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Naples, Italy – June 27th 2018

Subject: comment on research question KEM-20

To: whom may it concern

Please find below my comments to the questions posed in KEM-20. I hope they can help in proceeding further with it.

1. ***Can currently applied seismic impact assessment models used by NAM, and NPR be aligned or harmonized, improved based on a critically review checking amongst others the possibility of an accumulation safety risk factors in the underlying models.***

Comment: the differences between NPR 9998 (2015) and NAM (van Elk et al., 2017) risk analysis are mainly three: (1) the former one is a building code, while the latter is a probabilistic risk analysis; (2) the second is that the outcome of NAM includes models to evaluate personal consequences NPR stays at the structural level with code-based structural assumptions; (3) NAM risk analysis is at a large-scale NPR target individual structures. In the following, these issues are briefly deepened.

1. *Risk analysis versus code.*

   The risk analysis performed by NAM provides the annual rate (numerically similar to the annual probability if the rate is small enough) of observing a specific consequence (e.g., the *individual risk* or IR). This, in the *performance-based earthquake engineering* (Cornell & Krawinkler, 2000) approach, is obtained discretizing the domain of the ground motion intensity (e.g., the *peak ground acceleration* or PGA) in a number of values. For each value, its rate of exceedance at the site (i.e., the *seismic hazard*) is

multiplied by the probability that the considered consequences are observed in the system of interest; i.e., the structural *seismic fragility* (Crowley, Polidoro, Pinho, & Van Elk, 2017). Summing up these multiplications for all the considered intensity values yields the sought result (i.e., the risk). On the other hand, the NPR, as well as other seismic codes worldwide, do not aim at evaluating the seismic risk, they aim at warranting structural safety by design (of new structures or by retrofitting). Although the safety goal can be expressed in the same terms of the risk analysis (e.g., IR), the code does not directly verify that it is achieved, instead it considers a structure to satisfy the code if it performs as expected (i.e., does not violate the *design limit-state*) against specified seismic action, indirectly related to seismic hazard. In fact, the safety check in the code is not expressed in terms of a risk metric, but in terms of the design seismic demand on the structure that should be lower than the design seismic structural capacity; i.e., it replaces a probabilistic safety measure with a deterministic one. It has been shown elsewhere (Iervolino, Spillatura, & Bazzurro, 2017), that this approach does not allow to control the risk of the structure being designed.

2. *Code-based modelling assumptions.*

   Because the code aims at warranting the seismic structural safety via a simplified deterministic-format check that only considers one (or a few) ground motion scenarios and one (or a few) structural performances (limit-states) it necessary relies on a series of conventional and/or conservative assumptions. For example, the design values of the material characteristics are not the best guesses, they are instead lower percentiles of the material property distributions; this generally applies to all the factors intervening in the design procedure. Conversely, in risk analysis (such as that of NAM) conservative and non-conservative assumptions are to be avoided as much as possible, so as not to bias the evaluation of the risk and then of the decisions that are taken on the basis of the risk analysis. Moreover, the outcome of the NPR is at the structural level, and the models to pass from structural performance to the IR are not dealt with.

3. *Class-scale approach vs individual building design.*

   The NPR refer to individual buildings with a structure-specific building design, therefore the analysis carried out in the NPR framework are at the level of detail of a known, well-identified and described, structural model. This is essential for design because structures are, in general, unique piece of work poorly standardized. On the other hand, the risk

analysis carried out by NAM target risk in a very large area where many tens of thousands of structures are present. As such, it was necessary to grossly group the structures in building classes; i.e., grouped of buildings with relatively similar characteristics such that they can be analyzed with a single model, possibly accounting for building-to-building variations of characteristics; e.g., Iervolino, Manfredi, Polese, Verderame, & Fabbrocino, 2007. The result of this analysis may give an indication of the risk the class of buildings is exposed to. However, the risk evaluated via this class-scale approach lacks the level of detail and information to obtain a structure-specific risk measure; i.e., the risk of a building within the class can deviate significantly from that of the class and it is not straightforward, if not impossible, to retrieve it in the NAM analysis.

In summary, although the NAM and NPR approaches both target seismic structural safety, the latter aims at design and/or retrofit of individual structures, while the former aims at the risk analysis of large population of existing buildings. This fundamental difference results in different modelling assumptions and level of detail such that the results of the design for a specific building cannot be directly put in correspondence to the results of the NAM analysis and vice-versa.

2. ***Are the norms used for seismic risks and vibration hindrance (railway, pile installation, etc.) comparable, what are the best practices in modelling and can this be further harmonised and simplified in The Netherlands? What can be learned by the building sector?***

Comment: the state-of-the-art of earthquake-resistant design is determined by the nature of the seismic action, that is ground shaking, and the current degree of knowledge for its predictability for a specific site; i.e., probabilistic seismic hazard analysis (Cornell, 1968). Indeed, at its very beginning NPR determine the design action in terms of ground acceleration corresponding to a specific *return period* of exceedance (i.e., the average number of years between events able to cause the shaking level in question, at the site in question). This way of describing the phenomenon of interest is peculiar of natural hazards. An alignment of safety targets for other type of structures and infrastructures (also exposed to other risks) is directly possible if the actions of interest are subjected to the same type of probabilistic representation; this is less straightforward for spatially-distributed infrastructures, even if the seismic risk is considered (Esposito et al., 2015). Moreover, the structural/system performance (i.e., the tolerable level of

adverse consequence one should avoid in terms of design) should also be comparable. In other words, models should be available to make sure design warrant the safety in terms of the same metric. In more general terms, the way to compare different risks for different structures/systems is to express them in terms of expected loss, which is a common metric for all cases (e.g., Porter, Beck, & Shaikhutdinov, 2004). Although, in principle, the expected loss can be computed for all structures/systems, unless the safety representation and modelling are unified, it is hard to make sure different design warrant uniform risk levels.

In summary, the answer to the question is *yes*, but only in principle for most of the cases, at least so far. To be carried out, it requires major efforts in the long term.

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I hope this can help and I'd be happy to provide any further clarification if needed.

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Vergelijking NAM-HRA en NEN-NPR

Ter informatie
De Hazard en Risk Assessment (HRA) van NAM en de bouwpraktijkrichtlijn NPR 9998 van NEN geven andere inzichten over te versterken gebouwen. [redacted] heeft de beide aanpakken vergeleken. Hij is professor [redacted] aan de universiteit van [redacted]. Hij concludeert dat de HRA en de NPR andere doelen hebben en daarom ook andere uitgangspunten. Daardoor kunnen (en hoeven) ze niet dichter bij elkaar gebracht worden: ze hebben elk hun eigen toepassing. [redacted] stelt dat een HRA (probabilistisch) onvoldoende detailinformatie bevat om uitspraken te doen over een individueel gebouw. Dit is relevante informatie omdat in het advies van de Mijnraad wordt gewerkt met een probabilistische benadering en omdat ook de NEN commissie in de ontwikkeling van de NPR streeft naar het dichter bij elkaar brengen van beide benaderingen (kalibreren NPR aan HRA).

Afgestemd met
[redacted]

Bijlage
- [redacted]: Comment on research question KEM-20, 27 juni 2018

Aanleiding
De Hazard en Risk Assessment (HRA) van NAM en de bouwpraktijkrichtlijn NPR 9998 van NEN leveren andere inzichten over te versterken gebouwen. Niet duidelijk was waardoor de grote verschillen komen. Daarom heeft het Kennisprogramma Effecten Mijnbouw (KEM) de beide aanpakken door [redacted] laten vergelijken. Hoofdvraag was of de HRA en de NPR dichter bij elkaar gebracht kunnen en moeten worden.

Vergelijking HRA en NPR
Zowel de HRA als de NPR bekijken de veiligheid van constructies bij aardbevingsbelastingen. Maar ze hebben verschillende doelen en gebruiken daarom verschillende methoden en aannames. De verschillen in uitkomst tussen de HRA en de NPR zijn terug te voeren op de verschillen tussen een risico-assessment en een bouwrichtlijn. Daardoor kunnen (en hoeven) de HRA en de NPR niet dichter bij elkaar gebracht worden: ze hebben elk hun eigen toepassing.

De verschillen tussen de HRA en de NPR in een tabel samengevat:

	Hazard- & Risk Assessment	**NPR**
Wat is het?	Risico-assessment	Bouwrichtlijn
Doel	Een zo goed mogelijke inschatting van het seismische risico, om op basis daarvan beslissingen te kunnen nemen	Garanderen van constructieve veiligheid en dit borgen in ontwerp
Aanpak	Probabilistisch	Deterministisch
Detailniveau informatie	Groot gebied, 10.000-en gebouwen, opgedeeld in klassen/typologieën	Individueel gebouw met bekende constructie en detaillering
Uitgangspunt berekening	Combinatie van heel veel verschillende scenario's	Één of enkele scenario's voor (aardbevings-) belasting en capaciteit gebouw (limit states voor gebruik en veiligheid)
Aannames	Verwachtingswaarden (best guesses, mean values)	Conservatieve aannames (lage sterkte, hoge belasting)
Uitkomst	Jaarlijkse kans van optreden van een gebeurtenis binnen een gebied, bijvoorbeeld Individueel Risico (IR)	Gebouw voldoet wel/niet aan norm (bv IR<10^{-5}). Ontwerpbelasting overschrijdt wel/niet de ontwerpcapaciteit. Maar IR wordt niet bepaald, dus het is niet duidelijk hoe ver een gebouw onder of boven de norm zit.

Gebruik HRA voor risicobeoordeling individuele panden

[redacted] geeft aan dat de uitkomsten van de HRA een indicatie kunnen geven van het risico waaraan een bepaalde gebouwtypologie bloot staat. Dit kan gebruikt worden voor prioritering binnen een populatie gebouwen. Maar een HRA bevat onvoldoende detailinformatie om voor een individueel gebouw uitspraken over risico te kunnen doen.

PM

In de notitie van [redacted] wordt een tweede vraag geadresseerd. Deze gaat over de NPR en de SBR trillingsrichtlijn. De vraag is echter niet op die manier begrepen en wordt opnieuw geformuleerd binnen het KEM.