

## SE2382: Autodesk® Simulation Mechanical for the **Construction Industry**

James Herzing Simulation Evangelist



## **Class Summary**

optimization and fatigue will also be explored.

 During this class, you will learn the how Autodesk Simulation Mechanical software can be used for construction industry applications. Autodesk Simulation Mechanical will be used to create a global model with fine local details, such as a bolted connection in a steel structure. We will also cover critical effects such as pre-stress of bolts, contact between parts, plastic deformation, and dynamic behavior that captures real behavior. Additional common applications such as erection construction,



## Learning Objectives

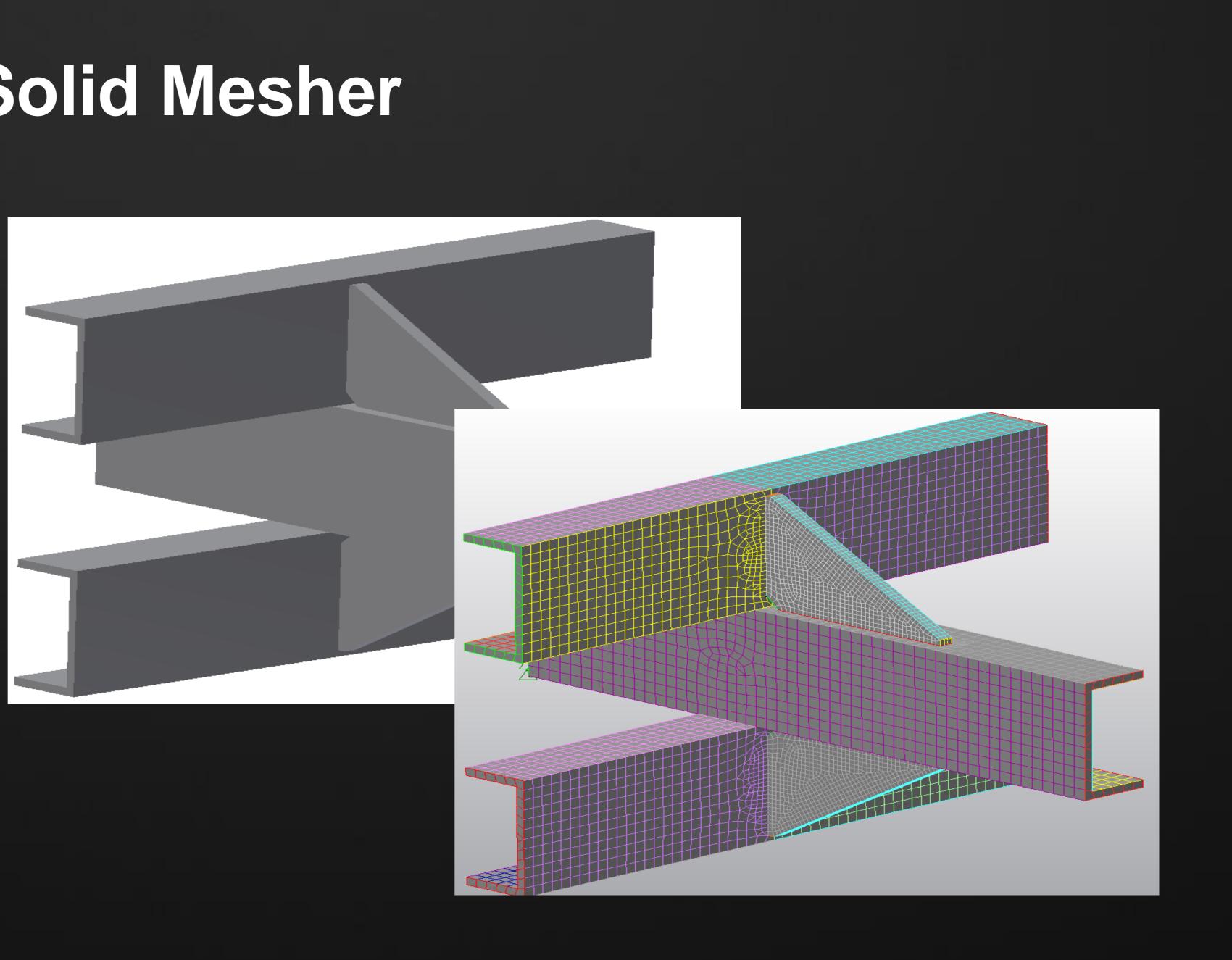
At the end of this class, you will be able to: Get an insight into the structural performance of an assembly Study the effect of pre-stressed bolts on your assemblies Simulate structure failures to understand why they failed Set up a global model with critical local detail • Understand how to setup an fabrication construction Run design optimization and fatigue analyses



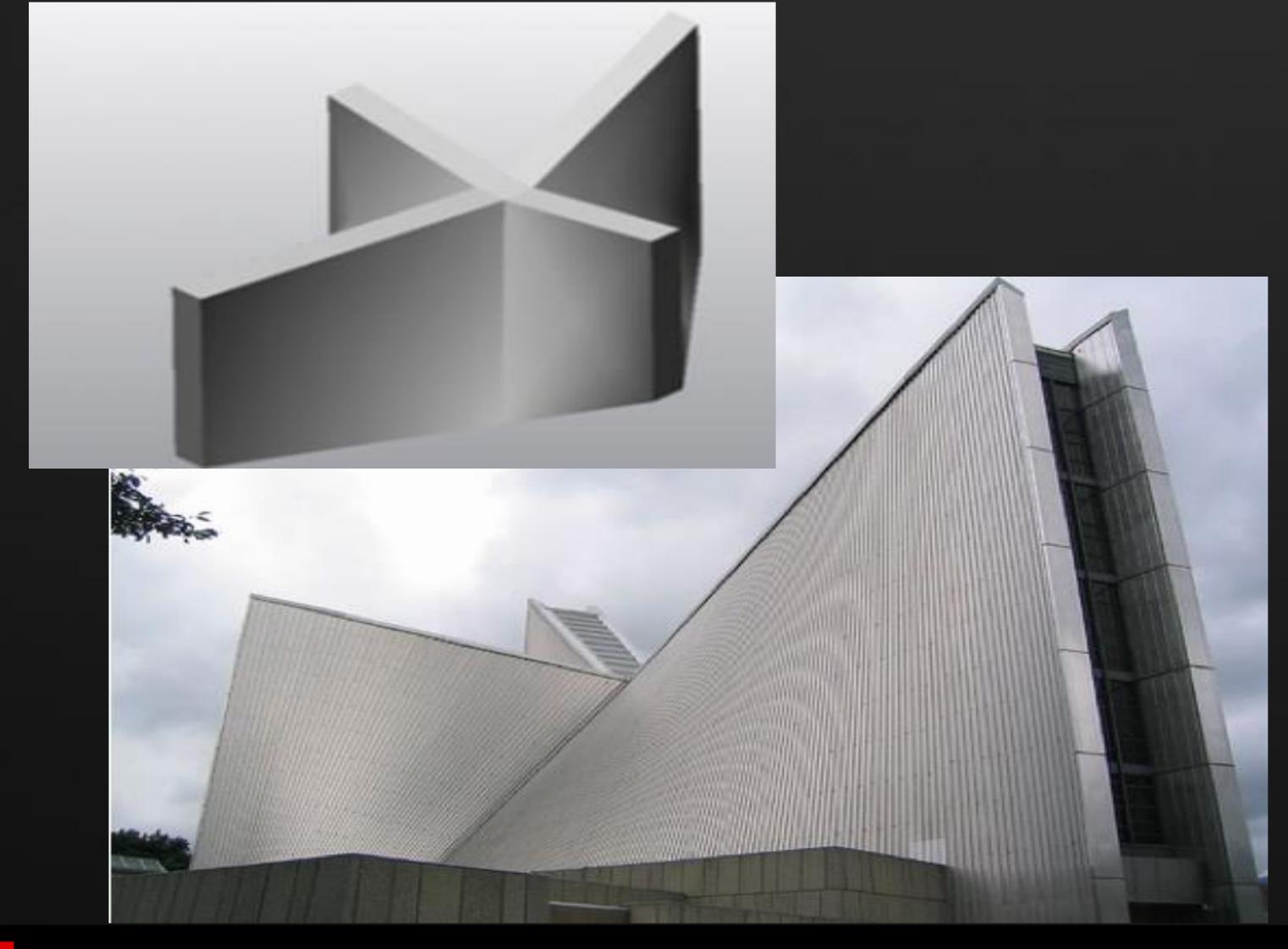
## Hexa-Dominent Solid Mesher

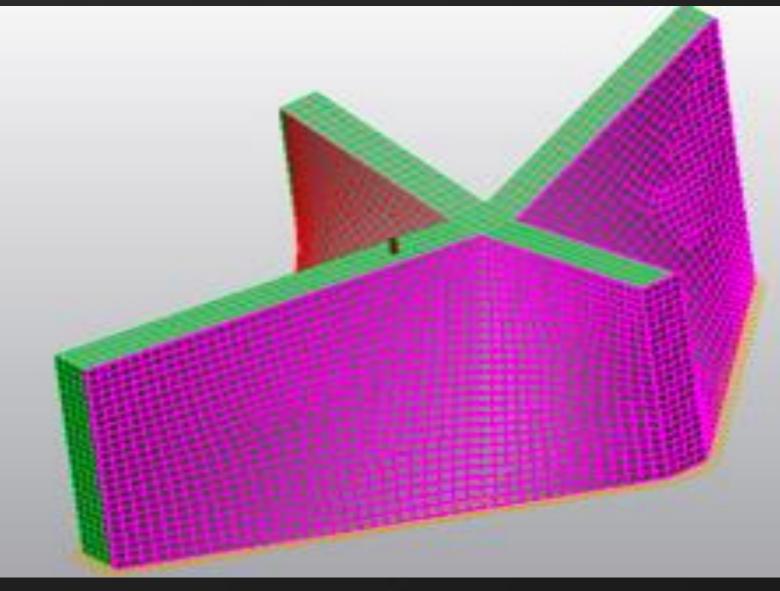
### **Solid Meshing Options:**

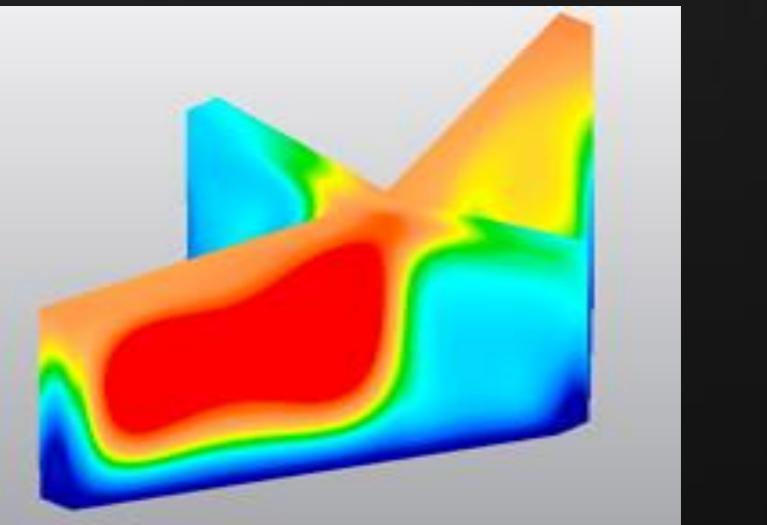
- Bricks and Tetrahedra
- All Tetrahedra
- Tetrahedra and wedges
- Bricks and wedges



## **Powerful Shell and Solid Mesher**



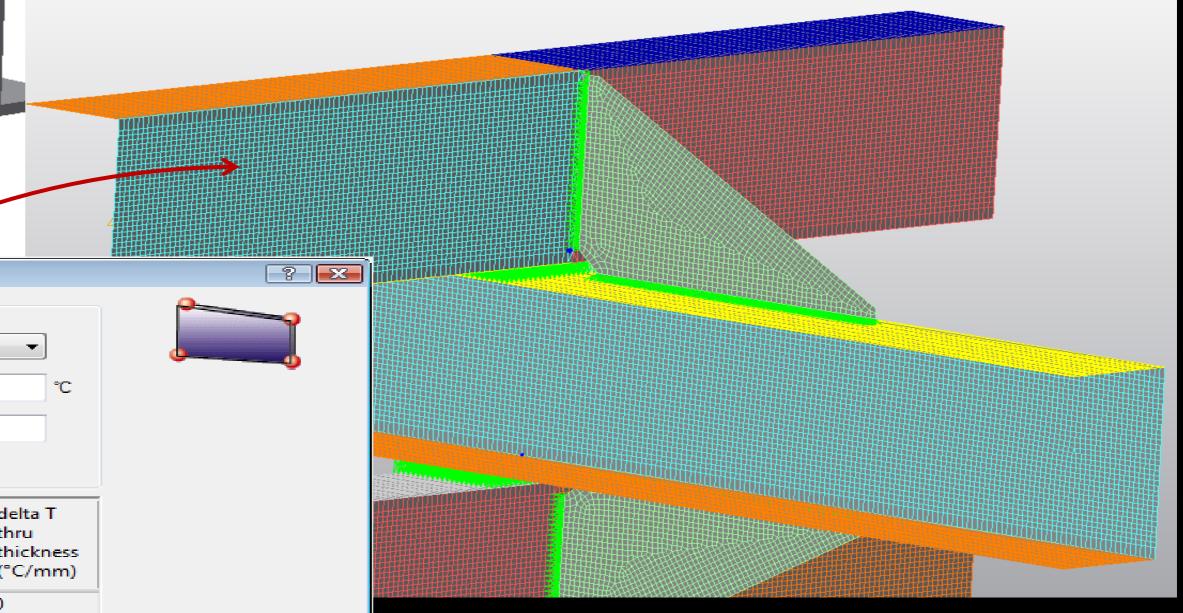






## Automatic Shell Meshing for Thin Solids

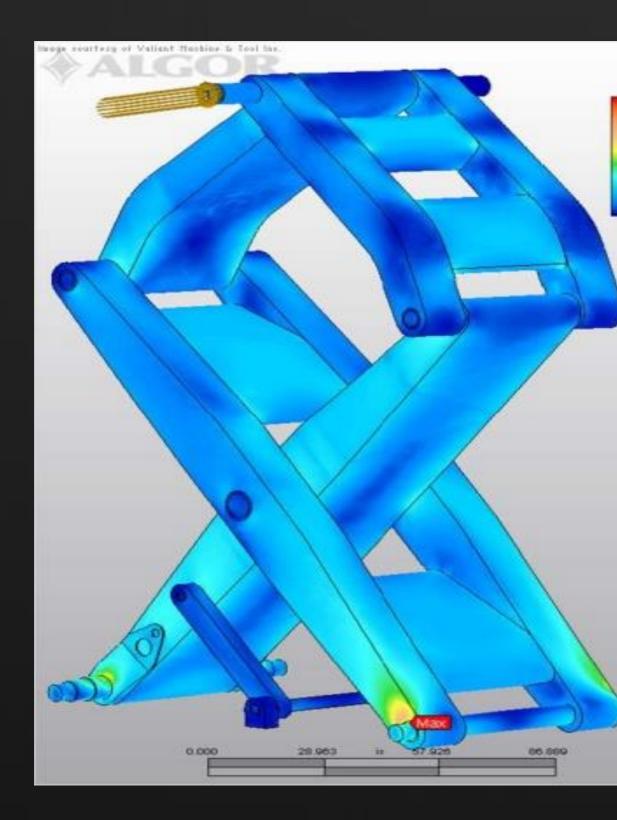
	📲 Model Mesh Settings 📃 🔀
	Mesh type Solid Midplane Plate/shell Options Mesh size Coarse Fine 
	Defaults OK Cancel Mesh model
Element Definition - Plate	
General Settings Material model Isotropic  Temperature Method Stress Free	
Material model     Isotropic     Temperature Method     Stress free       Element Formulation     Veubeke     Stress free reference temperature     0     °C	
Properties Part-based Twisting coefficient ratio 0.001	
Use mid-plane mesh thickness	
Design VariableThickness (mm)Normal Point (X) (mm)Normal Point (Y) (mm)Normal Point (Z) (mm)Nodal Nodal Order MethodNodal Point (X) (mm)Nodal Point (Y) (mm)Nodal Point (Y) (mm)Nodal Point (Y) (mm)Nodal Point (Y) (mm)Nodal Point (Y) (mm)Nodal Point (Y) (mm)Nodal Point (Y) (mm)Nodal Point (Y) 	
□ 15 0 0 0 Default 0 0 0 0	

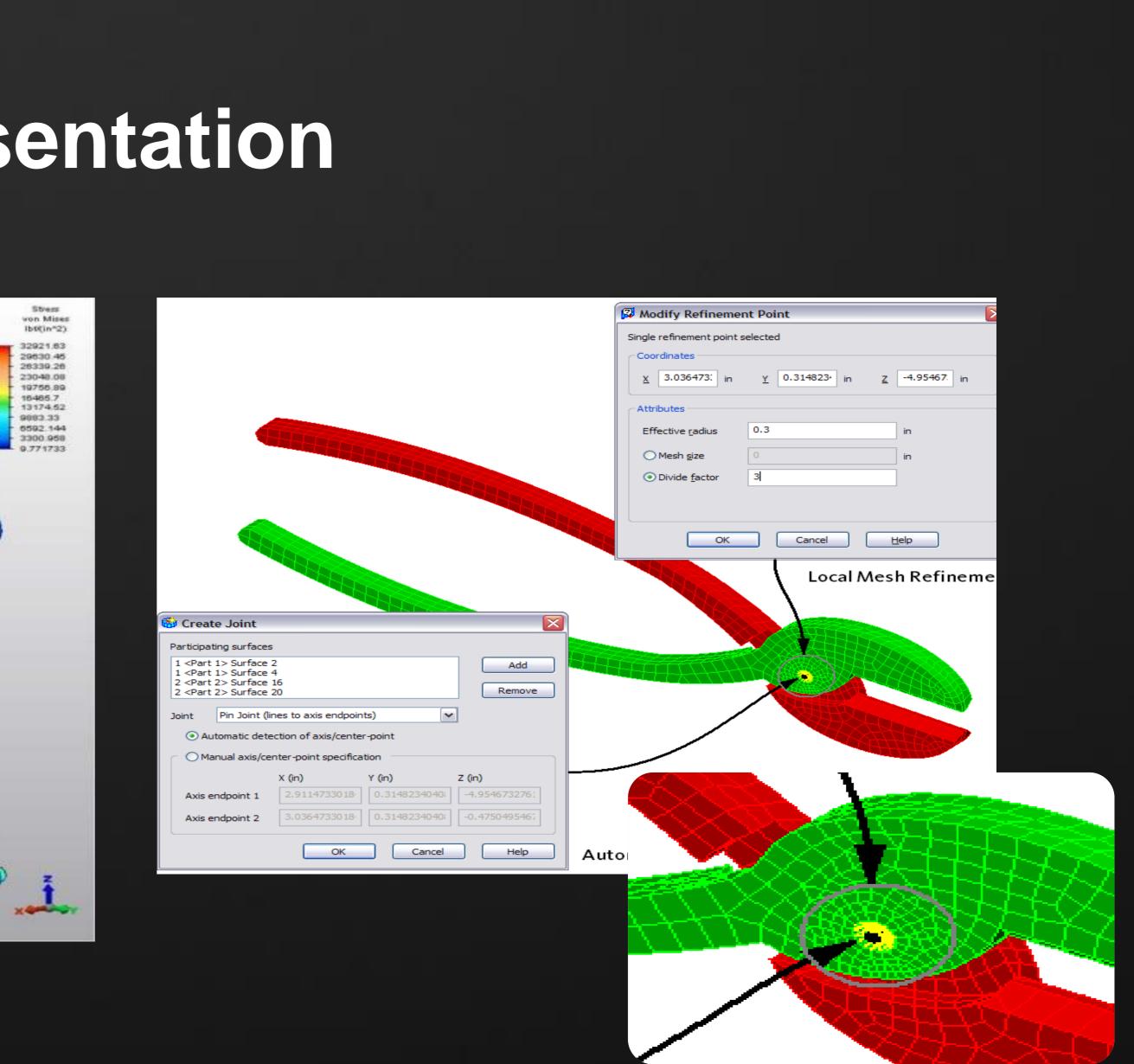


## Wizard for Joints Representation

#### Two Types of Joints:

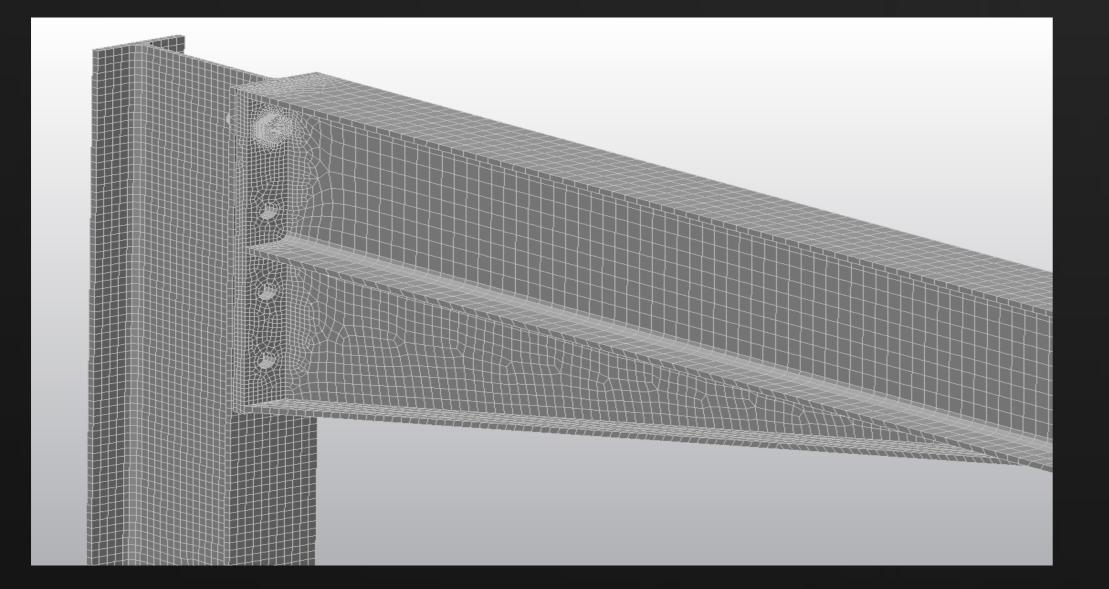
- Pin Joint
- Universal Joint



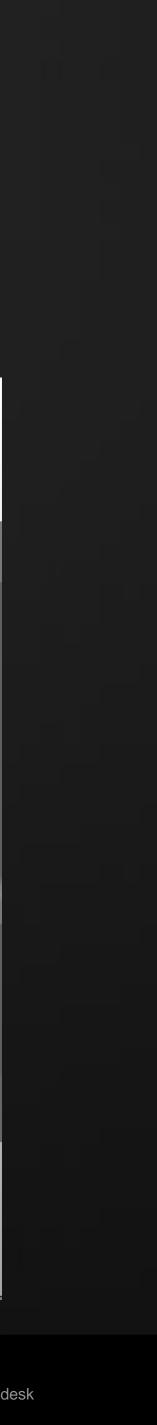


## Wizard for Bolts Representation

### Simple and efficient modeling for bolts WITH PRESTRESS

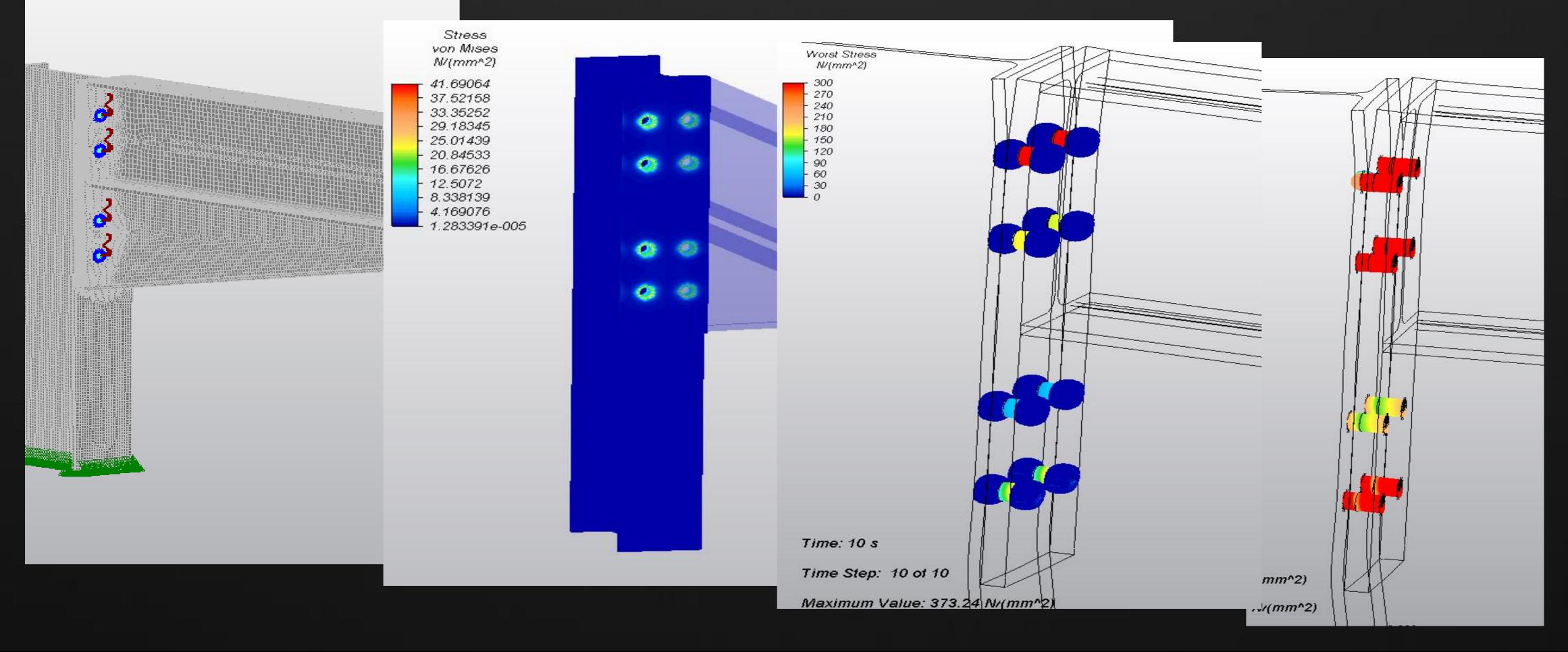


Generate Bolted Co	nnection		×		
Part Number 4 Bolt 20	mm	Type of Bolt	olt With Nut		
	ace 14	mm	Add Remove Add Remove		
Nut Contact surface(s 1 <part 1=""> Surfa</part>			Add	**	
Nut diameter	25	mm			
Preload magnitude					
Axial Force	Magnitude	10000	Ν		
C Torque	Magnitude Friction factor (K)	0	N*mm		
Do not dismiss after bolt gene	eration C	OK Cancel	Help	194.365	mm 388.



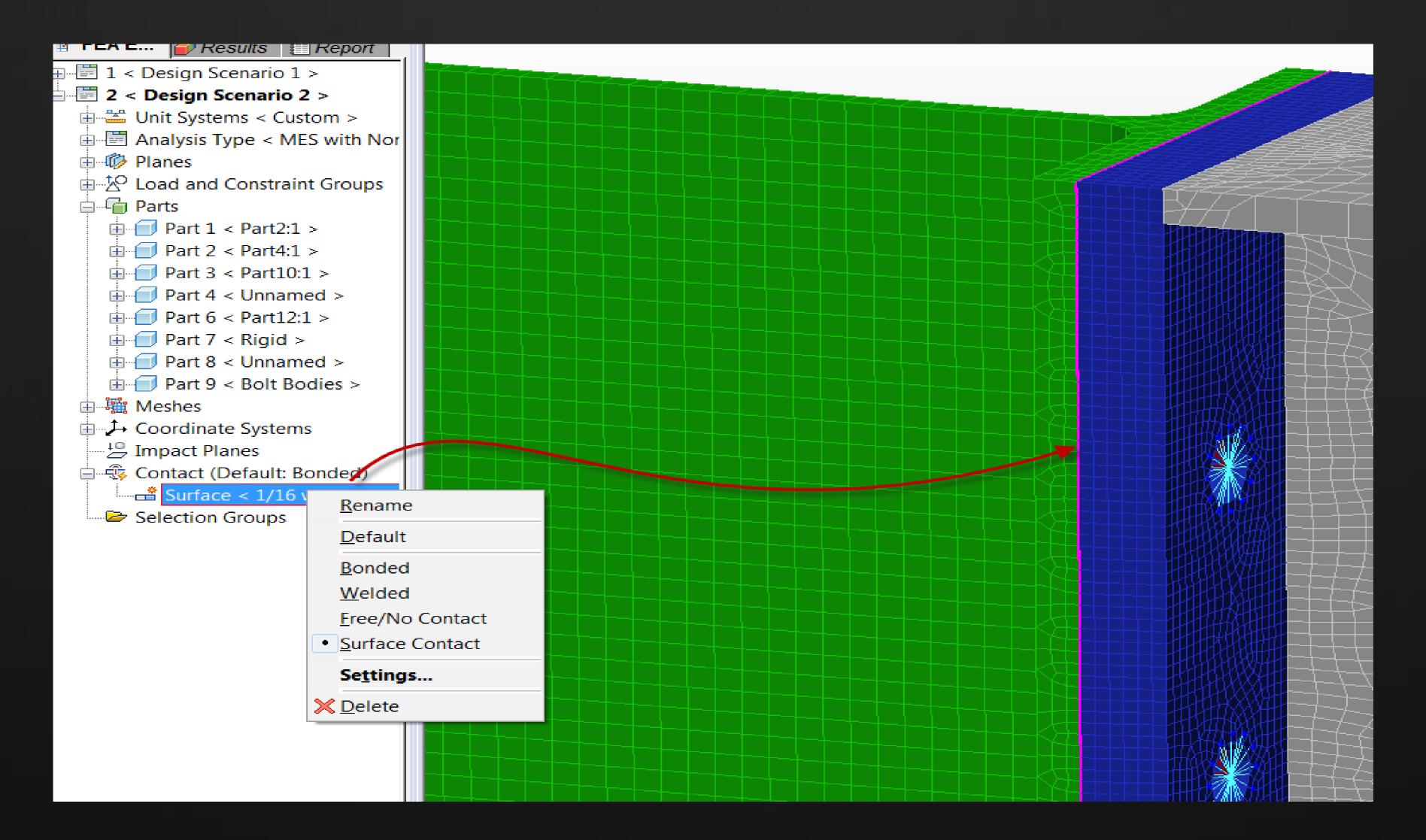
## Wizard for Bolts Representation

### Detailed post-processing of bolted connection



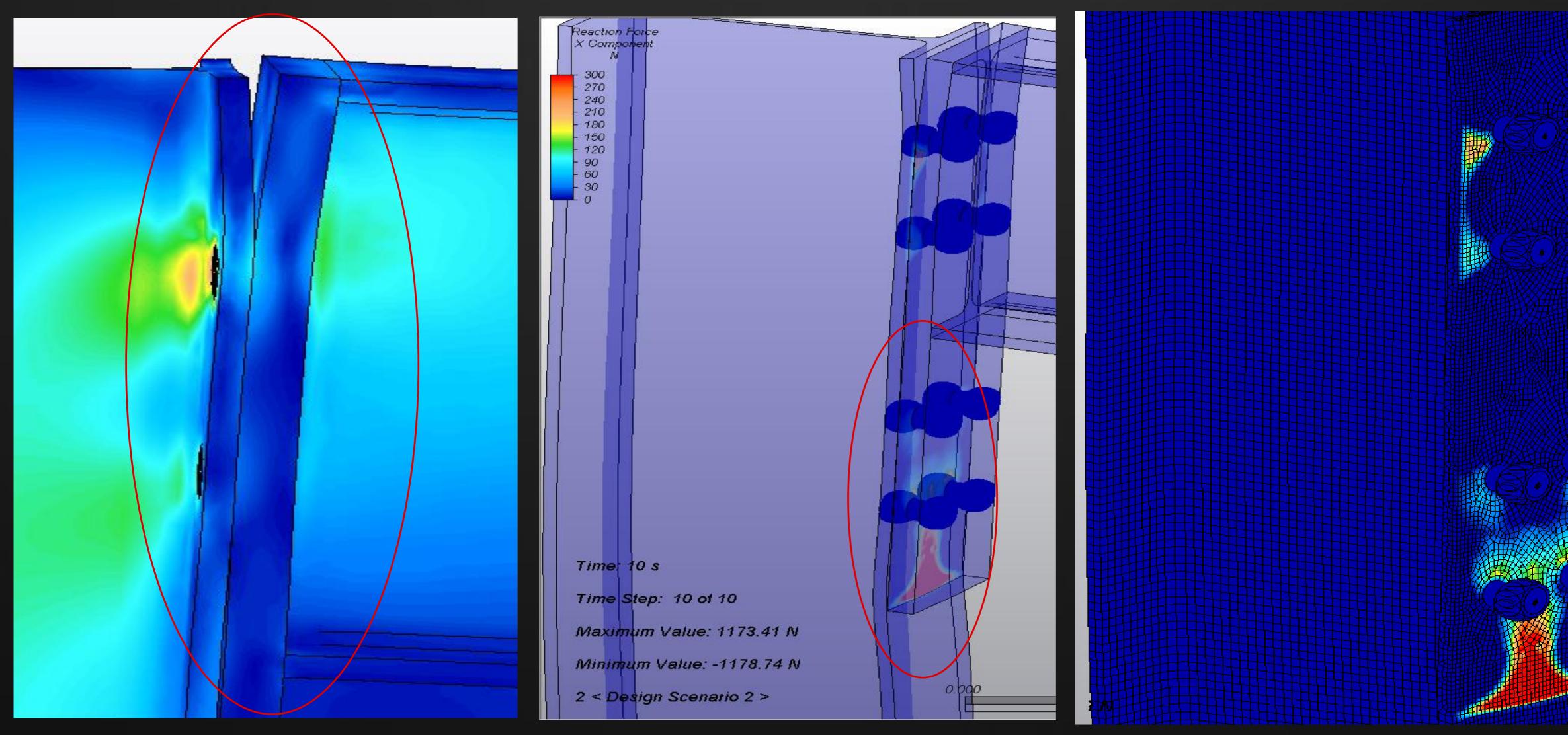


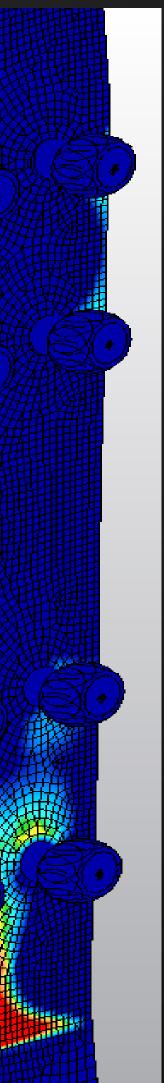
## Non-linear Contact





## Non-linear Contact





## Modeling Welds in Your Models

#### **Option 1**

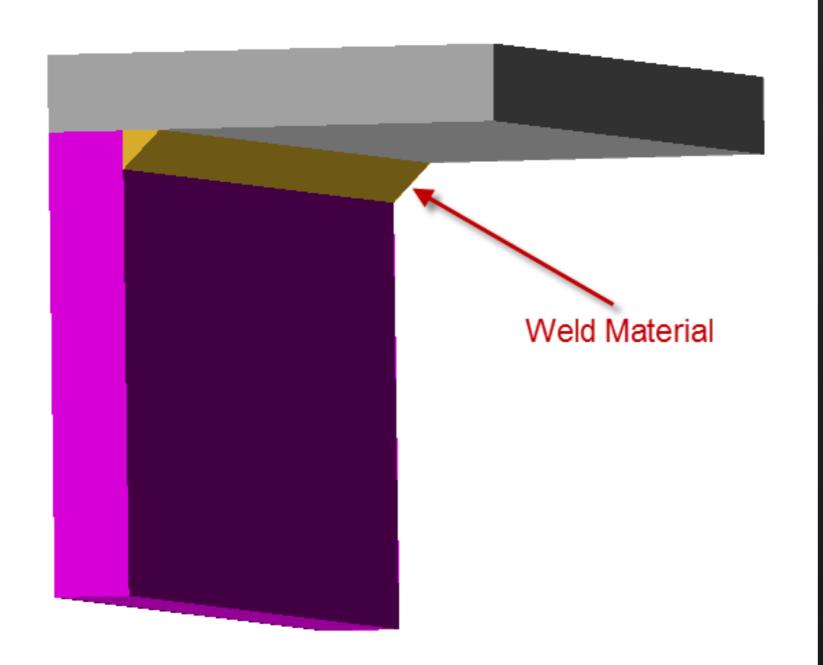
#### Bonded

Welded

Free/No Contact Surface Contact Sliding/No Separation Separation/No Sliding Edge Contact Shrink Fit/Sliding Shrink Fit/No Sliding

Settings...

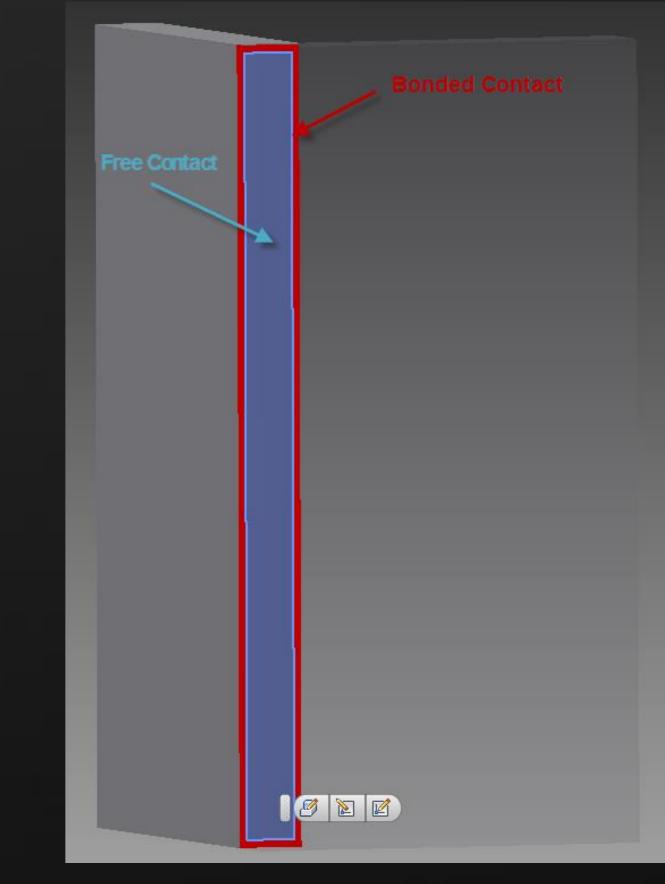
Expand All Children Collapse All Children

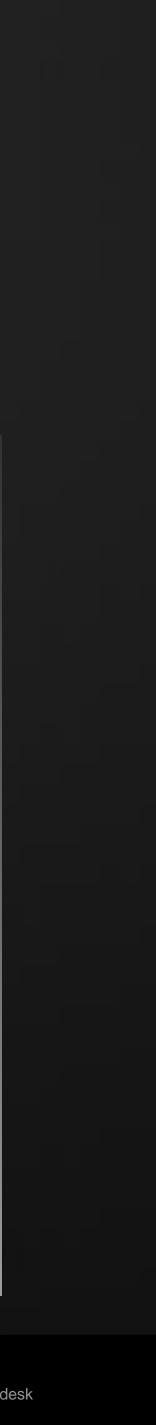


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### **Option 2**



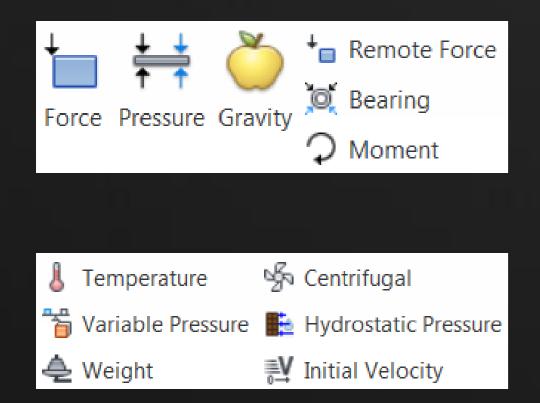


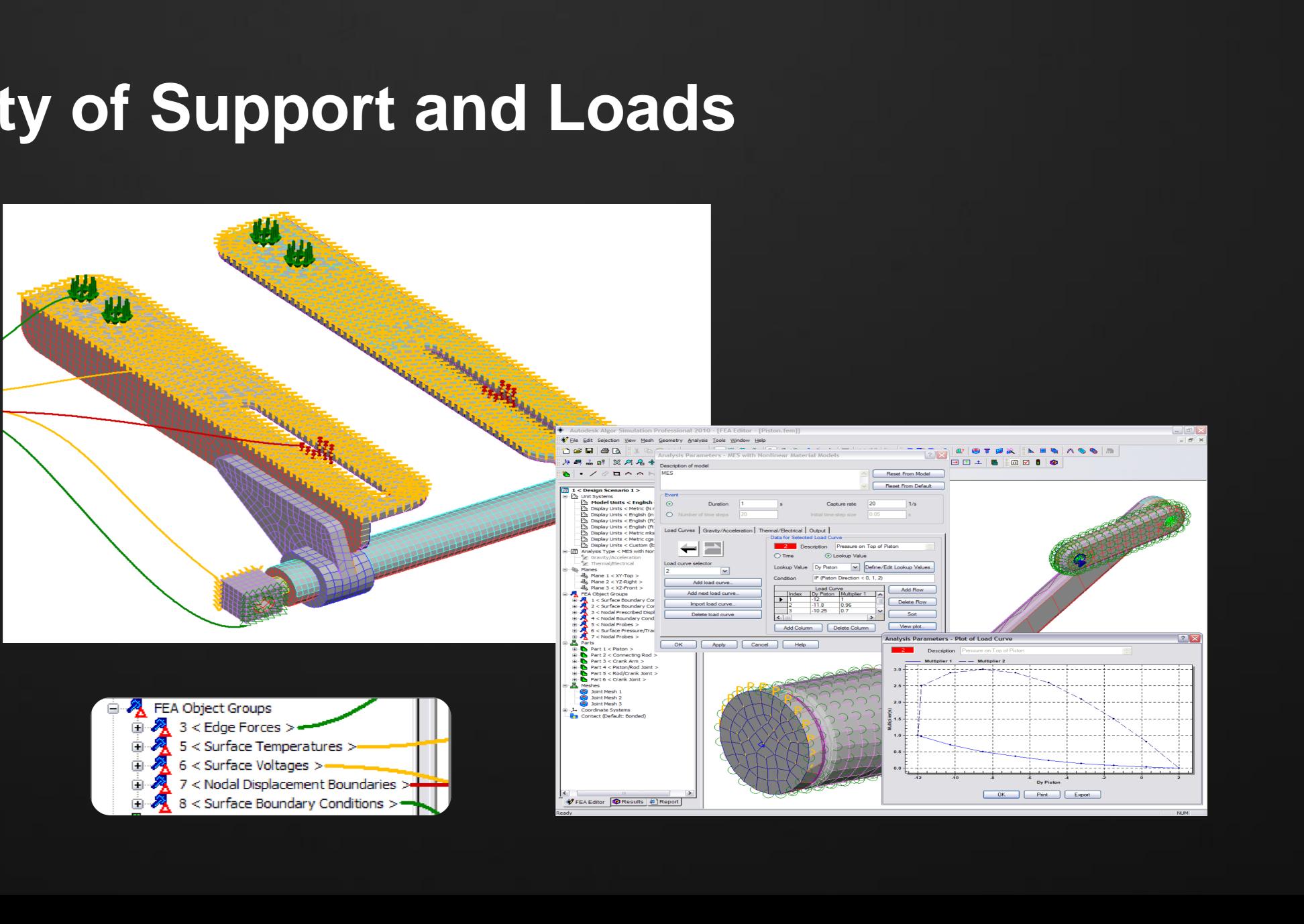


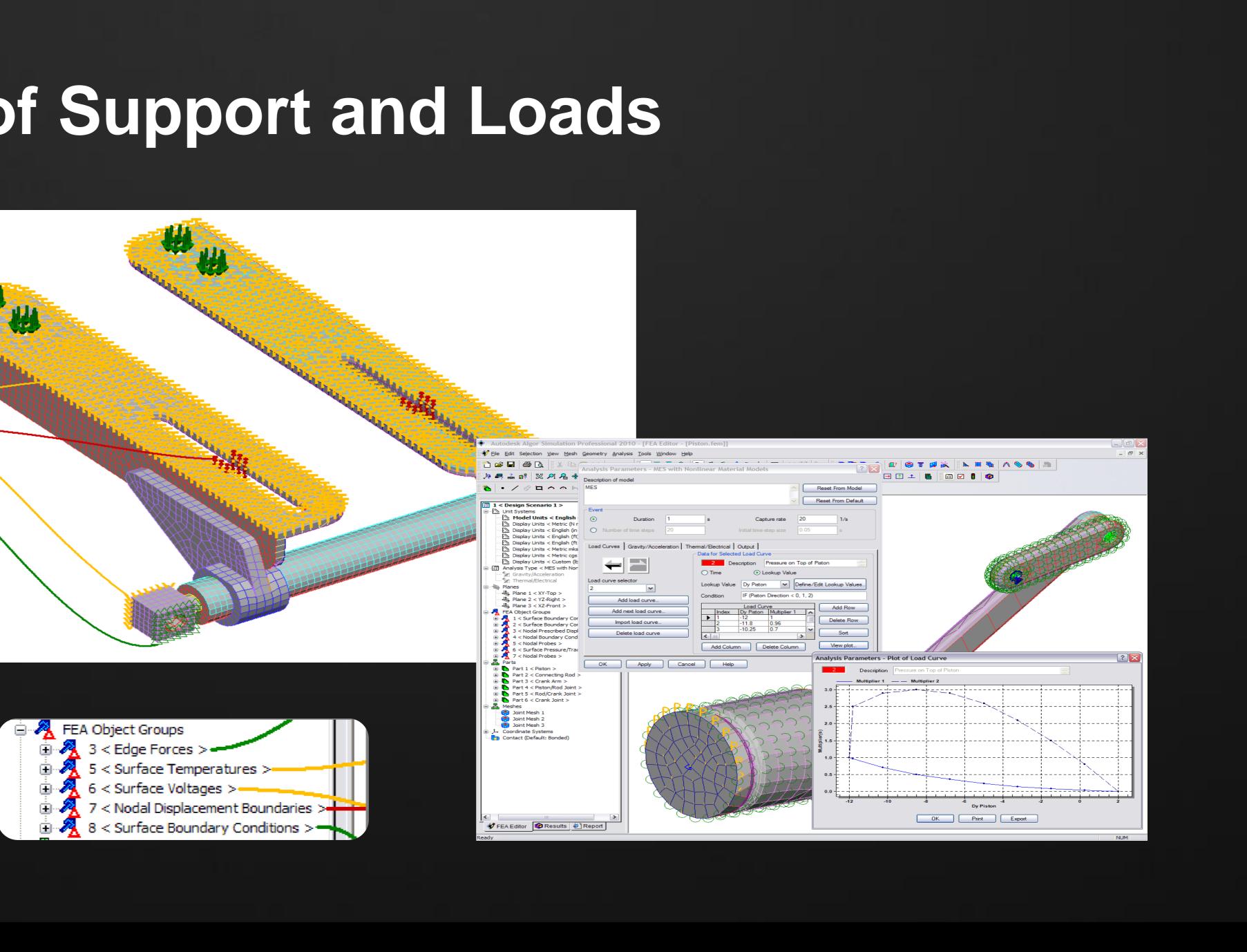
# Demonstration 1 General Construction Analysis Techniques



## Wide Variety of Support and Loads



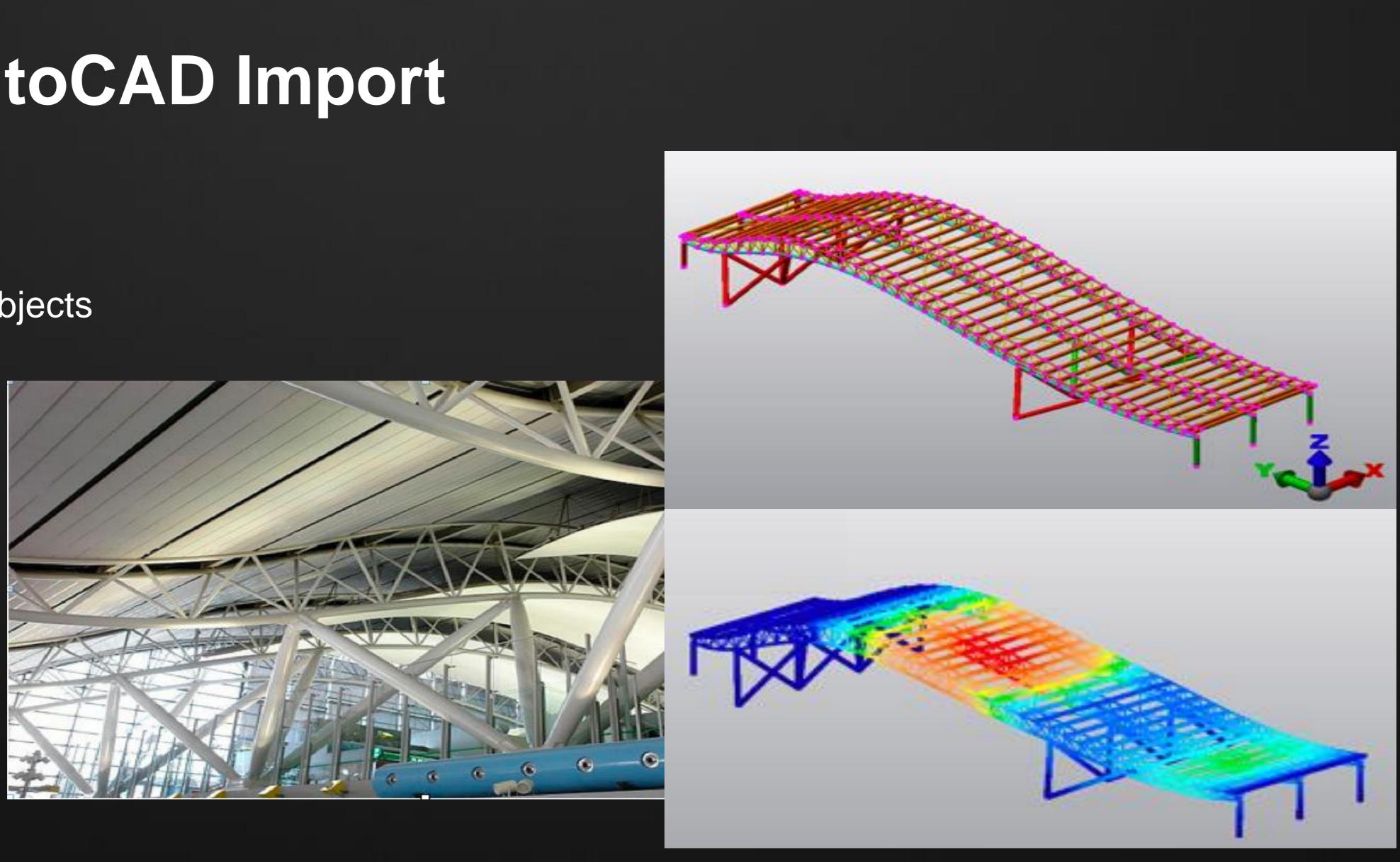


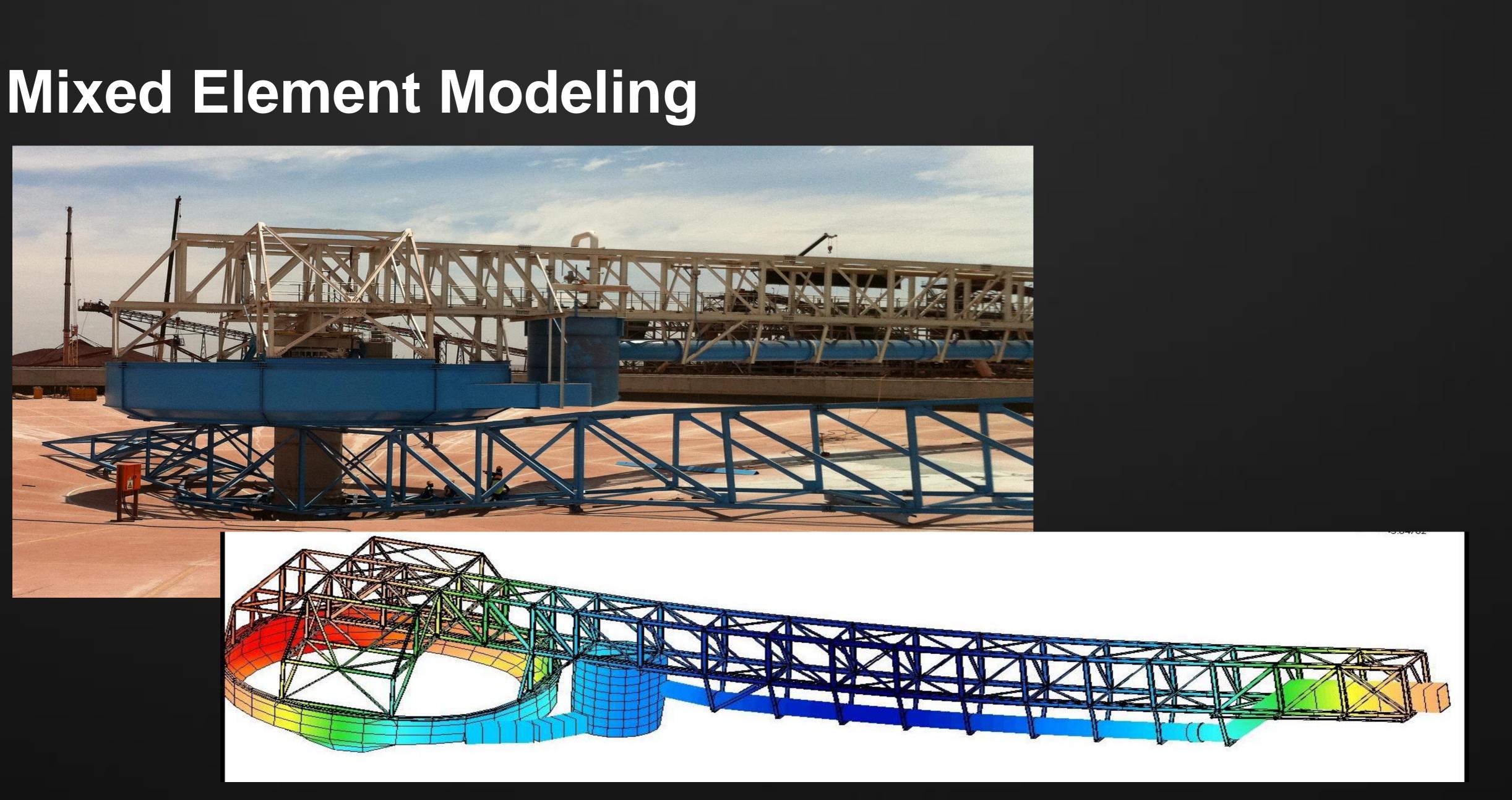


## Direct AutoCAD Import

### Importing for:

- **Construction Objects** •
- Beams ullet
- Trusses ullet
- 2-D models



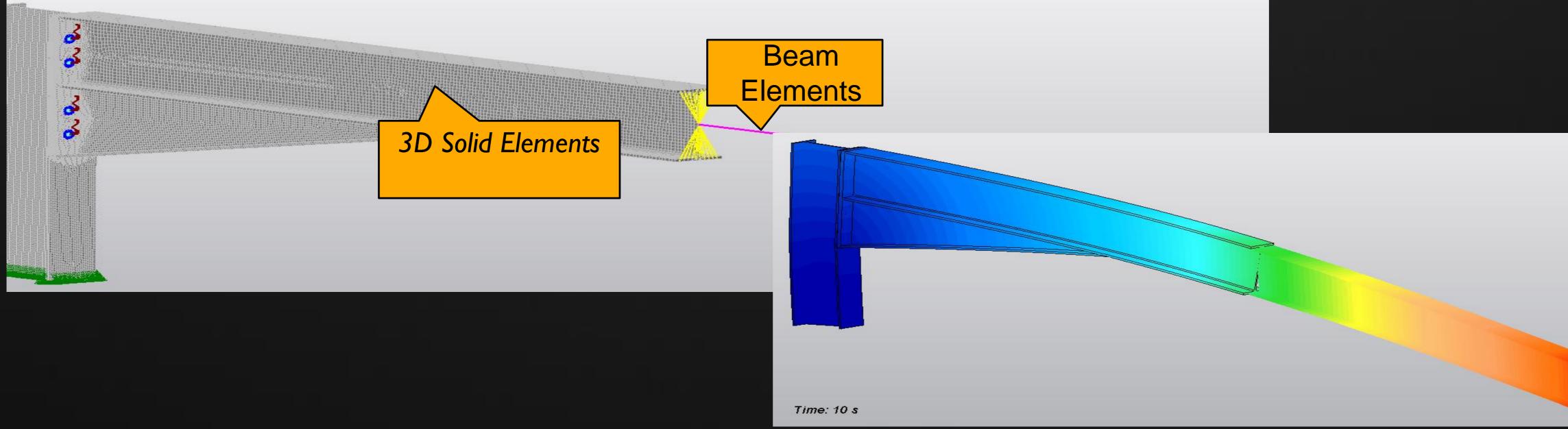




## **Mixed Element Meshing**

### **BENEFITS**:

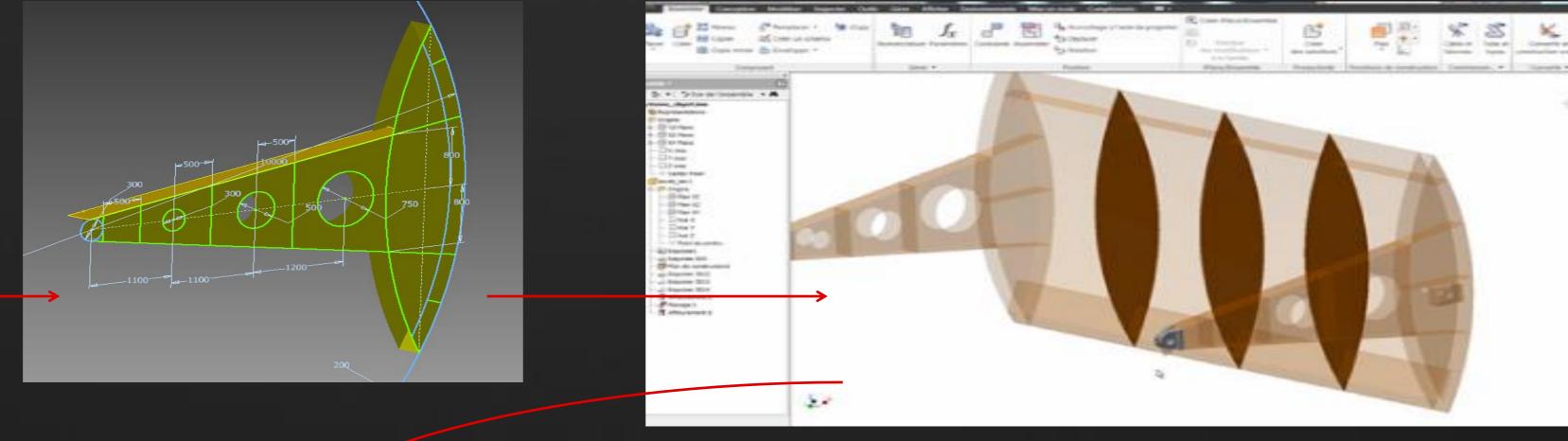
- Captures the detailed behavior of the critical zone ullet
- Includes the effect/stiffness of surrounding structure ullet
- Allows modeling connections like bolts, rivets, welds •

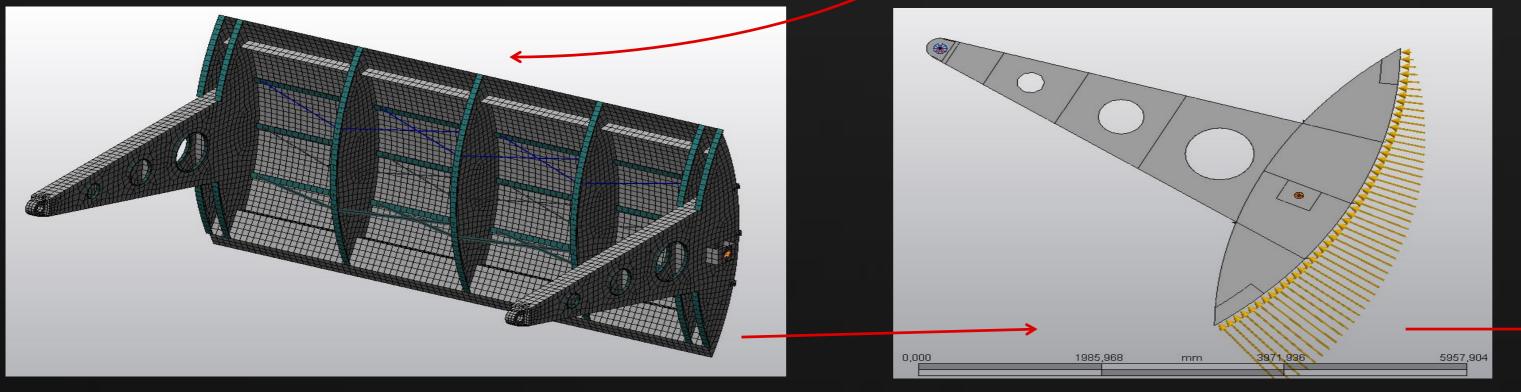


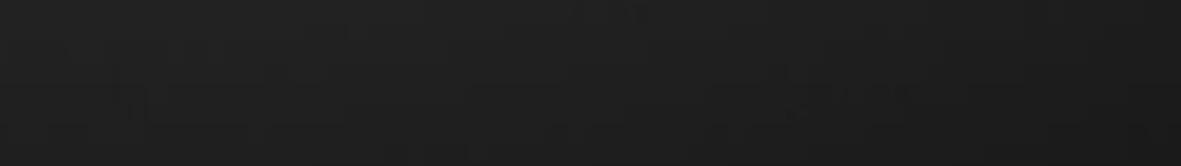


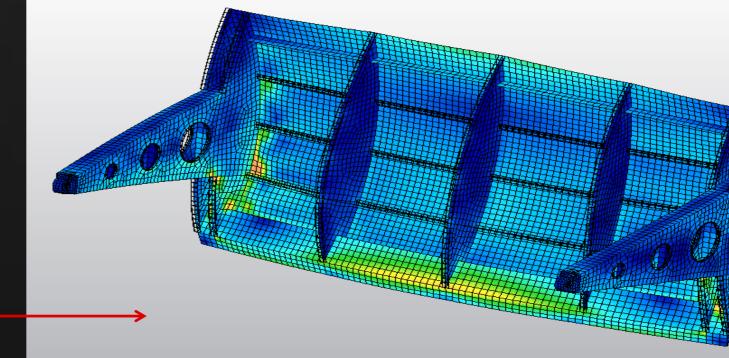
## Static Stress Analysis – Design Process

















## **Mixed Element Meshing**

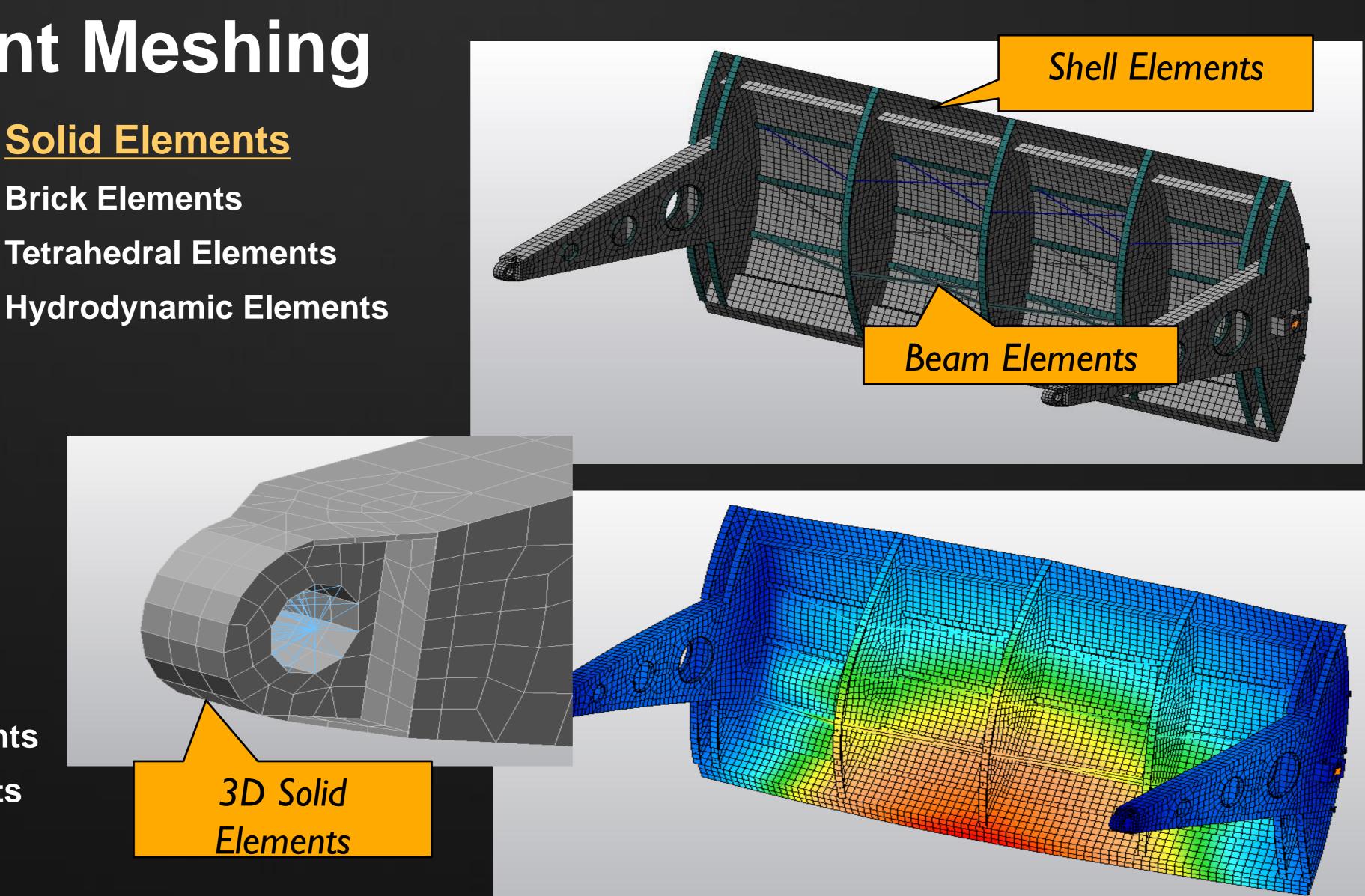
**Line Elements Beam Elements Gap Elements Rigid Elements Spring Elements Truss Elements** 

#### Solid Elements

**Brick Elements Tetrahedral Elements** 

#### **Surface Elements**

**2-D Elements Membrane Elements Plate Elements** Thick Composite Elements Thin Composite Elements

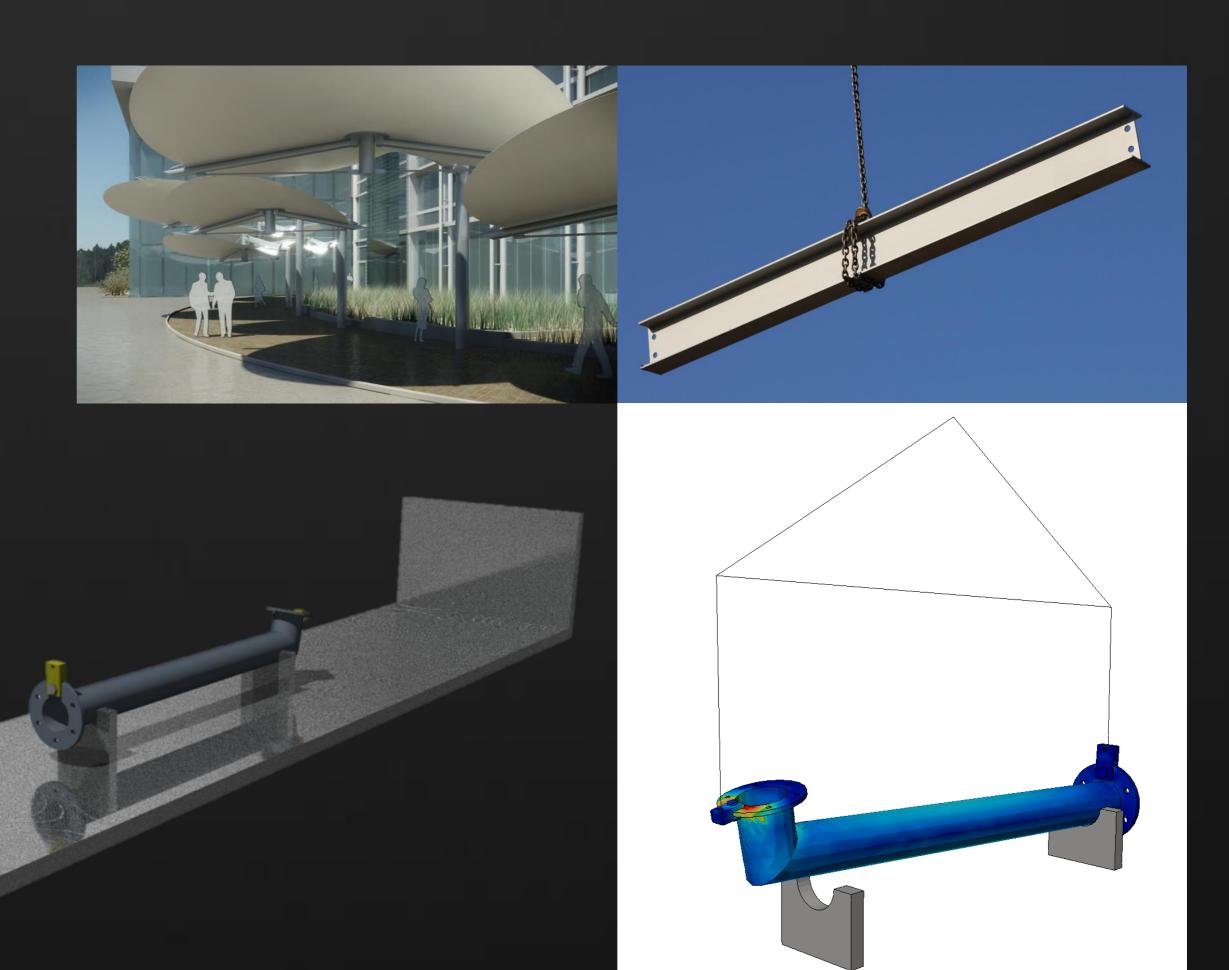


## **ERECTION ENGINEERING**

Advantages of Performing a **Structure Lifting Simulation:** 

- Nonlinear material considerations
- Stress & deformation vs. time and position
- What-if scenarios
  - Impact or drop test







# **Demonstration 2** Structure Erection Analysis



## Large Choice of Material Models

- Elastic
- Plastic
- Variable tangent
- Curve description
- Curve description with cutoff tension
- Drucker-Prager
- von Mises with isotropic hardening
- von Mises with kinematic hardening
- von Mises curve with isotropic hardening
- von Mises curve with kinematic hardening
- Temperature-dependent orthotropic
- Thermoelastic
- Thermoplastic
- Viscoelastic (thermal-creep)
- Viscoplastic (thermal-creep)
- Mooney-Rivlin (2, 5 and 9 constants)
- Ogden (1st 6th order)

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- Blatz-Ko (thermal and finite-strain viscoelastic)
- Hyperfoam (1st 6th order)
- Linear elastic isotropic
- Linear elastic orthotropic
- Linear temperature-dependent isotropic
- Linear temperature-dependent orthotropic
- Gasket (geometrically linear and nonlinear)
- Piezoelectric
- General piezoelectric
- General piezoelectric temperature-dependent anisotropic
- Anisotropic
- Temperature-dependent composite
- Composite laminate

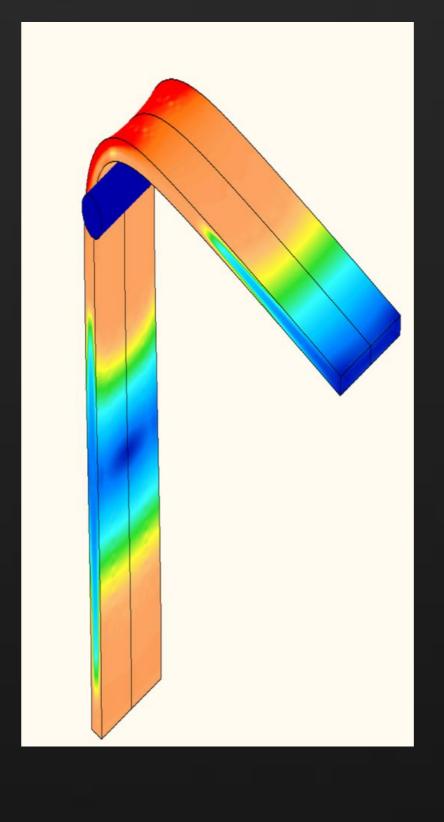
Arruda-Boyce (thermal and finite-strain Viscoelastic)

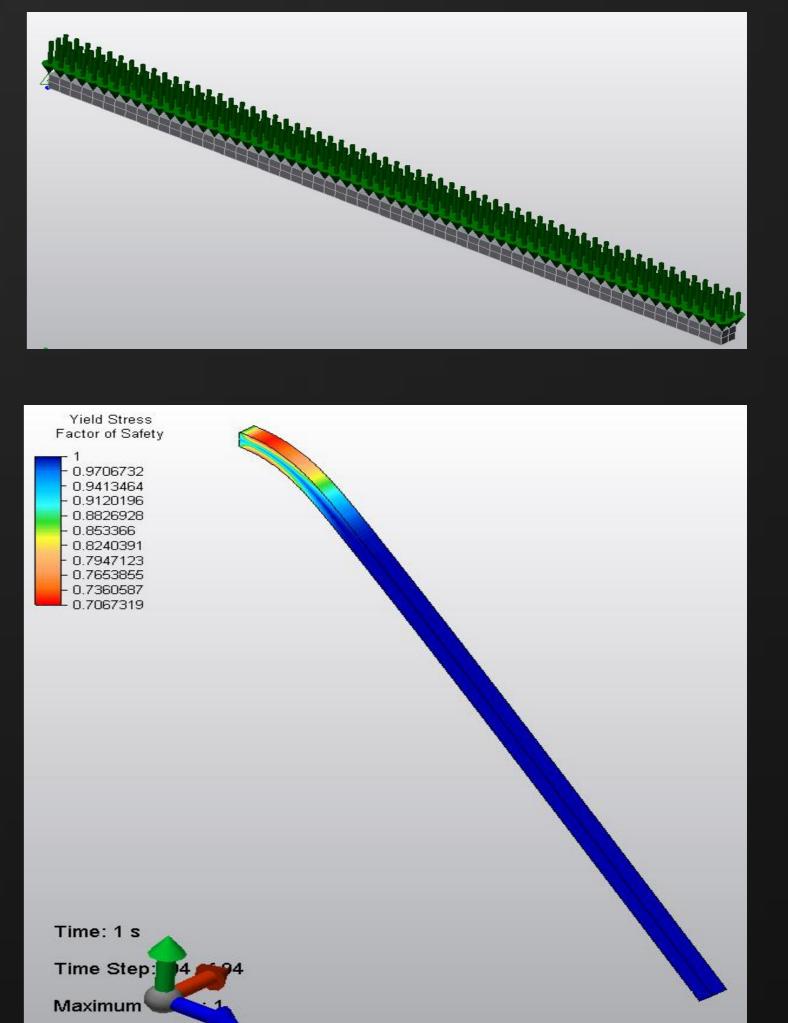


## Non-linear: Elasto-plastic Analysis

Element Definition - Brick/Tetrahedral	2 ×
General Thermal Orthotropic Advanced Soil General Settings	
Material model: von Mises with Isotropic Hardening	<del>ک و ک</del>
<ul> <li>F Viscoelastic Van der Waals</li> <li>Plasticity</li> <li>Plastic</li> <li>Von Mises with Isotropic Hardening</li> <li>Von Mises Curve with Isotropic Hardening</li> <li>Von Mises Curve with Isotropic Hardening</li> <li>Von Mises Curve with Kinematic Hardening</li> <li>Von Mises Curve with Kinematic Hardening</li> <li>Thermoplastic</li> <li>Viscoplastic</li> <li>Thermal Creep Viscoplastic</li> <li>Concrete</li> <li>Concrete</li> <li>Pleinforced Concrete</li> <li>Electrical</li> </ul>	
Midside Nodes Not Included   Analysis Type Large Displacement	
	Reset From Model
OK Cancel Help	Reset From Default

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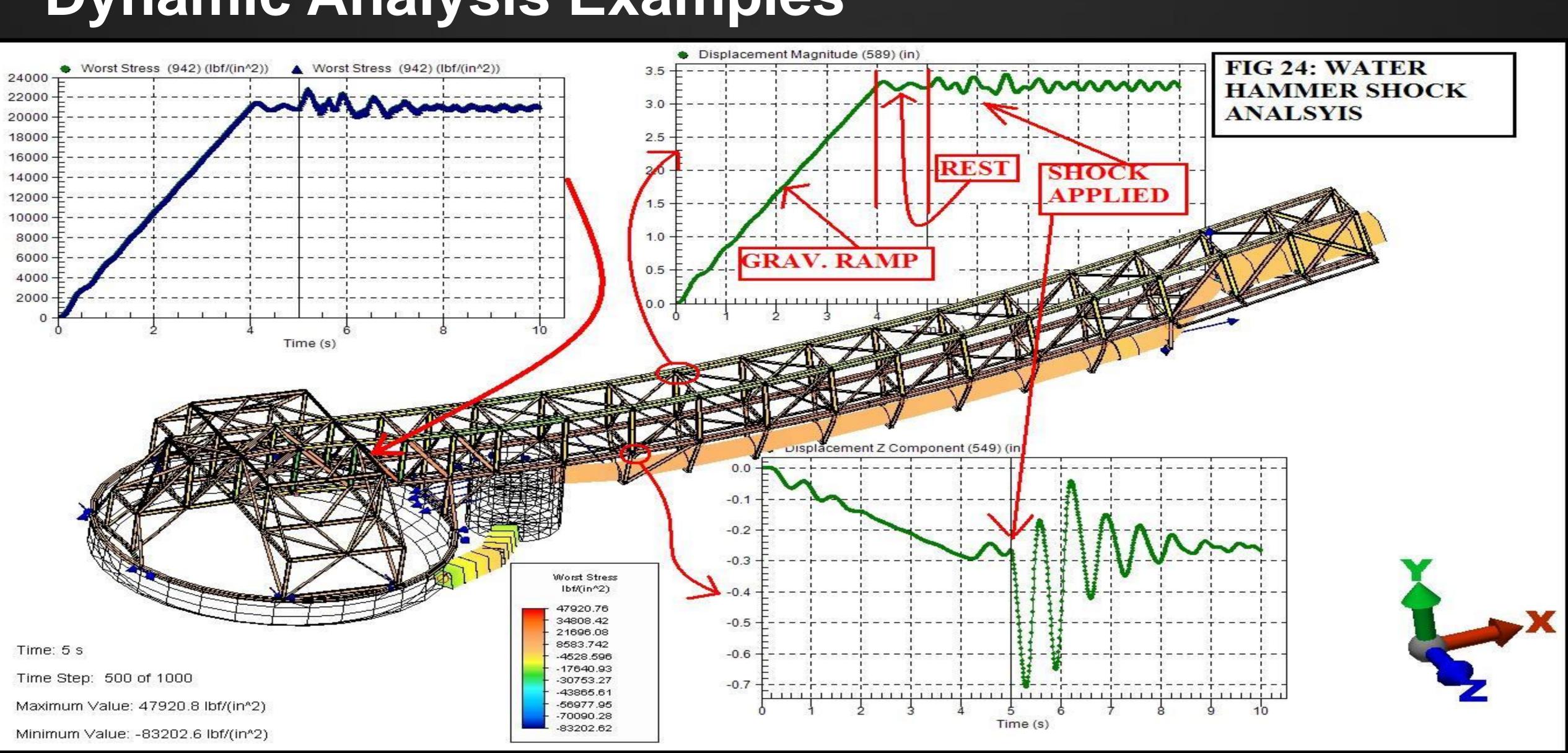


Minimum Value: 0.706732

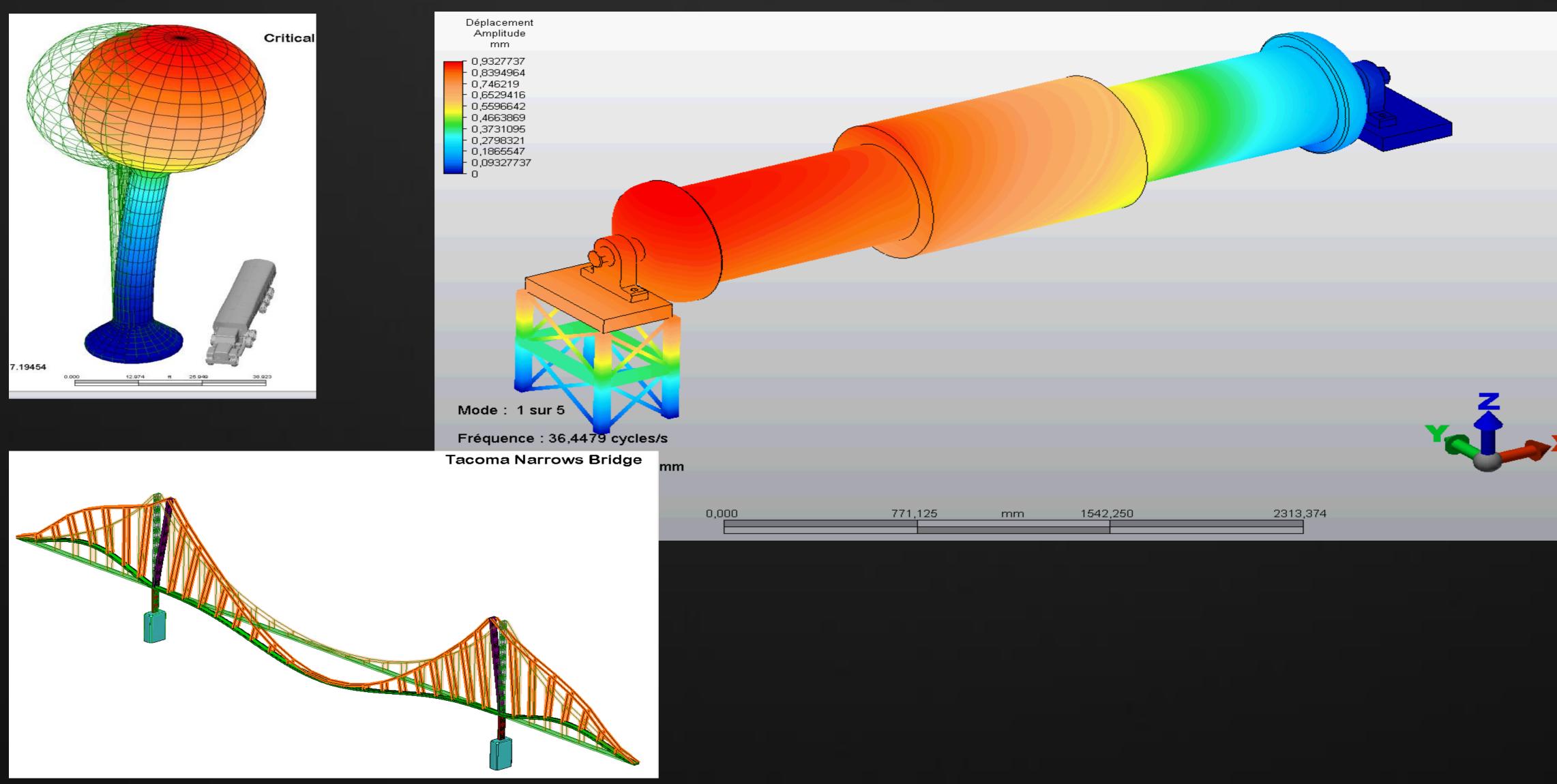




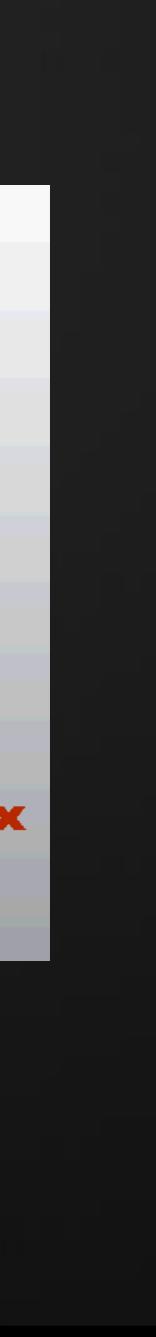
## **Dynamic Analysis Examples**



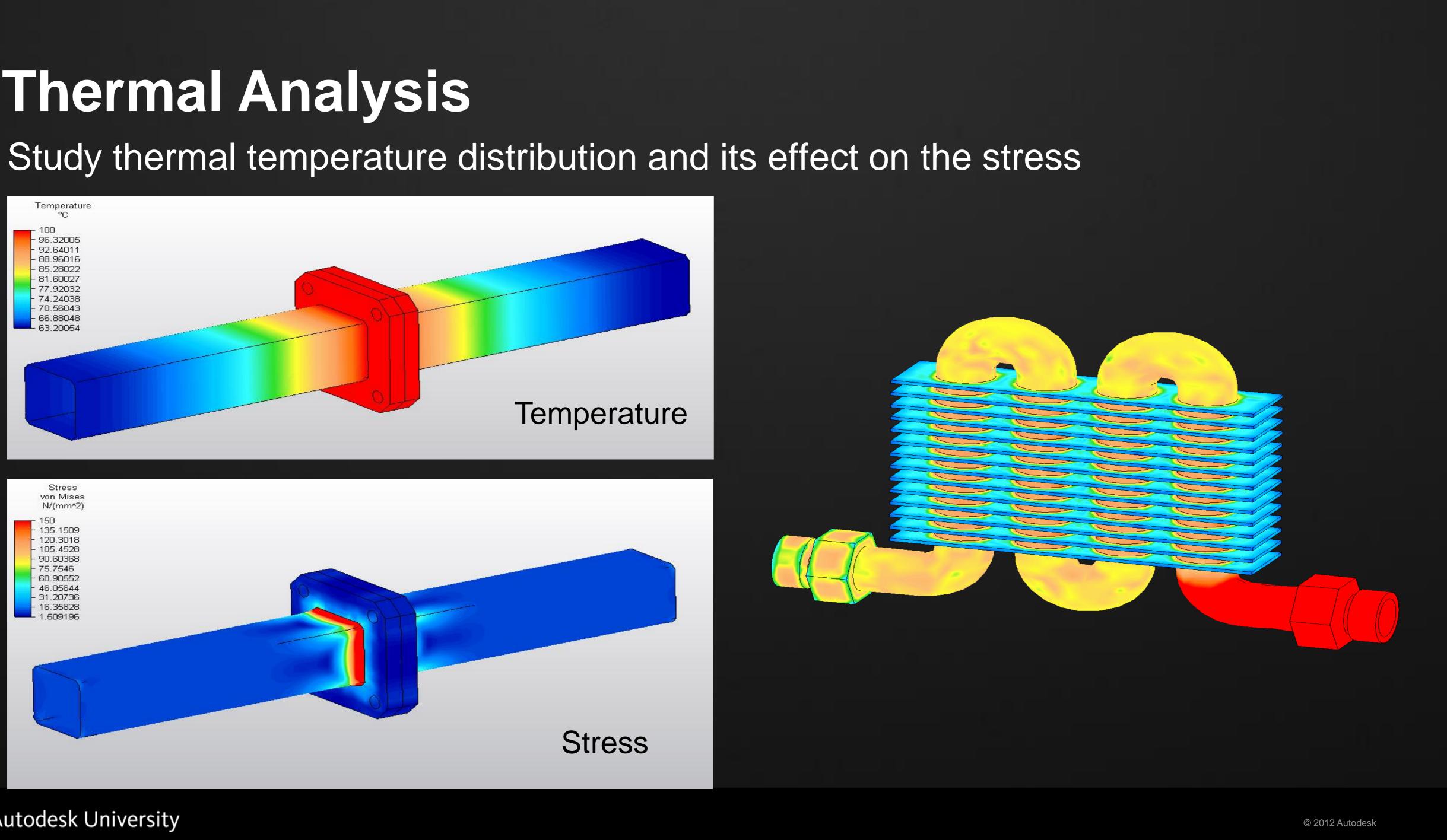
## Dynamic Analysis Examples

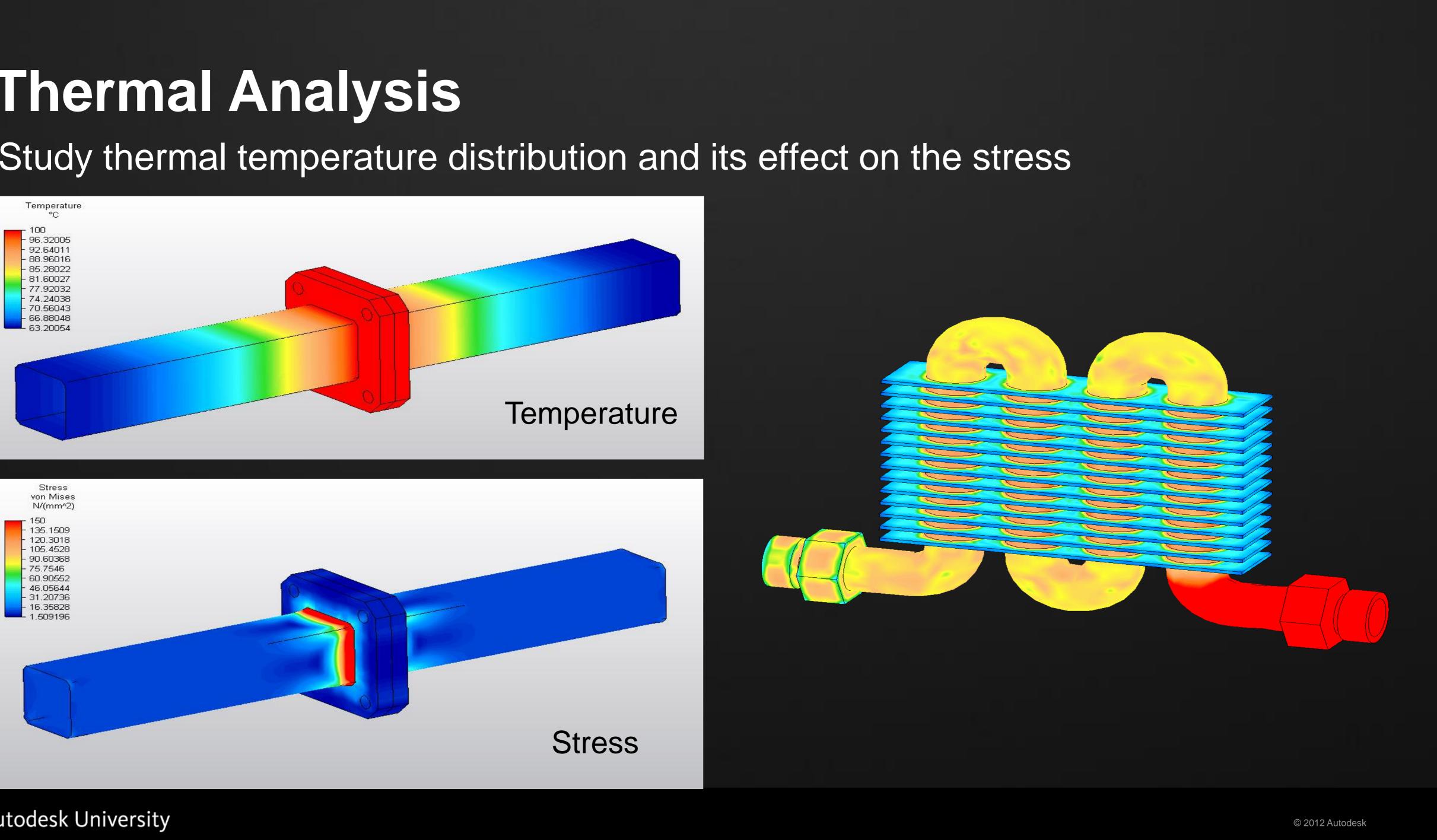




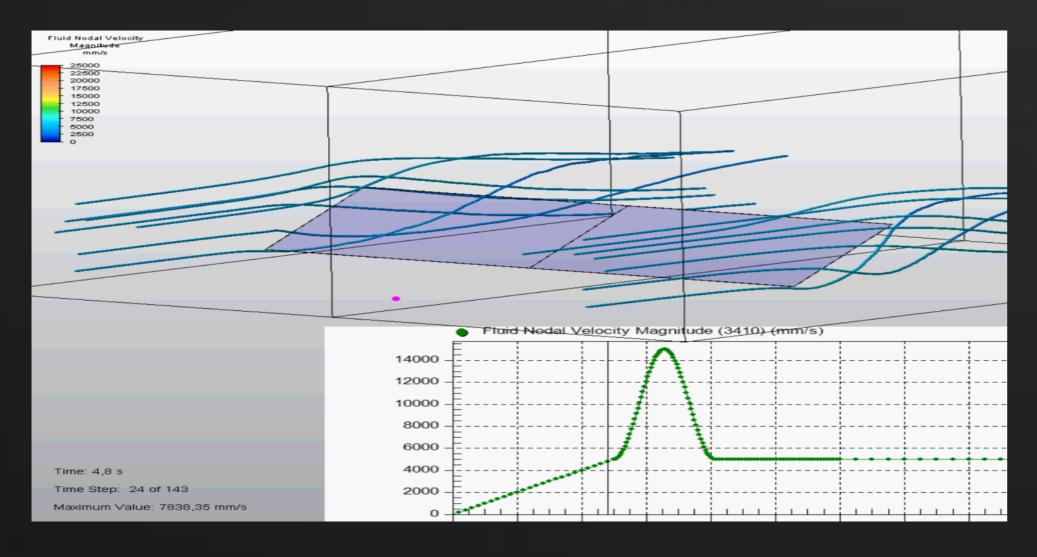


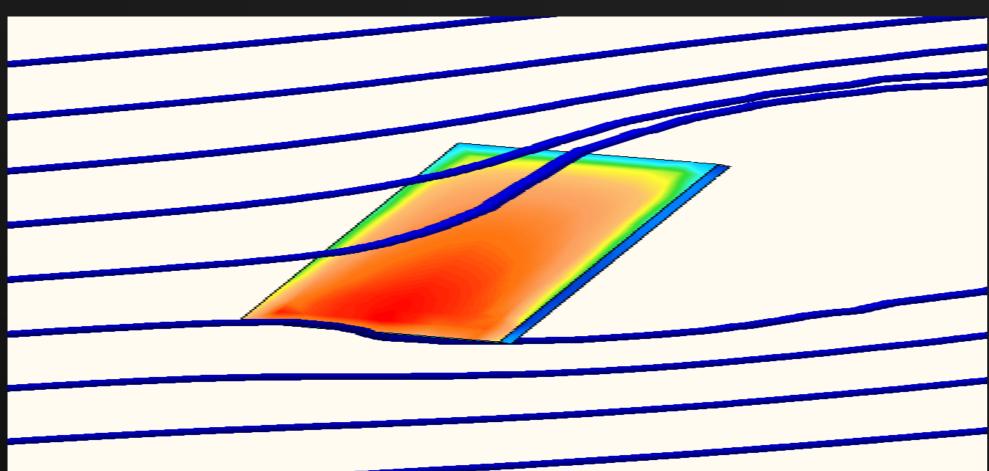
## Thermal Analysis





## Fluid-Structure Interaction





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### Representation of fluid pressure for structural analysis

### Check out Project Hydra on Autodesk Labs!!!





## **Multiphysics Analyses**

Study the effect of multiple physics on the structure:

- Thermal stress analysis
- Fluid and thermal analysis
- Fluid and structural analysis
- Electrostatic analysis
- Joule heating analysis
- Electromechanical analysis

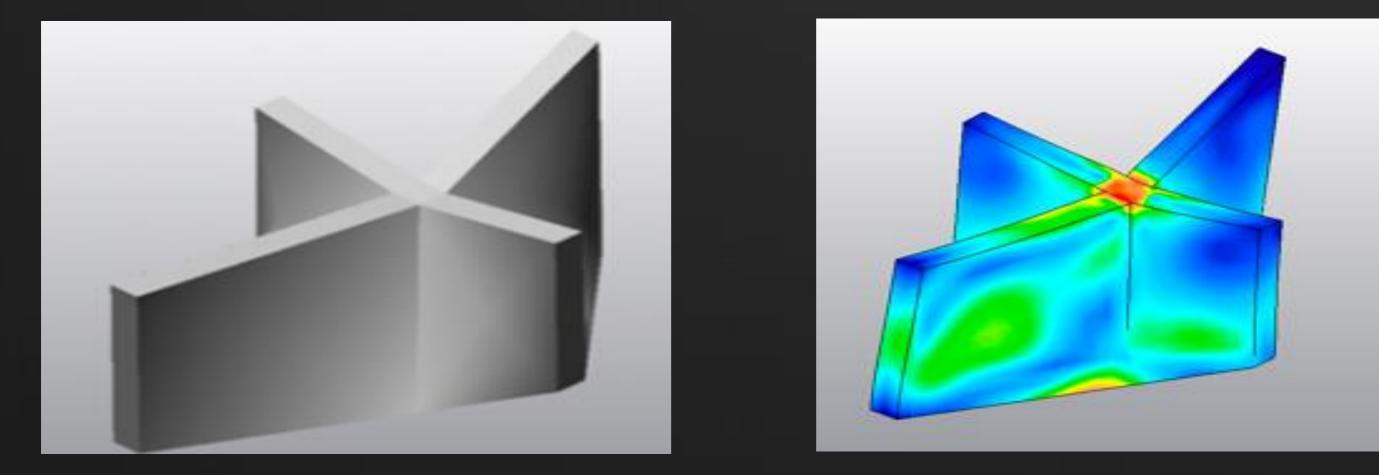
#### **Circuit Breaker** Joule Heating

Time: 5 secs.

Circuit Breaker Mechanical **Event Simulation** Time: 6.528 secs.

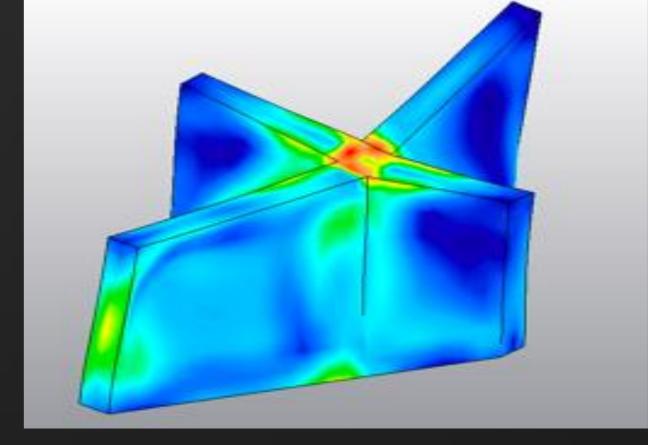


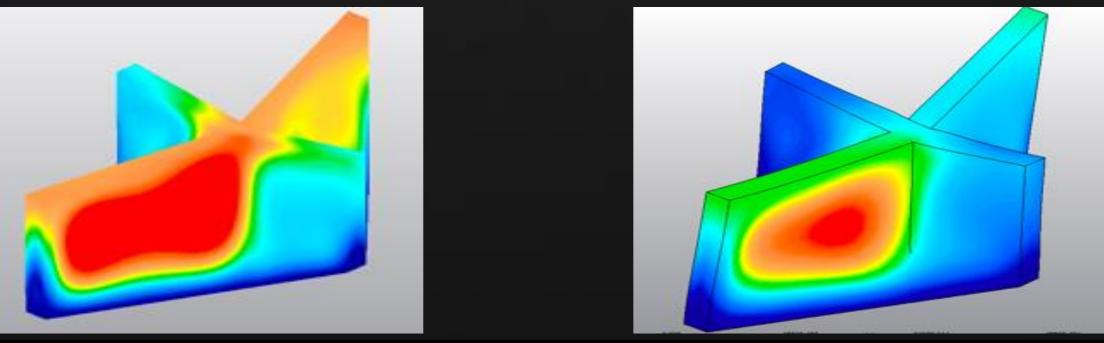
## **Design Optimization**



Thickness	<b>500mm</b>	<b>100mm</b>
Stress	3.82MPa	13.46 MPa
Deformation	11.282 mm	11.282 mm









## **Design Optimization**

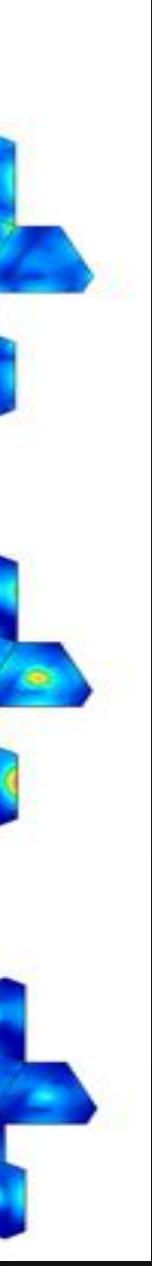


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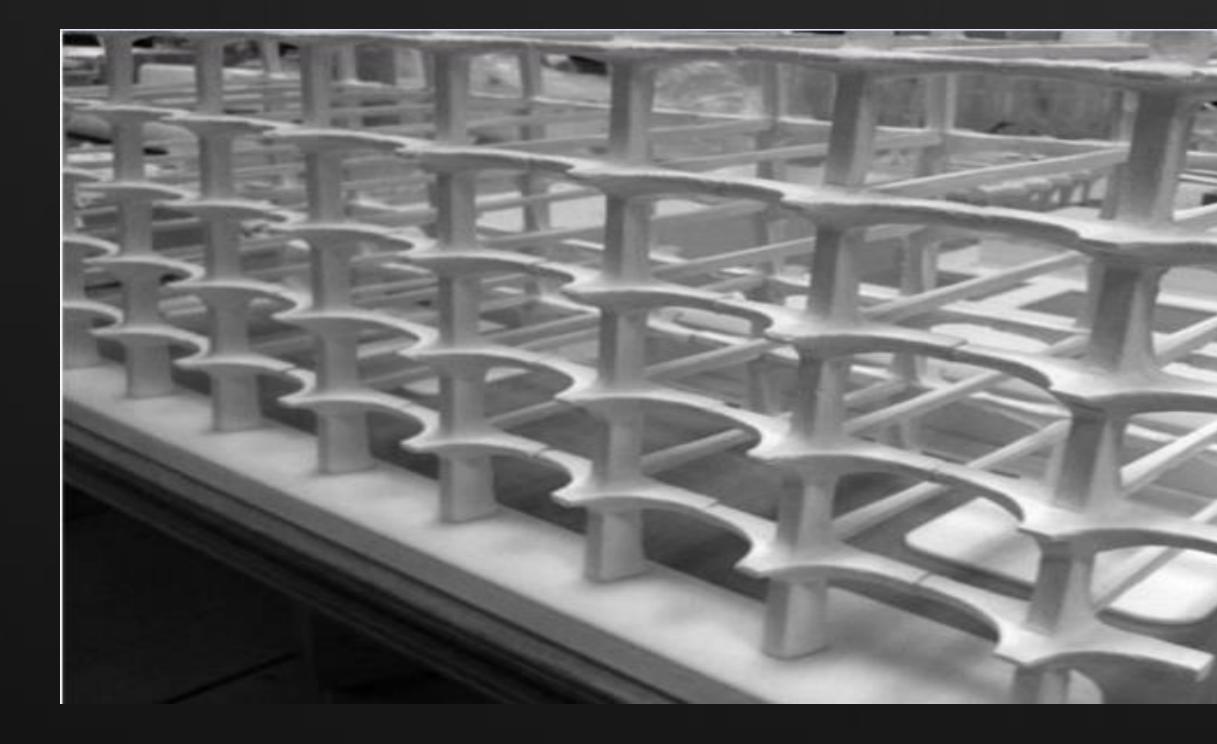
Columns at the end points of each polygonal unit

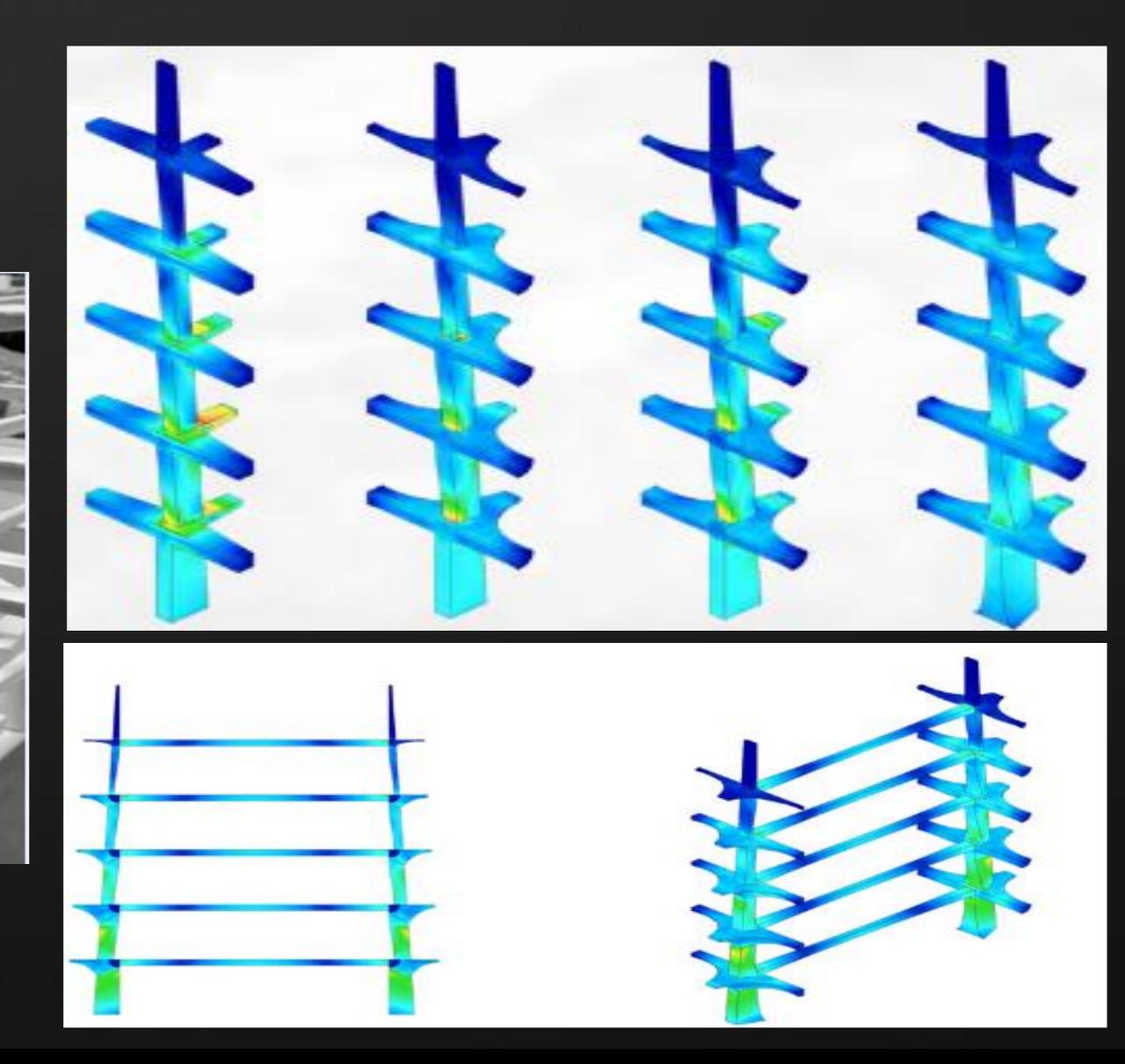
Reduction of columns Columns are positioned at centre of each unit

Roof Structural beams are multiplied to form a denser network.

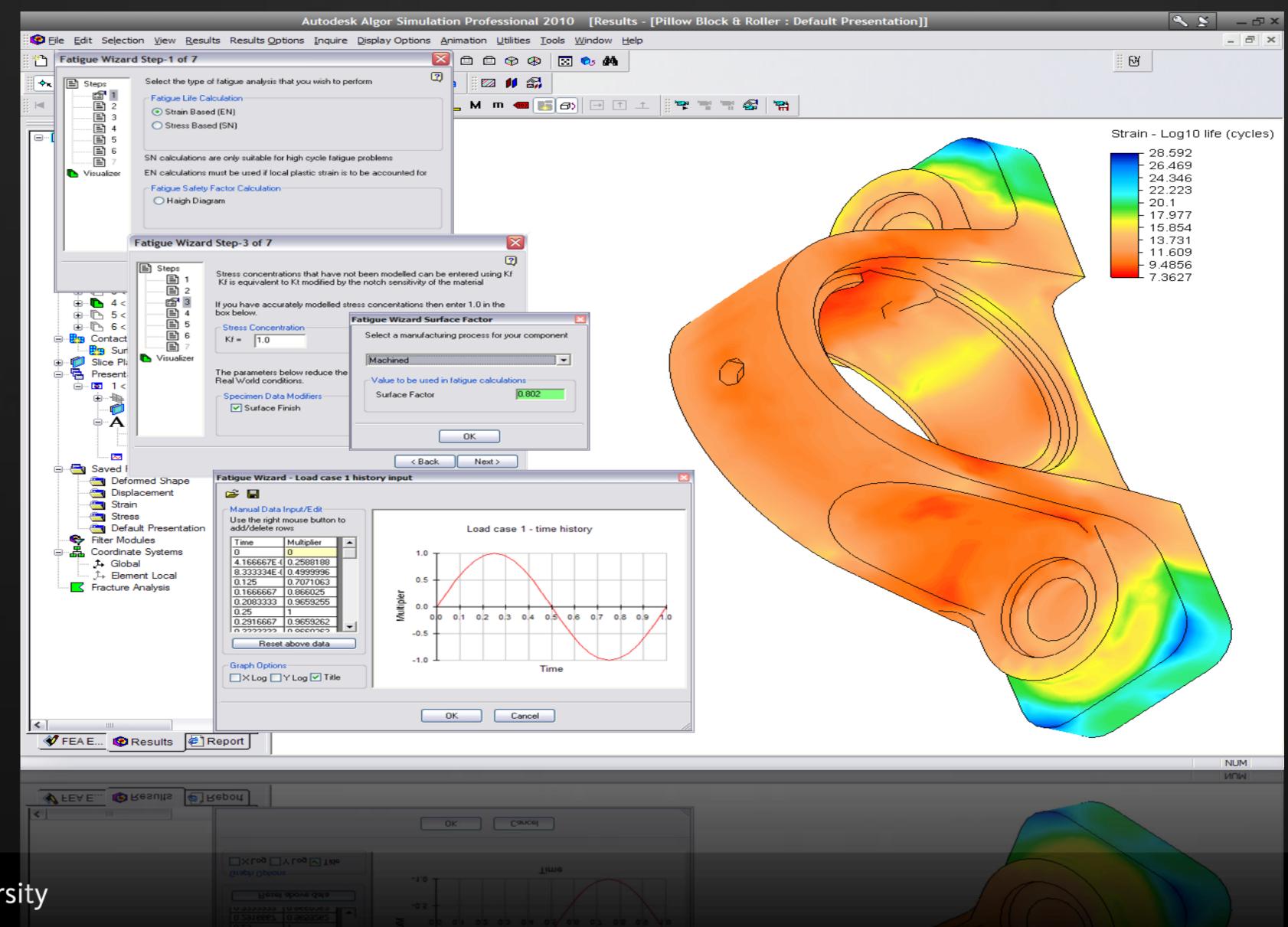


## **Design Optimization**





## Fatigue Analysis





# Demonstration 3 Design Optimization, Fatigue and Environmental Loading



## Summary

- **Construction Analysis Techniques** •
  - Detailed models with part simplification •
  - Bolt wizard  $\bullet$
  - Welding ullet
- Structure Erection Analysis with Mechanical Event Simulation •
  - Mixed modeling ullet
  - Prescribed displacements  $\bullet$
  - 360 solving power ullet
- **Optimization and Fatigue** ullet
  - Project Hydra ullet
  - Stress vs. strain fatigue  $\bullet$



## Questions? I have Answers!





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