

WELCOME TO AustraliaCDRhelp.Com

CAREER EPISODE 1

a) Introduction:

- 1.1 This episode is the elucidation of the academic project which was carried out to fulfill the requirement of the MINE6035-Rock and Soil slope Engineering course. It was named “**Design and Study of Slope Stabilization**”. I was selected as a team leader by the supervisor (Dr. Mostafa Sharifzadeh) because of my communication skills and competencies & fundamental understanding of slope stabilization theories. The time allocated to commence and complete this project was from September 2020 to November 2020. The research work was conducted in the engineering department of Curtin University, Kalgoorlie.

b) Background:

- 1.2 The prime focus of this project was to assume different cases which can significantly affect the stability of the concerned footwall and derive relevant outcomes. Therefore, in this case, the project was divided into three categories, i.e. first step involved entering all three material properties of the footwall along with secure output, such as UCS, cohesion, etc. Afterward, the given dip and dip directions of the location mentioned were added in the stereo net analysis and found that direct toppling failure is the only collapse that is happening. Then, in the second step, the provided values were entered into the rock topple software to obtain the factor of safety. Next, in the third step, Swedge analysis was conducted to find out the presence of any swedge failure and it was observed that no wedge formation was present.
- 1.3 Based on all these values, various cases like the impact of shear strength upon stability, the impact of friable zone upon stability, the impact of dewatering upon stability, the impact of ground support upon stability, impact of slope angle upon stability are analyzed and values of Factor of safety and maximum displacement were derived. In the case of support analyses, rock bolts and liners were used and it was observed that the overall stability gets increased with those additions. Overall, it provided an idea about analysis of various possibilities and provides the best solutions to meet the requirements as per the demand. Here, instead of going for a trial and error method, analysis done in software using predetermined possible values will give corresponding true output.

- 1.4 This project was intended to fulfill the following objectives:

1



1. To obtain the type of failure present, the factor of safety, and maximum displacement
2. To analyze the impact of shear strength upon stability
3. To analyze the impact of friable zone upon stability
4. To analyze the impact of dewatering on stability
5. To analyze the Impact of ground support on stability
6. To analyze the Impact of slope angle on stability

1.5

follows:

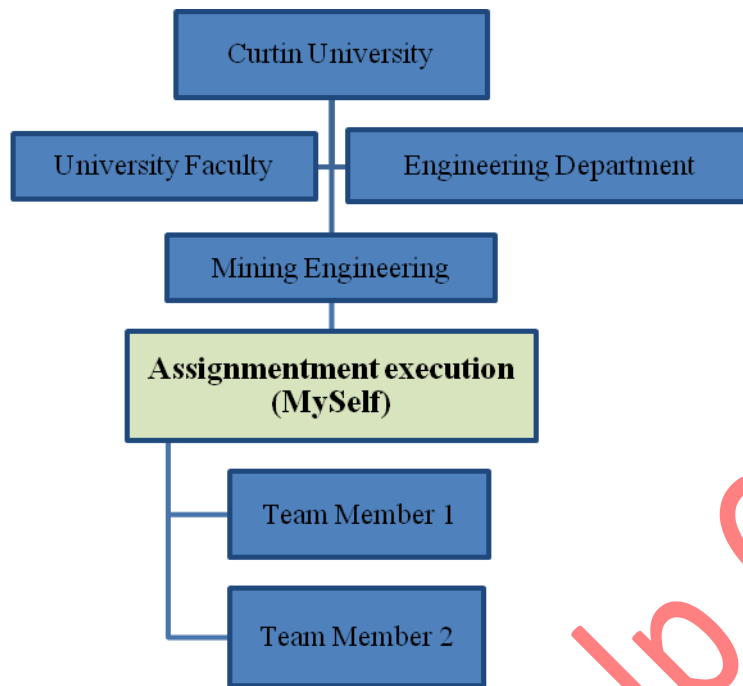
My duties as a team leader are as

- Underwent a study on soil stabilization of the open pit to enhance my understanding of the project.
- Determined stability parameters like cohesion, friction angle, and uniaxial strength to analyze and compare the stability difference seen in the case of each material.
- Performing Stereo net analysis is done to determine what type of failure is present.
- Analyzed Roc Topple failure dimensionally and determined the factor of safety.
- Performed Swedge analysis by adding the appropriate input parameters.
- Carried out design and analysis of the footwall.
- Analyzed maximum displacement and factor of safety for impact due to shear strength on slope stability, friable zone upon slope stability, dewatering upon slope stability, and ground support upon rock stability.
- Arranged team meetings to discuss project working strategies and developed a timeline to manage the project work.
- Attended technical meetings and prepared reports including all details.

1.6

figure:

My position is shown in the following



c) **Personal Engineering Activities:**

1.7 After understanding the requirement of this project, I arranged a kick-off meeting with my teammates to brainstorm over the project methodology, the latest methods to analyze the stability of the open pit, dimensions of the considered footwall, etc. I also recommended my teammates conduct comprehensive research on slope designing and stabilization so that we can perform well in our project and reduce the probability of design errors. For this purpose, I also took help from the supervisor who suggested us few international articles on stability analysis and slopes reinforcement design. Then, being an effective team leader, I equally distributed the articles among my teammates so that they can contribute equally to the project. This was a significant step to ensure working in compliance with the ethical regulations.

1.8 After this step, I arranged a meeting with the teammates to discuss our findings from the international articles showing software analysis results and future recommendations. Then, I planned all project tasks by creating a timeline including task details and their tentative deadlines. Moreover, I discussed with my team the required dimensions of the footwall so that we can analyze open stability, i.e. height of the pit to be 200m high, and the friable zone and bedding planes were considered to be parallel to the footwall. I discussed this plan with my supervisor as well and started working on the project after getting approval.

1.9 In the footwall, I considered a few major concerns, i.e. zones of extremely weak, friable, friable, thin, and tabular nature. Then, I assumed that the present footwall has components of friable, hematite

sandstone, and hematite siltstone. For analysis, I separated the two friable zones by 5m thick. At the same time, orebody-footwall contact was only separated from the first friable zone by a 4m thickness of competent material whereas both zones were continuous down dip. Next, I set three predominant discontinuities which might produce some significant impact on the footwall slope stability. After considering these parameters, I developed a scenario where the footwall slope consisted of interbedded quartzite and sandstone with varying amounts of hematite. I also assumed different thin bands of schist to separate the footwall slope from the main synclinal aquifer which was approximately 50m behind the existing footwall slope and referred to as the aquitard. Here, I knew that the schist aquitard limits water from the aquifer flowing into the footwall slope remaining to the pit. So, I built a water pressure near the aquitard which has an average water table of about 15m above the sea level. Furthermore, in this case, I considered the footwall slope as a dam with a depth of 180m of water behind. Also, I assumed that the footwall's steep slope angle to be ranging from 45 to 55 degrees so that shear stresses pit toe area increases with slope angle along with pit depth due to the gravity.

1.10 After considering these inputs, I added them to the roc data and Dips software to obtain relevant results. I assumed the E_i value for siltstone to be 49Gpa. Given that the slope angle of the footwall is based on a range from 45-55. But, for analysis, I considered it as 45 and the friction angle of the footwall as 38°C. Next, I started Roc Data analysis for sandstone to get the value of parameters like cohesion, friction angle, and uniaxial compressive strength. Then, the following figure was developed which provides a basic design of the project layout and these values can be used ahead for further analysis. These figures provided obtained values of Intact uniaxial compressive rock strength is Global strength.

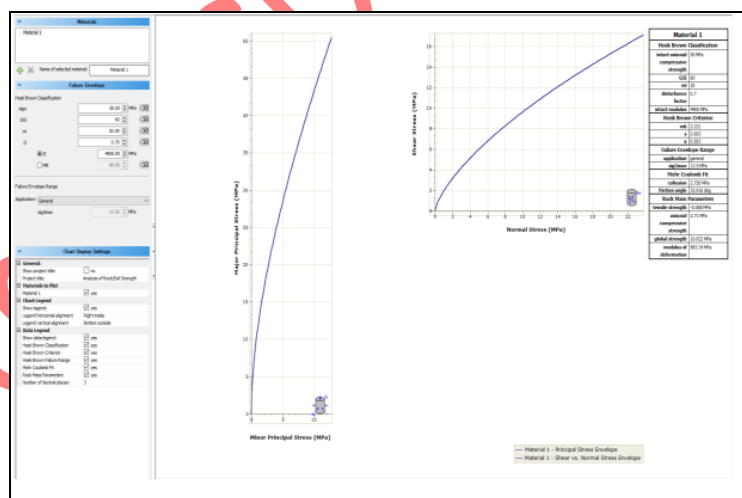


Figure 1 Sandstone Roc data

1.11 After Roc data analysis, I created Stereo nets using dips software to find out which particular one is showing a failure zone. Here, I only determined direct toppling failure. I found out that direct toppling failure occurred only when the main discontinuity set and slope surface orientations are opposite, and rock columns are overturned at the geometric center of the sliding mass. Whereas flexural toppling occurred in rock masses with continuous steep discontinuous systems, whereby individual blocks are broken off due to the rock mass bending forward in the overhanging part. The below figure shows the first analysis done. I noticed that direct toppling base plane is found critical with a percentage of 33% failure.

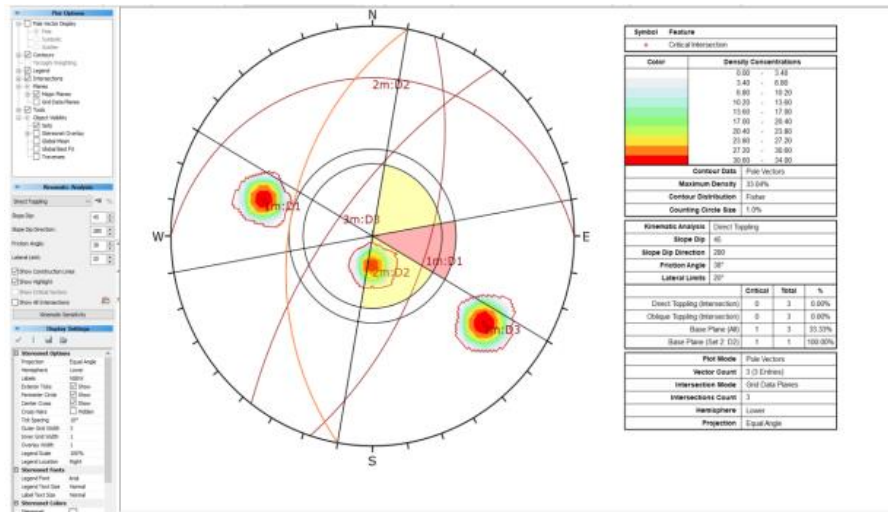
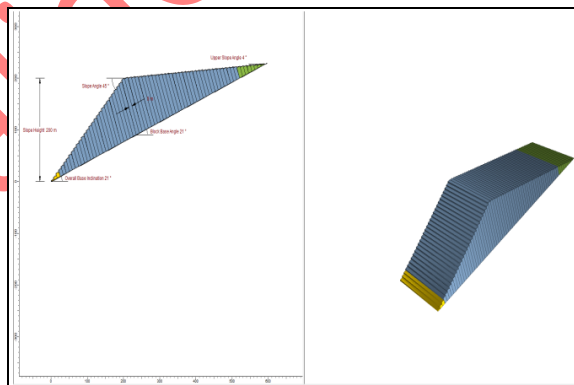


Figure 2 Direct Toppling stereo net

From the second analysis, I noticed no failure occurred for flexural toppling, whereas, in the third and fourth analyses, I again didn't notice any failure for planar stereo net and planar no limits stereo respectively. Similarly, in the fifth analysis for Wedge stereo net analysis, no failure was found. Hence, from the stereo net analysis, I found that direct toppling failure is only present in the open pit slope zone. So, to find the factor of safety of this particular situation, I used Roc topple software for this.

- 1.12 For Roc Topple analysis, I made a few assumptions like the spacing of 8m, rock unit weight of 21KN/m³, and factor of safety (FOS) as 0.921. After using these values in the system, I started analysis which provided a FOS value of less than 1 indicating direct toppling failure. Then, after finding FOS, the formation of the wedge was cross-checked.



- 1.13 For cross-checking, I performed Swedge analysis after adding the appropriate input parameters. From this analysis, I analyzed that no wedge formation was present on this slope. So, I checked the impact of shear strength of sandstone and schist upon slope stability which is the main factor in designing and analysis of footwall. In this case, I carried out maximum displacement and Factor of safety analysis for impact due to shear strength on slope stability, friable zone upon slope stability, dewatering upon slope stability, and ground support upon rock stability. For this, I developed the following four cases for displacement analysis:
- Case 1:** Here, I analyzed pore pressure and displacement values, and obtained⁵

result was used to improve the stability of the footwall. I obtained maximum displacement of 0.032m with $S_3 = 6.87\text{Kpa}$ and $S_1 = 7.14\text{Kpa}$. So, by dividing both values (S_3/S_1), I got 1.039 displacement

2. **Case 2:** I again performed analysis for pore pressure and displacement values with a maximum displacement of 0.024m, $S_3 = 6.87\text{Kpa}$, and $S_1 = 27.01\text{Kpa}$. So, I got the value of 3.93.
3. **Case 3:** I used the values of maximum displacement = 0.00117m, $S_3 = 6.86\text{Kpa}$, and $S_1 = 12.63\text{Kpa}$, so the total value was 1.84.
4. **Case 4:** I carried out an analysis for pore pressure and displacement values with $S_3 = 6.79\text{Kpa}$ and $S_1 = 7.51\text{Kpa}$.

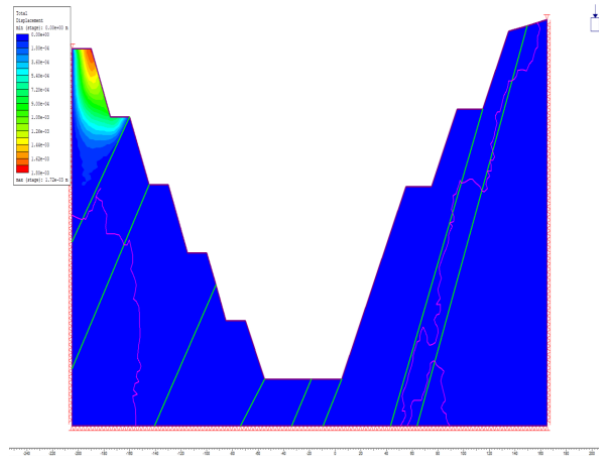


Figure 3: Displacement Analysis for Case 4

1.14 From the analysis, I made the following conclusions:

- From the stereo net analysis, direct toppling was only found as a failure.
- After that, using Roc topple software the FOS value indicating failure was found and no wedge formation was found in Swedge software.
- Moving to the analysis part, after observing the parameters of all the 4 mentioned cases, it was found that the FOS value was negligible in case 2 and for displacement value, the least value was found for case 4.
- For the Impact of friability of friable zone upon slope stability, I found that as the value of friction angle increases, the FOS value was decreasing.
- In the case of the impact of ground support upon slope stability, I observed that as the type of support system was changed from rock bolt to liners, the displacement value reduced very much from 0.0216 to 0.00000890m.

1.15 After obtaining all results, I organized a meeting with the supervisor to show analysis steps, graphs, and values obtained for displacement analysis. I also showed a table showing modeling results for the proposed deep pit and discussed the results of the impact of friability of friable zone upon slope stability. I explained that for the initial analysis of the footwall based upon the shear strength, I considered the whole wall to analyze the entire area to get an understanding of stress distribution throughout all areas receiving higher

stress. It gave me an insight that more stress concentration was found only on the footwall side. This helped to remove the other side and focus only on the footwall side for further analysis.

- 1.16 During the problem, I encountered a technical issue while figuring out the failure. Out of many software, dips did give an output, but I was not satisfied with the result because of its accuracy. So, to overcome this issue, I decided to use a FOS value of less than 1 in Roc Topple analysis, and fortunately, it provided more accuracy on the failure present. In the case of friability (considering all 3 cases, even though it's always safe to give a small friction angle for the footwall to maintain stability, in this case, the first one with a friction angle of 37 has FOS near 1 indicating fewer chances of failure and thus, I considered this friction angle value.
- 1.17 I followed ISO standards while determining the safety of processes, order of extraction, and safety of mine walls, evaluating the risk of slippage, and advising on the prevention of slippage and rockfalls. Moreover, I obeyed university rules and regulations so that I didn't violate any rules defined by the engineering department. I ethically performed all my project tasks and didn't take any data or detail from the internet. Also, I deal ethically with my teammates and provided them equal space or opportunity to put forward their valuable suggestions or opinions. This showed my understanding of the ethical code of conduct.
- 1.18 In the project, I used my engineering skills to provide better recommendations, i.e. in the rock stability analysis using rock bolts or liners and comparing it to rock bolts, I noticed that liners provided a negligible displacement and has more factors of safety than rock bolt. Thus, liners, which have more rate of return and are less economical than rock bolts must be used for the purpose because it would give more safety to the slope. The supervisor always appreciated my contribution to the project.
- 1.19 I created progress reports weekly so that I can explain each task in a better way and give the status of ongoing progress. These reports also showed upcoming weekly task details and predicted results so that the supervisor can guide us. Moreover, these reports helped me in preparing the final document using university rules and regulations.

d) Summary:

- 1.20 In this slope stability project, I gained technical skills relating to working on different analysis software, i.e. Rock data to determine Uniaxial compressive strength and Young's modulus, Dips to determine the type of failure present, RocTopple to determine the factor of safety for the failure present, and Swedge to determine the presence of any wedge. It developed my understanding of the slope structures and how their stabilities can be achieved. Also, I learned how to work in a team efficiently by giving importance to opinions given by my teammates.

CAREER EPISODE 2

a) Introduction:

2.1 The project presented in this episode was performed to fulfill the requirements for the award of the degree of Master of Engineering Science (Mining Engineering) from Curtin University. It was termed “Real-Time Rock Strength Monitoring Through Internet of Things (IoT)”. The project was started in March 2020 and completed in November 2020 and all activities were carried out in the Department of Mining Engineering & Metallurgical Engineering under the supervision of the supervisor (Dr. Mostafa Sharifzadeh)

b) Background:

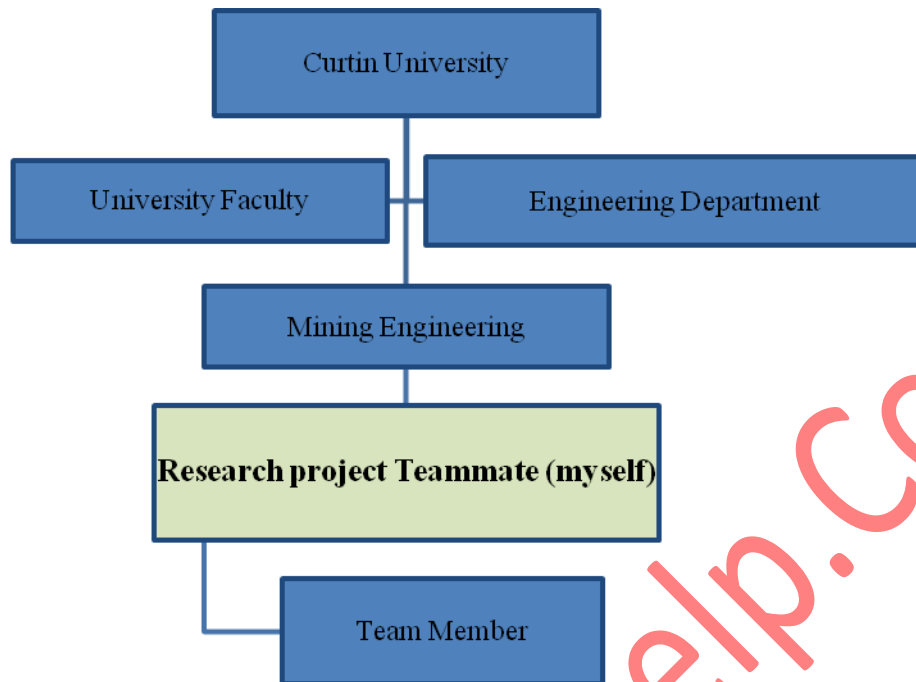
2.2 No doubt, sudden roof failures keep the life of workers underground and the whole mining crew at risk. Also, certain seismic events will influence the rock bolts installed and they can unpredictably have failures. To eliminate this a spontaneous action or a predicting working environment is a lifesaver, especially in underground mines. In this project, the Rock bolt and its arrangement present in a Mine in Goldfields was analyzed. Initially, the required rock bolt was analyzed and the sensor layout was determined which covers all the required areas of the rock bolt. This indicated an accurate result of a force acting. Since it is not economical and feasible to add a sensor to every rock bolt, therefore, a detailed analysis of the given area of excavation was performed with locations of high stress and low stress was determined. Then, based on this analysis, the layout of the bolt was determined. After adding the sensor, the data obtained through the sensor was connected further to an Arduino Nanochip. Furthermore, an online coding required was added to the chip. This provided a warning by an outbreak of sound from the adjacent connected alarm when the force acting on exceeds the threshold limit acting upon. This data was then sent by Bluetooth to the developed android application and triggered a warning.

2.3 In this project, I was accountable to work on the following tasks:

- Conducted background research on rock bolting which is used as a support for rock from rock failures.
- Understood the project's problem statement and then brainstormed to find out a feasible solution to overcome the current problem.
- Proposed research methodology and experimental/analytical design.
- Collected components required to develop a system as per technical specifications.
- Desi Rockbolt and connection and prepared experimental setup.
- Observed working of the sensor in the system.
- Analyzed types of failures that can affect the strength of the rock bolt.
- Performed stress calculations and software coding (JAVA) & execution.

2.4 The below hierarchy is used to show my position in this core project:

8



c) Personal Engineering Activities:

- 2.5 The first phase involved extensive research on rock bolts to understand how it would be useful in resolving the concerned issues, like sudden ground collapse which might cause catastrophic disaster, and default in sensors of a rock bolt due to dust, corrosion due to water presence, manual data observation errors, etc. This project intended to eradicate the problem of any disasters, such as rock bolts are basically fit to prevent the rock from sudden collapse, but when there is any kind of seismic events present, this will destroy the capacity of the bolt and thus leading to catastrophic failures killing all people under it. Hence, I conducted comprehensive literature to understand the types of rock bolts, contact stress, a hierarchy of sensors, location of rock mass, testing efficiency of rock bolts, latest current sensors, fiber optics, etc. to find out the best solution for this problem.
- 2.6 From the literature review, I came across that the sensor technology present in the rock bolts was far better compared to the traditional approaches in providing accurate results about the real-time data. Also, from the history of sensors, I found out that fiber optics have proved to overcome many obstacles seen in this way and come up with the precise output. I noticed that the fiber optic sensors with 2 slots in rock bolts were not efficient to give the shear stress load analysis also sensing points were less. But, later research on optical sensors present in 3 slots was found to produce results in all the surrounding directions and also for the shear stress. Modern instrumented rock bolts come up with a high cost.
- 2.7 Hence, based on these observations and data collection, I concluded that breakage of optical flow by the presence of any obstacle stated it as inefficient and

emerged with the concept of vibrating electrical strain gauges. Also, I concluded that efficient vibrating electrical strain gauges can suit this modern era by adding the Internet of things concept into this. That's why, in this project, I decided to use a wireless technology embedded into such an instrumented rock bolt because it is the best solution in finding out the stress acting upon the rock bolt and also the stresses surrounding the rock mass. In addition, I ensured that it can be economical and prevent any sudden catastrophic problems.

- 2.8 During this research tenure, I arranged multiple meetings with the supervisor to explain the outcome of each article or journal and took their precious opinions of him. Moreover, I also coordinated with my teammate so that we can collect maximum details as possible. Then, I presented my idea to the supervisor with facts and figures. The supervisor approved the idea and also, and I discussed the project research methodology and experimental work to develop a wireless instrumented rock block.
- 2.9 My first step involved collecting all required components which are necessary to design an instrumented rock bolt. I selected an optical sensing system because it is the best way for calculating strain along the length of a rock bolt using an optical fiber, however at the final stage, I didn't use the optical fiber concept in Instrumented Rock Bolt. The main reason for this was that, when there is any obstacle at any point of transfer through optics, the flow of data through light can get eliminated. Because of this sole reason, in this present scenario, I eliminated Fiber optical cables in the initial stage. So, in replacement, I decided to use IoT based Posimix rock bolt because it can provide flexibility in getting installed with jumbo and hand-held machines and protection from corrosion. Thus, for analysis, I used Posimix which was used in the Underground mine. So, I contacted one of the Australian manufacturing companies to manufacture instrumented rock bolts and the one used by them is Posimix Rockbolt.
- 2.10 Then, I opted for sensors, i.e. displacement sensor is more which is more reliable than the load sensor. The reason for its selection was that if there is any sudden displacement, it can be easily visualized by observing the roof wall as any outward projections can be easily seen and analyzed. Afterward, I opted for Arduino because it doesn't need an additional piece of hardware to upload any new code to the board. Now for interfacing the Arduino Nanochip with the load cell, I used an HX711 amplifier because it will amplify the output representing low voltage of the load cell and further sends it to Arduino such that the Arduino slowly calculate the required output from this data. Next, an online coding required was added to the chip to indicate a warning by an outbreak of sound from the adjacent connected alarm when the force acting on exceeds the threshold limit acting upon. This data can also send by Bluetooth to the developed android application and trigger a warning.
- 2.11 Afterward, I decided to add a buzzer in the system to alert underground mining workers, but in real life, this particular piezo buzzer wouldn't cause sufficient sound. To overcome such a problem, I replaced the buzzer with a solid relay and connected it to a loud siren. Then, after collecting all components, I developed a setup layout, i.e. the connection from the bolt was initially connected to the Arduino board so that data can be so received by the board. Then the data was transferred from the board to the android application through the so connected Bluetooth module. Here, based on the assigned threshold limits, the software gave give alarm or warning as the load limit on the rock support exceeds the capable capacity. 10



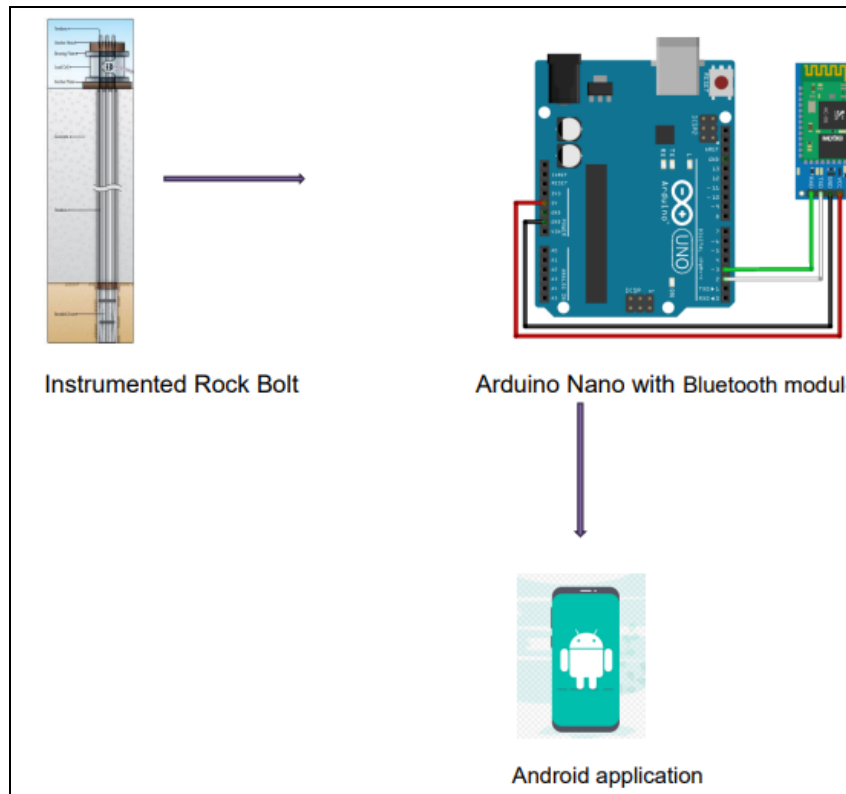


Figure 4 Setup Layout

2.12 Then, based on XYZ mine site data, I identified the below zone as the seismically active one. A relevant study on the roof support system and Rock bolt design was done after analyzing all given parameters and structure design.

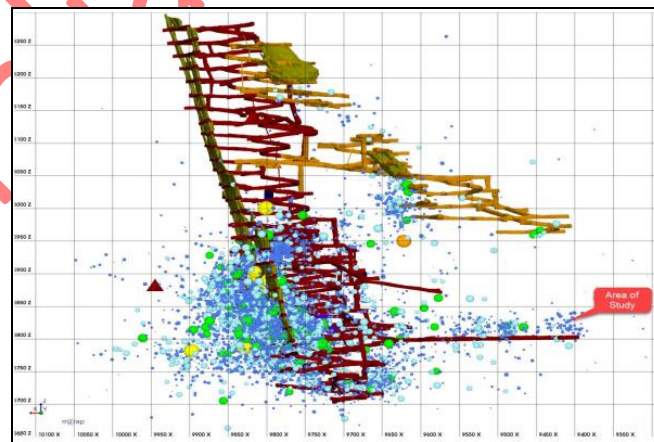


Figure 5 Seismic Zone

Next, I used sensors because the concept of an array of sensors would provide a less expensive way to continuously monitor the load present on rock strata. However, as Instrumented rock bolts are expensive, it was not possible to make every rock bolt an instrumented one. For this, I performed a careful analysis of the tunnel layout, several bolts, and the spacing between each of them.

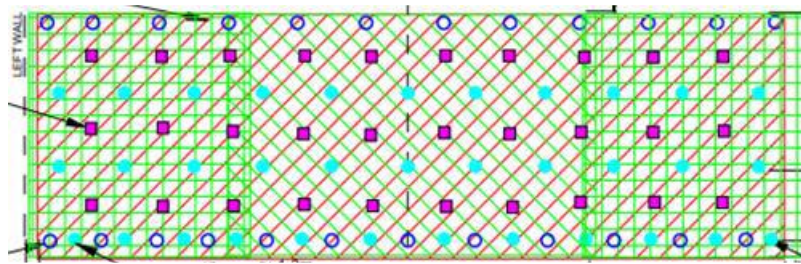


Figure 6 Tunnel layout

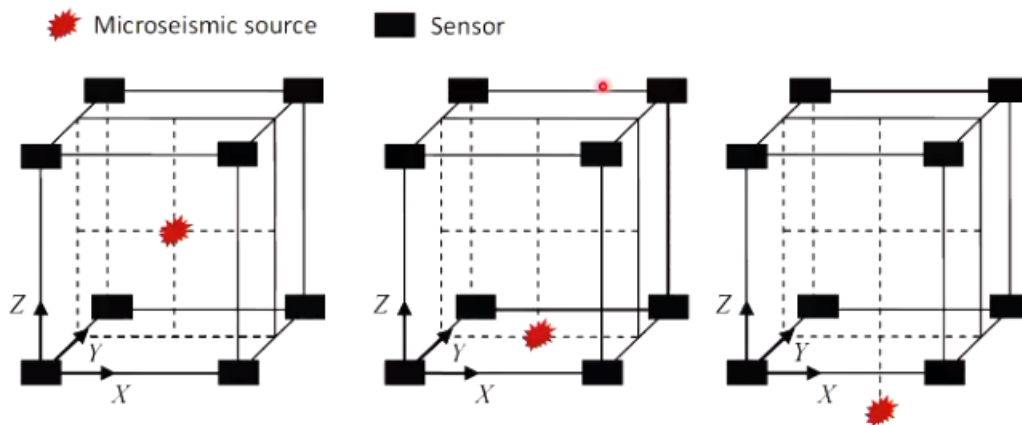


Figure 7 Sensor pattern

From the unfolded view, I noticed that a box pattern of sensors can provide a set of 4 sensors for 9 bolts, i.e.

- For 1st and last row, sensors have to be placed on alternate bolts
- For the middle row, each sensor can be placed in the footwall, hanging wall and the middle surface to obtain maximum accuracy in reading.

This provided a wide range to analyze the relevant stress acting along with a smaller number of instrumented bolts thus saving costs incurred.

2.13 I performed analysis and value finalization. For this purpose, I analyzed the type of failures that can affect the strength of the rock bolt which are as follows:

1. Stress controlled failures
2. Structural controlled failures
3. Water controlled failures

For this particular mine site, I found the following main affecting factors:

- a) Under structures - The majority are joints and a few are veins
- b) Under roughness - The majority are slightly rough, and a few are smooth & rough
- c) Under planarity - The majority are planar, and few are wavy
- d) Under weathering - All are unweathered

2.14 From the standard pre-analysis, it was derived that, to be operated on the safe side, the maximum value of load acting on the Rock bolt should not exceed, 20tonne/m, and the maximum allowable displacement is 150mm. So, I performed the following stress calculations, i.e.

Depth of area of study is $6280 - 5800 = 480\text{m}$

$\text{Sigma } 3 = 0.0278 * \text{depth} = 13.34$

$\text{Sigma } 2 = 0.0334 * \text{depth} + 1.7 = 17.732$

$\text{Sigma } 1 = 0.0406 * \text{depth} + 6.1 = 25.588$

2.15 After this step, I developed software coding and cases. Initially, all the required packets like Bluetooth, tone manager, etc. were imported. Secondly, a declaration of all required variables for the software was done. Thirdly, I did the initialization of the abovementioned declared variables. Fourthly, I added optional methods including both manual and random value generation. Then, text to speech addition and conversion of the input value to integers were done. Finally, based on the input data of both displacement and acted load, I added six conditions to the coding so that any input combination appearing will match with anyone condition mentioned and a corresponding warning was generated. Out of all the possible combinations analyzed, six conditions that can be added to secure true results are:

- If both are in the danger zone i.e. displacement above 150mm and load acting above 20tonne/m then the colour shown will be red.
- If both are in the transition zone i.e. displacement above 100 and <150mm and load acting above 10 and < 20tonne/m then the colour shown will be yellow.
- If both are in the safe zone i.e. displacement below 100mm and load acting is below 10 tonne/m then colour shown will be green
- If the combination has green and yellow, yellow will be shown
- If the combination has yellow and red, red will be shown
- If the combination has green and red, red will be shown

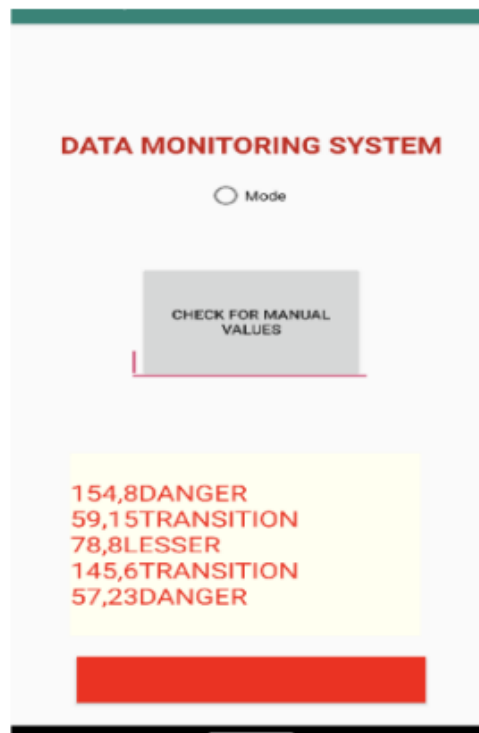


Figure 8 Program Execution

Based on the input values the software analyzed the input values. If any input value is sensed, it will be matched with the corresponding combination and suitable light and sound will be generated. Here, Danger is shown in red color Yellow is shown for transition Greenlight¹³



will appear for the safe zone.

- 2.16 During this project, I carried out a risk assessment before setting up the layout concept so that all problems can be mitigated in the initial phase. So, one of the major risks identified was relating to the installation of the rock bolt which can cause harm if not done properly, i.e. I noticed that if the sensor is not mounted properly or if the circuit connections are loose or wrong, it can cause inaccurate output at the display stage. Also, improper mounting can either damage the sensor during mounting or can fall and cause hurt to people working there. -Improper coding will give an alarm beep at the wrong threshold limit. I found that it can eliminate a lot of useful time and can create disturbance to other people who are working. Also, if the analysis made has identified the wrong section as a high-stress one, it will not be beneficial for the purpose. In addition, true high-stress regions will not be provided with any type of warning leading to catastrophic failures.
- 2.17 To control the identified risk, I provided the following mitigation measures.
1. Properly skilled personnel performing the installation.
 2. Correct installation of the sensors - Standard mounting of the sensors and the circuit boards.
 3. Coding is done by designated personnel and verified to prevent any type of future problems.
- Therefore, I did a stress-strain analysis with perfection making sure that the input is chosen, and all control parameters and material properties are added without making any errors.
- 2.18 In this project, I used my mining engineering advanced knowledge and competencies by connecting a lot of small things efficiently, a suitable IoT-based layout was created which acted as an early warning system using the android application that generated signal warning accordingly.
- 2.19 Throughout the project, I continued my research on Australian mining sites to check how my idea would help mitigate issues so that people can escape the area very easily. I coordinated with my teammate regularly and we planned the next step before proceeding to avoid errors. For project management, I developed a detailed timeline using MS Project Management software including all project tasks, available resources, milestones, deadlines, etc. This helped me to complete my assigned tasks on time.
- 2.20 I developed a thesis covering all details as per the university's standards and ethical regulations. I didn't take any data from the internet and conducted complete research to provide a unique cost reduction method. Lastly, I developed presentation slides in MS PowerPoint to represent my work by following Australian Mining standards and regulations.

d) Summary:

- 2.21 This project provided an extraordinary solution for Australian mine sites to reduce catastrophic failures. I focused on using the latest engineering components based on their technical specifications and cost. So, this project proved beneficial for me in terms of learning rock bolt working mechanisms, software coding, development of an application, etc.

14

CAREER EPISODE 3

a) Introduction:

3.1 The aforesaid episode is the description of a group project called “Advanced Resource Modelling and Estimation” where I performed my engineering duties and demonstrate project management skills as a group leader. In this project, a real case study was proposed to carry out orebody resource estimation using a software tool. The supervisor was instructed to complete the research work within a Month/Year. So, based on this timeline, I commenced project work on Month/Year and completed them in June 2020. This core project was conducted in the Mining Engineering Department of Curtin University to fulfill the course/subject requirement.

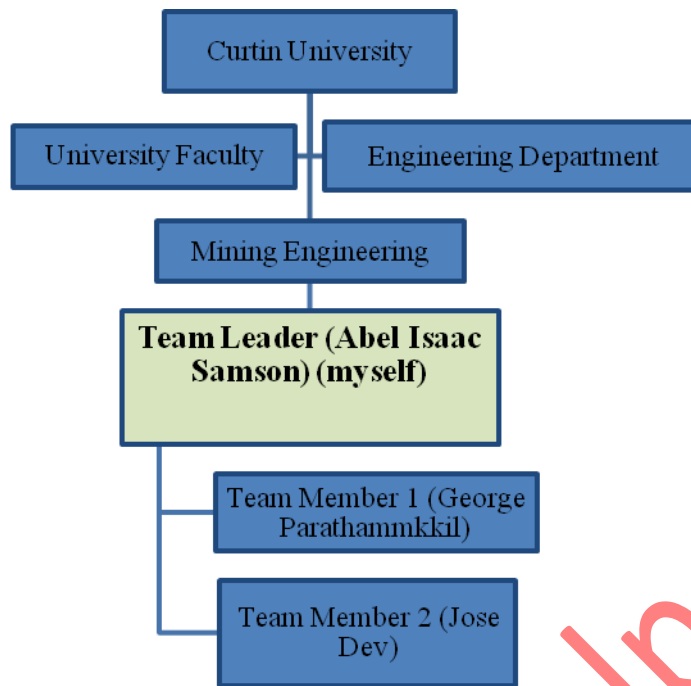
b) Background:

3.2 A real deposit was considered located on the eastern margin of the Laverton Tectonic Belt in the North Eastern Goldfields of Western Australia. It is hosted by a north-south striking granodiorite/syenite intrusion through the andesite host rock. Gold mineralization is majority hosted in a granodiorite/syenite intrusion with lower grade mineralization being present in the andesite country rock. Mineralization strikes north-north-west with a -40-degree dip to the west. Mineralization represents as strong hematite alteration through the intrusions with coarse pyrite. The mineralized zone consists of multiple mineralized zones over ~100m of thickness, 250m of north-south strike length, and 250m of dip length. Most zones display moderate continuity with individual zones being up to 40m thick and 100m of dip length. Mineralization is dominantly hosted within a granodiorite zone with a syenite intrusive on the western margin but also extends into the andesite country rock but is generally of lower grade and continuity.

3.3 Being a team leader, I was involved in the following major tasks:

- Studied required tasks provided by the supervisor and reviewed data files compiled from the exploration process by a geologist.
- Carried out estimation of ore body using Vulcan software by determining drill hole database.
- Viewed load and drillhole database both graphically and in database format
- Developed 10 horizontal sections and created a polygon modal for each section.
- Performed orebody modeling by designing a block model and assigned grades using the inverse distance grade estimation method.
- Calculated the reserve for the interpolation method.
- Developed a Grade-Tonnage Curve.
- Prepared a report and submitted it to the supervisor.
- Arranged meetings to discuss work strategies.

3.4 The following hierarchy is the description of my position in this project:



c) Personal Engineering Activities:

3.5 I attended a team meeting to discuss the project requirements and required tasks mentioned in the report provided by the supervisor. I thoroughly examined each task i.e. use of software packages to import data files into it, loading and viewing of drillhole database, composite the drillhole database, etc. I also discussed these tasks with my supervisor to fulfill the project criteria. The supervisor also provided project files compiled from the exploration process by a geologist. These files contained the necessary data for creating a drillhole database and block model to be used for resource estimation. I studied these files along with my teammates and descriptions of these files are given below:

File Name	Description
Collar.csv	Collar file containing the hole collar pickup information.
Survey.csv	Survey file containing the downhole survey information.
Assay.csv	Assay file containing the grade information
wasm.dsf	Database structure file
wasm_2020.all.isis	Drillhole database files
wasm_2020.all.isix	
topo_surface.00t	Topography triangulation
WASM.dg1	Project specification file

3.6 Then after studying these files, I decided to perform an estimation of the ore body using Vulcan. For this purpose, I developed a case study where there is a total of 72 drill holes. The Assay gives information about the gold content in each drill hole. I neglected arsenic values since they showed values of -999 which are treated as 0. From the survey files, I obtained information about the inclination of holes and the collar gives an idea about the location of each borehole.

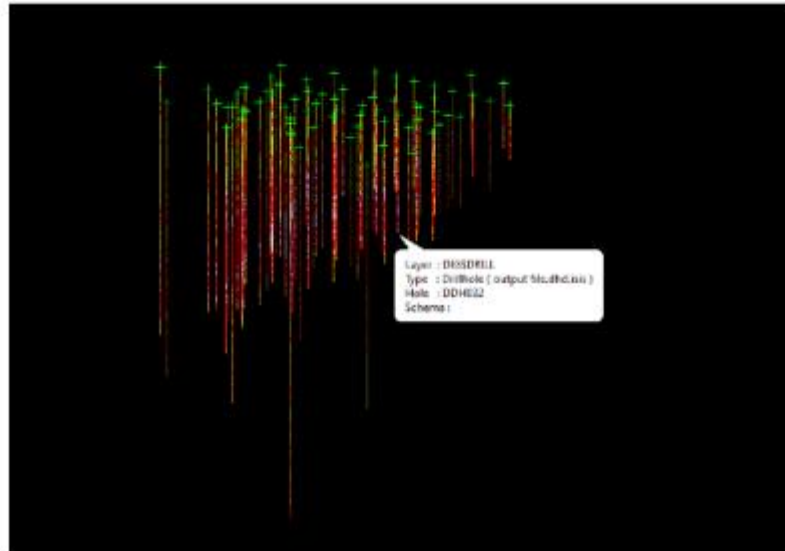


Figure 9 Drill hole database

Based on certain selected points of each drill hole representing specific grade zones, I created the polygon modal and hence through that the ore body model. Through this, I estimated the grade of the ore body.

- 3.7 Now to estimate a grade, I used a histogram of the Orebody deposit. Based on it, I developed 10 horizontal sections and created a polygon modal for each section. Finally, all these 10 polygons were joined together to form the ore body modal.

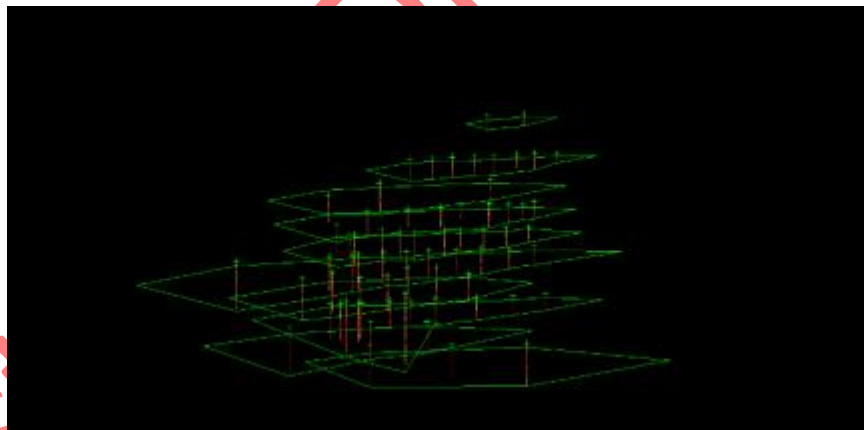


Figure 10 Sectional layers giving the shape of ore body model

- 3.8 Next, I designed the following orebody structure. After ore body formation, I created a composite with the help of my teammates. The composite provided an idea about the grade at every length of 1m. Here, since most of the values were coming to less than 0.05, In real life these many cannot be considered. But in this project, since all these grade values were considered, So I assumed the overall grade to be less.

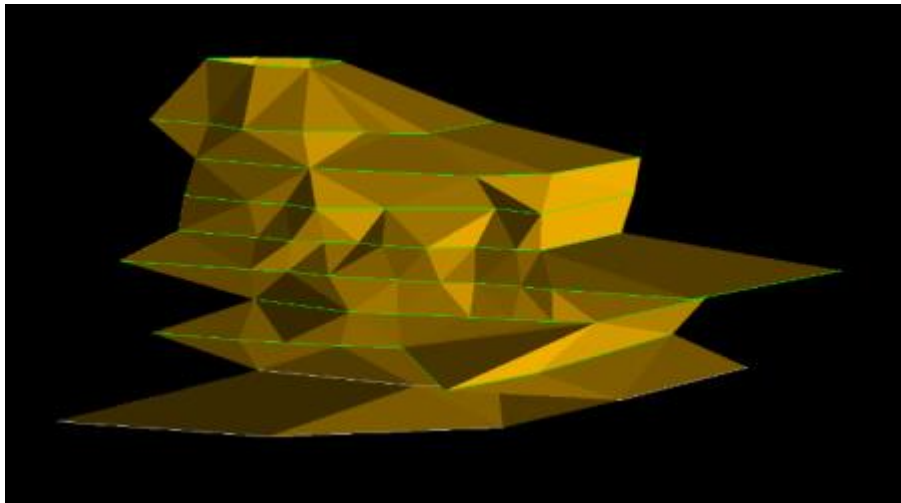


Figure 11 Orebody model

3.9 Then, I developed a composite data model and inclined composite body model. Now to create the blocking modal, I required both compositing and semivariogram data. So, I used the below figure which shows the Semivariogram obtained from the given deposit. Since I didn't standardize the sill, so obtained sill value was considered as 1.368.

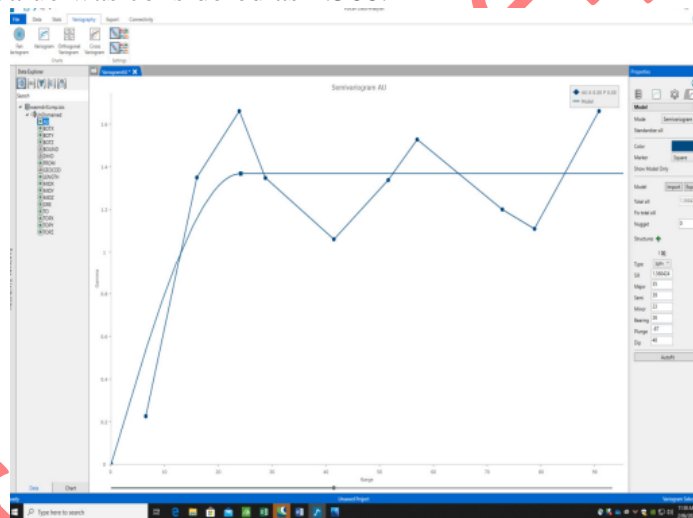


Figure 12 Generated Semi Variogram

From the above obtained major, minor, semi and sill values, I performed grade estimation using the Krigging technique, which is shown below. Then, from the analysis, I observed that out of 22500 blocks, only 1744 the grade was estimated i.e. blocks where the drill holes are placed. Hence, this accounted for about 7.8% and the remaining values were neglected.

```

Estimation Editor
Rotation about the Z axis: 90.0
Rotation about the Y axis: -87.0
Rotation about the X axis: 48.0

** Note: nugget is 0.000000

Report file written to 'wasme estimation_bef_id_report'.
Sample database: WASSPORILL_CMP_I515
Block model:      Block #rig.bef
Estimate file:   wasme estimation_bef
Estimate ID:     id

Beginning estimation ...
Starting 12 threads.
1744 estimated, 20756 not estimated, 100.0% out of 22500 total blocks

22500 Total blocks.
1744 ( 7.8%) estimated.
Estimation completed.

Press any key to continue ...

```

Figure 13 Generated Grade estimation

3.10 Afterward, I performed orebody modeling in the software and also developed a figure showing a sectional view of the block model to obtain ore grades which were 22,15,1. Using these values, I finally got the grade tonnage curve which was used to determine the total reserve and quantity in a particular cutoff grade. Then, from the grade tonnage graph, I understood that as the cutoff grade increased, the average grade also increased but the deposit decreased i.e. higher the cutoff grade less will be the tonnage.

Table 1 Generated grade tonnage file.

Cutoff	au_krig	Tonnes	Increment	Inc. au_krig	Inc. Tonnes
0.01	5.06	2000000.00	0.01 -	0.02	0.00
0.02	5.06	2000000.00	0.02 -	0.03	0.00
0.03	5.06	2000000.00	0.03 -	0.05	0.00
0.05	5.06	2000000.00	0.05 -	0.10	0.00
0.10	5.06	2000000.00	0.10 -	0.50	0.00
0.50	5.06	2000000.00	0.50 -	1.00	0.00
1.00	5.06	2000000.00	1.00 -	2.00	1.00
2.00	8.24	1120000.00	2.00 -	3.00	2.00
3.00	10.40	832000.00	3.00 -	5.00	3.57
5.00	12.92	608000.00	5.00 -	12.92	608000.00

3.11 I was also involved in project management because it was a team project. I showed professionalism by giving mutual respect to each member and it was a key aspect to avoid conflicts and resolving opinion differences by focusing on the best outcome. It helped me to create healthy relationships with my teammates. I also focused on efficiently transferring information between teams to avoid the delays associated with misinformation. I followed ethical work standards while distributing tasks among teammates and also reported to the supervisor about my team performance honestly.

3.12 I communicated with my teammates by arranging daily meetings with them and¹⁹

listening to their suggestions. Also, I prepared a timeline by considering the deadline and made it approved by the supervisor so that he knows the duties of all teammates. Also, I read out all report writing instructions mentioned in the report to prepare a good report. Before preparing a final report, I kept a record of all accomplished tasks in an MSWord file so that I can cover all important details in my final document.

3.13 I applied my engineering knowledge to estimate the grades of blocks using the Kriging Technique and built a block model. Furthermore, I also took help from my supervisor in developing the Grade-Tonnage Curve. I performed all my tasks by following Australian Mining standards to highlight my understanding of the standards and code.

d) Summary:

3.14 From the project, I conclude that the located deposit, which is intruded by a granodiorite/syenite is estimated through Vulcan analysis. The created ore body model then undertakes analysis through kriging and thus estimates the total number and tonnage of required grade blocks. The neglected ones were the unwanted and waste quantities present. The lower grade mineralization was analyzed to get an overall idea about the deposit and the grade present. Hence, I ensured that the type of study can be conducted in similar or complex ore bodies for quality results.

3.15 By working on this project, I familiarized myself with an orebody modeling and resource estimation software package. In addition, I understood the structure of exploration data files and learned how to create, validate and composite a drillhole database. I completed for my work in the provided time and the supervisor appreciated my efforts.

PROFESSIONAL ENGINEER

Summary Statement

Competency Element	A brief summary of how you have applied the element	Paragraph in the career episode(s) where the element is addressed
PE1 KNOWLEDGE AND SKILL BASE		

<p>PE1.1 Comprehensive, theory-based understanding of the underpinning natural and physical sciences and the engineering fundamentals applicable to the engineering discipline</p>	<p>My project involved understanding mining engineering to study slop stabilization by carrying out Swedge analysis, real-time strength monitoring to avoid sudden roof failures keeping the life of workers underground and the whole mining crew at risk, and estimation of ore body using Vulcan software by determining drill hole database.</p> <p>I used engineering theoretical knowledge to perform Roc data analysis and develop orebody modeling by designing a block model and assigned grades</p>	<p>1.9, 1.10, 2.9, 2.10, 2.11, 3.6, 3.7, 3.8</p>
<p>PE1.2 Conceptual understanding of the mathematics, numerical analysis, statistics, and computer and information sciences which underpin the engineering discipline</p>	<p>I collected data on the footwall slope as a dam with a depth of 180m of water behind and entered it into the software to perform Roc data analysis.</p> <p>I performed stress calculations and software coding (JAVA) & execution.</p> <p>I used the interpolation method to perform reserve calculations</p>	<p>1.9, 1.10</p> <p>2.14</p> <p>3.9, 3.10</p>

<p>PE1.3 In-depth understanding of specialist bodies of knowledge within the engineering discipline</p>	<p>I demonstrated a comprehensive understanding of mining engineering by analyzing the impact of shear strength, friable zone, dewatering, etc. upon stability.</p> <p>I used my engineering knowledge by providing a solution of using sensor in the rock bolt which will send an alert message to avoid hazards.</p> <p>I performed an estimation of the ore body using Vulcan software by determining the drill hole database.</p>	<p>1.10, 1.11, 1.12, 1.13</p> <p>2.6, 2.7</p> <p>3.6, 3.7, 3.8, 3.9</p>
<p>PE1.4 Discernment of knowledge development and research directions within the engineering discipline</p>	<p>I conducted comprehensive research on slope designing and stabilization to perform well in our project and reduce the probability of design errors.</p> <p>I did extensive research on rock bolts to understand how they would be useful in resolving the concerned issues, like sudden ground collapse which might cause catastrophic disaster, etc.</p> <p>I thoroughly examined each task i.e. use of software packages to import data files into it, loading and viewing of drill hole database, composite the drill hole database, etc.</p>	<p>1.7</p> <p>2.5</p> <p>3.5</p>

<p>PE1.5 Knowledge of contextual factors impacting the engineering discipline</p>	<p>In the slop of the footwall, I considered a few factors/parameters which helped me to develop a scenario where the footwall slope consisted of interbedded quartzite and sandstone with varying amounts of hematite.</p> <p>I collected all required components which are necessary to design an instrumented rock bolt.</p> <p>I used a histogram of the Orebody deposit. Based on it, I developed 10 horizontal sections and created a polygon modal for each section</p>	<p>1.9</p> <p>2.9, 2.10</p> <p>3.7, 3.8</p>
---	--	---

Australia

<p>PE1.6 Understanding of the scope, principles, norms, accountabilities, and bounds of contemporary engineering practice in the specific discipline</p>	<p>I focused on ISO standards while determining the safety of processes, order of extraction, and safety of mine walls, evaluating the risk of slippage, etc.</p> <p>I obeyed Australian Mining standards and regulations while designing instrumented rock bolt and orebody modelling & estimation.</p>	<p>1.17</p> <p>2.20, 3.13</p>
<p>PE2 ENGINEERING APPLICATION ABILITY</p>		

AustraliaCDR



<p>PE2.1 Application of established engineering methods to complex engineering problem solving</p>	<p>Out of many software, dips did give an output, but I was not satisfied with the result because of its accuracy, I reduced this error by changing a friction angle.</p>	<p>1.16</p>
	<p>I noticed that breakage of optical flow by the presence of any obstacle stated it as inefficient and emerged with the concept of vibrating electrical strain gauges. So, I used a wireless technology embedded into such an instrumented rock bolt because it is the best solution to overcome sudden roof failures and keep the life of workers underground</p>	<p>2.6, 2.7, 2.9, 2.10</p>
	<p>I carried out a risk assessment before setting up the layout concept so that all problems can be mitigated in the initial phase</p>	<p>2.16, 2.17</p>

Australia

<p>PE2.2 Fluent application of engineering techniques, tools, and resources</p>	<p>I performed Roc Topple analysis by making a few assumptions like the spacing of 8m, rock unit weight of 21KN/m3, and factor of safety (FOS) as 0.921.</p>	<p>1.12</p>
		<p>1.13</p>
	<p>I performed Swedge analysis after adding the appropriate input parameters.</p>	<p>2.15</p>
		<p>3.8, 3.9, 3.10</p>
	<p>I developed software coding and cases, i.e. software coding (JAVA) & execution.</p>	
	<p>I designed the orebody structure, composite data model, and inclined composite body model, and did orebody estimation in the software.</p>	

Australia

<p>PE2.3 Application of systematic engineering synthesis and design processes</p>	<p>I studied and designed slop stabilization by performing Swedge analysis by adding the appropriate input parameters.</p> <p>I collected the required components and assembled them to design instrumented rock bolts.</p> <p>I carried out orebody resource estimation using a software tool</p>	<p>1.9, 1.10, 1.11, 1.12, 1.13, 1.14</p> <p>2.9, 2.10, 2.11, 2.12, 2.13, 2.14</p> <p>3.6, 3.7, 3.8, 3.9, 3.10</p>
---	--	---

Australia

<p>PE2.4 Application of systematic approaches to the conduct and management of engineering projects</p>	<p>In the initial phase, I arranged meetings to understand project requirements and communicate with each member to plan each task.</p> <p>I described each selected material and then I contacted one of the Australian manufacturing companies to manufacture instrumented rock bolts and the one used by them is the Posimix Rock bolt.</p> <p>I did project management by timely communicating with the teammates</p>	<p>1.7, 2.8, 3.5</p> <p>2.9</p> <p>3.11</p>
---	---	---

PE3 PROFESSIONAL AND PERSONAL ATTRIBUTES

Australia

<p>PE3.1 Ethical conduct and professional accountability</p>	<p>I implemented all significant steps to ensure working in compliance with the ethical regulations.</p> <p>I ethically performed all my project tasks and didn't take any data or detail from the internet.</p> <p>I worked by following the university's standards and ethical regulations</p>	<p>1.7</p> <p>1.17</p> <p>2.20</p>
<p>PE3.2 Effective oral and written communication in professional and lay domains</p>	<p>I arranged team and technical meetings to discuss project working strategies and developed a timeline to manage the project work.</p> <p>I prepared progress reports to give an update in written form.</p>	<p>1.7, 1.8, 1.15, 2.8, 3.5, 3.12</p> <p>1.19, 3.12</p>

PE3.3 Creative innovative and proactive demeanor	I used my engineering skills to provide better recommendations. I noticed that liners provided a negligible displacement and have more factors of safety than rock bolts. Thus, liners, which have more rate of return and are less economical than rock bolts must be used.	1.18
	I analyzed the type of failures that can affect the strength of the rock bolt.	2.13, 2.14
	used my mining engineering advanced knowledge by creating a suitable IoT-based layout	2.18
	I applied my engineering knowledge to estimate the grades of blocks using the Kriging Technique and built a block model	3.13

Australia

<p>PE3.4 Professional use and management of information</p>	<p>I performed a literature review to collect details that were used in the project to design and study slop stabilization, orebody modelling, etc.</p> <p>I managed the information by developing a thesis document so that details can be used in the future.</p>	<p>1.7, 2.5</p> <p>1.19, 2.20, 3.12</p>
<p>,PE3.5 Orderly management of self, and professional conduct</p>	<p>I developed a detailed timeline using MS Project Management software including all project tasks, available resources, milestones, deadlines</p> <p>I did project management by managing each task and team members</p>	<p>2.19</p> <p>3.11</p>

Australia

PE3.6 Effective team membership and team leadership	I deal ethically with my teammates and provided them equal space or opportunity to put forward their valuable suggestions or opinions.	1.17
	I coordinated with my teammate so that we can collect maximum details as possible.	2.8, 2.19
	I communicated with my teammates by arranging daily meetings with them and listening to their suggestions.	3.11, 3.12

Australia