A Standardized Mechanism to Validate Crash Models for Ductile Plastics

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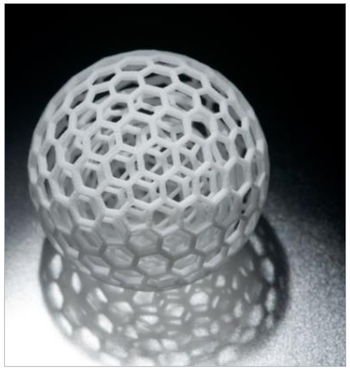
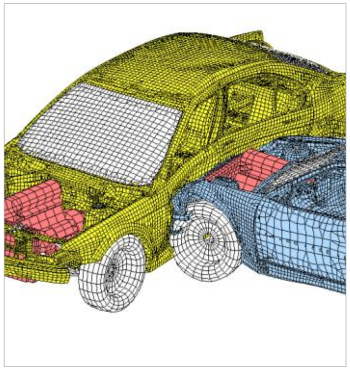
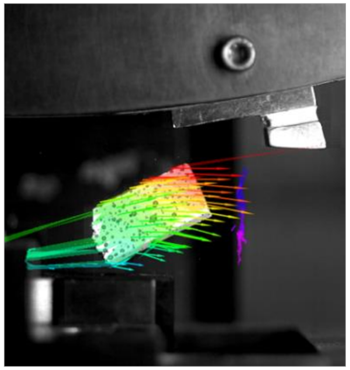

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  - Material cards
  - Test reports
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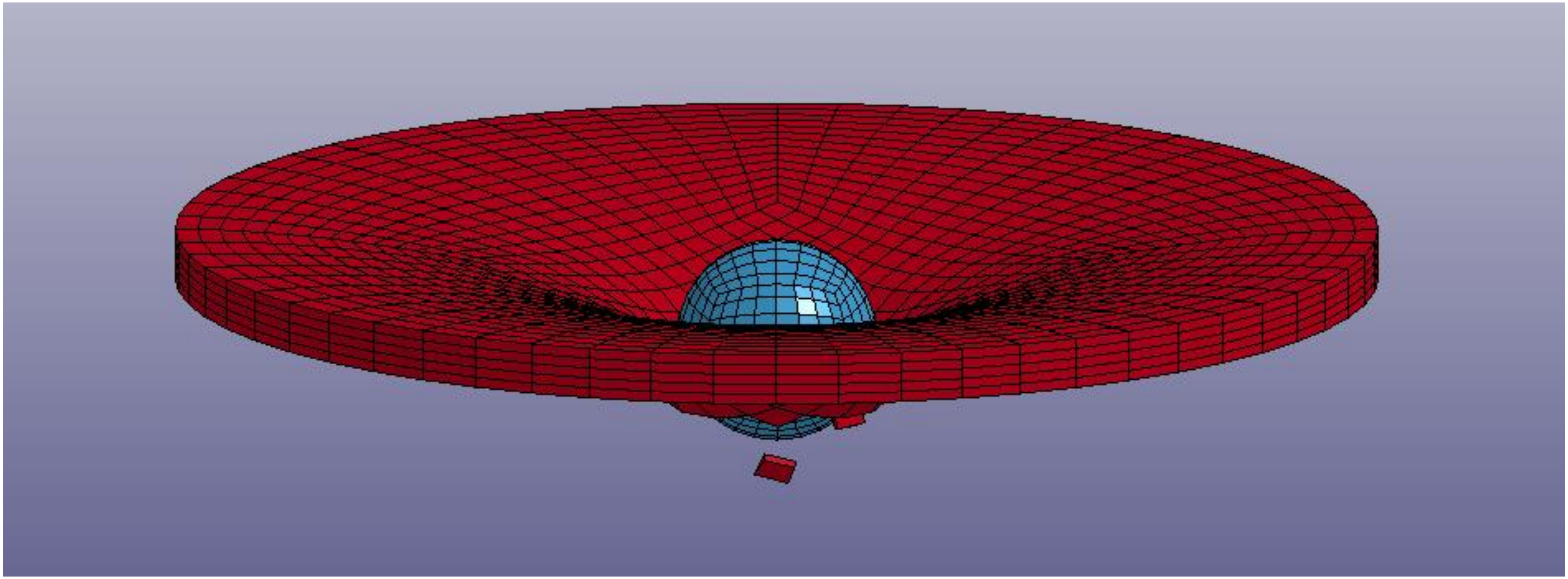
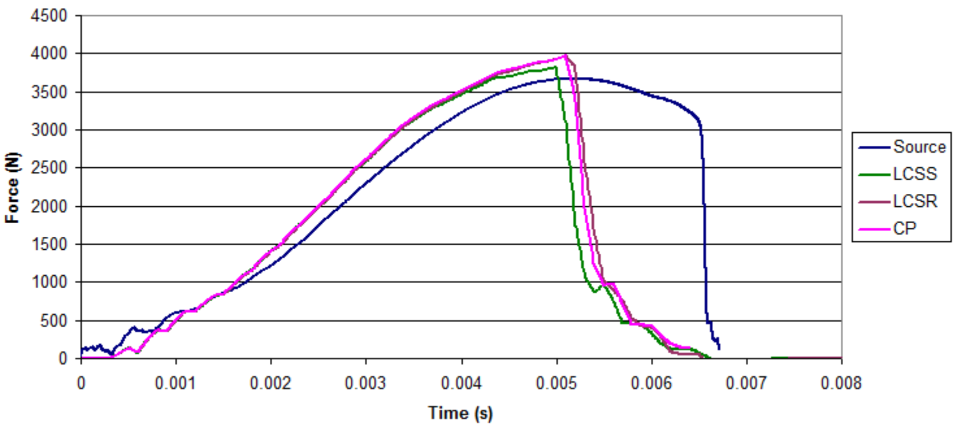
Impetus

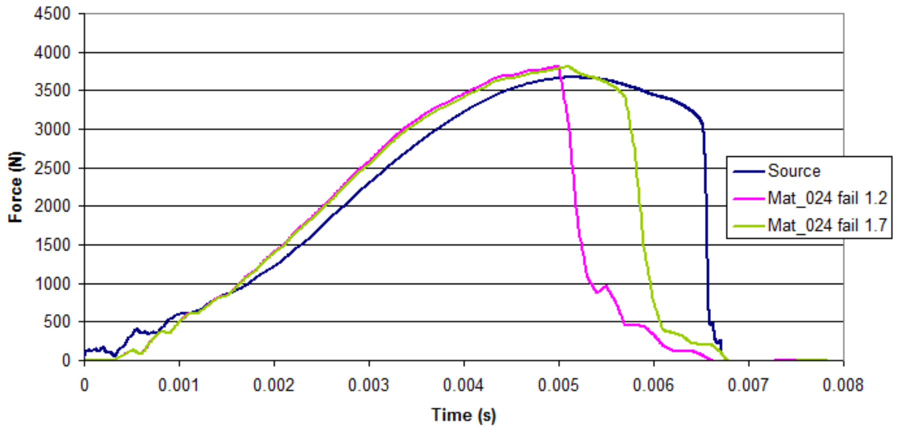
- Validating material models in crash applications for plastics
- Extending previous work to MAT_089, MAT_187
- Creating a standardized validation setup for crash models



Previous Work

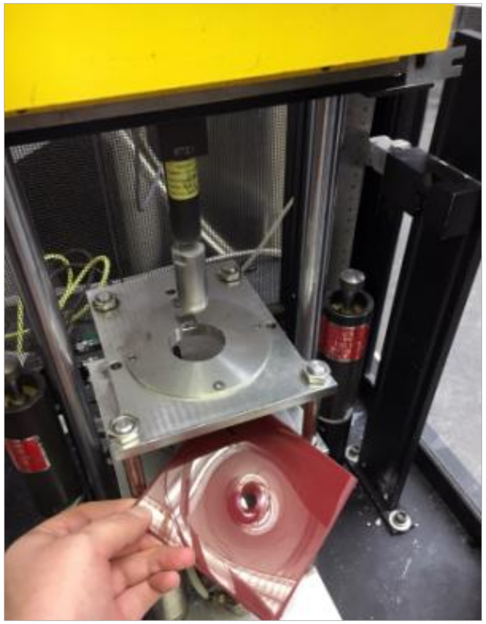
- **Comparison of Crash Models for Ductile Plastics,** presented at LS-DYNA conference 2015
- Detailed exploration of validation of MAT24
- Very good correlation up to failure

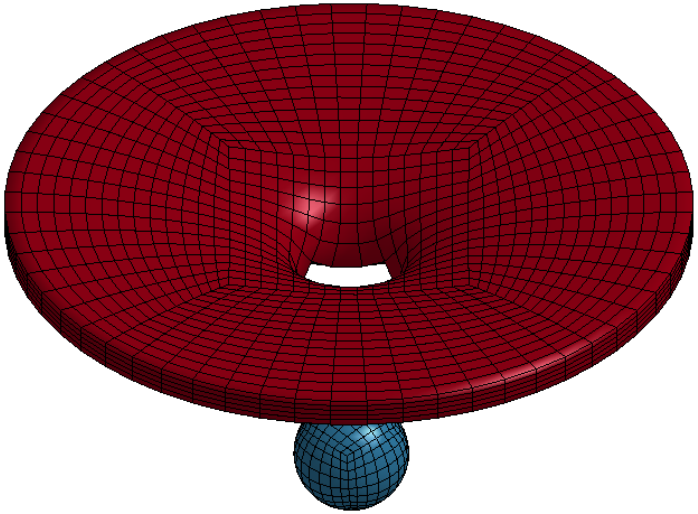




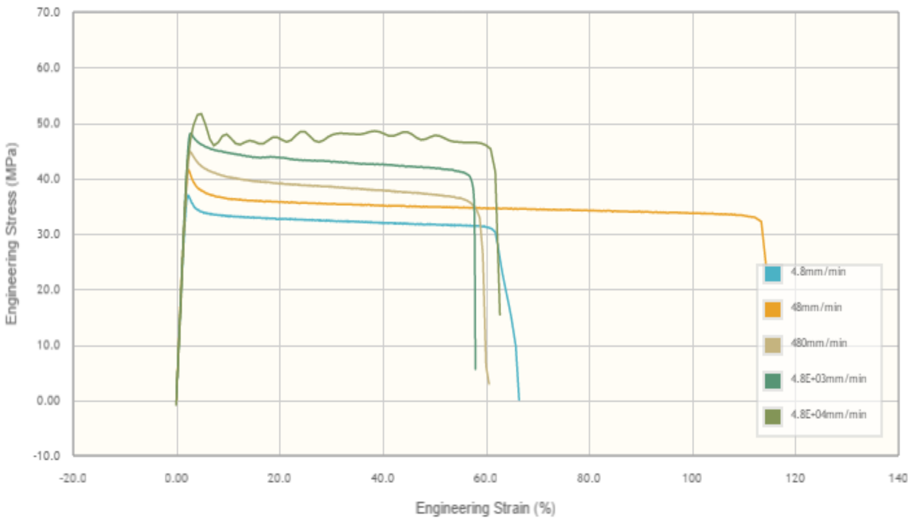
Simulation: BCs and ICs

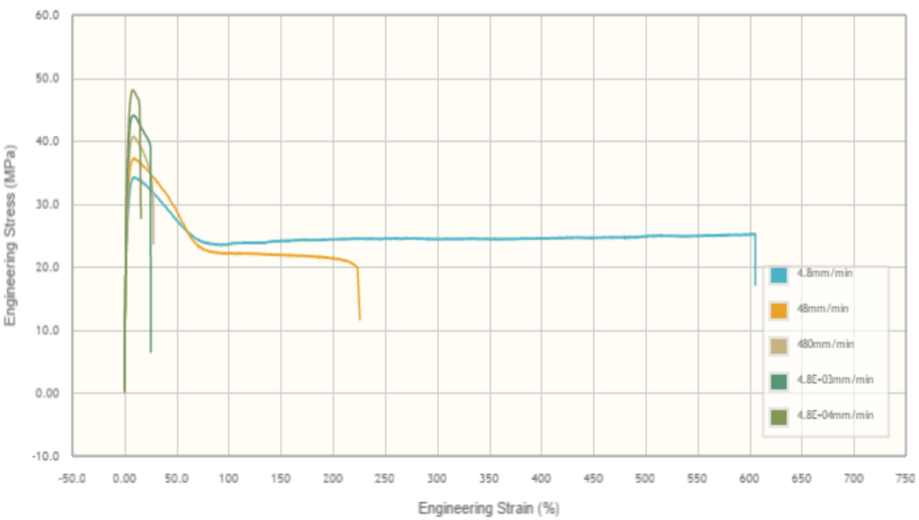
- Plate thickness: 3.175mm
- Dart diameter:12.7 mm
- Dart weight: 23 kg
- B.C.s: fixed sides
- Impact velocity: 3.35m/s





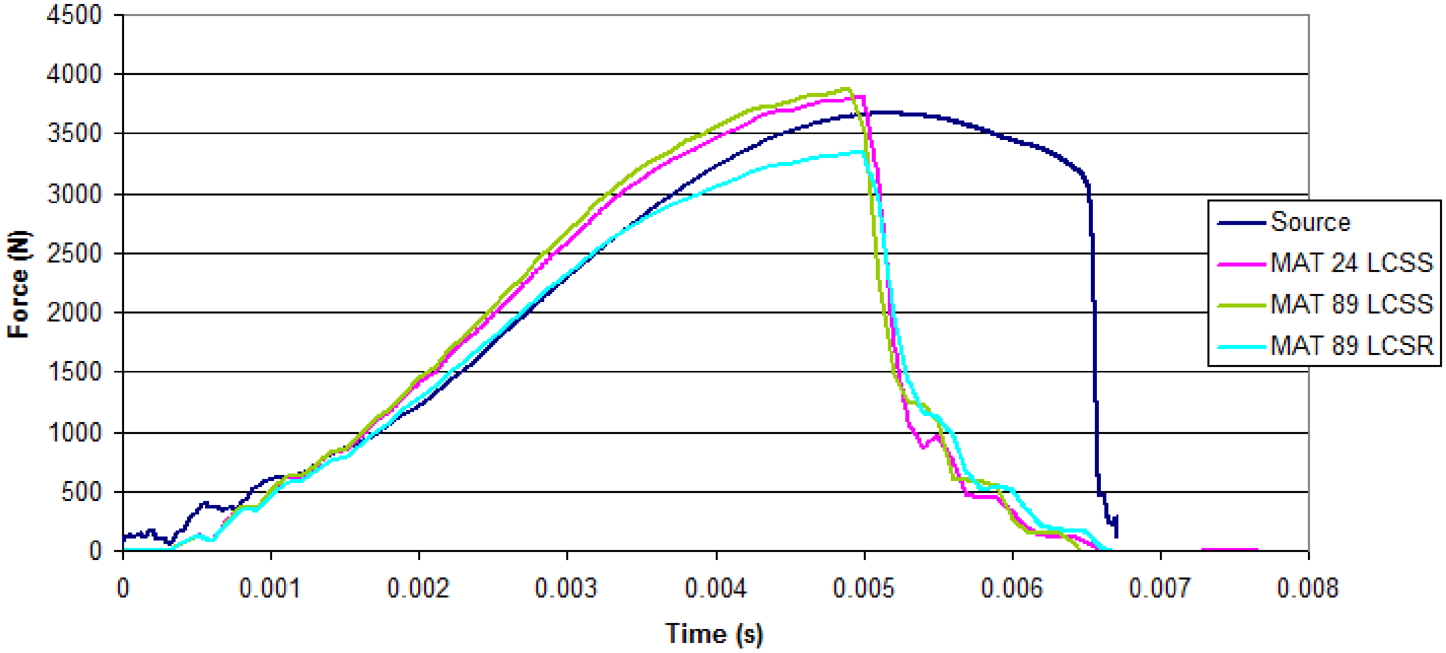
Material Testing ABS and PP





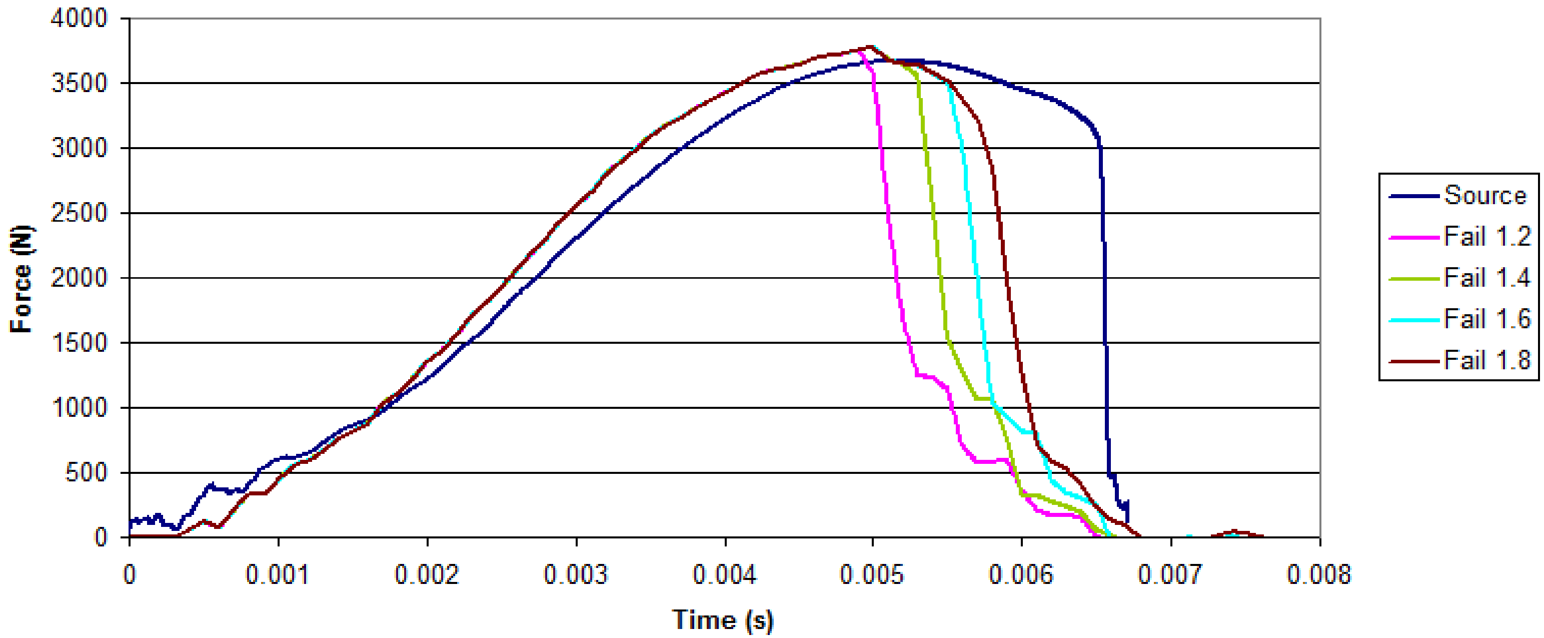
- Tensile testing at different rates from 0.01/s to 100/s
- For mat89 the true stress-strain curves were used for each strain rate

Validation Results: MAT_89 ABS



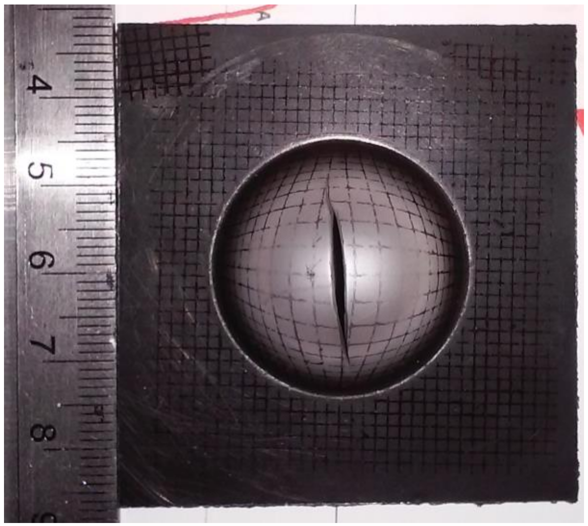
- Mat89 LCSS is alright and LCSR underpredicts a great amount

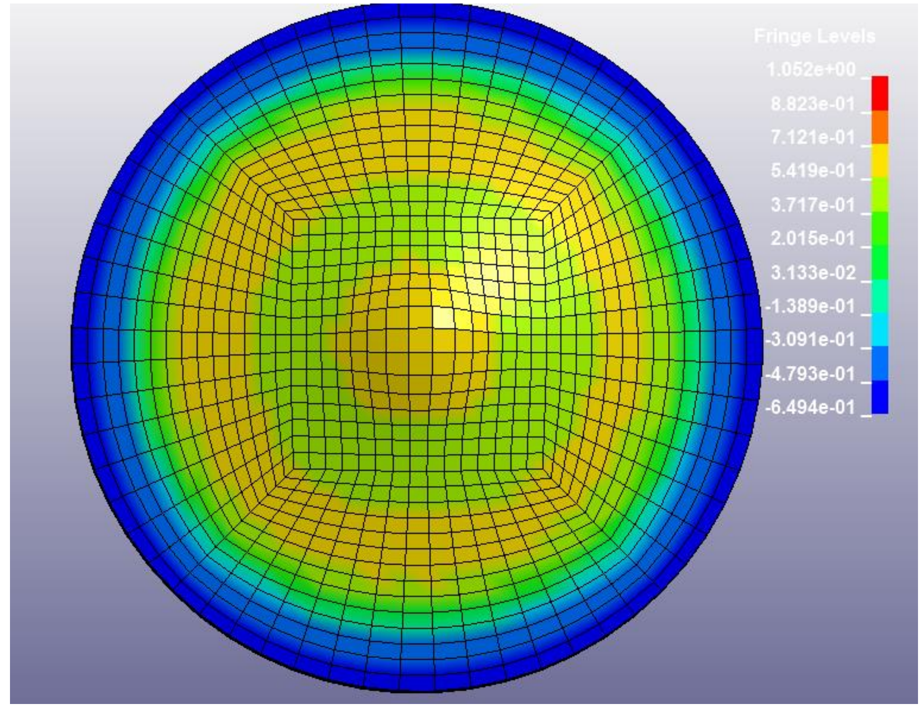
MAT_089 using LCSS settings with different failure strains



- Starting around failure strains of 1.8 elements begin to be deleted for negative volume instead of hitting the failure strain

Observation of biaxial failure strain for ABS

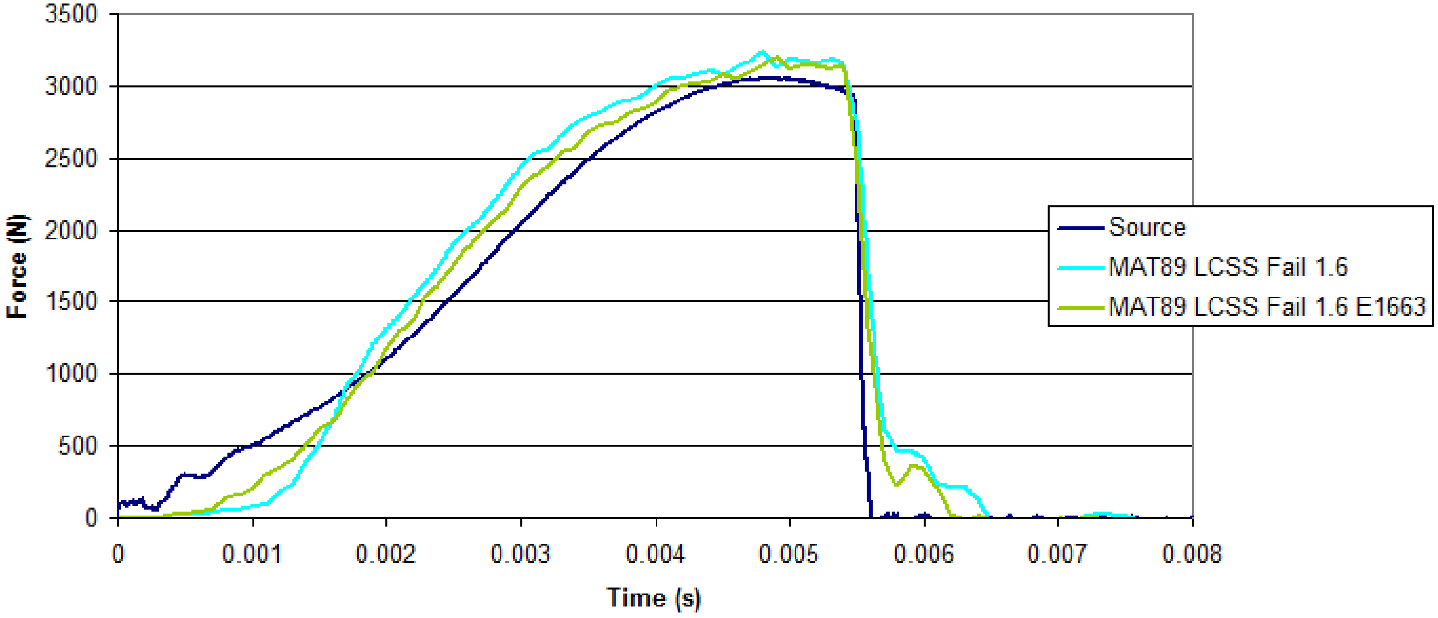




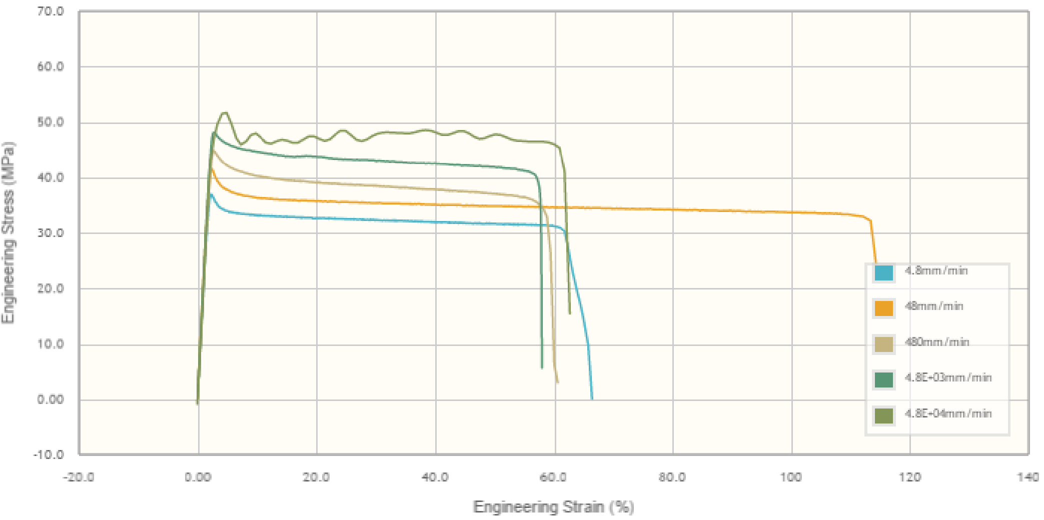
- Examining why the extrapolation improves the model, the mode where failure occurs is biaxial just before failure
- Measured biaxial fail strain at 1.8

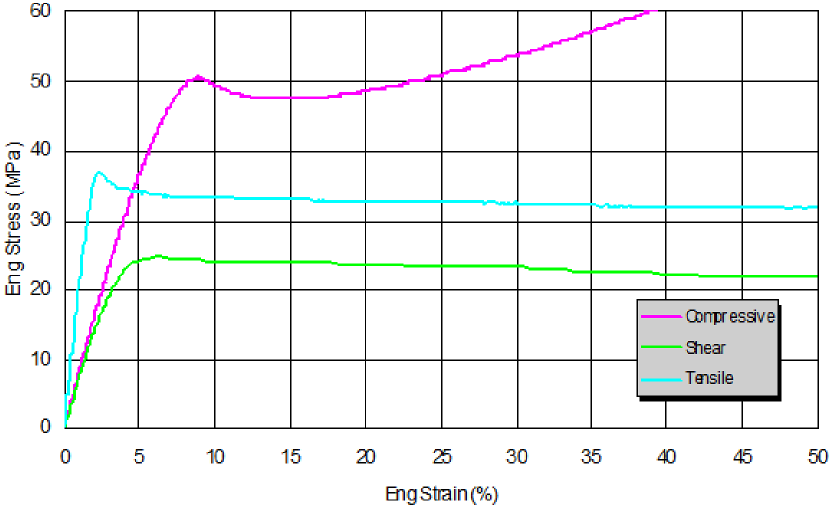
PP Elastic modulus variation

- MAT_089 for polypropylene using LCSS settings with the highest and lowest elastic modulus values.
- When the elastic modulus was changed to the lowest modulus corresponding to the slowest strain rate, a stiffer initial response was observed



Additional Testing for MAT_187: ABS

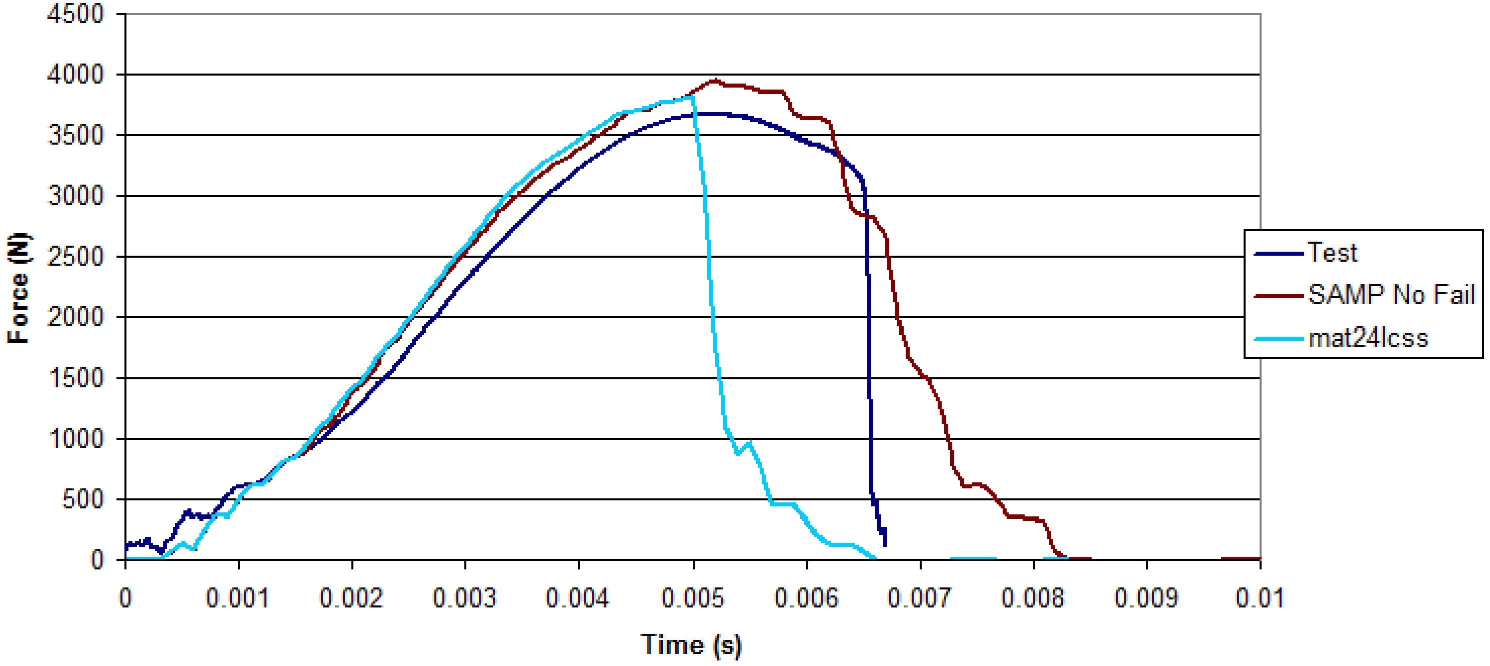




- Compressive Shear and Tensile testing for SAMP
- Plastic Poisson's Ratio not used at this stage (NUEP=0.5)
- Tensile (at all strain rates), compression, and shear stress-strain curves were decomposed into stress vs plastic strain

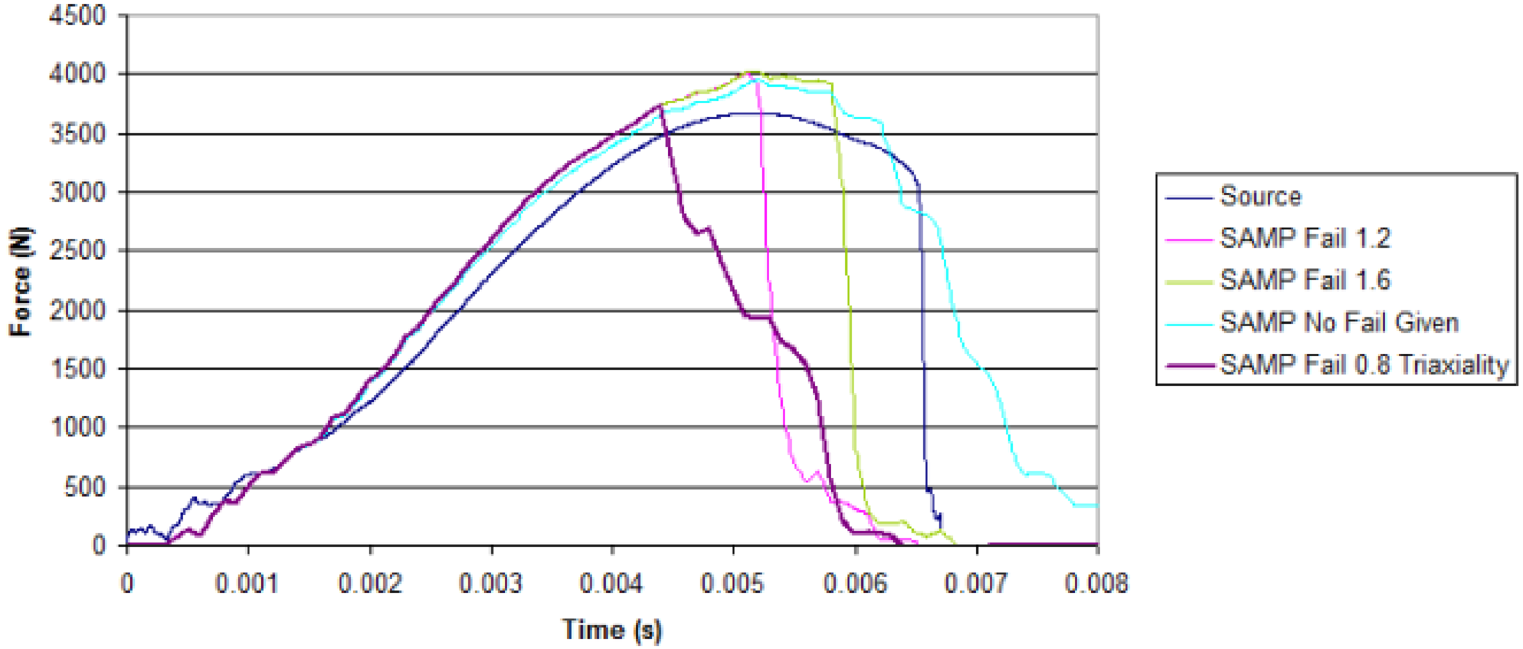
SAMP MAT_187

- MAT_187 for ABS using tension, compression, and shear stress-strain curves.
- FAIL = default (1e5) – failure due to element deletion



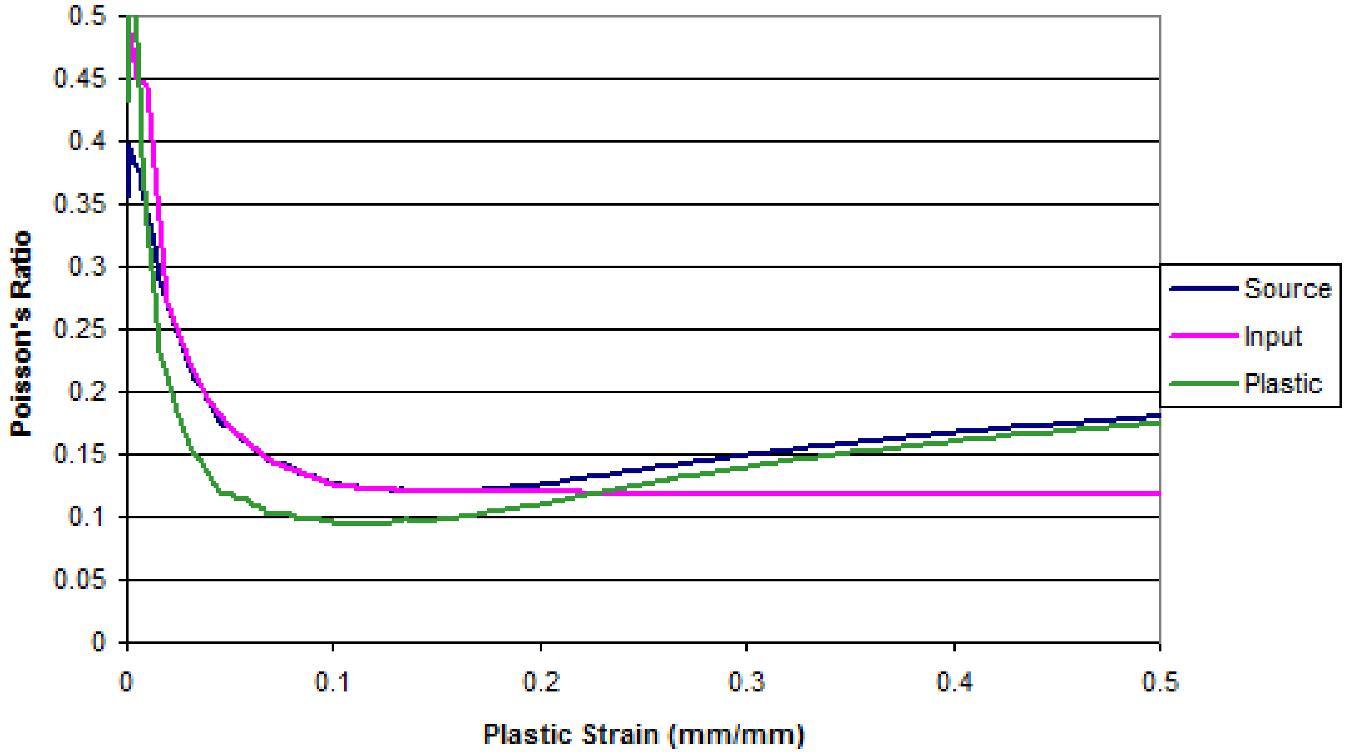
Modeling failure with MAT_187

- Applying failure strains eroded simulation quality
- Using triaxiality curve with measured failure values
  - tensile failure value (0.8)
  - biaxial failure value (1.8)



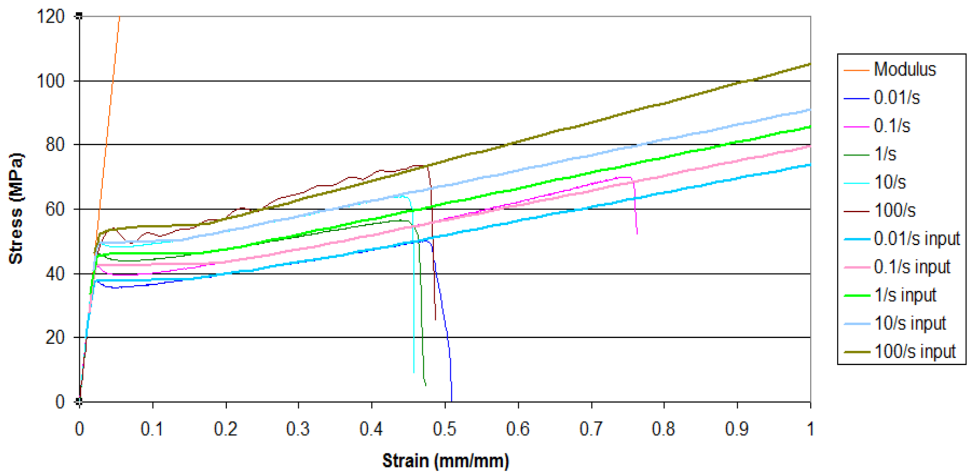
Adding Post-Yield Poisson's ratio to SAMP

- Mat_187 Poisson's ratio vs. plastic strain for ABS.

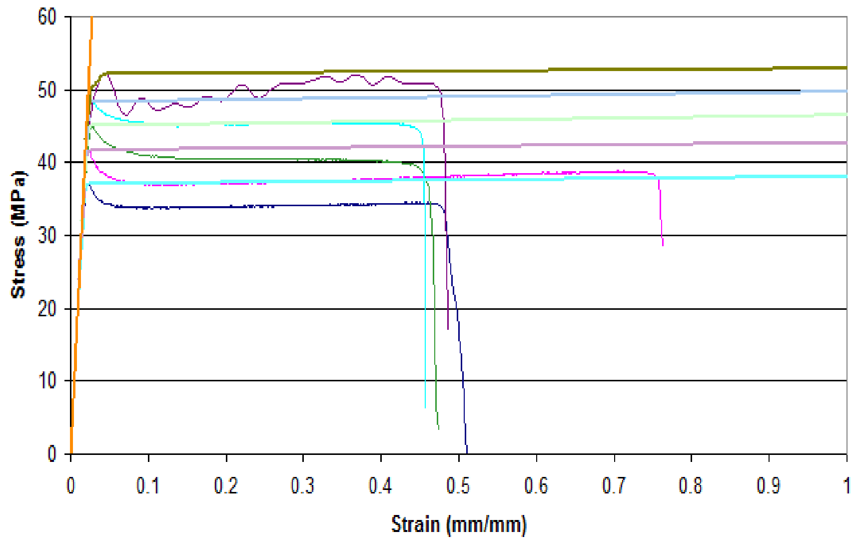


Incorporating Flow Rule

- Normally vp is assumed to be 0.5
- Test and extrapolated curves using the classical stress-strain calculation (left) and measured plastic Poisson's ratio (right).



Using vp=0.5

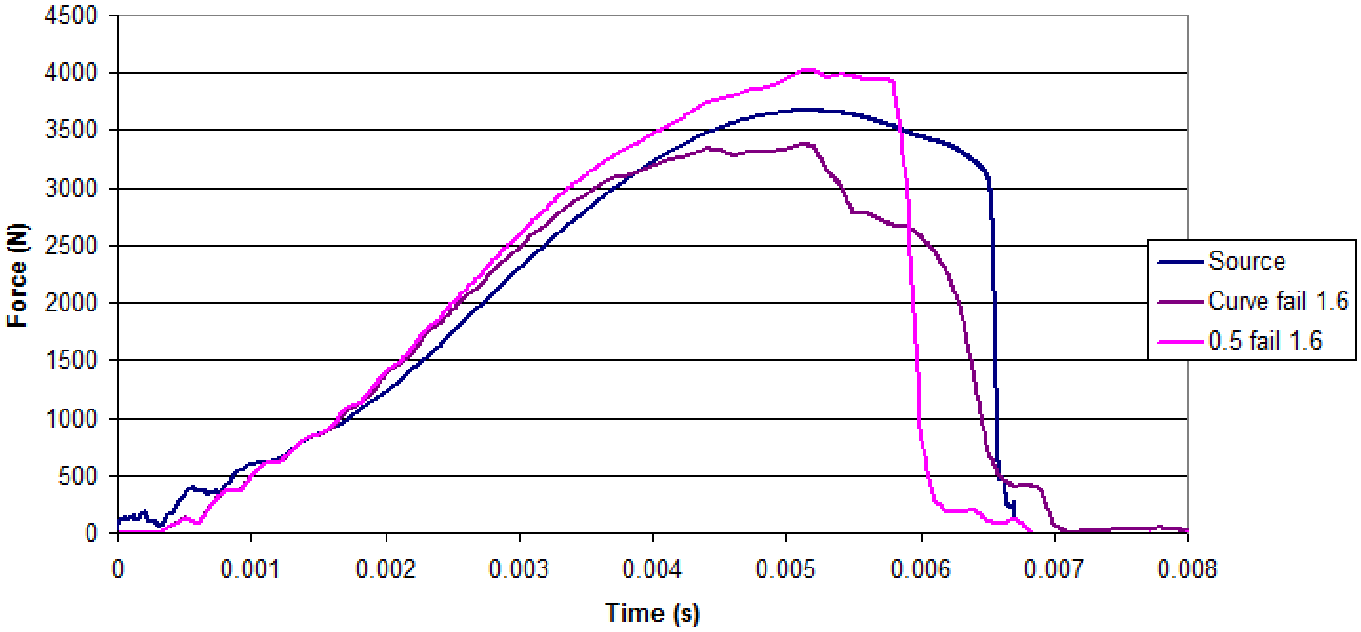


Using measured vp

$$\sigma_t = \sigma_e (1 + \varepsilon_e)^{2vp}$$

SAMP classical vs. varying Post-Yield Poisson's comparison

- Mat_187 for ABS with measured plasticity Poisson's ratio and EPFAIL of 1.6.



Conclusions Part 1

- MAT_089 performs well in cases where the modulus is not rate-dependent
  - The rate dependency option for failure strain also did not yield a positive result using tensile failure strains
- MAT_187 modeled the softening behavior prior to failure best
  - The best correlation for the ABS used the default failure strain 1E05. Negative volume in elements made this result unattractive.

Conclusions Part 2

- Measured tensile failure strain cannot be used for FAIL
  - Extrapolation needed to simulate failure
  - Measurements showed that biaxial strain at failure was close to simulation failure strains
  - Without testing the strains for a failure mode, the somewhat arbitrary choice of failure strain seems to be unavoidable with our approach.
- A solid benchmark of this kind is extremely valuable to test the various options of a material model and other simulation settings prior to use in real life applications.

Acknowledgements

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