Important Ultimate Strength Design of Concrete Columns Formulas PDF

Formulas
Examples
with Units

List of 22
Important Ultimate Strength Design of Concrete Columns Formulas

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

Evaluate Formula

Formula

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

Example with Units

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

2) Axial Load Capacity of Short Rectangular Members Formula

Evaluate Formula

Formula

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

Example with Units

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

3) Balanced Moment given Load and Eccentricity Formula

Evaluate Formula

Formula

$$M_b = e \cdot P_b$$

Example with Units

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

4) Column Ultimate Strength with Zero Eccentricity of Load Formula

Evaluate Formula

Formula

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

Example with Units

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

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

Evaluate Formula

Formula

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

Example with Units

$$16.8\,\text{mm}^2 = \frac{\left(\frac{680\,\text{N}}{0.850} \right) - \left(.85 \cdot 55.0\,\text{MPa} \cdot 5\,\text{mm} \cdot 10.5\,\text{mm} \right) + \left(15\,\text{mm}^2 \cdot 280\,\text{MPa} \right)}{250.0\,\text{MPa}}$$

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

Evaluate Formula

Formula

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

Example with Units

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

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

Evaluate Formula

Formula

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

Example with Units

$$23.7656\,\text{mm}^2 = \frac{\left(0.85 \cdot 55.0\,\text{MPa} \cdot 5\,\text{mm} \cdot 10.5\,\text{mm} \right) + \left(20.0\,\text{mm}^2 \cdot 250.0\,\text{MPa} \right) - \left(\frac{680\,\text{N}}{0.850} \right)}{280\,\text{MPa}}$$

8) Ultimate Strength for Symmetrical Reinforcement Formula

Evaluate Formula

Formula

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

Example with Units

$$670.0779\,\text{N} = 0.85 \cdot 55.0\,\text{MPa} \cdot 5\,\text{mm} \cdot 20\,\text{mm} \cdot 0.85 \cdot \left(\left(-0.5 \right) + 1 - \left(\frac{35\,\text{mm}}{20\,\text{mm}} \right) + \sqrt{\left(\left(1 - \left(\frac{35\,\text{mm}}{20\,\text{mm}} \right) \right)^2 \right) + 2 \cdot 0.5 \cdot \left(\left(0.4 - 1 \right) \cdot \left(1 - \left(\frac{10\,\text{mm}}{20\,\text{mm}} \right) \right) + \left(\frac{35\,\text{mm}}{20\,\text{mm}} \right) \right)} \right)$$

9) Yield Strength of Reinforcing Steel using Column Ultimate Strength Formula

Evaluate Formula

Formula

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

Example with Units

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

10) Circular Columns Formulas

10.1) Eccentricity for Balanced Condition for Short, Circular Members Formula

Evaluate Formula

Formula

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

Example with Units

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

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

Evaluate Formula

Formula

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

Example with Units

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

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

Evaluate Formula

Formula

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

Example with Units

$$0.0002\,\text{N} = 0.850 \cdot \left(\left(7\,\text{mm}^2 \cdot \frac{250.0\,\text{MPa}}{\left(3 \cdot \frac{35\,\text{mm}}{12\,\text{mm}} \right) + 1} \right) + \left(33\,\text{mm}^2 \cdot \frac{55.0\,\text{MPa}}{9.6 \cdot \frac{0.25\,\text{m}}{\left(0.8 \cdot 250\,\text{mm} + 0.67 \cdot 12\,\text{mm} \right)^2} + 1.18} \right) \right)$$

11) Column Strength when Compression Governs Formulas

11.1) Ultimate Strength for No Compression Reinforcement Formula

Evaluate Formula

Formula

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

Example with Units

$$689.8837\,\text{N} = 0.85 \cdot 55.0\,\text{MPa} \cdot 5\,\text{mm} \cdot 20\,\text{mm} \cdot 0.85 \cdot \left(\left(- 0.5 \cdot 0.4 \right) + 1 - \left(\frac{35\,\text{mm}}{20\,\text{mm}} \right) + \sqrt{\left(\left(1 - \left(\frac{35\,\text{mm}}{20\,\text{mm}} \right) \right)^2 \right) + 2 \cdot \left(0.5 \cdot 35\,\text{mm} \cdot \frac{0.4}{20\,\text{mm}} \right)} \right)$$

11.2) Ultimate Strength for Symmetrical Reinforcement in Single Layers Formula

Evaluate Formula

Formula

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

Example with Units

$$889.1433\,\text{N} = 0.85 \cdot \left(\left(20.0\,\text{mm}^2 \cdot \frac{250.0\,\text{MPa}}{\left(\frac{35\,\text{mm}}{20\,\text{mm}}\right) - 10\,\text{mm} + 0.5} \right) + \left(5\,\text{mm} \cdot 3000\,\text{mm} \cdot \frac{55.0\,\text{MPa}}{\left(3 \cdot 3000\,\text{mm} \cdot \frac{35\,\text{mm}}{20\,\text{mm}^2}\right) + 1.18} \right) \right)$$

12) Short Columns Formulas

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

Evaluate Formula

Formula

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

Example with Units

$$582742.6009\,\text{N} = 0.85 \cdot 5\,\text{mm} \cdot 3000\,\text{mm} \cdot 55.0\,\text{MPa} \cdot 0.850 \cdot \left(\left(\sqrt{\left(\left(\left(\frac{35\,\text{mm}}{3000\,\text{mm}}\right) - 0.5 \right)^2 \right) + \left(0.67 \cdot \left(\frac{12\,\text{mm}}{3000\,\text{mm}}\right) \cdot 0.9 \cdot 0.4 \right)} \right) - \left(\left(\frac{35\,\text{mm}}{3000\,\text{mm}}\right) - 0.5 \right) \right)$$

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

Evaluate Formula

Formula

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

Example with Units

$$1321.9762\,\text{N} = 0.850 \cdot \left(\left(7\,\text{mm}^2 \cdot \frac{250.0\,\text{MPa}}{\left(3 \cdot \frac{35\,\text{mm}}{12\,\text{mm}}\right) + 1} \right) + \left(33\,\text{mm}^2 \cdot \frac{55.0\,\text{MPa}}{\left(12 \cdot 3000\,\text{mm} \cdot \frac{35\,\text{mm}}{\left(3000\,\text{mm} + 0.67 \cdot 12\,\text{mm}\right)^2}\right) + 1.18} \right) \right)$$

13) Slender Columns Formulas

13.1) Axial Load Capacity of Slender Columns Formula

Evaluate Formula

Formula

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

Example with Units

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

13.2) Eccentricity of Slender Columns Formula

Evaluate Formula

Formula

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

Example with Units

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

13.3) Magnified Moment given Eccentricity of Slender Columns Formula

Evaluate Formula

Formula

$$M_c = e \cdot P_u$$

Example with Units

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

14) Wind Pressure Formulas

14.1) Height given Wind Pressure Formula

Evaluate Formula

Formula

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

Example with Units

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

14.2) Pressure Walls and Pillars subjected to Wind Pressure Formula

Evaluate Formula

Formula

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

Example with Units

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

14.3) Unit Weight of Material given Wind Pressure Formula

Evaluate Formula

Formula

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

Example with Units

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

Variables used in list of Ultimate Strength Design of Concrete Columns Formulas above

- **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 in list of Ultimate Strength Design of Concrete Columns Formulas above

- 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), Meter (m)
  Length Unit Conversion
- Measurement: **Area** in Square Millimeter (mm²)
  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/m³)
  Specific Weight Unit Conversion
- Measurement: **Stress** in Megapascal (MPa)
  Stress Unit Conversion

Download other Important Columns PDFs

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

Try our Unique Visual Calculators

- Reverse percentage
- HCF calculator
- Simple fraction

Please SHARE this PDF with someone who needs it!

This PDF can be downloaded in these languages

English Spanish French German Russian Italian Portuguese Polish Dutch

7/8/2024 | 7:20:24 AM UTC