World Academy of Science, Engineering and Technology
International Journal of Geotechnical and Geological Engineering
Vol:13, No:08, 2019

The Effect of Soil-Structure Interaction on the Post-Earthquake Fire Performance of Structures

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Abstract : The behaviour of structures exposed to fire after an earthquake is not a new area of engineering research, but there remain a number of areas where further work is required. Such areas relate to the way in which seismic excitation is applied to a structure, taking into account the effect of soil-structure interaction (SSI) and the method of analysis, in addition to identifying the excitation load properties. The selection of earthquake data input for use in nonlinear analysis and the method of analysis are still challenging issues. Thus, realistic artificial ground motion input data must be developed to certify that site properties parameters adequately describe the effects of the nonlinear inelastic behaviour of the system and that the characteristics of these parameters are coherent with the characteristics of the target parameters. Conversely, ignoring the significance of some attributes, such as frequency content, soil site properties and earthquake parameters may lead to misleading results, due to the misinterpretation of required input data and the incorrect synthesise of analysis hypothesis. This paper presents a study of the post-earthquake fire (PEF) performance of a multi-storey steel-framed building resting on soft clay, taking into account the effects of the nonlinear inelastic behaviour of the structure and soil, and the soil-structure interaction (SSI). Structures subjected to an earthquake may experience various levels of damage; the geometrical damage, which indicates the change in the initial structure's geometry due to the residual deformation as a result of plastic behaviour, and the mechanical damage which identifies the degradation of the mechanical properties of the structural elements involved in the plastic range of deformation. Consequently, the structure presumably experiences partial structural damage but is then exposed to fire under its new residual material properties, which may result in building failure caused by a decrease in fire resistance. This scenario would be more complicated if SSI was also considered. Indeed, most earthquake design codes ignore the probability of PEF as well as the effect that SSI has on the behaviour of structures, in order to simplify the analysis procedure. Therefore, the design of structures based on existing codes which neglect the importance of PEF and SSI can create a significant risk of structural failure. In order to examine the criteria for the behaviour of a structure under PEF conditions, a two-dimensional nonlinear elasto-plastic model is developed using ABAQUS software; the effects of SSI are included. Both geometrical and mechanical damages have been taken into account after the earthquake analysis step. For comparison, an identical model is also created, which does not include the effects of soil-structure interaction. It is shown that damage to structural elements is underestimated if SSI is not included in the analysis, and the maximum percentage reduction in fire resistance is detected in the case when SSI is included in the scenario. The results are validated using the literature.

Keywords : Abaqus Software, Finite Element Analysis, post-earthquake fire, seismic analysis, soil-structure interaction
Conference Title : ICSMG 2019 : International Conference on Soil Mechanics and Geotechnics
Conference Location : London, United Kingdom
Conference Dates : August 20-21, 2019