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Changes in Earthquake Hazard Levels in the draft Geoscience Australia National Seismic Hazard Assessment (NSHA18)

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The following information is excerpted from Allen et al. (2017) and from discussions that took place at the Annual Conference of the Australian Earthquake Engineering Society (AEES) in Canberra, November 24-26, 2017 and a preceding Pre-AEES Workshop on the National Seismic Hazard Assessment (NSHA18) project held on November 23.

Geoscience Australia (GA) has embarked on a project to update the seismic hazard model for Australia through the NSHA18 project. The draft NSHA18 update yields many important advances on its predecessors, including:

1) calculation in a full probabilistic framework using the Global Earthquake Model's OpenQuake-engine;
2) consistent expression of earthquake magnitudes in terms of moment magnitude, M_w;
3) inclusion of epistemic uncertainty through the use of alternative source models;
4) inclusion of a national fault-source model based on the Australian Neotectonic Features database;
5) the use of modern ground-motion models; and
6) inclusion of epistemic uncertainty on seismic source models, ground-motion models and fault occurrence and earthquake clustering models.

The draft NSHA18 seismic design ground motions are significantly lower than those in the current (1991-era) Standards Australia AS1170.4:2007 hazard map at the 1/500-year annual ground-motion exceedance probability (AEP) level. The large reduction in seismic hazard at the 1/500-year AEP level has led engineering design professionals to question whether the new draft design values will provide enough structural resilience to potential seismic loads from rare large earthquakes. These professionals are planning to use a seismic design factor of 0.08g as a minimum design level for the revised AS1170.4 standard, due to be released in 2018, and are discussing the idea of transitioning to a 1/2475-year ARP in the longer term, consistent with the trend in other countries including Canada and the United States.

The primary reason for the significant drop in seismic hazard is due to adjustments to earthquake catalogue magnitudes. Firstly, prior to the early 1990's, most Australian seismic observatories relied on the Richter (1935) local magnitude (M_L) formula developed for southern California. At regional distances (where many earthquakes are recorded), the Richter scale will tend to overestimate M_L relative to modern Australian magnitude formulae. Because of the likely overestimation of local magnitudes for Australian earthquakes recorded at regional distances, there is a need to account for pre-1990 magnitude estimates due to the use of inappropriate Californian magnitude formulae. A process was employed that systematically corrected local magnitudes using the difference between the original (inappropriate) magnitude formula (e.g., Richter, 1935) and the Australian-specific correction curves (e.g., Michael-Leiba and Malafant, 1992) at a distance determined by the nearest recording station likely to have recorded a specific earthquake (Allen, 2010).

Another important factor determining the reduction in hazard is the conversion of catalogue magnitudes such that magnitudes are consistently expressed in terms of moment magnitude, M_W. Moment magnitude is the preferred magnitude type for probabilistic seismic hazard analyses (PSHAs), and all modern ground-motion models (GMMs) are calibrated to this magnitude type. Relationships between M_W and other magnitude types were developed for the NSHA18. The most important of these is the relationship between M_L and M_W because of the abundance of local magnitudes in the Australian earthquake catalogue. The preferred bi-linear relationship demonstrates that M_W is approximately 0.3 magnitude units lower than M_L for moderate-to-large earthquakes ($4.0 < M_W < 6.0$). Together, the M_L corrections and the subsequent conversions to M_W effectively halve the number (and subsequently the annual rate) of earthquakes exceeding magnitude 4.0 and 5.0, respectively. This has downstream effects on hazard calculations when forecasting the rate of rare large earthquakes using Gutenberg-Richter magnitude-frequency distributions in PSHA.

The secondary effect of the M_L and M_W magnitude conversion is that it tends to increase the number of small and moderate-sized earthquakes relative to large earthquakes. This increases the Gutenberg–Richter *b*-value, which in turn further decreases the relative annual rates of larger potentially damaging earthquakes (Allen *et al.*, 2017).

The final main factor driving the reduction of calculated seismic hazard in Australia is the use of modern ground motion models (GMMs). While seismologists in stable continental regions (SCRs) worldwide recognise the complexity in characterising the likely ground motions from rare large earthquakes, more abundant ground-motion datasets of moderate-magnitude earthquakes are emerging. The NSHA18 hazard values are based on modern GMMs with improved understanding of instrumental ground-motion source amplitudes and attenuation in Australia and analogue regions. The peak ground accelerations (PGAs) predicted by these modern models in general are up to a factor of two lower than the Gaull *et al.* (1990) peak ground velocity (PGV)-based relationships at distances of engineering significance (generally less than 100 km). At larger distances, the lower rates of attenuation of the Gaull *et al.* (1990) relationships yield ground-motion values up to factors of 10 higher than modern GMMs (Allen *et al.*, 2017).

It is anticipated that the National Seismic Hazard Assessment (NSHA18) project will be complete in mid-2018, at which time Geoscience Australia has agreed in principle to provide a briefing on it in Sydney for the insurance Industry. The updated version of AS1170.4 will be released in 2018.

References

Allen, T., J. Griffin, M. Leonard, D. Clark and H. Ghasemi (2017). An updated National Seismic Hazard Assessment for Australia: Are we designing for the right earthquakes? Proceedings of the Annual Conference of the Australian Earthquake Engineering Society in Canberra, November 24-26, 2017.

Standards Australia (2007). Structural Design Actions, Part 4 Earthquake Actions in Australia. AS1170.4:2007.