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# Load Factor Design (LFD) Formulas

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# List of 28 Load Factor Design (LFD) Formulas

## Load Factor Design (LFD)

### Load and Resistance Factor for Bridge Columns

#### 1) Buckling Stress for Q Factor Less than or Equal to 1

$$f_x F_{cr} = \left( 1 - \left( \frac{Q_{\text{factor}}}{2} \right) \right) \cdot f_y$$

[Open Calculator !\[\]\(de95854c7ee024cfadc48187bbb781b2\_img.jpg\)](#)

$$\text{ex } 248.219\text{MPa} = \left( 1 - \left( \frac{0.014248}{2} \right) \right) \cdot 250\text{MPa}$$

#### 2) Buckling Stress given Maximum Strength

$$f_x F_{cr} = \frac{P_u}{0.85 \cdot A_g}$$

[Open Calculator !\[\]\(6a9b39b98eb945faa14c645ec99e4eaa\_img.jpg\)](#)

$$\text{ex } 248\text{MPa} = \frac{1054\text{kN}}{0.85 \cdot 5000\text{mm}^2}$$

#### 3) Buckling Stress when Q Factor is Greater than 1

$$f_x F_{cr} = \frac{f_y}{2 \cdot Q}$$

[Open Calculator !\[\]\(f1c5da15572e3e09d343161be98f508d\_img.jpg\)](#)

$$\text{ex } 260.4167\text{MPa} = \frac{250\text{MPa}}{2 \cdot 0.48}$$



#### 4) Column Gross Effective Area given Maximum Strength

$$fx \quad A_g = \frac{P_u}{0.85 \cdot F_{cr}}$$

[Open Calculator !\[\]\(cbe80b694ebd74fcfe136a095b608235\_img.jpg\)](#)

$$ex \quad 5000\text{mm}^2 = \frac{1054\text{kN}}{0.85 \cdot 248\text{MPa}}$$

#### 5) Maximum Strength for Compression Members

$$fx \quad P_u = 0.85 \cdot A_g \cdot F_{cr}$$

[Open Calculator !\[\]\(3e2231b1ad3ca8da8658228c00dd08e0\_img.jpg\)](#)

$$ex \quad 1054\text{kN} = 0.85 \cdot 5000\text{mm}^2 \cdot 248\text{MPa}$$

#### 6) Q Factor

$$fx \quad Q_{\text{factor}} = \left( \left( k \cdot \frac{L_c}{r} \right)^2 \right) \cdot \left( \frac{f_y}{2 \cdot \pi \cdot \pi \cdot E_s} \right)$$

[Open Calculator !\[\]\(0d5ec72f61334709c3fc9450209b754f\_img.jpg\)](#)

$$ex \quad 0.014248 = \left( \left( 0.5 \cdot \frac{450\text{mm}}{15\text{mm}} \right)^2 \right) \cdot \left( \frac{250\text{MPa}}{2 \cdot \pi \cdot \pi \cdot 200000\text{MPa}} \right)$$

#### 7) Steel Yield Strength given Buckling Stress for Q Factor Greater than 1

$$fx \quad f_y = F_{cr} \cdot 2 \cdot Q$$

[Open Calculator !\[\]\(b64b40baaee5acddc1eab8538ba84754\_img.jpg\)](#)

$$ex \quad 238.08\text{MPa} = 248\text{MPa} \cdot 2 \cdot 0.48$$



## 8) Steel Yield Strength given Buckling Stress for Q Factor Less than or Equal to 1

$$f_x \quad f_y = \frac{F_{cr}}{1 - \left( \frac{Q_{factor}}{2} \right)}$$

[Open Calculator !\[\]\(e78f798d4ea5c530c9db49e7d26e6b95\_img.jpg\)](#)

$$ex \quad 249.7794MPa = \frac{248MPa}{1 - \left( \frac{0.014248}{2} \right)}$$

## 9) Steel Yield Strength given Q Factor

$$f_x \quad f_y = \frac{2 \cdot Q_{factor} \cdot \pi \cdot \pi \cdot (r^2) \cdot E_s}{(k \cdot L_c)^2}$$

[Open Calculator !\[\]\(05be7c7a8995decd503647c99211f7c2\_img.jpg\)](#)

$$ex \quad 249.9949MPa = \frac{2 \cdot 0.014248 \cdot \pi \cdot \pi \cdot ((15mm)^2) \cdot 200000MPa}{(0.5 \cdot 450mm)^2}$$

## Load-Factor Design for Bridge Beams

### 10) Allowable Bearing Stresses on Pins for Buildings for LFD

$$f_x \quad F_p = 0.9 \cdot f_y$$

[Open Calculator !\[\]\(626ce8ac21792b9405bfddfea8e0c96a\_img.jpg\)](#)

$$ex \quad 225MPa = 0.9 \cdot 250MPa$$



### 11) Allowable Bearing Stresses on Pins not Subject to Rotation for Bridges for LFD

$$fx \quad F_p = 0.80 \cdot f_y$$

[Open Calculator !\[\]\(e2376d476d06eb31946dc01a69a4403a\_img.jpg\)](#)

$$ex \quad 200MPa = 0.80 \cdot 250MPa$$

### 12) Allowable Bearing Stresses on Pins Subject to Rotation for Bridges for LFD

$$fx \quad F_p = 0.40 \cdot f_y$$

[Open Calculator !\[\]\(0b5e7e25e8775f7e7e80906ada4f0021\_img.jpg\)](#)

$$ex \quad 100MPa = 0.40 \cdot 250MPa$$

### 13) Area of Flange for Braced Non-Compact Section for LFD

$$fx \quad A_f = \frac{L_b \cdot f_y \cdot d}{20000}$$

[Open Calculator !\[\]\(bd3b31712ad9bab5a241210fa6925cdd\_img.jpg\)](#)

$$ex \quad 4375mm^2 = \frac{1000mm \cdot 250MPa \cdot 350mm}{20000}$$

### 14) Depth of Section for Braced Non-Compact Section for LFD given Maximum Unbraced Length

$$fx \quad d = \frac{20000 \cdot A_f}{f_y \cdot L_b}$$

[Open Calculator !\[\]\(7bc43b319a082987e20f7bf78f4bab80\_img.jpg\)](#)

$$ex \quad 350mm = \frac{20000 \cdot 4375mm^2}{250MPa \cdot 1000mm}$$



### 15) Maximum Bending Strength for Symmetrical Flexural Braced Non-Compacted Section for LFD of Bridges

$$fx \quad M_u = f_y \cdot S$$

[Open Calculator !\[\]\(d3fb9f94af8b26d1c844efa9a98805b0\_img.jpg\)](#)

$$ex \quad 19.875kN \cdot mm = 250MPa \cdot 79.5mm^3$$

### 16) Maximum Bending Strength for Symmetrical Flexural Compact Section for LFD of Bridges

$$fx \quad M_u = f_y \cdot Z$$

[Open Calculator !\[\]\(e1d6102fe77919492c04879c8450f1f5\_img.jpg\)](#)

$$ex \quad 20kN \cdot mm = 250MPa \cdot 80mm^3$$

### 17) Maximum Unbraced Length for Symmetrical Flexural Braced Non-Compact Section for LFD of Bridges

$$fx \quad L_b = \frac{20000 \cdot A_f}{f_y \cdot d}$$

[Open Calculator !\[\]\(ab4e2b3fc7e7887b7a72f548aa6f5e60\_img.jpg\)](#)

$$ex \quad 1000mm = \frac{20000 \cdot 4375mm^2}{250MPa \cdot 350mm}$$

### 18) Maximum Unbraced Length for Symmetrical Flexural Compact Section for LFD of Bridges

$$fx \quad L = \frac{\left(3600 - 2200 \cdot \left(\frac{M_1}{M_u}\right)\right) \cdot r}{f_y}$$

[Open Calculator !\[\]\(5abce1a84a655b073239ab33e1199487\_img.jpg\)](#)

$$ex \quad 183mm = \frac{\left(3600 - 2200 \cdot \left(\frac{5kN \cdot mm}{20kN \cdot mm}\right)\right) \cdot 15mm}{250MPa}$$



## 19) Minimum Flange Thickness for Symmetrical Flexural Braced Non-Compact Section for LFD of Bridges

$$fx \quad t_f = \frac{b' \cdot \sqrt{f_y}}{69.6}$$

[Open Calculator !\[\]\(9dfdaff1d86ba3c1f8353b4d1b61b8c5\_img.jpg\)](#)

$$ex \quad 283.9689\text{mm} = \frac{1.25\text{mm} \cdot \sqrt{250\text{MPa}}}{69.6}$$

## 20) Minimum Flange Thickness for Symmetrical Flexural Compact Section for LFD of Bridges

$$fx \quad t_f = \frac{b' \cdot \sqrt{f_y}}{65}$$

[Open Calculator !\[\]\(2b376d1a92330ab09dad2665d2f89bf5\_img.jpg\)](#)

$$ex \quad 304.0652\text{mm} = \frac{1.25\text{mm} \cdot \sqrt{250\text{MPa}}}{65}$$

## 21) Minimum Web Thickness for Symmetrical Flexural Braced Non-Compact Section for LFD of Bridges

$$fx \quad t_u = \frac{h}{150}$$

[Open Calculator !\[\]\(c444627dab9fee9a1550c053ffaaaae2\_img.jpg\)](#)

$$ex \quad 9\text{mm} = \frac{1350\text{mm}}{150}$$



## 22) Minimum Web Thickness for Symmetrical Flexural Compact Section for LFD of Bridges

$$\text{fx } t_u = d \cdot \frac{\sqrt{f_y}}{608}$$

[Open Calculator !\[\]\(6605b201d6f14d9b3bcb8ab5f274d107\_img.jpg\)](#)

$$\text{ex } 9.101951\text{mm} = 350\text{mm} \cdot \frac{\sqrt{250\text{MPa}}}{608}$$

## 23) Width of Projection of Flange for Compact Section for LFD given Minimum Flange Thickness

$$\text{fx } b' = \frac{65 \cdot t_f}{\sqrt{f_y}}$$

[Open Calculator !\[\]\(e8fb589d58dad1692debababa5e928b6\_img.jpg\)](#)

$$\text{ex } 1.208623\text{mm} = \frac{65 \cdot 294\text{mm}}{\sqrt{250\text{MPa}}}$$

## Steel Yield Strength

### 24) Steel Yield Strength for Braced Non-Compact Section for LFD given Maximum Unbraced Length

$$\text{fx } f_y = \frac{20000 \cdot A_f}{L_b \cdot d}$$

[Open Calculator !\[\]\(e9474ce1d70442456f8fe9c393ea149c\_img.jpg\)](#)

$$\text{ex } 250\text{MPa} = \frac{20000 \cdot 4375\text{mm}^2}{1000\text{mm} \cdot 350\text{mm}}$$





## 25) Steel Yield Strength for Compact Section for LFD given Minimum Flange Thickness

$$fx \quad f_y = \left( 65 \cdot \frac{t_f}{b'} \right)^2$$

[Open Calculator !\[\]\(c3d993ca47bfe2a953c700506ce31fa0\_img.jpg\)](#)

$$ex \quad 233.7229MPa = \left( 65 \cdot \frac{294mm}{1.25mm} \right)^2$$

## 26) Steel Yield Strength on Pins for Buildings for LFD given Allowable Bearing Stress

$$fx \quad f_y = \frac{F_p}{0.90}$$

[Open Calculator !\[\]\(17413706fd4997a1a4bdf85c6864eee1\_img.jpg\)](#)

$$ex \quad 194.4444MPa = \frac{175MPa}{0.90}$$

## 27) Steel Yield Strength on Pins not Subject to Rotation for Bridges for LFD given Pin Stress

$$fx \quad f_y = \frac{F_p}{0.80}$$

[Open Calculator !\[\]\(4b7a79268f6ba26c1471d4232fffa85a\_img.jpg\)](#)

$$ex \quad 218.75MPa = \frac{175MPa}{0.80}$$



## 28) Steel Yield Strength on Pins subject to Rotation for Bridges for LFD given Pin Stress

$$\text{fx } f_y = \frac{F_p}{0.40}$$

[Open Calculator !\[\]\(0f848bbd71cef6b345273b16f905912a\_img.jpg\)](#)

$$\text{ex } 437.5\text{MPa} = \frac{175\text{MPa}}{0.40}$$



## Variables Used








- **$A_f$**  Flange Area (Square Millimeter)
- **$A_g$**  Gross Effective Area of Column (Square Millimeter)
- **$b'$**  Width of Projection of Flange (Millimeter)
- **$d$**  Depth of Section (Millimeter)
- **$E_s$**  Modulus of Elasticity (Megapascal)
- **$F_{cr}$**  Buckling Stress (Megapascal)
- **$F_p$**  Allowable Bearing Stresses on Pins (Megapascal)
- **$f_y$**  Yield Strength of Steel (Megapascal)
- **$h$**  Unsupported Distance between Flanges (Millimeter)
- **$k$**  Effective Length Factor
- **$L$**  Max Unbraced Length for Flexural Compact Section (Millimeter)
- **$L_b$**  Maximum Unbraced Length (Millimeter)
- **$L_c$**  Length of Member between Supports (Millimeter)
- **$M_1$**  Smaller Moment (Kilonewton Millimeter)
- **$M_u$**  Maximum Bending Strength (Kilonewton Millimeter)
- **$P_u$**  Strength of Column (Kilonewton)
- **$Q$**  Q Factors
- **$Q_{factor}$**  Factor Q
- **$r$**  Radius of Gyration (Millimeter)
- **$S$**  Section Modulus (Cubic Millimeter)
- **$t_f$**  Flange Minimum Thickness (Millimeter)



- **$t_u$**  Web Minimum Thickness (Millimeter)
- **Z** Plastic Section Modulus (Cubic Millimeter)










## Constants, Functions, Measurements used

- **Constant:** **pi**, 3.14159265358979323846264338327950288  
*Archimedes' constant*
- **Function:** **sqrt**, sqrt(Number)  
*Square root function*
- **Measurement:** **Length** in Millimeter (mm)  
*Length Unit Conversion* 
- **Measurement:** **Volume** in Cubic Millimeter (mm<sup>3</sup>)  
*Volume Unit Conversion* 
- **Measurement:** **Area** in Square Millimeter (mm<sup>2</sup>)  
*Area Unit Conversion* 
- **Measurement:** **Pressure** in Megapascal (MPa)  
*Pressure Unit Conversion* 
- **Measurement:** **Force** in Kilonewton (kN)  
*Force Unit Conversion* 
- **Measurement:** **Moment of Force** in Kilonewton Millimeter (kN\*mm)  
*Moment of Force Unit Conversion* 
- **Measurement:** **Stress** in Megapascal (MPa)  
*Stress Unit Conversion* 



## Check other formula lists

- [Additional Bridge Column Formulas](#) 
- [Allowable Stress Design for Bridges Formulas](#) 
- [Bearing on Milled Surfaces and Bridge Fasteners Formulas](#) 
- [Composite Construction in Highway Bridges Formulas](#) 
- [Load Factor Design \(LFD\) Formulas](#) 
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