External biofidelity of Flex-PLI compared to the THUMS pedestrian model

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I. INTRODUCTION

The Flex-PLI is a leg-form impactor currently used in different consumer tests [1] and evaluated for its potential use in Global Regulations [2] to assess pedestrian safety in the event of an accident. Although an important effort has been done to develop a biofidelic Flex-PLI [3], very little has been done to address its external biofidelity (i.e. its ability to generate human-like loads to the environment). This potential lack of external biofidelity can lead to an inaccurate injury prediction since the impactor may exhibit wrong kinematics, contact otherwise unreachable objects or generate artificially large or small contact forces. As a first assessment, this study analyses the differences in peak and time to peak of the forces generated by Flex-PLI and THUMS on the bumper beam.

II. METHODS

A finite element human body model (Academic THUMS Version 4.01) and a finite element model of the Flex-PLI (Humanetics Flex-PLI GTR Version 2.0.2) were used to evaluate the forces generated on the bumper beam during a pedestrian impact. The non-impacted leg of the human body model (HBM) was eliminated from the model in order to isolate the effect of the impacted leg.

Two vehicle types (sedan and SUV) were modelled in this study. In both cases, the contacts were configured to measure the forces generated on the bumper beam in sections of 50 mm. This enables us to track the forces along the bumper beam in order to observe the spatial distribution of forces generated through impact of the Flex-PLI compared to the HBM.

For each vehicle, simulations were conducted at the centre of the vehicle (labeled ’000L’) and 500 mm lateral of the centre line (’500L’). The impact velocity was 40km/h in all cases.

The HBM was positioned to a standard shoe height of 30 mm above the ground [4] while the Flex-PLI was positioned at two different heights: one matching the HBM knee height and a second one located 88.5 mm higher matching the Euro NCAP test position [1].

The maximum peak force values as well as their respective times to peak were represented in four pairs of plots. Each pair of plots shows the information about the forces generated by the two surrogates (with the Flex-PLI impacting at two different heights) at one impact location.

III. INITIAL FINDINGS

The results show a good agreement regarding the time to peak force between the HBM and the Flex-PLI especially in the case of sedan at 000L and SUV at 500L.

Regarding the peak force values, the Flex-PLI generates a much greater peak force on the bumper beam in the proximity of the impacted point. However, the Flex-PLI and HBM forces tend to converge at locations lateral to the impact point.

Figure 1 shows the gathered information about the peak and time to peak at the different sections of the bumper beam for the different impact locations. The plotted time is limited to 25ms since that time frame is enough to capture all the non-neglectable maximum values.

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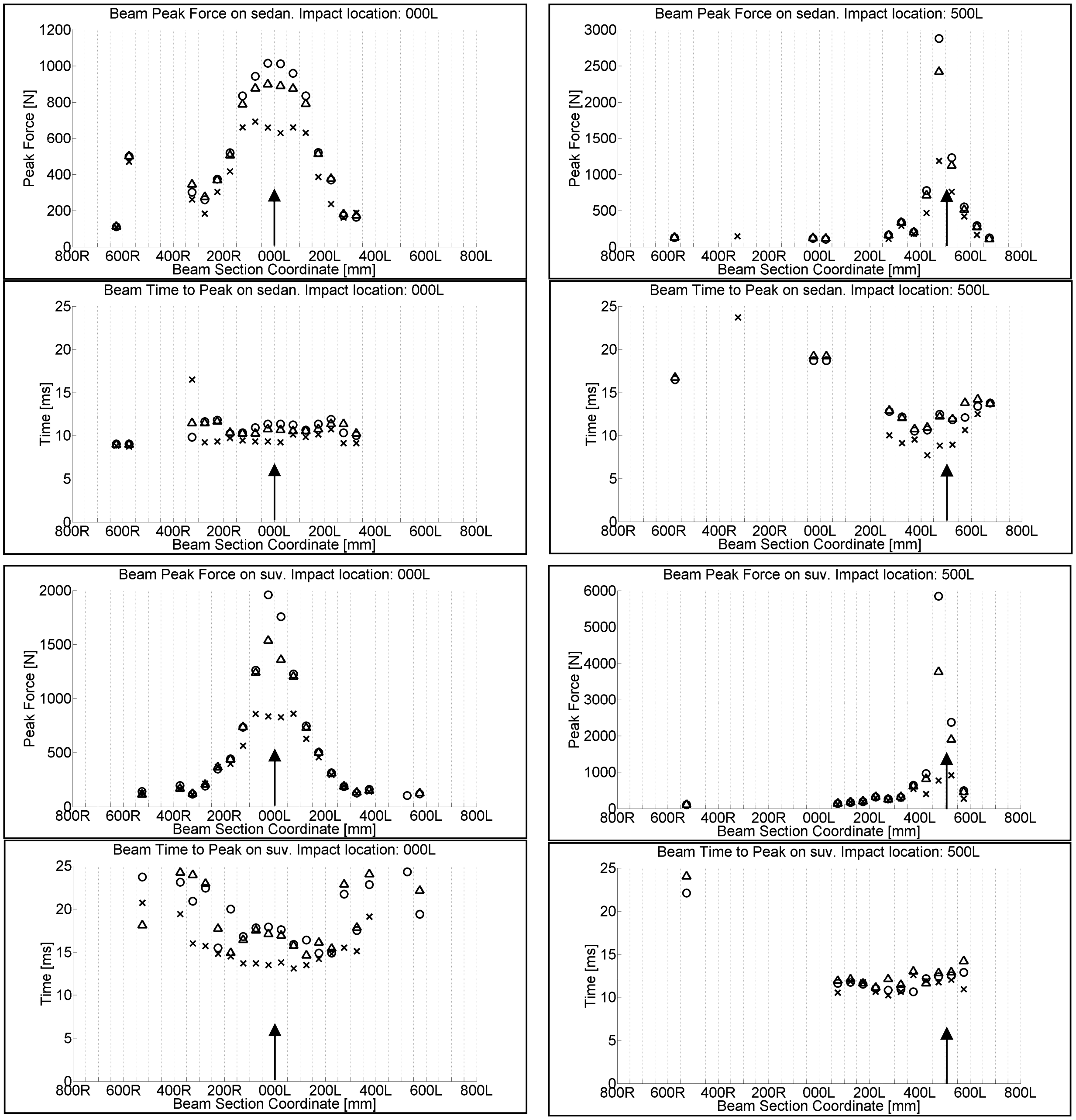

Fig. 1: Force information for THUMS (×), Flex-PLI (o) and Flex-PLI at Euro NCAP position (Δ) with an arrow representing the impact location

IV. DISCUSSION

As a result of the Flex-PLI geometry and its relatively stiff knee, it tends to intrude more than the HBM into the bumper beam. This increased penetration into the vehicle results in engagement with stiffer structures, resulting in larger forces in the immediate vicinity of the impact location. These data also suggest that the difference in peak force is vehicle-dependent, with a 145% difference in peak bumper beam force for the sedan compared to a 690% difference for the SUV. This interaction is especially important when considering potential surrogates for evaluating and tuning pedestrian impact sensor systems, as the results suggest that use of the Flex-PLI would tend to overstate forces generated in a sensor placed on the bumper beam in a manner that varies with design of the frontend of the vehicle.

V. REFERENCES

[1] EuroNCAP, 2015.

[2] United Nations, 2009.

[3] Konosu A. et al., Stapp Car Crash J, 2003.

[4] SAE, 2009.