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RamSeries - Validation Case 32

Beam buckling

RamSeries

Version
15.1.0

Compass Ingeniería y Sistemas http://www.compassis.com
Tel.: +34 932 181 989 - Fax.: +34 933 969 746 - E: info@compassis.com - C/ Tuset 8, 7o 2a, Barcelona 08006 (Spain)

http://www.compassis.com
info@compassis.com
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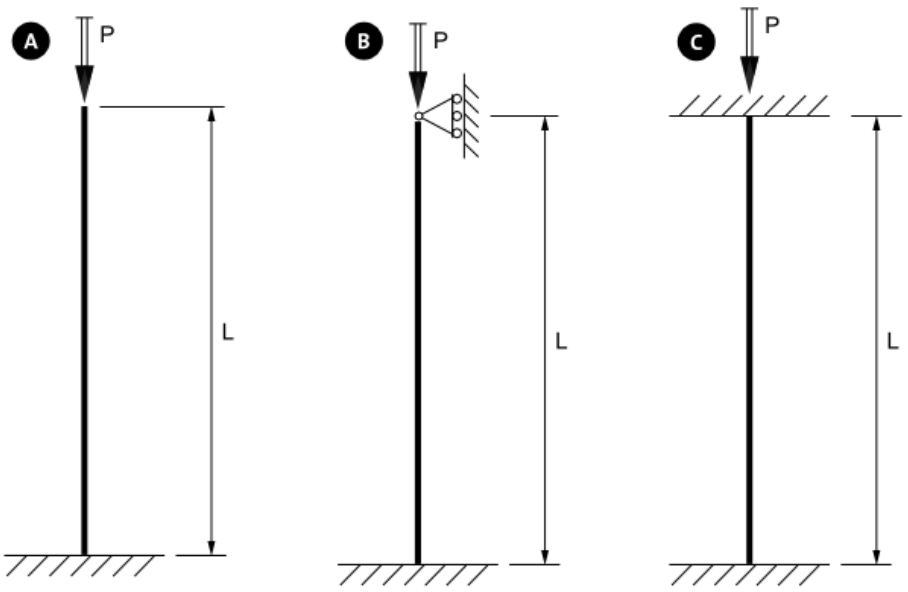
1 Validation Case 32 - Beam Linearized Buckling

Model description

The aim of this test is checking the first buckling mode in a column with diferent boundary conditions.

Geometry model



In all cases the lower end is fixed.

Case A: the upper end is free.

Case B: the upper end is pinned.

Case C: the upper end is fixed, but it can move downward.

Material properties of column

Section:

- Type: Rectangular
- Width y: 0.02 m (Iy = 2.08e-7 m^4)
- Width z: 0.05 m (Iz = 3.33e-8 m^4)

Material: Steel S-355N

- E (Young's modulus) = 2.1e11 N/m^2
- v (Poisson's ratio) = 0.3
- G (Shear modulus) = 8.1e10 N/m^2

Constraints

The lower end is fixed in all cases.

The upper end has a different restriction in each case:

- Case A: free
- Case B: pinned
- Case C: fixed

Buckling parameters:

In this example, only the first mode will be checked, so

Num. of buckling modes: 1

On the other hand, an Imperfections factor = 0.0.

Results

Analytical results

The maximum load (critical load) causes the column to be in a state of unstable equilibrium can be calculated with the following formula:

$$P=\frac{\pi^2 EI_{min}}{(KL)^2}$$

where

- P is the critical load
- E is the Young's modulus
- Imin is the lower section moment of inertia
- L length of column
- K column effective length factor, whose value depends on the constraints applied at the ends of the columns.
  - Case A: one end fixed and the other end free to move laterally, K=2.0.
  - Case B: one end fixed and the other end pinned, K=0.7.
  - Case C: both ends fixed, K=0.5.

Numerical results

For the sake of validation, three simulations have been run using the properties before described, one for each case.

Loads

In each case a vertical load has been applied in the upper end of the column equal to the critical load. Therefore, the critical factor for all case must be 1.

The critical loads calculated for each case are:

- Case A: 17271,8 N
- Case B: 140994,3 N
- Case C: 276348,9 N

Mesh

All models have been meshed using 20 linear elements.

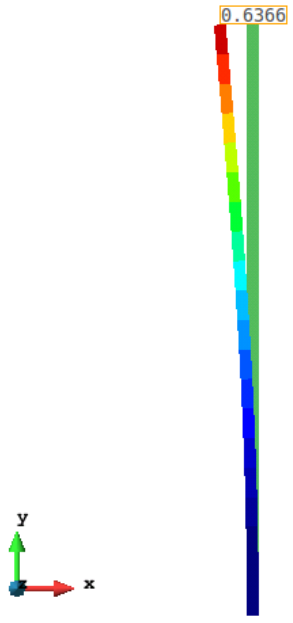
Results

The critical factor calculated in all simulations are shown below:

	Critical factor
Case A	1.001
Case B	1.007
Case C	1.008

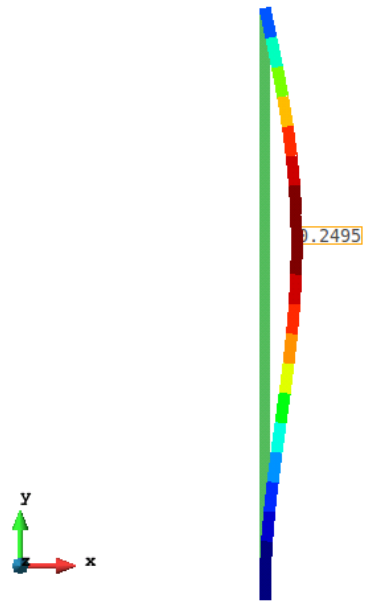
Finally, the results of the first mode of the three simulations are shown:

Case A: upper end free



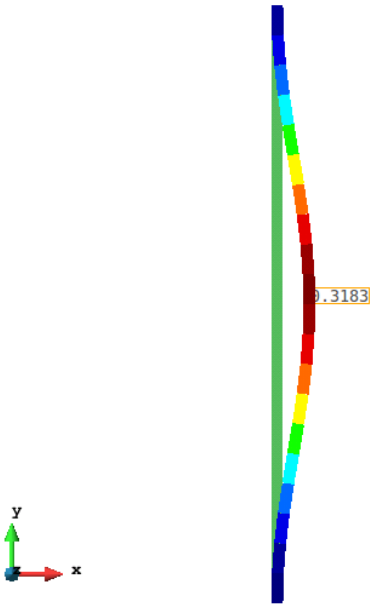
Deformed factor=2

Case B: upper end pinned



Deformed factor = 2

Case C: upper end fixed



Deformed factor = 2

References

[1] Timoshenko, Gere J (2002). Resistencia de Materiales (5ª Edición). Columnas (pp 755-763). Madrid, España: Thomson

[2] Buckling - Wikipedia, the free encyclopedia (2014). Retrieved July 14, 2014, from http://en.wikipedia.org/wiki/Buckling

Validation Summary

CompassFEM version	15.1.0
Tdyn solver version	15.1.0
RamSeries solver version	15.1.0
Benchmark status	Successfull
Last validation date	27/11/2018