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Rollovers of Commercial Vehicles

There are many factors to consider when investigating and evaluating a commercial vehicle rollover. Among them are vehicle configuration, load securement, roadway characteristics, suspension and tire attributes, and the actions of the driver. An understanding of these parameters and their effect on vehicle dynamics is paramount to a proper analysis and evaluation of the commercial vehicle rollover.

Commercial vehicle rollover crashes can cause serious injury or death, and often result in high property damage and environmental cleanup costs. Rollover accidents are often single vehicle accidents, leading to the investigation of the vehicle characteristics, roadway environment, and driver actions as causative factors.

Rollover occurs when lateral forces exceed the level of lateral roll stability for a given vehicle. In virtually all commercial vehicles this threshold lateral acceleration is reached before the capabilities of the tires are reached, resulting in the vehicle tipping before sliding out.

The threshold lateral acceleration varies widely among commercial vehicles depending on their configurations and characteristics. Several important variables to consider when investigating commercial vehicle rollovers include: center of gravity height, suspension parameters, tire parameters, vehicle configuration, load securement, and roadway/environment characteristics. An understanding of these parameters and their effect on vehicle dynamics is paramount to a proper investigation/evaluation of commercial vehicle rollover crashes.

Ruhl Forensic staff are experienced and knowledgeable in commercial vehicle dynamics, operation and load securement. We have experience in the investigation and reconstruction of all types of vehicle rollovers including straight trucks, box trailers, tankers, livestock trailers, flatbed trailers and buses.

Mechanics

Most passenger car rollovers are induced by external tripping mechanisms (e.g. deep furrowing off road). Only certain higher-profile passenger vehicles such as SUV's, pickups, and vans will experience untripped on-road rollovers. Commercial vehicles can and most typically do roll over as a result of their own tire forces without any external tripping mechanism. A significant number of rollovers occur while the commercial vehicle is in a steady-state maneuver such as negotiating a curve. Other maneuvers that can induce rollover are severe lane changes and accident avoidance maneuvers.

When a commercial vehicle is in a turn there is a lateral force exerted at the tire keeping the vehicle on the curve. As the lateral acceleration increases, the center of gravity moves outward and the tires on the inside of the curve become less loaded. Suspension, tire, and center of gravity height influence how much the center of gravity moves outward for a given lateral acceleration. The generally accepted "beginning" of rollover is when the inner tire force goes to zero.

Loads in commercial vehicles can account for over 50 percent of the gross weight of the vehicle and significantly raise the center of gravity above that of an empty vehicle. The proper securement of loads on and within these vehicles is vital to the roll stability. Shifting loads can have a severely detrimental effect on the vehicle's ability to operate safely.

There is great variation in commercial vehicle configurations. The vehicle dynamic analysis of LCVs (longer-combination vehicles) such as turnpike doubles, Rocky Mountain doubles, and triples is complicated by the number of articulation points. In addition, as the distance and number of articulation points between the tractor and the rear of the vehicle increases, the driver's feel for the stability of his vehicle decreases. Rearward amplification, offtracking, trailer sway, and the type of articulation connection can all affect the roll stability of a commercial vehicle.

Testing and Modeling

Ruhl Forensic staff has extensive involvement with research, modeling, and testing of the roll dynamics of commercial vehicles.

Ruhl Forensic has developed rollover models that can be used for basic analysis of rollover; these models are used internationally. The most widely used model in analyzing rollover is called a Static Roll Model (hereinafter referred to as "SRM").

The Static Roll Model uses basic physics to analyze the roll stability of a vehicle performing a steady state turning maneuver around a specified turning radius. Ruhl staff extended this basic model to include the effects of torsional stiffness of trailers (typically flatbed trailers exhibit the greatest effects from this parameter) and the coupling

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Our experts provide a continuum of service from initial on-site investigations through research, testing and reconstruction to courtroom testimony and presentation graphics and visualization.

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effects of a 5th wheel between the tractor and trailer. This analysis was peer reviewed and published through the Society of Automotive Engineers (SAE), paper number 973261. The Static Roll Model has proven to be a useful and computationally efficient tool for the tractor-trailer designer or user in predicting static roll threshold for commercial vehicles.

Our livestock trailer stability research has included full scale testing of cattle in a livestock trailer. This testing enabled clear comparisons to be made between the tests and models. Three-dimensional (3D) computer simulations of the subject commercial vehicle were run and compared with test data. The test data was also compared to the SRM results. This research has been peer reviewed and presented internationally as well as published through the Society of Automotive Engineers (SAE), SAE 1999-01-3732.

The SRM was again extended to review fluid load movement in a variety of tank truck configurations. Since liquid or loose cargo is not a static load, additional analysis was necessary to account for how the load movement would affect the vehicle dynamics. This analysis and model were presented in SAE 2000-01-3476.

In addition, review of rollover was evaluated from another perspective through analysis of the feasibility of modifying a semi-trailer air suspension to implement an anti-rollover system in SAE 2001-01-2733.

Case Study

The testing and modeling done by the firm has been brought to bear on many of the rollover cases that staff has investigated. For example, a tractor-trailer hauling steel coils rolled on an off-ramp as it was exiting the highway, seriously injuring the driver. The shipping company attributed the rollover to excessive speed in the curve. Ruhl Forensic was asked to determine if excessive speed, shifting of the unsecured load or some other element was the causal factor.

Using tests previously conducted by Ruhl staff on the friction generated between pallets and the trailer floor, calculations indicated that under reasonable driving maneuvers and speed in a turn with this configuration, forces could be generated that would cause the pallet to move within the trailer towards the front left before the trailer tires would lose traction with the roadway.

To determine what really happened, a virtual scene of the crash site was modeled in three dimensions within the HVE (human, vehicle, environment) system. A three-dimensional tractor and semi-trailer with a properly loaded and secured load were driven in this virtual environment.

The simulation demonstrated that a vehicle with a properly secured load could negotiate the turn at speeds significantly higher than those posted. By eliminating speed, the shifting load was left as the causal factor.

The jury found that the unsecured load had shifted and was the cause of the accident. They felt that both the shipper and the driver shared responsibility for the load being properly secured, but the shipper in this case had superior knowledge and control of the proper load securement.

Conclusion

Understanding and analyzing the rollover dynamics of a commercial vehicle is a complex task. Ruhl Forensic staff has the background and experience to analyze the dynamics of the rollover and to explain the results in an understandable manner to the trier of fact.

For more information on this topic contact, Ruhl Forensic staff at ruhl@ruhl.com, or by calling the Champaign, IL office at (800) 355-7800, the Scottsdale, AZ office at (800) 235-2808 or the Chicago, IL office at (800) 278-4095.

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