Q Design the following details of a plain cement concrete pavement for a two lane highway

(a) Spacing of expansion and contraction joint

(b) Pavement slab thickness

(c) Dowel bars for expansion joint

(d) Tie bars for longitudinal joint

Solutions

Assume width of expansion joint $= 2.5\,cm$

Joint spacing $\delta' = \frac{\text{Joint}}{2} = \frac{2.5}{2} = 1.25\,cm$

$$\boxed{\text{Spacing of expansion Joint } L_e = \frac{\delta'}{100\,C\,(T_2 - T_1)}} = \frac{1.25}{100 \times 10 \times 10^{-6}\,(35^\circ)}$$

$= 35.7\,m$

$C =$ coefficient of thermal expansion $= 10 \times 10^{-6}\,/^\circ C$

$T_2 - T_1 =$ Summer and winter temp variation

which is less than maximum Specified spacing of 140 m and so acceptable.

Contraction Joint in plain CC $\Rightarrow L_c = \frac{2 S_c \times 10^4}{W \cdot f} = \frac{2 \times 0.8 \times 10^4}{2400 \times 1.5}$

$= 4.45\,m$

$S_c =$ allowable tensile stress in CC during curing $= 0.8\,kg/cm^2$

which is less than maximum Specified spacing of 4.5 m and hence acceptable

there for provide Contraction Joint at 4.45 m spacing and expansion Joints at every 8th such Joint i.e $4.45 \times 8 = 35.5\,m$ spacing (instead of 35.7 m)

(b) Pavement Slab thickness $\Rightarrow$

Assume trial thickness of slab $= 20\,cm$

Radius of relative Stiffness $l = \left[\frac{Eh^3}{12k(1-\mu^2)}\right]^{1/4}$

$$= \left[\frac{3\times10^5\times20^3}{12\times8(1-0.15^2)}\right]^{1/4} = 71.1\,cm$$

$$\frac{L_x}{l} = \frac{445}{71.1} = 6.26 \qquad \frac{L_y}{l} = \frac{350}{71.1} = 4.92$$

warping stress coefficient C_x at $\frac{L_x}{l}$ of $6.26 = 0.92$

$$\frac{L_y}{l} = \cancel{35}\,4.92, \quad C_y = 0.72 < C_x$$

temperature differential for 20 cm thick slab $= 15.8°C$

warping stress at edge, $S_{te} = \frac{C_x \cdot E \cdot e \cdot t}{2}$

$$= \frac{0.92\times3\times10^5\times10\times10^{-6}\times15.8}{2}$$

$$= 21.8\,kg/cm^2$$

Residual strength in concrete slab at edge region $= \underset{\text{flexure strength (flexural stress)}}{40.0} - 21.8 = 18.2\,kg/cm^2$

load stress in edge region, using IRC chart

$$h = 20, \quad K = 8, \quad S_e = 27.5\,kg/cm^2$$

factor of safety available $= \frac{\text{residual strength}}{\text{edge load stress}} = \frac{18.2}{27.5} = 0.66$

as the factor of safety is less than 1.0, it is ~~unsafe~~ unsafe.

therefore assume a higher slab thickness $h = 24\,cm$

$$l = \left[\frac{3\times10^5\times24^3}{12\times8(1-0.15^2)}\right]^{1/4} = 81.53\,cm$$

$$\frac{L_x}{l} = \frac{445}{81.53} \Rightarrow C_x = 0.80$$

$$\frac{L_y}{l} = 4.29 \Rightarrow C_y = 0.6$$

temperature differential for 24cm thick slab $= 16.2°C$

$$S_{te} = \frac{C_x E \cdot e \cdot t}{2} = \frac{0.8 \times 3 \times 10^5 \times 10 \times 10^{-6} \times 16.2}{2}$$

$= 19.44\ kg/cm^2$

Residual strength at edge $= 40.0 - 19.44$

$= 20.56\ kg/cm^2$

Load stress at edge, using stress chart

$h = 4, \quad K = 8, \quad S_e = 19.2\ kg/cm^2$

factor of safety available $= \frac{20.56}{19.2} = 1.07$ which is safe and acceptable value

therefore provide tentative design thickness of 24cm.

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