GENERAL APPROACH FOR THE DESIGN OF CEMENT CONCRETE PAVEMENTS

1. Introduction

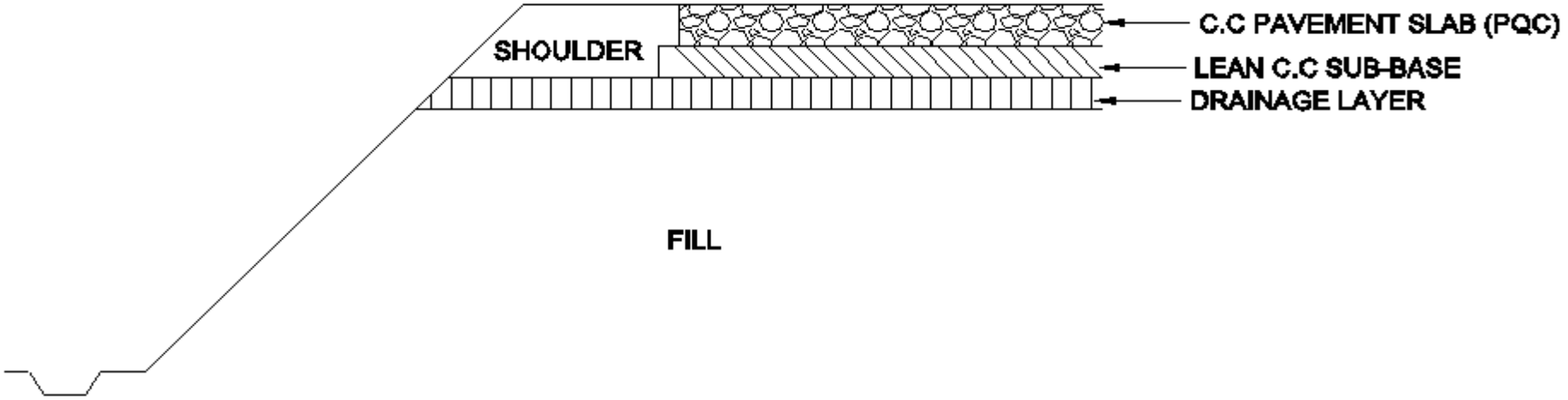
1.1 Behaviour of cement concrete (CC) pavement

1.2 Components of CC pavement

1.3 Advantages and limitations of CC pavements

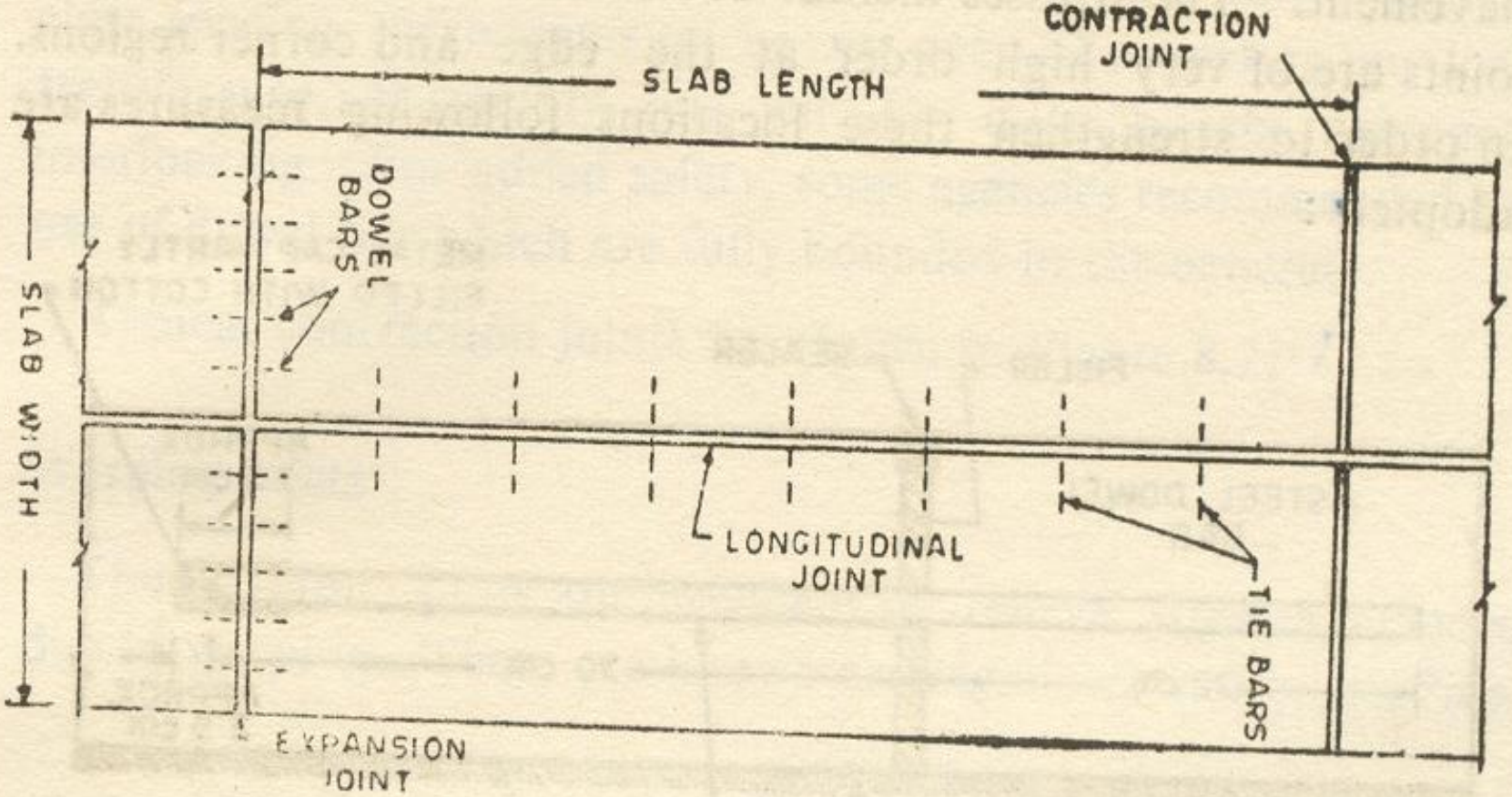
1.4 General layout and details

2. Typical Cross Section of CC Pavement



TYPICAL CROSSSECTION OF
CEMENT CONCRETE PAVEMENT

3. General Layout of Joints in CC Pavement



Location of Joints

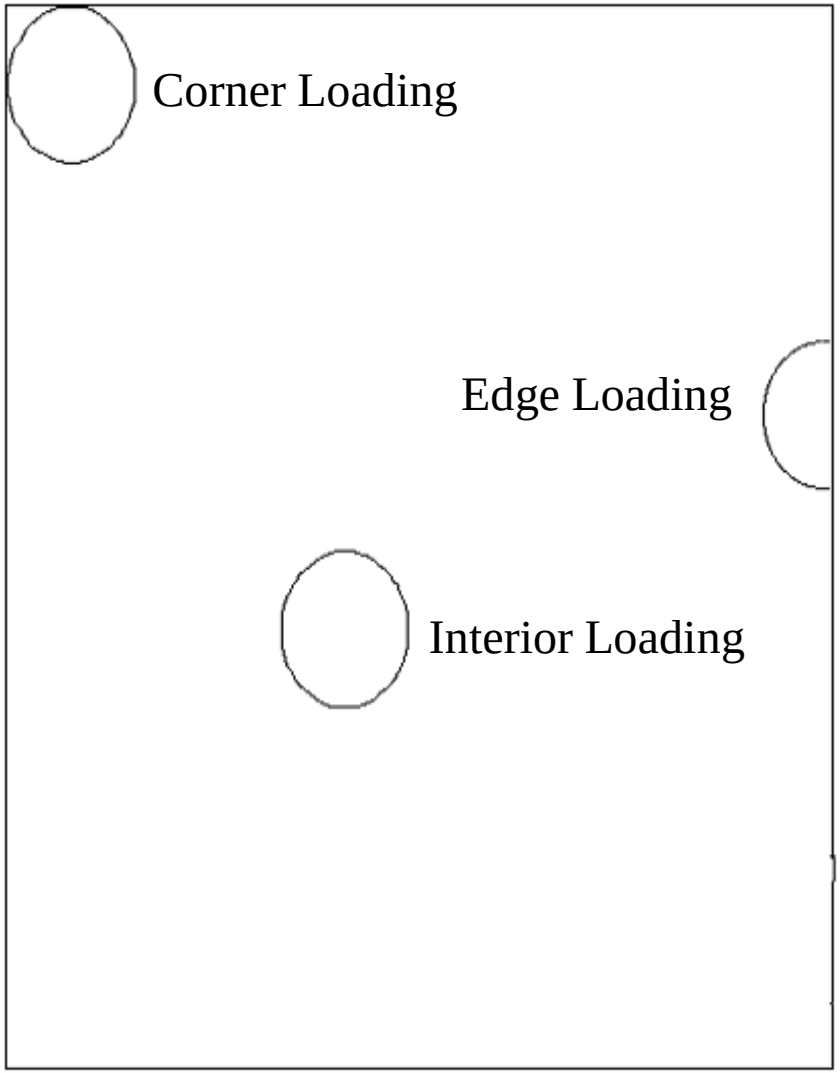
4. Stresses in CC Pavements

4.1 Wheel load stresses

- Westergaard's stress analysis
- Load (P, p, a)
- Critical locations
- Characteristics of the CC pavement (radius of relative stiffness)

WHEEL LOAD STRESSES

Critical Load Positions



Where

ℓ **= Radius of Relative Stiffness, cm**

b = Equivalent Radius of Resisting Sections, cm

$$\ell = \left[\frac{Eh^3}{12k\,(1-\mu^2)}\right]^{0.25}$$

b = a when a > 1.724 h

b = $(1.6\,a^2 + h^2)^{0.5} - 0.675\,h$ When a < 1.724 h

WHEEL LOAD STRESSES

$$S_i = \frac{0.316\,P}{h^2}\left[4\log \ell/b + 1.069\right]$$

$$S_e = \frac{0.572P}{h^2}\left[4\log \ell/b + 0.359\right]$$

$$S_c = \frac{3P}{h^2}\left(1 - \left(\frac{a\sqrt{2}}{\ell}\right)\right)$$

4.2 Modified load stress equations

- **Teller and Sutherland equation for stress at edge region**
- **Kelley equation for corner region**
- **Other equations**

4.3 Temperature stresses due to warping

- Maximum temperature differential
- Slab thickness
- Variation in temperature between day and night during different seasons
- Climatic factors - region / topography

TEMPRATURE STRESSES

$$S_{ti} = \frac{E\alpha t}{2}\left[\frac{C_x + \mu C_y}{1-\mu^2}\right]$$

$$S_{te} = \frac{E\alpha t}{2}\,(C_x \text{ or } C_y)$$

$$S_{tc} = \frac{E\alpha t}{3(1-\mu)}\,(a / \ell)^{0.5}$$

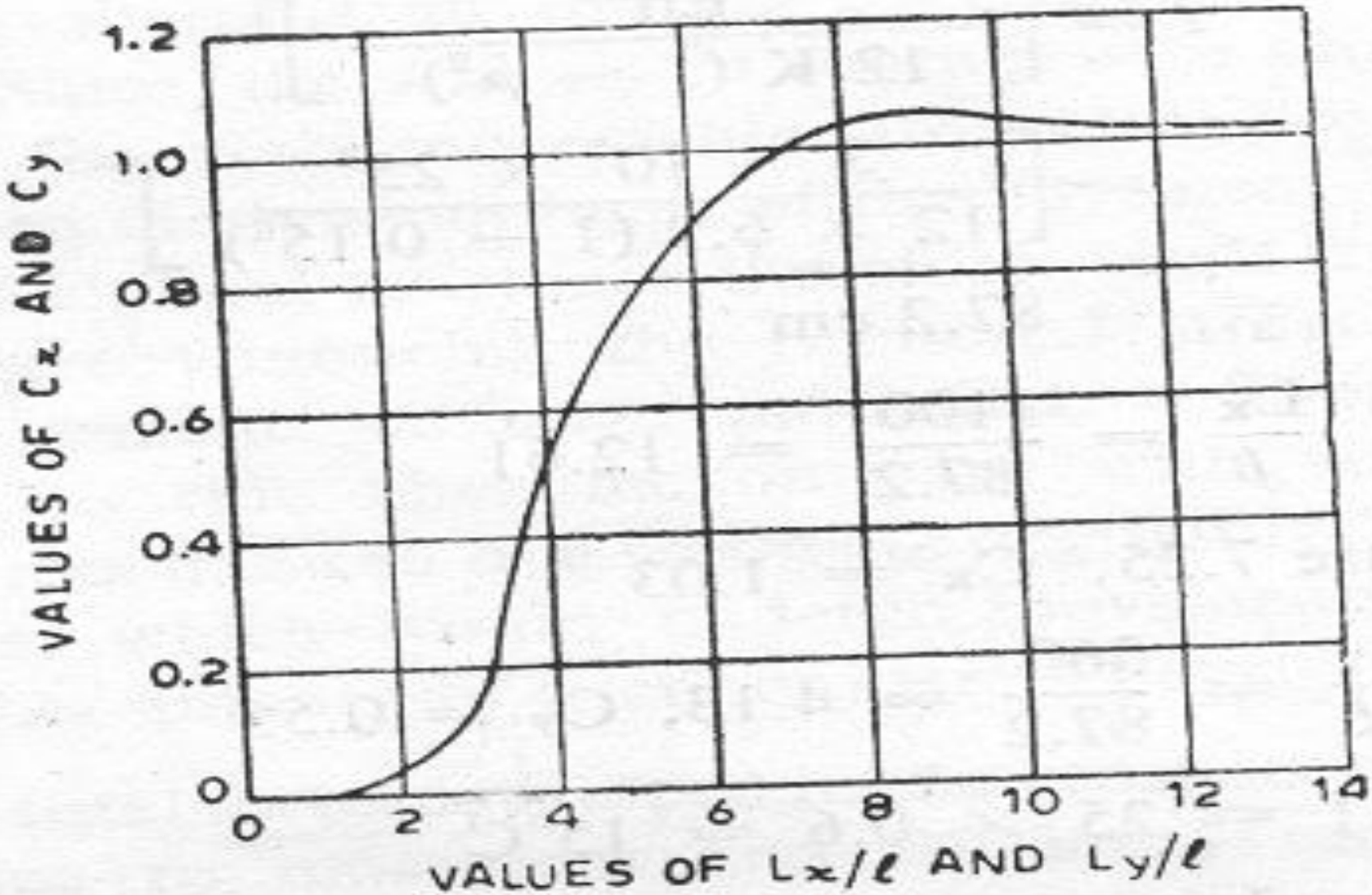
E = modulus of elasticity of concrete, kg/cm2

α = Coefficient of thermal expansion of concrete per ^{o}C

t = temperature difference between top and bottom of the slab, ^{o}C

Cx, Cy = Coefficient based on L_x/l or L_y/l

WARPING STRESSES



4.4 Temperature stress due to contraction / expansion

- effects of shrinkage during curing and contraction joint
- seasonal variation in temperature and expansion joint - load transfer through dowel bar system
- construction joint and load transfer through dowel bar system

FRICTIONAL STRESSES

➔ **Explanation**

$$Sf = \frac{WL\,f}{2 \times 10^4}$$

Sf = Unit Stress developed in cement concrete pavement, kg/cm^2

W = Unit wt. of concrete kg/cm^3 (about 2400 kg/cm^3)

f = Coefficient of subgrade restraint (1.5)

L = Slab length, m

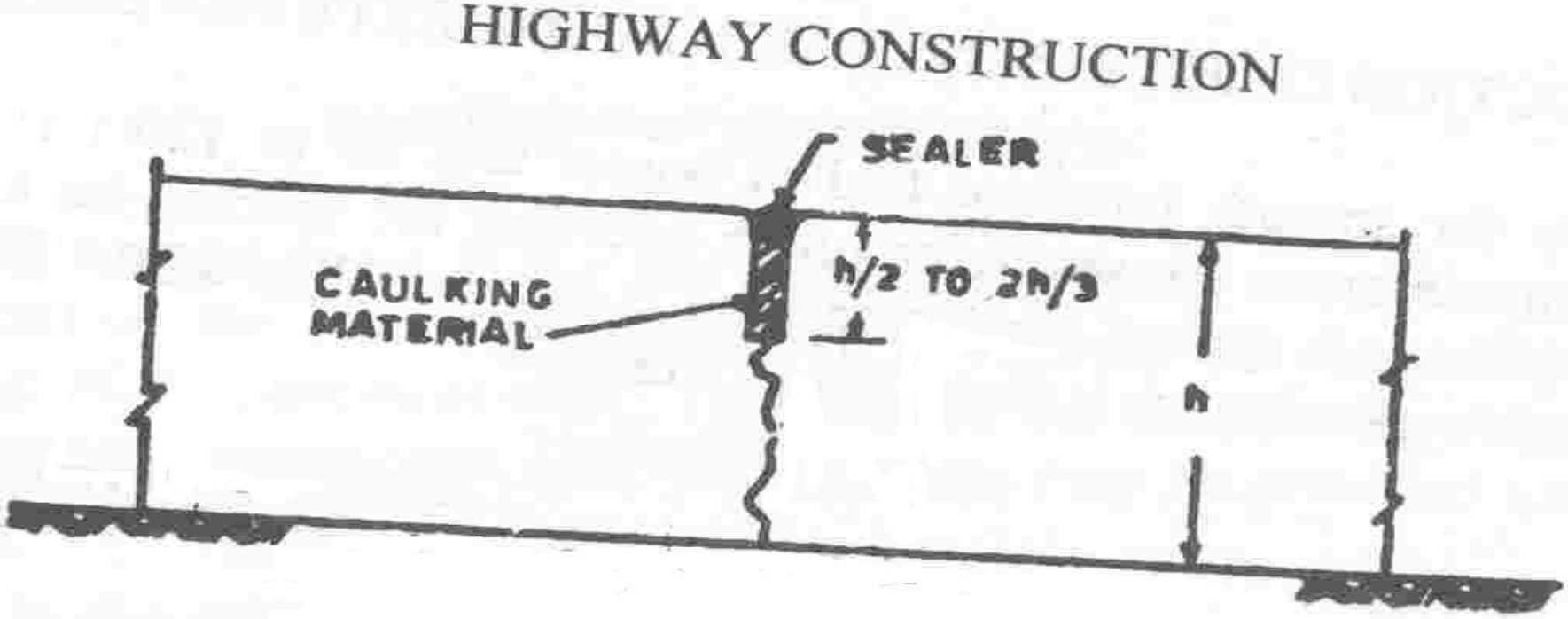
B = Slab width, m

CRITICAL COMBINATION OF STRESSES

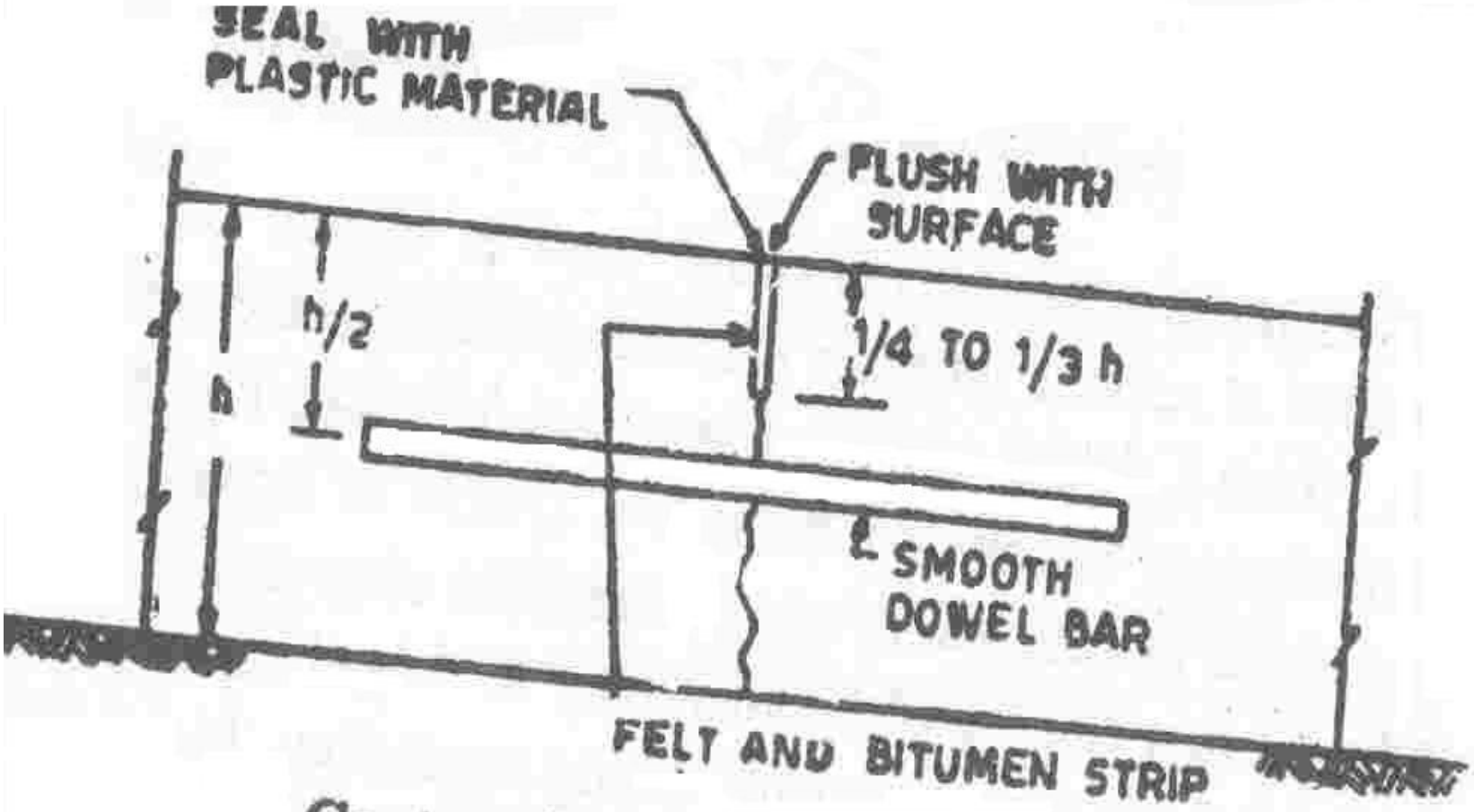
- **Summer (mid-day) – Load Stress + Warping Stress - Frictional stress (At edge region)**
- **Winter (mid-night) – Load Stress + Warping Stress + Frictional stress (At edge region)**
- **Corner (night) – Load Stress + Warping stress**

5. Joints in CC Pavements

5.1 Contraction joints

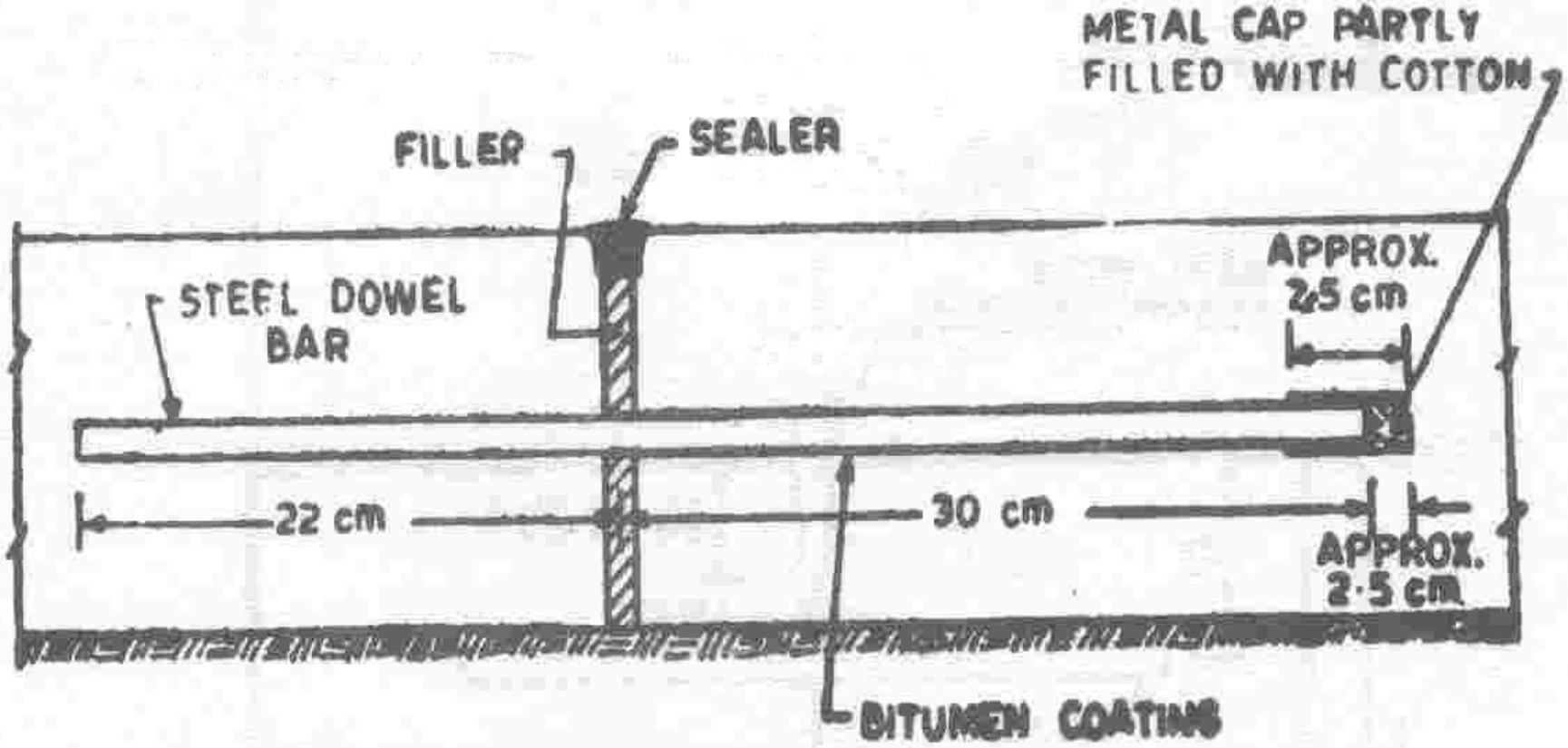


Plain Contraction



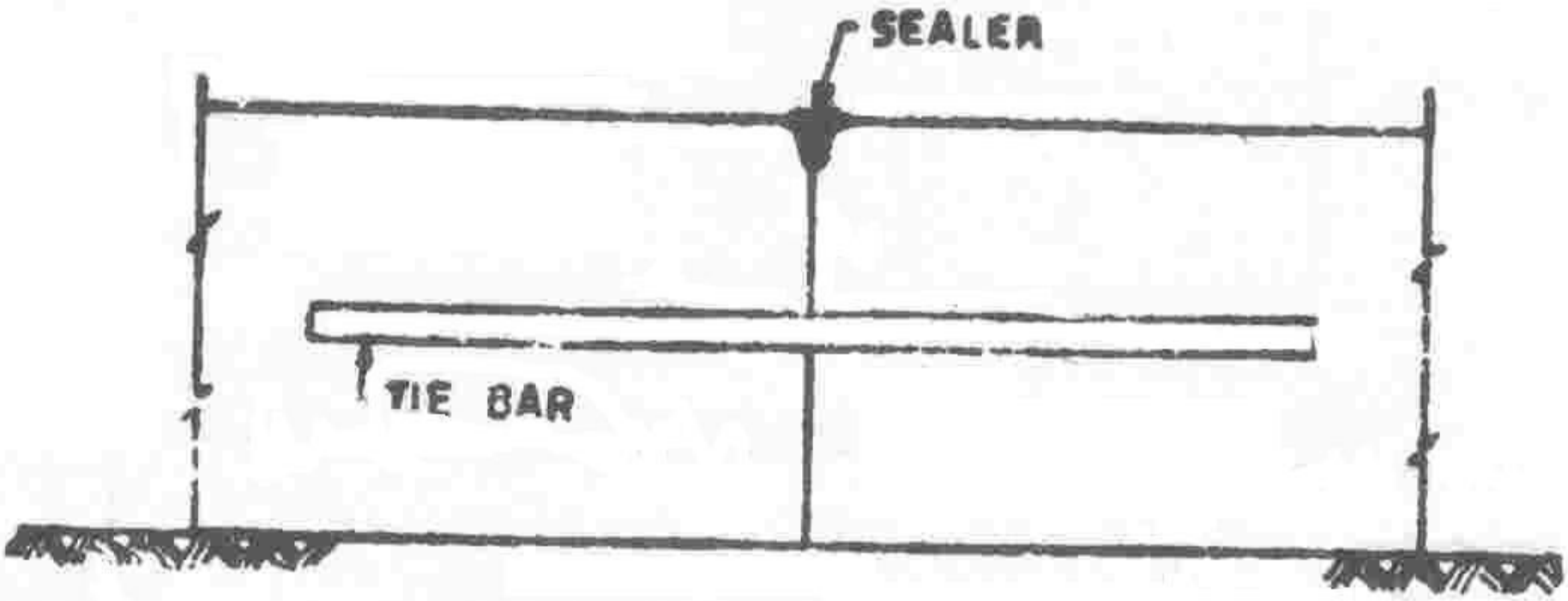
Contraction Joint with Dowel Bar

5.2 Expansion joints



Expansion Joint with Dowel Bar

5.3 Longitudinal joints with tie bars



Butt Joint with Tie Bar

6. Design Factors

6.1 Design life

6.2 Support condition (K-value)

6.3 Properties of CC slab

6.4 Traffic Loads

- heavy wheel loads and number of repetitions
- wheel load distribution and repetitions
- wheel load configuration

6.5 Temperature variations

- region and climatic factors
- daily variations
- seasonal variation

6.6 Friction factor (f)

6.7 Joints

- types
- spacing
- other design details of joints

6. Design Factors for Rigid (CC) Pavements

6.1 Load

- Wheel load : magnitude and repetitions
- Multiple wheel loads and ESWL for CC pavement
- Design wheel load based on cumulative distribution of loads
- Fatigue life due to loads in excess of design load during design life

6.2 Subgrade support - K value of subgrade and sub-base course

6.3 Maximum temperature variations in the location

- maximum temperature differential during the daily cycle
- maximum seasonal variation during annual cycle

6.4 Properties of CC / PQC used in pavement slab : specified compressive / flexural strength

6.5 Design of joints in CC pavement

- spacing of different contraction and longitudinal of joints
- dowel bars and tie bars / reinforcements at joints

7. General Steps for Design of CC Pavements

7.1 Design of joint types and spacing

7.2 Design of slab thickness

- warping stress and residual strength
- load stress and factor of safety
- fatigue due to repetition of heavy wheel loads considering stress ratio

7.3 Design details of Joints

- **Dowel bars at expansion and construction joints (design of dowel bar and dowel group)**
- **Tie bars at longitudinal joints**

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Thank You