PERFORMANCE OF EARTH MASONRY UNDER DYNAMIC LOADING

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Degree of Master of Science

Department of Civil Engineering

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Thesis submitted in partial fulfillment of the requirements for the degree Master of Science in Civil Engineering

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DECLARATION

I declare that this is my own work and this thesis does not incorporate without acknowledgement any material previously submitted for a Degree or Diploma in any other university or institute of higher learning and to the best of my knowledge and belief it does not contain any material previously published or written by another person except where the acknowledgement is made in the text.

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ABSTRACT

Masonry buildings are the most typical structural type which is commonly used for ancient historical structures and low to medium rise residential units from early days to present. However, increase in world population and their housing needs with limited resources tend to promote the usage of alternative building materials in the construction industry as much as possible. Among those alternatives, earth masonry has become one of the building materials in sustainable development process since its in-built properties such as economy, low embodied energy, low in CO_2 emissions, etc. However, the structural elements made from earth masonry such as rammed earth and compressed earth blocks (stabilized/un-stabilized), have not been much assessed on their seismic performance.

The main objective is to comparatively assess the in-plane and out-of-plane seismic performance of Cement Stabilized Earth Blocks (CSEB) and Cement Stabilized Rammed Earth (CSRE) walls with similar dimension via a series of shake table test and to recommend a most suitable numerical method for analysing the seismic performance of CSEB and CSRE walls.

For this purpose, a set of small scale physical models of compressed stabilized earth blocks and rammed earth were tested under scaled versions of El-Centro (ElC) earthquake north-south component and sine waves with different frequencies and amplitudes using one degree of freedom shaking table equipment.

For experiments, 110 mm thick compressed stabilized earth blocks and 150 mm thick rammed earth wall panels were selected. Two wall panels of each earth masonry type were prepared for around 596mm and 460mm height respectively. A 38 mm thick concrete layer was laid bottom and top of each specimen for confinement of the element. The tests were carried out under series of shake table tests and observed the deflection and acceleration behaviour at bottom, middle and top of wall panels, base shear values, failure mode and magnitude.

According to the experimental results from moderate to severe earthquakes, both CSEB and CSRE wall panels performed well without any visible cracks. In CSEB wall panels, maximum acceleration and displacement at the crest of the wall and base shear is 8.2%, 1.2% and 7.6% greater in out-of-plane loads than the in-plane walls under severe earthquake. But in RE wall panels those above considered values remain same for both in and out-of-plane walls.

To investigate the progressive damage behavior of earth walls, they subjected to sine waves with increasing amplitudes and frequencies. In CSEB walls, there were no visible cracks both in and out-of-plane walls until the 4Hz sine wave. But when the frequency become 6Hz, base crack was initiated and spread throughout the wall width in the out-of-plane wall and no visible cracks in the in - plane wall. In RE walls, there were no visible cracks both in and out-of-plane walls until the 4Hz sine wave. But when the frequency become 6Hz, base crack was developed through the wall width with rocking mode in the out-of-plane wall and base crack was developed with some translation to the loading direction in the in-plane wall.

Numerical models were prepared with Structural Analysis Program (SAP 2000) and ABAQUS with the intension of using experimental results to validate. It is found the ABAQUS model is capable of predicting the behaviour of earth masonry under seismic loading.
Key words: Earth masonry, Shake table test, In-plane loading, Out-of-plane loading, Numerical modelling.

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LIST OF ABBREVIATIONS

Abbreviation	Description
CSEB	Cement Stabilized Earth Block
CSRE	Cement Stabilized Rammed Earth
EQRF	Earthquake Resistant Feature
ElC	El-Centro
FEM	Finite Element Method
FRP	Fibre Reinforced Polymer
GFRP	Glass Fibre Reinforced Polymer
PGA	Peak Ground Acceleration
PP	Polypropylene
NZS	New Zealand Standard
RM	Reinforced Masonry
SAP	Structural Analysis Program
SLS	Serviceability Limit State
URM	Unreinforced Masonry

LIST OF APPENDICES