FEA on T type Passenger Boarding Bridge

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Introduction

FEA was executed using PTC Pro/Engineer Wildfire 3.0 Mechanica software. T-type bridge was modeled according to assembly and part drawings. Loads and constraints are calculated to meet requirements in standard EN 1915-2:2001 "Aircraft ground support equipment. General requirements. Part 2: Stability and strength requirements, calculations and test methods" and EN 1991-1-4:2005 Eurocode 1: Actions on structures Part 1-4 : General actions – Wind actions.

The model is approximated by using ideal beam and shell elements to speed up calculation and give better understanding in results. These idealizations are modeled to present "worst-case" scenario in actual construction. Mechanica solver is linear and can reliably used only to calculate stress lower than material yield limit.

Structure

Material: S355J2
Density: 7.85 kg/dm^3
Modulus of elasticity: 210 GPa

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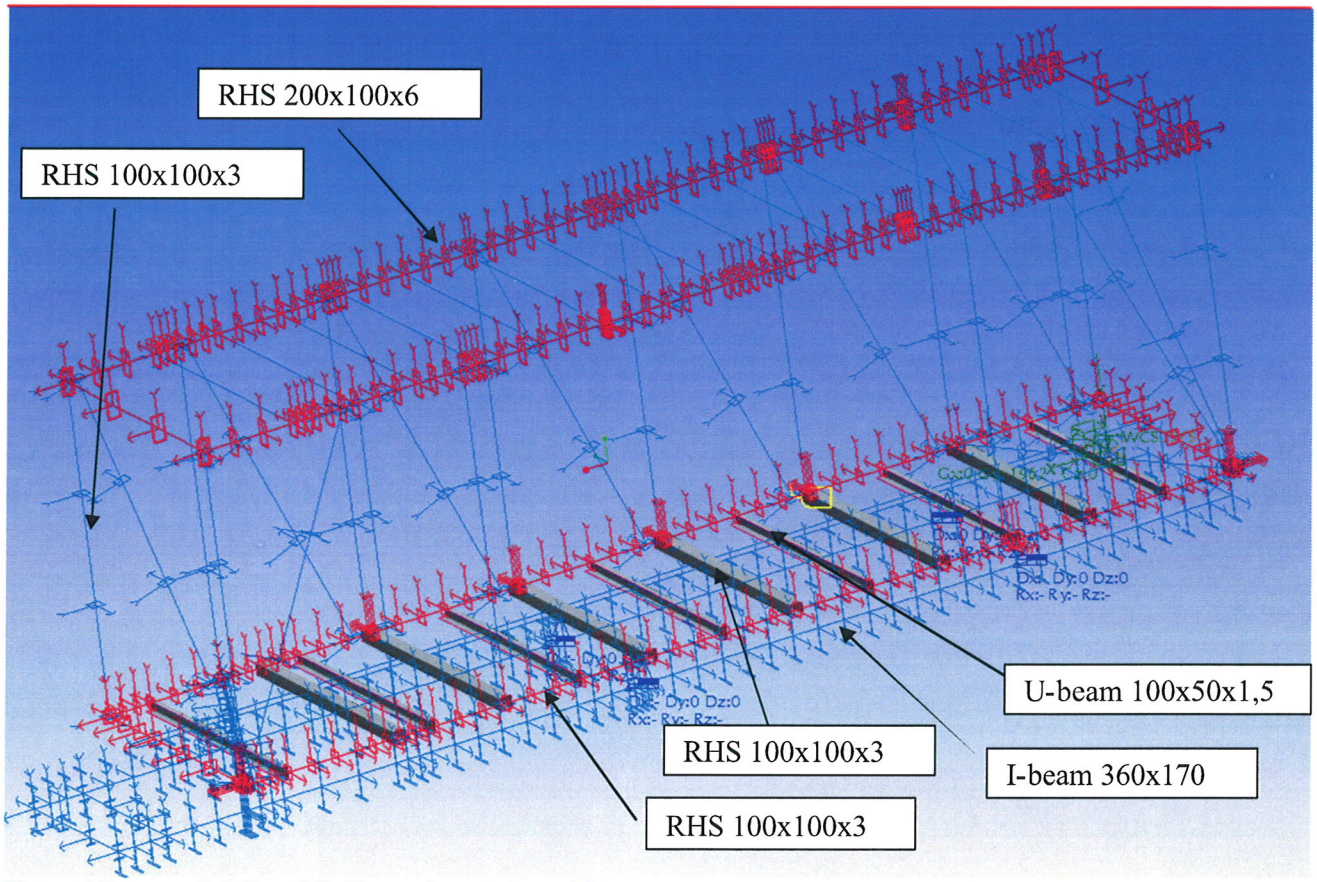

Picture 1 Beam- and shell modelled beam elements in model

The docking station and forces acting to it are modelled as a load in the endpoint of I-beams. All the beam element ends have rigid connections.

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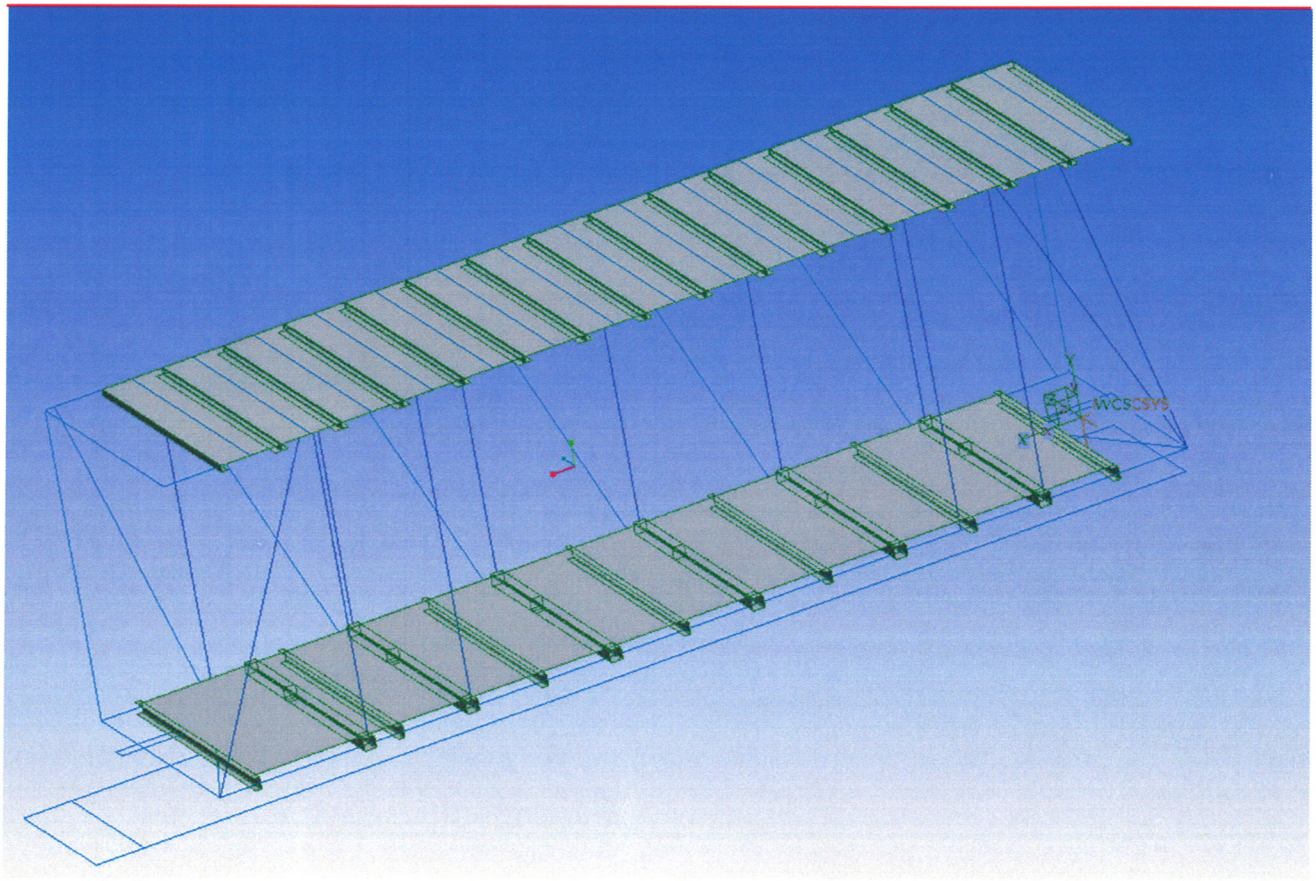

Picture 2 Shell elements

Floor beams are connected to I-beams with a rigid connection. U-profile beams are not connected to I-beams. The Shell plate on floor beams spreads the rated load evenly to the beams. Roofcasettes are not connected with each other. Connecting cassettes would lead to better load carrying capacity than it actually is.

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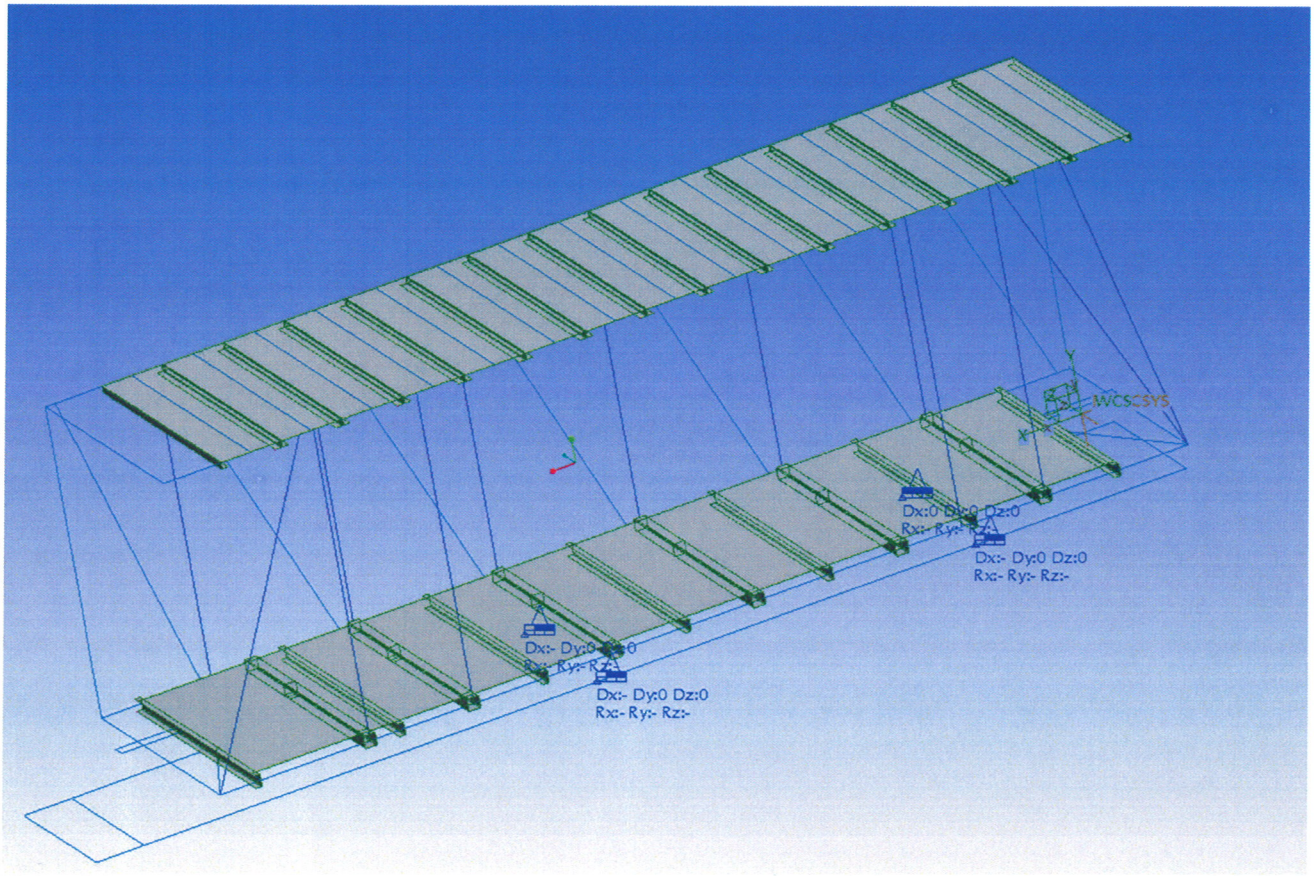
Constraints



Picture 3 Constraints

Model is constrained at 360x170 I-beams, at points where the tunnel lies on rolls. Constrains are shown in Picture 3. Dy:0, Dz:0 stand for displacement constraint in y and z direction. displacement in x direction is constrained only in one point. This will allow I-beam bending in other points.

Idealizations

The Floor is modeled using single surface to even out load distribution and give more realistic results in stress. Beams under floor are not idealized to beams as they interact with floor to take the stress. Also roof elements are modeled as surfaces to correct them correct shape. Non-supporting elements have been ignored in this model.

Loads

Model element stress calculation consists in one single load case. The docking station is represented by a load, which affects only to the other 360x170 I-Beam element of the structure (worst case).
Double gravity is used to describe weight which is added to bridge frame over steel structure.

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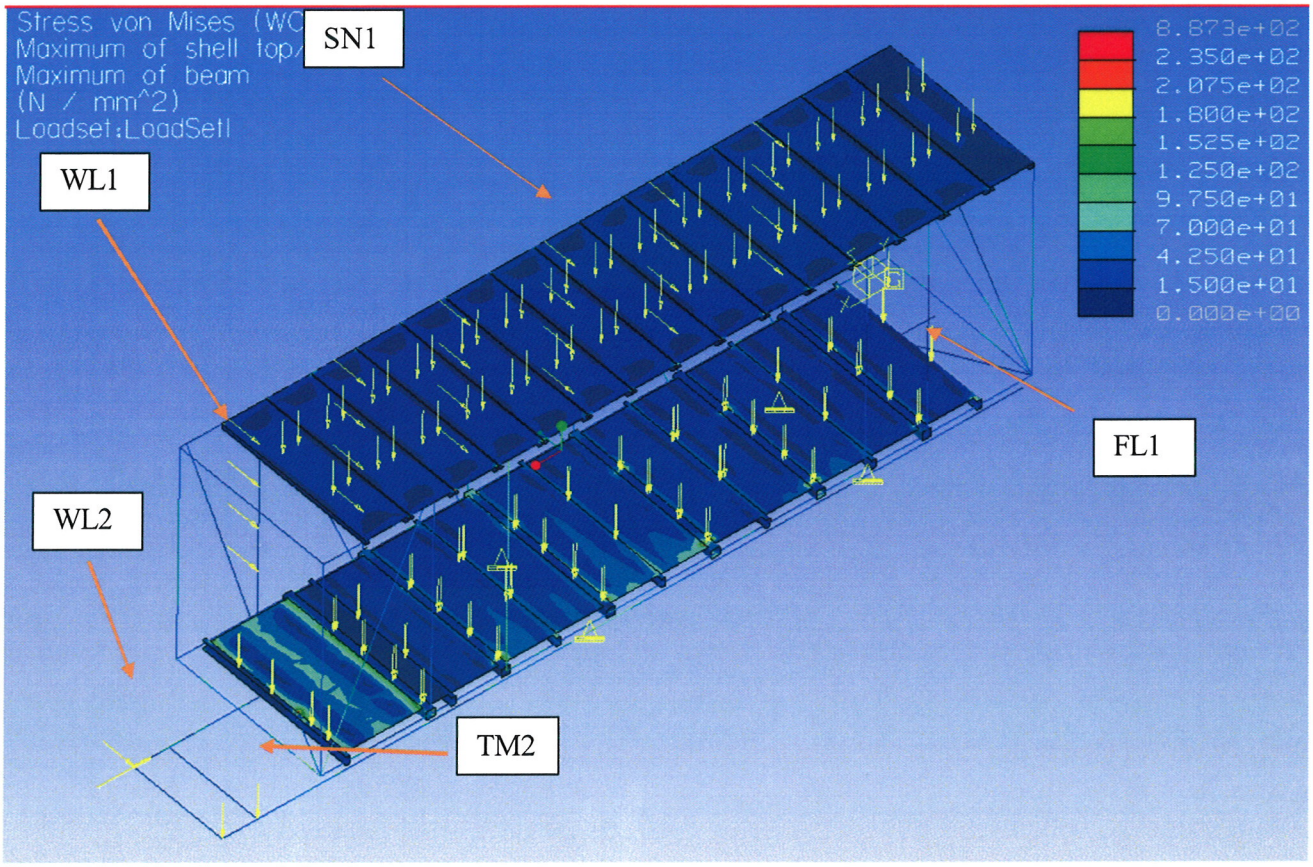

Picture 4 Load locations and directions

Loads and initial values are listed in table below. Wind- and snow load calculations according to EN 1915-2

	Rated load				
	3000	N/m^2			
					Note
Tunnel					
	width		1860	mm	
	length		7200	mm	
	Area		13.392	m^2	
	load		40176	N	FL1
Cabin					
	width		2500		
	length		1500		
	Area		3.75	m^2	
	load		11250	N	FL2
	wind force				
	shape factor	c	1.20		
	Air Density	?	1.225	Kg/m^3	
	Wind velocity	?	21	m/s	
	Pressure	q	270.1125		
Tunnel					
	Wall surface	Aw1	19.68	m^2	
	Force	Fw1	6378.977	N	WL1
Cabin					

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	Wall surface	Aw2	3.6	m^2	
	Force	Fw2	1191.196	N	WL2
	Snow load				
	Snow pressure	qsnow	785	N/m^2	
	Earth gravity	G	9.80665	m/s^2	
Tunnel					
	Ceiling surface	Ac1	23.0048	m^2	
	Force	Fc1	18058.77	N	SN1
Cabin					
	Ceiling surface	Ac2	3.75	m^2	
	Force	Fw2	2943.75	N	SN2
density			7.86E-06	kg/mm^3	
100x100x3	area	Ab1	1164	mm^2	
	length	Lb1	100423	mm	
	mass		9.18E+02	kg	
100x200x6	area	Ab2	3456	mm^2	
	length	Lb2	20152	mm	
	mass		5.47E+02	kg	
100x50x1.5	area	Ab3	295	mm^2	
	length	Lb3	13720	mm	
	mass		3.18E+01	kg	
roofcasette	area	Ab4	2100	kg	
	length	Lb4	1960	mm	
	mass		4.85E+02	kg	
Cabin	Mass		1860	kg	
Tunnel	Mass		1.98E+03	kg	
Cabin total load (FL2 + SN2 + MASS*2)			50674.49	N	TM2

Results

Mechanica threats constraints and connections as rigid parts of the model. Therefore resulting model shows particularly large values in stress around connections. This matter has been taken in consideration when studying results.

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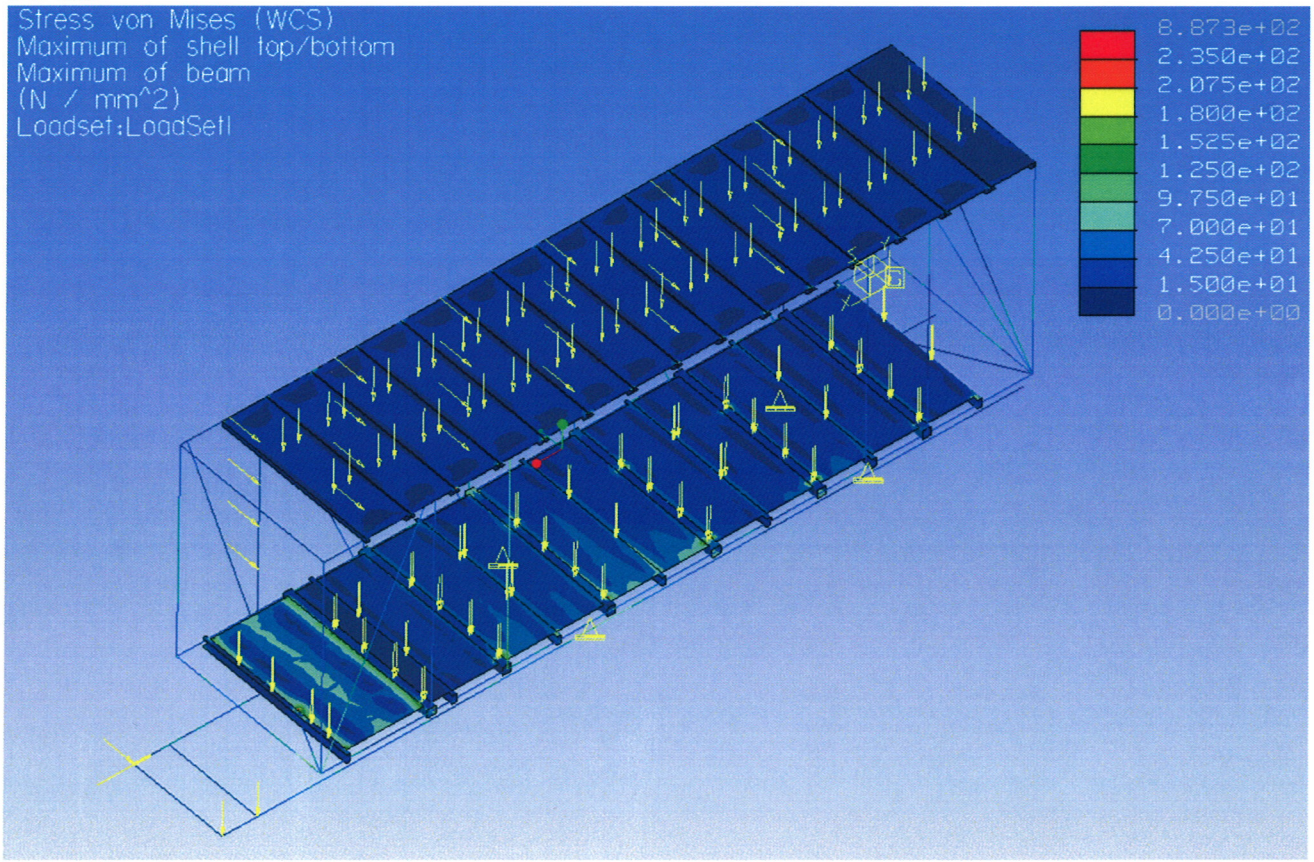
Stress



Picture 5 Overall stress distribution

Stress distribution is quite even over the whole structure. Color legend is defined from 15 MPa to 235 MPa.

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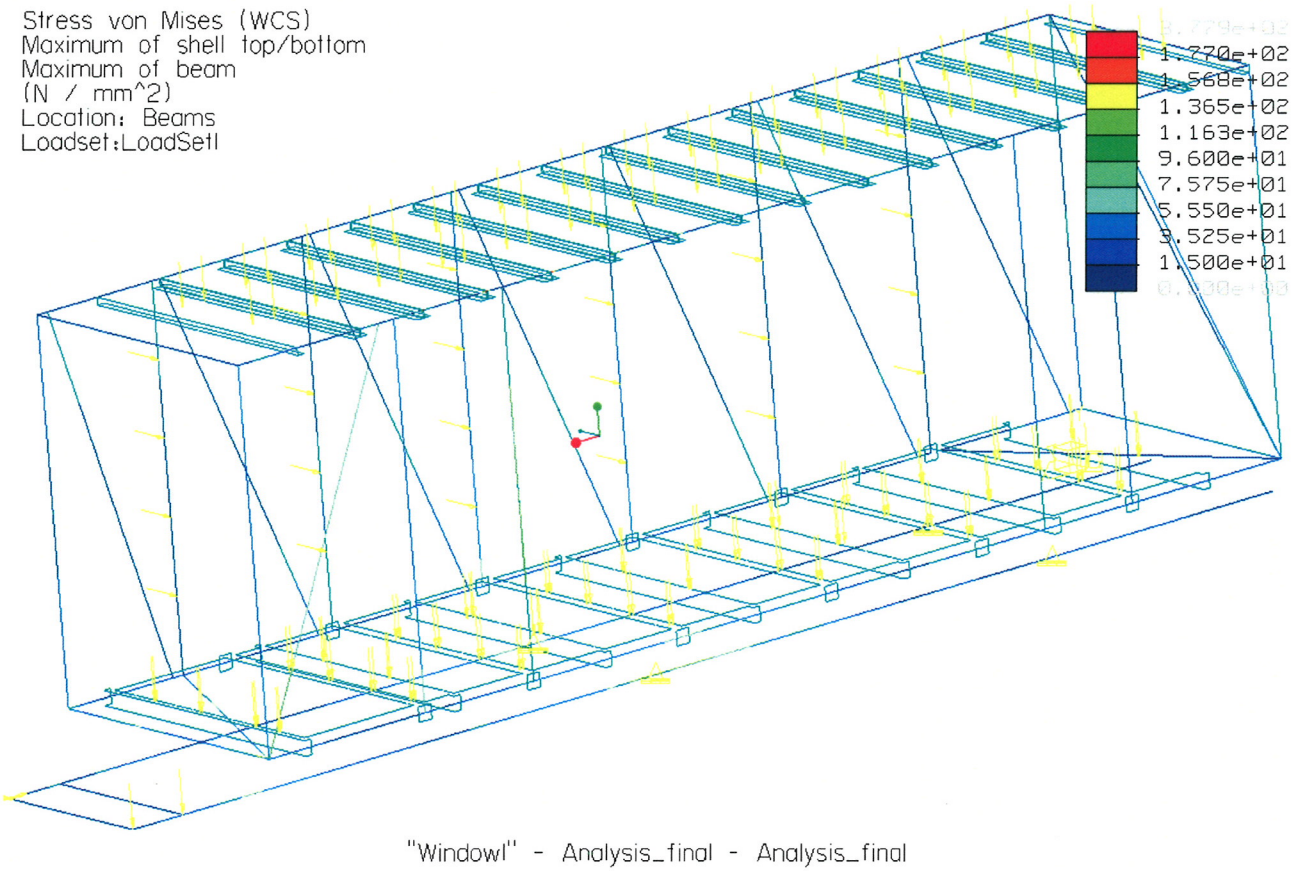

Picture 6 von-mises stress in beam elements

Overall stress distribution in beams.

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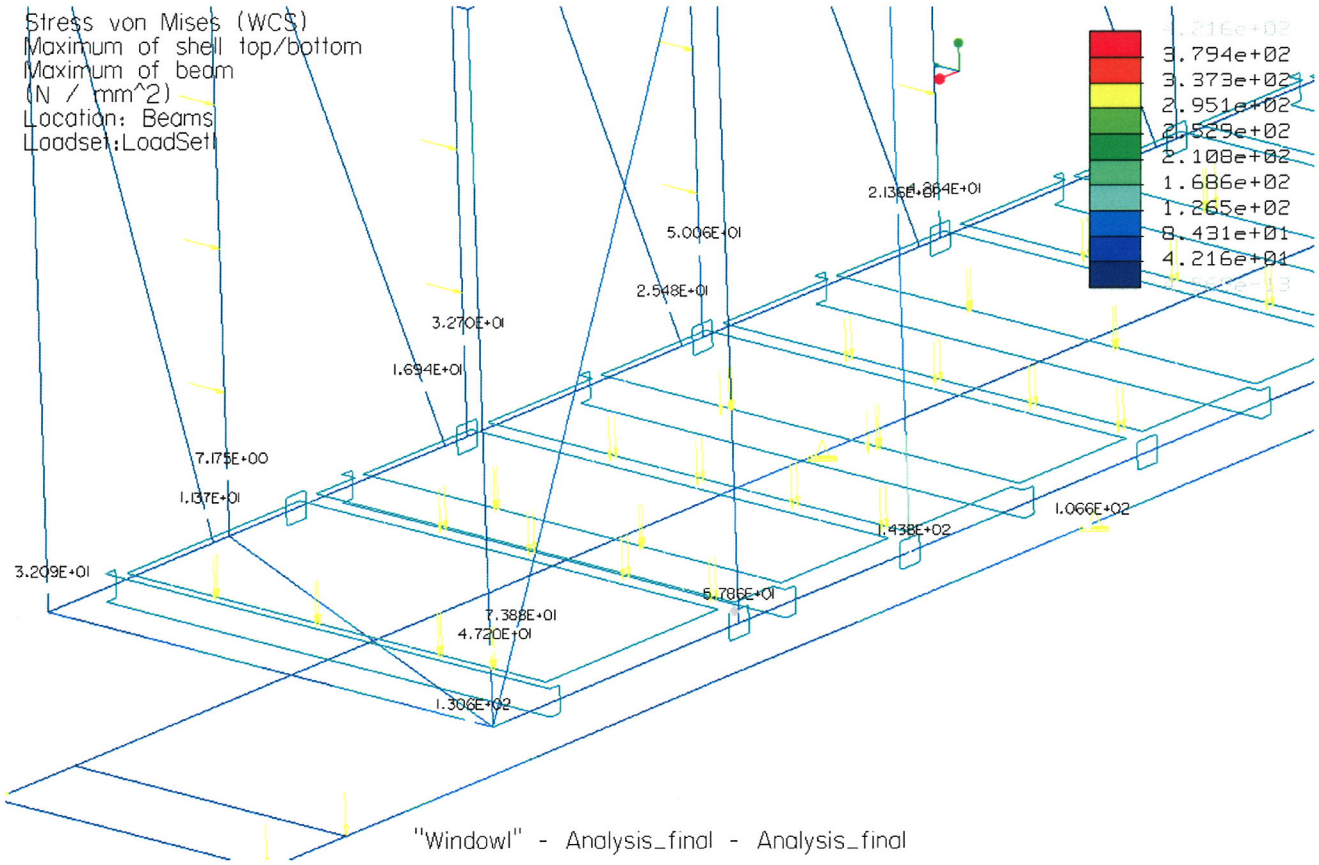

Picture 7 front side of the tunnel. Beam element stress

Maximum stress 130.6 MPa in 100x100x3 RHS beam
Maximum stress 106.6 MPa in 360x170 I-Beam

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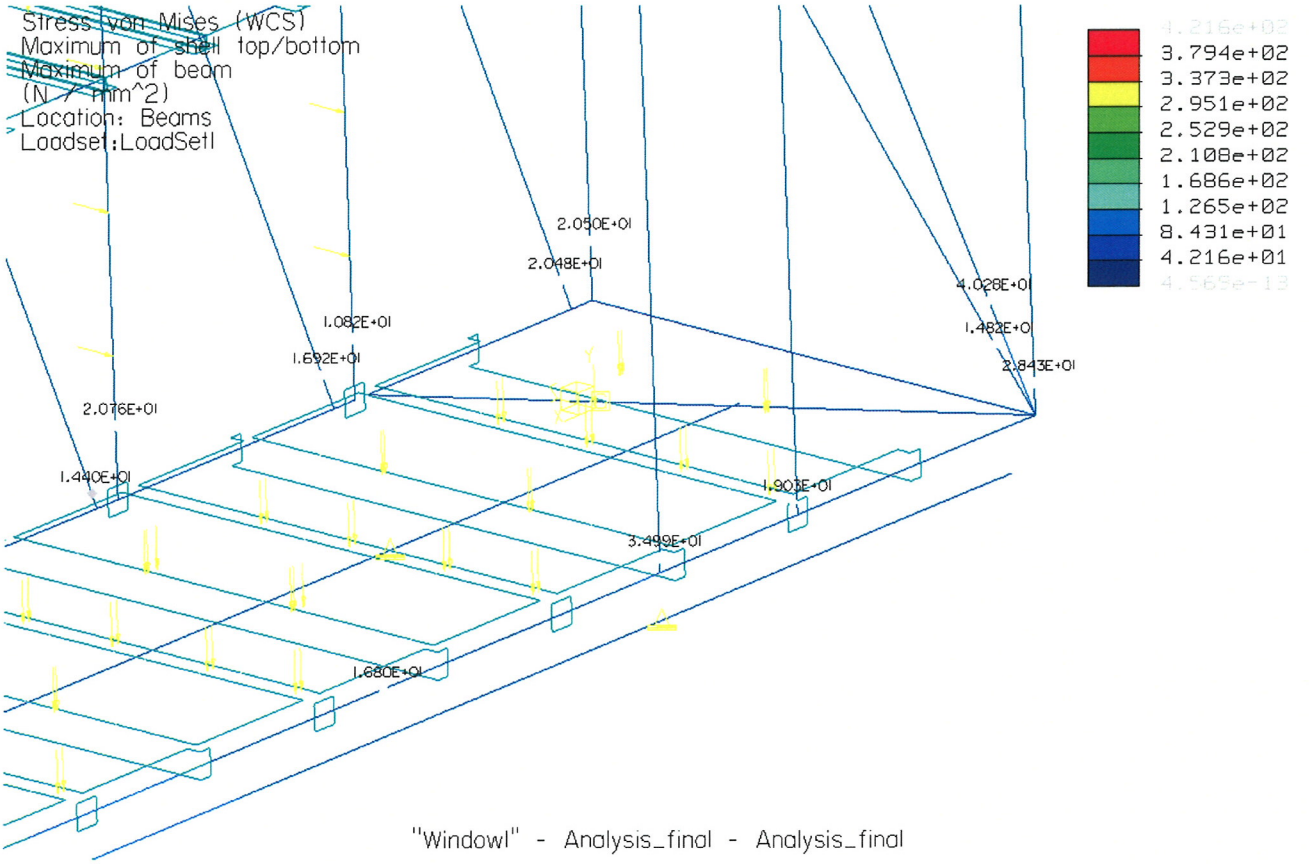

Picture 8 Back side of the tunnel

Maximum stress 40.2 MPa in 100x100x3 RHS crossing from side to side.

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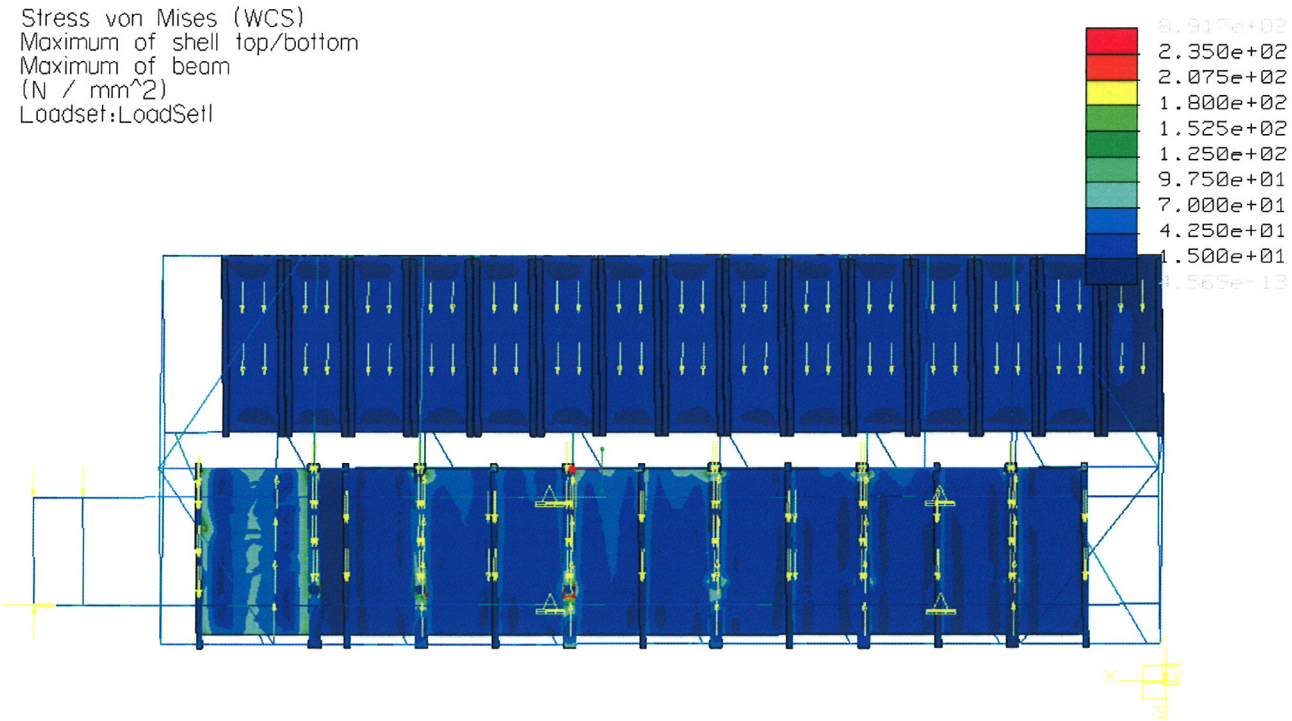

Picture 9 bottom side of the tunnel

Stress larger than 235 is shown in here. Both stresses appear is around rigid connection to a shell element and are only point stresses.

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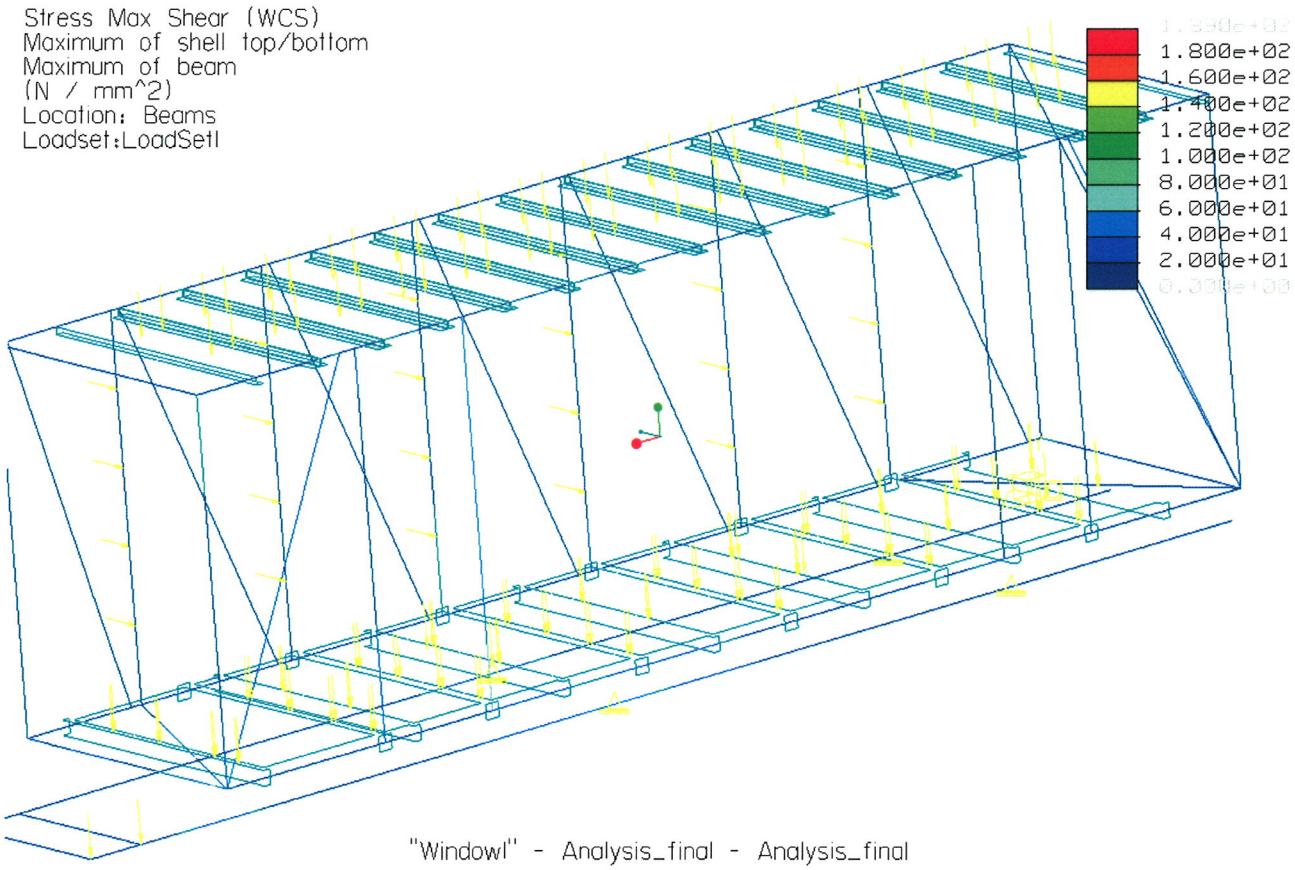

Picture 10 shear stress in tunnel beam elements

Color legend red-zone is set in 180 MPa. None of the beams have shear stress over 100 MPa.

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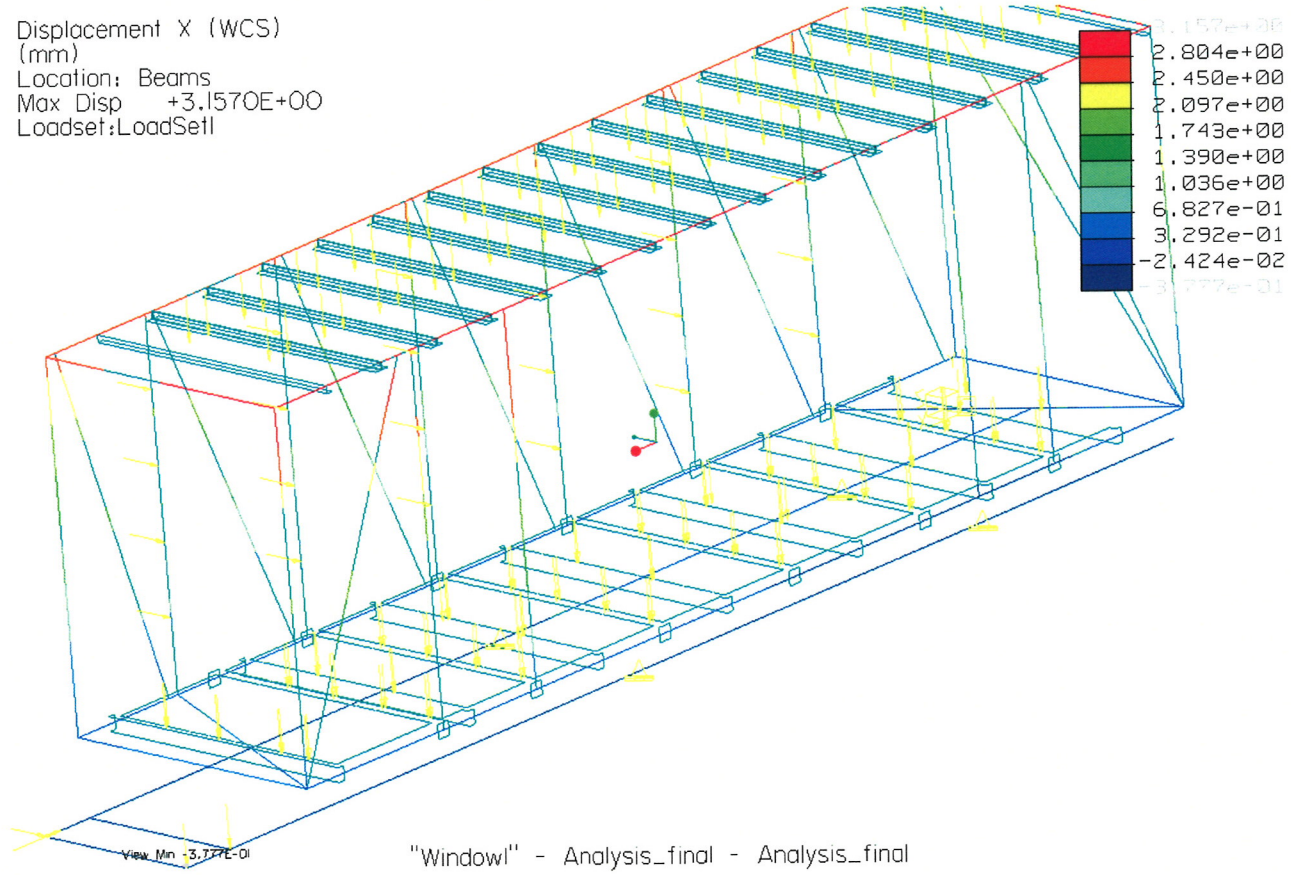
Displacement



Picture 11 Displacement X (lateral)

Displacement maximum (minimum in used coordinate system) is located in the end of the other I-beam. Value is 0.37 mm.

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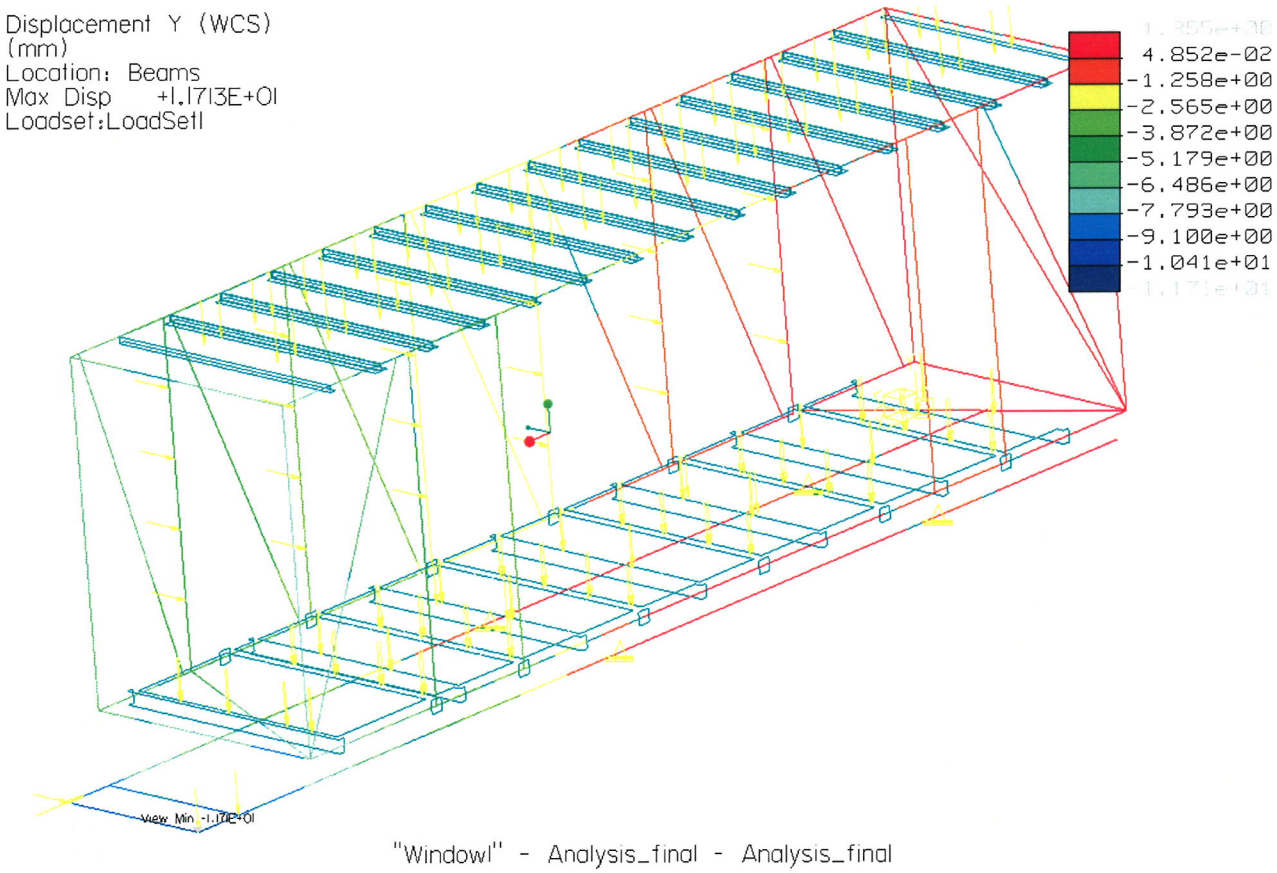

Picture 12 Displacement Y (vertical)

Displacement maximum (minimum in used coordinate system) is located, as expected, in the end of the other I-beam. Value is 11.7 mm.

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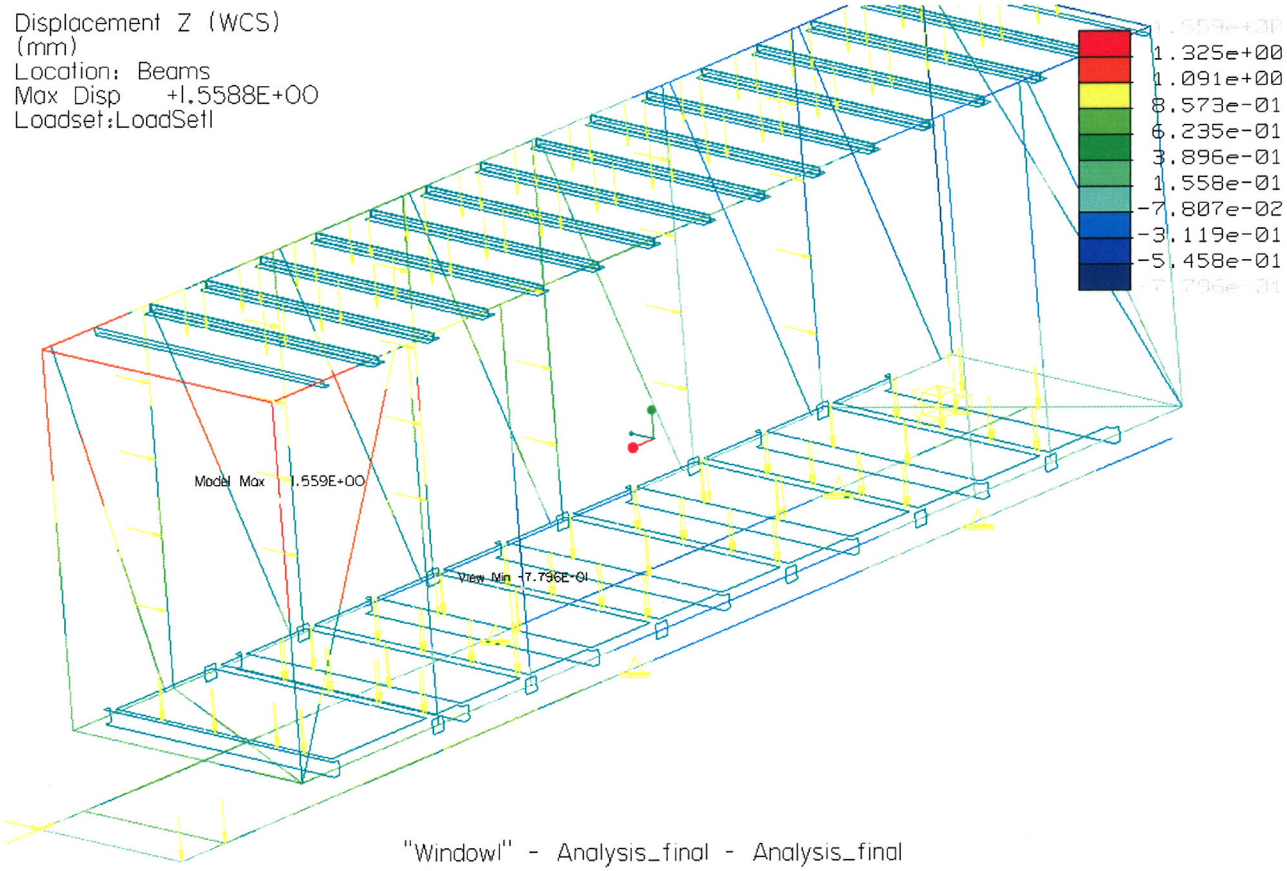

Picture 13 Displacement Z (horizontal)

Displacement maximum is located in support U-beams in the end of the tunnel. Displacement value 1.5mm.

Element calculations

Pro/Engineer preferences on element solver:

Generate elements automatically.
Checking the model after creating elements...

No errors were found in the model.

Mechanica Structure Model Summary

Principal System of Units: millimeter Newton Second (mmNs)

Length: mm
Force: N
Time: sec
Temperature: C

Model Type: Three Dimensional

Points: 3652

Edges:	8531
Faces:	4820
Springs:	0
Masses:	0
Beams:	243
Shells:	4820
Solids:	0
Elements:	5063

conclusions

Maximum combined (von-mises) stress affecting structure carrying beams is 130,6 MPa.
Shear stress maximum doesn't exceed 100 MPa.

EN 1915-2:2001 table 1 gives stress factors to tensile, compressive and shear stress.

$$shear: \tau = 1{,}7 * 100\ MPa = 170 MPa$$

$$comressive: \sigma_D = 1{,}4 * 130{,}6\ MPa = 182{,}84 MPa$$

margin to safety factor:

$$shear: \frac{R_m}{\tau} = \frac{355}{170} = 2{,}08 > 1$$

$$compressive: \frac{R_m}{\sigma_D} = \frac{355}{182{,}84} = 1{,}94 > 1$$

The T-type passenger boarding bridge structure fulfills design criteria in EN 1915-2

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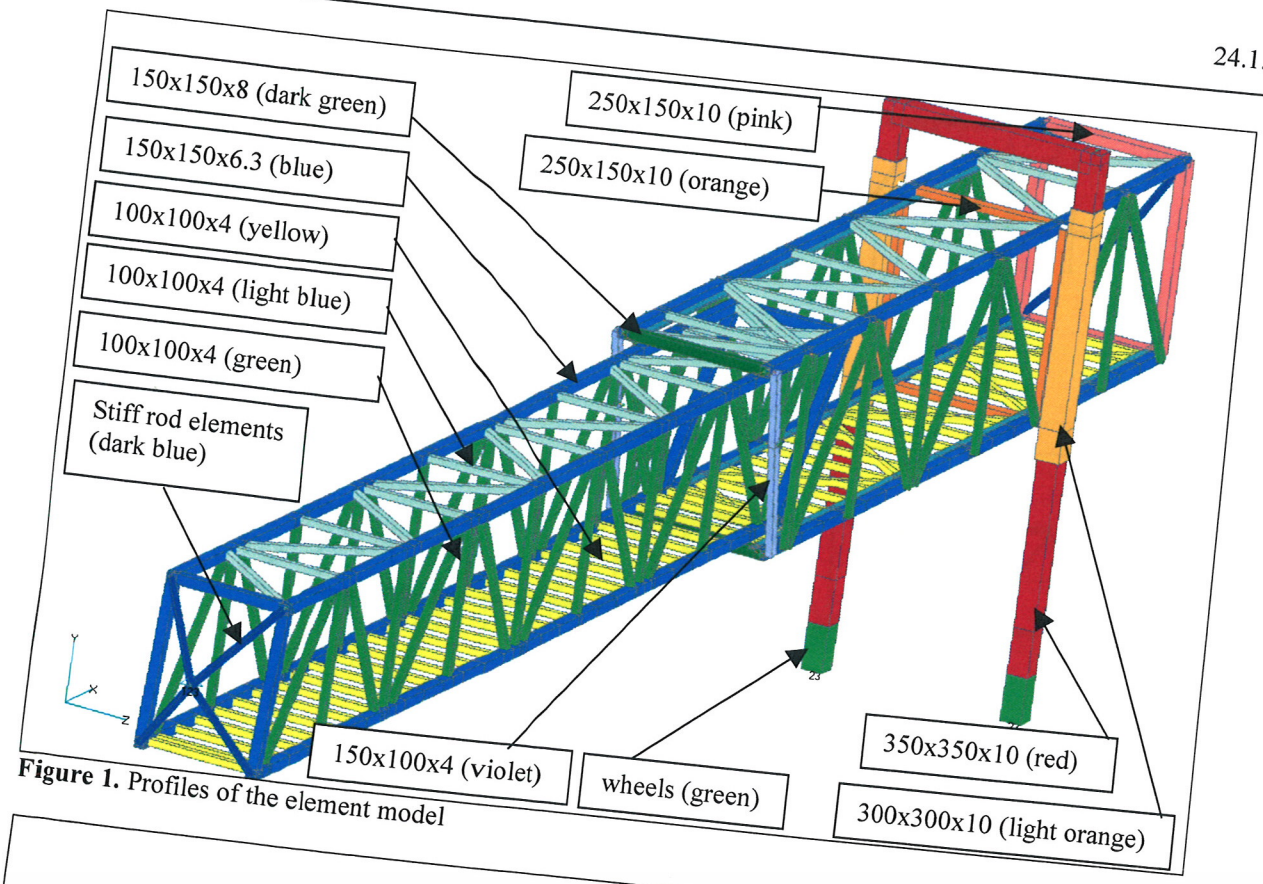

Figure 1. Profiles of the element model

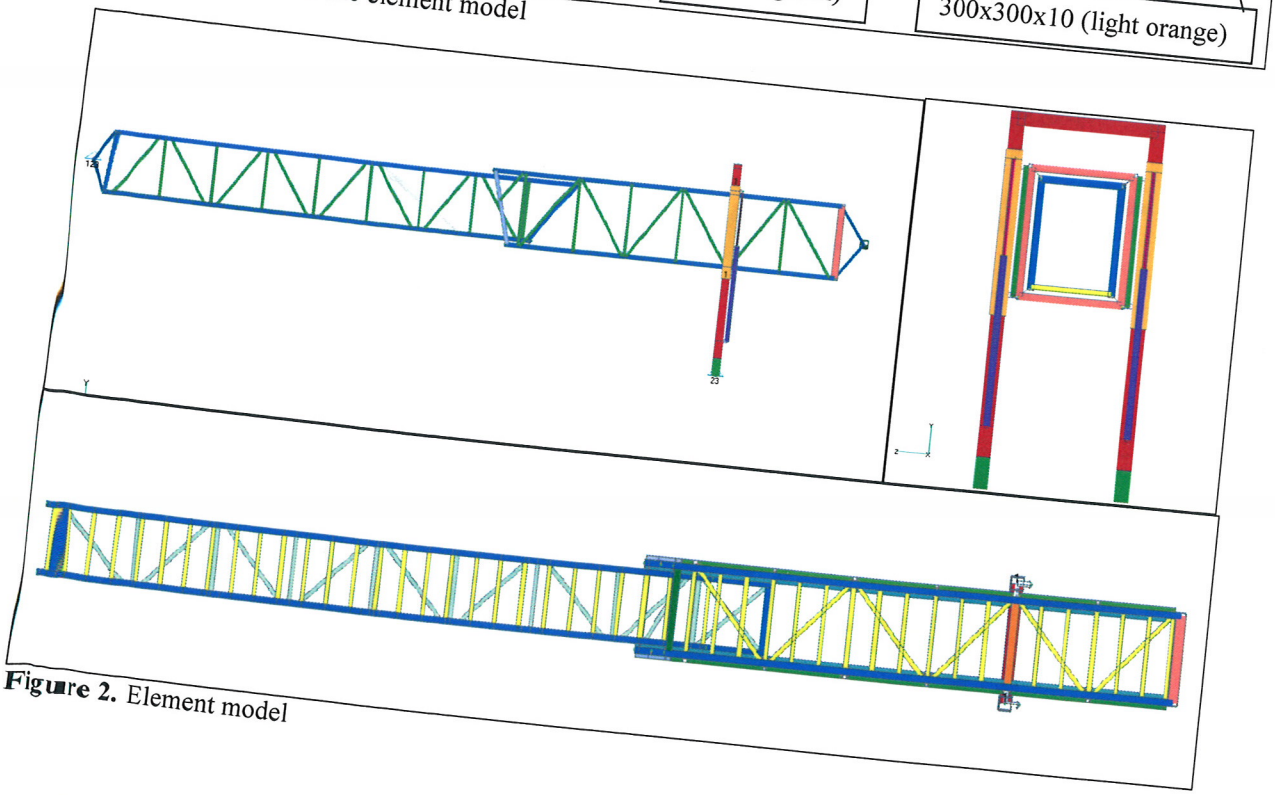

Figure 2. Element model

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