Important Working Stress Design Formulas PDF

Formulas
Examples
with Units

List of 15
Important Working Stress Design Formulas

1) Working Stress Design of Rectangular Beams with Tension Reinforcement Only Formulas

1.1) Allowable Shear Formulas

1.1.1) Allowable Stress in Stirrup Steel given Area in Legs of Vertical Stirrup Formula

Evaluate Formula

Formula

$$f_v = \frac{V' \cdot s}{A_v \cdot d'}$$

Example with Units

$$34.7228\,\text{MPa} = \frac{3500\,\text{N/m}^2 \cdot 50.1\,\text{mm}}{500\,\text{mm}^2 \cdot 10.1\,\text{mm}}$$

1.1.2) Area Required in Legs of Vertical Stirrup Formula

Evaluate Formula

Formula

$$A_v = \frac{V' \cdot s}{f_v \cdot d'}$$

Example with Units

$$496.0396\,\text{mm}^2 = \frac{3500\,\text{N/m}^2 \cdot 50.1\,\text{mm}}{35\,\text{MPa} \cdot 10.1\,\text{mm}}$$

1.1.3) Distance from Extreme Compression to Centroid given Area in Legs of Vertical Stirrup Formula

Evaluate Formula

Formula

$$d' = \frac{V' \cdot s}{f_v \cdot A_v}$$

Example with Units

$$10.02\,\text{mm} = \frac{3500\,\text{N/m}^2 \cdot 50.1\,\text{mm}}{35\,\text{MPa} \cdot 500\,\text{mm}^2}$$

1.1.4) Distance from Extreme Compression to Centroid given Nominal Unit Shear Stress Formula

Evaluate Formula

Formula

$$d' = \frac{V}{b_{ns} \cdot V_n}$$

Example with Units

$$10\,\text{mm} = \frac{3000\,\text{N}}{15\,\text{mm} \cdot 20\,\text{N/mm}^2}$$

1.1.5) Excess Shear given Area in Legs of Vertical Stirrup Formula

Evaluate Formula

Formula

$$V' = \frac{A_v \cdot f_v \cdot d'}{s}$$

Example with Units

$$3527.9441\,\text{N/m}^2 = \frac{500\,\text{mm}^2 \cdot 35\,\text{MPa} \cdot 10.1\,\text{mm}}{50.1\,\text{mm}}$$

1.1.6) Excess Shear given Stirrup Leg Area for Group of Bars Bent up Different Distances Formula

Evaluate Formula

Formula

$$V'_{LAB} = \frac{A_v \cdot f_v \cdot d' \cdot (\sin(\alpha) + \cos(\alpha))}{s}$$

Example with Units

$$4819.2613\,\text{N/m}^2 = \frac{500\,\text{mm}^2 \cdot 35\,\text{MPa} \cdot 10.1\,\text{mm} \cdot (\sin(30°) + \cos(30°))}{50.1\,\text{mm}}$$

1.1.7) Excess Shear given Vertical Stirrup Leg Area for Single Bar Bent at Angle a Formula

Evaluate Formula

Formula

$$V'_{vsl} = A_v \cdot f_v \cdot \sin(\alpha)$$

Example with Units

$$8750\,\text{N/m}^2 = 500\,\text{mm}^2 \cdot 35\,\text{MPa} \cdot \sin(30°)$$

1.1.8) Nominal Unit Shear Stress Formula

Evaluate Formula

Formula

$$V_n = \frac{V}{b_{ns} \cdot d'}$$

Example with Units

$$19.802\,\text{N/mm}^2 = \frac{3000\,\text{N}}{15\,\text{mm} \cdot 10.1\,\text{mm}}$$

1.1.9) Shear given Nominal Unit Shear Stress Formula

Evaluate Formula

Formula

$$V = b_{ns} \cdot d' \cdot V_n$$

Example with Units

$$3030\,\text{N} = 15\,\text{mm} \cdot 10.1\,\text{mm} \cdot 20\,\text{N/mm}^2$$

1.1.10) Stirrups Spacing given Stirrup Leg Area for Group of Bars Bent up Different Distances Formula

Evaluate Formula

Formula

$$s = \frac{A_v \cdot f_v \cdot d' \cdot (\sin(\alpha) + \cos(\alpha))}{V'_{LAB}}$$

Example with Units

$$50.4587\,\text{mm} = \frac{500\,\text{mm}^2 \cdot 35\,\text{MPa} \cdot 10.1\,\text{mm} \cdot (\sin(30°) + \cos(30°))}{4785\,\text{N/m}^2}$$

1.1.11) Stirrups Spacing using Area in Legs of Vertical Stirrup Formula

Evaluate Formula

Formula

$$s = \frac{A_v \cdot f_v \cdot d'}{V'}$$

Example with Units

$$50.5\,\text{mm} = \frac{500\,\text{mm}^2 \cdot 35\,\text{MPa} \cdot 10.1\,\text{mm}}{3500\,\text{N/m}^2}$$

1.1.12) Vertical Stirrup Leg Area when Group of Bars is Bent at Different Distances Formula

Evaluate Formula

Formula

$$A_v = \frac{V'_{LAB} \cdot s}{f_v \cdot d' \cdot (\cos(\alpha) + \sin(\alpha))}$$

Example with Units

$$496.4454\,\text{mm}^2 = \frac{4785\,\text{N/m}^2 \cdot 50.1\,\text{mm}}{35\,\text{MPa} \cdot 10.1\,\text{mm} \cdot (\cos(30°) + \sin(30°))}$$

1.1.13) Vertical Stirrup Leg Area when Single Bar is Bent at Angle a Formula

Evaluate Formula

Formula

$$A_v = \frac{V'_{vsl}}{f_v \cdot \sin(\alpha)}$$

Example with Units

$$500\,\text{mm}^2 = \frac{8750\,\text{N/m}^2}{35\,\text{MPa} \cdot \sin(30°)}$$

2) Working Stress Design for Torsion Formulas

2.1) Maximum Torsion due to Service Load for Torsion Effects Formula

Evaluate Formula

Formula

$$T = 0.55 \cdot \left(0.5 \cdot f'_c \cdot \Sigma x^2 y\right)$$

Example with Units

$$276.375\,\text{MPa} = 0.55 \cdot (0.5 \cdot 50\,\text{MPa} \cdot 20.1)$$

2.2) Spacing of Closed Stirrups for Torsion under Working Stress Design Formula

Evaluate Formula

Formula

$$s = \frac{3 \cdot A_t \cdot \alpha_t \cdot x_1 \cdot y_1 \cdot f_v}{\tau_{torsional} - T_u} \cdot \Sigma x^2 y$$

Example with Units

$$46.1672\,\text{mm} = \frac{3 \cdot 100.00011\,\text{mm}^2 \cdot 3.5 \cdot 250\,\text{mm} \cdot 500.0001\,\text{mm} \cdot 35\,\text{MPa}}{12\,\text{MPa} - 10\,\text{MPa}} \cdot 20.1$$

Variables used in list of Working Stress Design Formulas above

- A_t Area of One Leg of Closed Stirrup *(Square Millimeter)*
- A_v Stirrup Area *(Square Millimeter)*
- b_{ns} Beam Width for Nominal Shear *(Millimeter)*
- **d'** Compression to Centroid Reinforcement Distance *(Millimeter)*
- f'_c Specified 28-Day Compressive Strength of Concrete *(Megapascal)*
- f_v Allowable Stress in Stirrup Steel *(Megapascal)*
- **s** Stirrup Spacing *(Millimeter)*
- **T** Maximum Torsion *(Megapascal)*
- T_u Maximum Allowable Torsion *(Megapascal)*
- **V** Total Shear *(Newton)*
- **V'** Excess Shear *(Newton per Square Meter)*
- V'_{LAB} Excess Shear given Stirrup Leg Area for Bars Bent *(Newton per Square Meter)*
- V_n Nominal Shear Stress *(Newton per Square Millimeter)*
- V'_{vsl} Excess Shear given Vertical Stirrup Leg Area *(Newton per Square Meter)*
- x_1 Shorter Dimension Legs of Closed Stirrup *(Millimeter)*
- y_1 Longer Dimension Legs of Closed Stirrup *(Millimeter)*
- α Angle at which Stirrup is Inclined *(Degree)*
- α_t Coefficient
- $\Sigma x^2 y$ Sum for Component Rectangles of Section
- $\tau_{torsional}$ Torsional Stress *(Megapascal)*

Constants, Functions, Measurements used in list of Working Stress Design 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.
- Measurement: **Length** in Millimeter (mm)
  Length Unit Conversion
- Measurement: **Area** in Square Millimeter (mm²)
  Area Unit Conversion
- Measurement: **Pressure** in Megapascal (MPa), Newton per Square Meter (N/m²), Newton per Square Millimeter (N/mm²)
  Pressure Unit Conversion
- Measurement: **Force** in Newton (N)
  Force Unit Conversion
- Measurement: **Angle** in Degree (°)
  Angle Unit Conversion
- Measurement: **Stress** in Megapascal (MPa)
  Stress Unit Conversion

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