

Tutorial Sheet : Prestressed Concrete, Chapter 2 -

Exercise 1:

A concrete beam is subjected to a prestressing force of $P = 100$ kN, applied when the concrete compressive strength reaches 25 MPa. The characteristic compressive strength of the concrete at 28 days is $f_{c28} = 35$ MPa, the following is required:

1. Estimate the time (in hours) needed to reach 25 MPa.
2. Determine the compressive strength at ages $j = 3, 7$ and 90 days.
3. Evaluate tensile strength for these same ages.
4. Calculate the instantaneous longitudinal deformation modulus at $j = 3, 7$ and 90 days.

Exercise 2:

A rectangular concrete beam (250×400 mm²) is subjected to a centered prestressing load. Two cases are considered:

- **Mild steel** : Tensile stress under tension $\sigma_{s0} = 300$ MPa.
- **High-strength steel** : Tensile stress under tension $\sigma_{p0} = 1500$ MPa.

The initial prestressing force is $P_0 = 400$ kN. We are given: $E_s = E_p = 200\,000$ MPa, $E_b = 27\,500$ MPa, and $\varepsilon_d = 5 \times 10^{-4}$ (the deformation due to shrinkage and creep).

We are asked to:

1. The residual steel strain after concrete shortening.
2. The residual prestressing force (P) after accounting for concrete shortening for each type of steel.

Exercise 3:

Concrete is placed in a temperate dry climate (Zone B) with the following properties:

- Characteristic compressive strength at 28 days: $f_{c28} = 40$ MPa.
- Age of concrete at loading: $t_1 = 7$ days.
- Applied compressive stress: $\sigma_1 = 12$ MPa.
- Mean radius of the member: $r_m = 6$ cm.

Determine:

1. The ultimate shrinkage strain ε_r corresponding to the climatic zone.
2. The instantaneous strain ε_i produced by the applied stress.
3. The creep strain ε_f after **180 days** of sustained loading.

Exercise 4:

A prestressing strand consists of 19 identical wires, each having a diameter of 7 mm and an ultimate tensile strength of $f_{pu} = 1750$ MPa.

1. Verify the number of wires forming the strand.
2. Calculate the total steel cross-sectional area of the strand.
3. Estimate the theoretical ultimate tensile capacity of the strand.

Exercise 5:

A strength concrete $f_{c28} = 35$ MPa is tensioned by a $j = 2$ perforated cable, with a prestressing force $P = 500$ kN. We consider:

- Concrete maturation law (Eq. 2.1) for f_{cj} .
- Modulus of elasticity of concrete $E_j = 11000 f_{cj}^{1/3}$.
- Concrete section $A_c = 0,20$ m².

Determine:

1. The compressive strength of the concrete at 2 days.
2. Verify whether the concrete can safely withstand the prestressing force without cracking.
3. Discuss the evolution of the concrete stresses when the concrete reaches an age of 28 days.