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Shaking table test on seismic response of a planar irregular structure with differential settlements of foundation

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ABSTRACT

The differential settlement of the foundation not only causes the degradation of the static performance of structures, but also affects the seismic performance. To investigate the seismic response of a planar irregular steel frame structure under differential settlement of foundation, we proposed a method to mimic multi-point differential settlement of foundations of scaled models steel frame structures. Four columns in the settlement location are adjusted downward to the set settlement distance, and then, the columns are fixed with nuts to achieve the effect of settlement in one location. Then a shaking table test was carried out on a scaled-down building model to analyze the dynamic responses of the structure. Eight seismic waves and three ground shaking intensities were set to represent frequent, moderate, and rare earthquakes. The seismic response, location changes, and torsion of the irregular planar structure were analyzed via shaking table tests under different seismic waves with frequent, moderate, and rare earthquake excitation, as well as changing parameters such as settlement location and settlement depth. The results show that compared with other locations, when a differential settlement of the foundation occurs in the corner location of the structure plane, the structure is more likely to be torsional and more prone to seismic damage. For the same seismic intensity and settlement depth, the settlement location at the corner of the structure face exhibited the greatest seismic response to the structure. In contrast, the settlement located near the center of the structure face had the least effect on the seismic response of the structure. The proposed method enables a fast and efficient way to understand the dynamic response of the structures with differential settlement of foundations, which will further benefit the development and optimization of the seismic strengthening scheme for these structures.

1. Introduction

Differential settlement of foundation is a common engineering problem, which seriously threatens the performance and safety of civil structures. A large number of studies have indicated that the damage to buildings can be primarily caused by the differential settlement of their foundations. When the foundation of a building structure produces differential settlement, it may cause a series of problems, e.g., deformation of the superstructure, redistribution of the internal force of the structure, cracks in certain parts of the structure, etc. When the settlement is severe, the entire structure of the building may tilt or even collapse. Therefore, differential settlement of foundations is always a major concern in the civil engineering field.

In order to study the effect of the uneven settlement on the superstructures, Feng et al. [1] conducted a numerical study on prestressed concrete cylindrical pipes under different settlements, investigating interface interactions and combined loads. Hara [2] used finite element software to study the stress distribution and ultimate strength of reinforced concrete structures under the non-uniform settlement of column supports. Yuan [3] used finite element software to study the influence of uneven settlement of foundation on continuous rigid frame bridge. Although the seismic susceptibility of a structure with a differential

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