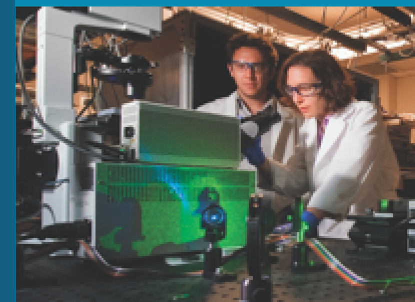
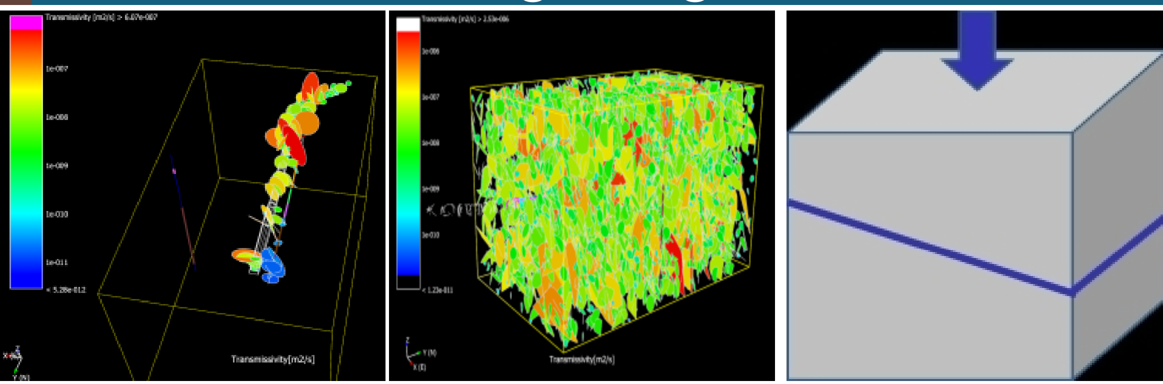
SAND2021-14138C

Sandia National Laboratories

DECOVALEX 2023 TASK G: Step1 and Step 2 - Benchmark Exercises: G1-M-BE-2D and G2-HM-BE-2D SNL Modeling Progress



DECOVALEX 2023
4th Workshop
Nov. 9, 2021



PRESENTED BY

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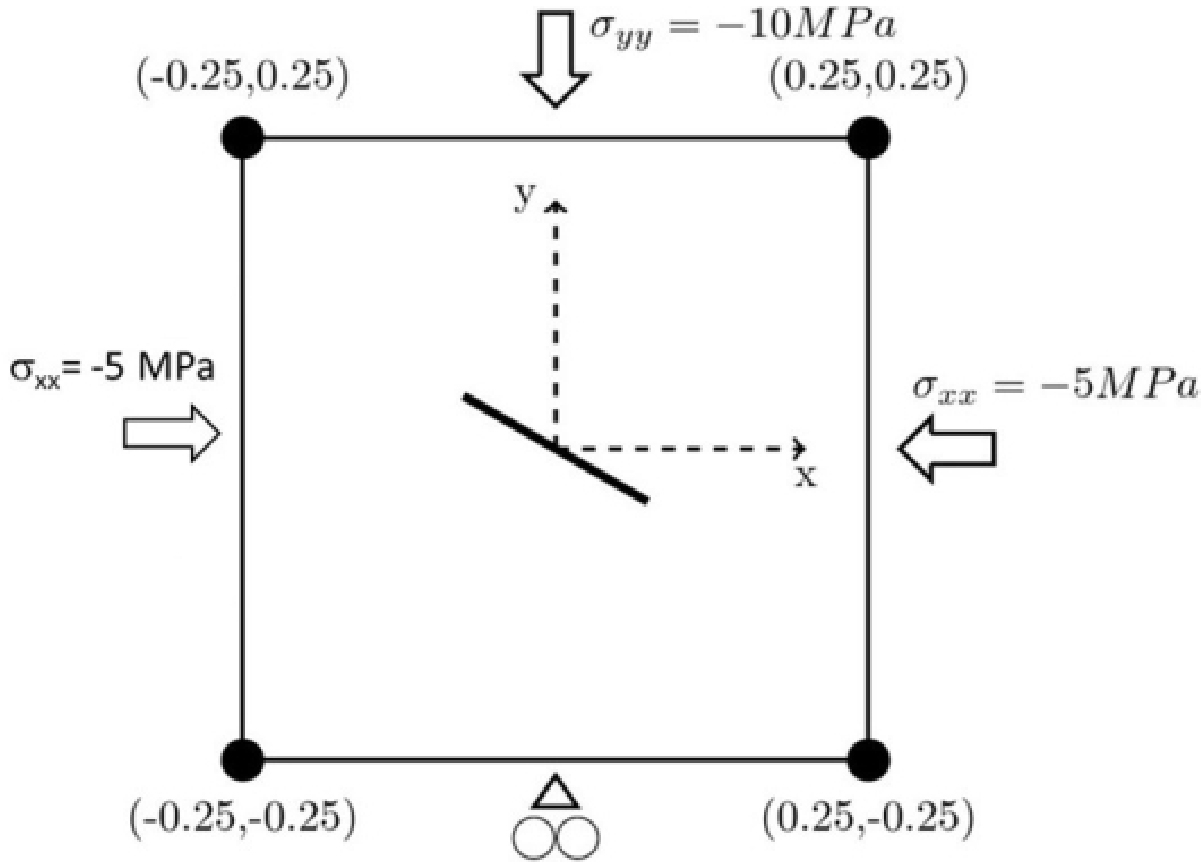
Outline

Objective: Understand the mechanical and hydromechanical response of single fracture under stress and internal pressure

- Step 1: Benchmark G1-M-BE-2D: Modeling of single fracture embedded in elastic and elastoplastic matrix
- Step 2: Benchmark G2-HM-BE-2D: Preliminary modeling of single fracture under internal pressure, embedded in a porous medium
- Summary and future work

1. Benchmark Exercise
Step1: G1-M-BE-2D



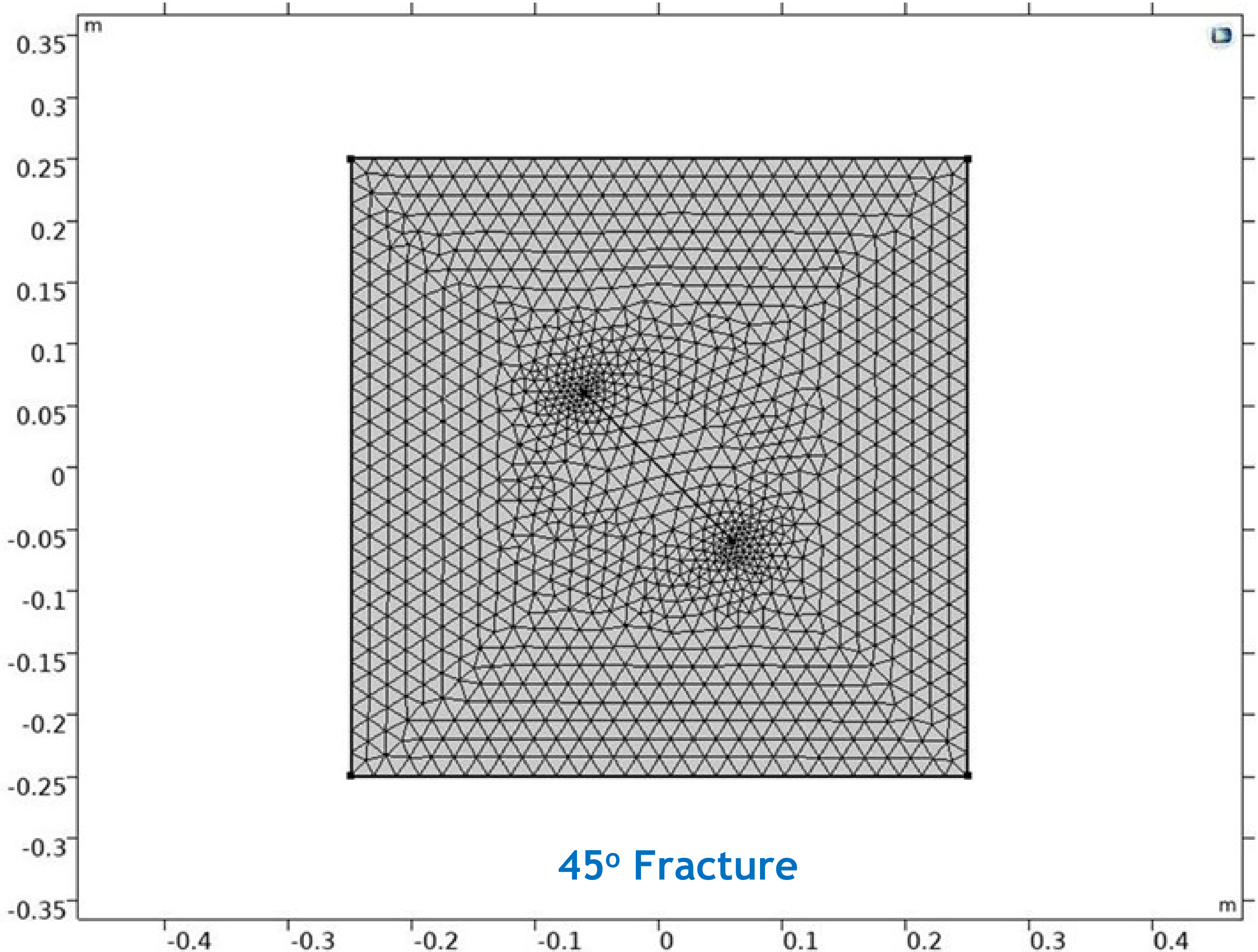
Model Set-Up for Step 1 Benchmark G1-M-BE-2D

- Preliminary simulations of embedded fracture in an elastic material were conducted.
- COMSOL Multiphysics was used for the simulations.
- The embedded fracture is represented as a spring foundation using Hooke's law.
- Smooth fracture assumptions in defining the stiffness matrix: the normal stiffness is high, and the shear stiffness is zero.
- Domain Size = 0.5 m x 0.5 m
- Single Fracture length = 0.17 m
- Fracture angle from horizontal = -30^{o}, -45^{o}, -60^{o}

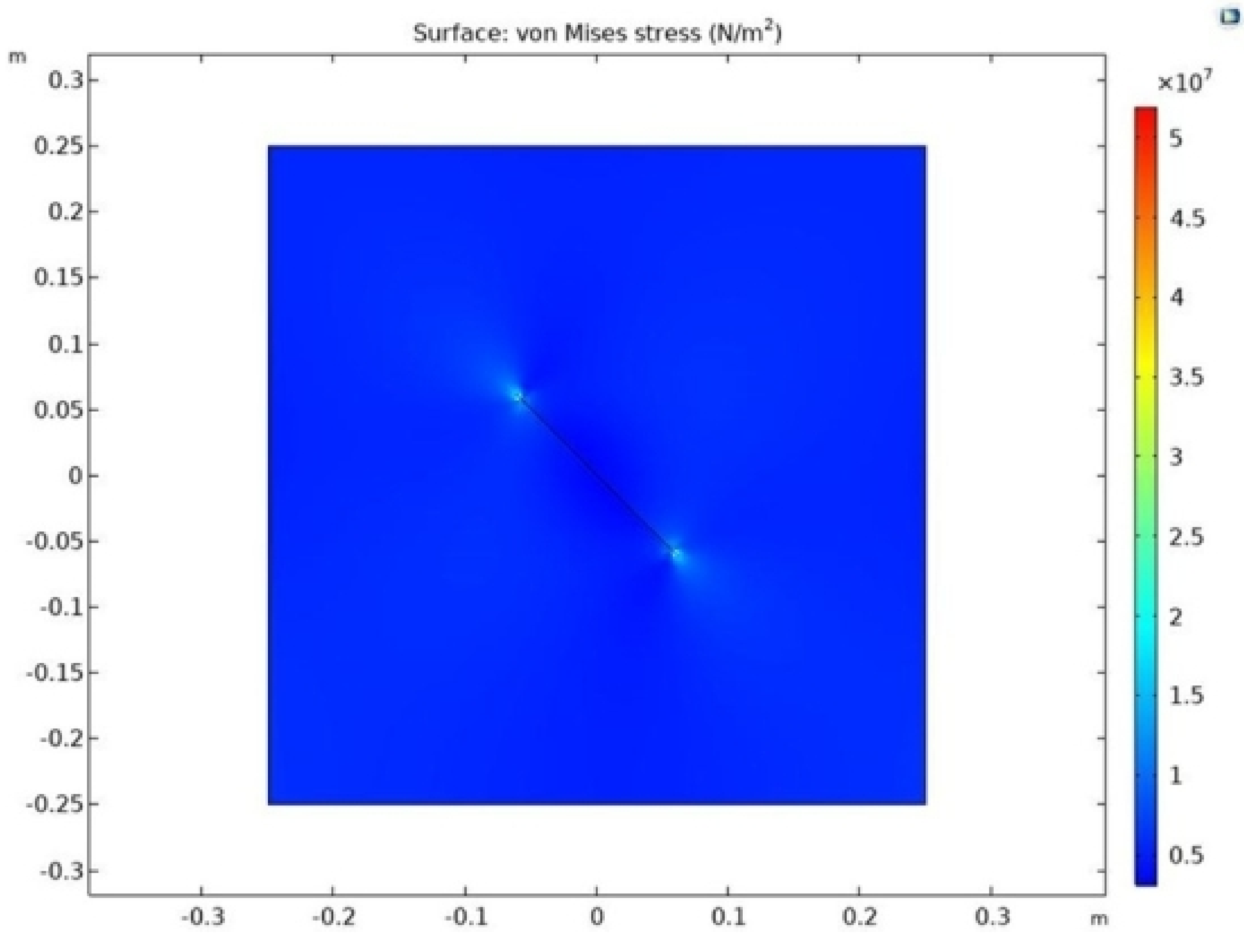
Material Properties

Parameter	Granite	Unit
Density	2590	kg/m^3
Elastic Modulus	49.75	GPa
Poisson's ratio	0.26	-

COMSOL Modeling Domain and Meshing

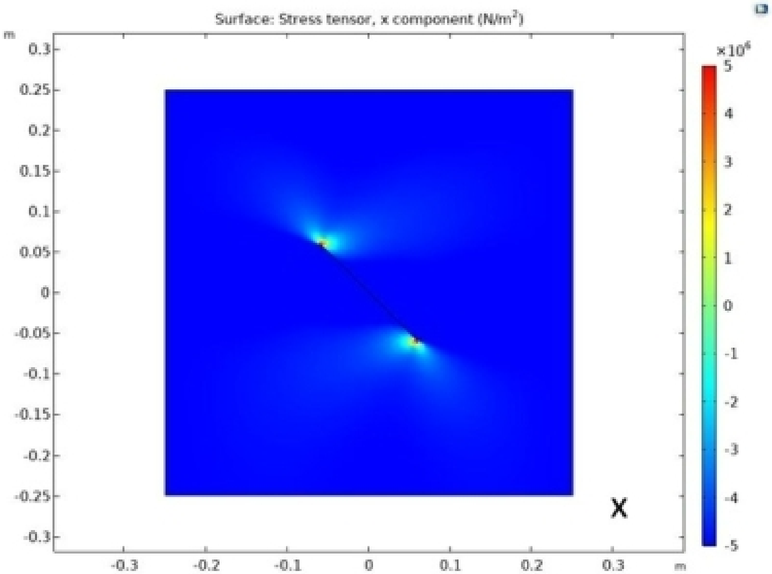


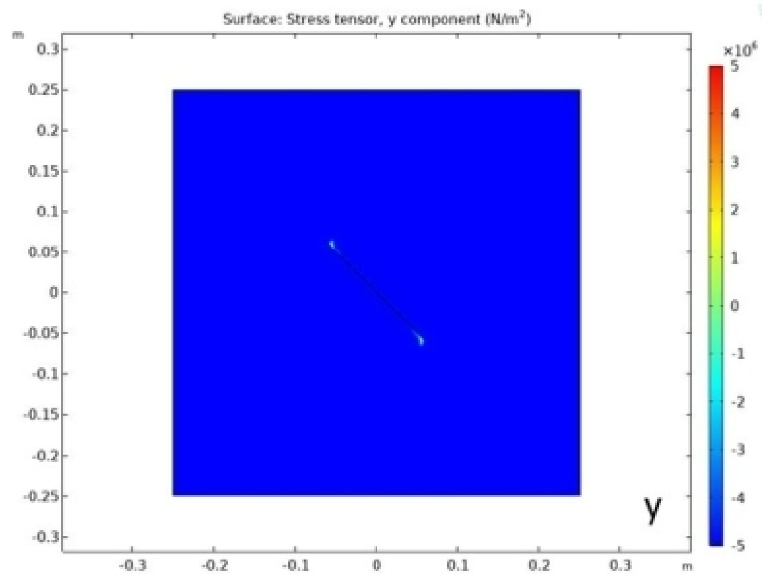
Step1 Results: Stress Distribution

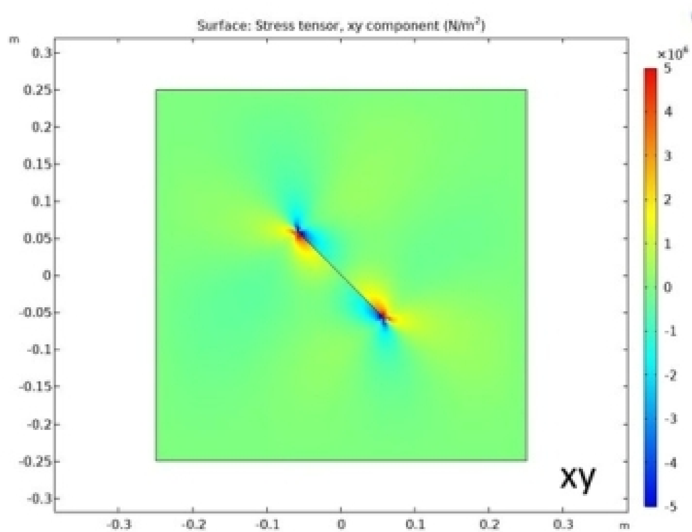


Fracture -45° from Horizontal

Step 1 Results: Stress Distribution, Contd.

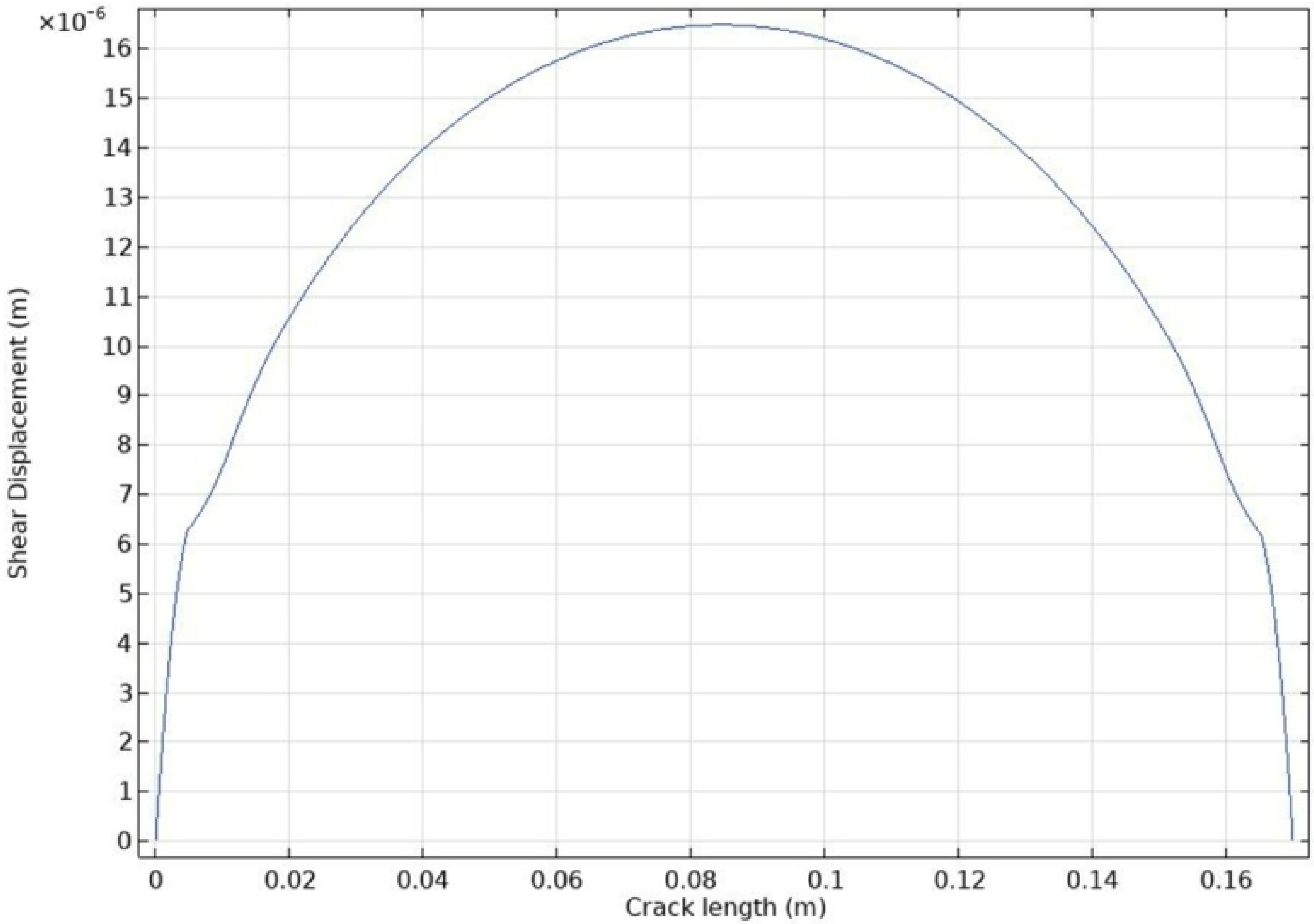






Results: Predicted Displacement along Fracture

Fracture -45º from Horizontal



Results compare well with analytical solution of Pollard and Segall (1987)

2. Benchmark Exercise Step2: G2-HM-BE-2D

- A porous material with an embedded fracture
- Fracture at an angle of 30º from the horizontal, and is loaded with internal fluid pressure
- Impermeable matrix
- Domain, fracture size and external loading and stresses as in Step 1
- **<u>Problem 1</u>: planar fracture with no external loading and an internal fluid pressure of 2 MPa**
- Compare modeled fracture opening with analytical solution:

Papachristos et al. (2017)

u is the surface deformation ; *r* is the radial distance from the centre of the fracture

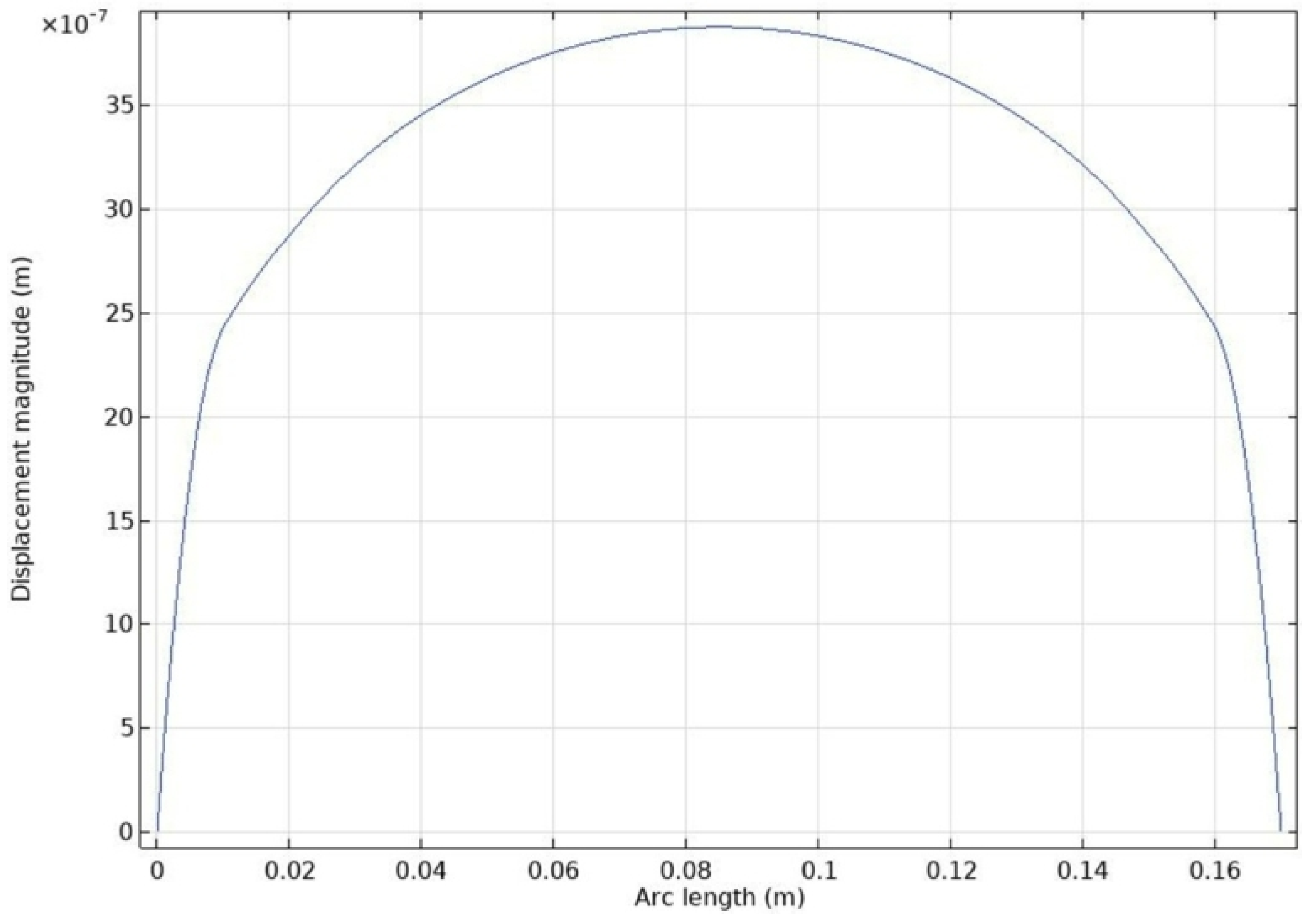
R is half length of fracture; ν is Poisson's ratio

G is the shear modulus ; P is the fluid pressure inside the fracture

Model Set-Up for Step 2 Benchmark G2-HM-BE-2D

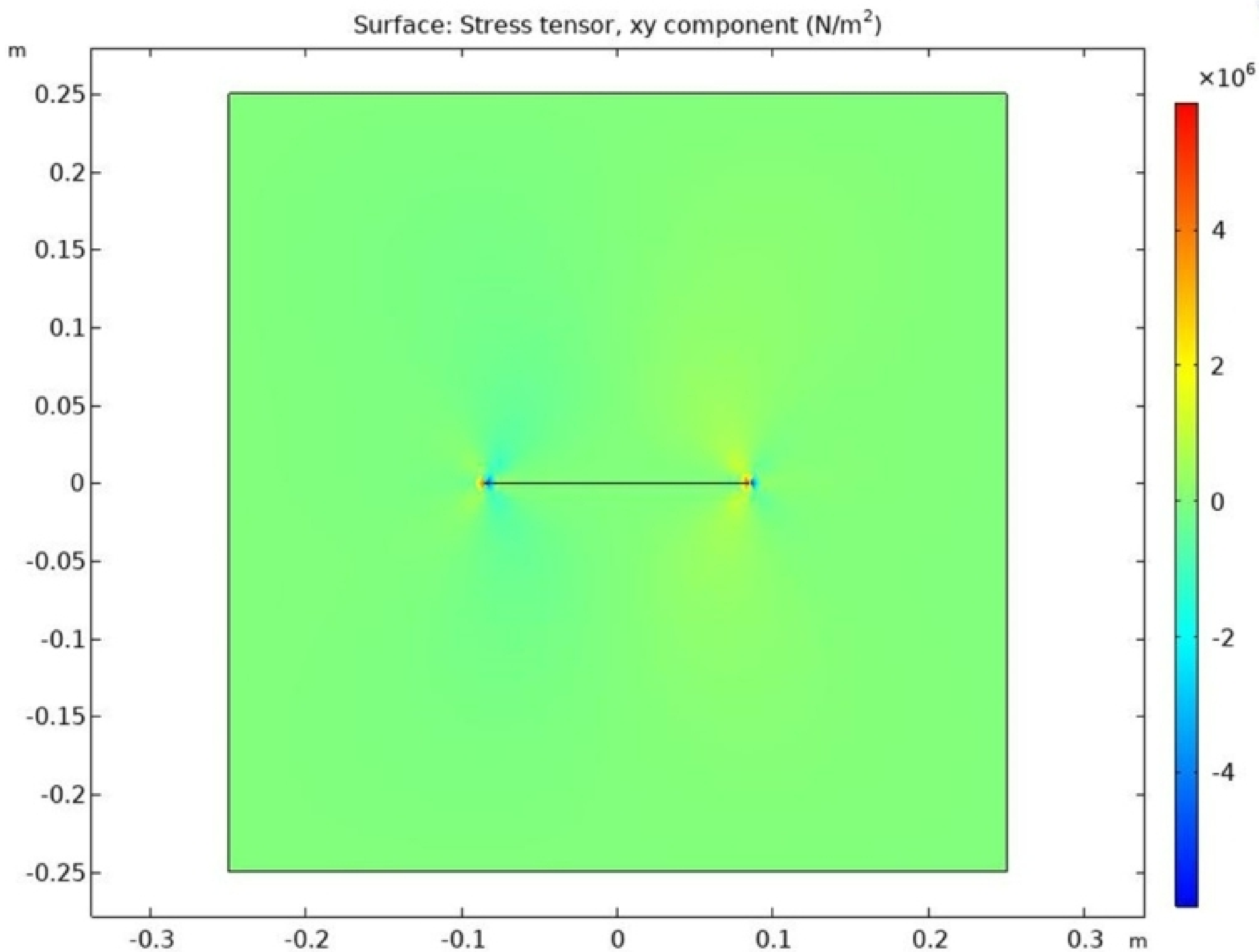
- Preliminary simulation of embedded fracture in an impervious material with internal fluid pressure of 2 MPa
- No external loading
- Domain Size = 0.5 m x 0.5 m
- Single Fracture length = 0.17 m
- Fracture angle from horizontal = 0^{o}, -30^{o}
- COMSOL Multiphysics used
- Material properties as in Step 1

Step 2 Results: Predicted Normal Displacement along Fracture

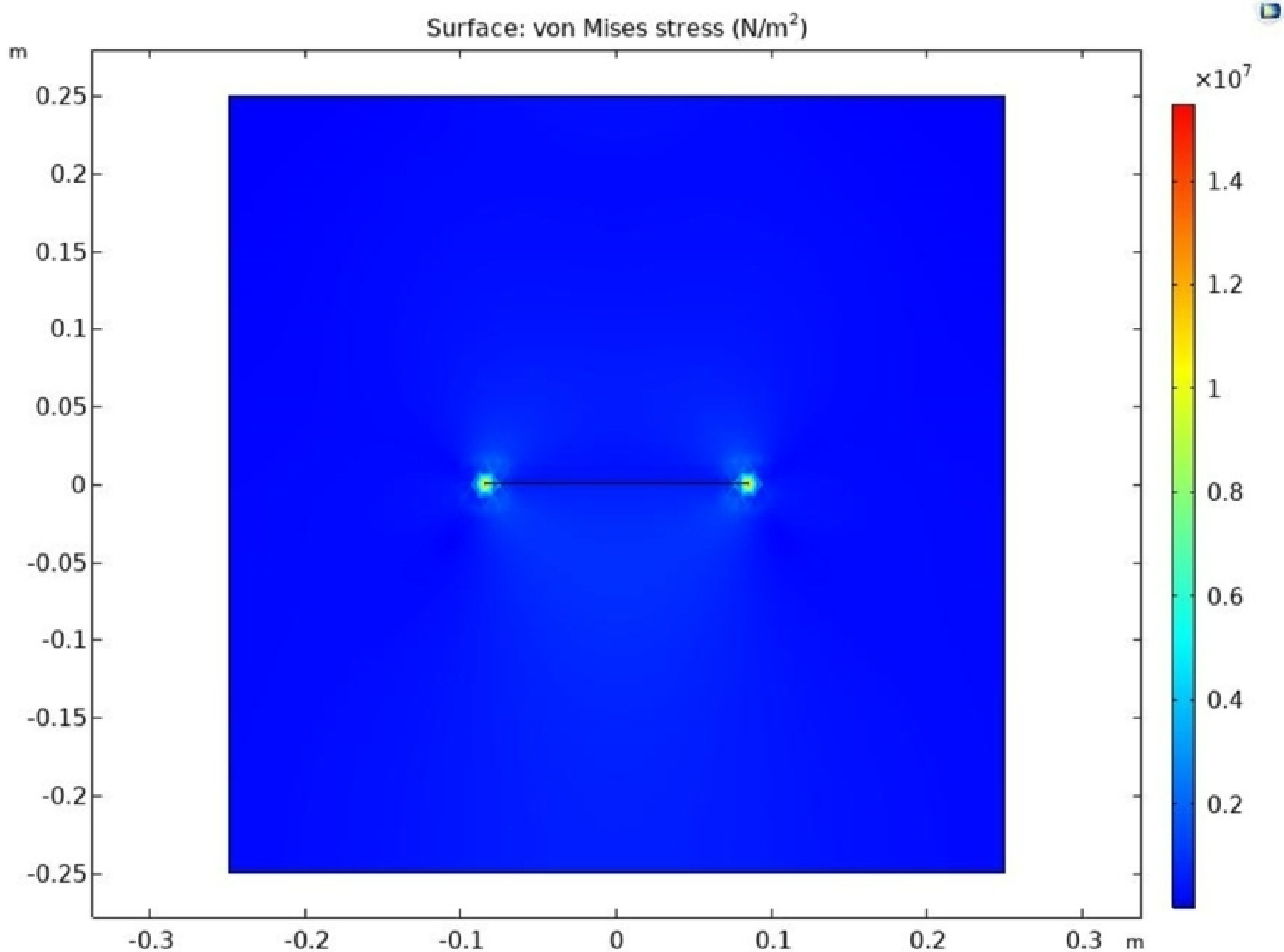


Results compare well with analytical solution (see *Papachristos et al., 2017)*

Step 2 Results: Predicted Distribution of Shear Stress



Step 2 Results: Predicted Distribution of von Mises Stress



Summary and Future Work

- Conducted preliminary modeling of Step 1: Benchmark Exercise G1-M-BE-2D
  - Modeled an embedded planar fracture in an elastic material with external loads
  - Compared modeling results with analytical solution
- Conducted preliminary modeling of Step 2: Benchmark Exercise G2-HM-BE-2D
  - Modeled a porous medium with an embedded planar fracture loaded by an internal fluid pressure
  - Compared modeling results with analytical solution
- Future work:
  - Step 1 with use of rough fractures
  - Step 2 with external loading included
  - Step 3: G3-TM-BE-2D-E/P (planar fracture case modeling)