Strengthening of masonry wallette with opening using geotextile

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Abstract -*The out -of -plane performance and in-plane behaviour of masonry wallettes with opening strengthened with non- woven geotextile was studied. The wallettes were strengthened on both sides. The patterns used were vertical and cross. Finite element analysis using ANSYS is carried out to find the out-of-plane performance and in-plane behaviour of the masonry wallettes. The results showed less brittle behaviour compared to the un-strengthened wallette. Also, the strengthening using geotextile enhanced the load carrying capacity and cross pattern was found more effective. Therefore, geotextile can be ideally used to strengthen masonry buildings in seismic prone areas.*

Key Words: Out- of -plane, In- plane, Masonry wallettes, Geotextile.

1.INTRODUCTION

Masonry is one of the oldest forms of construction. It is widely used due to its low cost, availability, thermal insulation, ease of construction etc. But masonry buildings have performed the worst in the history of past earthquakes. This not only leads to maximum structural damage but also leads to loss of life. Here comes the necessity of strengthening of masonry structures. Since a lot of historic structures too are made of masonry, it is really important to address the remediation, retrofit and seismic upgrading of such structures. It is also important to consider techniques that are less invasive in order to preserve the architectural and heritage values of the historic structures. A masonry wall experiences out-of-plane bending and in-plane shear during an earthquake. In out-of-plane, flexural bending of the plane is caused as a result of the load acting on the walls in the perpendicular direction where as in plane failure mechanisms includes shear failure, sliding failure, rocking failure and toe crushing failure. Various studies have been done over a number of years to develop strengthening techniques which will improve the performance of masonry. Strengthening methods such as the addition of new structural elements, steel plate bonding, external post tensioning, steel bracing, Fibre Reinforced Polymer (FRP) and many more have been applied with some degree of success. However, an innovative retrofitting technique using geotextile has recently gained recognition and acceptance.

The present study was conducted on masonry wallettes with opening. Both un- strengthened and strengthened wallettes were analysed. The in-plane and out-of-plane performance of the wallettes with opening strengthened using geotextile was studied. The wallettes were strengthened using two different patterns that is vertical and cross. Also, the strengthening was done on both sides of the wallettes.

1.1 Model definition

The dimension of the brick was 250mmX 125mmX 75mm.The dimension of the opening was 140mmX 125mmX 75mm.The mortar head joint and bed joint dimensions are 10mm and 12.5mm respectively. Seven courses of clay bricks were used to construct each wallette. The mortar is modelled in the Drucker-Prager formulation. For mortar the mesh size is 10mm and for brick the mesh size is kept 25mm.Perfect bond was assumed between mortar joint and brick unit. The in-plane behaviour is simulated under diagonal compression test whereas the out-of-plane performance is simulated under the four-point bending test. The properties of the masonry and geotextile are shown in the table below.

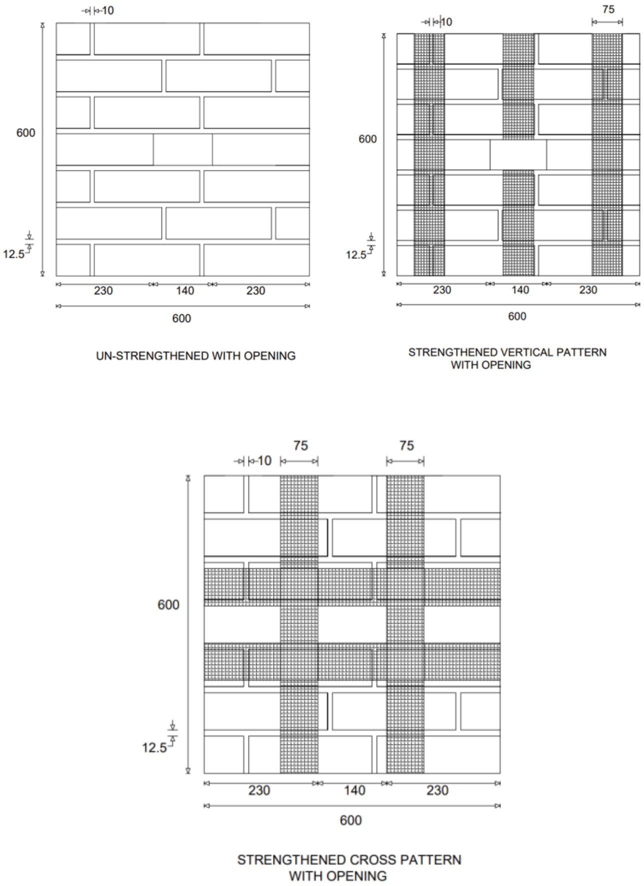
Table -1: Properties of the constituents of masonry

Properties	Brick	Mortar
Density, (kg/m^3)	1800	2200
Elasticity modulus, E (MPa)	2000	4000
Poisson's ratio	0.16	0.21
Ultimate tensile strength, f_t (MPa)	1.46	0.66
Ultimate compressive strength, f_c (MPa)	9.43	4.46

Table -2: Mechanical properties of non-woven geotextiles

Properties	Value
Tensile strength (MPa)	0.16
Young's modulus (MPa)	15700
Poisson's ratio	0.3
Thickness (mm)	2.1

In this study, masonry wallettes were strengthened using geotextile on both sides and mainly two patterns that is vertical and cross were considered. Both un-strengthened and strengthened wallettes were taken for the analysis to compare the results. Since the analysis was done to understand both in-plane and out-of-plane performances two sets of each wallette shown in Fig 1 were modelled in ANSYS.



ALL DIMENSIONS ARE IN "mm"

Fig -1: Details of masonry panels

2.OUT-OF-PLANE BENDING OF MASONRY WALLETTE STRENGTHENED USING GEOTEXTILE

2.1 Un-strengthened- Out-of-plane

Un-strengthened masonry wallette with opening was considered and it was subjected to four-point bending to find out the failure load. Fig 2 shows the model of the un-strengthened masonry wallette whereas fig 3 and 4 shows the total deformation and equivalent plastic strain results of the un-strengthened wallette.

The results showed a failure with displacement 1.0577mm under 73.423 kN load. The load displacement graph is shown in Chart 1.

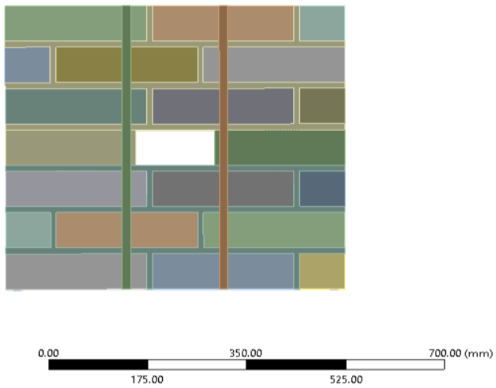


Fig -2: Model of un-strengthened wallette

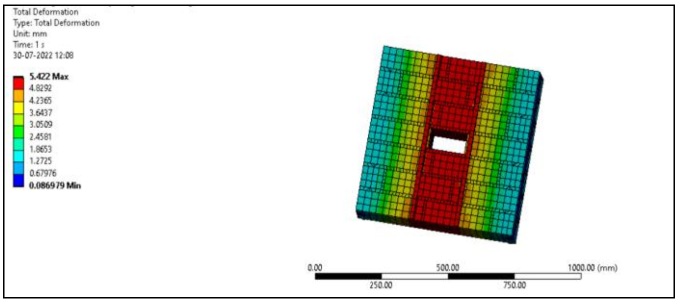


Fig -2: Total deformation of un-strengthened wallette

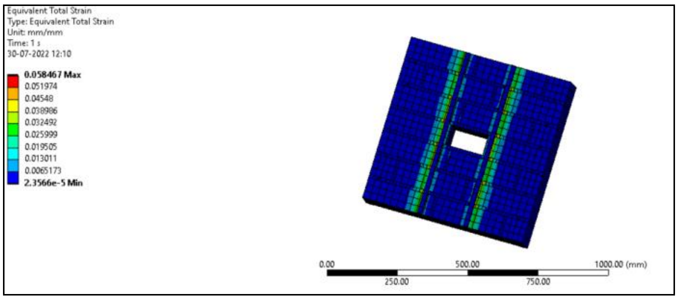


Fig -3: Equivalent plastic strain of un-strengthened wallette

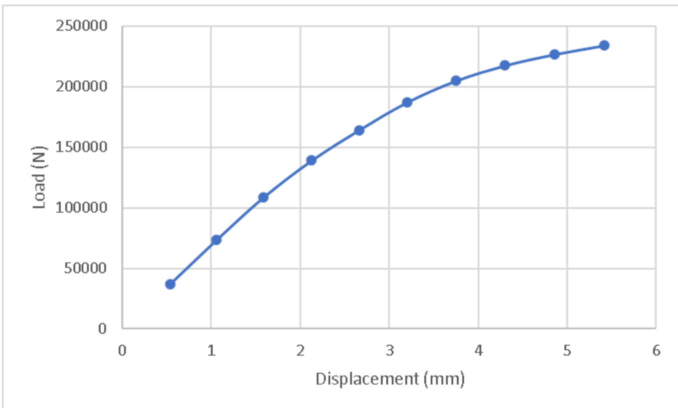


Chart -1: Un-strengthened- Load vs Displacement graph

2.2 Vertical pattern -Out-of-plane

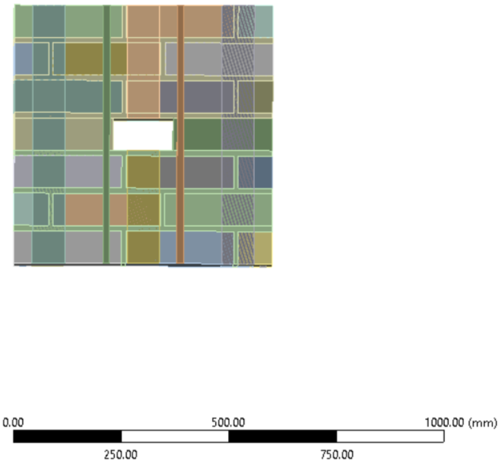


Fig -4: Model of wallette strengthened with vertical pattern

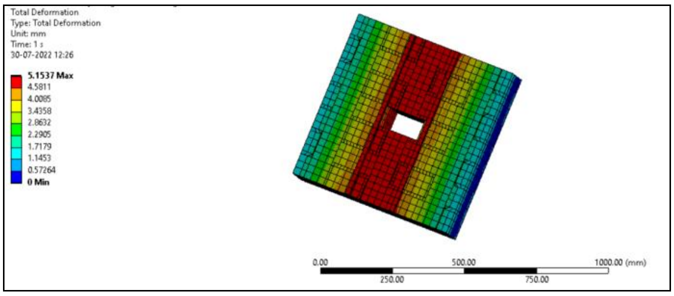


Fig -5: Total deformation of wallette strengthened with vertical pattern

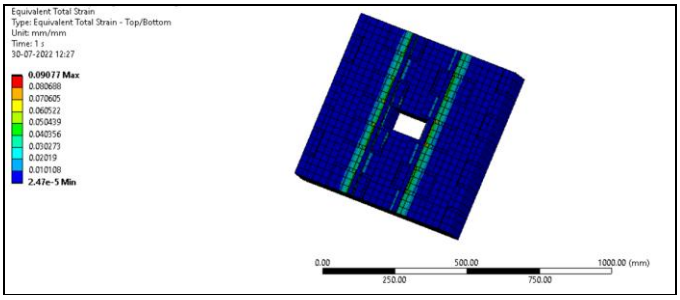


Fig -6: Equivalent plastic strain of wallette strengthened with vertical pattern

The results showed a failure with displacement 0.89593mm under 109.22 kN load. The load displacement graph is shown in Chart 2.

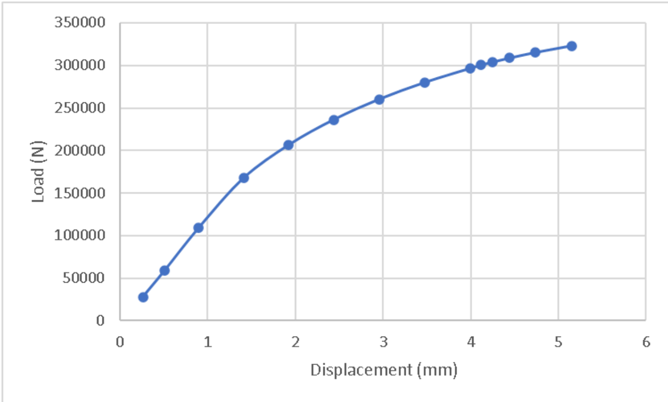


Chart -2: Vertical pattern- Load vs Displacement graph

2.3 Cross pattern-Out-of-plane

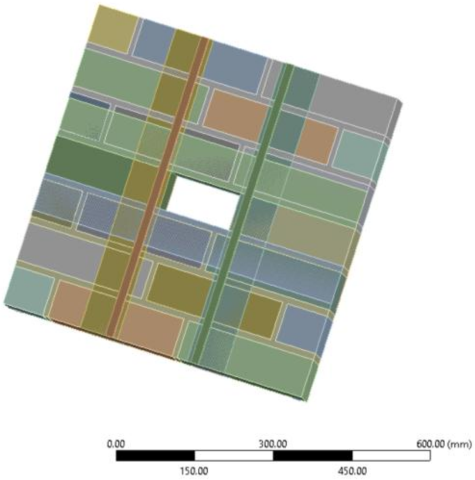


Fig -7: Model of wallette strengthened with cross pattern

The results showed a failure with displacement 2.4956 mm under 177.43 kN load. The load displacement graph is shown in Chart 3.

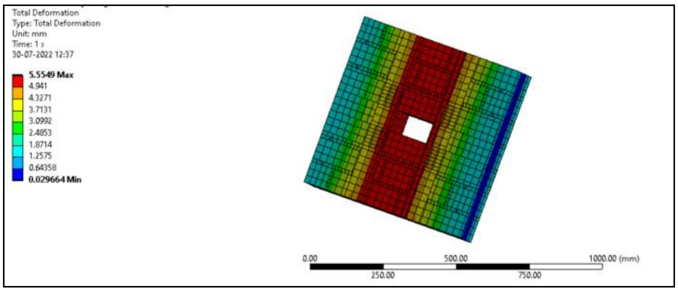


Fig -8: Total deformation of wallette strengthened with cross pattern

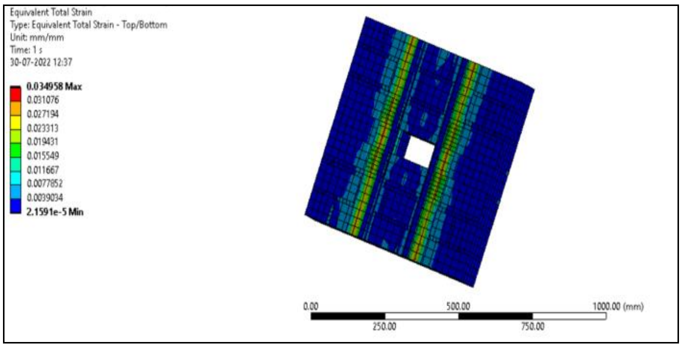


Fig -9: Equivalent plastic strain of wallette strengthened with cross pattern

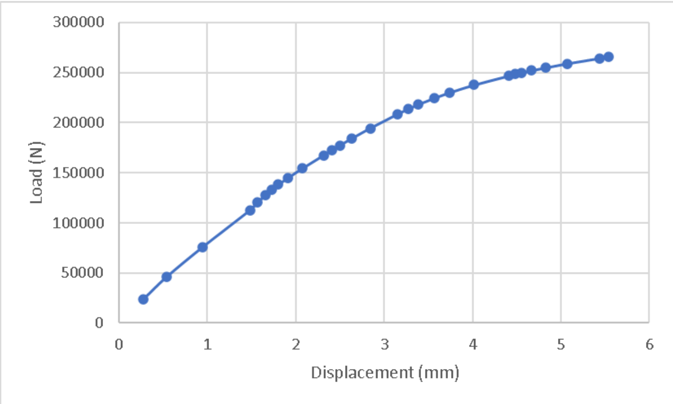


Chart -3: Cross pattern- Load vs Displacement graph

3.IN-PLANE STRENGTH OF MASONRY WALLETTE STRENGTHENED USING GEOTEXTILE

3.1 Un-strengthened- In-plane

Un-strengthened masonry wallette with opening was considered and it was subjected to diagonal compression to find out the failure load.

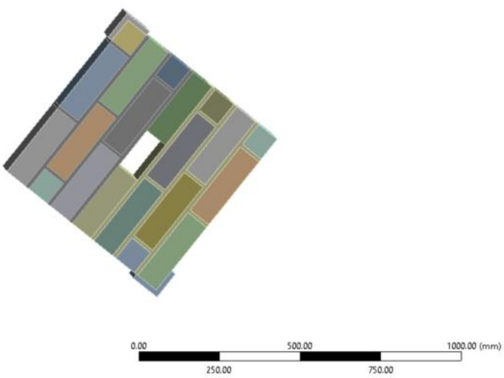


Fig -10: Model of un-strengthened wallette subjected to diagonal compression

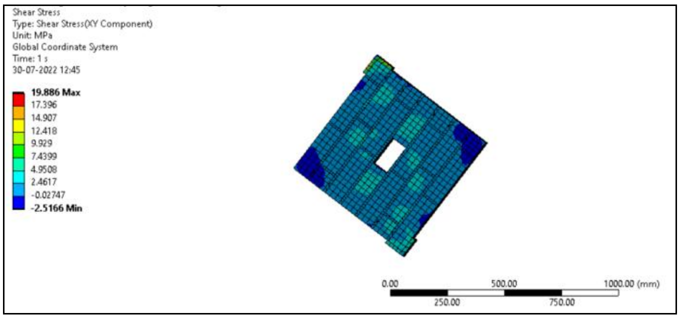


Fig -11: Shear stress contour for un-strengthened wallette.

The results showed a failure with displacement 0.87816mm under 47.792 kN load. The load displacement graph is shown in Chart 4.

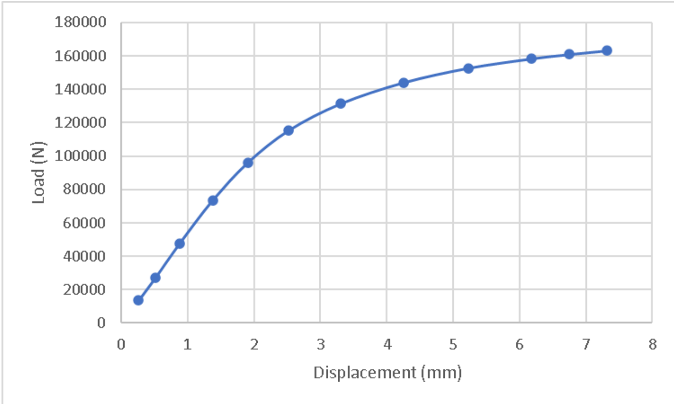


Chart -4: In-plane Un-strengthened- Load vs Displacement graph

3.2Vertical pattern-In-plane

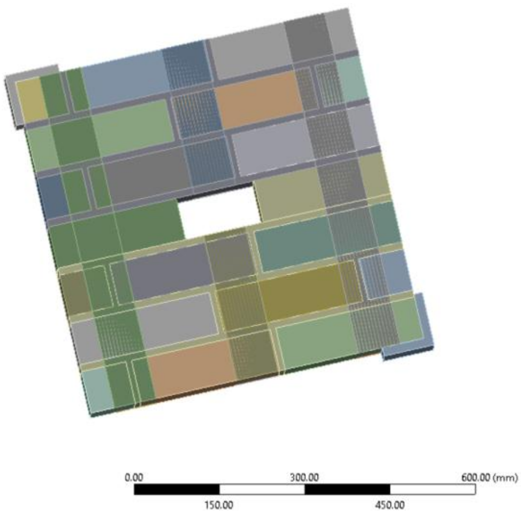


Fig -12: Model of strengthened Wallette with vertical pattern subjected to diagonal compression

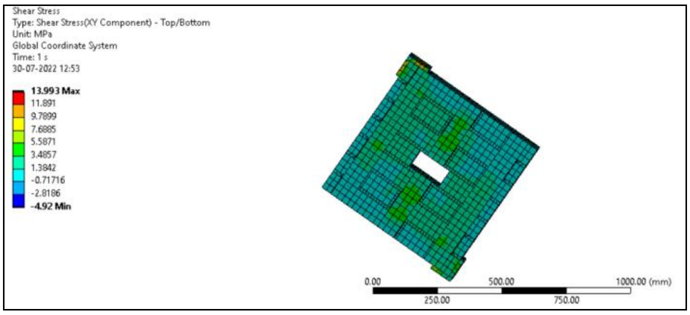


Fig -13: Shear stress contour for strengthened wallette with vertical pattern

The results showed a failure with displacement 1.2685mm mm under 64.030 kN load. The load displacement graph is shown in Chart 5.

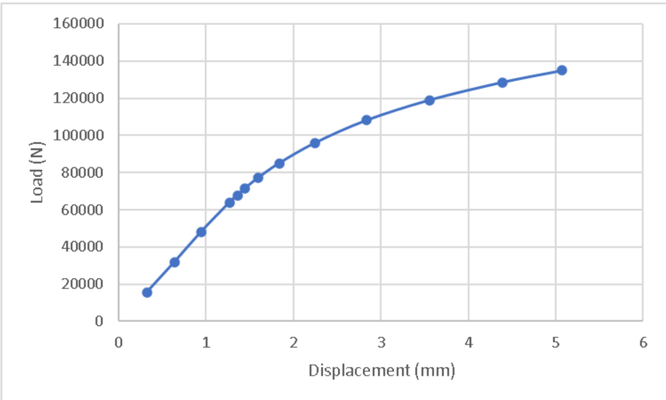


Chart -5: In-plane Vertical pattern- Load vs Displacement graph

3.3 Cross pattern-In-plane

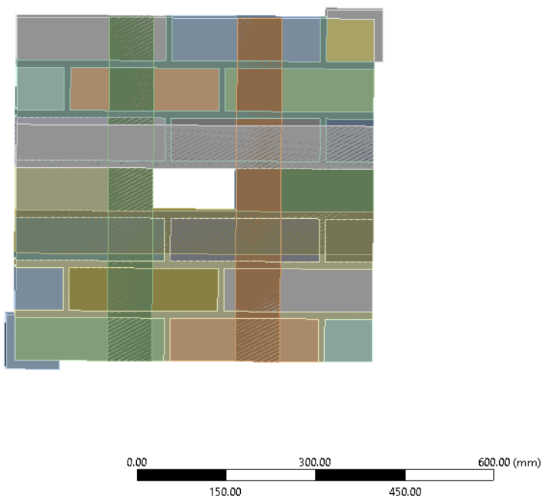


Fig -14: Model of strengthened Wallette with cross pattern subjected to diagonal compression

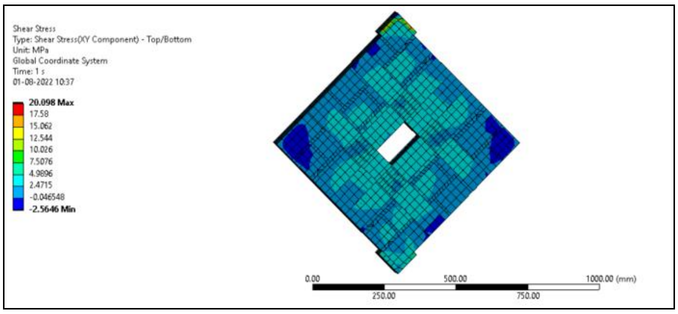


Fig -15: Shear stress contour for strengthened wallette with cross pattern

The results showed a failure with displacement 1.6447mm under 88.735 kN load. The load displacement graph is shown in Chart 6.

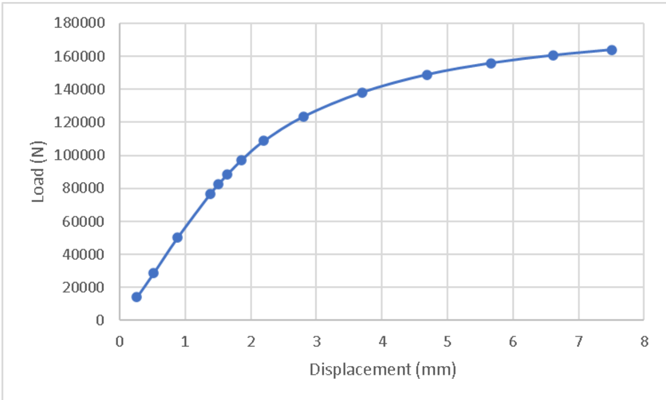


Chart -6: In-plane Cross pattern- Load vs Displacement graph

4. CONCLUSIONS

- Out of plane-From the study it was understood that the load carrying capability increases with maximum177.43 kN for cross pattern compared to the un-strengthened and vertical pattern. Even though the cross pattern was found to be more effective than the vertical pattern, the results showed that vertical pattern too provided a load carrying capability of 109.22 kN which when compared to the un-strengthened was found effective.

- In plane-The strengthened panels increased the failure load from47.792 kN to 88.735 kN. The cross pattern was found to be more effective than the other pattern. The vertical pattern too provided a load carrying capability of 64.030 kN.

- Therefore, from the above study and comparison of results it can be concluded that geotextile can be successfully used for strengthening masonry structures subjected to both in-plane and out of plane bending. The above technique was successful in enhancing the structural strength and seismic upgrading of the masonry structures. Also, can be used to preserve historic masonry structures.

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