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Testing of the Prototype Low-Durometer Hybrid III Neck for Improved Biofidelity

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ABSTRACT

This study is part of an ongoing research project aimed at mitigating catastrophic human neck injuries, predominantly due to neck bending, in rollover crashes. Presently, the Hybrid III dummy is considered to be the best available human surrogate for dynamic rollover tests. However, there are known biofidelity and instrumentation limitations associated with its use to predict catastrophic neck injuries in real-world rollover crashes.

A previous study investigated the use of the non-biofidelic Hybrid III dummy in a dynamic rollover test to accurately predict the predominant human neck bending injury sustained in real-world rollover crashes. An empirical relationship between upper and lower Hybrid III neck loading was derived. The effects of neck preflexion angle, roof impact speed, roof crush, onset-to-peak neck axial forces and moments, and impact duration on neck bending injury were identified. Peak neck injury measures were rejected.

For this study, the 67-durometer Hybrid III production neck was fabricated with more compliant 35-durometer butyl rubber in order improve the dummy biofidelity in rollover tests. The tests in the previous study were repeated. Correlations were established between the prototype and production necks. Parametric studies of the prototype neck revealed similar trends as observed with the Hybrid III production neck.

METHODS AND RESULTS

The Hybrid III production neck was modified as described in a companion paper. Figure 1 shows the test setup. The test matrix and results are summarized in Tables 1 and 2. Tests were conducted with different platen weights, platen drop heights, and allowable platen stroke distances after initial head contact. Altering the platen weight and drop height changed the head impact speed and deltaV. The effects of impact speed and platen stroke (roof crush) on neck loading were determined.

Figure 1: Test Setup

Table 1. Production Neck Pendulum Test Matrix

Test #	Platen Drop Height (cm) [in]	Platen Impact Speed (kph) [mph]	Platen Weight (kg) [#]	Platen Stroke (cm) [in]
9	15.2 [6]	6.3 [3.9]	43 [95]	10.2 [4]
7	30.5 [12]	8.9 [5.5]	43 [95]	10.2 [4]
8	45.7 [18]	10.8 [6.7]	43 [95]	10.2 [4]
11	76.2 [30]		70 [155]	5.1 [2]
10	76.2 [30]		70 [155]	10.2 [4]
12	76.2 [30]		70 [155]	15.2 [6]

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Table 2. Prototype Neck Pendulum Test Matrix

Test #	Platen Drop Height (cm) [in]	Platen Impact Speed (kph) [mph]	Platen Weight (kg) [#]	Platen Stroke (cm) [in]
9	15.2 [6]	6.3 [3.9]	43 [95]	10.2 [4]
7	30.5 [12]	8.9 [5.5]	43 [95]	10.2 [4]
8	45.7 [18]	10.8 [6.7]	43 [95]	10.2 [4]
11	76.2 [30]		70 [155]	5.1 [2]
10	76.2 [30]		70 [155]	10.2 [4]
12	76.2 [30]		70 [155]	15.2 [6]

Hybrid III Production Neck Tests (Effect of Impact Speed)

Pendulum tests were performed using the Hybrid III dummy with its production neck at 6”, 12” and 18” drop heights, corresponding to 3.9, 5.4 and 6.7 mph impact speeds. Correlations between dummy upper and lower neck load cell data were derived; they were virtually independent of neck orientation from the erect 90° body position to about 50° of forward flexion.

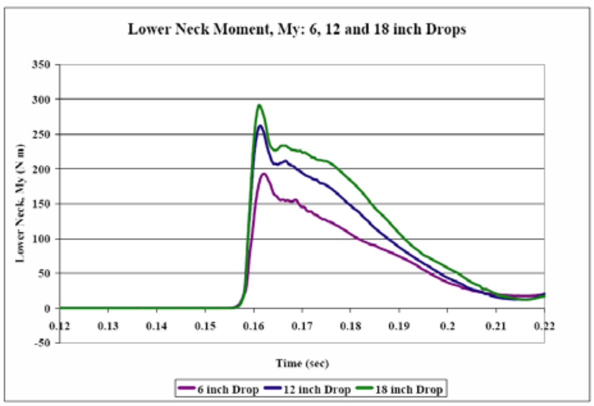

Figure 2 Production Neck (Effect of platen impact speed) (Peaks were normalized in time).

Prototype Neck Tests (Effect of Impact Speed)

Platen drop tests were conducted with the 35-durometer neck at 6”, 12”, and 18” drop heights (corresponding to 3.9, 5.4 and 6.7 mph impact speeds). The lower neck bending moment M_y measured in the 3 impact circumstances is shown in Figure 2.

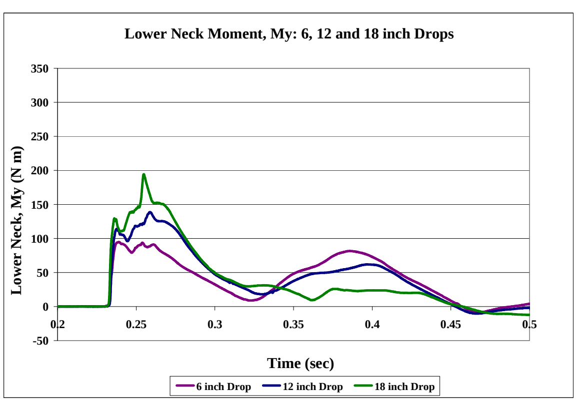

Figure 3: Prototype Neck (Effect of platen impact speed)

Production Neck Tests (Effect of Stroke after Head Contact)

Pendulum tests were performed using the Hybrid III dummy with its production neck at an 18” drop height (6.7 mph impact speed) and the stroke controlled to stop at 2”, 4”, and 6” after initial head contact.

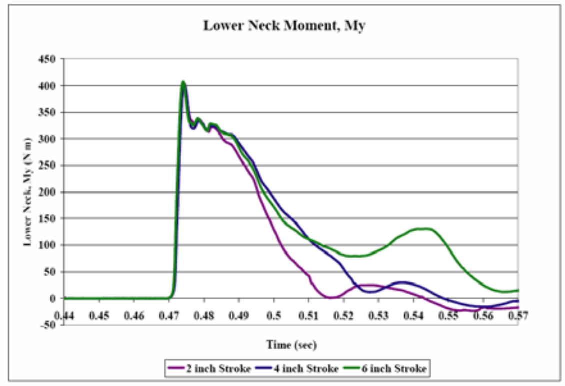

Figure 4: Bending moment after head contact (Effect of Stroke)
(Peaks normalized in time to 2” stroke test time)

Prototype Neck Tests (Effect of Stroke after Head Contact)

Tests were conducted at a speed of 6.7 mph with stroke limiting of 2”, 4” and 6”.

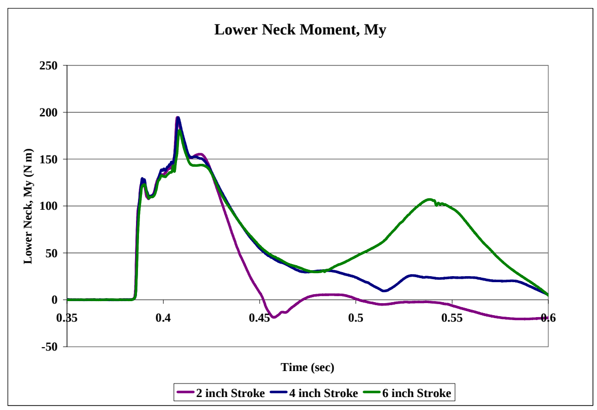

Figure 5: Bending moment after head contact (Effect of Stroke)

CONCLUSIONS

Parametric studies presented here show similar and repeatable findings for both the production and prototype Hybrid III necks.

- The onset-to-peak neck loading is very fast, about 5 ms, and independent of impact speed and stroke (roof crush).
- Lower neck moment duration is dependent on stroke (roof crush), but independent of speed.
- Peak neck loading is dependent on speed, but independent of stroke (roof crush). Peak neck load occurs quickly, before injury and before the roof crushes significantly. Peak neck load is not equal to injury.

REFERENCES

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