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ABSTRACT

Head injury is the most frequent type of injury that causes death or disability of motorcyclists in accidents. The only element of protective equipment that protects their head is the safety helmet. Therefore, its design and also performance assessment methods are of high importance. In this study, the influence of including the whole body in helmet drop tests (full-body impacts) on impact outcomes was investigated by using the Finite Element (FE) method.

A commercially available composite-shell helmet was developed in the LS-DYNA fem code. Shell lay-up was obtained from microscopy images. Material properties of the composite layers were estimated through using the rule of mixtures and the Halpin-Tsai equations. A major part of the shell was composed of an in-plane hybrid lamina. Its estimated mechanical properties were verified by comparing coupon test results with FE results. The liner was made of EPS. Its material properties were calculated by using semi-experimental equations which are only a function of the density of the foam.

The behaviour of the helmet model under impact was compared to experimental data. Drop tests were performed at front, rear and side of the helmet onto flat and kerbstone anvils according to the impact absorption test of the UNECE22.05 standard. The same impacts were simulated. Very good agreement was found between the virtual and experimental results for all impacts, except the rear impact onto the kerbstone anvil. The observed discrepancy was attributed to the material model of the shell, which needs further improvements.

The helmet model was employed to study the influence of the body on impact responses of the head and helmet. As a human surrogate, the Hybrid III dummy was used. Several drop tests were carried out on the helmeted dummy and the results were used to validate an FE model of the dummy equipped with the helmet model. The FE predictions were in good agreement with test results.

Comparison between virtual drop test results of the helmeted Hybrid III dummy and its helmeted detached head indicated that the liner crushing distance was greater in full-body impacts. This can potentially lead to the bottoming out of the foam liner. The solution to an analytical model of the helmeted headform drop test suggested increasing the mass of the head to include the effect of the body in detached-head impacts. The added mass was calculated using the full-body impact results and applied to the Hybrid III headform. The modified head impact results corroborated the idea of the added mass.