



US DEPARTMENT OF DEFENSE

BLAST INJURY RESEARCH PROGRAM COORDINATING OFFICE

Injury Models

Development of Methods to Measure and Quantify the Response of Skulls to Blast and Impact Loading

Animal studies are conducted to understand the effect of impact and blast loading on the brain. To extend the understanding we obtain from animal studies to humans, ARL has strived to understand the mechanical response of the constituent materials of the head of animals and human. In ongoing research currently at ARL, skulls from 6-month-old Göttingen pigs were fabricated into specimens and subjected to quasi-static compressive loading while measuring load, far-field displacement, and local strain fields on the gage area of the specimen using optical digital image correlation method. In addition, the microstructure of each specimen was analyzed using a micro-computerized tomography (CT) scan before and after loading to quantify the skull structure. These measurements include porosity and bone volume fraction, structure thickness and separation, tissue mineral density, and anisotropy information (based on construction of the mean intercept length fabric tensor). The anisotropy data (mean intercept length fabric tensor) can be used to obtain the orthotropic elastic tensor that represents the complex stiffness of the skull. These experimental results are being used to develop an inverse computational-experimental methodology to estimate constitutive model parameters. In addition, an elasticity-morphology relationship from the literature was extended to represent the modulus variation in the functionally gradient skull structure (bone volume fraction) by calibrating the relationship with the experimentally-derived local moduli. The final goal of these experimental studies is to facilitate the development of a blast loading rate dependent, microstructurally inspired, homogenized material model for the minipig skull. These methods will also be used to develop similar models for human skull. Understanding the response of animal and human skulls will help ARL to understand how animal blast experimental results relate to injury in humans, thus helping develop better Service Member head protection devices to mitigate blast and impact loading to the head of the Service Member.