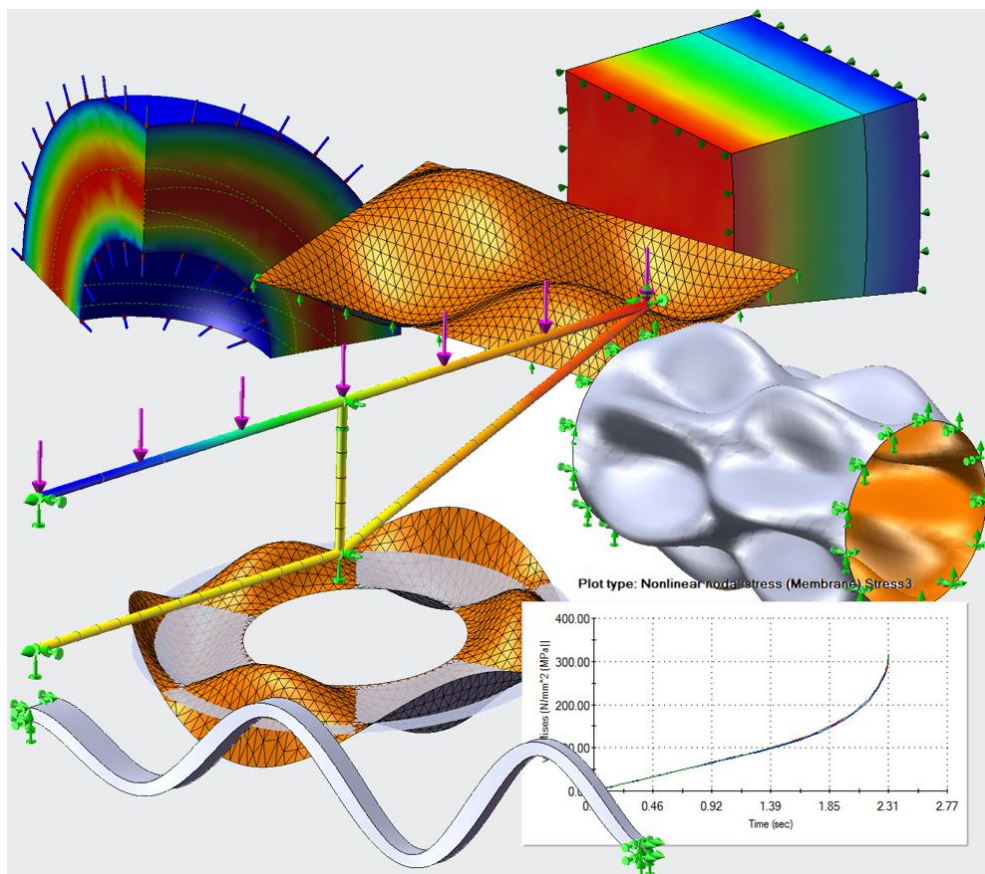


SOLIDWORKS Simulation 2019 Validation

BASED ON THE GUIDE DE VALIDATION DES PROGICIELS DE CALCULS DE STRUCTURES, by AFNOR

ABSTRACT

The purpose of this report is to present the accuracy of results given by SOLIDWORKS simulation 2019 using the Guide de validation des progiciels de calcul de structures (Structural Analysis Software Validation Guide) published by AFNOR (Association Française de NORmalisation, French Standardization Association). 101 validation examples (linear static analysis, vibration, dynamic response, thermal, nonlinear) from the guide are analyzed. Results given by SOLIDWORKS Simulation generally fall within 1% of the ideal solution.



The purpose of this report is to present the accuracy of results given by SOLIDWORKS Simulation 2019 using the *Guide de validation des progiciels de calcul de structures* (Structural Analysis Software Validation Guide).

This guide was published by AFNOR (Association Française de NORmalisation, French Standardization Association) and written and compiled by the SFM (Société Française des Mécaniciens).

This report compares results given by SOLIDWORKS Simulation 2019 with 101 examples representative of the *Guide de validation des progiciels de calcul de structures* published by AFNOR (Association Française de NORmalisation, French Standardization Association).

It is a compilation of 143 validation examples for Finite Elements Analysis software. The validation examples belong to a wide range of domains: linear static analysis, vibration, dynamic response, thermal, nonlinear, and fluid mechanics.

Not all of them fit in the range of analysis capabilities of SOLIDWORKS Simulation. That's the case of the validation examples in fluid dynamics, for instance. Therefore, a set of 101 examples were selected. They are presented in this report using the evaluation form template provided in the guide. In addition to the form, screen captures of the model and results have been added when useful for a better understanding. However, information about each model's geometry, material properties, loads, and boundary conditions have not been copied into this report. To obtain all the above information, the reader should refer to the guide itself.

While modeling each problem in SOLIDWORKS Simulation, the intent has been to meticulously follow the modeling guidelines recommended for each example. When not possible, an equivalent approach was used. For instance, when it was not possible to perform a study with the recommended element type, an equivalent study was set up with another element type. Wherever applicable and meaningful, however, the validation examples have been run with more than one element type.

As you will see in this report, this year again, results given by SOLIDWORKS Simulation generally fall within 1% of the reference solution.

Julien Boissat
SOLIDWORKS Simulation Expert Technical Support Engineer

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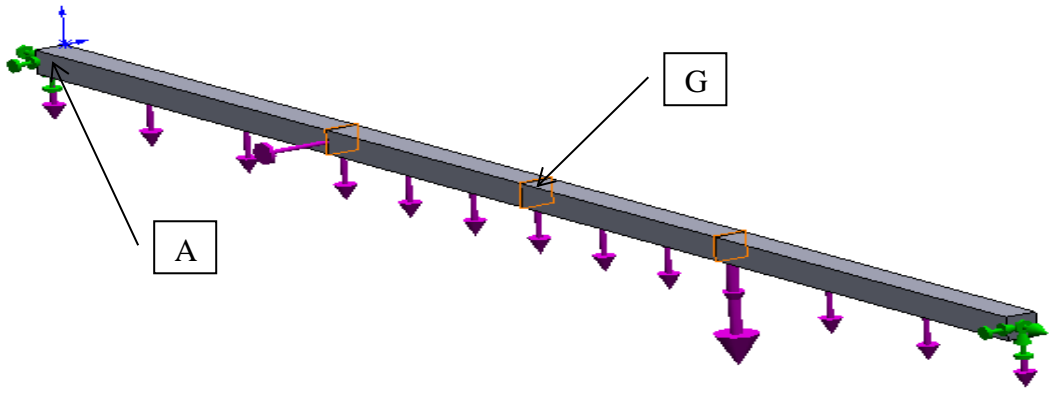
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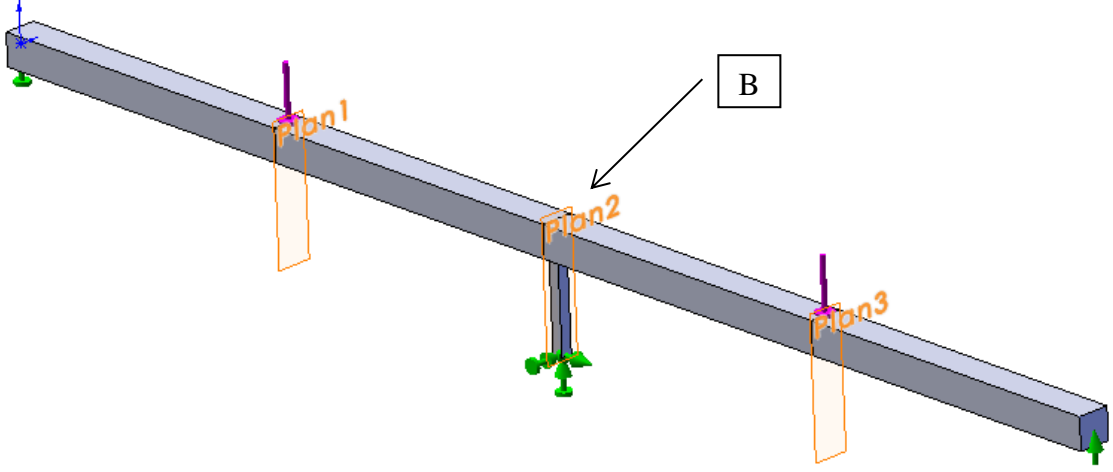
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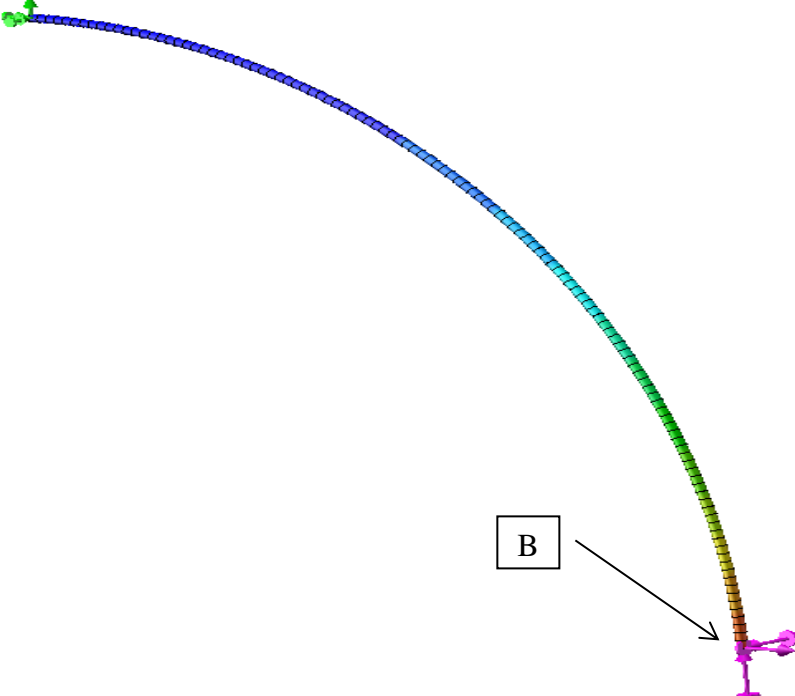
I. STRUCTURAL MECHANICS

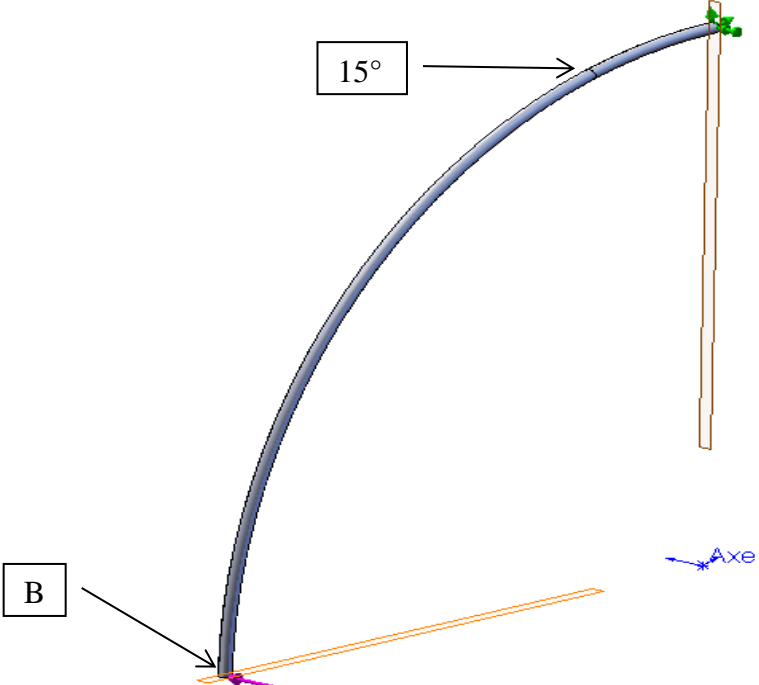
1. Linear static

EVALUATION FORM				
Software: SOLIDWORKS Simulation		Version: 2019 B3		
Computer configuration used: Lenovo ThinkPad W540, Windows 10 x64, Intel i7 vPro core, 16Gb RAM, Graphics Card Intel® HD Graphics 4600.				
Test name: SLENDER BEAM WITH BOTH ENDS FIXED Codification: SSSL 01-89				
				
Test performed by : Julien BOISSAT		Date : 3/25/2019		
Model used Finite elements <input checked="" type="checkbox"/> Boundary elements <input type="checkbox"/> Other <input type="checkbox"/> Element type : BEAM Number of degrees of freedom or mesh density : Nb of nodes = 135 Nb of elements = 130 Nb of DOF = 774				
Results :				
Location	Physical quantity and reference unit		Calculated value	Deviation (%)
Shear force in <i>G</i>	<i>V</i> (N)	-540	-547	1..29
Moment in <i>G</i>	<i>M</i> (Nm)	2800	2800	0
Displacement in <i>G</i>	<i>v</i> (m)	$- 4.92 \times 10^{-2}$	$- 4.92 \times 10^{-2}$	0
Axial force in <i>A</i>	<i>H</i> (N)	- 24000	- 24000	0
Comments :				

EVALUATION FORM				
Software: SOLIDWORKS Simulation		Version: 2019 B3		
Computer configuration used: Lenovo ThinkPad W540, Windows 10 x64, Intel i7 vPro core, 16Gb RAM, Graphics Card Intel® HD Graphics 4600.				
Test name: SLENDER BEAM ON THREE SIMPLE SUPPORTS				
Codification: SSSL 03-89				
				
Test performed by : Julien BOISSAT		Date : 3/25/2019		
Model used Finite elements <input checked="" type="checkbox"/> Boundary elements <input type="checkbox"/> Other <input type="checkbox"/> Element type : BEAM Number of degrees of freedom or mesh density : Nb of nodes = 132 Nb of elements = 126 Nb of DOF = 753				
Results :				
Location	Physical quantity and reference unit		Calculated value	Deviation (%)
Moment in <i>B</i>	<i>M</i> (Nm)	± 63000	± 62960	.06
Displacement in <i>B</i>	<i>v</i> (m)	- 0.010	- 0.010	0
Reaction force in <i>B</i>	<i>V</i> (N)	21010	21010	0
Comments : The vertical beam was modeled in order to simulate the elastic support.				

EVALUATION FORM				
Software: SOLIDWORKS Simulation		Version: 2019 B3		
Computer configuration used: Lenovo ThinkPad W540, Windows 10 x64, Intel i7 vPro core, 16Gb RAM, Graphics Card Intel® HD Graphics 4600.				
Test name: BIMETALLIC STRIP FIXED ON BOTH ENDS CONNECTED WITH A RIGID BAR				
Codification: SSSL 05-89				
Test performed by : Julien BOISSAT		Date : 3/25/2019		
Model used Finite elements <input checked="" type="checkbox"/> Boundary elements <input type="checkbox"/> Other <input type="checkbox"/> Element type : BEAM Number of degrees of freedom or mesh density : Nb of nodes = 357 Nb of elements = 353 Nb of DOF = 2112				
Results :				
Location	Physical quantity and reference unit		Calculated value	Deviation(%)
<i>B</i>	v (m)	-0.125	-0.123	1.6
<i>D</i>	v (m)	-0.125	-0.123	1.6
<i>A</i>	V (N)	500	500	0
<i>A</i>	M (Nm)	500	497.5	0.5
<i>C</i>	V (N)	500	500	0
<i>C</i>	M (Nm)	500	497.5	0.5
Comments :				

EVALUATION FORM																		
Software: SOLIDWORKS Simulation	Version: 2019 B3																	
Computer configuration used: Lenovo ThinkPad W540, Windows 10 x64, Intel i7 vPro core, 16Gb RAM, Graphics Card Intel® HD Graphics 4600.																		
Test name: FIXED THIN ARC UNDER INPLANE BENDING Codification: SSLL 06-89																		
																		
Test performed by : Julien BOISSAT	Date : 3/25/2019																	
Model used Finite elements <input checked="" type="checkbox"/> Boundary elements <input type="checkbox"/> Other <input type="checkbox"/> Element type : BEAM Number of degrees of freedom or mesh density : Nb of nodes = 1181 Nb of elements = 590 Nb of DOF = 3540																		
Results :																		
<table border="1" style="width: 100%; border-collapse: collapse; text-align: center;"> <thead> <tr> <th style="width: 20%;">Location</th> <th style="width: 30%;">Physical quantity and reference unit</th> <th style="width: 15%;">Calculated value</th> <th style="width: 35%;">Deviation (%)</th> </tr> </thead> <tbody> <tr> <td rowspan="3"><i>B</i></td> <td><i>u</i> (m)</td> <td>0.3791</td> <td>0.3790</td> <td>.03</td> </tr> <tr> <td><i>v</i> (m)</td> <td>0.2417</td> <td>0.2417</td> <td>0</td> </tr> <tr> <td><i>θ</i> (rad)</td> <td>0.1654</td> <td>0.1654</td> <td>0</td> </tr> </tbody> </table>		Location	Physical quantity and reference unit	Calculated value	Deviation (%)	<i>B</i>	<i>u</i> (m)	0.3791	0.3790	.03	<i>v</i> (m)	0.2417	0.2417	0	<i>θ</i> (rad)	0.1654	0.1654	0
Location	Physical quantity and reference unit	Calculated value	Deviation (%)															
<i>B</i>	<i>u</i> (m)	0.3791	0.3790	.03														
	<i>v</i> (m)	0.2417	0.2417	0														
	<i>θ</i> (rad)	0.1654	0.1654	0														
Comments :																		

EVALUATION FORM				
Software: SOLIDWORKS Simulation		Version: 2019 B3		
Computer configuration used: Lenovo ThinkPad W540, Windows 10 x64, Intel i7 vPro core, 16Gb RAM, Graphics Card Intel® HD Graphics 4600.				
Test name: FIXED THIN ARC UNDER OUT OF PLANE BENDING Codification: SSSL 07-89				
				
Test performed by : Julien BOISSAT		Date : 3/25/2019		
Model used Finite elements <input checked="" type="checkbox"/> Boundary elements <input type="checkbox"/> Other <input type="checkbox"/> Element type : BEAMS Number of degrees of freedom or mesh density : Nb of nodes = 539 Nb of elements = 269 Nb of DOF = 1614				
Results :				
Location	Physical quantity and reference unit		Calculated value	Deviation(%)
<i>B</i>	u_B (m)	0.13462	0.13449	0.1
For $\theta = 15^\circ$	M_t (Nm)	74.1180	74.183*	0.09
	M_f (Nm)	- 96.5925	-96.405*	0.19
Comments : * : Obtained by averaging the nodal values of two neighboring elements				

EVALUATION FORM

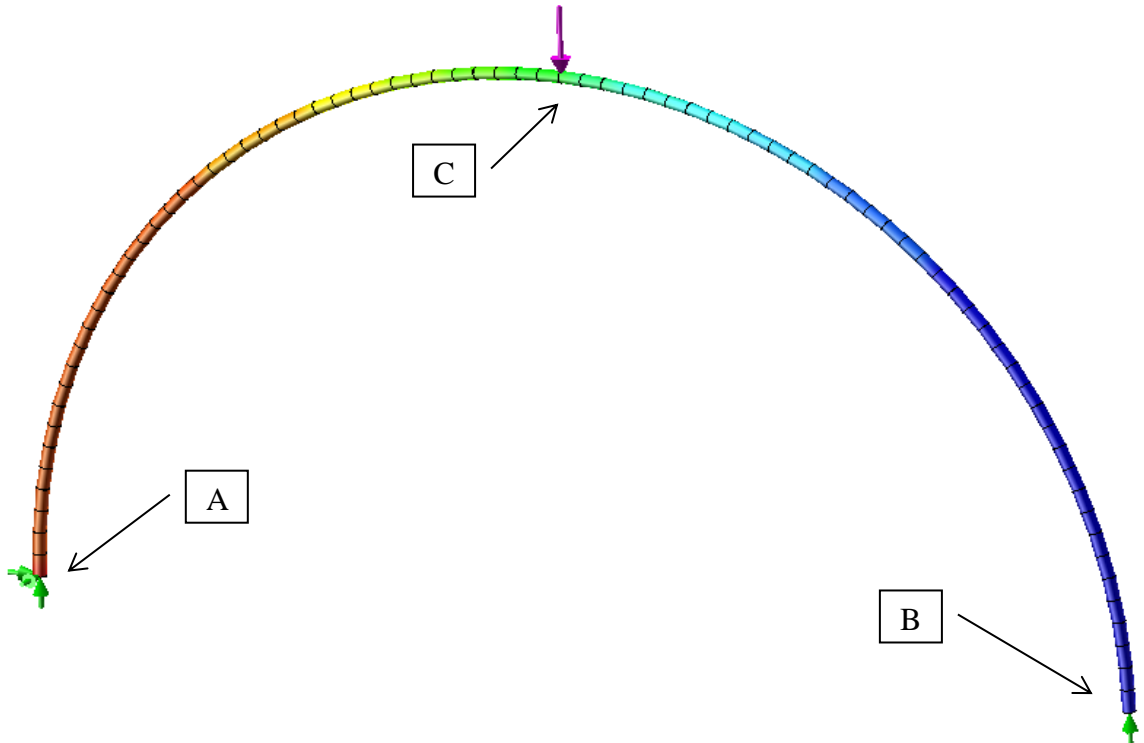
Software: SOLIDWORKS Simulation

Version: 2019 B3

Computer configuration used: Lenovo ThinkPad W540, Windows 10 x64, Intel i7 vPro core, 16Gb RAM, Graphics Card Intel® HD Graphics 4600.

Test name: SIMPLY SUPPORTED THIN ARC UNDER INPLANE BENDING

Codification: SSSL 08-89



Test performed by : Julien BOISSAT

Date : 3/25/2019

Model used

Finite elements

Boundary elements

Other

Element type : BEAM

Number of degrees of freedom or mesh density :

Nb of nodes = 561

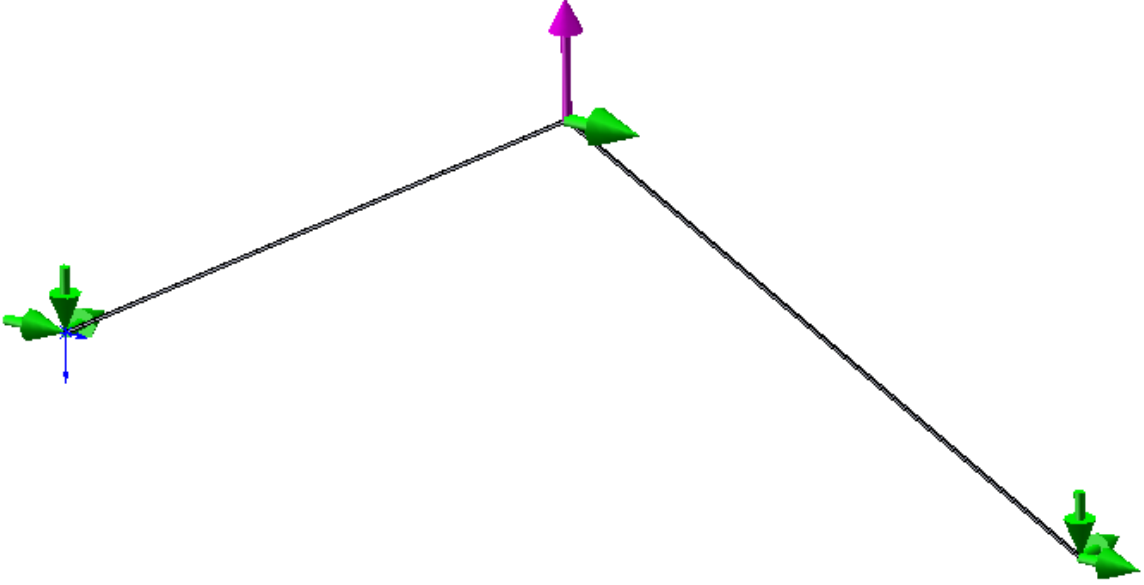
Nb of elements = 280

Nb of DOF = 1683

Results :

Location	Physical quantity and reference unit		Calculated value	Deviation (%)
A	θ_A (rad)	-3.0774×10^{-2}	-3.0774×10^{-2}	0
B	θ_B (rad)	3.0774×10^{-2}	3.0774×10^{-2}	0
C	v_C (m)	-1.9206×10^{-2}	-1.9218×10^{-2}	0.05
B	u_B (m)	5.3912×10^{-2}	5.3923×10^{-2}	0.02

Comments :

EVALUATION FORM																	
Software: SOLIDWORKS Simulation	Version: 2019 B3																
Computer configuration used: Lenovo ThinkPad W540, Windows 10 x64, Intel i7 vPro core, 16Gb RAM, Graphics Card Intel® HD Graphics 4600.																	
Test name: TWO BAR SYSTEM WITH THREE UNIVERSAL JOINTS Codification: SSSL 09-89																	
																	
Test performed by : Julien BOISSAT	Date : 3/25/2019																
Model used Finite elements <input checked="" type="checkbox"/> Boundary elements <input type="checkbox"/> Other <input type="checkbox"/> Element type : BAR Number of degrees of freedom or mesh density : Nb of nodes = 5 Nb of elements = 2 Nb of DOF = 3																	
Results :																	
<table border="1" style="width: 100%; border-collapse: collapse; text-align: center;"> <thead> <tr> <th style="width: 20%;">Location</th> <th style="width: 20%;">Physical quantity and reference unit</th> <th style="width: 20%;">Calculated value</th> <th style="width: 20%;">Deviatiion(%)</th> </tr> </thead> <tbody> <tr> <td><i>C</i></td> <td>v_C (m)</td> <td>-3×10^{-3}</td> <td>0</td> </tr> <tr> <td>Bar <i>AC</i></td> <td>σ (Pa)</td> <td>7×10^7</td> <td>0</td> </tr> <tr> <td>Bar <i>BC</i></td> <td>σ (Pa)</td> <td>7×10^7</td> <td>0</td> </tr> </tbody> </table>		Location	Physical quantity and reference unit	Calculated value	Deviatiion(%)	<i>C</i>	v_C (m)	-3×10^{-3}	0	Bar <i>AC</i>	σ (Pa)	7×10^7	0	Bar <i>BC</i>	σ (Pa)	7×10^7	0
Location	Physical quantity and reference unit	Calculated value	Deviatiion(%)														
<i>C</i>	v_C (m)	-3×10^{-3}	0														
Bar <i>AC</i>	σ (Pa)	7×10^7	0														
Bar <i>BC</i>	σ (Pa)	7×10^7	0														
Comments :																	

EVALUATION FORM

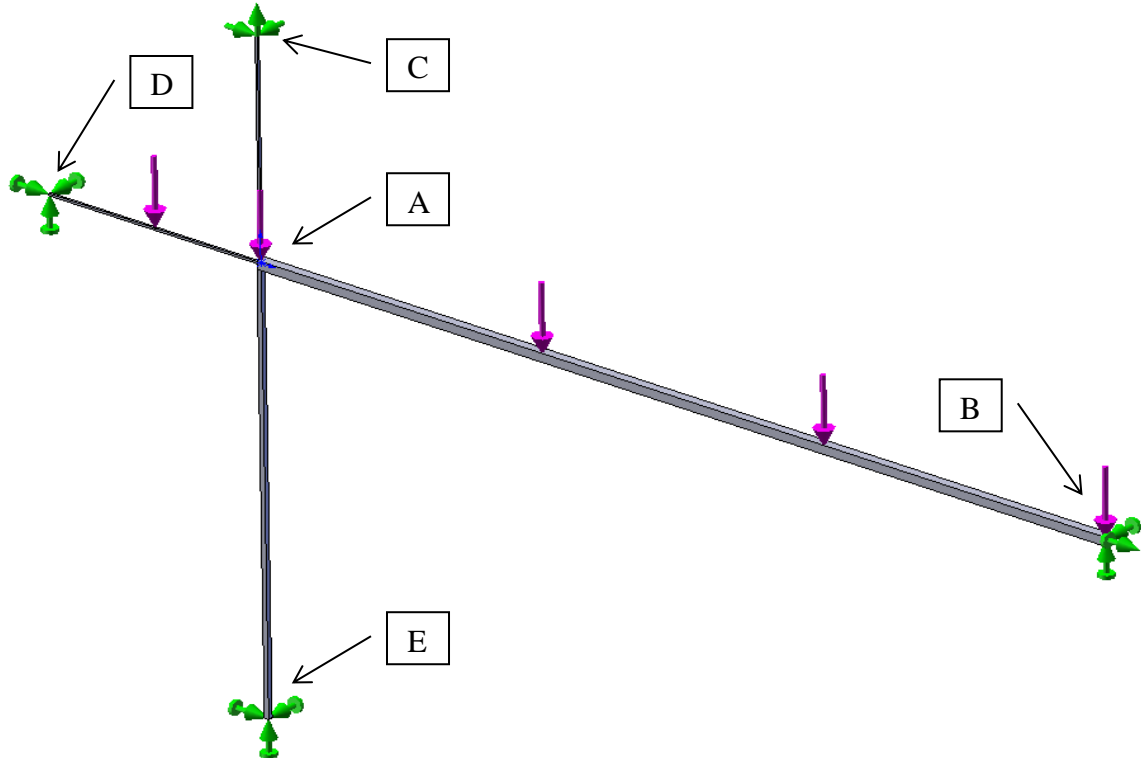
Software: SOLIDWORKS Simulation

Version: 2019 B3

Computer configuration used: Lenovo ThinkPad W540, Windows 10 x64, Intel i7 vPro core, 16Gb RAM, Graphics Card Intel® HD Graphics 4600.

Test name: FRAME WITH LATERAL CONNECTIONS

Codification: SSSL 10-89



Test performed by : Julien BOISSAT

Date : 3/25/2019

Model used

Finite elements

Boundary elements

Other

Element type : BEAM

Number of degrees of freedom or mesh density :

Nb of nodes = 417

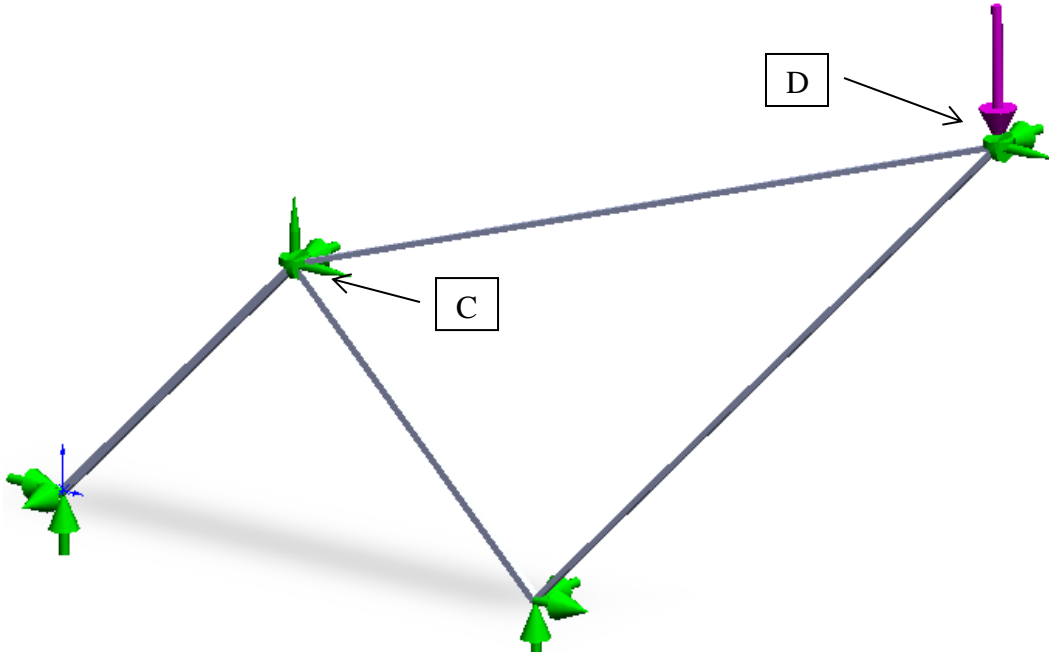
Nb of elements = 411

Nb of DOF = 2451

Results :

Location	Physical quantity and reference unit		Calculated value	Deviation (%)
A	θ (rad)	0.227118	0.2274	0.12
A	M_{AB} (Nm)	11023.72	11021	0.02
A	M_{AC} (Nm)	113.559	113.7	0.12
A	M_{AD} (Nm)	-12348.588	-12347	0.01
A	M_{AE} (Nm)	1211.2994	1213	0.13

Comments :

EVALUATION FORM																					
Software: SOLIDWORKS Simulation	Version: 2019 B3																				
Computer configuration used: Lenovo ThinkPad W540, Windows 10 x64, Intel i7 vPro core, 16Gb RAM, Graphics Card Intel® HD Graphics 4600.																					
Test name: FRAMEWORK OF ARTICULATED BASR UNDER CONCENTRATED LOAD Codification: SSSL 11-89																					
																					
Test performed by : Julien BOISSAT	Date : 3/25/2019																				
Model used Finite elements <input checked="" type="checkbox"/> Boundary elements <input type="checkbox"/> Other <input type="checkbox"/> Element type : BAR Number of degrees of freedom or mesh density : Nb of nodes = 4 Nb of elements = 4 Nb of DOF = 6																					
Results :																					
<table border="1" style="width: 100%; border-collapse: collapse; text-align: center;"> <thead> <tr> <th style="width: 15%;">Location</th> <th style="width: 20%;">Physical quantity and reference unit</th> <th style="width: 15%;">Calculated value</th> <th style="width: 50%;">Deviation(%)</th> </tr> </thead> <tbody> <tr> <td><i>C</i></td> <td>u_C (m)</td> <td>0.26517×10^{-3}</td> <td>0.2652×10^{-3}</td> </tr> <tr> <td><i>C</i></td> <td>v_C (m)</td> <td>0.08839×10^{-3}</td> <td>0.08839×10^{-3}</td> </tr> <tr> <td><i>D</i></td> <td>u_D (m)</td> <td>3.47902×10^{-3}</td> <td>3.479×10^{-3}</td> </tr> <tr> <td><i>D</i></td> <td>v_D (m)</td> <td>-5.60084×10^{-3}</td> <td>-5.6×10^{-3}</td> </tr> </tbody> </table>		Location	Physical quantity and reference unit	Calculated value	Deviation(%)	<i>C</i>	u_C (m)	0.26517×10^{-3}	0.2652×10^{-3}	<i>C</i>	v_C (m)	0.08839×10^{-3}	0.08839×10^{-3}	<i>D</i>	u_D (m)	3.47902×10^{-3}	3.479×10^{-3}	<i>D</i>	v_D (m)	-5.60084×10^{-3}	-5.6×10^{-3}
Location	Physical quantity and reference unit	Calculated value	Deviation(%)																		
<i>C</i>	u_C (m)	0.26517×10^{-3}	0.2652×10^{-3}																		
<i>C</i>	v_C (m)	0.08839×10^{-3}	0.08839×10^{-3}																		
<i>D</i>	u_D (m)	3.47902×10^{-3}	3.479×10^{-3}																		
<i>D</i>	v_D (m)	-5.60084×10^{-3}	-5.6×10^{-3}																		
Comments :																					

EVALUATION FORM

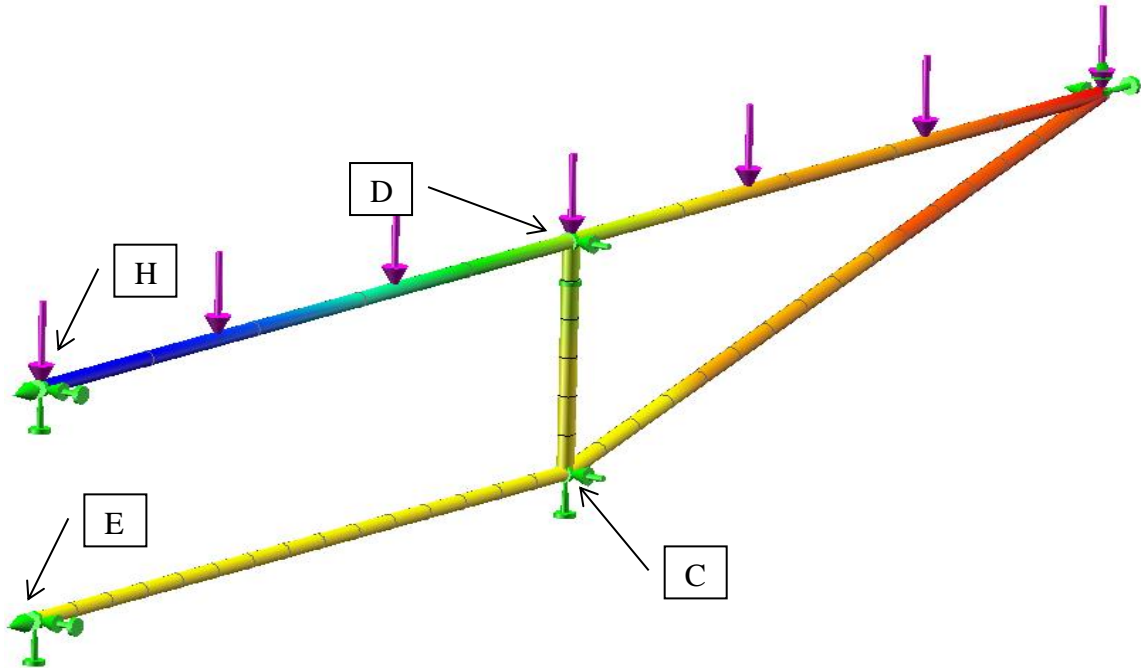
Software: SOLIDWORKS Simulation

Version: 2019 B3

Computer configuration used: Lenovo ThinkPad W540, Windows 10 x64, Intel i7 vPro core, 16Gb RAM, Graphics Card Intel® HD Graphics 4600.

Test name: PRE-STRESSED BAR

Codification: SSSL 13-89



Test performed by : Julien BOISSAT

Date : 3/25/2019

Model used

Finite elements

Boundary elements

Other

Element type : BEAMS

Number of degrees of freedom or mesh density :

Nb of nodes = 200

Nb of elements = 196

Nb of DOF = 1164

Results :

Location	Physical quantity and reference unit	Calculated value	Deviation (%)	
<i>CE</i>	N , traction force (N)	584584	586279	0.29
<i>H</i>	M , bending moment (Nm)	49249.5	48233	2.06
<i>D</i>	v_D (m)	-0.0005428	-0.0004901	10.75

Comments :

EVALUATION FORM

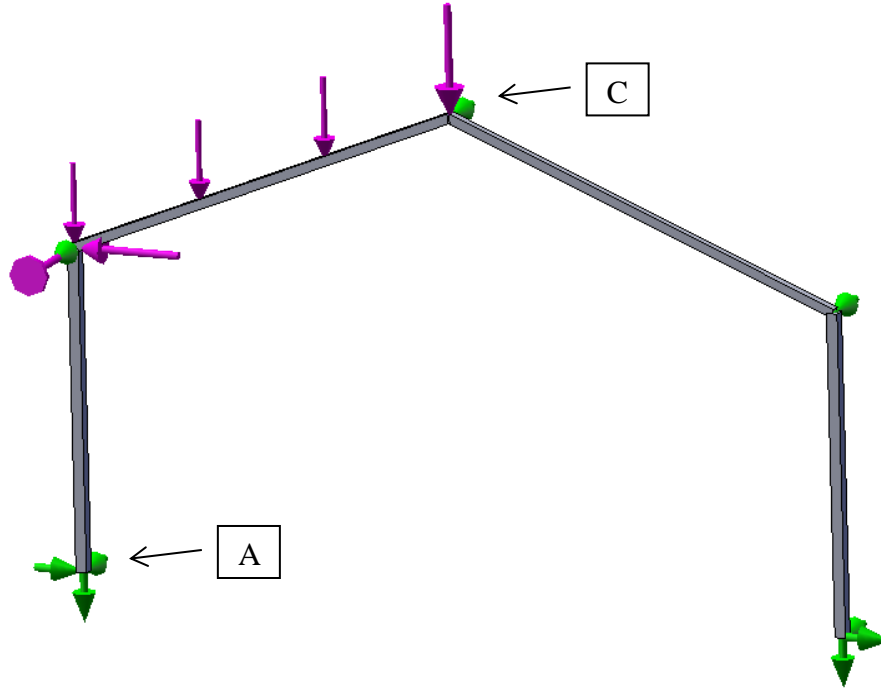
Software: SOLIDWORKS Simulation

Version: 2019 B3

Computer configuration used: Lenovo ThinkPad W540, Windows 10 x64, Intel i7 vPro core, 16Gb RAM, Graphics Card Intel® HD Graphics 4600.

Test name: SIMPLY SUPPORTED PLANAR FRAME

Codification: SSSL 14-89



Test performed by : Julien BOISSAT

Date : 3/25/2019

Model used

Finite elements

Boundary elements

Other

Element type : BEAM

Number of degrees of freedom or mesh density :

Nb of nodes = 285

Nb of elements = 280

Nb of DOF = 1680

Results :

Location	Physical quantity and reference unit	Calculated value	Deviation(%)	
A	V, vertical reaction (N)	31500.0	31500.6	0.002
A	H, horizontal reaction (N)	20239.4	20239.6	0.001
C	v_C (m)	-0.03072	-0.03079	0.23

Comments : Typo corrected in the guide: p=-30000N instead of 3000N/m

EVALUATION FORM

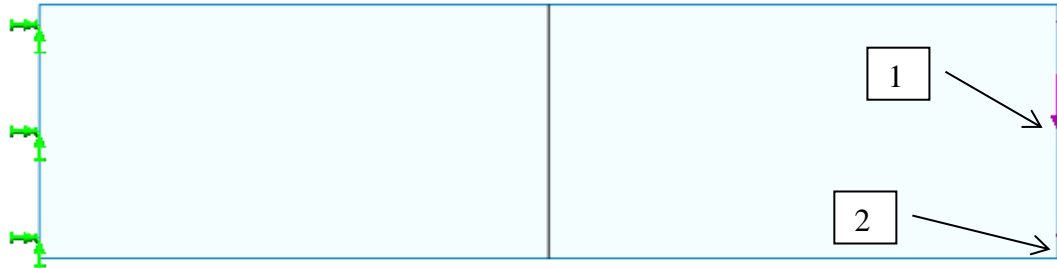
Software: SOLIDWORKS Simulation

Version: 2019 B3

Computer configuration used: Lenovo ThinkPad W540, Windows 10 x64, Intel i7 vPro core, 16Gb RAM, Graphics Card Intel® HD Graphics 4600.

Test name: PLATE UNDER BENDING AND SHEAR IN ITS OWN PLANE

Codification: SSLP 01-89



Test performed by : Julien BOISSAT

Date : 3/25/2019

Model used

Finite elements

Boundary elements

Other

Element type : SHELL 6

Number of degrees of freedom or mesh density :

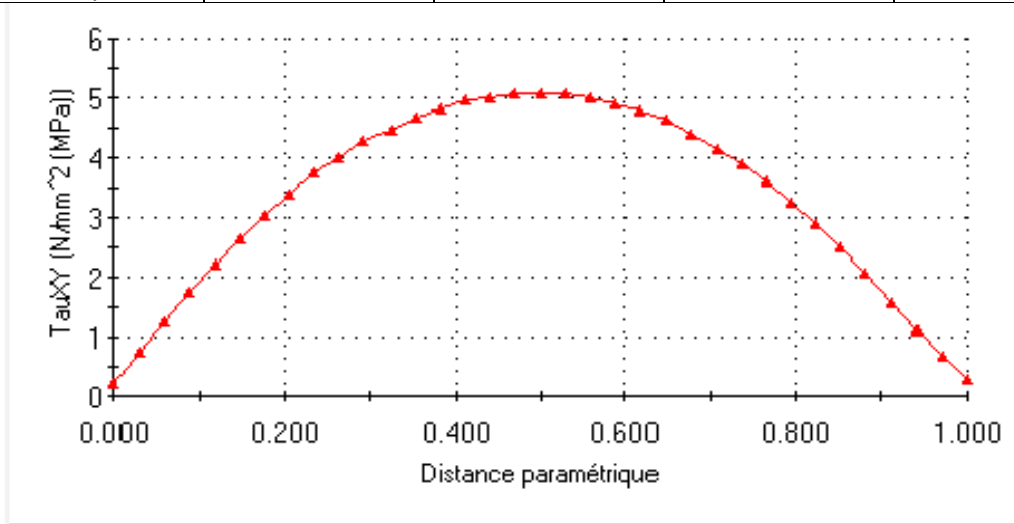
Nb of nodes = 5290

Nb of elements = 2541

Nb of DOF = 31530

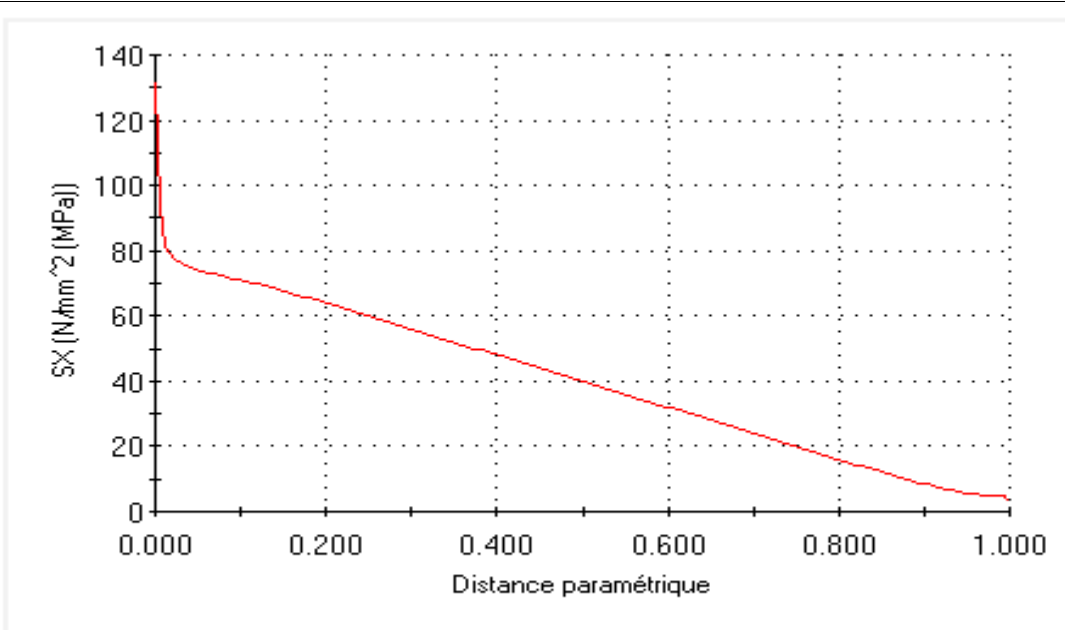
Results :

Location	Physical quantity	Reference value	Calculated value	Deviation (%)
(L,y)	v_1	0.3413	0.35607	4.328%
(L,y)	v_2	0.3573	0.35608	-0.341%

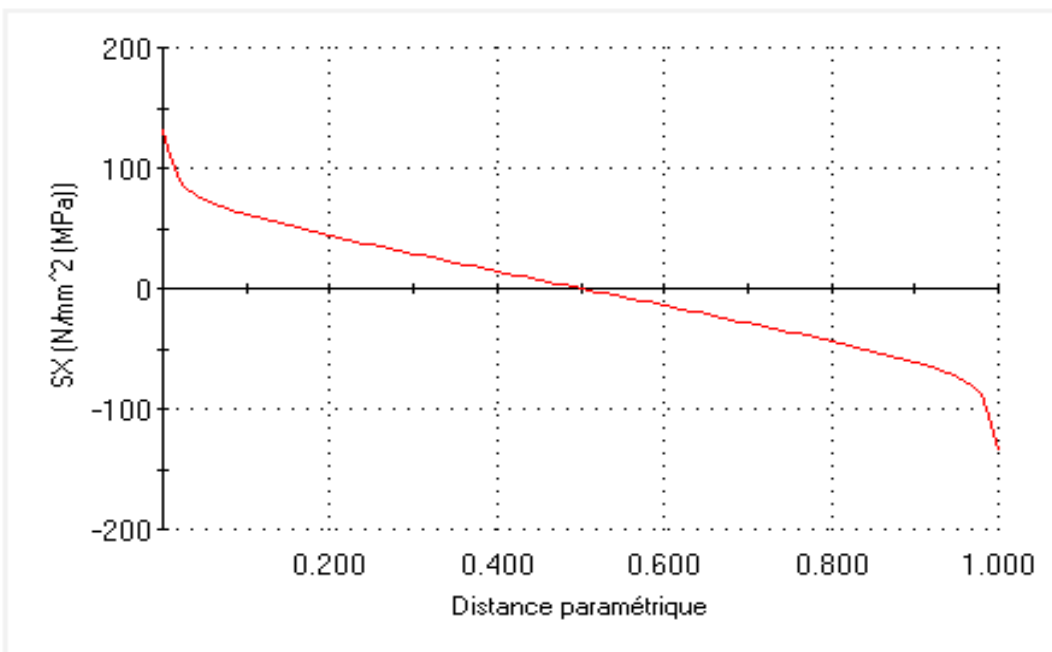


—▲— Tau_{XY} (N/mm² (MPa))

Distribution of Shear stress along Y

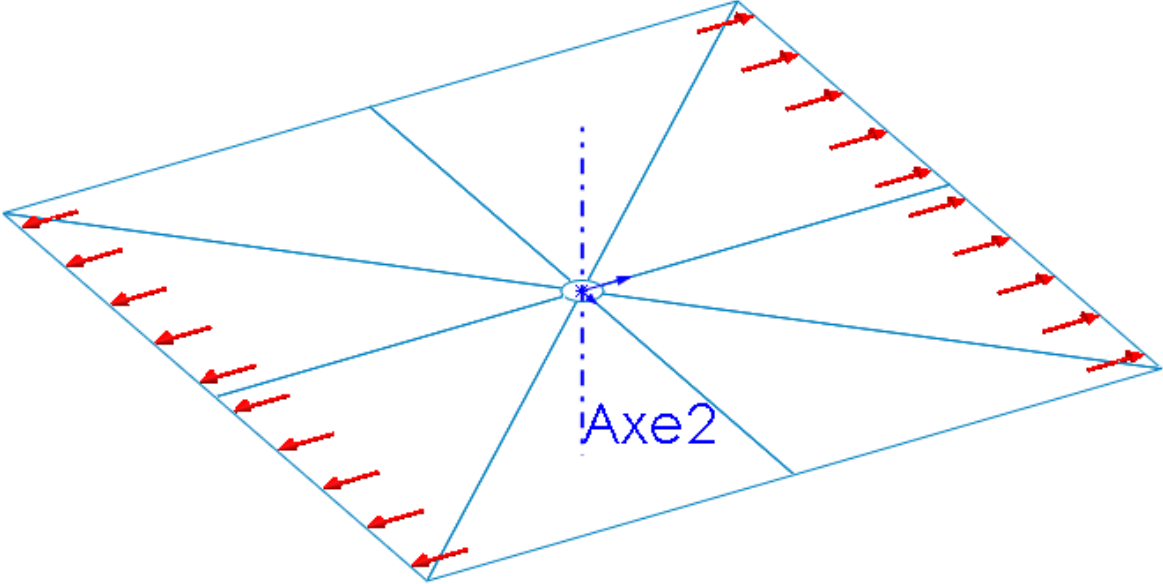


— SX (N/mm²) (MPa)
Distribution of SX stress along top edge



— SX (N/mm²) (MPa)
Distribution of SX stress along fixed edge

Comments :

EVALUATION FORM																					
Software: SOLIDWORKS Simulation	Version: 2019 B3																				
Computer configuration used: Lenovo ThinkPad W540, Windows 10 x64, Intel i7 vPro core, 16Gb RAM, Graphics Card Intel® HD Graphics 4600.																					
Test name: PERFORATED PLATE UNDER SIMPLE TRACTION Codification: SSLP 02-89																					
																					
Test performed by : Julien BOISSAT	Date : 3/25/2019																				
Model used Finite elements <input checked="" type="checkbox"/> Boundary elements <input type="checkbox"/> Other <input type="checkbox"/> Element type : SHELL 6 Number of degrees of freedom or mesh density : Nb of nodes = 7168 Nb of elements = 3424 Nb of DOF = 42444																					
Results :																					
<table border="1" style="width: 100%; border-collapse: collapse; text-align: center;"> <thead> <tr> <th style="text-align: left;">Location (Space-Time)</th> <th style="text-align: left;">Physical quantity (unit)</th> <th style="text-align: left;">Reference value</th> <th style="text-align: left;">Calculated value</th> <th style="text-align: left;">Deviation (%)</th> </tr> </thead> <tbody> <tr> <td style="text-align: left;">(a,0)</td> <td style="text-align: left;">$\sigma_{\theta\theta}$ (N/mm²)</td> <td style="text-align: left;">7.5</td> <td style="text-align: left;">7.584</td> <td style="text-align: left;">1.12</td> </tr> <tr> <td style="text-align: left;">(a,$\pi/4$)</td> <td style="text-align: left;">$\sigma_{\theta\theta}$ (N/mm²)</td> <td style="text-align: left;">2.5</td> <td style="text-align: left;">2.513</td> <td style="text-align: left;">0.52</td> </tr> <tr> <td style="text-align: left;">(a,$\pi/2$)</td> <td style="text-align: left;">$\sigma_{\theta\theta}$ (N/mm²)</td> <td style="text-align: left;">-2.5</td> <td style="text-align: left;">-2.559</td> <td style="text-align: left;">2.36</td> </tr> </tbody> </table>		Location (Space-Time)	Physical quantity (unit)	Reference value	Calculated value	Deviation (%)	(a,0)	$\sigma_{\theta\theta}$ (N/mm ²)	7.5	7.584	1.12	(a, $\pi/4$)	$\sigma_{\theta\theta}$ (N/mm ²)	2.5	2.513	0.52	(a, $\pi/2$)	$\sigma_{\theta\theta}$ (N/mm ²)	-2.5	-2.559	2.36
Location (Space-Time)	Physical quantity (unit)	Reference value	Calculated value	Deviation (%)																	
(a,0)	$\sigma_{\theta\theta}$ (N/mm ²)	7.5	7.584	1.12																	
(a, $\pi/4$)	$\sigma_{\theta\theta}$ (N/mm ²)	2.5	2.513	0.52																	
(a, $\pi/2$)	$\sigma_{\theta\theta}$ (N/mm ²)	-2.5	-2.559	2.36																	
Comments : The formulas of the analytical solution are solely applicable when the length and width of the sheet are large enough compared to the diameter of the hole. The stresses away from the hole should not be affected by its presence. With the given dimensions, the ratio between the diameter and the width is equal to 0.2 which is not enough. For the formulas to be applicable, the plate should be at least 4 times larger (ratio equal to 0.05). The values in the table above are given for such a modified geometry.																					

EVALUATION FORM

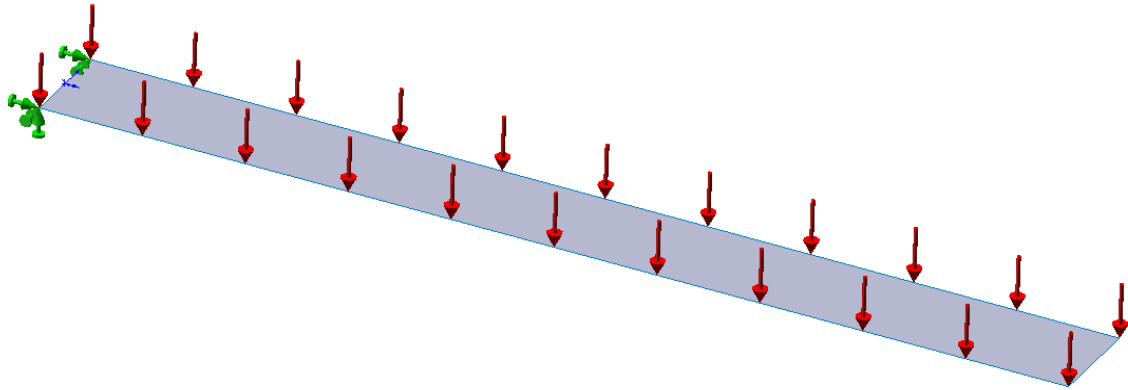
Software: SOLIDWORKS Simulation

Version: 2019 B3

Computer configuration used: Lenovo ThinkPad W540, Windows 10 x64, Intel i7 vPro core, 16Gb RAM, Graphics Card Intel® HD Graphics 4600.

Test name: CANTILEVER RECTANGULAR PLATE

Codification: SSLS 01-89



Test performed by : Julien BOISSAT

Date : 3/25/2019

Model used

Finite elements

Boundary elements

Other

Element type : SHELL 6

Number of degrees of freedom or mesh density :

Nb of nodes = 10467

Nb of elements = 5058

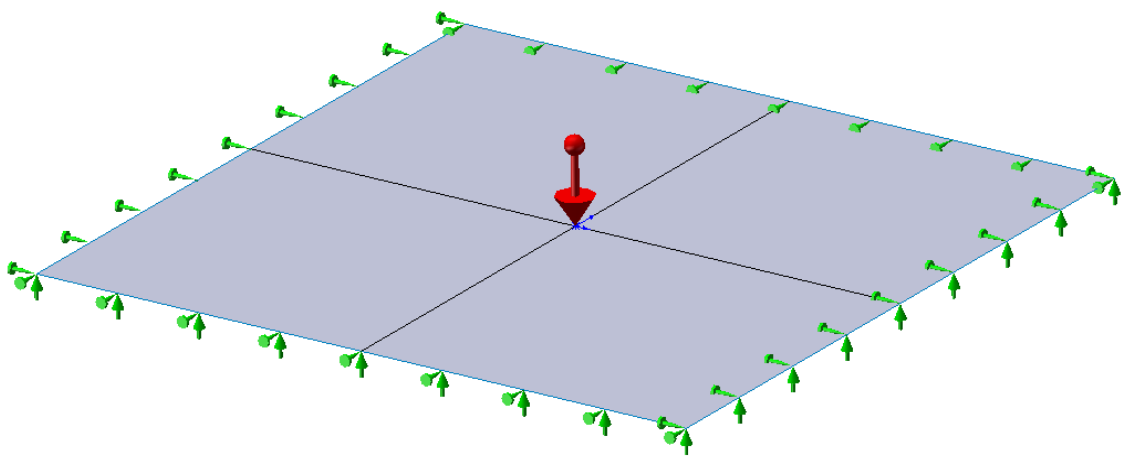
Nb of DOF = 62604

Results :

Location	Physical quantity	Reference value	Calculated value	Deviation (%)
Side $x = 1$	w (m)	-0.0973	-0.0958	1.57

Comments :

Do not perform Large Displacement calculations.

EVALUATION FORM											
Software: SOLIDWORKS Simulation	Version: 2019 B3										
Computer configuration used: Lenovo ThinkPad W540, Windows 10 x64, Intel i7 vPro core, 16Gb RAM, Graphics Card Intel® HD Graphics 4600.											
Test name: SIMPLY SUPPORTED SQUARE PLATE Codification: SSLS 02-89											
											
Test performed by : Julien BOISSAT	Date: 3/25/2019										
Model used Finite elements <input checked="" type="checkbox"/> Boundary elements <input type="checkbox"/> Other <input type="checkbox"/> Element type : SHELL 6 Number of degrees of freedom or mesh density : Nb of nodes = 4505 Nb of elements = 2184 Nb of DOF = 27030											
Results :											
<table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="width: 20%;">Location</th> <th style="width: 20%;">Physical quantity</th> <th style="width: 20%;">Reference value⁽¹⁾</th> <th style="width: 20%;">Calculated value</th> <th style="width: 20%;">Deviation (%)</th> </tr> </thead> <tbody> <tr> <td style="text-align: center;">Center <i>O</i></td> <td style="text-align: center;">w_0 (m)</td> <td style="text-align: center;">-0.1649×10^{-3}</td> <td style="text-align: center;">-0.1648×10^{-3}</td> <td style="text-align: center;">0.01</td> </tr> </tbody> </table>		Location	Physical quantity	Reference value ⁽¹⁾	Calculated value	Deviation (%)	Center <i>O</i>	w_0 (m)	-0.1649×10^{-3}	-0.1648×10^{-3}	0.01
Location	Physical quantity	Reference value ⁽¹⁾	Calculated value	Deviation (%)							
Center <i>O</i>	w_0 (m)	-0.1649×10^{-3}	-0.1648×10^{-3}	0.01							
Comments : (1) "Roark's Formulas for Stress & Strain" (6 th ed. p.458) gives the following formula for a thin simply supported square plate : $\text{Max } y = \frac{-\alpha b^4}{Et^3}$ where b is the width, a is the length, t the thickness and $\alpha = -0.0444$ for $\frac{b}{a} = 1$ which gives a maximum displacement $y_{\text{max}} = -0.1649 \times 10^{-3}\text{m}$.											

EVALUATION FORM

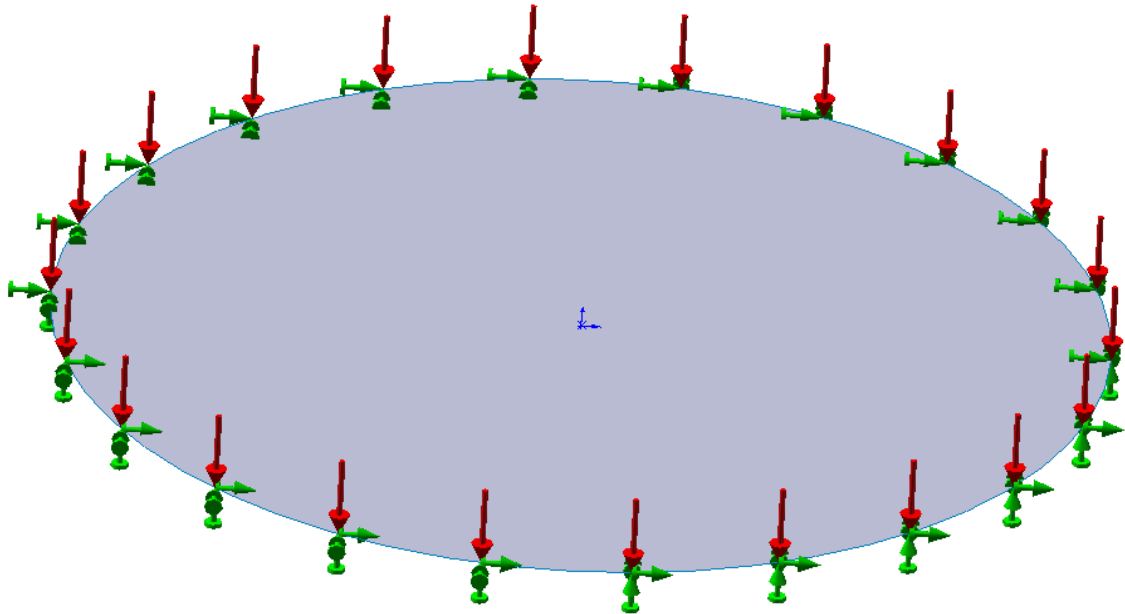
Software: SOLIDWORKS Simulation

Version: 2019 SP2

Computer configuration used: Lenovo ThinkPad W540, Windows 10 x64, Intel i7 vPro core, 16Gb RAM, Graphics Card Intel® HD Graphics 4600.

Test name: CIRCULAR PLATE UNDER UNIFORM PRESSURE LOAD

Codification: SLS 03-89



Test performed by : Julien BOISSAT

Date: 3/25/2019

Model used

Finite elements

Boundary elements

Other

Element type : SHELL 6 and SHELLAX

Number of degrees of freedom or mesh density :

SHELL 6:

Nb of nodes = 10343

Nb of elements = 5082

Nb of DOF = 59922

SHELLAX

Nb of nodes = 1525

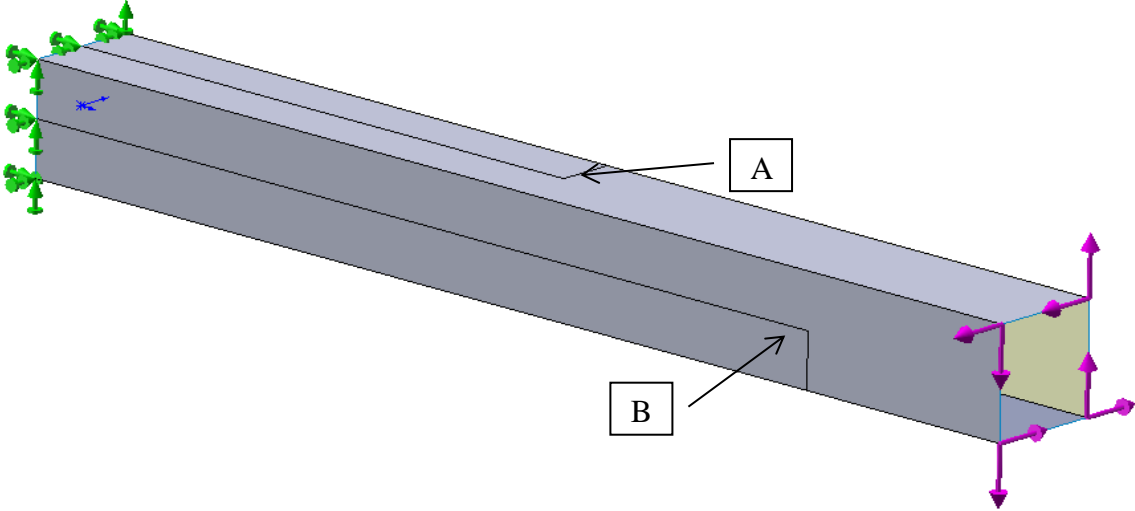
Nb of elements = 510

Nb of DOF = 3040

Results :

Location	Physical quantity	Reference value	Calculated value		Deviation (%)	
			SHELL 6	SHELLAX	SHELL 6	SHELLAX
Center <i>O</i>	w_O (m)	-0.0065	-0.0065	-0.0065	0	0

Comments :

EVALUATION FORM																																
Software: SOLIDWORKS Simulation	Version: 2019 B3																															
Computer configuration used: Lenovo ThinkPad W540, Windows 10 x64, Intel i7 vPro core, 16Gb RAM, Graphics Card Intel® HD Graphics 4600.																																
Test name: RECTANGULAR HOLLOW BEAM UNDER TORSION																																
Codification: SSSL 05-89																																
																																
Test performed by : Julien BOISSAT	Date: 3/25/2019																															
Model used Finite elements <input checked="" type="checkbox"/> Boundary elements <input type="checkbox"/> Other <input type="checkbox"/> Element type : SHELL 6 Number of degrees of freedom or mesh density : Nb of nodes = 10292 Nb of elements = 5114 Nb of DOF = 61368																																
Results :																																
<table border="1" style="width: 100%; border-collapse: collapse; text-align: center;"> <thead> <tr> <th style="width: 20%;">Location (Space-Time)</th> <th style="width: 20%;">Physical quantity (unit)</th> <th style="width: 20%;">Reference value</th> <th style="width: 20%;">Calculated value</th> <th style="width: 20%;">Deviation (%)</th> </tr> </thead> <tbody> <tr> <td rowspan="3">Point A (0.5,0,0.05)</td> <td>v (m)</td> <td>-0.617×10^{-6}</td> <td>-0.616×10^{-6}</td> <td>0.16</td> </tr> <tr> <td>θ_x (rad)</td> <td>0.123×10^{-4}</td> <td>0.123×10^{-4}</td> <td>0</td> </tr> <tr> <td>σ_{xy} (Pa)</td> <td>-0.11×10^6</td> <td>-0.1096×10^6</td> <td>0.36</td> </tr> <tr> <td rowspan="3">Point B (0.8,-0.05,0)</td> <td>w (m)</td> <td>-0.987×10^{-6}</td> <td>-0.986×10^{-6}</td> <td>0.1</td> </tr> <tr> <td>θ_x (rad)</td> <td>0.197×10^{-4}</td> <td>0.197×10^{-4}</td> <td>0</td> </tr> <tr> <td>σ_{xy} (Pa) ⁽¹⁾</td> <td>-0.11×10^6</td> <td>-0.1096×10^6</td> <td>0.36</td> </tr> </tbody> </table>		Location (Space-Time)	Physical quantity (unit)	Reference value	Calculated value	Deviation (%)	Point A (0.5,0,0.05)	v (m)	-0.617×10^{-6}	-0.616×10^{-6}	0.16	θ_x (rad)	0.123×10^{-4}	0.123×10^{-4}	0	σ_{xy} (Pa)	-0.11×10^6	-0.1096×10^6	0.36	Point B (0.8,-0.05,0)	w (m)	-0.987×10^{-6}	-0.986×10^{-6}	0.1	θ_x (rad)	0.197×10^{-4}	0.197×10^{-4}	0	σ_{xy} (Pa) ⁽¹⁾	-0.11×10^6	-0.1096×10^6	0.36
Location (Space-Time)	Physical quantity (unit)	Reference value	Calculated value	Deviation (%)																												
Point A (0.5,0,0.05)	v (m)	-0.617×10^{-6}	-0.616×10^{-6}	0.16																												
	θ_x (rad)	0.123×10^{-4}	0.123×10^{-4}	0																												
	σ_{xy} (Pa)	-0.11×10^6	-0.1096×10^6	0.36																												
Point B (0.8,-0.05,0)	w (m)	-0.987×10^{-6}	-0.986×10^{-6}	0.1																												
	θ_x (rad)	0.197×10^{-4}	0.197×10^{-4}	0																												
	σ_{xy} (Pa) ⁽¹⁾	-0.11×10^6	-0.1096×10^6	0.36																												
Comments : ⁽¹⁾ A typo was detected in the Guide: at point B, the table should read σ_{xz} instead of σ_{xy} .																																

EVALUATION FORM

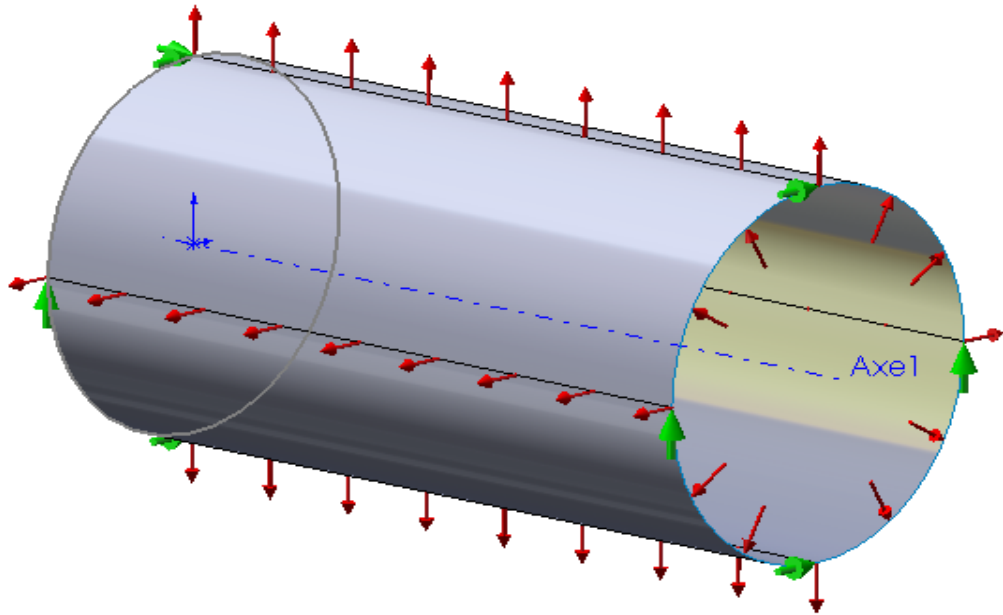
Software: SOLIDWORKS Simulation

Version: 2019 SP2

Computer configuration used: Lenovo ThinkPad W540, Windows 10 x64, Intel i7 vPro core, 16Gb RAM, Graphics Card Intel® HD Graphics 4600.

Test name: THIN CYLINDER UNDER UNIFORM RADIAL PRESSURE

Codification: SSSL 06-89



Test performed by : Julien BOISSAT

Date: 3/25/2019

Model used

Finite elements

Boundary elements

Other

Element type : SHELL6T

Number of degrees of freedom or mesh density :

Nb of nodes = 4296

Nb of elements = 2104

Nb of DOF = 25776

Results :

Location	Physical quantity	Reference value	Calculated value	Deviation (%)
All points	σ_{11} (Pa)	0.0	70 ⁽¹⁾	-
	σ_{22} (Pa)	5.00×10^5	5.02×10^5	0.4
	δR (m)	2.38×10^{-6}	2.38×10^{-6}	0
	δL (m)	-2.86×10^{-6}	-2.86×10^{-6}	0

Comments :

⁽¹⁾ $\sigma_{11} = 500$ Pa should be compared to the load and/or to σ_{22} . The result is acceptable (ratio equal to 1/1000).

EVALUATION FORM

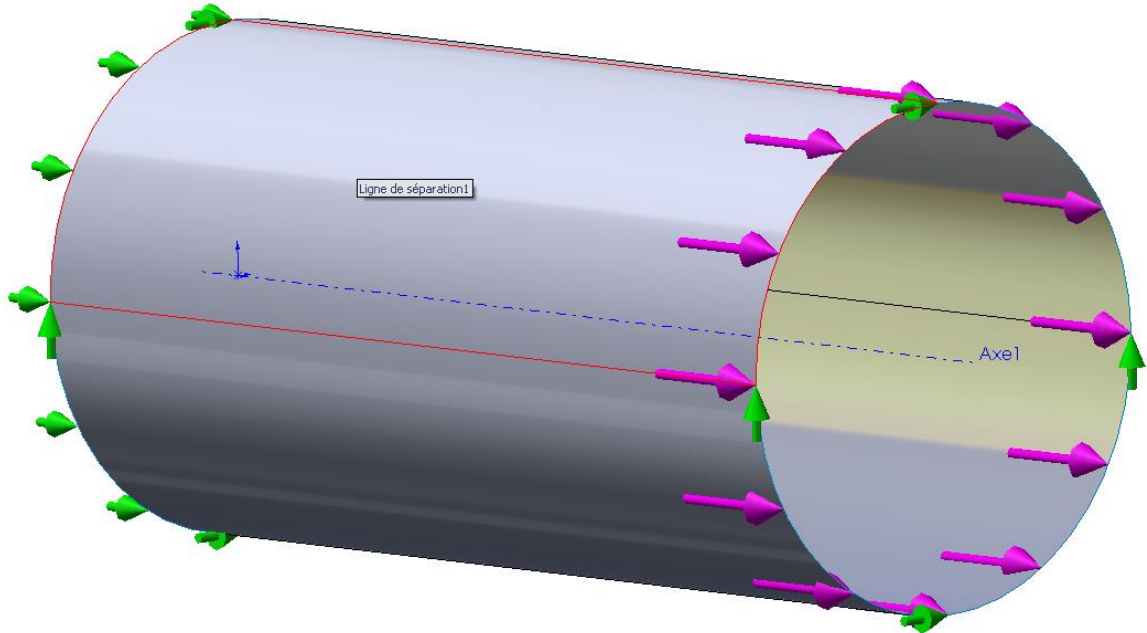
Software: SOLIDWORKS Simulation

Version: 2019 SP2

Computer configuration used: Lenovo ThinkPad W540, Windows 10 x64, Intel i7 vPro core, 16Gb RAM, Graphics Card Intel® HD Graphics 4600.

Test name: THIN CYLINDER UNDER UNIFORM AXIAL PRESSURE

Codification: SLS 07-89



Test performed by : Julien BOISSAT

Date: 3/25/2019

Model used

Finite elements

Boundary elements

Other

Element type : SHELL6

Number of degrees of freedom or mesh density :

Nb of nodes = 10368

Nb of elements = 5120

Nb of DOF = 62208

Results :

Location	Physical quantity	Reference value	Calculated value	Deviation (%)
All points	σ_{11} (Pa)	5.00×10^5	5.00×10^5	0
	σ_{22} (Pa)	0.0	152 ⁽¹⁾	-
	δL (m)	9.52×10^{-6}	9.525×10^{-6}	0.05
	δR (m)	-7.14×10^{-7}	-7.155×10^{-7}	0.14

Comments :

⁽¹⁾ $\sigma_{22} = 106$ Pa should be compared to the load and/or to σ_{11} . The result is acceptable (ratio smaller than 1/1000).

EVALUATION FORM

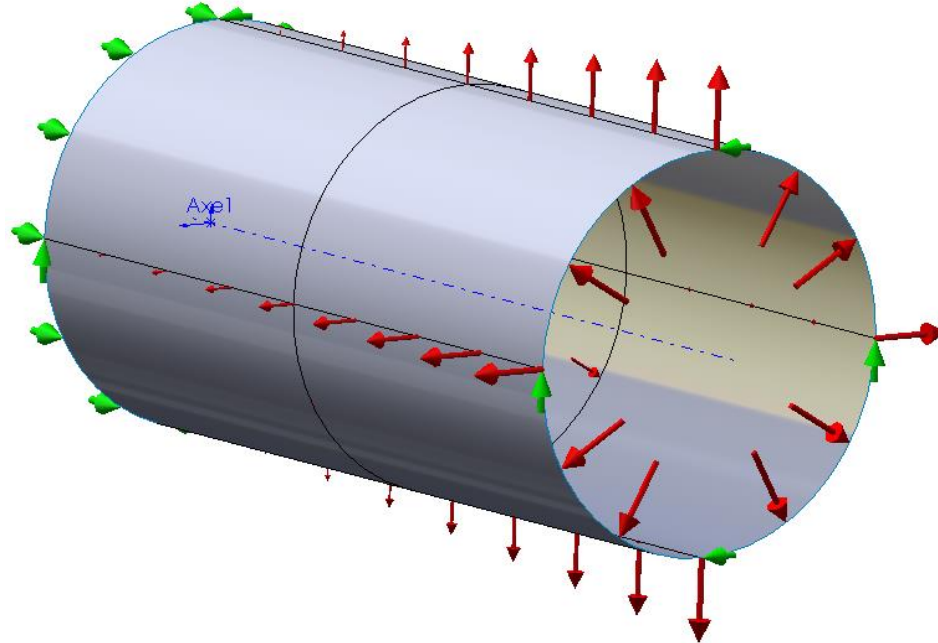
Software: SOLIDWORKS Simulation

Version: 2019 SP2

Computer configuration used: Lenovo ThinkPad W540, Windows 10 x64, Intel i7 vPro core, 16Gb RAM, Graphics Card Intel® HD Graphics 4600.

Test name: THIN CYLINDER UNDER HYDROSTATIC PRESSURE

Codification: SLS 08-89



Test performed by : Julien BOISSAT

Date: 3/25/2019

Model used

Finite elements

Boundary elements

Other

Element type : SHELL 6

Number of degrees of freedom or mesh density :

Nb of nodes = 4600

Nb of elements = 2256

Nb of DOF = 27504

Results :

Location	Physical quantity	Reference value	Calculated value	Deviation (%)
$\forall x$	σ_{11} (Pa)	0.0	$90^{(1)}$	-
$x = L/2$	σ_{22} (Pa)	5.00×10^5	4.99×10^5	0.2
$x = L/2$	δR (m)	2.38×10^{-6}	2.37×10^{-6}	0.42
$x = L$	δL (m)	-2.86×10^{-6}	-2.86×10^{-6}	0
	ψ (rad) ⁽²⁾	1.19×10^{-6}	1.185×10^{-6}	0.42

Comments :

(1) $\sigma_{11} = 640$ Pa should be compared to the load and/or to the calculated stress σ_{22} . The result is acceptable (ratio around 1/1000).

(2) ψ (rad) Derived from $\psi = \arcsin \delta R(l)/l = \delta R(x = L/2)/(L/2)$

EVALUATION FORM

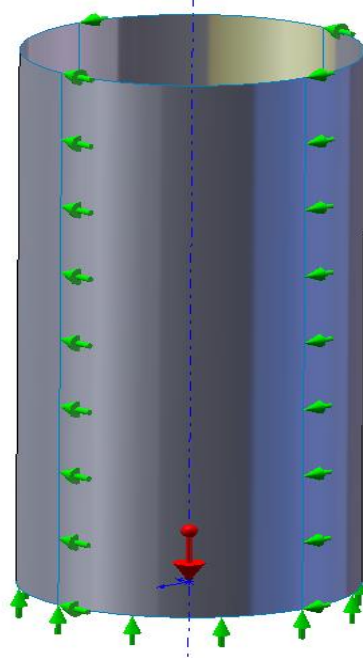
Software: SOLIDWORKS Simulation

Version: 2019 SP2

Computer configuration used: Lenovo ThinkPad W540, Windows 10 x64, Intel i7 vPro core, 16Gb RAM, Graphics Card Intel® HD Graphics 4600.

Test name: THIN CYLINDER UNDER ITS OWN WEIGHT

Codification: SSLS 09-89



Test performed by : Julien BOISSAT

Date: 3/25/2019

Model used

Finite elements

Boundary elements

Other

Element type : SHELL 6

Number of degrees of freedom or mesh density :

SHELL 6:

Nb of nodes = 33040

Nb of elements = 16188

Nb of DOF = 198240

Results :

Location	Physical quantity	Reference value	Calculated value	Deviation (%)
$\forall x$ $x = L$	σ_{22} (Pa)	0.0	48 ⁽¹⁾	-
	σ_{11} (Pa)	3.14×10^5	3.14×10^5	0
	δx (m)	2.99×10^{-6}	2.99×10^{-6}	0
	δR (m)	-4.49×10^{-7}	-4.49×10^{-7}	0
	ψ (rad)	-1.12×10^{-7}	-1.15×10^{-7}	2.68

Comments :

⁽¹⁾ σ_{22} = value should be compared to the load and/or to σ_{11} . The result is acceptable (ratio equal to 1/1000).

EVALUATION FORM

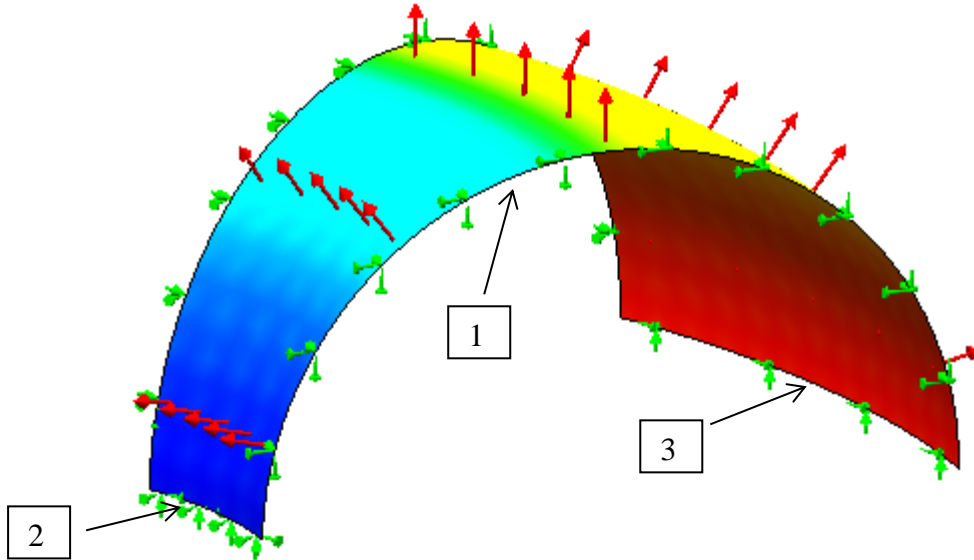
Software: SOLIDWORKS Simulation

Version: 2019 SP2

Computer configuration used: Lenovo ThinkPad W540, Windows 10 x64, Intel i7 vPro core, 16Gb RAM, Graphics Card Intel® HD Graphics 4600.

Test name: TORE UNDER INTERNAL UNIFORM PRESSURE

Codification: SSLS 10-89



Test performed by : Julien BOISSAT

Date: 3/25/2019

Model used

Finite elements

Boundary elements

Other

Element type : SHELL 6

Number of degrees of freedom or mesh density :

Nb of nodes = 813

Nb of elements = 374

Nb of DOF = 4866

Results :

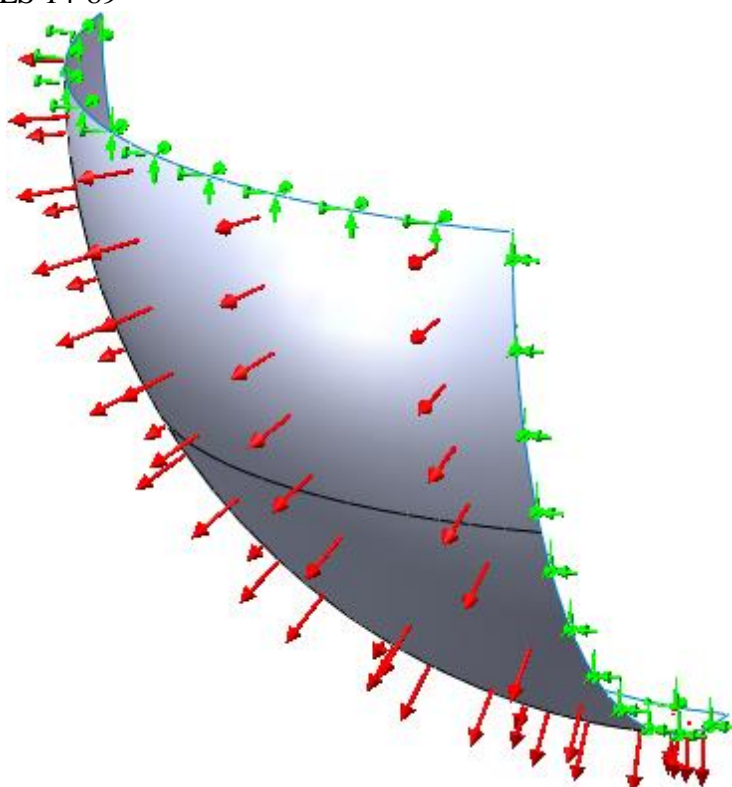
Location (Space-Time)	Physical quantity (unit)	Reference value	Calculated value	Deviation (%)
Any r	σ_{22} (Pa)	2.5×10^5	2.51×10^5	0.40
$r = a - b$	σ_{11} (Pa)	7.5×10^5	7.46×10^5	0.53
	δ_r (m)	1.19×10^{-7}	1.17×10^{-7}	-1.68
$r = a + b$	σ_{11} (Pa)	4.17×10^5	4.16×10^5	0.24
	δ_r (m)	1.79×10^{-6}	1.77×10^{-6}	-1.12

Comments :

Any r corresponds to edge 1.

$r = a - b$ corresponds to edge 2.

$r = a + b$ corresponds to edge 3.

EVALUATION FORM															
Software: SOLIDWORKS Simulation	Version: 2019 SP2														
Computer configuration used: Lenovo ThinkPad W540, Windows 10 x64, Intel i7 vPro core, 16Gb RAM, Graphics Card Intel® HD Graphics 4600.															
Test name: SPHERICAL CAP UNDER INTERNAL PRESSURE Codification: SSLS 14-89															
															
Test performed by : Julien BOISSAT	Date: 3/25/2019														
Model used Finite elements <input checked="" type="checkbox"/> Boundary elements <input type="checkbox"/> Other <input type="checkbox"/> Element type : SHELL 6 Number of degrees of freedom or mesh density : Nb of nodes = 2359 Nb of elements = 1134 Nb of DOF = 14145															
Results :															
<table border="1" style="width: 100%; border-collapse: collapse; text-align: center;"> <thead> <tr> <th style="width: 15%;">Location</th> <th style="width: 25%;">Physical quantity</th> <th style="width: 15%;">Reference value</th> <th style="width: 15%;">Calculated value</th> <th style="width: 30%;">Deviation (%)</th> </tr> </thead> <tbody> <tr> <td rowspan="2">For every θ $\theta = 90^\circ$</td> <td>$\sigma_{11} = \sigma_{22}$ (Pa)</td> <td>2.50×10^5</td> <td>2.50×10^5</td> <td>0</td> </tr> <tr> <td>δR (m)</td> <td>8.33×10^{-7}</td> <td>8.34×10^{-7}</td> <td>0.12</td> </tr> </tbody> </table>		Location	Physical quantity	Reference value	Calculated value	Deviation (%)	For every θ $\theta = 90^\circ$	$\sigma_{11} = \sigma_{22}$ (Pa)	2.50×10^5	2.50×10^5	0	δR (m)	8.33×10^{-7}	8.34×10^{-7}	0.12
Location	Physical quantity	Reference value	Calculated value	Deviation (%)											
For every θ $\theta = 90^\circ$	$\sigma_{11} = \sigma_{22}$ (Pa)	2.50×10^5	2.50×10^5	0											
	δR (m)	8.33×10^{-7}	8.34×10^{-7}	0.12											
Comments :															

EVALUATION FORM

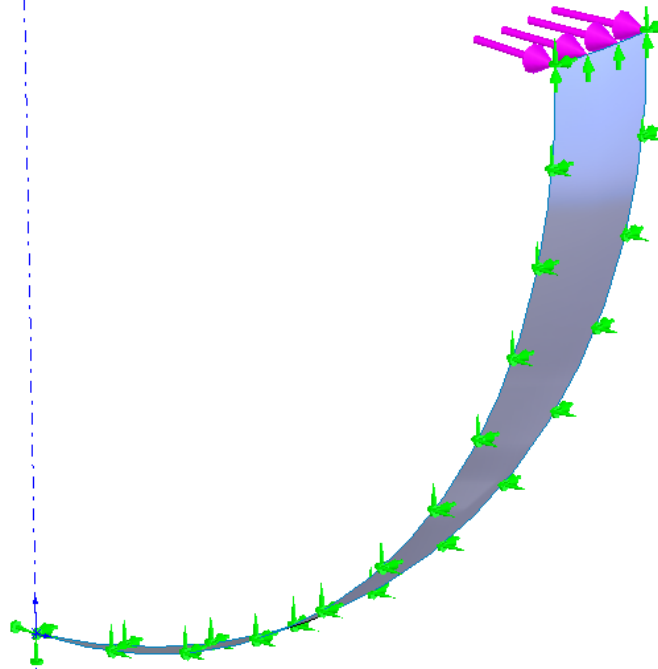
Software: SOLIDWORKS Simulation

Version: 2019 SP2

Computer configuration used: Lenovo ThinkPad W540, Windows 10 x64, Intel i7 vPro core, 16Gb RAM, Graphics Card Intel® HD Graphics 4600.

Test name: SPHERICAL CAP UNDER RADIAL FORCE

Codification: SSLS 15-89



Test performed by : Julien BOISSAT

Date: 3/25/2019

Model used

Finite elements

Boundary elements

Other

Element type : SHELL 6

Number of degrees of freedom or mesh density :

Nb of nodes = 4755

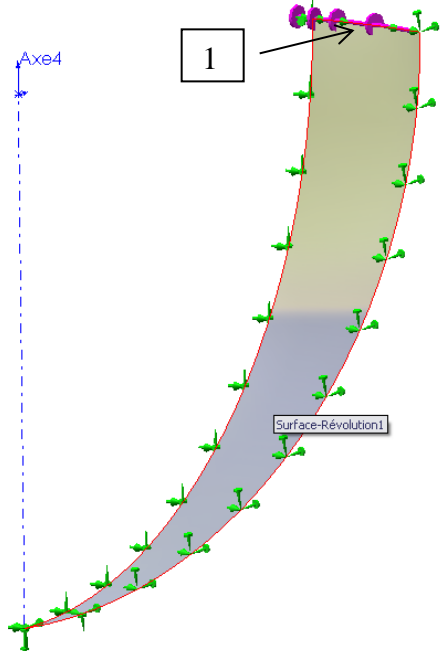
Nb of elements = 2244

Nb of DOF = 28527

Results :

Location	Physical quantity	Reference value	Calculated value	Deviation (%)
Mid-surface	σ_{11} (Pa)	0	8.7	-
On external plane	σ_{22} (Pa)	9.09×10^5	9.07×10^5	0.22
	δR (m)	4.33×10^{-6}	4.33×10^{-6}	0

Comments :

EVALUATION FORM																		
Software: SOLIDWORKS Simulation	Version: 2019 SP2																	
Computer configuration used: Lenovo ThinkPad W540, Windows 10 x64, Intel i7 vPro core, 16Gb RAM, Graphics Card Intel® HD Graphics 4600.																		
Test name: SPHERICAL CAP UNDER MOMENT Codification: SLS 16-89																		
																		
Test performed by : Julien BOISSAT	Date: 3/25/2019																	
Model used Finite elements <input checked="" type="checkbox"/> Boundary elements <input type="checkbox"/> Other <input type="checkbox"/> Element type : SHELL 6 Number of degrees of freedom or mesh density : Nb of nodes = 3130 Nb of elements = 1459 Nb of DOF = 18777																		
Results :																		
<table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="width: 20%;">Location</th> <th style="width: 20%;">Physical quantity</th> <th style="width: 20%;">Reference value</th> <th style="width: 20%;">Calculated value</th> <th style="width: 20%;">Deviation (%)</th> </tr> </thead> <tbody> <tr> <td rowspan="2" style="text-align: center;">Outer edge</td> <td style="text-align: center;">σ_{22} (Pa)</td> <td style="text-align: center;">8.26×10^5</td> <td style="text-align: center;">8.18×10^5</td> <td style="text-align: center;">-0.96</td> </tr> <tr> <td style="text-align: center;">δR (m)</td> <td style="text-align: center;">3.93×10^{-6}</td> <td style="text-align: center;">3.93×10^{-6}</td> <td style="text-align: center;">0</td> </tr> </tbody> </table>					Location	Physical quantity	Reference value	Calculated value	Deviation (%)	Outer edge	σ_{22} (Pa)	8.26×10^5	8.18×10^5	-0.96	δR (m)	3.93×10^{-6}	3.93×10^{-6}	0
Location	Physical quantity	Reference value	Calculated value	Deviation (%)														
Outer edge	σ_{22} (Pa)	8.26×10^5	8.18×10^5	-0.96														
	δR (m)	3.93×10^{-6}	3.93×10^{-6}	0														
Comments : Outer edge <i>corresponds to membrane stress on edge 1.</i>																		

EVALUATION FORM

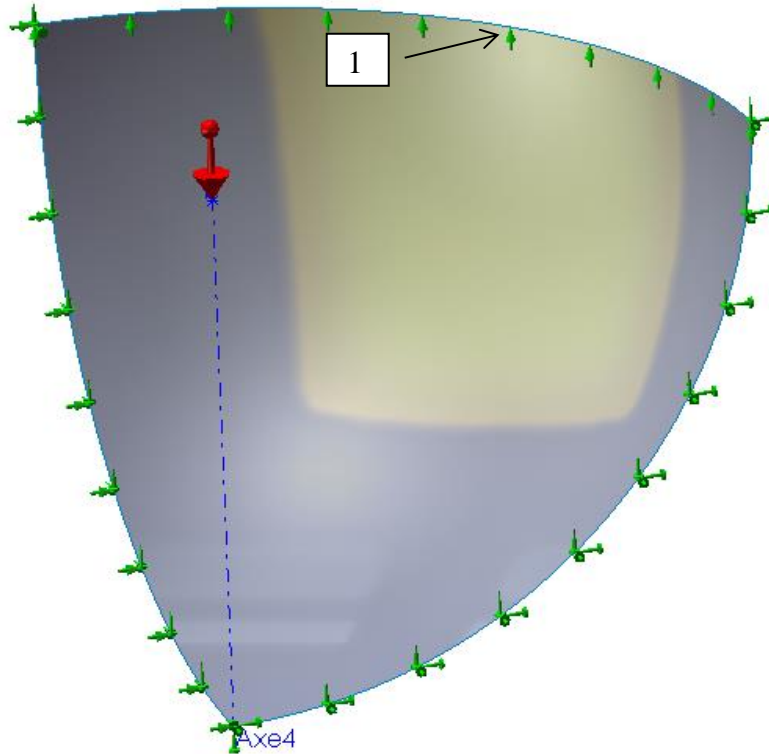
Software: SOLIDWORKS Simulation

Version: 2019 SP2

Computer configuration used: Lenovo ThinkPad W540, Windows 10 x64, Intel i7 vPro core, 16Gb RAM, Graphics Card Intel® HD Graphics 4600.

Test name: SPHERICAL CAP UNDER ITS OWN WEIGHT

Codification: SSLS 17-89



Test performed by : Julien BOISSAT

Date: 3/25/2019

Model used

Finite elements

Boundary elements

Other

Element type : SHELL 6

Number of degrees of freedom or mesh density :

Nb of nodes = 4607

Nb of elements = 2240

Nb of DOF = 27639

Results :

Location	Physical quantity	Reference value	Calculated value	Deviation (%)
$\theta = 90^\circ$	σ_{11} (Pa)	7.85×10^4	7.80×10^4	0.64
	σ_{22} (Pa)	-7.85×10^4	-7.90×10^4	0.64
	δR (m)	4.86×10^{-7}	4.88×10^{-7}	0.41

Comments :

$\theta = 90^\circ$ corresponds to edge 1.

EVALUATION FORM

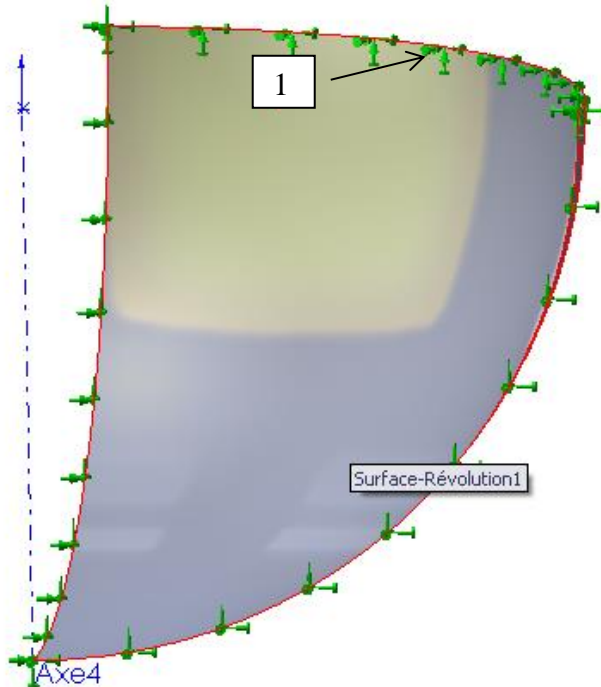
Software: SOLIDWORKS Simulation

Version: 2019 SP2

Computer configuration used: Lenovo ThinkPad W540, Windows 10 x64, Intel i7 vPro core, 16Gb RAM, Graphics Card Intel® HD Graphics 4600.

Test name: SPHERICAL CAP UNDER IMPOSED DISPLACEMENT

Codification: SLS 18-89



Test performed by : Julien BOISSAT

Date: 3/25/2019

Model used

Finite elements

Boundary elements

Other

Element type : SHELL 6

Number of degrees of freedom or mesh density :

Nb of nodes = 4607

Nb of elements = 2240

Nb of DOF = 27378

Results :

Location	Physical quantity	Reference value	Calculated value	Deviation (%)
Mid surface	V_1 (N) per radian	4.62×10^4	4.64×10^4	0.4
	σ_{11} (Pa)	0.0	6.9×10^4 ⁽¹⁾	-
	σ_{22} (Pa)	2.1×10^7	2.1×10^7	0
External plane	σ_{11} (Pa)	3.81×10^7	3.79×10^7	0.79
	σ_{22} (Pa)	3.24×10^7	3.33×10^7	2.78

Comments :

⁽¹⁾ Compared to σ_{22} , σ_{11} is negligible.

Mid surface corresponds to membrane stress on edge 1.

External plane corresponds to bottom stress on edge 1.

EVALUATION FORM

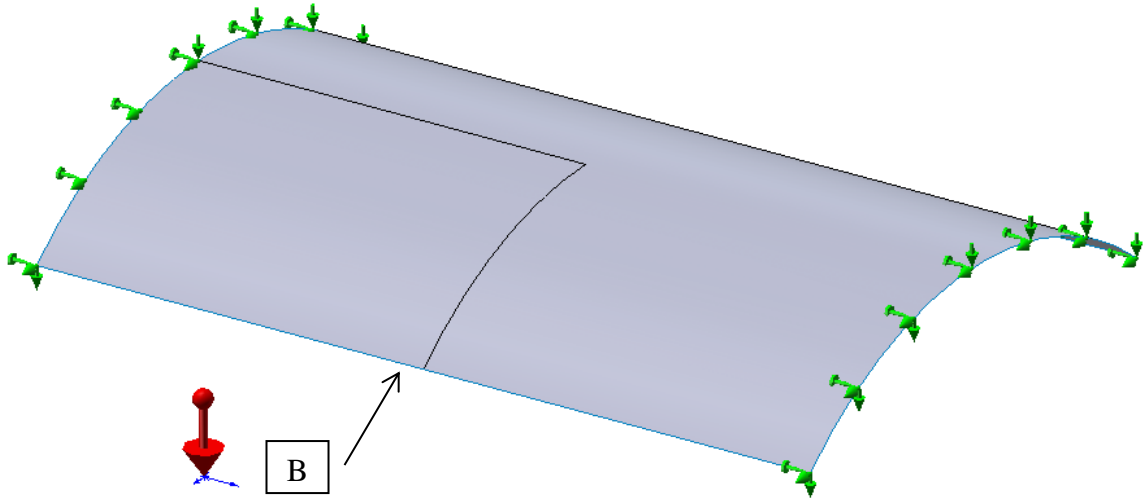
Software: SOLIDWORKS Simulation

Version: 2019 SP2

Computer configuration used: Lenovo ThinkPad W540, Windows 10 x64, Intel i7 vPro core, 16Gb RAM, Graphics Card Intel® HD Graphics 4600.

Test name: CYLINDRICAL SHELL UNDER ITS OWN WEIGHT

Codification: SSLS 19-89



Test performed by : Julien BOISSAT

Date: 3/25/2019

Model used

Finite elements

Boundary elements

Other

Element type : SHELL 6

Number of degrees of freedom or mesh density :

Nb of nodes = 4565

Nb of elements = 2214

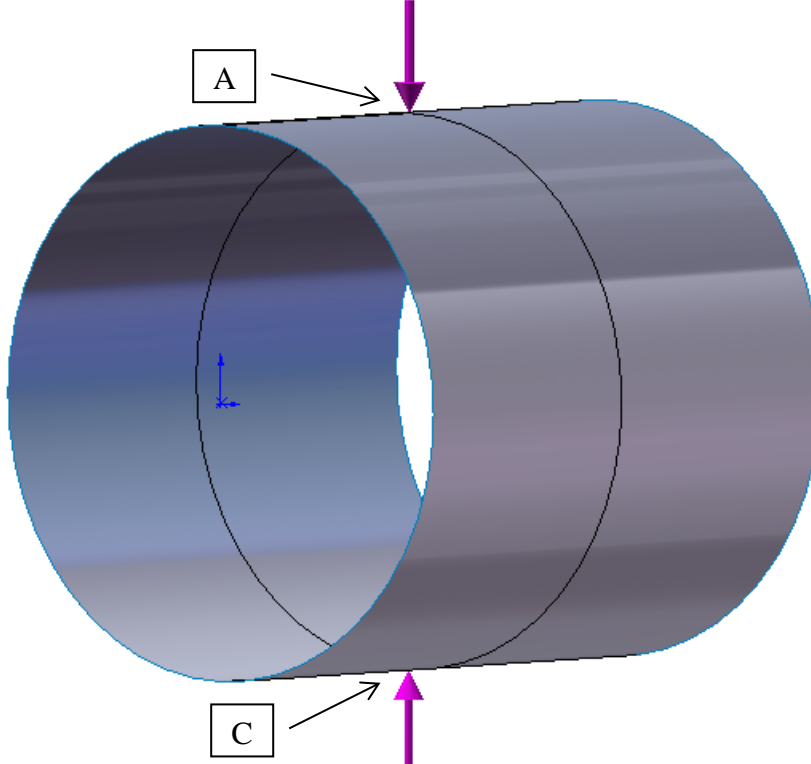
Nb of DOF = 27390

Results :

Location	Physical quantity	Reference value	Calculated value	Deviation (%)
<i>B</i>	w_B (m)	-3.70×10^{-2}	-3.6×10^{-2}	2.78

Comments :

In the Guide, the unit of γ was interpreted as N/m^3 instead of kg/m^3 .

EVALUATION FORM				
Software: SOLIDWORKS Simulation	Version: 2019 SP2			
Computer configuration used: Lenovo ThinkPad W540, Windows 10 x64, Intel i7 vPro core, 16Gb RAM, Graphics Card Intel® HD Graphics 4600.				
Test name: PINCHED CYLINDRICAL SHELL				
Codification: SSLS 20-89				
				
Test performed by : Julien BOISSAT	Date: 3/25/2019			
Model used Finite elements <input checked="" type="checkbox"/> Boundary elements <input type="checkbox"/> Other <input type="checkbox"/> Element type : SHELL 6 Number of degrees of freedom or mesh density : Nb of nodes = 4600 Nb of elements = 2240 Nb of DOF = 27600				
Results :				
Location	Physical quantity	Reference value	Calculated value	Deviation (%)
A	v (m) , displacement in y	-113.9×10^{-3}	-113.7×10^{-3}	0.18
Comments :				

EVALUATION FORM

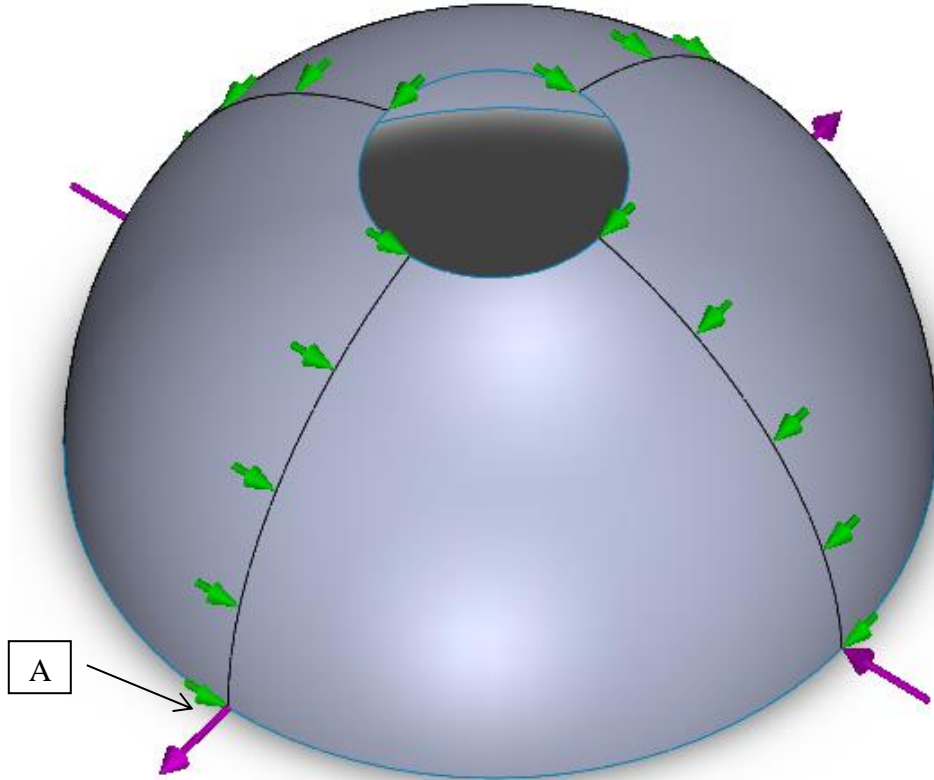
Software: SOLIDWORKS Simulation

Version: 2019 SP2

Computer configuration used: Lenovo ThinkPad W540, Windows 10 x64, Intel i7 vPro core, 16Gb RAM, Graphics Card Intel® HD Graphics 4600.

Test name: SPHERICAL SHELL WITH HOLE

Codification: SSLS 21-89



Test performed by : Julien BOISSAT

Date: 3/25/2019

Model used

Finite elements

Boundary elements

Other

Element type : SHELL 6

Number of degrees of freedom or mesh density :

Nb of nodes = 1188

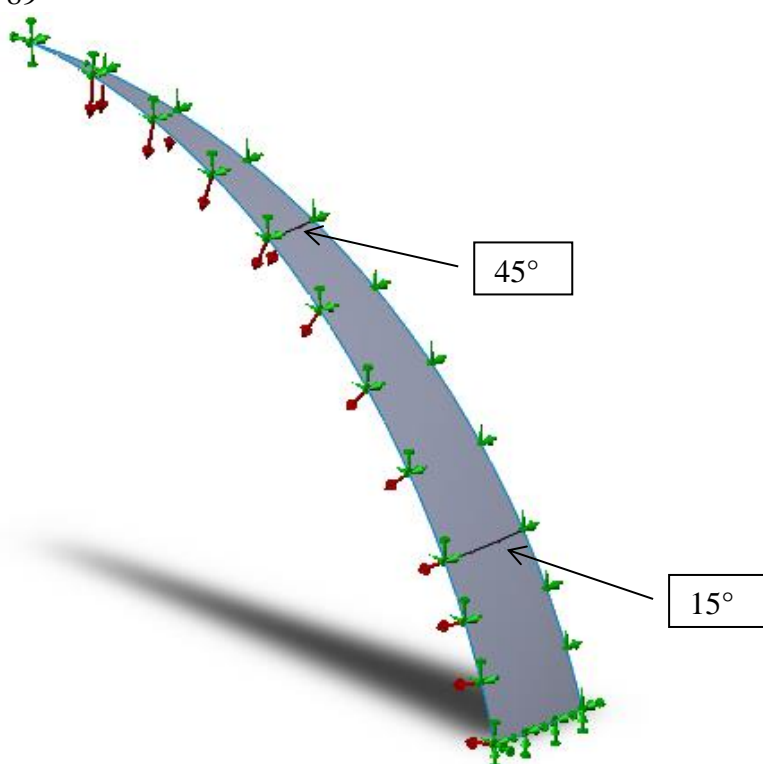
Nb of elements = 564

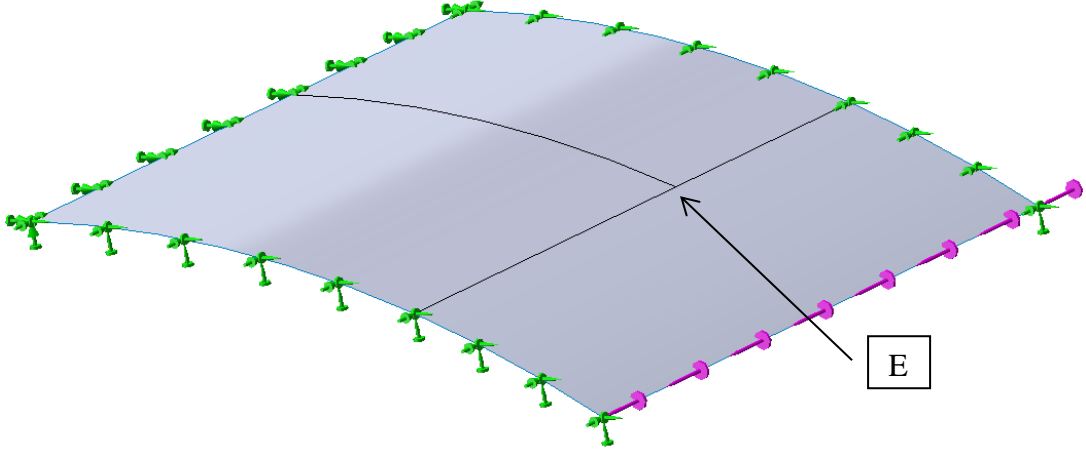
Nb of DOF = 7128

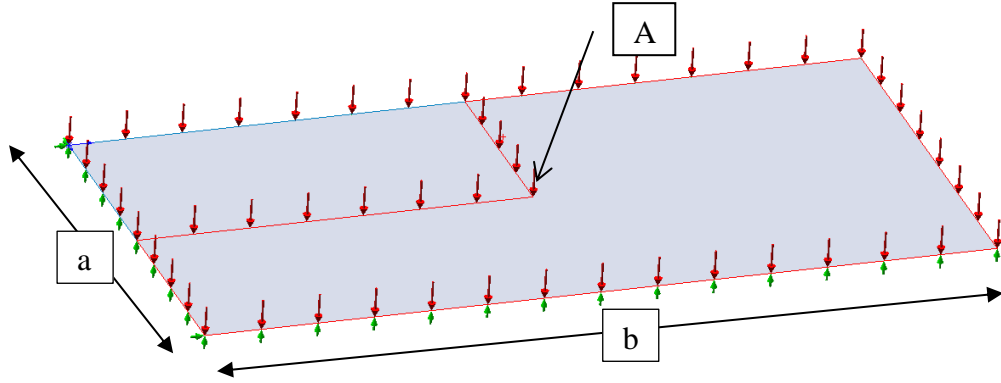
Results :

Location	Physical quantity	Reference value	Calculated value	Deviation (%)
$A(R,0,0)$	u_A (m) , displacement in x	94.0×10^{-3}	96.8×10^{-3}	2.89

Comments :

EVALUATION FORM				
Software: SOLIDWORKS Simulation	Version: 2019 SP2			
Computer configuration used: Lenovo ThinkPad W540, Windows 10 x64, Intel i7 vPro core, 16Gb RAM, Graphics Card Intel® HD Graphics 4600.				
Test name: SPHERICAL CAP UNDER EXTERNAL UNIFORM PRESSURE Codification: SLS 22-89				
				
Test performed by : Julien BOISSAT	Date: 3/25/2019			
Model used Finite elements <input checked="" type="checkbox"/> Boundary elements <input type="checkbox"/> Other <input type="checkbox"/> Element type : SHELL 6 Number of degrees of freedom or mesh density : Nb of nodes = 10347 Nb of elements = 4978 Nb of DOF = 61785				
Results :				
Location	Physical quantity	Reference value	Calculated value	Deviation (%)
$\psi = 15^\circ$	u (m),	-1.73×10^{-3}	-1.76×10^{-3}	1.73
$\psi = 45^\circ$	horizontal	-1.02×10^{-3}	-1.01×10^{-3}	0.99
$\psi = 15^\circ$	σ (Pa), external	-0.74×10^8	-0.69×10^8	7.25
$\psi = 45^\circ$	meridian	-0.68×10^8	-0.69×10^8	1.47
Comments :				

EVALUATION FORM													
Software: SOLIDWORKS Simulation	Version: 2019 SP2												
Computer configuration used: Lenovo ThinkPad W540, Windows 10 x64, Intel i7 vPro core, 16Gb RAM, Graphics Card Intel® HD Graphics 4600.													
Test name: CYLINDRICAL MEMBRANE UNDER BENDING Codification: SSSL 23-89													
													
Test performed by : Julien BOISSAT	Date: 3/25/2019												
Model used Finite elements <input checked="" type="checkbox"/> Boundary elements <input type="checkbox"/> Other <input type="checkbox"/> Element type : SHELL 6 Number of degrees of freedom or mesh density : First and second load Nb of nodes = 4473 Nb of elements = 2168 Nb of DOF = 26436													
Results :													
<table border="1" style="width: 100%; border-collapse: collapse; text-align: center;"> <thead> <tr> <th style="width: 20%;">Location</th> <th style="width: 30%;">Physical quantity</th> <th style="width: 15%;">Reference value</th> <th style="width: 15%;">Calculated value</th> <th style="width: 20%;">Deviation (%)</th> </tr> </thead> <tbody> <tr> <td rowspan="2">Point <i>E</i></td> <td rowspan="2">circumferential stress on external skin (MPa)</td> <td rowspan="2">60</td> <td>59.93</td> <td>-0.12</td> </tr> <tr> <td>59.80</td> <td>-0.33</td> </tr> </tbody> </table>		Location	Physical quantity	Reference value	Calculated value	Deviation (%)	Point <i>E</i>	circumferential stress on external skin (MPa)	60	59.93	-0.12	59.80	-0.33
Location	Physical quantity	Reference value	Calculated value	Deviation (%)									
Point <i>E</i>	circumferential stress on external skin (MPa)	60	59.93	-0.12									
			59.80	-0.33									
Comments :													

EVALUATION FORM				
Software: SOLIDWORKS Simulation	Version: 2019 SP2			
Computer configuration used: Lenovo ThinkPad W540, Windows 10 x64, Intel i7 vPro core, 16Gb RAM, Graphics Card Intel® HD Graphics 4600.				
Test name: SIMPLY SUPPORTED RECTANGULAR PLATE UNDER UNIFORM PRESSURE				
Codification: SSLS 24-89				
				
Test performed by : Julien BOISSAT	Date: 3/25/2019			
Model used				
Finite elements <input checked="" type="checkbox"/> Boundary elements <input type="checkbox"/> Other <input type="checkbox"/>				
Element type : SHELL 6				
Number of degrees of freedom or mesh density :				
<i>b/a</i> = 1	<i>b/a</i> = 2	<i>b/a</i> = 5		
Nb of nodes = 899	Nb of nodes = 1798	Nb of nodes = 4499		
Nb of elements = 418	Nb of elements = 853	Nb of elements = 2158		
Nb of DOF = 5391	Nb of DOF = 10785	Nb of DOF = 26991		
Results :				
Location	Physical quantity ⁽¹⁾	Reference value	Calculated value	Deviation (%)
<i>b/a</i> = 1.0	α (deflection at A)	0.0443	0.0444	0.23
	Bending moment β	0.0479	0.0479	0
	Bending moment β_1	0.0479	0.0479	0
<i>b/a</i> = 2.0	α (deflection at A)	0.1106	0.1106	0
	Bending moment β	0.1017	0.1017	0
	Bending moment β_1	0.0464	0.0463	0.22
<i>b/a</i> = 5.0	α (deflection at A)	0.1415	0.1415	0
	Bending moment β	0.1246	0.1245	0.08
	Bending moment β_1	0.0375	0.0376	0.27
Comments :				
Values α , β and β_1 are calculated from the values of w_{\max} , $\sigma_{x \max}$, $\sigma_{y \max}$ and the following formulas : $w_{\max} = \frac{\alpha pa^4}{Eh^3}$, $M_{x \max} = \beta pa^2$ and $M_{y \max} = \beta_1 pa^2$ and $\sigma_{Flex} = \frac{6M}{h^2}$.				
Practically, $\beta = SX_{\text{Bending}}(\text{Point A}) / 0.06$, $\beta_1 = SY_{\text{Bending}}(\text{Point A}) / 0.06$ and $\alpha = w_{\max} / 10$				
All in SI units.				

EVALUATION FORM

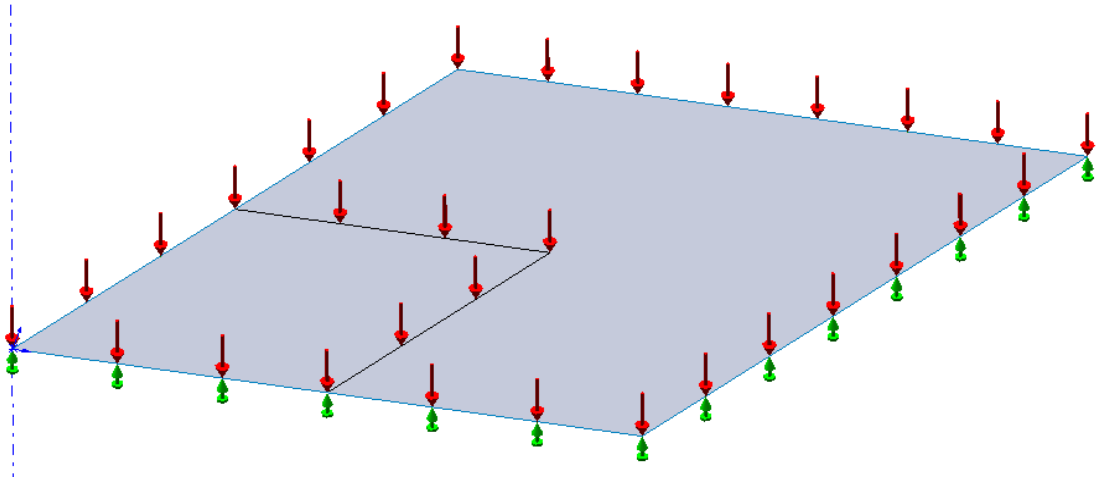
Software: SOLIDWORKS Simulation

Version: 2019 SP2

Computer configuration used: Lenovo ThinkPad W540, Windows 10 x64, Intel i7 vPro core, 16Gb RAM, Graphics Card Intel® HD Graphics 4600.

Test name: SIMPLY SUPPORTED RHOMB PLATE UNDER BENDING

Codification: SSLS 25-89



Test performed by : Julien BOISSAT

Date: 3/25/2019

Model used

Finite elements

Boundary elements

Other

Element type : SHELL 6

Number of degrees of freedom or mesh density :

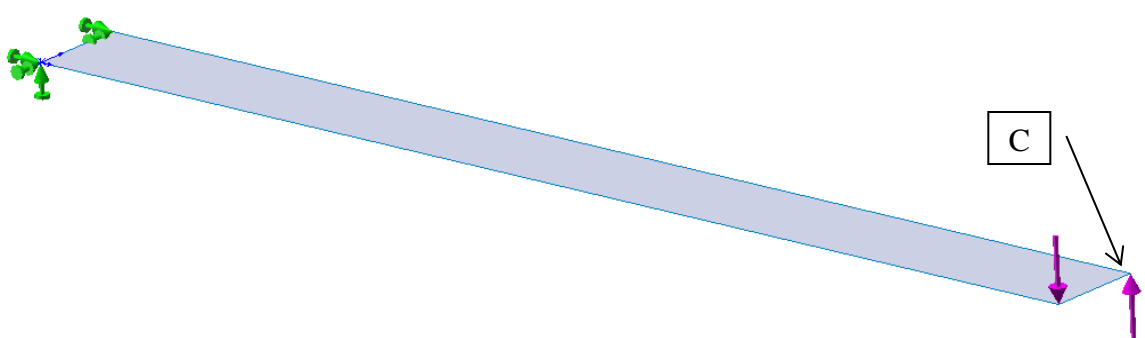
$\alpha = 80^\circ$	$\alpha = 60^\circ$	$\alpha = 40^\circ$	$\alpha = 30^\circ$
N. of nodes = 4657	N. of nodes = 4617	N. of nodes = 4701	N. of nodes = 4729
N. of elements=2260	N. of elements=2236	N. of elements=2266	N. of elements = 2268
N. of DOF = 27942	N. of DOF = 27702	N. of DOF = 28206	N. of DOF = 28374

Results :

Location	Physical quantity	Reference value	Calculated value	Deviation (%)
$\alpha = 80^\circ$	wc (mm)	1.409×10^{-3}	1.408×10^{-3}	-0.07
$\alpha = 60^\circ$		0.9318×10^{-3}	0.9320×10^{-3}	0.021
$\alpha = 40^\circ$		0.3487×10^{-3}	0.3506×10^{-3}	0.545
$\alpha = 30^\circ$		0.1485×10^{-3}	0.1503×10^{-3}	1.212

Comments :

A typo in the guide was corrected: $E = 30 \times 10^6$ Pa instead of 36×10^6

EVALUATION FORM											
Software: SOLIDWORKS Simulation	Version: 2019 SP2										
Computer configuration used: Lenovo ThinkPad W540, Windows 10 x64, Intel i7 vPro core, 16Gb RAM, Graphics Card Intel® HD Graphics 4600.											
Test name: PLATE UNDER NORMAL SHEAR Codification: SSLS 27-89											
											
Test performed by : Julien BOISSAT	Date: 3/25/2019										
Model used Finite elements <input checked="" type="checkbox"/> Boundary elements <input type="checkbox"/> Other <input type="checkbox"/> Element type : SHELL 6 Number of degrees of freedom or mesh density : Nb of nodes = 9663 Nb of elements = 4650 Nb of DOF = 57804											
Results :											
<table border="1" style="width: 100%; border-collapse: collapse; text-align: center;"> <thead> <tr> <th style="width: 15%;">Location</th> <th style="width: 25%;">Physical quantity</th> <th style="width: 20%;">Reference value</th> <th style="width: 20%;">Calculated value</th> <th style="width: 20%;">Deviation (%)</th> </tr> </thead> <tbody> <tr> <td>Point C</td> <td>Displacement w (m)</td> <td>35.37×10^{-3}</td> <td>35.30×10^{-3}</td> <td>-0.23</td> </tr> </tbody> </table>		Location	Physical quantity	Reference value	Calculated value	Deviation (%)	Point C	Displacement w (m)	35.37×10^{-3}	35.30×10^{-3}	-0.23
Location	Physical quantity	Reference value	Calculated value	Deviation (%)							
Point C	Displacement w (m)	35.37×10^{-3}	35.30×10^{-3}	-0.23							
Comments :											

EVALUATION FORM

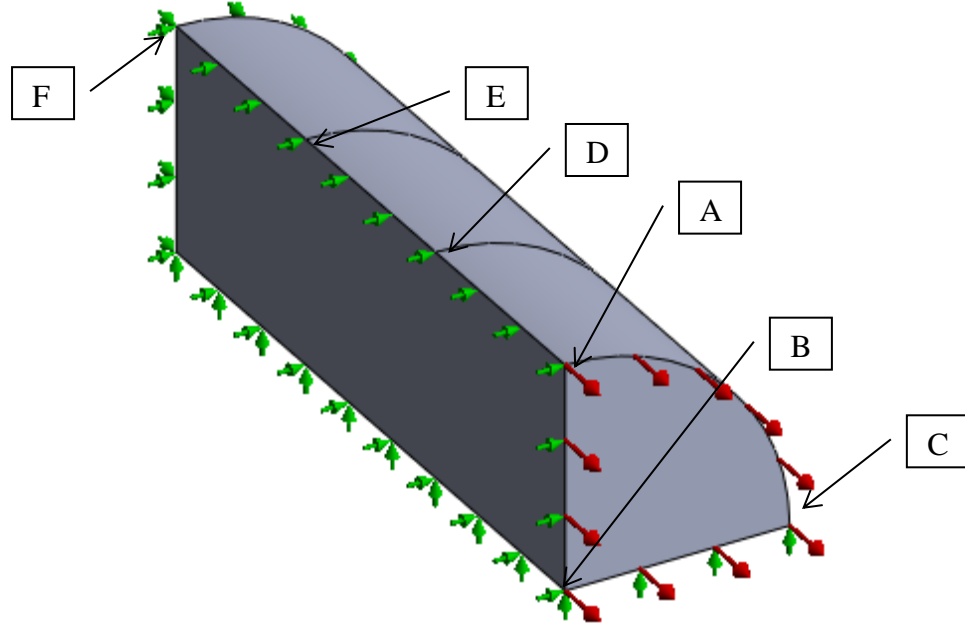
Software: SOLIDWORKS Simulation

Version: 2019 SP2

Computer configuration used: Lenovo ThinkPad W540, Windows 10 x64, Intel i7 vPro core, 16Gb RAM, Graphics Card Intel® HD Graphics 4600.

Test name: FULL CYLINDER UNDER SIMPLE TRACTION

Codification: SSLV 01-89



Test performed by : Julien BOISSAT

Date: 3/25/2019

Model used

Finite elements

Boundary elements

Other

Element type : TETRA 10

Number of degrees of freedom or mesh density :

Nb of nodes = 3188

Nb of elements = 1915

Nb of DOF = 9561

Results :

Location	Physical quantity	Reference value	Calculated value	Deviation (%)
point A	u_A (m)	1.5×10^{-3}	1.5×10^{-3}	0
point B	u_B (m)	1.5×10^{-3}	1.5×10^{-3}	0
point C	u_C (m)	1.5×10^{-3}	1.5×10^{-3}	0
point D	u_D (m)	1×10^{-3}	1×10^{-3}	0
point E	u_E (m)	0.5×10^{-3}	0.5×10^{-3}	0
point A	w_A (m)	-0.15×10^{-3}	-0.15×10^{-3}	0
point D	w_D (m)	-0.15×10^{-3}	-0.15×10^{-3}	0
point E	w_E (m)	-0.15×10^{-3}	-0.15×10^{-3}	0
point F	w_F (m)	-0.15×10^{-3}	-0.15×10^{-3}	0

Comments :

EVALUATION FORM

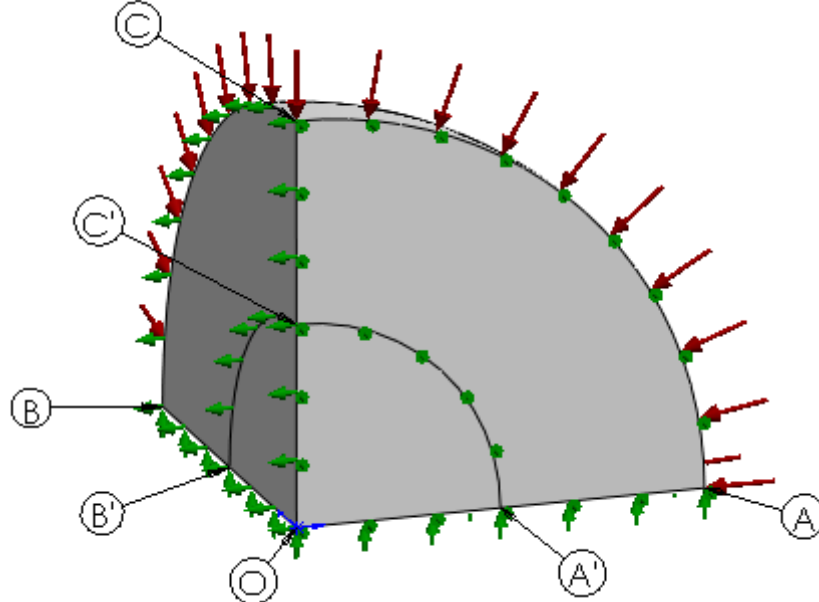
Software: SOLIDWORKS Simulation

Version: 2019 SP2

Computer configuration used: Lenovo ThinkPad W540, Windows 10 x64, Intel i7 vPro core, 16Gb RAM, Graphics Card Intel® HD Graphics 4600.

Test name: FULL SPHERE UNDER UNIFORM PRESSURE

Codification: SSLV 02-89



Test performed by : Julien BOISSAT

Date: 3/25/2019

Model used

Finite elements

Boundary elements

Other

Element type : TETRA 10

Number of degrees of freedom or mesh density :

Nb of nodes = 24086

Nb of elements = 16357

Nb of DOF = 72255

Results :

Location	Physical quantity	Reference value	Calculated value	Deviation (%)
point A	σ_x (MPa)	-100	-100.04	0.04
point B	σ_y (MPa)	-100	-99.77	-0.230
point C	σ_z (MPa)	-100	-100.09	0.090
point A	u_A (m)	-0.2×10^{-3}	-0.2×10^{-3}	0
point B	v_B (m)	-0.2×10^{-3}	-0.2×10^{-3}	0
point C	w_C (m)	-0.2×10^{-3}	-0.2×10^{-3}	0
point A'	σ_x (MPa)	-100	-99.973	-0.03
point B'	σ_y (MPa)	-100	-99.867	-0.133
point C'	σ_z (MPa)	-100	-99.901	-0.099
point A'	$u_{A'}$ (m)	-0.1×10^{-3}	-0.1×10^{-3}	0
point B'	$u_{B'}$ (m)	-0.1×10^{-3}	-0.1×10^{-3}	0
point C'	$u_{C'}$ (m)	-0.1×10^{-3}	-0.1×10^{-3}	0

Comments :

EVALUATION FORM

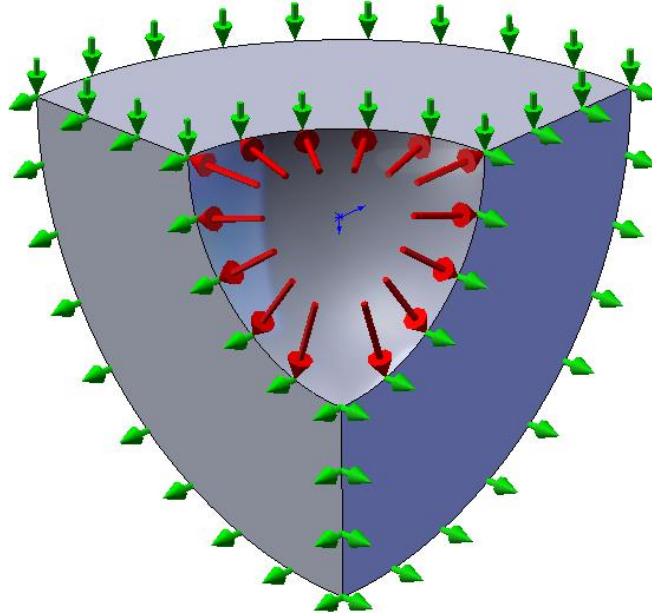
Software: SOLIDWORKS Simulation

Version: 2019 SP2

Computer configuration used: Lenovo ThinkPad W540, Windows 10 x64, Intel i7 vPro core, 16Gb RAM, Graphics Card Intel® HD Graphics 4600.

Test name: THICK SPHERICAL TANK UNDER INTERNAL PRESSURE

Codification: SSLV 03-89



Test performed by : Julien BOISSAT

Date: 3/25/2019

Model used

Finite elements

Boundary elements

Other

Element type : TETRA 10 or SHELLAX

Number of degrees of freedom or mesh density :

TETRA 10

SHELLAX

Nb of nodes = 11265

Nb of nodes = 2605

Nb of elements = 7439

Nb of elements = 1246

Nb of DOF = 33795

Nb of DOF = 5210

Results :

Location	Physical quantity	Reference value	Calculated value		Deviation (%)	
			SHELL 6	SHELLAX	SHELL 6	SHELLAX
Internal edge $r = a$	σ_{rr} (MPa)	-100	-99.082	-99.9	-0.92	-0.10
	$\sigma_{\theta\theta}$ (MPa)	71.43	71.414	71.4	-0.02	-0.04
	u (m)	0.4×10^{-3}	0.4×10^{-3}	0.4×10^{-3}	0	0
External edge $r = b$	σ_{rr} (MPa)	0	0.029	0	-	-
	$\sigma_{\theta\theta}$ (MPa)	21.43	21.429	21.41	0	0.09
	u (m)	1.5×10^{-4}	1.5×10^{-4}	1.5×10^{-4}	0	0

Comments :

EVALUATION FORM

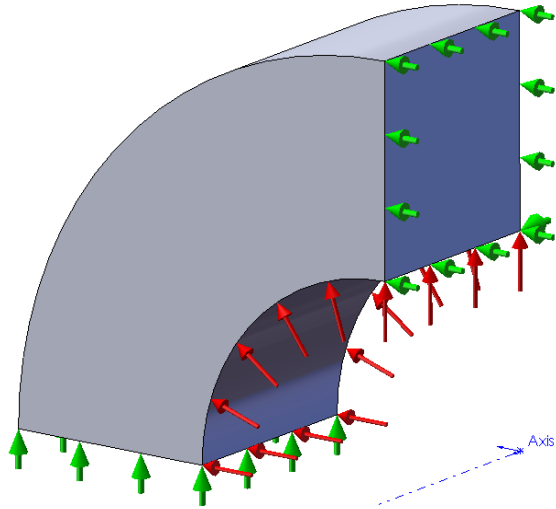
Software: SOLIDWORKS Simulation

Version: 2019 SP2

Computer configuration used: Lenovo ThinkPad W540, Windows 10 x64, Intel i7 vPro core, 16Gb RAM, Graphics Card Intel® HD Graphics 4600.

Test name: THICK INFINITE PIPE UNDER INTERNAL PRESSURE

Codification: SSLV 04-89



Test performed by : Julien BOISSAT

Date: 3/25/2019

Model used

Finite elements

Boundary elements

Other

Element type : TETRA 10 or SHELLAX

Number of degrees of freedom or mesh density :

TETRA 10

SHELLAX

Nb of nodes = 11865

Nb of nodes = 2505

Nb of elements = 7808

Nb of elements = 1202

Nb of DOF = 35595

Nb of DOF = 5010

Results :

Location	Physical quantity	Reference value	Calculated value		Deviation (%)	
			SHELL 6	SHELLAX	SHELL 6	SHELLAX
Internal wall	σ_r (MPa)	-60	-59.71	-59.966	-0.48	-0.06
	σ_θ (MPa)	100	99.96	99.973	-0.04	-0.03
	τ_{max} (MPa)	80	80.28	79.96	0.35	-0.05
	u_r (m)	59×10^{-6}	59×10^{-6}	59×10^{-6}	0	0
External wall	σ_r (MPa)	0	0.02	0.005	-	-
	σ_θ (MPa)	40	40	39.996	0	-0.01
	τ_{max} (MPa)	20	20.04	19.996	0.2	-0.02
	u_r (m)	40×10^{-6}	40×10^{-6}	40×10^{-6}	0	0

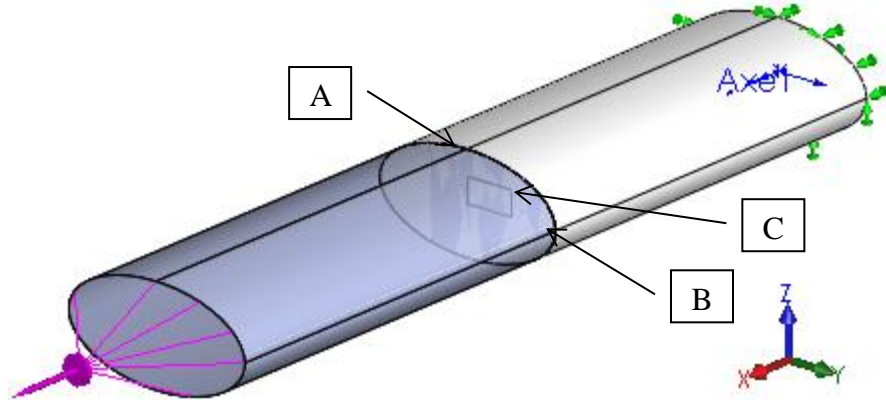
Comments :

EVALUATION FORM

Software: SOLIDWORKS Simulation | Version: 2019 SP2

Computer configuration used: Lenovo ThinkPad W540, Windows 10 x64, Intel i7 vPro core, 16Gb RAM, Graphics Card Intel® HD Graphics 4600.

Test name: BEAM WITH ELLIPTIC CROSS SECTION UNDER TORSION
Codification: SSLV 05-89



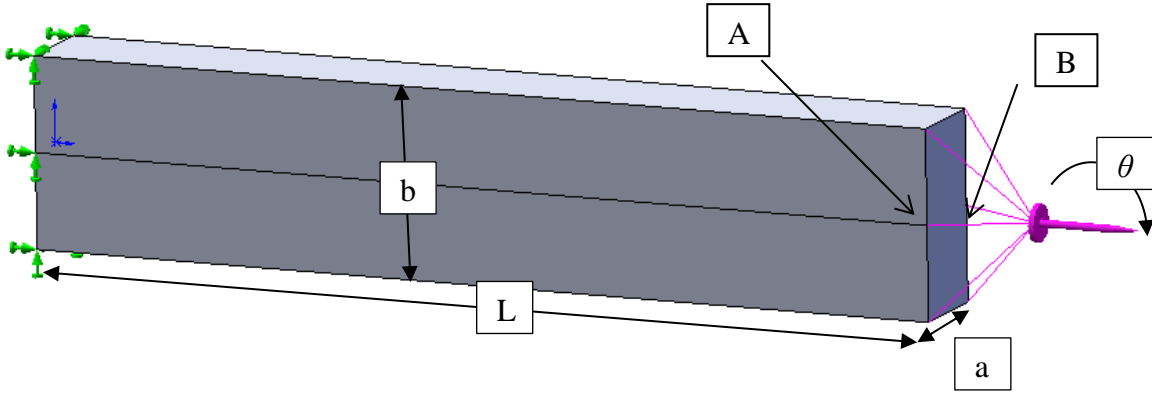
Test performed by : Julien BOISSAT | Date: 3/26/2019

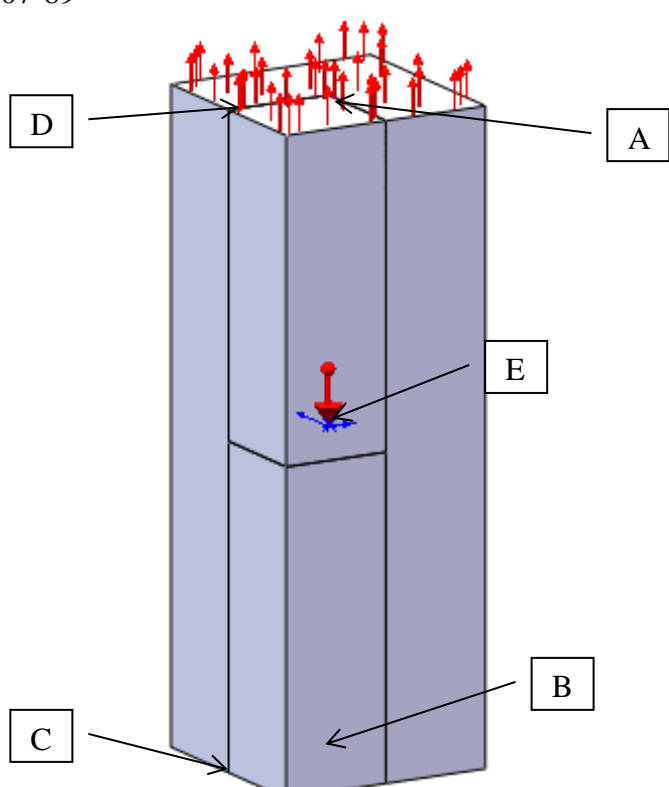
Model used
 Finite elements | Boundary elements | Other
 Element type : TETRA 10
 Number of degrees of freedom or mesh density :
 Nb of nodes = 10467
 Nb of elements = 6604
 Nb of DOF = 30930

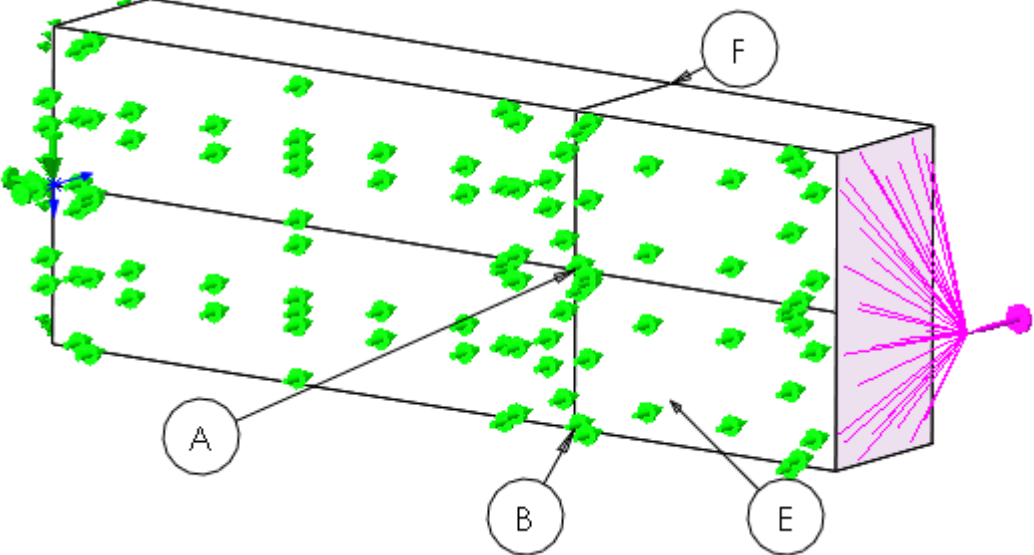
Results :

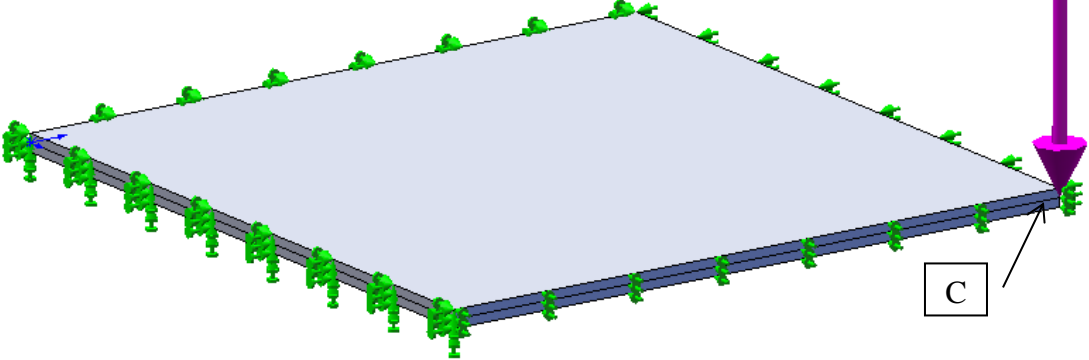
Location	Physical quantity	Reference value	Calculated value	Deviation (%)
Point A	σ_{xy} (MPa)	-39.5	-39.65	0.38
	σ_{xz} (MPa)	0	0	-
	$\sigma_{x\theta}$ (MPa)	39.5	39.65	0.38
	u (m)	0	0	-
	v (m)	-2.57×10^{-3}	-2.49×10^{-3}	-3.11
	w (m)	0	0	-
Point B	σ_{xy} (MPa)	0	0	-
	σ_{xz} (MPa)	19.8	19.73	-0.35
	$\sigma_{x\theta}$ (MPa)	19.8	19.73	-0.35
	u (m)	0	0	-
	v (m)	0	0	-
	w (m)	4.97×10^{-3} (1)	4.98×10^{-3}	0.20
Point C	u (m)	-9.6×10^{-5}	-9.64×10^{-5}	0.42

Comments :
 In order to avoid singularities near the prescribed displacements, results have been obtained with a 16m beam and a measure of the results done at section $x=8m$. It implied the modification of the Reference values using the formulas given in the validation guide.

EVALUATION FORM				
Software: SOLIDWORKS Simulation	Version: 2019 SP2			
Computer configuration used: Lenovo ThinkPad W540, Windows 10 x64, Intel i7 vPro core, 16Gb RAM, Graphics Card Intel® HD Graphics 4600.				
Test name: RECTANGULAR SECTION SHAPE BEAM UNDER TORSION Codification: SSLV 06-89				
				
Test performed by : Julien BOISSAT	Date: 3/27/2019			
Model used Finite elements <input checked="" type="checkbox"/> Boundary elements <input type="checkbox"/> Other <input type="checkbox"/> Element type : TETRA 10 Number of degrees of freedom or mesh density :				
$L = 10 \text{ m}$ Nb of nodes = 12137 Nb of elements = 7628 Nb of DOF = 35952	$L = 20 \text{ m}$ Nb of nodes = 23284 Nb of elements = 14643 Nb of DOF = 69393			
Results :				
Location	Physical quantity	Reference value	Calculated value	Deviation (%)
Points A and B, middle of the long sides				
$L = 10 \text{ m}$	θ/L (rd/m)	2.78×10^{-3}	2.74×10^{-3}	-1.44
	$\sigma_{xy _{\max}}$ (MPa)	$202.6^{(1)}$	202.7	0.05
$L = 20 \text{ m}$	θ/L (rd/m)	2.78×10^{-3}	2.78×10^{-3}	0
	$\sigma_{xy _{\max}}$ (MPa)	$203.7^{(1)}$	202.9	-0.39
Comments : ⁽¹⁾ The calculated $\sigma_{xy _{\max}}$ stress is the value found on the lines of the long sides when far enough from the extremities in order to avoid the singularities. "Roark's Formulas for Stress & Strain" (6 th ed. p.348) gives the following formula for a rectangular beam with a "2a x 2b" section ($a \geq b$) :				
$\text{Max } \tau = \frac{3T}{8ab^2} \left[1 + 0.6095 \frac{b}{a} + 0.8865 \left(\frac{b}{a} \right)^2 - 1.8023 \left(\frac{b}{a} \right)^3 + 0.9100 \left(\frac{b}{a} \right)^4 \right]$ which gives the reference value of 203.7 MPa. This value was used in place of the one prescribed by the validation guide which used one taken from an abacus (less accurate).				

EVALUATION FORM				
Software: SOLIDWORKS Simulation	Version: 2019 SP2			
Computer configuration used: Lenovo ThinkPad W540, Windows 10 x64, Intel i7 vPro core, 16Gb RAM, Graphics Card Intel® HD Graphics 4600.				
Test name: BLOCK STRETCHED UNDER ITS OWN WEIGHT				
Codification: SSLV 07-89				
				
Test performed by : Julien BOISSAT	Date: 3/27/2019			
Model used Finite elements <input checked="" type="checkbox"/> Boundary elements <input type="checkbox"/> Other <input type="checkbox"/> Element type : TETRA 10 Number of degrees of freedom or mesh density : Nb of nodes = 9810 Nb of elements = 6380 Nb of DOF = 29427				
Results :				
Location	Physical quantity	Reference value	Calculated value	Deviati on (%)
Point B	w_B (m)	1.72×10^{-6}	1.72×10^{-6}	0
Point B and C	Δw (m)	0.014×10^{-6}	0.014×10^{-6}	0
Point A and D	Δu (m)	0.17×10^{-6}	0.17×10^{-6}	0
Point A	σ_{zz} (MPa)	0.229	0.229	0
Point E	σ_{zz} (MPa)	0.1145	0.1148	0.26
Comments :				
w_B (m) is measured in $-Z$ direction, and hence is positive				

EVALUATION FORM																															
Software: SOLIDWORKS Simulation	Version: 2019 SP2																														
Computer configuration used: Lenovo ThinkPad W540, Windows 10 x64, Intel i7 vPro core, 16Gb RAM, Graphics Card Intel® HD Graphics 4600.																															
Test name: PRISMATIC BEAM UNDER PURE BENDING Codification: SSLV 08-89																															
																															
Test performed by : Julien BOISSAT	Date: 3/27/2019																														
Model used Finite elements <input checked="" type="checkbox"/> Boundary elements <input type="checkbox"/> Other <input type="checkbox"/> Element type : TETRA 10 Number of degrees of freedom or mesh density : Nb of nodes = 10221 Nb of elements = 6511 Nb of DOF = 30660																															
Results :																															
<table border="1" style="width: 100%; border-collapse: collapse; text-align: center;"> <thead> <tr> <th style="width: 20%;">Location</th> <th style="width: 25%;">Physical quantity</th> <th style="width: 20%;">Reference value</th> <th style="width: 20%;">Calculated value</th> <th style="width: 15%;">Deviation (%)</th> </tr> </thead> <tbody> <tr> <td>Point B⁽¹⁾</td> <td>σ_{zz} (MPa)</td> <td>10</td> <td>10</td> <td>0</td> </tr> <tr> <td>Point A</td> <td>u_A (m)</td> <td>-4×10^{-4}</td> <td>-4×10^{-4}</td> <td>0</td> </tr> <tr> <td>Point B</td> <td>w_B (m)</td> <td>2×10^{-4}</td> <td>2×10^{-4}</td> <td>0</td> </tr> <tr> <td>Point F or G</td> <td>$v_F = -v_G$ (m)</td> <td>0.15×10^{-4}</td> <td>0.15×10^{-4}</td> <td>0</td> </tr> <tr> <td>Point D or E</td> <td>$v_D = -v_E$ (m)</td> <td>-0.15×10^{-4}</td> <td>-0.15×10^{-4}</td> <td>0</td> </tr> </tbody> </table>		Location	Physical quantity	Reference value	Calculated value	Deviation (%)	Point B ⁽¹⁾	σ_{zz} (MPa)	10	10	0	Point A	u_A (m)	-4×10^{-4}	-4×10^{-4}	0	Point B	w_B (m)	2×10^{-4}	2×10^{-4}	0	Point F or G	$v_F = -v_G$ (m)	0.15×10^{-4}	0.15×10^{-4}	0	Point D or E	$v_D = -v_E$ (m)	-0.15×10^{-4}	-0.15×10^{-4}	0
Location	Physical quantity	Reference value	Calculated value	Deviation (%)																											
Point B ⁽¹⁾	σ_{zz} (MPa)	10	10	0																											
Point A	u_A (m)	-4×10^{-4}	-4×10^{-4}	0																											
Point B	w_B (m)	2×10^{-4}	2×10^{-4}	0																											
Point F or G	$v_F = -v_G$ (m)	0.15×10^{-4}	0.15×10^{-4}	0																											
Point D or E	$v_D = -v_E$ (m)	-0.15×10^{-4}	-0.15×10^{-4}	0																											
Comments : (1) Supposed typographic error in the validation guide: it should read "Point B" instead of "Point A" on this location to calculate σ_{zz} (MPa).																															

EVALUATION FORM					
Software: SOLIDWORKS Simulation		Version: 2019 B3			
Computer configuration used: Lenovo ThinkPad W540, Windows 10 x64, Intel i7 vPro core, 16Gb RAM, Graphics Card Intel® HD Graphics 4600.					
Test name: THICK PLATE WITH ITS EDGES FIXED Codification: SSLV 09-89					
					
Test performed by : Julien BOISSAT		Date: 3/27/2019			
Model used Finite elements <input checked="" type="checkbox"/> Boundary elements <input type="checkbox"/> Other <input type="checkbox"/> Element type : TETRA 10 Number of degrees of freedom or mesh density : In both cases, meshing and calculating were done with the default parameters.					
Results :					
Load : Pressure p = 1 MPa					
Location		Physical quantity	Reference value	Calculated value	Deviation (%)
$\lambda = 10$	H20	w_C (m) Note: w_C (m) is measured in $-Z$ direction, and hence is positive	0.76231×10^{-4}	0.7740×10^{-4}	1.17
	Q4		0.78661×10^{-4}		1.96
	Ana.		0.6552×10^{-4}		17.70
$\lambda = 20$	H20		0.53833×10^{-3}	0.5485×10^{-3}	1.72
	Q4		0.55574×10^{-3}		1.46
	Ana.		0.52416×10^{-3}		4.47
$\lambda = 50$	H20		0.80286×10^{-2}	0.8234×10^{-2}	2.43
	Q4		0.8348×10^{-2}		1.49
	Ana.		0.81900×10^{-2}		0.42
$\lambda = 75$	H20		0.26861×10^{-1}	0.2766×10^{-1}	2.75
	Q4		0.28053×10^{-1}		1.61
	Ana.		0.27641×10^{-1}		0.15
$\lambda = 100$	H20	0.63389×10^{-1}	0.6534×10^{-1}	0.53	
	Q4	0.66390×10^{-1}		5.03	
	Ana.	0.65520×10^{-1}		3.77	

Load : Concentrated force $F = 1 \times 10^6$ N

Location		Physical quantity	Reference value	Calculated value ⁽¹⁾	Deviation (%)
$\lambda = 10$	H20	w_C (m) Note: w_C (m) is measured in $-Z$ direction, and hence is positive	0.42995×10^{-3}	0.4261×10^{-3}	2.38
	Q4		0.41087×10^{-3}		2.15
	Ana.		0.29146×10^{-3}		44.00
$\lambda = 20$	H20		0.25352×10^{-2}	0.2606×10^{-2}	2.24
	Q4		0.25946×10^{-2}		0.10
	Ana.		0.23317×10^{-2}		11.16
$\lambda = 50$	H20		0.35738×10^{-1}	0.3700×10^{-1}	3.42
	Q4		0.37454×10^{-1}		1.32
	Ana.		0.36433×10^{-1}		1.45
$\lambda = 75$	H20		0.11837	0.12326	4.16
	Q4		0.12525		1.56
	Ana.		0.12296		0.28
$\lambda = 100$	H20	0.27794	0.2909	4.59	
	Q4	0.29579		1.72	
	Ana.	0.29146		0.26	

Comments :

⁽¹⁾ The values in the above table are the average of the calculated values on the vertical edge (thickness) going through Point C because a concentrated force creates a singularity. The test is clearly a success : it shows plainly the growing deviation between a calculated displacement with a “thin PLATE type” analytical solution and the displacement calculated with the SOLIDWORKS Simulation 3D model when the slenderness ratio decreases.

2. Non linear static

EVALUATION FORM

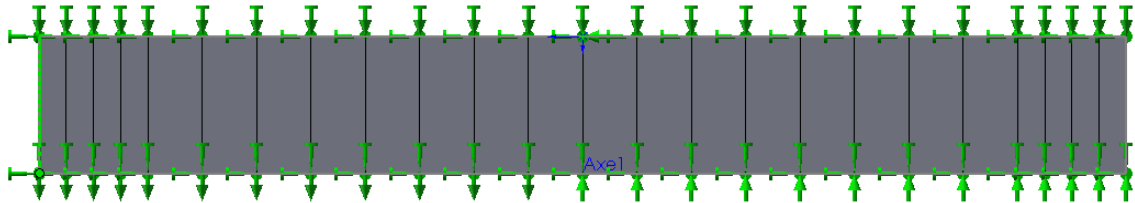
Software: SOLIDWORKS Simulation

Version: 2019 SP2

Computer configuration used: Lenovo ThinkPad W540, Windows 10 x64, Intel i7 vPro core, 16Gb RAM, Graphics Card Intel® HD Graphics 4600.

Test name: RECTANGLE UNDER PURE BENDING (PLANE STRESS, PERFECT PLASTICITY)

Codification: SSNP 11-89



Test performed by : Julien BOISSAT

Date: 3/27/2019

Model used

Finite elements

Boundary elements

Other

Element type :SHELL

Number of degrees of freedom or mesh density :

Nb of nodes = 100

Nb of elements = 144

Nb of DOF = 249

Results :

u_A (mm)	Value type	Reference value	Calculated value	Deviation (%)
0.02875	σ_{xx}^0 (MPa)	483.0	466.3	-3.46
	M_O (N.m)	805.0	789	-2.04
0.05	M	1074	1059	-1.35
0.1	M	1174	1163	-9.78
0.15	M	1193	1182	-2.56
0.2	M	1199	1186	-1.07
0.3	M	1204	1192	-0.96
0.4	M	1205	1193	-1.00
0.5	M	1206	1193	-1.08
↓	σ_{xx}^L	483	- ⁽¹⁾	-
∞	M_L	1207.5	-	-

Comments :

⁽¹⁾ The software cannot create an infinite displacement. Moreover, in order to obtain convergence, a non-zero tangent modulus was used.

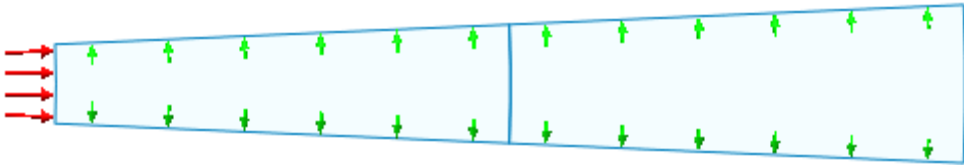
EVALUATION FORM																																														
Software: SOLIDWORKS Simulation	Version: 2019 SP2																																													
Computer configuration used: Lenovo ThinkPad W540, Windows 10 x64, Intel i7 vPro core, 16Gb RAM, Graphics Card Intel® HD Graphics 4600.																																														
Test name: CYLINDER UNDER PRESSURE (PLANE STRAIN, PERFECT ELASTOPLASTICITY) Codification: SSNP 13-89																																														
																																														
Test performed by : Julien BOISSAT	Date: 3/27/2019																																													
Model used Finite elements <input checked="" type="checkbox"/> Boundary elements <input type="checkbox"/> Other <input type="checkbox"/> Element type :PLANE 2D Number of degrees of freedom or mesh density : Nb of nodes = 2706 Nb of elements = 1237 Nb of DOF = 7836																																														
Results :																																														
<table border="1" style="width: 100%; border-collapse: collapse; text-align: center;"> <thead> <tr> <th style="width: 15%;">Pressure p (MPa)</th> <th style="width: 15%;">Radius r (mm)</th> <th style="width: 20%;">Physical quantity (MPa)</th> <th style="width: 15%;">Reference value</th> <th style="width: 15%;">Calculated value</th> <th style="width: 20%;">Deviation (%)</th> </tr> </thead> <tbody> <tr> <td rowspan="6">100 (elasticity)</td> <td>1</td> <td rowspan="3">σ_r</td> <td>-100</td> <td>-99.33</td> <td>0.67</td> </tr> <tr> <td>1.5</td> <td>-25.93</td> <td>-25.96</td> <td>0.11</td> </tr> <tr> <td>2</td> <td>0</td> <td>0.03</td> <td>-</td> </tr> <tr> <td>1</td> <td rowspan="3">σ_θ</td> <td>166.7</td> <td>165.98</td> <td>0.43</td> </tr> <tr> <td>1.5</td> <td>92.59</td> <td>92.68</td> <td>0.10</td> </tr> <tr> <td>2</td> <td>66.7</td> <td>66.77</td> <td>0.10</td> </tr> <tr> <td>Starts yielding</td> <td></td> <td>p_y</td> <td>129.68</td> <td>131</td> <td>1.02</td> </tr> <tr> <td>Complete yield</td> <td></td> <td>p_{lim}</td> <td>240.11</td> <td>239.99</td> <td>-0.39</td> </tr> </tbody> </table>		Pressure p (MPa)	Radius r (mm)	Physical quantity (MPa)	Reference value	Calculated value	Deviation (%)	100 (elasticity)	1	σ_r	-100	-99.33	0.67	1.5	-25.93	-25.96	0.11	2	0	0.03	-	1	σ_θ	166.7	165.98	0.43	1.5	92.59	92.68	0.10	2	66.7	66.77	0.10	Starts yielding		p_y	129.68	131	1.02	Complete yield		p_{lim}	240.11	239.99	-0.39
Pressure p (MPa)	Radius r (mm)	Physical quantity (MPa)	Reference value	Calculated value	Deviation (%)																																									
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	1	σ_θ	166.7	165.98	0.43																																									
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	2		66.7	66.77	0.10																																									
Starts yielding		p_y	129.68	131	1.02																																									
Complete yield		p_{lim}	240.11	239.99	-0.39																																									

Fig1: Tube starts yielding on inner face
 Plot type: Nonlinear nodal stress Onset of Yielding

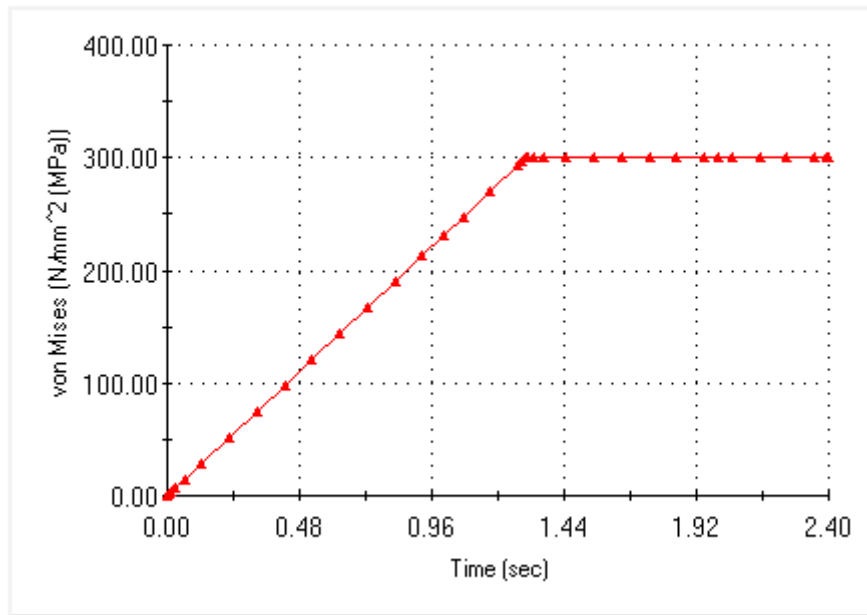
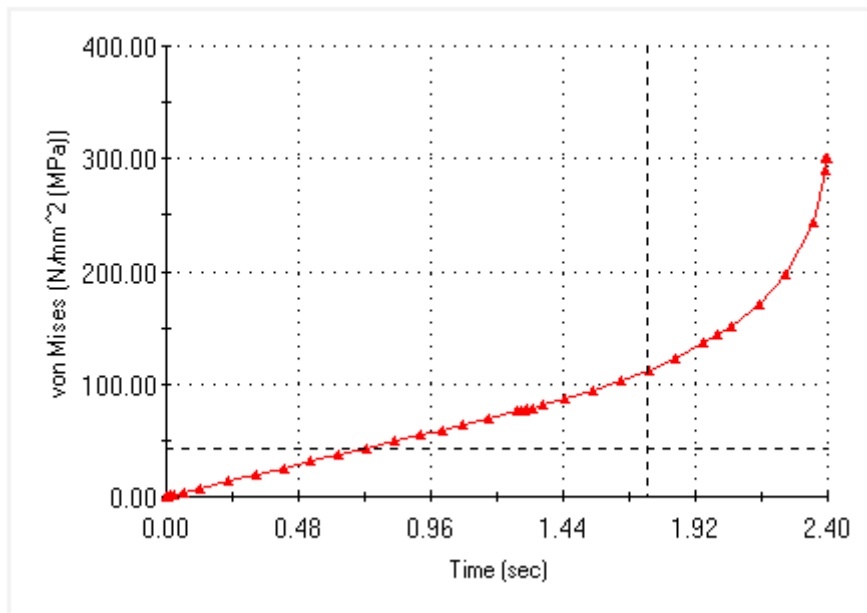
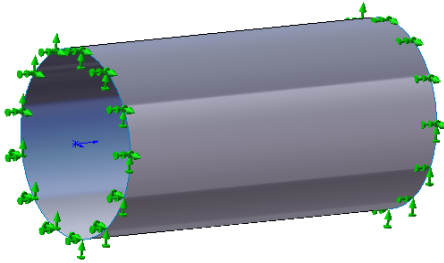


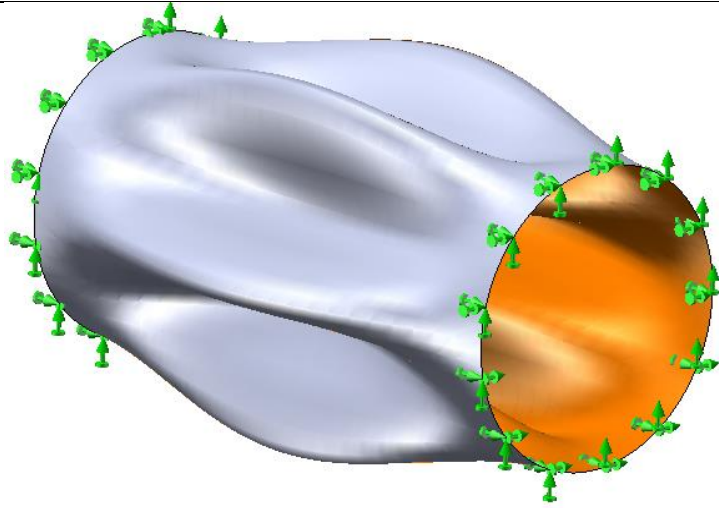
Fig2: Tube finishes yielding on outer face
 Plot type: Nonlinear nodal stress Complete yield



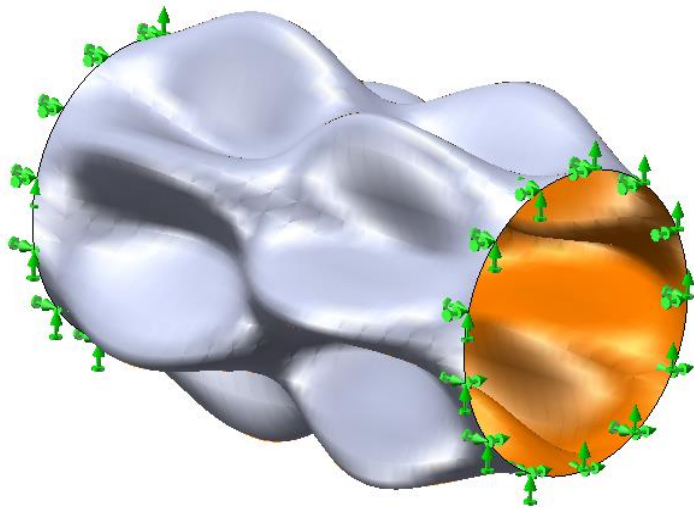
Comments :

3. Linear dynamic

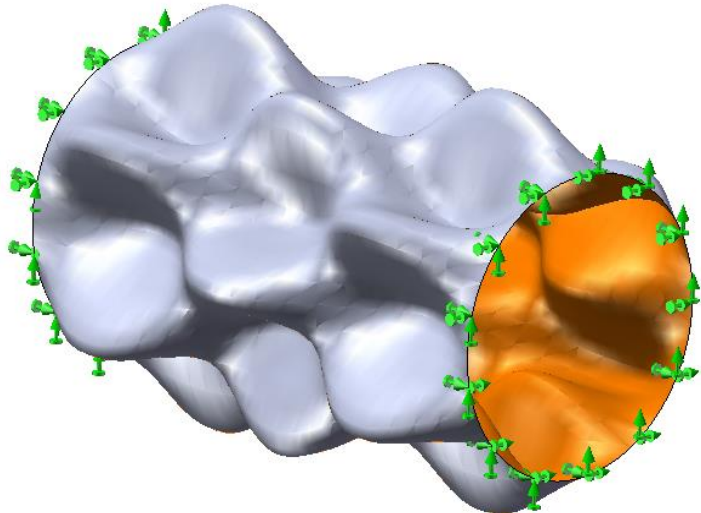
EVALUATION FORM								
Software: SOLIDWORKS Simulation				Version: 2019 SP2				
Computer configuration used: Lenovo ThinkPad W540, Windows 10 x64, Intel i7 vPro core, 16Gb RAM, Graphics Card Intel® HD Graphics 4600.								
Test name: THIN CYLINDER FIXED ON BOTH ENDS Codification: SDLA 01-89								
								
Test performed by : Julien BOISSAT				Date: 3/27/2019				
Model used Finite elements <input checked="" type="checkbox"/> Boundary elements <input type="checkbox"/> Other <input type="checkbox"/> Element type : SHELL 6 Number of degrees of freedom or mesh density : Nb of nodes = 4464 Nb of elements = 2190 Nb of DOF = 25776								
Results : Reference values								
Frequency (Hz)		<i>n</i> = 2	4	6	8	10	12	14
<i>m</i> = 1	<i>E</i>	-	700	525	720	1095	1559	2118
	<i>C</i>	1925.5	771.1	538.5	719.6	1081.8	1549.7	2108.5
	<i>S</i>	2772	880	568	742	1104	1573	2132
2	<i>E</i>	-	1620	980	900	1140	-	-
	<i>C</i>	3929.0	1775.8	1041.5	922.3	1165.6	1595.4	2140.9
	<i>S</i>	5251	2088	1121	952	1189	1620	2167
3	<i>E</i>	-	-	1650	1350	1325	1711	2225
	<i>C</i>	5892.7	2968.0	1764.9	1323.4	1361.3	1698.7	2207.5
	<i>S</i>	6997	3441	1915	1368	1383	1720	2233
Calculated values (Hz)		<i>n</i> = 2	4	6	8	10	12	14
<i>m</i> = 1	Result	1921.8	766.3	534.6	717.4	1079.4	1545	2099.1
	Deviation(%)	0.19	0.63	0.71	0.31	0.22	0.30	0.45
2	Result	3914.4	1760.5	1025.9	910.5	1157	1586.5	2127.4
	Deviation(%)	0.38	0.87	1.50	1.30	0.74	0.57	0.63
3	Result	5859	2934	1730	1292.1	1336.7	1677.2	2185.2
	Deviation(%)	0.58	1.16	2.00	2.41	1.84	1.28	1.02



$m = 1, n = 6$



$m = 2, n = 6$



$m = 3, n = 6$

Comments :

The deviation was calculated checking the results of SOLIDWORKS Simulation against the results « average of the 2 codes » (marked as “C” in the table).

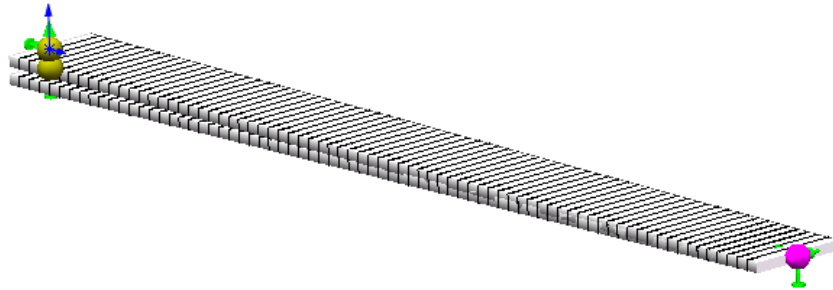
EVALUATION FORM

Software: SOLIDWORKS Simulation

Version: 2019 SP2

Computer configuration used: Lenovo ThinkPad W540, Windows 10 x64, Intel i7 vPro core, 16Gb RAM, Graphics Card Intel® HD Graphics 4600.

Test name: SLENDER FOLDED BEAM, ONE END FIXED THE OTHER FREE
 Codification: SDLL 02-89



Test performed by : Julien BOISSAT

Date: 3/27/2019

Model used

Finite elements

Boundary elements

Other

Element type : BEAM

Number of degrees of freedom or mesh density :

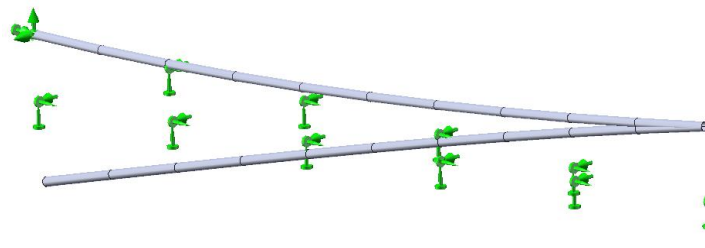
Nb of nodes = 151

Nb of elements = 150

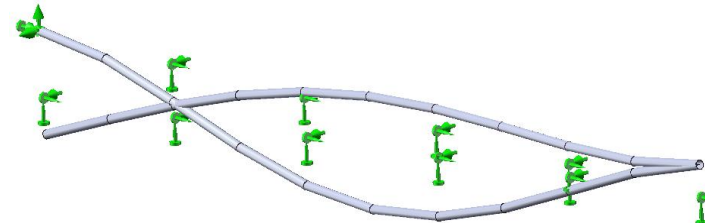
Nb of DOF = 888

Results :

Nature of the vibration mode		Frequency (Hertz)		Deviation (%)
<i>i</i>	Order	Reference value	Calculated value	
1	1,2	11.76	11.725	2.73
2	3,4	105.88	103.98	1.53
3	5,6	294.10	294.41	-0.38
4	7,8	576.44	565.32	-2.96



Order 2



Order 4

Comments :

The model was made with an arbitrary angle of 1° for the fold as it wasn't specified in the test description.

Using respectively the average frequency of modes (1,2), (3,4), (5,6) and (7,8).

EVALUATION FORM

Software: SOLIDWORKS Simulation

Version: 2019 SP2

Computer configuration used: Lenovo ThinkPad W540, Windows 10 x64, Intel i7 vPro core, 16Gb RAM, Graphics Card Intel® HD Graphics 4600.

Test name: SLENDER BEAM ON TWO SIMPLE SUPPORTS UNDER AXIAL FORCE
Codification: SDLL 05-89



Test performed by : Julien BOISSAT

Date: 3/27/2019

Model used

Finite elements

Boundary elements

Other

Element type : BEAM

Number of degrees of freedom or mesh density :

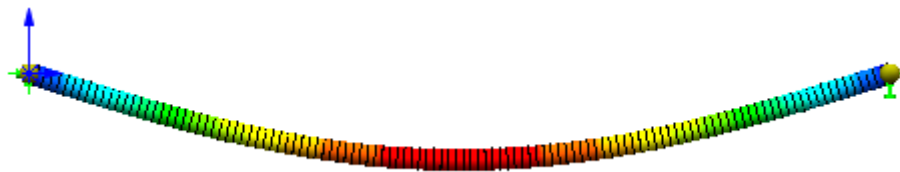
Nb of nodes = 119

Nb of elements = 117

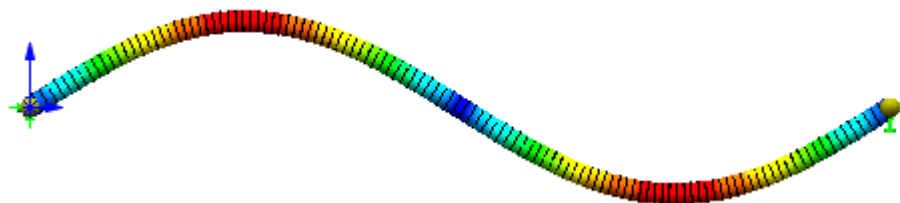
Nb of DOF = 705

Results :

Nature of the vibration mode		Frequency (Hertz)		Deviation (%)
		Reference	Calculated	
$ F_x = 0$	Bending 1	28.702	28.69	0.04
	Bending 2	114.807	114.57	0.21
$ F_x = 10^5 \text{N}$	Bending 1	22.434	22.422	0.05
	Bending 2	109.080	108.85	0.21



$|F_x| = 0 \text{ N}$, Bending 1



$|F_x| = 10^5 \text{ N}$, Bending 2

Comments :

EVALUATION FORM

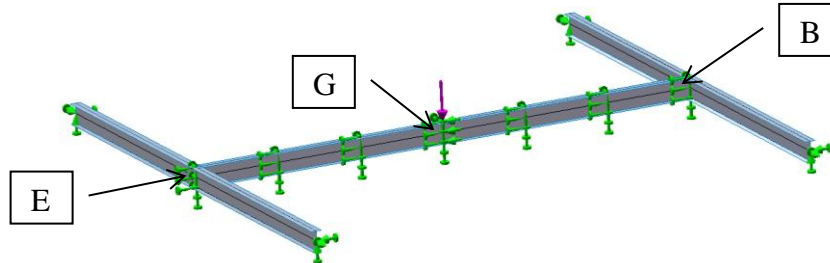
Software: SOLIDWORKS Simulation

Version: 2019 SP2

Computer configuration used: Lenovo ThinkPad W540, Windows 10 x64, Intel i7 vPro core, 16Gb RAM, Graphics Card Intel® HD Graphics 4600.

Test name: PLANAR FRAME MADE OF I BEAMS

Codification: SDLL 08-89



Test performed by : Julien BOISSAT

Date: 3/28/2019

Model used

Finite elements

Boundary elements

Other

Element type : SHELL

Number of degrees of freedom or mesh density :

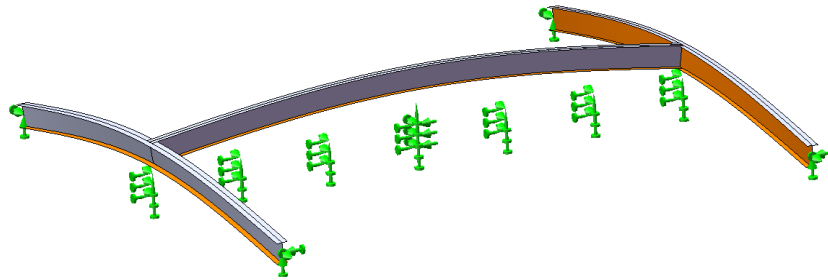
Nb of nodes = 5473

Nb of elements = 2524

Nb of DOF = 63486 **32814**

Results :

Order of the vibration mode	Frequency (Hertz)		Vibration mode w_B / w_G		Deviation (%)	
	Reference	Calculated	Reference	Calculated	Frequency	w_B / w_G
1	16.456	16.466	1.213	1.16	0.08	4.35
2	38.165	37.159	-0.412	-0.422	2.64	2.54



Mode 1

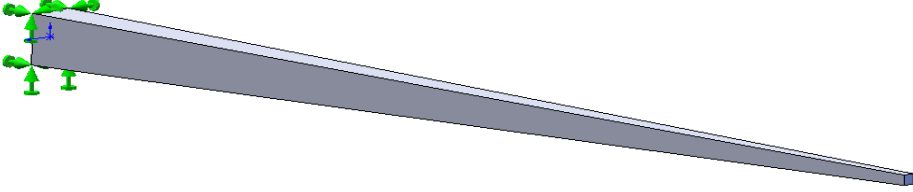
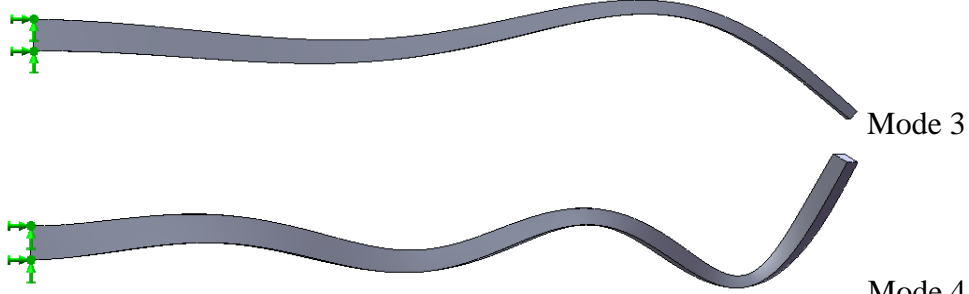
Dynamic response :

Point	Value type (m)	Values		Deviation (%)
		Reference	Calculated	
<i>B, E</i>	w_B max	-9.8×10^{-2}	-1.02×10^{-1}	3.92
<i>G</i>	w_G max	-12.5×10^{-2}	-12.4×10^{-2}	0.81
<i>G</i>	$w_B + w_G$ max	-2.27×10^{-1}	-2.26×10^{-1}	0.44

Comments :

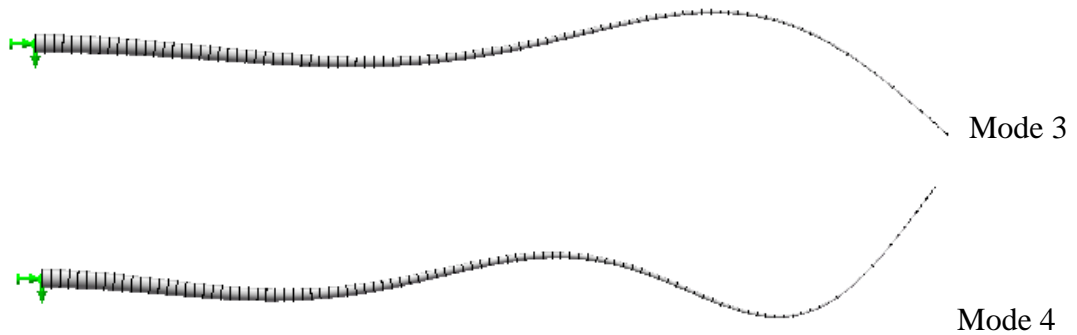
w_B is the deflection of the lateral beam at its center.

w_G is the deflection of the central beam at its center. Therefore $w_G =$ vertical displacement of point G $- w_B$

EVALUATION FORM							
Software: SOLIDWORKS Simulation				Version: 2019 SP2			
Computer configuration used: Lenovo ThinkStation S20, Windows 7 x64, Intel Xeon W3565, 12Gb RAM, graphics card NVIDIA Quadro 2000.							
Test name: SLENDER BEAM WITH VARIABLE RECTANGULAR SECTION, ONE END FIXED THE OTHER FREE							
Codification: SDLL 09-89							
							
Test performed by : Julien BOISSAT				Date: 3/28/2019			
Model used Finite elements <input checked="" type="checkbox"/> Boundary elements <input type="checkbox"/> Other <input type="checkbox"/> Element type : TETRA10 and BEAM Number of degrees of freedom or mesh density :							
TETRA10				BEAM			
$\beta = 4$							
Nb of nodes		= 11686		Nb of nodes		= 201	
Nb of elements		= 6691		Nb of elements		= 100	
Nb of DOF		= 34743		Nb of DOF		= 600	
$\beta = 5$							
Nb of nodes		= 13362		Nb of nodes		= 201	
Nb of elements		= 7980		Nb of elements		= 100	
Nb of DOF		= 39717		Nb of DOF		= 600	
Results :							
TETRA10 elements:							
Nature of the vibration mode	Frequency (Hertz) $\beta = 4$		Frequency (Hertz) $\beta = 5$		Deviation (%)		
	Reference	Calculated	Reference	Calculated	$\beta = 4$	$\beta = 5$	
Bending	1	54.18	54.19	56.55	56.56	0.02	0.02
	2	171.94	171.56	175.79	175.43	-0.22	-0.20
	3	384.40	381.97	389.01	386.57	-0.63	-0.63
	4	697.24	688.61	702.36	693.67	-1.24	-1.24
	5	1112.28	1090.1	1117.63	1095.5	-1.99	-1.98
							

BEAM elements:

Nature of the vibration mode		Frequency (Hertz) $\beta = 4$		Frequency (Hertz) $\beta = 5$		Deviation (%)	
		Reference	Calculated	Reference	Calculated	$\beta = 4$	$\beta = 5$
Bending	1	54.18	54.21	56.55	56.57	0.06	0.04
	2	171.94	171.93	175.79	175.76	-0.01	-0.02
	3	384.40	383.76	389.01	388.17	-0.17	-0.22
	4	697.24	694.11	702.36	698.49	-0.45	-0.55
	5	1112.28	1103.1	1117.63	1106.7	-0.83	-0.98



Comments :

EVALUATION FORM

Software: SOLIDWORKS Simulation | Version: 2019 PR1

Computer configuration used: Lenovo ThinkStation S20, Windows 7 x64, Intel Xeon W3565, 12Gb RAM, graphics card NVIDIA Quadro 2000.

Test name: SLENDER BEAM WITH VARIABLE RECTANGULAR SECTION, BOTH ENDS FIXED
 Codification: SDLL 10-89

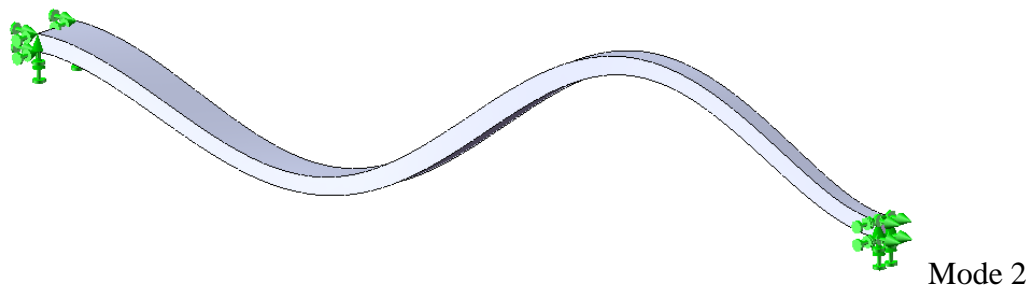
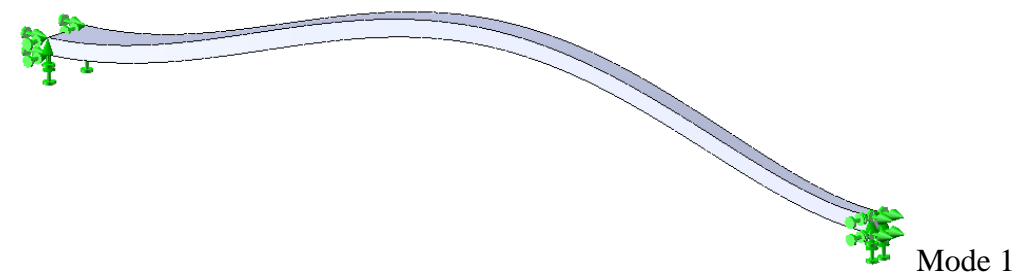


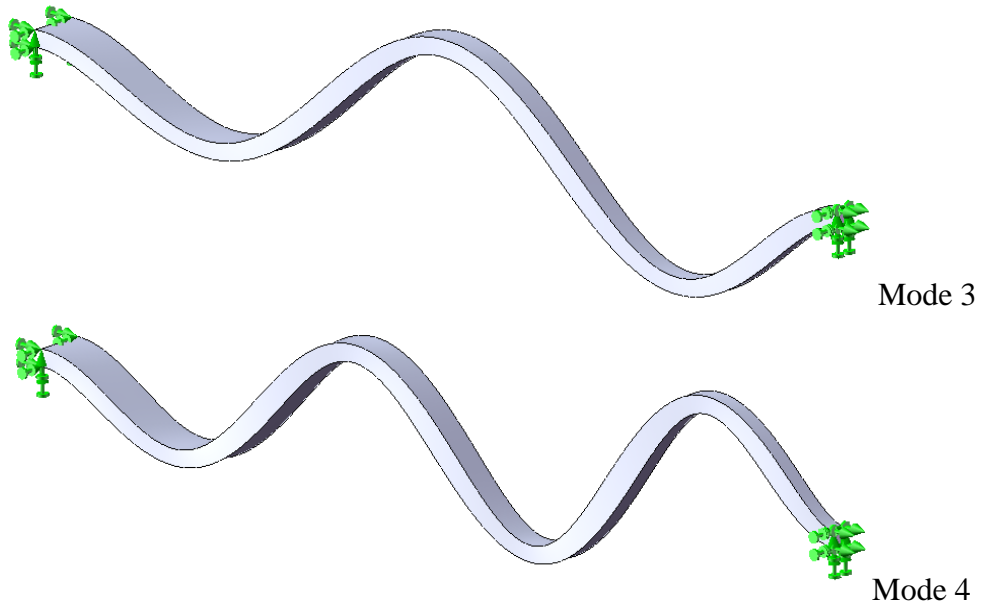
Test performed by : Julien BOISSAT | Date: 3/29/2019

Model used
 Finite elements Boundary elements Other
 Element type : TETRA10 and BEAM
 Number of degrees of freedom or mesh density :
 TETRA10 BEAM
 Nb of nodes = 15051 Nb of nodes = 541
 Nb of elements = 8761 Nb of elements = 270
 Nb of DOF = 44817 Nb of DOF = 1614

Results :

Vibration mode	Frequency of reference (Hz)	Frequency Calculated (Hz)		Deviation (%)	
		TETRA10	BEAM	TETRA10	BEAM
1	143.303	146.13	145.85	1.97	1.78
2	396.821	399.8	399.37	0.75	0.64
3	779.425	779.61	779.34	0.02	0.01
4	1289.577	1282.2	1282.5	0.57	0.55

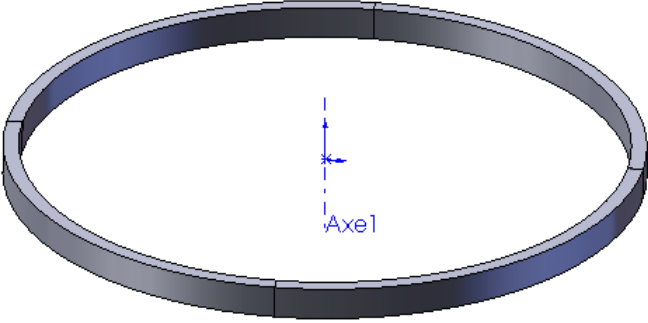
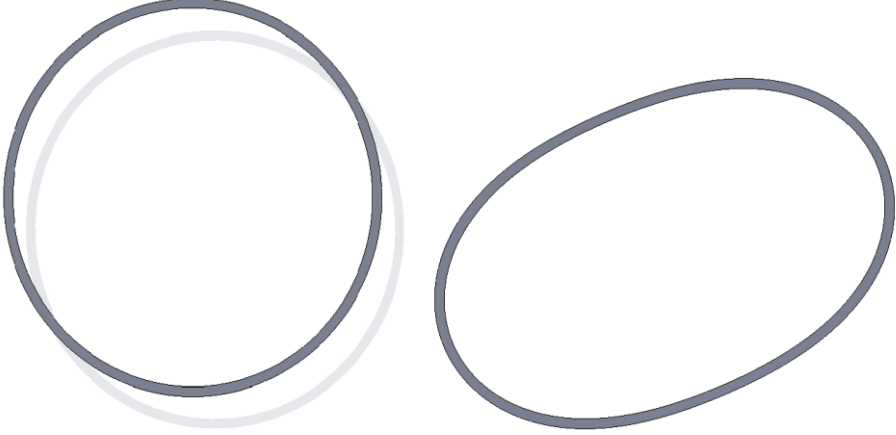


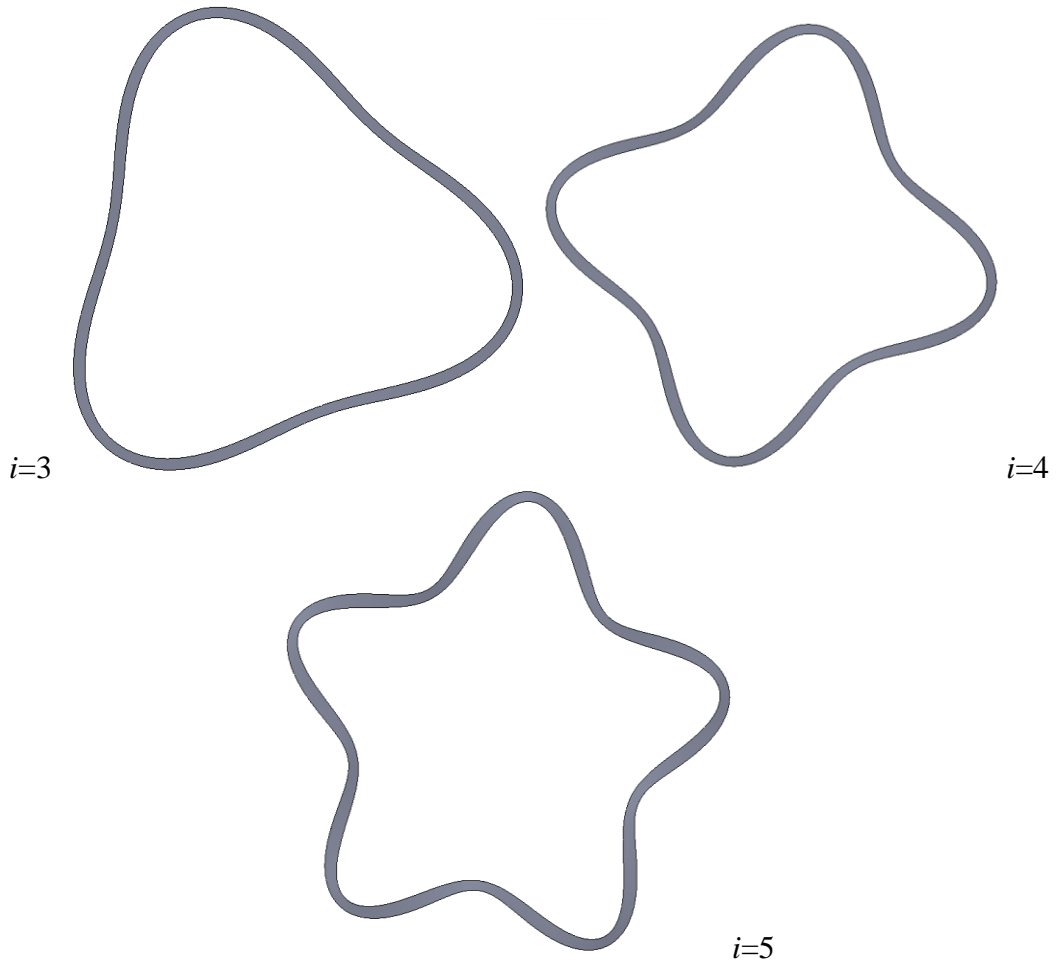


Order of the vibration mode		Vibration mode $\varphi_i(x)$						
		$x = 0.$	0.1	0.2	0.3	0.4	0.5	0.6
1	Reference	0	0.237	0.703	1	0.859	0.354	0
	TETRA10	0	0.236	0.703	1.000	0.861	0.356	0
	Deviation(%)	0	0.27	0.03	0.00	0.21	0.60	0
	BEAM	0	0.240	0.708	1.000	0.857	0.354	0
	Deviation(%)	-	1.24	0.67	0.00	0.24	0.01	-
2	Reference	0	-0.504	-0.818	0	1	0.752	0
	TETRA10	0	-0.503	-0.822	-0.004	1.000	0.755	0
	Deviation(%)	0	0.14	0.48	-	0.00	0.38	0
	BEAM	0	-0.506	-0.814	0.012	1.000	0.748	0
	Deviation(%)	-	0.47	0.48	-	0.00	0.58	-
3	Reference	0	0.67	0.21	-0.831	0.257	1	0
	TETRA10	0	0.669	0.214	-0.831	0.252	1.000	0
	Deviation(%)	0	0.14	1.71	0.01	1.84	0.00	0
	BEAM	0	0.674	0.194	-0.834	0.271	1.000	0
	Deviation(%)	-	0.65	7.57	0.33	5.42	0.00	-
4	Reference	0	-0.67	0.486	0	-0.594	1	0
	TETRA10	0	-0.674	0.486	0.005	-0.598	1.000	0
	Deviation(%)	0	0.52	0.02	-	0.61	0.00	0
	BEAM	0	-0.668	0.502	-0.026	-0.579	1.000	0
	Deviation(%)	-	0.28	3.32	-	2.54	0.00	-

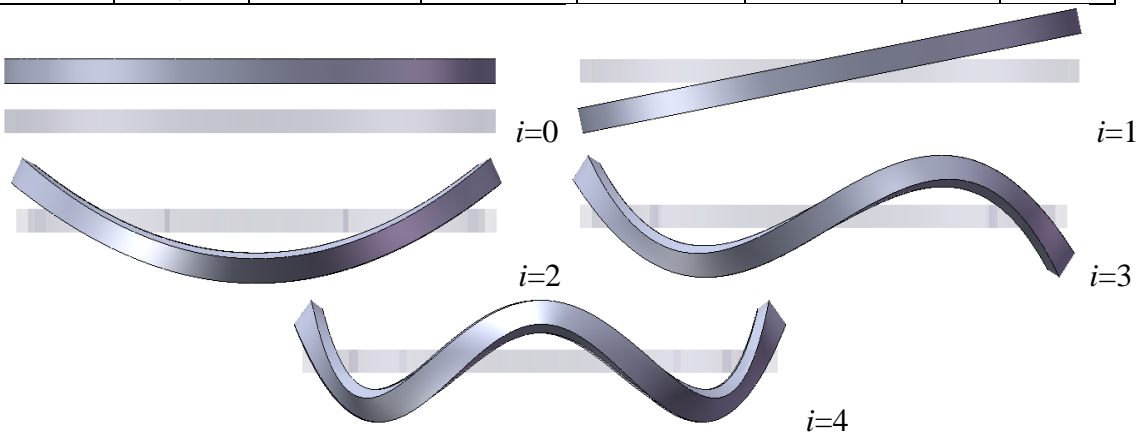
Comments :

$\varphi_i(x)$ is the value of the lateral displacement of the mode shape (normalized so that the value is 1 at the location of the max lateral displacement), at x . x is the distance along the beam length taken from the large cross section.

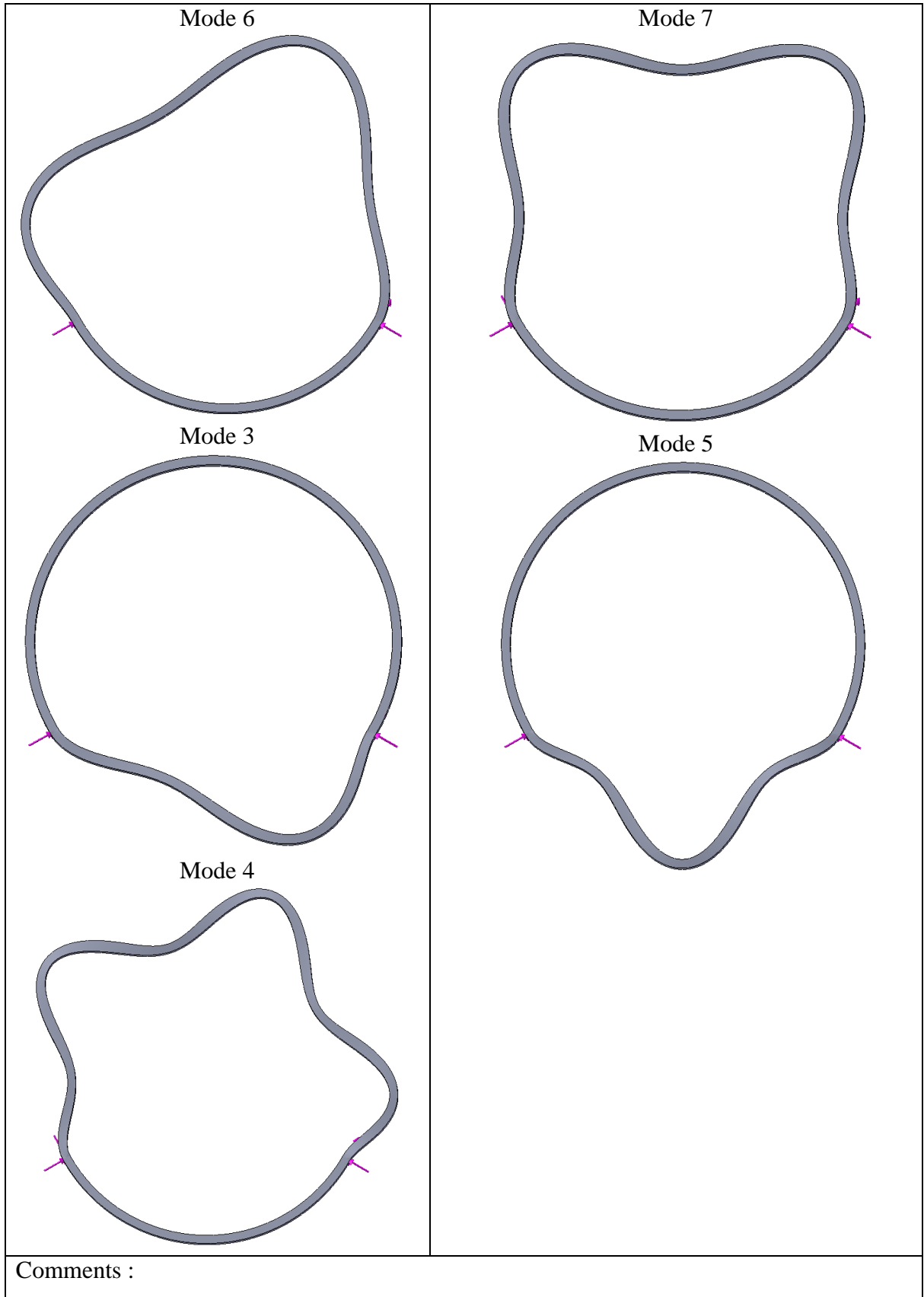
EVALUATION FORM							
Software: SOLIDWORKS Simulation				Version: 2019 SP2			
Computer configuration used: Lenovo ThinkStation S20, Windows 7 x64, Intel Xeon W3565, 12Gb RAM, graphics card NVIDIA Quadro 2000.							
Test name: THIN CIRCULAR RING COMPLETELY FREE Codification: SDLL 11-89							
							
Test performed by : Julien BOISSAT				Date: 3/29/2019			
Model used Finite elements <input checked="" type="checkbox"/> Boundary elements <input type="checkbox"/> Other <input type="checkbox"/> Element type : TETRA10 and BEAM Number of degrees of freedom or mesh density :							
Solid elements: Nb of nodes = 13955 Nb of elements = 7401 Nb of DOF = 41865				Beam elements Nb of nodes = 400 Nb of elements = 200 Nb of DOF = 1200			
Results :							
In plane							
Nature of the vibration mode		Frequency (Hz)				Deviation (%)	
		Reference value		Calculated value			
<i>i</i>	Order			Solid	Beam	Solid	Beam
0,1	1,2,3	0.	0	0	0	-	-
2	4,5	318.38	319.15	317.99	319.15	0.12	0.24
3	6,7	900.46	900.49	897.7	900.49	0.31	0.00
4	8,9	1726.55	1720.4	1716.6	1720.4	0.58	0.36
5	10,11	2792.21	2769.6	2766.4	2769.6	0.92	0.81
							
<i>i</i> =1				<i>i</i> =2			

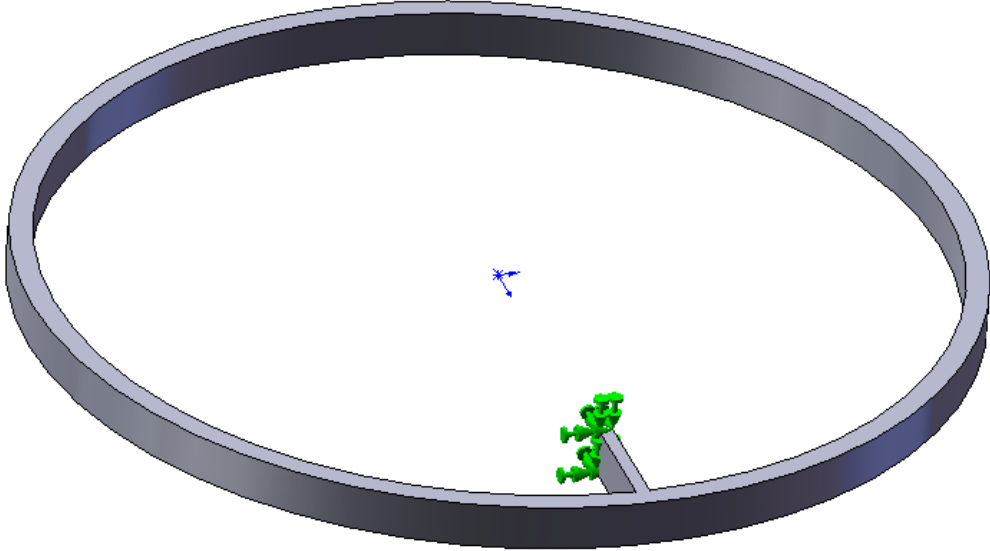


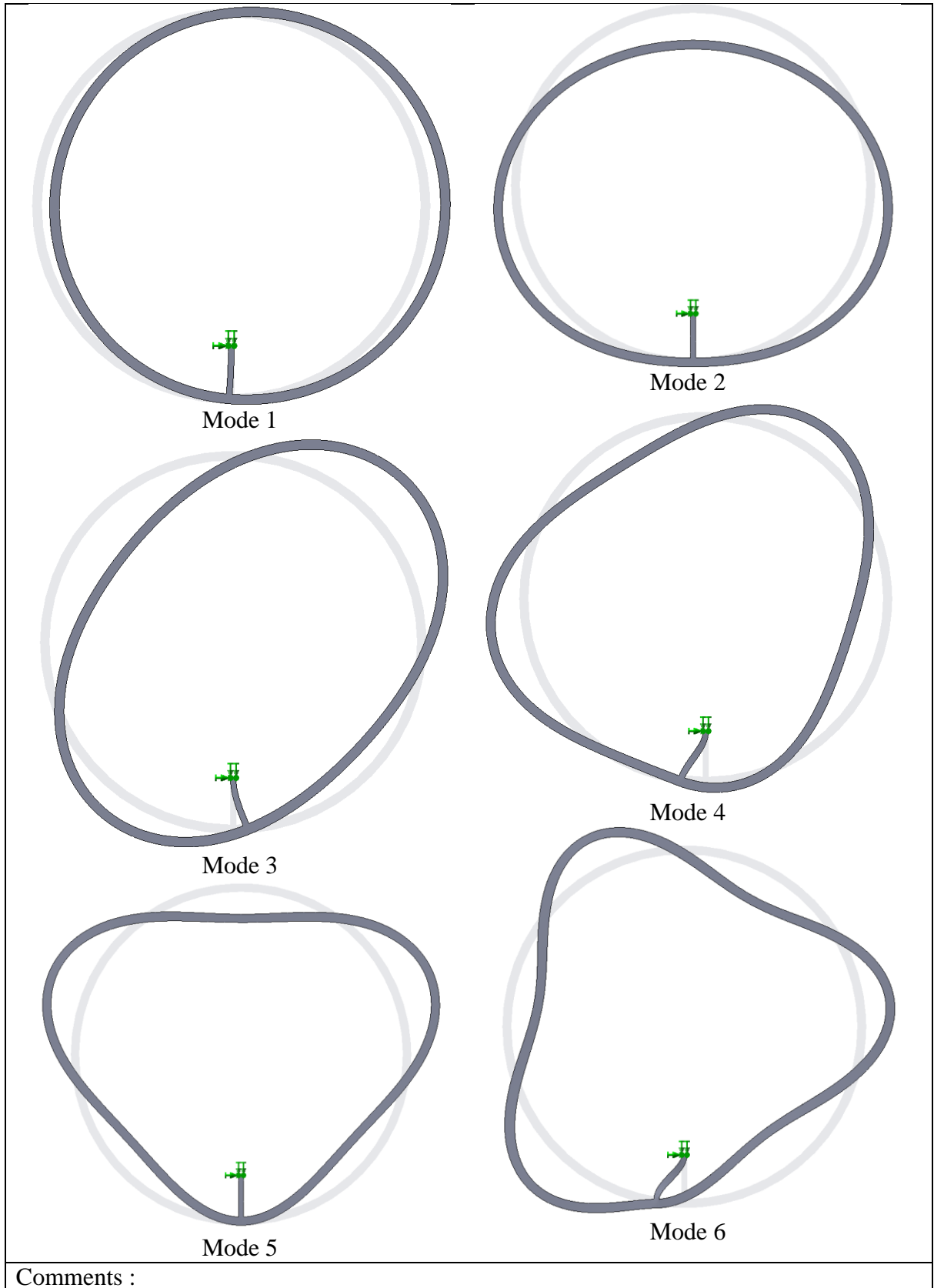
Out of plane							
Nature of the vibration mode		Frequency (Hz)				Deviation (%)	
<i>i</i>	Order	Reference value		Calculated value		Solid	Beam
				Solid	Beam		
0,1	1,2,3	0	0	0	0	-	-
2	4,5	510	508.5	510	508.6	0.20	0.47
3	6,7	1572	1577.5	1572	1577.6	1.13	0.78
4	8,9	3116	3150.8	3116	3151	2.14	1.04

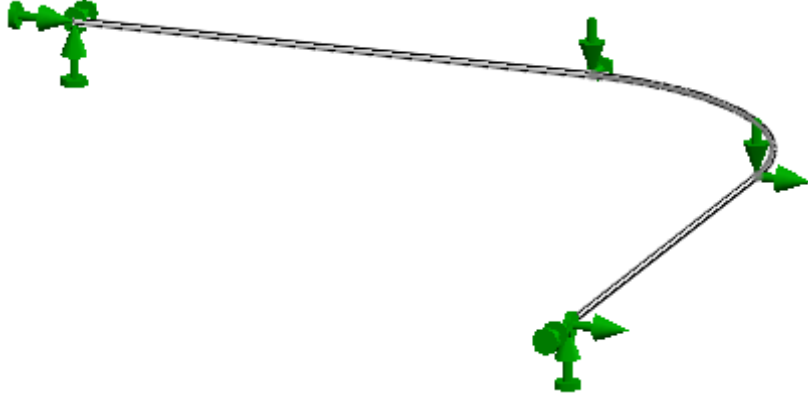


Comments :



EVALUATION FORM					
Software: SOLIDWORKS Simulation			Version: 2019 SP2		
Computer configuration used: Lenovo ThinkStation S20, Windows 7 x64, Intel Xeon W3565, 12Gb RAM, graphics card NVIDIA Quadro 2000.					
Test name: THIN CIRCULAR RING FIXED BY AN ELASTIC LEG Codification: SDLL 13-89					
					
Test performed by : Julien BOISSAT			Date: 3/29/2019		
Model used Finite elements <input checked="" type="checkbox"/> Boundary elements <input type="checkbox"/> Other <input type="checkbox"/> Element type : TETRA10 Number of degrees of freedom or mesh density :					
Solid elements Nb of nodes = 15149 Nb of elements = 8174 Nb of DOF = 45366			Shell elements Nb of nodes = 8672 Nb of elements = 3830 Nb of DOF = 51990		
Results :					
Nature of the vibration mode	Frequency (Hz)			Deviation (%)	
	Reference value	Calculated value		Solid	Shell
		Solid	Shell		
1 anti	28.8	30.0	29.9	4.00	3.82
2 sym	189.3	189.8	190.1	0.26	0.42
3 anti	268.8	268.7	269	0.04	0.07
4 anti	641.0	660.0	655.1	2.88	2.20
5 sym	682.0	681.8	683.2	0.03	0.18
6 anti	1063.0	1100	1092.2	3.48	2.75

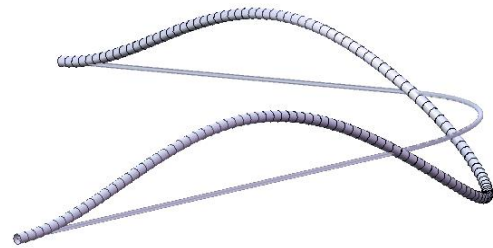
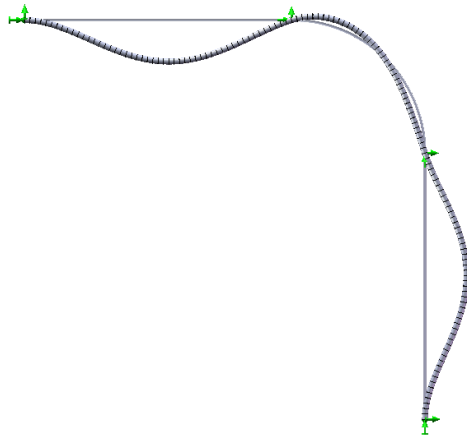


EVALUATION FORM				
Software: SOLIDWORKS Simulation	Version: 2019 SP2			
Computer configuration used: Lenovo ThinkStation S20, Windows 7 x64, Intel Xeon W3565, 12Gb RAM, graphics card NVIDIA Quadro 2000.				
Test name: VIBRATION MODES OF AN ELBOWED PIPE Codification: SDLL 14-89				
				
Test performed by : Julien BOISSAT		Date: 3/29/2019		
Model used				
Finite elements <input checked="" type="checkbox"/> Boundary elements <input type="checkbox"/> Other <input type="checkbox"/>				
Element type : BEAMS				
Number of degrees of freedom or mesh density :				
<i>l</i> = 0 m	<i>l</i> = 0.6 m	<i>l</i> = 2 m		
Nb of nodes = 561	Nb of nodes = 659	Nb of nodes = 829		
Nb of elements = 280	Nb of elements = 416	Nb of elements = 646		
Nb of DOF = 1674	Nb of DOF = 2490	Nb of DOF = 3870		
Results :				
Nature of the vibration mode	Frequency (Hz)		Deviation (%)	
	Reference	Calculated		
<i>l</i> = 0 m	Out of plane 1	44.23	44.13	0.23
	In plane 1	119	119.52	0.44
	Out of plane 2	125	125.9	0.72
	In plane 2	227	226.07	0.41
<i>l</i> = 0.6 m	Out of plane 1	33.4	33.21	0.57
	In plane 1	94	94.07	0.07
	Out of plane 2	100	98.8	1.20
	In plane 2	180	182.73	1.52
<i>l</i> = 2 m	Out of plane 1	17.9	17.65	1.40
	In plane 1	24.8	24.43	1.49
	Out of plane 2	25.3	24.94	1.42
	In plane 2	27	26.73	1.00

Modes for $l = 2$ m

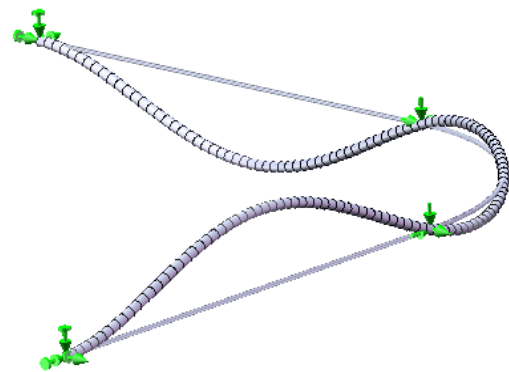
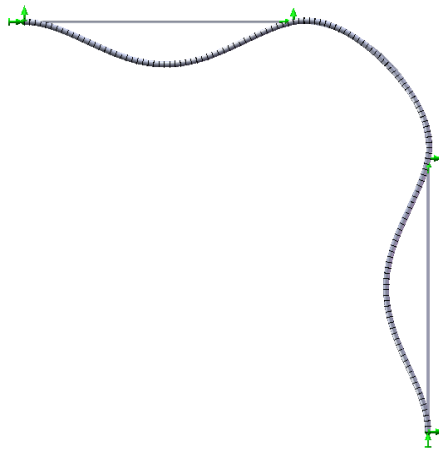
In plane

Out of plane



Mode 1

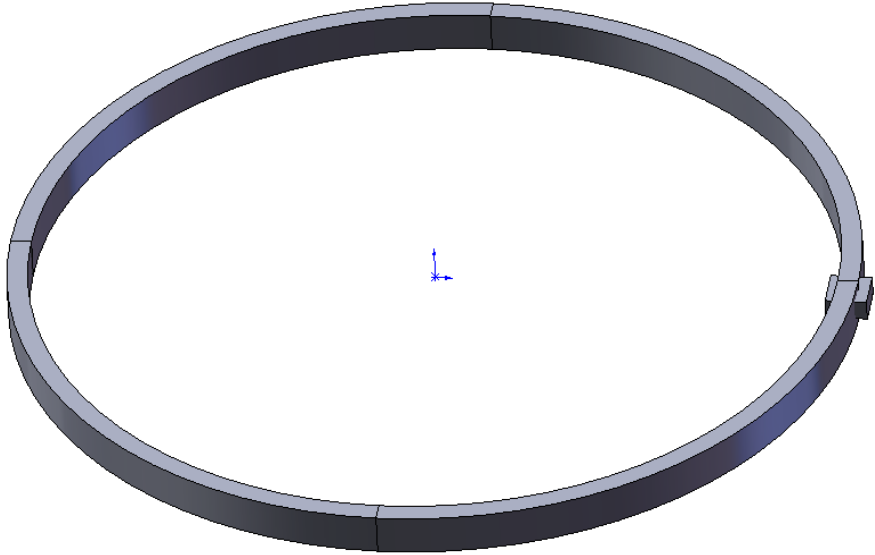
Mode 1



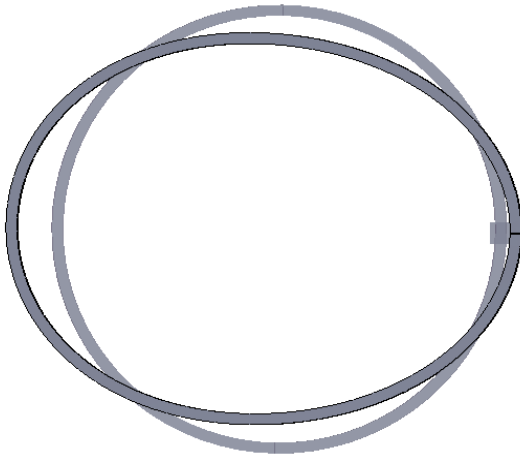
Mode 2

Mode 2

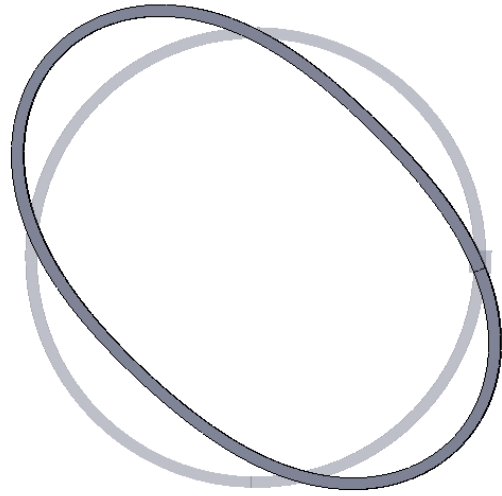
Comments :

EVALUATION FORM			
Software: SOLIDWORKS Simulation		Version: 2019 B3	
Computer configuration used: Lenovo ThinkStation S20, Windows 7 x64, Intel Xeon W3565, 12Gb RAM, graphics card NVIDIA Quadro 2000.			
Test name: THIN FREE RING WITH A PUNCTUAL MASS Codification: SDLL 16-89			
			
Test performed by : Julien BOISSAT		Date: 3/29/2019	
Model used Finite elements <input checked="" type="checkbox"/> Boundary elements <input type="checkbox"/> Other <input type="checkbox"/> Element type : TETRA 10 Number of degrees of freedom or mesh density : Nb of nodes = 13896 Nb of elements = 7360 Nb of DOF = 41829			
Results :			
Order of the vibration mode	Frequency (Hz)		Deviation (%)
	Reference	Calculated	
In plane			
1,2,3	0.	0	-
Sym 4	227.29	227.63	0.12
Anti 5	297.87	296.34	0.51
Sym 6	718.42	717.27	0.16
Anti 7	873.88	860.16	1.57
Transverse			
1,2,3	0.	0	-
4	409.8	409.21	0.15
5	510.2	508.21	0.38

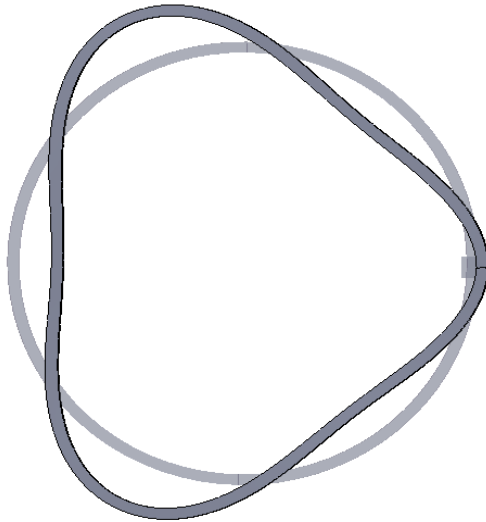
Vibration modes in plane



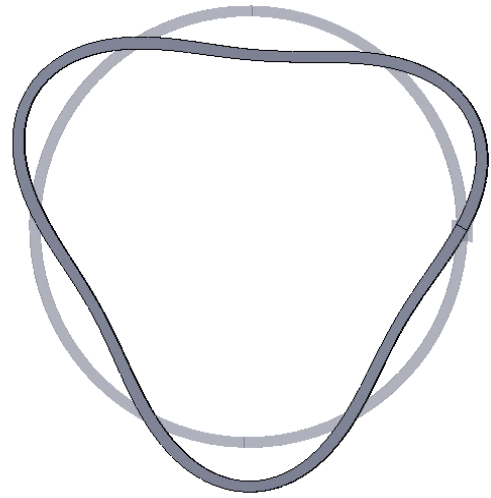
Mode 4



Mode 5



Mode 6

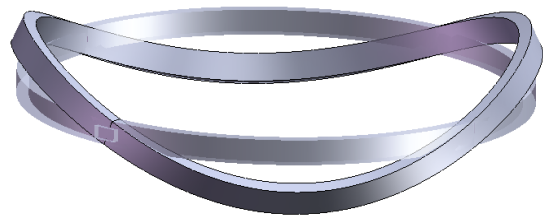


Mode 7

Vibration modes out of plane

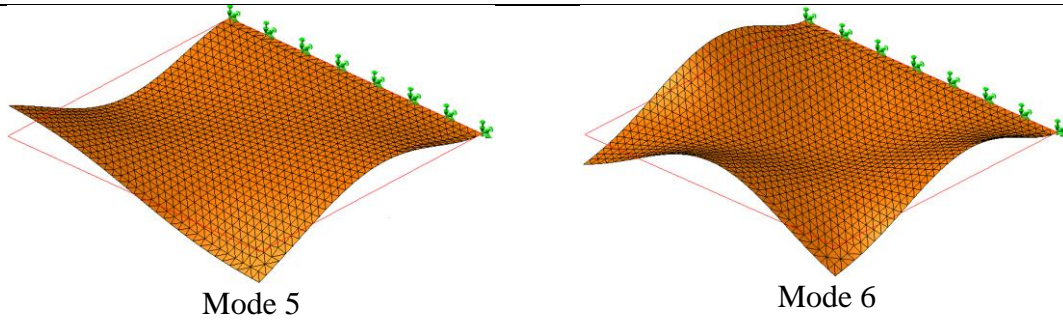


Mode 4



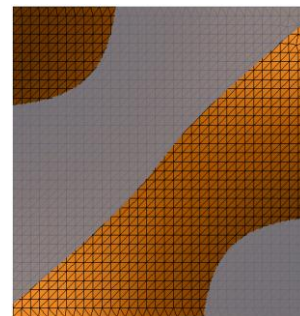
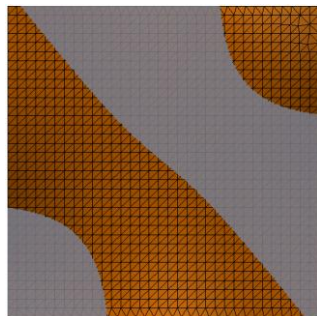
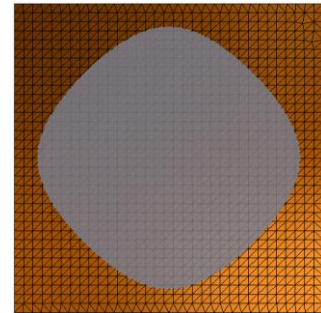
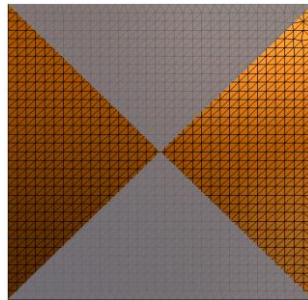
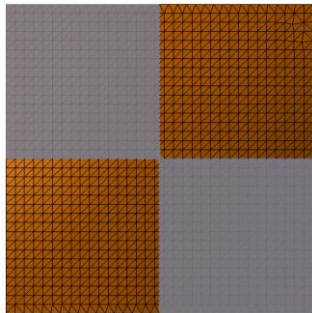
Mode 5

Comments :

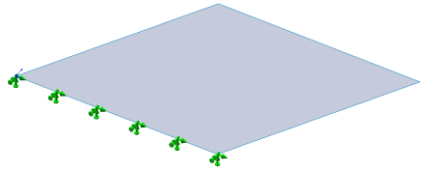
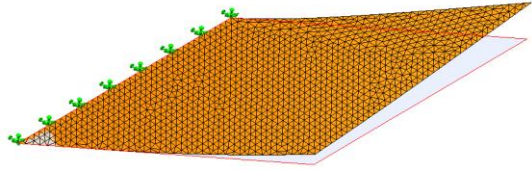
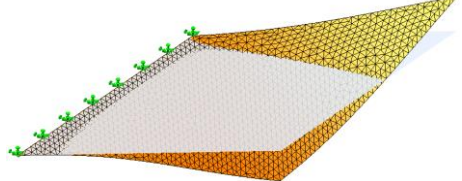


2.Free

Order of the vibration mode <i>i</i>	Frequency (Hertz)		Deviation (%)
	Reference value	Calculated value	
7	33.7119	33.645	0.20
8	49.4558	48.922	1.09
9	61.0513	60.604	0.74
10	87.5160	86.864	0.75
11	87.5160	86.907	0.7



Comments :

EVALUATION FORM				
Software: SOLIDWORKS Simulation	Version: 2019 SP2			
Computer configuration used: Lenovo ThinkStation S20, Windows 7 x64, Intel Xeon W3565, 12Gb RAM, graphics card NVIDIA Quadro 2000.				
Test name: THIN RHOMBOID PLATE FIXED ON ONE EDGE Codification: SDLS 02-89				
				
Test performed by : Julien BOISSAT	Date: 4/2/2019			
Model used Finite elements <input checked="" type="checkbox"/> Boundary elements <input type="checkbox"/> Other <input type="checkbox"/> Element type : SHELL 6 Number of degrees of freedom or mesh density :				
$\alpha = 0^\circ$	$\alpha = 15^\circ$			
Nb of nodes = 6561	Nb of nodes = 6381			
Nb of elements = 3200	Nb of elements = 3110			
Nb of DOF = 38880	Nb of DOF = 37800			
$\alpha = 30^\circ$	$\alpha = 45^\circ$			
Nb of nodes = 5701	Nb of nodes = 4737			
Nb of elements = 2770	Nb of elements = 2288			
Nb of DOF = 33720	Nb of DOF = 27936			
Results :				
Nature of the vibration mode		Frequency (Hertz)		Deviation (%)
		Reference value	Calculated value	
α	i			
$\alpha = 0^\circ$	1	8.6734	8.6734	0
	2	21.253	21.253	0
$\alpha = 15^\circ$	1	8.9990	8.9538	2.04
	2	22.1714	21.728	0.84
$\alpha = 30^\circ$	1	9.8987	9.8159	0.84
	2	25.4651	23.513	8.30
$\alpha = 45^\circ$	1	11.15	11.264	-1.01
	2	27	28.103	-3.91
Vibration modes $\alpha = 45^\circ$				
				
$f_1=11.26$ Hz		$f_2=28.1$ Hz		
Comments :				

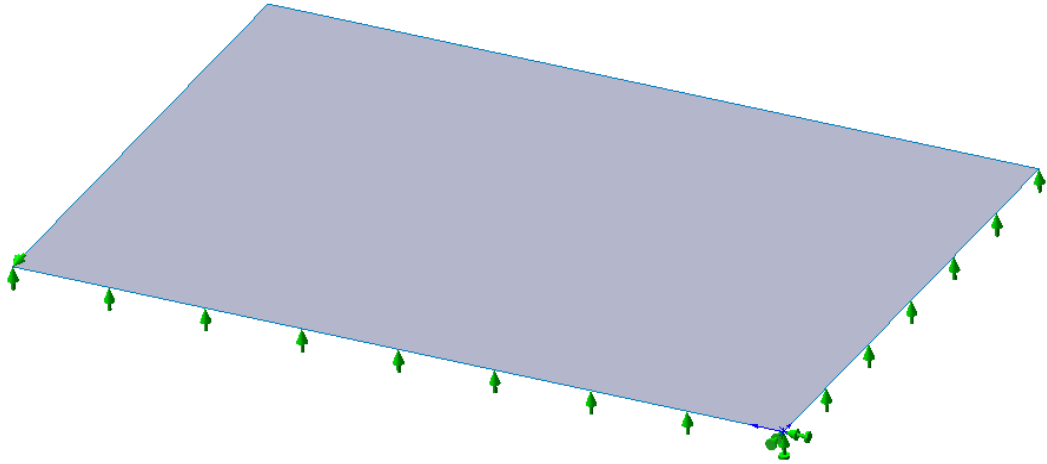
EVALUATION FORM

Software: SOLIDWORKS Simulation

Version: 2019 SP2

Computer configuration used: Lenovo ThinkStation S20, Windows 7 x64, Intel Xeon W3565, 12Gb RAM, graphics card NVIDIA Quadro 2000.

Test name: THIN RECTANGULAR PLATE SIMPLY SUPPORTED ON EDGES
Codification: SDLS 03-89



Test performed by : Julien BOISSAT

Date: 4/2/2019

Model used

Finite elements

Boundary elements

Other

Element type : SHELL 6

Number of degrees of freedom or mesh density :

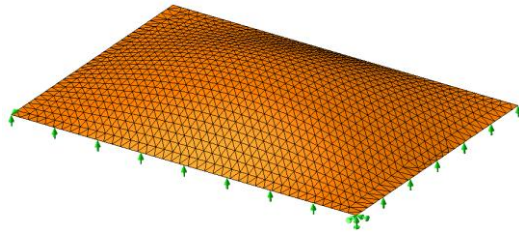
Nb of nodes = 4491

Nb of elements = 2176

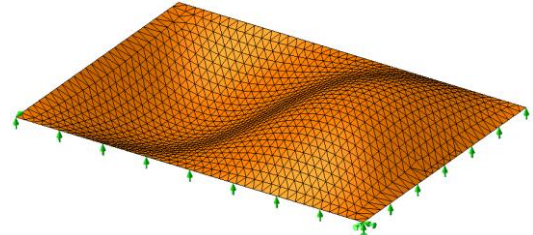
Nb of DOF = 26940

Results :

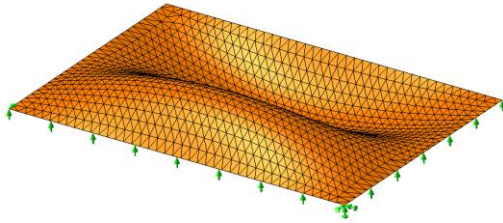
Nature of the vibration mode		Frequency (Hertz)		Deviation (%)
		Reference value	Calculated value	
<i>i</i>	<i>j</i>			
1	1	35.63	35.62	0.03
2	1	68.51	68.49	0.03
1	2	109.62	109.58	0.04
3	1	123.32	123.25	0.06
2	2	142.51	142.41	0.07
3	2	197.32	197.11	0.11



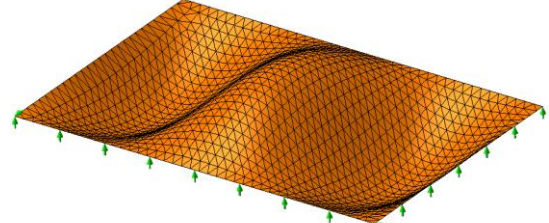
1,1



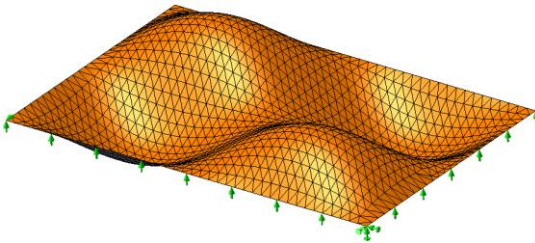
2,1



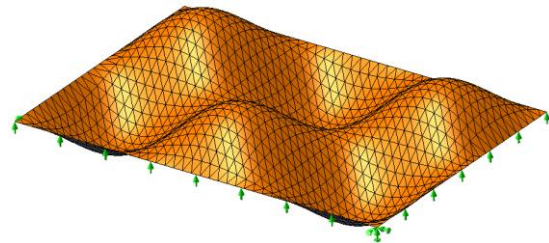
1,2



3,1

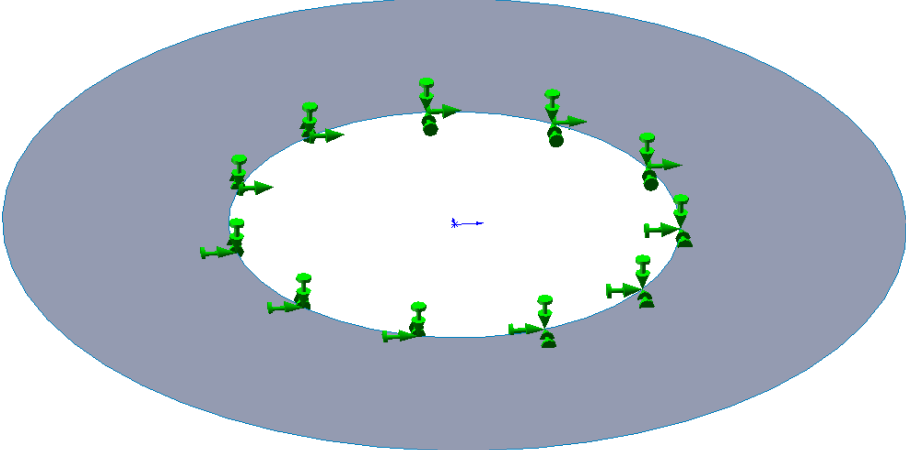


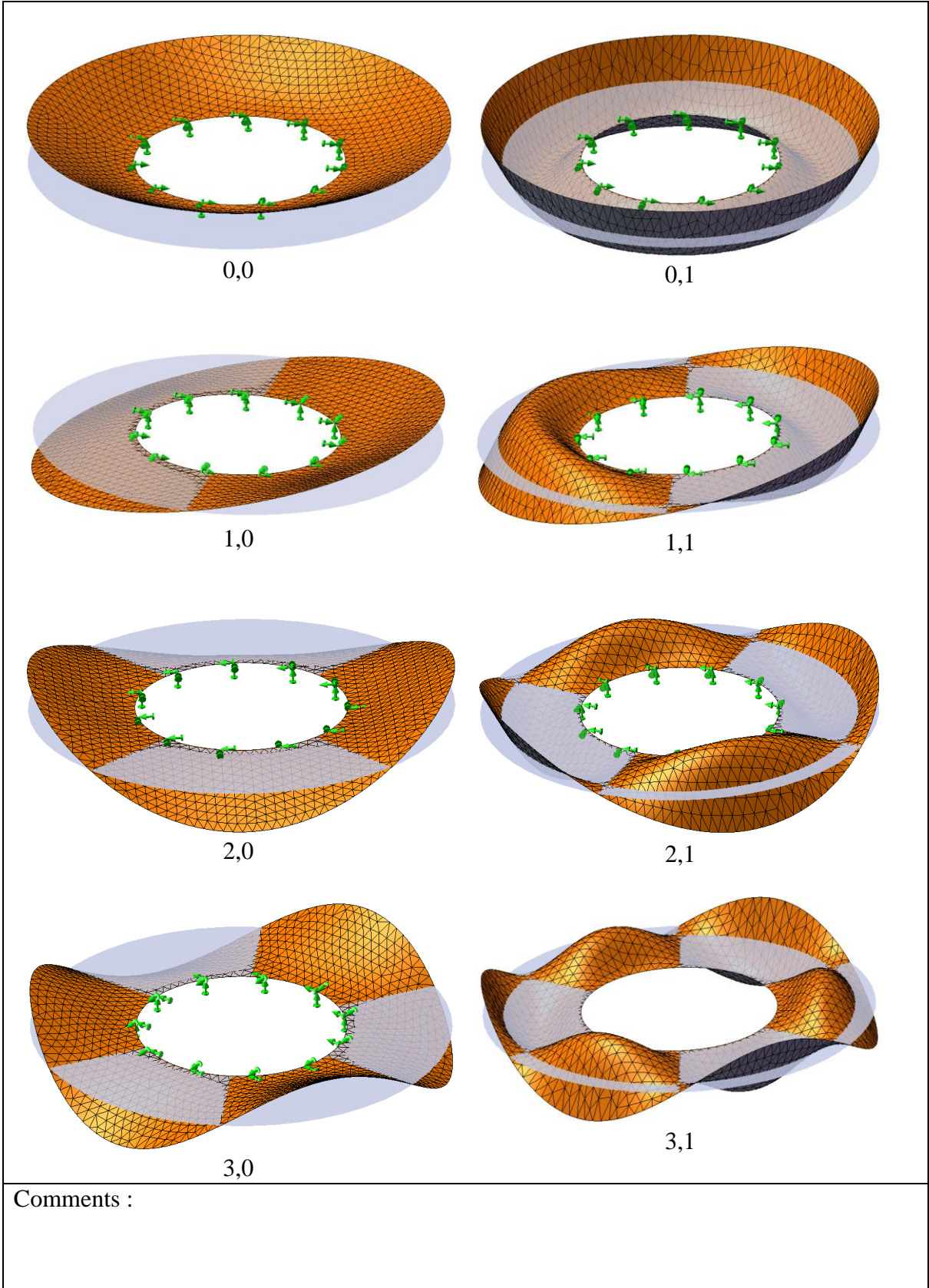
2,2

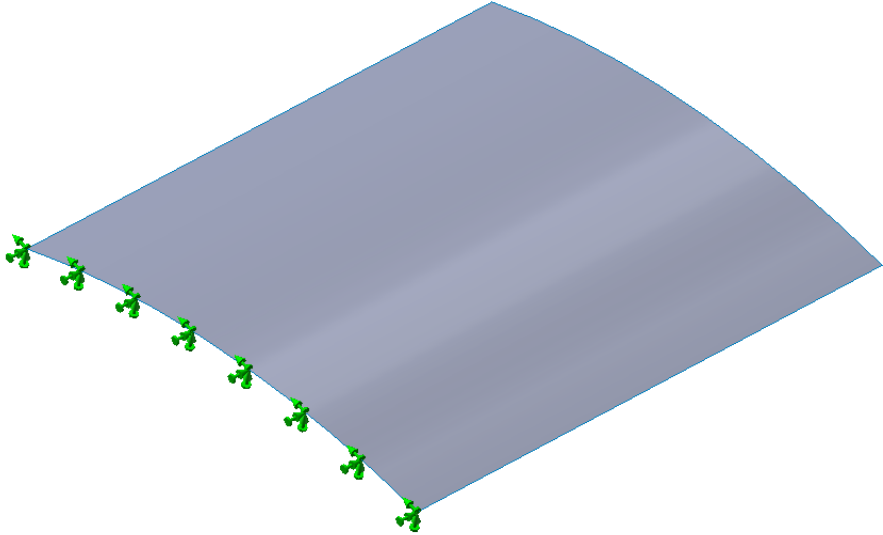


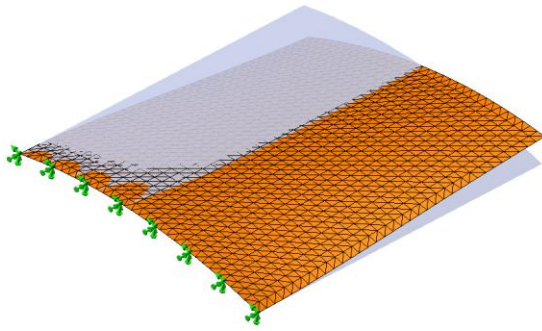
3,2

Comments :

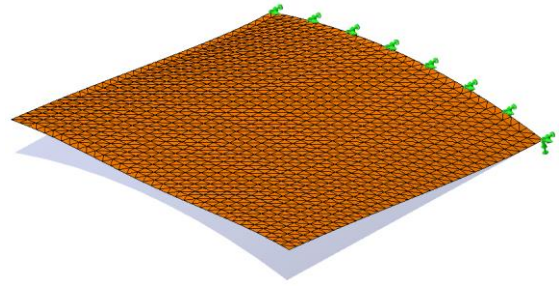
EVALUATION FORM				
Software: SOLIDWORKS Simulation			Version: 2019 SP2	
Computer configuration used: Lenovo ThinkStation S20, Windows 7 x64, Intel Xeon W3565, 12Gb RAM, graphics card NVIDIA Quadro 2000.				
Test name: THIN RING SHAPED PLATE FIXED ON INNER EDGE Codification: SDLS 04-89				
				
Test performed by : Julien BOISSAT			Date: 4/2/2019	
Model used Finite elements <input checked="" type="checkbox"/> Boundary elements <input type="checkbox"/> Other <input type="checkbox"/> Element type : SHELL 6 Number of degrees of freedom or mesh density : Nb of nodes = 4642 Nb of elements = 2218 Nb of DOF = 27024				
Results :				
Nature of the vibration mode		Frequency (Hertz)		Deviation (%)
		Reference value	Calculated value	
<i>i</i>	<i>j</i>			
0	0	79.26	79.34	0.10
0	1	518.85	516.37	0.48
1	0	81.09	80.95	0.17
1	1	528.61	526.68	0.37
2	0	89.63	89.56	0.08
2	1	559.09	556.98	0.38
3	0	112.79	113.04	0.22
3	1	609.70	607.96	0.29



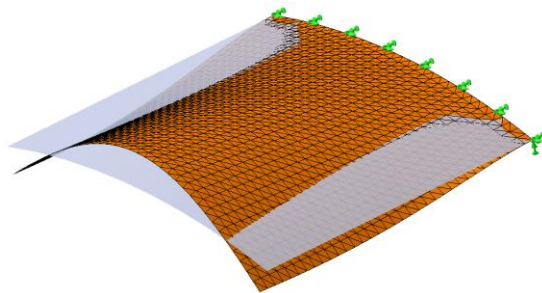
EVALUATION FORM			
Software: SOLIDWORKS Simulation		Version: 2019 SP2	
Computer configuration used: Lenovo ThinkStation S20, Windows 7 x64, Intel Xeon W3565, 12Gb RAM, graphics card NVIDIA Quadro 2000.			
Test name: COMPRESSOR BLADE: THIN SHELL FIXED-FREE Codification: SDLS 05-89			
			
Test performed by : Julien BOISSAT		Date: 4/2/2019	
Model used Finite elements <input checked="" type="checkbox"/> Boundary elements <input type="checkbox"/> Other <input type="checkbox"/> Element type : SHELL 6 Number of degrees of freedom or mesh density : Nb of nodes = 4629 Nb of elements = 2246 Nb of DOF = 27360			
Results :			
Nature of the vibration mode	Frequency (Hertz)		Deviation (%)
	Reference value	Calculated value	
1	85.6	85.9	0.35
2	134.5	138.4	2.82
3	259.0	246.9	4.90
4	351.0	342.4	2.51
5	395.0	386.4	2.23
6	531.0	528.2	0.53



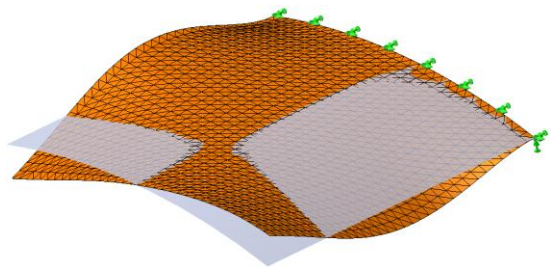
Mode 1



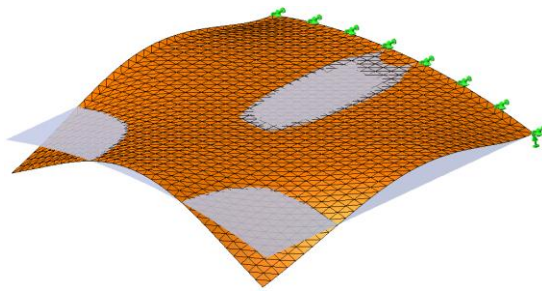
Mode 2



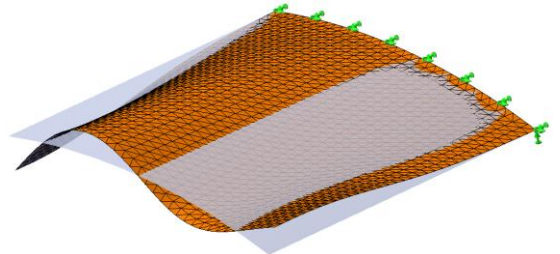
Mode 3



Mode 4

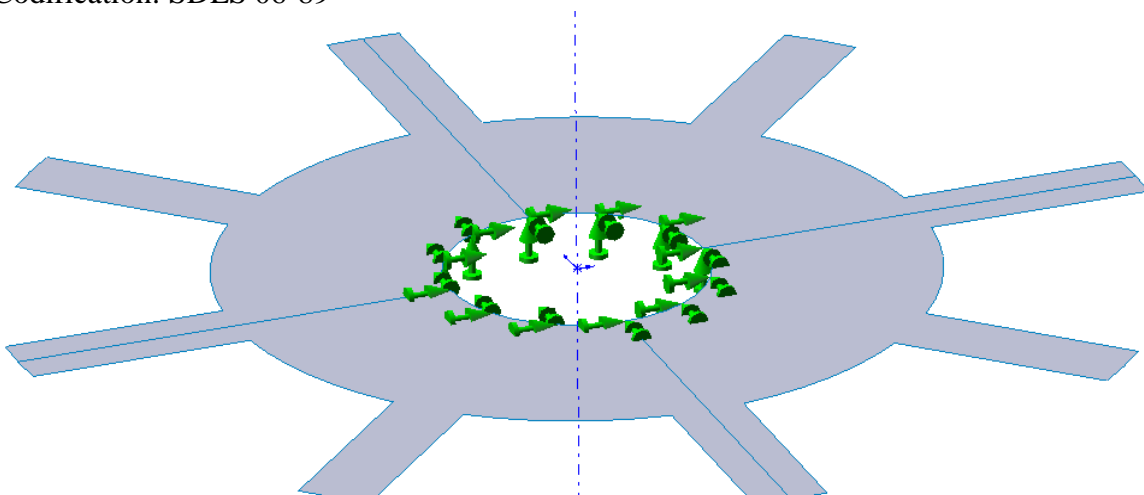


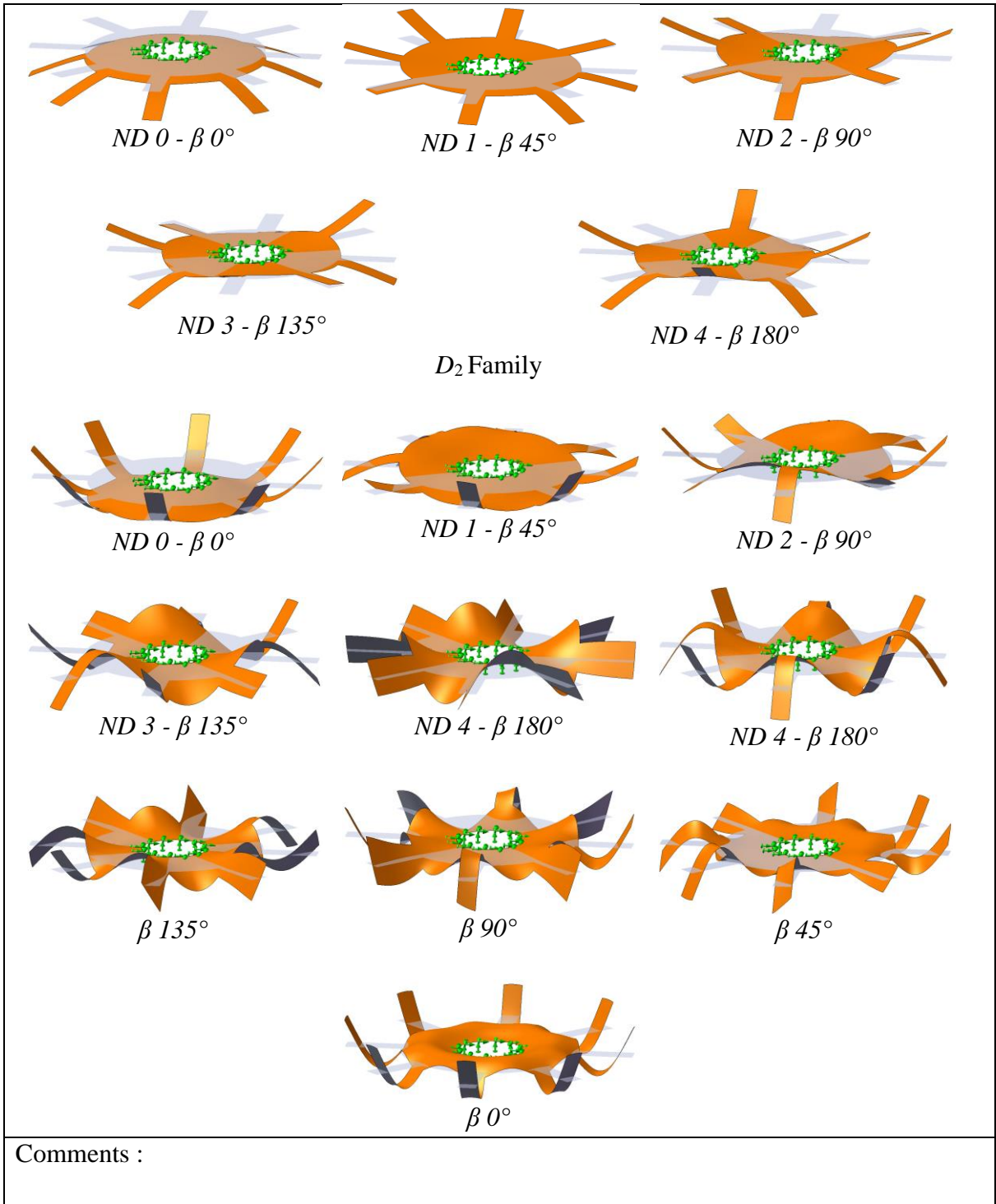
Mode 5

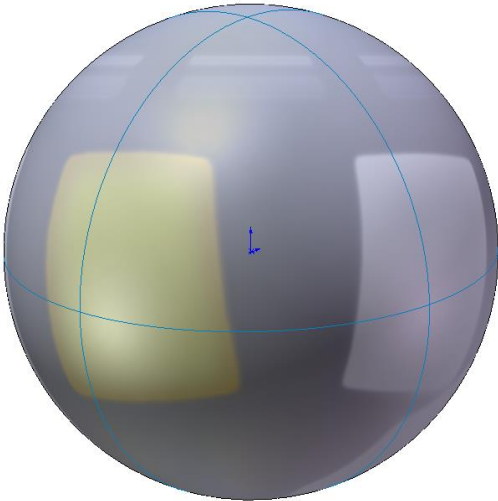


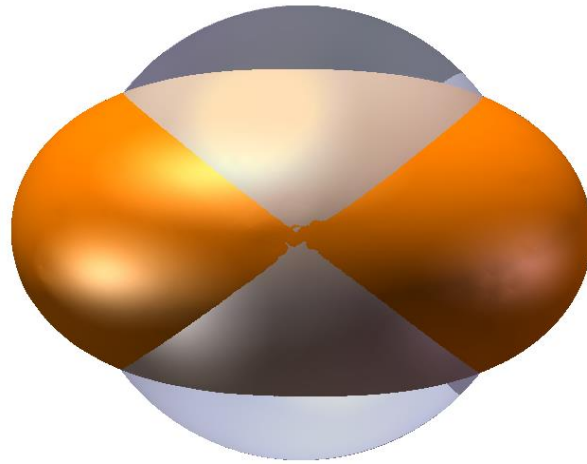
Mode 6

Comments :

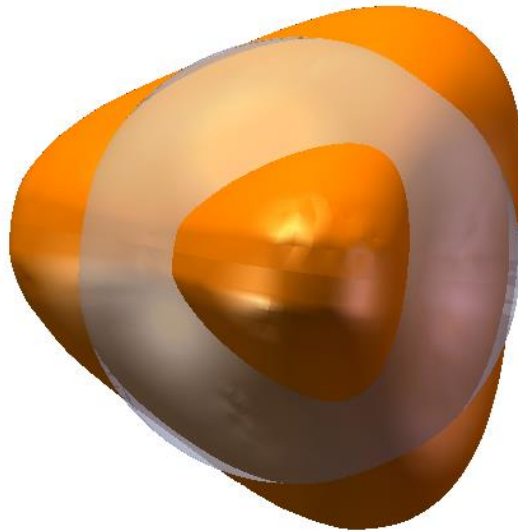
EVALUATION FORM							
Software: SOLIDWORKS Simulation				Version: 2019 SP2			
Computer configuration used: Lenovo ThinkStation S20, Windows 7 x64, Intel Xeon W3565, 12Gb RAM, graphics card NVIDIA Quadro 2000.							
Test name: THIN WINGED CIRCULAR PLATE							
Codification: SDLS 06-89							
							
Test performed by : Julien BOISSAT				Date: 4/2/2019			
Model used Finite elements <input checked="" type="checkbox"/> Boundary elements <input type="checkbox"/> Other <input type="checkbox"/> Element type : SHELL 6 Number of degrees of freedom or mesh density : Nb of nodes = 8796 Nb of elements = 4164 Nb of DOF = 52104							
Results :							
Nature of the vibration mode		Frequency (Hertz)				Deviation (%)	
		Reference value		Calculated value			
Torsion Bending		D_1	D_2	D_1	D_2		
ND	β (°)						
0	0	267.2	902	280.49	948.92	4.74	4.94
1	45	264.7	901	279.8	954.76	5.40	5.63
2	90	295.1	971	304.8	1017.3	3.18	4.55
3	135	361.1	1210	365.09	1242.5	1.09	2.62
4	180	--	1663		1679.4		0.98
4	180	390.5	1643	393.92	1670.8	0.87	1.66
	135	--	2189		2215.4		1.19
	90	--	2627		2681.9		2.05
	45	--	2783		2902.7		4.12
	0	--	2805		2932.6		4.35
D_1 Family							



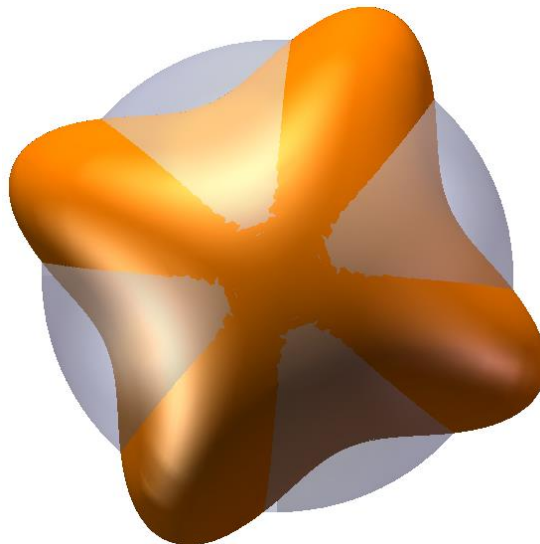
EVALUATION FORM							
Software: SOLIDWORKS Simulation				Version: 2019 SP2			
Computer configuration used: Lenovo ThinkStation S20, Windows 7 x64, Intel Xeon W3565, 12Gb RAM, graphics card NVIDIA Quadro 2000.							
Test name: THIN SPHERE COMPLETELY IMMERSSED IN A PERFECT AND INCOMPRESSIBLE FLUID							
Codification: SDLS 07-89							
							
Test performed by : Julien BOISSAT				Date: 4/2/2019			
Model used Finite elements <input checked="" type="checkbox"/> Boundary elements <input type="checkbox"/> Other <input type="checkbox"/> Element type : SHELL 6 Number of degrees of freedom or mesh density :							
In the void							
$t/R = 0.04$				$t/R = 0.004$			
		Nb of nodes = 4242				Nb of nodes = 10130	
		Nb of elements = 2120				Nb of elements = 5064	
		Nb of DOF = 25452				Nb of DOF = 60780	
Results :							
In vacuum							
Nature of the vibration mode		Frequency (Hertz)				Deviation (%)	
		Reference value		Calculated value			
		$t/R = 0.04$	$t/R = 0.004$	$t/R = 0.04$	$t/R = 0.004$		
<i>i</i>	<i>j</i>						
2	0	237.25	236.71	237.41	236.93	0.07	0.09
3	0	282.85	280.49	283.15	280.56	0.11	0.03
4	0	305.24	297.65	305.39	297.8	0.05	0.05
5	0	324.17	306.16	324.16	306.44	0	0.09
6	0	346.76	311.10	346.52	311.41	0.07	0.1
7	0	376.68	314.35	376.55	314.71	0.03	0.11
8	0	416.0	316.77	415.17	317.28	0.20	0.16
9	0	465.75	318.80	463.85	319.26	0.41	0.14
10	0	526.20	320.71	522.84	321.41	0.64	0.22



$i = 2$

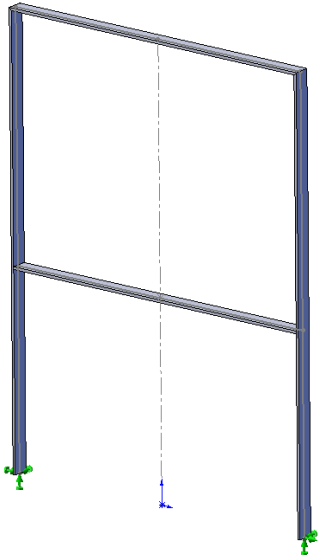


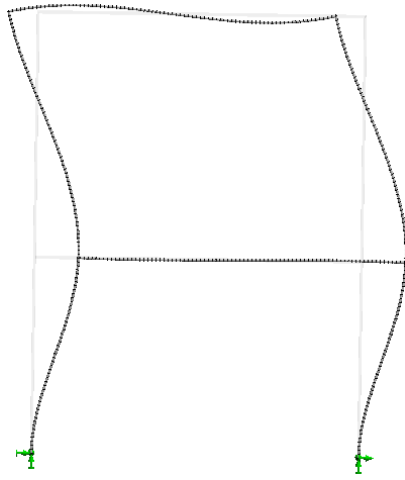
$i = 3$



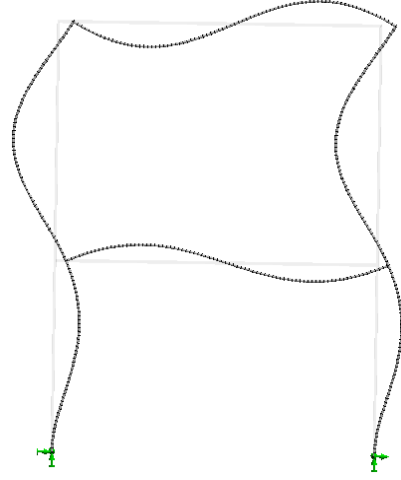
$i = 4$

Comments : The simulation of the immersed sphere is out of the software's range.

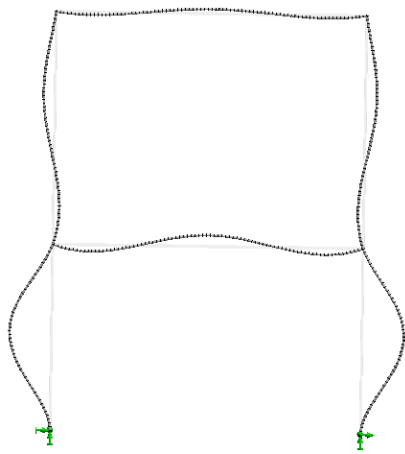
EVALUATION FORM			
Software: SOLIDWORKS Simulation		Version: 2019 SP2	
Computer configuration used: Lenovo ThinkStation S20, Windows 7 x64, Intel Xeon W3565, 12Gb RAM, graphics card NVIDIA Quadro 2000.			
Test name: BENDING OF SYMMETRICAL FRAME Codification: SDLX 01-89			
			
Test performed by : Julien BOISSAT		Date: 4/2/2019	
Model used Finite elements <input checked="" type="checkbox"/> Boundary elements <input type="checkbox"/> Other <input type="checkbox"/> Element type : BEAM Number of degrees of freedom or mesh density : Nb of nodes = 389 Nb of elements = 385 Nb of DOF = 2292			
Results :			
Nature of the vibration mode <i>i</i>	Frequency (Hertz)		Deviation (%)
	Reference value	Calculated value	
1 anti	8.8	8.8	0.00
2 anti	29.4	29.5	0.34
3 sym	43.8	43.8	0.00
4 sym	56.3	56.56	0.46
5 anti	96.2	95.97	0.24
6 sym	102.6	102.8	0.19
7 anti	147.1	146.6	0.34
8 sym	174.8	174.6	0.11
9 anti	178.8	178.8	0.00
10 anti	206	206.5	0.24
11 sym	266.4	264.7	0.64
12 anti	320	318.1	0.60
13 sym	335	333.1	0.57



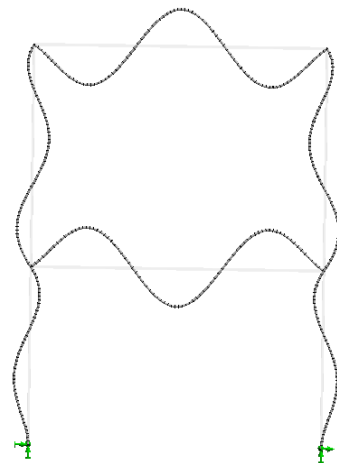
Mode 2



Mode 5

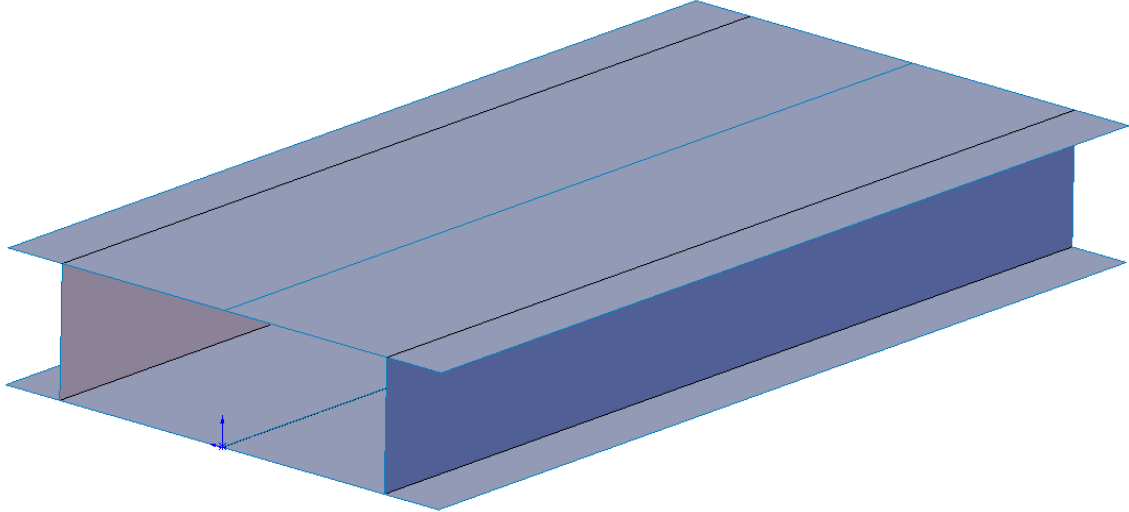


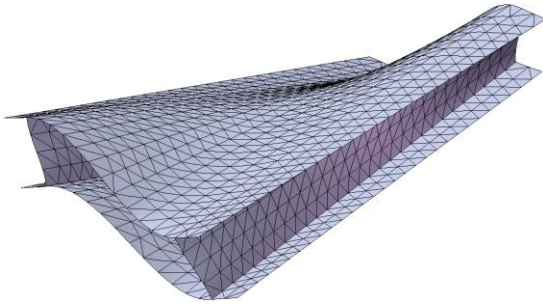
Mode 8



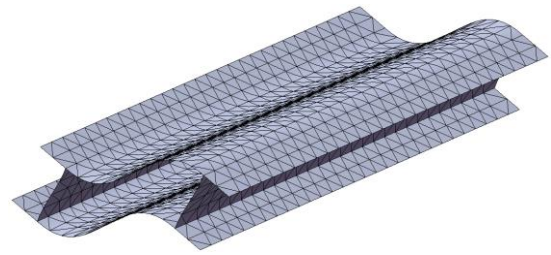
Mode 13

Comments :

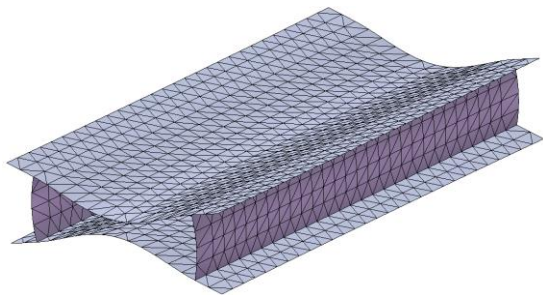
EVALUATION FORM					
Software: SOLIDWORKS Simulation			Version: 2019 SP2		
Computer configuration used: Lenovo ThinkStation S20, Windows 7 x64, Intel Xeon W3565, 12Gb RAM, graphics card NVIDIA Quadro 2000.					
Test name: ASSEMBLY OF THIN RECTANGULAR SHAPED SHEETS					
Codification: SDLX 03-89					
					
Test performed by : Julien BOISSAT			Date: 4/3/2019		
Model used Finite elements <input checked="" type="checkbox"/> Boundary elements <input type="checkbox"/> Other <input type="checkbox"/> Element type : SHELL 6 Number of degrees of freedom or mesh density : Nb of nodes = 4600 Nb of elements = 2260 Nb of DOF = 27600					
Results :					
Nature of the vibration mode <i>i</i>	Frequency (Hertz)			Deviation (%)	
	Experimental	Finite elements model	Calculated value	w.r.t. Exp.	w.r.t. FEM
1	606	584 ± 1%	585	3.59	0.17
2	760	826 ± 1.5%	826	7.99	0
3	865	855 ± 1.7%	852	1.53	0.35
4	944	911 ± 2%	912	3.51	0.11
5	1113	1113 ± 3.6%	1107	0.54	0.54
6	1144	1136 ± 4%	1157	1.12	1.82



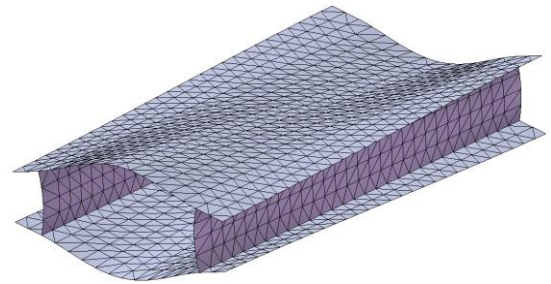
Mode 1



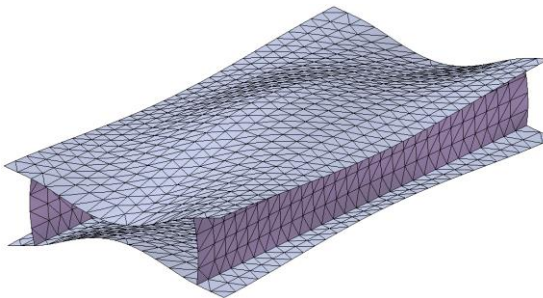
Mode 2



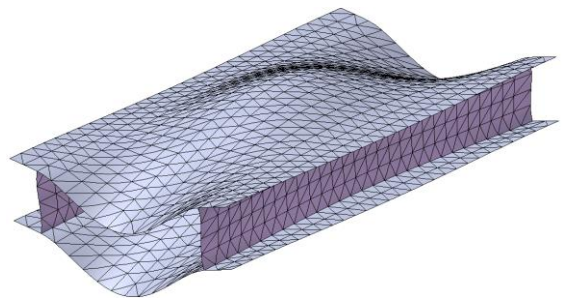
Mode 3



Mode 4



Mode 5



Mode 6

Comments :

II. THERMAL

1. Linear steady state thermal

EVALUATION FORM

Software: SOLIDWORKS Simulation | Version: 2019 B3

Computer configuration used: Lenovo ThinkStation S20, Windows 7 x64, Intel Xeon W3565, 12Gb RAM, graphics card NVIDIA Quadro 2000.

Test name: PIPE: PRESCRIBED TEMPERATURES

Codification: TPLA 01-89



Test performed by : Julien BOISSAT | Date: 4/3/2019

Model used

Finite elements | Boundary elements | Other

Element type : TRIANG

Number of degrees of freedom or mesh density :

2D - Extruded

Nb of nodes = 2921
 Nb of elements = 1370
 Nb of DOF = 2599

2D - Axi-symmetric

Nb of nodes = 6615
 Nb of elements = 3140
 Nb of DOF = 5985

Results :

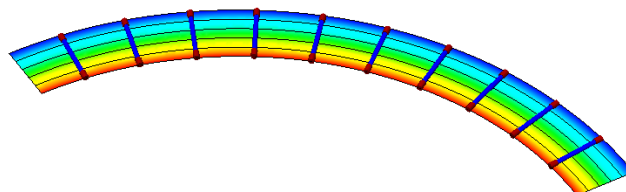
2D - Extruded

r (m)	Reference values		Calculated values		Deviation (%)	
	T (°C)	ϕ (W/m ²)	T (°C)	ϕ (W/m ²)		
0.3	100	1729.91	100	1729.94	0	0
0.31	82.98	1674.11	82.98	1674.07	0	0
0.32	66.51	1621.79	66.51	1621.73	0	0
0.33	50.54	1572.64	50.54	1572.61	0	0
0.34	35.04	1526.39	35.04	1526.27	0	0.01
0.35	20	1482.78	20	1482.67	0	0.01

Reference value of the output flux $\Phi/l = 3260.80$ W/m

Calculated value $\Phi/l = 3260.23$ W/m

Deviation (%) = 0.02



Temperature plot:

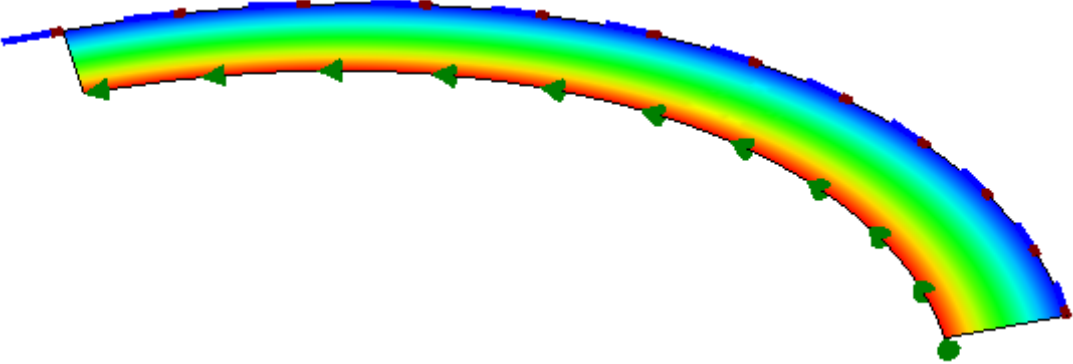
2D – Axi-symmetric						
r (m)	Reference values		Calculated values		Deviation (%)	
	T (°C)	φ (W/m ²)	T (°C)	φ (W/m ²)		
0.3	100	1729.91	100	1729.83	0	0
0.31	82.98	1674.11	82.98	1674.04	0	0
0.32	66.51	1621.79	66.51	1621.73	0	0
0.33	50.54	1572.64	50.54	1572.59	0	0
0.34	35.04	1526.39	35.04	1526.34	0	0
0.35	20	1482.78	20	1482.73	0	0

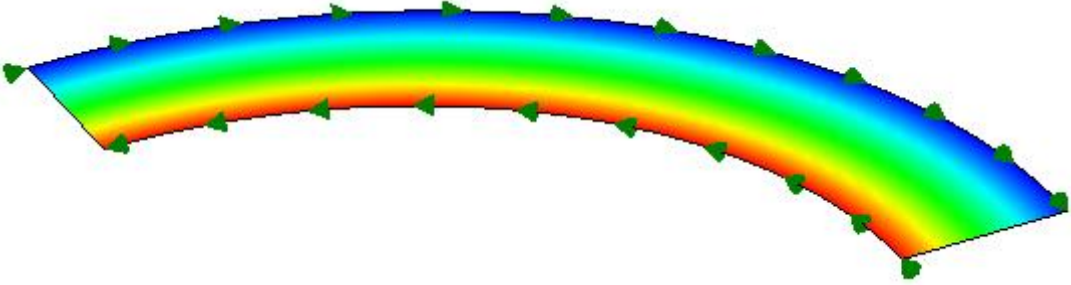
Reference value of the output flux $\Phi/l = 3260.80$ W/m
 Calculated value $\Phi/l = 3260.80$ W/m
 Deviation (%) = 0



Comments :

The Reference value of the output flux Φ/l is the heat flux for a 1m extrusion thickness, and for the entire cross section.

EVALUATION FORM						
Software: SOLIDWORKS Simulation			Version: 2019 SP2			
Computer configuration used: Lenovo ThinkStation S20, Windows 7 x64, Intel Xeon W3565, 12Gb RAM, graphics card NVIDIA Quadro 2000.						
Test name: PIPE : PRESCRIBED TEMPERATURE, CONVECTION						
Codification: TPLA 02-89						
						
Test performed by : Julien BOISSAT			Date: 4/3/2019			
Model used						
Finite elements <input checked="" type="checkbox"/> Boundary elements <input type="checkbox"/> Other <input type="checkbox"/>						
Element type : SHELL6						
Number of degrees of freedom or mesh density :						
Nb of nodes = 1180						
Nb of elements = 533						
Nb of DOF = 1069						
Results :						
<i>r</i> (m)	Reference values		Calculated values		Deviation (%)	
	<i>T</i> (°C)	ϕ (W/m ²)	<i>T</i> (°C)	ϕ (W/m ²)		
0.3	66.49	1005.29	66.49	1005.2	0	0.01
0.31	56.60	972.89	56.60	972.83	0	0.01
0.32	47.03	942.46	47.03	942.43	0	0
0.33	37.75	913.90	37.75	913.87	0	0
0.34	28.74	887.02	28.74	887.00	0	0
0.35	20	861.6	20	861.57	0	0
Reference value of the output flux $\Phi/l = 1894.94$ W/m						
Calculated value $\Phi/l = 1894.92$ W/m						
Deviation (%) = 0						
Comments :						
The Reference value of the output flux Φ/l is the heat flux for a 1m extrusion thicknes, and for the entire cross section.						

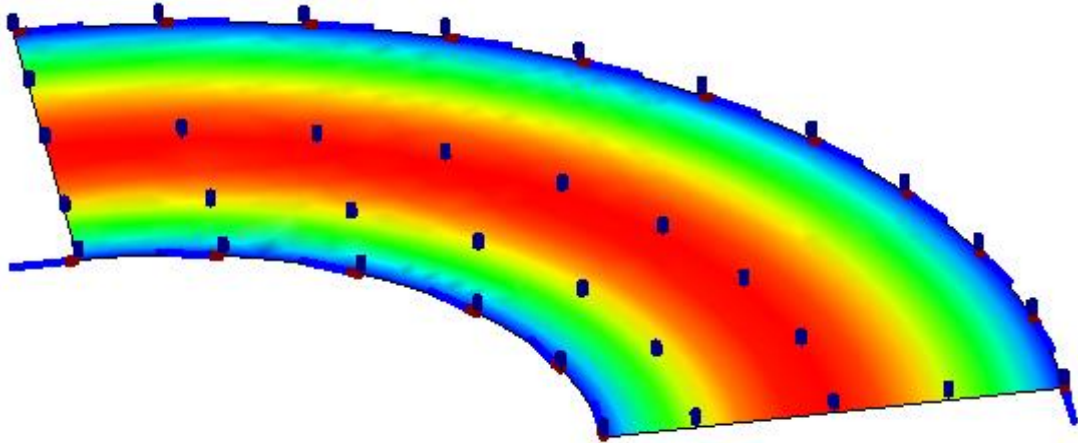
EVALUATION FORM																											
Software: SOLIDWORKS Simulation	Version: 2019 SP2																										
Computer configuration used: Lenovo ThinkStation S20, Windows 7 x64, Intel Xeon W3565, 12Gb RAM, graphics card NVIDIA Quadro 2000.																											
Test name: PIPE : CONVECTION Codification: TPLA 03-89																											
																											
Test performed by : Julien BOISSAT	Date: 4/3/2019																										
Model used Finite elements <input checked="" type="checkbox"/> Boundary elements <input type="checkbox"/> Other <input type="checkbox"/> Element type : SHELL6 Number of degrees of freedom or mesh density : Nb of nodes = 2147 Nb of elements = 1008 Nb of DOF = 2147																											
Results :																											
<table border="1" style="width: 100%; border-collapse: collapse; text-align: center;"> <thead> <tr> <th style="width: 30%;">Physical quantity</th> <th style="width: 20%;">Reference value</th> <th style="width: 20%;">Calculated value</th> <th style="width: 30%;">Deviation (%)</th> </tr> </thead> <tbody> <tr> <td>T_i (°C)</td> <td>272.27</td> <td>272.35</td> <td>0.03</td> </tr> <tr> <td>T_e (°C)</td> <td>205.05</td> <td>204.51</td> <td>0.27</td> </tr> <tr> <td>φ_i (W/m²)</td> <td>34160.01</td> <td>34146.32</td> <td>0.04</td> </tr> <tr> <td>φ_e (W/m²)</td> <td>26276.93</td> <td>26198.90</td> <td>0.30</td> </tr> <tr> <td>Φ/l (W/m)</td> <td>64390.11</td> <td>64364.26</td> <td>0.04</td> </tr> </tbody> </table>				Physical quantity	Reference value	Calculated value	Deviation (%)	T_i (°C)	272.27	272.35	0.03	T_e (°C)	205.05	204.51	0.27	φ_i (W/m ²)	34160.01	34146.32	0.04	φ_e (W/m ²)	26276.93	26198.90	0.30	Φ/l (W/m)	64390.11	64364.26	0.04
Physical quantity	Reference value	Calculated value	Deviation (%)																								
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φ_e (W/m ²)	26276.93	26198.90	0.30																								
Φ/l (W/m)	64390.11	64364.26	0.04																								
Comments : The Reference value of the output flux Φ/l is the heat flux for a 1m extrusion thicknes, and for the entire cross section.																											

EVALUATION FORM

Software: SOLIDWORKS Simulation | Version: 2019 SP2

Computer configuration used: Lenovo ThinkStation S20, Windows 7 x64, Intel Xeon W3565, 12Gb RAM, graphics card NVIDIA Quadro 2000.

Test name: POWER OUTPUT IN A PIPE
Codification: TPLA 04-89



Test performed by : Julien BOISSAT | Date: 4/3/2019

Model used
 Finite elements Boundary elements Other
 Element type : TRIANG
 Number of degrees of freedom or mesh density :
 Nb of nodes = 2619
 Nb of elements = 1252
 Nb of DOF = 2461

Results :

<i>r</i> (m)	Reference value		Calculated values		Deviation (%)	
	<i>T</i> (°C)	φ (W/m ²)	<i>T</i> (°C)	φ (W/m ²)		
1.0	20.00	-58.2	20.00	-58.16	0	0.07
1.2	28.73	-30.17	28.73	-30.17	0	0
1.5	32.62	2.87	32.62	2.878	0	0.28

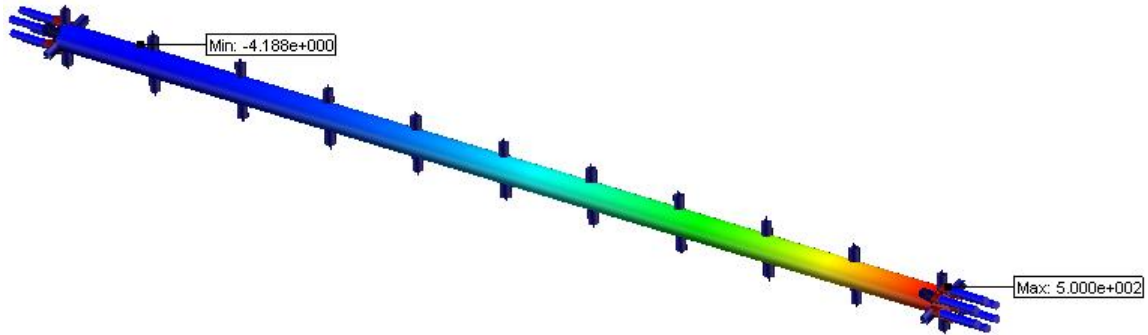
Comments :

EVALUATION FORM

Software: SOLIDWORKS Simulation | Version: 2019 SP2

Computer configuration used: Lenovo ThinkStation S20, Windows 7 x64, Intel Xeon W3565, 12Gb RAM, graphics card NVIDIA Quadro 2000.

Test name: CYLINDRICAL BAR WITH FLUX DENSITY
Codification: TPLA 05-89



Test performed by : Julien BOISSAT | Date: 4/3/2019

Model used

Finite elements | Boundary elements | Other

Element type : TETRA 10

Number of degrees of freedom or mesh density :

Nb of nodes = 25788

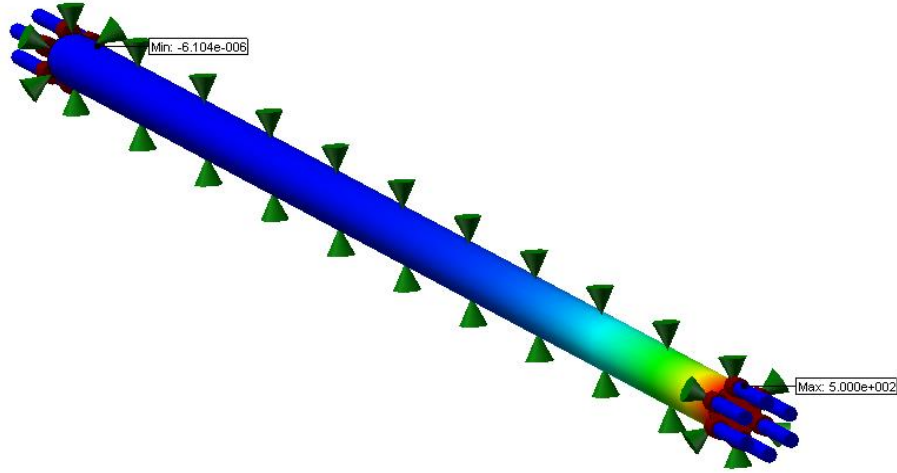
Nb of elements = 15387

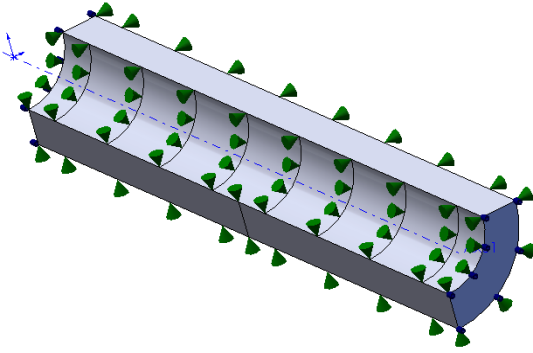
Nb of DOF = 25642

Results :

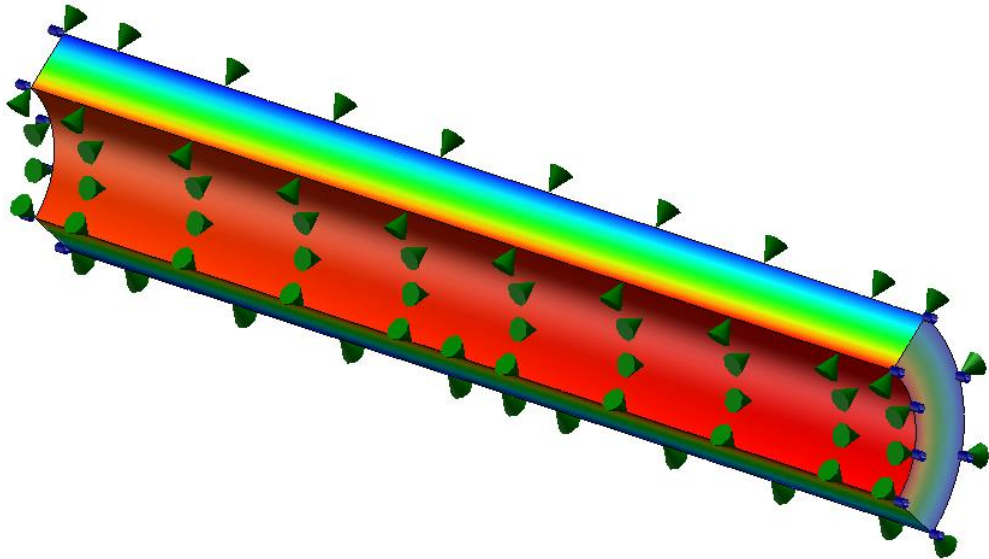
<i>z</i> (m)	Reference value <i>T</i> (°C)	Calculated value <i>T</i> (°C)	Deviation (%)
0.0	0.00	0.00	-
0.1	-4.00	-4.00	0
0.2	4.00	4.00	0
0.3	24.00	24.00	0
0.4	56.00	56.00	0
0.5	100.00	100.0	0
0.6	156.00	156.0	0
0.7	224.00	224.0	0
0.8	304.00	304.0	0
0.9	396.00	396.0	0
1.0	500.00	500.0	0

Comments :

EVALUATION FORM																																																			
Software: SOLIDWORKS Simulation	Version: 2019 SP2																																																		
Computer configuration used: Lenovo ThinkStation S20, Windows 7 x64, Intel Xeon W3565, 12Gb RAM, graphics card NVIDIA Quadro 2000.																																																			
Test name: CYLINDRICAL BAR WITH CONVECTION Codification: TPLA 06-89																																																			
																																																			
Test performed by : Julien BOISSAT	Date: 4/3/2019																																																		
Model used Finite elements <input checked="" type="checkbox"/> Boundary elements <input type="checkbox"/> Other <input type="checkbox"/> Element type : TETRA 10 Number of degrees of freedom or mesh density : Nb of nodes = 25788 Nb of elements = 15387 Nb of DOF = 25642																																																			
Results :																																																			
<table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="width: 15%;">z (m)</th> <th style="width: 25%;">Reference value <i>T</i> (°C)</th> <th style="width: 25%;">Calculated value <i>T</i> (°C)</th> <th style="width: 35%;">Deviation (%)</th> </tr> </thead> <tbody> <tr><td>0.0</td><td>0.00</td><td>0.00</td><td>-</td></tr> <tr><td>0.1</td><td>0.37</td><td>0.37</td><td>0</td></tr> <tr><td>0.2</td><td>0.97</td><td>0.97</td><td>0</td></tr> <tr><td>0.3</td><td>2.19</td><td>2.19</td><td>0</td></tr> <tr><td>0.4</td><td>4.78</td><td>4.79</td><td>0.21</td></tr> <tr><td>0.5</td><td>10.39</td><td>10.40</td><td>0.10</td></tr> <tr><td>0.6</td><td>22.56</td><td>22.56</td><td>0</td></tr> <tr><td>0.7</td><td>48.95</td><td>48.95</td><td>0</td></tr> <tr><td>0.8</td><td>106.21</td><td>106.2</td><td>0.01</td></tr> <tr><td>0.9</td><td>230.44</td><td>230.3</td><td>0.06</td></tr> <tr><td>1.0</td><td>500.00</td><td>500.0</td><td>0</td></tr> </tbody> </table>				z (m)	Reference value <i>T</i> (°C)	Calculated value <i>T</i> (°C)	Deviation (%)	0.0	0.00	0.00	-	0.1	0.37	0.37	0	0.2	0.97	0.97	0	0.3	2.19	2.19	0	0.4	4.78	4.79	0.21	0.5	10.39	10.40	0.10	0.6	22.56	22.56	0	0.7	48.95	48.95	0	0.8	106.21	106.2	0.01	0.9	230.44	230.3	0.06	1.0	500.00	500.0	0
z (m)	Reference value <i>T</i> (°C)	Calculated value <i>T</i> (°C)	Deviation (%)																																																
0.0	0.00	0.00	-																																																
0.1	0.37	0.37	0																																																
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1.0	500.00	500.0	0																																																
Comments :																																																			

EVALUATION FORM				
Software: SOLIDWORKS Simulation	Version: 2019 SP2			
Computer configuration used: Lenovo ThinkStation S20, Windows 7 x64, Intel Xeon W3565, 12Gb RAM, graphics card NVIDIA Quadro 2000.				
Test name: ORTHOTROPIC PIPE Codification: TPLA 07-89				
				
Test performed by : Julien BOISSAT	Date: 4/3/2019			
Model used Finite elements <input checked="" type="checkbox"/> Boundary elements <input type="checkbox"/> Other <input type="checkbox"/> Element type : TETRA 10 Number of degrees of freedom or mesh density : Nb of nodes = 40898 Nb of elements = 26460 Nb of DOF = 40898				
Results :				
z (m)	r (m)	Reference value T (°C)	Calculated value T (°C)	Deviation(%)
0	0.030	100.01	100.8	0.78
	0.035	81.90	82.95	1.27
	0.040	66.22	67.34	1.66
	0.045	52.38	53.39	1.89
	0.050	40.00	40.74	1.82
1/2	0.030	102.51	102.6	0.09
	0.035	84.40	84.44	0.05
	0.040	68.72	68.76	0.06
	0.045	54.88	54.91	0.05
	0.050	42.51	42.54	0.07
1	0.030	105.01	104.4	0.58
	0.035	86.90	85.93	1.13
	0.040	71.22	70.18	1.48
	0.045	57.38	56.43	1.68
	0.050	45.01	44.33	1.53

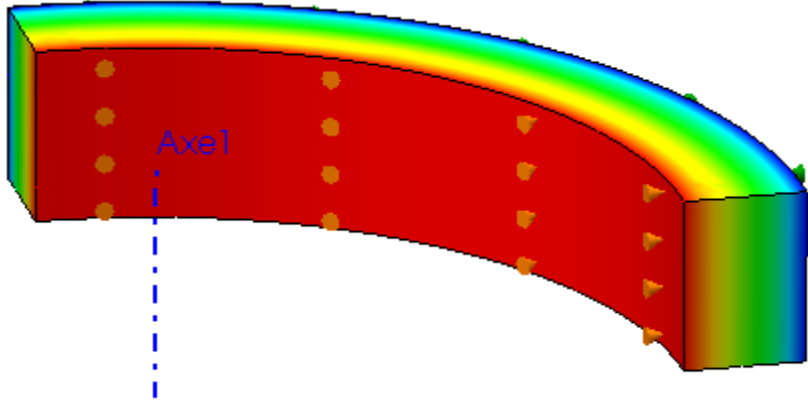
$\nabla r, \varphi_z$ (W/m ²)	-500	-	-
$\nabla z, \varphi_{Ri}$ (W/m ²)	11310	11310	0
$\nabla z, \varphi_{Re}$ (W/m ²)	6786	6778.8	-0.11

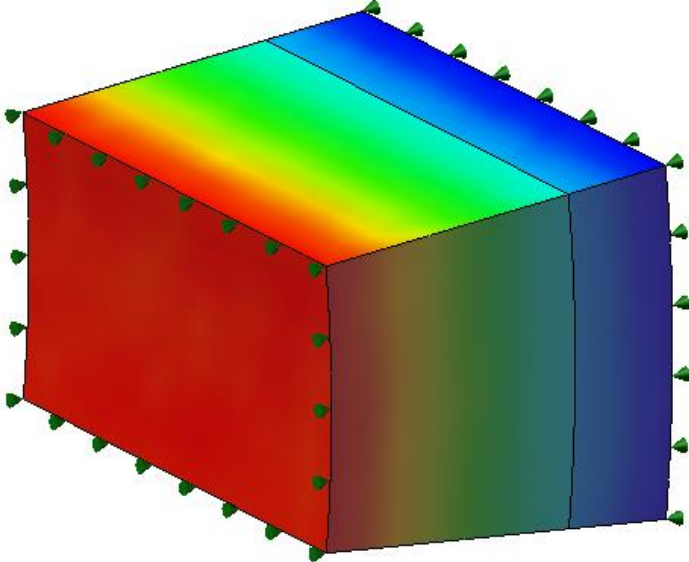


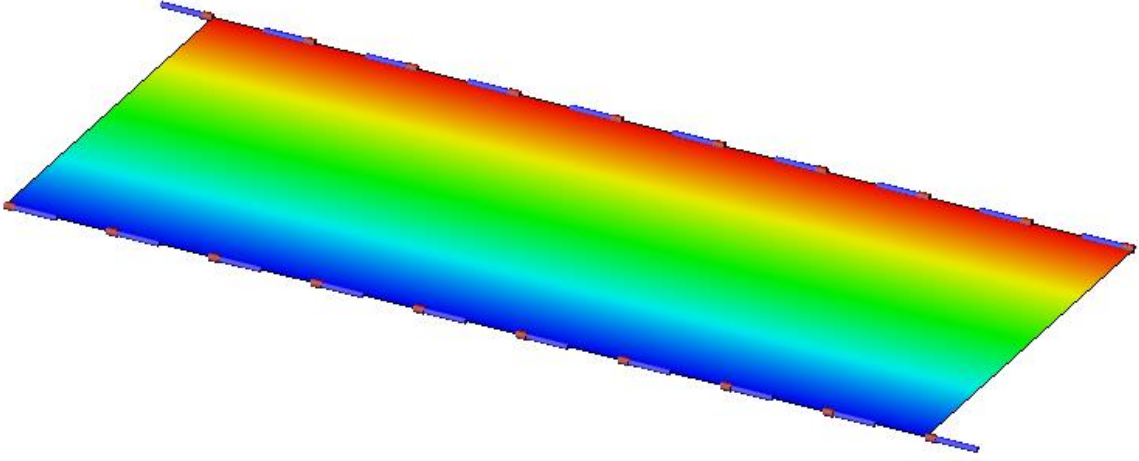
Comments :

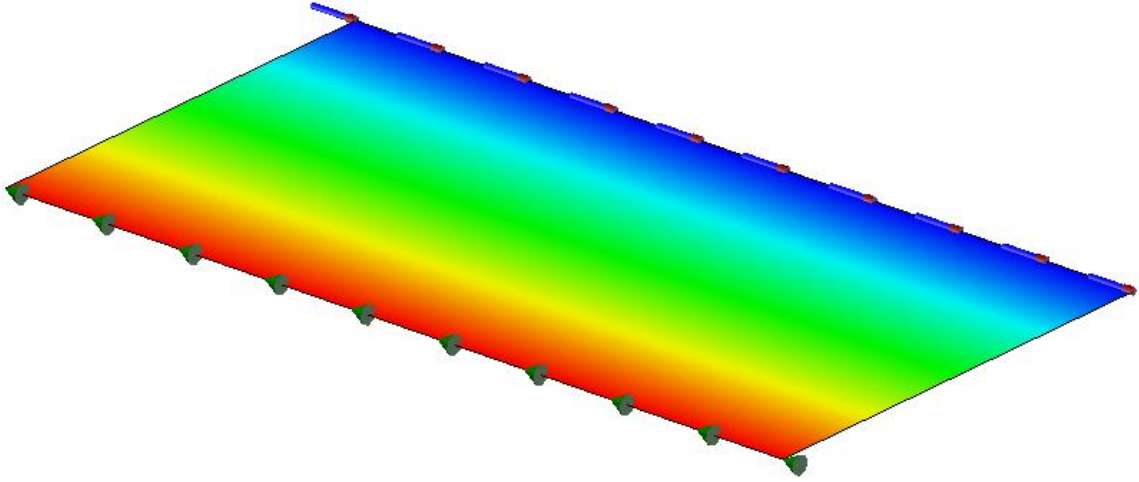
In order to satisfy the boundary conditions, the face was split and the convection was applied separately to each strip because the software does not currently allow ambient temperature variation for convection as a boundary condition.

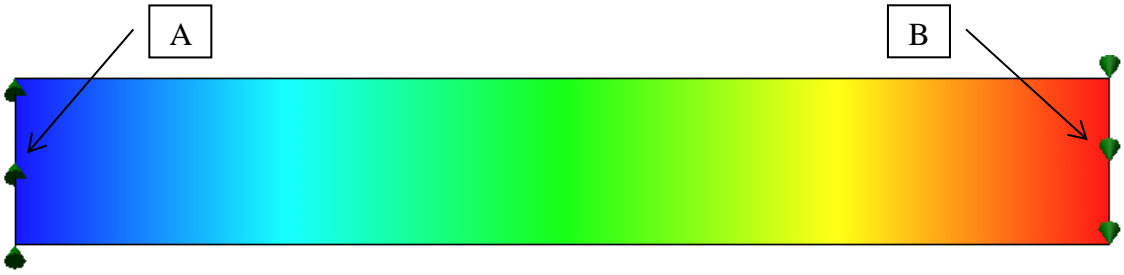
Because of this, the heat flux in Z is not uniform and the corresponding value $\nabla r, \varphi_z$ (W/m²) for is unavailable.

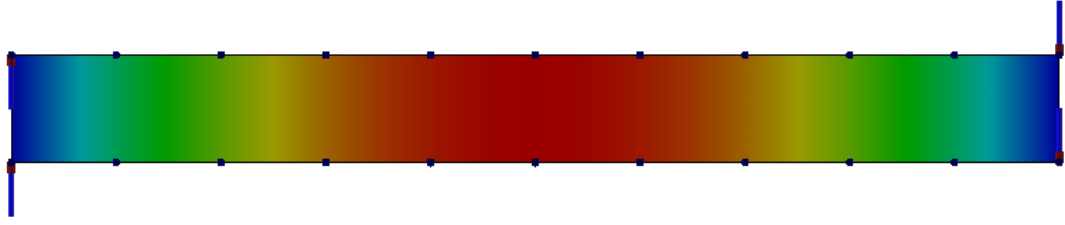
EVALUATION FORM					
Software: SOLIDWORKS Simulation			Version: 2019 SP2		
Computer configuration used: Lenovo ThinkStation S20, Windows 7 x64, Intel Xeon W3565, 12Gb RAM, graphics card NVIDIA Quadro 2000.					
Test name: TWO-MATERIAL PIPE : CONVECTION					
Codification: TPLA 08-89					
					
Test performed by : Julien BOISSAT			Date: 4/3/2019		
Model used					
Finite elements <input checked="" type="checkbox"/>		Boundary elements <input type="checkbox"/>		Other <input type="checkbox"/>	
Element type : TETRA 10					
Number of degrees of freedom or mesh density :					
Solid elements			Axisymmetric shell elements		
Nb of nodes	= 6500	Nb of nodes	= 2623		
Nb of elements	= 4063	Nb of elements	= 1260		
Nb of DOF	= 6500	Nb of DOF	= 2623		
Results :					
Physical quantity	Reference value	Calculated value		Deviation (%)	
		Solid	Shell	Solid	Shell
		T_i (°C)	25.42	25.42	25.42
T_m (°C)	17.69	17.69	17.69	0	0
T_e (°C)	12.11	12.11	12.11	0	0
φ_i (W/m ²)	6687.44	6686.2	6687.4	0.02	0
φ_m (W/m ²)	5732.09	5731.1	5732	0.02	0
φ_e (W/m ²)	5422.25	5421.4	5422.2	0.02	0
Φ/l (W/m)	12605.52	12603.2	12605.5	0.02	0
Comments :					
The Reference value of the output flux Φ/l is the heat flux for a 1m extrusion thicknes, and for the entire cross section.					

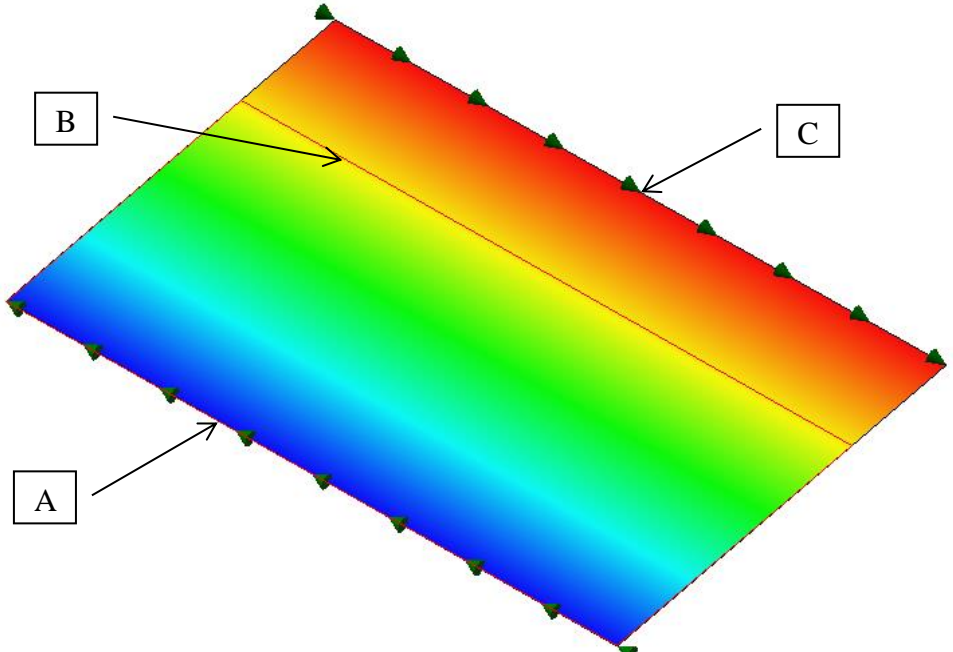
EVALUATION FORM																																					
Software: SOLIDWORKS Simulation	Version: 2019 SP2																																				
Computer configuration used: Lenovo ThinkStation S20, Windows 7 x64, Intel Xeon W3565, 12Gb RAM, graphics card NVIDIA Quadro 2000.																																					
Test name: TWO-MATERIAL PIPE : CONVECTION, THERMAL CONTACT RESISTANCE Codification: TPLA 09-89																																					
																																					
Test performed by : Julien BOISSAT	Date: 4/3/2019																																				
Model used Finite elements <input checked="" type="checkbox"/> Boundary elements <input type="checkbox"/> Other <input type="checkbox"/> Element type : TETRA 10 Number of degrees of freedom or mesh density : Nb of nodes = 12061 Nb of elements = 7645 Nb of DOF = 12061																																					
Results :																																					
<table border="1" style="width: 100%; border-collapse: collapse; text-align: center;"> <thead> <tr> <th style="text-align: left;">Physical quantity</th> <th>Reference value</th> <th>Calculated value</th> <th>Deviation</th> </tr> </thead> <tbody> <tr> <td style="text-align: left;">T_i (°C)</td> <td>25.11</td> <td>25.11</td> <td>0</td> </tr> <tr> <td style="text-align: left;">T_m^1 (°C)</td> <td>17.33</td> <td>17.33</td> <td>0</td> </tr> <tr> <td style="text-align: left;">T_m^2 (°C)</td> <td>5.91</td> <td>5.91</td> <td>0</td> </tr> <tr> <td style="text-align: left;">T_e (°C)</td> <td>0.3</td> <td>0.3</td> <td>0</td> </tr> <tr> <td style="text-align: left;">φ_i (W/m²)</td> <td>6732.90</td> <td>6732.7</td> <td>0</td> </tr> <tr> <td style="text-align: left;">φ_m (W/m²)</td> <td>5771.06</td> <td>5770.9</td> <td>0</td> </tr> <tr> <td style="text-align: left;">φ_e (W/m²)</td> <td>5459.11</td> <td>5459</td> <td>0</td> </tr> <tr> <td style="text-align: left;">Φ/l (W/m)</td> <td>12691.23</td> <td>12691.08</td> <td>0</td> </tr> </tbody> </table>		Physical quantity	Reference value	Calculated value	Deviation	T_i (°C)	25.11	25.11	0	T_m^1 (°C)	17.33	17.33	0	T_m^2 (°C)	5.91	5.91	0	T_e (°C)	0.3	0.3	0	φ_i (W/m ²)	6732.90	6732.7	0	φ_m (W/m ²)	5771.06	5770.9	0	φ_e (W/m ²)	5459.11	5459	0	Φ/l (W/m)	12691.23	12691.08	0
Physical quantity	Reference value	Calculated value	Deviation																																		
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φ_e (W/m ²)	5459.11	5459	0																																		
Φ/l (W/m)	12691.23	12691.08	0																																		
Comments : The Reference value of the output flux Φ/l is the heat flux for a 1m extrusion thicknes, and for the entire cross section.																																					

EVALUATION FORM																													
Software: SOLIDWORKS Simulation	Version: 2019 SP2																												
Computer configuration used: Lenovo ThinkStation S20, Windows 7 x64, Intel Xeon W3565, 12Gb RAM, graphics card NVIDIA Quadro 2000.																													
Test name: SIMPLE WALL : PRESCRIBED TEMPERATURES Codification: TPLL 01-89																													
																													
Test performed by : Julien BOISSAT	Date: 4/3/2019																												
Model used Finite elements <input checked="" type="checkbox"/> Boundary elements <input type="checkbox"/> Other <input type="checkbox"/> Element type : SHELL Number of degrees of freedom or mesh density : Nb of nodes = 5151 Nb of elements = 2500 Nb of DOF = 4949																													
Results : <table border="1" style="margin-left: auto; margin-right: auto; border-collapse: collapse; text-align: center;"> <thead> <tr> <th style="padding: 5px;">Location <i>x</i> (m)</th> <th style="padding: 5px;">Temperature <i>T</i> (°C)</th> <th style="padding: 5px;">Calculated value</th> <th style="padding: 5px;">Deviation (%)</th> </tr> </thead> <tbody> <tr><td style="padding: 5px;">0.00</td><td style="padding: 5px;">100.0</td><td style="padding: 5px;">100.0</td><td style="padding: 5px;">0</td></tr> <tr><td style="padding: 5px;">0.01</td><td style="padding: 5px;">84.0</td><td style="padding: 5px;">84.0</td><td style="padding: 5px;">0</td></tr> <tr><td style="padding: 5px;">0.02</td><td style="padding: 5px;">68.0</td><td style="padding: 5px;">68.0</td><td style="padding: 5px;">0</td></tr> <tr><td style="padding: 5px;">0.03</td><td style="padding: 5px;">52.0</td><td style="padding: 5px;">52.0</td><td style="padding: 5px;">0</td></tr> <tr><td style="padding: 5px;">0.04</td><td style="padding: 5px;">36.0</td><td style="padding: 5px;">36.0</td><td style="padding: 5px;">0</td></tr> <tr><td style="padding: 5px;">0.05</td><td style="padding: 5px;">20.0</td><td style="padding: 5px;">20.0</td><td style="padding: 5px;">0</td></tr> </tbody> </table>		Location <i>x</i> (m)	Temperature <i>T</i> (°C)	Calculated value	Deviation (%)	0.00	100.0	100.0	0	0.01	84.0	84.0	0	0.02	68.0	68.0	0	0.03	52.0	52.0	0	0.04	36.0	36.0	0	0.05	20.0	20.0	0
Location <i>x</i> (m)	Temperature <i>T</i> (°C)	Calculated value	Deviation (%)																										
0.00	100.0	100.0	0																										
0.01	84.0	84.0	0																										
0.02	68.0	68.0	0																										
0.03	52.0	52.0	0																										
0.04	36.0	36.0	0																										
0.05	20.0	20.0	0																										
Reference value of heat flux from face A to face B $\phi = 1200 \text{ W/m}^2$ Calculated value $\phi = 1200 \text{ W/m}^2$ Deviation (%) = 0																													
Comments :																													

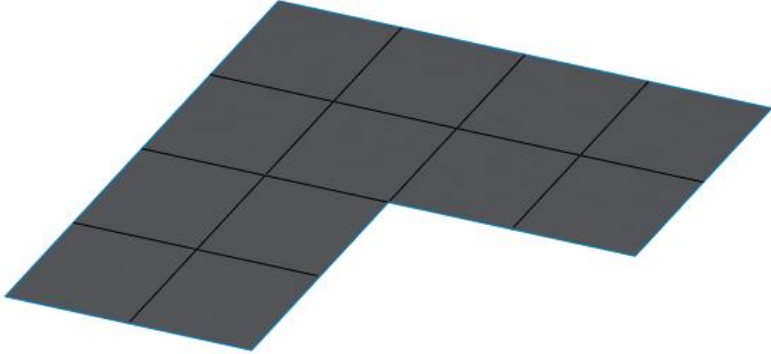
EVALUATION FORM																															
Software: SOLIDWORKS Simulation	Version: 2019 SP2																														
Computer configuration used: Lenovo ThinkStation S20, Windows 7 x64, Intel Xeon W3565, 12Gb RAM, graphics card NVIDIA Quadro 2000.																															
Test name: SIMPLE WALL : PRESCRIBED TEMPERATURES, CONVECTION Codification: TPLL 02-89																															
																															
Test performed by : Julien BOISSAT	Date: 4/3/2019																														
Model used Finite elements <input checked="" type="checkbox"/> Boundary elements <input type="checkbox"/> Other <input type="checkbox"/> Element type : SHELL Number of degrees of freedom or mesh density : Nb of nodes = 5151 Nb of elements = 2500 Nb of DOF = 5050																															
Results :																															
<table border="1" style="width: 100%; border-collapse: collapse; text-align: center;"> <thead> <tr> <th style="width: 15%;">Location <i>x</i> (m)</th> <th style="width: 20%;">Temperature <i>T</i> (°C)</th> <th style="width: 20%;">Calculated value</th> <th style="width: 20%;">Deviation (%)</th> </tr> </thead> <tbody> <tr><td>0.00</td><td>73.33</td><td>73.33</td><td>0</td></tr> <tr><td>0.01</td><td>62.67</td><td>62.67</td><td>0</td></tr> <tr><td>0.02</td><td>52</td><td>52</td><td>0</td></tr> <tr><td>0.03</td><td>41.33</td><td>41.33</td><td>0</td></tr> <tr><td>0.04</td><td>30.67</td><td>30.67</td><td>0</td></tr> <tr><td>0.05</td><td>20</td><td>20</td><td>0</td></tr> </tbody> </table>				Location <i>x</i> (m)	Temperature <i>T</i> (°C)	Calculated value	Deviation (%)	0.00	73.33	73.33	0	0.01	62.67	62.67	0	0.02	52	52	0	0.03	41.33	41.33	0	0.04	30.67	30.67	0	0.05	20	20	0
Location <i>x</i> (m)	Temperature <i>T</i> (°C)	Calculated value	Deviation (%)																												
0.00	73.33	73.33	0																												
0.01	62.67	62.67	0																												
0.02	52	52	0																												
0.03	41.33	41.33	0																												
0.04	30.67	30.67	0																												
0.05	20	20	0																												
Reference value of heat flux from face A to face B $\phi = 800 \text{ W/m}^2$ Calculated value $\phi = 800 \text{ W/m}^2$ Deviation (%) = 0																															
Comments :																															

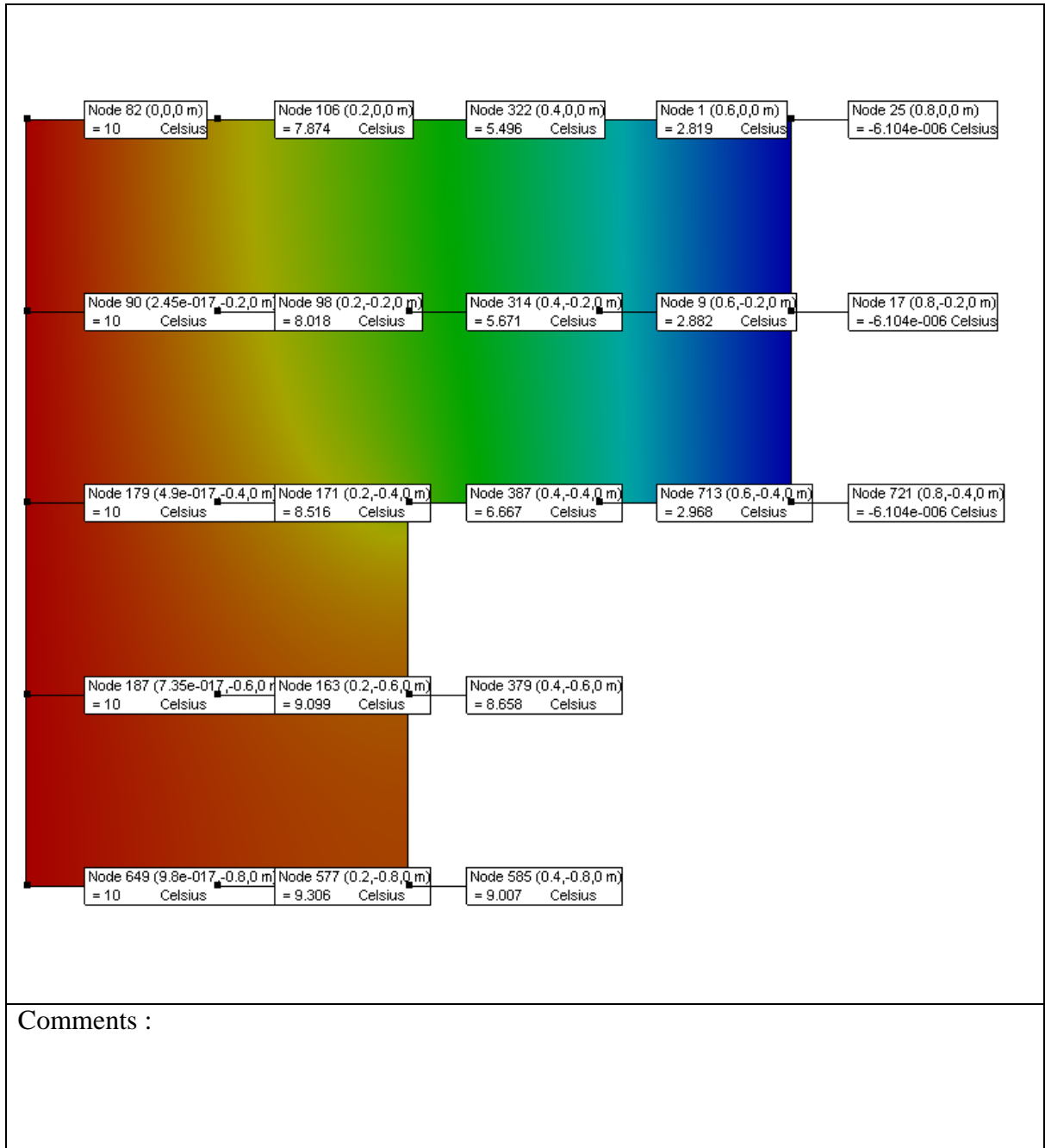
EVALUATION FORM																			
Software: SOLIDWORKS Simulation	Version: 2019 SP2																		
Computer configuration used: Lenovo ThinkStation S20, Windows 7 x64, Intel Xeon W3565, 12Gb RAM, graphics card NVIDIA Quadro 2000.																			
Test name: SIMPLE WALL : CONVECTION Codification: TPLL 03-89																			
																			
Test performed by : Julien BOISSAT	Date: 4/3/2019																		
Model used Finite elements <input checked="" type="checkbox"/> Boundary elements <input type="checkbox"/> Other <input type="checkbox"/> Element type : TRIANG Number of degrees of freedom or mesh density : Nb of nodes = 741 Nb of elements = 336 Nb of DOF = 741																			
Results :																			
<table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="width: 25%;">Location</th> <th style="width: 25%;">Reference value</th> <th style="width: 25%;">Calculated value</th> <th style="width: 25%;">Deviation(%)</th> </tr> </thead> <tbody> <tr> <td>T_A (°C)</td> <td style="text-align: center;">21.71</td> <td style="text-align: center;">21.71</td> <td style="text-align: center;">0</td> </tr> <tr> <td>T_B (°C)</td> <td style="text-align: center;">416.57</td> <td style="text-align: center;">416.57</td> <td style="text-align: center;">0</td> </tr> <tr> <td>ϕ (W/m²)</td> <td style="text-align: center;">834.2</td> <td style="text-align: center;">834.27</td> <td style="text-align: center;">0.01</td> </tr> </tbody> </table>				Location	Reference value	Calculated value	Deviation(%)	T_A (°C)	21.71	21.71	0	T_B (°C)	416.57	416.57	0	ϕ (W/m ²)	834.2	834.27	0.01
Location	Reference value	Calculated value	Deviation(%)																
T_A (°C)	21.71	21.71	0																
T_B (°C)	416.57	416.57	0																
ϕ (W/m ²)	834.2	834.27	0.01																
Comments :																			

EVALUATION FORM																									
Software: SOLIDWORKS Simulation	Version: 2019 SP2																								
Computer configuration used: Lenovo ThinkStation S20, Windows 7 x64, Intel Xeon W3565, 12Gb RAM, graphics card NVIDIA Quadro 2000.																									
Test name: POWER OUTPUT IN A BAR Codification: TPLL 04-89																									
																									
Test performed by : Julien BOISSAT	Date: 4/3/2019																								
Model used Finite elements <input checked="" type="checkbox"/> Boundary elements <input type="checkbox"/> Other <input type="checkbox"/> Element type : SHELL Number of degrees of freedom or mesh density : Nb of nodes = 4221 Nb of elements = 2000 Nb of DOF = 4179																									
Results :																									
<table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="width: 15%;">Location <i>x</i> (m)</th> <th style="width: 15%;">Reference value</th> <th style="width: 15%;">Calculated value</th> <th style="width: 15%;">Deviation (%)</th> </tr> </thead> <tbody> <tr> <td>0.0</td> <td rowspan="3" style="text-align: center;"><i>T</i> (°C)</td> <td>20.0</td> <td>0</td> </tr> <tr> <td>0.2</td> <td>28.0</td> <td>0</td> </tr> <tr> <td>0.5</td> <td>32.5</td> <td>0</td> </tr> <tr> <td>0.0</td> <td rowspan="3" style="text-align: center;">φ (W/m²)</td> <td>-50.0</td> <td>0</td> </tr> <tr> <td>0.2</td> <td>-30.0</td> <td>0</td> </tr> <tr> <td>0.5</td> <td>0.0</td> <td>0</td> </tr> </tbody> </table>		Location <i>x</i> (m)	Reference value	Calculated value	Deviation (%)	0.0	<i>T</i> (°C)	20.0	0	0.2	28.0	0	0.5	32.5	0	0.0	φ (W/m ²)	-50.0	0	0.2	-30.0	0	0.5	0.0	0
Location <i>x</i> (m)	Reference value	Calculated value	Deviation (%)																						
0.0	<i>T</i> (°C)	20.0	0																						
0.2		28.0	0																						
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0.2		-30.0	0																						
0.5		0.0	0																						
Comments :																									

EVALUATION FORM																					
Software: SOLIDWORKS Simulation	Version: 2019 SP2																				
Computer configuration used: Lenovo ThinkStation S20, Windows 7 x64, Intel Xeon W3565, 12Gb RAM, graphics card NVIDIA Quadro 2000																					
Test name: TWO-MATERIAL WALL : CONVECTION Codification: TPLL 05-89																					
																					
Test performed by : Julien BOISSAT	Date: 4/3/2019																				
Model used Finite elements <input checked="" type="checkbox"/> Boundary elements <input type="checkbox"/> Other <input type="checkbox"/> Element type : SHELL Number of degrees of freedom or mesh density : Nb of nodes = 4617 Nb of elements = 2240 Nb of DOF = 4617																					
Results :																					
<table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="width: 25%;">Location</th> <th style="width: 25%;">Reference value</th> <th style="width: 25%;">Calculated value</th> <th style="width: 25%;">Deviation(%)</th> </tr> </thead> <tbody> <tr> <td>T_A (°C)</td> <td style="text-align: center;">25</td> <td style="text-align: center;">25</td> <td style="text-align: center;">0</td> </tr> <tr> <td>T_B (°C)</td> <td style="text-align: center;">85</td> <td style="text-align: center;">85</td> <td style="text-align: center;">0</td> </tr> <tr> <td>T_C (°C)</td> <td style="text-align: center;">103</td> <td style="text-align: center;">103</td> <td style="text-align: center;">0</td> </tr> <tr> <td>φ (W/m²)</td> <td style="text-align: center;">-900</td> <td style="text-align: center;">-900</td> <td style="text-align: center;">0</td> </tr> </tbody> </table>		Location	Reference value	Calculated value	Deviation(%)	T_A (°C)	25	25	0	T_B (°C)	85	85	0	T_C (°C)	103	103	0	φ (W/m ²)	-900	-900	0
Location	Reference value	Calculated value	Deviation(%)																		
T_A (°C)	25	25	0																		
T_B (°C)	85	85	0																		
T_C (°C)	103	103	0																		
φ (W/m ²)	-900	-900	0																		
Comments :																					

EVALUATION FORM																									
Software: SOLIDWORKS Simulation	Version: 2019 SP2																								
Computer configuration used: Lenovo ThinkStation S20, Windows 7 x64, Intel Xeon W3565, 12Gb RAM, graphics card NVIDIA Quadro 2000.																									
Test name: TWO-MATERIAL WALL : CONVECTION, THERMAL CONTACT RESISTANCE Codification: TPLL 06-89																									
Test performed by : Julien BOISSAT	Date: 4/3/2019																								
Model used Finite elements <input checked="" type="checkbox"/> Boundary elements <input type="checkbox"/> Other <input type="checkbox"/> Element type : TETRA10 Number of degrees of freedom or mesh density : Nb of nodes = 11633 Nb of elements = 6971 Nb of DOF = 11633																									
Results : <table border="1" style="width: 100%; border-collapse: collapse; margin-top: 10px;"> <thead> <tr> <th style="text-align: center;">Location</th> <th style="text-align: center;">Reference value</th> <th style="text-align: center;">Calculated value</th> <th style="text-align: center;">Deviation (%)</th> </tr> </thead> <tbody> <tr> <td style="text-align: center;">T_A (°C)</td> <td style="text-align: center;">25</td> <td style="text-align: center;">25</td> <td style="text-align: center;">0</td> </tr> <tr> <td style="text-align: center;">T_{B^1} (°C)</td> <td style="text-align: center;">85</td> <td style="text-align: center;">85</td> <td style="text-align: center;">0</td> </tr> <tr> <td style="text-align: center;">T_{B^2} (°C)</td> <td style="text-align: center;">118.75</td> <td style="text-align: center;">118.75</td> <td style="text-align: center;">0</td> </tr> <tr> <td style="text-align: center;">T_C (°C)</td> <td style="text-align: center;">136.75</td> <td style="text-align: center;">136.75</td> <td style="text-align: center;">0</td> </tr> <tr> <td style="text-align: center;">φ (W/m²)</td> <td style="text-align: center;">-900</td> <td style="text-align: center;">-900</td> <td style="text-align: center;">0</td> </tr> </tbody> </table>		Location	Reference value	Calculated value	Deviation (%)	T_A (°C)	25	25	0	T_{B^1} (°C)	85	85	0	T_{B^2} (°C)	118.75	118.75	0	T_C (°C)	136.75	136.75	0	φ (W/m ²)	-900	-900	0
Location	Reference value	Calculated value	Deviation (%)																						
T_A (°C)	25	25	0																						
T_{B^1} (°C)	85	85	0																						
T_{B^2} (°C)	118.75	118.75	0																						
T_C (°C)	136.75	136.75	0																						
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Comments :																									

EVALUATION FORM																																																																			
Software: SOLIDWORKS Simulation	Version: 2019 SP2																																																																		
Computer configuration used: Lenovo ThinkStation S20, Windows 7 x64, Intel Xeon W3565, 12Gb RAM, graphics card NVIDIA Quadro 2000.																																																																			
Test name: L SHAPED PLATE WITH GEOMETRIC SINGULARITY Codification: TPLP 01-89																																																																			
																																																																			
Test performed by : Julien BOISSAT	Date: 4/3/2019																																																																		
Model used Finite elements <input checked="" type="checkbox"/> Boundary elements <input type="checkbox"/> Other <input type="checkbox"/> Element type : SHELL 6 Number of degrees of freedom or mesh density : Nb of nodes = 3201 Nb of elements = 1536 Nb of DOF = 3103																																																																			
Results :																																																																			
<table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="width: 33%;">Reference value T (°C)</th> <th style="width: 33%;">Calculated value T (°C)</th> <th style="width: 33%;">Deviation (%)</th> </tr> </thead> <tbody> <tr><td>10</td><td>10</td><td>0</td></tr> <tr><td>10</td><td>10</td><td>0</td></tr> <tr><td>10</td><td>10</td><td>0</td></tr> <tr><td>10</td><td>10</td><td>0</td></tr> <tr><td>10</td><td>10</td><td>0</td></tr> <tr><td>7.869</td><td>7.874</td><td>-0.06</td></tr> <tr><td>8.018</td><td>8.018</td><td>0</td></tr> <tr><td>8.514</td><td>8.516</td><td>-0.02</td></tr> <tr><td>9.001</td><td>9.099</td><td>-1.09</td></tr> <tr><td>9.316</td><td>9.306</td><td>0.11</td></tr> <tr><td>5.495</td><td>5.496</td><td>-0.02</td></tr> <tr><td>5.680</td><td>5.671</td><td>0.16</td></tr> <tr><td>6.667</td><td>6.667</td><td>0</td></tr> <tr><td>8.640</td><td>8.658</td><td>-0.21</td></tr> <tr><td>9.009</td><td>9.007</td><td>0.02</td></tr> <tr><td>2.816</td><td>2.819</td><td>-0.11</td></tr> <tr><td>2.881</td><td>2.882</td><td>-0.03</td></tr> <tr><td>2.972</td><td>2.968</td><td>0.13</td></tr> <tr><td>0</td><td>0</td><td>0</td></tr> <tr><td>0</td><td>0</td><td>0</td></tr> <tr><td>0</td><td>0</td><td>0</td></tr> </tbody> </table>		Reference value T (°C)	Calculated value T (°C)	Deviation (%)	10	10	0	10	10	0	10	10	0	10	10	0	10	10	0	7.869	7.874	-0.06	8.018	8.018	0	8.514	8.516	-0.02	9.001	9.099	-1.09	9.316	9.306	0.11	5.495	5.496	-0.02	5.680	5.671	0.16	6.667	6.667	0	8.640	8.658	-0.21	9.009	9.007	0.02	2.816	2.819	-0.11	2.881	2.882	-0.03	2.972	2.968	0.13	0	0	0	0	0	0	0	0	0
Reference value T (°C)	Calculated value T (°C)	Deviation (%)																																																																	
10	10	0																																																																	
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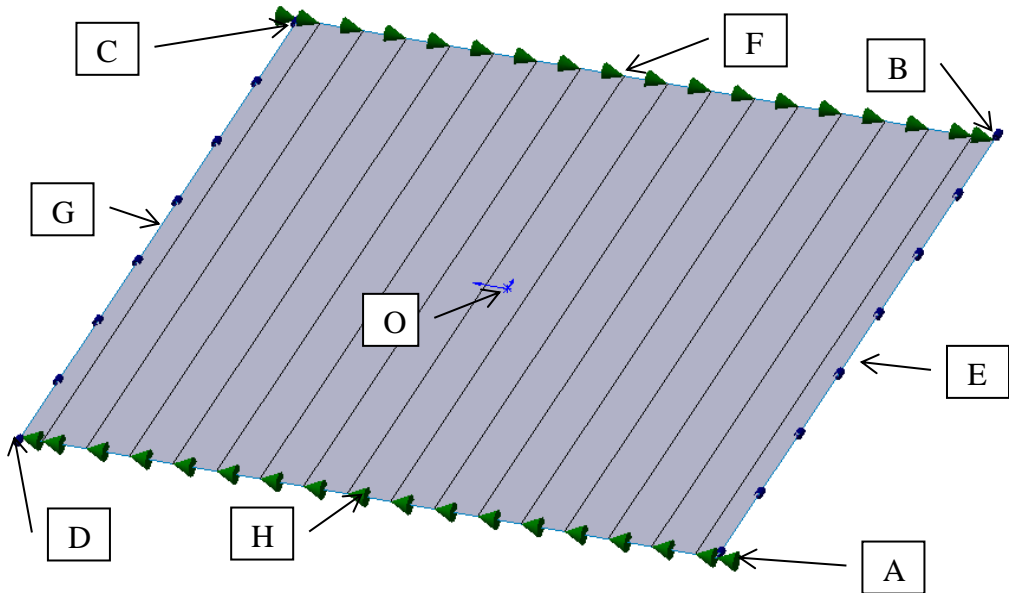


EVALUATION FORM

Software: SOLIDWORKS Simulation | Version: 2019 SP2

Computer configuration used: Lenovo ThinkStation S20, Windows 7 x64, Intel Xeon W3565, 12Gb RAM, graphics card NVIDIA Quadro 2000.

Test name: ORTHOTROPIC SQUARE
Codification: TPLP 02-89



Test performed by : Julien BOISSAT | Date: 4/3/2019

Model used

Finite elements | Boundary elements | Other

Element type : SHELL 6

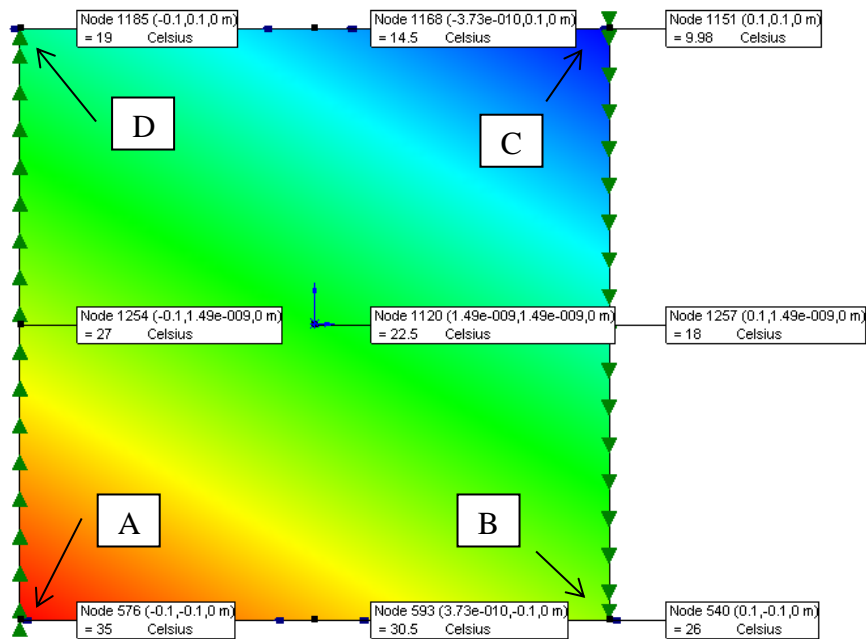
Number of degrees of freedom or mesh density :

Nb of nodes = 4575

Nb of elements = 2206

Nb of DOF = 4575

Results :



Point	Reference value T (°C)	Calculated value T (°C)	Deviation (%)
O	22.5	22.5	0
A	35.0	35.0	0
B	26.0	26.0	0
C	10.0	9.98	0.2
D	19.0	19.0	0
E	30.5	30.5	0
F	18.0	18.0	0
G	14.5	14.5	0
H	27.0	27.0	0
φ_x (W/m ²)	45.0	45.0	0
φ_y (W/m ²)	60.0	60.0	0

Comments :

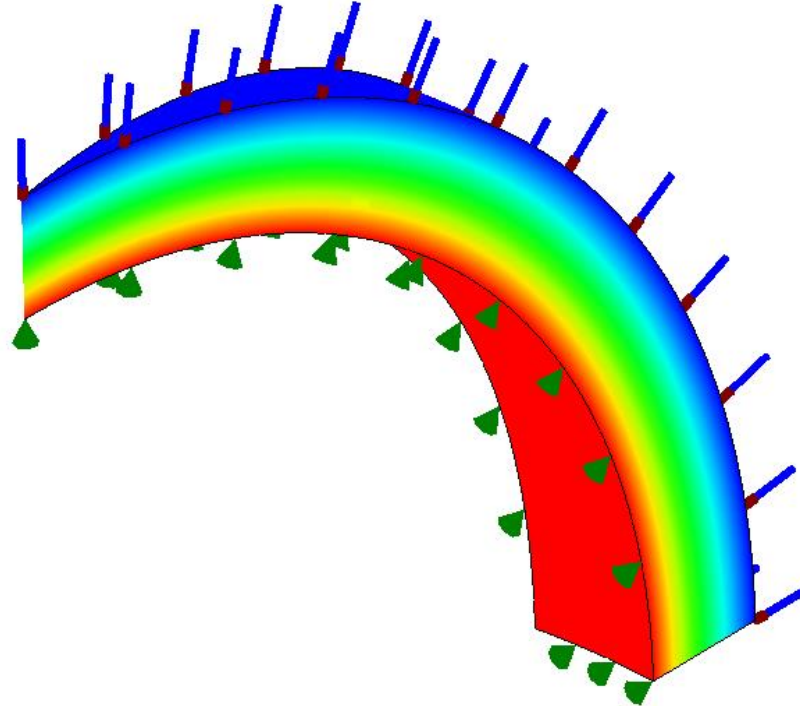
In order to apply the convection boundary condition, the edges in short were split in many shorter edged. The convection boundary condition was then applied separately to each one.

EVALUATION FORM

Software: SOLIDWORKS Simulation | Version: 2019 SP2

Computer configuration used: Lenovo ThinkStation S20, Windows 7 x64, Intel Xeon W3565, 12Gb RAM, graphics card NVIDIA Quadro 2000.

Test name: HOLLOW SPHERE: PRESCRIBED TEMPERATURES, CONVECTION
Codification: TPLV 02-89



Test performed by : Julien BOISSAT | Date: 4/3/2019

Model used

Finite elements | Boundary elements | Other

Element type : TETRA 10

Number of degrees of freedom or mesh density :

Nb of nodes = 7472

Nb of elements = 4441

Nb of DOF = 6765

Results :

<i>r</i> (m)	Reference value		Calculated value		Deviation (%)	
	<i>T</i> (°C)	φ (W/m ²)	<i>T</i> (°C)	φ (W/m ²)		
0.3	65.00	1050	65.00	1050.08	0	0.01
0.31	54.84	983.35	54.84	983.26	0	0.01
0.32	45.31	922.85	45.31	922.86	0	0
0.33	36.36	867.77	36.36	867.75	0	0
0.34	27.94	817.47	27.94	817.45	0	0
0.35	20.00	771.43	20.00	771.31	0	0.02

Comments :

EVALUATION FORM

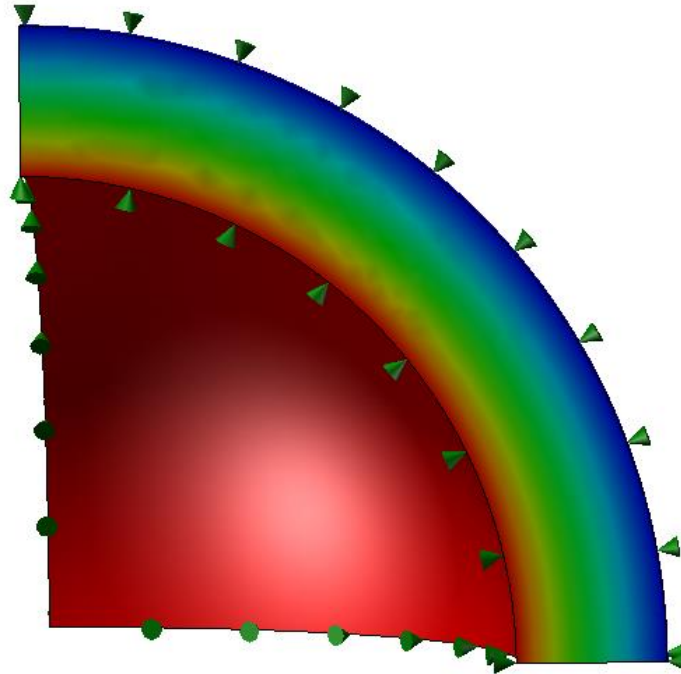
Software: SOLIDWORKS Simulation

Version: 2019 SP2

Computer configuration used: Lenovo ThinkStation S20, Windows 7 x64, Intel Xeon W3565, 12Gb RAM, graphics card NVIDIA Quadro 2000.

Test name: HOLLOW SPHERE: CONVECTION

Codification: TPLV 03-89



Test performed by : Julien BOISSAT

Date: 4/3/2019

Model used

Finite elements

Boundary elements

Other

Element type : TETRA 10 and TRIANG

Number of degrees of freedom or mesh density :

Solid elements

Nb of nodes = 11372

Nb of elements = 7252

Nb of DOF = 11372

Axisymmetric shell elements

Nb of nodes = 2697

Nb of elements = 1276

Nb of DOF = 2697

Results :

Physical quantity				Deviation (%)	
	Reference value	Calculated value		Solid	Shell
		Solid	Shell		
T_i (°C)	250.28	250.28	250.27	0	0
T_e (°C)	184.34	184.34	184.34	0	0
φ_i (W/m ²)	37458.77	37421.75	37448.18	0.10	0.03
φ_e (W/m ²)	21939.36	21923.73	21935.36	0.07	0.02
Φ (W)	42364.87	42364.8	42364	0	0

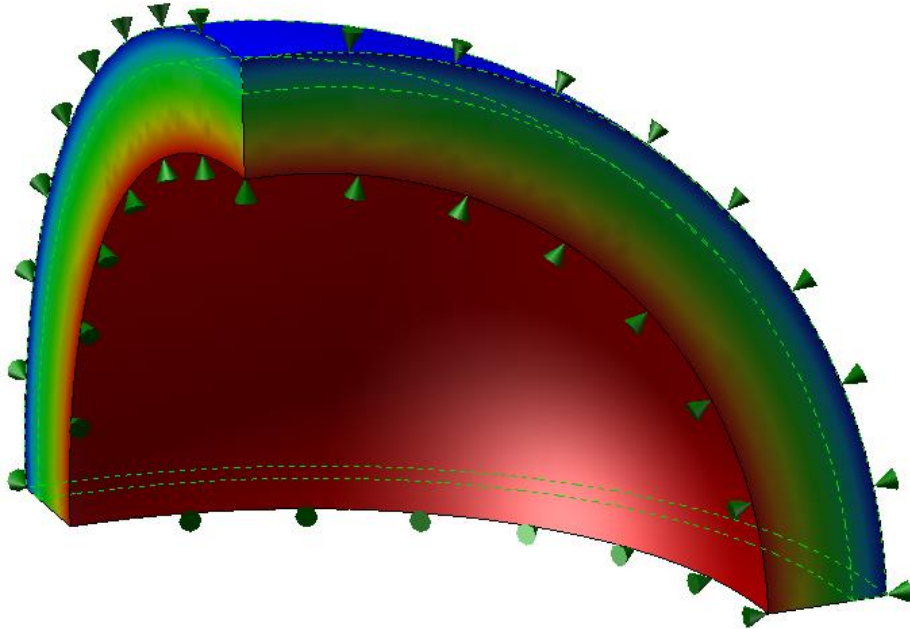
Comments :

EVALUATION FORM

Software: SOLIDWORKS Simulation | Version: 2019 SP2

Computer configuration used: Lenovo ThinkStation S20, Windows 7 x64, Intel Xeon W3565, 12Gb RAM, graphics card NVIDIA Quadro 2000.

Test name: TWO-MATERIAL HOLLOW SPHERE : CONVECTION
Codification: TPLV 04-89



Test performed by : Julien BOISSAT | Date: 4/3/2019

Model used

Finite elements | Boundary elements | Other

Element type : TETRA 10

Number of degrees of freedom or mesh density :

Nb of nodes = 8923

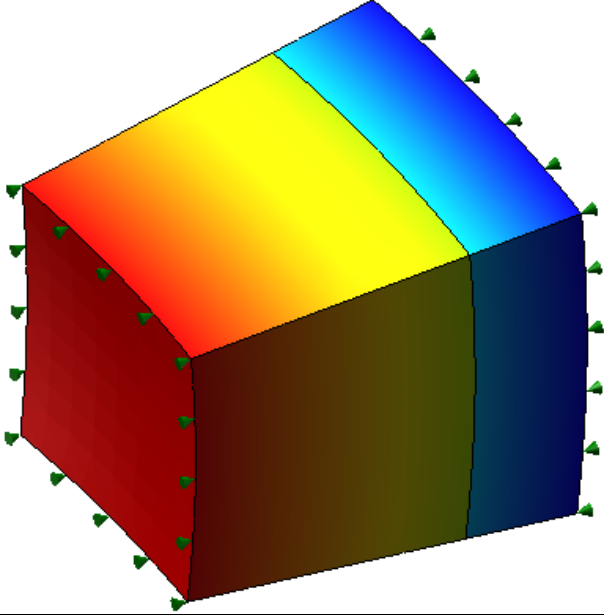
Nb of elements = 5498

Nb of DOF = 8923

Results :

Physical quantity	Reference value	Calculated value	Deviation (%)
T_i (°C)	25.06	25.06	0
T_m (°C)	17.84	17.84	0
T_e (°C)	13.16	13.16	0
φ_i (W/m ²)	6740.53	6729.3	-0.17
φ_m (W/m ²)	4952.23	4948.2	-0.08
φ_e (W/m ²)	4431.32	4430.9	-0.01
Φ (W)	7623.36	7623.36	0

Comments :

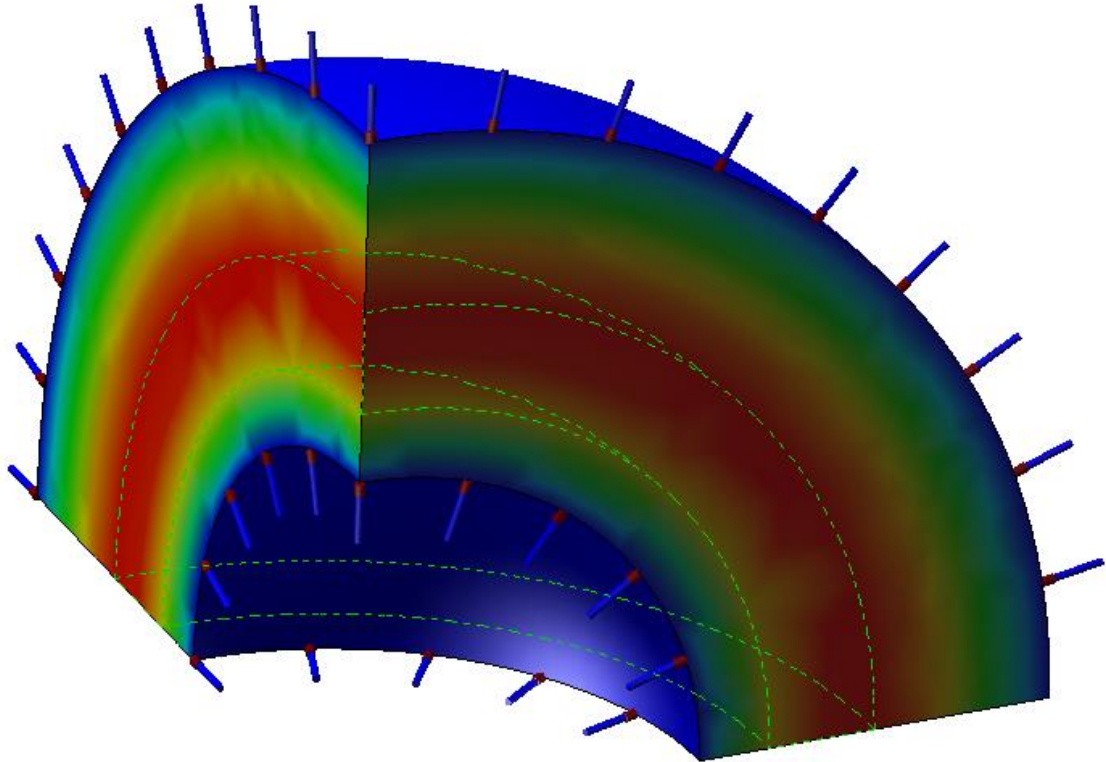
EVALUATION FORM																																					
Software: SOLIDWORKS Simulation	Version: 2019SP2																																				
Computer configuration used: Lenovo ThinkStation S20, Windows 7 x64, Intel Xeon W3565, 12Gb RAM, graphics card NVIDIA Quadro 2000.																																					
Test name: TWO-MATERIAL HOLLOW SPHERE: CONVECTION, THERMAL CONTACT RESISTANCE Codification: TPLV 05-89																																					
																																					
Test performed by : Julien BOISSAT	Date: 4/3/2019																																				
Model used Finite elements <input checked="" type="checkbox"/> Boundary elements <input type="checkbox"/> Other <input type="checkbox"/> Element type : TETRA 4 Number of degrees of freedom or mesh density : Nb of nodes = 10982 Nb of elements = 6973 Nb of DOF = 10982																																					
Results : <table border="1" style="width: 100%; border-collapse: collapse; margin-top: 10px;"> <thead> <tr> <th style="text-align: center;">Physical quantity</th> <th style="text-align: center;">Reference value</th> <th style="text-align: center;">Calculated value</th> <th style="text-align: center;">Deviation (%)</th> </tr> </thead> <tbody> <tr> <td style="text-align: center;">T_i (°C)</td> <td style="text-align: center;">25.02</td> <td style="text-align: center;">25.02</td> <td style="text-align: center;">0</td> </tr> <tr> <td style="text-align: center;">T_m^1 (°C)</td> <td style="text-align: center;">17.79</td> <td style="text-align: center;">17.79</td> <td style="text-align: center;">0</td> </tr> <tr> <td style="text-align: center;">T_m^2 (°C)</td> <td style="text-align: center;">7.87</td> <td style="text-align: center;">7.87</td> <td style="text-align: center;">0</td> </tr> <tr> <td style="text-align: center;">T_e (°C)</td> <td style="text-align: center;">3.18</td> <td style="text-align: center;">3.18</td> <td style="text-align: center;">0</td> </tr> <tr> <td style="text-align: center;">φ_i (W/m²)</td> <td style="text-align: center;">6747.33</td> <td style="text-align: center;">6746.8</td> <td style="text-align: center;">0.01</td> </tr> <tr> <td style="text-align: center;">φ_m (W/m²)</td> <td style="text-align: center;">4957.22</td> <td style="text-align: center;">4956.9</td> <td style="text-align: center;">0.01</td> </tr> <tr> <td style="text-align: center;">φ_e (W/m²)</td> <td style="text-align: center;">4435.79</td> <td style="text-align: center;">4435.5</td> <td style="text-align: center;">0.01</td> </tr> <tr> <td style="text-align: center;">Φ (W)</td> <td style="text-align: center;">7631.04</td> <td style="text-align: center;">7630.45</td> <td style="text-align: center;">0</td> </tr> </tbody> </table>		Physical quantity	Reference value	Calculated value	Deviation (%)	T_i (°C)	25.02	25.02	0	T_m^1 (°C)	17.79	17.79	0	T_m^2 (°C)	7.87	7.87	0	T_e (°C)	3.18	3.18	0	φ_i (W/m ²)	6747.33	6746.8	0.01	φ_m (W/m ²)	4957.22	4956.9	0.01	φ_e (W/m ²)	4435.79	4435.5	0.01	Φ (W)	7631.04	7630.45	0
Physical quantity	Reference value	Calculated value	Deviation (%)																																		
T_i (°C)	25.02	25.02	0																																		
T_m^1 (°C)	17.79	17.79	0																																		
T_m^2 (°C)	7.87	7.87	0																																		
T_e (°C)	3.18	3.18	0																																		
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Φ (W)	7631.04	7630.45	0																																		
Comments :																																					

EVALUATION FORM

Software: SOLIDWORKS Simulation | Version: 2019 B3

Computer configuration used: Lenovo ThinkStation S20, Windows 7 x64, Intel Xeon W3565, 12Gb RAM, graphics card NVIDIA Quadro 2000.

Test name: POWER OUTPUT IN A HOLLOW SPHERE
Codification: TPLV 06-89



Test performed by : Julien BOISSAT | Date: 4/3/2019

Model used

Finite elements | Boundary elements | Other

Element type : TETRA 10

Number of degrees of freedom or mesh density :

Nb of nodes = 11231

Nb of elements = 7431

Nb of DOF = 9817

Results :

r (m)	Reference value		Calculated value		Deviation (%)	
	T (°C)	Φ (W)	T (°C)	Φ (W)		
1.0	20.00	-837.8	20.00	-837.8	0	0
1.2	29.33	-532.8	29.33	-532.8	0	0
1.5	32.50	157.1	32.50	157.1	0	0

Comments :

EVALUATION FORM

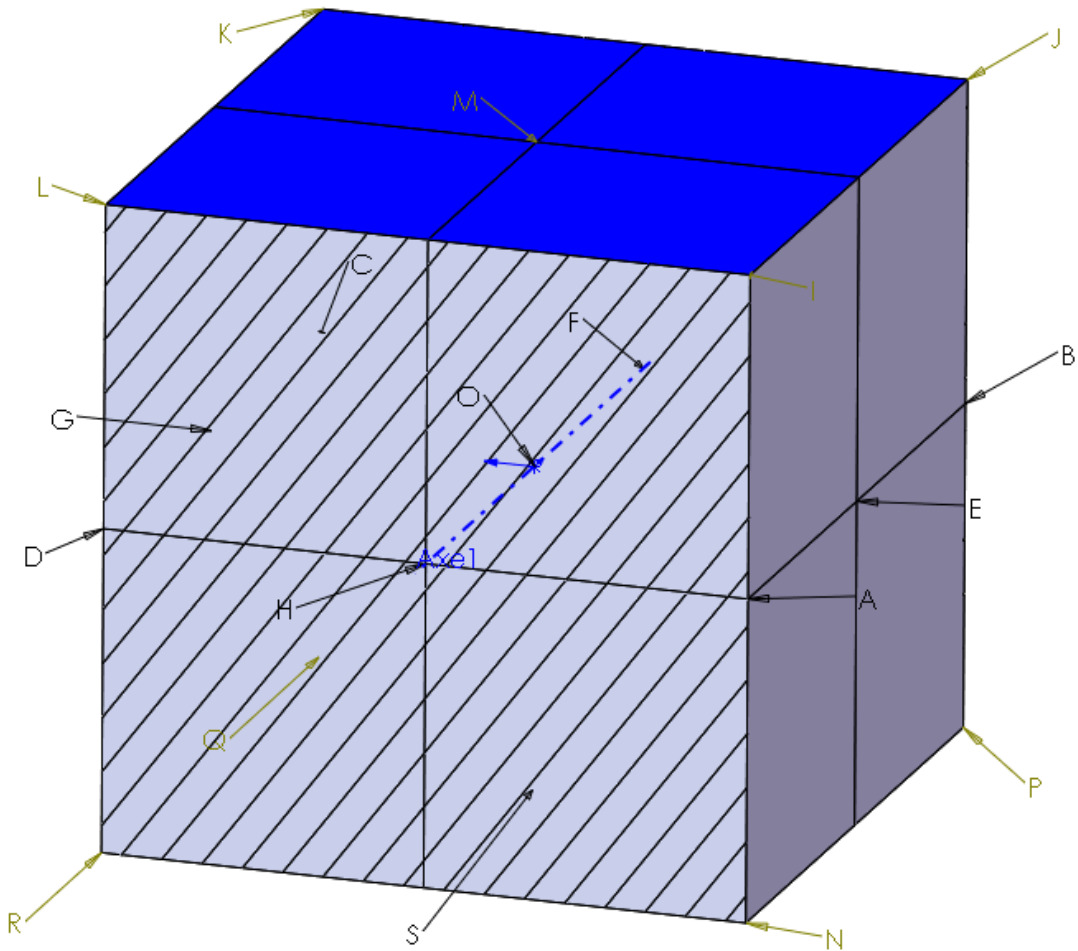
Software: SOLIDWORKS Simulation

Version: 2019 SP2

Computer configuration used: Lenovo ThinkStation S20, Windows 7 x64, Intel Xeon W3565, 12Gb RAM, graphics card NVIDIA Quadro 2000.

Test name: ORTHOTROPIC CUBE

Codification: TPLV 07-89



Test performed by : Julien BOISSAT

Date: 4/4/2019

Model used

Finite elements

Boundary elements

Other

Element type : TETRA 10

Number of degrees of freedom or mesh density :

Nb of nodes = 67289

Nb of elements = 46596

Nb of DOF = 67289

Results :

Point	Reference value T (°C)	Calculated value T (°C)	Deviation (%)
O	22.5	22.5	0
A	35.0	35.0	0
B	26.0	26.0	0
C	10.0	10.0	0
D	19.0	19.0	0
E	30.5	30.5	0
F	18.0	18.0	0
G	14.5	14.5	0
H	27.0	27.0	0
I	29.0	29.0	0
J	20.0	20.0	0
K	4.0	4.0	0
L	13.0	13.0	0
M	16.5	16.5	0
N	41.0	41.0	0
P	32.0	32.0	0
Q	16.0	16.0	0
R	25.0	25.0	0
S	28.5	28.5	0
φ_x (W/m ²)	45.0 = Cte	45.0	0
φ_y (W/m ²)	60.0 = Cte	60.0	0
φ_z (W/m ²)	30.0 = Cte	30.0	0

Comments :

In order to satisfy the boundary conditions, we had to split the faces and apply the convection separately to each small face because the software does not allow ambient temperature variation for convection as a boundary condition.

2. Non linear steady state thermal

EVALUATION FORM

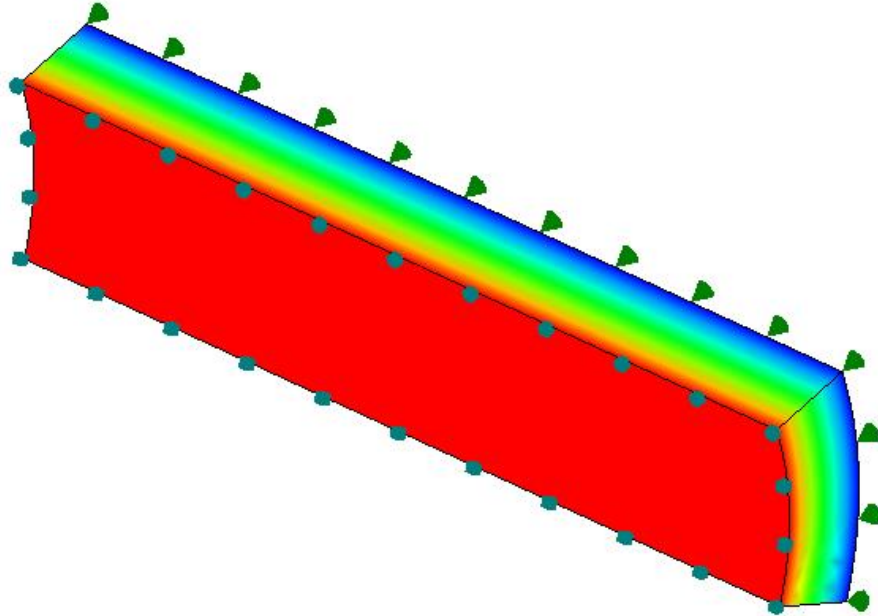
Software: SOLIDWORKS Simulation

Version: 2019 SP2

Computer configuration used: Lenovo ThinkStation S20, Windows 7 x64, Intel Xeon W3565, 12Gb RAM, graphics card NVIDIA Quadro 2000.

Test name: PIPE : CONVECTION, RADIATION

Codification: TPNA 01-89



Test performed by : Julien BOISSAT

Date: 4/4/2019

Model used

Finite elements

Boundary elements

Other

Element type : TETRA 10

Number of degrees of freedom or mesh density :

Nb of nodes = 8413

Nb of elements = 5164

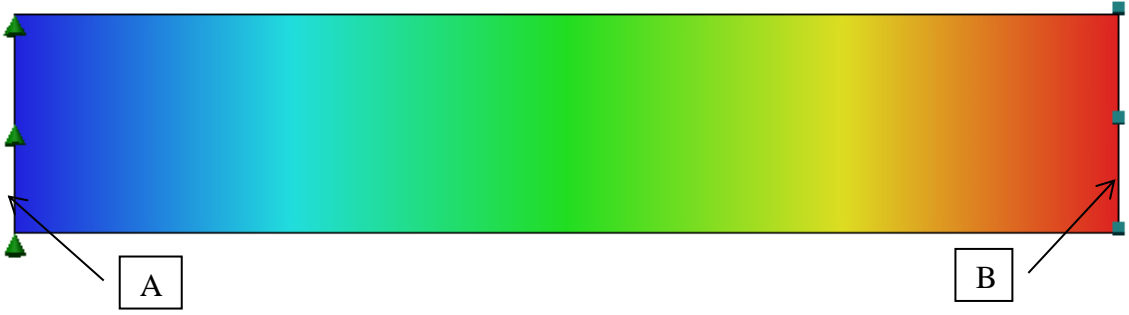
Nb of DOF = 8413

Results :

Physical quantity	Reference value	Calculated value	Deviation (%)
T_i (°C)	105.55	104.7	-0.81
T_e (°C)	82.56	81.93	-0.76
φ_i (W/m ²)	-11577.49	-11455.2	-1.06
φ_e (W/m ²)	-8822.98	-8790.55	-0.37
Φ (W)	21807.15	21605	-0.93

Comments :

The negative reference values for φ_i and φ_e indicate that their direction corresponds to the negative radial direction. Hence reporting values opposite to those given by the software for the radial direction.

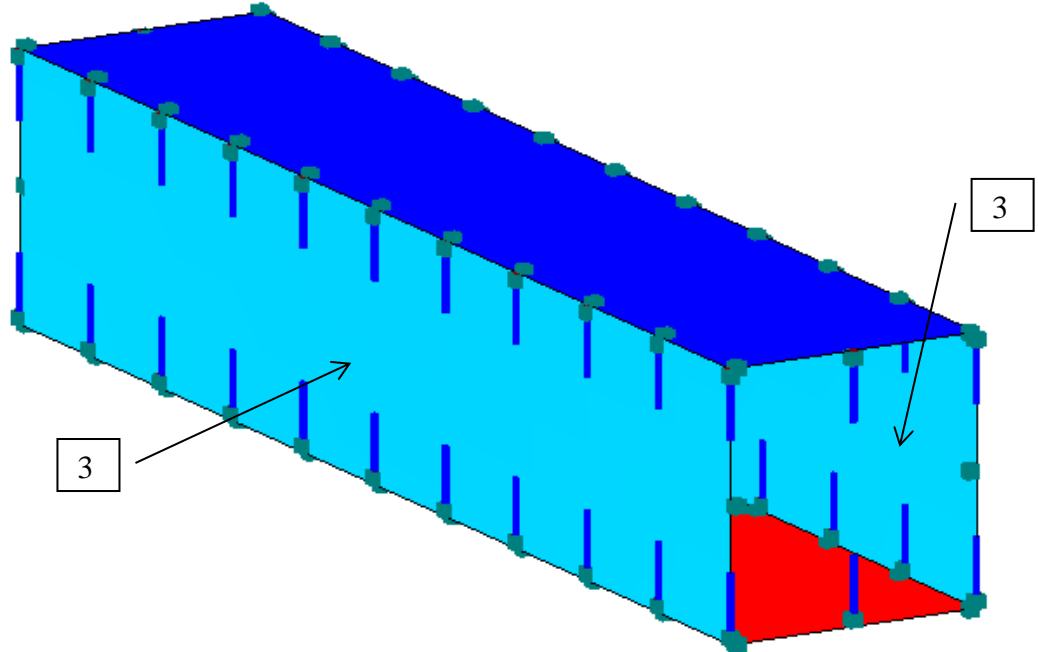
EVALUATION FORM																	
Software: SOLIDWORKS Simulation	Version: 2019 SP2																
Computer configuration used: Lenovo ThinkStation S20, Windows 7 x64, Intel Xeon W3565, 12Gb RAM, graphics card NVIDIA Quadro 2000.																	
Test name: SIMPLE WALL : CONVECTION, RADIATION Codification: TPNL 01-89																	
																	
Test performed by : Julien BOISSAT	Date: 4/4/2019																
Model used Finite elements <input checked="" type="checkbox"/> Boundary elements <input type="checkbox"/> Other <input type="checkbox"/> Element type : SHELL Number of degrees of freedom or mesh density : Nb of nodes = 4515 Nb of elements = 2168 Nb of DOF = 4515																	
Results : <table border="1" style="width: 100%; border-collapse: collapse; text-align: center;"> <thead> <tr> <th style="width: 25%;">Location</th> <th style="width: 25%;">Reference value</th> <th style="width: 25%;">Calculated value</th> <th style="width: 25%;">Deviation (%)</th> </tr> </thead> <tbody> <tr> <td>T_A (°C)</td> <td>28.56</td> <td>28.55</td> <td>0.04</td> </tr> <tr> <td>T_B (°C)</td> <td>488.27</td> <td>488.15</td> <td>0.02</td> </tr> <tr> <td>φ (W/m²)</td> <td>971.20</td> <td>971.05</td> <td>0.02</td> </tr> </tbody> </table>		Location	Reference value	Calculated value	Deviation (%)	T_A (°C)	28.56	28.55	0.04	T_B (°C)	488.27	488.15	0.02	φ (W/m ²)	971.20	971.05	0.02
Location	Reference value	Calculated value	Deviation (%)														
T_A (°C)	28.56	28.55	0.04														
T_B (°C)	488.27	488.15	0.02														
φ (W/m ²)	971.20	971.05	0.02														
Comments :																	

EVALUATION FORM

Software: SOLIDWORKS Simulation | Version: 2019 B3

Computer configuration used: Lenovo ThinkStation S20, Windows 7 x64, Intel Xeon W3565, 12Gb RAM, graphics card NVIDIA Quadro 2000.

Test name: RADIATION IN A SQUARE CAVITY
Codification: TPNP 01-89



Test performed by : Julien BOISSAT | Date: 4/4/2019

Model used

Finite elements | Boundary elements | Other

Element type : SHELL

Number of degrees of freedom or mesh density :

Nb of nodes = 608

Nb of elements = 968

Nb of DOF = 1272

Results :

Location	Reference value T (K)	Calculated value	Deviation (%)
Lateral face (3)	1192	1208.5	1.38

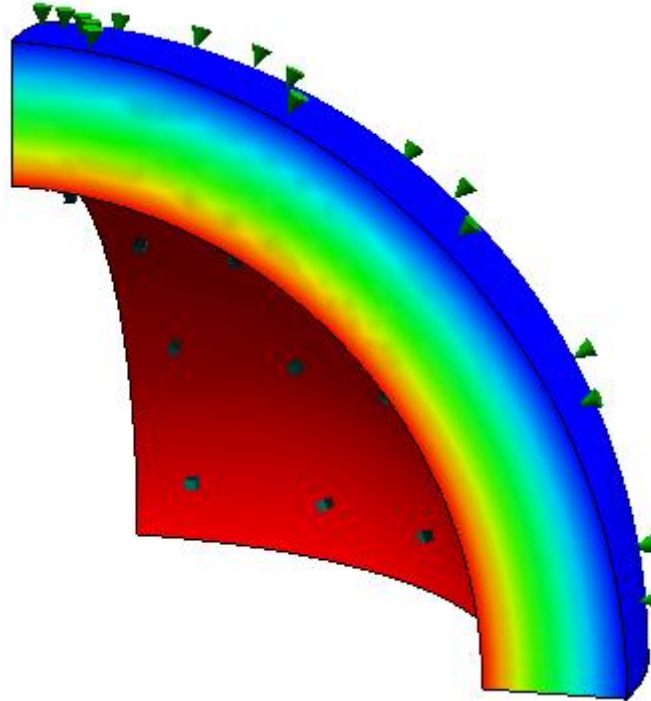
Comments :

EVALUATION FORM

Software: SOLIDWORKS Simulation | Version: 2019 SP2

Computer configuration used: Lenovo ThinkStation S20, Windows 7 x64, Intel Xeon W3565, 12Gb RAM, graphics card NVIDIA Quadro 2000.

Test name: HOLLOW SPHERE: CONVECTION, RADIATION
Codification: TPNV 01-89



Test performed by : Julien BOISSAT | Date: 4/4/2019

Model used
 Finite elements | Boundary elements | Other
 Element type : TETRA10
 Number of degrees of freedom or mesh density :
 Nb of nodes = 11421
 Nb of elements = 7298
 Nb of DOF = 11421

Results :

Physical quantity	Reference value	Calculated value	Deviation (%)
T_i (°C)	91.74	91.04	-0.76
T_e (°C)	71.13	70.70	-0.60
φ_i (W/m ²)	11666.60	11545	-1.04
φ_e (W/m ²)	6825.85 ⁽¹⁾	6763.6	-0.91
Φ (W)	13194.61	13069.6	-0.95

Comments :

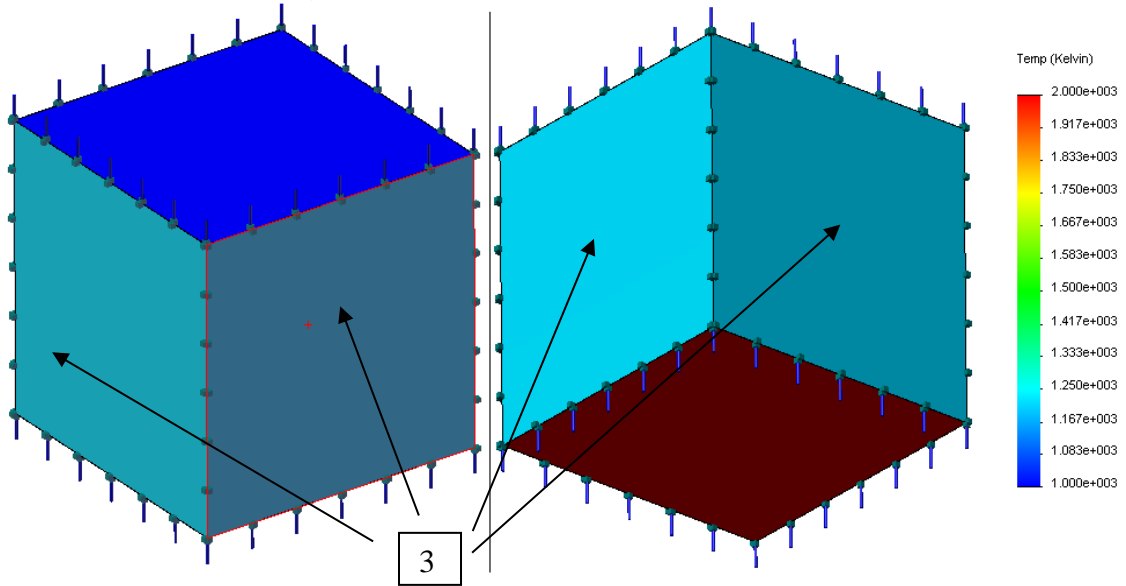
⁽¹⁾ Typo in the validation guide. Reference value φ_e was checked with the formula $\varphi_e = h_e(T_e - T_e^e)$

EVALUATION FORM

Software: SOLIDWORKS Simulation | Version: 2019 SP2

Computer configuration used: Lenovo ThinkStation S20, Windows 7 x64, Intel Xeon W3565, 12Gb RAM, graphics card NVIDIA Quadro 2000.

Test name: RADIATION IN A CUBIC CAVITY
Codification: TPNV 02-89



Test performed by : Julien BOISSAT | Date: 4/4/2019

Model used

Finite elements | Boundary elements | Other

Element type : SHELL 6

Number of degrees of freedom or mesh density :

Nb of nodes = 586

Nb of elements = 252

Nb of DOF = 628

Results :

Location	Reference value <i>T</i> (K)	Calculated value <i>T</i> (K)	Deviation (%)
Face (3) lateral	1223.4	1223.3	-0.008

Comments :

3. Transient linear THERMAL

EVALUATION FORM

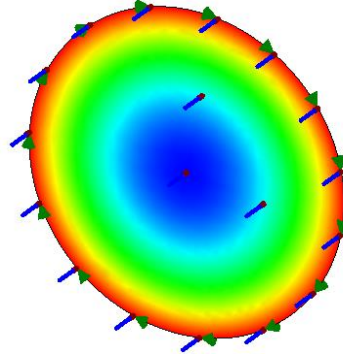
Software: SOLIDWORKS Simulation

Version: 2019 SP2

Computer configuration used: Lenovo ThinkStation S20, Windows 7 x64, Intel Xeon W3565, 12Gb RAM, graphics card NVIDIA Quadro 2000.

Test name: CYLINDER : HEAT TRANSFER BY CONVECTION

Codification: TTLA 01-89



Test performed by : Julien BOISSAT

Date: 4/4/2019

Model used

Finite elements

Boundary elements

Other

Element type : SHELL

Number of degrees of freedom or mesh density :

Nb of nodes = 1325

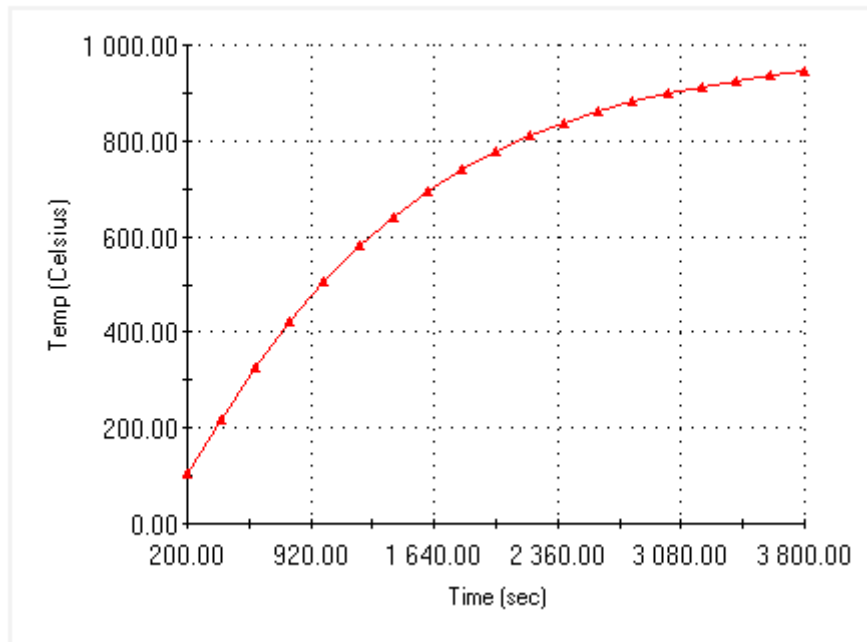
Nb of elements = 630

Nb of DOF = 1325

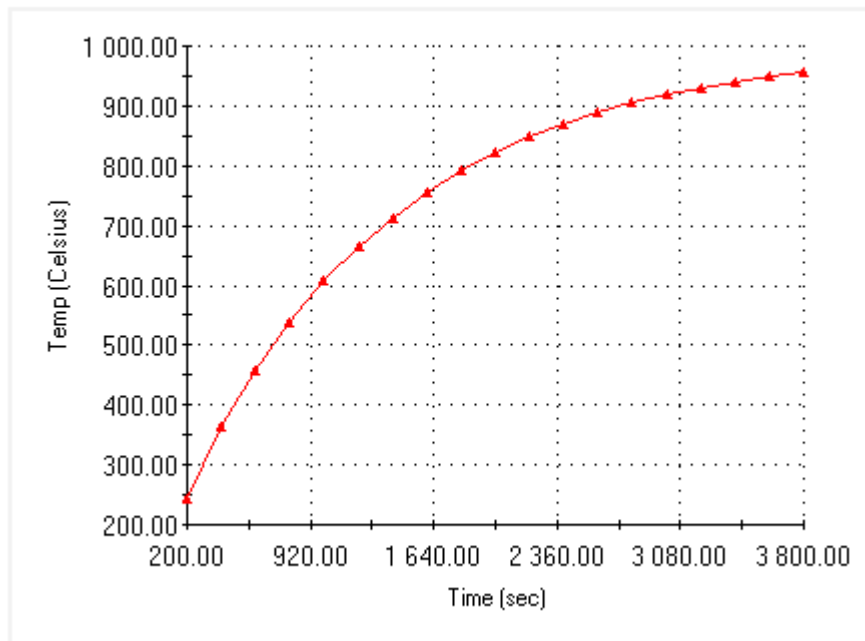
Results :

Time (s)	Reference values <i>T</i> (°C)		Calculated value <i>T</i> (°C)		Deviation (%)	
	Outer face	At center	Outer face	At center		
600	461	314	459	326	0.35	3.96
800	550	412	539	424	1.97	2.91
1000	637	510	607	508	4.73	0.36
1200	686	588	665	580	3.13	1.32
1400	735	657	714	642	2.89	2.32
1600	774	706	756	694	2.36	1.66
1800	813	755	792	739	2.64	2.10
2200	873	828	848	810	2.84	2.17
2600	910	880	889	862	2.25	2.08
3000	936	917	920	899	1.76	1.93
3400	951	941	941	927	1.01	1.52
3800	970	959	957	947	1.30	1.29

Temperature at center
Transient Sensor Graph



Temperature on outer face
Transient Sensor Graph



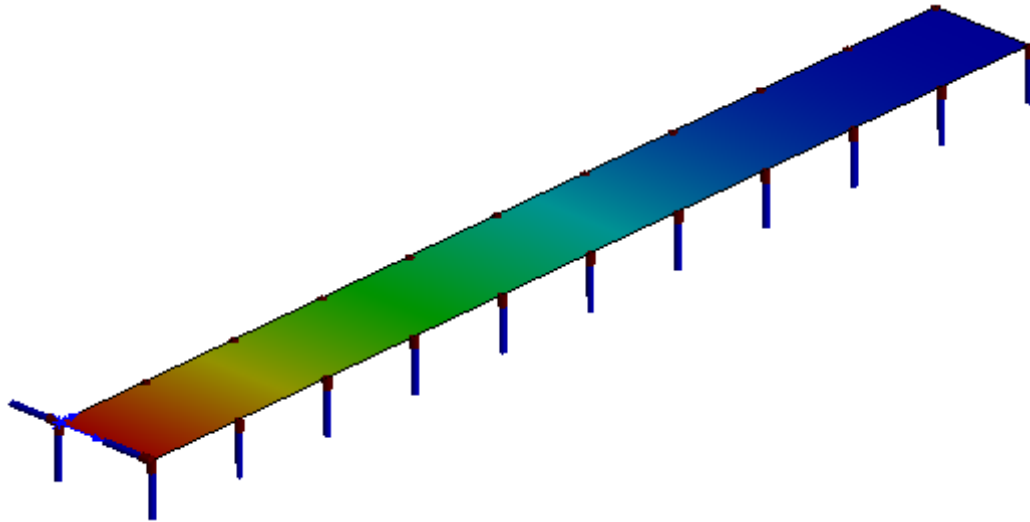
Comments :

EVALUATION FORM

Software: SOLIDWORKS Simulation | Version: 2019 SP2

Computer configuration used: Lenovo ThinkStation S20, Windows 7 x64, Intel Xeon W3565, 12Gb RAM, graphics card NVIDIA Quadro 2000.

Test name: WALL UNDER THERMAL SHOCK
Codification: TTLL 01-89



Test performed by : Julien BOISSAT | Date: 4/4/2019

Model used

Finite elements | Boundary elements | Other

Element type : SHELL

Number of degrees of freedom or mesh density :

Nb of nodes = 1111

Nb of elements = 500

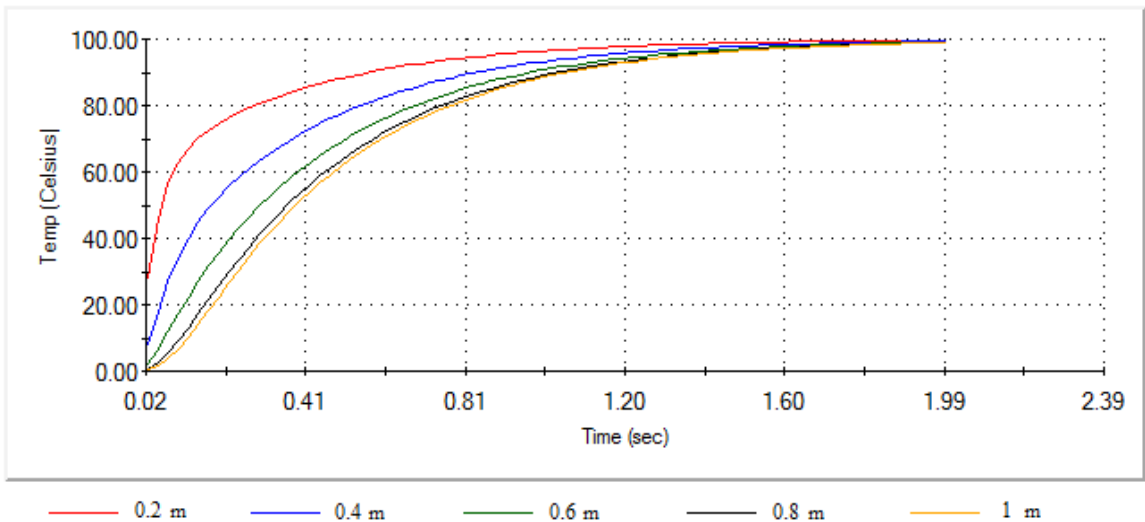
Nb of DOF = 1100

Results :

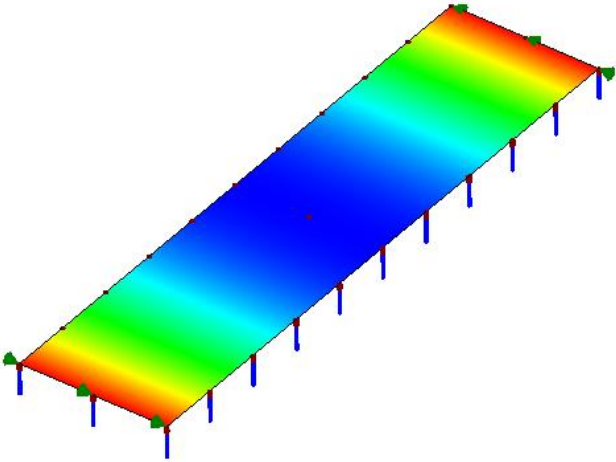
$T(x,t)$ n=45	Reference values			Calculated values			Deviation (%)		
	x (m)			x (m)			x (m)		
t (s)	0.2	0.4	0.6	62.49	34.27	17.26	4.56	7.74	4.88
0.1	62.49	34.27	17.26	74.61	52.46	35.82	1.29	2.57	3.09
0.2	74.61	52.46	35.82	80.64	63.31	49.71	0.67	1.47	2.24
0.3	80.64	63.31	49.71	84.87	71.25	60.46	0.54	1.19	1.87
0.4	84.87	71.25	60.46	88.11	77.39	68.88	0.48	1.05	1.59
0.5	88.11	77.39	68.88	90.65	82.21	75.51	0.44	0.92	1.37
0.6	90.65	82.21	75.51	92.64	86.00	80.73	0.40	0.80	1.18
0.7	92.64	86.00	80.73	94.21	88.98	84.83	0.34	0.69	1.00
0.8	94.21	88.98	84.83	95.44	91.33	88.06	0.30	0.60	0.86
0.9	95.44	91.33	88.06	96.41	93.17	90.60	0.26	0.51	0.72
1	96.41	93.17	90.60	97.78	95.77	94.18	0.19	0.37	0.52
1.2	97.78	95.77	94.18	98.62	97.38	96.39	0.14	0.26	0.36

1.4	98.62	97.38	96.39	98.62	97.38	96.39	0.14	0.26	0.36
1.6	99.15	98.38	97.77	99.15	98.38	97.77	0.09	0.19	0.25
1.8	99.47	98.99	98.62	99.47	98.99	98.62	0.07	0.13	0.18
2	99.67	99.38	99.14	99.67	99.38	99.14	0.05	0.08	0.12

$T(x,t)$ n=45	Reference values		Calculated values		Deviation (%)	
	x (m)		x (m)		x (m)	
t (s)	0.8	1	0.8	1	0.8	1
0.1	8.09	5.07	8.92	6.49	10.30	28.06
0.2	26.37	22.77	25.71	22.35	2.49	1.84
0.3	42.27	39.32	41.08	38.13	2.81	3.03
0.4	54.87	52.55	53.55	51.17	2.41	2.62
0.5	64.74	62.92	63.43	61.55	2.03	2.18
0.6	72.45	71.03	71.21	69.73	1.71	1.83
0.7	78.47	77.36	77.34	76.18	1.44	1.53
0.8	83.18	82.31	82.17	81.25	1.22	1.29
0.9	86.86	86.18	85.96	85.24	1.03	1.09
1	89.73	89.20	88.95	88.38	0.87	0.92
1.2	93.73	93.41	93.16	92.80	0.61	0.65
1.4	96.17	95.98	95.76	95.54	0.43	0.46
1.6	97.66	97.54	97.37	97.24	0.29	0.31
1.8	98.57	98.50	98.37	98.29	0.20	0.21
2	99.13	99.08	98.99	98.94	0.14	0.14



Comments :

EVALUATION FORM						
Software: SOLIDWORKS Simulation			Version: 2019 B1			
Computer configuration used: Lenovo ThinkStation S20, Windows 7 x64, Intel Xeon W3565, 12Gb RAM, graphics card NVIDIA Quadro 2000.						
Test name: PLATE : HEAT TRANSFER BY CONVECTION						
Codification: TTLL 02-89						
						
Test performed by : Julien BOISSAT			Date: 4/4/2019			
Model used Finite elements <input checked="" type="checkbox"/> Boundary elements <input type="checkbox"/> Other <input type="checkbox"/> Element type : SHELL Number of degrees of freedom or mesh density : Nb of nodes = 10251 Nb of elements = 5000 Nb of DOF = 10251						
Results :						
Time (s)	Reference temperatures(°C)		Calculated temperatures(°C)		Deviations (%)	
	On surface	At center	On surface	At center		
800	412	264	394	245	4.45	7.33
1000	461	314	441	303	4.30	3.34
1500	559	451	544	432	2.68	4.31
2000	647	550	628	536	2.95	2.52
2500	711	637	696	621	2.06	2.44
3000	764	710	752	691	1.54	2.66
3500	814	765	798	748	1.99	2.23
4000	848	813	835	794	1.53	2.30
5000	902	877	890	863	1.32	1.59
6000	936	920	927	909	0.98	1.22
7000	958	948	951	939	0.70	0.92
8000	972	966	968	960	0.46	0.67
Comments:						

III. THERMOMECHANICS

4. Linear static

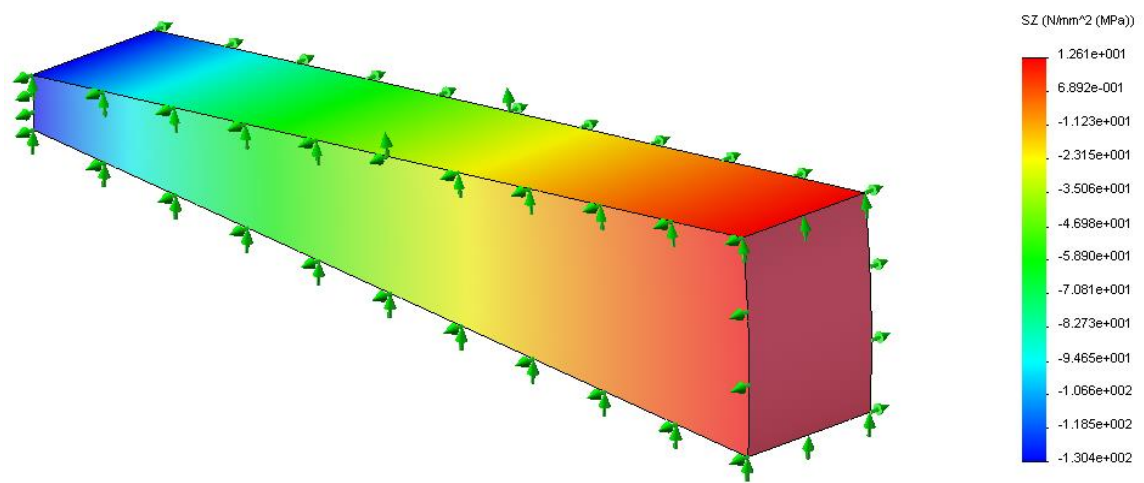
EVALUATION FORM

Software: SOLIDWORKS Simulation | Version: 2019 SP2

Computer configuration used: Lenovo ThinkStation S20, Windows 7 x64, Intel Xeon W3565, 12Gb RAM, graphics card NVIDIA Quadro 2000.

Test name: THICK PIPE SUBMITTED TO A THERMAL GRADIENT

Codification: HSLA 03-89



Test performed by : Julien BOISSAT | Date: 4/4/2019

Model used
 Finite elements | Boundary elements | Other
 Element type : TETRA 10
 Number of degrees of freedom or mesh density :
 Nb of nodes = 11361
 Nb of elements = 7238
 Nb of DOF = 34083

Results :

Location	Physical quantity and reference unit		Calculated value	Deviation (%)
$r = R_i$	σ_θ (Pa)	-100.86×10^6	-100.79×10^6	-0.07
	σ_z (Pa)	-130.26×10^6	-130.26×10^6	0.00
	u_r (m)	7.644×10^{-6}	7.644×10^{-6}	0.00
$r = R_e$	σ_θ (Pa)	42.00×10^6	42.00×10^6	0.00
	σ_z (Pa)	12.6×10^6	12.608×10^6	0.06
	u_r (m)	30.6×10^{-6}	30.508×10^{-6}	0.30

Comments :

IV. BIBLIOGRAPHY

Roark and Timoshenko books are classic references used by many engineers.

Title : Guide de validation des logiciels de calcul de structures

Author : Société Française des Mécaniciens

Editor : Association Française de Normalisation (AFNOR)

Language : French

ISSN: 0297-4827

ISBN-10: 2124866117

ISBN-13: 978-2124866113

Title : ROARK's Formulas for Stress & Strain 6th edition

Author : Warren C. Young

Editor : MCGRAW-HILL INTERNATIONAL EDITIONS

Language : English

ISBN-10: 0071003738

Title : Théorie des plaques et coques (Theory of plates and shells)

Author : S. Timoshenko, S. Woinowsky-Krieger

Editor : DUNOD

Language : French

Library polytechnique Ch. Beranger N° 5768 – 2nd trimestre 1968

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