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APCBEE Procedia 9 (2014) 217 – 221

Procedia APCBEE

www.elsevier.com/locate/procedia

2013 5th International Conference on Chemical, Biological and Environmental Engineering (ICBEE 2013)
2013 2nd International Conference on Civil Engineering (ICCEN 2013)

Seismic Performances of Brick Masonry Inverted Bell-Shaped Chedi

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Abstract

This research is aimed to perform seismic evaluation of an esteemed brick masonry inverted bell-shaped chedi at Phrathat Doi Suthep temple, Chiangmai, Thailand, by using the finite element analysis. The validated finite element model has been made through the full-scale ambient vibration tests (presented in the accompanied paper). First, twenty past earthquake records were selected and matching of the records to the seismic response spectrum was made for equating the local seismic conditions. Then, the matched seismic waves were used for the input of time history analyses. The results have shown that, the top of the pagoda was very sensitive to the seismic waves. It was deformed significantly, accelerations were amplified and the material was damaged by over-tensioning.

Selection and peer review under responsibility of Asia-Pacific Chemical, Biological & Environmental Engineering Society

Keywords: Time history analysis, Pagoda, Finite element

1. Introduction

As stated in the accompanied paper named "Ambient Vibration Tests and Finite Element Analysis for Dynamic Properties of Brick Masonry Inverted Bell-Shaped Chedi", Pagoda or a general term "Chedi" for Thais, is one of such a kind of the historical buildings having solid inverted bell shaped geometry with no interior space in typical. The geometrical dimension utilizes his self-weight enabling the brittle brick masonry material to be efficiently adopted with compressive-arch transferring mechanism under gravity loading, but not for the case of earthquake induced tension. The historical records have shown that the Northern region of

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2212-6708
Selection and peer review under responsibility of Asia-Pacific Chemical, Biological & Environmental Engineering Society
doi:10.1016/j.apcbee.2014.01.039

Thailand can be identified as a seismic prone area. As seen in Fig. 1a, the AD.1545earthquake hit Chiangmai city causing failure of top part of Chedi Luang. The total height of the building was dropped from 86 m. to 50 m. at present [1]. Recently, the 6.8 Richter earthquake at Shan State, Myanmar around the Thailand-Myanmar border made the top part of Prathat Chedi Luang, in Chiang san with about 100 km from the source, fallen down. The failure of the buildings exampled above indicate seismic vulnerability of the buildings and evaluation for seismic safety and strengthening are extremely needed.

In this paper, Chedi at Phrathat Doi Suthep temple shown in Fig. 2 was selected as a case study. The Chedi is one of the top sacred sites to Thai people located on Suthep Mountain, Chiangmai city, Thailand. The validated finite element model through the full-scale ambient vibration, presented in the accompanied paper, was used for the seismic analyses. Twenty past seismic waves were used for the time history analyses.

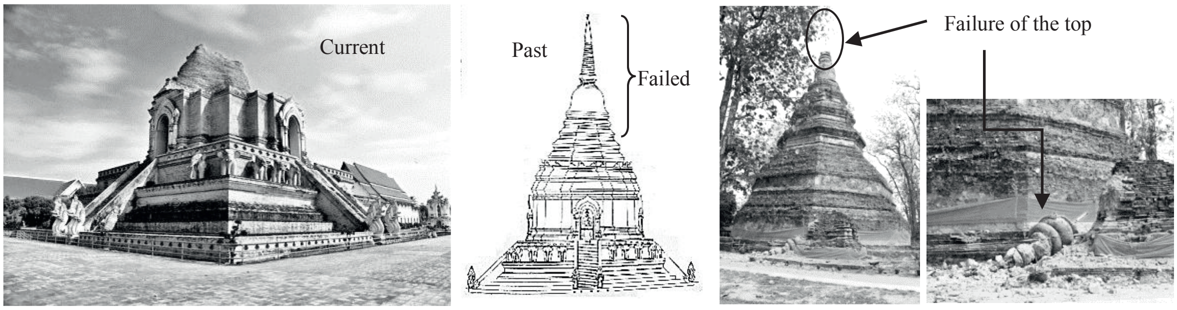

Fig. 1. Earthquake damage of Chedis; (a) Chedi Luang, Chiangmai [1] (b) Prathat Chedi Luang, Chiang san

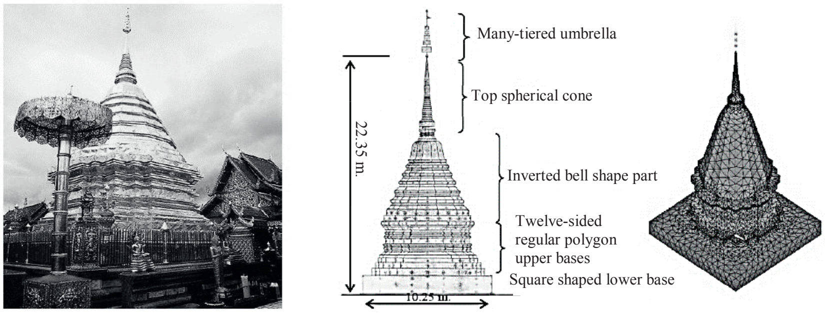

Fig. 2. Chedi Phrathat Doi Suthep; (a) Photo (b) Elevation (c) Finite element model

2. Finite element model and input ground motions

2.1. Finite element model

The esteemed masonry inverted bell-shaped chedi at Phrathat Doi Suthep temple has square lower base with 10.25 m. in width and upper bases below the inverted bell is twelve-sided regular polygon. Overall height is 22.35 m (excluding the height of many-tiered umbrella). With the complicated geometry and large number of elements, the study adopted the continuous modelling technique. Microscopic behavior considering interaction of composite mechanic was macroscopically assumed with a homogeneous elastic material. The commercial finite element package ANSYS program [2] was used in the three dimensional finite element model adopting 3D solid brick element coded SOLID45. The analysis was based on linear behavior with isotropic property assumption. The many-tiered umbrella at the topmost part (see Fig. 2) was modelled using