Welcome to Dr Paul Somerville

Dr Paul Somerville was born in Armidale, NSW and received his B.Sc. degree in Geophysics from the University of New England. After teaching at Brandi High School in Wewak, PNG and the PNG University of Technology in Lae, he went on to get his M.Sc. and Ph.D. in Geophysics at the University of British Columbia in Vancouver, Canada. He spent two years as a Visiting Research Fellow at the Earthquake Research Institute, University of Tokyo, and did research on two major damaging earthquakes that occurred during his stay.

Dr Somerville has worked at URS Corporation and its predecessor organization, Woodward-Clyde Consultants, first in San Francisco and then in Pasadena, lately as Manager of the Pasadena Office. He has worked in many aspects of seismic hazards, and been involved in the development of innovative seismological methods for specifying seismic design ground motions in earthquake engineering practice. He has applied these in the design and analysis of major buildings, bridges, dams and power generation facilities in many countries, including Australia, New Zealand, the United States and Japan. Dr Somerville has extensive research experience in Japan, where he pioneered the development of commonly used procedures for characterizing earthquake sources for the prediction of strong ground motion.

Dr Somerville has extensive experience in developing methods for assessing seismic hazards in stable continental regions such as Australia and the central and eastern United States. Using advanced computational seismology methods, he developed earthquake source models and ground motion attenuation relations for eastern North America that are used with other models to generate the USGS National Seismic Hazard Maps. He is actively involved in the development of building codes in the United States, including the NEHRP Recommended Provisions for Seismic Regulations for New Buildings. He led developments in the engineering characterization of near-fault ground motions, which were used in quantifying the near-source factor in the 1997 Uniform Building Code in California.

Dr Somerville has been a member of the Board of Directors of both the Seismological Society of America and the Earthquake Engineering Research Institute. He was Chairman of the EERI panel that wrote an NSF sponsored report entitled "Securing Society against Catastrophic Earthquake Losses," a plan for earthquake engineering research in the United States for the next 20 years. Paul was a member of the Seismology Committee and the Science of Earthquakes Committee of the National Research Council of the US National Academy of Science. He has fostered the implementation of seismological knowledge in earthquake engineering research and practice in his role as Manager of the Earthquake Engineering Implementation Interface of the Southern California Earthquake Center,

Dr Somerville has experienced numerous damaging earthquakes first hand, including the 1989 Loma Prieta, 1994 Northridge and 1995 Kobe earthquakes, and was involved in post-earthquake reconnaissance of these earthquakes, as well as other earthquakes in California, Japan, and Taiwan. He has served as an expert witness in legal proceedings related to the strength of ground shaking caused by major earthquakes in California, Guam, and Peru and has also analysed tsunamis generated by earthquakes in California, Japan and Peru.

Paul will be spending alternate months at Risk Frontiers this year as he gets through the process of repatriating his family to Australia.

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This Issue

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December 26, 2004 Sumatra Earthquake and Tsunami

Currently assessed as moment magnitude (M_w) 9.0, the Sumatra earthquake ranks as one of the largest of the past hundred years and was felt as far away as Bangladesh. A similar mega-thrust event off British Columbia and resulting losses to communities along the Pacific Northwest and Japan could have disastrous consequences for the insurance industry and so it is important to learn what we can from this most recent event.

With this in mind, I visited Sri Lanka and Banda Aceh (Indonesia) in the days immediately following the earthquake. Beginning in Colombo some damaged parts of the southwest coast were examined as far south as Galle (see later) and then parts of the northwest around Trincomalee and Kinniya. I then flew into Medan from where I hitched a ride on an Australian Air Force Hercules only to be prevented from landing at Banda Aceh because of a collision between a Boeing 737 and a water buffalo on the runway. A subsequent attempt two days later was more successful (Figure 1).

Then in early February, I explored the west coast of Sumatra travelling across the mountains to Meulaboh by 4-wheel drive and then again was lucky enough to score a helicopter trip up the coastline to Banda Aceh courtesy of some very obliging South African pilots. Other modes of transport commandeered were motorbikes, tuk-tuks and when all else failed, shanks's pony.

As the human scale of the catastrophe has been well covered by the world's media, the main focus here will be on building damage in Northern Sumatra, which being closest to the fault, bore the brunt of both the earthquake and resulting tsunami. Peak ground accelerations up to 0.3g are estimated to have occurred and run-up heights of 30m have been reported. For some reason, it is also the region by-passed by many field investigation teams from professional scientific bodies.

Figure 2 shows a schematic of the earthquake in cross section. Sumatra sits astride the Burma Plate. The earthquake fracture propagated northwestwards a distance of some 1200km at a speed estimated to be around 2 km/sec. These figures are consistent with anecdotal reports of significant ground shaking of seven minutes in Meulaboh.

Let's begin with tsunami damage. Run-up height is highly influenced by offshore bathymetry and on-shore topography and not surprisingly the level of destruction varies widely. Most coastal settlements in Sumatra occupy alluvial plains only a meter or so above sea level. On the peninsula at Meulaboh (Figure 3), waves attacked from three sides and damage to the military HQ can be seen to 8m above the current sea level. Few non-engineered structures can withstand such associated hydraulic forces and, as a result, some towns, such as Calang, no-longer exist. They have been simply blitzed! Further north at Lhok Nga only a lone mosque survives in the midst of a denuded landscape.

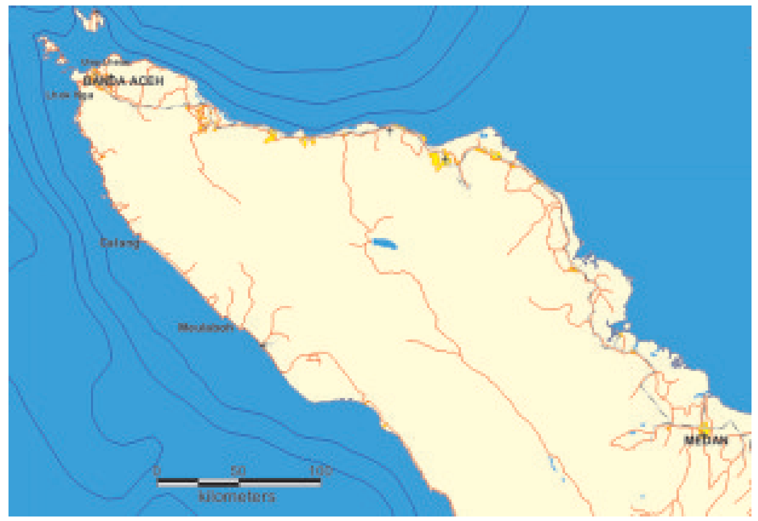

Figure 1: Northern Sumatra

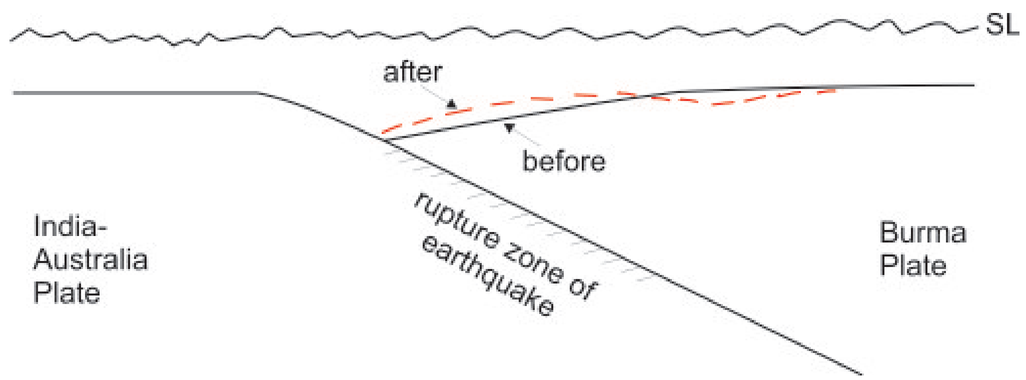

Figure 2: Before the earthquake, the India-Australia plate is dragging the western edge of the overriding Burma plate downwards because the interface between the two plates is locked. The earthquake causes the plates to become unlocked. The western edge of the overriding Burma plate rebounds upward, while that part of the Burma plate that overrides the bottom edge of the locked zone subsides. These changes in the shape and depth of the ocean floor cause almost instantaneous corresponding changes in the ocean surface level, which propagate across the ocean as tsunami waves (source: Dr Paul Somerville).

About 60% of Aceh's most populous city affected, Banda Aceh, was leveled by wave heights of 10m at the shoreline. Much of the debris from this destruction, spanning more than 3km, was swept into the town's centre where it caused additional damage and loss of life. Water heights here were around 3m and destroyed most of the city's commercial activity, even where buildings remained structurally intact, as lower storey shops and businesses were filled with jetsam (Figure 4).

It seems surprising anyone survived. Because of infected wounds, amputations were commonplace. An Australian military doctor, on his way home after nine days of surgery, said he could still not escape the stench of gangrene.

The destructive power of the wave correlates with water depth and the square of velocity. Using estimates of wave speed from video clips, the forces on structures can be shown to have been at least an order of magnitude higher than those that destroyed Darwin in 1979 in Cyclone Tracy.

Figure 3: On the peninsula at Meulaboh – waves attacked from three sides.

Water has a thousand-fold greater density than air and this attribute, together with enhanced drag coefficients due to partial inundation, more than compensate for lower fluid velocities.

In addition to the impact of the direct hydraulic forces, floating objects acting as battering rams also cause damage. (Similar effects are also true of cyclones.) This debris can destroy buildings that may otherwise have remained standing (Figure 5). Scouring may also undermine supporting walls.

All these modes of attack were evident but despite these complications, some general conclusions emerge:

* Few non-engineered buildings survive wave heights of 8m.
* Simple reinforced concrete frame buildings may withstand wave heights of 3m despite loss of masonry infill walls.

Figure 4: Rubble and death in the CBD, Banda Aceh

Figure 5: A building with a structural wall taken out by the force of water or floating debris.

Figure 6: Not all mosques survived.

* Low cost wooden buildings rarely survive wave heights of 2m.
* Mosques generally fare better than residential buildings due to their massive construction and open lower structure that allows water to flow through and equalise pressures (See Figure 6).
* Some hotels with open lobbies may survive for the same reason as do many mosques.

A few words now about damage due to ground motions from the earthquake. In those parts of Banda Aceh and Meulaboh untouched by the tsunami, there are some spectacular examples of pan-caked buildings. These structures mostly had 3 to 6 storeys. Since the majority of similarly constructed buildings survived unscathed, it is tempting to ascribe these failures to poor engineering design or construction. At least in some of these cases, some standard faults such as the *'strong-beam weak column'* design are obvious as is the common use of non-deformed (smooth) reinforcing steel.

Most one-, two- or three-storey buildings survived, however, an outcome that may be related to the frequency content of the ground motions but specialist engineering studies on building response are warranted.

We conclude with two general observations. First there has been a lot of talk about a tsunami warning system for the Indian Ocean. On a visit to Galle (Southern Sri Lanka), I was evacuated, despite my protestations, after a warning that another tsunami was imminent. It all went very smoothly, but I wonder how this warning would have been received if it had not been for the battalion of armed soldiers enforcing evacuation and preventing looting. And if the surviving population had not been already traumatized by recent events.

Lastly it came as some surprise to realize that few people in the affected regions believe this event to have been a natural phenomenon. Most take an 'Old Testament' view that the earthquake and tsunami were sent either as a test of faith or punishment. Venal activities such as drinking and dancing are often suggested as the cause. On the strength of this, I suggest that disaster relief agencies and catastrophic risk specialists take a closer look at Brazil, a country where such crimes are commonplace. Sydney also deserves a closer look.

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Figures 7 & 8: Earthquake damage.