Tension-Bending Risk Curves for the ATD Lower Lumbar Spine Subjected to Oblique Impact under FAA Emergency Landing Conditions

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ABSTRACT

Background – Increased interest in the airline industry to enhance occupant comfort and maximize seating density has prompted the design and installation of obliquely mounted seats in aircraft [1, 2]. In this configuration, the seats are mounted at an angle relative to the aircraft centerline (18-45 degrees) [3]. In a crash or emergency landing, an obliquely seated occupant is loaded in an entirely different manner than forward, aft or pure side facing occupants. Previous oblique whole-body sled tests demonstrated multiple failures, chiefly distraction-associated spinal injuries under oblique impacts [4]. It is estimated that such loading scenarios causes multi-axial bending along with tension in the spine.

Objective – To develop injury risk curves for the lower lumbar spine load cell of FAA-H3 dummy

Method – ATD tests were paired with Postmortem Human Subject (PMHS) tests and finite element method (FEM)simulations of an elderly occupant. The loading condition included variations in peak sled accelerations, the presence or absence of an armrest, the belt type (single and dual lap-belt systems), and seat orientation relative to impact vector (45° and 30°). A new spinal criterion, termed FAA-LL_{tb}, which is a linear combination of tensile load with forward flexion, and lateral bending moments, was developed to predict the injuries occurring to the lower lumbar spine and sacrum regions. The response data for the risk curve development were obtained from FAA-H3 tests, while the injury definitions were acquired from PMHS or FEM.

Result – The developed FAA-H3 risk curve represents AIS=3+ injury probability for the lower lumbar spinal levels. The survival analysis estimated normalized confidence interval size (NCIS) values were in fair and good categories at all levels of probability. At 5%, 25% and 50% risk levels, the combined loading metric values were 1.6, 1.8, and 2.0, respectively.

Conclusion – This study demonstrated that the combination of bending moments and tensile load was estimated to be a better injury criterion than any individual metric for assessing the injury to the lower lumbar spine and pelvis regions under oblique loading.

Reference

1. FAA 2020, Special conditions: The Boeing company model 787-10 series airplanes.
2. FAA 2021, Special conditions: The Boeing company, model 737-10 airplanes.
3. FAA 2018, Policy ANM-25-03-R1.
4. Humm, J.R., et al., 2016, Stapp.