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Analysis using Limit State Method Formulas

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List of 11 Analysis using Limit State Method Formulas

Analysis using Limit State Method

Doubly Reinforced Rectangular Sections

1) Bending Moment Capacity of Rectangular Beam

Open Calculator

$$B_M = 0.90 \cdot \left((A_{steel\ required} - A_{s'}) \cdot fy_{steel} \cdot \left(D_{centroid} - \left(\frac{a}{2} \right) \right) + (A_{s'} \cdot fy_{steel} \cdot (D_{centroid} - d')) \right)$$

ex

$$160.7422kN*m = 0.90 \cdot \left((35mm^2 - 20mm^2) \cdot 250MPa \cdot \left(51.01mm - \left(\frac{9.432mm}{2} \right) \right) + (20mm^2 \cdot 250MPa \cdot \right.$$

2) Depth of Equivalent Rectangular Compressive Stress Distribution

Open Calculator

$$a = \frac{(A_{steel\ required} - A_{s'}) \cdot fy_{steel}}{f_c \cdot b}$$

ex

$$9.433962mm = \frac{(35mm^2 - 20mm^2) \cdot 250MPa}{15MPa \cdot 26.5mm}$$

Flanged Sections

3) Depth when Neutral Axis is in Flange

Open Calculator

$$d_{eff} = K_d \cdot \frac{\beta 1}{1.18 \cdot \omega}$$

ex

$$3.39661m = 100.2mm \cdot \frac{2.4}{1.18 \cdot 0.06}$$

4) Distance when Neutral Axis Lies in Flange

Open Calculator

$$K_d = \frac{1.18 \cdot \omega \cdot d_{eff}}{\beta 1}$$

ex

$$118mm = \frac{1.18 \cdot 0.06 \cdot 4m}{2.4}$$

5) Maximum Ultimate Moment when Neutral Axis Lies in Web

Open Calculator

$$M_u = 0.9 \cdot \left((A - A_{st}) \cdot fy_{steel} \cdot \left(d_{eff} - \frac{D_{equivalent}}{2} \right) + A_{st} \cdot fy_{steel} \cdot \left(d_{eff} - \frac{t_f}{2} \right) \right)$$

ex $9E\hat{}9N*m = 0.9 \cdot \left((10m^2 - 0.4m^2) \cdot 250MPa \cdot \left(4m - \frac{25mm}{2} \right) + 0.4m^2 \cdot 250MPa \cdot \left(4m - \frac{99.5mm}{2} \right) \right)$

6) Value of Omega if Neutral Axis is in Flange

Open Calculator

$$\omega = K_d \cdot \frac{\beta 1}{1.18 \cdot d_{eff}}$$

ex $0.050949 = 100.2mm \cdot \frac{2.4}{1.18 \cdot 4m}$

Serviceability Limit States- Deflection and Cracking

Crack Control of Flexural Members

7) Equation for Crack Control Specific Limits

Open Calculator

$$z = f_s \cdot (d_c \cdot A)^{\frac{1}{3}}$$

ex $9043.907lb*f/in = 3.56kN/m^2 \cdot (1000.3in \cdot 1000.2in^2)^{\frac{1}{3}}$

8) Stress Calculated in Crack Control

Open Calculator

$$f_s = \frac{z}{(d_c \cdot A)^1}/3$$

ex $3.204466kN/m^2 = \frac{900lb*f/in}{(1000.3in \cdot 1000.2in^2)^1}/3$

Singly Reinforced Rectangular Sections

9) Bending Moment Capacity of Ultimate Strength given Area of Tension Reinforcement

Open Calculator

$$B_M = 0.90 \cdot \left(A_{steel\ required} \cdot fy_{steel} \cdot \left(D_{centroid} - \left(\frac{a}{2} \right) \right) \right)$$

ex $364.5652kN*m = 0.90 \cdot \left(35mm^2 \cdot 250MPa \cdot \left(51.01mm - \left(\frac{9.432mm}{2} \right) \right) \right)$

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10) Bending Moment Capacity of Ultimate Strength given Beam Width

Open Calculator

$$B_M = 0.90 \cdot \left(A_{\text{steel required}} \cdot fy_{\text{steel}} \cdot D_{\text{centroid}} \cdot \left(1 + \left(0.59 \cdot \frac{(\rho_T \cdot fy_{\text{steel}})}{f_c} \right) \right) \right)$$

$$51.35782\text{kN*m} = 0.90 \cdot \left(35\text{mm}^2 \cdot 250\text{MPa} \cdot 51.01\text{mm} \cdot \left(1 + \left(0.59 \cdot \frac{(12.9 \cdot 250\text{MPa})}{15\text{MPa}} \right) \right) \right)$$

11) Distance from Extreme Compression Surface to Neutral Axis in Compression Failure

Open Calculator

$$c = \frac{0.003 \cdot d_{\text{eff}}}{\left(\frac{f_{TS}}{E_s} \right) + 0.003}$$

$$157.4785\text{in} = \frac{0.003 \cdot 4\text{m}}{\left(\frac{24\text{kgf/m}^2}{1000\text{ksi}} \right) + 0.003}$$

Variables Used

- **a** Depth of Rectangular Stress Distribution *(Millimeter)*
- **A** Area of Tension Reinforcement *(Square Meter)*
- **A** Effective Tension Area of Concrete *(Square Inch)*
- $A_{s'}$ Area of Compression Reinforcement *(Square Millimeter)*
- A_{st} Tensile Steel Area for Strength *(Square Meter)*
- $A_{steel\ required}$ Area of Steel Required *(Square Millimeter)*
- **b** Beam Width *(Millimeter)*
- B_M Bending Moment of Considered Section *(Kilonewton Meter)*
- **c** Neutral Axis Depth *(Inch)*
- **d'** Effective Cover *(Millimeter)*
- d_c Thickness of Concrete Cover *(Inch)*
- $D_{centroid}$ Centroidal Distance of Tension Reinforcement *(Millimeter)*
- d_{eff} Effective Depth of Beam *(Meter)*
- $D_{equivalent}$ Equivalent Depth *(Millimeter)*
- E_s Modulus of Elasticity of Steel *(Kilopound Per Square Inch)*
- f_c 28 Day Compressive Strength of Concrete *(Megapascal)*
- f_s Stress in Reinforcement *(Kilonewton per Square Meter)*
- f_{TS} Tensile Stress in Steel *(Kilogram-Force per Square Meter)*
- fy_{steel} Yield Strength of Steel *(Megapascal)*
- K_d Distance from Compression Fiber to NA *(Millimeter)*
- M_u Maximum Ultimate Moment *(Newton Meter)*
- t_f Flange Thickness *(Millimeter)*
- **z** Crack Control Limits *(Pound-Force per Inch)*
- **β1** Constant β1
- ρ_T Tension Reinforcement Ratio
- **ω** Value of Omega

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Constants, Functions, Measurements used

- Measurement: **Length** in Millimeter (mm), Meter (m), Inch (in)
  Length Unit Conversion
- Measurement: **Area** in Square Millimeter (mm²), Square Meter (m²), Square Inch (in²)
  Area Unit Conversion
- Measurement: **Pressure** in Kilonewton per Square Meter (kN/m²), Kilogram-Force per Square Meter (kgf/m²), Kilopound Per Square Inch (ksi)
  Pressure Unit Conversion
- Measurement: **Surface Tension** in Pound-Force per Inch (lb*f/in)
  Surface Tension Unit Conversion
- Measurement: **Moment of Force** in Kilonewton Meter (kN*m), Newton Meter (N*m)
  Moment of Force Unit Conversion
- Measurement: **Stress** in Megapascal (MPa)
  Stress Unit Conversion

Check other formula lists

- **Analysis using Limit State Method Formulas**
- **Design of Beam and Slab Formulas**

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