



Modeling and Simulation of HD 1.3 Thermal Initiation Tests on a Small Reinforced Concrete Storage Structure

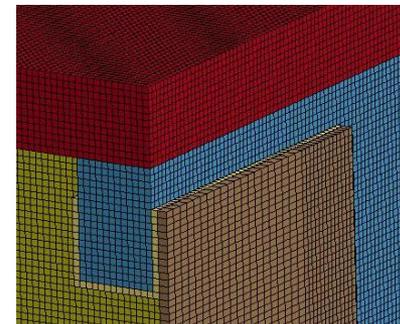
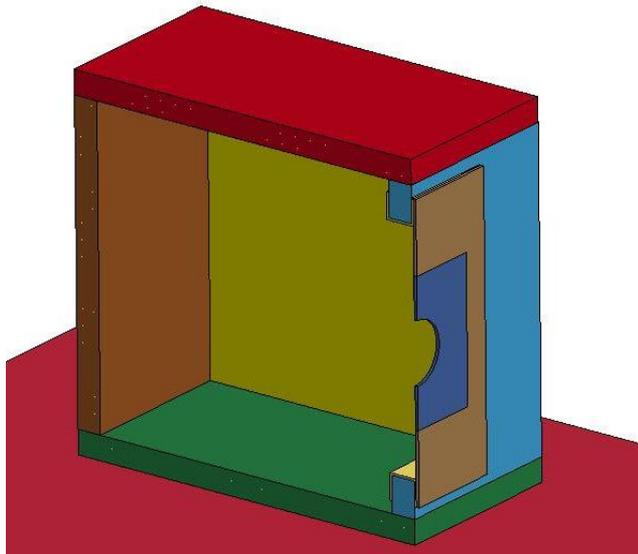
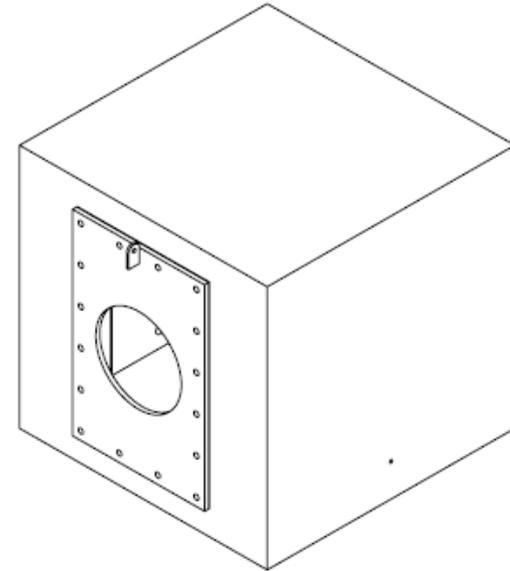
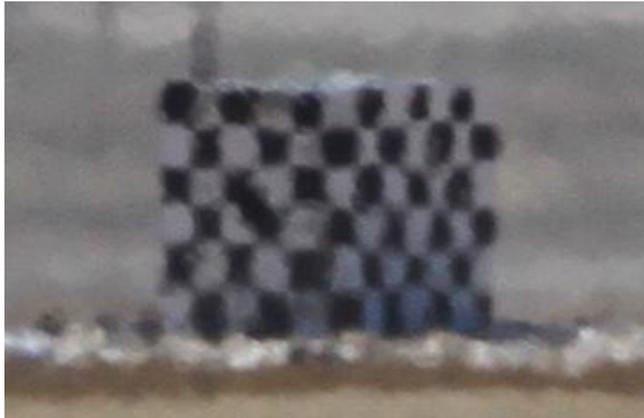
Ming Liu, Ph. D., P.E., , Michael Oesterle, Ph. D, P.E. and Robert Conway, P.E.
NAVFAC EXWC
CI7 Explosives Effects and Consequences

Josephine Covino, Ph. D. Department of Defense Explosives Safety Board (DDESB)

2018 International Explosives Safety Symposium and Exposition
San Diego, California, USA
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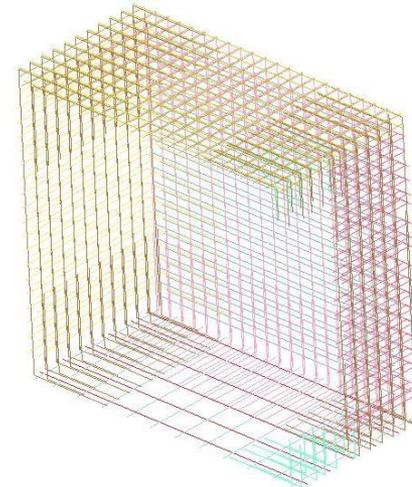


Kasun Structure (2m x 2m x 2m cube)



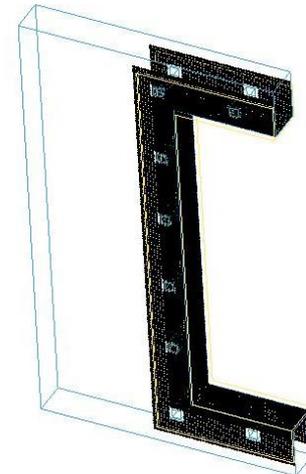
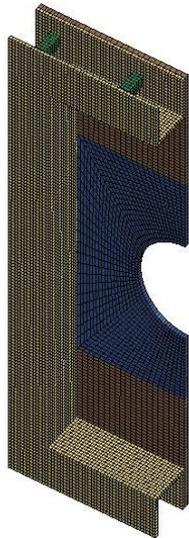
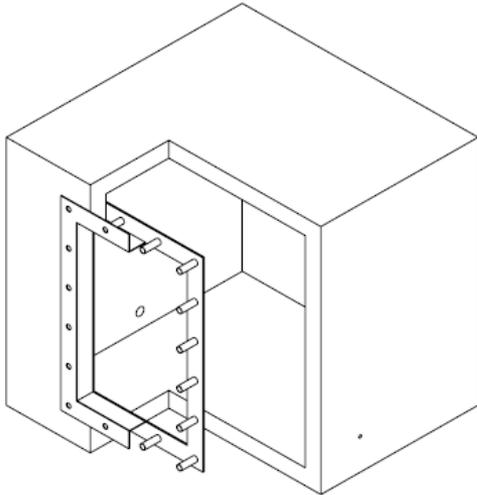


Details of Steel Reinforcement





Details of Steel Door



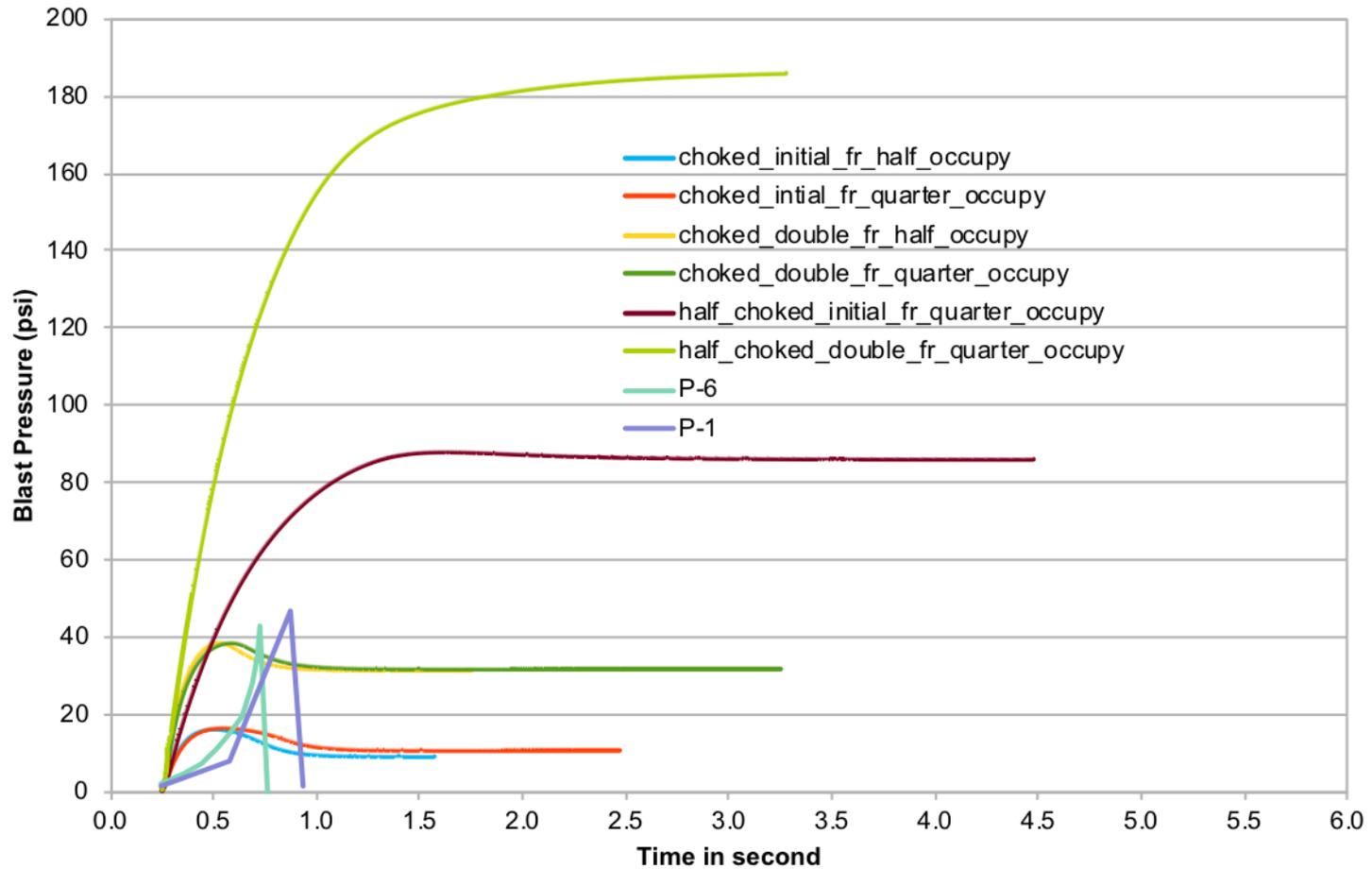


Door Connection





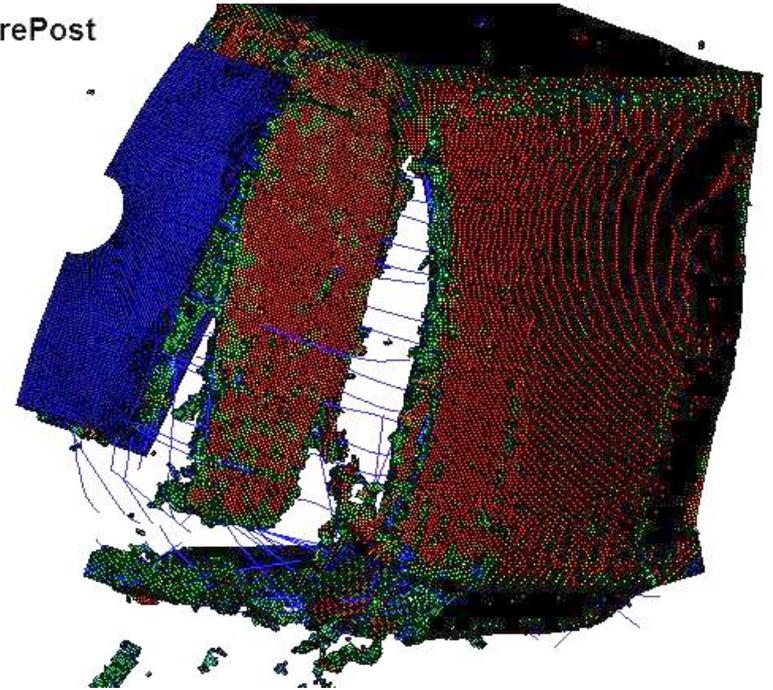
Loading Curves



LS-DYNA Simulations for Test No. 6



PrePost



Failure Modes of Tests No. 4 and No. 6

Debris Ejected from Roof

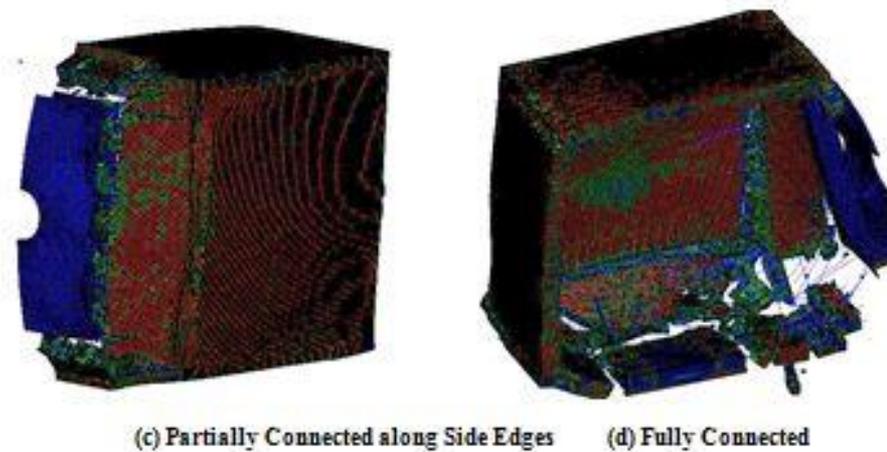
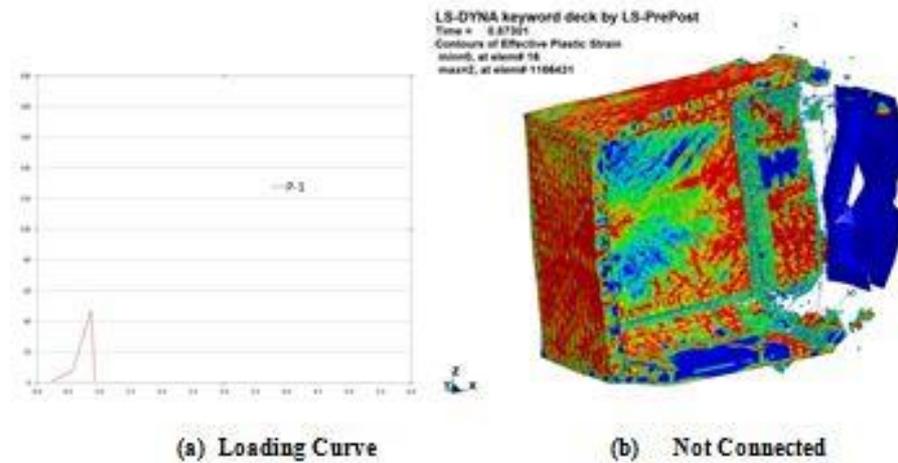


(a) Test 4 (Back View)

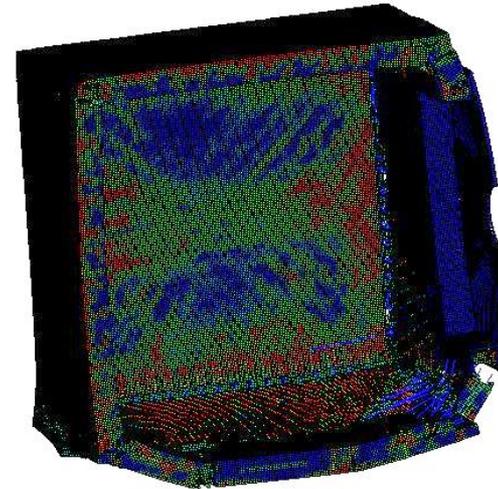
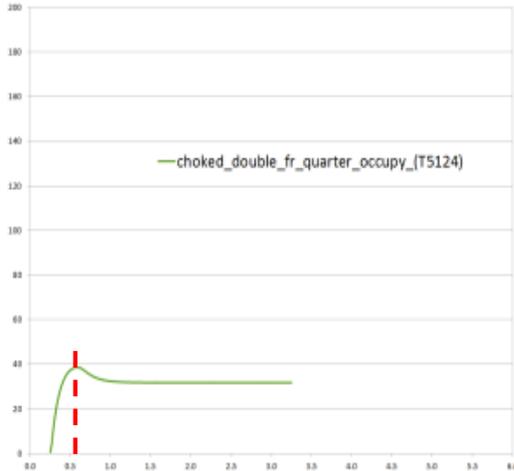


(b) Test 6 (Front View)

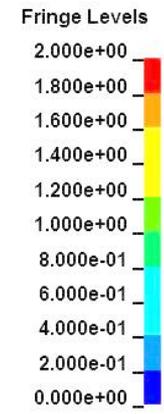
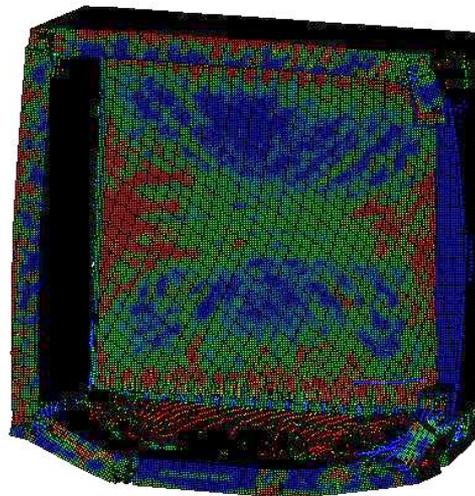
Effects of Door Connection on Failure Modes



T8124 Loading (Chocked, Double Fr)



LS-DYNA keyword deck by LS-PrePost
 Time = 0.54707
 Contours of Effective Plastic Strain
 min=0, at elem# 24
 max=1.99995, at elem# 92703



Z
Y X



T8124 Loading (Chocked, Double Fr)



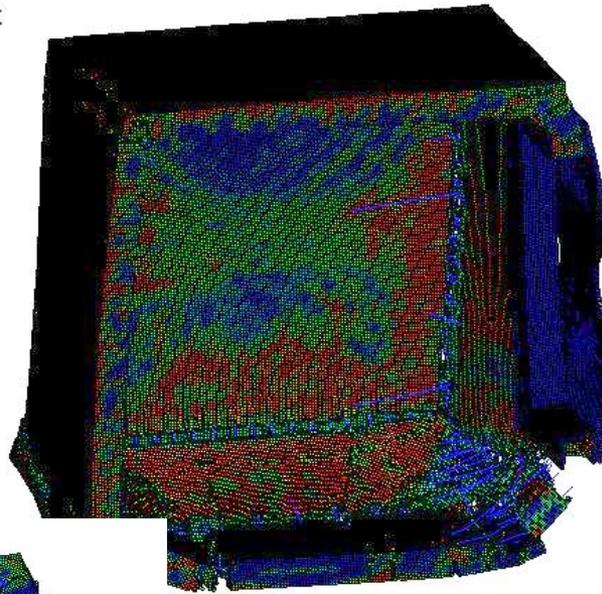
LS-DYNA keyword deck by LS-PrePost

Time = 0.55663

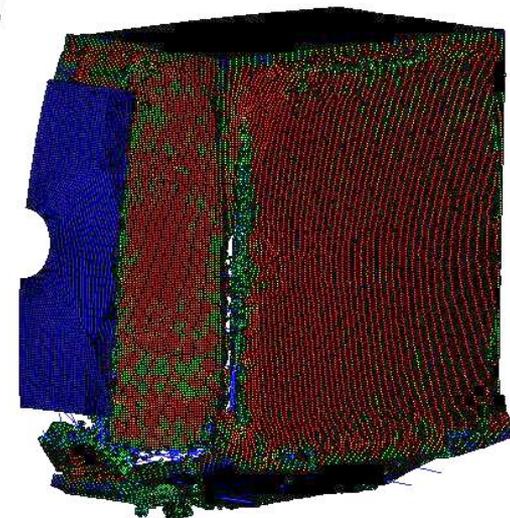
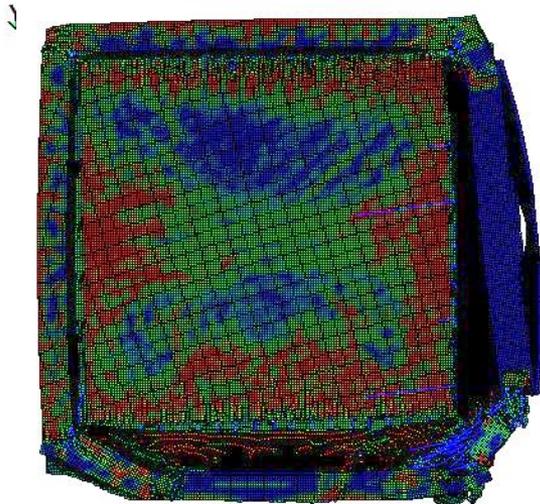
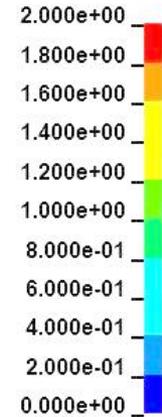
Contours of Effective Plastic Strain

min=0, at elem# 24

max=1.99995, at elem# 92703



Fringe Levels



T8124 Loading (Chocked, Double Fr)

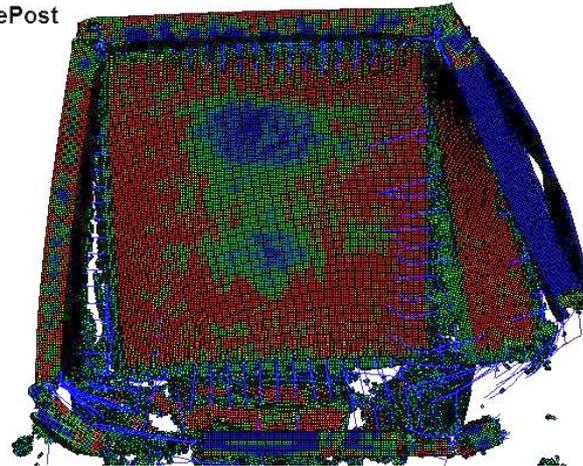
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Time = 0.58663

Contours of Effective Plastic Strain

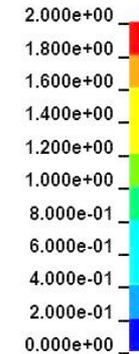
min=0, at elem# 24

max=1.99995, at elem# 92703



Z

Fringe Levels



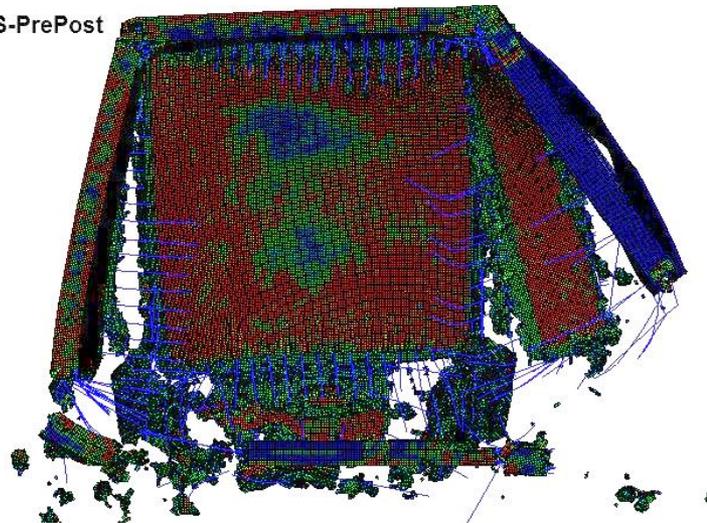
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Time = 0.59663

Contours of Effective Plastic Strain

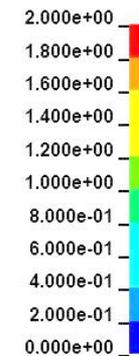
min=0, at elem# 24

max=1.99995, at elem# 92703



Z
X

Fringe Levels





T8124 Loading (Chocked, Double Fr)



LS-DYNA keyword deck by LS-PrePost

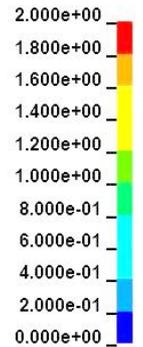
Time = 0.6

Contours of Effective Plastic Strain

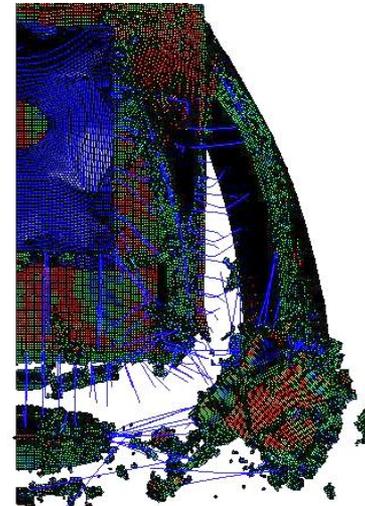
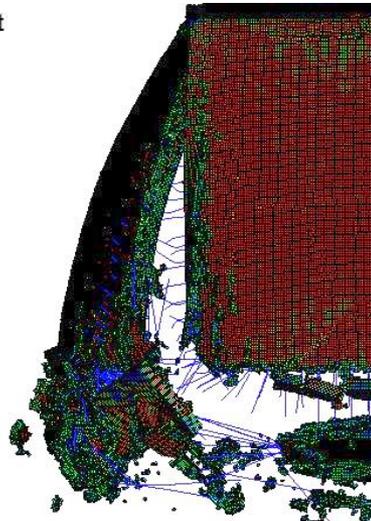
min=0, at elem# 24

max=1.99995, at elem# 92703

Fringe Levels

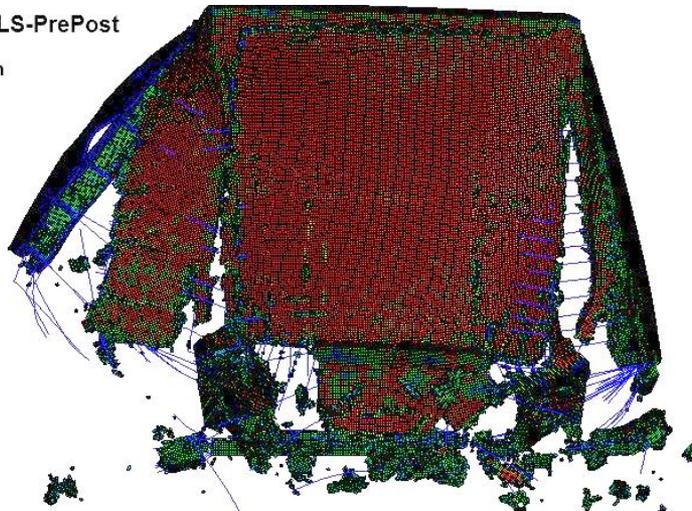


Z
Y X

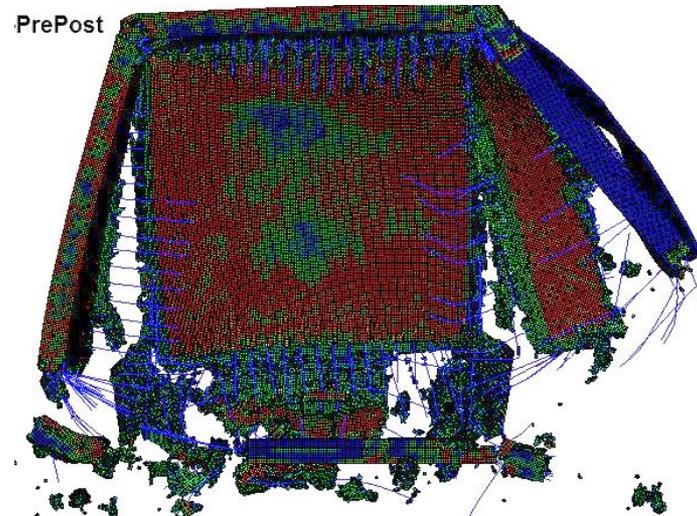


LS-PrePost

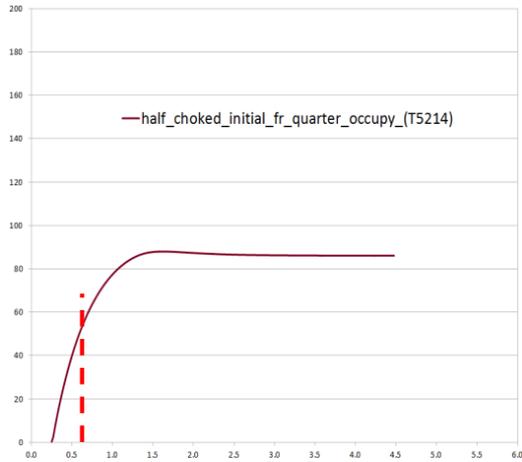
n



PrePost

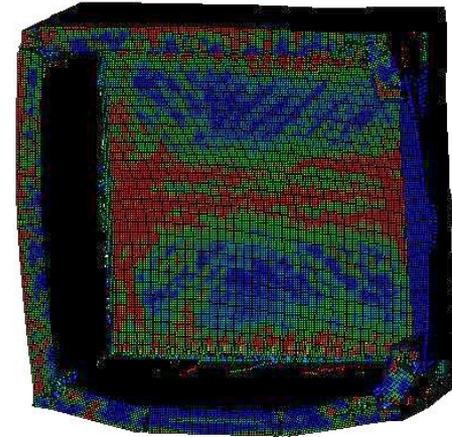


T8214 Loading (Half-Chocked, Initial Fr)

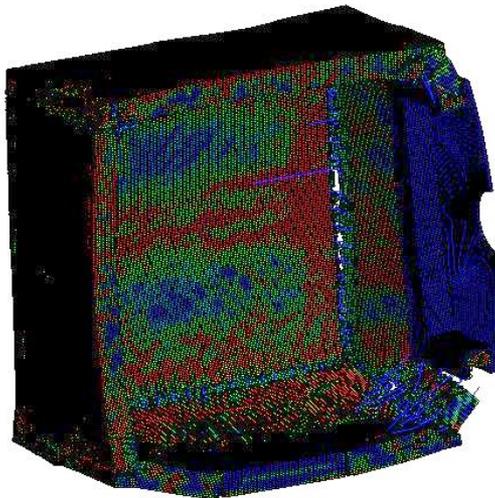


LS-DYNA keyword deck by LS-PrePost
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Contours of Effective Plastic Strain
min=0, at elem# 15
max=1.99971, at elem# 304765

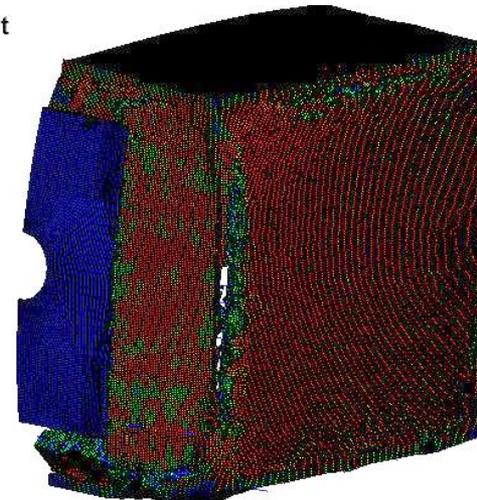
Z
Y X



Post

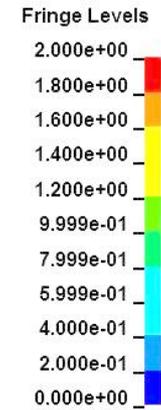
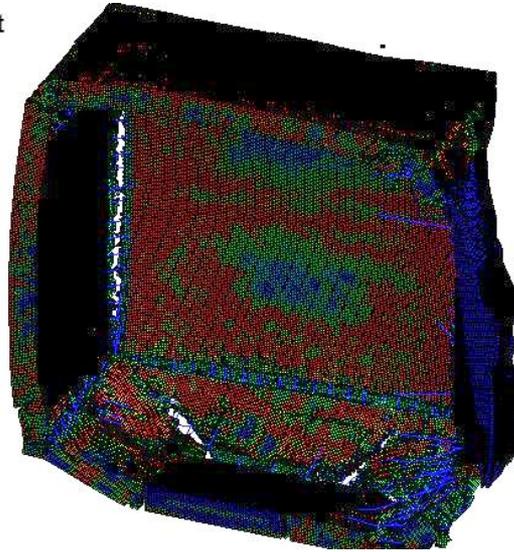


Post



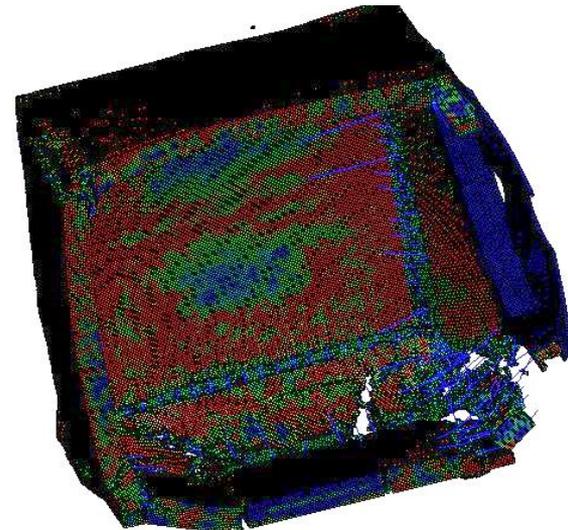
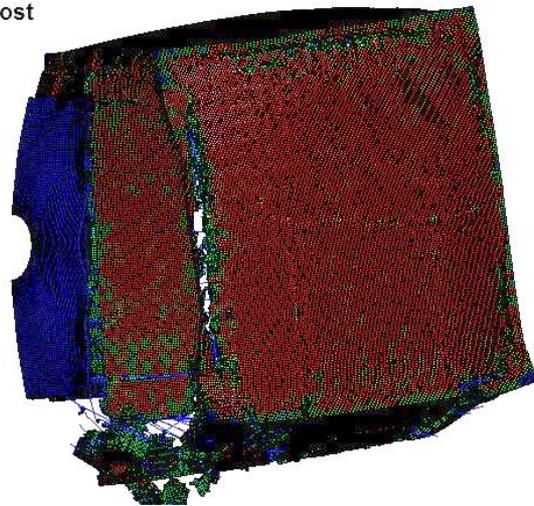
T8214 Loading (Half-Chocked, Initial Fr)

LS-DYNA keyword deck by LS-PrePost
Time = 0.57395
Contours of Effective Plastic Strain
min=0, at elem# 15
max=1.9998, at elem# 1168342



Z
y
x

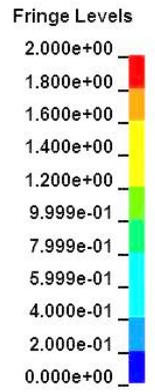
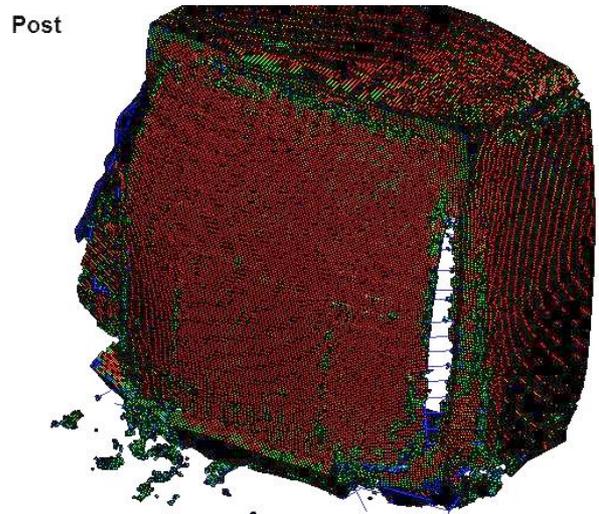
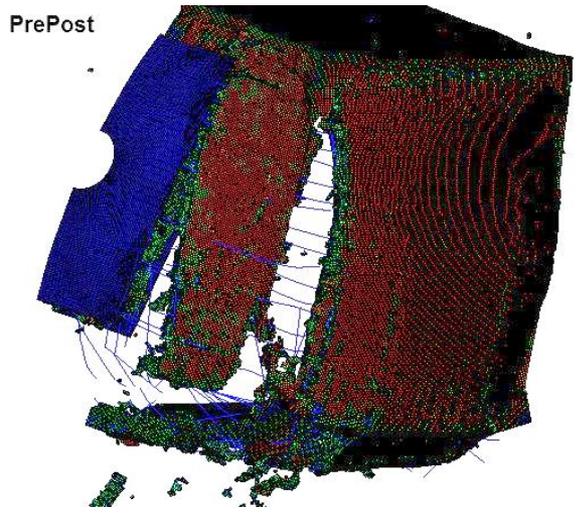
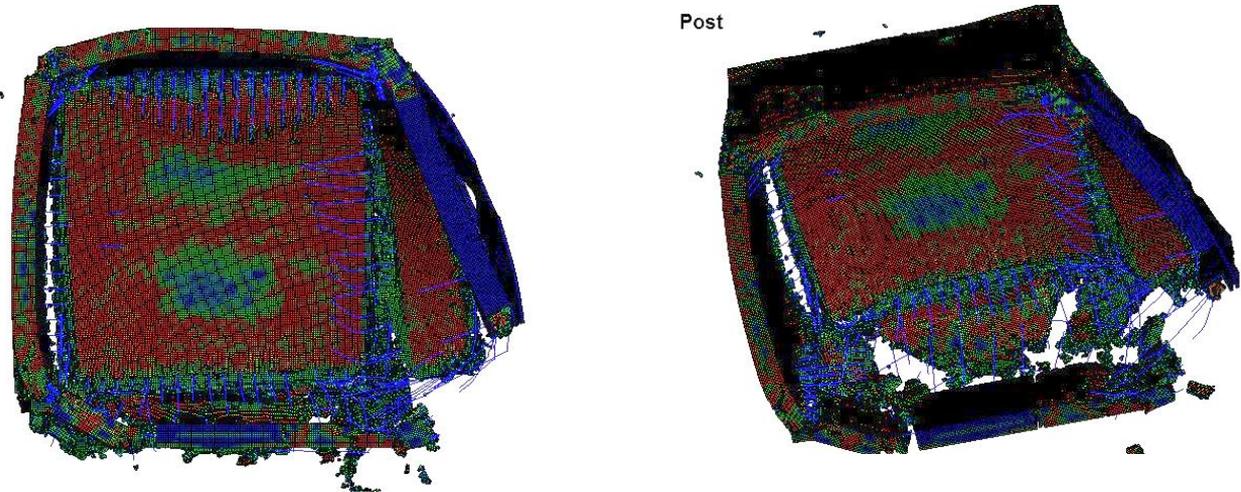
Post



T8214 Loading (Half-Chocked, Initial Fr)

LS-DYNA keyword deck by LS-PrePost
 Time = 0.58895
 Contours of Effective Plastic Strain
 min=0, at elem# 15
 max=1.99982, at elem# 1115996

Z
 X



T8214 Loading (Half-Chocked, Initial Fr)

LS-DYNA keyword deck by LS-PrePost

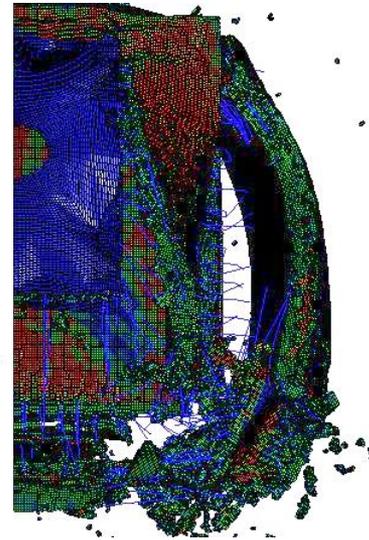
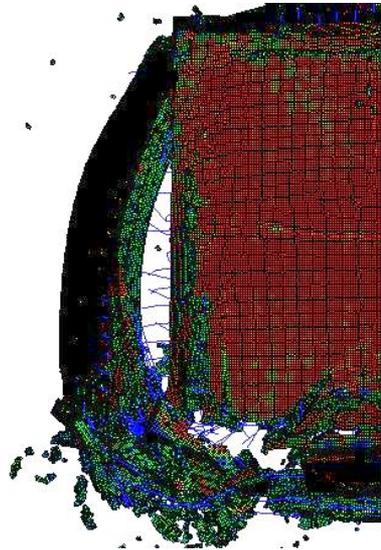
Time = 0.6

Contours of Effective Plastic Strain

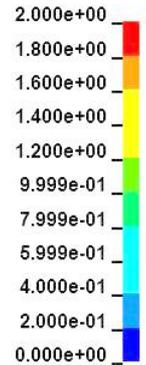
min=0, at elem# 15

max=1.9998, at elem# 1168354

Z
Y X

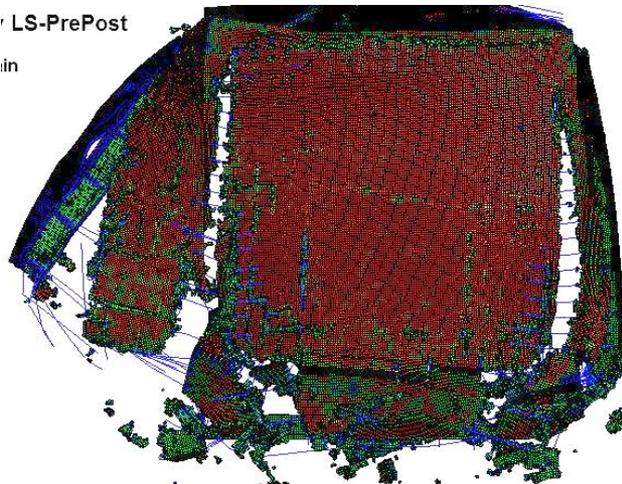


Fringe Levels

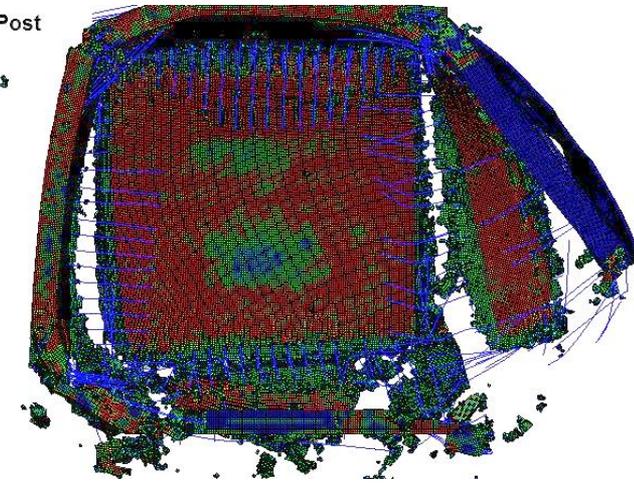


LS-PrePost

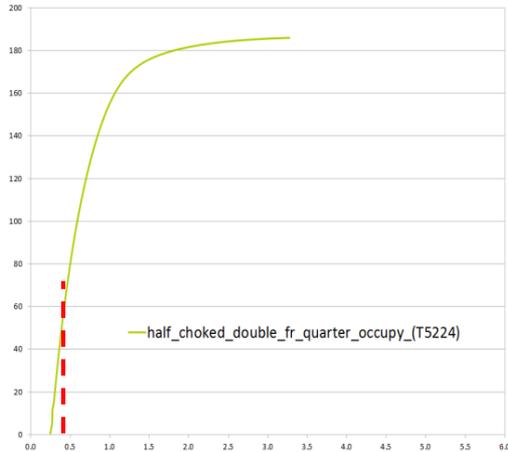
in



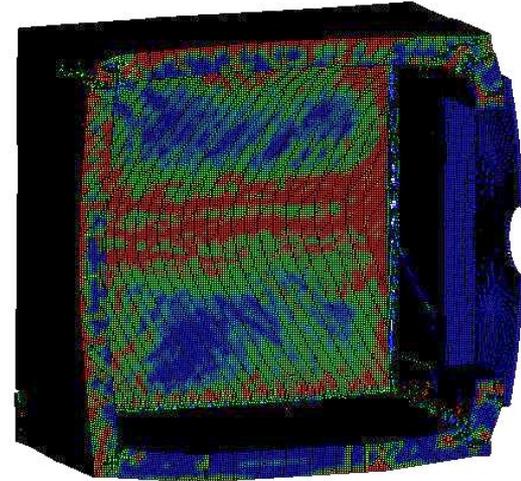
Post



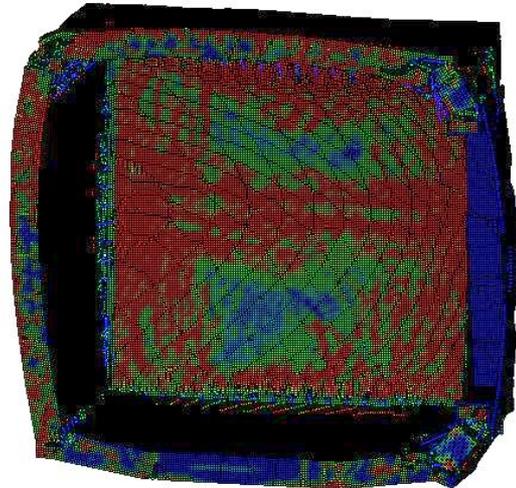
T8224 Loading (Half Chocked, Double Fr)



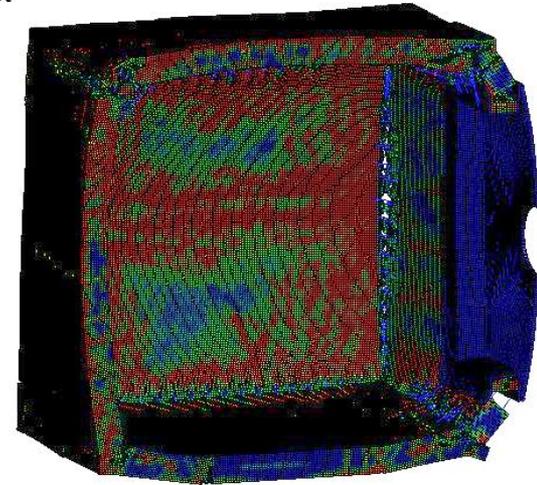
LS-DYNA keyword deck by LS-PrePost
 Time = 0.40895
 Contours of Effective Plastic Strain
 min=0, at elem# 26
 max=1.99993, at elem# 768020



LS-DYNA keyword deck by LS-PrePost
 Time = 0.42395
 Contours of Effective Plastic Strain
 min=0, at elem# 5158
 max=1.99993, at elem# 768020



Post

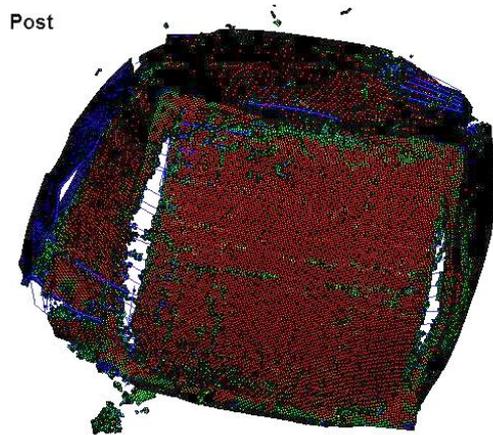
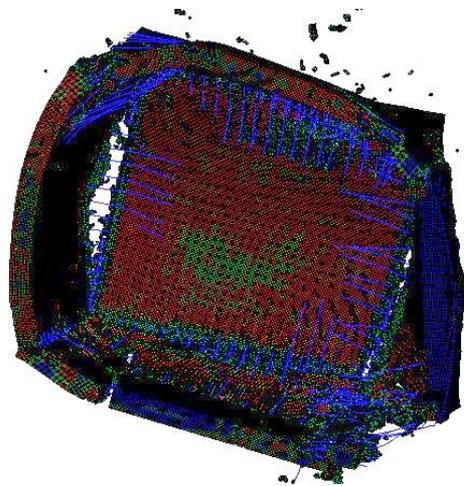


T8224 Loading (Half Chocked, Double Fr)

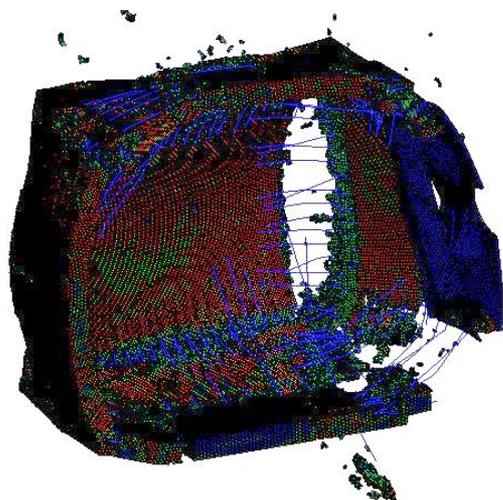
LS-DYNA keyword deck by LS-PrePost
 Time = 0.45
 Contours of Effective Plastic Strain
 min=0, at elem# 8195
 max=1.99993, at elem# 768020

Z
X

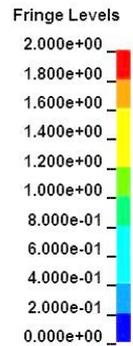
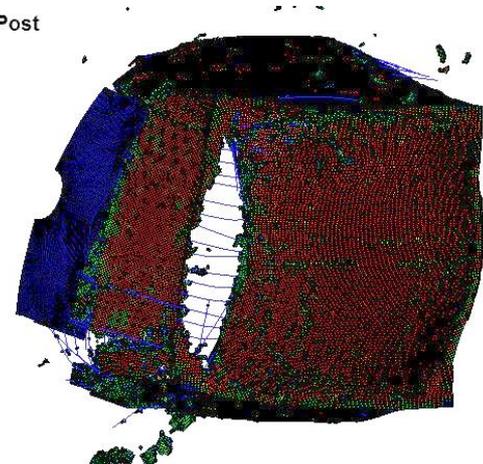
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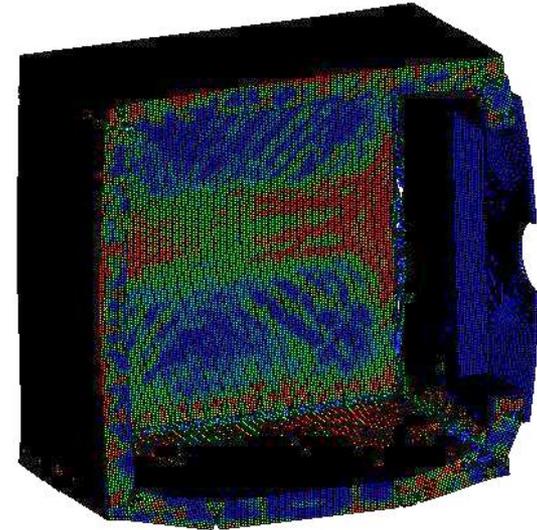
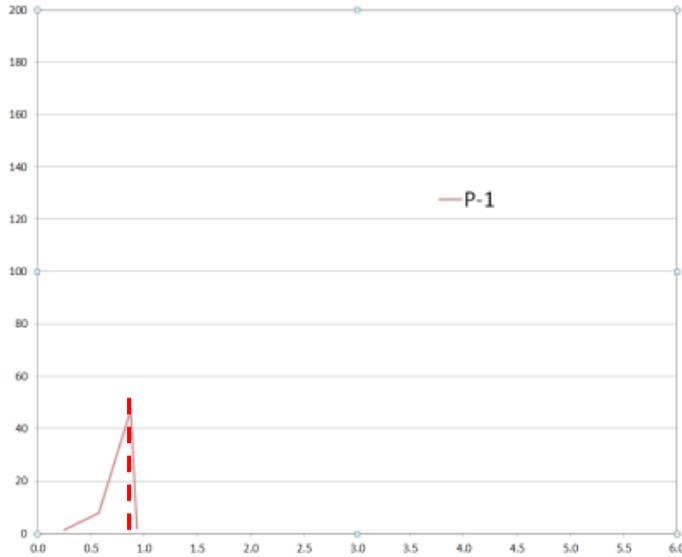
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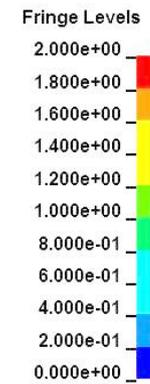
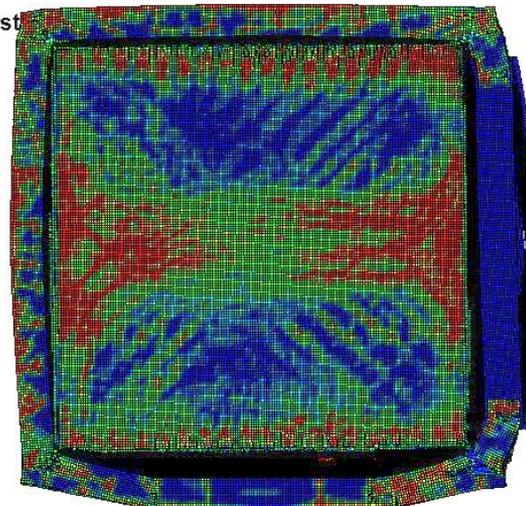
:Post



T8P1 Loading



LS-DYNA keyword deck by LS-PrePost
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 Contours of Effective Plastic Strain
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 max=2, at elem# 1084684

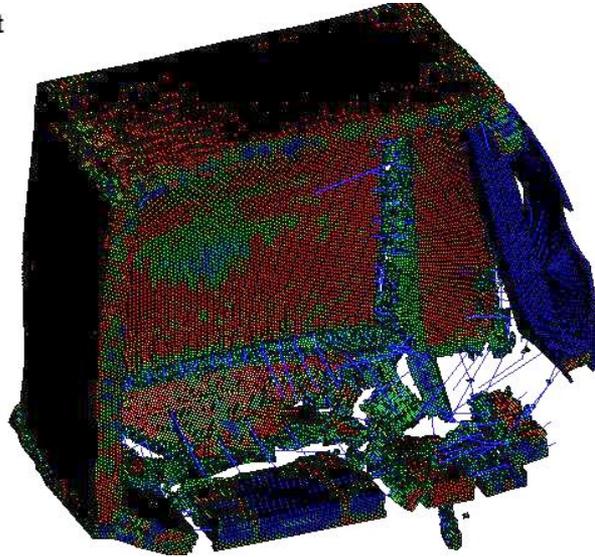


z
x

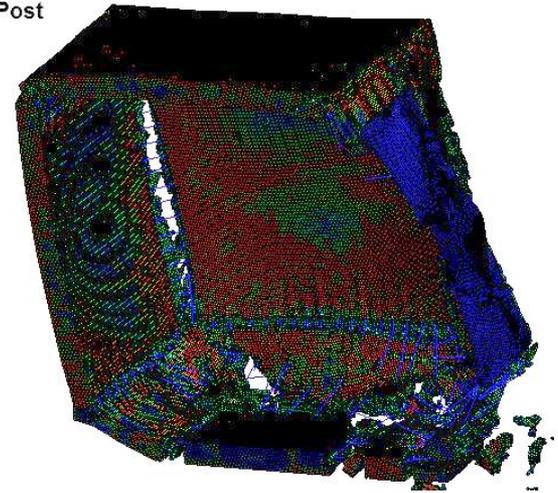
T8P1 Loading

LS-DYNA keyword deck by LS-PrePost
 Time = 0.89951
 Contours of Effective Plastic Strain
 min=0, at elem# 3076
 max=2, at elem# 1084684

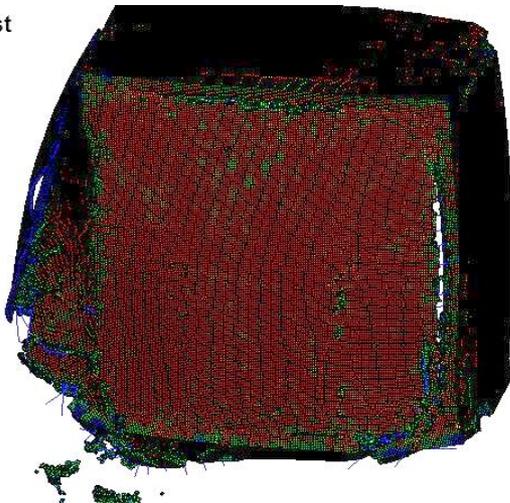
yz
x



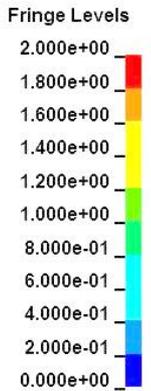
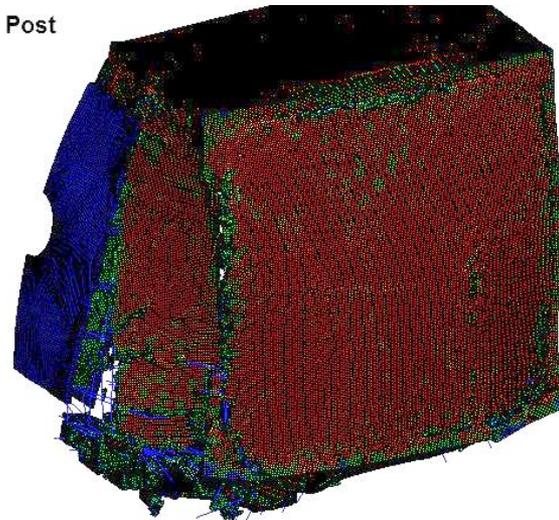
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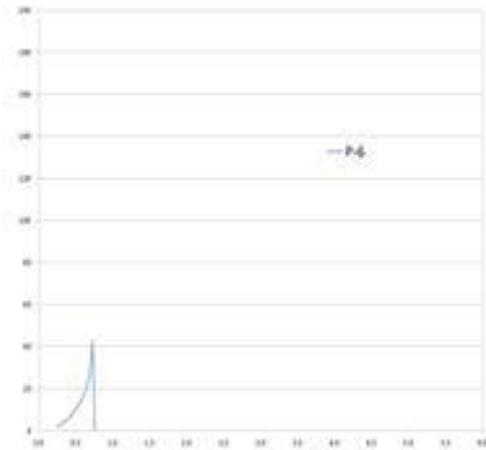
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Post

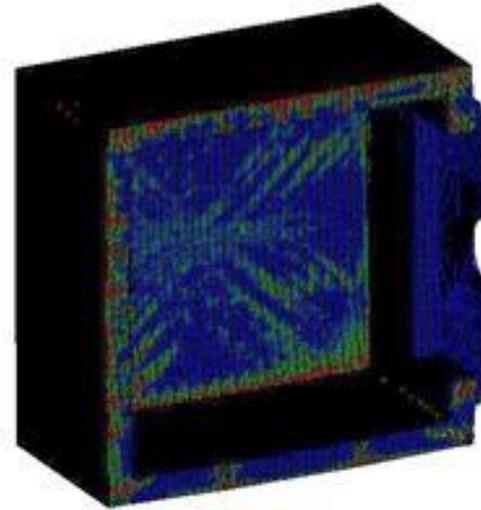


T8P6 Loading



(a) Loading Curve

with the peak pressure of 42.7 psi



(b) Damage Indices Contour

at 0.90 second



Lessons Learned



1. Modeling the rebar tied to the door and the corner rebar is critical.
2. Modeling the rebar contact each other is very important.

3. **Table 4-1: Break-Up Time and Blast Pressure for Full Connection Models**

Loading Curve	Flow Rate	Occupied	Failure Time (second)	Blast Pressure (psi)
Half Choked	double	quarter	0.420	60.0
Half Choked	initial	quarter	0.545	52.4
Choked	double	quarter	0.545	39.5
P1	N/A		0.858	47.0

3. **P6 Loading Curve: no break-up (peak pressure 42.7 psi)**