

EVALUATION OF HEAVY TRUCK ROLLOVER ACCIDENTS

Jeffrey L. Evans
Stephen A. Batzer
Stanley B. Andrews
Renfroe Engineering, Inc.
United States
Paper Number 05-0140

ABSTRACT

Given the large size and weight of heavy trucks, also known as tractor-trailer vehicles, a serious safety threat can be posed to the vehicle's occupants in the event of a rollover collision. This study evaluated heavy vehicle accidents from 1994-2002 by submitting queries to the Fatality Analysis Reporting System (FARS), which is administered by the National Highway Traffic Safety Administration (NHTSA), in order to determine the number of incapacitating and fatal injuries that occurred when the occupants were contained in the cab during a rollover accident. The specific query was for rollover accidents of heavy trucks where the rollover was the most harmful event; the rollover was either the first or subsequent event; the truck received severe and disabling deformation; the occupants were not ejected; and the injuries sustained were either incapacitating or fatal. This rollover accident data was also compared with the total number of heavy truck accidents where incapacitating or fatal injuries occurred as reported by FARS for the 1994-2002 time period. The average percent of persons involved in accidents that matched the rollover query was 18%, with a high of 21% in 2002 and a low of 17% occurring in 1994, 1995, and 1997. The average percentage per year of incapacitating and fatal injuries for restrained occupants during this time period was determined by further analyzing the data obtained from the above stated rollover query and was found to be 35%. The conclusion drawn from this study is that significant injuries can occur from rollover accidents of heavy trucks even for restrained occupants. Rollover crashworthiness of heavy trucks is also evaluated in this paper.

INTRODUCTION

Heavy trucks (those having a gross vehicle weight rating greater than 10,000 pounds) are an essential part of the transport of a vast array of commercial, industrial, and consumer products in the United States. According to the National Center for Statistics and Analysis, a division of NHTSA, in 2001 7,857,674 heavy trucks were registered in the

United States, accounting for 4% of all registered vehicles. In 1994 that number was only 6,587,885. This indicates a dramatic increase in the number of heavy vehicles. In 2002, 434,000 large trucks were involved in traffic accidents. Of those accidents 4542 involved fatalities [1]. Given the dramatic increase in heavy truck use as well as the large number of accidents and fatalities every year involving heavy trucks, increasing attention is being given to the study of heavy truck crashworthiness and safety.

Heavy trucks can also be involved in rollover accidents. This type of accident, as is the case with passenger vehicles, is not as likely as other types of accidents, but can result in significantly more damage to the vehicle and injuries to the occupants of the heavy truck.

This paper describes a study of the heavy truck accidents that occurred in the time period from 1994-2002. The data was collected from the FARS database, which is controlled by NHTSA [2]. The specific interest was to evaluate significant structural damage to the truck, and injuries that occurred to the restrained occupants of the large trucks during rollover accidents. The crashworthiness of large trucks is briefly examined. A case study of a heavy truck rollover is also presented.

DATA SELECTION

Several databases exist that can be queried for specific accident data. The University of Michigan Transportation Research Institute compiles statistical data for heavy trucks; however, they do not provide the specific data that was of interest in this study. The FARS database was chosen because of the high specificity that can be used in developing a query. The data of greatest interest was that which could be used to determine the injuries of large truck occupants during a rollover accident. The specific data of interest is described in the abstract of this paper. The chosen delimiters could be selected to create a query for the FARS database.

DATA ANALYSIS

All heavy truck accidents were first evaluated and then the previously stated rollover query was used. From a comparison of these two queries, the percentage of fatal and incapacitating accidents that correspond to the specific rollover accident in question could be determined.

Figure 1 shows the results of all accidents from 1994-2002. The number of fatal accidents per year for heavy trucks peaked in 1999 at 659. The lowest number of fatal accidents for this time period was 523, which occurred in 1996. A downward trend is apparent from 1999-2002, with only 537 fatal crashes occurring in 2002. Since this data looks at all fatal heavy truck accidents, the number of vehicles and persons involved are somewhat higher every year than the number of fatal accidents.

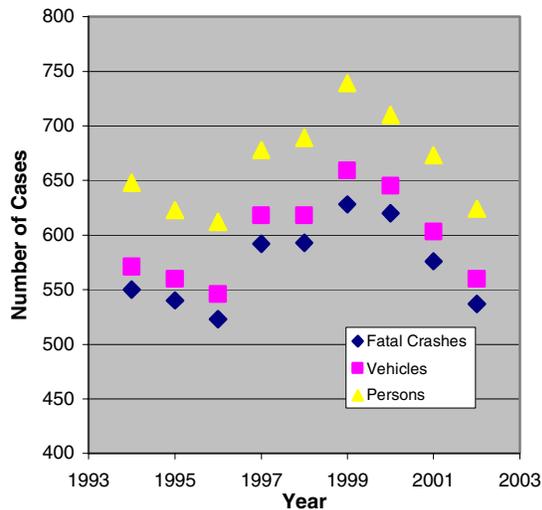


Figure 1. FARS data for all fatal and incapacitating heavy truck crashes from 1994-2002.

The rollover query was then submitted to the FARS database and the number of accidents that met the requirements of this query is shown in Figure 2. The average percent of fatalities and incapacitating injuries, which matched the rollover query, was 18%, with a high in 2002 of 21% and a low of 17% occurring in 1994, 1995, and 1997. Therefore, on average, 18% of all heavy truck incapacitating and fatal injuries were a result of a single vehicle rollover accident where the rollover was the most harmful event, either the first or subsequent event with contained occupants receiving fatal or incapacitating

injuries and the truck receiving severe and disabling damage. This is a very high percentage given such a specific type of accident.

The rollover data shown in Figure 2 shows some similar trends as the data for all heavy truck accidents shown in Figure 1. The highest number of fatal and incapacitating crashes, 126, occurred in 1998, with the lowest number of crashes, 93, being reported in 1993. A downward trend from 1998 to 2001 is seen, but in 2002 the number of crashes rose slightly from 107 in 2001 to 115 in 2002.

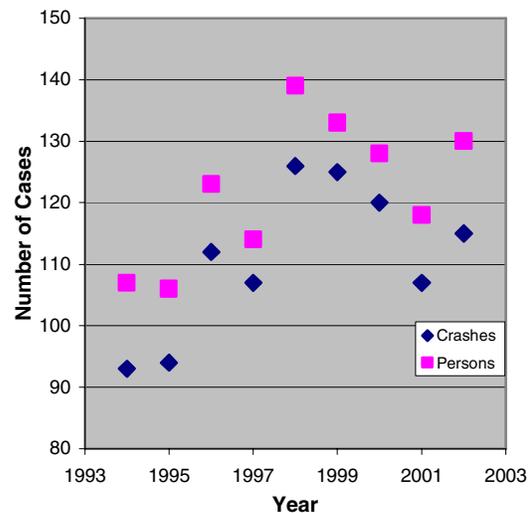


Figure 2. FARS data for heavy truck rollover accidents from 1994-2002 that meet the described query.

The results from the rollover query were further analyzed to determine the restraint use for these accidents. Table 1 shows the findings of this analysis. The average known restraint use during the 1994-2002 time period was almost 35% per year. The conclusion can be made from this data analysis that, on average, over 6% per year of all heavy truck fatalities and incapacitating injuries were restrained occupants in rollover accidents per the previously mentioned query.

Table 1.
Total fatalities and incapacitating injuries and percentage restrained in rollover accidents

Year	Total Incapacitated and Fatally Injured	Total Restrained Fatalities and Incapacitating Injuries	Percentage Restrained
1994	107	31	29.0
1995	106	35	33.0
1996	123	41	33.3
1997	114	44	38.6
1998	139	37	26.6
1999	133	48	36.1
2000	128	50	39.1
2001	118	44	37.3
2002	128	48	37.5

The overall conclusion from this data is that over 6% of the heavy truck incapacitating injuries and fatalities occur as a result of restrained occupants being killed or incapacitated from the severe or disabling deformation that occurs to the truck during a rollover accident.

ROLLOVER CRASHWORTHINESS

In 1991, UMTRI researchers Campbell and Sullivan reported at the 35th Stapp Car Crash Conference that about 60% of all heavy truck driver fatalities are associated with rollover accidents. They concluded from studying National Transportation Safety Board crash reports that, “Existing cab structures above the plane of the dash are not sufficient to withstand the forces produced during rollover” [3].

Several studies have been conducted to evaluate the crashworthiness of heavy trucks. Clarke and Leasure state that improving cab design to provide occupant survival space in a crash could enhance truck occupant protection [4]. In another crashworthiness study, Ranney concluded that heavy truck rollovers were the most frequent cause of truck occupant fatality and that the most frequent damage location in fatal rollovers was the top of the truck [5]. In 1978 Grattan and Hobbs of the United Kingdom conducted a study on injuries received by heavy truck occupants, from which they made the conclusion that making the cab more resistant to the crushing of its occupants could add to the protection offered by the seat belt [6].

Numerous other studies not mentioned have evaluated the injuries received during various types of heavy truck accidents. One conclusion can be drawn: insufficient survival space during rollover

accidents is a primary cause of death for the drivers of large trucks; therefore, structural integrity of the cab of the heavy truck is critical to occupant safety.

CASE STUDY

A seat-belted driver of a heavy truck was killed as a result of the structural collapse of his 1999 Freightliner FLD tractor cab during a 180° rollover accident. His truck was pulling a trailer carrying a full load of cylindrical hydrogen tanks. The rollover was precipitated by the impact of a full-size pick-up which swerved to the left, and struck the Freightliner truck, disabling the right steering mechanism. The Freightliner veered to the left and back to the right, eventually overturning and landing on the vehicle’s left side. The tractor and trailer slid down the roadway and started to slide onto the grassy shoulder to the right of the road. The tractor rolled onto its roof in the grass causing complete collapse of the cab. A photo of the accident vehicle is shown in Figure 3. The truck and trailer left the road and came to rest mostly parallel to the direction of traffic, with the trailer having crossed a driveway, and the cab resting on the driveway. According to the accident reconstruction, the speed of the tractor and trailer at the point of roll initiation was calculated to be in a range from 57 to 70 mph. The speed as the trailer exited the roadway was calculated to be approximately 35 mph.



Figure 3. Photograph of the accident vehicle – driver’s side.

The heavy truck suffered significant structural collapse during this rollover accident. The authors conducted an inspection of an exemplar vehicle and concluded that the all aluminum cab structure would not be sufficient for occupant protection in rollover accidents.

CONCLUSIONS

The FARS database was queried and data gathered for large truck rollover accidents. A specific query was designed to include rollover accidents of heavy trucks where the rollover was the most harmful event; the rollover was either the first or subsequent event; the truck received severe and disabling deformation; the occupants were not ejected; and the injuries sustained were either incapacitating or fatal. This rollover accident data was also compared with the total number of heavy truck accidents where incapacitating or fatal injuries occurred as reported by FARS for the 1994-2002 time period. This data was also then analyzed for restraint use. The following conclusions were made from this data analysis and review of a case study:

1. The average percent of persons involved in accidents, which matched the rollover query, was 18%, with a high in 2002 of 21% and a low of 17% occurring in 1994, 1995, and 1997.
2. The average yearly percentage of incapacitating and fatal injuries for restrained occupants was determined by analyzing the rollover data obtained from the FARS query and was found to be 35%.
3. The overall conclusion from this data is that over 6% of the heavy truck fatalities and incapacitating injuries occur as a result of restrained occupants being killed or incapacitated from the severe or disabling deformation that occurs to the truck during rollover accidents.
4. As stated by Campbell and Sullivan [3] and as was seen from the case study, "Existing cab structures above the plane of the dash are not sufficient to withstand the forces produced during rollover."

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