



UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 7 Examination in Engineering: March 2022

Module Number: CE7253

Module Name: Highway Maintenance and Management (N/C)

[Three Hours]

[Answer all questions. each question FIFTEEN marks]
[All standard notations denote their regular meanings]

- Q1. a) A homogeneous half-space was subjected to two circular loads, each 250 mm in diameter and spaced at 500 mm on centres. The pressure on both circular areas is 400 kPa. The half-space has an elastic modulus of 70 MPa and a Poisson ratio of 0.5. Determine the following parameters of a point 'A', which is located 750 mm below the centre of the first circle, using the Foster and Ahlvin charts shown in Figures from Q1-1 to Q1-5.
- Vertical stress
 - Tangential stress
 - Radial stress
 - Shear stress
 - Vertical strain
 - Radial strain
 - Vertical deflection
- [7.0 Marks]
- b) Draw sketches of the stress distribution and subgrade deflection prevailing under a rigid plate and a flexible plate having uniformly distributed load over it.
- [4.0 Marks]
- c) A plate loading test is carried out, using a rigid plate of 305 mm diameter, on the surface of the subgrade. A load of 35.6 kN was applied to the plate, and a deflection of 3.54 mm was measured. Assuming that the subgrade material has a Poisson ratio 0.4, determine the elastic modulus of the subgrade.
- [4.0 marks]
- Q2. a) Explain the importance of maintenance using a labelled 'user satisfaction percentage' vs 'time curve'.
- [4.0 Marks]
- b) Briefly explain the difference between 'Fatigue cracks' and 'block cracks' in a flexible pavement.
- [3.0 Marks]
- c) Define the term rutting occurring related to flexible pavements and briefly explain the method used to treat it?
- [4.0 Marks]
- d) Compare and contrast 'fog seal' and 'rejuvenating seal' in relation to flexible pavement.
- [4.0 Marks]

- Q3. a) A subgrade is subjected to a circular load having radius (R) 200 mm and contact pressure of 700 kPa. The subgrade soil is a sand with the relationship between the elastic modulus (E (MPa)) and the stress invariant (θ (MPa)) as follows.

$$E = 130000 \times (1 - 0.00151\theta)$$

The soil has a Poisson ratio 0.4, the unit weight is 19.0 kN/m³, and the coefficient of earth pressure at rest is 0.5. A total depth of $100R$ is considered for the analysis of deflection at the axis of symmetry. Analysis depth is divided into six layers so that the first five layers are having a thickness of $2 \times R$ and the rest is made up of layer 6 having. Determine the following at the axis of symmetry.

- i. Draw the layer system with dimensions
- ii. vertical, tangential and radial stresses at mid-height of the topmost layer
- iii. stress invariant at mid-height of the topmost layer
- iv. Resilient modulus at mid-height of the topmost layer
- v. Deflection at the top and bottom of the topmost layer
- vi. Deformation of the topmost layer.

[10.0 Marks]

- b) For the above case determine the total deflection at the axis of symmetry considering all layers using a tabular format. (No need to show any calculations.)

[5.0 Marks]

- Q4. Activities in a project and the time taken for each activity are shown in Table Q4-1. Use Table Q4-1 to answer the question below.

- a) Develop the project network diagram using the AON method to indicate the ES, EF, LS, LF and slack for each activity.

[6.0 Marks]

- b) What is the project duration?

[1.0 Marks]

- c) What is the critical path?

[2.0 Marks]

- d) For the project information given in Table Q4-2 below, what are the probabilities of completing the project in 93,100, and 150 days?

[6.0 Marks]

ANNEX: Equations, Tables and Figures

$$\sigma_{tc}^2 = \left(\frac{(b-a)}{6} \right)^2$$

$$\omega_o = \frac{\pi(1-v^2)qa}{2E}$$

$$\sigma_{tE} = \sqrt{\sum \sigma_{tc}^2}$$

$$Z = \frac{T_s - T_E}{\sigma_{tE}}$$

$$\sigma_z = q \left[1 - \frac{Z^3}{(a^2 + Z^2)^{1.5}} \right]$$

$$\sigma_r = \sigma_t = \frac{q}{2} \left[1 + 2v - \frac{2Z(1+v)}{(a^2 + Z^2)^{0.5}} + \frac{Z^3}{(a^2 + Z^2)^{1.5}} \right]$$

$$w = \frac{(1+v)qa}{E} \left\{ \frac{a}{(a^2 + Z^2)^{0.5}} + \frac{1-2v}{a} [(a^2 + Z^2)^{0.5} - Z] \right\}$$

$$\theta = \sigma_z + \sigma_r + \sigma_t + \gamma Z(1 + 2K_o)$$

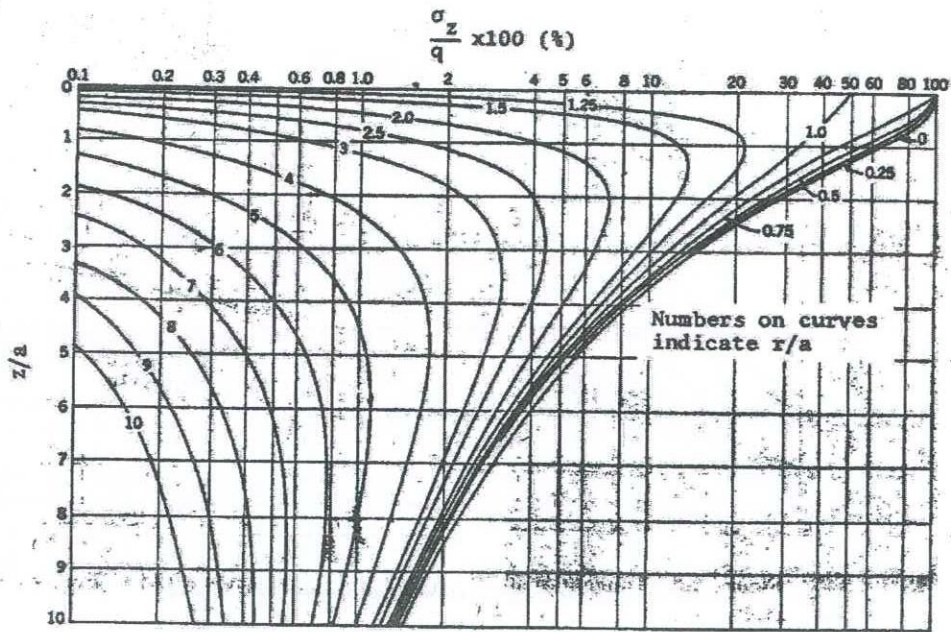


Figure Q1-1 Vertical stresses due to circular loading

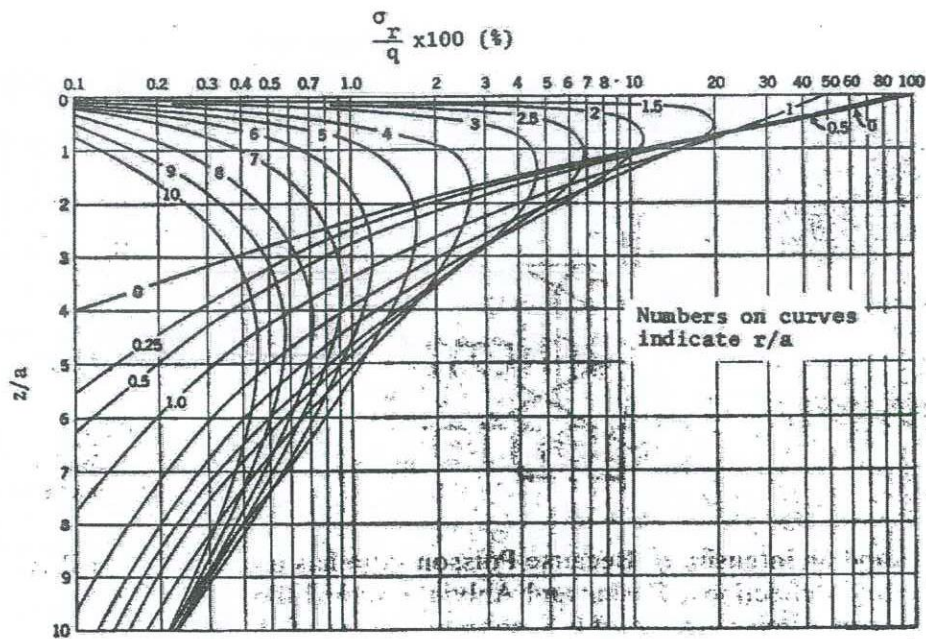


Figure Q1-2 Radial stresses due to circular loading

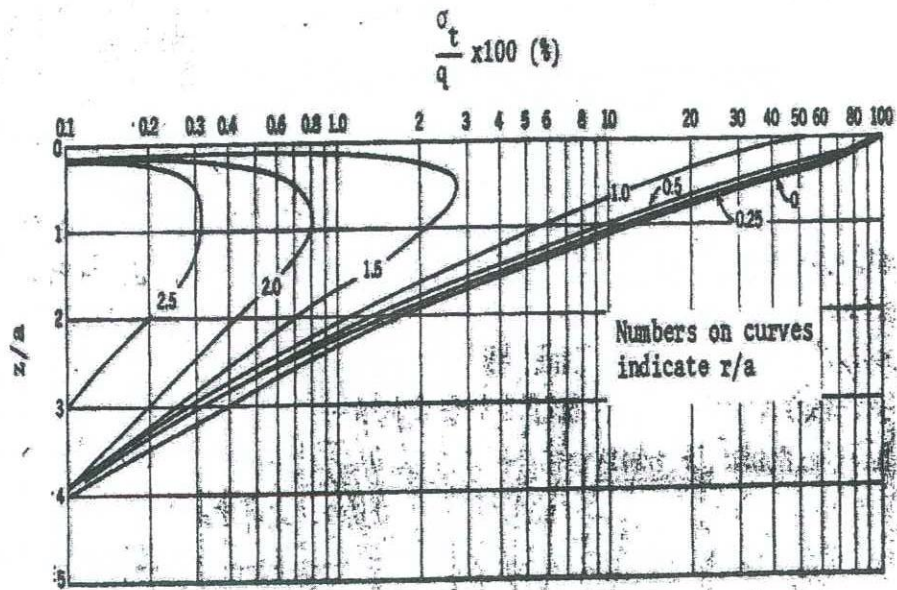


Figure Q1-3 Tangential stresses due to circular loading

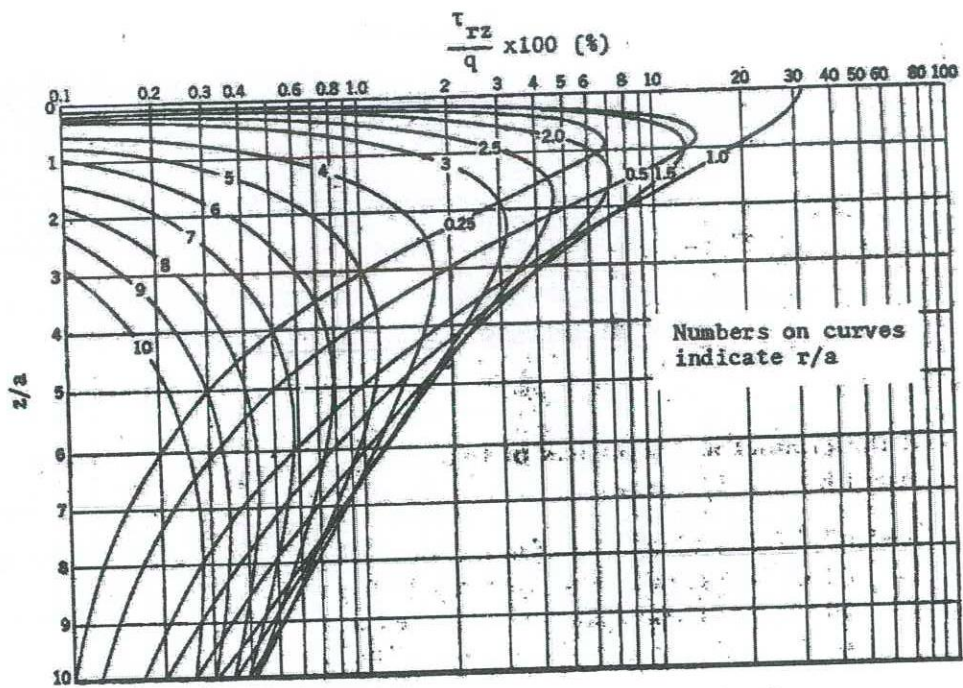


Figure Q1-4 Shear stresses due to circular loading

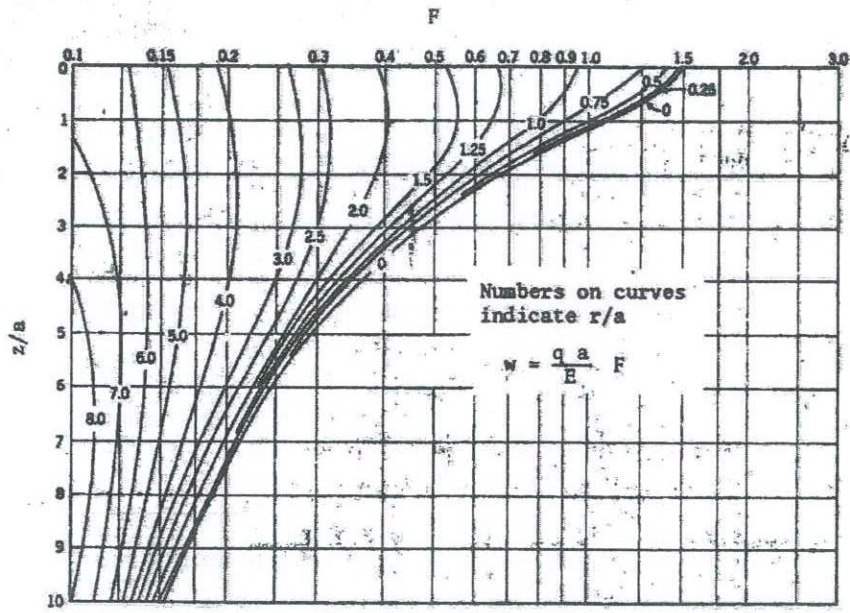


Figure Q1-5 Vertical deflections due to circular loading

Table Q4-1 Project activity relationships

Act-ID	Predecessor	Time (Days)
A	None	10
B	A	2
C	A	3
D	A	60
E	B	60
F	C	2
G	D	2
H	E, F	20
I	G	10
J	H, I	10
K	J	12
L	K	5

Table Q4-2 Project activity relationships

Act-ID	Predecessor	Optimistic (a)	Most likely (m)	Pessimistic (b)
1	None	6	12	24
2	1	16	19	28
3	1	4	7	10
4	2	21	30	39
5	2	17	23	47
6	3, 4, 5	4	7	10
7	6	13	16	19