Buckling-4

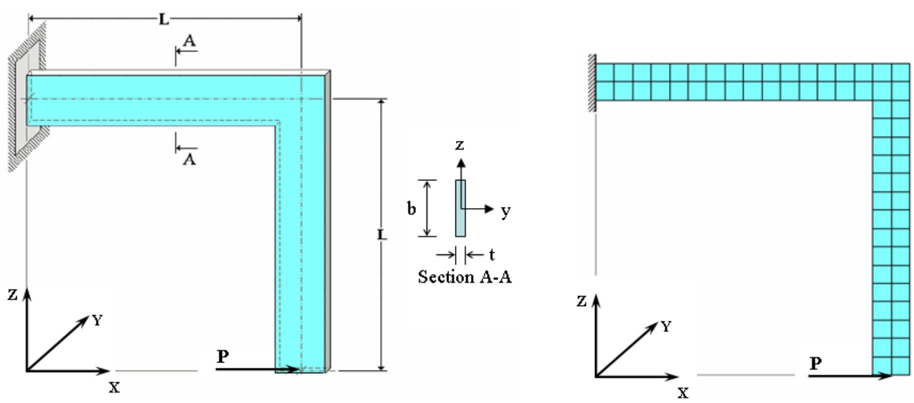
Title

Lateral buckling of a clamped right-angle frame subjected to a load at the tip

Description

A calmped right-angle frame of a narrow section is subjected to a horizontal load P at the centroid of the end. The buckling loads are determined for the four cases as described below (Case 1 ~ Case 4). The computed buckling loads are then compared with the results from the prominent papers [1, 2, 3, 4, 5].

Case 1: Beam element (total 2 elements: 1 element for each leg)
Case 2: Beam element (total 8 elements: 4 elements for each leg)
Case 3: Beam element (total 16 elements: 8 elements for each leg)
Case 4: Plate element (total 64 elements)



(a) Beam element model *(b) Plate element model*

Structural geometry and boundary conditions

Model

Analysis Type

Lateral torsional buckling

Unit System

N, mm

Dimension

Horizontal Length 240mm

Vertical Length 240mm

Element

Beam element and plate element (thick type without drilling dof)

Material

Young's modulus of elasticity $E = 71{,}240 N/mm^2$

Poission's ratio $\nu = 0.31$

Section Property

Beam element : solid rectangle 0.6×30 mm

Plate element : thickness 0.6mm, width 15mm, height 15mm

Boundary Condition

Left end is fixed, and the rest is free.

Load

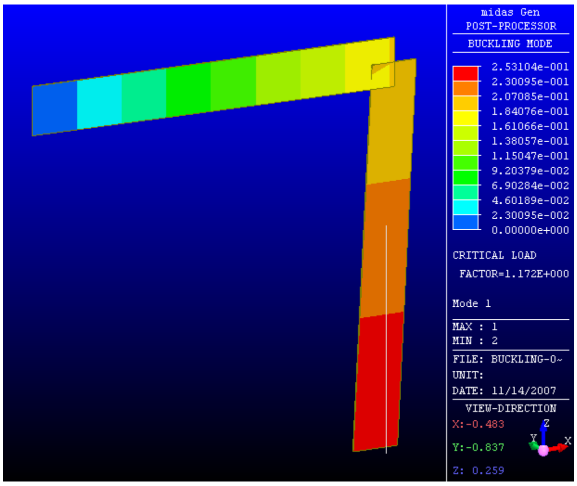
$P = 1.0$ N

Results

Buckling Analysis Results

Case 1: Beam element (total 2 elements)

1^{st} mode	Buckling load

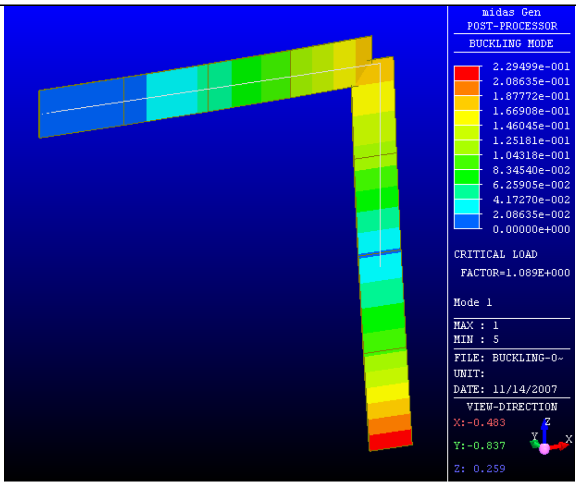


Isometric view

Mode	UX	UY
BUCKLING ANALYSIS		
Mode	Eigenvalue	Tolerance
1	1,172246	0,0000e+000
2	3,788853	0,0000e+000
3	11,200083	0,0000e+000

Case 2: Beam element (total 8 elements)

1^{st} mode	Buckling load

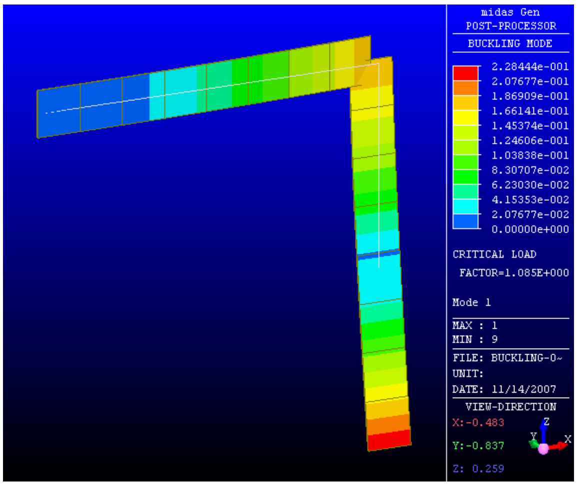


Isometric view

Mode	UX	UY
BUCKLING ANALYSIS		
Mode	Eigenvalue	Tolerance
1	1,089447	0,0000e+000
2	3,258116	0,0000e+000
3	5,257034	0,0000e+000
4	7,374790	0,0000e+000

Case 3: Beam element (total 16 elements)

1^{st} mode	Buckling load

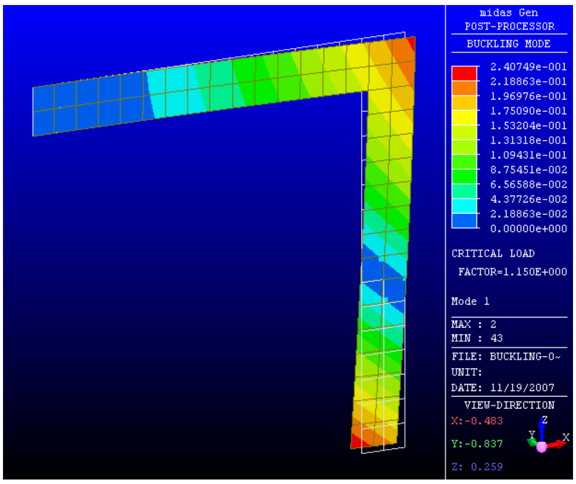


Isometric view

Mode	UX	UY
BUCKLING ANALYSIS		
Mode	Eigenvalue	Tolerance
1	1,085107	0,0000e+000
2	3,190925	0,0000e+000
3	5,062658	0,0000e+000
4	6,678459	0,0000e+000

Case 4: Plate element (total 64 elements)

1^{st} mode	Buckling load



Isometric view

Mode	UX	UY
BUCKLING ANALYSIS		
Mode	Eigenvalue	Tolerance
1	1,149661	1,4434e-019
2	2,908728	2,0800e-015
3	4,895403	7,4329e-015
4	6,347927	3,0005e-014

Comparison of Results

The analytical critical load P_{cr} of the clamped right-angle frame is not known, but a number of prominent authors have given approximate solutions obtained from their geometrically nonlinear ananyses [1, 2, 3, 4, 5].

Unit: N

Case	Type of element	No. of total elements	Critical load for 1st buckling
Argyris et al [1]	Triangular shell	86	1.163
Nour-Omid & Rankin [2]	Quadrilateral shell	64	1.130
McGuire et al [3]	Beam element	8	1.093
Simo & Vu-Quoc [4]	Beam element	10	1.090
Saleeb et al [5]	Beam element	12	1.092
MIDAS Case 1	Beam element	2	1.172
MIDAS Case 2	Beam element	8	1.089
MIDAS Case 3	Beam element	16	1.085
MIDAS Case 4	Plate element	64	1.150

References

1. Argyris, J.H., Hilpert, O., Malejannakis, G.A., Sharpf, D.W., (1979). "On the geometrical stiffnesses of a beam in space – a consistent V.W. approach," *Comp. Meth. Appl. Mech. Eng.,* Vol. 20, 105–31.
2. Nour-Omid B, Rankin C.C., (1991). "Finite rotation analysis and consistent linearization using projectors. *Comp. Meth. Appl. Mech. Eng.,* Vol. 93, 353–84.
3. McGuire, W., and Ziemian, R. (2000) "Steel frame stability : Out-of-plane effects." Proc., Fist Int. Conf. Structural Stability and Dynamics,7-9 December 2000, Taipei, Taiwan, Y.B. Yang, L.J.Leu, and S.H.Hsieh, eds, 5-20
4. Simo, J.C., Vu-Quoc, L.A., (1986). "A three dimensional finite strain rod model, Part II: Computational aspects," *Comp. Meth. Appl. Mech. Eng.,* Vol. 58, 79–115
5. Saleeb, A.F, Chang T.Y.P, Gendy A.S., (1992). "Effective modeling of spatial buckling of beam assemblages, accounting for warping constraints and rotation-dependency of moments," *Int. J. Num. Meth. Eng.*, Vol. 33, 469–502.