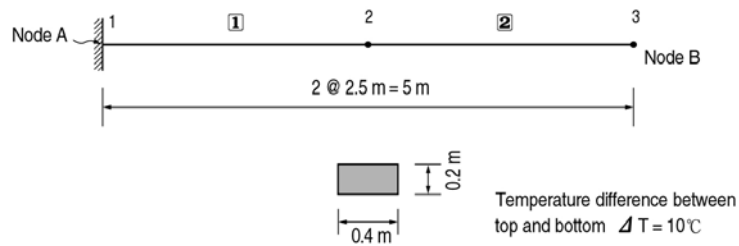# TS-2

Title

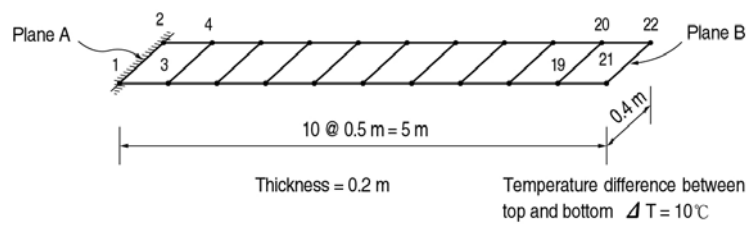Structure under a temperature gradient force

Description

Analyze a beam under a temperature gradient force. The structure is modeled with beam elements, plate elements and solid elements separately.
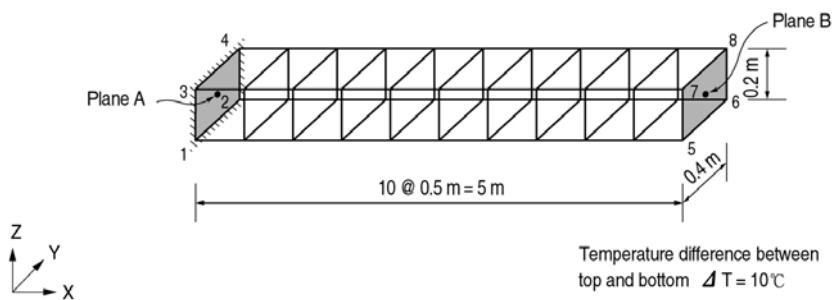Determine the displacements at the free end and the reaction when both ends are constrained for each case.

(a) Structure modeled with beam elements

(b) Structure modeled with plate elements

(c) Structure modeled with soild elements

Structural geometry and analysis model

MODEL

Analysis Type
   3-D static thermal stress analysis

Unit System
   m, tonf

Dimension
   Length 5m

Element
   Beam element, plate element (Thick type) and solid element

Material
   Concrete   Modulus of elasticity $E = 2.1 \times 10^6 \, \text{tonf/m}^2$
                     Coefficient of thermal expansion $\alpha_c = 1.0 \times 10^{-5} \, \text{m/m} \, °C$
                     Poisson's ratio $\nu = 0.167$

Section Property
   SB 200 × 400 mm

Boundary Condition
   Displacement calculation condition ; Constrain all DOFs of the nodes on the A-
                                                      plane
   Reaction force calculation condition ; Constrain all DOFs of the nodes on the A and B-
                                                      planes.

Analysis Case
   A temperature gradient of 10 degrees is applied through the depth of the structure.

Results

Displacements : Beam element model – TS-2-1

	Node	Load	DX (m)	DY (m)	DZ (m)	RX ([rad])	RY ([rad])	RZ ([rad])
▶	1	CASE1	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
	2	CASE1	0.000000	0.000000	-0.001563	0.000000	0.001250	0.000000
	3	CASE1	0.000000	0.000000	-0.006250	0.000000	0.002500	0.000000

Displacements : Plate element model – TS-2-2

	Node	Load	DX (m)	DY (m)	DZ (m)	RX ([rad])	RY ([rad])	RZ ([rad])
▶	1	CASE1	0,000000	0,000000	0,000000	0,000000	0,000000	0,000000
	2	CASE1	0,000000	0,000000	0,000000	0,000000	0,000000	0,000000
	21	CASE1	0,000000	0,000000	−0,006318	0,000100	0,002514	0,000000
	22	CASE1	0,000000	0,000000	−0,006318	−0,000100	0,002514	0,000000

Displacements solid element model – TS-2-3

	Node	Load	DX (m)	DY (m)	DZ (m)	RX ([rad])	RY ([rad])	RZ ([rad])
▶	1	CASE1	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
	2	CASE1	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
	3	CASE1	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
	4	CASE1	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
	5	CASE1	-0.000252	0.000010	-0.006350	0.000000	0.000000	0.000000
	6	CASE1	-0.000252	-0.000010	-0.006350	0.000000	0.000000	0.000000
	7	CASE1	0.000252	-0.000010	-0.006350	0.000000	0.000000	0.000000
	8	CASE1	0.000252	0.000010	-0.006350	0.000000	0.000000	0.000000

Comparison of Results

Unit : m, tonf· m

Result		Theoretical	Beam element	Plate element	Solid element
Displacement at the free end	In the Z direction	-0.00625	-0.006250	-0.006318	-0.006350
	In the Ry direction	0.0025	0.00250	0.002514	
Reaction when A and B planes are constrained		0.280	0.280	0.284	

Reference

Gere & Timoshenko, "*Mechanics of Materials*",Chapter7. 2nd Edition

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