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Columns of Special Materials Formulas

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List of 21 Columns of Special Materials Formulas

Columns of Special Materials

Aluminium Column Design

1) Critical Slenderness Ratio for Aluminium Columns

$$fx \quad \lambda = \sqrt{\frac{51000000}{\frac{Q}{A}}}$$

Open Calculator 

$$ex \quad 65.27367 = \sqrt{\frac{51000000}{\frac{633.213N}{52900mm^2}}}$$

2) Ultimate Load per Area for Aluminium Columns

$$fx \quad P = (34000 - 88 \cdot \lambda) \cdot A$$

Open Calculator 

$$ex \quad 1796.272N = (34000 - 88 \cdot 0.5) \cdot 52900mm^2$$



3) Ultimate Load per Area for Aluminium Columns given Allowable Load and Section Area

$$fx \quad P = \left(1.95 \cdot \left(\frac{Q}{A} \right) \right) \cdot A$$

[Open Calculator !\[\]\(cbe80b694ebd74fcfe136a095b608235_img.jpg\)](#)

$$ex \quad 1234.765N = \left(1.95 \cdot \left(\frac{633.213N}{52900mm^2} \right) \right) \cdot 52900mm^2$$

Axially Loaded Steel Columns Design

4) Allowable Compression Stress given Slenderness Ratio

$$fx \quad F_a = \frac{12 \cdot (\pi^2) \cdot E_s}{23 \cdot (\lambda^2)}$$

[Open Calculator !\[\]\(5361750c22c4e047a52f4eac1ec2d4cc_img.jpg\)](#)

$$ex \quad 4.325461MPa = \frac{12 \cdot (\pi^2) \cdot 210000MPa}{23 \cdot ((0.5)^2)}$$



5) Allowable Compression Stress when Slenderness Ratio is less than C_c 

$$f_x F_a = \frac{1 - \left(\frac{\lambda^2}{2 \cdot C_c^2} \right)}{\left(\frac{5}{3} \right) + \left(3 \cdot \frac{\lambda}{8 \cdot C_c} \right) - \left(\frac{\lambda^3}{8 \cdot (C_c^3)} \right)} \cdot F_y$$

Open Calculator

$$ex \ 16.55172MPa = \frac{1 - \left(\frac{(0.5)^2}{2 \cdot (0.75)^2} \right)}{\left(\frac{5}{3} \right) + \left(3 \cdot \frac{0.5}{8 \cdot 0.75} \right) - \left(\frac{(0.5)^3}{8 \cdot ((0.75)^3)} \right)} \cdot 40MPa$$

6) Slenderness Ratio between Inelastic from Elastic Buckling

$$f_x \ \lambda = \sqrt{\frac{2 \cdot (\pi^2) \cdot E_s}{F_y}}$$

Open Calculator

$$ex \ 321.9175 = \sqrt{\frac{2 \cdot (\pi^2) \cdot 210000MPa}{40MPa}}$$

Cast Iron Columns Design

7) Allowable Load per Area for Cast Iron Columns

$$f_x \ Q = (12000 - (60 \cdot \lambda)) \cdot A$$

Open Calculator

$$ex \ 633.213N = (12000 - (60 \cdot 0.5)) \cdot 52900mm^2$$



8) Critical Slenderness Ratio for Cast Iron Columns

$$\text{fx } \lambda = \frac{12000 - \left(\frac{Q}{A}\right)}{60}$$

[Open Calculator !\[\]\(e2376d476d06eb31946dc01a69a4403a_img.jpg\)](#)

$$\text{ex } 0.5 = \frac{12000 - \left(\frac{633.213\text{N}}{52900\text{mm}^2}\right)}{60}$$

9) Ultimate Load per Area for Cast Iron Columns

$$\text{fx } P = (34000 - 88 \cdot (\lambda)) \cdot A$$

[Open Calculator !\[\]\(0b5e7e25e8775f7e7e80906ada4f0021_img.jpg\)](#)

$$\text{ex } 1796.272\text{N} = (34000 - 88 \cdot (0.5)) \cdot 52900\text{mm}^2$$

Composite Columns

10) Design Strength of Axially Loaded Composite Column

$$\text{fx } P_n = 0.85 \cdot A_{\text{Gross}} \cdot \frac{F_{\text{cr}}}{\Phi}$$

[Open Calculator !\[\]\(0fb13ad0bfa3d86868cdd3883e5665b3_img.jpg\)](#)

$$\text{ex } 3060\text{N} = 0.85 \cdot 51\text{mm}^2 \cdot \frac{60\text{MPa}}{0.850}$$

11) Design Strength of Concrete for Direct Bearing

$$\text{fx } P_n = 1.7 \cdot \phi_c \cdot A_b \cdot f'_c$$

[Open Calculator !\[\]\(e50091943b385fe16d3277389202856f_img.jpg\)](#)

$$\text{ex } 2769.3\text{N} = 1.7 \cdot 0.6 \cdot 10\text{mm}^2 \cdot 271.5\text{MPa}$$



12) Gross Area of Steel Core given Design Strength of Axially Loaded Composite Column

$$\text{fx } A_{\text{Gross}} = P_n \cdot \frac{\Phi}{0.85 \cdot F_{\text{cr}}}$$

[Open Calculator !\[\]\(d3fb9f94af8b26d1c844efa9a98805b0_img.jpg\)](#)

$$\text{ex } 50.00017\text{mm}^2 = 3000.01\text{N} \cdot \frac{0.850}{0.85 \cdot 60\text{MPa}}$$

13) Loaded Area given Design Strength of Concrete for Direct Bearing

$$\text{fx } A_b = \frac{P_n}{1.7 \cdot \phi_c \cdot f'_c}$$

[Open Calculator !\[\]\(e1d6102fe77919492c04879c8450f1f5_img.jpg\)](#)

$$\text{ex } 10.8331\text{mm}^2 = \frac{3000.01\text{N}}{1.7 \cdot 0.6 \cdot 271.5\text{MPa}}$$

Reinforced Concrete Columns

Equivalent Column Concept

14) Curvature of Column Based on Column Mode of Failure

$$\text{fx } \Phi_m = e_o \cdot \frac{\pi^2}{L^2}$$

[Open Calculator !\[\]\(aab88c0d099e5d18d6533a97b13ec28d_img.jpg\)](#)

$$\text{ex } 0.24016 = 219\text{mm} \cdot \frac{\pi^2}{(3000\text{mm})^2}$$



15) Lateral Deflection of Equivalent Pin Ended Column at distance x

$$fx \quad e = e_o \cdot \sin\left(\frac{\pi \cdot x}{L}\right)$$

[Open Calculator !\[\]\(9dfdaff1d86ba3c1f8353b4d1b61b8c5_img.jpg\)](#)

$$ex \quad 189.6596\text{mm} = 219\text{mm} \cdot \sin\left(\frac{\pi \cdot 2000\text{mm}}{3000\text{mm}}\right)$$

16) Length of Equivalent Pin Ended Column given Max Deflection at Mid Height

$$fx \quad L = \sqrt{\frac{e_o \cdot \pi^2}{\Phi_m}}$$

[Open Calculator !\[\]\(2b376d1a92330ab09dad2665d2f89bf5_img.jpg\)](#)

$$ex \quad 3001.002\text{mm} = \sqrt{\frac{219\text{mm} \cdot \pi^2}{0.24}}$$

17) Maximum Deflection at Mid Height given Lateral Deflection of Pin Ended Column

$$fx \quad e_o = \frac{e}{\sin\left(\frac{\pi \cdot x}{L}\right)}$$

[Open Calculator !\[\]\(c444627dab9fee9a1550c053ffaaaae2_img.jpg\)](#)

$$ex \quad 219.3931\text{mm} = \frac{190\text{mm}}{\sin\left(\frac{\pi \cdot 2000\text{mm}}{3000\text{mm}}\right)}$$



18) Maximum Deflection at Mid-Height of Equivalent Pin-Ended Column

$$fx \quad e_o = \Phi_m \cdot \frac{(L)^2}{\pi^2}$$

[Open Calculator !\[\]\(6605b201d6f14d9b3bcb8ab5f274d107_img.jpg\)](#)

$$ex \quad 218.8538\text{mm} = 0.24 \cdot \frac{(3000\text{mm})^2}{\pi^2}$$

Minimum Eccentricity in Design of RCC Columns

19) Axial Load carrying Capacity of Column

$$fx \quad P_u = (0.4 \cdot f_{ck} \cdot A_c) + (0.67 \cdot f_y \cdot A_s)$$

[Open Calculator !\[\]\(f95dab70c751fda7d824b8b03650f7aa_img.jpg\)](#)

$$ex \quad 449.75\text{kN} = (0.4 \cdot 20\text{MPa} \cdot 52450\text{mm}^2) + (0.67 \cdot 450\text{MPa} \cdot 100.0\text{mm}^2)$$

20) Minimum Eccentricity

$$fx \quad e_{\min} = \left(\frac{L}{500} \right) + \left(\frac{b}{30} \right)$$

[Open Calculator !\[\]\(e9474ce1d70442456f8fe9c393ea149c_img.jpg\)](#)

$$ex \quad 21.00033\text{mm} = \left(\frac{3000\text{mm}}{500} \right) + \left(\frac{450.01\text{mm}}{30} \right)$$



21) Unsupported Length of Column given Minimum Eccentricity

[Open Calculator !\[\]\(666e09182d4cd268646ea700ea60dcdf_img.jpg\)](#)

$$fx \quad L = \left(e_{\min} - \left(\frac{b}{30} \right) \right) \cdot 500$$

$$ex \quad 2999.833\text{mm} = \left(21\text{mm} - \left(\frac{450.01\text{mm}}{30} \right) \right) \cdot 500$$



Variables Used






- **A** Section Area of Column (Square Millimeter)
- **A_b** Loaded Area (Square Millimeter)
- **A_c** Area of Concrete (Square Millimeter)
- **A_{Gross}** Gross Area of Steel Core (Square Millimeter)
- **A_s** Area of Steel required (Square Millimeter)
- **b** Least Lateral Dimension (Millimeter)
- **C_c** Value of Cc
- **e** Lateral Deflection (Millimeter)
- **e_{min}** Minimum Eccentricity (Millimeter)
- **e_o** Maximum Deflection at Mid Height (Millimeter)
- **E_s** Modulus of Elasticity of Steel (Megapascal)
- **F_a** Allowable Compression Stress (Megapascal)
- **f'_c** Maximum Compressive Stress of Concrete (Megapascal)
- **f_{ck}** Characteristic Compressive Strength (Megapascal)
- **F_{cr}** Critical Compressive Stress (Megapascal)
- **f_y** Characteristic Strength of Steel Reinforcement (Megapascal)
- **F_y** Minimum Specified Yield Stress of Steel (Megapascal)
- **L** Effective Length of Column (Millimeter)
- **P** Ultimate Load (Newton)
- **P_n** Nominal Load (Newton)
- **P_u** Ultimate Axial Load Carrying Capacity of Column (Kilonewton)



- **Q** Allowable Load (Newton)
- **x** Distance from One End of Pin Ended Column (Millimeter)
- **λ** Slenderness Ratio
- **Φ** Resistance Factor
- **Φ_c** Strength Reduction Factor
- **Φ_m** Curvature of Column



Constants, Functions, Measurements used

- **Constant:** **pi**, 3.14159265358979323846264338327950288
Archimedes' constant
- **Function:** **sin**, sin(Angle)
Trigonometric sine function
- **Function:** **sqrt**, sqrt(Number)
Square root function
- **Measurement:** **Length** in Millimeter (mm)
Length Unit Conversion 
- **Measurement:** **Area** in Square Millimeter (mm²)
Area Unit Conversion 
- **Measurement:** **Pressure** in Megapascal (MPa)
Pressure Unit Conversion 
- **Measurement:** **Force** in Newton (N), Kilonewton (kN)
Force Unit Conversion 
- **Measurement:** **Stress** in Megapascal (MPa)
Stress Unit Conversion 



Check other formula lists

- [Allowable Design for Column Formulas](#) 
- [Column Base Plate Design Formulas](#) 
- [Columns of Special Materials Formulas](#) 
- [Eccentric Loads on Columns Formulas](#) 
- [Elastic Flexural Buckling of Columns Formulas](#) 
- [Short Axially Loaded Columns with Helical Ties Formulas](#) 
- [Ultimate Strength Design of Concrete Columns Formulas](#) 

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