

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

**TITLE Liquefaction potential and relation to risk – a literature review**

**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 questions of this project were:

1. Is there currently a method available to assess the occurrence of liquefaction in the Groningen region and can it be implemented as a separate module in the HRA model (the version developed by TNO)?
2. Using the liquefaction module, most recent HRA model version and updated subsurface database, what is the liquefaction potential in the Groningen region?
3. Is it possible that for Groningen type earthquakes (PGA's, PGV's) liquefaction occurs, possibly resulting in lateral spreading? If so, what effect can be expected for buildings and infrastructure in Groningen?

The results of the project consist of a literature review about the liquefaction potential and its relationship with building damage. The review mostly focuses on some indices for liquefaction (namely LPI and LPI<sub>ish</sub>).

The team is considered fit for the purposes of the research question and the quality of the work is good. However, the produced results do not perfectly match the framework of the probabilistic seismic hazard and risk assessment for Groningen.

**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)*

The literature review is addressed adequately, although the choice of focussing on LPI and LPI<sub>ish</sub> indices seems somewhat arbitrary and could have been better taken, considering the probabilistic seismic hazard and risk assessment for Groningen.

The link between LPI and LPI<sub>ish</sub> and building damage has been found poor, in this respect the project has not been fully conclusive for Groningen, although certainly is a step forward to the understanding of the liquefaction risk in the region.

**KEM interpretation of the outcome**

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

It results from this study that the liquefaction potential indices considered in the project are not suitable for inclusions in the Groningen risk assessment and a quantitative and fully probabilistic (i.e., performance-based) approach to liquefaction, which is somewhat similar to non-linear site response analysis is required. This can be considered a useful result.

A follow up of this project would be to fund development of liquefaction fragility analysis for soil deposits and development of building fragility due to liquefaction for typical structures in Groningen. How much such a follow-up is a priority must be established based on the prospect abandonment of the field and the information gathered so far about liquefaction in the region (including this study)), and can be matter of discussion within the KEM-panel and the KEM PSHRA-subpanel.

**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)*

This project was aimed at addressing the soil liquefaction during earthquakes in Groningen for eventual inclusion in the risk assessment as an additional negative effect in the region. The work has been focused on some soil liquefaction potential indices for soil liquefaction potential. These indices have been found to be poorly explicative of the building damage; however, the results help to find a clear path for further developments about the consideration of seismic soil failure in Groningen.