*UNIVERSITY OF EXETER IN CORNWALL*

# CAMBORNE SCHOOL OF MINES

## EUROPEAN MINING COURSE

## FINAL EXAMINATIONS

## SURFACE EXCAVATION & DESIGN

**MODULE M076**

**March 2005** **2.5 HOURS**

**Answer THREE Questions, with at least ONE from each section.**

### SECTION A

1. (a) Describe, with the aid of two sketches, the components of a polygon of forces suitable for analysing the stability of a rock block liable to plane failure. The sketches should be a cross section of typical plane failure geometry, and a polygon of forces. The forces should be included in both sketches and the key dimensions and angles should be included in the cross section. The method of calculating the factor of safety should be indicated in the polygon of forces sketch. (8 marks)

(b) A rock block has been identified with the characteristics described below.

| | |
|---|---|
| Weight of block, W | 2020 kN/m |
| Water force in vertical tension crack, V | 190 kN/m |
| Water uplift force on failure plane, U | 390 kN/m |
| Dip of failure plane, $\varphi_p$ | 35° |
| Cohesion on failure plane, c | 50 kPa |
| Length of failure plane, L | 13 m |
| Friction on failure plane, $\phi$ | 40° |

Initially an active bolt tension force of 350 kN/m is considered, applied to the block face at an angle $\beta$ of 30° below horizontal.

Determine the factor of safety for the block in this case by constructing a polygon of forces. (10 marks)

(c) If the same factor of safety is to be achieved without tensioned bolts but using passive dowel support (shear only, equivalent to enhanced cohesion), what is the required additional shear force from the dowels (kN/m) ? Show how you calculate this shear force on the same polygon of forces as for part (b) (7 marks)

Over / ....

2. (a) Give an account of the different methods that are available to analyse circular failures in soil and weak rock slopes. Include consideration of both computer- and chart-based limit state methods, with their advantages and limitations, hence when it is appropriate to use each method. Use sketches to explain the computer based method. (7 marks)

(b) The attached sketch shows the final stage of a proposed slope, to be developed in 5 equal benches. The slope material has a cohesion of 40 kPa, friction angle of 35° and a unit weight of 20 kN/m$^3$. Determine the factors of safety for the whole slope, the top bench and the bottom bench using the charts provided *. Explain why you have selected the specific chart for each case. (12 marks)

(c) Comment on the factors of safety and any possible alterations to the design if the toe of the slope is to be adjacent to a busy highway. (6 marks)

3 Preliminary geotechnical investigation of a rock outcrop has identified several major joint sets. A proposed, 20 m high rock cutting has a dip of 75 degrees and is aligned West-East. A brief discontinuity survey has been conducted (less than 100 discontinuities sampled), with the following sets identified:

| Joint Set | Mean Dip (°) | Mean Dip Direction (°) |
|---|---|---|
| Joint Set A | 50 | 172 |
| Joint Set B | 80 | 186 |
| Joint Set C | 78 | 005 |
| Joint Set D | 80 | 126 |

(a) Construct suitably labelled overlays for kinematic analysis of different potential failure mechanisms. Where appropriate, indicate whether the overlay construction is suitable for either planar or polar analysis. In your overlay construction assume that the average angle of friction for the identified discontinuities is 30 degrees. (8 marks)

(b) Through appropriate stereographic overlay interpretation, identify any likely failure mechanisms that may occur in the rock slope (making sure that you justify any assumptions made and explain, if necessary, why particular failures are unlikely). Show, with sketches of the slope, any potential failure mechanisms identified. (8 marks)

**Hand in any overlay constructions if you answer this question**

(c) Provide a summary of key advantages and limitations of stereographic analysis when applied to this example. (5 marks)

(d) Base on your findings, suggest the next stage of slope stability investigation for the proposed rock cutting. (4 marks)

Over / ....

## SECTION B

4. (a) Describe why a Blasting Specification is necessary in an operating UK based quarry. (5 marks)

   (b) Describe, using annotated diagrams where appropriate, the various components that form a legal Blasting Specification. (20 marks)

5. (a) Describe how you would conduct a blast vibration analysis of an open pit so as to reduce the possibility of 1:40 blasts exceeding a peak particle velocity of 6 mm/s at the nearest property. (10 marks)

   (b) What do you understand by the terms:

   (i) MIC (5 marks)
   (ii) Sympathetic detonation (5 marks)
   (iii) Non-electric blast timing (5 marks)

**Examiners** **R.J. Pine, J.S. Coggan, A. Wetherelt**

**Accessories:** **Tracing paper, stereonet & drawing pin**

Figure Q.2

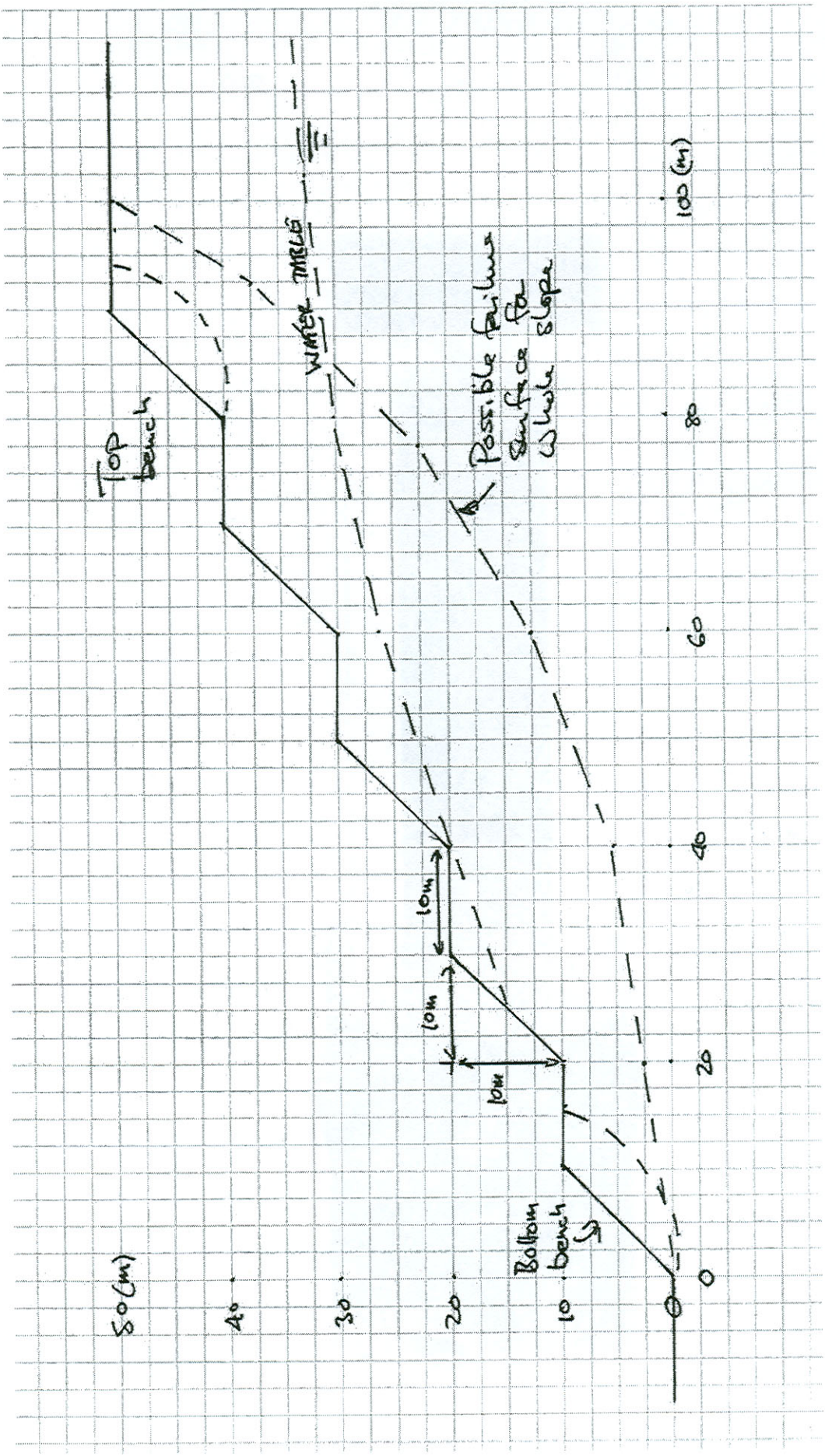
Top bench
Water table
Possible failure surface for whole slope
Bottom bench
10m
10m
10m
50 (m)
40
30
20
10
0
100 (m)
80
60
40
20

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Chart Q.2

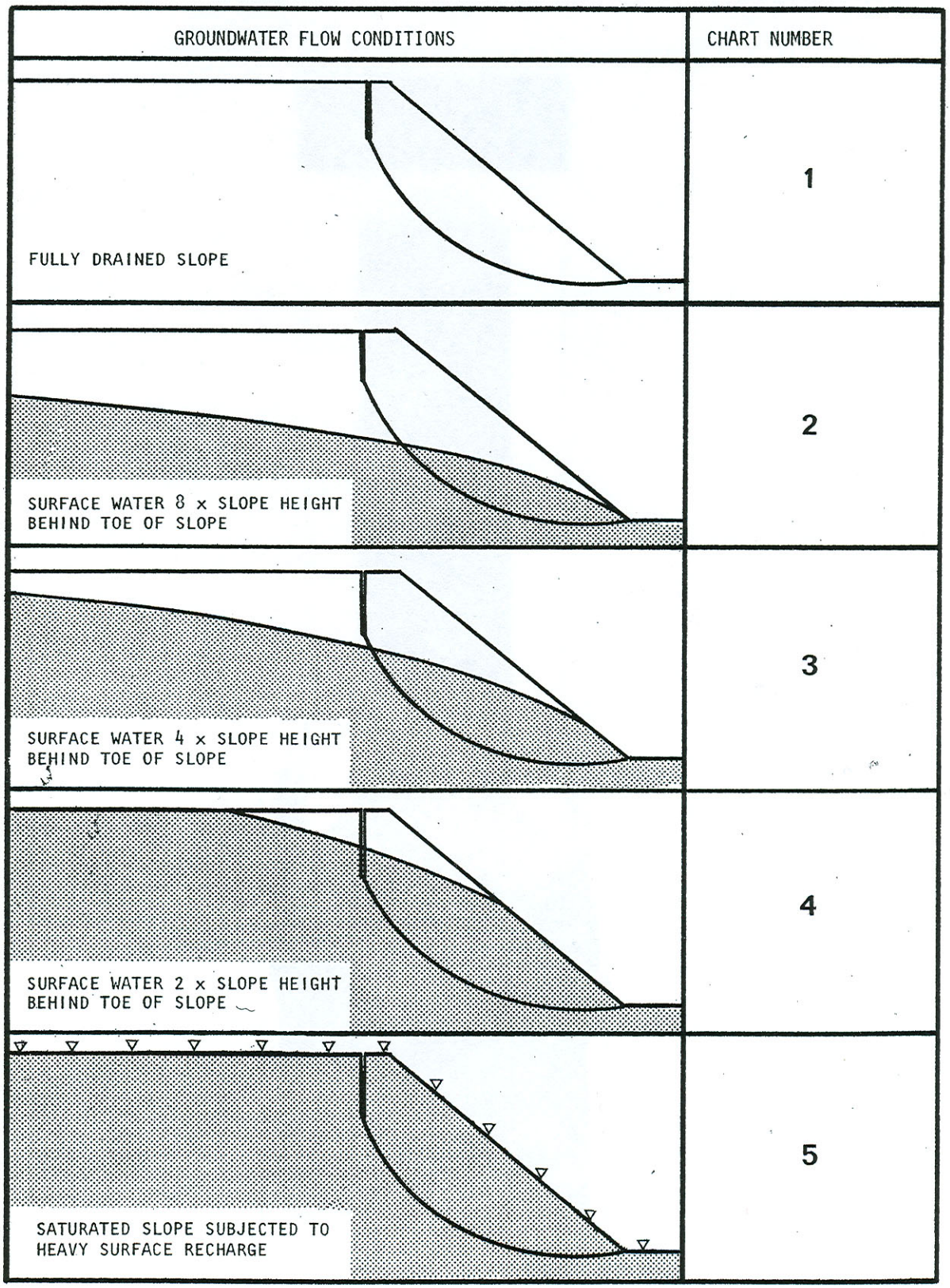

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Chart Q.2

# CIRCULAR FAILURE CHART NUMBER 1

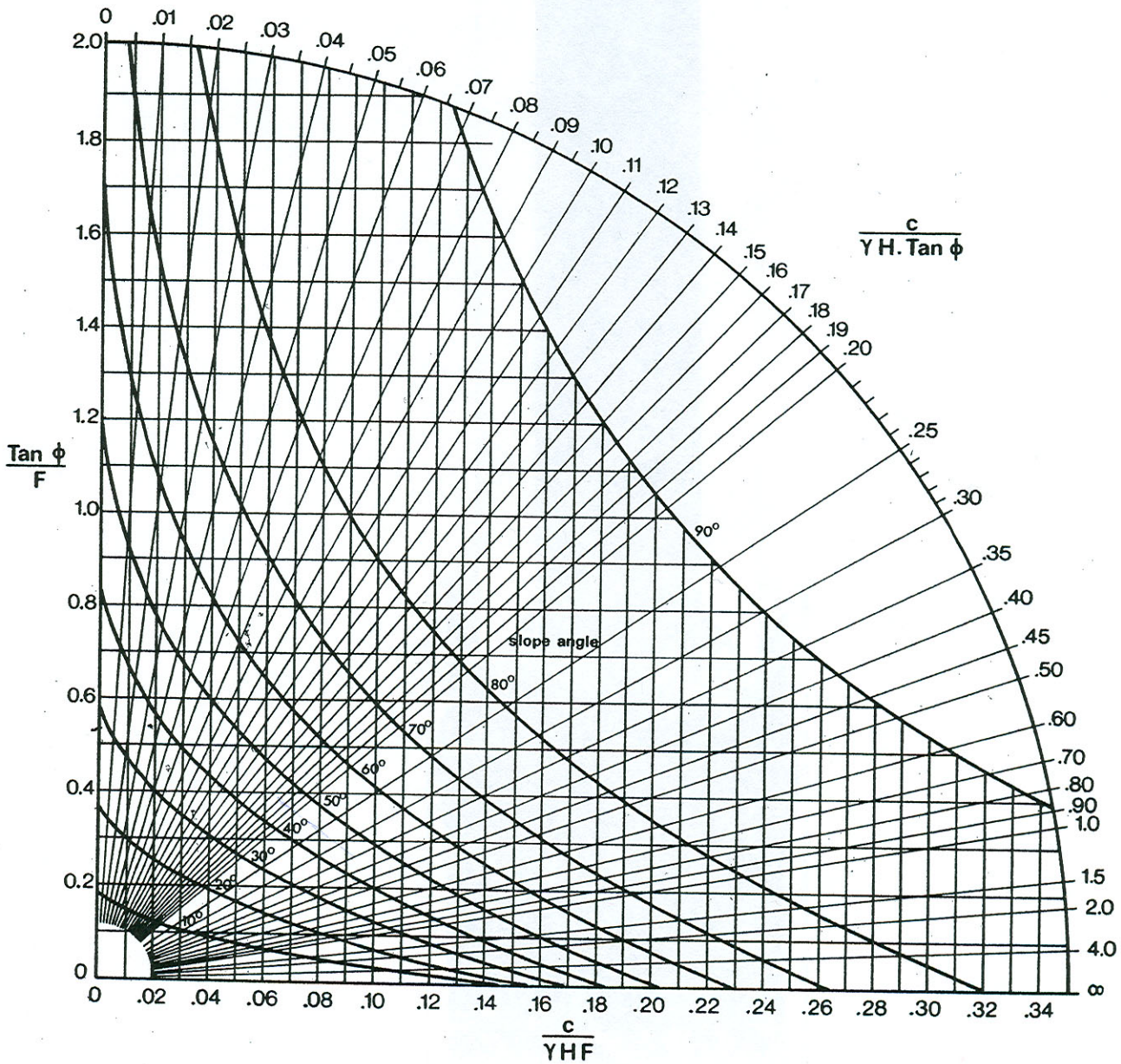

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Chart Q.2

# CIRCULAR FAILURE CHART NUMBER 3

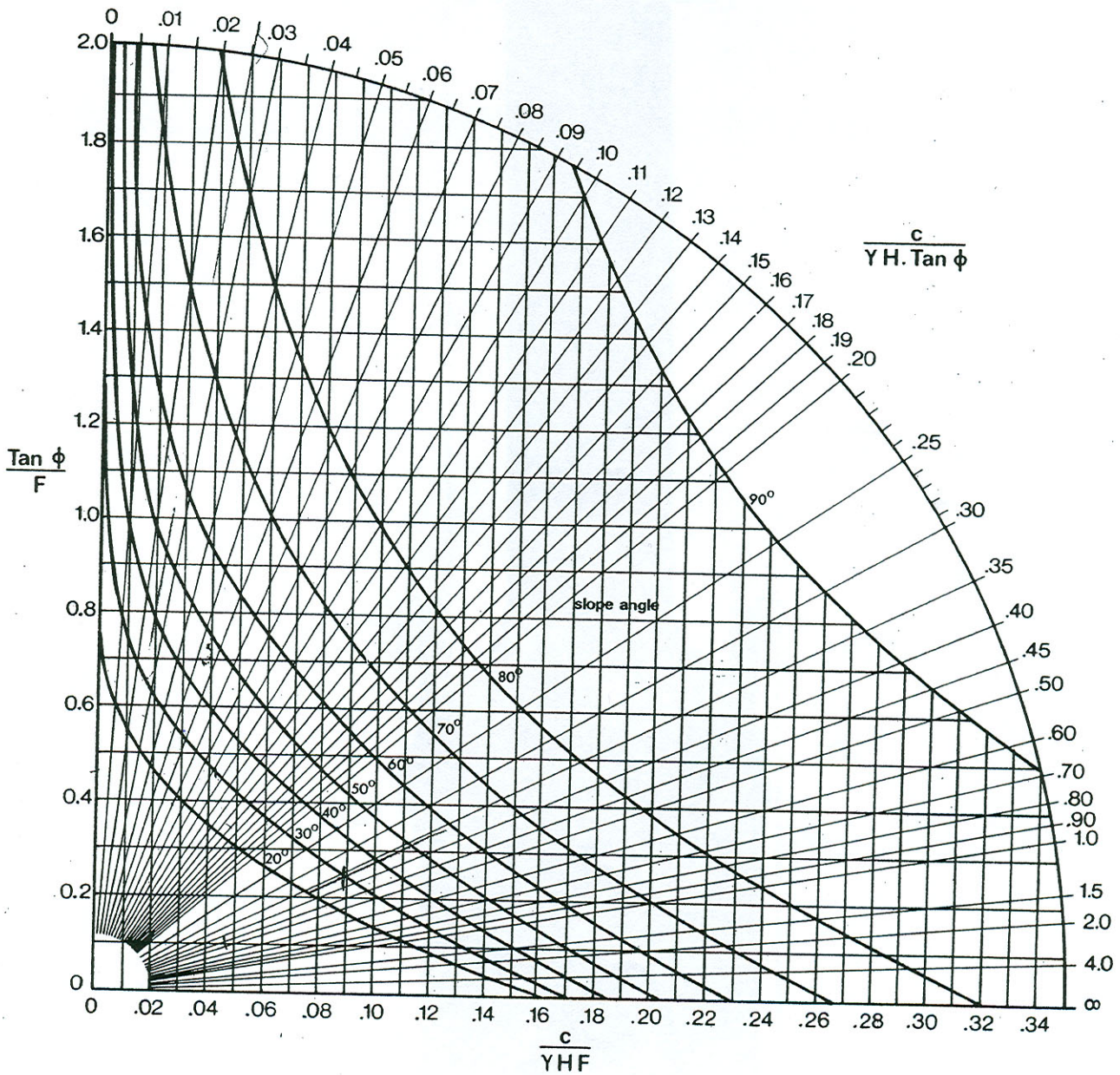

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Chart Q.2

# CIRCULAR FAILURE CHART NUMBER 5

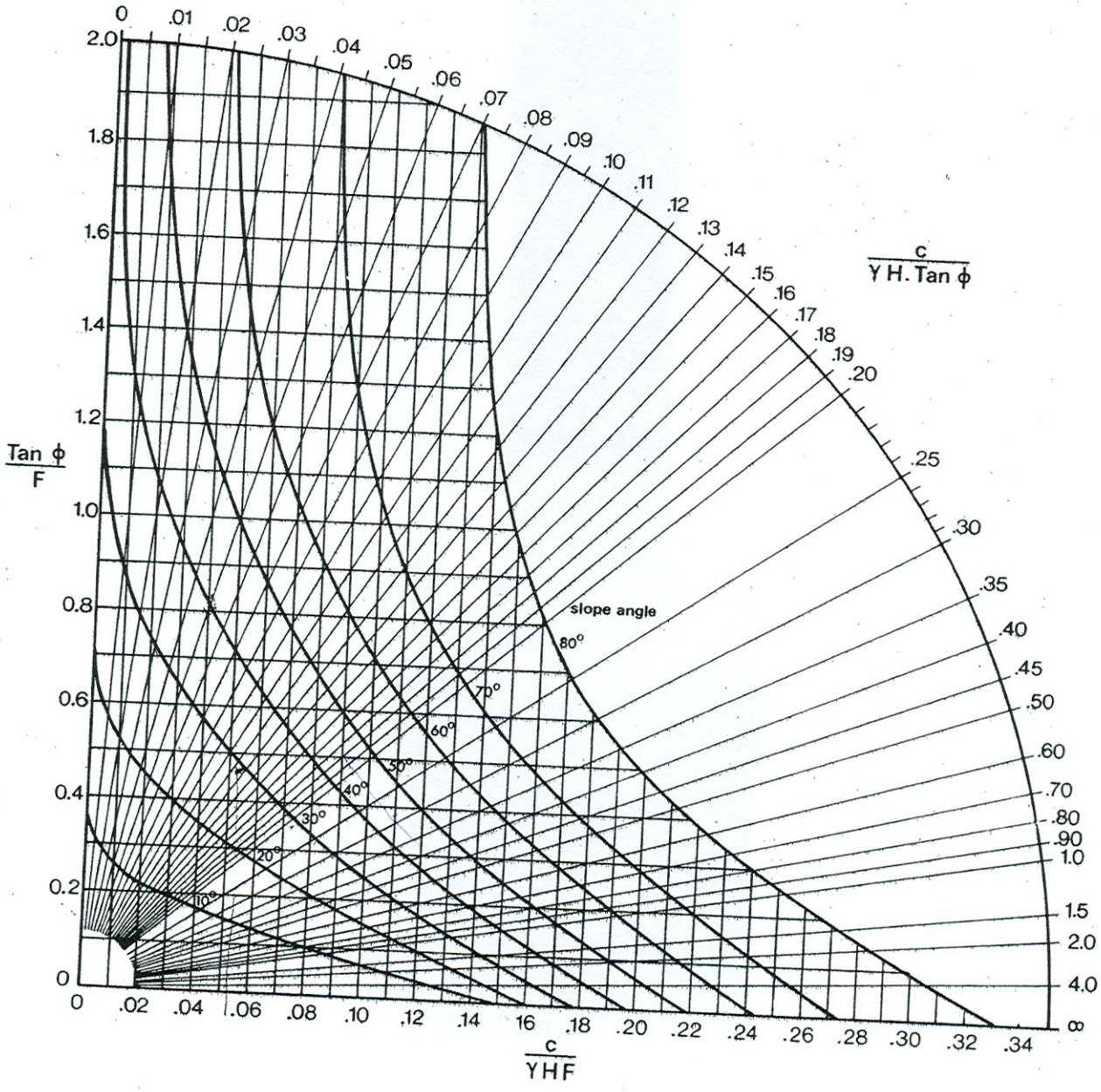

Figure Q.3