

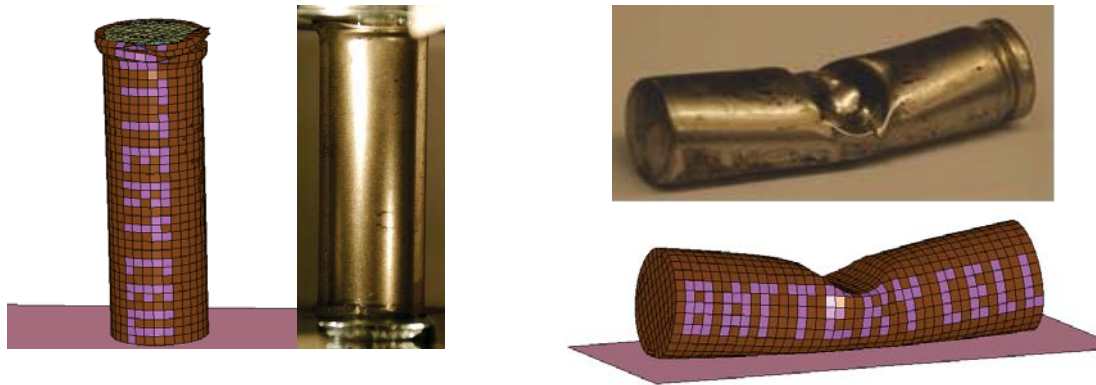
# Impact & Crashworthiness Laboratory

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## Modeling of Lithium-ion Cylindrical Batteries for Mechanical Integrity: Experiments, Calibrations, and Validation

by

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# **Modeling of Lithium-ion Cylindrical Batteries for Mechanical Integrity: Experiments, Calibrations, and Validation**

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## **Abstract**

Today it is unthinkable to develop any optimized system without a parallel computational model. And yet such detailed constitutive and computational models do not exist for lithium-ion batteries and are also not being developed by the world-wide battery and car industry. These models will substantially shorten the prototyping cycle by reducing the number of expensive tests and provide information on how small changes at the level of the electrode separator will affect the safety of the entire battery pack. Before one gets to that level of complexity, it is necessary to develop less detailed homogenized models which are needed for future multi-scale modeling of the cell. This study was focused on developing a procedure to extract material properties of the jelly roll of a single lithium-ion battery cell. There are two approaches available to develop such a model. One is to consider the jelly roll as a laminated composite and estimate the material properties based on properties of layers of active electrodes, electrode collectors, and the separator. The other method is to consider the jelly roll as a homogenized material and estimating the properties based on physical testing on the whole cell. The second method is adopted for this study, as it is considerably more time efficient, and gives a reasonably accurate prediction of the behavior of the cell. This study uses extensive testing on the battery cell and jelly roll of 18650 lithium ion cell, combined with the use of analytical solutions to estimate material properties of the cell and develop a finite element model of it. It was found that the suitably calibrated model of a high density compressible foam can give a very good prediction of crash behavior of cylindrical battery cell subjected to high intensity lateral and axial loads. The finite element of a single cell can be used to develop finite element models of different battery packs and ultimately the battery pack can be coupled with finite element models of whole vehicles. These models are useful for optimizing the design of the battery packs for application loads and for crash safety. This newly developed model will help minimize the overdesign of battery packs allowing safer, lighter, and more efficient electric vehicles.

*Keywords:* Lithium-Ion Batteries, Mechanical Integrity, Cylindrical Cell