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Characterisation of Liquefaction Effects for Beyond-Design Basis Safety Assessment of Nuclear Power Plants

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Preparedness of nuclear power plants to beyond design base external effects became high importance after 11th of March 2011 Great Tohoku Earthquakes. In case of some nuclear power plants constructed at the soft soil sites, liquefaction should be considered as a beyond design basis hazard. The consequences of liquefaction have to be analysed with the aim of definition of post-event plant condition, identification of plant vulnerabilities and planning the necessary measures for accident management. In the paper, the methodology of the analysis of liquefaction effects for nuclear power plants is outlined. The case of Nuclear Power Plant at Paks, Hungary is used as an example for demonstration of practical importance of the presented results and considerations. Contrary to the design, conservatism of the methodology for the evaluation of beyond design basis liquefaction effects for an operating plant has to be limited to a reasonable level. Consequently, applicability of all existing methods has to be considered for the best estimation. The adequacy and conclusiveness of the results is mainly limited by the epistemic uncertainty of the methods used for liquefaction hazard definition and definition of engineering parameters characterizing the consequences of liquefaction. The methods have to comply with controversial requirements. They have to be consistent and widely accepted and used in the practice. They have to be based on the comprehensive database. They have to provide basis for the evaluation of dominating engineering parameters that control the post-liquefaction response of the plant structures. Experience of Kashiwazaki-Kariwa plant hit by Niigata-ken Chuetsu-oki earthquake of 16 July 2007 and analysis of site conditions and plant layout at Paks plant have shown that the differential settlement is found to be the dominating effect in case considered. They have to be based on the probabilistic seismic hazard assessment and allow the integration into logic-tree procedure. Earlier studies have shown that the potentially liquefiable layer at Paks Nuclear Power Plant is situated in relatively large depth. Therefore the applicability and adequacy of the methods at high overburden pressure is important. In case of existing facilities, the geotechnical data gained before construction aren't sufficient for the comprehensive liquefaction analysis. Performance of new geotechnical survey is limited. Consequently, the availability of the data has to be accounted while selection the analysis methods. Considerations have to be made for dealing with aleatory uncertainty related to the knowledge of the soil conditions. It is shown in the paper, a careful comparison and analysis of the results obtained by different methodologies provides the basis of the selection of practicable methods for the safety analysis of nuclear power plant for beyond design basis liquefaction hazard.