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UNIVERSITY OF JOHANNESBURG

FACULTY OF SCIENCE

DEPARTMENT OF GEOLOGY

MODULE:
ENGINEERING GEOLOGY 2B (GLGB2B2) FOR CONSTRUCTION MANAGEMENT

CAMPUS: DFC

FEBRUARY 2021 SPECIAL EXAMINATION

DATE: TO BE ANNOUNCED **SESSION: TO BE ANNOUNCED**

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MODERATOR: **Dr. D. H. ROSE**

DURATION: 3 HOURS **TOTAL MARKS: 200**

NUMBER OF PAGES: 20

INSTRUCTIONS:

1. ANSWER ALL THE QUESTIONS IN SECTIONS A AND B BUT ANY FIVE IN SECTION C.
2. USE THE NUMBERED ALLOCATED SPACES ON THE ANSWER SCRIPT TO WRITE YOUR RESPONSES.
3. USE ONLY INK FOR ALL TEXT AS WELL AS SKETCHES.
4. ONLY SHORT, BULLETED ANSWERS ARE NECESSARY FOR THE QUESTIONS IN SECTION C.
5. YOUR INITIALS AND SURNAME (AS ON YOUR STUDENT CARD) AND STUDENT NUMBER MUST BE WRITTEN CLEARLY IN SEPARATE BLOCK CAPITALS (UPPER CASE) ON THE ANSWER SCRIPT.
6. SUBMIT BOTH THE QUESTION AND ANSWER SCRIPTS.

THESE ARE INSTRUCTIONS FOR SECTION A ONLY:

On the answer script, write, IN FULL, "TRUE", for a correct statement, and "FALSE", for an incorrect one. Do NOT use abbreviations "F" for "FALSE" or "T" for "TRUE". The mark for each question is 0.5 while the total for the section is 25. Use the answer sheet on PAGE 12.

1. Core samples of drill holes, which reach the lower mantle, assist in determination of the solid earth's composition.

2. The upper mantle, has an ultramafic mineral composition.

3. Continental and oceanic crust, have the same mineral and chemical compositions.

4. Normal faulting, is typical of zones, of tectonic plate divergence.

5. A mineral is a naturally occurring substance, with a more or less definite, chemical composition.

6. Rock-forming minerals may precipitate out of seawater.

7. Cleavage is one of the physical properties of a mineral, based on form.

8. Magnetite is identified partly on its ability, to swing a compass needle.

9. Volcanic rocks are formed, when magma is extruded, on to the earth's surface.

10. When the silica content, of a body of magma is relatively very high, it is acidic.

11. It is possible for one body of magma, to produce igneous rock types, with varying compositions.

12. Diorite is an igneous rock, with feldspar and pyroxene, as the essential minerals.

13. A dyke is an igneous rock, in the form of a sheet, that lies parallel to layering of the host rocks.

14. Fractional crystallization occurs when minerals, which form early, separate and form rocks which are different in composition, to the original magma.

15. Chemically derived sedimentary rocks form, due mainly to settling, of very fine clay material.

16. Clastic rocks composed of particles, between 0.05mm and 2mm, are known as siltstones.

17. Rocks comprising alternating layers of heamatite and chert, are known as banded ironstones.

18. Evaporites which are composed, dominantly of calcium-carbonate, are known as calcretes.

19. Dynamothermal metamorphism is caused by increase in heat energy, with little, or no rise in pressure.

20. The rock formed when an argillaceous rock, undergoes thermal metamorphism, is called marble.

21. The hade is the angle, by which a fault, is tilted from the horizontal plane. FALSE

22. In a reverse fault, the block above the fault moves upward, relative to the one below. TRUE

23. The axial plane of a symmetric fold is vertical. TRUE

24. If no relative displacement of adjacent blocks of rock occurs, the fracture between them, is known as a shear zone. FALSE

25. The Barberton Supergroup, is the oldest rock unit in South Africa. TRUE

26. Rocks of the Limpopo Belt, have undergone low-grade metamorphism, and little deformation. FALSE

27. The dominant rocks, in the Witwatersrand Supergroup, are metamorphosed lavas. FALSE

28. Carbonate rocks underlie some areas occupied by the Transvaal Supergroup. TRUE

29. The porosity of a rock, refers to the percentage of voids, between particles of a rock. TRUE

30. Coarse grained rudaceous rocks, have higher porosity than finer ones. TRUE

31. In the valley hosting an artesian spring, the water table lies below the surface. FALSE

32. Sinkholes are depressions, produced gently over a long period, and are characterised by gentle slopes. FALSE

33. Soils brought into their location from elsewhere, are known as sedentary soils. FALSE

34. During carbonatisation, minerals react with carbonic acid to produce bicarbonates. TRUE

35. Kaolinitic clays are derived from, the decomposition of calcium-rich feldspars. FALSE

36. The chemical weathering of dolomite, is mainly by oxidation. FALSE

37. Particle size has no impact, on the mechanical strength of soils. FALSE

38. A rock with tensile strength between 3 and 10, is a classified as strong mechanically. TRUE

39. Coarse grained rocks, have greater mechanical strength, than fine grained ones. TRUE

40. Rock mass is a term, used for an intact body of rock, without any internal discontinuities. FALSE

41. Dykes are a form of discontinuity, in a body of rock. TRUE

42. Both the Bieniawski and the Barton systems, utilize rock quality designation (RQD) in rock mass classification. TRUE

43. A construction site investigation, involves the study of the nature of the rocks, below the surface; the groundwater conditions have no impact, and may therefore be ignored. FALSE

44. Steep slopes of open excavations, in massively jointed, but otherwise homogenous gneiss, are stable. FALSE

45. Tunnels cut perpendicular, to the strike of steeply dipping strata, will have low potential for roof failure. TRUE

46. Rocks underlying a water reservoir, need to be impermeable. TRUE

47. Rocks underlying the catchment area of a water reservoir, need to be resistant to weathering and erosion. TRUE

48. Rocks to be used as aggregate, must be chemically reactive, for better concrete bonding. FALSE

49. Good quality concrete, may be produced, using rock fragments, that are permeable. FALSE

50. Rock material, that stains when exposed to the atmosphere, is suitable for use as dimension stone, as this adds colour. FALSE

SECTION B – MULTIPLE CHOICE
THESE ARE INSTRUCTIONS FOR SECTION B ONLY:

Select the correct or best answer. There is only one correct or best response for each question. Each question carries 1 mark; total 50 marks. Use the answer sheet on PAGE 12 to indicate the letter of the correct response. Use capitals (upper case) as has been done for the questions.

51. Areas likely to have unstable foundations, due to earth movements, are found:
(A) along tectonic plate boundaries.
(B) in centres of tectonic plates.
(C) in areas not related to any regions of tectonic plates.
(D) none of the above.

52. The edges of tectonic plates are associated with lithospheric,
(A) extension.
(B) compression.
(C) shearing.
(D) all of the above.
(E) none of the above.

53. The thickness of continental crust is closest to
(A) 5km.
(B) 10km.
(C) 40km.
(D) 100km.
(E) 400km.

54. Lithospheric movements, are caused directly by convection, which occurs in the
(A) asthenosphere.
(B) mantle.
(C) core.
(D) atmosphere.

55. The following is a physical property which may be used to distinguish minerals:
(A) habit.
(B) streak.
(C) fracture.
(D) all of the above.
(E) none of the above.

56. This mineral is identified in part due to its cubic cleavage:
(A) anorthite.
(B) galena.
(C) muscovite.
(D) hornblende.
(E) hypersthene.

57. In the list below, the mineral typical of ultrabasic rocks is
(A) quartz.
(B) magnetite.
(C) dolomite.
(D) haematite.
(E) olivine.

58. These processes lead to the formation of sedimentary rocks: the exception is
(A) weathering of pre-existing rocks.
(B) erosion of existing rocks.
(C) transportation of eroded material.
(D) deposition of transported material.
(E) lithification of deposited material.
(F) none of the above.

59. Magmas are acidic if
(A) the magnesium content is relatively high.
(B) the silica content is relatively high.
(C) the calcium content is relatively high.
(D) the iron content is relatively high.
(E) none of the above.

60. When an ultrabasic magma crystallises slowly, the first groups of minerals to form will be
(A) olivine and anorthite.
(B) pyroxene and albite.
(C) amphibole and microcline.
(D) biotite and quartz.

61. The Upper Zone of the Bushveld Complex, is composed of granitic rocks; their essential minerals are
(A) alkali feldspar only.
(B) amphibole and feldspar.
(C) pyroxene and feldspar.
(D) none of the above.

62. Gabbro is the coarse-grain equivalent of
(A) trachyte and syenite porphyry.
(B) andesite and diorite porphyry.
(C) rhyolite and granophyre.
(D) kimberlite.
(E) none of the above.

63. A body of igneous rock has a tabular shape, and is intruded parallel to layering of the host rocks: the body of rock is a
(A) dyke.
(B) sill.
(C) laccolith.
(D) lopolith.
(E) none of the above.

64. Pyroclastic rocks are represented by this group of rocks:
(A) tuffs.
(B) agglomerates.
(C) ashes.
(D) cinder cones.
(E) all of the above.

65. A sedimentary rock is composed of particulate material brought into a depositional basin: the rock is formed
(A) chemically.
(B) organically.
(C) residually.
(D) none of the above.

66. A clastic argillaceous rock, is composed of particles, whose diameter is
(A) 0.05mm to 0.005mm.
(B) 0.05mm to 0.5mm.
(C) 0.5mm to 2mm.
(D) 2mm to 8mm.
(E) none of the above.

67. This set of rocks represents evaporites:
(A) sandstone and conglomerate.
(B) limestone and dolomite.
(C) calcrete and dolocrete.
(D) petroleum and coal.
(E) none of the above.

68. The odd-one-out in this list of rocks is
(A) conglomerate.
(B) sandstone.
(C) arkose.
(D) greywacke.

69. The metamorphic style, likely to introduce new structures in rocks, is
(A) contact metamorphism.
(B) dynamic metamorphism.
(C) regional metamorphism.
(D) all of the above.
(E) none of the above.

70. Metamorphism may cause these changes, except
(A) introduction of new minerals.
(B) change in grain-size.
(C) introduction of new textures,
(D) introduction of new structures.
(E) none of the above.

71. The axial plane of an asymmetric fold
(A) bisects the angle between the fold limbs.
(B) is vertical.
(C) is horizontal.
(D) is non-vertical.
(E) (A) and (D)

72. In oblique faulting, the blocks of rock affected move, relative to each other,
(A) horizontally.
(B) vertically.
(C) both vertically and horizontally.
(D) none of the above.

73. A reverse fault, with a very low dip angle, is
(A) a lag.
(B) a thrust.
(C) a heave.
(D) none of the above.

74. A body of rock with many closely spaced sets of discontinuities, has
(A) massive jointing.
(B) cubic jointing.
(C) columnar jointing.
(D) sheet jointing.
(E) none of the above.

75. Rocks of the Witwatersrand Supergroup have an age of
(A) more than 3100 million years.
(B) 2600 to 3000 million years
(C) 1800 to 2600million years.
(D) 2050 milliion years
(E) none of the above.

76. The dominant lithologies of the Bushveld Complex are
(A) intrusive.
(B) hypabyssal.
(C) extrusive.
(D) chemical.

77. When conducting major construction projects in areas underlain by the Witwatersrand Supergroup, the main economic mineral deposits to look out for, are
(A) coal.
(B) diamonds.
(C) platinum.
(D) chromite.
(E) none of the above.

78. If basic rocks of the Upper Zone of the Bushveld Complex, are deeply weathered chemically, under acidic conditions, they are likely to produce
(A) kaolinitic clay.
(B) swelling clay.
(C) bentonitic clay.
(D) montmorillonitic clay.
(E) black turf.
(F) none of the above.

79. The spaces among particles of a rock may be connected: this increases the rock's
(A) permeability.
(B) porosity.
(C) density.
(D) moisture content.

80. Which of these statements is false about a stratum spring?
(A) An aquifer overlies an aquiclude.
(B) The aquifer and aquicludes form a syncline. ×
(C) Water accumulates in the aquifer.
(D) The water table reaches the surface.

81. This statement does not apply, to the formation of dolines:
(A) carbonates are present. ✓
(B) carbonates undergo carbonatisation. ✓
(C) ground fails into an underlying cavern. × Both
(D) the depression has steep slopes. ×
(E) none – all the statements apply to dolines.

82. For sinkholes to form, these conditions are necessary:
(A) the presence of carbonate.
(B) changes in climate.
(C) carbonatisation.
(D) formation of subsurface voids
(E) failure of ground into subsurface voids.
(F) all of the above.

83. The mechanical strength of a sandstone decreases as:
(A) the grains get more angular.
(B) the grains are more closely packed.
(C) the grains get coarser.
(D) the moisture content increases.
(E) none of the above is true.

84. The mineral, which, in most cases, influences the character of clay soils, is
(A) feldspar.
(B) calcite.
(C) magnetite.
(D) pyroxene.
(E) none of the above.

85. The mineral feldspar, undergoes weathering, mainly by
(A) carbonatisation.
(B) hydration.
(C) oxidation.
(D) reduction.
(E) all of the above.

86. When compared to montmorillonitic clay, kaolinitic clay
(A) has low water absorption.
(B) has low plasticity.
(C) has high permeability.
(D) all of the above
(E) none of the above.

87. Where gabbro is weathered physically, the main product is composed of
(A) montmorillonite-rich clays,
(B) chlorite.
(C) iron oxides.
(D) particles of gabbro.
(E) (A), (B) and (C).
(F) none of the above.

88. The mechanical strength of a rock, is determined by measuring the maximum
(A) compressive stress it can withstand before failure occurs.
(B) tensile stress it can withstand before failure occurs.
(C) shear stress it can withstand before failure occurs.
(D) all of the above.
(E) none of the above.

89. A body of rock will increase in its mechanical strength, under the following conditions, except if
(A) it becomes coarser in grainsize.
(B) its moisture content decreases.
(C) its porosity increases.
(D) it is under greater confining pressure.
(E) none of the above.

90. This list of cements of rock material is in increasing order of their bonding strengths
(A) silica, clay, carbonate, iron-oxide.
(B) iron-oxide, silica, clay, carbonate.
(C) carbonate, iron-oxide, silica, clay.
(D) none of the above.

91. Discontinuities in a body of rock, do not include
(A) bedding planes.
(B) joints.
(C) shear zones.
(D) folds.
(E) none of the above.

92. These rocks are listed in order from the weakest to the strongest mechanically:
(A) mudstone, siltstone, sandstone.
(B) rhyolite, granophyre, granite,
(C) basalt, dolerite, gabbro.
(D) all of the above.

93. The following need to be investigated during the study of a site targeted for a building
(A) ground water conditions.
(B) the extent of weathering.
(C) the properties of underlying rocks
(D) all of the above.
(E) none of the above.

94. Open excavations will have more stable slopes if the strike of the rocks
(A) is normal to the excavation axis.
(B) is parallel to the excavation axis.
(C) is oblique to the excavation axis.
(D) none of the above.

95. When a tunnel is excavated along a synclinal fold axis, as opposed to an anticlinal axis,
(A) the walls are more stable.
(B) the water drains into the tunnel
(C) the roof is less stable.
(D) all of the above.
(E) none of the above.

96. Suitable rocks, for foundations of the retaining wall of a water reservoir, must have this property:
(A) strong and competent.
(B) uniformity of rock types.
(C) stable when moist.
(D) all of the above.

97. Rocks with this property are suitable for the catchment area of a water reservoir:
(A) high permeability.
(B) prone to weathering.
(C) prone to erosion.
(D) none of the above.

98. Rocks are suitable for construction because
(A) they are readily available locally.
(B) they require little effort to extract.
(C) they require little energy to process.
(D) all of the above.

99. Rocks to be used as rip-rap need to have the following properties, except
(A) occurring near the construction site.
(B) being resistant to weathering.
(C) being able to take a polish.
(D) being fresh.

100. Characteristics of rocks suitable for coarse aggregate are listed below, with one exception, which is,
(A) they must free of cracks.
(B) they must be free of planar texture.
(C) they must be chemically reactive.
(D) they must be of satisfactory strength.

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FACULTY OF SCIENCE
ANSWER SHEET FOR SECTION A AND B

SECTION A - TRUE/FALSE QUESTIONS		SECTION B – MULTIPLE CHOICE QUESTIONS	
1	26	51	76
2	27	52	77
3	28	53	78
4	29	54	79
5	30	55	80
6	31	56	81
7	32	57	82
8	33	58	83
9	34	59	84
10	35	60	85
11	36	61	86
12	37	62	87
13	38	63	88
14	39	64	89
15	40	65	90
16	41	66	91
17	42	67	92
18	43	68	93
19	44	69	94
20	45	70	95
21	46	71	96
22	47	72	97
23	48	73	98
24	49	74	99
25	50	75	100

INSTRUCTIONS FOR SECTION C ONLY

Answer any five questions. Use the numbered corresponding spaces on the answer script. Give only brief answers. Only "bullet" points, preferably one per line, or clearly separated if on the same line, need be given. The questions carry equal marks – Total: 125 marks.

101. You are informed that the site targeted for a new housing complex, is underlain by basalt. The region has undergone, a long geological period of humid, but alkaline weathering conditions. The water table is very high and there are springs in the area after heavy rain.

(A) Concerning the stability of the foundations, and given the above conditions, outline a natural feature, that should be of concern to you, as the site manager, for the housing construction project. **(5 marks)**

(B) Describe the natural processes, leading to the occurrence of the natural feature, mentioned in 101 (A). **(10 marks)**

(C) What steps would you take, to ensure that the phenomenon mentioned in 101 (A), does not negatively impact the foundations, of the housing complex, during or after construction? **(10 marks)**

102. The Transvaal Supergroup includes impure carbonates. An area underlain by such rocks is targeted for a housing construction project. The region has been through two climatic periods, each going on for hundreds of thousands of years. The first was equatorial, with high rainfall and temperatures. The second was arid, but still hot.

(A) Considering the foundations of the intended construction project, mention a natural geological feature likely to have formed, which would negatively affect the stability, of the foundations. Describe the negative impact and the way in which it would affect the buildings' foundations. **(5 marks)**

(B) Outline, in order, the processes, circumstances and events, which led to the formation of the natural geological features mentioned in 102 (A). **(16 marks)**

(C) Mention the steps, you would take to avert the potential problems if you mentioned any in 102 (A). **(4 marks)**

103. There are two tunneling projects, one through gneiss, and the other in a region of steeply dipping slate. The slate is also jointed normal to the steep, slaty cleavage.

(A) List and briefly describe the advantages and disadvantages of tunneling in the gneissic area. **(5 marks)**

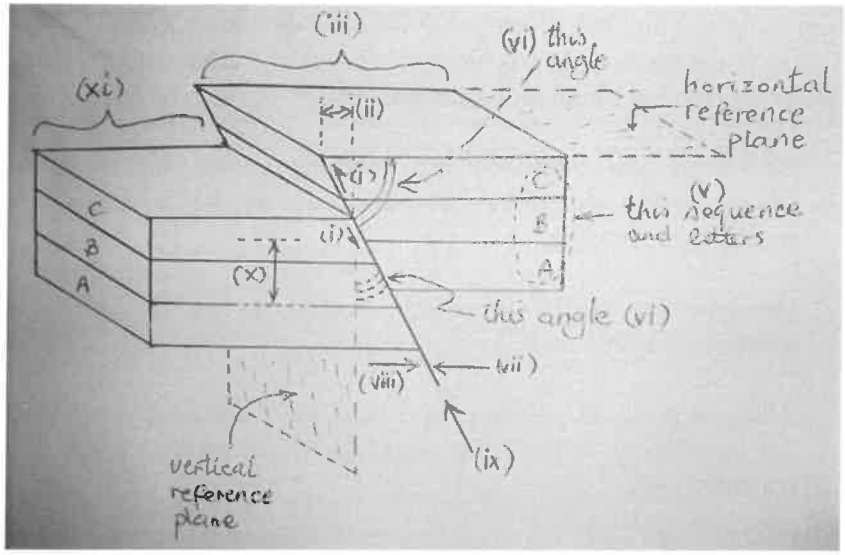
(B) List and briefly describe the advantages and disadvantages of tunneling in the slate area. **(5 marks)**

(C) Draw and fully label sketches, to illustrate the situation, when tunneling through the slate at right angles, to the strike of the slaty cleavage. **(5 marks)**

(D) Draw and fully label sketches, to illustrate the situation, if the tunneling is parallel, to the strike of the slaty cleavage. **(5 marks)**

(E) In terms of ground failure, which of the three situations, poses the greatest risk? Give reasons for your answer using, the comparisons made above. **(5 marks)**

104. (A) What kind of fault is shown in the sketch below? **(3 marks)**



(B) Name all the parts with pointer arrows. **(11 marks)**

(C) How will tunneling through the fault perpendicular to its strike, impact the stability of

(i) the tunnel roof, **(3 marks)**
(ii) the tunnel walls? **(3 marks)**

(D) Are there any differences, if the tunnel development approaches the fault, from the footwall-side, or from hanging-wall side? If so, what are the differences? **(2 marks)**

(E) Between the approach of the tunnel development from the footwall side, and the approach from hanging wall side, which is the better of the two, in terms of roof and wall stability? Give reasons for your response. **(3 marks)**

105. You are given a list of four rocks, namely, gabbro, mudstone and dolomite.

(A) Give a brief description of each of the rocks i. e. what are they? **(9 marks)**

(B) Imagine that you have to make an open, road excavation, though each of the rocks, and in every case:

(i) make a list of the positive characteristics of each, which will contribute towards stability of the excavation slopes. **(8 marks)**

(ii) make a list of the negative characteristics of each which will help reduce stability of the excavation slopes. **(8 marks)**

N. B. If any rocks have inherent layering, give responses for situations when such structures are steeply dipping, and when they are horizontal.

106. You are in charge of construction of a water reservoir. Mention and describe the characteristics of rocks suitable

(A) for the catchment area. **(4 marks)**

(B) for the reservoir area. **(4 marks)**

(C) for the dam wall zone. **(5 marks)**

(D) give one example of a rock type suitable for

(i) the catchment area. **(2 marks)**

(ii) the reservoir area. **(2 marks)**

(iii) dam wall zone. **(2 marks)**

(E) give one rock example which is unsuitable for

(i) the catchment area. **(2 marks)**

(ii) the reservoir area. **(2 marks)**

(iii) dam wall zone. **(2 marks)**

107. N. B. For this question, you will need a pen, paper and calculator. Write your answers on the paper and copy them onto the Blackboard platform at the end of the question, where the spaces for answers will be provided.

Using the Q-System of Barton, the accompanying field data (below), and the reference tables and graphs below, answer the questions (A) to (H) that follow. Use the spaces provided to give your answer. Use single word responses.

FIELD DATA

Parameter	Description
Rock Quality	Length of drilled core: 280m Length of core +100mm: 260
Joint set detail	Two joint sets
Joint surface description	Slickensided and discontinuous
Joint filling or alteration	Tightly healed, hard, non-softening impermeable rock mineral filling
Joint separation	0mm
Ground water	Dry excavation
Head of water	<10m
Stress reduction factor	Competent rock mass UCS = 225MPa Depth = 1190m, Density = 2755kg/m^3

JOINT SET NUMBER REFERENCE TABLE

Number of Joint Sets	Joint Set No. J_n
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 J_a for Joint Separation (mm)		
	<1.0[1]	1.0-5.0[2]	>5.0[3]
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*	6.0[4]	10.0
Softening or low friction clay mineral coatings and small quantities of swelling clays	4.0	8.0*	13.0*
Softening moderately over-consolidated clay mineral filling, with or without crushed rock	4.0*	8.0[4]	13.0
Shattered or micro-shattered (swelling) clay gouge, with or without crushed rock	5.0*	10.0[4]	18.0

JOINT WATER REDUCTION FACTOR REFERENCE TABLE

Condition of Groundwater	Head of water (m)	Joint Water Reduction Factor J_w
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

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

(Principal stress = ρ gh = σ_1) where g = 9.81

Competent rock/Stress problems	UCS /σ_1	σ_t / σ_1	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**

(A) Determine the Q-Value, TO ONE DECIMAL PLACE, Given that

Q-Value = RQD x Jr x Jw x Jw / (Jn x Ja x Ja x SRF), and

RQD = the Rock Quality Designation

Jr is the Joint Roughness Number

Jw is the Joint Water Reduction Factor

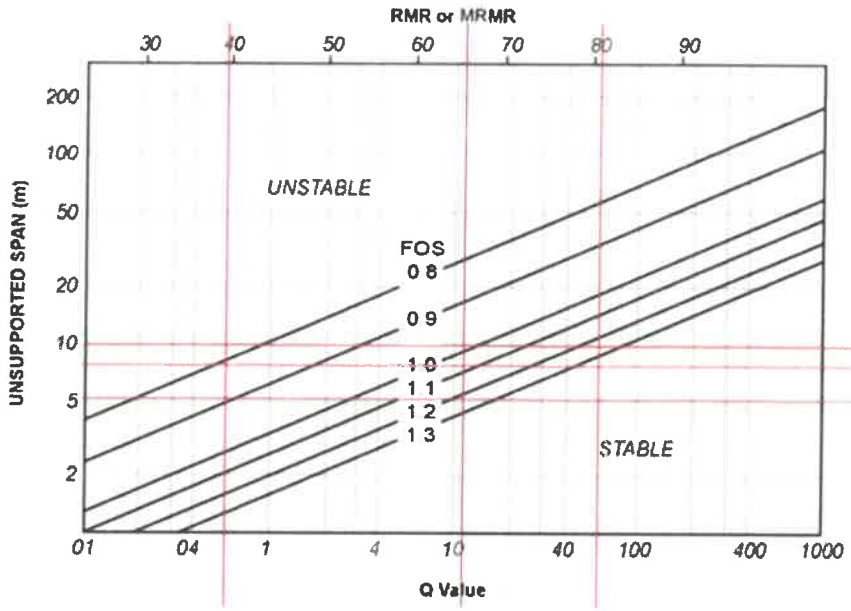
Jn is the Joint Set Number

SRF is the Stress Reduction Factor

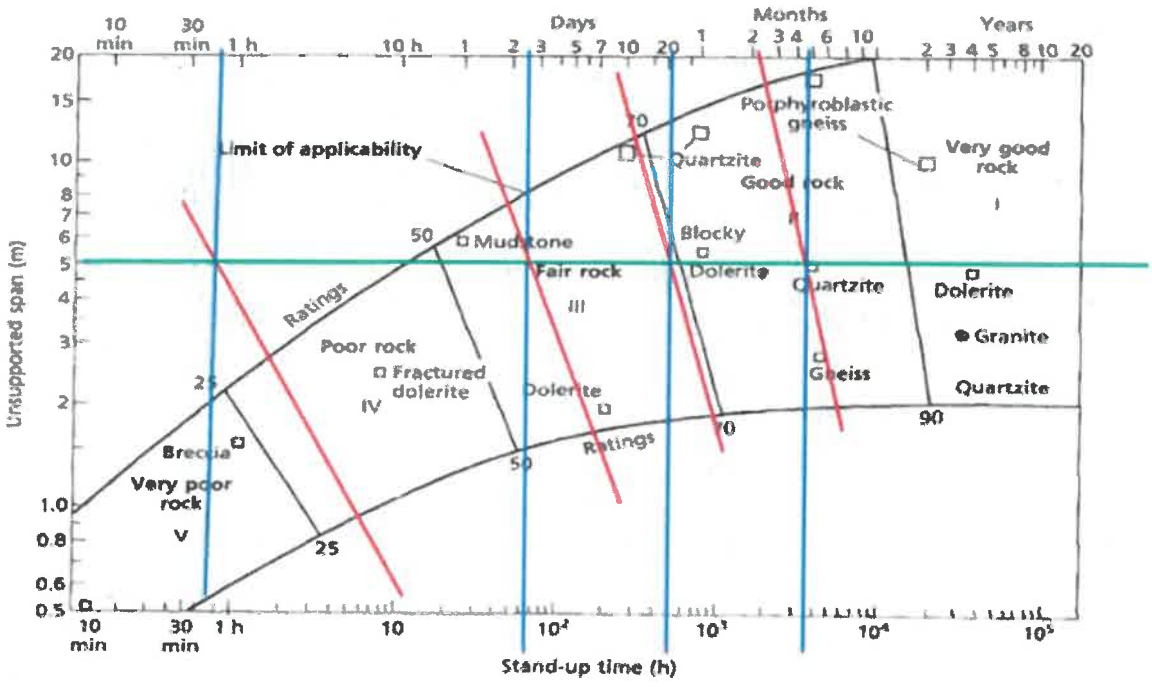
(10 marks)

(B) What is the equivalent Bieniawski rock mass rating (RMR) for the Q-Value just worked out, given that RMR = 9 x lnQ + 44? (2 marks)

(C) On the figure below, select the correct combination of the red plot lines, and determine the factor of safety (FOS) for a tunnel 5 metres wide . (2 marks)



(D) In the figure below, select the correct plot lines and read off the stand-up time for a tunnel with a span of 5m. Read the time on the top horizontal axis. (2 marks)



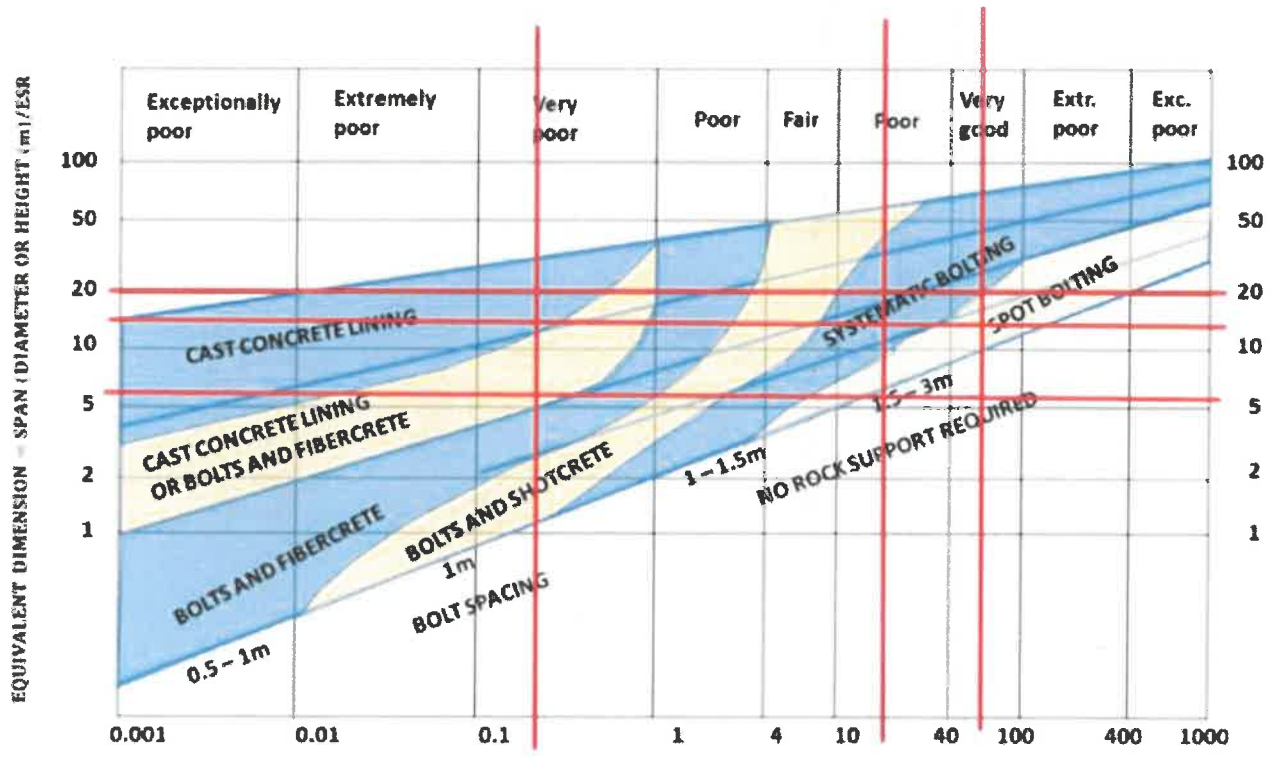
(E) Will the FOS and Stand-Up-Time increase or decrease if the tunnel span is changed to 15m? **(2 marks)**

(F) You are informed that the tunnel is 12m wide and for an underground nuclear station. Use the table of Equivalent Support Ratios (ESR) for Different Excavations, to determine the correct Equivalent Dimension (ED) where ED = Span/ESR. **(2 marks)**

EQUIVALENT SUPPORT RATIOS FOR DIFFERENT EXCAVATIONS

Excavation Category	Equivalent Support Ratio (ESR)	Excavation Category
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

(g) What is the preventative work necessary for the excavation to be stable. Use the diagram below, determine the correct pair of lines and their intersection to find the answer. (2 marks)



End of GLGB2B2 February 2021 special examination

101 (A) Swelling clay - due to weathering (alkaline) of plag feldspar in the basalt

(B) alkaline weathering of plagioclase feldspar → montmorillonite-rich clay → expands when invaded by water

(C) remove the clay
elevated foundations
block water ingress

102. (A) & (B) dolerites ; carbonatisation of the carbonate when WT is high due to high rainfall
leaves insoluble impurities

these shrink when dry
during later phase, low rainfall climatic shrinking → depression → foundation deformation → failure of houses

(C) map
geophysical surveys
drill
remove soil & build foundations on underlying rock and material

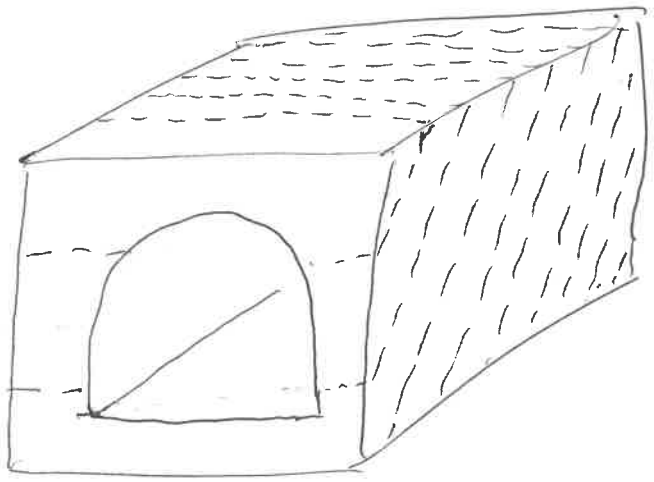
103. (A) ⊖ expensive to tunnel due to high rock mass strength
⊕ ⊖ layering gives zones of weakness prone to failure
⊕ strong rocks & rock masses → stable foundations

(B) ⊖ layering ⊖ mech weak
⊕ soft & therefore easy to excavate

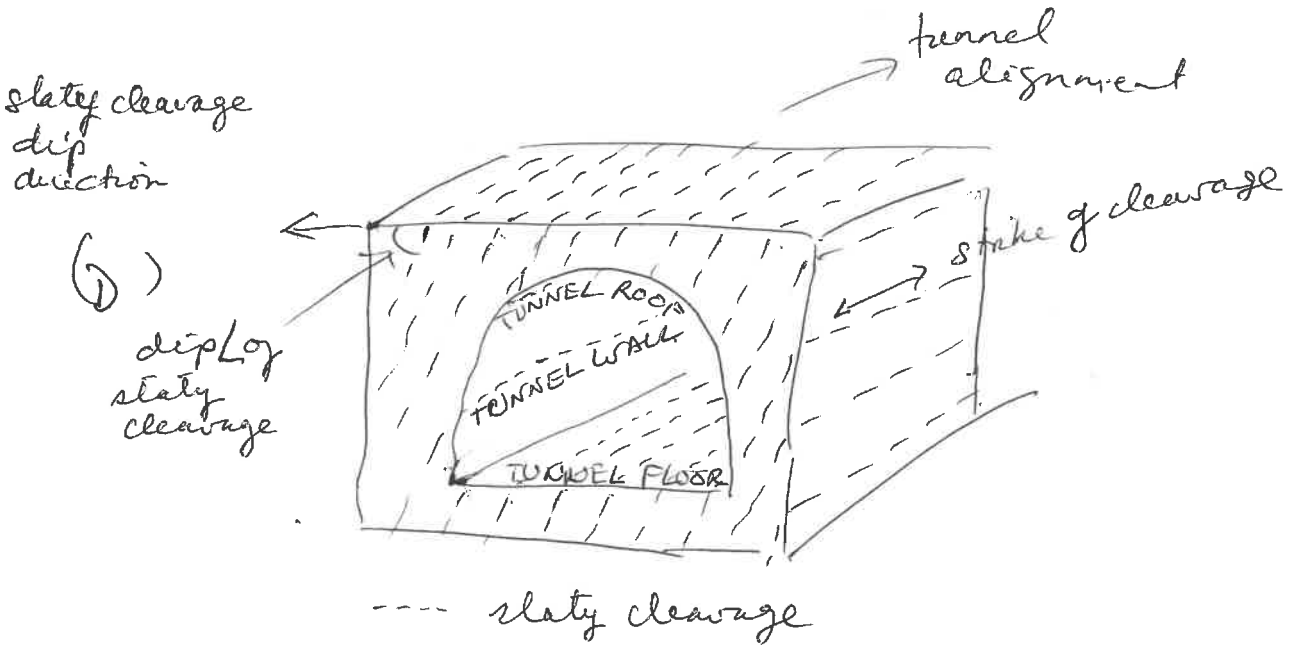
(C)

(P72)

(C)



See labels below.



(E) D. Due to (i) roof prism failure
(ii) dip into excavation (right wall)
(iii) slabbing (left wall)

PTO

104 (A) Reverse fault

104 (B) sense of movement (ii) throw (iii) hanging-wall block (iv) dip angle (v) marker units (vi) hade (vii) footwall (viii) hangingwall (ix) fault (reverse) (x) throw (xi) footwall block

104 (C) (i) stable (ii) stable

(D) hanging wall block side: fault encountered 1st on the floor of excavation - no danger of failure without warning

from footwall block side: fault intersected 1st in the roof. Potential of roof wedge failure without prior warning

(E) Better from hangingwall block side: fault encountered before failure in roof

105 (A) gabbro: igneous, coarse, essential plag feldspar & clinopyroxene

mudstone: sed, clastic, fine-grain, qtz, clay, ± mica

dolomite: sed, chem, fine - composed of the mineral dolomite

P 10

105 (B) & (C) gabbro – +ve : strong → stable walls
–ve : expensive to excavate due to high mech strength

mudstone – +ve – easy to excavate (low mech strength)
–ve – easily fail due to mech low strength
– may be prone to swelling if clay is montmorillonitic

dolomite – +ve – hard (strong mechanically
–ve – ~~dol~~ sinkhole potential high.

NB – mudstone layering steep – excavation // to strike, one wall will be prone to failure if layering dips into ~~road~~ excavation
– excavation ⊥ to strike. – stable slopes
– layering horiz – no effect on stability

dolomite layering – see above for ~~dol~~ mudstone.

106. (A) not prone to weathering + erosion
not permeable

(B) not permeable, strong

(C) not permeable, strong, not prone to change due to wetting + drying, dip into slope, not into dam

(D)(i) all igneous rocks, all mtc rocks (any one)
(ii) " " " " " " "
(iii) " " " " " " "

106 (E) (i) shale

(ii) sandstone

(iii) - ~~mudstone~~ shale

- slate dipping into the dam

107. (A) 0.6

(B) 39

(C) 1.1

(D) I

(E) increase

(F) 2

(G) bolts & fibercrete