C24 BioMedical Engineering Methodological Protocol for Testing Real World Helmet Performance

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After attending this presentation, attendees will understand how to objectively investigate helmet impacts and utilize proven protocols and techniques to test motorcycle helmets beyond standardized testing. The objective is to quantitatively compare and analyze impact performance of three types of DOT approved helmets and three types of Non-DOT approved helmets in real world impacts.

This presentation will impact the forensic science community by quantifying the dynamic differences between helmet choices in real world impacts beyond standardized testing methods. By increasing the knowledge base of engineers and scientists, helmets can be better designed to be most effective for the intended use.

Motorcyclists suffer serious trauma to the head more often than automotive occupants, primarily due to contact with non-yielding surfaces, such as asphalt and concrete, and/or direct impact from other motorized vehicles. A motorcycle helmet is the principal protection to the head from an impact once the occupant is ejected. In the United States, consumer helmets are initially divided into two distinct categories: DOT (Department of Transportation) approved and non-DOT approved (sometimes referred to as novelty helmets). For a helmet to be approved by the Department of Transportation it must pass a series of tests administered by the Department of Transportation, and once done so, the helmet will display a "DOT" sticker. DOT approved helmets must meet a series of performance testing requirements including impact, penetration, and retention tests. In terms of impact performance testing, the motorcycle helmet is dropped in a guided freefall at a set range of velocities onto a hemispherical or flat steel anvil, where data collected must not exceed critical accelerations of 400 g's maximum, 200 g's for two milliseconds, and 150 g's for four milliseconds. (Federal Motor Vehicle Safety Standard (FMVSS) No. 218). The testing methods used in this research project differ from the above because the helmet performance testing is conducted at higher impact velocities, different principal directions of force, and impact onto real world surfaces compared to the standardized testing.

To quantitatively compare the impact performance of the motorcycle helmets, including the energy dissipation characteristics, the forensic engineering method was utilized. The forensic engineering method is composed of five steps: (1) occurrence of precedent event; (2) define forensic engineering problem; (3) collect data; (4) analyze data; and, (5) develop and evaluate findings. The dynamics of the real world incident is studied thoroughly using longstanding forensic methods. The remaining four steps are then iteratively evaluated. The engineering problem definition in this instance is to quantitatively compare the impact performance, including the energy dissipation characteristics, of a sample of DOT approved helmets and a sample of non-DOT helmets at real world energy levels.

Six helmet types were tested; three types of DOT approved helmets and three types of non-DOT helmets. The impact tests were conducted using an inverted pendulum system with a helmeted Hybrid-III head-form. When dropped, the helmets contacted the exemplar surface (helmet performance can potentially be altered by the properties of the contact surface). Accelerometer data was acquired with a data acquisition system. The data from the sensors was filtered in accordance with SAE standard J211.

Four exemplars were tested for each of the six helmet types at two different velocities, yielding a total of 48 impact tests. For each test, a new helmet was fitted to the Hybrid III head-form and the chinstrap of the helmet was secured per the manufacturer's instructions. The real world principal direction of force can be utilized in the experimental design to replicate the subject head impact region. To initiate each test, an inverted pendulum protocol with Hybrid III head-form and helmet was raised to replicate the subject impact velocity ranges. Helmet performance was revealed.

The results quantify the performance by category and model, and proved to be consistent with the principals of rotational and translational energy, collinear contact of two bodies, and impact deformation. The higher delta t resulted in substantially lower peak accelerations for the DOT approved helmets when compared to the non-DOT approved helmets.

Motorcycle, Helmet, Head