Important Loss due to Anchorage Slip, Friction Loss and General Geometric Properties Formulas PDF

Formulas
Examples
with Units

List of 28
Important Loss due to Anchorage Slip, Friction Loss and General Geometric Properties Formulas

1) Force Variation Diagram and Loss Due to Anchorage Slip Formulas

1.1) Anchorage Slip given Settling Length Formula

Evaluate Formula

Formula

$$\Delta = 0.5 \cdot \Delta f_p \cdot \frac{l_{set}}{A_p \cdot E_s}$$

Example with Units

$$4.16\,\text{mm} = 0.5 \cdot 10\,\text{MPa} \cdot \frac{41.6\,\text{m}}{0.25\,\text{mm}^2 \cdot 200000\,\text{MPa}}$$

1.2) Area of Prestressing Steel given Settling Length Formula

Evaluate Formula

Formula

$$A_p = 0.5 \cdot \Delta f_p \cdot \frac{l_{set}}{\Delta \cdot E_s}$$

Example with Units

$$0.208\,\text{mm}^2 = 0.5 \cdot 10\,\text{MPa} \cdot \frac{41.6\,\text{m}}{5\,\text{mm} \cdot 200000\,\text{MPa}}$$

1.3) Loss of Prestress due to Slip Formula

Evaluate Formula

Formula

$$F = A_{Tendon} \cdot \frac{E_s \cdot \Delta}{PL_{Cable}}$$

Example with Units

$$4.2\text{E-}6\,\text{kN} = 0.21\,\text{mm}^2 \cdot \frac{200000\,\text{MPa} \cdot 5\,\text{mm}}{50.1\,\text{m}}$$

1.4) Pressure Drop given Setting Length Formula

Evaluate Formula

Formula

$$\Delta f_p = 2 \cdot P \cdot \eta \cdot l_{set}$$

Example with Units

$$9.989\,\text{MPa} = 2 \cdot 20.01\,\text{kN} \cdot 6 \cdot 41.6\,\text{m}$$

1.5) Pressure Drop when Anchorage Slip and Settling Length are Considered Formula

Evaluate Formula

Formula

$$\Delta f_p = \frac{\Delta \cdot A_p \cdot E_s}{l_{set} \cdot 0.5}$$

Example with Units

$$12.0192\,\text{MPa} = \frac{5\,\text{mm} \cdot 0.25\,\text{mm}^2 \cdot 200000\,\text{MPa}}{41.6\,\text{m} \cdot 0.5}$$

1.6) Prestressing Force after Immediate Loss when Reverse Friction Effect is Considered Formula

Evaluate Formula

Formula

$$P = \left(\frac{P_x}{\exp(\eta \cdot x)} \right) + \Delta f_p$$

Example with Units

$$0.01\,\text{kN} = \left(\frac{96\,\text{kN}}{\exp(6 \cdot 10.1\,\text{mm})} \right) + 10\,\text{MPa}$$

1.7) Prestressing Force at distance x when Reverse Friction is Considered Formula

Evaluate Formula

Formula

$$P_x = \left(P - \Delta f_p \right) \cdot \exp(\eta \cdot x)$$

Example with Units

$$21.2495\,\text{kN} = \left(20.01\,\text{kN} - 10\,\text{MPa} \right) \cdot \exp(6 \cdot 10.1\,\text{mm})$$

1.8) Settling Length given Pressure Drop Formula

Evaluate Formula

Formula

$$l_{set} = \frac{\Delta f_p}{2 \cdot \eta \cdot P}$$

Example with Units

$$41.6458\,\text{m} = \frac{10\,\text{MPa}}{2 \cdot 6 \cdot 20.01\,\text{kN}}$$

1.9) Settling Length given Prestressing Force Immediately after Loss Formula

Evaluate Formula

Formula

$$l_{set} = \sqrt{\Delta \cdot A_p \cdot \frac{E_s}{P \cdot \eta}}$$

Example with Units

$$0.0456\,\text{m} = \sqrt{5\,\text{mm} \cdot 0.25\,\text{mm}^2 \cdot \frac{200000\,\text{MPa}}{20.01\,\text{kN} \cdot 6}}$$

1.10) Slip of Anchorage Formula

Evaluate Formula

Formula

$$\Delta = F \cdot \frac{PL_{Cable}}{A_{Tendon} \cdot E_s}$$

Example with Units

$$0.0005\,\text{mm} = 400\,\text{kN} \cdot \frac{50.1\,\text{m}}{0.21\,\text{mm}^2 \cdot 200000\,\text{MPa}}$$

2) Friction Loss Formulas

2.1) Coefficient of Friction given Px Formula

Evaluate Formula

Formula

$$\mu_{friction} = \left(\frac{1}{a} \right) \cdot \left(1 - \left(\left(\frac{P_x}{P_{End}} \right) + (k \cdot x) \right) \right)$$

Example with Units

$$3.7042 = \left(\frac{1}{2^\circ} \right) \cdot \left(1 - \left(\left(\frac{96\,\text{kN}}{120\,\text{kN}} \right) + (0.007 \cdot 10.1\,\text{mm}) \right) \right)$$

2.2) Prestress Force at Distance X by Taylor Series Expansion Formula

Evaluate Formula

Formula

$$P_x = P_{End} \cdot \left(1 - \left(\mu_{friction} \cdot a\right) - \left(k \cdot x\right)\right)$$

Example with Units

$$119.7109\,\text{kN} = 120\,\text{kN} \cdot \left(1 - \left(0.067 \cdot 2^\circ\right) - \left(0.007 \cdot 10.1\,\text{mm}\right)\right)$$

2.3) Prestress Force at Stressing End using Taylor Series Expansion Formula

Evaluate Formula

Formula

$$P_{End} = \frac{P_x}{\left(1 - \left(\mu_{friction} \cdot a\right) - \left(k \cdot x\right)\right)}$$

Example with Units

$$96.2319\,\text{kN} = \frac{96\,\text{kN}}{\left(1 - \left(0.067 \cdot 2^\circ\right) - \left(0.007 \cdot 10.1\,\text{mm}\right)\right)}$$

2.4) Prestressing Force at Distance x from Stretching End for Known Resultant Formula

Evaluate Formula

Formula

$$P_x = \frac{N}{2 \cdot \sin\left(\frac{\theta}{2}\right)}$$

Example with Units

$$96.5926\,\text{kN} = \frac{50\,\text{kN}}{2 \cdot \sin\left(\frac{30^\circ}{2}\right)}$$

2.5) Resultant of Vertical Reaction from Concrete on Tendon Formula

Evaluate Formula

Formula

$$N = 2 \cdot P_x \cdot \sin\left(\frac{\theta}{2}\right)$$

Example with Units

$$49.6933\,\text{kN} = 2 \cdot 96\,\text{kN} \cdot \sin\left(\frac{30^\circ}{2}\right)$$

2.6) Subtended Angle given Resultant Reaction Formula

Evaluate Formula

Formula

$$\theta = 2 \cdot a\sin\left(\frac{N}{2 \cdot P_x}\right)$$

Example with Units

$$30.1896^\circ = 2 \cdot a\sin\left(\frac{50\,\text{kN}}{2 \cdot 96\,\text{kN}}\right)$$

2.7) Wobble Coefficient k given Px Formula

Evaluate Formula

Formula

$$k = \left(\frac{1}{x}\right) \cdot \left(1 - \left(\mu_{friction} \cdot a\right) - \left(\frac{P_x}{P_{End}}\right)\right)$$

Example with Units

$$0.0196 = \left(\frac{1}{10.1\,mm}\right) \cdot \left(1 - \left(0.067 \cdot 2°\right) - \left(\frac{96\,kN}{120\,kN}\right)\right)$$

3) General Geometric Properties Formulas

3.1) Area of Concrete Section when Transformed Area is Calculated Formula

Evaluate Formula

Formula

$$A_T = A_t - \left(m \cdot As\right)$$

Example with Units

$$965.14\,mm^2 = 4500.14\,mm^2 - \left(175 \cdot 20.2\,mm^2\right)$$

3.2) Area of Prestressing Steel given Transformed Area Formula

Evaluate Formula

Formula

$$As = \frac{A_t - A_T}{m}$$

Example with Units

$$20.0008\,mm^2 = \frac{4500.14\,mm^2 - 1000\,mm^2}{175}$$

3.3) Transformed Area of Prestressed Member Formula

Evaluate Formula

Formula

$$A_t = A_T + \left(m \cdot As\right)$$

Example with Units

$$4535\,mm^2 = 1000\,mm^2 + \left(175 \cdot 20.2\,mm^2\right)$$

3.4) Transformed Area of Prestressed Member given Gross Area of Member Formula

Evaluate Formula

Formula

$$A_t = A_g + \left(m - 1\right) \cdot As$$

Example with Units

$$4534.8\,mm^2 = 1020\,mm^2 + \left(175 - 1\right) \cdot 20.2\,mm^2$$

4) Losses due to Creep and Shrinkage Formulas

4.1) Creep Coefficient given Creep Strain Formula

Evaluate Formula

Formula

$$\Phi = \frac{\varepsilon_{cr,ult}}{\varepsilon_{el}}$$

Example

$$1.6 = \frac{0.8}{0.50}$$

4.2) Elastic Strain given Creep Strain Formula

Evaluate Formula

Formula

$$\varepsilon_{el} = \frac{\varepsilon_{cr,ult}}{\Phi}$$

Example

$$0.5 = \frac{0.8}{1.6}$$

4.3) Loss in Prestress given Creep Strain Formula

Evaluate Formula

Formula

$$\Delta f_{loss} = E_s \cdot \varepsilon_{cr,ult}$$

Example with Units

$$160\,\text{GPa} = 200000\,\text{MPa} \cdot 0.8$$

4.4) Loss in Prestress given Shrinkage Strain Formula

Evaluate Formula

Formula

$$\Delta f_{loss} = E_s \cdot \varepsilon_{sh}$$

Example with Units

$$0.06\,\text{GPa} = 200000\,\text{MPa} \cdot 0.0003$$

4.5) Shrinkage Strain for Post tensioning Formula

Evaluate Formula

Formula

$$\varepsilon_{sh} = \frac{0.002}{\log10\left(t + 2\right)}$$

Example with Units

$$0.0003 = \frac{0.002}{\log10\left(28\,\text{d} + 2\right)}$$

4.6) Ultimate Creep Strain Formula

Evaluate Formula

Formula

$$\varepsilon_{cr,ult} = \Phi \cdot \varepsilon_{el}$$

Example

$$0.8 = 1.6 \cdot 0.50$$

4.7) Ultimate Shrinkage Strain given Loss in Prestress Formula

Evaluate Formula

Formula

$$\varepsilon_{sh} = \frac{\Delta f_{loss}}{E_s}$$

Example with Units

$$0.1 = \frac{20\,\text{GPa}}{200000\,\text{MPa}}$$

Variables used in list of Loss due to Anchorage Slip, Friction Loss and General Geometric Properties Formulas above

- **a** Cumulative Angle *(Degree)*
- A_g Gross Area of Cross-Section *(Square Millimeter)*
- A_p Steel Area in Prestress *(Square Millimeter)*
- A_t Transformed Area of Prestressed Member *(Square Millimeter)*
- A_T Transformed Area of Concrete *(Square Millimeter)*
- A_{Tendon} Tendon Area *(Square Millimeter)*
- **As** Area of Prestressing Steel *(Square Millimeter)*
- E_s Modulus of Elasticity of Steel Reinforcement *(Megapascal)*
- **F** Prestressing Force *(Kilonewton)*
- **k** Wobble Coefficient
- l_{set} Settling Length *(Meter)*
- **m** Modular Ratio
- **N** Vertical Resultant *(Kilonewton)*
- **P** Prestressing force after Immediate Losses *(Kilonewton)*
- P_{End} End Prestress Force *(Kilonewton)*
- P_x Prestress Force at a Distance *(Kilonewton)*
- PL_{Cable} Cable Length *(Meter)*
- **t** Age of Concrete *(Day)*
- **x** Distance from Left End *(Millimeter)*
- **Δ** Slip of Anchorage *(Millimeter)*
- Δf_{loss} Loss in Prestress *(Gigapascal)*
- Δf_p Prestress Drop *(Megapascal)*
- $\varepsilon_{cr,ult}$ Ultimate Creep Strain
- ε_{el} Elastic Strain
- ε_{sh} Shrinkage Strain
- **η** Simplified Term
- **θ** Subtended Angle in Degrees *(Degree)*

Constants, Functions, Measurements used in list of Loss due to Anchorage Slip, Friction Loss and General Geometric Properties Formulas above

- Functions: **asin**, asin(Number)
  The inverse sine function, is a trigonometric function that takes a ratio of two sides of a right triangle and outputs the angle opposite the side with the given ratio.
- Functions: **exp**, exp(Number)
  n an exponential function, the value of the function changes by a constant factor for every unit change in the independent variable.
- Functions: **log10**, log10(Number)
  The common logarithm, also known as the base-10 logarithm or the decimal logarithm, is a mathematical function that is the inverse of the exponential function.
- Functions: **sin**, sin(Angle)
  Sine is a trigonometric function that describes the ratio of the length of the opposite side of a right triangle to the length of the hypotenuse.
- 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: **Time** in Day (d)
  Time Unit Conversion
- Measurement: **Area** in Square Millimeter (mm²)
  Area Unit Conversion
- Measurement: **Pressure** in Megapascal (MPa), Gigapascal (GPa)
  Pressure Unit Conversion
- Measurement: **Force** in Kilonewton (kN)
  Force Unit Conversion
- Measurement: **Angle** in Degree (°)
  Angle Unit Conversion

- $\mu_{friction}$ Prestress Friction Coefficient
- Φ Creep Coefficient of Prestress

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