UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 7 Examination in Engineering: October 2019

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

[Three Hours]

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

Q1. 'Present Serviceability Index' (PSI) is often used to determine the condition of the pavement and to recommend the priority of the maintenance activity. PSI cannot be determined directly, therefore, many studies have used 'Present Serviceability Rating' (PSR) to be an unbiased estimate of PSI.

a) Briefly outline the process of obtaining the PSR values for a road section.

[2.0 Marks]

b) Explain how the 'Performance Index' can be determined from the PSI value.

[2.0 Marks]

c) A study defined the PSI in the following format with usual notations;

$$PSI = A_0 + A_1 R_1 + B_1 D_1.$$

If PSR is the unbiased estimate of PSI, starting from the basics show that the error between PSR and PSI would be minimum when following three regression equations hold.

$$\overline{PSR} = A_0 + A_1\overline{R_1} + B_1\overline{D_1}$$

$$A_1 \sum([R_1 - \overline{R_1}]R_1) + B_1 \sum([D_1 - \overline{D_1}]R_1) = \sum([PSR - \overline{PSR}]R_1)$$

$$A_1 \sum([R_1 - \overline{R_1}]D_1) + B_1 \sum([D_1 - \overline{D_1}]D_1) = \sum([PSR - \overline{PSR}]D_1)$$

[3.0 Marks]

d) Table Q1-1 shows the data collected on 10 road sections for the purpose of calibrating the PSI equation stated in Q1.b). Selected functions of R_1 and D_1 were:

$$R_1 = \log(1 + \overline{SV}) \quad and \quad D_1 = \sqrt{C + P}.$$

Determine the values of A_0, A_1, and B_1 using the equations given in Q1.b)

[5.0 Marks]

Q2. a) A motorcycle is travelling at 30 kmph on a pavement which can be modelled as a homogeneous half-space. Tyre loads can be assumed as circular loads, each 100 mm in diameter and spaced at 750 mm on centres. The pressure on both circular areas is 200 kPa. The pavement has elastic modulus 80 MPa and Poisson ratio 0.5. Determine the following parameters of a point 'A', which is located 250 mm below the centre of the front tyre, using the Foster and Ahlvin charts shown in Figures from Q2-1 to Q2-5.

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 variation of vertical stress and vertical deflection with time at the point 'A' considering the time from 20 s before the front tyre approach above point 'A' to 20 s after it left the point 'A'.

[5.0 Marks]

Q3. a) Flexible pavements suffer from loss of flexibility with aging and become brittle. Explain how this happens and how it could be treated.

[3.0 Marks]

b) Briefly explain the procedure to estimate the rutting in flexible pavements.

[3.0 Marks]

c) Compare and contrast the dig out and local patching with respect to pavement maintenance.

[3.0 Marks]

d) With the help of neat sketches explain the process of semi-permanent patching to repair the potholes in the flexible pavement.

[3.0 Marks]

Q4. a) With the use of examples, compare a contrast a project with an organizational effort.

[3.0 Marks]

b) Explain the four stages of a project life cycle and provide one example process in each of the stages.

[3.0 Marks]

c) A re-bar bending team takes 15 minutes to prepare one set of re-bars. It was estimated that they have a 95% improvement ratio. If the team needs to prepare 200 sets of re-bars. What is the estimated time needed to complete this task?

[3.0 Marks]

d) If the same team stated in Q4.c) was used to prepare another 300 sets, determine the time they will spend to complete the 300 sets.

[3.0 Marks]

Q5. a) Compute the early, late, and slack times for the network plan for a construction project shown in Figure Q5-1 and determine the project duration. **Detach the Figure Q5-1 sheet and attach it your answer script.**

[3.0 Marks]

b) Using an approach of your choice, develop a loading chart for resources, Electrical Engineers (EE), and resource, Mechanical Engineers (ME). Assume only one of each resource exists.

[4.0 Marks]

c) Given your resource schedule as in Q5.b), compute the early, late, and slack times for the project. Determine the new critical path and project duration.

[3.0 Marks]

d) Could something like this happen in real projects? Elaborate on your answer.

[2.0 Marks]

ANNEX: Equations, Tables and Figures

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

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

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

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

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

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

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

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

Table Q1-1 The data collected on 10 road sections to calibrate the PSI

Section no.	Slope variance $\overline{SV}(10^{-6})$	Cracking and patching C + P (ft or ft²/1000 ft²)	Present serviceability rating (PSR)
1	52.0	60.8	2.0
2	6.5	4.0	4.2
3	22.2	53.5	2.6
4	26.2	53.3	2.3
5	47.8	130.0	1.2
6	25.5	16.0	2.8
7	3.2	0.0	4.4
8	70.0	88.6	1.7
9	20.0	18.0	2.1
10	5.8	7.7	4.2

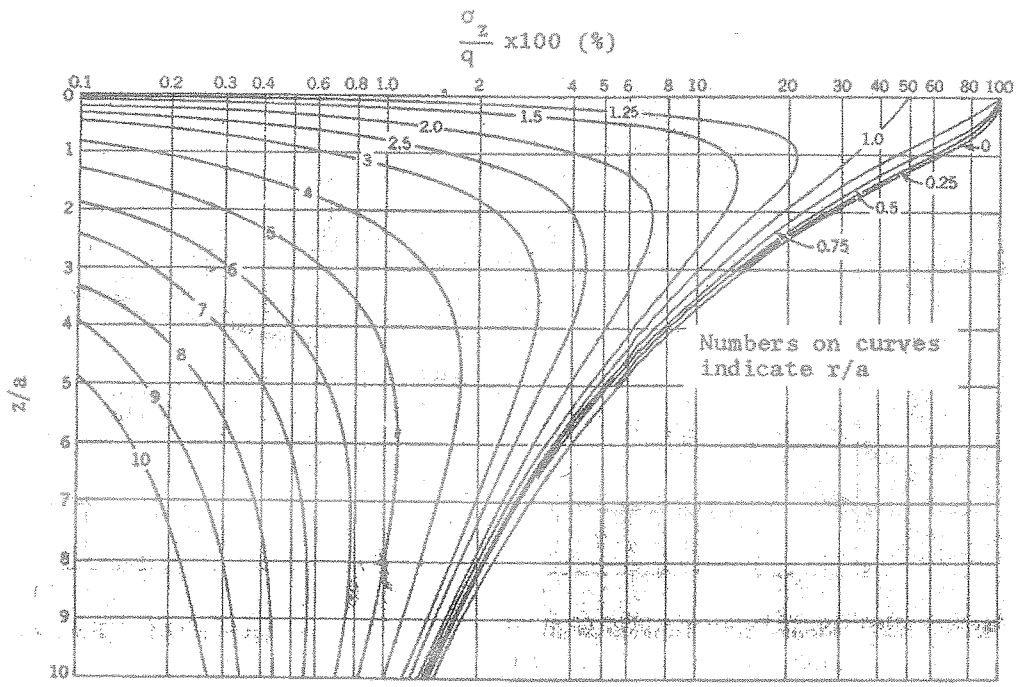

Figure Q2-1 Vertical stresses due to circular loading

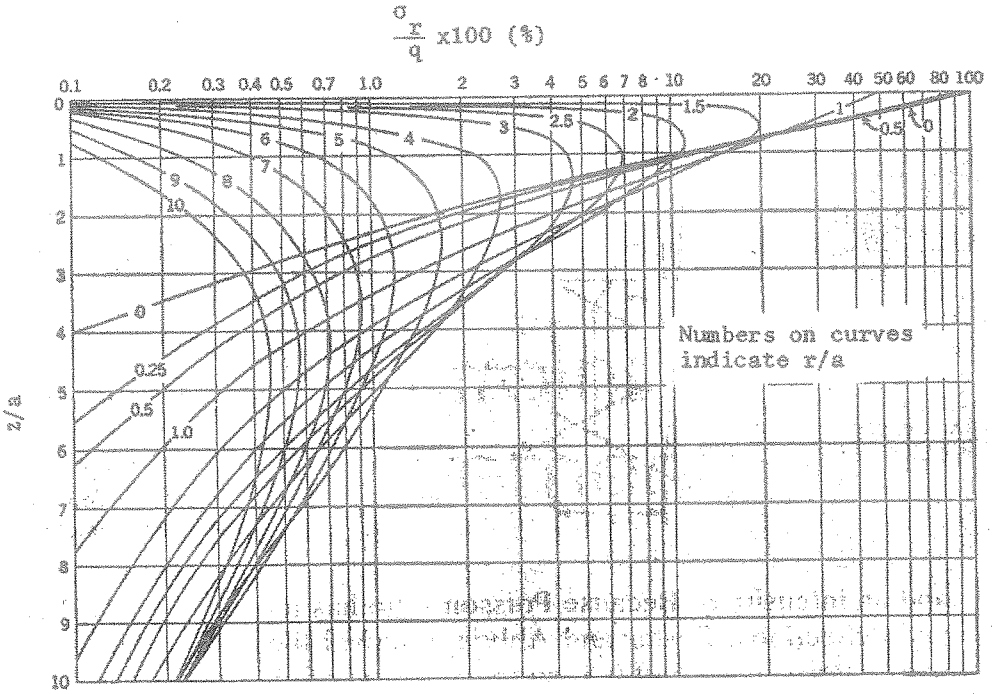

Figure Q2-2 Radial stresses due lo circular loading

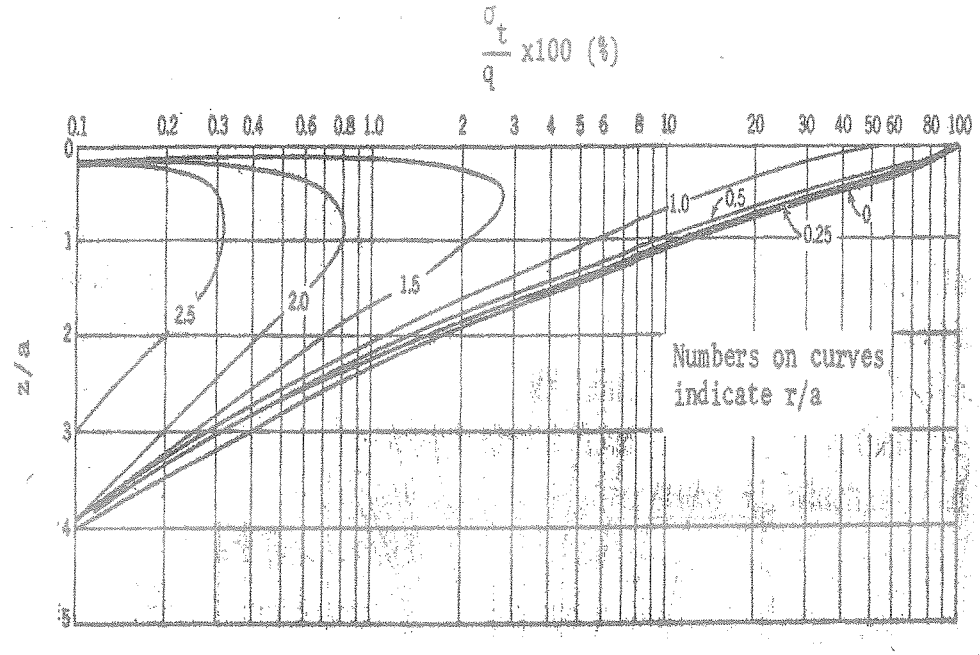

Figure Q2-3 Tangential stresses due to circular loading

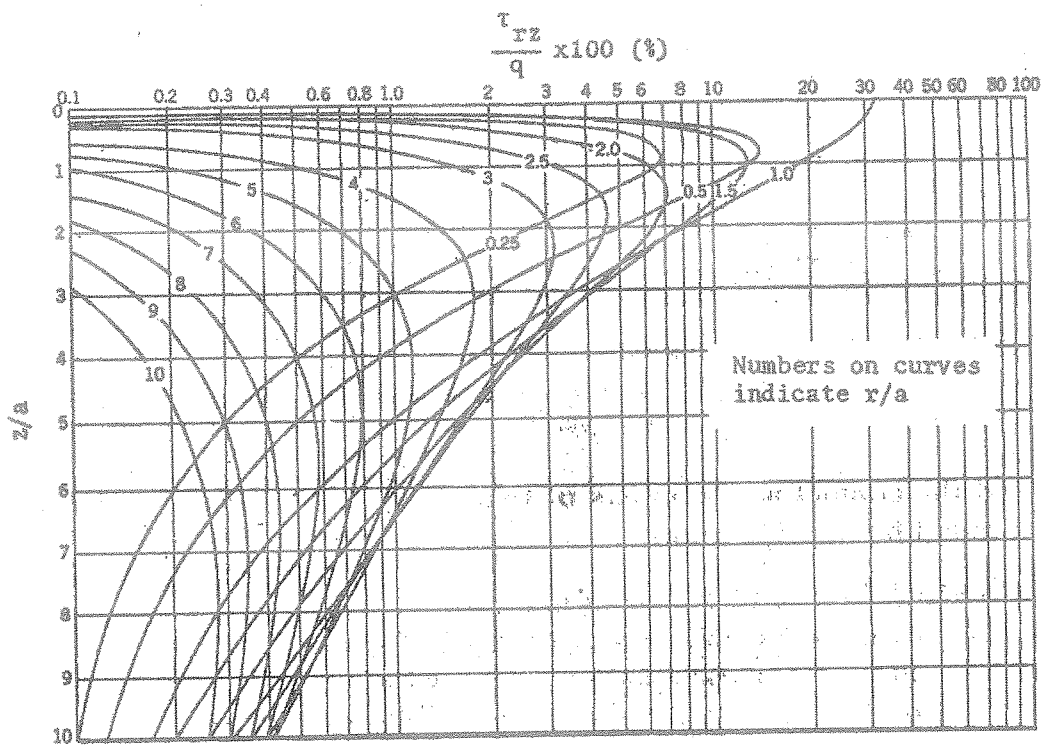

Figure Q2-4 Shear stresses due to circular loading

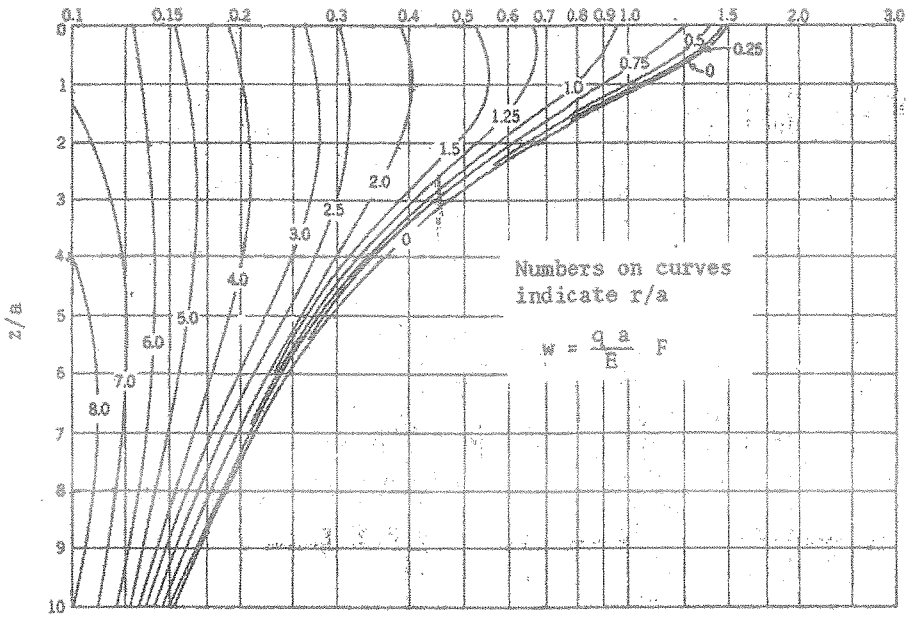

Figure Q2-5 Vertical deflections due to circular loading

Detach this sheet and attach it to your answer script

Index Number_____

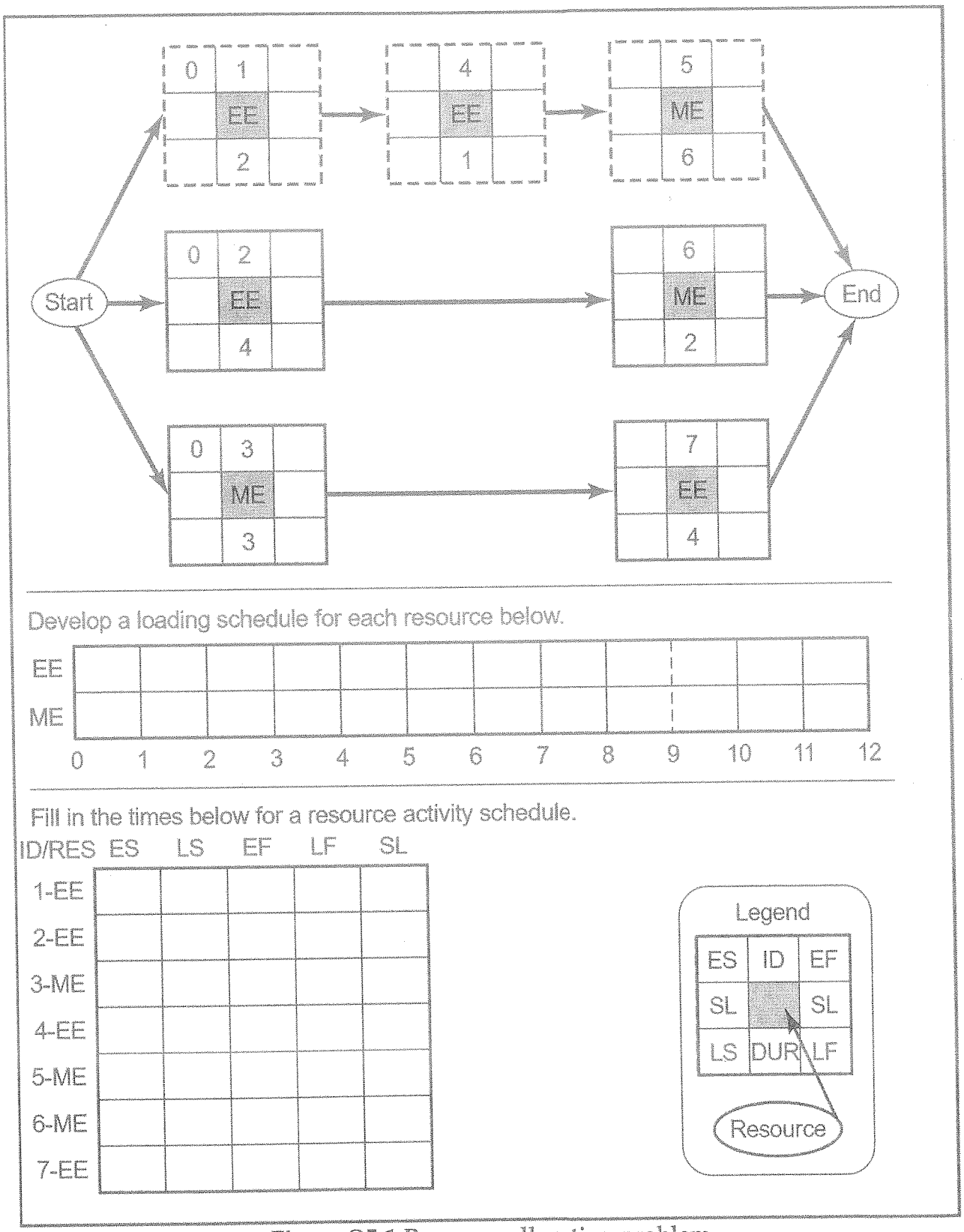

Figure Q5-1 Resource allocation problem