UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 7 Examination in Engineering: August 2018

Module Number: CE7253 **Module Name: Highway Maintenance and Management**

[Three Hours]

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

Q1. a) A homogeneous half-space subjected to two circular loads, each 250 mm in diameter and spaced at 500 mm on centres. The pressure on both circular areas are 400 kPa. The half-space has elastic modulus 70 MPa and Poisson ratio 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.

i. Vertical stress
ii. Tangential stress
iii. Radial stress
iv. Shear stress
v. Vertical strain
vi. Radial strain
vii. 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 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 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 first five layers are having a thickness of $2 \times R$ and 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 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 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

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

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

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

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

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

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

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

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

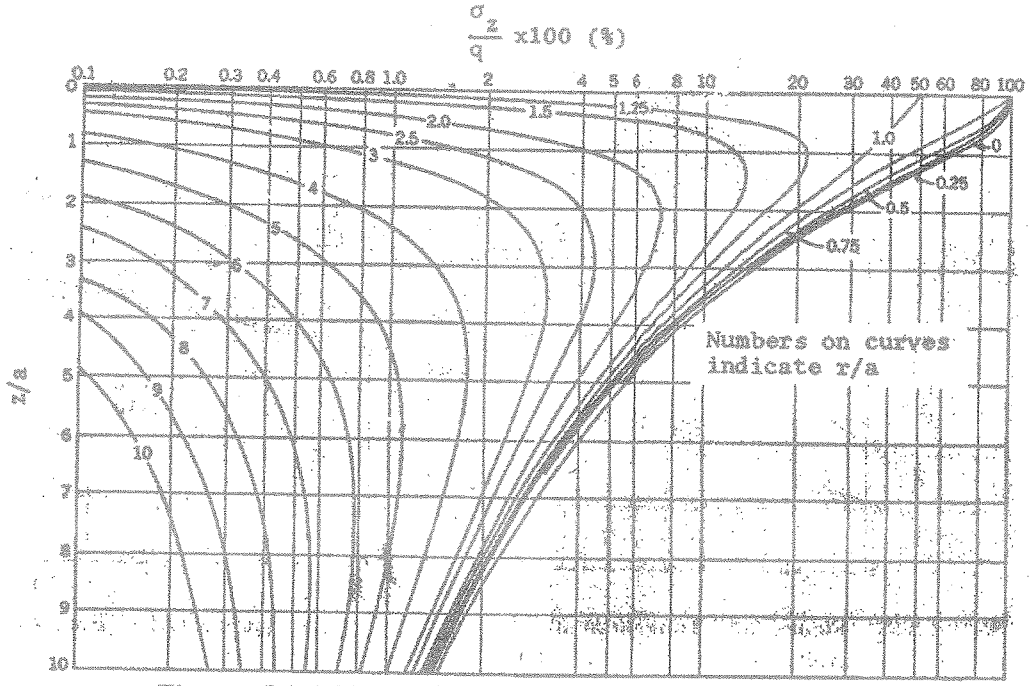

Figure Q1-1 Vertical stresses due to circular loading

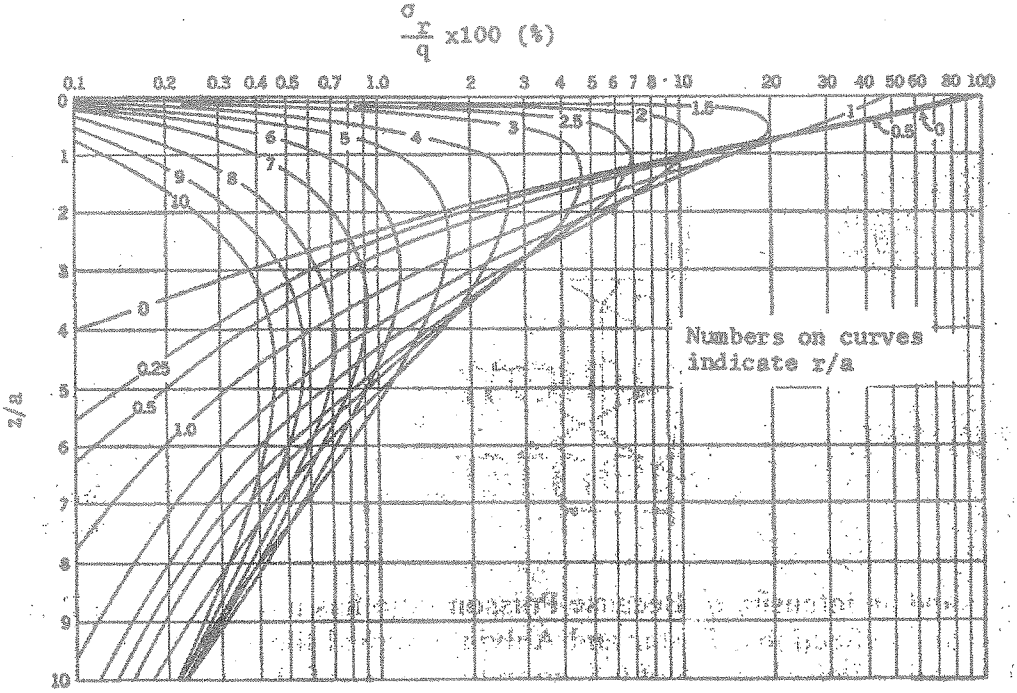

Figure Q1-2 Radial stresses due lo circular loading

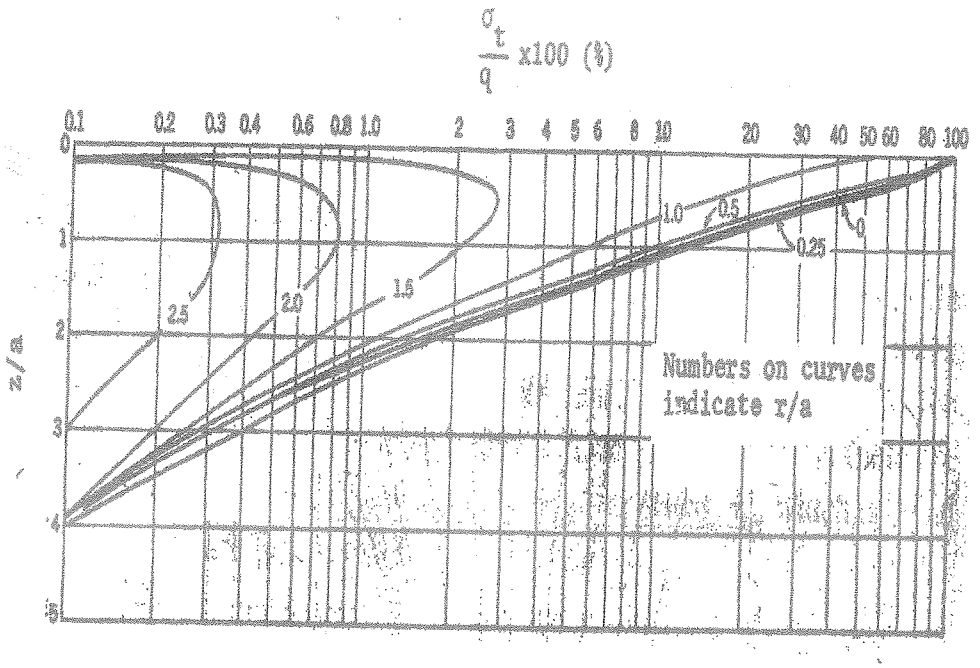

Figure Q1-3 Tangential stresses due to circular loading

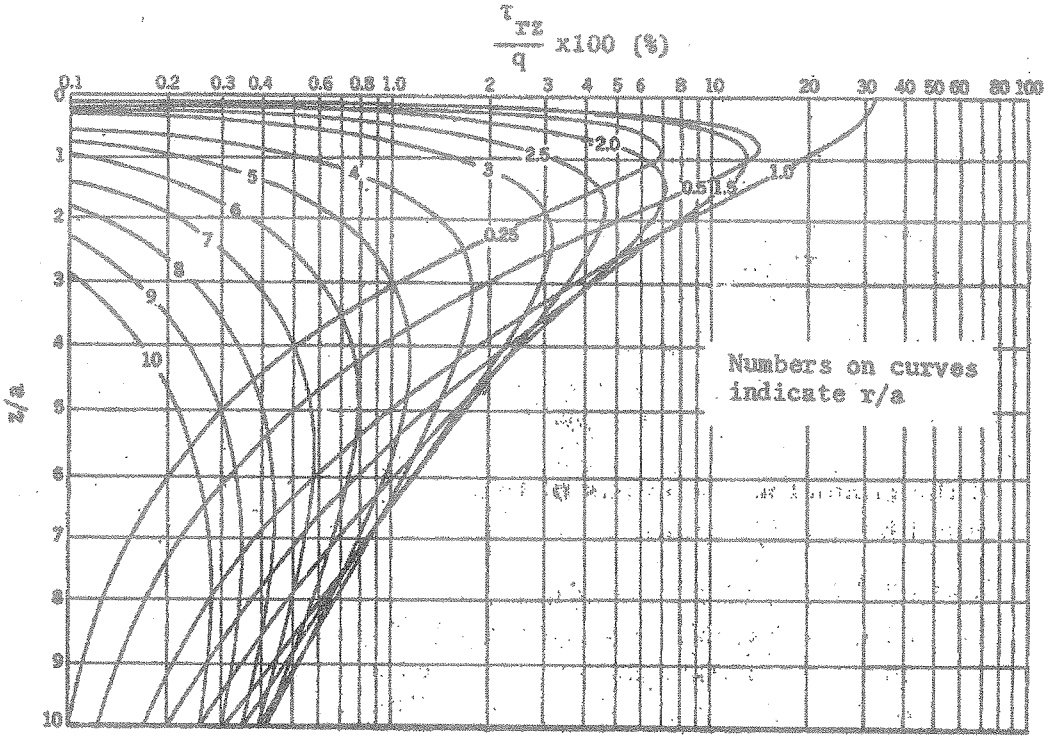

Figure Q1-4 Shear stresses due to circular loading

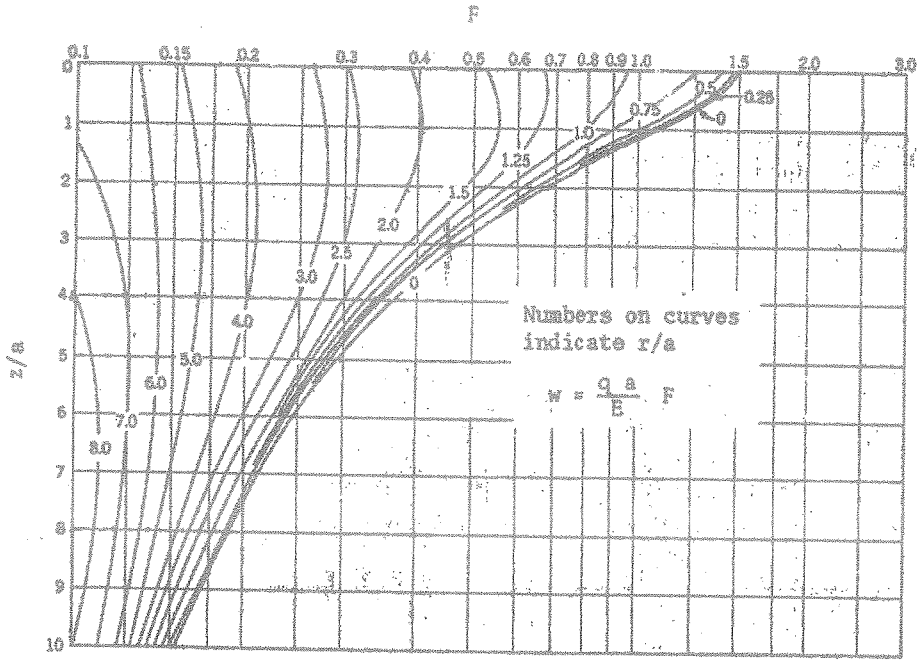

Figure Q1-5 Vertical deflections due to circular loading

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