

Static Test on Full Scale Rammed Earth Building with Mesh-wrap Retrofitting Strategy

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ABSTRACT

Rammed earth (RE) building construction is still considered as one of the most popular and sustainable construction practice in the present day Bhutan [1], particularly in the Western region of the country. These structures are however found to be vulnerable to recent earthquake occurrences in the region. The current work is aimed towards improving the seismic performance of these traditional Bhutanese rammed earth buildings with practically feasible and effective solutions.

This paper reports the experimental campaign for static tests performed on unreinforced (URE) and mesh retrofitted (RRE) full scale rammed earth building. Amongst the varying building patterns of traditional rammed earth houses found in Bhutan, a two storied building with full solid wall (small openings) in ground floor and larger opening in the front facade of the first floor was chosen. The prototype building has a floor area of 8.1 m × 5.4 m with 6.8 m height excluding the sloped roof. The proposed mesh-wrap retrofitting of the walls involved the use of 12 gauge (ϕ 2.0mm) as the main mesh and 16 gauge (ϕ 1.2mm) as a lapping mesh at the corners and along the height of the walls. Further, the mesh inside and outside of the wall were anchored using 12 mm diameter threaded bars inserted through the *Jugshing* holes (holes originally formed during formwork placement while ramming). A 30 mm thick cement plaster (cement sand at 1:3) was applied over the mesh to complete the retrofitting process. The floor joists were also connected using X-bracing with timber of size 75 mm × 75 mm.

The static test loading protocol involved the displacement controlled loading with control over the drift in the building. Each floor level of the building was subjected to displacement controlled loading through 4 hydraulic jacks (2 at each floor level) to a specified target story-drift value. Cracks and damage observations were done at the story-drift ratios of: 1/2000, 1/1000, 1/750, 1/500 for URE building. The same URE building was retrofitted afterwards and retested as RRE to story-drift ratios of: 1/2000, 1/1000, 1/750, 1/500, 1/250, 1/150, 1/100 and 1/80.

The mesh retrofitting is found effective in both damage control as well as strength enhancement over the unreinforced one. The URE building showed clear opening of shear and vertical cracks in in-plane loaded walls near the openings and *Jugshing* holes at the story-drift of 1/500. For the RRE building, significant cracks were observed at story-drift of 1/250 followed by spalling of plaster near the opening corners. With increment in drift, extension of old cracks and new cracks was detected. No delamination of mesh-wrap was observed. Substantial enhancement in strength characteristics was achieved with the mesh-wrap retrofitting. The RRE building showed enhancement in base shear by 2.5 times, ductility 2.6 times and energy absorption 12 times the URE counterpart.

REFERENCES

- [1] P. Wangmo, K.C. Shrestha, M. Miyamoto and T. Aoki, "Assessment of out-of-plane behavior of rammed earth walls by pull-down tests", *Int. J. Arch. Hert.*, Vol. **13**, pp. 273–287 (2019).