THE PAPUA NEW GUINEA UNIVERSITY OF TECHNOLOGY

DEPARTMENT OF MINING ENGINEERING

2020 SECOND SEMESTER EXAMINATION

THIRD YEAR MINING ENGINEERING

MN 316 – UNDERGROUND MINING

DATE: ***TUESDAY, 27TH OCTOBER, 2020***

TIME: 08:50 AM

TIME ALLOWED: 3 HOURS

INFORMATION FOR CANDIDATES:

1. You have 10 minutes to read this question paper you **SHOULD NOT** begin writing during this period.
2. There are **THREE** questions altogether. Answer **ALL THREE** questions. Marks to each question are shown on the paper.
3. **ALL** answers must be written on the answer book provided. No other written material will be accepted.
4. Write your **NAME** and **NUMBER** clearly on the **ANSWER BOOK**. Do this **NOW**.

QUESTION 1:

a. **Underground Mining Terminology**

(i) Explain the difference between "Adit" and "Drift".

(ii) Compare and explain the difference between a "cross-cut" and a "stope drive".

(iii). Compare and explain the difference between "Level" and "Sublevel".

(iv) Explain briefly so as to distinguish between a "Cut holes" and "Stopping holes".

(v) Explain briefly so as to distinguish between "Lifter holes" and "Contour holes".

(10 marks)

b. **Underground Mining methods**

The following are some of the common underground mining methods:

- Sublevel Stopping Method
- Shrinkage Stopping Method
- Block Caving Mining Method

With the help of a neat sketche describe any **ONE** of these methods, in relation to the following:

- Mining and geologic factors influencing their selection
- Stope developments
- Stopping sequence
- Stopping methods; this includes drilling and blasting and mucking methods

(Neat clear sketch of the method with concise descriptions will attract more marks).

(10 marks).

c. **Development Heading Designs**

A drift of 6.5m x 5.0m is to be excavated in Quartzite, using a drill that has a drillability factor of 0.8 relative to Bare Granite, the holes will be 40mm diameter, drill data on Bare Granite shows 13.5 mm/s drilling rate, and it has the capacity to drill 3.5m depth holes. The heading pull factor in this rock formation is 0.95. The type of design recommended is a 5-hole Burn-Cut blast design with 1 uncharged center hole. The explosive to use is ANFO pneumatically loaded having a density of 950 kg/m^3. Design constitutes the calculation of the following:

(i) the number of holes required to be drilled at the tunnel face if blasting factor is 0.4m^2/hole, and the number of holes needed as perimeter hole if spacing between the hole is 0.7m for smoother walls.

(ii) Load factor if hole diameter is 40mm, and the charge weight per hole

(iii) Total quantity (kg) of explosives needed per round, and Powder factor if quartzite has a SG (specific gravity) of 2.6.

(iv) Total time taken to drill one round, per drill if the hole depth is 3.5m and additional drill times include; bit change is 1 minute per hole, collaring time is 0.2minute, delays per hole is 3.0 minutes.

(v) Number of drills required, for a 8 hours shift, where only 3.5 hours are available for drilling, and also determine effective drilling time if more than 1 drill is required.

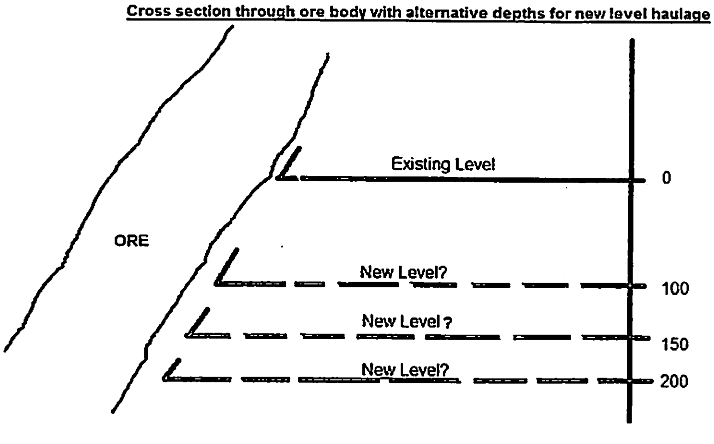
(25 marks)

QUESTION 2:

a. Stope Designs – Level Interval Selection

Determine an optimal level interval from the option of 80m, 100m , or either 150m interval if the following cost information is true to develop a gold deposit of width 25m, a strike length of 2000m,a depth of 1000m, and the density of ore is 2.6t/m^3: Consider following information to be true.

Cross section through ore body with alternative depths for new level haulage



(a) The production is estimated to be

4 million tonnes of ore per year.

(b) The investment is estimated to be:

- Fixed K30million
- Variable K50 million per 100m

(c) Interest rate is fixed at 15%

(d) Capital Investment Factor (F),

$$F = r\frac{(1+r)^n}{(1+r)^n-1},$$

Capital cost of initial investment (P),

P = Ci x F, Ci is total capital investment cost

(10 marks)

b. Stope Design – Stope Sizes

There are many factors that affect the selection of a stope size, especially stope wall span in underground mines, however one of the major dictating factor is the stability of the stope. Designed stopes must remain stable during their production period since any instability can halt the stope's production completely. The stability graph method is often used to assess the stability of designed stope or plan stope sizes. Consider the following situations concerning stope size selections appropriately:

i. An epidermal gold deposit is being planned to mine its ore using stope level interval of 40m and the stope wall span of 30m, using sublevel stopping method. Based on mine geological data the following geotechnical information have been derived; RQD is 90, Jn is 9, Jr is 3, Ja is 1, Stress factor is 1, Joint orientation factor is 0.3, gravity factor is 4.0. Given these determine if the planned stope size is acceptable for unsupported stopes and comment.

Useful formulae (all symbols carry usual meanings):

$N' = Q' x A x B x C$, $Q' = (RQD / Jn) x (Jr / Ja)$, $HR = (w \times h)/2(w+h)$,

Stability graph for unsupported stopes is given below.

ii. For the same mine in (i) above, the mine management recommends bigger stopes for the mine with the view of achieving larger production and suggests that the stope level interval be increased to 60m instead based on new studies, and wants the maximum allowable wall-span be selected for use. As such determine the maximum allowable wall-span, hence your new stope size design for production.

(5 + 5 marks)

QUESTION 3:

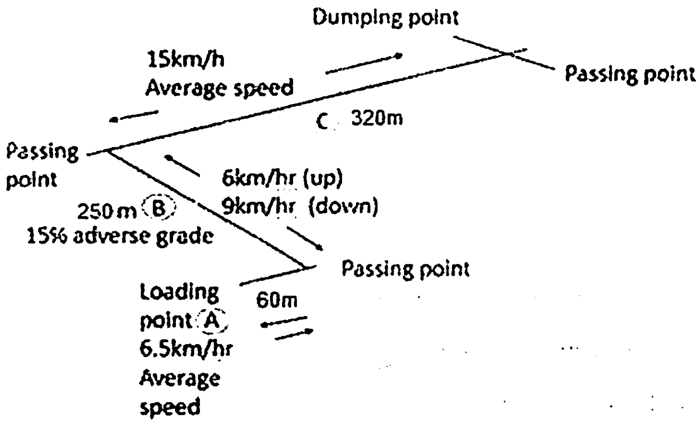
a. Underground Haulage Analysis

Consider a mine is to utilize a combination of LHD and mine trucks for ore haulage as shown on the layout below in an underground mine. A truck of box size of 8.0m^3 is to be used for haulage and a LHD having a bucket size of 4.0m^3 is expected to be used to fill the mine truck. The operation conditions are such that the following average times are true; Passing time for trucks is 0.5min, Spot to load time is 0.5, Load time per LHD bucket load is 1.3min, and maneuvering and dumping time is 0.5min. The working condition for the mine truck and LHD is generally "average" where effective production time per hour is 50 minutes. Truck box filling factor is 0.95 and the ore tonnage factor is 2.6t/m^3.

Given these determine the productivity of the:

i. Mine truck

ii. LHD (operating a loader)



Haulage profile

(10marks)

b. Underground Equipment Selection

An underground gold mine is considering to use LHDs combined with mine trucks as the main mode of haulage of broken ore from within the mine and to the surface. However, it is contemplating on what size of haulage equipment are most appropriate and economical to use. There are two options it has to choose from either; a larger capacity with fewer vehicles, but higher initial capital operating cost per vehicle, or chose smaller capacity with more number of vehicles, which have low capital and operating costs per equipment to achieve the desired production targets. The particulars of the two options are as follows:

Option 1:

LHD: Number of Units to use is 1; Payload capacity is 10tonne; factory price cost is K600,000.00; Freight and other landing cost is K35,000.00. Overall operating cost per LHD is K100.00 /hour, it has effective operating life of 30,000 hours

Mine Trucks: Number of Units needed is 2; Payload capacity is 20tonne; factory price cost is K550,000.00 per truck; Freight and other landing cost is K32,000.00 per truck. Overall operating cost per mine truck is K75.00 /hour. it has effective operating life of 25,000 hours.

Option 2:

LHD: Number of Units is 1; Payload capacity is 7.5 tonne; factory price cost is K450,000.00; Freight and other landing cost is K25,000.00. Overall operating cost per LHD is K80.00 /hour, it has effective operating life of 22,000 hours

Mine Trucks: Number of Units is 3; Payload capacity is 15tonne; factory price cost is K350,000.00 per truck; Freight and other landing cost is K20,000.00 per truck. Overall operating cost per mine truck is K65.00 /hour, it has effective operating life of 18,000 hours.

Based on these data, and appropriate ownership and operating cost considerations;

i. Select the option you would recommend to the mine, (show working to justify the selection)

ii. State your reason(s), why?

Note:

- The planned mine operating production schedules are; 20 hours per day; 7 days per week, 50weeks per year.
- 13% for interest, insurance, taxes for owning the equipment, apply to all options
- Hourly investment cost is calculated as follows:
  - $\frac{Total\ delivered\ price\ x\ Average\ annual\ investment\ factor\ x\ Interest\ rate}{Annual\ operating\ hours\ per\ year}$
- Hourly depreciation is determine as follows :
  - $\frac{Total\ capital\ cost\ of\ equipment}{Equipment\ life\ (hrs)}$
- Investment factors are given below

(10 marks)

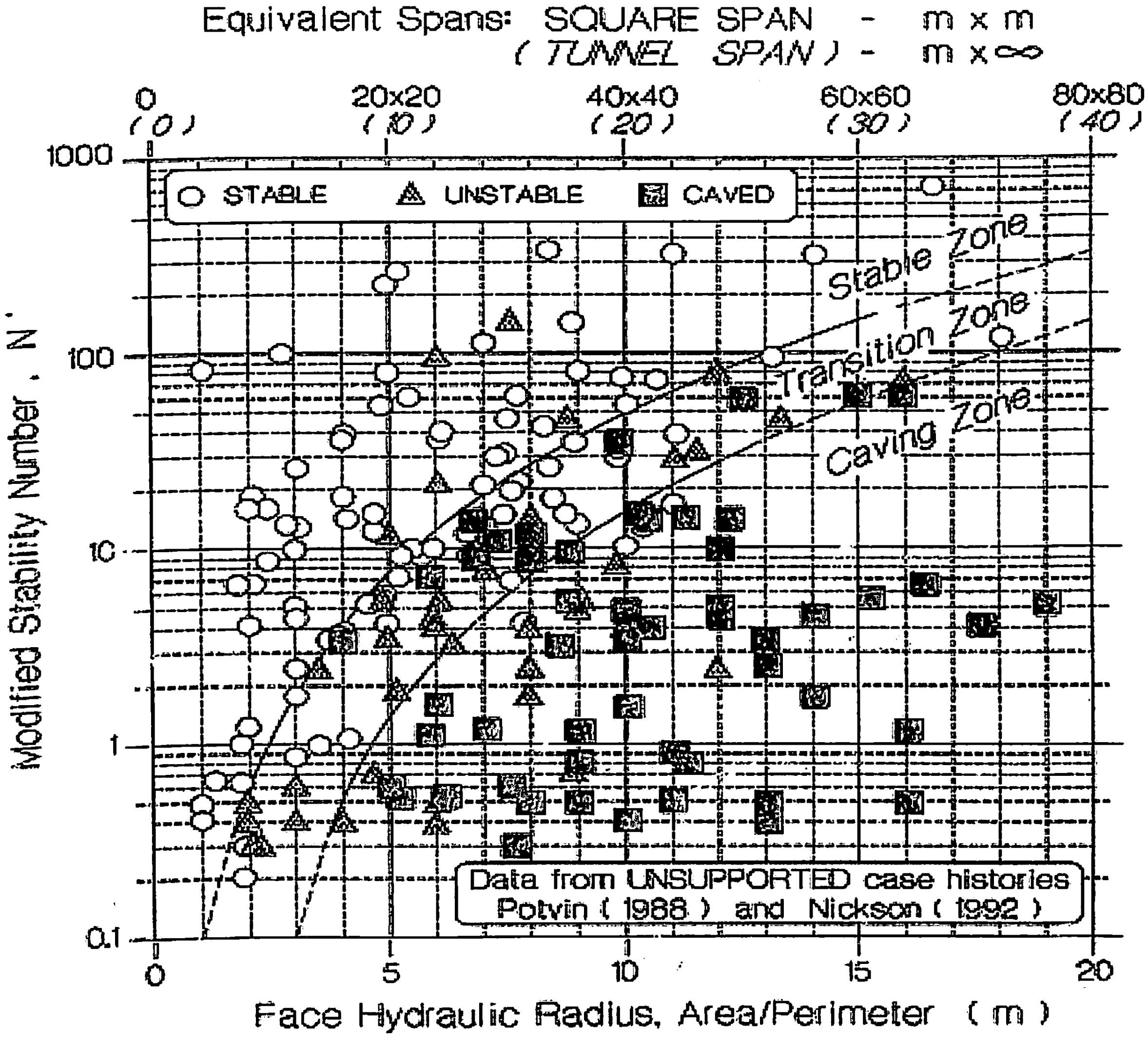


Table 1: Average Annual Investment Factor

Equipment life Number of years	*Investment Factor*
1	*1.00*
2	*0.75*
3	*0.67*
4	*0.63*
5	*0.60*
6	*0.58*
7	*0.57*