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Seismic Analysis of Vertically Irregular Reinforced Concrete Buildings using Artificial Neural Networks

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Abstract

The experiences from past earthquakes have shown that the regularity either in plan or in elevation is of crucial importance on earthquake performance of structures. Besides buildings that are irregular in plan, buildings with vertical irregularity have a paramount presence in the built infrastructure of Iran. Sudden changes in stiffness and strength between adjacent stories are associated with changes in structural system along the height, changes in story height, setbacks and changes in materials. The objective of this study is to investigate the adequacy of Artificial Neural Networks (ANN) to determine the dynamic response of vertically irregular reinforced concrete buildings in three dimensions subjected to ground motions. For this purpose, an ANN model is proposed to estimate the base shear forces, base bending moments and roof displacement of buildings in two directions. In the ANN model, a multilayer perceptron (MLP) with a back-propagation (BP) algorithm is employed using a scaled conjugate gradient. ANN model is developed, trained and tested in a MATLAB based program. A training set of 84 and a validation set of 28 buildings are produced from dynamic response of vertically irregular RC buildings under the seismic forces. Finite Element Analysis (FEA) is used to generate training and testing set of ANN model. It is demonstrated that the neural network based approach is highly successful to determine the response of RC buildings subjected to ground motions.

Keywords: Dynamic analysis, RC buildings, artificial neural networks, earthquake.

1. INTRODUCTION

The part of a structure responsible for resisting the earthquake forces is called the lateral force resisting system (LFRS). The LFRS of a building structure is of various types, the most common forms of which are special moment resisting frames, shear walls, and frame-shear wall dual systems. Damage from earthquake ground motion generally initiates at locations of structural weaknesses present in the LFRS. Further, these weaknesses tend to accentuate the structural degradation, often leading to complete collapse. These soft zones or weaknesses may be created by sudden changes in stiffness, strength and/or mass between adjacent stories. Sudden changes in stiffness and strength between adjacent stories are associated with changes in structural system along the height, changes in story height, setbacks, changes in materials and unanticipated participation of non-structural components. The experiences from past earthquakes have shown that the regularity either in plan or in elevation is of crucial importance on earthquake performance of structures. Therefore, the structural engineer needs to have a thorough understanding of the seismic response of irregular structures.

In the earlier versions of Iranian Code of Practice for Seismic Resistant Design of Buildings [1], there was no mention of vertical irregularity in building frames. However, in the recent version irregular configuration of buildings has been defined explicitly. Five types of vertical irregularity have been listed as shown in Figure 1. They are: stiffness irregularity (soft story), mass irregularity, vertical geometric irregularity (set-back), in-plane discontinuity in lateral-force-resisting vertical elements, and discontinuity in capacity (weak story).

NEHRP code [2] has classifications of vertical irregularities similar to those described in Iranian Code of Practice for Seismic Resistant Design of Buildings [1]. As per this code, a structure is defined to be irregular if the ratio of one of the quantities (such as mass, stiffness or strength) between adjacent stories exceeds a minimum prescribed value. These values (such as 70-80% for soft story, 80% for weak story, 150% for set-back structures) and the criteria that define the irregularities have been assigned by judgment. Further, various building codes suggest dynamic analysis (which can be elastic time history analysis or elastic response spectrum analysis) to come up with design lateral force distribution for irregular structures rather than using equivalent lateral force (ELF) procedures.