

Deformation signs

In order to interpret the signs in the normal force, shear force and bending moment diagrams correctly, one has to know the orientation of the coordinate system and the corresponding sign convention. Problems arise in situations where the coordinate system is not given or when the structure is composed of multiple beams with different orientations. In the latter case, each member has to be equipped with its own, local coordinate system and sign convention in order to avoid confusions.

Deformation signs have shown to be a useful way to record the direction of shear and bending deformations, without using coordinate systems [1]. The basic idea is that the deformation signs indicate how a structural component would deform under the action of a pure normal force, shear force or bending moment.

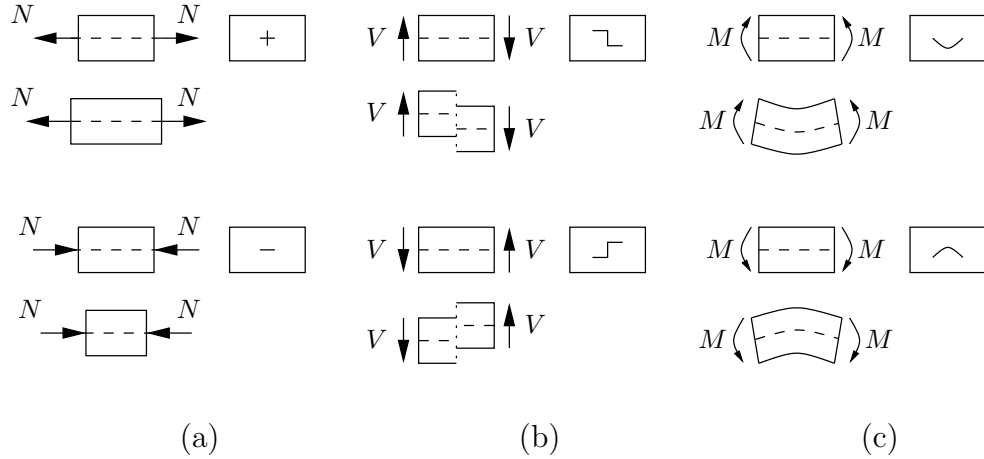


Figure 1: The deformation signs for a section of beam subjected to a pure normal force (a), a pure shear force (b) and a pure bending moment (c).

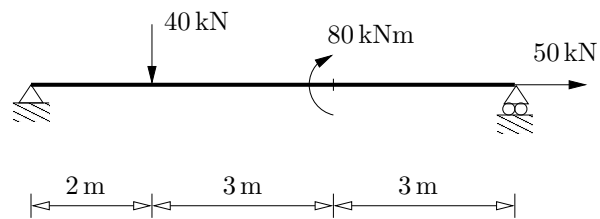
When using deformation signs the following rules apply:

- For the normal force diagram, we use the plus symbol (+) to denote tension and the minus symbol (−) to denote compression, see Figure 1(a). For the shear force, we use the shear sign, which represents the mode of deformation due to a pure shear force, Figure 1(b). For the bending moment we use the bending sign which represents the mode of deformation due to pure bending, see Figure 1(c);

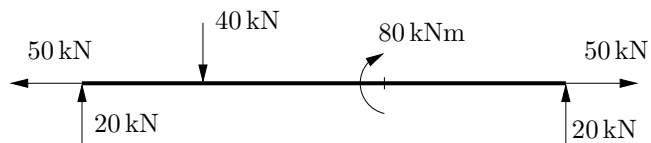
- The deformation symbol is always drawn inside the diagram. Important values (the values at maxima, kinks and jumps), are written as an absolute value.
- The bending moment diagram is always drawn on that side of the axis where the beam is loaded in tension. As a result, the open side of the bending sign is always directed towards the axis.
- The position of the normal- and shear-force diagram with respect to the axis is irrelevant.
- The direction of the slope of the bending moment diagram corresponds to the direction of the 'staircase' of the shear force deformation symbol.

Example

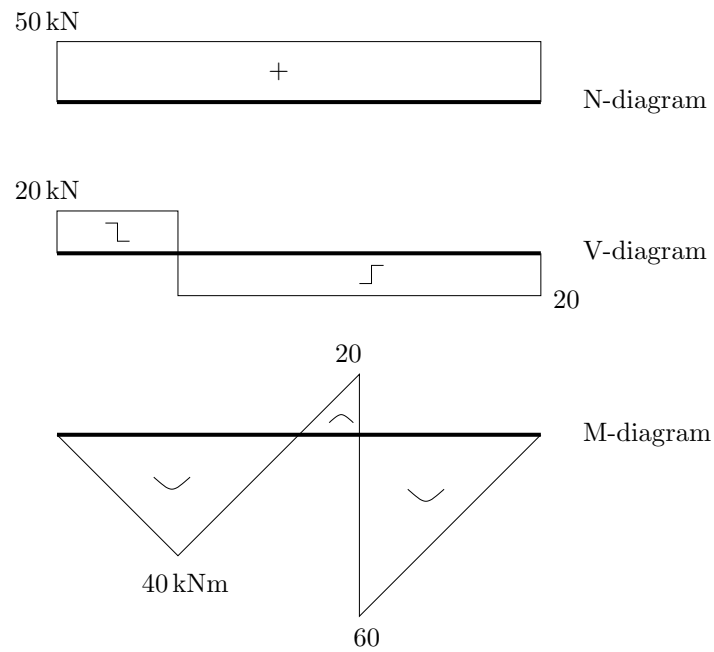
The use of the deformation signs is demonstrated in the following example. Consider the beam in the figure below:



The free-body diagram of the beam is:



The normal force, shear force and bending moment diagrams are:



References

- [1] C. Hartsuijker. Toegepaste Mechanica, Deel 1 Evenwicht. Academic Service. 1999.