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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

Open Calculator

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

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

#### 2) Ultimate Load per Area for Aluminium Columns

Open Calculator

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

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

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

Open Calculator

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

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

## Axially Loaded Steel Columns Design

### 4) Allowable Compression Stress given Slenderness Ratio

Open Calculator

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

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

### 5) Allowable Compression Stress when Slenderness Ratio is less than Cc

Open Calculator

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

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

### 6) Slenderness Ratio between Inelastic from Elastic Buckling

Open Calculator

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

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

## Cast Iron Columns Design

### 7) Allowable Load per Area for Cast Iron Columns

Open Calculator

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

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

### 8) Critical Slenderness Ratio for Cast Iron Columns

Open Calculator

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

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

### 9) Ultimate Load per Area for Cast Iron Columns

Open Calculator

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

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

## Composite Columns

### 10) Design Strength of Axially Loaded Composite Column

Open Calculator

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

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

### 11) Design Strength of Concrete for Direct Bearing

Open Calculator

$$P_n = 1.7 \cdot \phi_c \cdot A_b \cdot f'_c$$

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

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

Open Calculator

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

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

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

Open Calculator

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

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

# Reinforced Concrete Columns

## Equivalent Column Concept

### 14) Curvature of Column Based on Column Mode of Failure

Open Calculator

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

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

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

Open Calculator

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

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

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

Open Calculator

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

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

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

Open Calculator

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

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

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

Open Calculator

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

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

## Minimum Eccentricity in Design of RCC Columns

### 19) Axial Load carrying Capacity of Column

Open Calculator

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

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

### 20) Minimum Eccentricity

Open Calculator

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

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

## 21) Unsupported Length of Column given Minimum Eccentricity

Open Calculator

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

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

# 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
- $\phi_c$ Strength Reduction Factor
- $\Phi_m$ 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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