Ain Shams University
Faculty of Engineering

Assessment of Seismic Behavior of Monumental Minarets in Egypt

A THESIS SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR THE DEGREE OF MASTER OF SCIENCE IN
CIVIL ENGINEERING (STRUCTURAL ENGINEERING)

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STATEMENT

This thesis is submitted to the Faculty of Engineering at Ain Shams University in partial fulfillment of the requirement of the M.Sc. Degree in Civil Engineering (Structural Engineering).

Any kind of work included in this thesis has been done by the author. No part of the thesis has been submitted for a degree or a qualification at other university or institute.

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Abstract

Ancient masonry minarets have a historic and social significance and are considered as architectural heritage. One of the most important problems facing these structures is the dynamic response under lateral loads, especially under the effect of earthquake excitation. Previous seismic activity verified that especially old stone masonry minarets suffered severe damages, because of the poor seismic resistance. The 1992 & 2015 earthquake in Egypt has caused damage and even failure loss of several monumental masonry minarets in Cairo.

These study was carried out in main stages: overview the published literature in the field and numerical modeling and dynamic analysis are performed for the minaret in its current condition using linear and nonlinear finite element commercial software in order to investigate its seismic behavior and to assess its structural efficiency. The contribution of openings and spiral stairs on the dynamic behavior are examined, in addition to the influence of other modeling parameters. The obtained results regarding stresses and deformations within the structure are analyzed and related to the observed damages. The results indicate overall stability of the structure in its current condition while high stresses occur at several locations. The actions made for restoration and stabilization of the minaret are presented. After retrofit intervention, the seismic analysis has shown improvement of the seismic behavior of the minaret and demonstrated the effectiveness of the retrofit actions.

Key Words: Masonry; Tower; Historic; Finite Elements; Dynamic Analysis; Seismic; Assessment

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