**Testing the shock protection performance of Type I construction helmets using impactors of different masses**

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**Introductory Information**

Top impacts are considered essential tests to evaluate the shock absorption performance of commonly used type I industrial helmets. Currently, there are two major test standards that are widely applied in helmet industry: ANSI/ISEA Z89.1 and EN397. Since drop impacts are performed using different impactors and at drop heights, results obtained using different test standards are not directly comparable. The purpose of the current study is to evaluate and compare the helmet impact test results obtained using these two frequently used helmet test standards. A representative basic Type I construction helmet model was selected for the study. A total of 19 drop impact tests were performed at different drop heights and with two different impactors (3.6 kg and 5.0 kg). Group (a) contains 10 drop impacts performed using the 3.6 kg impactor at drop heights from 0.31 m to 1.93 m. Group (b) contains 9 drop impacts performed using the 5.0 kg impactor at drop heights from 0.22 m to 1.32 m. Each of the impact trials was replicated four times. Relationships between the peak impact force and the drop height for these two test groups were analyzed and compared. When the helmets were tested with potential impact energy smaller than critical values, a consistent trend for the relationship of peak impact force as a function of the potential impact energy was obtained. Our results show that our previously proposed quantitative evaluation approach for industrial helmets' shock absorption performance can be used with either the ANSI/ISEA Z89.1 or EN395 standard to quantify industrial helmets' shock absorption performance. Furthermore, our results illustrated that the peak impact force would not be a reliable parameter to evaluate the helmets' safety margin.

**Methods Collection**

* Experimental setup
* Type 1 impact tests were performed in the study, in which a free-falling impactor is impacted on the top crown of the helmet shell that is fitted on a fixed headform.
* Helmet drop impact trials were performed using a commercial drop tower test machine (H.P. White Laboratory, MD, USA), which complies with the ANSI Z89.1 standard.
* The forces transmitted to the headform are measured using a force sensor (Model 925M113, Kistler, Amherst, NY, USA), which is uniaxial and has a capacity of 22.2 kN (5 x 103 lbf) and an accuracy of +/- 2.5 % in full scale.
* The force sensor was installed between the base of the tower and the headform.
* The velocity of the impactor just before impact was measured via an optical sensor built in the system.
* The impactor was semi-spherical with a radius of 48 mm at the striking face. In the current study, two impactors were used: 3.6 kg and 5.0 kg.
* The headform is made of aluminum and had a mass of 3.64 kg.
* Experimental procedure
* A total of 19 drop impact trials were performed in two groups.
* In group (a), 10 drop impacts were performed using a 3.6 kg impactor at 10 drop heights from 0.31 m (1.0 ft) to 1.93 m (6.3 ft).
* In group (b), 9 drop impacts were performed using a 5.0 kg impactor at nine drop heights from 0.22 m (0.72 ft) to 1.32 m (4.32 ft).
* Each of the impact trials was replicated four times.
* Each drop impact was performed using a new helmet sample, which was disposed of following the drop impact tests.
* A total of 76 [(10 + 9) × 4] drop impacts were performed.
* One representative off-the-shelf Type 1 helmet model was used in this study.
* Data processing
* The recorded time-histories of forces were processed using a custom program developed using MATLAB software to find the maximal peaks during the impacts.
* The unfiltered raw data were used in the determination of the maximal peak values during the impacts.

**Citations**

1. Wu JZ, Pan CS, Ronaghi M, Wimer BM. Testing the shock protection performance of Type I construction helmets using impactors of different masses. Biomed Mater Eng. 2024;35(4):351-363. DOI: 10.3233/BME-230173.
2. Wu JZ, Pan CS, and Wimer BM, ”Quantification of the shock absorption performance of construction helmets in top impact” (Presentation, 42nd Annual Meeting of the American Society of Biomechanics, Rochester, MN, August 8-11, 2018).

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