# MINE 321

## ASSIGNMENT 2

### Problem 1

The measurement of the dynamic pressure around a blasthole is usually costly and difficult to

achieve because of high pressures and the violence associated with the blasting environment.

Computer simulations are often complicated, costly as well, and require considerable skill to run the sophisticated multi purpose programs available. Simple engineering solutions based on statistical interpretation of measurements are often useful to estimate the magnitude of such pressures. A commonly used form is given by Cole (1948):

where R is the distance, W is the mass of the charge and K and m are constants.

This equation assumes a point charge that is detonated deep in water, so the outgoing shock wave moves as a sphere, surrounding that charge, in the water

1. In boreholes, energy losses are different than in the case of a charge inside water, resulting in different K and m values. Use the measurements in a borehole provided in your slides and suggest new constants for the pressure equation. The mass of the explosive used in to obtain the data of the following table is 4.1 kg and the explosive had a weight strength 0.95 of that of ANFO.

|  |  |
| --- | --- |
| Distance, cm | Pressure, GPa |
| 10 | >2.5 |
| 25 | 0.61 |
| 40 | 0.4 |
| 60 | 0.35 |
| 100 | 0.19 |
| 150 | 0.12 |
| 200 | 0.11 |

The pressure history at a distance in water can be expressed by the following equations (Joachim and Welch, 1997):

where

where t is time in seconds.

To calculate energy delivered by a wave it is usual (Cole, 1948) to extend time to 6.7t0

1. How far away from the charge of the experiments, in water do you expect a charge of emulsion to detonate?
2. How far away from the charge of the experiments, in water do you expect the primer to detonate?
3. You operate in wet conditions, using decked charges (charges in the same borehole separated by a length of stemming) and the boreholes. Assume that in the above relationships, W is the mass of explosive contained in a borehole length of eight diameters, if the charge length is longer than this. Assume here that your charges will be equal to or longer than 8 diameters
4. What is the critical distance for initiation of the emulsion explosive used in the explosive decks, the pentolite primers used to initiate the explosive in the case of 102 mm and 165 mm diameter holes.
5. Plot the pressure – time histories of the wave that will impact the explosive at the critical distance in both cases of the 100 and 165 mm diameters.
6. Show how you would load 165 mm diameter 12 m long boreholes, where you are going to use two decks separated by stemming (assume wet conditions). The collar of the boreholes is 3.5 m of stemming. Provide a sketch with your answer and justify it.

The emulsion used has a density of 1.31 g/cm3 and relative to ANFO weight strength of 0.9.

The critical energy for shock initiation of Pentolite is 0.7 MJ/m2

The critical energy for shock initiation is 4 MJ/m2

The energy fluence criterion can be expressed in the following:

or

or

where P is the pressure pulse, t is time, tf is the time at the end of the pulse (its overall duration and in your case it is *6.7 x t0*), and C is the sonic wave velocity in the material. Up is the particle velocity.

If the energy fluence calculated is larger than the critical energy fluence, initiation will occur.

Assumptions:

1. Assume that the pressure pulse in the water is transmitted in the emulsion as is, and the wave attenuation in the emulsion is the same as in water. In other words you use equation (1) for your pressure calculations
2. Assume that the shock energy fluence delivered in the emulsion will be responsible for any accidental initiations (in the emulsion or primer). Hence 0=1.31 g/cm3 and C=1000 m/s. In other word the impedance (density x sonic wave velocity) in the last equation is the impedance of the emulsion.

### Problem 2

Pressures have been measured away from a detonating emulsion charge in parallel holes filled with a substance simulating an explosive. The diameter of the holes was 32 mm. The measurements in the holes are shown in Table 1. Distance are the distances from the detonating charge.

Table 1

|  |  |
| --- | --- |
| Centre to Centre distance, mm | Pressure, MPa |
| 197 | 23.0 |
| 210 | 27.8 |
| 210 | 17.9 |
| 241 | 15.4 |
| 254 | 16.0 |
| 254 | 20.2 |
| 260 | 12.4 |
| 305 | 8.3 |
| 305 | 15.5 |
| 311 | 6.8 |
| 311 | 10.2 |
| 406 | 12.1 |

The attenuation relationship is of the form:

where P is the pressure at a distance R, R0 is the radius of the charge and P0 and m are constants from the statistical interpretation of the above data.

1. Provide the parameters of the fit of the above equation.
2. What is the calculated pressure on the wall of the borehole? Why is this not equal to the expected explosion pressure, assuming reasonable parameters for the emulsion (density = 1.1 g/cm3 and velocity of detonation 4000 m/s)?
3. If the diameter of the blastholes in an underground tunneling application is 25 mm, what should the separation distance between charges be, if it is known that malfunction occurs at pressures above 250 MPa?
4. How does your answer compare to Liu’s suggestions in the presentation slides?

### References

Cole, R. H. 1948. Underwater Explosions. Princeton University Press, Princeton, NJ.

Joachim, C. E., and C. R. Welch. “ Underwater shocks from blasting”. Proceedings of the Twenty-third Annual Conference on Explosives and Blasting Technique, Las Vegas, Nevada. *International Society of Explosive Engineers, Cleveland, OH* (1997).

Keevin, T. M., and G. L. Hempen. "The environmental effects of underwater explosions with methods to mitigate impacts. 99 pp." *St. Louis, MO: US Army Corps of Engineers* (1997).