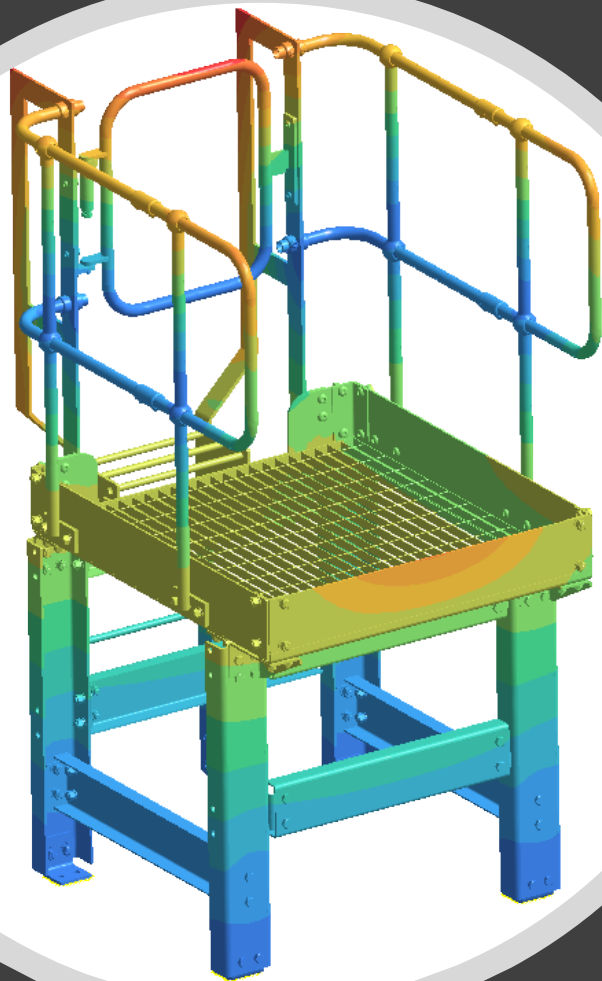




SYMETRI
ADDNODE GROUP



Altair

WEBINAR

Large Assemblies Simulation Made Easy

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

Something About Me



Wasim Younis



Working at Symetri for over 10 Years as Simulation Specialist

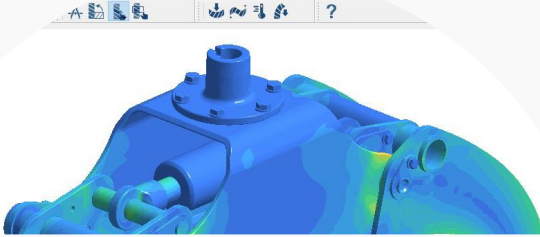


Experience with various Simulation Tools including, MSc, Ansys, Algor and Autodesk Simulation

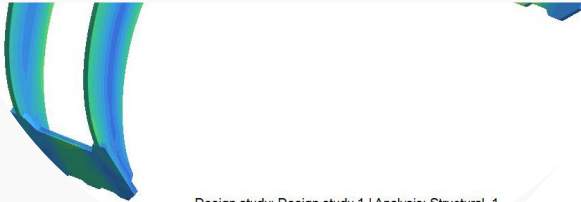


Authored the Up and Running with Autodesk Inventor/Nastran Simulation books





AGENDA



Design study: Design study 1 | Analysis: Structural 1

1

Traditional & SimSolid workflows

2

SimSolid Demonstration - Live

3

SimSolid Results and Accuracy

4

Question and Answers

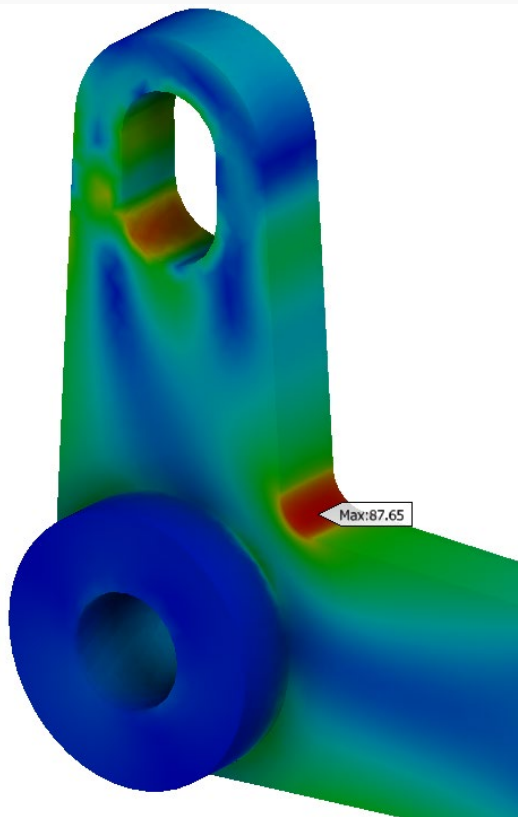
Comparison between Traditional & SimSolid (GEOMETRY SIMPLIFICATION)

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

Comparison between Traditional & SimSolid (MESHING AND CONVERGENCE)

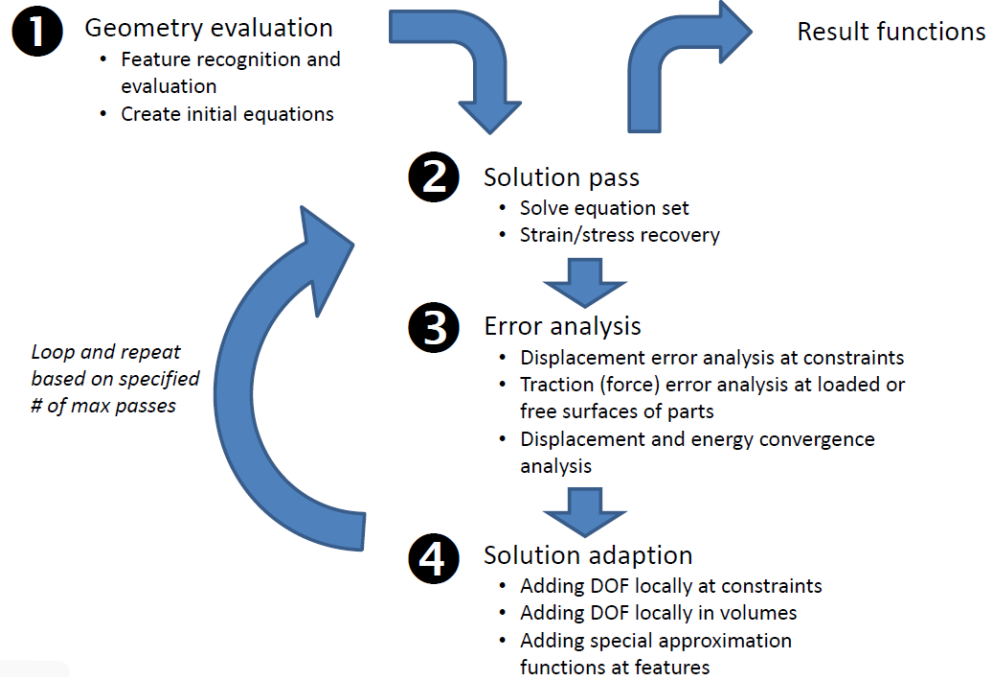
Inventor Nastran		SimSolid	
Task	Time	Task	Time
Meshing - sensitive to quality of geometry	Mins/ Hours?	Not applicable – SimSolid does not use a FE mesh	0
Mesh validation – aspect ratio, skew, warp, etc.	Mins?	Not applicable – SimSolid does not use a FE mesh	0
Need to run multiple analyses with different 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

Inventor Nastran Results Convergence



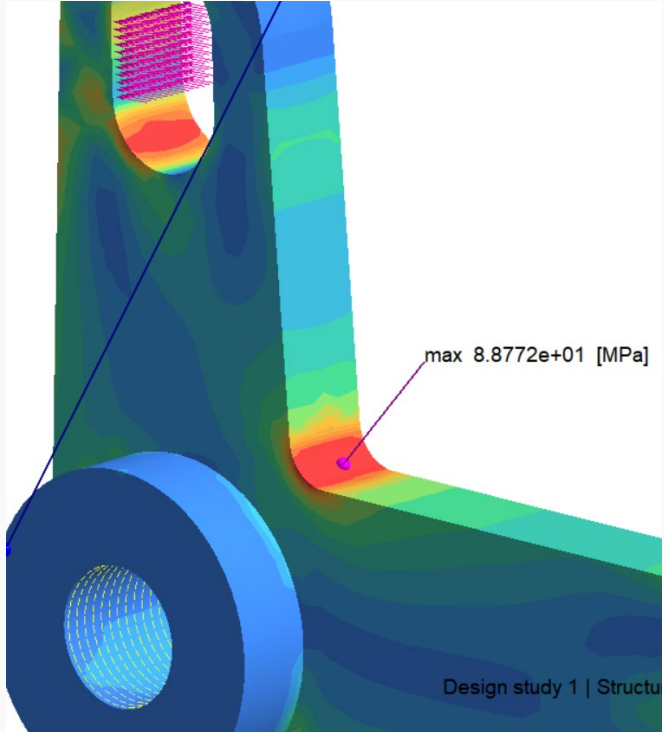
Mesh Size	Result	% Difference
2mm	83.98 MPa	-
1mm	81.9 MPa	2
0.5 local	87.08 MPa	6
0.25 local	87.65 MPa	0.6

SimSolid Workflow – Automatic convergence



DOWNLOAD – [SimSolid-technology-overview-whitepaper](#) from Handouts

SimSolid results convergence



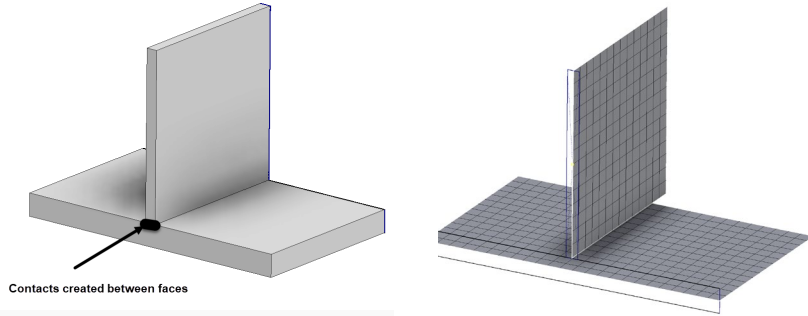
Convergence	Result	% Difference
Adapt for Stress	88.77 MPa	-
Nastran	87.65 MPa	1.2

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

WELDS

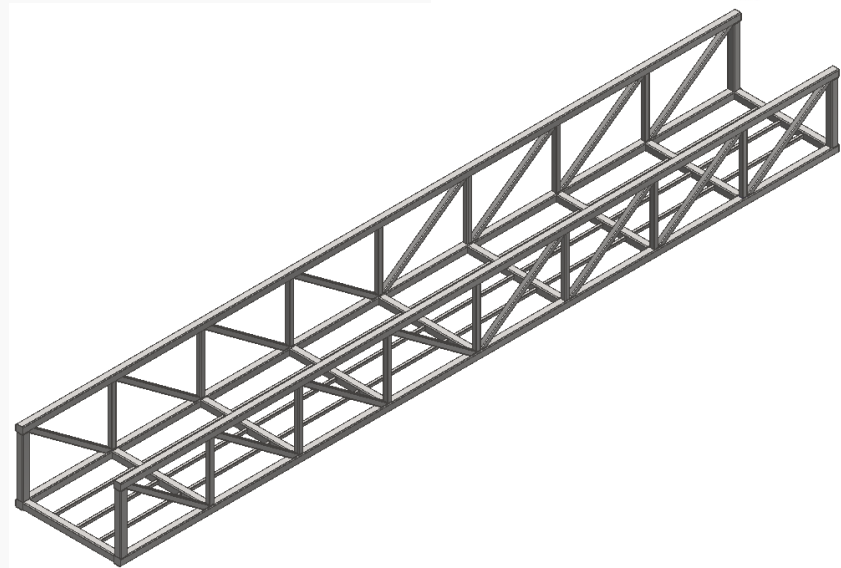
**Now lets have a look at Autodesk
Solutions Workflow?**

Inventor and Nastran Workflow

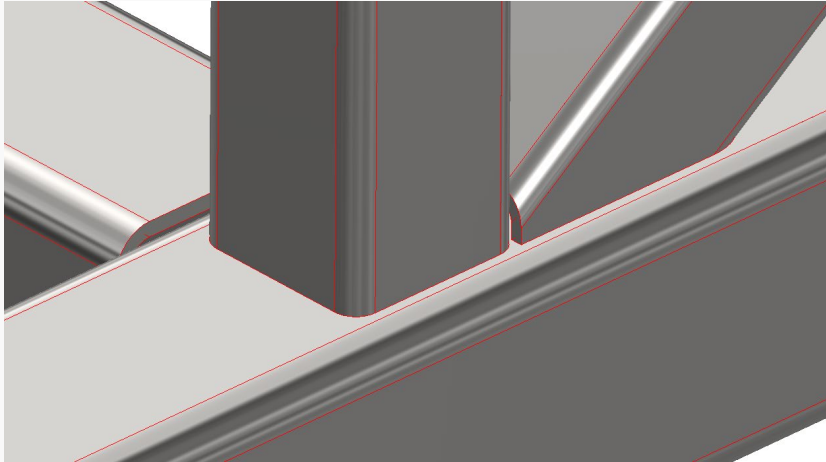


Options

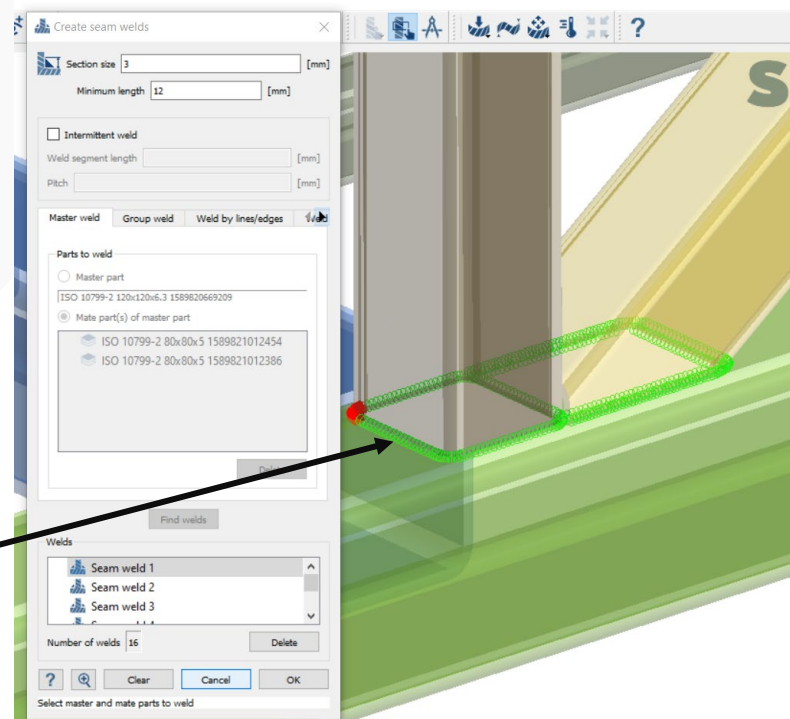
1. Solid Elements
 - Model Weld geometry
2. Shell Elements
 - Mid-surface extraction
 - No weld geometry
 - Surface Model
 - Welds are modelled as surfaces
 - Normally welds not accounted for
3. Beam Element
 - Welds not accounted for



SimSolid Workflow



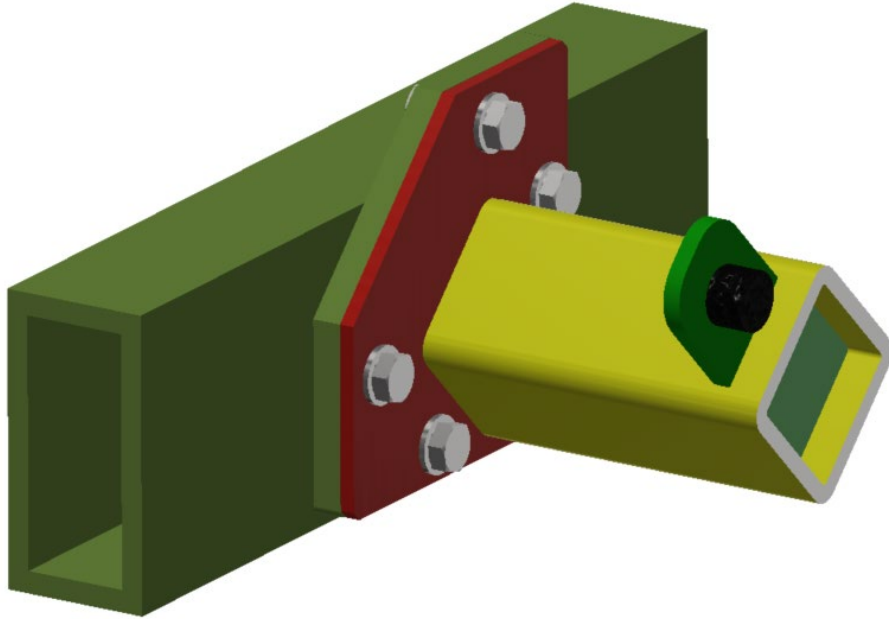
- Weld geometry can be used as welds
- Create welds between components



BOLTS

**Now lets have a look at Autodesk
Solutions Workflow?**

Inventor and Nastran Workflow



Inventor

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

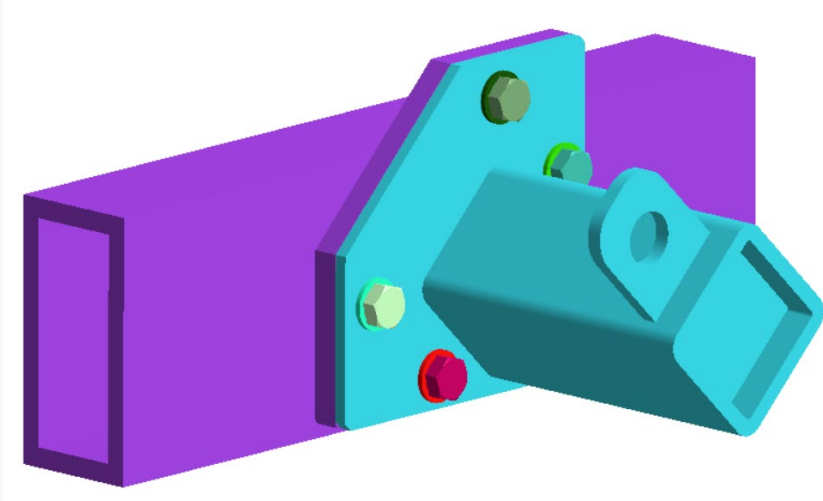
Nastran

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.

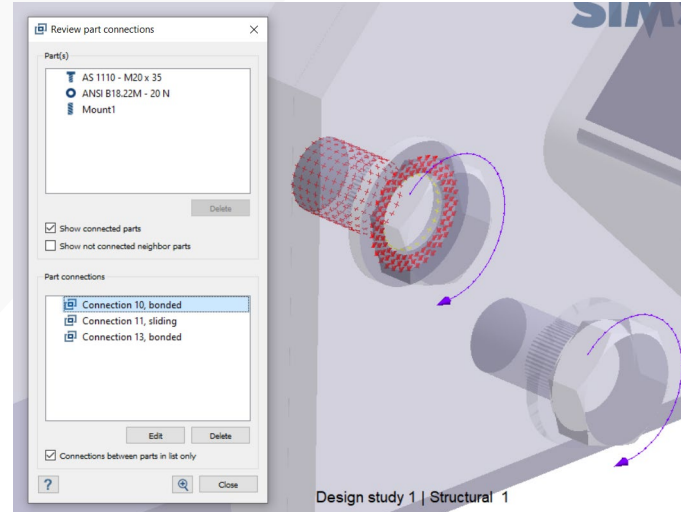
Workflow

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

SimSolid Workflow

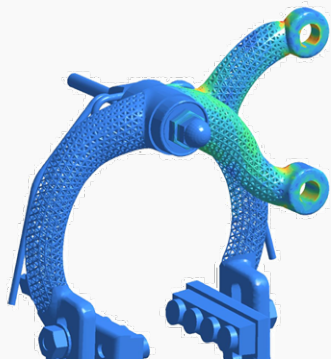


- You can reuse bolted connections



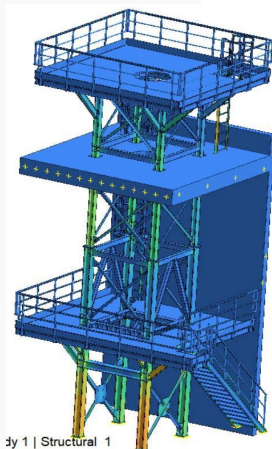
- Contacts are defined automatically

In brief - SimSolid



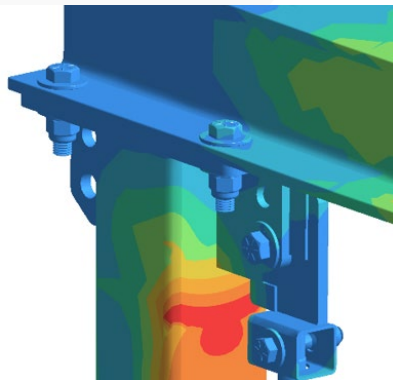
Complex models

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



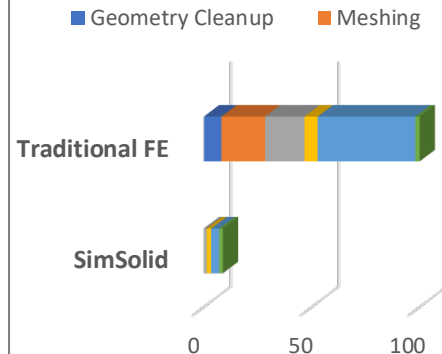
Large Scale models

- Building Structural framework
- Welded Fabrications



Original models

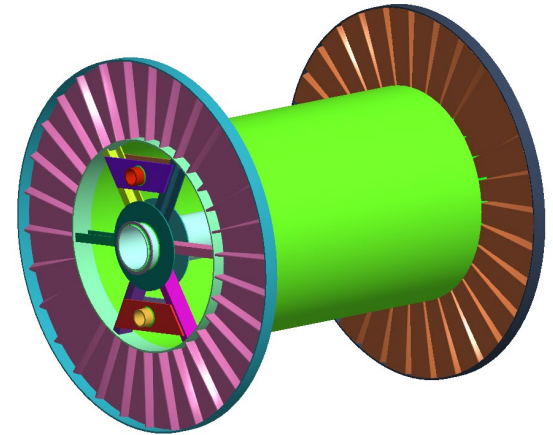
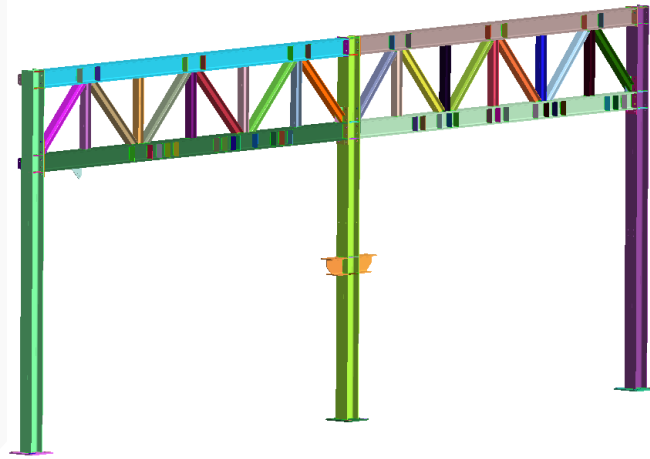
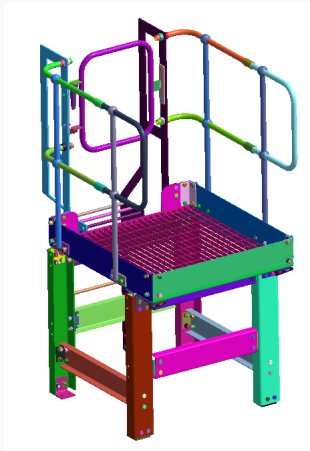
- Inventor Bolted Connections



Rapid Results

- Literally within minutes
- Automatic results convergence

SIMSOLID DEMONSTRATIONS - LIVE

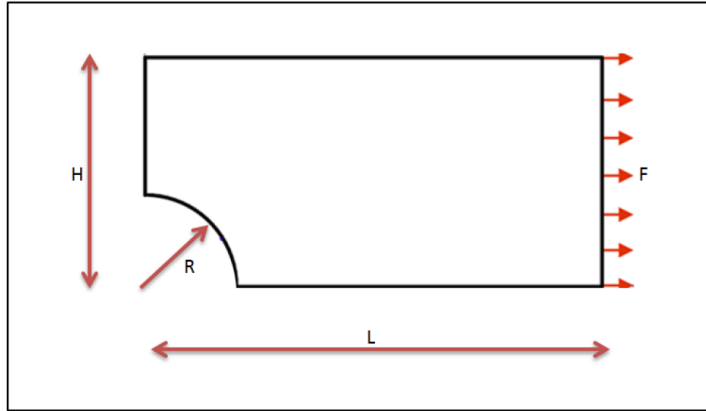


SIMSOLID RESULTS AND ACCURACY

Theoretical Example

Plate with Hole

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



Reference Solution

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

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

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

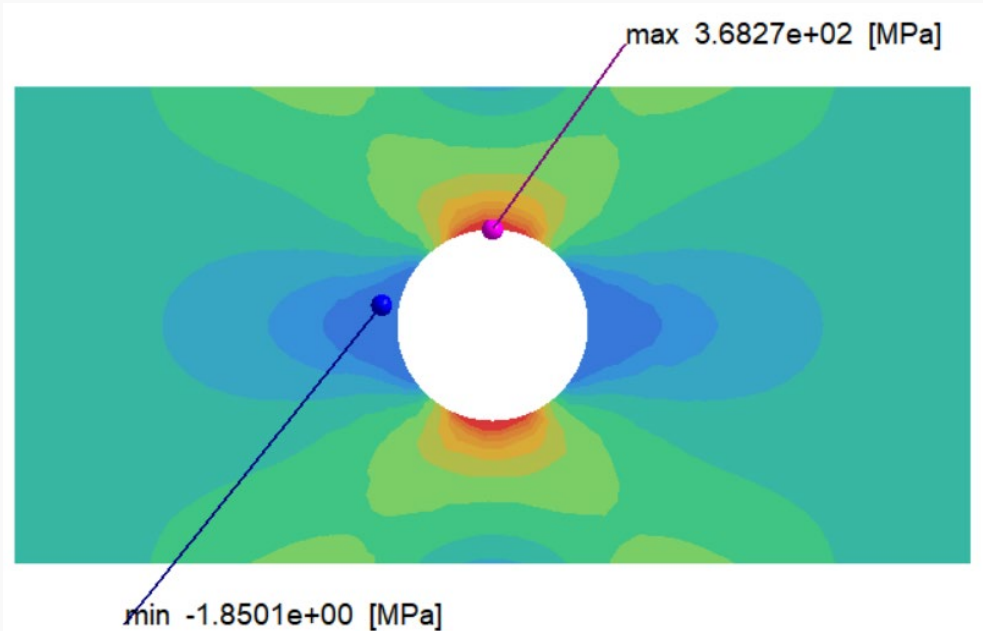
$$\sigma_{max} = 372.7 MPa$$

- 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

Further Info on theory

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

SimSolid Results



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

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



– 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

• Axisymmetric 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 axisymmetric

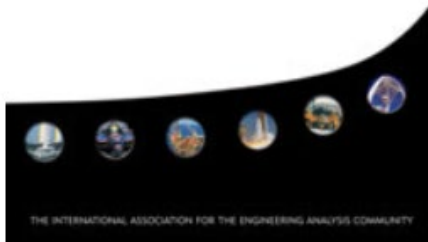
• Asymmetric branched shell-pressure - Analysis type: Linear elastic asymmetric

• Thick plate pressure - Analysis type: Linear elastic solid

• Solid cylinder/Taper/Sphere-Temperature - Analysis type: Linear elastic solid



The Standard NAFEMS Benchmarks

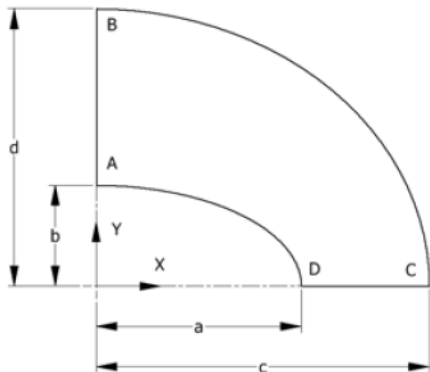


NAFEMS Benchmark Test LE1

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/mm ³
Tensile Yield Strength	207.0 MPa

Dimensions

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

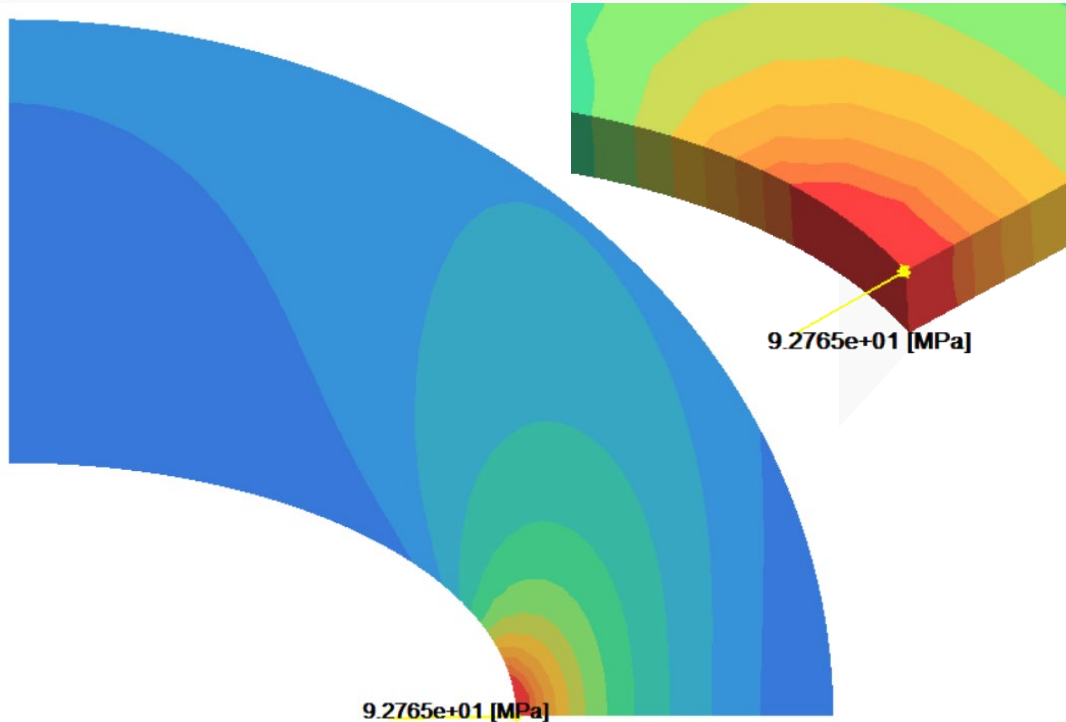
Load value

$P = 10$ MPa

Target Solution

Tangential Stress (σ_y) at Point D = 92.7 MPa

SimSolid Results



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

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

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

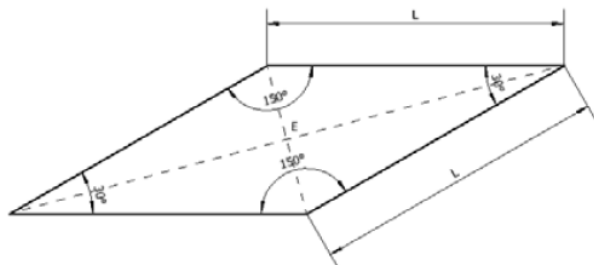
Steel	
Young's Modulus	2.1e+005 MPa
Poisson's Ratio	0.3
Mass Density	7.85e-006 kg/mm ³
Tensile Yield Strength	207.0 MPa

Dimensions

$L = 1000$ mm
 $t = 10$ mm

Load value

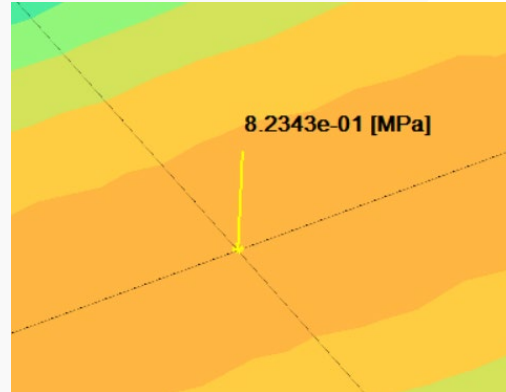
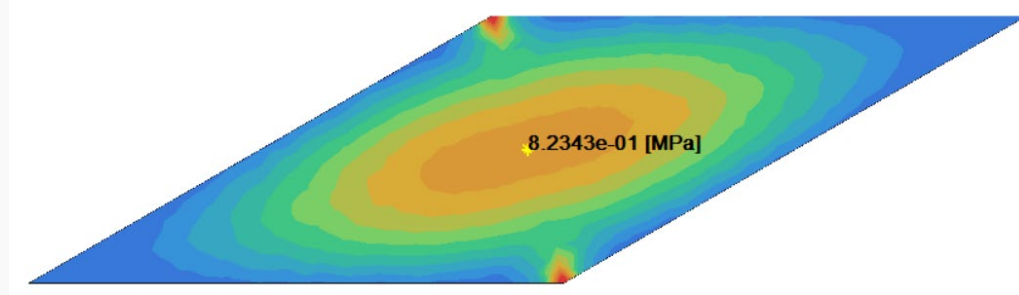
$P = 0.0007$ MPa



Target Solution

Maximum Principle Stress at Point E = 0.802 MPa

SimSolid Results



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

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

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

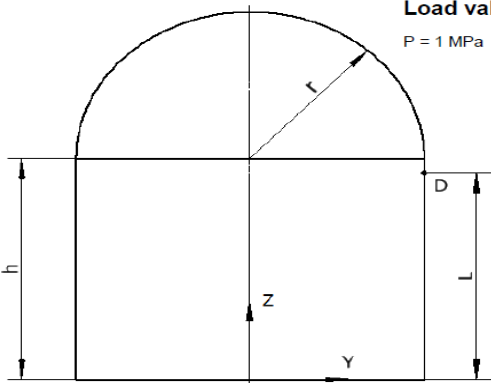
Steel	
Young's Modulus	2.1e+005 MPa
Poisson's Ratio	0.3
Mass Density	7.85e-006 kg/mm ³
Tensile Yield Strength	207.0 MPa

Dimensions

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

Load value

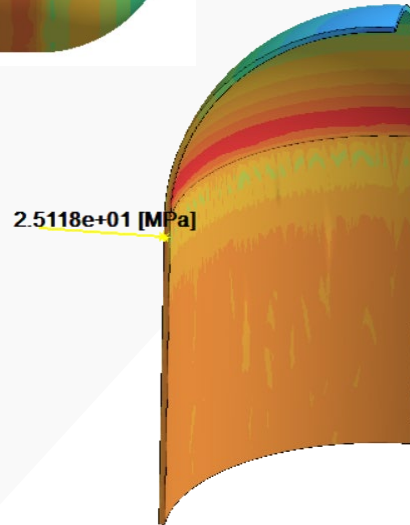
$P = 1$ MPa



Target Solution

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

SimSolid Results



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

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

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

SimSolid – Further Verification

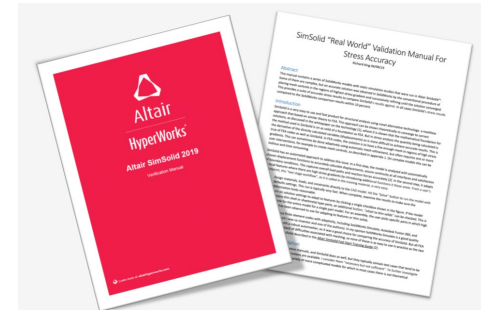
More Supporting documents

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

CAN SIMSOLID HELP YOU

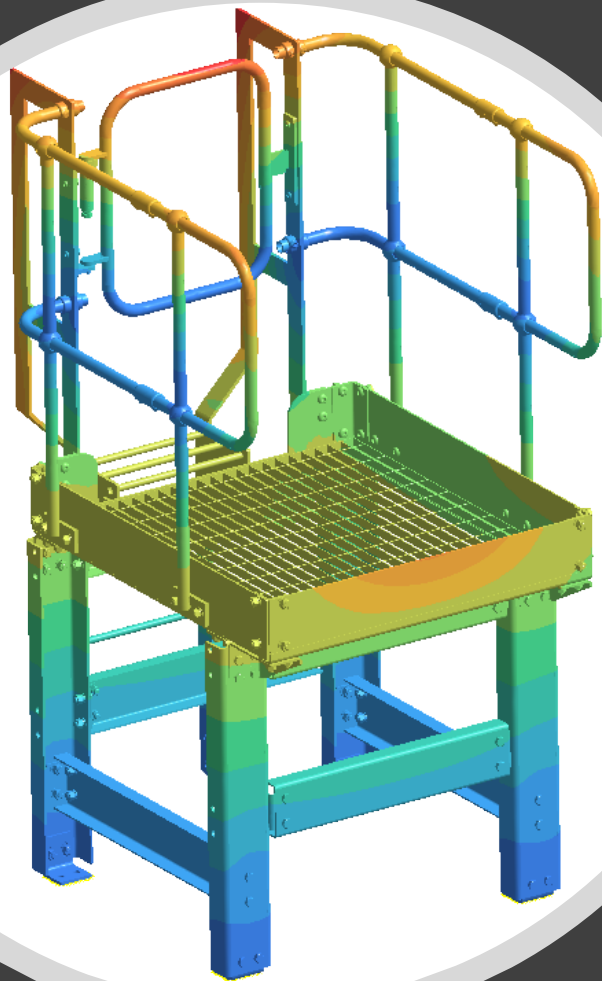
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Office Phone: +44 (0) 1924 232 995





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THANKS FOR
ATTENDING