FACULTY	: Science
DEPARTMENT	: Geology
CAMPUS	: DFC
MODULE	: CEGB211 ENGINEERING GEOLOGY 2B
SEMESTER	: Second
EXAM	: January 2020

DATE:	:	07 January 2020	SESSION:	11:30-1430
ASSESSOR(S):	:	Mr. F.E.D. SENZANI		
MODERATOR:	:	Dr. D.H. ROSE		
DURATION:	:	3 HOURS	MARKS:	185

NUMBER OF PAGES: 21 PAGES

STUDENT NUMBER	
STUDENT INITIALS	
STUDENT SURNAME	
STUDENT SERIAL NUMBER (SEE REGISTER)	

INSTRUCTIONS:

1. **Fill in the personal details in the table above, IN FULL**

2. **Answer ALL THE QUESTIONS in Sections A and B, using the table on Page 9, and any five in Section C.**

3. **Numbered spaces in this document must be used to answers the questions. Request additional paper if you need additional space.**

4. **Submit all of this document**

SECTION A – TRUE OR FALSE QUESTIONS
INSTRUCTIONS FOR SECTION A ONLY

(i) Write the full word "TRUE" OR "FALSE" in the right space in the table on page 9. Do not use "T" OR "F" instead.

(ii) Each question carries a 0.5 mark, with the total for the section being 30 marks.

(1) The solid earth's average density is 15g/cc.

(2) Seismic studies were used to determine the layering of the solid earth.

(3) The solid Earth's compressive earthquake waves travel through both fluid and solid media.

(4) The full life span of a radioactive atom must be known in order to use for the dating or rocks or minerals.

(5) The host rocks must be younger than the dyke that cuts across them.

(6) The manner in which mineral grains or crystals aggregate is known as the crystal habit.

(7) A mineral with an octahedral form consists of six identical triangular faces in four parallel pairs.

(8) A mineral with a tetrahedral form consists of six identical faces.

(9) The manner in which mineral grains or crystals aggregate is known as the crystal habit.

(10) When breaks form flat surfaces that are parallel to crystal directions it is known as cleavage.

(11) In a basic or ultrabasic magma that is cooling slowly, quartz will crystallise first while olivine will crystallise last.

(12) As the minerals crystallise from magma, separation of solid and liquid may occur in a process known as fractional crystallisation.

(13) Igneous rocks are extrusive when the magma is forced out and cools rapidly on the surface of the earth.

(14) A dyke is an igneous rock in the form of a sheet of that cuts parallel to the structural planes of the country rock.

(15) Discordant, lens-shaped intrusions are known as lopoliths, laccoliths or phacoliths depending on their overall concave or convex shape.

(16) A coarse-grained igneous rock composed of alkali feldspars and quartz as the essential minerals is a granite.

(17) Dolerite is an igneous rock composed essentially of quartz.

(18) In a basic magma that is cooling down slowly, calcium-rich feldspar will crystallise before sodium rich feldspar.

(19) If the silica content of a magma is relatively high, the magma is said to be basic.

(20) A coarse-grained igneous rock composed of alkali feldspars with little and quartz as the essential minerals is a gabbro.

(21) Igneous rocks formed at great depth in the crust, are fine grained.

(22) Mechanically derived sedimentary rocks are classified primarily on the basis of their grain size.

(23) Iron-ore may occur as a chemical sedimentary rock.

(24) Sedimentary limestone forms by inorganic means only.

(25) Carbonaceous sedimentary rocks may be characterized by high contents of carbonate.

(26) During diagenesis, sediment changes into a rock through increase in density, cohesion and cementation.

(27) During diagenesis, sediment changes into a rock through increase in density, cohesion and porosity.

(28) Increases in heat and pressure are agents of metamorphism but active fluids are not.

(29) The different ranges of temperature and pressure in which metamorphic rocks can form are referred to as metamorphic zones.

(30) At temperatures of 800°C and higher, rocks of granitic composition begin to melt partially in a process known as anatexis.

(31) Gneissic rocks form at very high temperatures and low pressure.

(32) Limbs of asymmetric folds necessarily dip in the same direction.

(33) Both the limbs and axial planes of a recumbent fold are vertical.

(34) The description of a planar rock structure such as bedding is not fully given when its inclination only is given.

(35) In a normal fault, the hanging wall block moves downwards relative to the foot wall block along the fault-plane.

(36) When rock breaks create approximately equidimensional blocks, the jointing style is of sugar cube texture.

(37) The Central Rand Group forms part of the Transvaal Supergroup.

(38) The Rustenburg Layered Suite forms part of the Bushveld Complex.

(39) The Bushveld Complex stretches from the Western Cape Province to the KwaZulu-Natal Province.

(40) A valley spring occurs when the surface of the ground falls below the water table.

(41) The water table forms a surface which runs parallel to a dissected land surface.

(42) Soil and near-surface rocks in an area of dolomite may collapse catastrophically into an underground cavern to form a doline.

(43) Physical disintegration refers to the mechanical breakdown of rocks.

(44) Kaolinite-rich clays are produced from breakdown of potassic feldspars.

(45) Hydrolysis of rock-forming minerals is an example of the physical breakdown of rocks.

(46) In the east of southern Africa, the climatic N-value is less than 5.

(47) Quartz is chemically unreactive, and tends to break down mechanically during weathering.

(48) Higher confining pressure reduces the shear strength of rock material.

(49) Folds are a type of discontinuity in a mass of rock.

(50) A rock with a comprehensive strength between 50Mpa and 120Mpa is classified as weak.

(51) Rock material is the term used to describe a body of rock including its discontinuities.

(52) It is common to refer to all fractures in a rock body as discontinuities.

(53) Different discontinuities in rocks have the same shear properties.

(54) Where the dip of discontinuities is from the wall into the excavation, the wall of the excavation is unstable.

(55) The presence of water in soil decreases the likelihood of collapse of the wall of an excavation.

(56) Low shearing strength increases the stability of a slope cut in a soil column.

(57) In the Bienawski rock mass rating (RMR) system, one of the parameters is the “Rock Quality Designation”.

(58) In the Barton rock mass rating (RMR) system, the parameters used contribute unequally to the strength of the body of rock.

(59) Additional stress caused by the weight of water in a dam may cause failure in the rocks forming the base or walls of the dam.

(60) Rocks in the catchment area of a dam, if soft and easily weathered, will cause siltation of the dam.

SECTION B – MULTIPLE CHOICE QUESTIONS

INSTRUCTIONS FOR SECTION B ONLY

(i) Select the correct answer, and enter your response in the table on page 9
(ii) There is only one correct or best answer for each question.
(iii) Each question carries 1 mark, total 30 marks

(61) The margins of a tectonic plate may be
(A) zones of extention.
(B) zones of shear.
(C) zones of collision.
(D) all of the above.
(E) none of the above.

(62) Parts of the Earth's lithosphere are known as tectonic
(A) segments.
(B) sectors.
(C) plates.
(D) portions.
(E) none of the above.

(63) The current location of continents may differ from their previous positions. This is due to
(A) movement of lithospheric tectonic plates
(B) movement of magma to the surface.
(C) movement of animal species that existed on the continents.
(D) migration of plant species that existed on the continents.

(64) Radiometric dating of a rock reveals:
(A) its absolute age.
(B) its relative age.
(C) both of the above.
(D) none of the above.

(65) The hardest mineral on Moh's Scale of Hardness is
(A) gypsum.
(B) talc.
(C) fluorite.
(D) (d) none of the above.
(E) none of the above

(66) Quartz is typical of
(A) felsic rocks.
(B) ultramafic rocks.
(C) intermediate rocks
(D) all of the above
(E) none of the above

(67) Nepheline and leucite are examples of
- (A) feldspars which have high contents of Na and K but are in low silica.
- (B) feldspathoids which have high contents of Na and K but are low in silica.
- (C) aluminosilicates which have high contents of Na and K but are high in silica.
- (D) feldspars with high contents of calcium but are moderate in silica.
- (E) none of the above

(68) When a basic magma crystallises, the last minerals to crystallise are rich in
- (A) FeO
- (B) SiO2
- (C) CaO
- (D) MgO

(69) Ventersdorp lavas are examples of
- (A) igneous rocks
- (B) extrusive rocks
- (C) sedimentary rocks
- (D) metamorphic
- (E) (A) and (B)
- (F) none of the above

(70) Granites are coarse-grain equivalents of
- (A) basalt and dolerite
- (B) trachyte and syenite porphyry
- (C) andesite and diorite porphyry
- (D) rhyolite and granophyre
- (E) kimberlite
- (F) none of the above

(71) Igneous rocks are formed when
- (A) minerals crystallise from a magma.
- (B) rocks are melted.
- (C) magma cools down.
- (D) (A) and (C).
- (E) all of the above.

(72) The rocks below are examples of chemical sedimentary deposits except
- (A) dolomite.
- (B) sandstone.
- (C) ironstone.
- (D) chert.

(73) Siltstones and mudstones are examples of
- (A) rudaceous rocks.
- (B) arenaceous rocks.
- (C) argillaceous rocks.
- (D) sandstones.
- (E) all of the above
- (F) none of the above

(74) When ions precipitate out of water to form rocks, the rocks are said to be
- (A) pyroclastically formed .
- (B) clastically formed.
- (C) organically formed.
- (D) chemically-formed.

(75) Slaty cleavage and schistocity are typical products of
- (A) thermal metamorphism.
- (B) dynamic metamorphism.
- (C) fluid invasion.
- (D) all of the above
- (E) none of the above

(76) The term “metamorphic facies’’ refers to
- (A) different ranges of temperatures of formation of metamorphic rocks.
- (B) different ranges of pressure of formation of metamorphic rocks.
- (C) different ranges of pressure and temperature of formation of metamorphic rocks.
- (D) the ranges of compositions of invading fluids during formation of metamorphic rocks.

(77) the axis of a fold
- (A) follows the hinge of the fold.
- (B) bisects the angle between the fold limbs.
- (C) is a horizontal line on one of the limbs.
- (D) all of the above.
- (E) none of the above.

(78) Dip-slip occurs on a fault with
- (A) horizontal movement alone.
- (B) vertical movement alone.
- (C) combined vertical and horizontal components.
- (D) all of the above
- (E) none of the above.

(79) The dominant rock types in the Bushveld Complex are
- (A) intrusive.
- (B) extrusive.
- (C) hypabyssal
- (D) all of the above
- (E) none of the above.

(80) The formation of manganiferous wad accompanies the occurrence of*
- (A) dolines
- (B) sinkholes.
- (C) caverns.
- (D) none of the above

(81) What is the main force that causes groundwater to flow in rocks?
- (A) van der Waal’s forces
- (B) porosity
- (C) plasticity
- (D) density
- (E) all of the above
- (F) none of the above

(82) The water-bearing rocks lying below the water table constitute
- (A) the saturated zone
- (B) the watertable
- (C) the aerated zone
- (D) all of the above

(83) Sedentary soils are those that have
(A) formed at one place but deposited at another.
(B) are found overlying the weathered source bedrock.
(C) are deposited in the deep sea.
(D) have been transported by air.

(84) This family of minerals, when weathered chemically, produce most the clay minerals
(A) quartz.
(B) feldspars.
(C) micas
(D) none of the above

(85) The strength of a rock is determined by
(A) by measuring its porosity.
(B) by measuring its grain size.
(C) by measuring its water content.
(D) by measuring its composition
(E) by determining its confining pressure
(F) none of the above

(86) Rock mass refers to
(A) a body of rock including its discontinuities.
(B) a body of intact rock without any discontinuities.
(C) the weight of the rocks being studied.
(D) all of the above.
(E) none of the above.

(87) The rock mass rating (rmr) system of classification uses the*
(A) strength of intact material.
(B) rock quality designation.
(C) spacing of joints.
(D) conditions of joints.
(E) conditions of groundwater.
(F) all of the above
(G) none of the above

(88) Investigation of one of these features is unnecessary when foundation rocks and soils are investigated. Which one is it?
(A) the mass of the building.
(B) the various forces acting on the building.
(C) what is the purpose of the building?
(D) the cost of construction.
(E) none of the above.

(89) In order to maximise stability, an excavation cut into this rock will require the most gently sloping walls:
(A) granite.
(B) sandstone.
(C) limestone.
(D) shale.

(90) Rocks are thinly and horizontally layered, a horizontal tunnel made through them will have
(A) wall failure.
(B) roof failure.
(C) floor failure.
(D) none of the above.

Answer page for sections A and B and Questions 1 to 90

Section A; Write True or False IN FULL				**Section B; use the upper case (CAPITAL LETTER)**	
1	16	31	46	61	76
2	17	32	47	62	77
3	18	33	48	63	78
4	19	34	49	64	79
5	20	35	50	65	80
6	21	36	51	66	81
7	22	37	52	67	82
8	23	38	53	68	83
9	24	39	54	69	84
10	25	40	55	70	85
11	26	41	56	71	86
12	27	42	57	72	87
13	28	43	58	73	88
14	29	44	59	74	89
15	30	45	60	75	90

INSTRUCTIONS FOR SECTION C ONLY

(i) Answer any <u>five</u> questions. Use the numbered corresponding spaces provided.

(ii) Give only brief answers. Only "bullet" points, preferably one per line, or clearly separated, if on the same line, need be given.

(iii) The questions carry equal marks – Total: 125 marks.

QUESTION 91

(A) Rocks are solid earth materials. Explain how it is that they may contain water. Use sketches if necessary. (03 marks)

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(B) With respect to groundwater, give an account of the term permeability. (03 marks)

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(C) What are springs? (02 marks)

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(D) Draw and label all parts of a valley spring. (07 marks)

(E) Why is it important to map out any springs that occur in an area targeted for construction? (02 marks)

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(F) What are the impacts of the presence of water at a construction site? (04 marks)

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(G) How can any negative impacts of the presence of water at a construction site? (04 marks)

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(Total 25 marks)

QUESTION 92

(A) Define the term “soil” in terms of civil construction. (02 marks)

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(B) Explain the term chemical weathering. (01 marks)

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(C) Give examples of chemical weathering processes, in each case giving a brief description. (08 marks)

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(D) List the factors that determine the strength of a soil. For each factor, describe how it varies, and how the variation may decrease or increase the strength. (14 marks)

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(Total 25 marks)

QUESTION 93

(A) Define the concept "the compressive strength of rock material", including how this is determined. (05 marks)

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(B) What factors determine the level of strength of rock material? For each, describe how it varies, and how the variation increases and decreases the strength. (18 marks)

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(C) Give an example of a weak rock. What are the features which make the rock weak? (02 marks)

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(Total: 25 marks)

QUESTION 94

A tunnel is being developed in a northward direction over very steeply dipping strata. The strata dip at more than 70 degrees to the south.

(A) Present a fully labelled sketch (or fully labelled sketches) of the situation just described above. (10 marks)

(B) Will the walls be stable? Why or why not? (03 marks)

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(C) Will the roof be stable? Why or why not? (03 marks)

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(D) What is the impact on stability for the walls if the tunnel is developed in an east-west direction, and why? (03 marks)

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(E) What is the impact on stability for the roof if the wall is developed in an east-west direction, and why? (03 marks)

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(F) Comparing the two tunnel development directions, which one would you prefer, and why? (03 marks)

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(Total: 25 marks)

QUESTION 95

(A) List and briefly describe the different zones considered in the siting of a water dam or reservoir. (08 marks)

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(B) For each of the above zones, list the properties of suitable rocks. (09 marks)

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(C) For each of the above zones, mention one suitable rock, and give reasons as to why it is suitable. Mention a rock only once. (04 marks)

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(D) For each of the above uses, list one unsuitable rock. Do not mention the same rock for more than one use. Mention a rock only once. (04 marks)

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(Total 25 marks)

QUESTION 96

For the Barberton Supergroup, write notes on the following:

(A) its chronological age, (02 marks)

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(B) its main stratigraphic components, (06 marks)

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(C) its region of occurrence in South Africa (04 marks)

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(D) the principal constituent rocks (06 marks)

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(E) The main concerns when foundations of building construction are considered for any one of the rocks,. (07 marks)

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(Total 25 marks)

QUESTION 97

Rocks to be tunneled through, during construction of an underground nuclear station, are being examined. You are supplied with a list of the Geomechanical Field characteristics of the body of rock, the ratings of the same characteristics, a graph of RMR/MRMR, a graph of the stand-up times of unsupported spans, an equivalent support ratio table and a graph of remedial steps for specific intended use tunnels.

Geomechanics Field Data

Item	Description
Rock quality designation	Length of drilled core = 500m Length of core <100mm = 125m
Number of joint sets	Two plus random random joints
Description of joint surface roughness	Rough and discontinuous
Condition of groundwater	Exceptionally high inflow upon excavation, decreasing with time
Description of gouge	Unaltered joint walls, surface staining only
Stress reduction factor data	Uniaxial compressive strength = 250Mpa Depth of tunnel = 1155m Average density of overlying rocks = 2207kgm^{-3} Acceleration due to gravity = 9.81ms^{-2}

(A) Determine Barton's Q-value for the body of rock given the formula:

$$Q = \frac{RQD}{Jn} \text{ x } \frac{Jr}{Ja} \text{ x } \frac{Jw}{Ja} \text{ x } \frac{Jw}{SRF}$$

in which RQD is the rock quality designation
J_n is the joint set number
J_r is the joint roughness number
J_a is the joint alteration number
J_w is the joint water reduction factor
SRF is the stress reduction factor.
. (08 marks)

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(B) Determine Bieniawski's rock mass rating (RMR) for the body of rock, given that RMR = 9 x lnQ + 44. (03 marks)

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(C) Plot the RMR on the graph of RMR/MRMR, Q-Value and the Factor of Safety (FOS), and determine, for a tunnel of 2.5 meters, the Factor of Safety (FOS). What is the FOS?

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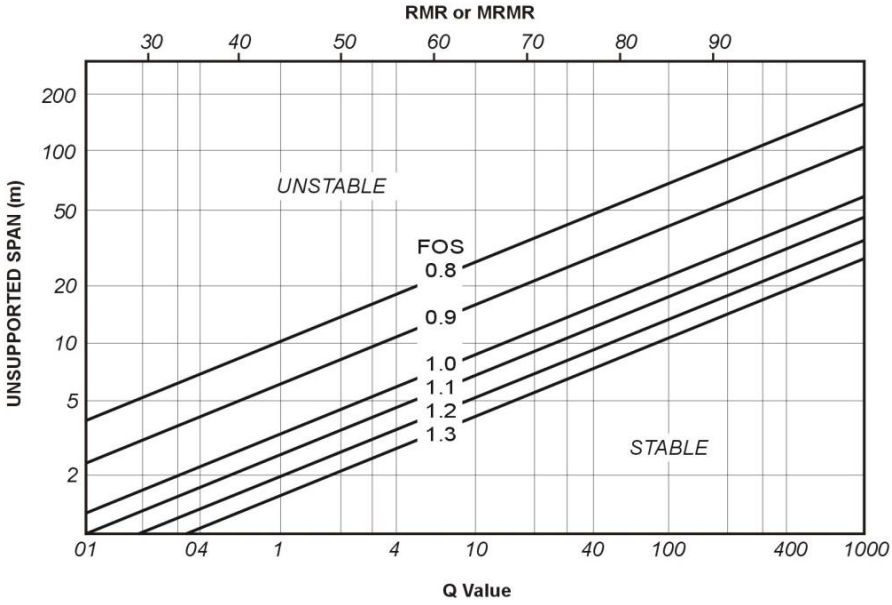
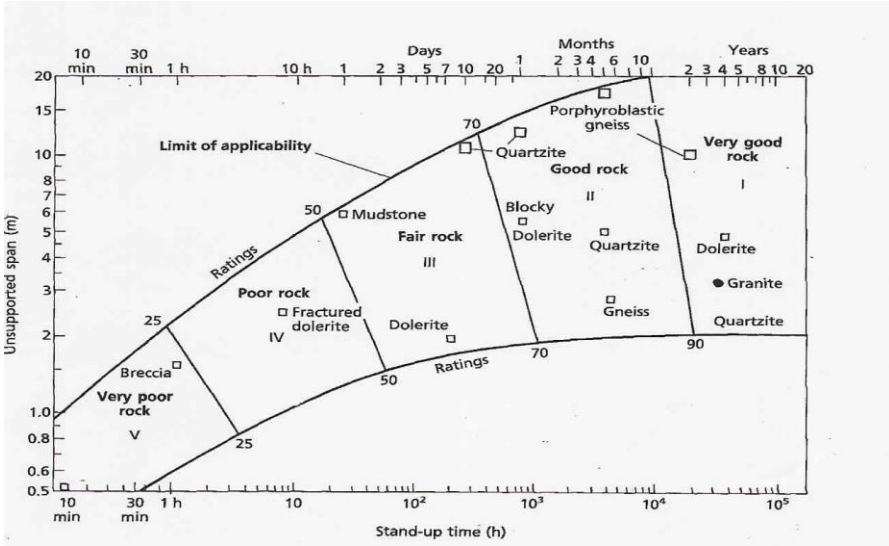
(03 marks)



(D) Plot the RMR on the graph of the stand-up times of unsupported spans and determine the stand-up time for the 2.5m wide tunnel. (03 marks)



Geomechanics classification of rock masses for tunnelling. South African case studies are indicated by squares

Stand-up time: ……

(E) What will be the consequence of using a span of 4 metres on

(i) the stand-up time, and

……..…… (01 marks)

(ii) the Factor of Safety?

……... (01 marks)

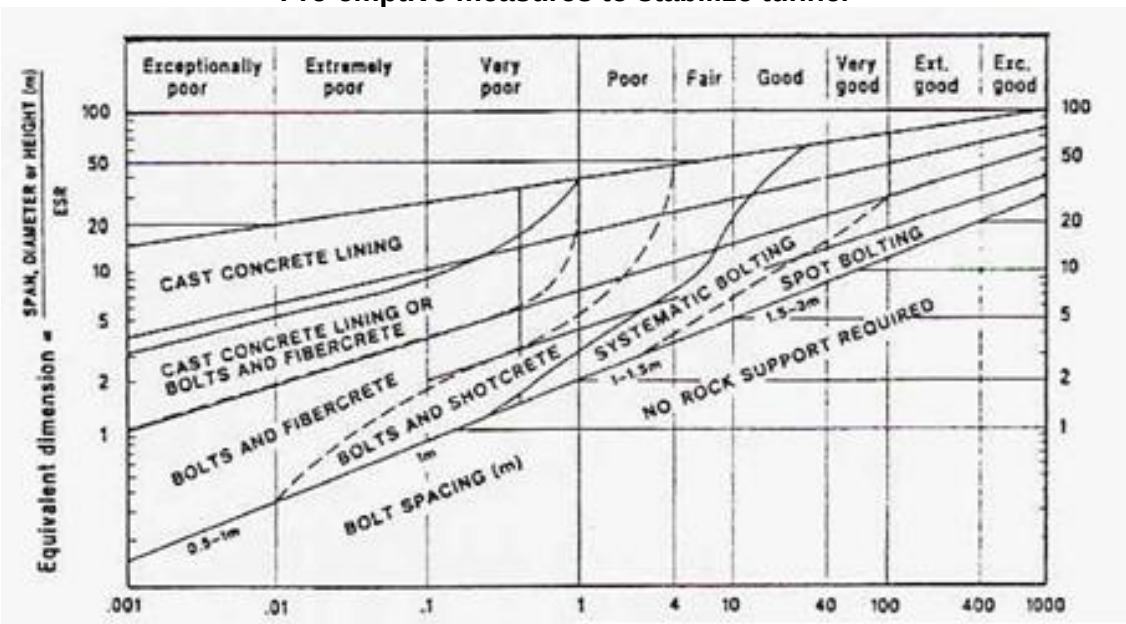
(F) Using the ESR table, and the graph of pre-emptive work, select the correct ESR.

Equivalent support ratio (ESR) for different excavations

	Excavation Category	Equivalent Support Ratio (ESR)
1	Temporary mine openings	3 -5
2	Vertical shafts; circular section	2.5
	Vertical shats; rectangular/square section	2.0
3	Permanent mine openings; water tunnels for hydropower (excluding high-pressure penstocks); pilot tunnels; drifts; headings for large excavations	1.6
4	Storage caverns, water treatment plants; minor highway and railway tunnels; surge chambers; access tunnels	1.4
5	Power stations; major highway or railroad tunnels; civil defence chambers; portals; intersections	1.0
6	Underground nuclear power stations; railroad stations; factories	0.8

Equivalent Support Ratio: …… (01 marks)

Pre-emptive measures to stabilize tunnel



(G) What is the work necessary to ensure stability of a 4m-wide tunnel?

…… (05 marks)

(Total 25 marks)

Joint set number reference table

Number of Joint Sets	Joint Set No. Jn
Intact, no or few joints	0.5 — 1.0
One joint set	2
One joint set plus random joints	3
Two joint sets	4
Two joint sets plus random joints	6
Three joint sets	9
Three joint sets plus random joints	12
Four or more joint sets, random, heavily jointed, sugar cube, etc.	15
Crushed rock, earth-like	20

Joint roughness number reference table

Description of Joint Surface Roughness	Discontinuous	Undulating	Planar
Rough	4.0	3.0	1.5
Smooth	3.0*	2.0	1.0
Slickensided	2.0*	1.5	0.5
Planes containing gouge thick enough to prevent rock wall contact	1.5*	1.0	1.0

Joint alteration number reference table

Description of Gouge	Joint Alteration Number Ja for Joint Separation (mm)		
	<1.01	1.0-5.02	>5.03
Tightly healed, hard, non-softening impermeable rock mineral filling	0.75		
Unaltered joint walls, surface staining only	1.0		
Slightly altered, non-softening, non-cohesive rock mineral or crushed rock filling	2.0	4.0	6.0
Non-softening, slightly clayey non-cohesive filling	3.0	6.0*	10.0*
Non-softening strongly over-consolidated clay mineral filling, with or without crushed rock	3.0*	6.04	10.0
Softening or low friction clay mineral coatings and small quantities of swelling clays	4.0	8.0*	13.0*
(F) Softening moderately over-consolidated clay mineral filling, with or without crushed rock	4.0*	8.04	13.0
(G) Shattered or micro-shattered (swelling) clay gouge, with or without crushed rock	5.0*	10.04	18.0

Joint water reduction factor reference table

Condition of Groundwater	Head of water (m)	Joint WaterReduction Factor Jw
Dry excavation or minor inflow 5 litre/minute locally	<10	1.0
Medium inflow, occasional outwash of joint/fissure fillings	10 – 25	0.66
Large inflow in competent ground with unfilled joints/fissures	25-100	0.5
Large inflow with considerable outwash of joint/fissure fillings	25-100	0.33
Exceptionally high inflow upon excavation, decaying with time	>100	0.2-0.1
Exceptionally high inflow continuing without noticeable decay	>100	0.1-0.05

Stress reduction factor reference table 1

For Zones of weakness	SRF Value
Multiple occurrences of weakness zones containing clay or chemically disintegrated rock, very loose surrounding rock (any depth)	10
Single weakness zones containing clay or chemically disintegrated rock (depth of excavation < 50m)	5
Multiple shear zones in competent rock (clay-free), loose surrounding rock (any depth)	2.5
Single shear zones in competent rock (clay-free), loose surrounding rock (any depth)	7.5
Single shear zones in competent rock (clay-free) (depth of excavation < 50m)	5.0
Single shear zones in competent rock (clay-free) (depth of excavation > 50m)	2.5
Loose open joints, heavily jointed or “sugar-cube” etc (any depth)	5.0

Stress reduction factor reference table 2

(Principal stress = $\rho gh = \sigma 1$) where g = 9.81

Competent rock/Stress problems	UCS /σ1	σt / σ1	SRF Value
Low stress, near-surface	>200	>13	2.5
Medium stress	200-10	13-0.66	1.0
High stress, very tight structure (usually favourable to stability, may be unfavourable for wall stability)	10-5	0.66-0.33	0.5-2
Mild rock burst (massive rock)	5-2.5	0.33-0.16	5-10
Heavy rock burst (massive rock)	<2.5	<0.16	10-20

End of January 2020 Engineering Geology 2B (CEGB211) (Construction Management)) Supplementary Examination