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Degree of Curve for Bending Moment Diagram Cantilever and Simply Supported Beam Carries an U.V.L

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Abstract: Determination of degree of curve for bending moment diagram (B.M.D) occurs in cantilever and simply supported beam carries uniformly varying load 'w/unit length' by using direct area method.
Keywords: Degree of curve for BMD carries UVL, Area and centre of gravity for B.M.D on simply supported beam acting UVL.

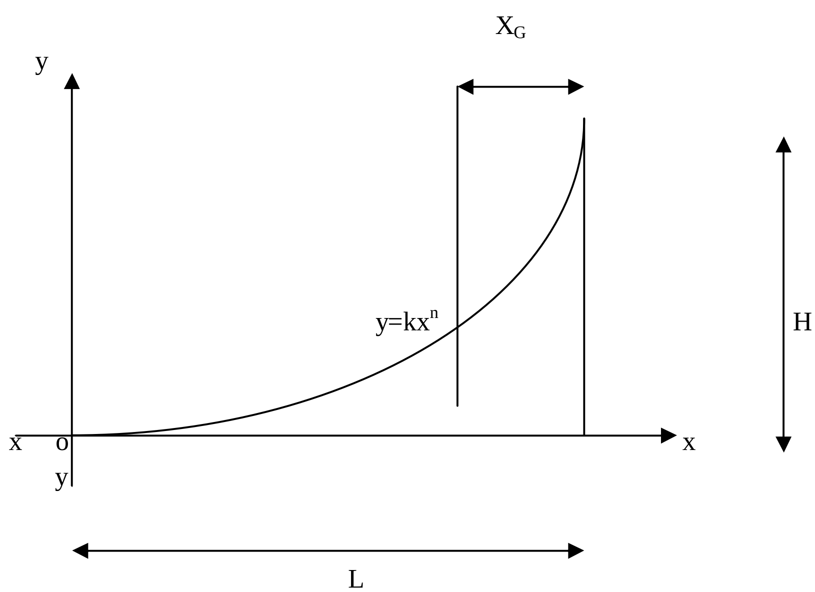
I. INTRODUCTION

The moment of load about a specified axis is always defined by the equation of a spandrel

$$y = kx^n$$

When 'n' is the degree of x.
The graph of the above equation is shown below:

Graph1:



Area of the curve (A) $= \frac{LH}{n+1}$

Centre of gravity of curve (X_G) $= \frac{L}{n+2}$

We considering all bending moment diagram occurs in beam due to uniformly varying load (U.V.L) is 3° curve. It is absolutely wrong. The beam carries an U.V.L of 'w/unit length' at fixed end to zero at the free end. The figure.1 which is shown below:

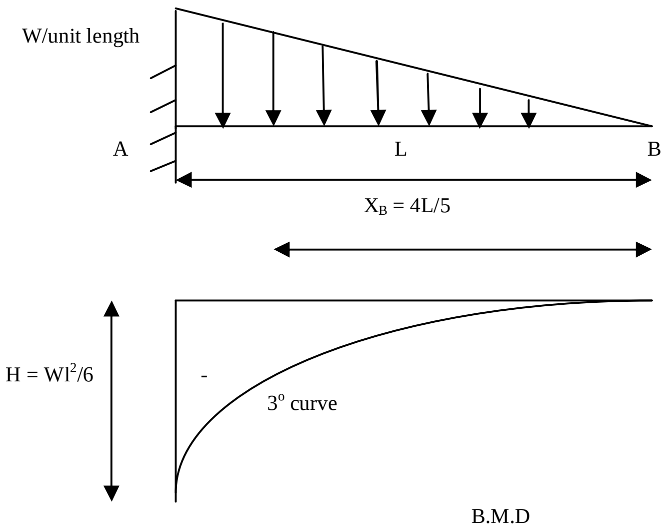


FIG.1

Degree of curve which is mentioned in the references to find out the slope and deflection of cantilever easily by using Mohr's theorems

1) Mohr's Theorem – I

By using Mohr's theorem-I to determine the maximum slope in the cantilever beam at free end.

$$\mathbf{i} = \frac{\textit{Area of BMD}}{\textit{Flexural rigidity}}$$

i = slope

Area of bending moment diagram for 3° curve for cantilever beam = $\frac{LH}{4}$

$$\mathbf{i} = \frac{1}{4} \times L \times H \times \frac{1}{EI}$$

$$\mathbf{i} = \frac{1}{4} \times L \times \frac{wL^2}{6} \times \frac{1}{EI}$$

$$\mathbf{i}_{\mathbf{max}} = \frac{wL^3}{24EI}$$

2) Mohr's Theorem – II

By using Mohr's theorem-II to determine the maximum deflection in the cantilever beam at free end.

$$Y = \frac{\textit{Area of BMD} \; x X_B}{\textit{Flexural rigidity}}$$

Y = Deflection

$X_B = \frac{4L}{5}$

$$\mathbf{Y} = \frac{wL^3}{24EI} \times \frac{4L}{5}$$

$$Y_{max} = \frac{wL^4}{30EI}$$

Flexural rigidity: The product of young's modulus (E) and moment of inertia (I) of the material is called flexural rigidity.

In case, if the cantilever beam is carrying U.V.L 'w/unit length' at free end to zero at fixed end which is shown in figure 2.

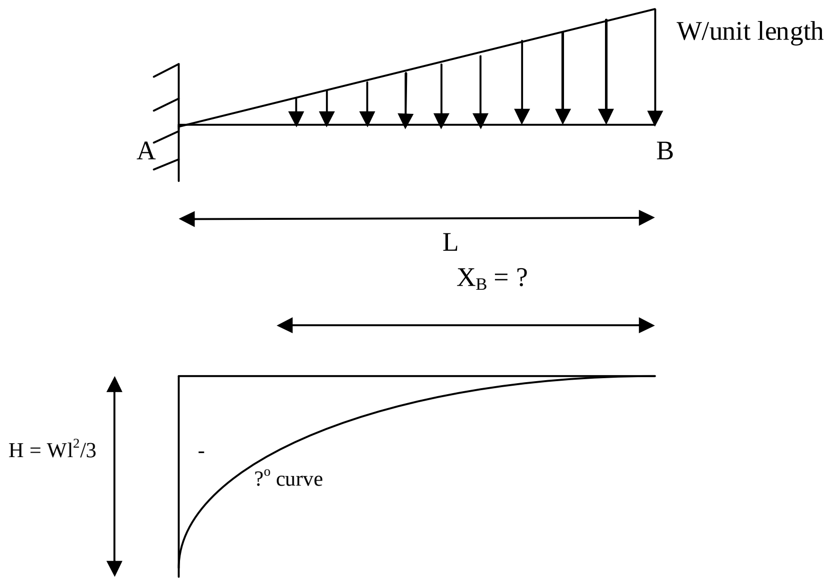


FIG.2

In this case, we can't find out slope and deflection by using area of bending moment diagram (LH/4) and centre of gravity formula (X_G = 4L/5).Because the curve which is not 3° and also it is not mentioned in any other references.

II. METHODOLOGY

Direct area method is the combination of double integration method and Mohr's theorem. In this method used to find out the area constant, centre of gravity by equation of slope and deflection formula generated from double integration method.

In Mohr's theorem I substituting the generated slope formula from double integration method to find out the area constant of bending moment diagram and also in Mohr's theorem II substituting the generated deflection formula from double integration method to find out the centre of gravity of bending moment diagram.

A. From Double Integration Method

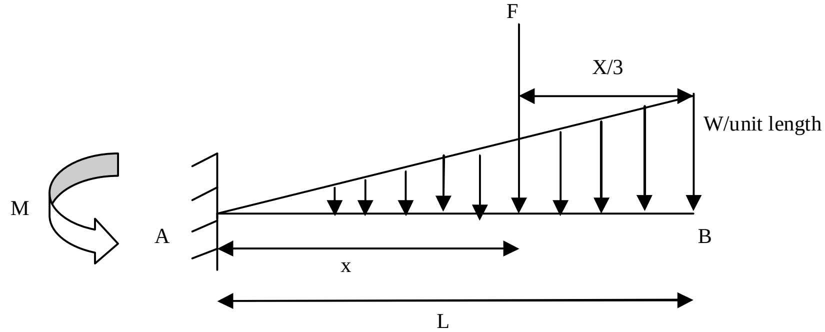


FIG.3

(V) Reaction at A = $\frac{wL}{2}$

(M) Bending moment at A = $\frac{wL^2}{3}$

Slope and deflection formulae generated from double integration method shown below:

Slope at distance 'X' from A:

$$i_x = -\frac{wL^2x}{3EI} + \frac{wLx^2}{4EI} - \frac{wx^4}{24EIL}$$

B. Deflection at distance 'X' from A

$$Y_x = -\frac{wL^2x^2}{6EI} + \frac{wLx^3}{12EI} - \frac{wx^5}{120EIL}$$

We know that maximum slope and deflection occurs at free end at cantilever beam.
So substitute x = L in the slope deflection formula generated from double integration method.
Maximum Slope at free end:

$$i_{max} = \frac{wL^3}{8EI}$$

C. Maximum Deflection at Free End

$$Y_{max} = \frac{11wL^4}{120EI}$$

From this,
By using Mohr's theorem-I find out area constant 'X' refer FIG.2.

$$i = \frac{\textit{Area of BMD}}{\textit{Flexural rigidity}}$$

$$\frac{wL^3}{8EI} = \mathbf{X} \ \text{x}\, L \,\text{x}\, H \,\text{x}\, \frac{1}{EI}$$

$$\frac{wL^3}{8EI} = \mathbf{X} \,\text{x}\, L \,\text{x}\, \frac{wL^2}{3} \,\text{x}\, \frac{1}{EI}$$

Area constant for the curve (X) $= \frac{3}{8}$

By using Mohr's theorem-II find out area constant 'X_B' refer FIG.2.

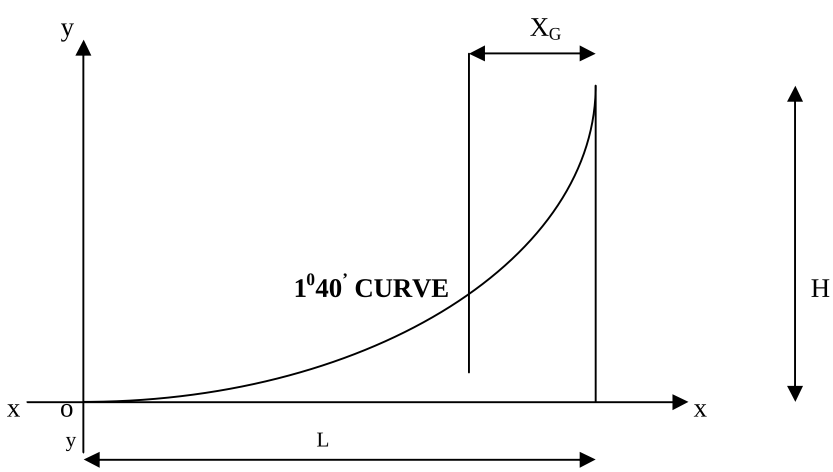
$$Y_{max} = \frac{\textit{Area of BMD} \, x X_B}{\textit{Flexural rigidity}}$$

$$\frac{11wL^4}{120EI} = \frac{wL^3}{8EI} \,\text{x}\, X_B$$

Centre of gravity for the curve (X_B) $= \frac{11L}{15}$

D. Degree of Curve

Graph2:



Area of the curve (A) $= \frac{LH}{n+1}$.. (1)

We know that area constant $= \frac{3}{8}$

Area of curve = area constant x B x H

Area of curve = $\frac{3}{8}$ x L x H

E. Substitute in the Equation (1) to find Degree of Curve

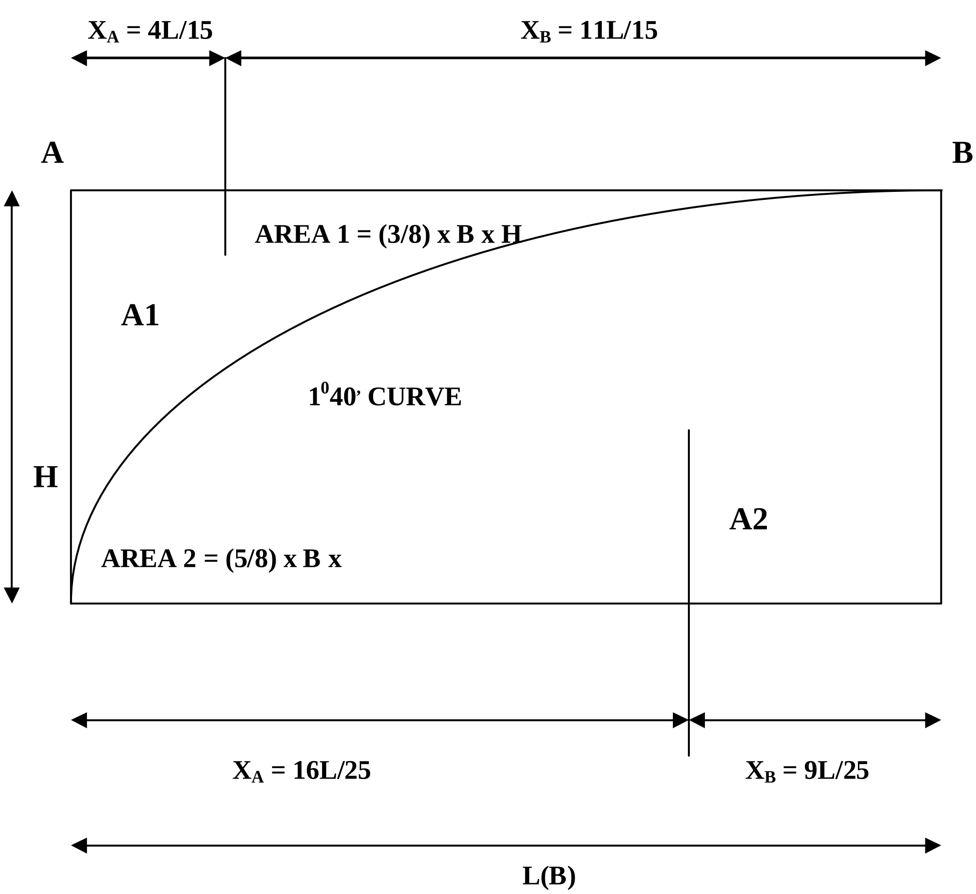
$$\frac{3LH}{8} = \frac{LH}{n+1}$$

From this,

$$n = 1.67 = 1^0 40'$$

So the degree of curve is $\mathbf{1^0 40'}$.

From this,
Area and Centre of gravity For $1^0\ 40'$ curve to length ‘L’ :



A1 = Area and centre of gravity for bending moment diagram to cantilever beam carries uniformly varying load ‘w/unit length’ at free end to zero at fixed end.
A2 = Area and centre of gravity for bending moment diagram to simply supported beam carries uniformly varying load ‘w/unit length’.

III. CONCLUSION

From the research $1^o\ 40'$ curves for bending moment diagram to simply supported beam carries an U.V.L 'w/unit length' and also cantilever beam carries uniformly varying load 'w/unit length' at free end to zero at fixed end.

IV. ACKNOWLEDGMENT

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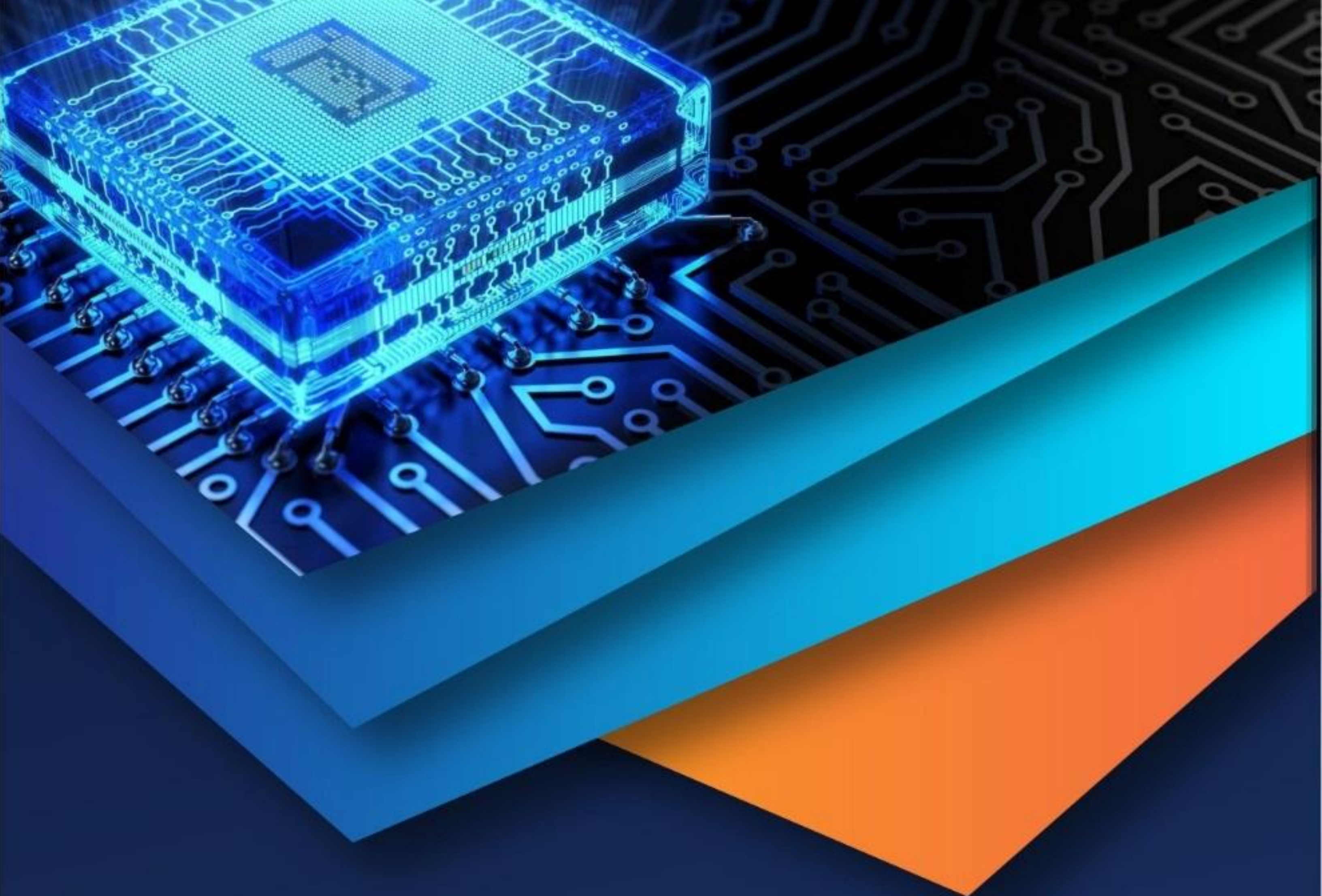

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