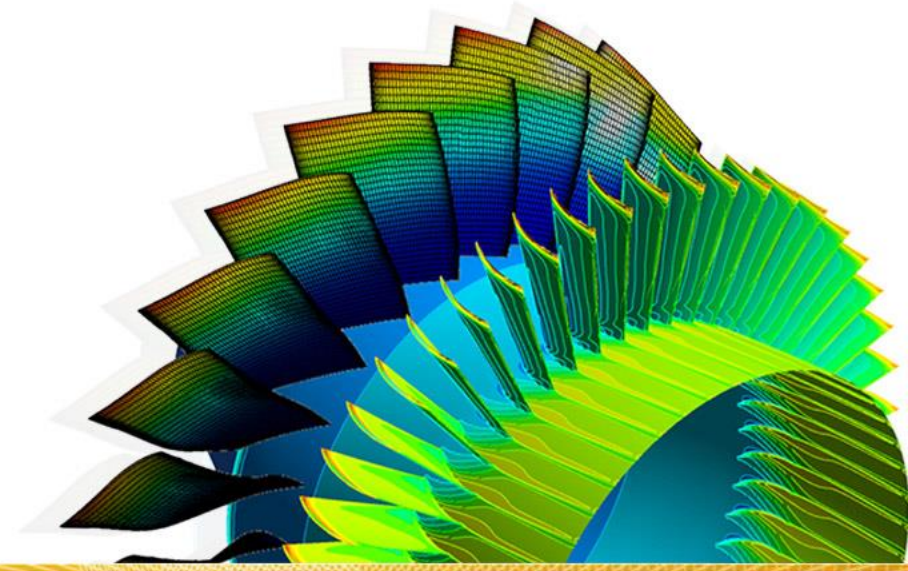
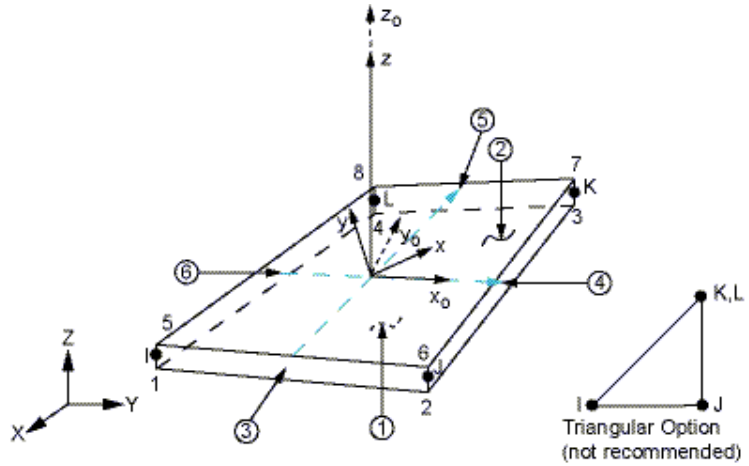
# ANSYS Composite PrepPost 19.0

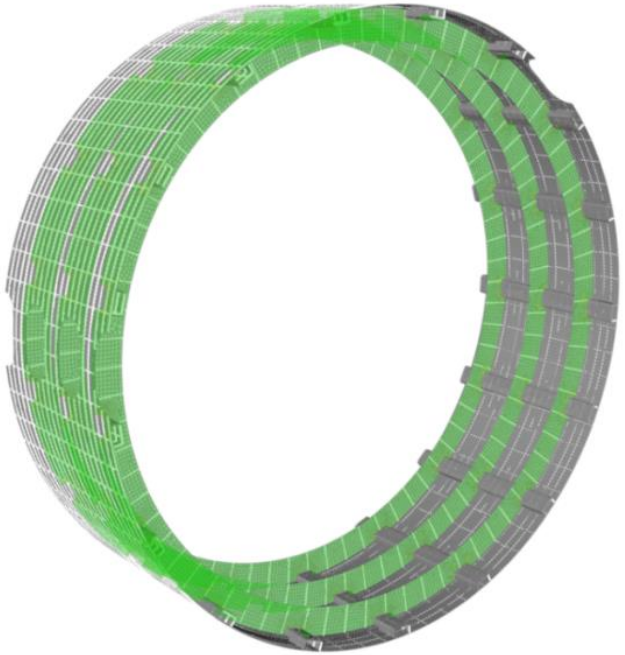
Module 7: Solid Modeling

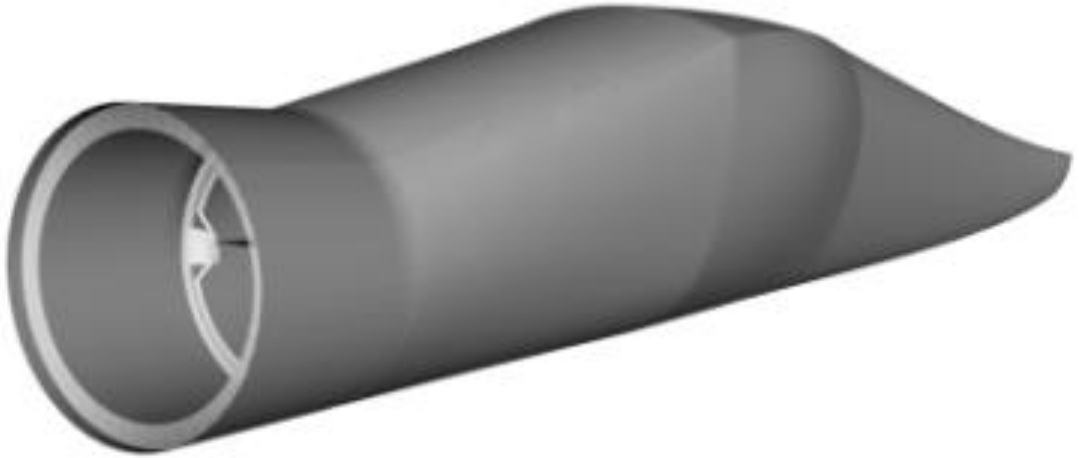


# 7. Solid Modeling

- Composites are usually thin structures suitable for shell modeling.
- The shell theory assumes zero stresses in the thickness direction of the element.



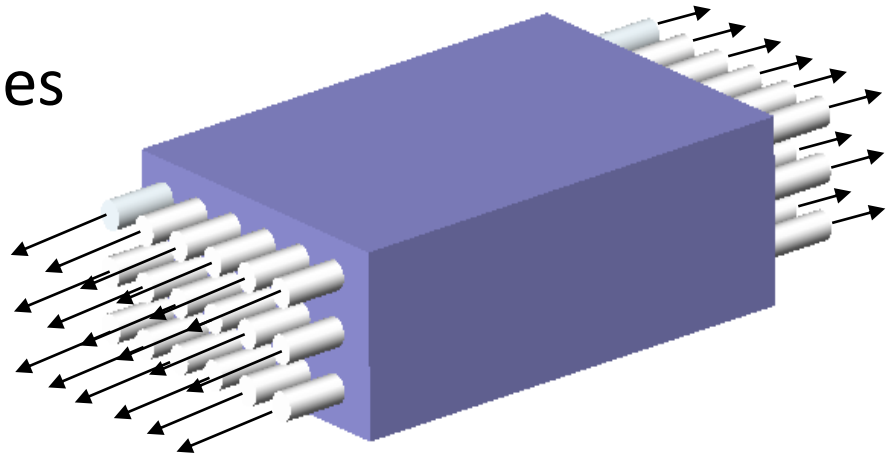





# 7. Solid Modeling

- Solid Models are required when stresses in thickness direction or shear stresses out of plane are significant.

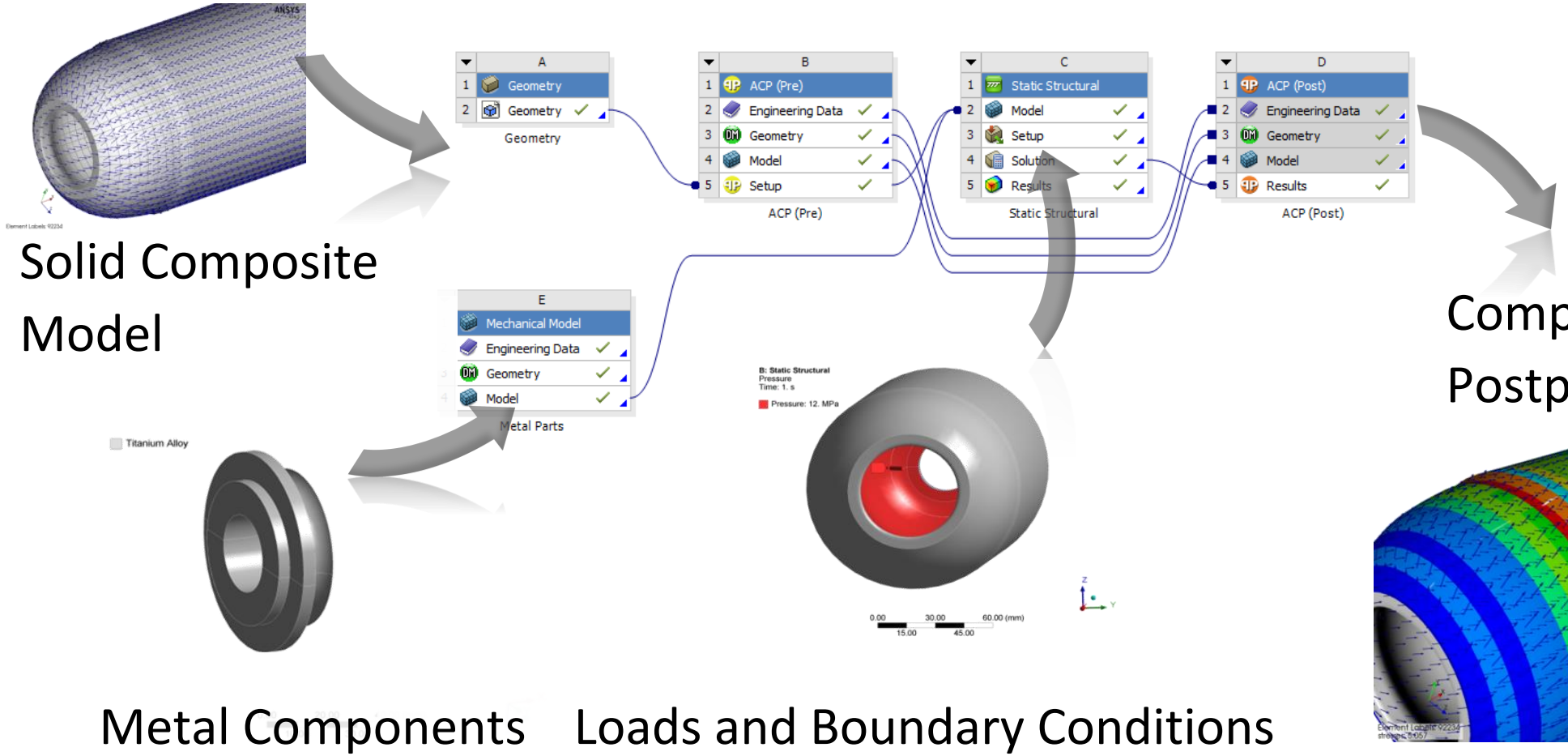
- Stresses in thickness direction are similar to stresses transversal to the fiber direction in plane. Small stresses could cause failure.



- When to use solid modeling:
  - With thick laminates
  - With large deformations
  - With loading in thickness direction

# 7. Solid Modeling

- Solid composite simulation process in ANSYS Workbench



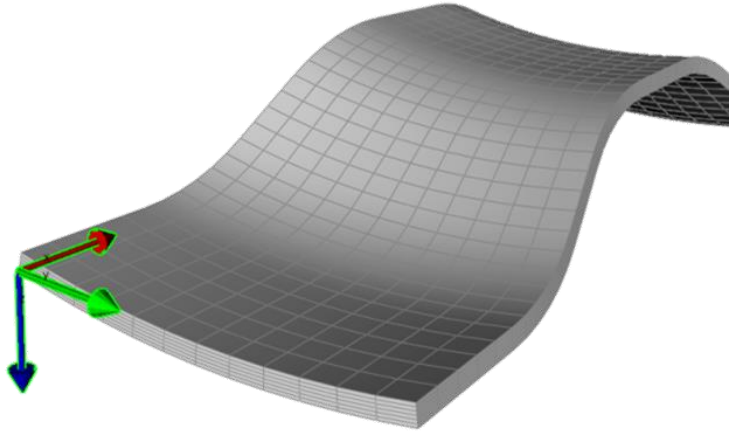

Solid Composite Model

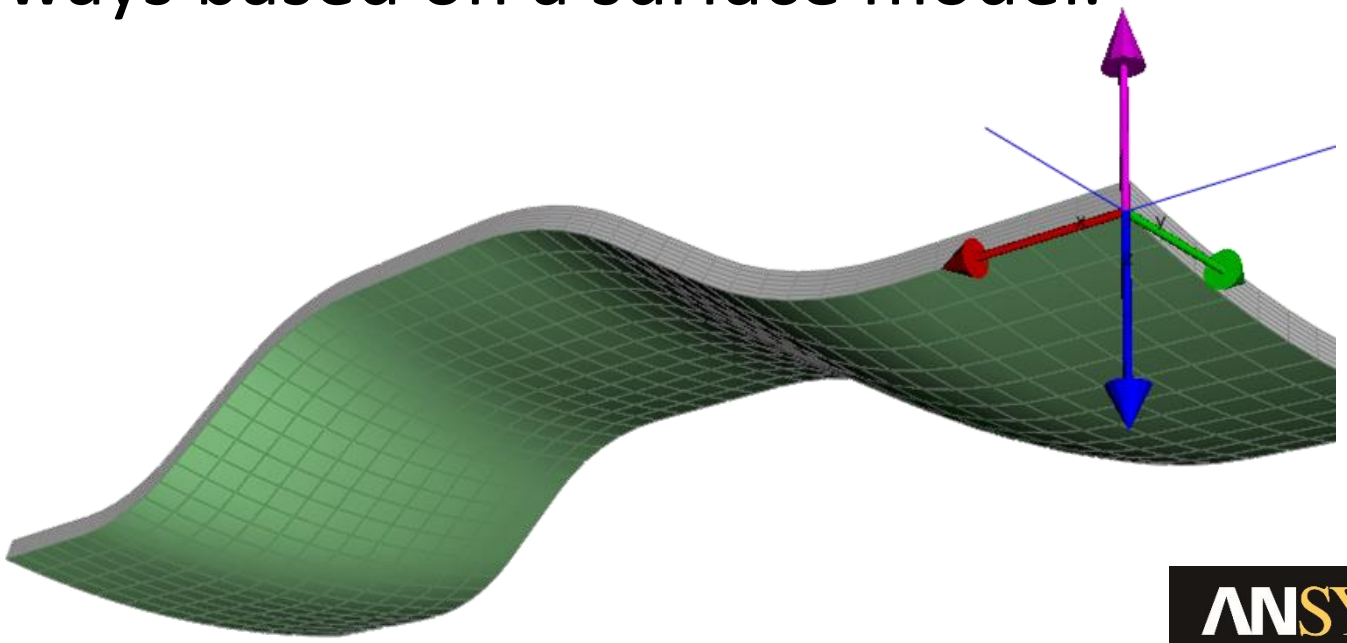
Composite Postprocessing

Metal Components  Loads and Boundary Conditions

# 7. Solid Modeling

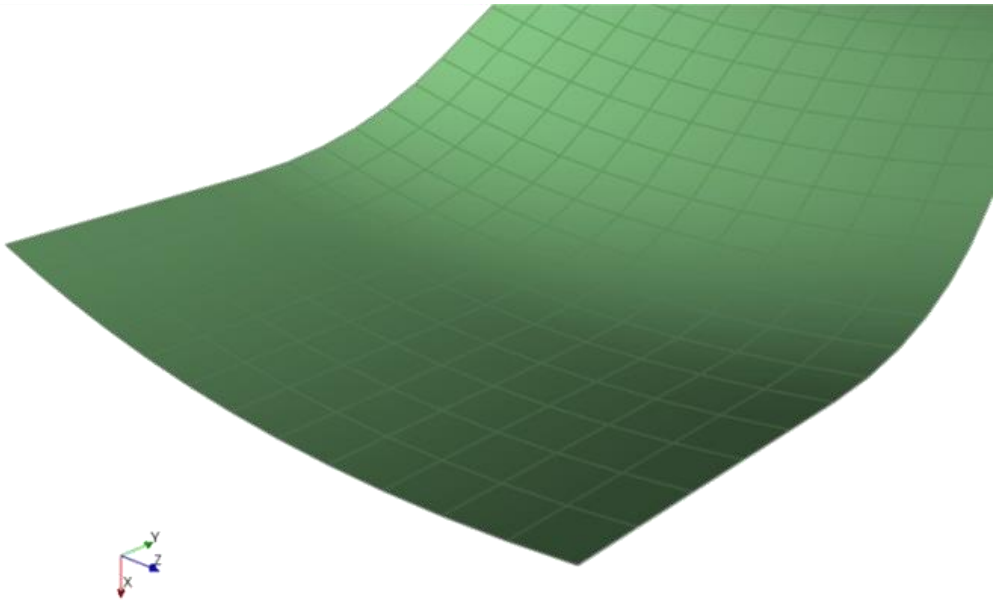
- The solid model process in ANSYS Composite PrepPost is based on the process for shell models. The composite model setup is identical to the setup of shell models.
- The composite layup is always based on a surface model.

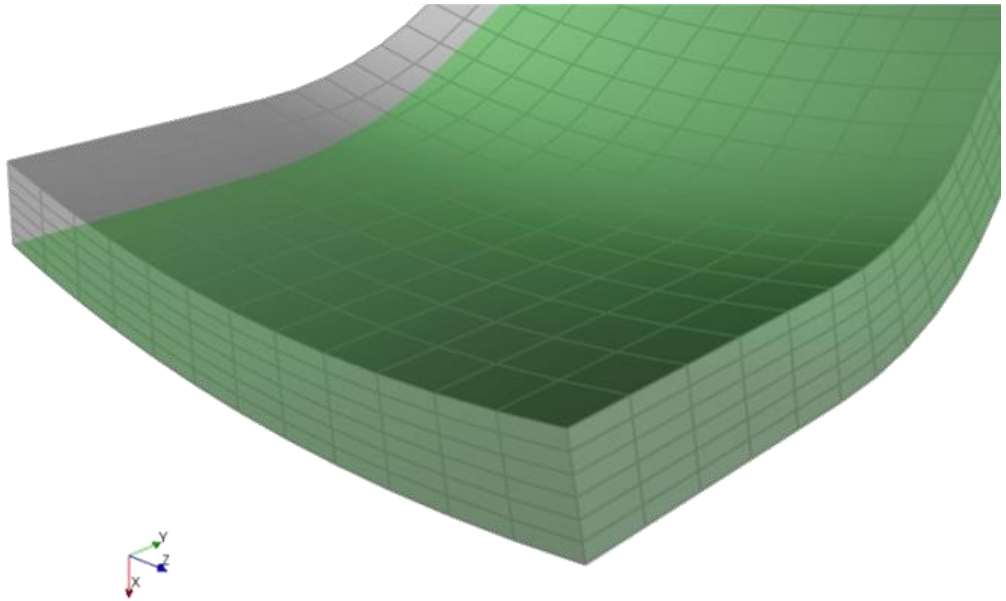




# 7. Solid Modeling

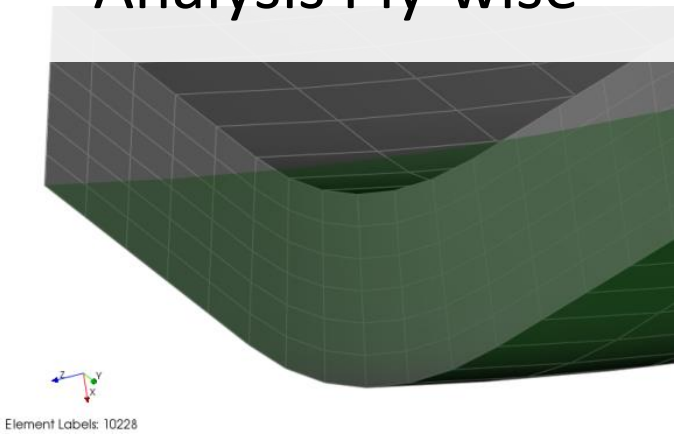
- A solid model of the layup is created by solid extrusion based on the surface of the layup.
- ANSYS composite PrepPost extrudes the solid model based on the layer information.



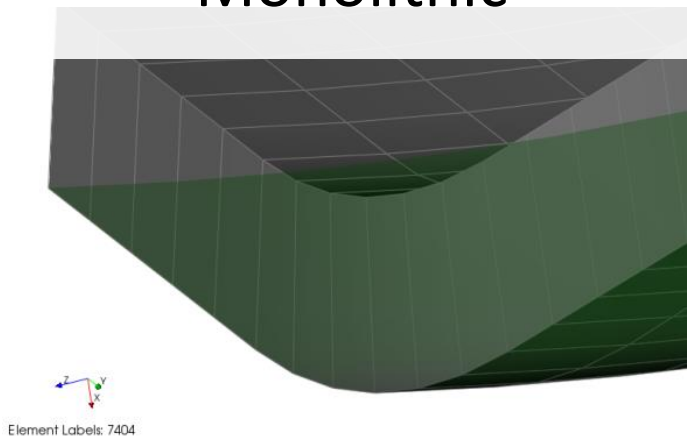


# 7. Solid Modeling

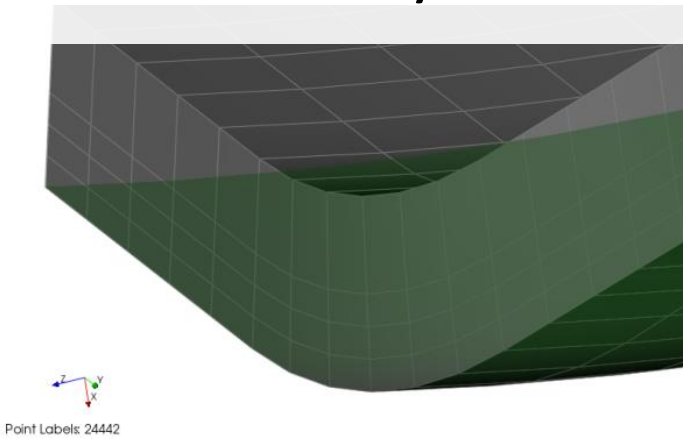
Analysis Ply-wise



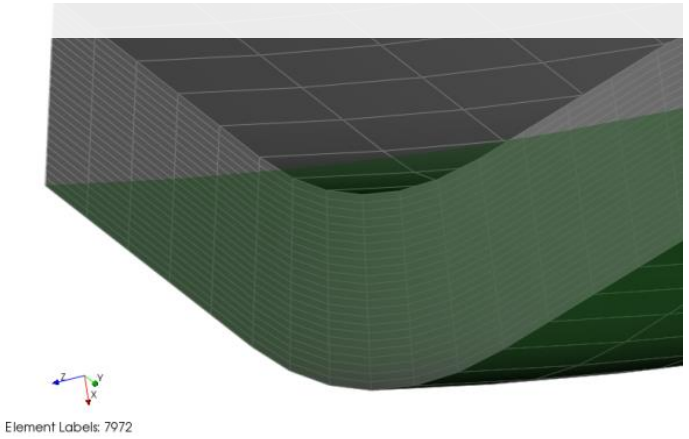

Monolithic




Production Ply-wise

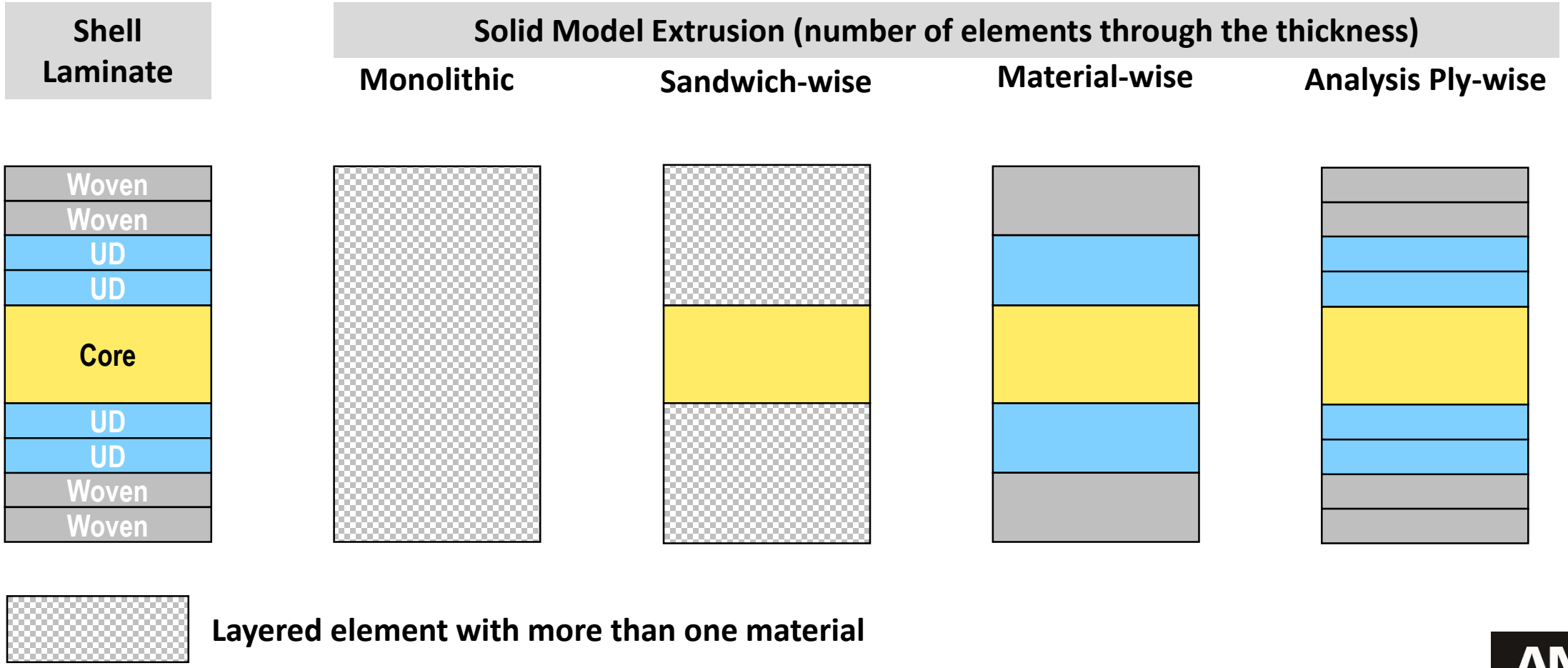



Specified Thickness



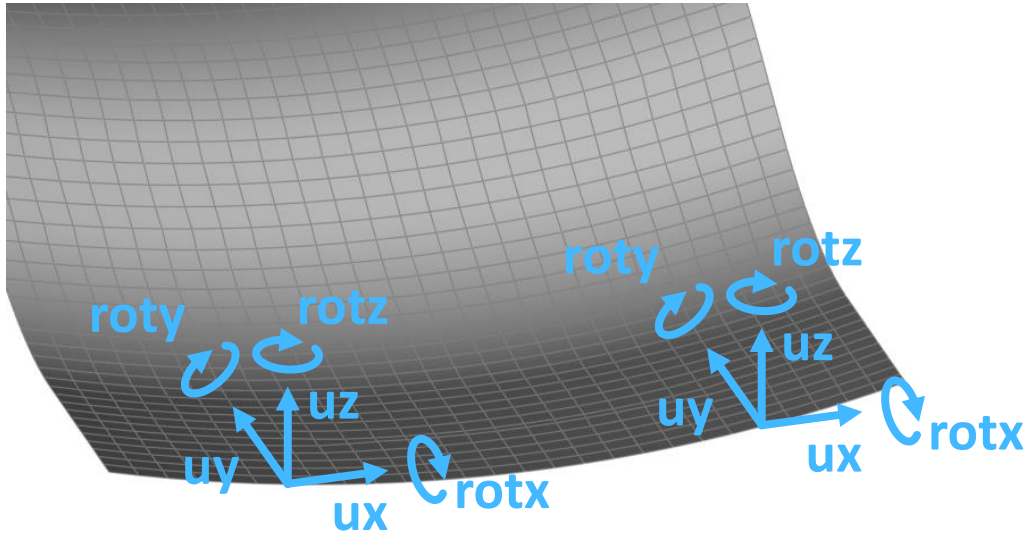
# 7. Solid Modeling

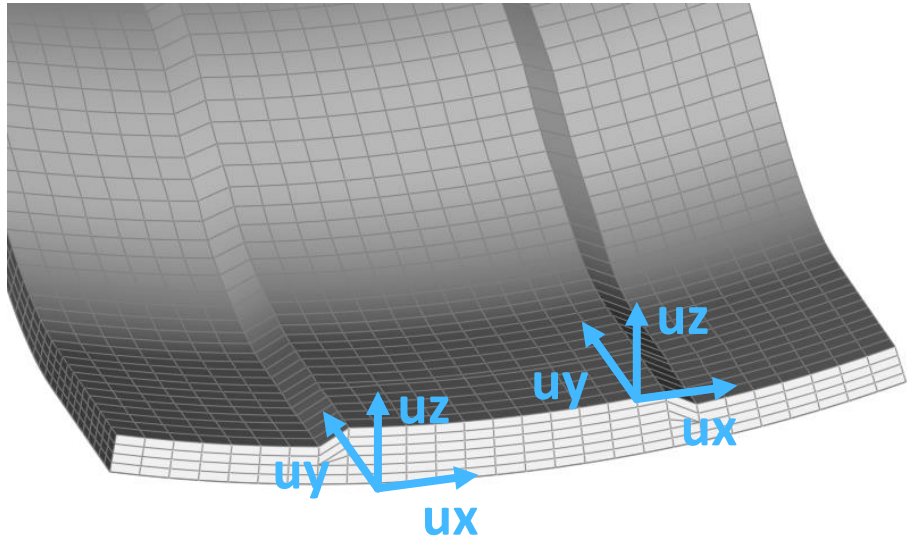
Illustration of different extrusion methods



# 7. Solid Modeling

- Solid models use different boundary conditions and degrees of freedoms than shell models.
- Within ANSYS Mechanical it is possible to use the solid model of the composite design and apply boundary conditions directly to the solid model.
- The solid composite can also be used in combination with other composite and/or metal components.



# 7. Solid Modeling

- **Step 1**

  Create composite layup

  based on shell model

- **Step 2**

  Create solid composite model

  in ANSYS Composite PrepPost

- **Step 3**

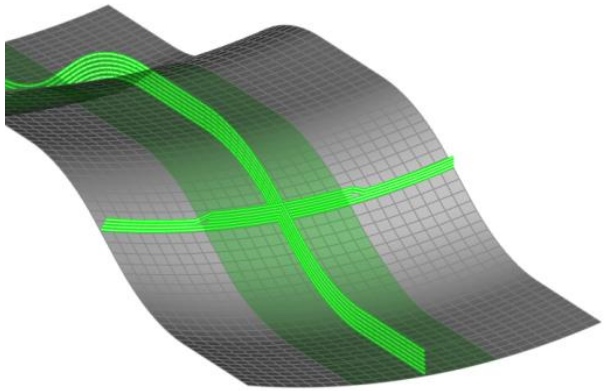
  Transfer composite model to

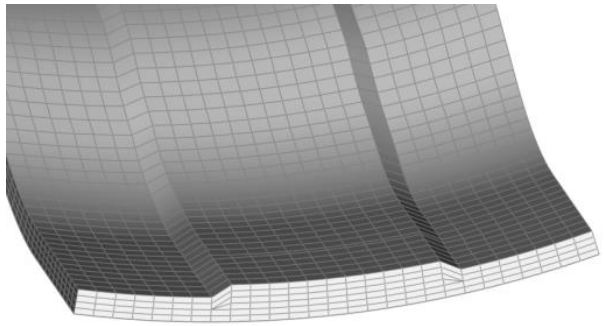
  ANSYS Mechanical and apply

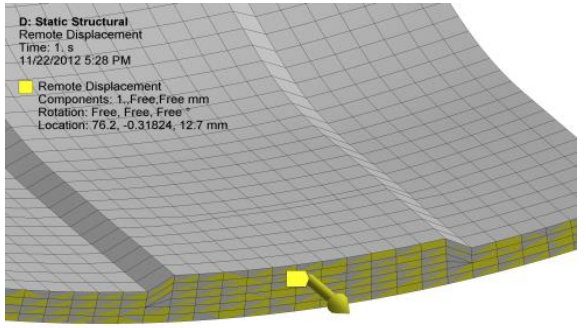
  boundary conditions

- **Step 4**

  Postprocess composite model in ANSYS Composite PrepPost

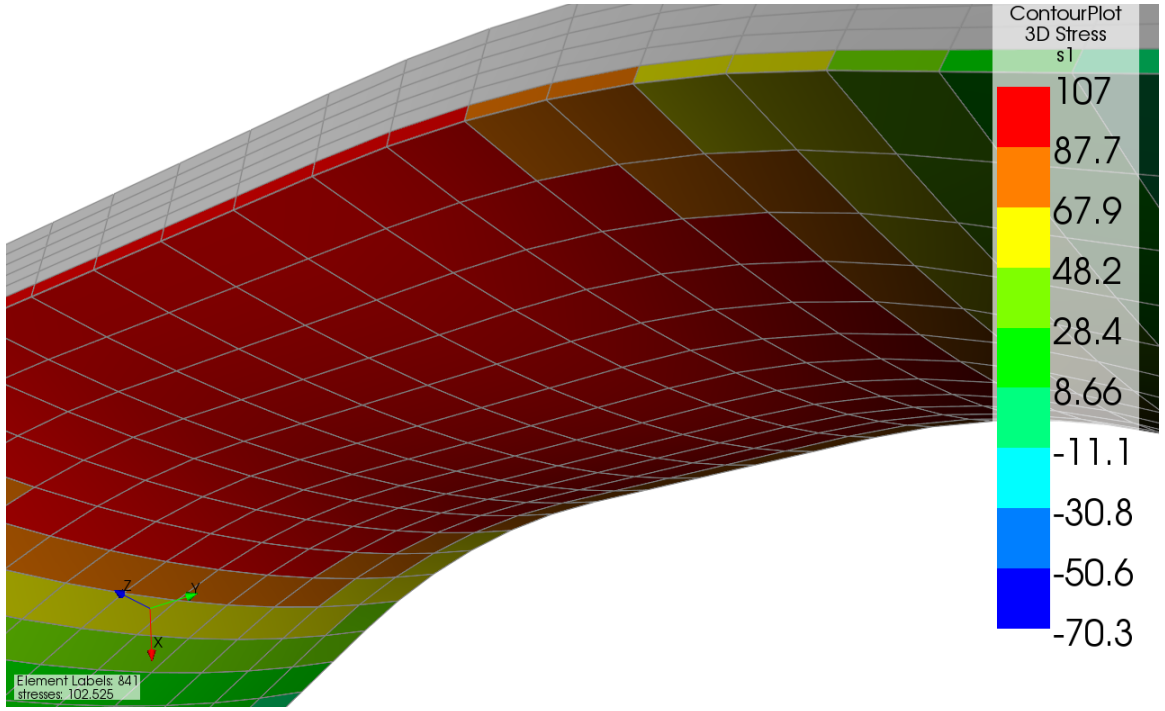


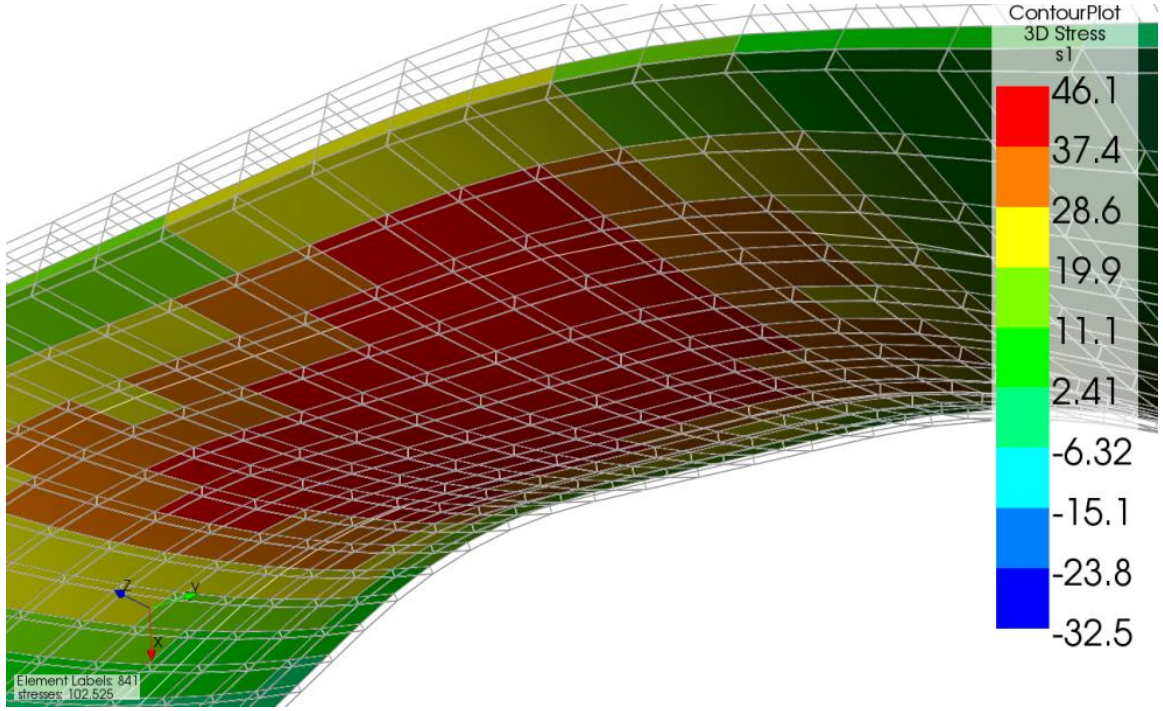




# 7. Solid Modeling

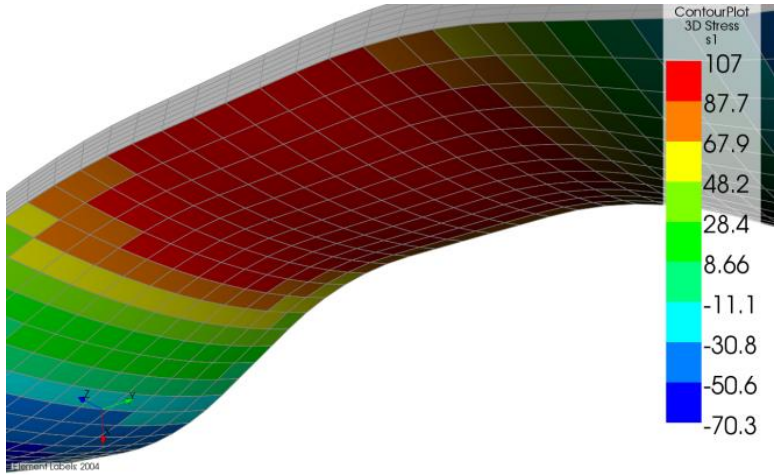
- Solid model results are evaluated in ANSYS Composite PrepPost.
- Unselected layers can be shown transparent.



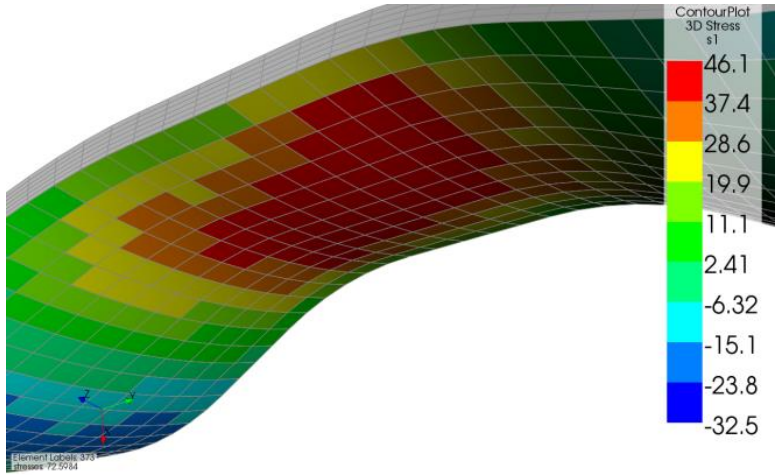



# 7. Solid Modeling

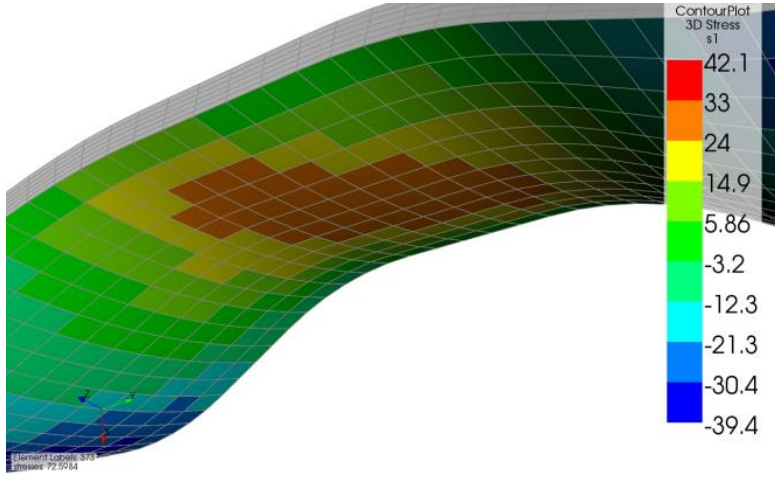
- Solid model results can be shown on a reference surface selected by ANSYS Composite PrepPost.
- This allows using annotations (failure criteria, layer, loadstep) for solid models.




Layer 1



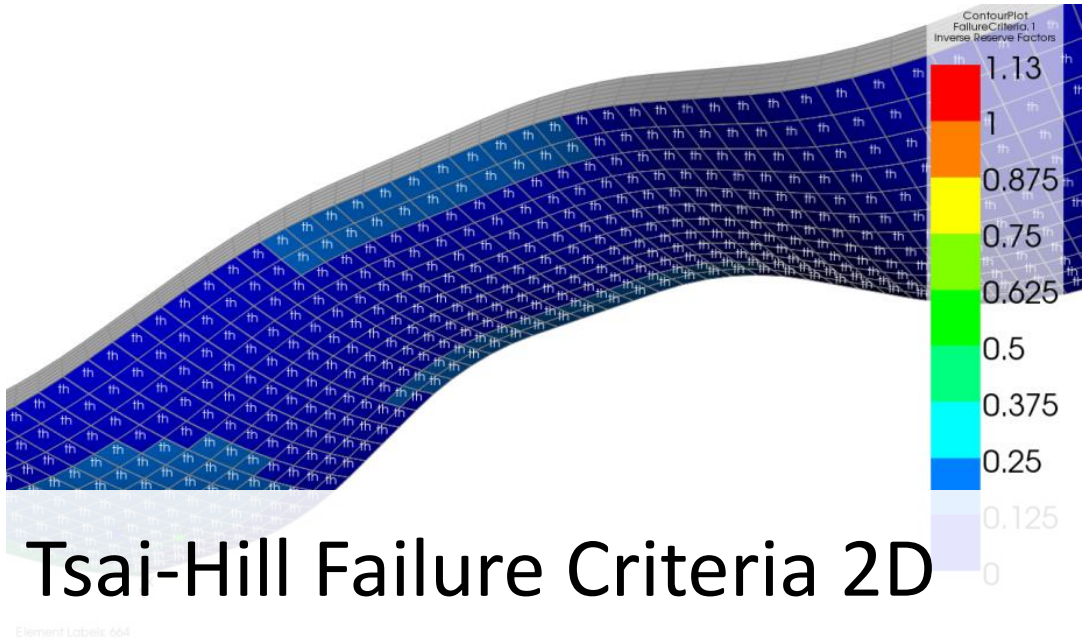

Layer 2



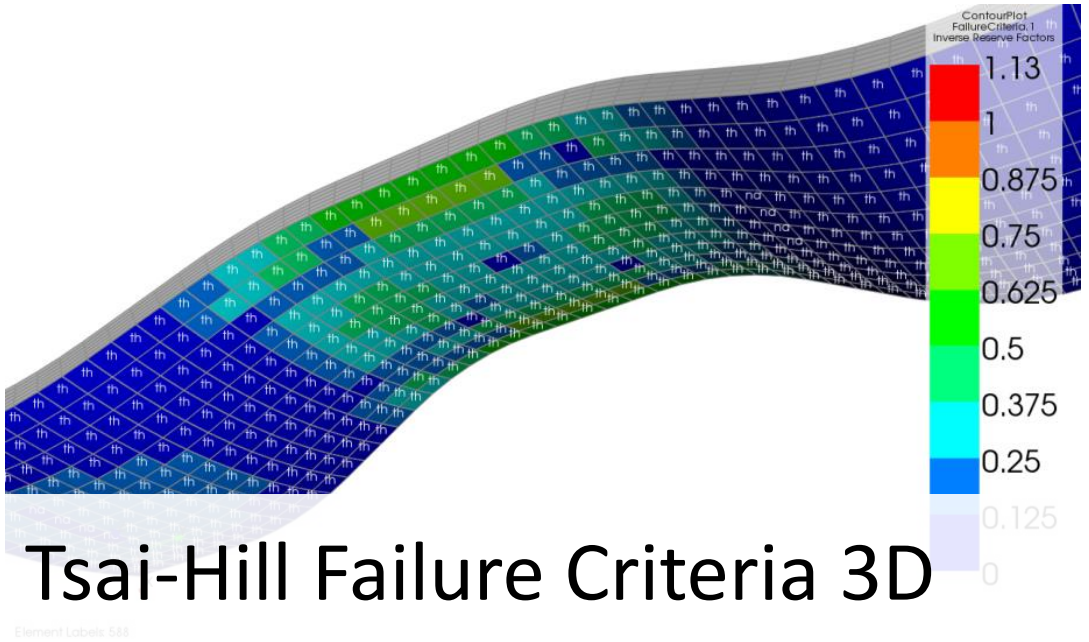

Layer 3

# 7. Solid Modeling

- Failure Criteria are available as three dimensional failure criteria (Maximum Stress, Maximum Strain, Hoffman, Tsai-Wu, Tsai-Hill, Puck, Hashin, Cuntze).
- The user has to specify if three dimensional failure criteria are used.



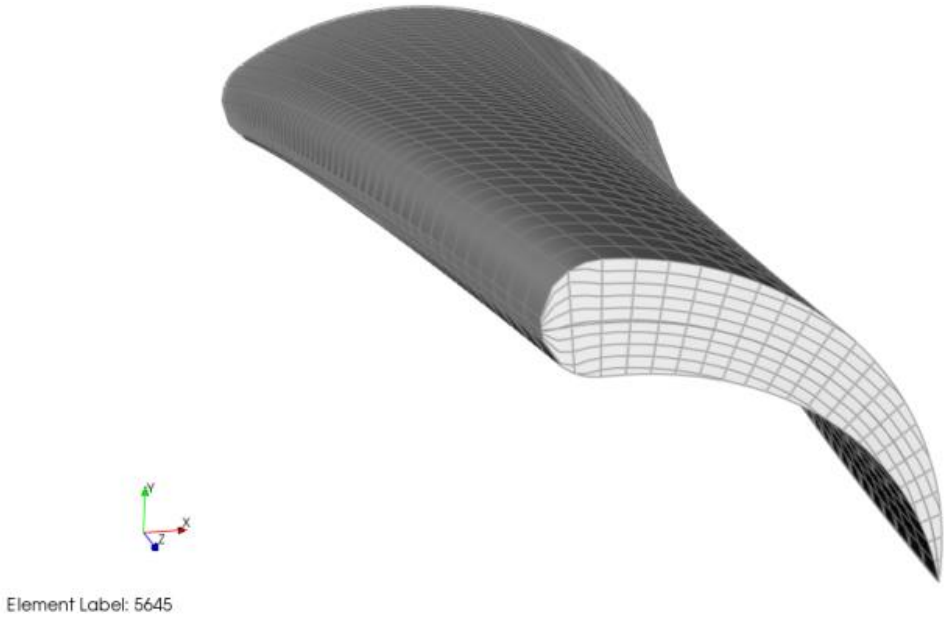

Tsai-Hill Failure Criteria 2D




Tsai-Hill Failure Criteria 3D

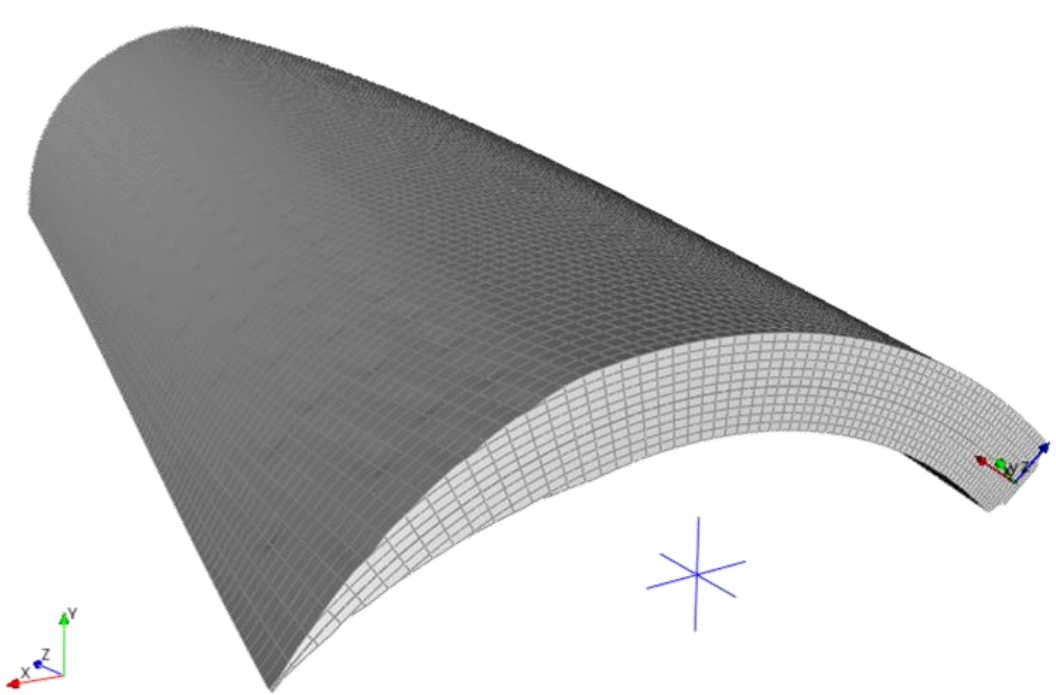
# 7. Solid Modeling

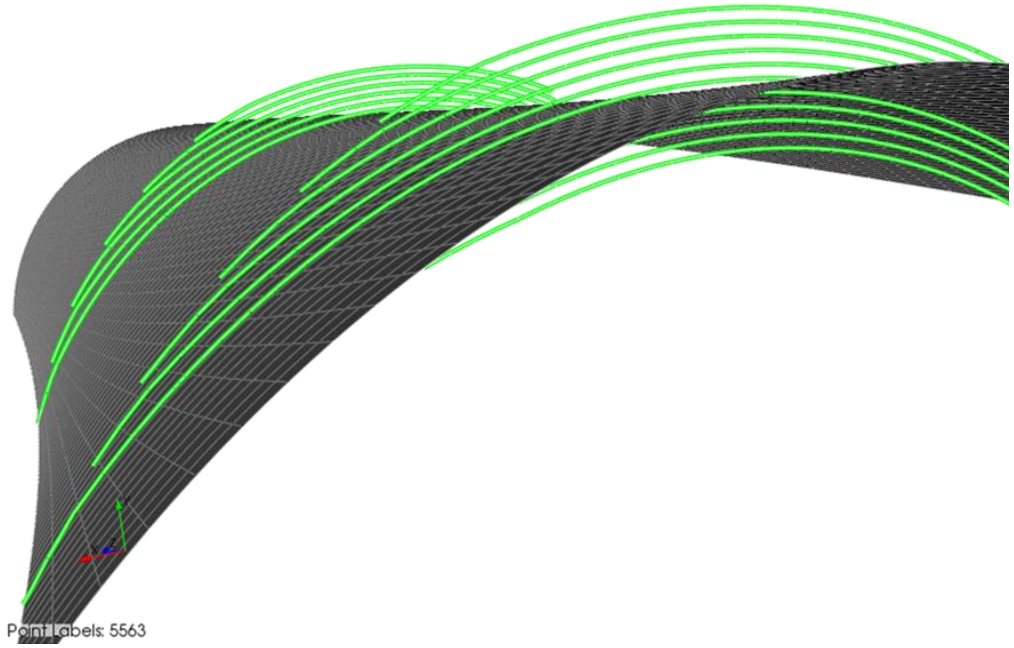
- Different features are available to create solid models. These features allow
  - Smooth surfaces
  - Ply Tapering
  - Extrusion Guidance
  - Cut-offs and Cut-outs

# 7. Solid Modeling

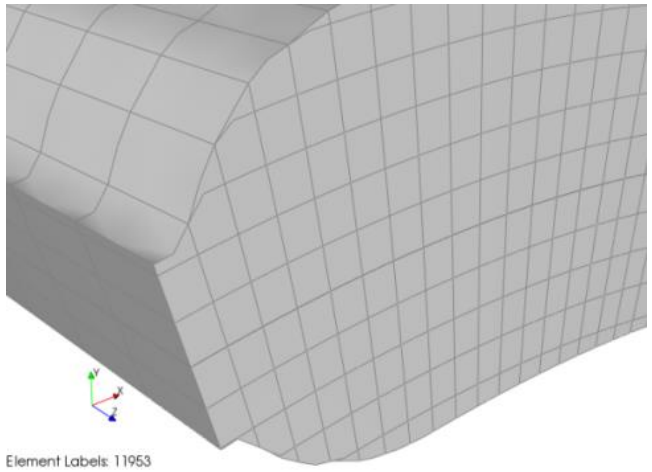
- Ply Tapering is possible using cut-off rules. Ply tapering is possible for shell models as well as solid models.

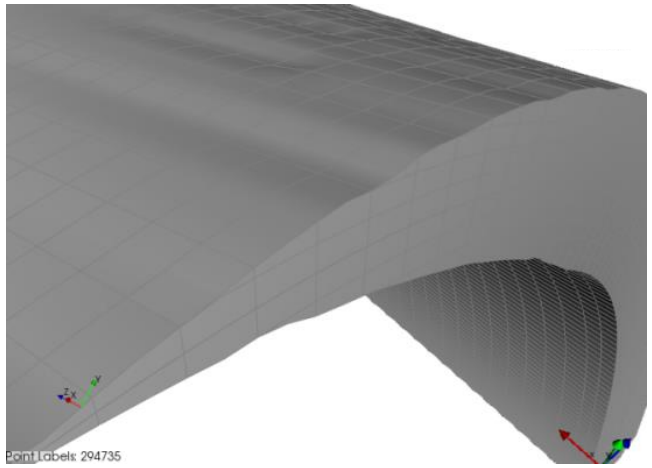


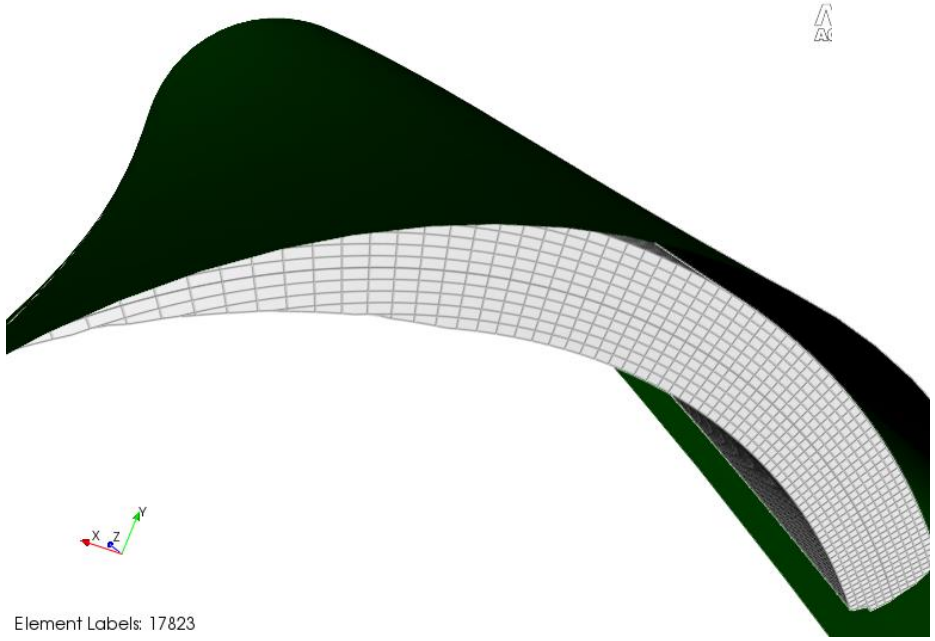



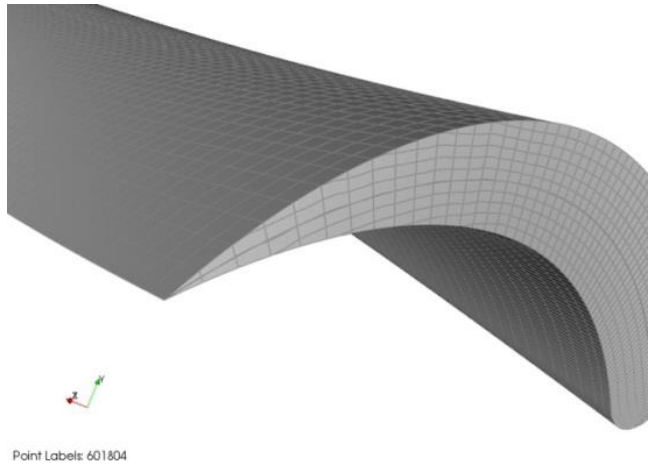
# 7. Solid Modeling

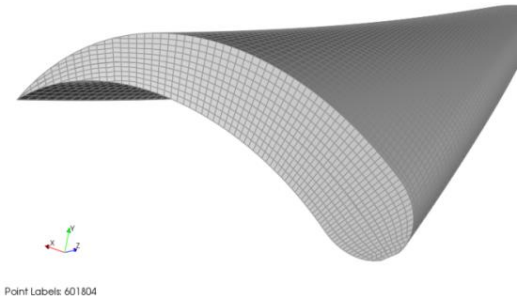
- Using the Snap-to-Geometry feature smooth surfaces (snapped to a CAD surface) are generated when extruding solid models.



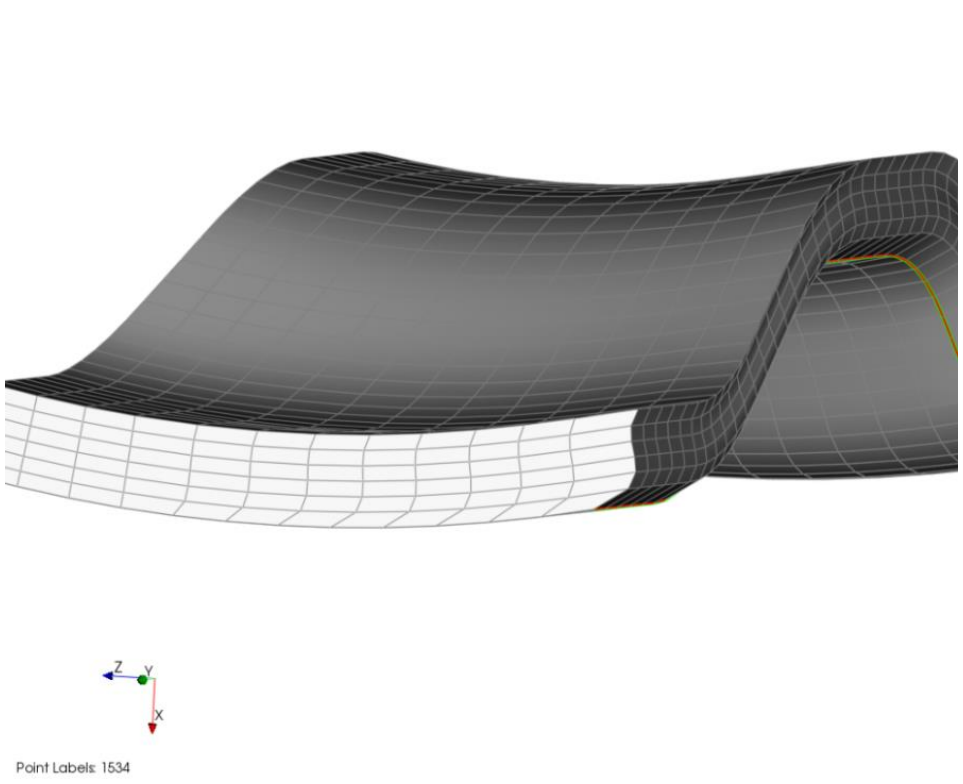



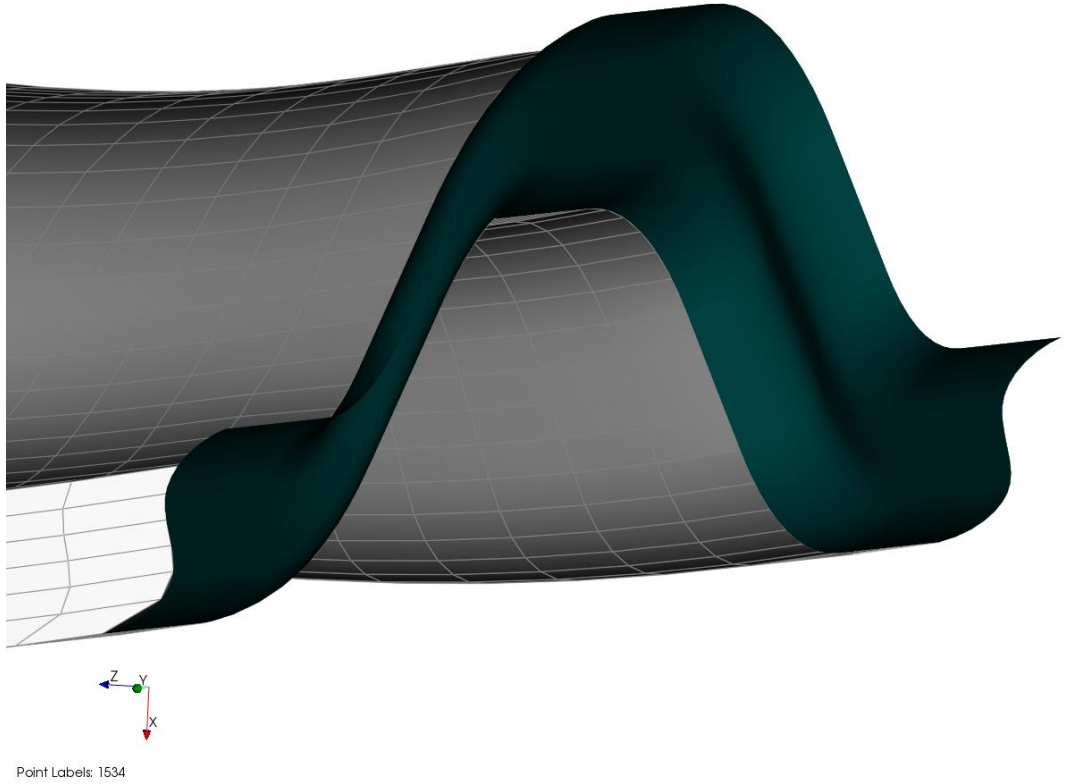



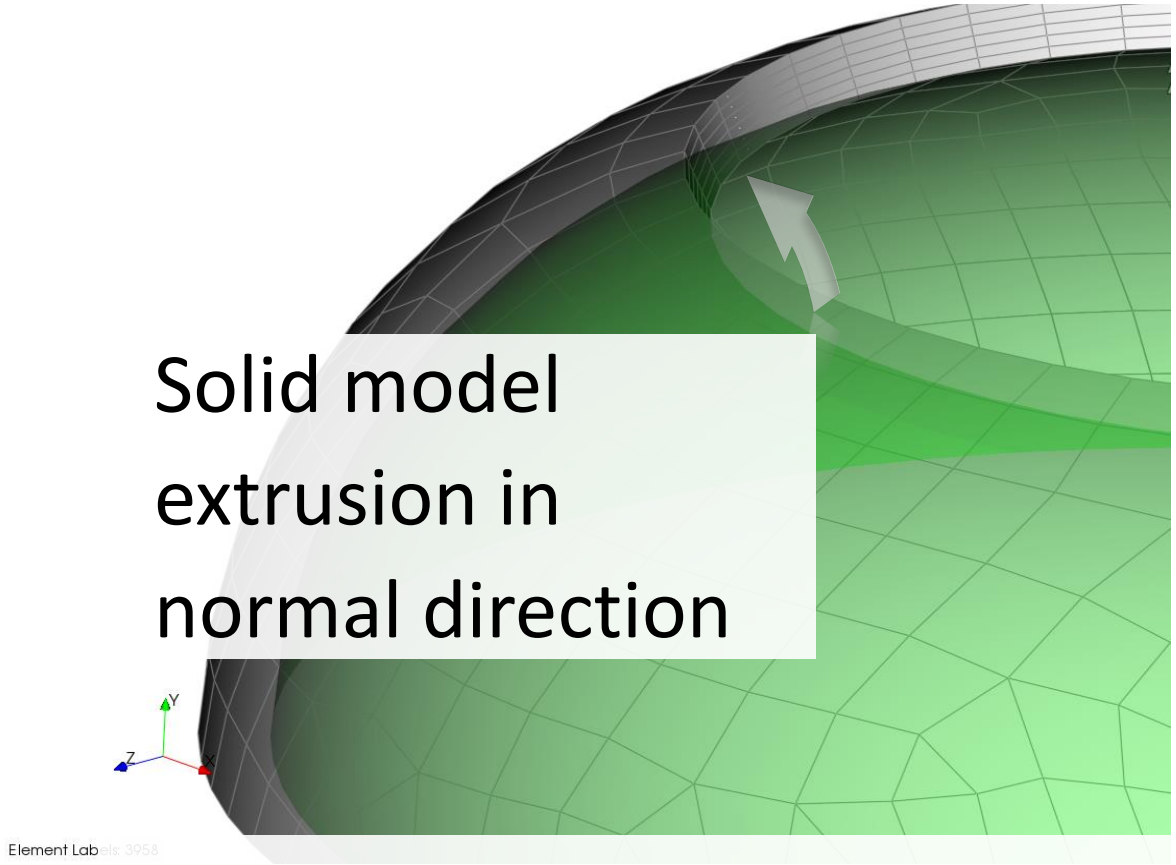
# 7. Solid Modeling

- Extrusion guidelines are used to extrude the solid model along a specified CAD surface.

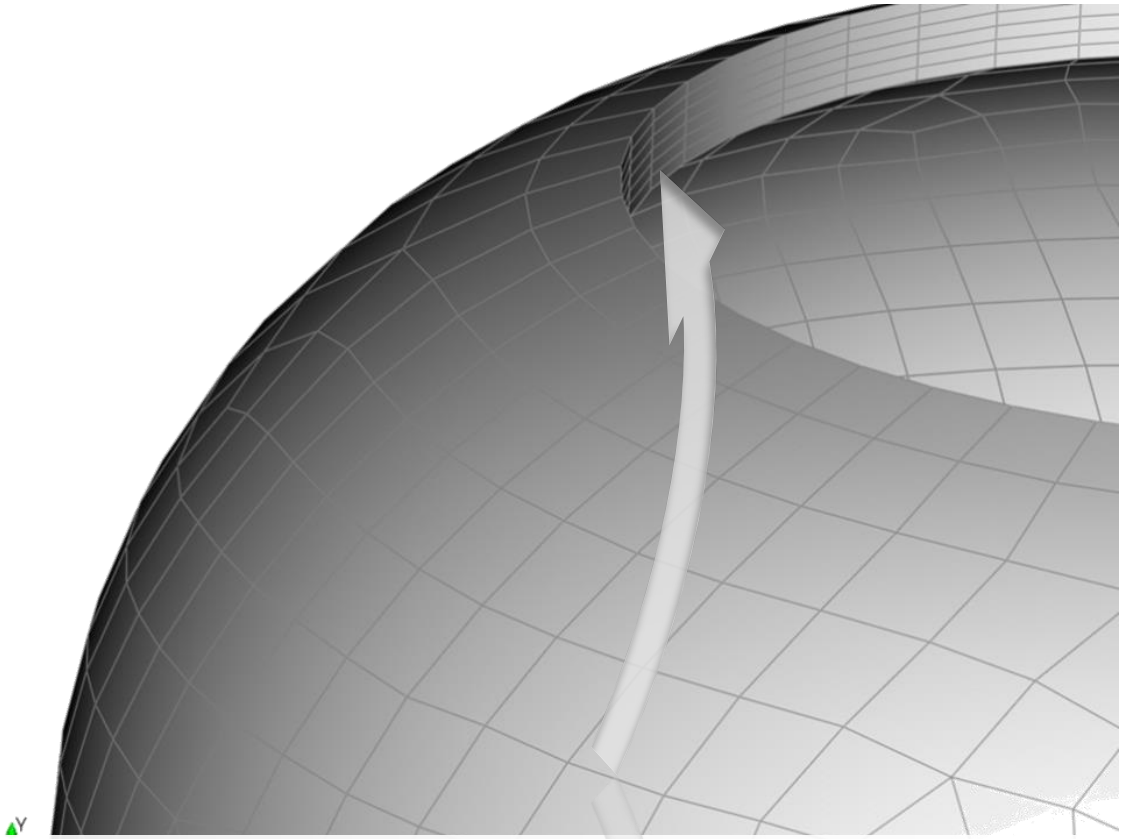


# 7. Solid Modeling

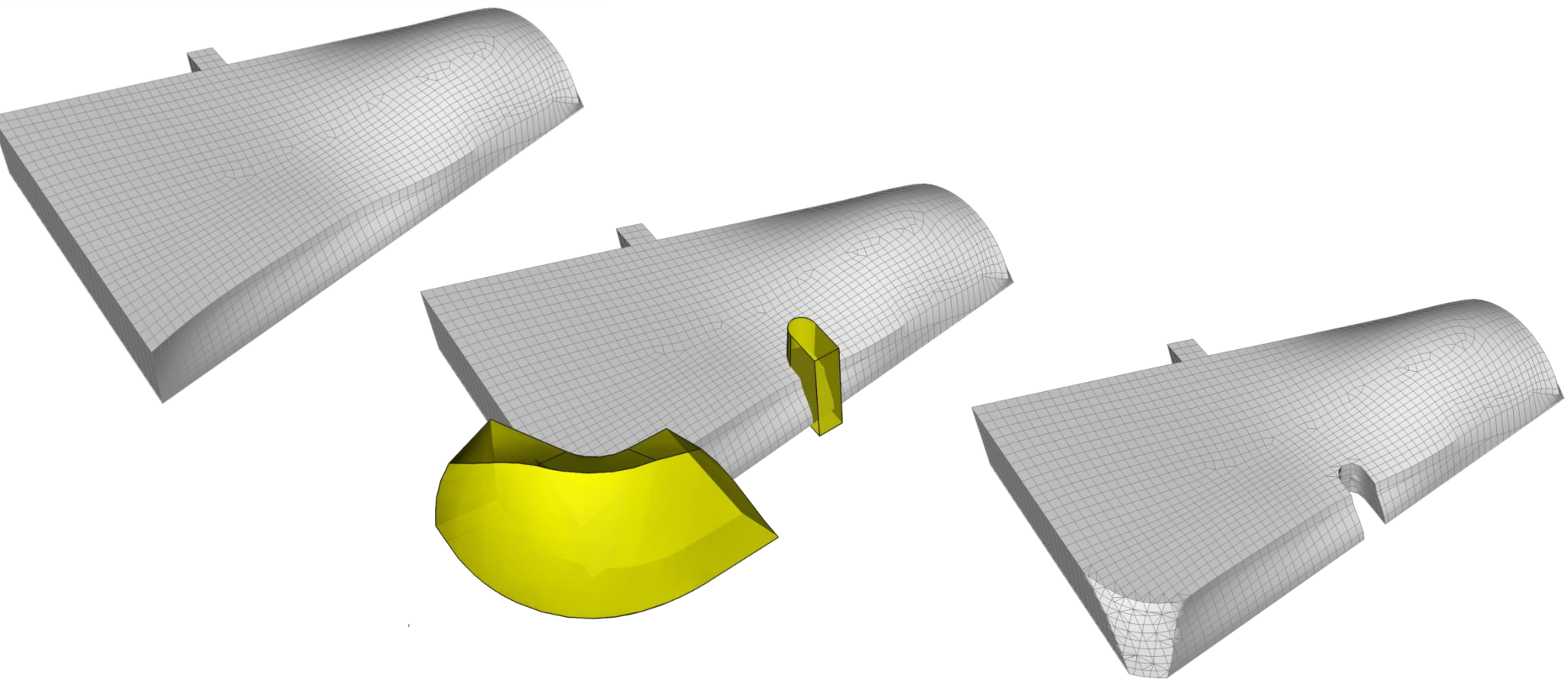



Solid model extrusion in normal direction




Extrusion using a specified direction (Bore hole on a curved surface)

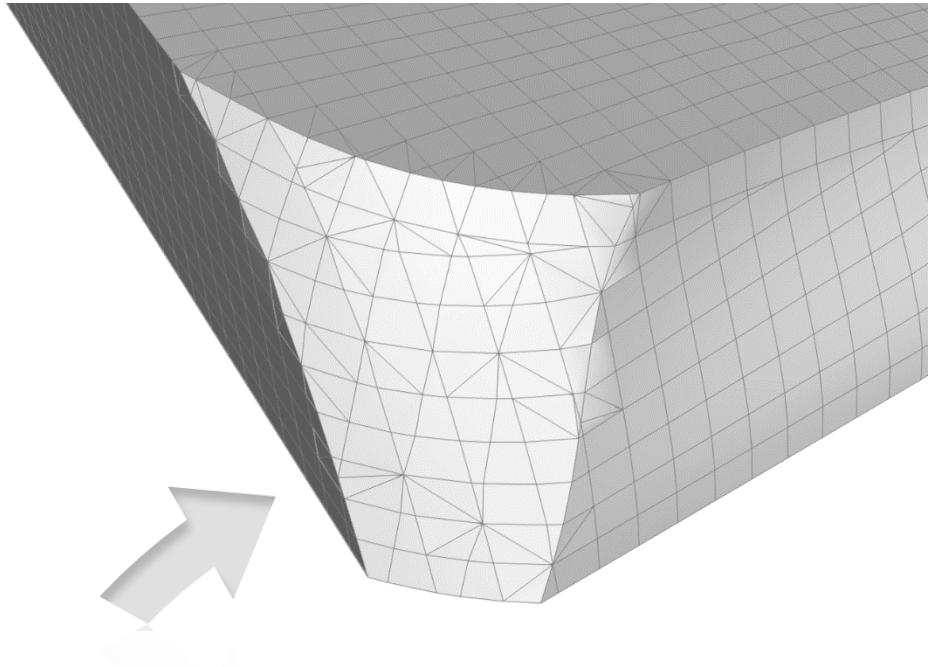
# 7. Solid Modeling



Define arbitrary cut-outs in your structured solid mesh

# 7. Solid Modeling

- Structured layered solid mesh is maintained
- Degenerated hexahedral elements  at the cut out boundaries or within drop-offs are decomposed into homogeneous prism and tetrahedral elements if needed.
- Material handling for drop-offs:
  - Global (default)
  - Custom per fabric/stackup
- Material handling for cut-offs:
  - Computed (default)
  - Global
  - Custom per fabric/stackup

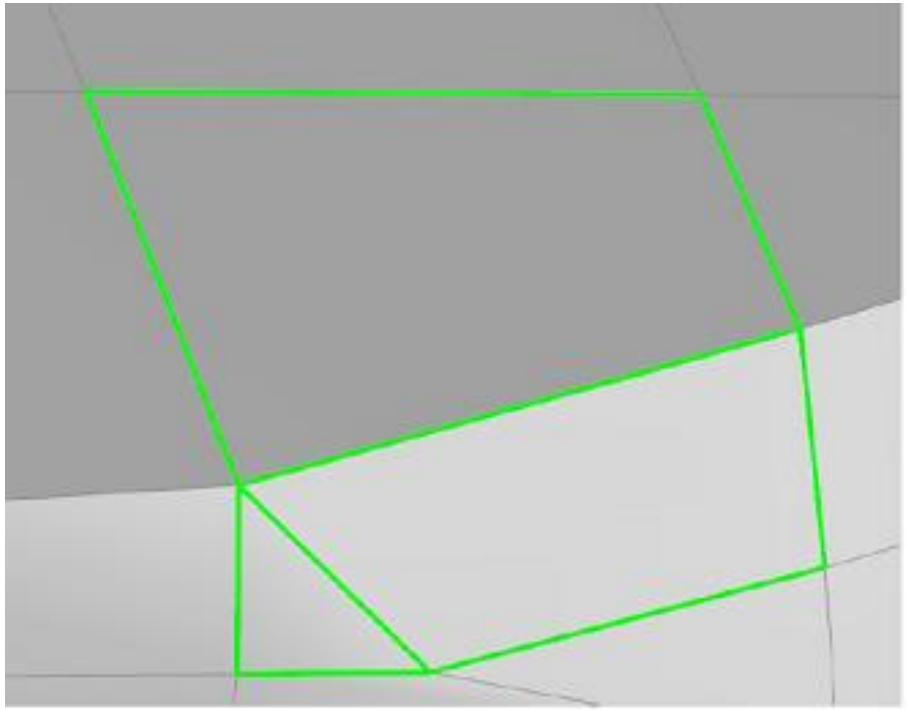


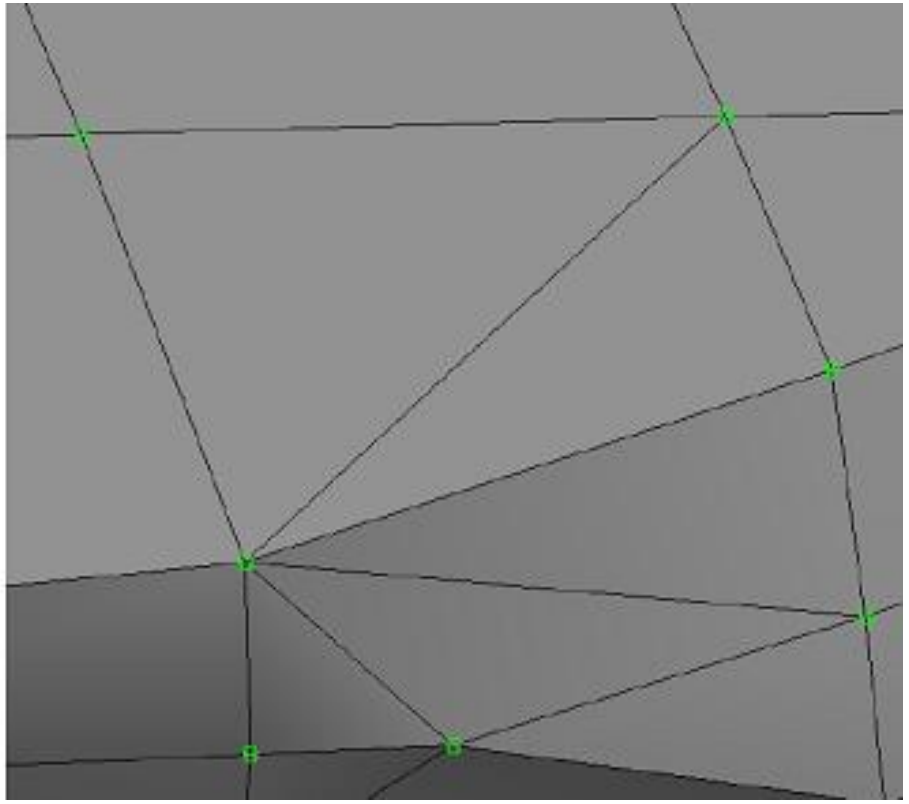
Decomposed Elements

# 7. Solid Modeling

## Decomposition

A Degenerated Hexahedral Element (left) is decomposed into several tetrahedral elements (right)

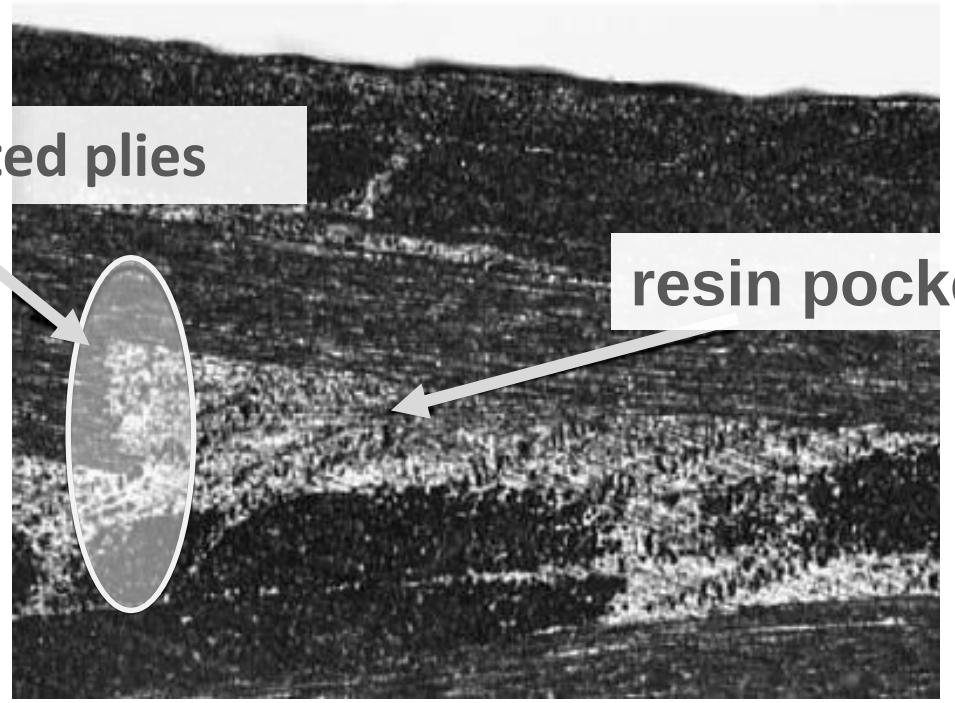


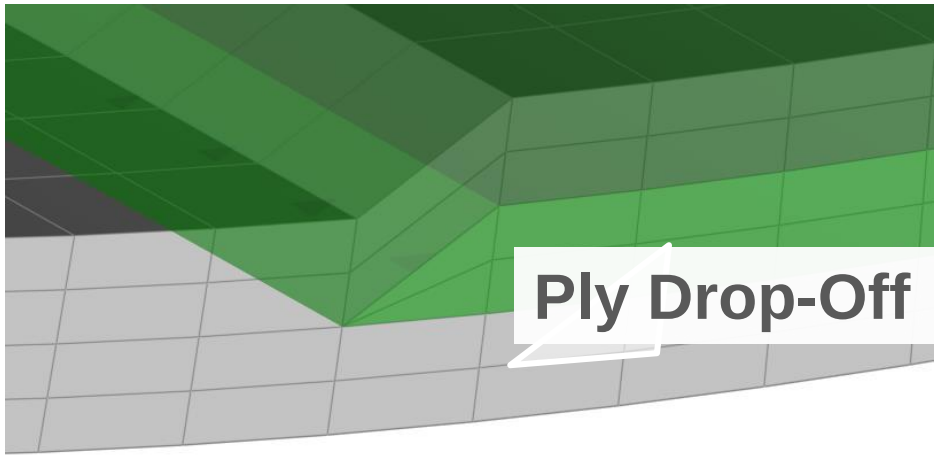


# 7. Solid Modeling

## Ply Drop-Off Handling

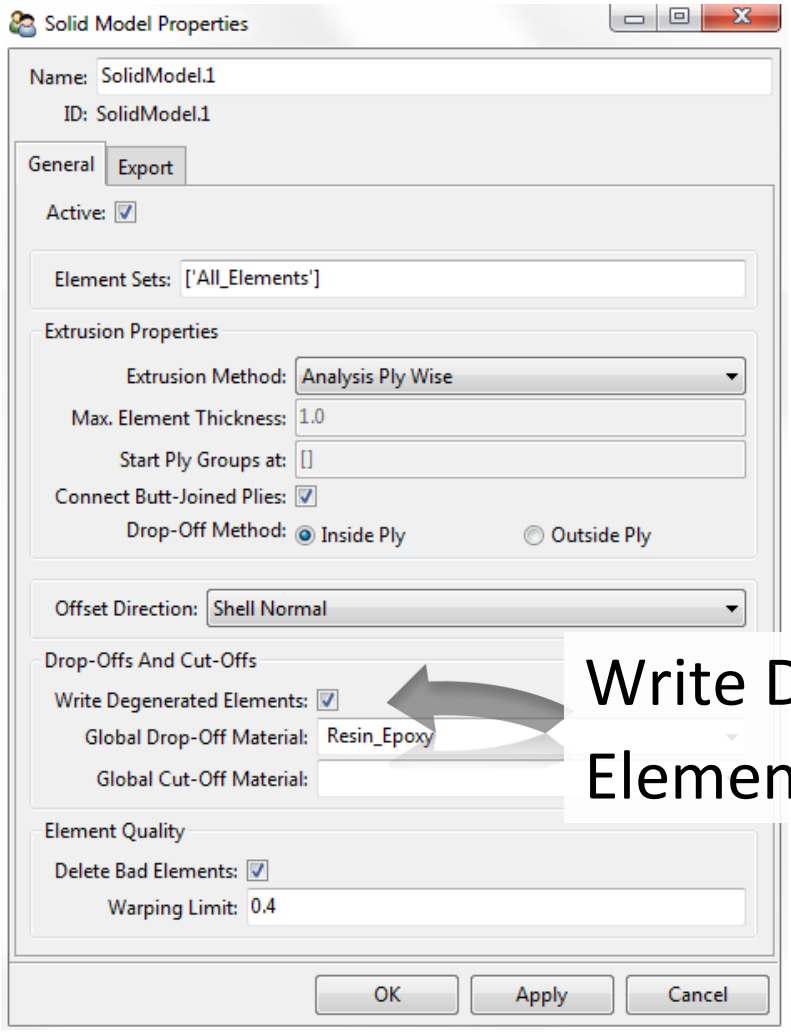
- Ply drop-offs can be a cause for damage and delamination in a composite layup
- In ANSYS Composite PrepPost the user has the option to include drop-off elements as so called degenerated brick elements, or to ignore the ply drop-offs.



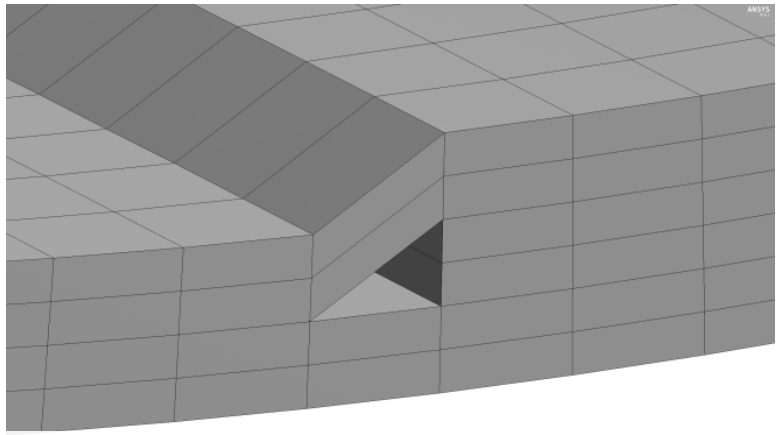



# 7. Solid Modeling

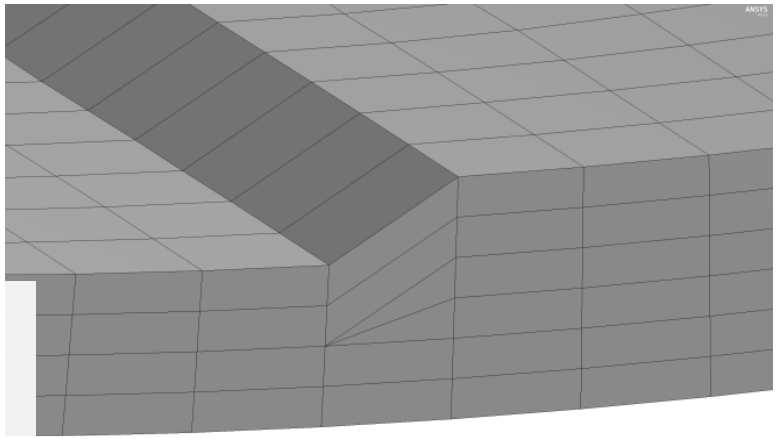
## Ply Drop-Off Handling




Write Degenerate (Drop-Off) Elements Option



Ply drop-offs excluded



Ply drop-offs included

# 7. Solid Modeling

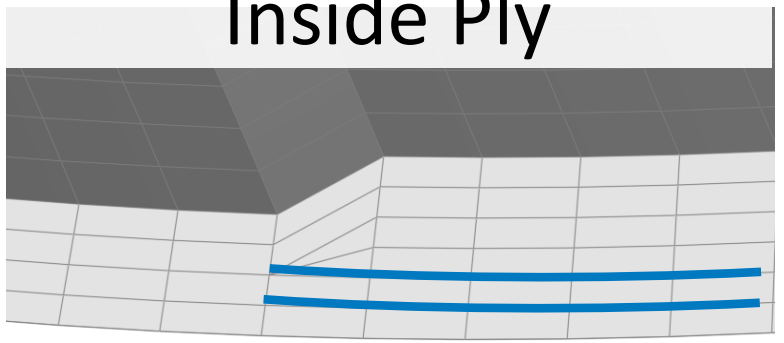
## Ply Drop-Off Handling

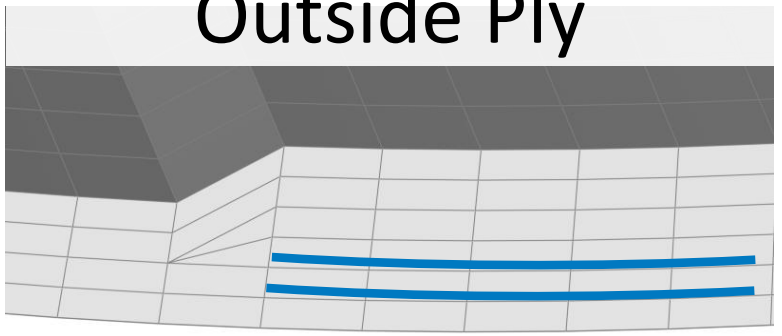
- It is recommended to use a homogenous drop off material (resin material).
- The ply drop of material is selected as global material for all ply drop-offs in the solid modeling properties window.
- Ply drop offs of sandwich cores should use the core material. For every fabric it is possible to specify whether the global ply drop-off material, or the material assigned to the fabric is used as ply drop-off material.

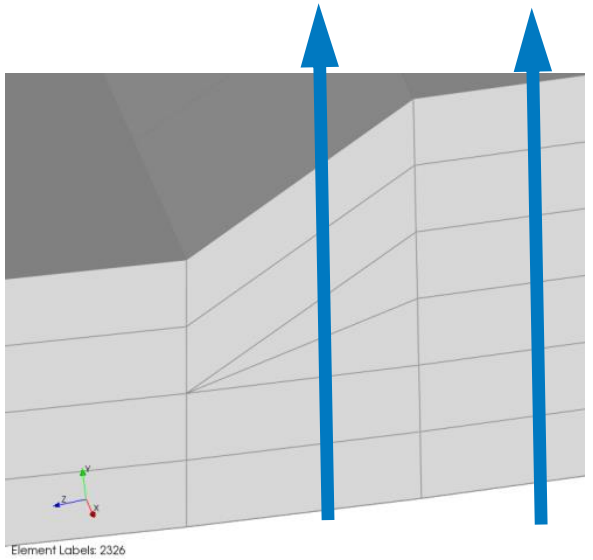
# 7. Solid Modeling

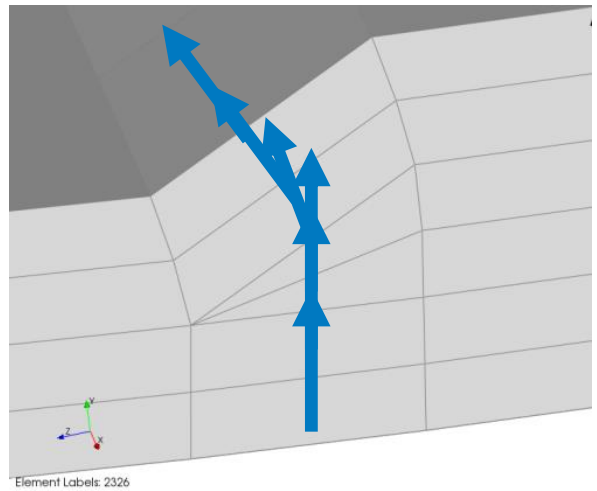
## Ply Drop-Off Handling

- It is possible to place the drop-off zone inside of the terminated ply area or outside.
- The solid model extrusion can be based on the surface model or re-evaluated with every solid layer.



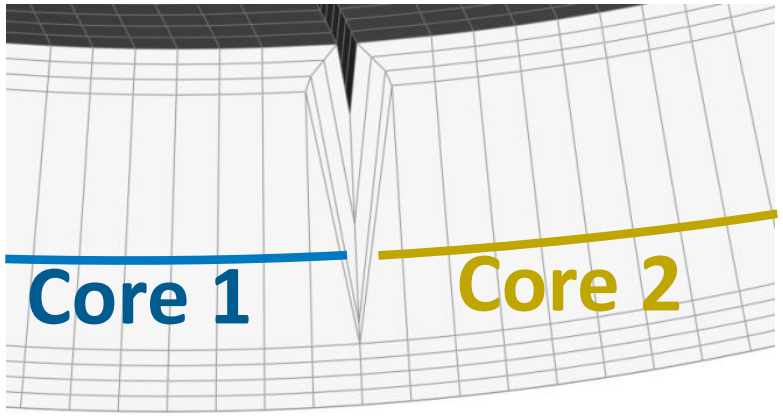



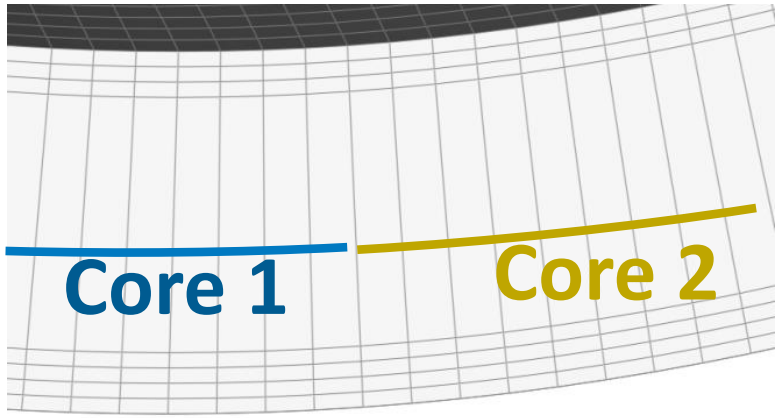
# 7. Solid Modeling

## Ply Drop-Off Handling

- ANSYS Composite PrepPost automatically connects butt-joints of two adjacent plies.
- For this option to work the plies must be arranged sequentially in the same ply group (in Modeling Groups).




Butt-Joined Plies not connected




Butt-Joined Plies connected