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C1 equals minus M End over 6, and then we've got L squared but we have to divide by L, so it's just going to be L. That means that x is 0. At x=4,y=0 ,C1=-135 Equation for slope (dy/dx):- EI (dy /dx)=-135 +90 x 2 /2 -40(x-1) 2 -120(x-3) Equation for deflection (y):- EIy = -135x + 90 x 3 /6 -80(x-1) 3 /6 -120(x-3) 2 /2 To find deflection at centre (i.e. x=2m, at mid span):- EIy=90(2) 3 /6 -135(2) -80/6(2-1) 3 /6 =-163.33 y=-163.33/(15×10 3)=-10.89×10 -3 m =-10.89 mm To find slope at centre (i.e. x=2m, at mid span):- EI (dy/dx) =90× (2) 2 /2-135-80(2-1) 2 /2 =+5 44. Now let's use the other boundary condition, EI y at x equals L equals 0. x both sides ,we get EI (y) = ∫ ∫ (M dx) dx + C1(x) + C2 where C1 and C2 are constant of integration Thus, integrating the differential equation w .r .t. These two constants must be evaluated from known conditions concerning the slope deflection at certain points of the beam. 4kN/m 10 KN 1m 2m 1m DA B C [Ans:θD=62.33/EI, y=-191/EI] Q-(6) Find the deflection at C and magnitude of maximum deflection. The first integration y' yields the slope of the elastic curve and the second integration y gives the deflection of the beam at any distance x. (iv) FLEXURAL RIGIDITY(EI):- The product of modulus of elasticity and Moment of Inertia is known as Flexural rigidity. So I will take x = 3.75 then the last portion of the equation will not come in to picture EI(0)=34/2(x1) 2 -75.06-30(x1-1) 2 /2 -20(x-3.75)2 EI(0)=34/2(x1)2 -75.06-30(x1-1)2 /2 zero 40. Q- (2) Determine the values of deflections at points C,D and E in the beam as shown in figure.Take E=2*10 5 MPa ; I= 60 *10 8 mm 4 1m 2m 10kN/m 1m 1m 20kN 30kN A C D E B [C=0.0603mm(downward), D=0.0953mm(downward) E=0.0606mm(downward)] 47 60. Q-(3) Find the position and magnitude of maximum deflection for the beam loaded as shown in fig. Support conditions: slope and deflection are zero at fixed support at x=3m,dy/dx=0 from equation (1), EI(0)=-15(3) 2 /2 + C1- 25(3-2)=0 C1=25+67.5=92.5 At C, y=0, x=3 from (2) EI(0)=-15 (3) 3 /6+92.5(3) +C2 -25(3-2) 2 /2 C2=12.5-277.5+67.5=-197.5 Now equation (1) EI(dy/dx)=-15x 2 /2+72.5 -25(x-2) 56. Take E=200GPa, I=7332.9 cm 4 Solution:- RA =34 KN, RB =36 KN A B RA RB 30KN 40KN 1m 5m 1.25m x X X c D Mx = RAx - 30(x-1) - 40(x-3.75) 34. Case (2) : When cantilever is subjected to an u .d. δmax1 ≠ δmax2 and θmax1 ≠ θmax2δmax1 ≠ δmax2 and θmax1 ≠ θmax2δmax1 ≠ δmax2 and θmax1 = θmax2δmax1 = δmax2 and θmax1 = θmax2 1. (3)While finding slope and deflection in the form (x-a) n ,if (x-a) becomes negative on substituting the value of x, neglect the term containing the factor (x – a) n 32. Support reactions: at x=0,y=0, C2=0 at x=5m,y=0 , C1=-8.25 Equation for slope:- EI (dy/dx)=3x 2 /2-8.25 –(x-1) 3 /3 +(x-4) 3 /3 ------(3) Equation for the elastic curve : EIy=x 3 /2 -8.25x –(x-1) 4 /12 +(x-4) 4 /12 ---------(4) Due to symmetry, deflection is maximum at centre at x=2.5m, EI ymax=(2.5) 3 /2 -8.25x(2.5)-(2.5-1) 4 /12=-13.23 ymax = -13.23/EI 52. EI ymax=34(2.56) 3 /6-75.06 × 2.56-30(2.56-1) 3 /6 Ymax=-116.13/EI=-7.918 × 10 -3 m =-7.918mm 39. What I'd like you to start off with is to solve for the reactions at the pin and the roller in this situation and then come on back. (ii) Cantilever Beam: Deflection and slope both are zero at fixed support. Take E=200GPa ,I=7500cm4 . dy/dx =5/(15×10 3)=3.33×10 -4 radians~ 0.019° =19.1×10 -3 degree ~ 0.02° (b)θA(at x=0) =-135/EI=-135/(15×103) θC (at x=1m) =[45× (1) 2 -135 ×1)/15 × 10 3 =-90/15 × 10 3 radian D (at x=3m)= [45 ×(3) 2 -135-40(2) 2] =110/15 × 10 3 radian 45. 17. Then, we're going to integrate again to find the deflection y. (ii) Slope at A,B,C and D, (iii) maximum deflection of the beam. Point C is the centre of curvature. Maximum slope at A when x=0 from (1) EI(dy/dx)A=92.5 (dy/dx)A=92.5/EI=7.708×10 -3 radian 57. Thus the equation for slope and deflection will be E I (dy / dx) =-75.1+17x 2 - 15(x-1) 2 -20(x-3.75) 2 - ----------(3) E I (y)= -75.1 x +17x 3 /3 -5(x-1) 3 -20(x-3.75) 3 /3 ---------(4) Total deflection at section of point loads At C x=1m , deflection y= yC (say) EI yC = -75.1×1 +17(1) 3 /3 =-69.393 Or, yC =-69.393/EI =-69.393/(200×10 6 ×7332.9×10 -8) =- 4.73× 10-3 m = - 4.73mm 36. (4)If a couple (moment) of magnitude 'c' is acting at a distance 'a' from the origin of the beam, then write the BM due to couple in the form c (x-a)0 . Now that we have that, what I'd like you to do is to draw the shear diagram. Macaulay recognized this fact and proposed a method which is known as the Macaulay's method to obtain the slope and deflection equations. (ii) Find the maximum deflection and maximum slope. Alternatively, RB =1/4[80×1-120] =-10KN =10 KN( ) EI (dy /dx)= C1 + 90x 2 /2 - 80(x-1) 2 /2 –120 (x-3) -------(1) EI(y)= C2+C1(x) + 90 x 3 /6 -80(x-1) 3 /6 -120(x-3) 2 /2 ------(2) Support reactions at x = 0 ,y = 0 , C = 0 MX= 90x - 80(x-1) -120(x-3) 0 Mx = 90 x – 80 (x-1) – 120 (x-3)0 43. Let's go ahead and integrate once. (b) Material of the beam is homogenous, isotropic and obey Hook's law .. The deflection is caused by the bending moment acting at various sections of the beam. EI (dy/dx)=3/2(x) 2 +C1 –(x-1) 3 /3 +(x-4) 3 /3 -------(1) EIy=3 x 3 /6 +C1x +C 2 – (x-1) 4 /12 +(x-4) 4 /12 ------(2) M =3(x) -2(x-1) 2 /2 +2 (x-4) 2 /2 51. Therefore, equation (3) becomes, EI(y)=-wx 4 /24 + wL 3 .x/6 –wL 4 /8--------(4) Maximum deflection It occurs at free end where x= 0 From (4),EIy=-0+0-wL4 /8 24. The distance CP = CQ = R = radius of curvature PQ = ds = tangent length ds = Rdφ Therefore, R=ds/dφ R= ds/dφ = (ds /dφ) ×(dx/dx) =(ds /dx)/(dφ/dx) = secφ/(dφ/dx) -------------(1) 9. (c) The modulus of elasticity is same in compression as well as in tension. This criterion is known as the STRENGTH CRITERION of design . We have from differential equation of flexure, EI d 2 y/dx 2 =M Integrating w. This is what you should have come up with so that we see here at x equals 0, we have a moment of 0, and then it's a ramp function where at the end where x equals L, the moment is equal to M sub End. slope θ is maximum at A and B and zero at middle of Span (at point of symmetry); At point of maximum deflection slope is zero θB C A B D θA A NOTE : SUPPORT CONDITIONS: (i) Simply supported beams: Deflection at support A and B are zero but more at free end and also at the centre of span . 58. ((ii) ELASTIC CURVE(OR, DEFLECTION CURVE):- The neutral axis in its deflected position after loading of the beam is known as its elastic curve or deflection curve 4. B.M at distance x from A= Mx = EI d 2 y/dx 2 =-w.x.x/2=-wx 2 /2 Integrating once, EI (dy/dx) =-wx 3 /6 + C1 -----------------------(1) where C1 is constant of integration BA L x w unit /m X X 22. Solution: B.M. at section 1-1 M= - P(x) EI d 2 y/dx 2 = M = - P (x) EI (dy /dx) = -P (x 2 /2) + C1 EI y = -P (x 3 /6) + C1x + C2 P 1 1 x A B θA l yA At fixed end, when x = L (x =0, at free end) (dy /dx) =0 (iii) What will be the deflection and slope at free end when P=6kN, L=3m, E=210GPa, I=16x104 cm4 . It is essentially modified method of double integration of the B.M. expression but following a set of rules given below:- 31. Any other use of the content and materials, including use by other academic universities or entities, is prohibited without express written permission of the Georgia Tech Research Corporation. Deflection at free end (i.e; at A):= yA = PL 3 /3EI (iii) θA=PL 2 /2EI slope θA=(dy/dx) at A radian5 83 233 100357.8)1016()10210(2)103(106 − ×= ×× ×× =)1016()10210(3)103(106 83 333 ×× ×× = = 0.161mm P 21. In general case of loading, where several loads are acting the B.M. expression for each of the different regions of loading is different .Then the method of double integration will become extremely lengthy and laborious. Due to symmetry dy/dx = 0 at x = L/2 24 3 1 wL C −= Integrating both side w.r.t. x, we get 2 343 242412 Cx wlwxwLx YEI +−= At x = 0, y = 0 C2=0 x wlwxwLx YEI 242412 343 −−=Hence Maximum deflection yc which occurs at centre C is obtained by substituting x = L/2 in the above equation 29. (dy/ dx) at B=1/EI[17 ×(5)2-75.06-15 ×(4)2-20 ×(1.25)2] =78.65/EI=5.363 × 10-3 rad =0.197 degree Assuming the deflection to be maximum in the region CD: (at point of maximum deflection dy/dx = 0) 38. If I take the entire equation i.e. I am assuming that slope is zero in the region DB then I will get x1= 7.09 or 2.9 (it is less than 3.75m) i.e., my assumption is not correct. 33. EXERCISE PROBLEMS : Q.(1) Figure shows a simply supported beam of span 5m carrying two point loads. Instead of having a moment at both ends, we're just going to put a moment on the right hand side where we have our roller constraint. x, we get the equation for slope (dy /dx) ,and integrating it twice w. But we want to find as our worksheet solution the deflection of the beam as a function of x. Interested parties may contact Dr. Wayne Whiteman directly for information regarding the procedure to obtain a non-exclusive license.View SyllabusSelect a languageArabicEnglishFrenchGermanItalianRussianSpanishVietnameseptPtHi, this is Module 4 of mechanics materials Part 4. Let's use the first boundary condition y of 0 equals 0. So here is our expression. Applying boundary conditions:- at x =L, dy/dx=0 from equation(1) 0=-wL 3 /6 + C1 C1 = wL 3 /6 therefore, EI dy/dx=-wx 3 /6 +wL 3 /6---------(2) Integrating once again, EI y=-wx 4 /24 + wL 3 .x/6 +C2 ---------------- (3) where C2 is 2nd constant of integration Applying boundary condition; at x=L, y=0 23. Take a section X-X at a distance x from A. Assuming the deflection to be maximum in the region CD: The x varies from 1 to 3.75 m (ie the section is between 1 and 3.75). Q-(4) Determine the magnitude and position of maximum deflection for the beam loaded as shown in fig. Take flexural rigidity EI = 15×109 kN-mm2 2m 2m 2m A C D B 20kN/ Solution: RA=33.333 kN, RB =46.667KN 40 kN M = 33.333x - 40(x-2) - 20(x-4)2 /2 46. 41. From equation(1), R= secφ /(dφ/dx) = sec 3 φ /(d 2 y/dx2) 1/R=(d 2 y/dx 2)/sec 3 φ =(d2 y/dx2)/ (sec2 φ)3/2 = (d2 y/dx2)/ (1+tan2 φ)3/2 =(d 2 y/dx 2)/[1+(dy/dx) 2] 3/2 In any practical case of bending of beams, the slope (dy/dx) is very small (because curve is almost flat); hence (dy/dx)2 can be ignored so, 1/R=d 2 y/dx 2 From relation ,M/I=E/R 1/R=M/EI=d2 y/dx2 M=EI(d2 y/dx2) 11. Here's the shear diagram as a result, and draw the moment diagram. MACAULAY'S METHOD For a general case of loading on the beam, though the expression for B.M. varies from region to region, the constants of integration remain the same for all regions. M =33.333(x) -40(x-2) - 10 (x-4) 2 EI (dy/dx)=C1+33.333 (x) 2 /2 – 40(x-2) 2 /2 -10(x-4) 3 /3 -------(1) EIY = C2+C1x + 33.333x3 /6 -20(x-2)3 /3 -10(x-4)4 /12 At x=0, y = 0 C2=0 At x=6m, y = 0 C1 = -126.667 47. of intensity w unit/m run over entire span Here A is the origin. L/2 L/2 P P C A B RA=P/2 RB=P/2 x X X Mx = (P/2) x EI d2 y/dx2 =(P/2)x EI dy/dx=(P/2)x2 /2 + C1 Due to symmetry slope at x = L/2 is zero C1 = -PL2 /16 EI dy/dx=(P/2)x2 /2 -PL2 /16 Integrating again we get EIY = (P/2)x3 /6 –(PL2 /16) x + C2 At x=0 , Y = 0 26. Here's the moment diagram that you should've come up with. Therefore, - (PL 2 /2) + C1= 0 C1= PL 2 /2 At x = L, y = 0, -PL 3 /6+(PL 2 /2) L+C2=0 or,C2= PL 3 /6 - PL 3 /2 = PL 3 /6[1-3]= - PL 3 /3 Therefore ,C2= - PL 3 /3 19. Let the tangents at P and Q make angle φ and (φ+dφ) with the x-axis at a point A and B respectively. Practice problems:- (Q-1) A cantilever beam of span L carries a udl of intensity w/unit length for half of its span as shown in figure.If E is the modulus of elasticity and I is moment of inertia,determine the following in terms of w,L,E and I. For instance, in the case of a simply supported beam with rigid supports, at x = 0 and x = L, the deflection y = 0, and in locating the point of maximum deflection, we simply set the slope of the elastic curve y' to zero. Find the maximum deflection and the maximum slope for the beam loaded as shown in figure. 18. Find (1)the deflection at the section of the point loads. (Q-2) (A) Obtain the equation for slope and elastic curve for the beam loaded as shown in figure and find the deflection and slope at mid- point of beam. Assuming the deflection to be maximum in the portion CD EI (dy/dx)=-126.667+33.333 (x) 2 /2 – 40(x-2) 2 /2 -10(x-4) 3 /3 EIY =-126.667x + 33.333x3 /6 -20(x-2)3 /3 -10(x-4)4 /12 (at point of maximum deflection dy/dx = 0) 0=-126.667+33.333 (x)2 /2 – 20(x-2)2 x2 - 24x +62 =0 x = 2.945m The assumption that the maximum is within the portion BC is correct. RB=WL/2 A x W unit / run B RA=WL/2 X X 1 32 2 2 2 2 64 22 22 C xwxwL dx dy EI xw x wL xd yd EI xw x wL Mx +−= −= −= 28. Let the co-ordinates of the point P be (x,y) and the horizontal and vertical distance from P to Q be dx and dy. Hence EIY = (Px3 /12) – (PL2 /16) x Deflection at mid span i.e. at x = L/2 is Y = -PL3 /48EI = PL3 /48EI (downward) Slope at support, is obtained by putting x = 0, in slop equation EI WLWL EIdx dy x A 1616 1 22 0 −= ⎟ ⎠ ⎞ ⎜ ⎝ ⎛ −= ⎟ ⎠ ⎞ ⎜ ⎝ ⎛ = = θ 27. Here are those results. INTRODUCTION The cross section of a beam has to be designed in such a way that it is strong enough to limit the bending moment and shear force that are developed in the beam. x both sides, we get EI (dy /dx) =∫M dx + C1 Integrating again w .r .t. Then dy /ds =sinφ dx /ds= cosφ dy/dx =tanφ Differentiating equation (a) w.r.t. x, we get Sec 2 φ.(dφ/ dx)=d 2 y/dx 2 Therefore, dφ/ dx =(d 2 y/dx 2)/sec 2 φ -------------(2) dy dxφ dx ds φ ds dy (a) 10. So we have EI dy dx is going to be equal to M sub End over L, and the integral of x is x squared over 2. Deflection is also caused due to shear but the magnitude is small compared to that due to bending and hence it is generally neglected. Methods for finding slope and deflection of beams: (i) Double integration method (ii) Macaulay's method (iii) Area moment method (iv) Conjugate beam method (v) Unit load method 15. ASSUMPTIONS MADE IN THE DEFLECTION:- (i) Axis of the beam is horizontal before loading. These are the reactions that you should have gotten at the pin and the roller. Take EI=15× 103 kNm 2 (B) Find the slope at A,C and D Solution:- Reactions RA=1/4[80×3+120] =90KN( ) RB =80-90=-10kN=10( ) 80KN 1m 120kNm x X X 2m1m A c D B 42. EI(d 2 y/dx 2)=-15x -25(x-2) 0 EI(dy/dx)= C1 -15x 2 /2 -25(x-2) EI(y)= C2 + C1x -(15/2) x 3 /3 -25(x-2) 2 /2 55. 1m 1m3m A C D B 2kN/m Solution: RA=RB = 2x3/2 = 3KN D B A 1m1m 3m C 2kN/m x M =3(x) -2(x-1) 2 /2 +2 (x-4) 2 /2 50. Another criterion for beam design is that the maximum deflection of the beam must not exceed a given permissible limit and the beam must be stiff enough to resist the deflection caused due to loading. By participating in the course or using the content or materials, whether in whole or in part, you agree that you may download and use any content and/or material in this course for your own personal, non-commercial use only in a manner consistent with a student of any academic course. Okay. (d) Plane section remain plane before and after bending 7. (Q.5) Find maximum slope and maximum deflection of the beam loaded as shown in fig. DOUBLE INTEGRATION METHODS : 16. t.. Definitions:- (i) DEFLECTION :-The vertical distance in transverse direction between positions of axis before and after loading at the section of the beam, is defined as the deflection of beam at that section. So we've integrated twice to find the deflection and we've introduced two constants of integration. (1)Assuming origin of the beam at extreme left end, take a section in the last region of the beam at a distance x from the origin and write the expression for B.M. at that section considering all the force on the left of section. EI wL dx dy endatSlope downward EI wl Yc EI wl Yc x A 24)(384 5 384 5 3 0 4 4 −= ⎟ ⎠ ⎞ ⎜ ⎝ ⎛ = = −= = θ 30. r .t. Slope is maximum at supports B and A 13. INTRODUCTION Under the action of external loads any beam bends and suffers deflection at various points along the length. Case 4:-Simply supported beam of span L carrying a uniformly distributed load of intensity w per unit run over the whole span. Case 3:-When simply supported beam is subjected to a single concentrated load at mid-span. The resulting solution must contain two constants of integration since EI y" = M is of second order. Deflection at support A and B are zero and maximum at the middle of Span. ymax=-wL 4 /8EI similarly maximum slope occurs at free end where x=0 from (2), EI (dy/dx) =-0+wL3 /6 (dy/dx)max=wL 3 /6EI 25. the undeformed axis. Now we have our moment curvature relationship and we have an expression for the moment as a function of x, and so what we're going to be able to do is to find the deflection by integrating it twice and using the boundary conditions to solve for the constants of integration. So here's our expressions. x, we get the equation for deflection (y). So we have EI y is equal to now M sub End over 2L, and if I integrate x squared, we get x cubed over 3 plus now C1 times x plus C2. 3KN/m20 KN A D B X 4m 4m 4m C X X [Ans:ymax at 3.7 m from A=-118/EI=7.99mm yc=-32/EI=-2.13mm] 48 61. Now equation (1) EI(dy/dx)=-15x 2 /2 +92.5 -25(x-2) ---------(1) and EI(y)=-15/2*x 3 /3+92.5x-197.5 -25(x-2) 2 /2 -----(2) Maximum Deflection at free end when x=0 EI(y)A=-197.5, yA=-197.5/EI=-16.458mm. EI d 2 y/dx 2 = 34 x -30(x-1) -40(x-3.75) Integrating once, EI (dy/dx) =c1 + 34 x2 /2 -30(x-1)2 /2 - 40(x-3.75)2 /2 ---(1) Integrating once again, ---------- (2) Support conditions: at x=0,y=0 therefore,C2=0 6)75.3(40 6)1(30 6 34 333 12 − − − −+·+= xxx xCCEIy 35. Find the maximum deflection. E is the modulus of elasticity of the beam, I represent the moment of inertia about the neutral axis, and M represents the bending moment at a distance x from the end of the beam. Case--1(i): Determine the slope and deflection equation for the beam loaded as shown in fig. Take EI=800Nm 2 E B D A C 1m1m 1m 1m [Ans:ymax =80 mm at 1.59m from A , yE =73mm] 120kNm 80kN 20kN 49 62. t. B θmax ymax A 14. EIYmax =-126.667×2.945 + 33.333×2.94453 /6 -20(2.945-2)3 /3 =-236.759 kN-m3 = -236.759 ×109 kN-mm3 Ymax = -15.784 mm 48. We're going to want to find the deflection of the beam as a function of x and then determine the maximum deflection and where it occurs. Plus, we're going to have a constant of integration which I'm going to call C1. SIGN CONVENTIONS: Linear horizontal distance x: positive when measured from left to right Vertical distance or deflection y is positive when measured above the axis and is negative when measured below the axis of beam. (dy/dx)D =[17 ×(3.75)2-75.06-15 ×(2.75)2] × 1/EI (when x=3.75m) =50.525/EI=3.445 radians. Therefore ,it is not generally used. What are the boundary conditions that we can use now to find the constants of integration? 0=-wL 4 /24+wL 4 /6+C2 Therefore, C2=wL4 /24-wL4 /6 C2=-wL 4 /8. Consider a piece of deflected curve of beam PQ = ds (length). So here's our expression for the slope now. The product EI is called the flexural rigidity of the beam. r. 3. Slope ,deflection and radius of curvature Φ Φ+dΦ P Q C dy dx A B y o x dΦ R ds 8. This is a worksheet where we're going to assume that E and I or the flexural rigidity of the beam is constant. EI is equal to this, and then this is C1. Determine the equation for the elastic curve for the beam loaded as shown in figure. Previously, we've seen that we came up with a differential equation for the elastic curve of a beam, and we said that if we now have an equation for the moment along the beam, we can find the deflection by integrating this equation twice and using boundary conditions to find the constants of integration, and that's what we're going to do in this module. L. So we can solve now for C1. DIFFERENTIAL EQUATION OF ELASTIC CURVE:- (SLOPE AND DEFLECTION) Differential equation of elastic curve E I(d2 y/dx2) = M 6. Module 4: Double Integration Method to determine beam deflectionsThis course explores the analysis and design of engineering structures considering factors of deflection, buckling, combined loading, & failure theories -- The copyright of all content and materials in this course are owned by either the Georgia Tech Research Corporation or Dr. Wayne Whiteman. Take EI=40MN-m 2 4m 2m 200KN1m BA C [Ans:ymax=-13.45mm, yC=-13.33mm] 50 The two constants of integration can be determined using the known conditions of deflection and slope at the supports The method of double integration is convenient only in few cases of loadings. (5)If the beam carries a U.D.L, extend it up to the extreme right end and superimpose an UDL equal and opposite to that which has been added while extending the given UDL on the beam. M= 34 x -20 (x-1) -10 (x-1)2 /2 + 10(x-3)2 /2 – 30 (x-4) 1m 1m2m A C D E 10kN/m 20 kN 30 kN B 1m Va ×5 -20 × 4 -10 × 2 × 3 -30 × 1=0 Va=34 kN 1m 1m2m A C D E 10kN/m 20 kN 30 kN B 1m x 53. What you should say is, well, we know the deflection at the left hand is equal to 0, and the deflection at the right hand where x equals L is equal to 0. iii (a) Simple Bending equation M/I=σ/y=E/R is applicable and all the assumptions made in simple bending theory are valid. In calculus, the radius of curvature of a curve y = f(x) is given by $\rho = \dfrac{[\,1 + (dy / dx)^2\,]^{3/2}}{\vert \, d^2y/dx^2 \, \vert}$ In the derivation of flexure formula, the radius of curvature of a beam is given as $\rho = \dfrac{EI}{M}$ Deflection of beams is so small, such that the slope of the elastic curve dy/dx is very small, and squaring this expression the value becomes practically negligible, hence $\rho = \dfrac{1}{d^2y/dx^2} = \dfrac{1}{y''}$ Thus, EI / M = 1 / y'' $y'' = \dfrac{M}{EI} = \dfrac{1}{EI}M$ If EI is constant, the equation may be written as: $EI \, y'' = M$ where x and y are the coordinates shown in the figure of the elastic curve of the beam under load, y is the deflection of the beam at any distance x. Slope and deflections are maximum at free end θ increases from point A towards B. [Ans (i)θA=WL 3 /48EI (ii)A =7wL 4 /384EI( ) (iii)P=7wL/128] L/2 L/2 w/m A B 46 59. say at x=x1 where dy / dx=0 From equation (3), EI(0)=34/2(x1) 2 -75.06-30(x1-1) 2 /2 =17 x1 2 -75.06 -15x1 2 +30x1 -15 =2x1 2 +30x1-90.06=0 x1= 2.56m The assumption that the maximum deflection is within the region CD is correct. So we get minus M End times L over 6 for C1. So that's our answer. 262 3 262 103273.723273.72, 104444.8 10667.126667.126, mmkNmkN dx dy EIBat radians dx dy mmkNmkN dx dy EIAat B A A −×−=−= ⎟ ⎠ ⎞ ⎜ ⎝ ⎛ ×−= ⎟ ⎠ ⎞ ⎜ ⎝ ⎛ −×−=−−= ⎟ ⎠ ⎞ ⎜ ⎝ ⎛ − Maximum slope occurs at the ends 49. (ii) Deflection due to S.F. is negligible. This criterion is known as 'STIFFNESS CRITERION of design" 2. Take E=200KN/mm 2 ,I=60 × 10 6 mm4 2m 1m 25kNm15kN x X X A B c 54. (2)Integrate the term of the form (x-a) n using the formula ∫(x-a) n dx=(x-a) n+1 /n+1 where a=distance of load from origin. So here's a demonstration of the system. NOTE : 12. At D, x = 3.75m, deflection y= yD (say) EIyD= -(75.06×3.75)+17(3.75) 3 /3-5(3.75-1) 3 =- 86.63 yc=-86.63/EI=-86.63 /(200×106 ×7332.9×10-8) = -5.907 × 10-3 m = -5.907mm At x=0, (dy/dx)A=-75.1/EI=5.121 × 10-3 radians At x=1m, (dy/dx)c=34 ×(1) 2 /2-75.1 or, (dy/dx)c =-58.1/EI=-3.96×10-3 radians. So that would be integrated, and we find out that this is the equation for the deflection. Now that we have the moment diagram, what I'd like you to do, we need an equation for the moment as a function of x, and for this moment diagram, go ahead and write an equation for the moment as a function of x. The double integration method is a powerful tool in solving deflection and slope of a beam at any point because we will be able to get the equation of the elastic curve. (iii) SLOPE:- The slope of the beam at any section is defined as the angle (in radians) of inclination of the tangent drawn at that section to the axis in its deflected position after loading, measured w. Today's learning outcome is to use the double integration method to determine the equation for the deflection of a beam. (i)A expression for slope(dy/dx)at free end (ii)An expression for deflection(y) at free end (iii)The magnitude of upward vertical force to be applied at free end in order to resume this end to the same horizontal level as built in end. . We'll see you next time. 5. So that equals M sub End over 6L times L cubed plus C1 times L, and then we know that C2 is equal to 0. Equation of slope; EI (dy/ dx) =-Px 2 /2 + PL 2 /2-----(1) Equation of deflection ,EI (y)=-Px 3 /6 + PL 2 x/2 - PL 3 /3-----(2) Maximum deflection : When x=0 (at free end) ,then from equation (2), EI (y)=-0+0-PL3 /3 ymax= -PL 3 /3EI Maximum Slope: Slope is maximum at free end (at x=0).hence from equation (1), EI (dy/ dx) = -0 + PL 2 /2 (dy /dx) max = PL 2 /2EI 20. Q-(5) Find the deflection and slope at free end for loaded beam shown in fig. This term drops out, x is 0, this term drops out and we're left with C2, and so we find out that C2 is equal to 0 as one of our constants of integration. 37.

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