Important Columns of Special Materials Formulas PDF

Formulas
Examples
with Units

List of 21
Important Columns of Special Materials Formulas

1) Aluminium Column Design Formulas

1.1) Critical Slenderness Ratio for Aluminium Columns Formula

Evaluate Formula

Formula

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

Example with Units

$$65.2737 = \sqrt{\frac{51000000}{\frac{633.213\,\text{N}}{52900\,\text{mm}^2}}}$$

1.2) Ultimate Load per Area for Aluminium Columns Formula

Evaluate Formula

Formula

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

Example with Units

$$1796.2724\,\text{N} = \left(34000 - 88 \cdot 0.5\right) \cdot 52900\,\text{mm}^2$$

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

Evaluate Formula

Formula

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

Example with Units

$$1234.7653\,\text{N} = \left(1.95 \cdot \left(\frac{633.213\,\text{N}}{52900\,\text{mm}^2}\right)\right) \cdot 52900\,\text{mm}^2$$

2) Axially Loaded Steel Columns Design Formulas

2.1) Allowable Compression Stress given Slenderness Ratio Formula

Evaluate Formula

Formula

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

Example with Units

$$4.3255\,\text{MPa} = \frac{12 \cdot \left(3.1416^2\right) \cdot 210000\,\text{MPa}}{23 \cdot \left(0.5^2\right)}$$

2.2) Allowable Compression Stress when Slenderness Ratio is less than Cc Formula

Evaluate Formula

Formula

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

Example with Units

$$16.5517\,\text{MPa} = \frac{1 - \left(\frac{0.5^2}{2 \cdot 0.75^2}\right)}{\left(\frac{5}{3}\right) + \left(3 \cdot \frac{0.5}{8 \cdot 0.75}\right) - \left(\frac{0.5^3}{8 \cdot \left(0.75^3\right)}\right)} \cdot 40\,\text{MPa}$$

2.3) Slenderness Ratio between Inelastic from Elastic Buckling Formula

Evaluate Formula

Formula

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

Example with Units

$$321.9175 = \sqrt{\frac{2 \cdot \left(3.1416^2\right) \cdot 210000\,\text{MPa}}{40\,\text{MPa}}}$$

3) Cast Iron Columns Design Formulas

3.1) Allowable Load per Area for Cast Iron Columns Formula

Evaluate Formula

Formula

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

Example with Units

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

3.2) Critical Slenderness Ratio for Cast Iron Columns Formula

Evaluate Formula

Formula

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

Example with Units

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

3.3) Ultimate Load per Area for Cast Iron Columns Formula

Evaluate Formula

Formula

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

Example with Units

$$1796.2724\,\text{N} = \left(34000 - 88 \cdot \left(0.5\right)\right) \cdot 52900\,\text{mm}^2$$

4) Composite Columns Formulas

4.1) Design Strength of Axially Loaded Composite Column Formula

Evaluate Formula

Formula

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

Example with Units

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

4.2) Design Strength of Concrete for Direct Bearing Formula

Evaluate Formula

Formula

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

Example with Units

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

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

Evaluate Formula

Formula

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

Example with Units

$$50.0002\,\text{mm}^2 = 3000.01\,\text{N} \cdot \frac{0.850}{0.85 \cdot 60\,\text{MPa}}$$

4.4) Loaded Area given Design Strength of Concrete for Direct Bearing Formula

Evaluate Formula

Formula

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

Example with Units

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

5) Reinforced Concrete Columns Formulas

5.1) Equivalent Column Concept Formulas

5.1.1) Curvature of Column Based on Column Mode of Failure Formula

Evaluate Formula

Formula

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

Example with Units

$$0.2402 = 219\,\text{mm} \cdot \frac{3.1416^2}{3000\,\text{mm}^2}$$

5.1.2) Lateral Deflection of Equivalent Pin Ended Column at distance x Formula

Evaluate Formula

Formula

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

Example with Units

$$189.6596\,\text{mm} = 219\,\text{mm} \cdot \sin\left(\frac{3.1416 \cdot 2000\,\text{mm}}{3000\,\text{mm}}\right)$$

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

Evaluate Formula

Formula

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

Example with Units

$$3001.0022\,\text{mm} = \sqrt{\frac{219\,\text{mm} \cdot 3.1416^2}{0.24}}$$

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

Evaluate Formula

Formula

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

Example with Units

$$219.3931\,\text{mm} = \frac{190\,\text{mm}}{\sin\left(\frac{3.1416 \cdot 2000\,\text{mm}}{3000\,\text{mm}}\right)}$$

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

Evaluate Formula

Formula

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

Example with Units

$$218.8538\,\text{mm} = 0.24 \cdot \frac{(3000\,\text{mm})^2}{3.1416^2}$$

5.2) Minimum Eccentricity in Design of RCC Columns Formulas

5.2.1) Axial Load carrying Capacity of Column Formula

Evaluate Formula

Formula

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

Example with Units

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

5.2.2) Minimum Eccentricity Formula

Evaluate Formula

Formula

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

Example with Units

$$21.0003\,\text{mm} = \left(\frac{3000\,\text{mm}}{500}\right) + \left(\frac{450.01\,\text{mm}}{30}\right)$$

5.2.3) Unsupported Length of Column given Minimum Eccentricity Formula

Evaluate Formula

Formula

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

Example with Units

$$2999.8333\,\text{mm} = \left(21\,\text{mm} - \left(\frac{450.01\,\text{mm}}{30}\right)\right) \cdot 500$$

Variables used in list of Columns of Special Materials Formulas above

- **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 in list of Columns of Special Materials Formulas above

- constant(s): **pi**, 3.14159265358979323846264338327950288 *Archimedes' constant*
- Functions: **sin**, sin(Angle) *Sine is a trigonometric function that describes the ratio of the length of the opposite side of a right triangle to the length of the hypotenuse.*
- 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 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*

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