**Dr. Mahalingam College of Engineering & Technology**

**Pollachi- 642003**

CONTINUOUS ASSESSMENT TEST – II

Class & Branch : III B.E. - CIVIL Max. Marks : 50

Sub. Code & Name : STRUCTURAL ANALYSIS - I Time :

Semester : V Date : 20/09/2011

**PART – A (10 x 2 = 20 Marks)**

**Answer all questions :**

1. State Muller-Breslau’s Principle.

The Müller Breslau Principle states that the ordinate value of an influence line for any functional response of any structure at given location is proportional to the ordinates of the deflected shape that is obtained by removing the restraint at that location corresponding to the functional response from the structure and introducing a force that causes a unit displacement in the positive direction.

1. What is indirect model analysis for influence lines? Why is it needed?

A method of using models of structures to get the influence lines for force quantities like bending moments, support moments, reactions, internal shears, thrusts, etc. based on Muller-Breslau’s principle is called indirect model analysis. It is needed for complex structure because :

(i) When the mathematical analysis of problem is virtually impossible.

(ii) Mathematical analysis is so complicated and time consuming then the model analysis offers a short cut.

(iii) The importance of the problem is such that verification of mathematical analysis by an actual test is essential.

1. What is Begg’s deformeter?

Begg’s deformeter is a device to carryout indirect model analysis on structures. It has the facility to apply displacement corresponding to moment, shear or thrust at any desired location of the model and to measure the consequent displacements all over the model accurately.

1. What is a linear arch?

An arch in which the internal forces are purely axial is called linear arch. The linear arch is therefore not subjected to internal shear force or bending moment.

1. What are the types of arches according support conditions and according to shapes?

Types of arches according to support conditions:

1. Three hinged arch, b) Two hinged arch, c) Fixed arch and d) one hinged arch

Common types of arches according to shapes:

1. Parabolic arch, b) Circular arch, c) Semi-circular arch, d) Elliptical arch. e) Polygonal arch.
2. What kind of arch and loading make the zero bending moment throughout the span of an arch? Why?

In case of udl throughout the span, bending moment in parabolic arch will be zero everywhere along the span. Because parabolic function of bending moment due to udl is nullified by the arch action which is also function of parabolic shape of the arch.

1. List the methods that are used for analysis of fixed arches.
2. Castiliano’s theorem, 2. Elastic centre method and Column Analogy method.
3. What are the assumptions made in slope-deflection method?

Assumptions made in slope-deflection method are

1. Beam section between the pair of supports is constant.
2. The joint in the structure may deflect or rotate as a whole, but angles between the members meeting at that joint remain the same. (ie. consists of rigid joints).
3. Write down the general slope-deflection equations and explain each term.

Slope deflection equation for end A (when other end is B) is

Where

MAB is the final fixed end moment

MFAB is the fixed end moment due to load

is the support moment induced due to the slope at joint A

is the support moment induced due to the slope at joint B

and is the support moment induced due to the difference in support levels.

1. Define sway and mention any 4 reasons due to which sway may occur in portal frames.

Sway is the lateral movement of joints in a portal frame.

Unsymmetric loading, unsymmetriacal geometry, unsymmetric support conditions, unsymmetric sections of the members, unsymmetrical settlement of the supports about the central vertical axis of the structure cause sway. Combination of the above also causes the sway.

**PART – B ( 3 x 10 = 30 Marks)**

**Answer any three of the following**

1. Using Muller-Breslau Principle, develop Influence lines for B.M at section D of the continuous beam shown in fig. 1. Compute, tabulate and plot the ordinates at 1m intervals. (10)

8m

A

B

6m

C

4m

D

Fig. 1

Solution OUTLINE

Step 1: Remove constraint to displacement corresponding to the response. In this case, ILD for BM at D is to be found, hence introduce hinge at D.

Step 2: Apply unit moment at D after introducing hinge.

Step 3: Find reactions.

Step 4: Arrive expression for bending moment for all the sections

Step 5: Find deflection curve for the section having the sufficient boundary conditions using macaulay’s method. Subsequently find the deflection curve for other sections also.

Step 6. Find the slopes at D for both the sections and find the total slope at D.

Step 7. Dividing the deflection curves obtained in step 5 by the total slope gives the ILD for BM at D.

**DETAIL SOLUTION**

Step 1: Remove constraint to displacement corresponding to the response.

In this case, ILD for Bending moment is to be drawn for location D. Hence, the corresponding displacement is rotation. In order to remove constrain to the rotation, introduce hinge at D.

Step 2: Apply unit moment at D after introducing hinge.

1kNm

B

A

8m

4m

C

D

6m

Step 3: Find reactions.

Considering left side section AD, Take Moment about D.

🡺 . From for AD,

**kN**

**kN**

Considering section DBC, take Moment about C.

🡺 **.** From for DBC,

Step 4 & 5: Arrive expression for bending moment for all the sections

Section (1) DBC (Measure x from C)

and substituting M

Integrating once, we get

Integrating once again, we get

Known boundary conditions for the section (1) DBC are

At . Applying these Boundary conditions,

🡪

🡪

Deflection curve for DBC :

Deflection at D :

Slope at D : = -9.986

Section (2) AD (Measure x from A)

and substituting M

Integrating once, we get   
Integrating once again, we get

Known boundary conditions for the section (2) AD are

At . Applying these Boundary conditions,

🡪

🡪

Deflection curve for AD :

Slope at D : = -8.654

Step 6. Find the slopes at D for both the sections and find the total slope at D.

TOTAL SLOPE = =

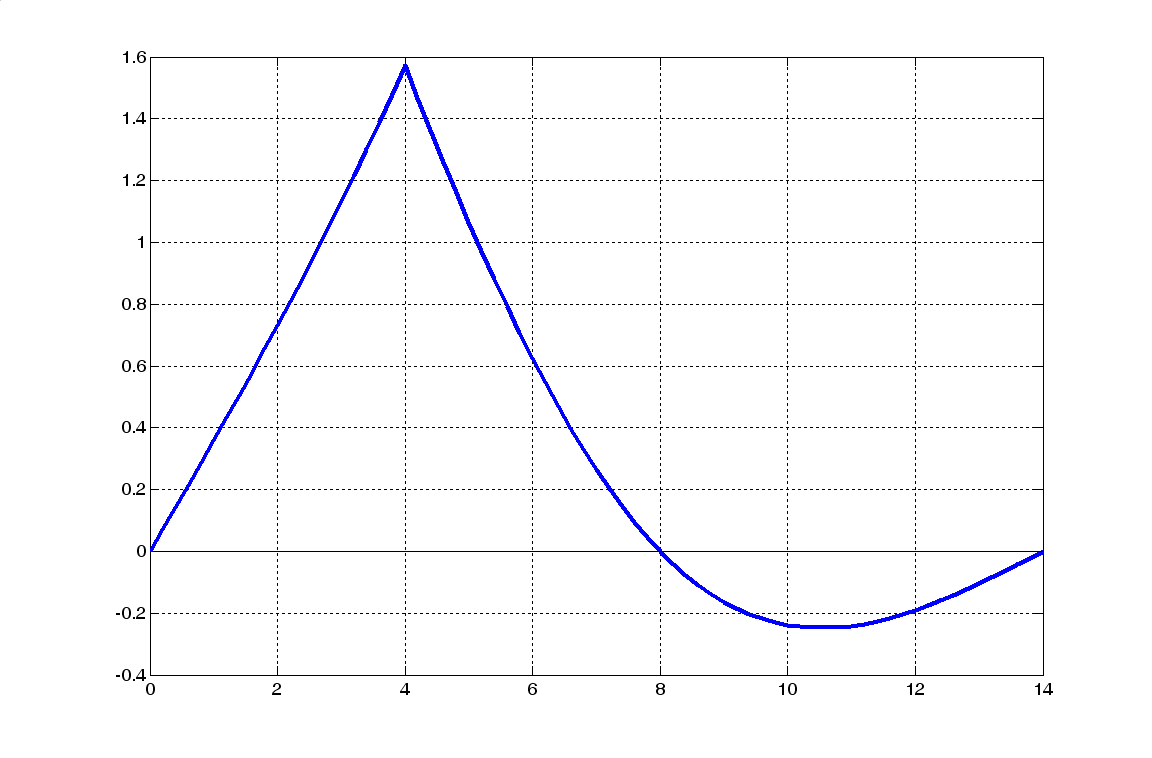
Step 7. Dividing the deflection curves obtained in step 5 by the total slope gives the ILD for BM at D.

For Section DBC (Measuring x from C)

For Section AD (Measuring x from A)

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|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Section | Section AD. *x* measured from A | | | | | Section DBC. Local *x* measured from C | | | | | | | | | | |
| Local x | 0 | 1 | 2 | 3 | 4 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| x from A | 0 | 1 | 2 | 3 | 4 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
| ILD | 0 | 0.359 | 0.732 | 1.131 | 1.571 | 1.571 | 1.064 | 0.624 | 0.265 | 0 | -0.164 | -0.239 | -0.241 | -0.191 | -0.104 | 0 |



ILD FOR BM AT D

1. A three hinged parabolic arched rib ACB is supported at different levels. It has a horizontal span of 15m, the hinge at the crown C being at 6 metres horizontally from A and 2 m vertically above it. The arch carries an UDL of 30kN/m from A to C. Calculate the maximum negative bending moment. Also find radial shear force and normal thrust at that location. (10)

2m

B

C

A

9m

6m

30 kN/m

Solution Outline

1. Find r2 which is the vertical distance between support B and the crown C.
2. Find reactions (by taking moment about C and about A)
3. Express bending moment for AC and BC
4. Differentiate BM w.r.t. span coordinate to find out the critical location where maximum negative bending moment occurs and find the max negative BM value
5. Find the Radial Shear and normal thrust at that location by resolving horizontal arch action and vertical shear force in radial and axial directions.

DETAIL SOLUTION

Step 1: Find r2 which is the vertical distance between support B and the crown C.

🡪 🡪 4.5m

Step 2: Find reactions (by taking moment about C and about A)

Take moment about C (consider right portion of the arch),

. . . . . . .(1)

Take moment about A

. . . . . . .(2)

Solving equations (1) and (2)

; ;

Step 3: Express bending moment for AC and BC

Consider section 1 (CB portion – measure x from B to the left)

Consider section 2 (AC portion – measure x from A to the right)

Step 4: Differentiate BM w.r.t. span coordinate to find out the critical location where maximum negative bending moment occurs and find the max negative BM value

For parabolic arch,

In this case, 🡪 y= 0.0556

Substituting values of VB, HB and y in the expression of M1, M1 becomes

To find the maxima and minima, Differentiate and equate to zero to find the location of maxima and minima

Solving x=4.504m.

BM at x=4.504m from B is obtained by substituting x in M1

BM4.504m from B = = -121.792 kNm

Consider section 2 (AC portion – measure x from A to the right)

In this case, 🡪 y= 0.0556

Substituting values of VA, HA and y in the expression of M2, M2 becomes

To find the maxima and minima, Differentiate and equate to zero to find the location of maxima and minima

Solving x=4.0 m.

BM at x=4.0m from A is obtained by substituting x in M2

BM4.0m from A= = +71.846 kNm

Hence, the maximum negative bending moment occurs at 10.496m from A (ie 4.504.m from B).

The value of maximum negative bending moments at that location is -121.792kNm.

Step5: Find the Radial Shear and normal thrust at that location by resolving horizontal arch action and vertical shear force in radial and axial directions.

Find y and at 10.496m from A.

=0.877m

or -26.5459o

Find Vx at 10.496m from A

Radial shear force at 10.496m from A

)= -64.45 kN

Axial thrust at 10.496m from A

)= +152.925 kN

1. Two hinged parabolic arch of span 30m and central rise 6m carries a uniformly distributed load of 50kN/m over the right half of the span. Find maximum positive bending moment and its location. Also find the normal thrust and radial shear at that section. Assume that the moment of inertia at a section varies as secant of the inclination (Io secθ). (10)

Solution outline

6m

B

C

A

30m

50 N/m

1. Find the reaction and arch action.
2. Express bending moment for AC and BC
3. Differentiate BM w.r.t. span coordinate  
   to find out the critical location where   
   maximum positive bending moment   
   occurs and find the max positive value.
4. Find the Radial Shear and normal thrust at that location by resolving horizontal arch action and vertical shear force in radial and axial directions.

DETAIL SOLUTION

Step 1: Find the reaction and arch action.

There are 4 reactions namely . Out of which , since there are no other horizontal force. Hence, there are three unknown reactions values to be found.

Find : Taking moment about B

🡪

Find H:

when I = Io secθ.

Hence, Numerator

Integrating, numerator is 105600+164740 = 270340

Step 2: Express bending moment for AC and BC

Consider section 1 (AC portion – measure x from A to the right)

Consider section 2 (CB portion – measure x from B to the left)

Step 4: Differentiate BM w.r.t. span coordinate to find out the critical location where maximum negative bending moment occurs and find the max negative BM value

Consider section 1

Differentiate and equate to zero to find the location of maxima and minima

Solving, x=7.519m.

BM at x=7.519m from A is obtained by substituting x in M1

BM11.407m from A=

Consider section 2

Differentiate and equate to zero to find the location of maxima and minima

Solving, x=7.481m.

BM at x=7.481m from B is obtained by substituting x in M2

BM7.481m from B=

Hence, the maximum positive bending moment is found at 7.481m from B (ie 22.519m from A).

The value of maximum positive bending moment at that location is 697.83kNm.

Step5: Find the Radial Shear and normal thrust at that location by resolving horizontal arch action and vertical shear force in radial and axial directions.

Find y and at 22.519m from A.

=4.4924m

or -21.8514o

Find Vx at 22.519m from A

Radial shear force at 22.519m from A

Axial thrust at 22.519m from A

)

1. Analyze the frame shown in fig 2. by the slope deflection method and sketch the bending moment diagram. (10)

60 kN

10 kN/m

Fig. 2

C

B

A

( Io )

( 2Io )

2m

3m

3m

(Io)

4m

Solution Outline

D

1. Find fixed end moments due to loads
2. Write slope-deflection equations
3. Obtain joint equilibrium equations
4. Solve joint equilibrium equation to get the slopes and deflections
5. Find final end moments by substituting slopes and deflections in slope-deflection equations.
6. Draw the bending moment diagram

DETAIL SOLUTION

Step 1: Find fixed end moments due to loads

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Step 2: Slope-deflection equations

Step 3: joint equilibrium equations

Joint A

­ . . . . . . . . . . . . . . . .(1)

Joint B

. . . . . . . . . . . . . . . .(1)

Step 4: Solve joint equilibrium equations to get the slopes and deflections

Solving Joint equilibrium equation, we get and

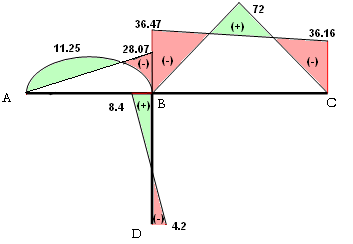
Step 5: Final Fixd end moments

Substituting and in slope-deflection equations, we get,

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;

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Bending moment Diagram

---- End ----