Effect of Sumatran earthquake of 29th March 2005 on SMART tunnel

At around 00:09 (KL time) on 29th March a major earthquake struck Sumatra and was felt in Kuala Lumpur. Current available details of the earthquake from the United States Geological Service (USGS) web site are given in Appendix 1. This indicates that the earthquake had a magnitude of 8.7 and was located 535km SSW from Kuala Lumpur. This compares to the 26th December 2004 earthquake which had a magnitude of 9.0 but was located 639km from Kuala Lumpur. Both of these earthquakes occurred in a known seismically active area and both are in the top 10 of the World's largest earthquakes since 1900 (the recent event ranks at number 8). The closer distance of the recent earthquake and the fact it happened at night may have accounted for the greater number of people apparently feeling the tremors despite the lower magnitude.

The USGS web site also contains a map of the severity of the measured tremor in the SE Asia region and the amount of damage based on reports made to the USGS. This map is presented in Appendix 2. The map indicates that the intensity of the earthquake in KL was between class II and IV which indicates weak to light shaking and generally no damage. The closest reported location which appears to have sustained light damage is Bandar Aceh in Sumatra.

The parameter often used to assess the damage potential of an earthquake is the Peak Particle Acceleration (PPA) of the ground. This can be estimated using published empirical equations if the magnitude and the distance to the earthquake are known. A very preliminary back analysis of the PPA for the recent event indicates that Kuala Lumpur may have experience a PPA in the order of 0.001g to 0.005g for the recent event. This compares to a published back analysis in Kuala Lumpur from an earthquake, also in Sumatra, in November 2002 where a PPA of 0.003g was estimated for a magnitude 7.4 earthquake at a distance of 600km from Kuala Lumpur. This estimate was carried out by the Universiti Teknologi Malaysia.

Our experience is that tunnels are relatively undamaged during earthquake events compared to surface structures as they move with the ground as opposed to surface structures which can be destabilized by ground movements. The 1989 San Francisco earthquake resulted in US$ 6.3 billion worth of property damage including modern elevated highways and the intensity of the damage was at a scale of IX. However, there was no damage to the subway tunnels in the city (reference san Francisco online museum). A paper by the Multidisciplinary Centre for Earthquake Engineering Research (MCEER) reports that the collapse of a station on the Kobe Rapid Transit Railway during the Kobe earthquake of 1995 "is the first instance of severe earthquake damage to a modern tunnel for reasons other than fault displacement and instability near the portal." Three issues here are important. The first is that the PPA at this location was estimated to be between 0.8-1.0g (i.e. 160 times greater than in KL during the recent earthquake). The second is that the station that collapsed was a cut and cover structure and the supporting columns appear to have failed. This is different from the circular bored tunnel structure on SMART which would be more resilient to earthquake forces. The third issue is that despite widespread damage at the surface during the Kobe earthquake, this is the only reported damage to the numerous tunnels in the city.

This would appear to corroborate experimental research into tunnels for nuclear repositories in the USA where tunnels did not suffer damage under a PPA of 0.41g (i.e. 82 times greater than the recent event in KL). The details of this experiment particularly the manner of tunnel construction is not known in detail.

In conclusion, it is considered that the PPA experienced in Kuala Lumpur during the recent earthquake event was not great enough to affect the structural integrity of the SMART tunnel. No damage to the tunnel has been reported. High rise buildings around the city would probably be more at risk of earthquake damage than a tunnel which is completely surrounded by the ground and, to our knowledge, there are no reports of structural damage in the city.

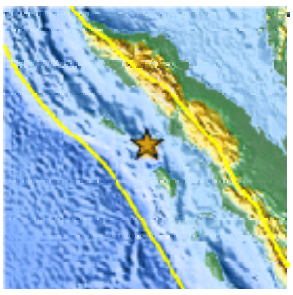
Appendix A: Information from United States Geological Survey (USGS) Web site 29th March 2005

Magnitude 8.7 - NORTHERN SUMATRA, INDONESIA
2005 March 28 16:09:36 UTC

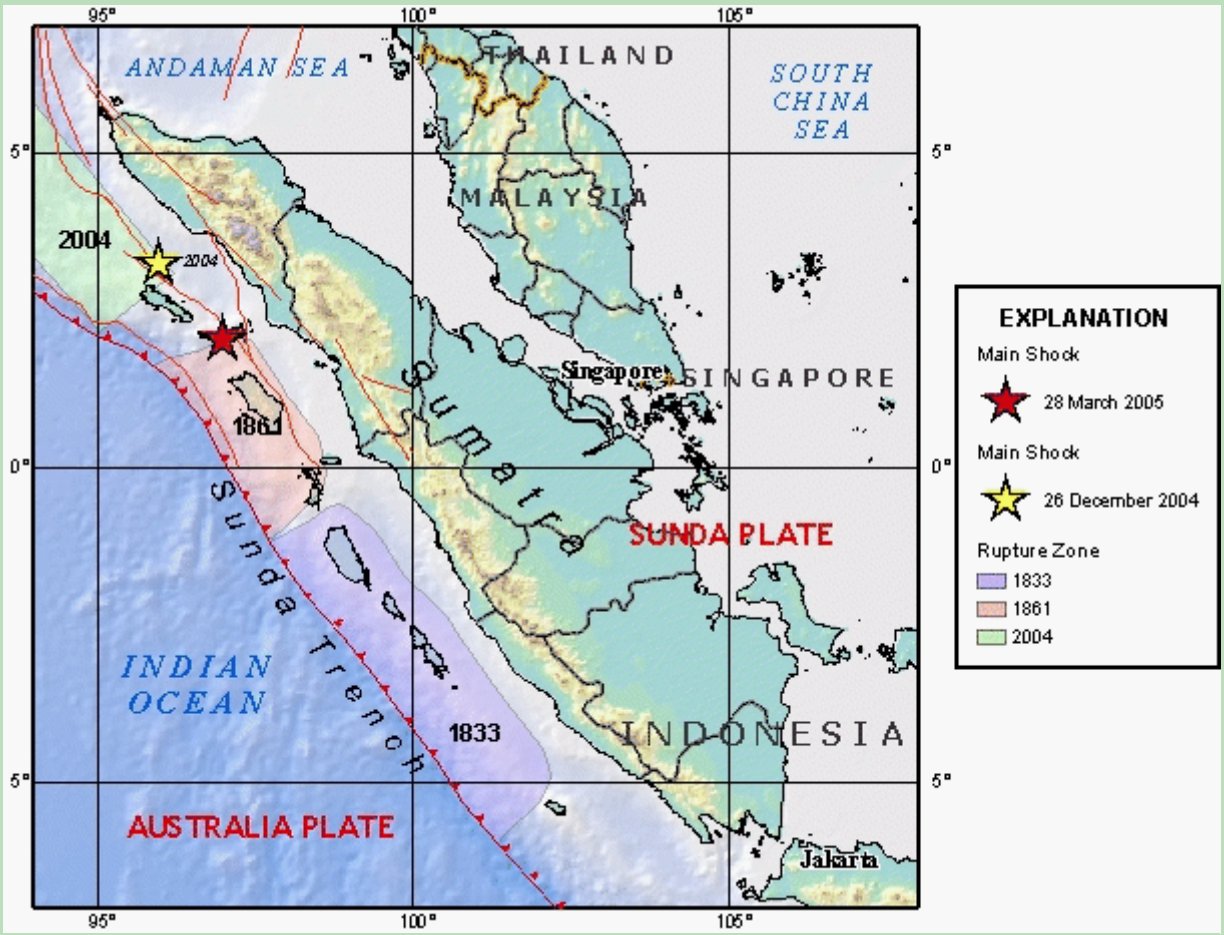
Preliminary Earthquake Report

U.S. Geological Survey, National Earthquake Information Center
World Data Center for Seismology, Denver

A great earthquake occurred at 16:09:36 (UTC) on Monday, March 28, 2005. The magnitude 8.7 event has been located in NORTHERN SUMATRA, INDONESIA. (This event has been reviewed by a seismologist.)



Magnitude	**8.7**
Date-Time	**Monday, March 28, 2005 at 16:09:36 (UTC)** = Coordinated Universal Time **Monday, March 28, 2005 at 11:09:36 PM** = local time at epicenter Time of Earthquake in other Time Zones
Location	2.065°N, 97.010°E
Depth	30 km (18.6 miles) set by location program
Region	**NORTHERN SUMATRA, INDONESIA**
Distances	205 km (125 miles) WNW of **Sibolga, Sumatra, Indonesia** 250 km (155 miles) SW of **Medan, Sumatra, Indonesia** 535 km (330 miles) WSW of **KUALA LUMPUR, Malaysia** 1410 km (880 miles) NW of **JAKARTA, Java, Indonesia**
Location Uncertainty	horizontal +/- 4.6 km (2.9 miles); depth fixed by location program
Parameters	Nst=239, Nph=239, Dmin=538.5 km, Rmss=0.79 sec, Gp= 25°, M-type=moment magnitude (Mw), Version=9
Source	USGS NEIC (WDCS-D)
Event ID	usweax
Felt Reports	At least 290 people killed, 100 injured and 300 houses destroyed on Nias. Extensive damage on Simeulue. Felt in Indonesia, Malaysia, Singapore and as far north as Bangkok, Thailand.



Higher Resolution Figure: JPEG PDF