



EXAMINATION PAPER

SUBJECT: CERTIFICATE IN ROCK MECHANICS PAPER 2: BASIC ROCK MECHANICS PRACTICE SUBJECT CODE: COMRMC DATE: 07 MAY 2025 TIME: 14H00 TO 17H00	EXAMINER: N Netshivhazwaulu MODERATOR: GR Gainsford TOTAL MARKS: 100 PASS MARK: 60%

NUMBER OF PAGES: 8

EXAMINATION FORMAT: CLOSED BOOK. NO REFERENCES OTHER THAN WHAT ARE PROVIDED ARE ALLOWED.

SPECIAL REQUIREMENTS:

1. Answer all the questions in legible English.
2. Write your ID number (no names) on the outside cover page of each script used and on any graph paper or other loose sheets handed in.
3. Show all calculations and check the calculations on which the answers are based.
4. Hand-held electronic calculators may be used for calculations. Reference notes may not be programmed into calculators.
5. Write legibly in black ink on the right-hand page only. Left-hand pages will not be marked.
6. Illustrate your answers using sketches or diagrams wherever possible.
7. Final answers must be given with accuracy typical of practical conditions; however, be careful not to use too few decimal places during your calculations, as rounding errors may result in incorrect answers.

NB: Ensure that the correct unit of measure (SI unit) is used as marks will be deducted if the incorrect unit is used even if the calculated value is correct.
8. In answering the questions, full advantage should be taken of your practical experience as well as the data given.
9. You are not allowed to contact your examiner or moderator regarding this examination.
10. Cell phones and other smart devices are not allowed on your person and must be handed to the invigilators or left in your vehicle.

QUESTION 1. SURFACE MINING AND REGULATION

1.1. What role does pre-split have in attaining the overall stability of an open-pit mine?	(4)																																																								
1.2. Your technical service manager has asked you to represent the following joint mapping data in a rose diagram to delineate joint sets before you can conduct a kinematic analysis. Plot the orientation of the joints shown in a rose diagram. <table><tr><th>Dip (°)</th><th>DDir (°)</th><th>Dip (°)</th><th>DDir (°)</th><th>Dip (°)</th><th>DDir (°)</th><th>Dip (°)</th><th>DDir (°)</th></tr><tr><td>53</td><td>183</td><td>49</td><td>170</td><td>54</td><td>164</td><td>55</td><td>92</td></tr><tr><td>54</td><td>78</td><td>56</td><td>85</td><td>85</td><td>120</td><td>73</td><td>336</td></tr><tr><td>63</td><td>107</td><td>59</td><td>84</td><td>87</td><td>123</td><td>56</td><td>85</td></tr><tr><td>56</td><td>78</td><td>42</td><td>62</td><td>31</td><td>126</td><td>54</td><td>87</td></tr><tr><td>89</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr><tr><td></td><td>121</td><td>49</td><td>63</td><td>35</td><td>49</td><td>54</td><td>86</td></tr></table>	Dip (°)	DDir (°)	Dip (°)	DDir (°)	Dip (°)	DDir (°)	Dip (°)	DDir (°)	53	183	49	170	54	164	55	92	54	78	56	85	85	120	73	336	63	107	59	84	87	123	56	85	56	78	42	62	31	126	54	87	89									121	49	63	35	49	54	86	(5)
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1.3. List the main responsibilities of the rock engineer in accordance with Regulation 14.1.8 (MHSA).	(3)																																																								
1.4. Explain two requirements for reporting falls of ground and one requirement for reporting caving to the Principal Inspector of mines as it is legally required in South Africa.	(3)																																																								
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QUESTION 2. MINING SUPPORT AND DESIGN

All underground mining methods and some surface mining methods require the use of various artificial mine support systems to ensure stability.

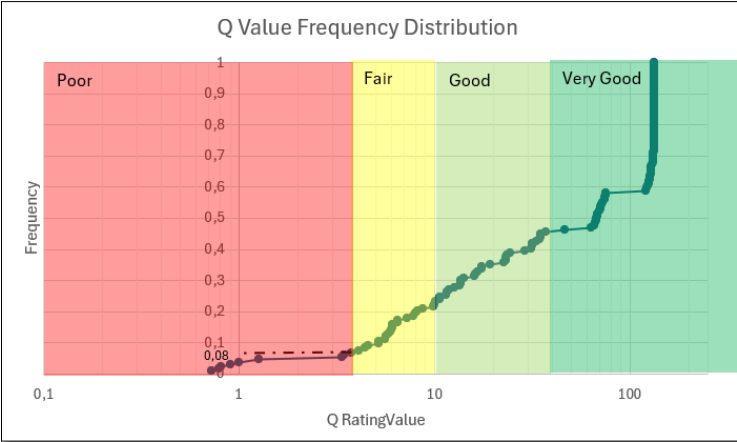
2.1. Backfill for underground is used in some mines as support:

a) Define and differentiate between hydraulic, paste, and cemented rock fill. Include the advantages and disadvantages of each. (6)

2.2. In a paste backfill mine, unexpected failures occurred in backfilled stopes. List three (3) possible causes and suggest remedial actions for each. (6)

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2.3. A gold mine at a depth of 840m below the surface, which employs conventional scattered breast mining, intends to extend the life of one of its sections. You are invited to be part of the extension project team as a rock engineering practitioner. The mine will access the reef through haulages and crosscuts, which are 3.5m wide and 3.5m high, and it is intended to mine 30m long panels, which will be supported by mine poles in the working area and a single line of mechanical props in the face area (3m from the face). The exploration program's off-reef rock mass classification results are shown in the graph below. The project team has asked you to determine the following:



a) Determine the requirement for the access tunnel, including bolt length, spacing and areal support (5).

b) Determine the support spacing for mine poles and mechanical props (FS=1.5), given that the mine's fall-out thickness is 1.0m, rock density is 3000kg/m³, and the last line of the mine pole must not be more than 4m from the face. (6)

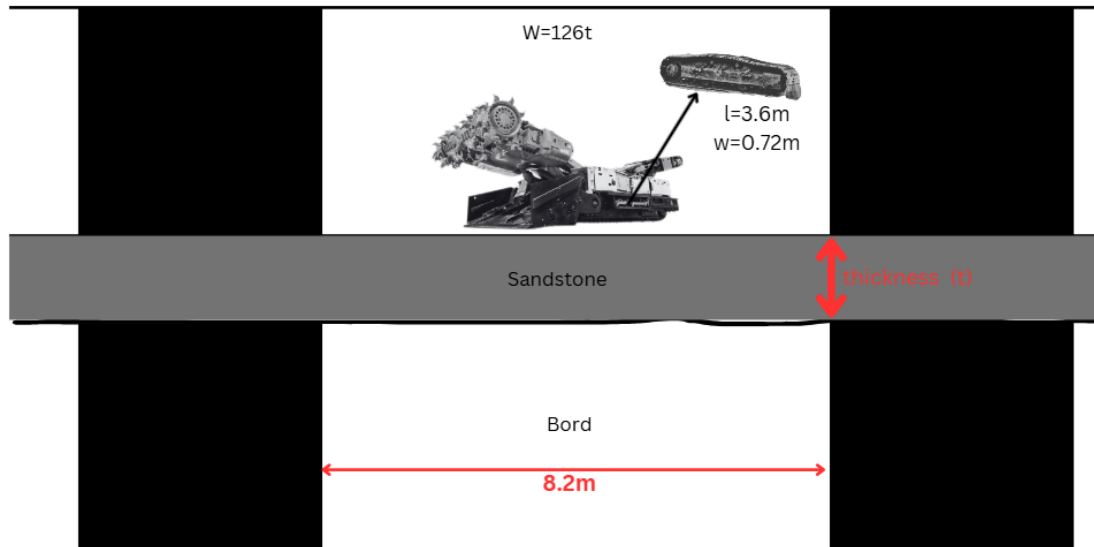
(13)

Support Unit	Peak Load (kN)
Mine Pole	220
Mechanical Props	150

c) Comment on how you could improve the design to cater to small rock falls. (2)	
	[25]

QUESTION 3. MINING METHODS

3.1 Briefly describe (in a table) the difference in the following mining method in terms of i) method description, ii) applicable depths, iii) broken ore (ROM) transportation from face to stockpile/plant: a) Sequential Grid b) Bord and Pillar c) Open Pit (Cut) d) Sub-level Caving	(12)
3.2. A coal mine located in Mmamabula employs a bord and pillar mining method with mechanised rock-cutting equipment, primarily continuous miners. Recently, the mine has declared economic reserves on a coal seam situated directly above the currently mined seam. To access this upper seam, new access roadways are planned, which some must be developed to traverse the overlying ground above existing mined-out workings. The pillars of the upper seam are planned to be superimposed to the lower seam and the roadways will be subject to the weight and vibrations of the largest equipment, which will operate directly above voids left in the lower seam. The middling separating the upper and lower seams must be sufficiently thick and stable to support the weight of the continuous miner during operations. The middling consists predominantly of sandstone, with a known density of 2400 kg/m³ and a tensile strength of 4.8 MPa. The rock mass is generally competent, with no major geological structures cutting across. It has also been said by the mechanical engineer on site that the weight of the continuous miner is 126 tons which is uniformly distributed through two (2) identical tracks.	



3.2.1. Describe the principle behind superposition of pillars in multiple ore-body mining.

(3)

3.2.2. List and briefly describe the three typical beam types described in Beam Theory as applied in rock mechanics.

(6)

3.2.3. Which beam type/analysis most appropriate describe the problem above and **Why?**

(3)

3.2.4. Determine the middling that will be required to yield a **FOS of 2** given a maximum tensile stress on the Sandstone of 6000 kN/m^2 under the following conditions:

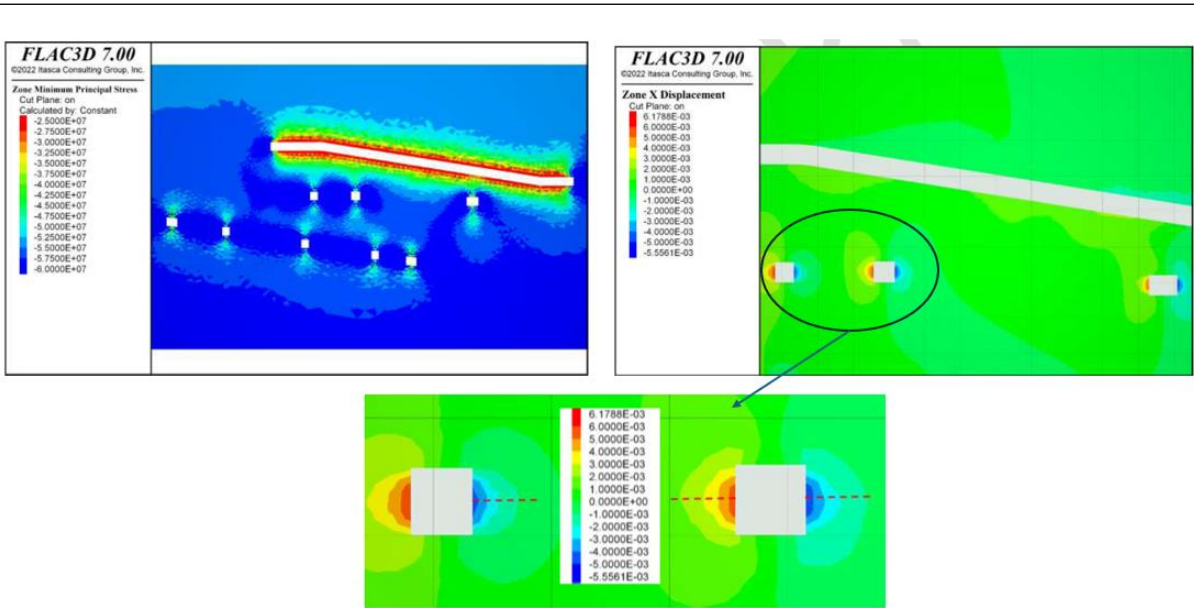
(6)

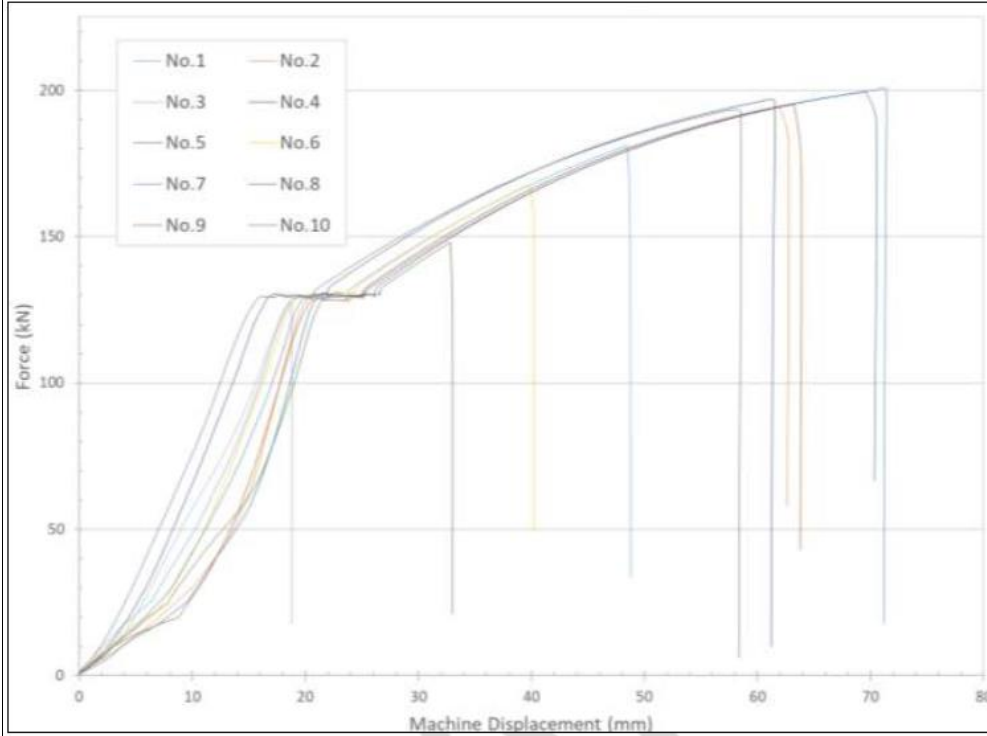
- a) There is no geological plane cutting through the middling (3).
- b) There is a single geological structure, cutting across vertically (3).

[30]

QUESTION 4. NUMERICAL MODELLING

4.1. Describe the rock engineering application where the following modelling may be applicable: a) Finite Element Method b) Finite Difference Methods c) Limit Equilibrium Methods d) Boundary Element Methods e) Keyblock Methods	(5)
4.2. Explain the difference between elastic and in-elastic modelling concepts as applied in rock engineering.	(3)
4.3. FLAC3D was used to evaluate the stability of a belt drive and its interaction with the belt drive in an underground mine. The belt drive was to be supported with 2.4m long rebars tested in the lab (see results). a) Given the results below, will the middling between the belt drive and the underlying tunnels be stable? Explain why. (3) b) Will the 2.4m rebars provide adequate yield capacity for the predicted deformations? (2) c) What will be one limitation of the results from FLAC3D compared with a Distinct Element method application? (2)	(7)





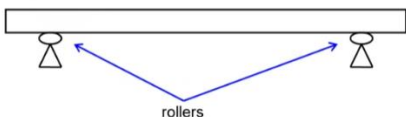
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QUESTION 5. MINE SEISMICITY

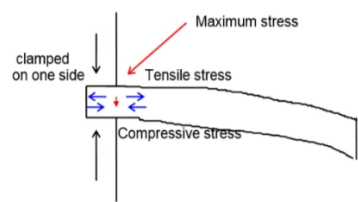
4.1. In a mine at a depth of 3021m below surface, the frequency of seismicity has been on the rise and is concentrated along fault zones; a) What engineering controls would you recommend to manage the risk (2) b) What role does pre-conditioning play in managing seismicity? Explain (2)	(4)
4.2. Discuss the importance of seismic network design in accurately locating and analysing seismic events during an investigation.	(6)
4.3. Two principal waves are generated during a seismic event; a) Explain what is the difference between these waves. (1) b) With an annotated sketch, visually show this difference. (4)	(5)
	[15]

Total Marks = [100]

FORMULA SHEET



$\sigma_{\max} = \frac{3.W.L^2}{4t^2}$ (centre) and $\tau_{\max} = \frac{3.W.L}{2.t}$ (ends)



$\sigma_{\max} = \frac{3.W.L^2}{t^2}$ and $\tau_{\max} = \frac{3.W.L}{2.t}$

Maximum stress
 Tensile stress
 Compressive stress
 clamped on one side

$$\sigma_1 = \sigma_3 + \sqrt{(s\sigma_c^2 + m\sigma_c\sigma_3)}$$

$$\sigma_1 = \sigma_c + \beta_o\sigma_3$$

$$\varepsilon_3 = \frac{[\sigma_3 - \nu(\sigma_1 + \sigma_2)]}{E}$$

$$\sigma_1 = \sigma_3 + \sigma_{ci} \left(m_b \frac{\sigma_3}{\sigma_{ci}} + s \right)^a$$

$$\sigma_1 = \sigma_3 + \sigma_{ci} \sqrt{m_i \frac{\sigma_3}{\sigma_{ci}} + 1}$$

$$\tau = C_o + \mu\sigma_n$$

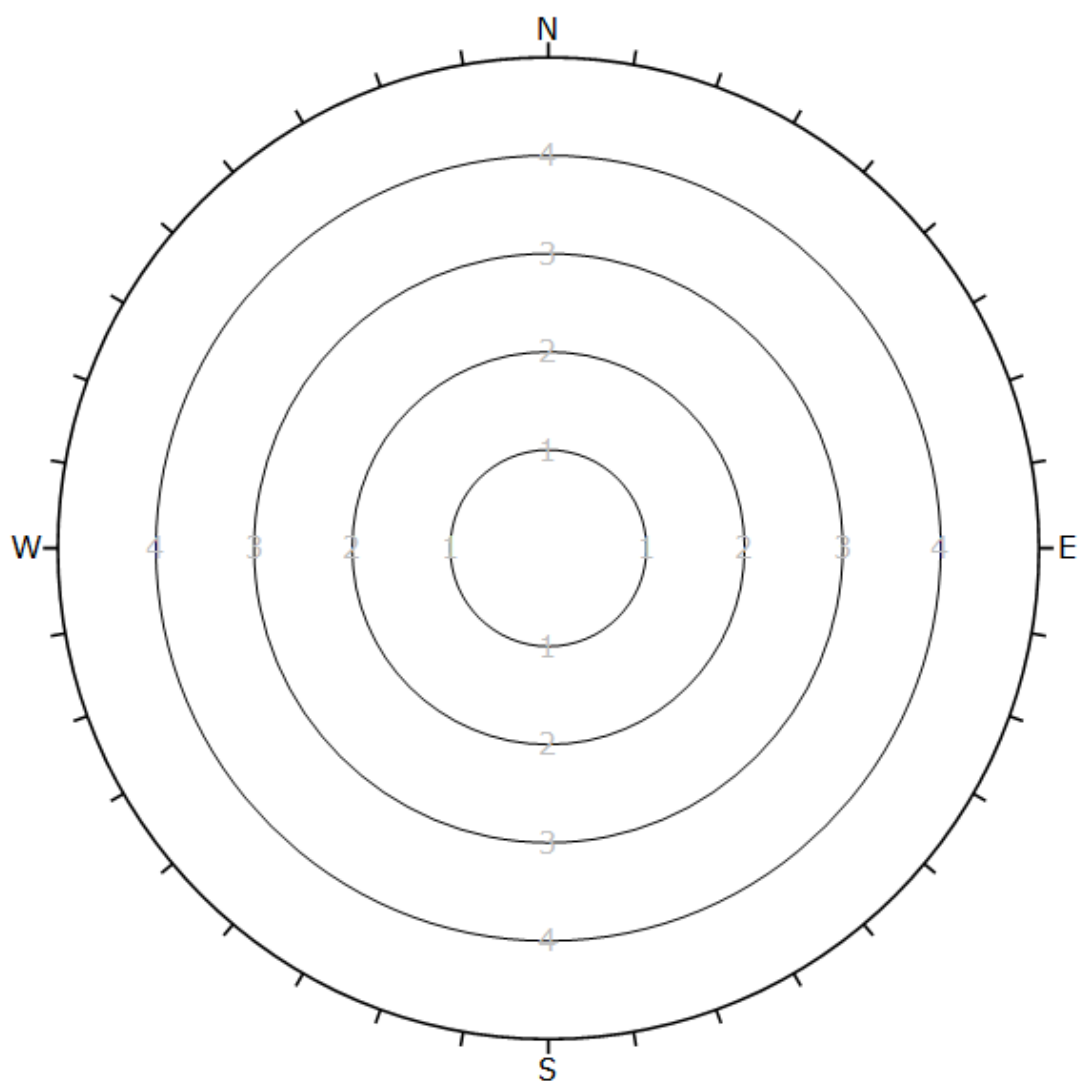
$$\tau_{\max} = \frac{1}{2}(\sigma_1 - \sigma_2)$$

$$\tau = \sigma' \tan \left(\phi + \text{JRC} \log_{10} \left(\frac{\text{JCS}}{\sigma'} \right) \right)$$

$$\phi_j \approx \tan^{-1} \left(\frac{J_r}{J_a} \right)$$

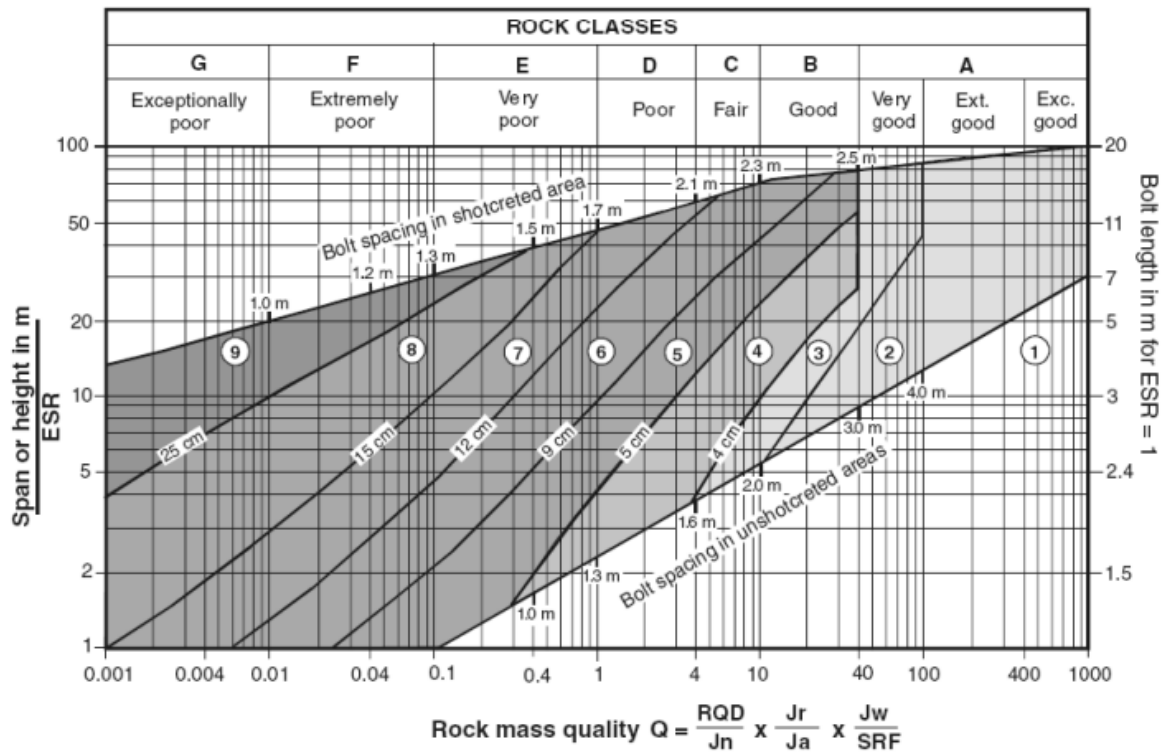
Appendix 1:

ID no _____



Appendix 2: Grimstad & Barton Chart

ID No _____



REINFORCEMENT CATEGORIES:

- | | |
|---|---|
| <ul style="list-style-type: none"> 1) Unsupported 2) Spot bolting 3) Systematic bolting 4) Systematic bolting, (and unreinforced shotcrete, 4 - 10 cm) 5) Fibre reinforced shotcrete and bolting, 5 - 9 cm | <ul style="list-style-type: none"> 6) Fibre reinforced shotcrete and bolting, 9 - 12 cm 7) Fibre reinforced shotcrete and bolting, 12 - 15 cm 8) Fibre reinforced shotcrete, > 15 cm, reinforced ribs of shotcrete and bolting 9) Cast concrete lining |
|---|---|