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The Challenge of Analytical Modeling: Case Study of Full Scale Shake Table Experiments on One-Storey RC Frames

Parisa Kamrani Moghaddam[1], Alireza Manafpour[2]

1- Ph.D. Student, Civil Engineering Department, Urmia University, Urmia, Iran
2- Assistant Professor, Civil Engineering Department, Urmia University, Urmia, Iran

par.kamrani@gmail.com

Abstract

Reliable prediction of the structural seismic behavior is one of the challenging issues which has a direct impact on the advancement of the knowledge, tools and methodologies for structural design and assessment. Full scale seismic experiments are among the rare opportunities to test our capabilities on all these aspects. In this paper, two one-storey reinforced concrete frames with the same overall geometry but different reinforcement details (i.e. ductility levels) were modeled using OpenSEES. The full scale 3D prototypes of the frames have been tested on LNEC shaking table in Lisbon, Portugal using an earthquake ground motion with four intensity levels. The paper presents the experiences gained from the pre- and post-test modeling of the structures. The analytical roof displacement time history response is compared with those recorded during the tests. The results shows an acceptable agreement between the numerical and experimental values, which is improved by some calibrations after the actual test.

Keywords: Blind Test Challenge, Nonlinear Dynamic Analysis, Full Scale Test, Analytical Modeling.

1 INTRODUCTION

The ultimate and primary goal in earthquake engineering is to control the damage and/or prevent the collapse of the structures so that to reduce economic risk as well as human life losses from severe earthquakes. To this end reliable means are required to predict the actual structural seismic behavior. Full scale seismic tests of the structures on the shaking tables are the best available approach in achieving a true insight to the actual response of the structures under earthquakes. However due to the large costs associated with this type of tests they are rarely conducted. The next available tool of significant role in understanding structural behavior under seismic loads would be numerical studies based on nonlinear dynamic analysis, provided that they are well calibrated with actual behavior of the real structures. This study attempts on assessing the capabilities of current numerical tools in predicting the actual seismic test outcome carried out on two full scale structures.

The two full-scaled one story RC structure, geometrically identical, designed for low and high ductility levels according to the EC8 provisions, were tested on shaking table in Lisbon, Portugal, using an earthquake ground motion with four intensity levels (Low, Medium, Reference & High) in two horizontal axes (X, Y). The scale factor for each level is 0.2, 0.4, 1.0, and 2.0, respectively.

Based on experimental material data and construction report [1, 1, 2], numerical modeling and analyses were carried out using OpenSEES program for two structures, considering differences, with linear or nonlinear alternatives. In order to calibrate the analytical model, the roof displacements from test results were compared with those from numerical results for each level of intensity.

2 EXPERIMENTAL ANALYSIS

Figure 1 shows a one story full-scaled RC structure with one bay in the transverse (X) direction and one bay in longitudinal (Y) direction that is used for both structures. The plan dimensions are 3.5m by 4m, and the structure is 3.2m tall. The slab has a thickness of 0.10m and does not cover the entire span in one direction. A set of nine additional masses of around 1200 kg each were placed on top of the slab as shown on Figure 1.