SCHOOL ZONE ROAD SAFETY: EVALUATION AND REDESIGN FOR PEDESTRIAN FACILITIES

A thesis submitted in partial fulfilment of the requirement for the award of the Degree of

MASTER OF ENGINEERING

In Civil Infrastructure

Submitted By

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DECLARATION:

I, hereby declare that the work presented in this thesis entitled "**School Zone Road Safety Evaluation and Re-Design for Pedestrians**" in partial fulfillment of the requirement for the award of the degree of **Master of Engineering** in the field of **Civil Engineering** with specialization in **Infrastructure Engineering** submitted at **Thapar Institute of Engineering and Technology (Patiala)** is an authentic record of my own work carried out during the period from 10 January 2019 to 29 July 2019 under the guidance of my supervisor Dr. Mansha Swami & Mrs. Neena Garg.

The matter embodied in this thesis has not submitted by me for the award of any other degree or diploma.

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It is certified that the above statement made by the student is correct to the best of my knowledge and belief

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ABSTRACT

Urban accident statistics reveal a good number of school going children get hit every year while on their journey to and from the schools. School Zones are an area which almost every child traverses in his/her daily trip. School Zone also becomes a daily trip generating point for parents or adults accompanying the child. Child pedestrian safety in school zones are a cause of worry to various international organizations which could identify this pattern. Back in India, not much study has been carried out in this domain as of yet. This Dissertation attempts to understand the attributes responsible for pedestrian safety in school zones. Literature was studied to identify various such attributes that impact the child pedestrian safety within the school zones.

Further, a study area comprising of 23 school zones was selected in South Delhi and studies were conducted to assess the current situation of child pedestrian safety at various school zone areas with the help of various surveys. Pedestrian perception survey was an important part of this research work wherein the perceptions of children, parents, school teachers and staff are recorded over the identified attributes. Pedestrian infrastructure inventory was recorded for all selected locations in the study area to assess the scenario of available or non-available pedestrian infrastructure. Further, Pedestrian volumes studies were carried out to understand the number and density of pedestrian footfall in various school zones. One school zone was selected to carry out detailed microscopic study through the use of simulation technique using PTV Vissim with Viswalk Module embedded. The school area was replicated in terms of geometry and road user input values. Few metrics were studied for performance. Some changes were made to the geometry keeping in mind the fact that the current situation was not ideal. Several modifications were made to the current geometry and studied again with the simulation technique. The results were then compared for the base scenario and the modified scenario to reveal the change in pedestrian behavior. Bases on literature and best practices being followed in different countries, several measures to enhance pedestrian safety experience were suggested in the recommendations chapter.

The results reveal that at several places the basic pedestrian infrastructural facilities were missing. Further, the condition of sidewalks were either not adequate in space or not appropriate in terms of quality to easily walk on. The encroachments and on street parking chaos also added

to the problem of pedestrians having lesser space to themselves. There was no coordination found between parents, school administration and local government bodies in terms of regulating the pedestrian traffic in these school areas. In fact, many of the adults were not even aware of the safe practices that should be practices for child pedestrian safety. The local enforcement agencies like municipal corporations and police had little interference in daily commute governance of these school areas. The lack of infrastructure and lack of awareness was only adding to the pedestrian safety concerns. Vehicular traffic management in these school zones was also identified as one of the concerns as there were no proper rules and regulations enforced in this regard. Vehicular speed management installations were present at several locations but then the enforcement was not being taken seriously. Many children travelled to school without adult supervision. There were no special zones designated for school drop off and pick up. Most schools had on the go drop off and pick up functioning amongst the vehicular traffic movement. Majority of schools were having no sidewalks, the ones that had sidewalks had no pedestrian guardrails which made the pedestrian sidewalk very vulnerable to the vehicular traffic adding to the chances of conflict between and pedestrian walking on the outer edge of the sidewalk and vehicular movement adjacent to the sidewalk. More than half of the schools did not have pedestrian crossing facility. Inadequate parking infrastructure, lack of vehicular speed management devices, poor road conditions, deteriorated sidewalk surfaces etc. were some of the issues faced by the pedestrians on a daily basis.

Adding to it the sensitive requirements of the vulnerable road users like children who have slower response times as compared to adults. All such findings indicated towards massive scope of improvement to be carried out in various contexts if the pedestrian safety was to be enhanced in the school zone area. This dissertation hopes to throw light on to the study and hopes to contribute to the literature.

TABLE OF CONTENTS

LIST OF TABLES:

LIST OF FIGURES:

LIST OF ABBREVIATIONS

GIS: Geographical Information System

HIC: High-income countries

Indo-HCM: Indian Highway Capacity Manual

IRAP: International road Assessment Programme

IRC: Indian Road Congress

LMIC: Low-income and middle-income countries.

MSL: Mandatory Speed Limit

NCT: National Capital Territory

NGO: Non-Government Organization

NRSP: National Road Safety Policy

PT: Private transport

PuT: Public transport

SRS2S: Safe Routes to school construction program

UNICEF: United Nations International Children's Education Fund

WHO: World Health Organization

WSB: Walking School Bus

CHAPTER 1

INTRODUCTION

1.1 GENERAL:

Road traffic accident near schools and death and injury of school children is a serious issue and is increasing gradually. The safety aspects related to school going children near school zones areas are usually overlooked.

Child pedestrians are the most vulnerable road users in India as they have no protection in case of accident. They are also the most vulnerable group in terms of their involvement in fatal accidents and serious injuries. The road user getting involved in road accident is increasing day by day and therefore we need to find solution to the problem of how to make roads and school zones safer for school going children.

1.2 GLOBAL SCENARIO:

Every year (according to WHO, Global Road Crash Statistics) in road crashes almost 1.25 million people die worldwide. More than 1,600 children die under the age of 15 years each year.

More than 260,000 in children under the age of 0-19 years died in road traffic accident in 2004. 93% of road fatalities are seen in low income and middle income countries and for higher income countries 50% of all child traffic Deaths are seen.

As pedestrian children are more vulnerable and 5-14years old are more at risk.

A table showing risk of road traffic injuries under up to the age of 20 years.

HIC = High-Income Countries;

LMIC = Low-Income and Middle-Income Countries.

Table No-1.1: Child road traffic injury rates per 100000 population by gender and age

Gender	Age in years					
	Infant under 1	**2years-4 years**	**5years-9years**	**10years-14years**	**15years-19years**	**Under 20 years**
Girls	7.4	8.3	9.3	4.5	7.9	7.5
Boys	11.5	11.5	13.3	8.7	23.4	13.8

Source: WHO (2008), Global Burden of Disease: 2004 update. (WHO & UNICEF)

According to IRAP 85% of roads do not have pedestrian crossing, 70% of roads have no side walk, 94% of roads have no bicycle facilities.

1.3 INDIAN SCENARIO

According to Save Life Foundation, (an Indian NGO working in the road safety sector), since 2008, over 55,000 children have lost their lives in road crashes in India. According to road crashes statistics 2016, it has been estimated that every day in India due to road accident 43 children die and around 20 children under the age of 14 die every day (WHO report).

6.4% road crash fatalities were attribute to children aged below 18 years, in 2017. Since the safety measures for adult do not apply to children, it is erroneous to believe that the same safety strategies for adult can work for children, therefore government should provide special focus on safety policies for children.

A survey revealed that in India, irresponsible and negligent road user behavior aren't the only factors that make commute unsafe for children. Poor infrastructure which involves lack of footpath, zebra crossing, proper signage also contribute to lack of safety during commute for children. With increase motorization, roads are crowded round the clock which makes road more unsafe for children when travelling by themselves. Also both driver and pedestrian are responsible for road crashes. Drivers required to be extra caution in school zone areas.

1.4 DELHI DEMOGRAPHIC AND PEDESTRIAN SCENARIO

Delhi, the capital of India, is bordered by Uttar Pradesh in east and Haryana on three side. The map of Delhi is shown in figure 1. It covers an area of 1,484 square kilometers. The population of Delhi was over 11 million according to the 2011 census, which is the 2nd highest in India.

Delhi's urban area is now considered to extend beyond the NCT boundaries and include the neighboring satellite cities of Faridabad, Gurgaon, Ghaziabad and Noida had an estimated 2016 population of over 26 million people, making it the world's second-largest urban area according to United Nations. As of 2016, recent estimates of the metro economy of its urban area have ranked Delhi either the most or second-most productive metro area of India.

Safety is a key concern for parents. They cannot always accompany your kids and guide them. Of course, parents ensure the safety of their child at home and teachers or school transportation authority ensure the kid’s safety in order to safeguard the credibility of the schools. As a matter of fact, children will not be mature enough to realize what is right or what is wrong, while walking on the roads. Without the appropriate guidance and awareness of road safety rules, it is risky to send children unaccompanied.

In Delhi there are almost 7,268 schools in 2017-2018 with 44.13 lakhs student (according to Delhi government statistic). In 2017, 25 children below the age of 18 were killed in road accident so the school transport has become a nightmare for parents.

There are many schools in Delhi which don’t have a proper pedestrian walk or proper installation of Signage near schools.

Figure -1.1 Map of Delhi

1.5 SOUTH DELHI AREA AND SCENARIO

South Delhi is an administrative district of Delhi in India which is bounded by the Yamuna River to the east, the districts of New Delhi to the north, Faridabad District of Haryana state to the southeast, Gurgaon District of Haryana to the southwest, and South West Delhi to the west.

It has 250 square kilometer (97 sq. mi.) (Delhi gov.) and a population of 2,258,367 (according to 2011 census), with a population density of 9,034 persons per km² (23,397 persons per mi²).

The district is divided into three main subdivisions, Saket, Hauz Khas, and Mehrauli as shown in figure 2. The district is a mix of modern buildings and historical monuments and is known for both commercial and residential values.

Figure 1.2 - Map of South Delhi

The main suburbs of South Delhi are

- R. K. Puram
- Friends Colony
- Golf Links
- Hauz Khas
- Defence Colony
- Kalkaji
- Lajpat Nagar
- Greater Kaiash
- Channakyapuri
- Vasant Vihar
- Vasant Kunj
- Saket

Increasing traffic on roads has leads to major fatalities of pedestrian. Since child pedestrian injuries are the leading causes of our country an attempt is made to study the roads facilities near schools area.

1.7 NEED AND SCOPE

The need to conduct this study arises from the fact that at many places across India and the world we see a rise in the child and pedestrian fatalities and injury rates. School Zones are an area which almost every child traverses in his/her daily trip. School Zone also becomes a daily trip generating point for parents or adults accompanying the child. There is very little work done as per literature in studying the specific aspects of safety for pedestrians and children in the School Zones in India and other developing countries.

The scope of this thesis is to study the literature and identify all parameters relating to the problem zones in school areas with respect to child and pedestrian safety. Further, Surveys shall be conducted to assess the current situation around several school areas in the selected study area. The geometric parameters of the school zone can be modified to make it more pedestrian friendly and safer for pedestrians. Further the impact of this re-design shall be studied with the help of simulation toolkit. Further, as based on global best practices and literature, several measures of enhancement are suggested with possible policy level changes to bring about a change in the school zones to aid the safety of pedestrians of all age groups in the vicinity of schools.

1.8 OBJECTIVE

1. Study of Literature to find out attributes responsible for pedestrian safety and convenience in school zones.
2. Pedestrian perception questionnaire based survey of school children, Parents, Teacher/ Staff to evaluate existing pedestrian issues in the study area.
3. Inventory based survey to assess availability of existing pedestrian infrastructure in the study area along with vehicular movement data.
4. Impact of modification in the attributes with respect to pedestrian friendly corridor studied with the help of virtual simulation technique using PTV Vissim/Viswalk software.
5. Recommendation to enhance the school zone pedestrian experience based on global standards and best practice case studies.

1.9 LAYOUT OF THESIS

This thesis has been organised into seven chapters. Introduction, Literature review, Study Area and Data collection, Assessment of current scenario, Redesign of school, Policies/ recommendation, Conclusion.

Chapter 1 describes the global and Indian scenario of roads and also the problem faced by child pedestrian along with scopes and objectives.

Chapter 2 deals with the literature review related to the hazard faced by the child pedestrian near school areas.

Chapter 3 deals with the study area taken and also includes the data collection method used in this research work.

Chapter4 deals with the current condition of the school zone and their analysis.

Chapter 5 deals with the design of base network and redesign of the network using the software PTV Vissim and analysis and comparing both the network.

Chapter 6 deal with the policies measures and recommendation.

Chapter 7 deals with the conclusion drawn from this research work.

CHAPTER 2

LITERATURE REVIEW

Several Researchers, Municipal Corporation's, NGO's, Social Workers and Government Agencies have worked in the area of road safety to make roads a safer travel area. Further, Since School areas involve movement of children who are vulnerable road users, literature from various sources was studied to gain more knowledge on the parameters affecting road safety for school zones with respect to school going children and pedestrians. Following are the extracts from various documents studied for literature review.

2.1. Research Publications

1. **Nishant Singh, *et al*. (2018)**, did a research on school based travel mode choice in Kanpur India. Data were collected from nine school using a questionnaire survey format. They also collected different data such as route characteristic, distance from home to school. From their survey they found out that children of younger age are less likely to bicycle, especially during the traffic. There is no difference in mode choice between ages. Girls were less likely to bicycle to school than boys. The result found that family income, distance from home to school also effect the travel mode choice. The mode of travel vs the percentage of respondent is shown in figure 2.1.

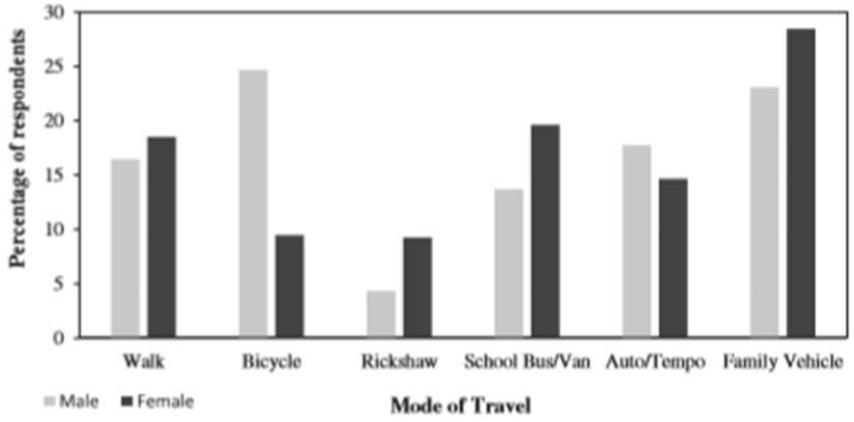


Figure 2.1: Travel mode vs percentage of respondent

The above figure shows the percentage of respondent for different modes of travel.

This study suggest that various travel mode choices like vehicle ownership including cycles, parent economic condition, age, gender, distance and sidewalk availability and presences of a broader main road in the surrounding the school.

2. **Milad Mehdizadeh *et al.* (2017)** did a research on active school travel and the factors affecting the active travel mode to school. For this research data were collected in Rasht, Iran in 9 school among children aged 7-9 years. Milad Mehdizadeh et al analyzed that household income, accessibility to public transport, attending public school, vehicle ownership affect the active school travel. These research was done to identify the threshold which may provide information about how to plan transport and roads around school.

3. **Shailaja Tetali, *et al.* (2016)** in this paper they examine the children mode of travel to school in urban area in Hyderabad. They conducted a questionnaire survey from children age 11 to 14years and collect the data from children who attend both government, private and semi-private school. To measure the correct distance between home and school in Hyderabad, Google Earth is used.

   They took 48 school based on socio economic status for data collection and prepared 21 questions consisting of distance and mode of travel and also surveyed the children perception on road safety. Out of 48 selected school 45 agree to participate leading to a 99% response rate. The survey found that out of these 57 % children walked, 6% cycled and 36 % used private transport. In private school the use of motorized vehicle was higher (41%) than that of children attending government schools which is 24%.

   They also found that if the distance from home to school is higher the use of motorized vehicle in high. Children living near school often cycle or walk to and from school. Research says less girls are found cycling to school than boys.

   From the research it is found that most of the children from Hyderabad cycle or walk their way to school, therefore maintenance is required to ensure that children who are walking and cycling have a safe and pleasant environment.

4. **Lesley Strawderman, *et al.* (2015)** they studied the driver behavior and accident frequency in school zones. Further, they observed that if there are too many signs then the driver may not be paying any attention to those signs. A research was done in the state Mississippi, United States where they examine driver's behavior near school zones and the sign saturation effect on accident frequency near the schools surroundings.

   Four school were selected considering the essential elements like sign boards, number of lanes of the road, sign type, accident frequency, speed calming. They took 168 hours (7 days 24 hours) for complete data collection.

   For the second part of the study the no of traffic collision for a year of each school zones was required. Speeding of vehicles is generally influenced by the number of factors such as, No of Lane (2-lane or 4-lane); presence of children; length of the speed zone; presence of fencing.

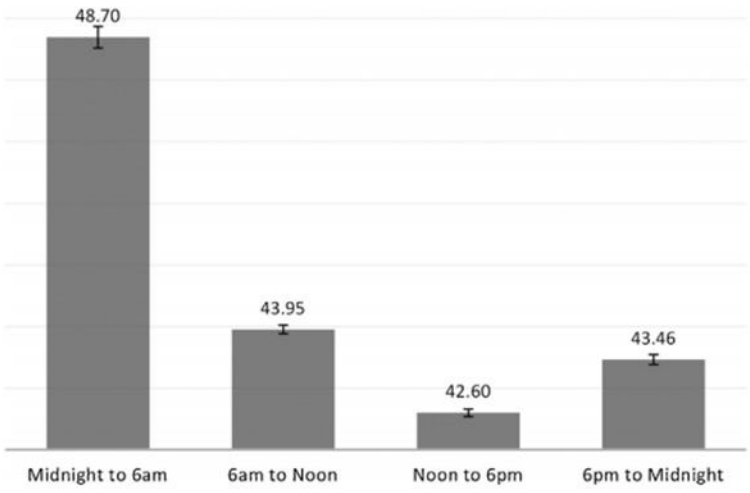


Figure 2.2: mean vehicle speed at different time
Source: (Lesley Strawderman, et al.; 2015)

From the figure 2.2, graph between mean speed and time, they observed that the mean speed was lowest from noon till 6 pm with highest percentage of compliance

In case of two lane road, traffic control device, presence of fencing and speed control device they found lower mean speed and higher rate of compliance. No negative impact of sign saturation was seen in the study. Four lane road is more effective as compared to two lane road. In urban areas drivers are more often seen complaint to school zone signage. There is evidence to suggest that drivers are more compliant to school zone signage in an urban setting. Therefore there is a need of placing school zone signs in urban areas.

5. **Lars B. Christiansen *et al.* (2014**) did a research on school transport and walkability site near school. They selected 1250 student between age 11-13 years and did a study in 14 school in southern Denmark. The studied the distance between home and school and also the school sites related to school transport and also studied the residential density. They concluded that children cycle upto 4 km. they recommended that further studies related to active commuting should be done to make a safe environment for pedestrian.

6. **Nasrudin N. *et al.* (2013)** examined the factors that influence the mode of transportation and also examine the awareness level the level to prevent environmental degradation about the merits of sustainable vehicles among parents.

   During the peak hour the school are often congested with vehicles. The most common mode of transportation are school buses and cars. Children walked and cycle to school are lesser amount compared to children travelling in vehicles. The Figure 2.3 shows the graph between gender and mode of transportation. The Nasrudin N. *et al* found that most of the parents use personal vehicles because of convenience and quickness to send children to school. The most useable mode of transportation is the private vehicle.

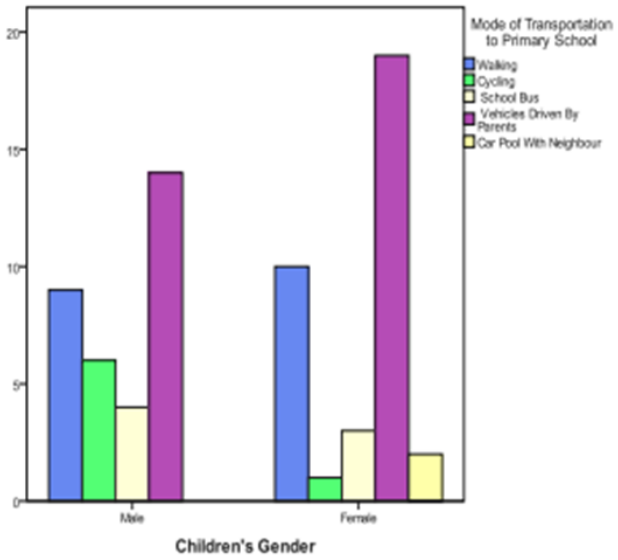


Figure 2.3: Gender Vs Mode of Transportation

Source: (Abd. Rahim Md. Nor et al. 2012)

Parents were questioned in this study about the factors they consider before they allow their ward to cycle or walk to school. The majority of parents answered that the safety of the school surroundings was the main element. Apart from the motorized vehicle, cycle, a distance less than 1 km also counts an important factor. Parents even allow their children to accompany their relative or friend to school rather focusing or suggesting the idea of an improved pedestrian crossing, walkways. This reflects that parents keep their child safety as the highest priority. Misconception about the safety rules have restricted the parents in encouraging their ward to cycle or walk their way to school. This misconception should be eradicated. Thereby multiple various studies on child's perceptions towards road safety and modes of transportation should be thoroughly conducted.

This results gave the detail overview of urban lifestyles as per school transportation and parental concerns towards safety, demands the need for a better and improved of public security, which was the primary element that uplifted the parents to let their child to peddle or walk their way to school.

7. **Lina Kattan, *et al.* (2011)** studied the speed limit around the schools and playground. They investigate the playground and schools in the city of Calgary in Alberta and studied the 85^{th} percentile speed, mean speed and speed compliance. To examine the speed they implement a reduce speed of 30km/hr near the playground and school which are clearly marked by traffic signals. They selected 16 playground and 11 schools and measure the speeds of the vehicles. Various other characteristics were also recorded such as no of children present and no of lane, fencing present or not present and whether speed signage is present in that area.

   They examine that 8:00 am till 4:30 pm was the peak hour of school and 8:30 till sunset was the peak hour of playground is between 8:30 a.m. till sunset.

   The speed of the vehicle were measured near the school and playground surroundings and to avoid effect of weather condition the measurement is taken only in dry condition.

   4580 vehicles speed was recorded and to access the changes in traffic speed the 85^{th} percentile speed & mean speed were used.

   Lina Kattan *et al.* examine that the overall mean speed was 32.96 km/hr and 6.61 km per hour standard deviation. The 85^{th} percentile speeds was found to be 38.8km/hr. 54.43 percent of vehicle driven over 30km/h. and only 10% of vehicles drove at more than 10 km/h over the speed limit of 30 km/h.

   Their result showed that in school zone the rate of compliance was higher but the mean speed was lower compared to the playground; two lane roads relative to four lane roads; roads having fencing, traffic control device and the presences of speed display device or children. This study recommended the need to improve the effectiveness of school and playground zones speed limits.

8. **Andrew P. Jones *et al.* (2010)** research whether school environment, routes and neighborhood effect the active commuting to school. The study was conducted in 92 school of children aged between 9-10 years in Norfolk, United Kingdom. They did a questionnaire based survey where data were filled by parents and children. Andrew P. Jones et al analysis

that the children who belong to deprived area and whose routes was direct were less likely to cycle or walk to school. Also they found that the student who has high density of streetlight were less likely to cycle to school where else those who had higher density of roads are more likely to walk.

Thus they concluded that routes and neighborhood effect the active commuters and therefore the urban design should be improve to influence children commuting behavior.

9. **Carle Hume *et al.* (2009)** did a research on active commuting i.e. walking and cycling to school in Melbourne, Australia. The data were collected during the year 2004 to 2006. Carle Hume el at found that the parents who know the people of the neighborhood are more likely to increase the child active commuting to school compare to other children. Parents who notice that there is insufficient pedestrian crossing and traffic light are less likely to walk and cycle to school. Thus the paper suggest that physical environmental characteristic and social factor has a major impact on active commuting to school.

10. **Xuemei Zhu *et al.* (2008)** did a research on surrounding safety for elementary school and also the walkability. Since there is a decline in walkability to school due to various reason, therefore a study was done in Austin considering 73 elementary school covering and area of 230 sq. miles. GIS was also used to measure the distance, walkability, pedestrian facility, residential density, street connectivity, land used and traffic dangers in that area. They also did a field audit to assess the walkability on the street focusing on the architectural and urban design. From the study they found that the school having the higher poverty, lesser distance from home to school, higher residential density and completed sidewalk has greater walkability level. The crime rate shows the disproportion related to walkability. Other factors also shows the effect on walkability such as traffic signal density, sidewalk and accident rate. The author conclude that economic and ethnic disparities exist in environmental supports for walking near school areas.

11. **Kelly J. Clifton. *et al.* (2006)** this paper examine the vehicular pedestrian collision near schools in Baltimore city and also their physical and social characteristic near school

such as playground, courts, fields, pools or track etc. the result found that the recreational facilities are attracted by the young children and thus they are more likely to collide with vehicle passing that particular zone.

12. **Jacqueline Kerr1 *et al.* (2005)** did a research to examine whether environmental characteristic effect the parent concern related to active commuting to school. They did a survey of parents having children between 5-18 years age group and question about children walking to school and the neighborhood environment.

    They collected data over 259 parents and children out of which 18.1% responded that they walked or biked to and from school and 25.1% are active commuter. The study reveal that no differences were seen between child age group, child gender, parent education, or parent gender. A parental concerns scale was most strongly associated with child active. Parent concerns and neighborhood aesthetics were independently associated with active commuting

    The paper concluded that both parent concerns and the built environment were associated with children's active commuting to school. To increase active commuting to school, interventions that include both environmental change and education campaigns may be needed.

13. **Damian C.A. Collinsa, *et al.* (2004)** did a research on walking school bus (WSB) and risks of child pedestrian injury adopted within metropolitan Auckland. WSB involves adult volunteers guiding the students while walking to and from school. This paper reports on a survey of the 34 Auckland primary schools which had adopted the scheme by November 2002. The research found out that WSB development highly concentrate in low deprivation neighborhoods. The inequitable socio-spatial distribution of WSBs in Auckland suggests that the ability to respond to road safety issues is closely correlated with socio-economic privilege (Damian C.A. Collinsa et al 2004). The main motive of this research is to survey the number of school adopting the WSB and also to promote health benefits.

    They surveyed the schools in Auckland out of which 54 WSB routes are in operation in 29 school. The author concluded that the higher uptake of WSB can ameliorate the traffic congestion near school zones.

In addition, it aims to promote personal health through walking, to modify prevailing parenting norms by offering an alternative to chauffeuring by car, The apparent popularity of WSBs is due not only to their perceived health and safety benefits, but also to the willingness of both parents and pupils to walk.

14. **Reid Ewing *et al.* (2004)** did a research on the factors affecting the mode choice of school travel and the area near the school. They took a sample of student from kindergartens till class 12 and studied the research mode choice. To collect the travel data they did a survey in Florida from which they analysis the mode trips. They also collect the minimum travel time from zone to zone. They did a questionnaire survey about vehicle ownership, household income, driving license etc. to get the socioeconomic idea. From the result the found that student with shorter distance are more likely to walk or bike to school.

15. **Olivier Duperrex, *et al.* (2002**) emphasized on safety education program for pedestrian and pedestrian motor vehicle collision. They identified 15 randomized controlled trials of safety education programs for pedestrians. Fourteen trials targeted children, and one targeted institutionalized adults. None assessed the effect of safety education on the occurrence of pedestrian injury, but six trials assessed its effect on behavior. They also included community based interventions such as media awareness campaigns and parental education programs. They analysis that the safety education can change the road crossing behavior but to prevent pedestrian road accident is doubtful if the appropriate speed limit of the vehicle is not enforced. Also the safety education of the pedestrian can decrease the risk of injury.

16. **M. Suzanne Zeedyk *et al*. (2001)** a program was designed by them to create awareness in children about road safety and ensure the effectiveness of their safety. Program designed by them failed to assess the effectiveness in children in terms of knowledge and improvement in behavior. In the first study method, the effectiveness of three various road safety measures were tested by using common commercial products for example-
    - A 3 D model related to traffic environment;
    - A board game about road safety
    - A Descripted poster and flip-charts.

Second study included the exchange of knowledge between children and their behavior in real traffic environment. A sample of 47 children was chosen. 120 class 1 children were selected for this study 58 of them were girls and rest 62 boys participated. All the children belonged to the age group of 4-5 years. They were given two situation one showing the safe situation and other shows the dangerous situation as listed in the Table 2.1.

Table 2.1: Table showing the safe and dangerous situation

Safe Situation	Dangerous Situation
with a parent	Behind a Bus
on a clear Rroad	With a Moving Traffic
With a Police Officer	Between Parked Cars
With a Crossing Guard (i.e. Lollipop Man/Lady)	At an Obscured Junction
At a pelican crossing with a green man showing on traffic lights	At a pelican crossing with a red man showing on traffic lights
	At a roundabout

Source: (M. Suzanne Zeedyk, et al.; 2001)

They concluded that-

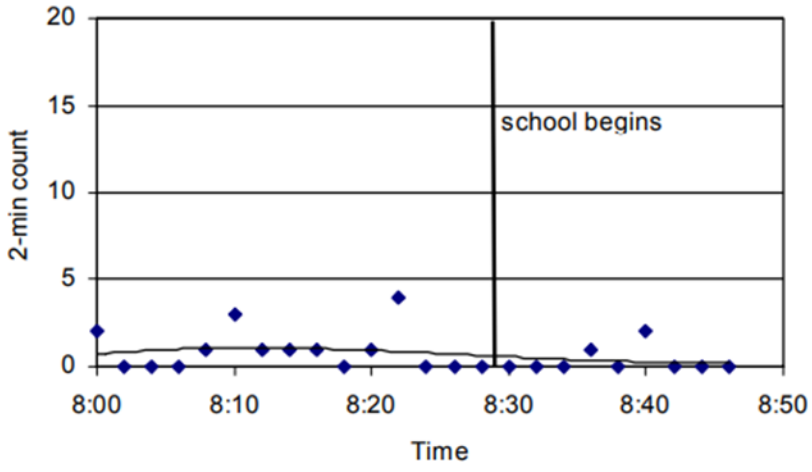
- Three marketed product used above in this study were efficient to increase the knowledge of children regarding safety and dangerous crossings. Therefore the products were proved to be beneficial for the schools and parents for their child's safety and awareness about road safety.
- Despite of all the trainings and the increased knowledge of the trained student did not brought out any noticeable improvisation in the children's behavior when they were introduced to the real traffic environment.
- After all these studies the researcher didn't find much difference in the behavior of the children, they were still struggling to manage to take a right crossing and were not taking any adult assistances to cross the road. Therefore for child's better performance in the real

traffic environment a serious look up is required and further illustrated research is required to coordinate the knowledge and behavior of children.

17. **Craig L. Andersion, (2002)** observes that the pedestrian accident among children near school are an important transportation issues. In his research they describe the some data to support pedestrian safety near school. The author surveyed few schools like Sheldon elementary school of contra costa county, Cesar Chavez school of Los Angeles country, Jasper elementary school, La Gloria where they found that the site has the highest pedestrian and bicyclist count during peak hours and also some congestion due with vehicles double parking near school and also traffic due to vehicular and pedestrian near the school. The author also examines that some student crossed mid-block on the other side of the road.

    They design the data for evaluating child safety program.

a. 2-minute child pedestrian & bicyclist counts



b. 2-minute vehicle counts

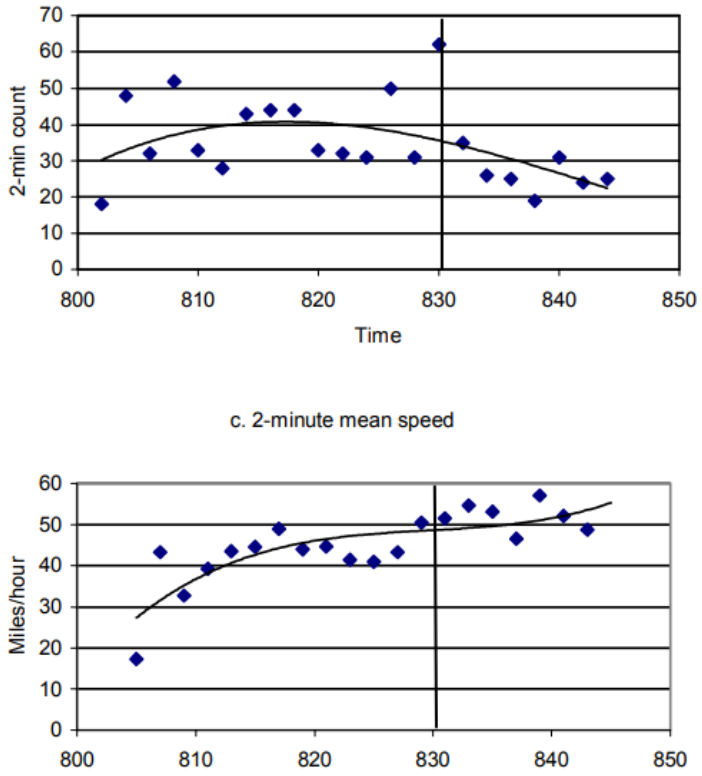
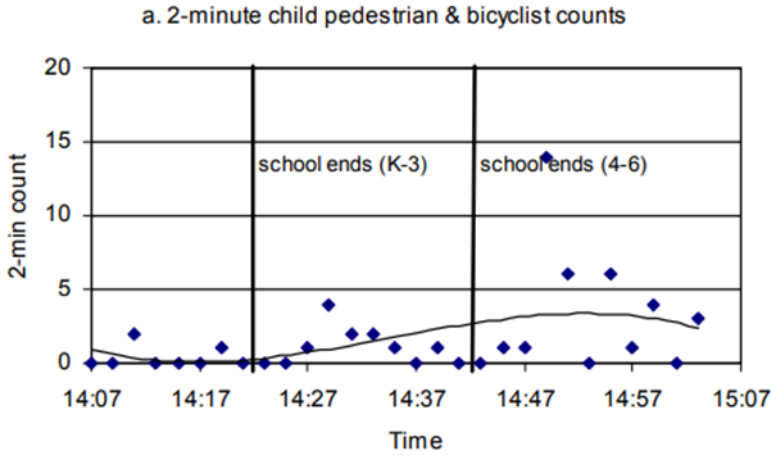


Figure 2.4: Sample examples of Sheldon elementary (before school)



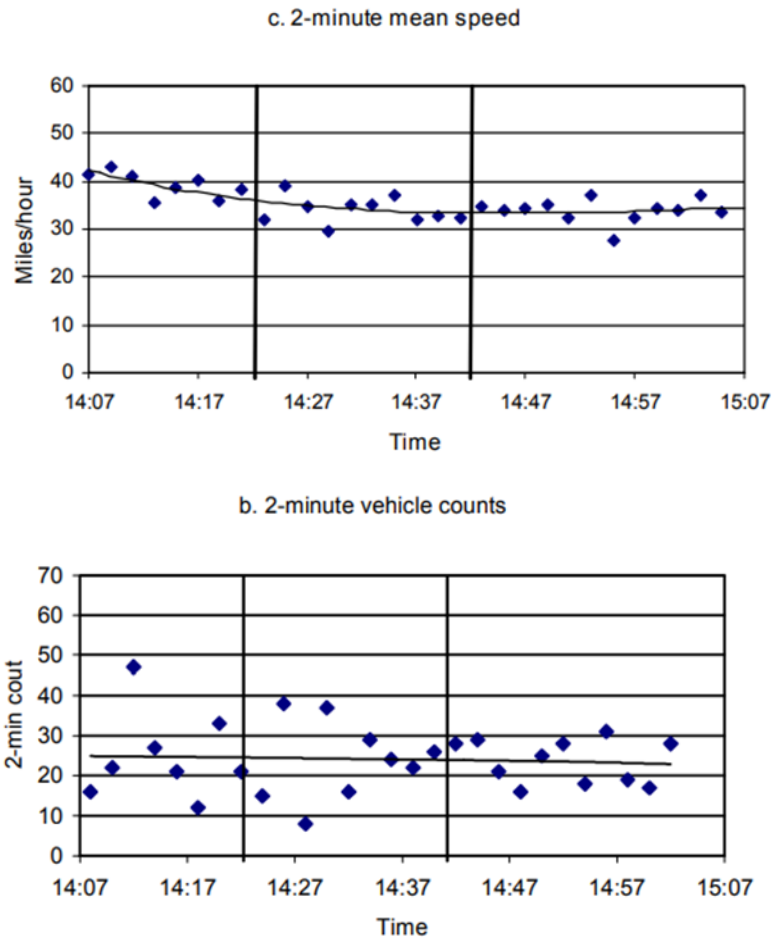


Figure 2.5: Sample examples of Sheldon elementary (after school)

All the school showed a rise in the vehicle sub-count during atleast one of the morning or afternoon in their observation as shown in figure 2.4 and figure 2.5. Given above is an example of Sheldon elementary school.

Based on their finding the classified school as “safe” and “unsafe”. The “unsafe” implies the school which are at risk for pedestrian accident compared to the school with lower traffic speed and volumes.

18. **Rune Elvik (2000)** did a research on cost and benefits of road safety measures for pedestrian and cyclist. They did a research in Norway related to pedestrian and cyclist including the changes in the amount of walking and cycling, changes in time travel,

changes in user behavior and health. According to the researcher the above changes impacts the cost of road safety.

19. **Tonya Russel *et al*. (1999)** research on the safety issues faced in rural areas by the child pedestrian. Research was done in Waipa district. The selected Hautapu School to study in depth about the child pedestrian safety at rural school.

    To obtain the required information various methodologies were applied such as parental survey, classroom discussion, analysis of regulation and policy, key informers interview.

    According to their survey they found that the roads has poor signage and also car parking congestion. 84% responded that the main road safety hazards faced by the children are the Speed, access and visibility. Of 69% responded that access to the school as being problem.

20. **Kwane Ampofo- Boateng and Janes A.Thomson; (1991)** investigate whether the children have the capability to choose between safe and unsafe place of crossing. The children were given with situation which were either safe or dangerous and were asked to identify and select a safe road for crossing.

    They presented the task in different ways

- By presenting photographs of road situation, which included junction, bends, parked cars or other obstruction
- And by taking the children to real roads near their schools zones.

Figure 2.6- Road safety experiment Models

Now from their results they found that 5-7 years judge the roads based on the visible cars and therefore exhibits poor skill in identifying dangerous crossing sites. 9 years olds showed a good level of judgement where else 11-years-olds showed quite good skill in selecting the safest road.

Thus the paper suggested that up to 9 years the children have low ability to recognize the dangerous location and are considerable risk.

2.2. Project Reports

Save life foundation (2019) is based in New Delhi, and has operations in over 10 states and union territories across the country. Save Life Foundation has impacted policy to bring permanent change in road safety India. They did a research on Child road safety in India and found that 91.4% of respondent feel the need of a strong child road safety law. 75.7% parents were not aware of child restraint system (seat belt) and only 20.1 % parents own child helmets. 11.7% of respondents admitted to be driving in the given speed limit while traveling the school zones. According to the survey most children responded that their parents were not following the traffic rules strictly. Only 28.2% parents were abiding by the traffic rules. They recommended that child helmet should be made mandatory. Speed calming measures, reduced speed limits should be introduce near school zones and also strict penalty action must be applied on violation of child safety laws.

Apart from Save Life Foundation, Other two NGO groups working towards the road safety awareness with the school children are Patiala Foundation from Patiala and Muskaan NGO in Jaipur. They basically conduct surveys on current accident and road safety metric of their constituencies apart from running massive awareness drives to reach out to various schools and institutions to strengthen the Education part of road safety amongst school going children and local authorities.

2.3 Global Guidelines

1. **World Health Organization & UNICEF (2008)** researched on child road safety injuries and found that 5 to 14 years are more at risk and also child pedestrian make up 3-15% of injured children. Boys are almost twice as likely as girl to be involved in road accident. They suggested some measures to reduce traffic accident such as to use protective equipment in vehicle, avoid drinking while driving, encouraging to use helmet for cyclist and motorcyclist, establishment and enforcing reduce speed near school. Establishing separate lane for cyclist and sidewalk for pedestrian can reduce road traffic injuries for children.

2. **IRAP,** International Road Assessment Programme**,** a private organization along with government, research institute and NGO's are working on improving the roads to make a safer environment. They did a study for improving school environment and found that the collisions between pedestrians and vehicles mostly occur due to walking in the vehicle routes, while crossing the road, children playing on the road, while boarding or alighting public transport vehicles. Thus to reduce pedestrian traffic collision proper improvement of infrastructure is needed. Star rating concept.

2.4. Government Policy based Guidelines (India)

1. **NRSP, National Road Safety Policy (2018)**

   In 2018, the government of India had formulated a National Road Safety Policy, according to which the safety of vulnerable road users shall be considered important.

Children are considered as vulnerable road users, since their cognitive skills to react to complex traffic situation are not fully developed. Further, the design and construction of all road spaces and movement areas (rural and urban) will be done keeping in mind their safety.

2. **Road safety audit (IRC SP 88- 2010)** a manual of Road Safety Audit by Indian Road Congress has suggested some principles for Road design to make the road safer for road user as well as for pedestrian. Vehicles parked on sidewalk affect the safety of Pedestrian. Pedestrian should be segregated from the vehicles as pedestrian are significant group of vulnerable road users, therefore they should be given detailed attention for their safety. Certain guidelines are given related to crossing, junction, road width, curve, road signs, and Parking space.

3. **Indo-HCM** some guidelines are given related to pedestrian facilities which should be considered to make a safe pedestrian environment. According to Indo-HCM the minimum space required for a pedestrian to walk freely on road is 0.35m x0.51m (total area of $0.18m^2$) without baggage and with baggage it is 0.52m x 0.51m ($0.26m^2$). Different crossing facilities are mention for pedestrian safety such as zebra crossing, signalized crossing, pelican crossing, puffin crossing, and toucan crossing. Stairways can also be use were ever necessary to reduce the conflict between the vehicles and the pedestrian while crossing.

4. **IRC 103-2012 "Guidelines for Pedestrian facilities**" the Indian Road Congress has given some guideline related to school zone improvement to make a safer environment for the children while communication to and from school. The school should not be located in arterial roads and should have safe routes for walking and cycling to and from school. The footpath should be wider near school so that larger group of child pedestrian can walk and need to be kept clear from obstruction. Separated drop off and pick up area should be provided near school to reduce congestion.

CHAPTER 3

STUDY AREA

3.1 SELECTION OF STUDY AREA:

The study area chosen is South Delhi because it is the center of major activities like residences, shopping, administrative buildings in Delhi, also it is one of the properly designed areas of Delhi after independence. It lies centrally to the Delhi-NCR Megacity.

The study Area selected is South-Delhi. South Delhi has more than 50 schools including government school, Private School and Physically Disable School out of which we selected 20 eligible schools based on their location which are listed in the table 3.1.

The schools which are selected are mostly in Haus Khas, RK Puram, Safdarjung, Saket, Malviya Nagar, Chattarpur, Vasant Kunj. The selected schools include both government and private schools.

Figure 3.1: Google Map view of study Area in South Delhi

3.2 LIST OF SCHOOL SELETECTED FOR DATA COLLECTION ALONG WITH THE REASON FOR SELECTION:

Table 3.1: List of school along with their location.

Serial No.	Name of School	Location	Reason for selection
1	DAV Model School	Yusuf Sarai Road name: Sri Aurobindo Marg	Private school situated next to the Green Park metro station and also near commercial area.
2	General Raj Public school	Yusuf Sarai Road Name: Balbir Saxena Marg	Private school situated in commercial area and near intersection.
3	Laxman Public School	Near Hauz khas metro Station Road Name: Outer ring road and Sri Krishna Chaitanya Mahaprabhu Marg	The school is located near intersection and also near Hauz Khas Metro station.
4	SDMC Primary School, Hauz Khas	Hauz Khas Village Road Name: Hauz Khas Fort Road	Government school situated near Hauz khas Fort.
5	Asha Hai	Hauz Khas Road Name: Hauz Khas Road	The school is for Physically challenged student
6	The Mother's International School	Kalu sarai Road Name: Sri Aurobindo Marg	Private school situated near the busy 3 lane road.
7	SDMC Primary Co-Edu School	Adhchini, Near NCERT Road Name: Sri Aurobindo Marg	It's a government school and is located in the busiest road i.e Sri Aurobindo Marg.
8	BND Public School	Katwaria Sarai	Government school till class 5, situated in Residential Area with no proper Road.
9	Saint Anthony senior Sec school	Safdarjung Development Area, hauz Khas Road Name: Jaideep road	Private school situated in residential and also near commercial area.
10	Saint Anthony Pre-Primary school		
11	St. Paul's School	Safdarjung Development Area, hauz Khas Road Name: Gate No 1 Road	Private school situated in residential area and next to Kailashpati Mandir.

12	Learning Tree Play School	Malviya nagar Road Name: Late Tirath Ram Sharma Marg	Play School Situated in Residential Area at the back of Pt. Madan Mohan Malviya Hospital
13	Ishani Government Sarvodaya Kanya Vidyalaya	Saket Road Name: Saket road	Government school near market Area (PVR Anupam) and near another school SDMC primary school
14	Amity International School	Saket M Block Road name: Saket Road	The school is located in front of another school i.e Government boys senior secondary school
15	Apeejay School	J-Block, Saket Road Name: Gurudwara Road	The school is located near the residential area
16	St. Mary's Junior School	Neb Sarai Road Name: IGNOU main Road	The school selected as it is located at the curve of the busiest Road i.e. IGNOU main Road
17	Little Millennium	Neb Sarai Road Name: IGNOU main Road	Play school selected as it is located at the curve of the busiest Road i.e. IGNOU main Road
18	Gyan Jyoti Public School	Chhatarpur Road Name: Shivalaya Road	School is located near market area with no proper road.
19	World of Kid Play School	Chhatarpur Road Name: Chhatarpur Temple Road	Play school selected since it is located near intersection and Market area
20	The Heritage school	Vasant Kunj Road name: Abdul Gaffar Khan Marg	Private school Situated near two intersection
22	DPS RK Puram	RK Puram , Sector 12 Road name: Kaifi Azmi marg	Private school located in 4 lane road

23	Kendriya Vidyalaya	Old JNU campus Ber sarai Road name: Baba Gang Nath Marg	School situated near JNU campus

3.3 The Existing Condition of Study Area:

The current condition of road near the school are surveyed to check whether they have proper roads, pedestrian sidewalk and Guard rail available. The study found out that out of the selected 20 schools only 12 schools have pedestrian sidewalk and only 3 have sidewalk Guard rail. The graph below shows the school having sidewalk as well as fencing. If the school have sidewalk then it is taken as 1 and if not then counted as 0. Same in case of fencing, if pedestrian fencing available then it is taken as 1 and if not is counted as 0.

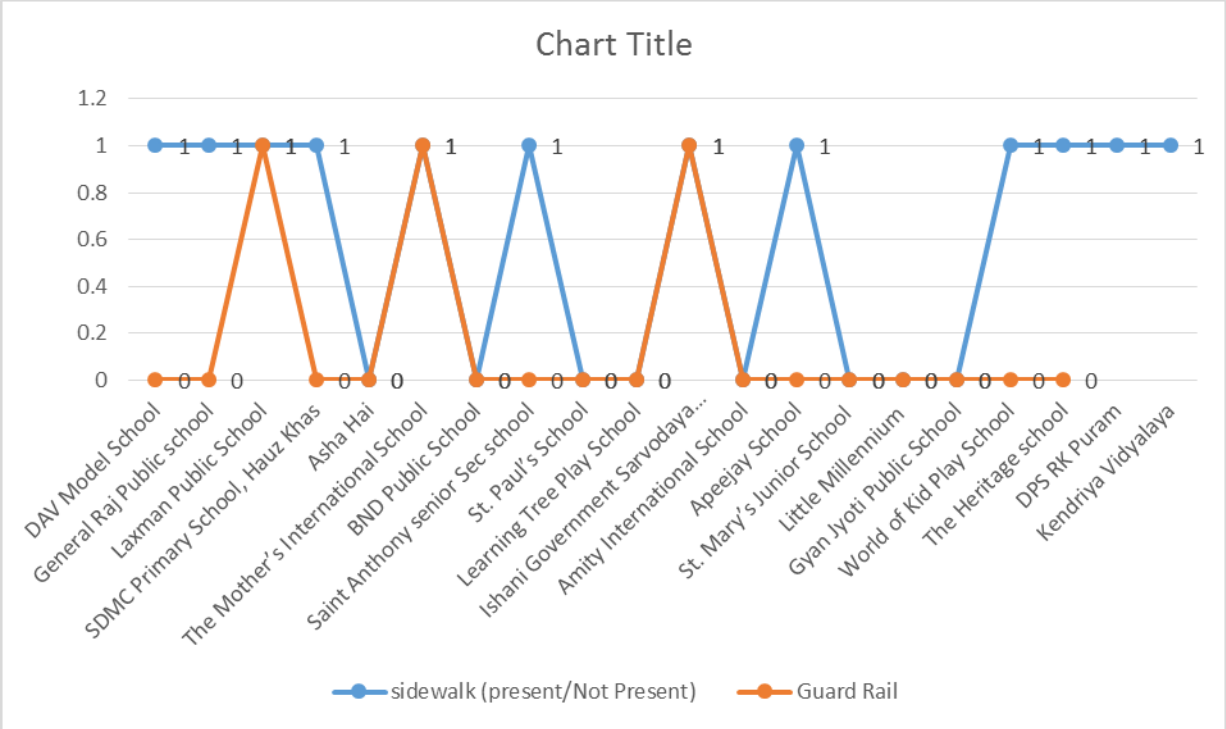


Figure 3.2: School vs Pedestrian sidewalk and Fencing

Figure 3.3: The existing condition near SDMC public co-educational school

The Picture above is the condition near SDMC public co-edu school, it has not proper sidewalk and has no guard rail and also vehicles are parked on the sidewalk leaving no space for pedestrian movement.

Figure 3.4: The current road condition near The Heritage School

The above picture, the surface of the sidewalk is uneven and also vehicles are parked on the sidewalk.

CHAPTER 4

DATA COLLECTION AND METHODOLOGY

4.1. DATA COLLECTION

After the study area is decided and the eligible schools are selected, we conduct the surveys. We selected 20 school for sample collection. The survey took almost 2 and half months starting from January till March 2019.

A survey format was designed to collect information on pedestrian road safety and some other related important factors such as distance between home to school. Basic data collection and other relevant parameters were identified after going through the literature and were adapted to the existing scenario of South Delhi.

Demographical Information (for example age of children, gender, educational background of parents) household information (example monthly income, vehicle ownership) were included in the questionnaire. A total of 500 samples for perception survey was collected. The data collection took place during the day time in the peak hours to observe the pedestrian movement and the conflicts area near the school zones.

The Data required for the study of Road safety required mainly the study of existing road facilities, the volume of pedestrian walking to and from school and also the safety perceptions of the parents, faculty staff and the students. The Data is collected in 3 formats –

a) Pedestrian Perception Survey

b) Pedestrian Infrastructure Inventory Survey

c) Pedestrian Volume Count.

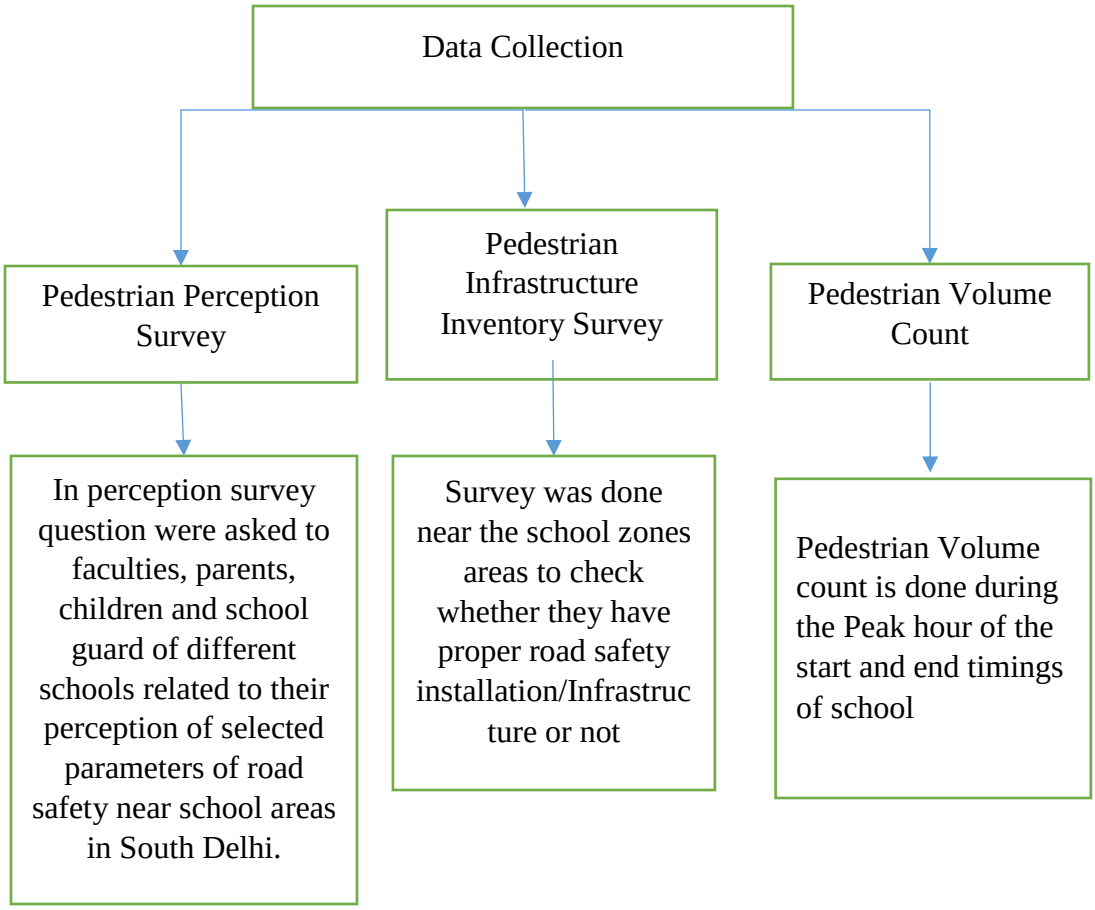


Figure 4.1 Methodology of Data Collection

4.2. PERCEPTION SURVEY:

Out of the 23 school selected few didn't allow to take the perception survey and 2 others were having board exams due to which perception survey could not be done. However Inventory and volume count survey were done for the same.

Before starting with the survey we contacted the school Principals and authorities of the schools for permitting us to collect the data. Some of them also helped with the data collection by distributing the perception survey format to the students and parents.

For Perception survey a questionnaire format was distributed to the faculty, parents, and students. The Principals of few schools helps me in distributing the format. The format was given to the students to home so that their Parents fill it. The formats are collected by next day or after two three days. The schools where we couldn't meet the Principal or the concern authorities, in that

case we went to the schools during the school start and end time and meet the parents and fill up the forms. Also for some school we email the concern authority for collecting the Perception Format.

4.3. INVENTORY SURVEY

Now for Inventory survey, we took help from IRAP (a Non-government organization of Delhi) and took their format for survey, with their permission. The Format consist of 30 question. The question are about like No of lanes, Width of lane, Road condition, Street light etc.

The Inventory survey took 2 months since all the schools are in different location and in one day only one school can be completed. The Inventory survey is done near the school areas and at a radial of 500 meter from the schools.

4.4. PEDESTRIAN VOLUME COUNT

For Pedestrian Volume count, we selected 20 schools. The volume count was done during the peak hours i.e. one hour during the start and the end time. Since the schools have different start and end time therefore the volume count was taken in different time for different school. The volume count was taken half an hour before start of the school till half an hour after start.

4.5. STUDY METHEDOLOGY

A Methodology was developed to obtain the data collection and

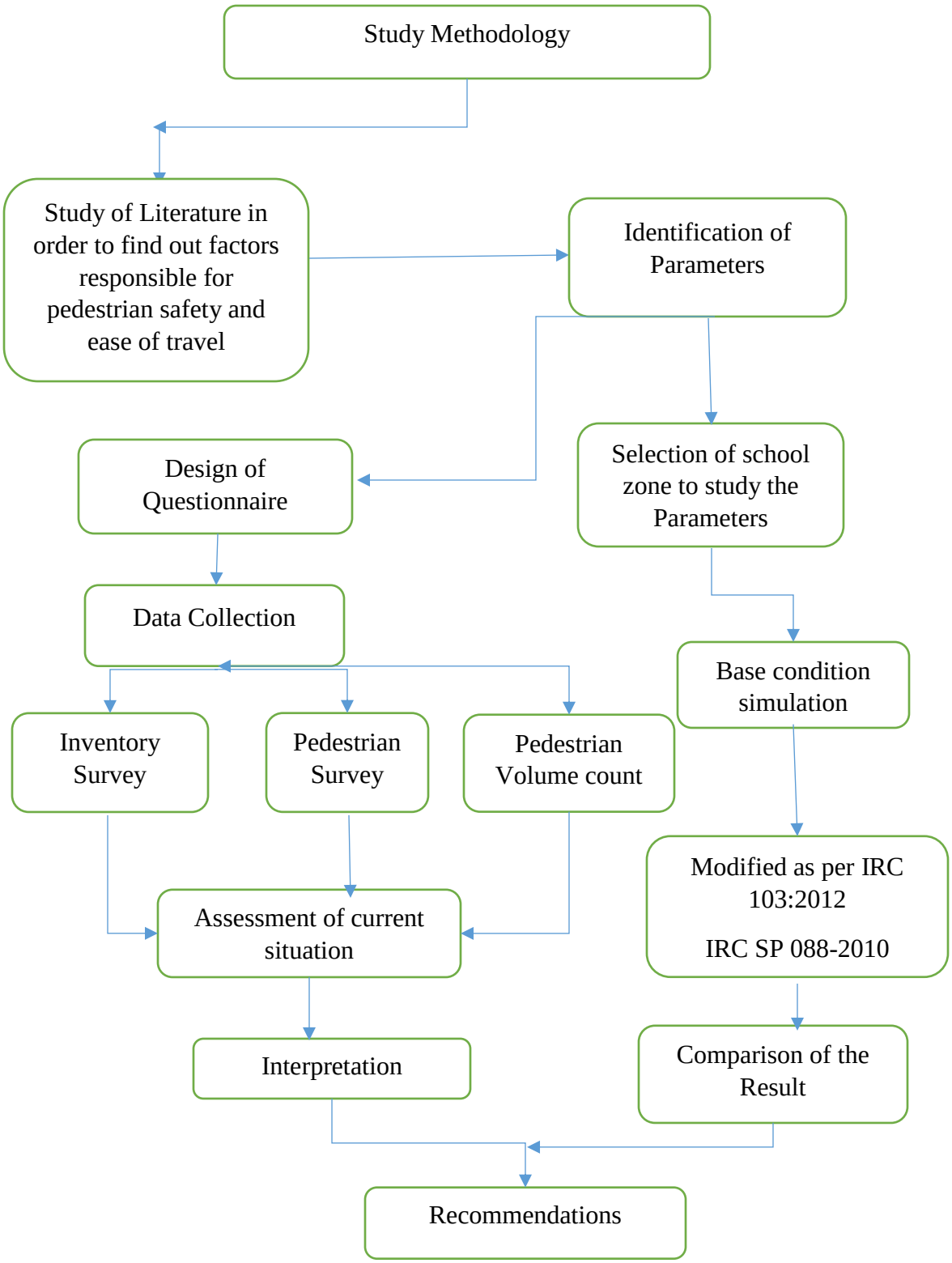


Figure 4.2 Study Methodology of Research Work

Step 1: Study of literature review is done to identify the factors responsible for safety of Pedestrian near the school zone.

Step 2: The relevant problem was identified based on the current condition of roads near the schools.

Step 3: The Questionnaires format were design to collect the data for perception, inventory survey and also for pedestrian volume count.

Step 4: The data collected are filtered to assess the current scenario near school zones.

Step 5: Data Interpretation are done

Step 6: School zone is selected to study the parameters based on the identification from the literature review.

Step 7: The base network is created and further pedestrian attributes added along with vehicular inputs and then simulated to generate result matrix.

Step 8: The network is redesign as per IRC: 103-2012 and IRC SP 88-2010 and other relevant inputs from literature.

Step 9: The simulation design of base network and the redesign network is then compared.

Step 10: Recommendations are made base on the comparison of both the network and the data interpreted from the assessment of current scenario.

4.6 SAMPLE SIZE DETERMINATION

For data collection we targeted a sample size of 385, the targeted data is calculated by using the sample size calculation for large population.

Delhi has a population of 2,258,367 and taking a margin of error (e) as 5% and standard deviation (p) 50% and 95% confidence level (z-score for 95% confidence level is 1.96) we calculate the sample size by the formula

Sample size= $[z^2 * p (1-p)] / e^2$

Calculation:

Sample size= $[(1.96)^2 * 0.5(1-0.5)] / (0.05)^2$

On calculating we get

Sample size= 384.16

Thus the targeted sample size for this research is taken as 385 approx.

CHAPTER 5

ASSESSMENT OF CURRENT ROAD SAFETY SCENARIO FOR SCHOOLS IN SOUTH DELHI:

5.1. EXISTING SCENARIO OF ROADS NEAR SCHOOL AREA IN SOUTH DELHI

The Objective of this research was to examine the current road safety scenario for school in South Delhi. The purpose of this objective is to plan safer roads for child pedestrian when travelling to and from school. To achieve this goal, we surveyed 20 schools in South Delhi based on their location and mode of transportation available nearby. Now the 20 schools were surveyed in two formats for the existing condition. Firstly the Inventory Survey secondly, the Perception survey.

5.1.1. Inventory Survey

The main motive of inventory survey is to examine the current road condition near school areas, whether proper road safety installation are available near the school zones, condition of footpath, and crossing facility etc.

The Procedure used for Inventory Survey are:

- Visiting the location as per the survey schedules.
- Viewing the location from different approaches and taking photographs accordingly
- Examine the footpath and roads near the school.
- Checking for school marking and signage.
- Checking for technical faults

The Data collected from inventory survey for different schools in South Delhi is shown in Table 5.1 below.

Table 5.1. Element observe in study area location:

School	Location	sidewalk (present/Not Present)	Pedestrian Fencing (P/NP)	No of lanes	Shoulder Rumble Strip	School Warning	Speed Limit Signage near school	Speed Mangement(P/NP)	Median Type	Crossing Type
DAV Model School	Yusuf Sarai	Present	Not Present	3 lane Divided	Not Present	None	40	Present	Metal Barrier	Marked
General Raj Public school	Yusuf Sarai	Present	Not Present	2 lane Divided	Not Present	Yes (School Ahead)	30	Not Present	Metal Barrier	marked
Laxman Public School	Hauz Khas	Present	Present	4 lane Undivided	Not Present	Yes (School Ahead)	40	Present	None	Subway/ crossing Light
SDMC Primary School, Hauz Khas	Hauz Khas	Present	Not Present	3 lane Divided	Not Present	None	50	Not Present	Metal Barrier	Marked
Asha Hai	Hauz Khas	Not Present	Not Present	2 lane Undivided	Not Present	None		Not Present	None	None
The Mother's International School	Kalu Sarai	Present	Present	3 lane Divided	Not Present	school ahead sign	50	Not Present	Metal Barrier	marked/ Crossing light
BND Public School	Katwaria Sarai	Not Present	Not Present	2 lane Undivided	Not Present	None		Not Present	None	None
Saint Anthony senior Sec school	Safdarjung Development Area,	Present	Not Present	2 lane Undivided	Not Present	None		Not Present	center line	None

St. Paul's School	Safdarjung Development Area,	Not Present	Not Present	2 lane Undivided	Not Present	None		Not Present	None	None
Learning Tree Play School	Malviya Nagar	Not Present	Not Present	2 lane Undivided	Not Present	None		Not Present	None	None
Ishani Government Sarvodaya Kanya Vidyalaya	Malviya Nagar	Present	Present	2 lane Divided	Not Present	Yes (School Ahead)	40	Present	concete Barrier	Marked
Amity International School	Saket	Not Present	Not Present	2 lane undivided	Not Present	Yes (School Ahead)	50	Present	center line	None
Apeejay School	Saket	Present	Not Present	4 lane Undivided	Not Present	Yes (School Ahead)		Present	marked	None
St. Mary's Junior School	Nebsarai	Not Present	Not Present	2 lane Undivided	Not Present	None		Not Present	None	None
Little Millennium	Nebsarai	Not Present	Not Present	2 lane Undivided	Not Present	None		Not Present	None	None
Gyan Jyoti Public School	Chhatarpur	Not Present	Not Present		Not Present	None		Not Present	None	None
World of Kid Play School	Chhatarpur	Present	Not Present	2 lane Divided	Not Present	None		Not Present	concete Barrier	marked
The Heritage school	vasant Kunj	Present	Not Present	4 lane Undivided	Not Present	None		Not Present	None	None

DPS RK Puram	RK Puram	Present	Not Present	2 lane Divided	Present	Yes (School Ahead)	30	Present	Divided 0-1 meter	Marked (Present on Main Road)
Kendriya Vidyalaya	Ber Sarai	Present	Not Present	4 lane Divided	Not Present	Yes (School Ahead)	40	Present	concete Barrier	None

Some Pictures showing the current condition of roads and sidewalks near schools in South Delhi

Figure5.1: Sidewalk, Laxman Public School, Hauz Khas

The sidewalk seen in the picture above leads to the school main gate of Laxman public school and during peak hours i.e. during the school start and school closing time when number of children enter and leaves the school by this sidewalk, these vehicles parked in the sidewalk minimized or make the road congested for the child pedestrian to walk on.

Figure 5.2: Condition near SDMC Primary co-Edu School

In the above picture we can see that the area near the school is not paved or uniform surface hence it may create problem in walking.

Figure5.3: Sidewalk in-front of DPS, RK Puram

The picture showed here have no Railing and the car parked is very close to the sidewalk therefore pedestrian may be at risk while walking to and from school.

Figure 5.4: Sidewalk near SDMC School

This picture shows a proper condition of sidewalk as the tress are planted at the side of the sidewalk giving a proper passage for the pedestrian, although guard rail should be provides to avoid vehicle parked on the sidewalks.

Figure 5.5: Sidewalk condition near SDMC co-Edu School

The above picture shows the inadequate footpath width near the school and thus forcing the children to walk on roads. The school children are a part of the vulnerable road users and walking

amongst the vehicles in a mixed traffic condition is a hazardous situation which may lead to serious conflicts.

Figure 5.6: Sidewalk in-font of The Heritage School.

The picture shows the Vehicles parked on the sidewalk and thus forcing the pedestrian to walk on the edges spilling over the road area.

Figure 5.7: sidewalk condition near The Heritage School

The picture above shows the distorted geometry of sidewalk and also vehicle parked on roads leaving very little space for the pedestrian to move. Also, there is no guardrail to demarcate a boundary of walking area between the vehicular movement and the pedestrian.

Figure 5.8: Road condition near Saint Anthony School

The above picture shows the road condition near Saint Anthony School. No sidewalk is available near the school area and vehicles are parked on the road leaving no space for pedestrian to move.

Figure5.9: Road condition near World of of Kid Play School, Chhatarpur.

The above picture we can see the two wheelers are parked on sidewalk and also sidewalk uneven with no guard rails. Separate drop off and Pick up zone should be provided to avoid Vehicles Park on sidewak.

Table 5.2: No of school having particular Infrastructure:

	Available	**Not Available**				
No of School where Pedestrian sidewalk present	12	8				
No of school having pedestrian sidewalk fencing	3	17				
Shoulder Rumble strip	1	19				
School Warning	8	12				
Speed Management Present	7	13				
Crossing Available	8	11				
Land Use	**Under Developed**	**Residential**	**Commercial**	**School**		
	0	9	8	3		
Vehicle Parking	**None**	**One Sided**	**Two sided**			
	1	6				
Road Condition	**Good**	**Medium**	**Poor**			
	9	4	7			
Intersection Type	**None**	**3 leg**	**4 leg**	**Curve**		
	6	9	2	3		
Speed Limit (Km/Hr)	**20**	**30**	**40**	**50**	**60**	**None**
		2	4	3		11

5.1.2. PERCEPTION SURVEY:

In order to understand the road user's perception on the traffic safety issue, perception survey was conducted. The purpose of the survey was to identify the level of road user/parental concern regarding the pedestrian safety near school areas in South Delhi.

A two page questionnaire consisting of 18 question (Appendix A) which includes question related to traffic safety, age of children, distance from home to school and vice versa and mode of transportation.

In few schools questionnaire was sent home so that parents can fill it. And in school where question couldn't be distributed there during the school start and end time we met the parents who came for dropping their child and ask them to fill the questionnaire. Few children who took the questionnaire to home fail to return the formats due to which the target no of data's were not achieve. A total of 350 Perception survey was collected from different schools in South Delhi.

Table 5.3: Percentage of Response (Inventory Survey)

	Yes	**No**				
Crossing Available	150	176				
Accompanied by Parents or Adult	167	183				
Supervisor Allotted	96	120				
Car driving Rate	**Very Fast**	**Fast**	**Normal Speed**	**Slow Speed**		
	49	121	92	28		
	Very Easy	**Easy**	**Somewhat Easy**	**Faced some problem**	**Difficult**	
Easy pick up and drop off	55	82	79	42	49	
	On a roadway	**In a Driveway**	**In a parking lot**	**Opposite side of Roadway**	**In front of school**	**Others**
where children are dropped	91	46	50	37	37	29

5.1.3. PEDESTRIAN VOLUME COUNT

Pedestrian volume count is done during the Peak hour for example start and end of school and an Inventory survey is done at a radial of 500 meter near school areas.

Pedestrian volume counts are taken in 15 minutes interval. The format of pedestrian volume count is shown in appendix B.

For an example -

S.D.M.C primary co-edu School: The school timing of SDMC primary school starts from 10 am in morning till 1:30 pm in afternoon.

Pedestrian volume count is taken during start and end time of school i.e. from 9:30am to 10:30 am in morning and from 1pm to 2pm in afternoon.

5.2. ANALYSIS OF CURRENT SCENARIO:

5.2.1. ANALYSIS OF INVENTORY SURVEY

After the analysis from the Inventory survey done for the selected 23 schools it was found that 40% school do not have Pedestrian sidewalk near school. 85% school do not have sidewalk guardrail. 95% school don't have rumble strip. 60% of school do not have school warning signage. 65% school do not have speed management and 55% school do not have pedestrian crossing facility. The Figure 13 shows the Road infrastructure facility available near school areas.

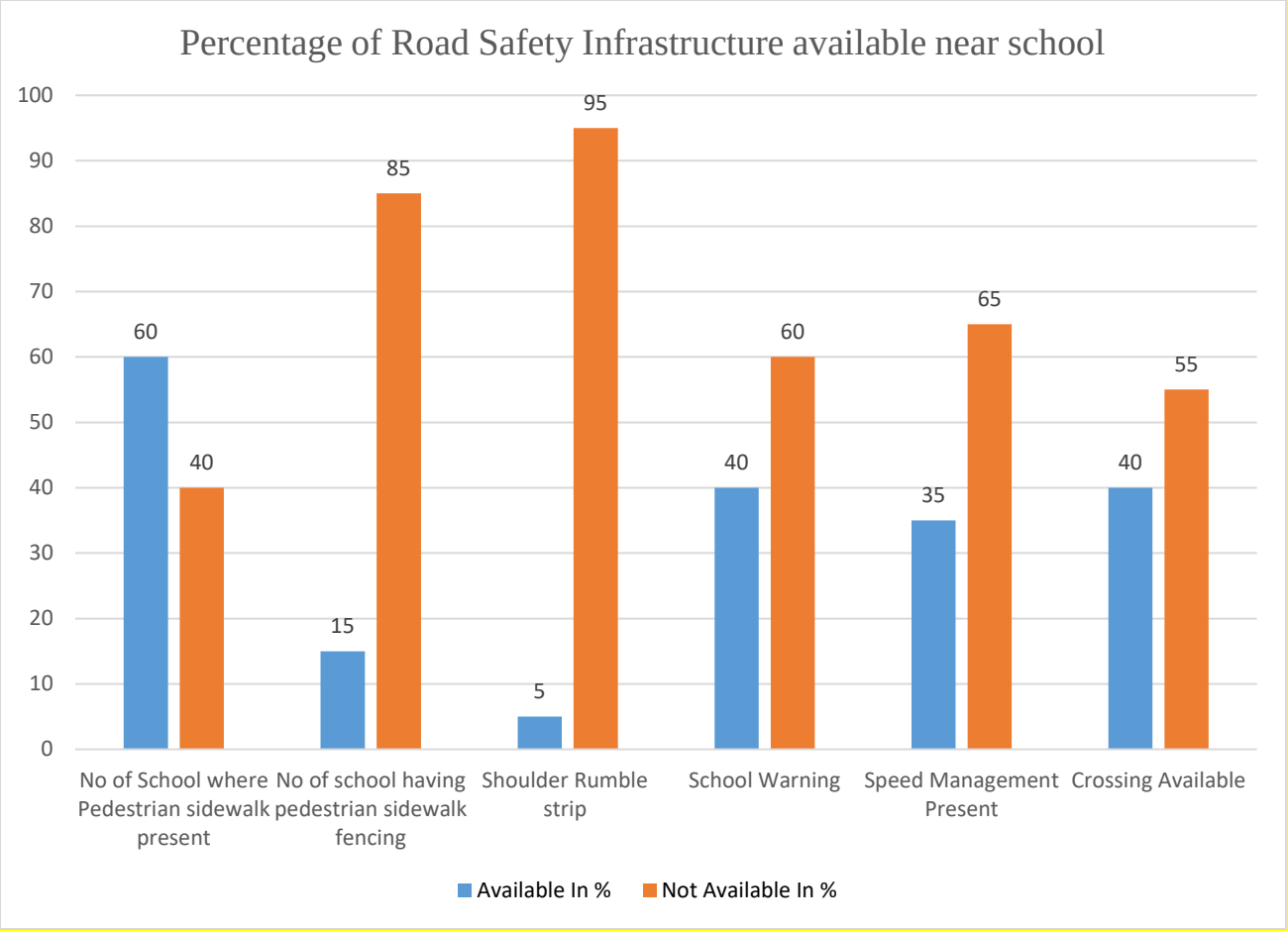


Figure 5.10: The graph between percentages of school vs Road Infrastructure

From the Inventory survey we found out that out of 23 selected school 45% schools are located in the Residential area of south Delhi. 40% schools are located in commercial places and 15% schools have other schools and institute nearby (table 5.4).

In 60% school vehicles are parked on two side and 30% school, vehicles are parked on one side. Only 5% school have no car parking near school entrance. The percentage of school where vehicles are parked on both the side has lot of congestion during the peak hours.

35% of school have poor road conditions. 20% of school have medium road conditions.

55% of schools have no speed limit signage near school areas. The table 5.4 below shows the percentage of school having the listed infrastructure near school zones.

Table 5.4: Analysis of Inventory Survey

	Under Developed	**Residential**	**Commercial**	**School**		
Land Use	0%	45%	40%	15%		
	None	**One Sided**	**Two sided**			
Vehicle Parking	5%	30%	60%			
	Good	**Medium**	**Poor**			
Road Condition	45%	20%	35%			
Intersection Type	**None**	**3 leg**	**4 leg**	**curve**		
	30	45	10	15		
	20	**30**	**40**	**50**	**60**	**None**
Speed Limit (Km/Hr)		10%	20%	15%		55%

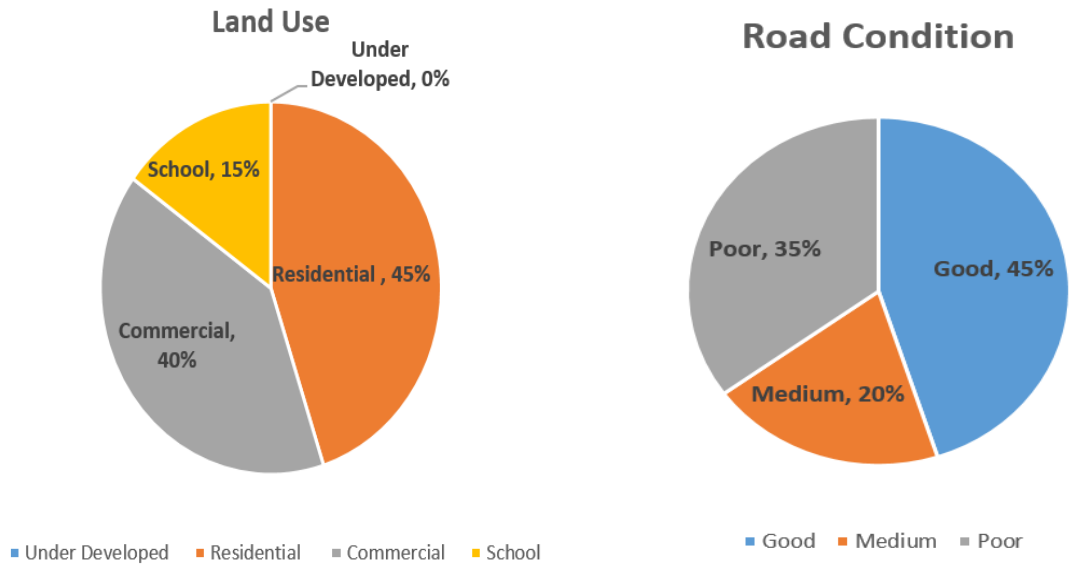


Figure 5.11: Distribution of Road condition and land use near school areas

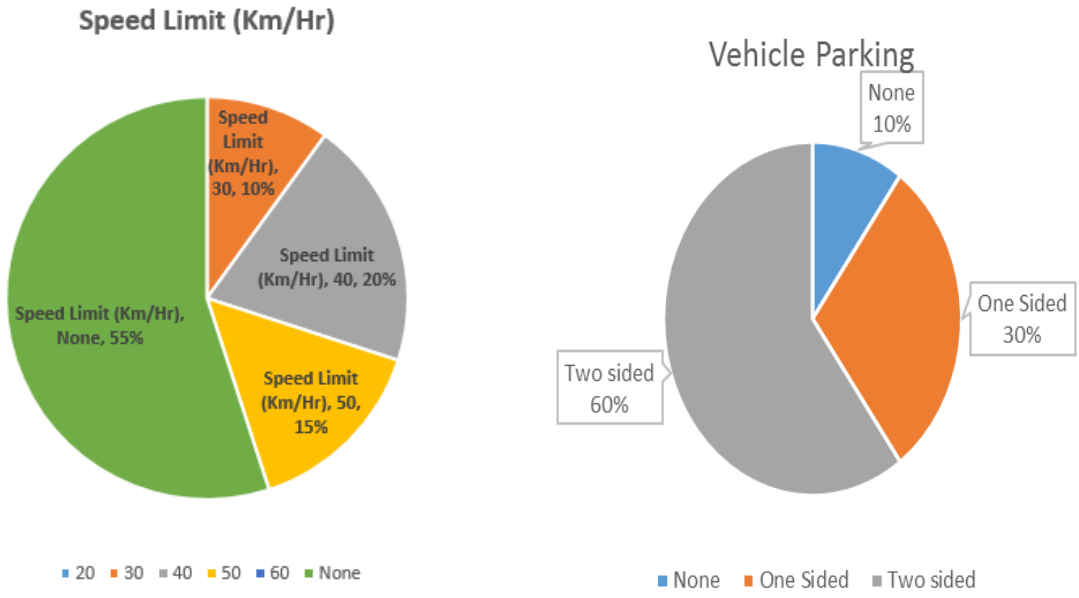


Figure 5.12: Distribution of Vehicle parking and speed limit

5.2.2. ANALYSIS OF PERCEPTION SURVEY

Nearly 500 questionnaire survey forms were distributed in the selected 20 schools, of these 382 were returned, resulting in a response rate of 76%. After quality check 350 response were considered suitable for analysis.

Of these responses 14% responded that the rate of car driving near the schools are very fast whereas 35% responded that they find the car driving rate are fast (Table 5.6).

14% responded that the school drop off and pick up is difficult as shown in table 9, whereas 12 % responded that they faced some problem while dropping off and pick up.

10.50% of children are dropped off in the opposite side of Roadway.14.30% are dropped off in the parking lot and 13% are dropped in a driveway.

From the survey we found that 27.70% used private vehicle and 35.40% walked to and from school (table 5.5).

Table 5.5: Analysis of Perception survey

	IN PERCENTAGE				
	Private Vehicle	**Bus**	**Metro**	**Auto**	**Walking**
Mode of Transportation	27.70%	8%	7.20%	10.30%	35.40%
	Highly Unsafe	**Unsafe**	**Medium Safety**	**Safe**	**Very safe**
Safety Level when drop off					
	Road Marking	**Traffic signs**	**Informative Signs**	**Mandatory signs like stop, school zone speed limit**	
Visibility of school could be increase	**4.50%**	**21.70%**	**35.70%**	**9.40%**	
	<5 lakhs	**5-10 lakhs**	**10-15 lakhs**	**> 15 lakhs**	
Income of parents	**33%**	**25.40%**	**2.30%**	**0**	

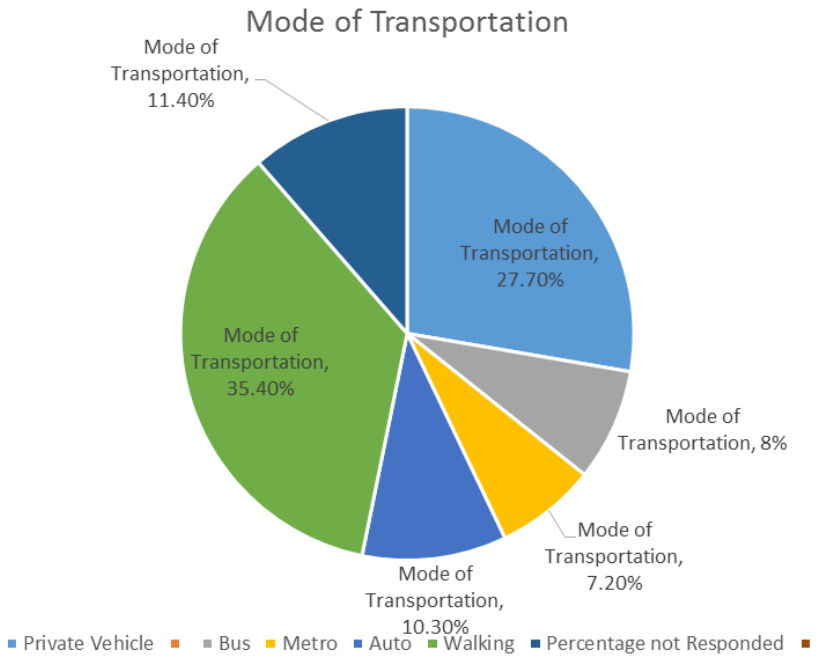


Figure5.13: Distribution as per Mode of transportation

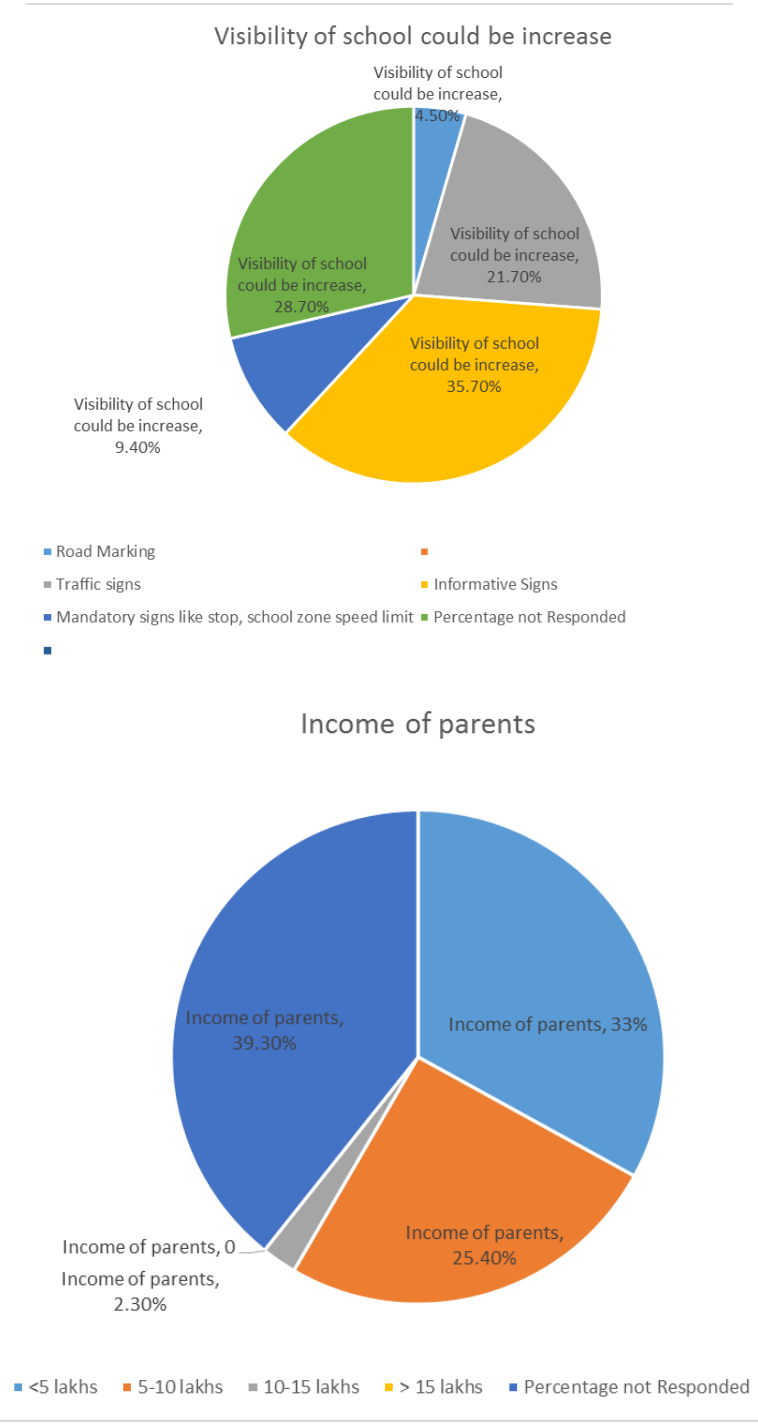


Figure5.14: Distribution of Income of Parents and visibility of school

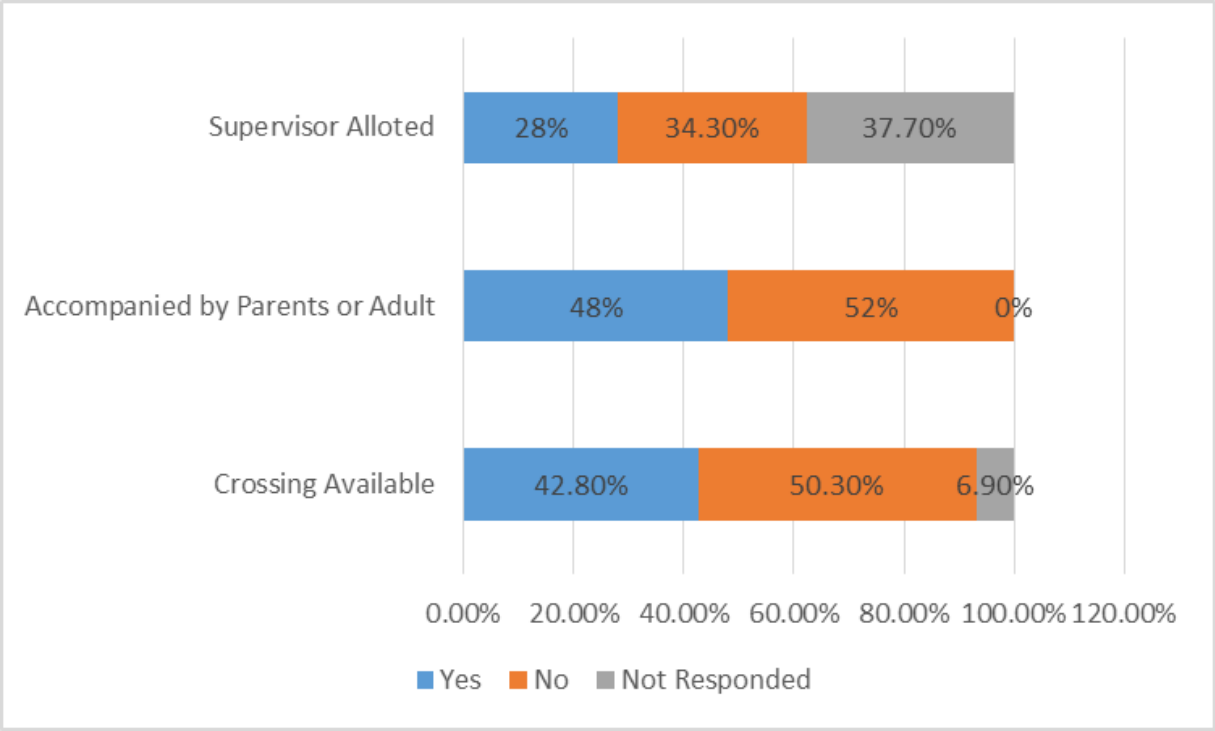


Figure 5.15: Histogram of Perception Survey

Table 5.6: Percentage of respondent in Perception Survey

Car driving Rate	**Very Fast**	**Fast**	**Normal Speed**	**Slow Speed**		
	14%	35%	26%	8%		
	Very Easy	**Easy**	**Somewhat Easy**	**Faced some problem**	**Difficult**	
Easy pick up and drop off	16%	24%	23%	12%	14%	
	On a roadway	**In a Driveway**	**In a parking lot**	**Opposite side of Roadway**	**Infront of school**	**Others**
where children are dropped	26%	13%	14.30%	10.50%	11%	8.20%

5.2.3. PEDESTRIAN VOLUME COUNT:

The Pedestrian volume count during the Peak hours for different schools are shown in the below table 5.7.

Table 5.7: Pedestrian Flow during Peak hour

School	Morning Peak hour Pedestrian Flow	After school peak hour flow
LearningTree	182	206
Gyanjyoti Public School	165	206
World of kid Play school	411	410
The Heritage school	830	767
Apeejay School	714	1094
DAV Public School	758	580
General Raj Public School	602	484
SDMC Primary Co-Edu	277	263
BND Public School	317	203
SDMC School Saket	825	796
Laxman Public school	1059	973
Saint Anthony School	825	779
Saint Paul School	185	281
Mothers International School	475	521
DPS RK Puram	825	812
Kendra Vidyalaya JNU old Campus	406	736

The highest pedestrian flow is seen in Laxman Public School (before school peak hour) and in Apeejay school (After school Peak hour). The reason for this is the strength of both the school is

high and also is located in a busy area where more pedestrian flow is seen. School such as learning tree play school, Gyanjoyti Public school shows low pedestrian count because the strength of student is low. Saint Paul School showed a low volume count because the students were having the board exam due to which only class X student were present. The graph of different volume count is shown in figure 5.16 below.

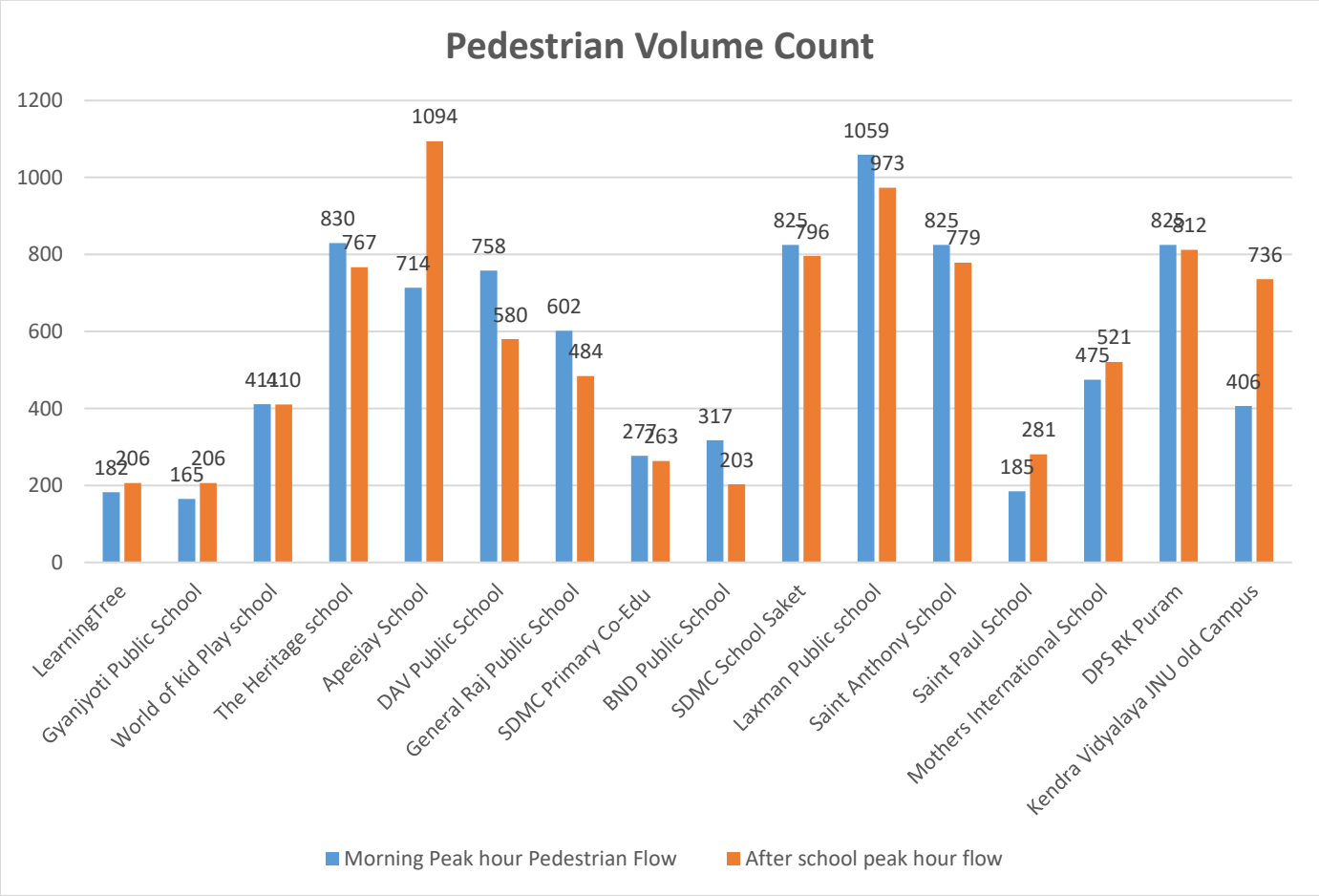


Figure 5.16: Graphs of Pedestrian Volume Count

CHAPTER 6

IMPACT ASSESSMENT OF SCHOOL ZONE RE_DESIGN USING SIMULATION SOFTWARE PTV VISSIM/VISWALK

6.1 ABOUT SIMULATION

A simulation is an approximate imitation of the operation of a process or system. For simulating n object it first requires a model which represent the key characteristic such as behavior, function and other physical properties. Traffic simulation is used to plan, design and operates the transportation system. Various national and local transportation agencies, construction firm use simulation based software to understand the transportation network.

Simulation in transportation is important because it can study the complicated models for analytical and numerical treatments and can produce visual demonstration of present and future scenarios.

6.2. ABOUT PTV VISSIM/VISWALK

6.2.1. ABOUT SOFTWARE

PTV Vissim and Viswalk are simulation software developed by German Company Planung Transport and Verkehr AG (PTV). PTV Vissim is the leading software for microscopic simulation program where both vehicles and pedestrian are simulated within a larger area. PTV Vissim is based on the Wiedemann's car following model, a rule based lane changing model. And PTV Viswalk id based on Social Force Model for Pedestrian Dynamic.

It is use for modelling urban and rural traffic as well as pedestrian flow. It belongs to the Vision Traffic Suite software. It provides realistic and accurate flow of traffic. PTV Vissim allows user to construct link and connector with any level of complexity. It further provide the user to use other system like signal controllers, traffic management or emission models.

The Viswalk program is embedded to Vissim which allow user to simulate both pedestrian vehicle flow and also pure pedestrian flow.

6.2.2. APPLICATION OF SOFTWARE

PTV Vissim is used for modeling pedestrian flow along with urban and rural traffic. In PTV Vissim a user can model both private transportation (PT) and public transportation (PuT) such as rood and rail based public transport.

It is simulated under various constraint such as signal head, lane distribution, and vehicle composition, waiting areas and making route choice. Vissim allows the user analyse the conflict araes and also the vehicle travel time, waiting time etc.

PTV Vissim/Viswalk helps the user to understand the current infrastructure in the cities and to improve the infrastructure where the pedestrian volume is high.

Vissim may be deployed to answer various issues. The following use cases represent a few possible areas of application

- Model various junction geometries.
- Simulate the traffic in multiple nodes
- Analysis the impact of urban development plans
- Investigate the visualised traffic in microscopic level.
- Models all details for bus, subways, and light rail transit and commuter rail operation.

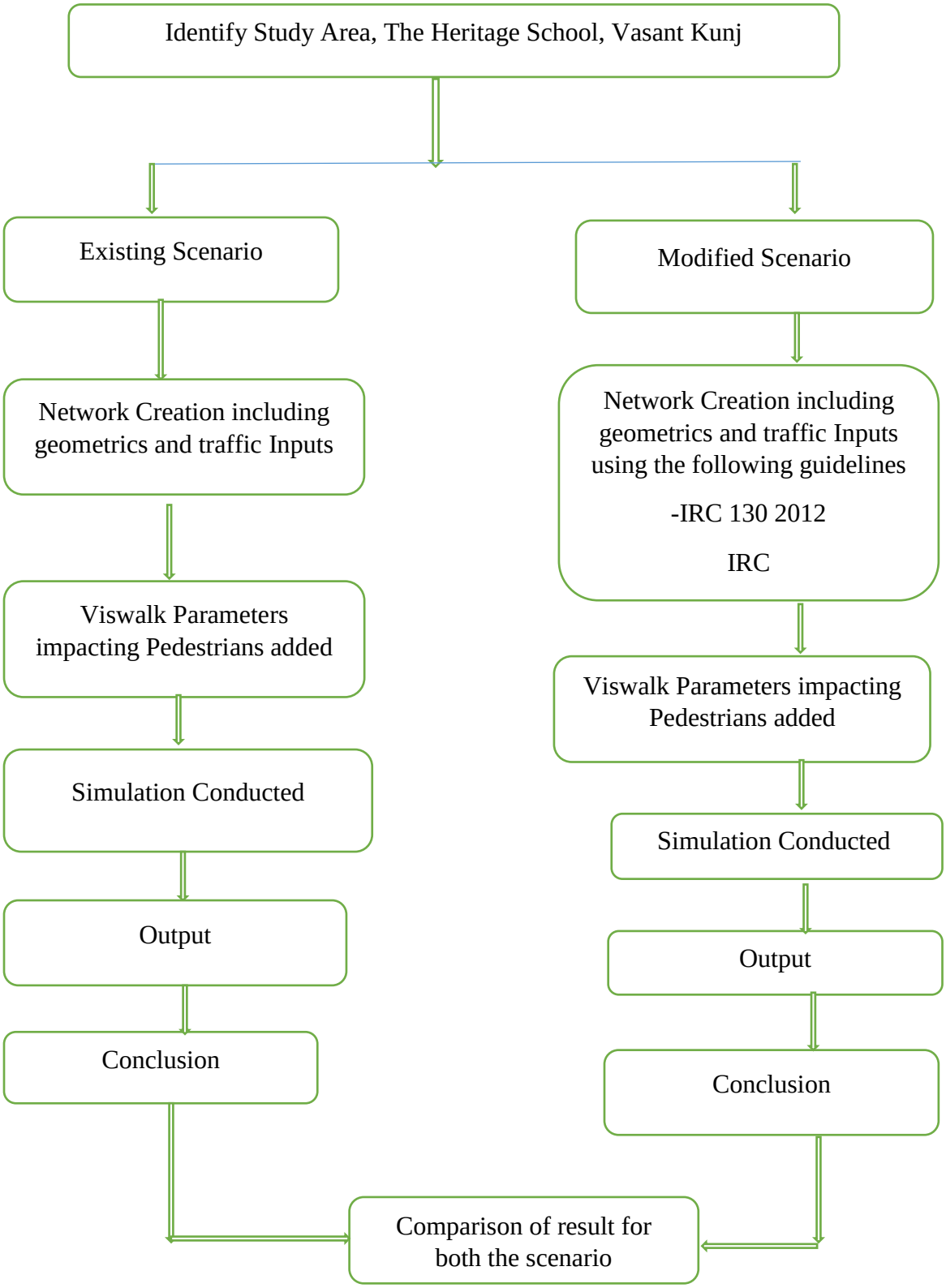
6.2.3. DETAILS ABOUT PTV VISWALK

In Pedestrian simulation PTV Viswalk is the leading software which is based on Social Forced Model. It reproduce the walking behaviour of pedestrian in the roads.

PTV Viswalk is use where pedestrian volume is high. For example to construct a large building such as Central station where pedestrian volume is large. By using Viswalk simulation we can analyses the pedestrian walking behaviour and the route choice. It allows the pedestrian to move more realistic.

However PTV Viswalk alone cannot simulate the vehicle flows. To simulate both vehicle and pedestrian flow we have to use PTV Vissim.

6.3. IDENTIFYING STUDY AREA, THE HERITAGE SCHOOL, VASANT KUNJ



The Study area taken for the simulation software is The Heritage School, Vasant Kunj, Delhi which is situated in Abdul Gaffar Khan Marg Road. The school is situated in the Residential area on left and in right it has a 3 leg intersection, the other parameters that are available near the school is given in the table 6.1. The school do have Pedestrian sidewalk but are often encroached with parked Vehicles which force the Pedestrian to walk on road making the child pedestrian unsafe and create congestion on road.

Table 6.1: Table showing the Infrastructure available near The Heritage School

School Name	***The Heritage School***
Road Name	***Abdul Gaffar Khan Marg***
sidewalk (present/Not Present)	Present
Pedestrian Fencing (P/NP)	Not Present
Width of Sidewalk	2.5meter
Vehicle Parking	One sided
No of lanes	2 lane undivided
Shoulder Rumble Strip	Not Present
School Warning	Yes (School Ahead)
Intersection Type	3 leg
Speed limit signage near school	None
Speed Management(P/NP)	Not Present
Lane Width	Medium
Road Condition	Good
Crossing Type	Marked

A Pedestrian Volume count was taken near the school zone in the peak hour i.e. during the school start and the end time. The 15 minutes volume count of Heritage school is shown in the table 6.2.

The pedestrian count is taken for both the direction i.e. pedestrian moving from Abdul Gaffar Khan Marg towards School and from school to Abdul Gaffar Khan Marg.

Table 6.2: No of pedestrian for particular time interval.

The table showing the pedestrian count near The Heritage School from both the direction i.e from Abdul Gaffar Khan Marg towards the school and vice versa.

From Abdul Gaffar Khan Marg towards school	
Time	No of Pedestrian
7:30-7:45	123
7:45-8:00	163
8:00-8:15	111
8:15-8:30	91
2:30-2:45	129
2:45-3:00	126
3:00-3:15	119
3:15-3:30	56

From School to Abdul Gaffar Khan Marg	
Time	No of Pedestrian
7:30-7:45	130
7:45-8:00	34
8:00-8:15	118
8:15-8:30	60
2:30-2:45	61
2:45-3:00	105
3:00-3:15	88
3:15-3:30	83

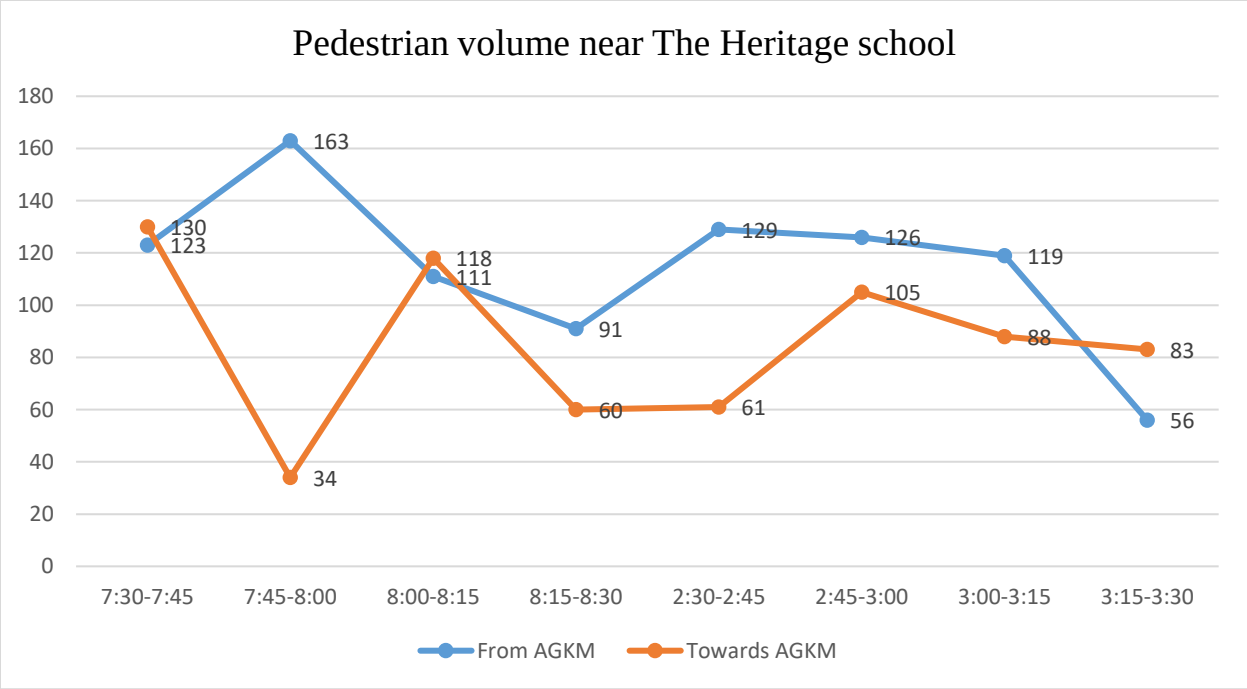


Figure 6.1: Graph of No of Pedestrian Vs Time

The above graph shows the volume of pedestrian flowing during the peak hours near The Heritage School.

A peak vehicle volume count is taken near The Heritage School and also near the Abdul Gaffar Khan Marg. (see Appendix D). The vehicle count is taken in the peak hour to get the maximum values. For the base network the no of vehicle in that particular zone is inputted in the simulation software.

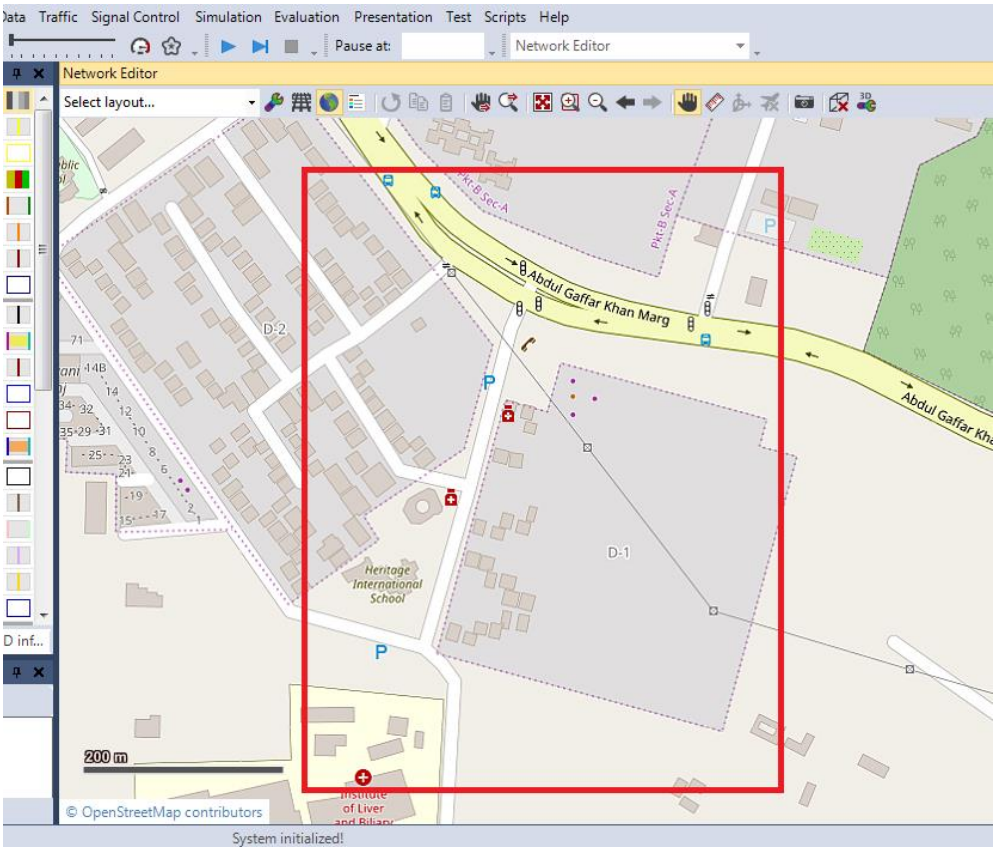


Figure 6.2: Map view of The Heritage School School in PTV Vissim

The above highlighted portion in the figure shows the area taken for designing the school zones in PTV Vissim.

The figure above shows the map view in PTV Vissim of The Heritage School, Vasant Kunj. Now to construct the existing scenario of the school we have to first design the links (lanes) in Vissim along with the connectors and areas for pedestrian. Vehicle and pedestrian inputs are given according to the collected data.

6.4. CONSTRUCTION OF NETWORK IN PTV VISSM

Two network have been constructed, firstly the base network which shows the current scenario of The Heritage school and secondly the redesign network. To design this network different element are used some of them are links, connector, Area,

Links: To enable the vehicle and pedestrian flow link have to be constructed in Vissim. Link is the basic element of road network in PTV Vissim. Links can run in one direction over one or more lanes. In the link drop down box you can specify the like behavior type, number of lanes nad the lane width as shown in the figure below.

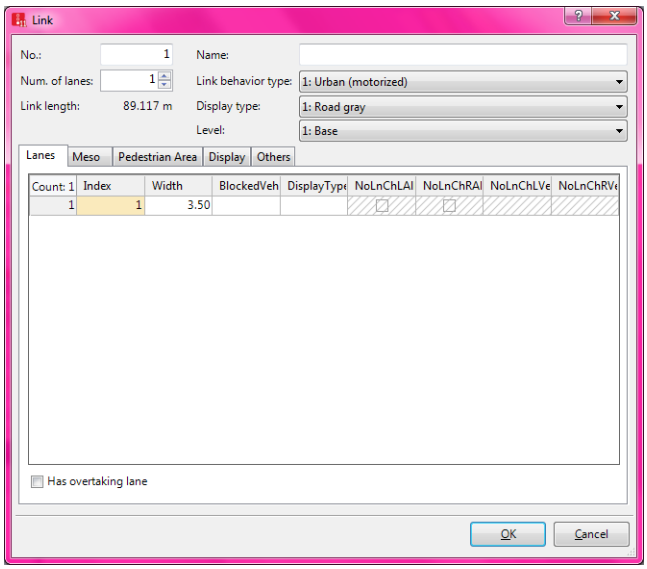


Figure 6.3: input for no of lanes and widths

Figure 6.4: Lane (links) in PTV Vissim

The figure 6.3 and 6.4 shows the inputs window for no of lanes, lane width and vehicle allowed on that particular lane and Figure21 shows the design lane near the school zone.

Connector: If the vehicle or pedestrian have to change from one line to another, connector has to be placed between two links to connect the both link together. The traffic can only flow from one link to another via connectors. Connectors can connect endless amount of links.

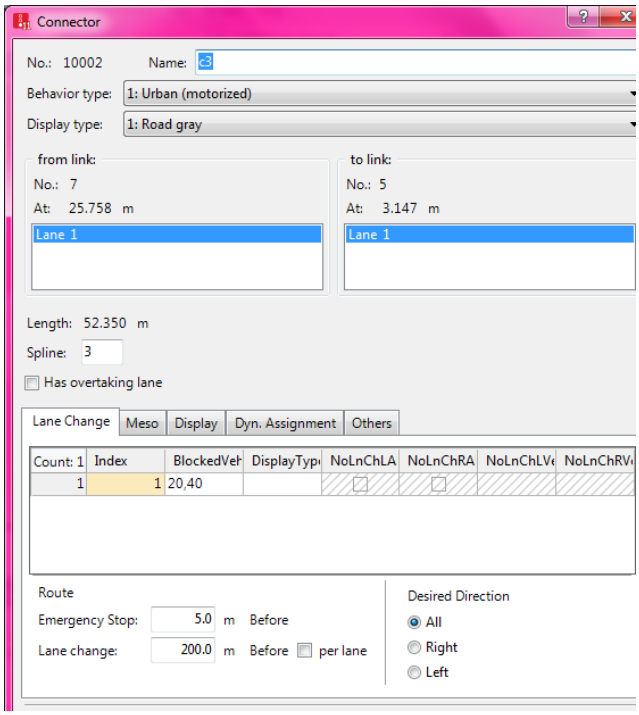


Figure 6.5: Input window for Connectors

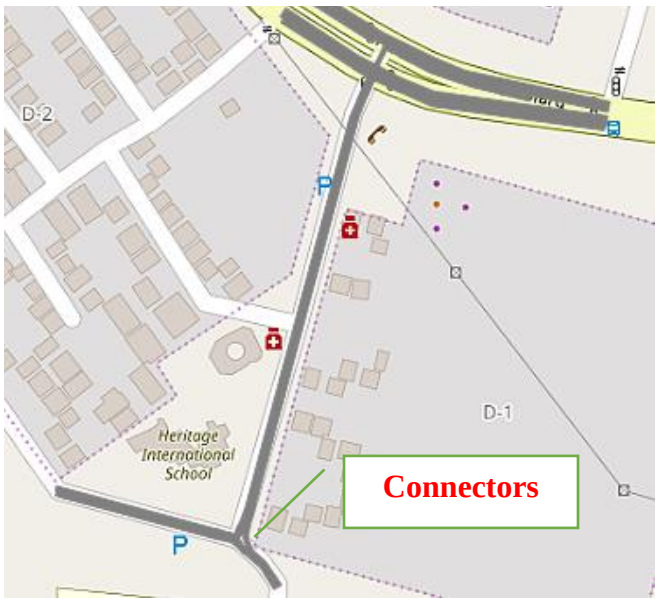


Figure 6.6: lanes connected by the connectors

Area: It defines the path in which pedestrian moves. Pedestrian are allowed to move more freely and realistically. Also the pedestrian inputs and pedestrian routes are define in the areas. The figure below shows the Area for pedestrian movement

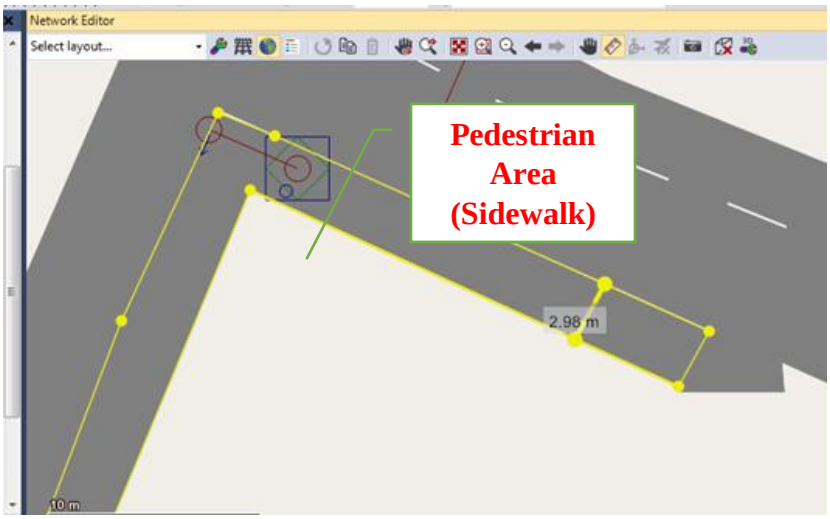


Figure 6.7: Pedestrian sidewalk (Area)

Parameter used in

1. **Link**
   - **Signal Controller:** Signal Controller are define in lanes and areas to control the movement of vehicles and pedestrians.

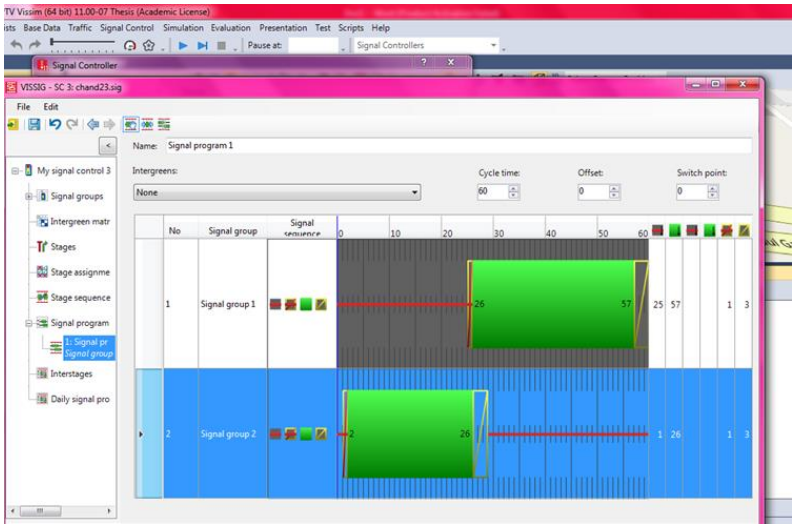


Figure 6.8: Signal controller window

- **Pavement marking:** Pavement making are placed on the links to mark the vehicle routes. Zebra crossing are also placed wherever necessary.
- **Vehicle input:** In every links (lanes) vehicles input should be assign to get the correct volume of vehicles on the links.

- **Vehicle route (static and Partial):** Vehicles movement and the links are define by the vehicle routes both static and partial.
- **Vehicle speed:** We can also define the speed of each vehicles in the vehicle parameters

2. Pedestrian area

- **Pedestrian input:** Pedestrian inputs are define to get the number of pedestrian walking in that area.

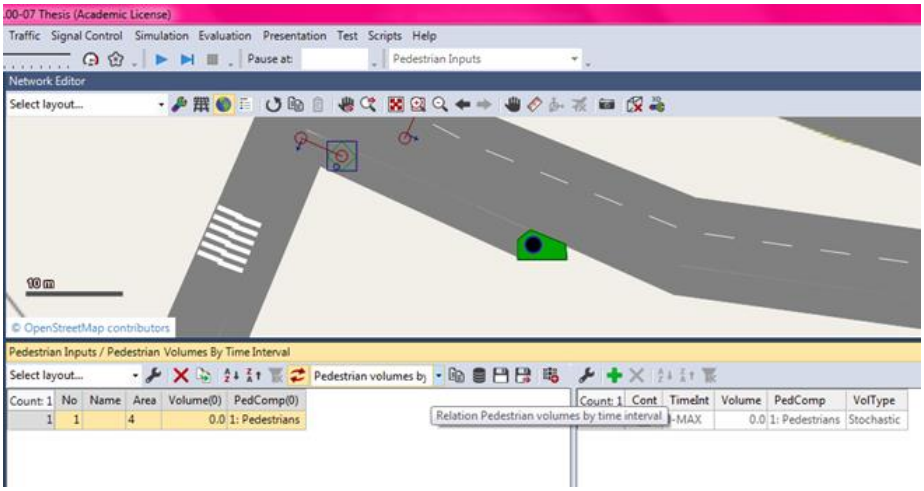


Figure 6.9: Pedestrian Input

- **Pedestrian routes (static and Partial):** In pedestrian area we can define the pedestrian routes both partial and static to get the movement.

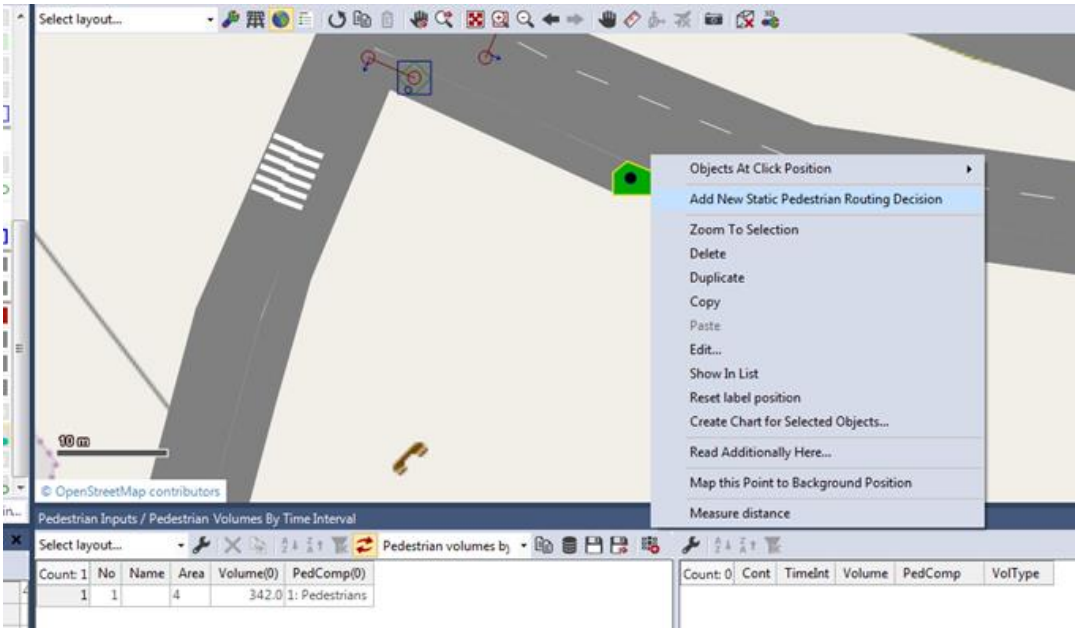


Figure 6.10: Pedestrian Routes

- **Pedestrian Type:** We can also define the type of pedestrian such as – Man, Woman, Woman with Child, Wheelchair etc. to get the actual condition of a particular area.
- **Pedestrian Speed:** In PTV Vissim pedestrian speed can be define for each type.

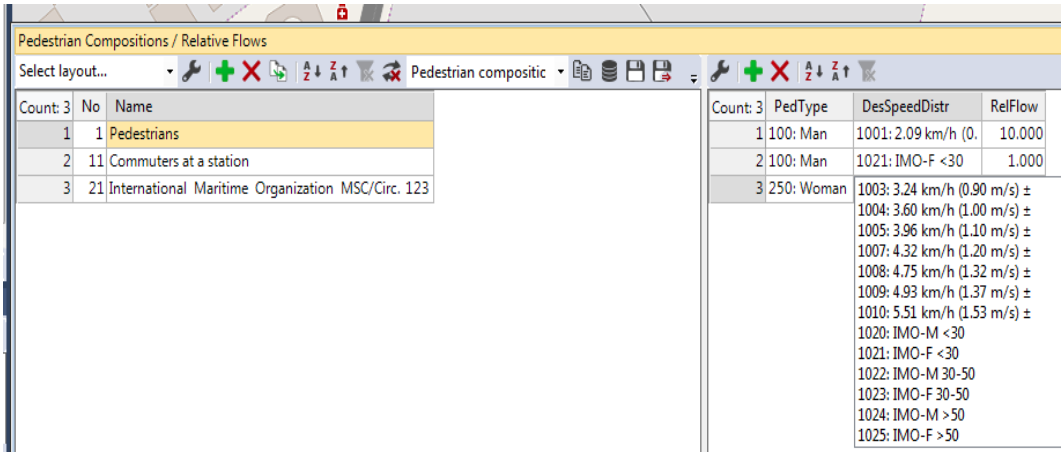


Figure 6.11: Pedestrian Speed Input

- **Obstacles:** Obstacles are used to block the areas where movement is not allowed. Obstructes such as tree, poles, parked vehicles, pot holes are used in the network.

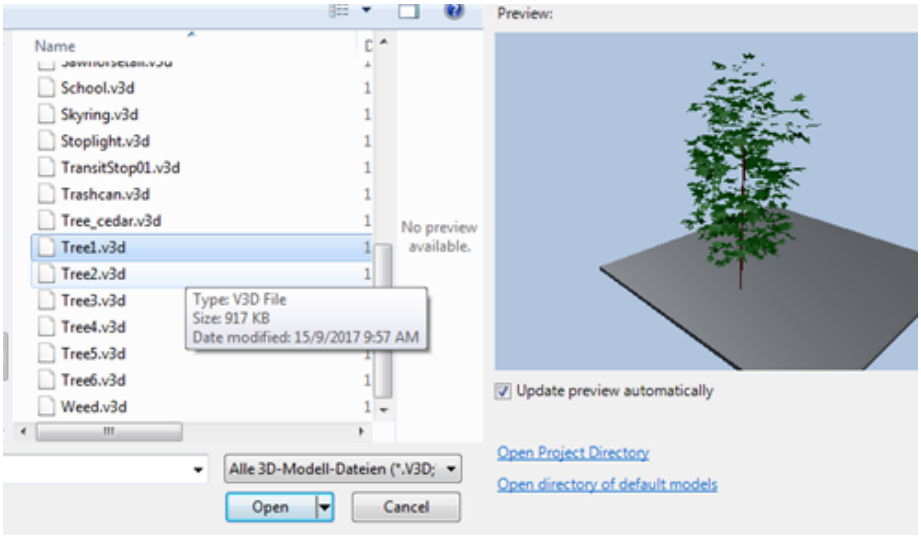


Figure 6.12: 3D models In the above figure a 3D model trees are used

6.5. EVALUATION ON PTV VISSIM

6.5.1 BASE NETWORK SIMULATION:

The existing scenario near The Heritage School was design in PTV Vissim to analysis the conflict areas, Pedestrian Movement, Pedestrian waiting time, Pedestrian speed etc. The base network is constructed by using the links, area, marking, obstacles on sidewalk (such as trees, poles parked vehicles etc.). The base network shows the current condition of The Heritage School. Figure 30 shows the outlook of the base network.

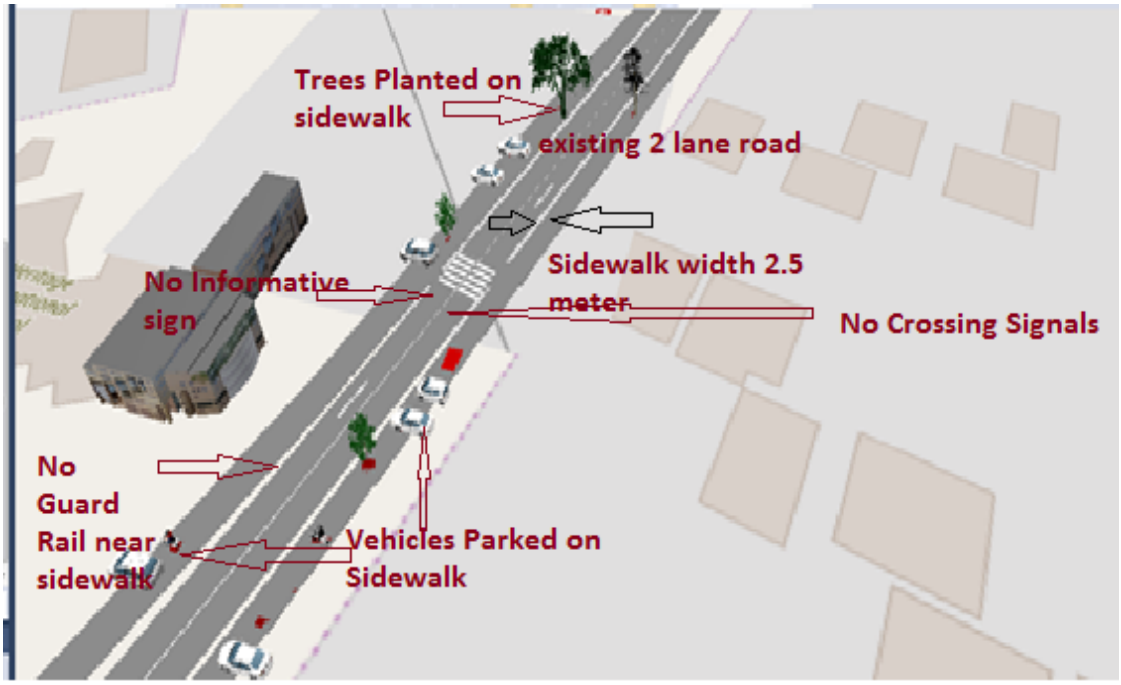


Figure 6.13: Base Network Specifications

The vehicles inputs and pedestrian inputs are given as per the volume count taken near the school during the peak hours. The pedestrian volume count from Abdul Gaffar Khan Marg toward school during the morning peak hours was 488 while from school toward Abdul Gaffar Khan Marg was 342 (total volume 830). The evening peak hour pedestrian count was 430 from Abdul Gaffar Khan Marg toward school and 337from school toward Abdul Gaffar Khan Marg (total volume 767). The base Network is design for the morning peaks hours taking the maximum pedestrian counts i.e. 830.

Similarly Vehicle count was taken near the school areas shown in appendix D. The vehicle count was taking from Chhatarpur Metro station toward Vasant Kunj which was found as 2455 vehicles i.e. 2403.7 PCU and from Vasant Kunj to Chhatarpur metro station was 2647 i.e.2583.4 PCU. Towards the Heritage school the vehicle count was 478 i.e 396.8 PCU and from The Heritage school was 456 i.e. 412.5 PCU. (See Appendix D)

Figure 6.14: Figure shows the virtual view of the PTV Vissim near The Heritage School.

After constructing the link, necessary connectors, areas, obstruction, signal controller etc. the simulation is run.

Evaluation: Evaluation is done considering the pedestrian delays, design speed, average walking speed.

Pedestrian Network performance were evaluated from PTV Vissim as shown in the figure below.

The average design speed of the pedestrian was 4.590 and the average speed of the pedestrian was 4.256.

Pedestrians In Network

Select layout...

Count: 3	No	PedType	Length	Width	Height	Level	ConstrElNo	ConstrElType	CoordCent	DesSpeed	Speed	StaRoutDecNo	StaRoutNo	PTState	MotionState
8	312	250: Wo	0.37	0.92	1.58	1: Bas	7	Area	-203.948 -2	3.82	4.01	2	1	None	Walking on I
9	313	100: Man	0.45	0.58	1.77	1: Bas	7	Area	-192.838 -2	5.54	4.33	2	1	None	Walking on I
10	314	250: Wo	0.37	0.92	1.61	1: Bas	3	Area	-190.566 -2	4.33	3.82	5	1	None	Walking on I
11	315	100: Man	0.46	0.57	1.65	1: Bas	3	Area	-195.135 -2	5.50	4.49	5	1	None	Walking on I
12	316	100: Man	0.44	0.59	1.75	1: Bas	3	Area	-168.706 -1	6.02	6.02	4	1	None	Walking on I
13	317	250: Wo	0.36	0.95	1.63	1: Bas	3	Area	-186.998 -2	4.21	4.06	4	1	None	Walking on I
14	318	250: Wo	0.37	0.96	1.60	1: Bas	3	Area	-189.330 -2	4.33	4.07	4	1	None	Walking on I
15	319	100: Man	0.40	0.62	1.78	1: Bas	7	Area	-204.260 -2	5.66	3.94	2	1	None	Walking on I
16	320	100: Man	0.39	0.65	1.63	1: Bas	15	Area	-181.546 -1	5.81	5.81	4	1	None	Walking on I
17	321	100: Man	0.43	0.61	1.84	1: Bas	3	Area	-186.359 -2	4.93	4.82	5	1	None	Walking on I
18	322	250: Wo	0.37	0.91	1.78	1: Bas	7	Area	-190.279 -1	4.14	4.14	3	1	None	Walking on I
19	323	100: Man	0.45	0.58	1.80	1: Bas	3	Area	-199.712 -2	4.25	4.18	2	1	None	Walking on I
20	324	100: Man	0.44	0.58	1.77	1: Bas	7	Area	-190.970 -1	5.56	5.54	3	1	None	Walking on I
21	325	100: Man	0.45	0.59	1.76	1: Bas	3	Area	-200.927 -2	3.77	3.77	4	1	None	Walking on I
22	326	100: Man	0.48	0.56	1.85	1: Bas	17	Area	-216.229 -2	4.57	4.57	2	1	None	Walking on I
23	327	100: Man	0.45	0.55	1.79	1: Bas	6	Area	-223.347 -2	5.94	5.94	2	1	None	Walking on I
24	328	250: Wo	0.34	0.92	1.80	1: Bas	7	Area	-179.952 -1	3.98	3.99	3	1	None	Walking on I
25	329	250: Wo	0.34	0.98	1.58	1: Bas	10	Area	-182.453 -1	4.06	4.00	3	1	None	Walking on I
26	330	250: Wo	0.36	0.90	1.75	1: Bas	9	Area	-192.062 -2	4.74	4.74	4	1	None	Walking on I
27	331	100: Man	0.42	0.65	1.81	1: Bas	10	Area	-190.346 -1	3.52	2.96	3	1	None	Walking on I
28	332	250: Wo	0.35	0.96	1.68	1: Bas	3	Area	-166.194 -1	4.19	4.16	5	1	None	Walking on I

1544.40 44.4 54 + 29 2.3 (120)

Figure 6.15: Pedestrian Evaluation

6.5.2. REDESIGN NETWORK:

The school was redesign according to the safety of children near the school zone. Modification were done according to IRC: 103- 2012 “Guidelines for Pedestrian Facilities”, IRC SP 88-2010 “Road safety Audit” and also as per Indo HCM. Certain parameter are change in the redesign as shown in the table 14.

The width of the sidewalk near The Heritage School is increase from 2.5 meters to 3.5 meters (IRC 103-2012). The width cannot be increase further since the residential area is located toward the left of the school and also in front of the school.

Pedestrian crossing were place in front of the school along with signal controller for safety crossing.

Since sidewalk fencing were not available in the existing scenario therefore in redesign fencing were used to remove the vehicle parking on the sidewalk and also conflit between the child pedestrian and vehicles.

Proper signage were paced such as school ahead signage, speed limit to alert the vehicles driver.

Speed calming were placed near the school zone to control the speed of the vehicles.

Obstacles such as trees, parked vehicles etc. are removed in the redesign network.

Table 6.3: Redesign Parameters

Paremeters	**Base Network**	**Redesign Network**
Width of sidewalk	2.5 meters	3.5 meters
Lane width	3meters	3 meters
Guard Rail	Not Present	Present
Obstruction on footpath such as vehicle parked on sidewalk, tress, shops etc.	Present	Removed (tress replanted to side)
Crossing Type	Zebra Crossing	Signal Controller + Zebra crossing
Speed calming	None	Placed

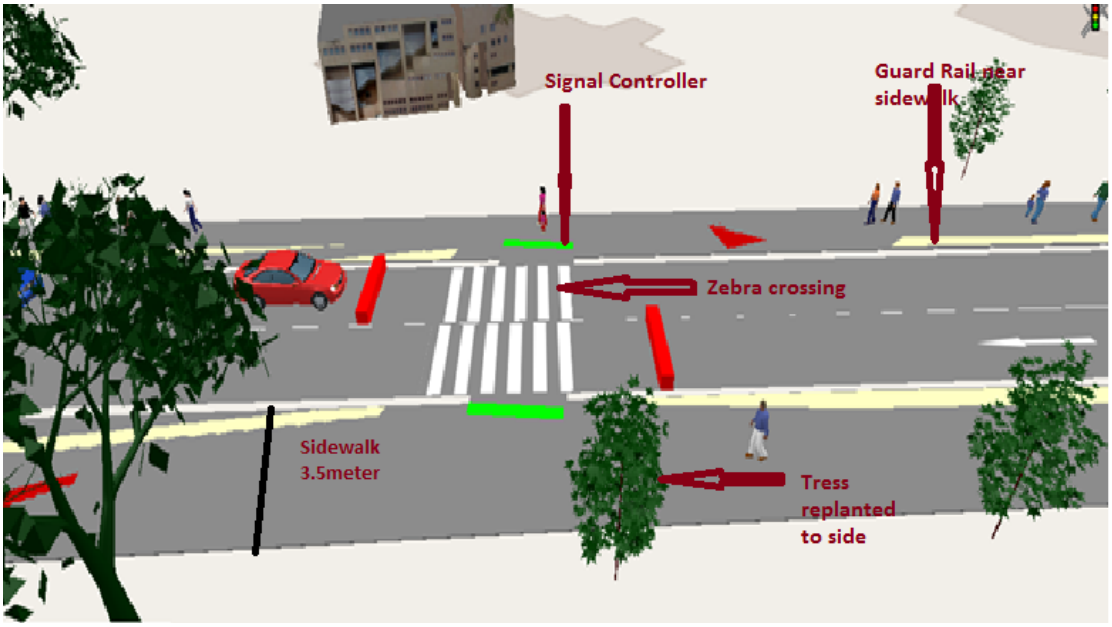


Figure 6.16: Redesign Network Specifications

6.5.3. RESULT FROM PTV VISSIM/VISWALK

In PTV Vissim we evaluate the pedestrian performance in both the network i.e. the base network and the redesign network. On comparing both the networks we notice a huge difference in the walking speed of the pedestrians was observed due to the obstacle in one of the network and no obstacles on the redesign network. The figure 6.17 shows the Average speed of both the network.

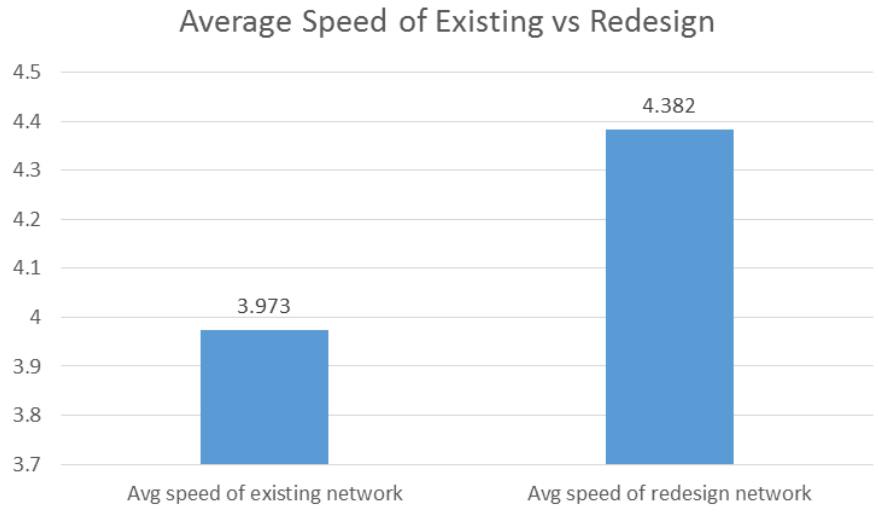


Figure 6.17: Histogram of Average Pedestrian speed m/s

The figure 6.18 shows the vehicles speed of the existing scenario i.e. in the base networks the average vehicle speed is taken as 32 km/he where as in redesign after extending the width and installing certain speed calming measures and speed limit signage the average speed is taken as 23.8Km/hr

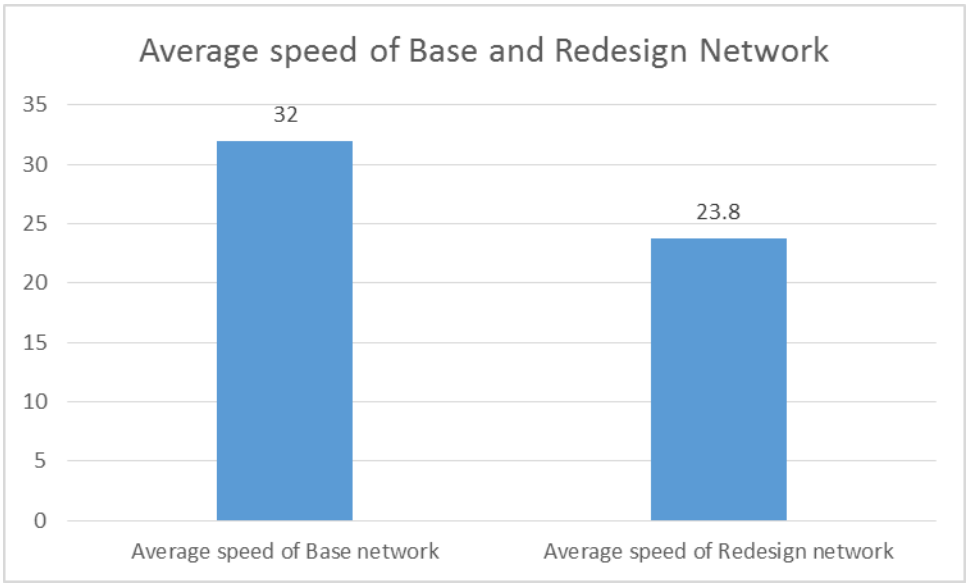


Figure 6.18 Histogram of vehicle speed kmph

The Pedestrian space of both the network are compare. The space available for a pedestrian in base network is 0.18 m^2 and for redesign the space available for a pedestrian is 0.261 m^2.

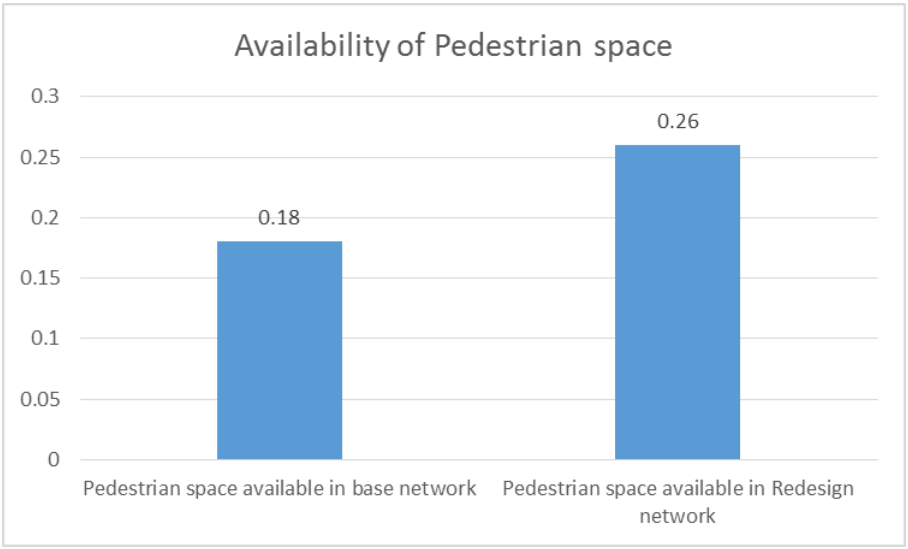


Figure 6.19 Histogram of space available for pedestrian

CHAPTER 7: RECOMMENDATION

7.1 ISSUES IDENTIFIED IN SCHOOL ZONE PEDESTRIAN SAFETY

The Child Pedestrian safety around school zones is a very strategic domain of urban transportation planning. It needs to co-align existence with the urban vehicular movement and at the same time make sure that in its own domain all aspects and infrastructural facilities are in place in order to conduct a safe pedestrian commute for the citizens. Many cities across the world have embraced the walkability concept and now have huge vehicle free pedestrian areas. But, mostly this practice is limited to central business district areas or areas of tourist importance. School Zones on the other hand see huge numbers of vehicular movement. These may be parent's vehicles coming for drop off or pick up activities, school buses, hired vehicles for children for school drop off and pick up, vehicles of school teachers and staff, through traffic passing from the school zone area.

In such a scenario, it is very important for not only the parent or school but also for the entire community to come up together to address the issue of pedestrian safety in school areas. In the preceding chapters, we saw that in the case study for South Delhi in India, The inadequate pedestrian infrastructure was not the only cause of concern for the pedestrian safety in school areas, but also the lack of awareness amongst students, as well as parents regarding pedestrian safety practices, and lack of enforcement on the part of local authorities were contributory factors towards the situation of unsafe pedestrian safety.

The pedestrian safety in school area depends upon Continuous and comprehensive coordination between several stakeholders along with getting the 4E's of road safety right. The following two sections put forward several recommendation that can be introduced in the policy level of a city, state or country to enhance the school zone pedestrian safety in an organized manner.

7.2 STAKEHOLDER RESPONSIBILITY STRUCTURING

The various stakeholders responsible to ensure safe school zones for children as well as adults who are walking to and from school areas are Schools, local governmental jurisdiction, local law

enforcement agencies, parents, guardians, school drives, non-profit organization and students. The manner in which each one of them s responsible is as follows

- **School:** the school administrations must take up the responsibility for overseen the schools walking routes and must conduct safety patrol programs they should play and active role in child pedestrian safety education and training of crossing guards along with orchestrating the drop off and pick up procedure. They also have a role in encouraging parents to model good pedestrian safety skills. Very recently in 2018 a local NGO called Patiala foundation issued challan booklets to the kids in which various challans were printed for various offence. The student were supposed to observes parents, guardians, neighbor w.r.t following of traffic rules and if they find any adult not adhering to the rules they can issue a challan to a respective adults. This exercise served two purposes, educating the child about traffic rules and well as making parents/guardians more responsible to present a model behavior in front of their children. Apart from all this the schools may distribute walk routes maps to parents and children's on an annual basis.

  Following the step by step procedure for developing, implementing and maintaining school walk route plans will result in creating clear and concise maps to show parents and children the preferred routes to schools. These steps are:

  - Assign responsibility
  - Prepare base maps
  - Inventory existing walking conditions
  - Inventory traffic characteristics
  - Design the walk routes
  - Prepare the draft walk route map
  - Review the route maps with district and community
  - Distribute and explain the maps
  - Evaluate the program
  - Maintain the program

- **Local government Jurisdictions:** The city level or state level agencies are required to coordinate with the schools in order to maintain the road near the school area and to ensure that pedestrian safety infrastructure/ traffic control devices in school zones is repaired/maintain/upgraded regularly. The local administrator is also responsible for zoning and building permits and as a result they can control or avoid high activity commercial properties from coming up near the school areas.

- **Local law enforcement agencies:** the local law enforcement officers are supposed to offer pedestrian safety education to students, parents and school patrol staff. The traffic police officers can be invited to school function or otherwise to deliver key note lecture, street play acts, illustrative poster based training, 3D model Demonstration, injury prevention and crash response training and various activities for primary children that can make them understand the importance of safety practices on roads.

- **Parents and Guardians:** parents can make very strong allies in promoting child pedestrian safety as they have a very strong influence on children. They should active review, read and explain the pedestrian safety educational material that comes home with their child. They should also always remember to model ideal pedestrian behavior in front of or even in the absence of their children. They can also travel the school walking route with their child and ensure that the child practices and understand safe walking behavior. Parents are a major fraction of drivers around the school pick up and dropping zones so they can be vigilance in this regard and coordinate with the school voluntarily or as a member of school council team to ensure smooth operation of child boarding/alighting process on a daily basis.
- **School bus/vehicles Driver:** Drivers have a substantial onus on them when it comes to school pedestrian safety. A good driver must always stop to allow a pedestrian to cross and must exercise extreme caution in the school zone and along the walking route to the school. The driver should be educated or trained towards sensitive need of vulnerable road users.

- **Non-Profit organization and other government agenesis**: Several agencies are responsible for infrastructure along the walking routes such a parks drainages, utilities railway crossings irrigation infrastructures and other common community based buildings. The agencies should make sure that no portion of their property which falls along a school walking routes is hazardous r unsafe for child pedestrian. They should encourage the concept of walkable communities around school areas and coordinate with schools to identify all problematic points, installation, curves etc. and fix the issues.

- **Students:** A student's personal responsibilities cannot be over emphasis for their own safety as pedestrian. The student /child must understand and follow the instruction given to him for a safe trip towards and from school. The child also may developed lifesaving pedestrian skill and awareness through practice under the supervision of educated adult through model safe pedestrian behavior.

7.3 THE FOUR E'S APPROACH

From this research and following the 4 E's i.e. **Engineering, Education, Encouragement and Enforcement** certain counter measures which are effective, feasible and practical are recommended as follows.

Engineering:

1. Adequate dimension of sidewalk should be available for the pedestrian near the school areas. The sidewalk should not be encroached with parked vehicle, vendors etc. so that the pedestrian are not forced to walk on roads due to lack of walkable space.

Figure7.1: Encroachment of Sidewalk by House Owner and Parking of vehicle on sidewalk leaves little space for adequate pedestrian usage.

Figure7.2 : Encroachment by street vendor forces pedestrian to walk on road with vehicular traffic.

2. Guardrails should be provided near the sidewalk to avoid children spilling on road or crossing on mid-block. Guardrails will also discourage vehicle parking over the sidewalks therefore preserving the pedestrian space. The guardrails for normal pedestrian areas differ from guardrails in school zone area as the guardrails in school zone area have a visibility gap after 2m of height for the convenience of children. The following Figure shows the guardrail with the visibility gap.

Figure7.3 : Sidewalk with Guardrail having visibility gap for school going children at 2 meters height

3. Mandatory Speed Limit (MSL) signage should be provided near the school zones. A speed of 20/30 km/hr would be a desirable speed limit to maintain a safe road for pedestrian.

(A)

(B)

(C)

(D)

Figure7.4 : Speed Limit Signage across the world (A) Speed Limit Sign (B) School Hours marked on partial speed restrictive signboard. (C) Flashing School Zone speed limit controller (D) Radar Feedback type school zone speed control device.

4. Awareness for school zone approach area should be increased by providing signs, rumble strip, speed calming measures so that the driver who is approaching the school zone area gets ample time to decelerate the vehicle and slow down the speed to the desired speed limits.


(A)

(B)


(C)


(D)

Figure 7.5: (A) Speed Breaker (B) Speed Calming Rumble Strip (C) School Zone Pavement Marking (D) School Zone Signboard

5. Drop off and Pick up Zone should be provided near school (According to IRC:103-2012)

(A)


(B)

Figure 7.6 : (A) Pick up and Drop off Zone Pavement Marking (B) Pick up and Drop off Zone Sign

(A)

(B)

Figure7.7 : (A) Pick up and drop off zone (B) No Cellphone Usage Signboard

Figure 7.8 : A typical layout for a school pick up and drop zone

6. Sufficient car parking space on/off street should be available near the school areas to avoid congestion.

7. Supervisor should be allotted for every school

Figure 7.9 : School Crossing Supervisor

8. If the school is near cross walk. Certain crosswalk safety measures should be provided such as

- Zebra Crossing: it is a type of pedestrian crossing which is painted in white stripes, where vehicles must stop if pedestrian which to cross.

Figure 7.10 : Zebra Crossing

- Toucan crossing: It is a kind of pedestrian crossing that also allows bicycle to cross. Since near school zone children may also cycle to and from school therefore safety for cyclist should also be taken into account.

Figure 7.11 : Toucan Crossing for pedestrians as well as cyclist

- Pelican Crossing: Pedestrians waiting at a pelican crossing are able to press a button that changes the traffic lights to red. So then the pedestrian can cross safely.

Figure 7.12 : Pelican crossing for pedestrians as well as cyclist

Education:

Educating the children related to Road Safety are necessary to because it develops the behavior and attitude for safe road use. The road safety education help the children to be safe user and to learn about road safety.

To educate the children, certain awareness and training program should be given to the children, press and media can help in this regard. Booklets, posters or 3D models can be made use to improve the awareness.

Some of the measures adopted to educate children about road safety procedures and rules are illustrated in the following figures.

Figure 7.13 : Workshops conducted to educate children about road safety signs and methods.

Figure 7.14: Teaching the importance of Traffic rules to children with the help of audio-visual aids

Figure 7.15: Running Pedestrian safety education programmes in order to create awareness in students about pedestrian safety.

Figure 7.16: Life Size Street Simulation Exercises to practically teach students how to conduct themselves in several different scenarios.

Safety Education at school is also important for child Pedestrian Safety. The following steps should be followed such as.

- They should learn to avoid the roads which are unsafe.
- Responding (under adult supervision) to the instruction regarding safe and unsafe behaviors on and near roads.
- Should learn to experience safe roads environments and describing and practicing explicit safety procedure.
- Sorting and using data to describe both safe and unsafe behavior around roads.
- Exploring decision making strategies to use when traveling to and from school.

- Embedded road safety education programs within a curriculum framework and frequent visits to the local traffic parks.
- School management support staff to implement road safety education

Applying investigation strategies to generalized findings that influence the development and implement the safe road and cycling environment

Enforcement:

Traffic police and other higher authorities are responsible to enforce the system. Police and law courts are responsible for penalizing the person not following the traffic rules. They should be penalized, which acts as a learning lesson for offender for future awareness. Enforcements are generally implemented in the formal ways through

- Targeting Crash risk areas
- Extra Patrols on Roads
- Speed Cameras

The law must be implemented strictly to make the road safer. No corruption should be allowed for the enforcing authority.

An assumption by highway engineers is that pedestrians will allot appropriate attention to their surroundings, therefore allowing these features to have a significant impact on their behaviour. Different situations and activities may, nevertheless, result in pedestrians not allotting appropriate attention to their surroundings. Some common distractions inhibiting situational awareness are cell phone conversations, text messaging, listening to music [i-pod], looking at something other than the direction of travel, waving away an insect, conversations with friends, eating on the run, looking at one's watch, attempting to find something in a backpack or luggage, reading a book or newspaper or simply being lost in thought etc.

(A)


(B)

Figure 7.17: Pedestrian Safety Guidelines mentioning regarding distractions while walking.

Encouragement:

The school and parents should encourage the children to follow the traffic rules. To encourage the child pedestrian as well as the pedestrian certain publicity campaigns can developed to improve the behavior towards road safety. The children can be encouraged by playing a fun interactive game out of guessing the correct traffic sign and meaning with your child. Teach your child to make sure all vehicles have stopped before entering the road. Show them how to make eye contact with drivers before crossing, even when the walk signal is on.

Children should be encouraged with the following measures:

- To wear helmet while cycling
- Use zebra crossing while crossing the road.
- Use footpath while walking to and from school.
  Some other parameters that child pedestrian should keep in mind while walking and crossing roads are:
- Never jaywalk or run to cross the street. Wherever possible, cross at intersection with pedestrian crossing light or marked crosswalk.
- Teach your child to make sure all vehicles have stopped before entering the road. Show them how to make eye contact with drivers before crossing, even when the walk signal is on.
- Make a habit of putting away all electronic device while you are walking, so you can hear approaching traffic that may be hard to see.
- Make sure your child is wearing bright clothes or reflective gear especially at night and in poor weather.
- Avoid shortcuts through parking lots or around parked cars where it's harder for drivers to see small children.
- Walk on the inside edge of the sidewalk so you're further away from traffic.

- Walk facing oncoming traffic. If there isn't a sidewalk, so you can see approaching traffic vehicles and make eye contact with the driver.

Various Research organizations, local bodies, NGO's can work together to identify attributes applicable to all school zone areas and further adopt best practices from across the globe to make their school zone pedestrian commute a very safe experience for children as well as parents. Once these targets are set, work should be done to continuously evaluate and upgrade the methodologies in this domain.

This research has been an attempt to address several aspects and attributes of child pedestrian safety for a developing country like India. There is a lot of scope for future work to be done in this direction as well. The conclusions and scope of future work related to this research has been discussed in the next chapter.

CHAPTER 8: CONCLUSIONS AND SCOPE OF FUTURE WORK

8.1 CONCLUSIONS

The present research work aimed to study impact of relevant attributes identified through literature in context of pedestrian road safety in school zones. The study area selected was 23 different school location in South Delhi locality of Delhi-NCR, the national capital of India. The results of surveys carried out and simulation technique adopted in this research work reveal interesting yet awakening results. The conclusion that can be drawn from this research work are as follows:

- Absence of sidewalks at more than 40% of the selected school zones. Wherever sidewalk was present, there also almost 85% sidewalks were not having pedestrian guardrails making vulnerable users like school children exposed to conflict with vehicular traffic.
- Vehicular Traffic management measures were highly inadequate. More than 60% school zones had no signs or speed management infrastructure to check high vehicular speeds in the school zone areas. Almost 95% of school zones did not have basic speed reduction installations such as rumble strips in order to calm down the traffic speeds before approaching the school area.
- There is no clear demarcation of parking areas around school gates. At several locations vehicles are haphazardly parked either on one or both sides of the road. Further, only 5% schools have no parking sign at the entrance gates. There is also no designated area for child drop off and pick up around the school areas.
- Wherever sidewalks are present the surface condition was studied. Amongst all school zone areas, 35% had poor sidewalk condition and 20% had medium conditions.
- Travel mode choice revealed that nearly 35.40% school goers preferred to reach school by walking mode from nearby areas, while 27.70% were using private vehicles. The remaining were using school bus services.
- Peak hour pedestrian volumes revealed varying volumes for different schools with some catering a very high volume of pedestrian traffic while some others with very low pedestrian counts.

- PTV Vissim along with an added module of PTV Viswalk was used to study the simulated scenario of the current existing road geometry and pedestrian infrastructure around Heritage School. Further, several modifications were made in this school zone and re-studied on the simulation platform to study the impacts of these changes in attributes.
- The results of simulation technique revealed a rise in pedestrian walking speed from 3.9m/s to 4.3 m/s in the redesigned scenario.
- The vehicular speed came to a reduction of 23.8 kmph in the redesign scenario from the initial 32 kmph in the base scenario
- The average pedestrian space increased owing to removal of encroachments and widening of sidewalk from 0.18m^2 to 0.26 m^2.
- Best practices from across the globe were studied to formulate step by step policy level recommendations in order to enhance the pedestrian road safety situation in Indian cities.

8.2 SCOPE FOR FUTURE WORK

- Multi-city surveys can be done to assess Indian child pedestrian safety scenario in a more comprehensive manner with larger data sets.
- Various statistical and co-relation based studies can be carried out in order to better understand the cause and effect situation in the different pedestrian safety attributes.
- Simulation Techniques can be conducted for other school areas in suburban and rural areas also to understand the effect of pedestrian safety attributes wherever schools are located on highways and busy suburban areas.
- A national Guideline or manual of instruction could be conceptualized in order to benchmark school zone pedestrian safety thresholds.

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Appendix

Appendix A: The Format of Perception survey:

Thapar Institute of Engineering and Technology

This survey is conducted for M.Tech Thesis for safety of child Pedestian.

1. Age of child (4-8)years /(9-11)Years/(12-16)Years
2. Mode of transportation
   - From home to school
     Private
     Vehicle/Bus/Metro/auto/Walking/other_____
   - From school to Home
     Private
     Vehicle/Bus/Metro/auto/Walking/other_____
3. Distance from home to school_____
4. Accompanied by Parents or adult
   - o Yes
   - o No
5. Travel time taken from home to school_____
6. Access/Egress time(time taken to reach nearest bus stand , metro, auto from home, not applicable to private vehicles)
   _____
7. What according to you is the main road safety problem in the school zones area?
   _____
   _____
8. How easy is it for you to drop off and pick up your child for school?
   - o Very easy
   - o Easy
   - o Somewhat easy
   - o Some problem is faced
   - o Difficult
9. Do car appears to be driving too fast creating a dangerous pedestrian environment on any roadway near school?
   - o Very fast
   - o Fast
   - o Adequate (Normal) speed
   - o Very slow speed
10. Where are children being dropped-off?
    - o On a roadway
    - o In a driveway
    - o In a parking lot
    - o Opposite side of the roadway(opposite side of the school)

    Other_____

1. In the case of pick up and drop off of children of opposite side of the school, is there availability of crossing infrastructure such as zebra crossing, light signal, stop sign?
   - o Yes
   - o No

2. If the child has to cross the road
   Crossing available?
   - o Yes
   - o No
3. If crossing infrastructure is available, which signal is available?
   - o Midblock
   - o Zebra crossing
   - o Crossing light signals

4. What is the safety level of children when dropped by bus in front of school (with respect to being injured by other passing vehicles)?

   - o Highly unsafe
   - o unsafe
   - o medium safety
   - o safe
   - o Very

5. What do u think about the visibility of the school from the adjacent approaching road? (Please indicate on scale below)
   - o Very visible
   - o Reasonably visible
   - o Not at all vis

6. How do you think that the visibility of the school could be increased?

   - o Road Marking
   - o Traffic Signs
   - o Informative signs
   - o Mandatory signs like stop, school zone speed limit signs.

7. From the school side is there any supervisor allotted to help the children across the road?

   - o Yes
   - o No

8. Please feel free to comment on any other issues relating to child pedestrian safety that have not been covered in this questionnaires.

Appendix B: Format of Pedestrian Volume count:

Pedestrian Volume data (Survey Format)

Date: Time:
Location:
School Zone Area
Name of Road
Direction

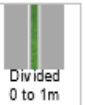
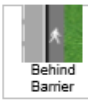
Sl. No.	Time Slot	No of Pedestrian crossing the road in given Time slot	Pedestrian facing speed problem due to Lack of Infrastructure
1	8:00-8:15		
2	8:15-8:30		
3	8:30-8-45		
4	8:45-9:00		
Post School times			
5	2:00-2:15		
6	2:15-2:30		
7	2:30-2:45		
8	2:45-3:00		

Appendix C: Format of Inventory Survey

User Name		Date	
School			
Road name		Section name	
Latitude		Longitude	
Comments			

Land Use Left	 Undeveloped	 Residential	 Commercial	 Industrial	 Farming	 School
Land Use Right	 Undeveloped	 Residential	 Commercial	 Industrial	 Farming	 School
Area Type	 Rural	 Urban				
Vehicle Parking	 None	 One Side	 Two Sides			
Sight Distance	 Adequate	 Poor				

	 2 Lane Undivided	 4 Lane Undivided	 2 Lanes Divided	 4 Lanes Divided		
Number of Lanes	1	2	3	4	1 & 2	2 & 3

Lane Width	Wide	Medium	Narrow		
Shoulder Rumble Strip	Present	Not present			
Road Condition	Good	Medium	Poor		
Skid Resistance	Good	Medium	Poor		
Grade	 0% to 7.5%	 7.5% to 10%	 > 10%		
Median type	 Centre line	 Wide line < 1m	 Hatching >1m	 Turn Lane	 Flexible posts
	 Divided 0 to 1m	 Divided 1 to 5m	 Divided 5 to 10m	 Divided 10 to 20m	 Divided 20m+
	 Metal Barrier	 Concrete Barrier	 Wire Barrier	 Motorcycle Barrier	 One Way
Delineation	Adequate	Poor			
Street Lighting	Present	Not present			
School Warning	 Flashing Beacon	 Signs / Markings	 No School Zone	 No School	
School Crossing Supervisor	 Supervisor	 No Supervisor	 No School		
Sidewalk Left	 None	 0 to 1m Away	 1 to 3m Away	 >3m Away	 Behind Barrier	 Informal 0 to 1m	 Informal > 3m
Sidewalk Right	 None	 0 to 1m Away	 1 to 3m Away	 >3m Away	 Behind Barrier	 Informal 0 to 1m	 Informal > 3m
Paved Shoulder Left	 None	0 to 1m Wide	1 to 2.4m Wide	>2,4m Wide			
Paved Shoulder Right	None	0 to 1m Wide	1 to 2.4m Wide	>2,4m Wide			
Pedestrian Fencing	Present	Not present			

	 None	 Present on Main Road	 Present on Side Road			
Crossing Type	 Lights	 Raised	 Bridge or Tunnel	 Marked	 Refuge	
Crossing Quality	Adequate	Poor				
Vehicle Flow						
Pedestrian Crossing Peak Hour Flow	0	0 to 5	6 to 25	26 to 50	50 to 100	101 to 200
	201 to 300	301 to 400	401 to 500	501 to 900	>900	
Pedestrian Along Left Peak Hour Flow	0	0 to 5	6 to 25	26 to 50	50 to 100	101 to 200
	201 to 300	301 to 400	401 to 500	501 to 900	>900	
Pedestrian Along Right Peak Hour Flow	0	0 to 5	6 to 25	26 to 50	50 to 100	101 to 200
	201 to 300	301 to 400	401 to 500	501 to 900	>900	
Intersection Type	 Merge Lane	 3 Leg	 4 Leg	 Roundabout	 Mini Roundabout	
	 Formal U Turn	 Informal U Turn	 Active Train	 Passive Train	 No Intersection	
Extra Features						

Property Access Point	 1 or 2 Driveways	 >3 Driveways	 Commercial				
Intersection Side Flow	0	0 to 100	101 to 1000	1,001 to 5,000	5,001 to 10,000	10,001 to 15,000	>15,000
Intersection Quality	Adequate	Poor					
Channelization	Present	Not present					

Curvature	 Straight	 Moderate	 Sharp	 Very Sharp		
Curve Quality	Adequate	Poor				
Speed Limit	 30	 40	 50	 60	 70	 80
	 90	 100	 110	 120	 130	 140
Speed Limit Unit	Km/h	Mph				
Operating Speed	-10	-5	0	+5	+10	+15
Speed Management	Present	Not Present				

Comments

Appendix D: TRAFFIC VOLUME DATA

Values of	PCU
car	1
Motorcycle	0.5
Bicycle	0.2
LCV	2.2
Bus,Truck	3.5
3 Wheeler	0.8

From Chhatarpur Metro station toward Vasant Kunj:

Time Interval							
	Car	Jeep/SUV	Bus/Truck	two wheeler	3 wheeler	LCV	
2:00-2:15	94	58	11	81	11	5	
2:15-2:30	104	52	7	69	16	1	
2:30-2:45	91	82	10	91	18	5	
2:45-3:00	101	92	10	83	29	0	
3:00-3:15	84	42	13	71	45	10	
3:15-3:30	73	91	17	89	51	8	
3:30-3:45	140	71	19	88	35	11	
3:45-4:00	141	81	21	85	41	7	
total	828	569	108	657	246	47	2455
PCU	828	569	378	328.5	196.8	103.4	
total			2403.7	PCU			

Toward Chhatarpur metro station							
Time Interval							
	Car	Jeep/SUV	Bus/Truck	two wheeler	3 wheeler	LCV	
2:00-2:15	94	61	11	81	11	4	
2:15-2:30	101	52	10	69	16	3	
2:30-2:45	115	82	9	100	21	5	
2:45-3:00	101	92	12	83	29	1	
3:00-3:15	91	72	13	91	59	9	
3:15-3:30	131	91	15	89	51	8	
3:30-3:45	89	83	18	99	81	7	
3:45-4:00	151	91	21	101	41	9	
total	873	624	109	713	309	46	2674
PCU	873	624	381.5	356.5	247.2	101.2	
total			2583.4	PCU			

Towards The Heritage school							
Time Interval							
	Car	Jeep/Suv	Bus/Truck	two wheeler	3 wheeler	LCV	
2:00-2:15	19	11	0	20	2	0	
2:15-2:30	22	9	0	18	7	0	
2:30-2:45	18	17	0	9	8	0	
2:45-3:00	28	9	1	15	5	0	
3:00-3:15	28	9	0	20	5	0	
3:15-3:30	17	16	0	18	8	0	
3:30-3:45	27	9	0	24	10	0	
3:45-4:00	20	17	0	21	11	0	
total	179	97	1	145	56	0	478
PCU	179	97	3.5	72.5	44.8	0	
total			396.8	PCU			

From The Heritage School							
Time Interval							
	Car	Jeep/Suv	Bus/Truck	two wheeler	3 wheeler	LCV	
2:00-2:15	31	10	0	25	2	0	
2:15-2:30	20	9	0	10	3	0	
2:30-2:45	15	14	0	9	8	0	
2:45-3:00	29	7	3	11	3	1	
3:00-3:15	22	9	5	18	6	0	
3:15-3:30	15	19	2	15	8	2	
3:30-3:45	27	9	0	21	9	0	
3:45-4:00	18	12	0	18	10	1	
Total	177	89	10	127	49	4	456
PCU	177	89	35	63.5	39.2	8.8	
Total			412.5	PCU			

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CHAPTER 1 INTRODUCTION 1.1 GENERAL: Road traffic accident near schools and death and injury of school children is a serious issue and is increasing gradually. The safety aspects related to school going children near school zones areas are usually overlooked. Child pedestrians are the most vulnerable road users in India as they have no protection in case of accident. They are also the most vulnerable group in terms of their involvement in fatal accidents and serious injuries. The road user getting involved in road accident is increasing day by day and therefore we need to find solution to the problem of how to make roads and school zones safer for school going children. 1.2 GLOBAL SCENARIO: Every year (according to WHO, Global Road Crash Statistics) in road crashes almost 1.25 million people die worldwide. More than 1,600 children die under the age of 15 years each year. More than 260 ,000 in children under the age of 0-19 years died in road traffic accident in 2004. 93% of road fatalities are seen in low income and middle income countries and for higher income countries 50% of all child traffic Deaths are seen. As pedestrian children are more vulnerable and 5-14years old are more at risk. A table showing risk of road traffic injuries under up to the age of 20 years. HIC = High-Income Countries; LMIC = Low-Income and Middle-Income Countries. Table No-1.1: Child road traffic injury rates per 100000 population by gender and age Gender Ag e in years Infant under 1 2years-4 years 5years- 9years 10years-14years 15years- 19years Under 20 years Girls 7.4 8.3 9.3 4.5 7.9 7.5 Boys 11.5 11.5 13.3 8.7 23.4 13.8 Source: WHO (2008), Global Burden of Disease: 2004 update. (WHO & UNICEF) According to IRAP 85% of roads do not have pedestrian crossing, 70% of roads have no side walk, 94% of roads have no bicycle facilities. 1.3 INDIAN SCENARIO According to Save Life Foundation, (an Indian NGO working in the road safety sector), since 2008, over 55,000 children have lost their lives in road crashes in India. According to road crashes statistics 2016, it has been estimated that every day in India due to road accident 43 children die and around 20 children under the age of 14 die every day (WHO report). 6.4% road crash fatalities were attribute to children aged below 18 years, in 2017. Since the safety measures for adult do not apply to children, it is erroneous to believe that the same safety strategies for adult can work for children, therefore government should provide special focus on safety policies for children. A survey revealed that in India, irresponsible and negligent road user behavior aren't the only factors that make commute unsafe for children. Poor infrastructure which involves lack of footpath, zebra crossing, proper signage also contribute to lack of safety during commute for children. With increase motorization, roads are crowded round the clock which makes road more unsafe for children when travelling by themselves. Also both driver and pedestrian are responsible for road crashes. Drivers required to be extra caution in school zone areas. 1.4 DELHI DEMOGRAPHIC AND PEDESTRIAN SCENARIO Delhi, the capital of India, is bordered by Uttar Pradesh in east and Haryana on three side. The map of Delhi is shown in figure 1. It covers an area of 1,484 square kilometers. The population of Delhi was over 11 million according to the 2011 census, which is the 2nd highest in India. Delhi's urban area is now considered to extend beyond the NCT boundaries and include the neighboring satellite cities of Faridabad, Gurgaon, Ghaziabad and Noida had an estimated 2016 population of over 26 million people, making it the world's second-largest urban area according to United Nations. As of 2016, recent estimates of the metro economy of its urban area have ranked Delhi either the most or second-most productive metro area of India. Safety is a key concern for parents. They cannot always accompany your kids and guide them. Of course, parents ensure the safety of their child at home and teachers or school transportation authority ensure the kid's safety in order to safeguard the credibility of the schools. As a matter of fact, children will not be mature enough to realize what is right or what is wrong, while walking on the roads. Without the appropriate guidance and awareness of road safety rules, it is risky to send children unaccompanied. In Delhi there are almost 7,268 schools in 2017-2018 with 44.13 lakhs student (according to Delhi government statistic). In 2017, 25 children below the age of 18 were killed in road accident so the school transport has become a nightmare for parents. There are many schools in Delhi which don't have a proper pedestrian walk or proper installation of Signage near schools. Figure -1.1 Map of Delhi 1.5 SOUTH DELHI AREA AND SCENARIO South Delhi is an administrative district of Delhi in India which is bounded by the Yamuna River to the east, the districts of New Delhi to the north, Faridabad District of Haryana state to the southeast, Gurgaon District of Haryana to the southwest, and South West Delhi to the west. It has 250 square kilometer (97 sq. mi.) (Delhi gov.) and a population of 2,258,367 (according to 2011 census), with a population density of 9,034 persons per km² (23,397 persons per mi²). The district is divided into three main subdivisions, Saket, Hauz Khas, and Mehrauli as shown in figure 2. The district is a mix of modern buildings and historical monuments and is known for both commercial and residential values. Figure 1.2 - Map of South Delhi The main suburbs of South Delhi are ? R. K. Puram ? Friends Colony ? Golf Links ? Hauz Khas ? Defence Colony ? Kalkaji ? Lajpat Nagar ? Greater Kaiash ? Channakyapuri ? Vasant Vihar ? Vasant Kunj ? Saket Increasing traffic on roads has leads to major fatalities of pedestrian. Since child pedestrian injuries are the leading causes of our country an attempt is made to study the roads facilities near schools area. 1.7 NEED AND SCOPE The need to conduct this study arises from the fact that at many places across India and the world we see a rise in the child and pedestrian fatalities and injury rates. School Zones are an area which almost every child traverses in his/her daily trip. School Zone also becomes a daily trip generating point for parents or adults accompanying the child. There is very little work done as per literature in studying the specific aspects of safety for pedestrians and children in the School Zones in India and other developing countries. The scope of this thesis is to study the literature and identify all parameters relating to the problem zones in school areas with respect to child and pedestrian safety. Further, Surveys shall be conducted to assess the current situation around several school areas in the selected study area. The geometric parameters of the school zone can be modified to make it more pedestrian friendly and safer for pedestrians. Further the impact of this re-design shall be studied with the help of simulation toolkit. Further, as based on global best practices and literature, several measures of enhancement are suggested with possible policy level changes to bring about a change in the school zones to aid the safety of pedestrians of all age groups in the vicinity of schools. 1.8 OBJECTIVE 1. Study of Literature to find out attributes responsible for pedestrian safety and convenience in school zones. 2. Pedestrian perception questionnaire based survey of school children, Parents, Teacher/ Staff to evaluate existing pedestrian issues in the study area. 3. Inventory based survey to assess availability of existing pedestrian infrastructure in the study area along with vehicular movement data. 4. Impact of modification in the attributes with respect to pedestrian friendly corridor studied with the help of virtual simulation technique using PTV Vissim/Viswalk software. 5. Recommendation to enhance the school zone pedestrian experience based on global standards and best practice case studies. 1.9 LAYOUT OF THESIS This thesis has been organised into seven chapters. Introduction, Literature review, Study Area and Data collection, Assessment of current scenario, Redesign of school, Policies/ recommendation, Conclusion. Chapter 1 describes the global and Indian scenario of roads and also the problem faced by child pedestrian along with scopes and objectives. Chapter 2 deals with the literature review related to the