FTA RESEARCH
FEDERAL TRANSIT ADMINISTRATION

REPORT SUMMARY

U.S. Department of Transportation
Federal Transit Administration

Crashworthiness Evaluation of Light Rail Vehicle Interiors

Background

In the United States, 25 different agencies operate 2,005 light rail vehicles (LRV) in major metropolitan areas. Light rail transit (LRT) has a higher incident rate of injury per passenger-mile than other forms of rail travel. LRVs often travel along city streets at low speeds with at-grade crossings, where accidents are most common. Frequent acceleration and deceleration in these transit areas by LRVs leads to injury by two main mechanisms, resulting from either the primary or secondary impacts. Collision injuries stemming from the primary impact of an LRV against another vehicle or obstacle occur from occupant compartment crush and reduction of survival space or penetration of the compartment by elements of the impacting vehicle. More commonly, injuries in LRVs arise from secondary impacts, those between the occupant and the interior of the vehicle or other occupants at some time following the initial collision. Previous information from the National Transit Database provides blanket data on injury and fatality rates, but does not discern between specific injuries or parties involved.

Objectives

The objective of this project is to identify injury mechanisms to LRV passengers and use the data to propose future areas of research that will provide guidelines for designing safer LRV interiors. The evaluation uses a four part approach to analyzing LRV interior crashworthiness.

- Literature review of passenger protection and crashworthiness standards.
    - A survey of existing standards and regulations.
    - Identification of areas where further standardization is needed.
- Data collection of general LRV interior design parameters and CAD model generation.
- Develop finite element (FE) and multi-body (MB) models of LRV and LRV interior.
- Identification of LRV interior crashworthiness design issues for low-, mid-, and high-severity crash scenarios.

Findings and Conclusions

Conclusions from the four part LRV study were successful in identifying common and likely injury mechanisms to LRV passengers. The study clearly indicates areas where research and current standards can be refined to improve passenger safety. Reports were found that provided data in understanding the principal characteristics and conditions in LRV accidents. Most LRV accidents occurred at low speeds (under 35mph) and along shared right-of-way track. The existing literature and data also provided information on the common construction of LRV interiors and passenger seating configurations. Using this information,

simulation models were created for low-, mid-, and high-severity crash conditions and simulated to provide data on passenger injury mechanisms.

Results of the study show that the most common and severe injuries to LRV passengers are to the head, neck, and lower extremity regions – primarily in high-impact crash scenarios. These injuries are most often the result of body-to-body contact between unrestrained passengers and/or body-to-seat structure contact. Current typical seating configurations were studied, and specific cabin layout recommendations were derived to optimize passenger safety. Also, importantly, analysis very clearly points to the need for a strategy of passenger compartmentalization – the need to construct LRV seats that provide better support and protection for a much wider range of body types.

Benefits

The value of the findings is myriad. LRT is one of the safest modes of transportation, with annual data that shows very low fatality and injury rates per passenger-mile. Nevertheless, in cases of high-energy impacts, severe injuries and fatalities can occur. Data in this report points to methods for improving passenger safety in improved LRV interior construction and suggests further research areas to improve the crashworthiness performance of Light Rail Vehicles.

Project Information

FTA Report No. 0005

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