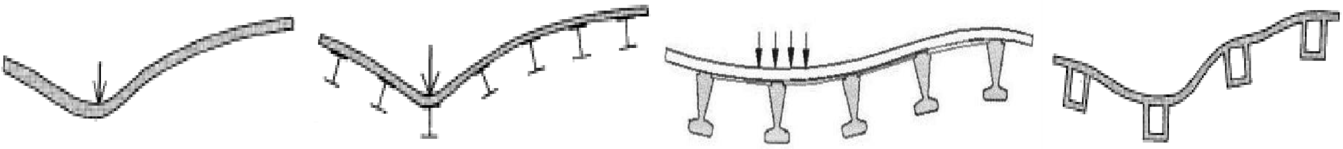
Intermediate and End Diaphragms between Girders

Distribution Factors

Axle load distribution factor (DF) is used because the moving load cannot be concentrated on one exterior or interior girder. Thereby, presence of concrete deck leads to distribute the live load into all supporting girders. The girder under the wheel line is subjected to a main fraction of load while the rest of fraction is participated by the adjacent girders.



Deflection of Beams and Deck under Axle Load

The (DF) values of moment differ from that used for shear. Also, the values of interior girder (DF_{int}) are different from that of exterior girder (DF_{ext}). In general, there are values for one (single) loaded lane and two or more (multiple) loaded lanes. So, the greater value governs in each interior and exterior girder. However, in case of precast prestress concrete girders, the greatest among the four values is governing.

$$M_{LL+IM} = DFM[(1 + IM)M_{Mo} + M_{Ln}]$$
$$V_{LL+IM} = DFV[(1 + IM)V_{Mo} + V_{Ln}]$$

The (DF) values can be determined from AASHTO Tables where equations are already adopted and multiple presence factor is included $(m = 1)$ but with local stipulations. Other cases, lever rule method is applicable where (m) value is required.

N_g: number of girders
L: length of span (mm)
S: spacing girders (mm)
h_d: thickness of deck (mm)
K_g: longitudinal stiffness parameter (mm^4)
e: transforming factor
d_e: distance from exterior girder center to the inside edge of curb or barrier (mm)

The longitudinal stiffness parameter (K_g) shall be taken as:

$$K_g = n(I_g + A_g.e_g{}^2)$$
$$n = E_g/E_d$$

where:

E_g: modulus of elasticity of girder material (MPa)
E_d: modulus of elasticity of deck material (MPa)
A_g: area of girder (mm^2)
I_g: moment of inertia of the basic girder (mm^4)
e_g: distance between the centers of gravity of the basic girder and deck (mm).

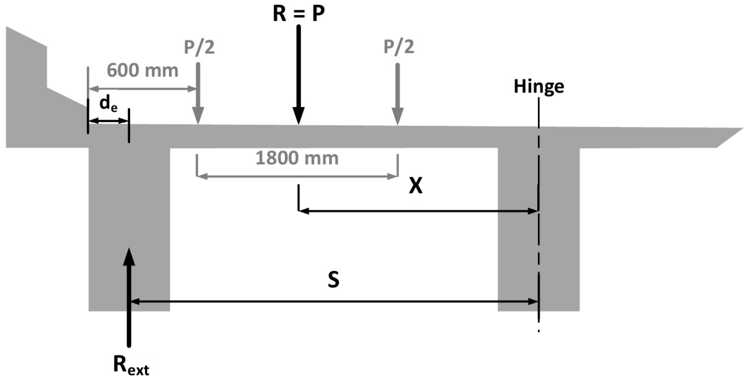
Distribution of Live Load per Lane for Concrete Deck on Steel or Concrete Beams

Location	Action	Equation	Range of Applicability
Interior	Moment	*Single Lane Loaded* $DFM_{si} = 0.06 + \left(\frac{S}{4300}\right)^{0.4}.\left(\frac{S}{L}\right)^{0.3}.\left(\frac{K_g}{L.h_d{}^3}\right)^{0.1}$	$N_g \geq 4$ $6x10^3 \leq L \leq 73x10^3$ $1.1x10^3 \leq S \leq 4.9x10^3$ $110 \leq h_d \leq 300$ $4x10^9 \leq K_g \leq 3x10^{12}$
		Multiple Lanes Loaded $DFM_{mi} = 0.075 + \left(\frac{S}{2900}\right)^{0.6}.\left(\frac{S}{L}\right)^{0.2}.\left(\frac{K_g}{L.h_d{}^3}\right)^{0.1}$	
	Shear	*Single Lane Loaded* $DFV_{si} = 0.36 + \frac{S}{7600}$	
		Multiple Lanes Loaded $DFV_{mi} = 0.2 + \frac{S}{3600} - \left(\frac{S}{10700}\right)^2$	
Exterior	Moment	*Single Lane Loaded* **Use Lever Rule**	$-300 \leq d_e \leq 1700$
		Multiple Lanes Loaded $DFM_{me} = e.DFM_{mi}$ $e = 0.77 + \frac{d_e}{2800}$	
	Shear	*Single Lane Loaded* **Use Lever Rule**	
		Multiple Lanes Loaded $DFV_{me} = e.DFV_{mi}$ $e = 0.6 + \frac{d_e}{3000}$	

Lever Rule

The (DF) is the reaction at the exterior girder (R_{ext}) about the Hinge. The axle load (P) is assumed to equal one-unit weight and the presence factor (m) almost for single lane loaded.

$$R_{ext} = X.R/S$$
$$R = 1 \rightarrow R_{ext} = X/S$$
$$DF = m.R_{ext}$$
$$\rightarrow DFM_{se} = DFV_{se} = 1.2\ x\ R_{ext}$$



Lever Rule for Exterior Beam

Skin Reinforcement

If the extreme tensile depth (d_t) of nonprestressed concrete members exceeds 900 mm, longitudinal skin reinforcement (A_{sk}) shall be uniformly distributed along both side faces of the component for a distance ($d_t/2$) nearest the flexural tension reinforcement.

The area of skin reinforcement (A_{sk}) in mm^2 on each side face shall satisfy:

- $A_{sk} = 0.001(d_t - 760).h_w$
  $\leq A_s/4$
- $s_{max} = d_t/6$
  $\leq 300\ mm$

where:

d_t: distance from extreme compression fiber to centroid of extreme tension steel element (mm)
A_s: required flexural tensile reinforcement (mm^2)
h_w: web height of girder (mm)
s_{max}: maximum skin reinforcement spacing on each side face (mm).

Design Procedure for Beams

- Determine the beam span length (L)
- From AASHTO Tables, find minimum overall thickness (h_{min}) and then use ($h \geq h_{min}$)
- Try a thickness value for the deck (h_d) and take flange thickness (h_f) equals it ($h_f = h_d$)
- Take the beams numbers ($N_g \geq 4$), locate the beams and then find the beam spacing (S) satisfies the deck overhang (w_o):
  - $w_o = 0.625S$
    $\leq 1800\ mm$
- Determine the effective flange width (b_f) while the:
  - $b_f = S_L/2 + S_R/2$ [interior beam]
    $= S/2 + w_o$ [exterior beam]
- Determine the minimum web thickness ($b_{w,min}$) and then use ($b_w \geq b_{w,min}$):
  - $b_{w,min} = 2(c_c + \emptyset_v) + N_b.\emptyset_b + (N_b - 1).s$