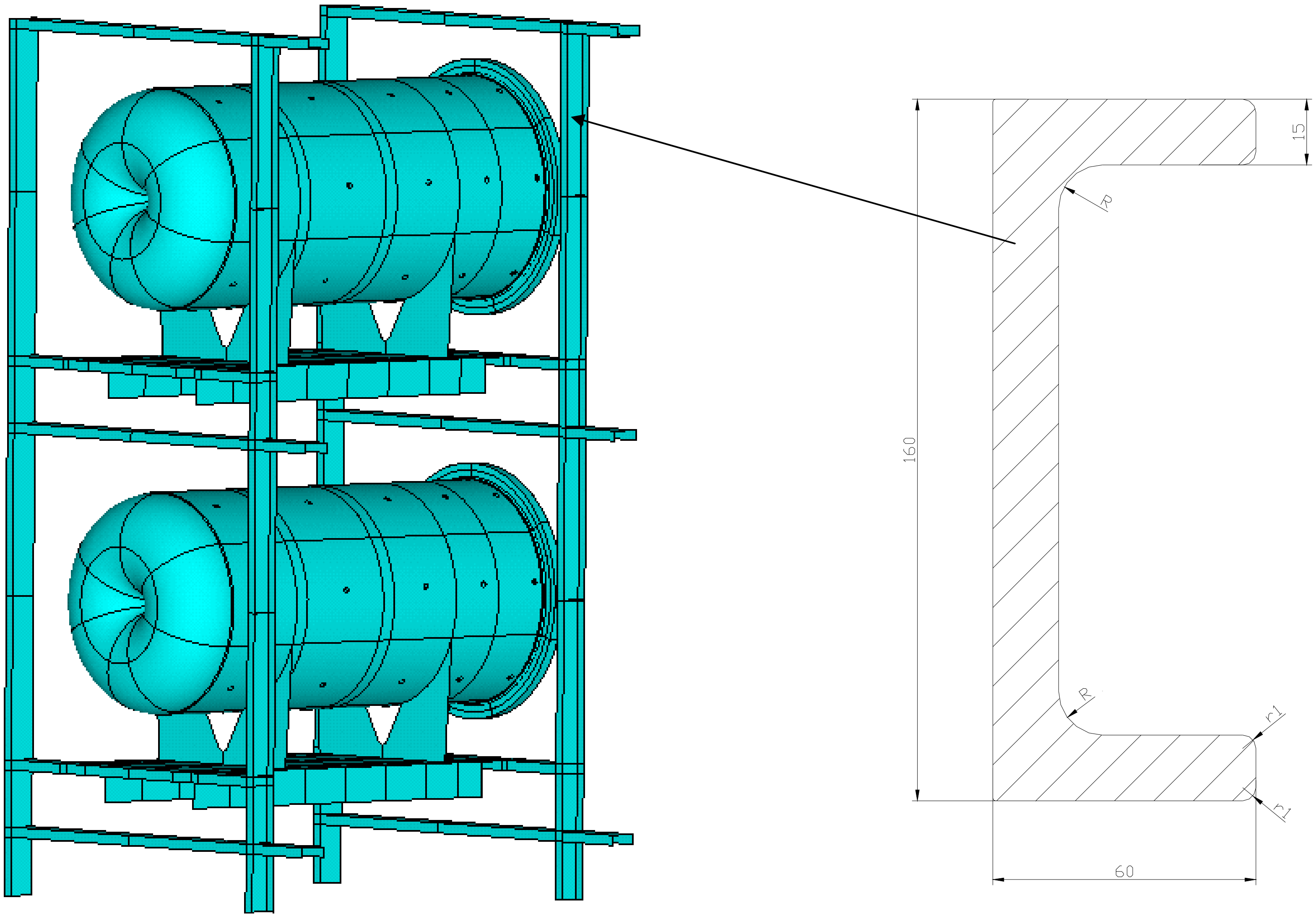
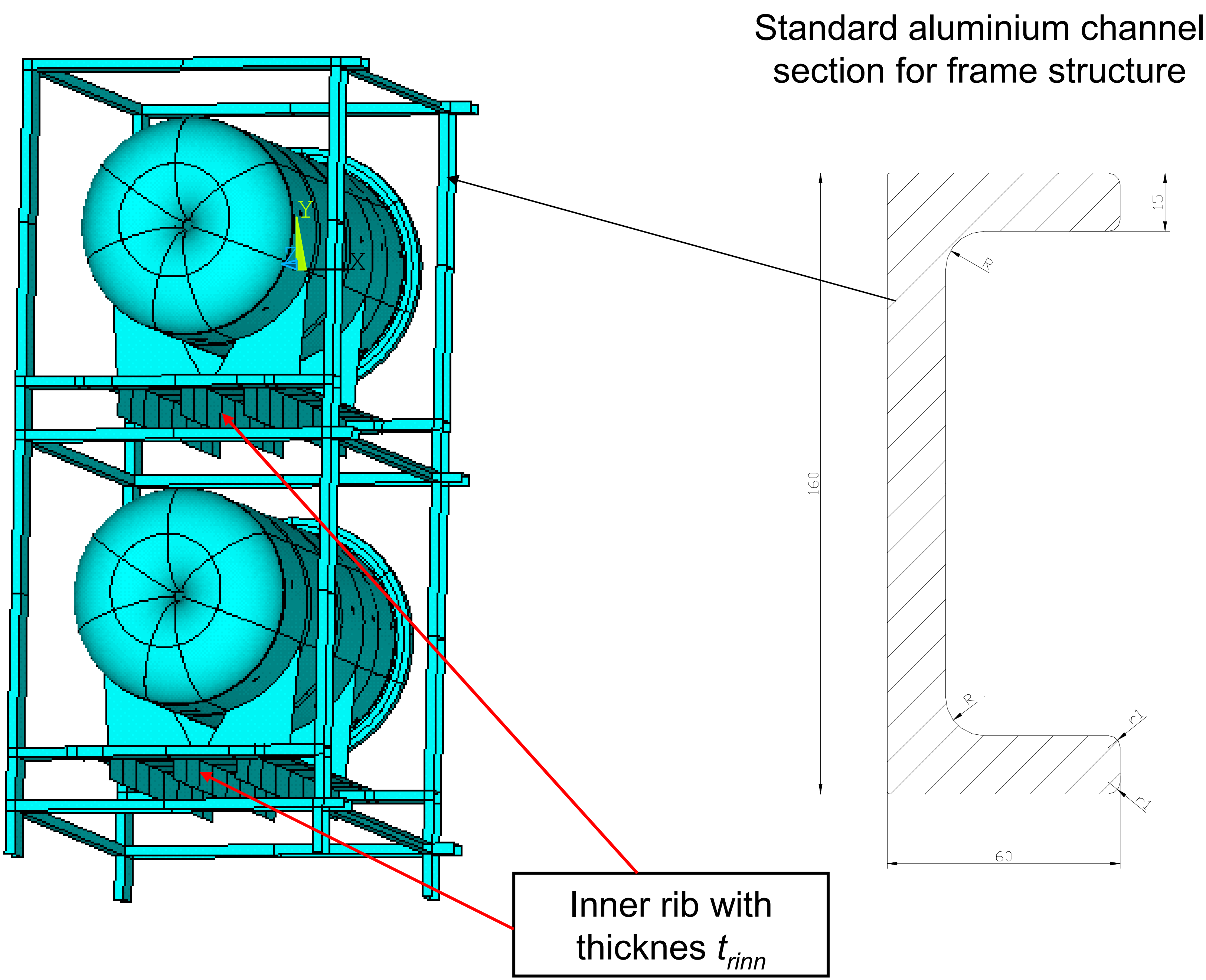
Four horns support system – update (17 April 2012)

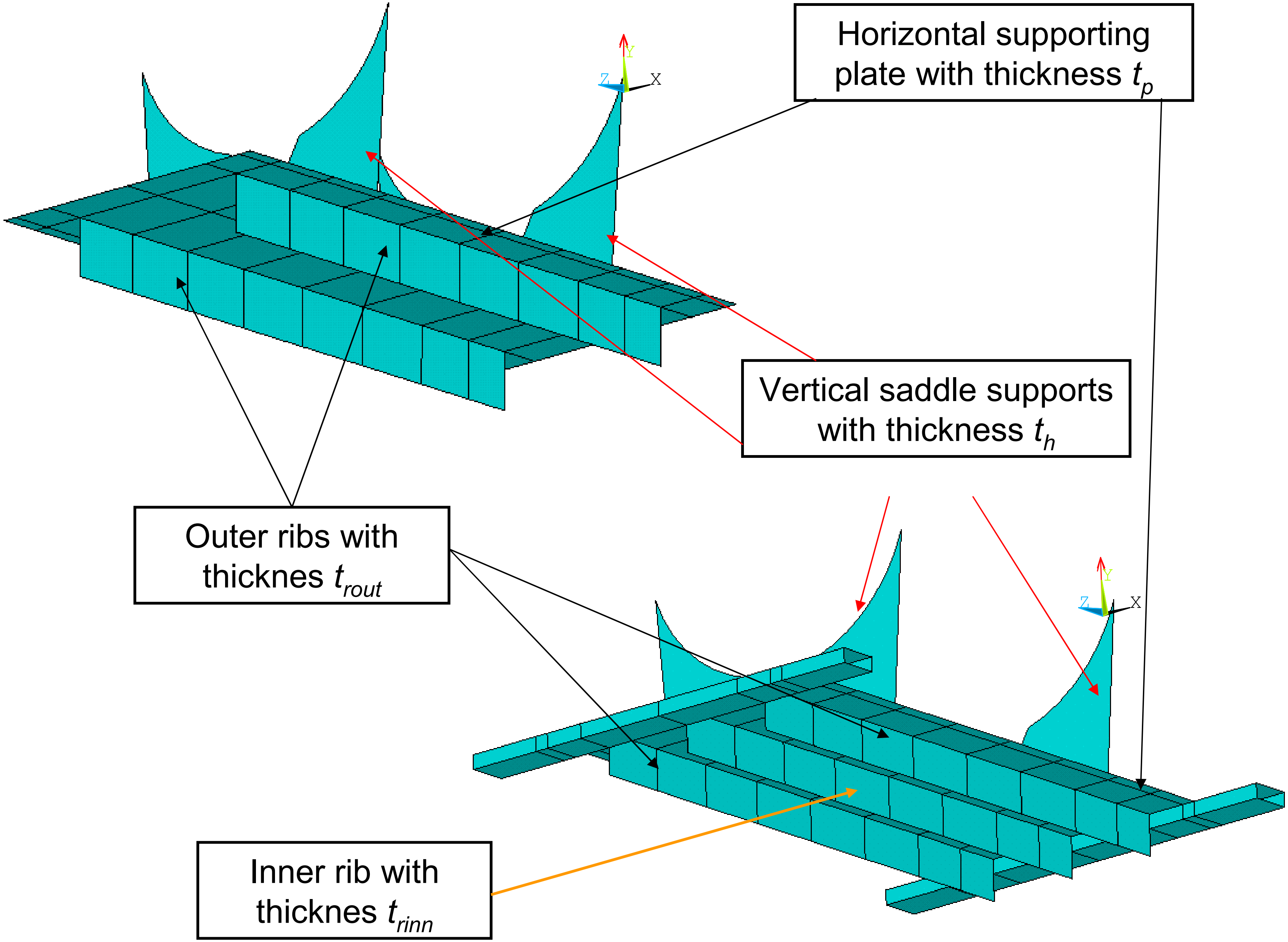
B.Szybiński, Cracow University of Technology

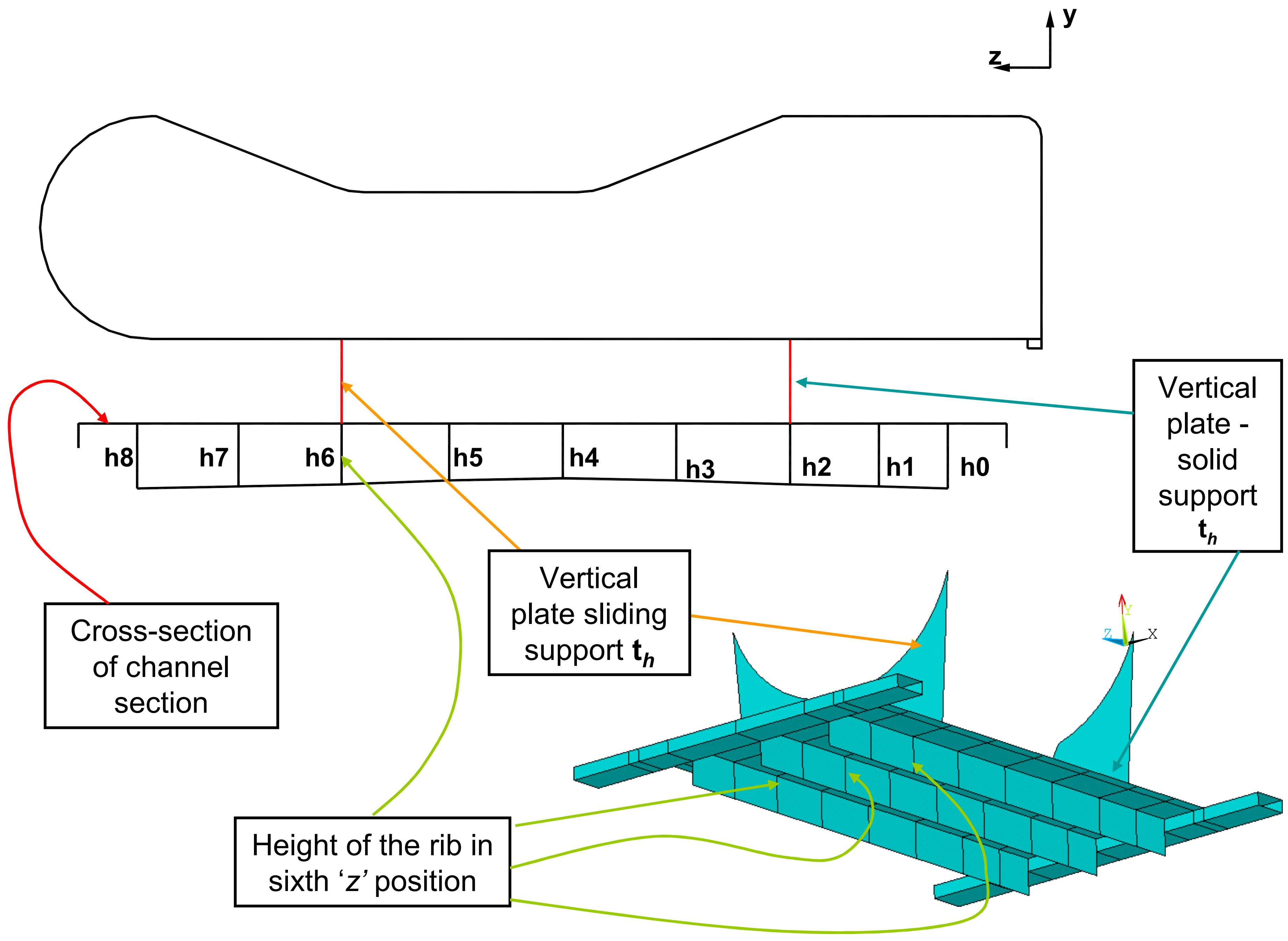
Standard aluminium channel
section for frame structure

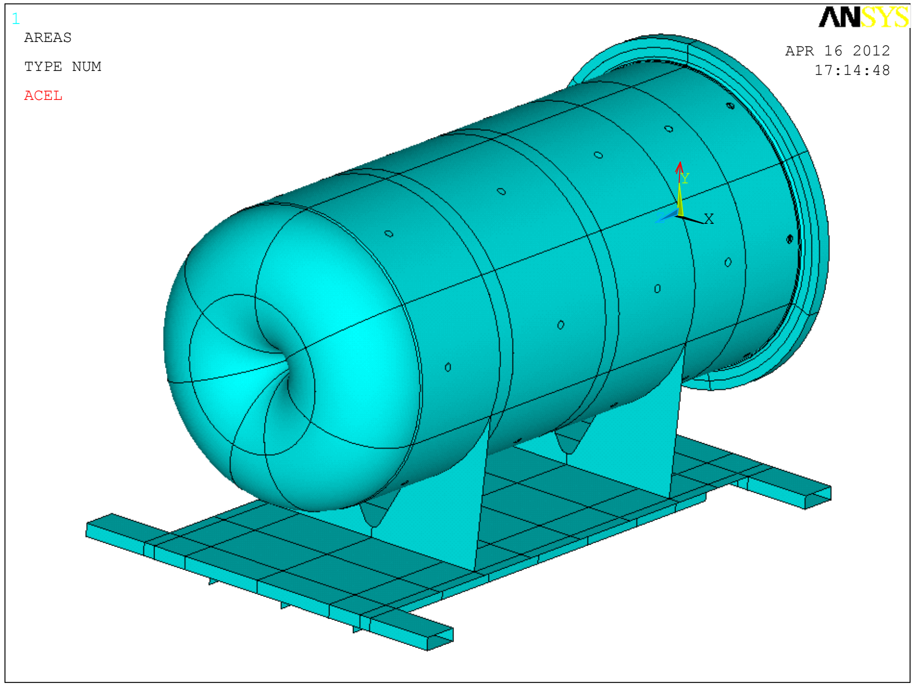


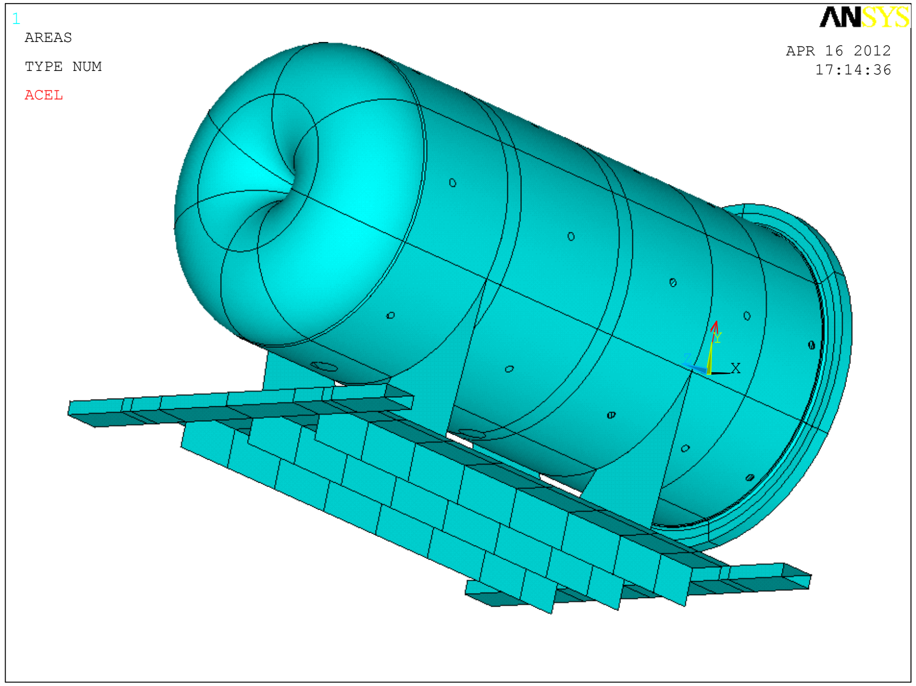


Standard aluminium channel section for frame structure
Y
X
15
R
160
R
r1
r1
60
Inner rib with thicknes t_{rinn}


Horizontal supporting plate with thickness t_p
Vertical saddle supports with thickness t_h
Outer ribs with thicknes t_{rout}
Inner rib with thicknes t_{rinn}
Y
Z
X


y
z
h8
h7
h6
h5
h4
h3
h2
h1
h0
Vertical plate - solid support t_h
Vertical plate sliding support t_h
Cross-section of channel section
Height of the rib in sixth 'z' position
Y
Z
X


1
AREAS
TYPE NUM
ACEL
ANSYS
APR 16 2012
17:14:48
Y
X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TYPE NUM
ACEL
ANSYS
APR 16 2012
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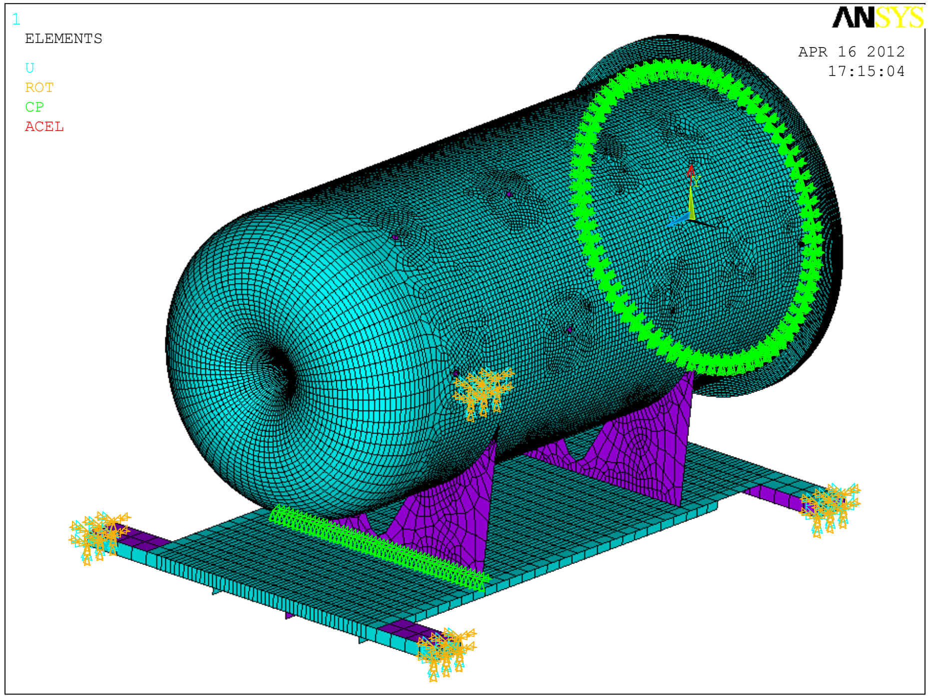
X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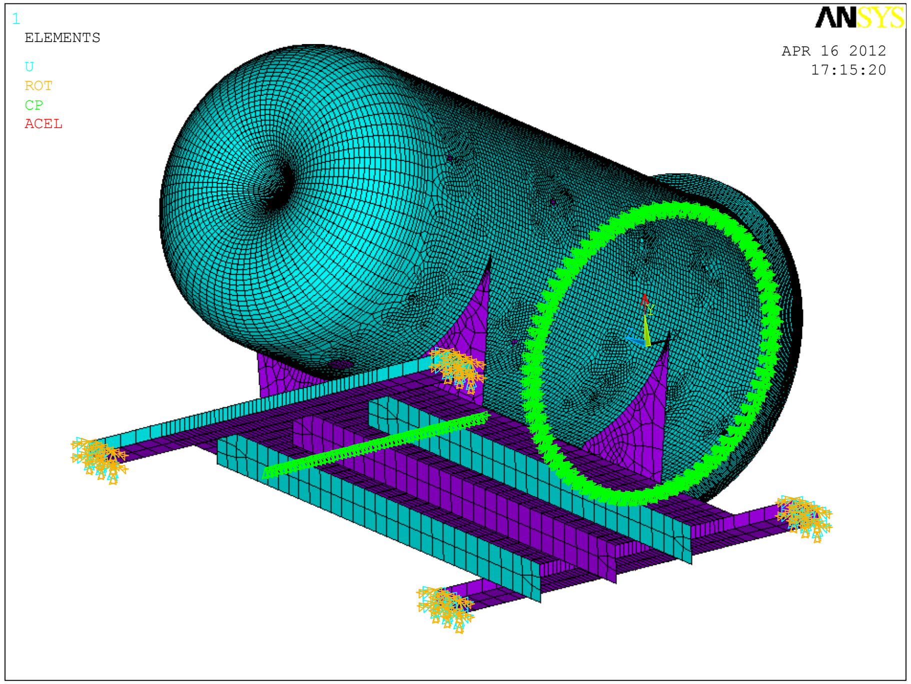
ELEMENTS
U
ROT
CP
ACEL
ANSYS
APR 16 2012
17:15:04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ROT
CP
ACEL
ANSYS
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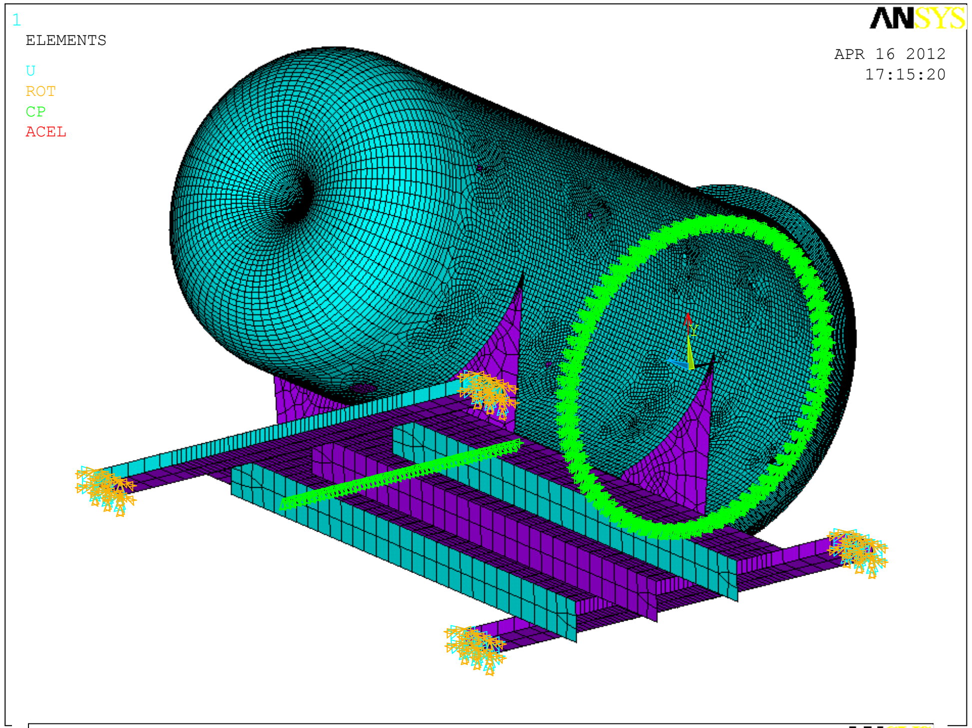
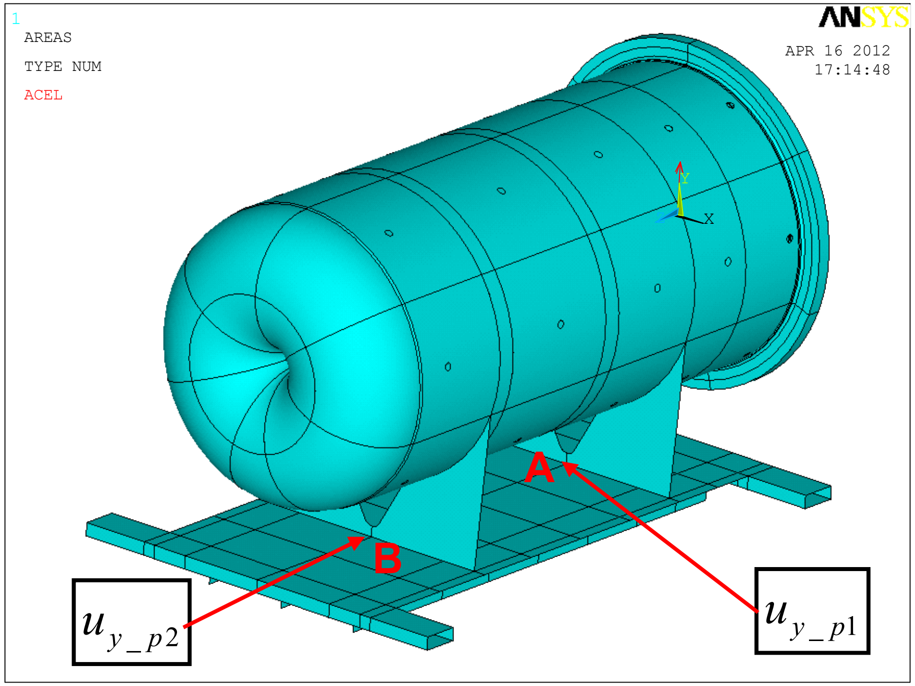
17:15:20





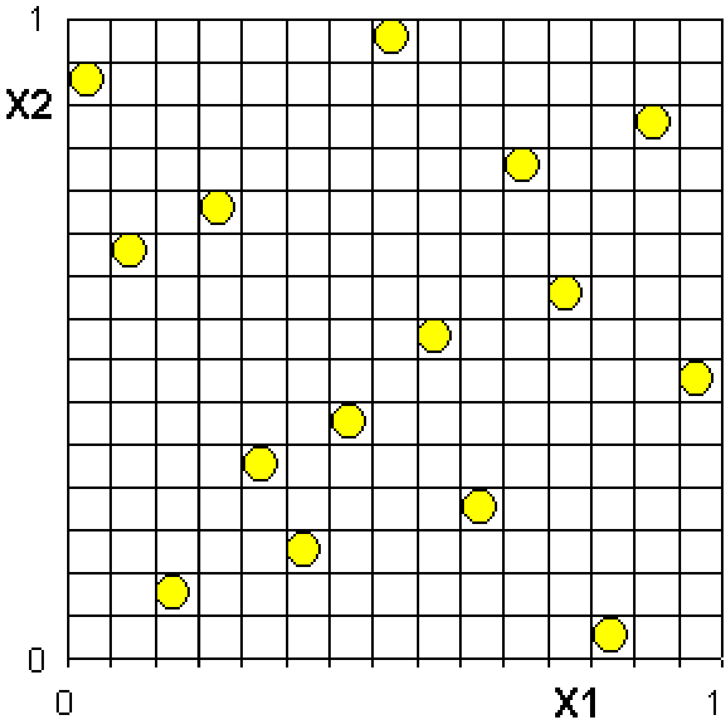
Design parameters (13 in total):

1. Two vertical plate supporting horn, thickness t_h
2. Horizontal plate with thickness t_p
3. Outer ribs with thicknes t_{rout}
4. Inner rib with thicknes t_{rinn}
5. Height of 8 ribs in chosen 'z' position, namely ***h0*** ÷ ***h8***

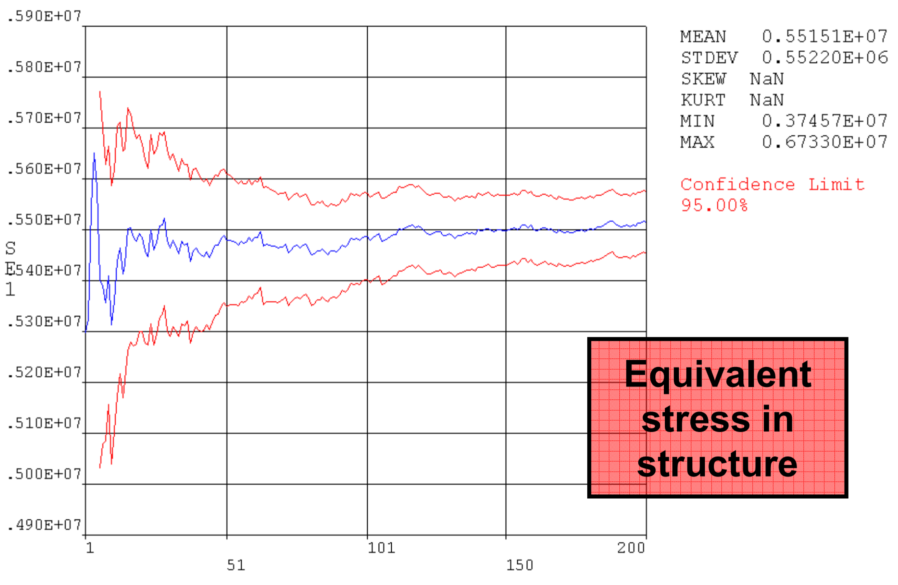
Control parameters (results):

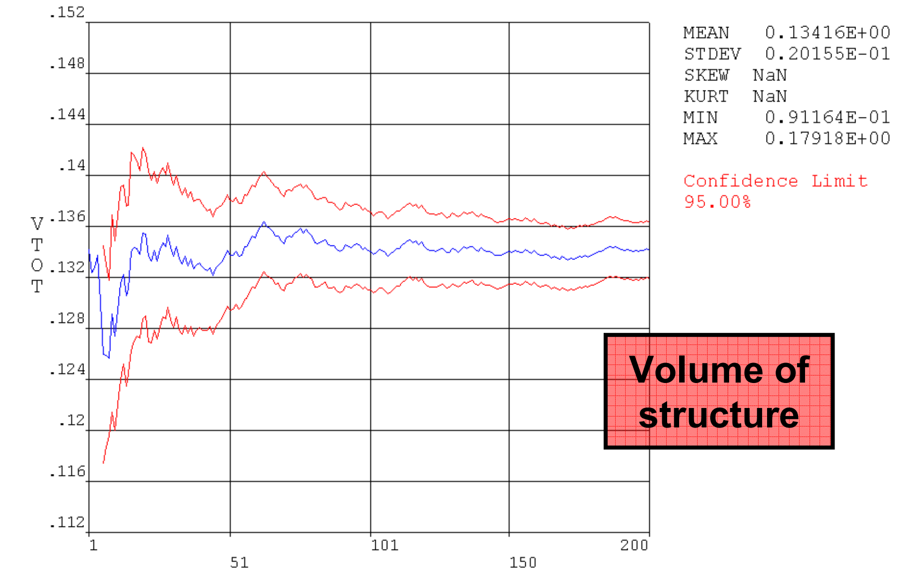
1. Maximum absolute value of vertical deflection: $|u_y| \leq 0.5mm$
2. Minimum absolute value for diference between vertical deflections in chosen points of supports: $|u_{y\_p1} - u_{y\_p2}|$
3. Equivalent stresses in horn and support as low as possible
4. Volume (mass) of the horn support

Application of ANSYS PDS module to asses the influence of design parameters on results



Monte Carlo simulation (over the whole design space) with Latin Hypercube Sampling. This technique helps to avoid clustering samples. In general this technique requires 20% to 40% fewer simulations loops in comparison with so-called Direct Monte Carlo Sampling to deliver results with the same accuracy. As a results parameters are divided into two groups important and unimportant from the point of view of control values.


MEAN 0.55151E+07
STDEV 0.55220E+06
SKEW NaN
KURT NaN
MIN 0.37457E+07
MAX 0.67330E+07
Confidence Limit
95.00%
Equivalent stress in structure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SKEW NaN
KURT NaN
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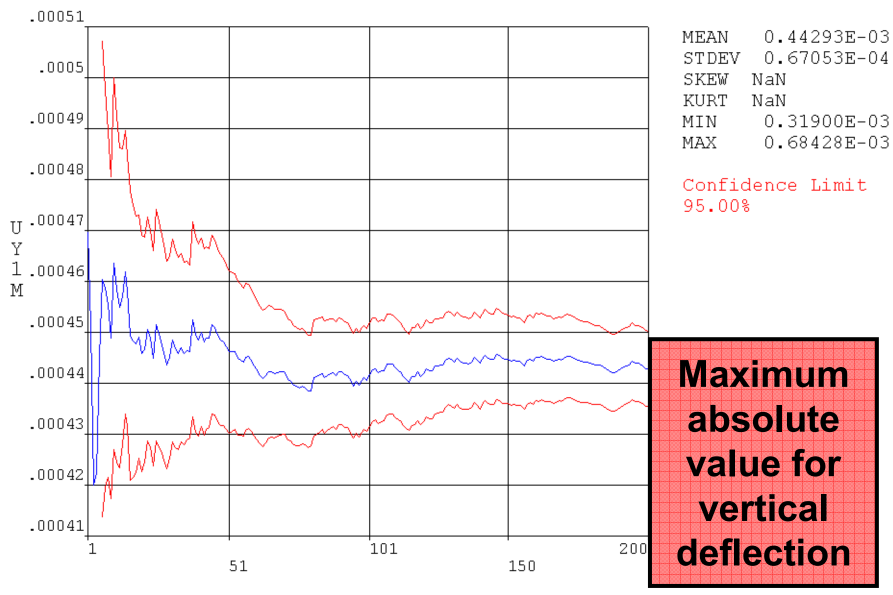
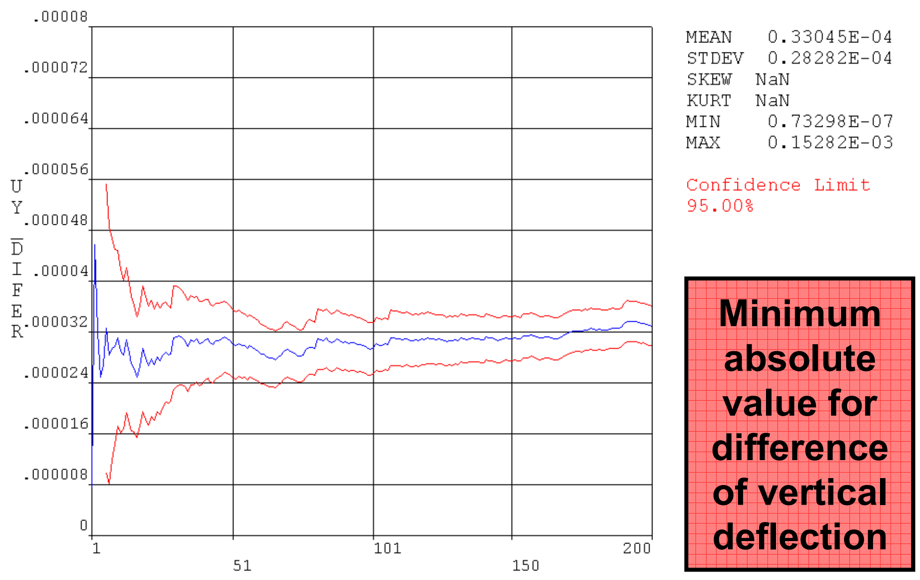
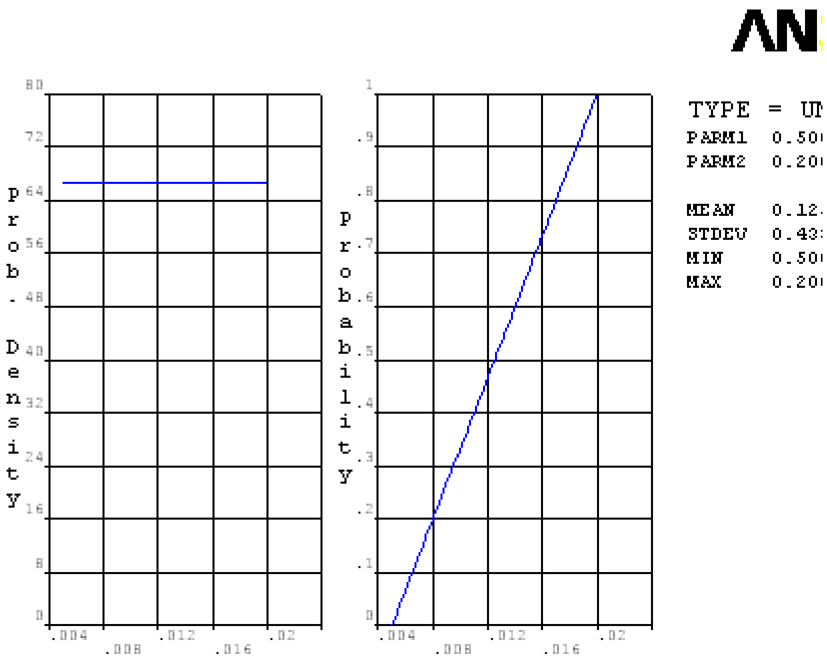
MAX 0.17918E+00
Confidence Limit
95.00%
Volume of structure


MEAN 0.44293E-03
STDEV 0.67053E-04
SKEW NaN
KURT NaN
MIN 0.31900E-03
MAX 0.68428E-03
Confidence Limit
95.00%
Maximum absolute value for vertical deflection


MEAN 0.33045E-04
STDEV 0.28282E-04
SKEW NaN
KURT NaN
MIN 0.73298E-07
MAX 0.15282E-03
Confidence Limit
95.00%
Minimum absolute value for difference of vertical deflection



ANSYS
Prob. Density
Probability
TYPE = UN
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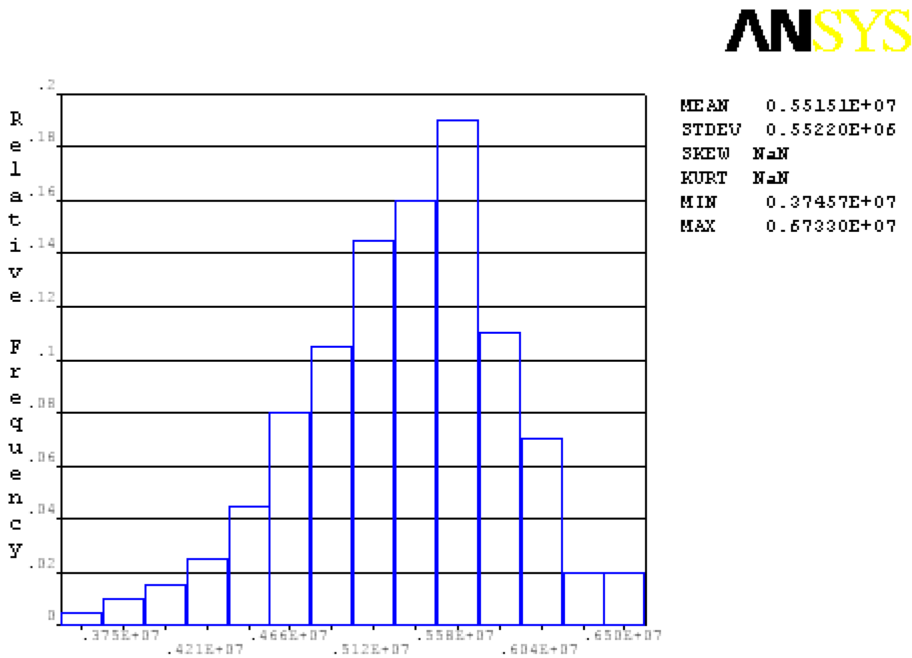
PARM2 0.20
MEAN 0.12
STDEV 0.43
MIN 0.50
MAX 0.20



ANSYS
Relative Frequency
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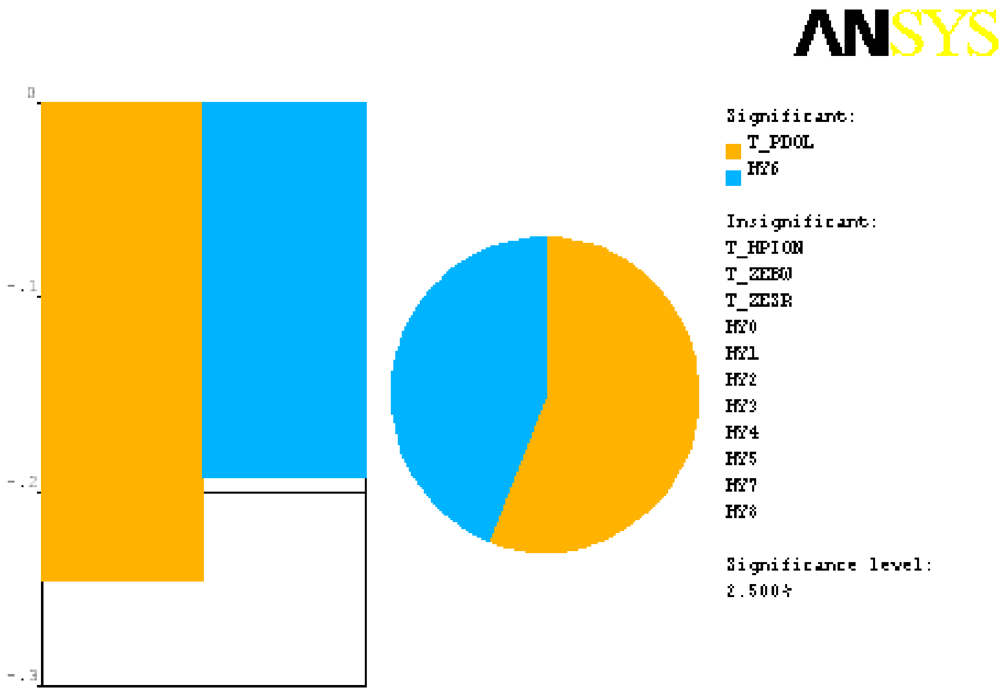
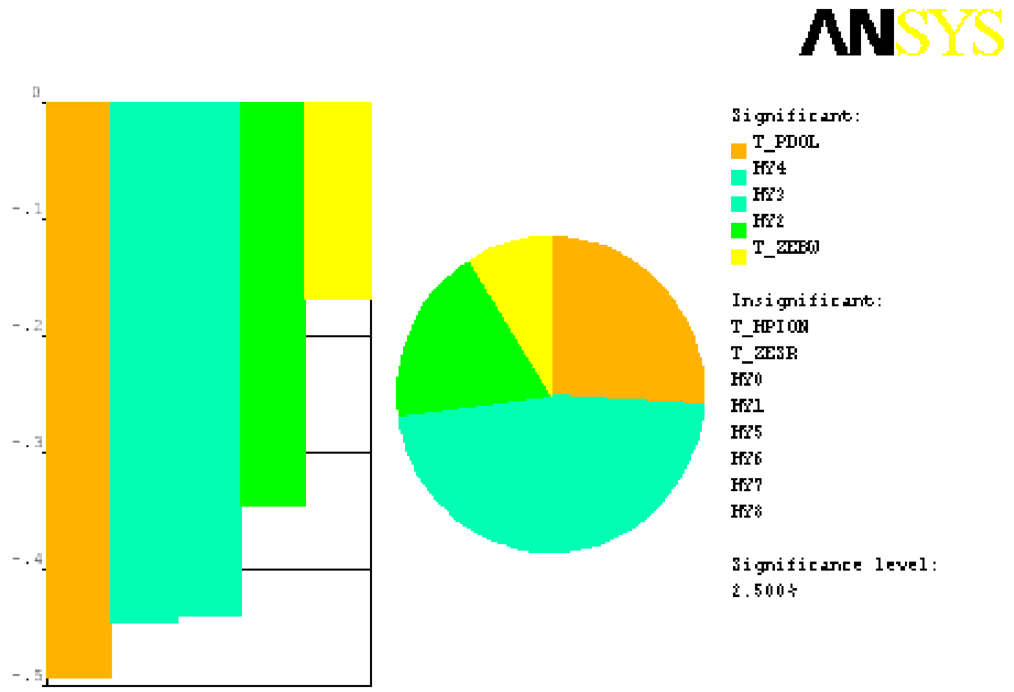
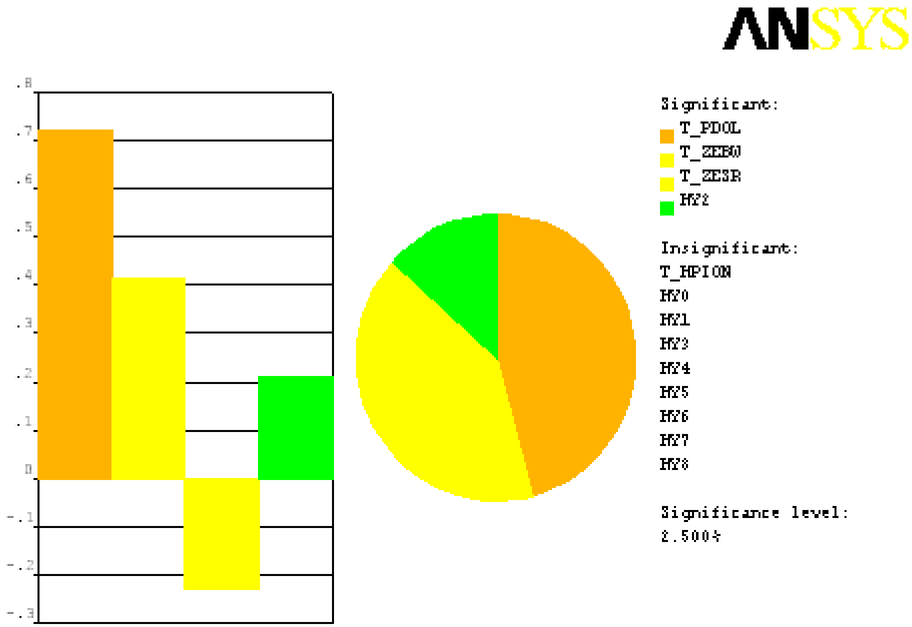
STDEV 0.55220E+06
SKEW NaN
KURT NaN
MIN 0.37457E+07
MAX 0.67330E+07

Maximum absolute value for vertical deflection



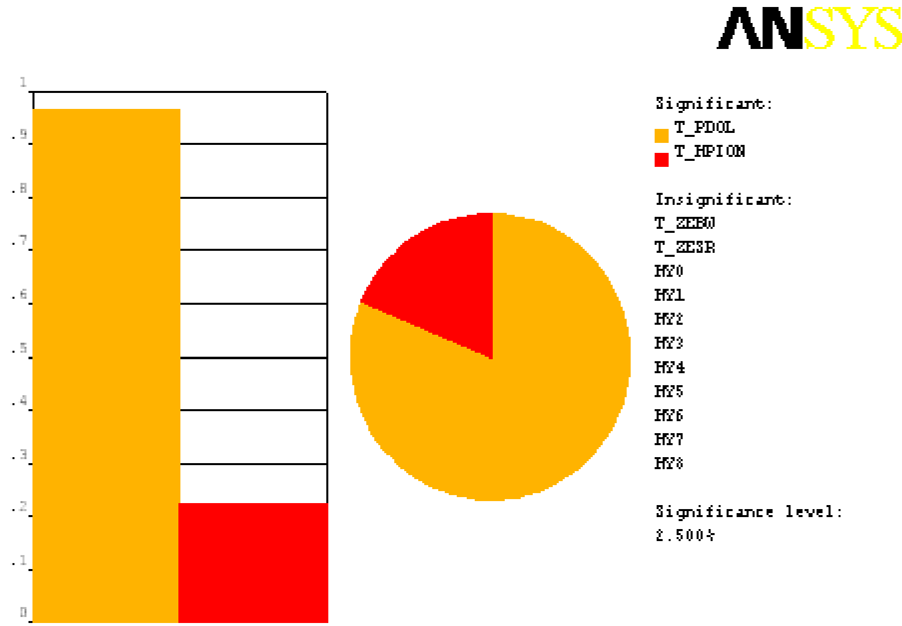
Minimum absolute value for difference of vertical deflection





Equivalent stress in structure

Volume of structure



Matrix of Rank-Order Correlation Coefficient(s)

Solution Set Label = HORN1
Simulation Method = Monte Carlo with Latin Hypercube Sampling
Number of Samples = 200

	T_HPION	T_PDOL	T_ZEBW	T_ZESR	HY0	HY1	HY2
UY_DIFER	(-0.069)	-0.246	(0.076)	(0.021)	(-0.041)	(-0.060)	(-0.144)
UYMIN	(-0.025)	-0.489	(-0.122)	(0.005)	(0.000)	(-0.101)	-0.327
UY1M	(-0.015)	-0.492	-0.168	(-0.010)	(0.013)	(-0.094)	-0.345
SE1	(-0.142)	0.719	0.413	-0.226	(0.050)	(0.146)	0.210
SE2	(0.031)	-0.339	-0.230	(-0.069)	(0.031)	(-0.082)	(-0.121)
VTOT	0.222	0.966	(0.126)	(0.098)	(-0.005)	(0.126)	(0.084)

	HY3	HY4	HY5	HY6	HY7	HY8
UY_DIFER	(-0.091)	(0.045)	(0.011)	-0.193	(0.090)	(-0.059)
UYMIN	-0.403	-0.356	(-0.097)	(-0.104)	(0.020)	(-0.089)
UY1M	-0.440	-0.445	(-0.103)	(-0.048)	(-0.001)	(-0.072)
SE1	(0.124)	(0.002)	(-0.092)	(-0.016)	(0.086)	(-0.025)
SE2	-0.267	-0.422	-0.277	-0.247	(-0.058)	(-0.084)
VTOT	(-0.058)	(0.048)	(-0.037)	(-0.004)	(0.022)	(-0.052)

NOTE: Values in brackets indicate that the correlation coefficient is NOT significant!
To indicate insignificant correlation coefficient a significance level of 2.500% has been used.

Probabilities That Above Correlation Coefficients Are Zero

	T_HPION	T_PDOL	T_ZEBW	T_ZESR	HY0	HY1	HY2
UY_DIFER	3.3e-001	4.5e-004	2.9e-001	7.6e-001	5.6e-001	4.0e-001	4.2e-002
UYMIN	7.3e-001	2.1e-013	8.5e-002	9.5e-001	1.0e+000	1.5e-001	2.3e-006
UY1M	8.4e-001	1.4e-013	1.7e-002	8.8e-001	8.5e-001	1.9e-001	5.6e-007
SE1	4.5e-002	3.9e-033	1.2e-009	1.3e-003	4.8e-001	3.9e-002	2.9e-003
SE2	6.7e-001	9.0e-007	1.0e-003	3.3e-001	6.6e-001	2.5e-001	8.7e-002
VTOT	1.6e-003	5.3e-118	7.5e-002	1.7e-001	9.4e-001	7.4e-002	2.4e-001

	HY3	HY4	HY5	HY6	HY7	HY8
UY_DIFER	2.0e-001	5.2e-001	8.8e-001	6.3e-003	2.1e-001	4.0e-001
UYMIN	3.4e-009	2.2e-007	1.7e-001	1.4e-001	7.8e-001	2.1e-001
UY1M	7.2e-011	4.2e-011	1.5e-001	5.0e-001	9.9e-001	3.1e-001
SE1	8.1e-002	9.8e-001	2.0e-001	8.2e-001	2.3e-001	7.3e-001
SE2	1.3e-004	4.8e-010	7.1e-005	4.2e-004	4.2e-001	2.3e-001
VTOT	4.2e-001	5.0e-001	6.1e-001	9.6e-001	7.5e-001	4.7e-001

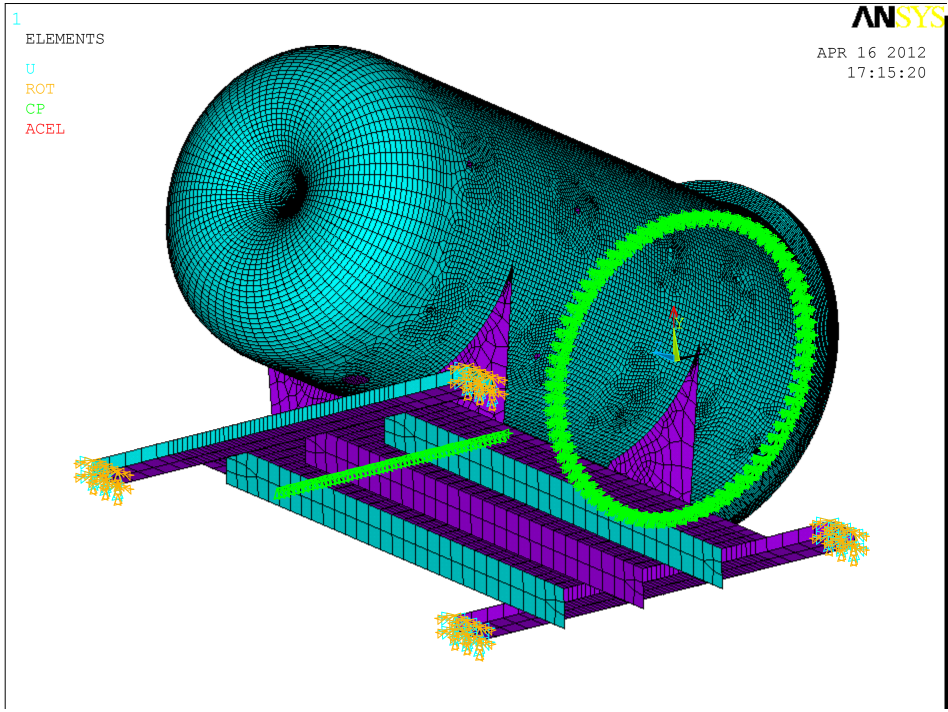
NOTE: Probabilities larger then 2.500% indicate that the corresponding correlation coefficient is zero, i.e. the correlation is NOT significant!

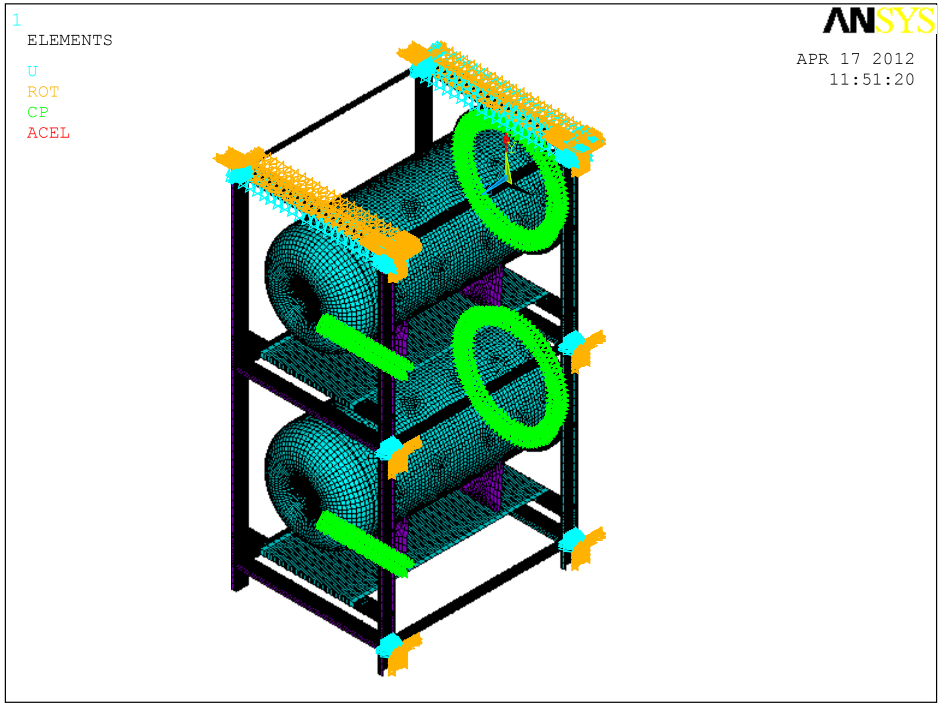
□□□

Summary of ‘important and unimportant design parameters’ with respect to output values

Control value	Signicant parametrs	Insignificant parameters
Absolute value of difference of vertical deflection in point A and B	t_p, ***h6***	t_b, t_{rout}, t_{rinn}, ***h0, h1, h2, h3, h4, h5, h7, h8***
Maximum absolute value of vertical deflection	t_p, ***h4, h3, h2,*** t_{rout},	t_{rinn}, t_b, ***h0, h1, h5, h7, h8***
Maximum equivalent stress in horns	t_p, t_{rout}, t_{rinn}, ***h2,***	***h0, h1, h3, h4, h5, h7, h8***
Total volume of supporting system	t_p, t_b	***h0, h1, h2, h3, h4, h5, h7, h8***

Additional assumption ***h0=h1=h2=h3= h4=h5=h7=h8,*** which also reduces the size of numerical task. Final design parameters: t_p, t_{rout}, t_{rinn}, ***h0***





Optimization is divided into two stages:

1. **Search of the set of optimal thickness and height of important design variables with minimum absolute difference of vertical deflections in supporting point A and B for 1 horn**
2. **Search of the set of optimal thickness of important design variables supporting lower horn while thickness of important design parameters for upper horn is set in teh 1st stage of the process**

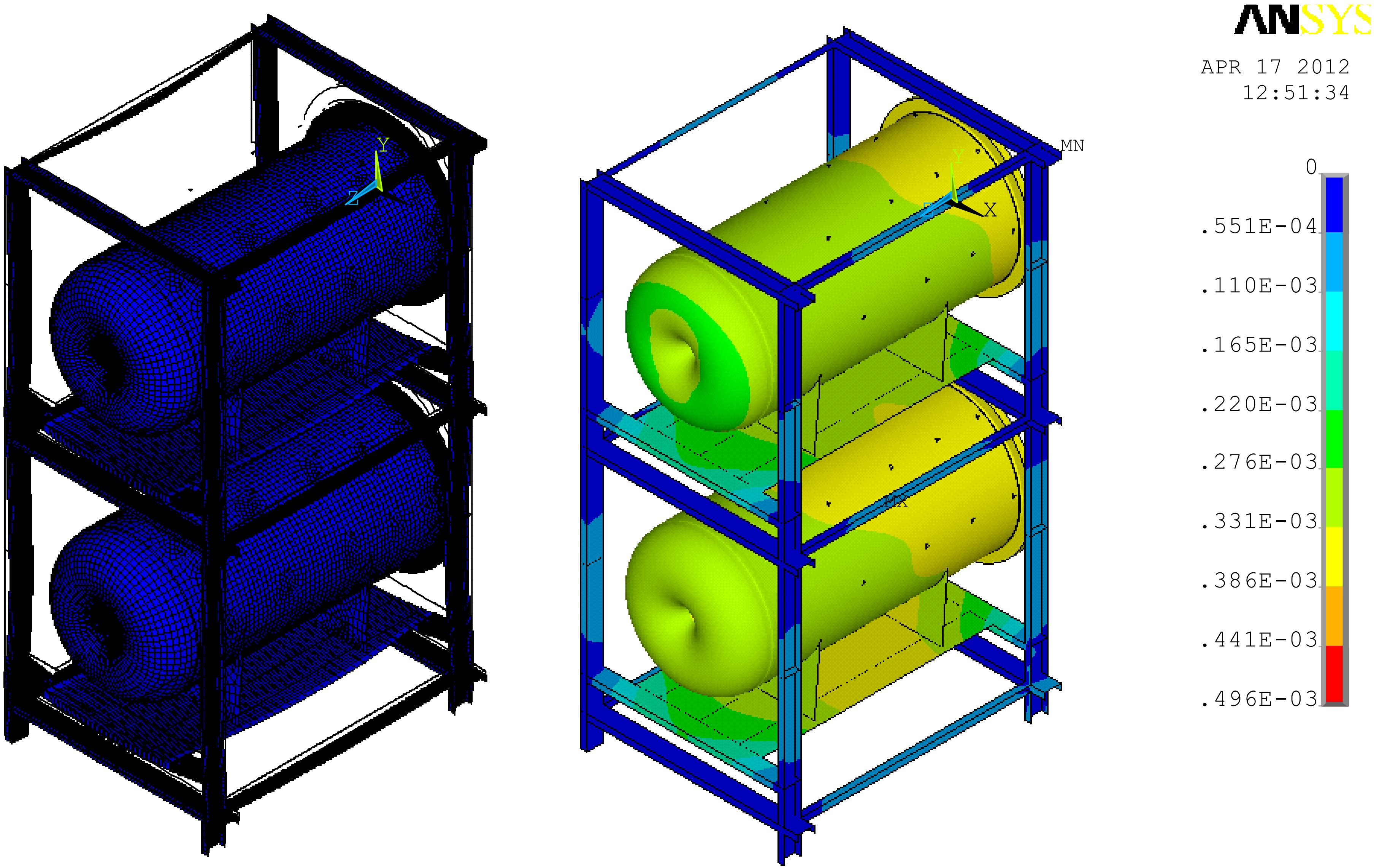
Objective function: minimization of absolute value of difference of vertical deflection in point A and B

$$\left|u_{y\_p1} - u_{y\_p2}\right|$$

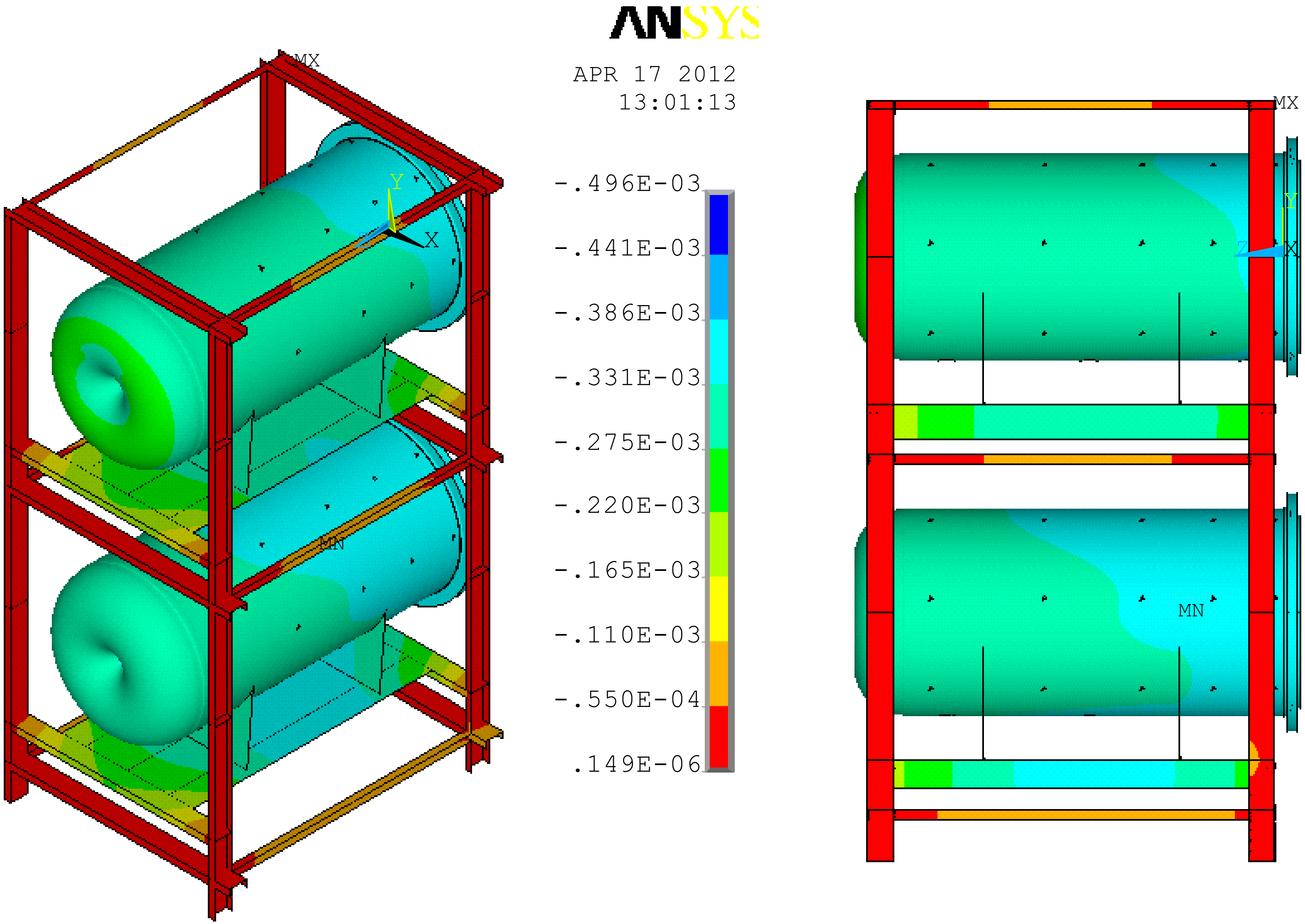
State variables:

1. **Maximum absolute value of vertical deflection;**
2. **Equivalent stress in horns**
3. **Equivalent stress in the whole structure**

Results after two stage optimization process

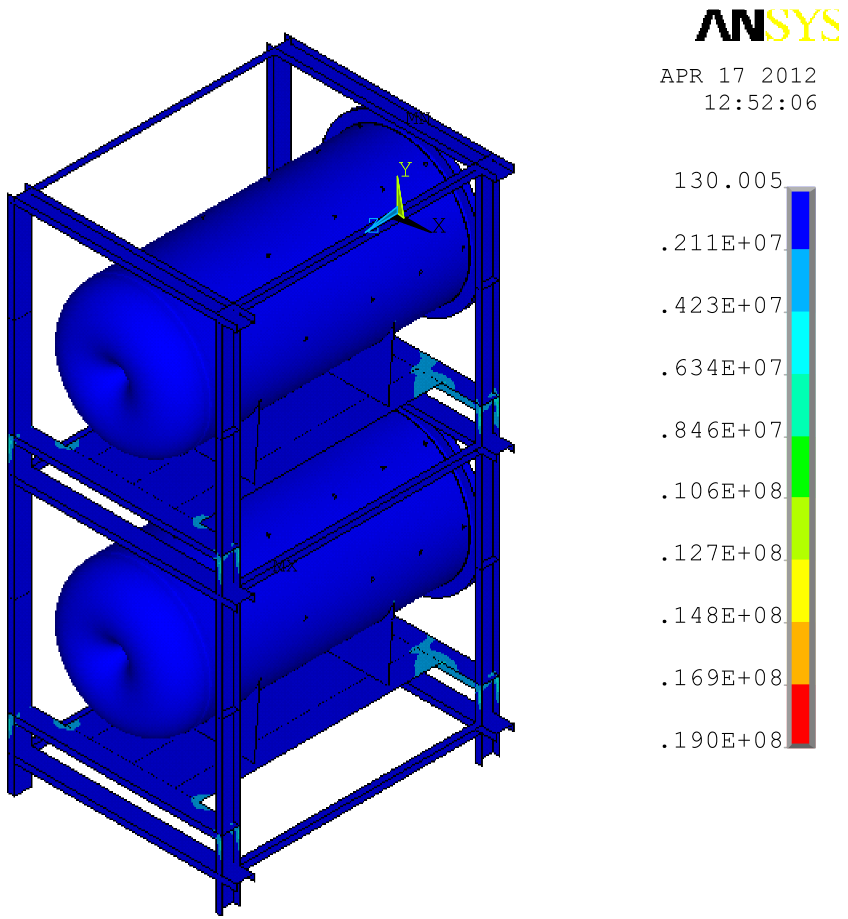


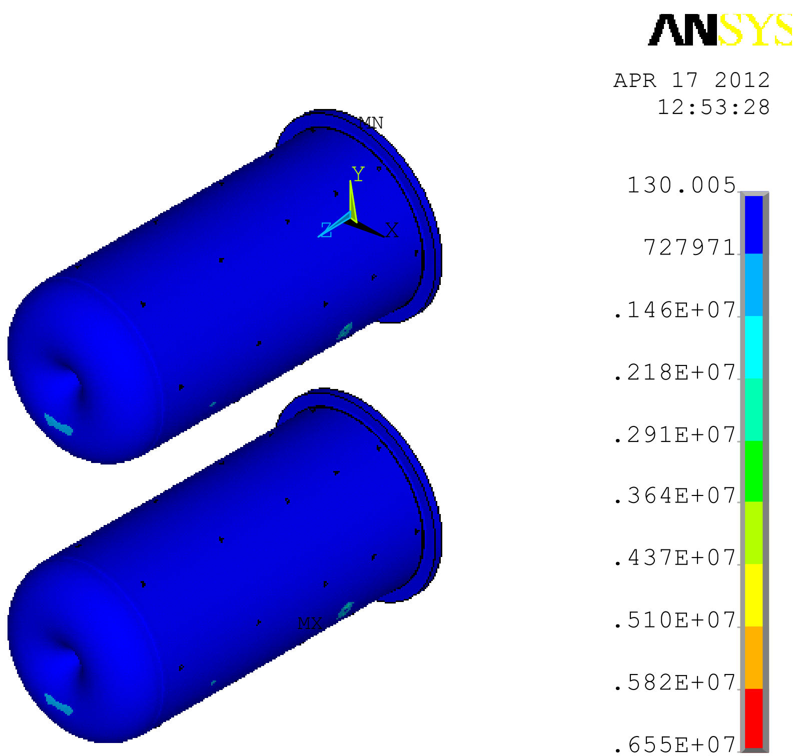
Results after two stage optimization process



Uy displacement in [*m*]

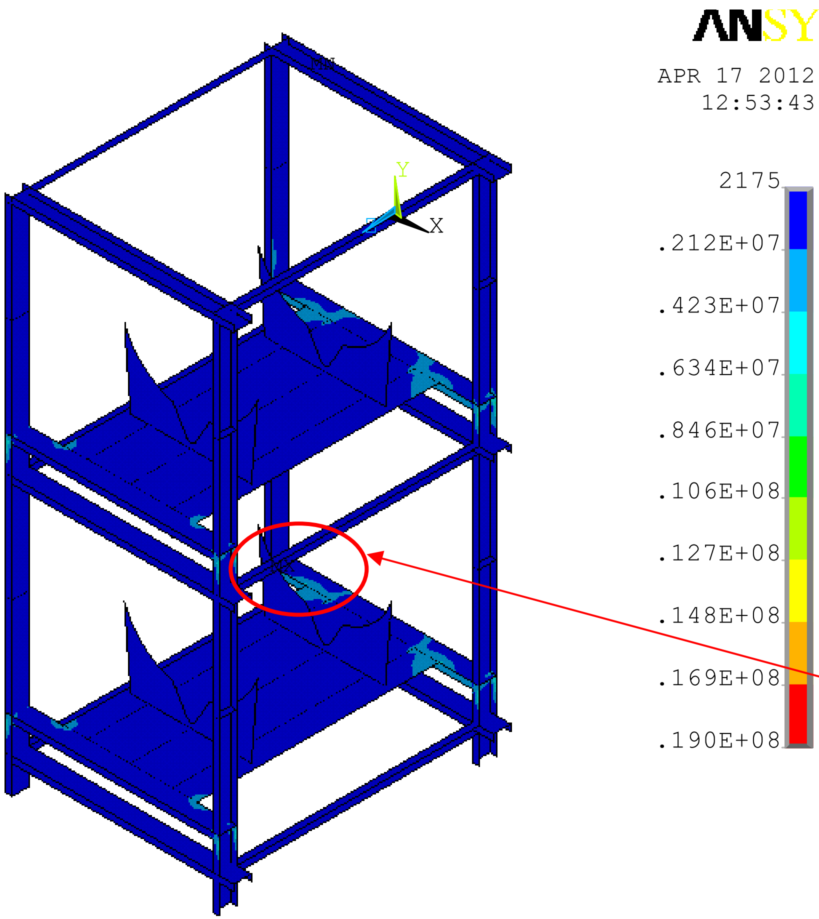
Results after two stage optimization process

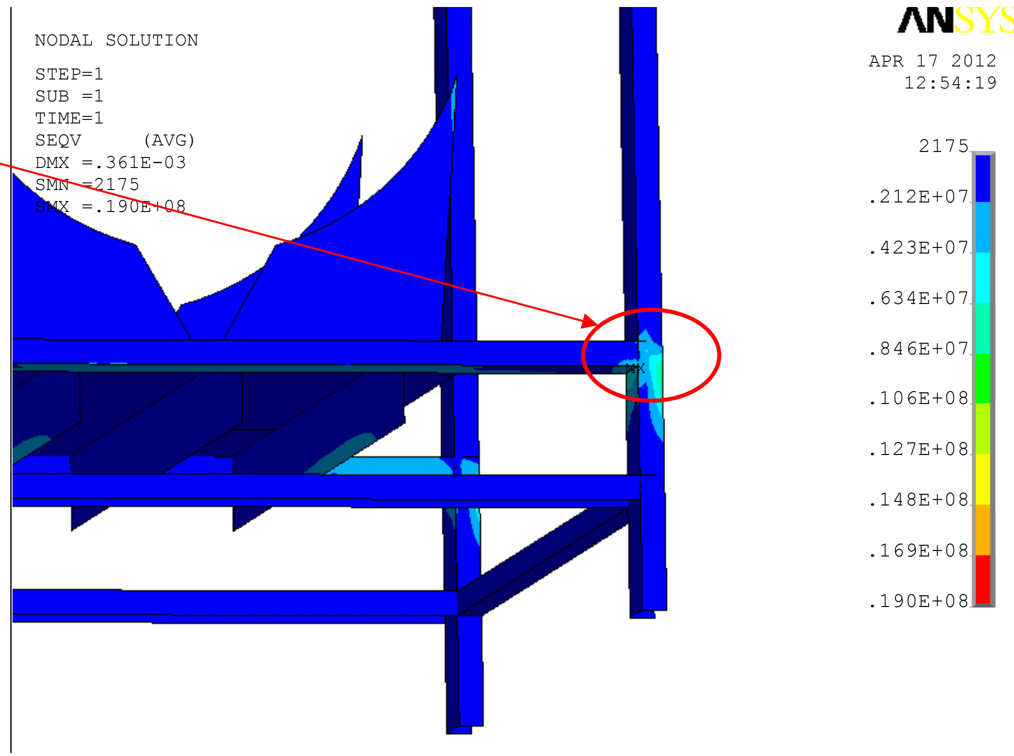




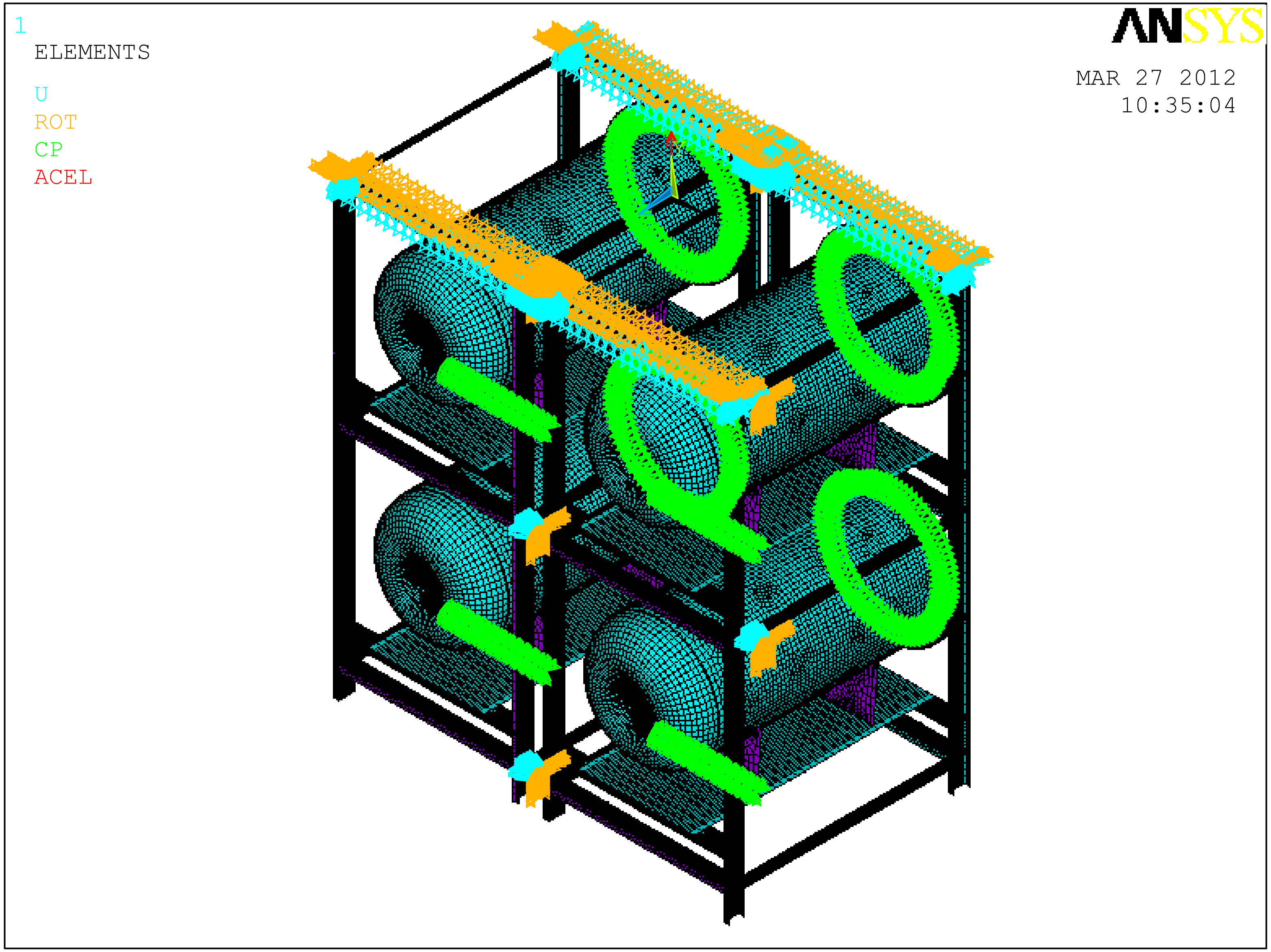
Distribution of equivalent stress in [*Pa*]

Results after two stage optimization process

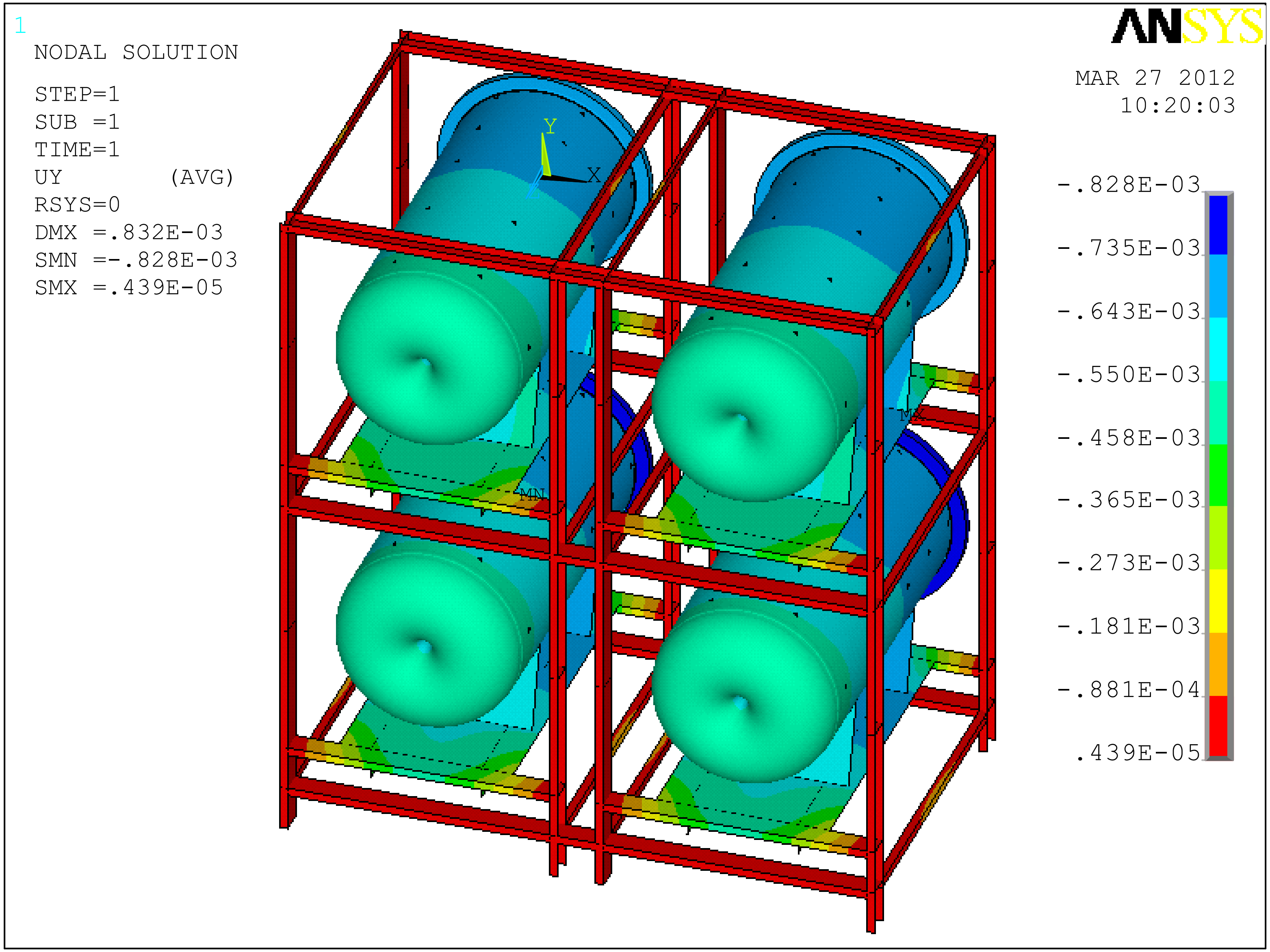




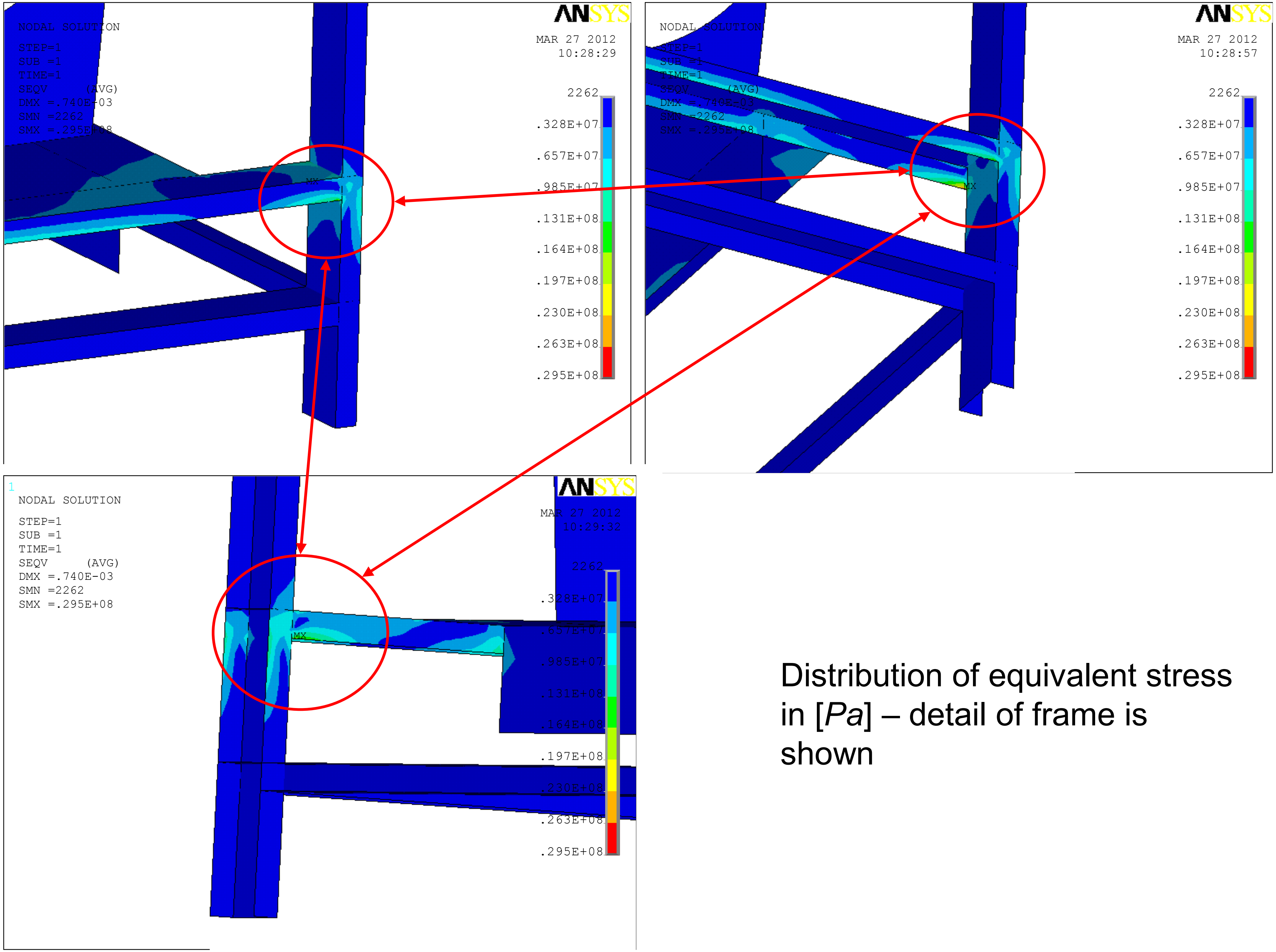
Distribution of equivalent stress in [*Pa*]



Isometric view of mesh with boundary conditions introduced



Uy displacement in [*m*], not optimized structure



Distribution of equivalent stress in [*Pa*] – detail of frame is shown

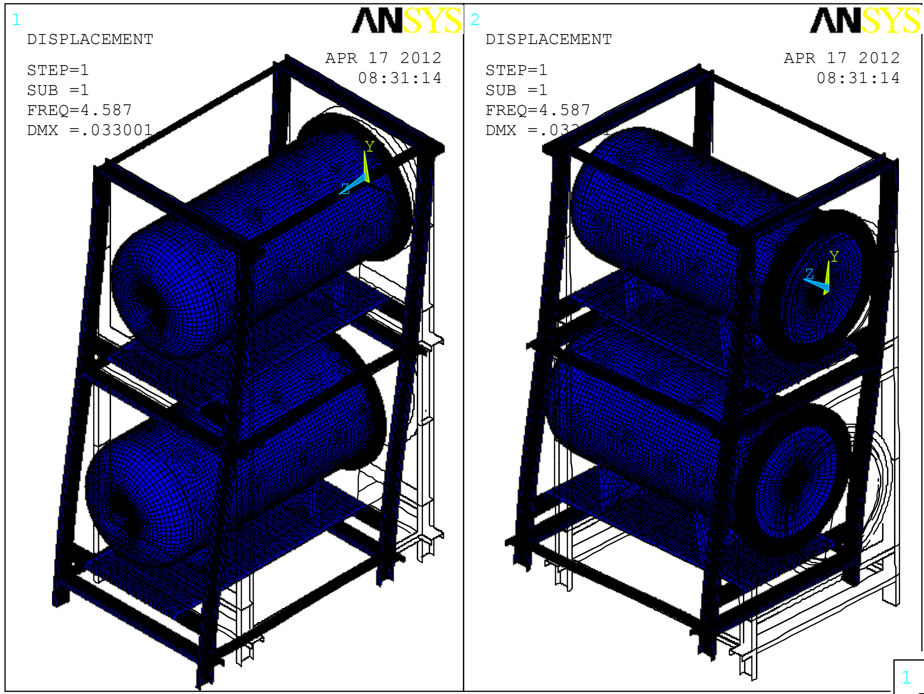
Comparison of results (deadweight only)

Strucutre, loads	$\lvert u_y \rvert_{max}$ *mm*	$\sigma_{eqv,\ max}$ *MPa* (horn)	$\sigma_{eqv,\ max}$ *MPa* (frame)
supporting plate with 2 ribs (not optimized structure)	0.83	5.2	29.5
supporting plates with 3 ribs (optimized thickness in two stage process)	0.50	6.6	19.0

Analysis of natural frequencies – results for symmetric half of 4 horns structure

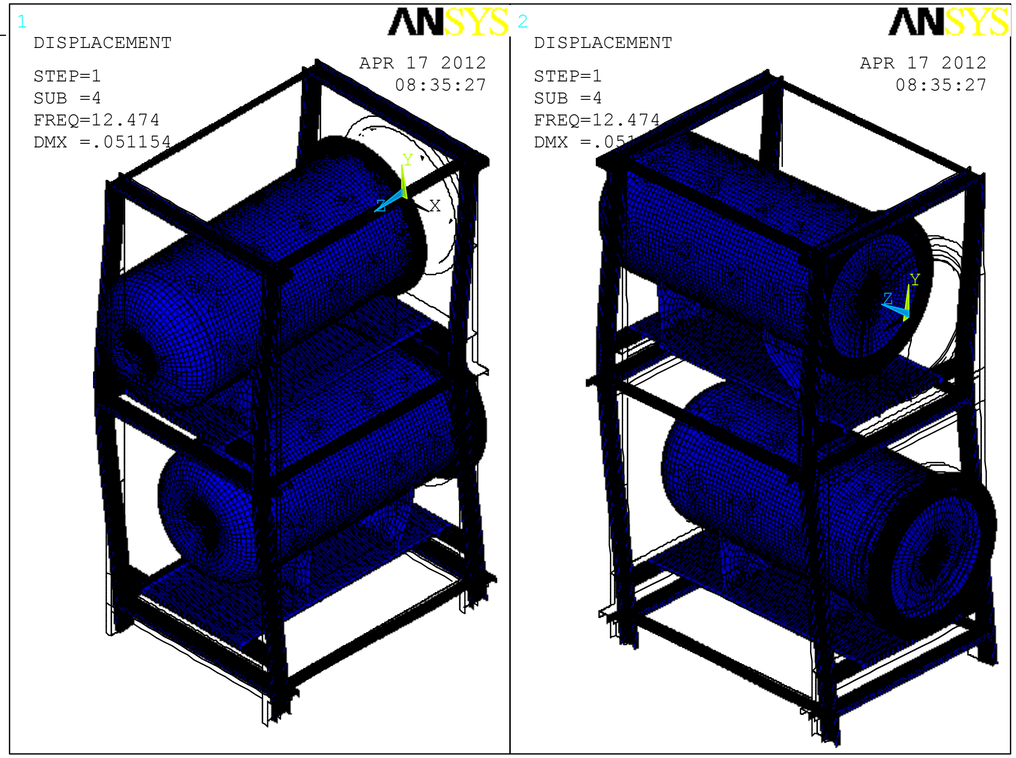
Mode	Freq.[Hz]
1	4.59
2	6.07
3	6.20
4	12.47
5	18.60
6	25.82
7	26.45
8	27.62

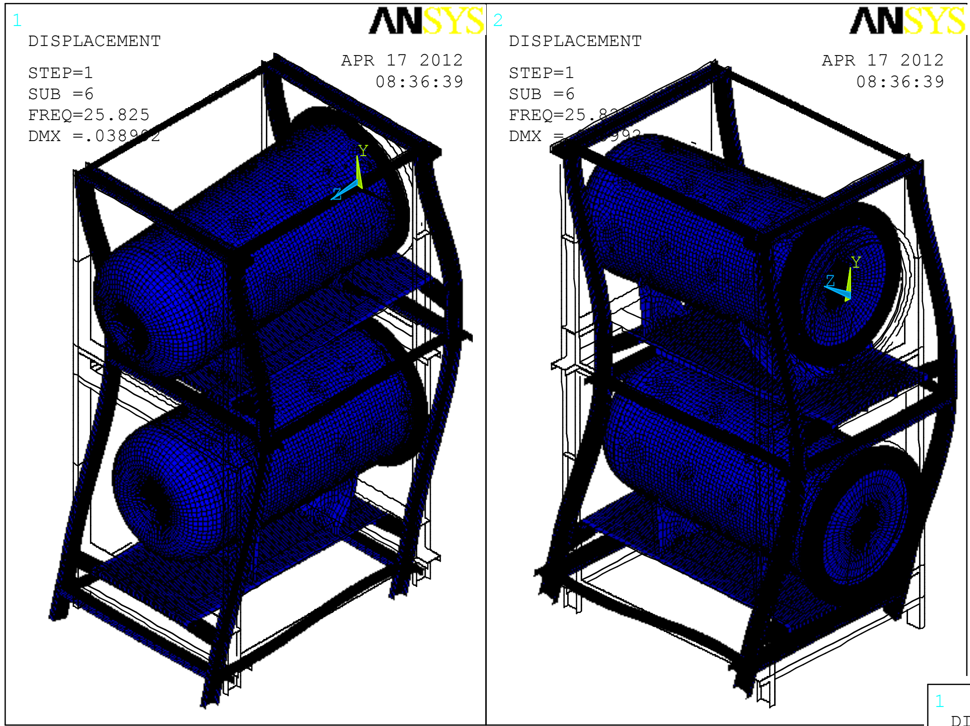
Mode	Freq.[Hz]
9	28.08
10	29.69
11	41.74
12	43.72
13	44.15
14	48.26
15	28.43



Mode 1, *f* = 4.59 *Hz*

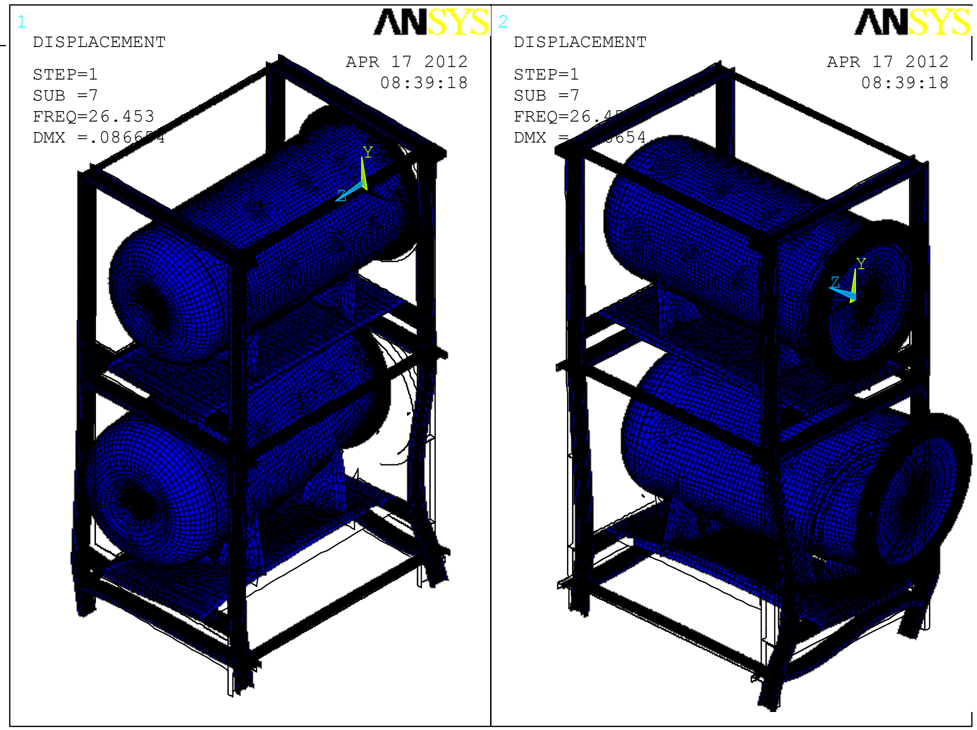
Mode 4, *f* = 12.47 *Hz*

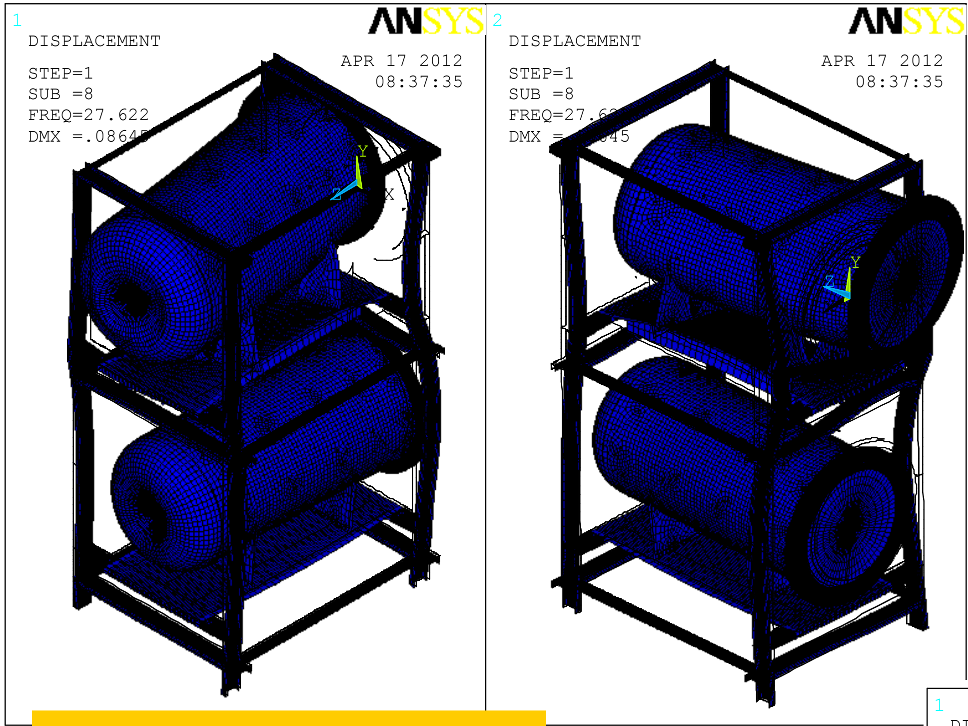




Mode 6, *f* = 25.82 *Hz*

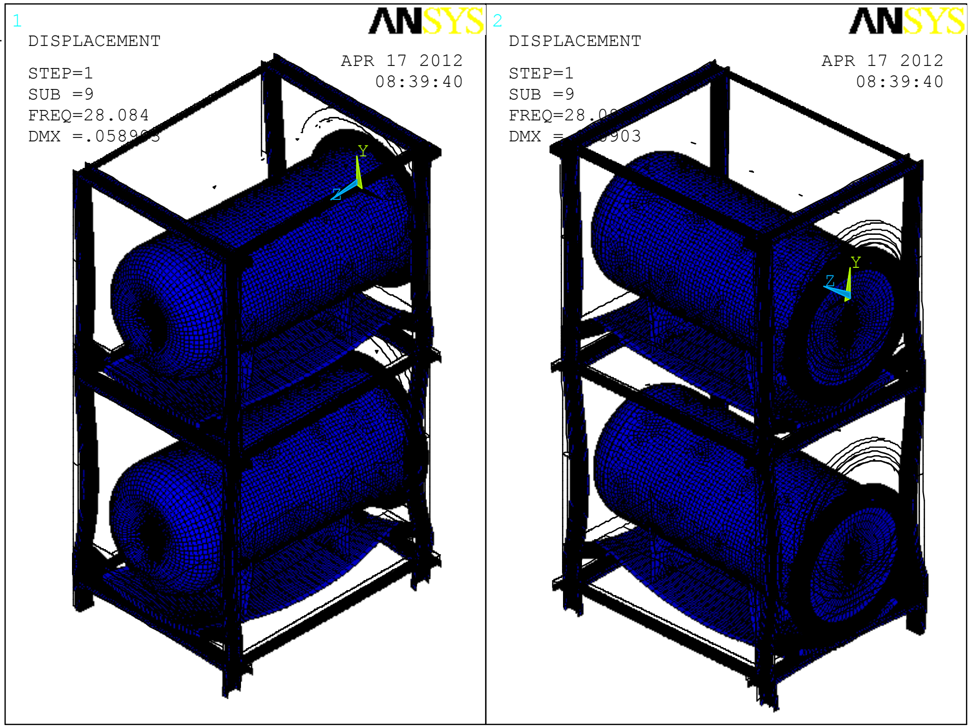
Mode 7, *f* = 26.45 *Hz*

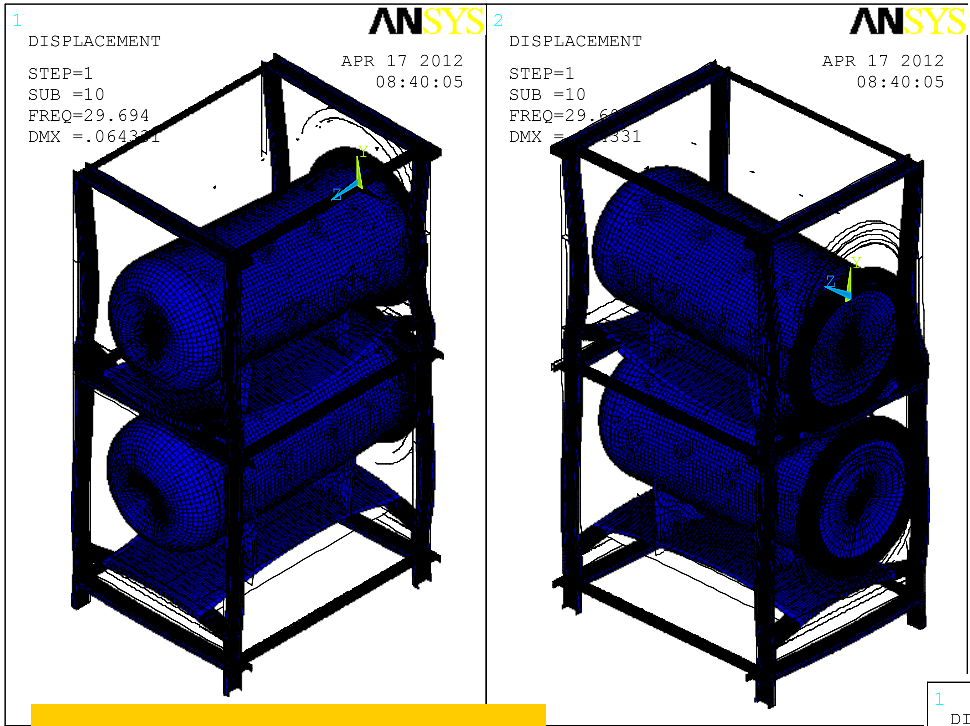




Mode 8, f = 27.62 *Hz*

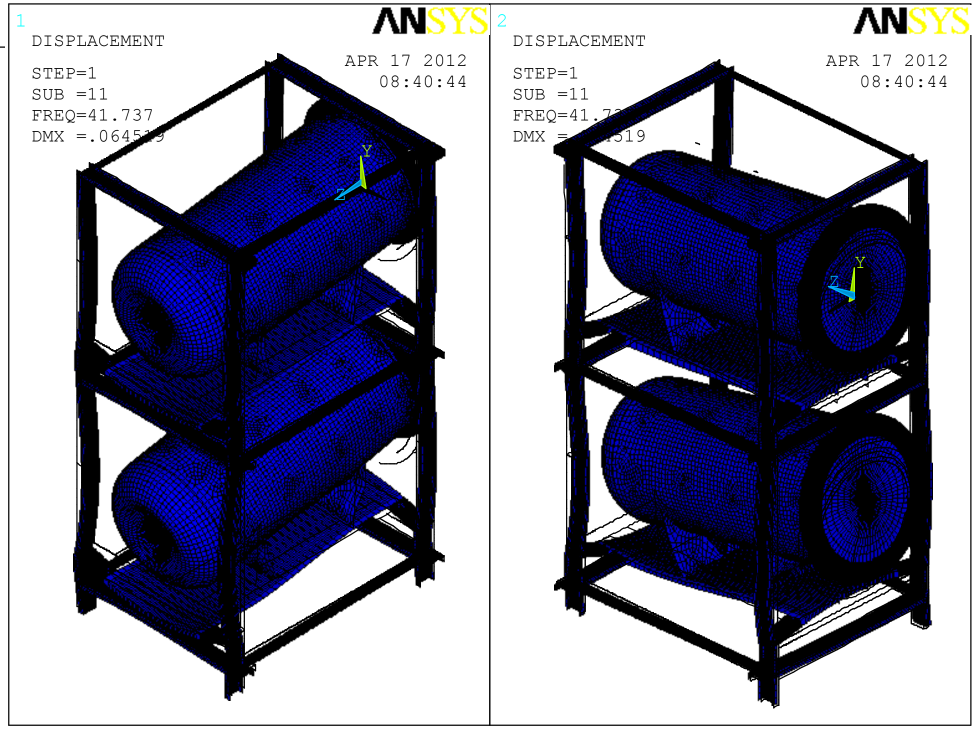
Mode 9, f = 28.08 *Hz*

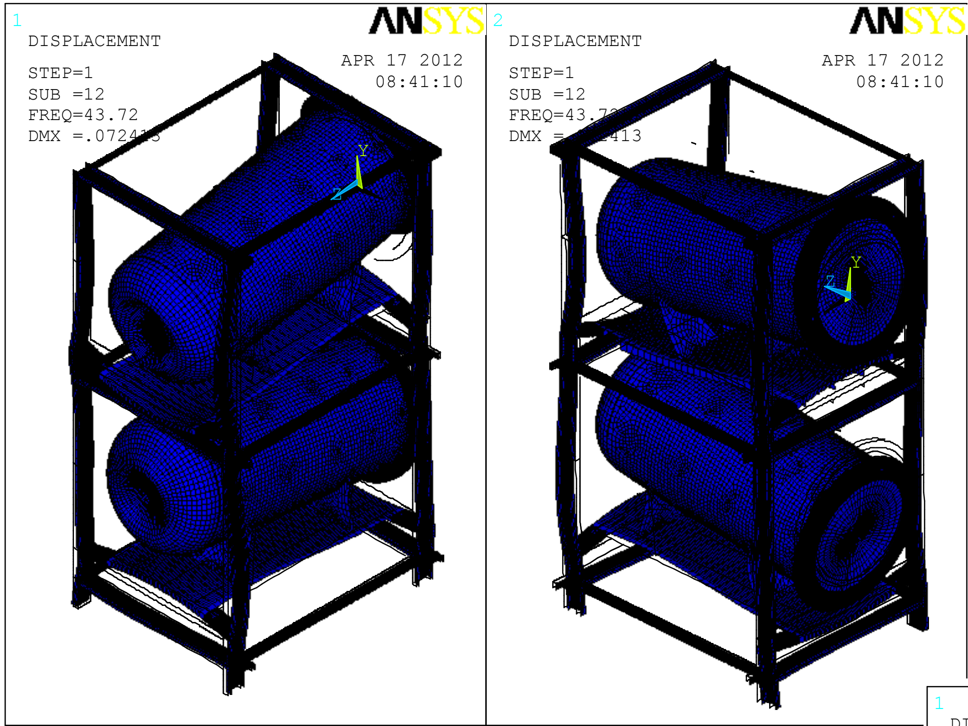




Mode 10, *f* = 29.69 *Hz*

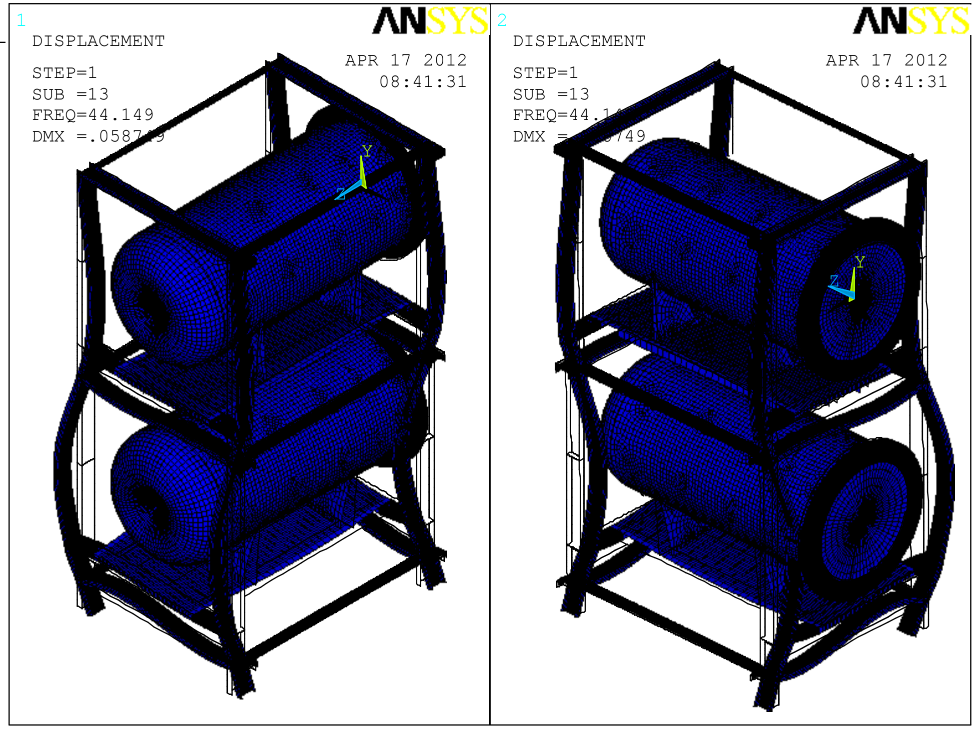
Mode 11, *f* = 41.74 *Hz*

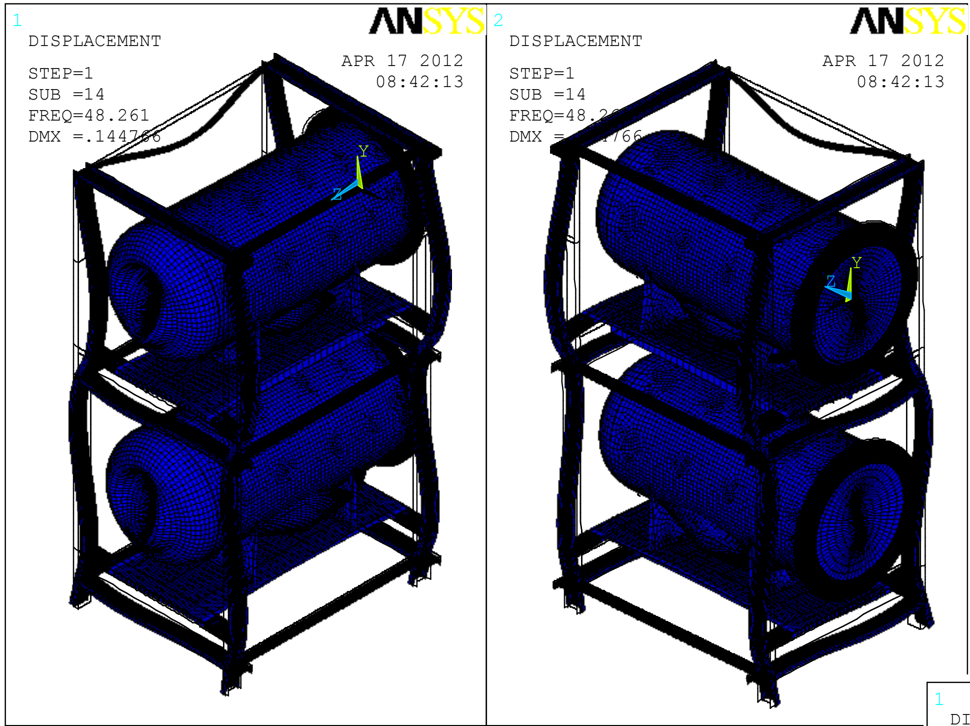




Mode 12, *f* = 43.72 *Hz*

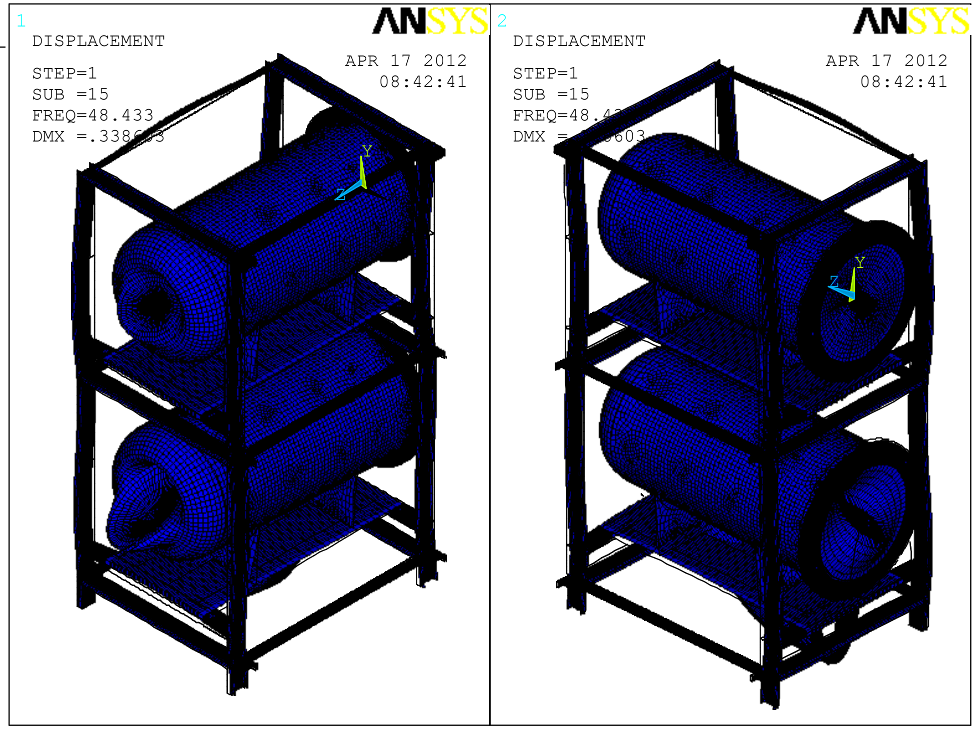
Mode 13, *f* = 44.15 *Hz*





Mode 14, f = 48.26 *Hz*

Mode 15, f = 48.43 *Hz*



Further steps to make:

1. Calculations of natural frequencies for the whole structure (not only symmetric half, partially done)

2. Introduction of water frame

3. Introduction of strip line plates

Thank you for your attention