Important Loss due to Elastic Shortening Formulas PDF

Formulas
Examples
with Units

List of 22
Important Loss due to Elastic Shortening Formulas

1) Post-Tensioned Members Formulas

1.1) Area of Concrete Section given Prestress Drop Formula

Evaluate Formula

Formula

$$A_c = m_{Elastic} \cdot \frac{P_B}{\Delta f_p}$$

Example with Units

$$12\,\text{m}^2 = 0.6 \cdot \frac{200\,\text{kN}}{10\,\text{MPa}}$$

1.2) Average Stress for Parabolic Tendons Formula

Evaluate Formula

Formula

$$f_{c,avg} = f_{c1} + \frac{2}{3} \cdot \left(f_{c2} - f_{c1} \right)$$

Example with Units

$$10.202\,\text{MPa} = 10.006\,\text{MPa} + \frac{2}{3} \cdot \left(10.3\,\text{MPa} - 10.006\,\text{MPa} \right)$$

1.3) Change in Eccentricity of Tendon A due to Parabolic Shape Formula

Evaluate Formula

Formula

$$\Delta e_A = e_{A2} - e_{A1}$$

Example with Units

$$9.981\,\text{mm} = 20.001\,\text{mm} - 10.02\,\text{mm}$$

1.4) Change in Eccentricity of Tendon B due to Parabolic Shape Formula

Evaluate Formula

Formula

$$\Delta e_B = e_{B2} - e_{B1}$$

Example with Units

$$10.07\,\text{mm} = 20.1\,\text{mm} - 10.03\,\text{mm}$$

1.5) Component of Strain at Level of First Tendon due to Bending Formula

Evaluate Formula

Formula

$$\varepsilon_{c2} = \frac{\Delta L}{L}$$

Example with Units

$$0.0294 = \frac{0.3\,\text{m}}{10.2\,\text{m}}$$

1.6) Prestress Drop Formula

Evaluate Formula

Formula

$$\Delta f_p = E_s \cdot \Delta \varepsilon_p$$

Example with Units

$$10\,\text{MPa} = 200000\,\text{MPa} \cdot 0.00005$$

1.7) Prestress Drop given Modular Ratio Formula

Evaluate Formula

Formula

$$\Delta f_p = m_{Elastic} \cdot f_{concrete}$$

Example with Units

$$9.96\,\text{MPa} = 0.6 \cdot 16.6\,\text{MPa}$$

1.8) Prestress Drop given Strain due to Bending and Compression in Two Parabolic Tendons Formula

Evaluate Formula

Formula

$$\Delta f_p = E_s \cdot \left(\varepsilon_{c1} + \varepsilon_{c2} \right)$$

Example with Units

$$106000\,\text{MPa} = 200000\,\text{MPa} \cdot \left(0.5 + 0.03 \right)$$

1.9) Prestress Drop given Stress in concrete at Same Level due to Prestressing Force Formula

Evaluate Formula

Formula

$$\Delta f_p = E_s \cdot \frac{f_{concrete}}{E_{concrete}}$$

Example with Units

$$33200\,\text{MPa} = 200000\,\text{MPa} \cdot \frac{16.6\,\text{MPa}}{100\,\text{MPa}}$$

1.10) Prestress Drop when Two parabolic Tendons are Incorporated Formula

Evaluate Formula

Formula

$$\Delta f_p = E_s \cdot \varepsilon_c$$

Example with Units

$$9000\,\text{MPa} = 200000\,\text{MPa} \cdot 0.045$$

1.11) Stress in Concrete given Prestress Drop Formula

Evaluate Formula

Formula

$$f_{concrete} = \frac{\Delta f_p}{m_{Elastic}}$$

Example with Units

$$16.6667\,\text{MPa} = \frac{10\,\text{MPa}}{0.6}$$

1.12) Variation of Eccentricity of Tendon B Formula

Evaluate Formula

Formula

$$E_{B(x)} = e_{B1} + \left(4 \cdot \Delta e_B \cdot \frac{x}{L} \right) \cdot \left(1 - \left(\frac{x}{L} \right) \right)$$

Example with Units

$$10.1091\,\text{mm} = 10.03\,\text{mm} + \left(4 \cdot 20.0\,\text{mm} \cdot \frac{10.1\,\text{mm}}{10.2\,\text{m}} \right) \cdot \left(1 - \left(\frac{10.1\,\text{mm}}{10.2\,\text{m}} \right) \right)$$

1.13) Variation of Eccentricity on Tendon A Formula

Evaluate Formula

Formula

$$E_{A(x)} = e_{A1} + \left(4 \cdot \Delta e_A \cdot \frac{x}{L}\right) \cdot \left(1 - \left(\frac{x}{L}\right)\right)$$

Example with Units

$$10.0596\,\text{mm} = 10.02\,\text{mm} + \left(4 \cdot 10.0\,\text{mm} \cdot \frac{10.1\,\text{mm}}{10.2\,\text{m}}\right) \cdot \left(1 - \left(\frac{10.1\,\text{mm}}{10.2\,\text{m}}\right)\right)$$

2) Pre-Tensioned Members Formulas

2.1) Initial Prestress given Prestress after Immediate Loss Formula

Evaluate Formula

Formula

$$P_i = P_o \cdot \frac{A_{Pretension}}{A_{Pre\ tension}}$$

Example with Units

$$200\,\text{kN} = 96000\,\text{kN} \cdot \frac{0.025\,\text{mm}^2}{12\,\text{mm}^2}$$

2.2) Initial Strain in Steel for Known Strain due to Elastic Shortening Formula

Evaluate Formula

Formula

$$\varepsilon_{pi} = \varepsilon_c + \varepsilon_{po}$$

Example

$$0.05 = 0.045 + 0.005$$

2.3) Modular Ratio given Prestress after Immediate Loss Formula

Evaluate Formula

Formula

$$m_{Elastic} = \Delta f_{Drop} \cdot \frac{A_{Pre\ tension}}{P_o}$$

Example with Units

$$2.5 = 0.02\,\text{MPa} \cdot \frac{12\,\text{mm}^2}{96000\,\text{kN}}$$

2.4) Prestress Drop given Initial Prestress Force Formula

Evaluate Formula

Formula

$$\Delta f_{Drop} = P_i \cdot \frac{m_{Elastic}}{A_{Pretension}}$$

Example with Units

$$0.0104\,\text{MPa} = 435\,\text{kN} \cdot \frac{0.6}{0.025\,\text{mm}^2}$$

2.5) Prestress Drop given Pressure after Immediate Loss Formula

Evaluate Formula

Formula

$$\Delta f_{Drop} = \left(\frac{P_o}{A_{Pre\ tension}}\right) \cdot m_{Elastic}$$

Example with Units

$$0.0048\,\text{MPa} = \left(\frac{96000\,\text{kN}}{12\,\text{mm}^2}\right) \cdot 0.6$$

2.6) Prestressing Force after Immediate Loss given Initial Prestress Formula

Evaluate Formula

Formula

$$P_o = P_i \cdot \frac{A_{Pre\ tension}}{A_{Pretension}}$$

Example with Units

$$208800\,\text{kN} = 435\,\text{kN} \cdot \frac{12\,\text{mm}^2}{0.025\,\text{mm}^2}$$

2.7) Residual Strain in Steel for Known Strain due to Elastic Shortening Formula

Evaluate Formula

Formula

$$\varepsilon_{po} = \varepsilon_{pi} - \varepsilon_c$$

Example

$$0.005 = 0.05 - 0.045$$

2.8) Strain in Concrete due to Elastic Shortening Formula

Evaluate Formula

Formula

$$\varepsilon_c = \varepsilon_{pi} - \varepsilon_{po}$$

Example

$$0.045 = 0.05 - 0.005$$

2.9) Transformed Area of Prestress Member for Known Pressure Drop Formula

Evaluate Formula

Formula

$$A_{Pretension} = m_{Elastic} \cdot \frac{P_i}{\Delta f_{Drop}}$$

Example with Units

$$0.013\,\text{mm}^2 = 0.6 \cdot \frac{435\,\text{kN}}{0.02\,\text{MPa}}$$

Variables used in list of Loss due to Elastic Shortening Formulas above

- A_c Concrete Occupied Area *(Square Meter)*
- $A_{Pre\ tension}$ Pre-Tensioned Area of Concrete *(Square Millimeter)*
- $A_{Pretension}$ Transformed Section Area of Prestress *(Square Millimeter)*
- $E_{A(x)}$ Eccentricity Variation of Tendon A *(Millimeter)*
- e_{A1} Eccentricity at End for A *(Millimeter)*
- e_{A2} Eccentricity at Midspan for A *(Millimeter)*
- $E_{B(x)}$ Eccentricity Variation of Tendon B *(Millimeter)*
- e_{B1} Eccentricity at End for B *(Millimeter)*
- e_{B2} Eccentricity at Midspan B *(Millimeter)*
- $E_{concrete}$ Modulus of Elasticity Concrete *(Megapascal)*
- E_s Modulus of Elasticity of Steel Reinforcement *(Megapascal)*
- $f_{c,avg}$ Average Stress *(Megapascal)*
- f_{c1} Stress at End *(Megapascal)*
- f_{c2} Stress at Midspan *(Megapascal)*
- $f_{concrete}$ Stress in Concrete Section *(Megapascal)*
- L Length of Beam in Prestress *(Meter)*
- $m_{Elastic}$ Modular Ratio for Elastic Shortening
- P_B Prestress Force *(Kilonewton)*
- P_i Initial Prestress Force *(Kilonewton)*
- P_o Prestressing Force after Loss *(Kilonewton)*
- x Distance from Left End *(Millimeter)*
- Δe_A Change in Eccentricity at A *(Millimeter)*
- Δe_B Change in Eccentricity B *(Millimeter)*
- Δf_{Drop} Drop in Prestress *(Megapascal)*
- Δf_p Prestress Drop *(Megapascal)*
- ΔL Change in Length Dimension *(Meter)*

Constants, Functions, Measurements used in list of Loss due to Elastic Shortening Formulas above

- Measurement: **Length** in Millimeter (mm), Meter (m)
  Length Unit Conversion
- Measurement: **Area** in Square Meter (m²), Square Millimeter (mm²)
  Area Unit Conversion
- Measurement: **Pressure** in Megapascal (MPa)
  Pressure Unit Conversion
- Measurement: **Force** in Kilonewton (kN)
  Force Unit Conversion

- $\Delta\varepsilon_p$ Change in Strain
- ε_c Concrete Strain
- ε_{c1} Strain due to Compression
- ε_{c2} Strain due to Bending
- ε_{pi} Initial Strain
- ε_{po} Residual Strain

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