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

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

Design for Beams and Ultimate Strength for Rectangular Beams with Tension Reinforcement

Bond and Anchorage for Reinforcing Bars

1) Beam Effective Depth given Bond Stress on Bar Surface

Open Calculator

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

ex $$3.996004\text{m} = \frac{320\text{N}}{0.8 \cdot 10\text{N/m}^2 \cdot 10.01\text{m}}$$

2) Bond Stress on Bar Surface

Open Calculator

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

ex $$9.99001\text{N/m}^2 = \frac{320\text{N}}{0.8 \cdot 4\text{m} \cdot 10.01\text{m}}$$

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

Open Calculator

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

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

4) Total Shear given Bond Stress on Bar Surface

Open Calculator

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

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

Shear Reinforcement

5) 28 Day Concrete Compressive Strength given Development Length for Hooked Bar

Open Calculator

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

$$15.00013\text{MPa} = \left(\frac{1200 \cdot 1.291\text{m}}{400\text{mm}}\right)^2$$

6) Area of Steel Required in Vertical Stirrups

Open Calculator

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

$$0.392864\text{mm}^2 = \frac{100\text{MPa} \cdot 50.1\text{mm}}{250\text{MPa} \cdot 51.01\text{mm}}$$

7) Bar Diameter given Development Length for Hooked Bar

Open Calculator

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

$$1.290994\text{m} = \frac{(400\text{mm}) \cdot \left(\sqrt{15\text{MPa}}\right)}{1200}$$

8) Development Length for Hooked Bar

Open Calculator

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

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

9) Nominal Reinforcement Shear Strength for Stirrup Area with Support Angle

Open Calculator

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

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

10) Nominal Shear Strength of Concrete

Open Calculator

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

ex

$$71.38707\text{MPa} = \left(1.9 \cdot \sqrt{15\text{MPa}} + \left((2500 \cdot 0.08) \cdot \left(\frac{100.1\text{kN} \cdot 51.01\text{mm}}{49.5\text{kN*m}}\right)\right)\right) \cdot (50.00011\text{mm} \cdot 51.01\text{mm})$$

11) Nominal Shear Strength Provided by Reinforcement

Open Calculator

$$V_s = V_n - V_c$$

ex

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

12) Stirrup Area given Stirrup Spacing in Practical Design

Open Calculator

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

ex

$$2119.728\text{mm}^2 = (50.1\text{mm}) \cdot \frac{1275\text{kN} - \left(2 \cdot 0.75 \cdot \sqrt{15\text{MPa}} \cdot 4\text{m} \cdot 300\text{mm}\right)}{0.75 \cdot 9.99\text{MPa} \cdot 4\text{m}}$$

13) Stirrup Area given Support Angle

Open Calculator

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

ex

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

14) Stirrup Spacing for Practical Design

Open Calculator

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

ex

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

15) Stirrups area for Inclined Stirrups

Open Calculator

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

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

16) Ultimate Shear Capacity of Beam Section

Open Calculator

fx $$V_n = (V_c + V_s)$$

ex $$190\text{MPa} = (90\text{MPa} + 100\text{MPa})$$

Variables Used

- 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)*
- **Φ** Capacity Reduction Factor

Constants, Functions, Measurements used

- Function: **cos**, cos(Angle)
  Trigonometric cosine function
- Function: **sin**, sin(Angle)
  Trigonometric sine function
- Function: **sqrt**, sqrt(Number)
  Square root function
- 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

Check other formula lists

- Properties of Basic Material of Concrete Structures Formulas
- Design for Beams and Ultimate Strength for Rectangular Beams with Tension Reinforcement Formulas
- Design of Compression Members Formulas
- Design of Retaining Walls Formulas
- Design of Two Way Slab System and Footing Formulas

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