EWCE-311

Structural Analysis And Design-I

Introduction of influence line

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Influence Line Definitions

Previous developments have been limited to structures subjected to fixed loads.

Structures are also subjected to live loads whose position may vary on the structure. This chapter focuses on such loads for statically determinate structures



Influence Line Definitions

Influence lines provide a systematic procedure of how force in a given part of structure varies as the applied loads moves along the structure.

Consider the bridge shown in previous slide. As the traffic moves across the bridge, the forces in the truss members change with the position of the traffic and the maximum force in each member will be at a different traffic location. The design of each member must be based on the maximum probable load each member will experience.

Therefore, the truss/beam/frame analysis for each member would involve determining the load position that causes the greatest force or stress in each member.

Influence Line Definitions

If a structure is to be safely designed, members must be proportioned such that the maximum force produced by dead and live loads is less than the available section capacity.

Structural analysis for variable loads consists of two steps:

1. Determining the positions of the loads at which the response function is maximum; and

2. Computing the maximum value of the response function

Influence Line Definitions

Response Function : support reaction, axial force, shear force, or bending moment.

Influence Line : graph of a response function of a structure as a function of the position of a downward unit load moving across the structure.

Influence Line Definitions

➢It is the diagram showing the variation in the shear, moment, reaction, stress in a truss member or any other direct function due to a unit load moving across the structure.

➢ An influence line is constructed by plotting direct under the point, where the unit load is placed.

➢An ordinate the height of which represents to some scale the value of the particular function being studied when the load is in that position.

➢***For determinate structures influence lines are always straight lines.***

Influence Line Definitions

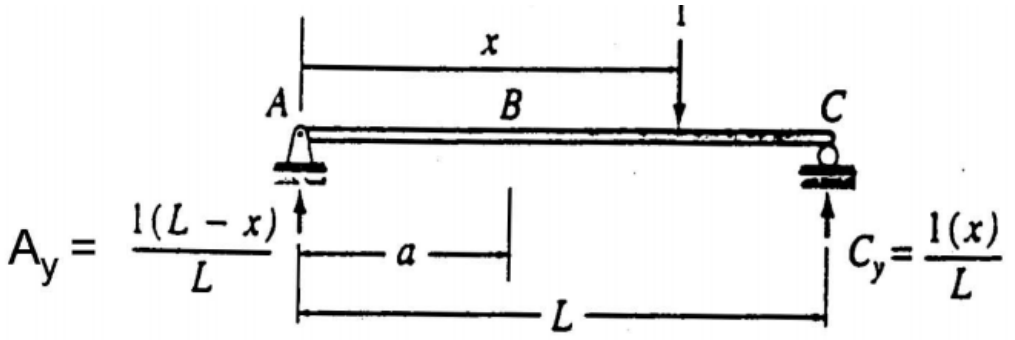
Once an influence line is constructed:

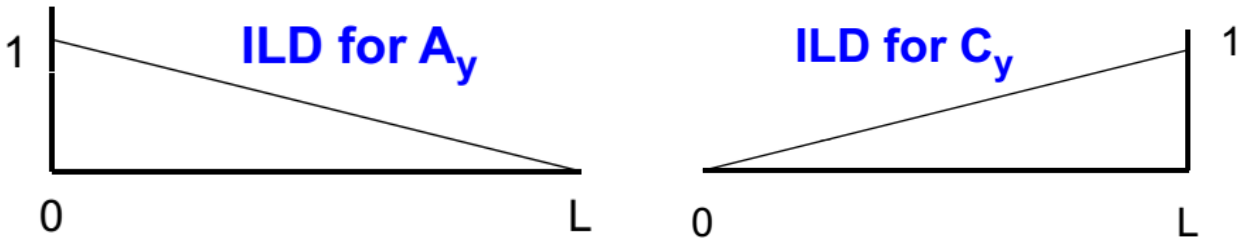
• Determine where to place live load on a structure to maximize the drawn response function; and

• Evaluate the maximum magnitude of the response function based on the loading.

Influence Line of Beam

Calculating Response Functions (Equilibrium Method)

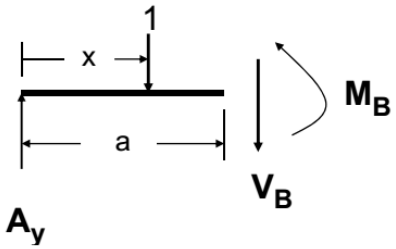




Influence Line of Beam

Shear and Moment at point B: **IL of VB:**
When load at left side of point B

Assume unit load is now at 0 < x < a (note here x is almost equal to a but slightly left side)



$0 < x < a$

$$A_y = \frac{1(L-x)}{L}$$

$$Ay = (1 - a/L)$$

$$\sum F_y = 0 \Rightarrow V_B = A_y - 1$$

$$\sum M_a = 0 \Rightarrow M_B = A_y a - 1(a - x)$$

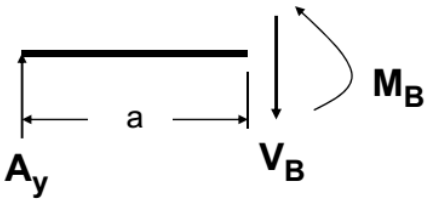
i.e. VB = 1 – a/L – 1 = -a/L

i.e. MB = (1 – a/L)*a

Influence Line of Beam

Shear and Moment at point B: **IL of VB:**
When load at right side of point B

Assume unit load is now at a < x < L (note here x is almost equal to a but slightly right side)



$a < x < L$

$$A_y = \frac{1(L-x)}{L}$$

So, Ay = 1- a/L

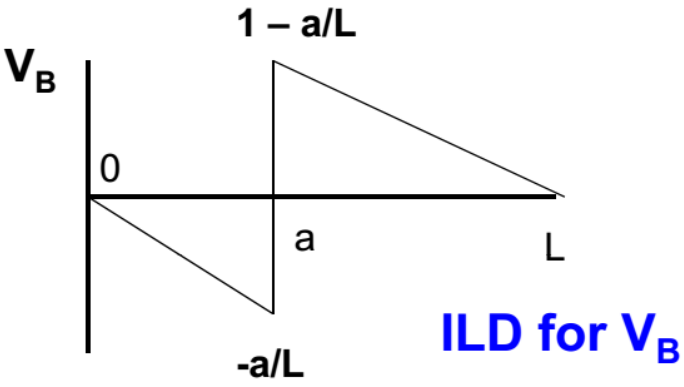
$$\sum F_y = 0 \Rightarrow V_B = A_y$$

i.e. VB = 1 – a/L

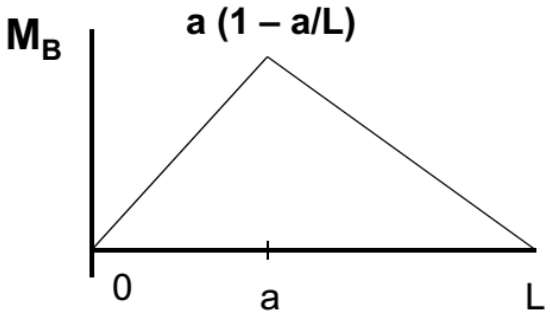
$$\sum M_a = 0 \Rightarrow M_B = A_y a$$

i.e. MB = (1 – a/L)*a

Influence Line of Beam



ILD for V_B



ILD for M_B

Influence Line of Beam

Muller-Breslau Principle :

In 1886, Heinrich Müller Breslau proposed a technique to draw influence lines quickly. The Müller Breslau Principle states that the ordinate value of an influence line for any function on any structure is proportional to the ordinates of the deflected shape that is obtained by removing the restraint corresponding to the function from the structure and introducing a force that causes a unit displacement in the positive direction.

Influence Line of Beam

Let us say, our objective is to obtain the influence line for the support reaction at A for the beam shown in Figure 38.1.

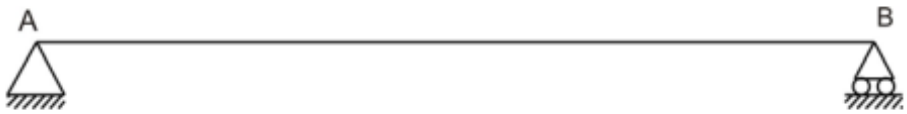


Figure 38.1: Simply supported beam

First of all remove the support corresponding to the reaction and apply a force (Figure 38.2) in the positive direction that will cause a unit displacement in the direction of R_A. The resulting deflected shape will be proportional to the true influence line (Figure 38.3) for the support reaction at A.

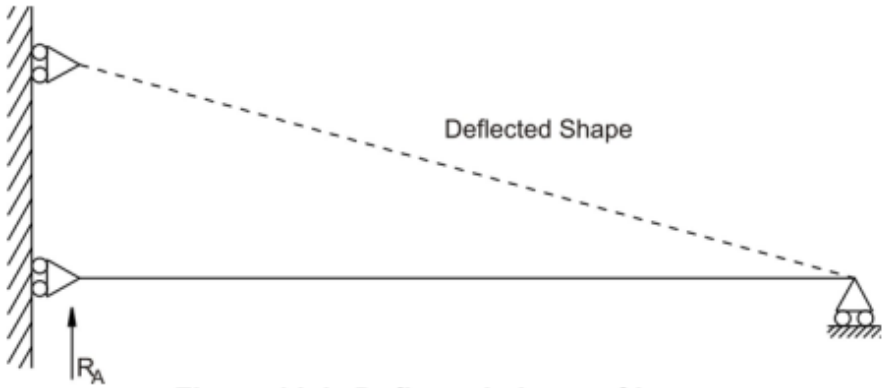


Figure 38.2: Deflected shape of beam

Influence Line of Beam

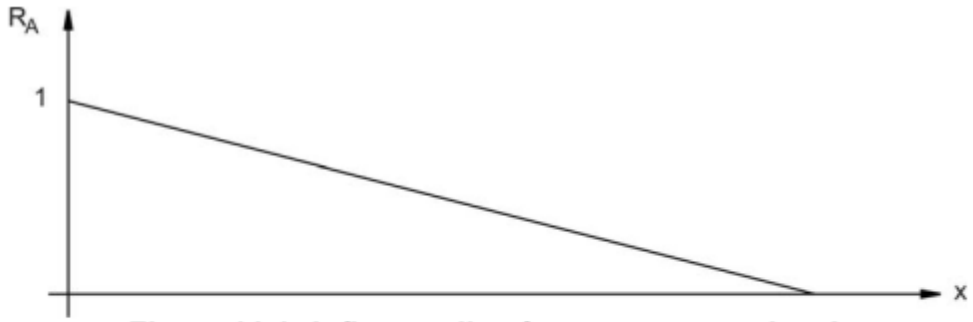


Figure 38.3: Influence line for support reaction A

The deflected shape due to a unit displacement at A is shown in Figure 38.2 and matches with the actual influence line shape as shown in Figure 38.3. Note that the deflected shape is linear, i.e., the beam rotates as a rigid body without any curvature. This is true only for statically determinate systems.

Influence Line of Beam

Here we are interested to draw the qualitative influence line for shear at section C of overhang beam as shown in Figure 38.4.

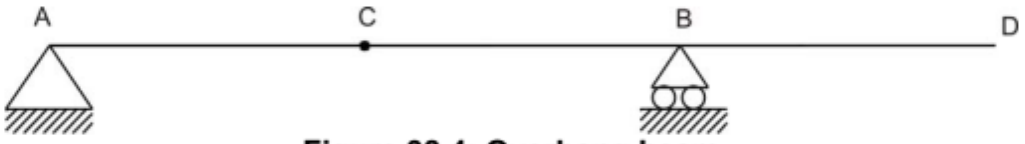


Figure 38.4: Overhang beam

As discussed earlier, introduce a roller at section C so that it gives freedom to the beam in vertical direction as shown in Figure 38.5.

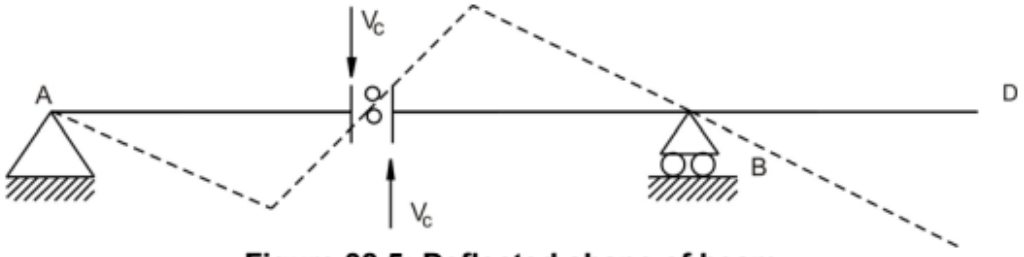


Figure 38.5: Deflected shape of beam

Now apply a force in the positive direction that will cause a unit displacement in the direction of V_C. The resultant deflected shape is shown in Figure 38.5. Again, note that the deflected shape is linear. Figure 38.6 shows the actual influence, which matches with the qualitative influence.

Influence Line of Beam

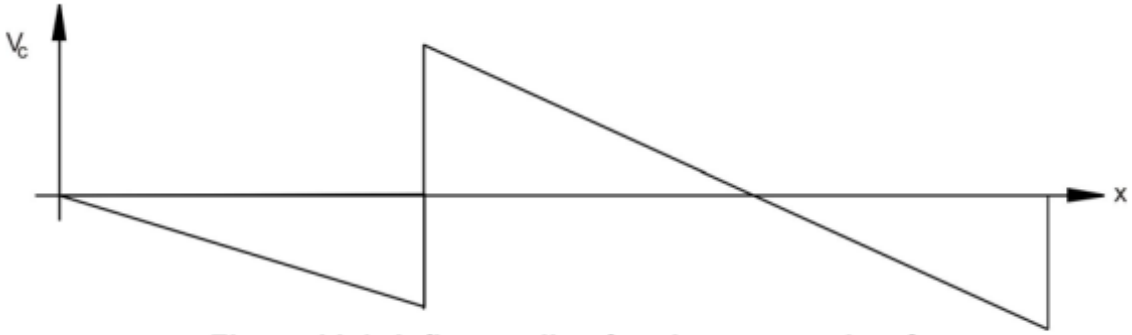


Figure 38.6: Influence line for shear at section C

Influence Line of Beam

In this second example, we are interested to draw a qualitative influence line for moment at C for the beam as shown in Figure 38.7.

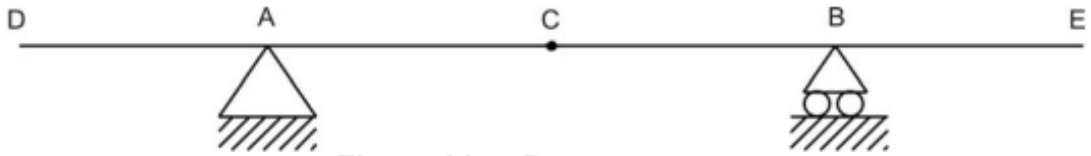


Figure 38.7: Beam structure

In this example, being our objective to construct influence line for moment, we will introduce hinge at C and that will only permit rotation at C. Now apply moment in the positive direction that will cause a unit rotation in the direction of M_c. The deflected shape due to a unit rotation at C is shown in Figure 38.8 and matches with the actual shape of the influence line as shown in Figure 38.9.

Influence Line of Beam

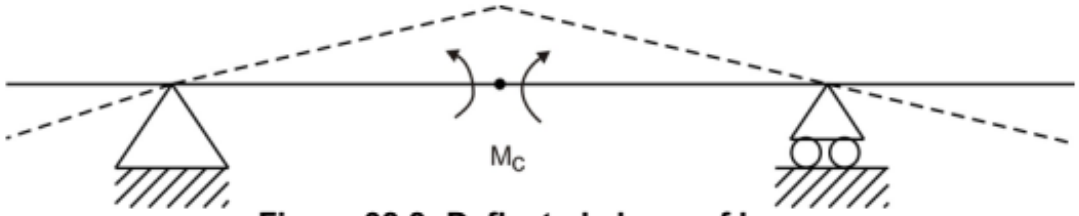


Figure 38.8: Deflected shape of beam

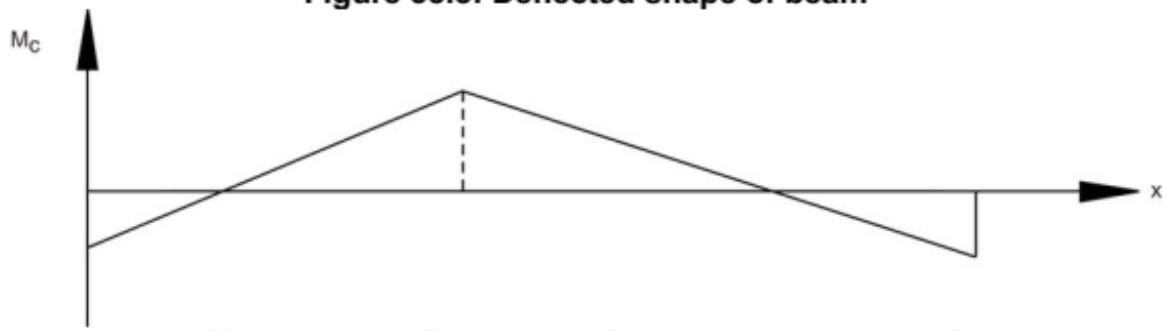


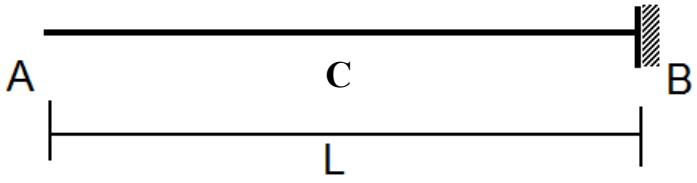
Figure 38.9: Influence line for moment at section C

1

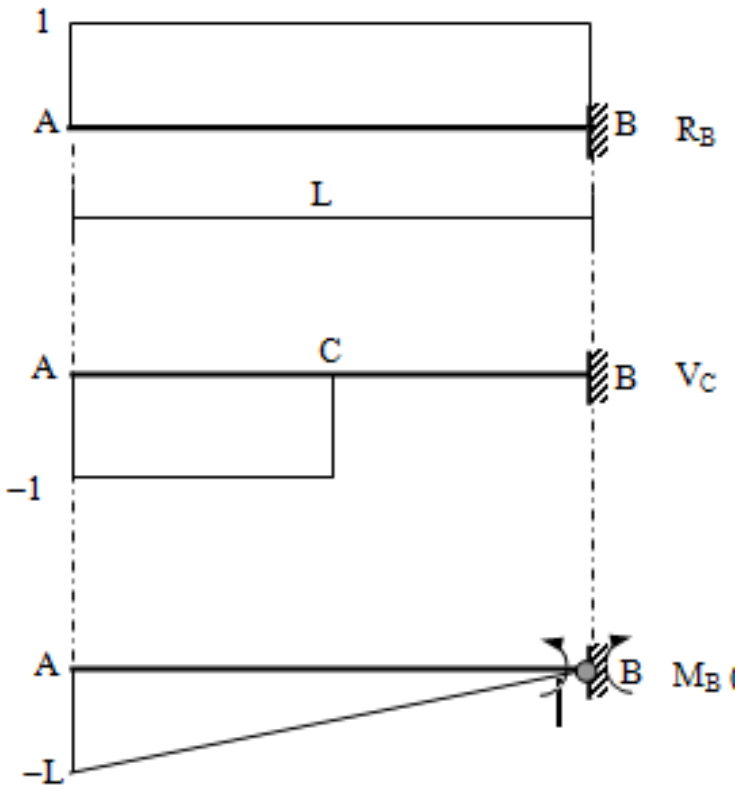
RA

Influence Line of Beam

Draw the influence lines of RB, Vc and MB for the cantilever beam shown below.

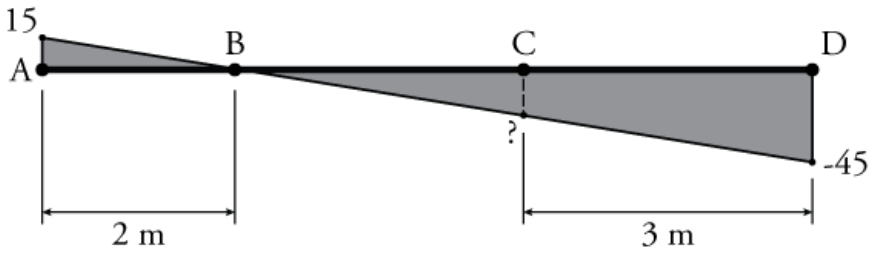


Influence Line of Beam



Influence Line of Beam

Interactive Quiz



Find the value of the diagram at point C. The line has a constant slope from A to D.

a) -22.5

b) 15

c) -15

d) 22.5

Influence Line of Beam

Interactive Quiz

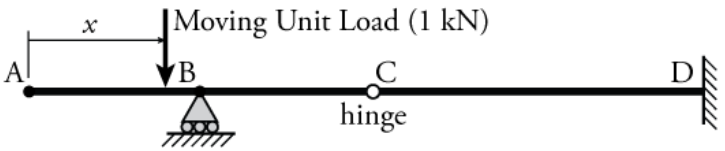
For the structure shown, what does the influence line for the vertical reaction at D (*Dy*) look like?

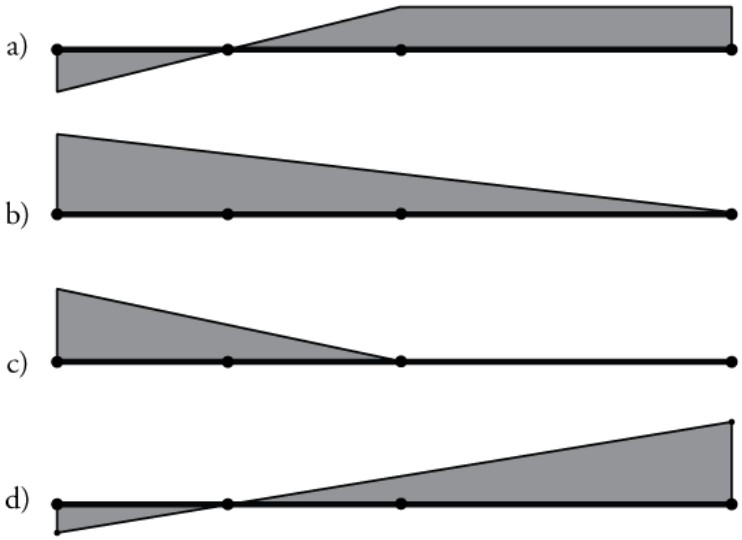
d)

b)

c)

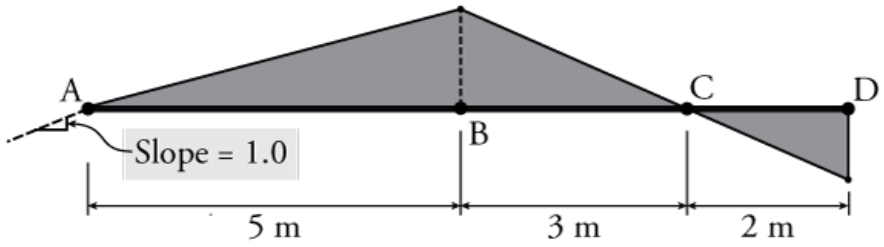
a)





Influence Line of Beam

Interactive Quiz



The influence line below for the moment reaction at A is incomplete. A unit rotation has been applied already at point A and the resulting shape is shown. Find the value of the influence line at point D.

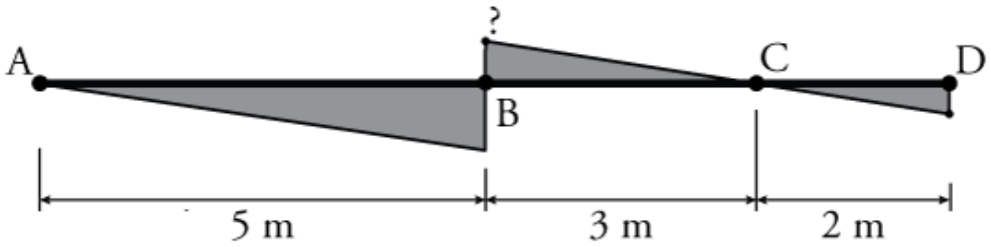
a) 3

b) 3.33

c) 2

Influence Line of Beam

Interactive Quiz



The diagram shown is an influence line for the internal shear at B. What is the value of the internal shear at B if a unit point load is placed just to the right of point B (the value indicated by the '?').

a) 3

b) 0.60

c) 0.38

d) 1.5