Seismic Behavior of Low Earthquake-Resistant Arch-Shaped Roof Masonry Houses Retrofitted by PP-Band Meshes

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Abstract: This paper introduces a technically feasible and economically affordable PP-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 PP-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. Therefore, the proposed method can be one of the optimum solutions for promoting safer building construction in developing countries and can contribute to earthquake disaster mitigation in the future. **DOI: 10.1061/(ASCE)SC.1943-5576.0000113.** *© 2012 American Society of Civil Engineers.*

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Introduction

Unreinforced masonry structure is one of the most popularly used constructions. It is also unfortunately the most vulnerable to the earthquakes. It collapses within a few seconds during earthquake movement and becomes a major cause of human fatalities. Therefore, retrofitting of low earthquake-resistant masonry structures is the key issue for earthquake disaster mitigation to reduce the casualties significantly. In proposing the retrofitting method in developing countries, the retrofitting method should respond to the structural demand on strength and deformability and to availability of material with low cost, including manufacturing and delivery, practicality of construction method, and durability in each region. Considering these issues, a technically feasible and economically affordable PP-band (polypropylene bands, which are commonly utilized for packing) retrofitting technique has been developed, and many different aspects have been studied by Meguro Laboratory, Institute of Industrial Science, The Univ. of Tokyo (Yoshimura and Meguro 2004).

Unreinforced masonry structures with masonry arch roofs are generally characterized by weak, brittle materials, weak element connections, and excessive weight. Buildings of this construction type can be found in the Middle East. Adobe materials are used on domes or arch-type roofs and the thick walls, which have been traditionally constructed since the ancient days. The design of the roof is in fact influenced by the culture and religion since the olden days, but this type of roof is very unstable.

The main points of weakness of the traditional masonry arch roofs that contribute to the poor seismic response can be summarized as follows:

1. Inability of the roof to act as a diaphragm: Masonry arch roofs are incapable of diaphragm action. This is attributable to their curved geometries, the load-carrying mechanisms, and the weak and brittle materials. The load-carrying mechanism of these types of roofs is primarily in compression. The nonhomogeneous masonry of the roofs is unable to carry tensile or flexural loads. As a result, they are not capable of restraining the top of their supporting walls during ground shaking, nor are they capable of transferring excessive horizontal inertia forces. Furthermore, they induce a preearthquake static horizontal force at the top of the walls as they transfer their compressive load to the walls. In the shared load-bearing walls, the thrust from the two adjoining arches cancels one another out. However, in the end arches, this force causes an unbalanced outward thrust on the wall.
2. Heavy weight of the roof: Perhaps the most important seismic weakness of the masonry arch is the excessive weight. The masonry arch roofs are, by nature, heavy, as a minimum roof thickness is required to enable the successful transfer of the gravity load in an arch action.

But the ability of the PP-band mesh to keep the structure integral during the shaking will help overcome these issues. Therefore, to understand the dynamic response of masonry houses with and without PP-band mesh retrofitting, crack patterns, failure behavior, and overall effectiveness of the retrofitting technique, shaking table tests were carried out.

A full-scale model test makes it possible to obtain data similar to real structures. However, it requires large-sized testing facilities and a large amount of research funds, so it is difficult to execute parametric tests by using the full-scale models. Therefore, in this study, scale-model tests to understand the overall behavior of the system were performed.

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