Module 6 : Influence Lines

Lecture 3 : Use of Influence Lines

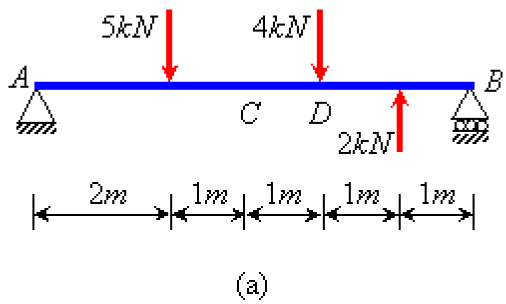
Objectives

In this course you will learn the following

- Use of influence line through an example

6.3 Use of Influence Lines

In this section, we will illustrate the use of influence lines through the influence lines that we have obtained in Section 6.2. Let us consider a general case of loading on the simply supported beam (Figure 6.4a) and use the influence lines to find out the response parameters (R_A, V_C and M_D) for their loading. We can consider this loading as the sum of three different loading conditions, (A), (B) and (C) (Figure 6.4b), each containing only one externally applied force.



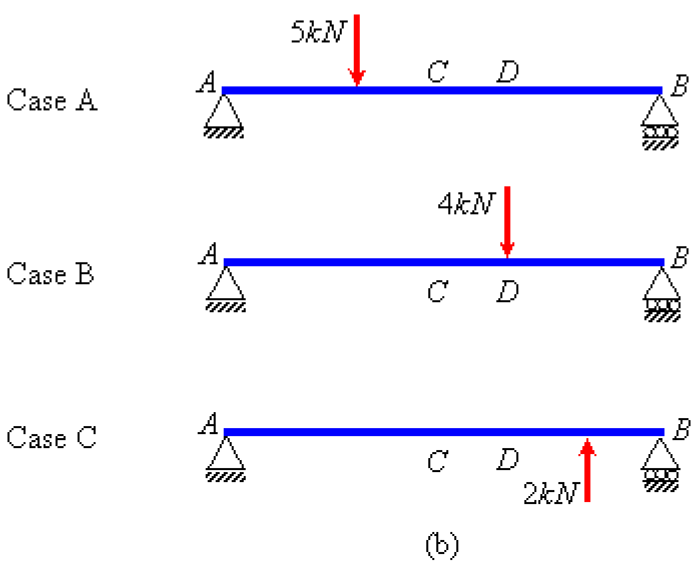


Figure 6.4 Application of influence lines for a general loading: (a) all the loads, and (b) the general loading is divided into single force systems

For loading case (A), we can find out the response parameters using the three influence lines. Ordinate of an influence line gives the response for a unit load acting at a certain point.

Therefore, we can multiply this ordinate by the magnitude of the force to get the response due to the real force at that point. Thus

$$R_A = 5kN \times (\text{ordinate of the } IL \text{ of } R_A \text{ at } x = 2m) = 5(1 - 2/6) = 3.33kN$$

$$V_C = 5kN \times (\text{ordinate of the } IL \text{ of } V_C \text{ at } x = 2m) = 5(2/6) = 1.67kN$$

$$M_D = 5kN \times (\text{ordinate of the } IL \text{ of } M_D \text{ at } x = 2m) = 5(2/3) = 3.33kNm$$

Similarly, for loading case (B):

$$R_A = 4kN \times (\text{ordinate of the } IL \text{ of } R_A \text{ at } x = 4m) = 4(1 - 4/6) = 1.33kN$$

$$V_C = 4kN \times (\text{ordinate of the } IL \text{ of } V_C \text{ at } x = 4m) = 4(4/6 - 1) = -1.33kN$$

$$M_D = 4kN \times (\text{ordinate of the } IL \text{ of } M_D \text{ at } x = 4m) = 4(2 \times 6/9) = 5.33kNm$$

And for case (C),

$$R_A = -2kN \times (\text{ordinate of the } IL \text{ of } R_A \text{ at } x = 5m) = -2(1 - 5/6) = -0.33kN$$

$$V_C = -2kN \times (\text{ordinate of the } IL \text{ of } V_C \text{ at } x = 5m) = -2(5/6 - 1) = 0.33kN$$

$$M_D = -2kN \times (\text{ordinate of the } IL \text{ of } M_D \text{ at } x = 5m) = -2(2 \times 6/3 - 2 \times 5/3) = -1.33kNm$$

By the theory of superposition, we can add forces for each individual case to find the response parameters for the original loading case (Figure 6.4a). Thus, the response parameters in the beam *AB* are:

$$R_A = (3.33 + 1.33 - 0.33)kN = 4.33kN$$

$$V_C = (1.67 - 1.33 + 0.33)kN = 0.67kN$$

$$M_D = (3.33 + 5.33 - 1.33)kN = 7.33kNm$$

One should remember that the method of superposition is valid only for linear elastic cases with small displacements only. So, prior to using influence lines in this way it is necessary to check that these conditions are satisfied.

It may seem that we can solve for these forces under the specified load case using equilibrium equations directly, and influence lines are not necessary. However, there may be requirement for obtaining these responses for multiple and more complex loading cases. For example, if we need to analyse for ten loading cases, it will be quicker to find only three influence lines and not solve for ten equilibrium cases.

The most important use of influence line is finding out the location of a load for which certain response will have a maximum value. For example, we may need to find the location of a moving load (say a gantry) on a beam (say a gantry girder) for which we get the maximum bending moment at a certain point. We can consider bending moment at point *D* of Example 6.3, where the beam *AB* becomes our gantry girder. Looking at the influence line of M_D, one can say that M_D will reach its maximum value when the load is at point *D* .

Influence lines can be used not only for concentrated forces, but for distributed forces as well, which is discussed in the next section.

Recap

In this course you have learnt the following

- Use of influence line through an example