Heavy Truck Crash Investigation and Data Collection Methodology on Indian National Highways

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Abstract – In India, heavy truck crashes on national highways account for a number of fatalities. But due to lack of in-depth crash data, detailed analysis is not possible to determine injury mechanisms, and to identify infrastructure, vehicle and human factors affecting these crashes. Over the past two years, researchers in India have established a crash investigation network, with the co-operation of the police and hospitals, to conduct crash investigations and in-depth crash data collection on national highways in the state of Tamil Nadu. This pioneering effort has resulted in the development of a heavy truck crash investigation methodology, the outcome of which is scientific and reliable crash data that has been able to provide good insight into truck crashes and their causes. This paper explains the need for truck crash investigations, the methodology, conclusions of the data analyzed up to date, and the need to focus on truck driver working conditions.

INTRODUCTION

Truck occupant fatalities in India

As per the National Crime Records Bureau, truck occupants have constituted the highest number of fatalities among all road users. Road fatalities data from 2005 to 2008 show that truck occupants accounted for an average of 21% of all road traffic fatalities [1]. In 2008, 25,135 truck occupants died in road traffic accidents in India [1]. Figure 1 shows the percentage of truck fatalities in each state in the year 2008, with the horizontal line showing the percentage of all India truck fatalities. Out of the 28 states, 15 states have truck fatalities as the highest among all other road user fatalities (Shaded bars).

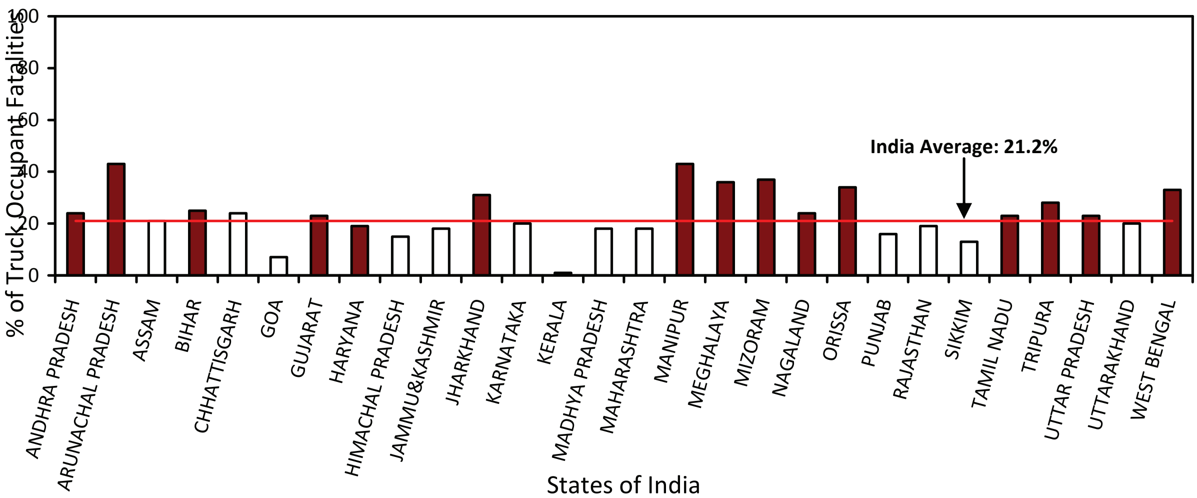

Figure 1. Percentage of Traffic Fatalities to Truck Occupant by State in 2008

Road accidents on national highways and need for truck crash data

The Indian road network spans up to 3,516,452 km (2009) [2] and is the second largest in the world. National highways are just 2% of this network, but have more than 38% of the total road traffic fatalities every year [3]. For example, in Tamil Nadu state, 33.2% of total crashes occurred on National Highways passing through the state [4]. Consequently, there is an urgent need to study heavy truck crashes on Indian national highways, to determine factors associated with these crashes and the injury mechanisms.

Crash investigations in India

Researchers at JP Research India Pvt Ltd[1] have established a crash investigation network with the help of the police and hospitals, and in the last two years have carried out on-scene crash investigations and in-depth data collection on five stretches of national highways in Tamil Nadu. The primary focus of these studies is:

1. To set up a crash investigation and in-depth crash data collection methodology for examining road traffic crashes in India.
2. Emphasize the importance of building a comprehensive crash database for India, which captures in-depth crash data and permits scientific research and analysis of road traffic crashes.

Based on these studies, the research team of JP Research India has developed a comprehensive truck crash investigation methodology tailored to studying heavy truck crashes occurring on Indian roads.

TRUCK CRASH INVESTIGATION METHODOLOGY

Selection of study area and creation of a crash notification network

After determining accident-prone stretches of national highways with the help of police data, researchers determine a base location from where all accidents on the stretch can be reached within 30 minutes of notification of a crash. In the event of a crash on the selected stretches, the police are informed to call up a dedicated phone number, which is manned by one of the researchers, 24 hrs a day. Researchers, on receiving this notification traveled to the crash spot within 30 minutes and perform detailed crash investigations as described below.

Crash scene examination

The crash scene examination involves taking measurements and photographs of any on-scene evidences such as tire skid marks, scuff marks, debris, final position of vehicles, etc. Hence, great emphasis was put on researchers accessing the crash site as soon as possible. In addition, other infrastructure related details including road dimensions, object dimensions in case of object impact, GPS log, weather and road conditions, roadway alignment/road type were noted. These factors were later represented on a bird's eye view of the crash scene, also called as "scene diagram". This to-scale diagram also shows the direction of travel of the vehicles, along with date, time and the dimensions recorded on the scene. An example of a scene diagram is shown in Figure 2.

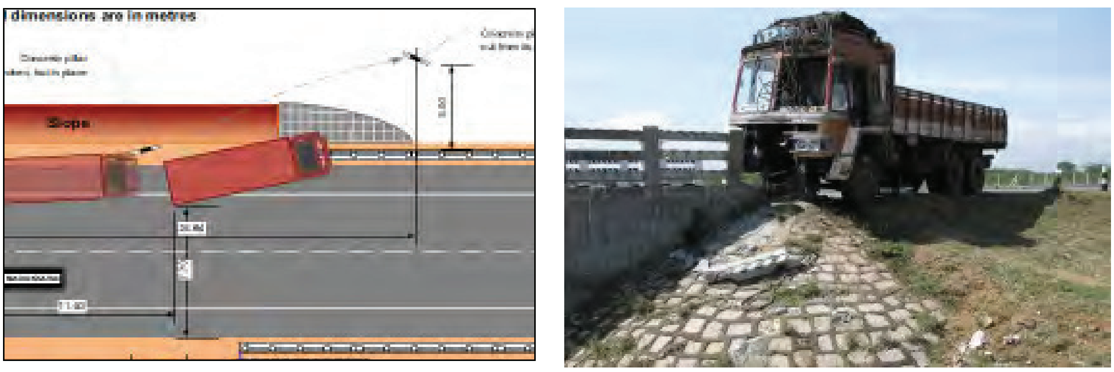

Figure 2. Scene Diagram (left) of the Truck Crash (right)

[1] JP Research India Pvt. Ltd. is a wholly owned subsidiary of JP Research, Inc., USA.

The scene was also examined for presence of gas stations, eateries and commercial places, availability of proper signage, warnings, and information boards for the road users. The road and crash site were photographed for future reference.

Exterior vehicle examination

The crashed vehicles were examined partly at the crash scene and then later at the police station under whose jurisdiction the crash had occurred. The following were the parameters recorded.

Heavy truck type and cargo

There were mainly four types of heavy trucks commonly seen plying on the Indian roads; straight unit truck, tanker, tractor (with/without a trailer), and tipper. Examples are shown in Figure 3. During vehicle examination, the type of truck, including the cargo being carried, was noted.

a. Straight Unit Truck

b. Tanker

c. Tractor with trailer

d. Tipper

Figure 3. Heavy Truck Types Commonly Seen in India

Crash damage and severity

Crash damage and severity involves recording damage information such as impact type, location of direct and indirect damage, damage measurements (such as height and width), crush profile, and maximum crush. This information was later applied in coding the Truck Deformation Classification or TDC [5], as shown in Figure 4.

Truck type:	Straight unit (2 axle)
Crash type:	Head-on collision
Direct damage width:	27 cm from right bumper corner
Maximum crush:	126 cm
TDC:	12FRAN7

Figure 4. Truck Damaged in a Crash with Crash Severity Details

The vehicle was photographed from various angles, and all damages (direct and indirect) were noted on a sketch for further reference.

Conspicuity

A number of truck crashes were observed at night due to poor conspicuity of trucks. Hence, the presence of conspicuity enhancing features such as tail lamps, indicators and reflectors was recorded. Tail lamps and side indicators availability on both sides of the truck were noted. The functioning of the lamps was determined by testing them at the inspection spot.

Researchers examined every crashed truck for the availability of reflectors on the front and rear of the vehicle, in adherence to the Rule 104 of the Central Motor Vehicle Rules (CMVR), India [6]. This rule states that every goods transport vehicle should have two white reflectors in the front and two red reflectors in the rear (on both sides), with the minimum reflecting area of each reflector being 28.5 square centimeters. The reflectors also need to be clean, free from any dirt on the surface or peeling for better conspicuity. Figure 5 shows examples of trucks with good and poor conspicuity features.

Figure 5. Truck with Good Conspicuity Features (left), Truck with Poor Conspicuity Features (right)

Tire information

Adequate tire pressure and tire tread depth is necessary for better control of a vehicle on road. By checking the tire pressure of a crash vehicle it can be determined, if the crash occurred due to a tire burst before lose of control. The gauge used for checking the tire pressure in trucks is shown in Figure 6. Also the tread depth of each tire of the truck was measured using the depth probe of a vernier caliper, and the tires were rated as good/fair/poor based on the tread depths measured.

Figure 6. Truck Tire Pressure Gauge (left), Researcher Checking Tire Pressure (center), Tread Depth of Crash Involved Truck (right)

Safety Devices

Under-Run Protection Devices (UPD) are safety equipment fitted on trucks (as shown in Figure 7) to prevent under-rides and used to decrease the crash severity and injury severity when smaller vehicles are involved. The presence of these devices on the front, rear and sides of a truck was noted. The ground clearances of the truck on all sides were also recorded.

Figure 7. UPD in a Truck (left) and an Under-Ride Crash (right)

Seat Belts are by far the cheapest and most effective safety equipment available for any vehicle. The availability of seat belts in the truck and also its usage by the occupants was checked during interior examination. Seat belt use was determined by checking the presence of stretch marks or melting of plastic on the belt, caused by the sudden movement of the belted occupant. Unfortunately, both studies did not find usage of seat belts by any truck occupants. In many cases, belts were not even available.

Brakes used by the majority of the trucks in India are pneumatically operated air brakes. After a crash, there are often chances of compressed air line breakage. This was checked by noting the air pressure from the dashboard gauge and, if possible, determining wheel lockup due to loss of air pressure.

Pedestrian contact mapping

For pedestrian crashes, two imaginary axes were drawn on the vehicle; a vertical along the center of the width of the vehicle on the windshield (i.e., X axis) and a horizontal at the bottom of the windshield (i.e., Y axis). The position of pedestrian contact points on the vehicle, like soft dents, cracks, blood smear, marks etc., were plotted by measuring their X and Y distances from the origin of the imaginary axes, and represented on a vehicle sketch as shown in Figure 8 and Table 1. This was mainly done to map the contact(s) made by the pedestrian(s) on the vehicle, not always captured by the photographs taken during vehicle examination (due to damages being very less in magnitude and visibility).

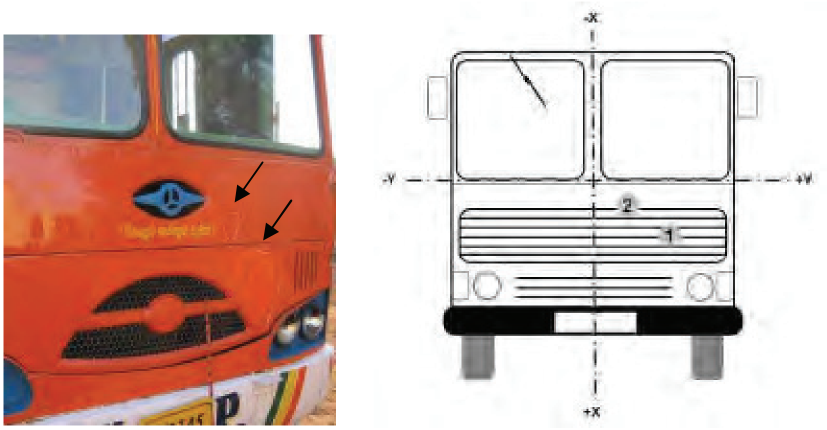

Figure 8. Plotting of Pedestrian Contact Points on Heavy Truck Fronts

Contact #	X-axis	Y-axis	Body region contacted	Confidence Level
1	+54	+46	Torso	Certain
2	+26	+31	Head	Probable

Table 1: Mapping of Pedestrian Contact Points

In addition, distance from the ground to the bumper bottom, bumper top, front grill, and bottom of the windshield was noted so that contacts could be matched with body parts of the pedestrian (if height of the struck pedestrian was obtained). This allowed a way to determine the common areas on the truck front needing pedestrian friendly changes.

Driver comfort and visibility

The type of driver seats present in the truck was recorded. Any seat not of the OEM quality (an example shown in Figure 9) was rated as poor. Any driver visibility issues such as like poor/cracked glazing, availability of wiper only on the driver side, and tiny rear view mirrors was checked. The truck was also checked for the availability of power steering.

Figure 9. Poor Seating for Truck Drivers and Absence of Seat Belts (left); Wiper Availability only on Driver Side (center); Weak Cab Strength (right)

Interior vehicle examination

The truck involved in the crash was inspected internally to locate intrusions into the cab. The intrusion measurements were taken in the crashed vehicle and then compared with those of an exemplar vehicle to obtain the amount of intrusion into the cab. An example of the intrusion measurements of a crash truck are shown in Figure 10.

Intruding Component	Intrusion Magnitude (in cm)
A-pillar	44
Instrument panel	54
Cab rear deformed due to cargo	20

Figure 10. Intrusion Measurements of a Truck Colliding with Roadside Tree

Occupant contact evidences such as hair samples, blood smears, windshield cracks, teeth marks, stress marks on dashboard, bent steering wheel, etc. were recorded. Photographs of all contacts were also taken for future reference and analysis. The cab strength, in many cases, was very weak as shown in Figures 10, and the interiors were distorted making it difficult to find occupant contact evidences.

Injury coding and correlation

With the cooperation of the police and health department, researchers were able to obtain injury reports on crash victims from the admitting hospitals. After receiving the injury reports, the sustained injuries were coded using the Abbreviated Injury Scale (AIS) [7], and International Statistical Classification of Diseases, 10th Revision (ICD-10) [8]. The injuries coded were then correlated to their respective injury sources (intrusions, occupant contacts), which gave a clear idea of the occupant kinematics during the crash and the causes of injuries. This helped to determine ways to mitigate the severity of such injuries. The injuries also gave an indication on the use of safety systems by the occupants. Table 2 shows an example of injury correlation of a truck occupant, seated in the passenger seat of the truck shown in Figure 10.

Injury Description	AIS Code	ICD 10	Injury Source
Multiple rib fractures over posterior region left side	450210.1	S22.4	Cab Rear
Fracture T10 vertebral body	650430.2	S22.0	Cab Rear
Cervical whiplash injury	640278.1	S13.4	Induced Injury
Fracture T10 and T11 with cord oedematous (Paraplegia)	640424.5	S22.0 S24.0	Cab Rear

Table 2. Example of Injury Correlation

Time of arrival of the ambulance to the crash scene and the time of the ambulance reaching the hospital was also obtained from injury reports or ambulance records to determine the time taken for the occupant to reach the hospital. This also provided a good understanding of the availability of rescue facilities in that particular area.

RESULTS AND CONCLUSIONS

Of the two studies performed results can be broken into three parts; infrastructure, vehicle, and human. The detailed analyses of these two studies were published as a paper [9] and a poster [10] at the SAE India Mobility Congress held in December 2009.

Infrastructure

1. Most crashes were front-rear collisions (20 of 36) and took place mainly with stationary trucks due to parking for breakdown, slowing near U-turns or at gas stations.
2. Proper communication was not provided through clear signage to the drivers on the presence of U-turns, gas stations, bay areas, and other areas of interest.

Vehicle

1. Rules 95, 102, 104, 124 and 125 as specified in the CMVR [6] which ensures that vehicles have acceptable tires, tail lamps, reflectors, under-run protection and seat belts respectively, needs to be strictly enforced.
2. Of trucks inspected 36 of 43 were found without rear under-run protection devices leading to increased injury severity during front-rear collisions.
3. Comfort, visibility, and safety for truck occupants needs to be addressed during design of truck cabs.

Human

1. More effort is required to educate and train truck drivers to encourage safe practices on Indian roads.
2. Basic data of truck drivers such as educational qualification, annual income, etc. needs to be known to understand working conditions.
3. More details about drivers trip schedules needs to be known such as miles travelled, trip time, and amount of rest hours to the driver. This could not be collected in this study.

By studying real world truck crashes it is possible to identify issues that need to be addressed in the area of truck road safety. The heavy truck crash investigation study performed in Tamil Nadu found several areas for improvement on the infrastructure, vehicle and human levels. More similar studies, along with additional information on truck drivers and their working conditions, can save many lives on the Indian roads every year.

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