Example 3.4

Determine the live load distribution factor (DF) values for bending moment and shear force acting on concrete slab bridge of simple span of 10 m effective length as shown below. The clear roadway (w) is 6 m between two concrete barriers of 0.5 m width.

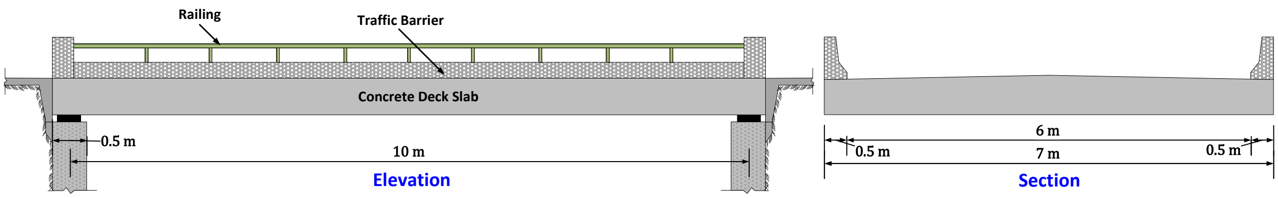

Figure 3-8: Details for Example 3.4

Solution 3.4

Interior Strip

$w = 6\text{ m}$

$\rightarrow N_L = 2$ each lane with 3 m width

$\because N_L = 2 \rightarrow \therefore$ check both E_{i1} and E_{i2}

$L_1 = L = 10\text{ m}$ governs

$\leq 18\text{ m}$

$W_1 = W = 7\text{ m}$ governs

$\leq 18\text{ m}$

$E_{i1} = 0.25 + 0.42\sqrt{L_1 W_1}$

$= 0.25 + 0.42\sqrt{(10)(7)} = 3.76\text{ m}$

$E_{i2} = 2.10 + 0.12\sqrt{L_1 W_1}$

$= 2.10 + 0.12\sqrt{(10)(7)} = 3.10\text{ m}$ governs

$\leq W/N_L = 7/2 = 3.5\text{ m}$

$\therefore E_i = 3.10\text{ m}$

$DF_{im} = DF_{iv} = 1/E_i = 1/3.1 = 0.32$

Exterior Strip

$E_e = W_e + 0.3 + E_i/4$

$= 0.5 + 0.3 + 3.1/4 = 1.58\text{ m}$

$\leq E_i/2 = 3.1/2 = 1.55\text{ m}$ governs

$\leq 1.8\text{ m}$

$\therefore E_e = 1.55\text{ m}$

$DF_{em} = DF_{ev} = 1/E_e = 1/1.55 = 0.65$

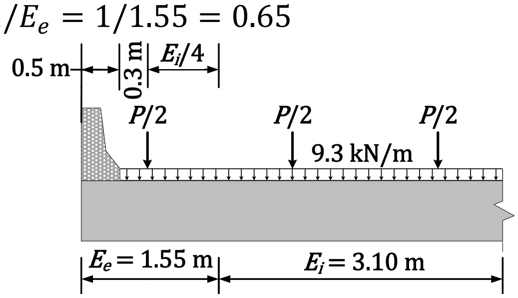

Figure 3-9: Section Configuration for Equivalent Strips

Example 3.5

Determine the live load distribution factor (DF) values for bending moment and shear force acting on concrete slab bridge of simple span of 20 m effective length as shown below. The clear roadway (w) is 9 m between two concrete barriers of 0.5 m width.

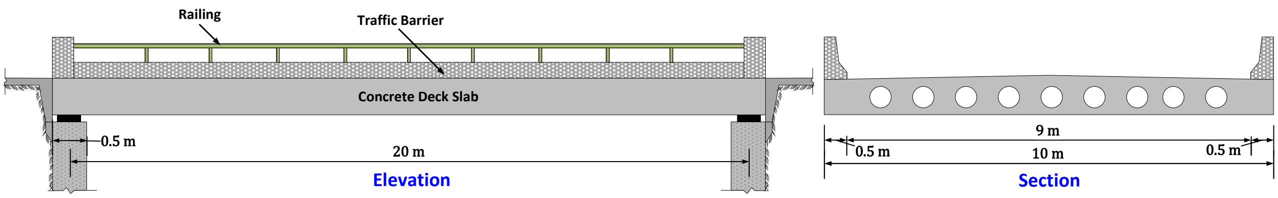

Figure 3-10: Details for Example 3.5

Solution 3.5

<u>Interior Strip</u>

$w = 9\ \text{m}$

$N_L = \text{INT}(\text{w}/3.6) = \text{INT}(9.0/3.6) = 2$

$\because N_L = 2 \rightarrow \therefore$ check both E_{i1} and E_{i2}

$L_1 = L = 20\ \text{m}$

$\le 18\ \text{m}$ governs

$W_1 = W = 10\ \text{m}$ governs

$\le 18\ \text{m}$

$E_{i1} = 0.25 + 0.42\sqrt{L_1 W_1}$

$= 0.25 + 0.42\sqrt{(18)(10)} = 5.88\ \text{m}$

$E_{i2} = 2.10 + 0.12\sqrt{L_1 W_1}$

$= 2.10 + 0.12\sqrt{(18)(10)} = 3.70\ \text{m}$ governs

$\le W/N_L = 10/2 = 5\ \text{m}$

$\therefore E_i = 3.7\ \text{m}$

$DF_{im} = DF_{iv} = 1/E_i = 1/3.7 = 0.27$

<u>Exterior Strip</u>

$E_e = W_e + 0.3 + E_i/4$

$= 0.5 + 0.3 + 3.7/4 = 1.72\ \text{m}$ governs

$\le E_i/2 = 3.7/2 = 1.85\ \text{m}$

$\le 1.8\ \text{m}$

$\therefore E_e = 1.72\ \text{m}$

$DF_{em} = DF_{ev} = 1/E_e = 1/1.72 = 0.58$

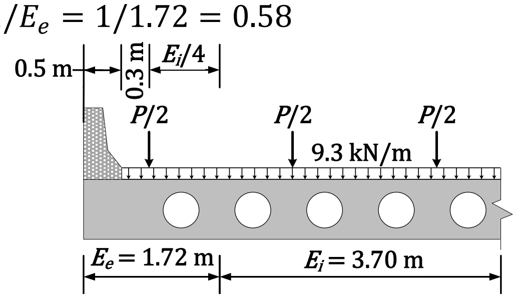

Figure 3-11: Section Configuration for Equivalent Strips

Example 3.6

Determine all the live load distribution factor (DF) values for the concrete beam bridge of simple span of 20 m between centers of bearings for which the elevation and section are shown below. The clear roadway (w) is 6 m between traffic barriers of 0.5 m width.

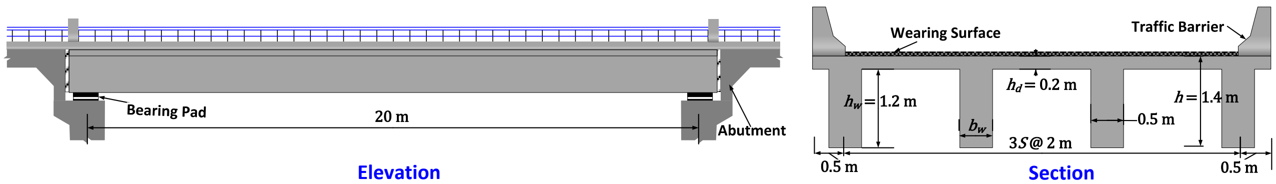

Figure 3-12: Details for Example 3.6

Solution 3.6

Interior Girder

Check the applicability criteria:

$N_g \geq 4$	$N_g = 4$	$\therefore$ OK
$6 \leq L \leq 73$	$L = 20$ m	$\therefore$ OK
$1.1 \leq S \leq 4.9$	$S = 1.5$ m	$\therefore$ OK
$110 \leq h_d \leq 300$	$h_d = 200$ mm	$\therefore$ OK
$4\text{x}10^9 \leq K_g \leq 3\text{x}10^{12}$	$K_g = 562\text{x}10^9$ mm^4	$\therefore$ OK

$$n = E_g/E_d = 1.0$$

$$I_g = b_w {h_w}^3/12 = (500)(1200)^3/12 = 72\text{x}10^9 \text{ mm}^4$$

$$A_g = h_f b_f + h_w b_w = (200)(2000) + (1200)(500) = 1\text{x}10^6 \text{ mm}^2$$

$$e_g = h_f/2 + h_w/2 = 200/2 + 1200/2 = 700 \text{ mm}$$

$$K_g = n(I_g + A_g {e_g}^2) = (1.0)[72\text{x}10^9 + 1\text{x}10^6(700)^2] = 562\text{x}10^9 \text{ mm}^4$$

$$w = 6 \text{ m}$$

$\rightarrow N_L = 2$ each lane with 3 m width

$\therefore$ check both g_{i1} and g_{i2}

Live load distribution factor for bending moment:

$$g_{im1} = 0.06 + (S/4.3)^{0.4}(S/L)^{0.3}\left(K_g/L{h_d}^3\right)^{0.1}$$

$$= 0.06 + (2/4.3)^{0.4}(2/20)^{0.3}[562\text{x}10^9/(20\text{x}10^3)(200)^3]^{0.1} = 0.48$$

$$g_{im2} = 0.075 + (S/2.9)^{0.6}(\text{S/L})^{0.2}\left(K_g/L{h_d}^3\right)^{0.1}$$

$$= 0.075 + (2/2.9)^{0.6}(2/20)^{0.2}[562\text{x}10^9/(20\text{x}10^3)(200)^3]^{0.1} = 0.65$$

$$\therefore DF_{im} = 0.65$$

Live load distribution factor for shear:

$$g_{iv1} = 0.36 + S/7.6$$

$$= 0.36 + 2/7.6 = 0.62$$

$$g_{iv2} = 0.2 + S/3.6 - (S/10.7)^2$$

$$= 0.2 + 2/3.6 - (2/10.7)^2 = 0.72$$

$$\therefore DF_{iv} = 0.72$$

Live load distribution factor for fatigue:

$$DF_{ifm} = g_{im1}/1.2 = 0.48/1.2 = 0.40$$

$$DF_{ifv} = g_{iv1}/1.2 = 0.62/1.2 = 0.52$$

Live load distribution factor for deflection:

$$DF_{\Delta} = mN_L/N_g = (1.0)(2)/4 = 0.50$$

Exterior Girder

Check the applicability criteria:

$-0.3 \leq d_e \leq 1.7$ $\quad\quad d_e = 0$ $\quad\quad \therefore$ OK

$\because N_L = 2 \rightarrow$ check both g_{e1} and g_{e2}

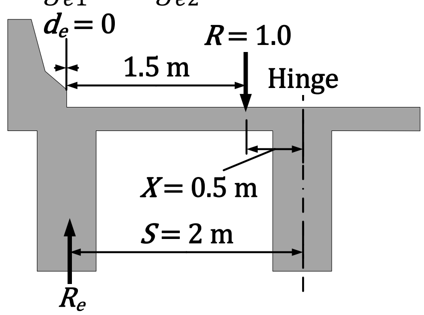

Figure 3-13: Level Rule for Exterior Girder

Live load distribution factor for bending moment:

$$R_e = X/S = 0.5/2 = 0.25$$

$$g_{em1} = mR_e = (1.2)(0.25) = 0.30$$

$$e_m = 0.77 + d_e/2.8 = 0.77$$

$$g_{em2} = e_m g_{im2} = (0.77)(0.65) = 0.50$$

$$\therefore DF_{em} = 0.50$$

Live load distribution factor for shear:

$$g_{ev1} = g_{em1} = 0.30$$

$$e_v = 0.6 + d_e/3 = 0.6$$

$$g_{ev2} = e_v g_{iv2} = (0.6)(0.72) = 0.43$$

$$\therefore DF_{iv} = 0.43$$

Live load distribution factor for fatigue:

$$DF_{efm} = g_{em1}/1.2 = 0.25$$

$$DF_{efv} = g_{ev1}/1.2 = 0.25$$

Live load distribution factor for deflection:

$$DF_{\Delta} = 0.50$$

Example 3.7

Determine all the live load distribution factor (DF) values for the concrete beam bridge of simple span of 30 m between centers of bearings for which the elevation and section are shown below. The clear roadway (w) is 9 m between traffic barriers of 0.5 m width.

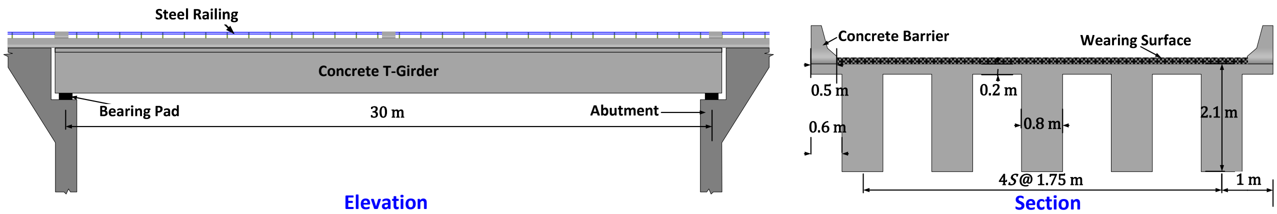

Figure 3-14: Details for Example 3.7

Solution 3.7

Interior Girder

Check the applicability criteria:

$N_g \geq 4$	$N_g = 5$	$\therefore$ OK
$6 \leq L \leq 73$	$L = 30$ m	$\therefore$ OK
$1.1 \leq S \leq 4.9$	$S = 1.75$ m	$\therefore$ OK
$110 \leq h_d \leq 300$	$h_d = 200$ mm	$\therefore$ OK
$4\text{x}10^9 \leq K_g \leq 3\text{x}10^{12}$	$K_g = 1.374\text{x}10^9$ mm^4	$\therefore$ OK

$$n = E_g/E_d = 1.0$$

$$I_g = b_w {h_w}^3/12 = (800)(1900)^3/12 = 457.27\text{x}10^9 \text{ mm}^4$$

$$A_g = h_f b_f + h_w b_w = (200)(1750) + (1900)(800) = 1.87\text{x}10^6 \text{ mm}^2$$

$$e_g = h_f/2 + h_w/2 = 200/2 + 1900/2 = 1050 \text{ mm}$$

$$K_g = n\left(I_g + A_g {e_g}^2\right) = (1.0)[457.27\text{x}10^9 + 1.87\text{x}10^6(700)^2] = 1.374\text{x}10^{12} \text{ mm}^4$$

$$w = 9 \text{ m}$$

$$N_L = \text{INT}(\text{w}/3.6) = \text{INT}(9.0/3.6) = 2 \therefore \text{check both } g_{i1} \text{ and } g_{i2}$$

Live load distribution factor for bending moment:

$$g_{im1} = 0.06 + (S/4.3)^{0.4}(S/L)^{0.3}\left(K_g/L{h_d}^3\right)^{0.1}$$

$$= 0.06 + (1.75/4.3)^{0.4}(1.75/30)^{0.3}[1.374\text{x}10^{12}/(30\text{x}10^3)(200)^3]^{0.1} = 0.41$$

$$g_{im2} = 0.075 + (S/2.9)^{0.6}(\text{S/L})^{0.2}\left(K_g/L{h_d}^3\right)^{0.1}$$

$$= 0.075 + (1.75/2.9)^{0.6}(1.75/30)^{0.2}[1.374\text{x}10^{12}/(30\text{x}10^3)(200)^3]^{0.1} = 0.57$$

$$\therefore DF_{im} = 0.57$$

Live load distribution factor for shear:

$$g_{iv1} = 0.36 + S/7.6$$

$$= 0.36 + 1.75/7.6 = 0.59$$

$$g_{iv2} = 0.2 + S/3.6 - (S/10.7)^2$$

$$= 0.2 + 1.75/3.6 - (1.75/10.7)^2 = 0.66$$

$$\therefore DF_{iv} = 0.66$$

Live load distribution factor for fatigue:

$$DF_{ifm} = g_{im1}/1.2 = 0.41/1.2 = 0.34$$

$$DF_{ifv} = g_{iv1}/1.2 = 0.62/1.2 = 0.49$$

Live load distribution factor for deflection:

$$DF_{\Delta} = mN_L/N_g = (1.0)(2)/5 = 0.40$$

Exterior Girder

Check the applicability criteria:

$-0.3 \leq d_e \leq 1.7$ $\quad d_e = 0.5$ $\quad \therefore$ OK

$\because N_L = 2 \rightarrow$ check both g_{e1} and g_{e2}

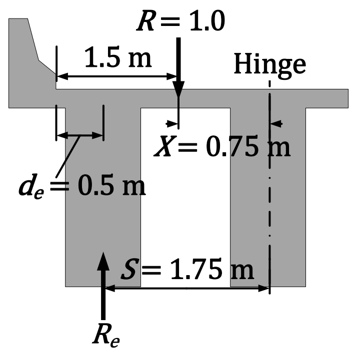

Figure 3-15: Level Rule for Exterior Girder

Live load distribution factor for bending moment:

$$R_e = X/S = 0.75/1.75 = 0.43$$

$$g_{em1} = mR_e = (1.2)(0.43) = 0.51$$

$$e_m = 0.77 + d_e/2.8 = 0.77 + 0.5/2.8 = 0.95$$

$$g_{em2} = e_m g_{im2} = (0.95)(0.57) = 0.54$$

$$\therefore DF_{em} = 0.54$$

Live load distribution factor for shear:

$$g_{ev1} = g_{em1} = 0.51$$

$$e_v = 0.6 + d_e/3 = 0.6 + 0.5/3 = 0.77$$

$$g_{ev2} = e_v g_{iv2} = (0.77)(0.66) = 0.51$$

$$\therefore DF_{iv} = 0.51$$

Live load distribution factor for fatigue:

$$DF_{efm} = DF_{efv} = 0.43$$

Live load distribution factor for deflection:

$$DF_{\Delta} = 0.40$$