Influence lines and Envelopes

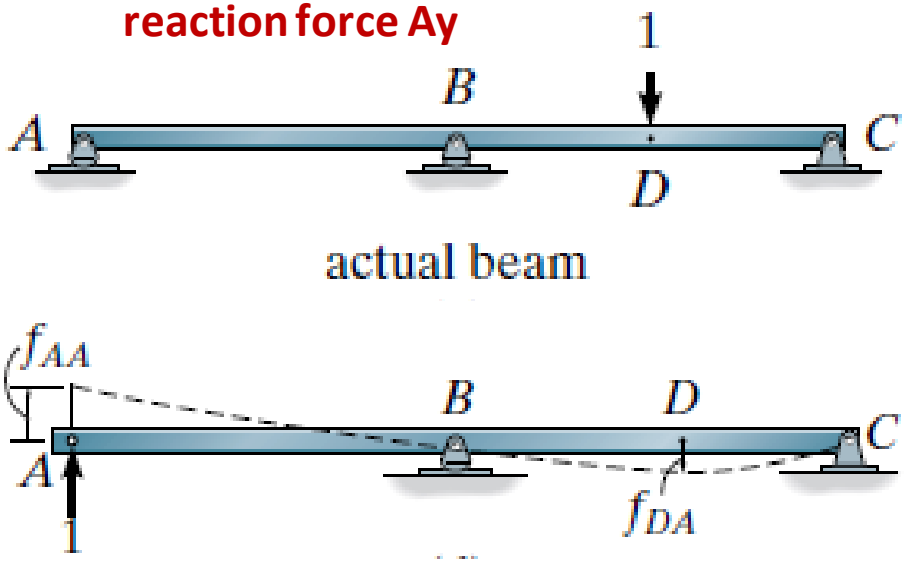
Influence line: definition and use

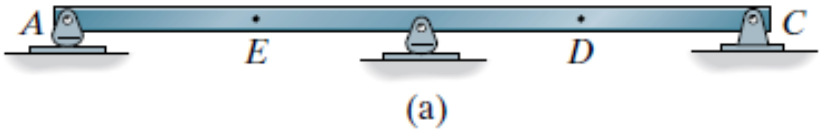
- Influence line is a diagram shows the relation of an **objective function** (reaction force, shear, bending moment) with the **position of loading**
- Why do we construct Influence lines?
  - **Live loads are variable in position**
  - To decide the critical load cases when considering the live load, and **develop load cases** to get the required design values (reaction force, shear, bending moment)

Qualitative approach to build influence lines - Mueller Breslau principle

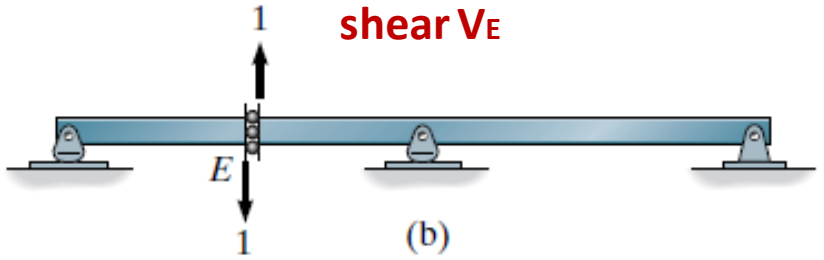
Induce a unit deformation, the deformed shape due to unit deformation is the shape of the influence line

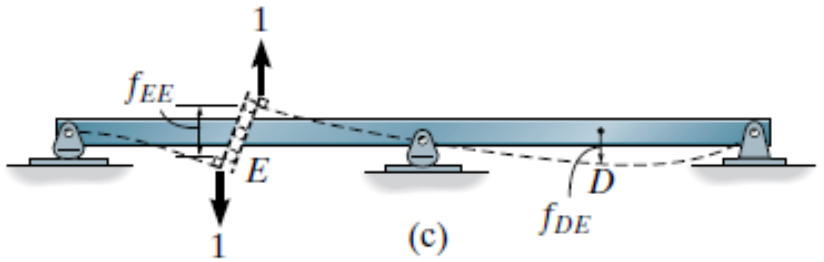
Influence line for reaction force Ay





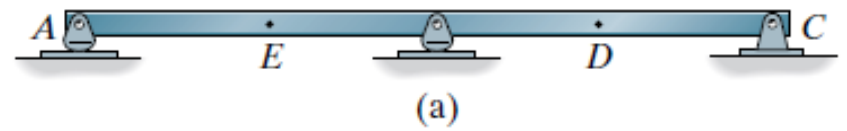
Influence line for shear V_E





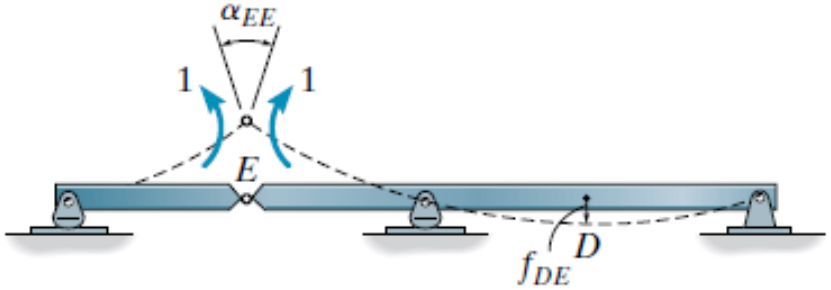
Qualitative Influence lines

Example: influence line for bending moment $\mathbf{M_E}$



(a)

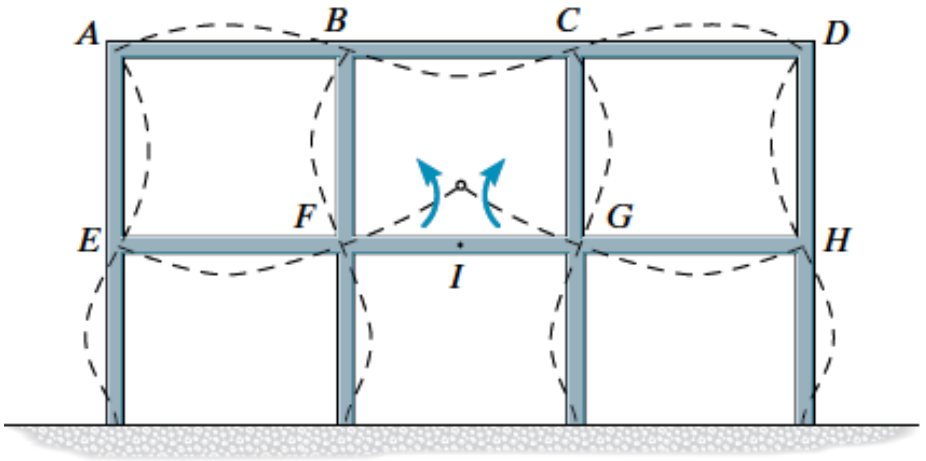
(b)



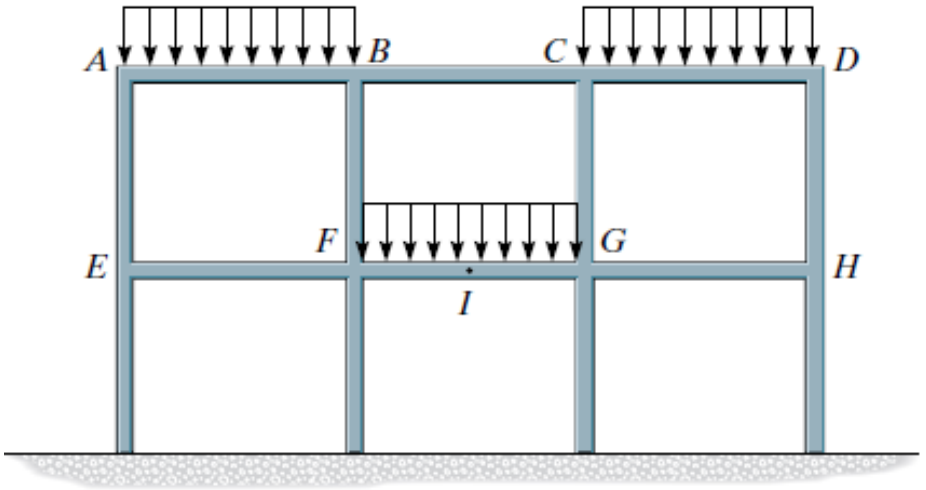
(c)

Qualitative influence lines: Use the influence lines to develop the load cases

The shown load case is for **max M_I**



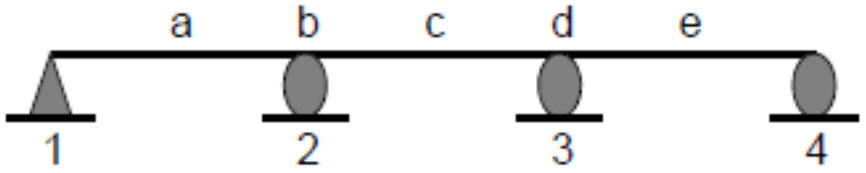
(a)



(b)

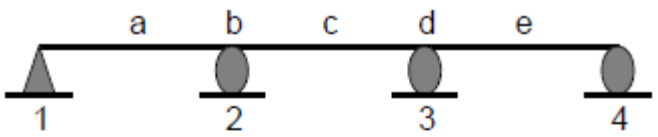
Example: three span beam

- Draw qualitative influence lines for the bending moment of the beam, and develop the load cases
- Draw qualitative influence lines for the shear of the beam
- Draw the envelope for bending moment values of the beam
- Span 1-2 = 10m. Span2-3=8m. Span 3-4=6m.
- w_D=5kN/m, w_L=8kN/m

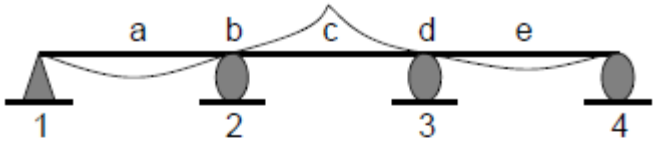


Three-Span Continuous Beam

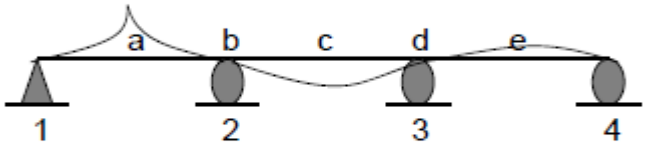
Influence line for bending moment



Three-Span Continuous Beam

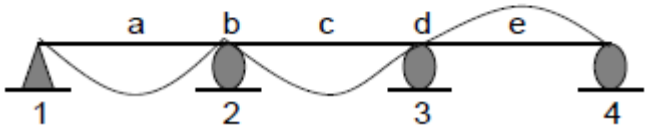


Influence line for Mc

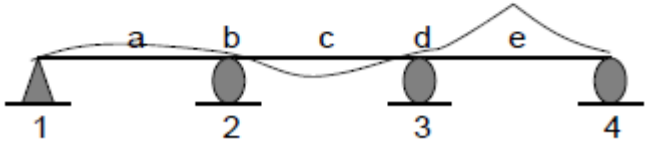


Influence line for Ma

Influence line for Md



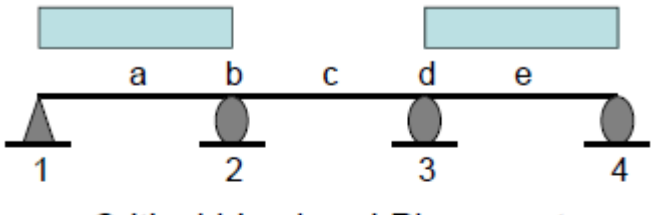
Influence line for Mb



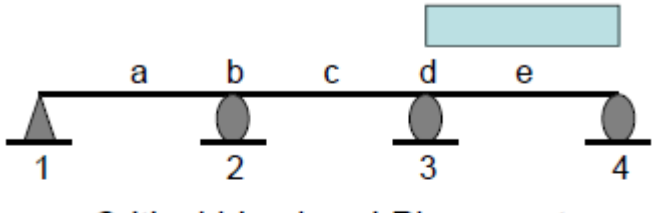
Influence line for Me

Load cases using developed influence lines

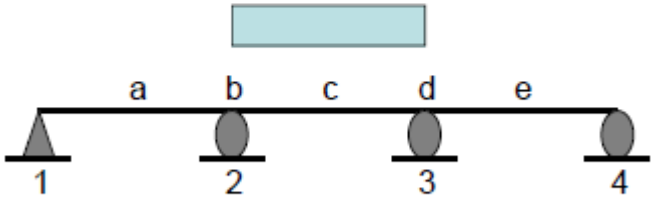
Dead load is applied over all spans, the following diagrams show the position of live load



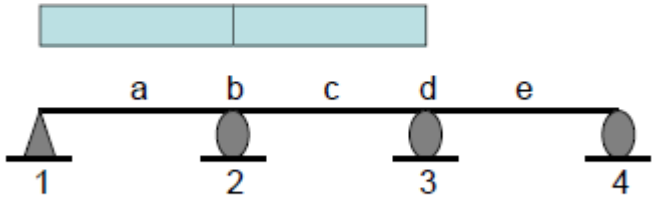
Load case (LC1) for max Ma



Load case (LC3) for max Mb



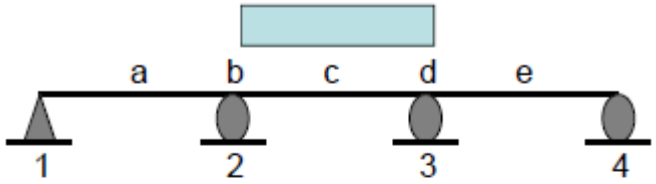
Load case (LC2) for min Ma



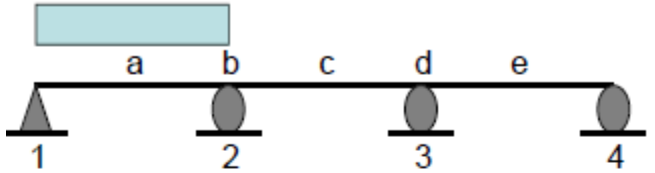
Load case (LC4) for min Mb

Load cases using developed influence lines

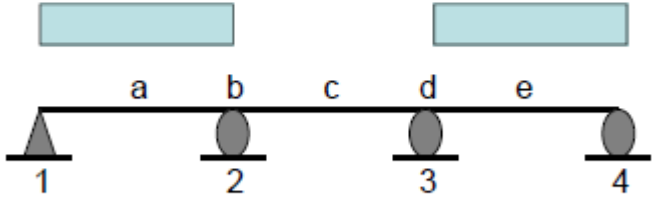
Dead load is applied over all spans, the following diagrams show the position of live load



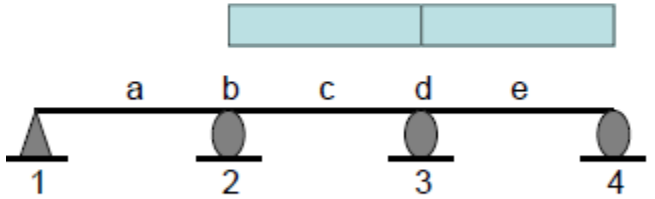
Load case for max Mc



Load case for max Md



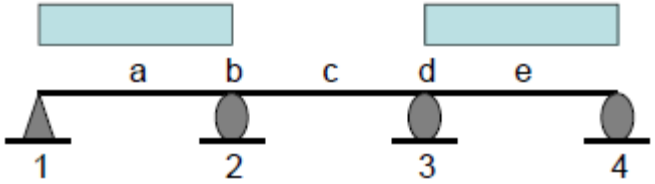
Load case for min Mc



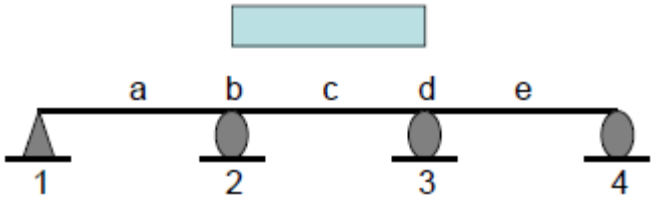
Load case for min Md

Load cases using developed influence lines

Dead load is applied over all spans, the following diagrams show the position of live load



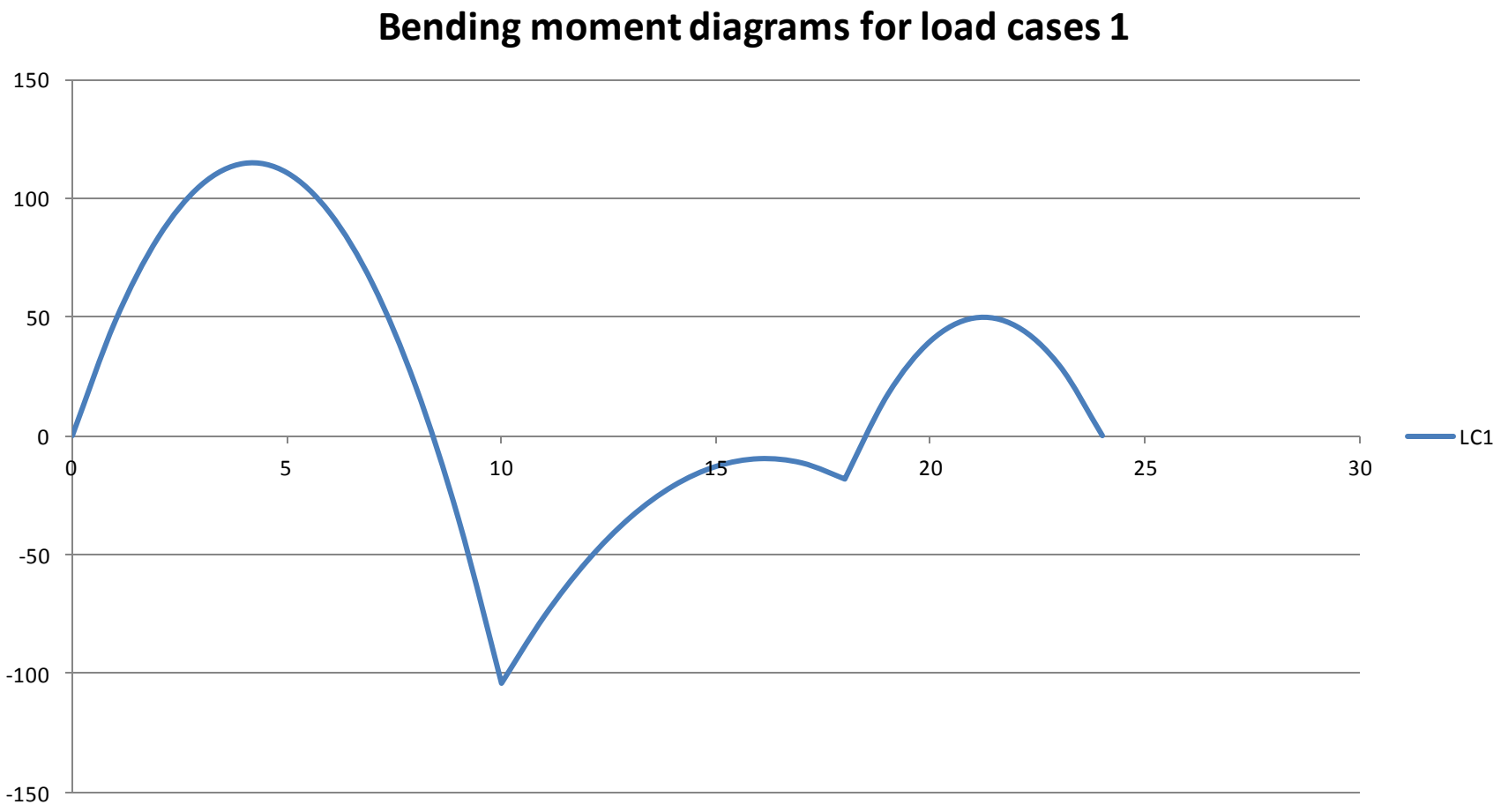
Load case for max Me



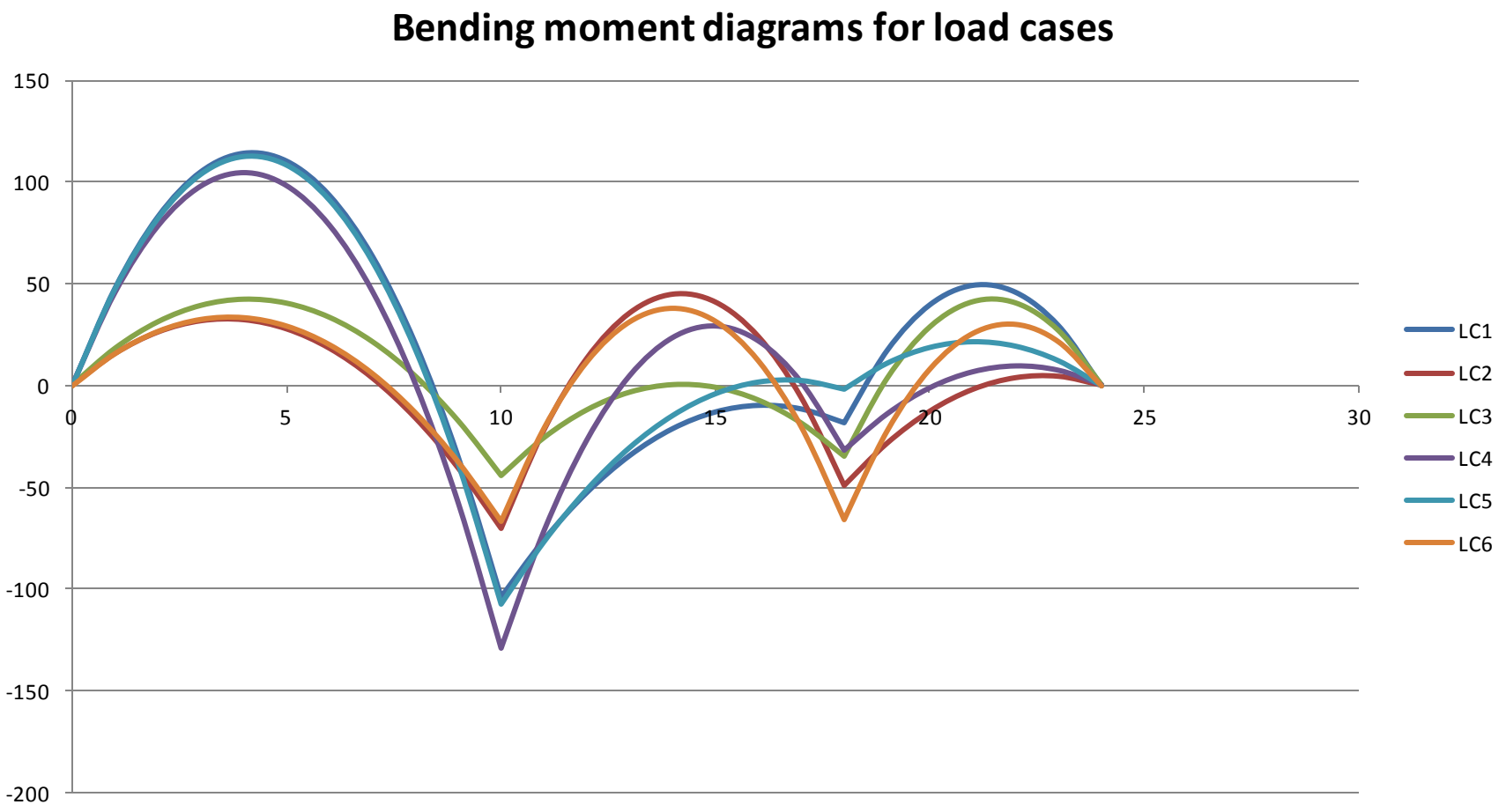
Load case for min Me

For every load case, we analyze the beam system and draw bending moment diagram

The following bending moment diagram is drawn after the analysis of LC1

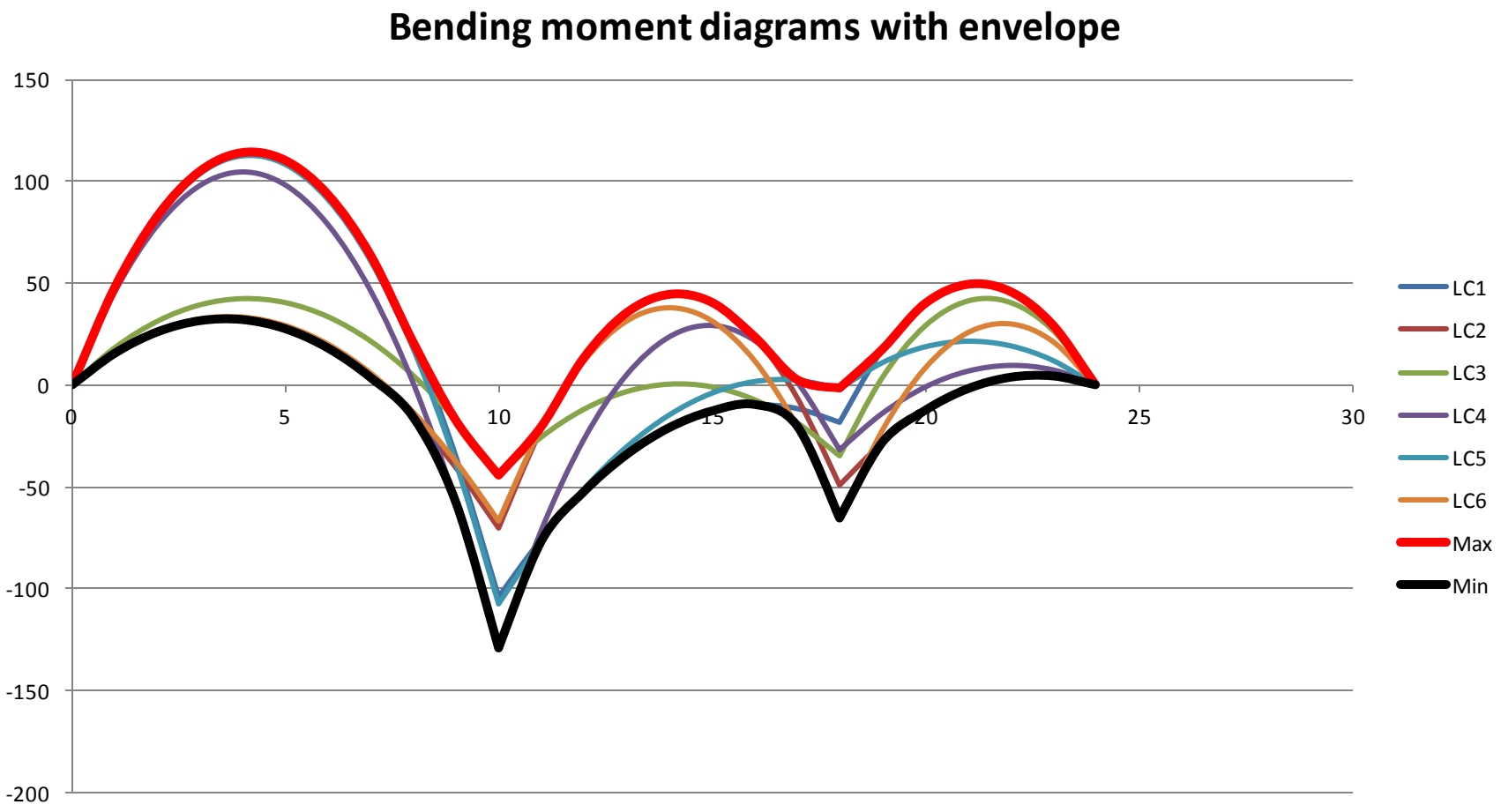


Bending moment diagram for all load cases

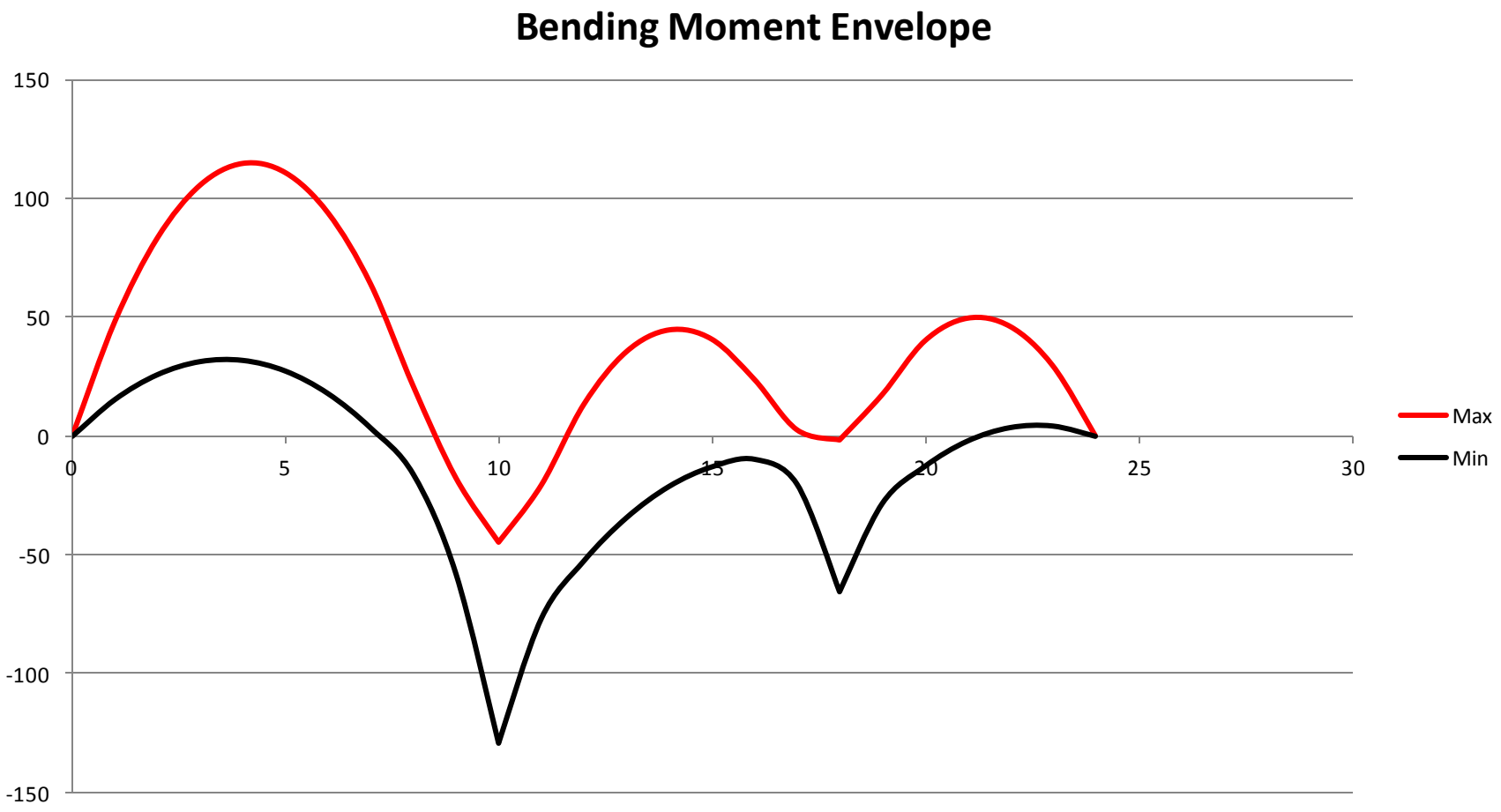


The envelope of the bending moment:

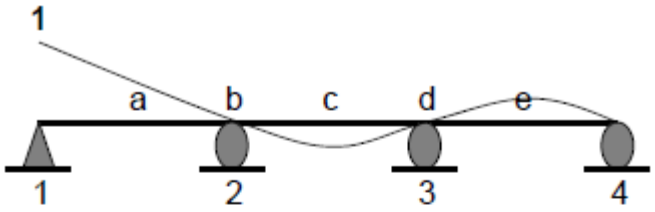
We determine **the values that envelope all the analysis results of the load cases**, which means determining the maximum and minimum of analysis results



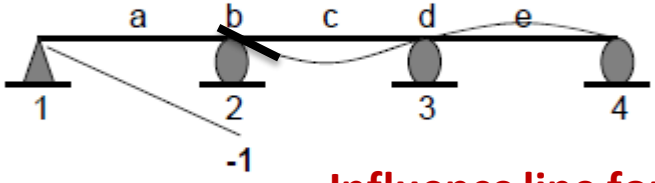
Envelope of bending moment values: these are values used in the design



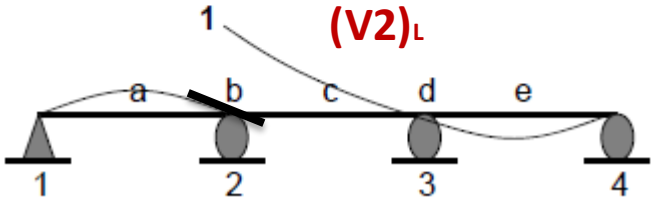
Influence line for shearing forces of the beam



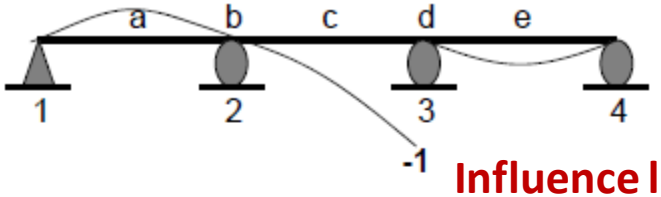
Influence line for V1



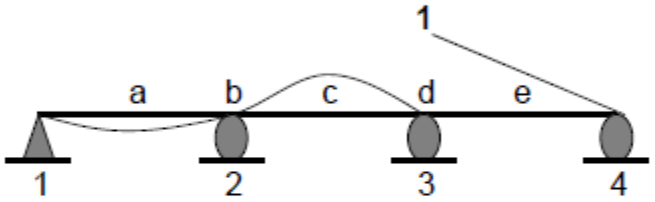
Influence line for $(V2)_L$



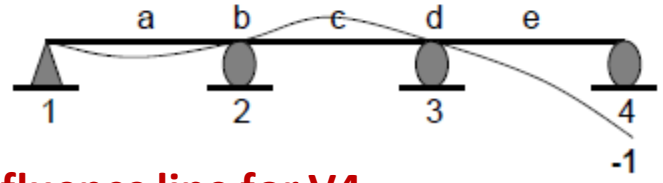
Influence line for $(V2)_R$



Influence line for $(V3)_L$



Influence line for $(V3)_R$



Influence line for V4