National Exams December 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
   Any non-communicating calculator is permitted.

3. Question 1 plus FOUR (4) questions from questions 2-6 constitute a complete exam paper.
   The first five 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; 36 marks total)

a. Provide a graph indicating velocity of detonation vs. depth of borehole in the case of an air bubble sensitized emulsion loaded in a 165 mm diameter, 17 m long borehole. Assume adequate priming.
b. What are the reasons for producing fumes (CO, NOx) in blasting?
c. Describe the effect of delay blasting on detonators (non electric, electronic).
d. What are the reasons for flyrock?
e. What are the effects of powder factor on downstream applications?
f. What parameters in blasting affects the quality of the final wall of an excavation?
g. How is fragmentation measured in a blast?
h. Where are fragmentation measurements needed?
i. How is explosives performance measured in a blast?
j. What are the effects of inter hole and inter row delays in a blast?
k. Identify the four main components in drilling (applies to all drills)
l. What drilling parameters control fragmentation and how?

Question 2 (a, 14 marks, b, 7 marks - 21 marks total)

Figure 1 shows a plan view of a blast in an iron mine. The rock is an iron ore with density of 3.2 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 406 mm and the bench height is 12 m.

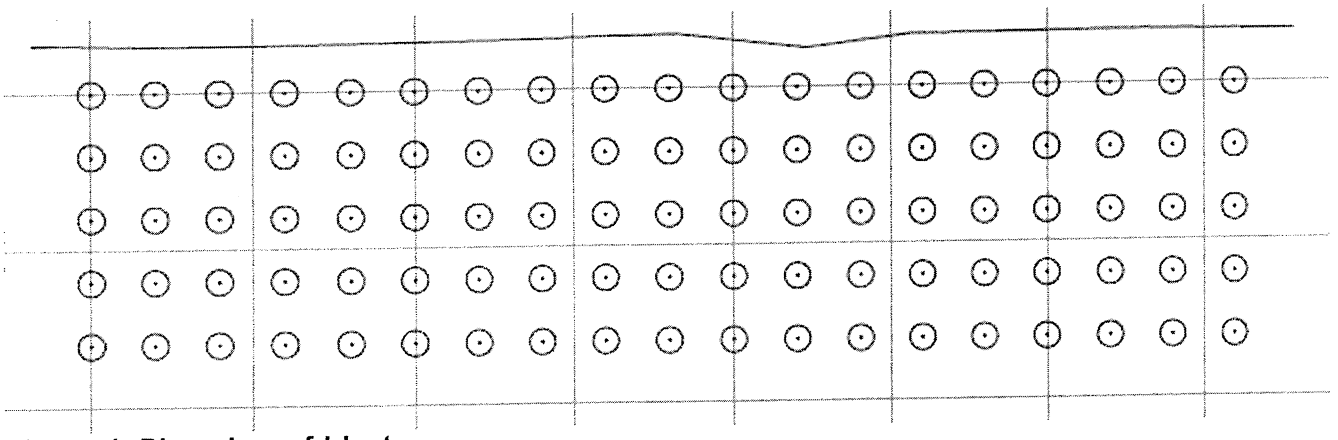

Figure 1. Plan view of blast

a. The mine wants to have the 80% passing size below 60 cm. Considering that the subgrade length is 1 m, the collar length is 4.6 m and the explosive is an emulsion/ANFO blend with a density of 1.32 g/cm^3 and weight strength relative to ANFO equal to 92%, and assuming ideal selection of detonators and no drilling deviation, what should the powder factor be to satisfy this requirement?
b. Using the drill pattern of Figure 1 suggest tie-ins and delays to be used.

Question 3 (a, 14 marks, b, 7 marks - 21 marks total)

a. In a limestone quarry you are conducting blasting with boreholes having a diameter of 102 mm. The bench has a height of 12 m and the blast is loaded with emulsion, having density of 1.25 g/cm^3. Figure 2 shows the results of cratering tests conducted in a similar material. The quarry wants to minimize flyrock, as a public road is at a distance of 300 m away, while controlling fragmentation. Ideally they want their 80% passing size to be around 50 cm. These objectives are currently achieved by trial and error using burden, spacing and collar length of 3 m, 4 m and 2.5 m respectively. To increase productivity the quarry wants to use holes with a diameter of 165 mm. Recommend appropriate pattern dimensions, blasthole loading and timing.

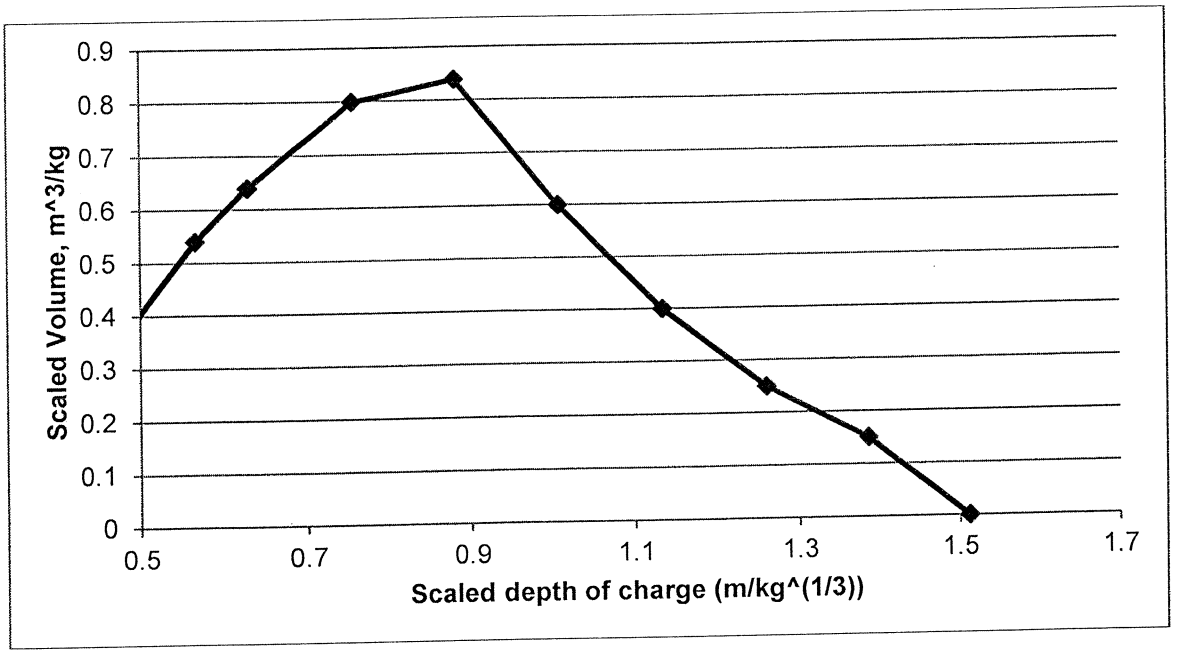

Figure 2. Cratering curve

b. What are the parameters controlling maximum flyrock range in this case?

Question 4 (a, 15 marks, b, 6 marks – 21 marks total)

The drilling pattern of an open pit blast is rectangular with dimensions 9 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 and the final row needs to be the same and no smaller than 165 mm. Provide design parameters.

b. Provide a sketch showing your loading and design.

Question 5 (a, 7 marks, b, 7 marks, c, 7 marks - 21 marks total)

a. Propose a burn cut design for the case of a tunnel where the blasthole diameter is 42 mm.
Indicate the sequence and the timing of the cut.
Discuss any problems that may arise from the design.

c. Propose the design of a 2m x 2m drop raise with boreholes having a diameter of 102 mm, loaded with an emulsion with density of 1.25 g/cm3. Provide loading of each hole, sequence and timing.

d. A ring blast drilling pattern is shown in Figure 3. Show how you would load, initiate and time the holes if you are firing two rings per blast.

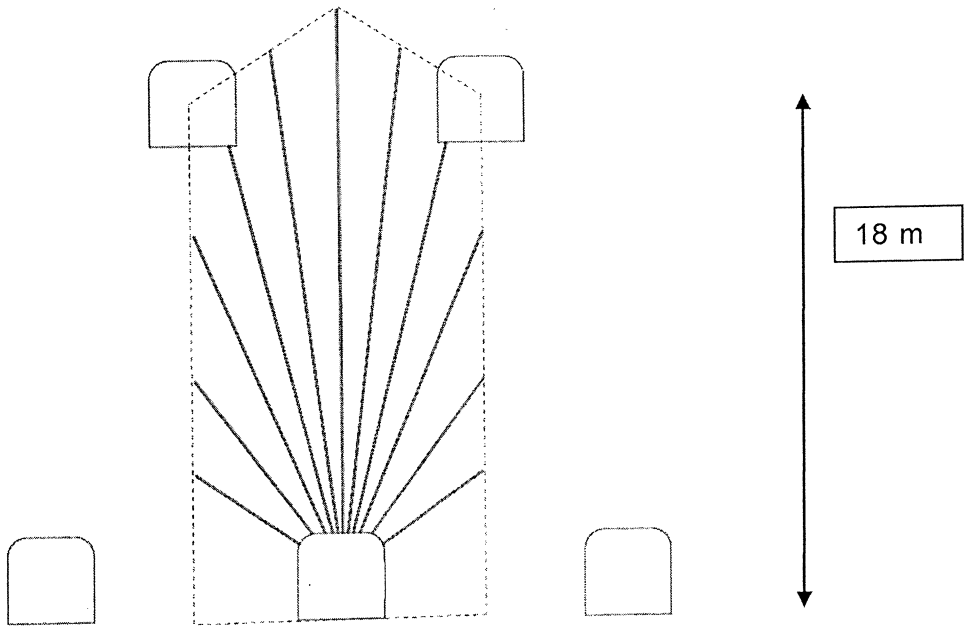

Figure 3. Ring blast

Question 6 (a, 14 marks, b, 7 marks – 21 marks total)

The relationship between peak particle velocity, and scaled distance is depicted in Figure 4.

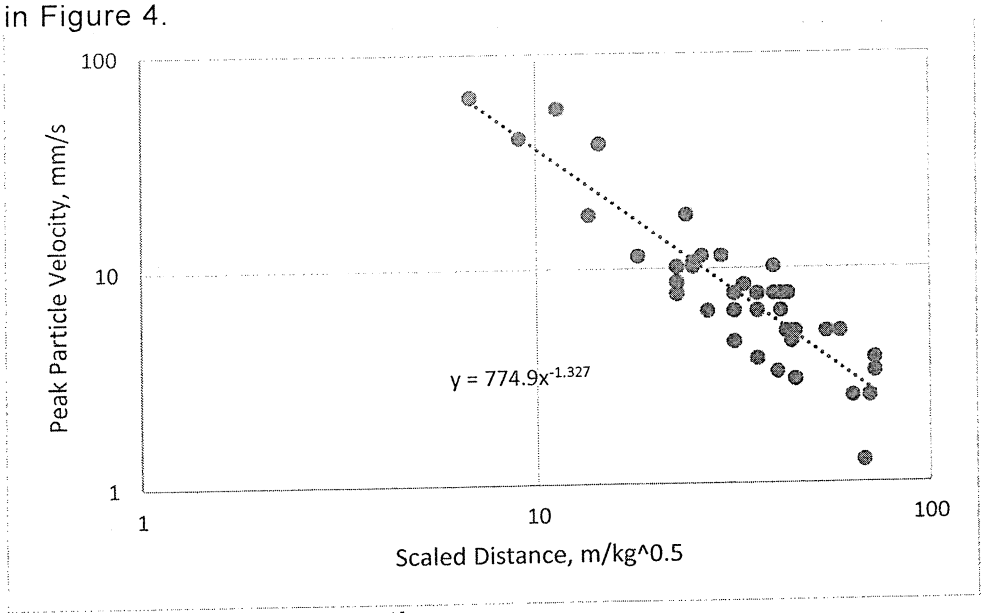

Figure 4. Vibration attenuation

a. Design (provide loading, sequence and timing) a quarry blast, consisting of 2 rows, each row with 12 boreholes, in a rectangular pattern that will be compliant with a vibration limit of 6 mm/s when the bench height is 12 m, the hole diameter 165 mm, the explosive used is AN/FO with density of 0.8 g/cm^3 and the distance to the nearest property 500 m.
b. Will your design be adequate to eliminate complaints from the neighbors? What additional steps would you take to ensure that complaints are minimized?