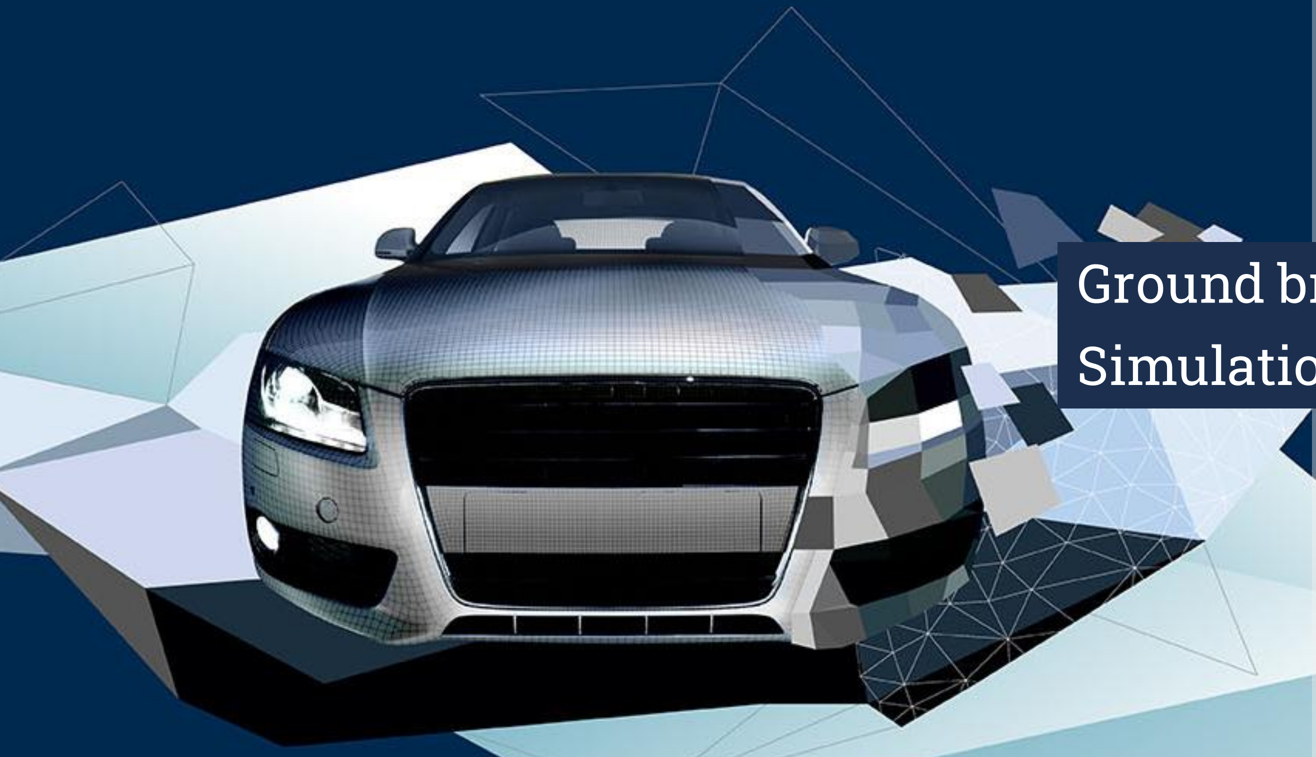
BETA

SIMULATION SOLUTIONS



Ground breaking Simulation Solutions

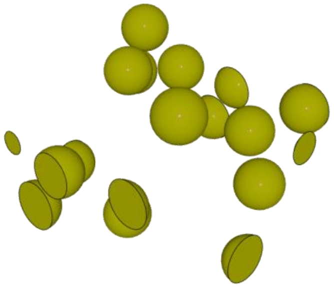
physics on screen

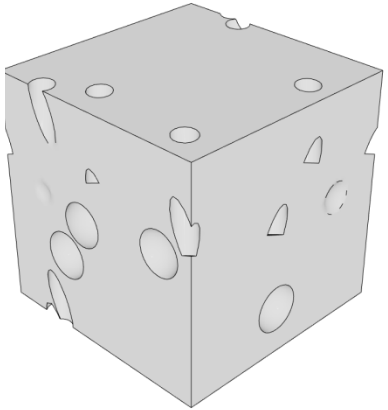
Non Linear Multi-scale Modeling of Composite Materials using ANSA tools

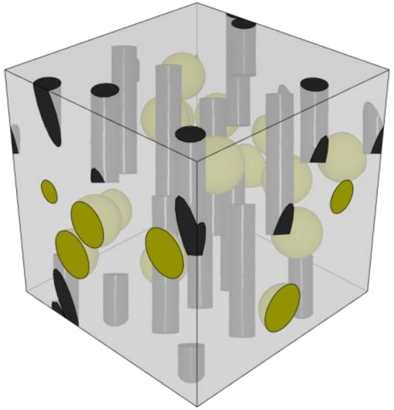
Eleftherios Tsivolas, Vangelis Palaiokastritis

physics on screen

Composite Materials Modeling -Engineering challenges



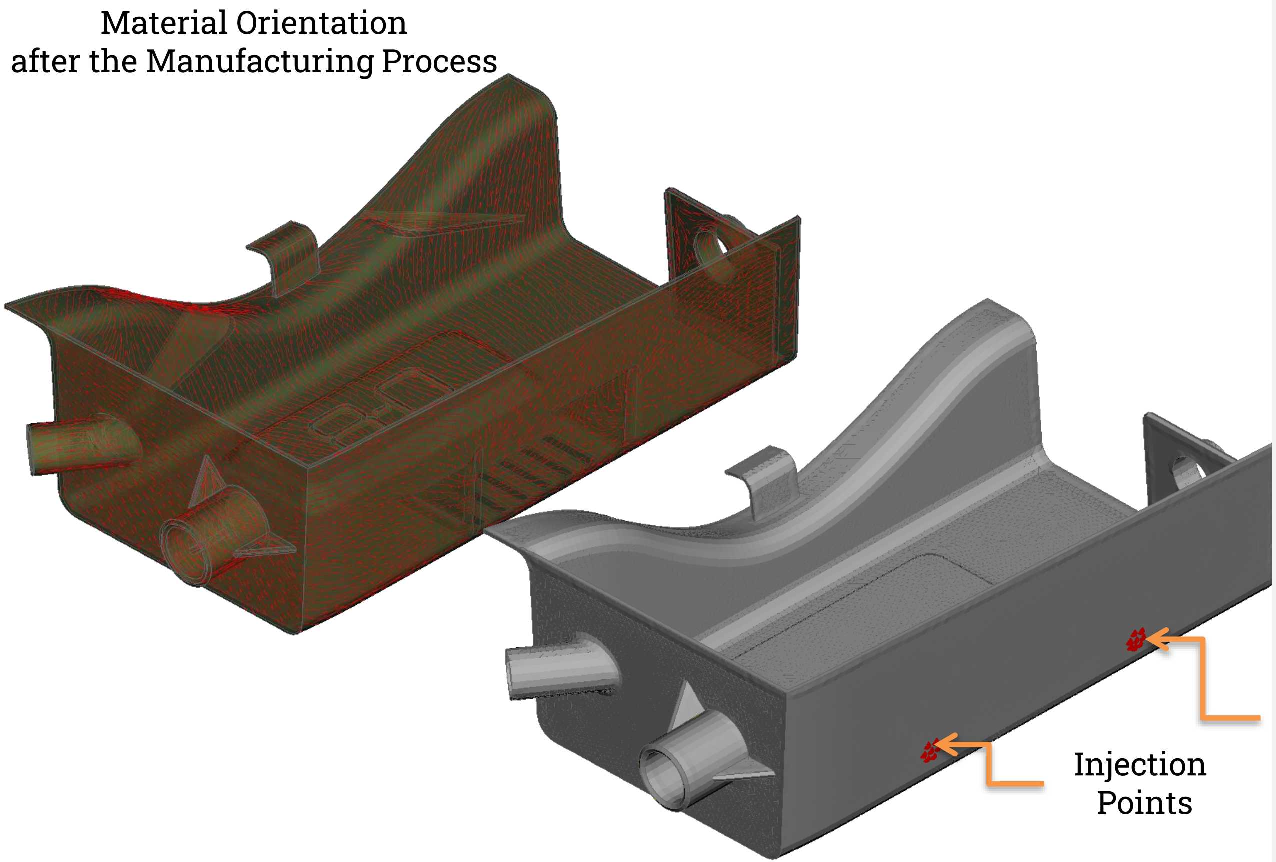




Mean Field
Homogenization

- Multi-Scale Approach
- Manufacturing Process Simulation
- Macro & Micro Structural Analysis

Composite Materials Modeling -Engineering challenges



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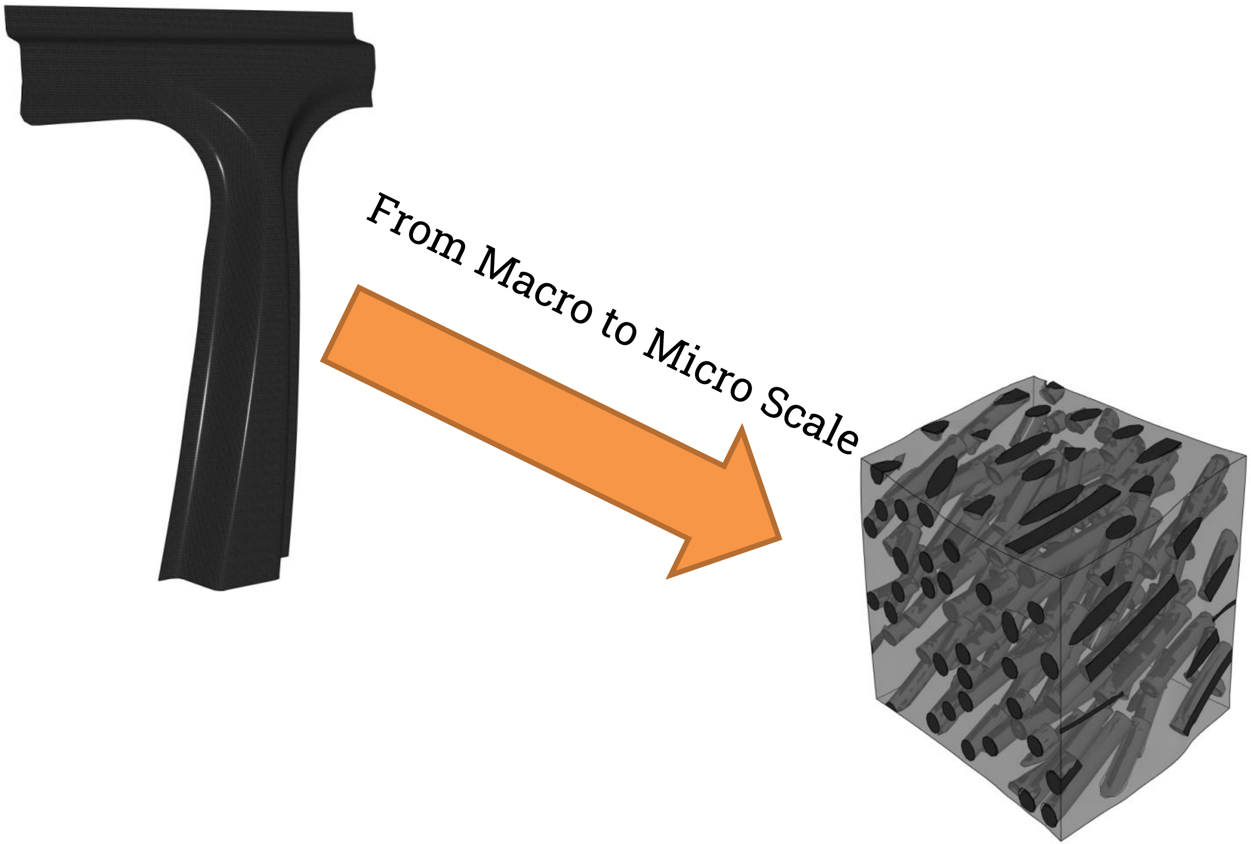
Composite Materials Modeling -Engineering challenges



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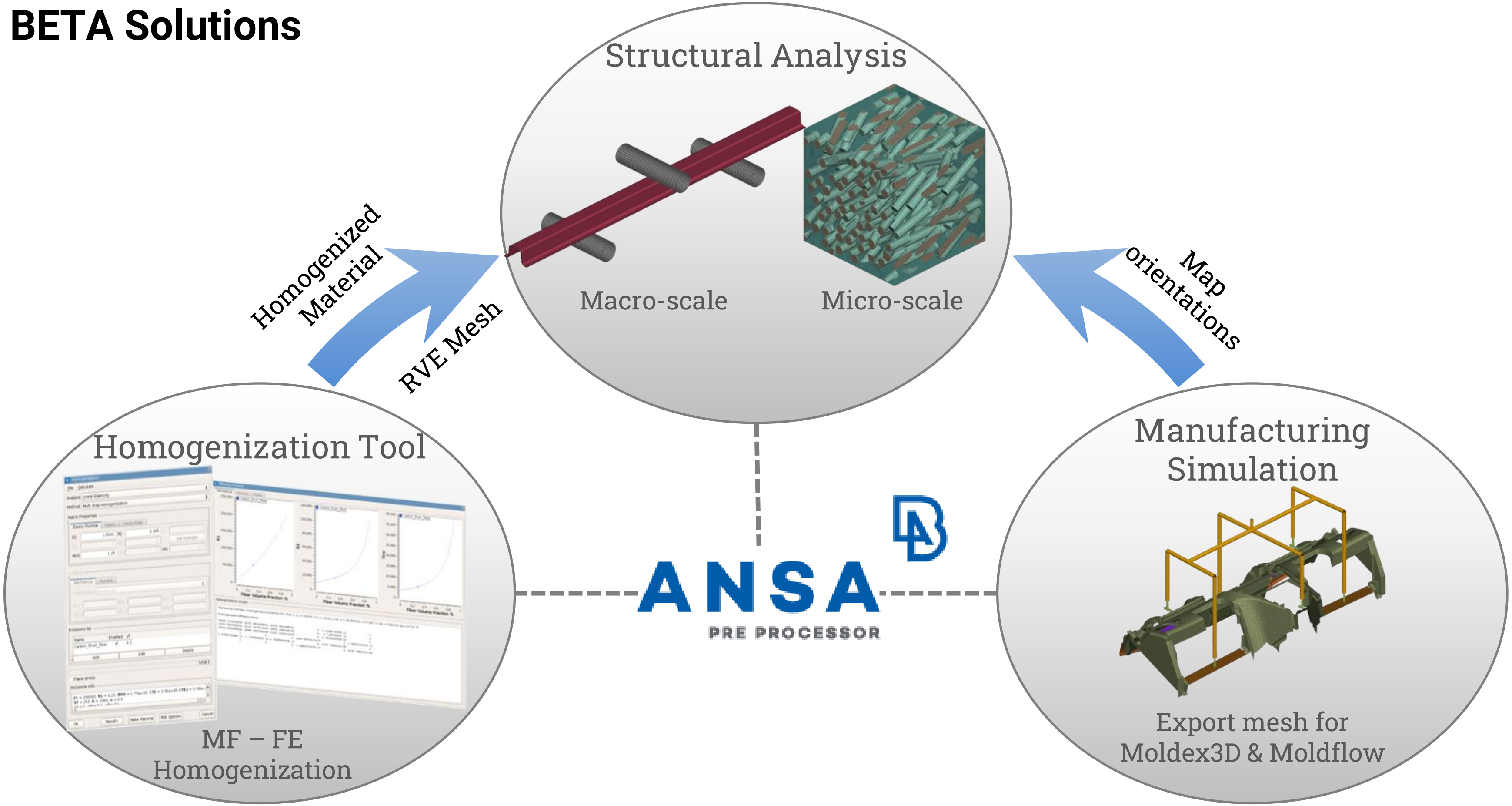
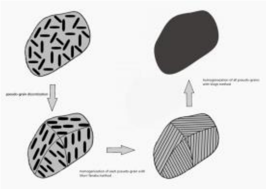
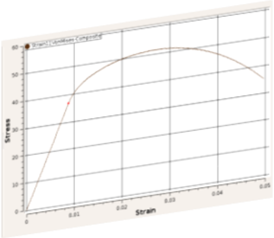
BETA Solutions



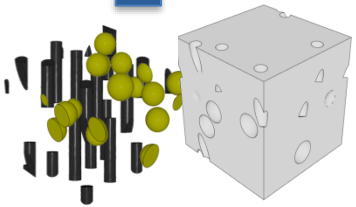
Homogenization Tool: Mean Field Homogenization



Homogenization



Material Model Export for Solvers

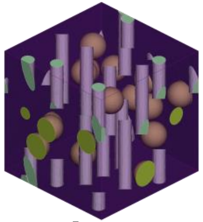


Matrix & Inclusion properties

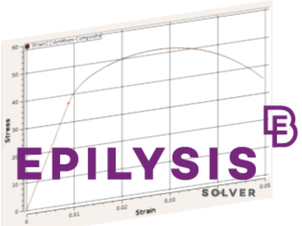
Methods	Material Models	Solvers
✔ Multistep	✔ Elastic	✔ Epilysis
✔ Mori-Tanaka	✔ Thermo-elastic	✔ Nastran
✔ Voigt	✔ Visco-elastic	✔ Abaqus
✔ Reuss	✔ Elasto-plastic & failure	✔ ANSYS
✔ Method of Cells	✔ Thermo-elasto- plastic & failure	✔ LS-DYNA
		✔ Radioss
	✔ Elasto-plastic-damage & failure	✔ Pam-Crash
	✔ Elasto-visco-plastic & failure	✔ PERMAS
		✔ OptiStruct
	✔ Thermal conductivity	

- Homogenization Methods
- Material Models
- Material Output for multiple solvers

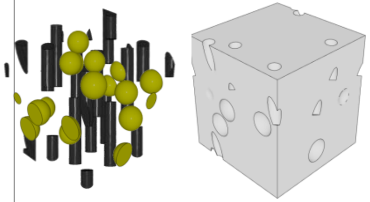
Homogenization Tool: Representative Volume Element (RVE) Mesh Generation



RVE Mesh Generation
(Random Sequential
Adsorption)



FE Homogenization



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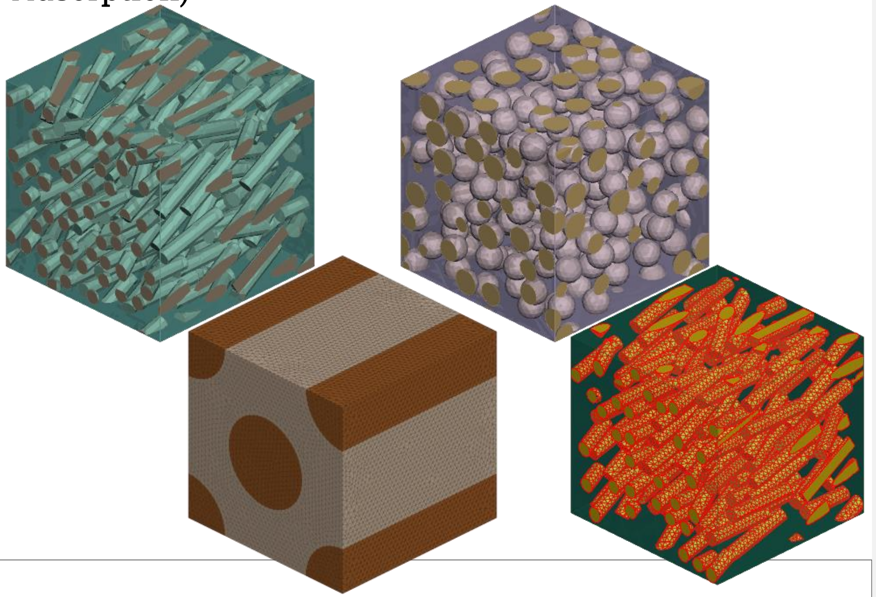


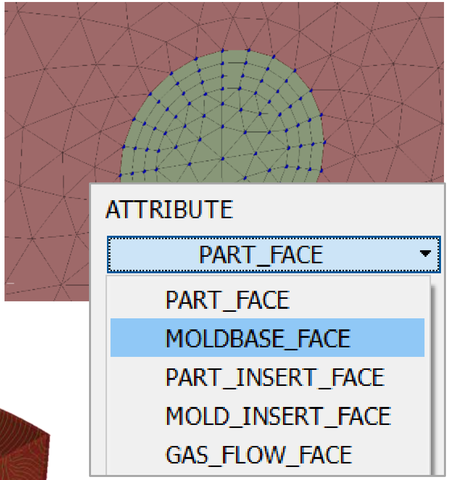
- Microstructure:
  Short fiber
  Long fiber
  Sphere Particles
  Multiple Inclusions
  Cohesive Interface

- FE Homogenization with Epilysis

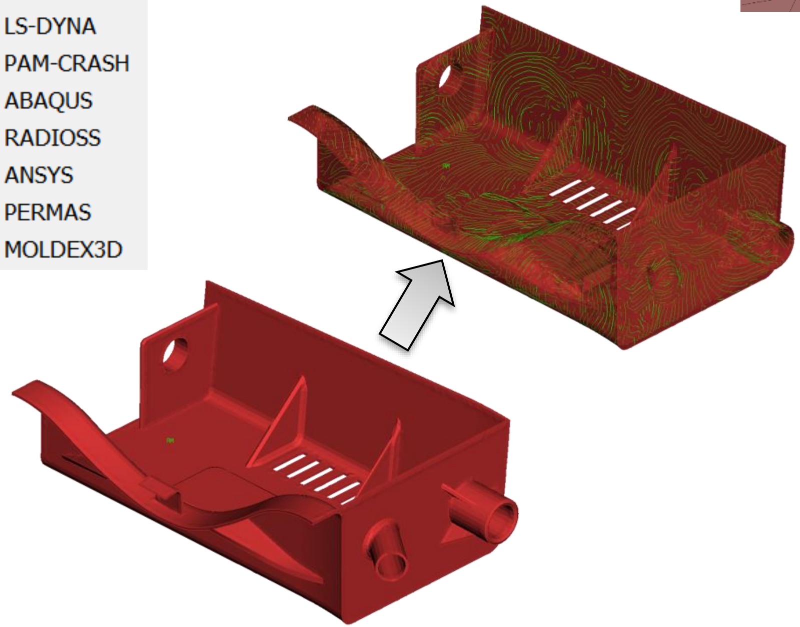
Molding Analysis Supported Decks:

*.msh *.mfe

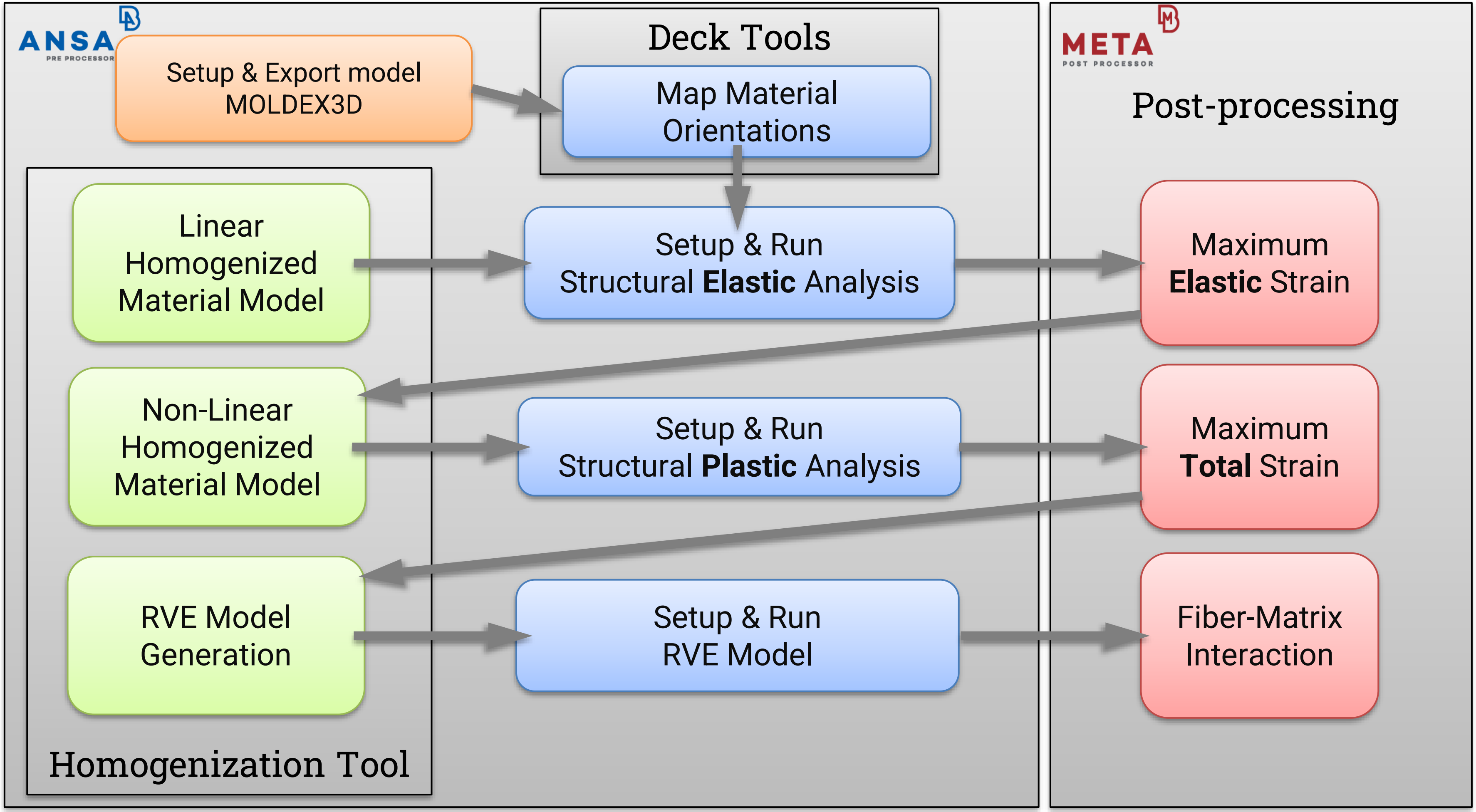
*.udm



- NASTRAN
- LS-DYNA
- PAM-CRASH
- ABAQUS
- RADIOSS
- ANSYS
- PERMAS
- MOLDEX3D

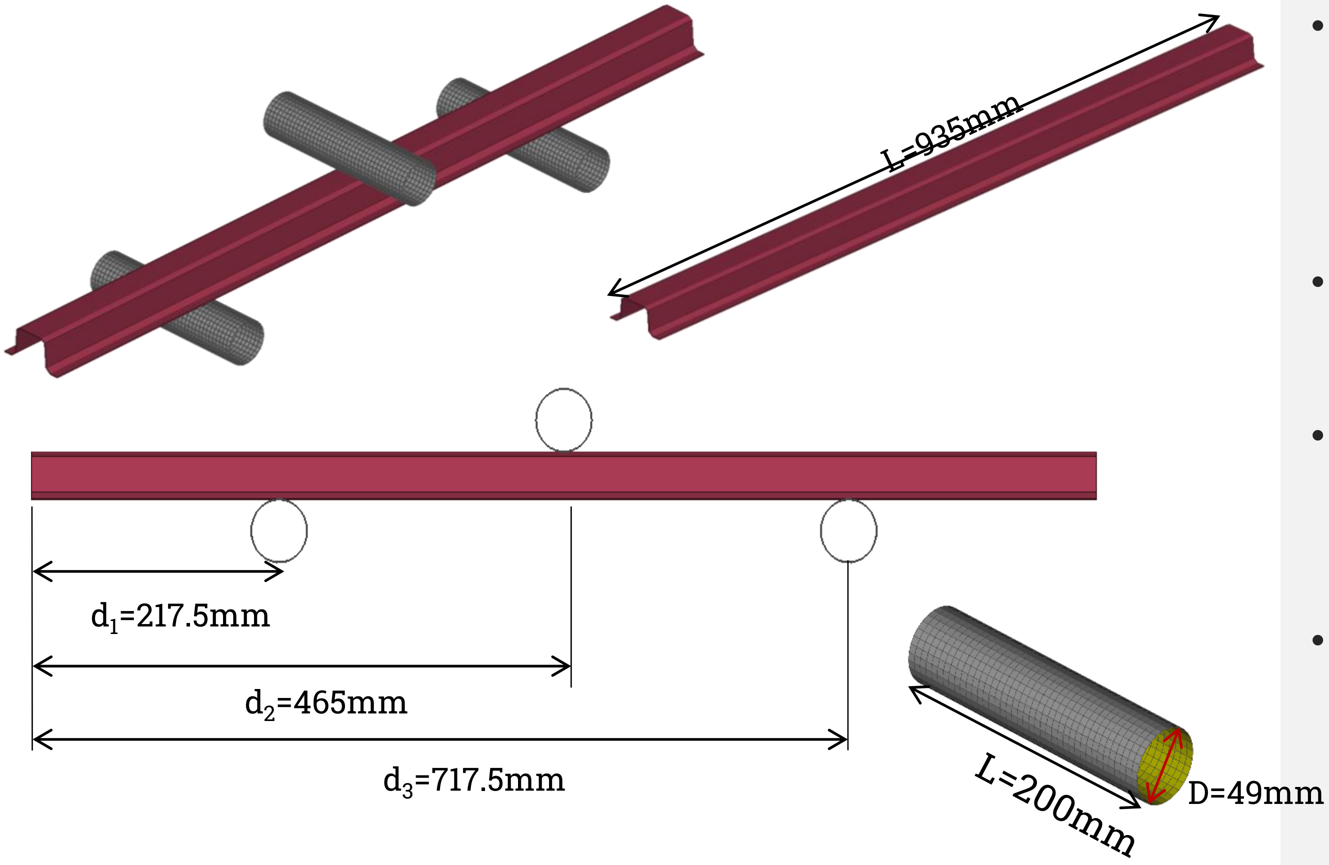


- I/O Moldex3d and Moldflow files
- Special molding environment
- Solver Entities:
  Point attributes
  Face & Pipe attributes
  Wizard for pipes creation
- Interoperability between decks
  Map Orientations & Homogenization



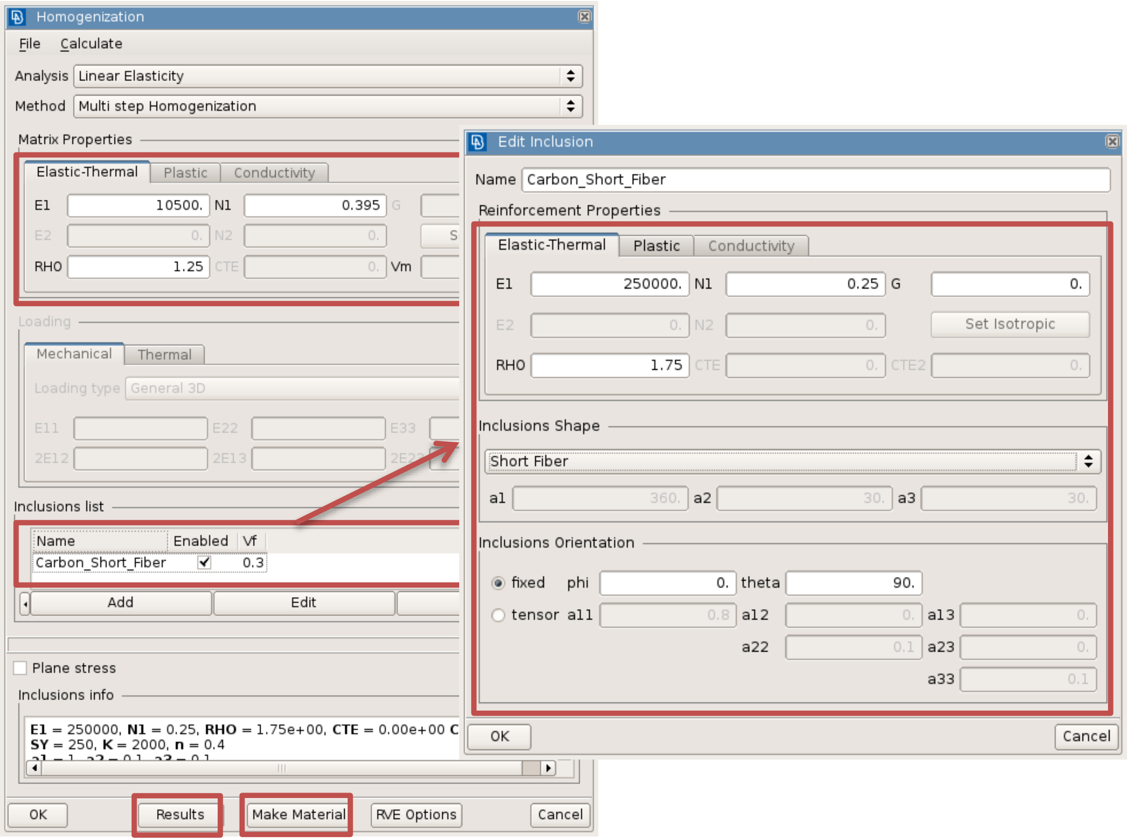
Workflow for multi-scale analysis of Composite components

Case Study: Geometry – FE Model



- Beam model:
  Solid mesh
  40392 HEXAs
  Thickness = 1mm
- Subjected into:
  3 Point Bending Test
- Aluminium Material:
  E = 68.9 GPa
  Rho = 2.7 kg/m^3
- Bending Jigs:
  3D Rigid Body

Case Study: Calculate Linear Elastic Composite Material



- Target Modulus

E_{alumin} = 68.9 GPa
Rho_{alumin} = 2.7 kg/m^3

- Constituents

Resin Epoxy:
E_{matrix} = 10.5 GPa
Rho_{matrix} = 1.25 kg/m^3

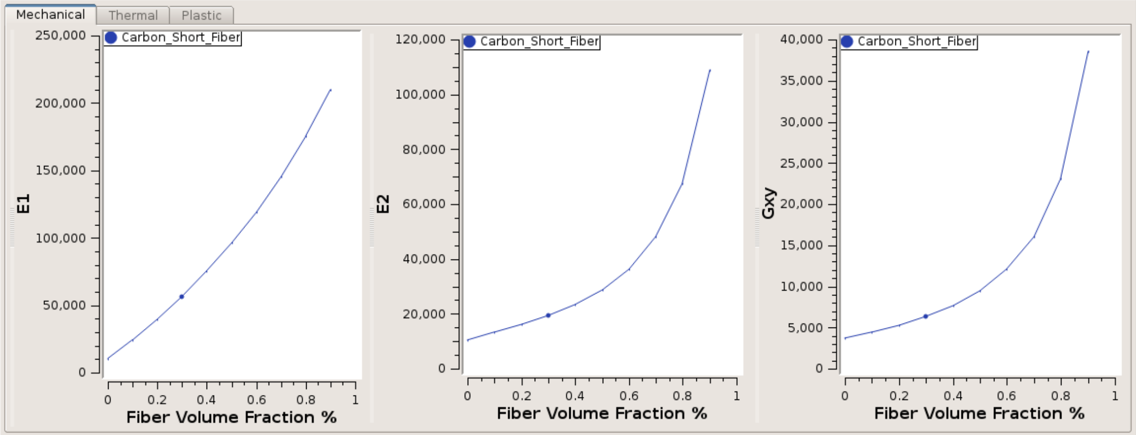
Short Carbon Fibers:
E_{fiber} = 250 GPa
Rho_{fiber} = 1.75 kg/m^3
aspect ratio = 12
v_f = 30%

- Composite's Properties

E_{1comp} = 56.6 GPa
Rho_{comp} = 1.4 kg/m^3

Case Study: Calculate Linear Elastic Composite Material

Effective Property



Homogenization results

Transversly isotropic homogenized properties for Vf=0.3: E1 = 56636.2 E2 = 19322.2 N1 = 0.363468 N2 = 0.536172 Gxy = 6289.09 Gyz = 6729.76

Homogenized stiffness tensor

70298.1243934928	18793.8915908201	18793.8915908201	0.	2.3295670299E-12	0.
18793.8915908201	32142.6335119425	19564.4582496189	0.	-4.718359961E-14	0.
18793.8915908201	19564.4582496189	32142.6335119425	0.	6.7829590343E-15	0.
0.	0.	0.	6289.08763116178	0.	2.6983279323E-14
2.3295670299E-12	-4.718359961E-14	6.7829590343E-15	0.	6729.75802431755	0.
0.	0.	0.	2.6983279323E-14	0.	6729.75802431755

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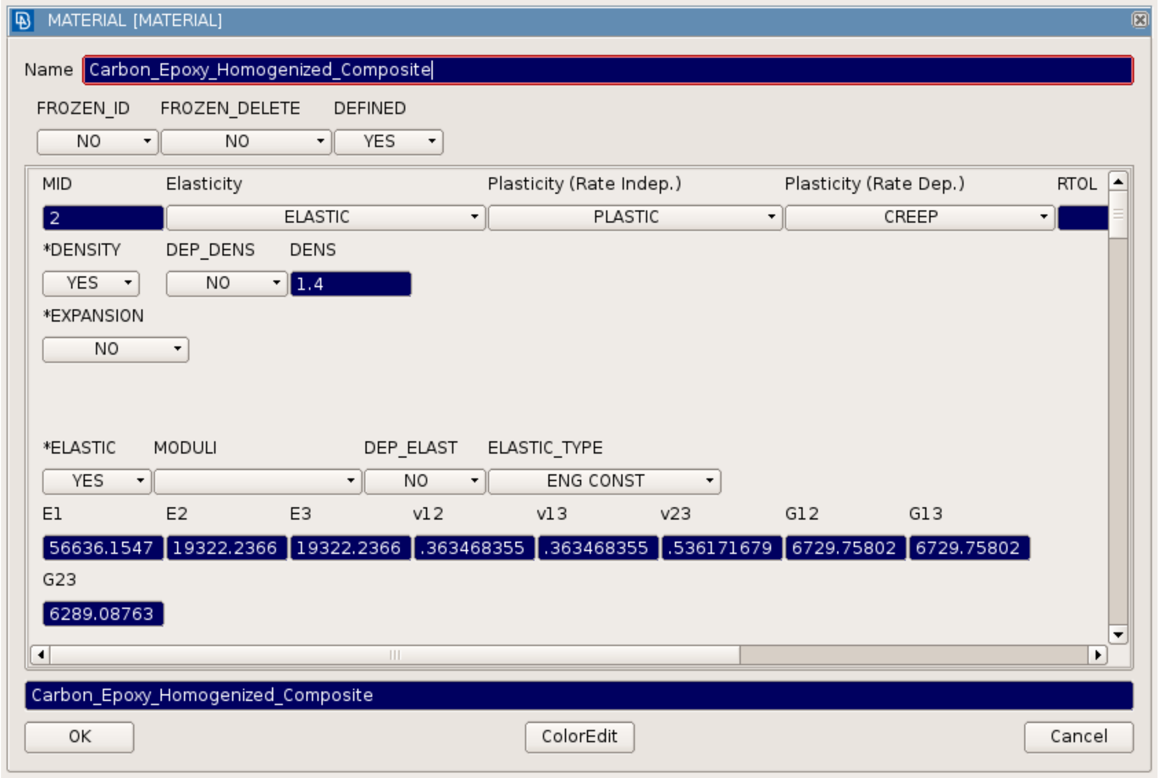

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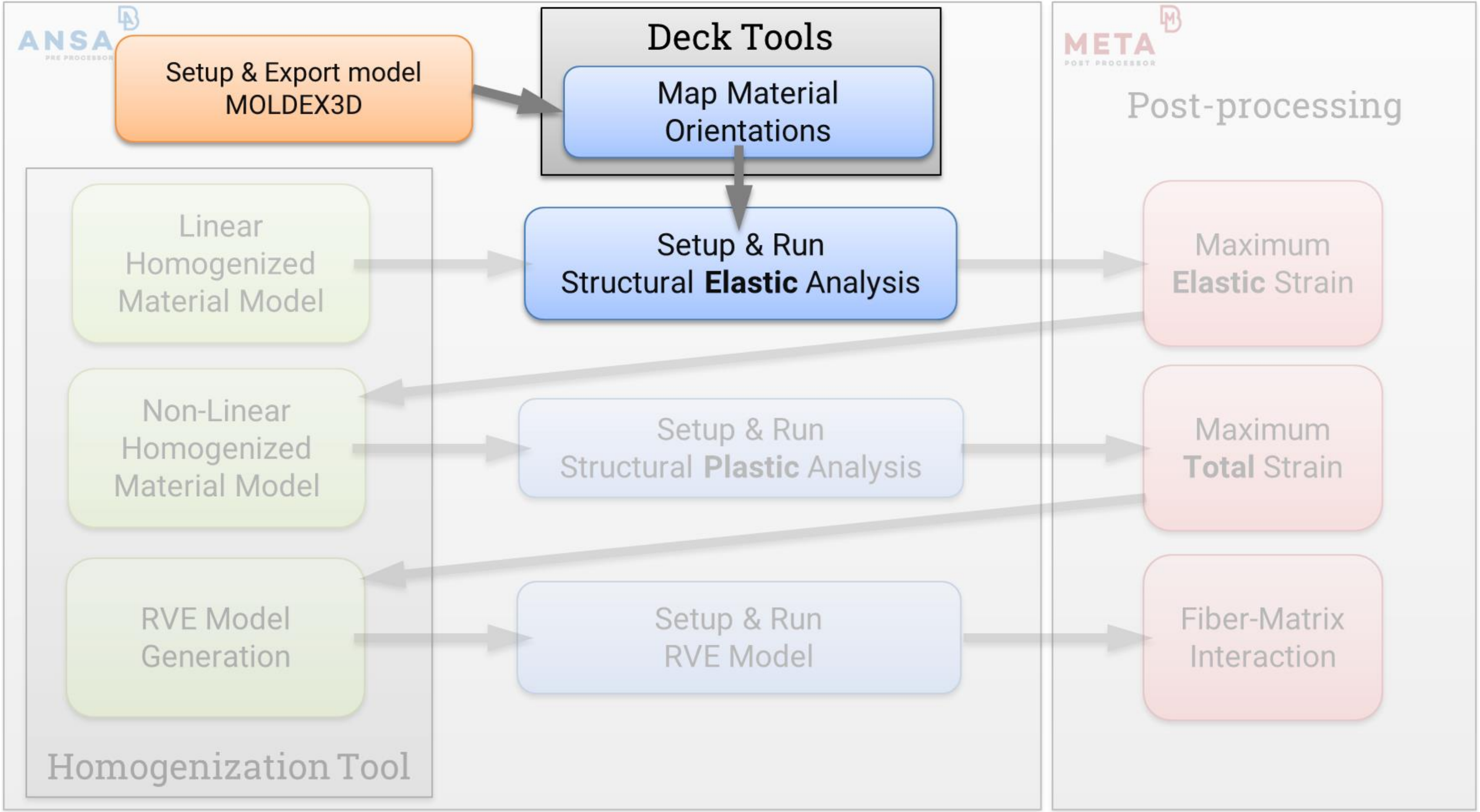
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Setup & Export model
MOLDEX3D
Deck Tools
Map Material
Orientations
META
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Maximum
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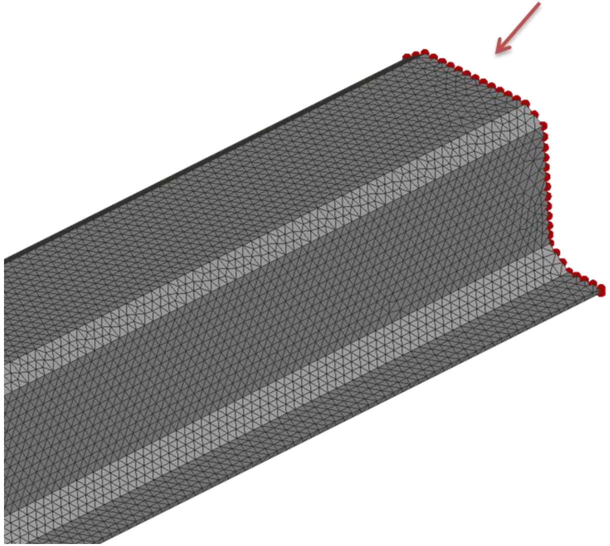
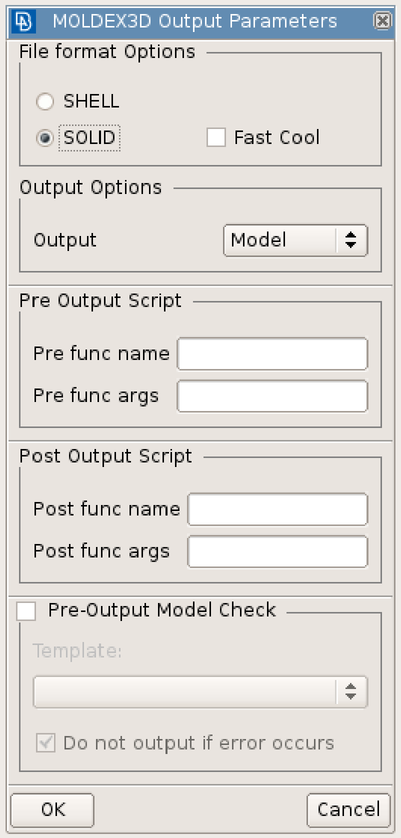
Maximum
Total Strain
RVE Model
Generation
Setup & Run
RVE Model
Fiber-Matrix
Interaction
Homogenization Tool

Case Study: Setup Moldex3D Analysis and Mapping

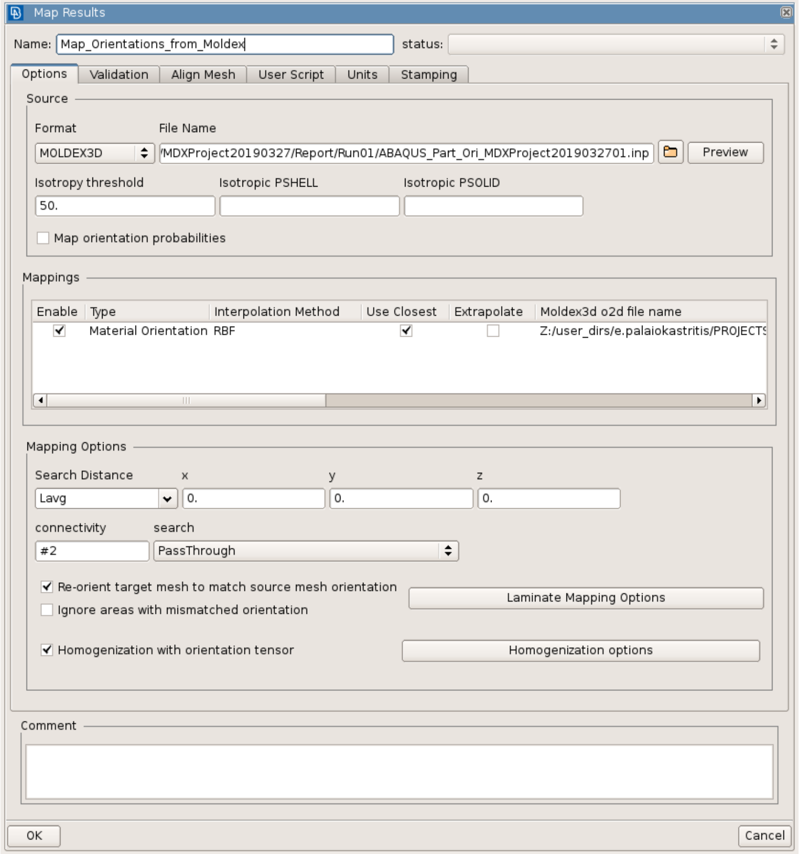
Assign Point Attribute: Melt Entrance





- Setup Point Attributes Melt Entrance
- Export Mesh for Moldex3D
- Run molding Analysis Get the material orientations file (*.o2d)
- Map Orientations

Case Study: Setup Moldex3D Analysis and Mapping



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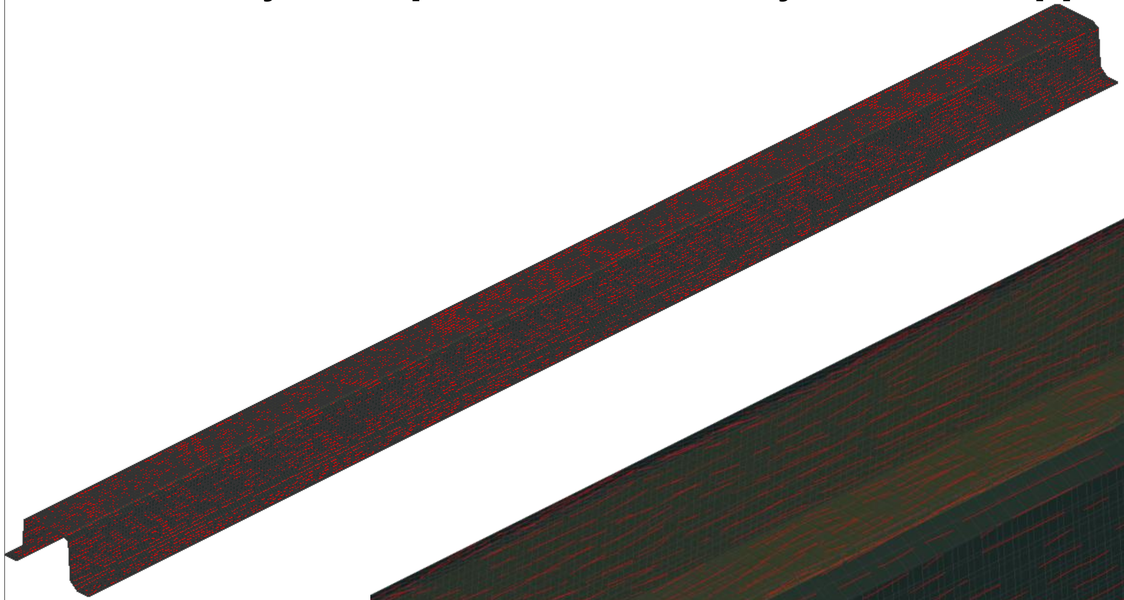

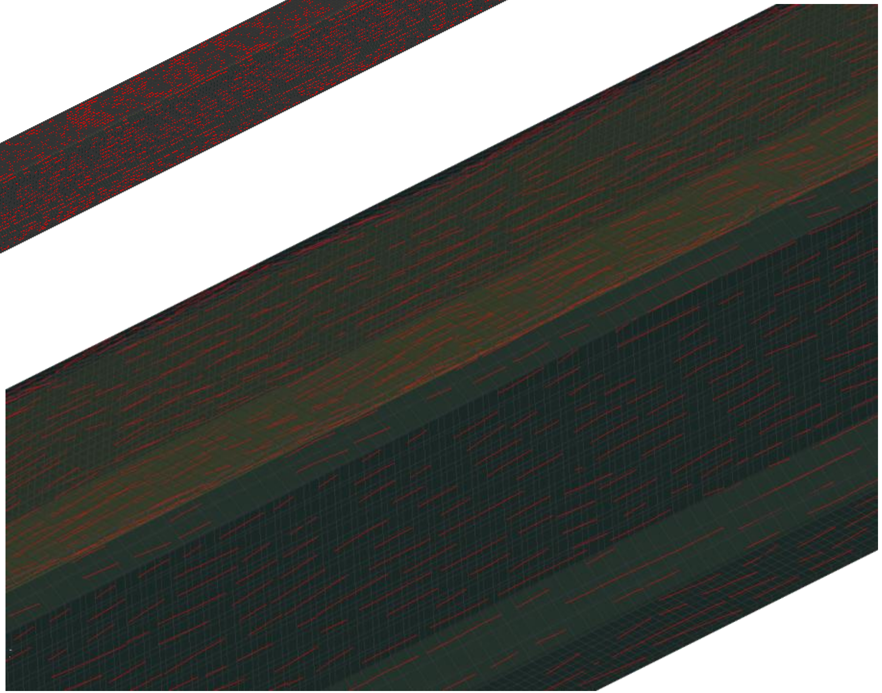

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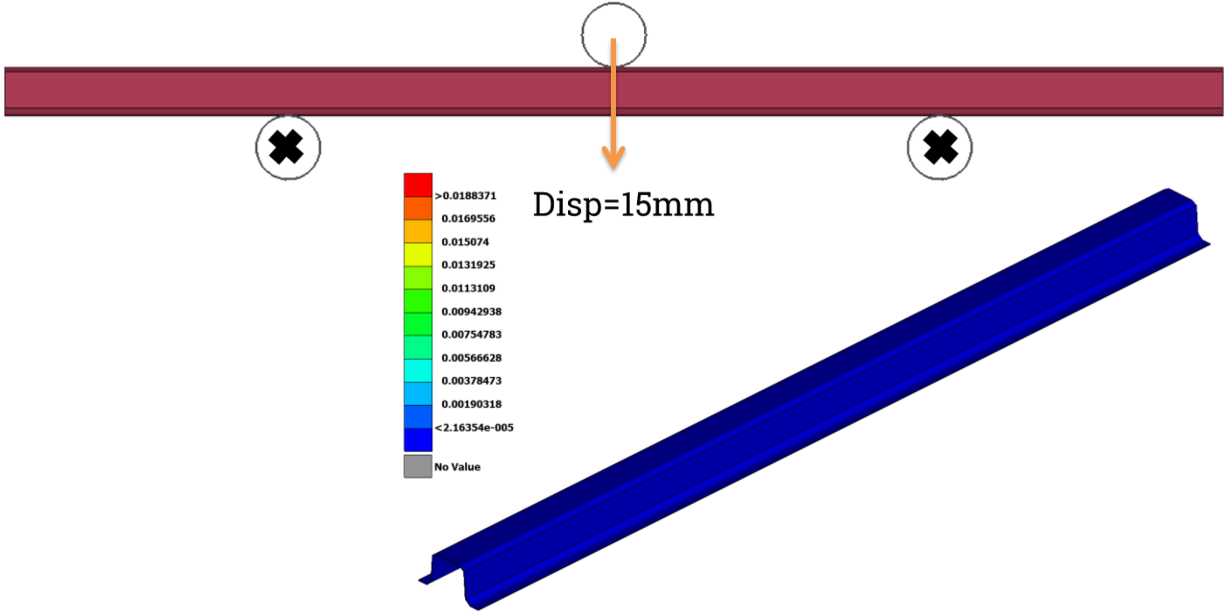
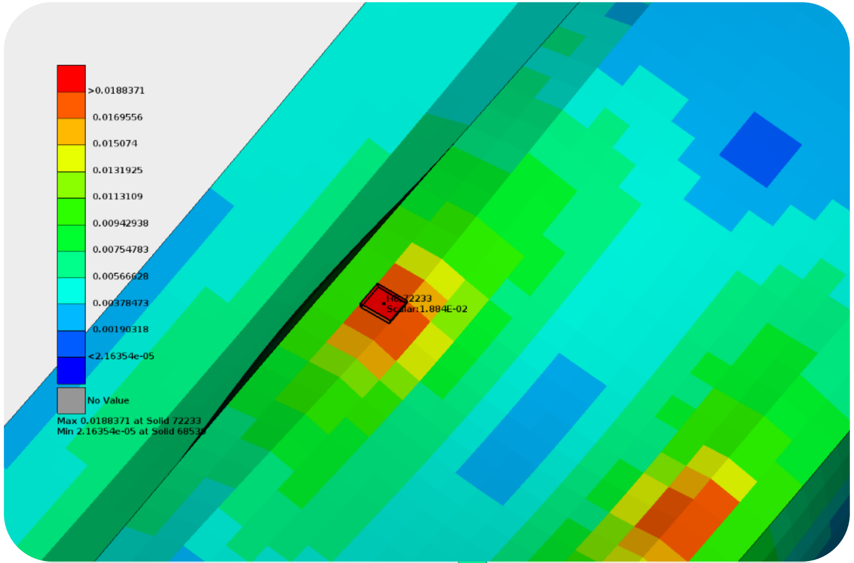
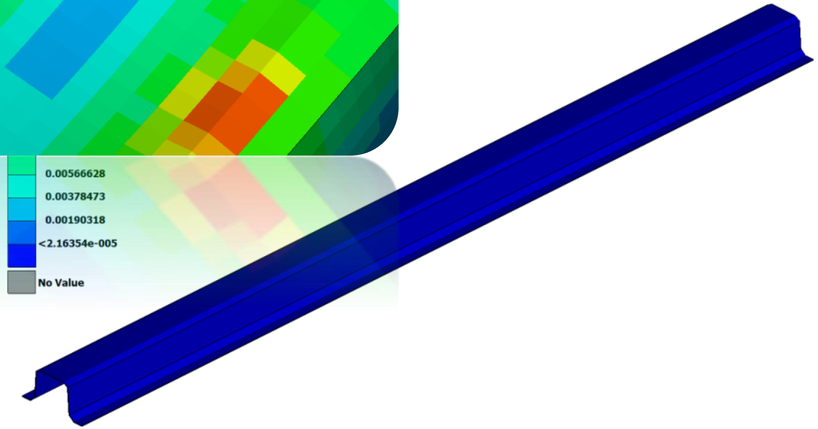


- Solve with Abaqus: Linear Elastic Material, Non Linear Geometry
- Isolate element with Max Strain: Use this Strain Tensor for calculation of the Elasto-plastic material model

Case Study: Solve Linear Elastic Model





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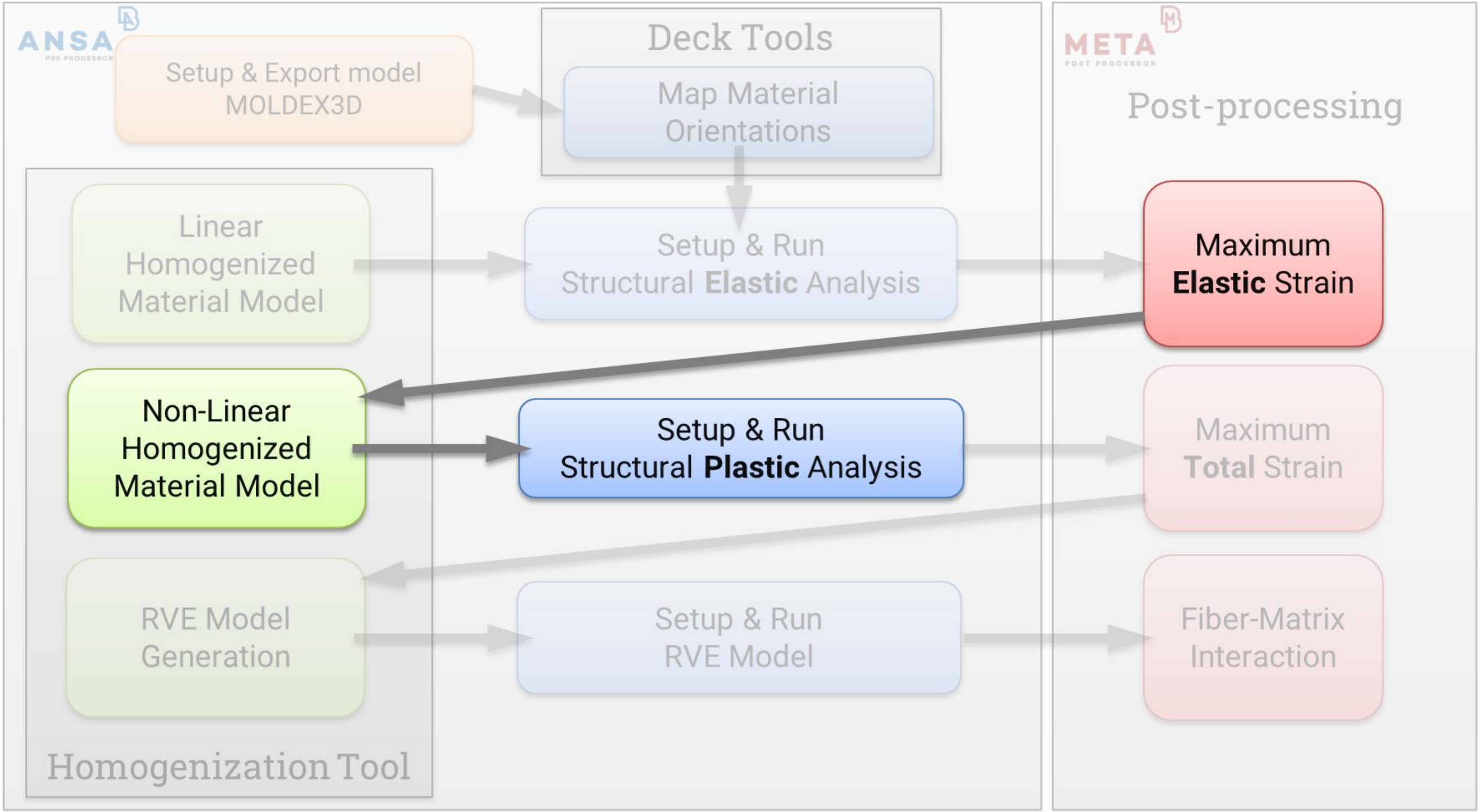
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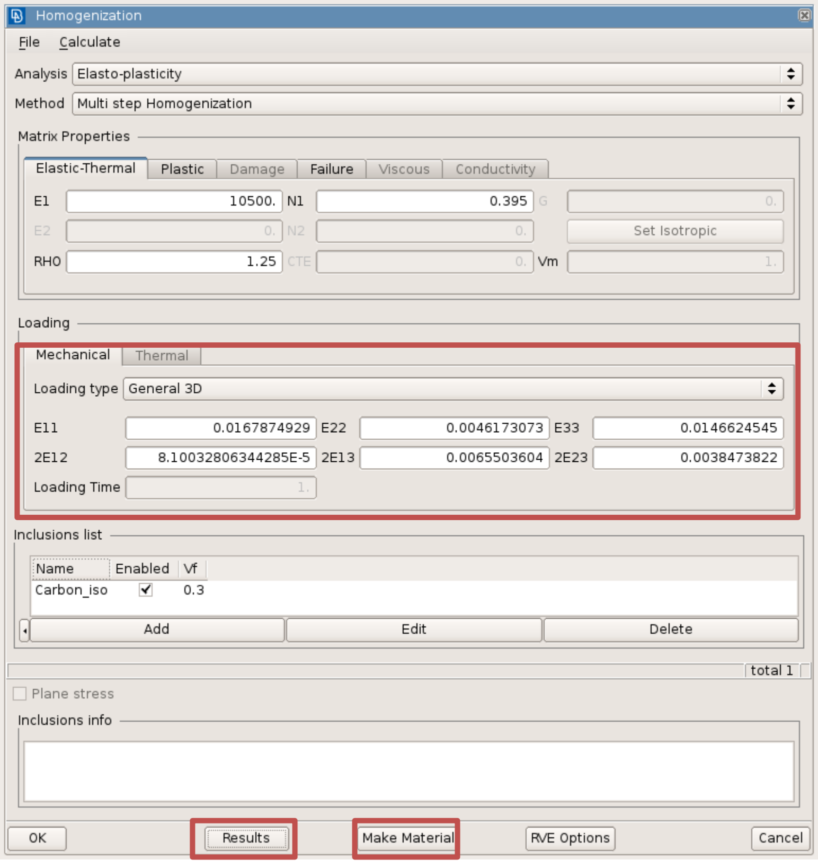
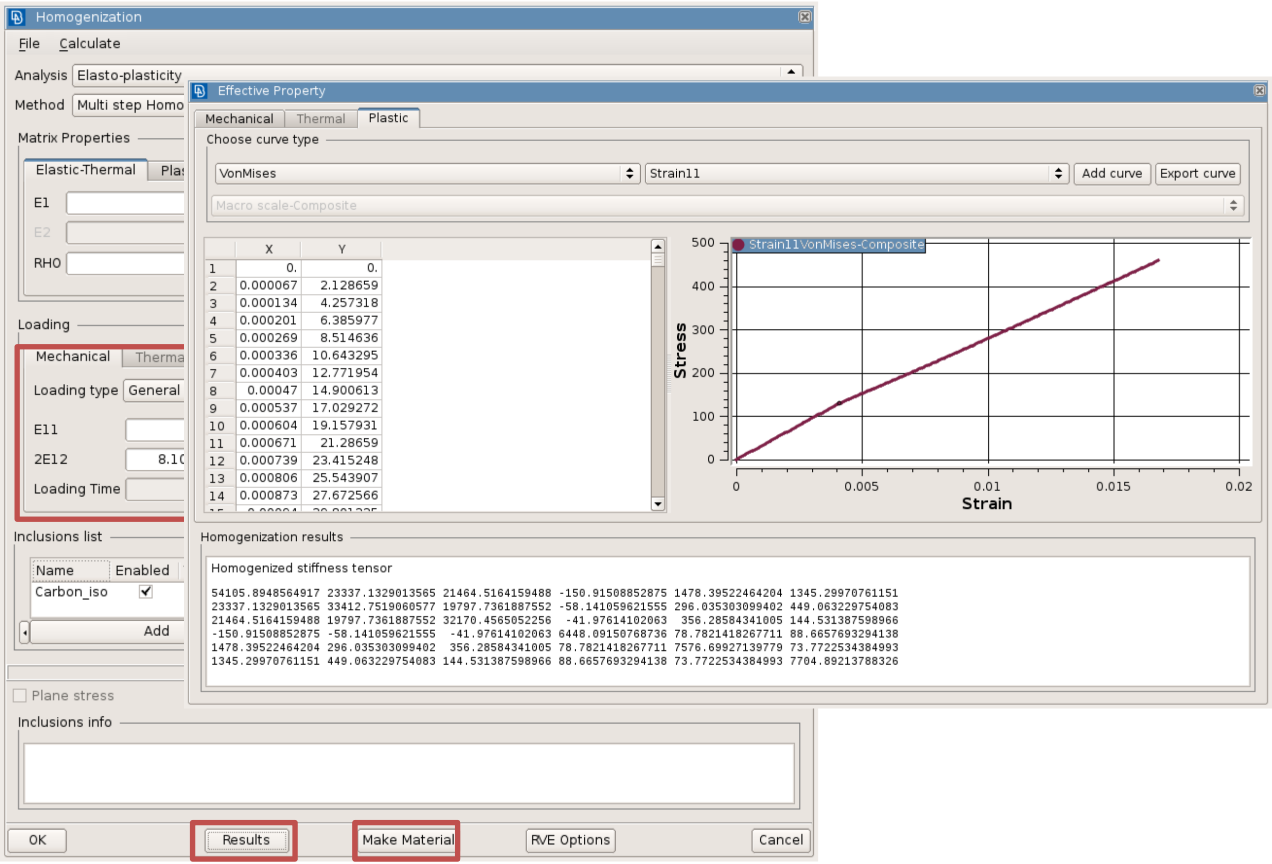
Fiber-Matrix Interaction
Homogenization Tool

Case Study: Calculate the Elasto-Plastic Composite Material



- Homogenization Tool
  Elasto-plasticity
  Strain Tensor for Loading
- Homogenized Material's behaviour:
  Elasto-plastic stress-strain curve
- Create the material entity:
  Abaqus material with *PLASTIC

Case Study: Calculate the Elasto-Plastic Composite Material



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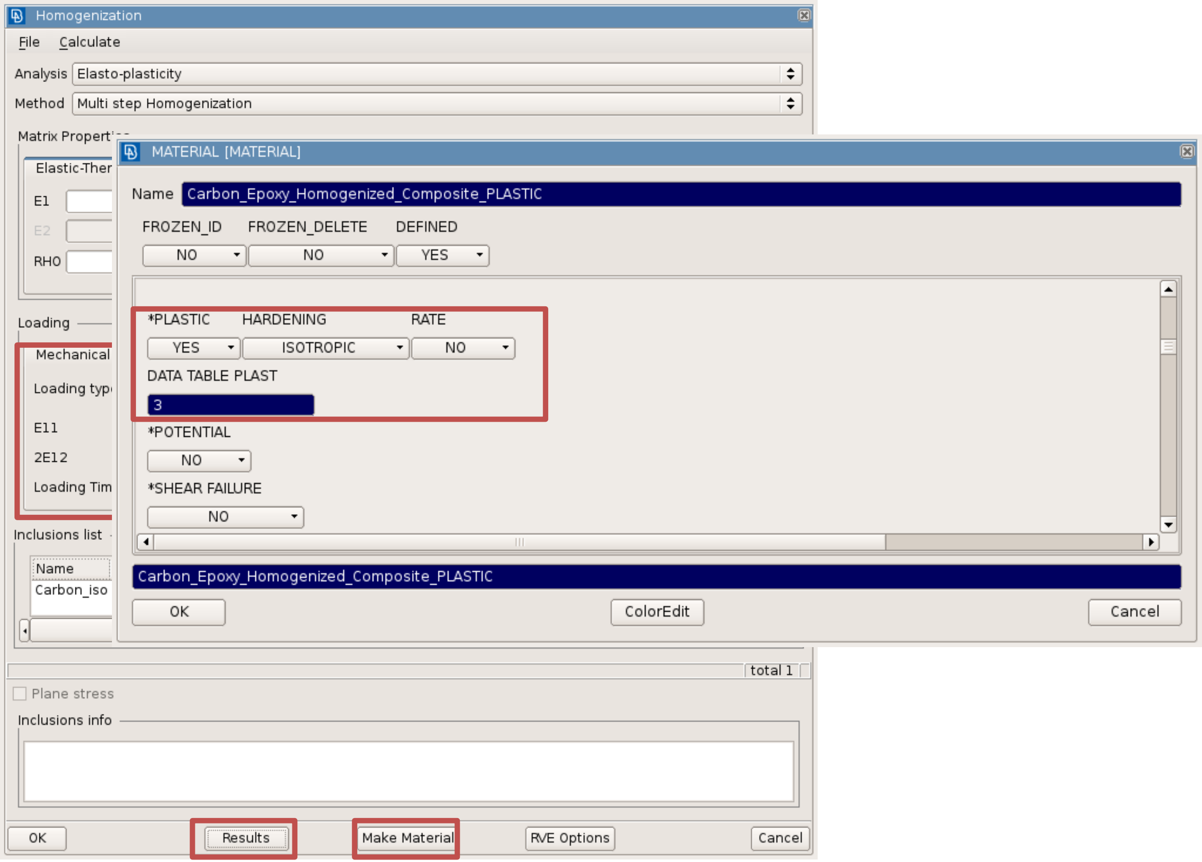

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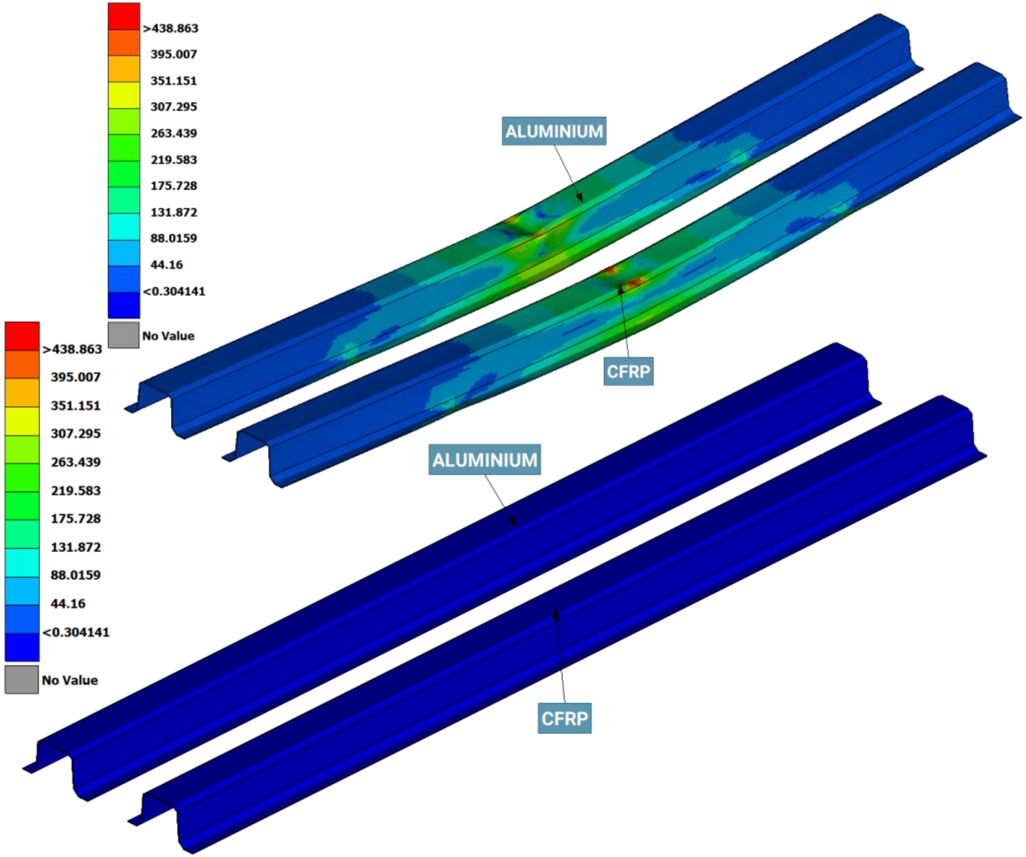

- Solve with Abaqus: Elasto-plastic Material, Non Linear Geometry

- Aluminium vs CFRP:
  $MaxStress_{alum}$ = 327 MPa
  $MaxStress_{comp}$= 438 MPa
  Weight Reduction ≅ 48%

- Isolate element with Max Strain :
  Use this strain in the RVE Model

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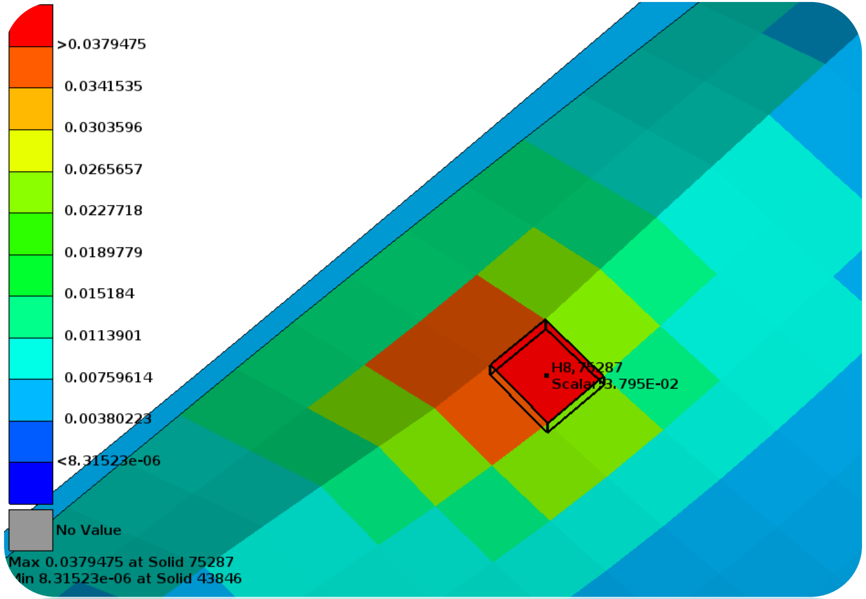

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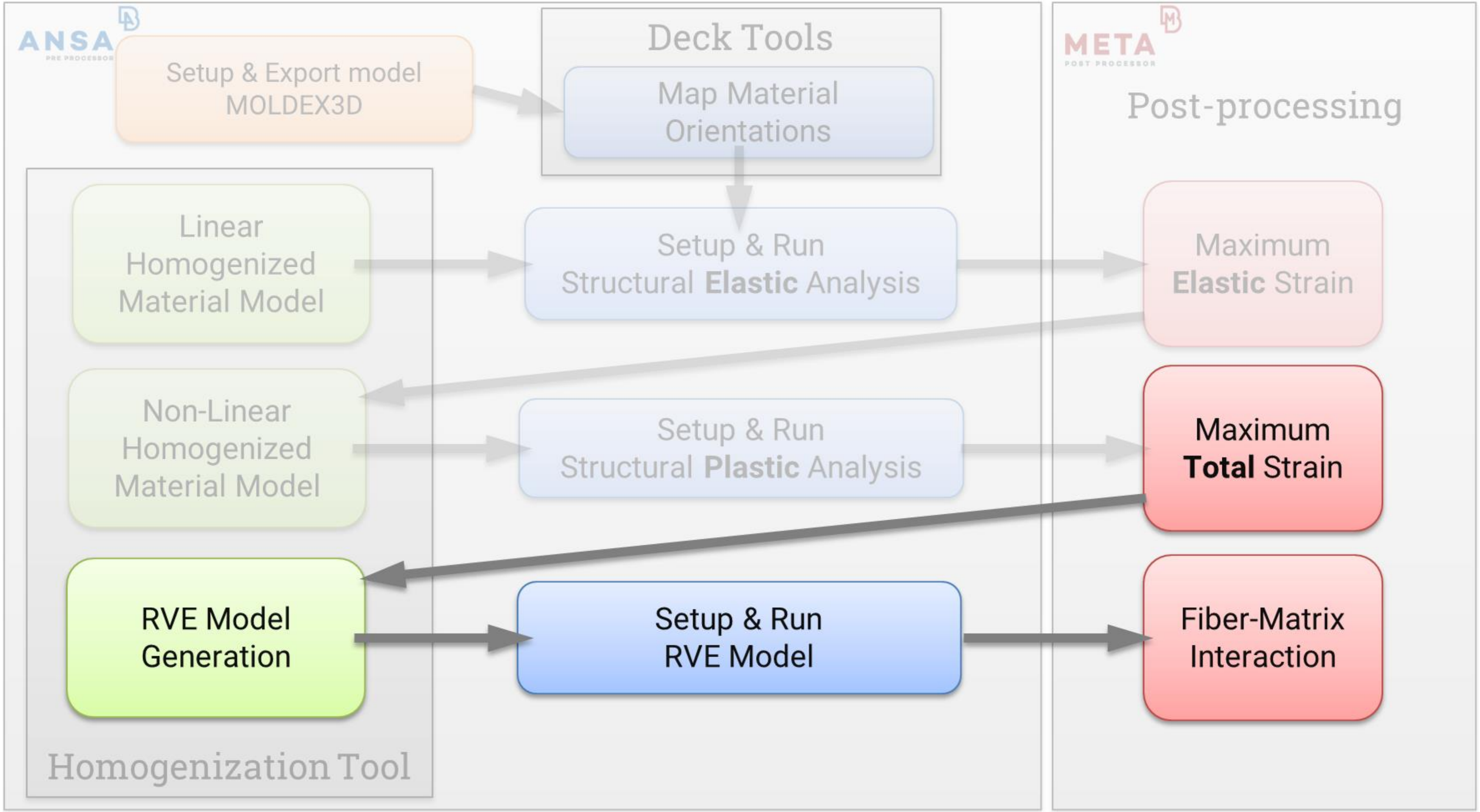
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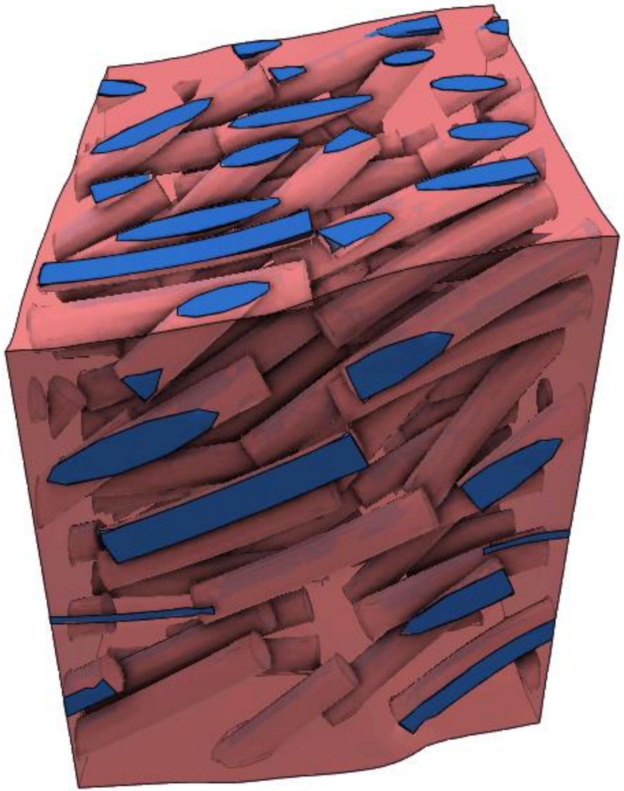
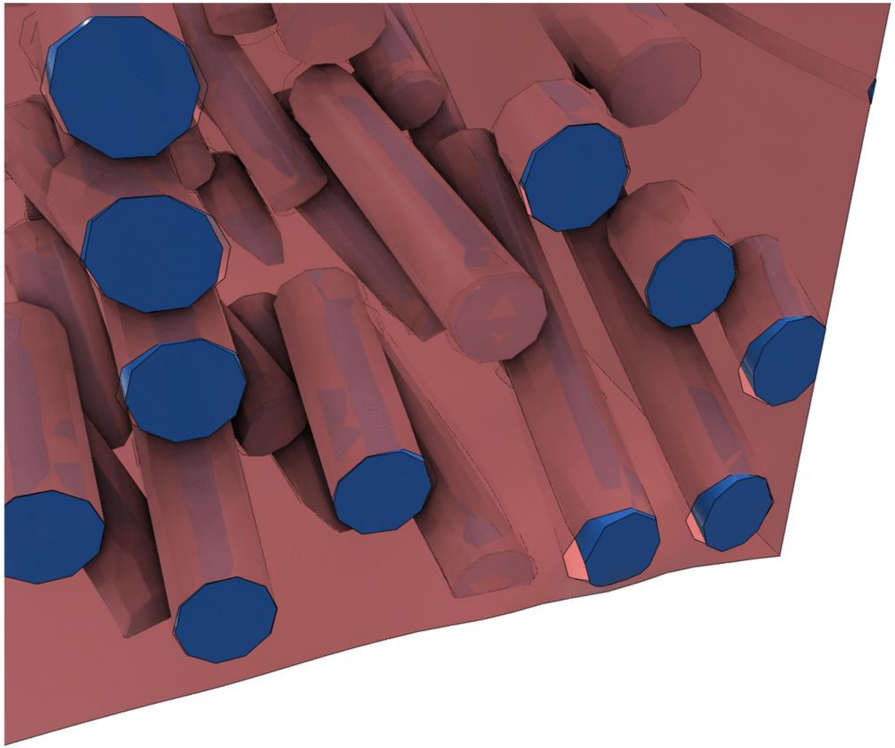
Case Study: RVE Model - Analysis



- RVE Mesh Generation: Contacts at the interface of fiber-matrix
- Subject it to the strain loading
- Examine the behavior of the interface
  Debonding
  Fiber-pull out

Case Study: RVE Model - Analysis



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Bridge Multi-scale Modeling, Manufacturing Simulation, Structural Analysis

Solutions provided in the multi-disciplinary environment of ANSA

Facilitate material design process

Automation capabilities with ANSA API.

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