Important Short Columns Formulas PDF

Formulas
Examples
with Units

List of 37
Important Short Columns Formulas

1) Design of Short Column in Compression with Uniaxial Bending Formulas

1.1) Modes of Failure in Eccentric Compression Formulas

1.1.1) Area of Cross Section of Column given Crushing Stress Formula

Evaluate Formula

Formula

$$A_{sectional} = \frac{P_c}{\sigma_{crushing}}$$

Example with Units

$$6.25\,\mathrm{m^2} = \frac{1500\,\mathrm{kN}}{0.24\,\mathrm{MPa}}$$

1.1.2) Area of Cross-Section given Compressive Stress Induced during Failure of Short Column Formula

Evaluate Formula

Formula

$$A_{sectional} = \frac{P_{compressive}}{\sigma_c}$$

Example with Units

$$6.25\,\mathrm{m^2} = \frac{0.4\,\mathrm{kN}}{0.000064\,\mathrm{MPa}}$$

1.1.3) Area of Cross-Section given Stress due to Direct Load for Long Column Formula

Evaluate Formula

Formula

$$A_{sectional} = \frac{P_{compressive}}{\sigma}$$

Example with Units

$$6.6667\,\mathrm{m^2} = \frac{0.4\,\mathrm{kN}}{0.00006\,\mathrm{MPa}}$$

1.1.4) Compressive Load given Compressive Stress Induced during Failure of Short Column Formula

Evaluate Formula

Formula

$$P_{compressive} = A_{sectional} \cdot \sigma_c$$

Example with Units

$$0.4\,\mathrm{kN} = 6.25\,\mathrm{m^2} \cdot 0.000064\,\mathrm{MPa}$$

1.1.5) Compressive Load given Stress Due to Direct Load for Long Column Formula

Evaluate Formula

Formula

$$P_{compressive} = A_{sectional} \cdot \sigma$$

Example with Units

$$0.375\,\mathrm{kN} = 6.25\,\mathrm{m^2} \cdot 0.00006\,\mathrm{MPa}$$

1.1.6) Compressive Stress Induced during Failure of Short Column Formula

Evaluate Formula

Formula	Example with Units
$\sigma_c = \frac{P_{compressive}}{A_{sectional}}$	$6.4E\text{-}5\,MPa = \frac{0.4\,kN}{6.25\,m^2}$

1.1.7) Crushing Load for Short Column Formula

Evaluate Formula

Formula	Example with Units
$P_c = A_{sectional} \cdot \sigma_{crushing}$	$1500\,kN = 6.25\,m^2 \cdot 0.24\,MPa$

1.1.8) Crushing Stress for Short Column Formula

Evaluate Formula

Formula	Example with Units
$\sigma_{crushing} = \frac{P_c}{A_{sectional}}$	$0.24\,MPa = \frac{1500\,kN}{6.25\,m^2}$

1.1.9) Maximum Stress for Failure of Long Column Formula

Evaluate Formula

Formula	Example with Units
$\sigma_{max} = \sigma + \sigma_b$	$0.0051\,MPa = 0.00006\,MPa + 0.005\,MPa$

1.1.10) Minimum Stress for Failure of Long Column Formula

Evaluate Formula

Formula	Example with Units
$\sigma_{min} = \sigma + \sigma_b$	$0.0051\,MPa = 0.00006\,MPa + 0.005\,MPa$

1.1.11) Section Modulus about Axis of Bending for Long Column Formula

Evaluate Formula

Formula	Example with Units
$S = \frac{P_{compressive} \cdot e}{\sigma_b}$	$320000\,mm^3 = \frac{0.4\,kN \cdot 4\,mm}{0.005\,MPa}$

1.1.12) Stress Due to Bending at Center of Column given Maximum Stress for Failure of Long Column Formula

Evaluate Formula

Formula	Example with Units
$\sigma_b = \sigma_{max} - \sigma$	$0.005\,MPa = 0.00506\,MPa - 0.00006\,MPa$

1.1.13) Stress Due to Bending at Center of Column given Minimum Stress for Failure of Long Column Formula

Evaluate Formula

Formula	Example with Units
$\sigma_b = \sigma_{min} - \sigma$	$0.0009\,MPa = 0.001\,MPa - 0.00006\,MPa$

1.1.14) Stress Due to Direct Load for Long Column Formula

Evaluate Formula

Formula

$$\sigma = \frac{P_{compressive}}{A_{sectional}}$$

Example with Units

$$6.4E\text{-}5\,\text{MPa} = \frac{0.4\,\text{kN}}{6.25\,\text{m}^2}$$

1.1.15) Stress Due to Direct Load given Maximum Stress for Failure of Long Column Formula

Evaluate Formula

Formula

$$\sigma = \sigma_{max} - \sigma_b$$

Example with Units

$$6E\text{-}5\,\text{MPa} = 0.00506\,\text{MPa} - 0.005\,\text{MPa}$$

2) Design of Short Column under Axial Compression Formulas

2.1) Allowable Bond Stress for Horizontal Tension Bars of Sizes and Deformations Conforming to ASTM A 408 Formula

Evaluate Formula

Formula

$$S_b = 2.1 \cdot \sqrt{f'_c}$$

Example with Units

$$18.783\,\text{N/m}^2 = 2.1 \cdot \sqrt{80\,\text{Pa}}$$

2.2) Allowable Bond Stress for Other Tension Bars of Sizes and Deformations Conforming to ASTM A 408 Formula

Evaluate Formula

Formula

$$S_b = 3 \cdot \sqrt{f'_c}$$

Example with Units

$$26.8328\,\text{N/m}^2 = 3 \cdot \sqrt{80\,\text{Pa}}$$

2.3) Allowable Stress in Vertical Concrete Reinforcing given Total Allowable Axial Load Formula

Evaluate Formula

Formula

$$f'_s = \frac{\frac{P_{allow}}{A_g} - 0.25 \cdot f'_c}{p_g}$$

Example with Units

$$3.995\,\text{N/mm}^2 = \frac{\frac{16.00001\,\text{kN}}{500\,\text{mm}^2} - 0.25 \cdot 80\,\text{Pa}}{8.01}$$

2.4) Concrete Compressive Strength given Total Allowable Axial Load Formula

Evaluate Formula

Formula

$$fck = \frac{\left(\frac{p_T}{A_g}\right) - \left(f'_s \cdot p_g\right)}{0.25}$$

Example with Units

$$19.808\,\text{MPa} = \frac{\left(\frac{18.5\,\text{N}}{500\,\text{mm}^2}\right) - \left(4.001\,\text{N/mm}^2 \cdot 8.01\right)}{0.25}$$

2.5) Gross Cross-Sectional Area of Column given Total Allowable Axial Load Formula

Evaluate Formula

Formula

$$A_g = \frac{P_{allow}}{0.25 \cdot f'_c + f'_s \cdot p_g}$$

Example with Units

$$499.251\,\text{mm}^2 = \frac{16.00001\,\text{kN}}{0.25 \cdot 80\,\text{Pa} + 4.001\,\text{N/mm}^2 \cdot 8.01}$$

2.6) Spiral Volume to Concrete-Core Volume Ratio Formula

Evaluate Formula

Formula

$$p_s = 0.45 \cdot \left(\frac{A_g}{A_c} - 1 \right) \cdot \frac{f'_c}{fy_{steel}}$$

Example with Units

$$0.0455 = 0.45 \cdot \left(\frac{500\,\text{mm}^2}{380\,\text{mm}^2} - 1 \right) \cdot \frac{80\,\text{Pa}}{250\,\text{MPa}}$$

2.7) Total Allowable Axial Load for Short Columns Formula

Evaluate Formula

Formula

$$P_{allow} = A_g \cdot \left(0.25 \cdot f'_c + f'_s \cdot p_g \right)$$

Example with Units

$$16.024\,\text{kN} = 500\,\text{mm}^2 \cdot \left(0.25 \cdot 80\,\text{Pa} + 4.001\,\text{N/mm}^2 \cdot 8.01 \right)$$

3) Design Under Axial Compression with Biaxial Bending Formulas

3.1) Axial Load at Balanced Condition Formula

Evaluate Formula

Formula

$$N_b = \frac{M_b}{e_b}$$

Example with Units

$$0.6667\,\text{N} = \frac{10.001\,\text{N*m}}{15\,\text{m}}$$

3.2) Axial Moment at Balanced Condition Formula

Evaluate Formula

Formula

$$M_b = N_b \cdot e_b$$

Example with Units

$$9.9\,\text{N*m} = 0.66\,\text{N} \cdot 15\,\text{m}$$

3.3) Bending Moment for Spiral Columns Formula

Evaluate Formula

Formula

$$M = 0.12 \cdot A_{st} \cdot f_y \cdot D_b$$

Example with Units

$$12.3812\,\text{kN*m} = 0.12 \cdot 8\,\text{m}^2 \cdot 9.99\,\text{MPa} \cdot 1.291\,\text{m}$$

3.4) Bending Moment for Tied Columns Formula

Evaluate Formula

Formula

$$M = 0.40 \cdot A \cdot f_y \cdot \left(d - d' \right)$$

Example with Units

$$419.62\,\text{kN*m} = 0.40 \cdot 10\,\text{m}^2 \cdot 9.99\,\text{MPa} \cdot \left(20.001\,\text{mm} - 9.5\,\text{mm} \right)$$

3.5) Circle Diameter given Maximum Permissible Eccentricity for Spiral Columns Formula

Evaluate Formula

Formula

$$D = \frac{e_b - 0.14 \cdot t}{0.43 \cdot p_g \cdot m}$$

Example with Units

$$9.7446\,\text{m} = \frac{15\,\text{m} - 0.14 \cdot 8.85\,\text{m}}{0.43 \cdot 8.01 \cdot 0.41}$$

3.6) Column Diameter given Maximum Permissible Eccentricity for Spiral Columns Formula

Evaluate Formula

Formula

$$t = \frac{e_b - 0.43 \cdot p_g \cdot m \cdot D}{0.14}$$

Example with Units

$$6.1732\,\text{m} = \frac{15\,\text{m} - 0.43 \cdot 8.01 \cdot 0.41 \cdot 10.01\,\text{m}}{0.14}$$

3.7) Maximum Permissible Eccentricity for Spiral Columns Formula

Evaluate Formula

Formula

$$e_b = 0.43 \cdot p_g \cdot m \cdot D + 0.14 \cdot t$$

Example with Units

$$15.3748\,\text{m} = 0.43 \cdot 8.01 \cdot 0.41 \cdot 10.01\,\text{m} + 0.14 \cdot 8.85\,\text{m}$$

3.8) Maximum Permissible Eccentricity for Tied Columns Formula

Evaluate Formula

Formula

$$e_b = \left(0.67 \cdot p_g \cdot m \cdot D + 0.17\right) \cdot d$$

Example with Units

$$44.0565\,\text{m} = \left(0.67 \cdot 8.01 \cdot 0.41 \cdot 10.01\,\text{m} + 0.17\right) \cdot 20.001\,\text{mm}$$

3.9) Reinforcement Yield Strength given Axial Load for Tied Columns Formula

Evaluate Formula

Formula

$$f_y = \frac{M}{0.40 \cdot A \cdot (d - d')}$$

Example with Units

$$9.5229\,\text{MPa} = \frac{400\,\text{kN*m}}{0.40 \cdot 10\,\text{m}^2 \cdot (20.001\,\text{mm} - 9.5\,\text{mm})}$$

3.10) Tension Reinforcement Area given Axial Load for Tied Columns Formula

Evaluate Formula

Formula

$$A = \frac{M}{0.40 \cdot f_y \cdot (d - d')}$$

Example with Units

$$9.5324\,\text{m}^2 = \frac{400\,\text{kN*m}}{0.40 \cdot 9.99\,\text{MPa} \cdot (20.001\,\text{mm} - 9.5\,\text{mm})}$$

4) Slender Columns Formulas

4.1) Load Reduction Factor for Column with Fixed Ends Formula

Evaluate Formula

Formula

$$R = 1.32 - \left(0.006 \cdot \frac{l}{r}\right)$$

Example with Units

$$1.2927 = 1.32 - \left(0.006 \cdot \frac{5000\,\text{mm}}{1.1\,\text{m}}\right)$$

4.2) Load Reduction Factor for Member Bent in Single Curvature Formula

Evaluate Formula

Formula

$$R = 1.07 - \left(0.008 \cdot \frac{l}{r}\right)$$

Example with Units

$$1.0336 = 1.07 - \left(0.008 \cdot \frac{5000\,\text{mm}}{1.1\,\text{m}}\right)$$

4.3) Radius of Gyration for Fixed End Columns using Load Reduction Factor Formula

Evaluate Formula

Formula

$$r = 1.32 - \left(0.006 \cdot \frac{l}{R}\right)$$

Example with Units

$$1.291\,\text{m} = 1.32 - \left(0.006 \cdot \frac{5000\,\text{mm}}{1.033}\right)$$

4.4) Radius of Gyration for Single Curvature Bent Member using Load Reduction Factor Formula

Evaluate Formula

Formula

$$r = 1.07 - \left(0.008 \cdot \frac{l}{R}\right)$$

Example with Units

$$1.0313\,\text{m} = 1.07 - \left(0.008 \cdot \frac{5000\,\text{mm}}{1.033}\right)$$

4.5) Unsupported Column Length for Single Curvature Bent Member given Load Reduction Factor Formula

Evaluate Formula

Formula

$$l = (1.07 - R) \cdot \frac{r}{0.008}$$

Example with Units

$$5087.5\,\text{mm} = (1.07 - 1.033) \cdot \frac{1.1\,\text{m}}{0.008}$$

Variables used in list of Short Columns Formulas above

- **A** Area of Tension Reinforcement *(Square Meter)*
- **A_c** Cross Sectional Area of Column *(Square Millimeter)*
- **A_g** Gross Area of Column *(Square Millimeter)*
- **$A_{sectional}$** Column Cross Sectional Area *(Square Meter)*
- **A_{st}** Total Area *(Square Meter)*
- **d** Distance from Compression to Tensile Reinforcement *(Millimeter)*
- **d'** Distance Compression to Centroid Reinforcement *(Millimeter)*
- **D** Column Diameter *(Meter)*
- **D_b** Bar Diameter *(Meter)*
- **e** Column Maximum Bending *(Millimeter)*
- **e_b** Maximum Permissible Eccentricity *(Meter)*
- **f'_c** Specified Compressive Strength at 28 Days *(Pascal)*
- **f'_s** Allowable Stress in Vertical Reinforcement *(Newton per Square Millimeter)*
- **f_y** Yield Strength of Reinforcement *(Megapascal)*
- **fck** Characteristic Compressive Strength *(Megapascal)*
- **fy_{steel}** Yield Strength of Steel *(Megapascal)*
- **l** Length of Column *(Millimeter)*
- **m** Force Ratio of Strengths of Reinforcements
- **M** Bending Moment *(Kilonewton Meter)*
- **M_b** Moment at Balanced Condition *(Newton Meter)*
- **N_b** Axial Load at Balanced Condition *(Newton)*
- **P_{allow}** Allowable Load *(Kilonewton)*
- **P_c** Crushing load *(Kilonewton)*
- **$P_{compressive}$** Column Compressive Load *(Kilonewton)*
- **p_g** Area Ratio of Cross Sectional Area to Gross Area

Constants, Functions, Measurements used in list of Short 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: **Volume** in Cubic Millimeter (mm³)
  Volume Unit Conversion
- Measurement: **Area** in Square Meter (m²), Square Millimeter (mm²)
  Area Unit Conversion
- Measurement: **Pressure** in Megapascal (MPa), Newton per Square Meter (N/m²), Pascal (Pa), Newton per Square Millimeter (N/mm²)
  Pressure Unit Conversion
- Measurement: **Force** in Kilonewton (kN), Newton (N)
  Force Unit Conversion
- Measurement: **Moment of Force** in Newton Meter (N*m), Kilonewton Meter (kN*m)
  Moment of Force Unit Conversion
- Measurement: **Stress** in Megapascal (MPa)
  Stress Unit Conversion

- **p_s** Ratio of Spiral to Concrete Core Volume
- **p_T** Total Allowable Load *(Newton)*
- **r** Radius of Gyration of Gross Concrete Area *(Meter)*
- **R** Long Column Load Reduction Factor
- **S** Section Modulus *(Cubic Millimeter)*
- **S_b** Allowable Bond Stress *(Newton per Square Meter)*
- **t** Overall Depth of Column *(Meter)*
- **σ** Direct Stress *(Megapascal)*
- **σ_b** Column Bending Stress *(Megapascal)*
- **σ_c** Column Compressive Stress *(Megapascal)*
- **$\sigma_{crushing}$** Column Crushing Stress *(Megapascal)*
- **σ_{max}** Maximum Stress *(Megapascal)*
- **σ_{min}** Minimum Stress Value *(Megapascal)*

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