University of Strathclyde

Course on Structural Mechanics for students from the University of Ales, July 2015

Example of course test July 2015

Figure 1 shows an analysis model of a truss

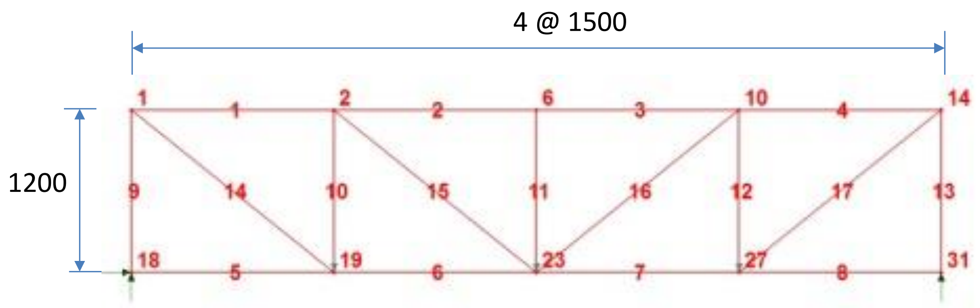


Figure 1 Analysis model of truss for a footbridge

All elements are type BEAM with no member end releases.

Vertical loads of -5kN at nodes 19, 23,27
Vertical load of -2.5 kN at nodes 1 and 14
Node 18 pinned, node 31 horizontal roller

All members RHS 80 x 40 x3
A = 674 mm^2 I_{zz} = 180E3 mm^4
E = 209 kN/mm^2

Q1. The axial load in the element 14 from the LUSAS model for the loading shown is 11.014 kN tension. Carry out a check on this value and state the reason for the difference between the two values

Q2 The vertical deflection at node 23 for the loading shown is 1.01 mm. Carry out a check on this value using the equivalent beam model (see Information Sheet 1)

Q3 Figure 2 shows the forces on the ends of the elements at node 1. Carry out a check for equilibrium of the force actions at this node.

Q4. Write definitions in English for the following six terms:
(The test paper will state which terms are to be defined. There will be no choice but the terms will be from the following list:

List of possible terms

Force	Deformation	Centre of gravity
Direct force	Displacement	Validation
Shear force	Gravity force	Verification
Moment	Bending moment	Lever arm
Torque	Centroid	Strain
Gravity constant	Resultant force action	Stress

(*Note:* A 'term' is a 'word or phrase used to describe a thing or to express a concept, esp. in a particular kind of language or branch of study'.)

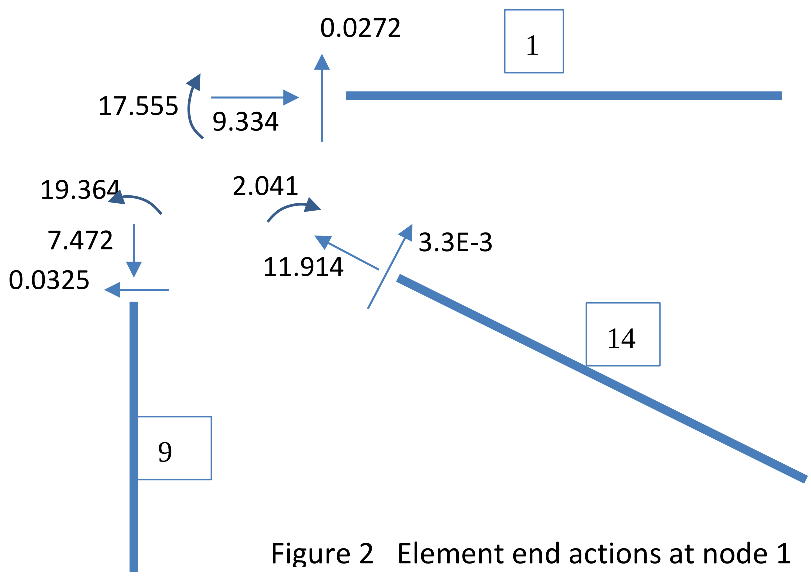


Figure 2 Element end actions at node 1

Supplementary information - 1
Equivalent beam formulae for calculating the deflection of a diagonally braced frame

Beam deflection

Deflection due to shear deformation

C_b and C_s from Table 1

W - total load
L - span
EI - stiffness parameter

$$\Delta = \Delta_b + \Delta_b = \frac{C_b W L^3}{E_c I_g} + \frac{C_s W L}{K_s}$$

Deflection due to bending deformation

E value for material of columns

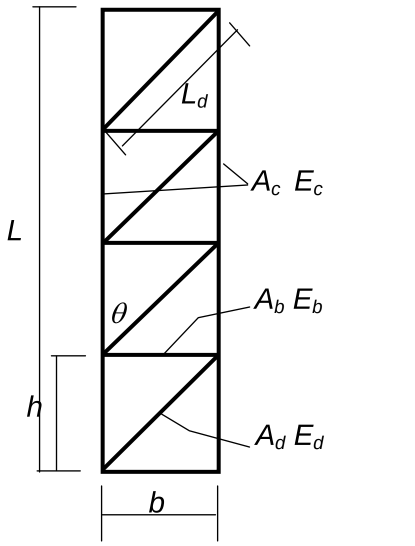
$$I_g = \frac{A_c b^2}{2}$$

Shear stiffness
See Equation (A1) or (A2)

$$K_{st} = \frac{1}{\dfrac{1}{f E_d A_d \sin^2\theta \cos\theta} + \dfrac{1}{E_b A_b \cot\theta}} \quad \text{(A1)}$$

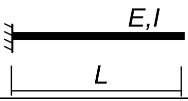
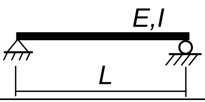
If axial flexibility of the beams can be neglected

$$K_{st} = f E_d A_d \sin^2\theta \cos\theta \quad \text{(A2)}$$



Parameters for diagonally braced frame

Table 1 Beam deflection coefficients

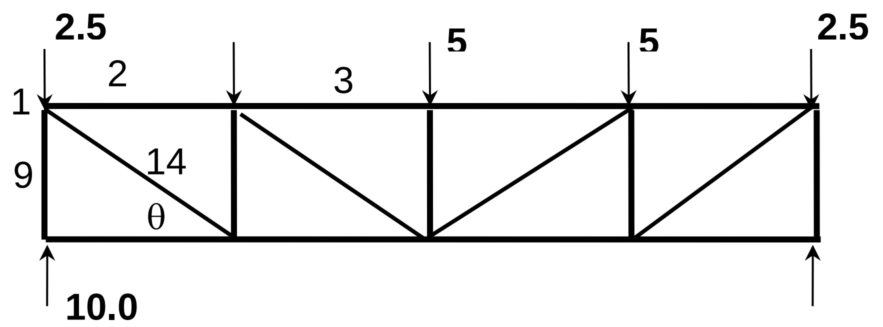
Structure	**Load**	**C_b bending**	**C_s shear**
Cantilever 	Point tip	1/3	1.0
	UD	1/8	1/2
Simply supported 	Point central	1/48	1/4
	UD	5/384	1/8

f = 1.0 for singly braced truss
= 2.0 with compressive cross bracing

With tensile only cross bracing, treat as singly braced.
With compressive cross bracing ignore flexibility of posts.

Solutions

Axial forces in a truss

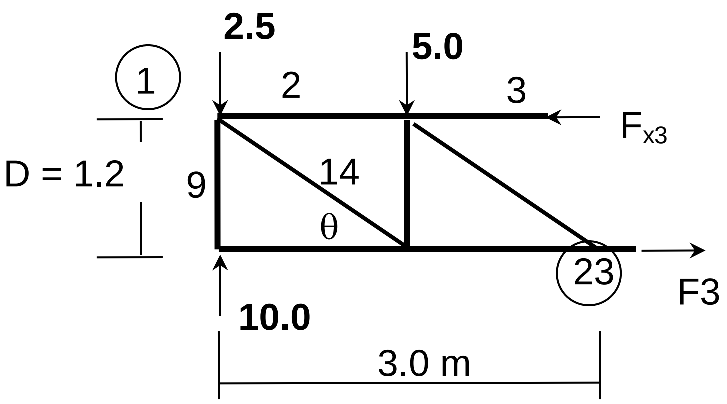


1. Diagonal with highest axial load - Element 14 - $F_{x,14}$

Resolve vertically in end panel
Vertical component of $F_{x,14}$ = shear force in panel
S = shear force in the panel = 7.5kN
$F_{x,14}$ sinθ = S, $F_{x,14}$ = 7.5/~~sin~~(.625) = 12.0 kN tension
From LUSAS model - $F_{x,14}$ = 11.914 kN
Where S is the shear in the truss
(sinθ = 1.2/sqrt(1.2^2+1.5^2) = 0.625)
The difference between the two values is due to the shear in the members of the truss in the external panel .

2. Highest axial load in chords - Element 3 - $F_{x,3}$

(This calculation is shown here for information. It is not required in the test.)
Take moments about node 23:
F_{x3}*D = 7.5*3 - 5*1.5 = 15 = M (moment at centre of truss)
F_{x3} = M/D = 15/1.2 = 12.5 kN
From LUSAS model - F_{x3} 12.5 kN



Truss deflection

$$\Delta = \Delta_b + \Delta_b = \frac{C_b W L^3}{EI} + \frac{C_s W L}{K_s}$$

Beam deflection

Deflection due to shear deformation

C_b and C_s from Table 3

W - total load
L - span
EI - stiffness parameter

Deflection due to bending deformation

Expressions for *I* see Table 1

Expressions for K_s see Table 1

Sinθ = 0.625 cosθ = 0.781

I = A_cb^2/2 = 674*1200^2/2 = 485.3E6

$K_{st} = fE_d A_d \sin^2\theta \cos\theta$ = 1.0*209*674*0.625^2*0.781 = 4.29E4

W = 20.0

Δ = (5/384*20*6000^3)/(209*485.3E6) = 0.555 mm
+ 1/8*20*6000/4.29E4 =0.350 mm

Total = 0.555 + 0.350 = 0.905 mm
Compares with 1.01 mm from LUSAS model - satisfactory correlation

Equilibrium at node 1

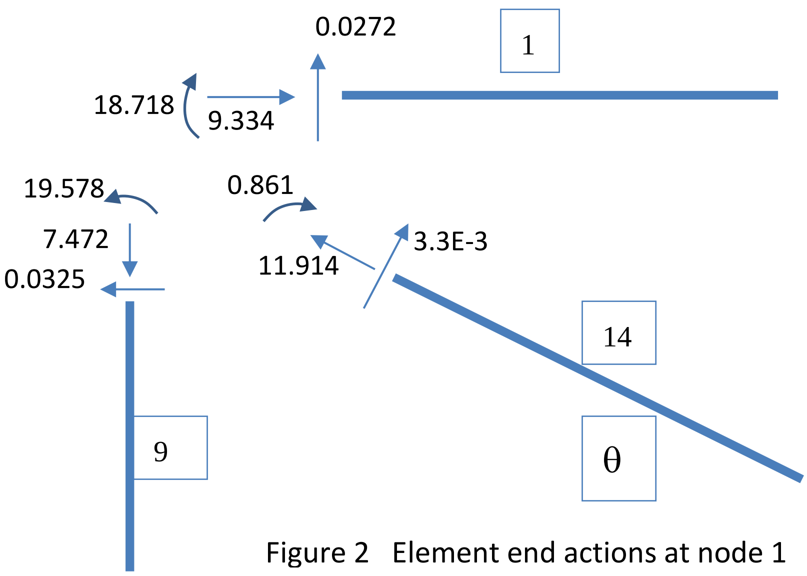


Figure 2 Element end actions at node 1

sinθ = 0.625 cosθ = 0.781
Horizontal force: 9.334 - 0.0325 - 11.914* 0.781 + 3.3E-3*0.625 = -0.00127 OK
Vertical force: 0.0272 - 7.472 + 11.914*0.625 + 3.3E-3*0.781 =0.0041 OK
Moment: 19.578 -18.718 - 0.861 = 0.001 OK (This calculation should be done in the test)