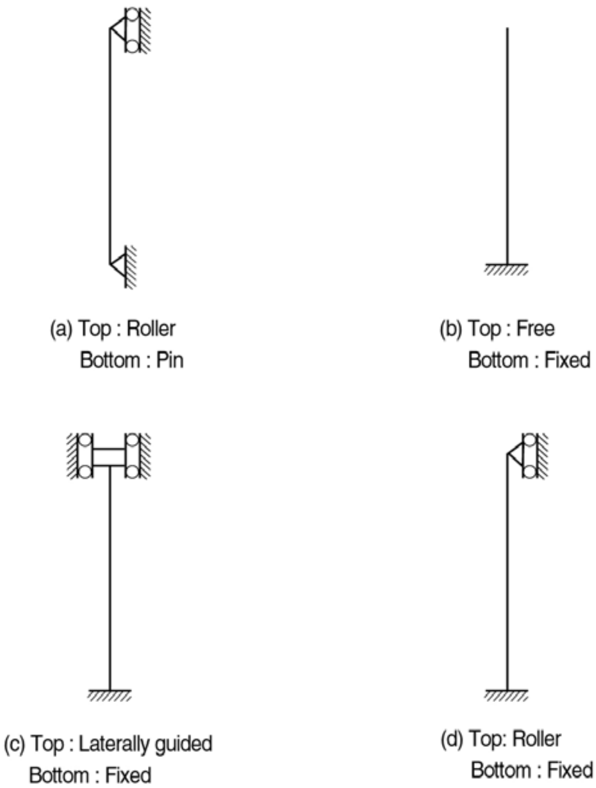
Buckling-1

Title

Buckling analyses of a column

Description

Determine the buckling modes and the corresponding critical loads of a column subjected to a vertical load with various boundary conditions.



Structural geometry and boundary conditions

Model

Analysis Type

Buckling analysis

Unit System

m, tonf

Dimension

Length 15 m

Element

Beam element and plate element (Thick type)

Material

Modulus of elasticity $E = 10000$ tonf/m^2

Section Property

Beam element Solid rectangular 0.25×0.25 m

Plate element Thickness 0.25m

Boundary Condition

Case 1 : The top end is a roller and the bottom is a pin support.

Case 2 : The top end is free and the bottom is a fixed support.

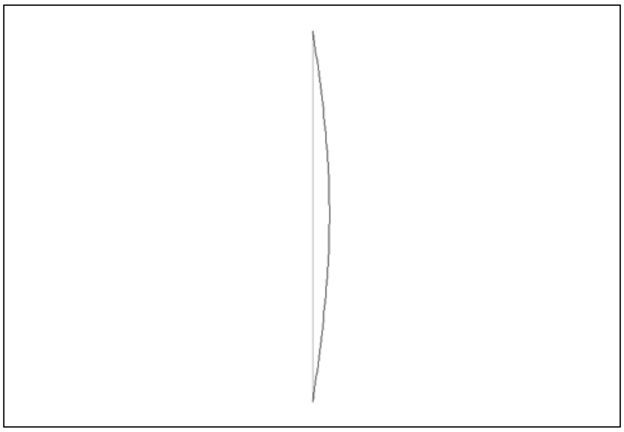
Case 3 : Lateral displacement and rotational displacement of the top end are constrained and the bottom is a fixed support.

Case 4 : The top end is a roller and the bottom is a fixed support.

Results

Buckling Analysis Results

Case 1 : The top end is a roller and the bottom is a pin support.



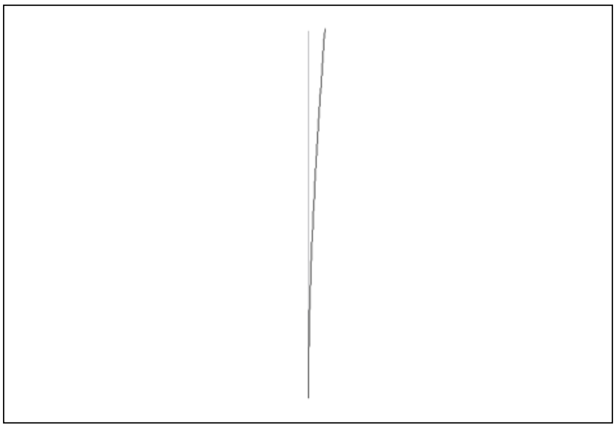
BUCKLING ANALYSIS		
Mode	Eigenvalue	Tolerance
1	0,570845	1,9060e-014
2	2,279632	3,8182e-014
3	5,115187	2,0992e-010
4	9,059105	3,7871e-009
5	14,086072	3,8813e-007

beam element model

BUCKLING ANALYSIS		
Mode	Eigenvalue	Tolerance
1	0,571158	4,4708e-015
2	2,284631	9,7191e-016
3	5,140428	3,2829e-015
4	9,138571	4,6010e-013
5	14,279127	2,0922e-009

plate element model

Case 2 : The top end is free and the bottom is a fixed support.



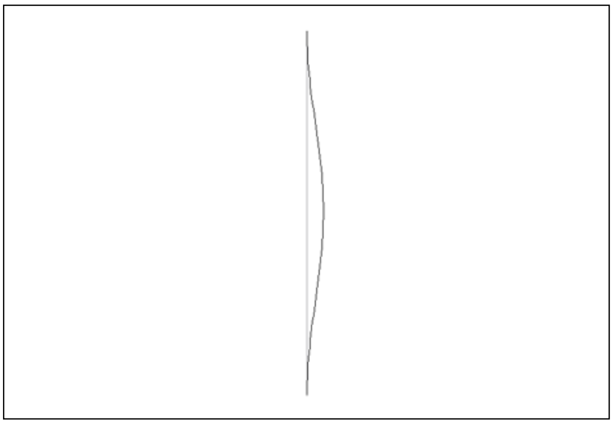
BUCKLING ANALYSIS		
Mode	Eigenvalue	Tolerance
1	0,142770	5,1518e-014
2	1,283521	8,6498e-016
3	3,557547	2,4729e-012
4	6,950026	3,7908e-009
5	11,439048	8,0757e-008

Beam element model

BUCKLING ANALYSIS		
Mode	Eigenvalue	Tolerance
1	0,142789	6,2202e-015
2	1,285105	5,8746e-015
3	3,569738	1,0574e-014
4	6,996703	2,5388e-015
5	11,566041	8,9668e-010

Plate element model

Case 3 : Lateral and rotational displacement of the top end are constrained and the bottom is a fixed support



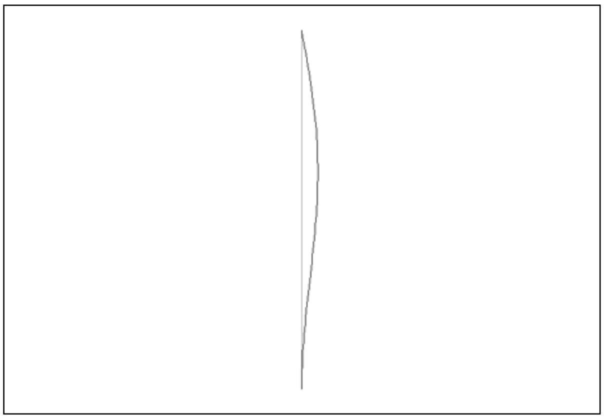
BUCKLING ANALYSIS		
Mode	Eigenvalue	Tolerance
1	2,279632	1,8896e-014
2	4,650850	3,2179e-013
3	9,059105	2,6082e-011
4	13,628078	3,4804e-009
5	20,164291	1,0699e-007

Beam element model

BUCKLING ANALYSIS		
Mode	Eigenvalue	Tolerance
1	2,284631	4,0820e-015
2	4,673787	1,3302e-015
3	9,138571	5,8314e-016
4	13,814874	2,6925e-013
5	20,562229	3,4113e-010

Plate element model

Case 4 : The top end is a roller and the bottom is a fixed support.



BUCKLING ANALYSIS		
Mode	Eigenvalue	Tolerance
1	1,167006	2,0549e-014
2	3,441884	5,3082e-012
3	6,834895	4,2946e-010
4	11,324475	4,3389e-008
5	16,882067	4,3357e-007

Beam element

BUCKLING ANALYSIS		
Mode	Eigenvalue	Tolerance
1	1,168445	4,9409e-015
2	3,453678	2,4431e-015
3	6,880800	7,7448e-016
4	11,450201	2,4567e-010
5	17,162037	1,7251e-007

Plate element

Comparison of Results

Unit : tonf

Case	Critical load for 1st buckling		
	Theoretical	MIDAS/Civil	
		Beam element	Plate element
1	0.5712	0.5708	0.5712
2	0.1428	0.1428	0.1428
3	2.2846	2.2796	2.2846
4	1.1684	1.1670	1.1684

※ Critical load : Load applied in the Load Case × Eigenvalue

Case 1 : $P_{cr} = \dfrac{\pi^2 EI}{L^2}$

Case 2 : $P_{cr} = \dfrac{\pi^2 EI}{4L^2}$

Case 3 : $P_{cr} = \dfrac{4\pi^2 EI}{L^2}$

Case 4 : $P_{cr} = \dfrac{2.046\pi^2 EI}{L^2}$

Reference

Gere & Timoshenko "*Mechanics of Materials*" Chapter 11