SAND2013-4687P

Modeling Blast Loading on Structures

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Summary

- A range of blast-on-structure simulations have been conducted with Sandia computational tools in recent years; codes show promise in ability to capture key phemonemon
- Codes of interest:
  - CTH (Eulerian Hydrocode)
  - Zapotec (Eulerian/Lagrangian coupled code)
  - 1-way coupling schemes (Eulerian to Lagrangian)
- This presentation includes analysis of:
  - Kinetic Plate
  - Blast Plate
  - Cylinder Test
  - Mine Blast

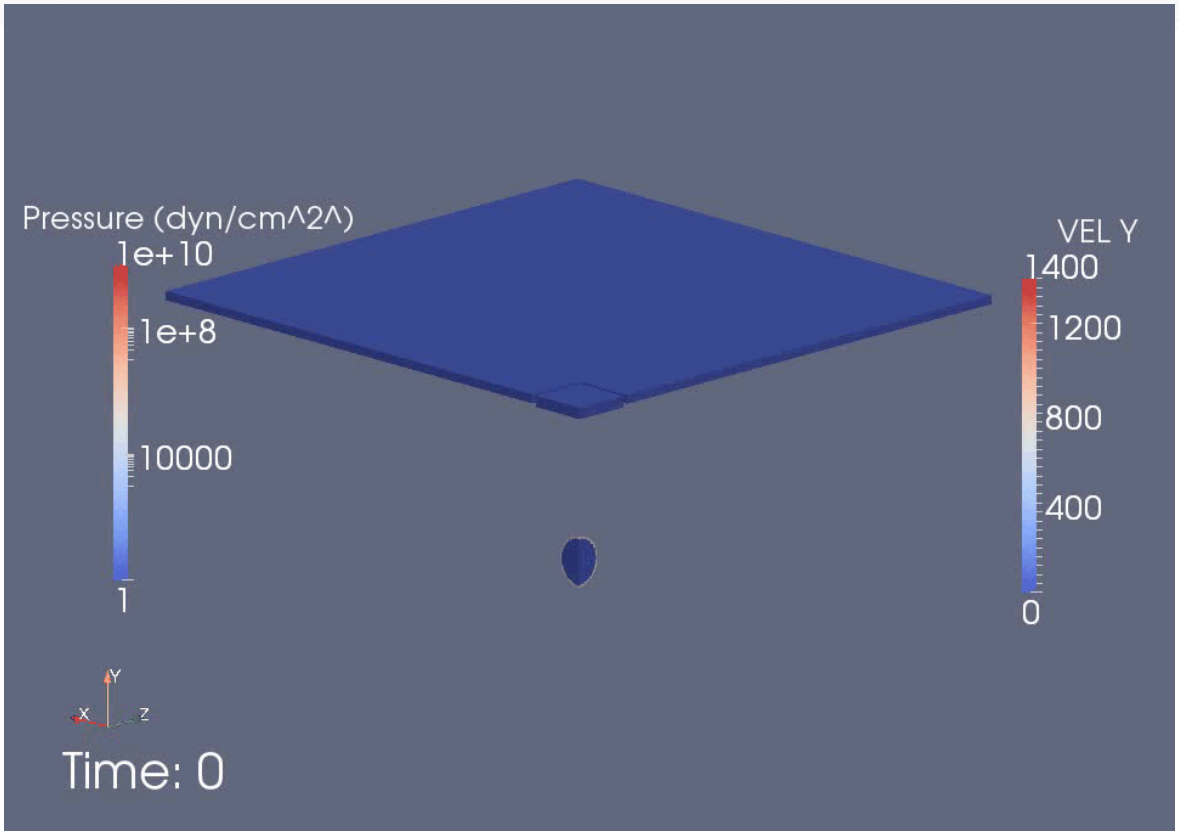
Kinetic Plate

- Experiment: explosive charge set off 6” from plate
- Metric: final velocity of plate
- Plate:
  - Thick enough to not deform
  - Loosely set in thick collar to eliminate wrap-around of gasses
  - PDV probes measure plate velocity
- Focus: CTH & Zapotec

Testing conducted at LANL

Kinetic Plate Simulations

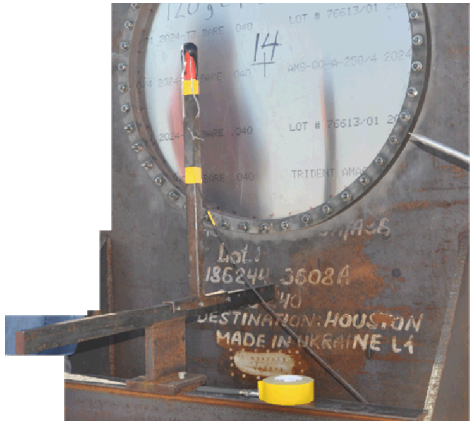
- CTH simulations match well (<2% error in final velocity at max refinement)
- Zapotec Simulation also close (~4%)



Zapotec Simulation

Blast Plate

- Experiment: explosive set 10” away from thin plate, rigidly held
- Plate:
  - Very thin (~millimeter)
  - Does not break in this test
- DIC used to measure plate displacement

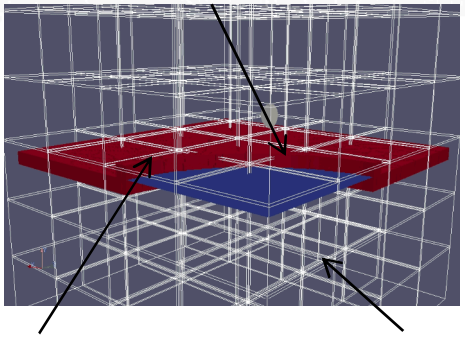


Testing conducted at Sandia

Blast Plate Simulation

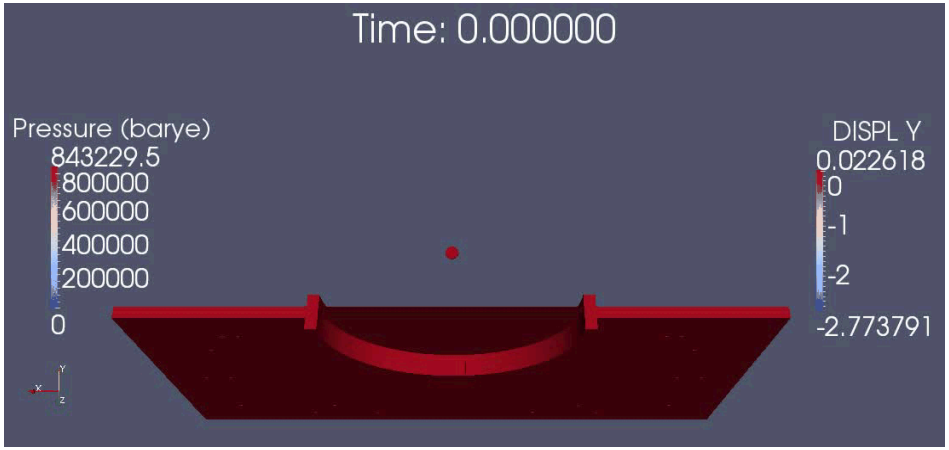
- **Comparison to data is favorable**
- **Large numbers of runs made to explore computational parameters**
- **Guidelines created for future simulations**

Explosive in Eulerian domain (CTH)

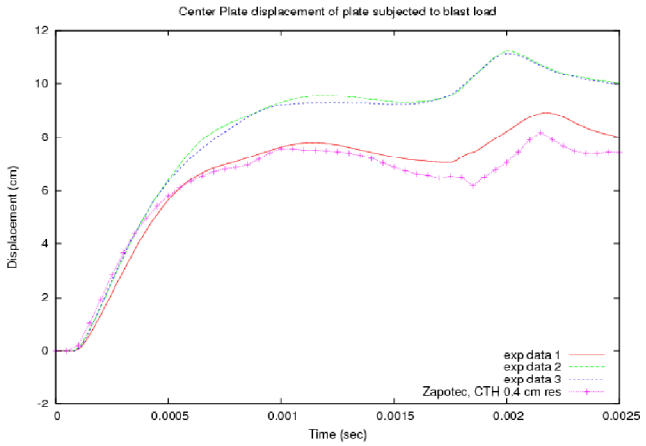


Lagrangian Mesh (Pronto)

Eulerian domain (CTH)



Sample Zapotec Simulation

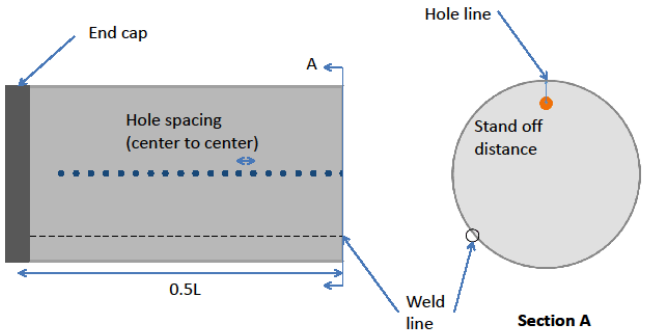


Comparison to Data

Stored Energy Test (SET)

- Experiment: Explosive charge placed inside large cylinder with pre-drilled holes
- Metric: Tearing of cylinder measured
- Internal pressure and mass of explosive charge varied
  - No tearing at low explosive mass
  - Complete tearing at higher levels

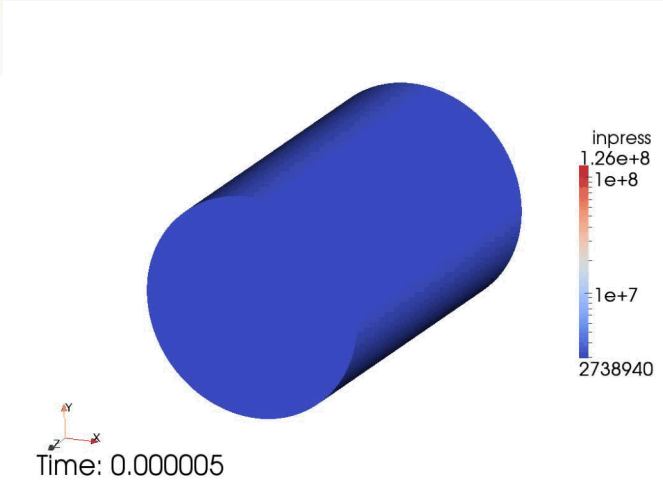
General Schematic



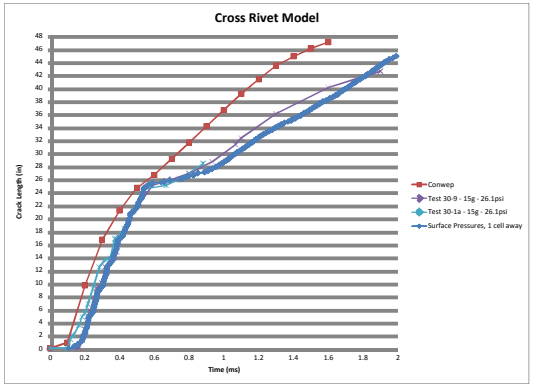
Testing conducted at Sandia

SET simulations

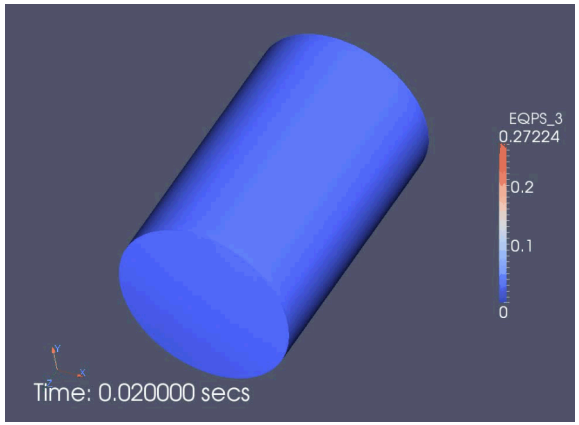
- **Problems run with 1-D coupling:**
  - **CTH AMR with tracers**
  - **Sierra/SM (Presto) with nodal applied pressures**
- **Tricky problem, but some correlations look good**



Applied Pressures (from CTH, to Presto)

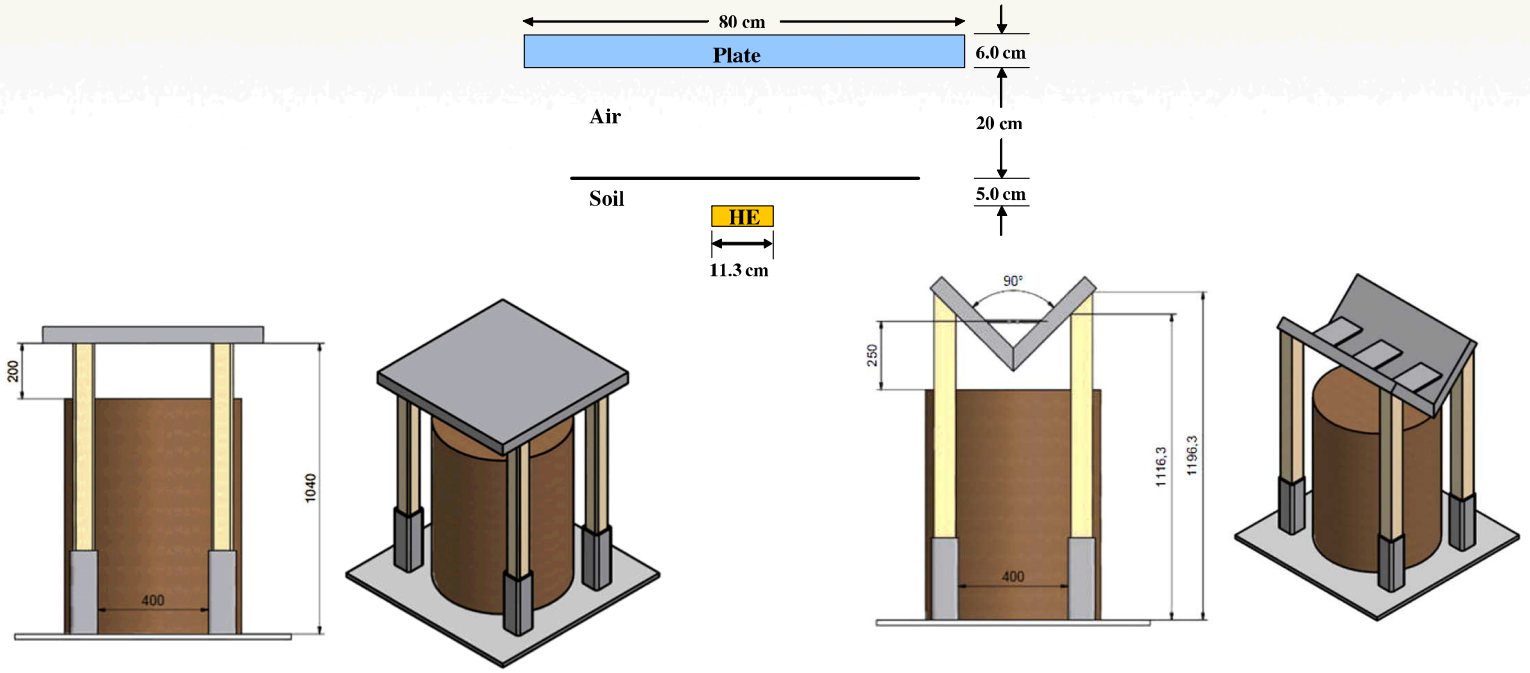


Crack growth curve: sim vs. Data



Tearing simulation (Presto)

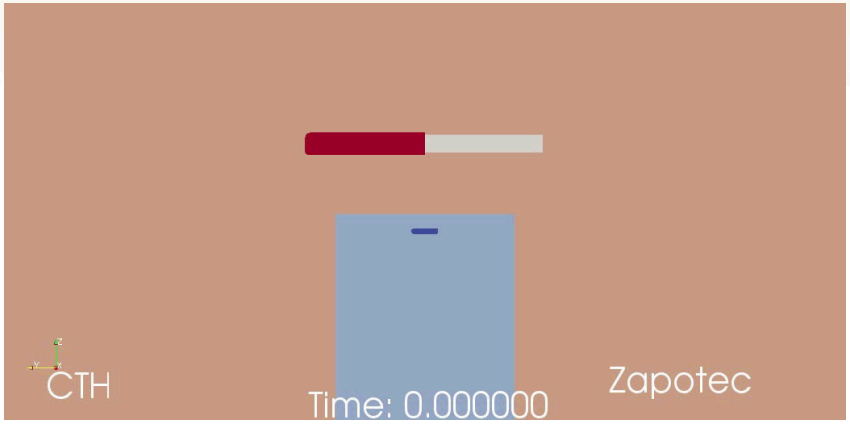
Mine Blast Test Series

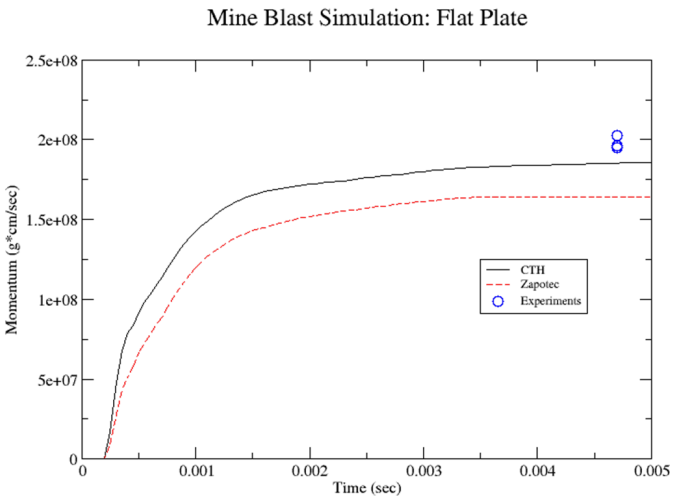


- Source: Anderson, C. E. et al., “Mine Blast Loading Experiments”, International Journal of Impact Engineering, 38 (2011) 697-706
- Six test series varying moisture content, plate shape, standoff – three repetitions per series

Flat plate simulation

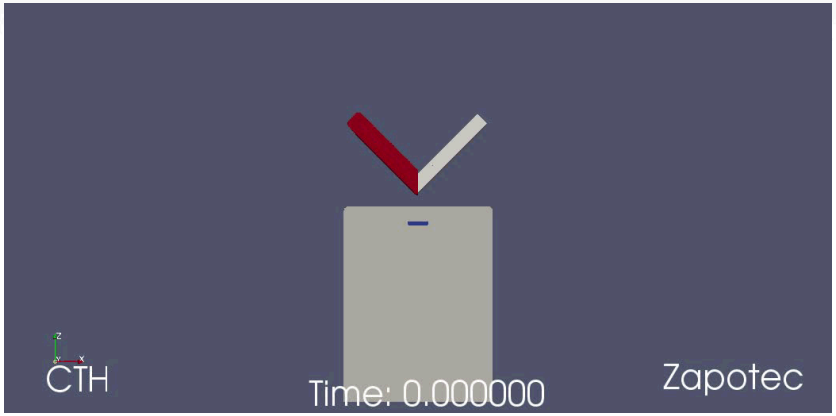
- Test case:
  - Flat plate
  - 20cm standoff
  - 7% moisture content sand
  - Explosive: 625 g Comp B
- Two modeling approaches:
  - CTH only
  - Zapotec: Lagrangian Plate, CTH everything else
- CTH within 6% of experiment, Zapotec within 17%

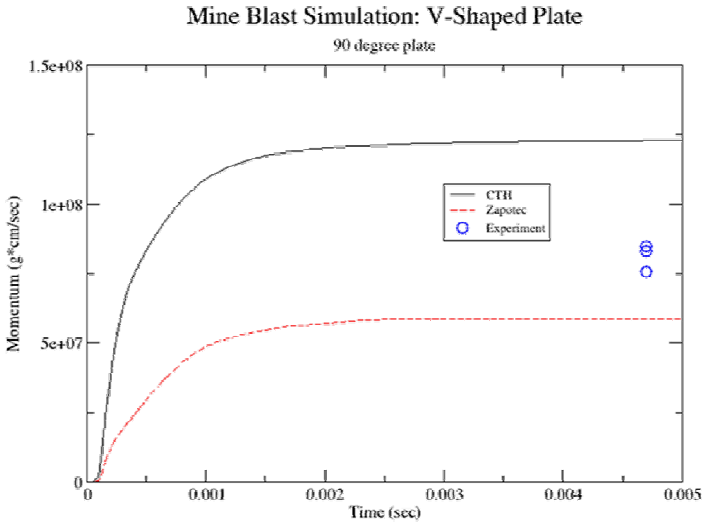




Flat plate simulation

- Test case:
  - V-shaped plate (90 degrees)
  - Flat plate
  - 25cm standoff to centroid
  - 7% moisture content sand
  - Explosive: 625 g Comp B
- Two modeling approaches:
  - CTH only
  - Zapotec: Lagrangian Plate, CTH everything else
- CTH within 51% of experiment, Zapotec within 28%





Observations

- Sandia capabilities are promising for these problems, further work can improve use
- Current developments underway:
  - ZapotecII: upgraded to Sierra/Sm & functional with CTH AMR
  - Alternative Eulerian/Lagrangian coupling (Fortissimo)
  - Possible improvements to 1-D coupling tools
  - Looks progressing for other methods
- Lots of details required to get proper solutions: documentation of these is ongoing