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

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

## Loss due to Anchorage Slip, Friction Loss and General Geometric Properties

## Force Variation Diagram and Loss Due to Anchorage Slip

### 1) Anchorage Slip given Settling Length

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

[Open Calculator !\[\]\(e474458956c9a37fbf9586ddb60a7fa1\_img.jpg\)](#)

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

### 2) Area of Prestressing Steel given Settling Length

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

[Open Calculator !\[\]\(4fe57c3593bf1b21d272ae7ac8dfaf77\_img.jpg\)](#)

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



3) Loss of Prestress due to Slip 

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

Open Calculator 


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

4) Pressure Drop given Setting Length 

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

Open Calculator 


$$ex \quad 9.988992MPa = 2 \cdot 20.01kN \cdot 6 \cdot 41.6m$$

5) Pressure Drop when Anchorage Slip and Settling Length are Considered 

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

Open Calculator 

$$ex \quad 12.01923MPa = \frac{5mm \cdot 0.25mm^2 \cdot 200000MPa}{41.6m \cdot 0.5}$$

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

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

Open Calculator 

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



## 7) Prestressing Force at distance x when Reverse Friction is Considered



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

Open Calculator

$$ex \ 21.24948kN = (20.01kN - 10MPa) \cdot \exp(6 \cdot 10.1mm)$$

## 8) Settling Length given Pressure Drop

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

Open Calculator

$$ex \ 41.64584m = \frac{10MPa}{2 \cdot 6 \cdot 20.01kN}$$

## 9) Settling Length given Prestressing Force Immediately after Loss

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

Open Calculator

$$ex \ 0.045632m = \sqrt{5mm \cdot 0.25mm^2 \cdot \frac{200000MPa}{20.01kN \cdot 6}}$$

## 10) Slip of Anchorage

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

Open Calculator

$$ex \ 0.000477mm = 400kN \cdot \frac{50.1m}{0.21mm^2 \cdot 200000MPa}$$



## Friction Loss

### 11) Coefficient of Friction given $P_x$

fx

Open Calculator 

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

$$\text{ex } 3.704172 = \left( \frac{1}{2^\circ} \right) \cdot \left( 1 - \left( \left( \frac{96\text{kN}}{120\text{kN}} \right) + (0.007 \cdot 10.1\text{mm}) \right) \right)$$

### 12) Prestress Force at Distance X by Taylor Series Expansion

fx

Open Calculator 

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

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

### 13) Prestress Force at Stressing End using Taylor Series Expansion

fx

Open Calculator 

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

$$\text{ex } 96.23187\text{kN} = \frac{96\text{kN}}{(1 - (0.067 \cdot 2^\circ) - (0.007 \cdot 10.1\text{mm}))}$$



## 14) Prestressing Force at Distance x from Stretching End for Known Resultant

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

[Open Calculator !\[\]\(9dfdaff1d86ba3c1f8353b4d1b61b8c5\_img.jpg\)](#)

$$\text{ex } 96.59258\text{kN} = \frac{50\text{kN}}{2 \cdot \sin\left(\frac{30^\circ}{2}\right)}$$

## 15) Resultant of Vertical Reaction from Concrete on Tendon

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

[Open Calculator !\[\]\(2b376d1a92330ab09dad2665d2f89bf5\_img.jpg\)](#)

$$\text{ex } 49.69326\text{kN} = 2 \cdot 96\text{kN} \cdot \sin\left(\frac{30^\circ}{2}\right)$$


## 16) Subtended Angle given Resultant Reaction

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

[Open Calculator !\[\]\(c444627dab9fee9a1550c053ffaaaae2\_img.jpg\)](#)

$$\text{ex } 30.18957^\circ = 2 \cdot a \sin\left(\frac{50\text{kN}}{2 \cdot 96\text{kN}}\right)$$




17) Wobble Coefficient  $k$  given  $P_x$  

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

Open Calculator 

$$ex \quad 0.01957 = \left( \frac{1}{10.1\text{mm}} \right) \cdot \left( 1 - (0.067 \cdot 2^\circ) - \left( \frac{96\text{kN}}{120\text{kN}} \right) \right)$$

General Geometric Properties 18) Area of Concrete Section when Transformed Area is Calculated 

$$fx \quad A_T = A_t - (m \cdot A_s)$$

Open Calculator 

$$ex \quad 965.14\text{mm}^2 = 4500.14\text{mm}^2 - (175 \cdot 20.2\text{mm}^2)$$

19) Area of Prestressing Steel given Transformed Area 

$$fx \quad A_s = \frac{A_t - A_T}{m}$$

Open Calculator 

$$ex \quad 20.0008\text{mm}^2 = \frac{4500.14\text{mm}^2 - 1000\text{mm}^2}{175}$$

20) Transformed Area of Prestressed Member 

$$fx \quad A_t = A_T + (m \cdot A_s)$$

Open Calculator 

$$ex \quad 4535\text{mm}^2 = 1000\text{mm}^2 + (175 \cdot 20.2\text{mm}^2)$$





## 21) Transformed Area of Prestressed Member given Gross Area of Member



$$fx \quad A_t = A_g + (m - 1) \cdot A_s$$

Open Calculator

$$ex \quad 4534.8\text{mm}^2 = 1020\text{mm}^2 + (175 - 1) \cdot 20.2\text{mm}^2$$

## Losses due to Creep and Shrinkage

### 22) Creep Coefficient given Creep Strain

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

Open Calculator

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

### 23) Elastic Strain given Creep Strain

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

Open Calculator

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

### 24) Loss in Prestress given Creep Strain

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

Open Calculator

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



## 25) Loss in Prestress given Shrinkage Strain

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

[Open Calculator !\[\]\(0f848bbd71cef6b345273b16f905912a\_img.jpg\)](#)

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

## 26) Shrinkage Strain for Post tensioning

$$fx \quad \varepsilon_{\text{sh}} = \frac{0.002}{\log_{10}(t + 2)}$$

[Open Calculator !\[\]\(3211b5d1d968fc1665909b34f9f16010\_img.jpg\)](#)

$$ex \quad 0.000313 = \frac{0.002}{\log_{10}(28d + 2)}$$

## 27) Ultimate Creep Strain

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

[Open Calculator !\[\]\(9c2e8d1b5bd77cb5c9f83b7a9cff79fd\_img.jpg\)](#)

$$ex \quad 0.8 = 1.6 \cdot 0.50$$

## 28) Ultimate Shrinkage Strain given Loss in Prestress

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

[Open Calculator !\[\]\(235bfe13ebf007ce2eea9e689707fac7\_img.jpg\)](#)

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



## Variables Used







- **a** Cumulative Angle (Degree)
- **A<sub>g</sub>** Gross Area of Cross-Section (Square Millimeter)
- **A<sub>p</sub>** Steel Area in Prestress (Square Millimeter)
- **A<sub>t</sub>** Transformed Area of Prestressed Member (Square Millimeter)
- **A<sub>T</sub>** Transformed Area of Concrete (Square Millimeter)
- **A<sub>Tendon</sub>** Tendon Area (Square Millimeter)
- **A<sub>s</sub>** Area of Prestressing Steel (Square Millimeter)
- **E<sub>s</sub>** Modulus of Elasticity of Steel Reinforcement (Megapascal)
- **F** Prestressing Force (Kilonewton)
- **k** Wobble Coefficient
- **l<sub>set</sub>** Settling Length (Meter)
- **m** Modular Ratio
- **N** Vertical Resultant (Kilonewton)
- **P** Prestressing force after Immediate Losses (Kilonewton)
- **P<sub>End</sub>** End Prestress Force (Kilonewton)
- **P<sub>x</sub>** Prestress Force at a Distance (Kilonewton)
- **PL<sub>Cable</sub>** Cable Length (Meter)
- **t** Age of Concrete (Day)
- **x** Distance from Left End (Millimeter)
- **Δ** Slip of Anchorage (Millimeter)
- **Δf<sub>loss</sub>** Loss in Prestress (Gigapascal)
- **Δf<sub>p</sub>** Prestress Drop (Megapascal)



- $\epsilon_{cr,ult}$  Ultimate Creep Strain
- $\epsilon_{el}$  Elastic Strain
- $\epsilon_{sh}$  Shrinkage Strain
- $\eta$  Simplified Term
- $\theta$  Subtended Angle in Degrees (*Degree*)
- $\mu_{friction}$  Prestress Friction Coefficient
- $\Phi$  Creep Coefficient of Prestress



## Constants, Functions, Measurements used

- **Function:** **asin**,  $\text{asin}(\text{Number})$   
*Inverse trigonometric sine function*
- **Function:** **exp**,  $\text{exp}(\text{Number})$   
*Exponential function*
- **Function:** **log10**,  $\text{log10}(\text{Number})$   
*Common logarithm function (base 10)*
- **Function:** **sin**,  $\text{sin}(\text{Angle})$   
*Trigonometric sine function*
- **Function:** **sqrt**,  $\text{sqrt}(\text{Number})$   
*Square root function*
- **Measurement:** **Length** in Millimeter (mm), Meter (m)  
*Length Unit Conversion* 
- **Measurement:** **Time** in Day (d)  
*Time Unit Conversion* 
- **Measurement:** **Area** in Square Millimeter ( $\text{mm}^2$ )  
*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 ( $^\circ$ )  
*Angle Unit Conversion* 



## Check other formula lists

- [Loss due to Anchorage Slip, Friction Loss and General Geometric Properties Formulas](#) 
- [Loss due to Elastic Shortening Formulas](#) 

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