Important Design of Beam and Slab Formulas PDF

Formulas
Examples
with Units

List of 27
Important Design of Beam and Slab Formulas

1) Curtailment of Flexural Tension Reinforcement Formulas

1.1) Development Length Requirements Formulas

1.1.1) Applied Shear at Section for Development Length of Simple Support Formula

Evaluate Formula

Formula

$$V_u = \frac{M_n}{Ld - La}$$

Example with Units

$$33.4\,\text{N/mm}^2 = \frac{10.02\,\text{MPa}}{400\,\text{mm} - 100\,\text{mm}}$$

1.1.2) Bar Steel Yield Strength given Basic Development Length Formula

Evaluate Formula

Formula

$$fy_{steel} = \frac{Ld \cdot \sqrt{f_c}}{0.04 \cdot A_b}$$

Example with Units

$$249.8699\,\text{MPa} = \frac{400\,\text{mm} \cdot \sqrt{15\,\text{MPa}}}{0.04 \cdot 155\,\text{mm}^2}$$

1.1.3) Basic Development Length for 14mm Diameter Bars Formula

Evaluate Formula

Formula

$$Ld = \frac{0.085 \cdot fy_{steel}}{\sqrt{f_c}}$$

Example with Units

$$5.4867\,\text{mm} = \frac{0.085 \cdot 250\,\text{MPa}}{\sqrt{15\,\text{MPa}}}$$

1.1.4) Basic Development Length for 18mm Diameter Bars Formula

Evaluate Formula

Formula

$$Ld = \frac{0.125 \cdot fy_{steel}}{\sqrt{f_c}}$$

Example with Units

$$8.0687\,\text{mm} = \frac{0.125 \cdot 250\,\text{MPa}}{\sqrt{15\,\text{MPa}}}$$

1.1.5) Basic Development Length for Bars and Wire in Tension Formula

Evaluate Formula

Formula

$$Ld = \frac{0.04 \cdot A_b \cdot fy_{steel}}{\sqrt{f_c}}$$

Example with Units

$$400.2083\,\text{mm} = \frac{0.04 \cdot 155\,\text{mm}^2 \cdot 250\,\text{MPa}}{\sqrt{15\,\text{MPa}}}$$

1.1.6) Computed Flexural Strength given Development Length for Simple Support Formula

Evaluate Formula

Formula

$$M_n = \left(V_u \right) \cdot \left(Ld - La \right)$$

Example with Units

$$10.02\,\text{MPa} = \left(33.4\,\text{N/mm}^2 \right) \cdot \left(400\,\text{mm} - 100\,\text{mm} \right)$$

1.1.7) Development Length for simple Support Formula

Evaluate Formula

Formula

$$Ld = \left(\frac{M_n}{V_u} \right) + \left(La \right)$$

Example with Units

$$100.3\,\text{mm} = \left(\frac{10.02\,\text{MPa}}{33.4\,\text{N/mm}^2} \right) + \left(100\,\text{mm} \right)$$

2) Design of Continuous One-Way Slabs Formulas

2.1) Use of Moment Coefficients Formulas

2.1.1) Negative Moment at Exterior Face of First Interior Support for More than Two Spans Formula

Evaluate Formula

Formula

$$M_t = \frac{W_{load} \cdot I_n^{\,2}}{10}$$

Example with Units

$$36.072\,\text{N*m} = \frac{3.6\,\text{kN} \cdot 10.01\,\text{m}^{\,2}}{10}$$

2.1.2) Negative Moment at Exterior Face of First Interior Support for Two Spans Formula

Evaluate Formula

Formula

$$M_t = \frac{W_{load} \cdot I_n^{\,2}}{9}$$

Example with Units

$$40.08\,\text{N*m} = \frac{3.6\,\text{kN} \cdot 10.01\,\text{m}^{\,2}}{9}$$

2.1.3) Negative Moment at Interior Faces of Exterior Support where Support is Column Formula

Evaluate Formula

Formula

$$M_t = \frac{W_{load} \cdot I_n^{\,2}}{12}$$

Example with Units

$$30.06\,\text{N*m} = \frac{3.6\,\text{kN} \cdot 10.01\,\text{m}^{\,2}}{12}$$

2.1.4) Negative Moment at Interior Faces of Exterior Supports where Support is Spandrel Beam Formula

Evaluate Formula

Formula

$$M_t = \frac{W_{load} \cdot I_n^{\,2}}{24}$$

Example with Units

$$15.03\,\text{N*m} = \frac{3.6\,\text{kN} \cdot 10.01\,\text{m}^{\,2}}{24}$$

2.1.5) Negative Moment at Other Faces of Interior Supports Formula

Evaluate Formula

Formula

$$M_t = \frac{W_{load} \cdot I_n^{\ 2}}{11}$$

Example with Units

$$32.7928\,\text{N*m} = \frac{3.6\,\text{kN} \cdot 10.01\,\text{m}^{\ 2}}{11}$$

2.1.6) Positive Moment for End Spans if Discontinuous End is Integral with Support Formula

Evaluate Formula

Formula

$$M_t = \frac{W_{load} \cdot I_n^{\ 2}}{14}$$

Example with Units

$$25.7657\,\text{N*m} = \frac{3.6\,\text{kN} \cdot 10.01\,\text{m}^{\ 2}}{14}$$

2.1.7) Positive Moment for End Spans if Discontinuous End is Unrestrained Formula

Evaluate Formula

Formula

$$M_t = \frac{W_{load} \cdot I_n^{\ 2}}{11}$$

Example with Units

$$32.7928\,\text{N*m} = \frac{3.6\,\text{kN} \cdot 10.01\,\text{m}^{\ 2}}{11}$$

2.1.8) Positive Moment for Interior Spans Formula

Evaluate Formula

Formula

$$M_t = \frac{W_{load} \cdot I_n^{\ 2}}{16}$$

Example with Units

$$22.545\,\text{N*m} = \frac{3.6\,\text{kN} \cdot 10.01\,\text{m}^{\ 2}}{16}$$

2.1.9) Shear Force at All Other Supports Formula

Evaluate Formula

Formula

$$M_t = \frac{W_{load} \cdot I_n^{\ 2}}{2}$$

Example with Units

$$180.3602\,\text{N*m} = \frac{3.6\,\text{kN} \cdot 10.01\,\text{m}^{\ 2}}{2}$$

2.1.10) Shear Force in End Members at First Interior Support Formula

Evaluate Formula

Formula

$$M_t = 1.15 \cdot \frac{W_{load} \cdot I_n^{\ 2}}{2}$$

Example with Units

$$207.4142\,\text{N*m} = 1.15 \cdot \frac{3.6\,\text{kN} \cdot 10.01\,\text{m}^{\ 2}}{2}$$

3) Doubly Reinforced Rectangular Sections Formulas

3.1) Bending Moment given Total Cross-Sectional Area of Tensile Reinforcing Formula

Evaluate Formula

Formula

$$Mb_R = A_{cs} \cdot 7 \cdot f_s \cdot \frac{D_B}{8}$$

Example with Units

$$52.2112\,\text{N*m} = 13\,\text{m}^2 \cdot 7 \cdot 1.7\,\text{Pa} \cdot \frac{2.7\,\text{m}}{8}$$

3.2) Cross-Sectional Area of Compressive Reinforcing Formula

Evaluate Formula

Formula

$$A_{s'} = \frac{B_M - M'}{m \cdot f_{EC} \cdot d_{eff}}$$

Example with Units

$$20.6126\,\text{mm}^2 = \frac{49.5\,\text{kN*m} - 16.5\,\text{kN*m}}{8 \cdot 50.03\,\text{MPa} \cdot 4\,\text{m}}$$

3.3) Total Cross-Sectional Area of Tensile Reinforcing Formula

Evaluate Formula

Formula

$$A_{cs} = 8 \cdot \frac{Mb_R}{7 \cdot f_s \cdot D_B}$$

Example with Units

$$13.1964\,\text{m}^2 = 8 \cdot \frac{53\,\text{N*m}}{7 \cdot 1.7\,\text{Pa} \cdot 2.7\,\text{m}}$$

4) Singly Reinforced Rectangular Sections Formulas

4.1) Area of Tension Reinforcement given Steel Ratio Formula

Evaluate Formula

Formula

$$A = \left(\rho_{\text{steel ratio}} \cdot b \cdot d'\right)$$

Example with Units

$$7.58\,\text{m}^2 = \left(37.9 \cdot 26.5\,\text{mm} \cdot 7547.15\,\text{mm}\right)$$

4.2) Beam Width given Steel Ratio Formula

Evaluate Formula

Formula

$$b = \frac{A}{d' \cdot \rho_{\text{steel ratio}}}$$

Example with Units

$$34.9605\,\text{mm} = \frac{10\,\text{m}^2}{7547.15\,\text{mm} \cdot 37.9}$$

4.3) Distance from Extreme Compression to Centroid given Steel Ratio Formula

Evaluate Formula

Formula

$$d' = \frac{A}{b \cdot \rho_{\text{steel ratio}}}$$

Example with Units

$$9956.6884\,\text{mm} = \frac{10\,\text{m}^2}{26.5\,\text{mm} \cdot 37.9}$$

4.4) Lever Arm Depth Factor Formula

Evaluate Formula

Formula

$$j = 1 - \left(\frac{k}{3}\right)$$

Example

$$0.7967 = 1 - \left(\frac{0.61}{3}\right)$$

4.5) Modular Ratio Formula

Evaluate Formula

Formula

$$m = \frac{E_s}{E_c}$$

Example with Units

$$43915.6515 = \frac{1000\,\text{ksi}}{0.157\,\text{MPa}}$$

4.6) Steel Ratio Formula

Evaluate Formula

Formula

$$\rho_{steel\ ratio} = \frac{A}{b \cdot d'}$$

Example with Units

$$50.0001 = \frac{10\,\mathrm{m^2}}{26.5\,\mathrm{mm} \cdot 7547.15\,\mathrm{mm}}$$

4.7) Stress in Steel with Tension Reinforcement only Formula

Evaluate Formula

Formula

$$f_{TS} = \frac{m \cdot f_{comp\ stress} \cdot (1 - k)}{k}$$

Example with Units

$$255.7377\,\mathrm{kgf/m^2} = \frac{8 \cdot 50\,\mathrm{kgf/m^2} \cdot (1 - 0.61)}{0.61}$$

Variables used in list of Design of Beam and Slab Formulas above

- **A** Area of Tension Reinforcement *(Square Meter)*
- **A_b** Area of Bar *(Square Millimeter)*
- **A_{cs}** Cross-Sectional Area *(Square Meter)*
- **$A_{s'}$** Area of Compression Reinforcement *(Square Millimeter)*
- **b** Beam Width *(Millimeter)*
- **B_M** Bending Moment of Considered Section *(Kilonewton Meter)*
- **d'** Distance from Compression to Centroid Reinforcment *(Millimeter)*
- **D_B** Depth of Beam *(Meter)*
- **d_{eff}** Effective Depth of Beam *(Meter)*
- **E_c** Modulus of Elasticity of Concrete *(Megapascal)*
- **E_s** Modulus of Elasticity of Steel *(Kilopound Per Square Inch)*
- **f_c** 28 Day Compressive Strength of Concrete *(Megapascal)*
- **$f_{comp\ stress}$** Compressive Stress at Extreme Concrete Surface *(Kilogram-Force per Square Meter)*
- **f_{EC}** Extreme Compressive Stress of Concrete *(Megapascal)*
- **f_s** Reinforcement Stress *(Pascal)*
- **f_{TS}** Tensile Stress in Steel *(Kilogram-Force per Square Meter)*
- **fy_{steel}** Yield Strength of Steel *(Megapascal)*
- **l_n** Length of Span *(Meter)*
- **j** Constant j
- **k** Ratio of Depth
- **La** Additional Embedment Length *(Millimeter)*
- **Ld** Development Length *(Millimeter)*
- **m** Modular Ratio
- **M'** Bending Moment of Singly reinforced Beam *(Kilonewton Meter)*

Constants, Functions, Measurements used in list of Design of Beam and Slab Formulas above

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

- M_n Computed Flexural Strength *(Megapascal)*
- M_t Moment in Structures *(Newton Meter)*
- Mb_R Bending Moment *(Newton Meter)*
- V_u Applied Shear at Section *(Newton per Square Millimeter)*
- W_{load} Vertical Load *(Kilonewton)*
- $\rho_{steel\ ratio}$ Steel Ratio

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7/8/2024 | 11:17:22 AM UTC