

FRANC3D Training Workshop: Part 5

Finite Element (FE) Model Import

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Workshop Agenda

- Part 1: Introduction to Fatigue and Damage Tolerance
- Part 2: Introduction to Fracture Mechanics Analysis
- Part 3: Introduction to FRANC3D
- Part 4: FRANC3D User Interface
- **Part 5: Finite Element (FE) Model Import**
- Part 6: Crack Insertion
- Part 7: Static Crack Analysis & SIF Computation
- Part 8: SIFs from FE Analysis
- Part 9: Crack Growth
- Part 10: SIF History & Fatigue Life
- Part 11: Miscellaneous Topics

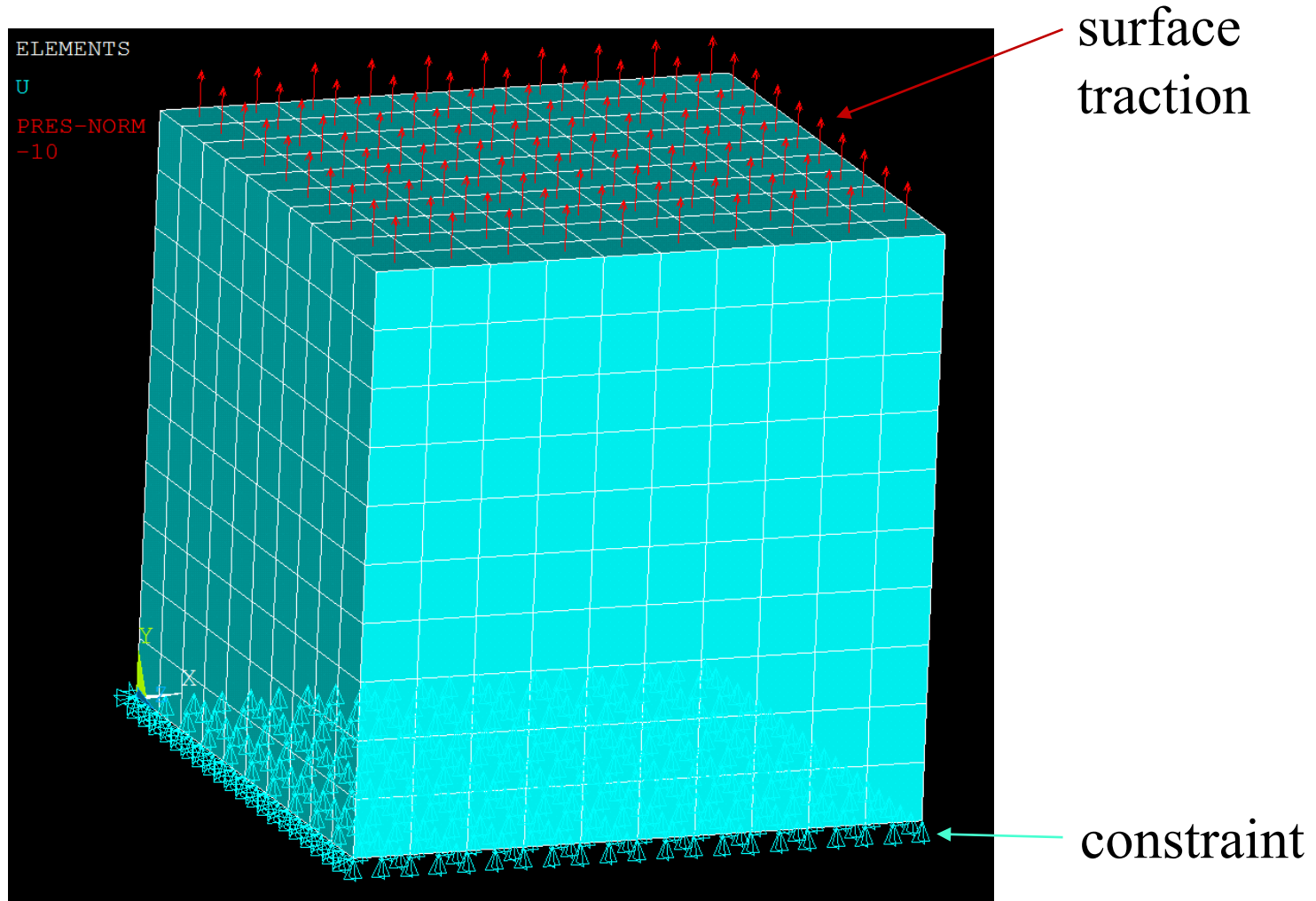
Finite Element (FE) Model Import

- Supported Input FE Model Files
- Options for Importing Uncracked FE Models
- Boundary Condition Surfaces
- Export Model
- Demo & Hands On: FE Model Import

Supported Input FE Files

- FRANC3D supports the following input finite element files:
 - ANSYS: *.cdb files
 - The .dat file from ANSYS WorkBench is supported, but a working ANSYS version must be accessible as FRANC3D executes ANSYS in the background to convert the .dat into a .cdb
 - ABAQUS: *.inp files
 - NASTRAN: *.bdf (*.nas, *.dat) files

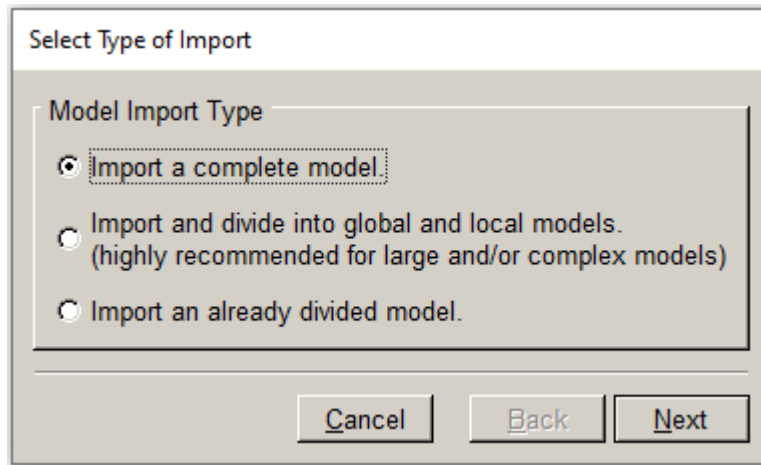
Import a FE Model – a simple cube



Importing Uncracked FE Models

Three options for importing uncracked FE models:

- Import a complete model
- Import and divide the model in FRANC3D
- Import an already divided model

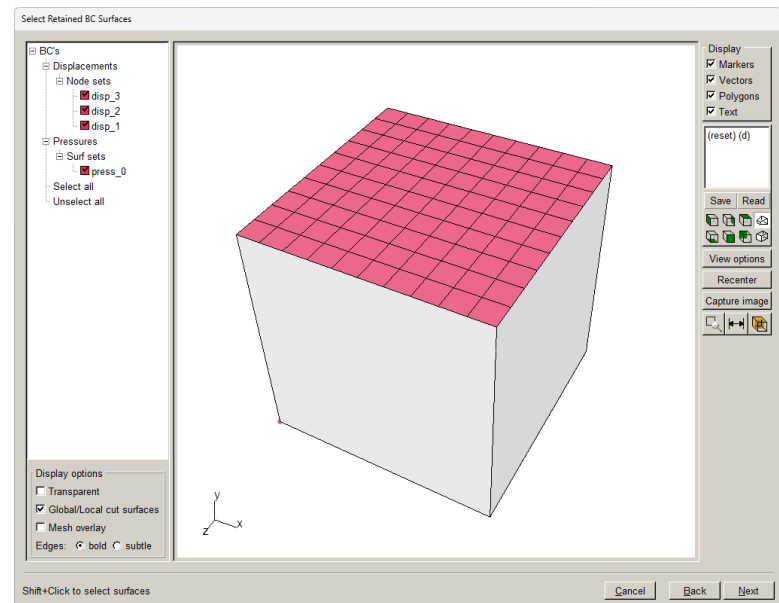
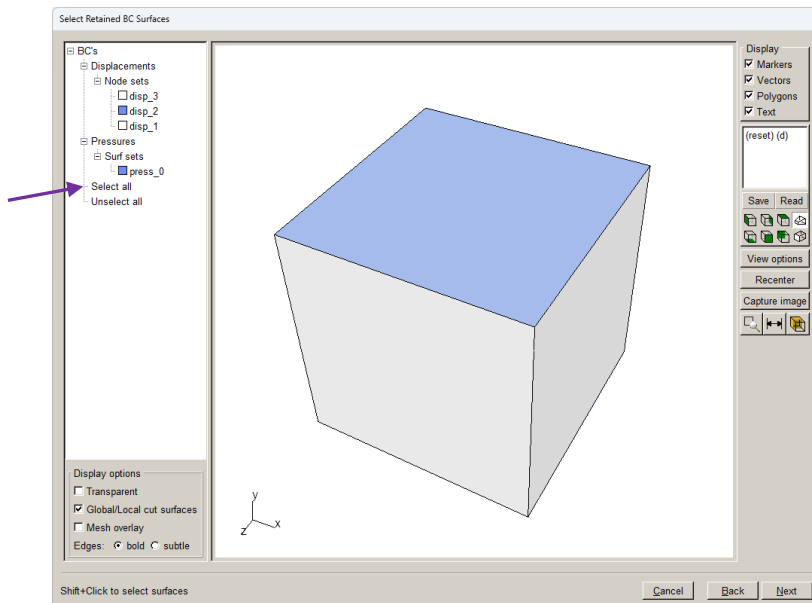


Depending on the selection, different dialogs are displayed after **Next**.

Start with importing a complete model - the complete cube.

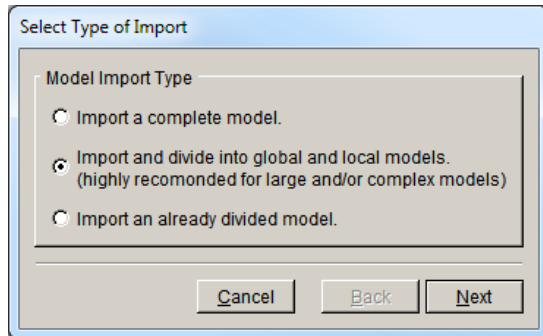
Boundary Condition Surfaces

- After importing the FE model into FRANC3D, the **Select Retained BC Surfaces** dialog is displayed
- Any surface that has boundary conditions will be highlighted in blue
- Use Select all and the blue surfaces will be colored red



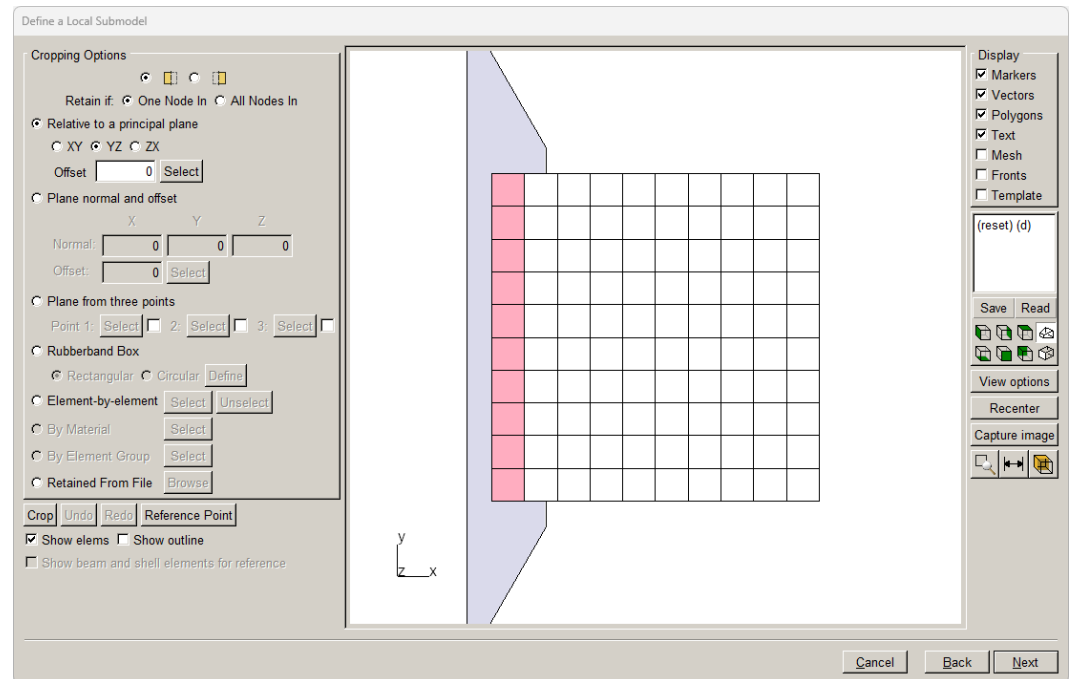
NOTE: do not retain facets where a crack will be inserted.

Import and Divide the Model in FRANC3D



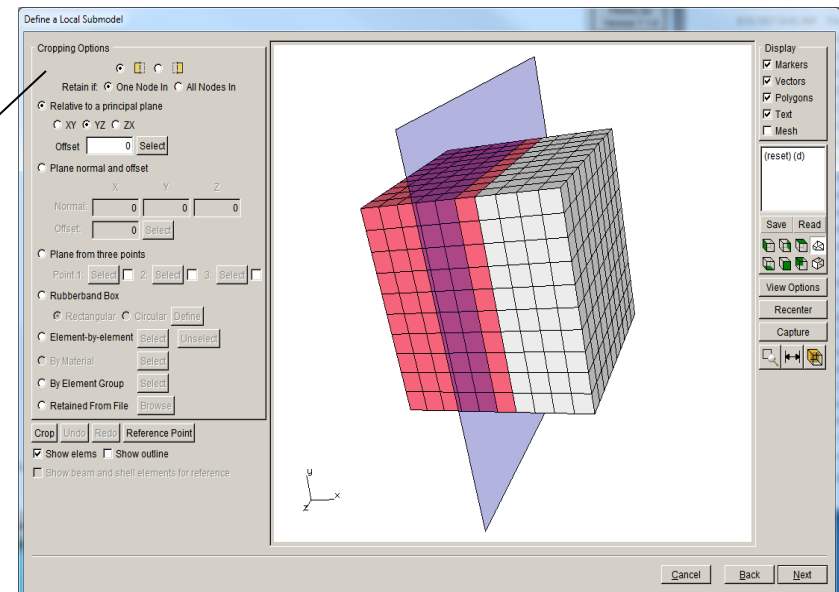
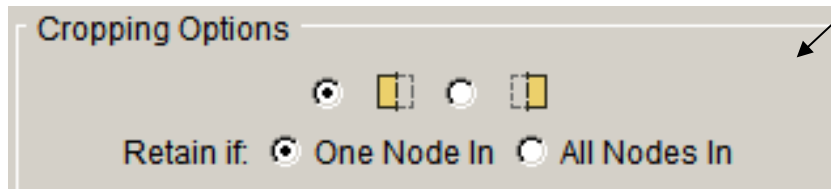
The **Define Local Submodel** dialog is displayed after selecting the FE model file.

- FRANC3D has several options for extracting a sub-model.
- The **size of the local submodel** should be based on the extent of crack growth and the geometry of the model.
- After extracting the sub-model, the **Select Retained BC Surfaces** dialog is displayed if the sub-model has boundary conditions, node sets, or surfaces.



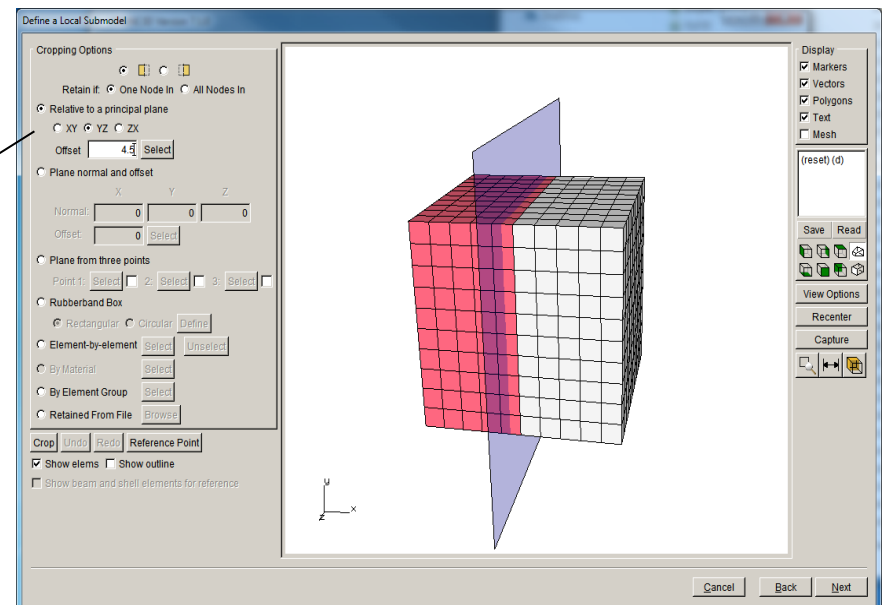
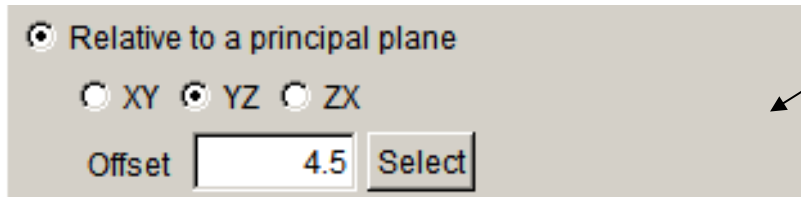
Import and Divide the Model in FRANC3D

- Cropping Options
 - Specify which ‘side’ of the selection plane or box is selected
 - Selected elements are colored red



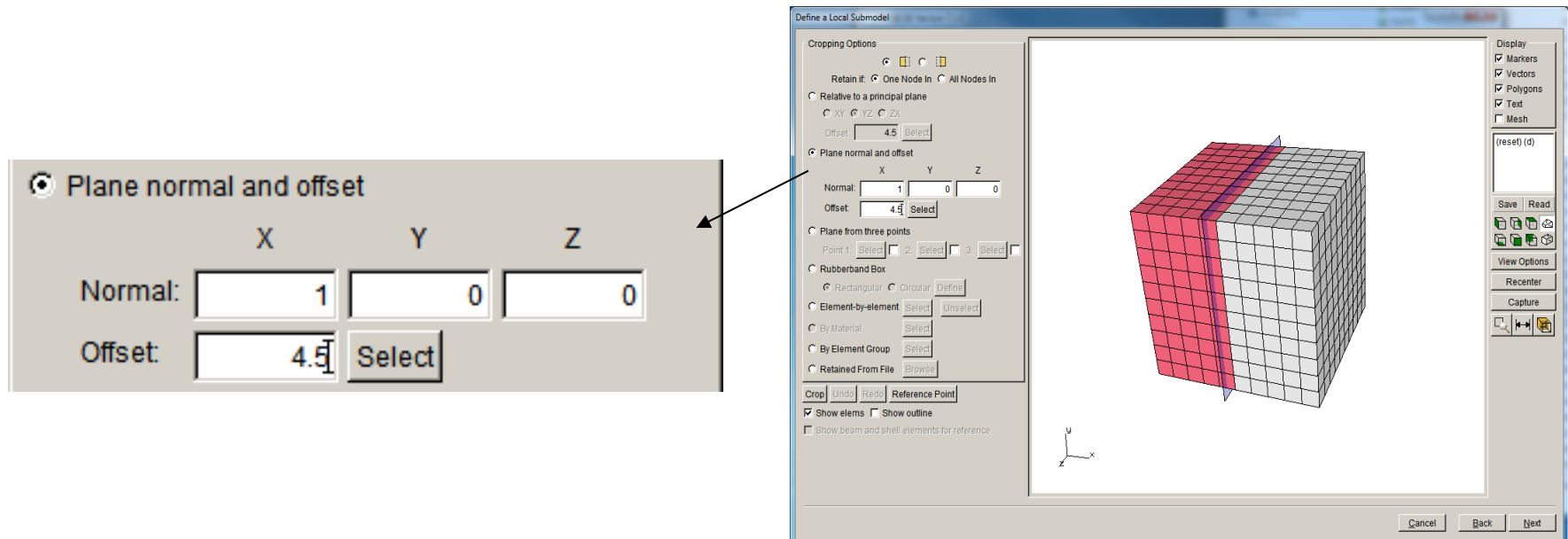
Import and Divide the Model in FRANC3D

- Relative to a principal plane:
 - Choose a plane that is aligned with the Cartesian axe
 - Plane can be offset from the origin



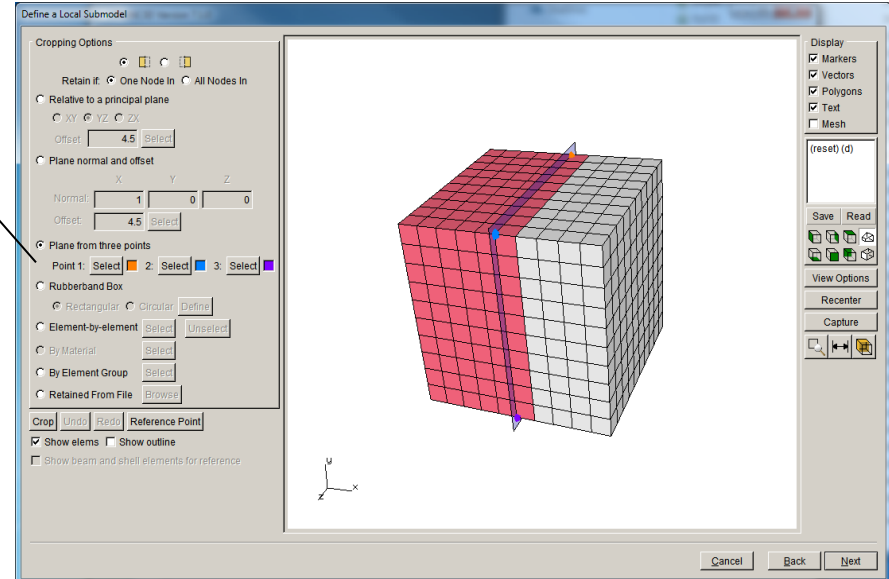
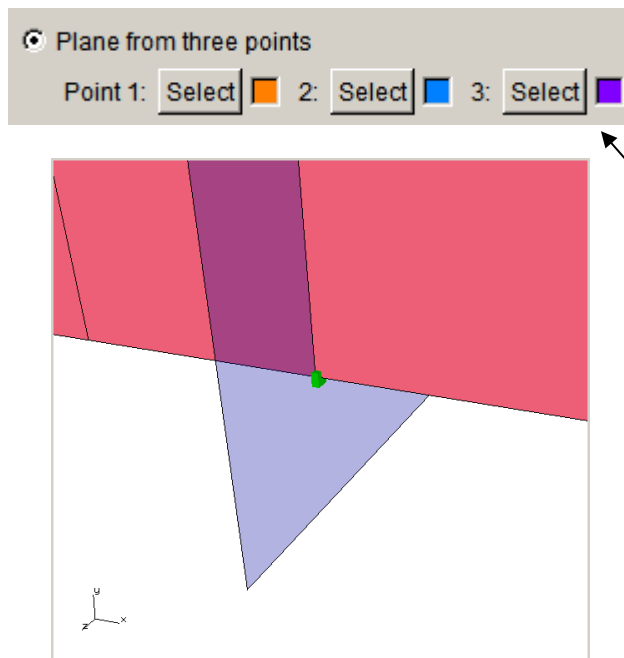
Import and Divide the Model in FRANC3D

- Plane normal and offset
 - Define a plane that is normal to the unit vector defined by the x, y and z coordinates
 - Plane can be offset from the origin



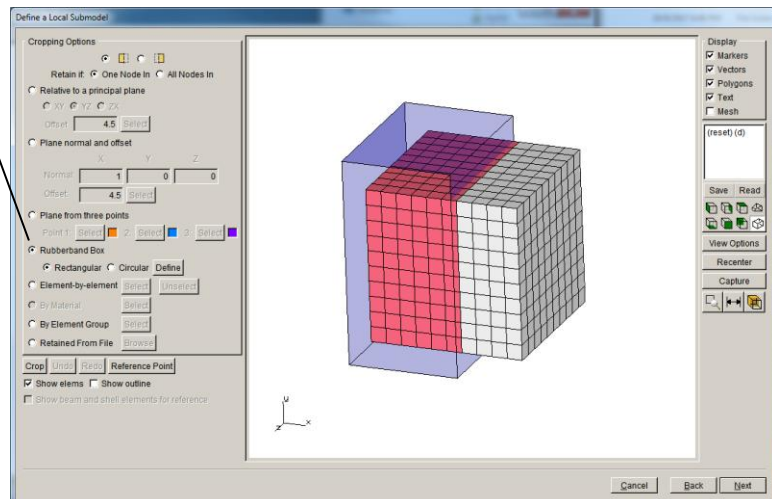
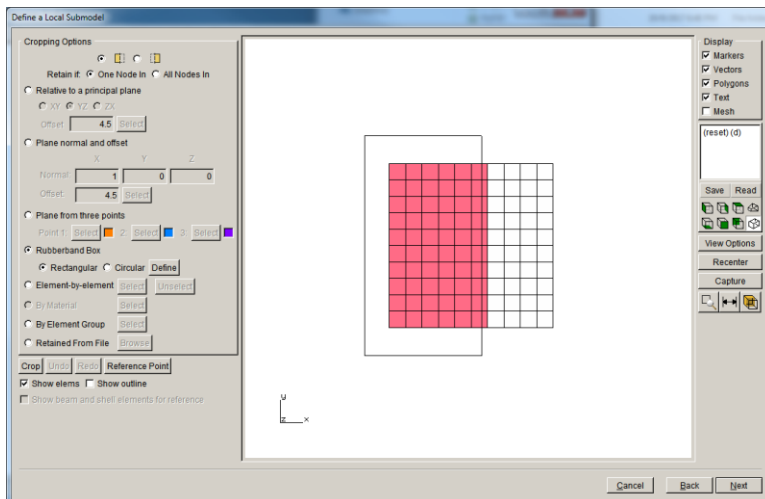
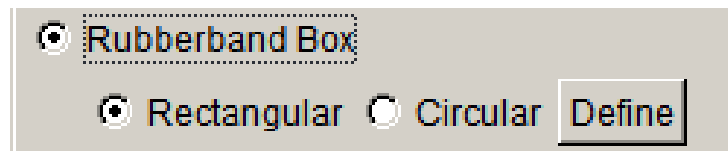
Import and Divide the Model in FRANC3D

- Plane from three points
 - Define a plane based on the selection of three points
 - Use the (cross) cursor to pick points; three points of a triangle define the plane



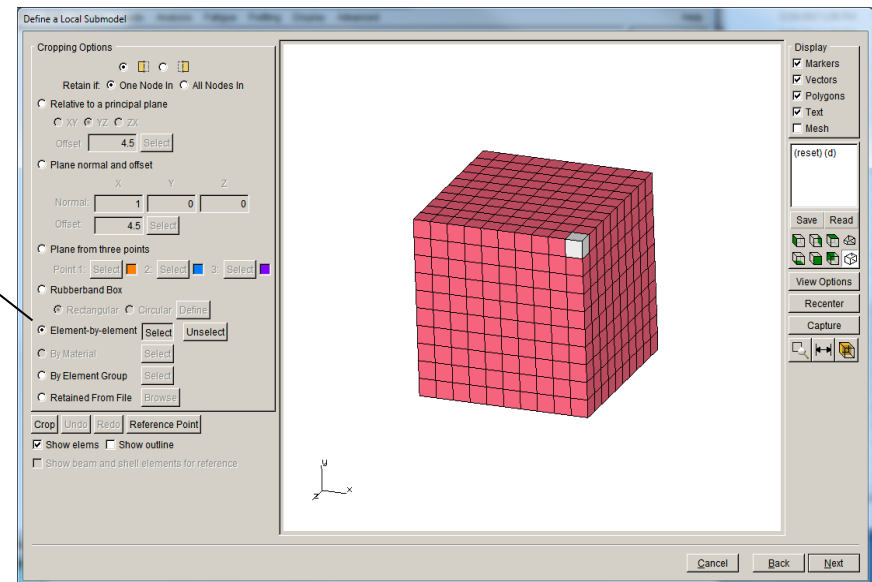
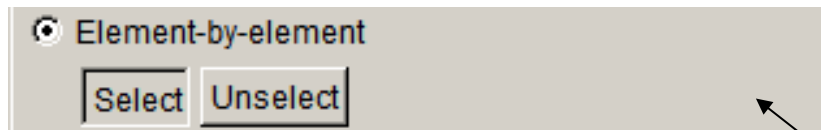
Import and Divide the Model in FRANC3D

- Rubberband box
 - Define a box (or cylinder) using the left-mouse button to drag the outline on the screen



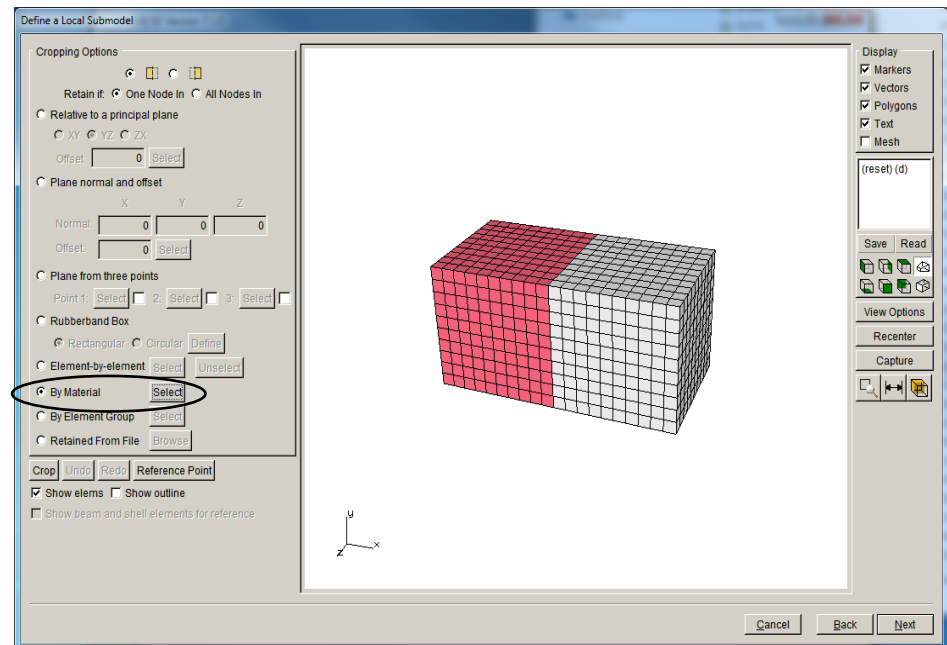
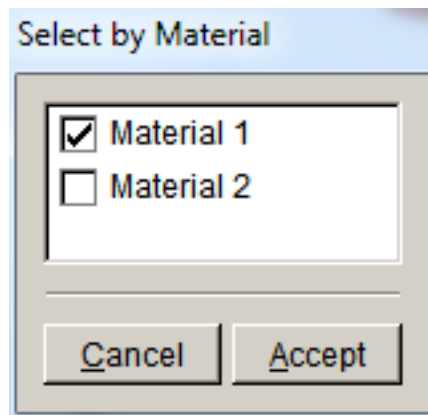
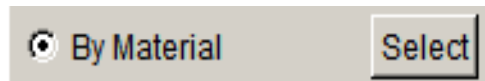
Import and Divide the Model in FRANC3D

- Element by element
 - Select (or unselect) individual elements
 - User presses the **Select** button and then uses the left-mouse button to select elements one at a time



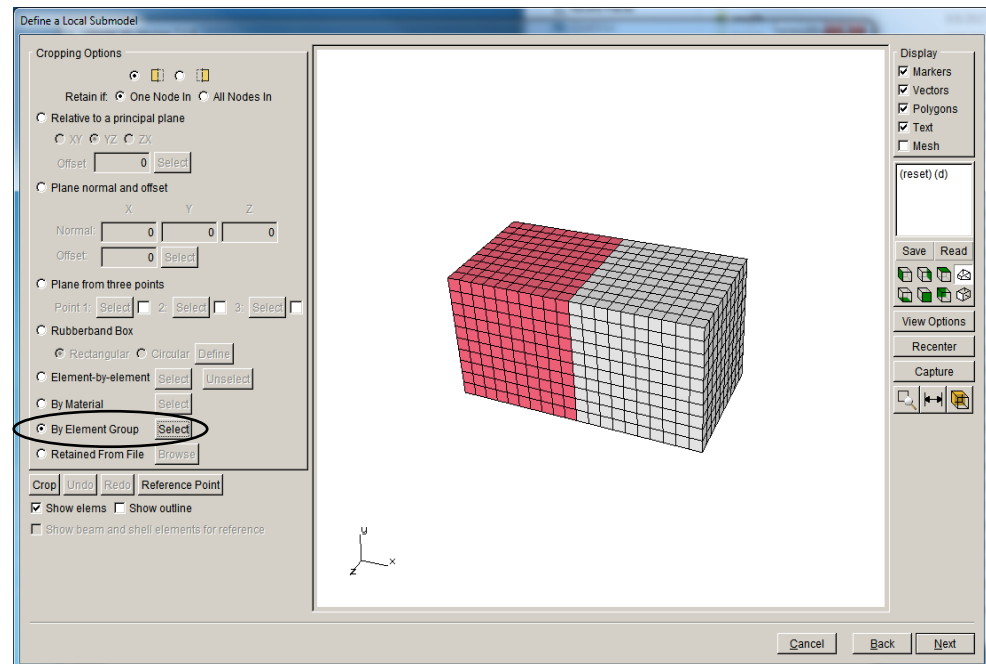
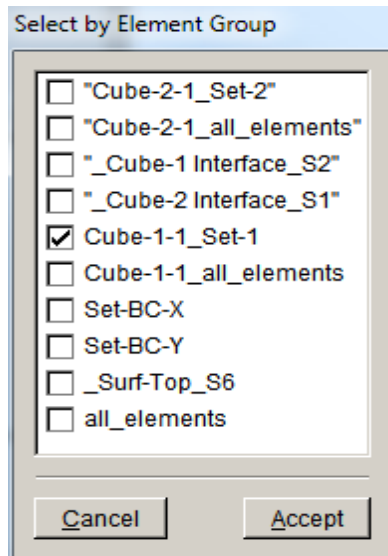
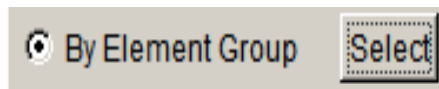
Import and Divide the Model in FRANC3D

- By material
 - Select elements based on material ID



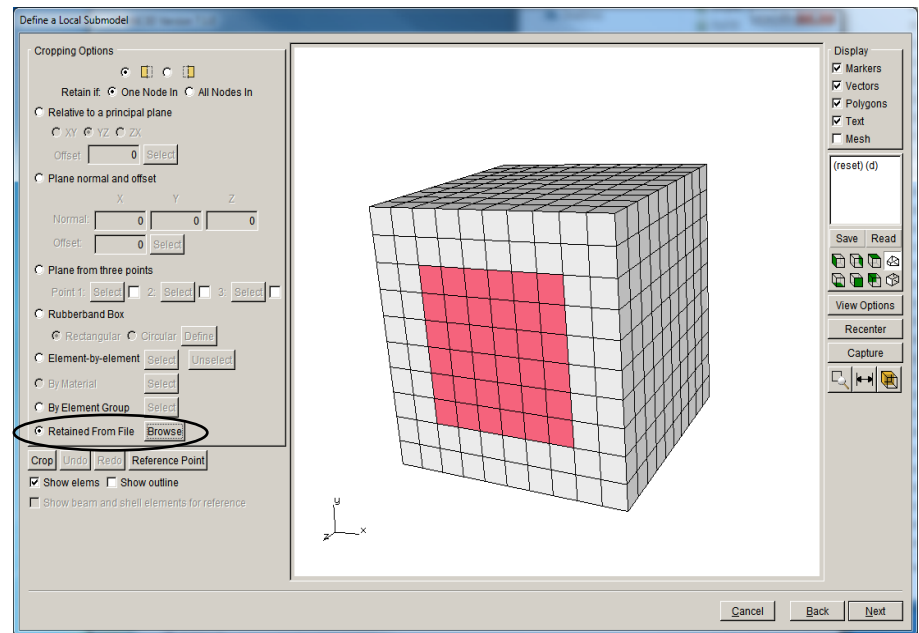
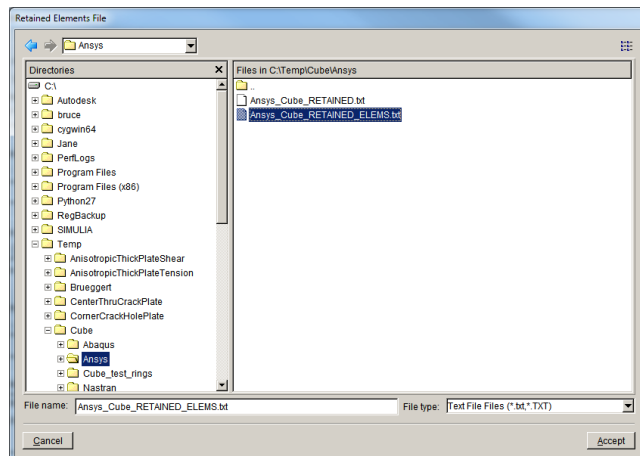
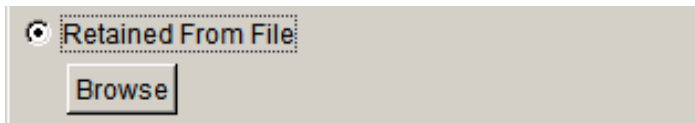
Import and Divide the Model in FRANC3D

- By element group
 - Select elements based on a group name



Import and Divide the Model in FRANC3D

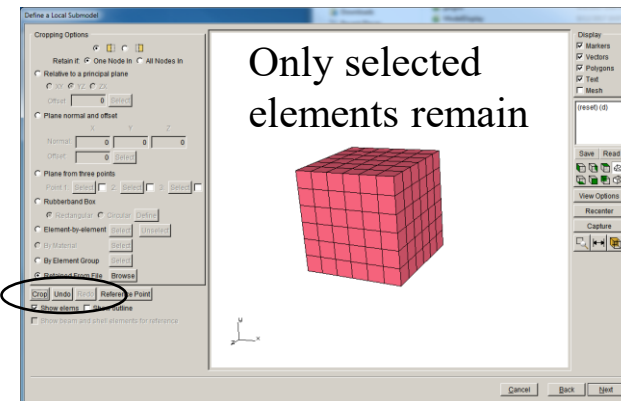
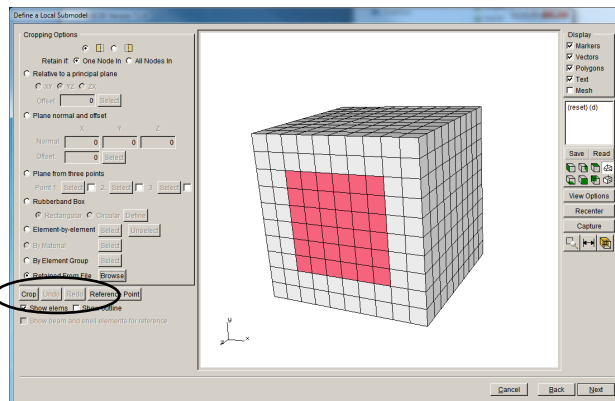
- Retained from file
 - Select **element IDs** from a .txt file
 - Useful for re-selecting elements that were selected during a previous import



Import and Divide the Model in FRANC3D

- Crop, Undo and Redo

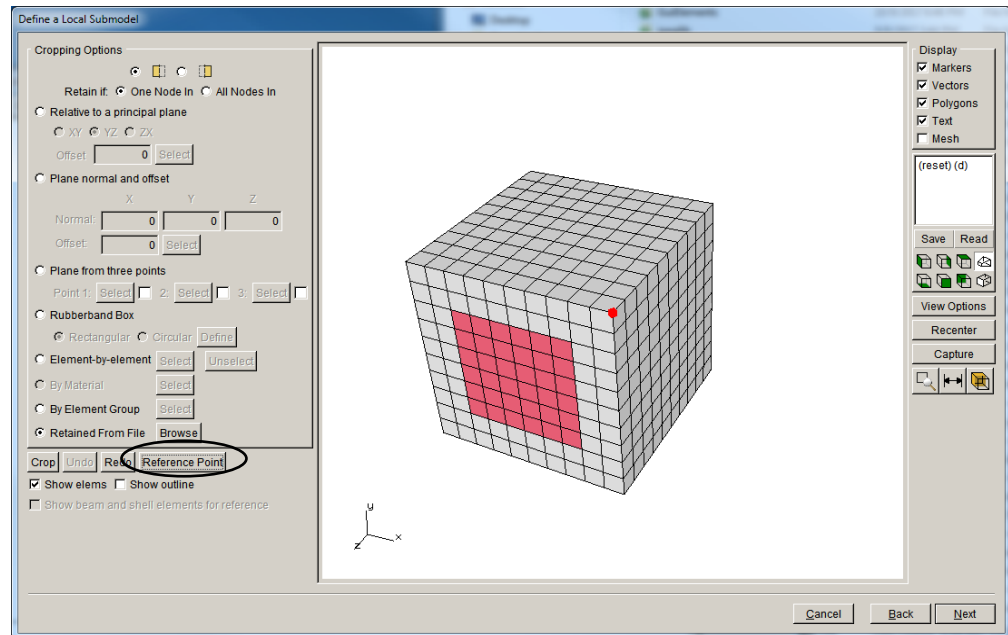
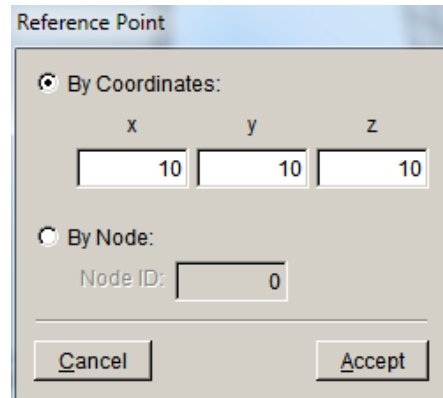
- The **Crop** button at the bottom on the left side performs the actual cropping operation
- Once the selection is made, elements are cropped by pressing the **Crop** button
- Un-selected elements are removed
- User can **Undo** or **Redo** cropping operations
- Multiple selections and crops can be performed in sequence



Import and Divide the Model in FRANC3D

- Reference Point

- The user can select a node or xyz coordinates for a reference point in the model. The center of rotation is automatically adjusted to this position.

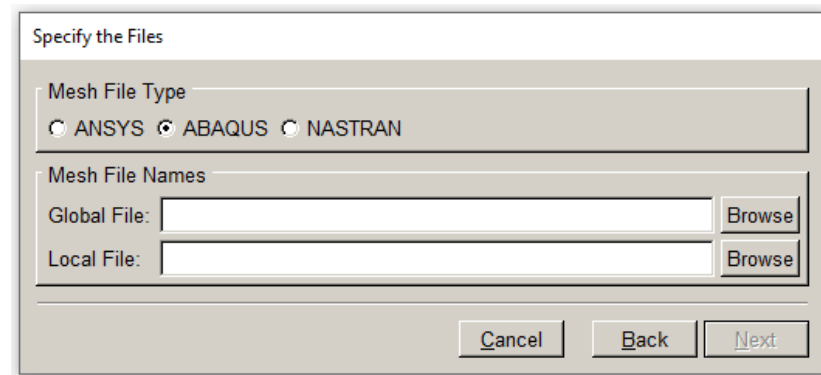
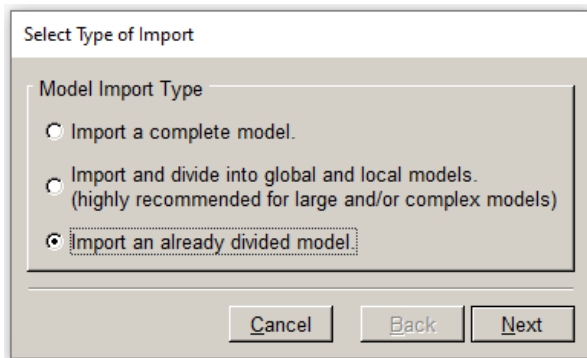


Import and Divide the Model in FRANC3D

- Once an element set has been selected and cropped, the following files are saved:
 - Local model
 - Global model
 - File with the base file name followed by `_RETAINED_ELEMS.txt`
 - Contains the element IDs for the local model
 - Can be used with the Retained From File option when defining the local submodel dialog box
 - Can be re-used during playback of a session log
- Local and global models can be recreated by the using the original FE model and the `_RETAINED_ELEMS.txt` file
- FRANC3D automatically creates an `AUTO_CUT_SURF` for the local portion and a `GLOBAL_CONNECT_SURF` for the global portion

Import Already Divided Model

- If the user has already divided the FE model into global and local model files, these files can be imported directly.

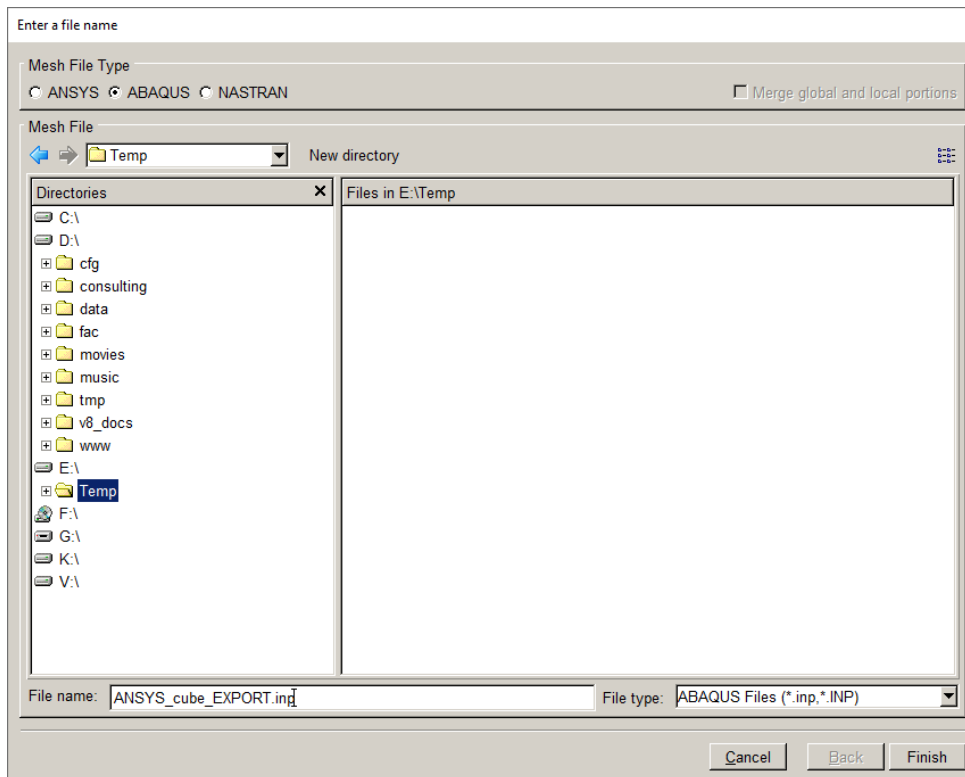


Import Already Divided Model

- This option can be used:
 - Once `_LOCAL` and `_GLOBAL` files are saved using the second option (import and divide) in FRANC3D
 - If the FE model is divided using other tools/software
 - it is important to remember to collect the node sets (components) that define the cut-surface between the local and global portions so that these can be selected later when merging the cracked-remeshed local portion with the global portion. The sets must have different names in the local and global portions.

Export Model

- File **Export** menu item can be used to save the FE model data without saving the FRANC3D .fdb
- User selects the analysis FE model type and enters the file name
- Used to convert FE model files from one type to another

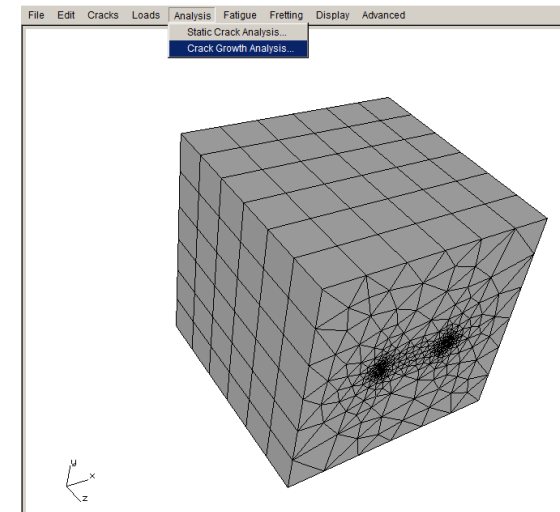
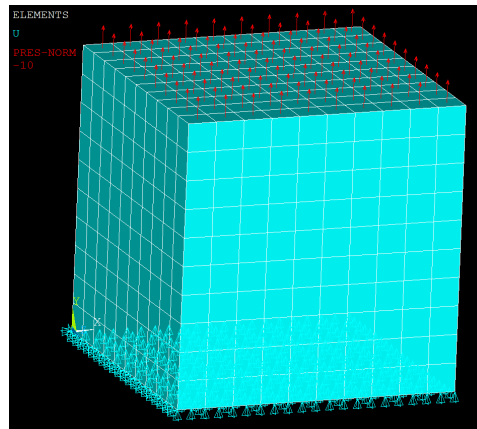


FRANC3D tries to “pass-through” as much of the FE data as possible, so converted files might have data that is not compatible.

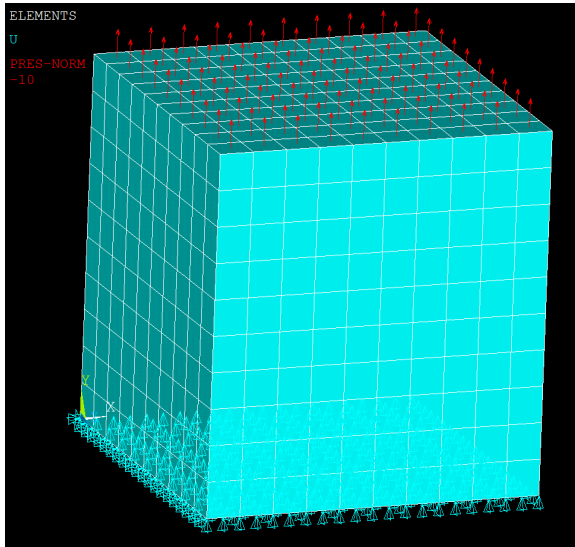
Demo & Hands On (Homework): FE Model Import

- FRANC3D
Documentation:
 - FRANC3D/ABAQUS Tutorial
 - FRANC3D/ANSYS Tutorial
 - FRANC3D/NASTRAN Tutorial
 - FRANC3D/SIERRA Tutorial

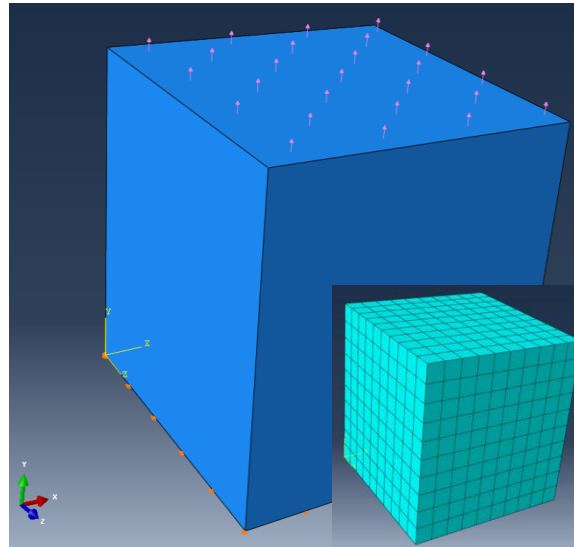
Tutorial #1: Crack Insertion and Growth in a Cube



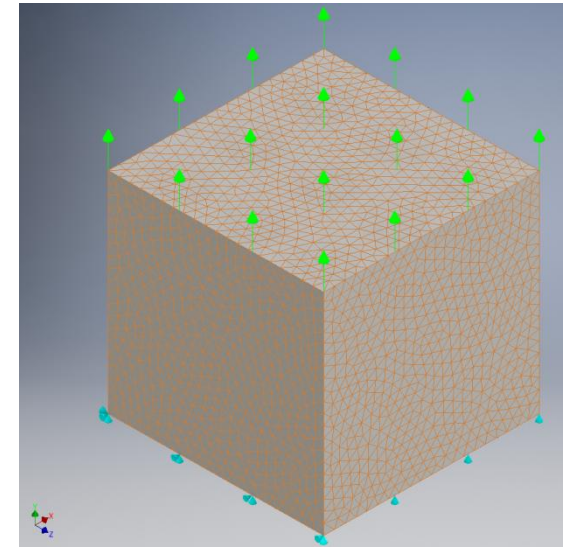
FRANC3D Tutorial 1



ANSYS

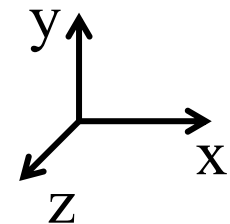


ABAQUS



NASTRAN

- 10x10x10 cube; units of length are mm
- subdivide edges for meshing using 10 to 20 subdivisions
- use quadratic brick or tetrahedral elements
- material properties: $E=10000$ MPa and $\nu=0.3$
- uniform traction (a negative pressure) on the top surface of 10 MPa in Y-direction
- bottom surface constrained in the y-direction, bottom left edge is also constrained in the x-direction, and the point at the origin is also constrained in the z-direction



FRANC3D Tutorial 1

Step 1: Build the FE model or use the pre-made model

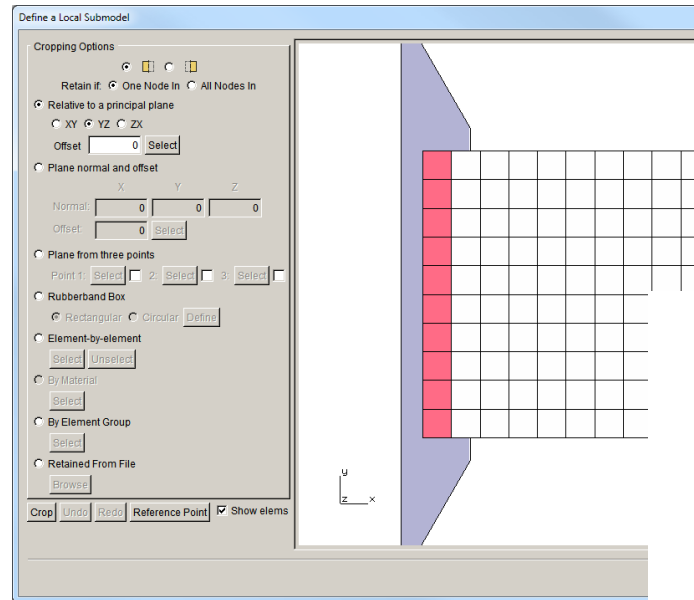
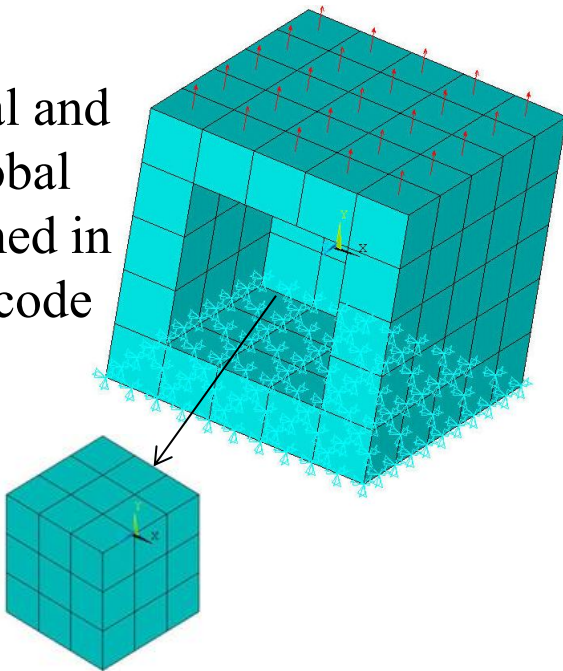
- from FAC downloads

Step 2: Extract local sub-model portion

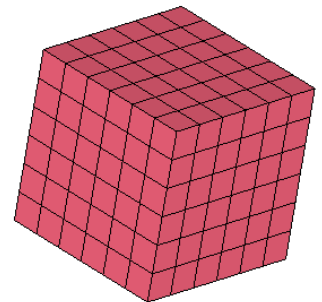
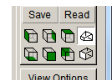
- node component/set for cut-surface(s) automatically created
- write local and global portions as separate model files
- local and global FE data automatically made consistent

Step 3: Import sub-model portion into FRANC3D

Local and
global
defined in
FE code



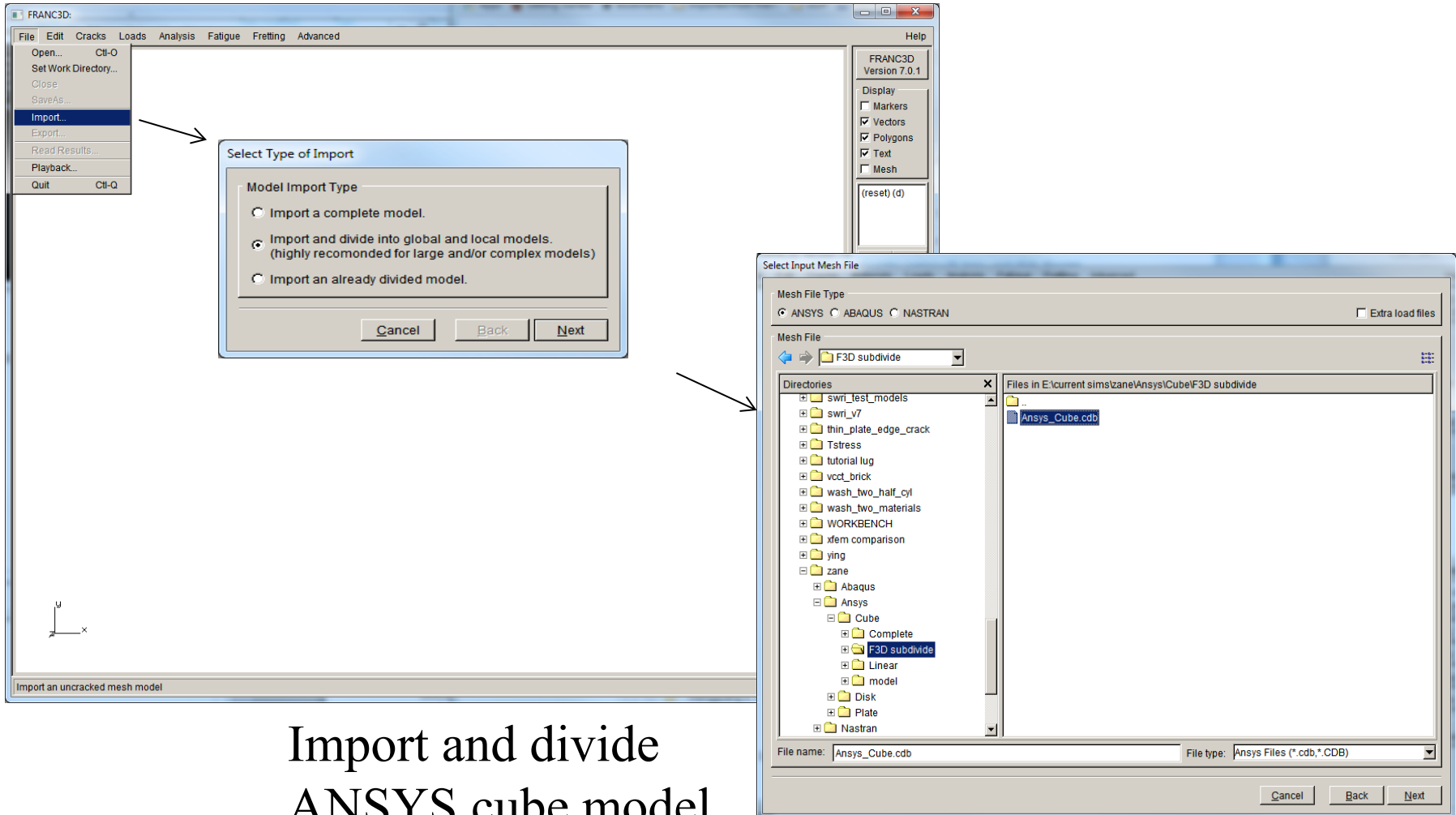
Local and
global
defined in
FRANC3D



Demo/Hands On (Homework): Importing and Dividing FE Model

FRANC3D Tutorial 1 – Import FE Model

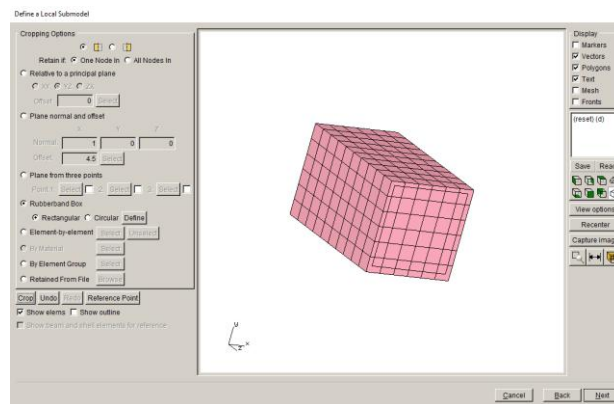
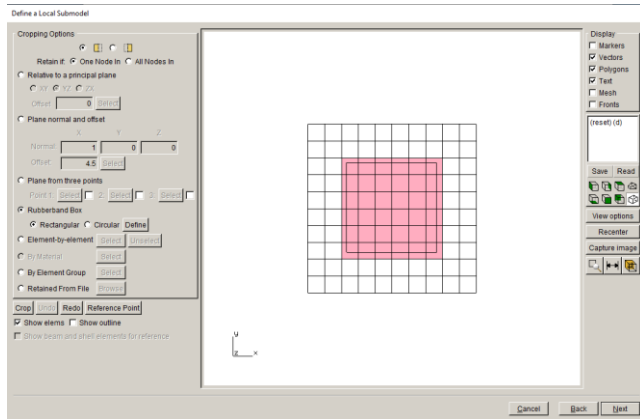
For Step 2 when using FRANC3D:



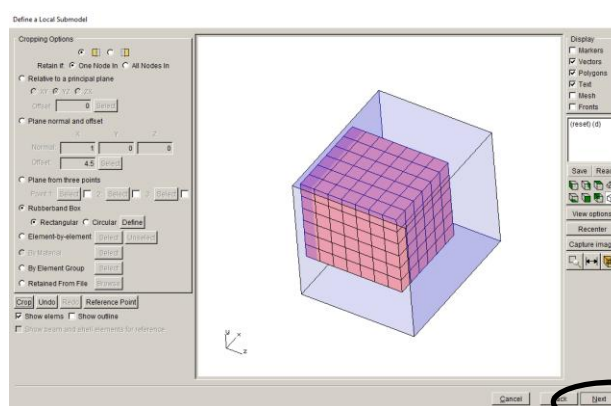
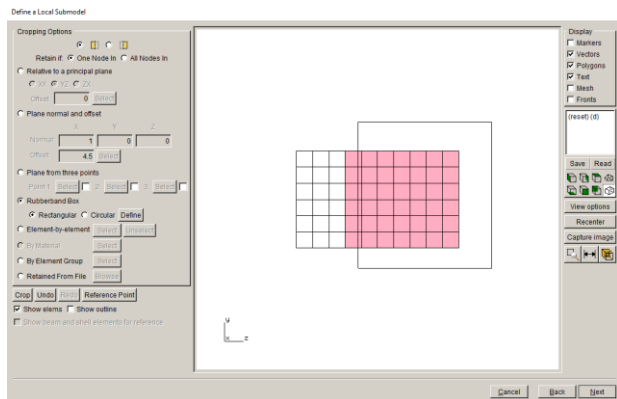
FRANC3D Tutorial 1 – Import FE Model

Submodel Tool:

- Elements shown in red are retained when the model is **Cropped**
- Rubberband Box tool demonstrated



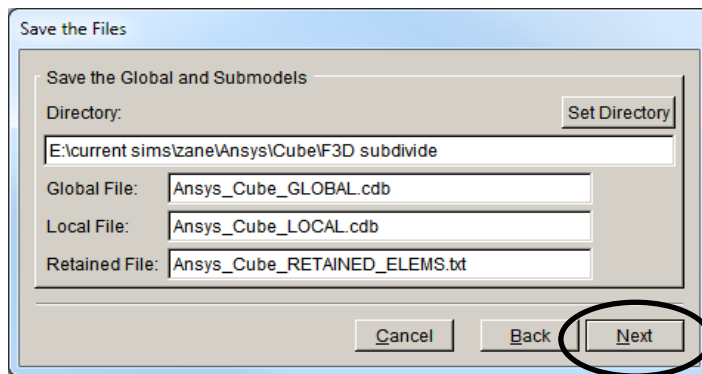
After selecting the elements to retain and using the **Crop** button – select **Next**.



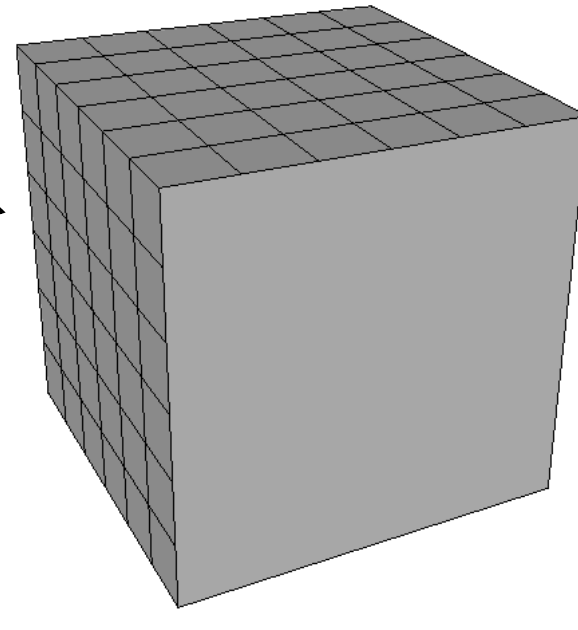
FRANC3D Tutorial 1 – Import FE Model

Submodel Tool:

- Local and global portions saved along with the list of retained elements; the latter allows for scripted restarts (*i.e.*, playback).



Cut-surface mesh facets retained



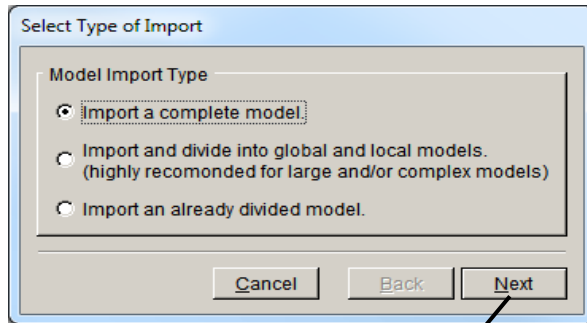
Note that there are no boundary conditions on this particular (local) sub-model selection.

Demo/Hands On (Homework): Importing Complete FE Model

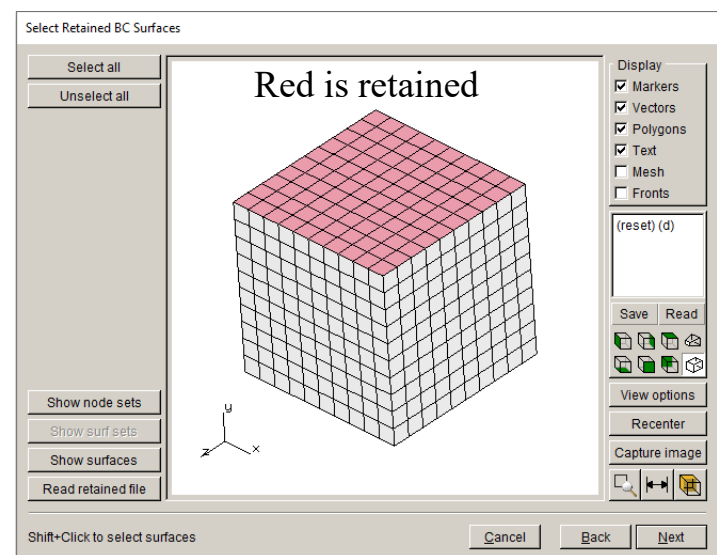
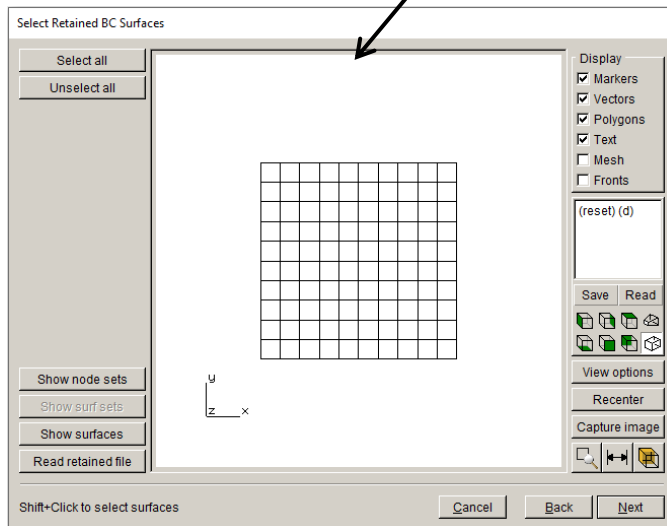
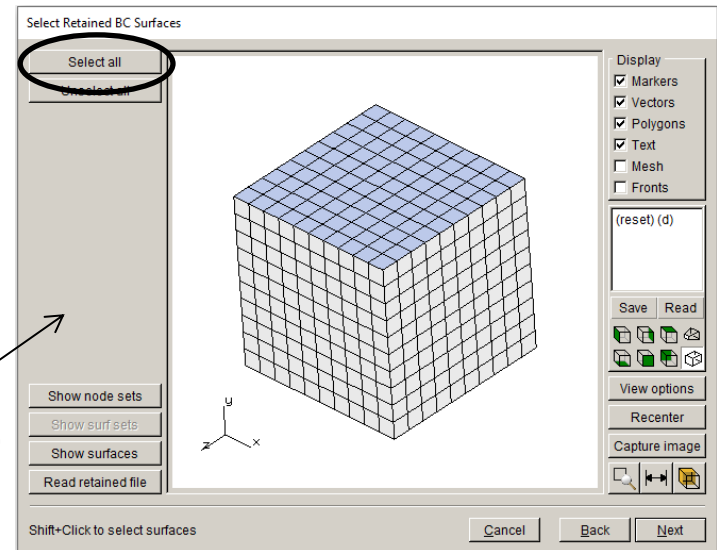
Note: **File** → **Close** the prior import.

Importing Full Model

Import complete cube model:

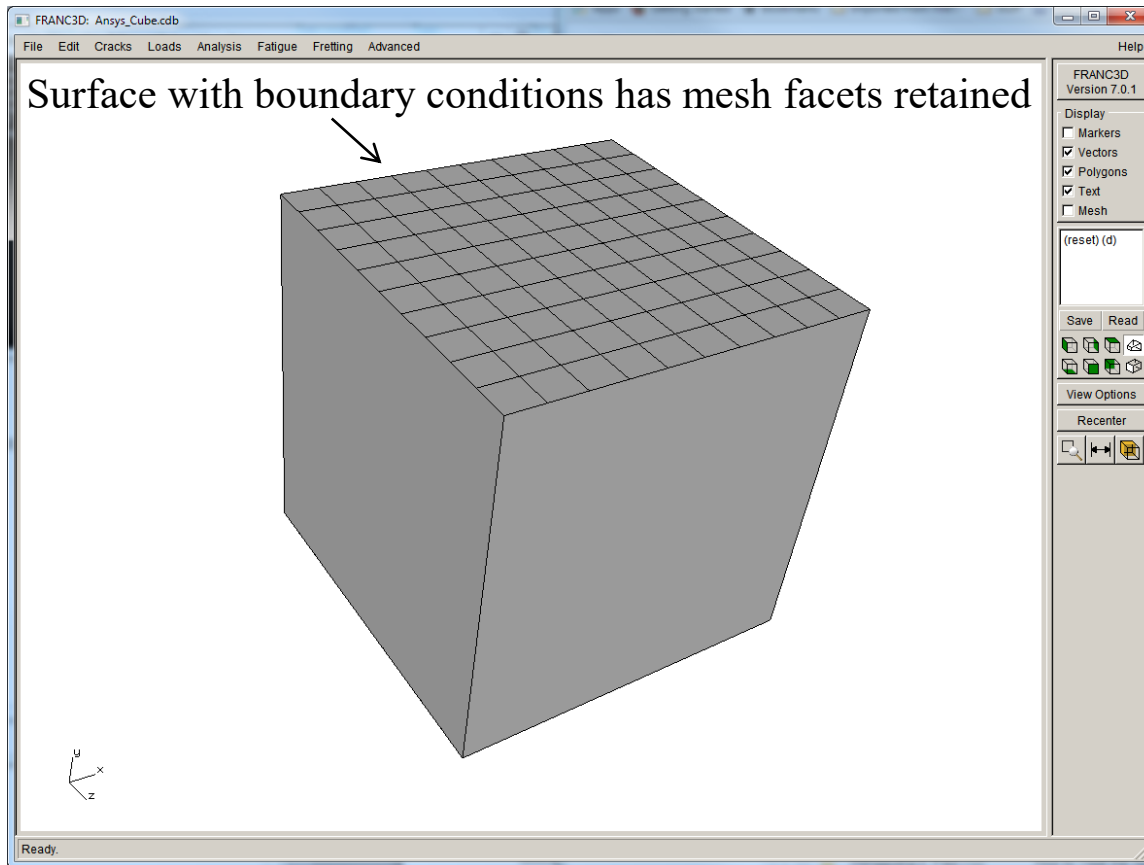


Use mouse to rotate model



FRANC3D Tutorial 1 – Import FE Model

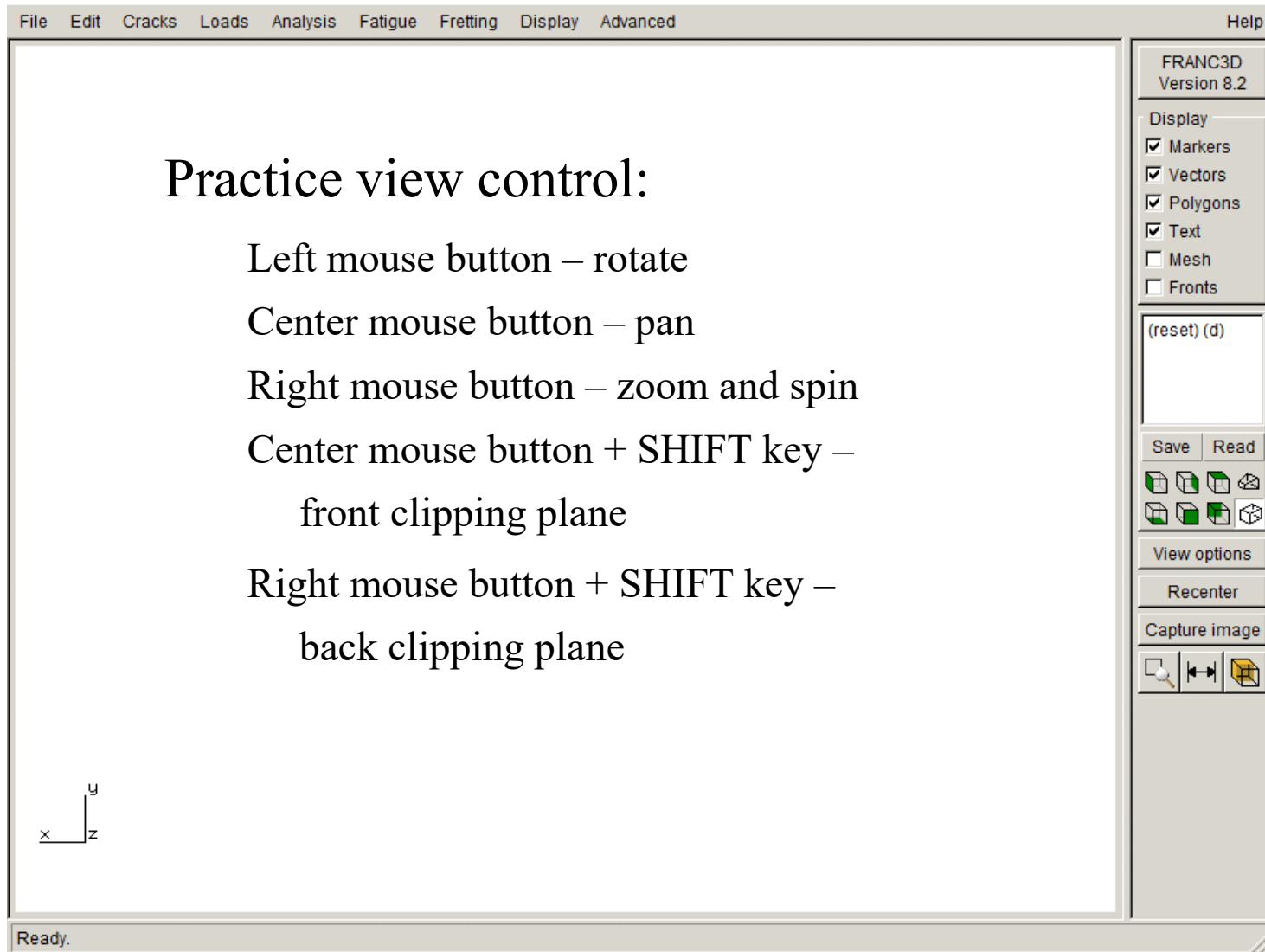
Surface mesh facets are retained where boundary conditions are applied *and selected to be retained*.



Reminder – you can not insert a crack into a surface where facets are retained.

Demo/Hands On (Homework): Viewing the Model

FRANC3D Tutorial 1 – Viewing Options



End Part 5