Parametric Study on Diagonal Shear Behavior of Masonry Wall Retrofitted by PP-band Mesh

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1. Introduction

PP-band mesh retrofit technology is a simple, economical and efficient retrofit method developed at International Centre for Urban Safety Engineering (Meguro Lab), Institute of Industrial Science, The University of Tokyo. This technology has been developed considering retrofitting material availability, economical affordability and social acceptability together with technical feasibility for masonry buildings in earthquake prone regions.

To evaluate the beneficial effects of the proposed PP-band mesh retrofit technology, diagonal shear tests were carried out on masonry wallettes with and without retrofitting for burned bricks. In addition to them, efficiency of different meshes pitch and effect of looseness in attachment were also examined. The test results are reported in this paper.

2. Axial Tensile Test of Polypropylene Bands

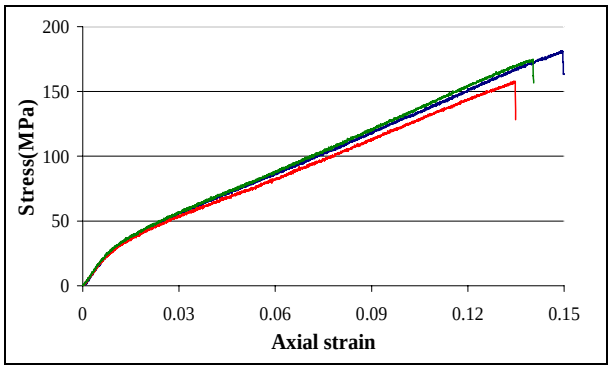


Figure 1: Behavior of PP-band under tension

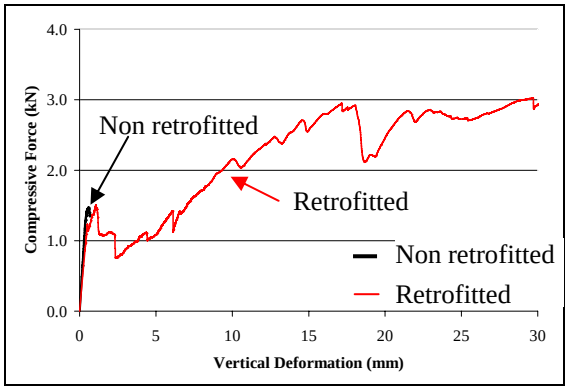
Preliminary testing of the PP-band was carried out to check its deformational properties and strength. To determine the modulus of elasticity and ultimate strain, 3 bands were tested under uni-axial tensile test. The test was carried out under displacement control condition. The results are shown in Figure 1. To calculate the stress in the band, its nominal cross section $15.5\times0.6mm^2$ was used.

All of the bands exhibited a large deformation capacity, with more than 13% axial strain. The stress-strain curve is fairly bilinear with an initial and residual modulus of elasticity of 3,200MPa and 1,000MPa, respectively. Considering its large deformation capacity, it is expected that it will contribute to improve the structure ductility.

3. Diagonal Shear Test

To evaluate the beneficial effects of PP-band mesh retrofit technology, diagonal shear tests were carried out on masonry wallettes with and without retrofitting [1]. The wallette dimensions were $275\times275\times50$ mm^3 and consisted of 7 brick row of 3.5 brick each. The mortar joint thickness was 5mm. Cement/Water ratio of cement mortar used was 0.14.

(a) Failure patterns of masonry wallettes with and without retrofitting by PP-band mesh



(b) Force vs. vertical deformation for masonry wallettes with and without retrofitting

Figure 2: Diagonal shear Test Results

Figure 2(a) shows the non-retrofitted and retrofitted specimens at the end of the test, which corresponded to vertical deformations equal to 0.71mm and 50mm, respectively. In the non-retrofitted case, the specimens split into two pieces after the first diagonal crack occurred and no residual strength was left. In the retrofitted case, diagonal cracks appear progressively, each new crack followed by a strength drop. Although the PP-band mesh influence was not observed before the first cracking, after it, each strength drop was quickly regained due to the PP-band mesh effect. Although at the end of the test almost all the mortar joints were cracked, the retrofitted wallettes did not lose stability.

Figure 2(b) shows the diagonal shear strength variation with vertical deformation for the non-retrofitted and retrofitted specimens. In the non-retrofitted case, the average initial strength was 1.5kN and there was no residual strength after the first crack. However, in the retrofitted case, although the initial cracking was followed by a sharp drop,

at least 50% of the peak strength remained. Subsequent drops were associated with new cracks like the one observed at the deformation of 4mm. After this, the strength was regained by readjusting and packing by PP-band mesh. When the strength exceeded 3.0kN individual PP-bands started to fail. However, this did not reduce considerably strength of the specimen, because stresses redistributed to other PP-bands. The specimen quickly recovered its strength. The final strength of the specimen was equal to 3.0kN relatively higher than initial strength of 1.5kN.

4. Effect of PP-band mesh pitch and attachment condition

For retrofitted specimen, four cases varying PP-band mesh pitch of 33mm, 40mm, 50mm, 66mm were used for retrofitting keeping other parameters same. To easy compare the behavior of retrofitted masonry wallettes; the behavior idealized as shown in Figure 4. Initial strength (Vo) and Initial stiffness (Ko) were mainly depend on the masonry properties. Residual strength after initial crack (Vr) and residual stiffness (Kr) mainly depend on PP-band properties.

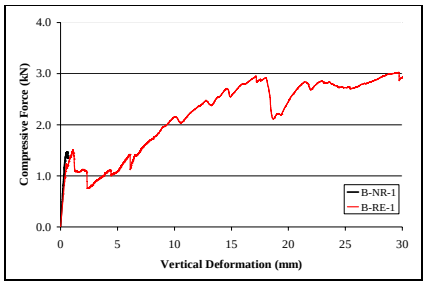


Figure 3: Real behavior

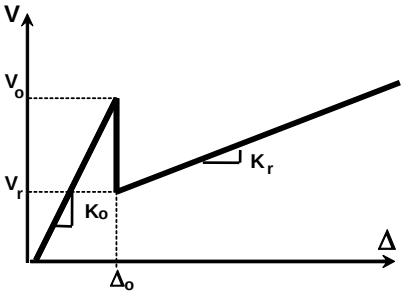


Figure 4: Ideal behavior

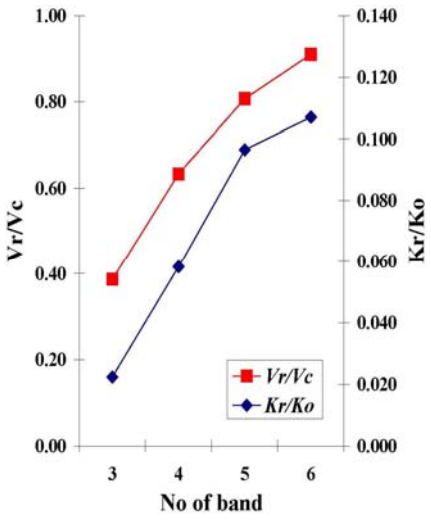


Figure 5 : Effect of pitch of PP- band mesh

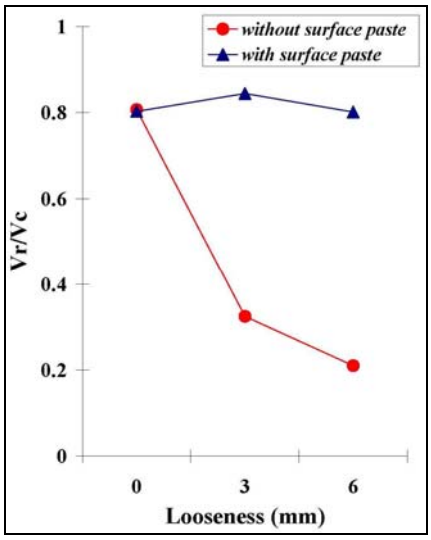


Figure 6 : Effect of looseness between PP-band mesh and wallette

Figure 5 shows the residual strength/ initial strength (Vr/Vo) variation with number of PP-band per one side of the masonry wallette. From the experiment it was found that there is a significant role of PP-band pitch in behavior of masonry wallettes.

In General residual strength of masonry wallette was directly proportional to number of PP-band per wallette. But this rule only follows for up to some optimum value of PP-band mesh amount. After that not much influence was observed in increase in residual strength, even increase in PP-band mesh amount. Although in residual stiffness too similar behavior was observed.

Figure 6 shows the residual strength/ initial strength (Vr/Vo) variation with looseness of attachment between PP-band mesh and masonry wallettes. The result shows that; when there is looseness it's highly reduce the residual strength of the masonry wallettes after initial crack. Bet when we applied the surface paste above the masonry wallette, due to surface paste fill the gap between PP-band mesh and masonry wallette; even the after initial crack at least 80% of the initial strength remained.

5. Conclusion

The diagonal shear tests showed that:

(1) In the retrofitted case, larger residual strength after the formation of the first diagonal shear cracks was observed. Furthermore, as deformation increased, the wallette achieved strength higher than the initial cracking strength.
(2) The retrofitted wallettes achieved at least over 2.5 times larger strengths and 45 times larger deformations than the non-retrofitted wallettes did.
(3) In the retrofitted case, residual strength directly proportional to PP-band density
(4) Looseness of the PP-band attachment with specimen reduces the residual strength of the specimen. But application of surface paste makes beneficial effect in residual strength.

References

(1) Sathiparan N., Mayorca P., Nesheli K., Ramesh G., and Meguro K. (2005). "*In-plane and out-of-plane behavior of pp-band retrofitted masonry wallettes*", Proc. of the 4th International Symposium on New technologies for urban Safety of Mega Cities in Asia, 18-19 Oct 2005, Nanyang Technological University, Singapore, Page 231-240.