Proceedings of the 11th International Forum of Automotive Traffic Safety, 2014, pp 54-57
No. ATS.2014.108

Multiple Analysis of Heavy Vehicle Accident Based on Real-life Cases

Wenchao Liu, Zhiqiang Zhou
Road Traffic Safety Research Center of the Public Security Ministry, Beijing, China, 100062
E-mail: liuwenchao03@163.com

Abstract: This study chose 17 real-life heavy vehicle accidents from 2010-2013 which take more than 10 deaths on average as data base to analyze sorts of basic reasons including roll stability, mass breakpoint and driving behavior when unexpected occurs. The result shows that it's not just the stable roll angle value but also the test process which could play a crucial role on roll stability of heavy vehicles. The breakpoint model of mass and dimension works efficiently for over-loaded influence calculation, especially for lorries. The accident rates of the fleets where defensive driving training has applied decrease by more than thirty percent. Consequently it suggests to test the stable roll angle with the most uneven center of gravity and set the breakpoint schedule for mass and dimension of heavy vehicles. Defensive driving education and training also play a significant role in vehicle accident prevention.

Keywords: heavy vehicle accident, roll stability, mass breakpoint, defensive driving

1 Introduction

Each year there are tens of thousands of people dead in road traffic accidents, which include far more injuries. Among all the fatal accidents with all sorts of vehicles, the heavy vehicle accidents often take conspicuously more death and injuries on average. According to the annual road traffic accident reports of recent years, most of the heavy vehicle accidents involved incorrect emergency response, vehicle rollover and foundational defection such as brake system, transmission shaft etc[1]. Multiple analysis of heavy vehicle accidents should consider both the human and vehicle factors related to the tragedy, which includes stable roll angle, mass breakpoint and space cushion driving in this study.

2 Method and Material

2.1 Real-life Heavy Vehicle Accidents

This study chose 17 real-life heavy vehicle accidents from 2010-2013 which take more than 10 deaths on average as data base to analyze sorts of basic reasons including roll stability, mass breakpoint and driving behavior when unexpected occurs. All of these accidents had something to do with passenger vehicles, middle-size or large, or both. Through the 17 accidents chosen to be analyzed for causes, there are 9 cases with rollover movement during the collisions occurred, and 15cases in which the drivers made incorrect decisions before the just moment the beginnings. On the other hand, it's important to figure out that almost thirty percent (5 cases) of all the chosen accidents had something to do with foundational defection such as brake system, transmission shaft etc. Based on drawings of scene for road traffic accident[2] and accident reports, this study chose roll stability, mass breakpoint and driving behavior as multiple causes of heavy vehicle collision analysis and reconstruction.

2.2 Driving Simulation Analysis and Real Vehicle Detection

Comparing with the counterpart of the U.S. transportation department, it's found that almost all the pivotal data and regulations of vehicle product standards including stable roll angle are detected and measured through static test process. Considering that most of passenger vehicles involved in fatal accidents lost control of themselves during the process of collisions, set the contrast test of even and uneven loaded situations to measure the stable roll angle. Discuss the model of breakpoints of mass and dimension[3] from the state of New South Wales, Australia, which could be taken for developing our own breakpoint model as a reference. Finally take the defensive driving as active safety technology of drivers facing the straight risk of all sorts. Introduce defensive driving education and training[4] to the local fleets in Shanxi and Hebei provinces, evaluate the difference of the traffic violation and collision rate before and after the introduction.

3 Results

3.1 Limit Gauging of Stable Roll Angle

Contrast tests are set for measuring the difference of stable roll angle of passenger vehicles with all the passengers and load even and uneven distributed. According to the regulation of safety specifications for vehicles operating on roads[5], the stable roll angle of passenger vehicle's both sides should be more than 28° , which is tested with the full and complete passengers and empty cargo loaded. Considering that all the passengers or loads of moving vehicles could be distributed extremely uneven at the most dangerous moment before the rollover occurs, it's significant to set the stable roll angle test with all the passengers and cargo on the same side. With the same large passenger vehicle loaded differently in the stable roll angle tests for five times, the results show that extremely uneven loaded situation could be 3-4° different from traditional test situation as table 1.

Table 1 stable roll angle test

No.	even loaded left	uneven loaded left	even loaded right	uneven loaded right
1	29.8°	27.1°	29.2°	26.8°
2	29.9°	27.2°	29.4°	26.9°
3	29.6°	26.9°	29.4°	27.0°
4	29.4°	26.7°	29.1°	26.6°
5	29.5°	26.6°	29.2°	26.8°

The rollover movement of passenger vehicle is formed from stable roll angel, lateral centrifugal acceleration and coefficient of road adhesion[6]. When the stable roll angel is smaller than lateral centrifugal acceleration, the vehicle would roll over rather than slip away. Comparing with the extremely uneven loaded situation during the real collisions, the traditional test process of stable roll angle is not sufficient for sure.

3.2 Breakpoint Model of Overloaded Vehicles

Every vehicle has its own dimension and loading requirements, which should not be broken for any bit. However, most countries with such laws and regulations barely have the measurable risk relationship between overload and foundational defections. In the state of New South Wales, Australia, there is the breakpoint model of overloaded vehicles as table 2.

Table 2 breakpoint risk level of overloaded vehicle

vehicle types	legal axle weight limit (t)	risk category break points (t)		
		minor	substantial	severe
rigid 2 axle truck	6.0 (1st axle)	6.2	⩾6.3	⩾7.2
	9.0 (2nd axle)	9.4	⩾9.5	⩾10.8
rigid 3 axle truck	6.0 (1st axle)	6.2	⩾6.3	⩾7.2
	16.5 (2nd and 3rd axles)	17.3	⩾17.4	⩾19.8
rigid 4 axle truck	27.5 (gross)	28.8	⩾28.9	⩾33.0
articulated 4 axle truck	6.0 (1st axle)	6.2	⩾6.3	⩾7.2
	9.0 (2nd axle)	9.4	⩾9.5	⩾10.8
	16.5 (3rd and 4th axles)	17.3	⩾17.4	⩾19.8
articulated 5 axle truck	6.0 (1st axle)	6.2	⩾6.3	⩾7.2
	16.5 (2nd and 3rd axles)	17.3	⩾17.4	⩾19.8
	16.5 (4th and 5th axles)	17.3	⩾17.4	⩾19.8
articulated 6 axle truck	6.0 (1st axle)	6.2	⩾6.3	⩾7.2
	16.5 (2nd and 3rd axles)	17.3	⩾17.4	⩾19.8
	20.0 (4th, 5th and 6th axles)	20.9	⩾21.0	⩾24.0

Breakpoint risk level model of overloaded vehicles describes concrete load with risk level on every axle of the goods transportation vehicles, which could inform the drivers and operators of the correct disadvantage of overloading instead of traditional methods such as "illegal" or "dangerous". On the other hand, breakpoint risk level model suggests reliable basis for legal punishments of overloading.

3.3 Defensive Driving Simulation Experiment

Defensive driving behavior, sometimes under the name of space cushion driving in the United States or Australia, has come to use for more than sixty years, which was originally put out from Harold Smith in the United States. Defensive driving highlights the advantage of eyes and brain rather than the hands and feet when before the wheel. There are five key points[7] such as "aim high in steering", "get the big picture", "keep your eyes moving", "leave yourself an out" and "make sure they see you". By setting and taking 20 drivers involved in driving simulation experiment and real vehicle driving in the traffic environment for more than two years, it's delighted to tell the distinct characters of driving behavior before and after the education and training. Taking the original amount of traffic violation as the targeted objective, it measured the average amount of each driver during every six months and found that almost all the drivers declined their traffic violation behavior by contrast as table 3.

Table 3 traffic violation rate of each driver

No.	original	0-6 months	7-12 months	13-18 months
1	16	15	9	5
2	15	15	11	7
3	11	12	8	4
4	15	13	10	7
……				
20	12	12	9	4

According to the instructors of defensive driving, most of the drivers were unwilling to accept the concept at first, and few could comply with the suggestions literally. Things got better from the second 6 months, during which period most drivers' traffic violation behaviors began to decline. On the other hand, both fleets in Shanxi and Hebei provinces which took the defensive driving courses showed remarkable drop in the accident rate year by year.

4 Conclusions

The dynamical stable roll angle plays the most significant role on roll stability of moving vehicles, which often exists with all the passengers or loads distributed unevenly at the most dangerous moment before the rollover occurs. It's important to test the stable roll angle in extreme cases with the most uneven center of gravity.

Axle breakpoint does not only depend on the gross weight but also relate to the axle load distribution. Setting the breakpoint schedule for mass and dimension of various types of heavy vehicles makes it more reasonable for the loader or manger to keep the shipping suitable.

Defensive driving education and training focus on space cushion concepts and skills, which help keeping the drivers away from potential hazards of traffic environment, not just reaction to emergency. Active safety system of drivers themselves usually works much better than that of all the other objects including vehicles and road traffic facilities.

References

[1] The Public Security Ministry of Peoples Republic of China. The road traffic accident report of 2013 [J]. Beijing: Traffic Management Research Institute of Ministry of Public Security , 2014. (in Chinese)

[2] The Public Security Ministry of Peoples Republic of China. GA49-2009, Public security industry standard of the People's Republic of China—The drawing of scene for road traffic accident [S]. Beijing : China Standards Press, 2009. (in Chinese)

[3] NSW road and maritime service. Heavy Vehicle Driver Handbook [M]. Sydney : NSW Government, 2011. (in English)

[4] Smith System®. The Smith 5 Keys Handbook [M]. Arlington：Smith System®, 2013. (in English)

[5] Traffic Management Research Institute of Ministry of Public Security etc. GB 7258-2012 [S]. Beijing : Standards Press of China, 2012: 12.

[6] Cao Libo,Yan Lingbo. Overview of Rollover Associated Safety Studies and Tests [J]. Chinese Journal of Automotive Engineering, 2002, 2(4): 236—237. (in Chinese)

[7] Smith System®. Arrive Alive Safety Meeting Series [M]. Arlington：Smith System®, 2014. (in English)