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# Review on Performance of Polypropylene Band –Retrofitted Masonry: Evaluation of Seismic Behavior

**Santhosh. L.S[1], Guruprasad. T.N[2], T.V. Mallesh[3], S.R. Ramesh[4]**

[1]*PG Scholar, Sri Siddhartha Institute of Technology, Tumkur, Karnataka.*
[2]*Assistant Professor, Department of Civil Engineering, SSIT, Tumkur, Karnataka.*
[3]*Head of the Department, Department of Civil Engineering, SSIT, Tumkur, Karnataka.*
[4]*Professor, Department of Civil Engineering, SSIT, Tumkur, Karnataka.*

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***Abstract*** *- Masonry structures have exhibited their extreme vulnerability even in event of the past minor to moderate earthquakes. This paper investigates a recently developed retrofitting technology specifically aimed at preventing or prolonging the collapse of the masonry buildings under strong earthquakes. On the other hand, the retrofitting technique proposed in this paper is economical and easy to apolypropylenely. This paper aims at examining the performance of retrofitting technique using the polypropylene (Polypropylene) band. In this paper the monotonic load displacement behaviors of a URM wall and the wall retrofitted with Polypropylene band are compared. It was observed that the Polypropylene band–retrofitted masonry building survived, whereas many nearby buildings experienced severe damage and some of them collapsed. This study demonstrates the efficacy and practicability of use of Polypropylene band for improving seismic resistance of a URM structure.*

***Key Words***: Unreinforced masonry; retrofitting technique; Polypropylene Band, dynamic loading, Load-displacement behavior.

## 1. INTRODUCTION

During earthquakes, structural elements in direct contact with the ground undergo structural displacement or ground displacement will take place in response to the movement of the structure during earthquake. Further, many structures of historical importance are made of URM constructions and need to be preserved against earthquakes or wind loads. Thus, the technical .Various retrofitting techniques are used to improve the seismic performance of unreinforced masonry. However, composite materials like fiber-reinforced polymers are often preferred because of their high strength-to-weight ratio and corrosion resistance. community are compelled to consider this serious issue, which in turn will not only be a solution for the safe habitat for common people, but also help in preserving historical buildings and other important structures. When research on URM structures is not properly carried out, the socioeconomic consequences of failure of such structures may be enormous. Existing studies therefore show that the presence of openings deteriorates the seismic performance of URM structures. The strengthening/retrofitting techniques adopted in a previous study are not only costly but also require special technical expertise along with sophisticated equipment for implementation. In this context, the present study is an effort to investigate the effectiveness of simple strengthening techniques without requiring any technical rigor or appreciable enhancement in cost for URM structures with openings.

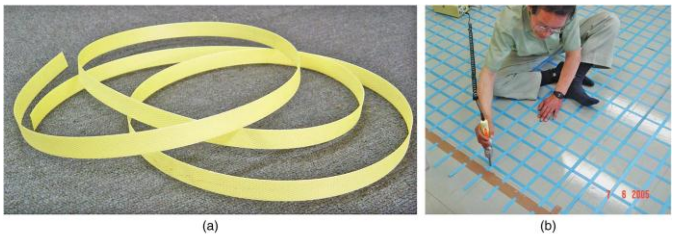

Fig 1: (a) polypropylene-band used for retrofitting; (b) polypropylene-band mesh preparation

### 1.1. Polypropylene-Band Mesh Retrofitting

The simple, earthquake-proof reinforcement technology of the polypropylene -band that is proposed in this paper is an earthquake-proof, reinforcing technology of the house using the band made of the polymer resin (polypropylene) that is in general widely being used for packing. This method for retrofitting masonry structures is economic, the material is accessible in all parts of the world, and the installation method is easy to use and culturally acceptable. Meshes are attached on both sides of the masonry wall through wires. To protect the mesh from ultraviolet rays, mortar is laid after the mesh is installed.

### 1.2. Polypropylene-Band Properties

The test was carried out under displacement control method.

The results are shown in Fig. 2. To calculate the stress in the band, its nominal cross-section 15:5 × 0:6 mm2 was used. In fact, the band had a corrugated surface, and, therefore, its thickness was not uniform. All 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 3.2 GPa (464 ksi) and 1.0 GPa (145 ksi), respectively. Given its large deformation capacity, it is expected that it will contribute to improve the structure ductility.

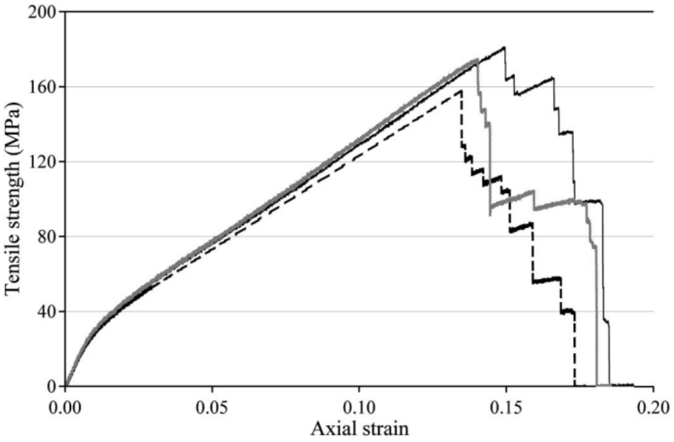

Fig. 2: Behavior of polypropylene-band under tension

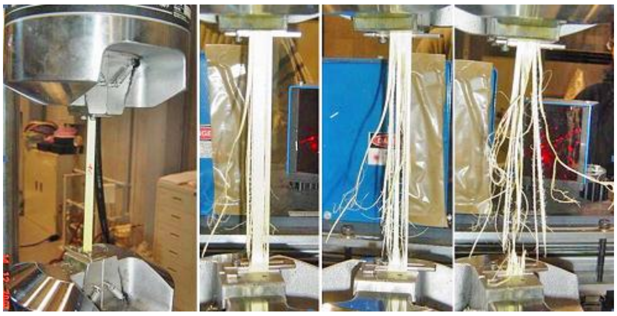

Fig. 3: Tensile test setup and failure pattern

## 2. LITERATURE REVIEW

Kimiro Meguro et al. [2011] this paper introduces a technically feasible and economically affordable polypropylene-band (polypropylene band) retrofitting for low earthquake-resistant masonry structures in developing countries. Results of the basic material tests and shaking table tests on building models show that the polypropylene-band retrofitting technique can enhance safety of both existing and new masonry buildings even in worst case scenarios of earthquake ground motion as in the Japan Meteorological Agency (JMA) seismic intensity scale 7.

Sanket Nayak et al. [2014] in this paper the effectiveness of the same economic approaches and their combinations has been studied for similar scaled-down models with proportionate openings representing doors and windows, as a logical further scope of the previous study testing these models on a shaking table. Experiments have shown that polypropylene bands were more effective than horizontal L-shaped reinforcing bars in arresting cracks and preventing collapse of the models, even those severely damaged. Further, the most important aspect of the study is that the technique is economical and can be implemented without involvement of any technical manpower or sophisticated equipment.

Muslum Murat Maras et al. [2016] this paper aims to investigate into repair and strengthening methods of masonry structures, advantages and disadvantages. In addition, we presented most suitable seismic retrofitting methods for unreinforced masonry structures considering efficiency and economic problems. It has been show that surface treatment methods and Re-pointing are more preferable for unreinforced masonry structures owing to their low cost as well as a no requirement for high working capacity.

Sekhar Chandra Dutta et al. [2016] this study is an attempt to underline the lack of preparedness and the nature of immediate further measures to be taken for facing a moderate earthquake in Indian subcontinents. In this context, the present study makes an effort to validate proposed modified rapid visual screening schemes for low cost houses frequently available in India. This may be used extensively for quick vulnerability assessment of a locality. Thus this study may be helpful for quick vulnerability assessment and adopting retrofitting measures for identified structures for earthquake prone developing countries.

Jamshid Zohreh Heydariha [2018] This paper aims at examining the performance of the retrofitting technique using polypropylene band. The displacement-controlled lateral deformation has been investigated experimentally. The monotonic load displacement behaviors of a URM wall and the wall retrofitted with polypropylene band are compared. It was found that the URM wall retrofitted by polypropylene band improves the ductility and energy absorption capacity by three and two times, respectively. Performance of a full-scale masonry building retrofitted with PP band in Nepal during the last Gorkha earthquake of April 25, 2015, has also been presented in this paper. It was observed that the polypropylene band–retrofitted masonry building survived, whereas many nearby buildings experienced severe damage and some of them collapsed. This study demonstrates the efficacy and practicability of use of PP band for improving seismic resistance of a URM structure.

## 3. EXPERIMENTAL METHOD AND RESULTS

This study was completed using full-scale tests on two masonry wall specimens. The test setup and test specimen are shown in Fig. 3. Two specimens were built and tested under monotonically increasing displacement-controlled load until failure occurred. The objective was to determine the effectiveness of the retrofit technique of a URM wall using PP band.

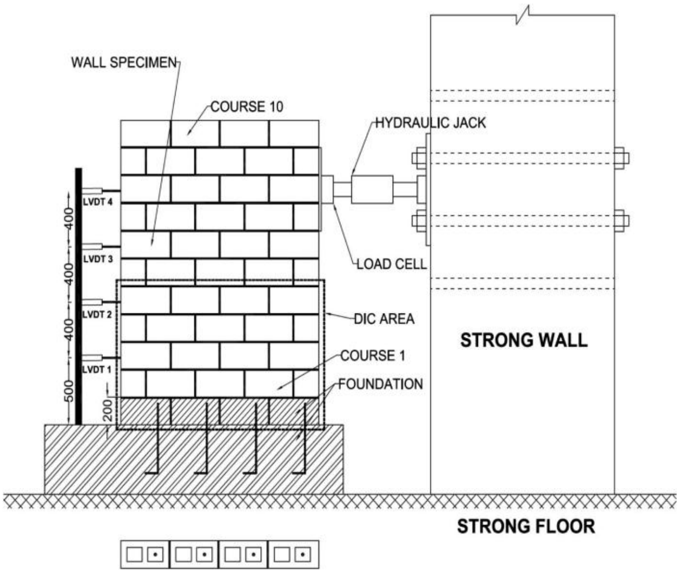

Fig. 4: Test setup of masonry wall

| *Specimen 1* | *Specimen 2* |
|---|---|
| 1. Specimen 1 was a Unreinforced masonry (URM) wall or control specimen. | 1. Specimen 2 was retrofitted using external PP band. |
| 2. Wall was 2,000 mm (10 courses) high, 1,600 mm (four block lengths) long, and 200 mm (one block width) thick. | 2. The PP band used in this study is 12.7 mm wide and 0.67 mm thick, and the breaking strength is 1.23 kN. |
| 3. Exhibited a maximum load of approximately 5.75 kN, a maximum displacement of 5.74 mm, and the specimen separated in two parts along the bed joint between the third and fourth courses. | 3. Each wall was 2,000 mm (10 courses) high, 1,600 mm (four block lengths) long, and 200 mm (one block width) thick. |
| 4. Specimen 1 was a Unreinforced masonry (URM) wall or control specimen. | 4.Exhibited maximum load carrying capacity of 7 kN, and the test was discontinued when the displacement reached 12.9 mm |
| 5. Wall was 2,000 mm (10 courses) high, 1,600 mm (four block lengths) long, and 200 mm (one block width) thick. | 5. Specimen 2 was retrofitted using external PP band. |

Table.1: specimen details

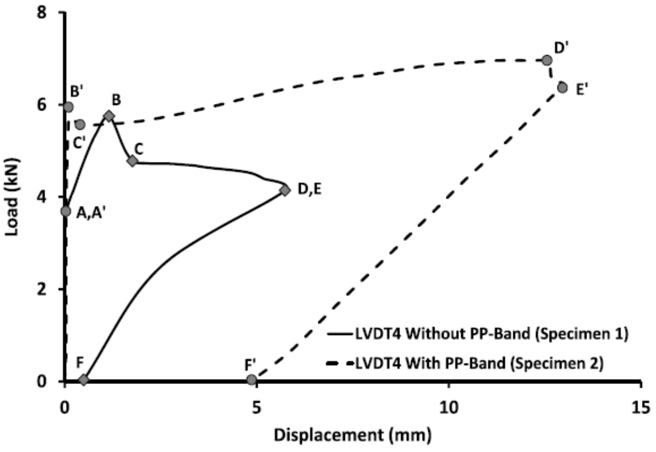

Fig. 5: Load-displacement behavior.

The load-displacement behavior for both wall specimens is shown in Fig. 5. Such load- displacement behaviors for masonry are extremely rare in the literature, although these curves are important for understanding the structural behavior, failure mechanism, and ductility in seismic action. In Fig. 5, the curve indicated by Points A–F and a solid line is for the Specimen 1 (URM wall specimen), whereas the curve shown by Points A0–F0 with a broken line is for Specimen 2 (retrofitted specimen). The load data were collected using the load cell connected to the loading jack. The displacement data were collected using four LVDTs located at four different heights (LVDT 1–4 in Fig. 4). LVDT 1 and LVDT 4 were located at 300 and 1,500 mm above the top of the foundation, respectively. The displacement reported in Fig. 5 was acquired through LVDT 4, which was located at 1,500 mm above the top of the foundation. Digital image correlation (DIC) technique was used to monitor crack initiation, crack growth, and strain distributions.

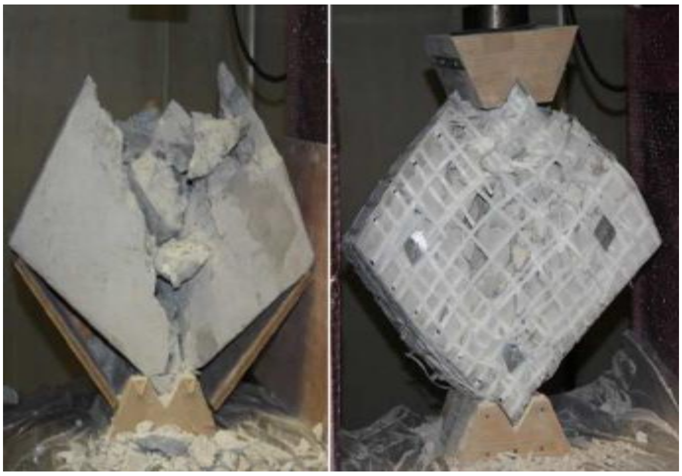

Fig -6: Non retrofitted specimen failure pattern and Retrofitted specimen failure pattern

### 3.1 Comparative result of various retrofitting techniques

Table.2: Comparative result of various retrofitting techniques

| | **RCC** | **GI welded wire mesh** | **Steel bar mesh** | **PP-Band** |
|---|---|---|---|---|
| Max no of storey | Suitable up to 2 storey | Suitable up to 3 storey | Suitable up to 4 storey | Suitable up to 1 storey |
| Architectural changes | Extensive | Less | Less | Less |
| Intervention time | Moderate | Moderate | Long | Short |
| Performance objectives | Life safety | Life safety-immediate occupancy | Life safety-immediate occupancy | Delay collapse-life safety |
| Cost per sq ft | US $ 4-6 | US $ 5-7 | US $ 6-8 | US $ 2 |

### 3.2 Procedure for masonry house using PP-band mesh retrofitting

The procedure presented below is illustrated with photos in Figure 7 taken during the preparation of the experimental program.

1. PP-bands are arranged in meshes and connected at their intersection points using a portable plastic welder.

2. Structure walls are cleaned and any loose pieces of brick should be removed.

3. Straw, which placed in holes are removed. In case of existing structures, holes can be prepared by drilling through the wall.

4. Walls are wrapped by meshes around the corners and wall edges. The overlapping length should be long enough to accommodate sufficient wire connectors as this is the only system used to connect meshes to the structure.

5. Wires are passed through wall holes and used to connect the meshes on both wall sides. In order to prevent the wires from cutting the PP-band meshes, a plastic piece or any other stiff element is placed between the band and the wire. It is desirable to have connectors as close as possible to the wall intersections and corners.

6. The top/bottom mesh edges are connected with steel wires. The bottom edge should be connected to the structure foundation as much as possible. In installing the PP-band mesh on existing houses, it was considered that it would be hard to excavate the ground to bury and fix the mesh bottom to the foundation of the house.

7. Fixed connectors around the openings after the mesh was cut and overlapped on the other side.

Fig. 7: PP-band mesh Retrofitting procedure for masonry house

## 4. CASE STUDY

i. full-scale house during the gorkha (nepal) earthquake:

Damage of the reinforced (using PP band) masonry house during the Gorkha (Nepal) earthquake of April 25, 2015, of magnitude 7.8, is presented in Fig. 8 Mortar cover of the PP band spalled out, but no major damage occurred, whereas many neighboring URM buildings collapsed. Another common failure of masonry building consists of separation of corner junctions leading to out-of-plane collapse of the wall in the orthogonal direction of shaking. This on-site case study showed that the initiation of such a failure can be avoided by peripheral PP bands The figure shows that the joint separation started, but the out-of-plane collapse did not occur because of the binding effect of peripheral PP band having high tensile strength.

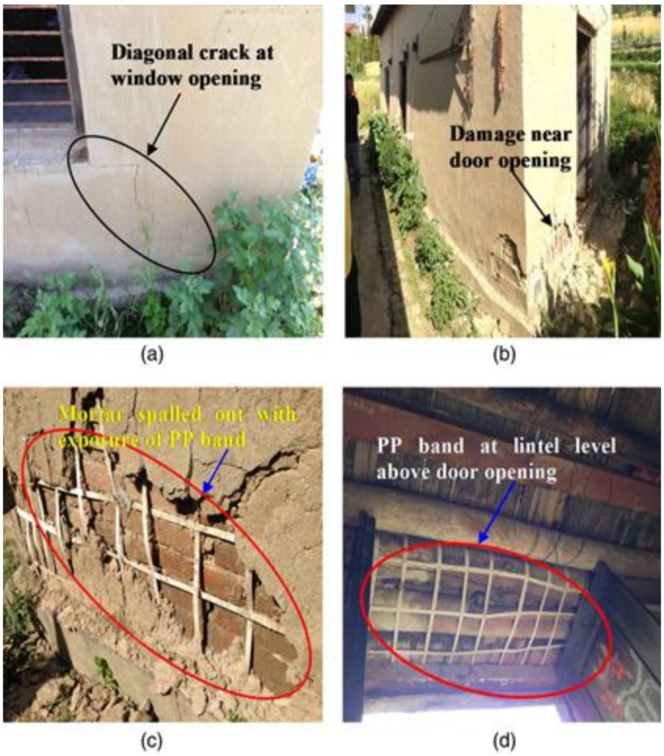

Fig. 8: Damage condition of various parts of the masonry building reinforced with PP band.

Fig. 9: Different stages of reinforcing the masonry building with PP band: (a) wrapping near window; (b) wrapping near door; (c) plastering after wrapping; and (d) completed PP band–retrofitted building

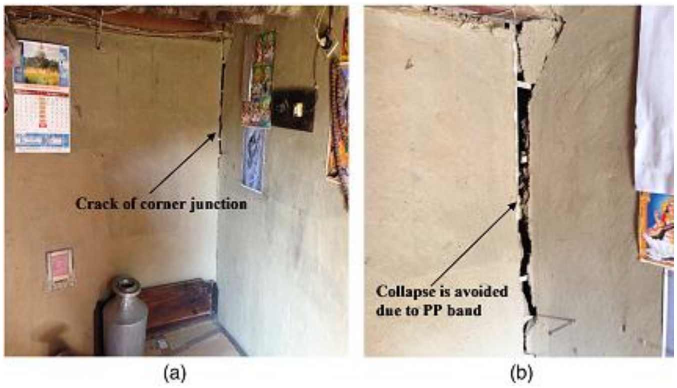

Fig. 10: Failure of the corner junction: (a) initiation of crack; and (b) collapse avoided owing to the presence of PP band

## 5. CONCLUSIONS

1. Have shown that masonry structure when reinforced with PP band has exhibited greater resistance to earthquake.
2. This is attributed to a 22% increase in maximum load carrying capacity of the PP band–retrofitted URM wall.
3. The ductility of the URM wall wrapped with PP bands is increased by 125%.
4. The other valuable part of the paper is the observed performance of a PP band–retrofitted building during a real earthquake. It shows that a PP band–reinforced masonry house survived during the last Gorkha (Nepal) earthquake of April 25, 2015, of magnitude 7.8.
5. This endeavor as a whole can be a starting point for this retrofit technique that is scientifically acceptable and practically applicable.

## REFERENCES

[1]. Nayak, S., and S. C. Dutta. 2016b. "Improving seismic performance of masonry structures with openings by polypropylene bands and L-shaped reinforcing bars." J. Perform. Constr. Facil. 30 (2): 04015003 w2https://doi.org/10.1061/ (ASCE) CF.1943-5509.0000733.

[2]. Dutta, S. C., S. Nayak, G. Acharjee, S. K. Panda, and P. K. Das. 2016. "Gorkha (Nepal) earthquake of April 25, 2015: Actual damage, retrofitting measures and prediction by RVS for a few typical structures." Soil Dyn. Earthquake Eng. 89: 171–184. https://doi.org/10.1016/j.soildyn.2016.08.010.

[3]. Bhattacharya, S., S. Nayak, and S. C. Dutta. 2014. "A critical review of retrofitting methods for

unreinforced masonry structures." Int. J. Dis. Risk Reduct. 7: 51–67.

[4]. Sathiparan, N., and K. Meguro. 2011. "Seismic behavior of low earthquake-resistant arch shaped roof masonry houses retrofitted by PP-band meshes." Pract. Period. Struct. Des. Constr. 17 (2): 54–64. https://doi.org/10.1061/(ASCE)SC.1943-5576.0000113.

[5]. Mayorca, P., N. Sathiparan, G. Ramesh, and K. Meguro. 2006. "Comparison of the seismic performance of different strength masonry structures retrofitted with PP-band meshes." In Proc., 5th Int. Symp. on New Technologies for Urban Safety of Mega Cities in Asia, 535–544. Thailand.

[6]. Meguro, K., P. Mayorca, N. Sathiparan, R. Guragain, and N. Nesheli. 2005. "Shaking table tests of 1/4 scaled masonry models retrofitted with PP-band meshes." In Proc., 3rd Int. Symp. on New Technologies for Urban Safety of Mega Cities in Asia, 9–18. Singapore.

## BIOGRAPHIES

**Mr. Santhosh. L.S**
Post-Graduate Student,
Department of Civil Engineering,
Sri Siddhartha institution of Technology,
Tumakuru, India- 572105

**Mr. Guruprasad. T.N**
M.Tech ( CAD Structures),BE (Civil),
Assistant Professor,
Department of Civil Engineering,
Sri Siddhartha institution of Technology,
Tumakuru, India-572105