Important Crack Width and Deflection of Prestress Concrete Members Formulas PDF

Formulas
Examples
with Units

List of 40
Important Crack Width and Deflection of Prestress Concrete Members Formulas

1) Calculation of Crack Width Formulas

1.1) Average Strain at Selected Level given Crack Width Formula

Evaluate Formula

Formula

$$\varepsilon_m = \frac{W_{cr} \cdot \left(1 + \left(2 \cdot \frac{acr - C_{min}}{h - x}\right)\right)}{3 \cdot acr}$$

Example with Units

$$0.0005 = \frac{0.49\,\text{mm} \cdot \left(1 + \left(2 \cdot \frac{2.51\,\text{cm} - 9.48\,\text{cm}}{20.1\,\text{cm} - 50\,\text{mm}}\right)\right)}{3 \cdot 2.51\,\text{cm}}$$

1.2) Center to Center Spacing given Shortest Distance Formula

Evaluate Formula

Formula

$$s = 2 \cdot \sqrt{\left(acr + \left(\frac{D}{2}\right)\right)^2 - \left(d'^2\right)}$$

Example with Units

$$54.1032\,\text{cm} = 2 \cdot \sqrt{\left(2.51\,\text{cm} + \left(\frac{0.5\,\text{m}}{2}\right)\right)^2 - \left(50.01\,\text{mm}^2\right)}$$

1.3) Crack Width on Surface of Section Formula

Evaluate Formula

Formula

$$W_{cr} = \frac{3 \cdot acr \cdot \varepsilon_m}{1 + \left(2 \cdot \frac{acr - C_{min}}{h - x}\right)}$$

Example with Units

$$0.4901\,\text{mm} = \frac{3 \cdot 2.51\,\text{cm} \cdot 0.0005}{1 + \left(2 \cdot \frac{2.51\,\text{cm} - 9.48\,\text{cm}}{20.1\,\text{cm} - 50\,\text{mm}}\right)}$$

1.4) Depth of Neutral Axis given Crack Width Formula

Evaluate Formula

Formula

$$x = h - \left(2 \cdot \frac{acr - C_{min}}{3 \cdot acr \cdot \varepsilon} - 1\right)$$

Example with Units

$$3052.0765\,\text{mm} = 20.1\,\text{cm} - \left(2 \cdot \frac{2.51\,\text{cm} - 9.48\,\text{cm}}{3 \cdot 2.51\,\text{cm} \cdot 1.0001} - 1\right)$$

1.5) Diameter of Longitudinal Bar given Shortest Distance Formula

Evaluate Formula

Formula

$$D = \left(\sqrt{ \left(\frac{z}{2} \right)^2 + d'^2 } - acr \right) \cdot 2$$

Example with Units

$$0.0498\,\text{m} = \left(\sqrt{ \left(\frac{40\,\text{A}}{2} \right)^2 + 50.01\,\text{mm}^2 } - 2.51\,\text{cm} \right) \cdot 2$$

1.6) Effective Cover given Shortest Distance Formula

Evaluate Formula

Formula

$$d' = \sqrt{ \left(acr + \left(\frac{D}{2} \right) \right)^2 - \left(\frac{z}{2} \right)^2 }$$

Example with Units

$$275.1\,\text{mm} = \sqrt{ \left(2.51\,\text{cm} + \left(\frac{0.5\,\text{m}}{2} \right) \right)^2 - \left(\frac{40\,\text{A}}{2} \right)^2 }$$

1.7) Minimum Clear Cover given Crack Width Formula

Evaluate Formula

Formula

$$C_{min} = acr - \frac{ \left(\left(\frac{3 \cdot acr \cdot \varepsilon_m}{W_{cr}} \right) - 1 \right) \cdot (h - x) }{2}$$

Example with Units

$$9.4799\,\text{cm} = 2.51\,\text{cm} - \frac{ \left(\left(\frac{3 \cdot 2.51\,\text{cm} \cdot 0.0005}{0.49\,\text{mm}} \right) - 1 \right) \cdot (20.1\,\text{cm} - 50\,\text{mm}) }{2}$$

1.8) Evaluation of Average Strain and Neutral Axis Depth Formulas

1.8.1) Area of Prestressing Steel given Tension Force Formula

Evaluate Formula

Formula

$$As = \frac{N_u}{E_p \cdot \varepsilon}$$

Example with Units

$$26.3132\,\text{mm}^2 = \frac{1000\,\text{N}}{38\,\text{kg/cm}^3 \cdot 1.0001}$$

1.8.2) Average Strain under Tension Formula

Evaluate Formula

Formula

$$\varepsilon_m = \varepsilon_1 - \frac{ W_{cr} \cdot (h_{Crack} - x) \cdot (D_{CC} - x) }{ 3 \cdot E_s \cdot A_s \cdot (L_{eff} - x) }$$

Example with Units

$$0.0005 = 0.000514 - \frac{ 0.49\,\text{mm} \cdot (12.01\,\text{m} - 50\,\text{mm}) \cdot (4.5\,\text{m} - 50\,\text{mm}) }{ 3 \cdot 200000\,\text{MPa} \cdot 500\,\text{mm}^2 \cdot (50.25\,\text{m} - 50\,\text{mm}) }$$

1.8.3) Compression Force for Prestressed Section Formula

Evaluate Formula

Formula

$$C_c = As \cdot E_p \cdot \varepsilon$$

Example with Units

$$767.7768\,\text{N} = 20.2\,\text{mm}^2 \cdot 38\,\text{kg/cm}^3 \cdot 1.0001$$

1.8.4) Couple Force of Cross Section Formula

Evaluate Formula

Formula

$$C = 0.5 \cdot E_c \cdot \varepsilon_c \cdot x \cdot W_{cr}$$

Example with Units

$$0.0033\,\text{kN} = 0.5 \cdot 0.157\,\text{MPa} \cdot 1.69 \cdot 50\,\text{mm} \cdot 0.49\,\text{mm}$$

1.8.5) Depth of Neutral Axis given Couple Force of Cross Section Formula

Evaluate Formula

Formula

$$x = \frac{C}{0.5 \cdot E_c \cdot \varepsilon_c \cdot W_{cr}}$$

Example with Units

$$430.7305\,\text{mm} = \frac{0.028\,\text{kN}}{0.5 \cdot 0.157\,\text{MPa} \cdot 1.69 \cdot 0.49\,\text{mm}}$$

1.8.6) Height of Crack Width at Soffit given Average Strain Formula

Evaluate Formula

Formula

$$h_{Crack} = \left(\frac{(\varepsilon_1 - \varepsilon_m) \cdot (3 \cdot E_s \cdot A_s \cdot (d - x))}{W_{cr} \cdot (D_{CC} - x)} \right) + x$$

Example with Units

$$67415.7803\,\text{m} = \left(\frac{(0.000514 - 0.0005) \cdot (3 \cdot 200000\,\text{MPa} \cdot 500\,\text{mm}^2 \cdot (85\,\text{mm} - 50\,\text{mm}))}{0.49\,\text{mm} \cdot (4.5\,\text{m} - 50\,\text{mm})} \right) + 50\,\text{mm}$$

1.8.7) Modulus of Elasticity of Concrete given Couple Force of Cross-Section Formula

Evaluate Formula

Formula

$$E_c = \frac{C}{0.5 \cdot \varepsilon_c \cdot x \cdot W_{cr}}$$

Example with Units

$$1.3525\,\text{MPa} = \frac{0.028\,\text{kN}}{0.5 \cdot 1.69 \cdot 50\,\text{mm} \cdot 0.49\,\text{mm}}$$

1.8.8) Modulus of Elasticity of Prestressed Steel given Compression Force Formula

Evaluate Formula

Formula

$$E_p = \frac{C_c}{As \cdot \varepsilon}$$

Example with Units

$$37.125\,\text{kg/cm}^3 = \frac{750\,\text{N}}{20.2\,\text{mm}^2 \cdot 1.0001}$$

1.8.9) Strain at Selected Level given Average Strain under Tension Formula

Evaluate Formula

Formula

$$\varepsilon_1 = \varepsilon_m + \frac{W_{cr} \cdot \left(h_{Crack} - x \right) \cdot \left(D_{CC} - x \right)}{3 \cdot E_s \cdot A_s \cdot \left(L_{eff} - x \right)}$$

Example with Units

$$0.0005 = 0.0005 + \frac{0.49\,\text{mm} \cdot \left(12.01\,\text{m} - 50\,\text{mm} \right) \cdot \left(4.5\,\text{m} - 50\,\text{mm} \right)}{3 \cdot 200000\,\text{MPa} \cdot 500\,\text{mm}^2 \cdot \left(50.25\,\text{m} - 50\,\text{mm} \right)}$$

1.8.10) Strain given Couple Force of Cross Section Formula

Evaluate Formula

Formula

$$\varepsilon_c = \frac{C}{0.5 \cdot E_c \cdot x \cdot W_{cr}}$$

Example with Units

$$14.5587 = \frac{0.028\,\text{kN}}{0.5 \cdot 0.157\,\text{MPa} \cdot 50\,\text{mm} \cdot 0.49\,\text{mm}}$$

1.8.11) Strain in Longitudinal Reinforcement given Tension Force Formula

Evaluate Formula

Formula

$$\varepsilon s = \frac{N_u}{A_s \cdot Es}$$

Example with Units

$$10 = \frac{1000\,\text{N}}{500\,\text{mm}^2 \cdot 200000}$$

1.8.12) Strain in Prestressed Steel given Tension Force Formula

Evaluate Formula

Formula

$$\varepsilon = \frac{N_u}{As \cdot E_p}$$

Example with Units

$$1.3028 = \frac{1000\,\text{N}}{20.2\,\text{mm}^2 \cdot 38\,\text{kg/cm}^3}$$

1.8.13) Width of Section given Couple Force of Cross Section Formula

Evaluate Formula

Formula

$$W_{cr} = \frac{C}{0.5 \cdot E_c \cdot \varepsilon \cdot x}$$

Example with Units

$$7.133\,\text{mm} = \frac{0.028\,\text{kN}}{0.5 \cdot 0.157\,\text{MPa} \cdot 1.0001 \cdot 50\,\text{mm}}$$

2) Deflection Formulas

2.1) Deflection due to Self Weight given Short Term Deflection at Transfer Formula

Evaluate Formula

Formula

$$\Delta sw = \Delta po + \Delta st$$

Example with Units

$$5\,\text{cm} = 2.5\,\text{cm} + 2.50\,\text{cm}$$

2.2) Short Term Deflection at Transfer Formula

Evaluate Formula

Formula

$$\Delta st = -\Delta po + \Delta sw$$

Example with Units

$$2.6\,\text{cm} = -2.5\,\text{cm} + 5.1\,\text{cm}$$

2.3) Deflection due to Prestressing Force Formulas

2.3.1) Deflection due to Prestressing for Parabolic Tendon Formula

Evaluate Formula

Formula

$$\delta = \left(\frac{5}{384}\right) \cdot \left(\frac{W_{up} \cdot L^4}{E \cdot I_A}\right)$$

Example with Units

$$48.0857\,\text{m} = \left(\frac{5}{384}\right) \cdot \left(\frac{0.842\,\text{kN/m} \cdot 5\,\text{m}^4}{15\,\text{Pa} \cdot 9.5\,\text{m}^4}\right)$$

2.3.2) Deflection due to Prestressing for Singly Harped Tendon Formula

Evaluate Formula

Formula

$$\delta = \frac{Ft \cdot L^3}{48 \cdot E \cdot I_p}$$

Example with Units

$$48.0864\,\text{m} = \frac{311.6\,\text{N} \cdot 5\,\text{m}^3}{48 \cdot 15\,\text{Pa} \cdot 1.125\,\text{kg·m}^2}$$

2.3.3) Deflection due to Prestressing Force before Losses when Short Term Deflection at Transfer Formula

Evaluate Formula

Formula

$$\Delta po = \Delta sw - \Delta st$$

Example with Units

$$2.6\,\text{cm} = 5.1\,\text{cm} - 2.50\,\text{cm}$$

2.3.4) Deflection due to Prestressing given Doubly Harped Tendon Formula

Evaluate Formula

Formula

$$\delta = \frac{a \cdot \left(a^2\right) \cdot Ft \cdot L^3}{24 \cdot E \cdot I_p}$$

Example with Units

$$49.2405\,\text{m} = \frac{0.8 \cdot \left(0.8^2\right) \cdot 311.6\,\text{N} \cdot 5\,\text{m}^3}{24 \cdot 15\,\text{Pa} \cdot 1.125\,\text{kg·m}^2}$$

2.3.5) Flexural Rigidity given Deflection due to Prestressing for Doubly Harped Tendon Formula

Evaluate Formula

Formula

$$EI = \frac{a \cdot \left(a^2\right) \cdot Ft \cdot L^3}{24 \cdot \delta}$$

Example with Units

$$17.2751\,\text{N*m}^2 = \frac{0.8 \cdot \left(0.8^2\right) \cdot 311.6\,\text{N} \cdot 5\,\text{m}^3}{24 \cdot 48.1\,\text{m}}$$

2.3.6) Flexural Rigidity given Deflection due to Prestressing for Parabolic Tendon Formula

Evaluate Formula

Formula

$$EI = \left(\frac{5}{384}\right) \cdot \left(\frac{W_{up} \cdot L^4}{\delta}\right)$$

Example with Units

$$0.0142\,\text{N*m}^2 = \left(\frac{5}{384}\right) \cdot \left(\frac{0.842\,\text{kN/m} \cdot 5\,\text{m}^4}{48.1\,\text{m}}\right)$$

2.3.7) Flexural Rigidity given Deflection due to Prestressing for Singly Harped Tendon Formula

Evaluate Formula

Formula

$$EI = \frac{Ft \cdot L^3}{48 \cdot \delta}$$

Example with Units

$$16.8702\,\text{N*m}^2 = \frac{311.6\,\text{N} \cdot 5\,\text{m}^3}{48 \cdot 48.1\,\text{m}}$$

2.3.8) Length of Span given Deflection due to Prestressing for Doubly Harped Tendon Formula

Evaluate Formula

Formula

$$L = \left(\frac{\delta \cdot 48 \cdot E \cdot I_p}{a \cdot \left(4 - 3 \cdot a^2\right) \cdot Ft} \right)^{\frac{1}{3}}$$

Example with Units

$$4.2198\,\text{m} = \left(\frac{48.1\,\text{m} \cdot 48 \cdot 15\,\text{Pa} \cdot 1.125\,\text{kg·m}^2}{0.8 \cdot \left(4 - 3 \cdot 0.8^2\right) \cdot 311.6\,\text{N}} \right)^{\frac{1}{3}}$$

2.3.9) Length of Span given Deflection due to Prestressing for Singly Harped Tendon Formula

Evaluate Formula

Formula

$$L = \left(\frac{\delta \cdot 48 \cdot E \cdot I_p}{Ft} \right)^{\frac{1}{3}}$$

Example with Units

$$5.0005\,\text{m} = \left(\frac{48.1\,\text{m} \cdot 48 \cdot 15\,\text{Pa} \cdot 1.125\,\text{kg·m}^2}{311.6\,\text{N}} \right)^{\frac{1}{3}}$$

2.3.10) Moment of Inertia for Deflection due to Prestressing for Parabolic Tendon Formula

Evaluate Formula

Formula

$$I_p = \left(\frac{5}{384}\right) \cdot \left(\frac{W_{up} \cdot L^4}{e} \right)$$

Example with Units

$$137.0443\,\text{kg·m}^2 = \left(\frac{5}{384}\right) \cdot \left(\frac{0.842\,\text{kN/m} \cdot 5\,\text{m}^4}{50\,\text{Pa}} \right)$$

2.3.11) Moment of Inertia for Deflection due to Prestressing in Doubly Harped Tendon Formula

Evaluate Formula

Formula

$$I_p = \frac{a \cdot \left(a^2\right) \cdot Ft \cdot L^3}{48 \cdot e \cdot \delta}$$

Example with Units

$$0.1728\,\text{kg·m}^2 = \frac{0.8 \cdot \left(0.8^2\right) \cdot 311.6\,\text{N} \cdot 5\,\text{m}^3}{48 \cdot 50\,\text{Pa} \cdot 48.1\,\text{m}}$$

2.3.12) Moment of Inertia for Deflection due to Prestressing of Singly Harped Tendon Formula

Evaluate Formula

Formula

$$I_p = \frac{Ft \cdot L^3}{48 \cdot e \cdot \delta}$$

Example with Units

$$0.3374\,\text{kg·m}^2 = \frac{311.6\,\text{N} \cdot 5\,\text{m}^3}{48 \cdot 50\,\text{Pa} \cdot 48.1\,\text{m}}$$

2.3.13) Uplift Thrust given Deflection due to Prestressing for Doubly Harped Tendon Formula

Evaluate Formula

Formula

$$Ft = \frac{\delta \cdot 24 \cdot E \cdot I_p}{a \cdot \left(3 - 4 \cdot a^2\right) \cdot L^3}$$

Example with Units

$$442.7386\,\text{N} = \frac{48.1\,\text{m} \cdot 24 \cdot 15\,\text{Pa} \cdot 1.125\,\text{kg·m}^2}{0.8 \cdot \left(3 - 4 \cdot 0.8^2\right) \cdot 5\,\text{m}^3}$$

2.3.14) Uplift Thrust given Deflection due to Prestressing for Singly Harped Tendon Formula

Evaluate Formula

Formula

$$Ft = \frac{\delta \cdot 48 \cdot E \cdot I_p}{L^3}$$

Example with Units

$$311.688\,\text{N} = \frac{48.1\,\text{m} \cdot 48 \cdot 15\,\text{Pa} \cdot 1.125\,\text{kg·m}^2}{5\,\text{m}^3}$$

2.3.15) Uplift Thrust when Deflection due to Prestressing for Parabolic Tendon Formula

Evaluate Formula

Formula

$$W_{up} = \frac{\delta \cdot 384 \cdot E \cdot I_A}{5 \cdot L^4}$$

Example with Units

$$0.8423\,\text{kN/m} = \frac{48.1\,\text{m} \cdot 384 \cdot 15\,\text{Pa} \cdot 9.5\,\text{m}^4}{5 \cdot 5\,\text{m}^4}$$

2.3.16) Young's Modulus given Deflection due to Prestressing for Doubly Harped Tendon Formula

Evaluate Formula

Formula

$$E = \frac{a \cdot \left(3 - 4 \cdot a^2\right) \cdot Ft \cdot L^3}{48 \cdot \delta \cdot I_p}$$

Example with Units

$$5.2785\,\text{Pa} = \frac{0.8 \cdot \left(3 - 4 \cdot 0.8^2\right) \cdot 311.6\,\text{N} \cdot 5\,\text{m}^3}{48 \cdot 48.1\,\text{m} \cdot 1.125\,\text{kg·m}^2}$$

2.3.17) Young's Modulus given Deflection due to Prestressing for Parabolic Tendon Formula

Evaluate Formula

Formula

$$E = \left(\frac{5}{384}\right) \cdot \left(\frac{W_{up} \cdot L^4}{\delta \cdot I_A}\right)$$

Example with Units

$$14.9955\,\text{Pa} = \left(\frac{5}{384}\right) \cdot \left(\frac{0.842\,\text{kN/m} \cdot 5\,\text{m}^4}{48.1\,\text{m} \cdot 9.5\,\text{m}^4}\right)$$

2.3.18) Young's Modulus given Deflection due to Prestressing for Singly Harped Tendon Formula

Evaluate Formula

Formula

$$E = \frac{Ft \cdot L^3}{48 \cdot \delta \cdot I_p}$$

Example with Units

$$14.9958\,\text{Pa} = \frac{311.6\,\text{N} \cdot 5\,\text{m}^3}{48 \cdot 48.1\,\text{m} \cdot 1.125\,\text{kg·m}^2}$$

Variables used in list of Crack Width and Deflection of Prestress Concrete Members Formulas above

- **a** Part of Span Length
- **A_s** Area of Reinforcement *(Square Millimeter)*
- **acr** Shortest Distance *(Centimeter)*
- **As** Area of Prestressing Steel *(Square Millimeter)*
- **C** Couple Force *(Kilonewton)*
- **C_c** Total Compression on Concrete *(Newton)*
- **C_{min}** Minimum Clear Cover *(Centimeter)*
- **d** Effective Depth of Reinforcement *(Millimeter)*
- **d'** Effective Cover *(Millimeter)*
- **D** Diameter of Longitudinal Bar *(Meter)*
- **D_{CC}** Distance from Compression to Crack Width *(Meter)*
- **e** Elastic Modulus *(Pascal)*
- **E** Young's Modulus *(Pascal)*
- **E_c** Modulus of Elasticity of Concrete *(Megapascal)*
- **E_p** Prestressed Young's Modulus *(Kilogram per Cubic Centimeter)*
- **E_s** Modulus of Elasticity of Steel Reinforcement *(Megapascal)*
- **EI** Flexural Rigidity *(Newton Square Meter)*
- **Es** Modulus of Elasticity of Steel
- **Ft** Thrust Force *(Newton)*
- **h** Total Depth *(Centimeter)*
- **h_{Crack}** Height of Crack *(Meter)*
- **I_A** Second Moment of Area *(Meter⁴)*
- **I_p** Moment of Inertia in Prestress *(Kilogram Square Meter)*
- **L** Span Length *(Meter)*
- **L_{eff}** Effective Length *(Meter)*
- **N_u** Tension Force *(Newton)*
- **s** Center to Center Spacing *(Centimeter)*
- **W_{cr}** Crack Width *(Millimeter)*

Constants, Functions, Measurements used in list of Crack Width and Deflection of Prestress Concrete Members 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), Centimeter (cm), Meter (m), Angstrom (A)
  Length Unit Conversion
- Measurement: **Area** in Square Millimeter (mm^2)
  Area Unit Conversion
- Measurement: **Pressure** in Megapascal (MPa), Pascal (Pa)
  Pressure Unit Conversion
- Measurement: **Force** in Newton (N), Kilonewton (kN)
  Force Unit Conversion
- Measurement: **Surface Tension** in Kilonewton per Meter (kN/m)
  Surface Tension Unit Conversion
- Measurement: **Density** in Kilogram per Cubic Centimeter (kg/cm^3)
  Density Unit Conversion
- Measurement: **Moment of Inertia** in Kilogram Square Meter ($kg \cdot m^2$)
  Moment of Inertia Unit Conversion
- Measurement: **Second Moment of Area** in Meter⁴ (m^4)
  Second Moment of Area Unit Conversion
- Measurement: **Flexural Rigidity** in Newton Square Meter ($N*m^2$)
  Flexural Rigidity Unit Conversion

- **W_{up}** Upward Thrust *(Kilonewton per Meter)*
- **x** Depth of Neutral Axis *(Millimeter)*
- **z** Center-to-center Distance *(Angstrom)*
- **δ** Deflection due to Moments on Arch Dam *(Meter)*
- **Δpo** Deflection due to Prestressing Force *(Centimeter)*
- **Δst** Short Term Deflection *(Centimeter)*
- **Δsw** Deflection due to Self Weight *(Centimeter)*
- **ε** Strain
- **ε_1** Strain at Selected Level
- **ε_c** Strain in Concrete
- **ε_m** Average Strain
- **εs** Strain in Longitudinal Reinforcement

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