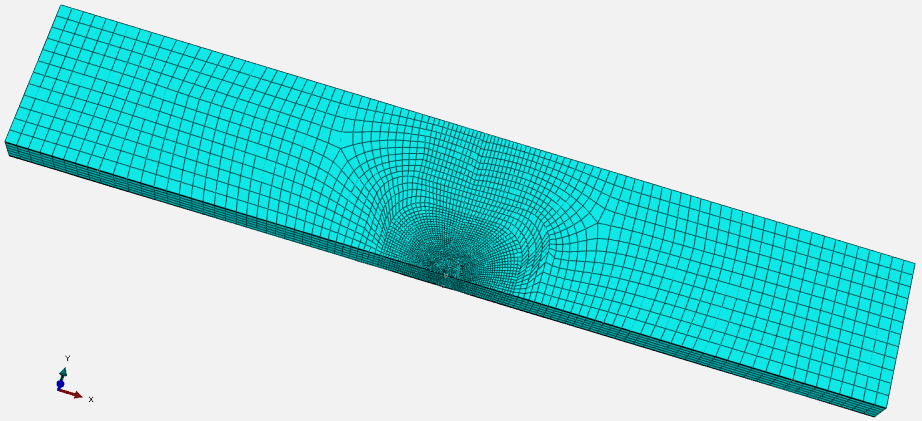
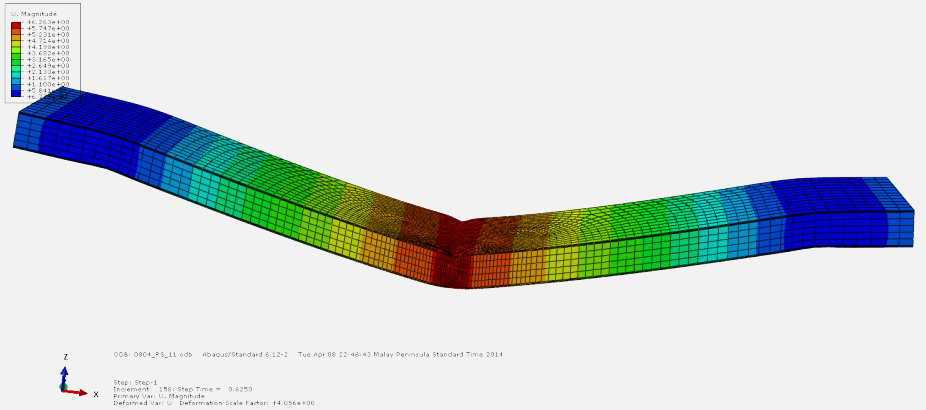
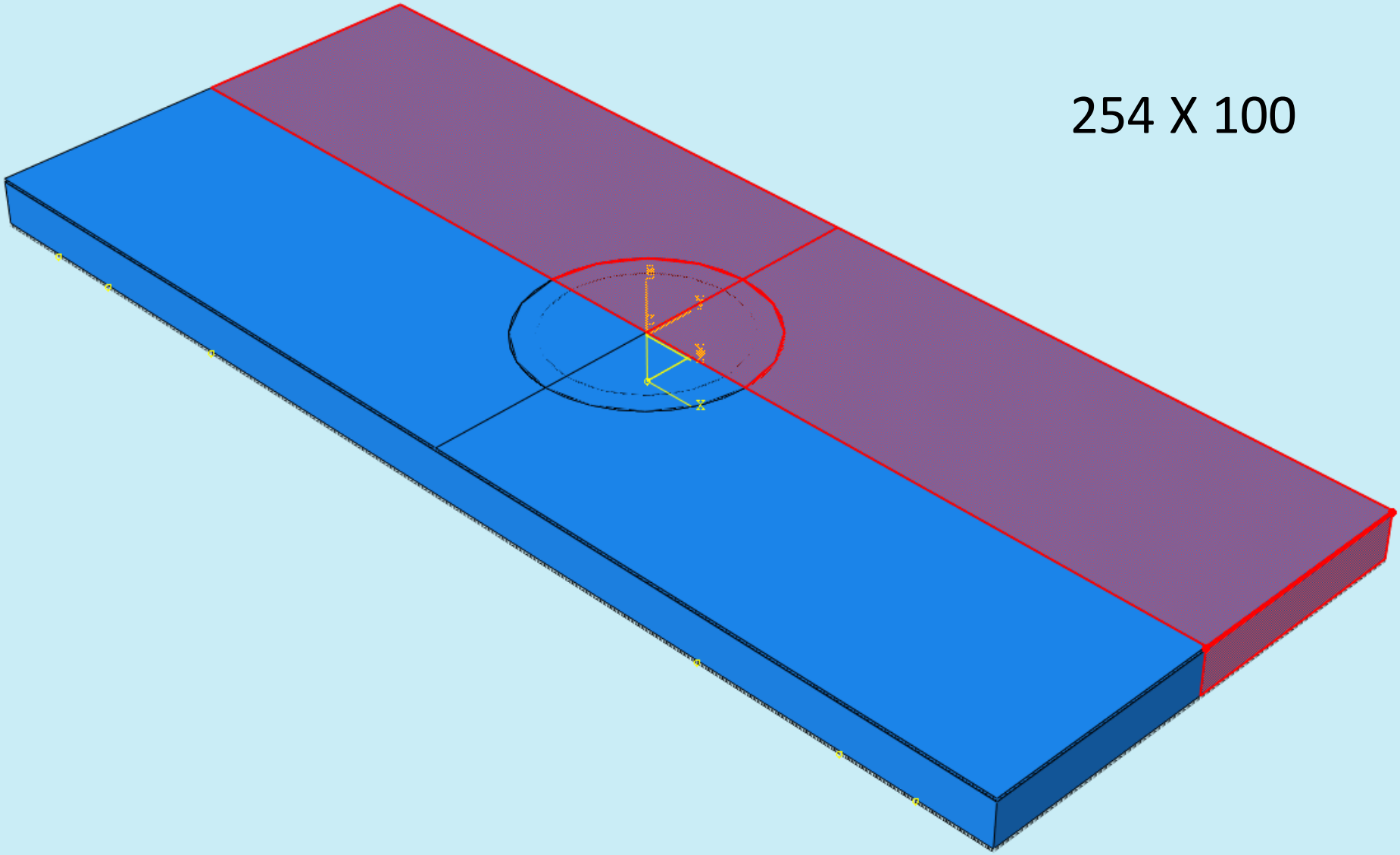
FEA SIMULATION

- Model Specifications
- Abaqus Modelling
- Types of Models
- Analysis of FEA Results

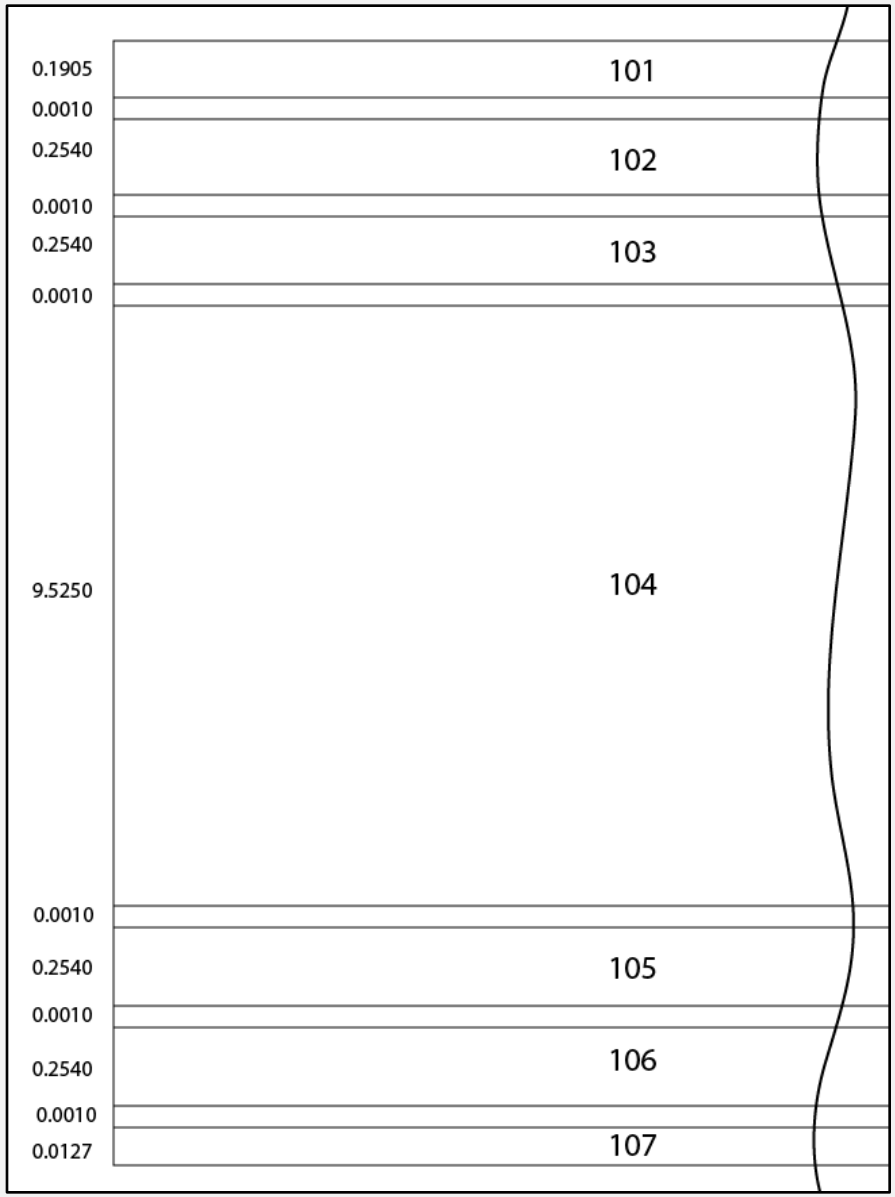


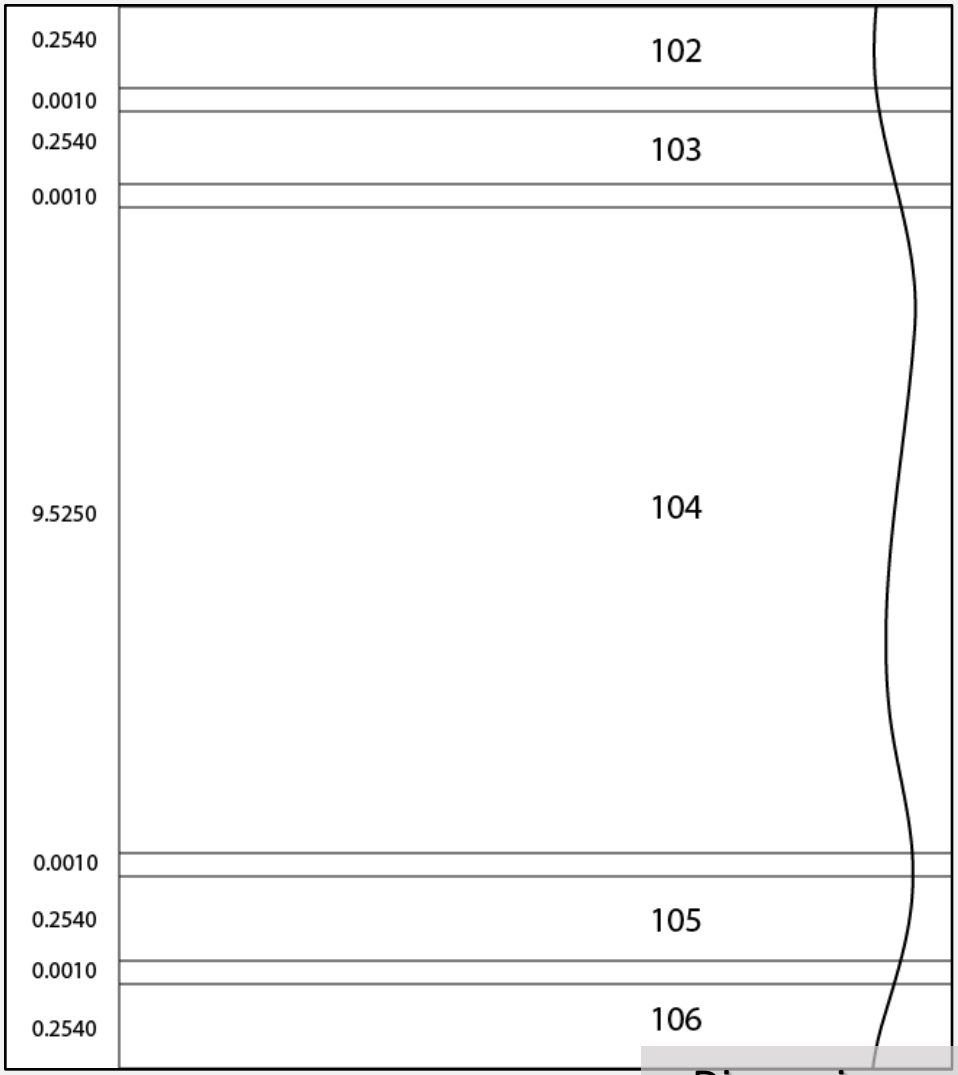


MODEL SPECIFICATIONS



MODEL SPECIFICATIONS (CONTD.)



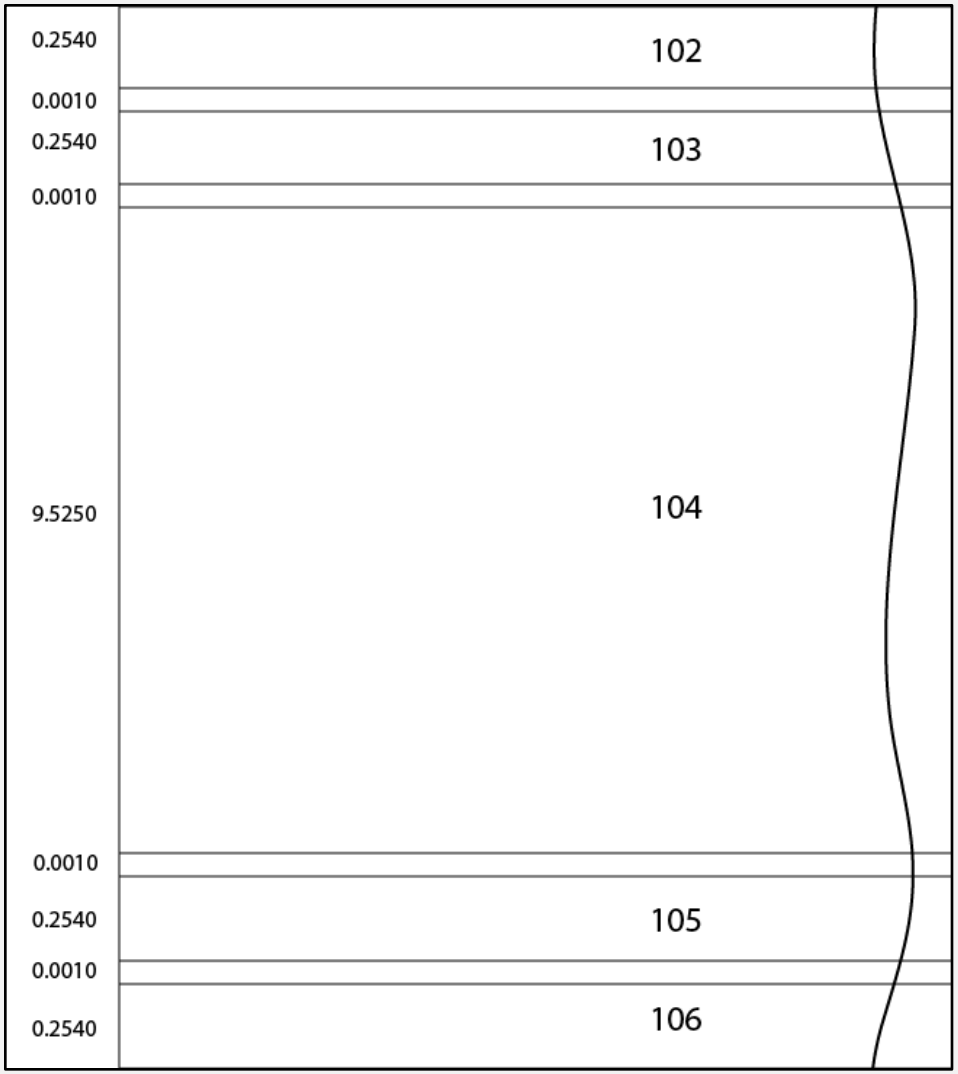


Dimensions

MODEL SPECIFICATIONS (CONTD.)

Materials

1. Plies – Kevlar 49/Epoxy (102, 103, 105, 106)
2. Core – Nomex Honeycomb (104) (Aramid Fibre, Phenolic Coated)
3. Cohesive (0.001 mm layers)



MODEL SPECIFICATIONS (CONTD.)

Plies - Kevlar 49/epoxy

- Continuum Shell Element

Elastic (MPa)								
E1	E2	E3	Nu12	Nu13	Nu23	G12	G13	G23
76000	5500	5500	0.34	0.34	0.4	2300	2300	1800

Hashin Damage (MPa)					
Longitudinal Tensile Strength	Longitudinal Compressive Strength	Transverse Tensile Strength	Transverse Compressive Strength	Longitudinal Shear Strength	Transverse Shear Strength
1400	235	12	53	34	34

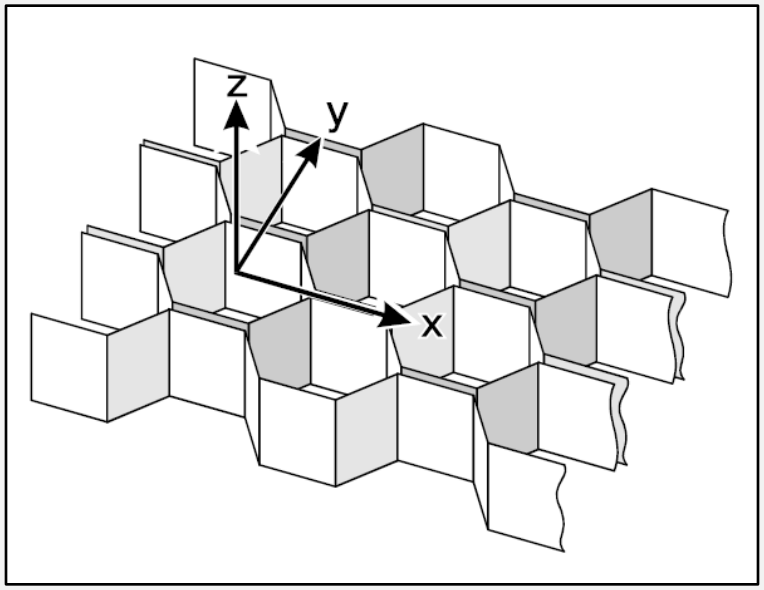
Damage Evolution (kN)			
Longitudinal Tensile Fracture Energy	Longitudinal Compressive Fracture Energy	Transverse Tensile Fracture Energy	Transverse Compressive Fracture Energy
117.8	52.8	0.3	0.8

MODEL SPECIFICATIONS (CONTD.)

Core – Nomex Honeycomb (Aramid Fibre, Phenolic Coated)

- Solid (3D Stress), Homogeneous Element

Elastic (MPa)								
E1	E2	E3	Nu12	Nu13	Nu23	G12	G13	G23
0.1	0.1	60	0	0	0	0.1	25	17



MODEL SPECIFICATIONS (CONTD.)

Cohesive

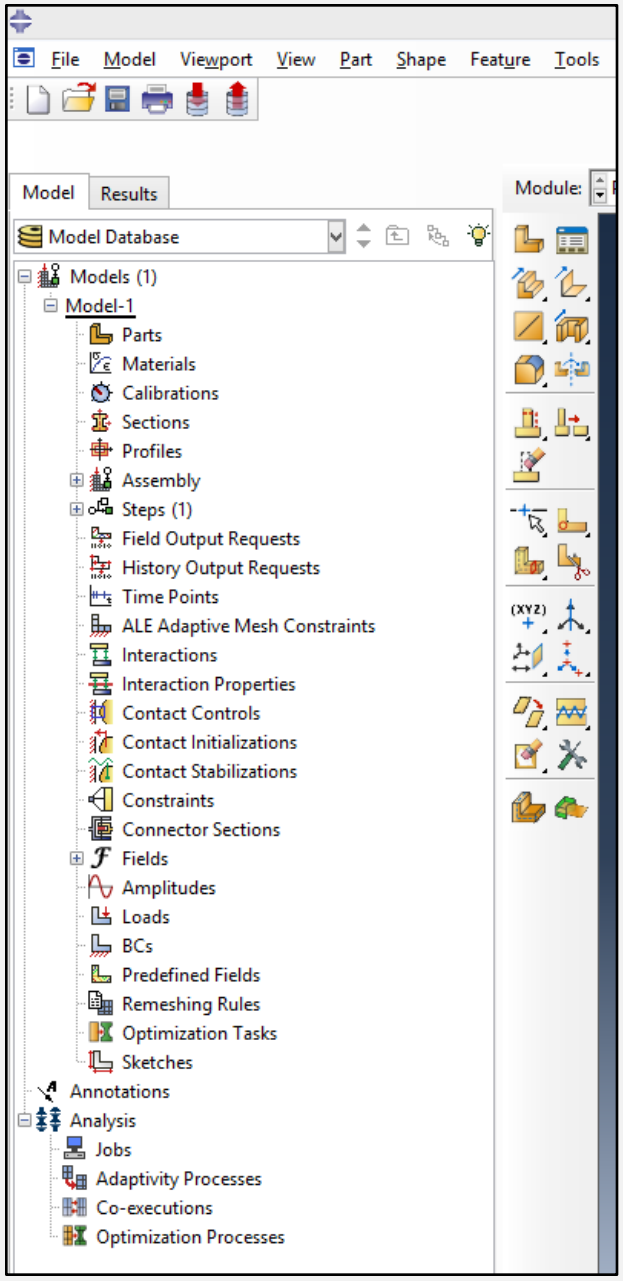
- Cohesive Element

Cohesive Behavior (MPa)		
K_{nn}	K_{ss}	K_{tt}
1,000,000	800,000	800,000
Quads Damage (MPa)		
Nominal Stress Normal-only mode	Nominal Stress First Direction	Nominal Stress Second Direction
30	60	60
Damage Evolution (kN) (Power BK =1)		
Normal Mode Fracture Energy	Shear Mode Fracture Energy First Direction	Shear Mode Fracture Energy Second Direction
0.2	0.8	0.8

ABAQUS MODELLING

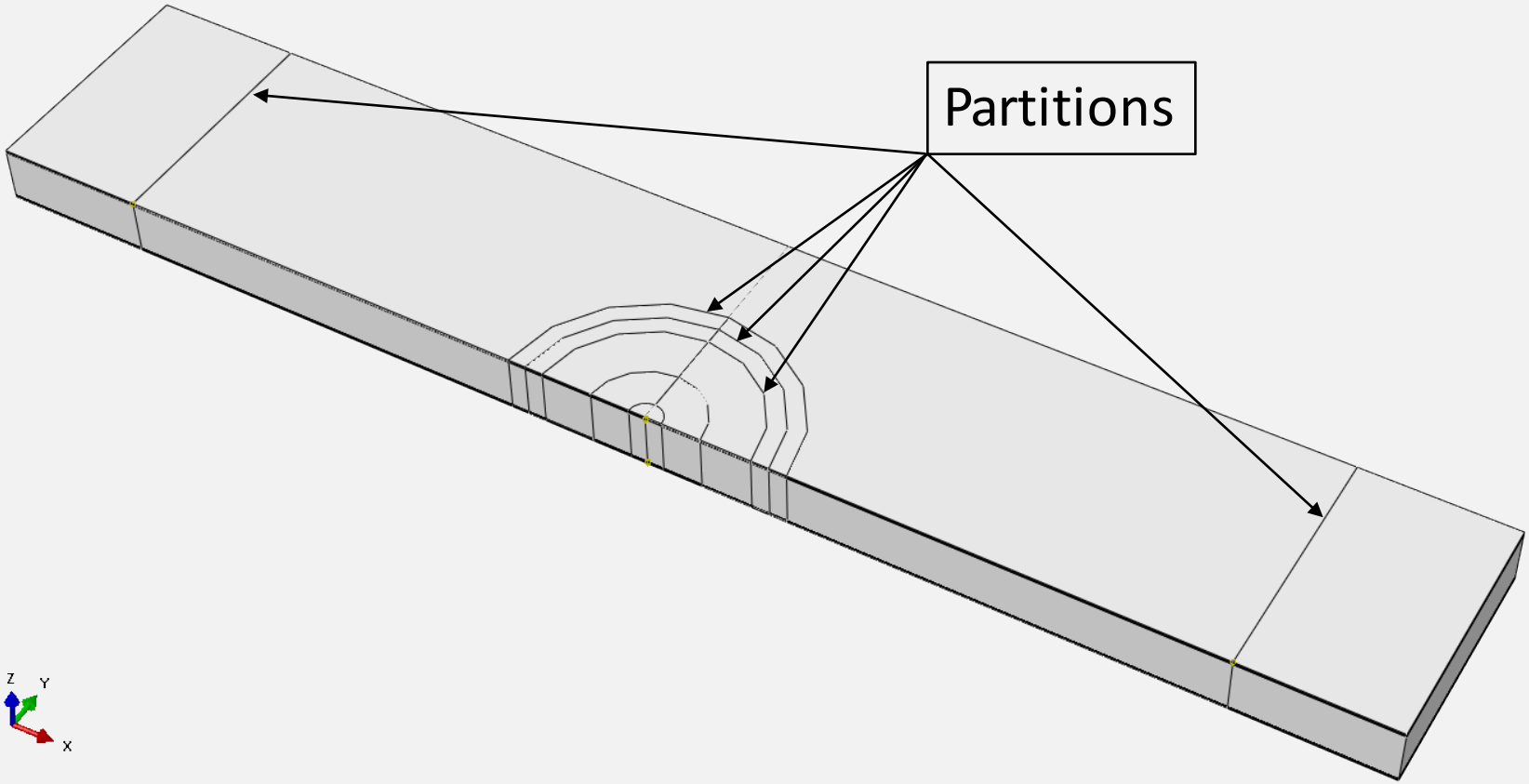
- 7 Modules:

1. Part
2. Property
3. Assembly
4. Step
5. Load
6. Mesh
7. Job



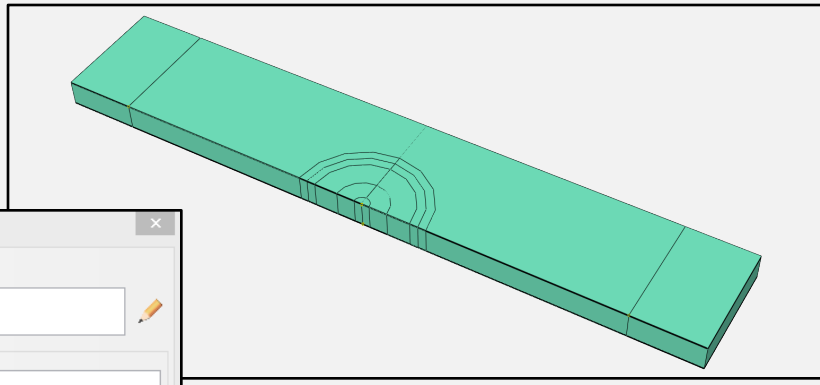
ABAQUS MODELLING (CONTD.)

1. PART



ABAQUS MODELLING (CONTD.)

2. PROPERTY & ASSEMBLY



Edit Material

Name: Ply

Description:

Material Behaviors

Hashin Damage
Damage Evolution
Elastic

General Mechanical Thermal Electrical/Magnetic Other

Elastic

Type: Engineering Constants

Suboptions

Use temperature-dependent data

Number of field variables: 0

Moduli time scale (for viscoelasticity): Long-term

No compression

No tension

Data

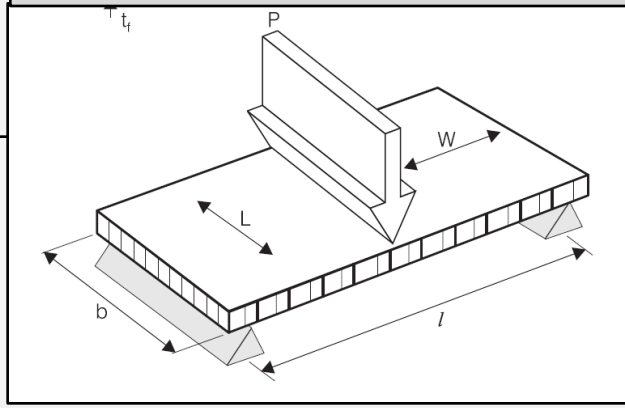
	E1	E2	E3	Nu12	Nu13	Nu23	G12	G13	G23
1	76000	5500	5500	0.34	0.34	0.4	2300	2300	1800

OK Cancel

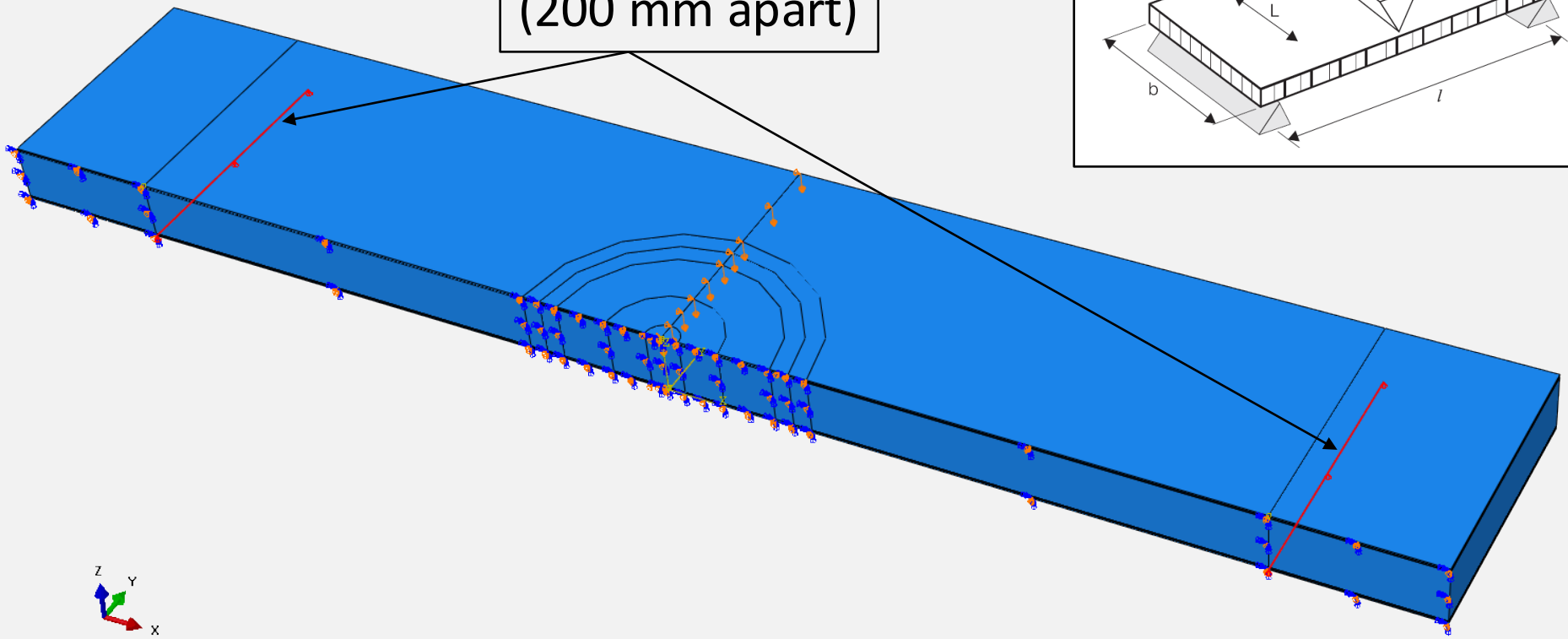
ABAQUS MODELLING (CONTD.)

3. STEP & LOAD

3-Point Bending

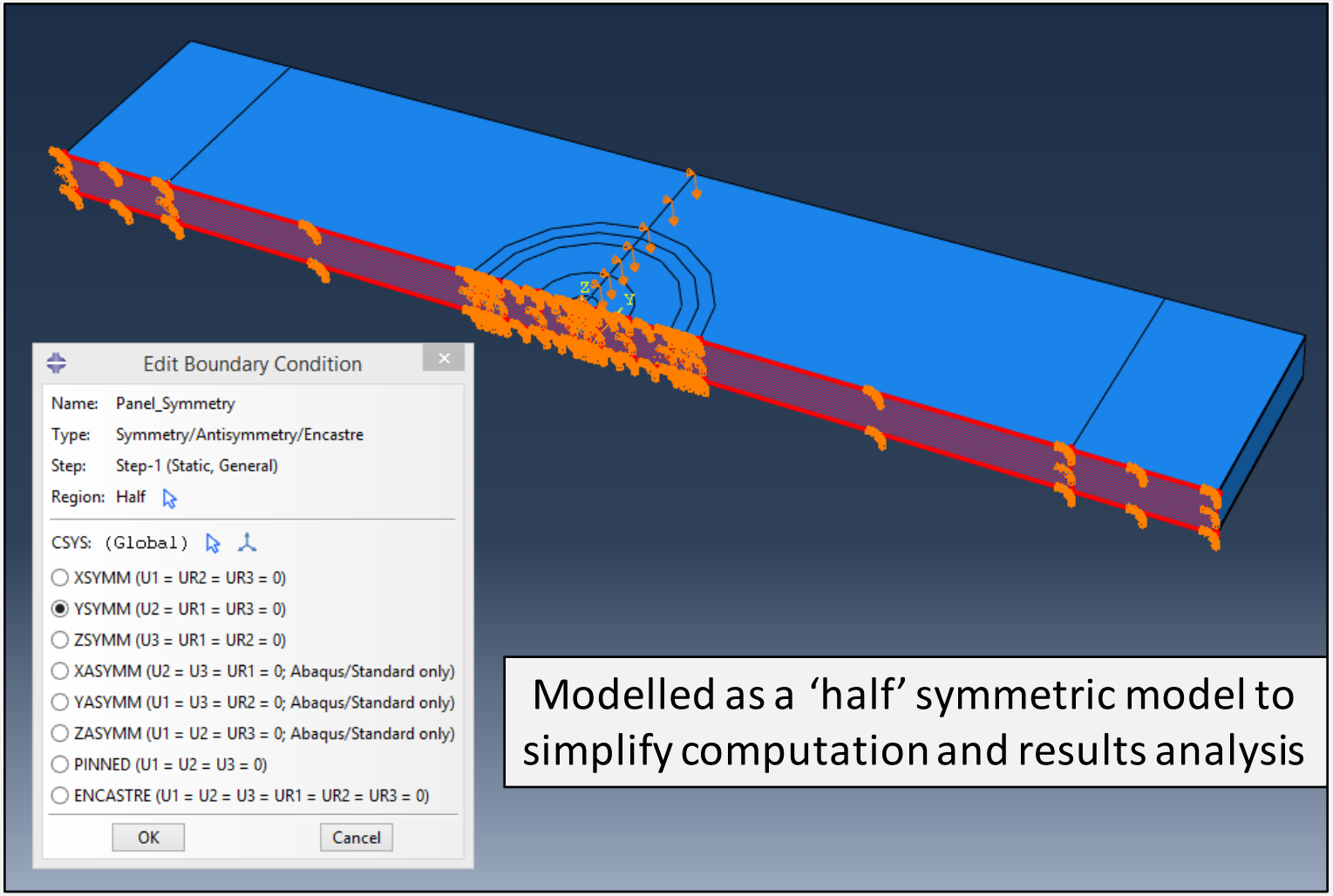


Supports
(200 mm apart)



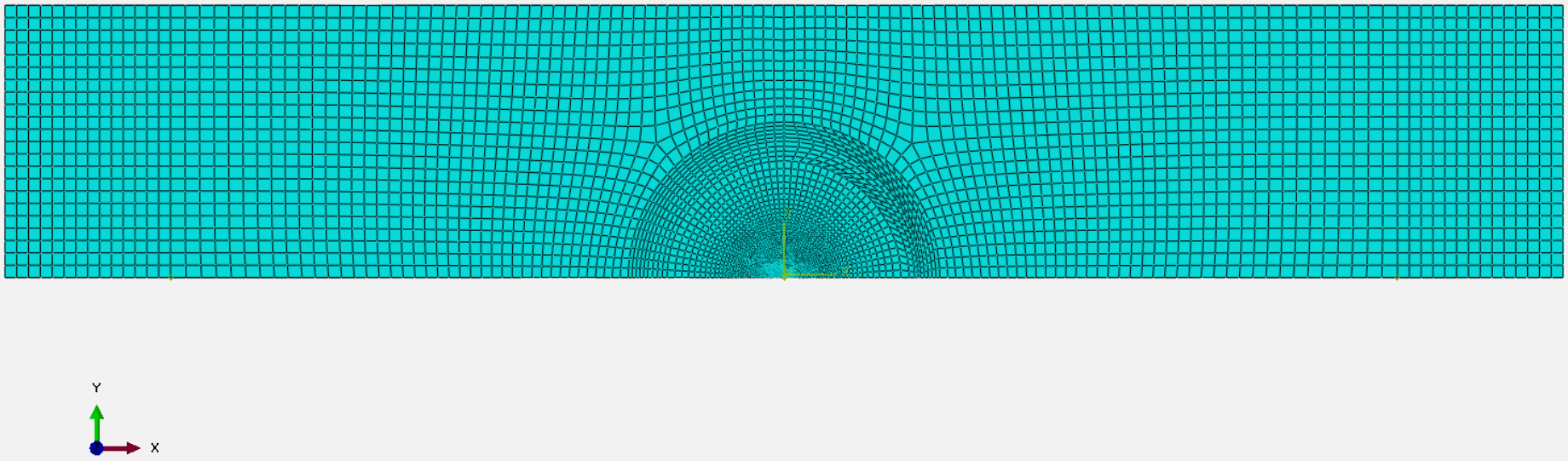
ABAQUS MODELLING (CONTD.)

3. STEP & LOAD

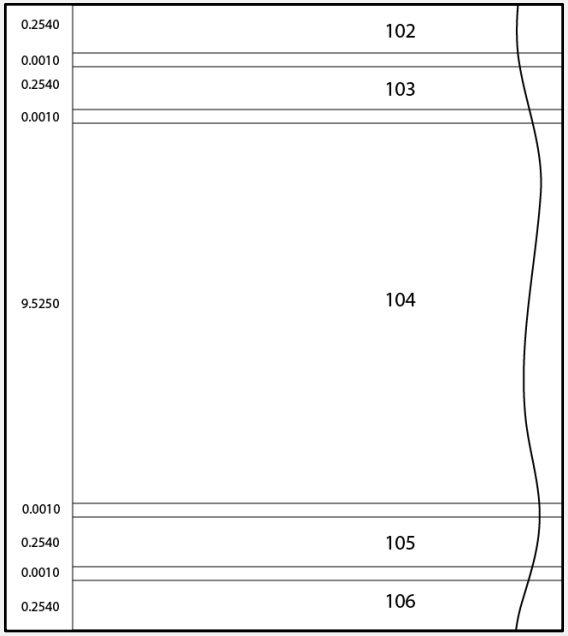


ABAQUS MODELLING (CONTD.)

4. MESH



TYPES OF MODELS



1. Unrepaired (Undamaged)

2. Circular Step-Sanded
3. Circular Taper-Sanded
4. Rectangular Step-Sanded

A. 102 and 103

B. 102, 103, & 104

TYPES OF MODELS (CONTD.)

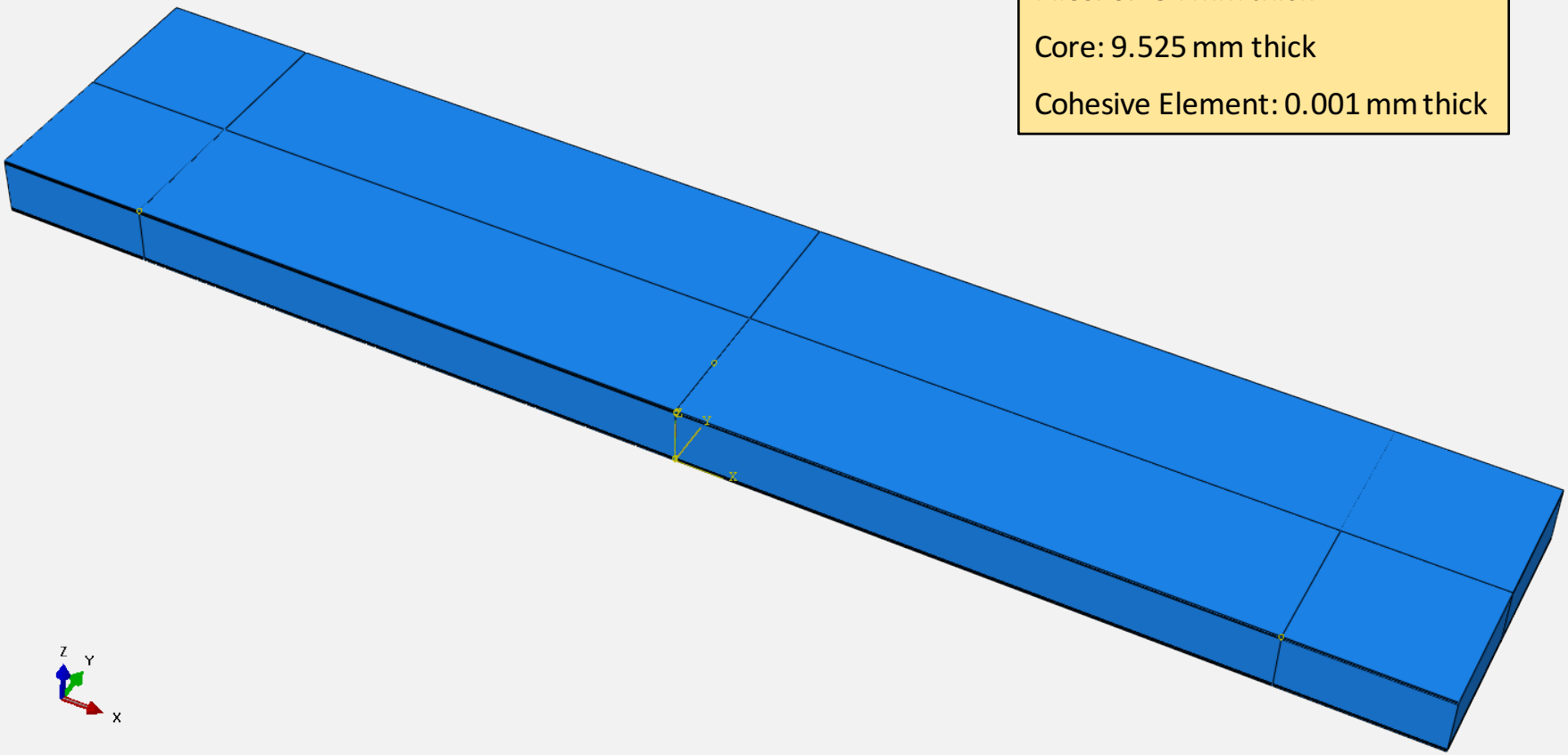
1. UNREPAIRED

Dimensions: 200 mm x 50 mm

Plies: 0.254 mm thick

Core: 9.525 mm thick

Cohesive Element: 0.001 mm thick

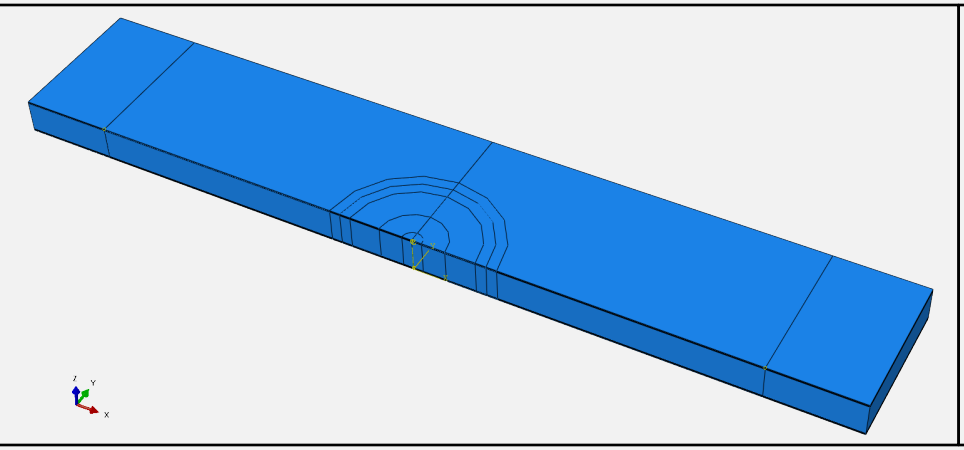


TYPES OF MODELS (CONTD.)

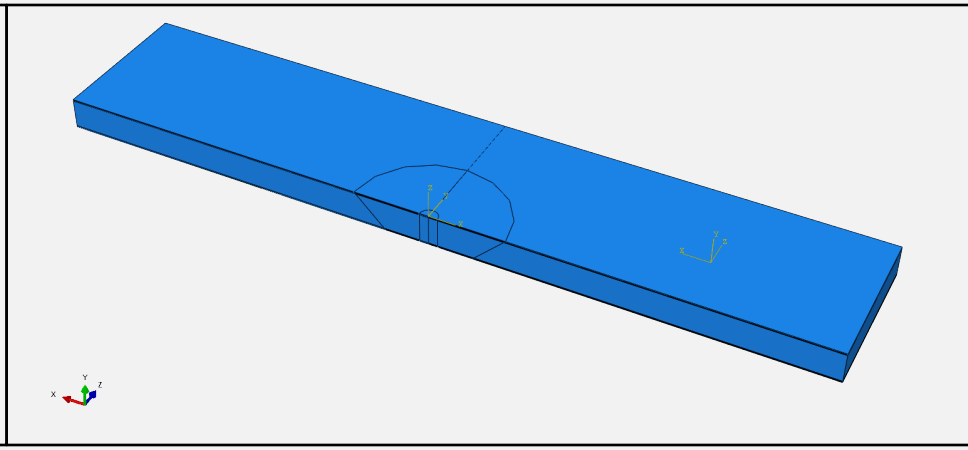
2. CIRCULAR SCARFED

Circular Patch (102) : R25.4 mm

Circular Step-Sanded

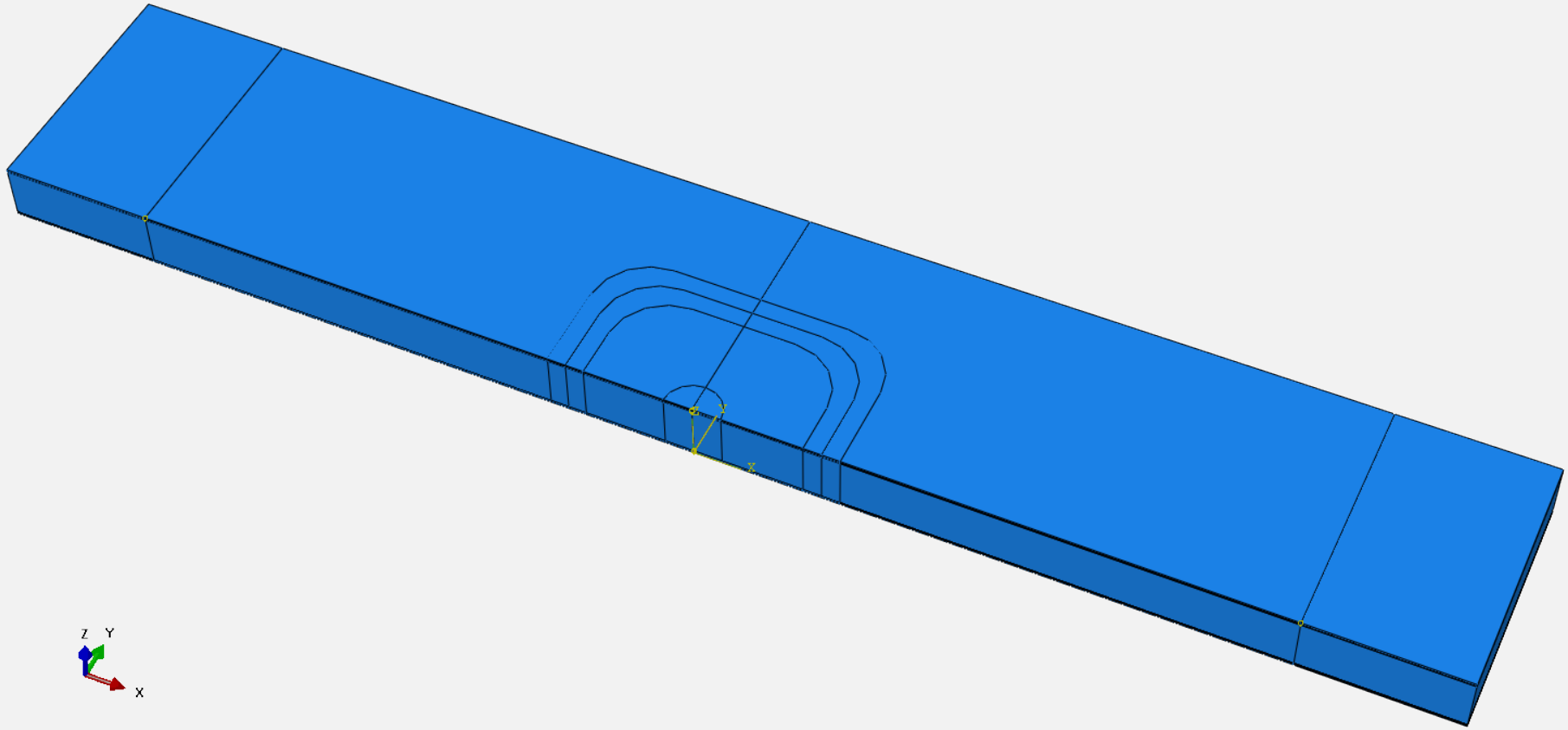


Circular Taper-Sanded

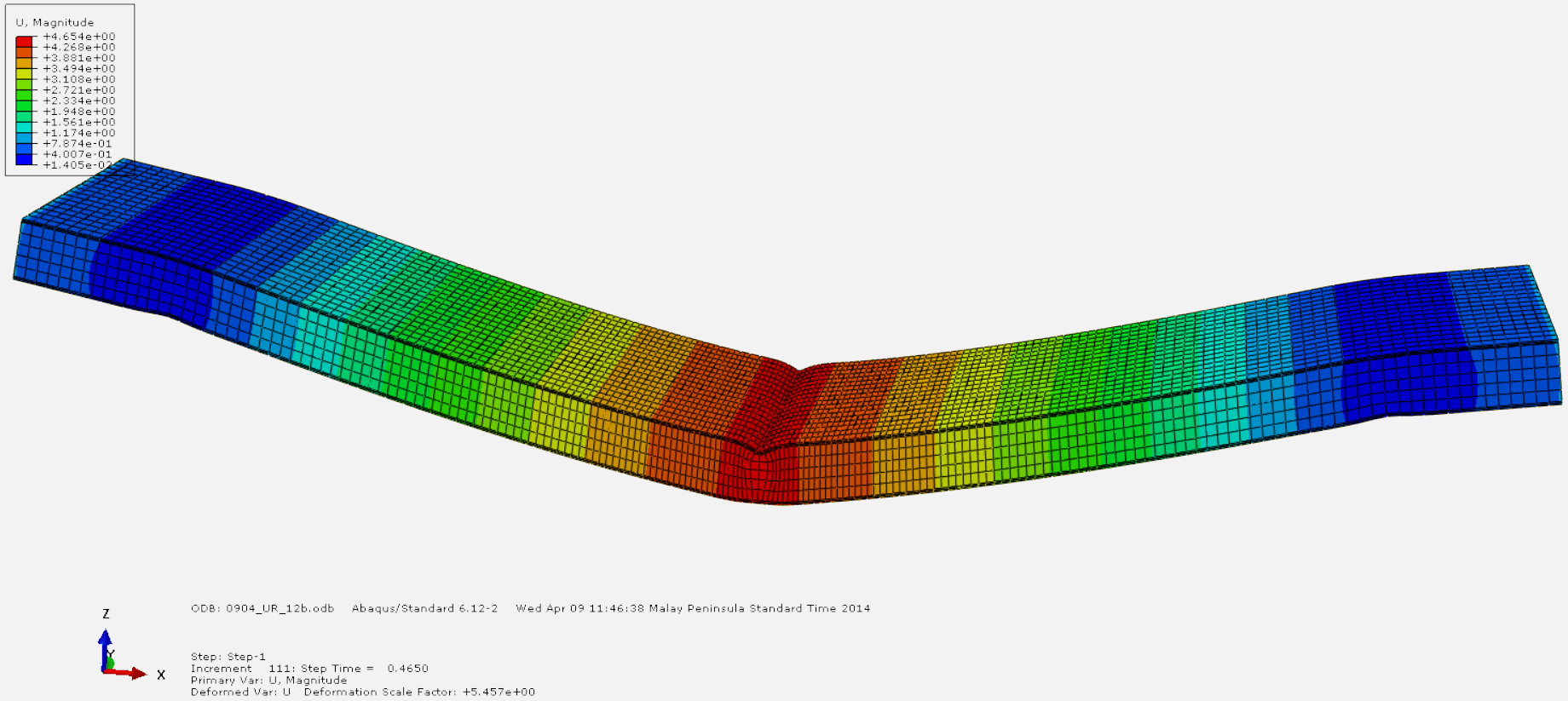


TYPES OF MODELS (CONTD.)

3. RECTANGULAR SCARFED



ANALYSIS OF RESULTS

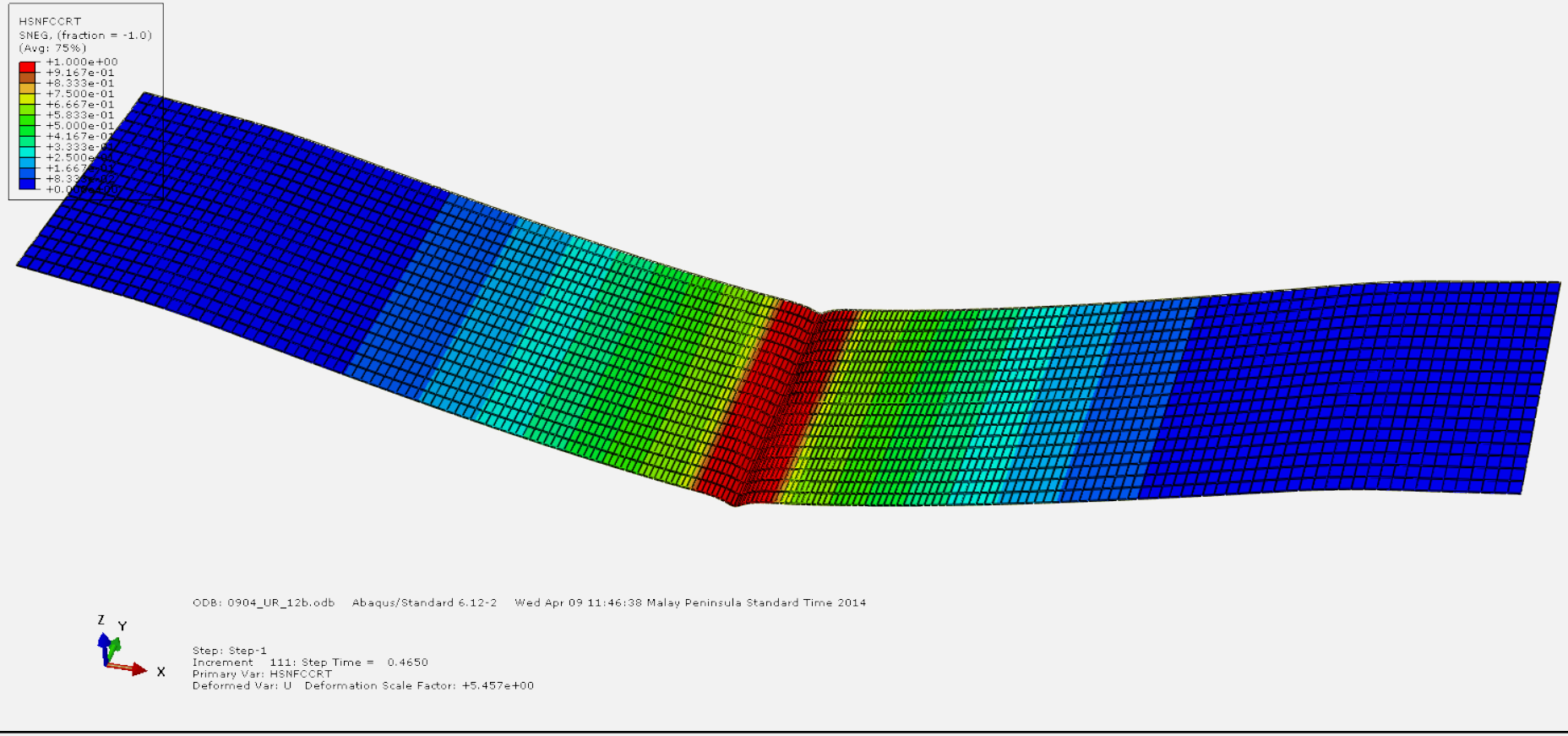


ANALYSIS OF RESULTS

- Reaction force at the loading nodes
  - ✓ Plot of Force vs. Displacement
  - ✓ Damage on 1st ply (102)
- Maximum force for various models compared
- Other results studied:
  - ✓ Stresses and damage patterns on plies, patches, cohesive elements and honeycomb core

ANALYSIS OF RESULTS (CONTD.)

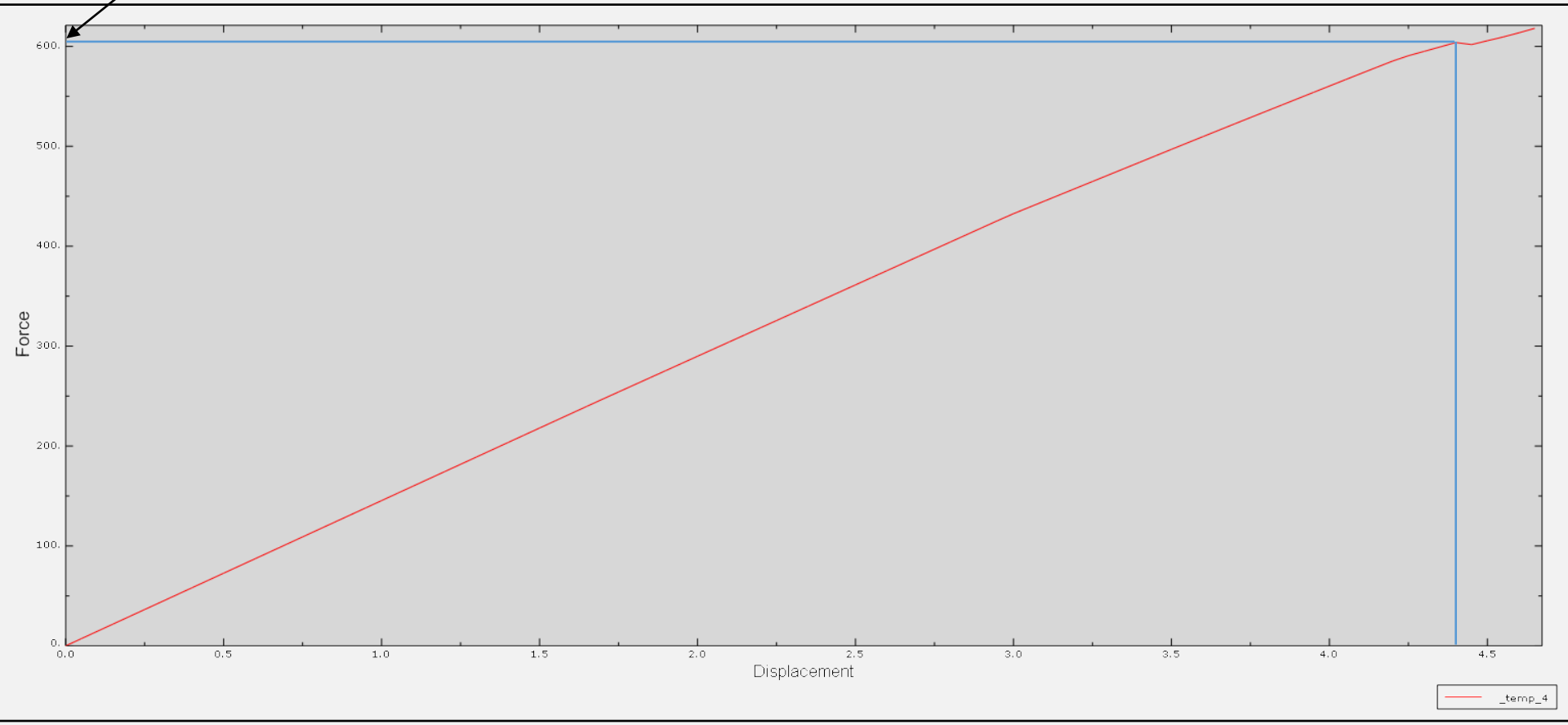
1. UNREPAIRED MODEL



ANALYSIS OF RESULTS (CONTD.)

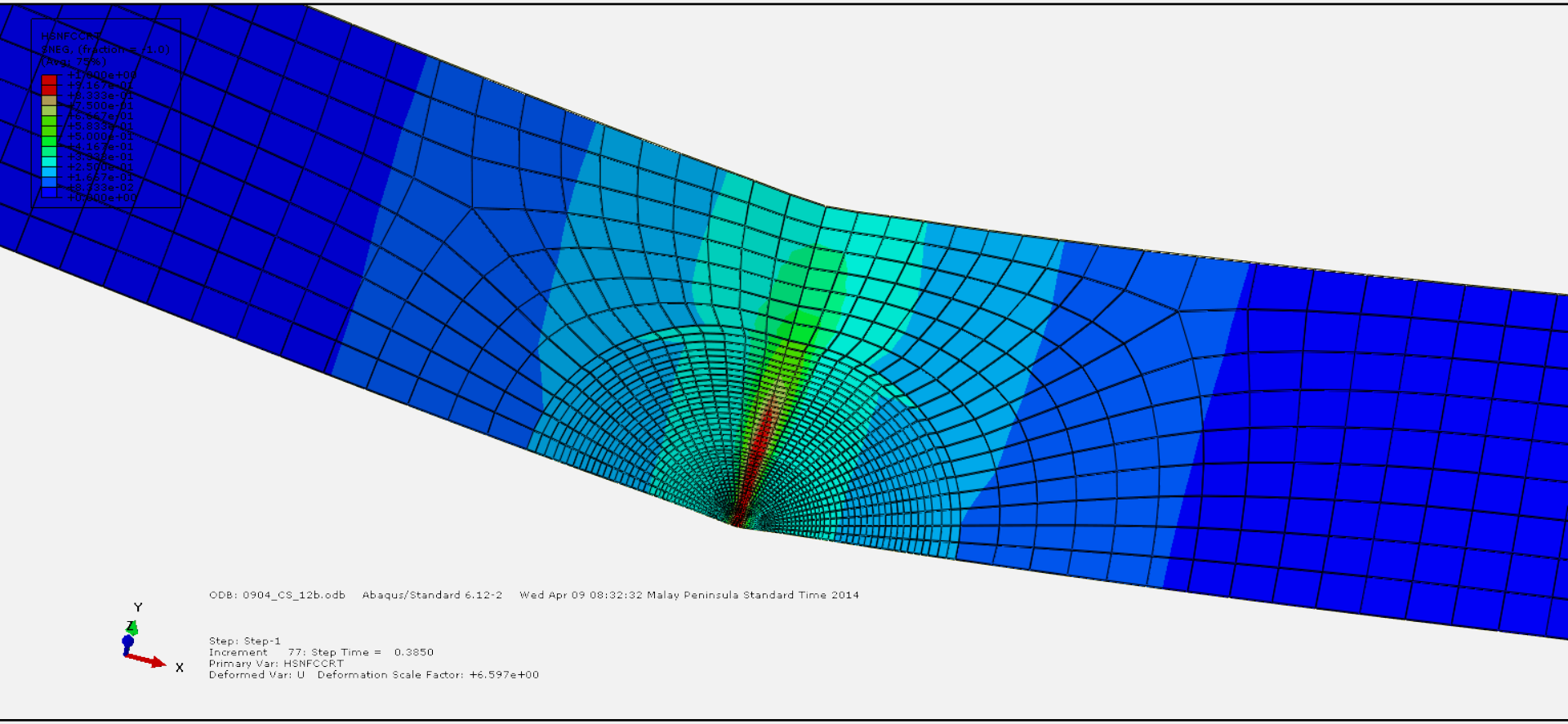
1. UNREPAIRED MODEL

605 N



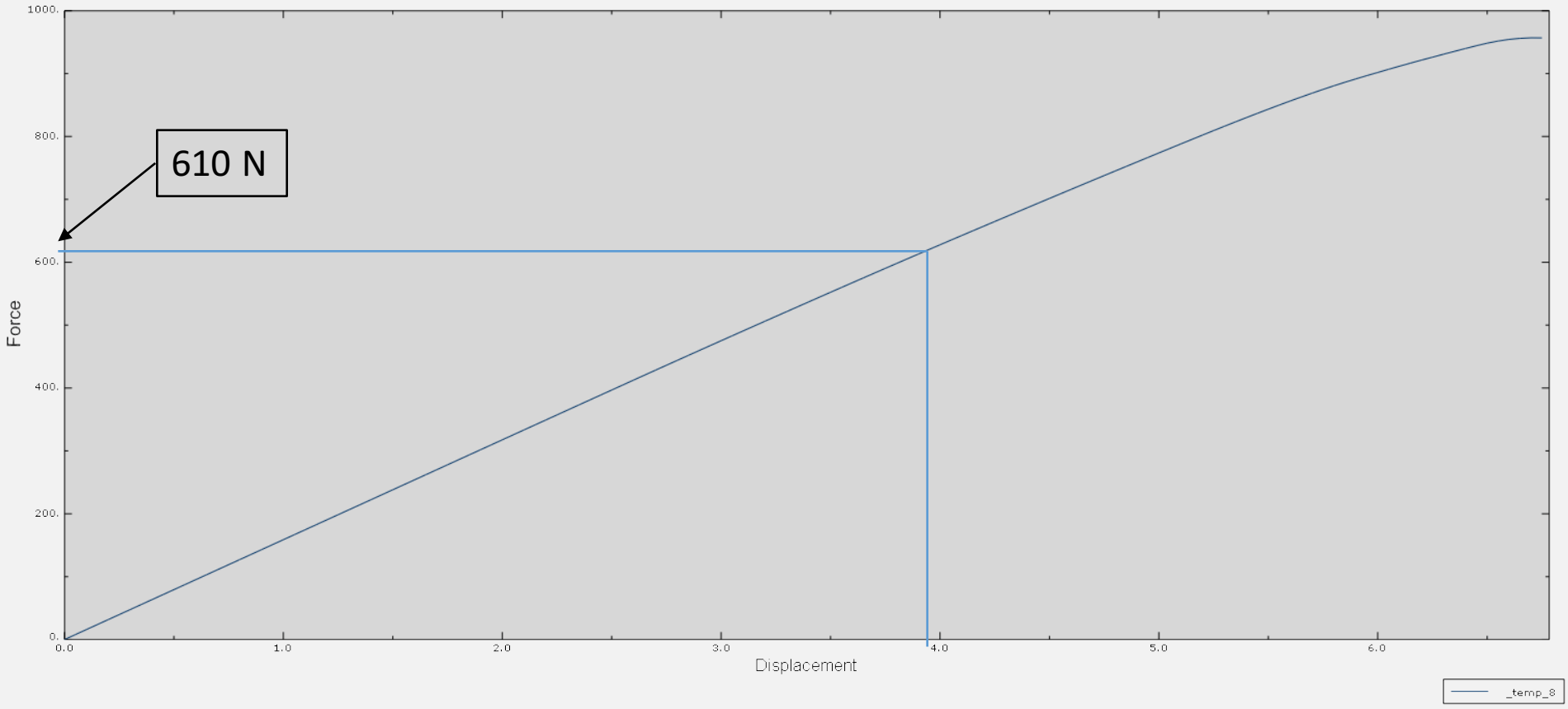
ANALYSIS OF RESULTS (CONTD.)

2. CIRCULAR SCARFED MODEL



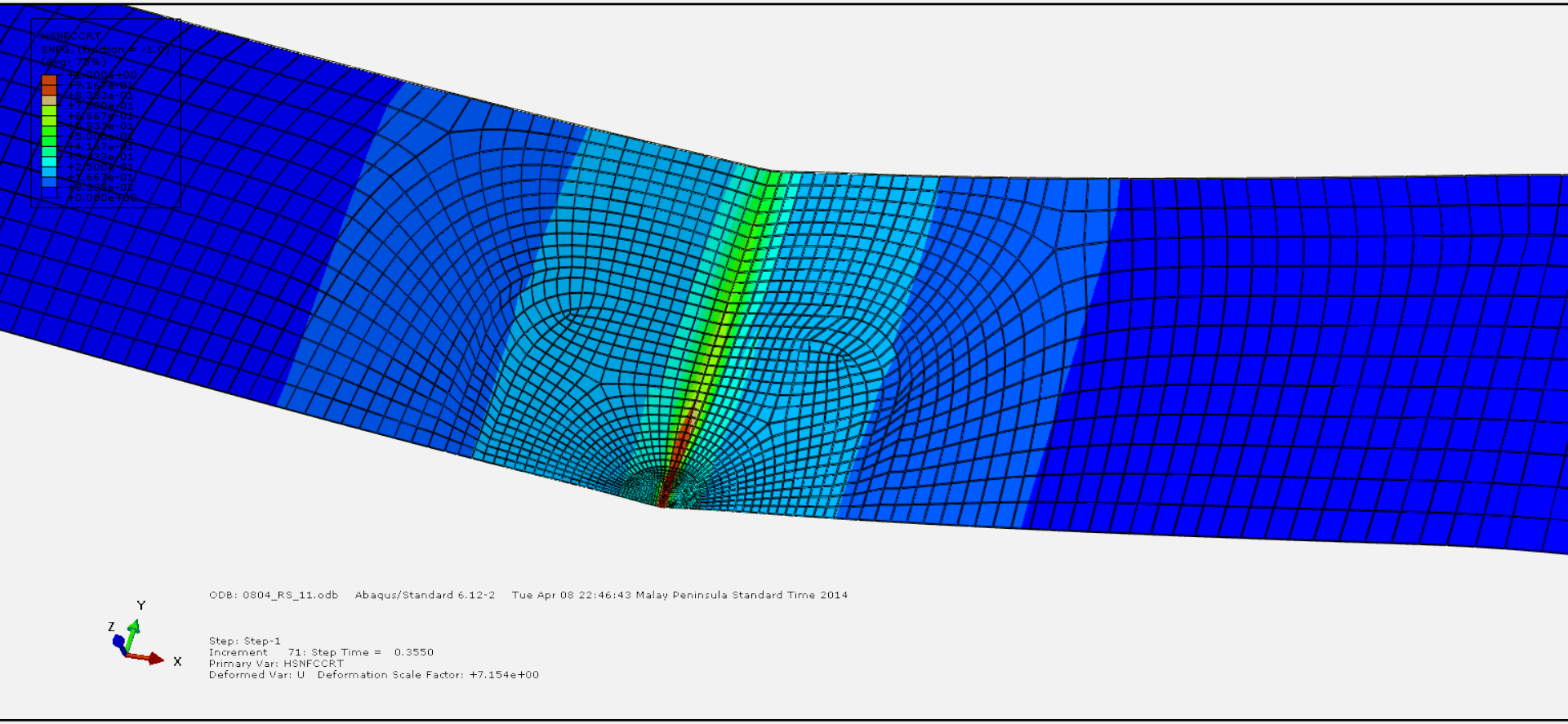
ANALYSIS OF RESULTS (CONTD.)

2. CIRCULAR SCARFED MODEL



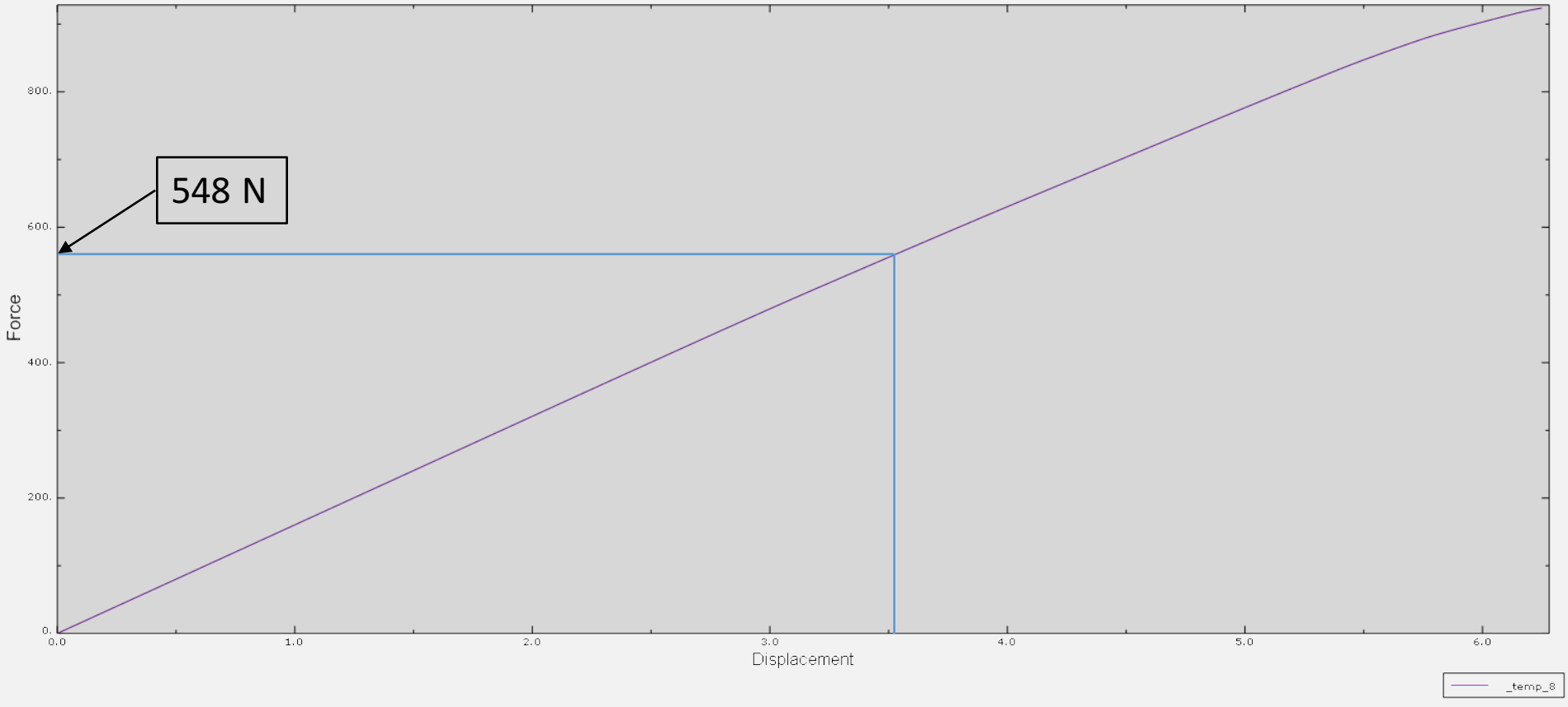
ANALYSIS OF RESULTS (CONTD.)

3. RECTANGULAR SCARFED MODEL



ANALYSIS OF RESULTS (CONTD.)

3. RECTANGULAR SCARFED MODEL



ANALYSIS OF RESULTS (CONTD.)

SUMMARY

MAXIMUM LOAD (kN)		
Undamaged Panel	Repaired Panel (Circular Scarfed)	Repaired Panel (Rectangular Scarfed)
0.605	0.610	0.548

CONCLUSION

- ✓ The optimum repair method and parameters were determined and validated
- ✓ Simulate various models using FEA to determine the optimum model and parameters for the chosen repair method – [scarf repair] (NUS & PKU)
- ✓ The optimum repair method was validated (for its mechanical performance) by fabricating the model and conducting 3-point bending test (UofT)