

The impact of deep drilling on seismic vulnerability of existing steel structures with parametric analysis

Abstract

Along with increasing urban activities, and developing underground facilities, subway stations, parking spaces and other underground structures, excavations made with various depths in urban areas around existing structures have turned into an inevitable issue. The excavations cause significant changes in the stress and strain fields of the soil under the existing building foundations and finally result in horizontal and vertical displacements under the foundation as well as large changes in static and dynamic response of existing structures. The main objective in the present study is in particular to investigate the above-mentioned problems using a study performed on 4 types of soil as classified in Standard 2800 earthquake regulations with a model of deep excavation in the vicinity of a steel framed building. In this study in order to evaluate the effect of deep excavations on seismic vulnerability of existing buildings, the required analyses have been carried out in three parts using PLAXIS and SAP2000. Nonlinear dynamic analysis of soil has been performed using PLAXIS software in which due to its inability to perform nonlinear dynamic structural analysis, the SAP2000 software is used for nonlinear dynamic analysis. In the first part of the study, using PLAXIS software for conducting the static analysis, horizontal and vertical displacements under the foundation subjected to dead and live loads have been calculated in two stages before and after the excavation. In the second part, using PLAXIS software, dynamic analysis has been conducted for both mentioned stages with the application of ten scaled records which are chosen based on the model of each site. Afterwards, the acceleration response under the foundation is calculated. This part aims to evaluate the effect of excavation on the acceleration response and to use it as an input for structural analysis in SAP2000 software. In the third part, for the structure modeled in SAP2000, the displacements resulted from the first part are applied to the foundation and using the acceleration response (output of PLAXIS), nonlinear dynamic analysis of the structure is conducted in two stages. The results indicate that the excavation made in all models causes the increased horizontal and vertical displacements. Therefore, by increasing the excavation depth and installing struts, vertical displacements and horizontal displacements increase by a smaller and bigger percentage of change, respectively. The acceleration response under the foundation in soil types 1, 2, 3, and 4 increases 51%, 35%, 66% and 27%, respectively. In addition, the maximum displacement of the structure increases 1.6, 1.3, 1.9 and 2.5 times more as compared to that before excavation, respectively.

Keywords: deep excavation, seismic vulnerability of existing structures, soil-structure interaction, dynamic analysis.