KEM Research review, evaluation and interpretation (max. 4 pages + annex)

TITLE ***Literature study on the cumulative effect of repetitive seismic events on subsidence rates***

KEM Quality review

Description of the scientific quality of the results (team, research method, research results, quality of the products, …), if needed external review result (project evaluation text website)

The research question was established to address these issues:

1. What effects on near surface sediment settlement can be expected due to repetitive earthquake tremors?
2. Can the effect of repetitive earthquakes tremors cause damage to buildings (in relation to the specific situation in the Netherlands)?
3. If so, can the effect of repetitive earthquakes tremors be tested and quantified?
4. Can the effects of repetitive earthquake tremors be disentangled form other comparable processes common in soft soils in the Netherlands?

The following conclusions were reached:

1. In sand: cumulative settlement; in clay: no or only minor loss of strength
2. Depends on amount of settlement determined by earthquakes
3. Can be tested with cyclic tests on soil samples or geo-centrifuge tests (recommendation: assess shear strain amplitude due to present day earthquakes)
4. Depends on amount of settlement during earthquakes to date

The literature review seems to be of good quality, with the team and the methods appropriate for the task. Although not all questions were addressed with the same level of depth, it must be acknowledged that for some sub-issues the literature is very poor. In general, the quality seems sufficient or good; i.e., the evaluation is positive.

KEM Evaluation of the results

Evaluation whether the research questions are addressed adequately (questions answered, precision and uncertainties on outcomes, potential consequences on current practice addressed, ..) (project evaluation text website)

Most of the research questions seem to be answered adequately, although with limited precision and with qualitative outcomes in some cases. Several issues are recommended for further hands-on research to reach a more quantitative and conclusive outcome. In any case the results seem, in general, fit for the purpose of gaining a basic understanding of the effect of repeated earthquakes on subsidence in Groningen.

KEM interpretation of the outcome

The interpretation of the results (consequences on methods/data to be used in practice, can risk instrument modules, on inspection procedures and operator procedures, ..) (project evaluation text website)

The interpretation is that, for the Groningen risk assessment, to pursue in the field of this research question is not an immediate priority.

Closure text for the website

A summary in simple terms of the goal, the outcome and impact on mining policies or toolboxes of the research project (project evaluation text website)

The goal of this project was to understand the possible effect on subsidence of repeated earthquakes in Groningen and the potential detrimental effects on the built environment. It was decided to pursue a comprehensive literature review to gather a basic understanding on the topic and the relevance for Groningen. It was found that past research is very limited, and it can be concluded that the Groningen situation can be considered very peculiar.
Nevertheless, the work allowed to gather a preliminary understanding of this issue and provides clear recommendations to deepen it further. All in all, based on the outcomes of this project, the investigated issues seem not an immediate priority for inclusion in the Groningen probabilistic seismic hazard and risk assessment model, which is a valuable result.