

CUSTOMER SUPPORT NOTE

Prestress Wizard Glossary

Note Number:	CSN/LUSAS/1026
--------------	-----------------------

This support note is issued as a guideline only.



Forge House, 66 High Street, Kingston upon Thames, Surrey, KT1 1HN, UK
Tel: +44 (0)20 8541 1999 Fax: +44 (0)20 8549 9399
Email: info@lusas.com www.lusas.com

Introduction

This note explains the various inputs required for use of the LUSAS Prestress Wizard facilities. It is specifically written with reference to prestressing to Eurocodes, but most of the information is also applicable to the AASHTO and British Standard options. The order of the inputs defined corresponds to the order in which they are presented in the Multiple Tendon Wizard, but the names and definitions also correspond to those in the Single Tendon Wizard.

Please see the **Application Manual (Bridge, Civil and Structural)>Prestress Loading** for more information.

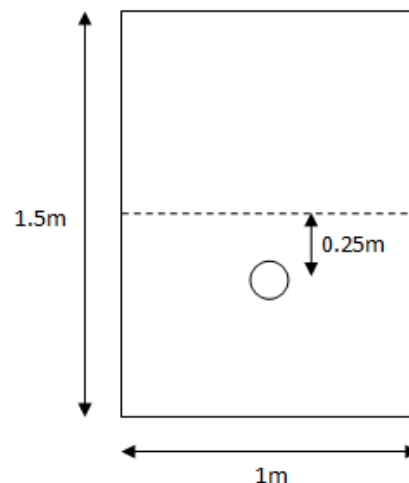
Description

Tendon area – the cross-sectional area of the tendon. Entered in mm^2 .

Modulus of elasticity for tendon – The “Design value of modulus of elasticity of prestressing steel”, entered in units of kN/m^2 . Typically 195GPa (i.e. $195\text{E}6 \text{ kN/m}^2$) from EN 1992-1-1 clause 3.3.6(3) for strand.

Concrete stress at transfer – Total in-service stress in the concrete adjacent to the tendon in question, due to prestressing forces and self-weight. Units of kN/m^2 . If this varies along the length of the tendon (in general it will) an average value should be used. This value is used for the calculation of elastic shortening and creep losses.

As an example, consider a 20m long simply supported beam, of section 1m wide by 1.5m deep, with a straight tendon of average force 5000kN (after losses) located 0.25m below the centroid of the section. There are two components of the stress in the concrete: stress due to self weight and stress due to prestress.



$$\text{Area} = 1 \times 1.5 = 1.5\text{m}^2$$

Assume density of RC to be $25\text{kN/m}^3 \rightarrow 1.5 \times 25 = 37.5\text{kN/m}$ self weight

$$\text{Midspan moment} = wL^2/8 = 37.5 \times 20^2 / 8 = 1875\text{kNm}$$

Bending moment diagram is parabolic, therefore average bending moment
 $= 2/3 \times 1875 = 1250\text{kNm}$

$$I_{zz} = b.d^3/12 = 1 \times 1.5^3 / 12 = 0.281\text{m}^4$$

Stress at tendon location due to moment $= M.y/I = 1250 \times 0.25 / 0.281 = 1112\text{kN/m}^2$

Therefore the stress due to self weight is 1112kN/m^2 (tensile).

The prestress has two effects on the section – an axial force and a moment.

The stress due to the axial force is calculated by $P/A = 5000/1.5 = -3333\text{kN/m}^2$ (compressive).

The moment due to the eccentricity of the tendon is $P.e = 5000 \times 0.25 = 1250\text{kNm}$

The stress due to this moment is $M.y/I = 1250 \times 0.25 / 0.281 = -1112\text{kN/m}^2$ (compressive).

Therefore the stress due to prestress is -4445kN/m^2 (compressive)

Therefore the total stress in the concrete adjacent to the tendon is $1112 - 4445 = -3333\text{kN/m}^2$ (compressive)

NOTE: Stress at transfer is input as a **positive number** (i.e. 3333kN/m^2) in the LUSAS dialog which by default it is assumed to be compressive.

Modulus of elasticity for concrete at transfer – $E_{cm}(t)$ (see EN1992-1-1 clause 5.10.5.1(2)).

$E_{cm}(t)$ is defined as “the secant modulus of elasticity of concrete at time t”. From clause 5.10.3, time $t=t_0$ (immediately after tensioning and anchoring) should be used for this calculation. That means “t” should reflect the age of the concrete at the time of stressing being applied e.g. 7 days. So take the 28-day Young’s Modulus from EN1992-1-1 Table 3.1 and adjust it according to clause 3.1.3(3). It should be remembered that the strength of prestressed concrete components do not, like reinforced concrete, rely on bond strength and hence they may be struck after shorter times, e.g. 36 hours rather than, say, 14 days for RC beams.

e.g. Typical $f_{ck}=40\text{MPa}$; from Table 3.1 $f_{cm}=48\text{MPa}$, $E_{cm}=35\text{GPa}$

Then from clause 3.1.2(6) $f_{cm}(7)=0.77*48=37.4\text{MPa}$. And from clause 3.1.3(3) $E_{cm}(7)=(37.4/48)0.335=32.5\text{GPa}$

Unintentional angular displacement – The value entered here is k, used in the calculation of losses due to friction according to EN1992-1-1 clause 5.10.5.2 – for the component sometimes referred to as “wobble” loss. It is also used in the calculation of anchorage losses. k is defined as “an unintentional angular displacement for internal tendons (per unit length)”. Units of radians/m. EN1992-1-1 clause 5.10.5.2(3), gives the range $0.005 < k(\text{Euro}) < 0.01$ radians per metre

Duct friction coefficient – The coefficient of friction between the tendons and the duct. Suitable values for internal tendons may be taken from EN1992-1-1 Table 5.1. Typical (strand) $\mu = 0.19$

Tensile strength of prestressing steel - This value is used for the calculation of the absolute value of relaxation losses to EN1992-1-1 clause 3.3.2(7) and incorporated into the time dependent loss calculation of clause 5.10.6(2).

Relaxation class - This is used along with f_{pk} to calculate relaxation losses. Classes 1, 2 and 3 are defined in EN1992-1-1 clause 3.3.2(4).

Relaxation loss at 1000 hours – The loss in steel stress caused by relaxation of the strands. This value generally depends on the stress level in the tendon and is often published by the tendon manufacturer.

Time after tensioning (for relaxation calcs) - This is used along with “Tensile strength of prestressing steel”, “Relaxation Class” and “Relaxation loss at 1000 hours” to calculate relaxation losses. According to EN1992-1-1 clause 3.3.2(8), long term (final) values of the relaxation losses may be estimated for a time t equal to 500 000 hours (i.e. around 57 years).

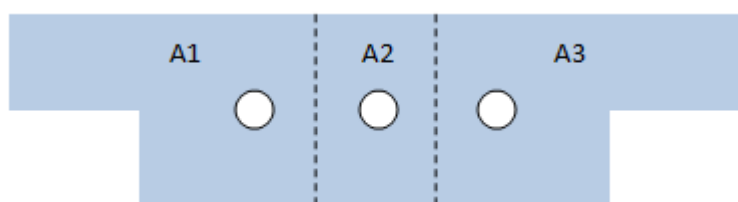
Shrinkage strain – The expected shrinkage strain in the concrete, in ‘per mil’ (i.e. thousandths). For example the default value of -0.4 actually means a strain of $-0.4E-3$. The actual value for ϵ_{cs} entered by the user should be calculated from EN1992-1-1 clause 3.1.4(6), and depends on notional size, relative humidity, concrete strength and cement class.

Creep coefficient – The value entered here is $\phi(t,t_0)$, in the calculation of losses due to creep according to EN1992-1-1 clause 5.10.6(2). The actual value for $\phi(t,t_0)$ entered by the user should be calculated from EN1992-1-1 clause 3.1.4(2), dependent upon notional size, relative humidity, concrete strength, cement class and maturity of the concrete when the load is first applied – see Figure 3.1.

Secant modulus of elasticity for concrete – E_{cm} , the secant modulus of elasticity of concrete from EN1992-1-1 Table 3.1.

Change in stress due to loads after transfer – This is used to adjust “Concrete stress at transfer” according to permanent loads applied after transfer, to give the concrete stress appropriate for the calculation of the creep component of time-dependent losses according to EN1992-1-1 clause 5.10.6(2) i.e. $\sigma_{c,QP} = \Delta\sigma_c(t) + \Delta\sigma_{cg}$. Note that $\Delta\sigma_{cg}$ is typically negative since applied loads oppose the prestress which dominates $\Delta\sigma_c(t)$.

Area of concrete section – The area of the concrete member to which the prestress forces will be applied. If the member is a standalone beam element, the area of the beam should be used. If the beam member represents part of a larger structure (for example a certain width of slab) then only the area of the portion represented by this particular beam member should be used. Please note that the prestress wizard is designed to work for a single beam member, not for a subdivided portion of slab or wide beam element, so using it in this way is at the engineer’s judgment.



Second moment of area of concrete – The second moment of area of the concrete area described in the last definition.

Prestress force – The jacking force in the tendon or total force in the group of tendons, entered in kN.

Jacking angle – The angle between the line of the tendon at the jacking point and the jack used to tension it. If the jack is angled to be in line with the tendon (as is usual) a value of zero should be entered. Entered in degrees.

Jacking slip – The expected slip of the tendon when ‘locking off’ the tendon. Typically a few millimetres, but entered here in metres (e.g. 0.008).

Compute loading (tick box) – Leave this ticked for the wizard to compute loading when you click 'finish'. You would only want to untick this if you want to exit the wizard to change something in the model before calculating loading later on.

Generate graph datasets (tick box) – If this box is ticked, the wizard will calculate sets of data which can be graphed using the inbuilt graph wizard. It is usually a good idea to tick this and check the graphs for unusual sudden drops in tendon force, which can indicate a problem with the tendon profile definition.

Generate report (tick box) – Leave this box ticked for the prestress report to be generated when the wizard is run. The report includes all of the input data and tendon profiles, forces and losses for inclusion in calculations.