COMPUTATIONAL MECHANICS 34th conference with international participation 2018 Srní October 31 - November 2, 2018

Development of a simple helmet finite element model

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Motorcycle riders belong to the group of so called vulnerable road users, which protection against an impact is an issue due to the multi-directional loading and the complex kinematics due to the impact. Virtual biomechanical human body models play an important role to assess injuries especially for such complex scenarios.

The major motorcycle rider's personal protective equipment is the helmet. There are not many numerical models of the motorcycle helmet available, which is probably caused by the fact that each helmet on the market has a different design and the condition for any helmet is just to fulfil the territory dependent regulations [7].

Whilst Deck et al. [2] used their model for helmet optimization based on the head injury assessment, Fernandez et al. [3] developed a concrete commercial road helmet model for its evaluation. The model developed by Ghajari et al. [4, 5] was used for the evaluation of the head response and the effect of the body influence in oblique impacts and also for the diverse population based Head Injury Criterion HIC assessment by Bońkowski [1]. Pavlata [6] used his model for the accident reconstruction.

The present work concerns the simple helmet finite element model development and validation for the European regulation [9] to be coupled to the existing human body model for motorcycle riders’ safety assessment. The advantage of the helmet is the low calculation time step by fulfilling the ECE R22.05 regulation [9]. For the geometry, the AVG-T2 helmet [4, 5] was taken as a pattern. The finite element mesh was developed in order to be consistent with the human body model [8], which would be coupled to the helmet for future analyses. The helmet is composed of two parts, namely the outer shell with the thickness equal to 4 mm and the inner protective padding with the thickness of 40 mm. The material data were used the same as published by Deck et al. [2].

Each helmet entering the market must fulfil the ECE-R22.05 regulation [9], which concerns the dynamic test of the retention system, the rigidity test, the shock absorption test and the resistance to penetration visor test. For the head protection against an impact, the shock absorption test is done. According to the regulation, the helmet with the headform inside is dropped against an anvil with a velocity of 7.5 m/s. According to the ECE R22.05 regulation, the M size headform having the mass equal to 5.6 kg was used for the developed helmet size. Two anvils (flat and kerbstone) and four impact configurations points are defined. Fig. 1 shows the four impact configurations for the flat anvil.

The developed helmet is tested for 8 impact configurations (4 impact directions for both anvils). The ECE R22.05 regulation [9] defines, that the maximum acceleration must not exceed 275 g and the maximum HIC must not exceed 2400 for each impact and the helmet fulfils the requirement.

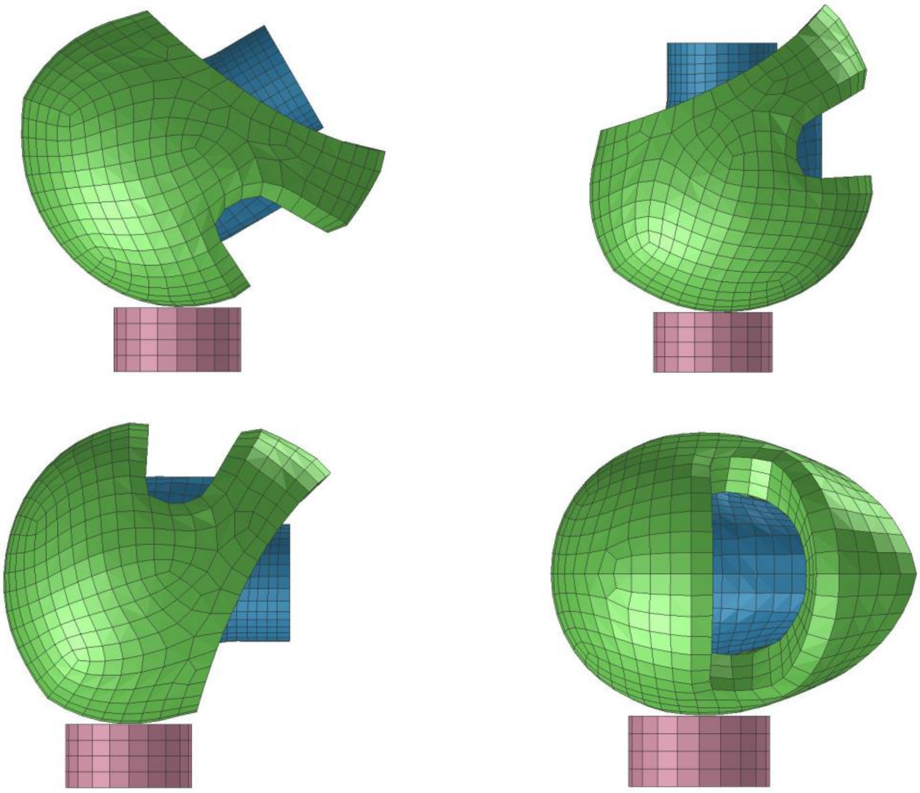

Fig. 1. Four helmet impact configurations against a flat anvil

Acknowledgements

W. Lyu was supported by the project LO1506 of the Czech Ministry of Education, Youth and Sports. L. Hynčík was supported by the project LTC17001 as the national link to the COST Action TU1407. T. Bońkowski was supported by the project SGS-2016-059.

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