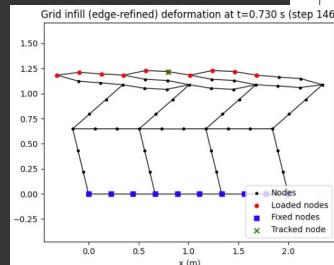
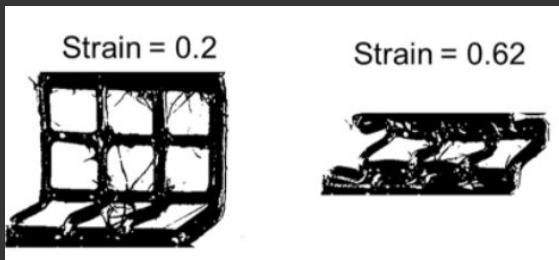


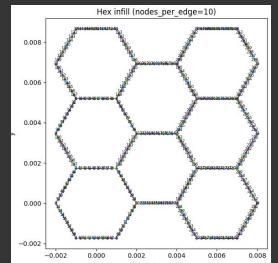
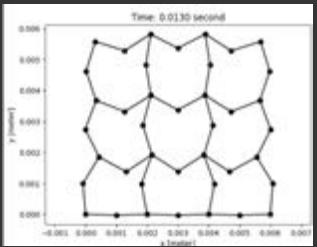
Modeling FDM-Printed TPU Energy Absorption for Impact-Resistant Armor in Combat Robotics

Problem Statement & Motivation

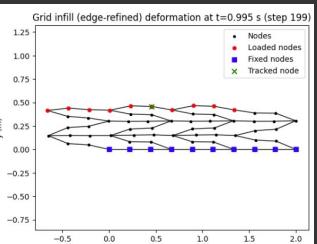
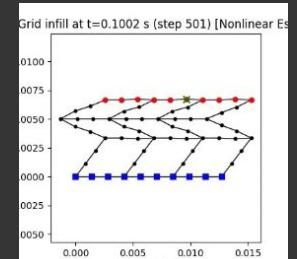
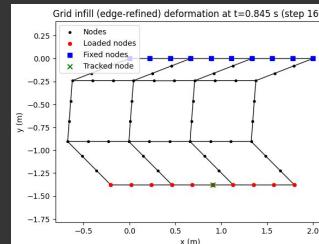
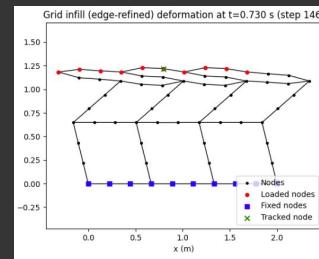
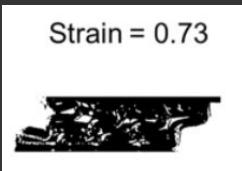
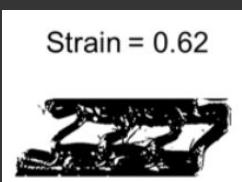
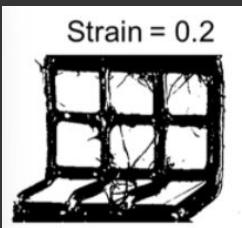
- Develop a spring network simulation to visualize FDM-printed TPU component infill topology (grid & hex) for impact-resistant combat-robot armor
- Quantify the energy absorption capabilities of various TPU geometries and print configurations to guide design choices in combat robotics.



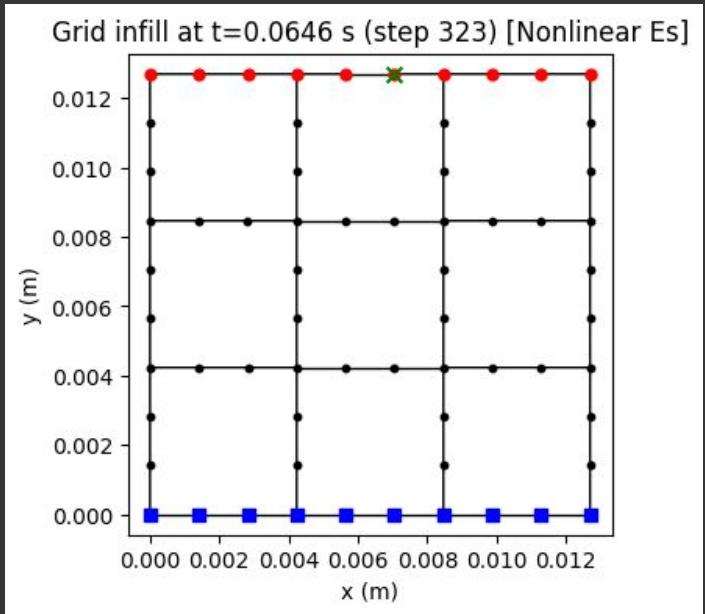
Initial Spring Network



Final NonLinear Es & Linear Eb Model



Source: Khatri & Egan (2024). Energy Absorption of 3D Printed ABS and TPU Multimaterial Honeycomb Structures.



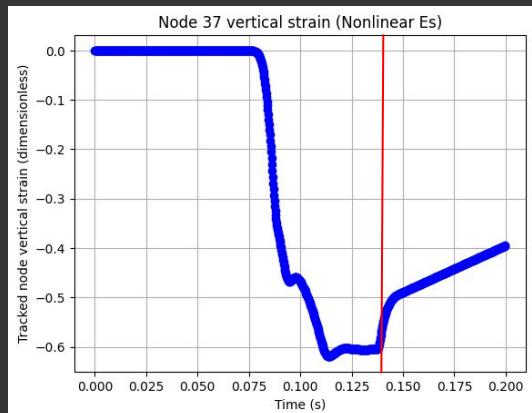
Model Parameters

- TPU 95A
 - Linear E: 67MPa
 - Nonlinear uniaxial tensile data from Gallup et al. (2023) Third-order Mooney-Rivlin model
- 3x3 Grid Infill
 - 2 middle nodes per edge
- 12.5 mm x 12.5 mm x 12mm
- Top row Force loading
 - Initially then release
- Bottom row fixed
- Position Based Dynamics
- Numerical Rayleigh Damping
- Nonlinear Es, linear Eb estimation

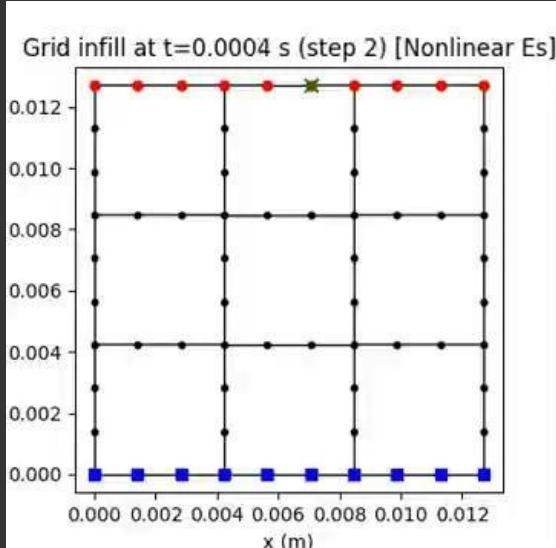
$$E_s \sim AL_0 \int_0^{\varepsilon} \sigma(\varepsilon') d\varepsilon',$$



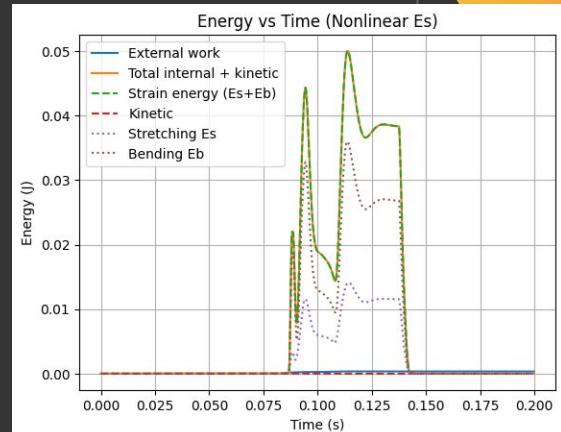
Final NonLinear Es & Linear Eb Model



Top Row Vertical Strain with time
(Loading Removed at t = 0.138s)

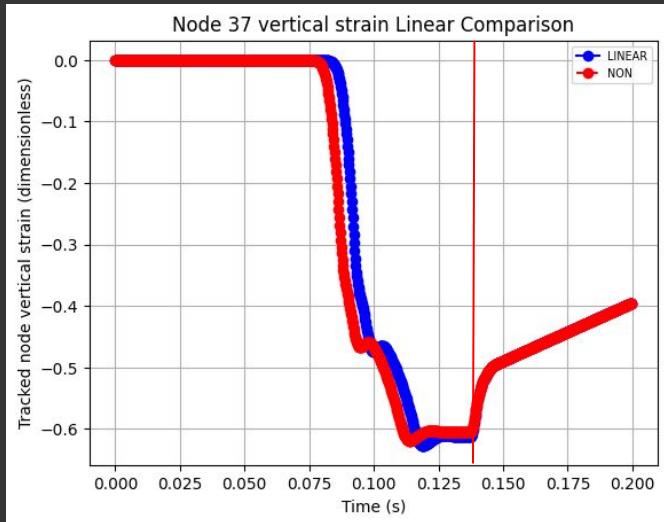


Structure with time
(Blue - Fixed Boundary)
(Red - Loading)

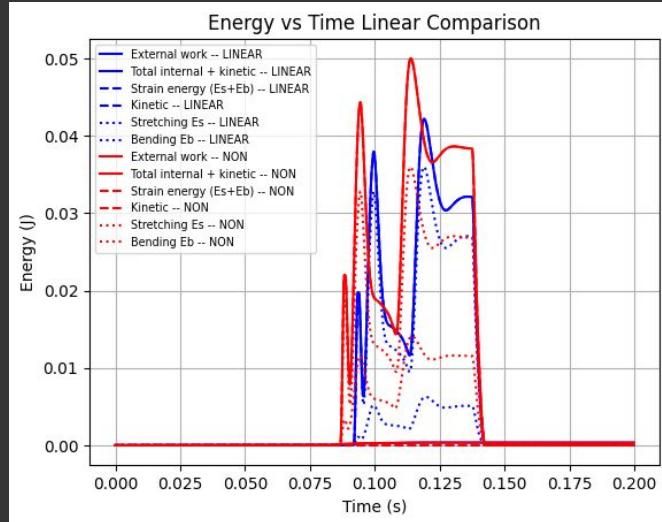


Energy changes with time
(Middle Dotted - Eb)
(Lower Dotted - Es)

Linear Es vs NonLinear Es Comparison

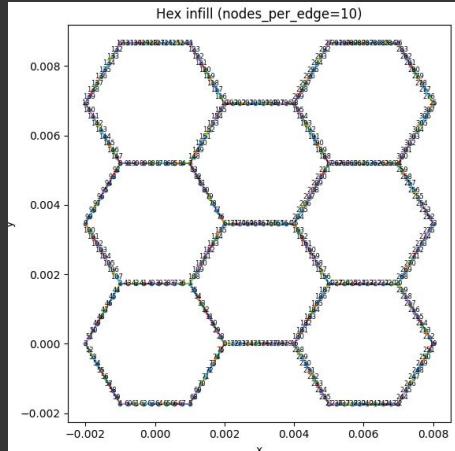


Top Row Vertical Strain with time
(Red - Nonlinear)
(Blue - Linear)



Energy changes with time
(Red - Nonlinear)
(Blue - Linear)

Future Works & Limitations



- Forced Based Simulation Collision
- Viscoelastic Damping
- Hexagonal Infill and out of plane compressions
- Displacement controlled loading

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