iRAP Baseline Data Collection in India

Final Report – Gujarat Phase

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Introduction
The India Four States Project is an initiative of the Global Road Safety Facility (GRSF) funded with support from Bloomberg Philanthropies. The project includes iRAP road infrastructure risk assessments and preparation of investment plans for the 'Four States Network', as follows:
- Andhra Pradesh: 440km
- Assam: 970km
- Gujarat: 570km
- Karnataka: 1,800km

The Four States Project is being delivered in two phases. The first phase has been managed by the GRSF, which procured road inspections and coding (including coder training and supervision) according to iRAP specifications. The contract for these services was awarded to ARRB Group and their Indian partner company, Indian Road Survey and Management (IRSM).

The second phase of the project includes collection of supporting data and generation of iRAP Star Ratings and Safer Roads Investment Plan. This phase has been contracted to JP Research India Pvt. Ltd. (JPRI) for the states of Karnataka and Gujarat. The details of this project are as below:

Project Objectives
The objective of this project is to collect data for selected road corridors that can be used by:
1. The World Bank to establish a baseline for monitoring of road safety performance.
2. iRAP in the generation of Star Ratings and Safer Roads Investment Plans.

Road Corridors
This project focuses on the following four state highways:
1. SH17: Maddur to Mysore, Karnataka: 53 km
2. SH20: Belgaum to Hungund, Karnataka: 171 km
3. SH6: Dahej to Bharuch, Gujarat: 45 km
4. SH13: Ankleshwar to Valia, Gujarat: 30 km

Data Required
1. The data required for each of the road corridors is:
   a. Accident data and fatalities
   b. Traffic speeds
   c. Traffic volumes
2. The data is to be collected through primary research (in the field) and secondary research (liaison with local authorities).

Project Timeline
The project duration including reporting is to be completed by 31 March 2012.

Objective of this report
This report documents the Gujarat Phase of the project and includes the data collected, analysis, findings and conclusions of the following state highways:
SH6 – Dahej to Bharuch
SH13 – Ankleshwar to Valia
About JP Research India

JP Research India Pvt. Ltd. (JPRI) is a research firm involved in the business of automotive accident data collection and analysis since 2006. The company, a fully owned subsidiary of JP Research, Inc., is a forerunner in road safety research and has undertaken pioneering on-scene accident and in depth data collection projects aimed at scientifically understanding and mitigating road accident fatalities in India.

Accident research has proven to be the best way to understand the characteristics of real-world road traffic accidents. Countries such as the USA, UK, Germany and Japan have been able to use the results of such research to significantly reduce the number of road traffic fatalities in their countries. The fact that India has been losing more than 100,000 lives on road every year makes it imperative that we, too, conduct this kind of research to identify and then take swift steps to address the key factors influencing the high traffic injury and mortality rate in our country.

JPRI is experienced in using accident research methodologies developed in other nations and customizing these to suit India’s unique traffic conditions. After conducting numerous studies and on-site accident research projects on Indian roads, JP Research India has developed its own India-specific accident data collection forms, a methodology for conducting site and vehicle accident investigations in the inimitable Indian traffic environment, and a searchable database of in-depth accident data. In addition, the company’s experts offer training in all of these areas, for those who would prefer to perform their own data collection and analyses.

In other words, JPRI’s overriding objective is to understand Indian roads, traffic and road users in ways that can be used to save lives - ours and yours.

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SH6: Baseline Data Collection

Shown above is a picture of the State Highway 6 (SH6) from Dahej to Bharuch. It shows a truck travelling in the opposite direction and a two-wheeler rider trying to avoid the truck. Also in the picture is a pedestrian walking on the paved shoulder which seems too narrow in width.
The following sections describe the area of study, data collected, findings and conclusions for the State Highway 6 (SH6) corridor from Dahej to Bharuch.

**The Study Area**

The study area, a 45 km stretch of SH6 connecting Dahej to Bharuch was selected based on instructions provided by iRAP for performing traffic volume, speed and accident data collection.

SH6 is a four lane divided road which, at the time of the study, was under construction to be converted into a six lane divided highway. SH6 is the most important road for connectivity with Dahej, which is an industrial area and houses the Gujarat Industrial Development Corporation (GIDC), Dahej Special Economic Zone (SEZ) and Dahej Port. Most of the road stretch was under construction during the study period. The under-construction part was dug up, on both sides of the road. Although some parts of the stretch did have a third lane in either direction, this third lane did not have road markings and was used by vehicles as a parking lane rather than a travel lane.

**Traffic Volume and Speed Data**

The following section gives details of the traffic volume and speed data collection for SH6.

**Spot Selection**

The stretch was carefully studied to determine places where significant traffic was being added to the highway or being subtracted from it. These places usually include major towns or villages that draw frequent on/off traffic, either as destinations in themselves or as connections to some other place. Spots around these locations offer a good idea of the traffic volume for the whole stretch selected. The study sites on SH6 have been identified as per the Global Positioning System (GPS) coordinates provided in Table 1, and they are shown graphically in Figures 1 and 2.

<table>
<thead>
<tr>
<th>Sites</th>
<th>GPS Coordinates</th>
<th>Area Type</th>
<th>Posted Speed Limit (kmph)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>21° 42' 49.07&quot; N 72° 38' 34.82&quot; E</td>
<td>Rural</td>
<td>50</td>
</tr>
<tr>
<td>B</td>
<td>21° 43' 29.74&quot; N 72° 44' 59.02&quot; E</td>
<td>Rural</td>
<td>50</td>
</tr>
<tr>
<td>C</td>
<td>21° 42' 45.30&quot; N 72° 48' 37.34&quot; E</td>
<td>Rural</td>
<td>50</td>
</tr>
<tr>
<td>D</td>
<td>21° 41' 47.82&quot; N 72° 55' 17.54&quot; E</td>
<td>Rural</td>
<td>50</td>
</tr>
</tbody>
</table>

Table 1: GPS Coordinates, area type and posted speed limit of the four study sites on SH6
Figure 1: Screen shot from Google Earth, showing the study sites (Sites A, B, C, and D)

Site A  
(Welspun Company)

Site B  
(Bhelsli Village)

Site C  
(2kms from Navetha Junction towards Dahej)

Site D  
(Near Patel Weigh Bridge)

Figure 2: Photos of the study sites on SH6 (Sites A, B, C and D)
Data Sample Collected

Data collection for traffic volume count and speeds was as per the guidelines laid down by iRAP. Please refer to the “iRAP Baseline Data Collection in India – Inception Report” published by JPRI on November 1, 2011.

The data sample collected for traffic volume count and speed on all sites of SH6 at 4 time durations (06:01 to 12:00, 12:01 to 18:00, 18:01 to 24:00, and 00:01 to 06:00) is shown below:

- 4 locations were monitored (Sites A, B, C and D).
- 7286 vehicles were counted during four time durations.
- 6661 speeding incidents were recorded.
- 1471 minutes of data was collected.

The status of data collection (speed and traffic volume) at all study sites at different time durations are shown in Table 2.

<table>
<thead>
<tr>
<th>Study Sites</th>
<th>00:01 to 06:00 hrs</th>
<th>06:01 to 12:00 hrs</th>
<th>12:01 to 18:00 hrs</th>
<th>18:01 to 24:00 hrs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Site A</td>
<td>Data collected</td>
<td>Data collected</td>
<td>Data collected</td>
<td>Data collected</td>
</tr>
<tr>
<td>Site B</td>
<td>Data collected</td>
<td>Data collected</td>
<td>Data collected</td>
<td>Data collected</td>
</tr>
<tr>
<td>Site C</td>
<td>Data collected</td>
<td>Data collected</td>
<td>Data collected</td>
<td>Data collected</td>
</tr>
<tr>
<td>Site D</td>
<td>Data collected</td>
<td>Data collected</td>
<td>Data collected</td>
<td>Data collected</td>
</tr>
</tbody>
</table>

Table 2: Status of traffic speed and volume data collected at different study sites on SH6

Traffic Volume Count

To standardize the observed time for comparison, JPRI normalized the count in a given site for a given 6 hours’ time duration to an one hour sample. This was done by using the following formula.

\[
\text{Number of vehicles passing in one hour at one site} = \frac{\text{Number of vehicles counted in time } (t, \text{ in minutes}) \times 60 \text{ minutes}}{(t, \text{ in minutes})}
\]

This one hour sample was then extrapolated to the specific 6 hours’ time duration. The end results were then added to get an estimation of the number of vehicles passing through a given site in 24 hours. Based on the above calculation, the new total vehicle count obtained for SH6 is **66444** and the total vehicle count at each site is as show below in Figure 3.
Figure 3: Traffic volume count at each site on SH6 estimated for 24 hours.

The 24 hour data sample for traffic volume count was distributed by vehicle type and the result is as shown in Figure 4. *The definition for each vehicle type is provided in Appendix A.*

Figure 4 indicates that cars (38%) constituted the highest road user type counted on the SH6. This was followed by trucks (36%) and motorised two wheelers (18%). Other motor vehicles, buses, pedestrians, bicyclists and non-motorized vehicles together accounted for only 8% of the total traffic volume.

It is important to note that:

1. Cars, trucks and motorized two-wheelers form 92% of the vehicles on SH6.
2. Although motorized two wheelers are the third highest vehicle type, they account only for 18% of the vehicles on SH6.

**Traffic volume percentage counts for each time duration**

Traffic volume counts were taken at different durations of the day (the four time durations) at each of the four study sites (A, B, C, and D). The data for each time duration is as shown in Figure 5.
Figure 5: Traffic volume percentage distribution by vehicle type for the four time durations on SH6
The resulting data provides an estimate of the volume and types of vehicles seen on weekdays on the study stretch for each of the time durations. Traffic volume was lowest during the night hours (00:01 to 06:00) and trucks were the main road users plying at this time. Trucks constitute the highest road users during the time durations of 00:01 to 06:00 and 12:01 to 18:00, while cars are the highest road users for 06:01 to 12:00 and 18:01 to 24:00. Motorized two wheelers showed more presence on road during the day (06:01 to 18:00) compared to the night.

85th Percentile Speeds

The “85th percentile speed” is the speed at or below which 85% of the vehicles were found to travel. This measure is different from the “average” speed. By omitting speed variations possibly caused by very few vehicles that travelled at high speeds (variations that would necessarily be included if a simple average was calculated), the 85th percentile reflects the speed at which most vehicles travel on a given stretch of road. The overall 85th percentile speed for each vehicle type (averaged across all four sites) is shown in Figure 6.

![Figure 6: Average “85th percentile speed” of each road user type in all study sites on SH6](image)

It can be seen from Figure 6 that cars were found to be travelling the fastest with 85th percentile speed of 85 kmph. Cars were followed by buses, motorized two wheelers and trucks with 85th percentile speed of 70 kmph, 60 kmph and 58 kmph respectively. Clearly all vehicle types (except for other vehicles like auto rickshaws, tractors etc.) were seen to be above the posted speed limit of 50 kmph on this road. The 85th percentile speed for all vehicles was 71 kmph and it was 66 kmph when cars were excluded from the calculations.

Findings and Observations

The following are the findings and observations of the speed and traffic volume count study on SH6:

- Trucks and cars constitute the highest number of road users on SH6.
- Motorised two wheelers constituted only 18% of the traffic volume and their presence is mainly seen in the day.
- Trucks are highest in volume during the night (00:01 to 06:00 hrs) and afternoon (12:01 to 18:00 hrs) while cars are highest in volume during the morning (06:01 to 12:00 hrs) and evening (18:01 to 24:00 hrs).
• Traffic was seen to be very low between 00:01 to 06:00 hrs and mainly constituted trucks (87%).
• Almost all vehicle types were seen to be travelling above the posted speed limit of 50 kmph.
• 85th percentile speed for cars was the highest at 85 kmph.
• 85th percentile speed of all vehicles on the stretch was 71 kmph, and it was 66 kmph when cars were excluded. Hence, cars seem to influence speed data a lot.
• The 85th percentile speeds of trucks and motorized two wheelers (which together account for 54% of the traffic volume) were found to be 58 to 60 kmph.
• Cars, including vans and jeeps, are used as private transport vehicles and most people commute to work and back in them. This and the low volume of buses highlight the lack of public transportation facilities.

A summary is provided below for the speed and traffic volume data for each site.

### Traffic Speed

<table>
<thead>
<tr>
<th>SITE</th>
<th>Car</th>
<th>Bus</th>
<th>Truck</th>
<th>M2W</th>
<th>Others</th>
<th>All Vehicles</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>83</td>
<td>68</td>
<td>57</td>
<td>60</td>
<td>41</td>
<td>68</td>
</tr>
<tr>
<td>B</td>
<td>80</td>
<td>68</td>
<td>57</td>
<td>59</td>
<td>42</td>
<td>69</td>
</tr>
<tr>
<td>C</td>
<td>89</td>
<td>74</td>
<td>60</td>
<td>63</td>
<td>42</td>
<td>74</td>
</tr>
<tr>
<td>D</td>
<td>86</td>
<td>71</td>
<td>58</td>
<td>59</td>
<td>47</td>
<td>72</td>
</tr>
</tbody>
</table>

### Traffic Volume Count

<table>
<thead>
<tr>
<th>SITE</th>
<th>Car</th>
<th>Bus</th>
<th>Truck</th>
<th>M2W</th>
<th>Others</th>
<th>Pedestrian</th>
<th>Bicycle</th>
<th>Total Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>32%</td>
<td>2%</td>
<td>40%</td>
<td>19%</td>
<td>4%</td>
<td>2%</td>
<td>1%</td>
<td>16734</td>
</tr>
<tr>
<td>B</td>
<td>42%</td>
<td>5%</td>
<td>35%</td>
<td>14%</td>
<td>3%</td>
<td>1%</td>
<td></td>
<td>16872</td>
</tr>
<tr>
<td>C</td>
<td>39%</td>
<td>2%</td>
<td>40%</td>
<td>16%</td>
<td>3%</td>
<td>1%</td>
<td></td>
<td>13782</td>
</tr>
<tr>
<td>D</td>
<td>40%</td>
<td>3%</td>
<td>29%</td>
<td>21%</td>
<td>7%</td>
<td>1%</td>
<td></td>
<td>19056</td>
</tr>
</tbody>
</table>
**Police Data**

Police reported accident data was collected from three police stations (whose jurisdiction includes the study area, namely Dahej police station, Bharuch Taluka police station and B-Division police station). Police records showed 152 accidents were reported on SH6 during 2009 to 2011 (1st January 2009 to 30th November 2011) between Dahej and Bharuch. The status of police data collection for SH6 is as shown in Table 3 below.

<table>
<thead>
<tr>
<th>Police Station</th>
<th>2009</th>
<th>2010</th>
<th>2011</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dahej</td>
<td>Data collected</td>
<td>Data collected</td>
<td>Data collected</td>
</tr>
<tr>
<td>Bharuch Taluka</td>
<td>Data collected</td>
<td>Data collected</td>
<td>Data collected</td>
</tr>
<tr>
<td>B-Division</td>
<td>Data collected</td>
<td>Data collected</td>
<td>Data collected</td>
</tr>
</tbody>
</table>

Table 3: Status of police reported accident data collection on SH6

*Each police reported accident was personally reviewed by researchers by accessing police registers for case details and coded in a standardized coding form prepared by JPRI (Appendix B).*

The data collected and analyzed is presented below:

**General Overview of Police Data**

**Injury Severity**

Highest injury severity of an accident in the police record was confirmed by researchers by looking at the Section of Indian Penal Code (IPC) under which the case was booked. The IPC sections for road traffic accidents and their interpretations for highest injury severity of the road accident is explained in Table 4.

**Table 4**: Sections of Indian Penal Code (IPC) relating to road traffic accidents and their interpretation for injury severity.

<table>
<thead>
<tr>
<th>INDIAN PENAL CODE SECTION</th>
<th>DEFINITION</th>
<th>HIGHEST INJURY SEVERITY OF THE ACCIDENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>IPC 304(A)</td>
<td>Causing death by negligence</td>
<td>Fatal/Killed</td>
</tr>
<tr>
<td>IPC 338</td>
<td>Causing grievous hurt by act endangering life or personal safety of others</td>
<td>Hospitalized/Grievous</td>
</tr>
<tr>
<td>IPC 337</td>
<td>Causing hurt by act endangering life or personal safety of others</td>
<td>Minor Injury</td>
</tr>
<tr>
<td>IPC 279</td>
<td>Rash driving or riding on a public way</td>
<td>No Injury</td>
</tr>
</tbody>
</table>

A total of 152 accidents resulted in 58 fatal victims and 207 injured victims. The accidents were divided based on the highest injury severity for each road accident. The distribution of accidents during the three years by injury severity is shown in Figure 7. It is good to note that the number of fatal accidents is reducing each year.
The distribution of all road accidents for 2009 to 2011 by highest injury severity is as shown in Figure 8. Fatal accidents constitute over one-third of all police reported road accidents on SH6 while nearly half of the road accidents had the highest injury severity as hospitalized. Hence, over 80% of the road accidents on SH6 involved killed or seriously injured victims.

**Time of Accidents**

The police reported accidents were then plotted against time durations of 3 hours to identify times when accidents increase.
The data shows highest number of accidents occurred during the time durations of 09:01 to 12:00 hrs and 15:01 to 18:00 hrs. Also the highest number of killed or seriously injured accidents took place during these same time durations. Interestingly the number of accidents is highest in the day or late evening with 80% of the accidents occurring between 09:00 to 24:00 hrs. Time duration of 00:01 to 09:00 hrs does not have a significant effect on roads accidents.

Road Users Involved
As can be seen from Figure 10, trucks (41%) are the highest involved vehicles in road accidents followed by motorized two wheelers (17%), cars (14%) and pedestrians (13%). These four road user types constitute 85% of the road users involved in road accidents on SH6. Unknown road users (4%) were usually vehicles involved in hit-and-run cases and hence were not identifiable from the police reports.

Figure 10: Percentage distribution of road user types involved in the accidents on SH6

Killed/Seriously Injured Road Users
As shown in Figure 11, motorized two wheelers (27%) were the most vulnerable road users being involved in fatal or hospitalized road accidents, followed by pedestrians (25%), trucks (21%) and cars (15%). These four road user types constitute 88% of the road users killed or seriously injured in road accidents on SH6. Unknown road user types (1%) were not clearly identifiable from the police reports.

Figure 11: Percentage distribution of road user type killed or seriously injured on SH6
Motorized two wheelers and pedestrians account for 30% of the road users involved in road accidents, but constitute 52% of the killed or seriously injured road users. Hence, they are considered as the most vulnerable road users on the SH6. Cars are the next most vulnerable road users on SH6 (involvement is 14% while killed/seriously injured is 15%). Trucks have a high involvement in road accidents (41%) while they also constitute one-fifth (21%) of the killed or seriously injured road user types.

**Crash Configuration**

The 152 accidents were distributed as per the crash configurations and results were plotted as shown below in Figure 12. The definitions for the various types of crash configurations are provided in Appendix C.

![Crash Configuration Chart](image)

- **Figure 12:** Percentage of accidents on SH6 by crash configuration and injury severity

Front-rear collisions (36%) constitute highest number of accidents involving killed or seriously injured victims followed by pedestrian impacts (28%), head-on collisions (10%) and rollovers (7%) on SH6. These four crash configurations together constitute 82% of the total accidents.

Based on the above details the following are the important points:

1. There is a high involvement of trucks in road accidents on SH6.
2. Motorized two wheelers, pedestrians and cars are the major affected road user types.
3. Trucks not only have a high involvement in road accidents, but also are the third highest killed or seriously injured road users on SH6.
4. Front-rear collisions, pedestrian impacts, head-on collisions and rollovers are the major crash type occurring on the SH6.

To understand these accidents in more detail, the crash configuration for each accident was analyzed to understand the pre-crash event (critical event leading to the crash) and the reasons for the occurrence of the pre-crash event. The following sections show the results of the analysis.
**In-Depth Analysis of Police Data**

The four major crash configurations are analyzed in detail below to understand and identify the pre-crash events and the contributing infrastructure factors that led to these road accidents.

**Front-Rear Collisions (54 out of 152, 35%)**

The 54 front-rear collisions were distributed as per the vehicle type and their respective injury severity. The results were plotted as shown below in Figure 13.

![Figure 13: Percentage distribution of road user types in front-rear collisions on SH6 by injury severity](image)

Out of 54 road users sustaining serious injuries, motorized two wheelers were the highest affected road users constituting 34% followed by trucks (30%) and cars (18%). It is also observed that 80% of the affected vehicles in front-rear collisions are motorized two-wheelers, trucks and cars.

**Pre-crash event**

Front-rear collisions were analyzed to identify and determine the pre-crash event leading to the collision. The results are as shown below in Figure 14.

![Figure 14: Pre-crash events for front-rear collisions on SH6](image)

From Figure 14 above, it is evident that most of the front-rear collisions were caused due to parked or stationary vehicles on the road side. Vehicles that were parked alongside the road, also occupied part of the driving lane due to insufficient shoulder widths. Thirty five (35%) of the front-rear collisions were caused by vehicles which slowed down in the front due to various factors.
probable reasons (taking U-turns, overtaking, intersections, turning in or off the road, etc.) which was not available in police records.

The main pre-crash event, i.e. parked/standing on road side was analyzed for the parked vehicles by their vehicle types as shown in the Figure 15 below.

![Figure 15: Type of the parked vehicles involved in 26 front-rear collisions](image)

As can be seen from Figure 15, trucks constitute 85% (22 out of 26) of the vehicles which were parked alongside the road causing a front-rear collision on SH6. This indicates that trucks parked on roadside need to be considered for road safety improvements.

**Problems identified:**
The following are the problems identified that lead to front-rear collisions. These problems need to be clearly understood from in-depth accident investigations.

1. *Front-rear collisions involving parked trucks on the road side.*
2. *Front-rear collisions involving vehicles slowing down.*

**Pedestrian Impacts (39 out of 152, 26%)**
The 39 pedestrian accidents were distributed as per the struck vehicle type and the resulting injury severity of the pedestrian. The results are plotted as shown below in Figure 16.

![Figure 16: Percentage distribution of pedestrian impacts on SH6 by struck vehicle type and the resulting injury severity of the pedestrian](image)
As shown in the Figure 16, highest percentages of fatal or hospitalized pedestrian impacts were caused due to trucks (28%) followed by cars (26%) and motorized two wheelers (23%). Vehicle type was not available for seven (7) accidents in police records, which were probably hit and run cases and were hence coded as unknown vehicle type.

**Pre-crash event**

Pedestrian impacts are considered as the most dominant single vehicle accidents and hence the pre-crash events for these accidents were looked into to understand the pedestrian and vehicle activity just before impact. The results were plotted in Figure 17. In 59% of the pedestrian impacts, the pedestrian was walking alongside or crossing the road. This indicates the urgent attention required towards pedestrian infrastructure like footpaths/sidewalks and pedestrian crossings.

![Pre-crash event - Pedestrian Impacts](image)

**Figure 17: Pre-crash events for pedestrian impacts on SH6**

In 5 pedestrian impacts coded as Vehicle Backing Up (13%), the pedestrian got hit by vehicles reversing. In these cases, pedestrians were behind the vehicle (standing, sleeping or sitting), and the driver of the vehicle unknowingly reversed the vehicle and ran over them. For 28% of the pedestrian impacts, the exact pre-crash event could not be noted from the police records and usually involved hit and run cases. In most cases the pedestrians were walking alongside the road or crossing and these were especially at junctions (also called “chokdi” in local language) near villages, companies and bus stands.

**Problems identified:**

The following are the problems identified that lead to pedestrian impacts. These problems need to be clearly understood from in-depth accident investigations.

1. **Pedestrian impacts while pedestrians are walking alongside the road.**
2. **Pedestrian impacts while pedestrians are crossing the road.**

**Head-on Collisions (19 out of 152, 13%)**

The 19 head-on collisions were distributed as per the vehicle type and their respective injury severity. The results were plotted as shown below in Figure 18.
Cars constitute 42% of the vehicle types affected in killed or seriously injured head-on collisions followed by motorized two wheelers (33%) and trucks (25%).

**Pre-crash event**
Head-on collisions were analyzed to identify and determine the pre-crash event leading to the collision. The results are as shown below in Figure 19.

Head-on collisions were mostly caused by vehicles travelling in the wrong direction as seen in Figure 19. As per our observation, vehicles used to travel in the opposite direction to access the nearest U-turn or driveway. This led to head-on collisions with oncoming vehicles. Eleven (11%) of the head-on accidents were due to vehicles losing control and crossing the median. These vehicles then hit other vehicles coming in the opposite direction on the other side of the median.

The vehicles travelling in the wrong direction were identified and the result is plotted in Figure 20 below.
As can be seen from the figure, trucks constitute 69% of vehicles travelling in wrong direction, followed by cars (15%).

Problems identified:
The following are the problems identified that lead to head-on collisions. These problems need to be clearly understood from in-depth accident investigations.

1. Head-on collisions due to vehicles (usually trucks) travelling in the wrong direction.
2. Head-on collisions due to vehicles losing control and crossing the median.

Rollovers (12 out of 152, 8%)
The 12 rollovers were distributed as per the vehicle type and their respective injury severity. The results were plotted as shown in Figure 21 below.

The above graph shows that, trucks constitute 62.5% of the vehicles with killed or seriously injured victims due to rollovers on SH6. It can be noted that most of the rollover accident cases (8 out of 12) reported are either fatal or seriously injured cases. It was observed that minor injury rollover accident cases are generally not reported to the police.
**Pre-crash event**
Out of the 12 rollovers which occurred 50% of them were stated in police reports to be caused due to vehicle loss of control. Exact reason for the loss of control in these cases could not be found in the police reports. Also, for the rest of 50% cases, the police report does not mention any clear reason for these rollovers.

**Problems identified:**
Rollover accidents, especially involving trucks, need to be clearly understood from in-depth accident investigations.

**Summary of police data analysis**
Based on the above data analysis, the important findings are listed below:

1. Front-rear collisions are the highest in occurrence on SH6. This was caused due to parked/standing vehicles (mostly trucks) on the road side, or due to vehicles slowing down for unknown reasons.
2. Pedestrian impacts were the second highest in occurrence. In most cases the pedestrians were walking alongside the road or crossing and these were especially at junctions (also called “chokdi” in local language) near villages, companies and bus stands.
3. Head-on collisions were due to vehicles (mostly trucks) travelling in the wrong direction or because of vehicles losing control and crossing the median onto the other side.
4. Rollover accidents involved a high number of trucks but the exact reasons could not be ascertained from the police records.

*JPRI then analyzed the on-site accident investigation data to get a better understanding of the infrastructure problems causing the above.*

**Accident Investigation Data**
With the support of iRAP, the Gujarat Engineering Research Institute (GERI), and the Bharuch District Police, the JPRI team performed detailed investigations of accidents that occurred along the stretch of SH6 defined as the study area. In-depth data was collected on all accidents occurring in this area from 01 December 2011 to 14 January 2012. During this period, 11 accidents had taken place along this stretch out of which only 9 were examined in detail. Two (2) could not be examined in detail due to late notification from police and insufficient data on scene.

**General Overview of Accident Investigation Data**

**Injury Severity**
A total of 11 traffic accidents occurred on the study stretch of SH6 over a period of 45 days. These accidents involved a total of 5 fatal victims and 6 minor-injury victims. As shown in Figure 22, 36% of the accidents examined during this study period resulted in fatalities.

No accidents were seen during the study period with the highest injury severity as hospitalized or grievous injuries.
Road Users Involved

The percentages of the road users involved in road accidents examined on SH6 are shown in Figure 23.

Trucks (52%) formed the majority of the accident-involved vehicles, followed by pedestrian (18%), motorized two-wheelers (18%) and finally cars and buses (6% each).

Killed/Seriously Injured Road Users

As per Figure 24, pedestrians (50%) and motorcyclists (50%) were the only fatal victims of accidents.
Out of the 2 pedestrian impacts, one of them involved two pedestrians who were walking alongside the road in the night when a truck hit them from the back killing them both on the spot. In a rather peculiar type of accident, a road under construction was used as a parking space for buses. A bus while trying to park, hit a large non-fixed concrete barrier that was kept on the road. The barrier then fell on a person who was sitting in front of it, and killed him on the spot. This victim was considered as a pedestrian. Out of two M2W fatal accidents, one was single vehicle accident. The rider lost the control of the bike and slipped. The other M2W accident was a front-side accident, which happened at an intersection when the motorized two-wheeler was crossing the intersection.

**Crash Configuration**

Out of the 11 accidents examined, the crash configuration was determined and the results are as shown in Figure 25. Most of the accidents seen were rollovers (37%). Front-side collisions and pedestrian impacts were equally distributed (18% each).

![Figure 25: Percentage of accidents by crash configuration and injury severity examined on SH6](image)

Based on the above details the following are the important points observed during the accident investigations:

1. There is a high involvement of trucks in road accidents on SH6.
2. Motorized two wheelers and pedestrians were the only road users on SH6 with fatal injuries.
3. Pedestrian impacts were the most severe crash types observed on SH6.
4. A high number of rollovers were examined, but most of them were not police reported cases as they involved minor injuries.
Comparison of Police Data and Accident Investigation Data

The data obtained from police records for the three years and the data obtained from crash investigations by JPRI have been compared in the table 5 below:

<table>
<thead>
<tr>
<th></th>
<th>Police Data</th>
<th>JPRI Accident Investigation Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Duration</td>
<td>3 years</td>
<td>45 days</td>
</tr>
<tr>
<td>Number of accidents</td>
<td>152</td>
<td>11 (only 5 were police reported)</td>
</tr>
<tr>
<td>Killed/Seriously Injured Road Users</td>
<td>M2W (27%), Pedestrians (25%), Truck (21%), Car (15%), Others (M3W, Bus, Bicycle, Unknown) (12%)</td>
<td>Pedestrians (60%), M2W (40%)</td>
</tr>
<tr>
<td>Crash Configuration</td>
<td>Front-Rear (35%), Pedestrian Impact (26%), Head-On (13%), Rollover (8%)</td>
<td>Rollover (37%), Pedestrian Impact (18%), Front-Side (18%), Front-Rear (9%)</td>
</tr>
</tbody>
</table>

Table 5: Comparison of police data and accidents examined on SH6

Based on the above comparison, the following observations have been made:

1. As per the accident investigation study, there were on an average of 7 accidents per month (11 in 45 days), whereas police records show only 4 accidents per month (152 cases in 3 years).
2. Only 5 out of the 11 accidents (45%) examined on this stretch were reported by police. The other 6 accidents were not recorded since it resulted in minor or no injuries. In this aspect, the data from police records could have an under reporting of minor and no injury cases. Underreporting is seen in single vehicle accidents such as rollovers which do not involve fatalities and multiple vehicle accidents involving only minor or no injuries.
3. Data from police reports show that front-rear collisions, head-on collisions, pedestrian impacts and rollovers are the four major crash configurations on SH6. While data from accident investigations show that rollovers, pedestrians, front-side and front-rear are the four major crash configurations on SH6.
4. Police reports show that rollover accidents account for 8% of the total accidents whereas data from the accident investigation study show that rollovers constitute 37% (4 out of 11).
5. Pedestrians and motorized two wheelers were the most affected road users observed on SH6.

As the sample size of the data obtained from the accident investigation study is too small to be a representative sample of accidents on SH6, hence, this data has been used to understand the pre-crash events of the accidents noted in the police data better.
**Front-Rear Collisions**

As per police data, front-rear collisions account for 35% of accidents on SH6 and are also the most severe accidents. It has already been identified using police data that the major problems leading to these accidents are:

1. *Parked trucks on the road side.*
2. *Vehicles slowing down.*

These problems have been examined by JPRI through field investigations and are discussed below:

**Parked/Standing vehicles (usually trucks) on the road side**

During the study period no crashes were observed as a result of this pre-crash event. Pictures depicting this problem, as seen by researchers, are shown below.

![Figure 26: Parked/standing vehicles on road side](image)

As can be seen from the pictures, the road side paved shoulder width (1.5 m) is insufficient for parking heavy vehicles (like trucks). When trucks are parked on these shoulders, part of the truck width is on the main carriageway and obstructs traffic. This condition leads to front-rear collisions, especially when the vehicle in the rear does not realize that the vehicle in front is parked/standing on the road side.

**Identification of contributing infrastructure factor**

Based on the above it can be seen that narrow paved shoulders (1.5 m width) influence front-rear collisions due to parked/standing vehicles.

**Vehicles slowing down**

During the study period there was only one front-rear collision examined. In this accident, a driver of a truck entered the highway from the driveway of Welspun Company. After joining the highway, the truck was rear-ended by another truck travelling at a higher speed. This problem was caused due to the truck joining the main highway at a lower speed compared to other vehicles travelling on the highway.
Identification of contributing infrastructure factor
The following infrastructure factors can be seen to be influencing these accidents:

1. Non-availability of merging/entry/exit lanes for vehicles turning in/off the highway and at gaps-in-medians (U-turns).

2. Narrow paved shoulders (1.5 m width) can also create this problem due to vehicles slowing down on seeing parked vehicles in front.

Pedestrian Impacts
As per police data, pedestrian impacts account for 26% of accidents on SH6 and 28% of killed/severely injured accidents. It has already been identified using police data that the major problems leading to these accidents are:

1. Pedestrians walking alongside the road.
2. Pedestrians crossing the road.
Pedestrians walking alongside the road

In this pedestrian impact case examined by JPRI, two pedestrians were walking along the roadside at night. They were hit from behind by a truck and both of them were fatal on the spot. This was a hit and run case.

Pedestrians crossing the road

As many of the pedestrian impacts were at junctions to village roads (called “chokdis” in local language), these junctions could be modified to accommodate better pedestrian separation facilities and slow down traffic in these areas.

Proper pedestrian facilities were not seen at various junctions, crossing, bus stands and driveways due to which the pedestrians were seen walking on the roadway and sharing the same space as motorists. This resulted in vehicles impacting the pedestrians. Pictures illustrating the major pedestrian pre-crash event - pedestrian walking/standing alongside the road are shown below.

Identification of contributing infrastructure factors

The following infrastructure factors can be seen to be influencing these accidents:

1. Non-availability of proper pedestrian infrastructure like footpaths.
2. Lack of pedestrian separation facilities at bus stops, intersections, villages, etc.
3. Absence of zebra crossing/pedestrian crossing warning signs and lighting at intersections.
4. Lack of speed reduction devices at high pedestrian density areas such as bus stops, intersections, company driveways, etc.
**Head-On Collisions**

As per police data, head-on collisions account for 13% of accidents on SH6 and 10% of killed/severely injured accidents. It has already been analysed that vehicles travelling in wrong direction (usually trucks) account for 68% of head-on collisions. Vehicles losing control and crossing the median, leading to head-on collisions with oncoming vehicles was a second cause. No head-on collisions were reported during the study period. It has already been identified using police data that the major problems leading to these accidents are:

1. **Vehicles (usually trucks) travelling in the wrong direction.**
2. **Vehicles losing control and crossing the median.**

**Vehicles travelling in the wrong direction**

As per the police data, majority of head-on collisions were reported due to vehicles that were travelling in wrong direction (68%). JPRI researchers observed that vehicles travel in opposite direction to access a driveway or junction quicker in comparison to going in the correct direction and taking a U-turn which would mean travelling a longer distance and spending more time/fuel. Figure 31 illustrates this major problem for head-on collisions.

![Figure 31: Travelling in wrong direction](image)

**Identification of contributing infrastructure factor**

The main infrastructure factor seen to be influencing these accidents are improper location of gaps-in-median in relation to driveways and joining roads.

**Vehicles losing control**

Police data did not have sufficient information to understand the reasons for these accidents. JPRI researchers did not come across any such case during the study period. Hence, this issue, although less significant in comparison to other crash types, still needs to be investigated in detail.

**Identification of contributing infrastructure factor**

The main infrastructure factor influencing these accidents could not be properly determined due to insufficient data as mentioned above. Crash barriers, at the sites where loss of control problems occur, could be a solution for preventing vehicles from jumping into the oncoming lanes and causing head-on collisions.

**Rollovers**

As per police data, rollover accidents account for 8% of accidents on SH6 and 7% of killed/severely injured accidents. The reasons for these accidents could not be determined from police data. However, four rollover accidents were examined during the study period. Of the 4 cases, 2 rollover accidents involved vehicles falling over on to the road side due to road
constructions which created a large difference in height of the road and the road side area. One rollover occurred when a truck tried to avoid a head-on collision with another oncoming truck travelling in the wrong direction. Reasons for the fourth rollover could not be ascertained as the accident could not be examined in detail due to late notification. Out of the 4 rollovers, only one is reported to the police. This indicates that rollover accidents resulting in minor or no injuries are underreported in police data.

The major problems identified using JPRI crash investigation data, leading to these accidents are:

1. Vehicles rolled off the road edge due to road under construction.
2. Vehicles (usually trucks) travelling in the wrong direction.

**Vehicle rolled off the road edge**

The SH6 stretch was under construction for converting the 4-lane road into 6-lane road. It was noticed that at most places, the edge of the road had been dug up (as shown in Figure 32 below) without any kind of a warning sign or a delineator to warn motorists of the sudden change in height of the road and the road side area. This caused vehicles travelling on the edge of the road to fall over into the ditch when they manoeuvred towards the road edge.

![Image](figure32.png)

**Figure 32:** The road edge was dug up without any barrier or delineator for warning drivers

**Identification of contributing infrastructure factor**

The main infrastructure factor seen to be influencing these rollovers are road constructions where road side areas are dug up. This problem can be reduced through use of proper signage and delineation during road construction work.

**Rollovers due to avoiding vehicles travelling in the wrong direction**

Roadside topography was of a downhill grade near a few places on the stretch as shown in Figure 33. Vehicles sometimes went to the edge of the road while trying to avoid any oncoming vehicle. Subsequently the vehicles would rollover into the ditch.
Figure 33: Absence of crash barriers where the road side is steep, caused vehicles to roll to the side

**Identification of contributing infrastructure factor**

Based on the above it can be seen that:

2. Crash barriers at such locations could help prevent vehicles from rolling off the road side.

**Front-Side Collisions**

Front-side collisions account for only 3% of police reported data, but during the study period, two (2) front side cases were examined out of which one was fatal. In this fatal accident, an over speeding car hit a motorized two wheeler on its left side at the intersection shown in Figure 34 on SH6.

Figure 34: Scene diagram of a front-side collision on SH6
Vehicles travel in high speeds near intersections increase the chances of intersection accidents between vehicles on SH6 and crossing-over vehicles. Hence it is important to reduce the speed of vehicles approaching the intersections. In this regard, traffic calming devices such as roundabouts can be considered as a road safety measure to avoid intersection accidents.

Also intersections having staggered crossroads caused driver vision obstruction for vehicles trying to cross over as they cannot see vehicles coming towards the junction on SH6. Vehicles crossing staggered intersections cross the road obliquely, thus causing them to spend more time in the middle of the junction which is not safe.

**Identification of contributing infrastructure factor**

Based on the above it can be seen that:

1. Staggered intersections.
2. Driver vision obstruction due to plants.
3. Lack of traffic calming devices to slow down traffic at junctions/intersections.

**Conclusions**

Based on the above analysis of accidents on SH6, the results of the road safety issues and the contributing infrastructure factors have been tabulated below:

<table>
<thead>
<tr>
<th>Crash Configurations</th>
<th>Pre-crash Event</th>
<th>Contributing Infrastructure Factor</th>
<th>Percentage Contribution (out of 152 accidents in 3 years)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Front-Rear Collisions</td>
<td>Parked vehicles</td>
<td>Insufficient shoulder width</td>
<td>17.10%</td>
</tr>
<tr>
<td></td>
<td>Slowed down vehicles</td>
<td>Junctions/Gaps-in-median</td>
<td>12.50%</td>
</tr>
<tr>
<td>Pedestrian Impacts</td>
<td>Walking alongside and crossing the road</td>
<td>Poor Pedestrian Infrastructure</td>
<td>15.13%</td>
</tr>
<tr>
<td>Head-On Collisions</td>
<td>Traveling in wrong lane</td>
<td>Junctions/Gaps-in-median</td>
<td>9.21%</td>
</tr>
<tr>
<td></td>
<td>Loss of Control</td>
<td>Unknown</td>
<td>1.30%</td>
</tr>
<tr>
<td>Rollovers</td>
<td>Loss of Control/Avoiding vehicle in wrong direction</td>
<td>Unknown/Gaps-in-median</td>
<td>3.94%</td>
</tr>
<tr>
<td></td>
<td>Infrastructure issues</td>
<td>Road Under Construction</td>
<td>3.94%</td>
</tr>
<tr>
<td>Front-Side Collisions</td>
<td>Vehicles crossing</td>
<td>Junctions</td>
<td>3%</td>
</tr>
</tbody>
</table>

Table 6: Determination of contributing infrastructure factors and their influence on accidents
Areas of improvement in infrastructure
1. From the above table we see that gaps-in-medians/junctions influence at least 25% of accidents on SH6.
2. Narrow shoulder widths result in 17% of the road accidents due to vehicles parking on the road side.
3. Poor pedestrian infrastructure resulted in pedestrian impacts which constituted 15% of the accidents.
4. Rollovers account for a small percentage in police records. But as most rollovers involving minor or no injuries are not reported, JPRI believes that these single-vehicle accidents need to be considered for improving infrastructure.

Road users to be considered
1. Trucks – High involvement in accidents
2. Cars – High volume and speed
3. M2Ws and Pedestrians – Most vulnerable road users

Other important issues to be considered
1. Road signs and advance warnings to drivers about upcoming junctions, pedestrian crossings and gaps-in-medians should be installed to communicate with the drivers before-hand about the road environment ahead.
2. Better pedestrian infrastructure is very essential in places where there is more pedestrian density (near villages, companies, bus stops, junctions/intersections, etc.).
3. Plants on the median should be trimmed near U-turns, which would improve driver visibility when approaching a junction/intersection or gap-in-median.
4. Speed limits need to be updated. But this is a challenge considering the wide variation in speed as well as vehicle types. Lane separation for separating slow moving vehicles from fast moving vehicles should be considered before enforcing speed limits.
5. Truck lay-bys should be made available with sufficient facilities for road users to avoid parking on road side.
SH13: Baseline Data Collection

Shown above is a picture of the State Highway 13 (SH13) from Ankleshwar to Valia. This road is a 2-lane undivided road. A truck can be seen overtaking an auto rickshaw (slow moving vehicle). A two-wheeler rider trying to avoid the truck is also in the picture. Again, as in SH6, the paved shoulder seems too narrow in width.
The following sections describe the area of study, data collected, findings and conclusions for the State Highway 13 (SH13) corridor from Ankleshwar to Valia.

**The Study Area**

The study area, a 30 km stretch of SH13 connecting Ankleshwar to Valia was selected based on instructions provided by iRAP for performing traffic volume, speed and accident data collection.

SH13 is a two lane undivided road with the lanes separated by white broken line (road marking). The road has paved shoulders of 1.5 m on both sides along the stretch. Ankleshwar section of SH13 is an industrial area which houses the Gujarat Industrial Development Corporation (GIDC), mostly urban/semi-urban, with a lot of shops, buildings, and hospitals, while Valia section of SH13 is rural area connecting small towns and villages.

**Traffic Volume and Speed Data**

The following section gives details of the traffic volume and speed data collection for SH13.

**Spot Selection**

The stretch was carefully studied to determine places where significant traffic was being added to the highway or being subtracted from it. These places usually include major towns or villages that draw frequent on/off traffic, either as destinations in themselves or as connections to some other place. Such locations offer a good idea of the traffic volume for the whole stretch selected. The study sites on SH13 have been identified as per the Global Positioning System (GPS) coordinates provided in Table 1, and they are shown graphically in Figures 1 and 2.

<table>
<thead>
<tr>
<th>Sites</th>
<th>GPS Coordinates</th>
<th>Area Type</th>
<th>Posted Speed Limit (kmph)</th>
</tr>
</thead>
<tbody>
<tr>
<td>E</td>
<td>21° 34' 50.70&quot; N 73° 11' 16.56&quot; E</td>
<td>Rural</td>
<td>Not Available</td>
</tr>
<tr>
<td>F</td>
<td>21° 33' 50.84&quot; N 73° 07' 19.82&quot; E</td>
<td>Rural</td>
<td>Not Available</td>
</tr>
<tr>
<td>G</td>
<td>21° 34' 49.10&quot; N 73° 03' 16.46&quot; E</td>
<td>Rural</td>
<td>Not Available</td>
</tr>
</tbody>
</table>

Table 1: GPS Coordinates, area type and posted speed limit of the three study sites on SH13

Figure 1: Screen shot from Google Earth, showing the study sites (Sites E, F and G)
Data Sample Collected

Data collection for traffic volume count and speeds was as per the guidelines laid down by iRAP. Please refer to the “iRAP Baseline Data Collection in India – Inception Report” published by JPRI on November 1, 2011.

The data sample collected for traffic volume count and speed on all sites of SH13 at 3 time durations (06:01 to 12:00, 12:01 to 18:00 and 18:01 to 24:00) is shown below:

- 3 locations were monitored (Sites E, F and G).
- 3655 vehicles were counted during three time durations.
- 3246 speeding incidents were recorded.
- 755 minutes of data was collected.

The status of data collection (speed and traffic volume) at all study sites at different time durations are shown in Table 2.
Night time data was not collected in sites E, F and G due to safety concerns. Data collection was not done during the time duration 00:01 to 06:00 hrs in all three sites; while in site E data collection was not done even during time duration 18:01 to 24:00 hrs. This was due to the fact that researchers were told that local inhabitants in these areas often resorted to robberies by stopping vehicles in the night time and stealing their belongings. Researchers were advised not to be in this area after 7pm in the evening as it was dangerous.

Traffic Volume Count
To standardize the observed time for comparison, JPRI normalized the count in a given site for a given 6 hours’ time duration to an one hour sample. This was done by using the following formula.

\[
\text{Number of vehicles passing in one hour at one site} = \frac{\text{Number of vehicles counted in time } (t, \text{ in minutes}) \times 60 \text{ minutes}}{(t, \text{ in minutes})}
\]

This one hour sample was then extrapolated to the specific 6 hours’ time duration. The end results were then added to get an estimation of the number of vehicles passing through a given site in 18 hours. Based on the above calculation, the new total vehicle count obtained for SH13 is \(28716\) and the total vehicle count at each site is as show below in Figure 3.

The 18 hour data sample for traffic volume count was distributed by vehicle type and the result is as shown in Figure 4. *The definition for each vehicle type is provided in Appendix A.*

---

<table>
<thead>
<tr>
<th>Study sites</th>
<th>00:01 to 06:00 hrs</th>
<th>06:01 to 12:00 hrs</th>
<th>12:01 to 18:00 hrs</th>
<th>18:01 to 24:00 hrs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Site E</td>
<td>Data not collected</td>
<td>Data collected</td>
<td>Data collected</td>
<td>Data not collected</td>
</tr>
<tr>
<td>Site F</td>
<td>Data not collected</td>
<td>Data collected</td>
<td>Data collected</td>
<td>Data collected</td>
</tr>
<tr>
<td>Site G</td>
<td>Data not collected</td>
<td>Data collected</td>
<td>Data collected</td>
<td>Data collected</td>
</tr>
</tbody>
</table>

Table 2: Status of traffic speed and volume data collected at different study sites on SH13
Figure 4 indicates that motorised two wheelers (38%) constituted the highest road user type counted on the SH13. This was followed by cars (31%) and trucks (18%). Other motor vehicles, buses, pedestrians, bicyclists and non-motorized vehicles together accounted for only 13% of the total traffic volume.

Figure 4: Percentage composition of road users counted on SH13
(Sample Size: 28716 vehicles counted at all sites during the three time durations*)

*Data not collected at site E for time duration "18:01hrs to 24:00hrs"

Traffic volume percentage counts for each time duration
Traffic volume counts were taken at different duration of the day (the three time durations) at each of the three study sites (E, F, and G). The data for each time duration is as shown in Figure 5.
The “85th percentile speed” is the speed at or below which 85% of the vehicles were found to travel. This measure is different from the “average” speed. By omitting speed variations possibly caused by very few vehicles that travelled at high speeds (variations that would necessarily be included if a simple average was calculated), the 85th percentile reflects the speed at which most vehicles travel on a given stretch of road. The overall 85th percentile speed for each vehicle type (averaged across all three sites) is shown in Figure 6.

It can be seen from Figure 6 that cars were found to be travelling the fastest with 85th percentile speed of 79 kmph. Cars were followed by buses, trucks and motorized two wheelers with 85th percentile speeds of 63 kmph, 61 kmph, and 58 kmph respectively. The 85th percentile speed for all vehicles was 70 kmph, and it was 62 kmph when cars were excluded from the calculation.

Findings and Observations
The following are the findings and observations of the speed and traffic volume count study on SH13:

- Motorized two wheelers, cars and trucks were seen to be the highest number of road users on SH13 in all three time durations.
- Trucks are the third highest road users, but constitute only 18% of the traffic volume.
• Traffic volume increases from site E to Site G, i.e. while moving from Valia to Ankleshwar indicating urban influence. Valia is rural while Ankleshwar is urban.
• 85th percentile speed for cars was the highest at 79 kmph.
• 85th percentile of all vehicles on the stretch was 70 kmph, and it was 62 kmph when cars were excluded.
• Cars, including vans and jeeps, are used as private transport vehicles and most people commute to work and back in them. This and the low volume of buses highlight the lack of public transportation facilities.

A summary is provided below for the speed and traffic volume data for each site.

<table>
<thead>
<tr>
<th>Site</th>
<th>Traffic Speed</th>
<th>Traffic Volume Count</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>SITE G</strong></td>
<td>Car – 76 kmph</td>
<td>Car – 29%</td>
</tr>
<tr>
<td></td>
<td>Bus – 67 kmph</td>
<td>Bus – 2%</td>
</tr>
<tr>
<td></td>
<td>Truck – 58 kmph</td>
<td>Truck – 19%</td>
</tr>
<tr>
<td></td>
<td>M2W – 58 kmph</td>
<td>M2W – 39%</td>
</tr>
<tr>
<td></td>
<td>Others – 46 kmph</td>
<td>Others – 9%</td>
</tr>
<tr>
<td></td>
<td>All vehicles – 67 kmph</td>
<td>Bicycle – 1%</td>
</tr>
<tr>
<td></td>
<td>Total Count – 12798</td>
<td>Pedestrian – 1%</td>
</tr>
<tr>
<td><strong>SITE F</strong></td>
<td>Car – 75 kmph</td>
<td>Car – 31%</td>
</tr>
<tr>
<td></td>
<td>Bus – 59 kmph</td>
<td>Bus – 2%</td>
</tr>
<tr>
<td></td>
<td>Truck – 59 kmph</td>
<td>Truck – 18%</td>
</tr>
<tr>
<td></td>
<td>M2W – 55 kmph</td>
<td>M2W – 36%</td>
</tr>
<tr>
<td></td>
<td>Others – 46 kmph</td>
<td>Others – 10%</td>
</tr>
<tr>
<td></td>
<td>All vehicles – 67 kmph</td>
<td>Bicycle – 1%</td>
</tr>
<tr>
<td></td>
<td>Total Count – 11514</td>
<td>Pedestrian – 1%</td>
</tr>
<tr>
<td><strong>SITE E</strong></td>
<td>Car – 86 kmph</td>
<td>Car – 31%</td>
</tr>
<tr>
<td></td>
<td>Bus – 72 kmph</td>
<td>Bus – 3%</td>
</tr>
<tr>
<td></td>
<td>Truck – 67 kmph</td>
<td>Truck – 16%</td>
</tr>
<tr>
<td></td>
<td>M2W – 61 kmph</td>
<td>M2W – 41%</td>
</tr>
<tr>
<td></td>
<td>Others – 48 kmph</td>
<td>Others – 6%</td>
</tr>
<tr>
<td></td>
<td>All vehicles – 77 kmph</td>
<td>Bicycle – 2%</td>
</tr>
<tr>
<td></td>
<td>Total Count – 4404</td>
<td>Pedestrian – 1%</td>
</tr>
</tbody>
</table>
**Police Data**

Police reported accident data was collected from two police stations (whose jurisdiction includes the study area, namely Valia police station and Ankleshwar police station). Police records showed 63 accidents were reported on SH13 during 2009 to 2011 (1st January 2009 to 30th November 2011) between Ankleshwar and Valia. The status of police data collection for SH13 is as shown in Table 3 below.

<table>
<thead>
<tr>
<th>Police Station</th>
<th>2009</th>
<th>2010</th>
<th>2011</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valia</td>
<td>Data collected</td>
<td>Data collected</td>
<td>Data collected</td>
</tr>
<tr>
<td>Ankleshwar</td>
<td>Data collected</td>
<td>Data collected</td>
<td>Data collected</td>
</tr>
</tbody>
</table>

Table 3: Status of police reported accident data collection on SH13

*Each police reported accident was personally reviewed by researchers by accessing police registers for case details and coded in a standardized coding form prepared by JPRI (Appendix B).*

The data collected and analyzed is presented below:

**General Overview of Police Data**

**Injury severity**

Highest injury severity of an accident in the police record was confirmed by researchers by looking at the Section of Indian Penal Code (IPC) under which the case was booked. The IPC sections for road traffic accidents and their interpretations for highest injury severity of the road accident are explained in Table 4.

<table>
<thead>
<tr>
<th>INDIAN PENAL CODE SECTION</th>
<th>DEFINITION</th>
<th>HIGHEST INJURY SEVERITY OF THE ACCIDENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>IPC 304(A)</td>
<td>Causing death by negligence</td>
<td>Fatal/Killed</td>
</tr>
<tr>
<td>IPC 338</td>
<td>Causing grievous hurt by act endangering life or personal safety of others</td>
<td>Hospitalized/Grievous</td>
</tr>
<tr>
<td>IPC 337</td>
<td>Causing hurt by act endangering life or personal safety of others</td>
<td>Minor Injury</td>
</tr>
<tr>
<td>IPC 279</td>
<td>Rash driving or riding on a public way</td>
<td>No Injury</td>
</tr>
</tbody>
</table>

Table 4: Sections of Indian Penal Code (IPC) relating to road traffic accidents and their interpretation for injury severity.

A total of 63 accidents resulted in 21 fatal victims and 41 injured victims. The accidents were divided based on the highest injury severity for each road accident. The distribution of accidents during the three years by injury severity is shown in Figure 7. Although the number of police reported accidents is very low, it should be noted that fatal accidents show an increasing trend year on year.
The accidents were divided based on the highest injury severity for each accident. The result can be seen as shown in Figure 8, out of the 63 accidents, 34% were fatal, 27% were grievous and involved hospitalization, while 39% involved minor injuries.

**Figure 8: Road accidents on SH13 distributed by highest injury severity (2009 to 2011 – 63 road accidents)**

**Time of Accidents**
The police reported accidents were then plotted against time durations of 3 hours to identify times when accidents increase.

**Figure 9: Distribution of accidents on SH13 over different time durations**
The data shows a high number of accidents occur between 15:01 to 21:00 hrs. Also the highest number of accidents involving killed/seriously injured victims takes place in the evening hours of 18:01 to 21:00 hrs.

**Road Users Involved**

As can be seen from Figure 10, motorized two wheelers and trucks (25% and 24% respectively) are the highest involved vehicles in road accidents followed by cars (20%) and pedestrians (14%). These four road user types constitute 83% of the road users involved in road accidents on SH13. Unknown road users (6%) were usually vehicles involved in hit-and-run cases and hence were not identifiable from the police reports.

**Killed/Seriously Injured Road Users**

As shown in Figure 11, motorized two wheelers (42%) were the most vulnerable road users being involved in fatal or hospitalized road accidents, followed by pedestrians (26%), cars (13%) and trucks (8%). These four road user types constitute 89% of the road users killed or seriously injured in road accidents on SH13. Unknown road user types (3%) were not clearly identifiable from the police reports.

Motorized two wheelers and pedestrians account for 49% of the road users involved in road accidents, but constitute 68% of the killed or seriously injured road users. Hence, they can be considered as the most vulnerable road users on the SH13. Cars are the next most vulnerable road users on SH13 (involvement is 20% while killed/seriously injured is 13%). Trucks have a
high involvement in road accidents (24%) while they also constitute only 8% of the killed or seriously injured road user types.

**Crash Configuration**

The 63 accidents were distributed as per the crash configurations and results were plotted as shown below in Figure 12. *The definitions for the various types of crash configurations have been provided in Appendix C.*

![Crash Configuration Chart](image)

**Figure 12: Percentage of accidents on SH13 by crash configuration and injury severity**

Head-on collisions (39%) constitute highest number of accidents involving killed or seriously injured victims followed by pedestrian impacts (26%), rollovers (8%) and sideswipes (8%) on SH13. These four crash configurations together constitute 78% of the total accidents.

Based on the above details the following are the important points:

1. There is a high involvement of motorized two wheelers, trucks and cars in road accidents on SH13.
2. Motorized two wheelers and pedestrians are the major affected road user types.
3. Trucks have a high involvement (24%) in road accidents, but they constitute only 8% of killed or seriously injured road users on SH13.
4. Head-on collisions, pedestrian impacts, rollovers and sideswipes are the major crash types occurring on the SH13.

To understand these accidents in more detail, the crash configuration for each accident was analyzed to understand the pre-crash event (critical event leading to the crash) and the reasons for the occurrence of the pre-crash event. The following sections show the results of the analysis.

**In-Depth Analysis of Police Data**

The four major crash configurations are analyzed in detail below to understand and identify the pre-crash events and the contributing infrastructure factors that led to these road accidents.
Head-on Collisions (24 out of 63, 38%)
The 24 head-on collisions were distributed as per the vehicle type and their respective injury severity. The results were plotted as shown below in Figure 13.

![Figure 13: Percentage distribution of road user types affected in head-on collisions on SH13 by injury severity](image)

Cars constitute 53% of the killed/seriously injured road user types in head-on collisions followed by motorized two wheelers (20%), and trucks and motorized three wheelers (7% each). Most of the fatal victims were motorized two wheeler riders.

**Pre-crash event**
Head-on collisions were analyzed to identify and determine the pre-crash event leading to the collision. The results are shown below in Figure 14.

![Figure 14: Pre-crash events for head-on collisions on SH13](image)

From Figure 14, it is evident that 38% of head-on collisions were caused as result of one of the vehicles overtaking. For 58% of cases, the exact pre-crash event could not be found in the police records, but it is quite understandable that head-on collisions on this undivided 2-lane highway can only occur when a vehicle is travelling in the wrong lane. The reason for this could be either overtaking another vehicle or avoiding an obstacle.

**Problems identified:**
The main problem leading to head-on collisions is vehicles travelling in the wrong lane while overtaking another vehicle or avoiding an obstacle on the road.
Pedestrian Impacts (16 out of 63, 25%)
The 16 pedestrian impacts were distributed as per the struck vehicle type and the resulting injury severity of the pedestrian. The results were plotted as shown below in Figure 15.

![Figure 15: Percentage distribution pedestrian impacts on SH13 by struck vehicle type and the resulting injury severity of the pedestrian](image)

From Figure 15, it is evident that half of the pedestrian impacts are caused due to motorized two wheelers and trucks. Vehicle type was not available for two (2) accidents in police records, which were probably hit and run cases and were hence coded as unknown vehicle type.

**Pre-crash event**
The pre-crash event is not known as this could not be obtained from police records. But it can be safely assumed that most of these cases involve pedestrians walking alongside or crossing the road.

**Problems identified:**
The following are the problems generally observed that may lead to pedestrian impacts. These problems need to be clearly understood from in-depth accident investigations.

1. Pedestrian impacts while pedestrians are walking alongside the road.
2. Pedestrian impacts while pedestrians are crossing the road.

Rollovers (6 out of 63, 9%)
The 6 rollovers were distributed as per the vehicle type and their respective injury severity. The results were plotted as shown in Figure 16 below.

![Figure 16: Percentage distribution of vehicle types involved in rollovers on SH13 by injury severity](image)
The killed or seriously injured rollover accidents were high for cars (67%). Cars (4) were found to be highly involved vehicles in rollover accidents. Pre-crash event could not be ascertained from police reports.

**Sideswipe (4 out of 63, 6%)**

Sideswipes on SH13 occur when two vehicles travelling in opposite directions make contact on the sides. All the four sideswipes involved motorized two wheelers as the killed/seriously injured victims. The pre-crash events can be considered as the same conditions similar to head-on collisions.

**Problems identified:**
The main problem leading to sideswipe collisions is vehicles travelling in the wrong lane while overtaking another vehicle or avoiding an obstacle on the road.

**Summary of police data analysis**

Based on the above police data analysis, the important findings are listed below:

1. Head-on collisions are the highest in occurrence on SH13. This was caused due to vehicles travelling on the wrong side of the road while overtaking or avoiding an obstacle on the road.
2. Pedestrian impacts were the second highest in occurrence. Not much information could be gathered from these accidents, but it is assumed that in most cases the pedestrians were walking alongside the road or crossing.
3. Rollover accidents involved cars and trucks but the exact reasons could not be ascertained from the police records.
4. Sideswipe collisions were caused due to the same reasons as head-on collisions.

*JPRI then analyzed the on-site accident investigation data to get a better understanding of the infrastructure problems causing the above.*

**Accident Investigation Data**

With the support of iRAP, the Gujarat Engineering Research Institute (GERI), and the Bharuch District Police, the JPRI team performed detailed investigations of accidents that occurred along the stretch of SH13 defined as the study area. In-depth data was collected on all accidents occurring in this area from 01 December 2011 to 14 January 2012. During this period, 7 accidents had taken place along this stretch out of which only 5 were examined in detail. Two (2) could not be examined in detail due to late notification from police and insufficient data on scene.

**General Overview of Accidents**

**Injury Severity**

A total of 7 traffic accidents occurred on the study area of SH13 over a period of 45 days. These accidents involved a total of 4 fatal victims and 1 grievously injured victim. As shown in Figure 17, 71% of the accidents examined during this study period resulted in fatality or grievous injury. Over 50% of the accidents examined were fatal accidents.
Road Users Involved
The percentages of the road users involved in road accidents examined on SH13 are shown in Figure 18. Motorized two wheelers (30%) formed the majority of the accident-involved vehicles, followed by cars (23%) and truck (15%). It can be supported by the fact that total volume on this stretch showed motorised two wheelers as the highest (38%), and they were involved in 30% of the accidents.

Killed/Seriously Injured Road Users
Of the 7 accidents examined, the road users who were killed/seriously injured involved motorized two wheelers, pedestrians, bicyclists and motorized three wheelers, as shown in Figure 19.
Crash Configuration

Out of the 7 accidents examined, crash configuration was not known in 1 accident where the vehicles were not available for inspection and due to insufficient data about the accident location. Analysing the most severe crash configuration of all accidents, most of the accidents seen were head-on/sideswipe (30%). Pedestrian impact, bicycle impact, front-rear and rollover were equally distributed (14% each). The results can be seen in Figure 20.

Comparison of Police Data and Accident Investigation Data

The data obtained from police records for the three years and the data obtained from crash investigations by JPRI have been compared in the table 5 below:
<table>
<thead>
<tr>
<th></th>
<th>Police Data</th>
<th>JPRI Accident Investigation Data</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Duration</strong></td>
<td>3 years</td>
<td>45 days</td>
</tr>
<tr>
<td><strong>Number of accidents</strong></td>
<td>63</td>
<td>7 (6 were police reported)</td>
</tr>
<tr>
<td><strong>Killed/Seriously Injured Road Users</strong></td>
<td>M2W (42%) Pedestrians (26%) Car (13%) Truck (8%) M3W (5%)</td>
<td>M2W (40%) Pedestrians (20%) M3W (20%) Bicyclist (20%)</td>
</tr>
<tr>
<td><strong>Crash Configuration</strong></td>
<td>Head-on/Sideswipe (44%) Pedestrian Impact (25%) Rollover (9%)</td>
<td>Head-on/Sideswipe (30%) Pedestrian Impact (14%) Rollover (14%) Bicycle Impact (14%) Front-Rear (14%)</td>
</tr>
</tbody>
</table>

Table 5: Comparison of police data and accidents examined on SH13

Based on the above comparison, the following observations have been made:

1. As per the accident investigation study, there were on an average of 5 accidents per month (7 in 45 days), whereas police records show only 2 accidents per month (63 cases in 3 years).
2. Out of 7, 6 cases examined on this stretch were reported to the police. One (1) accident was not police reported since it involved only minor injuries. In this aspect, the data from police records could have an under reporting of minor and no injury cases.
3. From police reports, head-on collisions are the highest crash types on SH13 followed by pedestrian accidents. This is also the same in case of accident investigation data.
4. In two cases examined by JPRI, it was observed that the police had reported it as single vehicle accidents. JPRI researchers were able to examine the accident vehicles in more detail and ascertain that an unknown vehicle was involved. (Details in the following sections). This indicates that the police need to be trained in crash investigation skills. Also it indicates that single vehicle accidents in police reports may not be accurate due to insufficient/missing data.

As the sample size of the data obtained from the accident investigation study is too small to be a representative sample of accidents on SH13, hence, this data has been used to understand the pre-crash events of the accidents noted in the police data better.
Head-On/Sideswipe Collisions

As per police data, head-on and sideswipe collisions together account for 44% of the accidents on SH13 and are the highest crash type on SH13. The problems leading to the accidents have already been identified as vehicles travelling in the wrong direction. During the study period, 2 collisions were examined, and they are presented below.

Vehicles travelling in the wrong lane

JPRI researchers were informed by the police that an auto rickshaw (motorized three wheeler) had rolled over while trying to avoid a dog on SH13. On closer inspection of the auto rickshaw and the scene by JPRI researchers, it was found that another unknown vehicle was also involved in the accident. It seems that this unknown vehicle was overtaking another vehicle and struck the auto rickshaw after the auto rickshaw had rolled over. Researchers were then able to identify that it is due to this second event, unknown vehicle colliding with the auto rickshaw, that the driver of the auto rickshaw was fatal and the dog was probably killed by the same unknown vehicle. Unfortunately, the police had recorded this as a single vehicle accident and that the auto rickshaw driver died due to rollover only. But, as per JPRI researchers, it was the head-on collision with an unknown vehicle which caused the fatality.

Figure 21: The auto rickshaw with marks indicating contact with another vehicle.

Figure 22: Scene diagram for the above discussed case on SH13
In another case at Siludi junction, near Valia, a motorized two wheeler sideswiped a car (Maruti Omni). The car was standing alongside the road and the driver took U-turn without looking behind. The motorcycle was travelling at high speed and swiped the car. After the impact, the motorcycle, with two riders, lost balance and skidded off the road and collided with fencing poles. Due to this second event the rider got severe head injuries that led to his death. The pillion rider was hospitalized for treatment. Even this case was reported as single vehicle accident by police.

![Motorcycle involved in sideswipe crash indicating the damage caused by other involved vehicle](image1)

**Figure 23:** Motorcycle involved in sideswipe crash indicating the damage caused by other involved vehicle

![Path of the motorcycle and the concrete pole which caused fatal injury](image2)

**Figure 24:** Path of the motorcycle and the concrete pole which caused fatal injury

The junction where this accident happened (Figure 25, GPS Co-ordinates – 21.565088, 73.149897) seemed to be very confusing to the road users. Due to the absence of a roundabout or any other traffic calming feature, vehicles were seen criss-crossing to access different roads. According to police, this junction was a black spot for accidents.
Identification of contributing infrastructure factor
Undivided roads with only one-lane for each direction influence head-on collisions. With a large mix of vehicles travelling at different speeds, vehicles moving into the oncoming lane for overtaking, turning, taking U-turn, or avoiding an obstacle (animal, pothole, etc.) is unavoidable and hence lanes need to be increased to separate slow moving and fast moving traffic and the road needs to be divided.

Pedestrian Impacts
As per police data, pedestrian impacts account for 25% of accidents on SH13. The common problems leading to the accidents have already been identified as pedestrians walking alongside or crossing the road.

Pedestrians crossing the road
One fatal pedestrian impact took place near Kondh village. In this case a lady got hit by a vehicle while crossing the road at night. The vehicle could not be inspected as it was a hit and run case. The site where this accident occurred is shown in Figure 27 below. This lady was trying to cross the road from her house to the grocery shop on the other side of the road. There is no street...
lighting or pedestrian warning signs to warn motorists of the possibility of pedestrians crossing in this area.

Figure 27: Location of pedestrian impact showing pedestrian crossing area and the purpose.

**Identification of contributing infrastructure factor**

The following infrastructure factors can be seen to be influencing these accidents:

1. Non-availability of proper pedestrian infrastructure like footpaths.
2. Lack of pedestrian separation facilities at bus stops, intersections, villages, etc.
3. Absence of zebra crossing and street lighting at intersections.
4. Lack of speed reduction devices at high pedestrian density areas such as bus stops, intersections, etc.

**Rollovers**

One rollover was inspected and this case was not registered as it was single vehicle accident with minor injuries. A van (Maruti Omni) lost control due to jammed differential and rolled over on the road.

Figure 28: Defective differential of the van inspected on SH13
In the previously discussed case of the auto rickshaw (refer Head-on/Sideswipe collisions), researchers think that the auto rickshaw could have rolled over while steering away and trying to avoid the oncoming vehicle. Even in police reported data, we have one case which involves rollover as a result of overtaking. Hence, undivided roads allow vehicles to go in oncoming lane for overtaking which can also lead to rollovers.

**Identification of contributing infrastructure factor**

Undivided roads with only one-lane for each direction allow vehicles to go in opposite lane for overtaking and can influence rollover accidents. Although it needs to be specified at this point that both the rollover cases discussed involve vehicle defects (differential locking up in the van and instability of motorized three wheelers).

**Conclusions**

Based on the above analysis of accidents on SH13, the results of the road safety issues and the contributing infrastructure factors have been tabulated below:

<table>
<thead>
<tr>
<th>Crash Configurations</th>
<th>Pre-crash Event</th>
<th>Contributing Factor in Infrastructure</th>
<th>Percentage Contribution (out of 63 accidents in 3 years)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Head-On Collisions</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Vehicle in oncoming lane while overtaking</td>
<td>Undivided road</td>
<td>14.3%</td>
</tr>
<tr>
<td></td>
<td>Vehicle in oncoming lane trying to avoid animal in roadway</td>
<td>Undivided road</td>
<td>1.6%</td>
</tr>
<tr>
<td></td>
<td>Vehicle in oncoming lane due to unknown reasons</td>
<td>Undivided road</td>
<td>22.2%</td>
</tr>
<tr>
<td><strong>Pedestrian Impacts</strong></td>
<td>Walking alongside and crossing the road</td>
<td>Poor Pedestrian Infrastructure</td>
<td>26%</td>
</tr>
<tr>
<td><strong>Rollovers</strong></td>
<td>Avoiding overtaking vehicle</td>
<td>Undivided road</td>
<td>1.5%</td>
</tr>
<tr>
<td></td>
<td>Unknown</td>
<td>Unknown</td>
<td>8%</td>
</tr>
<tr>
<td><strong>Sideswipe Collisions</strong></td>
<td>Overtaking</td>
<td>Undivided road/improper junction design</td>
<td>6%</td>
</tr>
</tbody>
</table>

Table 6: Determination of contributing infrastructure factors and their influence on accidents
Areas of improvement for infrastructure
1. From the above table we see that undivided roads influence nearly 46% of accidents on SH13. These accidents include head-on collisions, sideswipe collisions and rollovers.
2. Poor pedestrian infrastructure resulted in pedestrian impacts which constituted 26% of the accidents.
3. Junctions on SH13 need to be improved with better traffic flow and traffic movement control.

Road users to be considered
- M2Ws – Highest volume, high involvement in accidents and most vulnerable road user
- Pedestrians – Most vulnerable road users after M2Ws
- Cars – High volume and high speed (overloading conditions)
- Trucks – Generally overloaded and oversize. Low volume but high involvement in accidents.
- Auto rickshaws, tractors, etc. – Slow speeds and low volume but create conditions for overtaking.

Other important issues to be considered
1. Road signs and advance warnings to drivers about upcoming junctions and pedestrian crossings should be installed to communicate with the drivers before-hand about the road environment ahead.
2. Better pedestrian infrastructure is very essential in places where there is more pedestrian density (near villages/settlements, bus stops, junctions/intersections, etc.).
3. Speed limits need to be updated. But this is a challenge considering the wide variation in speed as well as vehicle types.
4. SH13 is an undivided 2-lane highway which will hopefully be upgraded to a 4-lane divided highway. This change will surely help improve road safety on SH13, but the learning from SH6 should also be incorporated to avoid accidents occurring on divided highways (generally front-rear collisions).
Appendix A: Vehicle Type Definitions

M2W - Motorized two wheelers
Any vehicle that is motorized and operates on two wheels. This includes bikes, mopeds, scooters and scooterettes.

- Bike
- Moped
- Scooter
- Scooterette

M3W - Motorized three wheelers
Any vehicle that is motorized and operates on three wheels. This includes three wheeled auto rickshaws that are exploited either as a goods carrier or passenger carrier.

- Goods carrier
- Passenger carrier

Car
Any vehicle that is motorized and operates on four wheels and essentially conceived as a passenger carrier. This includes all types of passenger cars like sedan, jeep, van and hatchback.

- Sedan
- Jeep
- Van
- Hatchback

Truck
Any vehicle that is motorized and operates on four or more wheels and is essentially conceived to carry goods. This includes pickup trucks, two axle trucks, three axle trucks, multi axle trucks, tipper trucks, tanker trucks and tractor trailers.

- Light commercial truck
- Light commercial truck (pick-up)
- Tractor
- Tipper truck
- Tractor with trailer
- Multi axle truck
- Two axle truck
- Tanker
**Bus**
Any vehicle that is motorized and operates on four or more wheels and is essentially conceived as passenger carrier. This includes four wheeled mini bus, six wheeled city bus, six wheeled intercity liner, ten wheeled (three axle) intercity liner.

![Mini bus](image1)
![Two axle bus](image2)
![Multi axle bus](image3)

**Others**
Any vehicle that is motorized and that does not come under the above said categories. This includes heavy earth movers, farm tractors, and specialized custom made vehicles.

![Farm tractor](image4)

**Non-motorized**
Any vehicle that is not motorized and is either used as a passenger carrier or a goods carrier. This includes animal driven carts and carriages and cycle rickshaws.

![Bullock cart](image5)

**Bicycle**
Any vehicle that operates essentially on two wheels and is not motorized.

![Bicycle](image6)
Appendix B: Police Data Coding Format

Following variables are collected from police reported accidents:

1. FIR No.
2. Injury Severity
3. Date of Accident
4. Time of Accident
5. IPC Section
6. Location of Accident
7. No. of Fatal
8. No. of Injured
9. Vehicles Involved
10. Fatal/Serious Injury
11. Road User Type
12. Pre-Crash Event
13. Crash Configuration
Appendix C: Crash Configuration Types
Crash configuration can be roughly defined as the type of accident based on the direction of travel and the general area of damage to vehicles during the collision. For this study, crash configuration was generally divided into one of seven categories:

1. Front-Rear Collision
2. Front-Side Collision
3. Head-On Collision
4. Sideswipe
5. Rollover or Loss of Control
6. Pedestrian/Bicycle Impact
7. Animal or Object Impact

These categories are described, with examples, in the following paragraphs.

**Front-Rear Collision**
This type of collision occurs between two vehicles, where one vehicle (leading) is travelling/stopped ahead of the other vehicle (following), both travelling in the same direction. Usually such collisions occur due to the slowing down of the leading vehicle, or with a stationary (parked/stopped) vehicle, as shown in figure. Note that this example also shows a trailer under-ride, which can be particularly dangerous to occupants of the following vehicle since that vehicle may have virtually no protective/bumper contact with the leading vehicle until its bumper reaches that vehicle’s tires (or until the windshield/cab of the passenger compartment contacts the rear of the truck/trailer).

**Front-Side Collision**
This type of collision occurs between two vehicles, where the front plane of one vehicle's contacts the side plane of another vehicle during collision. Most commonly, this sort of collision takes place in intersections and during U-turns.

**Head-On Collision**
When two vehicles approaching each other in opposite directions collide with each other, such a collision is called a head-on collision. It is most common on undivided roads, when one vehicle is trying to overtake and is in the oncoming lane. Speed and relative size of the colliding vehicles can greatly affect how serious this type of collision is in terms of occupant injury and vehicle damage. The
head-on collision shown in figure, for example, reveals very little crumple; the same scenario with a compact car in the place of one of the trucks would likely show a very different outcome.

**Sideswipe**
Side-swap is when two vehicles, travelling in the same direction or in opposite direction to each other, collide in such a way that their side planes (as shown in figure), just rub each other with a very little overlap between the two.

**Rollover or Loss of Control**
Rollover describes the overturning of a vehicle along its longitudinal or lateral axis. The usual case is when a vehicle loses control, goes off-road, and rolls. However, a rollover can also take place on-road. In case of two wheelers losing control and falling down, such an event would only be called a “Loss of Control”. As shown in figure, a rollover means that multiple sides of the vehicle will come into contact with ground or other objects, presenting multiple opportunities for occupant contact with the vehicle's interior and for the vehicle to come into contact with objects that could lead to intrusion into the passenger compartment. Rollovers can also be initiated by any another type of collision (a sideswipe, for example), but often they are single-vehicle crashes.

**Pedestrian/Bicycle Impact**
When a vehicle hits a pedestrian or a bicycle, such an impact is coded as a pedestrian/bicyclist impact.

**Animal or Object Impact**
When a vehicle hits an animal, it is coded as an animal impact. When the impact is with an inanimate object that is not a vehicle, it is coded as an object impact.