Duntroon Quarry Operations Fact Sheet: Blasting and Vibration

July 2008

As a quarry operator, blasting is an important aspect of our business. The most efficient fracturing of the bedrock is done at the blast face. Our challenge is to balance the effective fracturing of the rock with the control of impacts from the blast.
This fact sheet explains the science of vibration and the craft of blasting. Please continue to ask questions, raise concerns and share ideas. We are constantly seeking new and innovative ways to improve our operations in ways that benefit the environment, our neighbours, and our business.

What is a blast?

A blast is a controlled event that places a designed amount of energy into rock to fragment it for processing. Noise and vibration from a blast is energy that was not consumed in the fragmentation of the rock. It is wasted energy, which results in wasted money and potential environmental impacts. Designing a blast is about balancing the need to adequately fragment the bedrock with the need to minimize environmental impacts.

A blast begins with the design. A plan of the drill hole pattern is developed that identifies the size of the holes, the number of holes, the spacing between the holes, the size of the burden and the sequence in which the holes detonate in the blast.

The drill pattern is then laid out on top of the quarry bench and measured to ensure accurate spacing and depth of holes. The drill then drills a column into the rock. The hole is drilled slightly lower than the quarry floor (subgrade) to ensure that the bottom of the hole kicks out at a consistent level. When drilling is complete, the hole is loaded with a specific weight of explosive. The first thing down the hole is an electric detonator inserted into a booster, followed by the explosive. The detonator sets off the booster, which then detonates the remainder of the explosive in the bore hole.

The explosives are loaded by one of three explosive suppliers in the province. An ammonium nitrate emulsion is pumped from the supplier's truck into each bore hole. The hole is not filled to the top with explosives; space is left at the top, which is referred to as the collar. The emulsion is gassed in order to sensitize the explosive in the hole. The collar at the top of each bore hole is then filled with crushed stone stemming. The purpose of the stemming is to contain the explosive energy during detonation to help fragment and move the bedrock.

Each hole is detonated separately. A blast is actually a series of small detonations as each hole is detonated. Each hole is detonated with at least an 8 millisecond delay between them. A typical blast at Duntroon would be approximately a ½ second in duration.

We're working on it...

What Walker does to minimize nuisance of blasting effects:

- ✓ designs all shots with millisecond delays between holes to reduce vibration
- ✓ notifies immediate residents in advance
- ✓ watches the weather
- ✓ monitors vibration levels at 3 stations

Vibration levels recorded to date have been well within the provincial guideline limits.

How does the energy of the blast *move?*

There are 2 types of energy produced from a blast: air over pressure and ground vibration.

The detonation of an explosive produces a very rapid and dramatic increase in volume due to the conversion of the explosive from a solid to a gaseous state. When this occurs within the confines of a borehole, the bedrock in the area immediately adjacent to the explosive product is crushed. As the energy from the detonation radiates outward from the borehole, the bedrock between the borehole and quarried face becomes fragmented and is displaced, while the bedrock behind the borehole is fractured.

Energy not used in the fracturing and displacement of the bedrock dissipates in the form of ground vibrations, sound and air concussion. This energy attenuates rapidly from the blast site due to geometric spreading and natural damping.

The rate at which ground vibrations attenuate or decrease with increased distance from a blast depends on a variety of conditions, including the type and condition of the bedrock being blasted, depth and composition of the earth covering deposits (soil), and the general topography.

Air vibration effects are influenced by the prevailing weather conditions. On a still day, air overpressure travels in the opposite direction of ground vibration. However, wind direction has an impact on air overpressure and can focus it in one direction. Weather conditions do not change the intensity of the air concussion, weather only influences how that energy is distributed. For example, wind can influence its direction and cloud cover or a temperature can influence how far up into the atmosphere this energy dissipates.

How are blasts controlled?

Ground vibrations and air overpressures from a blast are controlled by controlling the amount of explosive detonated within any single delay within the blast. The amount of explosives detonated is controlled by the size and depth of the hole and the timing of detonation of each hole.

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Measuring Vibration

Because there are two types of energy from blasting, blast monitors need two different instruments to measure them: one to measure the seismic waves caused by ground vibration and one to measure the pressure waves traveling through the air caused by air overpressure.

The Ministry of the Environment has established guideline limits for both ground vibrations and air overpressure in Noise Pollution Control (NPC) publication 119 of the Model Municipal Noise Control By-Law, dated August, 1978. Air overpressure is determined by measuring the peak pressure level. The ground vibration is determined by measuring the vibration velocity.

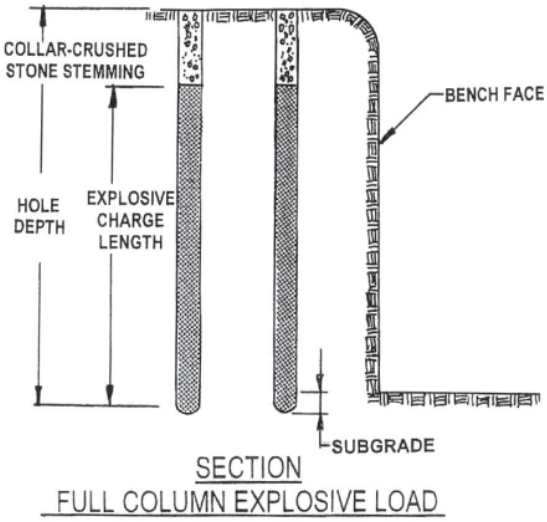
The peak particle velocity limit for ground vibration resulting from blasting operations in a quarry is 12.5mm/s.

The peak pressure level limit for air overpressure resulting from blasting operations in a quarry is 128dBL. Air overpressure is measured as decibels in the Linear or unweighted mode. This is in contrast to the dBA, which is used to measure sound.

Blasting and the weather

Weather conditions, such as high humidity or the presence of cloud cover, can cause the levels of overpressure and noise to seem more severe than there would be on a day when the humidity is low and there is lack of cloud cover. When possible, we generally avoid blasting when weather conditions include the following:

- significant temperature inversions
- strong winds
- foggy, hazy or smoky conditions with little or no wind
- still, cloudy days with a low cloud ceiling



SECTION
FULL COLUMN EXPLOSIVE LOAD

Structural Response To Ground Vibrations

Peak Particle Velocity		Ground Vibration Effect
in/s	mm/s	
24.0	600	Microcracks start developing in rock.
6.0	150	150-250 mm/s, limit often set for concrete.
3.0	75	Cracks start developing in plaster.
2.0	50	50 mm/s, limit often set for construction blasting.
1.0	25	19 - 32 mm/s, OSM frequency dependent limit
0.4	10	12.5 mm/s, Ontario limit for quarries.
0.02	0.50	0.3-0.5 mm/s, ground vibrations become perceptible to humans

in/s=inches per second mm/s=millimetres per second

Structural Response To Air Vibrations

Overpressure		Air Blast Effect
dBL	Pa	
181	22440	Conventional structures severely damaged
171	7096	Most windows break
151	710	Some older windows may break
141	224	Some large plate glass windows may break/crack
131	71.0	129- 134 dBL, USBM interim limit
121	22.4	128 dBL, Ontario limit for Quarries

dBL = decibels, linear (different from noise)

Pa = Pascals, measure of pressure

How do humans perceive vibration?

The human body can detect vibration at very low levels. Humans can start to feel vibrations at levels of 0.3 to 0.5 mm/s. This threshold of human perception of vibration is well below the levels at which even cosmetic damage occurs to structures and below the limits set by the Ministry of Environment guidelines.

How people perceive vibration will depend on what they are doing. People who are sitting or lying down will be more perceptive to vibration than those taking part in an activity. The determination of whether a vibration is annoying is dependent on the individual. Vibration from blasting can be perceived as annoying as it is unexpected unlike the vibrations that we regularly experience in our homes, such as when we walk up and down stairs or open and close doors. Slamming a door can produce vibrations up to about 12 mm/s. Footfalls register at about 0.8 mm/s.

Please refer to "Georgian Aggregates and Construction Inc. Duntroon Quarry Expansion Planning Report and Aggregate Resource Act Summary Statement", MHBC Planning, September 2005 for more details.

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