PP-BAND RETROFITTING ASSESSMENT
- FULL SCALE SHAKING TABLE TESTS (1) -

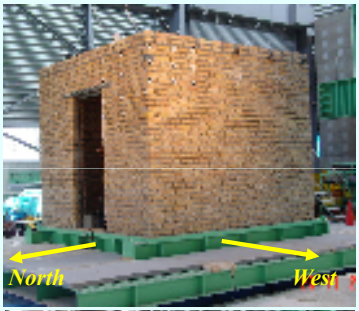
安価な材料を用いた効果的な耐震補強法の研究
－ＰＰバンドメッシュで補強した組積造構造物の振動台実験(1) -

Introduction

Full scale shaking table tests were carried out to verify the suitability of PP-band meshes to improve the seismic performance of weak masonry structures. Four specimens, two non-retrofitted and two retrofitted with PP-band meshes were tested. The specimens were designed following typical Iranian architecture. The experiments clarified the structural dynamic response, crack propagation, and failure behavior of the specimens. It was concluded that the PP-band mesh retrofitting significantly contributed to improve the performance of the masonry structures.

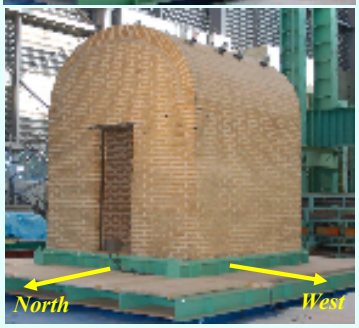
Specimen construction

Two specimens were built with brick units and two with adobe units. Two specimens, one of each set, were retrofitted with 10cm pitch PP-band mesh. Each band width was 15.5mm which is the most common in the market. No special curing was provided. Although the retrofitting process requires providing a final mortar cover, this was not included in this occasion in order to clearly observe the crack propagation in the retrofitted specimens. The specimens dimensions and material properties are shown below.



Brick Masonry

Geometry of the models:
Length: 3m
Breadth:3m
Height: 2.5m
Wall thickness: 210mm
Door size: 790mm x 2110mm
Window size: 790mm x 1150mm
Additional weight at roof level: 18kN
Roof type: Jack arch shaped RC slab

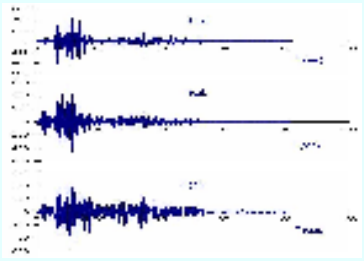


Adobe Masonry

Geometry of the models:
Length: 3m
Breadth:3m
Height: 3.825m
Wall thickness: 250mm
Door size: 840mm x 2135mm
Window size: 840mm x 1150mm
Roof type: Vault

Load Characteristics

Manjil Earthquake, Iran (1990)

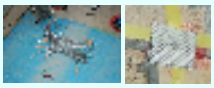


Two set of input motions were used in these tests; the strong ground motion registered during the Manjil Earthquake, Iran (1990) and a one directional sinusoidal wave. On June 20, 1990, GMT 21:00 earthquake with an approximate magnitude of mb 7.3 and Ms7.7 occurred in Gilan and Zanjan provinces, in Iran.

The Manjil Earthquake waveform was scaled to reach a peak ground acceleration of 100,200,300 and 553 gals, which correspond to shakes of Seismic Intensity 4, 5-, 5+ and 6- of JMA scale respectively. The other waveform, a sinusoidal one, had duration of one minute and varying frequencies and amplitudes. The wave parameters were chosen so as to excite the structure and induce damage.

Retrofitting Process

1. Drilling holes on wall



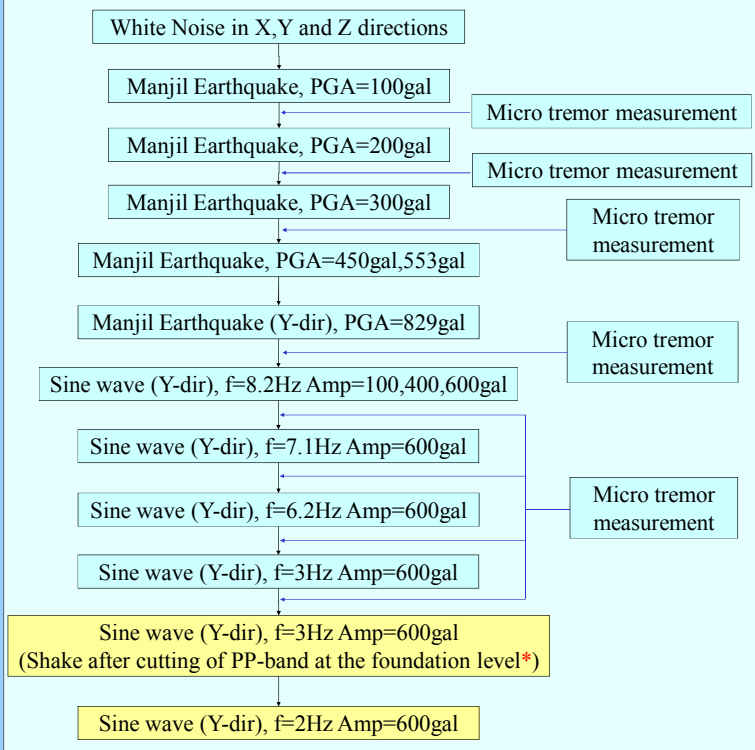
Wires and aluminum plate

2. Connecting inner and outer meshes by wires and aluminum plates

3. PP-band mesh is wrapping around openings and fixed by connecters

4. Retrofitted Brick specimen

Input Sequence – Brick models



Loading steps for both non-retrofitted and retrofitted house

Loading steps for retrofitted model after non-retrofitted house collapse

* *To simulate possible worst case scenario in field if PP-band meshes not connected to foundation level.*

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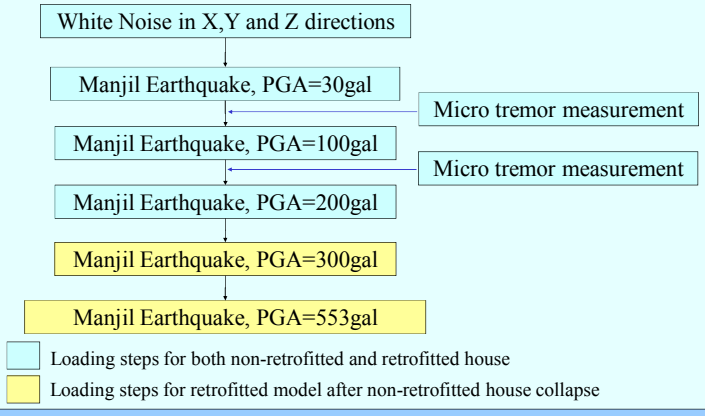
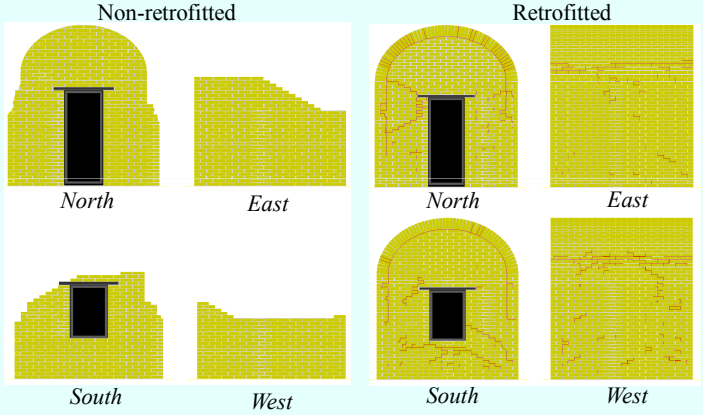
Input Sequence – Adobe models



Adobe - Failure

Crack patterns

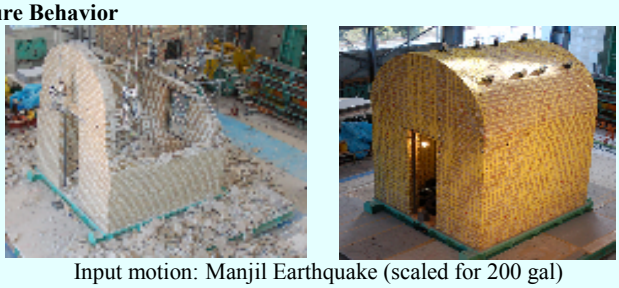


Final stage of the test: Manjil Earthquake, PGA=200gal for non-retrofitted building & Manjil Earthquake, PGA=300gal for retrofitted building

Damage Level

Input motion	Non-retrofitted building	Retrofitted building
Manjil Earthquake, PGA=100gal	Slight cracking	Slight cracking
Manjil Earthquake, PGA=200gal	Total collapse	Crack progressive
Manjil Earthquake, PGA=300gal		Crack progressive
Manjil Earthquake, PGA=553gal		Total collapse

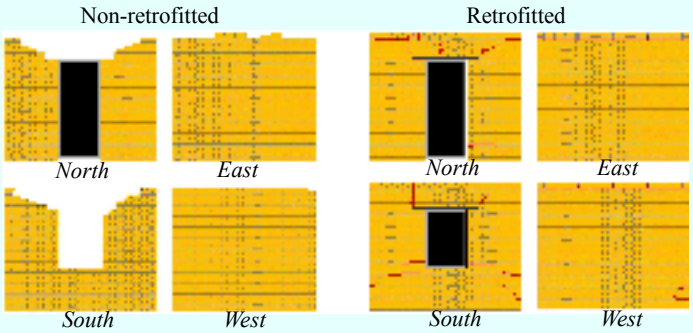
Failure Behavior



Input motion: Manjil Earthquake (scaled for 200 gal)

Brick - Failure

Crack patterns



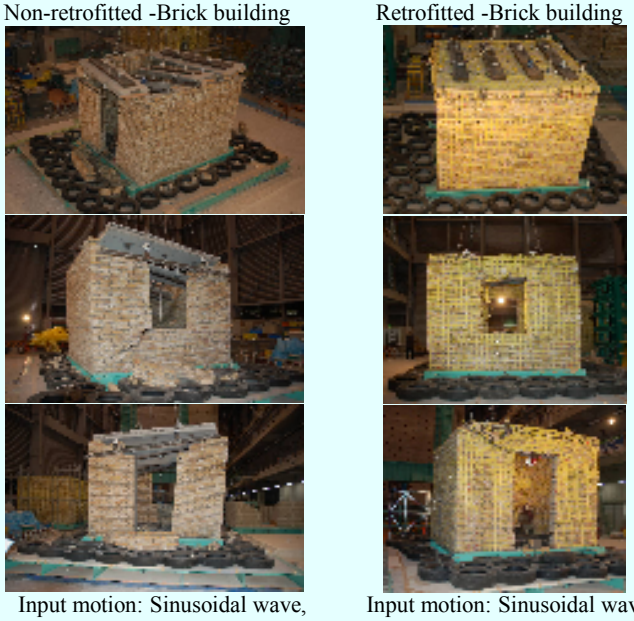
Final stage of the test: Sinusoidal wave (Y-dir), f=3Hz Amp=600gal for non-retrofitted building & Sinusoidal wave (Y-dir), f=3Hz Amp=600gal 2nd trail for retrofitted building

Damage Level

Input motion	Non-retrofitted building	Retrofitted building
Manjil Earthquake (Y-dir), PGA=829gal	Little damage mostly concentrated at the roof level	Little damage mostly concentrated at the roof level
Sine wave (Y-dir), f=8.2Hz Amp=600gal	Damage in walls	Damage in walls
Sine wave (Y-dir), f=6.2Hz Amp=600gal	Progressive damage	Progressive damage
Sine wave (Y-dir), f=3Hz Amp=600gal*	Roof collapse. End of the test	Progressive damage
Sine wave (Y-dir), f=2Hz Amp=600gal		Extensive damage. End of test

** For retrofitted model this input was applied two times, one after cutting PP-band at the foundation level*

Failure Behavior



Input motion: Sinusoidal wave, f=3 Hz, Amp-=600 Gal, 60s

Input motion: Sinusoidal wave, f=3 Hz, Amp=600 Gal, 60s: 2nd trail

The test results show that the seismic performance of both the models, adobe and brick, was significantly enhanced by PP-band mesh retrofitting.

Because of the thrust force induced on the walls by the vault roof, the retrofitted model failure was fragile. This was not the case of the brick specimen which had a horizontal roof. By using tie bars to reduce the roof induced thrust force and PP-band mesh to keep the integrity of the walls, the seismic strength of the type of structures can be significantly improved.

Meguro Lab., IIS