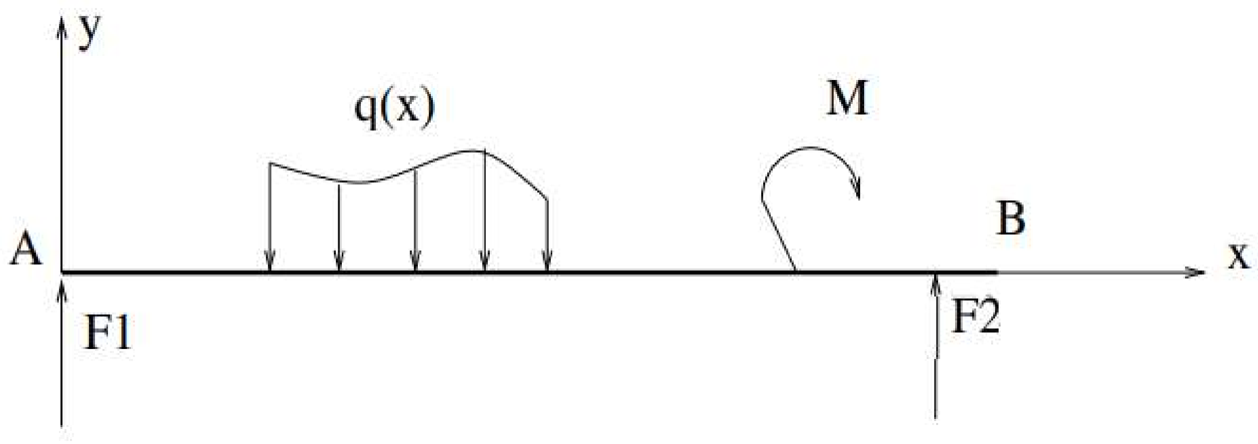
Chapter 5
Simple plane Bending

1.Definition

A beam is in plane bending when all the external forces are perpendicular to the mean line, and all external moments are around the z axis.



A beam is considered to be subjected to simple plane bending if:

- ❑ The system of external forces reduces to a planar system.
- ❑ The forces are perpendicular to the mean line. A beam is therefore subject to simple bending if its cohesion torsor is

$$\tau_{coh} = \begin{Bmatrix} N = 0 \\ T \neq 0 \\ M_f \neq 0 \end{Bmatrix}$$

Simple bending is a load condition such that in any straight section beam, there is only one bending moment $\boldsymbol{M_f}$ and one shear force $\boldsymbol{T}$

Internal forces

In plane bending, N is always null, and M_f and T are generally non-null.

Additional hypotheses specific to bending

- The mean line of the beam is straight
- The beam has a plane of symmetry
- All forces applied to the beam are:
  - Perpendicular to the mean line
  - Located in the longitudinal plane of symmetry or symmetrically distributed in relation to it
  - Concentrated at one point or distributed according to a specific law.

Determining internal forces:

Since the objective is to dimension a beam, it is necessary to define the maximum stresses to be applied.

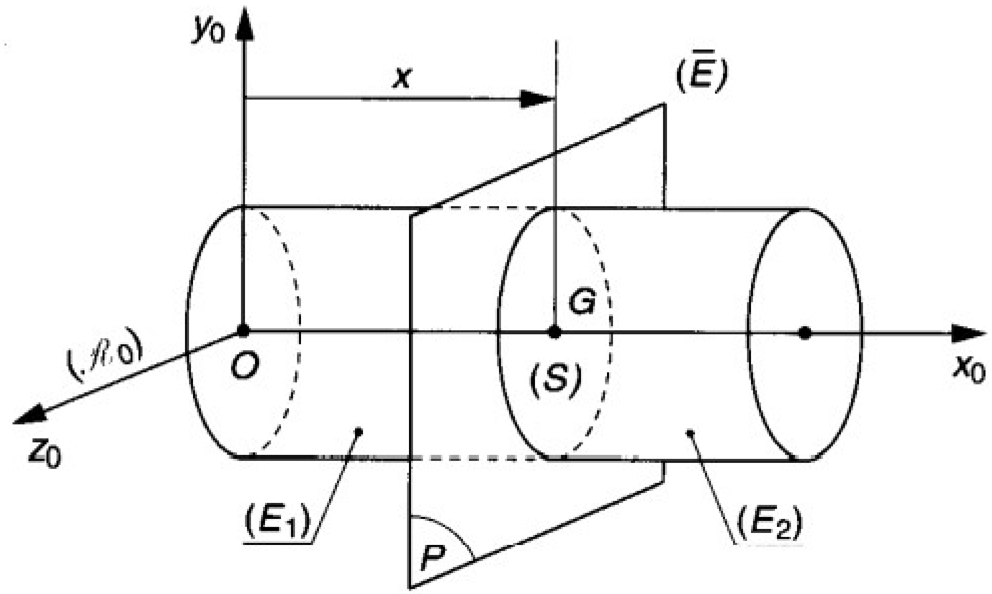
To do this, we need to draw internal stress diagrams also known as cohesive force diagrams.

How to determine the cohesive forces?

Section method

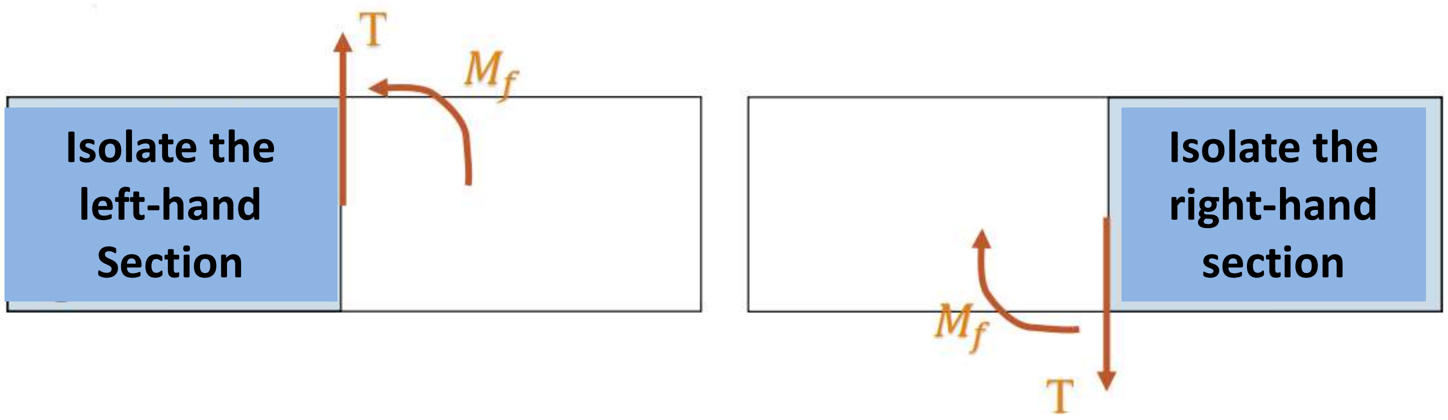
Determining internal forces

- Isolate the complete structure and determine the unknown links
- Identify all external actions
- Make a cut in a section



Determination of internal forces

Isolate the left-hand section or the right-hand section



Between the left-hand section and the right-hand section, a connecting link transmits three action components:

$T(x)$: Shearing force

$M_f(x)$: Bending moment

In the case of simple bending $N(x)=0$

Determination of internal forces

Apply the fundamental principle of static (PFS) to the isolated section

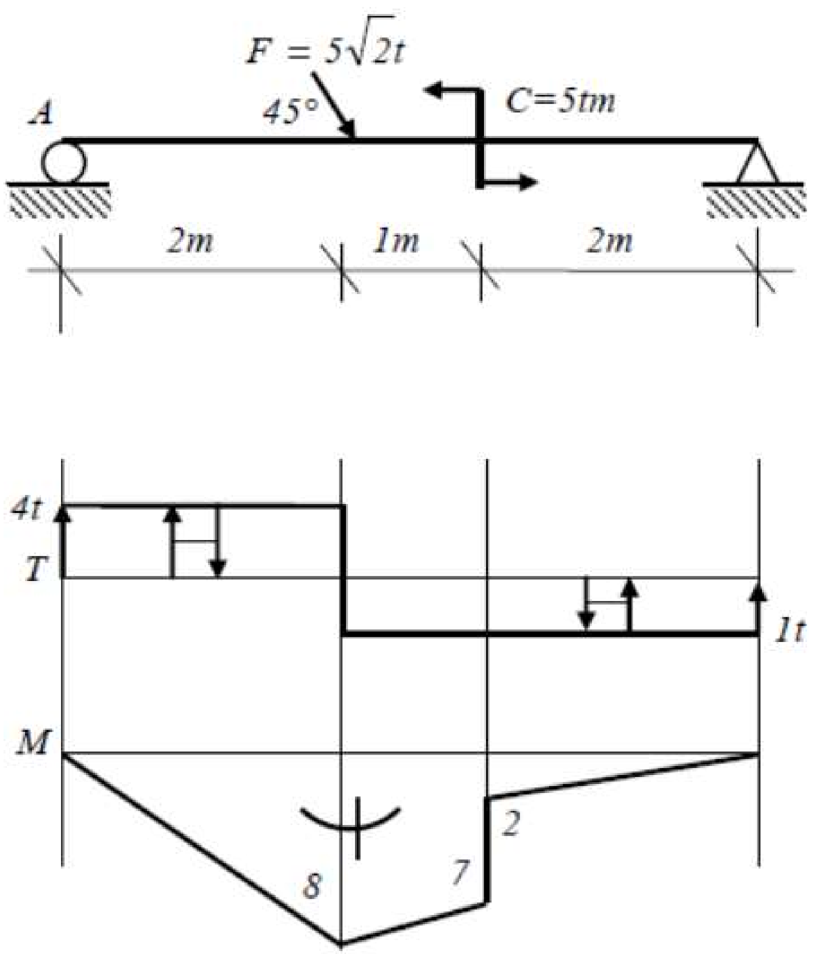
$$T(x) = -\sum F_{exty} \text{ of the left-hand Section } = \sum F_{exty} \text{ of the right-hand Section}$$

$$M_f(x) = -\sum M_{F/p} \text{ of the left-hand Section } = \sum M_{F/p} \text{ of the right-hand Section}$$

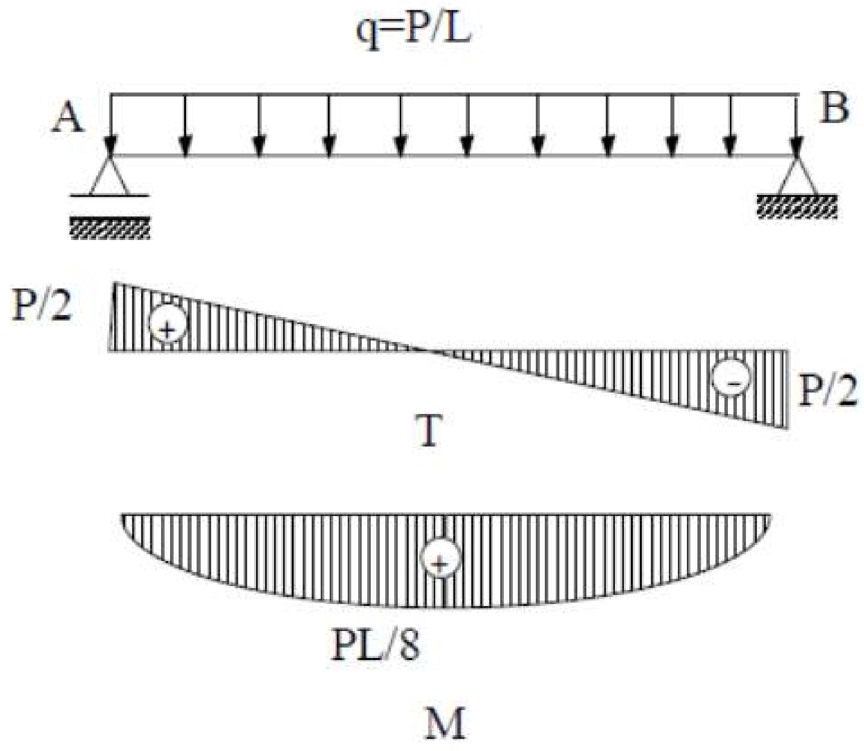
Repeat the cuts as many times as necessary to cover the entire beam and finish by plotting the diagrams of the internal forces T and M as a function of x (abscissa of the centre of gravity of the section where the cut is made)

Control of T and M diagrams

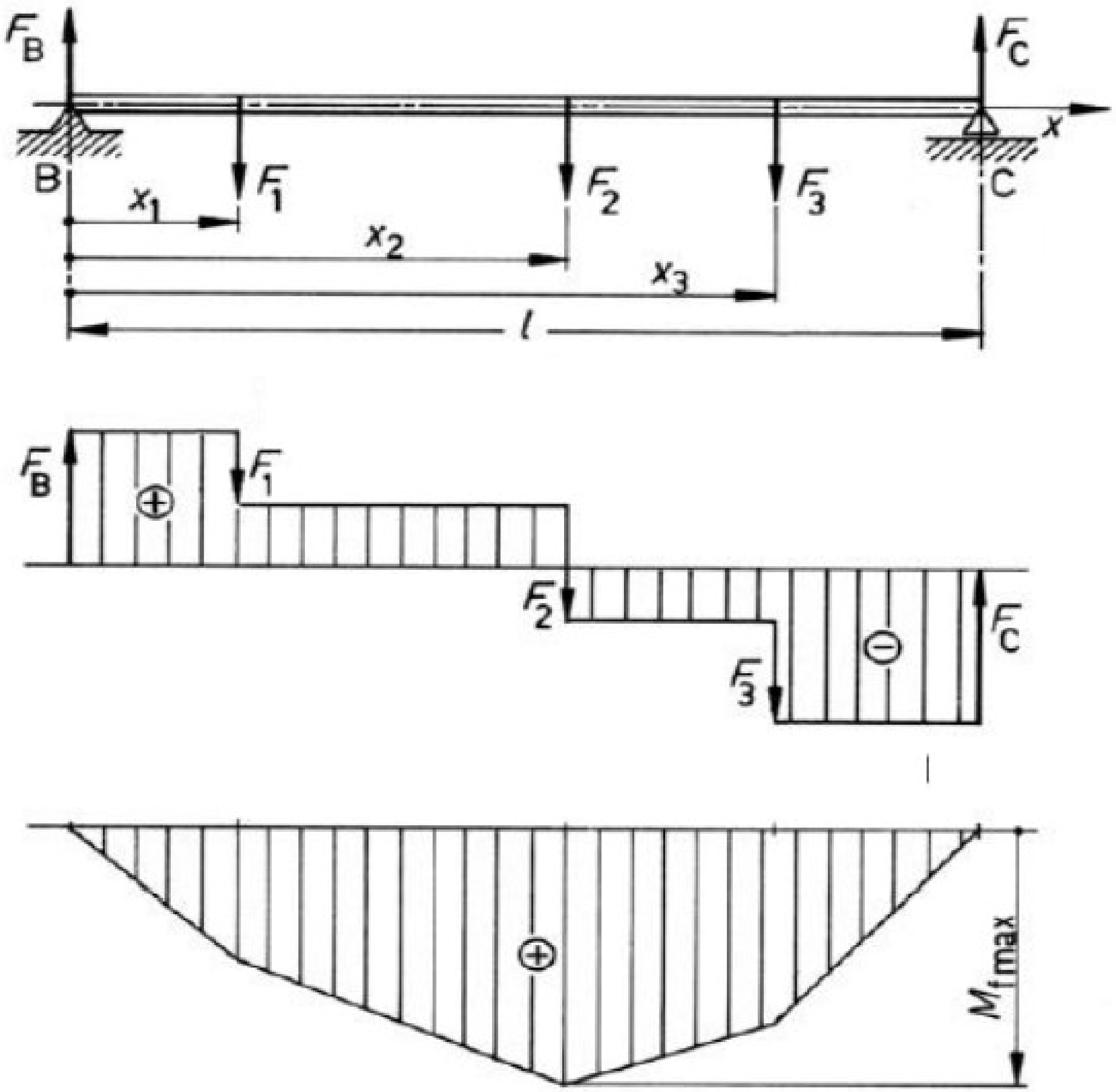
- Where T is zero, M has a maximum value.
- Where T crosses zero discontinuously, the M diagram loses its monotonic shape.
- In sections where concentrated loads are applied T is subjected to a jump, the diagram of M presents an angular point (M changes slope).
- In sections where concentrated moments are applied M is subject to a jump in proportion to these moments, whereas T will not change.
- The M diagram of a symmetrical system (geometry and loading) is symmetrical, while that of T is antisymmetric



F = 5√2t
45°
C=5tm
A
2m
1m
2m
4t
T
1t
M
8
7
2



q=P/L
A
B
P/2
P/2
T
PL/8
M



F_B
F_C
x
B
C
F_1
F_2
F_3
x_1
x_2
x_3
l
F_B
F_1
⊕
F_2
F_3
⊖
F_C
⊕
M_f max