Spectrum

Blasting near buildings

Peace-loving citizens are apt to become annoyed when engineers begin blasting operations nearby. The explosions create two startling effects: a loud noise, and tremor of the ground underfoot.

Noise is relatively easy to measure, and environmental regulations can simply specify a maximum permissible noise level.

Measuring the amount of ground vibration is more difficult, and needs carefully placed seismometers. These instruments have shown that most people sense a movement of the earth underfoot of 250 μm, at a frequency of 10 cycles per second (hertz), as 'unpleasant'; higher levels are painful.

The displacement figure appears low, but its action reflects a very tangible back-and-forth acceleration of 0·1 g, and a peak instantaneous velocity of 10 mm per second.

Of more long-term concern is the damage that such movements can cause to buildings. Ground tremors induced by nearby blasting can crack walls and break windows.

For many years, an Australian Standard has specified the maximum permissible ground vibration from blasting so as to safeguard the integrity of neighbouring buildings, and to protect the comfort of their occupants. The Explosives Code of the Standards Association of Australia originally permitted a peak instantaneous ground movement of 19 mm per second for vibrations above 15 hertz, 10 mm per sec. at 8 Hz, and lesser values at even lower frequencies.

However, investigations by Mr John Goldberg and colleagues at the CSIRO Division of Applied Physics have demonstrated that this specification does not make sufficient allowance for a building's tendency to amplify ground movement.

Many structures, particularly large multi-storey ones, can resonate — like sand on a drum skin — at the same low frequencies as generated by explosions. Buildings often resonate near 8 Hz, they found, and magnification of ground vibration by a factor of 10 is possible at this frequency. The Code had assumed a magnification of less than 2.

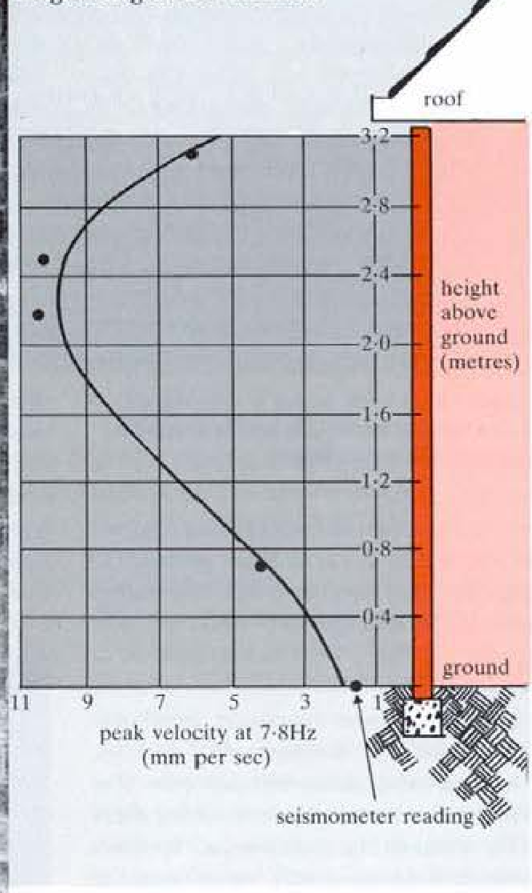
As a result of their work, more recent versions of the Australian Standard qualify the limit on ground vibration by saying that the influence on buildings and people should be below the amount that might lead to damage or human discomfort.

In other words, the actual upper level of ground vibration is no longer a fixed quantity, and those undertaking blasting work may need to take measurements on actual buildings to establish that their activities are not creating undue disturbance. This is particularly the case when large buildings with suspended floors are nearby, or when houses have brick-veneer walls.

Indeed, as a result of his studies, Mr Goldberg considers that halving the stated measured limit — to a peak movement of 5 mm per sec. at 8 Hz — would be a safe

Transducers were placed on a brick-veneer wall to measure its response to ground tremors from nearby blasting. Results showed that the wall's response was many times that of the ground.

A brick-veneer wall magnifies ground vibration



Setting up an array of seismometers next to Newcastle Hospital to measure ground vibration from nearby blasting.

move, in view of the susceptibility to damage of brick veneer at this frequency and the large variability in the ground's response to blasts of the same size.

In those cases where it is not practical to monitor buildings, he recommends that the peak ground movement be limited to 0·5 mm per sec. at 8 Hz to allow for building resonance magnifying the disturbance by 10 times.

Mr Goldberg began investigations in 1979 when it was reported that a hospital and several houses in Newcastle, N.S.W., were affected by blasting operations associated with deepening of the harbour. These operations exceeded 1500 blasts, each employing from 5 kg to more than 1600 kg of explosive.

He and his colleagues set up seismometers in the ground near the affected buildings, and attached transducers to them to measure their movement.

The transducers attached to various levels of the 11-storey hospital showed that the building would flex from side to side at 4 Hz, and rock up and down on its foundations at 2 Hz. Both these effects could magnify ground motion by between two and four times.

More seriously, a suspended floor on the tenth floor amplified a ground motion of 0·5 mm per sec. by a factor of ten. In this way, the blasts produced vibrations that could be described as 'unpleasant'.

The walls of full-brick and brick-veneer houses were also monitored. They showed magnifications of vibration by factors of 6 or 7, as they swayed in and out.

Mr Goldberg believes that compliance with the vibration limits of the revised Explosives Code should prevent damage to buildings. However, the real problem is knowing how much ground vibration will be produced by a detonation of given size. The Newcastle data have shown there is a 10% chance that the ground vibration from a known charge can be twice that predicted — or only half as great.

Public reaction is sometimes even more unpredictable; residents have been known to complain strongly about a small detonation, and ignore a charge of a thousand kilograms fired shortly after.

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The response of high-rise and domestic buildings to ground vibration from blasting, and its relevance to the SAA Explosives Code AS2187. J.L. Goldberg, B.H. Meldrum, and P. Drew. *Transactions of the Institution of Engineers, Australia (Civil Transactions)*, 1985, CE-27, 251–62.