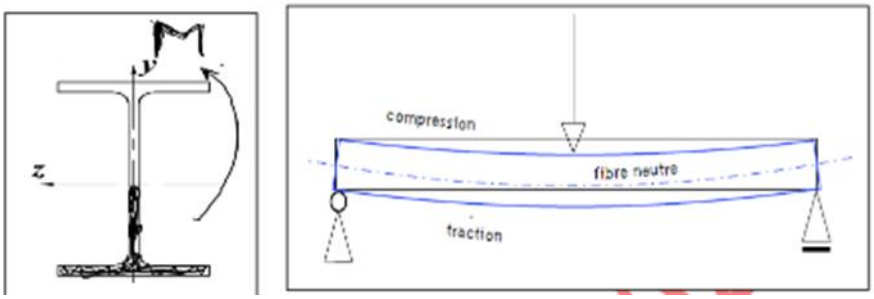
Chapter 5: Calculation of Flexed Elements

The elements subjected to simple bending in metal structures are
generally the beams that transmit the loads distributed on the floors to the columns. The bending can be mono axial if it has a single direction (a single plane of application), as it can be biaxial if applied on two planes, it is the deflected bending.

1- Definition

A bending moment (M), is a moment that causes the beam to bend and separate the cross-section in two parts; one compressed and the other tense).



2. CALCULATION AND VERIFICATION ACCORDING TO EC3

Let be a section stressed to simple bending in a single direction.
The rules of the MDR are used to search for the critical section that corresponds to the maximum moment (M), of course, after having determined the combinations of loads most unfavorable to the ULS . we identify critical (hazardous) cross-sections for each load as well as max moment (Mmax), max shear force (Vmax) and Max Deflection (Fmax).
There are two cases:

1- Bending moment alone (without shear effort, i.e. (M≠0 and V=0))

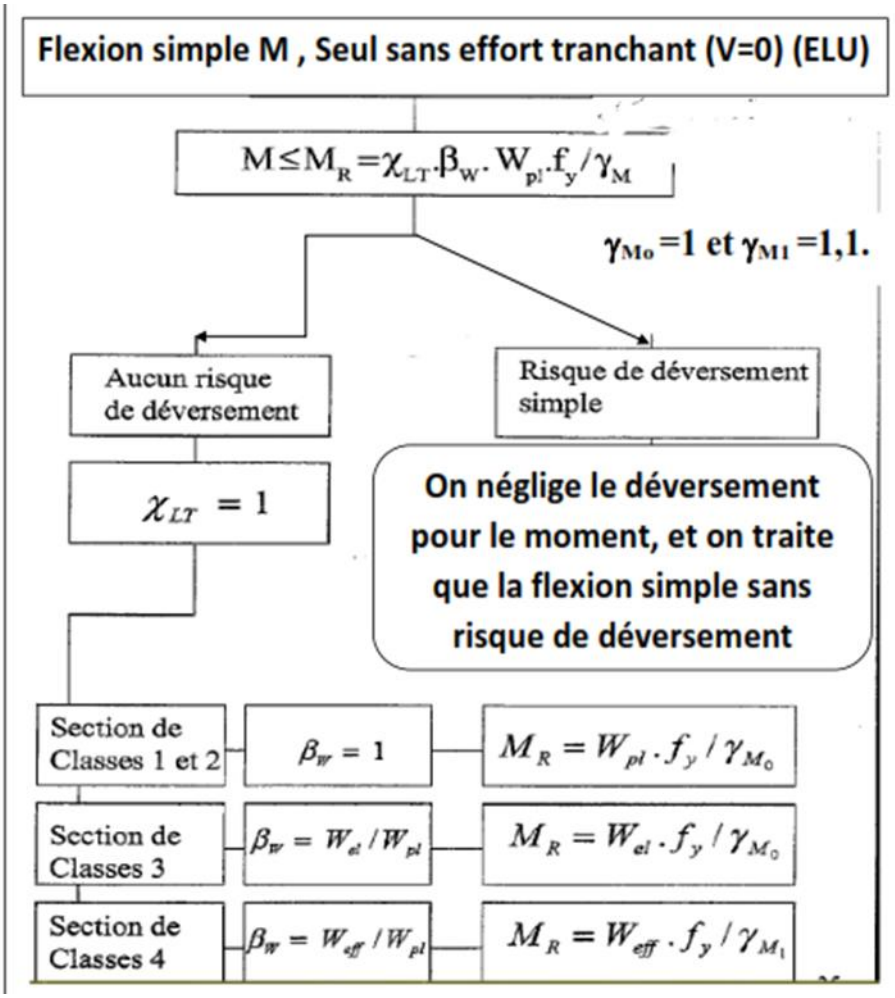
2- Bending moment with shear force (at the same time), i.e. (M≠0 and V≠0) .

The EC3 design is carried out according to the limit states
Ø The ultimate limit state (ULS), a condition of resistance.
Ø the serviceability limit state (ELS), deflection condition.

2.1. VERIFICATION BY THE ELECTED OFFICIAL

2.1.1. MOMENT ALONE CASE (SHEAR FORCE V=0)

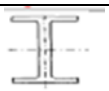
In this case, for the section to be resistant, this max moment (M), must Check the conditions listed in the following summary flowchart:



NB: The right side of the organizational chart does not concern us for the moment because it is dealing with the spill, so it will be neglected.

- The classes of the cross-sections used in the beams (IPE and HEA) are given in the tables **(pages 29, 30chapter 2),** and they are all classes 1 and 2 with a few exceptions. So we limit ourselves to calculating for Classes 1, 2 and 3
- Class 4 sections will not be treated at this time.
- The partial safety coefficients: γMB = 1 and M1=1.1.
- The geometrical characteristics of the sections (Wel and Wpl) are given in tables I (**at the end of the chapter)**

- We take (Wely or Welz) or (Wply or Wplz), depending on the layout of the section:

Common case (the most common meaning Resistant: max inertia with respect to yy)		W_{ely} ou W_{ply}
Rare case (the direction of low inertia with respect to zz)		W_{elz} ou W_{plz}

2.1.2. DEFLECTION CHECK (at the SLE)

- The max deflection (*f*max) must check the following condition:

***f*max = *f*adm**

- **the deflection (f max) is calculated by combinations of the loads at the ELS, without any increases in charges.**
- the deflection (*f* max) is calculated by the forms given by the RDM according to the state of the loads and the nature of the supports **(see Table II)**
- the permissible deflection (*f*adm) is given according to the nature of the element

Structural as a function of beam length (*L)*

Cas de structure	Flèche admissible max (δ adm)
Toitures en général	$\frac{\ell}{200}$
Toitures supportant fréquemment du personnel d'entretien	$\frac{\ell}{250}$
Planchers en général	$\frac{\ell}{250}$
Planchers et toitures supportant des cloisons en plâtre	$\frac{\ell}{250}$
Planchers supportant des poteaux	$\frac{\ell}{400}$

2.1.3. VERIFICATION OF THE SHEAR FORCE ALONE (M=0 and V≠0) (to the ELECT)

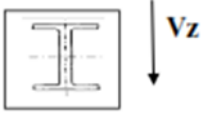
Let (V) be the maximum shear force **(Table II)** this force must satisfy the The following condition:

Effort tranchant V

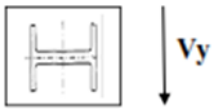
$$V \le V_{pl} \text{ avec } V_{pl} = (f_y \cdot A_V)/(\sqrt{3} \cdot \gamma_{M_0})$$

Av: the area of the section stressed to the shear force, it is given to the tables of the geometric characteristics of the sections**; (Table I)**

Ø **We take Av(z) if the cross-section is in the direction of max inertia if:**

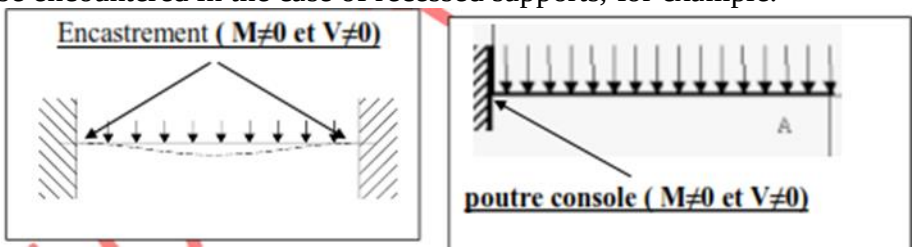


Ø **We take Av(y) if the cross-section is in the direction of inertia min if:**

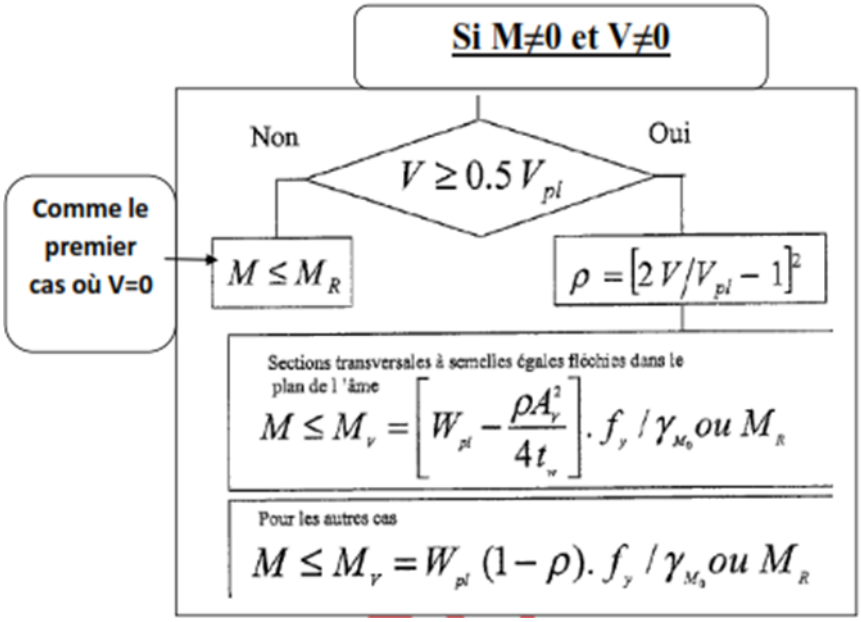


2.1.4. CURRENT CASE WITH SHEAR FORCE (M≠0 AND V≠0)

This case can be encountered in the case of recessed supports, for example:

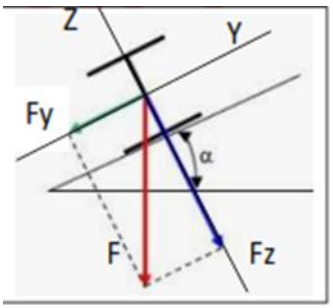


In this case, the verification of the resistance to the bending moment will be like follows:



3. DEFLECTED BENDING (BI-AXIAL OR OBLIQUE) (ELECTED)

The bending is said to be deflected, if it has two planes of action. It is due to the deflection or composition of the load or the inclination of the section or the Two moments in two different shots.



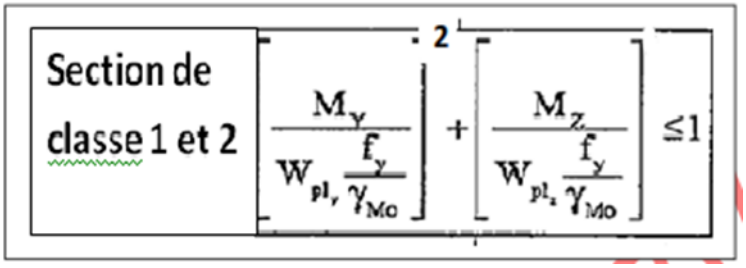
Fy=Fsinα et Fz=Fcosα

Fy ⟶ Mz

Fz ⟶ My

3.1. CALCULATION AND VERIFICATION

For sections in: IPE and HEA class 1 or 2 we must check:



3.2. DEFLECTION VERIFICATION (SLS)

We must check

***f*max = *f*adm**

- **Il faut vérifier chaque flèche à part :**
- **Sens (y) on a δy calculée par (Fz et Iz)**
- **Sens (Z) on a δz calculée par (Fy et Iz)**