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Study on Seismic Dynamic Response of Shallow-Buried Subway Station Structure and Ancillary Facilities

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Abstract

Strong earthquakes can cause damages to structural members and also yield non-negligible damages to nonstructural facilities, the latter being closely related to earthquake-induced inertial forces. At present, the acceleration response regularity of shallow-buried subway station structure is not very clear. Using the finite-element software ABAQUS, a dynamic soil-structure interaction model for a two-story subway station structure is established. The distribution of the peak acceleration response of the structure is obtained, and the damage assessment of non-structural facilities is carried out based on the structural acceleration response. The results demonstrate that, in general, the peak acceleration responses of the subway station structure increase from lower to upper story levels, while the peak acceleration responses at the same height are practically equal. Moreover, the peak accelerations of a shallow-buried subway station structure are generally less than or close to the peak ground acceleration. Furthermore, the nonstructural facilities are slightly damaged when subjected to a peak bedrock input acceleration of 0.1 g, and moderately damaged under a peak bedrock input acceleration in the range 0.2 – 0.6 g. Based on the acceleration response characteristics, it is proposed that the peak surface acceleration can be used as an index to evaluate the damage of non-structural facilities in shallow-buried subway station structure, which is simple, practical and basically meets the precision requirements.

Keywords: Subway Station Structure; Shallow-Buried Structure; Seismic Dynamic Response; Ancillary Facilities; Damage Evaluation.

1. Introduction

With the continuation of modern city development and underground space utilization, urban rail transit lines, which mainly consist of subways, have become an important means to resolve traffic problems. During the 1995 Great Hanshin earthquake in Japan, the Daikai, Luzawa, Nagata, and Sannomiya stations, suffered from various degrees of damage [1, 2]. In particular, the earthquake damage of Daikai subway station is extremely serious. It is the first large-scale underground structure earthquake damage case that has been completely destroyed in human history. A large number of theoretical, numerical and experimental research work has been carried out and the seismic damage mechanism and failure mode have been deeply and systematically analyzed [3]. The vibration table test can visually reveal the earthquake damage phenomenon. A multi-story subway station test was carried out to investigate the seismic effect. The result demonstrates that central columns are vulnerable components in multi-story subway stations [4]. The result of vibration table tests for subway station in loess soil shows that the Fourier spectrum values of accelerations increase at low-frequency components and decrease at high-frequency components form bottom to top of soil. The seismic responses of structure are controlled by surrounding soils in severe earthquake because of strong soil-structure interaction [5]. The seismic analysis results for the subway structures in soft soil area show that: The earthquake action

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