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Numerical evaluation of dynamic response of a steel structure model under various seismic excitations

Tomasz Falborski[a,*], Robert Jankowski[a]

[a]*Gdańsk University of Technology, ul. Narutowicza 11/12, 80-233 Gdańsk, Poland*

Abstract

The present paper reports the results of the study, which was designed to perform a numerical evaluation of dynamic response of a single-storey steel structure model. The experimental model was previously subjected to a number of different earthquake ground motions during an extensive shaking table investigation. The analyzed structure model was considered as a 1-DOF system with lumped parameters, which were determined by conducting free vibration tests. In order to solve the dynamic equation of motion, Newmark's average acceleration method was adopted. The results obtained from the numerical analysis confirm the accuracy in assuming lumped parameters to characterize the analyzed single-storey structure.

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Keywords: earthquakes; dynamic excitations; seismic performance; numerical analysis.

1. Introduction

Earthquakes are identified among the most severe and unpredictable threats to the building structures and, therefore, have become an issue of major concern of professional and research communities (see, for example, [1-4]). Strong ground motions may cause a lot a damage (see [5,6]) in a wide variety of ways, leaving sometimes thousands of casualties in their wake. During the last few years alone, the world has witnessed many major earthquakes, five of which have caused far-reaching consequences of a national scale for Haiti (January 2010), Chile (February 2010), New Zealand (February 2011), Japan (March 2011), and Turkey (October 2011).

* Corresponding author. Tel.: +48 (58) 347-21-17
E-mail address: tomfalbo@pg.gda.pl

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Shaking table testing is the most commonly adopted approach to simulate earthquake forces. It allows to analyze the seismic performance and provides a valuable insight into the dynamics of building structures, which helps to improve their future safety and reliability. The present study aims to conduct a numerical evaluation of dynamic response of a single-storey steel structure model, which was previously examined during an extensive shaking table investigation. In order to perform the numerical research, lumped-mass system was employed. The results obtained from both experimental and numerical studies were compared and discussed.

2. Experimental model and shaking table investigation

In order to conduct the experimental investigation, a single-storey steel structure model was firstly prepared. The welded steel frame was constructed using the rectangular hollow section elements (RHS 15×15×1.5 mm). The columns were arranged in a rectangular pattern with spacing of 0.465 m in the longitudinal direction and 0.556 m in the transverse one. Additional diagonal bracing was used in the sidewall planes to counteract transverse and torsional vibrations. Moreover, two concrete plates (50×50×7 cm) were used to simulate the weight of the floor and foundation slabs. The single-storey structure model consisting of one steel frame and two concrete plates was 1.20 m high and weighs 95.12 kg (see Fig. 1). The seismic response of the experimental model under a number of earthquake ground motions was extensively studied during a comprehensive shaking table investigation carried out with the use of a middle-sized shaking table located at Gdańsk University of Technology, Poland. The results obtained from the shaking table study for both single- and two-storey steel structure models have already been presented in previous publications (see [7-9]).

Fig. 1. Single-storey steel structure model mounted on the shaking table platform.