Important Load-and-Resistance Factor Design for Buildings Formulas PDF

Formulas Examples with Units

List of 20
Important Load-and-Resistance Factor Design for Buildings Formulas

1) Beams Formulas

1.1) Beam Buckling Factor 1 Formula

Evaluate Formula

Formula

$$X_1 = \left(\frac{\pi}{S_x}\right) \cdot \sqrt{\frac{E \cdot G \cdot J \cdot A}{2}}$$

Example with Units

$$3005.6532 = \left(\frac{3.1416}{35\,\text{mm}^3}\right) \cdot \sqrt{\frac{200\,\text{GPa} \cdot 80\,\text{GPa} \cdot 21.9 \cdot 6400\,\text{mm}^2}{2}}$$

1.2) Beam Buckling Factor 2 Formula

Evaluate Formula

Formula

$$X_2 = \left(\frac{4 \cdot C_w}{I_y}\right) \cdot \left(\frac{S_x}{G \cdot J}\right)^2$$

Example with Units

$$63.854 = \left(\frac{4 \cdot 0.2}{5000\,\text{mm}^4/\text{mm}}\right) \cdot \left(\frac{35\,\text{mm}^3}{80\,\text{GPa} \cdot 21.9}\right)^2$$

1.3) Critical Elastic Moment Formula

Evaluate Formula

Formula

$$M_{cr} = \left(\frac{C_b \cdot \pi}{L}\right) \cdot \sqrt{\left(\left(E \cdot I_y \cdot G \cdot J\right) + \left(I_y \cdot C_w \cdot \left(\frac{\pi \cdot E}{(L)^2}\right)\right)\right)}$$

Example with Units

$$6.7919\,\text{N*m} = \left(\frac{1.960 \cdot 3.1416}{12\,\text{m}}\right) \cdot \sqrt{\left(\left(200\,\text{GPa} \cdot 5000\,\text{mm}^4/\text{mm} \cdot 80\,\text{GPa} \cdot 21.9\right) + \left(5000\,\text{mm}^4/\text{mm} \cdot 0.2 \cdot \left(\frac{3.1416 \cdot 200\,\text{GPa}}{(12\,\text{m})^2}\right)\right)\right)}$$

1.4) Critical Elastic Moment for Box Sections and Solid Bars Formula

Evaluate Formula

Formula

$$M_{bs} = \frac{57000 \cdot C_b \cdot \sqrt{J \cdot A}}{\frac{L}{r_y}}$$

Example with Units

$$69.7095\,\text{N*m} = \frac{57000 \cdot 1.960 \cdot \sqrt{21.9 \cdot 6400\,\text{mm}^2}}{\frac{12\,\text{m}}{20\,\text{mm}}}$$

1.5) Limiting Buckling Moment Formula

Evaluate Formula

Formula

$$M_r = F_l \cdot S_x$$

Example with Units

$$3.85\,\text{kN*m} = 110\,\text{MPa} \cdot 35\,\text{mm}^3$$

1.6) Limiting Laterally Unbraced Length for Full Plastic Bending Capacity for I and Channel Sections Formula

Evaluate Formula

Formula

$$L_p = \frac{300 \cdot r_y}{\sqrt{F_{yf}}}$$

Example with Units

$$200\,\text{mm} = \frac{300 \cdot 20\,\text{mm}}{\sqrt{900\,\text{MPa}}}$$

1.7) Limiting Laterally Unbraced Length for Full Plastic Bending Capacity for Solid Bar and Box Beams Formula

Evaluate Formula

Formula

$$L_p = \frac{3750 \cdot \left(\frac{r_y}{M_p}\right)}{\sqrt{J \cdot A}}$$

Example with Units

$$200.3315\,\text{mm} = \frac{3750 \cdot \left(\frac{20\,\text{mm}}{1000\,\text{N*mm}}\right)}{\sqrt{21.9 \cdot 6400\,\text{mm}^2}}$$

1.8) Limiting Laterally Unbraced Length for Inelastic Lateral Buckling Formula

Evaluate Formula

Formula

$$L_{lim} = \left(\frac{r_y \cdot X_1}{F_{yw} - F_r}\right) \cdot \sqrt{1 + \sqrt{1 + \left(X_2 \cdot F_l^{\,2}\right)}}$$

Example with Units

$$30235.0405\,\text{mm} = \left(\frac{20\,\text{mm} \cdot 3005}{139\,\text{MPa} - 80.0\,\text{MPa}}\right) \cdot \sqrt{1 + \sqrt{1 + \left(64 \cdot 110\,\text{MPa}^{\,2}\right)}}$$

1.9) Limiting Laterally Unbraced Length for Inelastic Lateral Buckling for Box Beams Formula

Evaluate Formula

Formula

$$L_r = \frac{2 \cdot r_y \cdot E \cdot \sqrt{J \cdot A}}{M_r}$$

Example with Units

$$777.9314\,\text{mm} = \frac{2 \cdot 20\,\text{mm} \cdot 200\,\text{GPa} \cdot \sqrt{21.9 \cdot 6400\,\text{mm}^2}}{3.85\,\text{kN*m}}$$

1.10) Maximum Laterally Unbraced Length for Plastic Analysis Formula

Evaluate Formula

Formula

$$L_{pd} = r_y \cdot \frac{3600 + 2200 \cdot \left(\frac{M_1}{M_p}\right)}{F_{yc}}$$

Example with Units

$$424.4444\,\text{mm} = 20\,\text{mm} \cdot \frac{3600 + 2200 \cdot \left(\frac{100\,\text{N*mm}}{1000\,\text{N*mm}}\right)}{180\,\text{MPa}}$$

1.11) Maximum Laterally Unbraced Length for Plastic Analysis in Solid Bars and Box Beams Formula

Evaluate Formula

Formula

$$L_{pd} = \frac{r_y \cdot \left(5000 + 3000 \cdot \left(\frac{M_1}{M_p}\right)\right)}{F_y}$$

Example with Units

$$424\,\text{mm} = \frac{20\,\text{mm} \cdot \left(5000 + 3000 \cdot \left(\frac{100\,\text{N*mm}}{1000\,\text{N*mm}}\right)\right)}{250\,\text{MPa}}$$

1.12) Plastic Moment Formula

Evaluate Formula

Formula

$$M_p = F_{yw} \cdot Z_p$$

Example with Units

$$1000.8\,\text{N*mm} = 139\,\text{MPa} \cdot 0.0072\,\text{mm}^3$$

1.13) Specified Minimum Yield Stress for Web given Limiting Laterally Unbraced Length Formula

Evaluate Formula

Formula

$$F_{yw} = \left(\frac{r_y \cdot X_1 \cdot \sqrt{1 + \sqrt{1 + \left(X_2 \cdot F_l^{\,2} \right)}}}{L_{lim}} \right) + F_r$$

Example with Units

$$139.0001\,\text{MPa} = \left(\frac{20\,\text{mm} \cdot 3005 \cdot \sqrt{1 + \sqrt{1 + \left(64 \cdot 110\,\text{MPa}^{2} \right)}}}{30235\,\text{mm}} \right) + 80.0\,\text{MPa}$$

2) Columns Formulas

2.1) Critical Buckling Stress when Slenderness Parameter is greater than 2.25 Formula

Evaluate Formula

Formula

$$F_{cr} = \frac{0.877 \cdot F_y}{\lambda_c}$$

Example with Units

$$97.4444\,\text{MPa} = \frac{0.877 \cdot 250\,\text{MPa}}{2.25}$$

2.2) Critical Buckling Stress when Slenderness Parameter is Less than 2.25 Formula

Evaluate Formula

Formula

$$F_{cr} = 0.658^{\lambda_c} \cdot F_y$$

Example with Units

$$97.4874\,\text{MPa} = 0.658^{2.25} \cdot 250\,\text{MPa}$$

2.3) Maximum Load on Axially Loaded Members Formula

Evaluate Formula

Formula

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

Example with Units

$$296.82\,\text{kN} = 0.85 \cdot 3600\,\text{mm}^2 \cdot 97\,\text{MPa}$$

2.4) Slenderness Parameter Formula

Evaluate Formula

Formula

$$\lambda_c = \left(\frac{k \cdot l}{r} \right)^2 \cdot \left(\frac{F_y}{286220} \right)$$

Example with Units

$$2.506 = \left(\frac{5 \cdot 932\,\text{mm}}{87\,\text{mm}} \right)^2 \cdot \left(\frac{250\,\text{MPa}}{286220} \right)$$

3) Shear in Buildings Formulas

3.1) Shear Capacity for Web Slenderness less than Alpha Formula

Evaluate Formula

Formula

$$V_u = 0.54 \cdot F_{yw} \cdot A_w$$

Example with Units

$$6.3801\,\text{kN} = 0.54 \cdot 139\,\text{MPa} \cdot 85\,\text{mm}^2$$

3.2) Shear Capacity if Web Slenderness is between 1 and 1.25 alpha Formula

Evaluate Formula

Formula

$$V_u = \frac{0.54 \cdot F_{yw} \cdot A_w \cdot \alpha}{\frac{H}{t_w}}$$

Example with Units

$$6.2206\,\text{kN} = \frac{0.54 \cdot 139\,\text{MPa} \cdot 85\,\text{mm}^2 \cdot 39}{\frac{2000\,\text{mm}}{50.0\,\text{mm}}}$$

3.3) Shear Capacity if Web Slenderness is greater than 1.25 alpha Formula

Evaluate Formula

Formula

$$V_u = \frac{23760 \cdot k \cdot A_w}{\left(\frac{H}{t_w}\right)^2}$$

Example with Units

$$6.3112\,\text{kN} = \frac{23760 \cdot 5 \cdot 85\,\text{mm}^2}{\left(\frac{2000\,\text{mm}}{50.0\,\text{mm}}\right)^2}$$

Variables used in list of Load-and-Resistance Factor Design for Buildings Formulas above

- **A** Cross Sectional Area in Steel Structures *(Square Millimeter)*
- **A_g** Gross Cross-Sectional Area *(Square Millimeter)*
- **A_w** Web Area *(Square Millimeter)*
- **C_b** Moment Gradient Factor
- **C_w** Warping Constant
- **E** Elastic Modulus of Steel *(Gigapascal)*
- **F_{cr}** Critical Buckling Stress *(Megapascal)*
- **F_l** Smaller Yield Stress *(Megapascal)*
- **F_r** Compressive Residual Stress in Flange *(Megapascal)*
- **F_y** Yield Stress of Steel *(Megapascal)*
- **F_{yc}** Minimum Yield Stress of Compression Flange *(Megapascal)*
- **F_{yf}** Flange Yield Stress *(Megapascal)*
- **F_{yw}** Specified Minimum Yield Stress *(Megapascal)*
- **G** Shear Modulus *(Gigapascal)*
- **H** Height of Web *(Millimeter)*
- **I_y** Y Axis Moment of Inertia *(Millimeter⁴ per Millimeter)*
- **J** Torsional Constant
- **k** Effective Length Factor
- **l** Effective Column Length *(Millimeter)*
- **L** Unbraced Length of Member *(Meter)*
- **L_{lim}** Limiting Length *(Millimeter)*
- **L_p** Limiting Laterally Unbraced Length *(Millimeter)*
- **L_{pd}** Laterally Unbraced Length for Plastic Analysis *(Millimeter)*
- **L_r** Limiting Length for Inelastic Buckling *(Millimeter)*
- **M_1** Smaller Moments of Unbraced Beam *(Newton Millimeter)*
- **M_{bs}** Critical Elastic Moment for Box Section *(Newton Meter)*
- **M_{cr}** Critical Elastic Moment *(Newton Meter)*
- **M_p** Plastic Moment *(Newton Millimeter)*
- **M_r** Limiting Buckling Moment *(Kilonewton Meter)*
- **P_u** Maximum Axial Load *(Kilonewton)*
- **r** Radius of Gyration *(Millimeter)*

Constants, Functions, Measurements used in list of Load-and-Resistance Factor Design for Buildings Formulas above

- constant(s): **pi**, 3.14159265358979323846264338327950288
  Archimedes' constant
- Functions: **sqrt**, sqrt(Number)
  A square root function is a function that takes a non-negative number as an input and returns the square root of the given input number.
- Measurement: **Length** in Meter (m), Millimeter (mm)
  Length Unit Conversion
- Measurement: **Volume** in Cubic Millimeter (mm^3)
  Volume Unit Conversion
- Measurement: **Area** in Square Millimeter (mm^2)
  Area Unit Conversion
- Measurement: **Pressure** in Gigapascal (GPa)
  Pressure Unit Conversion
- Measurement: **Force** in Kilonewton (kN)
  Force Unit Conversion
- Measurement: **Moment of Force** in Newton Meter (N*m), Kilonewton Meter (kN*m), Newton Millimeter (N*mm)
  Moment of Force Unit Conversion
- Measurement: **Moment of Inertia per Unit Length** in Millimeter⁴ per Millimeter (mm^4/mm)
  Moment of Inertia per Unit Length Unit Conversion
- Measurement: **Stress** in Megapascal (MPa)
  Stress Unit Conversion

- r_y Radius of Gyration about Minor Axis *(Millimeter)*
- S_x Section Modulus about Major Axis *(Cubic Millimeter)*
- t_w Web Thickness *(Millimeter)*
- V_u Shear Capacity *(Kilonewton)*
- X_1 Beam Buckling Factor 1
- X_2 Beam Buckling Factor 2
- Z_p Plastic Modulus *(Cubic Millimeter)*
- α Separation Ratio
- λ_c Slenderness Parameter

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