Seismic Experts Explain Key Technical Issues in the Draft of National Annex to Eurocode 8

CIVIL AND STRUCTURAL ENGINEERING TECHNICAL DIVISION

reported by

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A 2-Day workshop on seismic analysis methods for regions of low-to-moderate seismicity, with emphasis on Eurocode 8 and the proposed National Annex for Malaysia, was held at the Armada Hotel in Petaling Jaya on 11-12 April, 2017. The aim was to explain the distinctive features of the post-public comment draft National Annex prepared by IEM and the justifications for their adoption, citing results of studies that had been undertaken along with recommendations by world literature.

It saw a record attendance of 165 participants, comprising 90% consulting engineers and the remaining 10% others, including academicians. IEM had invited international and local experts to give presentations during the workshop. They included (in alphabetical order) as below:

- Professor Azlan Adnan (Universiti Teknologi Malaysia): He leads local experts in undertaking probabilistic seismic hazard analysis in different parts of Malaysia.
- Professor Robert Geller (retired, University of Tokyo, Japan): World expert in earthquake sciences.
- Ir. Adjunct Specialist M.C. Hee (MC Hee & Associates, Malaysia): An expert in earthquake engineering and mentor of the team which drafted the NA. He has his own structural design consulting firm and is a leading figure in code developments.
- Professor Nelson Lam (University of Melbourne, Australia): Experienced in the drafting of earthquake codes, with some 30 years' engagement in earthquake engineering and structural dynamics research. He was a member of the code committee developing the Australian Standard for seismic actions and led the drafting of the Malaysia NA.
- Ir. Lim Ek Peng (Hashim & Neh Consultants, Malaysia): A leader in the structural design of buildings and a key contributor in the drafting of the Malaysia NA.
- Professor Kyriazis Pitilakis (Aristotle University of Thessaloniki, Greece): A world leader in geotechnical earthquake engineering who is co-leading the continuing development of Eurocode 8.
- Dr Hing-Ho Tsang (Swinburne University, Australia): A key contributor to the drafting of the NA, he also wrote a book on earthquake hazard assessment (Tsang and Lam, 2010).

Figure 1: Presenters and session chairs (from left), Prof. Azlan Adnan, Dr Hing-Ho Tsang, Prof. Nelson Lam, Prof. Kyriazis Pitilakis, Prof. Robert Geller, Ir. Adjunct Specialist MC Hee, Ir. Prof. Jeffrey Chiang, Ir. K.P. Mun and Ir. E.P. Lim

In his opening address, Professor Lam outlined the topics that the workshop would focus on:

1. Justification for the minimum design PGA value of 0.07g for the peninsula, Sarawak and Western Sabah, and 0.12g for Central and Eastern Sabah.
2. Justification for the use of a response spectrum model which is different to Eurocode 8 Type 1 and 2 response spectra.
3. Justification for the site factor model which features the use of the site natural period as a parameter for site classification and determination of the site amplification factor.
4. A review of seismic zonation maps that were originally proposed by IEM in the draft NA (2015), maps proposed by Professor Felix Tongkul during public comment period (2016), maps by a team led by UTM (2016) and maps submitted by IEM as a proposal to reach a consensus (2017).

Professor Lam presented a table which listed important references in support of the minimum design PGA value of 0.07g to allow for uncertainties in a stable (intraplate) environment.

*Table 1: Presented by Prof. Lam citing support from world literature in specifying a minimum design PGA value of 0.07g (*Note: Probabilistic Seismic Hazard Assessment (PSHA), Peak Ground Acceleration (PGA)*

Ref.	Literature References	Comments / Recommendations
1.	Mulargia, Stark & Geller (2017)	"The **insufficiency of the available seismicity data** means that it is **highly questionable that PSHA can provide reliable and accurate hazard** analyses".
2.	Lam, Tsang, Lumantarna Wilson (2016)	**Minimum design PGA value of 0.07g** is recommended for stable regions.
3.	Wilson (2015)	**Minimum design PGA value of 0.08g** is recommended for the **stable region of Australia**.
4.	Tongkul (2016)	**Design PGA value of 0.05g - 0.1g** is recommended for **Peninsular Malaysia and Sarawak**.
5.	Pinto (2000)	Minimum design PGA value of **0.07g - 0.1g**.

The concept of taking the design PGA value as 2/3 of the value predicted for a return period of 2,475 years, was also explained, citing recommendations in the textbook authored by Professor Michael Fardis (Fardis, 2009), chairman of the CEN sub-committee CEN/TC250/SC8 for Eurocode 8: "Design of Structures for Earthquake Resistance" (1999-2005). Prof. Fardis led the development of its six parts into European Standards; he is the Director of Structures Laboratory, Civil Engineering Department, University of Patras, Greece. Given that local buildings will remain non-ductile instead of going for capacity design principles, then global collapse in a very rare event will not be prevented even though the Design Seismic Actions will take care of Life Safety (no local collapse).

In this case, we have to do something to the strength of the building. To take care of Collapse Prevention we must design for a 2% probability of exceedance in a design life of 50 years (i.e. designing for 2,475-year Return Period).

In explaining the rationale behind the adoption of the response spectrum model that had been written into the Draft NA, Professor Lam made references to long-distance earthquake hazards generated by high seismic sources in the Sumatran Island and subduction sources offshore of Sumatra as well as from the Philippines in combination with local incidences of small and medium magnitude intraplate earthquakes. This unique combination of seismic hazard not commonly seen in Europe, explained the need to specify a response spectrum model which was different from the standard Eurocode Type 1 and 2 response spectrum models (*Lam et al., 2009*).

For the same reason, Singapore had redefined the shape of the response spectrum, neither using EC8 Type 1 nor Type 2 in its provisions Clause 3.2.2.2(2)p Note 1, to allow for long distance seismic hazards affecting the city state. Figure 2 shows the normalised spectrum shape compared to the proposed response spectrum model in the Malaysia NA and the generic EC8 for Europe and the Singapore NA.

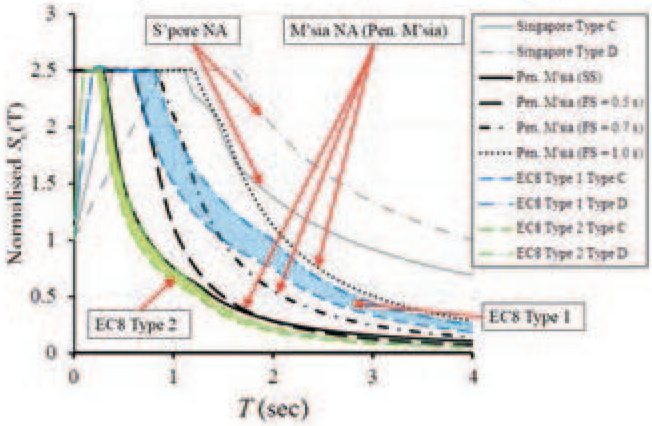
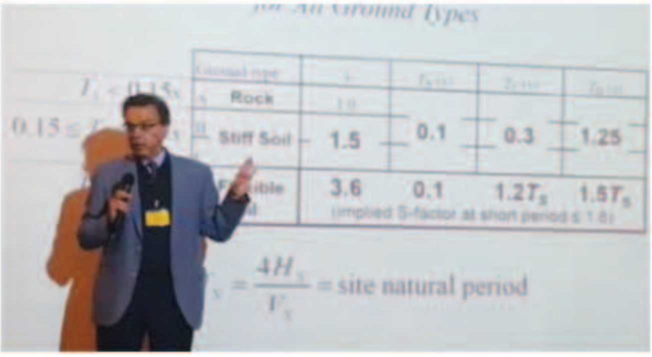


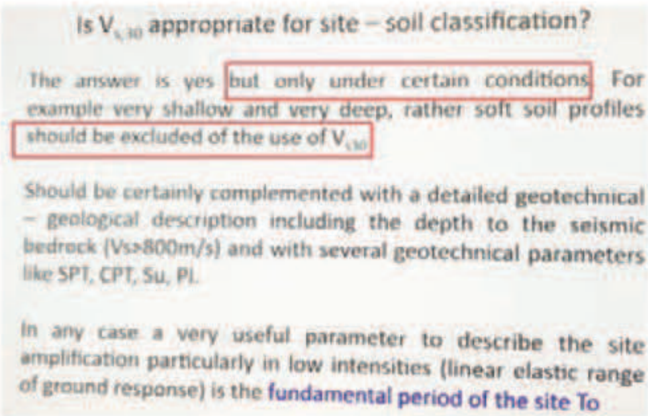
*Figure 2: Normalised spectrum shape comparison of the proposed response spectrum model in the Malaysia NA (Peninsular Malaysia) with the generic EC8 for Europe and the Singapore NA. *Note: Stiff Soil (SS) and Flexible Soil (FS) with site natural period*

In a later session, Dr Tsang presented the site factor model (*Tsang et al., 2017*) which had been written into the draft National Annex. The model incorporated the site natural period (which took into account the depth of soil sediment to bedrock) as a modelling parameter in view of its importance in controlling the potential occurrence of resonance with non-ductile construction.

Professor Pitilakis, who is also Vice President of the European Association of Earthquake Engineering (EAEE), had led the drafting of Eurocode 8 in relation to geotechnical matters. Both speakers explained that the inability of the current site factor model in EC8 to properly address deep site geology was a matter of concern. It is planned to have the next edition of Eurocode 8 to be revised to the form (*Riga et al., 2016; Pitilakis et al., 2013; Pitilakis et al., 2012*) which is consistent with the model proposed by IEM.



(a)



(b)

Figure 3: (a) Prof. Pitilakis spoke in favour of the proposed site factors model NA. (b) Slide presented by Prof. Pitilakis cautioning use of current provisions in EC8 as basis of soil classification

On the second day of the workshop Prof. Lam presented the seismic zonation map that had been written into the draft NA prepared by IEM, along with a map prepared independently by Prof. Tongkul (Tongkul, 2016). Prof. Azlan then presented the seismic hazard map generated by conventional probabilistic seismic hazard analysis (PSHA) prepared by a team led by Universiti Teknologi Malaysia (see Figure 4).

In his presentation, Professor Geller pointed at the great uncertainties of PSHA in view of the poor track record of the methodology in terms of predicting earthquake hazards for the future (*Stein et al. 2012, 2013; Mulargia et al., 2017*). The credibility of the predictions is further compromised in the case of Malaysia, which has only 38 years (from 1979) of complete instrumental record (Che Abas, 2001; MOSTI, 2009) on a small land area showing 2 earthquakes exceeding magnitude 5 (12 February, 1994, & 1 May, 2004) occurring in the Peninsula and Sarawak combined. He advocated the use of common sense as opposed to believing in information generated by the computer as there is definitely insufficient information to precisely predict the location of future earthquake occurrences. An approach based on averaging global rate of occurrence of earthquakes in tectonically stable regions (*Lam et al., 2016*) is supported. Figure 5 shows the slide presented by Prof. Geller citing the highly uncertain nature of PSHA.

Figure 5: Slide presented by Professor Geller, citing the highly uncertain nature of PSHA

In a bid to reach a consensus while addressing the concern of modelling uncertainties, Prof. Lam presented a seismic zonation map (Figure 6) which featured a minimum design PGA value of 0.07g for the peninsula, Sarawak and west Sabah (including Kota Kinabalu), and 0.12g for central & eastern Sabah to avoid leaving out areas with a design PGA value which was too low, as featured in results of PSHA presented by the local UTM-led teams.

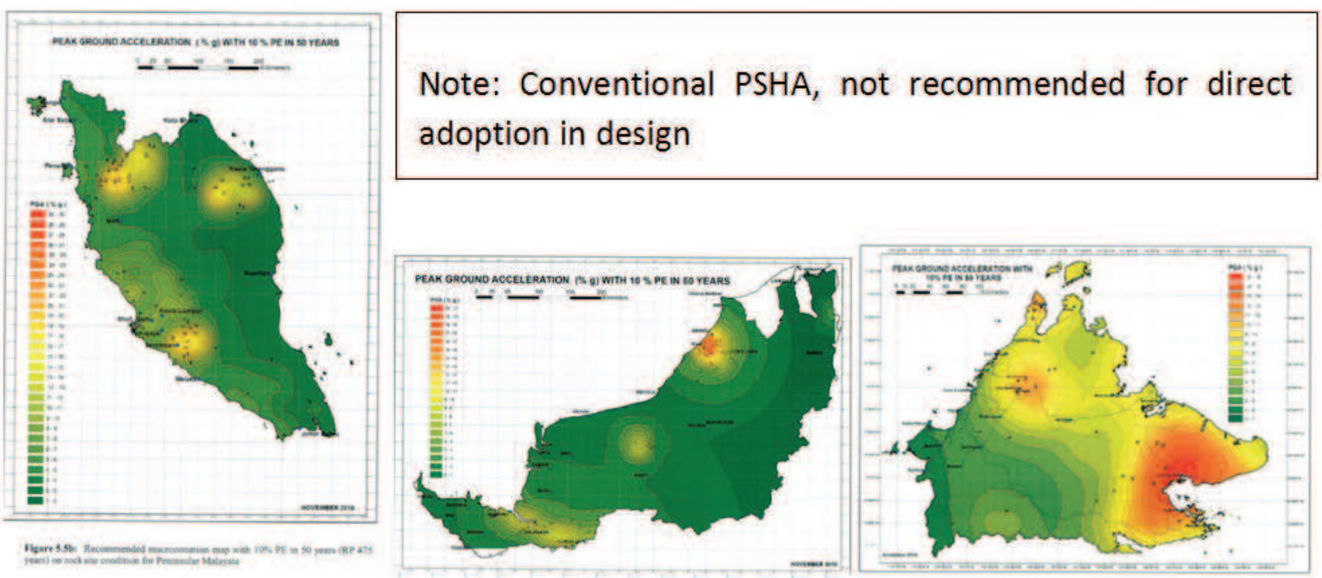


Figure 4: Seismic hazard contours generated by conventional PSHA for the peninsula, Sarawak and Sabah prepared by local team led by Prof. Azlan

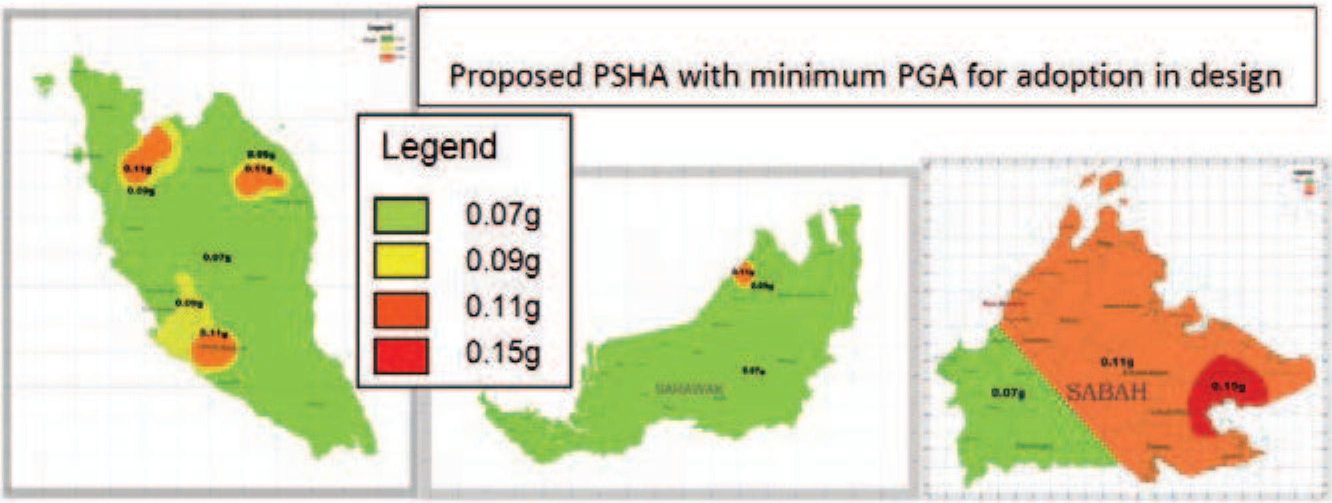


Figure 6: Proposed seismic hazard contours featuring a minimum design PGA value to reach consensus

CLOSING REMARKS

What was demonstrated at the 2-day workshop was that the draft National Annex had incorporated contemporary principles of seismic hazard assessment, taking into account the development of knowledge and practice since Eurocode 8 was first developed two decades ago. Particular attention was devoted to the importance of maintaining the following key features in the draft National Annex by IEM:

1. A minimum design PGA value of 0.07g (0.12g for central & east Sabah) irrespective of results from PSHA because of considerable modelling uncertainties.
2. Response spectrum models which deviate from EC8 Type 1 and 2 because of the need to address both local and long distance seismic hazard and.
3. A site classification and site amplification model which incorporates the site natural period as a design parameter (as opposed to only considering the upper 30 m of soil sediments). ■

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