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Load-and-Resistance Factor Design for Buildings Formulas

Calculators! Examples! Conversions!

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

Load-and-Resistance Factor Design for Buildings

Beams

1) Beam Buckling Factor 1

Open Calculator

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

ex $$3005.653 = \left(\frac{\pi}{35\text{mm}^3}\right) \cdot \sqrt{\frac{200\text{GPa} \cdot 80\text{GPa} \cdot 21.9 \cdot 6400\text{mm}^2}{2}}$$

2) Beam Buckling Factor 2

Open Calculator

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

ex $$63.85396 = \left(\frac{4 \cdot 0.2}{5000\text{mm}^4/\text{mm}}\right) \cdot \left(\frac{35\text{mm}^3}{80\text{GPa} \cdot 21.9}\right)^2$$

3) Critical Elastic Moment

Open Calculator

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

ex $$6.791907\text{N*m} = \left(\frac{1.960 \cdot \pi}{12\text{m}}\right) \cdot \sqrt{\left((200\text{GPa} \cdot 5000\text{mm}^4/\text{mm} \cdot 80\text{GPa} \cdot 21.9) + \left(5000\text{mm}^4/\text{mm} \cdot 0.2 \cdot \left(\frac{\pi \cdot 2}{(1}\right.\right.\right.}$$

4) Critical Elastic Moment for Box Sections and Solid Bars

Open Calculator

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

ex $$69.70946\text{N*m} = \frac{57000 \cdot 1.960 \cdot \sqrt{21.9 \cdot 6400\text{mm}^2}}{\frac{12\text{m}}{20\text{mm}}}$$

5) Limiting Buckling Moment

Open Calculator

fx $$M_r = F_l \cdot S_x$$

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

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

Open Calculator

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

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

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

Open Calculator

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

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

8) Limiting Laterally Unbraced Length for Inelastic Lateral Buckling

Open Calculator

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

ex $$30235.04\text{mm} = \left(\frac{20\text{mm} \cdot 3005}{139\text{MPa} - 80.0\text{MPa}}\right) \cdot \sqrt{1 + \sqrt{1 + \left(64 \cdot (110\text{MPa})^2\right)}}$$

9) Limiting Laterally Unbraced Length for Inelastic Lateral Buckling for Box Beams

Open Calculator

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

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

10) Maximum Laterally Unbraced Length for Plastic Analysis

Open Calculator

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

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

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

Open Calculator

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

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

12) Plastic Moment

Open Calculator

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

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

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

Open Calculator

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

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

Columns

14) Critical Buckling Stress when Slenderness Parameter is greater than 2.25

Open Calculator

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

ex $$97.44444\text{MPa} = \frac{0.877 \cdot 250\text{MPa}}{2.25}$$

15) Critical Buckling Stress when Slenderness Parameter is Less than 2.25

Open Calculator

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

ex $$97.48735\text{MPa} = 0.658^{2.25} \cdot 250\text{MPa}$$

16) Maximum Load on Axially Loaded Members

Open Calculator

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

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

17) Slenderness Parameter

Open Calculator

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

ex $$2.505956 = \left(\frac{5 \cdot 932\text{mm}}{87\text{mm}}\right)^2 \cdot \left(\frac{250\text{MPa}}{286220}\right)$$

Shear in Buildings

18) Shear Capacity for Web Slenderness less than Alpha

Open Calculator

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

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

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

Open Calculator

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

ex $$6.220598\text{kN} = \frac{0.54 \cdot 139\text{MPa} \cdot 85\text{mm}^2 \cdot 39}{\frac{2000\text{mm}}{50.0\text{mm}}}$$

20) Shear Capacity if Web Slenderness is greater than 1.25 alpha

Open Calculator

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

ex $$6.31125\text{kN} = \frac{23760 \cdot 5 \cdot 85\text{mm}^2}{\left(\frac{2000\text{mm}}{50.0\text{mm}}\right)^2}$$

Variables Used

- **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 *(Millimeter^4 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)*
- **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

Constants, Functions, Measurements used

- Constant: **pi**, 3.14159265358979323846264338327950288
  Archimedes' constant
- Function: **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 Millimeter^4 per Millimeter (mm^4/mm)
  Moment of Inertia per Unit Length Unit Conversion
- Measurement: **Stress** in Megapascal (MPa)
  Stress Unit Conversion

Check other formula lists

- **Allowable-Stress Design Formulas**
- **Base and Bearing Plates Formulas**
- **Bearing, Stresses, Plate Girders & Ponding Considerations Formulas**
- **Cold Formed or Light Weighted Steel Structures Formulas**
- **Composite Construction in Buildings Formulas**
- **Design of Stiffeners under Loads Formulas**
- **Economical Structural Steel Formulas**
- **Load-and-Resistance Factor Design for Buildings Formulas**
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