Experimental Study on Out-of-Plane Behavior of Masonry Wallettes Retrofitted by PP-Band Meshes

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1. Introduction

Unreinforced masonry is one of the most popularly used construction materials in the world. It is also unfortunately, the most vulnerable during earthquakes. This combined with the widespread use of masonry in earthquake prone regions of the world has resulted in a large number of casualties due to the collapse of this type of structures. This is a serious problem for the societies. Apparently, its solution is straight forward: retrofitting the existing structures. Several methods have been proposed to improve strength, ductility and energy dissipation capability of masonry structures. However, in developing countries, retrofitting masonry structures should be economic, the retrofitting material, accessible, and the workmanship, locally available. Considering these points, a new retrofitting technique has been proposed based on the use of polypropylene band (PP-band) meshes. PP-band is commonly utilized for packing and it is available all over the world at a very low price.

To evaluate the beneficial effects of the proposed PP-band mesh retrofitting method, out-of-plane tests were carried out on masonry wallettes with and without retrofitting. From tests results, which are highlighted in the paper, it could be seen that PP-band retrofitted masonry wallettes had larger residual strength after the first crack in out-of-plane loading. It was clear that PP-band mesh retrofitting improved the overall stability and ductility of the structure.

2. Axial tensile test of Polypropylene bands

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 method. The results are shown in Figure 1. To calculate the stress in the band, its nominal cross section 15.5×0.6mm^2 was used.

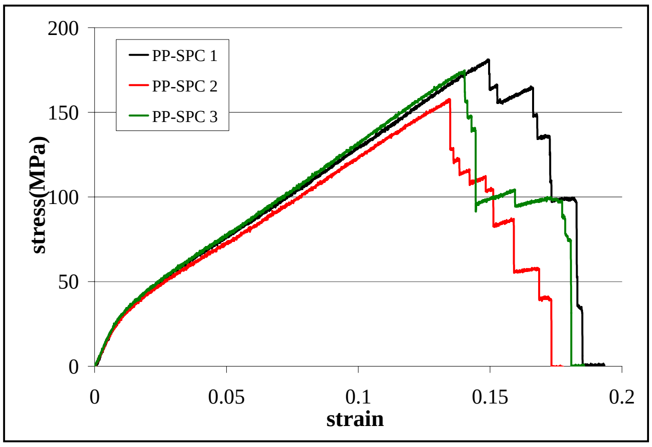

Figure 1 Behavior of PP-band under tension

All the bands exhibited a large deformation capacity more than 13% strain. The stress-strain curve is fairly bilinear with an initial and residual modulus of elasticity of 3.19 GPa and 1.06 GPa, respectively. Given its large deformation capacity, it is expected that it will contribute to improve the structural ductility. Also progress failure was observed after PP-band reached its peak strength. This behavior was due to the individual failure of PP-band fibers as shown in Figure 2.

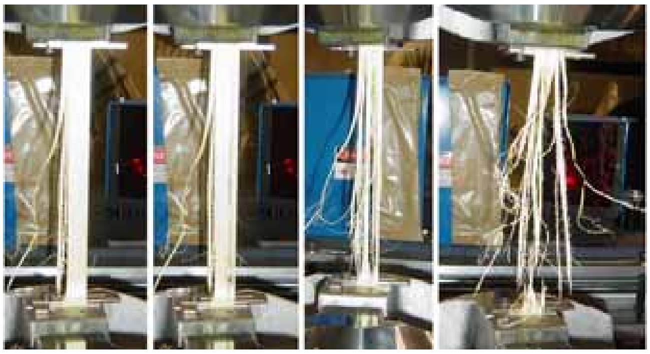

Figure 2 Failure pattern of PP-band under tensile force

3. Out-of-plane test

Out-of-plane tests were carried out, in order to investigate the PP-band mesh effectiveness in walls exhibiting arching action. The nominal dimensions of these walls were 475mm by 235mm; their thickness was 50mm. A total of 6 wire connectors were used to attach the meshes with masonry wallettes. Considering the stability of the specimens, cement/water ratios equal to 0.25 and 0.45 were used for burned and unburned brick, respectively.

Bond tests were performed to characterize the engineering properties of the material used in the investigation. The average tensile strength of burned brick and unburned brick masonry obtained from bond test were 0.162MPa and 0.006MPa, respectively.

The specimens were named according to the following convention: **M-T** in which **M** is **B**: Burned or **U**: Unburned; **T** is **NR**: Non-retrofitted or **RE**: Retrofitted by overlapping of PP-band meshes and wire connectors.

Specimens were tested 28 days after construction under displacement control. The wallettes were simply supported with a 440mm span. Steel rods were used to support the wallettes at the two ends. The masonry wallettes were tested under a line load which was applied by a 20mm diameter steel rod at the mid-span of the wallettes. The loading rate was 0.05mm/min for the non-retrofitted case. For the retrofitted case, it was also 0.05mm/min for the first 30mm vertical deflection, and then it was increased to 2mm/min for the remaining test period. The retrofitted wallettes were applied up to 60mm vertical displacement. The test setup is shown in Figure 3.

Key Word: unreinforced masonry, polypropylene band,out-of-plane test, residual strength, wire connectors, wallettes
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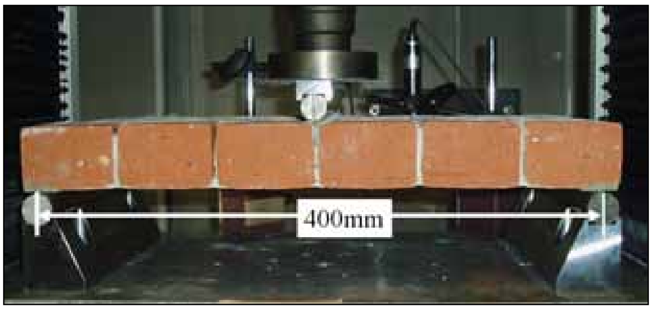

Figure 3 Out-of-plane test setup

Figure 4 shows the non-retrofitted and retrofitted masonry wallettes at the end of the test, which corresponded to a mid-span net deformation (deformation at wallette centre point) equal to 2.8mm and 70.0mm, respectively. In the non-retrofitted case, the specimens split in two pieces just after the first crack occurred at mid-span, and no residual strength was left. In the retrofitted case, on the other hand, although PP-band mesh influence was not observed before the first cracking, after it, strength was regained progressively due to the PP-band mesh effect.

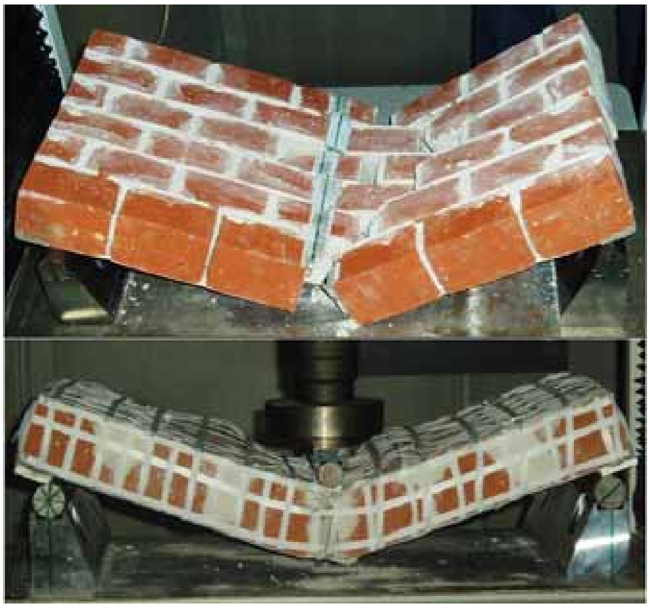

Figure 4 Failure patterns of brick masonry wallettes without and with retrofitting

Figure 5 shows the out-of-plane load variation in terms of net vertical deformation for the non-retrofitted and retrofitted wallettes in the mid-span. For burned brick, in the non-retofitted case, the initial strength was 0.63 kN and there was some residual strength remaining for further small amount of deformation after the first crack. This behavior was observed due to interlocking between bricks and also the application of load under displacement control. In the retrofitted case, although the initial cracking was followed by a sharp drop, at least 45% of the peak strength remained.

As expected, the initial strength of the burned brick was relatively higher than that of the unburned brick. Even higher cement/water ratio was used for unburned brick, the poor bonding between mortar and unit led to separation along the brick and mortar. On the other hand, in the burned brick case, failure occurred within the mortar. This behavior highly influenced the initial strength of the specimens.

After the initial drop in strength, the mesh presence positively influenced the wallette behavior. Both types of retrofitted brick wallettes showed similar behavior in strength up to a net vertical deformation equal to 8mm. At this point, brick crushing was observed in the unburned brick case. Due to that, the overall strength of the unburned brick wallettes was considerably smaller than that of burned brick wallettes. There after, if two types of bricks are compared, almost 40% difference in strength was observed.

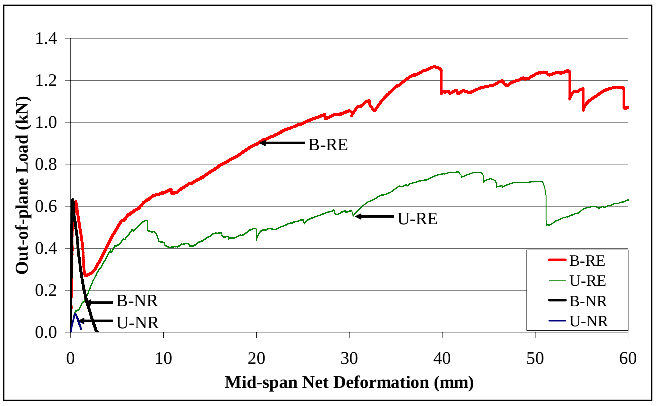

Figure 5 Out-of-plane load variations in terms of net vertical deformation

4. Conclusions

This paper discusses the results of a series of out-of-plane tests that were carried out on non-retrofitted and retrofitted wallettes. The tests showed that,

1. In the non-retrofitted case, the specimens split in two pieces just after the first crack occurred at mid-span and no residual strength was left.
2. In the retrofitted case, on the other hand, PP-band mesh influence was not observed before the first cracking. After cracking, strength was regained progressively due to the PP-band mesh effect.
3. Initial strength of the burned brick was relatively higher than that of unburned brick.
4. Both types of brick wallettes showed the same behavior in strength up to vertical deformation equal to 8mm. but after that point, in the unburned brick case, individual crushing was observed. Due to that overall strength of the unburned brick wallettes considerably reduced compared with burned brick wallettes. There after if two type of bricks are compared, almost 40% of difference in strength was observed.

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Reference:

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