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Newsletter #5

08 May 2021

This issue

Editorial and Organizational Development

Editorial

The new started a few months ago and still many countries are suffering from the COVID-19 pandemic. Watching TV transmissions and talk shows any person with a scientific background understands that the communication of scientific facts in a time characterized by information overload and incompetent communication of hazards and risks became very difficult. The old theorem of social sciences that more science (thus more specialisation) creates less general scientific knowledge in the population found an impressive confirmation in many media. On the other side, more people understand that humanity cannot control nature and has to be prepared against natural hazards, and this does not include diseases, only. The pandemic has shown how vulnerable our society is and this is true for seismic hazards, too. Each larger earthquake shows again and again that people are insufficiently prepared against its consequences, but the necessary conclusions for disaster prevention are not taken. Decision-makers prefer to gamble with nature relying on presumably low probabilities of earthquakes and on the misleading term of return periods which seem to be very large. The newsletter #5, the first in 2021, contains the second part of the historical review on the development of seismic hazard methodology. It highlights how it became possible that subjective expert judgement started to replace scientific facts in Probabilistic Seismic Hazard Analysis

Organizational Activities

New Members:

We welcome our new members:

Dr. Jia, Junbo

Dr. Venisti, Nicola

ISSO thanks Dr. Venisti for agreeing to be our webmaster. He recently started the update of our website: www.issoquake.org . It is worth to have a look at our updated website. ISSO members are kindly invited to share information (presentations, opensource publications etc.) which are of interest for our organisation by sending them to the president or to the webmaster directly.

Next General Assembly meeting:

The COVID-19 pandemic still hinders activities of many organisations. ISSO is also affected. Therefore, we plan the next General Assembly meeting in the format of a ZOOM conference in autumn 2021 including elections.

ISSO is still looking for a volunteer taking over the work on our website.

ISSO board meetings:

The ISSO board resumes its activities starting from May 2021. The main objectives of the next meetings are the preparation of the next general assembly meeting and the ISSO charta.

Implementation of Scientific Strategy

At the General Assembly meeting in Vienna 2016, ISSO members agreed on the scientific strategy for the next years. It was elaborated that the most feasible option for promoting the Intention of ISSO to represent the interests of public safety by being prepared for the worst credible event in combination with sound engineering consists in the support of the use of seismic intensities in seismic hazard analysis. For achieving this objective ISSO endorses a paradigm change in seismic hazard analysis moving away from the subjective and mathematically questionable PSHA methodology anchored in many national regulations to physics based deterministic seismic hazard analysis focussing on the analysis of the consequences of maximum credible earthquakes which lead to the largest impact on human lives and civil constructions. These methods entirely rely on data and on the state of the art physical and engineering modelling of earthquake consequences meeting engineering as well as risk analyst's needs. Missing information is compensated by robust assumptions and safety factors derived on a sound scientific basis, not by subjective opinion. Construction of seismic hazard maps for larger regions by the help of neodeterministic seismic hazard analysis (NDSHA) provides a sound basis for the development of seismically robust infrastructure including residential and industrial buildings. The design of critical infrastructure like lifelines (bridges, hospitals, nuclear power plants) is based on site-specific deterministic analysis defining the design earthquake as the maximum credible earthquake leading to the highest site intensity including an additional safety factor considering the prediction uncertainty of future earthquakes.

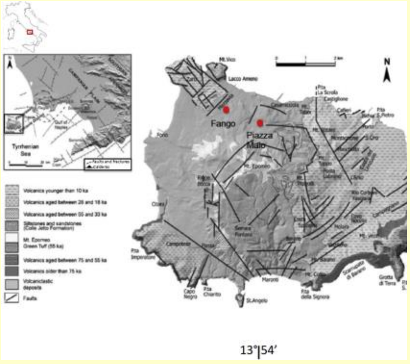
Implementation of Scientific Strategy of ISSO

ISSO has happy to inform its members that the book "Earthquakes and Sustainable Infrastructure: neodeterministic (NDSHA) approach guarantees prevention rather than cure" (Panza G.F., Kossobokov V.G., Laor E. and De Vivo B., Eds.) is now in print.

Some other recent publications on the use of NDSHA method published by or under participation of our members are:

a) J. Bela & G.F. Panza, *NDSHA – The New Paradigm for RSHA – An Updated Review*, Vietnam Journal of Earth Sciences 43 (2), 111- 188, 2021, https://doi.org/10.15625/0866-7187/15925, here RSHA denotes ***R**eliable* ***S**eismic* **H**azard **A**nalysis.

b) Giuseppe De Natale, Stefano Petrazzuoli, Fabio Romanelli, Claudia Troise, Franco Vaccari, Renato Somma, Antonella Peresan, Giuliano F. Panza, *Seismic risk mitigation at Ischia island (Naples, Southern Italy): An innovative approach to mitigate catastrophic scenarios*, Engineering Geology, 261 (2019), https://doi.org/10.1016/j.enggeo.2019.105285



Volcanological and structural map of Ischia island. In the upper left inset, the tectonic map of Campania Region is schematically shown – taken from reference b)

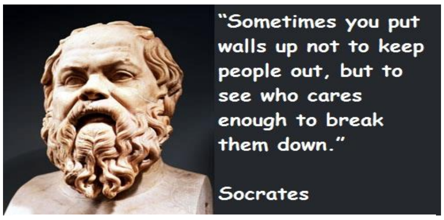
c) Paolo Rugarli, Franco Vaccari, Giuliano Panza, Seismogenic nodes as a viable alternative to seismogenic zones and observed seismicity for the definition of seismic hazard at regional scale, Vietnam Journal of Earth Sciences, 41 (4), 2019, 289-304, https://doi.org/10.15625/0866-7187/41/4/14233

These publications show the robustness and the broad spectrum of possible applications of the neodeterministic method. The increasing number of earthquake time-history recordings alleviates the task of engineers to link site intensity (macroseismic, characterizing observable damage) with engineering design parameters, be it in terms of realistic response spectra or directly in the form of time-histories for dynamic analyses as it is required for the design of critical infrastructures. Registered time-histories complement synthetic seismograms used in the NDSHA method or the use of computer intensive complex physical models (kinematic or even dynamic fault models) allowing to capture the variability of ground motions for sites of interest.

Alternatively, the use of regionally validated empirical correlations applied for a rapid assessment of the consequences of the Maximum Credible Earthquake (MCE) at a site of interest remain to be the solution of choice for many earthquake engineers. They can help to check the plausibility of more complex seismic hazard analyses provided by academic scientists. It is worth to remember that earthquake disaster prevention does not need seismic hazard results with an (imagined) accuracy up to a single percent. Disaster prevention needs robust solutions with safety margins. Such solutions can be achieved in different ways, the simpler, the better.

Development of SHA – Part II – Introduction of Expert Judgement into PSHA

In the last newsletter we covered the promotion and rise of PSHA as a part of the U.S programme for the development of atomic energy. From the U.S.A PSHA propagated through out the world anticipated a part of the "American way of science". In the second part we'll discuss the introduction of logic trees and expert judgement into PSHA and the contribution of the use of these methods to the Fukushima accident.



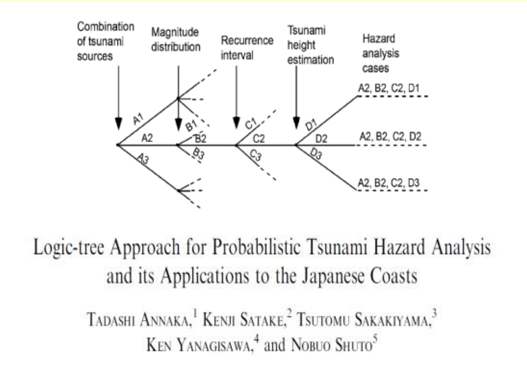
It is time to break the PSHA walls.

SHA – History Part I

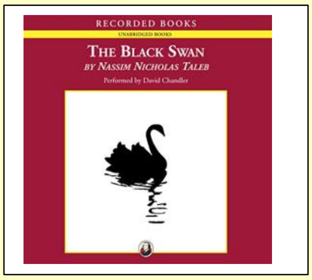
In the early phase of the deployment of nuclear reactors in the U.S. PSHA did not play the dominant role for the seismic design of the plants. It was merely a complement to deterministic analysis used for siting decisions. Things changed drastically with the construction of the Diablo Canyon Nuclear Power Plant in California. The original design basis following the seismic hazard analysis methodology of US NRC (a simplified incomplete deterministic approach) at that time consisted of a design spectrum anchored at 0.23g. Strangely enough, site investigations offshore of the Californian coast were not required by the regulatory authorities. During the construction phase the Hosgri fault along the Californian coast was discovered. The impact of potential earthquakes of magnitude M7+ on the nuclear power plant were tremendous. The design basis PGA jumped to 0.75g. The larger part of planning and of manufacturing of key components were completed. How to save the project? The solution was found easily. The "deterministic" method (actually it was the incomplete interpretation of the deterministic method by U.S. NRC) was blamed of overlooking the Hosgri fault and the shift to PSHA was performed. At the same time the fairy tale was born that a key advantage of the PSHA is that it considers all seismic sources. What is not told is that the occurrences of earthquakes from seismic sources are weighted with probability (usually lower 1). Therefore, the impact of earthquakes on the nuclear power plant is downscaled and smoothed. This is just what was needed!

Fukushima, 2011 – a consequence of probabilistic hazard analysis?

The second big application of PSHA started after the TMI2 (1979) accident. To avoid more stringent regulatory requirements to cope with station blackout scenarios (the total loss of all AC power sources) which would have resulted in the need to backfit high-capacity battery power sources to all U.S. nuclear power plants the idea was born to perform an individual plant examination (IPE) to identify safety margins using best estimate analysis methods. For this, among others, probabilistic risk assessments (PRA) were allowed to be used. These PRAs already included a broad use of expert judgement as a key part of the analysis of severe accidents (NUREG-1150). Later on, the plant examination was extended to include external hazards (IPEE). As a part of defining review earthquakes (which should be stronger than the design basis) PSHA was accepted as a method to define them. EPRI from the side of the industry and the Lawrence Livermore Institute on behalf of the NRC performed large scale PSHA studies involving the use of experts to identify and quantify uncertainties of the assessment.



Dr. Ellis Krinitzsky identified the large deficiencies and the contradictory assessments of these studies in many of his publications. As a key reference we provide here: E. Krinitzsky, The Hazard in Using Probabilistic Seismic Hazard Analysis for Engineering, Environmental & Engineering Geoscience, Vol IV, No. 4, winter 1998, pp. 425-443. The contradictions between these studies were so obvious, that the NRC was forced to react. This deemed necessary, because the search for a final repository of radioactive waste started in this time period. Instead of returning to a sound geophysical approach based on facts and date they claimed that the expert opinion elicitation and aggregation process used in the studies was imperfect and has to be developed further. As a consequence the Senior Seismic Hazard Assessment Committee was founded led by G. Apostolakis, a later NRC commissioner with huge expertise in PRA but not in geosciences. The SSHAC procedures (NUREG 6372, 1997) were born. The basic idea of achieving a "scientific consensus" by expert opinion elicitation by agreeing on "the centre, body and range" of the technically informed community was believed to help to promote the Yucca Mountain project as the final repository of radioactive waste. The "technically informed community" is defined straight away as scientists who accept PSHA as the only method of seismic hazard analysis. The critics to the application of these methods in Switzerland (see the discussion in Engineering Geology, 2005) led to a further superficial refurbishment of the procedures, the latest with NUREG-2312 (2018). It is worth to mention that expert judgement is required for any type of scientific investigations. The difference is that in the SSHAC procedures the expert judgement represents the final result of the assessment, while in science it represents a temporary, intermediate state of knowledge helping to identify areas, in which further investigations are required to obtain more reliable results. This understanding is deeply rooted in specifics of the understanding of system science in the U.S. asserting that the world is not cognoscible, and knowledge represents a mere, fuzzy image of the real world (constructivism). If this is the basis of science, formalized rational logic is able to replace empirical observation and learning from empirical evidence is not possible and even not needed. This position entirely contradicts to engineering experience and reminds one to scholastic discussions of medieval times. Another practical consequence is, that PSHA results cannot be validated, and it is claimed, that validation is not even needed.



Unfortunately, this position leads to ignorance of empirical evidence obtained from earthquake disasters and, at the final end, to a complete loss of ability to learn from experience. This position contributed to large disasters in many areas. In the financial system these disasters were anticipated as "Black Swan" events, in daily life these disasters were observed as catastrophes from natural hazards, like the Fukushima disaster. Although logic trees, characteristic for contemporary probabilistic analysis of natural hazards, also include branches for extreme scenarios the latter hardly affect the final results due to the low probabilistic weights assigned to them. Probabilistic tsunami hazard studies performed by TEPCO before the Fukushima disaster contained branches for extreme tsunamis (Annaka et al, 2007), but they effectively were excluded from further consideration by focussing on the mean hazard results ignoring the "Black Swan" extremes.

The only way to prevent repetition of such catastrophes is to return to science and robust engineering, learning from empirical evidence and to force a change of paradigm in hazard analysis from probabilistic methods to sound physics and facts-based methods.