

CAVEMAN FE Model: Consideration to Biological Variabilities in the Computational Evaluation of Lower Leg Injuries during Underbody Blast Loading Conditions

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Improvised explosive devices (IED) being used against U.S. military vehicles in recent conflicts have led to an increased need to accurately predict mounted warfighter injuries. The lower extremities are the most commonly injured region of the body in underbody blast (UBB) events. Computational injury assessment in conjunction with experimental anthropomorphic test devices (ATD) in loading conditions similar to UBB occurrences provides more comprehensive occupant safety analyses for military vehicles. A chief benefit of computational injury assessment is its ability to describe soft tissue failures that are otherwise difficult to capture in experimental ATD testing. The Computational Virtual Experiment Man (CAVEMAN) is a detail oriented human body model focused on expanding the capability for injury prediction of both skeletal and soft tissues. The CAVEMAN finite element (FE) model is based on a 50th percentile human male and is developed for use in high performance computing. Comparisons to postmortem human surrogate (PMHS) experimental data have been performed with the CAVEMAN lower extremity model in order to validate its sub-injurious response (Butz, et al. 2017). The objective of this research is to further develop the injury prediction capabilities of the CAVEMAN lower leg model in loading conditions similar to an UBB event and compare to an injurious PMHS experimental data set (Bailey 2016). A sensitivity study concerning biological variabilities such as positioning, material properties, and anatomical geometry was performed to understand how such parameters affect injury localization and severity. Angle positioning data from the Bailey test series was used to reposition the CAVEMAN leg, and the injury consequences of leg positioning is to be analyzed. Stiffness definitions for various parts of the lower leg (tendons, muscles, ligaments, heelpad, bone) were adjusted by values plus and minus a significant factor to determine how variation in these components effects leg response. The geometric factor to be examined is the impact of variation in cortical bone thickness on injury severity and location. It has been determined that certain ligaments in the foot are most sensitive to material definition change causing the greatest impact on the force response and kinematics of the CAVEMAN FE leg. Positioning and variations in cortical thickness did not contribute greatly to the force response, and continuing analysis is examining the impacts on injury with respect to the variation of these parameters.

References:

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