ASSIGNMENT 4

1. A two lane (7.0 m wide) cement concrete pavement, 250 mm thick, with a longitudinal joint at the centre is constructed on a subgrade with a modulus of subgrade reaction of 81.6 MN/m^3. The spacing of contraction joints is planned based on an allowable tensile stress of 80 kPa in concrete during curing period and based on an allowable joint opening of 1.5 mm. (i) Find the curling stresses in the pavement slab at interior and edge. (ii) Find the spacing and length of 12 mm tie bars provided across the longitudinal joint.

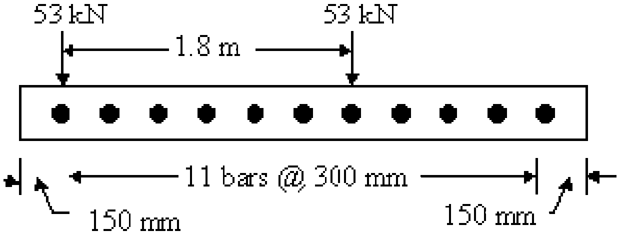
   Use the following data:

   Maximum value of temperature differential in the slab = 15^0 C
   Coefficient of thermal expansion of concrete = $10 \times 10^{-6} / {}^0$ C
   Modulus of elasticity of concrete = 27.6 GPa
   Unit weight of concrete = 23.6 kN/m^3
   Poisson's ratio of concrete = 0.15
   Coefficient of subgrade friction = 1.5
   Allowable tensile stress in steel = 186 MPa
   Allowable bond stress = 2.4 Mpa
   Shrinkage starin = 1.0×10^{-4}
   Adjustment factor for subgrade friction =0.65
   Temperature at placement = 40 ^{0} C; Lowest mean monthly temperature = 10 ^{0} C

2. Determine the longitudinal and transverse temperature steel required for a two-lane CC pavement, 203 mm thick, 18.3 m long and 7.0 m wide, with a longitudinal joint at the centre, given the following data.

   Unit weight of concrete = 23.6 kN/m^3
   Coefficient of subgrade friction = 1.5
   Allowable tensile stress in wire fabric = 297 Mpa

3. A concrete slab has a width of 3.30 m, a thickness of 250 mm, and a modulus of subgrade reaction of 81.6 MN/m^3. A 106 kN axle load with a wheel spacing of 1.80 m is applied at the joint with one wheel 150 mm from the edge as shown in the figure. Determine the maximum bearing stress between concrete and dowel, assuming 100% efficiency in load transfer across the joint. Assume 6.35 mm joint opening (z) and 25 mm dia. (d) dowel bars at 300 mm on centres. The maximum negative moment is assumed to occur at a distance of 1.8l from the load, where l is the radius of relative stiffness. Take modulus of elasticity of concrete, E_c = 27.6 GPa; modulus of elasticity of dowel steel, E_d = 200 GPa; modulus of dowel support, K = 407 GN/m^3.



4. A 400 mm thick plain CC pavement is resting on a silty clay subgrade with a modulus of subgrade reaction of 54.3 MN/m^3 Determine the extreme fibre stress for the interior load case for the following using influence charts. Take modulus of elasticity of concrete as 27.6 *GPa* and Poisson's ratio of cement concrete as 0.15.

   i) Single wheel, 222.5 kN, 690 kPa tyre pressure
   ii) Dual wheels, 222.5 kN per wheel, 690 kPa tyre pressure, wheels spaced 950 mm centre to centre

5. A set of dual tyres is spaced at 850 mm centre to centre and carries a total load of 200 kN with a tyre pressure of 705 kPa. Assuming the pavement to be homogeneous half space, determine ESWL for a pavement of 635 mm thick using (a) equal vertical stress criteria - one layer theory and (b) equal vertical deflection criteria - one layer theory (Foster and Ahlvin's method).

6. A pavement is subjected to the single-axle loads shown in the Table on the design lane. Determine the ESAL for a design period of 20 years. Take the annual growth rate of traffic as 3.5%.

Axle Load (kN)	**Equivalent Axle Load Factor**	**Number per Day**
54	0.176	200.0
63	0.314	117.4
72	0.604	84.5
80	1.00	61.4
90	1.57	47.2
99	2.34	21.4
108	3.36	12.9
117	4.67	6.1
126	6.29	2.9
135	8.28	1.2
144	10.7	0.7
153	13.6	0.3

7. For finding the truck factor on a two-lane flexible pavement a sample of 165 trucks were weighed. The number of axles for each load group and the corresponding EALF are given in the table. Compute the truck factor. Also find the ESAL for a design period of 20 years, if the highway has an AADT of 4000 during the current year, 25% trucks, 4% annual growth rate, and combined lane and directional distribution factor of 0.75.

Axle Load (kN)	EALF	Number of Axles
Single axle		
Under 13	0.0002	0
13-30	0.0050	1
31-36	0.0320	6
37-53	0.0870	144
54-71	0.3600	16
72-133	5.3890	1
Tandem Axles		
Under 26	0.0100	0
26-53	0.0100	14
54-80	0.0440	21
81-107	0.1480	44
108-133	0.4260	42
134-142	0.7530	44
143-145	0.8850	21
146-151	1.0020	101
152-160	1.2300	43

8. Traffic on a two-lane two-way highway with flexible pavement is observed to grow at 4% per annum. Compute the ESAL for a design period of 20 years using the axle load survey data given in the table. Also find the allowable tensile strain (ε_t) at the bottom of AC layer and allowable vertical strain (ε_z) at the top of subgrade using the following distress models. Take the elastic modulus of AC as 1966 MPa.

$$N_F = 2.21\times10^{-4}\left(\frac{1}{\varepsilon_t}\right)^{3.89}\left(\frac{1}{E}\right)^{0.854}$$

$$N_R = 4.1656\times10^{-8}\left(\frac{1}{\varepsilon_z}\right)^{4.5337}$$

Axle load	Count on an average day in both directions	EALF
45 kN (single axle)	300	0.118
80 kN (single axle)	120	1.000
102 kN (single axle)	100	3.500
142 kN (tandem axle)	100	0.889
142 kN (single axle)	30	13.900

9. Find the design subgrade resilient modulus to be used in Asphalt Institute method of design of flexible pavements from the following values of resilient moduli obtained from triaxial test on soil subgrade. The design ESAL is 10^5.

Resilient muduli: 42.8, 47.3, 58.3, 60.7, 65.2, 70.1, 73.5, 78.0, 82.5, 86.6, 93.2, 97.7 MPa.