National Exams May 2016

09-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 a CLOSED BOOK EXAM. One aid sheet written on both sides is permitted
   A Casio or Sharp calculator is permitted.
3. QUESTION 1 plus FOUR (4) questions from questions 2-6 constitute a complete exam paper.
   Question 1 plus the first 4 questions as they appear in the answer book will be marked.
4. Some questions require quantitative answers. Please state your assumptions clearly and provide clear answers.
5. Provide short and precise answers.

Question 1 (questions a-l, 3 marks each, question m, 4 marks; 40 marks total)

a. What are the expected products of detonation for a mix of AN/FO with aluminum (Al)? The composition is 95% AN/FO (94% Ammonium Nitrate/6% Fuel Oil) and 5% Al.
b. Describe the effect of density on the critical diameter of a bubble sensitized emulsion explosive.
c. Describe two ways by which an explosive can be desensitized by shock.
d. What is the effect of a shock wave, produced by a near-by detonation, on initiating devices (delay detonators).
e. Describe the use of air-decking for wall control applications and collar fracturing purposes. What aspects of the blast design control the mechanisms that may result in such different blasting results?
f. What are the advantages and disadvantages of using image analysis for fragmentation analysis of a muckpile?
g. Which are two of the commonly used equations describing particle size distributions produced by blasting? What are the advantages and disadvantages of each?
h. What is the effect of timing on vibration control? Is a delay time of 9 ms between successive detonations sufficient in all situations? Explain.
i. Why is frequency an important parameter of the vibration wave?
j. What is the effect of timing on air blast control? What delay is appropriate?
k. What affects back break in a blast?
l. What parameters control drilling deviation?
m. What are the reasons of Nitrogen Oxide (NO_x) emissions during a blast?

Given are: Ammonium Nitrate: NH_4NO_3, Fuel oil: CH_2, Aluminum, Al. Atomic weights: C:12, H:1, N:14, O:16, Al:27

Question 2 (a, 7.5 marks, b, 7.5 marks - 15 marks total)

a. In a granite quarry you are using three rows of boreholes, each row having 12 boreholes. The boreholes have a diameter of 102 mm and the bench has a height of 12 m. The blast is loaded with emulsion, having density of 1.25 g/cm^3. The burden, spacing and collar length are 2.5 m, 3.5 m and 3 m respectively. The distance from the quarry to the nearest structure is 300 m. To increase productivity the quarry wants to use 165 mm diameter holes without sacrificing fragmentation while, at the same time avoiding flyrock that could endanger its neighbors. Recommend appropriate pattern dimensions and timing.

b. In the above problem, vibration levels are predicted by the following attenuation relation: $PPV = 745\left(\frac{R}{\sqrt{W}}\right)^{-1.3}$

Where PPV is the peak particle velocity in mm/s, R is the distance in m and W the mass of explosive per delay in kg. The vibration limit used is 12 mm/s. Design the blast to be in compliance with the vibration limit.

Question 3 (a, 7.5 marks, b, 7.5 marks - 15 marks total)

A drift has a cross section with a width of 6 m and height 4.7 m. The diameter of the holes is 51 mm. The available explosive is an emulsion in diameters of 17, 25, 32, 40 and 45 mm and has a density of 1.15 g/cm^3 The manufacturer has suggested an ideal detonation velocity of 5500 m/s for the product.

a. Design the wall holes for wall control application and provide appropriate loading and delay timing for them. Show loading and important design parameters in a sketch. How will this blast be sequenced and timed in relation to the tunnel blast? Which is the optimum type of detonator for your application? Discuss.
b. Design the cut of the tunnel round if you can drill open holes with a diameter of 75 mm. Provide loading, sequence and timing.

Question 4 (a, 5 marks, b, 5 marks, c, 5 marks - 15 marks total)

The drilling pattern of an open pit blast is square. The rock is an iron ore with density of 3.0 g/cm^3, considered massive with UCS (uniaxial compressive strength) of 300 MPa, Young's modulus of 110 GPa and p-wave velocity of 6 km/s. The diameter of the boreholes is 311 mm and the bench height is 14 m.

a. Suggest loading for these blastholes and the dimensions of the drilling pattern to obtain an average fragmentation of 30 cm. You can use explosive blends ranging from a straight ANFO (density 0.8 g/cm^3) to a straight emulsion (density 1.4 g/cm^3); however you must justify your selection of explosive(s).
b. Calculate the fragmentation resulting from your design.
c. Recommend the sequence and timing for a five-row blast with one initial free face (other than the horizontal surface). Loading of the muckpile is to be done using a rope shovel.

Question 5 (a, 10 marks, b, 5 marks – 15 marks total)

The drilling pattern of an open pit blast is rectangular with dimensions 7 m x 9 m. The rock is a copper ore with density of 2.7 g/cm^3, considered massive with UCS (uniaxial compressive strength) of 140 MPa and p-wave velocity of 5 km/s. The diameter of the boreholes is 311 mm and the bench height is 16 m. The slope of the free face is 80 degrees. The conditions are dry.

a. Develop a wall control program as you approach the final pit wall. Design a buffer zone as well as the final row of holes. The diameter for the buffer holes is 175 mm and the diameter for the final row can be 100 mm. Propose explosives to be used, loading, sequence and timing. Justify the parameters selected.
b. Provide a sketch showing your loading and design.

Question 6 (15 marks total)

An underground mine uses the Vertical Retreat Method (VRM or VCR). Design a blast with a borehole diameter of 160 mm and cratering information (scaled crater volume vs. scaled depth of charge) provided in the following Figure (Figure 1). Use an appropriate explosive for cratering applications, justify its use and assume necessary properties (i.e. density, energy, velocity of detonation if needed). Produce a sketch to indicate the loading of each of the holes of the blast and another one to indicate pattern dimensions and delay times for the blast.

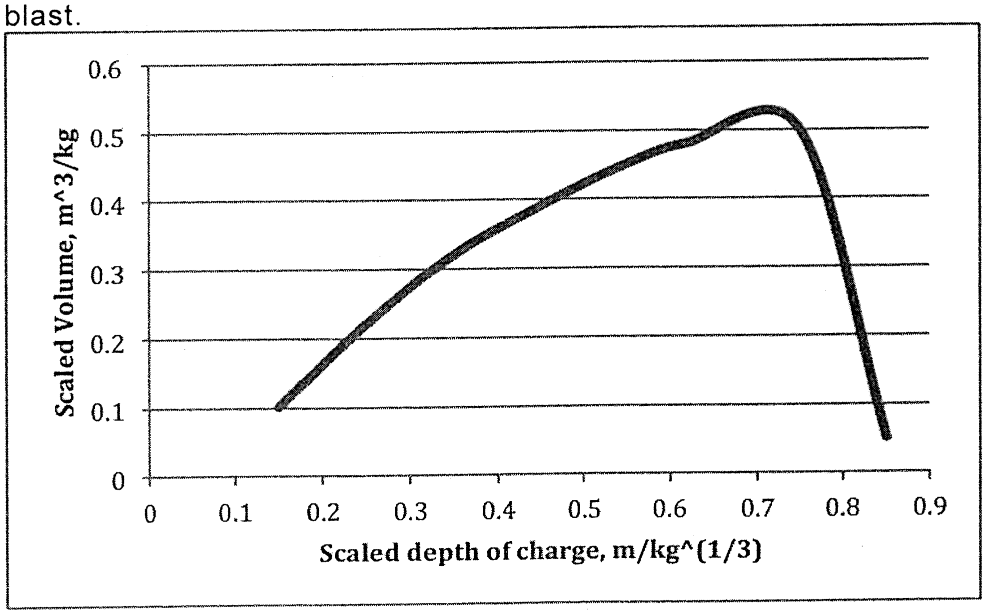

Figure 1. Cratering curve for problem 6.