Development in Seismic Actions Study in Malaysia and Implications to Professional Practice in the Local Construction Industry (Part 1)

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INTRODUCTION

The watershed events of 26 December 2004 and 28 March 2005 – when two major earthquakes struck the eastern seaboard side of Sumatra, in Banda Aceh and Nias respectively, have literally sent shockwaves throughout the world, while in the region, more than 200,000 lives have been lost. Malaysia has also experienced a number of casualties (particularly due to the tsunami tidal waves) from the Boxing Day disaster of 2004. Figure 1 shows two types of seismic zones on the island of Sumatra, *i.e*. the subduction plates out to sea on west coast side, and the inland fault right along the spine of the island.

These two earthquakes were felt in Peninsular Malaysia, in which some high rise building structures oscillated quite alarmingly for long periods, sending their occupants fleeing to the ground level. This has raised concern about the safety and vulnerability of existing building structures and the use of current structural design standards which do not specify the need for seismic design in Malaysia.

The Institution of Engineers, Malaysia (IEM) took the initiative to study the earthquake issues and published a position paper which was released in 2007. It basically recommends the drafting of a guideline for seismic design for structures which are deemed to be vulnerable, especially to the far field effect of earthquake felt from Sumatra.

The formation of a technical committee at IEM spearheaded the effort to draft a Malaysian Standard on seismic design, and representation in the committee encompasses stakeholders in the local construction industry. Working groups were formed to tackle various issues of interest and concern, of which the most critical are in determining accurate peak ground acceleration, and to study the vulnerability of building structures. One of the working groups is looking into non-structural components, and it is presently led by a registered practicing architect.

Besides highlighting the current status in seismic standard development in Malaysia, this paper also presents the key elements of earthquake engineering insofar as measuring its intensity and to predict the response and behaviour of structures. Along the way, an understanding was achieved on how to ensure such structures can be designed to withstand or to minimise the damages due to earthquake effects.

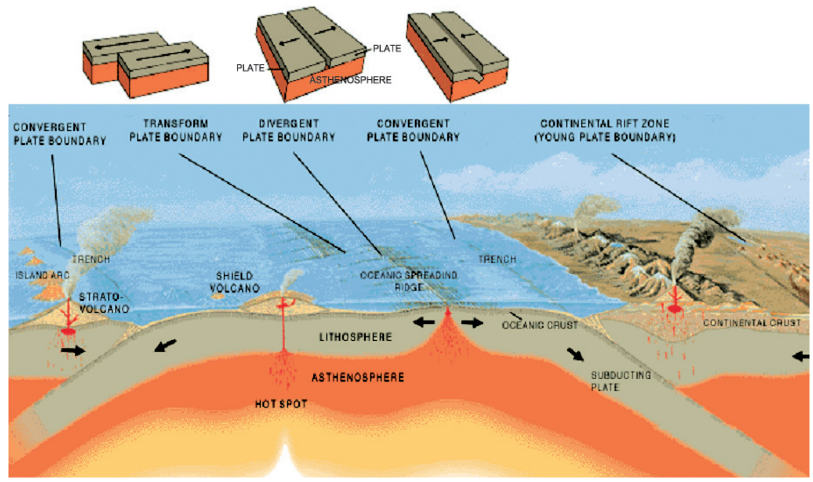

Figure 1: Tectonic boundaries a typical on the island of Sumatra

BACKGROUND

The issue of earthquake concern in Malaysia has always been tied to the tremors felt from far field seismic effect from nearby Sumatra – just over 350km away from the major populated areas in the Klang Valley and along the west coastal zones in Peninsular Malaysia. Local earthquakes occur infrequently but are of very low magnitudes, especially in Peninsular Malaysia. The maximum observed seismic intensity so far was VI on the Modified Mercalli (MM) scale (*i.e*. moderate shaking severity with falling objects). Nevertheless, higher magnitude earthquakes had occurred in parts of East Malaysia, particularly in the Lahad Datu area in Sabah, some of which resulted in some damaged properties and even human injuries.

Besides the local earthquakes, East Malaysia is also affected by large earthquakes which originated from the Southern Philippines and in the Straits of Macassar, Sulu Sea and Celebes Sea. The maximum observed intensity so far was VII on MM scale (*i.e*. strong shaking severity with non-structural damage).

IEM undertook the position to draft and publish a position paper on this issue which was released in 2007. In the short term, IEM recommended these initiatives:

1. Urging for the need for more seismic monitoring stations in Malaysia.
2. Exhorting for the setting up of instrumentation for measuring the seismic response of buildings.

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3. Undertake seismic vulnerability studies of existing important buildings or structures, particularly in high-risk areas.
4. Review of the current Engineering Design and Construction Standards and Practices.
5. Propose for the design of high-rise buildings to cater for long period vibration. In addition, site specific ground motions are required for consideration in the design of high-rise structures of seven storeys and above. This range of building's height is found to be particularly vulnerable to the effects of earthquake.

Figure 2: Seismological stations in Malaysia

In the long run, IEM is recommending these courses of actions by various players and stakeholders in the local engineering industry:

1. Develop or adopt a suitable code of practice with the necessary modification for the construction industry with regards to seismic design after the review.
2. Sensitive and important structures (*e.g*. hospital, BOMBA, police stations, important bridges, dams, power supply structures, telecommunication structures, *etc*) shall be checked for vulnerability when exposed to seismic ground motion.
3. Introduction of earthquake engineering education curriculum in the universities and other tertiary institutions of higher learning.
4. Sourcing for substantial rolling research fund for earthquake engineering research and also to include monitoring and risk assessment works.
5. Continuing education for practicing engineers is required in the areas of earthquake engineering in line with the call from the Board of Engineers Malaysia (BEM).

CURRENT SITUATION

(a) Seismograph Network in Malaysia

A seismic wave radiated by the sudden release of energy from the earth will propagate to all directions and will arrive at a certain place depending on its velocity and the distance from the source to the site. If several sensors located at different places are operated and were able to detect approaching seismic waves, then a set of data of the arrival time will be obtained. From this record, the location of the source can be determined.

The precision in tracing back the source will depend on the quality of the measured data, which is influenced by several factors such as timing system, pointing up the seismic phase, position of the source with respect to the stations, *etc*., besides the variety of the responses of the ground through which the moving waves have passed.

Figure 2 shows the current location of seismological stations in both Peninsular and East Malaysia, which were set up and managed by the Malaysian Meteorological Service (MMS), which serves as the national information centre for seismology. MMS provides information, advice and consultation related to earthquake to users such as engineers, architects and planners for the socioeconomic development of the country. The first few stations were set up and operated in 1979 at Petaling Jaya, Kluang, Ipoh and Kota Kinabalu.

As the need arose, three more stations, one at Kuala Terengganu, and the other two at Tawau and Kuching, were installed from 1986 to 1988. To meet the increasing demand for seismological information in the country, five more stations were installed (at Kuala Lumpur, Kudat, Sandakan, Bintulu and Sibu) from 1992 to 1998. Three from the total of 12 stations (Figure 2) are equipped with strong-motion accelerographs, *i.e*. Sibu, Bintulu and Sandakan – in anticipation of the higher intensity of the local earthquake felt there.

It has been said that with this network, the MMS has the capability to detect and identify earthquakes which occur in and around Malaysia with some degree of accuracy in the first hour after the event.

(b) The Need to Draft a Malaysian National Standard for the Seismic Design of Building Structures

Based on the recommendation by the IEM Position Paper, the Technical Committee (TC) on Earthquake Design was formed by the IEM upon the approval of the Department of Standards Malaysia (DSM) and SIRIM in March 2009. In order to be inclusive and transparent, most if not all major stakeholders in the construction industry were invited to send representatives to be members of the TC. This includes consultants, academics, contractors, government agencies and others. Five working groups (WGs) were formed to study the various aspects of the issue:

- Determining peak ground acceleration, seismic response spectrum and seismic mapping for Peninsular Malaysia;
- Vulnerability study of new and existing building structures to seismic actions in Peninsular Malaysia;
- Geotechnical study of ground conditions affecting seismicity and seismic design for structures in Peninsular Malaysia;

- Effect of seismic actions on non structural elements of building structures in Peninsular Malaysia; and
- Base isolation methods to minimise the adverse effects of seismic actions on building structures in Peninsular Malaysia

The work of both the TC and the WGs have been ongoing since March 2009, and is being treated very seriously by the Construction Industry Development Board (CIDB) through its commercial arm CREAM, and also by the Ministry of Science Technology and Innovation (MOSTI) through the MMS. Both agencies have pledged some funding support for the work and activities of the TC.

(C) Outcome of Previous Local Research Undertaken

Universiti Teknologi Malaysia (UTM) has carried out a number of research projects on local earthquakes for the past 10 years or more, from the seismic zone mapping for Malaysia, and the application of local rubber bearing products as base isolators for infrastructural designs. As a well-established public university, a large amount of funding support was made available via Jabatan Kerja Raya (JKR) and also CIDB.

In 2007, JKR produced a Draft Guidelines on Earthquake Design for Reinforced Concrete Buildings in Malaysia, which is based on the research work undertaken by UTM. In it, the design procedures referred very much to two international earthquake standards, *i.e.* the American International Building Code (IBC2000) and the Eurocode EN1998. IEM was asked to make a technical assessment of the document, and in a technical paper published in 2008 (see Figure 3), two members of the TC commented critically on the Draft JKR Guidelines for Earthquake Design.

Basically, the guidelines were not acceptable to be adopted for use in the local industry due to its overestimation of the peak ground accelerations, and its full blown seismic design procedures which are straight out of the IBC2000 and EN1998, without suitable justifications for Malaysian practices. The industry would be in an uproar should such a guideline be made mandatory, rendering higher design costs than necessary – which would eventually be passed on to the purchasers.

Due to that technical assessment by the IEM, JKR decided not to release or finalise the document for the local industry practice. The TC is of the opinion that the recommended peak ground accelerations (PGA) in the Draft JKR Guidelines was excessive, *e.g.* for West Malaysia, a PGA of 0.08g – 0.10g was cited, whereas the recorded PGA by MMS (at the height of both the Banda Aceh and Nias earthquakes) were in the range of 0.001g to 0.003g. The problem is, JKR's recommendations were based on the research work of UTM, which is very much probabilistic in approach – requiring recorded data of earthquakes in Malaysia, which is not available. And this approach is very much adopted from the research work of Pietersen which has formed the basis of earthquake modelling in North America, *i.e.* more suitable for near field earthquake, as opposed to the far field earthquake effect felt in Peninsular Malaysia.

The TC then decided to consult a regional panel of international experts who had years of research experience in earthquake engineering. In particular, Professor Nelson Lam of Melbourne University and his team of co-researchers had produced an earthquake prediction model which is widely known as the Component Attenuation Model (CAM) which had been successfully applied in India and Singapore. The advantage of this model is that it is quite accurate in determining the PGA of the regions which either have low to very low earthquake intensity, or do not have sufficient recorded earthquake data. And this fits in very much with the situation in Malaysia and even Singapore.

(d) Collaborations with an International Panel of Seismic Experts

It was in September 2009 when the TC invited Professor Lam to Malaysia to conduct joint seminars on earthquake design and analysis based on his research carried out at Melbourne University. In particular, he applied the CAM analytical model in Australia, and it has been found to be reasonably accurate, if applied to Malaysia and

FEATURE

Technical Review of JKR's "Handbook on Seismic Design Guidelines for Concrete Buildings in Malaysia"

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BACKGROUND

In recent years, Malaysia has experienced the effects of earthquake originated mainly from epicenters in the western subduction zones of Sumatra. East Malaysia also has its fair share of local earthquakes which are considered as moderate. Recently, Jabatan Kerja Raya Malaysia (JKR) has drafted a document which presented the proposed seismic design guidelines for concrete buildings in Malaysia in April 2007. It was then sent to The Institution of Engineers Malaysia (IEM) for their technical review and feedback.

INTRODUCTION

This paper represents the views of two members of the IEM Technical Committee on Earthquake, which was formed in early 2006 to study the possibility of producing a design guideline on earthquake design suitable for the construction industry in Malaysia. The objective of the IEM Technical Committee on Earthquake is two-fold – to ensure adequate protection of the community in the event of earthquake tremors, as well as to ensure that the design provisions and construction practices (whether existing or amended) are suitable and practical for Malaysian professional practices.

The review presented herein will not focus on style and format of presentation, for example, the inconsistency in the title. The front page cover title may be "Handbook on Seismic Design Guidelines For Concrete Buildings in Malaysia" but the header title inside the handbook is "Development of Seismic Design Guidelines for Concrete Buildings in Malaysia for JKR". These types of inconsistencies can be sorted out by the author/s. The scope of review is on the content itself or the lack of consistencies in the methodology. This review will be followed by a more comprehensive comments on the detailed calculations found in the Guidelines, which will be forthcoming in future issue of IEM Jurutera Bulletin.

COMMENT ON THE INTRODUCTION OF THE DESIGN HANDBOOK:

The Introduction section consists of:-

- Seismic Historical Background of Malaysia
- Scope of Handbook
- National Annex
- Standard Code Applied

As a general guide, the seismic historical background is informative, but it would be more appropriate to place it in the foreword or in the appendix. Furthermore, it is also misleading in one particular paragraph, in which it stated, "The 9.0 magnitude earthquake on 26 December 2004, about 100 miles from the western coast of Indonesia's Sumatra Island, has generated tsunami in the Indian Ocean. The worst affected areas in Malaysia were Penang and Kedah, where 68 people had been killed and more than 100 people were injured." Now, an impartial reader on reading it may be alarmed as it gives the impression that the Aceh's earthquake has caused over 100 casualties in Malaysia, whereas the reality is that these number of casualties are due to the tsunami which hit the shores in Penang and Kedah. Therefore this piece of information would be more appropriate for a design guideline for tsunami effect, and not seismic.

On a more technical note, as a guide, readers may need to have more information on how to use the Guidelines, such as basic design criteria, and design requirements. These are not clearly defined or outlined, neither in the introduction nor in the guideline proper. After the introduction section, the guideline jumps straight into the procedures of design and analysis of buildings, and followed by analysis and design examples.

Basic terms and definitions are not presented, neither at the beginning nor at the end of the Guidelines. As a first Malaysian's reference document on seismic design, basic terms and definitions are necessary, for example, the use of the word 'gals' (in the macrozonation seismic mapping), 'peak ground acceleration' (PGA), seismic response spectrum, g-term, and many others are very useful not only for the designers but also for the general readers.

Another important aspect of seismic effect not clearly stated or defined is "Far field effect of earthquake", which is exactly the seismic effect experienced by population in Peninsular Malaysia because of the distance effect transmitted from a far epicenter of earthquake in Sumatra. This has implication on whether to adopt a full-scale design approach for seismic actions (as if Malaysia experiences direct earthquakes, with local active fault lines and epicenters) or to use a minimized design approach (as in a far field or distance seismic effect). This should be clearly explained at the beginning so as to justify the design approaches to be specified in later sections.

On the use of National Annex, it is more suited if there is an intention to adopt the Eurocode 8 on seismic design, which again is not stated clearly. This is because in the standard code to be applied, two international design codes for seismic actions were cited as references, i.e. Eurocode 8 and the American-based IBC 2000. This is not the usual and accepted norm in adopting a design guideline, as both "...shared the same objectives but may produce

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Figure 3: Technical input by the IEM of the JKR Draft Seismic Design Guidelines (JURUTERA - March 2008)

Singapore, based on recent published technical papers by his co-researchers in Singapore. In an interesting development, Professor Lam had proposed the following:

- Instead of focusing on the determining PGA which is the conventional approach in ultimately calculating the base shear which is then used to predict the response of building structures to earthquake motion, he proposed the primary objective in studying the peak ground velocity and even peak ground displacement – which would give a better perspective in studying the vulnerability of building structures to earthquake.
- Since the far field earthquake (due to tremors felt from the seismic active areas in Sumatra) had proven to be of a lesser threat, he suggested for Malaysian researchers to focus instead on local earthquake or near field earthquake. In particular, in areas in the vicinity of the 80km long Bentong fault, close to Bukit Tinggi, where recorded earthquakes of low magnitude around M3.5 has occurred. And this study should also be extended across to East Malaysia where there are also some active fault lines.

Out of this collaboration with renowned international experts, the TC has organised further activities in 2010, in which Professor Lam was invited to conduct an extended joint seminar in June 2010 together with Dr Tsang Hing Ho from Hong Kong University. This culminated in an intensive two-day workshop in which three invited panel experts (Professor Lam, Dr Tsang and Dr Kusno Megawati from the Nanyang Technological University of Singapore), had provided timely advice and recommendations in the way forward for Malaysia to undertake seismic studies to the next level.

Dr Tsang was involved in the aftermath study of the Sichuan earthquake devastation in China in 2008, whereas Dr Kusno Megawati had worked closely with both Professor Lam and Dr Tsang in Hong Kong and also in Singapore on geological mapping for seismic studies.

Further joint research collaboration effort are planned for 2011, in the form of a geophone seismic survey exercise to be carried out in Hong Kong. Malaysia has been invited to send representatives to observe and study the procedure and equipment usage, so that the same exercise can then be adopted in a similar survey planned for the Bentong fault and in areas of close proximity. It has to be noted that the Bentong fault is only about 30km-35km away from Kuala Lumpur city centre, and earthquake is an event that is very unpredictable in nature – both in the probability of happening and also in the magnitude and devastation which can be inflicted upon nearby occupied structures. ■

Remarks: *Part 2 would be published in May 2011 issue.*