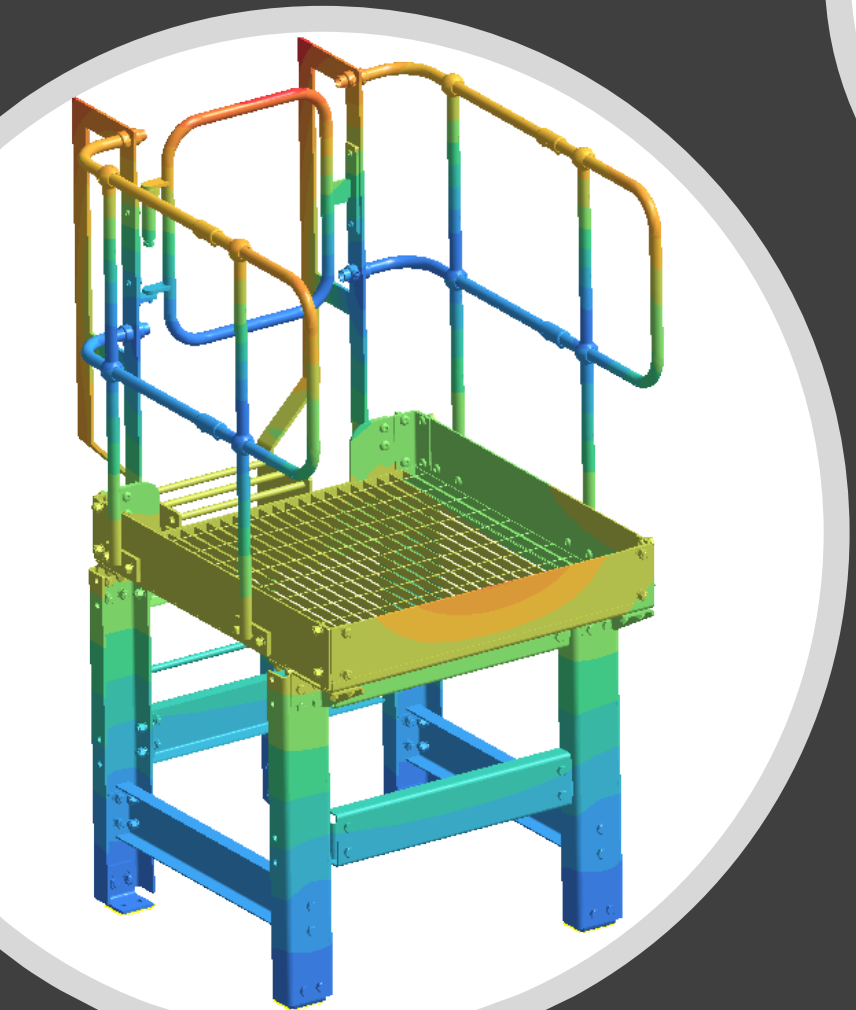

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WEBINAR

Large Assemblies

Simulation Made Easy

20th September 2020 - 14:00 – 15:00 GMT

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Something About Me

Wasim Younis

- Working at Symetri for over 10 Years as Simulation Specialist
- Experience with various Simulation Tools including, MSc, Ansys, Algor and Autodesk Simulation
- Authored the Up and Running with Autodesk Inventor/Nastran Simulation books

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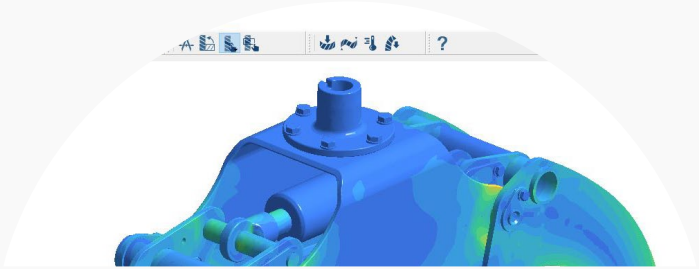
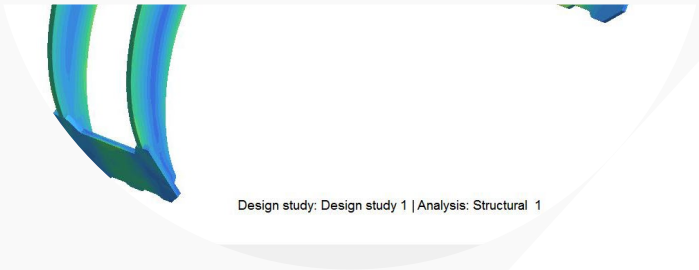


AGENDA



1 Traditional & SimSolid workflows

2 SimSolid Demonstration - Live

3 SimSolid Results and Accuracy

4 Question and Answers

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Comparison between Traditional & SimSolid (GEOMETRY SIMPLIFICATION)

Inventor Nastran		SimSolid	
Task	**Time**	**Task**	**Time**
Geometry simplification - remove small features	Mins/ Hours?	Not required - SimSolid works on full fidelity CAD assembly	0
Geometry replacement - convert solids to surfaces, beams, bars, etc.	Hours?	Not applicable - SimSolid handles multi-scale geometry efficiently	0
Geometry clean up - make sure surfaces align, remove gaps and cracks	Hours?	Not required - SimSolid is tolerant of gaps and overlaps	0

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Comparison between Traditional & SimSolid (MESHING AND CONVERGENCE)

Inventor Nastran		SimSolid	
Task	**Time**	**Task**	**Time**
Meshing - sensitive to quality of geometry	Mins/ Hours?	Not applicable – SimSolid does not use a FE mesh	0
Mesh validation – aspect ratio, skew, warp, etc.	Mins?	Not applicable – SimSolid does not use a FE mesh	0
Need to run multiple analyses with different mesh sizes to get stress results convergence	Hours?	Solution Convergence always done.	0
Solution Convergence – not practical for large assemblies	Hours?	Solution Convergence always done.	0

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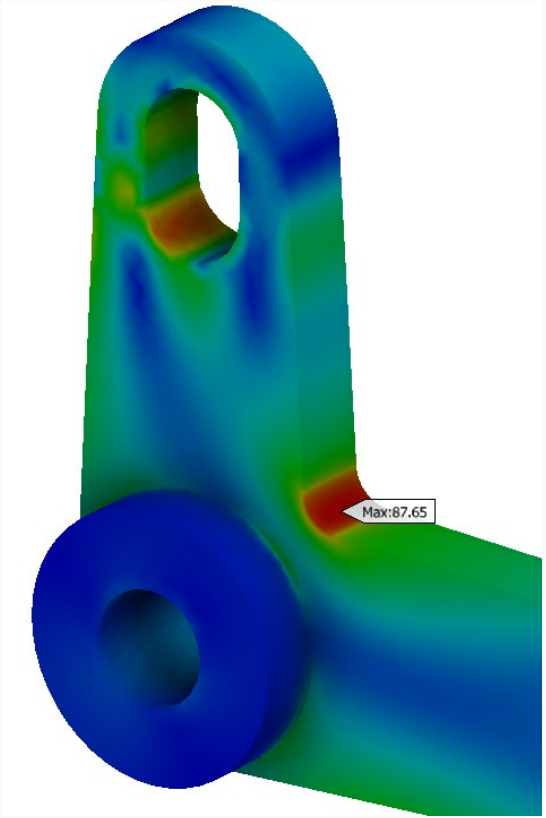
Inventor Nastran Results Convergence



Mesh Size	Result	% Difference
2mm	83.98 MPa	-
1mm	81.9 MPa	2
0.5 local	87.08 MPa	6
0.25 local	87.65 MPa	0.6

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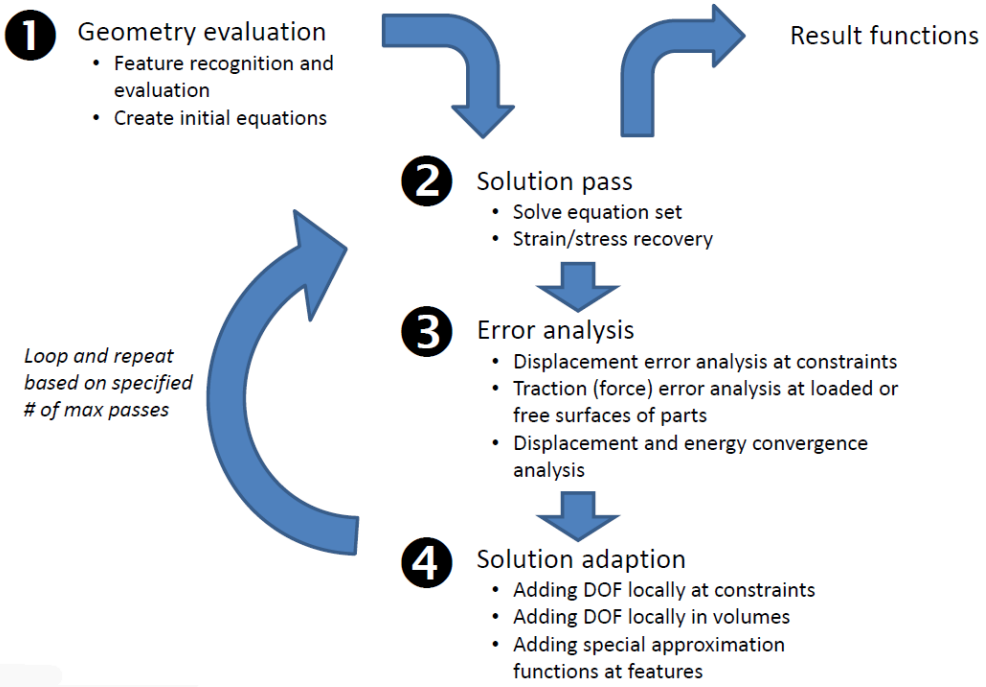
SimSolid Workflow – Automatic convergence



DOWNLOAD – SimSolid-technology-overview-whitepaper from Handouts

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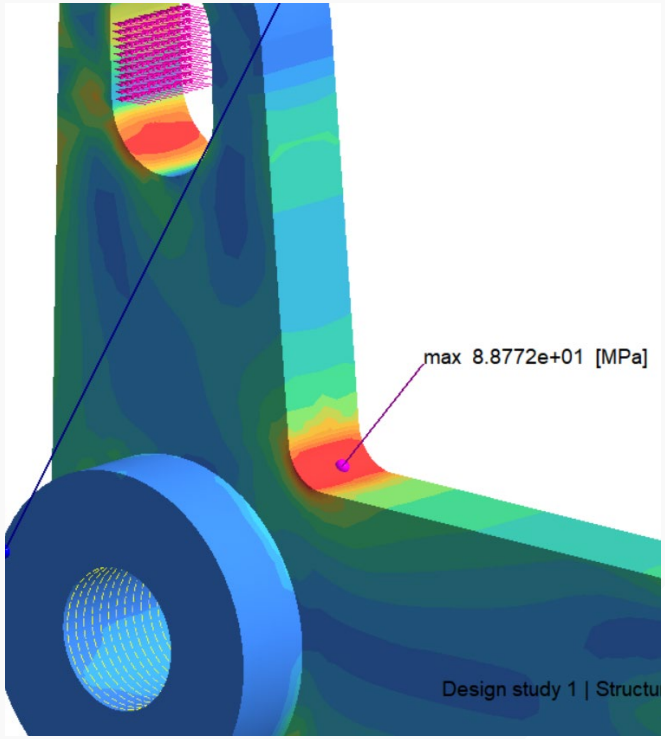
SimSolid results convergence



Convergence	Result	% Difference
Adapt for Stress	88.77 MPa	-
Nastran	87.65 MPa	1.2

$$Difference = \frac{88.77 - 87.65}{87.65} = \frac{1.12}{87.65} = 0.012$$

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WELDS

Now lets have a look at Autodesk Solutions Workflow?

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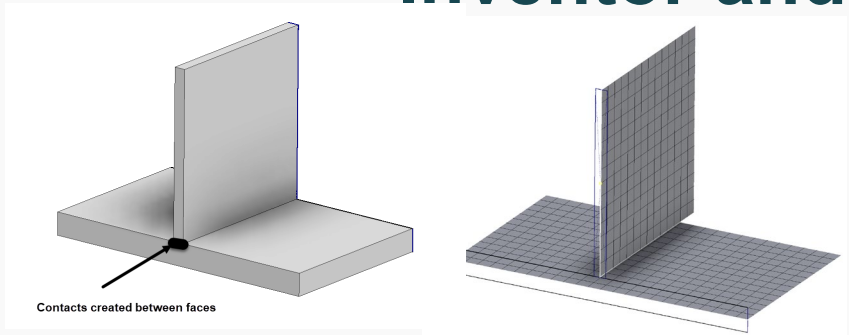
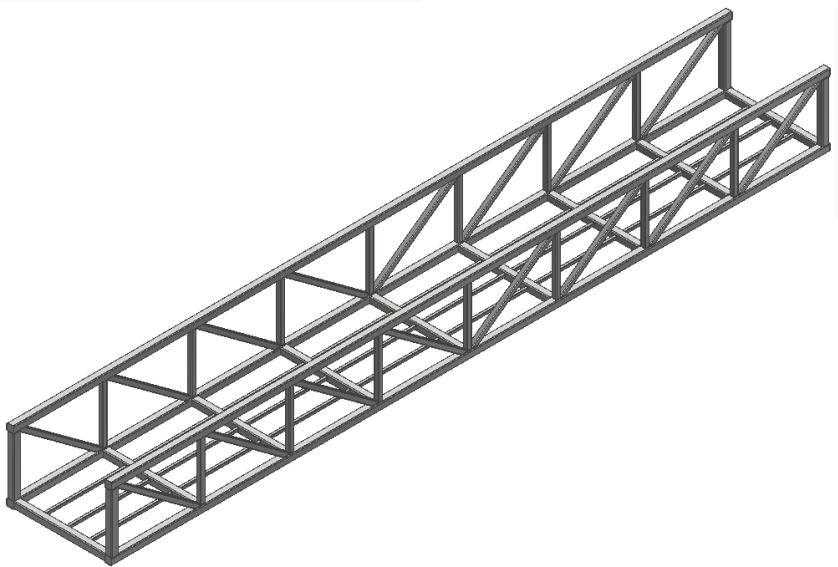
Inventor and Nastran Workflow





Options

1. Solid Elements
   - Model Weld geometry
2. Shell Elements
   - Mid-surface extraction
     - No weld geometry
   - Surface Model
     - Welds are modelled as surfaces
     - Normally welds not accounted for
3. Beam Element
     - Welds not accounted for

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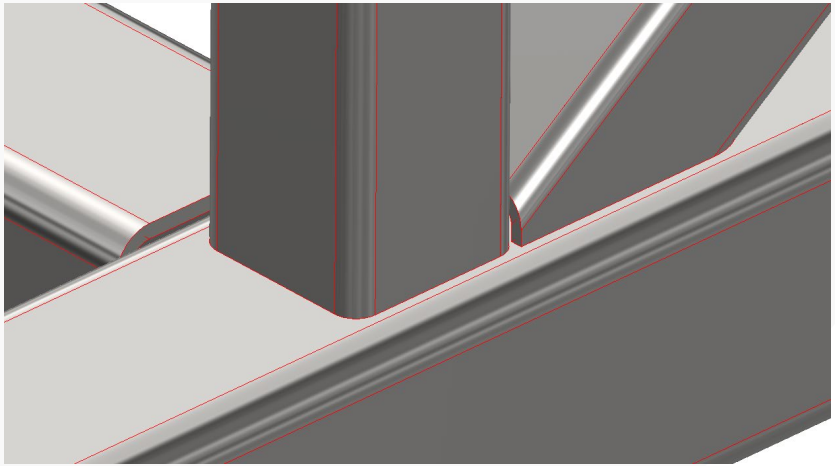
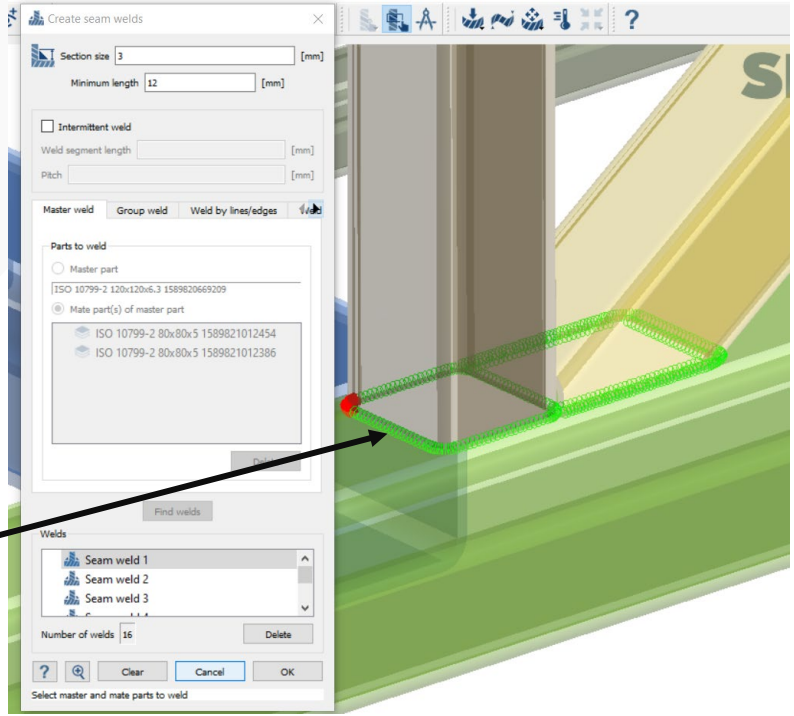
SimSolid Workflow



- Weld geometry can be used as welds
- Create welds between components



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BOLTS

Now lets have a look at Autodesk Solutions Workflow?

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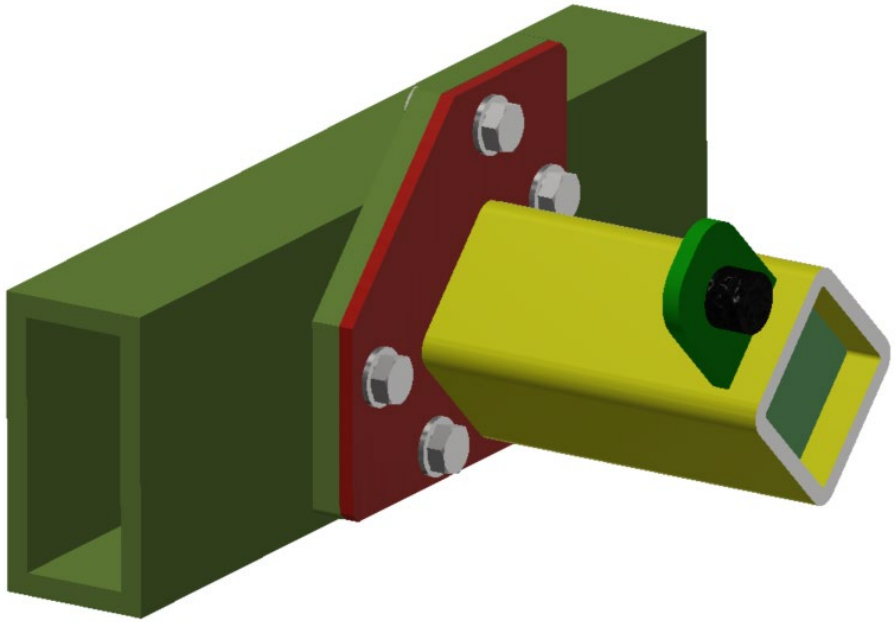
Inventor and Nastran Workflow



Inventor

1. Cannot analyse bolted connections with preload and will need modify automatic contacts manually.

Nastran

1. Can analyse bolted connections using beams elements (Classical method).
   - Cannot simulate friction/bolted connection contact behaviour.
2. Cannot make reuse of inventor bolted connections (if you want to apply preload).
   - Will need to modify contacts for all bolts.

Workflow

1. Suppress Bolted Connections
2. Split faces to transfer loads from washer/bolt/nuts/threads
3. Redefine bolted connections within Nastran

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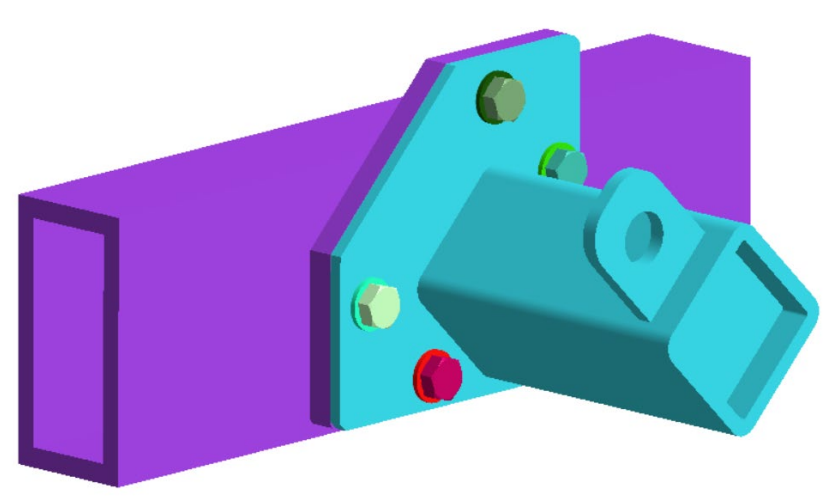
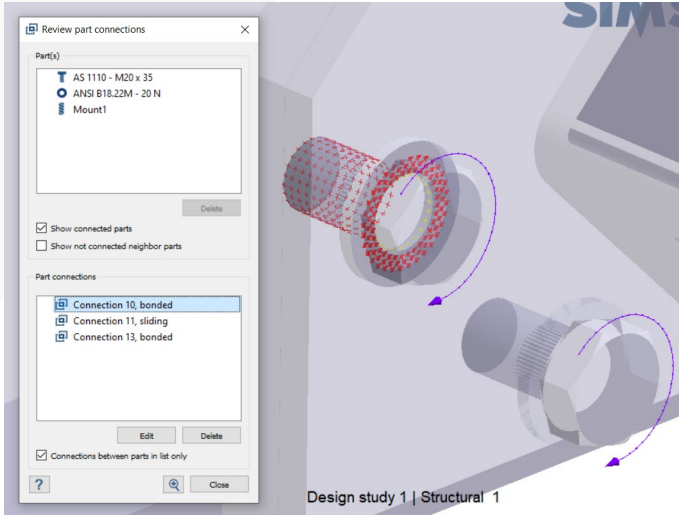
SimSolid Workflow





- You can reuse bolted connections
- Contacts are defined automatically

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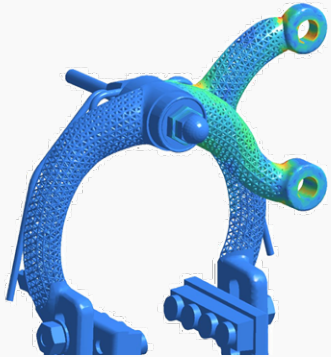
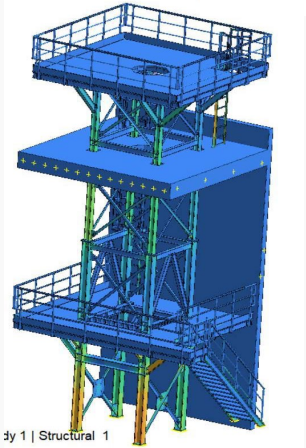
In brief - SimSolid



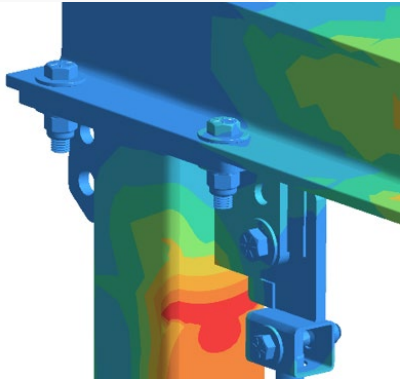
Complex models

- 3D Printed
- Additive Manufactured
- Lattice structures
- Organic Structures



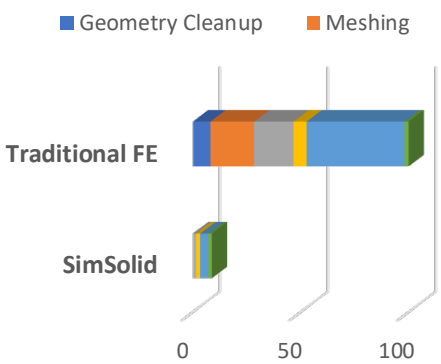
Large Scale models

- Building Structural framework
- Welded Fabrications



Original models

- Inventor Bolted Connections



Rapid Results

- Literally within minutes
- Automatic results convergence

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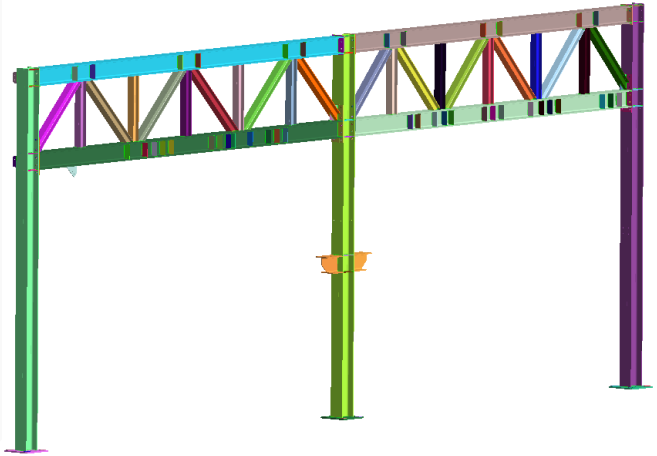
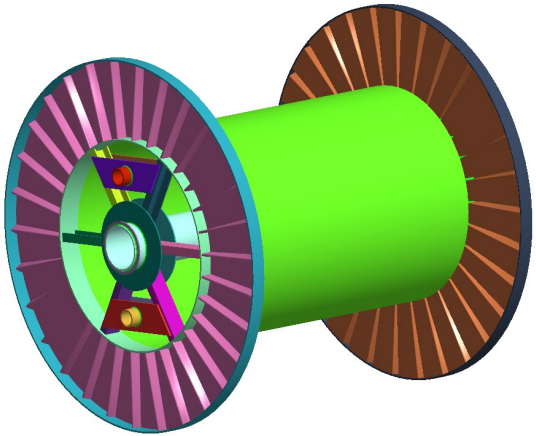
SIMSOLID DEMONSTRATIONS - LIVE





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SIMSOLID RESULTS AND ACCURACY

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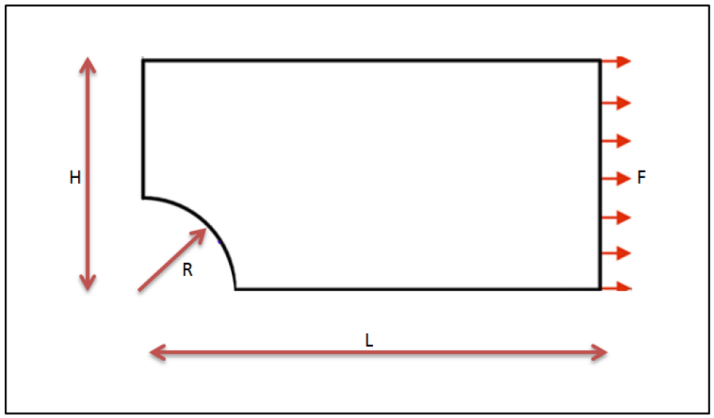
Theoretical Example

Plate with Hole

Due to symmetry, only 1/4 section was analyzed as shown.



- Units are SI.
- L= 100 mm, H=50 mm, R=20 mm
- Elastic Modulus=2.1e+11 Pa, Poisson's Ratio=0.3
- **Thickness = 10mm F = 100 N/mm²**

Reference Solution

$$\sigma_{max} = k\sigma_{nom} \qquad \text{with} \qquad k = 3$$

$$\sigma_{nom} = F\frac{h}{h-r} = 166,7MPa$$

$$k = 3 - 3.13(\frac{d}{h}) + 3.66(\frac{d}{h})^2 - 1.53(\frac{d}{h})^3 = 2.2357$$

$$\boxed{\sigma_{max} = 372.7MPa}$$

Further Info on theory

https://www.fracturemechanics.org/hole.html

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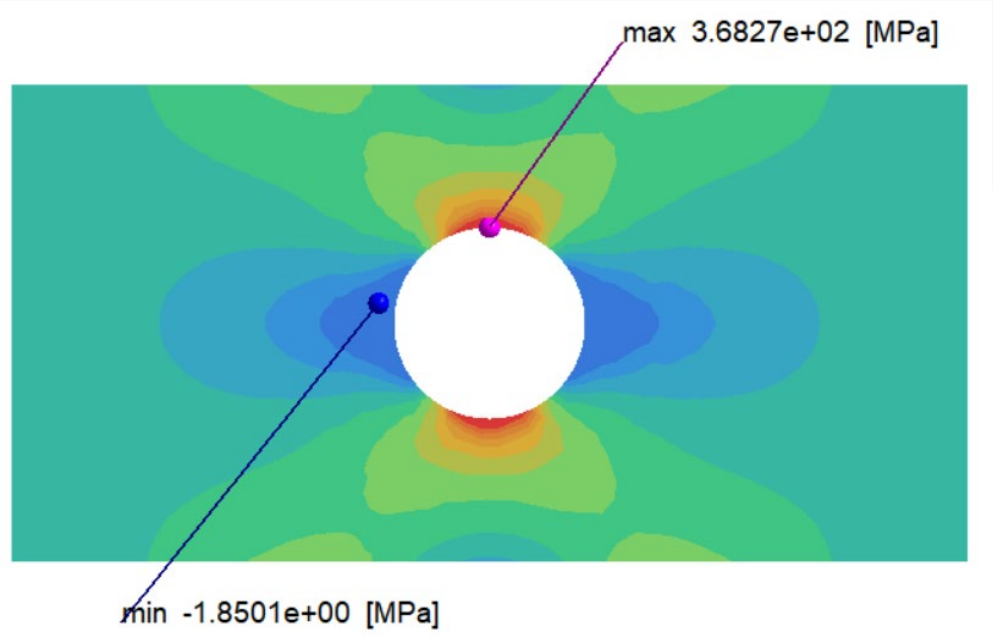
SimSolid Results



Target Solution	372.7 MPa
SimSolid (Max Principal)	368.3 MPa
% difference	1%

$$Difference = \frac{372.7 - 368.3}{372.7} = \frac{4.4}{372.7} = 0.0118$$

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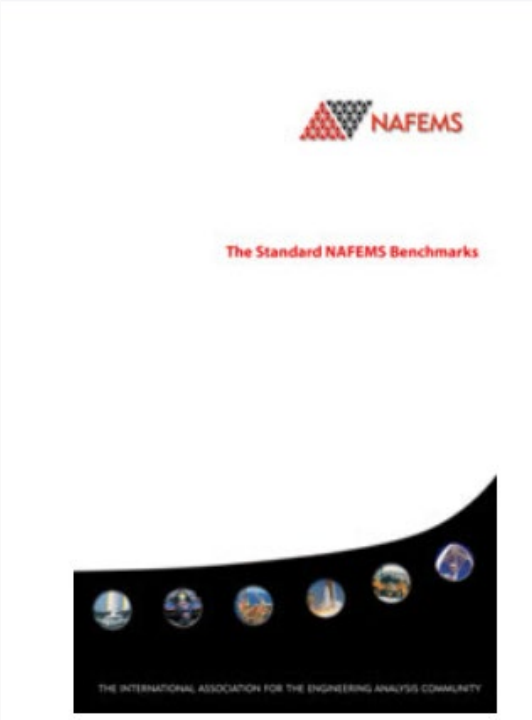
NAFEMS – Benchmark Tests

https://www.nafems.org/publications/resource_center/p18/



Content

- **Elliptic Membrane** - Analysis type: Linear elastic
- **Cylindrical Shell patch test** - Analysis type: Linear elastic
- **Hemisphere-point loads** - Analysis type: Linear elastic
- **Axisymetric hyperbolic shell, edge loading** - Analysis type: Linear elastic
- **Z-section cantilever** - Analysis type: Linear elastic
- **Skew Plate Normal Pressure** - Analysis type: Linear elastic plate bending
- **Asymmetric cylinder/sphere-pressure** - Analysis type: Linear elastic asymmetric
- **Asymmetric Shell Pressure** - Analysis type: Linear elastic axisymetric
- **Asymmetric branched shell-pressure** - Analysis type: Linear elastic asymmetric
- **Thick plate pressure** - Analysis type: Linear elastic solid
- **Solid cylinder/Taper/Sphere-Temperature** - Analysis type: Linear elastic solid

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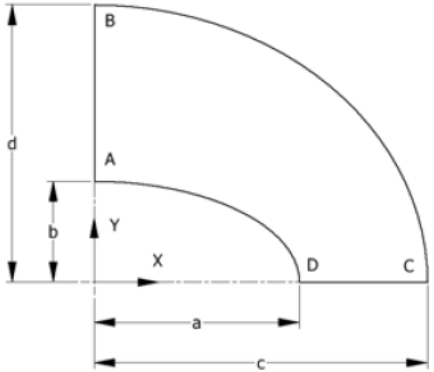
NAFEMS Benchmark Test LE1

1. Elliptic plate under tensile

Case description

An elliptic plate with thickness t is supported to a uniform outward pressure P on the outer elliptic cylindrical face, and unloaded at inner face. The plate is symmetric about YZ plane and ZX plane. Determine the tangential edge stress at corner point D on middle plane.



Material data

Steel	
Young's Modulus	2.1e+005 MPa
Poisson's Ratio	0.3
Mass Density	7.85e-006 kg/mm³
Tensile Yield Strength	207.0 MPa

Dimensions

a = 2000 mm
b = 1000 mm
c = 3250 mm
d = 2750 mm
t = 100 mm

Load value

P = 10 MPa

Target Solution

Tangential Stress (σy) at Point D = 92.7 MPa

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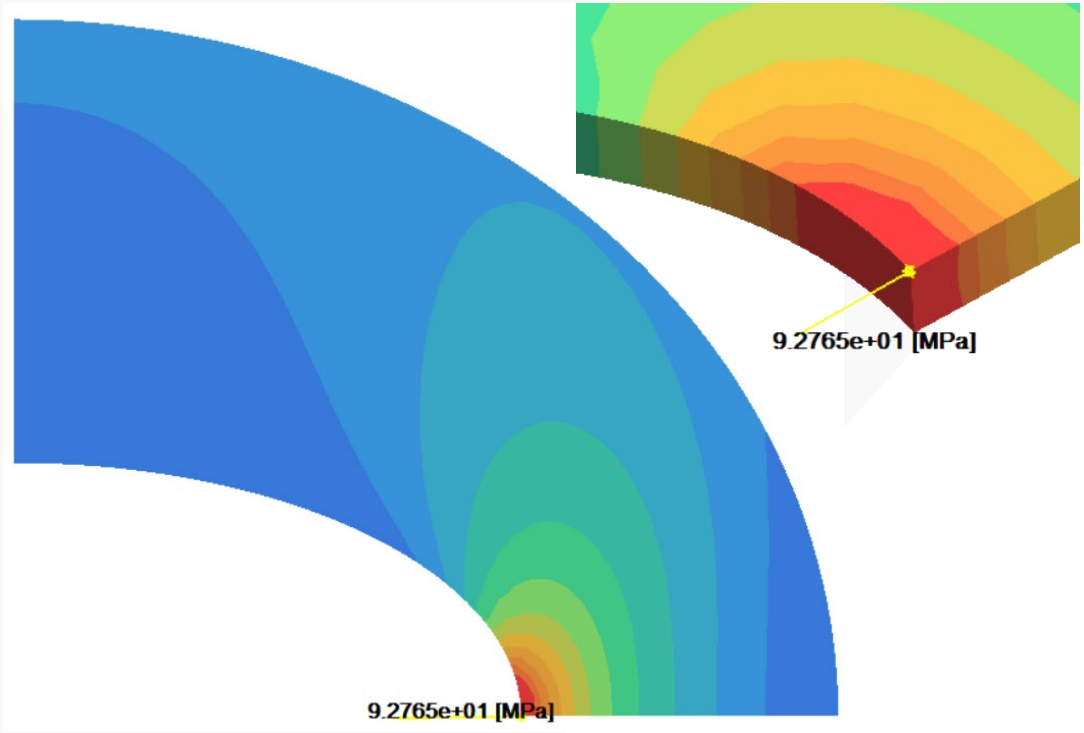
SimSolid Results



Target Solution	92.7 MPa
SimSolid (σ_y)	92.7 MPa
% difference	0%

$$Difference = \frac{372.7 - 368.3}{372.7} = \frac{4.4}{372.7} = 0.0118$$

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NAFEMS Benchmark Test LE6

2. Skew plate under normal pressure

Case description

A rhombic skew plate with thickness t and length L is subjected to a normal pressure P on top face. The plate is simply supported on four side faces. Determine the maximum principle stress at plate center point E on bottom surface.

Material data

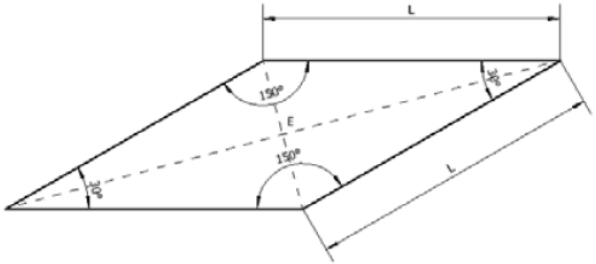
Steel	
Young's Modulus	2.1e+005 MPa
Poisson's Ratio	0.3
Mass Density	7.85e-006 kg/mm³
Tensile Yield Strength	207.0 MPa

Dimensions

L = 1000 mm
t = 10 mm

Load value

P = 0.0007 MPa



Target Solution

Maximum Principle Stress at Point E = 0.802 MPa

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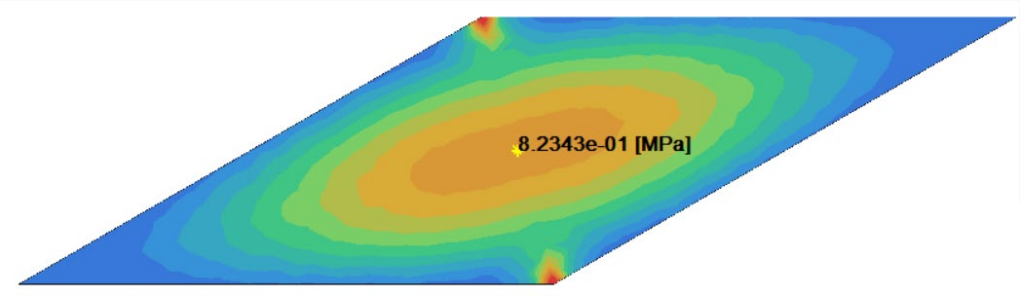
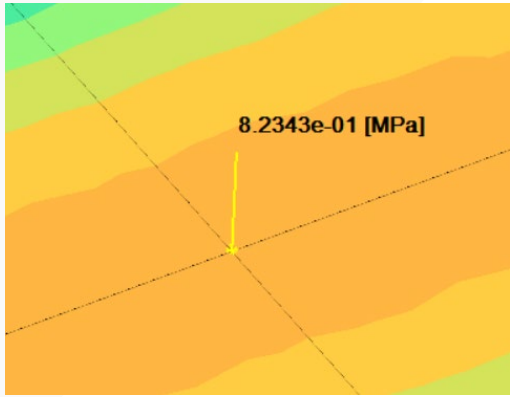
SimSolid Results





Target Solution	0.802 MPa
SimSolid (Max Principal)	0.82 MPa
% difference	2.2%

$$Difference = \frac{0.82 - 0.802}{0.802} = \frac{0.018}{0.802} = 0.0224$$

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NAFEMS Benchmark Test LE7

3. Axisymmetric cylinder/sphere shell under pressure

Case description

An axisymmetric shell composed of cylinder and hemisphere with thickness t is subjected to an inner pressure valued P. The shell is symmetric about bottom surface. Determine the axial stress at point D on outer surface.

Material data

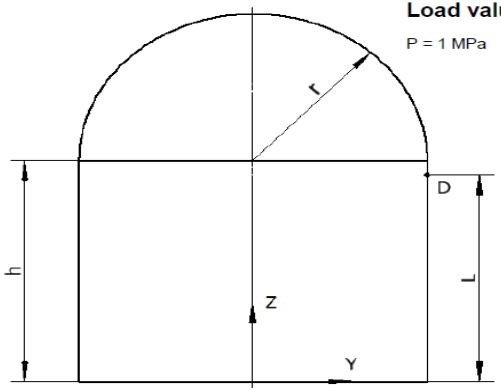
Steel	
Young's Modulus	2.1e+005 MPa
Poisson's Ratio	0.3
Mass Density	7.85e-006 kg/mm³
Tensile Yield Strength	207.0 MPa

Dimensions

h = 1500 mm
r = 1000 mm
L = 1403.4 mm
t = 25 mm

Load value

P = 1 MPa



Target Solution

*Axial Stress (σz) at Point D on outer surface = 25.86 MPa

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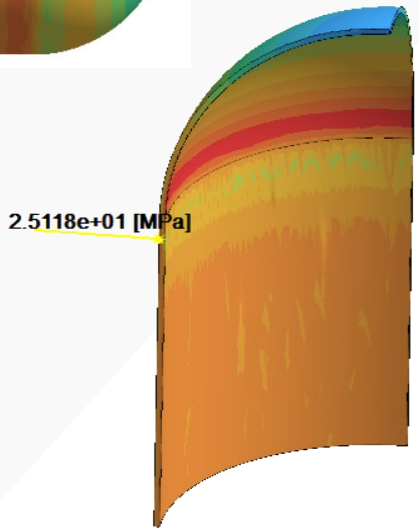
SimSolid Results



Target Solution	25.86 MPa
SimSolid (σ_z)	25.7 MPa
% difference	0.6%

$$Difference = \frac{25.86 - 25.7}{25.86} = \frac{0.018}{0.802} = 0.006$$

$$Difference = \frac{25.86 - 25.1}{25.86} = \frac{0.76}{0.802} = 0.029$$

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SimSolid – Further Verification

More Supporting documents

NAFEMS

- https://www.symetri.co.uk/media/2237/simsolid-verification-by-nafems.pdf

Altair Verification Manual.

- https://web.altair.com/simsolid_validation_guide

DOWNLOAD – SimSolid-validation-manual from Handouts

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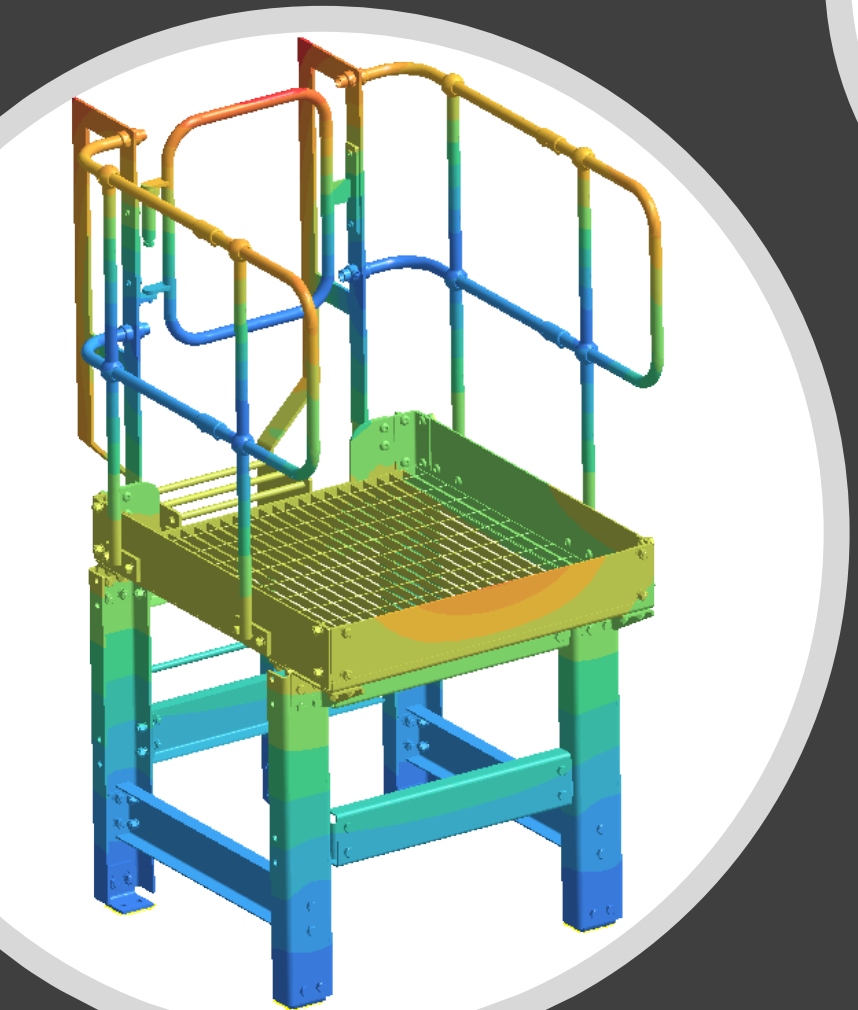
CAN SIMSOLID HELP YOU

My Contact Details
Email: wasim.younis@symetri.com
Mobile Phone: +44 (0) 7980 736255
Office Phone: +44 (0) 1924 232 995



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THANKS FOR ATTENDING