TMC – Tinni Management Consulting

PAVEMENT INFORMATION NOTE

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Check of CRCP Terminal Anchor Lug Requirements

It is the normal requirement to have three lugs, 1200 mm terminal anchors for CRC Pavements. However, this only applies once the "free end" length of ~140 m is exceeded. This means that the pavement length would be at least 280 m. If this length is shorter, eg 150 m, then the slip length becomes 75 m and it is cost effective to do a design check of the lug requirement. This is generally overlooked by designers. The following background will enable this to be done.

Ref. "Use of Pavement Anchors is Concrete Pavements", A Tinni and RJ Stubbs. Report to RTA September, 1994.

Basic Concepts for Multi-lug Anchors

- Where thermal expansion strains are larger than the shrinkage contraction strains, the base slab goes into compression, but does not slide on the subbase until near the end, where the cumulative friction (or anchor) forces from the slab terminal are less than the compression force required to fully restrain the slab.
- The anchor system is under significant expansive load only in the summer following winter casting, before the full shrinkage contraction has taken place and is associated with the normal expansive movement of the slab end of approximately 6-13 mm under the effect of the transient thrust load.
- The load capacity of multi-lug terminal anchors is sensitive to the cohesion of the native material below the subgrade.
- For the anchors to develop resistance to the thrust forces, some end movement must take place.
- A 1200 mm deep anchor lug in dense sand theoretically develops full passive soil loading in conjunction with a rotation of 0.005, which produces a 6 mm displacement of the top of the lug. In design, this 6 mm is usually adopted for calculations.

Assumptions

- Base concrete = 35 MPa
- Slab thickness = 250 mm
- Density of concrete = 2400 kg/m^3
- Coefficient of Friction = 1.5
- Seasonal variation of slab movements (net) = 180 μm (Coastal)

Check calculations

Using average temperature ranges and shrinkage characteristics, it can be shown that a thrust of 1350 kN/m width is produced if no end movement is allowed to take place.

Modulus of Elasticity of Concrete: $E_c = (\rho)^{1.5} \times 0.043\sqrt{f_c}$

where ρ = density of concrete

f_c = mean compressive strength of concrete

$E_c = 2400^{1.5} \times 0.043\sqrt{35}$

= 29,930, say 30,000 MPa

Slab Compressive Force = Expansion (180 μm) x E_c (30,000 MPa) x Slab area (0.25 m^2/m width)

= 1,350 kN

Slip Friction Force = Weight x Coefficient of Friction

= 0.25 x Slip length L_s x 24 kN/m^3 x 1.5

= $9L_s$ = 1,350 kN/m width (at load balance or "no slip" point)

Slip length L_s = 1350/9 = 150 m

End Slip Movement = Average compressive stress [675 kN / 0.25 m^2] / E_c x L_s

= [675/0.25] / [30,000 / 150]

= 13.5 mm

The maximum thrust from expansion is 1350 kN/m and occurs when no end movement is allowed. For the anchors to develop maximum resistance, end movement of 6 mm is usually required. It should be noted that where the CRCP abuts a bridge approach slab or another rigid pavement, there is always an isolation joint and hence the maximum 6 mm movement has no structural significance.

Design Evaluation

As lugs cost some $5,000 each, for short pavement lengths, it is worth getting an assessment of the approximate value of the subgrade soil cohesion. It should be noted that of that 1200 mm lug depth, 150 mm is the LMC and 300 mm the SMZ. This is a bonus already

It can be shown that against the 1350 kN no movement thrust, a 6 mm end movement will reduce the maximum thrust per metre width to 690 kN. This inturn requires a soil cohesion of not less than 33 kPa for a three lug anchor or a minimum of 66 kPa for a two lug anchor. (Note that the Rule of Thumb is that the 6 mm movement reduces the no move thrust by about half).

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