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HANSON CONSTRUCTION MATERIALS PTY LTD

INFORMATION TO ADDRESS COMMUNITY QUESTIONS REGARDING BLASTING OPERATIONS AT HANSON LYSTERFIELD QUARRY

The following information has been provided to help address some questions recently asked by local community members around the effects of blasting at Hanson Lysterfield Quarry on the surrounding area.

GROUND VIBRATION LIMITS FOR QUARRIES: HUMAN COMFORT LIMITS vs DAMAGE LIMITS

Ground vibration and airblast levels from quarry operations are regulated under state legislation by Earth Resources Regulation (ERR), a branch of the Victorian Government Department of Jobs, Precincts and Regions. The limits apply at "sensitive sites" such as occupied residences, schools and hospitals, and are observed to help minimise potential disturbance and annoyance from blasting operations. The limits are set below levels at which vibration damage to light-framed, residential-type buildings is known to occur.

The ERR ground vibration limit that applies to Hanson Lysterfield Quarry's approved Work Plan is 10mm/s Peak Particle Velocity (or PPV). Routine blast monitoring around Lysterfield Quarry began in 2010 and no exceedance of the ERR PPV limit has been recorded to date. 38 blasts were fired at the quarry during 2018 (January to end November), with an average PPV at Sandford Close of 1.38 mm/s and a maximum reading of 2.97 mm/s. The maximum reading is less than one third of the quarry's ground vibration limit.

Buildings can withstand relatively high levels of ground vibration without damage occurring. Australian Standard AS2187.2 (2006) contains guideline damage criteria from overseas standards and research. One such guideline is sourced from British Standard BS7385.2 (1993). The British criterion was developed from investigations of confirmed cases of blasting damage and is approved for use in Australian conditions. In accordance with the British criterion, the threshold at which there is an *increasing possibility of cosmetic damage* is 18 mm/s (at a typical blast vibration frequency of 10 Hz). The threshold for minor damage is 36mm/s and the threshold for major/structural damage is 72 mm/s. Guideline vibration limits used to prevent damage to buildings are conservative by design. Australian research has shown PPV levels below 70mm/s to be non-damaging to double storey brick veneer houses (Australian Coal Association Research Project C9040 *Structure Response to Blast Vibration,* 2002).

THE BEHAVIOUR OF SOIL UNDER GROUND MOTIONS FROM BLASTING

It has been claimed by a small number of Rowville residents that ground vibration generated by weekly blasting at Hanson Lysterfield Quarry causes gradual, permanent displacement or slippage of the ground which can adversely affect the integrity of buildings and other structures. Worldwide, this theory is untested and we are unaware of any formal scientific studies have been undertaken, presumably because it is not a subject that warrants investigation.

Permanent ground movement (deformation) may occur up to 10 meters or so from a quarry blast site. This is caused by pressure from explosives gases penetrating the nearby rock structure which may result in crack formation and permanent displacement of the ground surface (sometimes referred to as "back break"). Beyond this zone, the ground is naturally elastic and returns to its original position after the vibration waves have passed. The brief, non-permanent displacement of the ground at regulated PPV levels is small. At PPV level of 3mm/s from a normal quarry blast, the peak (non-permanent) displacement is 0.068mm, or 68 microns, which is around half the thickness of a human hair.

The Lysterfield Hills are not recognised as being prone to landslip and there is no indication of permanent ground movement on the steeper slopes of the hills surrounding the quarry pit which are subject to considerably higher PPV levels than is permitted at houses. Likewise, there is no evidence of blast related permanent ground displacement or damage to Hanson buildings and infrastructure located inside the quarry such as the quarry's offices and weighbridge. Experience at other quarries draws the same conclusions.

While soil dynamics is a complex field of science, the following statement by Lewis L. Oriard broadly addresses the question in regard to clay soils.

"Despite the shrinking and expanding that takes place with changes in moisture in clay soils, they are not very sensitive to ground vibrations. Because of the high values of cohesion, clay offers high resistance to transient loading, yet it will creep or move slowly under static loading. Such soils can creep statically for the life of the structure, yet not respond unfavourably to regulated levels of ground vibration. Thus we have a paradoxical situation that some of the soils that are most likely to move under environmental forces are the least likely to be affected by blasting vibrations." - L. Oriard, *The Effects of Vibrations and Environmental Forces*, 1999.

Many of the houses in the foothills to the west of Lysterfield Quarry are built on cut and fill sites with soil containing clay. While clay soils alone can be highly reactive to seasonal changes in moisture content, inconsistent compaction of cut and fill sites prior to house construction can also lead to differential ground settlement around properties, with potential to cause movement of house footings which may lead to leading to crack formation or more serious structural problems. In areas with sandy soils, erosion from water runoff is a leading cause of foundation and footing movement. Foundation soil movement is widespread throughout metropolitan Melbourne (and beyond) and is not limited to houses located near quarries. It has been estimated that at least one third of houses in the metropolitan region have some damage caused by foundation soil movement.

More information on soil characteristics and specifications for compacting fill on sloping sites can be found in Australian Standard AS2870 *Residential Slabs and Footings* (2011).

The Effects of Ground Motion on Dams and Embankments

Research has been conducted into the movement and failure of slopes and embankments exposed to large ground motions from earthquakes because of the potentially catastrophic consequences of failure of some dams. A study into the effects of natural seismicity (earthquakes) on earth embankment dams concluded that;

"*Dams constructed of clay soils have withstood extremely strong shaking from 0.35 to 0.8g from a magnitude 8 earthquake with no apparent damage."* – R. Fells, *Geotechnical Engineering of Dams*, 2005.

A magnitude 8 earthquake, from the Modified Mercalli Scale (MMX), is broadly equivalent to PPV levels greater than 700mm/s. Movement of natural slopes in the environment is not noted until Magnitude 6 earthquakes (MMVIII) which is equivalent to a PPV of 180mm/s. However, earthquakes cannot be readily compared to blast vibration because seismic events have lower, potentially damaging frequencies (≤2 Hz), can have large displacements of several centimetres, and events may last for tens of seconds. Blast vibration occurs at higher frequencies, has small displacements, lasts for 2-4 seconds and is non-damaging at low, regulated PPV levels.

The potential for movement of earthen wall dams and bunds close to large scale blasting operations at mines has also been investigated in the Hunter Valley coalfields, where open cut blasts may have up to 3 tonnes of explosives per blast hole (i.e. 25 times more explosive than in a typical quarry blast hole).

Some conservative PPV limits that currently apply at dam walls under load range from 50-100mm/s, based non-damaging levels of 100-200mm/s. Melbourne water currently observe a 50mm/s PPV limit for earthen dam walls. More information on the effect of blasting on dams and embankments can be found in Australian Coal Association Research Project C14057 *Effect of blasting on Infrastructure* (2008).

THE INFLUENCE OF HEANY PARK LAKE ON BLAST VIBRATION LEVELS

The lake at Heany Park is unlikely to influence ground vibration levels at nearby properties due to its small size and shallow depth. Under certain conditions, deep excavations such as trenches may reduce PPV levels from close vibration sources by inhibiting the transmission of vibration waves at the surface. However, any such effect from the lake at Heany Park lake would be negligible and difficult to detect.

FATIGUE FAILURE FROM REPETETIVE LOADING

When a material is loaded dynamically as a cyclical or repetitive load, the possibility of fatigue failure exists. The building element most susceptible to fatigue failure is plasterboard and this material's static failure load has been determined through laboratory testing. Testing has shown the lower the dynamic load (F_{max}) is in relation to the ultimate static failure load of the material (F_{ult}), more loading cycles are required for fatigue to occur. The results of a series of tests (Konig 1989) are summarised below.

Ratio $\frac{F_{max}}{F_{ult}}$	Frequency (Hz)	No. cycles to failure of Plasterboard
0.50	4	1,028,000
0.33	4	1,422,800

Observing Lysterfield Quarry's maximum PPV reading of 2.97 mm/s (F_{max}) and the conservative damage threshold of 18mm/s (F_{ult}) from BS7385.2, the dynamic load to failure load ratio is 0.17. At this ratio, the number of cycles required for fatigue failure is approximately 1,794,000. At an average 50 cycles per blast, the number of blasts required for fatigue failure in plasterboard to occur is 35,880. At a maximum 50 quarry blasts per year, fatigue failure may occur after 718 years. This estimate is conservative because only 2-3 cycles per blast occur at the maximum PPV level and ground motion frequencies from blasting are typically above 4 HZ.

Houses are also subject to repetitive loading from natural forces such as temperature cycles and variable foundation soil moisture levels which impart considerably larger strains on the structural elements of buildings and damage may occur after relatively few cycles.

CONCLUDING COMMENT

While blast vibration is perceptible in areas up to 2km from the Hanson Lysterfield Quarry, residents and building owners should have confidence that blasting at the Hanson Lysterfield Quarry will not cause permanent ground displacement or damage to houses in the short or long term, either directly or by fatigue failure, whilst compliance with strict Victorian Government regulation is adhered to by the quarry operators.

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