Interoir bay slab design

For these calculations the emperical method for interior bays shall be used - LRFD 9.7.2
9.7.2 States that the emperical method can not be applied to overhangs.

Beam Spacing (ft) = bs := 8.0

Top cover (in) = tc := 2.5

Slab thickness (in) = ts := 8.25

Bar diameter (in) = bd := 0.75

Slab concrete strength (ksi) = fc := 4

Strength of rebar (ksi) = fy := 60

Overhang distance (ft) = ov := 4.25

Width of top flange (in) = fw := 20

Is rail continuous ("yes" or "no") cont := "no"

Rail width (in) = rw := 13

Rail weight (k/ft) = rwt := 0.5

9.7.2.4 Design Conditions

- cross frames are used at lines of support
- beams are made of steel or concrete
- deck is uniform depth
- 18 > S/ts > 6
- Core depth > 4"
- S < 13.5
- ts > 7.0
- overhang > 5*ts
- fc >= 4 ksi
- deck is composite

LRFD 9.7.2.5 - primary reinforcing

4 layers of reinforcement shall be provided

As(min) for top layer = 0.18 in^2/ft
As(min) for bottom layer = 0.27 in^2/ft

Spacing shall ot be greater than 18 in.

Say #5 @ 1'-0" As1 := 0.31

LRFD 9.7.3.2 - Distribution Reinforcement

For primary reinforcement perpendicular to traffic $\frac{220}{\sqrt{S}} \le 67\%$

$$p1 := \min\left(\begin{pmatrix} 67 \\ \frac{220}{\sqrt{bs}} \end{pmatrix}\right) \qquad p1 = 67$$

Required Steel for distribution (in^2) = $As2 := As1 \cdot \frac{p1}{100}$ $\qquad As2 = 0.208$

NOTE: The overhang design will probably require more steel than for interior bay design.

Deck overhang design

LRFD A13.4.1

CASE I: Transverse and longitudinal forces specified in A13.2 extreme limit state.
CASE II: Vertical forces specified in A13.2 extreme limit state.
CASE III: Loads specified in 3.6.1 - strength limit state.

Equivalent strip width

LRFD 3.6.1.3.4 - commentary states that a 25 ft strip may be used if the rail/parapet is continuous. If the rail is not continuous or is of the "flow through" type use the strip as defined in Table 4.6.2.1.3-1.

$strip1 := 25$

$$x := ov - \frac{rw}{12} - \frac{fw}{24} \qquad x = 2.333$$

$$strip2 := \frac{45 + 10 \cdot x}{12} \qquad strip2 = 5.694$$

CASE I

Height of impact (in) = $He := 24$

Height of rail (in) = $H := 27$

Length of impact contact area (ft) = $Lt := 4$ $Ll := 4$

Vertical force (k) = $Fv := 4.5$

Longitudinal force (k) = $Fl := 18$

Transverse force (k) = $Ft := 54$

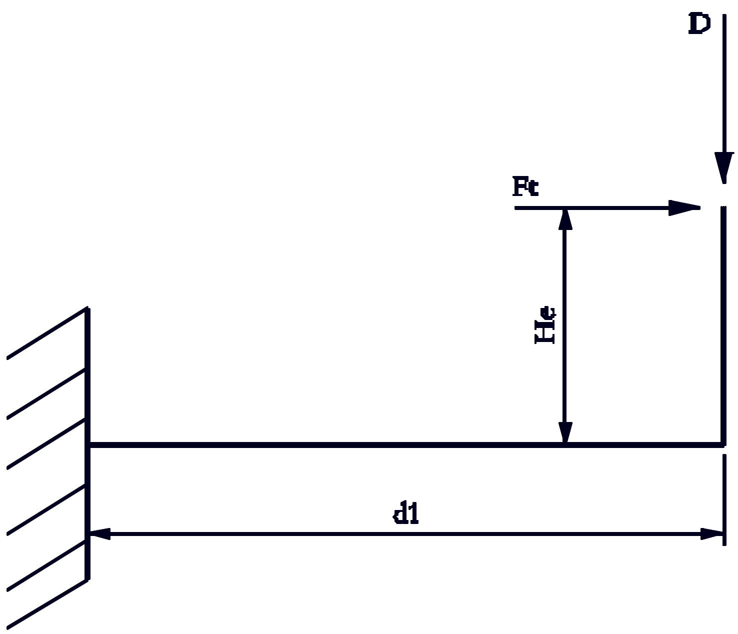
The impact area shall be added to the equivalent strip width because the load is considered to be a strip and not a true point load.

$strip3 := strip2 + Lt$ $strip3 = 9.694$

Slab weight per foot (k/ft) = $w1 := \frac{ts}{12} \cdot \left(ov - \frac{fw}{24} \right) \cdot 0.15$ $w1 = 0.352$

Effective depth of slab (in) = $d := ts - tc - \frac{bd}{2}$ $d = 5.375$

Distance from fix point to slab edge less rail width (ft) = $d1 := ov - \frac{fw}{24} - \frac{rw}{12}$ $d1 = 2.333$



$D := strip3 \cdot (w1 + rwt)$ $D = 8.263$

Applied moment (k*ft) = $Mu := Ft \cdot \frac{He}{12} + D \cdot d1$ $Mu = 127.28$

$As3 := 0$

Required Steel (in^2) = $As3 := root\left[1.0 \cdot As3 \cdot fy \cdot \left(d - \frac{As3 \cdot fy}{0.85 \cdot fc \cdot strip3 \cdot 12}\right) - Mu \cdot 12, As3\right]$

$As3 = 5.631$

Required Steel per foot (in^2) = $As4 := \frac{As3}{strip3}$ $As4 = 0.581$

Spacing of # 5 bars (in) = $s5 := \frac{0.31}{As4} \cdot 12$ $s5 = 6.405$

Spacing of # 6 bars (in) = $s6 := \frac{0.44}{As4} \cdot 12$ $s6 = 9.09$

Case II

Moment (k*ft) = $M2 := Fv \cdot d1$ $M2 = 10.5$

| "Does not control" if M2 < Mu | = "Does not control"
| "This load controls" otherwise

Case III

LRFD C3.6.1.3.4 States that a 25 k vertical load shall be placed a distance of 1 ft from the front face of the rail.

$d2 := ov - \frac{rw}{12} - 1 - \frac{fw}{24}$ $d2 = 1.333$ If this value is zero (0) then the wheel is inside the beam flange and thus will not control.

Revisit distribution reinforcement reinforcement

Required Steel per foot (in^2/ft) = $As5 := As4 \cdot \frac{p1}{100}$ $As5 = 0.389$

Spacing of # 5 bars (in) = $s5 := \frac{0.31}{As5} \cdot 12$ $s5 = 9.559$

Spacing of # 6 bars (in) = $s6 := \frac{0.44}{As5} \cdot 12$ $s6 = 13.568$