# AN INNOVATIVE AND COST-EFFECTIVE APPROACH TO MASONRY CONSTRUCTION RENOVATION

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**ABSTRACT**

Because of its low cost and ease of construction, masonry constructions are frequently used. Every year, earthquakes cause the collapse of masonry buildings, killing or injuring many people despite the existence of building codes for earthquake-resistant homes. It's vital to consider both the cost of materials and the ease of building when trying to get the general public interested in upgrading existing brick houses. Polypropylene bands embedded in a cement mortar overlay are used in this new retrofitting approach for brick and stone structures. Shear test results for unreinforced and reinforced walls are provided and analysed.

**Key words:** Masonry renovation, earthquake damage, polypropylene band, shear wall, experiment, mortar overlay.

## Introduction

Because of its low cost and ease of construction, using concrete is a widespread building method around the world. The world's unbaked soil is home to more than a third of the world's people **(Guillaud & Houben, 1994)** Earthquake-related human deaths were caused primarily by unreinforced masonry structures failing, which resulted in more than 60% of deaths over the last century. Masonry constructions' seismic sensitivity has long been recognised, and much effort has gone into formulating suggestions for earthquake-resistant housing construction. Despite this, earthquake-caused brick building collapses kill or injure individuals every year, according to reports. There are a multitude of options to adapt unreinforced masonry buildings.. This article takes a comprehensive look at them. **(Mayora & Meguro, n.d.)**. Retrofitting operations can be divided into four categories: 1) grout and epoxy injection, 2) surface coatings, 3) reinforced or post-tensioned cores, and 4) the installation of structural sections. The structural integrity of stone projects can be preserved while being greatly enhanced using these methods. A multitude of retrofitting options exist, each having pros and cons. Unreinforced masonry constructions in developing countries can be made more seismically resistant by using a retrofitting process that not only improves efficiency but also ensures safety (strength, ductility and energy dissipation). The materials used are inexpensive and widely available in the area, and the level of labour expertise required is small. These factors should be considered. When it comes to retrofitting unreinforced masonry structures, a new solution has been proposed.

## 2. Novel innovative method

As a result of the foregoing, we offer a brand-new renovation technique utilising polypropylene bands (PP-bands) embedded in a cement mortar overlay, laid out in a mesh pattern. These bands are widely utilised in the packaging industry all over the world. Their low cost is matched by their high level of resistance and ease of handling. On another page, we go into greater depth about the retrofitting process4. In the following, we'll give you a quick rundown of the setup process. This is done by first setting up PP-bands with different pitches and angles depending on the needed seismic resistance**(Coburn & Spence, 2003).** After that, the masonry surfaces are cleaned and four times the mesh pitch-spaced holes are drilled through the wall. It's then time to install and secure the PP-band meshes, which will cover both wall surfaces. To keep the mesh in place, galvanised steel wires are threaded through the wall apertures. The wall is still in the planning stages, as evidenced by photo 1. After that, a mortar overlay is applied to the wall to complete the installation.

## 3. Experimental program

Eight masonry walls were erected, four with and four without reinforcement, to test the effectiveness of retrofitting with PP-band mesh. a brick wall measuring 985x1072x100mm with 4.5 bricks in each row **(Abrams, 2001).** The building material of choice was clay brick. The cement-to-sand volume ratio was 1:4.5 with a joint thickness of 10mm. Steel channels were used to hold the bricks in place at the bottom and top. For fourteen days, water spray healed the walls. The upper channel was fitted after the curing process was complete. The test apparatus and specimen dimensions are shown in

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Figure 1. Each modified wall received two meshes. The mesh pitch was set at 45mm to ensure that at least three bands spanned each brick. Due to the strength of the bricks, the 27 connectors were only used at the mortar interface. Because of this restriction, the band's inclination could only be set to 50 degrees. For the 8mm thick protective overlay, a cement mortar mix (cement to sand: 1:3) was employed **(Erbay & Abrams, 2001).** Figure 1: Setup for the experiment and measurements in millimetres six horizontal rods had their bottom ends bolted shut to apply a vertical pre-compression load. Each time the applied force increased, they paid great attention to it. It was therefore decided on where to put the actuator in order to adjust any force imbalances on the vertical rods that existed. The horizontal loading was finally applied using a hydraulic pump that was manually operated after five steps. The first stage was to apply pressure on the wall until it started to break in the middle. A 10mm push in the same direction on the wall immediately followed. Phase three involved switching the actuator's displacement direction and loading the specimen until a diagonal crack emerged in the other direction. In the fourth phase, an additional 10mm of weight was applied to the wall in the same direction. The wall has to be unloaded at some point. The summary of the experiment programme can be found in Table 1. Masonry built with this brick was much stronger than that found in poor countries because of the brick's great strength. Some of the walls had holes bored through them in order to purposely reduce the wall's strength and emphasise the retrofitting effect. It was decided to consider uniform and diagonal hole distributions. **(Guillaud & Houben, 1994)**

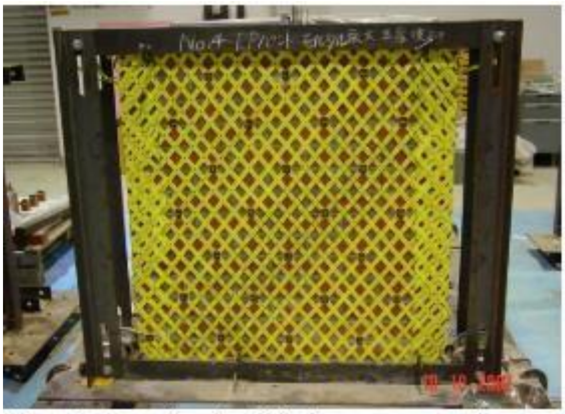

**Photo 1** Retrofitted wall before mortar overlay setting

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| Case name | VL (kN) | PP-band | Mortar | Holes |
|---|---|---|---|---|
| Bare wall | 9 | | | None |
| Bare wall w/ holes | 9 | | | Uniform |
| Bare wall w/mortar | 9 | | O | None |
| Reinforced wall | 9 | O | O | None |
| Reinforced wall w/ holes | 9 | O | O | Uniform |
| Bare wall w/mortar | 30 | | O | None |
| Reinforced wall | 30 | O | O | None |
| Reinforced wall w/ diagonal holes | 30 | O | O | Diagonal |

**Table 1** Summary of experiment conditions Case

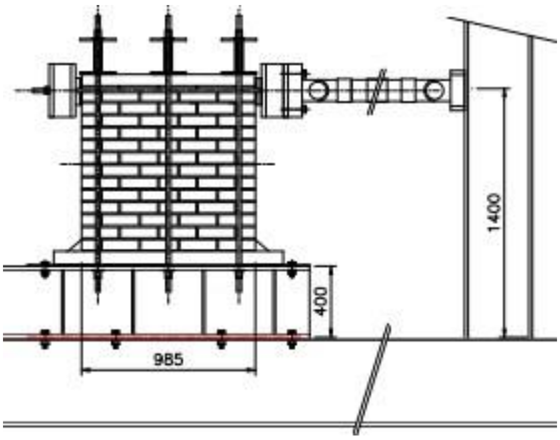


**Figure 1** Test setup and dimensions in mm **(Abrams, 2001)**

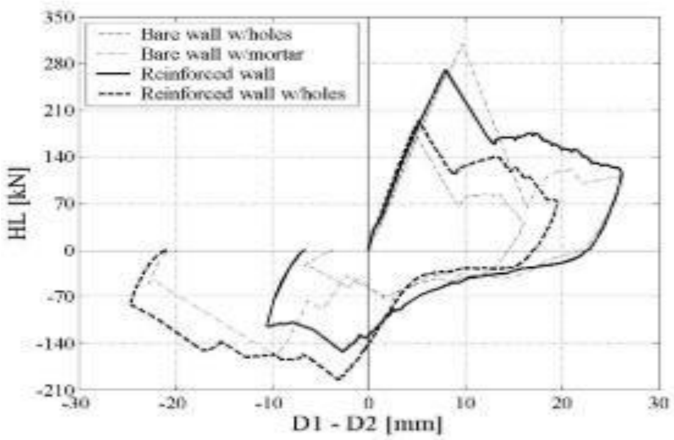


**Figure 2.**Force-deformation curve (VL=9kN)**(Mayorca & Meguro, 2003)**

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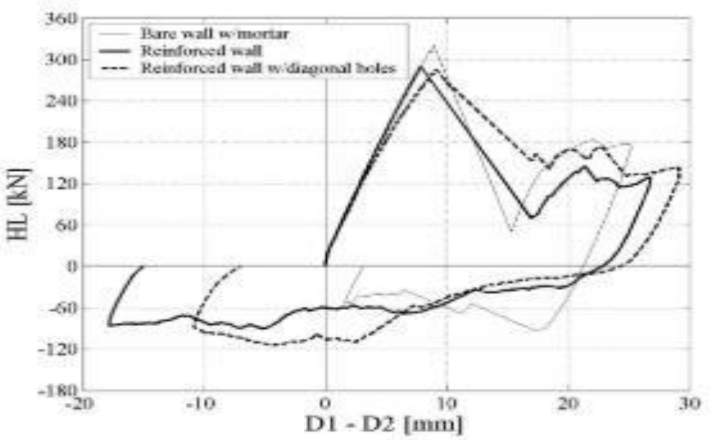


**Figure 3** Force-deformation curve (VL=30kN) release**d(Mayorca & Meguro, 2003)**

### 4. Results discussion

Pictures 2 and 3 depict crack patterns. Figures 2 and 3 show force-deformation curves grouped by pre-compression load from several experiments. The following section summarises the experiment's findings.

Reinforcing does not change the pattern of cracks as shown in photographs 2 and 3. Early in both loading processes, flexural forces caused a crack in the lowest layer of mortar. This crack grew wider and longer as the horizontal load increased. Because the crack in the reinforced walls proceeded slowly, the force-deformation curve did not reveal a drop in wall strength. This impact may be seen on 9kN VL walls. When the shear-flexural mechanism delivered horizontal force to the support, the flexural crack permitted a compression strut to withstand it. The specimen stresses had been building up due to the bottom crack's failure to propagate when a diagonal crack appeared. After the first diagonal crack developed, the failed wall's strength was notoriously reduced, and the imposed deformation that followed was linked to the movement of the failing wall's upper half. As soon as the load was reversed, the flexural cracking stopped completely. The biggest shift occurred along the top of the wall. After the initial shear crack closed, the stresses re-accumulated, resulting in the emergence of a second diagonal crack on the opposite diagonal. Between the unreinforced and

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reinforced walls, the biggest difference was in the pace at which cracks propagated, rather than where they first formed.

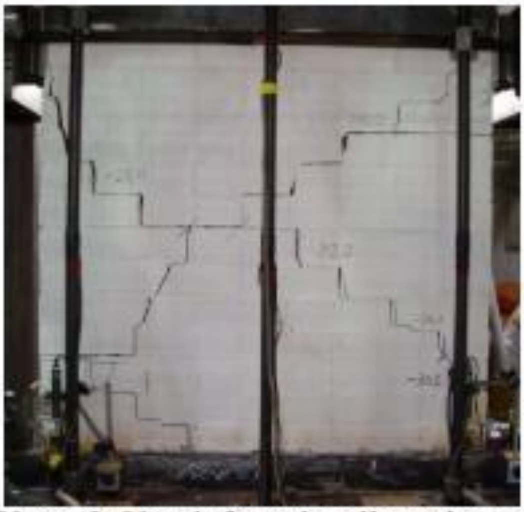

**Photo 2**. Unreinforced wall crack pattern

**(2) Stiffness** With regard to stiffness, reinforced walls exhibit a slight increase, as seen in Figure 2. The deformations depicted in the images are a result of two factors: the deformation of the walls themselves, and the wall's overall rotation. The latter is more substantial. For example, in Figure 4, the shear deformation can be seen along the diagonals of the wall. Remarkably, there isn't much difference between reinforced and unreinforced walls when it comes to distortion Because of this stiffness difference, it may be concluded that the reinforcement restraint on wall rotation is primarily to blame for the force deformation curves' stiffness discrepancy.

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**Photo 3**. Reinforced wall crack pattern

**(3) Peak strength** The PP-bands are significantly less rigid than the masonry walls. Thus, they had no impact on the peak strength of the wall in any way! There are a few variances, but they are all related to the existence of mortar overlay, the bonding of the mortar overlay to the masonry wall, and changes in the masonry's properties as a result of the workmen's handiwork. The PP-band mesh could not be seen until a crack appeared in the wall.

**(4) Post-peak strength** Figure 5 shows how the force-deformation relationship shift as peak strength rises. After the peak, the unreinforced walls' normalised strength decreased by 10% to 40%. Even after significant deformations, the reinforced walls still retained 60% of their original strength compared to the unreinforced walls. The strengthened walls' normalised strength grew in the opposite way as well.

**(5) Effect of connectors and mortar overlay** It's important to pay attention to the reinforced wall with VL=30kN because it lost roughly 25% of its peak strength following a diagonal crack. Only this particular reinforced wall has such a sharp loss in strength. When the specimen was analysed following the test, it was determined that there were broken wire connectors. Drying shrinkage had caused major cracks in the mortar overlay before the testing. Mortar support may have been weakened, putting more strain on wire connections until they broke. This was the first time a retrofitting wall had been constructed, and the steel wires may have been harmed as a result. Keep this in mind.

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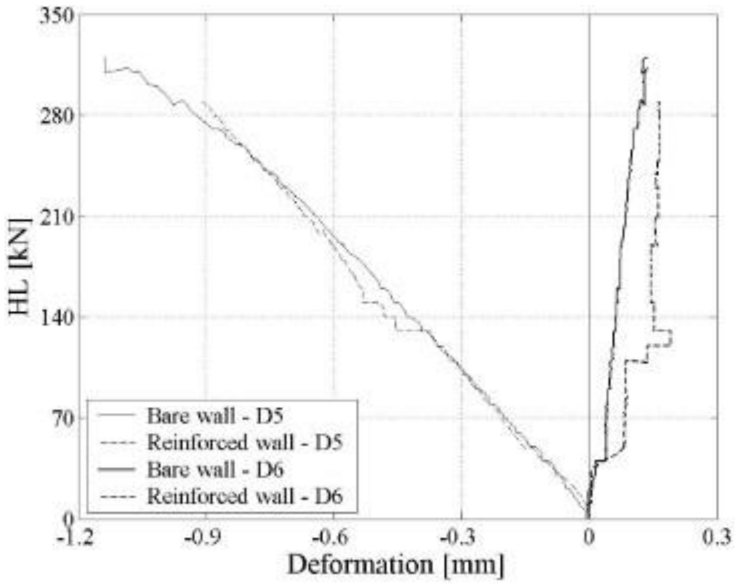


**Figure 4** Diagonal deformation (VL=30kN)**(Mayorca & Meguro, 2003)**

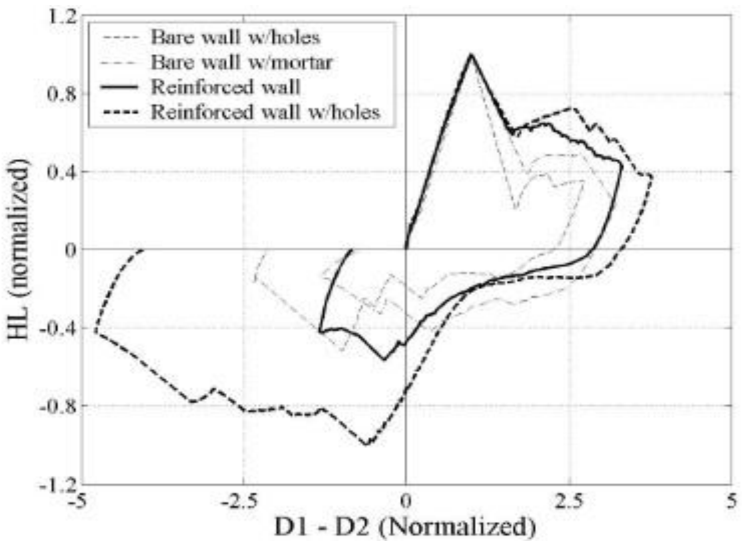


**Figure 5.**Normalized force-deformation relation (VL=9kN) connections,**(Mayorca & Meguro, 2003)**

## 5. Conclusions

It's been proposed to employ PP-bands to reinforce masonry structures instead of traditional methods. According to the results of shear wall testing, reinforcement changed the behaviour of the masonry wall. The strengthening, on the other hand, improved the structure's overall performance even while crack prevention or propagation was not improved. The strengthened walls had higher

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post-peak strength because they could sustain huge deformations better. The retrofitted wall's overall performance was dependent on the connectors and mortar overlay.

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