Two-Day International Seminar & Workshop on Presentation and Reviewing of the Draft Malaysian National Annex to Eurocode 8

CIVIL & STRUCTURAL ENGINEERING TECHNICAL DIVISION

reported by Ir. Prof. Dr Jeffrey Chiang

Ir. Prof. Dr Jeffrey Chiang *is currently Honorary Treasurer of IEM. He has previously served as Honorary Secretary of IEM and is still serving as a member of IEM Technical Division of Civil & Structural Engineering, and as Chairman of IEM Technical Committee on Earthquake. He is also the Dean of Faculty of Engineering & Built Environment at SEGi University, Kota Damansara Campus.*

Speaker presenting his paper

IEM Civil & Structural Engineering Technical Division and IEM Technical Committee on Earthquake organised a two-day International Seminar & Workshop on Presentation and Reviewing of the Draft Malaysian National Annex to Eurocode 8 on 9-10 February 2015 at Armada Hotel, Petaling Jaya, Selangor.

A total of 63 participants attended the seminar cum workshop, including 10 invited international and local speakers who presented their respective papers relating to earthquake engineering standards requirements for low to moderate seismic zones such as Peninsular Malaysia, Sabah and Sarawak. This was a follow-up forum to two earlier symposium/workshops on earthquake engineering organised by IEM in 2011 and 2013.

The list of invited international and local speakers and their paper presentation titles are as follow:

1. Prof. Dr Koh Chan Ghee (National University of Singapore) – *"Consideration of Sumatra Earthquakes for Seismic Design in Singapore"*.
2. Prof. Dr Friedemann Wenzel (Karlsruhe Institute of Technology, Germany) – *"Seismic Hazard and Residual Risk"*.
3. Prof. Dr Ray Su (University of Hong Kong) – *"Simplified Seismic Assessment of RC Buildings in Malaysia under Rare Earthquake Actions"*.
4. Dr Kushan Wijesundara (University of Peradeniya, Sri Lanka) – *"Direct Displacement Based Design of Steel Concentrically Braced Frame"*.
5. Prof. Dr Murat Saatcioglu (University of Ottawa, Canada) – *"Canadian Design Practice for Reinforced Concrete Buildings in Regions of Low to Moderate Seismicity"*.
6. Prof. Dr Han Seon Lee (Korea University, Seoul) – *"Seismic Design Implications for Low-to-Moderate Seismicity Regions from Earthquake Simulation Tests on RC Building Structures in Korea"*.
7. Prof. Dr Nelson Lam (University of Melbourne, Australia) – *"Key Features of the Proposed Malaysian NA to MS EN 1998"*.

8. Dr Tsang HingHo (Swinburne University, Australia) – *"Soil Response Spectrum Model in the Draft Malaysian NA for EC 8"*.
9. Engr. Daniel Looi Ting Wee (University of Hong Kong) – *"Operational Details of Malaysia Response Spectrum"*.
10. Ir. Adjunct Prof. MC Hee (The Institution of Engineers Malaysia) – *"The Cost Implications and Engineer's Perspectives of NA to MS EN 1998"*.

Ir. Mun Kwai Peng (Chairman of WG3 Geotechnical Aspect of Earthquake – part of TC Earthquake) chaired the first day of the seminar, while Ir. Prof. Dr Jeffrey Chiang (Chairman of TC Earthquake) chaired the seminar/workshop session on the second day.

The seminar/workshop had the support of Jabatan Kerja Raya (JKR) which sponsored 6 of its engineers to attend the event. Ir. Mohd Noor Azudin bin Mansor, a senior Principal Assistant Director of JKR, was also invited to chair the first paper presentation on the first day.

SEMINAR PROCEEDINGS

The first speaker, Prof. Dr Koh Chan Ghee started with his presentation by focusing on Singapore's experience in publishing its own NA to Eurocode 8. Some recent studies seemed to suggest that higher than expected peak ground acceleration was recommended for design of buildings against earthquakes. This was likely attributed to adoption of unsuitable attenuation equations. Probabilistic seismic hazard analysis (PSHA) was conducted by assessing the existing ground motion prediction equations (GMPE). New GMPE was developed based on recorded ground motions experienced from long-distance earthquakes from Sumatra strike-slip fault and the Sunda trench subduction zone. These were compared and verified against works by other researchers.

Interestingly, Prof. Koh concluded that the PGAs of Singapore and Kuala Lumpur (for a 500-year return period) were 0.009g and 0.0155g respectively. Compare this to some local researchers' results of more than 0.08g to 0.10g - which were considered unrealistically high by IEM technical reviewers. When based on 2,500-year return period, Prof. Koh calculated the PGAs to be 0.013g and 0.023g for Singapore and Kuala Lumpur respectively. Singapore's NA to Eurocode 8 actually adopted a PGA of 0.0175g, a more conservative value than Prof. Koh's findings.

Second speaker Prof. Dr Friedemann Wenzel's presentation can best be summarised as follows:

- The determination of hazard results, for the purpose of categorisation (such as producing zoning or mapping) can be significantly different for subsequent assessments, without obvious reasons-most notably in earthquake events which are very unpredictable in magnitude and frequency, not to mention even in timing and location.
- Validation of hazard results is still in its infancy.
- Achieving equal safety standards using return periods as a guide, is not exact but is still considered as probably good, as the best alternative.
- There is a need to produce loss exceedance curves as a measure of societal risk, and ultimately this should control the design levels – the best example is in determining the importance factor for design of buildings for earthquake resistance.
- An alternative to loss exceedance curves, may be to use proxies based on hazards faced, such as likelihood of tsunami occurrence with earthquake events.

The next speaker, Prof. Ray Su, spoke on an interesting topic which proposed the use of a versatile Timonshenko beam model to assess the seismic performance of low-rise RC frames and high-rise RC wall buildings. This model is integrated with a modal response spectrum analysis, and the focus is on rare earthquake design load with a return period of 2,475 years in Peninsular Malaysia. He estimated that based on that seismic design load, high-rise wall buildings of 14-40 storeys and low-rise infilled RC frames of 2-10 storeys can sustain these rare earthquake loads with their inherent lateral strength and deformation capacity. However, low-rise framed buildings without shear walls, but less than 16m height may still satisfy the 475-year return period requirement (in accordance to Eurocode 8), with perhaps some damage to non-structural elements.

The next speaker, Dr Kushan Wijesundara, was the only speaker who talked about the seismic effect on steel structures, in particular, steel concentrically braced frame. His methodology of design is direct displacement-based design, which emphasises ductility, non-linearity in structural behaviour and equivalent viscous damping – which is derived from procedures originated by renowned seismic expert Nigel Priestley in 2006. At the end, Dr Kushan concluded that, from results obtained from the non-linear dynamic analysis, it was proven that the presumed linear displacement profile proposed by Priestley for low-rise moment resisting frames (MRFs) was reasonably valid for low-rise steel concentrically braced frames. For medium-rise MRFs, the use of inelastic first mode displacement profile with higher drift concentration at the lower floors also gave a good estimation with actual measured values.

The analysed behaviour/performance of such structures was in agreement with direct displacement design approach. This was a point that needed to be stressed: The general approach in developing the Malaysian NA to Eurocode 8 is based on displacement method, which is the preferred choice in seismic analytical approach nowadays.

Prof. Dr Murat Saatcioglu from Ottawa University was no stranger to this forum, as he was a panel speaker in the first symposium held in 2011. His presentation touched on the Canadian practice in using NBCC 2010 and CSA 2004 as performance criteria in design of buildings – firstly for the safety of occupants, followed by damage-limitation control and finally, structures still functional in post-disaster scenarios.

He said Canada was also moving towards accepted international practices in adopting a return period of 2,475 years in earthquake predictions instead of the previous norm of 475 years. He emphasised that the authorities had the role and responsibility to ascertain the importance factor to be attached to certain critical buildings requiring special attention in earthquake events, such as heritage buildings and buildings used in post-disaster recovery, e.g. hospitals, fire and police stations, telecommunication facilities. NBCC had provisions for ductility and over-strength factors in adjusting related force from seismic events, exerted on different building configurations. He also presented the importance of considering torsional effects for structural having certain irregularities in its outlook and profile.

Prof. Dr Han Seon Lee gave an insight into South Korea's experience in tackling the issues of design for earthquake for RC buildings, in low to moderate seismic regions there. He presented the experimental simulation tests done on scaled-down RC buildings, using shaking table tests and pushover tests by his co-researchers. The South Korean practice follows closely the American ACI318-05 standards for design of concrete structures. This is a good guide for Malaysian code drafters in producing the National Annex to Eurocode 8.

KEY WORKSHOP PRESENTATIONS FOR NA TO EUROCODE 8

As a key panel speaker and the main contributor to the development of NA to Eurocode 8, Prof. Dr Nelson Lam is a familiar face at many IEM-organised seminars over the years, in particular on dynamic analysis of structures under earthquake loadings. For this particular seminar, in view of the near-to-completion of the NA to Eurocode 8, he presented the updates of the development of MS EN 1998 on justifications and verifications of analysed data and models prescribed for Peninsular Malaysia, Sabah and Sarawak.

Key presentation by Prof. Dr Lam was on the following areas:

1. Introduction to Malaysian Seismic Hazard
2. Hybrid model for Peninsular Malaysia
3. Modelling of local earthquakes
4. Performance objectives and return period considerations
5. Design peak ground acceleration
6. Ductility or behaviour q-factor
7. Summary

Prof. Dr Lam referred to two previous Earthquake Symposia where the following resolutions were presented and endorsed by majority of participants present then:

1. In 2011, the hybrid response spectrum (in which both near-and far-field earthquake effects were incorporated into one spectrum) was presented and adopted as the basis for developing the NA to Eurocode 8 besides the inclusion of site natural period as an additional parameter for site classification.
2. In 2013, it was decided that the 2,500 years return period and the displacement-based approach would be used as the basis in developing the NA to Eurocode 8 as well as adopting one unified response spectrum for the whole of Peninsular Malaysia while a two-tier site factor approach would be used.

There was some confusion, judging from some of the questions posed by the audience. A prominent local university seismic researcher queried why probabilistic analysis was not used in place of the deterministic approach. Prof. Lam answered that in his presentation slides, it was shown that the modelling of the response spectra was done by including the probabilistic seismic hazard assessment (PSHA) approach. That showed the level of understanding in Malaysia, even among the local seismic experts.

Below is a summary of his presentation:

1. Separate response spectrum models have been recommended for Peninsular Malaysia, Sabah and Sarawak.
2. A hybrid model has been adopted for Peninsular Malaysia to model contributions from both local and distant seismic hazards.
3. The low (short) period part of the response spectrum is controlled by local earthquakes whereas the high (long) period part by distant earthquakes.
4. In regions of low to moderate seismicity areas, a global modelling approach is recommended as opposed to PSHA, which is based upon analysing the disposition of a few local events.
5. Consequently, a uniform level of hazard is specified within the peninsula, Sarawak and Sabah, without involving contouring or zonation.
6. A design PGA value of 0.10g was estimated by the Global Model for the peninsula and Sarawak for a return period of 2,500 years.
7. A design PGA value of 0.16g was estimated by the Global Model for Sabah for a return period of 2500 years.
8. Performance criterion of No Collapse (NC) was used as the basis of design as per Eurocode 8 modelling principles.
9. No collapse performance criterion is not to be confused with Near Collapse performance criterion, which is at Ultimate Limit State (ULS).
10. The term: Full Design Seismic Action or Design Seismic Action (or Design PGA) is based on a return period of 2,500 years and is used for the design of Importance Class IV buildings such as hospitals.
11. The term: Reference Seismic Action (or Reference PGA) is Design Seismic

Action divided by 1.5 and is used for the design of Ordinary (Importance Class II) buildings.

Another speaker, Dr Tsang Hing-Ho, was also a regular panel speaker at previous earthquake seminars organised by IEM. He is one of the international advisors to the Technical Committee on Earthquake. He presented on four key areas:

1. Fundamentals of local site effects
2. Review of codified soil spectrum models
3. Latest development of soil spectrum models
4. Adapting Eurocode 8 model for Malaysia

His findings on effects of earthquake from source to site are: Theoretically, for flexible soil sites, de-amplification occurs at short period range (normally for near earthquake events), while large amplification happens at medium to long period range (distant earthquakes). In short, softer (or more flexible) soils usually de-amplify more.

He contended that Eurocode 8 allowed flexibility as code drafters may define suitable response spectra in their own National Annex, by specifying respective corner periods, T_B, T_C and T_D which are relevant to local conditions. This is clearly spelt outin Eurocode 8-1: Cl. 3.2.2.2 (2)P.

The recommended response spectra for Malaysia is based on Type 2 spectrum model given in Eurocode 8, where the surface-wave magnitude M_s is not greater than 5.5, which is relevant to a low-to-moderate seismic zone like Malaysia. Singapore is also following this step, although they prefer to stick to the Eurocode 8 recommendation of 500-year return period, while Malaysia is moving forward to a 2,500-year return period, consistent with international practice where both near and far-field earthquakes are to be considered.

Dr Tsang went on to make some recommendations for Malaysia in adapting to Eurocode 8 provisions:

Table 1 – Values of the parameters describing the recommended Type 2 elastic response spectra (based on Eurocode 8)

Site natural period	Group type		Soil factor	Corner periods in response spectrum (s)		
			S	T_B	T_C	T_D
$T_s < 0.15$s	A	Rock	1.0	0.1	0.3	1.25
$0.15 \leq T_s < 0.5$s	B	Stiff soil	1.5			
	C					
$T_s > 0.5$s	D	Flexible Soil	3.6	0.1	$1.2T_s$	$1.5T_s$
			Implied S-factor at short period ≤ 1.8			

Note: Site natural period is given by: $T_s = 4H_s / V_s$, where H_s = height of soil profile, V_s = shear wave velocity of soil

The operational details on how the National Annex on the proposed Malaysian Response Spectrum came about, was presented by Engr. Daniel Looi, a PhD candidate at Hong Kong University under the supervision of Prof. Dr Ray Su. Engr. Looi went through the steps in constructing the response spectrums, in terms of acceleration, displacement and velocity, deciding on the consideration of PGA with respect to importance factors attached to building types and functionality.

He used the equivalent static load method of analysis, to describe the process in producing the necessary results for the local parameters to come out with the response spectra.

1. Assume information and data on building type, properties and importance factor attached, using also sample borehole log information to ascertain soil type.
2. Calculate for the site natural period, T_s
3. Choose the corresponding response spectrum based on calculated site natural period.
4. Estimate the building natural period from the selected response spectrum.
5. Calculate the base shear, F_B of the building.
6. Distribution of base shear to every floor of the building from base to the top, using recommended formulation.
7. Use standard analytical methods (manual or computerised) to determine structural deflection, e.g. 3D-frame analysis.
8. Calculate effective displacement, using recommended formulation.
9. Calculate effective mass (of the building structure), again using recommended formulation.
10. Calculate the effective stiffness of the building using the calculated base shear and effective displacement.
11. Calculate the effective natural period of the building using the effective mass and effective stiffness, in the standard formula for natural period.
12. Calculate the improved displacement and compared this with the first estimation found earlier; use this improved displacement to re-work the base shear, F_B
13. Re-distribute the base shear to all floors-and re-analyse the structure.
14. So the iteration process goes on – until a refined value of displacement is obtained, with little difference in the improved value and the last estimation.

One of the most intriguing topics was presented by Ir. Adjunct Prof. MC Hee on preliminary cost implications once the NA to Eurocode 8 takes effect and is applied in the industry, with the use of hybrid model of response spectrum for Peninsular Malaysia, Sabah and Sarawak.

First, he described the types of structures he had considered when studying the impact of earthquake design, namely one-storey, five-storey high moment-resisting structure frames, and 10-storey, 30-storey dual (MRF and shear walls). He referred to the findings of the international panel of experts in terms of referenced peak ground accelerations recommended, i.e. 0.07g for both Peninsular Malaysia and Sarawak, and 0.12g for Sabah – all based on a 2,500 years return period in the hybrid model response spectrum for NA to Eurocode 8.

He also made assumptions of some basic costings, i.e.

1. Formwork used = RM40 per sq. metre
2. Concrete grade C30/37 used = RM300 per cu. metre
3. Steel reinforcement used = RM3.50 per kg mass

Using these with some advanced level structural analysis on computer software, he produced calculations showing reduced stiffnesses and behaviour factor changes, due to detailing changes required for seismic design considerations. The two tables below are samples of his recommendations.

Table 2 – Cost summary for Peninsular Malaysia upon implementation of Eurocode 8 Design of Structures for Earthquake Resistance

Building type	No. of stories	% increase in structural cost (on reduced stiffness)	% increase in structural cost (on behaviour factor)
2-D 1-storey MRF	1	0	0
2-D 5-storey MRF	5	0	0
2-D 10-storey Dual	10	+0.7	+0.8
2-D 30-storey Dual	30	0	0

Table 3 – Preliminary % increase in structural cost with one standard deviation for office buildings (based on behaviour factor, q = 1.5

Building type	% change in structural cost		
	Peninsular Malaysia	Sarawak	Sabah
2-D 1-storey MRF	+0.7	+0.3	+7.7
2-D 5-storey MRF	+0.9	+0.3	+2.5
2-D 10-storey Dual	+1.1	+0.8	+6.4
2-D 30-storey Dual	+0.3	+0.4	+1.4

OUTCOME OF THE OPEN FORUM DISCUSSION

In the Open Forum Discussion session in the late afternoon, Prof. Dr Nelson Lam gave an overview of the presentations made by all the invited international speakers, including himself. After this, questions or comments were invited from the floor.

One question posed by a noted local university earthquake researcher was on the lack of local research incorporated into the National Annex to Eurocode 8. Prof. Dr Lam pointed out that the work done by local researchers were considered in the first two symposiums (2011 and 2013) and were found wanting, simply due to lack of data verifications and publications in prominent international journals of earthquake engineering.

This was on top of the in appropriateness of the local research findings which covered only long-distance earthquakes from Sumatra subduction faults, in which the attenuation formulas were based on high seismicity zones from USA. Hence, the predictions were relatively high at near to 0.10g PGA for Peninsular Malaysia, especially for a 500-year return period, whereas prominent regional researchers like Balendra (NUS) and Megawati (NTU) have published in respectable journals presenting predictions of ground motions in Singapore and Peninsular Malaysia to be at PGA of 0.03g or even much lower, which dovetailed to the measured readings in MMD stations at West Coastal zones in the peninsula.

In the proposed NA to Eurocode 8, the recommended PGA values of 0.07g for Peninsular Malaysia, is for a 2,500-year return period, covering both near and distant earthquakes. If a 500-year return period was used, the predicted PGA values would be much lower, perhaps at 0.03g or less.

Another member of the audience, an experienced consultant, said he fully supported the work by the IEM Technical Committee on Earthquake, aided by the international panel of experts. He pointed out that consultants in the industry were not well-versed in seismic design as it was never a requirement in the British Standards and was not required in the Uniform Building By-Laws. He suggested that the committee come out with simple procedures which consultants can follow easily. He added that he was not too fussy over how the figures of PGA came about, so long as there were technical merits and justifications for use in the local context, were spelt out clearly and logically in the NA to Eurocode 8.

The event was officially closed by the Chairman of the session at 5.00p.m.

All the invited speakers and chairpersons were duly thanked and applauded by the participants. They were then presented with tokens of appreciation by the organisers. ■

The attentive audience at the seminar