Earthquake damage in underground roadways

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Solid Energy operates the two coal mines, Terrace and Spring Creek, on the West Coast of the South Island. They asked the MISG group to quantify the damage likely to occur in their mines due to a magnitude eight earthquake on the Alpine fault. The mine workings are typically 200-400m deep and they are about 40 km distant from the Alpine fault.

Firstly, the group investigated the wavelength and type of waves likely to be incident upon the mine workings. Using published data, it was determined that the most energetic wavelengths in the earthquake response spectrum were 200-500m in length. Also, the group calculated that Rayleigh, or surface waves, decay to one per cent of their surface energies at a distance approximately 100 metres below the surface. A survey paper in the literature indicated that of 132 cases of earthquakes at mine sites moderate or heavy damage rarely occurred below 100 metres. This result fits nicely with the decay scale of the Rayleigh waves calculated by the MISG group. Hence Rayleigh waves have no impact and the mine workings are subject to long S and P body-waves only.

Secondly, an empirical relationship from the literature was used to determine the peak acceleration of the waves at the mine workings, in terms of the earthquake magnitude and the distance from the fault. For the Terrace and Spring Creeks mines peak accelerations were estimated to be 0.2 g, where g is the acceleration due to gravity. The literature suggests severe damage occurs for accelerations greater than 0.5 g; hence it is likely that the Terrace and Spring Creeks mines would be subject to light damage only.

Thirdly, the interaction of S body-waves and the mine roadway was considered numerically using a finite-element package. The roadways can be 500 metres long, which is comparable to the wavelength so the possibility of resonant interactions was investigated. The numerical results indicated that some slight amplification of the strain did occur, due

to the presence of the roadway, but resonant amplification did not occur.

Finally, consideration of the energy released by a magnitude 8 earthquake on the Alpine Fault suggested that this may occur either as one event (as is usually assumed), or as a series of discrete events, analogous to domino collapse. The latter scenario could reduce the calculated damage, especially in the near field.

In summary, serious damage to the Terrace and Spring Creek mine workings, which are 200 to 400m deep, is unlikely to occur as the result of a magnitude eight earthquake. Rayleigh waves are likely to damage the mine portal however, and damage to the surface portal seems a good area for future investigation.