation was found to be 4.5% for specimen B3 compared to B2. An increase in strength is evidenced by the increase in the maximum load of 36.6% for B3 compared with B2. The failure pattern observed in the specimens B2 and B3 was diagonal tension. These failure patterns indicate that the failure of the infill is due to weak infill and strong frame. Hence, to prevent the failure of the infill walls the addition of chicken mesh is a viable solution.

4. CONCLUSION

Static cyclic load is applied at the top of the beam using hydraulic actuators in steps of 1kN. Three cycles were given for each increment of loading. From the experimental investigations, yield displacement (Δy), Initial stiffness (Ki), Ultimate loads(Pu), Ultimate displacement(Δu), Ductility (μ) and Cumilative energy dissipation capacity are estimated. It is observed that the incorporation of skin reinforcement for infill walls improved the ductility, energy dissipation, ultimate loads and reduced the displacements. From the hysterisis curves it was further observed that opening and closing of the cracks is greatly reduced. The crack propogation is also seen to reduce due to the presence of skin reinforcement. Since, the weight of the chicken mesh is very less the increase in mass of the structure can be marginal.

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چکیده

مصالح ساختمانی به دلیل استفاده از مصارف و دسترسی به آن به عنوان مصالح ساختمانی به طور گسترده ای مورد استفاده قرار گرفته است. شکست و ترک خوردگی این دیوارهای سنگی در طول زلزله های گذشته اهمیت اطمینان از ایمنی دیواره های پرش را در هنگام بارگذاری جانبی نشان داده است. در صفحه و در نواحی مختلف صفحه، در بسیاری از ساختمان های مسلح بتن مسلح با استفاده از سنگ تراشی دیده می شود. محققان برای جلوگیری از شکست محفظه های دیافراگم بر روی تکنیک های مختلف محوطه سازی مانند ملات تقویت شده ملات، سیمان فریز و پرانتز مورب با استفاده از FRP و غیره کار کرده اند. در این مقاله مش مرغ به عنوان یک روش محصوره مورد استفاده قرار گرفت و تحقیقات تجربی برای افزایش مقاومت و خواص صفحه از دیوارهای سنگ تراشی مانند کشش و برش قطر، در نتیجه بهبود قدرت درون صفحه دیوار فوم سنگ تراشی. برای مطالعه ظرفیت بار جانبی دیوار فیدلر، دو نمونه از این موارد به شمار می آیند: i) دیوار فاقد مش مشبک (B2، ii) دیوار فوری با مش (B3). واحد خالص، یکپارچه ۱: ۳ کاهش یافته است. فریم های RCC طراحی شده به عنوان نگرش آینده در هر کدام با مقیاس کوچک ساخته شده برای آجر برای ساخت دیوار استفاده گردید.

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