

EARTHQUAKE GROUND MOTION MODELLING FOR AUSTRALIAN BEDROCK CONDITIONS

NELSON LAM¹, JOHN WILSON¹ and GRAHAM HUTCHINSON¹

1. INTRODUCTION

Although most earthquakes occur along tectonic plate boundaries, destructive intraplate earthquakes can occur in unexpected areas. Earthquakes exceeding magnitude 6 occur on average once every five years in Australia which is completely within the Indo-Australian plate.

Like many earthquake loading standards and codes of practices around the world, the current Australian Earthquake Loading Standard AS1170.4¹ has been based on the Uniform Building Code²(UBC) from the United States. However, the code provisions have principally been derived from empirical information and experience in California.

Research into intraplate earthquake hazard in recent years has focused on the frequency and duration characteristics of the earthquake ground motion. Studies have also been carried out reviewing both the intraplate site responses and the behaviour of limited ductility structures. These studies have typically been carried out within the conventional boundaries dividing the seismological and engineering disciplines.

The following extended abstract briefly reviews research progress and highlights current challenges in the following areas of earthquake engineering : (i) **Bedrock motion modelling** (ii) **Seismic hazard modelling**.

2. BEDROCK MOTION MODELLING

The design response spectra specified by many earthquake loading standards is based on, or related to, the well known response spectrum model developed by Newmark-Hall³. Peak ground velocity (PGV) is often used to scale the spectrum to take into account the seismicity of the site. However, the frequency content represented by this spectrum does not vary to reflect regional variations in the seismicity and the attenuation characteristics of rock.

¹ Dept. of Civil & Environmental Engineering, The University of Melbourne, Parkville, Vic 3052, Australia.

In contrast, the **Uniform Hazard Spectra** (UHS) introduced recently in the United States by Algermissen & Leyendecker⁴ reflect differences in the average frequency content of earthquakes across the country. However, the probabilistic response spectra cannot distinguish the frequency content of a small earthquake at close range from that of a larger and more distant earthquake. The effect this bedrock motion frequency content has upon site amplifications can be quite significant.

Empirical models have been used extensively in interplate areas such as the Western United States to model the frequency content of earthquakes. However, such models cannot be developed easily in intraplate areas due to the paucity of near field strong motion data. Semi-empirical methods such as the use of **Empirical Green Functions** can be employed to model the waveform of future earthquakes. The model is valid for a particular faulting arrangement and geological conditions surrounding the transmission path of the earthquake waves. However, many major intraplate earthquakes occurred in unexpected areas and on previously unknown faults.

A **Geophysical Model** has been developed in the United States since the early 1980's to predict the frequency content of an earthquake based on only the moment magnitude, focal distance, stress drop and attenuation of waves through rock. Intraplate earthquakes have been distinguished from interplate earthquakes by assuming a higher stress drop associated with the characteristics of the reverse faulting mechanism. The geophysical model has been modified recently by Atkinson⁵ to match field measurements taken during major intraplate earthquake events that have occurred in recent years in the intraplate regions of Middle and Eastern North America.

However, applying this model to Australia, for example, has the following difficulties:

- (i) Existing local seismicity data is expressed in terms of the Local Magnitude, instead of the Moment Magnitude.
- (ii) The expected stress-drop, which depends on the size of the earthquake, is still uncertain due to lack of local data.
- (iii) The directivity effect has not been taken into account in the model.

Once these problems have been overcome, then the design properties associated with intraplate earthquakes will be able to be predicted with reasonable accuracy and reliability.

3. SEISMIC HAZARD MODELLING

The seismic hazard of a site is normally quantified in terms of a probabilistic ground motion parameter (eg. peak ground velocity) which is determined by integrating contributions from all surrounding earthquake sources, based on the predicted level of activity in each source zone and the attenuation function in the region. Although the parameter is easy to interpret for engineering applications, the amount of computation and editing required to produce and revise seismic hazard maps can be costly and time consuming. Further, seismic hazard maps need frequent updating in intraplate areas.

With the **Geophysical Model**, the design earthquake ground motion can be predicted readily based on combinations of magnitude and epicentral distance for a given return period assuming the spatial distribution of earthquakes is random. For a given probability of occurrence, the larger the epicentral distance, the larger the magnitude of the earthquake since the source area is larger. Preliminary analysis shows that the 1 in 500 years seismic hazard of major coastal cities in Australia is dominated by a Magnitude 5 to 6 event at an epicentral distance of about 30 to 50km. Earthquakes within 20km epicentral distance generally have a small probability of exceeding Magnitude 5. On the other hand, the maximum credible earthquake is around 7⁶.

4. CONCLUSION

(i) A geophysical model has been developed to predict the frequency content of the bedrock excitation based on the moment magnitude, epicentral distance and stress-drop of the earthquake. However, further research is required to determine suitable moment magnitude and stress drop for input into the model for Australian conditions.

(ii) With the geophysical model, the design earthquake ground motion can be predicted readily based on combinations of magnitude and epicentral distance for a given return period. The seismic hazard level of a site can be represented by such combinations.

5. ACKNOWLEDGEMENT

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6. REFERENCES

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