A FIBER OPTIC BASED SENSOR FOR MEASURING CHEST AND ABDOMINAL DEFLECTION UNDER IMPACT LOADING

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INTRODUCTION

Deflection measurements need to be conducted on both crash test dummies and human cadavers in order to evaluate thoracic and abdominal injury risk. Because internal measurement is not always possible on human subjects, an accurate external measurement technique is desired. The objective of this study is to investigate the use of a fiber optic based sensor, ShapeTape, as an alternative method of measuring abdominal and chest deflection in impact biomechanics applications, and to compare its performance to the historically used chestband [1-3].

METHODS

The ShapeTape used in this study was 101.2 cm x 1.6 cm x 1.5 mm with 32 sensors and was covered by a protective ribbed sheath with outside dimensions of 101.2 cm x 2.54 cm x 1.27 cm (Measurand Inc, S1680 Analog-output ShapeTape, New Brunswick, Canada). The chestband used in this study was 140 cm x 3.2 cm x 0.35 cm with 42 sets of 4 gauges along its length (Denton, 42 gauge chestband, Rochester Hills, MI). Drift, pressure, and temperature tests were conducted for ShapeTape alone under static conditions, whereas quasi-static and dynamic loading tests were conducted as comparison tests between the chestband and ShapeTape. For both the quasi-static and dynamic loading tests, a chest form was created to represent the torso of a 50th perctile Hybrid III dummy. The instrumented chest form was secured to a rigid base, which in turn was secured to the base of a material testing machine (Instron, Model 8874, Canton, MA). For both sets of tests, five cylindrical indenters were used measuring 5.08 cm, 7.62 cm, 10.16 cm, 12.70 cm, and 15.24 cm in diameter. For the quasi-static tests, the chest form was compressed by the arm of the impactor with a cylindrical indenter in 1 cm increments until a deflection of 6 cm was reached. For the dynamic tests, a loading rate of 150 cm/s was used to reach the target compression of 7 cm.

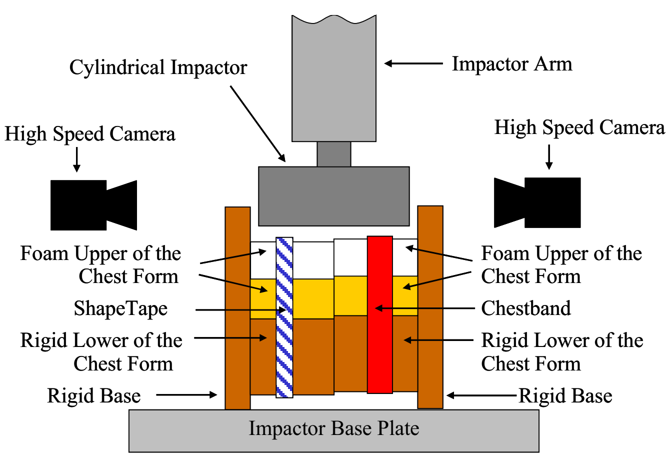

Figure 1: Side view of the set-up for the quasi-static and dynamic loading tests.

RESULTS AND DISCUSSION

Over the period of three hours, there was an average voltage change of 0.26% full scale seen by the 32 ShapeTape sensors, with a maximum of 0.55% full scale drift. This amount of drift is considered negligible. Over the five minute heating of the ShapeTape, the sensors experienced an average voltage change of 1.20% full scale. For the range of forces experienced during distributed airbag loading, 250 N - 750 N, the sensor that was loaded had a 3.24% full scale voltage difference. For the range of forces experienced during focused belt loading, 1000 N - 1600 N, the sensor that was loaded had a 12.32% full scale voltage change. During quasi-static loading, the average error in measuring peak displacement was 3.35% and 1.70% for ShapeTape and the chestband respectively. The average error in measuring peak displacement under dynamic loading was 8.60% and 10.01% for ShapeTape and the chestband respectively. The contour representations of the chest form from the chestband and ShapeTape under both loading conditions were comparable to what was captured from the video analysis (Figure 2).

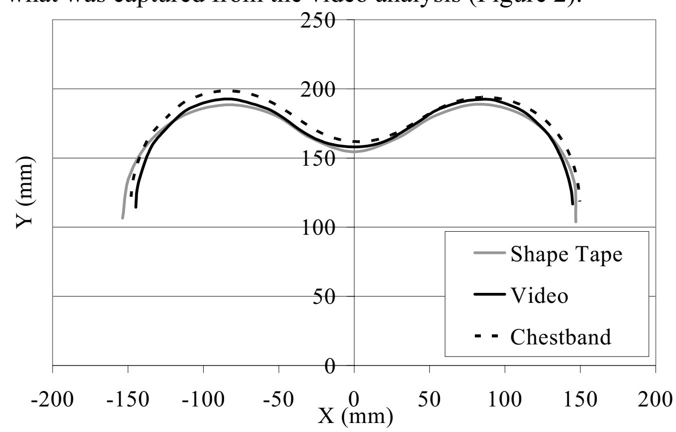

Figure 2: Chestband and ShapeTape contours compared to video data points, taken at 6 cm compression for the quasi-static compression test with a 10.16 cm diameter indenter.

CONCLUSIONS

The contour output for the ShapeTape and chestband were both very similar to the video and overlapped in many cases. From the data collected in this study, ShapeTape appears to demonstrate the same degree of accuracy as the chestband in measuring deflection and visualizing contours during quasi-static and dynamic impact loading.

REFERENCES

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