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RamSeries - Validation Case 28

Free Vibration of a Cable

Version
15.1.0

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November 2018

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1 Validation Case 28 - Free Vibrating Cable

Model Description

This test case is based on the example "Free vibration of a cable" described in Ref. [1]. A cable, initially mantained in horizontal position and reached the static equilibrium, is let go at one end under the action of gravitational load. Such cable is subjected to free vibrations.

The cable has the following properties:

Area: A = 0.0001 m^2

Length: L = 1 m

Spec. Weight: ρ = 0.1 kg/m = 9806.5 N/m^3

After performing an initial non-linear load incremental analysis for the cable, the tension obtained is:

Cable pre-stress: σ = 0.69071e4 N/m^2

Results

For the sake of validation, a simulation was run using the properties described in the previous section, using a linear beam element mesh (45 nodes and 44 elements).

Initial equilibrium state:

As stated previously, a first analysis (non-linear, incremental load) is performed in order to obtain the initial equilibrium position and tension of the cable, resting under the gravitational load and constrained at both ends.

The simulation is performed using a non-linear solver, with 50 equal load increments.

In certain analyses, singular and very bad conditioned (high condition number) stiffness matrices may appear. This usually happens, for example, when dealing with cables, membranes or very thin shells elements.

In general, if the analyses are solved dynamically, there should be no problem achieving convergence, for the damping would compensate the singularity of the stiffness matrix ($M \cdot \Delta x'' + C \cdot \Delta x' + K \cdot \Delta x = F_{ext}$)

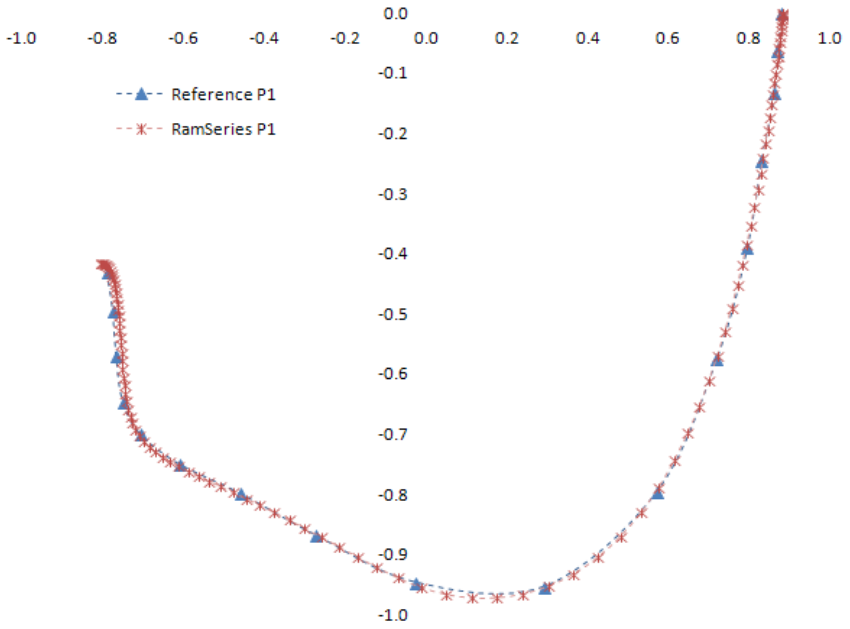
Nevertheless, for static non-linear (incremental) analyses, like in this case, convergence problems may arise when the mentioned type of elements are involved, due to the lack of damping ($K \cdot \Delta x = F_{ext}$). Therefore, a method is implemented in RamSeries so that convergence can be achieved. This is done via adding an stabilization or "artificial damping". So, after finishing the total number of load increments, RamSeries performs extra increments in order to stabilize the analysis and achieve the desired convergence.

In this case, and for all meshes, an stabilization factor of 5 has been used, and 50 extra increments were performed. The obtained initial geometry (previous image) and tension

(0.69071e4 N/m^2) are used for the free vibration dynamic analysis, which results are showed next.

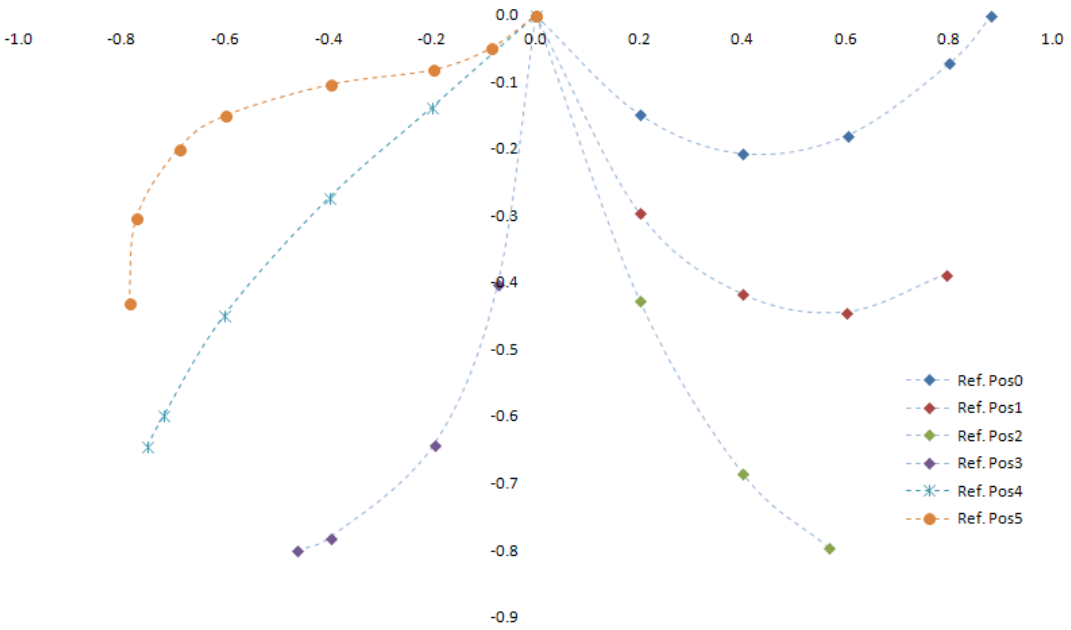
Displacements results (dynamic analysis):

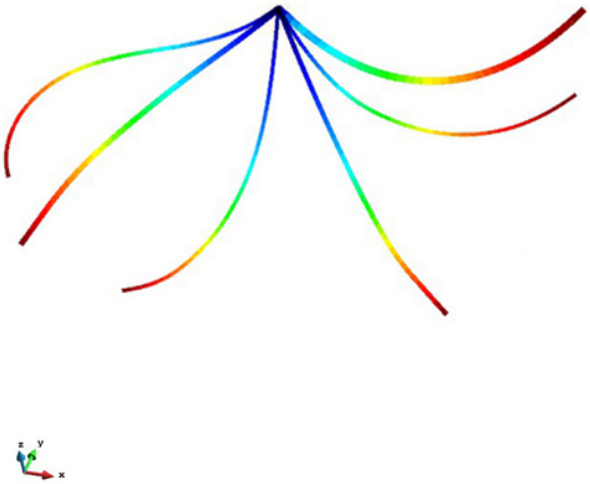
The following image shows the evolution of the displacements of the cable´s free end (P1). Results from RamSeries are compared with the experimental values given in Reference [1].



Extreme point evolution (m)

Next images show differents position of the cable, during the evolution of the free vibration to which it is subjected. Image on the left shows the experimental data from reference, while the image on the right shows the solution obtained in RamSeries.





References

[1] Massimiliano Lazzari, Anna V. Saetta, Renato V. Vitaliani. Non-linear dynamic analisis of a cable-suspended structures subjected to wind actions. Computer and Structures 79 (2001) 953-969. ELSEVIER.

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