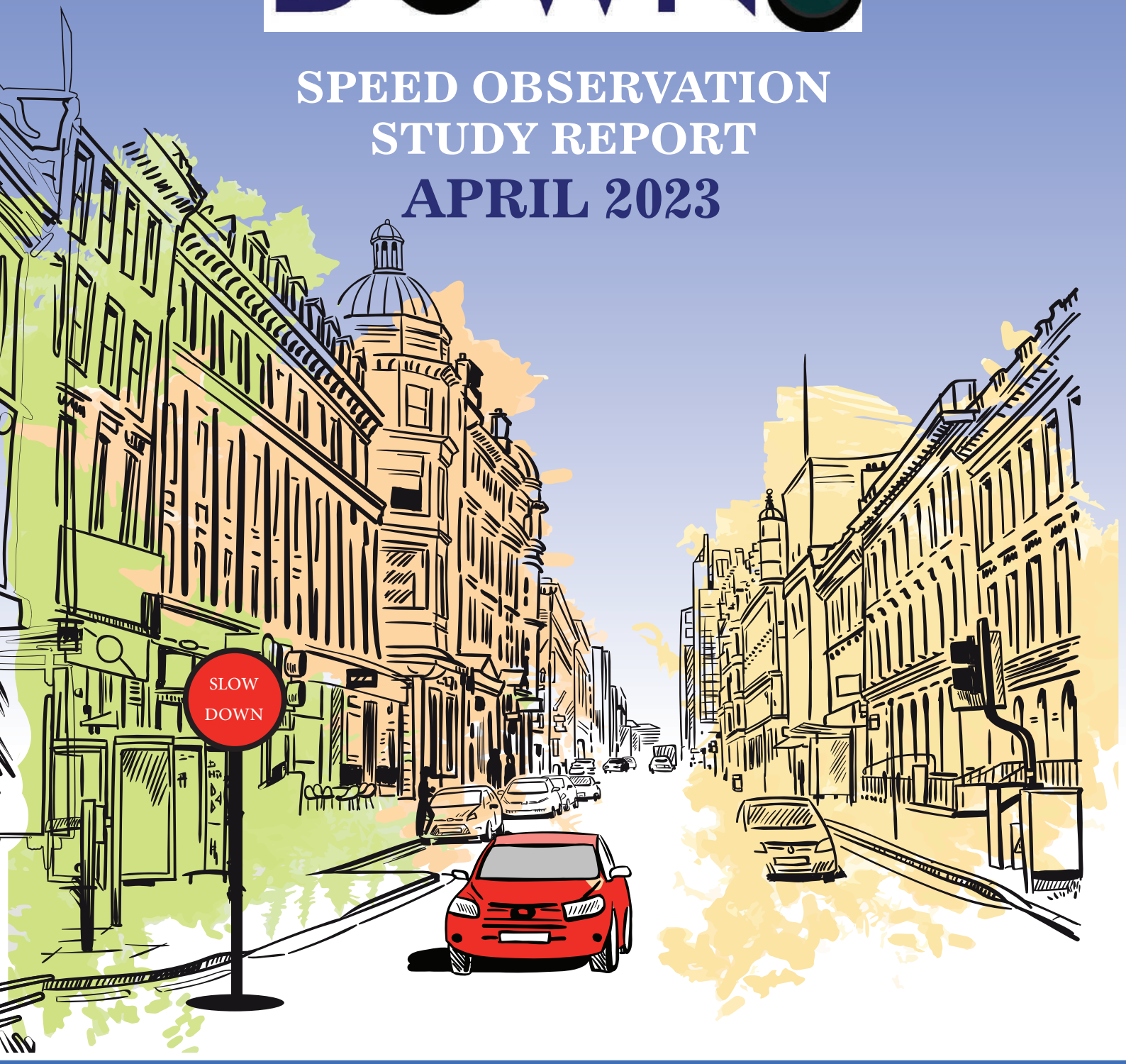
SPEED OBSERVATION STUDY REPORT

APRIL 2023



United Way Mumbai

SPEED OBSERVATION STUDY REPORT

FOCUSING ON

TRAFFIC SPEED MANAGEMENT AND IMPROVING SAFETY IN MUMBAI CITY

By

United Way Mumbai

In association with

Indian Institute of Technology Bombay

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PREFACE

George Aikara,
Chief Executive Officer,
United Way Mumbai

I am pleased to present to you the Speed Observation Report, prepared by United Way Mumbai in collaboration with IIT-Bombay, as part of the "Slow Down" project. The report captures critical observations about present road conditions and recommends speed-calming measures to facilitate better speed management at 20 identified blackspots in Mumbai. The report assumes great significance in the context of road safety interventions in India, given that speed is one of the leading causes of fatal road traffic crashes. This report is evidence-based and provides a scientific assessment of the blackspots, which is a critical requirement for evidence-based enforcement.

United Way Mumbai, through the "Slow Down" project, has taken a comprehensive approach towards road safety interventions. Along with scientific assessments, we have also leveraged our expertise in community mobilisation to ensure a sense of ownership among local stakeholders towards road safety. This has resulted in the formation of Road Safety Advocacy Clubs across all the blackspots. These clubs comprise active and concerned citizens and local community volunteers who have been capacitated to work closely with the Mumbai Traffic Police for implementing the measures recommended in the report.

The scientific and participatory approach adopted by us while preparing this report will go a long way in guiding the path to developing the speed management policy at the state and national level. We are confident that the report and recommendations will be helpful for the Mumbai Traffic Police in their endeavour to stricter enforcement of speed control measures across Mumbai city.

I would like to express my sincere gratitude to the Global Road Safety Partnership, Mumbai Traffic Police, IIT- Bombay and the community stakeholders for their invaluable contribution to the Slow Down project.

I am confident that the scientific and participatory approach adopted by us while preparing this report will go a long way in guiding the path to developing the speed management policy at the state level and the national level.

George Aikara

Vivek L. Bhimanwar, IAS,
Transport Commissioner,
Govt. of Maharashtra

Faster and safer vehicles are much more affordable today than ever before. This largely resonates with the technological advancements in the recent years across the World. Particularly in India, the technological adoption has been much quicker than any comparable developing country and this has resulted in unique benefits and its own challenges. One of the key challenges being the safety of all road users on our roads.

In India, and across the World, speeding has been a case of concern contributing to nearly 1/3rdof road traffic fatalities World-wide. This emphasises the need for installing adequate infrastructure capable of handling high speed, supported by extensive awareness campaigns to instill safe-driving road sense in the minds of budding drivers and technology assisted enforcement systems for effective enforcement. India, with over 1.3 billion people, 63 lakh kilometres of road and 32 crore vehicles registered, stands among the top in terms of population, road network and vehicle population. This necessitates a need for a profound ground-level understanding of the impact of interactions between people, vehicles, and infrastructure.

The work initiated by United Way Mumbai in this regard is appreciable and by bringing together inputs from all relevant stakeholder departments, this report shall be beneficial for the decision makers. I wish the team at United Way Mumbai all the very best and look forward to more field-based impact driven initiatives in the times to come.

Vivek Bhimanwar

Pravin Padwal, IPS
Jt. Commissioner of Police, Traffic, Mumbai

Road traffic crashes are an increasing public health concern globally and in India. Mumbai city, too, has been facing the issue of a sizeable number of road traffic crashes and crash fatalities. At Mumbai Traffic Police, we have been committed to working towards reducing road traffic crashes and making the roads safer for all.

Speed has proven to be one of the major risk factors causing road traffic crashes. Recognising the severity of this issue, Mumbai Traffic Police has been garnering support from various key stakeholders in the city to work with a comprehensive approach to tackle this issue.

I am aware that United Way Mumbai has collaborated with the Mumbai Traffic Police on several road safety projects. Slow Down is an initiative by United Way Mumbai, where they have been working in consultation with the Mumbai Traffic Police to support stricter enforcement of speed control measures at select twenty blackspots across Mumbai. This speed observation study report has been the result of a scientific assessment of all twenty blackspots and consultation with the local enforcement officials and the neighbourhood citizens. The report thoroughly captures the critical observations about the present road conditions at these blackspots that lead to the speeding behaviour among motorists. The report has also recommended some very critical speed-calming measures that can facilitate better speed management.

Evidence-based reports and recommendations like these will come in handy for all government agencies to improve road safety at these blackspots, thereby eliminating the blackspots in the near future.

I also understand that United Way Mumbai has formed Road Safety Advocacy Clubs at each of these twenty blackspots whereby active neighbourhood citizens have been educated and empowered to address road safety issues in their neighbourhood. We at Mumbai Traffic Police appreciate this step and would look forward to the local citizens' continued engagement.

I appreciate the efforts taken by the team from United Way Mumbai as part of the Slow Down project, and I am confident that, the Speed Observation Study Report will prove to be a useful tool for Mumbai Traffic Police in enforcing stricter speed management policies at the identified blackspots.

Pravin Padwal

Dr. Judy Fleiter,
Global Manager,
Global Road Safety Partnership

This report is the outcome of a Speed Survey study undertaken by United Way Mumbai as part of their advocacy efforts to improve road safety in India and in particular, to support the implementation of the Motor Vehicle Amendment Act 2019, especially as it relates to managing speed. The project was completed in close collaboration with the Indian Institute of Technology Bombay.

This report assesses the prevalence of speeding through observational techniques and pictorial representation of 20 blackspot locations that were jointly identified with the Mumbai Traffic Police. The observational data are complemented by secondary data obtained from the police (infringement and crash data) that was disaggregated by age group, gender, type of road user and time of occurrence.

A range of public policy recommendations for interventions to address speeding as a key multi-dimensional risk factor are presented in the report

The Global Road Safety Partnership (GRSP) has administered the Road Safety Grants Programme since 2012 to support road safety work in countries across Asia, Africa and Latin America. Work conducted by organisations that receive grant funding through the Road Safety Grants programme helps to facilitate stronger laws and their implementation to protect all road users. We commend the efforts of United Way Mumbai in undertaking this work to support safer speeds to enhance the lives of all those who use the roads in Mumbai.

Judy Fleiter

PREFACE

Dr. P. Vedagiri,
Associate Dean,
Dept. of Civil Engineering, IIT- Bombay

Road safety is an issue of concern for all countries globally, as approximately 1.3 million people die each year around the world as a result of road traffic crashes as per World Health Organization data. More than half of all road traffic deaths and injuries involve vulnerable road users, such as pedestrians, cyclists and motorcyclists and their passengers.
As per the 'Road Accidents in India 2020' published by MORTH, there were 3,66,138 unfortunate incidences of road accidents during 2020 which claimed 1,31,714 lives and caused injuries to 3,48,279 persons. In 2020, under the category of Traffic Rule Violations, over speeding is a major killer, accounting for 69.3 % of the persons killed followed by driving on the wrong side (5.6 %).

Speeding, one of the main risk factors leading to road crashes is the focal point of this study undertaken by the Transportation Systems Engineering Group of IIT Bombay in collaboration with United Way Mumbai (UWM). As the preliminary step, field observations were made at the identified twenty black spots spread across Mumbai to understand the site-specific issues. Base line speed surveys were then carried out in 2019 using radar guns at the black spots to capture the spot speed of different classes of vehicles by enumerators from IITB as well as from UWM.

The speed data captured during the surveys were analyzed and average speed variability of different vehicle types were plotted. Traffic crash data analysis along with the speed data studies were used to give recommendations and suggest improvement measures to manage and reduce speed. These recommendations include speed management measures, traffic calming measures at intersections, pedestrian facilities, other safety related measures, etc. and they have been broadly divided into Engineering interventions, Behavioural risk factors vis-à-vis interventions and Traffic management and enforcement interventions. Wherever possible, the recommendations have also been classified as short term and long term based on the time required and the easiness in carrying them out. The report also discusses in detail the site-specific recommendations based on the field observations. Once these measures are implemented, the end line surveys will be planned. After completion, assessment of pre and post enforcement or design impacts on traffic speed can be done.

We hope this document will be instructive and useful for the enforcers, policy makers, and society at large in making Mumbai roads safer for all road users.

Prof. P. Vedagiri

INTRODUCTION

2.1 About United Way Mumbai

United Way Mumbai is a part of the 130+ year old United Way movement spanning 40 countries across the world. Our mission is to improve lives by mobilizing the caring power of communities to advance the common good.

We work closely with a network of 500+ NGOs and a large number of corporates for their CSR programmes, workplace giving campaigns and other events. This includes designing of CSR policies and strategies, due diligence of NGO partners, programme implementation, employee volunteering, impact assessments and financial and programmatic reporting.

Over the past 21 years, we have partnered with over 300 companies and over 1,00,000 individual donors investing close to INR 843 crore for community development projects. Our expertise lies in identifying, designing & implementing high-impact projects in the areas of Education, Health, Income, Environment, & Public Safety, in urban as well as rural communities across the country.

In recognition of the urgent need for road safety interventions, and in line with the United Nations Decade of Action for Road Safety, United Way Mumbai commenced interventions under the aegis of the project United for Road Safety. As part of this project, we have partnered with companies, the Mumbai Traffic Police, Regional Transport Office and community based stakeholders to make our roads safer for all.

2.2 Speed-related Scenario in India

India ranks first in the number of road crash deaths across the 199 countries reported in the World Road Statistics, 2018 followed by China and US. As per WHO's Global Report on Road Safety, 2018, India accounts for almost 11% of road crash related deaths in the World. This is a setback considering that in 2017 the country had registered a 3% decrease in road deaths - from 0.151 million in 2016 to 0.148 million.

The safe and efficient movement of road traffic is directly related to traffic flow characteristics, volume, speed and density. These, in turn, are affected by the wide range of vehicles and road users, geometric features of the road, environmental conditions and other regulatory measures. Vehicular population has considerably increased in the last decade due to rapid urbanization and economic development (rising income), alongside which road crashes have significantly increased. According to statistics, more than 70 percent of road crashes are due to speeding. United Way Mumbai (UWM) has collaborated with Indian Institute of Technology, Bombay (IITB) to study 20 black spot locations in the city of Mumbai.

According to the Ministry of Road Transport and Highways Report, 2019, road crashes kill almost 1.51 lakh people annually in India. Over-speeding is a major cause of these crashes, accounting for 71% of them as well as resulting in 67.3% deaths and 72.4% injuries. National Highways accounts for 73.5 % crashes due to speeding. Young adults in the age group of 18 - 45 years accounted for nearly 69.3% of road crash victims. Vulnerable road users, who have less protection than the occupant of a motor vehicle, accounted for 54% percent in the total road crash deaths.

The most important initiative taken by the Ministry of Road Transport and Highways last year with respect to road safety has been the enactment of the Motor Vehicle Amendment Act 2019 which, inter-alia, provides for a stiff hike in penalties for traffic violations. The other provisions of the Act include setting up of a National Road Safety Board, protection of "Good Samaritans"; cashless treatment during the "Golden Hour"; provision of third party insurance; constitution of a motor vehicle fund with increased compensation for hit and run; automated fitness testing for vehicles; introduction of the provision for recall of vehicles; etc. The Ministry of Road Transport and Highways has been undertaking multiple initiatives, including those related to vehicular and road engineering as well as educational measures for raising awareness in the field of Road Safety.

Legislations:

MVA Bill 2017 provisions for the penalty between 1,000/- to 2,000/- for 1st offender LMVs and between 2,000/- to 4,000/- for HMVs. For the second/subsequent offence, the Driving Licence of the defaulter can be impounded. (Notification for this is still awaited in the state of Maharashtra)

Examples with respect to speed enforcement (Delhi revises Speed limit – 8th June 2021)

The Delhi Traffic Police has revised speed limits for different types of roads and vehicles plying within the national capital.

- 30 km per hour limit has been set for all roads within residential/commercial areas, markets, and service roads.
- For most arterial roads, speed limit has been set between 50 and 70 Kms per hour.

Initiatives taken by Mumbai Traffic Police till date:

- Installation of more than **90 speed cameras** across Mumbai (month and year).
- Introduction of **E-Challan** for speeding related offences.
- **Variable Messaging System** (VMS) installation across Mumbai to display information Traffic Law Awareness and city-related messages.
- **Group SMS System** to help police personnel and citizens to get alerts, warnings and informative messages for safety.
- **Advanced Speed Guns** to prevent excessive speeding. A Speed Gun device equipped with a laser light wave is used to determine the speed at which the vehicle is moving to keep speeding in check and, thus avoid crashes.

2.3. About Slow Down Project:

United for Road Safety, is a community impact initiative of United Way Mumbai which aims to address various aspects related to the promotion of road safety in Mumbai, India.

The project aims to enhance road safety in Mumbai, focusing on safer public mobility and safer personality mobility through collaboration and collective action. The "Slow Down

The Project advocates improved enforcement of speed control measures and speed management policies in Mumbai to curb speeding behavior amongst motorists; thereby reducing the number of road crashes, serious injury and death caused by excessive speeding. The key objectives of the project are as given below;

- **Objective 1:** Support MVA implementation in the state of Maharashtra especially related to speeding and strict enforcement of speed management in Mumbai
- **Objective 2:** Create mass awareness to curb speeding through mass awareness activities and support the state and city authorities in planning and implementing public/ mass awareness campaigns to promote “Slow Down”.

Speed Observation Study:

The key objectives of the Speed Observation Study are as given below;

- **Objective 1:** To study and identify the causal factors of speeding at the select blackspots
- **Objective 2:** To recommend speed calming measures in order to support stricter enforcement speed limits at these blackspots
- **Objective 3:** To provide to the Mumbai Traffic Police, the evidence of instances of over speeding and the need for speed calming interventions recommendations so that, they can plan and implement suitable enforcement measures

The Speed Observation Study was carried out in a phase-wise manner as given below;

- **Phase 1: Identification of 20 blackspots**

Under this project till date United Way Mumbai, in consultation with the office of Jt. Commissioner of Police, Traffic (Mumbai) identified 20 black spots across Mumbai where fatalities occur mainly because of speeding. At these speeding spots, the road crash data and speed challan data available with the Mumbai Traffic Police were gathered.

- **Phase 2: Speed observation study for baseline data collection:**

A day-long-baseline speeding survey on weekdays and weekends jointly by enumerators of IIT Bombay and United Way Mumbai so as to understand the vehicle flow and speeding pattern at the spot.

- **Phase 3: Observational study of the blackspots:**

United Way Mumbai and IIT- Bombay teams jointly visited the spots and the neighbourhoods to observe various aspects in the neighbourhood. The teams also interacted with the local citizens/ shop owners/ police officials to understand their perspectives on the risks of speeding at the given spots.

- **Phase 4: Follow up observational studies post relaxation of the national lockdown**

Follow up visits to all the blackspots for observational study to understand the changes at the spot post the relaxation of the national lockdown. This helped in updating the observations and the recommendations of the report as per the present conditions at the blackspots.

Formation of Road Safety Advocacy Clubs:

One of significant component of this project was the engagement of the local community members in advocating the cause of road safety in their neighbourhood. United Way Mumbai identified local citizen groups/individuals and formed Road Safety Advocacy Clubs (RSACs) to advocate the cause of road safety in their neighbourhood. Based on the recommendations of the Speed Observation Study Report, these RSACs will work closely with the local traffic police officials to implement the simple and cost-effective interventions in order to reduce the road traffic crashes.

Thus, United Way Mumbai has formed 20 Road Safety Advocacy Clubs around all the selected blackspots.

Other awareness activities under Slow Down Project:

During course of the project, United Way Mumbai organized a wide range of awareness campaigns and activities with the help of the members of the Road Safety Advocacy Clubs and college volunteers. These activities were organized on the relevant occasions such as; Global Road Safety Week, National Road Safety week, World Day of Remembrance for road traffic victims, etc. The activities were mainly focused on the theme of "Slow Down" and were aimed at sensitizing the motorists about the consequences of over speeding.

These campaign aimed to:

1. Sensitize and encourage road users to pledge to Slow Down and adhere to speed limits on the road
2. Educate road users about mechanisms put in place by the Mumbai Traffic Police for speed calming

During world day of remembrance United way Mumbai, RSAC members and members from the community paid homage to individuals from their own neighbourhoods who lost their lives in road crashes. Individuals or family members of the victims shared their road crash testimonials and lighted candles to express their respect.

Project Stakeholders:

Slow Down" is supported by the GRSP A & G Programme, focused on spreading awareness regarding adhering to speed limits.

- **Global Road Safety Partnership (GRSP)**

Supporting the "Slow Down" project as a donor, and also assisting UWM with technical guidance for planning advocacy strategies

- **Mumbai Traffic Police**

The traffic control branch Mumbai has formally collaborated with United Way Mumbai for this project and will help facilitate the implementation of relevant recommendations from the study and support RSAC members.

- **Local citizen groups and individuals around the spot**

We identified local community members around the spots, motivated to work for the safety of the community using the roads. They will be made a part of RSAC for the specific spot who will work jointly with the local traffic division to reduce speeding and crashes at these spots. After formation of Road Safety Advocacy Clubs, various meetings were conducted with these members on developing a joint action plan for the installation of necessary speed limit signages at the black spots.

- **Indian institute of technology Bombay (IITB)**

IIT- B conducted the baseline survey and shared a detailed report on existing speed calming measures and speeding patterns with the help of speed measuring tools and providing relevant recommendations.

2.4. Executive summary:

The speed observation study report has been divided into 8 chapters and it consists of all the main components of the speed observation study. Chapter 2 consists of information about United Way Mumbai, Road safety scenario in India and Background of the Slow Down project. Chapter 3 involves the scope of the speed observation study, how selection of 20 black spots was done, stakeholders/partners involved in the study and General & spot specific observations and recommendations. Chapter 4 majorly speaks about speed data collection and analysis which includes different methods of speed measurement, speed statistics and analysis on speed violation. Chapter 5 consists of recommendations and conclusions such as speed management measures, traffic calming measures and overall other recommendations. Chapter 6 talks about various stakeholder consultations conducted and the plan for advocating for implementation / enforcement of recommendations. Chapter 7 covers all the acknowledgements followed by chapter 7 with all the list of references used in this report

SPEED OBSERVATION STUDY:

3.1. Scope of the speed observation study by IIT Bombay and United Way Mumbai

The scope of the speed observation study is as follows:

1. Field visits to selected 20 study sections (100 to 500 m length of each section) at different locations in Mumbai city, identified by United Way Mumbai

2. Investigation of existing speed calming or speed management measures at the selected locations.

3. Study of the road and its environment, including the behavior of different types of road users and other influencing factors to enable a full assessment of speed related injury risks and identification of vulnerable road users.

4. Analysis of the information such as different road users, specific times of the days when motorists tend to over speed, number of road crashes caused due to speeding/rash driving (minor & major) based on the data provided by United Way Mumbai.

5. Analysis of the information related speed challans generated at the spot by week/time over last years with particular observations of time of the day and day of the week. This information will be collected by United Way Mumbai and provided to IITB.

6. Analysis of the data of earlier road crash incidents shared by Mumbai Traffic Police of last 5 years at selected locations, to study the critical cause & circumstances which causes the crash keeping speed in focus (Source: Mumbai Traffic Police)

7. Obtain and maintain approvals and permission letters from the relevant government departments for all activities. United Way Mumbai will facilitate this and obtain required permission for conducting surveys.

8. Conduct baseline spot speed field observation surveys using radar gun at selected 20 locations for 2 days each (one-week day and one-week end day). The surveys were carried out by two enumerators from 10.30 am to 11.00 pm (5 sessions of 90 minutes duration each). United Way Mumbai team members too joined the enumerators for conducting surveys. An IITB representative was present throughout the survey to provide necessary guidance for conducting surveys and to monitor the data collection process.

9. Data collection of overall speeding patterns of the vehicles, numbers of specific types of vehicles in speeding and percentage of speeding with the help of speed measuring tools.

10. Conduct similar end line field observation surveys at same locations to identify the impact on speeding on the respective spots with improvements and assess pre and post enforcement/design impacts on traffic speed. Duration and timings will be the same as
11. baseline speed observation.

    Total number of field speed surveys = 20 locations (1 weekday +1weekend) 2 time (pre and post improvement) locations = 80 days.

12. Prepare a report to be published based on the speed observation study's key findings

3.2. Selection of the 20 Black Spots:

United Way Mumbai finalized 20 black spots out of 58 black spots identified by the Mumbai Traffic Police after consulting with the office of Joint Commissioner of Police, Mumbai.

The team from IIT Bombay accompanied by United Way Mumbai team visited these 20 black spot locations, observed around 100 m to 500 m length of the road section at each location during November and December of 2019. The identified black spots include midblock sections, intersections, underpasses, and merging and diverging sections. The locations were surveyed for existing traffic calming facilities, visibility issues and other road safety deficiencies. The traffic violations, plausible causes for crashes were noted and rough sketches of the black spot locations were made. A follow-up visit was then made in February, 2021 by the team from UWM to observe and evaluate the existing field conditions and other safety issues. Based on these site visits and the analysis made on the crash data obtained for each black spot location, probable safety measures have been recommended

3.3. Methodology:

The main components of the speed observation study were to observe vehicle density, speeding patterns of the vehicles, nature of road crashes – severe/minor injuries or fatalities and also evaluation of existing infrastructure to curb speeding and working on the strategies to implement the interventions.

This study included the identified black spot locations, including the behavior of different types of road users and other influencing factors to enable a full assessment of speed related injury risks and identification of vulnerable road users. Rough sketches of the locations were made after the field visits to understand the risky pattern, the areas with chances of conflict and for reference.

Baseline spot speed field observation surveys were conducted using a radar gun at selected 20 locations for 2 days each (one-week day and one-week end day from 10.30 am to 11 .00 pm). Measuring speed using radar uses reflected waves of very high frequency from the radar speed meter to the moving vehicle. The reflected wave is directly measurable and is proportional to the speed at which the vehicle is moving.

The procedure involved in the speed data collection was simple. During the data collection surveys, a spot was chosen at the black spot location such that a clear view of the oncoming traffic was available but the enumerator was inconspicuous. If the enumerator holding the radar gun stands out, the drivers tend to slow down and the free flow speed will not be obtained. During the survey, the enumerator points the radar gun so that the vehicle is either moving directly toward the radar gun or directly away from the gun. The enumerator will then press the trigger and the speed will be displayed on the screen. The speed gun was in continuous mode and hence it allows the enumerator to detect the speed of the vehicle without having to press the button for each vehicle.

3.4. Stakeholders/partners involved in the study

- Mumbai Traffic Police (Office of the Jt. Commissioner of Police, Traffic- Mumbai and officials of the concerned Traffic Police Divisions under whose purview the selected 20 blackspots fall)
- Community members in the neighbourhoods of all the 20 blackspots
- Indian Institute of Technology- Bombay (IIT-B), Department of Civil Engineering
- Road owning authorities (MCGM, PWD, MMRDA)
- Motor vehicle department (Office of the Transport Commissioner- Maharashtra and the Road Safety Cell)
- District road safety committee, Mumbai City

3.5. Common Observations and Recommendations

Common observations (Enforcement):

- Only **7 spots** out of the **20 spots** have **posted speed limits**
- **Critical road signages are missing** such as; 'Speed limit', 'Crash prone spot' signs and 'merging section ahead' **at 11 locations** and were **inappropriately placed at 2 locations**
- **Side friction** observed due to the **illegal roadside parking** at **7 locations**
- **Pedestrians walking on the carriageway** instead of the footpaths at **7 locations** (encroached footpaths)

Common observations (Engineering):

- Road /lane markings were absent or faded at 17 locations
- Poor visibility at night was observed at 3 locations
- Inadequate road signs were observed at 11 locations
- Potential conflict points observed at merging sections at 6 locations
- Good road conditions coupled with the straight stretch results in speeding of the vehicles

Common recommendations (Enforcement):

- Traffic wardens can be deployed for regulating the traffic during the peak hours
- Vendor encroachment should be controlled on the road to avoid side friction
- CCTV surveillance can be used to check the culprits of rash and speeding and fines should be imposed
- Undisciplined parking needs to be regulated

Common recommendations (Engineering):

- Installation of signboards (such as; speed limit signs, merging section ahead, road signs, caution boards etc.)
- Road markings to be painted at some locations
- Pedestrian walkway, zebra crossing markings and controlled pedestrian walk-way must be installed with advance warning signs
- “Crashes prone spot” boards to be visibly installed at all the 20 locations at least 50 meters ahead of the spot and at the spot
- Adequate road signs to be installed at locations wherever observed to be missing/inadequate
- Informatory sign boards to guide and direct the road users should be installed at 100 mts. and 50 mts. interval
- Speed calming measures such as; speed humps and rumble strips to be installed wherever found to be missing
- Continuous stretch of well-maintained footpath is needed to discourage the pedestrians walking on the carriageway where the chances of conflicts are high
- Pavement distresses such as potholes, rutting (grooves) should be removed and its condition should be improved for better level of service.
- Medians should be repainted with retro-reflective paint to improve the visibility at night at certain locations wherever poor visibility at night was observed
- Need to smoothen the uneven road surface approach to flyover and to be marked properly at ascending and descending spots of flyovers

3.6. Spot specific Observations and Recommendations for 20 black spots

1. Location 1: Eastern Express Highway, Near Ramabai Nagar Bus Stop, Near Sainagar Nala, Retiwala, Ghatkopar East

Figure 1: Google earth view of Eastern Express Highway, Near Ramabai Nagar Bus Stop, Near Sainagar Nala, Retiwala, Ghatkopar East

The study location at Ramabai Nagar Bus Stop, near Sainagar Nala, Retiwala, Ghatkopar East is shown in Figure 1. It is a mid-block section with 10 lane divided carriageway and 2 service lanes on either side. The diagrammatic sketch of this junction is shown in Figure 2.

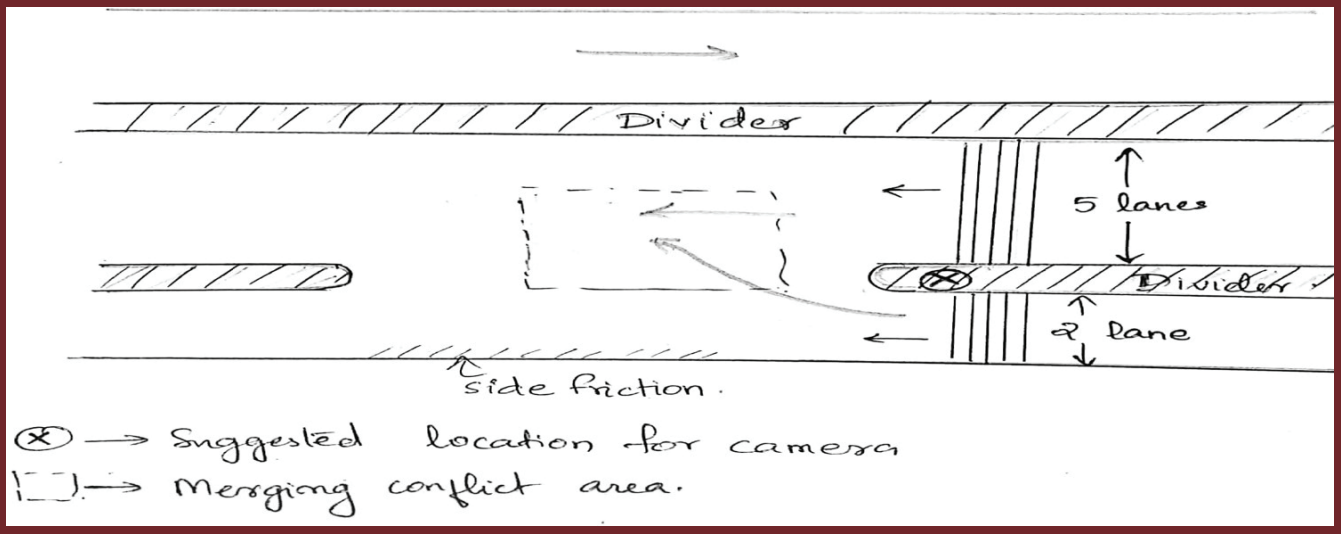


Figure 2: Rough field diagram of the location near Ramabai Nagar Bus Stop, Ghatkopar East

Observations made at the site:

- Risky merging section: High speed vehicles coming from the service lane merge into the high- speed vehicles in the main lane. The absence of a gradual merging section is a big issue.
- Presence of a central island: Proper channelizing absent at the location. Difficulty in seeing the central island and medians during night time due to the absence of reflectors.
- Existing rumble strips are not very effective in reducing the high speed of the expressway users.
- No speed limit signs and merging section ahead sign board.
- Side friction is present because of parked trucks on the road side.
- Existing road markings were observed to be faded and some temporary road markings were provided as a part of the Metro construction being carried out at the location.
- The present site conditions of Ramabai Nagar Bus Stop, near Sainagar Nala, Retiwala, Ghatkopar East can be seen in Figure 3.

- **Figure 3: Identified safety issues observed during the site visit at Ramabai Nagar Bus Stop**

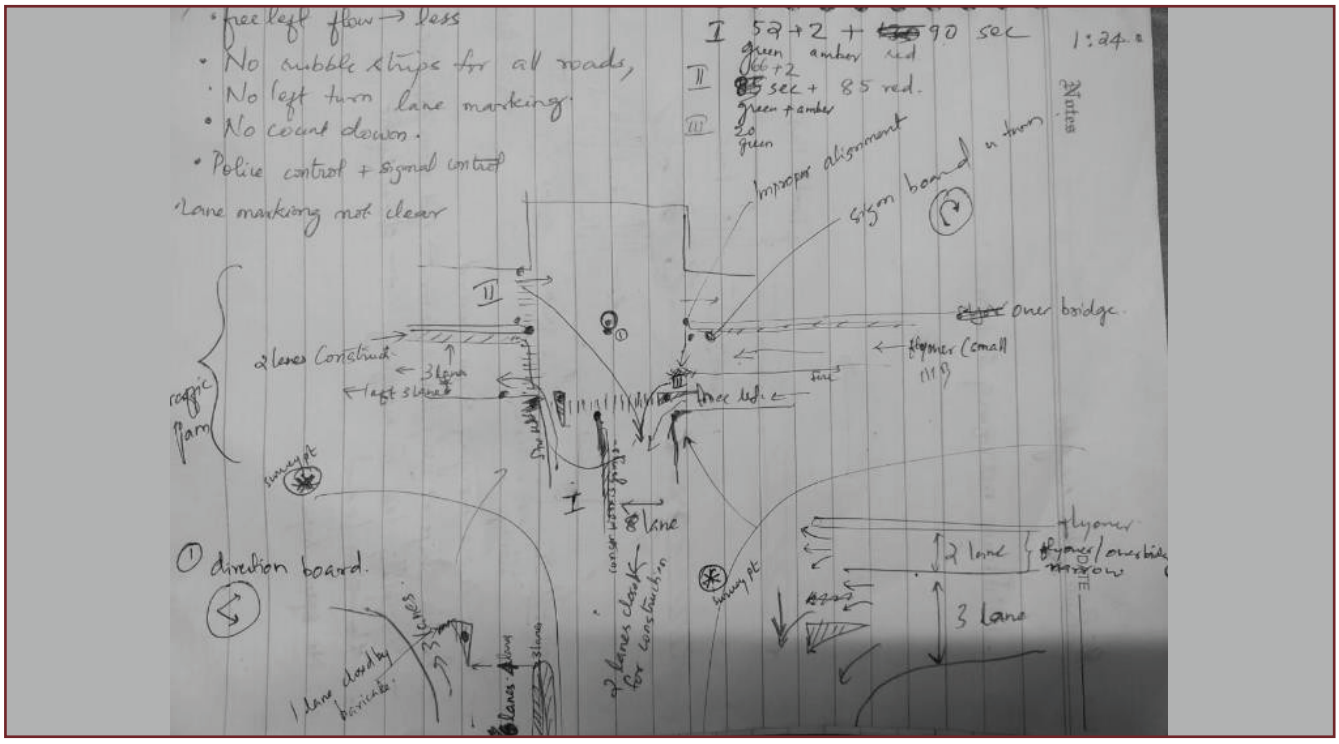
Recommendations:

- Gradual merging section with “Merging Traffic Ahead” sign board as per IRC: 67-2012 should be provided.
- Hazard markings and channelizing markings like diagonal and chevron markings as per IRC: 35-2015 can be provided to demarcate the neutral area at the nose of the channelizing island which can help in reducing the incidence of collision with kerb nose. They direct the entering and exiting traffic into the proper angle for smooth movements of divergence and convergence.
- Additional rumble strips and road studs with complementary warning signs and flashing beacons can be installed on the expressway to encourage the users to reduce their speed.
- Speed breakers with complementary warning signs can be provided on the service lane before the merging section to warn the users.
- Staggering can be done on the service lane by providing chicanes or angled kerb blisters before the merging section to reduce the speed with which the service lane users merge into the expressway.
- Reflectors on the central island can be provided for better visibility especially at night and the median should be repainted with retro-reflective paint.
- Pavement distresses like potholes, rutting should be fixed and improved.
- Adequate speed limits signs should be installed to alert the road users.
- Informatory sign boards to guide and direct the road users should be installed to help the motorists make informed decisions before reaching the location.

2. Location 2: Chheda Nagar & SCLR Bridge Chheda Nagar, Bus Stop, Chembur East

The study location at Chheda Nagar Bus Stop, Chembur East is shown below. It is a signalized T-intersection with no countdown timer. Mostly, traffic officials control the traffic here. Metro construction is also being carried out on either side of this particular stretch. The carriageway at Chheda Nagar consists of 8 lanes (Ghatkopar - Mankhurd) divided by roads as shown in Figure 4. Eastern Express Highway passes over the Chembur junction, shown in Figure 5.

- **Figure 4: Google earth view of Chheda Nagar & SCLR Bridge Chheda Nagar, Bus Stop, Chembur East**



- **Figure 5: Rough field diagram of Chheda Nagar & SCLR Bridge Chheda Nagar, Bus Stop, Chembur East**

Observations made at the site:

- Traffic signal system is implemented at the junction (Green time of 65 seconds, red time of 85 seconds) without countdown timing in the signal; during peak hours, the traffic was in fully jammed/congested condition starting from the flyover exit. Police were controlling the overall traffic at this junction.
- Potential conflict points are at merging.
- Rumble strips were absent on all the approach roads and vehicles were moving at very high speed during the off-peak time (from exit of flyover).
- No speed limit signs, no merging sign board.
- Improper alignment of the carriageway.Lane markings such as Zebra crossings were faded and left turning lane marking was absent.
- Poor visibility at night.
- Available road width reduced due to the metro construction work going on both sides. Side friction is more because of parked auto rickshaws on the left side of the road.
- The present site conditions can be seen in Figure 6. These figures indicate the present issues at Chheda Nagar Junction.

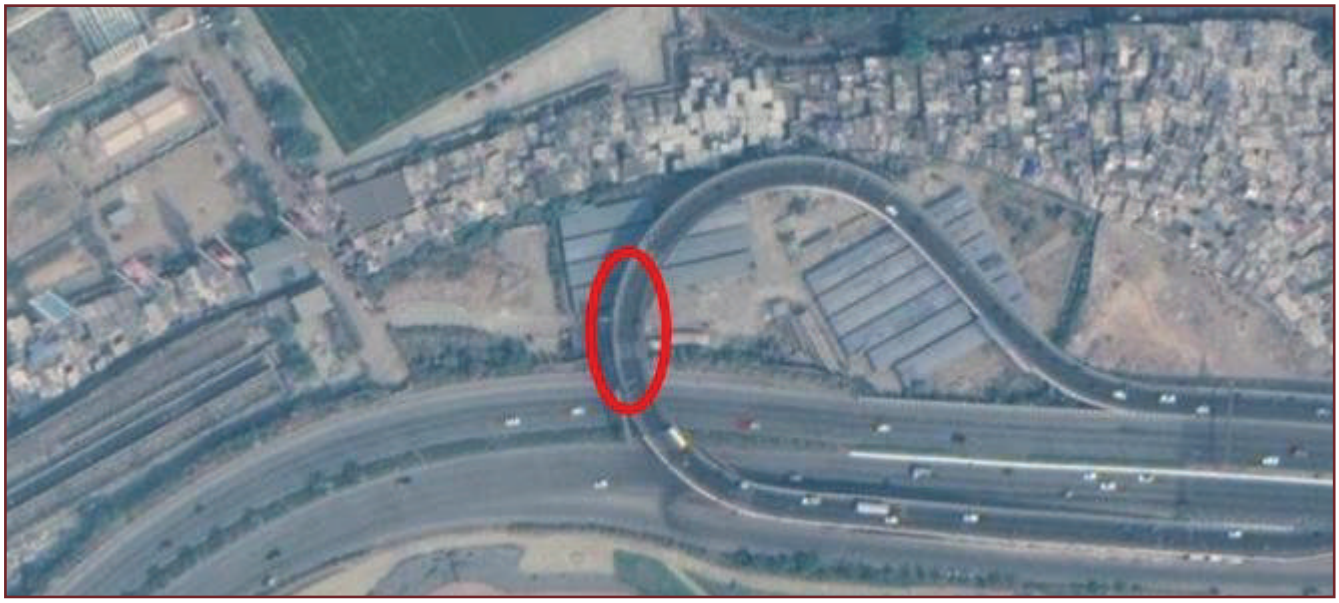
- **Figure 6: Identified safety issues observed during the site visit at Chheda Nagar Bus Stop, Chembur East**

Recommendations:

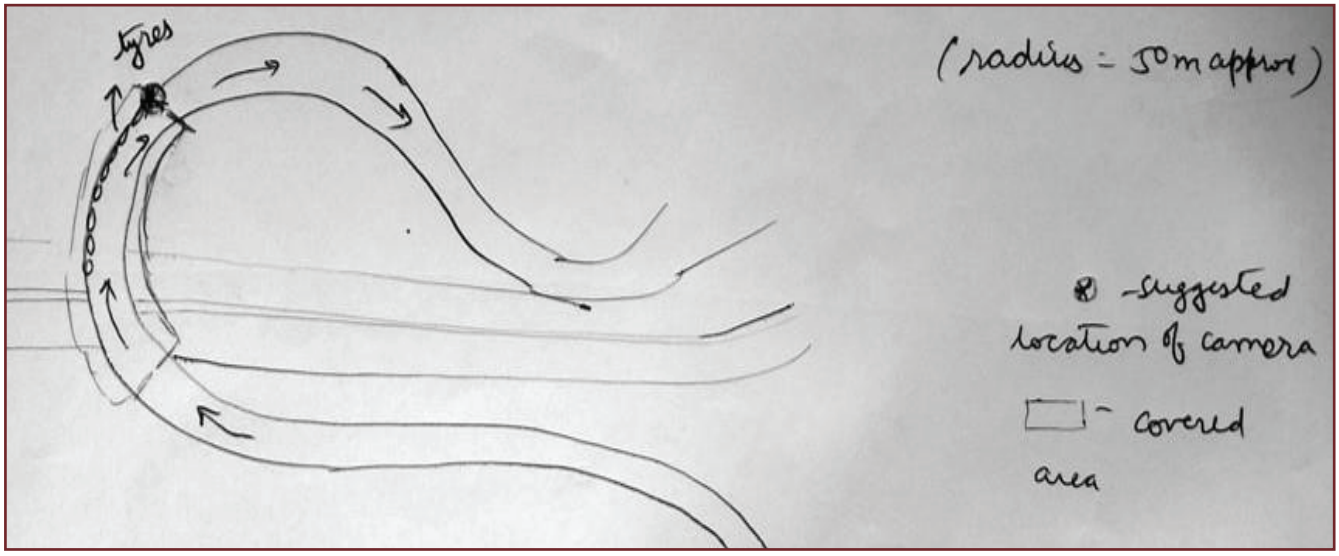
- Speed tables which have raised pedestrian crossing can be provided for the safety of the pedestrians as they are effective in curbing the high speeds
- Rumble strips with advance warning signs should be installed on the approach to the junctions to encourage the drivers to reduce their speed.
- Adequate speed limits sign and merging ahead signboards should be installed to alert the road users.
- Providing raised intersections with textured pavements and other traffic calming measures may also be helpful in capturing the attention of the road user.
- Clear delineation is required at intersections to inform road users that there is an intersection present and to provide information about the types of manoeuvres that may occur. Proper road markings as per IRC: 35-2015 and road signs as per IRC: 67-2012 should be provided near the intersections to guide the merging and diverging traffic accordingly.
- Hazard markings and channelizing markings like diagonal and chevron markings as per IRC: 35-2015 can be provided to demarcate the neutral area at the merging section which can help in reducing the incidence of collision with kerb nose. Alternatively, soft barricading can also be provided at the section where there is uneven elevation between the carriageway of the approach and the Eastern Express Highway to help the motorists in navigating the section safely.
- Median islands (or splitter islands) can be used on the approaches to intersections to improve the prominence of intersections (including by the provision of additional signs on median islands), and provide an additional benefit as they channelize traffic and may provide pedestrian protection, if designed well.
- The medians and channelizing islands should be installed with median reflectors and should be painted with retro-reflective paint to ensure visibility during night; flashing beacons can also be used to capture the attention of the road users.
- Traffic actuated signals or well-designed signal timings catering to the morning and evening peaks can be provided for managing the congestion.
- Work zone traffic management signs and reflectors should be provided near the ongoing construction work to warn the road user and drivers as discussed in 5.7 Safety at Metro Construction Zones.

3. Location 3: Towards Sea Link, Mahim Causeway Junction, Near Bandra Chowky, U – Bridge, Western Express Highway, Bandra West

The study location at Mahim Causeway Junction, Bandra West can be seen in Figure 7. It is an 8- lane divided carriageway in very good condition. The proximity of Bandra Promenade makes it a popular tourist place. There is provision for wide footpaths due to its tourist attraction. Speed limit sign of 30 kmph was present at the location. The diagrammatic sketch of this location is shown in Figure 8.



- **Figure 7: Google earth view of Mahim Causeway Junction, Near Bandra Chowky, U – Bridge, Western Express Highway, Bandra West**



- **Figure 8: Rough field diagram of Mahim Causeway Junction, Near Bandra Chowky, U – Bridge, Western Express Highway, Bandra West**

Observations made at the site:

- Speeding was observed at the location as the pavement was in good condition, despite the presence of the curve making it dangerous.
- Speed calming measures such as speed humps and rumble strips were missing.
- Signs such as “No parking”, “Go slow” and those regarding the upcoming toll plaza and Rajiv Gandhi Setup were observed at the location.
- Lack of proper pedestrian crossing facility and pedestrian walkway along the road and near the beginning of the U-Bridge due to the metro construction work has prompted the pedestrians to walk on the carriageway and cross the road wherever they pleased. This has resulted in conflicts between the drivers and the pedestrians leaving the pedestrians very vulnerable.

Recommendations:

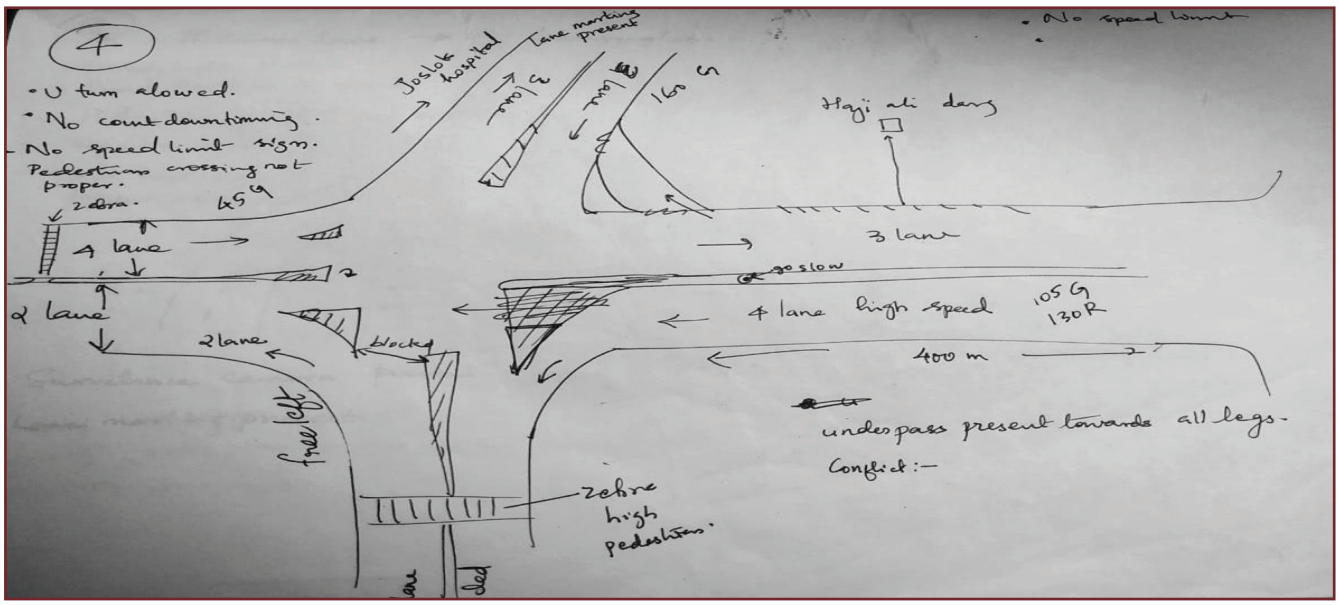
- Driver feedback signs displaying the spot speed of the road user can be used to alert the road user of their speed.
- Rumble strips complemented by flashing beacons with advance warning signs can be provided on the curve section, approaches and upstream of the junction area to control the high approach speed of the vehicles.
- Reduced speed limits signs and chevron signs should be installed to alert the road users.
- Rolling barriers can be used to minimize the impact of vehicles losing control and hitting the crash barriers, thereby reducing crashes.
- Sign notifying the presence of the curve ahead as per IRC: 67-2012 can be provided to alert the road user.
- “No stopping” sign boards as per IRC: 67-2012 can be provided to discourage vehicles from stopping at the high-speed section, to avoid congestion and crashes.
- Maintaining the appropriate amount of pavement friction is also critical for safe driving as low pavement friction allows vehicles to skid and lose control. Authorities can address this issue by monitoring the pavement friction values and improving them when they fall below a certain level.
- Pedestrian walkway and zebra crossing markings must be installed with advance warning signs to guide the pedestrians to cross the road safely as well as to encourage the drivers to reduce their speed.

4. Location 4: Haji Ali Junction

This is a major intersection adjacent to Haji Ali Dargah, a major tourist attraction. The study location can be seen in Figure 9. There is no right turn or straight movement allowed for vehicles coming from Tardeo road, i.e., only free left.

- **Figure 9: Google earth view of Haji Ali Junction**

Temporary barriers were installed to block the traffic coming from Tardeo road from going straight or turning right. There is a subway which is supposed to be used by pedestrians to cross this junction. However, many pedestrians ignore the subway and prefer to cross the road haphazardly. Due to its strategic importance, there is continuous police surveillance at this location. Many roadside vendors were present on the footpath, which effectively reduced the available width of the footpath. The intersection has all proper channelizing islands, and all the roads are 6 to 8 lanes divided by carriageway. The pavement is in good condition. The diagrammatic sketch of this location is shown in Figure 10.



- **Figure 10: Rough field diagram of Haji Ali Junction**

Observations made at the site:

- Traffic signal with a green time of 105 seconds for eastern leg, green time of 160 seconds for northern leg, green time of 45 seconds for western leg and free left only at all times for southern leg was observed. No countdown timer was observed at the traffic signal and it may be confusing for the drivers.
- Additional Traffic Police force was observed to be deployed at the time of site visit.
- Heavy flow results in speed reduction, so the average speeds are low. However, at the onset of the red or green of a signal, the flow becomes erratic and dangerous due to the tendency of drivers to start early or ignore the final few seconds of the red phase of the traffic signal.
- No speed limit signs present.
- The availability of carriageway in good condition with 3 to 4 lanes per direction led to high approach speeds in the arms which in turn might lead to rear end collisions.
- Pedestrians were observed to be walking on the carriageway instead of the footpath due to the encroachment.
- The pedestrians were also observed to be crossing the road at grade. They resorted to jumping over the median to cross the road which in turn caused conflict with the oncoming traffic who had to swerve or apply emergency brakes to avoid hitting the pedestrians.

The present site conditions can be seen in Figure 11

- **Figure 11: Identified safety issues observed during the site visit at Haji Ali Junction**

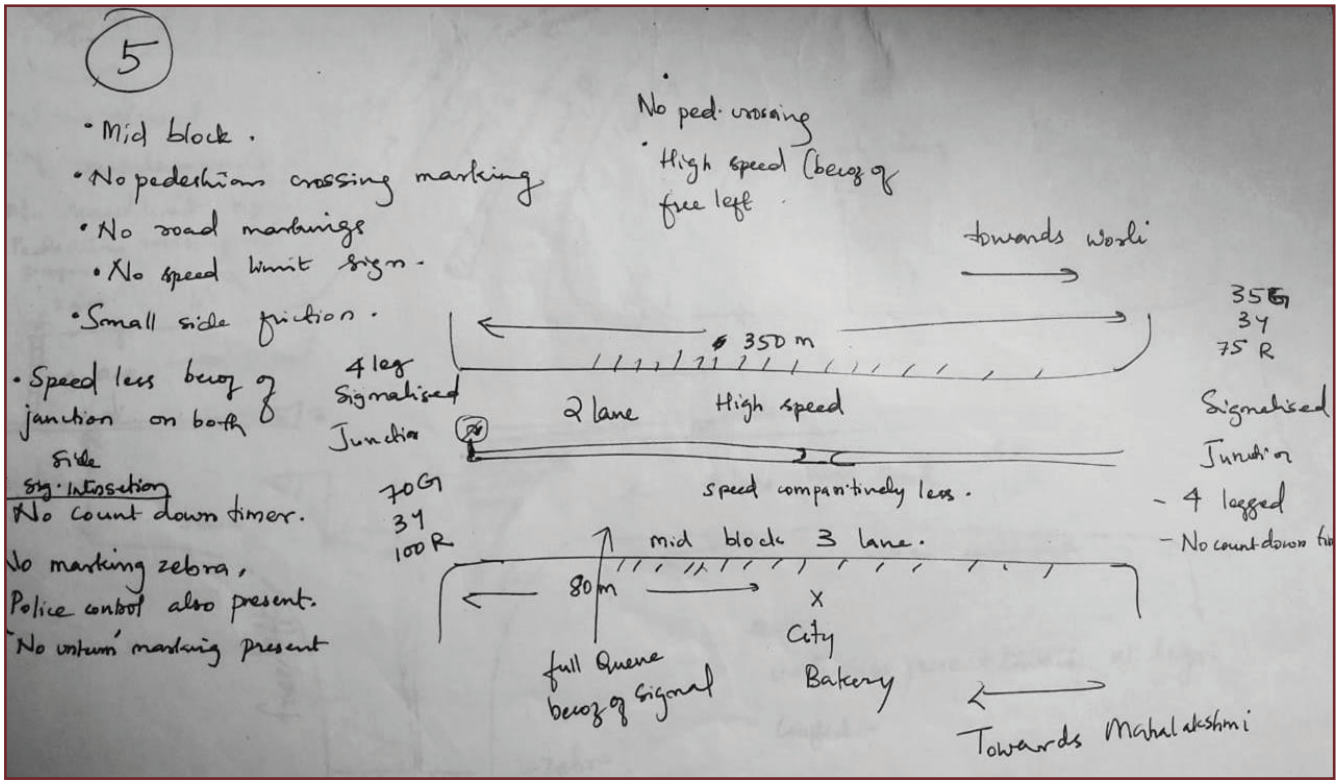
Recommendations:

- Zebra crossing markings or raised pedestrian crossing must be installed with advance warning signs to guide the pedestrians and they should be encouraged to use the subway to cross the road.
- As per IRC: 70-2017, sometimes, guardrails or high curbs are built to prevent pedestrians from crossing the street. Hence, to discourage the pedestrians from jumping over the median, height of the median can be increased. Alternatively, soft barricading on top of the existing median can be provided for the same.
- Rumble strips with advance warning signs can be provided on the approaches to control the approach speed of the drivers.
- Adequate speed limits signs with flashing beacons should be installed to alert the road users on the major approaches.
- Providing raised intersections with textured pavements and other traffic calming measures may also be helpful in capturing the attention of the road user
.
- All red time needs to be provided so that vehicles in the junction are given enough time to clear.
- Continuous footpath in good condition with guard rails and free of encroachment should be ensured so as to encourage the pedestrians to stop using the road and use the footpath. The same should be done for the subway to enable the pedestrians to cross the road safely.
- Vendor encroachment on the road and the pavement should be controlled.
- Proper road markings as per IRC: 35-2015 and road signs as per IRC: 67-2012 should be provided.

5. Location 5: City Bakery, Jafarkhan Bridge, at Worli Naka, Worli

The study location of Gafarkhan Bridge, at Worli Naka can be seen in Figure 12. This is a mid-block location with slight side friction. Although the section is between two signalized intersections, the speeds are not very high. No U-turn allowed on the downstream signal (towards Mahalaxmi). The diagrammatic sketch of this location is shown in Figure 13.

- **Figure 12: Google earth view of City Bakery, Jafarkhan Bridge, at Worli Naka, Worli**



- **Figure 13: Rough field diagram of the location near City Bakery, Gafarkhan Bridge, at Worli Naka, Worli**

Observations made at the site:

- Traffic signal to control the traffic provided with no countdown timer and green
- Time of 70 seconds, red time of 100 seconds, amber time of 3 seconds for downstream signal (towards Mahalaxmi) and green time of 35 seconds, red time of 75 seconds, amber time of 3 seconds for upstream signal (towards Worli).
- Pedestrian crossing signs and speed limit signs were missing.
- Road markings absent along the stretch and pedestrian crossing markings absent at the median opening. Pedestrians were observed to randomly cross the road without waiting for the traffic to stop.
- Most of the road section has adequately wide footpaths. The present site conditions can be seen in Figure 14.

- **Figure 14: Identified safety issues observed during the site visit at Gafarkhan Bridge, at Worli Naka**

Recommendations:

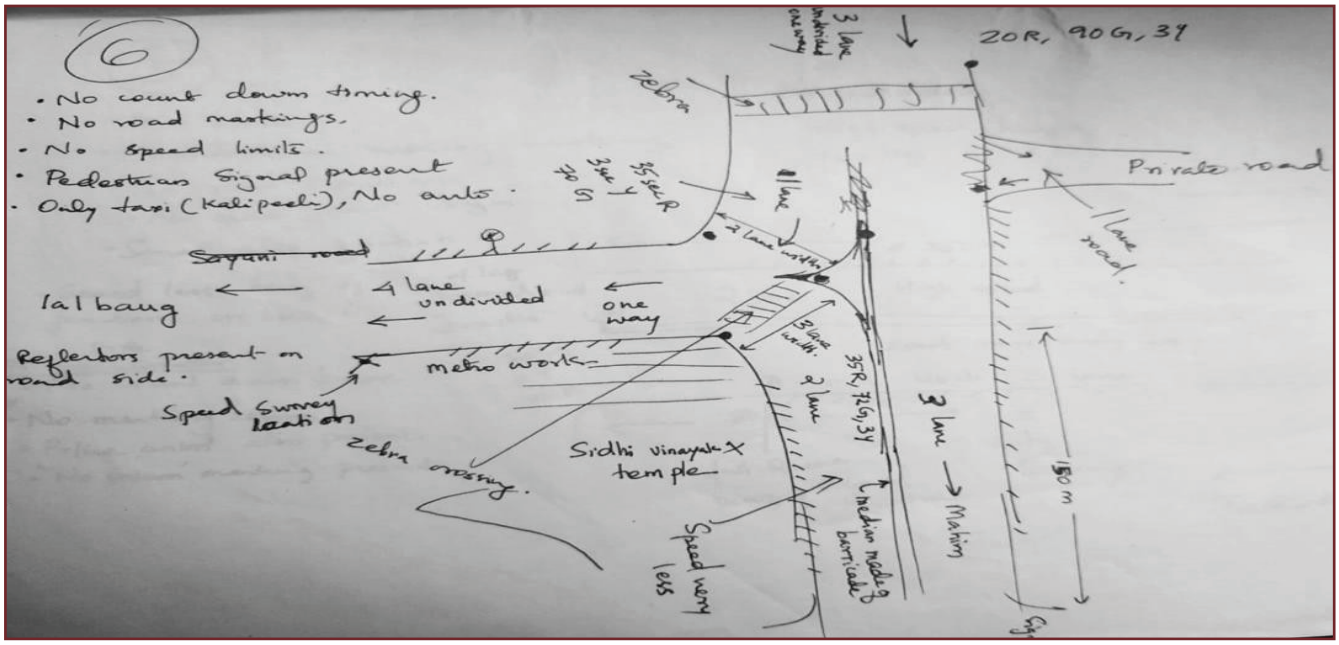
- Speed tables (raised pedestrian crossing) or Zebra crossing markings must be installed with advance warning signs at the median openings to guide the pedestrians and to alert the drivers of the presence of pedestrians on the carriageway.
- Provision for pedestrian FOB can be explored for the safety of the pedestrians as the median opening at the City Bakery caters to heavy pedestrian traffic.
- Adequate street lighting and median reflectivity will improve the night-time visibility.
- Proper road markings as per IRC: 35-2015 and road signs as per IRC: 67-2012 should be provided near the intersections to guide the road users.
- Flashing beacons or blinkers can be installed at the pedestrian crossing to warn the road users.
- The illegal parking should be monitored and regulated at the black spot to reduce the side friction.

  Note: Details and specifications of the recommendations have been discussed elaborately in Chapter 5 Recommendations and Conclusions.

6. Location 6: Front of Sane Guruji Udyan, Near Siddhivinayak Temple, Prabhadevi

The study location near Siddhivinayak Temple, Prabhadevi can be seen in Figure 15. This location is adjacent to a major tourist attraction as well as a very important road. Due to its strategic location, the presence of the temple, and other major businesses, it is mostly congested throughout the day with pedestrians. The road towards Lalbaug is one way and there is no provision of going straight for vehicles coming from Mahim. Metro construction is being carried out adjacent to this T section. Speed limit sign of 20 kmph was present at the location. The diagrammatic sketch of this location is shown in Figure 16.

- **Figure 15: Google earth view of the location in front of Sane Guruji Udyan, Near Siddhivinayak Temple, Prabhadevi**



- **Figure 16: Rough field diagram of the location in front of Sane Guruji Udyan, Near Siddhivinayak Temple, Prabhadevi**

Observations made at the site:

- No countdown timer in the traffic signal.
- Pedestrian crossing provisions were not provided and they were observed to be crossing the road randomly. They were also observed to be walking on the carriageway instead of using the footpath.
- Road markings were found to be absent or faded.
- Road users were observed to be neglecting traffic rules.
- The side road joining the main road has been closed for road works. The present site conditions can be seen in Figure 17

- **Figure 17: Identified safety issues observed during the site visit near Siddhivinayak Temple, Prabhadevi**

Recommendations:

- Speed tables (raised pedestrian crossing) or Zebra crossing markings must be installed with advance warning signs at the median opening to guide the pedestrians and to alert the drivers of the presence of pedestrians on the carriageway. At places where the pedestrians cannot cross the road in one go, refuge islands should be provided to shield them safely from the oncoming vehicular traffic.

- Since pedestrian traffic is high at the location, continuous footpaths in good condition should be maintained so as to encourage the pedestrians to use it instead of walking on the carriageway where the chances of conflicts are high.

- Adequate speed limits signs should be installed to alert the road users.

- Informatory signs regarding the presence of the major tourist attraction should be installed.

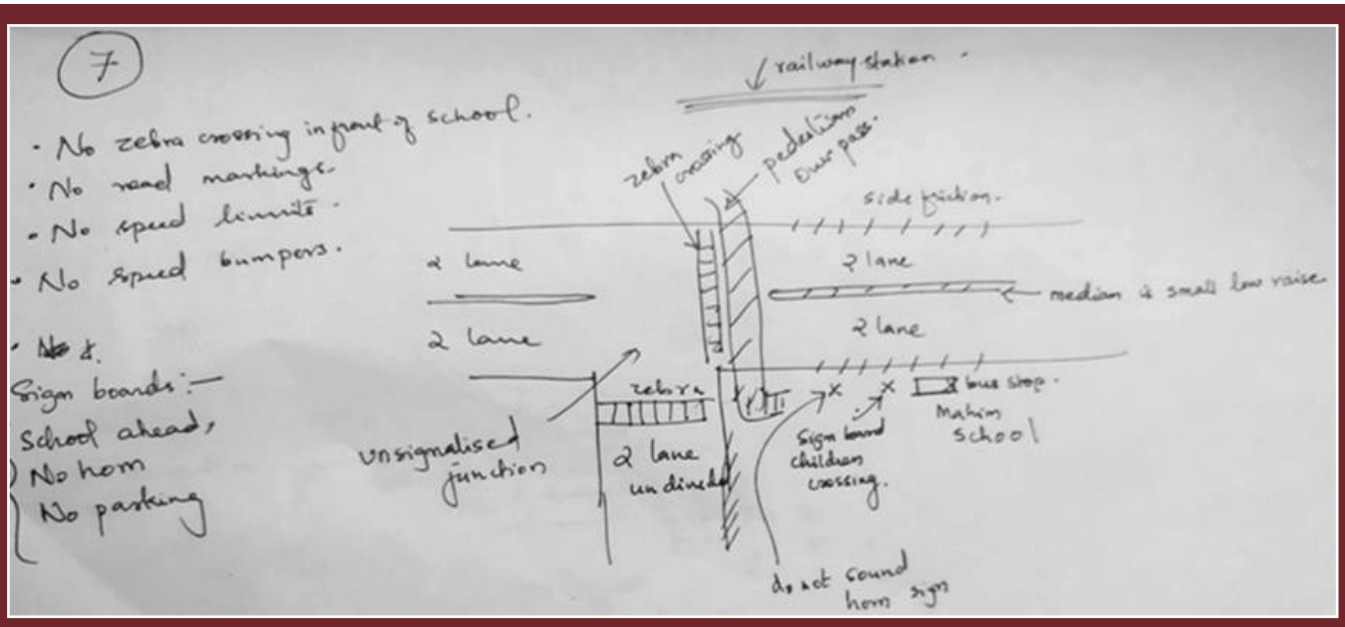
- Proper road markings as per IRC: 35-2015 and road signs as per IRC: 67-2012 should be provided.

- Adequate street lighting and median reflectivity will improve the night time visibility.

7. Location 7: Opposite Sarswati Vidhya Mandir, Near Mahim Phatak, Senapati Bapat Road, Mahim

The study location opposite to Sarswati Vidhya Mandir, near Mahim Phatak, Senapati Bapat Road, Mahim can be seen in Figure 18. It is a mid-block section, near a minor intersection. There is a provision for FOB for pedestrians wishing to go to Mahim (East) across the railway track. There is a school on the side of the road. Therefore, it might be congested during mornings and afternoons due to the school buses or private vehicles for dropping students. The carriageway is divided with 4 lanes. The side friction consists mainly of heavy vehicles parked by the side of the road. There are sign boards stating the presence of a school and “no-honking”. The diagrammatic sketch of this location is shown in Figure 19.

- **Figure 18: Google earth view of the location opposite to Sarswati Vidhya Mandir, near Mahim Phatak, Senapati Bapat Road, Mahim**



- **Figure 19: Rough field diagram of the location opposite to Sarswati Vidhya Mandir, near Mahim Phatak, Senapati Bapat Road, Mahim**

Observations made at the site:

- Accompanied with the rush hour during beginning or end of school hours, the general office going public will also add to the pedestrian volume and congestion.
- Pedestrian traffic was found to be very high at the location due to the presence of the school, the residential area, an important railway station and it being a key market location.
- Vehicles were observed to be travelling at high speeds. This resulted in frequent conflicts between the pedestrians and the vehicles.
- Wrong side driving was observed at the location.
- The footpath was in unusable condition due to it being broken and discontinuous due to the encroachment by street vendors and parking at several locations.
- Illegal parking was observed at the location. There were many buses and trucks parked along the road adding to the side friction.
- Median is broken from various places, allowing small cars and motorcycles to pass through, at their will.
- Road markings are barely visible.
- The present site conditions can be seen in Figure 20.

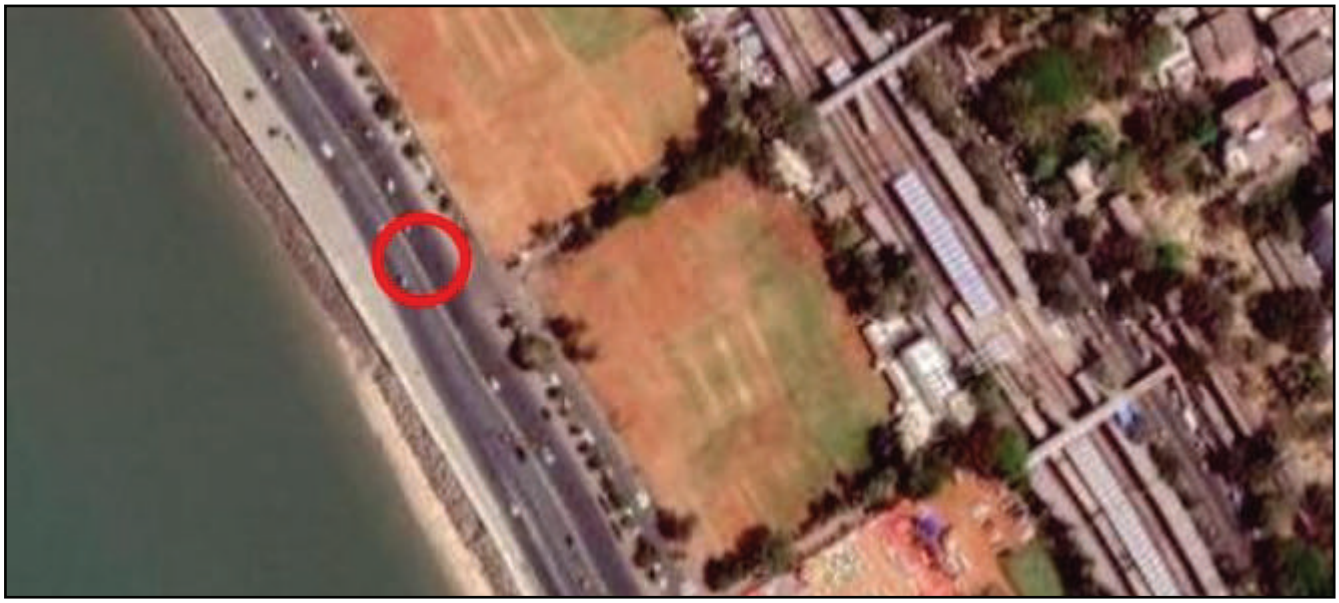
- **Figure 20: Identified safety issues observed during the site visit Near Mahim Phatak, Senapati Bapat Road, Mahim**

Recommendations:

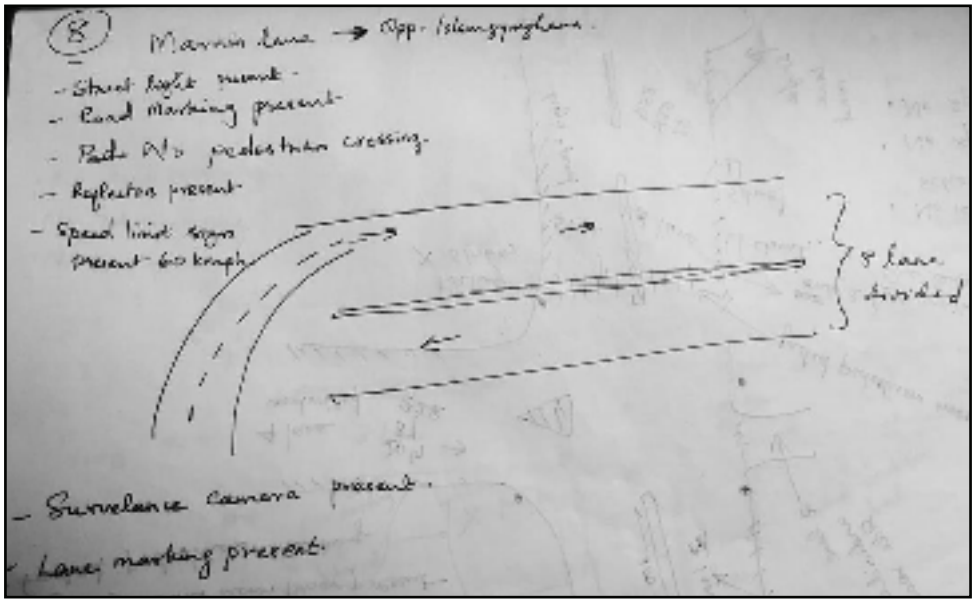
- Speed tables or raised pedestrian crossing should be provided for the safe crossing of the pedestrians. They should also be encouraged to use the foot over bridge for safety.
- Since pedestrian traffic is high at the location, continuous footpaths in good condition with guard rails and free of encroachment should be ensured so as to encourage the pedestrians to stop using the road and use the footpath.
- Reduced speed limit can be decided as it is close to the school and it should be installed to warn the users.
- Feasibility of providing a Pelican crossing (5.5 a) or a Puffin crossing (5.5 b) as discussed in Pedestrian Facilities of Recommendations can be explored near the School.
- Traffic wardens can be employed for regulating the traffic during the morning and afternoon peak hours or signal timings can be fixed to incorporate separate pedestrian crossing phases for the crossing of the pedestrians.
- Adequate speed limits signs complemented by flashing beacons should be installed to alert the road users.
- Adequate street lighting and median reflectivity will improve the night time visibility.

8. Location 8: Megdoot Bridge, Opposite Islam Gymkhana, N. S. Road

The study location of Megdoot Bridge, opposite Islam Gymkhana, N.S. Road can be seen in Figure 21. The location is one of the major tourist attractions of South Mumbai. It is an 8-lane divided facility. Pedestrian sidewalk in good condition is provided. The road conditions are very good. Street lighting is present. Reflectors have also been installed on the road. Speed limit sign of 60 kmph is present. The diagrammatic sketch of this location is shown in Figure 22.



- **Figure 21: Google earth view of Megdoot Bridge, opposite Islam Gymkhana, N.S. Road**



- **Figure 22: Rough field diagram of the location near Megdoot Bridge, opposite Islam Gymkhana, N.S. Road**

Observations made at the site:

- The main conflict was the merging of the Meghdoot bridge with the Highway where the vehicles from Meghdoot bridge were observed to join the Highway at high speeds.
- Speed limit signs of 60 kmph and surveillance cameras have been installed but they are not visible due to the Metro construction work at the location.
- Signs warning the presence of pedestrian crossing near the location were absent. The pedestrians wishing to access the local railway station from Marine Drive cross the road randomly.
- The pedestrians waiting to cross often stood between the plantation on the divider. They were often difficult to locate and resulted in causing conflicts with the oncoming traffic.
- Street lights, road markings and reflectors were observed at the location.
- The good road conditions coupled with the straight stretch results in speeding of the vehicles.

The present site conditions can be seen in Figure 23.

- **Figure 23: Identified safety issues observed during the site visit at Megdoot Bridge, opposite Islam Gymkhana, N. S. Road**

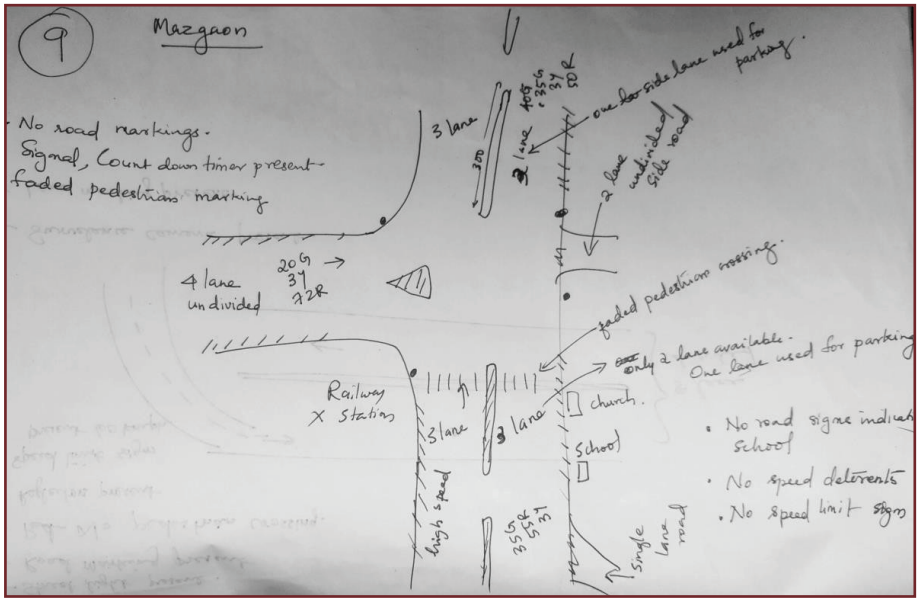
Recommendations:

- Rumble strips with advance warning signs and flashing beacons can be provided on the approaches to control the approach speed of the drivers.
- Reduced speed limit could be provided at the merging section for the vehicles merging from the Meghdoot bridge.
- Speed tables or Zebra crossing markings must be installed with advance warning signs to guide the pedestrians as well as to encourage the drivers to reduce their speed.
- Driver feedback signs displaying the spot speed of the road user can be used to alert the road user of their speed.
- “Merging section ahead” signs should be ensured to be in good condition throughout the year
- Providing textured pavements at the merging section may also be helpful in capturing the attention of the road user.
- Informatory signs to safely guide the pedestrians wishing to access the Marine Lines railway stations should be installed. Soft barricading can be provided on the median so as to discourage the pedestrians from crossing wherever they pleased. This would help in reducing the conflicts between pedestrians and the oncoming high-speed traffic.
- Footpaths with safety guard rails can be provided to protect the pedestrians from the vehicles.
- CCTV surveillance can be used to check the culprits of rash driving and fines should be imposed.

9. Location 9: Barrister Nath Pai Road, Church Signal, Canara Bank, In Front of ATM, Nearby Dockyard Station, Mazgaon

Figure 24 depicts the Google earth view of Barrister Nath Pai Road, Church Signal, Canara Bank, in front of ATM, nearby Dockyard Station, Mazgaon. It is a three-legged signalized T-junction. Approaching speed of vehicles in this junction is high. The carriageway consists of six lane divided major road and four lanes undivided minor road. Most of the time vehicles are parked near the side of the main road effectively reducing one lane. Due to the presence of a dockyard railway station and school, pedestrian flow at this junction is high. The diagrammatic sketch of this location is shown in Figure 25.

- **Figure 24: Google earth view of Barrister Nath Pai Road, Church Signal, Canara Bank, in front of ATM, nearby Dockyard Station, Mazgaon**



- **Figure 25: Rough field diagram of Barrister Nath Pai Road, Church Signal, Canara Bank, in front of ATM, nearby Dockyard Station, Mazgaon**

Observations made at the site:

- It is a signalized T-Intersection with a Countdown timer. Total cycle time is 100 seconds with a green time of 35 seconds, red time of 55 seconds and amber time of 5 seconds allotted for the major road and a green time of 25 seconds, red time of 72 seconds and amber time of 3 seconds allotted for the minor road.
- Late at night, the signals are turned off and the amber blinker is turned on.
- Speed deterrents such as speed breakers, rumble strips absent at the location. Hence, vehicles moving at very high speed are forced to reduce the speed as they approach the T-intersection, which may result in rear end collisions.
- Speed limit signs, “School ahead” sign boards absent and some of the signs are not visible due to improper placement.
- Congestion at the junction was caused when dockyard shipment employees leave work. This often resulted in the impatient motorists cutting through lanes recklessly resulting in crashes. Side friction due to the parked vehicles reduces the effective width of the carriageway
- Traffic rules are frequently neglected by the road users.
- Faded pedestrian crossing markings and other road markings. The zebra crossing marking was obstructed due to the plantation on the divider.

The photographs taken during the site inspection can be seen in Figure 26. These photographs indicate the present issues at Barrister Nath Pai Road, Church Signal, Canara Bank, in front of ATM, nearby Dockyard Station, Mazgaon

- **Figure 26: Identified safety issues observed during the site visit at Barrister Nath Pai Road, Church Signal, Canara Bank, in front of ATM, nearby Dockyard Station, Mazgaon**

Recommendations:

- Speed tables (raised pedestrian crossing) or Zebra crossing markings must be installed with advance warning signs at the median opening to guide the pedestrians and to alert the drivers of the presence of pedestrians on the carriageway. At places where the pedestrians cannot cross the road in one go, refuge islands should be provided to shield them safely from the oncoming vehicular traffic.

- A separate pedestrian crossing phase can be included in the traffic signal to accommodate pedestrian safety. Feasibility of lane narrowing can be explored at the location.

- Providing raised intersections with textured pavements and other traffic calming measures may also be helpful in capturing the attention of the road user

- Rumble strips with advance warning signs and flashing beacons can be provided on the approaches to control the approach speed of the drivers.

- Provision for pedestrian FOB can be explored for the safety of the pedestrians. Traffic wardens can be employed for regulating the traffic during the peak hours when the dockyard employees leave work to manage the traffic and the traffic violations.

- To avoid conflicts and to improve intersection visibility, road side illegal parking and encroachment should be restricted.

- Cautionary signs signalling crash prone areas to warn the road user of the black spot can be installed at the location to alert the road users.

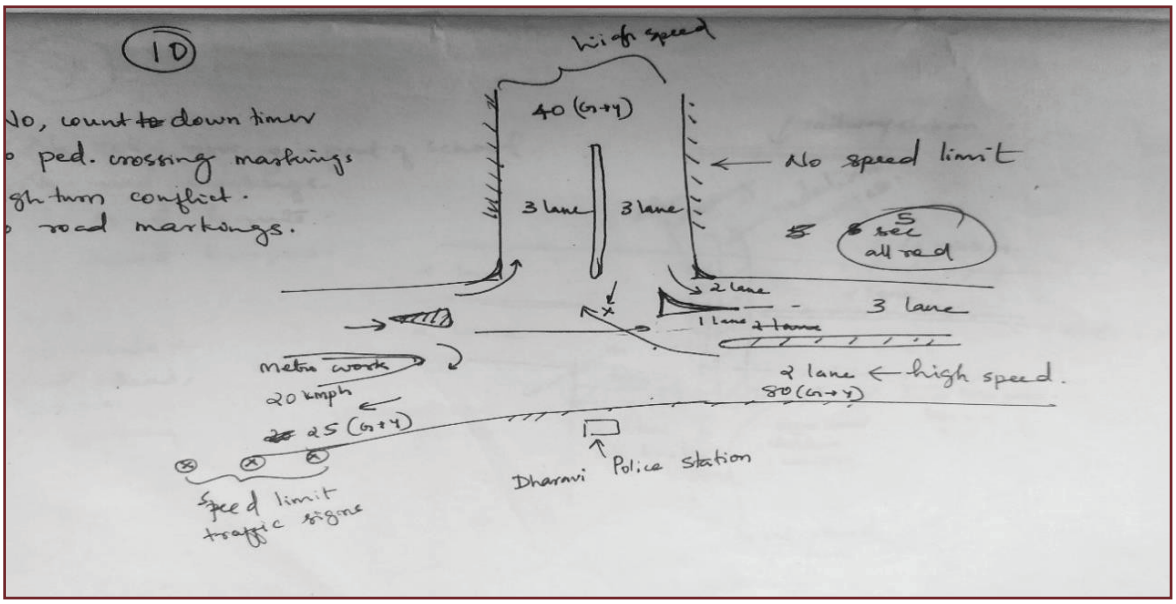
- Feasibility of keeping the signals in operation 24x7 should be explored so as to keep the speeding at night in check.

- Proper road markings as per IRC: 35-2015 and road signs as per IRC: 67-2012 should be provided.

10. Location 10: Y Junction, Sion Bandra Link Road, Dharavi

Figure 27 depicts the Google earth view of Y Junction, Sion Bandra Link Road, Dharavi. It is a three-legged signalized T- junction with a total cycle time of 160 seconds. The major traffic is coming from Sion-Bandra link road to this junction at high speeds. This carriageway is divided into six lanes. The carriageway is reduced and the speed of the vehicles is low on the carriageway due to the metro construction work carried out on Mahim-Sion link road. Merging conflict is high at this junction. The diagrammatic sketch of this section is shown in Figure 28.

- **Figure 27: Google earth view of the Y- Junction, Sion Bandra Link Road, Dharavi, Mumbai**

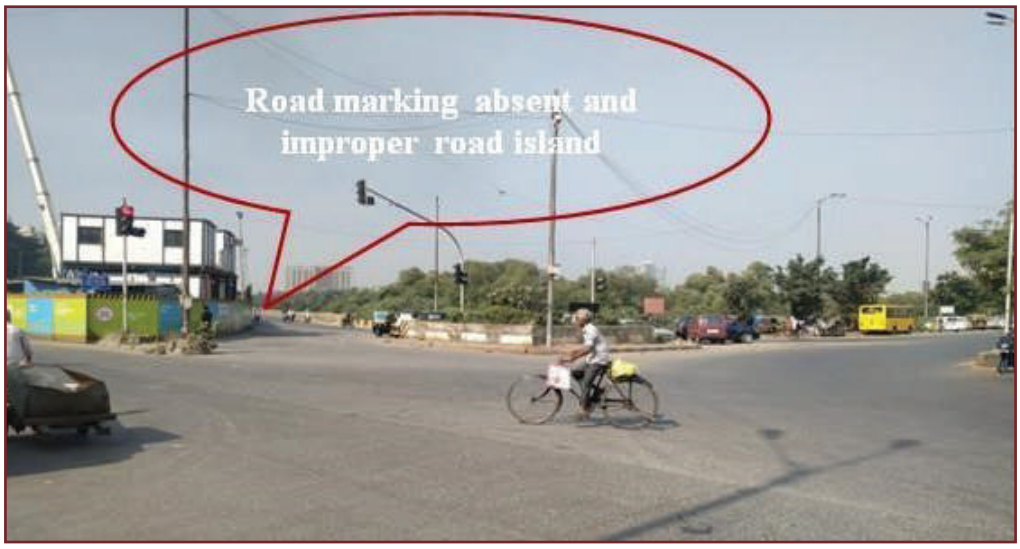


- **Figure 28: Rough field diagram of Y Junction, Sion Bandra Link Road, Dharavi**

Observations made at the site:

- It is a signalized T-Intersection with no countdown timer. Traffic signals are provided with 80 seconds Green time for northern, 40 seconds Green time for eastern and 25 seconds Green time for western.
- Speed deterrents such as speed breakers, rumble strips absent at the location. Hence, vehicles moving at very high speed are forced to reduce the speed as they approach the T-intersection, which may result in rear end collisions.
- Speed limit signs were present.
- Lack of proper channelization led to vehicles crossing the intersection haphazardly and dangerously once the signal turned green for turning movements.
- Faded pedestrian crossing markings and other road markings. Left turn lane marking absent.
- Available road width was reduced on both sides due to the metro construction work.
- Side friction around the junction was caused due to the parked vehicles.
- Right turn conflicts and pedestrian vehicle conflicts were observed to be more.
- Drivers and pedestrians were observed to be negligent of traffic rules and regulations.

The photographs taken during the site inspection can be seen in Figure 29. These photographs indicate the present issues at Y Junction, Sion Bandra Link Road, Dharavi



- **Figure 29: Identified safety issues observed during the site visit at Y Junction, Sion Bandra Link Road, Dharavi**

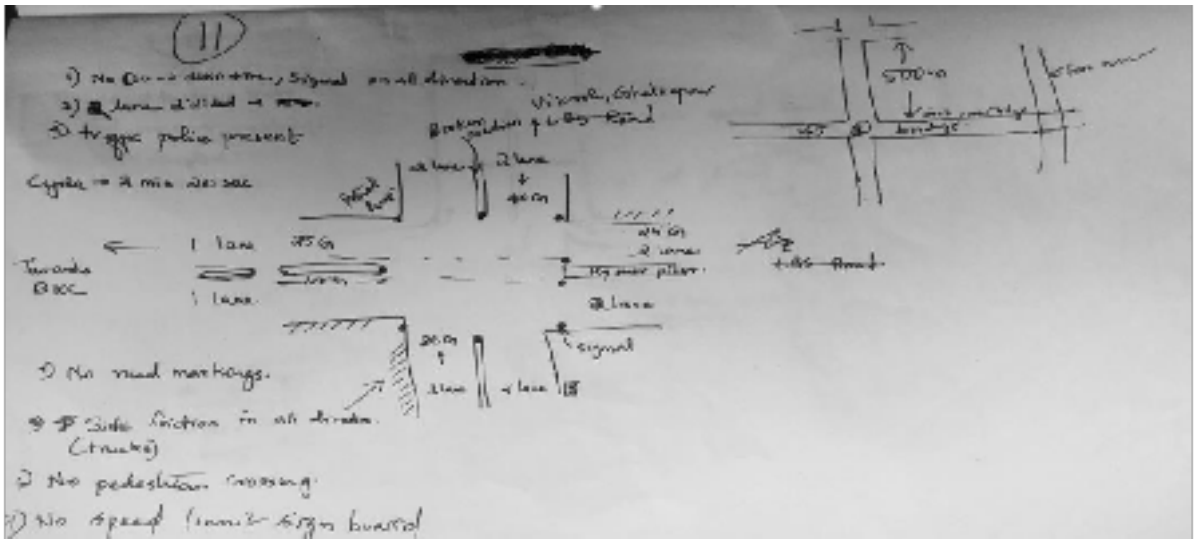
Recommendations:

- Rumble strips with advance warning signs and flashing beacons can be provided on the approaches to control the approach speed of the drivers. Feasibility of lane narrowing should be considered at the location to reduce the high speeds while approaching the intersection
- Driver feedback signs displaying the spot speed of the road user can be used to alert the road user of their speed.
- Providing raised intersections with textured pavements and other traffic calming measures may also be helpful in capturing the attention of the road user.
- Traffic actuated signals or well-designed signal timings catering to the morning and evening peaks can be provided for managing the congestion.
- Channelizing islands should be provided at the intersection to guide the drivers to better predict the path and speed of other drivers.
- Speed limits suitable for each of the approaches to the intersection should be installed as per IRC: 67-2012.
- Proper road markings as per IRC: 35-2015 and road signs as per IRC: 67-2012 should be provided at the intersection.
- To avoid conflicts and to improve intersection visibility, road side illegal parking and encroachment should be restricted.
- Work zone traffic management signs and reflectors should be provided near the ongoing construction work to warn the road user and drivers as discussed in 5.7 Safety at Metro Construction Zones.

11. Location 11: CST Bridge, Near Kurla Bus Depot, Kurla West

Figure 30 depicts the Google earth view of CST Bridge, Near Kurla Bus Depot, Kurla West. It is a four legged signalized intersection. Land use is mixed in nature. The intersection does not have a proper channelizing island and all the roads are 4 lanes (divided) with broken medians. The road conditions are not good. Metro construction work has started from the CST road. In that portion, the speed of the vehicles is very less because of reduction in width of lanes. High side friction was observed due to heavy vehicles parked by the roadside at CST and Tamasi-Bandat road. Mumbai-Pune highway also passes through this junction. Speed limit sign of 20 kmph was present at the location. The diagrammatic sketch of this section is shown in Figure 31.

- **Figure 30: Google earth view of CST Bridge, near Kurla Bus Depot, Kurla West**



- **Figure 31: Rough field diagram of location near CST Bridge, near Kurla Bus Depot, Kurla West**

Observations made at the site:

- It is a four-legged signalized intersection with no countdown timer. Traffic signals are provided with a green time of 30 seconds for northern, green time of 25 seconds for eastern, green time of 40 seconds for southern and green time of 25 seconds for western. Traffic officials were also observed to be controlling the traffic.
- As the traffic is heavy in this section, speeds of the vehicles were observed to be low.
- Speed deterrents such as speed breakers, rumble strips absent at the location.
- The new BKC connector opened in 2020 and it seems to have reduced the traffic congestion along this stretch.
- Pedestrian traffic was found to be very high at the location due to the presence of the residential area and it being a key market location.
- Pedestrian crossing signs were absent at the location. Some sign boards are present but not properly placed.
- Road markings such as left turn markings, pedestrian crossing markings, etc., were absent and some of them were faded.
- Available road width was reduced due to the metro construction work being carried out on both sides of the roads.
- Improper alignment of the carriageway and pavement surface was in poor condition.
- Side friction around the junction was caused due to the parked vehicles.
- Drivers were observed to be negligent of traffic rules and regulations.
- Footpath or sidewalk was observed to be in poor condition.

The photographs taken during the site inspection are shown in Figure 32 and Figure 33. These photographs indicate the present issues at CST Bridge, near Kurla Bus Depot, Kurla West.

- **Figure 32: Identified safety issues observed during the site visit at CST Bridge, Kurla West**

- **Figure 33: Congestion at the starting stage of CST road flyover, CST Bridge**

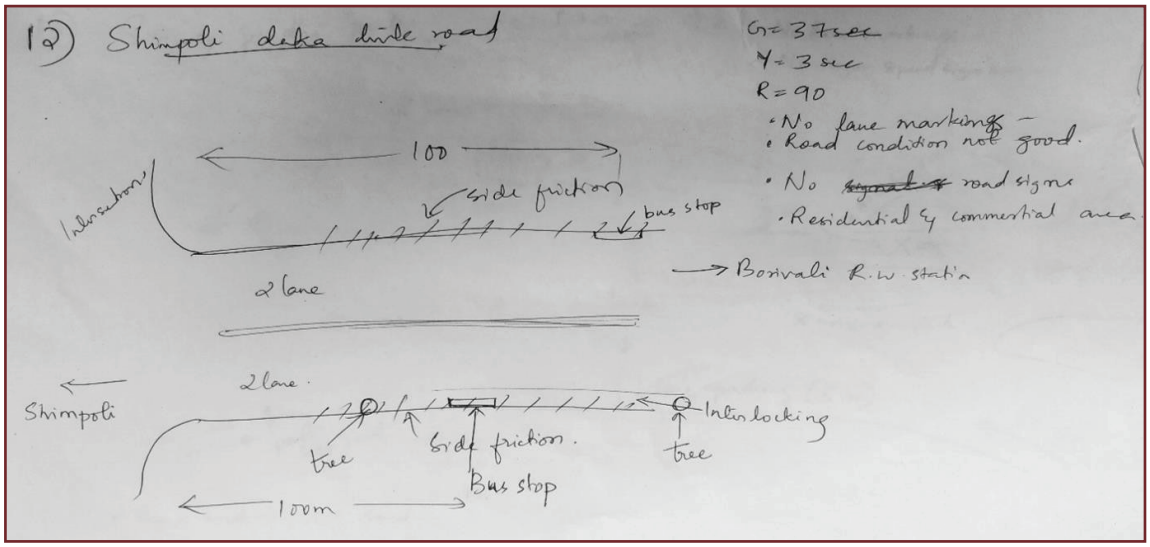
Recommendations:

- Speed breakers or rumble strips with advance warning signs can be provided on the approaches to control the approach speed of the drivers.
- Providing raised intersections with textured pavements and other traffic calming measures may also be helpful in capturing the attention of the road user.
- Traffic actuated signals or well-designed signal timings catering to the morning and evening peaks can be provided for managing the congestion.
- Clear delineation is required at intersections to inform road users that there is an intersection present and to provide information about the types of maneuvers that may occur. Proper road markings as per IRC: 35-2015 and road signs as per IRC: 67-2012 should be provided near the intersections to guide the merging and diverging traffic accordingly.
- Median islands (or splitter islands) can be used on the approaches to intersections to improve the prominence of intersections (including by the provision of additional signs on median islands), and provide an additional benefit as they channelize traffic and may provide pedestrian protection if designed well.
- Channelizing islands should be provided at the intersection to guide the drivers to better predict the path and speed of other drivers. The medians and the islands should be installed with median reflectors and should be painted with retro-reflective paint to ensure visibility during night; flashing beacons can also be used to capture the attention of the road users.
- Adequate speed limits signs complemented by flashing beacons should be installed to alert the road users.
- Cautionary signs highlighting crash prone areas to warn the road user of the black spot should be properly installed at the location to alert the road users.
- Work zone traffic management signs and reflectors should be provided near the ongoing construction work to warn the road user and drivers as discussed in 5.7 Safety at Metro Construction Zones.
- Vehicle conflicts can be reduced and the intersection visibility can be improved by restricting roadside illegal parking and encroachment.
- Pavement distresses such as potholes, rutting should be removed and its condition should be improved for better level of service.

12. Location 12: Shimpoli Naka Link Road, Shimpoli Gorai Road, Near Shimpoli Choki, Borivali West

Figure 34 depicts the Google map view of Shimpoli Naka Link Road, Shimpoli Gorai Road, near Shimpoli Choki, Borivali West. It is a four-lane divided midblock section. Traffic flow in this corridor is high due to the proximity of Borivali railway station. Moreover, land use is mixed in nature. The diagrammatic sketch of this section is shown in Figure 35.

- **Figure 34: Image and Google map view of Shimpoli Naka Link Road, Borivali West**



- **Figure 35: Rough field diagram of Shimpoli Naka Link Road, Shimpoli Gorai Road, Near Shimpoli Chowki, Borivali West**

Observations made at the site:

- Lack of proper pedestrian crossing facility and pedestrian walkway along the road due to the parked vehicles has prompted the pedestrians to walk on the carriageway and cross the road wherever they pleased. This has resulted in conflicts between the drivers and the pedestrians leaving the pedestrians very vulnerable.
- Pedestrian traffic was found to be high at the location due to the presence of the residential area nearby.
- Signs such as speed limit, pedestrian crossing sign, etc., and other relevant signs were absent at the location. Some of the signs were placed incorrectly.
- Road markings as well as pedestrian crossing markings, etc., were absent.
- Available road width was reduced due to the parked vehicles which created side friction on both sides of the roads. This also reduced the line of sight for the drivers.
- Road surface was observed to be in poor conditions.
- Visibility at night was observed to be very poor.
- The median was observed to be devoid of the retro-reflective paint and was found to be broken at certain locations.
- Vehicles were observed to be travelling at high speeds at night.
- The vehicles parked on the road caused side friction.

The photographs taken during the site inspection are shown in Figure 36. These photographs indicate the present issues at Shimpoli Naka Link Road, Shimpoli Gorai Road, Near Shimpoli Choki, Borivali West.

- **Figure 36: Identified safety issues observed during the site visit at Shimpoli Naka Link Road, Borivali West**

Recommendations:

- Speed tables or Zebra crossing markings with flashing beacons must be installed with advance warning signs to guide the pedestrians as well as to encourage the drivers to reduce their speed.
- Adequate speed limits signs complemented by flashing beacons should be installed to alert the road users.
- Vehicle conflicts can be reduced by regulating side friction such as illegal parking and encroachment. This will also improve the line of sight of the drivers.
- Broken median should be repaired and the median should be painted with retro-reflective paint to ensure visibility during night time.
- Proper road markings as per IRC: 35-2015 and road signs as per IRC: 67-2012 should be installed at the location and periodic maintenance should be done to ensure their efficiency

13. Location 13: Near Sanjay Gandhi National Park Gate, Under Flyover, Borivali East

It is a complex intersection near the main gate of Sanjay Gandhi National Park. Flyover (western express highway) is passing through this junction as shown in Figure 37. Moreover, two main roads (Mahatma Gandhi road and Carter road) are connected to the Sanjay Gandhi road. The location is a popular tourist attraction, and it is crowded for most part of the day. Pedestrian as well as vehicular traffic was found to be high. One side of the carriage way consists of 3 lane road with one lane parking facilities. Merging conflict was observed to be more at the location. There are many openings present in this junction, where the vehicles are used to taking a U turn. It leads to vehicle-vehicle conflict. Under the flyover, one lane is dedicated to auto-rickshaws to cross the junction. And on the other side, one lane is dedicated to all the other categories of vehicles.

- **Figure 37: Google earth view of Sanjay Gandhi National Park Gate, under Flyover, Borivali East**

Observations made at the site:

- Traffic officials were observed to be controlling the traffic. The traffic signal at the intersection was operational only during the peak hours.
- A large number of conflicts could be seen at the location, especially at merging.
- As the traffic is heavy in this section, speeds of the vehicles were observed to be low.
- Signs such as speed limit signs, “Merging Ahead” signs, etc., were found to be missing. Some of the signs were incorrectly placed.
- Traffic violators were also abundant in this location in the absence of proper traffic calming measures.
- Pedestrian traffic was found to be very high at the location due to the presence of the Interstate bus terminal facility and the residential area.
- Pedestrian crossing marking and sign was found to be absent. Road markings were also observed to be absent.
- Vehicles parked on either side of the road near the intersection and the street hawkers created side friction.
- Improper alignment of the carriage way and pavement was also not in good condition.
- Construction work of the sidewalk was being carried out at the location.

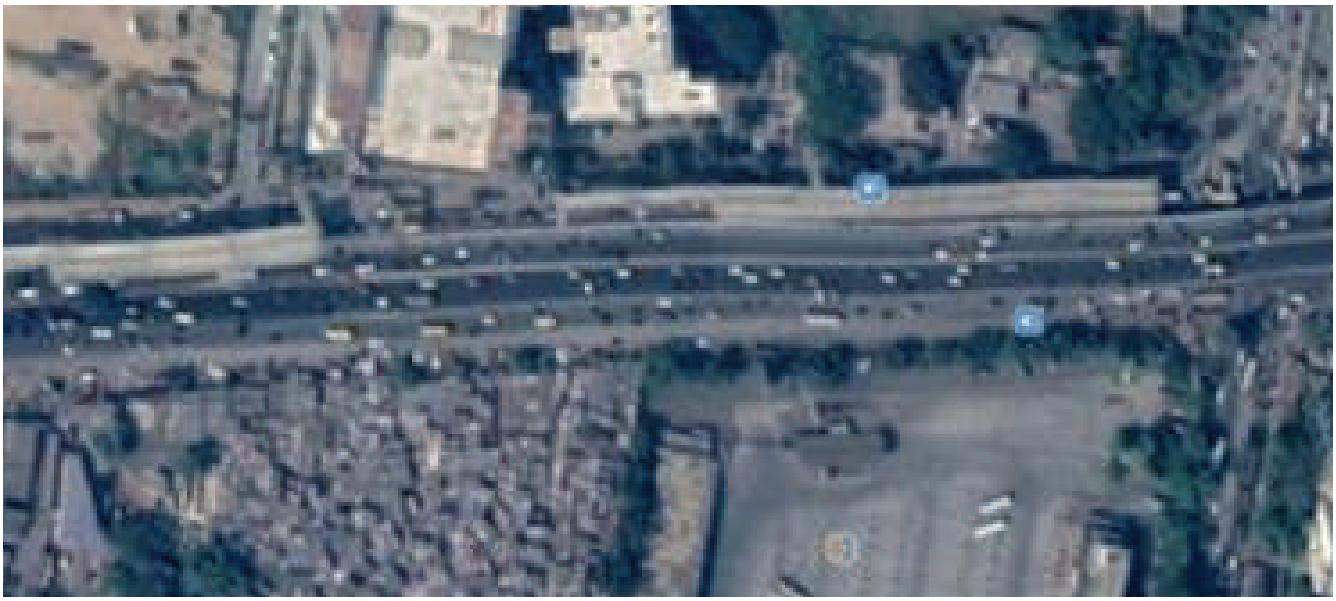
- **Figure 38: Identified safety issues observed during the site visit at Sanjay Gandhi National Park Gate, Under Flyover, Borivali East**

Recommendations:

- Zebra crossing markings or raised pedestrian crossing must be installed with advance warning signs to guide the pedestrians to cross the road safely.
- A separate pedestrian crossing phase can be incorporated in the traffic signal for the crossing of the pedestrians safely.
- Providing raised intersections with textured pavements and other traffic calming measures may also be helpful in capturing the attention of the road user.
- Gradual merging section with “Merging Traffic Ahead” sign board as per IRC: 67-2012 should be provided.
- Clear delineation is required at intersections to inform road users that there is an intersection present and to provide information about the types of maneuvers that may occur. Proper road markings as per IRC: 35-2015 and road signs as per IRC: 67-2012 should be provided near the intersections to guide the merging and diverging traffic accordingly.
- Median islands (or splitter islands) can be used on the approaches to intersections to improve the prominence of intersections (including by the provision of additional signs on median islands), and provide an additional benefit as they channelize traffic and may provide pedestrian protection if designed well.
- Channelizing islands should be provided at the intersection to guide the drivers to better predict the path and speed of other drivers. The medians and the islands should be installed with median reflectors and should be painted with retro-reflective paint to ensure visibility during night; flashing beacons can also be used to capture the attention of the road users.
- Adequate speed limits signs complemented by flashing beacons should be installed to alert the road users.
- Vehicle conflicts can be reduced by regulating roadside illegal parking and encroachment.
- Broken median should be repaired or a new one should be constructed and painted with retro- reflective paint.

14. Location 14: Near Metro Mall, North Bound Magathane Depot Bridge Junction near Annex Mall, W.E.H, Borivali East

Figure 39 indicates the Google earth view of Magathane Depot Bridge Junction near Annex Mall, W.E.H, Borivali East. This location consists of a mid-block section and a junction near it. The mid- block section is with 6 lanes towards Andheri direction; 3 lane carriageway from the flyover joins with 3 lane road on the side. Almost one lane width is obstructed by the parked vehicles creating side friction. Road towards Borivali direction consists of 3 lane road leading to the flyover; 1 lane side road merges with this 3-lane road about 100 m before the start of flyover. 2 lane service road is provided towards Borivali direction. The service lane is diverted towards another side road because of Metro construction. There are many openings present on the divider and is used by vehicles for taking a U turn. The junction has a major approach with 4 lane road towards Andheri and 2 lane road towards Borivali. The minor approach consists of a 10 lane divided road on one side and a 4 lane divided road on the other side.



- **Figure 39: Google earth view of Magathane Depot Bridge Junction near Annex Mall, W.E.H, Borivali East**

Observations made at the site:

- The cycle length of the traffic signal at the junction is 160 seconds with a green time of 45 seconds towards Borivali, green time of 25 seconds towards Andheri, green time of 50 seconds towards Jai Maharashtra road and green time of 35 seconds towards Dattapada road. 3 seconds amber time is given to all phases.

- A 30 m opening in the divider is provided right before the beginning of the flyover, which is used by high-speed vehicles from the flyover to take U turns (currently this opening is temporarily closed by barricades and ropes).

- High speed vehicles from the flyover and vehicles from the side road merge suddenly in the absence of a gradual merging section (towards Andheri side). Also, there is a difference in elevation between the approach road and the slip road which proved dangerous to the vehicles coming down from the flyover.

- Towards Borivali side, vehicles from the single lane service road merge with the high-speed vehicles from the main road about 100 m before the start of the flyover. Merging is sudden and not gradual.
- No speed signs, no “Merging Ahead” sign board, no reflectors were observed near merging section
- Pedestrian traffic was found to be very high at the location due to the presence of the residential area and the Metro mall.
- Absence of higher order facilities such as foot over bridges or subways makes it difficult for pedestrians to cross the road safely.
- The road markings are faded. In the absence of Stop lines on the approaches, vehicles stopped in the junction area during red time.

The present site conditions can be seen in Figure 40.

- **Figure 40: Identified safety issues observed during the site visit at Magathane Depot Bridge Junction near Annex Mall**

Recommendations:

- The 30 m opening in the divider right before the beginning of the flyover must be permanently closed. A U-turn facility can be provided at some other location farther away from the flyover.

- Zebra crossing markings or raised pedestrian crossing must be installed with advance warning signs to guide the pedestrians to cross the road safely. Additionally, informatory signs to safely guide the pedestrians to use the zebra crossing markings for crossing the road can be installed.

- Separate pedestrian crossing phases can be included in the traffic signal to accommodate pedestrian safety.

- Driver feedback signs displaying the spot speed of the road user can be used to alert the road user of their speed. Adequate speed limits signs should be installed to alert the road users.

- The roads merging into the Western Express Highway should be equipped with speed breakers with advance warning to encourage the drivers to reduce their speed when merging into the expressway.

- Gradual merging section with “Merging Traffic Ahead” sign board as per IRC: 67-2012 should be provided wherever applicable to enable the gradual merging of the vehicles.

- Hazard markings and channelizing markings like diagonal and chevron markings as per IRC: 35-2015 can be provided to demarcate the neutral area at the merging section which can help in reducing the incidence of collision with kerb nose. Alternatively, soft barricading can also be provided at the section where there is uneven elevation between the carriageway of the flyover and the slip road to help the motorists in navigating the section safely.

- Channelizing islands should be provided at the intersection to guide the drivers to better predict the path and speed of other drivers. The medians and the islands should be installed with median reflectors and should be painted with retro-reflective paint to ensure visibility during night; flashing beacons can also be used to capture the attention of the road users.

- All red time needs to be provided so that vehicles in the junction are given enough time to clear.

- Adequate speed limits signs complemented by flashing beacons should be installed to alert the road users.

- Work zone traffic management signs and reflectors should be provided near the ongoing construction work to warn the road user and drivers as discussed in 5.7 Safety at Metro Construction Zones.

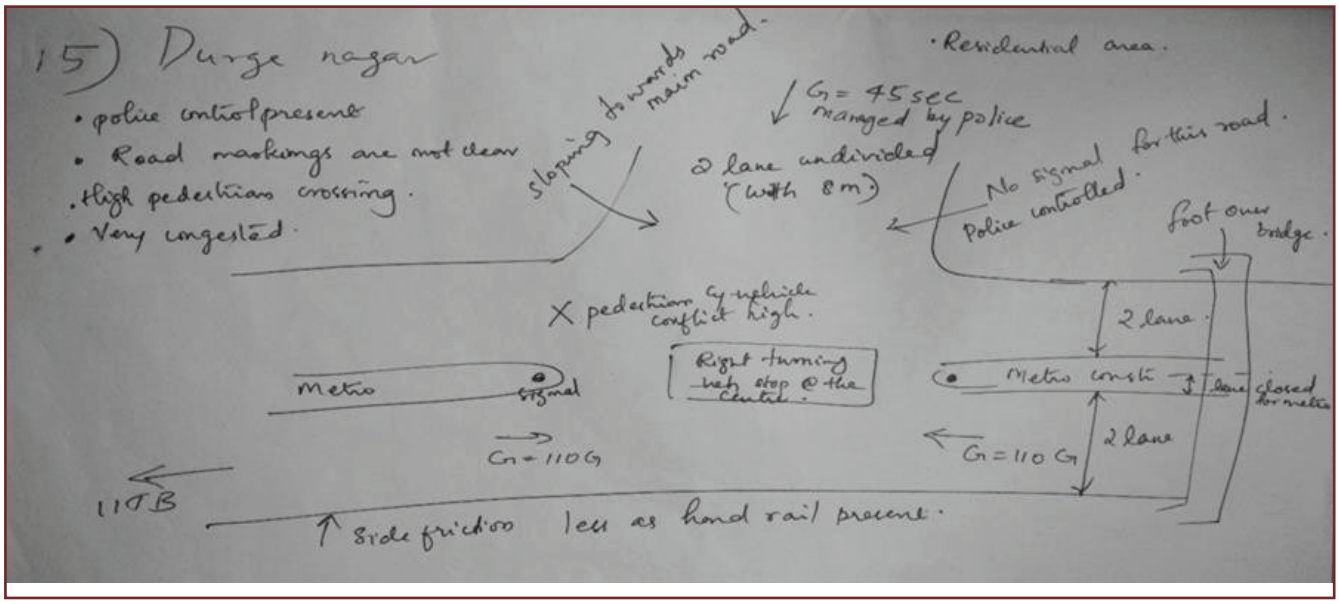
- Pavement conditions can be improved to provide a better level of service to the users.

- Proper road markings as per IRC: 35-2015 and road signs as per IRC: 67-2012 should be provided at the intersection.

15. Location 15: Durga Nagar Junction, JVLR, Jogeshwari

The location of Durga Nagar Junction, JVLR, Jogeshwari as seen in Figure 41 is a 3-legged intersection. The main approach road is a 6 lane divided road with one lane on each direction closed for metro construction. The side road is a two-lane undivided road with approximately 8m width. The location is in a residential area and hence the pedestrian crossing volume is very high. Signal timing for main approach: 110 seconds green for the main approach road in both directions, 3 seconds amber. The traffic from the side road is controlled manually by police and approximately 45 seconds is given as green time in each cycle by the police. Side friction is less as handrail present on the side. The diagrammatic sketch of this section is shown in Figure 42.

- **Figure 41: Google earth view of Durga Nagar Junction, JVLR, Jogeshwari**



- **Figure 42: Rough field diagram of Durga Nagar Junction, JVLR, Jogeshwari**

Observations made at the site:

- The side road joins the intersection in a small downward gradient as a result of which the vehicles join the intersection at high speeds.
- The footpath was in unusable condition due to it being broken and discontinuous due to the encroachment by street hawkers at several locations.
- No speed limit signs present.
- Large number of vehicle-vehicle and vehicle-pedestrian conflicts present at the junction area especially by right turning traffic on all approaches.
- Even though a foot over bridge is provided, the majority of the pedestrians do not make use of this facility. Pedestrians and vehicles from the side road cross the road together making the movement riskier for pedestrians.
- Road markings are very faded.
- Traffic during peak flow conditions is congested as lanes are closed for metro construction.

The present site conditions can be seen in Figure 43.

- **Figure 43: Identified safety issues observed during the site visit at Durga Nagar Junction, JVLR, Jogeshwari**

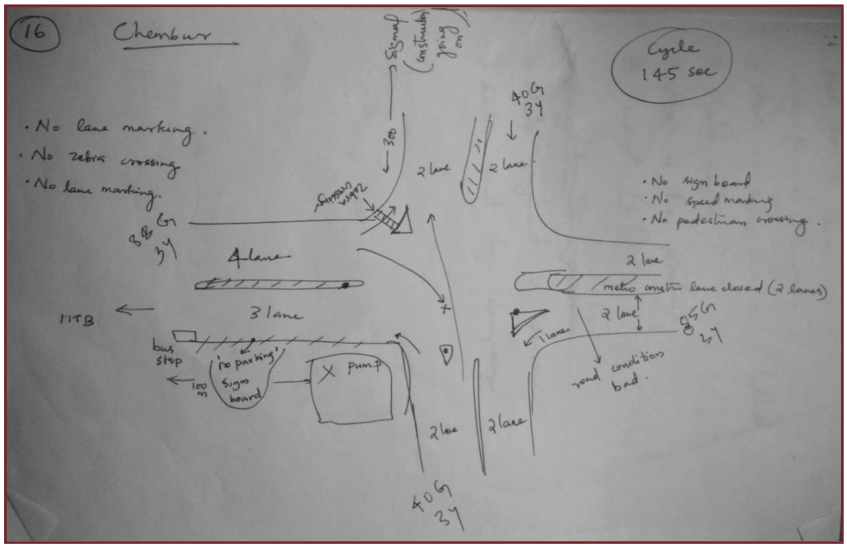
Recommendations:

- Zebra crossing markings or raised pedestrian crossing must be installed with advance warning signs to guide the pedestrians and they should be encouraged to use the Foot over bridge to cross the road safely. Encroachment by street hawkers should be controlled and regulated by the concerned authorities.
- Speed breaker with warning signs should be installed on the side road to bring down the speed of the vehicles while joining the main road.
- Adequate speed limits signs should be installed to alert the road users.
- Providing raised intersections with textured pavements and other traffic calming measures may also be helpful in capturing the attention of the road user.
- Channelizing islands should be provided at the intersection to guide the drivers to better predict the path and speed of other drivers. The medians and the islands should be installed with median reflectors and should be painted with retro-reflective paint to ensure visibility during night; flashing beacons can also be used to capture the attention of the road users.
- Work zone traffic management signs and reflectors should be provided near the ongoing construction work to warn the road user and drivers as discussed in 5.7 Safety at Metro Construction Zones.
- Pavement conditions can be improved to provide better service to the users.
- Proper road markings as per IRC: 35-2015 and road signs as per IRC: 67-2012 should be provided at the intersection.

Location 16: Opposite to Akbar Ali, Umarshi Bappa Chowk, Near Guru Prasad Bar, Sion Trombay Road, Chembur

The study location opposite to Akbar Ali, Umarshi Bappa Chowk, near Guru Prasad Bar, Sion Trombay Road, Chembur can be seen in Figure 44. It is a 4-legged intersection. The major approach is a 3-lane carriageway towards IIT Bombay and 4-lane carriageway towards the other direction on the left side of the intersection. On the right side of the intersection, the one lane on each side of the major approach is closed for metro construction. Minor approaches on both sides have a 4 lane divided carriageway. Free Left turn and channelizing islands are provided for major approaches in both directions. One lane is allotted for free left turn vehicles. Speed limit sign of 20 kmph was present at the location. The diagrammatic sketch of this section is shown in Figure 45.

- **Figure 44: Google earth view of Umarshi Bappa Chowk, near Guru Prasad Bar, Sion Trombay Road, Chembur**



- **Figure 45: Rough field diagram of location opposite to Akbar Ali, Umarshi Bappa Chowk, near Guru Prasad Bar, Sion Trombay Road, Chembur**

Observations made at the site:

- It is a signalized four-legged intersection with a total cycle time of 145 seconds. The major approach has a green time of 88 seconds and an amber time of 3 seconds in both directions.
- The minor approach has a green time of 40 seconds and an amber time of 3 seconds in both directions.
- Pedestrian crossing facilities such as foot paths, foot over bridges, etc., are absent which leaves the pedestrians vulnerable as the vehicles approach the intersection at high speeds.
- Relevant road signs were observed to be absent.
- Vehicles from one approach start moving before all the vehicles have cleared from the junction area causing vehicle-vehicle conflicts.
- Conflicts between heavy and light commercial vehicles and two wheelers were observed due to lack of lane discipline.
- In the absence of Stop lines on the approaches, vehicles stopped in the junction area during red time.
- Pavement is in poor condition on the side with metro construction.
- Road markings as well as pedestrian crossing markings, etc., were absent.

The present site conditions can be seen in Figure 46.

- **Figure 46: Identified safety issues observed during the site visit atUmarshi Bappa Chowk, near Guru Prasad Bar, Sion Trombay Road, Chembur**

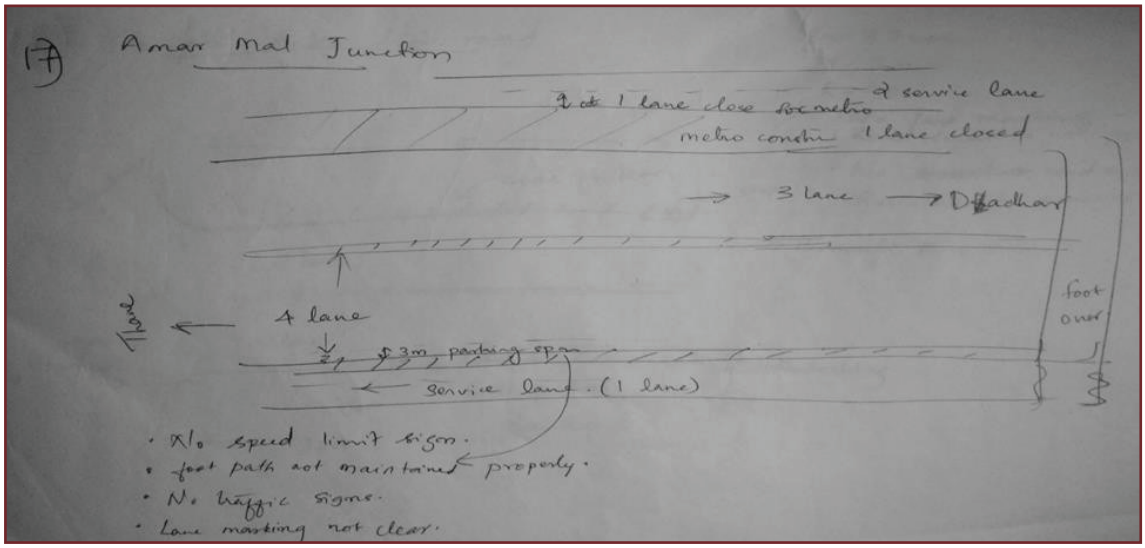
Recommendations:

- Speed tables or Zebra crossing markings must be installed with advance warning signs to guide the pedestrians as well as to encourage the drivers to reduce their speed. Feasibility of lane narrowing could be explored at the location.
- Driver feedback signs displaying the spot speed of the road user can be used to alert the road user of their speed.
- Providing raised intersections with textured pavements and other traffic calming measures may also be helpful in capturing the attention of the road user.
- Separate pedestrian crossing phases can be included in the traffic signal to accommodate pedestrian safety.
- Higher order facilities such as foot over bridges or pedestrian subways should be provided at the locations to segregate the pedestrians from the vehicle and to guide them to cross the road safely.
- All red time needs to be provided so that vehicles in the junction are given enough time to clear.
- Proper road markings as per IRC: 35-2015 and road signs as per IRC: 67-2012 should be provided near the intersections to guide the merging and diverging traffic accordingly.
- The unauthorized parking should be monitored and regulated by the concerned authority at the black spot to reduce the side friction.
- Pavement conditions can be improved to provide a better level of service to the users.
- Adequate street lighting and median reflectivity will improve the night time visibility.

Location 17: Near Amar Mahal Junction, Towards Thane, Starting of Amar Mahal Bridge

The study location of Amar Mahal Junction, towards Thane, starting from Amar Mahal Bridge can be seen in Figure 47. This is a mid-block section near the starting of Amar Mahal flyover. It is an 8-lane divided road with 4 lanes towards thane and 3 lanes (1 lane closed for metro construction) towards Dadar. Extra one lane allotted as service lane towards thane and 2 lanes as service lane towards other direction (But almost nearly one lane closed for metro construction). Main road and service lane separated by a divider. The diagrammatic sketch of this section is shown in Figure 48.

- **Figure 47: Google earth view of Amar Mahal Junction, towards Thane, starting of Amar Mahal Bridge**



- **Figure 48: Rough field diagram of location near Amar Mahal Junction, starting of Amar Mahal Bridge**

Observations made at the site:

- Vehicles move with high speed as speed regulating measures such as speed signs, rumble strips, lane markings, etc., are absent.
- Sign boards such as speed limit sign, Foot over bridge ahead, etc., were absent at the location. Road markings were faded as well.
- Pedestrians do not make use of the foot over bridge provided and hence, the risk of vehicle- pedestrian conflict is high. Footpath was observed to be in poor condition.

The present site conditions can be seen in Figure 49.

- **Figure 49: Identified safety issues observed during the site visit at Amar Mahal Junction, Towards Thane, Starting of Amar Mahal Bridge**

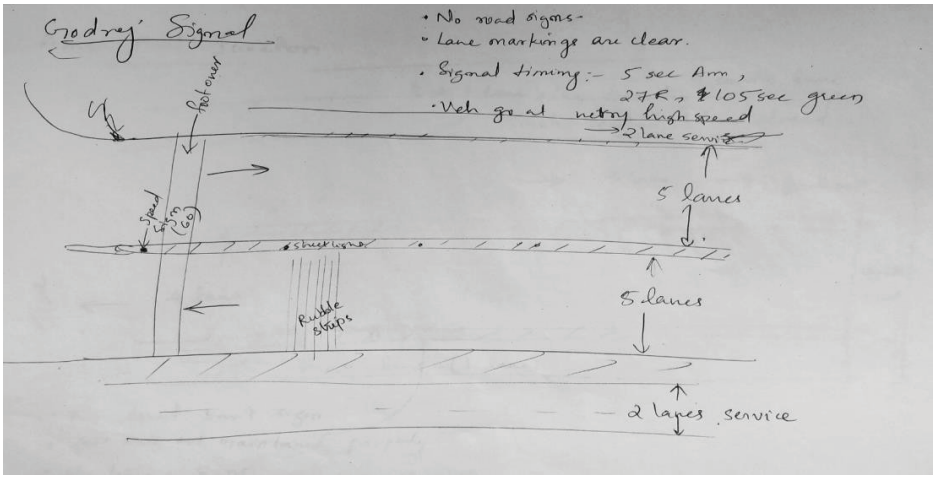
Recommendations:

- Sign board indicating the presence of the foot over bridge as per IRC: 67-2012 and IRC: 103- 2012, should be installed to guide the pedestrians, thereby encouraging them to use the Foot over bridge to cross the road.
- Driver feedback signs displaying the spot speed of the road user can be used to alert the road user of their speed. Adequate speed limits signs should be installed to alert the road users.
- Rumble strips coupled with flashing beacons and advance warning can be provided to encourage the drivers to reduce their speed.
- Work zone traffic management signs and reflectors should be provided near the ongoing construction work to warn the road user and drivers as discussed in 5.7 Safety at Metro Construction Zones.
- Pavement conditions can be improved to provide a better level of service to the users.
- Proper road markings as per IRC: 35-2015 and road signs as per IRC: 67-2012 should be provided at the intersection.

Location 18: Godrej Ghoda Gate Signal, Thane- Mumbai Way, Vikhroli East

Figure 50 shows the Google earth view of Godrej Ghoda Gate Signal, Thane- Mumbai Way, Vikhroli (East). It is a three-legged signalized junction with Eastern Express Highway passing through it. Approaching speed of vehicles in this junction is high. The carriageway at Godrej consists of 10 lanes divided by road as shown in Figure 50. It also has a two-lane service road on either side of the junction. Foot over bridge is also present for the smooth movement of pedestrians. Speed limit sign of 60 kmph was present at the location. The diagrammatic sketch of this section is shown in Figure 51.

- **Figure 50: Google earth view and photograph of Godrej Ghoda Gate Signal, Vikhroli (East)**



- **Figure 51: Rough field diagram of Godrej Ghoda Gate Signal, Vikhroli (East)**

Observations made at the site:

- Traffic signal system has a countdown timer with a green time of 105 seconds, red time of 27 seconds and an amber time of 5 seconds.
- Buses were sometimes found to stop in the second lane for passenger alighting rather than maneuvering close to the Godrej Soap bus stop posing serious conflict risks.
- Pedestrians do not use foot over bridges.
- Potential conflict can be caused due to rear end conflicts due to vehicles abruptly slowing down because of the signal.
- Rumble strips are provided on the expressway.
- Speed limit sign of 60 kmph was observed at the location, but vehicles could be observed to be traveling at higher speeds on the Expressway.
- Lane markings are slightly faded.
- Road signs were observed to be absent.
- Inadequate road signs.

The present site conditions can be seen in Figure 52. These images indicate the present safety issues at the location.

- **Figure 52: Identified safety issues observed during the site visit at Godrej Ghoda Gate Signal, Thane- Mumbai Way**

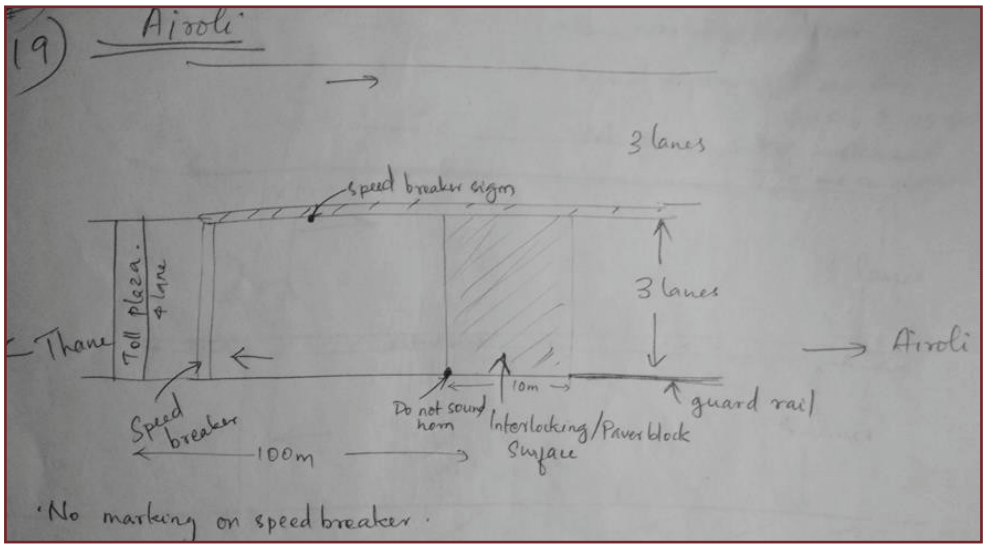
Recommendations:

- Driver feedback signs displaying the spot speed of the road user can be used to alert the road user of their speed. Adequate speed limits signs should be installed to alert the road users.
- Additional rumble strips and road studs can be provided behind the existing ones to complement the existing ones.
- Flashing beacons can be provided at the junctions to capture the attention of the driver.
- CCTV surveillance can be used to check the offenders of rash driving and fines should be imposed on them based on vehicle number plates. (Enforcement to control the traffic)
- Proper road markings as per IRC: 35-2015 and road signs such as the speed limit, intersection, bus stop, etc., as per IRC: 67-2012 should be provided at the intersection and the faded markings should be redone.
- The foot over bridge should be periodically maintained, kept free of anti-social activities and installed with CCTV cameras and adequate warning signs so as to encourage the pedestrians to use it cross the road rather than crossing at grade.

Location 19: Near Airoli Toll Naka, Before Airoli Bridge, Thane- Mumbai Way, Airoli Mulund Way

This is a six-lane divided, mid-block section near the Airoli toll Naka as seen in Figure 53 with vehicles traveling at high speeds. The diagrammatic sketch of this section is shown in Figure 54.

- **Figure 53: Google earth view of Airoli Toll Naka, before Airoli Bridge, Thane-Mumbai Way, Airoli Mulund Way**



- **Figure 54: Rough field diagram of the location near Airoli Toll Naka, before Airoli Bridge, Thane-Mumbai Way, Airoli Mulund Way**

Observations made at the site:

- Speed limit signs were absent and the “Do not sound horn” was placed facing the wrong direction
- The retro-reflective paint on the speed breaker was found to be worn out compromising the visibility at night.
- Lane markings and other markings were found to be faded or absent.
- Median openings without signs warning its presence were observed.
- Pavement was in poor condition.

The present site conditions can be seen in Figure 55

- **Figure 55: Identified safety issues observed during the site visit at Airoli Toll Naka, Before Airoli Bridge, Thane-Mumbai Way, Airoli Mulund Way**

Recommendations:

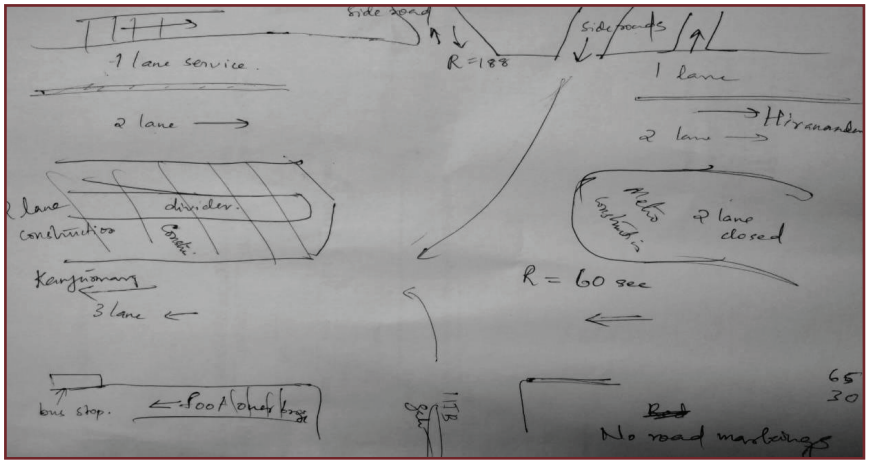
- Speed tables or Zebra crossing markings must be installed with advance warning signs to guide the pedestrians as well as to encourage the drivers to reduce their speed.
- The median opening should be equipped with median reflectors and “Gap in median” sign board as per IRC: 67-2012 to provide sufficient warning to the motorists.
- Speed cameras can be installed at the locations as vehicles were observed to be speeding as soon as the signal turns green.
- Adequate speed limits signs should be installed to alert the road users.
- Reflectivity of the speed breaker should be improved by repainting the marking to notify the road users. The reflectivity of the advance warning sign should also be ensured.
- The “Do not sound horn’ sign is installed in the wrong direction. The sign boards should be provided in direction visible to the vehicles coming in that direction.

- Pavement conditions can be improved to provide a better level of service to the users.
- Proper road markings as per IRC: 35-2015 and road signs such as Toll booth ahead, as per IRC: 67-2012 should be provided at the intersection.
- Reflectivity of the paint on the median should also be ensured for better visibility at night.

Location 20: Opposite IIT Bombay Main Gate, IIT Bombay Signal, Powai

The study location opposite IIT Bombay Main Gate, IIT Bombay Signal, Powai can be seen in Figure 56. It is a signalized intersection with a countdown timer. Traffic officials were also observed to be controlling the traffic at this junction. Metro construction work is being carried out on this stretch. The carriageway consists of an 8 lane divided road with two service lanes on either side of roads. The service roads were discontinued towards the IIT Bombay market gate. JVLR, connecting Eastern and Western Express Highway carrying heavy traffic is passing through the location. Speed limit sign of 20 kmph was present at the location due to the Metro construction at the location. The diagrammatic sketch of the location opposite IIT Bombay Main Gate, IIT Bombay Signal, Powai is shown in Figure 57.

- **Figure 56: Google earth view of opposite IIT Bombay main gate, IIT Bombay Signal, Powai**



- **Figure 57: Rough field diagram of the location opposite to IIT Bombay main gate, Powai**

Observations made at the site:

- It is a signalized intersection with a countdown timer and a green time of 175 seconds and a red time of 65 seconds. The traffic was mainly controlled by the traffic officials.
- Vehicles coming at high speeds are abruptly stopped at the junction leading to vehicle-vehicle collision.
- Potential conflict points are created at merging sections.
- Available road width was reduced due to the metro construction work going on both sides of the roads.
- During peak hours, the traffic was in fully jammed /congested condition starting from Powai lake side. During the off-peak hours, vehicles were moving at very high speed.
- Side friction is more because of parked auto rickshaws on the left side of the road side.
- Faded lane markings and pedestrian crossing markings were observed at the location.
- Pedestrian jaywalking could be observed.
- Median could be observed to be broken between the service road and the main road and its paint has also worn out.
- Drivers neglecting traffic rules and regulations could be observed and vehicles were observed speeding late at night.
- Pedestrians ignored the foot over bridge for crossing.

The photographs taken during the site inspection are shown in Figure 58. These photographs indicate the present issues at the location opposite to IIT Bombay Main Gate, IIT Bombay Signal, Powai.

- **Figure 58: Identified safety issues observed during the site visit at location opposite to IIT Bombay main gate, IIT Bombay Signal, Powai**

Recommendations:

- Speed tables or Zebra crossing markings must be installed with advance warning signs to guide the pedestrians as well as to encourage the drivers to reduce their speed.
- Driver feedback signs displaying the spot speed of the road user can be used to alert the road user of their speed. Adequate speed limits signs should be installed to alert the road users
- Traffic actuated signals or well-designed signal timings catering to the morning and evening peaks can be provided for managing the congestion.
- Providing raised intersections with textured pavements and other traffic calming measures may also be helpful in capturing the attention of the road user.
- Flashing beacons can be provided at the junctions to capture the attention of the driver.
- The foot over bridge should be periodically maintained, kept free of anti-social activities and installed with CCTV cameras and adequate warning signs so as to encourage the pedestrians to use it cross the road rather than crossing at grade.
- Work zone traffic management signs and reflectors should be provided near the ongoing construction work to warn the road user and drivers as discussed in 5.7 Safety at Metro Construction Zones.
- Proper road markings as per IRC: 35-2015 and road signs as per IRC: 67-2012 should be provided at the intersection.
- Medians should be repainted with retro-reflective paint to improve the visibility at night.

SPEED DATA COLLECTION AND ANALYSIS

4.1. SPEED MEASUREMENT

The current work studies traffic speed characteristics of black spots in the city of Mumbai. United Way Mumbai has collaborated with Indian Institute of Technology, Bombay (IITB) to evaluate the road safety at 20 locations across Mumbai. Baseline speed surveys were conducted in 2019 in the 20 black spot locations and the End line surveys will be conducted after the implementation of the improvement measures suggested by IITB.

Speed

Speed is defined as the distance traveled by a vehicle during a unit of time and is generally expressed in Kilometers per hour (Km/hr) or Meter per second (m/sec). It generally describes the quality of the journey and the performance of the road network in accommodating traffic demand. The speed limit is the maximum speed at which a vehicle may legally travel on a particular stretch of road safely considering various factors related to road conditions.

Spot Speed

Spot speed is defined as the instantaneous speed of a vehicle at a specified location. It refers to the measurement of individual speeds of vehicles passing a point on a roadway. The spot speeds are affected by several factors such as geometric features, traffic conditions, time, place, environment conditions (like weather, visibility) and driver. Speed data is essential for a variety of aspects in traffic engineering such as:

- Monitoring speed trends
- Planning traffic control and in traffic regulations
- Establishing highway design elements
- To use in crash studies
- Evaluating highway capacity
- Assessing highway safety
- Measuring effectiveness of changes

Spot Speed Measurement

There are a number of methods to measure spot speed. The spot speed may be obtained either by finding the running speed of vehicles over a short distance of less than 50 meters or by finding the instantaneous speed while crossing a section, depending on the method used. The spot speeds of a few typical samples of vehicles are found during the sampling periods of the day, days of the week and month of the year. Different methods to obtain the spot speeds are:

1. Manual, 2. Video, and, 3. Radar

Manual data collection is one of the simplest methods of finding spot speed by using an enoscope. This method is simple and cheap however, it is difficult to spot out typical vehicles and the number of samples observed will be less and there is a possibility of human error as well.

Videotaping technique can be used to record the traffic movement over a period of time and then the speed of the vehicles can be extracted using a predefined trap length. This method provides sufficient sample size as any required vehicle speed can be extracted however, this is time consuming and tedious.

Measuring speed using radar uses reflected waves of very high frequency from the radar speed meter to the moving vehicle. The reflected wave is directly measurable and is proportional to the speed at which the vehicle is moving.

Radar speed guns, like other types of radar, consist of transmitter and receiver. They send out a radio signal in a narrow beam, then receive the same signal back after it bounces off the target object (moving vehicle). Based on the Doppler Effect phenomenon, from the difference of the reflected frequency, the radar speed gun can calculate the speed of the object from which the waves had bounced.

The procedure involved in the speed data collection was simple. During the data collection surveys, a spot was chosen at the black spot location such that a clear view of the oncoming traffic was available but the enumerator was inconspicuous. If the enumerator holding the radar gun stands out, the drivers tend to slow down and the free flow speed will not be obtained. During the survey, the enumerator points the radar gun so that the vehicle is either moving directly toward the radar gun or directly away from the gun. See Figure 59. The enumerator will then press the trigger and the speed will be displayed on the screen. The speed gun was in continuous mode and hence it allows the enumerator to detect the speed of the vehicle without having to press the button for each vehicle.

Figure 59: Speed data being collected at the black spots by the Enumerators

The forms used for collecting site details and spot speeds can be seen in Figure 116 and Figure 117.

4.2. SPEED STATISTICS

Common descriptive statistics can be computed from the speed data collected. These statistics describe the important characteristics of the speed distribution.

Average speed (Mean Speed)

The arithmetic average speed is the most frequently used speed statistics. It is the measure of the central tendency of the data. Mean speed is calculated as follows:

$$v_t = \frac{\sum v_i}{n}$$

Where, vt is the mean speed, vi is the individual speed of the ith vehicle

Standard Deviation

The most common statistical measure of dispersion in a distribution is the standard deviation. It is a measure of how far data spreads around the mean value. In simple terms, the standard deviation is the average value of the difference between individual observations and the average value of those observations. The Standard deviation, σs, of the sample can be calculated by

$$\sigma_s = \frac{\sqrt{\sum (v_i - v_v)^2}}{n - 1}$$

Percentile Speeds

The 85th and 15th percentile speeds give a general description of the high and low speeds observed by most reasonable drivers. It is generally thought that the upper and lower 15% of the distribution represents speeds that are either too fast or too slow for existing conditions.

85th Percentile Speed

The 85th percentile speed is defined as, the speed at or below which 85 percent of the vehicles are observed to travel unaffected by slower traffic or poor weather. This speed indicates the speed that the motorists consider safe and reasonable under ideal conditions.

15th Percentile Speed

The 15th percentile speed is defined as, the speed at or below which 15 percent of the vehicles are observed to travel unaffected by slower traffic or poor weather.
All the above-mentioned speed statistics are calculated to obtain the current trend using the base line speed survey data. Based on the field observations and speed analysis, safety measures have been suggested. Once the proposed safety measures are implemented in the field, improvement in the flow characteristics can be compared with the end line survey speed data. The speed characteristics for all the 20 locations are listed below in Table 1 to Table 4.

Speed Data Statistics (Measured at observational spots)

Table 1: Average speed statistics for all 20 locations

Average Speed (Kmph)										
Location/ Vehicle Type	Weekday					Weekend				
	Bike	Car	Auto	Truck	Bus	Bike	Car	Auto	Truck	Bus
Location 1	46.54	46.06	41.42	40.03	41.29	45.51	47.50	41.76	43.23	42.14
Location 2	35.48	35.11	33.07	34.84	31.11	43.78	46.11	44.39	43.80	42.18
Location 3	45.96	47.36	42.33	42.22	42.42	45.35	45.67	41.99	40.38	39.71
Location 4	52.12	53.15	NA	47.54	44.74	43.01	42.36	NA	37.90	38.50
Location 5	36.54	35.12	NA	33.39	31.89	37.63	35.89	NA	33.82	31.02
Location 6	35.23	33.61	NA	28.67	33.44	36.71	34.25	NA	32.07	38.33
Location 7	39.46	39.11	NA	36.25	34.50	44.14	43.59	NA	37.94	38.89
Location 8	49.51	46.50	NA	42.33	41.75	54.43	51.69	NA	50.89	41.20
Location 9	26.77	25.38	NA	25.14	24.19	38.87	37.49	NA	35.10	34.00
Location 10	36.43	38.84	36.51	33.79	33.41	40.85	40.87	36.02	35.23	32.80
Location 11	32.35	32.89	32.44	29.88	27.12	26.59	28.80	25.84	30.30	28.13
Location 12	31.64	31.17	29.99	31.76	30.72	31.31	30.13	29.10	29.70	28.79
Location 13	28.63	29.32	25.73	24.90	24.32	28.33	27.97	26.75	26.62	26.75
Location 14	44.02	42.03	39.16	39.09	40.27	44.65	43.38	40.70	42.02	40.93
Location 15	25.41	25.12	24.33	24.03	23.61	26.78	25.73	25.00	24.52	24.27
Location 16	33.79	31.70	31.93	31.39	30.58	30.37	28.73	27.90	26.59	26.70
Location 17	47.09	49.01	42.64	43.52	40.84	54.20	55.40	51.20	52.56	50.79
Location 18	54.12	54.93	50.00	48.34	51.84	59.90	62.17	56.27	55.81	52.42
Location 19	80.78	81.91	80.96	71.21	62.96	68.01	72.79	56.70	44.83	43.74
Location 20	36.27	35.02	34.94	35.01	30.51	41.08	41.66	37.58	37.39	36.02

Table 2: 15th percentile statistics for all 20 locations

15th Percentile Speed (Kmph)										
Location/ Vehicle Type	**Weekday**					**Weekend**				
	Bike	**Car**	**Auto**	**Truck**	**Bus**	**Bike**	**Car**	**Auto**	**Truck**	**Bus**
Location 1	38.00	38.00	33.00	31.00	32.00	38.00	39.00	34.00	35.00	34.55
Location 2	27.00	27.00	26.00	28.00	24.00	38.00	40.25	40.00	33.60	32.85
Location 3	40.00	41.00	36.00	35.00	35.30	40.00	40.00	37.40	35.00	32.00
Location 4	43.00	44.00	NA	39.40	37.35	35.00	35.00	NA	30.00	33.50
Location 5	31.00	30.00	NA	25.95	25.05	31.00	30.00	NA	28.00	25.00
Location 6	30.00	30.00	NA	27.00	26.75	31.00	30.00	NA	30.00	30.00
Location 7	33.00	33.00	NA	32.00	30.00	36.90	37.00	NA	31.00	34.00
Location 8	41.00	39.00	NA	32.50	34.50	45.40	43.00	NA	38.35	34.00
Location 9	20.00	20.00	NA	19.00	19.00	32.00	31.00	NA	30.35	32.25
Location 10	27.00	30.00	30.00	25.00	26.60	33.00	34.00	29.70	29.00	28.00
Location 11	22.00	24.00	22.00	20.50	20.00	19.00	20.00	18.00	21.00	21.00
Location 12	26.00	26.00	26.00	27.85	25.85	26.00	26.00	26.00	25.00	25.60
Location 13	22.00	22.30	19.00	18.00	18.00	23.00	22.00	21.00	22.25	20.35
Location 14	36.00	35.00	32.00	30.00	32.00	38.00	37.00	35.95	36.00	36.00
Location 15	19.00	19.00	19.00	19.00	18.00	20.00	20.00	20.00	20.00	19.50
Location 16	25.00	24.00	25.00	25.00	23.00	22.00	22.00	22.00	21.00	21.00
Location 17	33.00	35.00	32.00	31.75	26.35	44.00	46.00	40.45	40.00	41.60
Location 18	44.00	41.00	41.95	39.00	40.00	47.00	51.00	46.90	46.05	43.35
Location 19	80.00	82.00	81.00	43.05	35.00	45.00	47.40	38.00	28.00	27.00
Location 20	27.00	28.00	27.00	30.00	20.55	33.00	32.05	30.00	31.35	28.00

Table 3: 85thpercentile statistics for all 20 locations

85th Percentile Speed (Kmph)										
Location/ Vehicle Type	Weekday					Weekend				
	Bike	Car	Auto	Truck	Bus	Bike	Car	Auto	Truck	Bus
Location 1	55.00	55.00	49.00	49.00	52.00	53.00	56.00	50.45	51.40	52.00
Location 2	43.00	43.00	39.95	42.05	38.00	50.00	52.00	49.70	52.40	50.15
Location 3	52.00	53.00	48.00	48.00	48.00	52.00	52.00	47.00	45.00	47.10
Location 4	60.00	61.00	NA	54.00	53.65	51.00	49.00	NA	44.00	43.50
Location 5	43.00	40.00	NA	42.00	37.90	44.65	42.00	NA	39.95	37.00
Location 6	40.00	38.00	NA	31.00	39.25	43.00	39.00	NA	34.80	44.25
Location 7	46.00	45.00	NA	42.00	39.00	53.00	52.00	NA	45.15	47.40
Location 8	59.00	54.00	NA	52.50	49.00	63.00	59.00	NA	64.20	50.00
Location 9	32.00	31.00	NA	30.00	31.00	46.00	44.00	NA	40.00	36.00
Location 10	45.85	48.40	44.00	42.55	39.60	48.00	48.00	42.00	40.00	38.35
Location 11	41.00	41.00	42.00	40.00	33.70	35.00	37.00	35.00	39.95	35.00
Location 12	37.00	36.00	34.00	37.00	41.15	36.00	34.00	32.00	33.00	31.40
Location 13	35.25	35.00	33.00	32.00	32.00	35.00	35.00	34.00	30.00	34.30
Location 14	52.00	50.00	46.10	48.00	48.00	51.00	50.00	46.00	48.50	48.00
Location 15	32.00	30.00	29.00	30.00	28.00	33.00	31.00	29.00	28.90	29.50
Location 16	41.00	38.00	39.00	39.00	38.00	38.25	36.00	35.00	32.00	32.00
Location 17	60.00	60.75	53.00	55.25	53.00	65.00	65.00	61.00	64.00	59.60
Location 18	68.00	69.00	58.00	58.00	64.60	77.00	77.00	68.10	61.95	65.25
Location 19	87.00	87.00	87.00	86.00	86.75	86.00	86.00	84.00	64.50	56.20
Location 20	45.00	41.00	42.00	38.30	38.45	49.00	51.00	45.00	44.65	43.00

Table 4: Standard deviation of speed for all 20 locations

Standard Deviation										
Location/ Vehicle Type	**Weekday**					**Weekend**				
	Bike	**Car**	**Auto**	**Truck**	**Bus**	**Bike**	**Car**	**Auto**	**Truck**	**Bus**
Location 1	8.63	8.74	7.83	8.43	9.58	7.98	8.55	7.70	7.84	8.28
Location 2	7.61	7.71	8.33	7.75	6.51	7.66	7.08	6.14	9.86	8.82
Location 3	6.41	6.71	5.37	6.49	6.55	6.07	6.20	4.97	5.26	6.80
Location 4	8.39	9.14	NA	7.15	9.63	8.33	6.63	NA	7.59	4.58
Location 5	6.20	4.86	NA	6.99	6.35	6.99	6.03	NA	6.61	5.08
Location 6	5.42	4.70	NA	2.08	5.73	8.35	4.61	NA	3.56	6.96
Location 7	6.58	5.92	NA	4.74	4.62	7.67	6.95	NA	6.99	5.78
Location 8	9.56	8.08	NA	10.57	7.08	9.45	7.69	NA	12.66	6.91
Location 9	6.16	4.97	NA	5.38	5.11	7.02	5.75	NA	4.49	1.87
Location 10	8.98	9.25	8.03	7.99	7.61	7.85	7.11	6.78	6.41	4.81
Location 11	9.07	8.20	8.96	7.81	7.40	8.01	7.68	7.98	9.05	7.83
Location 12	5.55	5.37	3.94	3.97	6.26	5.15	4.28	3.24	3.64	2.52
Location 13	6.42	6.01	6.50	5.83	6.24	6.07	6.07	5.70	5.65	6.07
Location 14	8.32	7.60	6.78	8.58	7.31	7.28	6.60	5.87	6.32	5.62
Location 15	6.25	5.18	4.81	5.48	4.80	6.16	5.08	4.50	4.73	4.33
Location 16	7.67	6.67	7.00	6.41	7.04	7.80	6.66	5.93	5.91	5.50
Location 17	13.18	12.21	10.05	11.19	12.40	10.57	9.49	9.66	10.50	9.03
Location 18	10.83	13.11	9.59	8.78	10.54	12.96	12.80	12.71	10.57	10.78
Location 19	13.02	12.09	13.37	20.32	24.22	19.93	18.13	19.30	17.96	14.62
Location 20	9.97	7.27	8.18	5.38	8.39	9.15	9.86	7.35	6.40	7.65

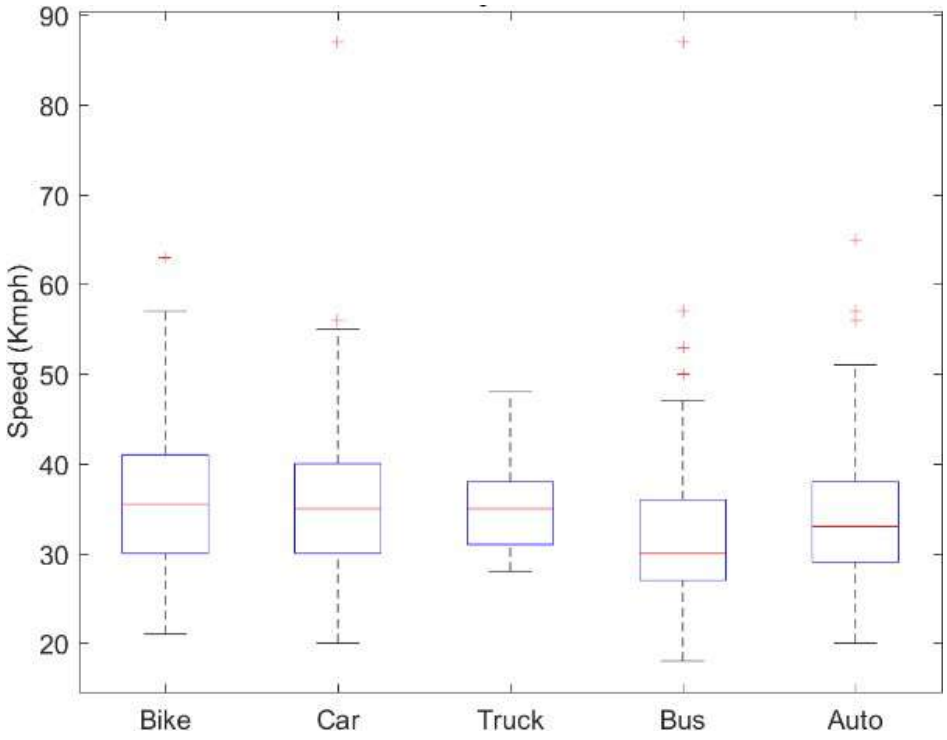
Box plots and histograms were derived from the field data to understand the descriptive statistics and speed trends for different vehicles throughout the day on weekdays and weekends. Box plots and speed histogram are explained in detail below:

SAMPLE LOCATION: CHHEDA NAGAR & SCLR BRIDGE CHHEDA NAGAR, BUS STOP, CHEMBUR EAST

Box Plot

The box plot shows a box encased by two outer lines known as whiskers. The box contains the middle 50% of the data sample – the bottom and top of the box are the 25th and 75th percentile (the lower and upper quartiles), respectively. The single line inside the box represents the median. The remaining 50% of the sample is contained within the areas between the box and the whiskers. All data were contained within the whiskers (−1.5 × interquartile range to + 1.5 × interquartile range) without any extreme cases (outliers). Figure 60 shows that the speed distribution of the motorized two wheelers (bike) is normally distributed because the median line is located near the center of the box and the box is nearly centered between the whiskers. All the extreme values (outliers) are the vehicles with either too high or low speeds compared to the other vehicular population.

Figure 60: Box plot of all vehicle types in Chheda Nagar Bus Stop, Chembur East (weekday)



Speed Histogram

A histogram is used to graphically summarize and display the distribution of the data set. The Speed Histogram report (Figure 61) provides the speed profile at a site. Modal speed can be obtained from the frequency plot. Modal speed is defined as the single value of the speed that is most likely to occur. Histogram makes our task easier to identify different data, the frequency of the data occurring in the dataset and categories which are difficult to interpret in a tabular form. It helps to visualize the distribution of the data.

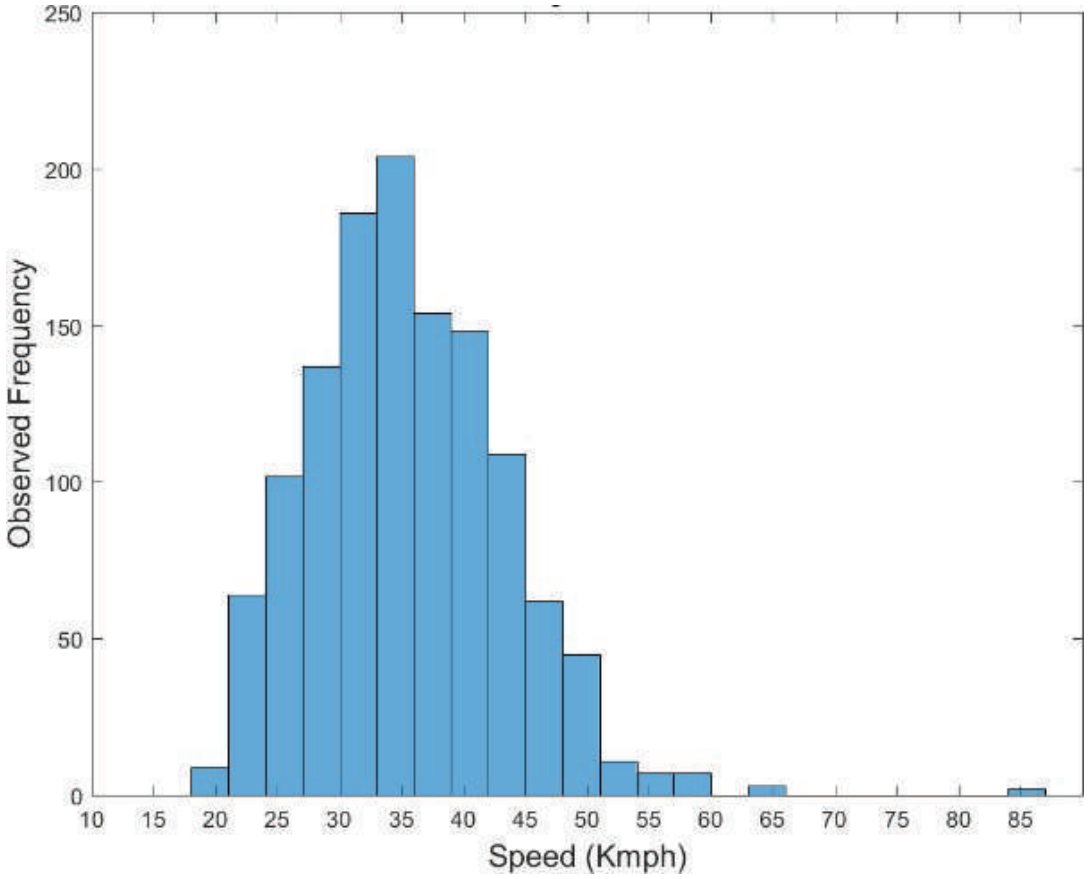


Figure 61: Speed histogram for Chheda Nagar Bus Stop, Chembur East (weekday)

4.3. SPEED VIOLATION ANALYSIS

As per the crash statistics, one of the major factors for road crashes is due to speeding of the vehicles. The present study considered 20 blackspots identified by United way Mumbai (UWM) to understand the speed violation statistics.

Speed limits of 7 black spots were posted at the locations which are given in Table 5. In some locations throughout Mumbai such as near IIT Main Gate, Powai, a reduced speed limit of 20 kmph was provided due the construction of Metro in the area. But since speed data is measured at straight stretches away from junctions, original speed limits are considered despite the reduced speed limits. For locations with no posted speed limits, the values were considered based on the Mumbai Traffic Police circular shared by UWM and the standards suggested by Indian Road Congress (IRC) code book, as per IRC: 70-2017 [Guidelines on Regulation and Control of Mixed Traffic in Urban Areas (First Revision)] (Table 34).

Table 6 shows the speed limits considered for locations with no posted speed limits for further analysis. Figure 118 and Figure 119 shows the Mumbai Traffic Police circular giving the speed limits on the major roads of Mumbai.

Table 5: Speed limits in kmph posted at the black spots

Sl No.	Black Spot Location Name	Speed Limits posted at the location (kmph)
1	Towards Sea Link, Mahim Causeway Junction, Near Bandra Chowky, U – Bridge, Western Express Highway, Bandra West	**30**
2	In Front of Sane Guruji Udyan, Near Si ddhivinayak Temple, Prabhadevi	**20**
3	Megdoot Bridge, Opposite Islam Gymkhana, N. S. Road	**60**
4	CST Bridge, Near Kurla Bus Depot, Kurla West	**20**
5	Opp. To Akbar Ali, Umarshi Bappa Chowk, Near Guru Prasad Bar, Sion Trombay Road, Chembur	**20**
6	Godrej Ghoda Gate Signal, Thane - Mumbai Way, Vikhroli East	**60**
7	Opposite IIT Bombay Main Gate, IIT Bombay Signal, Powai	**50 (20) ***

*Original speed limit of 50 kmph was considered for analysis, despite the reduced speed limit of 20 kmph due to Metro construction.

The posted speed limits of 20 kmph – 30 kmph observed at the locations due to the on-going Metro constructions.

Table 6: Speed limits considered at the black spots for analysis (kmph)

Sl No.	Black Spot Location Name	Speed Limits considered for Analysis (kmph)
8	Eastern Express Highway, Near Ramabai Nagar Bus Stop, Near Sainagar Nala, Retiwala, Ghatkopar East	**70**
9	Chheda Nagar & SCLR Bridge Chheda Nagar, Bus Stop, Chembur East	**50**
10	Haji Ali Junction	**50**
11	City Bakery, Jafarkhan Bridge, at Worli Naka, Worli	**50**
12	Opp. Sarswati Vidhya Mandir, Near Mahim Phatak, Senapati Bapat Road, Mahim	**50**
13	Barrister Nath Pai Road, Church Signal, Canara Bank, In Front Of ATM, Nearby Dockyard Station, Mazgaon	**50**
14	Y Junction, Sion Bandra Link Road, Dharavi	**50**
15	Shimpoli Naka Link Road, Shimpoli Gorai Road, Near Shimpoli Choki, Borivali West	**50**
16	Near Sanjay Gandhi National Park Gate, Under Flyover, Borivali East	**50**
17	Near Metro Mall, North Bound Magathane Depot Bridge Junction, Near Annex Mall, W.E.H, Borivali East	**50**
18	Durga Nagar Junction, JVLR, Jogeshwari	**50**
19	Amar Mahal Junction, Towards Thane, Starting of Amar Mahal Bridge	**70**
20	Near Airoli Toll Naka, Before Airoli Bridge, Thane-Mumbai Way, Airoli-Mulund Way	**50**

The speed data for different vehicle types were collected throughout the day in five different window timings (Table 7) in order to understand the speed variability throughout the day. Also, the speed data was collected on weekdays and weekends to understand the speed variation on different days.

Table 7: Data Collection Window Timings

Vehicle Count / Survey	Time	
Survey Window 1	**10:30-12:00**	15-minute vehicle count was done in each window
Survey Window 2	**14:00-15:30**	
Survey Window 3	**16:30-18:00**	
Survey Window 4	**19:00-20:30**	
Survey Window 5	**21:30-23:00**	

Analysis based on vehicle type

Analysis was performed to understand the percentage of different vehicle types over-speeding at each of the 20 selected locations. Also, each vehicle type over-speeding was analyzed for both weekday and weekend. Table 8 and Table 9 shows the percentage of vehicles over-speeding at the selected blackspots with respect to vehicle type.

Table 8: Percentage of vehicles over-speeding on weekdays with respect to vehicle type at each black

Weekday	Bike	Car	Auto	Truck	Bus
Location 1	0.00	0.91	0.39	0.00	0.00
Location 2	1.92	1.41	2.19	4.85	0.00
Location 3	100.00	99.83	98.82	97.47	97.22
Location 4	55.40	61.97	NA	46.15	31.58
Location 5	3.71	0.50	NA	4.35	2.70
Location 6	100.00	100.00	NA	100.00	100.00
Location 7	6.41	4.56	NA	0.00	0.00
Location 8	12.79	4.62	NA	6.67	0.00
Location 9	0.36	0.00	NA	0.47	0.00
Location 10	6.51	9.89	4.57	1.77	4.55
Location 11	87.92	93.63	86.99	85.00	80.77
Location 12	0.62	1.11	0.00	0.00	0.00
Location 13	1.01	0.00	0.00	0.00	0.00
Location 14	22.51	14.20	6.01	11.95	8.94
Location 15	0.35	0.00	0.00	0.00	0.00
Location 16	96.53	96.18	98.44	98.86	98.58
Location 17	3.80	3.37	0.00	0.57	1.27
Location 18	26.15	30.80	12.25	9.28	18.42
Location 19	91.89	93.59	91.11	73.68	56.00
Location 20	4.82	2.10	2.62	1.85	0.79

Table 9: Percentage of vehicles over-speeding on weekends with respect to vehicle type at each black spot

Weekend	Bike	Car	Auto	Truck	Bus
Location 1	0.16	0.87	0.00	0.00	0.00
Location 2	12.96	23.93	13.04	20.90	14.29
Location 3	99.81	99.75	99.18	97.53	91.07
Location 4	15.35	11.09	NA	0.00	0.00
Location 5	4.86	1.72	NA	0.00	0.00
Location 6	100.00	100.00	NA	100.00	100.00
Location 7	20.87	19.27	NA	4.35	5.56
Location 8	20.86	10.34	NA	22.22	0.00
Location 9	6.32	1.79	NA	1.27	0.00
Location 10	10.29	7.96	1.79	3.05	0.00
Location 11	74.15	83.53	65.57	89.19	87.10
Location 12	0.69	0.00	0.00	0.00	0.00
Location 13	0.28	0.34	0.00	0.00	0.00
Location 14	17.40	14.44	4.73	13.33	6.56
Location 15	0.41	0.00	0.00	0.00	0.00
Location 16	93.98	93.66	92.87	91.55	85.71
Location 17	7.05	5.06	2.89	2.94	0.00
Location 18	38.73	45.95	20.29	19.30	21.05
Location 19	70.23	82.16	54.60	36.00	25.93
Location 20	11.92	16.14	3.53	5.08	3.66

NA – Not Applicable (Autos were not observed at these locations)

By carefully reading the table, we can infer the trend of traffic violation at each location. The speeds of the vehicles depend on various factors such as available road infrastructure, road width, surrounding environmental conditions etc, so it is exceedingly difficult to draw a specific conclusion about a vehicle type. However, based on the analysis we can clearly identify certain locations where there is maximum over-speeding. For example, location 6 (In front of Sane Guruji Udyan, Near Siddhivinayak Temple, Prabhadevi) can be identified as a location with maximum speed violations. Almost all the vehicles plying on location 6 are traveling at speeds greater than the posted speed limits.

Analysis based on time of the day

As mentioned earlier speed data was collected at 5 different windows throughout the day. Analysis was performed to understand what time of the day saw the maximum speed violations. Table 10 and Table 11 shows the percentage of vehicles over-speeding during the time of day.

Table 10: Percentage of vehicles over-speeding during the time of day (Weekdays)

Weekday	10:30 to 12:00	14:00 to 15:30	16:30 to 18:00	19:00 to 20:30	21:30 to 23:00
Location 1	0.00	0.94	1.41	0.00	0.25
Location 2	2.40	6.00	1.71	0.00	0.00
Location 3	99.41	99.00	99.65	99.43	100.00
Location 4	70.09	55.44	42.00	57.80	79.00
Location 5	1.71	2.24	1.20	0.50	2.40
Location 6	100.00	100.00	100.00	100.00	100.00
Location 7	3.13	7.80	8.80	2.67	1.67
Location 8	1.60	1.20	4.33	6.67	16.33
Location 9	0.22	0.57	0.00	0.00	0.00
Location 10	0.48	1.25	1.42	13.14	14.29
Location 11	99.58	95.02	57.82	98.80	99.33
Location 12	0.00	0.67	0.86	0.00	0.00
Location 13	0.23	1.25	0.00	0.00	0.00
Location 14	15.11	15.33	19.50	8.25	13.75
Location 15	0.00	0.00	0.44	0.00	0.00
Location 16	91.78	98.40	99.34	98.75	99.67
Location 17	4.75	3.00	3.20	0.47	2.50
Location 18	24.00	43.40	17.00	15.25	18.86
Location 19	82.25	82.86	92.75	98.00	99.67
Location 20	7.50	5.00	2.00	0.00	1.00

Table 11: Percentage of vehicles over-speeding during the time of day (Weekends)

Weekend	10:30 to 12:00	14:00 to 15:30	16:30 to 18:00	19:00 to 20:30	21:30 to 23:00
Location 1	1.37	0.18	0.00	0.15	0.97
Location 2	24.33	10.20	10.64	6.19	19.70
Location 3	99.33	100.00	99.40	98.44	99.80
Location 4	5.93	2.90	11.00	12.80	33.85
Location 5	3.51	3.29	1.78	2.20	4.00
Location 6	100.00	100.00	100.00	100.00	100.00
Location 7	8.00	9.67	14.33	13.00	36.86
Location 8	19.33	8.33	17.67	9.67	14.33
Location 9	2.67	2.00	8.00	6.67	1.67
Location 10	2.10	10.60	8.75	8.25	12.25
Location 11	68.44	78.40	55.05	74.07	91.36
Location 12	0.00	0.33	0.25	0.25	0.27
Location 13	0.00	0.75	0.25	0.00	0.00
Location 14	9.60	12.00	20.25	12.25	10.75
Location 15	0.00	0.00	0.25	0.50	0.00
Location 16	90.86	69.39	94.00	96.84	97.56
Location 17	7.43	7.50	0.75	3.56	6.75
Location 18	55.11	52.00	46.75	15.25	30.00
Location 19	72.00	49.75	74.00	75.00	51.50
Location 20	9.75	14.67	6.00	11.75	8.75

From the above analysis one can understand at what time of the day saw the maximum speed violations. Although specific trends are not observed considering all locations. But variation in the violations can be observed on weekdays and weekends. It can be seen that the speed violation increased significantly during weekends. One of the possible reasons might be the lower traffic volumes contributing to higher vehicular speeds.

Summary

The speed data was collected at the selected 20 locations to understand the speed trend and speed variability currently prevailing. The speed statistics gives us the idea about the average speed variability of different vehicle types in a given location throughout the day. Box plots and histograms have been developed to interpret the collected data in pictorial representation, which can be easily understood. Also, various other speed statistics that are commonly used are tabulated for all the selected 20 locations. Speed violations were found to be more influenced by factors such as available road infrastructure, road width, surrounding environmental conditions etc, rather than vehicle types and timings. Lesser traffic on the road during weekends were also observed to influence traffic violations. Once the site-specific safety measures are implemented in the specified location, the speed data can be collected to understand the speed trend and variability of the site after the implementation of the safety measures and the effect of the measure on their speed variability.

4.4. CRASH DATA ANALYSIS

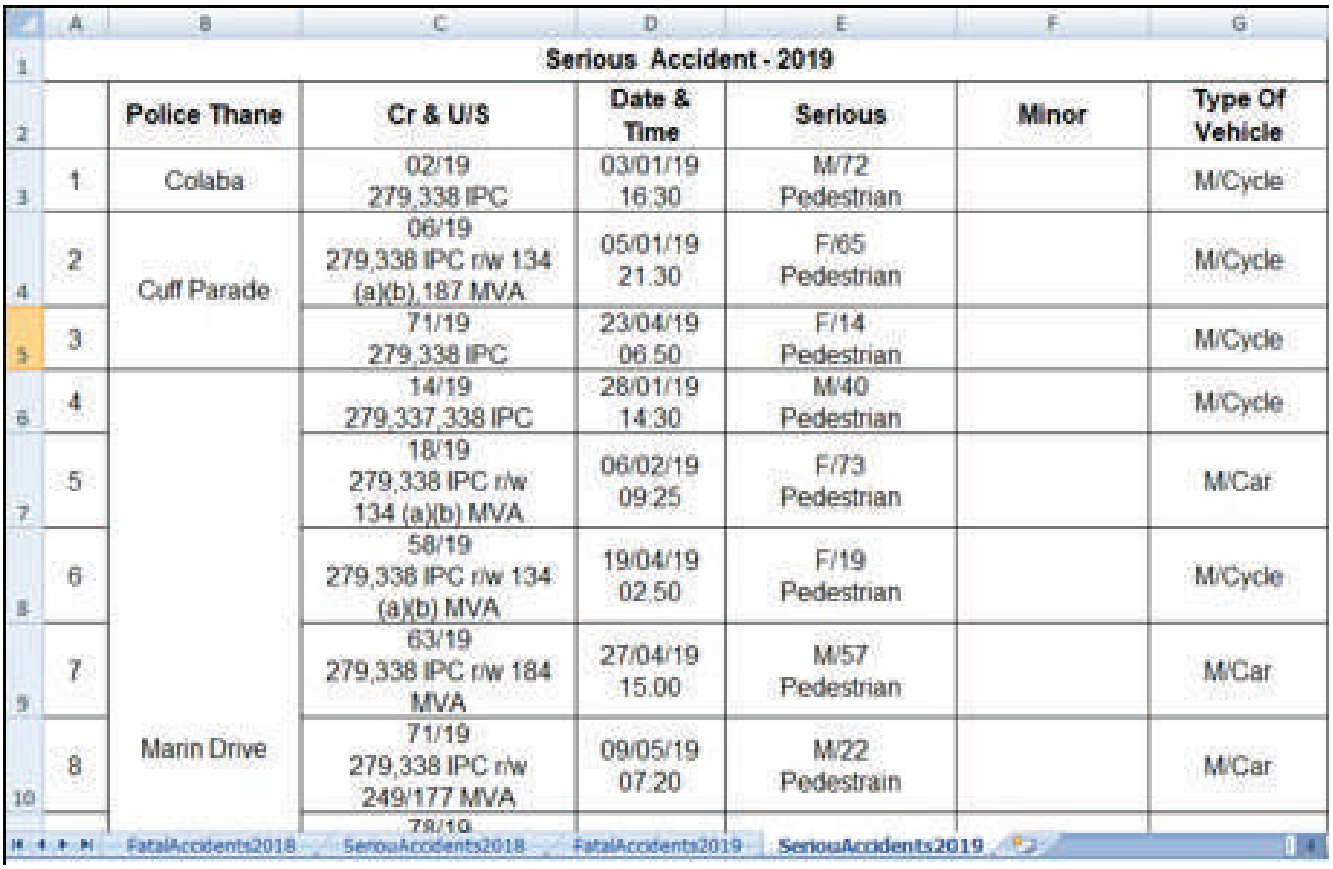
The crash data was collected from the Mumbai Traffic Police and provided to the IITB team by United Way Mumbai. The first set of data shared by United Way Mumbai contained details such as location of the black spot, police station and traffic division, year wise data (01/10/2015 to 30/09/2018), no. of fatal and grievous crashes, no. of injured persons (grievously injured and minor injured), no. of fatalities and reason for frequent crashes (rash & negligent driving, speeding was reported for all locations). See Figure 62.

PS. Sr. NO.	Name of District	LOCATION OF BLACK SPOT	POLICE STATION	TRAFFIC DIVICION	YEAR	NO. OF ACCIDENTS		NO. OF INJURED PERSONS		NO. OF FATALITIES	REASON FOR FREQUENT ACCIDENT
						Fatal Accidents	Grievious Accidents	Grievously Injured	Minor Injured		
10	Mumbai	AMAR MAHAL JUNCTION, TOVARDS THANE, STARTING OF AMAR MAHAL BRIDGE	TILAK NAGAR	CHEMBUR	01/10/2015 to 30/09/2016	0	6	6	0	0	RASH & NEGLIGEN DRIVING, OVER SPEEDING
					01/10/2016 to 30/09/2017	3	7	8	0	4	
					01/10/2017 to 30/09/2018	2	7	7	1	2	
11	Mumbai	CHEDA NAGAR NAGAR & SCLR BRIDGE CHEDA NAGAR BUS STOP CHEMBUR EAST			01/10/2015 to 30/09/2016	3	7	7	0	3	
					01/10/2016 to 30/09/2017	4	7	9	0	4	
					01/10/2017 to 30/09/2018	0	10	13	3	0	
12	Mumbai	EEH, NEAR RAMABAI NAGAR BUS STOP, NEAR SAINAGAR NALA, RETIWALA, GHATKOPAR-E	PANTNAGAR	VIKROLI	01/10/2015 to 30/09/2016	0	3	5	0	0	RASH & NEGLIGEN DRIVING, OVER SPEEDING
					01/10/2016 to 30/09/2017	0	4	4	0	0	
					01/10/2017 to 30/09/2018	3	6	8	0	3	
13	Mumbai	GODREJ GHODAGATE SIGNAL, THANE-MUMBAI VAY, VIKROLI-E, MUMBAI	Vikhroli	VIKROLI	01/10/2015 to 30/09/2016	5	4	6	2	5	
					01/10/2016 to 30/09/2017	4	6	9	0	4	
					01/10/2017 to 30/09/2018	2	7	7	0	2	
14	Mumbai	NEAR AIROLI TOL NAKA, BEFORE AIROLI BRIDGE, THANE- MUBAI VAY, AIROLI-MULUND VAY	NAYGHAR	VIKROLI	01/10/2015 to 30/09/2016	0	9	12	0	0	RASH & NEGLIGEN DRIVING, OVER SPEEDING
					01/10/2016 to 30/09/2017	1	4	4	0	1	
					01/10/2017 to 30/09/2018	8	9	9	2	8	
15	Mumbai	OPP IIT MAIN GATE, IIT SIGNAL, PAWAI, MUMBAI	PAWAI	SAKINAKA	01/10/2015 to 30/09/2016	0	2	2	0	0	
					01/10/2016 to 30/09/2017	0	4	5	0	0	
					01/10/2017 to 30/09/2018	1	3	4	0	1	
16	Mumbai	TOVARDS SEA LINK, MAHIM CAUSE VAY JUNCTION, NEAR BANDRA CHOWKY, U-BRIDGE,VEH, BANDRA-V	BANDRA	BANDRA	01/10/2015 to 30/09/2016	2	2	5	0	2	
					01/10/2016 to 30/09/2017	5	10	13	1	6	
					01/10/2017 to 30/09/2018	2	10	14	1	2	
		DURGA NAGAR JUNCTION, JVLR			01/10/2015 to 30/09/2016	0	4	4	0	0	

Figure 62: First set of crash data received from Mumbai Traffic Police

For detailed analysis, the IITB team then requested United Way Mumbai to gather additional details such as time of the crash, nature of the crash, specific cause for the crash, road features and road conditions, intersection type, weather condition, type of vehicles involved and speed challans. Additional data was then collected from Mumbai traffic police and shared with the IITB team. This data contained area wise data, date and time of the crash, details of victims involved in fatal, serious and minor crashes (gender, age and pedestrian), type of vehicle involved, etc., of fatal crashes (2018 and 2019) and serious crashes (2018 and 2019). See Figure 63. The data of speed challan contained the total speed challan count for 2016, 2017, 2018 and 2019 as shown in Figure 64.

Figure 63: Second set of crash data shared by Mumbai Traffic Police



	A	B	C	D	E	F	G
1	Serious Accident - 2019						
2		Police Thane	Cr & U/S	Date & Time	Serious	Minor	Type Of Vehicle
3	1	Colaba	02/19 279,338 IPC	03/01/19 16:30	M/72 Pedestrian		M/Cycle
4	2	Cuff Parade	06/19 279,338 IPC r/w 134 (a)(b),187 MVA	05/01/19 21.30	F/65 Pedestrian		M/Cycle
5	3		71/19 279,338 IPC	23/04/19 06.50	F/14 Pedestrian		M/Cycle
6	4	Marin Drive	14/19 279,337,338 IPC	28/01/19 14:30	M/40 Pedestrian		M/Cycle
7	5		18/19 279,338 IPC r/w 134 (a)(b) MVA	06/02/19 09:25	F/73 Pedestrian		M/Car
8	6		58/19 279,338 IPC r/w 134 (a)(b) MVA	19/04/19 02.50	F/19 Pedestrian		M/Cycle
9	7		63/19 279,338 IPC r/w 184 MVA	27/04/19 15.00	M/57 Pedestrian		M/Car
10	8		71/19 279,338 IPC r/w 249/177 MVA	09/05/19 07.20	M/22 Pedestrain		M/Car
			78/19				

FatalAccidents2018 SeriousAccidents2018 FatalAccidents2019 SeriousAccidents2019

Figure 64: Speed challan count data shared by Mumbai Traffic Police

Speed Challan Count Report		
Year	District Name	Challan Count
Speed Challan Count Report		
2016	Mumbai Traffic Division	16290
2017	Mumbai Traffic Division	41235
2018	Mumbai Traffic Division	787704
2019(Till 4 Dec)	Mumbai Traffic Division	105874

4.5. SPOT WISE CRASH DATA ANALYSIS:

As crash data exclusive to the black spot locations were not mentioned in the data, areas in and around the selected black spot locations were only taken for the detailed analysis. The areas taken for analysis were Ghatkopar (including Pant Nagar), Chembur (including RCF and Tilaknagar), BKC and Bandra, Worli, Marine Drive, Dharavi, Kurla (including V.B. Nagar, Nehru Nagar and Chunabhatti), Borivali, Jogeshwari (including Meghwadi), Vikhroli and Powai. The data was analyzed to see the distribution of fatal and serious crashes, daytime and nighttime crashes, age group of the crash victims, gender of crash victims and the type of vehicles involved in the crashes.

Sample Location: Ghatkopar area

According to the crash data shared by United Way Mumbai, the most vulnerable road user was found to be pedestrians. All of the victims reported in the fatal and serious crashes of 2018 and 2019 were the pedestrians. Table 12 gives the distribution of crashes in 2018 and 2019.

Table 12: Distribution of crashes in 2018 and 2019 in the Ghatkopar area

Parameter Analyzed	2018	2019
Type of crashes	**No: of crashes**	
No: of fatal crashes	5	3
No: of serious crashes	32	29
Crash timings	**No: of crashes**	
Daytime (7 am to 6:59 pm)	20	20
Night time (7 pm to 6:59 am)	17	12
Age group of crash victims	**No: of crashes**	
Less than 18	7	6
Greater than or equal to 18	34	29
Gender of crash victims	**No: of crashes**	
Male	14	23
Female	27	12

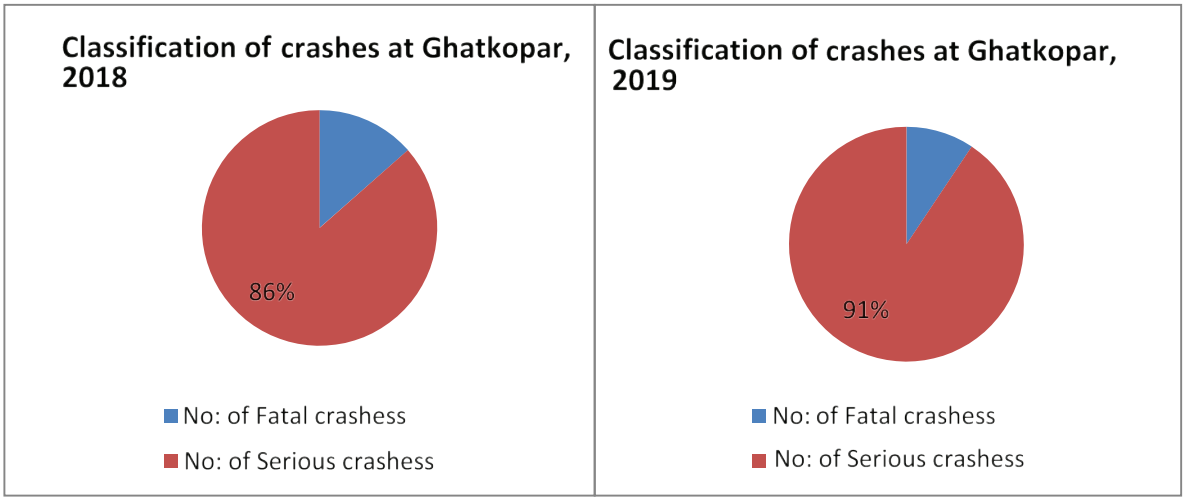


Figure 65: Distribution of fatal and serious crashes in the Ghatkopar area in 2018 and 2019

Figure 65 shows that the percentages of fatal crashes have reduced by a small percentage in the Ghatkopar area from 2018 to 2019. Crashes during the day time were found to be more than the crashes during the night time in 2018 as well as 2019 and the age group of victims involved in the crashes were above 18 years old. See Figure 66 and Figure 67.

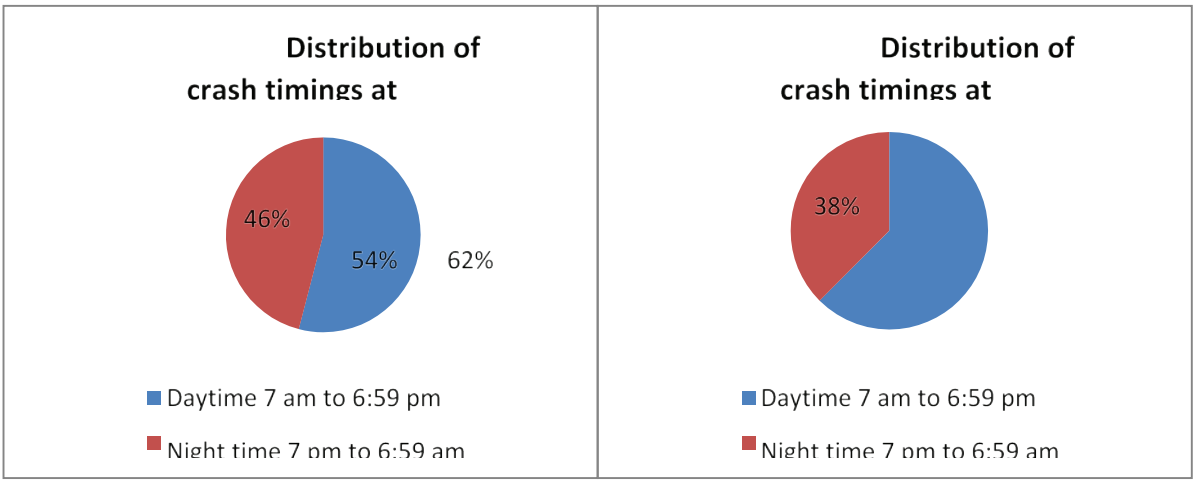


Figure 66: Distribution of daytime and night time crashes in the Ghatkopar area in 2018 and

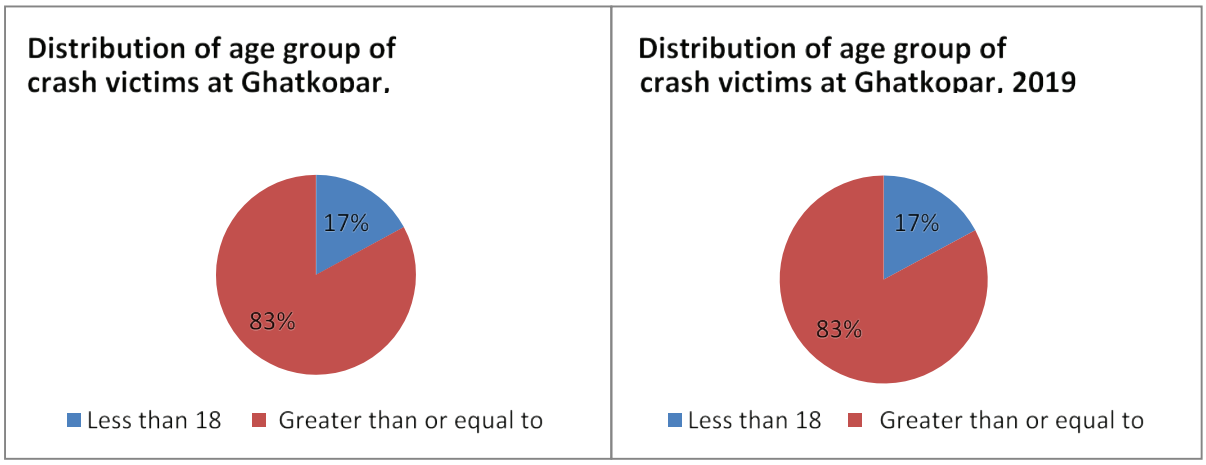


Figure 67: Distribution of age group of crash victims in the Ghatkopar area in 2018 and 2019

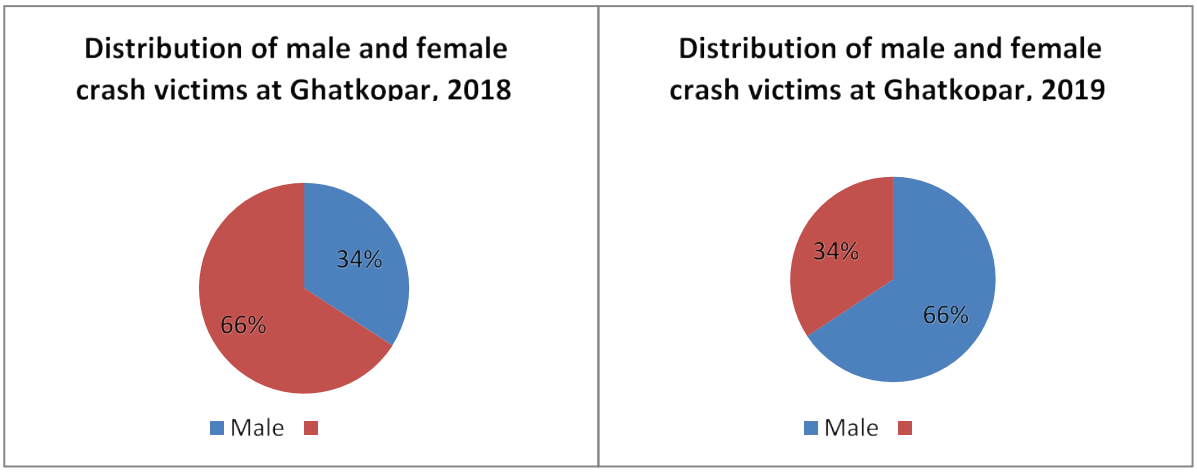


Figure 68: Distribution of male and female crash victims in the Ghatkopar area in 2018 and

In 2018, the number of female victims were higher when compared to 2019 and the number of male victims were higher in 2019 in comparison to 2018 as seen in Figure 68. As per Table 13 and Figure 69, the no: of crashes involving cycles were higher in 2019 when compared to 2018.

Table 13: Distribution of vehicle types involved in the crashes in the Ghatkopar area in 2018 and 2019

Vehicle types involved in crashes	2018	2019
	No: of crashes	
Car	10	4
Motorcycle	3	2
Pickup / Light truck / Truck / Large truck	3	2
Tempo	5	2
Cycle	8	10
Unknown Vehicle	2	3
Auto Rickshaw	6	7
Bus	0	2

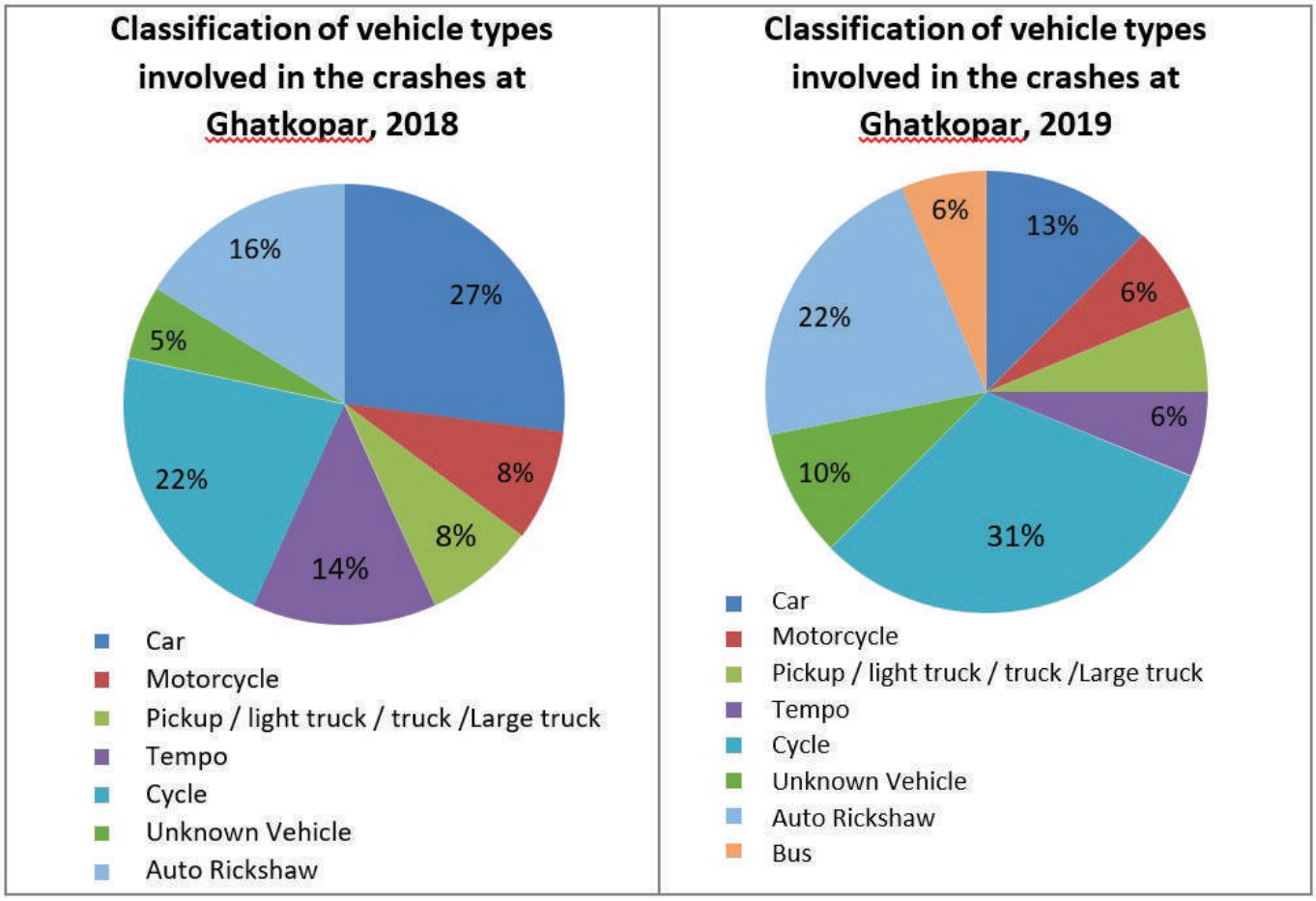


Figure 69: Distribution of vehicle types involved in the crashes in the Ghatkopar area in 2018

The distribution of crashes in the rest of areas has been shown below in Table 14 to Table 33.

Table 14: Distribution of crashes in 2018 and 2019 in the Chembur area

Parameter Analyzed	2018	2019
Type of crashes	**No: of crashes**	
No: of fatal crashes	7	6
No: of serious crashes	33	21
Crash timings	**No: of crashes**	
Daytime (7 am to 6:59 pm)	17	14
Night time (7 pm to 6:59 am)	23	13
Age group of crash victims	**No: of crashes**	
Less than 18	4	4
Greater than or equal to 18	42	24
Gender of crash victims	**No: of crashes**	
Male	38	21
Female	8	7

Table 15: Distribution of vehicle types involved in the crashes in the Chembur area in 2018 and 2019

Vehicle types involved in crashes	2018	2019
	No: of crashes	
Car	8	6
Motorcycle	2	2
Pickup / Light truck / Truck / Large truck	6	1
Tempo	0	1
Cycle	12	6
Unknown Vehicle	4	3
Auto Rickshaw	8	4
Bus	0	3
Ambulance	0	1

Table 16: Distribution of crashes in 2018 and 2019 in the Bandra area

Parameter Analyzed	2018	2019
Type of crashes	No: of crashes	
No: of fatal crashes	4	3
No: of serious crashes	31	17
Crash timings	No: of crashes	
Daytime (7 am to 6:59 pm)	14	19
Night time (7 pm to 6:59 am)	21	11
Age group of crash victims	No: of crashes	
Less than 18	7	3
Greater than or equal to 18	31	27
Gender of crash victims	No: of crashes	
Male	31	22
Female	7	8

Table 17: Distribution of vehicle types involved in the crashes in the Bandra area in 2018 and 2019

Vehicle types involved in crashes	2018	2019
	No: of crashes	
Car	7	11
Motorcycle	2	2
Pickup / Light truck / Truck / Large truck	0	1
Tempo	2	0
Cycle	16	5
Unknown Vehicle	0	4
Auto Rickshaw	5	5
Bus	3	2

Table 18: Distribution of crashes in 2018 and 2019 in the Worli area

Parameter Analyzed	2018	2019
Type of crashes	No: of crashes	
No: of fatal crashes	3	1
No: of serious crashes	16	11
Crash timings	No: of crashes	
Daytime (7 am to 6:59 pm)	11	7
Night time (7 pm to 6:59 am)	8	5
Age group of crash victims	No: of crashes	
Less than 18	2	2
Greater than or equal to 18	18	10
Gender of crash victims	No: of crashes	
Male	18	10
Female	2	2

Table 19: Distribution of vehicle types involved in the crashes in the Worli area in 2018 and 2019

Vehicle types involved in crashes	2018	2019
	No: of crashes	
Car	8	8
Motorcycle	1	1
Tempo	1	0
Cycle	7	3
Bus	1	0
Crane	1	0

Table 20: Distribution of crashes in 2018 and 2019 in the Marine Drive area

Parameter Analyzed	2018	2019
Type of crashes	No: of crashes	
No: of fatal crashes	4	0
No: of serious crashes	13	9
Crash timings	No: of crashes	
Daytime (7 am to 6:59 pm)	8	4
Night time (7 pm to 6:59 am)	9	5
Age group of crash victims	No: of crashes	
Less than 18	5	0
Greater than or equal to 18	12	9
Gender of crash victims	No: of crashes	
Male	10	7
Female	7	2

Table 21: Distribution of vehicle types involved in the crashes in the Marine Drive area in 2018 and 2019

Vehicle types involved in crashes	2018	2019
	No: of crashes	
Car	11	5
Tempo	1	0
Cycle	5	2
Unknown Vehicle	0	1
Bus	0	1

Table 22: Distribution of crashes in 2018 and 2019 in the Dharavi area

Parameter Analyzed	2018	2019
Type of crashes	No: of crashes	
No: of fatal crashes	3	0
No: of serious crashes	11	8
Crash timings	No: of crashes	
Daytime (7 am to 6:59 pm)	8	3
Night time (7 pm to 6:59 am)	6	5
Age group of crash victims	No: of crashes	
Less than 18	2	1
Greater than or equal to 18	12	7
Gender of crash victims	No: of crashes	
Male	4	5
Female	10	3

Table 23: Distribution of vehicle types involved in the crashes in the Dharavi area in 2018 and 2019

Vehicle types involved in crashes	2018	2019
	No: of crashes	
Car	2	4
Pickup / Light truck / Truck / Large truck	2	0
Tempo	3	0
Cycle	6	2
Auto Rickshaw	0	1
Bus	1	1

Table 24: Distribution of crashes in 2018 and 2019 in the Kurla area

Parameter Analyzed	2018	2019
Type of crashes	No: of crashes	
No: of fatal crashes	17	9
No: of serious crashes	53	39
Crash timings	No: of crashes	
Daytime (7 am to 6:59 pm)	31	28
Night time (7 pm to 6:59 am)	39	20
Age group of crash victims	No: of crashes	
Less than 18	4	6
Greater than or equal to 18	74	48
Gender of crash victims	No: of crashes	
Male	60	43
Female	18	11

Table 25: Distribution of vehicle types involved in the crashes in the Kurla area in 2018 and 2019

Vehicle types involved in crashes	2018	2019
	No: of crashes	
Car	13	12
Motorcycle	2	2
Pickup / Light truck / Truck / Large truck	4	4
Tempo	5	0
Cycle	28	15
Unknown Vehicle	5	4
Auto Rickshaw	8	9
Bus	3	2
Van	1	0
Roller	1	0

Table 26: Distribution of crashes in 2018 and 2019 in the Borivali area

Parameter Analyzed	2018	2019
Type of crashes	No: of crashes	
No: of fatal crashes	0	1
No: of serious crashes	15	17
Crash timings	No: of crashes	
Daytime (7 am to 6:59 pm)	7	12
Night time (7 pm to 6:59 am)	8	6
Age group of crash victims	No: of crashes	
Less than 18	2	2
Greater than or equal to 18	15	17
Gender of crash victims	No: of crashes	
Male	10	10
Female	7	9

Table 27: Distribution of vehicle types involved in the crashes in the Borivali area in 2018 and 2019

Vehicle types involved in crashes	2018	2019
	No: of crashes	
Car	5	4
Motorcycle	1	1
Tempo	0	1
Cycle	3	7
Auto Rickshaw	5	3
Bus	1	2

Table 28: Distribution of crashes in 2018 and 2019 in the Jogeshwari area

Parameter Analyzed	2018	2019
Type of crashes	No: of crashes	
No: of fatal crashes	4	1
No: of serious crashes	16	15
Crash timings	No: of crashes	
Daytime (7 am to 6:59 pm)	5	12
Night time (7 pm to 6:59 am)	15	4
Age group of crash victims	No: of crashes	
Less than 18	4	2
Greater than or equal to 18	17	15
Gender of crash victims	No: of crashes	
Male	15	12
Female	6	5

Table 29: Distribution of vehicle types involved in the crashes in the Jogeshwari area in 2018 and 2019

Vehicle types involved in crashes	2018	2019
	No: of crashes	
Car	4	4
Motorcycle	0	1
Pickup / Light truck / Truck / Large truck	1	0
Tempo	1	1
Cycle	9	4
Unknown Vehicle	2	0
Auto Rickshaw	3	6

Table 30: Distribution of crashes in 2018 and 2019 in the Vikhroli area

Parameter Analyzed	2018	2019
Type of crashes	No: of crashes	
No: of fatal crashes	9	9
No: of serious crashes	42	14
Crash timings	No: of crashes	
Daytime (7 am to 6:59 pm)	26	11
Night time (7 pm to 6:59 am)	25	12
Age group of crash victims	No: of crashes	
Less than 18	2	0
Greater than or equal to 18	51	25
Gender of crash victims	No: of crashes	
Male	43	19
Female	10	6

Table 31: Distribution of vehicle types involved in the crashes in the Vikhroli area in 2018 and 2019

Vehicle types involved in crashes	2018	2019
	No: of crashes	
Car	15	10
Motorcycle	3	1
Pickup / Light truck / Truck / Large truck	4	1
Tempo	1	0
Cycle	13	6
Unknown Vehicle	7	3
Auto Rickshaw	5	0
Bus	2	0
Fire Brigade	1	0
Ambulance	0	1

Table 32: Distribution of crashes in 2018 and 2019 in the Powai area

Parameter Analyzed	2018	2019
Type of crashes	No: of crashes	
No: of fatal crashes	5	4
No: of serious crashes	8	11
Crash timings	No: of crashes	
Daytime (7 am to 6:59 pm)	9	10
Night time (7 pm to 6:59 am)	4	5
Age group of crash victims	No: of crashes	
Less than 18	3	0
Greater than or equal to 18	13	16
Gender of crash victims	No: of crashes	
Male	12	12
Female	4	4

Table 33: Distribution of vehicle types involved in the crashes in the Powai area in 2018 and 2019

Vehicle types involved in crashes	2018	2019
	No: of crashes	
Car	5	4
Pickup / Light truck / Truck / Large truck	0	1
Tempo	2	0
Cycle	3	5
Unknown Vehicle	2	2
Auto Rickshaw	0	1
Bus	1	2

4.6. INFERENCES

Crash data of the previous two years, 2018 and 2019 has been analyzed to understand the factors associated with the conflicts between different road users on the basis of time, day and cause of crash. Following are the points inferred from the crash data analysis:

1.Crash data has revealed that the most affected and vulnerable road users are the pedestrians. The existing facilities do little to protect pedestrians. Hence, efforts should be made to eliminate or decrease the vehicle-pedestrian interactions to reduce the crashes by providing pedestrian facilities such as continuous footpaths, Foot over bridges, Subways, Raised pedestrian crossings or Speed tables.

2. Crash data reveals that a higher percentage of crashes reported had taken place during the day time. This may be attributed to more vehicles present on roads during the peak traffic hours. Even then, a significant number of crashes happened in the night time (7 pm to 6:59 am), which indicates that efforts have to be made in order to enhance the visibility and pavement conditions for the night time driving.

3. Although all vehicle types were involved in the crashes, the number of passenger cars and cyclists involved were higher. They were closely followed behind by trucks and Auto rickshaws. Two wheelers were concluded to be the safest road users while comparing the crash fatalities.

4. Speeding and driving on the wrong side were observed during the site visit inspection. These along with negligent and rash driving (as reported in the crash data), violation of other rules such as, drunken driving, red light jumping and use of mobile phones, etc., all contribute to the road crashes in Mumbai. Violations such as speeding and driving on the wrong side may be caused due to possible fault in road design and can be rectified by improving road engineering measures. Violations such as drunken driving, red light jumping and use of mobile phones could be solely attributable to traffic rules enforcement.

5. The data also shows that child fatality is relatively low in Mumbai, but the most productive age group of working adults of above 18 years were the ones most affected.

RECOMMENDATIONS AND CONCLUSIONS

The general recommendations have been broadly divided into 3 categories - Engineering interventions, Behavioral risk factors vis-à-vis interventions and Traffic management and enforcement interventions. All of these categories are interrelated, for example, engineering interventions are provided so as to modify the road user behavior by capturing or focusing their attention to the conditions on the road. Hence, for the benefit of the reader wherever possible, the recommendations have been categorized into the above-mentioned interventions. These along with the recommendations which can be classified as short term and long term based on the time required and the easiness in carrying them out have been discussed in detail in this section. These recommendations for the issues observed are suitable for all the black spot locations and implementation of them as per the specifications shall help in reducing the pedestrian – vehicle conflict and ensure safety of the road users.

5.1. SPEED MANAGEMENT MEASURES

A. Engineering interventions

Speed Limit

As per IRC: 70-2017, speed limits as a measure of safety on urban roads under mixed traffic conditions is indicated in Table 34. The speed limit, if not fixed, can be decided based on these values. Actual limits may be imposed after duly considering all relevant conditions including percentage of mixed traffic.

Table 34: Design Speed for Different Road Classification in kmph

Different categories of roads and streets	Speed limits in kmph	
	Light and Medium Vehicles	Heavy Vehicles
Arterial and Sub-Arterial roads	50	40
Road stretches within 100 m of land uses with high pedestrian footfall such as mass transit stations, hospitals, universities, markets, etc.	20	20

- IRC: 70-2017 states that, State government can determine or restrict the traffic speed if it is in the interest of the public safety or convenience or because of the nature of the road or bridge, by notification in the official gazette. Hence the Maharashtra government can bring down the existing speed limits at the black spots to a safer speed suggested by the experts and give adequate publicity through campaigns and media advertisements to inform the general public. The new safer speed limits should be enforced strictly using speed camera enforcements and traffic police to deter the over-speeding nature of the drivers. It should be ensured that the penalties and sanctions issued for over-speeding at these black spots are free of bribery and corruption. The reduced speed limits and the enforcement will ingrain safe driving behavior and sticking to reduced speeds in the drivers

- 85th percentile speed indicates that speed at which 85 percent of the vehicles are travelling at or below this speed for the given conditions. This is generally used by the practitioners for deciding the speed limits for the facilities based on the existing conditions. Speed data at these selected locations (black spots) were collected from 10:30 am to 11:00 pm (in selected intervals) to obtain the 85th percentile speed. As discussed earlier, speed limits are usually a State subject where the speed limits are adopted based on the facilities and in the interest of public safety. Generally, speed limits suggested by IRC are based on the different categories of roads and streets. For the safety of the road users at the black spot locations under study, it is recommended to reduce the existing limits to the prescribed reduced speed limits based on the 85th percentile speeds observed at these locations. The speed limit ranges suggested (as shown in Table 35) can be used as reference by the Traffic Police and the concerned authorities to fix a reduced posted speed limit at the black spots.

Table 35: Recommended Speed Limit Ranges at the Black Spots based on 85th Percentile Speed

Sl. No.	Name of Location	85th Percentile Speed (kmph)	Speed range (kmph)
Location 1	Eastern Express Highway, Near Ramabai Nagar Bus Stop, Near Sainagar Nala, Retiwala, Ghatkopar East	52.00	45-55
Location 2	Chheda Nagar & SCLR Bridge Chheda Nagar, Bus Stop, Chembur East	41.20	35-45
Location 3	Towards Sea Link, Mahim Causeway Junction, Near Bandra Chowky, U – Bridge, Western Express Highway, Bandra West	49.80	40-50
Location 4	Haji Ali Junction	57.16	45-55
Location 5	City Bakery, Jafarkhan Bridge, at Worli Naka, Worli	40.73	35-45
Location 6	In Front of Sane Guruji Udyan, Near Siddhivinayak Temple, Prabhadevi	37.06	30-40
Location 7	Opp. Sarswati Vidhya Mandir,Near Mahim Phatak, Senapati Bapat Road, Mahim	43.00	35-45
Location 8	Megdoot Bridge, Opp Islam Gymkhana, N.S.Road	53.63	45-55
Location 9	Barrister Nath Pai Road, Church Signal, Canara Bank, In Front Of ATM, Nearby DockYard Station, Mazgaon	31.00	25-35
Location 10	Y Junction, Sion Bandra Link Road, Dharavi	44.08	35-45
Location 11	CST Bridge, Near Kurla Bus Depot, Kurla West	39.54	30-40
Location 12	Shimpoli Naka Link Road, Shimpoli Gorai Road, Near Shimpoli Choki, Borivali West	37.03	30-40
Location 13	Near Sanjay Gandhi National Park Gate, Under Flyover, Borivali East	33.45	25-35

Note: These proposed speed limits may be considered in consultation with Mumbai traffic police

- Designated speed limit can be reduced to a safer speed during peak hours to ensure safety. This has been practiced and found to be effective in various countries and hence can be applied in India as well. Reducing the posted speed limit near intersections and school zones can be accomplished by using signage such as "25 KMPH WHEN FLASHING", in conjunction with yellow flashing beacons. i.e flash beacons working during peak hours. Traffic wardens used in conjunction with this treatment may increase driver compliance with speed limits.

- Driver Feedback Signs (DFS) as seen in Figure 70 and Figure 71 can be used to display real-time feedback about the speed of the vehicle to the driver. It measures the speed of the vehicle by using radar and displays the real-time speed of the vehicle on a LED display. They present the driver with a highly visible display in the daytime or night-time and under all-weather conditions. DFS with its better sign visibility alerts motorists when they are speeding and helps protect pedestrians and other vulnerable road users. The idea is to warn speeding vehicles continuously and inculcate a culture of driving within suggested speed limits.

Figure 70: Driver Feedback Sign installed at Chandigarh

Figure 71: Driver Feedback Sign displaying vehicle speeds

- Setting up quirky sign boards such as "Thank you for not speeding" can help in capturing the attention of the road users.

- Speed breakers: Speed breakers such as speed tables, speed bumps, rumble strips, etc., with proper warning signs can be provided on the road leading to the school to encourage vehicles to slow down.

- The retro-reflective markings reinforced with road studs on speed breakers are necessary to warn drivers about the hazard ahead in advance. Speed breaker markings shall be supplemented with warning signs in advance of zebra crossing location and informatory signs at the location of zebra crossing.

- Figure 72 shows the types of markings to be equipped on the speed breaker, which comprises two rows of checquered markings consisting of alternate black and white bands of 500 mm width on either side of tapering. The triangular markings in the case of both round top and flat top humps shall be marked. The width of the base of the triangular marking shall be 750 mm and the height from base to its apex shall be a maximum of 1850 mm. The triangular block and chequer block shall be as per the dimension given in Table 37.

- The geometric details for construction of road humps and various chord lengths for facilitating different speeds have been illustrated in Figure 72.

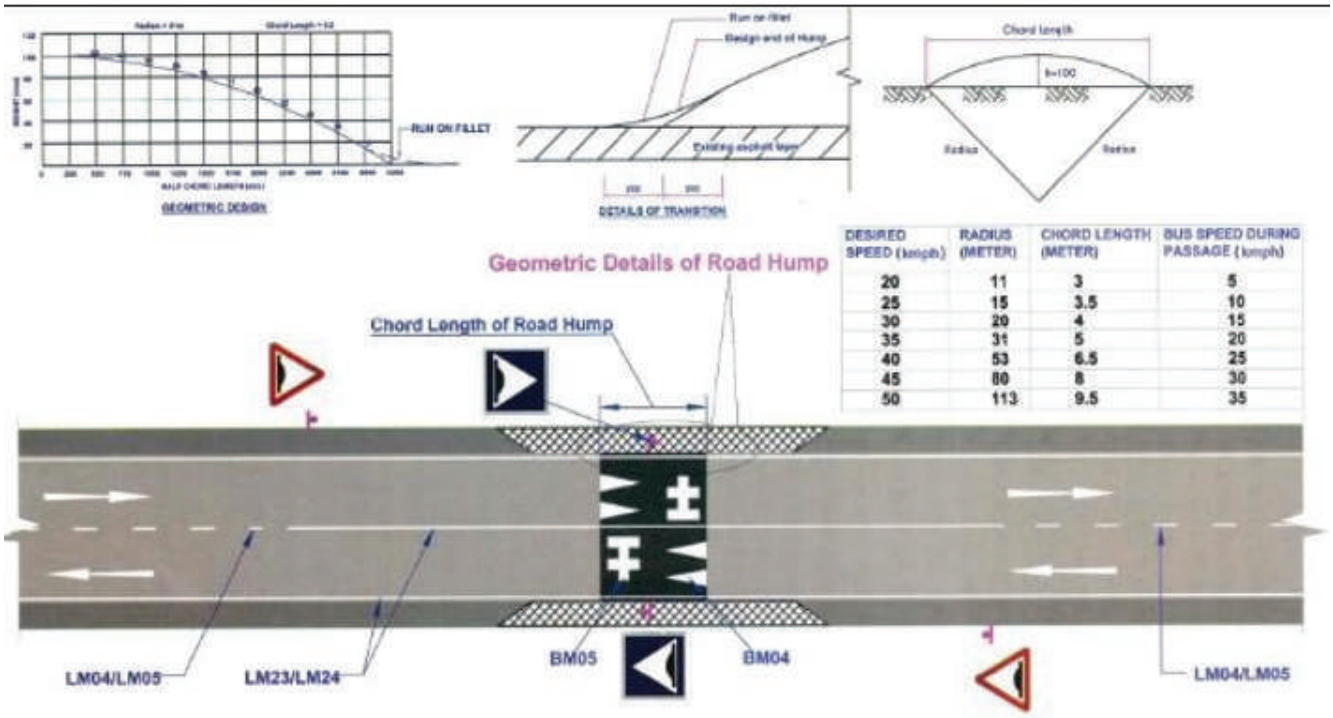


Figure 72: Speed breaker design and marking

- Speed Tables: The speed tables or raised pedestrian crossing (as per IRC: 99-2018 and IRC: 103-2012) discussed in 5.5 Pedestrian Facilities would help in preventing the violating traffic from using the shoulder with their motive to avoid road hump installed in the main carriageway. See Figure 73

Figure 73: Speed tables or raised pedestrian crossing

- Rumble Strips: According to IRC: 99 - 2018, rumble strips are provided at places where speed control is unavoidable in highways and arterial roads. The rumble strip can be cast in situ with cement concrete or premix bituminous materials. Rumble strips may be provided across the entire width of carriageway and paved shoulders (if any). Raised section should be 20 to 30 mm high, 200-300 mm wide and spaced about one-meter centre to centre of roughly 6 numbers at one location as shown in Figure 74.

- These are placed across the entire carriageway including the shoulder. Proper workmanship must be exercised to achieve the required height. On approaches to narrow bridges, rumble strips can be used in shoulder to force the driver to slow down and drive on restricted width of pavement in approaches, where shoulder gets terminated or in some case shoulder space is converted to raised footpath etc. In crash prone locations, where crashes have occurred due to departure of vehicles from shoulder on to side slope of embankment, rumble strips can be used on such a shoulder side also.

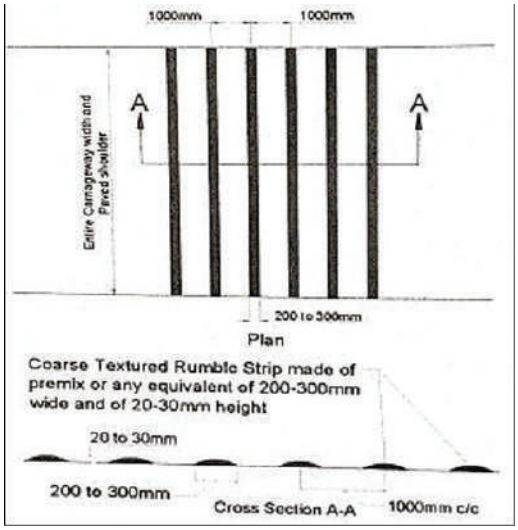


Figure 74: Rumble strips (Not to scale) as per IRC: 99-2018

- Retro-reflective Pavement Markers (RRPMs) or road studs: As per IRC: 35-2015, retro- reflective studs are used to supplement longitudinal/transverse reflectorized road markings, which would improve visibility in night-time and adverse weather conditions. The road studs are to be placed on broken longitudinal markings and it shall always be placed at the centre of the gap and shall never be upon the line segment or by the side of the line segment. However, in the case of the road studs to be placed on carriageway having a paved shoulder, it shall be placed outside the shoulder side edge line and shall be set back by a distance of 50 mm from the edge line. When road studs are to be placed on the shoulder edge line having no paved shoulder, it can be placed on edge line due to space constraints. Road studs in addition to being used to enhance road visibility, they are also used across the carriageway to serve as Speed Arrestor coupled with eschewing warning through the creation of the rumbling sensation to the user. Series of such road reflector studs have to be laid in advance of junction/crossings/end of the flyover section wherein road crashes are prevalent. So, the existing studs should be replaced with new ones immediately to increase the safety at the intersection.

- Lane Narrowing: According to IRC: 99-2018, lane narrowing can reduce the speed of cars, but its effect is minimal for two wheelers. The narrowing should be indicated using lane marking or texture change or colour change or kerb markers. This also reduces the carriageway space pedestrians have to cross as the curb is extended into the intersection. Similar programs such as Road or Lane Diets aim to change the physical infrastructure by thinning car lanes or reducing their number to widen the sidewalks or add bicycle lanes. Lane narrowing can be seen in Figure 75 and Figure 76.

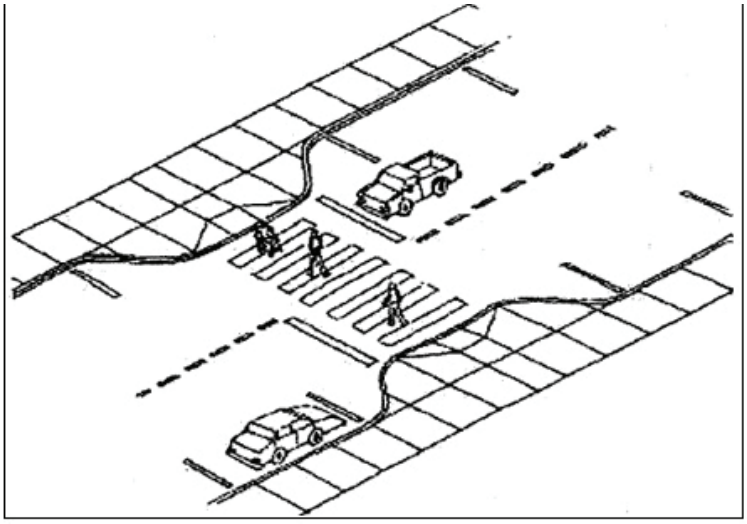


Figure 75: Lane narrowing at a mid block section

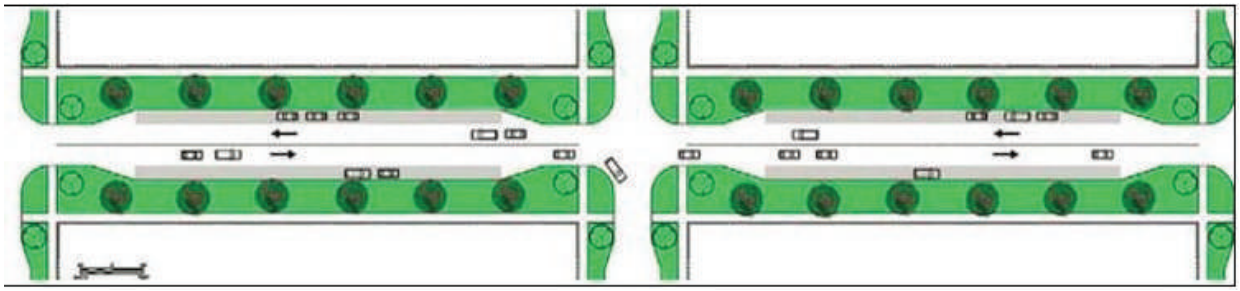


Figure 76: Lane narrowing near intersections

- Staggering by means of Angled Kerb Blisters or Chicanes: It is done by horizontal deviation of vehicles on the road, restricting them to known turning radii, which would be different speeds for different vehicle types. Hence, sharper the bend, slower would be the speed. According to IRC: 99-2018, the angled kerb blisters which create a horizontal deflection is sufficient to slow vehicles to travel comparable to speed at hump (i.e., 20-25 kmph at the device). The device operates differently for single- and two-lane devices as shown in Figure 77 and Figure 78. Horizontal shifts in the carriageway are less effective than vertical ones in achieving reductions in speed; however, their impact is significantly increased when used in combination with a vertical shift. Horizontal deflection by chicane shall always be provided with hazardous markings and retro-reflective hazard markers to make the chicane conspicuous at all times as shown in Figure 79 and Figure 80.

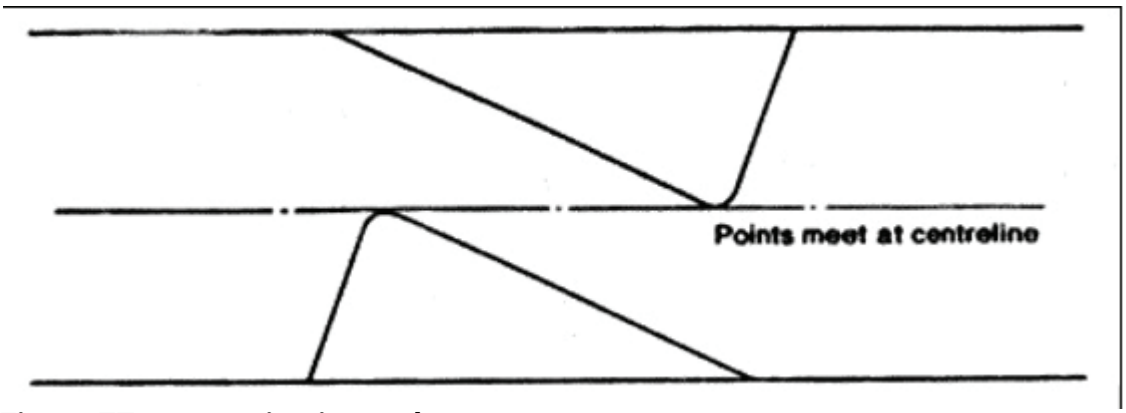


Figure 77: Staggering in one lane

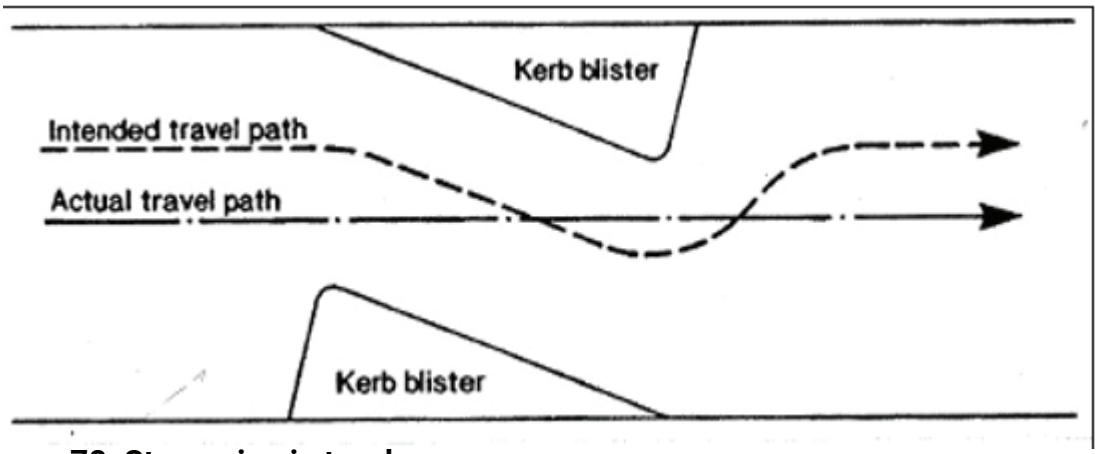


Figure 78: Staggering in two lanes

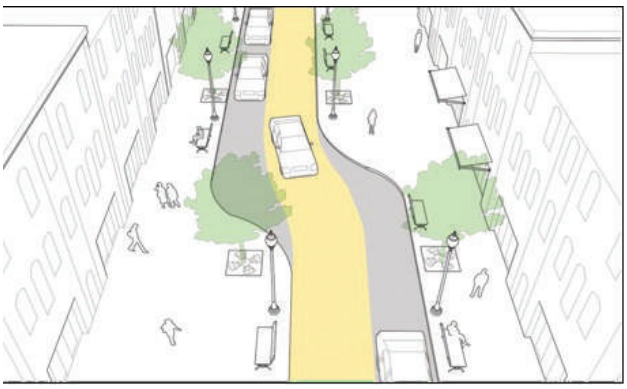


Figure 79: Staggering in one lane by providing chicanes

Figure 80: Staggering in two lanes by providing chicanes

- Raised Intersections and Textured Pavements: According to IRC: 99 – 2018, raised intersections are used to bring all users to a common speed limit without affecting the cyclists too much. They can be used on junctions where the intervention does not affect the movement of high volume through traffic. Textured pavements are effective for reducing speed of small cars but, are to be combined with other measures to be effective for buses and other large sized cars. The kinds of crashes that generally occur with speed breakers and speed humps with vertical shifts generally do not occur with uneven road surface or with stone set pavement. See Figure 81.

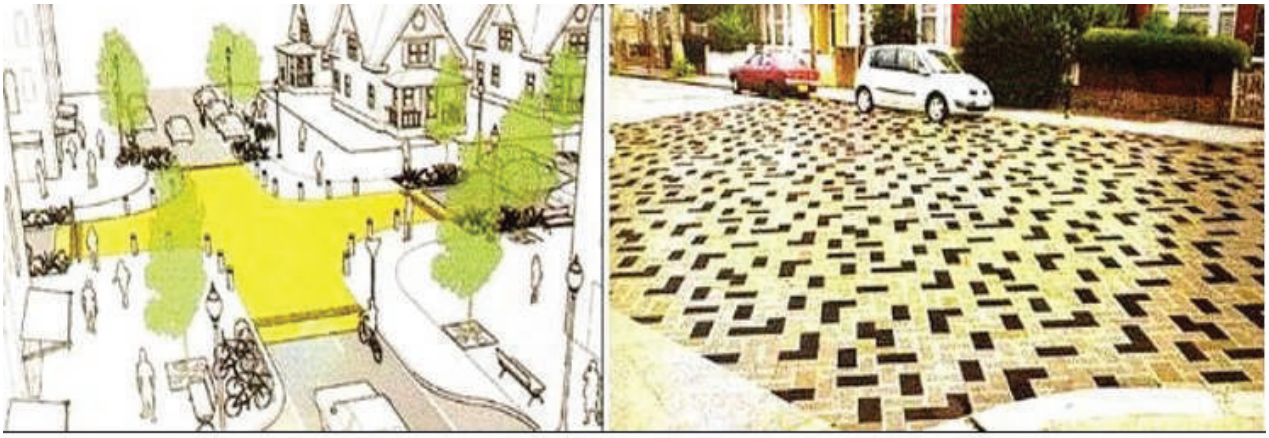


Figure 81: Raised intersection and textured paving over raised crossing

B. Behavioral risk factors vis-à-vis interventions

- The main purpose of the engineering interventions mentioned previously is to capture the attention of the driver thereby encouraging them to reduce their speed. This will help in modifying their over-speeding nature on the road at the particular sections.

- Interventions such as speed breakers (speed tables, speed bumps, rumble strips, etc.), retro- reflective pavement markers (RRPMs), raised intersections and textured pavements all aim to capture the attention of the users through the creation of the rumbling sensation. This in turn will encourage the driver to remain alert and reduce the speed of the vehicle.

- The lane narrowing, staggering by means of angled kerb blisters or chicanes, creates a reduction of width of the carriageway, forcing the drivers to reduce their speed so as to prevent crashing onto them.

- When drivers perceive that their speed is being monitored and displayed on a variable message sign, they demonstrate better speed limit compliance. Driver feedback signs alert the drivers of their current speed and the presence of the speed camera motivates them to modify their speed, thereby sticking to driving within suggested speed limits.

- Road safety and speed management can be incorporated in the school level curriculum. Educating children from a young age about speed risk in appropriate ways can be helpful in creating a speed-risk conscious generation.

- The communication carriers or media including the written press, radio, television, cinema, internet, etc., can be used effectively to disseminate persuasive traffic and road safety messages.

- Public awareness and education on road safety should be given higher priority and media advertisements should be done involving celebrities and politicians to influence the public. Stories of real-life victims and eye-witness accounts from people involved in crashes due to over-speeding should also be included so as to provide a realistic picture of the life-threatening issue. Driver education and training programs aimed at addressing aggressiveness/risk-taking traits might help reduce repeated speeding offenses among drivers.

- People from local communities near the black spots can be encouraged to arrange and be a part of community-based programmes such as education initiatives, community members constructing speed humps or other traffic slowing devices on the roadway, or retribution directed at reckless drivers, under proper guidance of road safety experts. Apart from public awareness, voluntary community work can also help to offset the costs of speed management programmes.

- Prevention campaigns with messages that are broadcast on TV or radio, or through promptings displayed to drivers along the road, on variable-message signs (VMS) can be set up at the black spots. Quirky comments such as “Enjoy speeding? What about the fine?”, “Kill your speed, not your passengers”, etc., can be targeted to speeders by appearing only when speeding is detected. In a study conducted in Spain on mass-media public advertising campaigns, with a marked shift from gentle messages to threat-based advertisements, the results show that a reduction in numbers of deaths and injuries is always achieved when the level of harshness in the messages is increased after a period of several years of mild advertising.

- Several studies on anti-speeding messages have shown that in contrast to crash-related messages, uncommon anti-speeding messages regarding fuel consumption or environmental pollution are less expected by the road users (Chaurand et al., 2015; Delhomme et al., 2010). Hence, they capture attention and have more probability to change people’s behavior. Fighting pollution is a positively perceived behaviour. Adopting driving behaviour that observes speed limits will reduce both fuel consumption and the emission of pollutants in the atmosphere. Campaigns using environmental-protection arguments (e.g., speeding and air-pollution, eco-driving, or emphasizing speeding and fuel consumption) seem to be good options likely to lead drivers to intend to observe speed limits and thus to potentially reduce the number of crashes.

- In Malaysia, speed management is part of the driving curriculum (Hamid et al., 2017; Ab Rashid et al., 2021). It is extremely important when learning to drive that new drivers learn to drive at the right speed for the prevailing conditions. Even when no obvious limits or clear engineering measures are present, drivers are expected to be able to adjust speed according to the environment. Driving schools in the city can be invited to take part in road safety campaigns and should be encouraged to emphasize speed management in their driving lessons.

- With the advances in vehicle technology, it is now possible to deliver consistent feedback personalized for an individual driver. Such feedback, when presented properly, can provide both immediate benefits on driving performance and long-term positive changes in behaviour. Technology such as smartphone apps with speed alerts when drivers exceed the limit, On- Board Driving Monitors such as DriveCam, SmartDrive technology, etc., which use video recording to monitor driver behaviour have been used in various countries as an effective tool for measuring driving behaviour and potentially improving safe driving behaviour. The in- vehicle information systems, such as a forward collision system, a lane departure warning system, an intelligent speed adaptation system, or an assistive driving advisory system have been shown to benefit drivers in certain aspects of the driving task. These systems facilitate the delivery of feedback, which is situation specific, thus is accurately tailored to the driver's needs. Developing such technology tailor made for Indian traffic conditions under the initiative of the Government has potential in aiding the speed management and should be explored

C. Traffic management & enforcement interventions

In order to reduce speeding and speed-related crashes, speed enforcement in most countries is undertaken by police. Enforcement of speed limits plays a critical role in managing speeds effectively. Police enforcement has a dual role:

1.General deterrence: This describes the process of deterring road users from speeding because they see police enforcing the law, even if they do not get caught themselves. It aims to create the impression that enforcement is occurring and therefore, that road users should expect that they may be caught in future if they are speeding.

2.Specific deterrence: This describes the process of deterring people from speeding in future because they have already been caught speeding and received the legal penalty.
Together, these two kinds of deterrence can work together to reduce the prevalence of speeding. Best practice policing principles encourage police to conduct speed enforcement manually (i.e., police on the roadside measuring speed and stopping motorists who are speeding to issue a violation) and automatically (i.e. via automated speed cameras). A combination of these types of enforcement, coupled with appropriate penalties and a system that allows penalties to be followed up if not paid, are critical to managing speeds.
The use of negative feedback via penalties for violating the law is a widely used tool in many countries like Spain, Hong Kong, Australia, etc. (Chen et al., 2020; Izquierdo et al., 2011; Watson et al., 2020) Studies indicate that contingent negative feedback via penalties such as driving-offence points (e.g., demerit or merit points), monetary fines, and license suspensions can have a positive impact on reducing speeding behaviours

- Reduced Speed Limit: Reduced speed limits as recommended by the experts should be fixed for the black spots in Mumbai. The revised speed limits should be announced to the public and warning sign boards should be installed at the black spots. They should be strictly enforced by the Mumbai Traffic Police and the offenders should receive penalties appropriate to the risk. This would greatly reduce over-speeding at the black spots, bringing down the crashes at the locations.

- Warnings: Warning notices can be issued in the time between any new law being passed and its full implementation. These notices inform drivers and riders that they have committed an offence under the new law, and that in the future a penalty will be imposed for breaking it.

- Penalties: Fixed penalties can be issued by the Mumbai traffic police with a written infringement or violation handed out on-the-spot, requiring the offending driver or rider to pay a fine to a given department (which can be separate from the police department) by a specified date. The system should be systematized such that no money transactions occur at the interception point, and a full audit of any financial transactions is maintained. This will minimize allegations of bribery, corruption, and favoritism at the roadside.

- Stricter penalties are intended to promote safer driving and compliance with all speed limits, which could reduce the number of road fatalities by half. With the higher fines, people will think twice about jumping a signal or riding without a helmet. Seeing other friends or family pay a hefty fine is also expected to deter motorists from violating the traffic rules. Some motorists who violate the rules in India follow it in other countries because they know they can't get away paying a bribe. Stricter implementation of the new Motor Vehicles (Amendment) Bill, 2019 will lead to general deterrence which in turn will encourage the motorists to follow the rules even when a traffic constable is not present.

- All violators should receive appropriate retribution that cannot be avoided such as the penalties mentioned below. This will greatly reduce the rule breaking tendency of drivers on the road.

- Non-Monetary Penalties: Besides imposing monetary penalties, non-monetary punishments like punching holes on the driving license for every violation (a practice that has been in place in some countries to identify repeat offenders), or suspending the violator's license after a certain number of offenses may be effective in reducing repeated offenses.

- Driving Offense Points or Demerit Points or Penalty Points: Driving-offense points (DOPs) are a form of penalty imposed when particular traffic offenses are committed (Chen et al., 2020; Izquierdo et al., 2011). When issued with a learner's license/driver license, each driver has no driving-offence points. DOPs accumulate if a driver commits an offence that carries demerit points. A fine will often be imposed together with these demerit or offence points. The offence points remain valid for a number of years (often three years) and the legislation specifies sanctions, which are imposed when the number of 'points' reaches a particular level (e.g., cancellation of a license with 12 or more points). DOPs are found to be more effective than monetary fines in deterring speeding offences. These schemes require the licensing authority to maintain accurate records with regard to all individuals holding licenses so that each conviction for an offence reported can be recorded and attributed to the correct person.

- License suspension (and for very high speeds, licence cancellation) can be an effective deterrent against speeding, and in some countries immediate licence loss can take place when drivers are caught traveling at 25 km/h or more above the speed limit. It is also critical that where license sanctions are imposed – such as suspensions, disqualifications, or cancellations – police and licensing authorities have the ability to ensure that these sanctions are rigorously enforced

- The levels of fines and/or offence points incurred towards license suspension should escalate as the level of speeding above a speed limit increases. When appropriate regard is given to the risks associated with small increases in speeds above speed limits, it is important that the level of penalties for various levels of speeding reflect the relative risk to human life that the particular level of speeding poses.

- Vehicle impoundment or confiscation for extreme or repetitive speeding can be explored so as to curb the unsafe driving behaviours. In Australia, vehicle impoundment is one countermeasure which has been implemented to discourage drivers from engaging in high-range speeding (Watson et al., 2020). Vehicles which are impounded are held in a storage facility for a pre-determined amount of time (e.g., anywhere from 48 h to several months). Impoundments typically occur for more serious offences (e.g., excessive speeds, careless driving) or for repeat offenses (e.g., a second driving while disqualified offense). Vehicle impoundment has been used to reduce drink-driving and unlicensed driving in the US for over 20 years. Overall, the results for impoundment were generally positive with lower offence rates during the impoundment period compared to pre-impoundment, post-license restoration and post ban unlicensed periods.

- Legal action of imprisonment for excessive speeding can also help to reduce the likelihood of non-rule compliance among the driving population. In Norway, the punishment variables for speeding offences consist of a fine, the suspension of driving license for a certain period of time and additionally, and imprisonment in cases of extreme speeding (Jorgensen et al., 2005). The level of fine increases stepwise according to the level of speeding. - Fixed fine only (minor speeding offences), Fine and suspension of driving license, Fine, suspension of driving licence and imprisonment. The suspension period of the driving license ranges from 3 to 36 months. The length of the imprisonment period for speeding is normally 2 or 3 weeks. Normally, fines are not imposed on offenders in cases of prison sentence.

- In Spain, a combination of three factors: the penalty point system, the gradual stepping up of surveillance measures and sanctions, and the publicity given to road safety issues in the mass media was the key to success of the penalty point system (Izquierdo et al., 2011). Introducing a driving offense points system in India reinforced by the same factors as in Spain will help to deter drivers from continuing to re-offend for a range of road-law related offenses.

- Speed Camera Enforcement: Enforcement using high resolution surveillance cameras, hand-held laser speed detection devices, mobile radar speed cameras, Automatic Number Plate Registration cameras and Red-Light Violation Detection cameras, have been found to be efficient in encouraging drivers to comply with the posted speed limits. The speed cameras provide consistency of enforcement, reduce individual police discretion, and remove points of interception collection of penalties. This reduces the potential for corrupt enforcement practices. Installation of speed cameras at the black spots will be greatly instrumental in bringing down the high speed of the vehicles.

- Warning drivers of an upcoming camera-based enforcement section through sign boards, media advertising, variable-message signs, etc., has been found to increase speed compliance. Almost all drivers comply with speed limits when they reach a camera housing section of the road. Speed cameras at the black spots should be complemented by these warning signs so as to give the drivers adequate time to regulate their speed.

- Operating highly visible speed enforcement cameras at the black spots all the time is likely to result in drivers being deterred from speeding at least in those locations.

- Traffic Police Enforcement: Police patrolling at the black spots will always be effective as many drivers get embarrassed and fear verbal reprimand when confronted by a police officer. This elevates the cumulative cost of being detained by the police to be even higher than the fear of risking one's life or that of others through speeding.

- Operating a mix of highly visible and strategically directed police patrols or speed cameras increases public perception that speed enforcement can happen anywhere and at any time. The unpredictability of where and when speed enforcement operations take place will have a more general deterrent effect by encouraging drivers to drive within the speed limit no matter where or when they are travelling.

- Where camera-based operations cannot be introduced in the short term, effective compliance can be achieved with widespread use of hand-held radar or laser devices, coupled with normal traffic patrols and relevant interception strategies. The visibility of police operating to ensure speed compliance is often far more effective than issuing traffic infringements or tickets. Behavioural change will occur when the public perceive there is a high risk of being detected speeding, and that detection will lead to a penalty. Equipment can later be upgraded to car-mounted, mobile radar devices and in-car video equipment which now provides the most up-to-date, high-impact police enforcement tool for traffic offenders.

- Studies have shown that even a strategic placement of a placard on the road with a photograph of a traffic policeman has an impact. If there is a perception of surveillance, or someone looking at you, there is less chance of people breaking rules. This is worth giving a shot at the black spots as a temporary remedial measure.

- In any campaign where government is seeking to change often deeply embedded behaviour (such as speeding) in a substantial proportion of the driving population, it is useful to seek to obtain the agreement of politicians, senior public officials, police and road authority staff to comply with speed limits in their driving tasks – and not only with work-related driving. Having 'opinion leaders' and celebrities to support speed campaigns can be very useful in getting public support. It is unhelpful if public officials or politicians are known to be flouting the law. Obtaining their commitment to respect speed limits is also a very interesting way to assess underlying government support for behavioural change.

- As a programme moves from the development phase to the implementation phase it is vital to continue to encourage the active involvement of senior government officials. Wide-scale speed enforcement programmes, particularly automated enforcement programmes, affect large numbers of people. It is important that the implementation of initiatives is actively monitored, and that ongoing results are regularly reported to senior government leaders. Wherever possible, senior political leaders should be given a public role in announcing speed management initiatives. This will strengthen their commitment and ensure that they are fully briefed on the details of the initiatives.

- Conducting publicity campaigns to advise motorists that there will be strong levels of enforcement will assist in persuading them that if they exceed speed limits, they are likely to be caught. This will also help to avoid adverse reactions against the police. Enforcement is needed to make this element effective.

- Incentive: Countries like USA have introduced incentives (although these tend to be small) for drivers to comply with limits (and other road laws) (Rodriguez et al., 2006). The potential benefit is improved public acceptance of tougher speed enforcement. One scheme in operation in Victoria, Australia, provides a 30% rebate on license renewal for drivers with no offences (for any road laws) in the prior three years. This scheme could be explored by the government as a speed management initiative.

- Offering incentives to encourage compliance with speed limits can be taken up by the employers and insurers. Insurance companies and organizations can be encouraged to offer incentives to promote road safety among their employees and clients as a part of corporate social responsibility (CSR).

- Employer's Initiative: Transport companies are increasingly using GPS tracking systems to monitor their vehicle fleet, as well as driving speeds. Used in a vehicle, the device allows a driver to plot the best directions to a location, but it could also allow employers to track their movements. Some employers are now requiring vehicles to be fitted with speed alert and/or speed limiter devices to give drivers feedback, or to directly constrain the vehicles to predetermined speed limits. Transport companies and taxi booking businesses operating in Mumbai can be motivated to adopt similar methods like installing speed governors to monitor the driving behaviour of their driver and encourage them to drive safely and follow road safety by offering incentives.

- Through monitoring the number and severity of breaches of speed limits leading to a traffic infringement or more serious charge, employers can have an effect upon the behaviour of drivers who are traditionally more likely to speed than others. Employers can be motivated to build in a range of incentives or sanctions to encourage compliance. They can also use technology (such as speed governors or tachographs) to reduce travel speeds.

- Other ways that employers seek to monitor speeding and other unsafe road behaviours is through the installation of bumper stickers seeking public feedback. In this way, drivers know that if they drive at unsafe speeds or in other dangerous ways, someone may report this to their employer. In some cases, high-profile companies with vehicles featuring their name or logo will be contacted if their drivers seem to be travelling at excessive speeds or displaying other unsafe or uncourteous road behaviours. As speeding is one of the major factors in work-related road crashes, employers can be assisted or advised to educate their employees about this risk.

- Licensing: New drivers rarely have a good sense of relative speeds and some may be a little over-confident. To cover this, some countries license new drivers in stages. In India, stricter and corruption proof policies should be designed and enforced while licensing new drivers

- In some countries, when drivers are starting to learn, they are sometimes required to have a licensed driver with them while driving and to drive at speed limits set lower than the limits for fully licensed drivers. Restricting the speed that new drivers or riders can travel, will reduce the likelihood and severity of crashes as a result of inexperience. However, this has to be enforced strictly for it to be effective.

- Some countries require one or two additional levels of provisional license that new drivers must pass through before finally receiving a full license, each with speed restrictions and sometimes restrictions on the number of demerit points they may receive without losing their license.

5.2. TRAFFIC CALMING MEASURES AND INTERSECTIONS

A. Engineering interventions

Speed Limit

- As per IRC: 70-2017, traffic calming measures include visual measures such as speed limit signs, painted strips across the road, zebra crossing, road surface pattern, etc., and physical measures such speed breakers, rumble strips, speed tables, lane narrowing, etc. See Figure 82.

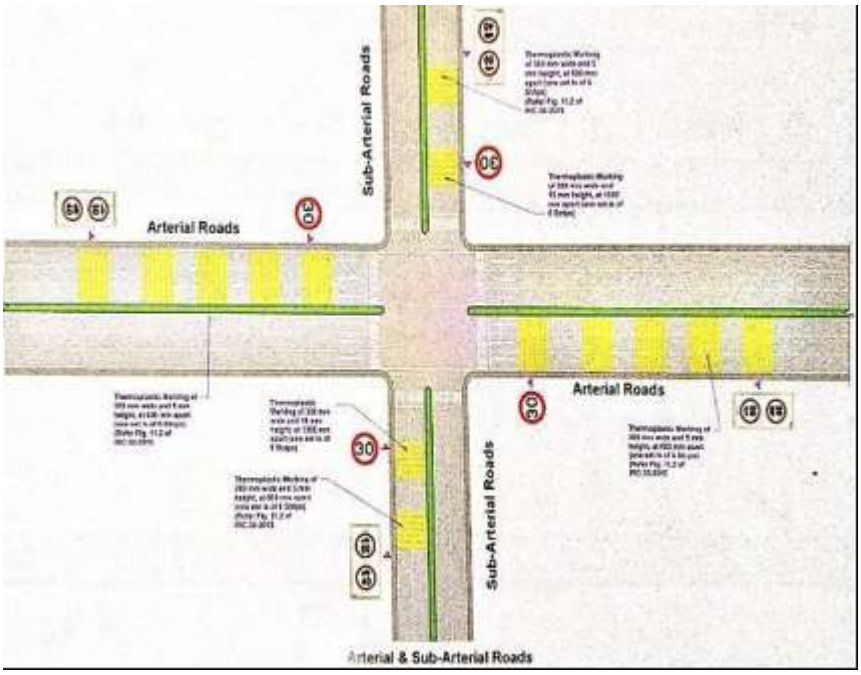


Figure 82: Urban road with traffic calming measures

- Turning radii at intersections: According to IRC: 70-2017, turning radii at intersections of arterial, sub-arterial and collector streets shall not exceed 9 m, enabling vehicles to slow down and see the pedestrian and cyclists.

- Channelization: It involves the use of islands at intersections to guide and protect the traffic. It provides reference points within the intersection which enable drivers to better predict the path and speed of other drivers. They increase the driver's ability to avoid crashes and congestion. Channelized islands should be at least 4.7m2 and preferably 7.1 m2 in area, not less than 2.4 m and preferably 3.6 m on any side after rounding of corners if triangular and at least 1.2 m and preferably 3.6 m if elongated.

- Pedestrian refuge islands and median with reflectors: Pedestrian refuge islands separate conflicts so that pedestrians can judge whether it is safe to cross by looking at and analyzing fewer travel lines and directions of traffic at a time. The retro- reflective paint on the medians and islands should be redone to improve the visibility during night time. Reflectors with retro- reflective paint should be provided on the islands and medians to notify the road users of their presence especially in the night time.

- Signal Phasing: The optimal phasing design is determined by the relative volume of various movements taking place at an intersection. Large intersections with heavy pedestrian traffic such as near schools can be provided with separate signal phases for pedestrians depending on the pedestrian movement.

- Flashing beacon: As per IRC 93-1985, flashing beacons with yellow lens illuminated with rapid intermittent flashes to signify the drivers to proceed with caution can be provided at locations where proper traffic signals cannot be provided. They can also be provided near the black spots as well as locations of pedestrian crossings to alert the road users about the presence of students.

- Convex mirrors: Convex mirrors can be placed at black spot locations with poor sight distance, such as side roads joining the main road and near curves to improve the visibility (Figure 83).

Figure 83: Convex mirror on the minor road to improve sight distance

- Rolling Barriers: The rolling barriers as seen in Figure 84 and Figure 85 are the barrier that absorbs impact energy and converts that impact energy into rotational energy and directs the vehicles forward rather than potentially breaking through an immovable barrier. Urethane Rollers invented by the ETI (Evaluation in Traffic Innovation) company from South Korea has served to redirect the uncontrolled moving vehicles and to balance it again causing reduction of crashes. Rolling barriers provide cushioning effect during a crash, reduces the high-speed effect, constitutes material resilience with stiffness and have other performance characteristics that reduce injury to occupants and damage to the vehicle. The roller barriers are extremely effective and its implementation has given signified results in reducing the road crashes at flat roads, curved roads sections, ramps, medians, entrances/exit ramps in the parking garage etc. steep curved roads as in the mountainous terrain. On the occasion of a crash, roller on the barrier absorbs initial collision shock, which converts to rotational energy. Then, the second shock is absorbed by the front rail of the barrier, third shock is absorbed by the back rail and furthermore metal pipe is inserted in these rolling road barriers to strengthen the post. Frictional rotating stopper boards installed to the top and bottom of the rollers act as clutch plates to decrease speed. The product is flame retardant and recyclable. Adding or removing rollers can adjust the barrier for complete suitability to any landscape. Rolling barriers have been installed along the curves of the East Coast Road (ECR), Tamil Nadu in the same context for the achievement of higher degree of safety on road.

Figure 84: Rolling Barriers at the roadside and vehicle collision

Figure 85: Rolling barriers along a curve

- Measures at Intersections: Clear delineation is required at intersections to inform road users that there is an intersection present and to provide information about the types of manoeuvres that may occur. Improvements to intersection delineation can be made by making adjustments to, or installing new traffic islands, street lighting, lane marking and warning signs. Poor delineation (such as unclear approach lane lines and faded or missing Stop or Give Way markings) may result in late braking behaviour by road users who are required to stop, or wish to make turns.

- Median islands (or splitter islands) can be used on the approaches to intersections to improve the prominence of intersections (including by the provision of additional signs on median islands), and provide an additional benefit as they channelize traffic and may provide pedestrian protection if designed well.

- The medians and channelizing islands should be installed with median reflectors and should be painted with retro-reflective paint to ensure visibility during night; flashing beacons can also be used to capture the attention of the road users.

- Proper road markings as per IRC: 35-2015 and road signs as per IRC: 67-2012 should be provided near the intersections to reduce the vehicle conflicts.

B. Behavioural risk factors vis-à-vis interventions

- Purpose of the engineering interventions such as median, channelizing islands, flashing beacons, etc., are to encourage the drivers to slow down at the locations and then proceed ahead with caution.

- The convex mirror installed at locations with poor line of sight provides better visibility to the drivers thereby encouraging them to reduce speed in case of vehicles coming in the opposite direction to avoid conflict.

C. Traffic management & enforcement interventions

- Sight visibility at intersections can be compromised by vehicles parked too close to the intersection, vegetation, advertisements, sign boards, etc. These factors should be kept in check by the concerned authority to ensure proper visibility for the vehicles approaching the intersection.

- Presence of traffic police at the black spots with intersections during peak hours will discourage drivers from jumping the red signal and over-speeding

5.3. ROAD MARKINGS

A. Engineering interventions

- Road markings such as centre line, edge line and traffic lanes should be provided to help in segregating the traffic as per the specifications of IRC 35-2015 with respect to design graphics, dimensions, font size, colour and material. The faded or missing road markings should be maintained periodically to serve their purpose.

- At intersections, markings indicating stop line, pedestrian crossing, directional arrows, junction marking, diagonal lines and chevron should be applied as specified under IRC 35-2015.

- In case of traffic approaching the grade separated intersections or merging with other major roads, there is a likelihood that the lane change from the main carriageway to the auxiliary lanes or vice versa generally takes place at high speed and hence has to be dealt with carefully. The basic issue to be addressed in this regard is to enable the driver to distinguish clearly between through traffic lanes and auxiliary lanes. Additional emphasis has to be provided by means of chevron markings in the neutral area as specified in IRC: 35-2015. The traffic merging and diverging occurring in the vicinity of the flyover or VUP are generally carried out without any lane gain or lane drop as shown in Figure 86. If there is substantial quantum of traffic either diverging or merging, the merging or diverging operations are to be facilitated by the provision of a lane gain or lane drop as presented in Figure 87. For diverging and merging situations with two lane slip roads, a safer practice of lane gain and lane drop shall be carried out with ghost markings as given in Figure 88.

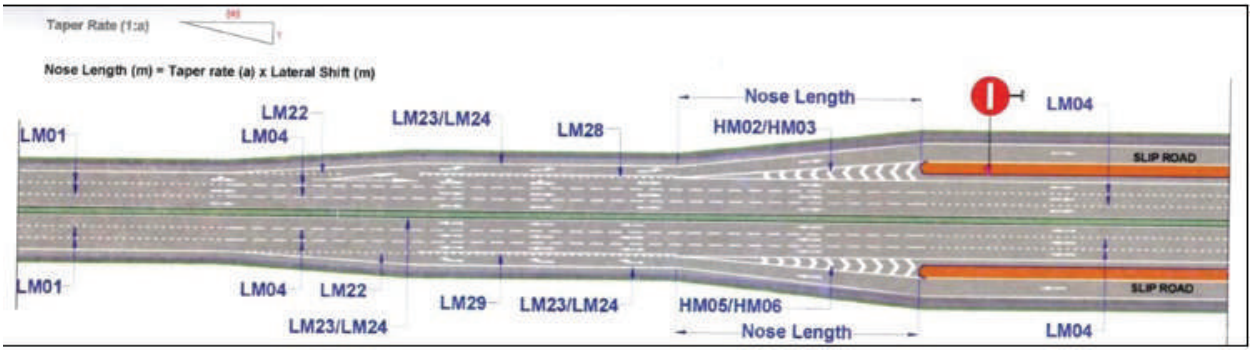


Figure 86: Merging/Diverging (without Lane Gain/Lane Drop)

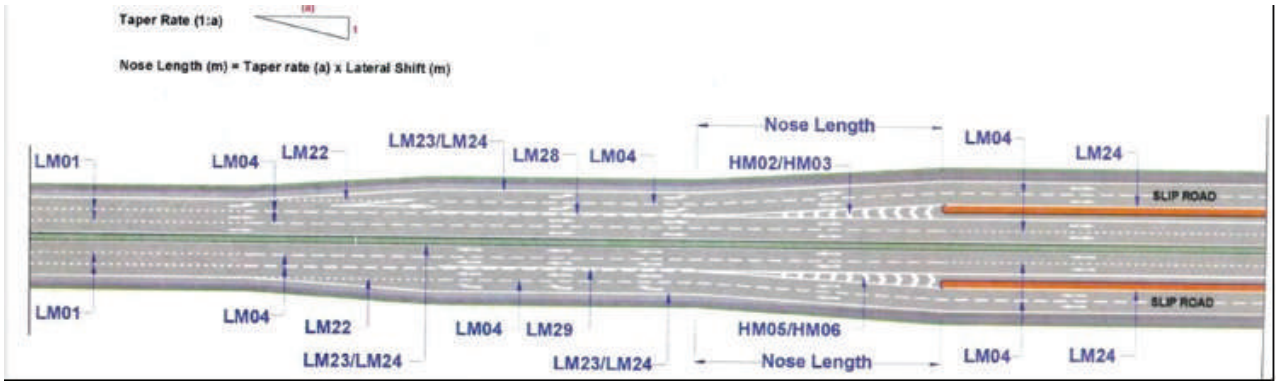


Figure 87: Merging/Diverging (with Lane Gain/Lane Drop)

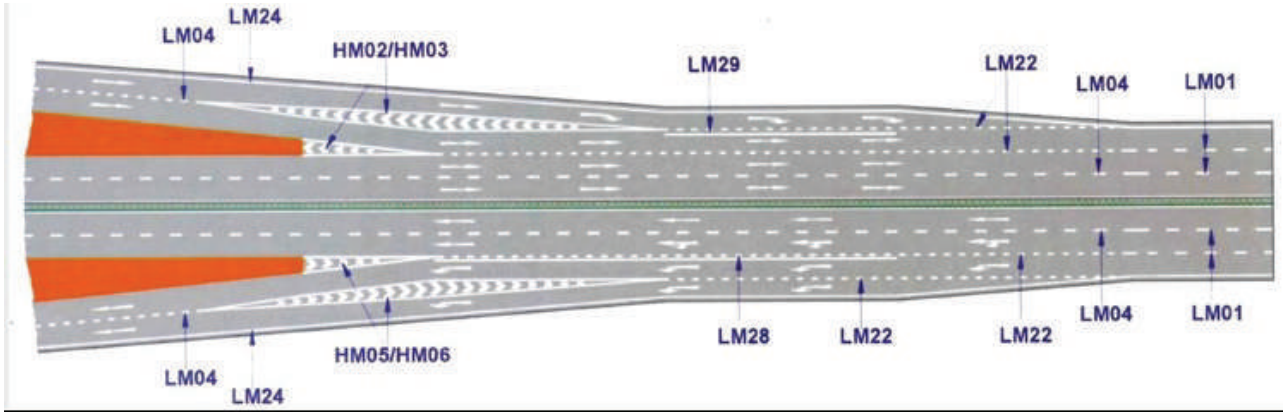


Figure 88: Merging/Diverging with ghost markings (with Lane Gain/Lane Drop)

- The pavement marking that facilitating traffic merging/diverging, prohibiting to cross-over and to deflect the traffic ahead of hazardous situations, generally done with like chevron and diagonal marking, hatch marking and prohibitory marking and such markings are classified under Hazard Marking in IRC: 35-2015. Since hazard markings are provided ahead of diverging and merging and around a hazardous location, its compliance is also vital. The hazard marking shall always be accompanied with appropriate signs. Channelizing markings like diagonal and chevron markings are utilized to demarcate the neutral area at the nose of a channelizing island which can help in reducing the incidence of collision with kerb nose. They direct the entering and exiting traffic into the proper angle for smooth movements of divergence and convergence. The diagonal and chevron markings are generally placed at locations where traffic is expected to change position either to diverge or converge. The total length of longitudinal chevron and diagonal marking varies with site conditions and the length should be such that to accommodate at least two or three chevrons or diagonals. The chevrons must always point towards approaching traffic and the chevron should be reversed when traffic is merging. The gap between chevron and boundary line shall be 100 mm to facilitate drain of surface runoff.

- Markings indicating parking, prohibition of parking, bus stops and intermediate para transit stands such as taxi and auto rickshaw stands should be clearly applied.

B. Behavioral risk factors vis-à-vis interventions

- The markings serve as a psychological barrier and thus help to signify the delineation of traffic path and its lateral clearance from traffic hazards facilitating safe movement. Further, the road markings channelize the pedestrians and cyclist's movement into safe locations and in effect, provide for an extension of the side walk/cycle track across the roadway.

- The lane markings on the road conveys to the driver the width available for them to follow lane discipline and to traverse without intercepting other vehicles.

- Retro-reflective road markings on speed breakers and on pedestrian crossings near intersections should be ensured to alert the drivers of the impending situation and thereby encourage them to slow down so as to prevent any chance of conflict.

- Retro-reflective studs provided on the edge of the road produce a rumbling sensation when the vehicle veers off the road which helps to bring back the focus of the driver.

C. Traffic management & enforcement interventions

- As per IRC: 35-2015, road marking shall be preferably subjected to routine inspection desirably once in six months for all the characteristics such as retro-reflectivity, dry and wet, wear, luminance coefficient and skid resistance. The retro-reflective paint on the markings of the speed breakers and the pedestrian crossing should be repainted when they start fading so as to forewarn the drivers without fail.

- Drivers stopping on or beyond the STOP line at the intersections should be strictly and severely penalized or berated by the traffic police to discourage them from repeating the offence.

5.4. ROAD SIGNS

A. Engineering interventions

- The purpose of road signs is to promote road safety and efficiency by providing for the orderly movement of all road users on all roads in both urban and non-urban areas. The road signs give information about the road conditions ahead, provide instructions to be followed at the major crossroads or junctions warn or guide drivers and ensure the smooth flow of traffic.

- Placement of Sign: The road signs are the means of communication to the road users, especially drivers. Placement of road signs should be within road user's view. To aid in conveying proper meaning, road signs should be with respect to the location or situation to which it applies. The location and legibility of the road sign should be such as to provide adequate response time to road users to read and take action at the operating speed. Therefore, the signs shall be so placed that the drivers can recognize them easily and in time. Normally the signs shall be placed on the left-hand side of the road around 15 to 25 m from the object or school to warn the road user. For two lane roads, normally the signs may be placed on the left side of the carriageway, repeated on the other side of the carriageway, if local conditions are such that the signs might not be seen in time by the drivers.

- On all roads with or without kerb and with or without shoulder the extreme edge of the ground mounted sign adjacent to the roadway shall be at a distance of 600 mm to 3 m from the carriageway or paved shoulder edge depending upon the local conditions. For roads with kerbs, it shall not be less than 300 mm away from kerb line, but in no case shall any part of the sign come in the way of vehicular traffic.

- As per IRC: 67-2012, the following are the essential road signs which should be installed especially near intersections, near schools, etc., for safe and efficient traffic operation.

- Speed limit Sign in Urban Area: The speed limit sign in cities shall be placed on each of the roads where the speed changes or on the exit arms of the junctions. The vehicles travelling through a junction are reassured about the speed limit on the new road by placing a speed limit sign at 25 m from the intersection. The size of speed limit sign (the first sign indicating the changed speed on major road after crossing the junction) shall be 600 mm, except for the dual carriageway roads with speed limit of 50 kmph or more, where the sign size shall increase to 900 mm. For sections of bad crash history or substandard curves, speed limit sign can be provided in a yellow backing plate to make it more prominent. Also, the advisory speed limit can be attached to the sign post as supplementary plate indicating the permissible speed for the particular curve.

- Speed Breaker: This sign (Figure 89) should be used to warn the drivers of the presence of the speed breaker and speed tables.

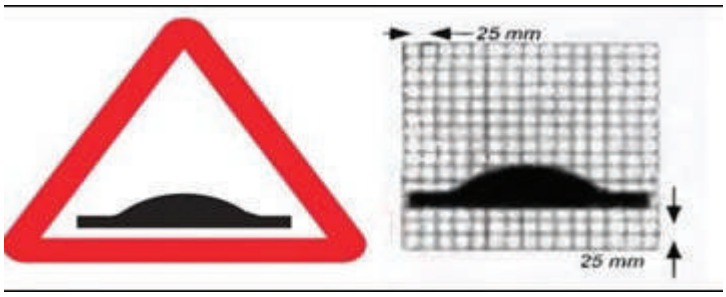


Figure 89: "Speed Breaker" sign

- Rumble Strip: The sign should be posted 50-60 m in advance of the rumble strips provided on the road to control and reduce the speed. This is to warn the drivers of the presence of the rumble strips (Figure 90). If required, the sign can be repeated at a short distance ahead of the rumble strips, indicating the distance to the rumble strip with a supplementary plate, i.e. Figure 90 + Supplementary plate indicating "10 m" or

Figure 90: Sign for "Rumble strips"

- Merging Traffic Ahead: This sign is posted in situations where the traffic from other road is merging and the drivers are required to slow down their vehicles for safe travel (Figure 91). In special cases of interchanges, there can be merging from the right-hand side also, for which appropriate sign shall be used as shown in Figure 91.

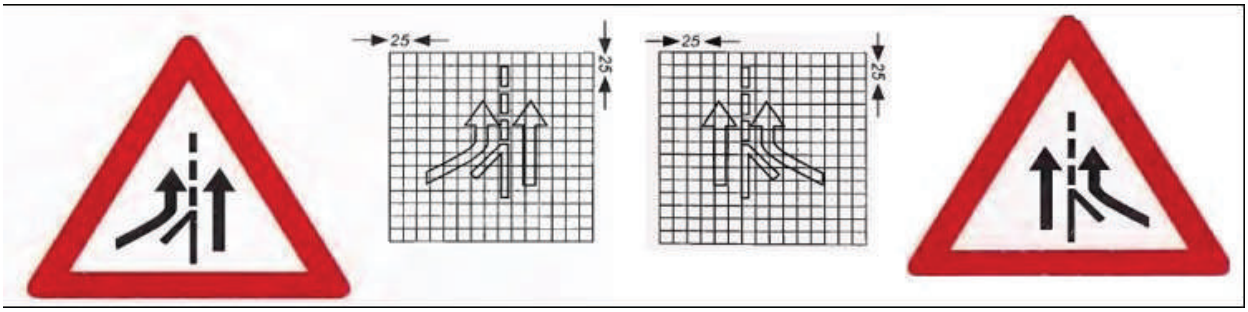


Figure 91: Sign for "Merging Traffic" (From Left and From Right)

- **Zebra (pedestrian) Crossing:** This sign (Figure 92) should be erected in advance on both approaches to uncontrolled pedestrian crossings. This is absolutely essential when visibility of the crossing is impaired by a bend or hump in the road.

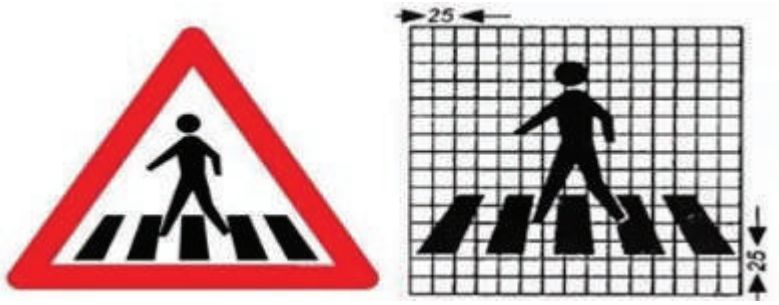


Figure 92: Zebra crossing sign

- **School Ahead:** This sign (Figure 93) should be erected where school buildings or grounds are adjacent to the road, and wherein the opinion of the controlling authority, passing traffic can create a hazard to children.

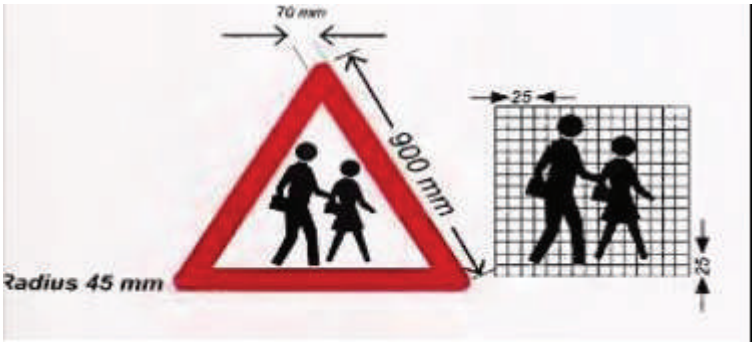


Figure 93: "School Ahead" sign

Chevron Signs: As per IRC 67-2012, at the curved alignment of a roadway, the chevron signs shall be used to inform the drivers about sharpness of curve. The chevron sign shall be a vertical rectangle and shall be installed always on the outside of a turn or curve, in line with and at approximately right angle to approaching traffic. See Figure 94. Spacing of Chevron signs should be such that the road user always has at least two signs in view, until the change in alignment eliminates the need for the sign. Chevron signs should be visible for a sufficient distance to provide the road user with adequate time to react to the change in alignment. Depending upon the sharpness of the curve, Single Chevron, Double Chevron sign and Triple Chevron Sign can be installed. If the Single Chevron signs are to be used for roads operating at or more than 100kmph, relatively bigger size single chevron shall be used.

- **Figure 94: "Single Chevron" sign**

- All other mandatory signs, cautionary signs and informatory signs ought to be installed in the right way to alert the drivers and to encourage them to slow down as per the guidelines and specifications laid down in IRC: 67-2012.

- Faded and missing signs should be maintained and re-installed again as per IRC standards so as to alert the road users beforehand.

B. Behavioral risk factors vis-à-vis interventions

- Road signs notify road users of regulations and provide warning and guidance needed by the driver to take appropriate measure to modify their driving suitably to the impending situation.

- Mandatory and regulatory signs such as overtaking prohibited, STOP signs, speed limit signs, etc., need to be complied with and any violation of the rules and regulations conveyed by these signs is a legal offence. Awareness of the significance of these signs motivates the driver to exercise caution while traversing through those locations.

- Cautionary or warning signs such as Narrow Bridge, Gap in Median, School Ahead, etc., indicate a need for special caution by road users and may require a reduction in speed or some other manoeuvre. The aim of such signs is to capture the attention of the driver, who in turn will process the information and then drive appropriately to prevent conflicts or crashes.

- Informatory signs like direction information, fuel station, parking, etc., are used to give such information to road users which will help them along the route in most simple and direct manner. This will help the driver to take informed decision while heading for a destination, thus aiding them to drive responsibly.

- Studies have shown that presence of sign boards warning drivers of an upcoming camera-based enforcement section has been found to increase speed compliance, modifying the over- speeding nature. This can be implemented effectively at the black spots

C. Traffic management & enforcement interventions

- The authority responsible for the road signs should ensure that all signs are inspected at least twice a year both in day and night times and at least once a year in the rain.

- They should also ensure that the signs are replaced at the end of the warranty period provided for the retro-reflective sheeting used on the sign. Damaged signs shall also be replaced immediately.

- The authority should also ensure that only those signs as specified by IRC are present at the locations. Presence of any other unwarranted sign boards or advertisements which reduces the visibility of the drivers or may cause potential harm to the road users by distracting them should be immediately removed from the black spots.

5.5. PEDESTRIAN FACILITIES

A. Engineering interventions

Short Term Recommendations:

According to crash data analysis, pedestrians are the most vulnerable road users at the black spots. The existing facilities are not much effective in protecting the pedestrians and hence additional facilities should be provided for the same.

- Width of the footpath: As per IRC 103-2012, footpath with a minimum width of 1.8 m which can go up to 2.5 m (Figure 95) should be provided wherever possible. Minimum width of sidewalk as per adjacent land-use according to IRC: 70-2017 is given in Table 36

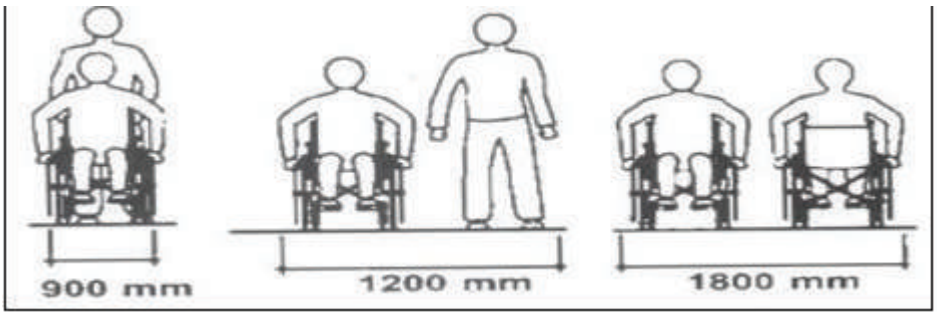


Figure 95: Width of a clear footpath

Table 36: Minimum width of pedestrian zone as per adjacent land-use

Sl No.	Zone	Minimum Width (m)
1	Predominantly Res idential Zone	1.8
2	Predominantly Commercial Zone	2.5
3	High Intensity Commercial Zone	4

- Ramps: Ramps allows for the smooth movement of the differently abled users at the meeting point of footpaths and roads. As per "UN-Accessibility for the Disabled: A Design Manual for a Barrier Free Environment", the maximum recommended slope of ramp is 1:20. See Figure 96.

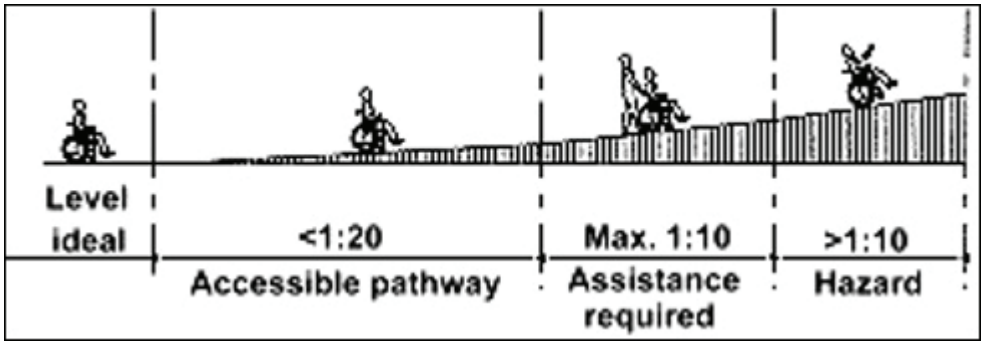


Figure 96: Ramp slope standards according to "UN-Accessibility for the Disabled: A Design Manual for a Barrier Free Environment"

- **Bollards:** As per standards, bollards should be painted in a contrasting colour or in coloured stripes with the distance between guiding posts around 1.20 m. See Figure 97.

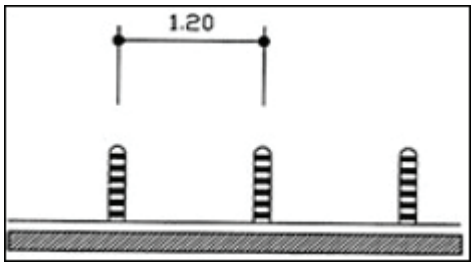


Figure 97: Bollards at 1.20m spacing and coloured stripes

- **Safety guards:** Safety guards or railings should be installed around hazardous areas, stairs, ramps, accessible roofs, mezzanines, galleries, balconies and raised platforms more than 0.40 m high. This provides guidance in the proper direction of pedestrian traffic so that the pedestrians cross the streets at predetermined and safe locations. See Figure 98.

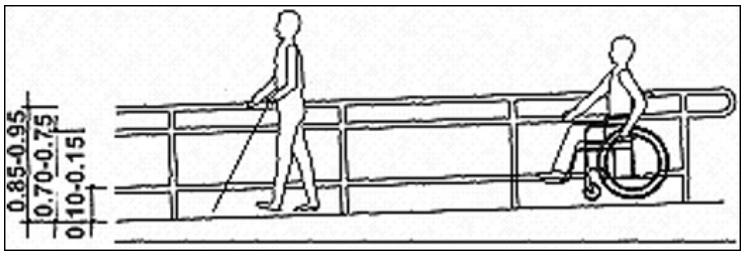


Figure 98: Guide rails as per standards

- Drainage Cover: Drainage Cover or gratings can be hazardous to wheelchair users, cane and crutch users, parents with prams and women with high heels, if they are not properly installed. Manholes, drains and gratings should generally be placed outside the pedestrian pathway. Gratings should be flush with the pathway surface and should have narrow patterns of not more than 13 mm.

- Guide lines: The path of travel should be easy to detect by a visually impaired pedestrians using a long white cane. Natural guide lines and guide strips using tactile tiles are used to help identify travel routes. A guide strip is a line means constructed in or on the road surface to facilitate orientation for visually impaired users in the following manner:

- To replace missing natural guidelines, fill gaps of more than 10.0 m in a guide strip (See Figure 99)

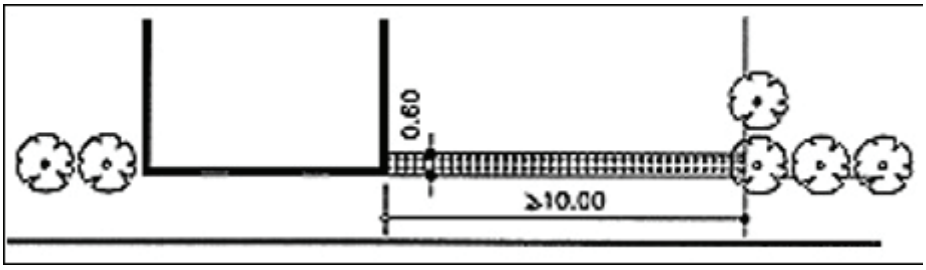


Figure 99: Schematic diagram of laying of guide strip

- Guide strips should be laid in a simple and logical manner and should not be located close to manholes or drains to avoid confusing the visually impaired users. Guide strips should have a colour which contrasts with the surrounding surface for the benefit of people with sight problems. The guide strip ridge profile should be parallel to the main direction of movement and should be flush with the top layer of the adjacent road surface so as not to hinder people with mobility problems. Where travel routes change direction, there should be a gradual change in the direction of the guiding strip as shown in Figure 100.

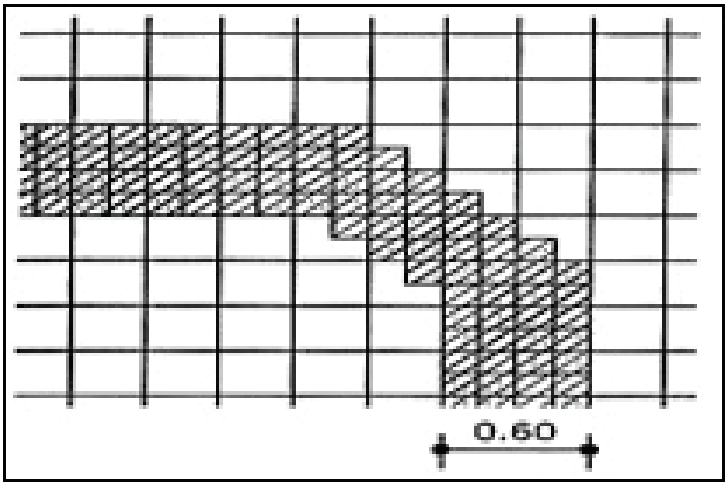


Figure 100: Gradual change in the direction of the guide strips

- Kerbs: Barrier type kerbs should be provided wherever absent and they should also be painted with vertical black and white stripes of 500mm wide as per IRC 35-2015 specifications. All kerbs to be mounted by pedestrian shall never be more than 50 mm and shall be user friendly facilitating wheel chair usage by the disabled at urban locations

- Continuity: Continuous footpath without any obstructions such as trees, electric posts, shops, etc., should be ensured to encourage the pedestrians to use it instead of using the carriageway. This will help in reducing the vehicular pedestrian conflicts common at the black spot locations.

- Pedestrian Crossing: According to IRC: 70-2017 and IRC: 35-2015, pedestrian crossing will be constructed as raised crosswalks, or painted zebra crossings.

- They shall be provided with clear markings and proper signs at important intersections and is essential where substantial conflict exists between vehicular and pedestrian movements such as locations where considerable pedestrian traffic accumulates, at mid-blocks and schools. The success of the pedestrian crossings depends on where and how they are marked. Site should be selected such that the pedestrians are subjected to minimum inconvenience and pedestrian would have enough visibility to see the oncoming vehicles and at the same time, the vehicular traffic is not interrupted very often.

- As per IRC: 70-2017, pedestrian crossing will be located at every 80-250 m in residential areas and every 80-150 m in commercial and mixed-use area.

- At intersections, the pedestrian crossings should invariably be preceded by a stop line. At an unsignalized pedestrian crossing, the stop line shall be set back 2 m to 3 m from the start of zebra crossing marking. In a signalised intersection, zebra crossing shall be 1 m ahead of primary signal and stop line shall be placed another 1 m ahead of the start of zebra crossing.

- If pedestrian crossing length is more than 10.5 m in one go, there shall be Refuge Island in between of at least 1.2 m width to serve as shelter place with sufficient space to wait.

- Width of the pedestrian crossing is governed by the pedestrian volume crossing and by local requirements, but in no case should it be less than the width of footpath subject to minimum of 2.0 m. The width of the crossing generally lies between 2 m to 4 m.

- Pedestrian crossing in priority control T-intersection is given in Figure 101. Pedestrian crossing midblock is shown in Figure 102. The raised median and triangular island shall be depressed so as to make it comfortable for pedestrians and even for wheel chairs. Road marking to be provided in vulnerable road section like schools is shown in Figure 103.

Figure 101: Pedestrian crossing marking on priority junction

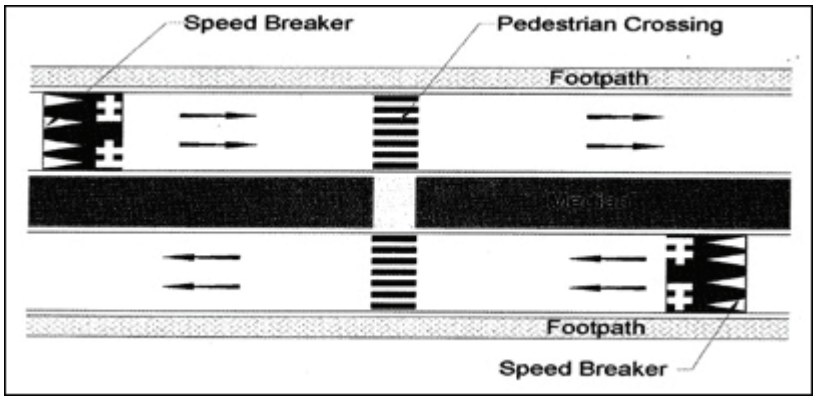


Figure 102: Pedestrian crossing marking at mid-block

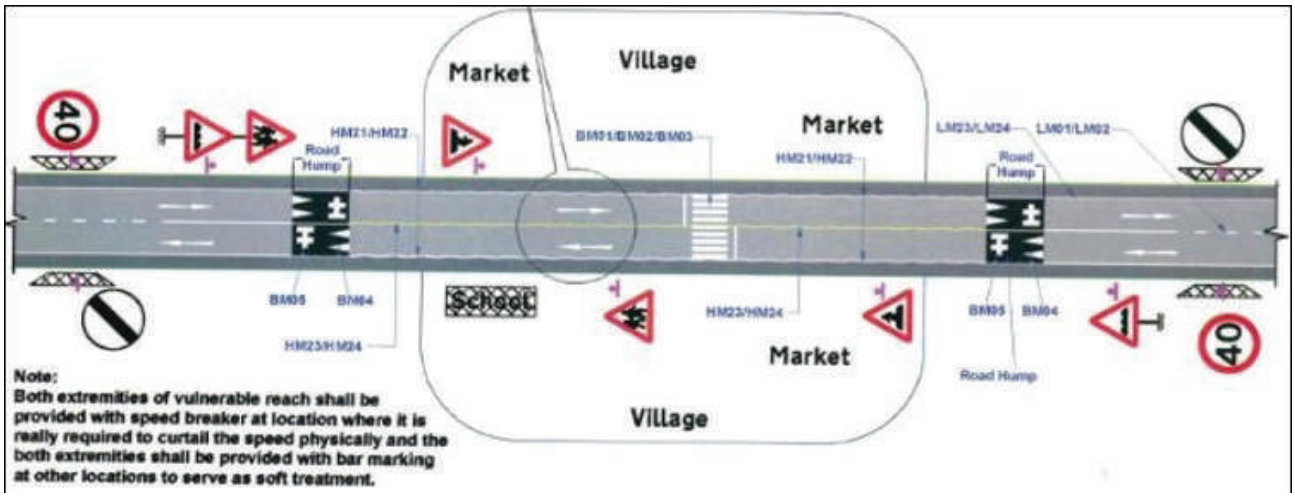
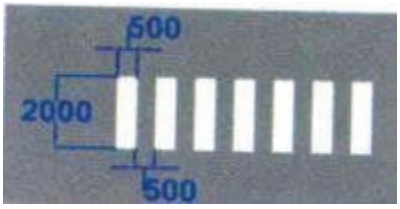
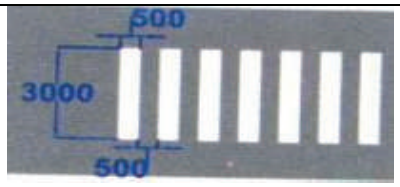
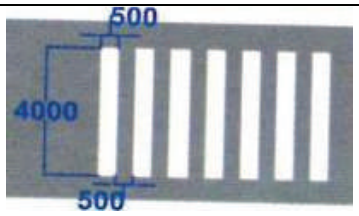
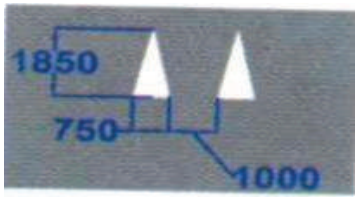
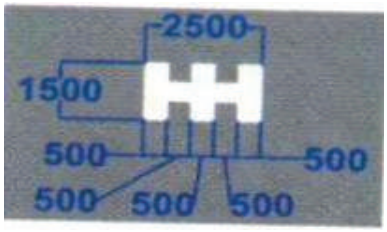


Figure 103: Special treatment to be applied near vulnerable road sections like schools

- **The size of the block markings is given in Table 37.**

Mark Abbreviation	Type	Dimension in (mm)		Gap in between	Colour	Pattern
		Length	Breadth			
BM01	Rectangular Block	2000	500	500	White	
BM02		3000				
BM03		4000				
BM04	Triangular Block	750	1850	1000	White	
BM05	Chequer Block	500	500	500	White	

- Raised Pedestrian Crossing (Speed Table): According to IRC: 99-2018, in a road section having substantial pedestrian crossing, raised pedestrian crossing called speed table is a solution, where vertical deflection can be achieved to reduce traffic speed and flat-topped portion for pedestrian to cross. The raised crossing extends the full width of the carriageway between the kerbs and extends over a longer length of road than humps. In a corridor having considerable buses, the length of the speed table should be sufficient to accommodate the full wheelbase of the bus to reduce passenger discomfort to a minimum. See Figure 104.

- According to IRC: 103-2012, raised crossings, where the car lanes are raised by ramps of slope (1:10) and brought to the level of the footpath (+150 mm from carriageway). The pavers on the footpath should continue over the raised crossings with vehicle load taken into account for the area subjected to vehicular traffic. Raised table top crossings may also be introduced and shall invariably be provided at slip roads with a minimum 20-second pedestrian signal to allow pedestrian and cyclists to cross the road safely and comfortably at the same level.

- At grade pedestrian crossing both near intersection and mid-block, raised pedestrian crossing (table top) should be made mandatory in case of multilane roads with heavy volume of vehicular traffic. Raised Crossings for pedestrian footpath across property entrances, petrol pump entrances, minor roads. service lane access and un-signalized intersections should be provided.

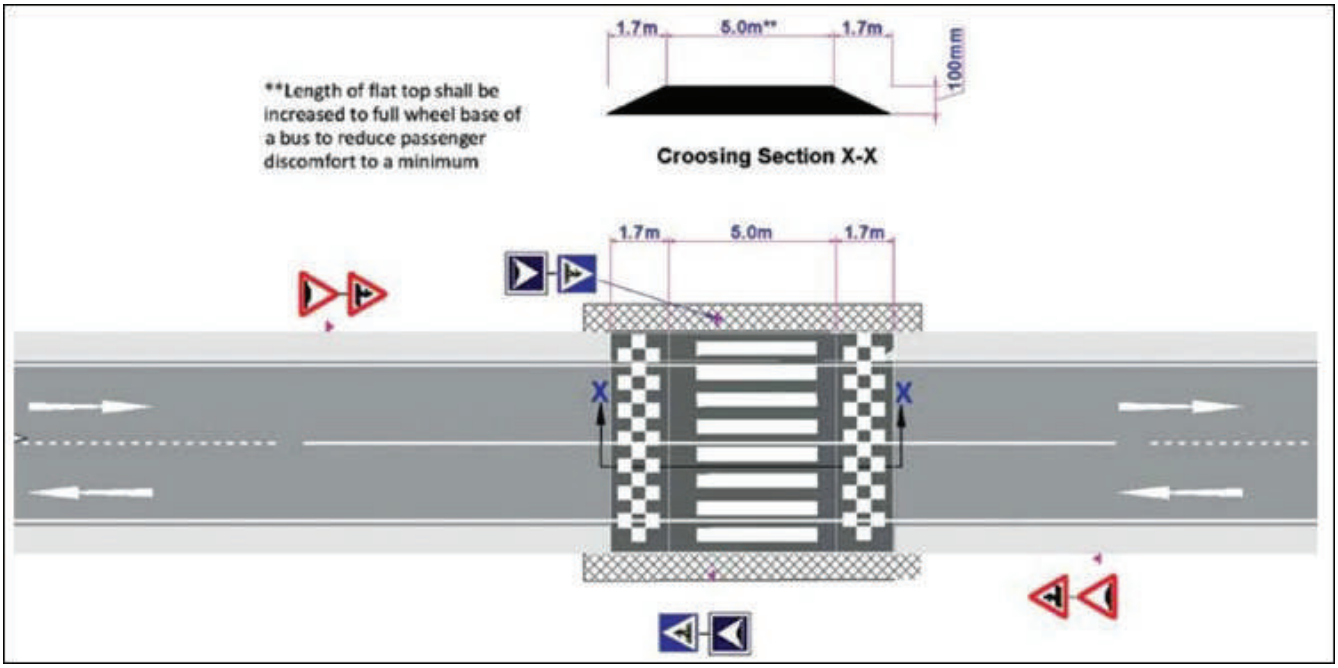


Figure 104: Geometric Details of Speed Table/Raised Pedestrian Crossing as per IRC: 99-2018

- At un-signalised crossings, raised crosswalks shall be constructed. Raised crosswalks shall have a minimum width of 3 m, elevated to the level of the adjacent footpath, with ramps for motor vehicles with a slope of 1:8.

- Innovative 3–Dimensional zebra crossings (Figure 105) can be provided in order to improve the safety of the road users.

Figure 105: 3-Dimensional zebra crossings

- The pedestrian crossings can be uncontrolled type where the pedestrian cross-walk is marked by studs or paints but not controlled by any system of signals. Flashing beacons may, however, be provided at uncontrolled pedestrian crossings where there is sporadic appearance of pedestrians and high speed of vehicles. Controlled pedestrian cross-walks are those where the passage of pedestrians and vehicles conflicting with each other is regulated by traffic signals.

- Depending upon the conditions, the signals can be actuated either by means of pedestrian detectors or by pedestrian push buttons. Pedestrian crossings such as pelican crossing, puffin crossing, toucan crossing, etc., can be implemented to serve the similar purpose.

- Pelican Crossing: This crossing is activated when a pedestrian presses a button. The traffic lights will then change from green to amber and then to red. After a period of time, the traffic lights will then change to a flashing amber light (meaning that you can drive on as long as the pedestrians are no longer on the crossing) and then green. Give way to any pedestrians that are still on the crossing even if you have a green light. This applies to all pedestrian crossings. A Pelican crossing is the only crossing which has a flashing amber light as part of its sequence. If a pedestrian is waiting at the crossing and it looks as though they've pressed the button then you can anticipate that the traffic lights may change soon. Pelican crossings (Figure 106) may be in a straight line or staggered. If the pelican crossing goes straight across the road, then you would treat it as one crossing even if it has a central refuge. If the crossing is staggered and not in line then the crossings are treated as separate.

Figure 106: Pelican Crossing

- Puffin Crossing: Unlike the older pelican crossing designs, where the pedestrian signal lights are mounted on the opposite side of the road, the puffin crossing has them mounted at the near road side, set diagonally to the road edge. This allows the pedestrian to monitor passing traffic while waiting for the signal to cross. A second reason for the design is that having the lights closer to the user assists visually impaired people who could have difficulty viewing the signal from across the carriageway. See Figure 107. After a request to cross (by button press), a kerb side detector monitors the pedestrian's presence at the crossing. Should the pedestrian cross prematurely, walk away from the crossing, or wait outside the detection area, the pedestrian's request to cross could be automatically cancelled. This is so traffic is not halted unnecessarily. An on-crossing detector ensures that the signal for vehicles remains red until pedestrians have finished crossing (within practical limits). Unlike the pelican crossing, there is no transitional "flashing" phase.

Figure 107: Puffin Crossing

Long Term Recommendations:

- According to IRC: 70-2017, the provision of sub-ways or foot over bridges for the exclusive use of pedestrians may be thought of for exceptional locations where the pedestrian volume crossing a wide carriageway is extremely large and cannot be regulated by other traffic control measures without causing undue delay both to the pedestrians and the vehicular traffic.

- According to IRC: 70-2017, grade separated facilities such as foot over bridges, subways and skywalks are often unsafe and inaccessible and inconvenient to many users. They are also unsafe with regard to sexual assaults and general crime, and often double as urinals. Hence, the facility, if provided shall be well-lighted, ventilated and equipped with Surveillance cameras to ensure safety.

- As pedestrian bridges and sub-ways are usually fairly short and are intended solely for movements a higher capacity than of ordinary side-walks is recommended.

- The recommended capacity is not more than 50 persons per minute per m on the level and 35 persons per minute per m on stairs or ramps.

- According to Institute of Urban Transport, Code of Practice (Part 1) the ideal situation on urban roads is one where the pedestrian does not have to change level. In case a level change needs to be accommodated and the area permits, a half subway or foot-over bridges can be considered (Figure 108). This would help the pedestrian cross the road safely without having to interact with the vehicles on roads with heavy traffic.

Figure 108: Pedestrian underpass and foot over bridges

- In half subways, both the car lane users and the pedestrians (including cyclists, wherever segregated facility is provided) need to have a change in level. The car lanes are raised (+1.5m) using a ramp of 1:30 and the pedestrian paths (cycle tracks, wherever provided) are lowered using ramps of slope 1:20 with landing at appropriate intervals to equally achieve a clear minimum height of 2.75m. (-1.5m). The advantage of such subways is that the walking length of a pedestrian is not increased to the extent that it discourages him from using it.

- The approaches to footbridges and underpasses should comprise ramps / elevator, steps and handrails, except that in the underpass situation, the widths should be as generous as possible to provide an open aspect.

- A slope of 8% (1 in 12) on footbridge ramps, where a slope of 5% (1 in 20) with appropriate resting places, is preferable.

- Within the underpass, a handrail set at 850mm - 900mm above the walking surface should be provided.

- To assist visually impaired people, warning tiles and, if possible, a colour contrast should be provided at the top and bottom of every flight of steps.

- The top and bottom steps should be brightly coloured and these areas should be well lit.

- Elevator/lift should be provided on both the entrances/exits and should have minimum internal dimensions of 1400mm x 1400mm.

- As per IRC: SP: 84-2014, the pedestrian crossings (PUP/FOB) shall have provision for movement of physically challenged persons. Pedestrian underpass / Foot over Bridge (FOB) shall also be provided within a distance of 200 m from a school.

B. Behavioural risk factors vis-à-vis interventions

- A continuous, well-maintained footpath with no interruptions and free of parked vehicles encourages the pedestrians to utilize it, thereby reducing the pedestrian conflicts with vehicular traffic.

- Well announced crossings like raised pedestrian crossing and 3–dimensional zebra crossings, etc., are effective in attracting the driver's attention which in turn results in them reducing their speed at locations with high pedestrian traffic.

C. Traffic management & enforcement interventions

- Stopping or parking of vehicles on the pedestrian crossing marking should be monitored and strictly enforced by the traffic police so as to prevent the pedestrians crossing the road elsewhere.

- Parking of vehicles on the footpath should also be monitored and the violators should be strictly penalized by the traffic police at the black spots.

5.6. ON-STREET PARKING

Private cars and two wheelers occupy most of the street space, yet they serve less than a third of all trips. It's widely known that private vehicles are voracious consumers of space as they require a parking spot at each leg of a journey- at home, at the market, and at the office. Streets are crowded with parked vehicles that block traffic and turn sidewalks into obstacle courses for pedestrians. Furthermore, it is difficult to know whether it's a footpath that the vehicle is parked on or if it's the street because parking itself is not clearly delineated.

Many public agencies push for more parking in buildings, confident that this will fix the problem. Paradoxically, more parking invites more car use, contributing to traffic jams, toxic air, and miserable urban life. While large sums of public funds are spent creating multi-level parking and flyovers, facilities for walking, cycling, and public transport continue to languish. The answer to the parking problem is not creating more parking but to manage the parking that's available in a much better fashion. The efficiency can be maximised by how we manage our parking and simultaneously start investing in other modes, like better walking and cycling environments, better public transportation, so that people also have better alternatives. As a result of weak on-street parking management, many of Delhi's off-street "pay-and-park" garages sit largely empty. Unless the on-street parking is managed, all of the extra off-street parking is under-utilized and wasted.

A. Engineering interventions

Short Term Recommendations:

- Parking configuration: According to IRC: 70-2017, parallel parking configuration, where vehicles are parked parallel to the kerb must be preferred over angular and perpendicular parking configurations for all vehicles including motor cars, LCVs, buses and trucks.
- Parking should not be allowed within 5 m before and after the crosswalk and bus stops.
- Parking slots: Parking slots must be defined through physical means such as kerbs, paving and road markings.
- Parking markings and signs: Parking zones should be demarcated with its own parking rates, rules, and transport improvement plan. Within each zone, parking and no-parking areas should be defined on streets through physical design, signage, and road markings.
- Parking can be restricted near institutions and schools to reduce the congestion during peak hours. As per IRC 35-2015, the stretch in which parking is to be restricted has to be delineated with yellow kerb painting coupled with the provision of the yellow edge line. Restrictions like Keep Clear markings (Figure 109) can be effective on road stretches located in front of the institutions by providing zig-zag marking and this may be further supplemented by painting the kerb using yellow colour marking for the length intended to be kept clear of traffic along with proper signs to complement the road markings.

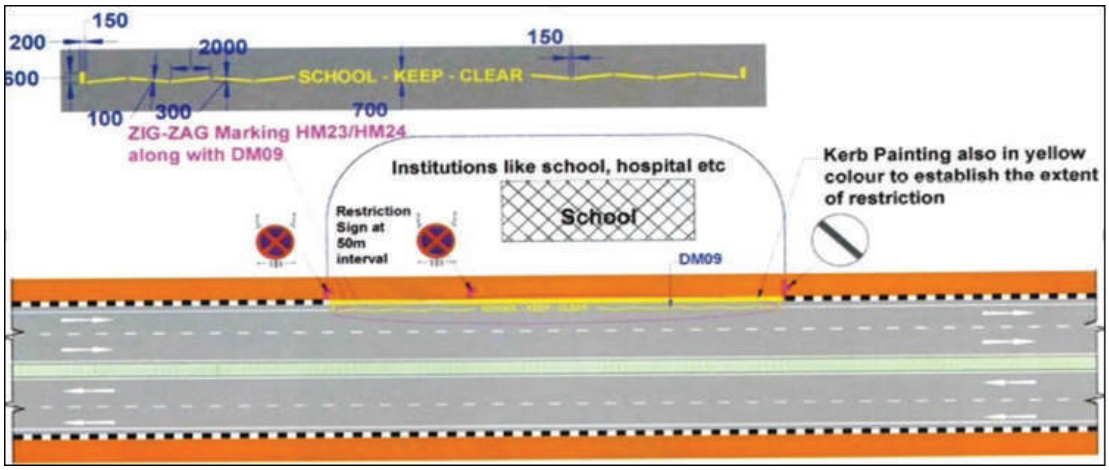


Figure 109: "Keep clear" markings

- A stretch of road in which parking is prohibited for certain hours can be distinguished with yellow single solid edge (Figure 110) with the sign board specifying the time restriction.

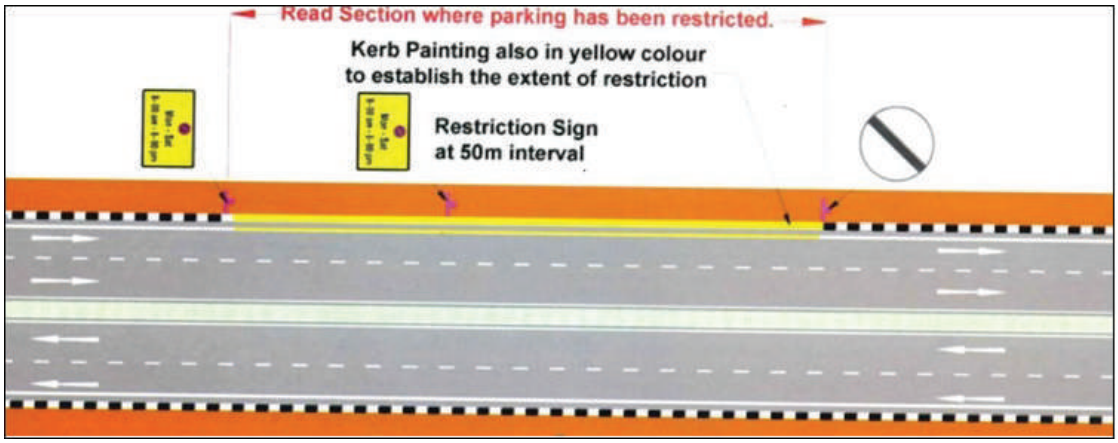
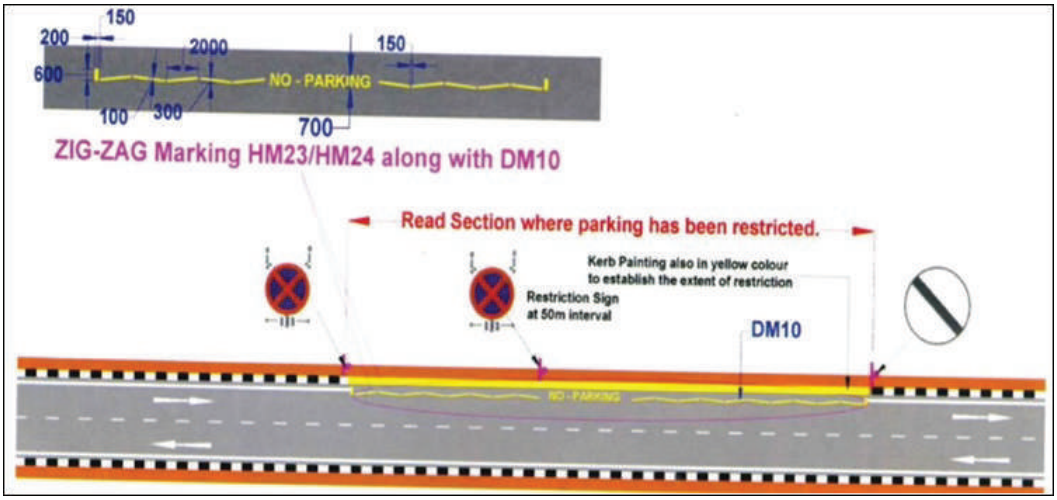


Figure 110: No-Parking for certain hours

- A stretch in which parking or waiting is prohibited at all times has to be distinguished by providing yellow double solid edge as shown in Figure 111 with the restriction signboard installed.

Figure 111: No Parking

- In order to make the 'No-Parking' or 'No-Waiting' for stricter compliance, lest the lane would be blocked leading to a chaotic situation shall be delineated with zig-zag marking as shown in Figure 112 with the restriction signboard installed



Long Term Recommendations:

- The feasibility of installing a prefabricated automated multi-level car or two-wheeler parking can be considered as shown in Figure 113. This can be considered in commercial areas and public spaces with demand for vehicle parking. Prefabricated facility such as these help to reduce the parking crisis to an extent with an efficient on-street parking management.

Figure 113: Prefabricated automated multi-level parking

B. Behavioral risk factors vis-à-vis interventions

- The parking signs and markings coupled with an efficient on-street parking management guide the drivers to utilize the available parking slots effectively. This will reduce the haphazard parking of vehicles on the footpath leaving it accessible to the pedestrians which in turn will minimize the pedestrian vehicular conflicts.

- Presence of on-street parking is found to slow speeds because drivers perceive a potentially more hazardous driving environment. The speed is affected due to the narrowing of the carriageway, which may reduce the amount of usable road space in which a vehicle can travel.

C. Traffic management & enforcement interventions

- **Parking management:** ITDP India had worked with Pune, Chennai and Ranchi to improve their on-street parking management. According to them, a parking policy is needed to ensure that the frustration and hassle of parking is addressed sustainably and efficiently. Different ways to aid in parking management suggested by ITDP India has been discussed below.

- **Use parking fees to manage demand:** Free parking is often overused and mishandled. Charging an appropriate parking fees helps the business by increasing the turnover and make it easier for customers to find spaces close to where they want to go. Charges should be fixed according to the size of the vehicle. The price of parking influences user choice. When demand is high, the price should be increased so that people who have the highest willingness to pay are able to find vacant slots.

- **Use parking fees to pay for better facilities:** Revenue from parking fees can help fund street improvements such as footpath maintenance, tree planting, benches, and trash collection. The fee revenue can also be used to build cycle tracks or provide better public transport service. Visible improvements provide assurance that parking fee revenue is being put to good use.

- **Enforcement officers:** Enforce parking rules in both parking and no parking areas through random spot checks by enforcement officers. The defaulters in the no parking zones should be fined to ensure that no unauthorised parking occurs. Dedicated parking wardens under the control of local government can be used alternatively to Police-based enforcement if they are indisposed or disinclined.

- **Information technology backed parking management system:** A mobile phone-based payment system can be developed to enable quick and hassle-free payment of parking fees. Information about parking policies, benefits of parking management, new parking regulations, and system features can be disseminated through customer-oriented parking systems. Real-time information can be provided to customers through various media, including the internet, smart phone apps, and on-street signage.

- **Complete prohibition of parking** for any type of vehicle near the intersections, bus stops and areas with high traffic congestion or prohibition of parking for a period exceeding 30 minutes during peak hours can help in improving safety and reducing congestion.

- Separate one-sided paid parking lanes can be imposed wherever possible with a minimum width of 2.5 m to prevent haphazard parking.

- **Case studies of parking management by ITDP India Pune:**
  The Pune Municipal Corporation heralded a new era of travel demand management by regulating on-street parking. The city's elected body decided that the only way to get better value from Off-street parking is to manage the On-street parking. In 2018, the city adopted the Pune Parking Policy that introduces a fee for on-street parking based on demand levels (demand-based parking price setting), as well as better enforcement techniques such as IT- based parking management that eliminate the need for cash collection, thereby reducing revenue leakage. ITDP India had been urging Shop-style demand responsive price setting, so that whenever the demand for parking increases beyond a certain level (eighty-five to ninety percent occupancy during peak hours) then the price should go up. According to the policy, parking rates will be determined across the city for both on-street and off-street parking, depending on location, time and type of vehicles. Pune's parking policy has determined parking fees based on vehicle dimensions, parking demand at particular locations, time (peak or off-peak hours), and occupancy to enable a fair fee structure. The Policy aims to be proactive in ensuring that parking information is available to commuters through various means (such as real time digital displays, smartphone apps etc.) to reduce redundant trips for hunting parking spaces. In a move to promote cycling as an affordable and sustainable mode of transport, the policy exempts bicycle parking from any charge. Exemptions are also extended to daytime ambulances, special-aid vehicles and paratransit parked in designated lots.

- Chennai:
  The parking management system in Chennai utilises technology for information, payment and enforcement. ITDP India had been working with Chennai to avoid the trust problems associated with parking attendants collecting cash (the usual approach in India). So, Chennai is adopting a modern mobile-based payment system where the people register themselves with the parking management system. They have an account and as and when they park at a certain location, either through an automated process or through a couple of very simple steps on their mobile phone, they can start and stop the virtual parking meter, and make payment for that through their account.

  Demand-based parking fees combined with strong enforcement will ensure that cars are not irresponsibly parked in front of residence gates or on footpaths. This will also help shoppers find parking spots more conveniently through their phones. saving time. and fuel. The abutting streets are being redesigned to accommodate parking in an efficient manner and monitored through the Parking Management System. Off Street parking spaces have also been provided to accommodate the parking needs. The management plan includes starting a citywide parking management system, covering around 12,000 parking slots across the city with parking fees of between 20 to 40 rupees per hour for cars and 5 to 10 rupees for motorcycles.

Another important innovation in the management plan is the approach to the parking management contract. Most Indian parking fee contracts are simply a matter of the city renting public space to private contractors in return for allowing them to collect fees. But Chennai is focused on parking management and the contract says that the operator will be paid per parking slot per hour at a fixed rate in return for their management services, including fee collection. The revenue will go directly to the city not the parking operator which is then used to pay the operator as well as for public transport improvements and better walking and cycle infrastructure.

Chennai, Pune, Ranchi, etc., have been thinking of setting up an Urban Transport Fund into which they would put the money - the revenue generated from parking surplus - or the revenue surplus from parking management. And utilise that towards better implementation of walking and cycling infrastructure and public transportation. In other cities, traditionally the money just goes into a central account of the Municipal Corporation and then just gets spent in any direction.

5.7. SAFETY AT METRO CONSTRUCTION ZONES

A. Engineering interventions

- Proper temporary traffic control devices should be placed to give advanced warning to road users. The advanced warning zone should alert drivers that the traffic patterns and conditions will change and that they should take extra caution and reduce speeds. Devices placed there should be visible during day and night.

- The presence of the construction work and road testing should be alerted through relevant signages of retro-reflective sheet of high intensity grade such as the "Road Work Ahead" sign, accompanied by the distance to the work zone. The reduction in the number of lanes and the reduced speed limit within the traffic control zones, the length of restriction can be provided for general information.

- Delineators like safety cones, traffic cylinders, tapes, drums, painted lines, raised pavement markers, guide posts, and post-mounted reflectors etc., should be installed to outline the roadway or portion thereof. Delineators are basically driving aids and should not be regarded as a substitute for warning signs or barriers for out-of-control vehicles. All delineators must conform to IRC 79-1981.

- Proper lighting arrangements for illuminating the signs should be made during the night hours. Most of the crashes at nights involve collision between vehicles and objects rather than vehicle to vehicle collision. Reflective paints/sheets will therefore be used for the signs/barricaded so that these are visible at all times. Lighting devices such as floodlights, flashing warning beacons, warning lights, and steady-burn electric lamps can be used to supplement retro- reflectorized signs, barriers, and channelizing devices. During normal daytime maintenance operations, the functions of flashing warning beacons may be provided by high-intensity rotating, flashing, oscillating, or strobe lights on a maintenance vehicle. A temporary but mandatory speed limit, lower than the existing speed limit on the approaches and through the working zone can be introduced as only one lane is available for traffic. Rumble Strips can also be installed on the main carriageway while approaching the work zone complemented by adequate warning signs.

- All the workers, exposed to moving roadway traffic or equipment in road construction zones shall wear high-visibility safety apparel, headgear, boots, gloves and protective gears for their protection. The safety headgear or protective helmet shall protect the wearer against falling objects and possible serious injury. It shall address requirements of shock absorption, and having resistance to penetration, flame resistance, chin strap anchorages, comfortable wearing and shall meet the requirements of Bureau of Indian Standards (IS:2925).

- Signs, lights, barriers and other traffic control devices, as well as the riding surface of diversions shall be maintained in a satisfactory condition. The temporary diversion road shall be kept free of dust by frequent applications of water, if necessary. All the signs/barricades are to be maintained properly and kept clean of dust at all times. Sufficient stock of these will be maintained at the site so as to replace the damaged or vandalized signs/barricades.

B. Behavioural risk factors vis-à-vis interventions

- The temporary traffic control devices, signages, delineators and barricades all serve to caution the drivers of the construction activities and warn them to reduce their speed so as to prevent risky situations.

- Updated information regarding the locations with Metro construction should be broadcasted regularly through the media and news so as to keep the drivers and road users vigilant at the locations and to drive responsibly.

C. Traffic management & enforcement interventions

- The authority responsible should ensure that the traffic control devices are in place and that they are in good condition to keep the road users warned of the activities throughout the construction period.

- Traffic at the black spots with Metro construction should be brought under the control of the traffic police so as to reduce conflicts and congestion.

- Construction safety should be ensured to meet the standards with sufficient warning at all construction zones.

5.8. OTHER RECOMMENDATIONS

A. Engineering interventions

- Street lights can be provided to improve the visibility and safety on the roads during night time.

- Periodical maintenance of road signs, retro-reflective markings on the pavement as well as median edges, traffic calming measure, pedestrian facilities, pavement, etc. should be carried out religiously to provide the best level of service to the road users

B. Behavioural risk factors vis-à-vis interventions

- Improving the visibility at the locations will improve the decision-making capacity and the reaction time of the driver in risky situations

C. Traffic management & enforcement interventions

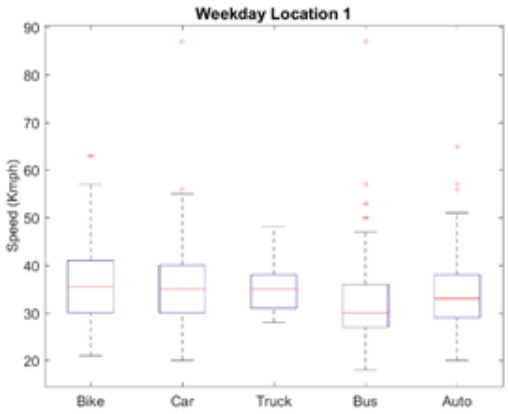
- Presence of traffic wardens at busy intersections and in front of schools during peak hours can help to control and regulate the traffic and safeguard pedestrians, the most vulnerable road users as per the crash analysis.

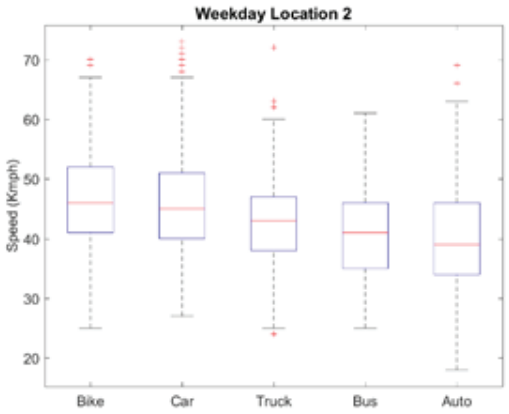
- The traffic rules and regulations should be properly enforced by penalizing the violator by the traffic police or other respective personnel to curb the negligent attitude of the road users. Systems using red light cameras or the "photo radar" can been used to capture the lawbreakers. Any vehicle crossing the sensors on red light triggers the camera and a photo is produced showing the car, licence plate, together with the date and time of the violation.

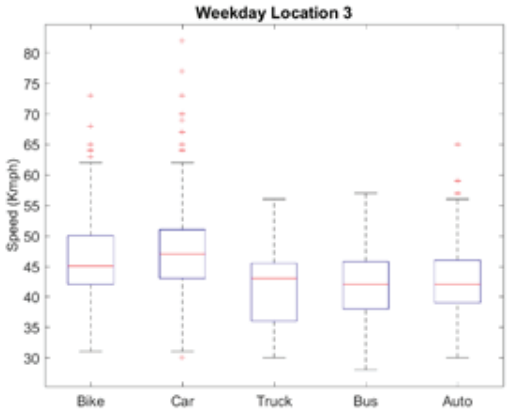
- Installing surveillance cameras at the intersections, near the school, etc., would be helpful in discouraging the road users from violating traffic rules.

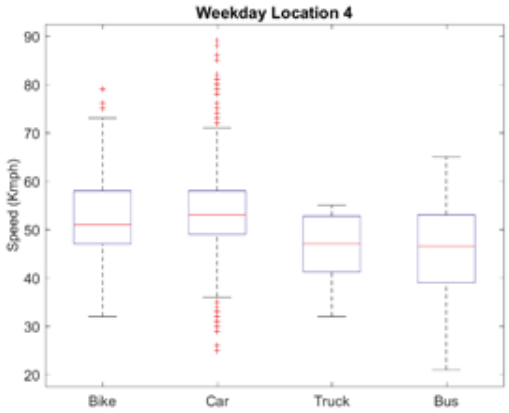
APPENDIX

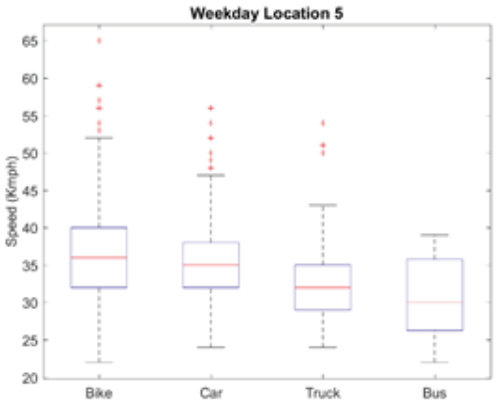
Weekday Speed Data Analysis – Box plots and Speed histograms

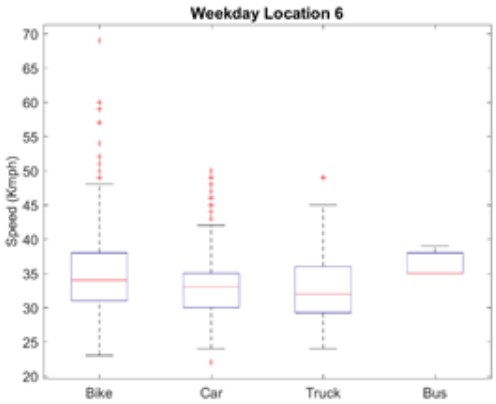


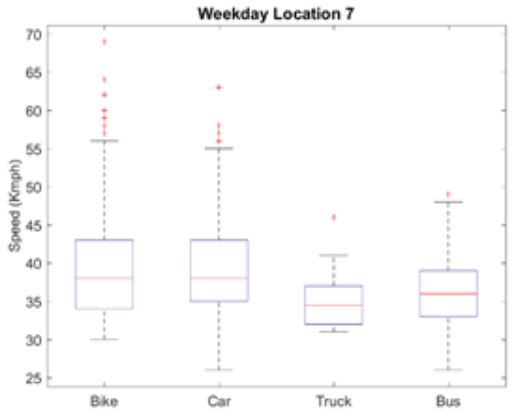


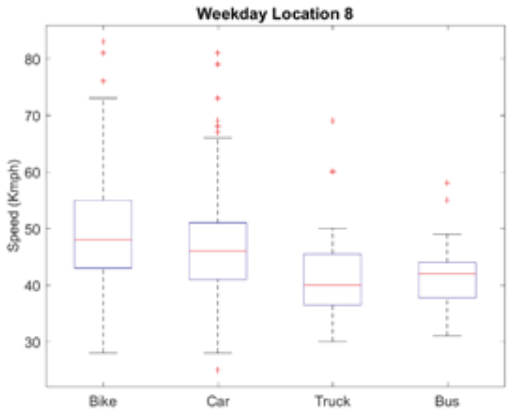


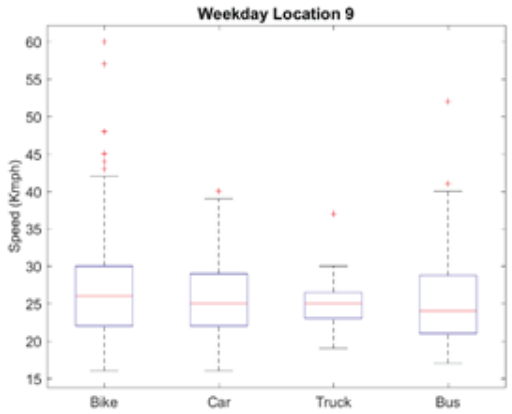


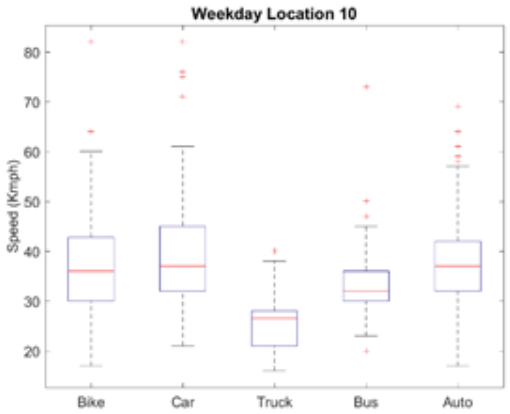


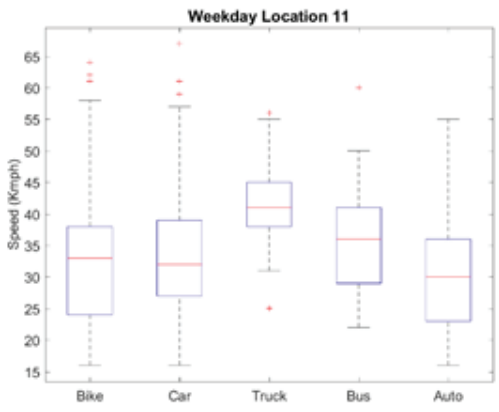


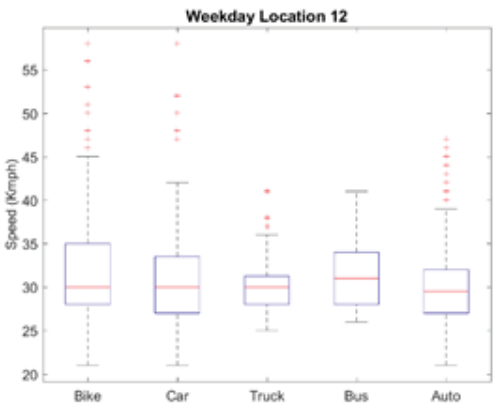

Weekday Location 7
Speed (Kmph)
70
65
60
55
50
45
40
35
30
25
Bike
Car
Truck
Bus

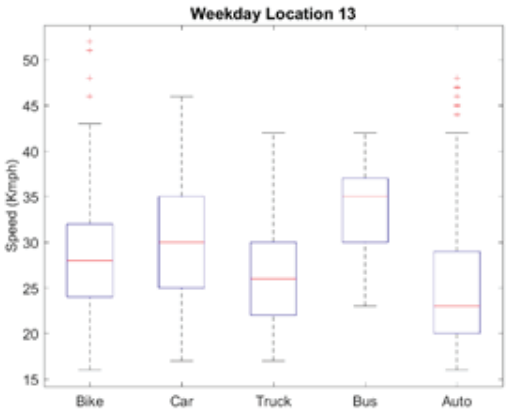

Weekday Location 8
Speed (Kmph)
80
70
60
50
40
30
Bike
Car
Truck
Bus

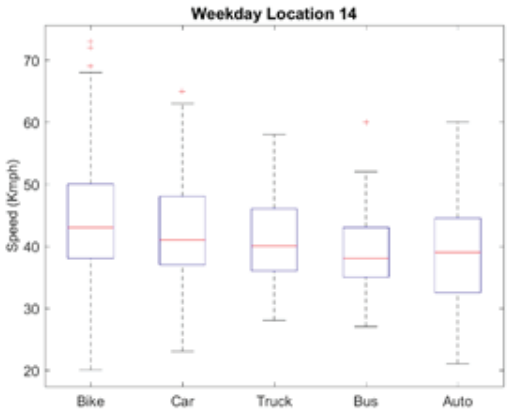

Weekday Location 9
Speed (Kmph)
60
55
50
45
40
35
30
25
20
15
Bike
Car
Truck
Bus

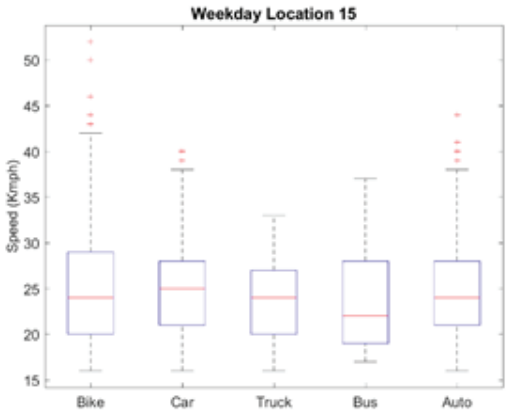

Weekday Location 10
Speed (Kmph)
80
70
60
50
40
30
20
Bike
Car
Truck
Bus
Auto

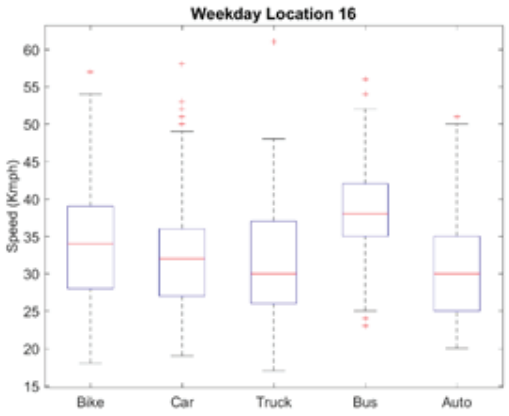

Weekday Location 11
Speed (Kmph)
65
60
55
50
45
40
35
30
25
20
15
Bike
Car
Truck
Bus
Auto

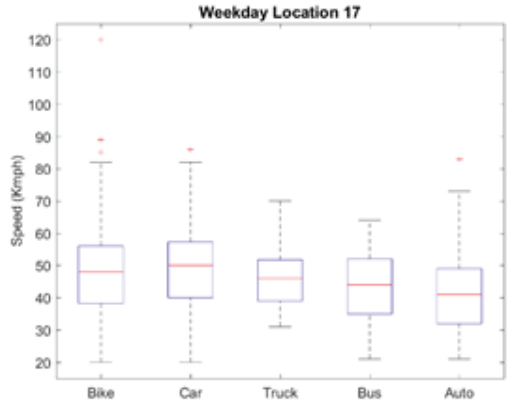

Weekday Location 12
Speed (Kmph)
55
50
45
40
35
30
25
20
Bike
Car
Truck
Bus
Auto

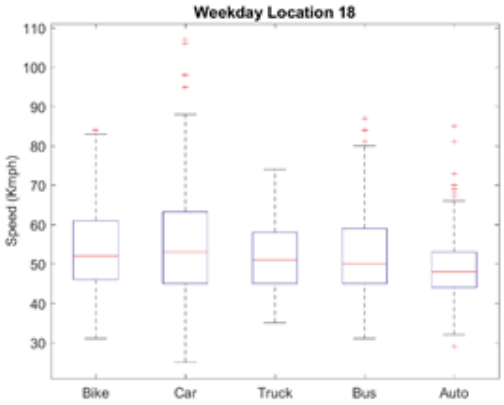

Weekday Location 13
Speed (Kmph)
50
45
40
35
30
25
20
15
Bike
Car
Truck
Bus
Auto

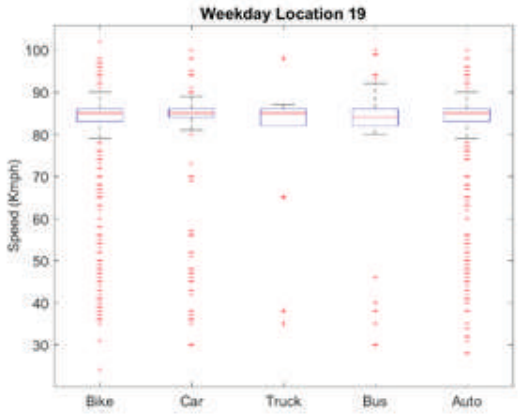

Weekday Location 14
Speed (Kmph)
70
60
50
40
30
20
Bike
Car
Truck
Bus
Auto

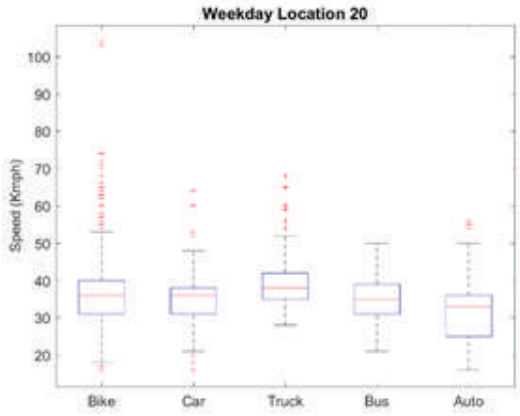

Weekday Location 15
Speed (Kmph)
50
45
40
35
30
25
20
15
Bike
Car
Truck
Bus
Auto

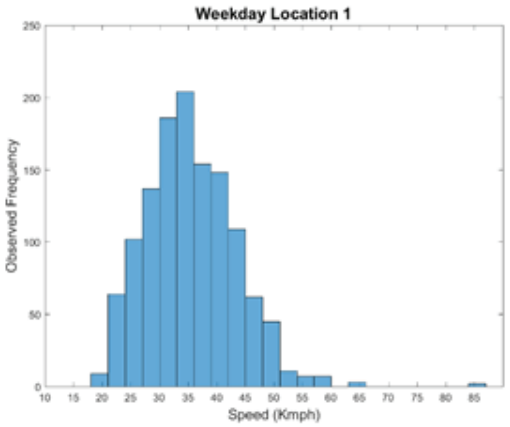

Weekday Location 16
Speed (Kmph)
60
55
50
45
40
35
30
25
20
15
Bike
Car
Truck
Bus
Auto

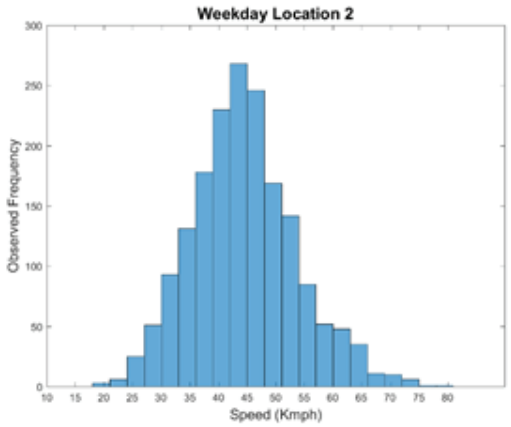

Weekday Location 17
Speed (Kmph)
120
110
100
90
80
70
60
50
40
30
20
Bike
Car
Truck
Bus
Auto

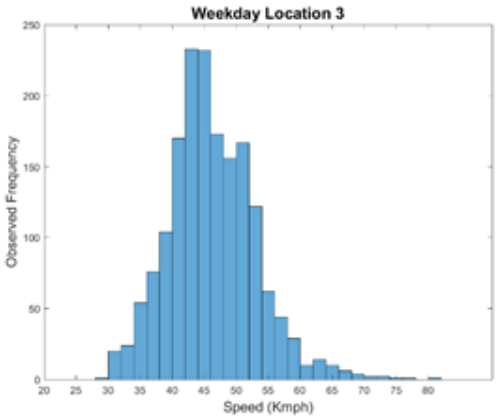

Weekday Location 18
Speed (Kmph)
110
100
90
80
70
60
50
40
30
Bike
Car
Truck
Bus
Auto

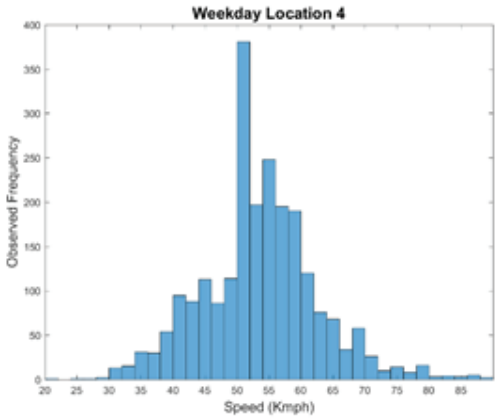

Weekday Location 19
Speed (Kmph)
Bike
Car
Truck
Bus
Auto

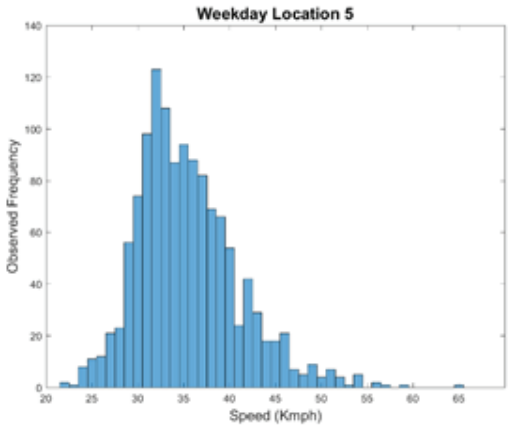

Weekday Location 20
Speed (Kmph)
Bike
Car
Truck
Bus
Auto

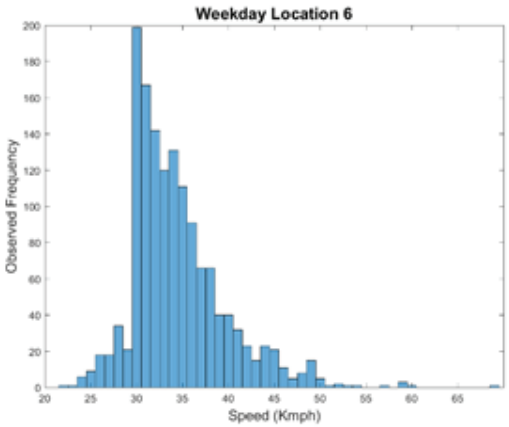

Weekday Location 1
Observed Frequency
Speed (Kmph)

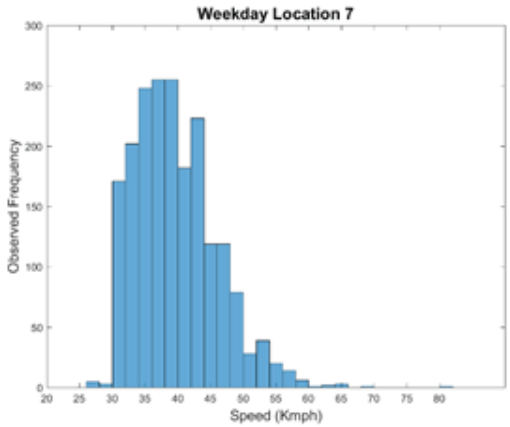

Weekday Location 2
Observed Frequency
Speed (Kmph)

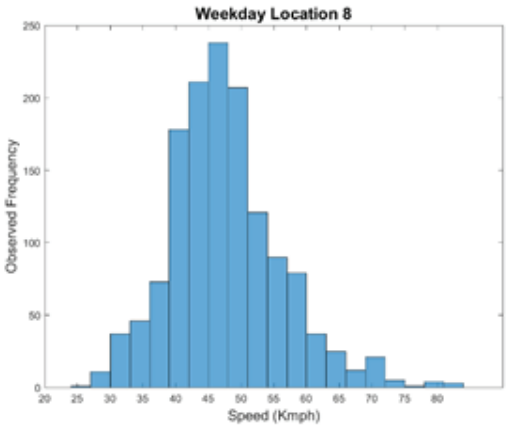

Weekday Location 3
Observed Frequency
Speed (Kmph)

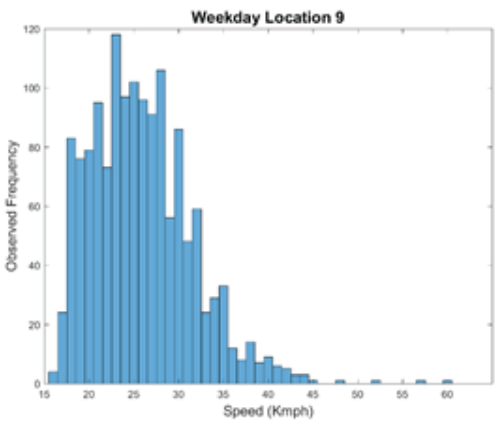

Weekday Location 4
Observed Frequency
Speed (Kmph)

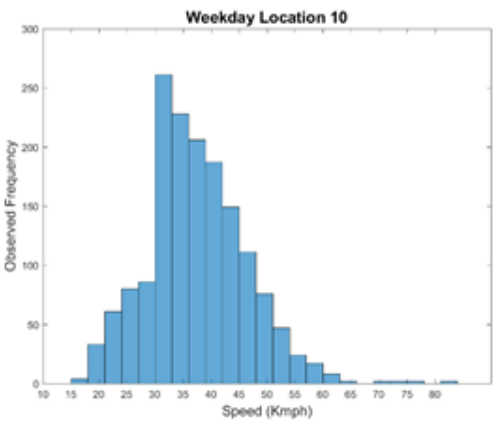

Weekday Location 5
Observed Frequency
Speed (Kmph)

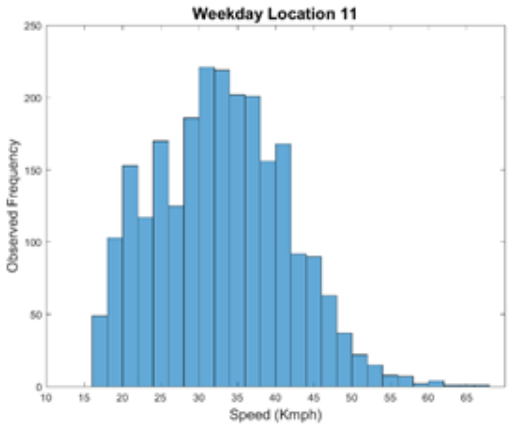

Weekday Location 6
Observed Frequency
Speed (Kmph)

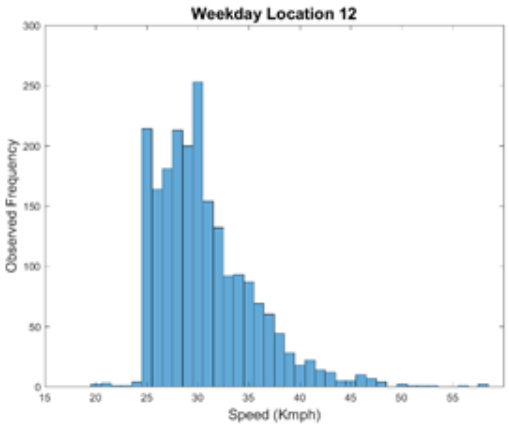

Weekday Location 7
Observed Frequency
Speed (Kmph)

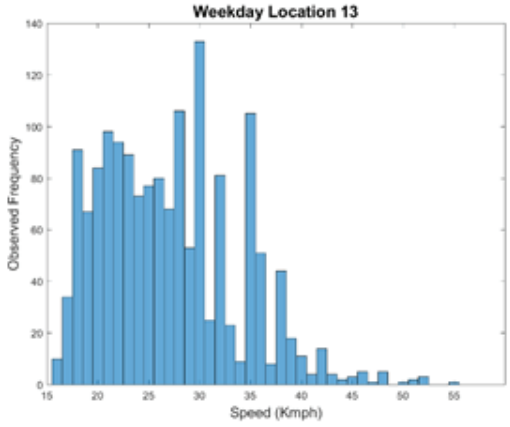

Weekday Location 8
Observed Frequency
Speed (Kmph)

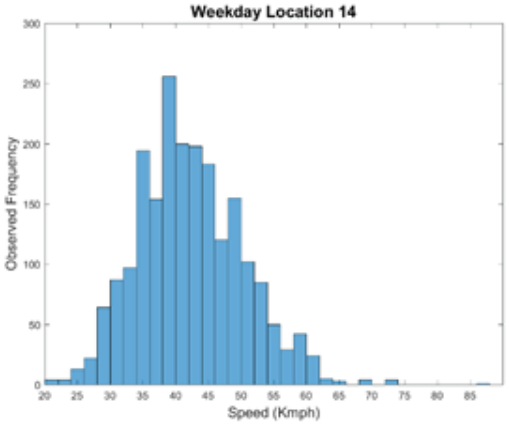

Weekday Location 9
Observed Frequency
Speed (Kmph)

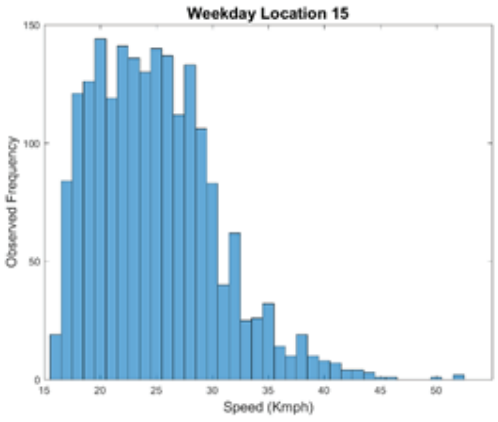

Weekday Location 10
Observed Frequency
Speed (Kmph)

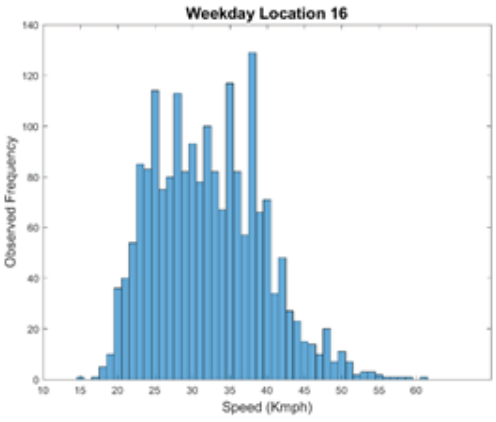

Weekday Location 11
Observed Frequency
Speed (Kmph)


Weekday Location 12
Observed Frequency
Speed (Kmph)


Weekday Location 13
Observed Frequency
Speed (Kmph)


Weekday Location 14
Observed Frequency
Speed (Kmph)


Weekday Location 15
Observed Frequency
Speed (Kmph)


Weekday Location 16
Observed Frequency
Speed (Kmph)

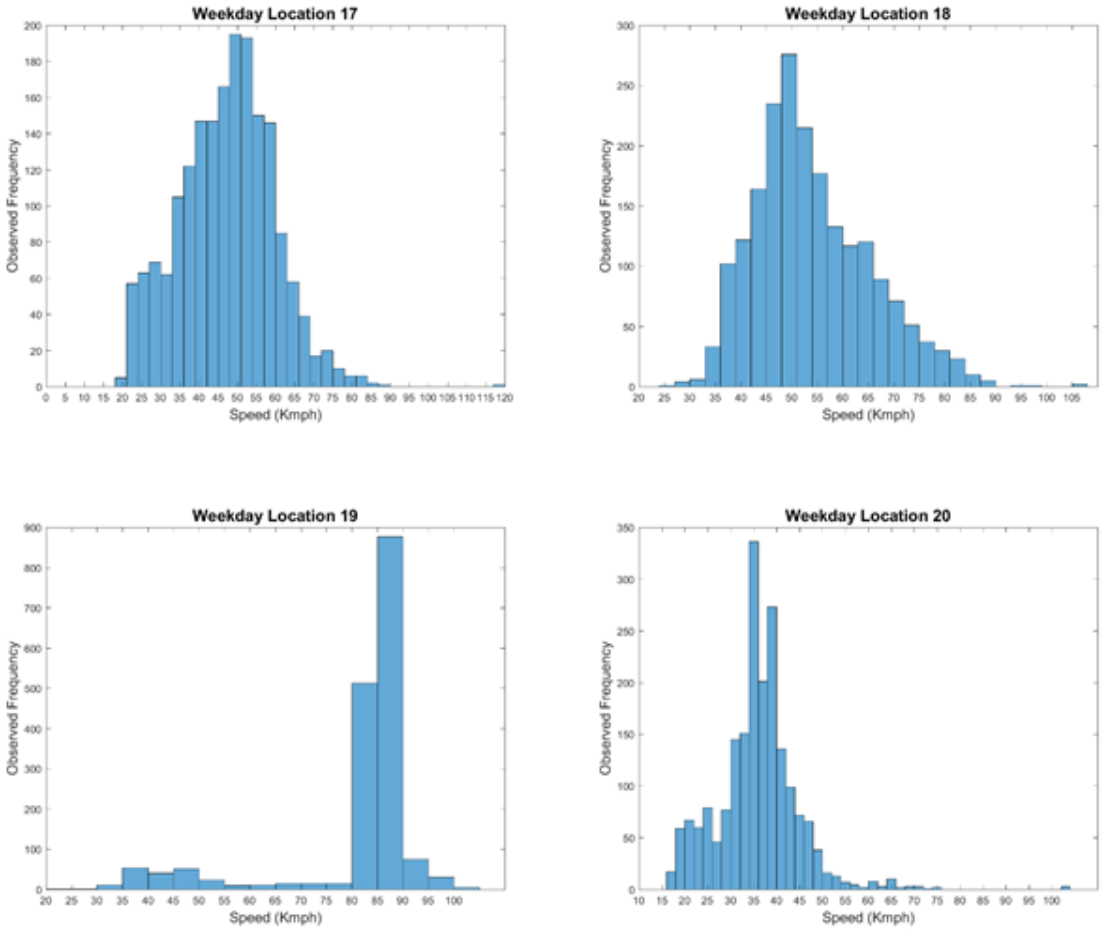
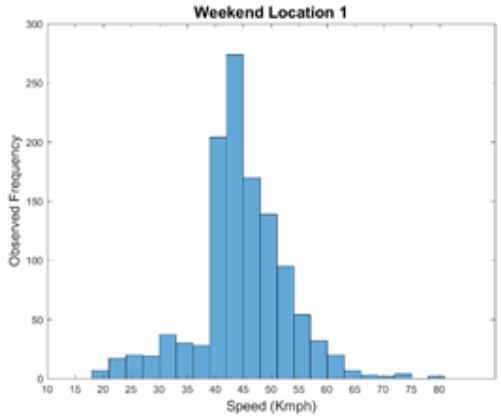
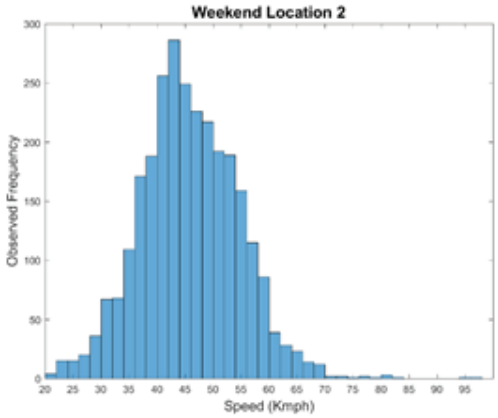
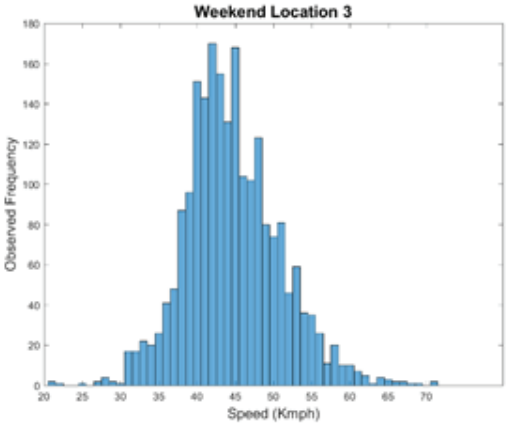


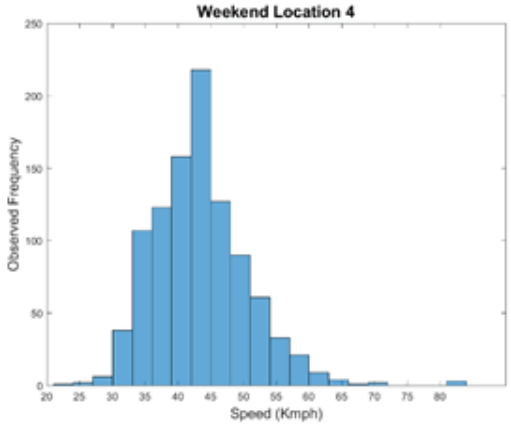
Figure 114: Box plots and speed histograms of the weekday speed data analysis for all the 20 locations

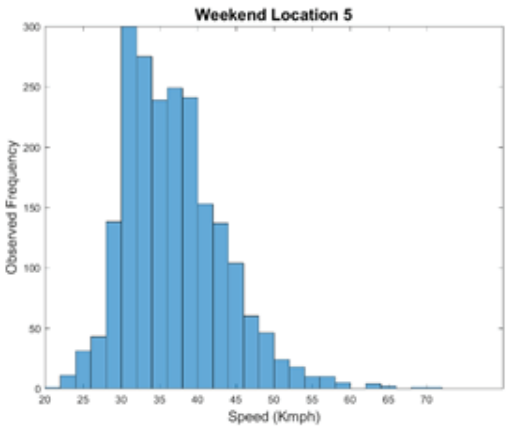
Weekend Speed data Analysis - Speed histograms and Box plots

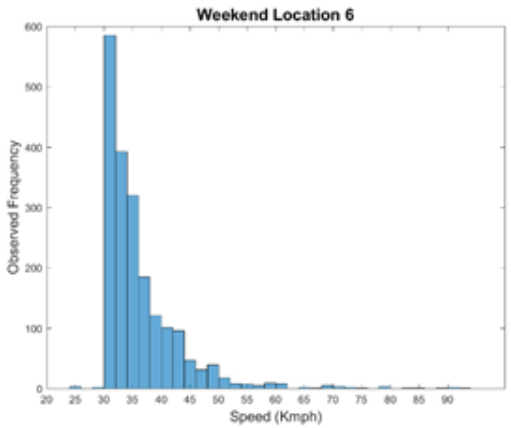


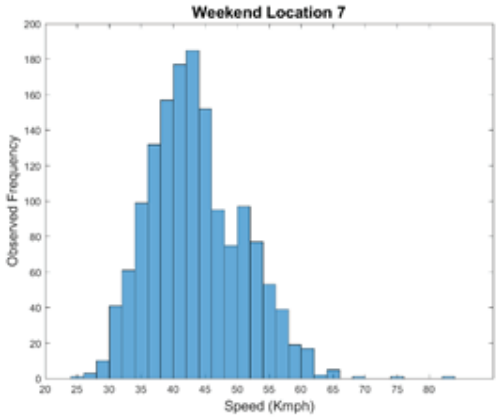


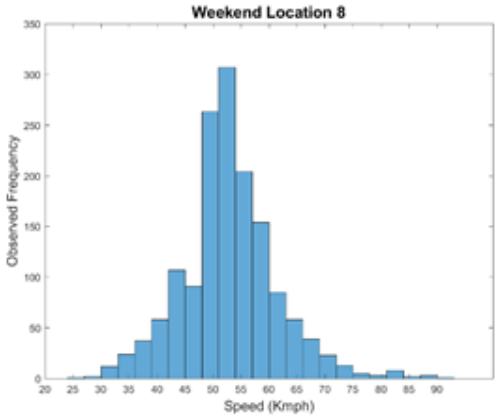


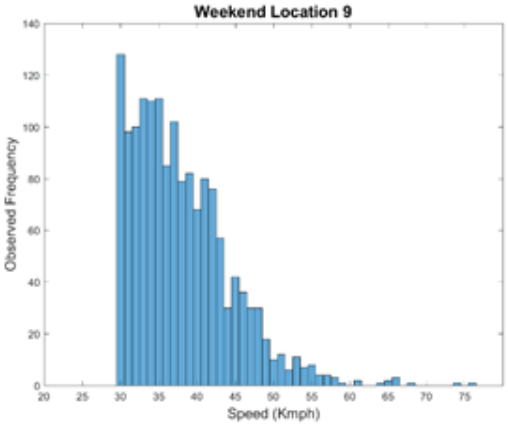


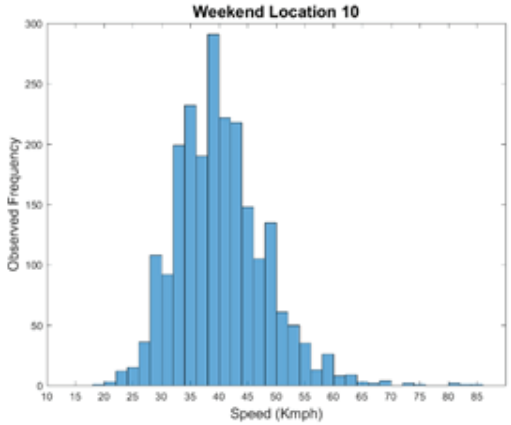


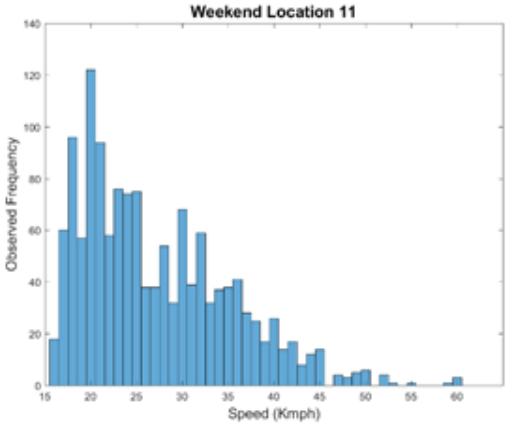


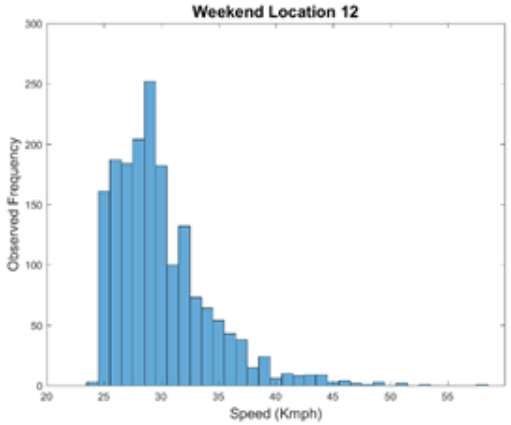

Weekend Location 7
Observed Frequency
Speed (Kmph)

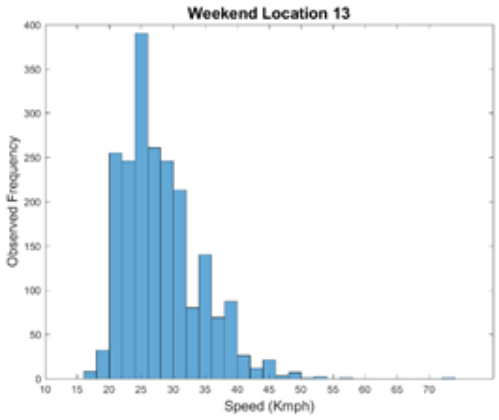

Weekend Location 8
Observed Frequency
Speed (Kmph)

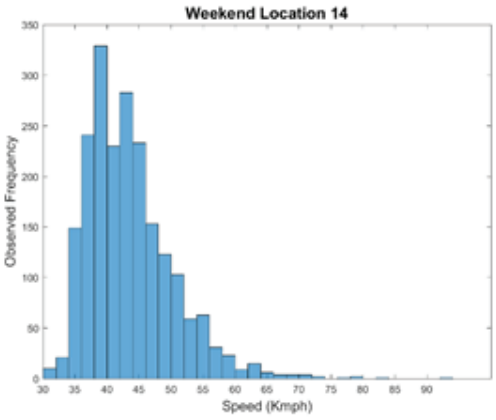

Weekend Location 9
Observed Frequency
Speed (Kmph)

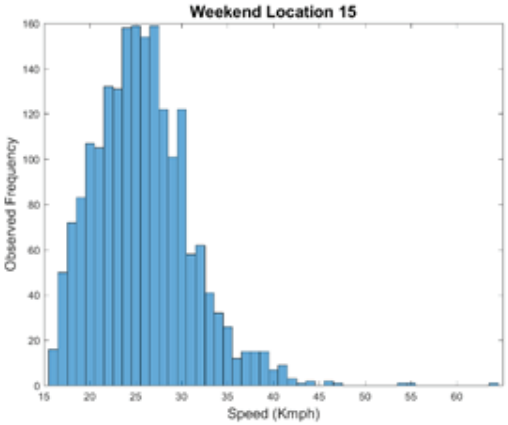

Weekend Location 10
Observed Frequency
Speed (Kmph)

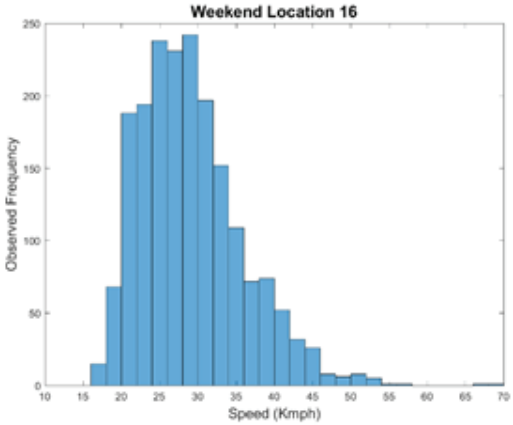

Weekend Location 11
Observed Frequency
Speed (Kmph)

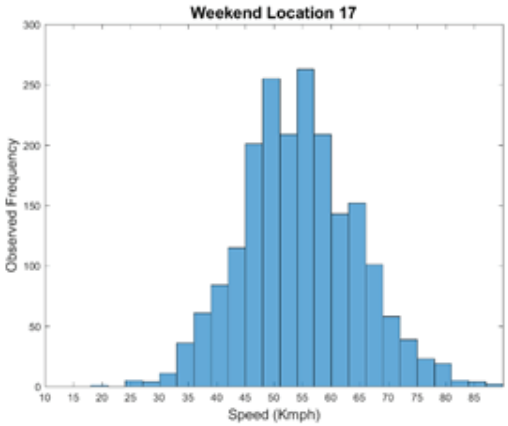

Weekend Location 12
Observed Frequency
Speed (Kmph)

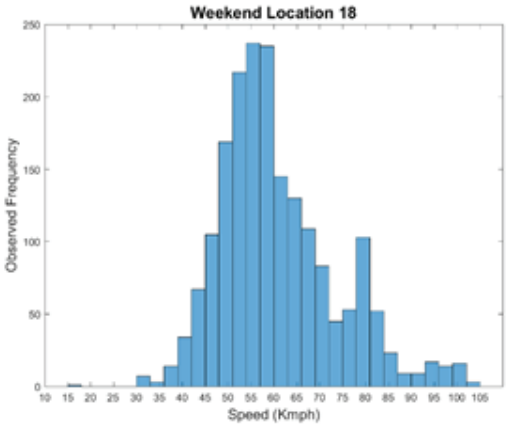

Weekend Location 13
Observed Frequency
Speed (Kmph)

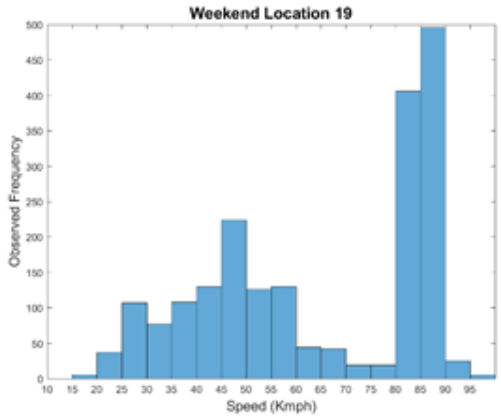

Weekend Location 14
Observed Frequency
Speed (Kmph)

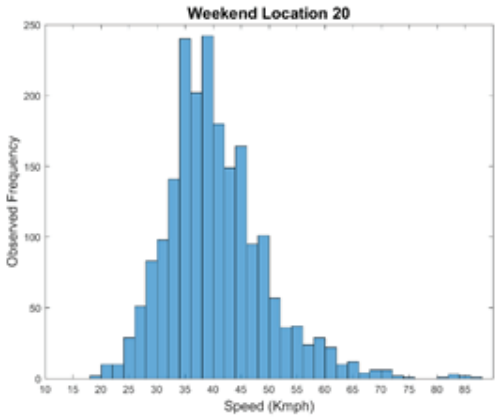

Weekend Location 15
Observed Frequency
Speed (Kmph)

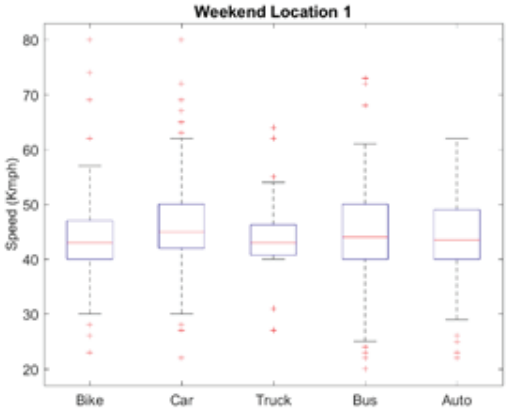

Weekend Location 16
Observed Frequency
Speed (Kmph)

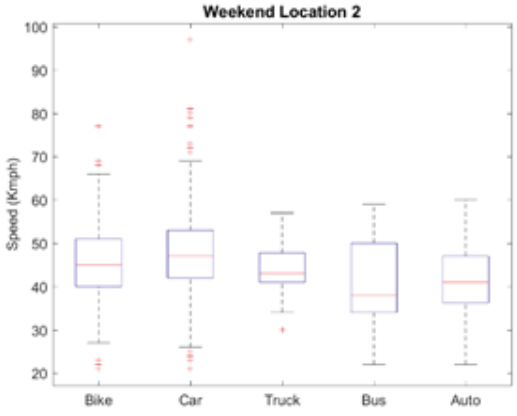

Weekend Location 17
Observed Frequency
Speed (Kmph)

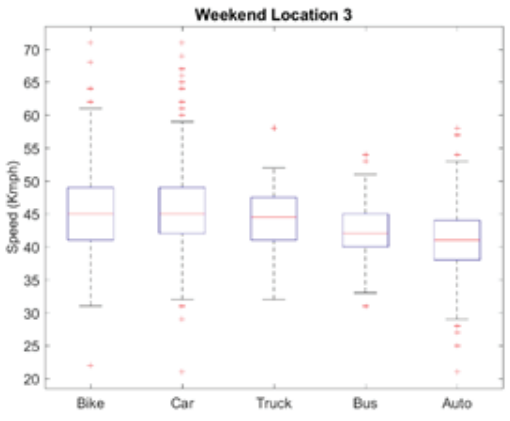

Weekend Location 18
Observed Frequency
Speed (Kmph)

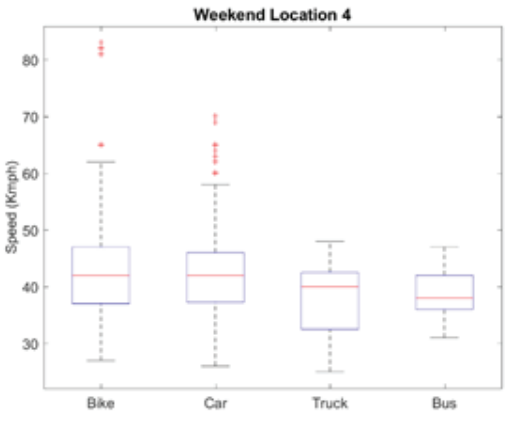

Weekend Location 19
Observed Frequency
Speed (Kmph)

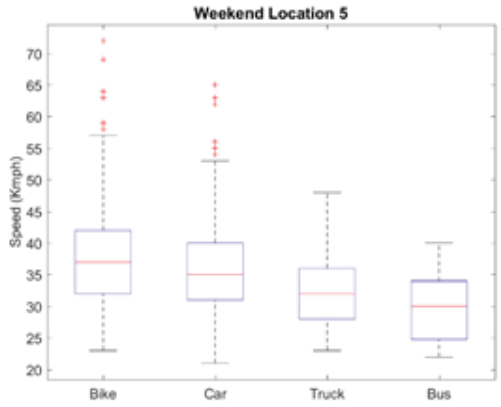

Weekend Location 20
Observed Frequency
Speed (Kmph)

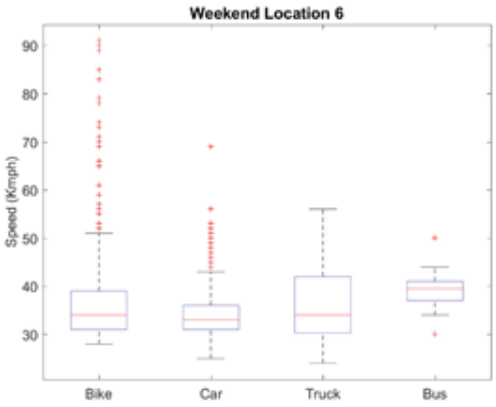

Weekend Location 1
Speed (Kmph)
Bike
Car
Truck
Bus
Auto

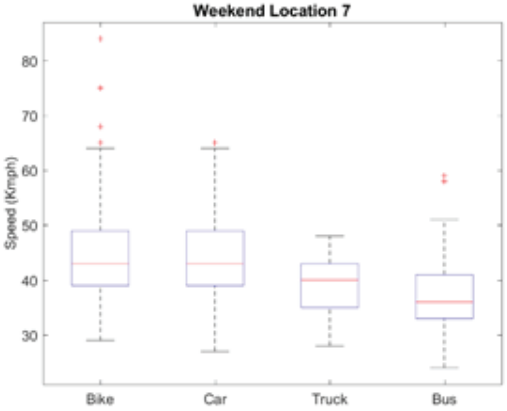

Weekend Location 2
Speed (Kmph)
Bike
Car
Truck
Bus
Auto

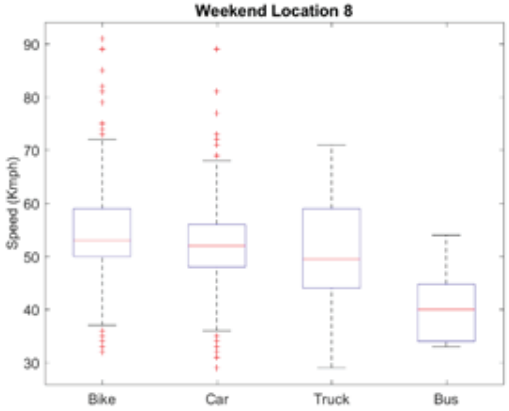

Weekend Location 3
Speed (Kmph)
Bike
Car
Truck
Bus
Auto

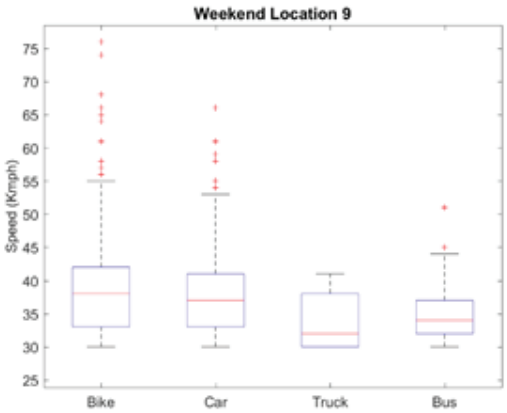

Weekend Location 4
Speed (Kmph)
Bike
Car
Truck
Bus

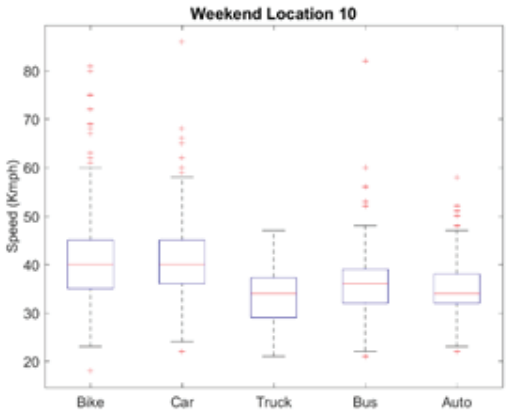

Weekend Location 5
Speed (Kmph)
Bike
Car
Truck
Bus

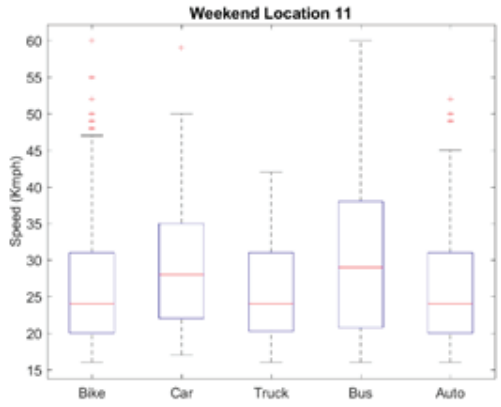

Weekend Location 6
Speed (Kmph)
Bike
Car
Truck
Bus

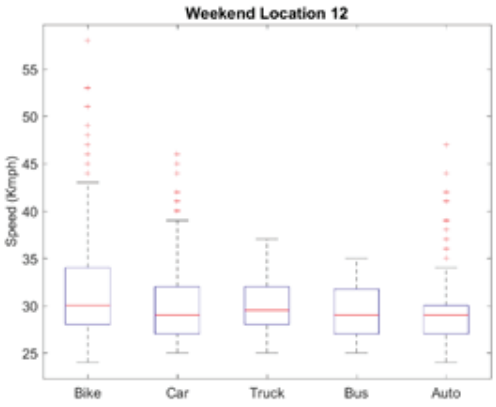

Weekend Location 7
Speed (Kmph)
Bike
Car
Truck
Bus

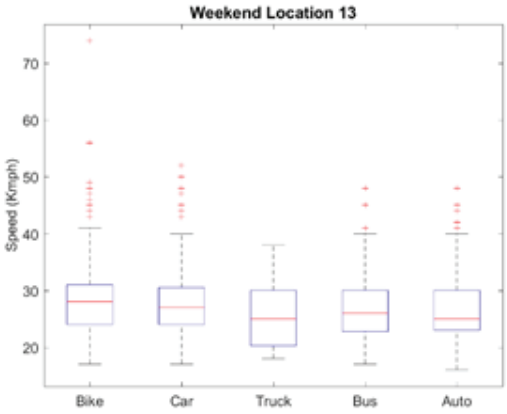

Weekend Location 8
Speed (Kmph)
Bike
Car
Truck
Bus

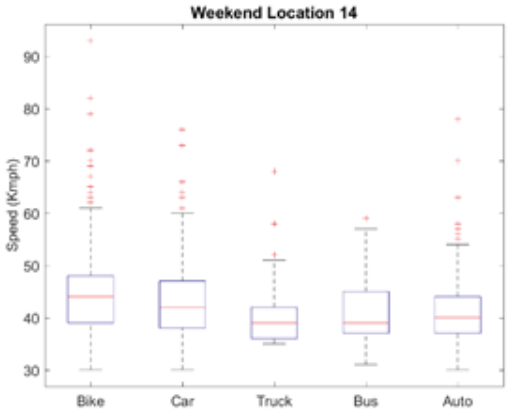

Weekend Location 9
Speed (Kmph)
Bike
Car
Truck
Bus

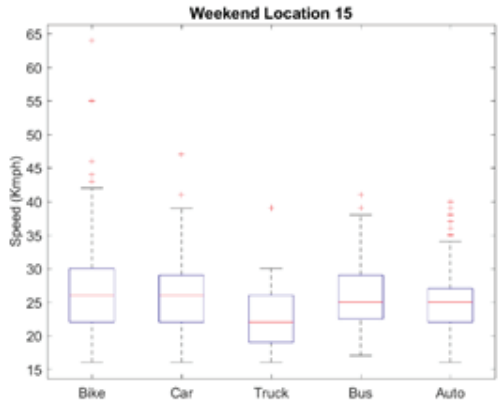

Weekend Location 10
Speed (Kmph)
Bike
Car
Truck
Bus
Auto

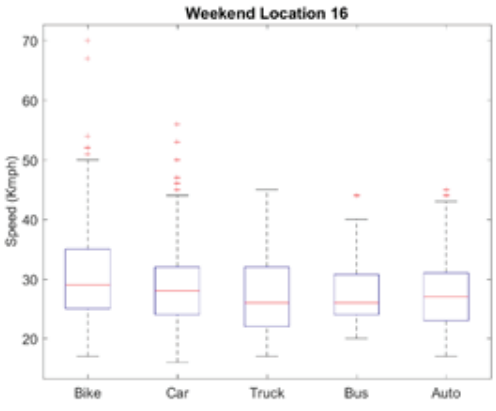

Weekend Location 11
Speed (Kmph)
Bike
Car
Truck
Bus
Auto


Weekend Location 12
Speed (Kmph)
Bike
Car
Truck
Bus
Auto


Weekend Location 13
Speed (Kmph)
Bike
Car
Truck
Bus
Auto


Weekend Location 14
Speed (Kmph)
Bike
Car
Truck
Bus
Auto


Weekend Location 15
Speed (Kmph)
Bike
Car
Truck
Bus
Auto


Weekend Location 16
Speed (Kmph)
Bike
Car
Truck
Bus
Auto

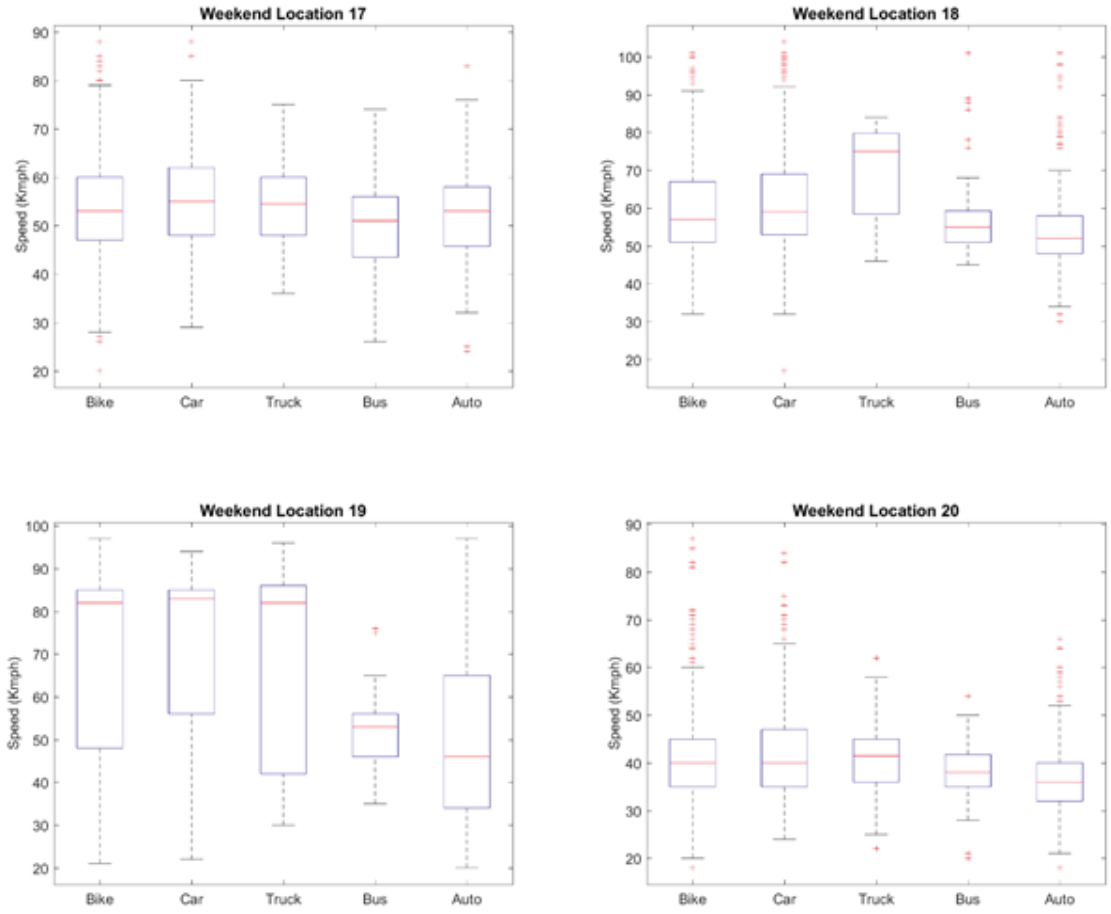


Figure 115: Speed histograms and box plots of the weekend speed data analysis for all the 20 locations

Forms Used for Collecting Site Details and Spot Speeds

Site Description form for Field Visit

Date:

1. **Location:**
2. **Facility Type:** Midblock/Uncontrolled Intersection/Signalized Intersection/Other _____
3. **Rough diagram** of the facility with traffic movements, available road markings and sign boards along with approx. distances
4. Any **traffic control devices** present at the location? If yes, list the details of the same.
5. **Signal Timings** at the intersection (if signalized intersection)
6. Any **potential conflicts** observed at the location. Like merging and diverging manoeuvres.
7. Any other observations
8. Details of members visiting the location (IITB and any other members)

Figure 116: Site description form used during the site visits

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Spot Speed Data Observation Form

Instructions:

- Each observation session should last 90 minutes.
- Please assess and record road traffic volume at each observation site for 15 minutes. Please follow instructions provided in the protocol.
- Please record the posted speed limit for the road at the site
- For every observed vehicle, please record the speed as measured by the observer
- For every vehicle observed, under 'vehicle type' and 'vehicle ownership type' mark the type of the vehicle following the codes provided at the end of the form.
- General codes:
  - Please use '7' for 'Other' in cases where you would like to add detail not covered by the provided options
  - Please use '888' for 'Non observable' cases such as when driver/passenger or vehicle characteristics are not observable (for example, age/sex of driver/passenger could not be determined)
  - Please use '999' for 'Not applicable' cases when the variable/question is not applicable (for example, there is no passenger)

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Name of observer (FULL NAME: first name and last name): _____

Name of recorder (FULL NAME: first name and last name): _____

Site of the observation in Mumbai: _____

Date (DD/MM/YYYY): _____

Start time (1-24; e.g. 15:30): _____ **End time (1-24; e.g. 15:30):** _____
Note: please type in the fixed start time and end time of the measurement session, not the specific time of each observation

Direction of travel of the vehicles being surveyed (e.g. *from Vikhroli to Chembur*): _____

Vehicle Count (15 minutes): _____

Weather (check one): Dry/no rain _____ Light rain/drizzle _____ Rain _____ Snow _____ Fog _____ Hail _____ Other *(Specify)* _____

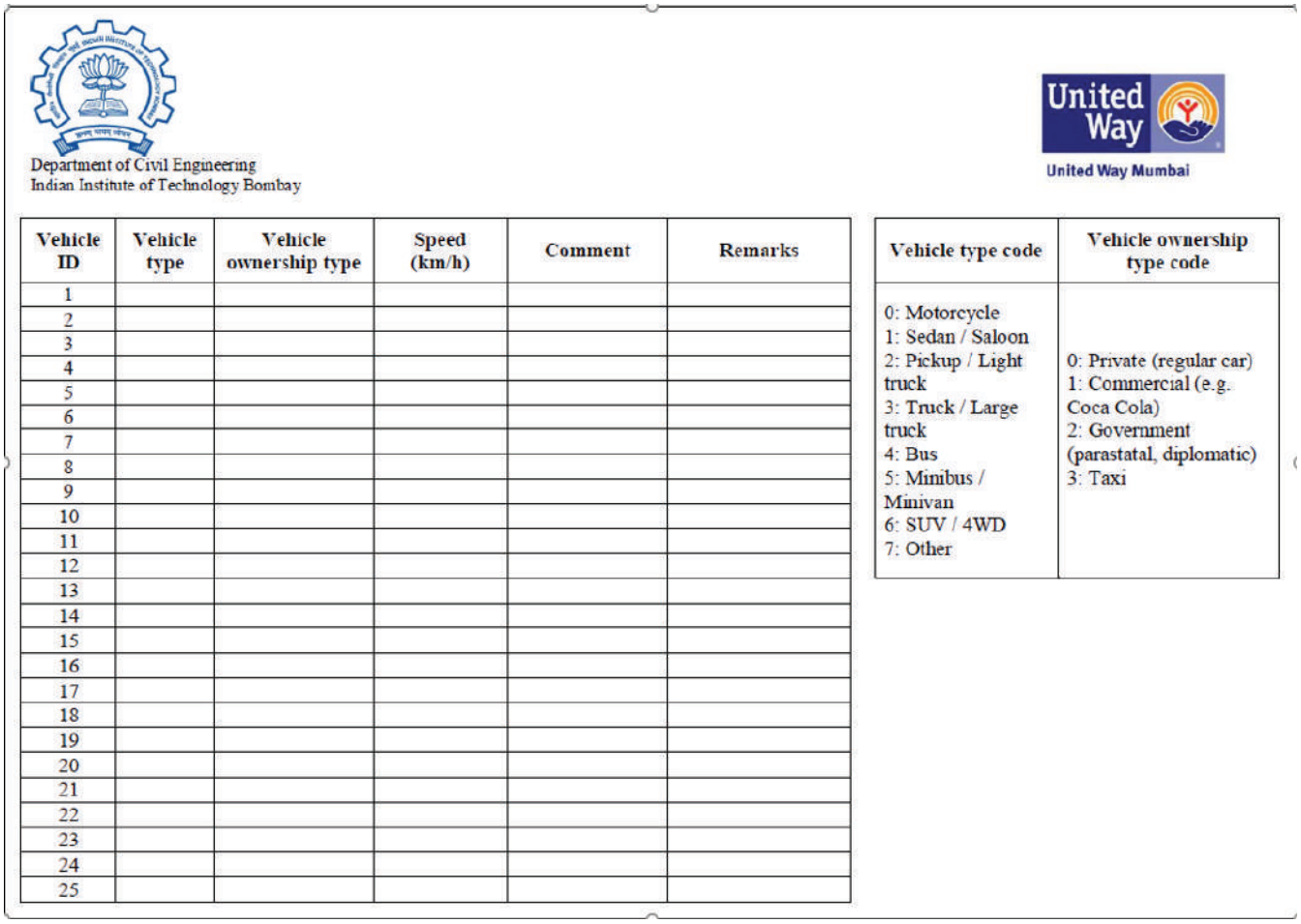
Visible presence of SPEED LIMIT sign: If Yes, **Posted Speed Limit** (km/h) _____ No _____

Type of speed deterrent (check as many as apply): Speed bumps/rumble strips _____ Stop signs _____ Cross walk _____ Other *(Specify)* _____
Note: Please consider 500 m (0.5 km) range of distance between (either side of) observation site and any type of speed deterrent

Visible presence of law enforcement (police presence) (check one): Yes _____ No _____

Presence of camera enforcement (check one): Yes _____ No _____

General observations, if any: _____



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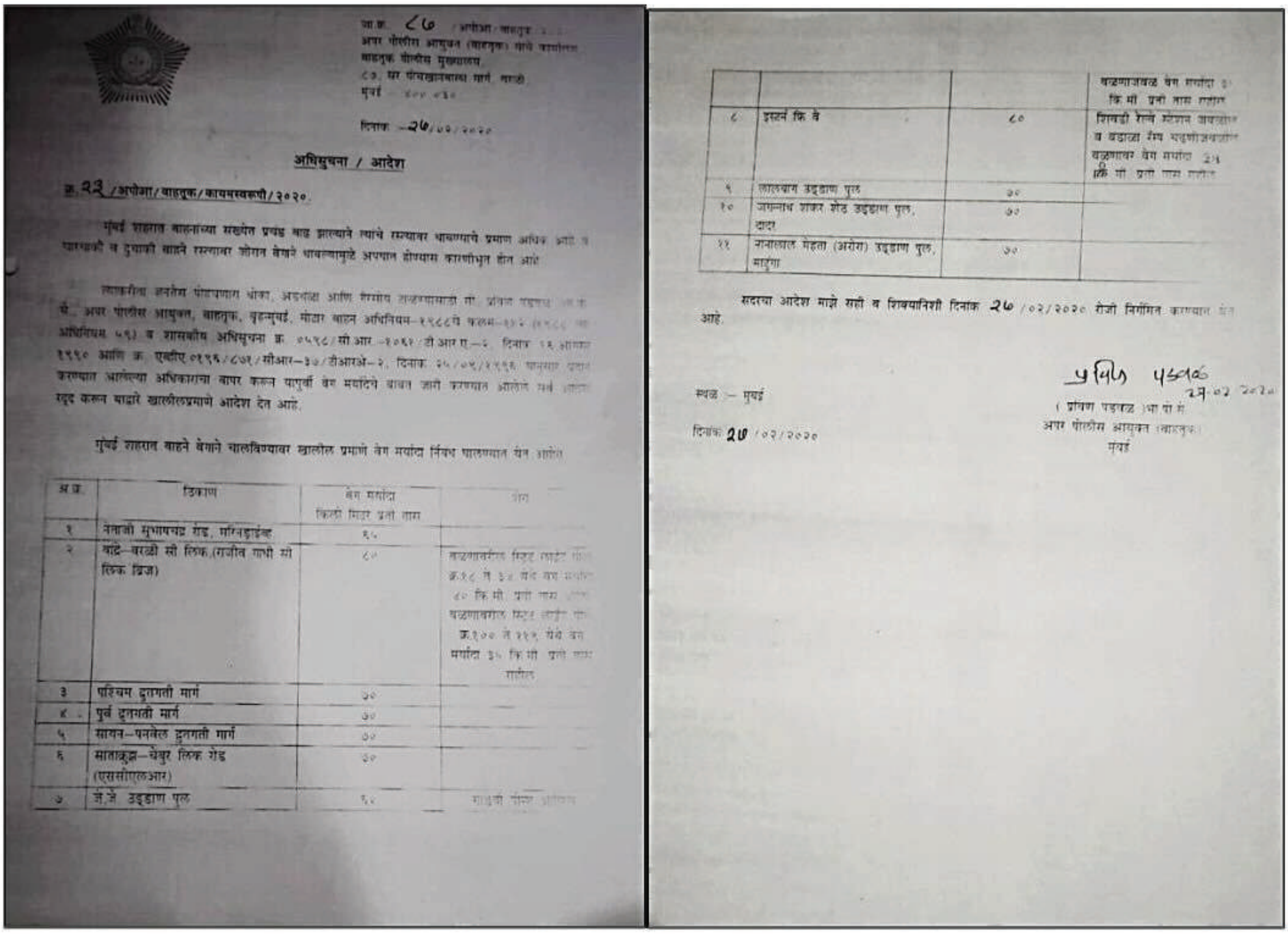
Indian Institute of Technology Bombay

United Way Mumbai

Vehicle ID	Vehicle type	Vehicle ownership type	Speed (km/h)	Comment	Remarks
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					
15					
16					
17					
18					
19					
20					
21					
22					
23					
24					
25					

Vehicle type code	Vehicle ownership type code
0: Motorcycle 1: Sedan / Saloon 2: Pickup / Light truck 3: Truck / Large truck 4: Bus 5: Minibus / Minivan 6: SUV / 4WD 7: Other	0: Private (regular car) 1: Commercial (e.g. Coca Cola) 2: Government (parastatal, diplomatic) 3: Taxi

Figure 117: Form used for collecting spot speeds



अपर पोलीस आयुक्त (वाहतूक) यांचे कार्यालय
वाहतूक पोलीस मुख्यालय
मुंबई

दिनांक -२६/०२/२०२०

अधिसूचना / आदेश

क्र.२३/अपोआ/वाहतूक/कायमस्वरुपी/२०२०.

मुंबई शहरात वाहनांच्या संख्येत प्रचंड वाढ झाल्याने त्यांचे रस्त्यावर धावण्याचे प्रमाण अधिक [illegible] व चारचाकी व दुचाकी वाहने रस्त्यावर जोरात वेगाने धावल्यामुळे अपघात होण्यास कारणीभूत होत आहे.

त्याकरीता जनतेचा [illegible] धोका, अडथळा आणि गैरसोय टाळण्यासाठी मी, [illegible] अपर पोलीस आयुक्त, वाहतूक, बृहन्मुंबई, मोटार वाहन अधिनियम-१९८८ चे कलम-[illegible] अधिनियम ५९) व शासकीय अधिसूचना क्र. ०५९८/सीआर-[illegible]/टीआरए-२, दिनांक [illegible] १९९० आणि क्र. एमडीए ०१९६/८७१/सीआर-३७/टीआरओ-२, दिनांक [illegible] अन्वये प्रदान करण्यात आलेल्या अधिकारांचा वापर करून यापुर्वी वेग मर्यादेचे बाबत जारी करण्यात आलेले सर्व आदेश रद्द करून याद्वारे खालीलप्रमाणे आदेश देत आहे.

मुंबई शहरात वाहने वेगाने चालविण्यावर खालील प्रमाणे वेग मर्यादा निर्बंध घालण्यात येत आहेत

अ.क्र.	ठिकाण	वेग मर्यादा किलो मिटर प्रती तास	शेरा
१	नेताजी सुभाषचंद्र रोड, मरिनड्राईव्ह	६०	
२	वांद्रे–वरळी सी लिंक (राजीव गांधी सी लिंक ब्रिज)	८०	[illegible]
३	पश्चिम द्रुतगती मार्ग	७०	
४	पुर्व द्रुतगती मार्ग	७०	
५	सायन–पनवेल द्रुतगती मार्ग	७०	
६	सांताक्रुझ–चेंबुर लिंक रोड (एससीएलआर)	७०	
७	जे.जे. उड्डाण पुल	५०	[illegible]
८	ईस्टर्न फ्रि वे	८०	[illegible]
९	लालबाग उड्डाण पुल	७०	
१०	जगन्नाथ शंकर शेठ उड्डाण पुल, दादर	७०	
११	नानालाल मेहता (अरोरा) उड्डाण पुल, माटुंगा	७०	

सदरचा आदेश माझे सही व शिक्यानिशी दिनांक २६/०२/२०२० रोजी निर्गमित करण्यात येत आहे.

स्थळ – मुंबई
दिनांक २६/०२/२०२०

(प्रविण पडवळ) भा.पो.से.
अपर पोलीस आयुक्त (वाहतूक)
मुंबई

Figure 118: Mumbai Traffic Police Circular on the Speed Limits on major roads in Mumbai shared by UWM

H.Q. 87, Upper Commissioner of Police
(Traffic) Office,
Traffic Police Headquarters,
Sir Pochkhanawala Road, Worli,
Mumbai- 400 030.

Date -27-02-2020

Notification / Order

No. 23/Upper Commissioner of Police/Traffic/ Permanent 2020

Due to the massive increase in the number of vehicles in the city of Mumbai, the number of vehicles plying on the roads is very high. Further, over speeding by the four-wheelers and two-wheelers is resulting in road traffic crashes.
In order to avoid the risks, deterrence and inconvenience caused to the public, I Praveen Padwal, IPS, Upper Commissioner of Police (Traffic), Greater Mumbai, as per the powers conferred to me by the section 112 of the Motor Vehicles Act, 1988 (the 59th Act of 1988) and Government Notification No. 0598/ CR-1061/ TRA-2, dated 16th August 1990, and number AVA 0196/871/CR-37/ TRA-2, dated 25/09/1996; hereby am revoking all orders issued in the past with regards to the speed limits and am hereby issuing the orders as given bellow;
The following speed limits are being imposed on speeding of vehicles in Mumbai city.

Sr. No.	Location	Speed Limit (Kmph)	Remark
1	Netaji Subhash Chandra Road, Marine Drive	65	
2	Bandra-Worli Sea Link (Rajiv Gandhi Sea Link Bridge)	80	The Speed limit near the turn i.e. street light pole No. 18 to 34 will be 40 kilometers per hour and The Speed limit near the turn i.e. street light pole No. 100 to 119 will be 35 KMPH.
3	Western Express Highway	70	
4	Eastern Express Highway	70	
5	Sion-Panvel Expressway	70	
6	Santacruz-Chembur Link Road (SCLR)	70	
7	J.J. Flyover	60	The speed limit at the turn near Mandvi Post Office will be 35 KMPH.

Figure 119: Mumbai Traffic Police Circular on the Speed Limits on major roads in Mumbai (Translated)

Sr. No.	Location	Speed Limit (Kmph)	Remark
8	Eastern Freeway	80	The speed limit near the Sewri Railway Station and on the turn at climbing Wadala Ramp will be 35 kilometers per hour.
9	Lalbaug Flyover	70	
10	Jagannath Shankar Sheth Flyover, Dadar	70	
11	Nanalal Mehta (Arora) Flyover, Matunga	70	

These orders are being issued on 27/02/2020 with my signature and seal.

Place- Mumbai

Date -27-02-2020

Signature

Pravin Padwal, IPS

Upper Commissioner of Police (Traffic)

Mumbai

WAY FORWARD

The Speed Observation Study report is aimed at supporting the Mumbai Traffic Police in developing evidence based strategy for provisioning various speed management interventions at the blackspots as well as in developing an action for stricter enforcement of speed limits in the city. We at United Way Mumbai are confident that, the methodology and approach adopted during this study paves way for replicating the similar strategies to systematically analyzing all the other blackspots not only within Mumbai city, but also across the state of Maharashtra.

Besides the scientific study of the blackspots, United Way Mumbai has categorically worked towards mobilizing the community stakeholders in form of the Road Safety Advocacy Clubs right from the initial phase of the Slow Down project. These clubs comprise of various active citizens and representatives of community-based organisations in the neighbourhoods of the respective blackspots. This has ensured development of sense of ownership among the local community stakeholders towards the cause of road safety at large in their own neighbourhoods. The members of these clubs have been also introduced to the local officials of the respective traffic police divisions. United Way Mumbai has also shared with the club members the findings and recommendations of the Speed Observation Study with respect to the blackspots in their neighbourhood. Some of the members of these Road Safety Advocacy Clubs have been now independently pursuing and advocating with the local traffic officials and the municipal road department officials seeking implementation of the recommended measures for speed management.

United Way Mumbai is committed to continue mentoring the Road Safety Advocacy Clubs so as to help them in pursuing implementation of various recommended speed management measures at the respective blackspots. These members are also proving to be potential local resource for the Mumbai Traffic Police to drive the local Traffic Advisory Committees and ensure decentralized traffic management and road safety interventions across Mumbai.

Additionally, the office of Jt. Commissioner of Police, Traffic- Mumbai has also initiated a dialogue with the Road department of Municipal Corporation of Greater Mumbai seeking to implement the recommended measures of this report along with various other measures as recommended by the Mumbai Traffic Police. United Way Mumbai is committed to providing all the necessary support to the Mumbai Traffic Police and the BMC in this endeavor.

The initiatives such as the Slow Down project, have great potential in creating far reaching impact by way of influencing the development of speed management policy at the state level. United Way Mumbai is committed to provide inputs to the Motor Vehicle Department, Govt. of Maharashtra based on its learning during implementation of the project Slow Down.

ACKNOWLEDGEMENT:

United Way Mumbai would like to sincerely acknowledge various stakeholders for their valuable contribution to this Speed Observation Report as mentioned below;

- Office of the Jt. Commissioner of Police (Traffic), Traffic Control Branch, Mumbai Police and all the officials of the Traffic Police Divisions across Mumbai city who have participated in this project activities and provided their valuable guidance and inputs

- Office of the Transport Commissioner, Motor Vehicle Department, Govt. of Maharashtra and all the transport officials who have participated in this project activities and provided their valuable guidance and inputs

- Indian Institute of Bombay (IIT-B), Department of Civil Engineering

- Members of all the twenty Road Safety Advocacy Clubs formed by United Way Mumbai around the select blackspots as part of the Slow Down project

REFERENCES

1. Chaurand, N., Bossart, F. and Delhomme, P., 2015. A naturalistic study of the impact of message framing on highway speeding. Transportation research part F: traffic psychology and behaviour, 35, pp.37-44.

2. Delhomme, P., Chappé, J., Grenier, K., Pinto, M. and Martha, C., 2010. Reducing air-pollution: A new argument for getting drivers to abide by the speed limit?. Accident Analysis & Prevention, 42(1), pp.327-338.

3. Ab Rashid, A.A., Poi, A.W.H., Jawi, Z.M. and Kassim, K.A., 2021. Revisiting Speed Management Strategies in Malaysia. Journal of the Society of Automotive Engineers Malaysia, 5(2), pp.318-330.

4. Hamid, H., Fin, L.S., Hua, L.T., Sheng, T.K., Nor, N.A.A.M., Ghani, A.H.A., Othman, N. and Voon, W.S., 2017. Establishing baseline for the 2017 revised road safety education module for primary school through context, input, process and product (CIPP) model. Malaysian Institute of Road safety Research.

5. Izquierdo, F.A., Ramírez, B.A., McWilliams, J.M. and Ayuso, J.P., 2011. The endurance of the effects of the penalty point system in Spain three years after. Main influencing factors. Accident Analysis & Prevention, 43(3), pp.911-922.

6. Chen, T., Sze, N.N., Saxena, S., Pinjari, A.R., Bhat, C.R. and Bai, L., 2020. Evaluation of penalty and enforcement strategies to combat speeding offences among professional drivers: A Hong Kong stated preference experiment. Accident Analysis & Prevention, 135, p.105366.

7. Watson, A., Kaye, S.A., Fleiter, J. and Freeman, J., 2020. Effectiveness of vehicle impoundment for high-range speeding offences in Victoria, Australia. Accident Analysis & Prevention, 145, p.105690.

8. Jørgensen, F. and Pedersen, H., 2005. Enforcement of speed limits—actual policy and drivers' knowledge. Accident Analysis & Prevention, 37(1), pp.53-62.

9. Rodriguez, D.A., Targa, F. and Belzer, M.H., 2006. Pay incentives and truck driver safety: a case study. ILR Review, 59(2), pp.205-225.