Important Design for Beams and Ultimate Strength for Rectangular Beams with Tension Reinforcement Formulas PDF

Formulas
Examples
with Units

List of 16
Important Design for Beams and Ultimate Strength for Rectangular Beams with Tension Reinforcement Formulas

1) Bond and Anchorage for Reinforcing Bars Formulas

1.1) Beam Effective Depth given Bond Stress on Bar Surface Formula

Evaluate Formula

Formula

$$d_{eff} = \frac{\Sigma S}{j \cdot u \cdot Summation_0}$$

Example with Units

$$3.996\,\text{m} = \frac{320\,\text{N}}{0.8 \cdot 10\,\text{N/m}^2 \cdot 10.01\,\text{m}}$$

1.2) Bond Stress on Bar Surface Formula

Evaluate Formula

Formula

$$u = \frac{\Sigma S}{j \cdot d_{eff} \cdot Summation_0}$$

Example with Units

$$9.99\,\text{N/m}^2 = \frac{320\,\text{N}}{0.8 \cdot 4\,\text{m} \cdot 10.01\,\text{m}}$$

1.3) Tensile Reinforcing Bars Perimeters Sum given Bond Stress on Bar Surface Formula

Evaluate Formula

Formula

$$Summation_0 = \frac{\Sigma S}{j \cdot d_{eff} \cdot u}$$

Example with Units

$$10\,\text{m} = \frac{320\,\text{N}}{0.8 \cdot 4\,\text{m} \cdot 10\,\text{N/m}^2}$$

1.4) Total Shear given Bond Stress on Bar Surface Formula

Evaluate Formula

Formula

$$\Sigma S = u \cdot \left(j \cdot d_{eff} \cdot Summation_0 \right)$$

Example with Units

$$320.32\,\text{N} = 10\,\text{N/m}^2 \cdot \left(0.8 \cdot 4\,\text{m} \cdot 10.01\,\text{m} \right)$$

2) Shear Reinforcement Formulas

2.1) 28 Day Concrete Compressive Strength given Development Length for Hooked Bar Formula

Evaluate Formula

Formula

$$f_c = \left(\frac{1200 \cdot D_b}{Ld} \right)^2$$

Example with Units

$$15.0001\,\text{MPa} = \left(\frac{1200 \cdot 1.291\,\text{m}}{400\,\text{mm}} \right)^2$$

2.2) Area of Steel Required in Vertical Stirrups Formula

Evaluate Formula

Formula

$$A_s = \frac{V_s \cdot s}{fy_{steel} \cdot D_{centroid}}$$

Example with Units

$$0.3929\,\text{mm}^2 = \frac{100\,\text{MPa} \cdot 50.1\,\text{mm}}{250\,\text{MPa} \cdot 51.01\,\text{mm}}$$

2.3) Bar Diameter given Development Length for Hooked Bar Formula

Evaluate Formula

Formula

$$D_b = \frac{(Ld) \cdot \left(\sqrt{f_c}\right)}{1200}$$

Example with Units

$$1.291\,\text{m} = \frac{(400\,\text{mm}) \cdot \left(\sqrt{15\,\text{MPa}}\right)}{1200}$$

2.4) Development Length for Hooked Bar Formula

Evaluate Formula

Formula

$$Ld = \frac{1200 \cdot D_b}{\sqrt{f_c}}$$

Example with Units

$$400.0017\,\text{mm} = \frac{1200 \cdot 1.291\,\text{m}}{\sqrt{15\,\text{MPa}}}$$

2.5) Nominal Reinforcement Shear Strength for Stirrup Area with Support Angle Formula

Evaluate Formula

Formula

$$V_s = A_v \cdot fy_{steel} \cdot \sin(\alpha)$$

Example with Units

$$62500\,\text{MPa} = 500\,\text{mm}^2 \cdot 250\,\text{MPa} \cdot \sin(30°)$$

2.6) Nominal Shear Strength of Concrete Formula

Evaluate Formula

Formula

$$V_c = \left(1.9 \cdot \sqrt{f_c} + \left((2500 \cdot \rho_w) \cdot \left(\frac{V_u \cdot D_{centroid}}{B_M}\right)\right)\right) \cdot (b_w \cdot D_{centroid})$$

Example with Units

$$71.3871\,\text{MPa} = \left(1.9 \cdot \sqrt{15\,\text{MPa}} + \left((2500 \cdot 0.08) \cdot \left(\frac{100.1\,\text{kN} \cdot 51.01\,\text{mm}}{49.5\,\text{kN*m}}\right)\right)\right) \cdot (50.00011\,\text{mm} \cdot 51.01\,\text{mm})$$

2.7) Nominal Shear Strength Provided by Reinforcement Formula

Evaluate Formula

Formula

$$V_s = V_n - V_c$$

Example with Units

$$100\,\text{MPa} = 190\,\text{MPa} - 90\,\text{MPa}$$

2.8) Stirrup Area given Stirrup Spacing in Practical Design Formula

Evaluate Formula

Formula

$$A_v = (s) \cdot \frac{Vu - \left(2 \cdot \Phi \cdot \sqrt{f_c} \cdot d_{eff} \cdot bw \right)}{\Phi \cdot f_y \cdot d_{eff}}$$

Example with Units

$$2119.7275\,\text{mm}^2 = (50.1\,\text{mm}) \cdot \frac{1275\,\text{kN} - \left(2 \cdot 0.75 \cdot \sqrt{15\,\text{MPa}} \cdot 4\,\text{m} \cdot 300\,\text{mm} \right)}{0.75 \cdot 9.99\,\text{MPa} \cdot 4\,\text{m}}$$

2.9) Stirrup Area given Support Angle Formula

Evaluate Formula

Formula

$$A_v = \frac{Vs}{f_y} \cdot \sin (\alpha)$$

Example with Units

$$10010.01\,\text{mm}^2 = \frac{200\,\text{kN}}{9.99\,\text{MPa}} \cdot \sin (30°)$$

2.10) Stirrup Spacing for Practical Design Formula

Evaluate Formula

Formula

$$s = \frac{A_v \cdot \Phi \cdot fy_{steel} \cdot d_{eff}}{(Vu) - \left((2 \cdot \Phi) \cdot \sqrt{f_c} \cdot bw \cdot d_{eff} \right)}$$

Example with Units

$$295.7346\,\text{mm} = \frac{500\,\text{mm}^2 \cdot 0.75 \cdot 250\,\text{MPa} \cdot 4\,\text{m}}{(1275\,\text{kN}) - \left((2 \cdot 0.75) \cdot \sqrt{15\,\text{MPa}} \cdot 300\,\text{mm} \cdot 4\,\text{m} \right)}$$

2.11) Stirrups area for Inclined Stirrups Formula

Evaluate Formula

Formula

$$A_v = \frac{Vs \cdot s}{(\sin (\alpha) + \cos (\alpha)) \cdot f_y \cdot d_{eff}}$$

Example with Units

$$183.5623\,\text{mm}^2 = \frac{200\,\text{kN} \cdot 50.1\,\text{mm}}{(\sin (30°) + \cos (30°)) \cdot 9.99\,\text{MPa} \cdot 4\,\text{m}}$$

2.12) Ultimate Shear Capacity of Beam Section Formula

Evaluate Formula

Formula

$$V_n = \left(V_c + V_s \right)$$

Example with Units

$$190\,\text{MPa} = \left(90\,\text{MPa} + 100\,\text{MPa} \right)$$

Variables used in list of Design for Beams and Ultimate Strength for Rectangular Beams with Tension Reinforcement Formulas above

- A_s Area of Steel required *(Square Millimeter)*
- A_v Stirrup Area *(Square Millimeter)*
- B_M Bending Moment of Considered Section *(Kilonewton Meter)*
- b_w Width of Beam Web *(Millimeter)*
- **bw** Breadth of Web *(Millimeter)*
- D_b Bar Diameter *(Meter)*
- $D_{centroid}$ Centroidal Distance of Tension Reinforcement *(Millimeter)*
- d_{eff} Effective Depth of Beam *(Meter)*
- f_c 28 Day Compressive Strength of Concrete *(Megapascal)*
- f_y Yield Strength of Reinforcement *(Megapascal)*
- fy_{steel} Yield Strength of Steel *(Megapascal)*
- **j** Constant j
- **Ld** Development Length *(Millimeter)*
- **s** Stirrup Spacing *(Millimeter)*
- $Summation_0$ Perimeter Sum of Tensile Bars *(Meter)*
- **u** Bond Stress on Surface of Bar *(Newton per Square Meter)*
- V_c Nominal Shear Strength of Concrete *(Megapascal)*
- V_n Ultimate Shear Capacity *(Megapascal)*
- V_s Nominal Shear Strength by Reinforcement *(Megapascal)*
- V_u Shear Force in considered Section *(Kilonewton)*
- **Vs** Strength of Shear Reinforcement *(Kilonewton)*
- **Vu** Design of Shear Stress *(Kilonewton)*
- **α** Angle at which Stirrup is inclined *(Degree)*
- $ρ_w$ Reinforcement Ratio of Web Section
- **ΣS** Total Shear Force *(Newton)*

Constants, Functions, Measurements used in list of Design for Beams and Ultimate Strength for Rectangular Beams with Tension Reinforcement Formulas above

- Functions: **cos**, cos(Angle)
  Cosine of an angle is the ratio of the side adjacent to the angle to the hypotenuse of the triangle.
- 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 Meter (m), Millimeter (mm)
  Length Unit Conversion
- Measurement: **Area** in Square Millimeter (mm²)
  Area Unit Conversion
- Measurement: **Pressure** in Newton per Square Meter (N/m²), Megapascal (MPa)
  Pressure Unit Conversion
- Measurement: **Force** in Newton (N), Kilonewton (kN)
  Force Unit Conversion
- Measurement: **Angle** in Degree (°)
  Angle Unit Conversion
- Measurement: **Moment of Force** in Kilonewton Meter (kN*m)
  Moment of Force Unit Conversion
- Measurement: **Stress** in Megapascal (MPa)
  Stress Unit Conversion

- Φ Capacity Reduction Factor

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