The Effects of Various Parameters on Dynamic Loads at the Top Tether Anchor

Jordan Majstorovic[1], Rakshit Ramachandra[1], Aditya Belwadi[2], Matt Maltese[2], John Bolte[1], Yun Seok Kang[1]

[1]Injury Biomechanics Research Center, The Ohio State University, Columbus, OH
[2]Children's Hospital of Philadelphia, Philadelphia, PA

Abstract

Lower anchors and tethers for children (LATCH) is a standardized method for attaching child restraints systems (CRS) to vehicle seats, in an effort to reduce misuse and improper installation. The Federal Motor Vehicle Safety Standard (FMVSS) No. 225 evaluates the strength of the LATCH child restraint anchorage systems in vehicles under a static loading test. The issue with the static loading evaluation is the dynamic conditions of a motor vehicle crash are not taken into account, and the evaluation of the top tether anchor independently from the lower anchors is not covered by the standard. The goal of this study was to construct and validate a finite element (FE) sled test model in an effort to understand the dynamic loads experienced at the top tether anchor and the effect of various parameters on these loads.

A finite element sled test environment simulating frontal impacts, described by the FMVSS No. 213 standard, was constructed utilizing the FMVSS No. 213 test bench, a forward facing CRS, and a HIII 6YO anthropomorphic test device (ATD). The CRS was secured to the bench with the flexible LATCH system, and anchor loads and ATD kinematics were recorded for each simulation. The model was validated with top tether and lower anchor peak loads from a sled test performed by Transport Canada. Utilizing the validated model, a parametric study was performed in which top tether anchor location, CRS, and bench seat foam stiffness were varied. The four top tether anchor locations modeled were the shelf, seatback, roof, and floor; while two CRS (CRS A & B) and three seat foam stiffness were utilized.

The largest to smallest top tether peak loads were observed at the following top tether anchor locations in order: (1) roof (2) shelf (3) floor (4) seatback. This trend held true regardless of the seat foam stiffness and CRS used in the simulation. The largest top tether anchor peak loads for the roof, shelf, floor, and seatback were 9.13 kN, 7.03 kN, 4.05 kN, and 3.88 kN, respectively. A significant mechanism for reducing top tether anchor peak loads was interaction between the top tether and bench seatback. Additionally, it was observed that CRS B produced larger top tether loads than CRS A for every scenario but the rigid seat foam, shelf location simulation. It was also noticed that as seat foam stiffness increased, some scenarios *showed a consistent decreasing trend for top tether loads while the rest showed no definitive trend.*

This study provides time history data of LATCH anchor loads and ATD kinematics during FE sled test simulations. The effects of top tether anchor location, child restraint, and seat foam stiffness should provide valuable information for vehicle safety and child restraint design.