3rd International Conference on Applied Researches in
Structural Engineering
and Construction Management
Sharif University of Technology - June 2019

Field Investigation of the Effect of Nonstructural Walls on Structural Dynamic Characteristics: Case Study of a 4-Story Steel Building Damaged in Sarpol-e Zahab Earthquake

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Abstract

Structural dynamic characteristics including natural frequency, mode shapes, and damping are the most important parameters in determining the seismic response of any structure. The present study investigated the dynamic characteristics of a damaged four-story steel building at Sarpol-e Zahab province in two conditions by ambient vibration test. At the first condition, the building contained nonstructural elements while at the second condition, nonstructural elements of the third and the fourth story were eliminated. Experimental results indicate that nonstructural elements have significant effects on the building's natural frequency and the damping.

Keywords: Dynamic characteristics, nonstructural elements, Damping, Ambient Vibration Test.

1. INTRODUCTION

Generally, structure's behavior under the extreme vibrations e.g. earthquake is dependent on the structural dynamic features like natural frequency, damping and mode shapes. Among these parameters, fundamental natural frequency related to the first mode could be considered as the most important key parameter. The first mode in force design approach has an essential role in determining the amount of structural seismic lateral forces and the base shear as a result. In order to estimate the structural fundamental period, current codes have proposed empirical equations, which mainly are based on the field and experimental tests. Additionally, another effective parameter in seismic response is damping which has been recommended to be considered five percent in the frequent codes.

Various factors can affect the dynamic parameters of a building including nonstructural elements, soil–structure interaction, and environmental conditions like temperature. Moreover, the presence of damage in structural and nonstructural elements may have significant effects on structural dynamic characteristics of a building. In 2003, many studies investigated the structural dynamic responses of totally 205 buildings including 137 steel structures, 25 RC buildings, and 43 composite buildings [1]. The increase in the height of the investigated structures, which clearly increase the fundamental period of those structures, result in the decrease of the damping ratio of the first mode. Moreover, structural damping may be influenced by the nonstructural elements like partitions. The more nonstructural elements in a building, the higher the structural damping. Dynamic responses of 330 buildings were investigated for the purpose of risk evaluation and structural vulnerability in Beirut, Lebanon [2]. The results have shown that higher natural frequency in the buildings, leads to less structural damping and higher structural periods in those buildings constructed on soft soil. In 2003, based on seismic responses of 42 steel buildings and 27 RC buildings in California with moment resisting frames as the lateral force resisting system, fundamental periods of the structures were determined [3]. Subsequently, Best curve fitted on the experimental results and for steel and RC structures with moment resisting frames as the lateral force resisting system some empirical equations were proposed which are the basis for estimating the first fundamental period of the buildings in current design and evaluation codes.