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Subject Name: **Structural Analysis-I**

Subject Code: **CE-4005**

Semester: **4th**



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UNIT-V

Rolling loads and Influence Lines: Maximum SF and BM curves for various types of rolling loads, focal length, EUDL, Influence Lines for Determinate Structures- Beams, Three Hinged Arches

INFLUENCE LINE DIAGRAMS

Introduction

In the previous lessons, we have studied about construction of influence line for the either single concentrated load or uniformly distributed loads. In the present lesson, we will study in depth about the beams, which are loaded with a series of two or more than two concentrated loads.

Maximum shear at sections in a beam supporting two concentrated loads

Let us assume that instead of one single point load, there are two point loads P_1 and P_2 spaced at y moving from left to right on the beam as shown in Figure 1.1. We are interested to find maximum shear force in the beam at given section C. In the present case, we assume that $P_2 < P_1$.

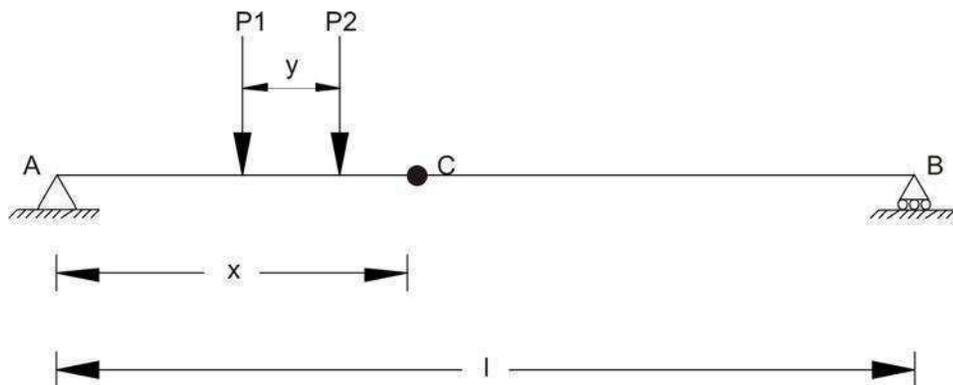


Figure 1.1: Beam loaded with two concentrated point loads

Now there are three possibilities due to load spacing. They are: $x < y$, $x = y$ and $x > y$.

Case 1: $x < y$

This case indicates that when load P_2 will be between A and C then load P_1 will not be on the beam. In that case, maximum negative shear at section C can be given by

$$V_C = -P_2 \cdot x_1 \quad \text{---}$$

and maximum positive shear at section C will be

Case 2: $x = y$

In this case, load P_1 will be on support A and P_2 will be on section C. Maximum negative shear can be given by

$$V_C = -P_2 \cdot x_1 \quad \text{---}$$

be

Case 3: $x > y$

With reference to Figure 1.2, maximum negative shear force can be obtained when load P_2 will be on section C. The maximum negative shear force is expressed as:

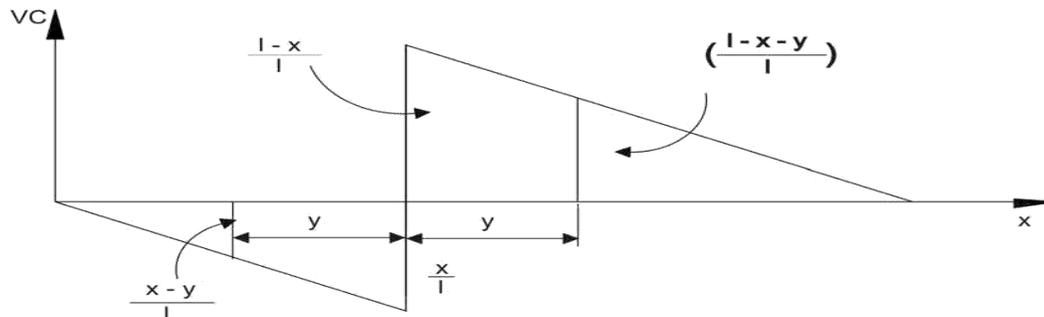


Figure 1.2: Influence line for shear at section C

$$V_C^1 = -P_2 x/l - P_1 (x-y)/l$$

And with reference to Figure 1.2, maximum positive shear force can be obtained when load P_1 will be on section C. The maximum positive shear force is expressed as:

$$V_C^2 = -P_1 x/l + P_2 (l-x-y)/l$$

From above discussed two values of shear force at section, select the maximum negative shear value.

Maximum moment at sections in a beam supporting two concentrated loads

Let us assume that instead of one single point load, there are two point loads P_1 and P_2 spaced at y moving left to right on the beam as shown in Figure 1.3. We are interested to find maximum moment in the beam at given section C.

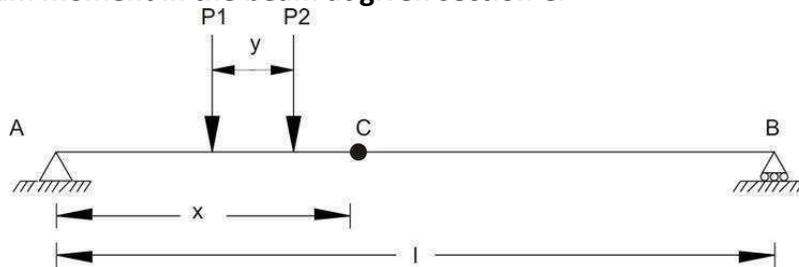


Figure 1.3: Beam loaded with two concentrated loads

With reference to Figure 1.4, moment can be obtained when load P_2 will be on section C. The moment for this case is expressed as:

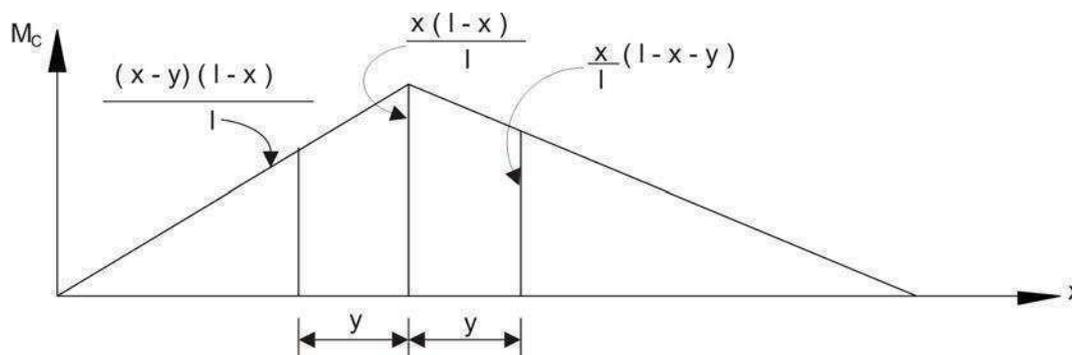


Figure 1.4: Influence line for moment at section C

$$M_c^1 = P_1 \frac{(x-y)(1-x)}{l} + P_2 \frac{x(1-x-y)}{l}$$

With reference to Figure 1.4, moment can be obtained when load P_1 will be on section C. The moment for this case is expressed as:

$$M_c^2 = P_1 \frac{x(1-x-y)}{l} + P_2 \frac{(x-y)(1-x)}{l}$$

From above two cases, maximum value of moment should be considered for maximum moment at section C when two point loads are moving from left end to right end of the beam.

Maximum end shear in a beam supporting a series of moving concentrated loads

In real life situation, usually there are more than two point loads, which will be moving on bridges. Hence, in this case, our aim is to learn, how to find end shear in beam supporting a series of moving concentrated loads. Let us assume that as shown in Figure 1.5, four concentrated loads are moving from right end to left end on beam AB. The spacing of the concentrated load is given in Figure 1.5.

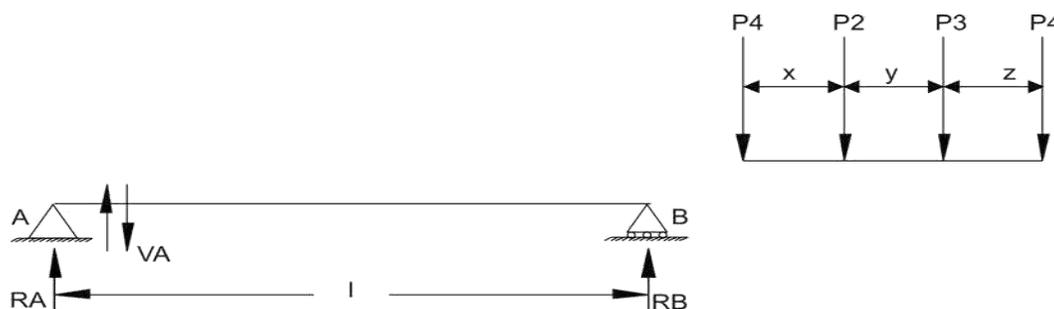


Figure 1.5: Beam loaded with a series of loads

As shown in figure, we are interested in end shear at A. We need to draw influence line for the support reaction A and a point away from the support at infinitesimal distance on the span for the shear V_A . The influence lines for these cases are shown in Figure 1.6 and 1.7.

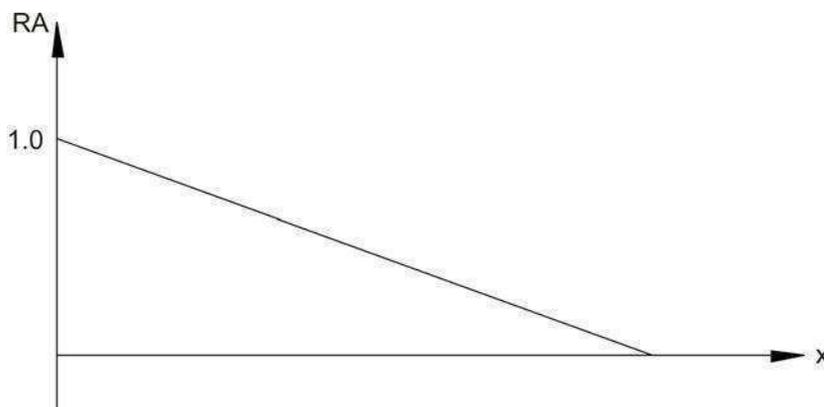


Figure 1.6: Influence line for reaction at support A

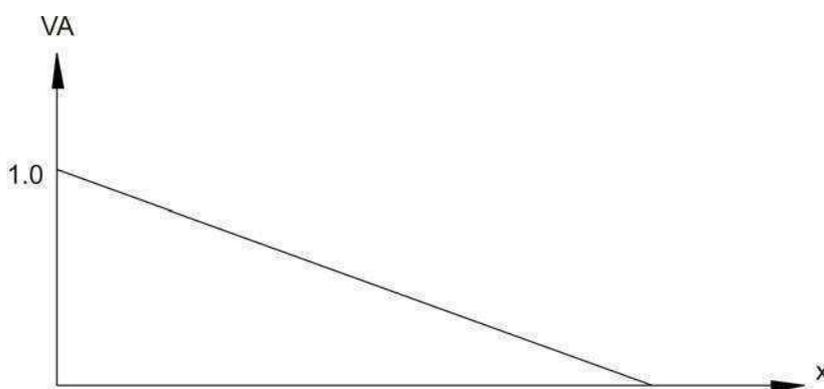


Figure 1.7: Influence line for shear near to support A.

When loads are moving from B to A then as they move closer to A, the shear value will increase. When load passes the support, there could be increase or decrease in shear value depending upon the next point load approaching support A. Using this simple logical approach, we will find out the change in shear value near support and monitor this change from positive value to negative value. Here for the present case let us assume that ΣP is summation of the loads remaining on the beam. When load P_1 crosses support A, then P_2 will approach A. In that case, change in shear will be expressed as

$$dV = \Sigma P^x - P_1$$

When load P_2 crosses support A, then P_3 will approach A. In that case change in shear will be expressed as

$$dV = \Sigma P^y - P_2$$

In case if dV is positive then shear at A has increased and if dV is negative, then shear at A has decreased. Therefore, first load, which crosses and induces negative changes in shear, should be placed on support A.

Numerical Example

Compute maximum end shear for the given beam loaded with moving loads as shown in Figure 1.8.

When first load of 4 kN crosses support A and second load 8 kN is approaching support A, then change in shear can be given by

$$dV = \sum^{(8+8 \pm 4)2} - 4 = 0 \quad 10$$

When second load of 8 kN crosses support A and third load 8 kN is approaching support A, then change in shear can be given by

$$dV = \sum^{(8 \pm 4)3} - 8 = -3.8 \quad 10$$

Hence, as discussed earlier, the second load 8 kN has to be placed on support A to find out maximum end shear (refer Figure 1.9).

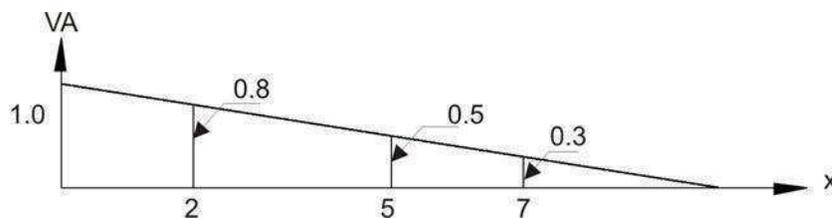


Figure 1.9: Influence line for shear at A.

$$V_A = 4 \times 1 + 8 \times 0.8 + 8 \times 0.5 + 4 \times 0.3 = 15.6 \text{ kN}$$

Maximum shear at a section in a beam supporting a series of moving concentrated loads

In this section we will discuss about the case, when a series of concentrated loads are moving on beam and we are interested to find maximum shear at a section. Let us assume that series of loads are moving from right end to left end as shown in Figure. 1.10.

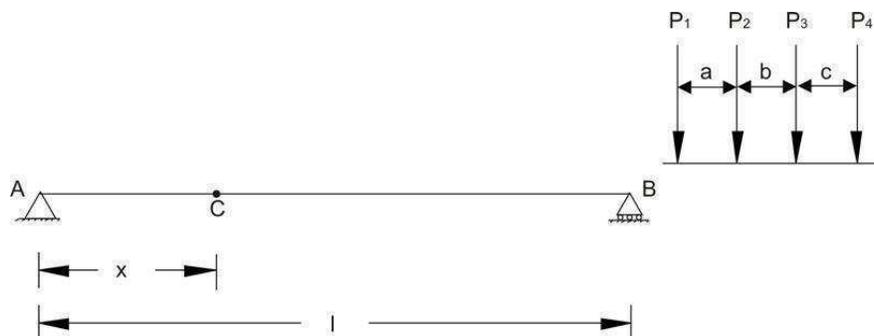


Figure 1.10: Beam loaded with a series of loads

Monitor the sign of change in shear at the section from positive to negative and apply the concept discussed in earlier section. Following numerical example explains the same.

Numerical Example

The beam is loaded with concentrated loads, which are moving from right to left as shown in Figure 1.12. Compute the maximum shear at the section C.

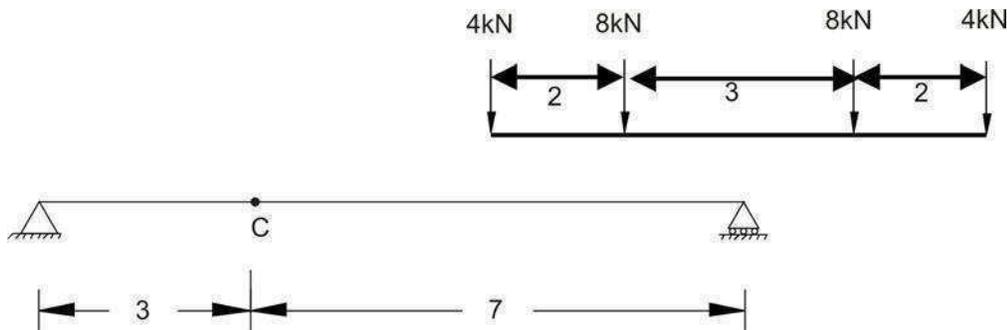


Figure 1.12: Beam loaded with a series of loads

The influence line at section C is shown in following Figure 1.13.

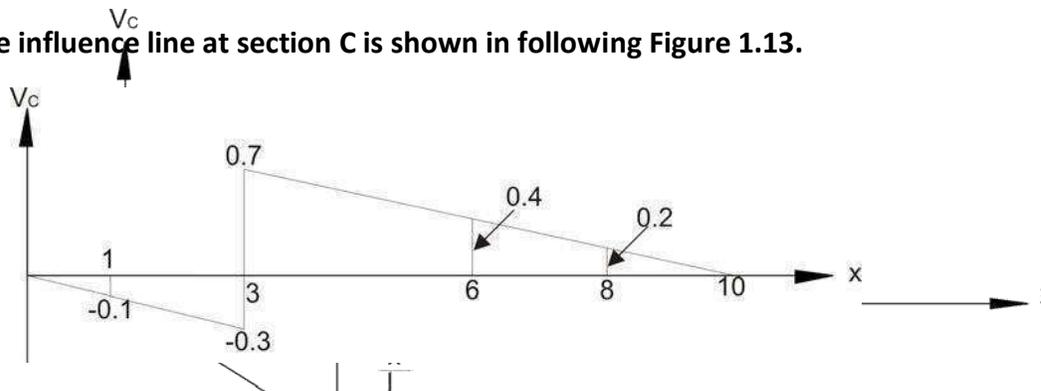


Figure 1.13: Influence line for shear at section C

When first load 4kN crosses section C and second load approaches section C then change in shear at a section can be given by

$$dV = \frac{20}{10} \times 2 - 4 = 0$$

When second load 8 kN crosses section C and third load approaches section C then change in shear at section can be given by

$$dV = \frac{12}{10} \times 3 - 8 = -4.4$$

Hence place the second concentrated load at the section and computed shear at a section is given by

$$V_C = 0.1 \times 4 + 0.7 \times 8 + 0.4 \times 8 + 0.2 \times 4 = 9.2 \text{ kN}$$

Maximum Moment at a section in a beam supporting a series of moving concentrated loads

The approach that we discussed earlier can be applied in the present context also to determine the maximum positive moment for the beam supporting a series of moving concentrated loads. The change in moment for a load P_1 that moves from position x_1 to x_2 over a beam can be obtained by multiplying P_1 by the change in ordinate of the influence line i.e. $(y_2 - y_1)$. Let us assume the slope of the influence line (Figure 1.14) is S , then $(y_2 - y_1) = S(x_2 - x_1)$.

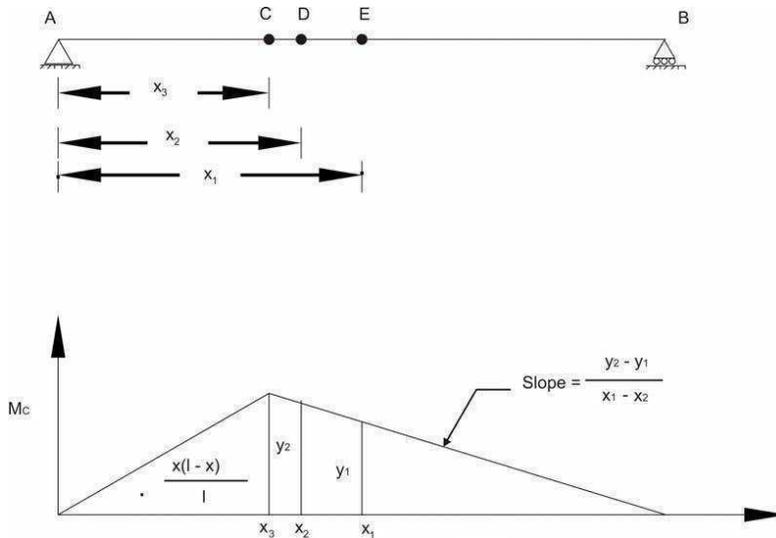
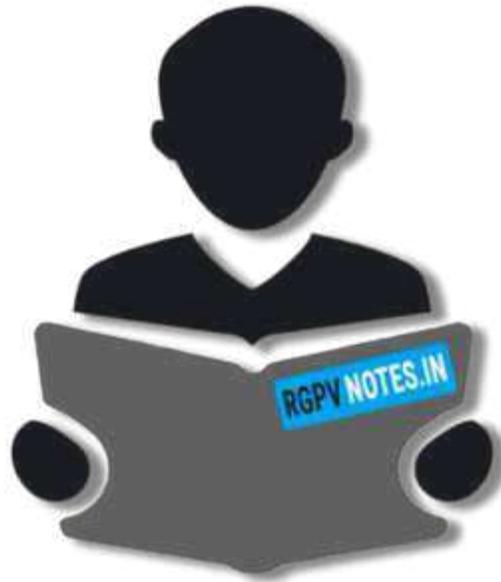


Figure 1.14: Beam and Influence line for moment at section C

Hence change in moment can be given by $dM = P_1 S(x_2 - x_1)$

Let us consider the numerical example for better understanding of the developed concept.



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