Due Monday March 19, 2007

As seen in class, the vertical stress, $\sigma$, in square pillars of width $W_p$ separated by a distance $W_o$ and located at a depth, $z$, is equal to

$$\sigma = \gamma z (1 + \frac{W_o}{W_p})^2$$  \hspace{1cm} (2)

The pillar stress must not exceed the pillar strength $q$. Let $F$ be the safety factor against failure with $F=q/\sigma$. The strength $q$ is defined using the Hoek and Brown failure criterion for rock mass strength, which under uniaxial condition reduces to

$$q = \sigma_c s^{1/2}$$  \hspace{1cm} (3)

where $\sigma_c$ is the unconfined compressive strength of the intact rock and $s$ is a reduction factor that ranges between 1.0 (for intact rock) and 0.0000... (for very fractured rock).

a) Combining equations (2) and (3), show that

$$\frac{W_o}{W_p} = \sqrt{\frac{\sigma_c s}{F \gamma z}} - 1$$  \hspace{1cm} (4)

The ratio $W_o/W_p$ must always be positive. It is equal to zero (no mining possible) at a depth $z_c$ equal to $(\sigma_c s)/(F \gamma)$.

b) The extraction ratio, $R$, is defined as the ratio between the mined area and the total area. Show that it is equal to

$$R = 1 - \frac{1}{(1 + \frac{W_o}{W_p})^2}$$  \hspace{1cm} (5)

c) As a numerical example, consider an iron ore with an intact compressive strength $\sigma_c = 75$ MPa, and a unit weight $\gamma = 0.027$ MPa/m. Show the variation of $W_o/W_p$ and $R$ with depth for depths less than 1000 m, for $F = 1.0, 1.5$ and $2.0$ and for selected values of $s = \{0,1\}$. Conclude on the importance of rock mass fracturing on the mine design.