

ABSTRACT

Gabion walls are increasingly adopted due to their adaptability to ground settlements, drainage properties, ease of construction, and sustainability. However, their seismic behavior remains largely unexplored. Existing design methods rely on previous studies on rigid retaining walls and do not accurately represent the flexible and discrete nature of gabion walls. This study presents a comprehensive experimental and numerical investigation into the dynamic performance of gabion walls.

Shake table tests were conducted on scaled gabion wall models without backfill for varying base accelerations (0.1g–0.4g) and frequencies (3–9 Hz). Results indicate that acceleration amplification and top displacements increase significantly with frequency. Bottom embedment reduced base-level deformations considerably and acceleration amplification at the top by up to 8%, although top-layer rocking remained largely unaffected. Another set of model tests was performed with sand backfill, where the gabion retaining wall showed significant top deformation and failed at 0.2g due to rocking and separation of top gabion units from the backfill. A 10° wall inclination reduced the top deformation significantly by 70% and delayed the failure to 0.3g. Particle Image Velocimetry (PIV) revealed shear strain concentration in the upper layers of the backfill. From tests, the natural frequency of the model retaining wall with backfill is obtained as 11 Hz, which scales to 4 Hz for a 5 m prototype wall and falls within the range of major earthquake frequencies, indicating potential resonance risks unlike traditional concrete walls. Numerical models developed in PLAXIS-2D separately modeled gabion baskets and infill using beam and soil elements with appropriate interface properties, accurately replicating the rocking and failure behavior of the gabion walls.

A seismic analysis was also performed on the 40 m high Mechanically Stabilized Earth (MSE) gabion wall at Section 520 of Pakyong Airport using time histories from the 2011 Sikkim earthquake (Magnitude, $M_w = 6.8$) in PLAXIS-2D. The crest experienced 447 mm lateral displacement (1.1% of height), with a maximum of 552 mm at mid-height and 93 mm at the toe. These deformations fall within the acceptable limits prescribed by AASHTO LRFD Bridge Design Specifications (2007) for flexible Mechanically Stabilized Earth (MSE) walls, but raise serviceability concerns for very tall structures. Shear failure near reinforcement ends in the upper blocks was observed due to insufficient reinforcement lengths. Anchoring the uppermost reinforcement layers, an approach informed by model tests on reinforced gabion walls, reduced crest deformation by 27%, highlighting its effectiveness in improving seismic stability in tall gabion walls.

KEYWORDS: Gabion retaining wall; Dynamic behavior; Shake table test; Soil-structure interaction; Numerical analysis; Tall MSE wall.