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

TITLE *KEM – 02 Evaluating, validating and improving the site-amplification component of the Groningen Seismic Risk Model*

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)

Research question 1: The evaluation of the existing site amplification model by NAM has been carried out by a verification by applying modelling using basic 1D and 2D methods. Advanced methods such as 2D or 3D wave propagation modelling to better understand the relevant processes have not been applied. The results generically indicate possible effects of topography and soil heterogeneity.

Research question 2: A straightforward HRA site response model validation has been carried out. This study applied standard methods and was sound and able to detect and reveal several possible flaws and sources of uncertainty in the HRA site response model. It was not conclusive on these issues.

Research question 3: The deliverable of RQ3 (report) gives a short summary of deliverables and of research questions 1 and 2 and their results, followed by recommendations mostly related to further studies or increased measurements/monitoring of the field.

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...)

Question 1: The research question is addressed via standard exercises using some models from literature. The work does provide a basic understanding of the addressed topographical effect issues. Uncertainty is basically not quantified, and it is, at this stage, not possible to conclude how important the outcomes for Groningen are. In fact, using the insights form the project, it seems possible to answer the topographical effect question to do the following: (1) take a digital elevation model with sufficient resolution for the area (e.g., 1m); (2) overlap with the urbanization/building inventory map; (3) find areas where topographic amplification is possible; (4) choose an amplification model to update the hazard and risk assessment for these locations/buildings (if the amplification model is not amplitude-dependent this does not require to re-run the HRA, but its results can be updated).
Unfortunately, due to external factors, the sub-questions of knipklei could not been tackled during the project so no conclusions could be reached on this issue.

Question 2: The research question is addressed via several analyses with different levels of complexity. The evaluation of the effect of local heterogeneity at shallow depths in the GMMs seem to have significant overlapping with full wave modelling analysis in other projects. This also applies to the effectiveness of 1D site amplification modelling. The investigation about site response (STRATA, 2D, large ground motion extrapolation, soil response from recordings) is helpful to somewhat improve the knowledge base about Groningen soil response.

Question 3 This provides a summary of results of RQ1 and RQ2 and (mostly) a straightforward possible follow up based on those results.

KEM interpretation of the outcome

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

It remains questionable whether topographic amplification is an issue for risk assessment in Groningen. Only after a regional assessment as indicated relevance for the risk assessments could be determined.
This also applies to lateral spreading as it relates to site amplification. It seems that the more recent versions of the GMM are improving in providing unbiased estimates. Nevertheless, it is intuitive that for site-specific analyses deeper investigations are needed. It is also clear that a more extended grid of measurements for site response would be beneficial.
As it regards the spatial variability of the GMM predictions it must be recalled that the developed GMM models are isotropic, while the large- and small-scale propagation mediums in Groningen are not. In conclusion, it seems that 2D and 3D full wave modelling provides, directly or indirectly, could provide for more comprehensive answers to the questions of this project.

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 KEM – 02 project investigated by investigating literature, seismic records of Groningen earthquakes and 2D modelling a series of issues for variations in soil response during earthquakes in Groningen, which in turn can causes damage or losses to the built environment. These issues can be roughly summarised as:

1. the modification effect (amplification) of topography of the area on ground motion in case of earthquakes;
2. the lateral spreading following liquefaction of the soil (saturated of water) in the case of earthquakes in Groningen;
3. how well are the soil characteristics and spatial variability in Groningen captured in the current risk assessment;

The results generically indicate possible effects of topography and soil heterogeneity, not included in current versions of earthquake risk assessment instruments. Topographic effects may locally occur to some extend and could be included in the risk instruments, as detailed topographic information is available. Lateral spreading effect is highly unlikely given liquefaction risk assessments study results. Soil heterogeneity is captured in the earthquake risk assessments to a km scale, 1-10m variations are not included due to lack of information and can only be captured in uncertainty ranges.

The results of this project can provide additional information for understanding variations in ground motions at short distances and for further updating of the earthquake risk assessment in Groningen.