CVEN30008 Engineering Risk Analysis (Semester 1, 2017)

Assignment 2 (Quantitative Risk Analysis)

Background

Open pit mines are employed when minerals deposits are found near the surface. Excavation of rocks is one of the major costs in open pit mines. Implementing steeper slope angles decreases the amount of excavated rock and is, therefore, an effective way to reduce the excavation cost. However, the steepening of slope increases the risk of failure and may lead to higher clean-up costs. Major slope failures in the past have resulted in the closure of mine operations. Engineers face the challenging act of balancing the risk of failure and excavation cost.

Assuming that you are part of the geotechnical team in the ABC open pit mine site owned by Travis Gold Mining. Your team has been asked to investigate two slopes in the mine that are prone to planar slope failures. Planar failure on rock slopes occurs when a rock mass fails on a relatively flat surface. The failure surface is often due to defects in the rock. A picture of the ABC open pit mine is shown in Figure 1. The highlighted areas show the two slopes under investigation.

Figure 1 – ABC Open pit mine and the slope under investigation. Blue Slope was excavated recently and rock testings have been performed on samples from the slope. Yellow Slope was excavated last year and slope stability analyses were previously carried out on the slope.

Slope stability analysis is a complicated exercise but it is now simplified for the purpose of this assignment. Slope analyses results are often represented as Factor of Safety (FoS) and Probability of Failure (PoF). The FoS measures the ratio between the driving force and resisting force in a system:

$$\text{FoS} = \frac{\text{Total Resisting Forces}}{\text{Total Driving Forces}} = \frac{\tan \phi}{\tan \beta} \qquad (1)$$

Where β = Angle of sliding plane

ϕ = Friction angle, a property of the rock which measures the ability of the material to withstand sliding across the failure surface.

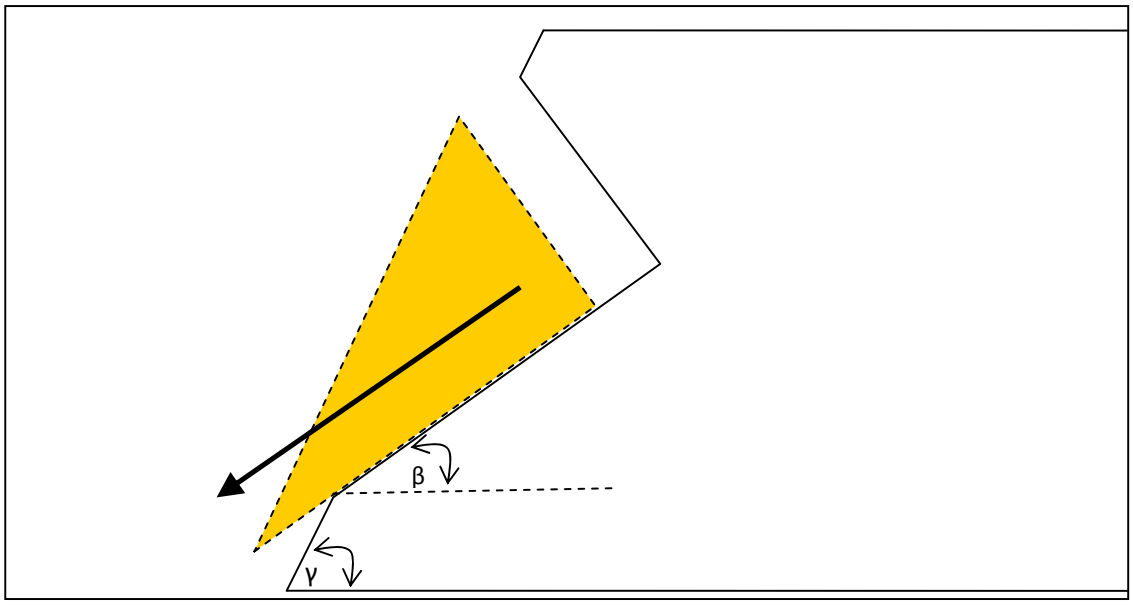

Figure 2 – Potential slope failure. β is the angle of sliding plane and γ is the slope angle.

In theory, stability of the slope is achieved when FoS is equal to 1. However, due to the variability of geotechnical parameters, probabilistic approaches are introduced to run slope analysis. Probabilistic analysis treats FoS as a random variable and calculates the probability of FoS with a value less than 1. The probability of failure (PoF) is defined as:

PoF = Probability (FoS < 1) (2)

Your team has been asked to present a report to the management team of Travis Gold Mining, addressing the questions below. The report must be consistent with AS/NZS ISO 31000:2009 Risk management – Principles and guidelines.

Figure 3 – An example of a slope failure.

Questions

1. Discuss the most critical risk factors related to the **Blue Slope** and **Yellow Slope**. Some research is expected and you are required to provide appropriate references (e.g. government reports and research papers).

2. Perform quantitative risk analysis using MATLAB in relation to the **Blue Slope** by assuming the following:
   - Friction angle (ϕ) is normally distributed.
   - Angle of sliding plane (β) = 40^o.
   - Cleanup cost of failed rock mass = \$120/m^3.

   (a) Tests were carried out on samples from the Blue Slope to estimate the friction angle (ϕ). The test results can be found in the "data.txt" file which is provided in the Assignment 2 folder on LMS. From this data, use MATLAB to produce a descriptive statistics summary for ϕ.

   (b) Find the 99% confidence interval of ϕ.

   (c) Based on experience, the geotechnical engineer believes that the mean of $\phi < 53^o$, with a 5% level of significance. Test the engineer's hypothesis.

   (d) Using the findings in part (a), perform Monte Carlo simulation (1000 runs) to determine the PoF by using MATLAB. Each group could use the last 3 digits of a member's student number as random seed (The seed number MUST be indicated in your assignment report) to generate 1000 samples. Generate a histogram for FoS. Assuming the volume of the possible failed rock mass is

200,000 m^3, quantify the risk of failure in dollars.

3. Perform quantitative risk analysis of the Yellow Slope by using the following assumptions:
   - Existing slope angle (γ) is 70°.
   - Excavation cost = $120,000 per degree of slope.
   - Assume the slope failure cost to be $17,500,000 for all γ.
   - Only consider γ between 20° and 70°.

(a) Use MATLAB to perform linear regression on the values in Table 1

(b) Calculate the excavation costs for γ between 20° and 70° in dollars. Present your answers in 5° intervals.

(c) Calculate the risk of failure for γ between 20° and 70° in dollars. Again, present your answers in 5° intervals.

(d) Recommend to management team the optimal value of γ that will result in the lowest total cost.

Table 1 – Slope analysis on Yellow Slope

Slope angle (γ)	PoF
70º	0.42000
60º	0.30000
50º	0.21000
40º	0.16000
30º	0.05800
20º	0.03200

4. Recommend the preferable risk treatment options to the project management committee and suggest an ongoing monitoring and review plan.

The Assignment Report must include at least the following sections:

1. **Executive summary (less than 200 words)**
2. **Introduction and purpose**
3. **Risk identification**
4. **Quantitative risk analysis**
5. **Risk treatments and proposed implementation**
6. **Findings and recommendations**
7. **Reference**
8. **Appendix (MATLAB Code)**

You are to undertake this assignment in groups of four students, each member to receive the same grading. All students should stay in the groups that were allocated for assignment 1. Please identify the group members and your tutor in the submission. This report is worth 15% of the subject result and should contain no more than 15 pages excluding the cover page and appendix (MATLAB codes). **The seed number and the name of your tutor MUST be indicated on your assignment cover sheet**.

Submissions must be lodged no later than 10 am Friday, May 19, 2017. The submission instructions are as follows:

- Two soft copies of your assignment report on LMS via both LMS Assignment Submission Tool and Turnitin by one of the group members. The links to upload your report will be provided on LMS/Assignment section. Please rename the title of your submission to reflect your tutorial and group number (e.g. Tutorial06_Group03).
- All students are required to conduct Peer Review on LMS via PRAZE before the assignment submission deadline. Late submission will not be accepted. Your marks will be affected without the completion of PRAZE on time.

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