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Natural Hazards and Earth System Sciences
Discussions

Interactive comment on "From rapid visual survey to multi-hazard risk prioritisation and numerical fragility of school buildings in Banda Aceh, Indonesia" *by* Roberto Gentile and Carmine Galasso

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Legend: blue – reviewer's comment. Black – answers from the authors.

I feel that this manuscript needs to improve their structure, connection between sections (especially the last section on fragility functions), add some explanations and proper references.

We would like to thank this reviewer for the valuable comments on our manuscript. We will improve the manuscript structure and connection between sections accordingly.

General Comments I think the authors should better show uniqueness of their rapid survey form, i.e. how their new rapid survey form differs to other rapid survey forms, easier/faster to fill?, can be used for various purposes, etc.

This reviewer is acknowledged for this comment. In fact, although the main features of the INSPIRE Rapid Visual Survey (RVS) are discussed in the manuscript, the comparison with other approaches and its uniqueness will be better stressed-out in the revised version of the paper. The unique features of the INSPIRE form are related to: 1) the possibility to calculate both a seismic and a tsunami index while requiring a reasonable amount of time to be filled; 2) the consideration of qualitative confidence levels for each parameter, which is particularly useful in deriving statistics, defining archetype buildings and/or numerical models (as shown in the paper); 3) with simple customisations, it can be used for other purposes (e.g., considering other types of hazards).

Is INSPIRE developed mainly for earthquake and tsunami or applicable to other hazards? If the later, more explanations are needed as only examples on earthquake and tsunami were demonstrated. Currently, the INSPIRE RVS form is optimised for earthquake and tsunami. This is why the specific case study in the illustrative application (i.e., Banda Aceh) is mainly affected by such hazards. However, simple modifications of the form could be easily implemented to include other hazards (e.g., more information related to roof type/quality/connections is required when dealing with wind vulnerability). This concept will be emphasised in the revised manuscript. It is worth mentioning, however, that the multi-hazard considerations presented in Section 3.3 are still valid, and are not limited to the earthquake and tsunami hazards.

The newest PTVA is PTVA4 that calibrated their vulnerability based on comments and questionnaire results from experts in this field. Why don't you use the newest one? Reference: Dall'Osso, F., Dominey-Howes, D., Tarbotton, C., Summerhayes, S., and Withycombe, G.: Revision and improvement of the PTVA-3 model for assessing tsunami building vulnerability using "international expert judgment": introducing the PTVA-4 model, Nat. Hazards, 83, 1229–1256,2016. Izquierdo, T., Fritis, E., and Abad, *M.: Analysis and validation of the PTVA tsunami building vulnerability model using the 2015 Chile post-tsunami damage data in Coquimbo and La Serena cities, Nat. Hazards Earth Syst. Sci., 18, 1703-1716, 2018. Alternatively, you can also use or compare with previously developed tsunami fragility functions of RC buildings. Reference: Suppasri, A., Charvet, I., Imai, K. and Imamura, F. (2015) Fragility curves based on data from the 2011 Great East Japan tsunami in Ishinomaki city with discussion of parameters influencing building damage, Earthquake Spectra, 31 (2), 841-868.* The reviewer is particularly acknowledged for this comment. In the revised manuscript, the newly-calibrated PTVA4 index will be used. In the figures below, the results of the PTVA4 index (right column) for the analysed building portfolio are compared to the previously-adopted PTVA3 index (left column). The resulting vulnerability index for some of the buildings has indeed slightly changed when the new methodology is applied. However, it is worth highlighting that using the new calibration (PTVA4) has limited-to-negligible effects on the overall multi-hazard prioritisation for the considered portfolio.

Specific comments P2 L3: Needs reference The reference (last Italian census of 2011) will be added in the revised manuscript:

Istituto nazionale di STATistica, ISTAT (2011). 15th general census of population and housing (in Italian). http://dati-censimentopopolazione.istat.it.

Introduction section shall be rearranged for better readability. For example, grouping the literature reviews to RC building, school building and structure of INSPIRE. At present, explanations of methods and objectives are mixed up, please rearrange and make it clear (page 3). To improve the readability of the paper, the literature review in the introduction will be rearranged as suggested from the reviewer.

P9 L1-2: Calibrate the baseline score to what? Why DS3 is used? The reviewer is acknowledged for this comment. Firstly, the correct wording in this case should be "to define" rather than "to calibrate" the baseline score, and this change will be implemented in the revised manuscript. Moreover, as discussed in Section 3.1, the definition of the

baseline score of the index is based on the DS3 damage state, as defined in HAZUS. This is because DS3 is deemed to be related to the Life-Safety performance objective in modern seismic codes. To further expand on this, when considering an RC member within a frame (e.g., beam or column), DS3 corresponds to the member ultimate capacity, which can be related to flexural failure (ultimate strain in concrete or steel, buckling of the reinforcement), shear or lap-splice failure. According to modern seismic codes (e.g. NZSEE 2017, ASCE 41-13, EuroCode 8), such a damage condition (for one or a few members) would define the ultimate limit state of the frame, which is "conventionally" related to the safety of people occupying the structure (i.e., Life-Safety). Such more-detailed comments will be implemented in the revised manuscript.

NZSEE: New Zealand Society for Earthquake Engineering, The seismic assessment of existing buildings - technical guidelines for engineering assessments. Wellington, New Zealand, 2017.

ASCE 41-13 (2014), Seismic Evaluation and Retrofit of Existing Buildings, American Society of Civil Engineer and Structural Engineering Institute, Reston, Virginia, USA.

EC8 (2005), 'European Comittee for Standardisation. Eurocode 8: Design of structures for earth- quake resistance. Part 3: Strengthening and repair of buildings'.

P10 Table 3: How these weight factors obtained? If from HAZUS, how certain these values can be applied globally? The secondary parameters are selected to account for aspects of the analysed building which are not-explicitly considered in the HAZUS framework (i.e., in the baseline score). Such parameters, if present in the building, are deemed to negatively-affect its seismic performance. As mentioned in Section 3.2, the weights for such parameters (representing their relative importance) are defined according to the analytic hierarchy process, in turn based on all the possible pairwise comparisons between such parameters. At the present stage, the expert judgement that defines the pairwise comparisons is provided by the authors. However, in the future such coefficients will be updated considering the opinion of a group of experts in the field of structural and earthquake engineering. Finally, the weights of the secondary parameters are portfolio-specific, and therefore they should be calibrated differently for each analysis situation. Such concepts will be further discussed in the revised manuscript.

P12 Section 3.3: If there are three hazards or more, how equation 7 and Fig. 3 will be? And how to avoid such double count of subsequent damage? This comment is particularly acknowledged. Equation 7 (Section 3.3) is defined for an arbitrary number of dimensions k. A high-dimensional Euclidean space is considered in which each dimension represents the vulnerability/risk index for one hazard. A building subjected to k different hazards will be defined as a point in this space. It is proposed to define a multi-hazard index as the distance of this point from the origin. The second part of the comment relates to subsequent/cumulative damage. It worth mentioning that considering cumulative damage related to the different hazards is outside the scope of this prioritisation scheme. Such important concept will be discussed in the revised manuscript.

P14 L31: Needs reference The reference will be added in the revised manuscript.

Seta, W.J.,: Atlas Lengkap Indonesia dan Dunia (untuk SD, SMP, SMU, dan Umum). Pustaka Widyatama. p.7, 2000.

P15 and/or P19: I think you should give more explanations about tsunami hazard in your study area in the past/future. How the flow depth of the 2004 Indian Ocean tsunami used in INSPIRE. I am not sure if they have measured flow depth in all buildings in your study if so, the flow depths are from model simulation? This comment is particularly appreciated. The tsunami height (relative to the ground) related to the 2004 Indian Ocean event is based on the field-measures by Iemura et al., 2012. In this work, a correlation model between the distance from the coast and the tsunami height was developed. Such a model is adopted here to calculate, for each building in the portfolio, the expected tsunami height as a function of the distance from the coast.

Such considerations will be added in Section 4.2 of the revised paper.

Iemura, H., Pradono, M.H., Sugimoto, M., Takahashi, Y. and Husen, A.: Tsunami height memorial poles in banda aceh and recommendations for disaster prevention. Proceedings of the International Symposium on Engineering Lessons Learned from the 2011 Great East Japan Earthquake, March 1-4, 2012, Tokyo, Japan, 2012.

P20 Fig. 8 There should be some discussions that point out importance of considering multi-hazard scenarios. For example, buildings that became higher risk when tsunami is considered and comments on how the developed map can be used for disaster planning. We thank the reviewer for this comment and agree on the importance of considering multi-hazard scenarios for risk prioritization. Indeed, a specific comment on this aspect will be added after Figure 8. Furthermore, a comment on how these maps can be used for disaster planning will be added. For instance, the developed maps could be used to identify “safer areas” where strategic buildings (e.g., schools or hospitals) should be located. While specific recommendations on disaster planning are outside the scope of this study, a few references to this aspect will be included in the revised paper:

Alexander D.: Disaster and Emergency Planning for Preparedness, Response, and Recovery, Oxford Research Encyclopedia of Natural Hazard Science, doi: 10.1093/acrefore/9780199389407.013.12, 2019.

P16 Fig. 5: Add photo taken dates These pictures have been taken during the fieldwork carried out between 16 and 19 October 2018. This information will be added in the revised manuscript.

P21 Section 4.3: I feel that this section is not related to others otherwise, it should be used to compare with analysis results of other previous sections. What was the purpose of this section? Why didnt the authors use their own developed fragility functions instead of HAZUS? As mentioned in the introduction of the paper, the ISPIRE form has multiple purposes, allowing to carry out analyses with different levels of refinement. Clearly, a prioritisation scheme can be defined according to the relative risk index. Moreover, the form provides enough data to build refined numerical models for one or more selected buildings (e.g., an “average” archetype building or the buildings with the highest relative risk index). The purpose of Sections 4.2 and 4.3 is respectively to illustrate the above-mentioned purposes of the form. Accordingly, a more clear aim for Section 4.3 and a better link to the previous sections will be added in the revised manuscript.

In this context, the HAZUS-based fragilities are not used to derive quantitative estimates of the seismic risk of one or more specific building in the database, but only to define relative estimates (i.e., the prioritisation scheme). Conversely, the structure-specific fragilities obtained with the analyses in Section 4.3 can be used to provide such quantitative estimates of the seismic risk. Therefore, comparing the HAZUS-based fragility curves with the refined ones derived in Section 4.3 is deemed to be inappropriate.

Finally, adopting the refined fragilities as an input for the INSPIRE index would have the opposite of the desired effect. The index is defined as a quick and practical estimation tool for large portfolios (level 1). A time-consuming fragility estimation (level 2) should not be used as an input to a quick relative-risk method.

Please also note the supplement to this comment:
https://www.nat-hazards-earth-syst-sci-discuss.net/nhess-2018-397/nhess-2018-397-AC1-supplement.pdf

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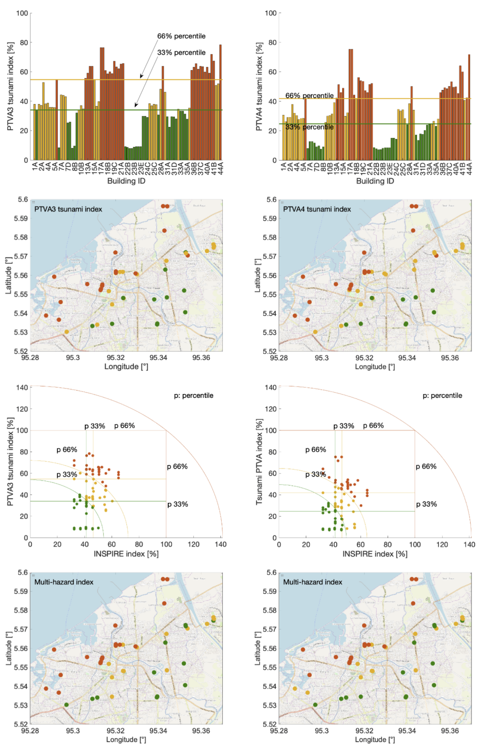

Fig. 1: comparison of the prioritisation based on the PTVA3 and PTVA4 indices.

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