D35 An Experimental Study of Inertial Mechanisms of Motorcycle Helmet Accident Retention Failures

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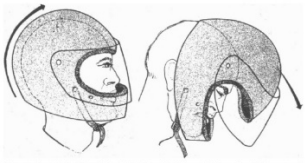
Learning Overview: This goal of this presentation is to demonstrate an experimental method for forensic study of motorcycle and motocross helmet inertial-induced detachment mechanisms during motorcycle crashes by using the National Highway Traffic Safety Administration (NHTSA) Pendulum anthropomorphic Hybrid-III head-neck test device for comparison of potential defective helmet retention systems.

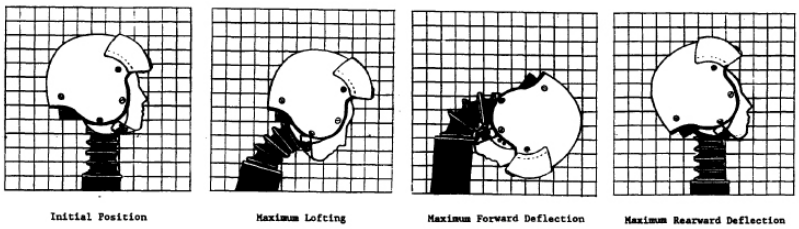
Impact on the Forensic Science Community: This presentation will impact the forensic science community by showing an experimental method to evaluate the tendency of motorcycle and motocross helmets to be displaced from the head during inertial loading in a collision prior to the rider impact-contact with the ground.

Discussed in a prior American Academy of Forensic Sciences (AAFS) presentation, the protective capability of a motorcycle and motocross helmet is diminished or becomes non-existent if the helmet becomes displaced or ejected during an accident or sudden impact.[1] Earlier helmet research on displacement-detachment during crashes was published by Richards and Hurt, et al.[2,3] The United Kingdom Department for Transport reported "helmet detachment…in 10% to 14% of casualties."[4] Restrained helmets can be significantly displaced or ejected off the head in motorcycle impacts, due to loose fastening of the chin strap and possibly a loose-fitting helmet. Hurt noted, "helmets properly fitted, retention system securely fastened, but the helmet is ejected."[3] Richards diagrammed how properly fitted and securely fastened helmets can eject in frontal impacts where "the torso is slowed…but forward inertia of the helmet, the geometric attachment of the chin strap system, plus head rotation, allows the helmet to roll off the head before impact with another vehicle, and/or other fixed objects."[2]



Manner in which helmet is detached at high speed, showing (left) normal position and (right) helmet pivoting forward on strap during accident.

In this current study, the NHTSA Pendulum anthropomorphic Hybrid-III head-neck test device was used for experimental evaluation of helmet detachment due to inertial unloading caused by the helmet design and retention system. Experimental methodology is based on earlier research by the United States Army Aeromedical Research Laboratory related to helicopter and military helmet retention during inertial impact loading.[5] The figure below, from reference 5, shows phases of head/helmet flexion (head bend toward chin), head/helmet extension (head/helmet bend reward), and helmet lofting from the head due to centrifugal forces.



The figure below shows video clips of similar testing recently conducted at IDIADA-KARCO on motorcycle helmets, using the NHTSA pendulum. New helmet models were impacted at different impact speeds (6.8 and 5.3m/s) and helmet sizes (M & L).

The figure above shows four inverted video clips (i.e., top of head in pendulum test is actually oriented toward floor) from different time frames of NHTSA pendulum impact testing at 5.3 meters per second (m/s) on a new, large-size motocross helmet mounted to a Hybrid-III 50th%tile male head/neck. The upper left video clip is taken at the start of pendulum contact-impact just before the pendulum arm crushes an aluminum honeycomb pad. Prior to testing, the helmet

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was tightly cinched to headform. The upper right video clip is 41msec after impact. The upper two video clips show initially, during the neck-flexion phase, the helmet becomes loose from the headform, lags behind the head rotation so the headform chin protrudes noticeably below the chin-bar, and the forehead rotates into the face opening of helmet. Detachment of the helmet from the headform is caused by the centrifugal force induced into the combined headform and flexible neck, which are affixed to the base of the rigid pendulum bar stopped suddenly by crushing of the deformable honeycomb pad. The next time clip at 176ms shows the helmet rotated back to almost the same position as the contact impact. Then the head-neck system goes into neck "extension" rotational mode such that the helmet is displaced from the headform and the chin again protrudes beneath the chin bar of helmet (i.e., 260ms clip). Although tightly cinched before impact, the helmet easily slides "loosely" back and forth over several degrees relative to the start of inertial impact.

In summary, the experimental methodology utilized by authors discussed in this presentation enables a more realistic, proper forensic evaluation of helmet system retention performance, regardless of compliance with limited government or independent safety standards, such as the "roll-off" test. It has been pointed out that existing helmet Standards FMVSS 218, British Standard 6658, and ECE Standard 22.05 do not adequately evaluate helmet retention deficiencies or potential head injury risks like the inertial testing employed in this study.[5] Typically, these standards only utilize a simplified "roll-off" test where a small weight is attached by a loose cable to the rear edge of the helmet mounted on an inclined metal headform. Weight is then dropped about 0.6 meters to cause limited "sudden jerking motion" to helmet. This method does not address the more realistic "flexion" and "extension" kinematics achieved with the pendulum test method.

Reference(s):

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2. Richards, P.G. Detachments of Crash Helmets during Motorcycle Accidents. *British Medical Journal* 288, pp 1758, 10 March 1984.
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Motorcycle Helmet, Retention, Impact