BAT2 EXERCISE: COMPOSITE BEAM

(2 PROBLEMS, 1 TO SOLVE, 2 TO STUDY WITH SOLUTION)

Problem 1, secondary beam

Data

The structural system is a building floor consisting of a mixed slab, supported by secondary (2m apart) and main beams located at the same level. The secondary beams were pre-dimensioned as IPE 330 in structural steel S235. The static system of those composite beams is equivalent to a single span beam with a span of 10 m, see Figure 1.1.

The profiled sheetings are laid and nailed to the secondary beams, with the sheetings interrupted on each beam (see fig. 1.2). The sheetings are Cofrastra 40/0.75, steel SE 320 G (f_{yp} = 320 N/mm^2), height h_p = 40 mm, b_0 = 102.5 mm, A_p = 1184 mm^2 . They form a diaphragm that stabilises the beams horizontally. Total thickness: h_c = 100 mm.

Concrete: C25/30 (f_{ck} = 25 N/mm^2 , E_{cm} = 34.4 kN/m^2).

Reinforcement: welded mesh, diameter 4 mm, s = 100 mm, B500B steel (f_{sk} = 500 N/mm^2).

The design values for internal forces (under uniform loads, moment given at mid-span, shear force at supports) are as follows:

Construction stage: M_{Ed} = 131.4 kNm

V_{Ed} = 58.8 kN

Final stage : M_{Ed} = 269.2 kN

V_{Ed} = 104.2 kN

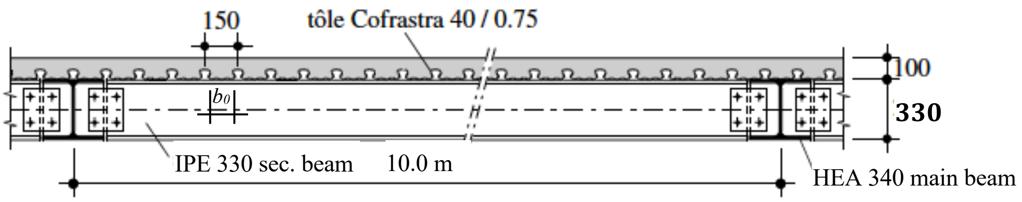


***Figure 1.1 -** Beam system, elevation view of the secondary beams*

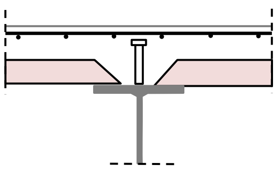


***Figure 1.2 -** Cross-section of a secondary beam (with the sheeting in pink)*

Questions

1. Check the structural safety of secondary beams at the construction stage, EE calculation
2. Check the structural safety of the secondary beams at the final stage, EP calculation

Problem 2, continuous main beams over 3 bays (TGC11 § 10.7.3)

Data

The building used in the one in BAT1 problem 3 (see also TGC11 § 6.9.3); it is shown again in Figure 2.1 below. We're going to look at the deck main beams of an office floor. It is made up of a mixed slab, resting on second. and main beams. The top flanges of the secondary and main beams are located at the same level (see Fig. 2.2). It is assumed that the reaction of the sec. beams on the main beams can be simplified as a uniformly distributed load. The characteristic values of the actions, as well as the load cases to be considered, are defined below. For your convenience, the values of the corresponding internal forces are also given. The participating slab width is determined according to the definition in EN 1994-1-1.

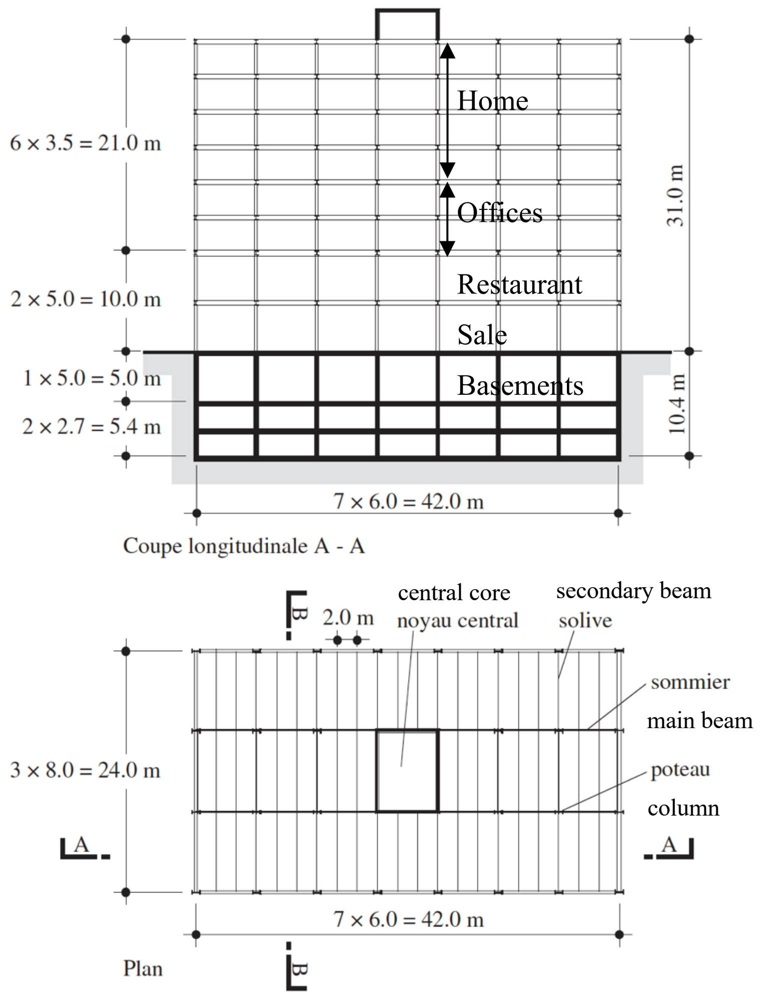


***Figure 2.1** - Load-bearing structure of the building*

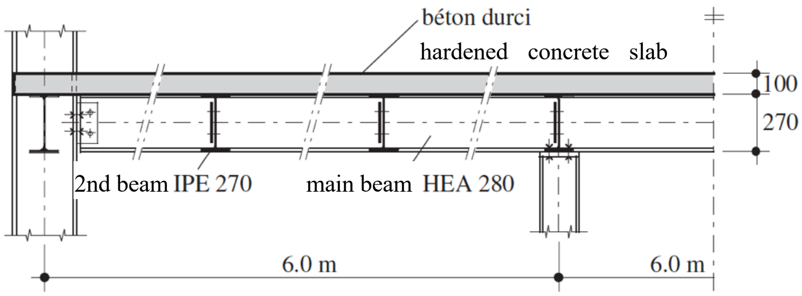


***Figure 2.2** - Mixed floor supports*

Sommiers	:	HEA 280 en acier S 235 ($f_{ya} = 235$ N/mm²), $g_a = 0.764$ kN/m
Solives	:	IPE 270 en acier S 235 ($f_{ya} = 235$ N/mm²), $g_a = 0.361$ kN/m
Dalle mixte	:	Tôle profilée Cofrastra 40/0.75, acier S 350 GD ($f_{yp} = 350$ N/mm²)
		Epaisseur totale : $h = 100$ mm
		Epaisseur équivalente : $h_{eq} = 86.4$ mm
		Béton : C25/30 ($f_{ck} = 25$ N/mm², $E_m = k_E \sqrt[3]{f_{cm}} = 34.4$ kN/mm²)
		Armature : treillis soudé 4 mm, $s = 100$ mm, acier B500B ($f_{sk} = 500$ N/mm²) ;
		Armature sur appui : barres en acier B500B ($f_{sk} = 500$ N/mm²)
Connexion	:	Goujons : $d_D = 16$ mm, $h_D = 75$ mm, acier S 235 J2, formé à froid ($f_{uB} = 450$ N/mm²)

Valeurs caractéristiques des actions à considérer

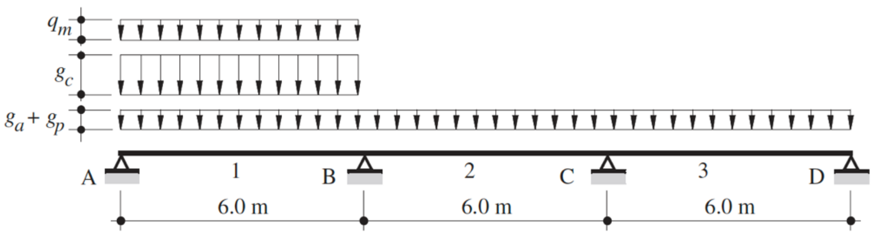
- Stade de construction
  - Poids propre des sommiers et solives : $g_a = 0.764 \text{ kN/m} + \left(\dfrac{0.361 \text{ kN/m} \cdot 8 \text{ m}}{2 \text{ m}}\right) = 2.2 \text{ kN/m}$
  - Poids de la tôle : $g_p = 0.099 \text{ kN/m}^2 \cdot 8 \text{ m} = 0.8 \text{ kN/m}$
  - Poids du béton frais : $g_c = 2.25 \text{ kN/m}^2 \cdot 8 \text{ m} = 18 \text{ kN/m}$
  - Charge de construction : $q_m = 2 \text{ kN/m}$
- Stade définitif
  - Poids propre des sommiers et solives : $g_a = 2.2 \text{ kN/m}$
  - Poids propre de la dalle (tôle + béton) : $g_b = g_p + g_c = 18.8 \text{ kN/m}$
  - Poids des finitions : $g_{fin} = 1.6 \text{ kN/m}^2 \cdot 8 \text{ m} = 12.8 \text{ kN/m}$
  - Charge utile : $q_k = 3.0 \text{ kN/m}^2 \cdot 8 \text{ m} = 24 \text{ kN/m}$

Situations de risque et cas de charge

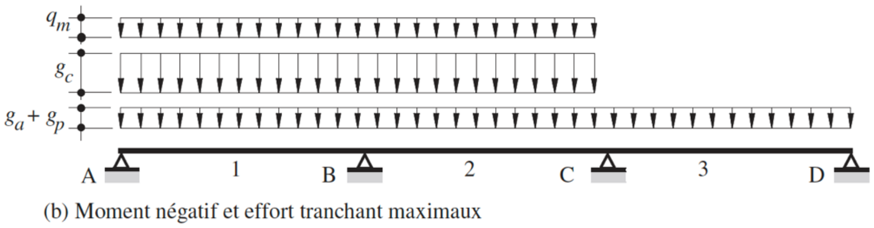
- Stade de construction
  Le sommier est soumis à une situation de risque : charge de construction prépondérante.
  Le cas de charge correspondant est donné par (état-limite type 2) :
  $E_d = E\{\gamma_G(g_a + g_p + g_c) + \gamma_Q q_m\}$
- Stade définitif
  La poutre mixte est soumise à une seule situation de risque : charge utile prépondérante.
  Le cas de charge correspondant est donné par (état-limite type 2) :
  $E_d = E\{\gamma_G(g_a + g_b + g_{fin}) + \gamma_Q q_k\}$

Valeurs de calcul des efforts intérieurs

- Stade de construction
  Calcul élastique des efforts
  Situation de risque : charge de construction prépondérante



(a) Moment positif maximal



(b) Moment négatif et effort tranchant maximaux

Questions

1. Check the local buckling and lateral torsional buckling criteria of the main beams
2. Determining internal forces and check structural safety at the construction stage
3. Determine the internal forces at the final stage, for an EP calculation with redistribution
4. Check structural safety at the final stage, EP calculation
5. Check the deflections at the construction and final stages.