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# Loss due to Elastic Shortening Formulas

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# List of 22 Loss due to Elastic Shortening Formulas

## Loss due to Elastic Shortening

### Post-Tensioned Members

#### 1) Area of Concrete Section given Prestress Drop

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

[Open Calculator !\[\]\(de95854c7ee024cfadc48187bbb781b2\_img.jpg\)](#)

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

#### 2) Average Stress for Parabolic Tendons

$$fx \quad f_{c,\text{avg}} = f_{c1} + \frac{2}{3} \cdot (f_{c2} - f_{c1})$$

[Open Calculator !\[\]\(6a9b39b98eb945faa14c645ec99e4eaa\_img.jpg\)](#)

$$ex \quad 10.202\text{MPa} = 10.006\text{MPa} + \frac{2}{3} \cdot (10.3\text{MPa} - 10.006\text{MPa})$$

#### 3) Change in Eccentricity of Tendon A due to Parabolic Shape

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

[Open Calculator !\[\]\(f1c5da15572e3e09d343161be98f508d\_img.jpg\)](#)

$$ex \quad 9.981\text{mm} = 20.001\text{mm} - 10.02\text{mm}$$



#### 4) Change in Eccentricity of Tendon B due to Parabolic Shape

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

[Open Calculator !\[\]\(cbe80b694ebd74fcfe136a095b608235\_img.jpg\)](#)

$$ex \quad 10.07\text{mm} = 20.1\text{mm} - 10.03\text{mm}$$

#### 5) Component of Strain at Level of First Tendon due to Bending

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

[Open Calculator !\[\]\(3e2231b1ad3ca8da8658228c00dd08e0\_img.jpg\)](#)

$$ex \quad 0.029412 = \frac{0.3\text{m}}{10.2\text{m}}$$

#### 6) Prestress Drop

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

[Open Calculator !\[\]\(0d5ec72f61334709c3fc9450209b754f\_img.jpg\)](#)

$$ex \quad 10\text{MPa} = 200000\text{MPa} \cdot 0.00005$$

#### 7) Prestress Drop given Modular Ratio

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

[Open Calculator !\[\]\(b64b40baaee5acddc1eab8538ba84754\_img.jpg\)](#)

$$ex \quad 9.96\text{MPa} = 0.6 \cdot 16.6\text{MPa}$$

#### 8) Prestress Drop given Strain due to Bending and Compression in Two Parabolic Tendons

$$fx \quad \Delta f_p = E_s \cdot (\varepsilon_{c1} + \varepsilon_{c2})$$

[Open Calculator !\[\]\(aff7c69c44a5e015f18c35867ef3f5c3\_img.jpg\)](#)

$$ex \quad 106000\text{MPa} = 200000\text{MPa} \cdot (0.5 + 0.03)$$



## 9) Prestress Drop given Stress in concrete at Same Level due to Prestressing Force

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

[Open Calculator !\[\]\(e78f798d4ea5c530c9db49e7d26e6b95\_img.jpg\)](#)

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

## 10) Prestress Drop when Two parabolic Tendons are Incorporated

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

[Open Calculator !\[\]\(05be7c7a8995decd503647c99211f7c2\_img.jpg\)](#)

$$ex \quad 9000\text{MPa} = 200000\text{MPa} \cdot 0.045$$

## 11) Stress in Concrete given Prestress Drop

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

[Open Calculator !\[\]\(fe3aebe81acea8d45108cd2768939da7\_img.jpg\)](#)

$$ex \quad 16.66667\text{MPa} = \frac{10\text{MPa}}{0.6}$$

## 12) Variation of Eccentricity of Tendon B

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

[Open Calculator !\[\]\(899d8b7697d64725bf017d3296cfcf1b\_img.jpg\)](#)

$$ex \quad 10.10914\text{mm} = 10.03\text{mm} + \left( 4 \cdot 20.0\text{mm} \cdot \frac{10.1\text{mm}}{10.2\text{m}} \right) \cdot \left( 1 - \left( \frac{10.1\text{mm}}{10.2\text{m}} \right) \right)$$



### 13) Variation of Eccentricity on Tendon A

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

[Open Calculator !\[\]\(e2376d476d06eb31946dc01a69a4403a\_img.jpg\)](#)

ex

$$10.05957\text{mm} = 10.02\text{mm} + \left(4 \cdot 10.0\text{mm} \cdot \frac{10.1\text{mm}}{10.2\text{m}}\right) \cdot \left(1 - \left(\frac{10.1\text{mm}}{10.2\text{m}}\right)\right)$$

### Pre-Tensioned Members

#### 14) Initial Prestress given Prestress after Immediate Loss

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

[Open Calculator !\[\]\(6bb0e4f14c4133b37d2887cb37e67ddd\_img.jpg\)](#)

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

#### 15) Initial Strain in Steel for Known Strain due to Elastic Shortening

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

[Open Calculator !\[\]\(799877f5c2f906134441300079881630\_img.jpg\)](#)

$$ex \quad 0.05 = 0.045 + 0.005$$


#### 16) Modular Ratio given Prestress after Immediate Loss

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

[Open Calculator !\[\]\(4436e6b00b9d5e62c2a161129eb3e4d0\_img.jpg\)](#)

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



17) Prestress Drop given Initial Prestress Force 

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

[Open Calculator !\[\]\(d3fb9f94af8b26d1c844efa9a98805b0\_img.jpg\)](#)

$$ex \quad 0.01044 \text{MPa} = 435 \text{kN} \cdot \frac{0.6}{0.025 \text{mm}^2}$$

18) Prestress Drop given Pressure after Immediate Loss 

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

[Open Calculator !\[\]\(e1d6102fe77919492c04879c8450f1f5\_img.jpg\)](#)

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

19) Prestressing Force after Immediate Loss given Initial Prestress 

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

[Open Calculator !\[\]\(ab4e2b3fc7e7887b7a72f548aa6f5e60\_img.jpg\)](#)

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

20) Residual Strain in Steel for Known Strain due to Elastic Shortening 

$$fx \quad \epsilon_{po} = \epsilon_{pi} - \epsilon_c$$

[Open Calculator !\[\]\(5abce1a84a655b073239ab33e1199487\_img.jpg\)](#)

$$ex \quad 0.005 = 0.05 - 0.045$$



## 21) Strain in Concrete due to Elastic Shortening

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

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

$$ex \quad 0.045 = 0.05 - 0.005$$

## 22) Transformed Area of Prestress Member for Known Pressure Drop

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

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

$$ex \quad 0.01305\text{mm}^2 = 0.6 \cdot \frac{435\text{kN}}{0.02\text{MPa}}$$



## Variables Used

- $A_c$  Concrete Occupied Area (Square Meter)
- $A_{\text{Pre tension}}$  Pre-Tensioned Area of Concrete (Square Millimeter)
- $A_{\text{Pretension}}$  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)
- $E_{\text{concrete}}$  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)
- $f_{\text{concrete}}$  Stress in Concrete Section (Megapascal)
- $L$  Length of Beam in Prestress (Meter)
- $m_{\text{Elastic}}$  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)
- $\Delta e_A$  Change in Eccentricity at A (Millimeter)









- $\Delta e_B$  Change in Eccentricity B (Millimeter)
- $\Delta f_{Drop}$  Drop in Prestress (Megapascal)
- $\Delta f_p$  Prestress Drop (Megapascal)
- $\Delta L$  Change in Length Dimension (Meter)
- $\Delta \epsilon_p$  Change in Strain
- $\epsilon_c$  Concrete Strain
- $\epsilon_{c1}$  Strain due to Compression
- $\epsilon_{c2}$  Strain due to Bending
- $\epsilon_{pi}$  Initial Strain
- $\epsilon_{po}$  Residual Strain



## Constants, Functions, Measurements used

- **Measurement: Length** in Millimeter (mm), Meter (m)  
*Length Unit Conversion* 
- **Measurement: Area** in Square Meter (m<sup>2</sup>), Square Millimeter (mm<sup>2</sup>)  
*Area Unit Conversion* 
- **Measurement: Pressure** in Megapascal (MPa)  
*Pressure Unit Conversion* 
- **Measurement: Force** in Kilonewton (kN)  
*Force 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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