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Ultimate Strength Design of Concrete Columns Formulas

Calculators! Examples! Conversions!

List of 22 Ultimate Strength Design of Concrete Columns Formulas

Ultimate Strength Design of Concrete Columns

1) 28-day Concrete Compressive Strength given Column Ultimate Strength

Open Calculator

fx $$f'_c = \frac{P_0 - f_y \cdot A_{st}}{0.85 \cdot (A_g - A_{st})}$$

ex $$55\text{MPa} = \frac{2965.5\text{MPa} - 250.0\text{MPa} \cdot 7\text{mm}^2}{0.85 \cdot (33\text{mm}^2 - 7\text{mm}^2)}$$

2) Axial Load Capacity of Short Rectangular Members

Open Calculator

fx $$P_u = \Phi \cdot ((.85 \cdot f'_c \cdot b \cdot a) + (A'_s \cdot f_y) - (A_s \cdot f_s))$$

ex $$680.0021\text{N} = 0.850 \cdot ((.85 \cdot 55.0\text{MPa} \cdot 5\text{mm} \cdot 10.5\text{mm}) + (20.0\text{mm}^2 \cdot 250.0\text{MPa}) - (15\text{mm}^2 \cdot 280\text{MPa}))$$

3) Balanced Moment given Load and Eccentricity

Open Calculator

fx $$M_b = e \cdot P_b$$

ex $$3.5\text{N*m} = 35\text{mm} \cdot 100\text{N}$$

4) Column Ultimate Strength with Zero Eccentricity of Load

Open Calculator

fx $$P_0 = 0.85 \cdot f'_c \cdot (A_g - A_{st}) + f_y \cdot A_{st}$$

ex $$2965.5\text{MPa} = 0.85 \cdot 55.0\text{MPa} \cdot (33\text{mm}^2 - 7\text{mm}^2) + 250.0\text{MPa} \cdot 7\text{mm}^2$$

5) Compressive Reinforcement Area given Axial-Load Capacity of Short Rectangular Members

Open Calculator

fx $$A'_s = \frac{\left(\frac{P_u}{\Phi}\right) - (.85 \cdot f'_c \cdot b \cdot a) + (A_s \cdot f_s)}{f_y}$$

ex $$16.79999\text{mm}^2 = \frac{\left(\frac{680\text{N}}{0.850}\right) - (.85 \cdot 55.0\text{MPa} \cdot 5\text{mm} \cdot 10.5\text{mm}) + (15\text{mm}^2 \cdot 280\text{MPa})}{250.0\text{MPa}}$$

6) Tensile Stress in Steel for Axial-Load Capacity of Short Rectangular Members

Open Calculator

fx $$f_s = \frac{(.85 \cdot f'_c \cdot b \cdot a) + (A'_s \cdot f_y) - \left(\frac{P_u}{\Phi}\right)}{A_s}$$

ex $$443.625\text{MPa} = \frac{(.85 \cdot 55.0\text{MPa} \cdot 5\text{mm} \cdot 10.5\text{mm}) + (20.0\text{mm}^2 \cdot 250.0\text{MPa}) - \left(\frac{680\text{N}}{0.850}\right)}{15\text{mm}^2}$$

7) Tension Reinforcement Area for Axial-Load Capacity of Short Rectangular Members

Open Calculator

fx $$A_s = \frac{(0.85 \cdot f'_c \cdot b \cdot a) + (A'_s \cdot f_y) - \left(\frac{P_u}{\Phi}\right)}{f_s}$$

ex $$23.76562\text{mm}^2 = \frac{(0.85 \cdot 55.0\text{MPa} \cdot 5\text{mm} \cdot 10.5\text{mm}) + (20.0\text{mm}^2 \cdot 250.0\text{MPa}) - \left(\frac{680\text{N}}{0.850}\right)}{280\text{MPa}}$$

8) Ultimate Strength for Symmetrical Reinforcement

Open Calculator

fx $$P_u = 0.85 \cdot f'_c \cdot b \cdot d \cdot \text{Phi} \cdot \left((-\text{Rho}) + 1 - \left(\frac{e'}{d}\right) + \sqrt{\left(\left(1 - \left(\frac{e'}{d}\right)\right)^2\right) + 2 \cdot \text{Rho} \cdot \left((m\right.}\right.$$

ex $$670.0779\text{N} = 0.85 \cdot 55.0\text{MPa} \cdot 5\text{mm} \cdot 20\text{mm} \cdot 0.85 \cdot \left((-0.5) + 1 - \left(\frac{35\text{mm}}{20\text{mm}}\right) + \sqrt{\left(\left(1 - \left(\frac{35\text{mm}}{20\text{mm}}\right)\right)^2\right) +}\right.$$

9) Yield Strength of Reinforcing Steel using Column Ultimate Strength

Open Calculator

fx $$f_y = \frac{P_0 - 0.85 \cdot f'_c \cdot (A_g - A_{st})}{A_{st}}$$

ex $$250\text{MPa} = \frac{2965.5\text{MPa} - 0.85 \cdot 55.0\text{MPa} \cdot (33\text{mm}^2 - 7\text{mm}^2)}{7\text{mm}^2}$$

Circular Columns

10) Eccentricity for Balanced Condition for Short, Circular Members

Open Calculator

fx $$e_b = (0.24 - 0.39 \cdot \text{Rho}' \cdot m) \cdot D$$

ex $$24.9\text{mm} = (0.24 - 0.39 \cdot 0.9 \cdot 0.4) \cdot 250\text{mm}$$

11) Ultimate Strength for Short, Circular Members when Controlled by Tension

fx Open Calculator

$$P_u = 0.85 \cdot f'_c \cdot \left(D^2\right) \cdot \Phi \cdot \left(\sqrt{\left(\left(\left(\left(0.85 \cdot \frac{e}{D}\right) - 0.38\right)^2\right) + \left(Rho' \cdot m \cdot \frac{D_b}{2.5 \cdot D}\right)} - \left(\left(0.85\right.\right.\right.$$

ex

$$1.3E^6N = 0.85 \cdot 55.0MPa \cdot \left((250mm)^2\right) \cdot 0.850 \cdot \left(\sqrt{\left(\left(\left(\left(0.85 \cdot \frac{35mm}{250mm}\right) - 0.38\right)^2\right) + \left(0.9 \cdot 0.4 \cdot \frac{12}{2.5 \cdot 2}\right.\right.}\right.$$

12) Ultimate Strength for Short, Circular Members when Governed by Compression

Open Calculator

fx
$$P_u = \Phi \cdot \left(\left(A_{st} \cdot \frac{f_y}{\left(3 \cdot \frac{e}{D_b}\right) + 1}\right) + \left(A_g \cdot \frac{f'_c}{9.6 \cdot \frac{D_e}{(0.8 \cdot D + 0.67 \cdot D_b)^2} + 1.18}\right)\right)$$

ex
$$0.00018N = 0.850 \cdot \left(\left(7mm^2 \cdot \frac{250.0MPa}{\left(3 \cdot \frac{35mm}{12mm}\right) + 1}\right) + \left(33mm^2 \cdot \frac{55.0MPa}{9.6 \cdot \frac{0.25m}{(0.8 \cdot 250mm + 0.67 \cdot 12mm)^2} + 1.18}\right)\right)$$

Column Strength when Compression Governs

13) Ultimate Strength for No Compression Reinforcement

fx Open Calculator

$$P_u = 0.85 \cdot f'_c \cdot b \cdot d \cdot Phi \cdot \left((-Rho \cdot m) + 1 - \left(\frac{e'}{d}\right) + \sqrt{\left(\left(1 - \left(\frac{e'}{d}\right)\right)^2\right) + 2 \cdot \left(Rho \cdot\right.}\right.$$

ex

$$689.8837N = 0.85 \cdot 55.0MPa \cdot 5mm \cdot 20mm \cdot 0.85 \cdot \left((-0.5 \cdot 0.4) + 1 - \left(\frac{35mm}{20mm}\right) + \sqrt{\left(\left(1 - \left(\frac{35mm}{20mm}\right)\right)\right.}\right.$$

14) Ultimate Strength for Symmetrical Reinforcement in Single Layers

Open Calculator

fx $$P_u = Phi \cdot \left(\left(A'_s \cdot \frac{f_y}{\left(\frac{e}{d}\right) - d' + 0.5} \right) + \left(b \cdot L \cdot \frac{f'_c}{\left(3 \cdot L \cdot \frac{e}{d^2}\right) + 1.18} \right) \right)$$

ex $$889.1433N = 0.85 \cdot \left(\left(20.0mm^2 \cdot \frac{250.0MPa}{\left(\frac{35mm}{20mm}\right) - 10mm + 0.5} \right) + \left(5mm \cdot 3000mm \cdot \frac{55.0MPa}{\left(3 \cdot 3000mm \cdot \frac{35mm}{(20mm)^2}\right) + \ldots} \right.\right.$$

Short Columns

15) Ultimate Strength for Short, Square Members when Controlled by Tension

Open Calculator

fx $$P_u = 0.85 \cdot b \cdot L \cdot f'_c \cdot \Phi \cdot \left(\left(\sqrt{\left(\left(\left(\frac{e}{L} \right) - 0.5 \right)^2 \right) + \left(0.67 \cdot \left(\frac{D_b}{L} \right) \cdot Rho' \cdot m \right)} \right) - \left(\left(\frac{e}{L} \ldots \right.\right.\right.$$

ex $$582742.6N = 0.85 \cdot 5mm \cdot 3000mm \cdot 55.0MPa \cdot 0.850 \cdot \left(\left(\sqrt{\left(\left(\left(\frac{35mm}{3000mm} \right) - 0.5 \right)^2 \right) + \left(0.67 \cdot \left(\frac{12mm}{3000mm} \ldots \right.\right.}\right.\right.$$

16) Ultimate Strength for Short, Square Members when Governed by Compression

Open Calculator

fx $$P_u = \Phi \cdot \left(\left(A_{st} \cdot \frac{f_y}{\left(3 \cdot \frac{e}{D_b}\right) + 1} \right) + \left(A_g \cdot \frac{f'_c}{\left(12 \cdot L \cdot \frac{e}{(L + 0.67 \cdot D_b)^2}\right) + 1.18} \right) \right)$$

ex $$1321.976N = 0.850 \cdot \left(\left(7mm^2 \cdot \frac{250.0MPa}{\left(3 \cdot \frac{35mm}{12mm}\right) + 1} \right) + \left(33mm^2 \cdot \frac{55.0MPa}{\left(12 \cdot 3000mm \cdot \frac{35mm}{(3000mm + 0.67 \cdot 12mm)^2}\right) + 1.18} \right) \right)$$

Slender Columns

17) Axial Load Capacity of Slender Columns

Open Calculator

fx $$P_u = \frac{M_c}{e}$$

ex $$680\text{N} = \frac{23.8\text{N*m}}{35\text{mm}}$$

18) Eccentricity of Slender Columns

Open Calculator

fx $$e = \frac{M_c}{P_u}$$

ex $$35\text{mm} = \frac{23.8\text{N*m}}{680\text{N}}$$

19) Magnified Moment given Eccentricity of Slender Columns

Open Calculator

fx $$M_c = e \cdot P_u$$

ex $$23.8\text{N*m} = 35\text{mm} \cdot 680\text{N}$$

Wind Pressure

20) Height given Wind Pressure

Open Calculator

fx $$L = \frac{p}{W_{\text{Column}}}$$

ex $$3000\text{mm} = \frac{72\text{Pa}}{24\text{kN/m}^3}$$

21) Pressure Walls and Pillars subjected to Wind Pressure

Open Calculator

fx $$p = \left(W_{\text{Column}} \cdot L\right)$$

ex $$72\text{Pa} = \left(24\text{kN/m}^3 \cdot 3000\text{mm}\right)$$

22) Unit Weight of Material given Wind Pressure

Open Calculator

fx $$W_{\text{Column}} = \frac{p}{L}$$

ex $$24\text{kN/m}^3 = \frac{72\text{Pa}}{3000\text{mm}}$$

Variables Used

- **a** Depth Rectangular Compressive Stress *(Millimeter)*
- **A_g** Gross Area of Column *(Square Millimeter)*
- **A_s** Area of Tension Reinforcement *(Square Millimeter)*
- **A'_s** Area of Compressive Reinforcement *(Square Millimeter)*
- **A_{st}** Area of Steel Reinforcement *(Square Millimeter)*
- **b** Width of Compression Face *(Millimeter)*
- **d** Distance from Compression to Tensile Reinforcement *(Millimeter)*
- **d'** Distance from Compression to Centroid Reinforcment *(Millimeter)*
- **D** Overall Diameter of Section *(Millimeter)*
- **D_b** Bar Diameter *(Millimeter)*
- **D_e** Diameter at Eccentricity *(Meter)*
- **e** Eccentricity of Column *(Millimeter)*
- **e'** Eccentricity by Method of Frame Analysis *(Millimeter)*
- **e_b** Eccentricity with respect to Plastic Load *(Millimeter)*
- **f'_c** 28-Day Compressive Strength of Concrete *(Megapascal)*
- **f_s** Steel Tensile Stress *(Megapascal)*
- **f_y** Yield Strength of Reinforcing Steel *(Megapascal)*
- **L** Effective Length of Column *(Millimeter)*
- **m** Force Ratio of Strengths of Reinforcements
- **M_b** Balanced Moment *(Newton Meter)*
- **M_c** Magnified Moment *(Newton Meter)*
- **p** Columns Pressure *(Pascal)*
- **P_0** Column Ultimate Strength *(Megapascal)*
- **P_b** Load Balanced Condition *(Newton)*
- **P_u** Axial Load Capacity *(Newton)*
- **Phi** Capacity Reduction Factor
- **Rho** Area Ratio of Tensile Reinforcement
- **Rho'** Area Ratio of Gross Area to Steel Area
- **W_{Column}** Unit weight of RCC Column *(Kilonewton per Cubic Meter)*
- **Φ** Resistance Factor

Constants, Functions, Measurements used

- Function: **sqrt**, sqrt(Number)
  Square root function
- Measurement: **Length** in Millimeter (mm), Meter (m)
  Length Unit Conversion
- Measurement: **Area** in Square Millimeter (mm^2)
  Area Unit Conversion
- Measurement: **Pressure** in Pascal (Pa)
  Pressure Unit Conversion
- Measurement: **Force** in Newton (N)
  Force Unit Conversion
- Measurement: **Moment of Force** in Newton Meter (N*m)
  Moment of Force Unit Conversion
- Measurement: **Specific Weight** in Kilonewton per Cubic Meter (kN/m^3)
  Specific Weight 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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