

## EXPERIMENTAL STUDY ON IN-PLANE AND OUT-OF-PLANE BEHAVIOR OF PP-BAND RETROFITTED MASONRY WALLETTTE MADE OF SHAPELESS STONES

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**Abstract:** Unreinforced masonry structure is one of the most popularly used constructions in the world, especially in developing countries. It is also unfortunately, the most vulnerable to the earthquake and its damage has caused many human casualties. Therefore, from global viewpoint, retrofitting of low earthquake-resistant masonry structures is essential to reduce the casualties by earthquake disaster. In developing countries, retrofitting method should be technically feasible and economically affordable, the retrofitting material, accessible, and the workmanship, locally available. Considering these points, PP-band (polypropylene bands, worldwide available and cheap material, commonly used for packing) retrofitting technique has been developed by Meguro Laboratory, The University of Tokyo. In this research, we conducted a series of experiments to verify the suitability of PP-band retrofitting for masonry structures made of shapeless stones. Material tests were conducted to understand the basic parameters of stone masonry, i.e. shear, tension and compression strength. After the material tests, diagonal compression test and out-of-plane test were carried out using masonry walleette made of shapeless stones with and without retrofitting. From both test results, it was clear that PP-band retrofitting improved drastically the overall stability and ductility of stone masonry structures made of shapeless stones.

### 1. INTRODUCTION

Masonry structure, constructed by piling burned bricks or unburned, just sun-dried, bricks called adobes, stones or concrete blocks, is one of the most popularly used constructions in the world, but also the most vulnerable to earthquakes. Because distribution of the masonry structures overlap with high seismicity area in the world, it has caused many human casualties during earthquake. Therefore in global viewpoint, retrofitting of low earthquake-resistant masonry structures is very important to save people from earthquake disaster. Considering these points, a new retrofitting technique for masonry has been developed based on the use of polypropylene band (PP-band) meshes by Meguro laboratory, The University of Tokyo<sup>1)</sup>. This PP-band retrofitting technique prevents masonry structures from collapsing by giving the stabilization.

Up to now PP-band retrofitting study mainly focus on houses build by regularly shaped bricks and adobes. But the masonry has many different kinds of construction and the effect of PP-band is not confirmed for all kinds of masonry. Especially in the mountainous region in developing countries, stone masonry is constructed using shapeless or shaped stones as constructing material<sup>3)</sup>. But stone masonry house, particularly shapeless stone masonry house is the most vulnerable during earthquake as shown in Table 1.

Therefore further test of stone masonry walleettes should be carried out.

Table 1 Vulnerability Table<sup>2)</sup>

Type of structure		Vulnerability Class					
		A	B	C	D	E	F
MASONRY	Rubble stone, field stone						
	Adobe (earth brick)	○					
	Simple stone		○				
	Massive stone		○				
	Unreinforced, with manufactured stone units		○				
	Unreinforced, with RC floors		○				
	Reinforced or confined		○				
REINFORCED CONCRETE	Frame without earthquake-resistant design (ERD)		○				
	Frame with moderate level of ERD		○				
	Frame with high level of ERD		○		○		
	Walls without ERD		○				
	Walls with moderate level of ERD		○				
	Walls with high level of ERD		○		○		
STEEL	Steel structures		○				
WOOD	Timber structures		○				
		○ : Most likely vulnerability class					
		— : Probable range					
		- - - : Less probable range, exceptional cases					

### 2. MATERIAL TEST

#### 2.1 Test Setup

Figure 1 shows the specimens used for shear, tension and compression tests to obtain the mechanical properties of the stone masonry. Shapeless stones whose size range from 60mm to 80mm were used for preparation of specimens. A