Live Load Distribution Factors for a Three Span Continuous Precast Girder Bridge

BridgeSight Solutions™
for the
AASHTO LRFD Bridge Design Specifications

BridgeSight
Software™

Creators of effective and reliable solutions for the world's bridge engineers

2688 Venado Way
Rescue, CA 95672
Phone: 530-672-1569
E-mail: rdp@BridgeSight.com
Internet: www.BridgeSight.com

Title	Live Load Distribution Factors For A Three Span Continuous Precast Girder Bridge	**Publication No**.	BSS01011999-2

Abstract

This design example illustrates the procedure for calculating live load distribution factors for the approximate method of analysis described in Article 4.6.2 of the AASHTO LRFD Bridge Design Specifications. The example focuses on beam and slab bridge types. Live load distribution factors are computed for a three span continuous precast girder bridge for moment, shear, and reactions.

Notes

Author	Staff - BridgeSight Software	**Sponsor**	BridgeSight Software 2688 Venado Way Rescue, CA 95672

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Introduction

One of the first things an engineer learns about the AASHTO LRFD Bridge Design Specification is the live load distribution factor calculations are very much different than the S/D method prescribed in the AASHTO Standard Specification for Highway Bridges. As the LRFD Specification evolves, as evidenced by the interim provisions in 1996 and 1997 and a second edition in 1998, the method of calculating live load distribution factors has been refined. The purpose of this design example is to illustrate the latest technique of computing live load distribution factors for the approximate method of analysis described in Article 4.6.2.

Live load distribution factors are computed for a three span continuous precast girder bridge. The calculations shown in this design example are also applicable to steel I-girders with concrete deck bridges.

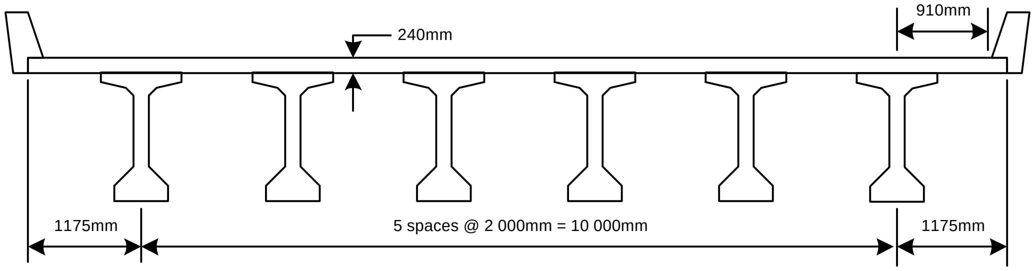
Live load distribution factors are computed for moment, shear, and reactions for interior and exterior girders. The distribution factors are computed for strength, service, extreme event, and the fatigue limit state.

This design example is part of the BridgeSight Solutions™ series. The BridgeSight Solutions™ series is comprised of design aids and design examples to assist practicing engineers and engineering students learn and implement the AASHTO LRFD Bridge Design Specification. Visit the BridgeSight Solutions™ section of our web site at www.BridgeSite.com for more information.

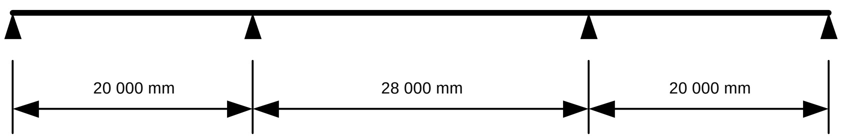
Code Reference

Design Example

Compute the live load distribution factors for the prestressed, precast girder bridge shown below.



Typical Section



Span Configuration

Girder Properties

AASHTO Type V Girders

A = 653587 mm^2

I = 216.9 x 10^9 mm^4

Y_b = 812 mm

Y_t = 788 mm

Concrete Properties

Girder f'_c = 48 MPa

Slab f'_c = 27.5 MPa

Assumptions

Assume the bridge contains intermediate diaphragms.

Solution

Lets begin by selecting our cross section type from Table 4.6.2.2.1-1. The superstructure of the bridge is precast concrete I beams with a cast in place concrete deck. This configuration corresponds to typical cross section type k.

Longitudinal Stiffness Parameter

Through out the tables given in Article 4.6.2.2, a longitudinal stiffness parameter, K_g, is used. We will compute this parameter now.

Eqn 4.6.2.2.1-1

$$K_g = n\left(I + Ae_g^2\right)$$

Code Reference

where:

n = modular ratio between beam and deck material

$$n = \frac{E_{beam}}{E_{slab}}$$

I = moment of inertia of the beam (mm^4)

A = area of beam (mm^2)

e_g = distance between the centers of gravity of the basic beam and deck (mm)

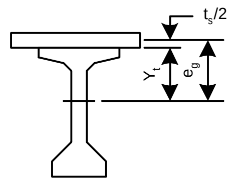
$$E_{concrete} = 0.043 g_c^{1.5} \sqrt{f'_c}$$

5.4.2.4

Eqn 5.4.2.4-1

$$n = \frac{0.043 g_c^{1.5} \sqrt{48\,MPa}}{0.043 g_c^{1.5} \sqrt{27.5\,MPa}} = 1.32$$

$$e_g = Y_t + \frac{t_s}{2} = 788mm + \frac{240mm}{2} = 908mm$$



$$K_g = 1.32\left[216.9x10^9\,mm^4 + \left(653587mm^2\right)\left(908mm\right)^2\right] = 997.6x10^9\,mm^4$$

Number of Design Lanes

3.6.1.1.1

The number of design lanes is equal to the integer portion of the roadway width divided by 3600mm.

$$N_L = \frac{11820mm}{3600mm} = 3 Lanes$$

Live Load Distribution Factors for Moment

Distribution of Live Loads Per Lane for Moments in Interior Beams

C4.6.2.2.1

Determine Span Length Parameter L

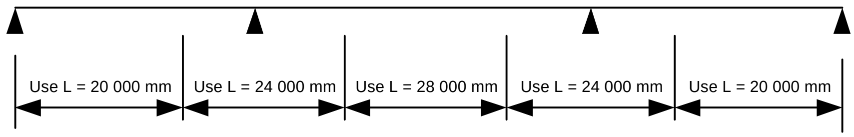
Before we can compute the live load distribution factor for a particular force effect, we must first determine the span length parameter L, that will be used in the equations. The 1996 interim provisions to the 1st Edition of the LRFD specification introduced Table C4.6.2.2.1-1 which defines L for various force effects. This table was updated again in 1998 in the 2nd Edition of the Specification.

For positive moment, Table C4.6.2.2.1-1 defines L for positive moment as the span length for which moment is being calculated. In spans 1 and 3, L is equal to 20 000mm and in span 2 L is equal to 28 000mm.

Table C4.6.2.2.1-1 provides two definitions for L when computing live load distribution factors for negative moment. For negative moments near interior supports of continuous bridges, between points of contraflexure from a uniform load on all spans, the average length of the adjacent spans will be used for L. In all other locations, the length of the span for which moment is being calculated is used for L.

The span length L for live load distribution factors for negative moment is summarized in the figure below.

Code Reference



It is important to determine the locations of the points of contraflexure for all spans loaded with a uniform load so we can apply the distribution factors correctly to live load moments. To simplify this task, we will use the BridgeSight Solutions™ design aid *Contraflexure Points for Continuous Highway Bridges*.

The span ratio for our bridge is

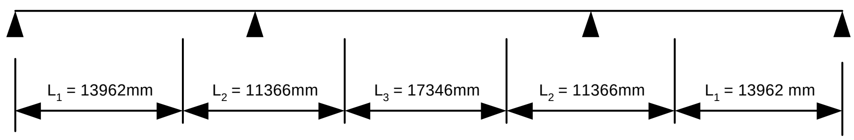
$$N = \frac{L_{\text{interior}}}{L_{exterior}} = \frac{28000mm}{20000mm} = 1.4$$

From Table 2.1 SI in the design aid we get

$$\frac{L_1}{L} = 0.6981 \Rightarrow L_1 = (0.6981)(20000mm) = 13962mm$$

$$\frac{L_2}{L} = 0.5683 \Rightarrow L_2 = (0.5683)(20000mm) = 11366mm$$

$$\frac{L_3}{L} = 0.8673 \Rightarrow L_3 = (0.8673)(20000mm) = 17346mm$$



Check Range of Applicability

Tbl 4.6.2.2.2b-1

Before we can proceed with this method of computing live load distribution factors, we must check the range of applicability. If our structure falls outside the range of applicability, this computational method cannot be used. In the second column of Table 4.6.2.2.2b-1, look for our cross section type, type k. It will be in the third row. This row contains the range of applicability criteria in the fourth column and the live load distribution factor equations in the third column.

1100mm ≤ S ≤ 4900mm	S = 2000mm	**OK**
110mm ≤ t_s ≤ 300mm	t_s = 240mm	**OK**
6000mm ≤ L ≤ 73000mm	Spans 1 and 3, L = 20000mm	**OK**
	Span 2, L = 28000mm	**OK**
N_b ≥ 4	N_b = 5	**OK**

Note that if S exceeds 4900 mm we would use the lever rule to compute all the live load distribution factors. Also note that if N_b is equal to 3 additional considerations are required.

Live Load Distribution Factors for Positive Moments in Interior Beams

Distribution Factors for Spans 1 and 3

Because the span length parameter L is the same for spans 1 and 3 we will calculate their distribution factors together.

One Design Lane Loaded

Code Reference

The live load distribution factor for one design lane loaded is given by

$$gM_1^{i+} = 0.06 + \left(\frac{S}{4300}\right)^{0.4}\left(\frac{S}{L}\right)^{0.3}\left(\frac{K_g}{Lt_s^3}\right)^{0.1}$$

$$gM_1^{i+} = 0.06 + \left(\frac{2000}{4300}\right)^{0.4}\left(\frac{2000}{20000}\right)^{0.3}\left(\frac{997.6x10^9}{20000 \cdot 240^3}\right)^{0.1} = 0.480$$

Two or More Design Lanes Loaded

The live load distribution factor for two or more design lanes loaded is given by

$$gM_{2+}^{i+} = 0.075 + \left(\frac{S}{2900}\right)^{0.6}\left(\frac{S}{L}\right)^{0.2}\left(\frac{K_g}{Lt_s^3}\right)^{0.1}$$

$$gM_{2+}^{i+} = 0.075 + \left(\frac{2000}{2900}\right)^{0.6}\left(\frac{2000}{20000}\right)^{0.2}\left(\frac{997.6x10^9}{20000 \cdot 240^3}\right)^{0.1} = 0.649 \Leftarrow \textbf{Controls}$$

Distribution Factors for Span 2

Now lets compute the positive moment live load distribution factors for the interior beams in span 2.

One Design Lane Loaded

$$gM_1^{i+} = 0.06 + \left(\frac{2000}{4300}\right)^{0.4}\left(\frac{2000}{28000}\right)^{0.3}\left(\frac{997.6x10^9}{28000 \cdot 240^3}\right)^{0.1} = 0.427$$

Two or More Design Lanes Loaded

$$gM_{2+}^{i+} = 0.075 + \left(\frac{2000}{2900}\right)^{0.6}\left(\frac{2000}{28000}\right)^{0.2}\left(\frac{997.6x10^9}{28000 \cdot 240^3}\right)^{0.1} = 0.594 \Leftarrow \textbf{Controls}$$

Live Load Distribution Factors for Negative Moments in Interior Beams

Distribution Factors for Spans 1 and 3 - End of Span to Point of Contraflexure

For spans 1 and 3, from the exterior support to the point of contraflexure (the region defined by L_1), L is equal to the length of the exterior spans. This will results in distribution factors that are the same as for positive moment.

One Design Lane Loaded

$$gM_1^{i-} = 0.480$$

Two or More Design Lanes Loaded

$$gM_{2+}^{i-} = 0.649 \Leftarrow \textbf{Controls}$$

Distribution Factors for Spans 1 and 2 and Spans 2 and 3 - Between Points of Contraflexure Near Interior Support

Code Reference

For the region between points of contraflexure near the interior supports (the region defined by L_2), L is equal to the average of the interior and exterior span lengths.

One Design Lane Loaded

$$gM_1^{i-} = 0.06 + \left(\frac{2000}{4300}\right)^{0.4}\left(\frac{2000}{24000}\right)^{0.3}\left(\frac{997.6x10^9}{24000 \cdot 240^3}\right)^{0.1} = 0.450$$

Two or More Design Lanes Loaded

$$gM_{2+}^{i-} = 0.075 + \left(\frac{2000}{2900}\right)^{0.6}\left(\frac{2000}{24000}\right)^{0.2}\left(\frac{997.6x10^9}{24000 \cdot 240^3}\right)^{0.1} = 0.618$$ 🡐 **Controls**

Distribution Factors for Span 2 - Between Points of Contraflexure

For the region between points of contraflexure in span 2 (the region defined by L_3), L is equal to the length of span 2. This will results in distribution factors that are the same as for positive moment in span 2.

One Design Lane Loaded

$$gM_1^{i-} = 0.427$$

Two or More Design Lanes Loaded

$$gM_{2+}^{i-} = 0.594$$ 🡐 **Controls**

Distribution of Live Loads Per Lane for Moments in Exterior Beams

C4.6.2.2.1

Check Range of Applicability

Before applying the equations for live load distribution factors in Table 4.6.2.2.2d-1 we must check the range of applicability for this table.

Tbl 4.6.2.2.2d-1

-300mm ≤ d_e ≤ 1700mm d_e = 910mm   **OK**

Live Load Distribution Factors for Positive Moments in Exterior Beams

Distribution Factors for Spans 1 and 3

One Design Lane Loaded

From Table 4.6.2.2.2d-1 we see that for one design lane loaded, the live load distribution factor is computed using the lever rule. The lever rule is a method of computing the distribution factor by summing moments about the first interior girder to get the reaction at the exterior girder, assuming there is a notional hinge in the bridge deck directly above the first interior girder.

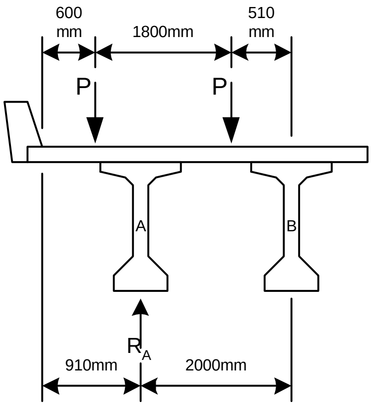
The wheel lines of the design truck are placed 1800 mm apart.

The design truck is placed as far away from the first interior girder as possible to maximize the reaction on the exterior girder. The design truck may be positioned transversely on the bridge deck such that the center of any wheel is not closer than 600 mm from the edge of the design lane.

Fig 3.6.1.2.2-1

3.6.1.3.1

Code Reference



Using statics, we sum moments about girder B.

$$\sum M_B = P(1800mm + 510mm) + P(510mm) - R_A(2000mm) = 0$$

$$R_A = 1.41P$$

The lane fraction carried by the exterior girder is $R_A/2P = 1.41P/2P = 0.705$

However, we must include the multiple presence factor of 1.2. 3.6.1.1.2

$$gM_1^{e+} = (1.2)(0.705) = 0.846 \Leftarrow \textbf{Controls}$$

Two or More Design Lanes Loaded

The live load distribution factor for two or more design lanes loaded is given by

$$gM_{2+}^{e+} = (e)\cdot\left(gM_{2+}^{i+}\right)$$

where

$$e = 0.77 + \frac{d_e}{2800}$$

$$e = 0.77 + \frac{910}{2800} = 1.095$$

$$gM_{2+}^{e+} = (1.095)(0.649) = 0.711$$

Check Rigid Method

For slab on girder bridges with diaphragms, the distribution factor for exterior beams must not be less than that which would be obtained assuming the cross section deflects and rotates as a rigid unit. 4.6.2.2.2d C4.6.2.2.2d

This additional check is required because the distribution factors given in Table 4.6.2.2.1-1 were determined without considering the effects of diaphragms. The procedure described in Article C4.6.2.2.2d is an interim solution until additional research can be conducted.

$$gM^{e+} = m\cdot R$$

where m is a multiple presence factor given in Article 3.6.1.1.2 and

Eqn C4.6.2.2.2d-1

Code Reference

$$R = \frac{N_L}{N_b} + \frac{X_{ext}\sum^{N_L} e}{\sum^{N_b} x^2}$$

where

R = Reaction on exterior beam in terms of lanes

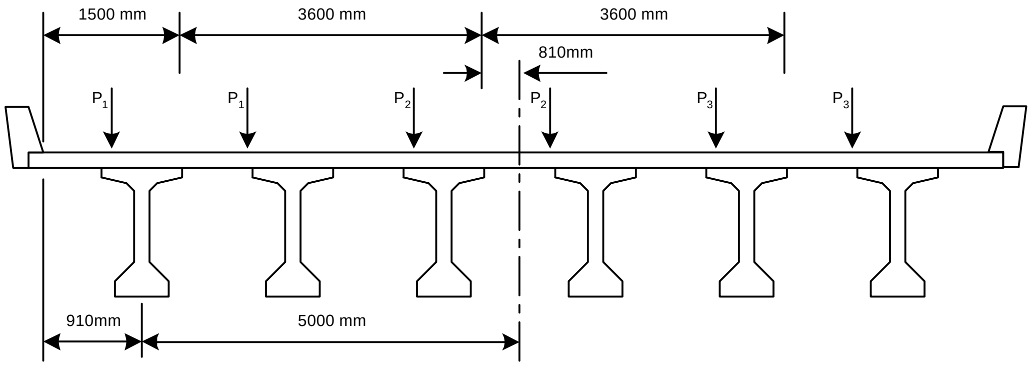
N_L = number of loaded lanes under consideration

e = eccentricity of a design truck or a design lane load from the center of gravity of the pattern of girder (mm)

x = horizontal distance from the center of gravity of the pattern of girders to each girder (mm)

x_{ext} = horizontal distance from the center of gravity of the pattern of girders to the exterior girder (mm)

N_b = number of girders



One Loaded Lane

m = 1.2

$$R = \frac{1}{6} + \frac{5000mm(3600mm + 810mm)}{2\left[(5000mm)^2 + (3000mm)^2 + (1000mm)^2\right]} = 0.482$$

$$gM_1^{e+} = (1.2)(0.482) = 0.578$$

Two Loaded Lanes

m = 1.0

$$R = \frac{2}{6} + \frac{5000mm\left[(3600mm + 810mm) + 810mm\right]}{2\left[(5000mm)^2 + (3000mm)^2 + (1000mm)^2\right]} = 0.706$$

$$gM_2^{e+} = (1.0)(0.706) = 0.706$$

Code Reference

Three Loaded Lanes

m = 0.85

$$R = \frac{3}{6} + \frac{5000mm\left[(3600mm + 810mm) + 810mm - (3600mm - 810mm)\right]}{2\left[(5000mm)^2 + (3000mm)^2 + (1000mm)^2\right]} = 0.674$$

$$gM_3^{e+} = (0.85)(0.674) = 0.573$$

Note that we don't consider four or more loaded lanes. Recall that this bridge only has 3 design lanes.

Distribution Factors for Span 2

4.6.2.2.3

The live load distribution factors for negative moment are very similar to those for spans 1 and 3.

One Design Lane Loaded

Computed using the lever rule.

$$gM_1^{e+} = 0.846 \Leftarrow \textbf{Controls}$$

Two or More Design Lanes Loaded

$$gM_{2+}^{e+} = (e) \cdot \left(gM_{2+}^{i+}\right)$$

$$gM_{2+}^{e+} = (1.095)(0.594) = 0.650$$

Check Rigid Method

One Loaded Lane

$$gM_1^{e+} = 0.578$$

Two Loaded Lanes

$$gM_2^{e+} = 0.706$$

Three Loaded Lanes

$$gM_3^{e+} = 0.573$$

Live Load Distribution Factors for Negative Moments in Exterior Beams

Since our bridge does not have skewed piers, the span length parameter L does not figure into the calculation of live load distribution factors in exterior beams. As such, the live load distribution factors for negative moment are exactly the same as for positive moment.

Distribution Factors for Spans 1 and 3

One Design Lane Loaded

$$gM_1^{e-} = 0.846 \Leftarrow \textbf{Controls}$$

Code Reference

Two or More Design Lanes Loaded

$gM_{2+}^{e-} = 0.711$

Check Rigid Method

One Loaded Lane

$gM_{1}^{e-} = 0.578$

Two Loaded Lanes

$gM_{2}^{e-} = 0.706$

Three Loaded Lanes

$gM_{3}^{e-} = 0.573$

Distribution Factors for Span 2

One Design Lane Loaded

$gM_{1}^{e-} = 0.846$ 🡐 **Controls**

Two or More Design Lanes Loaded

$gM_{2+}^{e-} = 0.650$

Check Rigid Method

One Loaded Lane

$gM_{1}^{e-} = 0.578$

Two Loaded Lanes

$gM_{2}^{e-} = 0.706$

Three Loaded Lanes

$gM_{3}^{e-} = 0.573$

Live Load Distribution Factors for Shear

Distribution of Live Load Per Lane for Shear in Interior Beams

4.6.2.2.3a

Once again referring to Table C4.6.2.2.1-1 we see the span length used in the calculation of shear distribution factors is equal to the length of the span for which shear is being calculated.

Code Reference

Check Range of Applicability

The range of applicability is slightly different for shear.

$1100mm \le S \le 4900mm$	$S = 2000mm$	**OK**
$6000mm \le L \le 73000mm$	Spans 1 and 3, $L = 20000mm$	**OK**
	Span 2, $L = 28000mm$	**OK**
$110mm \le t_s \le 300mm$	$t_s = 240mm$	**OK**
$4x10^9mm^4 \le K_g \le 3\xi10^{12}mm^4$	$K_g = 997.6x10^9mm^4$	**OK**
$N_b \ge 4$	$N_b = 5$	**OK**

Distribution Factors for Spans 1, 2, and 3

One Design Lane Loaded

The live load distribution factor for one design lane loaded is given by

$$gV_1^i = 0.36 + \frac{S}{7600}$$

$$gV_1^i = 0.36 + \frac{2000}{7600} = 0.623$$

Two or More Design Lanes Loaded

The live load distribution factor for two or more design lanes loaded is given by

$$gV_{2+}^i = 0.2 + \frac{S}{3600} - \left(\frac{S}{10700}\right)^{2.0}$$

$$gV_{2+}^i = 0.2 + \frac{2000}{3600} - \left(\frac{2000}{10700}\right)^{2.0} = 0.721$$ ← **Controls**

Distribution of Live Load Per Lane for Shear in Exterior Beams

4.6.2.2.3b

Distribution Factors for Spans 1, 2, and 3

One Design Lane Loaded

The live load distribution factor for shear in exterior beams for one design lane loaded is determined by the lever rule. This will produce the same results and the distribution factors for negative moment.

$$gV_1^e = gM_1^e = 0.846$$ ← **Controls**

Two or More Design Lanes Loaded

The live load distribution factor for two or more loaded lanes is given by

$$gV_{2+}^e = e \cdot gV_{2+}^i$$

where

$$e = 0.6 + \frac{d_e}{3000}$$

Code Reference

$$e = 0.6 + \frac{910}{3000} = 0.903$$

$$gV_{2+}^{e} = (0.903)(0.721) = 0.651$$

Check Rigid Method

The provisions of Article 4.6.2.2.2d shall apply to the shear distribution factors as well; 4.6.2.2.3b

One Loaded Lane

$$gV_1^e = gM_1^e = 0.578$$

Two Loaded Lanes

$$gV_2^e = gM_2^e = 0.706$$

Three Loaded Lanes

$$gV_3^e = gM_3^e = 0.573$$

Live Load Distribution Factors for Reactions

The LRFD Specification doesn't explicitly provide live load distribution factors for reactions. We will use the distribution factors for shear noting that the LRFD Specification does prescribe the span length parameter L for computing reactions in Table C4.6.2.2.1-1..

Distribution of Live Load Per Lane for Reactions at Exterior Piers

As you can probably guess by now, we begin by referring to Table C4.6.2.2.1-1 to determine the span length that is to be used for computing live load distribution factors for reactions at exterior piers. For reactions at exterior piers, the length of the adjacent exterior span is to be used.

Distribution of Live Load Per Lane for Reactions at Exterior Piers in Interior Beams

One Design Lane Loaded

$$gR_1^e = 0.623$$

Two or More Design Lanes Loaded

$gR_{2+}^{e} = 0.721$ 🡐 **Controls**

Distribution of Live Load Per Lane for Reactions at Exterior Piers in Exterior Beams

One Design Lane Loaded

$gR_1^e = 0.846$ 🡐 **Controls**

Two or More Design Lanes Loaded

$$gR_{2+}^{e} = 0.651$$

Code Reference

Check Rigid Method

One Loaded Lane

$gR_1^e = 0.578$

Two Loaded Lanes

$gR_2^e = 0.706$

Three Loaded Lanes

$gR_3^e = 0.573$

Distribution of Live Load Per Lane for Reactions at Interior Piers

For the last time we refer to Table C4.6.2.2.1-1 to determine the span length that is to be used for computing live load distribution factors for reactions at interior piers. For reactions at interior piers in continuous bridges, the average length of the adjacent spans is to be used. However, since L only comes into play for skew corrections, it has no bearing on the distribution factors for reactions at interior piers.

Distribution of Live Load Per Lane for Reactions at Interior Piers in Interior Beams

One Design Lane Loaded

$gR_1^e = 0.623$

Two or More Design Lanes Loaded

$gR_{2+}^e = 0.721$ 🡐 **Controls**

Distribution of Live Load Per Lane for Reactions at Interior Piers in Exterior Beams

One Design Lane Loaded

$gR_1^e = 0.846$ 🡐 **Controls**

Two or More Design Lanes Loaded

$gR_{2+}^e = 0.651$

Check Rigid Method

One Loaded Lane

$gR_1^e = 0.578$

Two Loaded Lanes

$gR_2^e = 0.706$

Code Reference

Three Loaded Lanes

$$gR_3^e = 0.573$$

Live Load Distribution Factors for Fatigue Truck

3.6.1.4.3b

3.6.1.1.2

The distribution factors for one design lane loaded are used for the fatigue truck. The distribution factors must be divided by the multiple presence factor of 1.2.

Distribution of Live Loads Per Lane for Moments in Interior Beams

Live Load Distribution Factors for Positive Moment in Interior Beams

Distribution Factors for Spans 1 and 3

$$gM_1^{i+} = \frac{0.480}{1.2} = 0.400$$

Distribution Factors for Span 2

$$gM_1^{i+} = \frac{0.427}{1.2} = 0.356$$

Live Load Distribution Factors for Negative Moment in Interior Beams

Distribution Factors for Spans 1 and 3 - End of Span to Point of Contraflexure

$$gM_1^{i-} = \frac{0.480}{1.2} = 0.400$$

Distribution Factors for Spans 1 and 2 and Spans 2 and 3 - Between Points of Contraflexure Near Interior Support

$$gM_1^{i-} = \frac{0.450}{1.2} = 0.375$$

Distribution Factors for Span 2 - Between Points of Contraflexure

$$gM_1^{i-} = \frac{0.427}{1.2} = 0.356$$

Distribution of Live Loads Per Lane for Moment in Exterior Beams

Live Load Distribution Factors for Positive Moment in Interior Beams

Distribution Factors for Spans 1 and 3

Lever Rule

$$gM_1^{e+} = \frac{0.846}{1.2} = 0.705 \Leftarrow \textbf{Controls}$$

Code Reference

Check Rigid Method

$$gM_1^{e+} = \frac{0.578}{1.2} = 0.482$$

Distribution Factors for Span 2

Lever Rule

$$gM_1^{e+} = \frac{0.846}{1.2} = 0.705$$ 🡐 **Controls**

Check Rigid Method

$$gM_1^{e+} = \frac{0.578}{1.2} = 0.482$$

Live Load Distribution Factors for Negative Moment in Interior Beams

Distribution Factors for Spans 1 and 3

$$gM_1^{e-} = \frac{0.846}{1.2} = 0.705$$ 🡐 **Controls**

Check Rigid Method

$$gM_1^{e-} = \frac{0.578}{1.2} = 0.482$$

Distribution Factors for Span 2

$$gM_1^{e-} = \frac{0.846}{1.2} = 0.705$$ 🡐 **Controls**

Check Rigid Method

$$gM_1^{e-} = \frac{0.578}{1.2} = 0.482$$

Live Load Distribution Factors for Shear

Distribution of Live Load Per Lane for Shear in Interior Beams

4.6.2.2.3a

Distribution Factors for Spans 1, 2, and 3

$$gV_1^{i} = \frac{0.623}{1.2} = 0.519$$

Code Reference

Distribution of Live Load Per Lane for Shear in Exterior Beams

Distribution Factors for Spans 1, 2, and 3

$gV_1^e = gM_1^e = 0.705$ ← **Controls**

Check Rigid Method

$gV_1^e = gM_1^e = 0.482$

Live Load Distribution Factors for Reactions

Distribution of Live Load Per Lane for Reactions at Exterior Piers

Distribution of Live Load Per Lane for Reactions at Exterior Piers in Interior Beams

$$gR_1^e = \frac{0.623}{1.2} = 0.519$$

Distribution of Live Load Per Lane for Reactions at Exterior Piers in Exterior Beams

$$gR_1^e = \frac{0.846}{1.2} = 0.705$$ ← **Controls**

Check Rigid Method

$$gR_1^e = \frac{0.578}{1.2} = 0.482$$

Distribution of Live Load Per Lane for Reactions at Interior Piers

Distribution of Live Load Per Lane for Reactions at Interior Piers in Interior Beams

$$gR_1^e = \frac{0.623}{1.2} = 0.519$$

Distribution of Live Load Per Lane for Reactions at Interior Piers in Exterior Beams

$$gR_1^e = \frac{0.846}{1.2} = 0.705$$ ← **Controls**

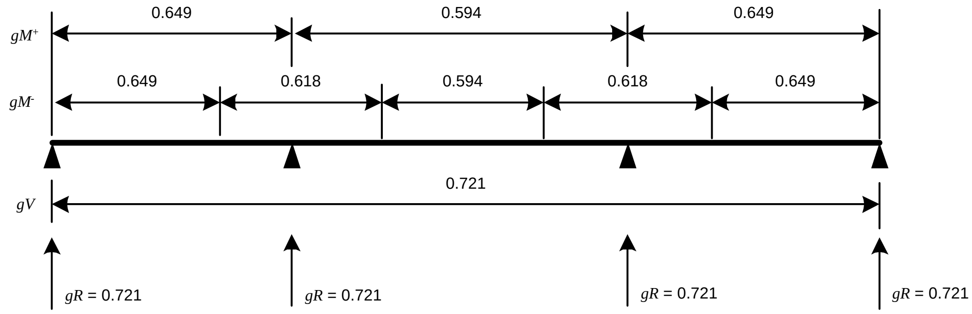
Check Rigid Method

$$gR_1^e = \frac{0.578}{1.2} = 0.482$$

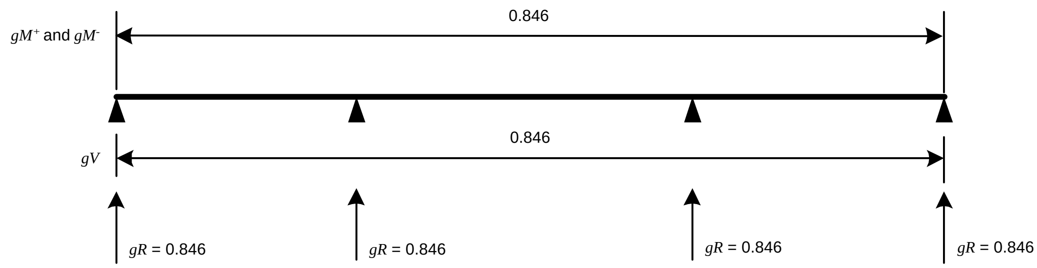
Live Load Distribution Factor Summary

Code Reference

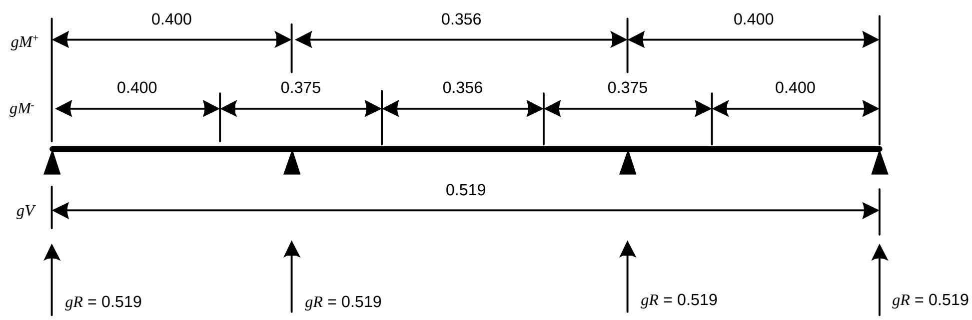
Interior Beams for Strength, Service, and Extreme Event Limit States



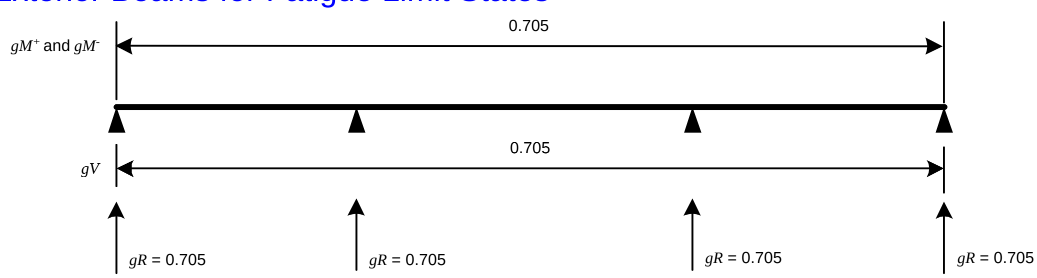
Exterior Beams for Strength, Service, and Extreme Event Limit States



Interior Beams for Fatigue Limit States



Exterior Beams for Fatigue Limit States



Appendix

Conversion Factors

Multiply	By	To Produce
in	25.40	mm
ft	0.3048	m
in^2	645.2	mm^2
ft^2	0.0929	m^2
in^3	16387	mm^3
ft^3	0.0283	m^3
in^4	416231	mm^4
ft^4	0.00863	m^4
lbf	4.448	N
kip	4.448	kN
ton	8.896	kN
lbf/in	0.175	N/mm
lbf/ft	0.015	N/mm
kip/in	175.2	kN/m
kip/ft	14.6	kN/m
lbf	0.453	kg
lbm	0.453	kg
slug	14.594	kg
ft/sec^2	0.3048	m/sec^2
psi	6894.757	Pa
ksi	6.895	MPa
psf	47.88	Pa
ksf	0.04788	MPa
°F	(°t-32°)/1.8	°C

Multiplication Factor	Prefix	Symbol
1,000,000,000 = 10^9	giga	G
1,000,000 = 10^6	mega	M
1,000 = 10^3	kilo	k
100 = 10^2	hecto	h
1 = 1		
0.01 = 10^{-2}	centi	c
0.001 = 10^{-3}	milli	m
0.000001 = 10^{-6}	micro	µ
0.00000001 = 10^{-9}	nano	n

Reinforcing Bar Properties

Bar Size	Nominal Mass	Nominal Diameter	Nominal Area	Bar Size	Nominal Weight	Nominal Diameter	Nominal Area
No.	kg/m	mm	mm^2	No	lb/ft	in	in^2
10	0.560	9.5	71	3	0.376	0.375	0.11
13	0.994	12.7	129	4	0.668	0.500	0.20
16	1.552	15.9	199	5	1.043	0.625	0.31
19	2.235	19.1	284	6	1.502	0.750	0.44
22	3.042	22.2	387	7	2.044	0.875	0.60
25	3.973	25.4	510	8	2.670	1.000	0.79
29	5.060	28.7	645	9	3.400	1.128	1.00
32	6.404	32.3	819	10	4.303	1.270	1.27
36	7.907	35.8	1006	11	5.313	1.410	1.56
43	11.380	43.0	1452	14	7.650	1.693	2.25
57	20.240	57.3	2581	18	13.600	2.254	4.00