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54th Annual NDIA Fuze Conference; May 12, 2010

TITLE

Dynamic impact simulation of “high *g* hardened fuzes”.

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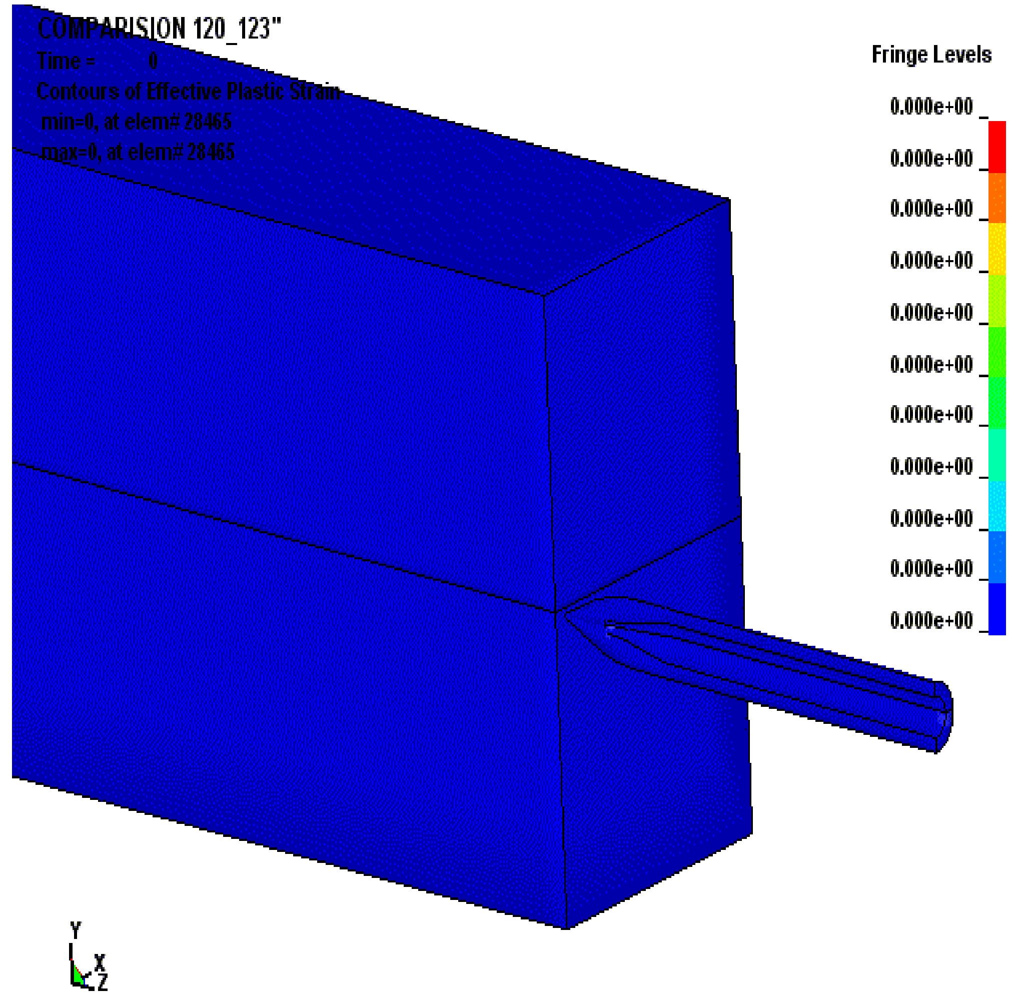


Purpose and goal

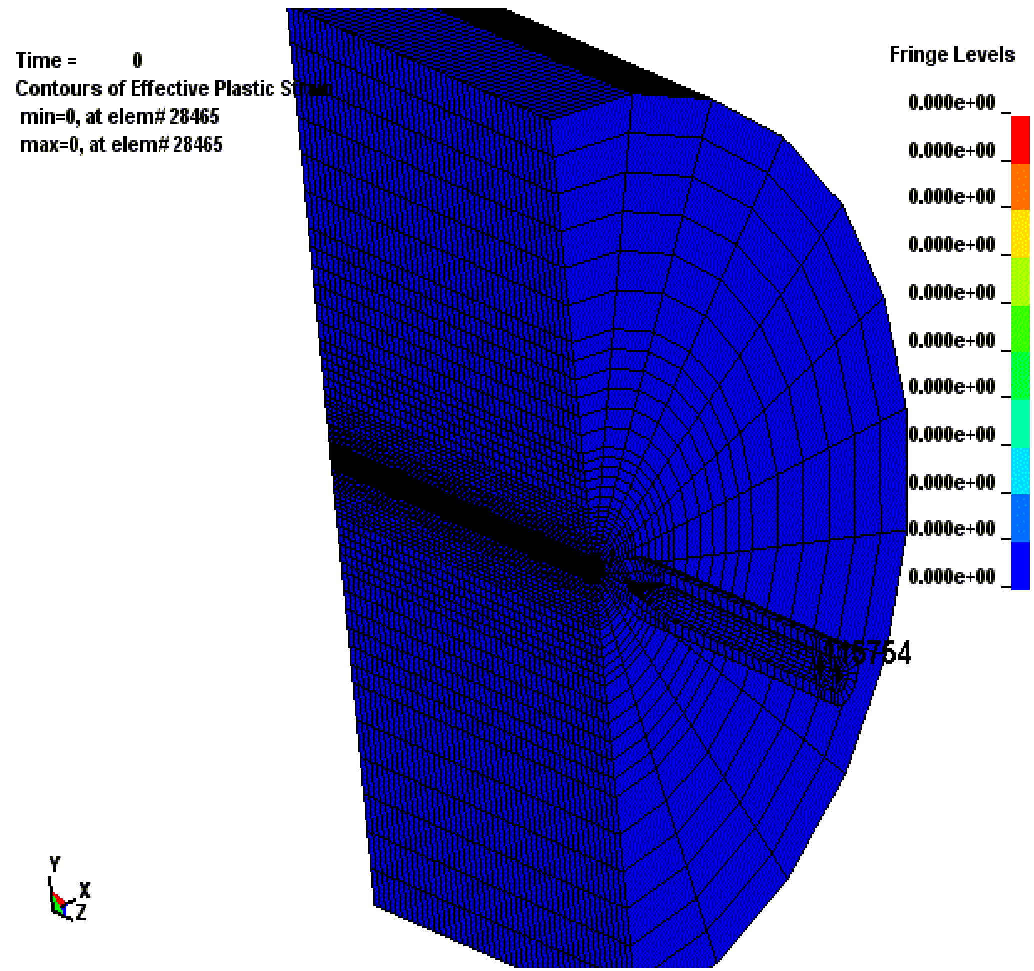
- The purpose of this paper is to document the development of a new simulation tool which is being employed to simulate deceleration, stress, and strain imposed on penetrators and fuzes during typical cannon and sled tests.
- The secondary goal is to create standard "LS-DYNA input templates" which can be employed by the "non-expert user" to simulate cannon and sled tests.

New Simulation method

Concrete model
*MAT_159
Failure damage
User friendly
Fast / Robust

Lower stiffness material dominates performance
e.g. concrete
10 times lower mod
10 times lower yield

Concrete model is critical
Penetrator is secondary



Down load written paper

- UNCLASSIFIED LS_DYNA input template can be down loaded DTIC website
- UNCLASSIFIED written paper version of presentation may be down loaded DTIC website
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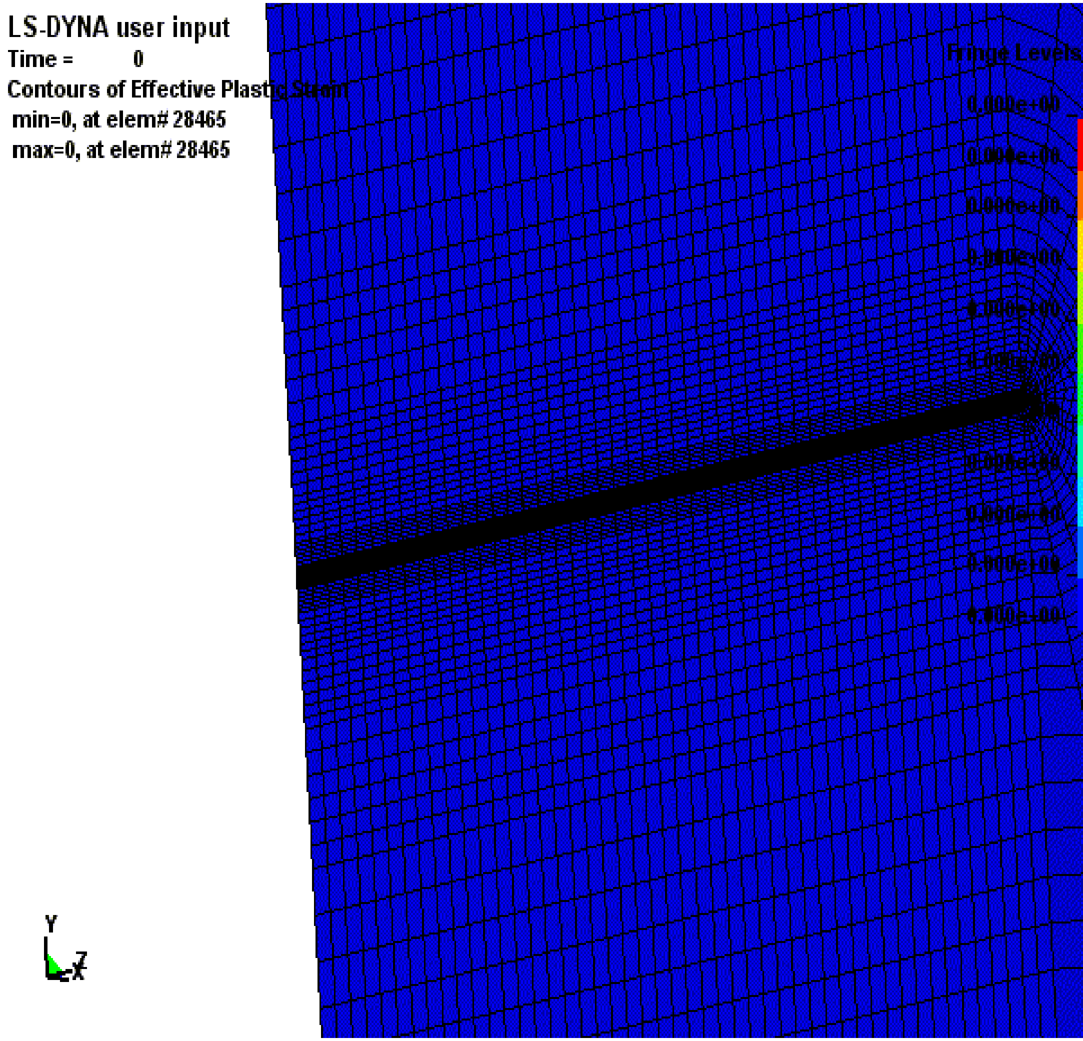


BACKGROUND

- Cannon tests and rocket propelled sled tests are the standard test methods employed to “proof test” the successful operation of hardened fuzes.
- The new LS-DYNA concrete material model (*MAT 159) and eroding contact option allows rapid simulation of impact penetration and by-passes the need for excessive computer run times often required for Arbitrary Largrangian Eulerian (ALE) LS-DYNA models and equation of state (EOS) material models.
- This paper describes a simple, fast running LS-DYNA application for simulating cannon and sled tests which runs on a “Dell workstation employing one Intel processor” in a few hours of equation-solver time and accurately predicts; depth of penetration, exit velocity, deceleration, and the typical “conical” entrance and exit fracture patterns in a concrete target.

Three types of impacts

Three impact cases are investigated and the results compared to test data. The three cases are:

- Case-1, typical calibration impact case of a known penetrator impacting, arrested, and captured by a large concrete block. Compare to open literature.
- Case-2, typical cannon test with concrete target blocks. Compare to on-board data recorder.
- Case-3, typical sled test with a sequential target set consisting of concrete blocks, air voids, and back stop. Compare to prior tests.

Post-test photographs of the impact face of the 1.83, 1.37, and 0.91-m diameter targets.

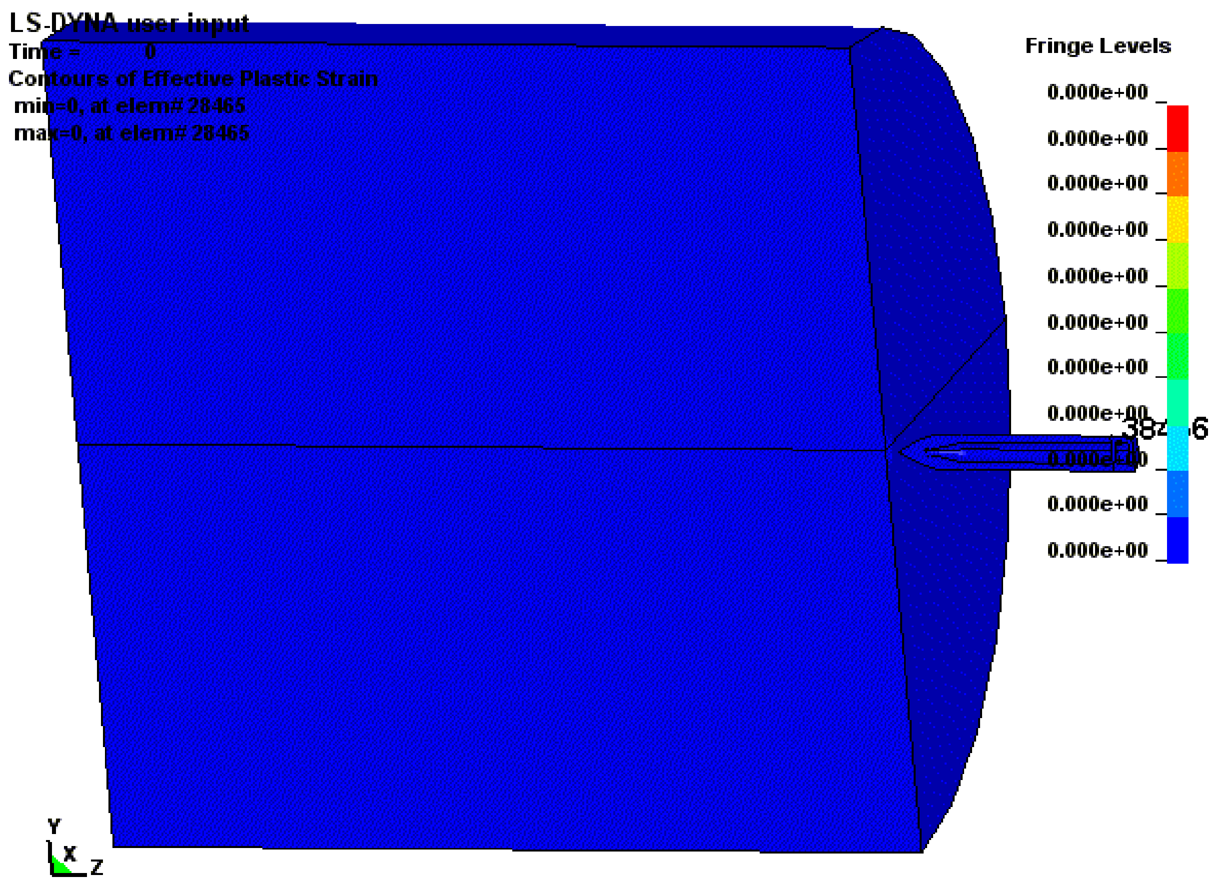
D/d = 24
V_s = 335 m/s

D/d = 18
Vs = 332 m/s

D/d = 12
Vs = 337 m/s

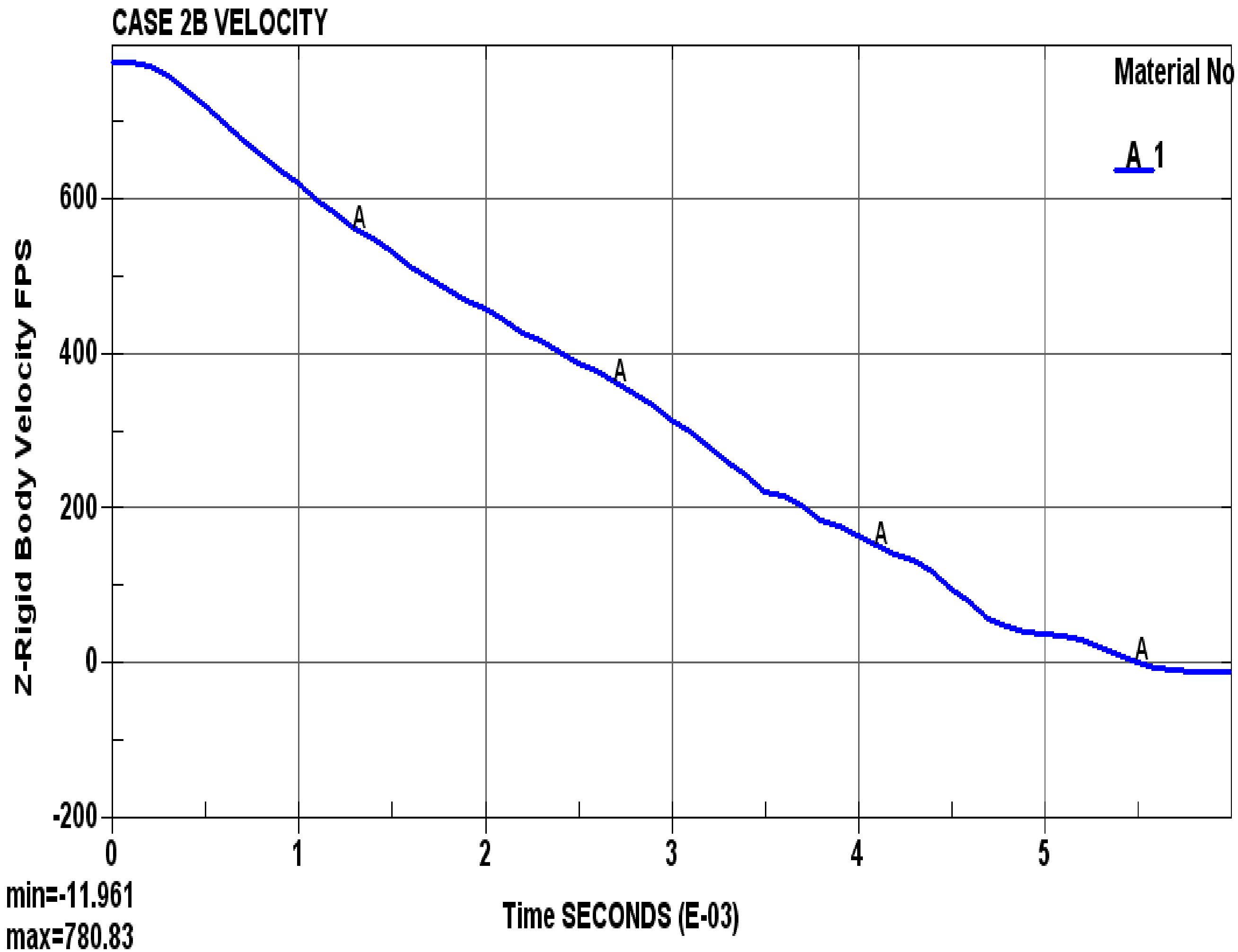
Case 1b, no exit, large target, correct damage pattern, penetration and rigid body deceleration

1/3 to 1/2 dia damage



Case 1b Velocity

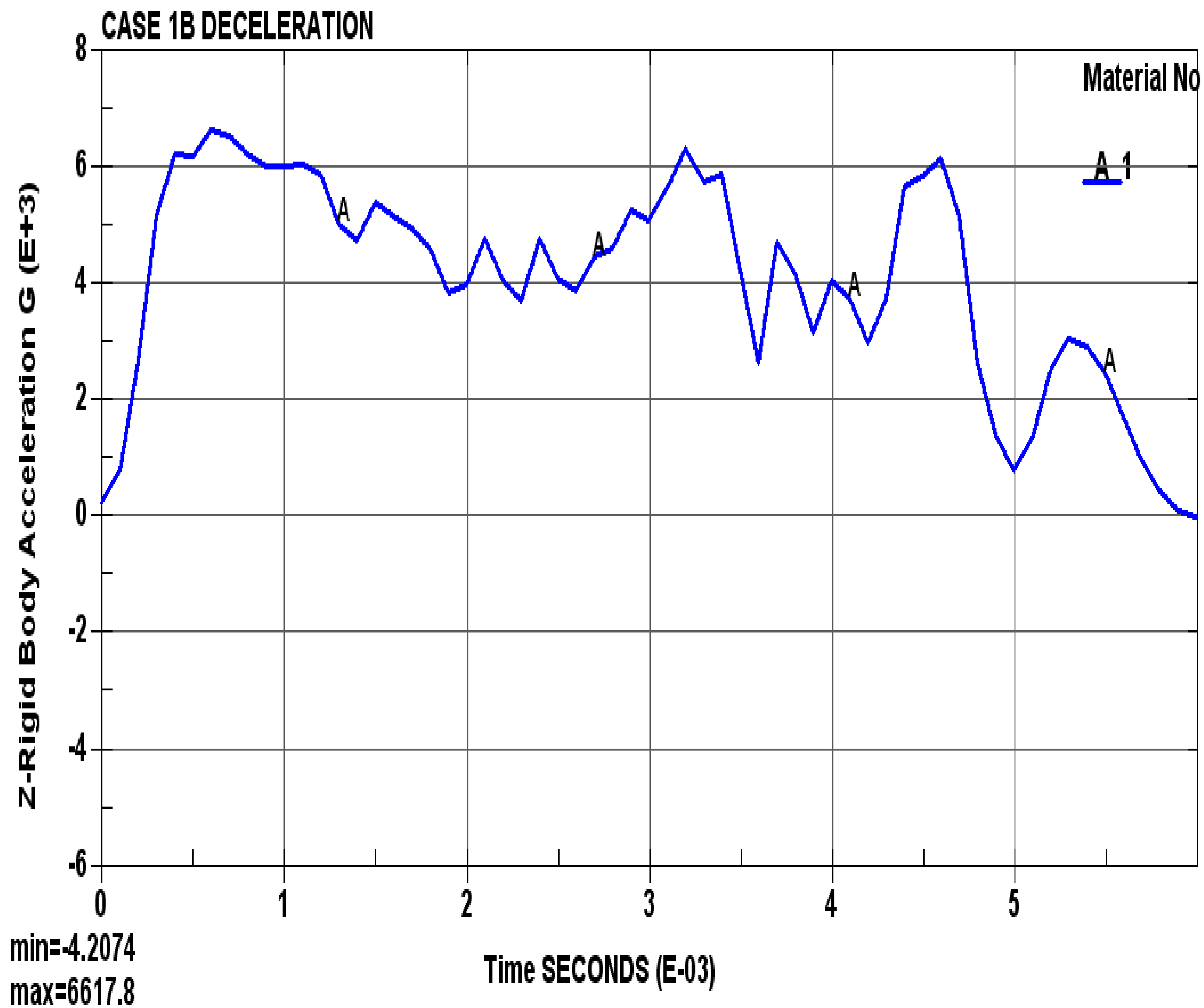
Approx
Linear negative slope



Case 1b Deceleration

Square wave
Deceleration pulse
For case1 only

Concrete acts as
Energy absorber
Applications
Back stop

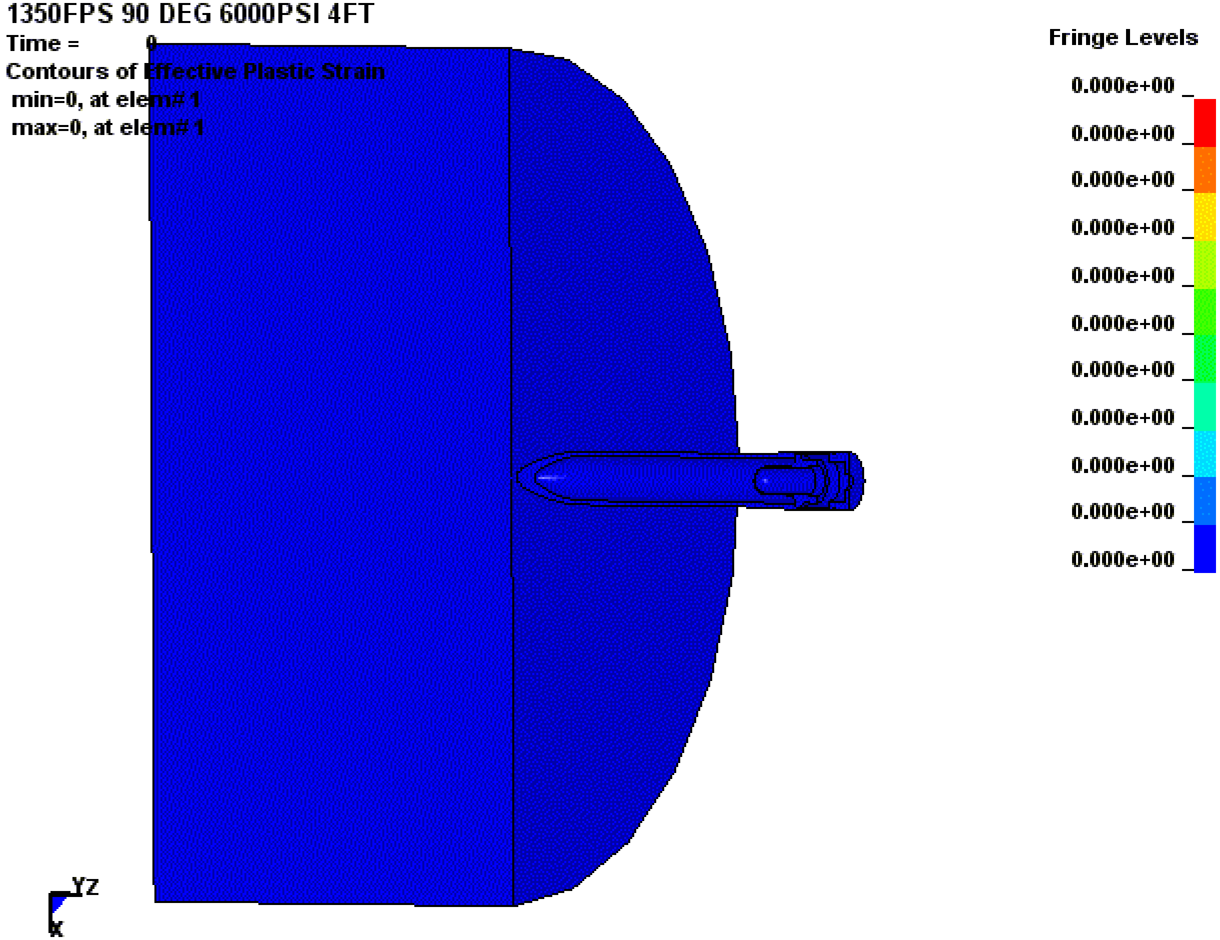


Case 2 Eglin Air Force Cannon test

Case 2 Eglin Cannon test exit face

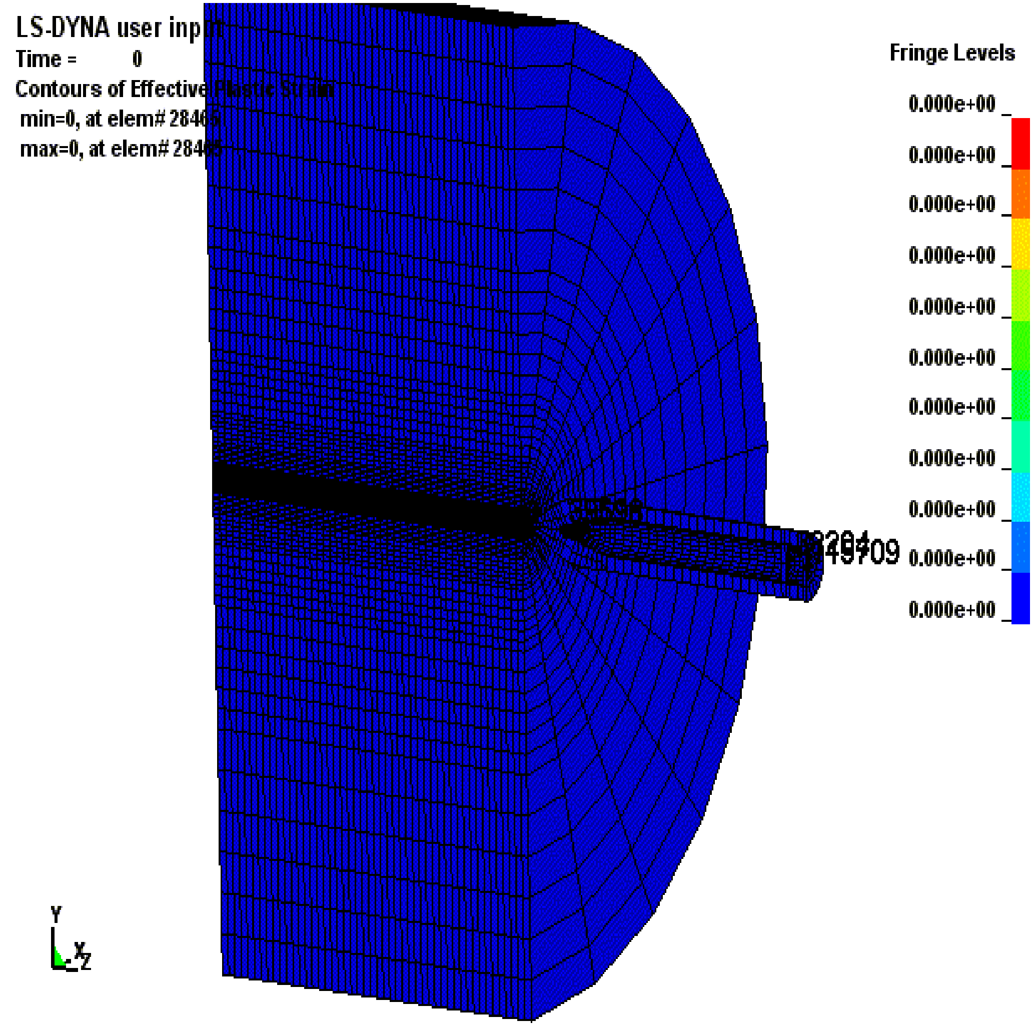
Note exit face 100% fracture

Case 2, cannon, 4 feet concrete correct exit velocity and deceleration

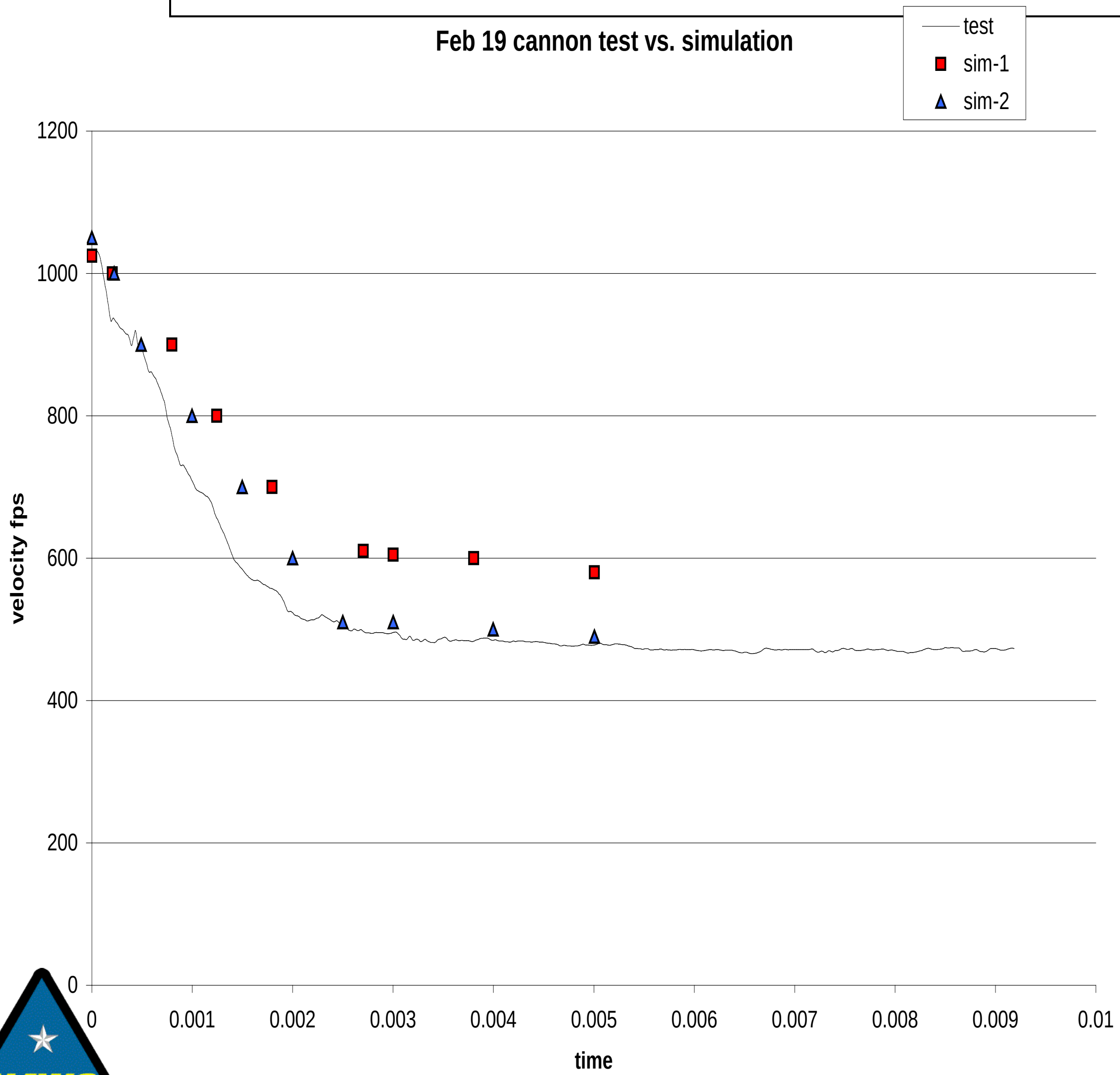


Approx fracture pattern

The concrete fracture region (erosion region) and spall pattern of the present methodology also agrees in general appearance with high speed test film but varies from test to test due to the nearly random crack propagation of concrete. The high speed film of the test shows that the concrete continues to fracture after the penetrator has exited the target.



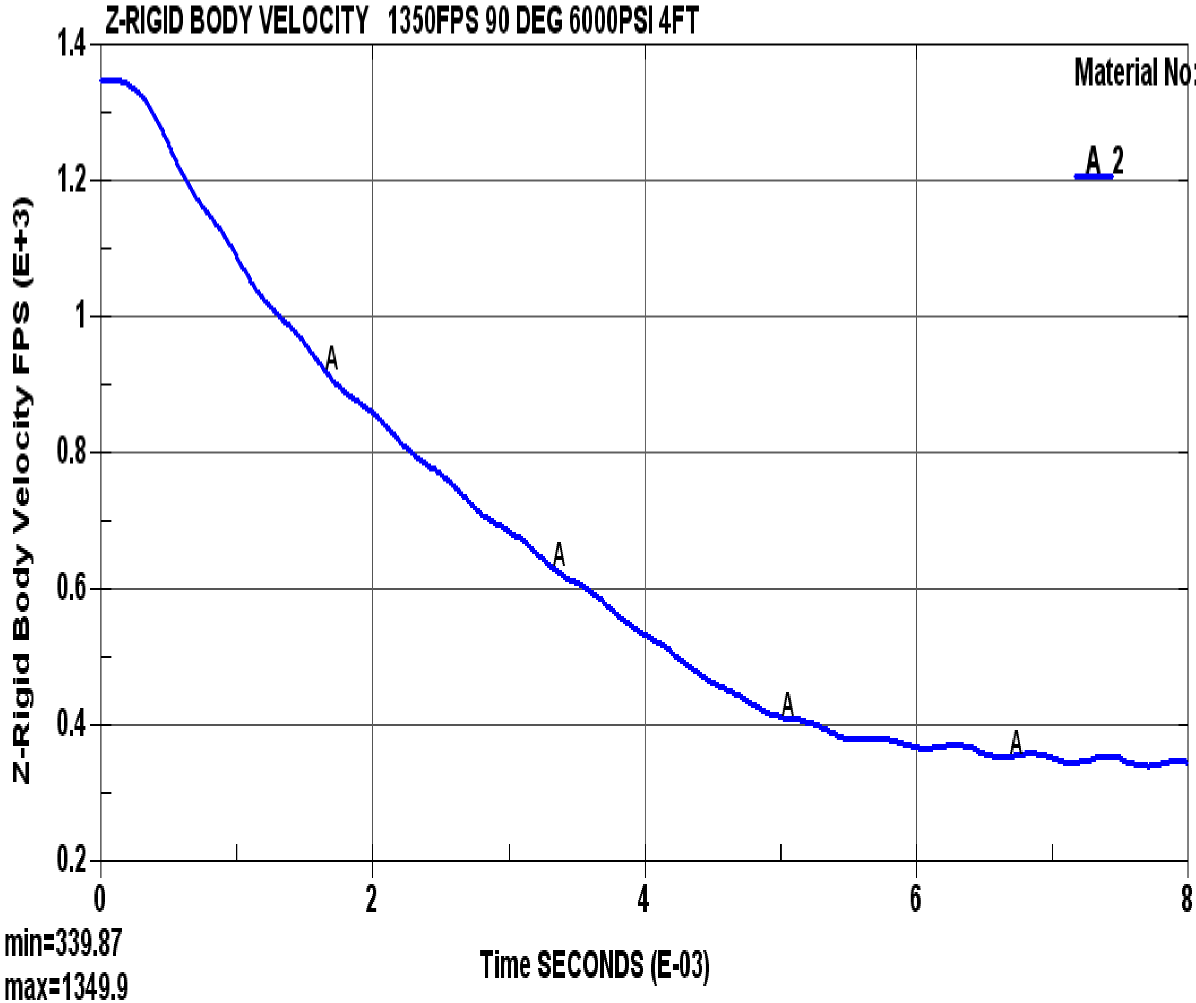
Comparison test vs. simulation; velocity vs. time



Second iteration
Approx matches
Test data

Concave curve
Entrance max negative slope
Break exit face
Sliding friction

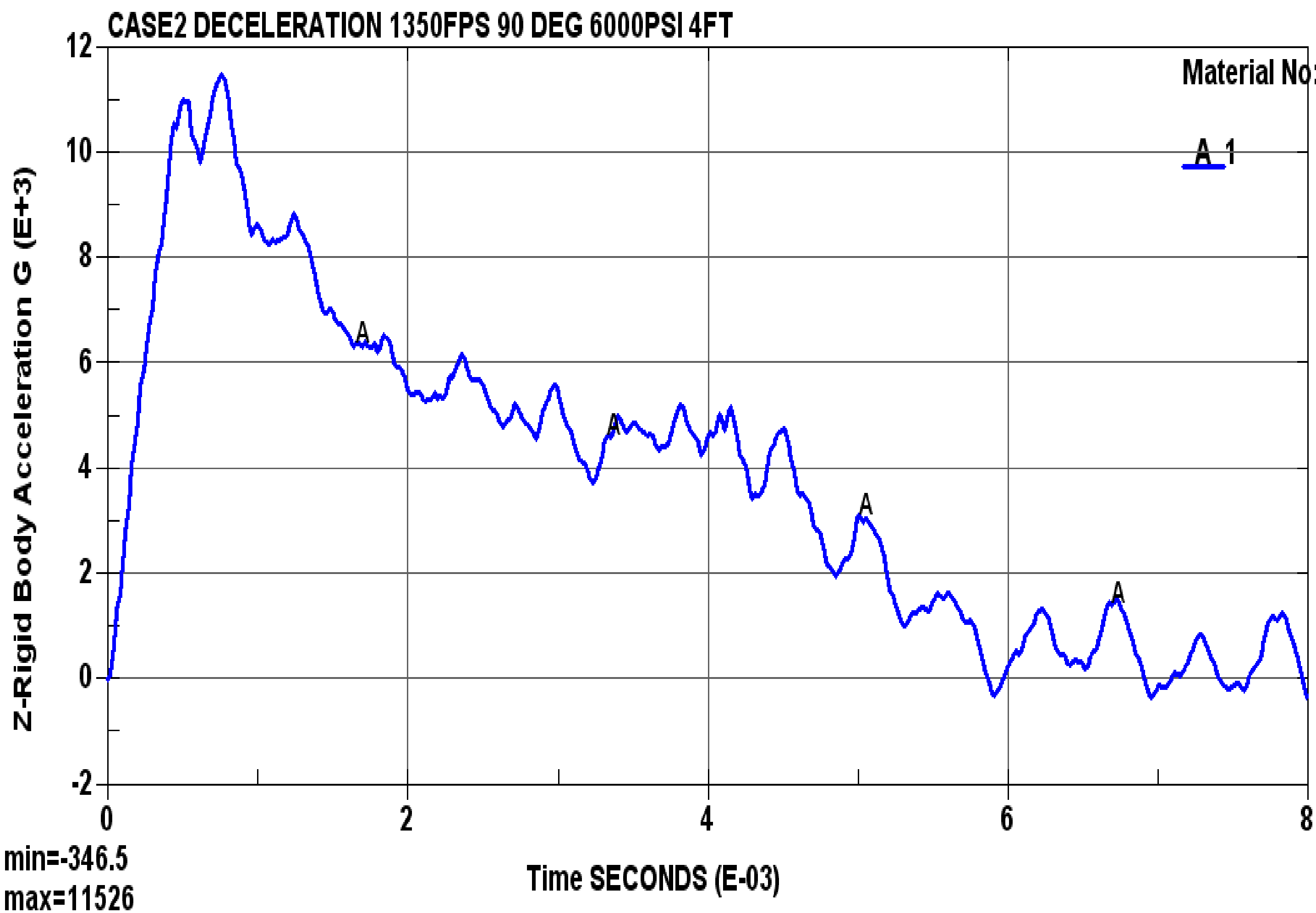
Rigid body velocity exit 340 vs. 358



Concave curve
Break exit face
Sliding friction

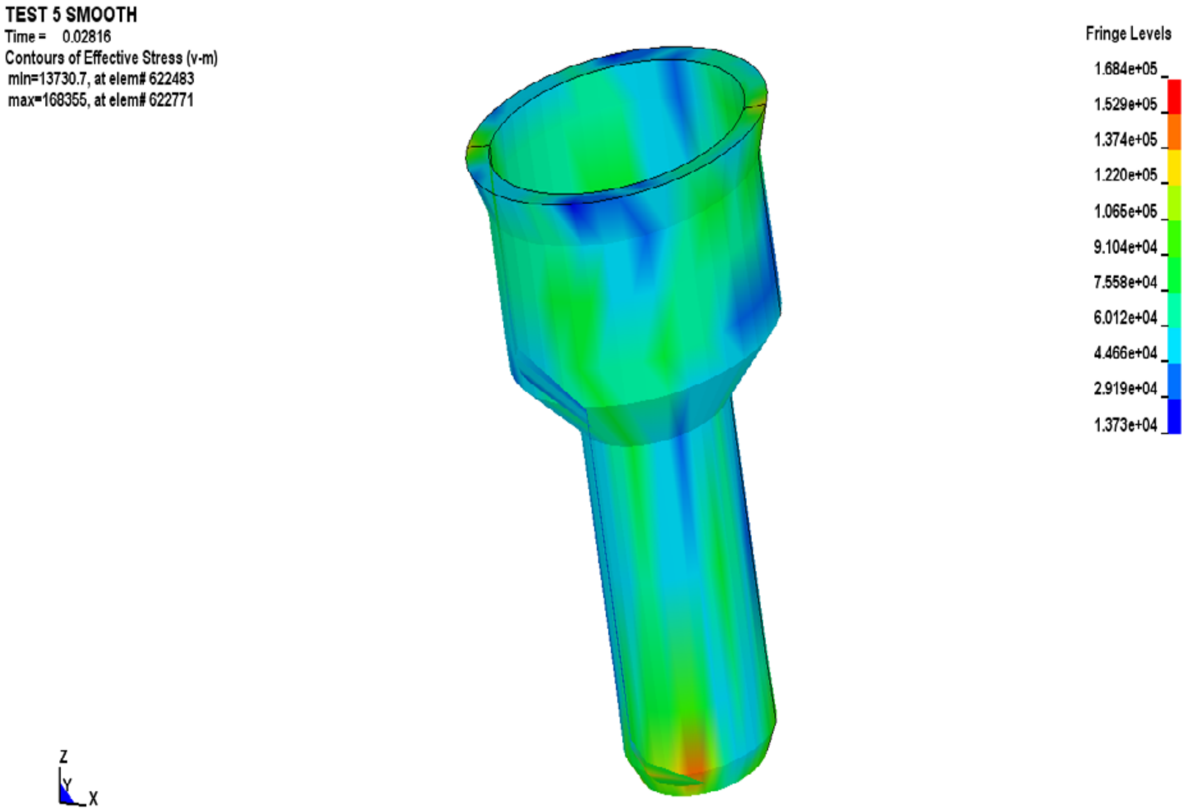
Rigid body deceleration

Peak G reported depends on
Filter
Location
Type accelerometer
Sampling rate



Max stress during impact for generic fuze well

Max strain and stress
For each part at each time step
Determine failure

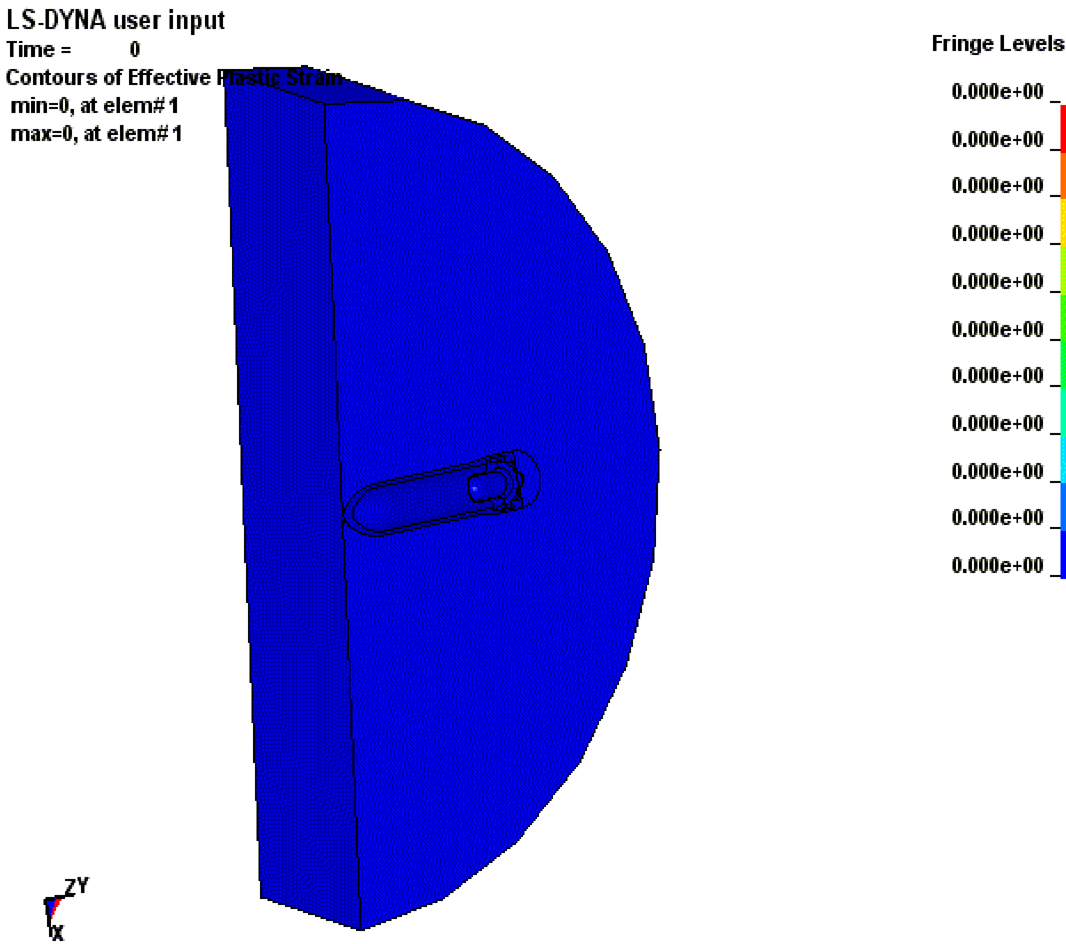


Case 2b, 15 degree, 2 feet concrete

Same Input parameters for;

6 target sets
Large and small penetrators
Large and small diameter targets
Range of impact velocities
Range of angles of impact
Half and quarter models
Course and fine mesh

All compare well with test data

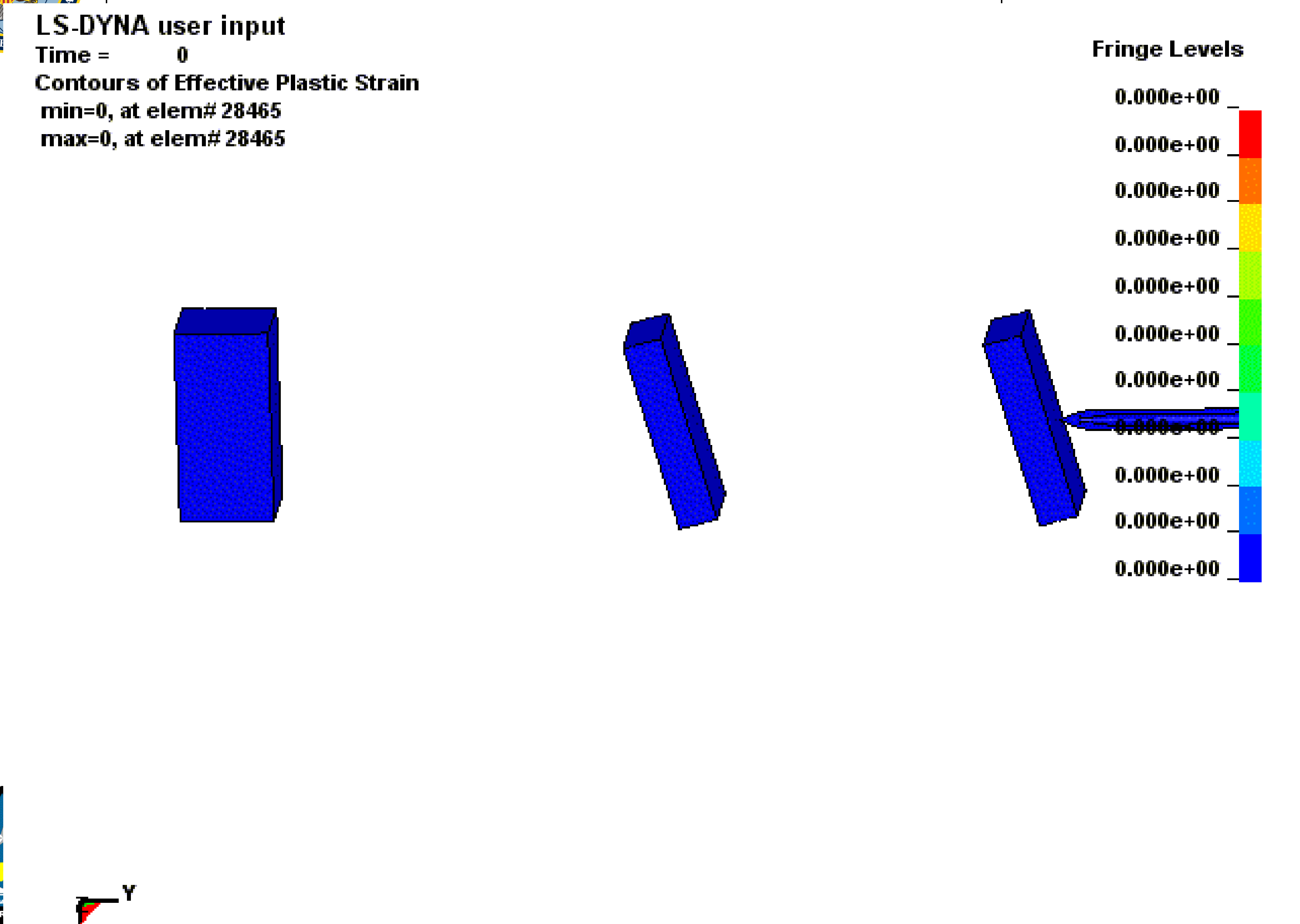


Case 3 SNORT Rocket sled track test

Full scale China Lake test

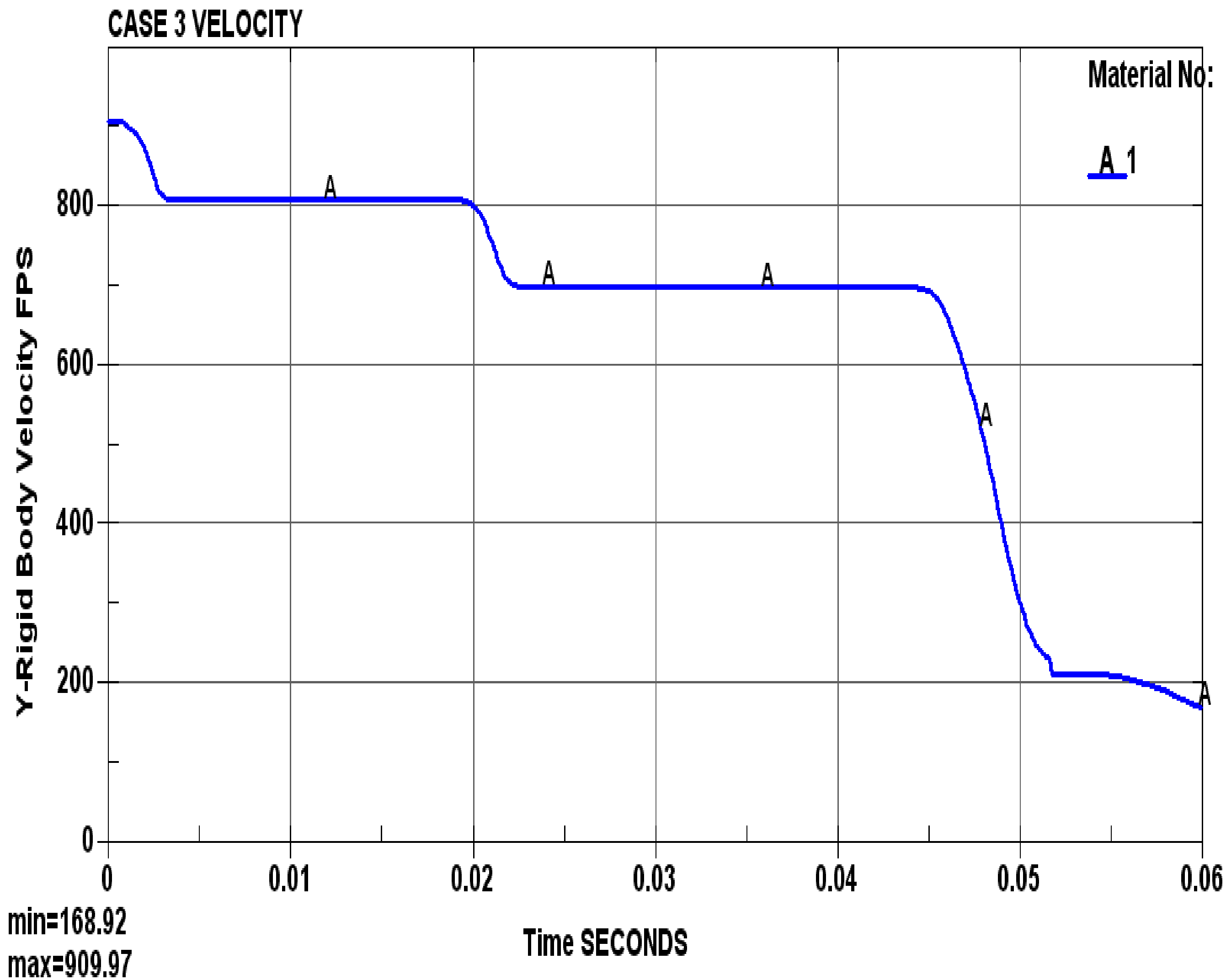
AOA for SNORT tests is random 1-3 deg

Case 3 SNORT test

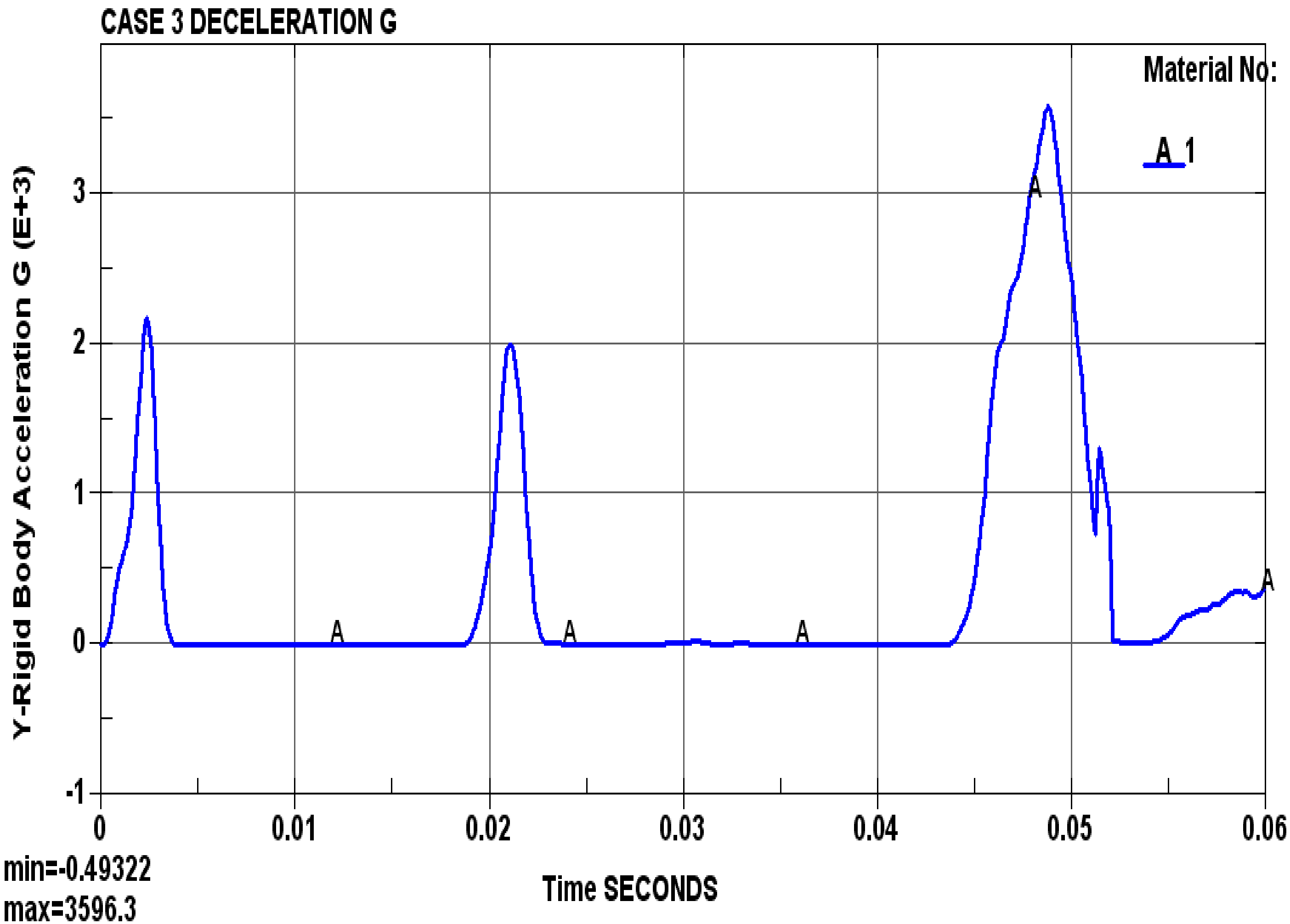


Case 3 velocity vs. time

Smooth well
Behaved curve
Fuze can Sense
velocity



Case 3 Deceleration, g

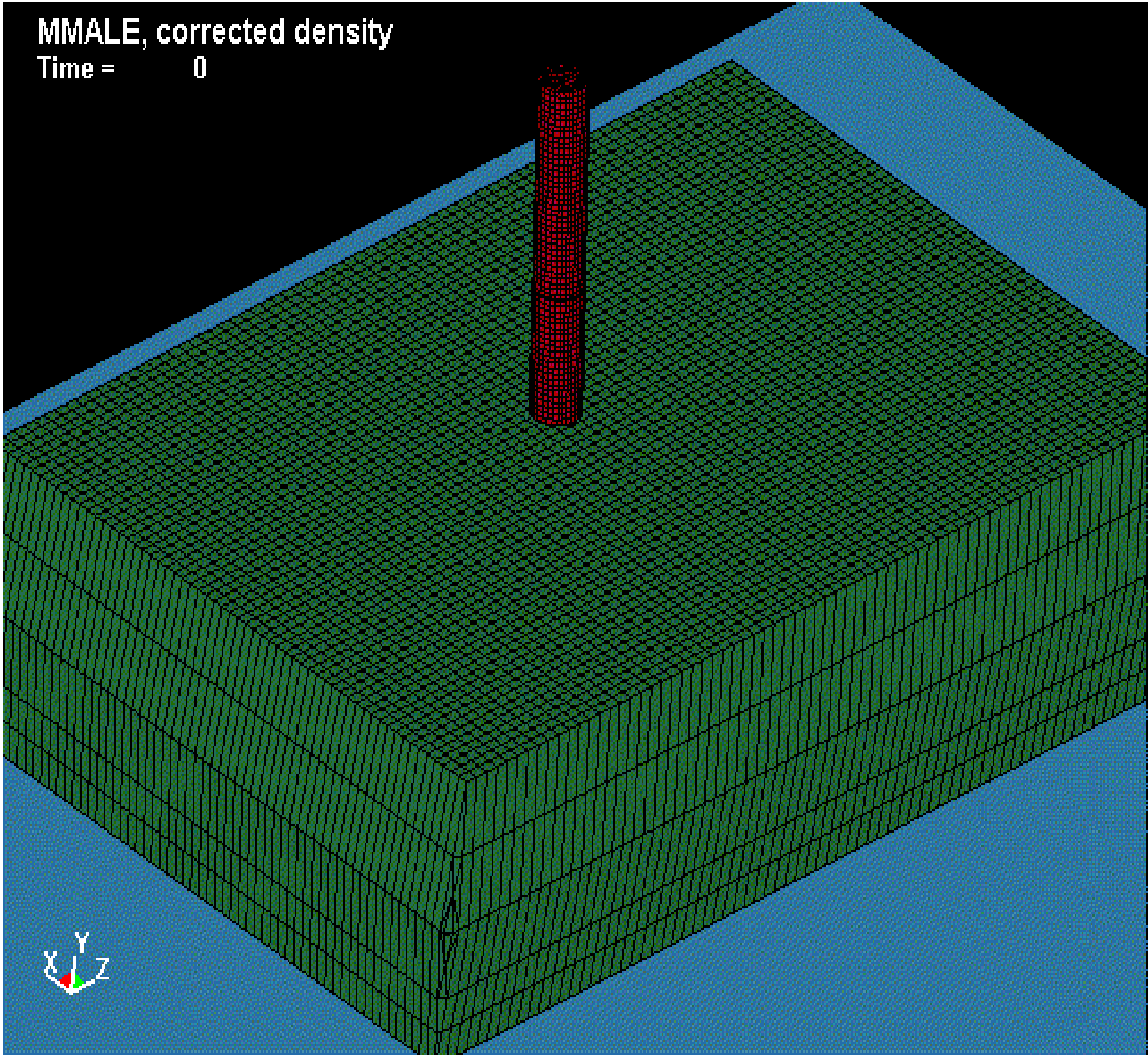


Short Deceleration Pulses

May approach High frequency noise

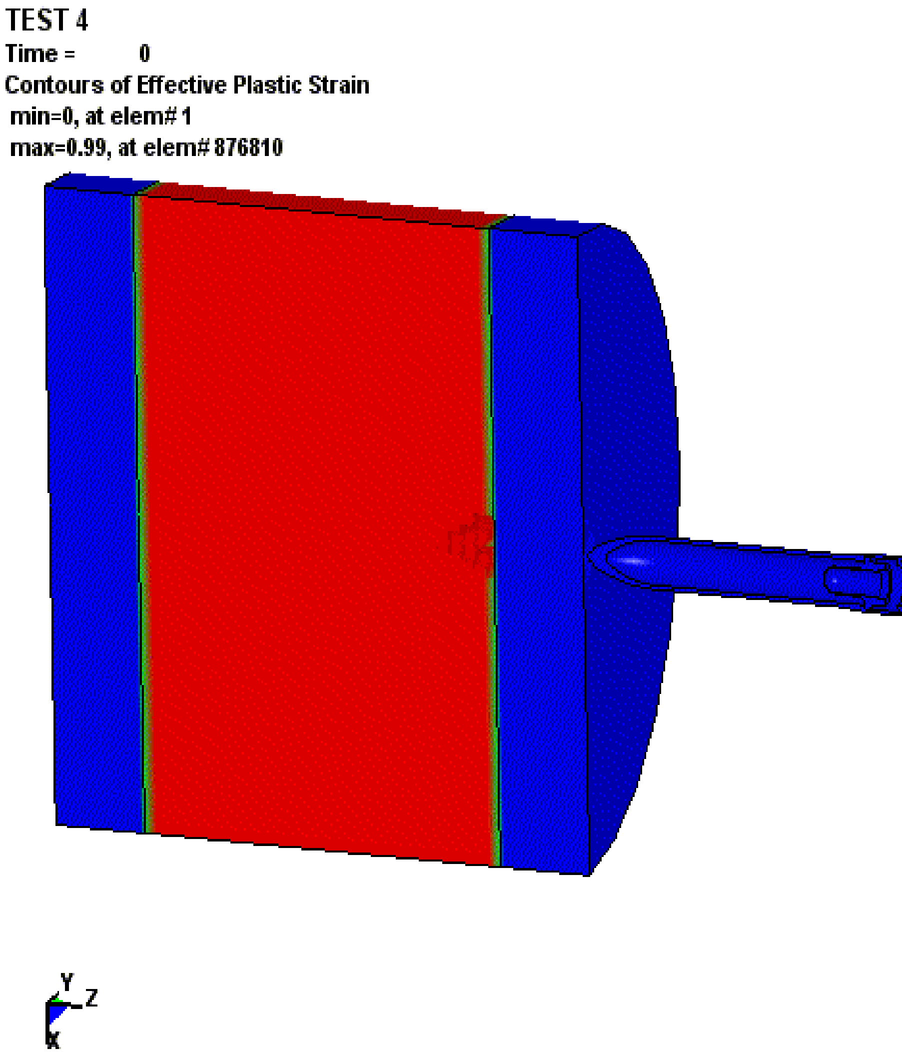
FLUID example requiring full ALE method with fluid interaction

low velocity impact into air bag floating on “China Lake”



Recommendations

- TEST---Better concrete and soil target specification; density, compression mod, no aggregate, consistent mix
- Peak deceleration----better specification of filter, location, standard method
- Fuze--- velocity sensor
- Simulation---Standard template for each test



Conclusion

- A new application of LS-DYNA has been developed by the Safe-Arm Development Branch, NAWCWD to determine stress and strain loadings on fuzes during cannon and sled tests. The simulation results are in good agreement with test data. The new simulation tool will find application as a standard method of specifying fuze performance requirements and allows calculation of stress and strain, under a wide range of impact conditions and targets.

Thank You

- Please download the written paper and direct questions to
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