Elliptical Shape Perforations:
an engineering application based on Cosserat modelling

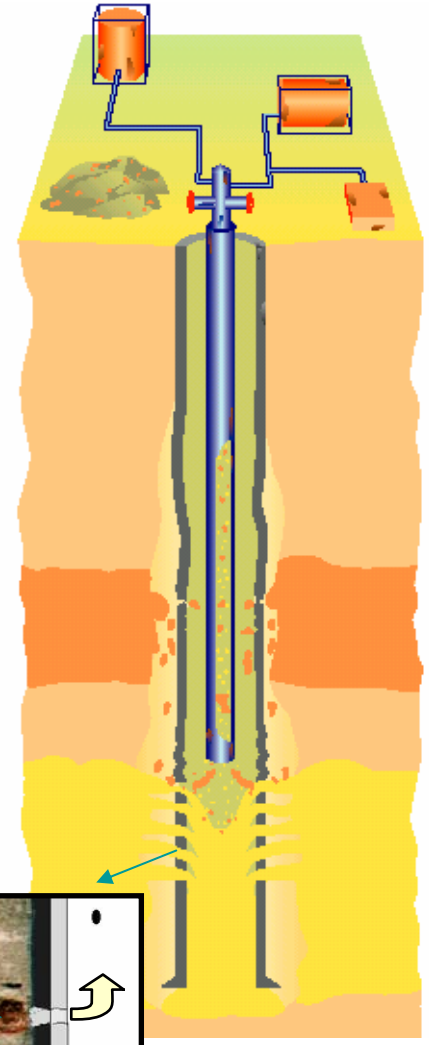
Papanastasiou, 2000

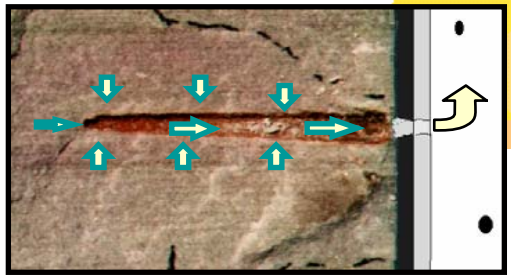
Outline

- Introduction
  - sand avoidance from perforated intervals
- Computational results
  - elastic analysis
  - Cosserat elastoplastic analysis
- Conclusion
  - practical application

Sand production and avoidance

- Sanding problem ($2 billion/year)
  - blocks perforations, damages of equipment, requires separation from the oil and disposal
- Avoidance
  - gravel packing and screening, preferential perforating, fracturing
- Objective
  - develop models to predict sanding and optimum completion

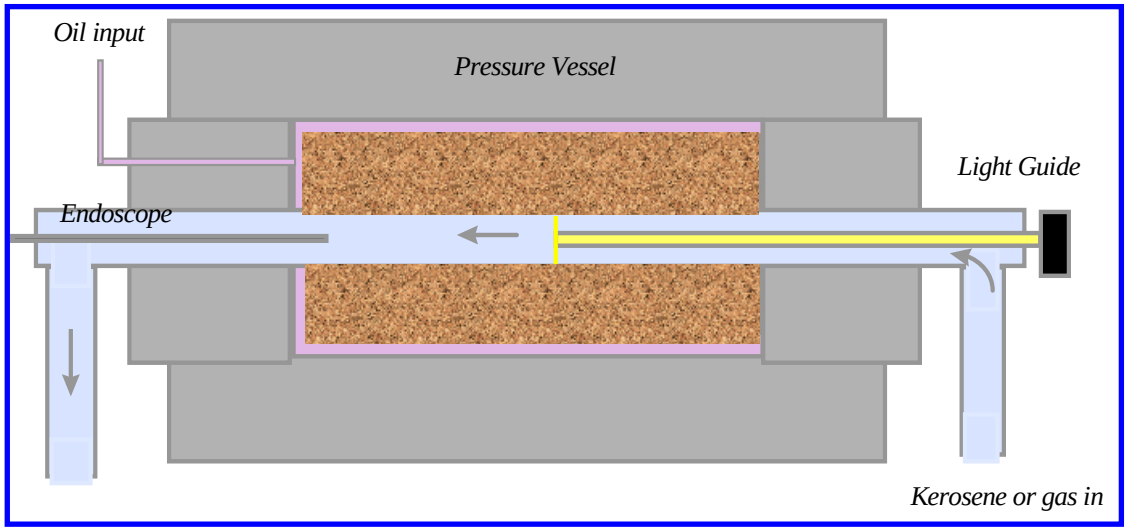


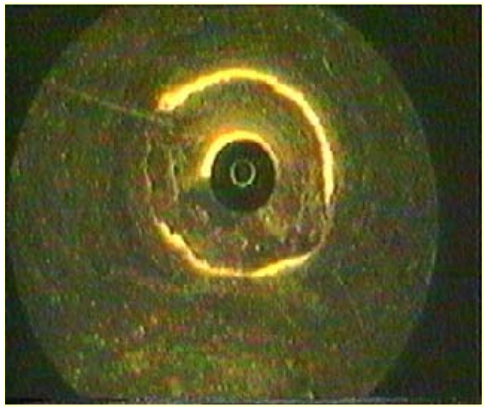


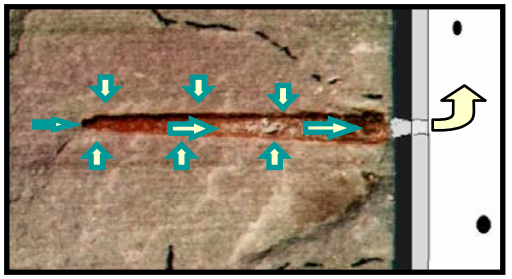
Real perforation

Mechanisms of sand production

- Hollow Cylinder Tests
  - various weak sandstones
  - 10-20 mm perforation size
  - hydrostatic pressure
- Sand production in two stages
  - stresses due to drawdown and depletion fail the rock
  - high flow velocities transport loose grain
- Unconsolidated formation
  - erosion mechanism



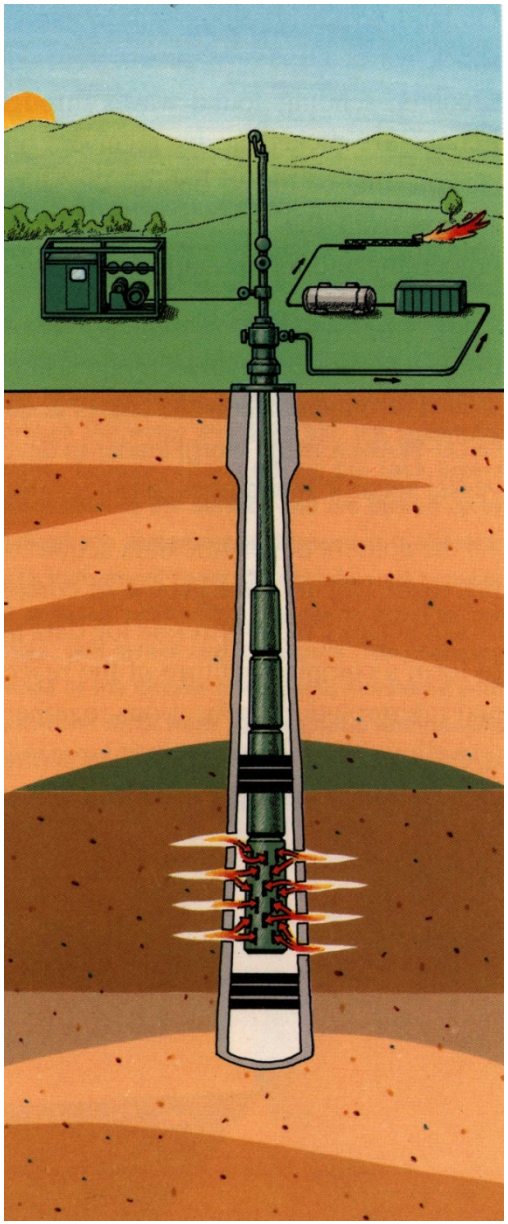


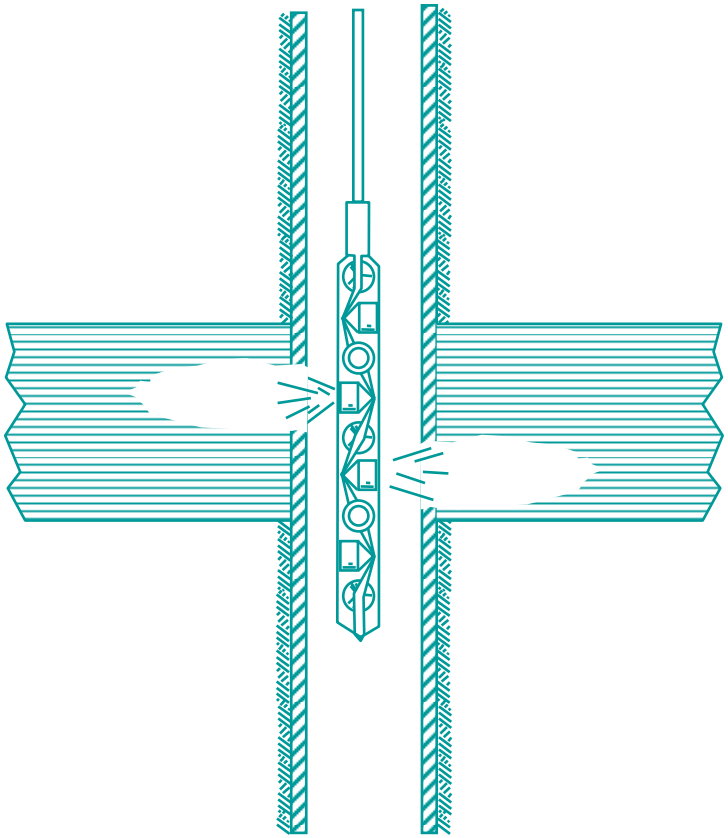


Real perforation

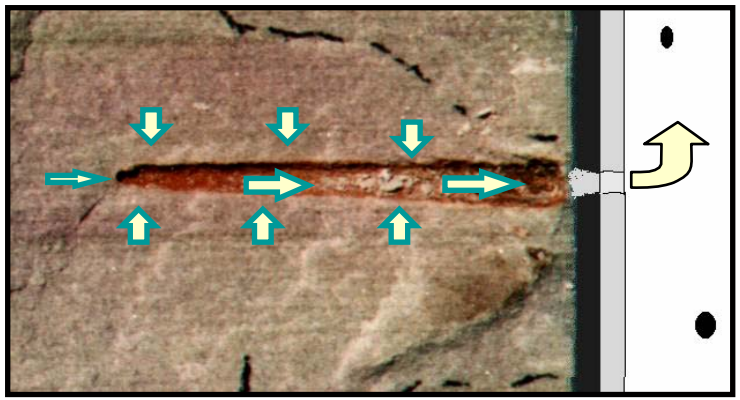
Cook and Nicholson (SCR)

Production from perforated intervals



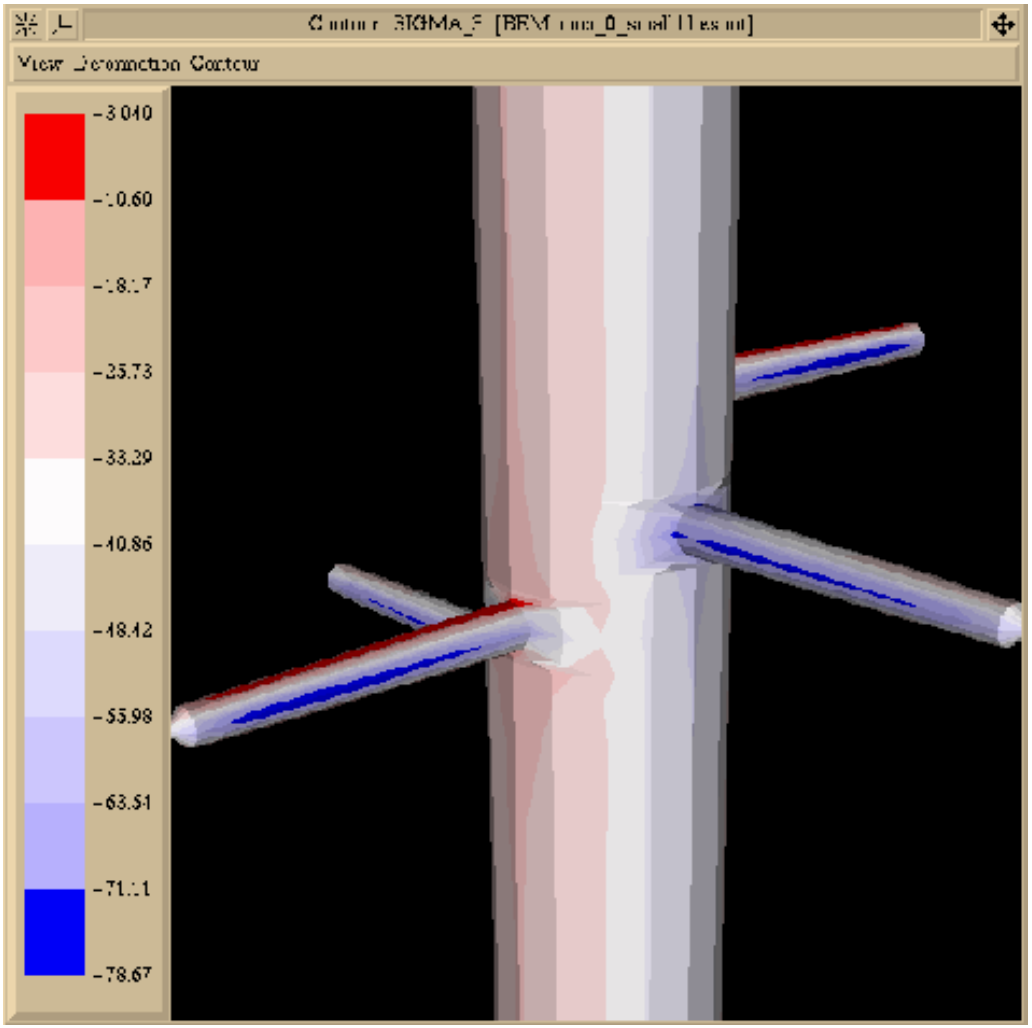


Perforating tool



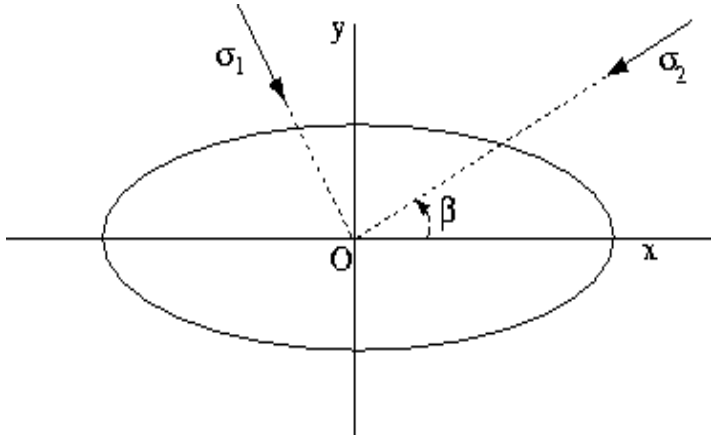
Real perforation

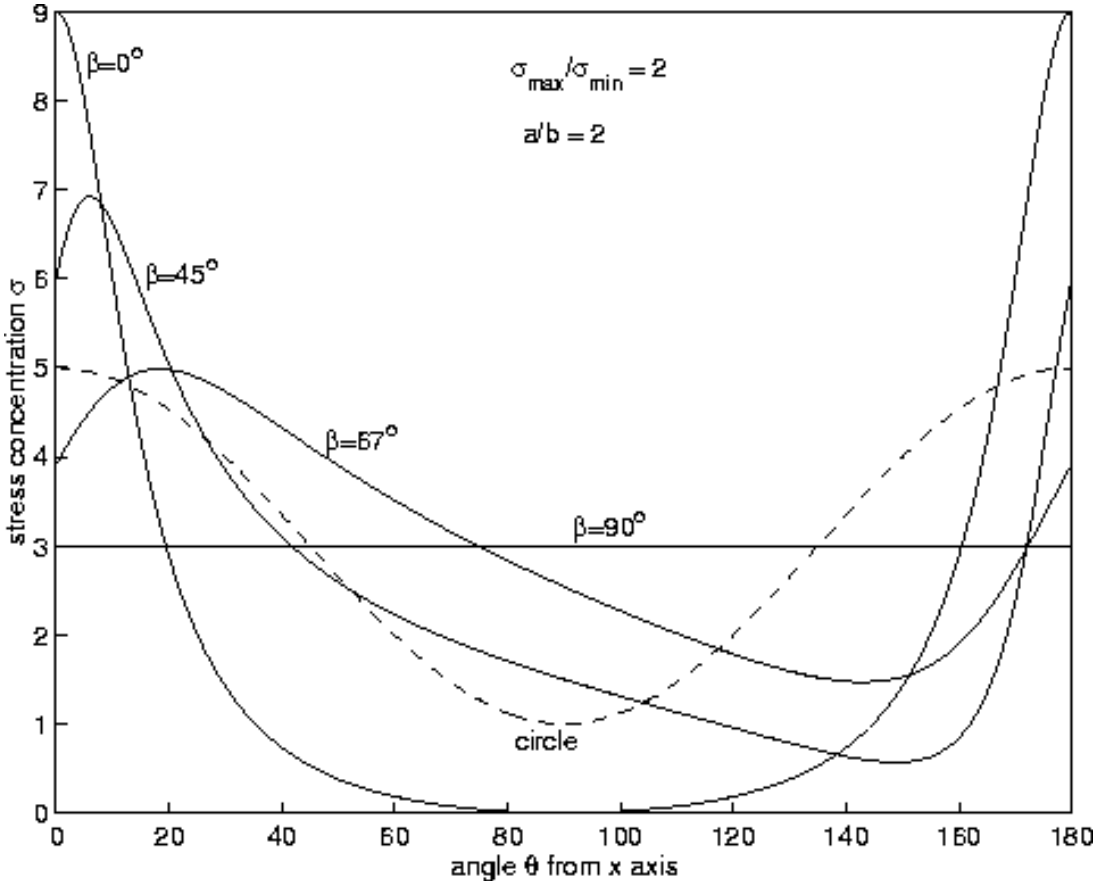
Sand avoidance



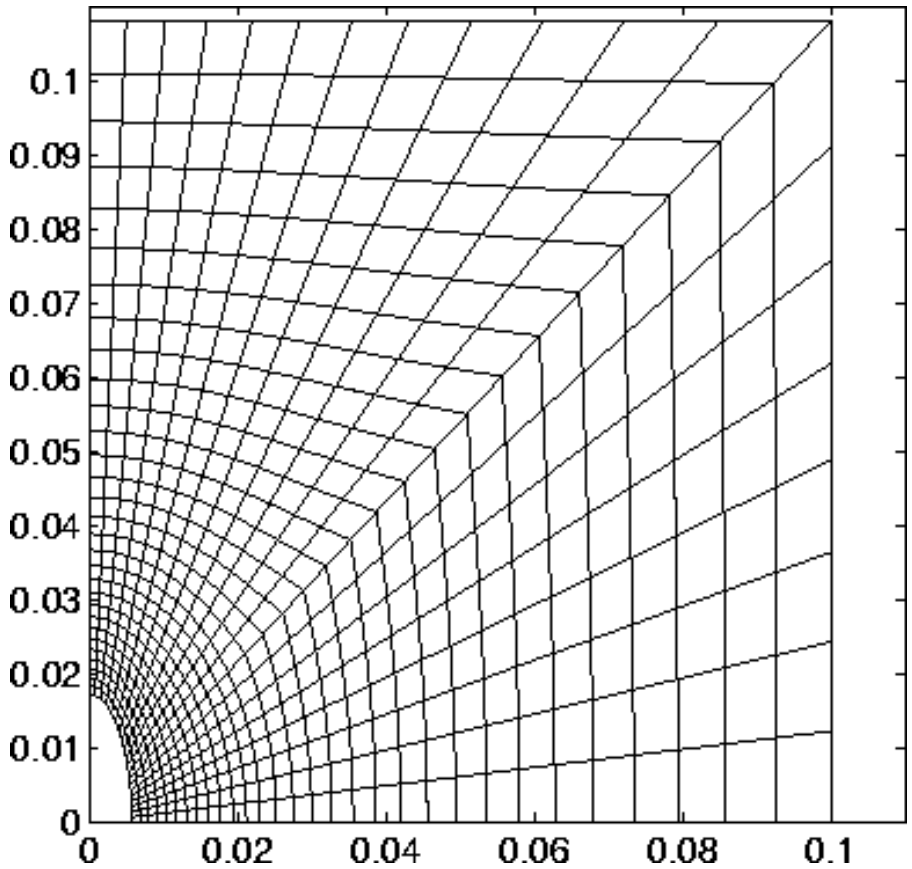
- perforation failure caused by high compressive stresses results in sand production
- redistribute the stresses on perforations by changing their shape
  - elliptically shaped perforations

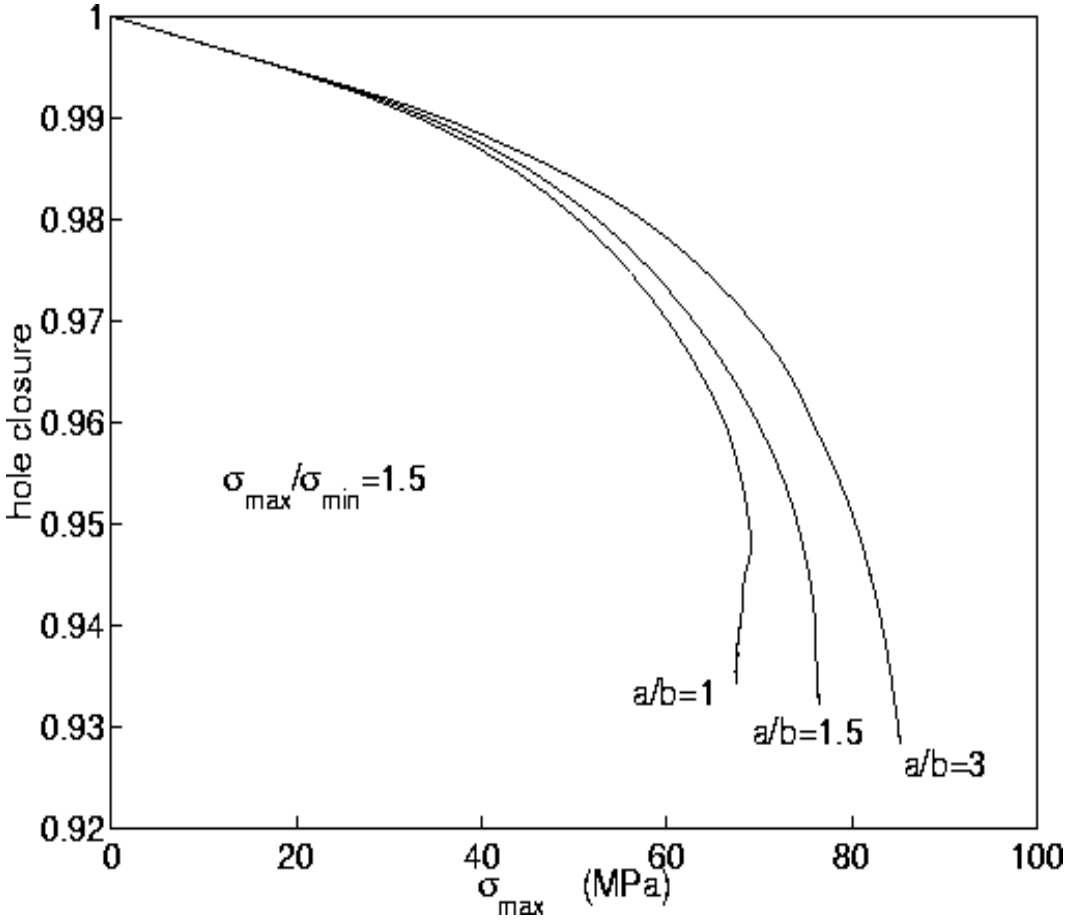
Elastic stress analysis

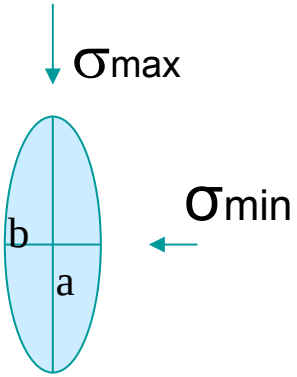




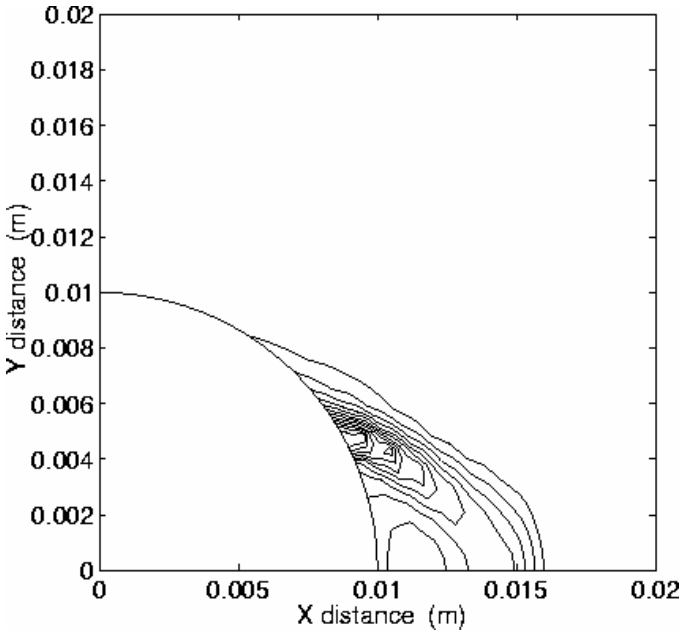
- uniform stress distribution if axis ratio is equal to the insitu stress ratio
- risk of perforation misalignment 23 degrees



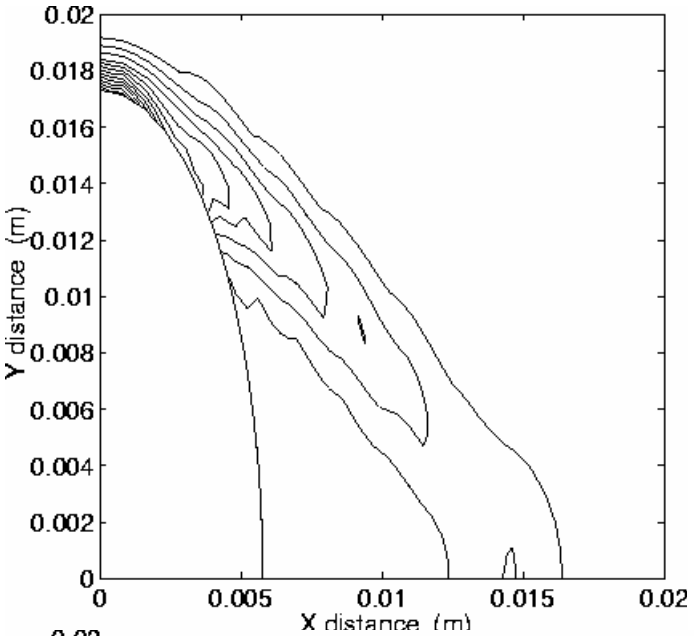


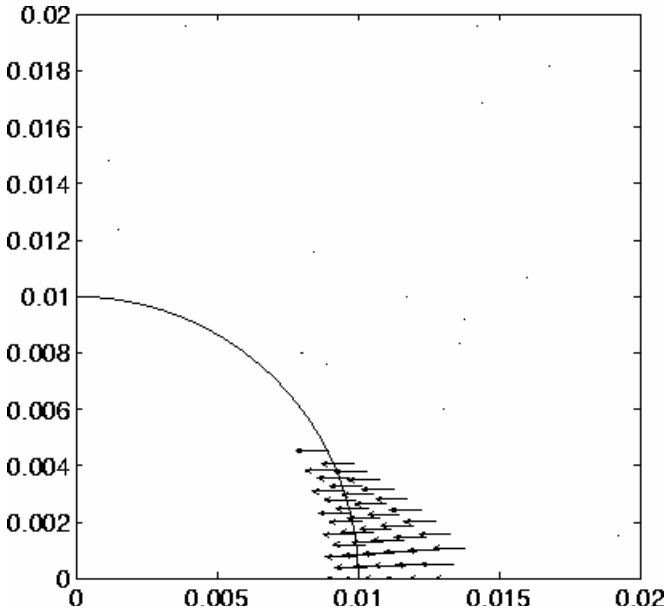


- compare cylindrical with elliptical perforations of the same cross-sectional area (flow area)
- strongest perforations: ellipse with the highest axis ratio

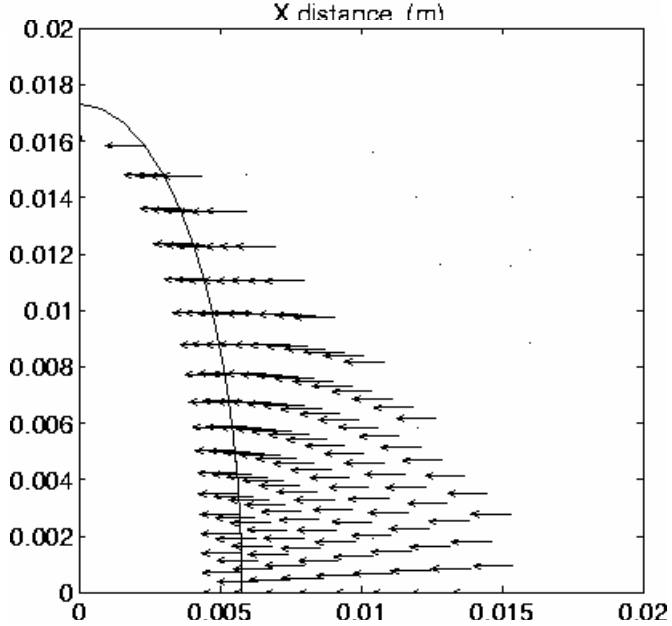


Plastic Strain



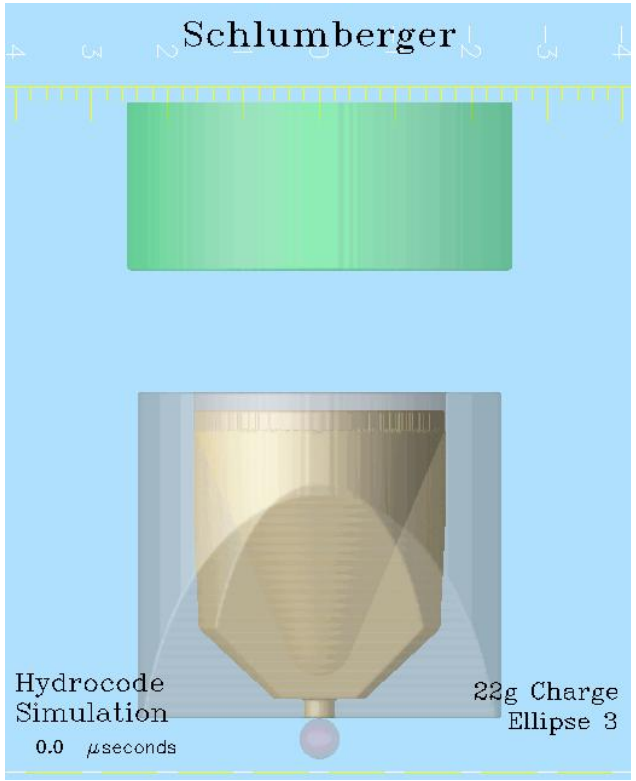


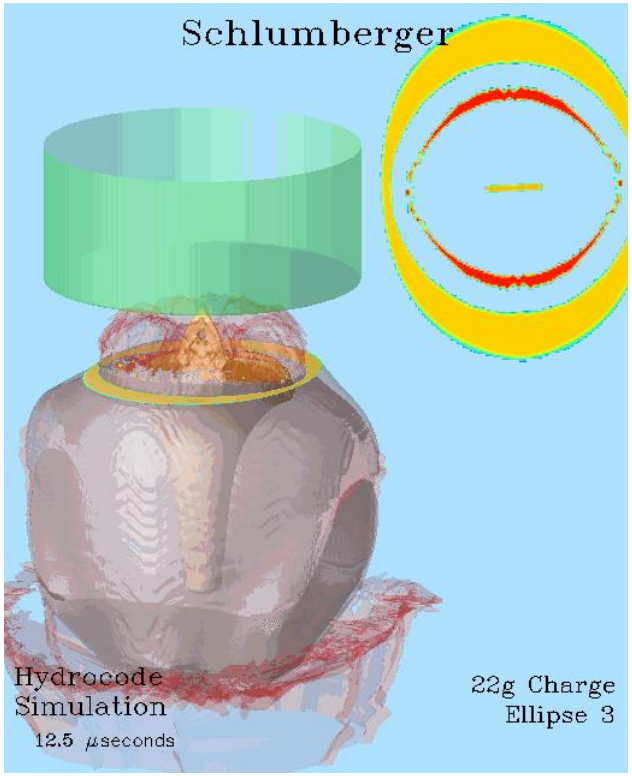
Displacement Field



Creation of elliptical perforations

- 3-D simulations using hydro-codes
- simple changes in the charge case resulted in highly elliptical jets (aspect ratio > 5:1)





Conclusion

- elliptically shaped perforations are stronger than conventional perforations
- this result was found using Cosserat modelling
- results predicted by classical stress analysis were not applicable
- Cosserat allows for robust localization analysis
- Limited applications in design and practise