Comparison of the Impact Performance of Motorcycle Helmets Qualified to Three Different International Motorcycle Helmet Standards

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I. INTRODUCTION

The protective capabilities of motorcycle helmets against fatality and risk of head injury are well documented [1]. Internationally, there are numerous motorcycle helmet standards that have been developed to provide a minimum standard for head protection for powered two wheel (PTW) operators and their passengers. Traditionally, helmet manufacturers have provided products that are in compliance with the national requirements of where the product will be sold (e.g. FMVSS 218 in USA, UN/ECE 22 in Europe, etc.); however, in locations that do not have a national motorcycle helmet standard or adequate enforcement of a given helmet standard, there exists a wide range in terms of helmet quality [2]. Furthermore, there is often criticism that one standard is better than another standard in terms of protection offered; however, to date there has been no real world study published that can confirm or refute such claims. The purpose of this research is not to prove whether or not one standard is "better" than another, but to evaluate the performance characteristics of a group of helmets that are qualified to different international standards when subjected to a common set of impact conditions.

II. METHODS

All impact testing was performed using an ISO Size J headform fitted with a uniaxial accelerometer (PCB Model 353B18) and attached to a monorail freefall impact tower (Cadex Inc., Quebec, Canada). The total system mass was 5.0 kg. Five size medium test samples of six different helmet models were purchased for this study. Two open face or jet style helmet models were qualified to the UN/ECE 22 helmet standard and were purchased online from a European internet retailer and shipped to the helmet testing laboratory in Los Angeles, California. Two shorty helmets that were qualified to FMVSS 218 were purchased online. The remaining two helmet models were purchased in Hanoi, Vietnam and were qualified to the QCVN 2:2008/BKHCN motorcycle helmet standard. Four impact locations were selected (front, rear, right side and left side) for testing. Each impact site was located 50mm above the reference plane of an ISO Size J test headform and at the intersection of either the sagittal plane (front and rear locations) or the coronal plane (left side and right side impact locations).

Experimental Testing

All helmets were conditioned under ambient laboratory conditions prior to impact testing. The test headform was oriented to the selected impact location and the test sample was placed on the helmet in accordance with a helmet positioning index determined by the technician. The helmet and headform assembly was then raised to a height which would result in an impact against the flat anvil at either 3, 4, 5, 6 or 7 m/s. For reference, the FMVSS 218 and QCVN 2:2008 standards evaluate helmet response from a 6.0 m/s flat anvil impact while the UNE ECE 22 standard evaluates helmet response from a 7.5 m/s flat anvil impact.

A custom data acquisition software package (Cadex, Inc.) captured the acceleration data at 33.3 kHz, applied an SAE J211 Class 1000 digital filter to the acceleration signal and computed a peak g value for each test. Each test sample was evaluated at four different impact locations at a given velocity. The average peak g's for the four impact locations and the standard error were calculated for each test sample at each impact velocity. An analysis of variance (ANOVA) was performed to identify significant differences in the peak acceleration response across helmets certified to the different helmet test standards and across impact velocities.

III. INITIAL FINDINGS

Comparison of the average peak headform acceleration at each impact velocity is shown in Figure 1 and presented across impact velocities in Table 1. The data shows that no helmet produced the lowest peak headform accelerations across all test impact velocities. One sample (DOT2) consistently produced the highest average peak headform acceleration values across all impact velocities. This research confirms that there are

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differences in the response characteristics of different helmets qualified to the same motorcycle helmet standard. The peak acceleration data for a given helmet showed little variance across impact locations at a given impact velocity. Overall, there was no significant difference in the peak headform acceleration response between helmet standards when evaluated across all impact velocities ($p>0.05$).

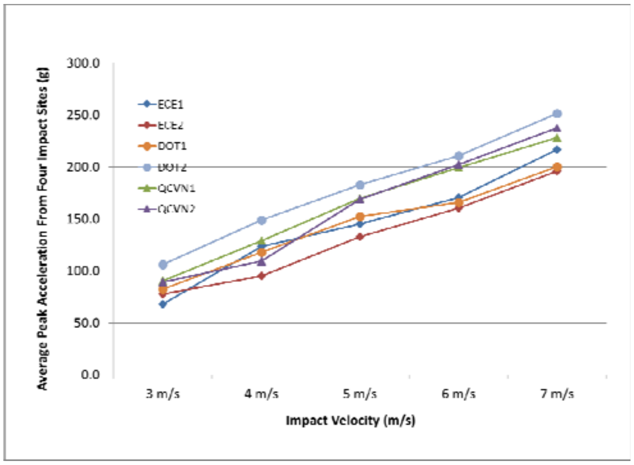

Fig. 1. Comparison of average peak headform acceleration of test samples across different impact velocities

TABLE I

AVERAGE PEAK HEADFORM ACCELERATION (G) BY HELMET AND BY IMPACT VELOCITY

Helmet ID	Impact Velocity (standard error in parentheses)				
	3 m/s	4 m/s	5 m/s	6 m/s	7 m/s
ECE1	67.8 (2.8)	123.4 (1.7)	144.9 (5.1)	170.6 (8.2)	216.6 (2.1)
ECE2	77.7 (1.1)	94.9 (4.1)	132.9 (4.6)	160.3 (5.3)	195.9 (4.1)
DOT1	82.5 (2.3)	118.0 (2.3)	152.4 (4.1)	165.9 (1.5)	200.2 (1.7)
DOT2	106.2 (1.2)	149.1 (3.8)	182.9 (2.7)	210.9 (1.9)	251.5 (3.2)
QCVN1	90.4 (2.2)	129.0 (2.6)	169.6 (2.2)	199.3 (1.4)	228.2 (5.9)
QCVN2	89.3 (2.5)	109.6 (5.1)	168.7 (2.9)	202.1 (3.5)	237.5 (4.7)

IV. DISCUSSION

Although this study was limited in that only six different helmet models were evaluated and only one sample was impacted at each given impact velocity, the data shows that when considered across a range of impact velocities, there was no significant difference in the peak headform acceleration response of helmets qualified to either ECE 22, FMVSS 218 and QCVN 2:2008 helmet standards. This study did not take into account factors such as helmet cost, helmet design, helmet weight and helmet ventilation, all factors which affect rider acceptance of wearing a given motorcycle helmet. While this research includes only 6 helmet models and does not fully replicate all PTW impacts that occur in the real world, it does suggest that helmets qualified to ECE 22, FMVSS 218 and QCVN 2:2008 will all provide similar protection to a PTW rider or passenger involved in an accident. Additional tests with additional helmet models would be needed to fully confirm this observation. As noted above, some helmets provide more protection (e.g. lower peak acceleration) than others at a given impact velocity. In real world accidents, the performance of a helmet depends upon many factors such as impact velocity, impact surface, and surface geometry. Unfortunately, helmets cannot protect against all foreseeable impacts and there will likely be real world impacts which fully compromise the protective capabilities of helmets qualified to these standards; however, as noted above, the proper use of a qualified motorcycle helmet will significantly reduce the risk of fatality and serious head injuries.

V. REFERENCES

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