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Design of Beam and Slab Formulas

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List of 27 Design of Beam and Slab Formulas

Design of Beam and Slab

Curtailment of Flexural Tension Reinforcement

Development Length Requirements

1) Applied Shear at Section for Development Length of Simple Support

$$fx \quad V_u = \frac{M_n}{L_d - L_a}$$

Open Calculator 

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

2) Bar Steel Yield Strength given Basic Development Length

$$fx \quad f_y = \frac{L_d \cdot \sqrt{f_c}}{0.04 \cdot A_b}$$

Open Calculator 

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



3) Basic Development Length for 14mm Diameter Bars

$$\text{fx } L_d = \frac{0.085 \cdot f_y}{\sqrt{f_c}}$$

[Open Calculator !\[\]\(cbe80b694ebd74fcfe136a095b608235_img.jpg\)](#)

$$\text{ex } 5.486726\text{mm} = \frac{0.085 \cdot 250\text{MPa}}{\sqrt{15\text{MPa}}}$$

4) Basic Development Length for 18mm Diameter Bars

$$\text{fx } L_d = \frac{0.125 \cdot f_y}{\sqrt{f_c}}$$

[Open Calculator !\[\]\(3e2231b1ad3ca8da8658228c00dd08e0_img.jpg\)](#)

$$\text{ex } 8.068715\text{mm} = \frac{0.125 \cdot 250\text{MPa}}{\sqrt{15\text{MPa}}}$$

5) Basic Development Length for Bars and Wire in Tension

$$\text{fx } L_d = \frac{0.04 \cdot A_b \cdot f_y}{\sqrt{f_c}}$$

[Open Calculator !\[\]\(0d5ec72f61334709c3fc9450209b754f_img.jpg\)](#)

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

6) Computed Flexural Strength given Development Length for Simple Support

$$\text{fx } M_n = (V_u) \cdot (L_d - L_a)$$

[Open Calculator !\[\]\(b64b40baaee5acddc1eab8538ba84754_img.jpg\)](#)

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



7) Development Length for simple Support

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

[Open Calculator !\[\]\(e78f798d4ea5c530c9db49e7d26e6b95_img.jpg\)](#)

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

Design of Continuous One-Way Slabs

Use of Moment Coefficients

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

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

[Open Calculator !\[\]\(dd161862f9164df98f62b726e9846241_img.jpg\)](#)

$$ex \quad 36.07204N*m = \frac{3.6kN \cdot (10.01m)^2}{10}$$

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

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

[Open Calculator !\[\]\(a8f9309f944226d1420f5fed22e2b6e6_img.jpg\)](#)

$$ex \quad 40.08004N*m = \frac{3.6kN \cdot (10.01m)^2}{9}$$



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

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

[Open Calculator !\[\]\(e2376d476d06eb31946dc01a69a4403a_img.jpg\)](#)

$$\text{ex } 30.06003\text{N}\cdot\text{m} = \frac{3.6\text{kN} \cdot (10.01\text{m})^2}{12}$$

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

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

[Open Calculator !\[\]\(0b5e7e25e8775f7e7e80906ada4f0021_img.jpg\)](#)

$$\text{ex } 15.03001\text{N}\cdot\text{m} = \frac{3.6\text{kN} \cdot (10.01\text{m})^2}{24}$$

12) Negative Moment at Other Faces of Interior Supports

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

[Open Calculator !\[\]\(bd3b31712ad9bab5a241210fa6925cdd_img.jpg\)](#)

$$\text{ex } 32.79276\text{N}\cdot\text{m} = \frac{3.6\text{kN} \cdot (10.01\text{m})^2}{11}$$



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

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

[Open Calculator !\[\]\(d3fb9f94af8b26d1c844efa9a98805b0_img.jpg\)](#)

$$\text{ex } 25.76574\text{N}\cdot\text{m} = \frac{3.6\text{kN} \cdot (10.01\text{m})^2}{14}$$

14) Positive Moment for End Spans if Discontinuous End is Unrestrained

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

[Open Calculator !\[\]\(e1d6102fe77919492c04879c8450f1f5_img.jpg\)](#)

$$\text{ex } 32.79276\text{N}\cdot\text{m} = \frac{3.6\text{kN} \cdot (10.01\text{m})^2}{11}$$

15) Positive Moment for Interior Spans

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

[Open Calculator !\[\]\(ab4e2b3fc7e7887b7a72f548aa6f5e60_img.jpg\)](#)

$$\text{ex } 22.54502\text{N}\cdot\text{m} = \frac{3.6\text{kN} \cdot (10.01\text{m})^2}{16}$$



16) Shear Force at All Other Supports

[Open Calculator !\[\]\(feabb98897b440bc8695a03336a6e2df_img.jpg\)](#)

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

$$\text{ex } 180.3602\text{N}\cdot\text{m} = \frac{3.6\text{kN} \cdot (10.01\text{m})^2}{2}$$

17) Shear Force in End Members at First Interior Support

[Open Calculator !\[\]\(642aa997563f9a325b310230bb5078b7_img.jpg\)](#)

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

$$\text{ex } 207.4142\text{N}\cdot\text{m} = 1.15 \cdot \frac{3.6\text{kN} \cdot (10.01\text{m})^2}{2}$$

Doubly Reinforced Rectangular Sections

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

[Open Calculator !\[\]\(c444627dab9fee9a1550c053ffaaaae2_img.jpg\)](#)

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

$$\text{ex } 52.21125\text{N}\cdot\text{m} = 13\text{m}^2 \cdot 7 \cdot 1.7\text{Pa} \cdot \frac{2.7\text{m}}{8}$$



19) Cross-Sectional Area of Compressive Reinforcing

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

[Open Calculator !\[\]\(6605b201d6f14d9b3bcb8ab5f274d107_img.jpg\)](#)

$$\text{ex } 20.61263\text{mm}^2 = \frac{49.5\text{kN}\cdot\text{m} - 16.5\text{kN}\cdot\text{m}}{8 \cdot 50.03\text{MPa} \cdot 4\text{m}}$$

20) Total Cross-Sectional Area of Tensile Reinforcing

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

[Open Calculator !\[\]\(e8fb589d58dad1692debababa5e928b6_img.jpg\)](#)

$$\text{ex } 13.19639\text{m}^2 = 8 \cdot \frac{53\text{N}\cdot\text{m}}{7 \cdot 1.7\text{Pa} \cdot 2.7\text{m}}$$

Singly Reinforced Rectangular Sections

21) Area of Tension Reinforcement given Steel Ratio

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

[Open Calculator !\[\]\(e9474ce1d70442456f8fe9c393ea149c_img.jpg\)](#)

$$\text{ex } 7.57998\text{m}^2 = (37.9 \cdot 26.5\text{mm} \cdot 7547.15\text{mm})$$

22) Beam Width given Steel Ratio

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

[Open Calculator !\[\]\(9db214d549b9aeebe72aa11d3a5c4b1a_img.jpg\)](#)

$$\text{ex } 34.96051\text{mm} = \frac{10\text{m}^2}{7547.15\text{mm} \cdot 37.9}$$



23) Distance from Extreme Compression to Centroid given Steel Ratio 

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

Open Calculator 

$$ex \quad 9956.688\text{mm} = \frac{10\text{m}^2}{26.5\text{mm} \cdot 37.9}$$

24) Lever Arm Depth Factor 

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

Open Calculator 

$$ex \quad 0.796667 = 1 - \left(\frac{0.61}{3} \right)$$

25) Modular Ratio 

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

Open Calculator 

$$ex \quad 43915.65 = \frac{1000\text{ksi}}{0.157\text{MPa}}$$


26) Steel Ratio 

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

Open Calculator 

$$ex \quad 50.00013 = \frac{10\text{m}^2}{26.5\text{mm} \cdot 7547.15\text{mm}}$$



27) Stress in Steel with Tension Reinforcement only [Open Calculator](#) 

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

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



Variables Used








- **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 Reinforcement (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)
- **f_y** Yield Strength of Steel (Megapascal)
- **l_n** Length of Span (Meter)
- **j** Constant j
- **k** Ratio of Depth
- **La** Additional Embedment Length (Millimeter)



- **L_d** Development Length (Millimeter)
- **m** Modular Ratio
- **M'** Bending Moment of Singly reinforced Beam (Kilonewton Meter)
- **M_n** Computed Flexural Strength (Megapascal)
- **M_t** Moment in Structures (Newton Meter)
- **M_{bR}** Bending Moment (Newton Meter)
- **V_u** Applied Shear at Section (Newton per Square Millimeter)
- **W_{load}** Vertical Load (Kilonewton)
- **ρ_{steel ratio}** Steel Ratio



Constants, Functions, Measurements used

- **Function:** **sqrt**, sqrt(Number)
Square root function
- **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 



Check other formula lists

- [Analysis Using Limit State Method Formulas](#) 
- [Design of Beam and Slab Formulas](#) 

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