Development of an FE model for FlexPLI with Upper Body Mass for enhanced pedestrian safety assessment

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I. INTRODUCTION

The Flexible Pedestrian Legform Impactor (FlexPLI) used in the current pedestrian regulatory and consumer programmes is focused on assessing injuries to tibia bone and knee ligaments during a pedestrian car collision. The tool has been modified under the European Union (EU) project SENIORS (**S**afety-**EN**hancing **I**nnovations for **O**lder **R**oad user**S**) to implement an Upper Body Mass (UBM) to the standard FlexPLI hardware. The UBM is needed to simulate a portion from the inertia of the torso mass, hip joint rotation and the response time lag between leg and upper body, in order to produce a more human-like leg response. The assessment of the femur injuries and assessment of vehicles with a higher bonnet leading edge (BLE) have become feasible with the introduction of the UBM. The new tool also improves the test method at the end of the bumper test area, bringing it closer to human-like lower extremity kinematics and loading. The key benefit is that the UBM can be added to the existing standard FlexPLI hardware being used in the current test procedures.

The current efforts describe the development of the FlexPLI-UBM finite element (FE) model and validation of the model against a selected test condition.

II. METHODS

The detailed UBM model is developed and integrated with the existing, fully validated FE model for the regulated FlexPLI GTR impactor [1]. The combined model is referred to hereafter as the FlexPLI-UBM model. The geometry and connectivity for the UBM model were obtained from the hardware design (Fig. 1(a)) and modeled in detail. Material testing was carried out to obtain the material properties, and implementation to the FE model, for the rubber element (Fig. 1(a)) that represents the hip joint stiffness during rotation of the UBM.

The FlexPLI-UBM model (Fig 1(b)) comprises a total of 233K nodes and 340K elements. The total model mass is 19.6 kg within the hardware tolerance limits. The initial time-step size for the model is 0.78 micro-second, which is in line with the common industry practices. The FlexPLI-UBM model has all the instrumentations for femur, tibia and knee regions, including all available optional channels based on the FlexPLI GTR tool in the current test procedures.

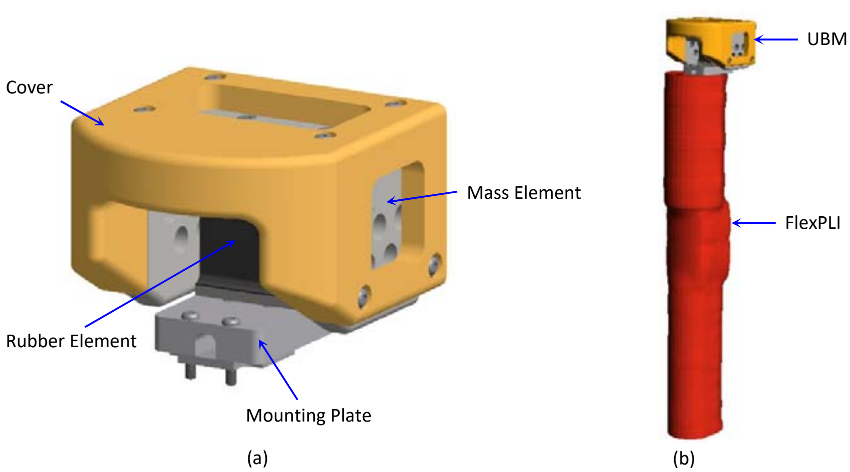

Fig. 1. UBM Design (a), and the FlexPLI with UBM FE model (b).

The FlexPLI-UBM model was validated against a test condition for a sedan-like vehicle front profile, referred to as SAE buck [2], using the FlexPLI-UBM hardware at 0° orientation with perpendicular line to the bumper of

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the SAE buck. The FlexPLI-UBM hardware impacted the stationary SAE buck at the impact velocity of 11.1 m/s. All the standard moment output within tibia and femur, knee elongations and knee acceleration were recorded during the test and used for validation of the FE model. The model was set up to exactly mimic the test condition as depicted in Fig. 2.

(a) (b)

Fig. 2. SAE buck test condition for the FlexPLI-UBM hardware (a), and FE model set up (b).

III. INITIAL FINDINGS

The model response was compared against the hardware output for the femur moments (Fig. 3(a)), tibia moments (Fig. 3(b)), knee elongations (Fig. 3(c)) and knee acceleration (Fig. 3(d)) injury output measurements. The initial findings of the FlexPLI-UBM FE model reveal that the model showed promising correlation for the simulated load case.

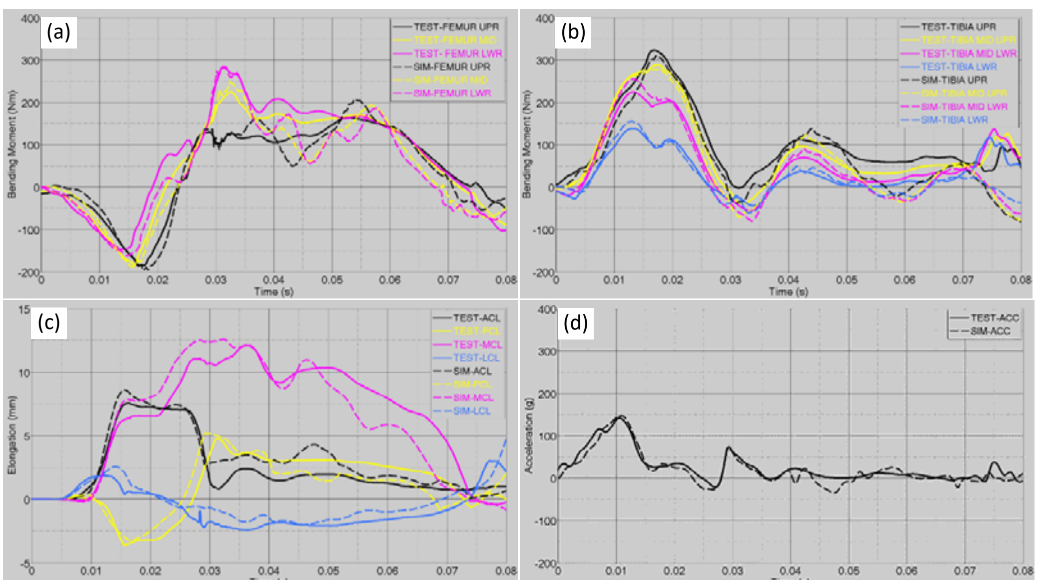

Fig. 3. FlexPLI-UBM model response comparison to the hardware test.

IV. DISCUSSION

The FlexPLI-UBM tool enables the assessment of the injury risk for the femur, closer to human-like lower extremity injury, and also the assessment of vehicles with a higher front profile. The FlexPLI-UBM FE model is currently being validated against a selected load case and will be further validated against additional load cases as they become available.

V. ACKNOWLEDGEMENT

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VI. REFERENCES

[1] FLEX-PLI GTR Regulated V1.0.2 Model Technical Report, Humanetics Innovative Solutions, Inc., 2016.

[2] Pipkorn, B., *et al.*, IRCOBI, 2014.