National Exams May 2015

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 an CLOSED BOOK EXAM. One aid sheet written on both sides is permitted
   One of two calculators is permitted any Casio or Sharp approved models.

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 quantitative answers. Please state your assumptions clearly and provide clear answers.

6. Provide short and precise answers

Question 1 (5 marks per question; 20 marks total)

a. Explain the term Oxygen Balance. How are explosives fumes affected by Oxygen Balance?
b. Calculate the oxygen balance of AN/FO at a composition of 93% Ammonium Nitrate, 7% Fuel Oil
c. Calculate the stoichiometric composition (oxygen balanced composition for AN/FO)
d. What affects the fumes produced by the detonation of AN/FO?

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

Question 2 (4 marks per question; 20 marks total)

a. List the parameters affecting explosives sensitivity
b. What is meant by "minimum primer"?
c. What is the optimum primer in a blast?
d. Describe sensitivity problems when you use emulsion explosives in tunnel blasting as well as in larger diameter blasting with decks.
e. List the drawbacks of major blast initiation systems.

Question 3 (5 marks per question; 20 marks total)

a. List parameters affecting drilling accuracy of blastholes
b. List the implications of drilling inaccuracy on blasting
c. How can you compensate for faulty drilling that results in:
a. Excessive burden
b. Insufficient burden
c. Short holes
d. Long holes
e. Smaller diameter (than required) boreholes
f. Larger diameter (than required) boreholes
d. What controls air bailing velocity in drilling?

Question 4 (a, b, c, d – 3 marks each; e – 8 marks; 20 marks total)

a. List the parameters that affect the average fragment size obtained by blasting. Describe the effect of each parameter (one sentence per parameter).
b. List the parameters that affect uniformity of blast fragmentation. Describe the effect of each parameter (one sentence per parameter).
c. What are the blast parameters controlling flyrock travel? Describe the effect of each parameter (one sentence per parameter).
d. A limestone quarry uses 102mm diameter boreholes loaded with AN/FO (density: 0.85 g/cm3). The collar is 2.0 m and they do not have flyrock

problems. To increase productivity they want to use 165mm diameter holes. What is the recommended collar they should use and why? What are the implication of such a decision on fragmentation and flyrock?

e. Provide a blast design that approaches a final wall for the case of open pit blasting in a massive rock having a compressive strength of 200 MPa. The bench height is 14m and the diameter of the boreholes you can drill are 311mm and 165mm. Assume massive rock and required average fragment size of 25cm (this may used as an indicator of the required blast result). The explosives you may use are AN/FO (density: 0.85 g/cm^3) and a blend (emulsion/ANFO) with a density of 1.3 g/cm^3 and a weight strength relative to ANFO of 0.95. The blast will have a length of 100m and width of 50m.

Question 5 (a, b – 5 marks each, c – 10 marks; 20 marks total)

a. List the parameters that affect air blast caused by blasting operations. Describe the effect of each parameter.
b. What are the implications of frequency of the air pressure – time record on the measurement of air blast?
c. Estimate the overpressures 250m away from a quarry in horizontally layered limestone. The bench height is 17m and the boreholes have a diameter of 102mm. The explosive used is ANFO with density 0.85 g/cm^3. The burden and spacing are 3.0 and 4.0m respectively while the stemming length is 2.2m. Because of complaints you are required to modify your blast design. Monitoring suggested an attenuation relationship that can be described by the following equation:

$$P = 6\left(\frac{R}{\sqrt[3]{W}}\right)^{-1.1}$$

Where P is overpressure in kPa, W is the charge mass per delay in kg and R is the distance between the blast and the monitoring station in m. If the acceptable overpressure limit is 128 dB describe how you would load every hole of the blast. Suggest a delay time for the blast. The formula to convert kPa to dB is given below:

$$P = 20\log\left(\frac{P_r}{P_0}\right)$$

where P is the pressure in dB, P_r is the pressure in kPa and $P_0=2*10^{-8}$ kPa

Question 6 (a, b, c – 4 marks each; d – 8 marks; 20 marks total)

a. List the parameters that affect vibration caused by blasting operations. Describe the effect of each parameter.
b. Describe the effect of frequency of vibration on the response of structures experiencing the vibration.
c. Can frequency of vibration be a controllable parameter in blasting? Please explain.
d. In an open pit operation the particle velocity produced by blasting is given by the following attenuation relationship, which expresses the 95%

confidence line:

$$PPV = 700\left(\frac{R}{\sqrt{W}}\right)^{-1.3}$$

where PPV is the peak particle velocity in mm/s
R is the distance between the blast and the monitoring instrument (m) and
W is the mass of the charge detonated per delay in kg.
Provide a blast design for the operation so that you do not exceed a vibration limit of 12 mm/s at a distance of 350 m from the blast. The diameter of the boreholes is 270mm and the bench height is 14m. The boreholes are loaded with ANFO at a density of 0.85 g/cm^3 and the powder factor is 1.2kg/m^3; Assume your blast has a square pattern of 20 holes per drilling row and there are 5 rows of holes. You are dealing with a corner blast, the tie-ins are diagonal and the material you are blasting is iron ore (hard rock).Indicate the timing to be used. Assume that you can use any type of detonators

Question 7 (a – 10 marks; b – 6 marks, c – 4 marks; 20 marks total)

a. In underground tunneling, please provide a cut design for a tunnel with width of 5m and height of 4m, using 50mm diameter holes with a length of 5m. Assume you can drill holes with a diameter of 76mm as the empty holes of the cut. Show the geometry of the cut, the initiation sequence and the delays to be used.
b. Design a final wall blast (provide distance between holes and loading) with holes having a diameter 50mm and length of 5m. The rock has a compressive strength of 160 MPa, tensile strength 5 MPa and you can use an emulsion which comes in diameters of 25mm, 32mm, 40mm or 50mm. The density of the emulsion is 1.15 g/cm^3 and its velocity of detonation is an average of 5500 m/s.
c. Design a final wall blast for an open pit operation (provide distance between holes and loading) with vertical holes, having a diameter of 102 mm, length of 12m. The explosive of choice is ANFO, density 0.85 g/cm^3.