Composite Capability in LS-PrePost

January 14, 2016

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Current Status

Versions Released and OS Supported

- **Version Status**

  4.2 is the current released version
  4.3 is development version, available for testing with new features

- **Supported OS**

  Linux 64bit - Centos5, 6, 7, Opensuse 10,11,12,13, Suse Enterprise 10,11,12

  64bit Windows 7, 8, 10

  Apple Mac OS 10.6, 10.9

- **Where to download:**

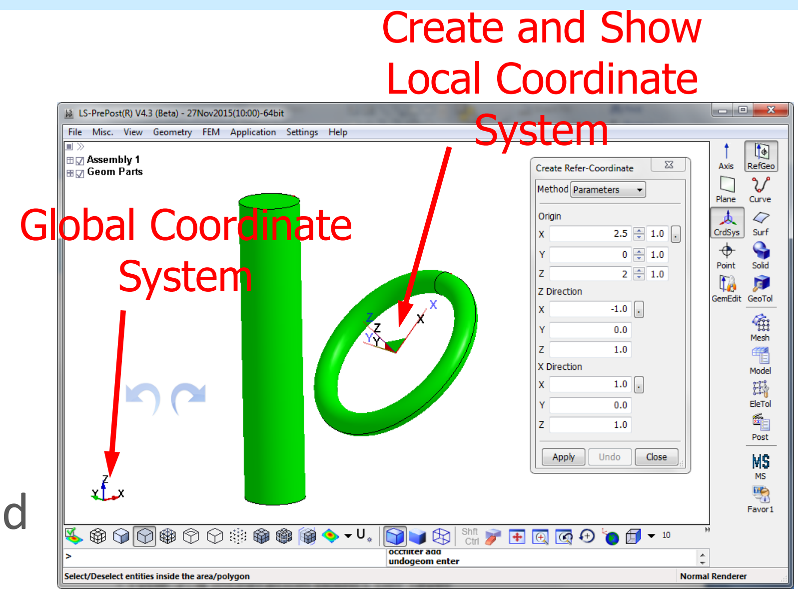
  http://ftp.lstc.com/anonymous/outgoing/lsprepost/4.2

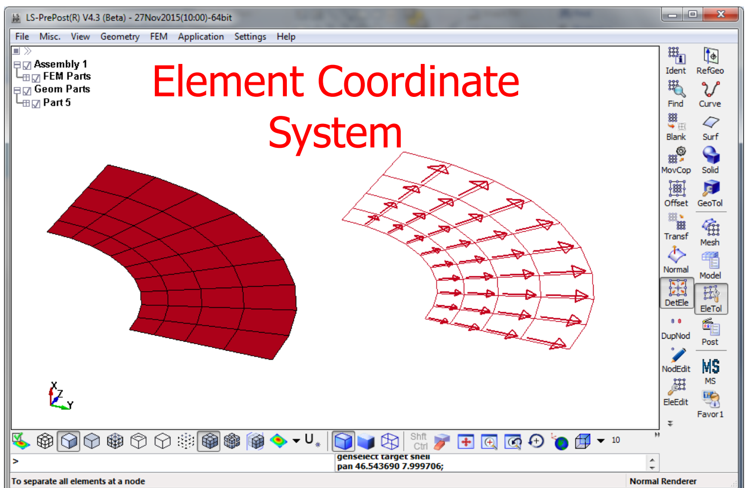
  http://ftp.lstc.com/anonymous/outgoing/lsprepost/4.3

Introduction

Coordinate Systems for Isotropic materials

- Global Coordinate System
  - Cartesian coordinate system [x,y,z]
  - The default coordinate system
- Local Coordinate System
  - Cartesian coordinate system [x’,y’,z’]
  - Define load and boundary conditions, and many other keywords.
- Element Coordinate System
  - Curvilinear coordinate system [ξ,η,ζ]
  - Define element variables for co-rotational elements (Shells & Thick Shells)
  - May be reduced to Cartesian coordinate system in some elements.

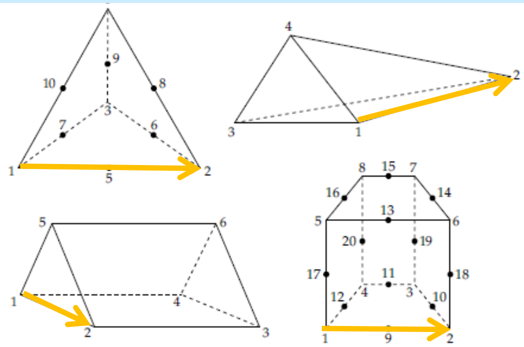




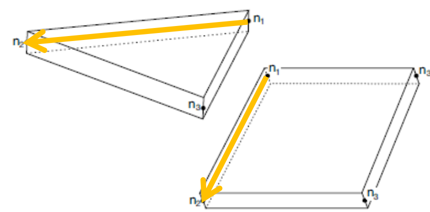
Preprocessing: Element Coordinate System

to define Material Coordinate System

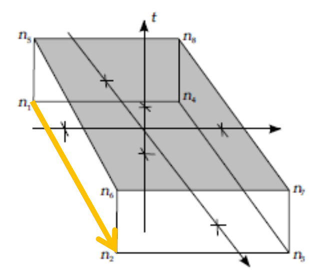
- Element Coordinate System is determined by **NODE 1 and NODE 2** only.
  - Node 1 => 2: direction V1
  - Node 1 => 4: direction V2
  - Element Normal V3 = ***V1*** x ***V2*** for Shells
  - The middle plane is used for Solids and Thick Shells)
  - Directions V1, V2, V3 may NOT be orthogonal, and are used for define the material coordinate system.
- LS-Prepost provides complete set of tools for manipulating node numbering for Shells, Thick Shells, and Solids .



Solid Element



Shell Element

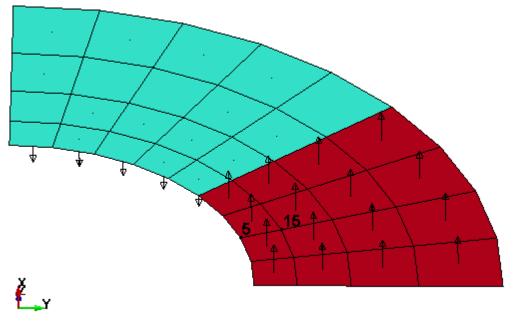


Thick Shell Element

Preprocessing: Align Shell Normal

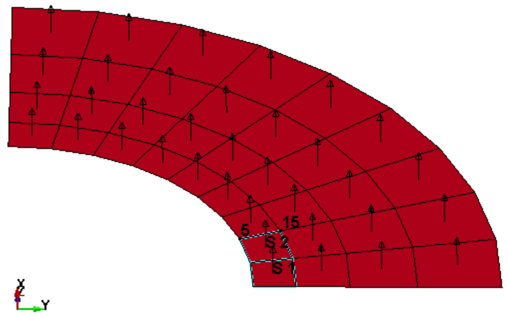
for Shells and Tshell

- Step 1: Show Element Normal
  - EleTol -> Normal -> Element Type=Shell
  - Choose “Show Normal” and select all elements
  - A vector will be drawn for each element in its normal direction.



Show Element Normal

- Step 2: Align Element Normal
  - Method 1:
    Choose “Reverse Normal” and
    Select the elements and click “Reverse” Buttion
  - Method 2:
    Choose “Align” and
    Pick up a seed element and click “AutoRev” Button



Align Element Normal

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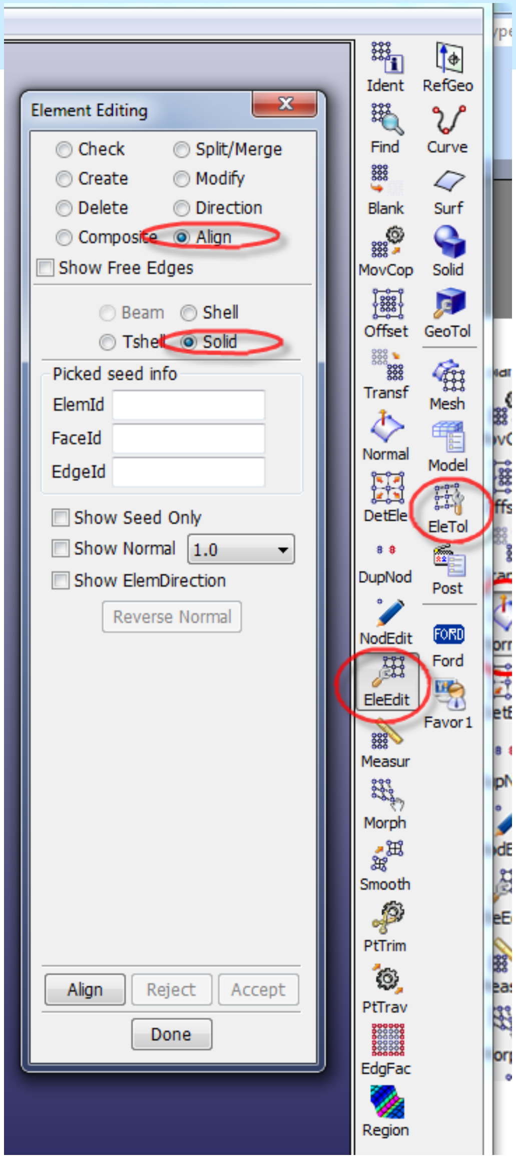
Preprocessing: Align Connectivity

for Shells/Solid/ThickShell

To re-align the connectivity of a group of solid/tshell elements such that the orientation of the elements will be consistent

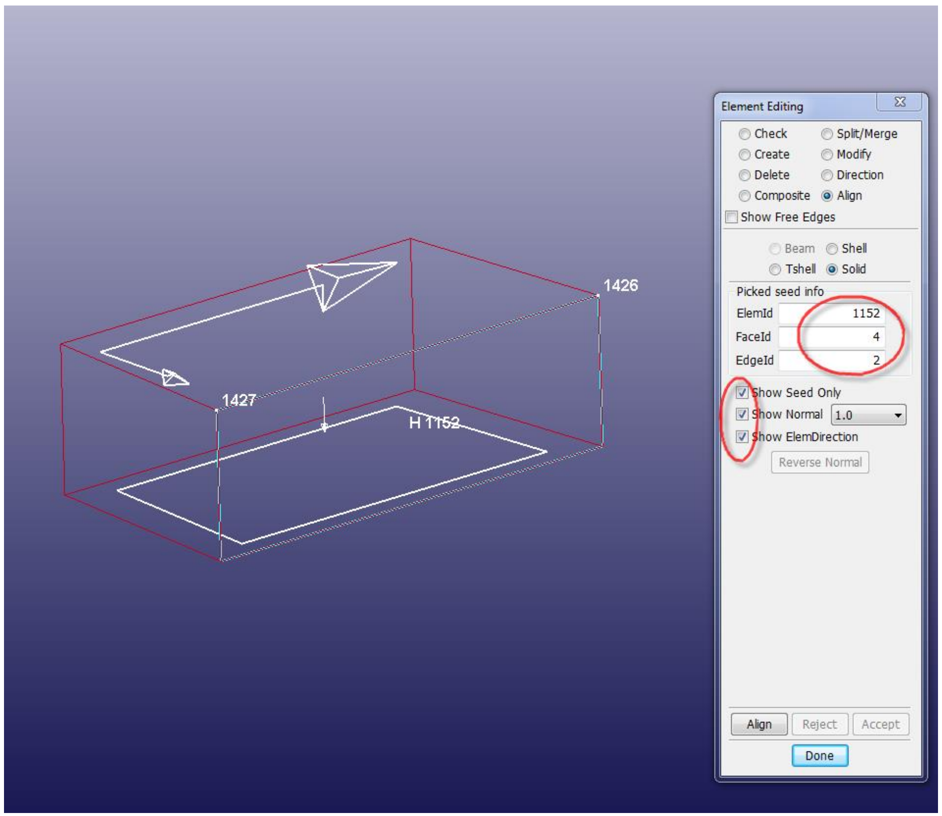
- Pick the face and edge of a seed element, the picked face will be used as face one, and the picked edge will be used as n1->n2 (first edge)
- Show Seed only will show the picked element and allow user to select different face/edge
- Show normal, show direction will show element orientation

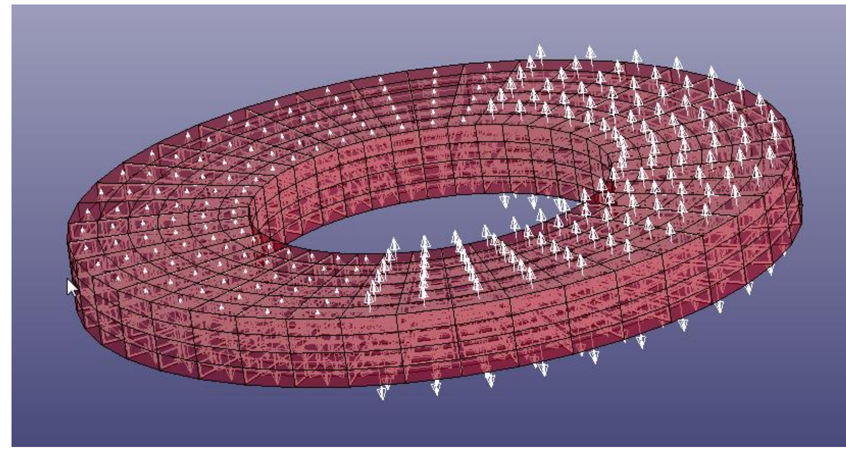


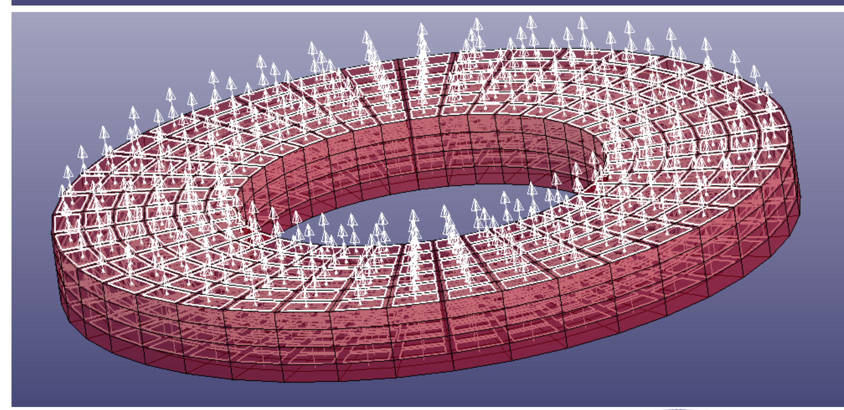
Preprocessing: Align Connectivity

for Shells/Solid/ThickShell

Solid/Tshell connectivity re-alignment – to re-align the connectivity of a group of solid/tshell elements such that the orientation of the elements will be consistent





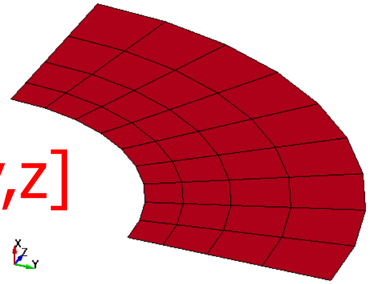


Material Coordinate Systems

Material Coordinate Systems for orthotropic/anisotropic materials

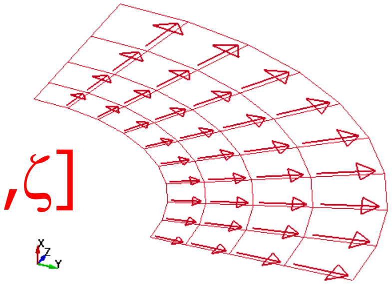
- Material Coordinate System
    - Cartesian coordinate system in most elements [a,b,c]
    - Material's properties are directionally dependent, as opposed to isotropy.
    - A composite material is a material made from two or more constituent materials.
    - Most composites are orthotropic/anisotropic
    - The strong direction is referred as a-direction in LS-DYNA.
    - Constitutive relations are defined in the material coordinate system.
- Material Coordinate System needs to be specified for EVERY element!

[x,y,z]



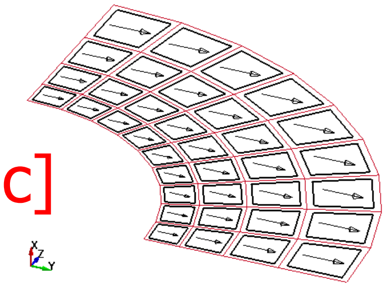
Global Coordinate System

[ξ,η,ζ]



Element Coordinate System

[a,b,c]

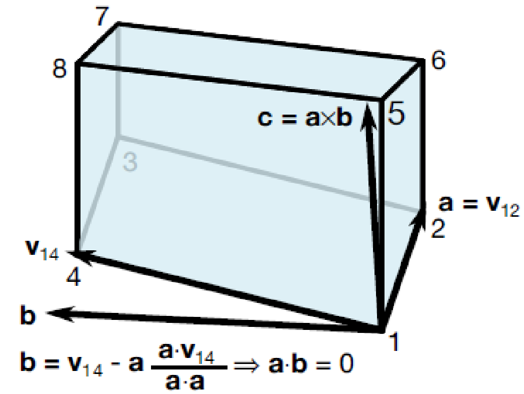


Material Coordinate System

Preprocessing: Material Coordinate System

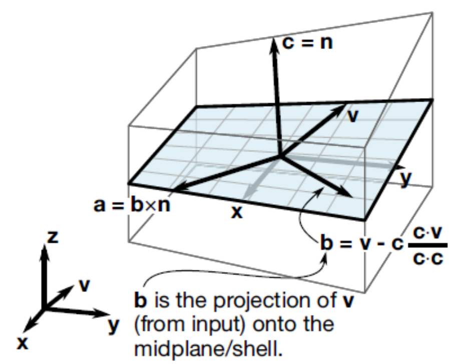
Defined with the use of Element Coordinate System

- Option 1: AOPT=0
  - a-direction: Node 1 => 2 (as V1)
  - b-direction: Orthogonalized Node 1 => 4
  - c-direction: ***a*** x ***b***
  - for structural mesh only



AOPT=0 for
Shells, Thick Shells, and Solids

- Option 2: AOPT=3
  - c-direction: Element Normal
  - b-direction: *a given vector **V*** projected to the midplane
  - a-direction: ***b*** x ***c***
  - quite useful if most elements share b-direction (such as a cylinder)



AOPT=3 for
Shells, Thick Shells, and Solids

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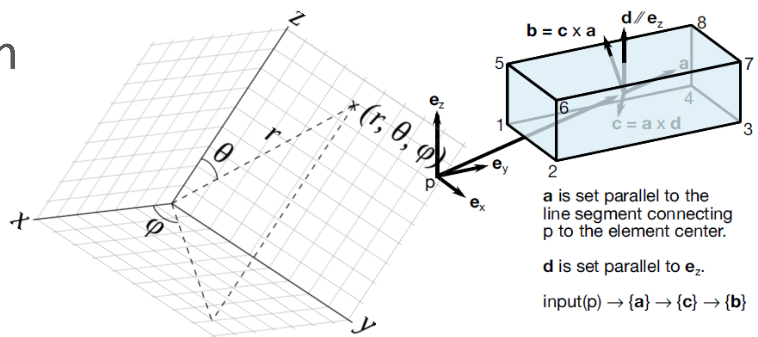
Preprocessing: Material Coordinate System

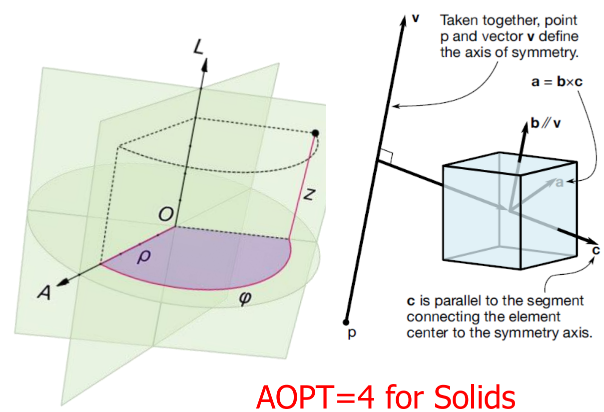
Defined in local spherical and Cylindrical coordinate systems (for solids ONLY)

- Spherical Coordinate System: AOPT=1
  - Define a local spherical coordinate system with an origin **P** and a vector **Z**
  - a-direction: radial direction
  - b-direction: polar angle direction
  - c-direction: azimuthal angle direction



AOPT=1 for Solids

- Cylindrical Coordinate System: AOPT=4
  - Define a local cylindrical coordinate system with an origin **P** and a longitudinal axis **Z**
  - c-direction: radial direction
  - b-direction: axial direction
  - a-direction: angular direction



AOPT=4 for Solids

- Material directions a,b,c can be switched in *MAT cards.

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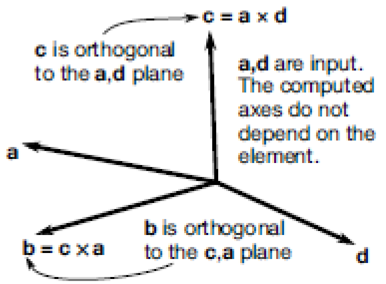
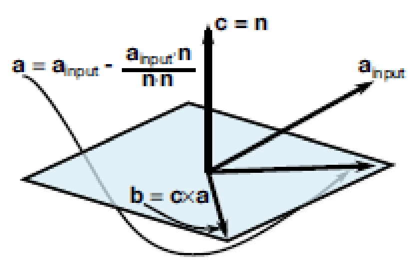
Preprocessing: Material Coordinate System

Define one local Cartesian coordinate system for ALL elements

- A local Cartesian Coordinate System for Solids: AOPT=2
  - a-direction is specified in the input deck as a constant vector for all solids.
  - c-direction: a second input vector ***d*** for all solids, which is normal to ***a***
  - b-direction: ***c*** x ***a***
- A local Cartesian Coordinate System for Shells and Thick Shells: AOPT=2
  - c-direction: element normal
  - a-direction is specified in the input deck and orthogonalized to ***c***
  - b-direction: ***c*** x ***a***
  - This option is quite similar to AOPT=3 for shells and thick shells but sharing a-direction



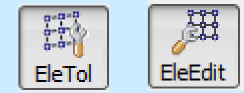
AOPT=2 for Solids



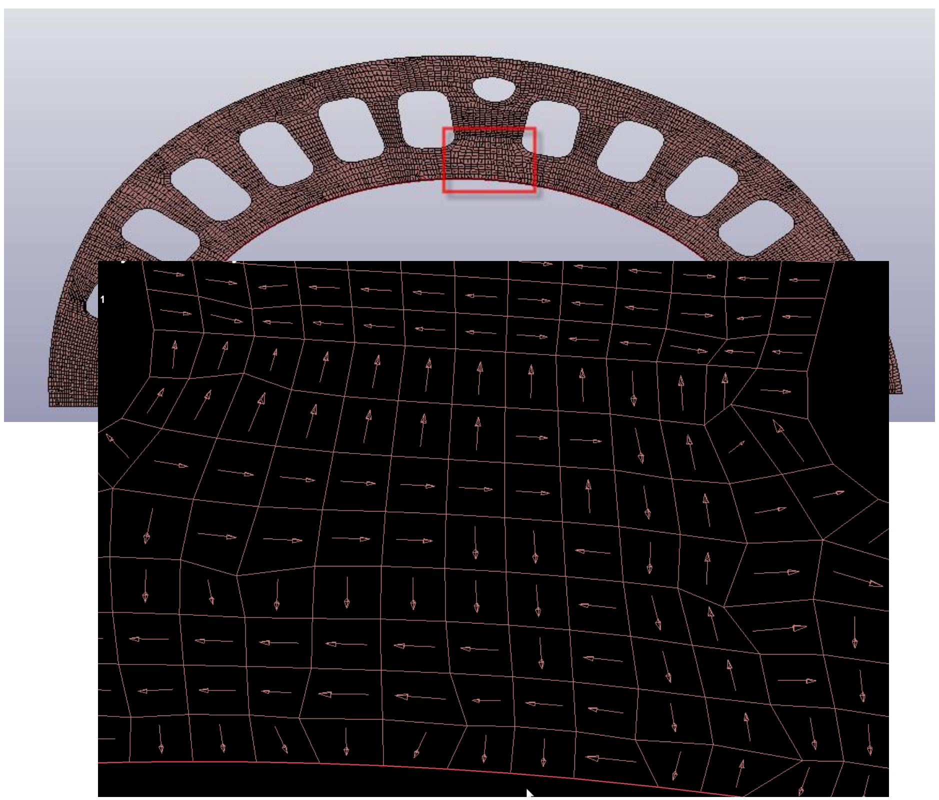
AOPT=2 for Shells and Thick Shells

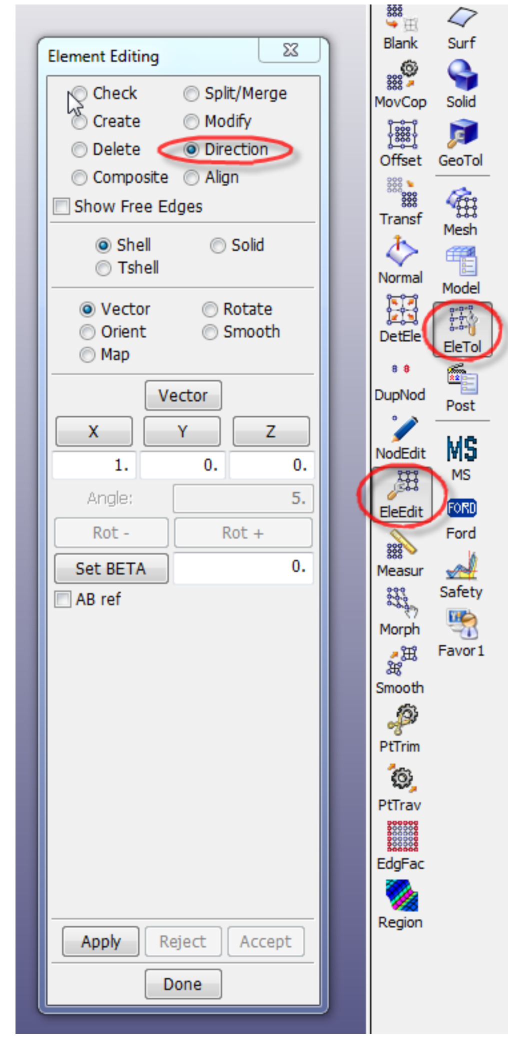
Preprocessing: Material Coordinate System

Define a local Cartesian coordinate system for EACH element



- Keywords to support Material Coordinate System for each element:
  *ELEMENT_SHELL_BETA
  *ELEMENT_TSHELL_BETA
  *ELEMENT_SOLID_ORTHO





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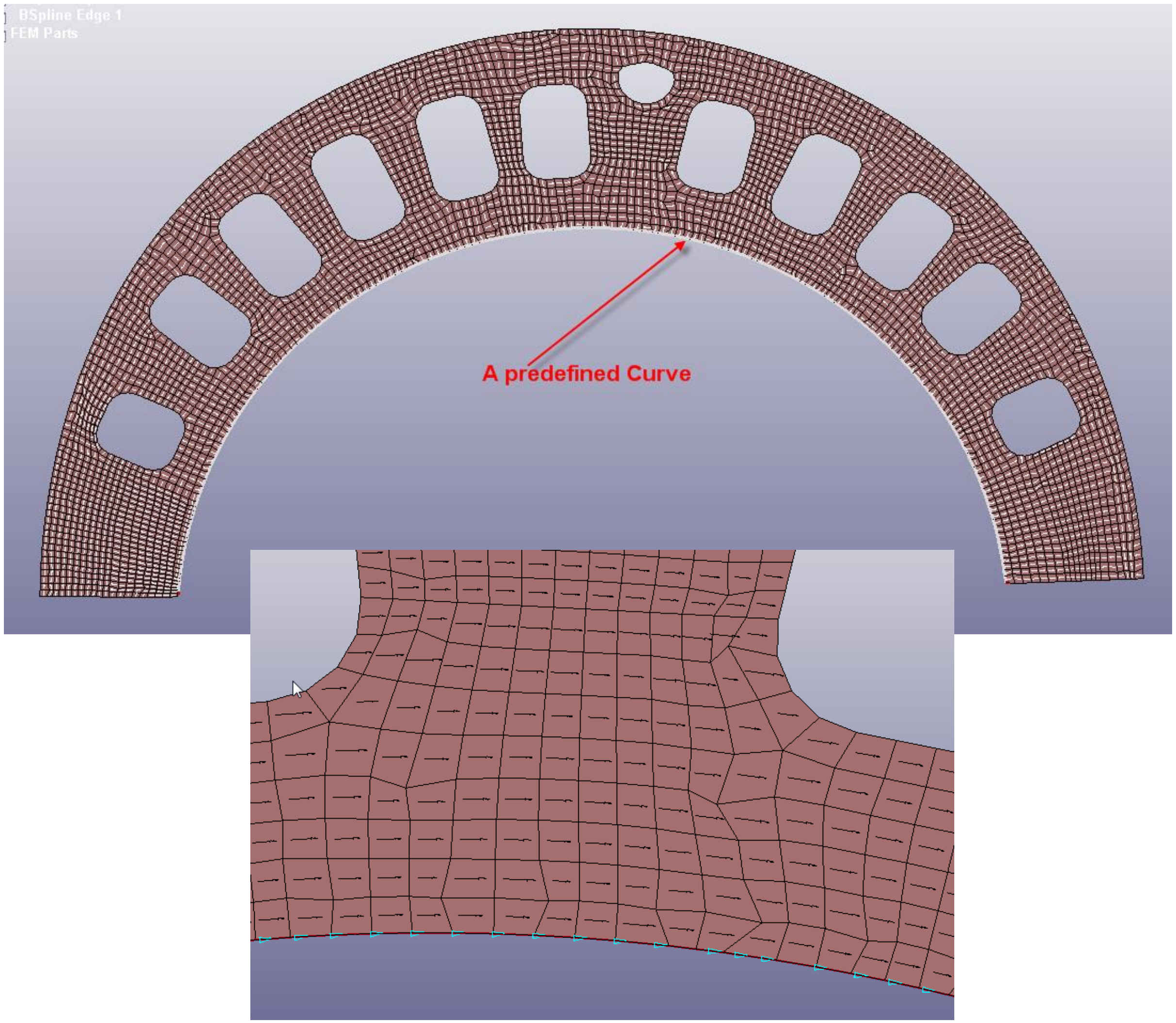
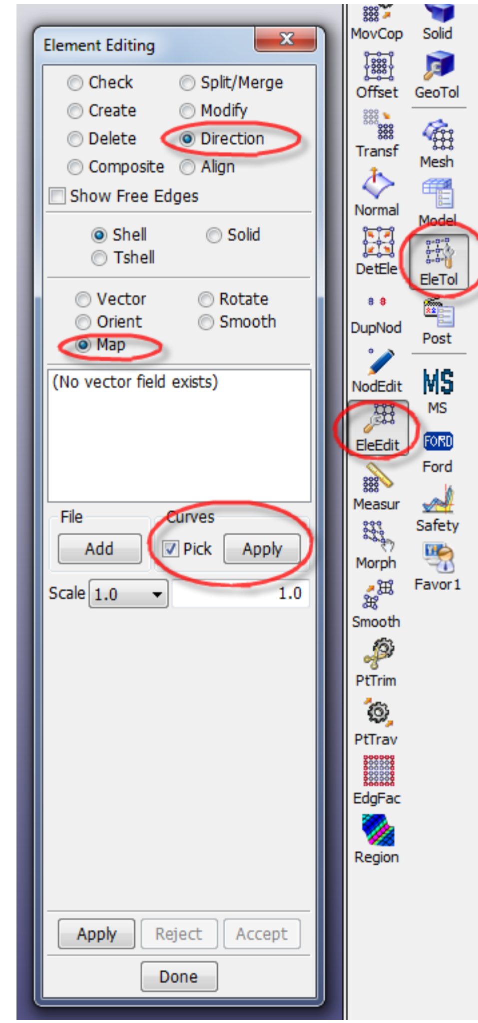
Preprocessing: Material Coordinate System

Change the Beta Angle for each element by Mapping to a curve





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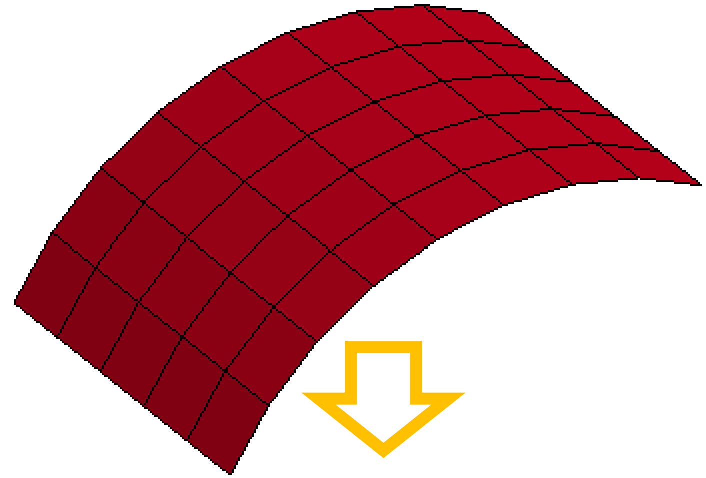
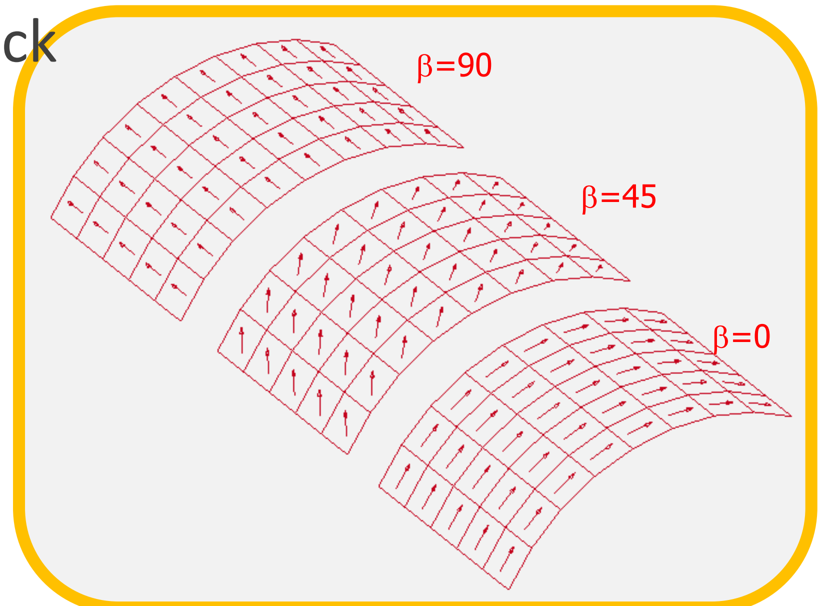
Preprocessing: Laminate Composites

Define BETA angles with the use of Material Coordinate System

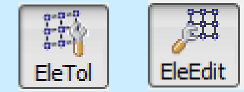
- Step 1: define the primary Material Coordinate System (as done in the previous section)
- Step 2: Specify layer properties through keywords:
  *PART_COMPOSITE for Shells
  *PART_COMPOSITE_TSHELL for Thick Shells
  - Material model (through *MAT cards)
  - Thickness
  - Beta Angle (ply orientation)
- Restrictions:
  - All layers are defined for the whole PART.
  - All elements in one layer have a same BETA Angle



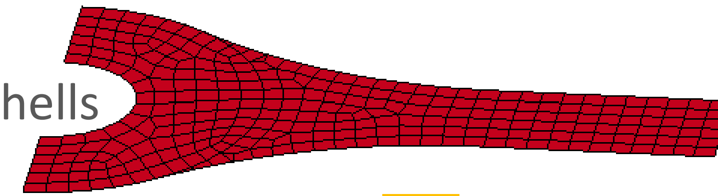


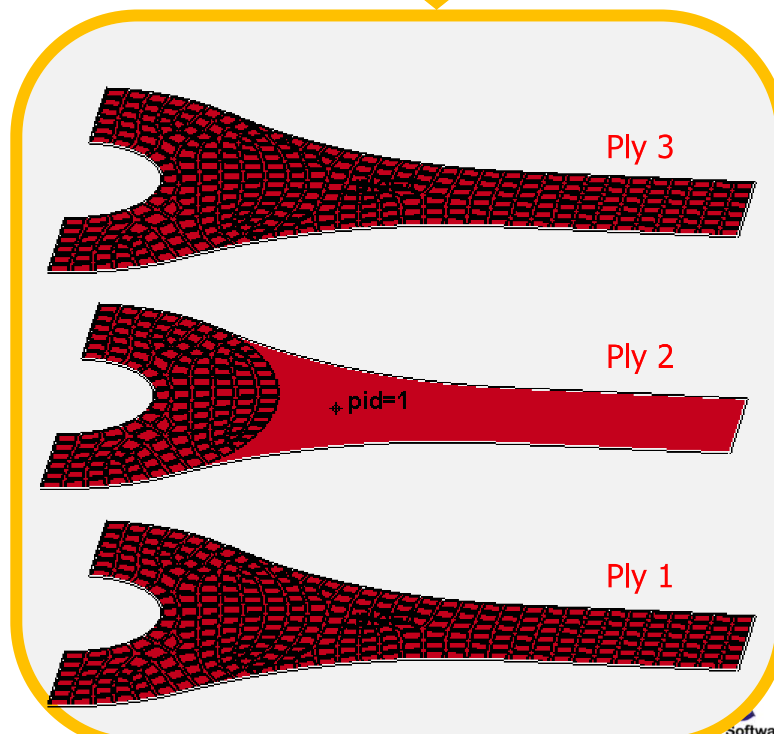
Preprocessing: Laminate Composites

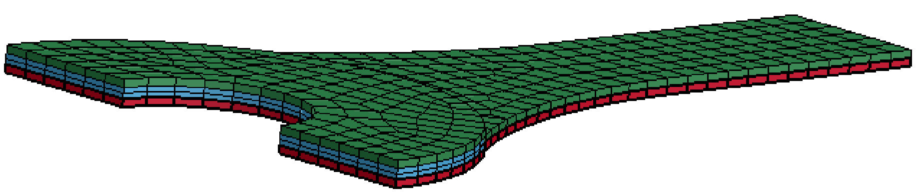
Create Layers



- Keywords:
  - *ELEMENT_SHELL_COMPOSITE for shells
  - *ELEMENT_TSHELL_COMPOSITE for thick shells
- Create Layers
  - EleTol -> EleEdit-> Composite
  - Pick up one part as the target
  - Select the corresponding elements to define a "ply", as the shape of the layer
- Specify Layer properties
  - Material model
  - Thickness
  - Offset





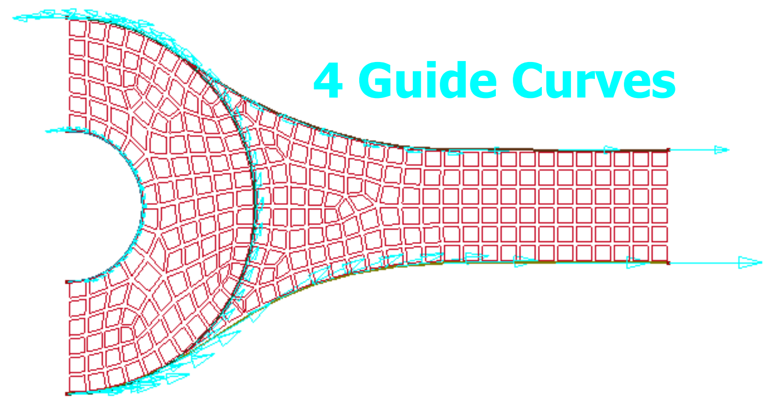


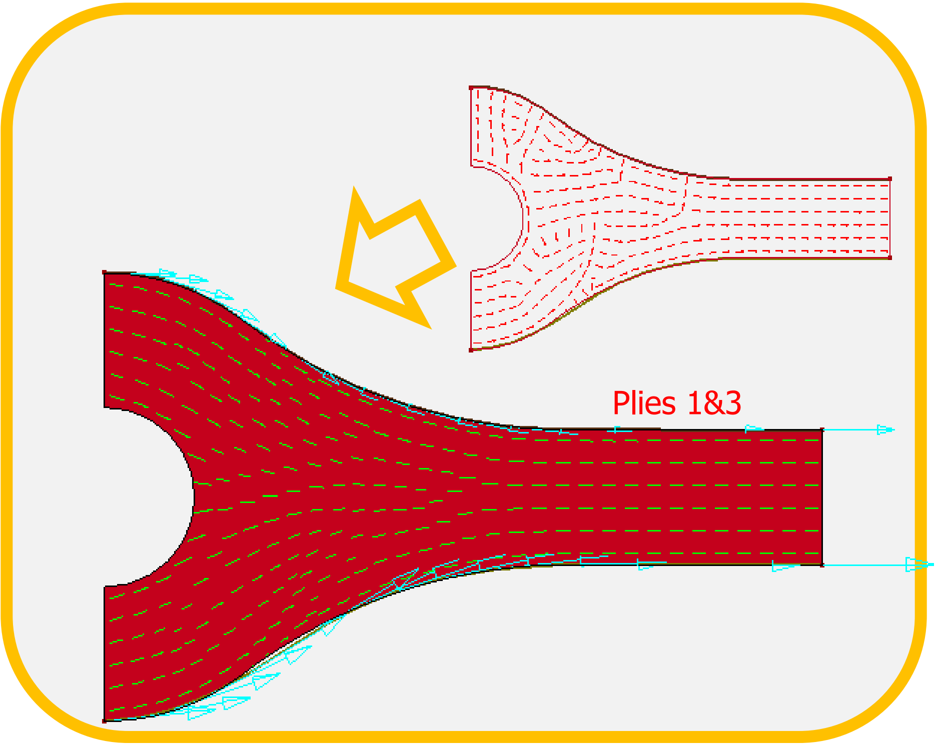
Preprocessing: Laminate Composites

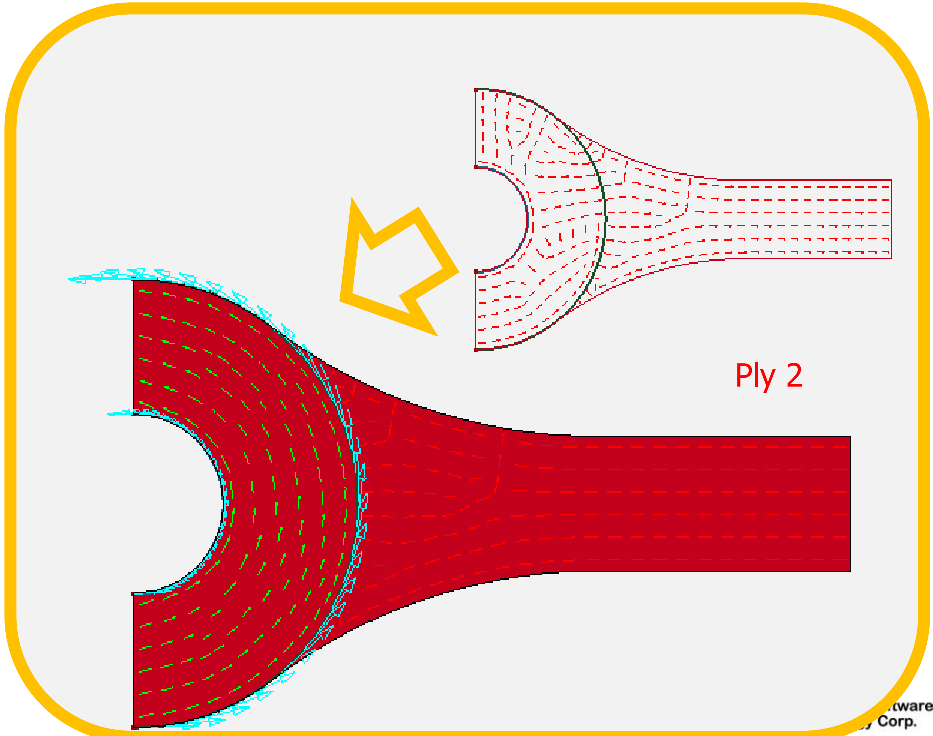
Define Material Coordinate System for EACH Layer

EleTol EleEdit

- Material Coordinate System through Mapping function.
  - EleTol -> EleEdit-> Composite -> Directions
  - Create curves as the guide of a-direction
  - Map the guide curves to the elements



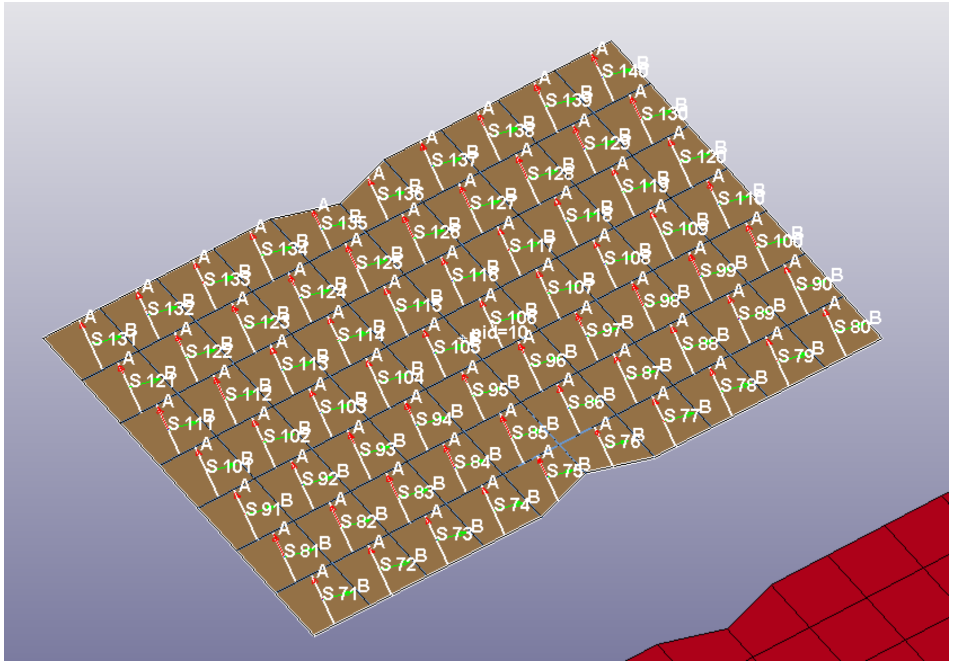


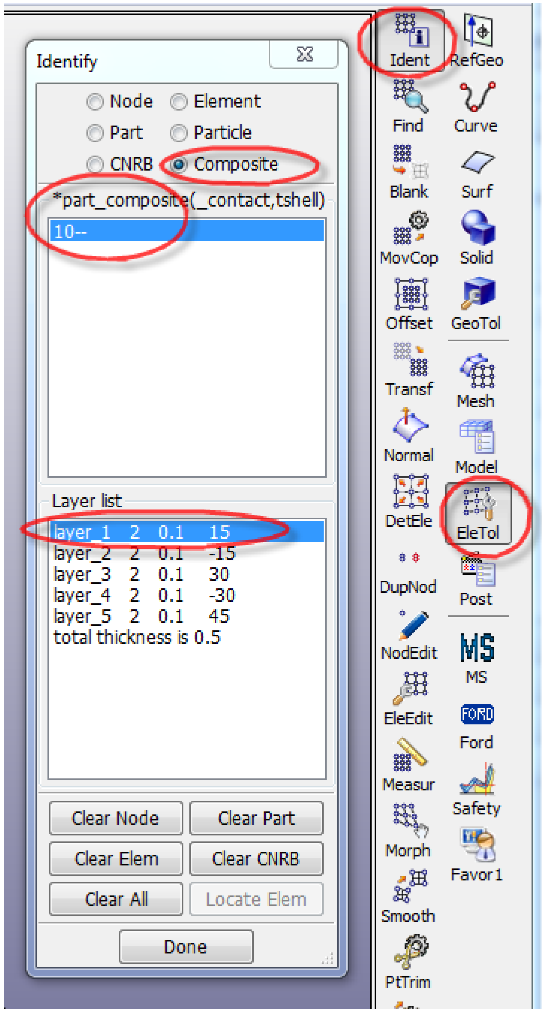


Preprocessing: Laminate Composites

Viewing *PART_COMPOSITE Layer information

- Layer information shown in tabulated form
- Later formulation, thickness, and rotation angle, plus total thickness
- Layer rotation angles can be graphically shown





Post-processing: Fringing in material direction

The CMPFLG flag

- Stresses are traditionally output in global system in d3plot
- BUT: stresses are output in MATERIAL system if CMPFLG=1
- However the CMPFLG flag is not stored in the d3plot file
- LS-PrePost needs to read keyword data to know about the CMPFLG (Hopefully in the future LS-DYNA will save this flag in d3plot)

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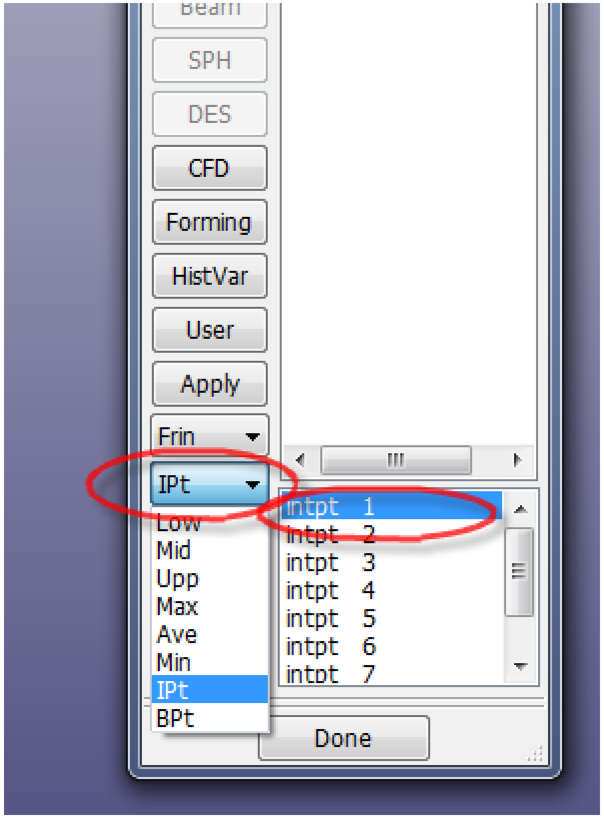
Post-processing: Fringing Composite

Stress/Strain Output Location

- Beside the standard top/middle/Bottom of the element, Ipt (integration point) is used to select the stress output for each later



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Post-processing: Fringing Composite

Stress/Strain Output direction

- If the keyword input file is read with the d3plot file (treated as same model) one can choose to fringe the data in different direction:
  - D3plot – original data in d3plot
  - Elem – element direction
  - Glob – Global direction
  - Mtri – Material direction
  - User – User defined coordinate system (default same as global if this option is chooen but no defined user system is used)