Composite Capability in LS-PrePost

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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:**

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 \([\xi,\eta,\zeta]\)
  - Define element variables for co-rotational elements (Sheels & 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 = \( \mathbf{V1} \times \mathbf{V2} \) 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.
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.

- **Step 2: Align Element Normal**
  - Method 1:
    Choose “Reverse Normal” and
    Select the elements and click “Reverse” Button
  - Method 2:
    Choose “Align” and
    Pick up a seed element and click “AutoRev” Button
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!
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: $a \times b$
- for structural mesh only

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

- **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

- Material directions $a,b,c$ can be switched in *MAT cards.
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: \( c \times a \)

- **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: \( c \times a \)
  - This option is quite similar to AOPT=3 for shells and thick shells but sharing a-direction
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*
Preprocessing: Material Coordinate System

Change the Beta Angle for each element by Mapping to a curve
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
Keywords:
- *ELEMENT_SHELL_COMPOSITE for shells
- *ELEMENT_TSHELL_COMPOSITE for thick shells

Create Layers
- EleToI -> 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

- 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

- 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)
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
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 chosen but no defined user system is used)