MULTISCALE HYBRID ELEMENT MODELING OF TRIAXIAL BRAIDED COMPOSITE

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ABSTRACT

In this work, a multi scale finite element (FE) analysis modeling approach in LSDYNA has been developed to simulate the impact of triaxially braided composite structures. This approach, referred to as the multiscale hybrid element analysis (MHEA), used meso-scale solid elements to discretize the area around the impact region and transited to macro-scale continuum shell elements in the surrounding region.

Within the impact area, a meso mechanical FE model was used to consider the detailed braiding architecture for the purpose of investigating the mechanical behavior and local damage initiation and propagation of fiber tows, matrix, and interface between different constituents. Fiber tows and matrix were modeled explicitly and meshed as solid elements. To mimic interface bonding and debonding between fiber tows and between fiber tow and matrix, tiebreak contacts were defined. With refined model, it is feasible to study the details of localized behavior that happen in the complex constituents.

To reduce computational effort, a macro mechanical FE model based on an existing subcell approach was applied at the region away from the impact point to capture the global response of the entire structure. In this subcell model, each unit cell of triaxial braided composite compromised of four subcells and each subcell was represented by a continuum shell element. Fiber tow orientations and failure properties were defined at the through thickness integration points of shell elements. By incorporating

the macro mechanical FE model, accuracy and fineness of modeling resolution with computational effort was well balanced.

Lastly, a surface based tied contact was adopted in order to connect solid elements in meso-scale region and continuum shell elements in macro-scale region. Impedances have been matched across the meso-macro interface to prevent interfacial reflections of the strain wave.

The MHEA method was calibrated and correlated by applying it to coupon bars experiment where material damage and failure in both axial direction and transverse direction are studied. Then the same method will be used to predict impact test of flat circular panel. The MHEA approach enables the full use of the advantages of both the meso scale model to describe the details of local deformation and macro scale model to capture the overall response of the entire feature.