PENETRATION MECHANICS OF THICK-SECTION COMPOSITES

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BACKGROUND

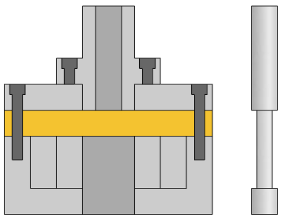
- The ballistic penetration resistance behavior of a material is difficult to determine experimentally
- Quasi-static punch shear testing (QS-PST; Gama and Gillespie, 2008) provides a means of determining a material's ballistic behavior from its quasi-static behavior
- Penetration mechanics is a complex problem involving many variables, including:
  - Projectile and target material properties
  - Target dimensions and boundary conditions
  - Projectile dimensions, geometry, mass, and impact velocity
- Dimensional analysis permits grouping of these variables to reduce the complexity of the problem

RESEARCH OBJECTIVES

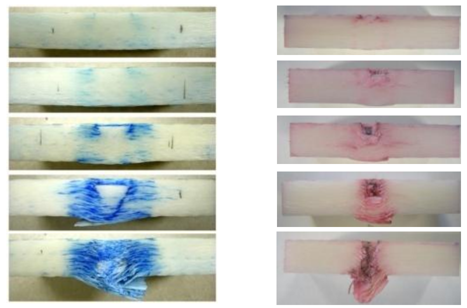
- Develop a dimensionless model for application of the QS-PST method to different target dimensions and projectile dimensions and geometries
- Verify this model with analytical, numerical, and experimental tools

QS-PST TEST FIXTURE

- Fixture allows variation of many experimental parameters, including:
  - Support span
  - Specimen thickness
  - Punch diameter
  - Punch geometry
  - Penetration depth



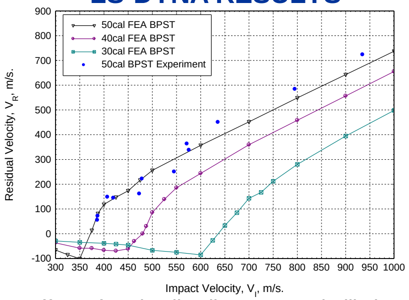
DIMENSIONAL EFFECTS



Partial penetration of 22L S-2 glass/SC15 epoxy panels with span-to-punch ratio=2.0 at similar loading points

- Penetration mechanisms are a function of the punch-to-thickness ratio
- Stiffer panels accumulate more damage from shear than bending

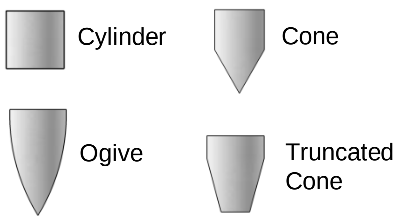
LS-DYNA RESULTS



Effect of projectile diameter on ballistic penetration curve (cylindrical projectile)

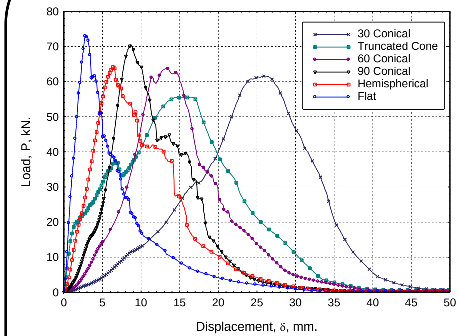
- Larger projectile-to-thickness ratio has greater penetrating ability

PROJECTILE GEOMETRIES



- Change in penetrator-target contact area with penetration depth due to projectile geometry effects the shape of the load-displacement curve

GEOMETRIC EFFECTS



Effect of punch geometry on the shape of the load-displacement curve

DIMENSIONLESS NUMBERS

- Useful dimensionless relationships:
  - **Nose geometry function, N –** represents slenderness of projectile
  - **Response number, Rn –** relates severity of impact with dimensions and material properties of the target

$$N = \frac{M}{\rho d^3}\frac{1}{BN_2} \qquad Rn = \frac{\rho_C \left(u_P^C\right)^2}{\sigma_C^{CS}}\left(\frac{D_P}{H_C}\right)^2$$

ACKNOWLEDGEMENTS

This work is supported by the Army Research Office and the Army Research Laboratory under Cooperative Agreement Number W911NF-07-1-0294.