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Specialists in Explosives, Blasting and Vibration
Consulting Engineers

April 10, 2014

The James Dick Group Inc.
P.O. Box 470
Bolton, Ontario
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Attention: Mr. Leigh Mugford

Subject: Proposed James Dick Hidden Quarry Licence Application
Blasting Flyrock

Dear Mr. Mugford,

In response to your inquiry regarding the potential for flyrock from the proposed James Dick Hidden Quarry, this report expands on our earlier comments.

Flyrock is the term used to define rocks which are propelled from the blast area by the force of the explosion. This action is a predictable and necessary component of a blast and requires that every blast have an exclusion zone established within which no persons or property which may be harmed are permitted.

Government regulations strictly prohibit the ejection of flyrock off of quarry property. The regulations regarding flyrock are enforced by the Ministries of Natural Resources, Environment and Labour. In the event of an incident where flyrock does leave a site, the punitive measures include suspension / revocation of licences and fines to both the blaster and quarry owner / operator. Fortunately, flyrock incidents are extremely rare due to the possible serious consequences of such an event. It is in the best interest of all, stakeholders and non-stakeholders, to ensure that dangerous flyrock does not occur. Through proper blast planning and design, it is possible to control and mitigate the possibility for flyrock.

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Theoretical Horizontal Flyrock Calculations

We have analyzed theoretical flyrock projection distances based on a quarry operating in the dry. It is critical to note that the proposed Hidden Quarry intends to operate in a wet environment. It has been our experience that the presence of the water will restrict rock projection by up to 90% when compared to the calculations contained below.

Flyrock occurs when explosives in a hole are poorly confined by the stemming or rock mass and the high pressure gas breaks out of confinement and launches rock fragments into the air. The three primary sources of fly rock are as follows:

- **Face burst:** Lack of confinement by the rock mass in front of the blast hole results in fly rock in front of the face.

- **Cratering:** Insufficient stemming height or weakened collar rock results in a crater being formed around the hole collar with rock projected in any direction.

- **Stemming Ejection:** Poor stemming practice can result in a high angle throw of the stemming material and loose rocks in the blasthole wall and collar.

The horizontal distance flyrock can be thrown (L_H) from a blast hole is determined using the expression:

$$L_H = \frac{V_o^{\,2} Sin2\theta_0}{g} \qquad [1]$$

where:

V_o = launch velocity (m/s)

θ_0 = launch angle (degrees)

g = gravitational constant (9.8 m/s^2)

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The theoretical maximum horizontal distance fly rock will travel occurs when θ_0 = 45 degrees, thereby yielding the equation:

$$L_{H\max} = \frac{V_o^{\,2}}{g} \qquad [2]$$

The normal range of launch velocity for blasting is between 10m/s - 30m/s. To calculate the launch velocity of a blast the following formula is used:

$$V_o = k\left(\frac{\sqrt{m}}{B}\right)^{1.3} \qquad [3]$$

where:

k = a constant
m = charge mass per meter (kg/m)
B = burden (m)

By combining equations 2 and 3 and taking into account the different sources of fly rock, the following equations can be used to calculate the maximum fly rock thrown from a blast:

Face burst:

$$L_{H\max} = \frac{k^2}{g} * \left(\frac{\sqrt{m}}{B}\right)^{2.6}$$

Cratering:

$$L_{H\max} = \frac{k^2}{g} * \left(\frac{\sqrt{m}}{SH}\right)^{2.6}$$

Stemming Ejection:

$$L_{H\max} = \frac{k^2}{g} * \left(\frac{\sqrt{m}}{SH}\right)^{2.6} Sin2\theta$$

where: θ = drill hole angle
L_{hmax} = maximum flyrock throw (m)
m = charge mass per meter (kg/m)
B = burden (m)
SH = stemming height (m)
g = gravitational constant
k = a constant

For calculation purposes, we have assumed 76mm (3”) diameter holes on a 2.1m x 2.1m (7’ x 7’) pattern, with total depths of up to 34m (112’) and a collar length of 1.5m (5’) to 4.0m (13’).

The range for the constant k is 13.5 for soft rocks and 27 for hard rocks. Given dolostone bedrock in the area, we have applied a k value of 20. The explosive density is assigned to be 1200 kg/m^3 for emulsion products and the drill hole angles are assumed to be 90 degrees (i.e. vertical).

The maximum horizontal throw for the flyrock using a varied collar is shown in Table 1 below.

Table 1 – Maximum Flyrock Horizontal			
Collar Lengths (m)	**Maximum Throw Face Burst** (m)	**Maximum Throw Cratering** (m)	**Maximum Throw Stemming Ejection** (m)
1.5	52	129	0
2.0	52	61	0
2.5	52	34	0
3.0	52	21	0
3.5	52	14	0
4.0	52	10	0

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We reiterate that actual observed flyrock will be drastically restricted due to the presence of the water. Portions of the rock above the water level would not leverage this same benefit.

Through proper blast design and diligence in inspecting the geology before every blast, flyrock can readily be maintained within the quarry limits. It may be necessary to increase collars when blasting along the perimeter. The operational plan for the quarry has been designed to retreat towards the closest receptors thereby projecting flyrock and overpressures away from the receptors.

We trust the above provides the clarification requested. Should you require any additional information, we remain available as necessary.

Kindest regards,

LICENSED PROFESSIONAL ENGINEER
R. J. CYR
PROVINCE OF ONTARIO

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