National Exams December 2009

98-MMP-B2, Rock Fragmentation

3 hours duration

NOTES:

1. If doubt exists as to the interpretation of any question, the candidate is urged to submit with the answer paper, a clear statement of any assumptions made.

2. This is an OPEN BOOK EXAM.
   Any non-communicating calculator is permitted.

3. FIVE (5) questions constitute a complete exam paper.
   The first five questions as they appear in the answer book will be marked.

4. Each question is of equal value.

5. Some questions require an answer in essay format. Clarity and organization of the answer are important.

1.0 Question 1

a. Table 1 shows the blast fragmentation obtained by screening a small blast.

What are the 50% and 80% passing sizes?

TABLE 1. Fragmentation data

Size, mm	Material on screen, t
-16	7.6
+ 16 -38	12
+38-76	24
+76-152	65
+152-254	78
+254-508	81.9
+508	60

b. What fragmentation distribution equations are used in blasting? What are their advantages and disadvantages?

c. Which blasting parameters affect the average fragment size?

d. In a rectangular pattern the burden is 5m, the spacing is 6m and the average fragment size in 25cm. Estimate the change of the average fragment size if the burden is increased to 6m, the spacing to burden ratio stays the same and the rest of the blasting parameters remain unchanged?

2.0 Question 2

a. Design an open pit blast to produce average fragment size of 30cm. The following data are given:

hole diameter: 270 mm
bench height: 14 m
collar height: 5.5m
Spacing to burden ratio (drilling): 1
Explosive: ANFO with density equal to 850 kg/m^3

The rock is massive, has a density of 3000 kg/m^3 UCS (uniaxial compressive strength) of 160 MPa and Young's modulus equal to 62 GPa. The p-wave velocity of the rock is 4.6 km/s.

b. What delay times you will use in the blast assuming there are no vibration concerns? Explain your answer.

c. Show the blast layout for a corner blast where you have 5 drilled rows with 10 holes per drilled row.

3.0 Question 3

a. In a limestone quarry the peak particle velocity produced by a blast is given by the following equation:

$$PPV = 700\left(\frac{R}{W^{0.5}}\right)^{-1.45}$$

where PPV is the peak particle velocity, mm/s,
R is the distance, m and
W is the mass of the explosive per delay, kg.

The bench height is 17m and the diameter of the boreholes 165 mm while the explosive is ANFO with a density of 0.85 kg/m^3. Due to vibration complaints, a limit of 5mm/s has been accepted for the nearest residence which is 400m away. Provide blasthole loading and timing for the quarry to satisfy the vibration limit.

b. Vibration simulations have shown that with the delay of 25ms a vibration at the distance of a neighbour's house has a peak particle velocity of 6mm and a frequency of 10Hz, while with a delay of 42ms the peak particle velocity is 8mm and the principal frequency is 25Hz. Which delay is preferable and why?

c. Explain the difference between air blast and noise. Which is more likely to introduce structural response?

4.0 Question 4

a. In a tunnel, drilling is conducted using 50mm diameter 5m long boreholes. The rock is a granite with UCS of 240 MPa. Provide the spacing between the perimeter holes as well as guidelines for

loading them to avoid damage of the final wall. Describe any concerns regarding the holes closest to the perimeter holes. Available explosives are given in Table 2:

TABLE 2. Explosives available

Product	density, g/cm$^{1/3}$	Diameter, mm	Velocity of Detonation, m/s
A	1.2	17	5000
B	1.0	25	4000
C	1.2	32	5500
D	1.2	45	5500

b. In medium rock (uniaxial compressive strength: 140MPa, density: 2.6 t/m^3) it has been proposed to use wall control techniques at the perimeter of the excavation. The production holes have a diameter of 165mm, the bench height is 15m and the free face slope is 80 degrees. The mine uses ANFO for its production shots and packaged explosive products are unavailable. Design the perimeter (wall control) blast and discuss any concerns you may have. ANFO has a density of 0.85 g/cm^3 and ideal velocity of detonation of 4900 m/s.

5.0 Question 5

a. Design a Vertical Retreat Mining (VRM or VCR) blast when the boreholes have a diameter of 200mm, the explosive is an emulsion with a density of 1300kg/m^3, and the optimum scaled depth is 0.9 m/kg$^{1/3}$. For simplicity, assume that at the optimum scaled depth the scaled crater radius is 0.9 m/kg$^{1/3}$

b. What are the desirable explosive properties in crater blasting?

b. Show the firing sequence, delay times and loading (schematically) for a drop raise having a cross section 2mx2m. Assume a diameter of the loaded holes equal to 165mm. Make assumptions and present them clearly.

6.0 Question 6

a. Estimate the penetration rate of a rotary drill having a diameter of 200mm, drilling a limestone with compressive strength of 80MPa. The rotary speed is 80 r/min. What changes are anticipated when drilling a harder rock?

b.Discuss factors controlling drilling deviation. What are the effects of drilling deviation in fragmentation and wall control blasting?