Analysis of plane frame with variable arbitrary cross-sections

Joint coordinates - xJ; yJ

,

Elements - [J1; J2]

Element endpoint coordinates

,

,

Element length -

Element directions

,

Transformation matrix

Diagonal 3x3 block -

Generation of the full transformation matrix

Supports - [Joint; cx; cy; cr]

Loads - [Element, qx, qy]

Load values on elements

Scheme of the structure



Materials

Modules of elasticity -

Poisson coefficients -

Shear modules -

Assignment on elements -

Cross-sections

Section S1 - ,

Section S2 - ,

General representation

Width -

Height -

Cross section properties

Area -

First moment of area -

Centroid -

Second moment of area -

First moment of area below z -

Shear area -

Element stiffness matrix

Elastic properties for element "e"

Stiffness matrix for element with variable cross-section

Displacement due to Fx = 1 in primary system -

Displacement due to Fy1 = 1 in primary system, with account of shear deflections -

Rotation due to Fy1 = 1 in primary system - + 0

Displacement due to M1 = 1 in primary system -

Rotation due to M1 = 1 in primary system - + 0

Determinant -

Displacement due to Fy2 = 1 in primary system -

Rotation due to F2 = 1 in primary system - + 0

Displacement due to M2 = 1 in primary system -

Rotation due to M2 = 1 in primary system -

Determinant -

3x3 blocks of the stiffness matrix for element "e"

Full element stiffness matrix

Stiffness matrices obtained in local coordinates

Stiffness matrices obtained in global coordinates

Global stiffness matrix

Element load vector

Load functions

Shear -

Axial -

Functions of internal forces in primary system

Axial forces -

Shear forces -

Bending moments -

Reactions at element ends

Displacements along “x“ due to axial loads -

Displacements along “y“ due to lateral loads -

Rotations due to lateral loads -

Element endpoint loads in local coordinate system

For joint “1”:

For joint “2”:

Element endpoint loads in global coordinate system

For joint “1”:

For joint “2”:

Element load vector

Global load vector

Results

**Solution of the system of equations**

**Joint displacements**

**Support reactions**

,

Joint **J1 -**

Joint **J5 -**

**Element end forces**

**Element internal forces**

**Axial forces diagram, kN**



**Shear forces diagram, kN**



**Bending moments diagram, kNm**



**Deformed shape**

Shape function in relative coordinates ξ = x/l (approximate)

Element endpoint displacements and rotations

, ,

, ,

Displacement functions

Deformed shape, mm

