

# RamSeries - Validation Case 7

Large displacements in beam



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http://www.compassis.com info@compassis.com November 2018



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# 1 Validation Case 7 - Large displacements in beam

#### **Model Description**

This test case is based on the Sample Solution "Large displacement three-dimensional analysis of a 45-degree bend", described in Ref. [1], and deals with the large displacement response of a cantilever 45-degree bend subjected to a concentrated end load, as shown in the following figure:







The bend has an average radius of R=100 in, cross-sectional area of A=1 in<sup>2</sup>, and lies in the X-Y plane. The concentrated tip load is applied into the Z direction.

The material is assumed to be linear elastic:

 $E = 10^7 \text{ psi}$ 



μ = 0

# Results

#### Validation Case 7 - Large displacements in beam>Results

For the sake of validation, a simulation was run using the properties described in the previous chapter, and with the following load and problem conditions:

#### Loads:

LoadCase	P (lbf)
1	100
2	300
3	600
4	900

Loadcases 2 and 3 (P=300 lbf and P=600 lbf) correspond to the reference loads (Ref. [1], page 980) for results comparing and validation.

The simulation has been performed using a non-linear solver, with 20 equal load steps/increments.

## Mesh:

A mesh of 8 linear beam elements (9 nodes) has been used.

## Displacements results:

The following graph corresponds to the load parameter study, coming from RamSeries results. It can be compared with the graph from the reference (Ref. [1], page 982).

In the graph, the horizontal axis corresponds to the load parameter:

$$k = (P \cdot R^2) / (E \cdot I)$$

In the vertical axis, the ratio of main deformations/radio of the circular bend are represented (|u|/R, |v|/R, |w|/R).





The following images show the deformed configurations of the 45-degree circular bend, obtained with RamSeries, for P=300 lbf (left), and P=600 lbf. They can be compared with the graph from the reference (Ref. [1], page 983).



The results obtained in RamSeries and the difference with respect to the reference solution are shown next:



Point A (in)	x0		
	29.29		
	x1 (RamSeries)	x1 (Ref.)	Difference (%)
P=100 lbf	27.99		
P=300 lbf	22.14	22.5	1.6
P=600 lbf	15.59	15.9	1.96
P=900 lbf	11.81		
	y0		
	70.71		
	y1 (RamSeries)	y1 (Ref.)	Difference (%)
P=100 lbf	68.55		
P=300 lbf	58.59	59.2	1.04
P=600 lbf	46.93	47.2	0.57
P=900 lbf	39.77		
	z0		
	0.0		
	z1 (RamSeries)	z1 (Ref.)	Difference (%)
P=100 lbf	18.0		
P=300 lbf	40.49	39.5	2.51
P=600 lbf	53.69	53.4	0.53
P=900 lbf	59.2		

# **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

# References

[1]Klaus-Jürgen Bathe, Saïd Bolourchi. Large Displacement Analysis of three-dimensional



Beam Structures. International Journal for Numerical Methods in Engineering. VOL. 14, 961-986 (1979).