MODELING TECHNIQUES AND COMPUTING TIME FOR IMPACT SIMULATIONS ON WOVEN FABRICS

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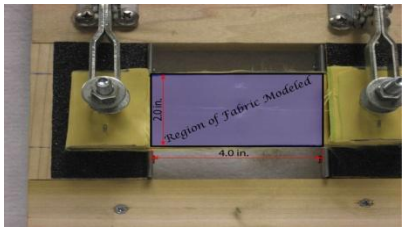
INTRODUCTION

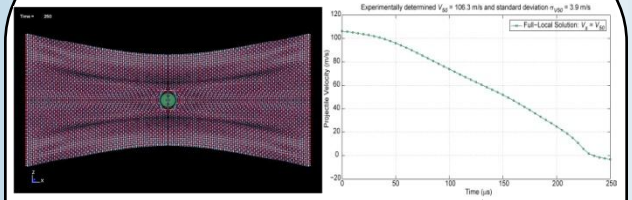
Model Impact Response of 600 Denier Kevlar KM2



Fabric Specifications:
- 34 yarns per inch.
- Areal density = 180 g/m^2.
- Single layer fabric thickness = 0.23 mm.

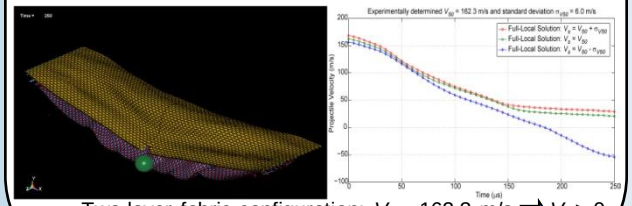
Modeling strategies:
- Yarn level resolution 3D FE models – Full-Local (FL) Solutions.
- Multi-scale models combining 3D undulating yarns and homogenized domains – Global-Local (GL) Solutions.

FULL-LOCAL SOLUTIONS



One-layer fabric configuration: V_s = 106.3 m/s ⇨ V_r < 0

Full-Local Model Validated



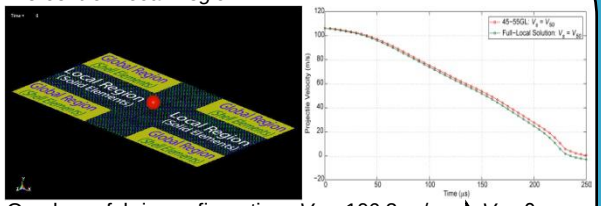
Two-layer fabric configuration: V_s = 162.3 m/s ⇨ V_r > 0

V_s = 168.3 m/s ⇨ V_r > 0 and V_s = 156.3 m/s ⇨ V_r < 0

Full-Local Model Validated

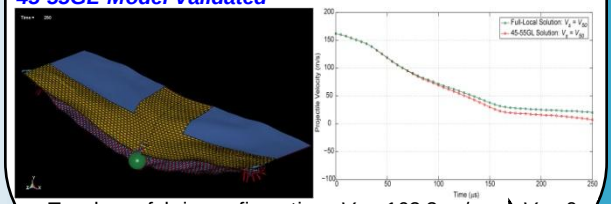
GLOBAL-LOCAL SOLUTIONS

α–βGL ⇒ α = Mass Percent of Global Region; β = Mass Percent of Local Region.



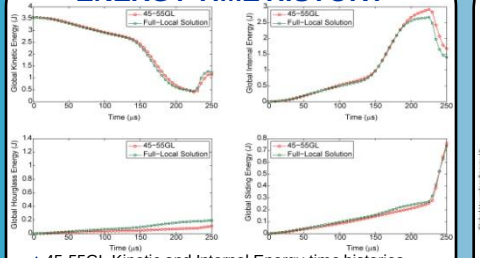
One-layer fabric configuration: V_s = 106.3 m/s ⇨ $V_r \approx 0$

45-55GL Model Validated



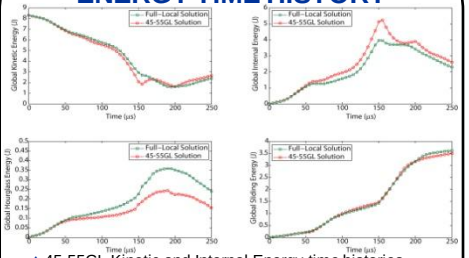
Two-layer fabric configuration: V_s = 162.3 m/s ⇨ V_r > 0; bounded by previous result: ***45-55GL Model Validated***

ONE-LAYER FABRIC: SYSTEM ENERGY TIME HISTORY



- 45-55GL Kinetic and Internal Energy time histories exhibit response *compliance* – yet close enough to the Full-Local Solution.
- Fully-integrated shell elements in Global regions reduce Hourglass effects in the 45-55GL solution.
- The Sliding Energy appears to be closely approximated by the 45-55GL solution.

TWO-LAYER FABRIC: SYSTEM ENERGY TIME HISTORY



- 45-55GL Kinetic and Internal Energy time histories exhibit response *stiffness* – yet close enough to the Full-Local Solution.
- Fully-integrated shell elements in Global regions reduce Hourglass effects in the 45-55GL solution.
- The Sliding Energy appears to be closely approximated by the 45-55GL solution.

COMPUTING TIME

Layers	T_{FL} Hours	$T_{45\text{-}55GL}$ Hours	%savings= $\left(\frac{T_{FL}-T_{45\text{-}55GL}}{T_{FL}}\right)\times 100$
1	0.82	0.63	23.2
2	19.5	14.7	24.6

T_{FL} ⇒ Time for FL Solution; $T_{45\text{-}55GL}$ ⇒ Time for GL Solution

CONCLUSIONS

- Validated the FL models against experimental V_{50} data.
- Successfully developed the Global/Local modeling technique for both one- and two-layer fabrics.

CONCLUSIONS

- Demonstrated acceptable agreement between FL and GL solutions.
- GL modeling accrues appreciable savings in computing time.

FUTURE WORK

- Perform bounding simulations to characterize the effect of scatter in yarn modulus.
- Investigate the suitability of other GL mesh configurations for reducing computing time.
- Model four-layer fabrics based on the GL technique.
- Model large-scale fabrics measuring about 18” by 18” in-plane with 10-12 layers.

ACKNOWLEDGEMENTS

This work is supported by the Army Research Laboratory through the Composite Applied Research and Technology program.