Important Doubly Reinforced Rectangular Sections Formulas PDF

Formulas
Examples
with Units

List of 18
Important Doubly Reinforced Rectangular Sections Formulas

1) Force Acting on Compressive Steel Formula

Evaluate Formula

Formula

$$C_{s'} = F_T - C_c$$

Example with Units

$$10\,\text{N} = 760\,\text{N} - 750\,\text{N}$$

2) Force Acting on Tensile Steel Formula

Evaluate Formula

Formula

$$F_T = C_c + C_{s'}$$

Example with Units

$$760.2\,\text{N} = 750\,\text{N} + 10.2\,\text{N}$$

3) Moment Resistance in Compression Formula

Evaluate Formula

Formula

$$M_R = 0.5 \cdot \left(f_{ec} \cdot j \cdot W_b \cdot \left(d^2 \right) \right) \cdot \left(K + 2 \cdot m_{Elastic} \cdot \rho' \cdot \left(1 - \left(\frac{D}{K \cdot d} \right) \right) \right)$$

Example with Units

$$1.6661\,\text{N*m} = 0.5 \cdot \left(10.01\,\text{MPa} \cdot 0.8 \cdot 18\,\text{mm} \cdot \left(5\,\text{mm}^2 \right) \right) \cdot \left(0.65 + 2 \cdot 0.6 \cdot 0.60 \cdot \left(1 - \left(\frac{2.01\,\text{mm}}{0.65 \cdot 5\,\text{mm}} \right) \right) \right)$$

4) Moment Resistance of Tensile Steel given Area Formula

Evaluate Formula

Formula

$$M_{TS} = \left(A_s \right) \cdot \left(f_{TS} \right) \cdot \left(j_d \right)$$

Example with Units

$$11540.4461\,\text{kN*m} = \left(100.0\,\text{mm}^2 \right) \cdot \left(24\,\text{kgf/m}^2 \right) \cdot \left(50\,\text{mm} \right)$$

5) Moment Resisting Capacity of Compressive Steel given Stress Formula

Evaluate Formula

Formula

$$M'_s = 2 \cdot f'_s \cdot A_{s'} \cdot \left(d - D \right)$$

Example with Units

$$0.0161\,\text{kN*m} = 2 \cdot 134.449\,\text{MPa} \cdot 20\,\text{mm}^2 \cdot \left(5\,\text{mm} - 2.01\,\text{mm} \right)$$

6) Stress in Extreme Compression Surface given Moment Resistance Formula

Evaluate Formula

Formula

$$f_{ec} = 2 \cdot \frac{M_R}{\left(j \cdot W_b \cdot \left(d^2\right)\right) \cdot \left(K + 2 \cdot m_{Elastic} \cdot \rho'\right) \cdot \left(1 - \left(\frac{D}{K \cdot d}\right)\right)}$$

Example with Units

$$17.0055\,\text{MPa} = 2 \cdot \frac{1.6\,\text{N*m}}{\left(0.8 \cdot 18\,\text{mm} \cdot \left(5\,\text{mm}^2\right)\right) \cdot \left(0.65 + 2 \cdot 0.6 \cdot 0.60\right) \cdot \left(1 - \left(\frac{2.01\,\text{mm}}{0.65 \cdot 5\,\text{mm}}\right)\right)}$$

7) Stress in Tensile Steel to Stress in Extreme Compression Surface Ratio Formula

Evaluate Formula

Formula

$$fsc_{ratio} = \frac{k}{2} \cdot \left(\rho_T - \left(\frac{\rho' \cdot \left(K_d - d'\right)}{D_{centroid} - K_d}\right)\right)$$

Example with Units

$$3.9441 = \frac{0.61}{2} \cdot \left(12.9 - \left(\frac{0.031 \cdot \left(100.2\,\text{mm} - 50.01\,\text{mm}\right)}{51.01\,\text{mm} - 100.2\,\text{mm}}\right)\right)$$

8) Total Compression on Concrete Formula

Evaluate Formula

Formula

$$C_b = C_{s'} + C_c$$

Example with Units

$$760.2\,\text{N} = 10.2\,\text{N} + 750\,\text{N}$$

9) Total Compressive force on Beam Cross Section Formula

Evaluate Formula

Formula

$$C_b = C_c + C_{s'}$$

Example with Units

$$760.2\,\text{N} = 750\,\text{N} + 10.2\,\text{N}$$

10) Check for Stress in Beams Formulas

10.1) Distance from Neutral Axis to Compressive Reinforcing Steel Formula

Evaluate Formula

Formula

$$c_{sc} = f_{sc} \cdot \frac{I_A}{2 \cdot n \cdot B_M}$$

Example with Units

$$25.2228\,\text{mm} = 8.49\,\text{MPa} \cdot \frac{10E7\,\text{mm}^4}{2 \cdot 0.34 \cdot 49.5\,\text{kN*m}}$$

10.2) Distance from Neutral Axis to Face of Concrete Formula

Evaluate Formula

Formula

$$K_d = f_{\text{fiber concrete}} \cdot \frac{I_A}{B_M}$$

Example with Units

$$100.202\,\text{mm} = 49.6\,\text{MPa} \cdot \frac{10E7\,\text{mm}^4}{49.5\,\text{kN*m}}$$

10.3) Distance from Neutral Axis to Tensile Reinforcing Steel Formula

Evaluate Formula

Formula

$$c_s = f_{\text{unit stress}} \cdot \frac{I_A}{n \cdot B_M}$$

Example with Units

$$594.7712\,\text{mm} = 100.1\,\text{MPa} \cdot \frac{10\text{E}7\,\text{mm}^4}{0.34 \cdot 49.5\,\text{kN*m}}$$

10.4) Moment of Inertia of Transformed Beam Section Formula

Evaluate Formula

Formula

$$I_{TB} = \left(0.5 \cdot b \cdot \left(K_d^{\,2}\right)\right) + 2 \cdot \left(m_{\text{Elastic}} - 1\right) \cdot A_{s'} \cdot \left(c_{sc}^{\,2}\right) + m_{\text{Elastic}} \cdot \left(c_s^{\,2}\right) \cdot A$$

Example with Units

$$2.1243\,\text{kg·m}^2 = \left(0.5 \cdot 26.5\,\text{mm} \cdot \left(100.2\,\text{mm}^{\,2}\right)\right) + 2 \cdot \left(0.6 - 1\right) \cdot 20\,\text{mm}^2 \cdot \left(25.22\,\text{mm}^{\,2}\right) + 0.6 \cdot \left(595\,\text{mm}^{\,2}\right) \cdot 10\,\text{m}^2$$

10.5) Total Bending Moment given Unit Stress in Extreme Fiber of Concrete Formula

Evaluate Formula

Formula

$$B_M = f_{\text{fiber concrete}} \cdot \frac{I_A}{K_d}$$

Example with Units

$$49.501\,\text{kN*m} = 49.6\,\text{MPa} \cdot \frac{10\text{E}7\,\text{mm}^4}{100.2\,\text{mm}}$$

10.6) Total Bending Moment given Unit Stress in Tensile Reinforcing Steel Formula

Evaluate Formula

Formula

$$Mb_R = f_{\text{unit stress}} \cdot \frac{I_A}{n \cdot c_s}$$

Example with Units

$$49.481\,\text{N*m} = 100.1\,\text{MPa} \cdot \frac{10\text{E}7\,\text{mm}^4}{0.34 \cdot 595\,\text{mm}}$$

10.7) Unit Stress in Compressive Reinforcing Steel Formula

Evaluate Formula

Formula

$$f_{sc} = 2 \cdot n \cdot B_M \cdot \frac{c_{sc}}{I_A}$$

Example with Units

$$8.4891\,\text{MPa} = 2 \cdot 0.34 \cdot 49.5\,\text{kN*m} \cdot \frac{25.22\,\text{mm}}{10\text{E}7\,\text{mm}^4}$$

10.8) Unit Stress in Extreme Fiber of Concrete Formula

Evaluate Formula

Formula

$$f_{\text{fiber concrete}} = B_M \cdot \frac{K_d}{I_A}$$

Example with Units

$$49.599\,\text{MPa} = 49.5\,\text{kN*m} \cdot \frac{100.2\,\text{mm}}{10\text{E}7\,\text{mm}^4}$$

10.9) Unit Stress in Tensile Reinforcing Steel Formula

Evaluate Formula

Formula

$$f_{\text{unit stress}} = n \cdot B_M \cdot \frac{c_s}{I_A}$$

Example with Units

$$100.1385\,\text{MPa} = 0.34 \cdot 49.5\,\text{kN*m} \cdot \frac{595\,\text{mm}}{10\text{E}7\,\text{mm}^4}$$

Variables used in list of Doubly Reinforced Rectangular Sections Formulas above

- **A** Area of Tension Reinforcement *(Square Meter)*
- A_s Area of Steel required *(Square Millimeter)*
- $A_{s'}$ Area of Compression Reinforcement *(Square Millimeter)*
- **b** Beam Width *(Millimeter)*
- B_M Bending Moment of Considered Section *(Kilonewton Meter)*
- C_b Total Compression on Beam *(Newton)*
- C_c Total Compression on Concrete *(Newton)*
- c_s Distance Neutral to Tensile Reinforcing Steel *(Millimeter)*
- $C_{s'}$ Force on Compressive Steel *(Newton)*
- c_{sc} Distance Neutral to Compressive Reinforcing Steel *(Millimeter)*
- **d** Distance to Centroid of Tensile Steel *(Millimeter)*
- **d'** Effective Cover *(Millimeter)*
- **D** Distance to Centroid of Compressive Steel *(Millimeter)*
- $D_{centroid}$ Centroidal Distance of Tension Reinforcement *(Millimeter)*
- f_{ec} Stress in Extreme Compression Surface *(Megapascal)*
- $f_{fiber\ concrete}$ Unit Stress in Fiber of Concrete *(Megapascal)*
- f'_s Stress in Compressive Steel *(Megapascal)*
- f_{sc} Unit Stress in Compressive Reinforcing Steel *(Megapascal)*
- F_T Force on Tension Steel *(Newton)*
- f_{TS} Tensile Stress in Steel *(Kilogram-Force per Square Meter)*
- $f_{unit\ stress}$ Unit Stress in Tensile Reinforcing Steel *(Megapascal)*
- fsc_{ratio} Tensile to Compressive Stress Ratio
- I_A Moment of Inertia of Beam *(Millimeter⁴)*

Constants, Functions, Measurements used in list of Doubly Reinforced Rectangular Sections Formulas above

- Measurement: **Length** in Millimeter (mm)
  Length Unit Conversion
- Measurement: **Area** in Square Millimeter (mm²), Square Meter (m²)
  Area Unit Conversion
- Measurement: **Pressure** in Megapascal (MPa), Kilogram-Force per Square Meter (kgf/m²)
  Pressure Unit Conversion
- Measurement: **Force** in Newton (N)
  Force Unit Conversion
- Measurement: **Moment of Inertia** in Kilogram Square Meter (kg·m²)
  Moment of Inertia Unit Conversion
- Measurement: **Moment of Force** in Newton Meter (N*m), Kilonewton Meter (kN*m)
  Moment of Force Unit Conversion
- Measurement: **Second Moment of Area** in Millimeter⁴ (mm⁴)
  Second Moment of Area Unit Conversion

- I_{TB} Moment of Inertia Transformed Beam *(Kilogram Square Meter)*
- **j** Constant j
- j_d Distance between Reinforcements *(Millimeter)*
- **k** Ratio of Depth
- **K** Constant k
- K_d Distance from Compression Fiber to NA *(Millimeter)*
- $m_{Elastic}$ Modular Ratio for Elastic Shortening
- M_R Moment Resistance in Compression *(Newton Meter)*
- M'_s Moment Resistance of Compressive Steel *(Kilonewton Meter)*
- M_{TS} Moment Resistance of Tensile Steel *(Kilonewton Meter)*
- Mb_R Bending Moment *(Newton Meter)*
- **n** Elasticity Ratio of Steel to Concrete
- W_b Width of Beam *(Millimeter)*
- **ρ'** Value of ρ'
- ρ_T Tension Reinforcement Ratio
- ρ' Compression Reinforcement Ratio

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