**USE OF BASE ISOLATION SYSTEMS AGAINST INDUCED EARTHQUAKES: CASE OF GRONINGEN**

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**ABSTRACT**

Base isolation is an effective system for both existing and new buildings. The design of the isolation system as well as the expected response of the super-structure heavily depends on the actual seismic demand. This is because the lateral displacement of the isolator system is correlated to the hysteretic energy consumed, which in turn, affects the overall displacement and force demand. Therefore, if the earthquake intensity on the project site is much smaller than that assumed in the design phase, the response of the base isolation system, as well as its effectiveness, do differ considerably.

The occurrence of several earthquakes, all much smaller than the design level but still able to cause public unrest and some minor damage, is the case for induced earthquakes in Groningen, Netherlands. The largest on-land gas field in the world is in Groningen and is being exploited since early 60s. Several small earthquakes occurred in the past, with the most damaging one being in 2012, the Huizinge earthquake of magnitude 3.6 in Richter scale. The maximum recorded horizontal PGA is 0.11g in the area. Due to soft soil properties, as well as high seismic vulnerability of the local construction, even such small earthquakes can incur damage on houses that are mostly made of unreinforced masonry (URM).

Several base isolation projects have been completed in the Groningen area by designing the isolators for the design level earthquake. The more frequent and smaller earthquakes, however, which have been the main source of public concern in the area, are not taken into consideration. This paper, by making use of a representative case study, investigates whether base isolation is an effective answer to this kind of question where small repetitive earthquakes are major part of the problem. Furthermore, the present study also evaluates, by comparing different isolator responses, what type of isolation system would provide the optimum solution for the case of Groningen induced earthquakes or in similar cases. Nonlinear analyses on a calibrated full-scale shake-table test of an URM structure, representing Groningen houses, have been employed for demonstrating the findings of the study. Performance of different isolator types, such as curved surface friction isolators and rubber isolators, are compared. Smaller and frequent earthquakes as well as design-level earthquake motions have been considered in the nonlinear response history analysis.

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