

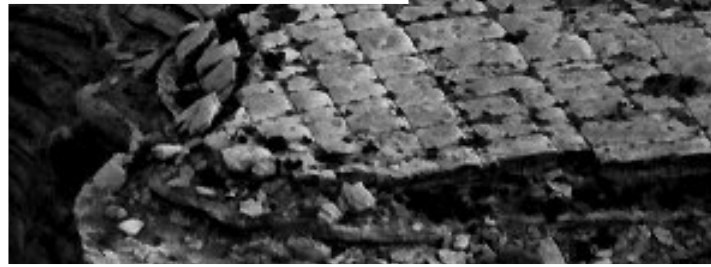
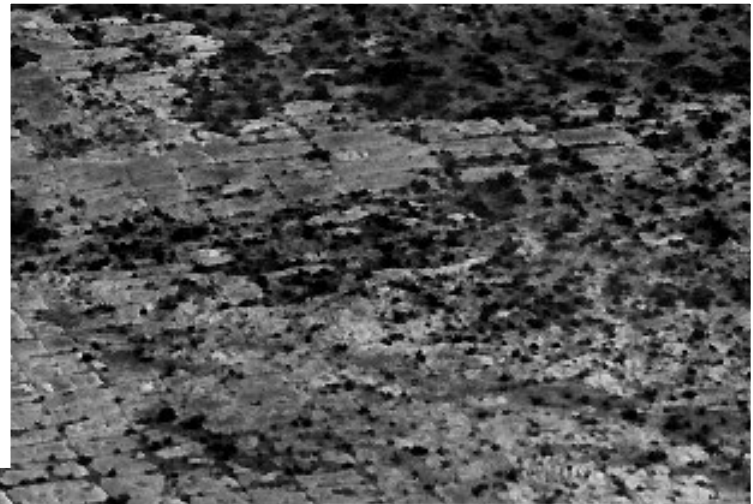
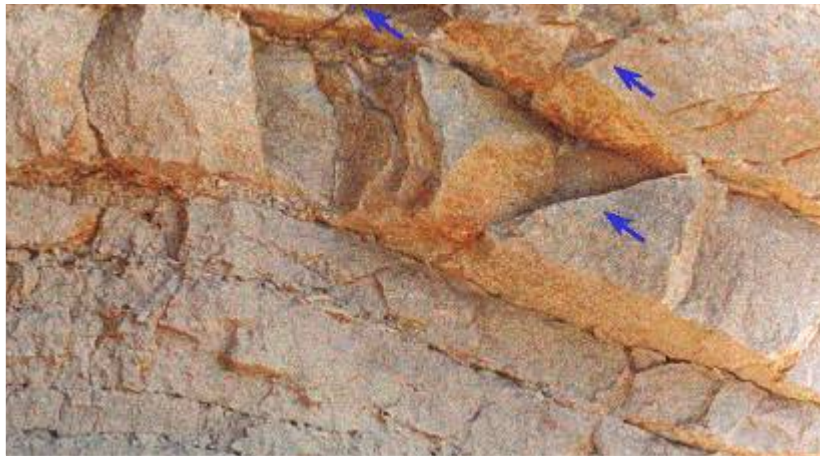
Femlab Modeling of Multiple Crack Systems

Vladimir Grechka (*Shell*)

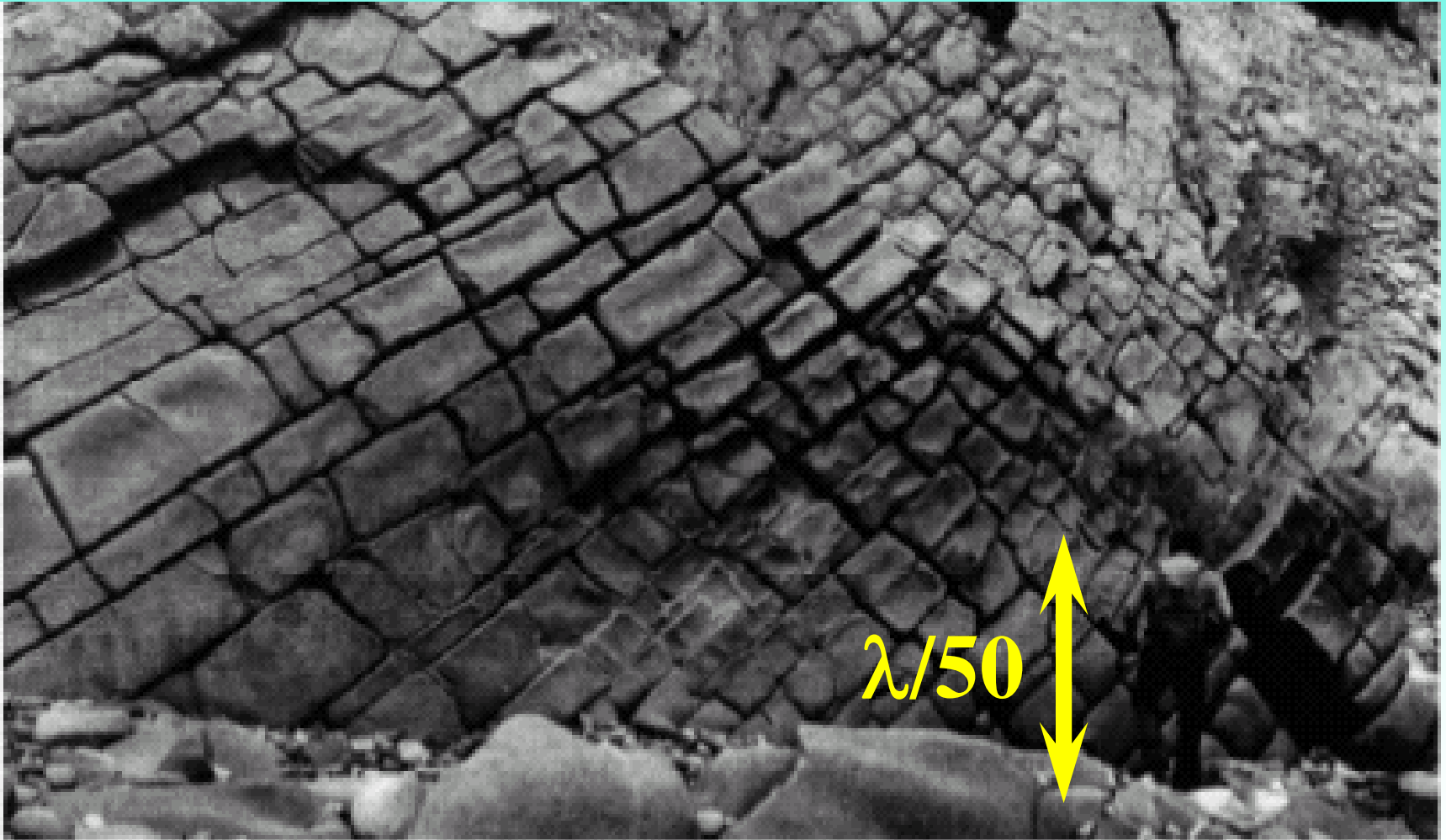
Mark Kachanov (*Tufts University*)



Cracks in Rocks

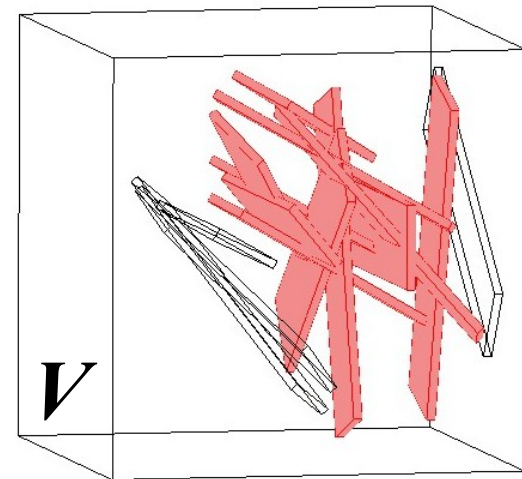
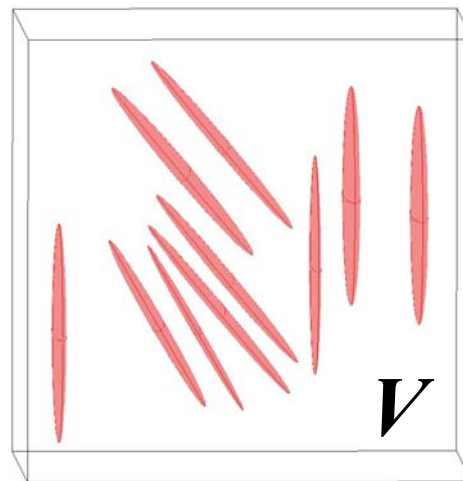


Cracks in Rocks



Homogenization Theories vs. Reality

	theories	reality
crack shape	ellipsoid	irregular
interactions	no	yes
intersections	no	yes



Goal

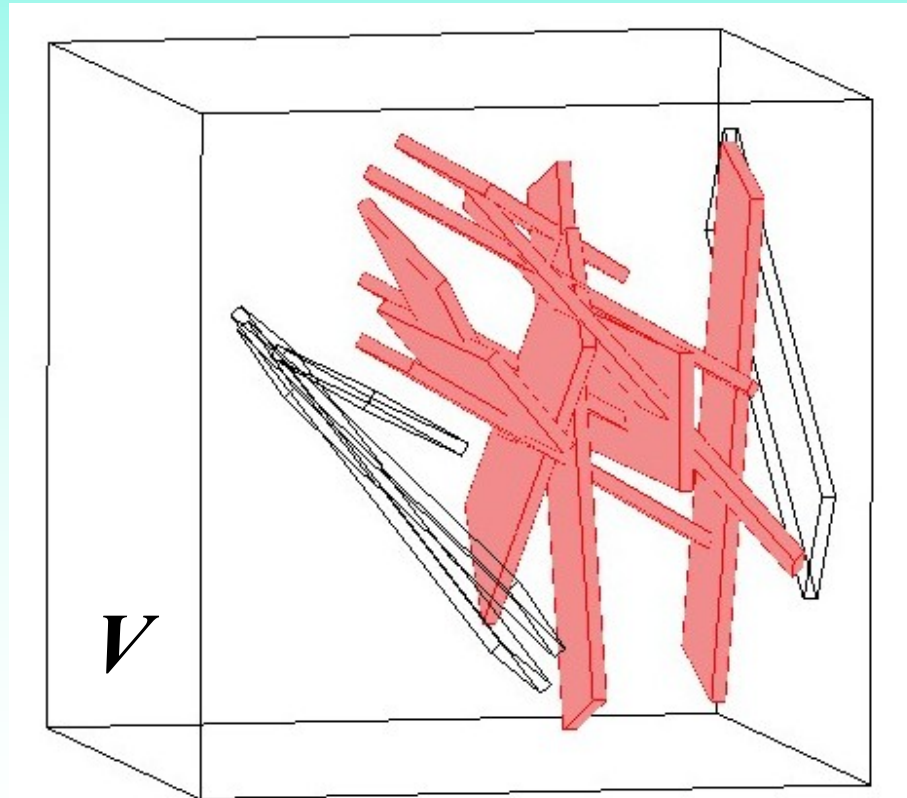
- **extend the existing theoretical results to realistic fractures in rocks**

Requirements for Solution

- rock volume V supposed to be representative
- effective stiffness tensor c_e should be independent of
 - ✓ spatial locations of cracks in V
 - ✓ applied boundary conditions

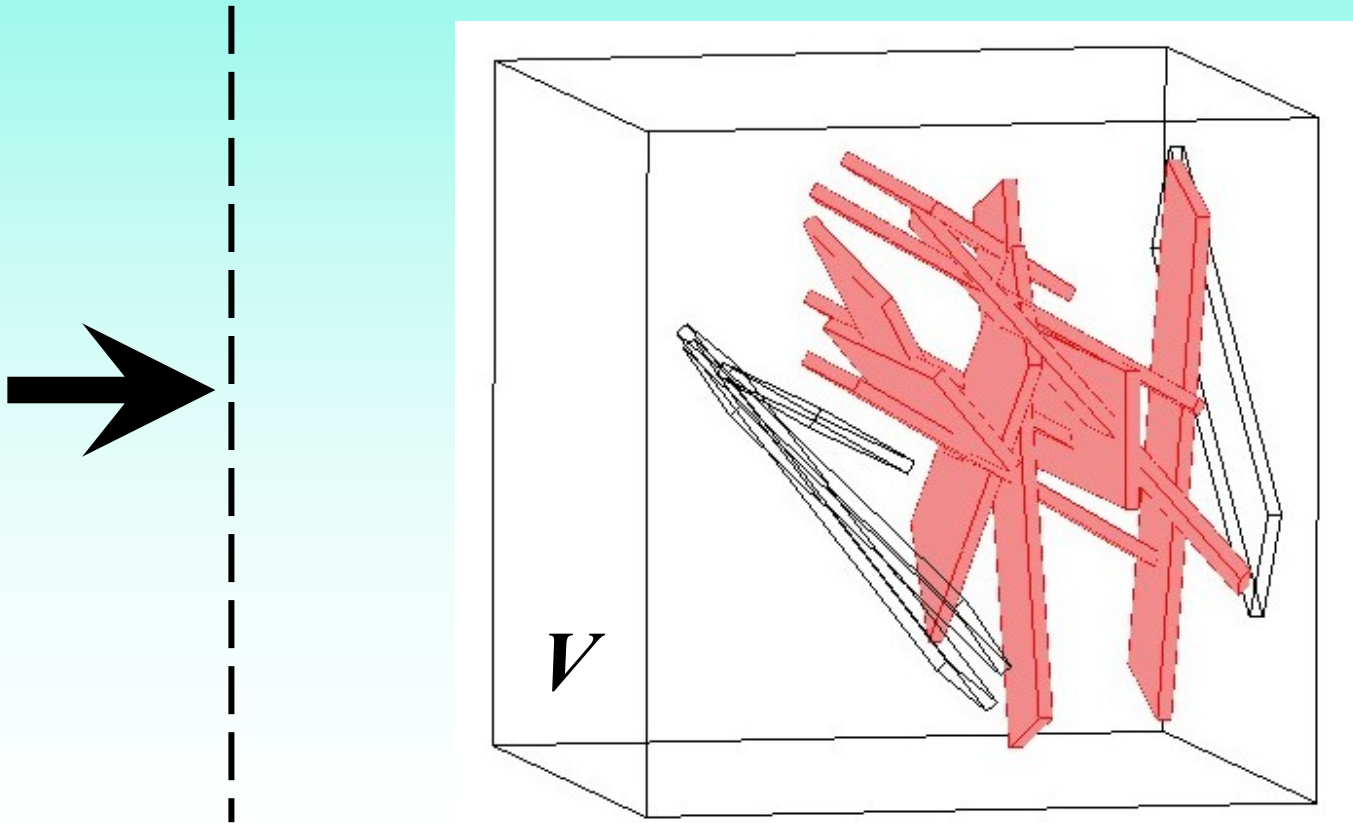
Modeling Procedure – 1

- build a model



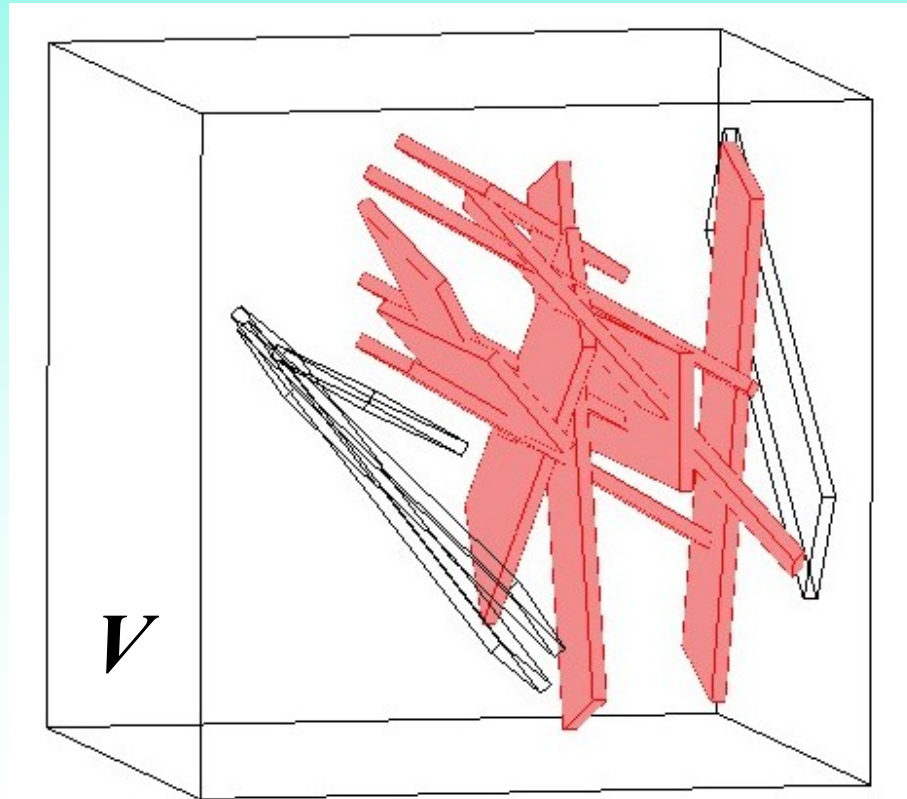
Modeling Procedure – 2

- solve static equilibrium equations for at least six independent boundary conditions

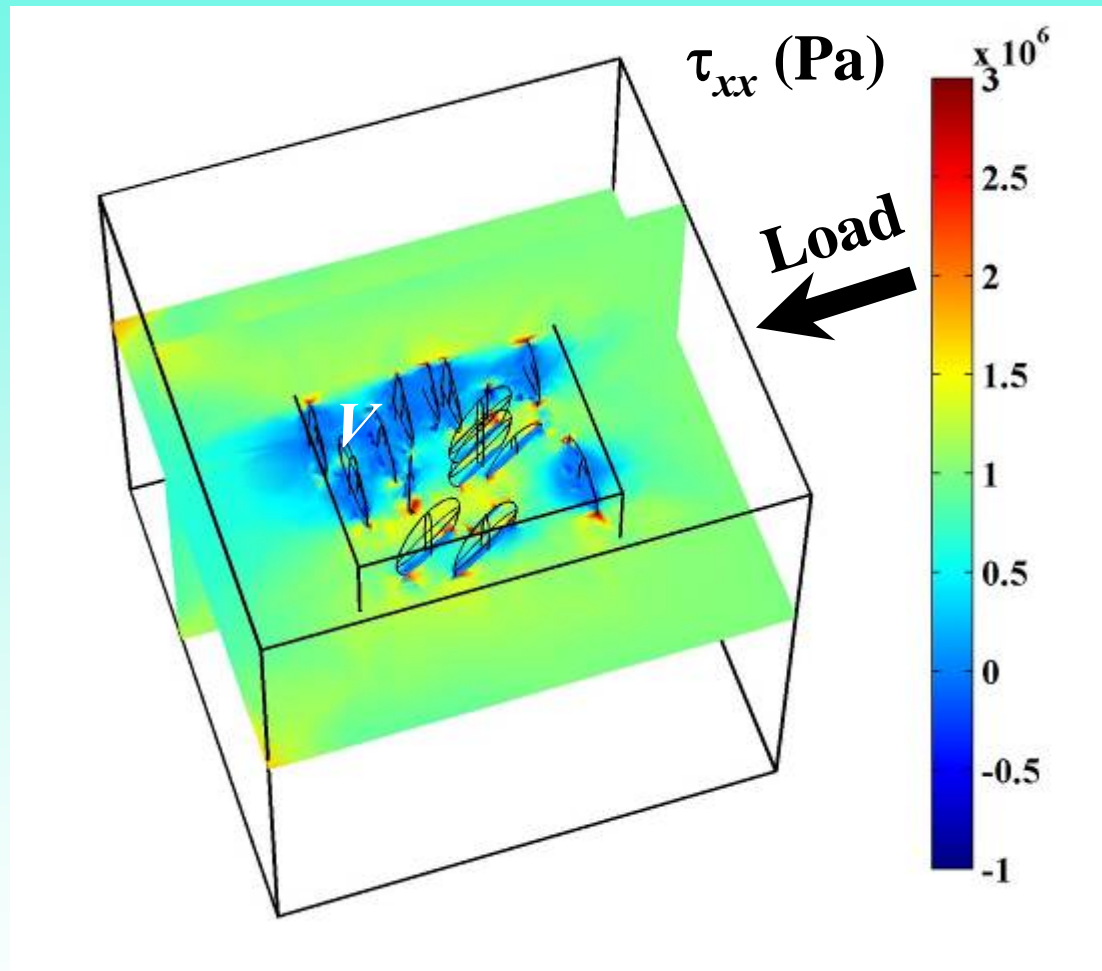


Modeling Procedure – 3

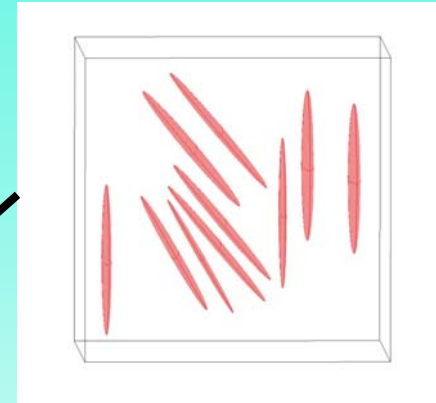
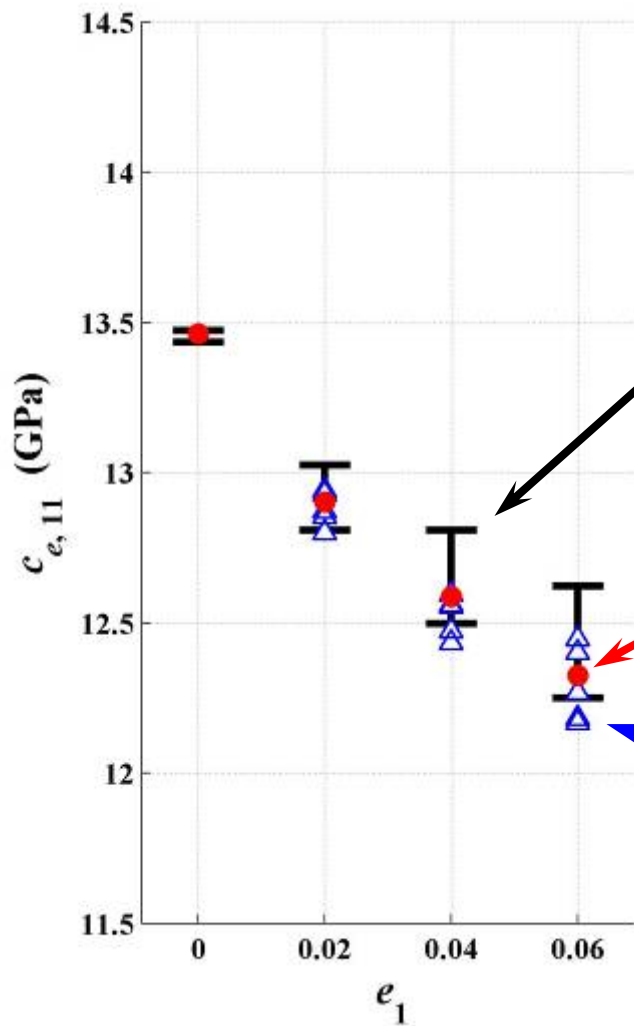
- integrate stresses and strains over V and solve the homogenized Hooke's law for c_e



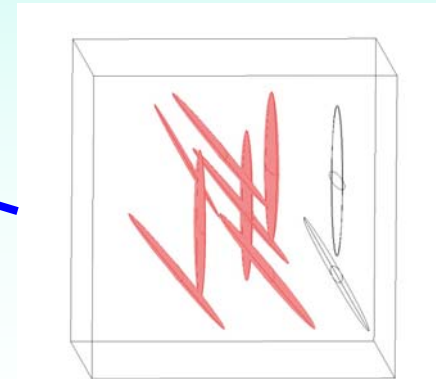
Femlab Modeling: Crack Interactions



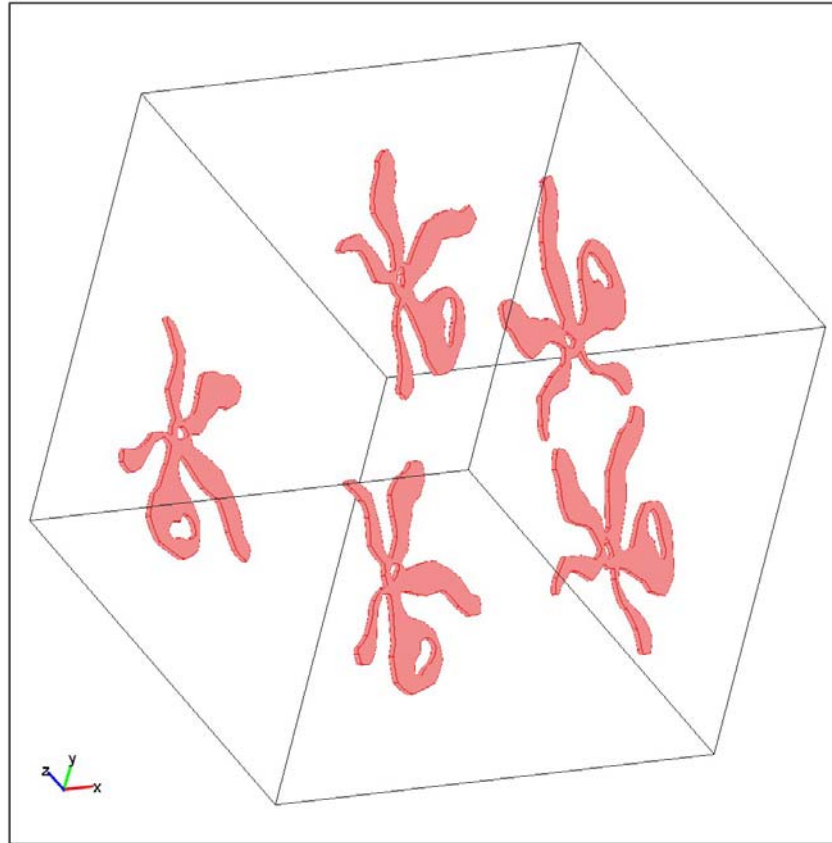
Crack Intersections



non-interaction theory

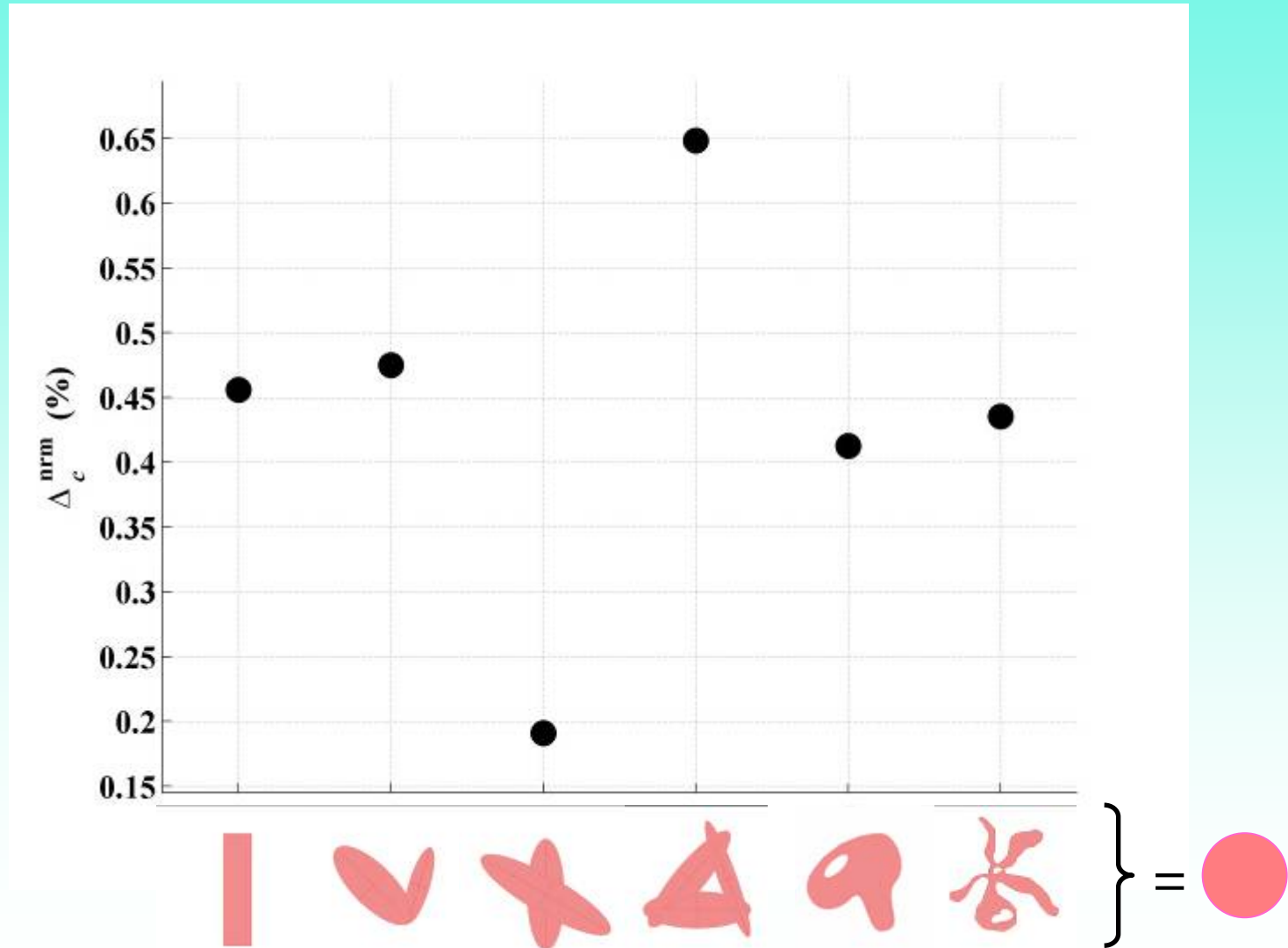


Crack Shapes

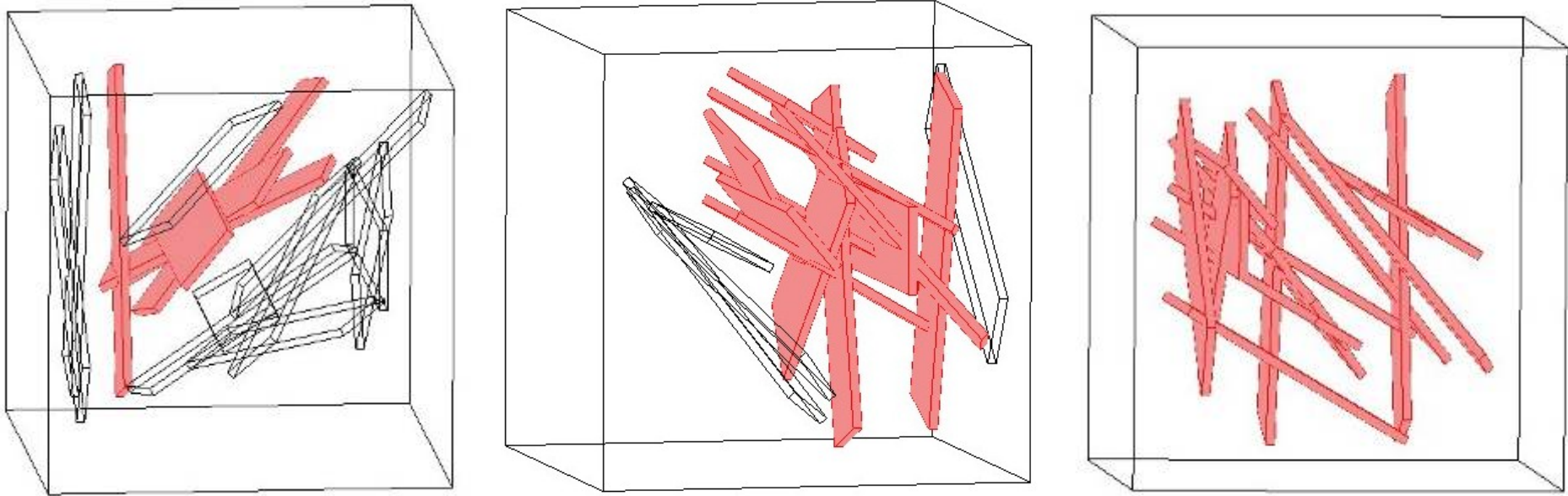


Can we replace irregular fractures with circular ones?

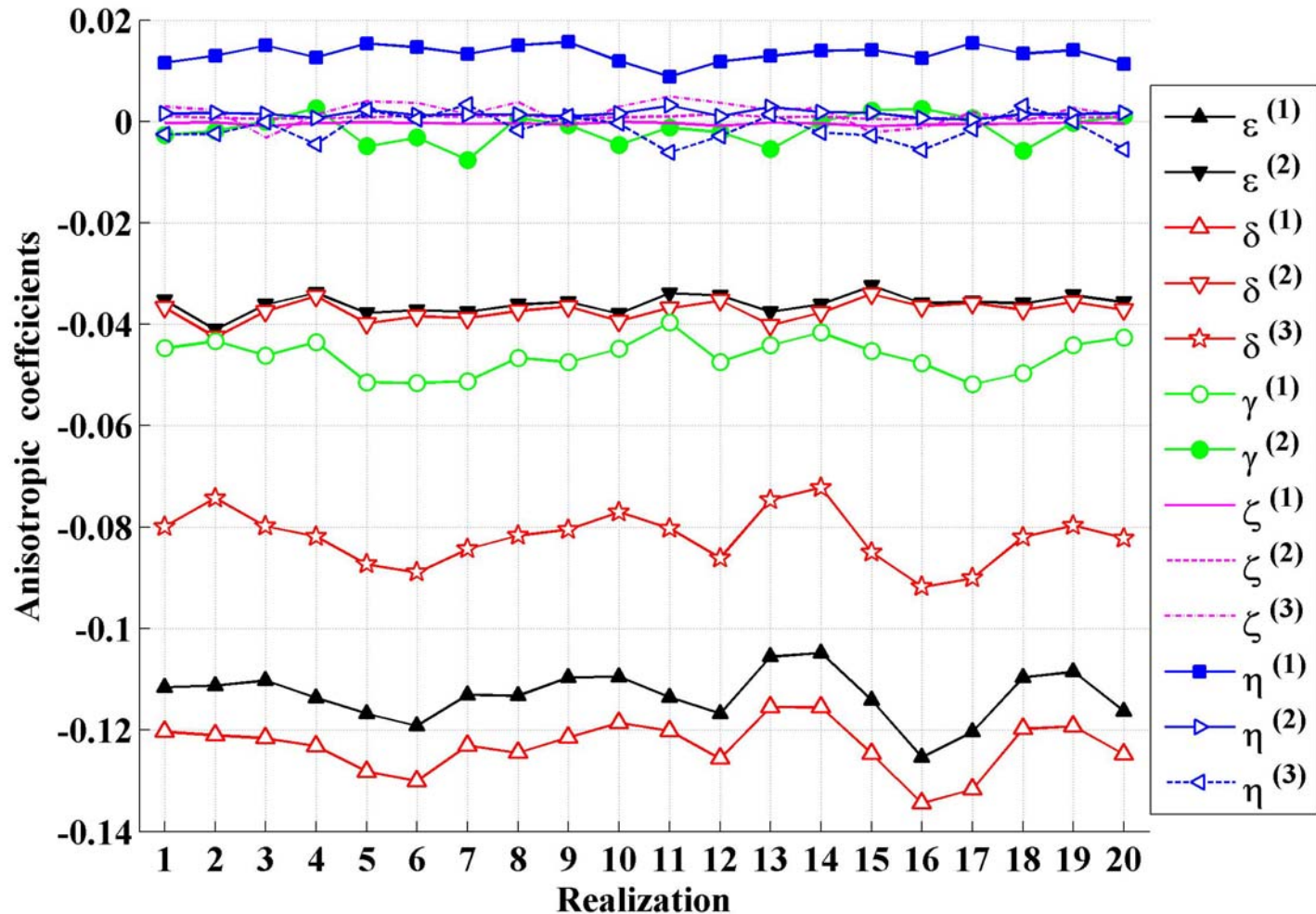
Equivalence of Irregular and Circular Cracks



Three Sets of Rectangular Cracks

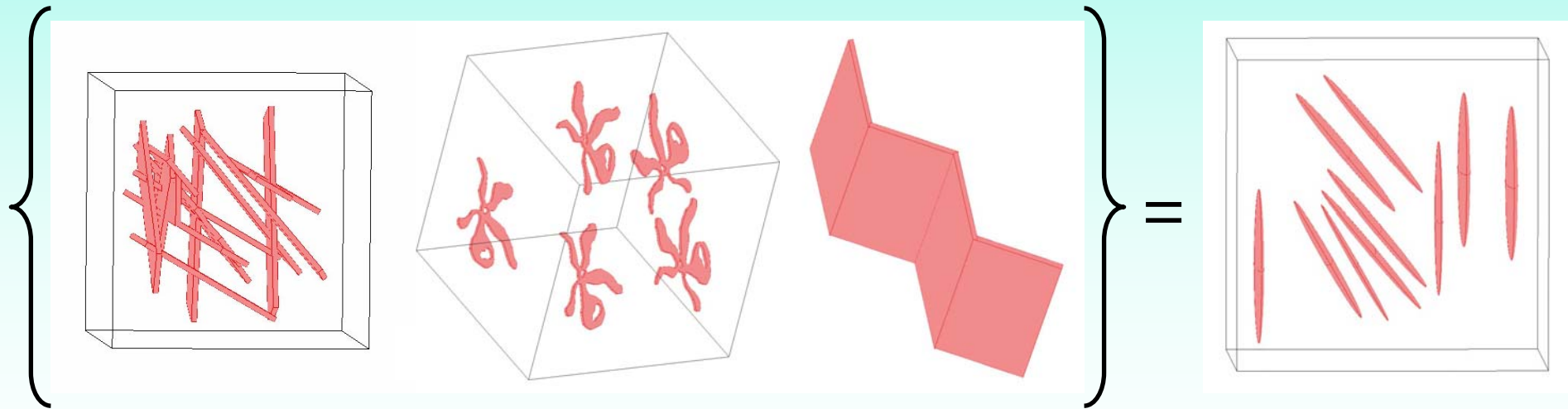


Effective Orthotropy



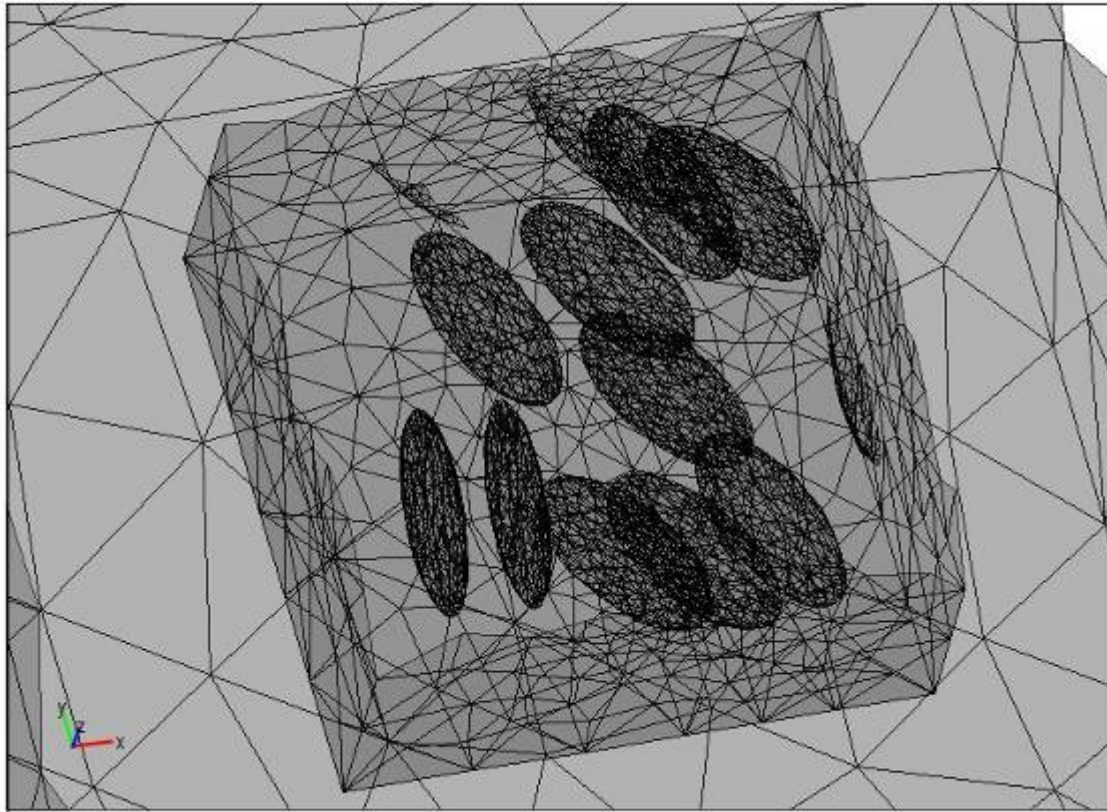
Conclusions

- **standard theoretical results for circular cracks in isotropic background hold for *any* fractures regardless of their shapes, orientations, types of infill, and presence or absence of intersections**



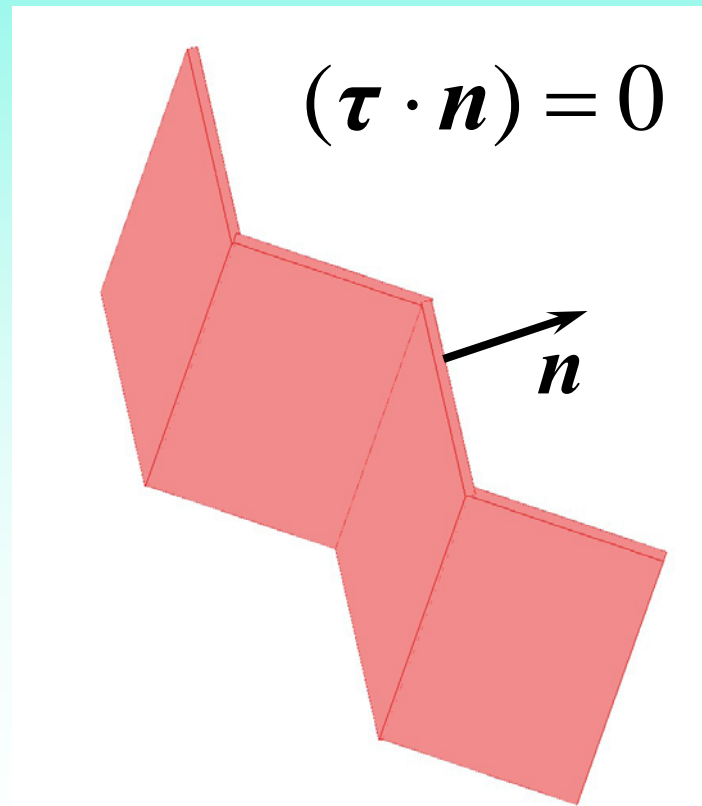
It Would Be Good...

- to make meshing easier



It Would Be Good...

- to impose zero-traction boundary conditions on interior surfaces



And Finally...

- **why .m files written for older versions of Femlab/Comsol often do not run on newer versions?**

Acknowledgement

- **Shell E & P for letting us**
 - ✓ **do such a fun work**
 - ✓ **talk about its results**