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RamSeries - Validation Case 27

Inflation of Isotropic Airbag

RamSeries

Version
15.1.0

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1 Validation Case 27 - Inflation of Isotropic Airbag

Model Description

This test case is based on the example "Inflation of an isotropic airbag" described in Ref. [1].

In this example, the eficency of the wrinkling model under deformation dependent forces is investigated. Initially, a flat square isotropic membrane is gradually inflated by a constant pressure until its magnitude reaches 5 kPa.

The membrane has the following properties:

Thickness: t = 0.06 cm

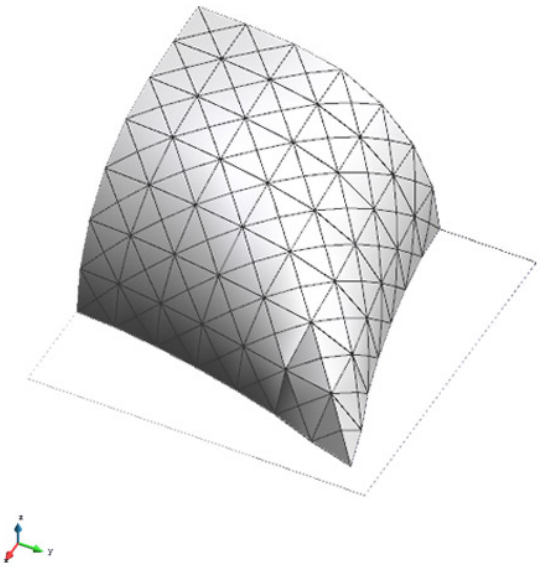
Length (diagonal): L_d= 120 cm

Elastic Modulus: E = 58.8 kN/cm^2

Poisson´s ratio: v = 0.4

Results

For the sake of validation, a simulation was run using the properties described in the previous section, using different triangular structured meshes.



The simulation is performed using a non-linear solver, with 25 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 50 has been used, and 25 extra increments were performed.

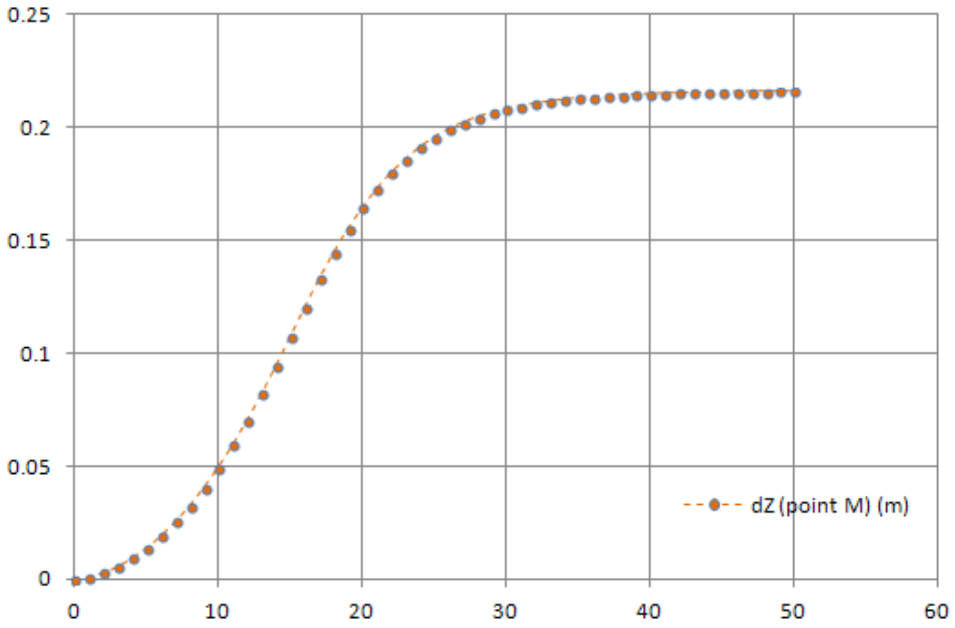
Displacements and stresses results:

The next table shows the results obtained with RamSeries, compared with those showed in the reference (Ref. [1]). The comparison is made for each of the different meshes used (25, 41, 85 and 113 nodes). Note that the number of nodes are not exact for Reference and RamSeries model. This is due to the different type of element used: in RamSeries, a three noded triangle structured mesh is used, while in the reference, structured quadrilateral meshes are defined. Different results are compared in the table:

- Z_M: Vertical displacement of point M.
- S_M: Maximal principal stress.
- d_A: Displacement of point A along the AC direction.
- V_B: Horizontal displacement of point B along the Y axis.

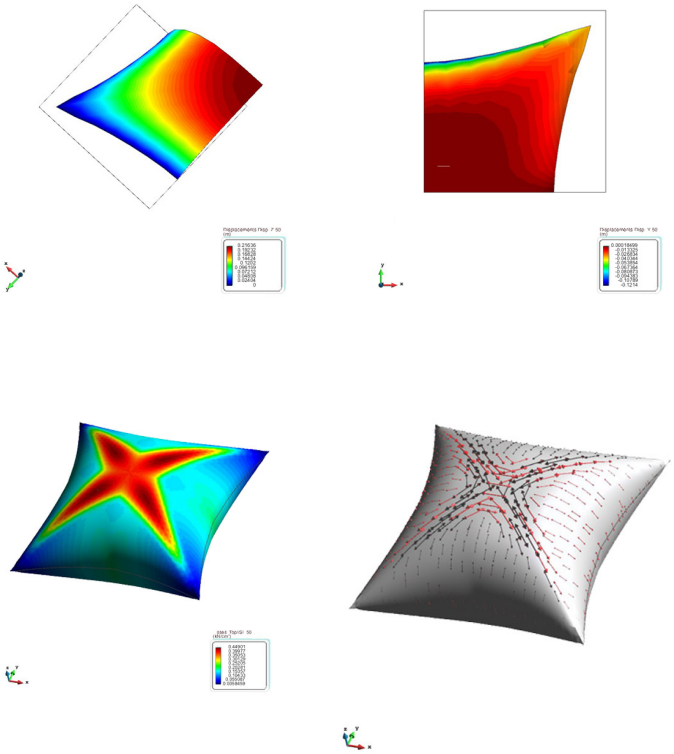
Num. nodes	25	25	36	41	81	85	121	113
	Reference	RamSeries	Reference	RamSeries	Reference	RamSeries	Reference	RamSeries
Z_M (cm)	21.49	21.88	21.59	21.671	21.657	21.66	21.669	21.64
S_M (kN/cm2)	0.324	0.3771	0.36	0.3865	0.38	0.3964	0.3814	0.3934
d_A (cm)	9.72	5.2768	8.82	5.1449	7.38	4.9908	6.92	4.9908
V_B (cm)	12.02	12.110	12.15	12.24	12.27	12.25	12.37	12.21

Next image shows the convergence of the analysis to the solution, for point M (vertical displacement).

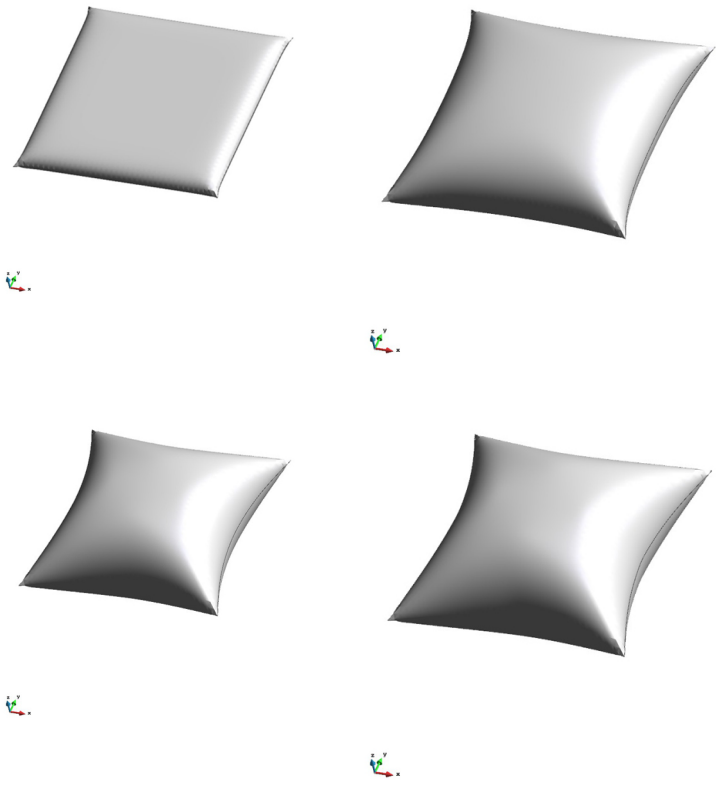


Vertical dislpacement of point M [m], during the load increments.

The following images show some stress and displacement results for the inflated airbag:



The following sequence shows different stages of the inflation process:



References

[1] A. Jarasjarungkiat, R. Wüchner, K.-U. Bletzinger. Efficient sub-grid scale modeling of membrane wrinkling by a projection method. Comput. Methods. Appl. Mech. Engrgr. 198 (2009) 1907-1116. 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