

Residual Capacity Predictions of Concrete Constitutive Models Subjected to Impulsive Loads

Rebecca Nylén

Ph.D. Candidate

School of Civil and Environmental Engineering

Georgia Institute of Technology

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FEM Residual Capacity Study

SIERRA SM explicit dynamics solver

Elements

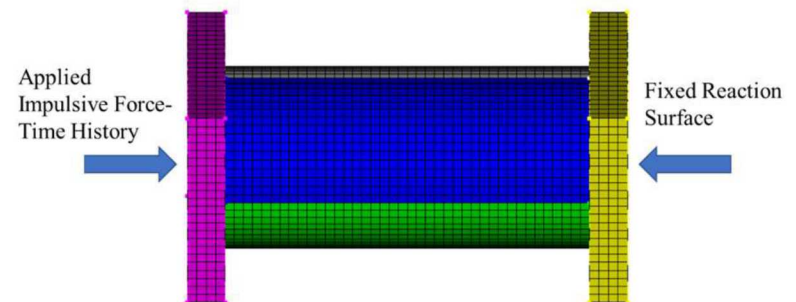
- Under-integrated solid elements
- Hourglass control

Loads

- Dynamic: Scaled impulse from data
- Quasi-static: Displacement controlled

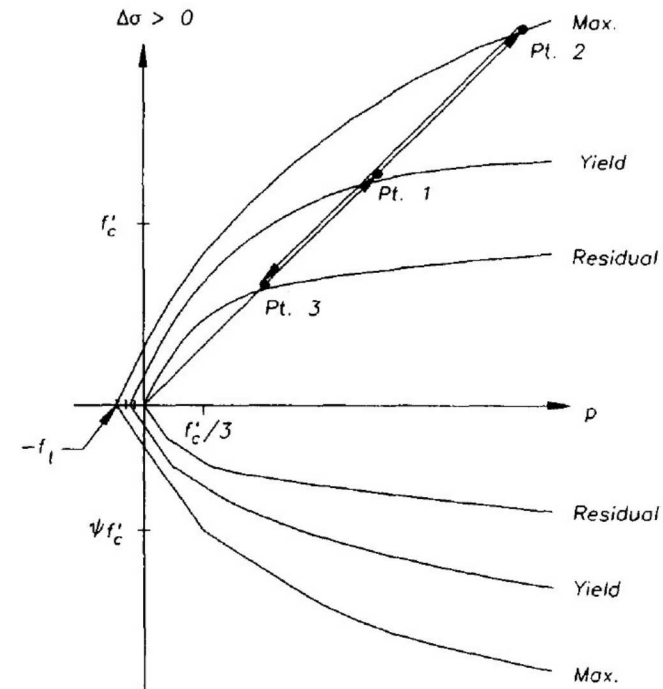
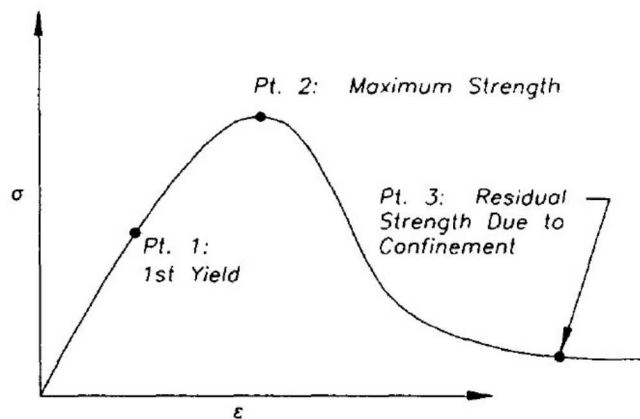
Material models

- Steel: Elastic-plastic
- Karagozian and Case Model (K&C)
- Holmquist-Johnson-Cook Model (HJC)
- Johnson Holmquist Ceramic Model (JH-2)



Karagozian and Case Model (K&C)

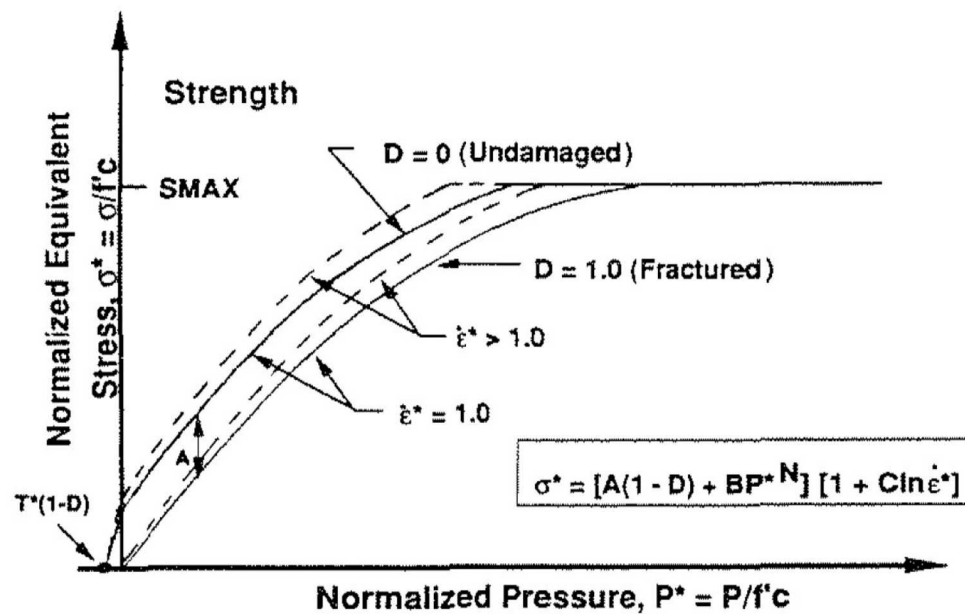
Damage formulation based on effective plastic strain



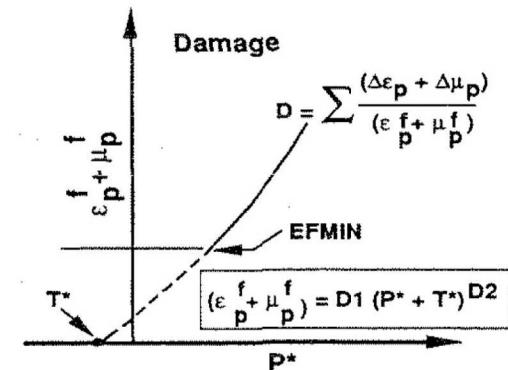
Description of K&C Yield Surfaces

Malvar, L., Crawford, J., Wesevish, J., Simons, D. (1997). "A plasticity concrete material model for DYNA3D." *In. J. Impact Eng.* Vol. 16.

Holmquist-Johnson-Cook Model (HJC)



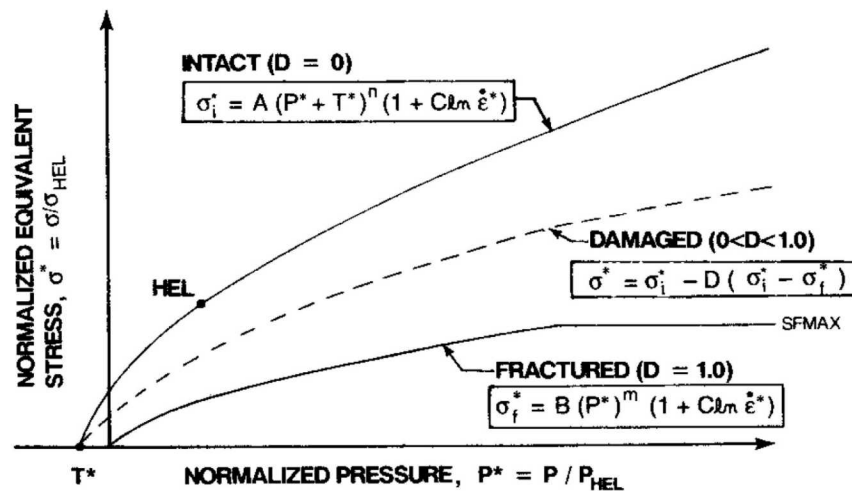
Yield Surfaces



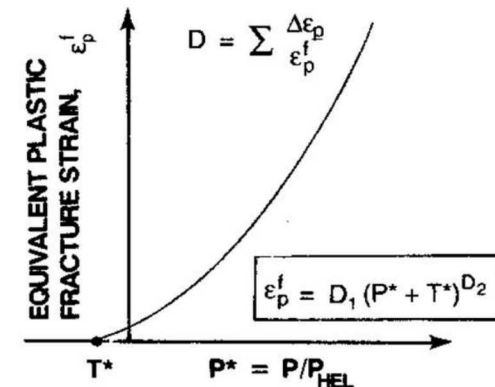
Damage Formulation

Holmquist, T., Johnson, G., Cook, W. (1993). "A computational constitutive model for concrete subjected to large strains, high strain rates, and high pressures." *14th International Symposium on Ballistics*.

Johnson-Holmquist Ceramic Model (JH-2)



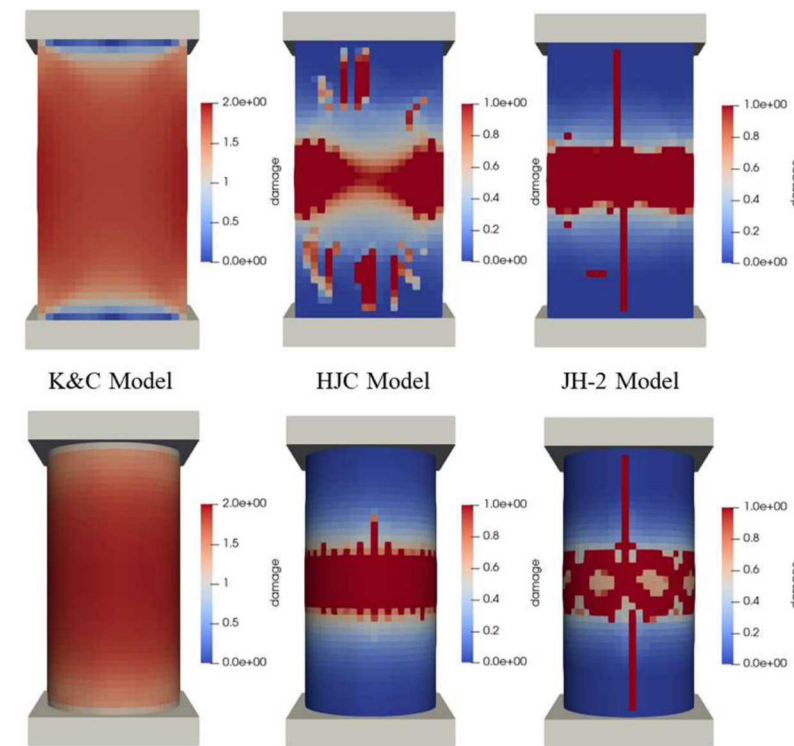
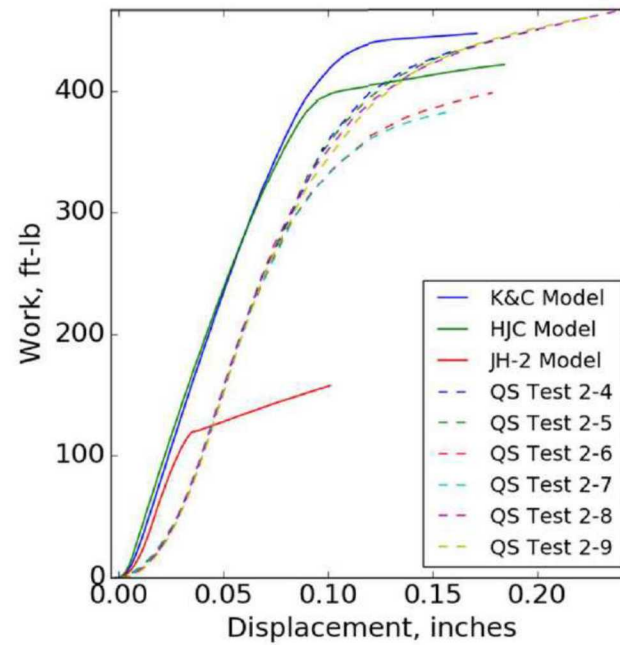
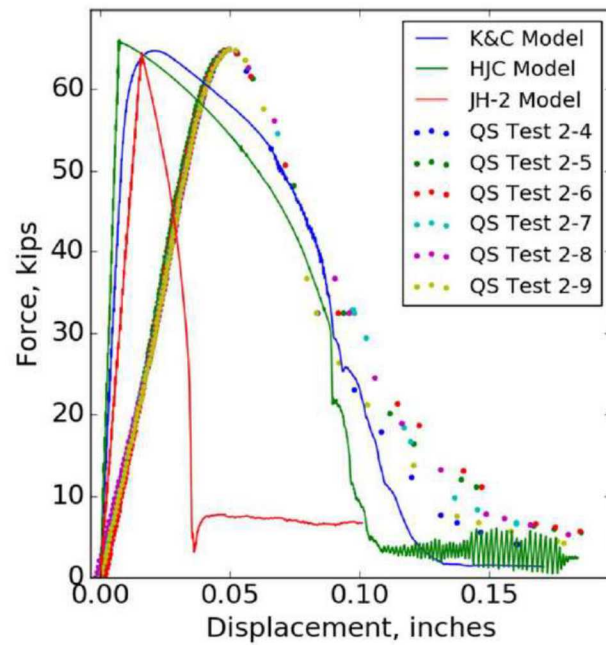
Yield Surfaces



Damage Formulation

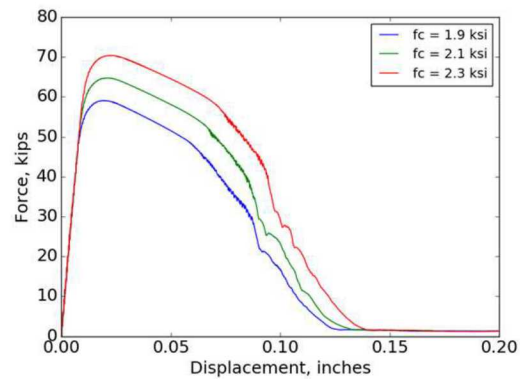
Johnson, G.R. and T.J. Holmquist. (1994). "An improved computational constitutive model for brittle materials." in *AIP Conference Proceedings*. American Institute of Physics.

Calibration to Uniaxial Compression Test Data

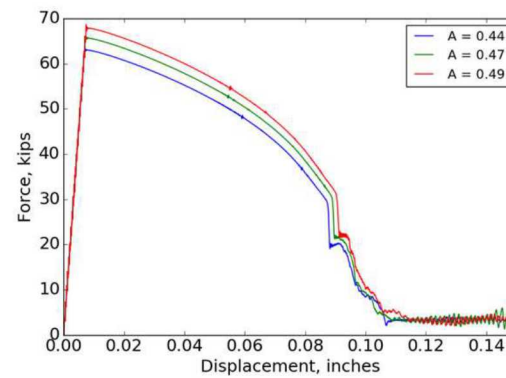


Calibration to Uniaxial Compression Test Data

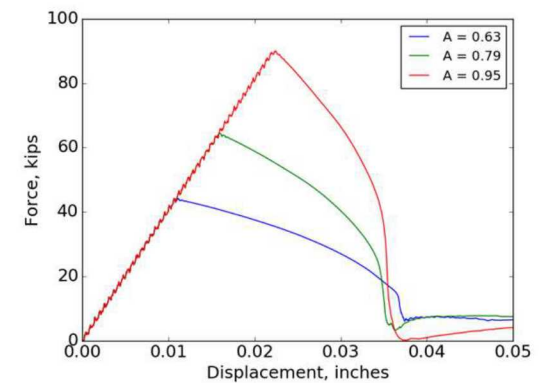
K&C: varying f'_c



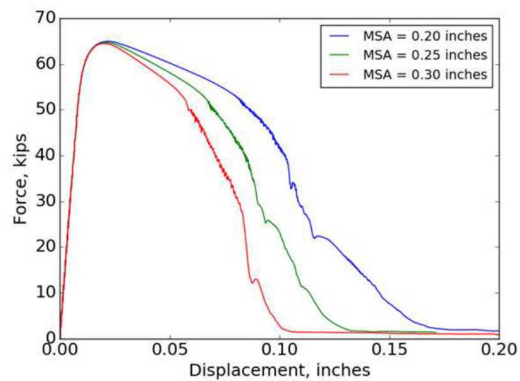
HJC: varying A



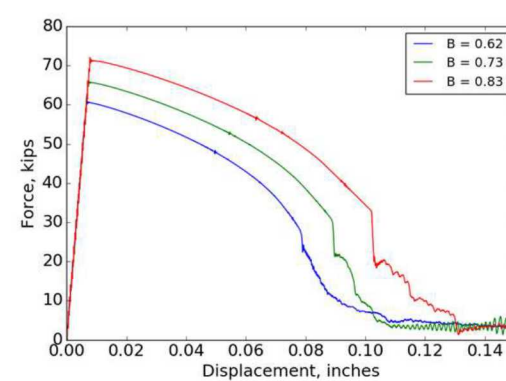
JH-2: varying A



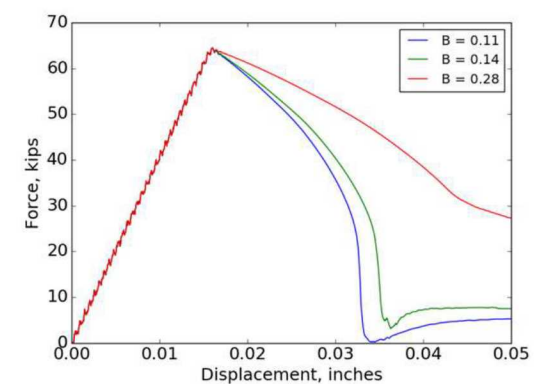
K&C: varying MSA



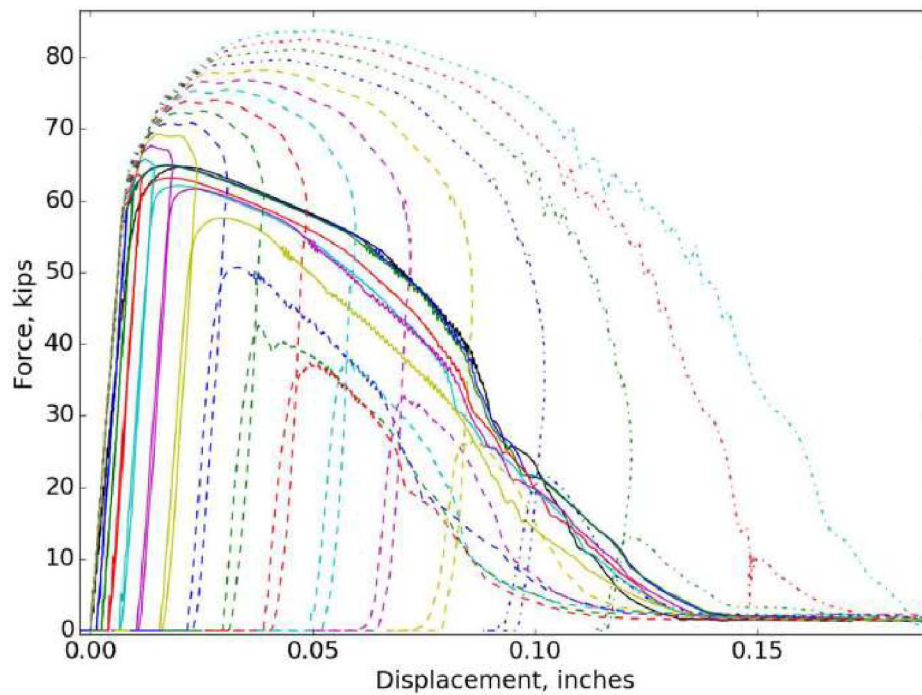
HJC: varying B



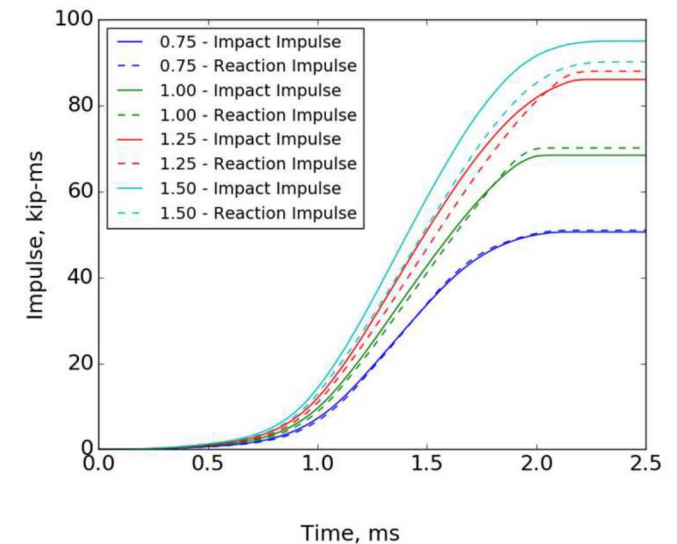
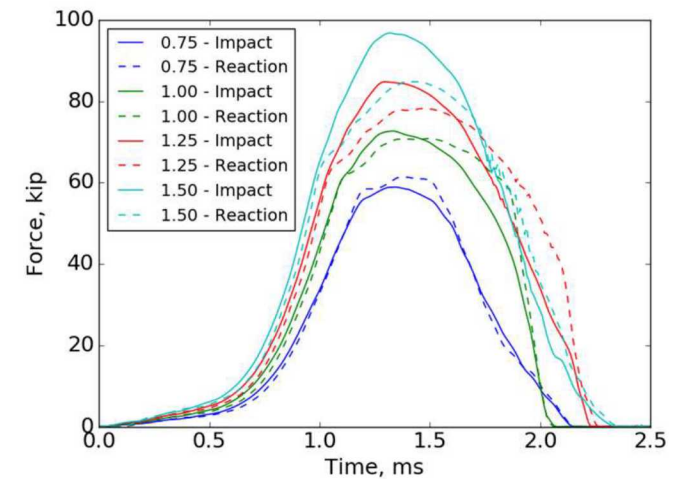
JH-2: varying B



Residual Capacity Study: K&C Model

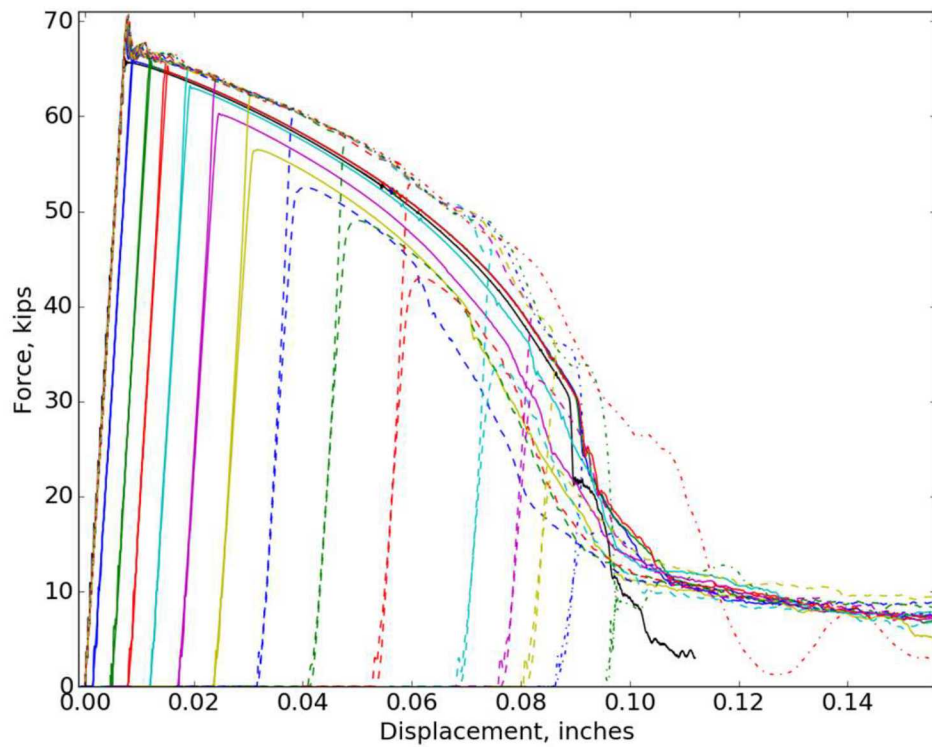


Combined dynamic and quasi-static results

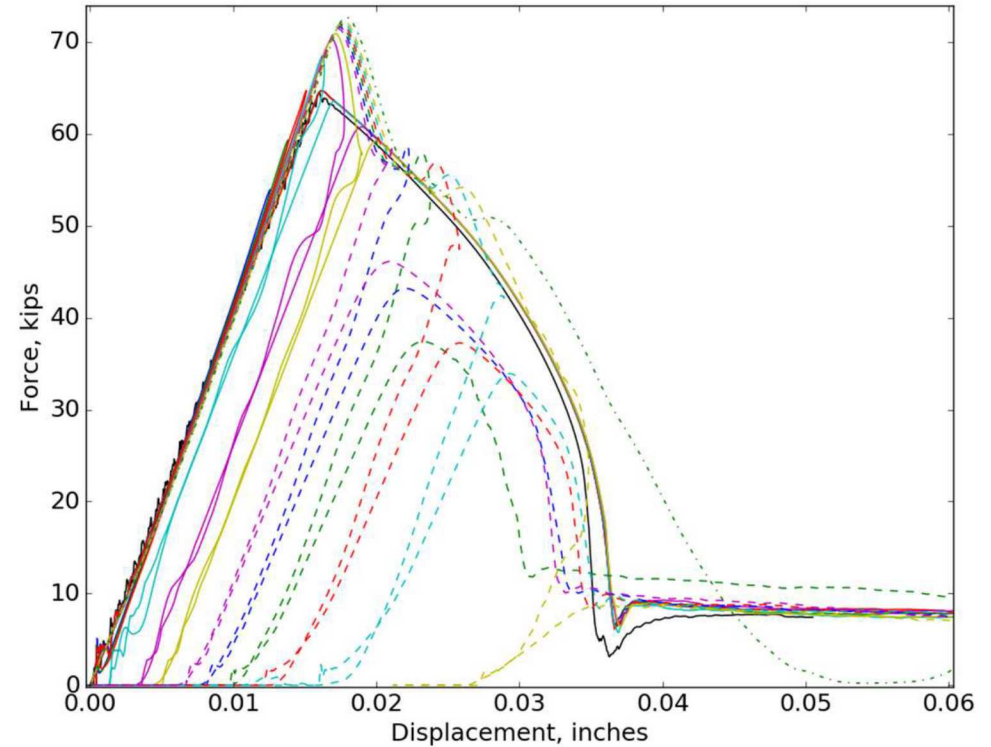


Force and impulse for varying impulsive loads

Residual Capacity Study: HJC and JH-2 Models

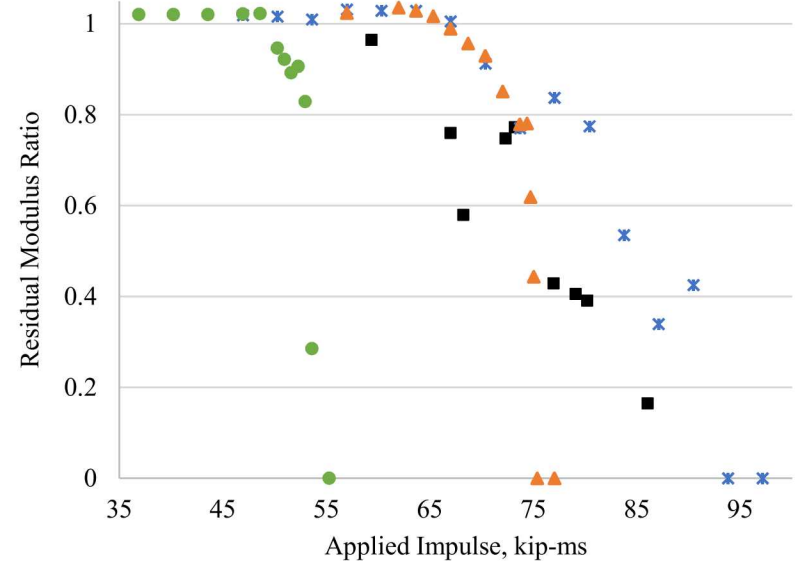
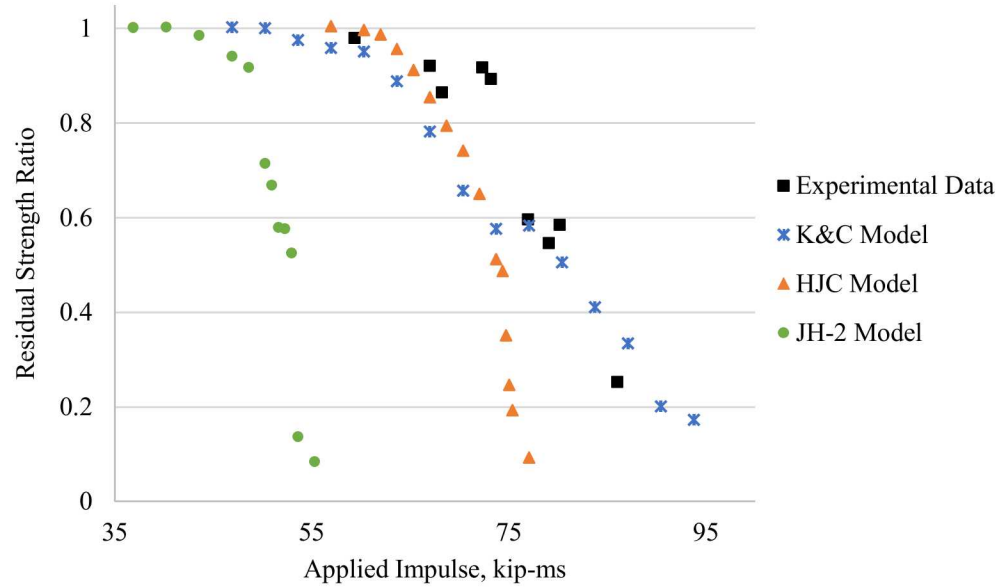


HJC Model

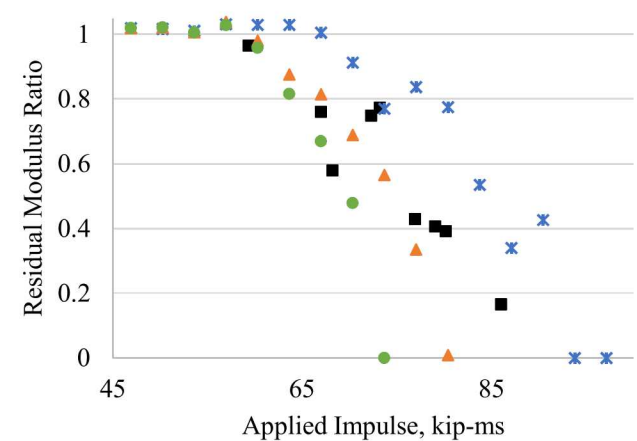
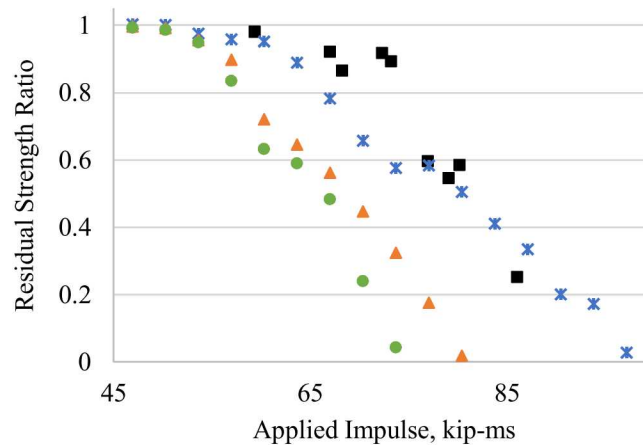
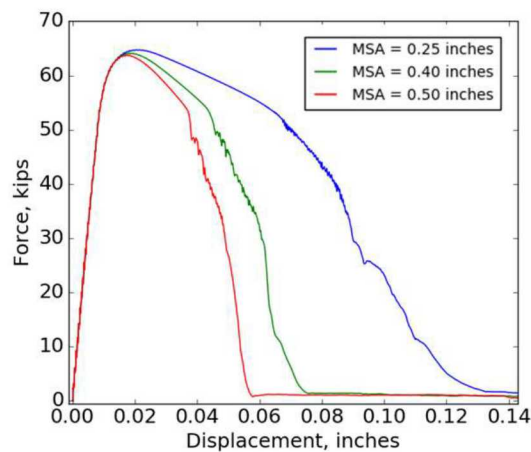


JH-2 Model

Simulation Results

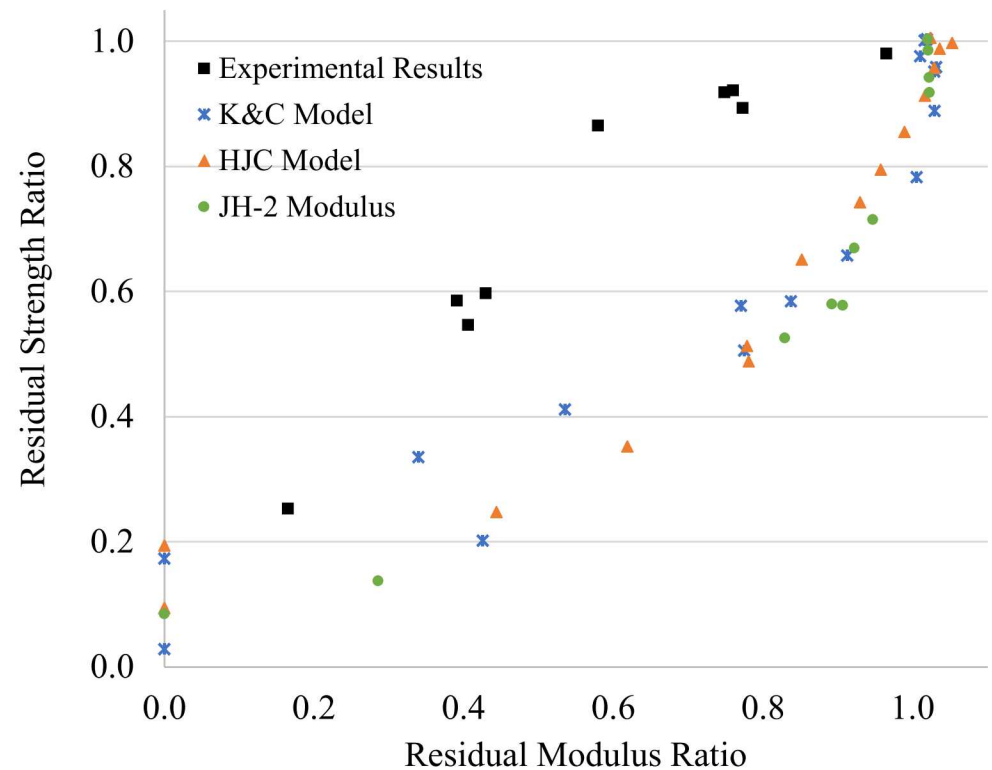


Influence of Descending Branch on Residual Capacity Predictions: K&C Model

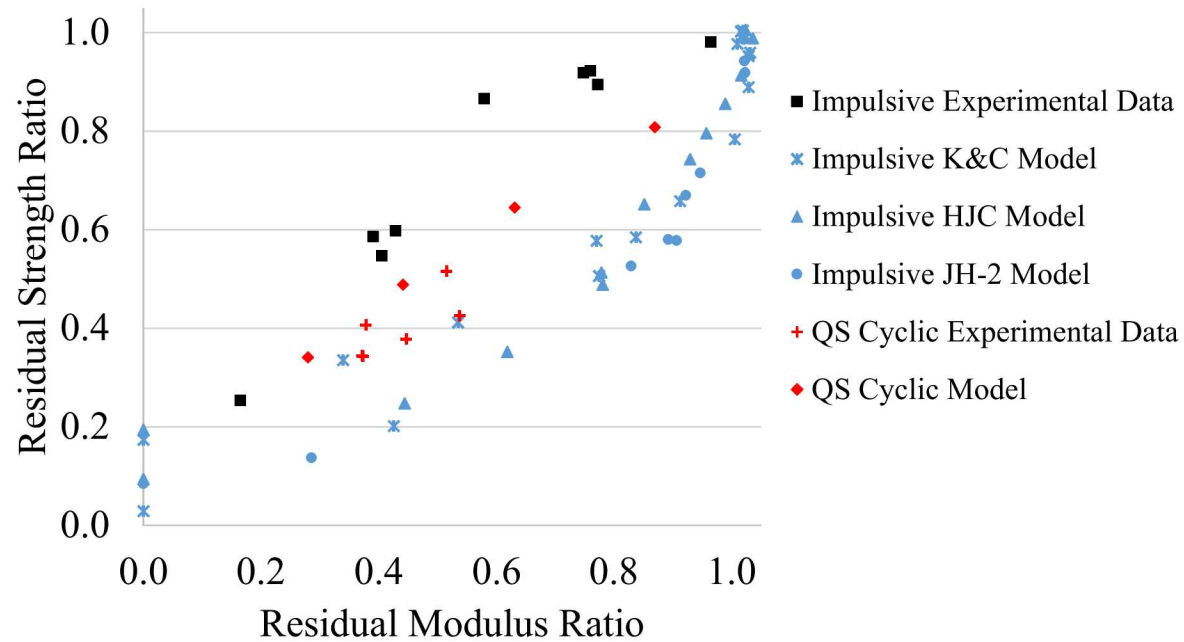


Residual Strength versus Residual Modulus

- Experimental data shows that a significant loss of stiffness occurs before a notable loss in strength
- Models do not capture this loss of stiffness



Summary of Residual Capacity Predictions



Acknowledgements

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