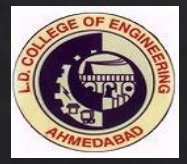
Improving Pedestrian Facility in Congested Urban Area

(*Pedestrian Simulation)*

Gujarat Technological University

Chandkheda, Ahemdabad



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Content of Study

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- Problem Statement
- Objective
- Scope
- About VISSIM
- Literature Review
- Study aspects and proposed methodology
- Data collection and Analysis
- Design and Conclusion

Introduction

- Need to simulate pedestrian as they are also the part of lane users.
- Simulation can be done using VISSIM software.
- There is need to Improve Pedestrian facility in heavily congested urban area.
- No delay occurrences for pedestrian.
- The purpose of the embedding pedestrian facility like skywalks is efficient dispersal of commuters from congested areas to strategic locations such as bus stations, taxi stands, shopping areas, etc.

Problem Statement

- High influence of pedestrian and vehicle collaboration.
- Heavy congestion effect the lane user everyday.
- Vehicle – pedestrian interaction is such that pedestrian suffer anxiety.
- Conceiving all this situation there must be some providence of Pedestrian facility.

Objective

- To carry out the feasibility study for Pedestrian Facilities in urban area.
- To collect data on traffic and pedestrians for real time study.
- To collect data that provide delay to the pedestrians in the main traffic stream.
- To show the real life situation of vehicles and Pedestrians interaction and suggest the Remedial measure for reducing the obstruction to pedestrians.
- To simulate the pedestrians with use of Microscopic simulation model (VISSIM Software).

Scope

- Finding existing traffic vehicle hourly volume, pedestrian hourly volume and delay to pedestrians in high traffic zone.
- Gathering all inputs into the software for proper simulation of pedestrian in the main Traffic zone.
- Comparing the real life situation to the simulated one and suggest for improving pedestrian facility.
- Provide design facility based on results obtained through simulation.

About VISSIM

- Microscopic ,time step and behaviour-based simulation model developed to model urban traffic, public transport operations and flows of pedestrians.
- Pedestrian flows can be modelled, either exclusively or combined with private traffic and/or public transport.
- Simulate and visualize the interactions between road traffic and pedestrians.
- Psycho-physical driver behaviour model developed by wiedemann (1974).
- Traffic simulator- Car following and lane change logic.

Literature Review

Simulation research on crossing behaviour of the pedestrians and vehicles at the Pedestrian crossing based on simulation software VISSIM.(Lu Wang , Shunqiang Ye, Min Tang in 2013)

- Simulating the behavior of the pedestrians and motor vehicles when they cross the intersection with no signal.
- The data which is got from simulation system is not quietly different from the actual data (5%).

A simulation model for pedestrian flow through walkways with corners *Ren-Yong Guo a,⇑, Tie-Qiao Tang 2011*

- A MPM is developed for simulating pedestrian flow through walkways with not only perpendicular corners.
- Flow-density relation, are investigated by numerical simulations.
- Flow through walkways with corners, compared with that of pedestrian flow through bottleneck, is more complex.
- Effects of the corner of walkway and the degree of pedestrian preference to the inside routes on the pedestrian queue dissipation and movement trajectory.

Modeling and simulation of pedestrian traffic flow

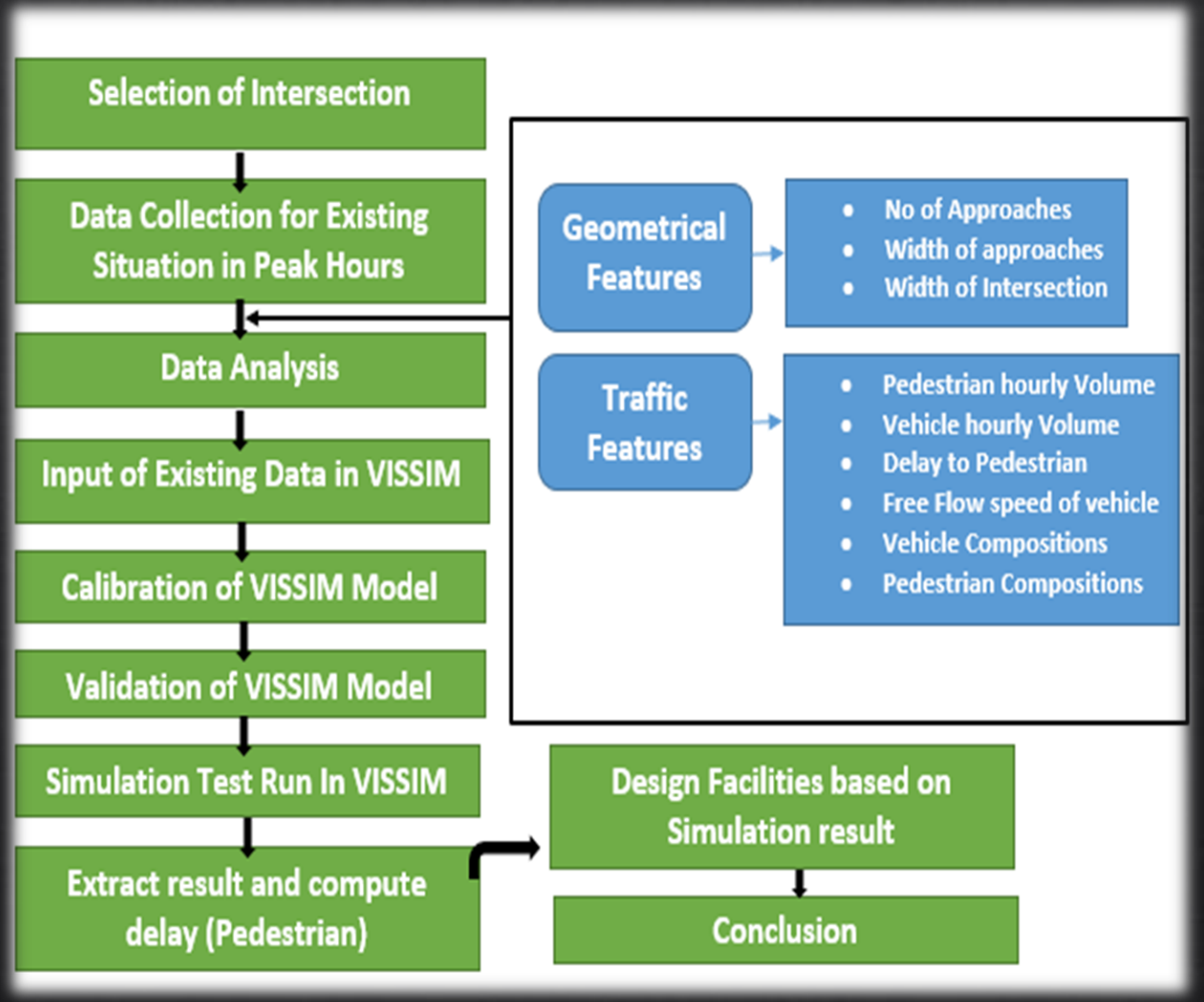
Gunnar G. Løvås 1994 Published by Elsevier.

- The efficiency and safety of pedestrian traffic systems are of major importance in the planning and design of such systems.
- Pedestrian facility can be modeled as a network of walkway sections that can be modeled as a queuing network process, where each pedestrian is treated as a separate flow object, interacting with the other objects.
- He also presents a simulation tool, of which the main objective is to estimate the relevant performance measures of the pedestrian traffic system.

Study Aspects and Proposed Methodology

- Careful assessment of demand, design standards, functional elements, and space design is called for in pedestrian facility planning.
- Factors should be kept in mind while designing Pedestrian facilities are:
    1. Comfort
    2. Convenience
    3. Safety
    4. Security
    5. Economy

Methodology



Study area

Selection of study area:

1. The site must have regular bus service routes.
2. The site must have atleast one nearside bus stops.
3. The intersection must be signalized for vehicular traffic.
4. The intersection requisite of maximum pedestrians flow.
5. Heavy conflicts between Vehicular-Pedestrian traffic.
6. The pedestrian flow is consisting of mixed type including all men or women having different age and with kind of purpose of trip.

Data collection

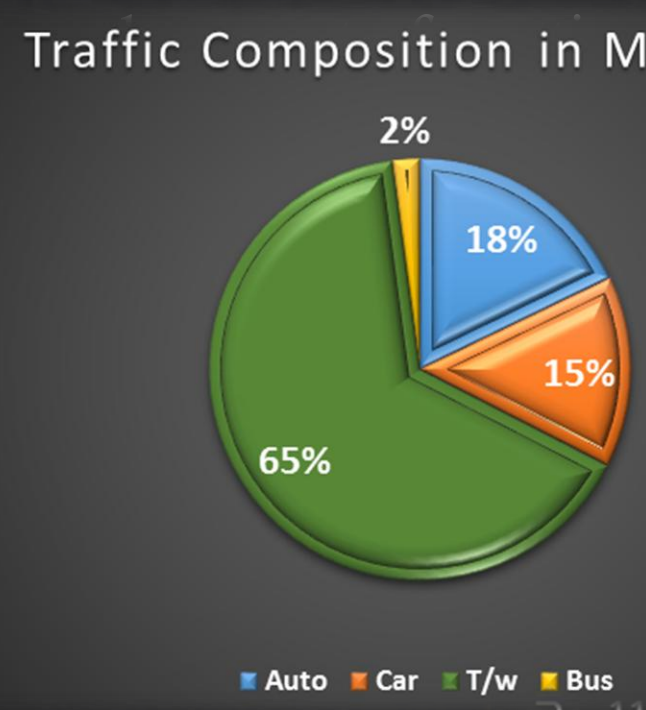
Income Tax Intersection

Pedestrian traffic exposed to road accident

REASON FOR SITE SELECTION

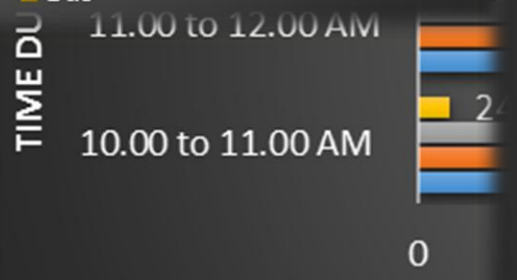
- While crossing pedestrian faces some problems at intersection.
- Enforcement of stop sign is not observed properly.
- Absence of proper pedestrian signal.
- Guard rails are not provided on leg Gandhi Bridge Road and S.P.Stadium Road.
- Vehicle occupy space of the footpath.

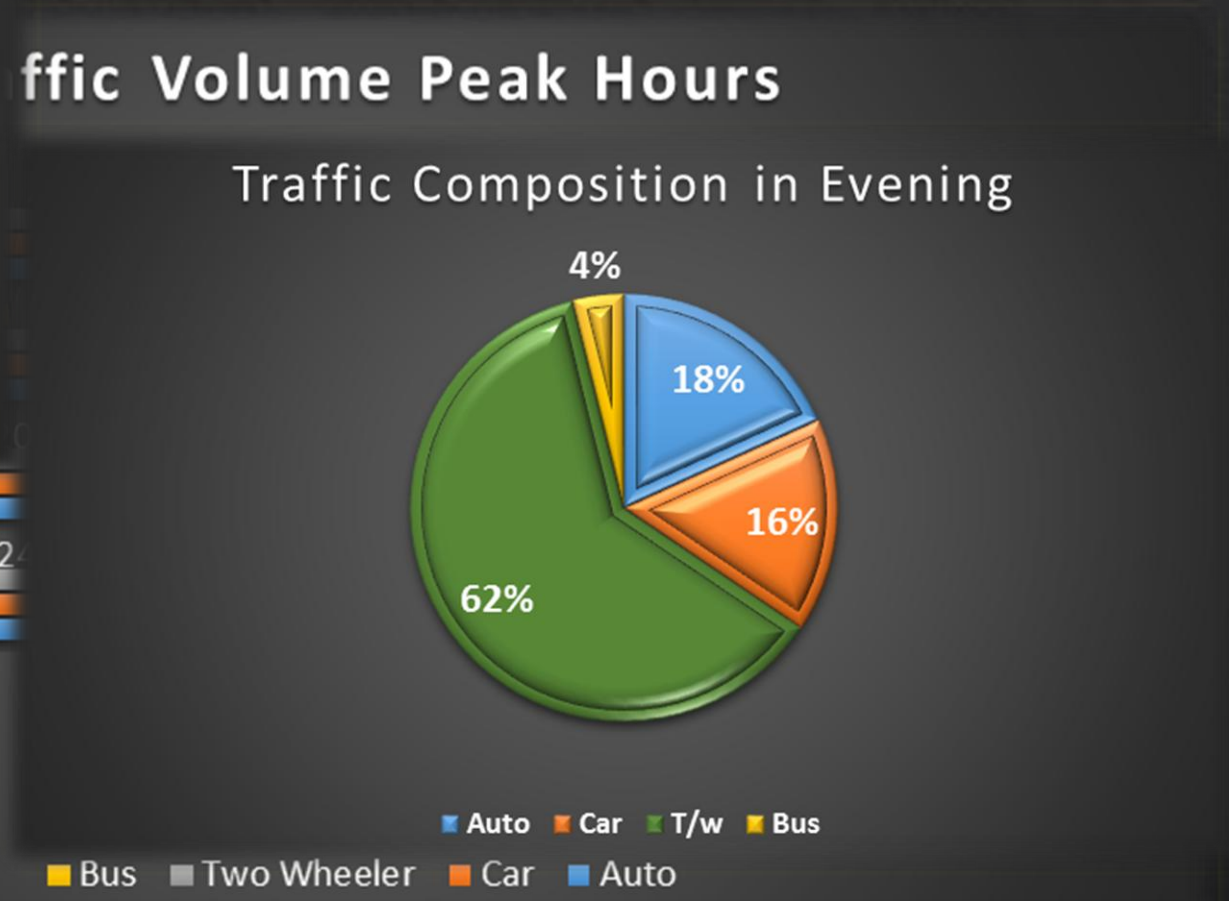
Traffic volume count survey



s within which one hour interval

ulted distribution of vehicle is :



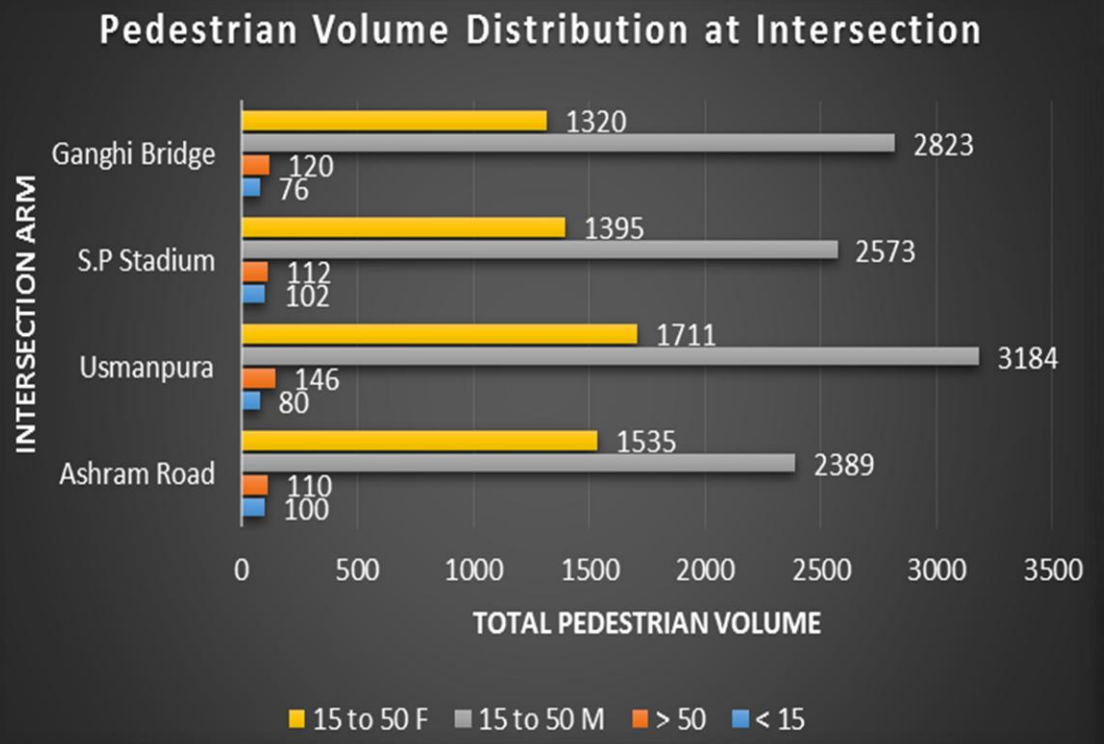


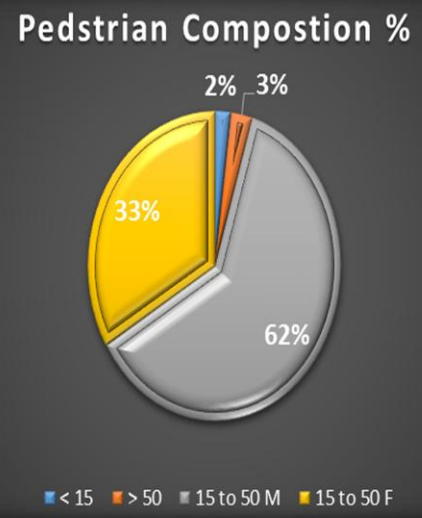
Pedestrian Volume Count Survey

Videography count of continuous two hours within which one hour interval is used to obtain this data. In which the resulted pedestrian distribution is gathered as:

Pedestrian/hour

Gandhi bridge- 1221
S.P.Stadium- 1798
Ushmanpura-1511
Ashram Road-1336

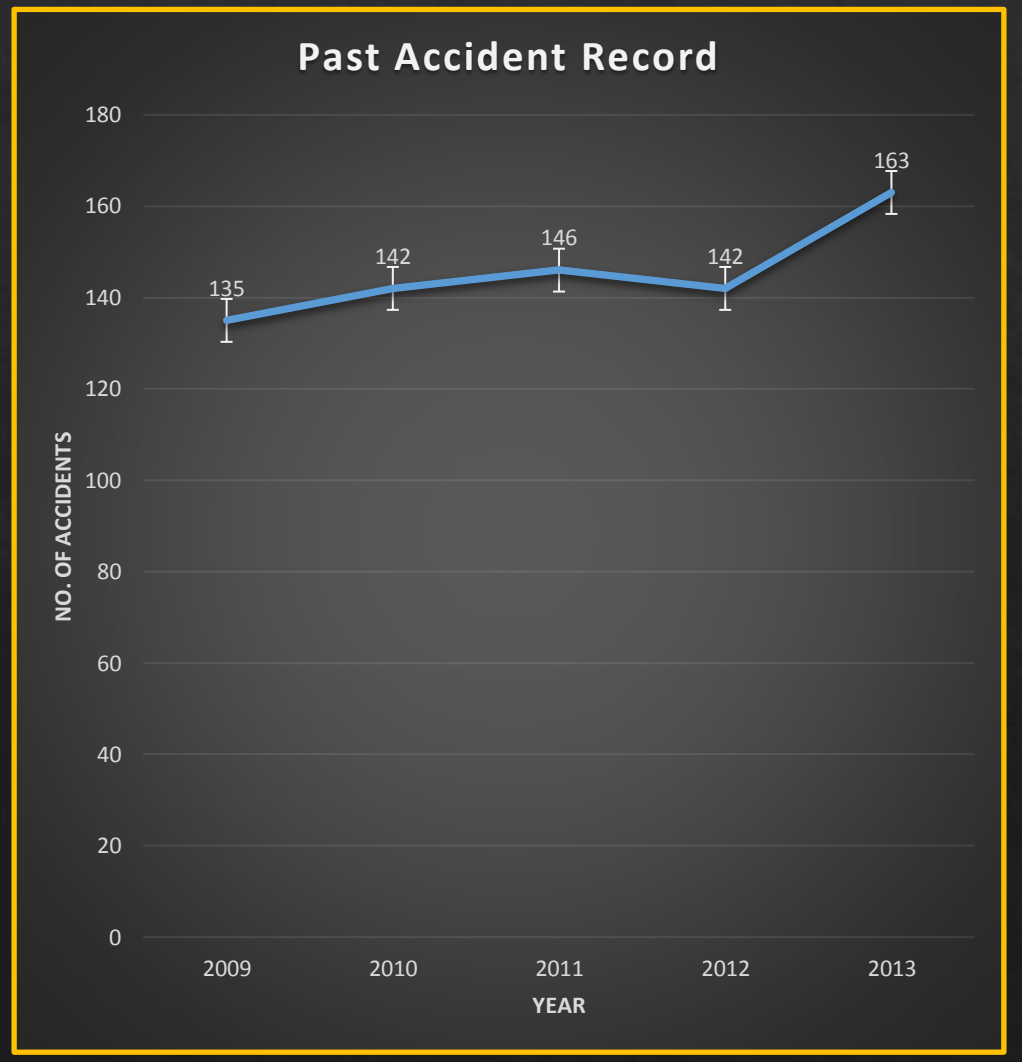




Road Inventory Survey

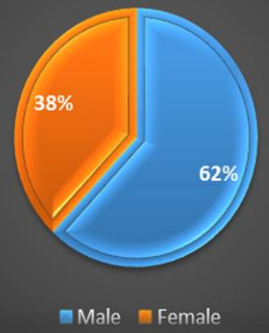
INCOME TAX INTERSECTION		Gandhi Bridge	Ashram Road	Usmanpura	S.P.Stadium
Footpath width(m)	LHS	1.3	1.5	1.5	1.5
	RHS	1.2	1.5	1.5	1.5
Carriageway width(m)	LHS	10.55	11.3	11.2	10.15
	RHS	9.56	11.42	10.89	11.45
Median width (m)	LHS/RHS	0.5	0.63	0.63	0.55
Pedestrian Sign	LHS	Yes	Yes	Yes	Yes
	RHS	Yes	Yes	Yes	Yes
Guard Rail	LHS	No	Yes	Yes	Yes
	RHS	No	Yes	Yes	No
Bus Stand	LHS	No	Yes	Yes	Yes
	RHS	No	Yes	Yes	No
Street Light	LHS	Yes	Yes	Yes	Yes
	RHS	Yes	Yes	Yes	Yes

Past Accidents Record

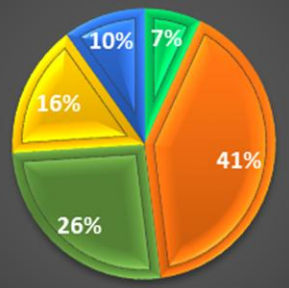


Pedestrian opinion survey at Income Tax

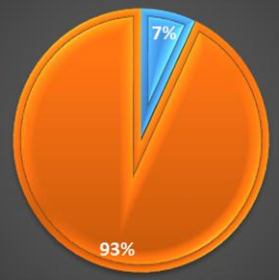
Gender



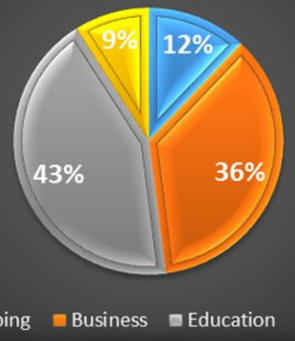
Age Distribution



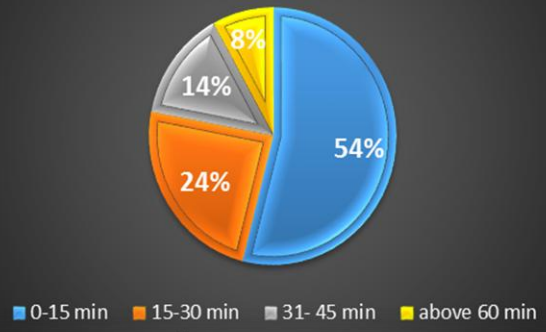
Physical Disability



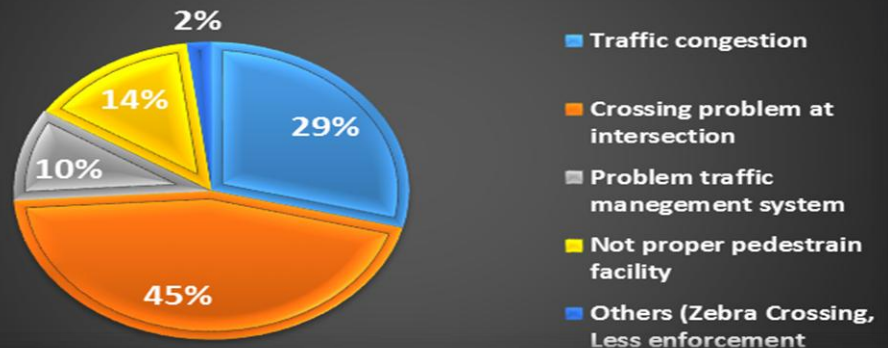
Purpose of Trip



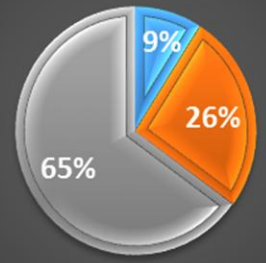
Time spent walking per day



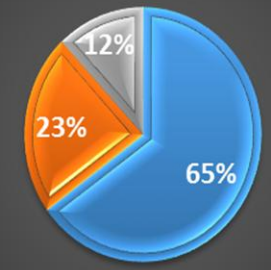
Feedback on Present Facility



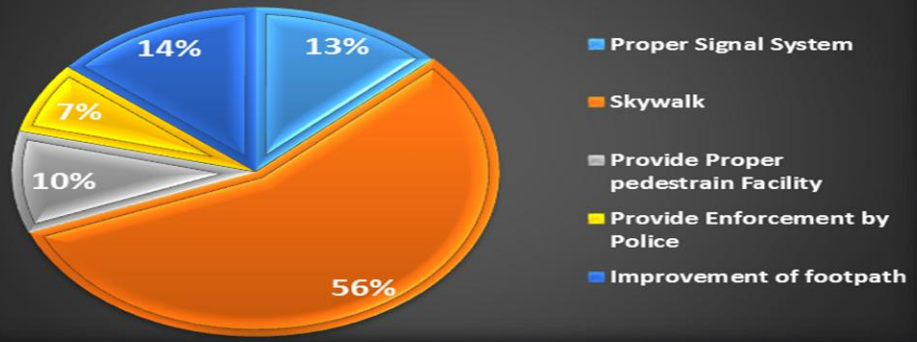
Road Crossing Delay



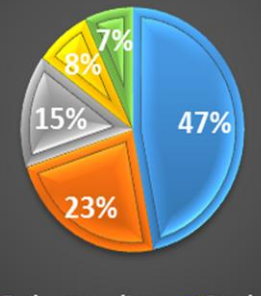
Frequency



Suggestion by Pedestrian

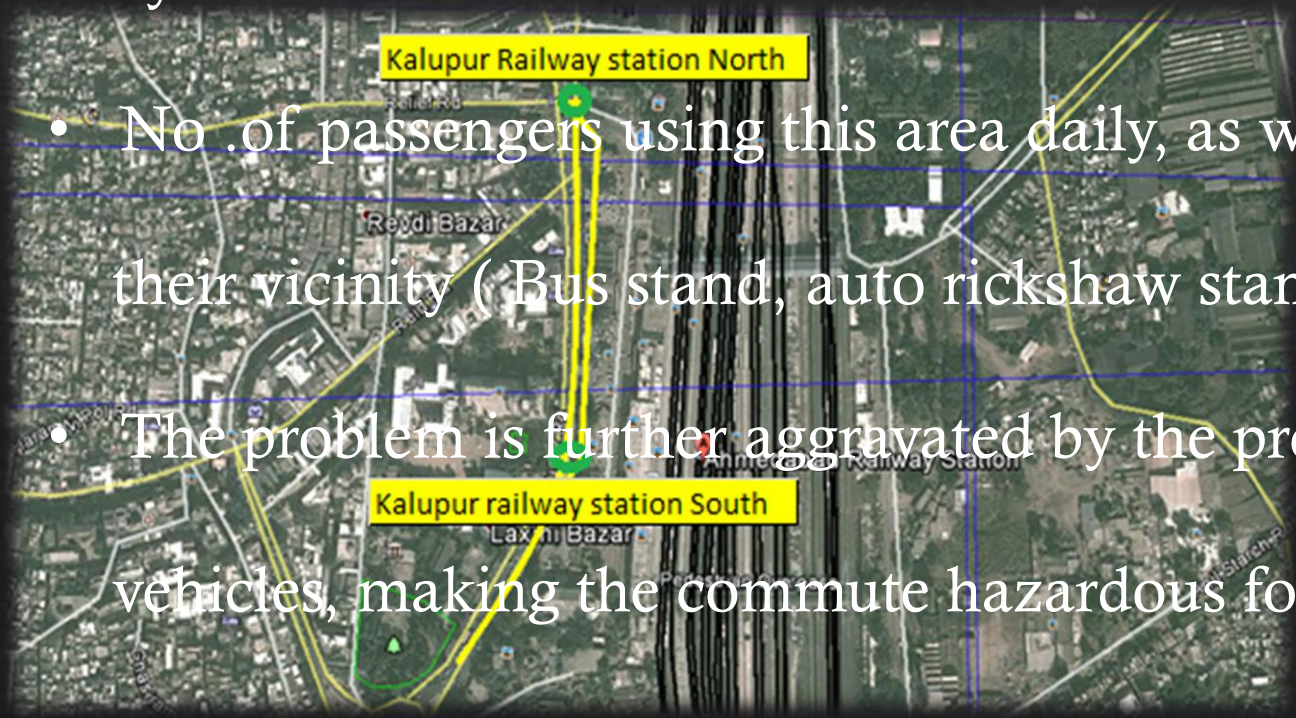


Road Crossing Convenience

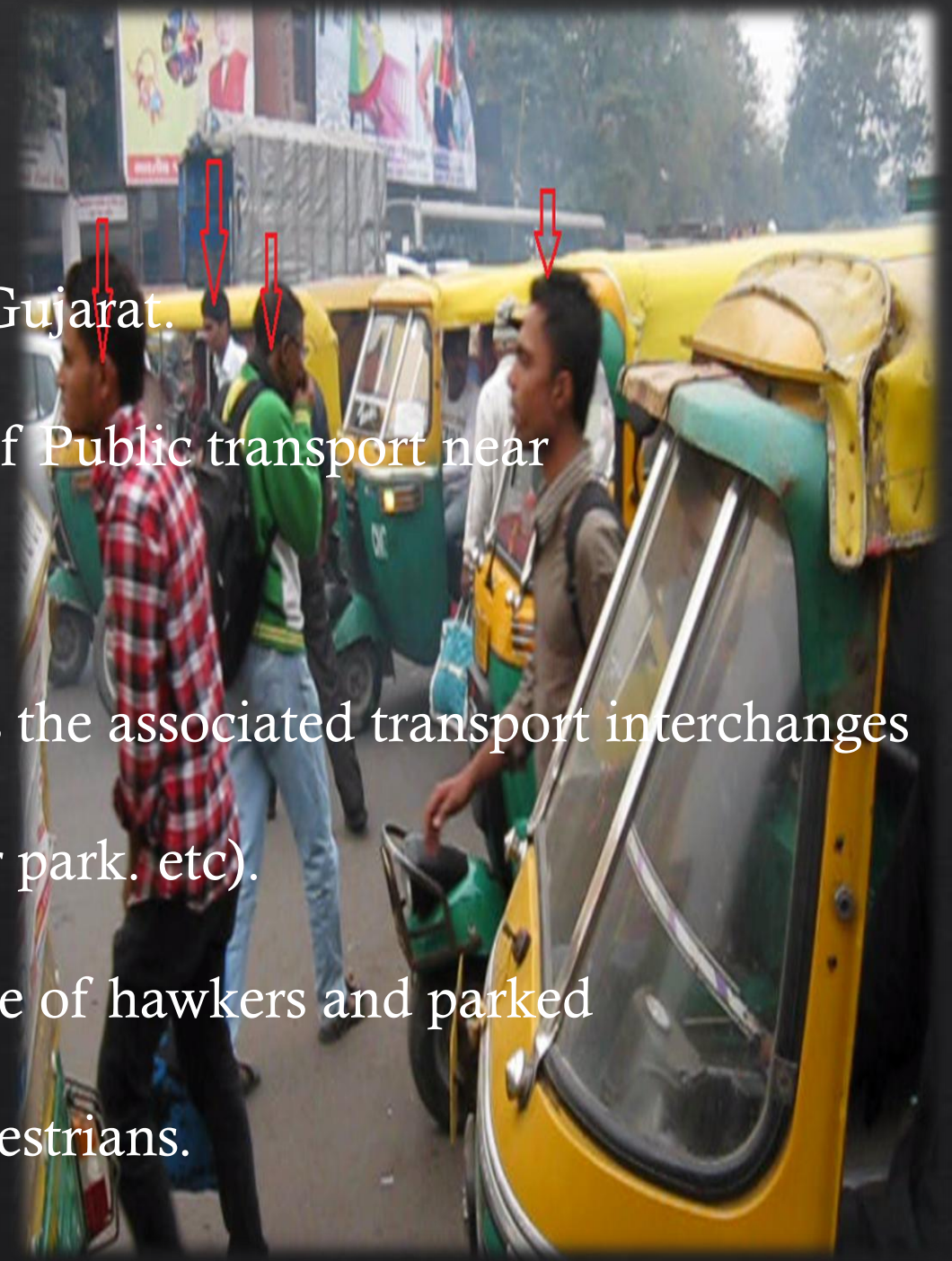


Kalupur Railway Station

- It is the biggest & busiest railway station within Gujarat.
- High movement of pedestrians due to presence of Public transport near by this location.

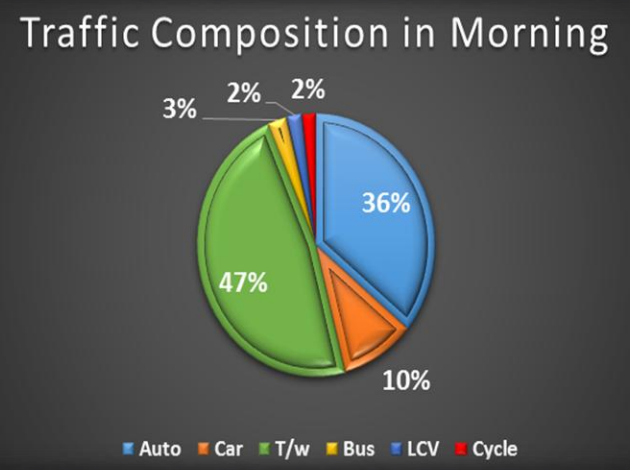


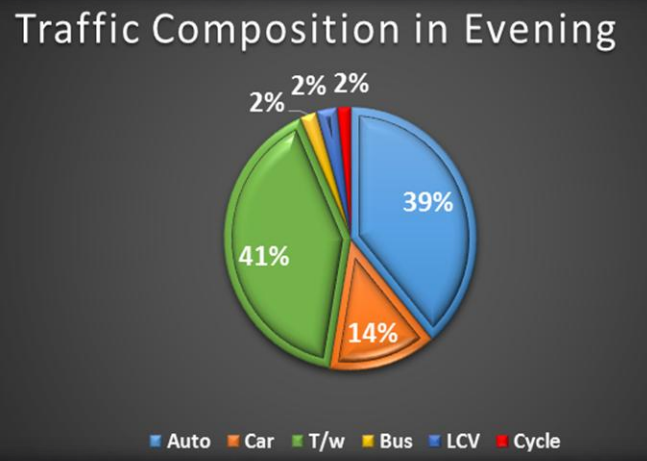
- No .of passengers using this area daily, as well as the associated transport interchanges their vicinity (Bus stand, auto rickshaw stand car park. etc).
- The problem is further aggravated by the presence of hawkers and parked vehicles, making the commute hazardous for pedestrians.



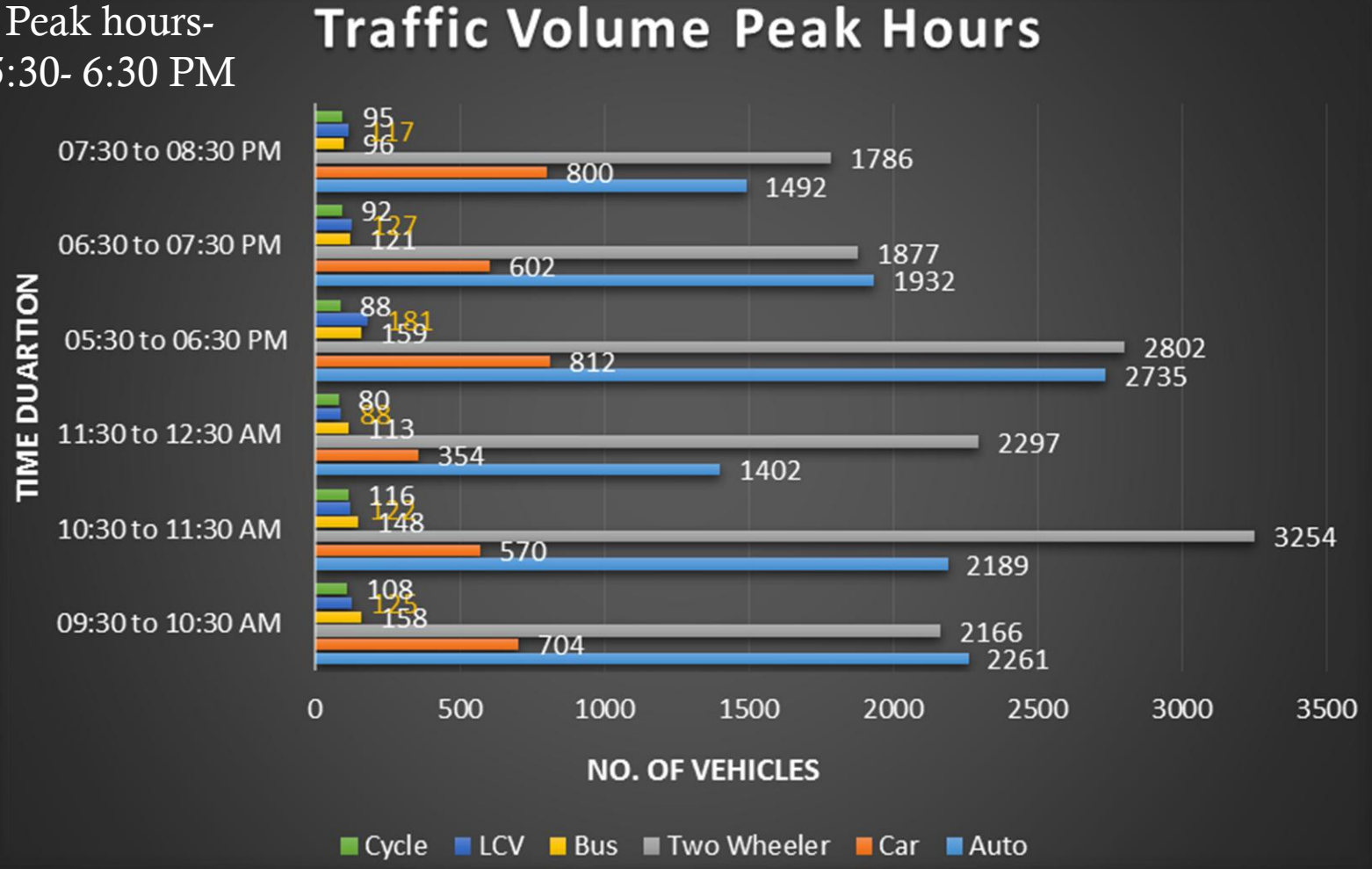
Traffic volume count survey

The survey is taken by Manually around morning peak hours at 09:30 to 12:30 AM and also in evening peak hours at 05:30 to 08:30 PM by employing enumerators at each location.





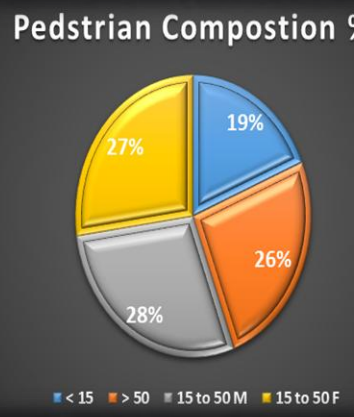
Peak hours-
5:30- 6:30 PM

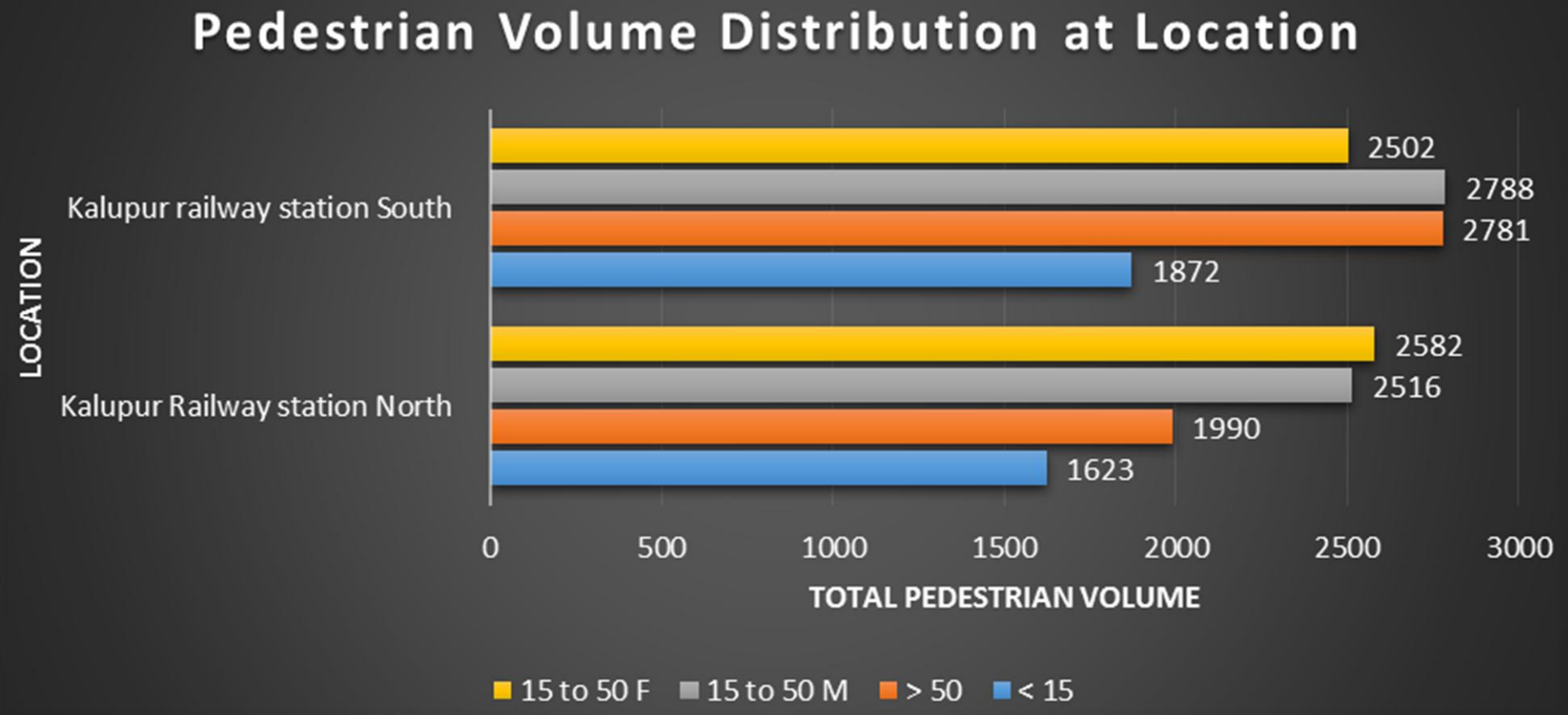


Pedestrian Volume Count Survey

The survey is taken by Manually around morning peak hours at 09:30 to 12:30 AM and also in evening peak hours at 05:30 to 08:30 PM by employing enumerators at each location

Pedestrian/hour
North- 1848
South- 1798
-

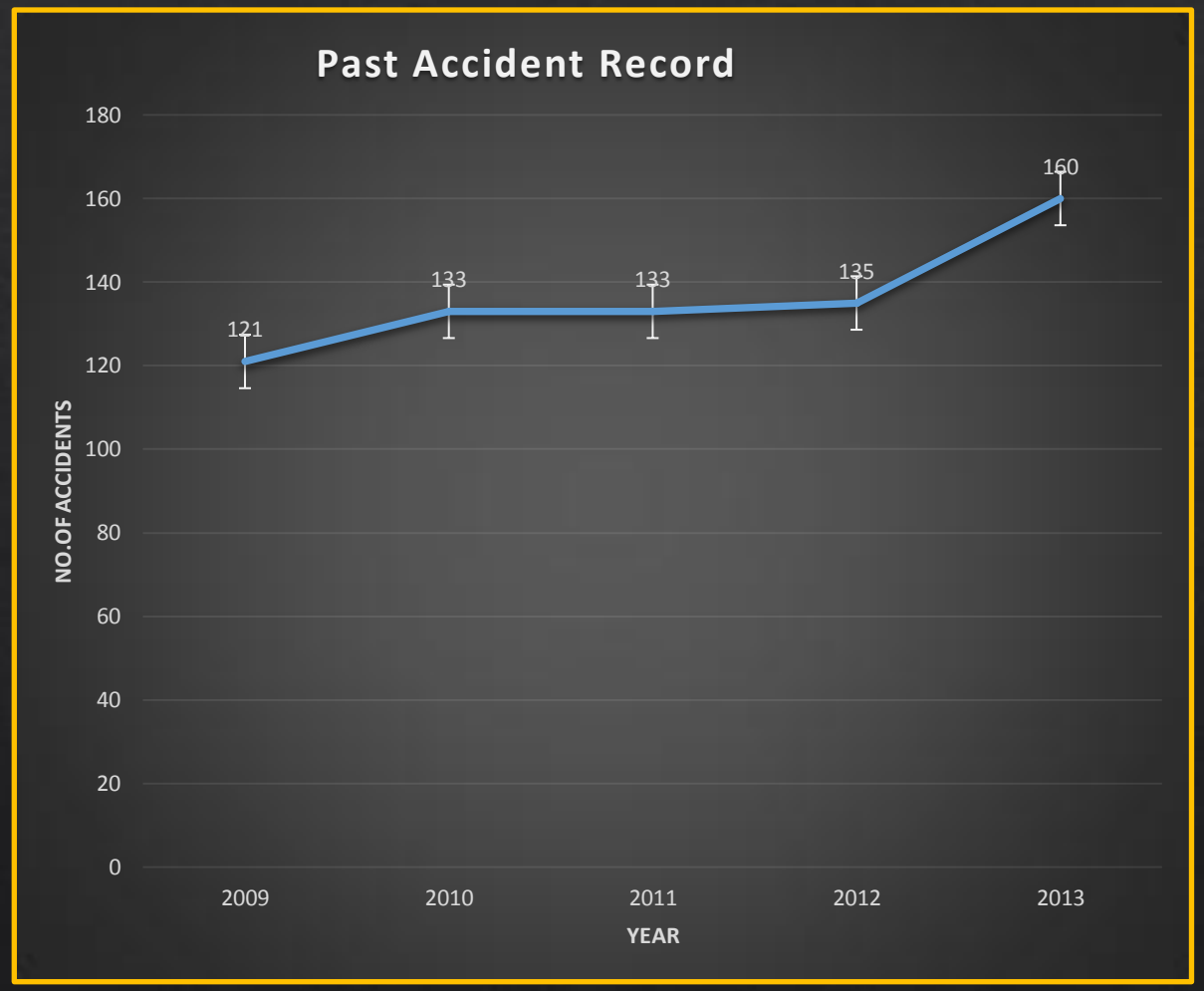




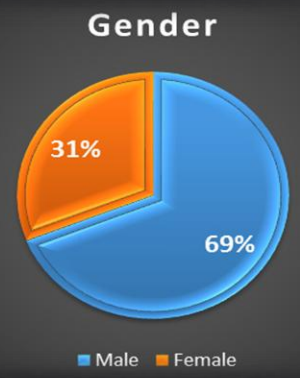
Road Inventory Survey

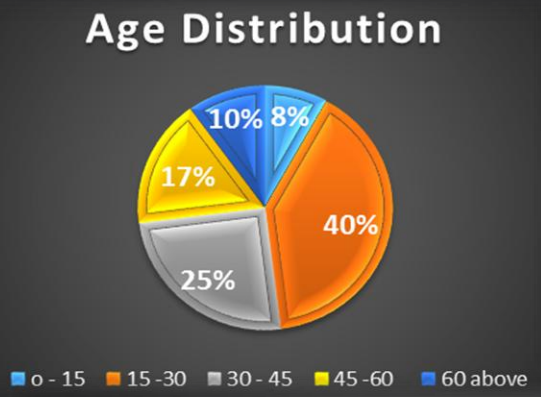
KALUPUR RAILWAY STATION ROAD	Kalupur Railway station North	Kalupur Railway station South
Footpath width(m)	1	1
Carriageway width(m)	3.5	3.5
Median width(m)	.32	.32
Pedestrian Sign	No	No
Guard Rail	No	No
Bus Stand	Yes	Yes
Street Light	Yes	Yes

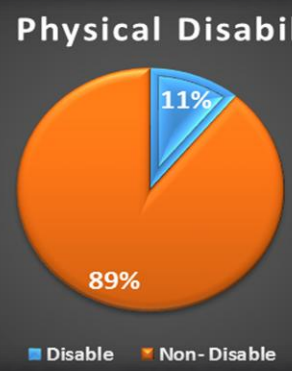
Past Accidents Record

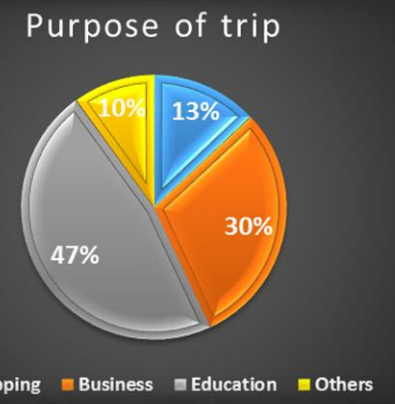


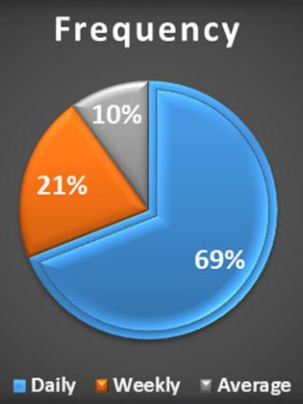
Pedestrian opinion survey at Kalupur

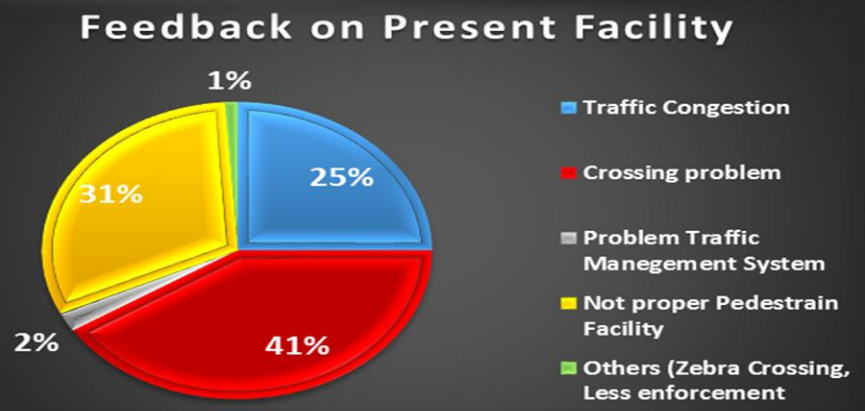


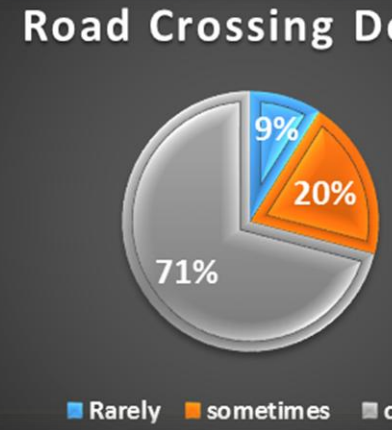


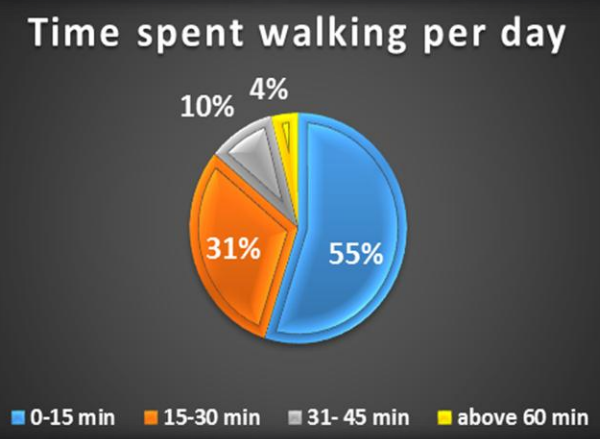


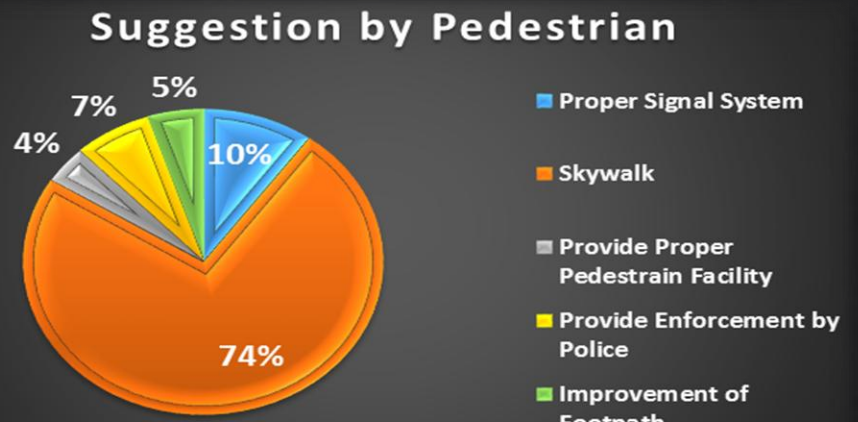


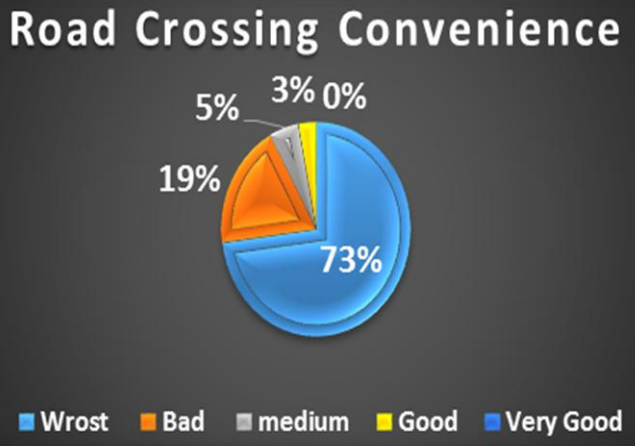












Approach Speed Measurement

- By using speed gun each individual vehicle is target and speed data is taken on that basis.

Sr no.	Type of vehicle	Speed in Km/hr
1	T/w	22.2
2	Auto	17.53
3	Car	18.35
4	Bus	14.17
5	LCV	11
6	Cycle	7

Analysis of Field data at Income Tax Intersection

As Per IRC:103-2012

- At grade pedestrian crossing - pedestrian cross carriageway at same level as that of vehicular movement.
- Grade Separated crossing - pedestrian cross carriageway at different level as that of vehicular movement.

➢ Controlled crossing at grade may be warranted when one or more of the following condition exist as:

1. Peak hour volume of Pedestrian (P) and Vehicle (V) are such that $PV^2 > 10^8$ for undivided carriageway and $PV^2 > 2x10^8$ for divided carriageway.

✦ In our case-$PV^2 > 2x10^8$ ($7.9 \times 10^{11} > 2x10^8$)

2. Waiting time for pedestrian/vehicle becomes too long.

✦ From the opinion survey and cycle length, pedestrian have to wait about 60 sec.

Analysis Cont…

3. Accident records indicates 5 or more injuries to pedestrian in a year due to collision with vehicle.
   - From the past accident record it is more than 5 injuries to pedestrian in a year.
4. Approach speeds of vehicles exceed 65 kph.

The control measure usually adopted in this case is to provide traffic signal with exclusive Pedestrian Phase.

Analysis Cont…

- Fixed time signal system is to determine the cycle time.

$$Co = \frac{1.5\,L+5}{1-Y}$$

Co= Optimum Cycle

L= Total Lost time per cycle

Y= y1+y2+y3+…+yn …are the max. Ratios of flow to saturation where q is Flow and S is Saturation Flow.

S= 1326w PCU/Hr

G(usmanpura-ashram road)=y_{ua} (Co-L)/ Y

G(s.p.stadium-gandhi bridge)= ysg (Co-L)/ Y

G(ashram road-usmanpura)= yau (Co-L)/ Y

G(gandhi bridge-s.p.stadium)= ygs (Co-L)/ Y

Analysis Cont…

Table: Calculation of Signal Phase for Vehicular and Pedestrian traffic

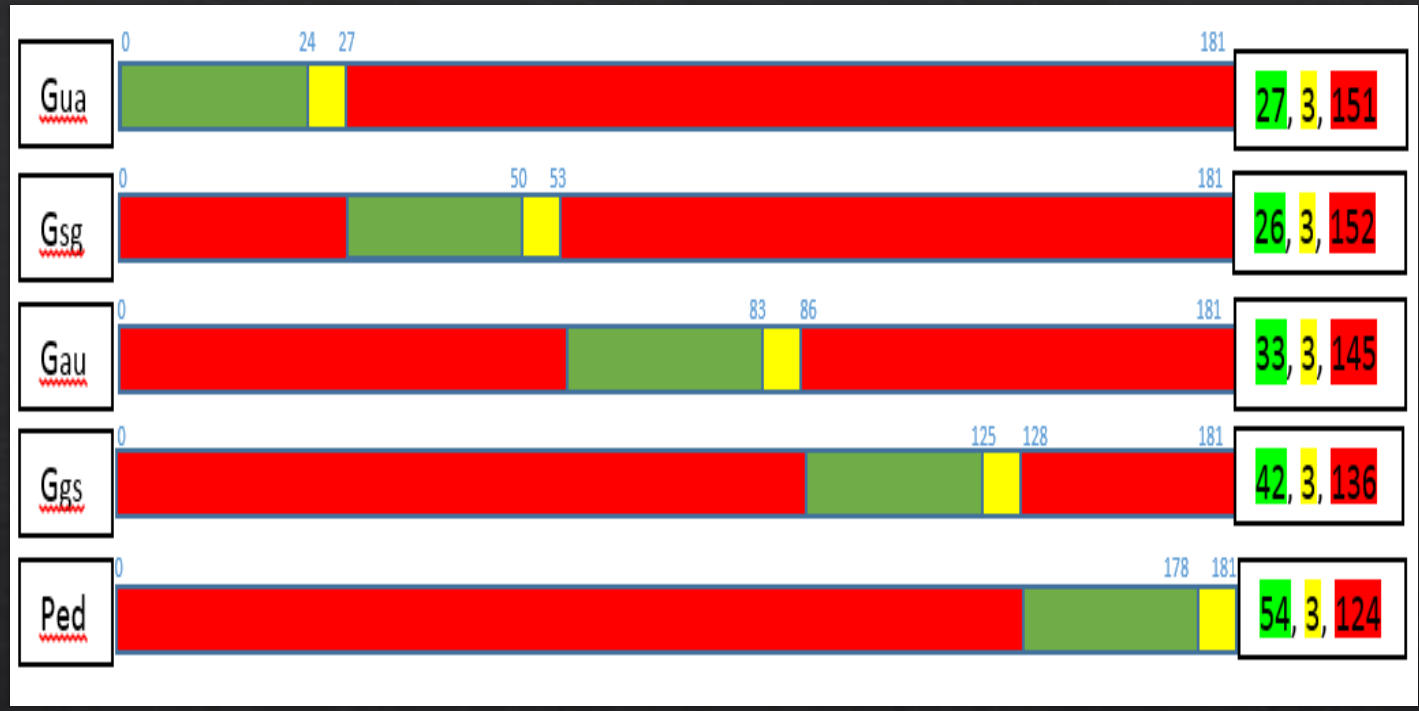
Leg	Usmanpura			Ashram raod			Gandhi brigde			S.P.Stadium		
Directions	L	S	R	L	S	R	L	S	R	L	S	R
No. of Veh.	177	947	336	144	709	572	224	1180	609	129	987	225
Cr-Left Turn	44			36			56			32		
Cr-Right Turn			252			429			457			169
Total	221	947	588	180	709	1001	280	1180	1066	161	987	394
Road Width	3	10.55		3	9.55		3	9.75		3	9.7	
PCU/Hr		1535			1710			2246			1381	
S	13989.3			12663.3			12928.5			12862.2		
y=q/S	0.10972672			0.135035891			0.17370538			0.107349443		
y	0.53											
L	54											
c_o	181.4											
c_{o-L}	127.4											
G ua	27											
Gsg	26											
Gau	33											
Ggs	42											
Ped	54											

Analysis Cont…

Where,dp = average pedestrian delay (s), g = effective green time (for pedestrians) (s), and C = cycle length(s).

$$dp = \frac{0.5(C - g)2}{C}$$

Signal program of Income tax Intersection



- Result in congestion aspect –

The average delay per pedestrian comes as 44 sec.

Analysis of Field data at Kalupur Railway Station

Pedestrian Characteristics at Kalupur Railway Station Road

No.	Direction	Overall width (m)	Effective walkway width(m)	Flow ped/hour	15-min peak flow
1	Kalupur Railway Station North	1.35	1	1848	342
2	Kalupur Railway Station South	1.47	1	1798	487

$$Vp = \frac{V_{15}}{15 * W_E}$$

Vp = pedestrian unit flow rate (p/min/m),
V_{15} = peak 15-min flow rate (p/15-min), and
W_E = effective walkway width (m).

- Using the relation: $Vp = \frac{487}{15 \times 1.47}$

$= 22.08$ Ped/min/m

Pedestrian LOS criteria for Walkway and Sidewalk

Leg	LOS	Space (m2/p)	Flow rate (p/min/m)	Speed (m/s)	v/c ratio
A	B	>3.7-5.6	> 16-23	>1.27-1.30	> 0.21-0.31
B	C	>2.2-3.7	>23-33	>1.22-1.27	>0.31-0.44

Analysis Cont…

- For a single pedestrian, critical gap is computed according to (HCM-2000)

$$tc = L/Sp + ts$$

Where, tc = critical gap for a single pedestrian (s), Sp = average pedestrian walking speed (m/s), L = crosswalk length (m), and ts = pedestrian start-up time and end clearance Time (s).

$$tc = \frac{9 + 180}{1.27}$$

$$= 187 \text{ s}$$

- Average delay of pedestrians at an unsignalized intersection crossing depends on the critical gap, average delay per pedestrian for a crosswalk is

$$dp = \frac{1}{v}(e^{vt_G} - vt_G - 1)$$

Analysis Cont…

- Where, dp = average pedestrian delay (s), v = vehicular flow rate (veh/s), and t_G = group critical gap from :$t_G = t_c + 2(N_p - 1)$, Np=spatial distribution of pedestrians (p).

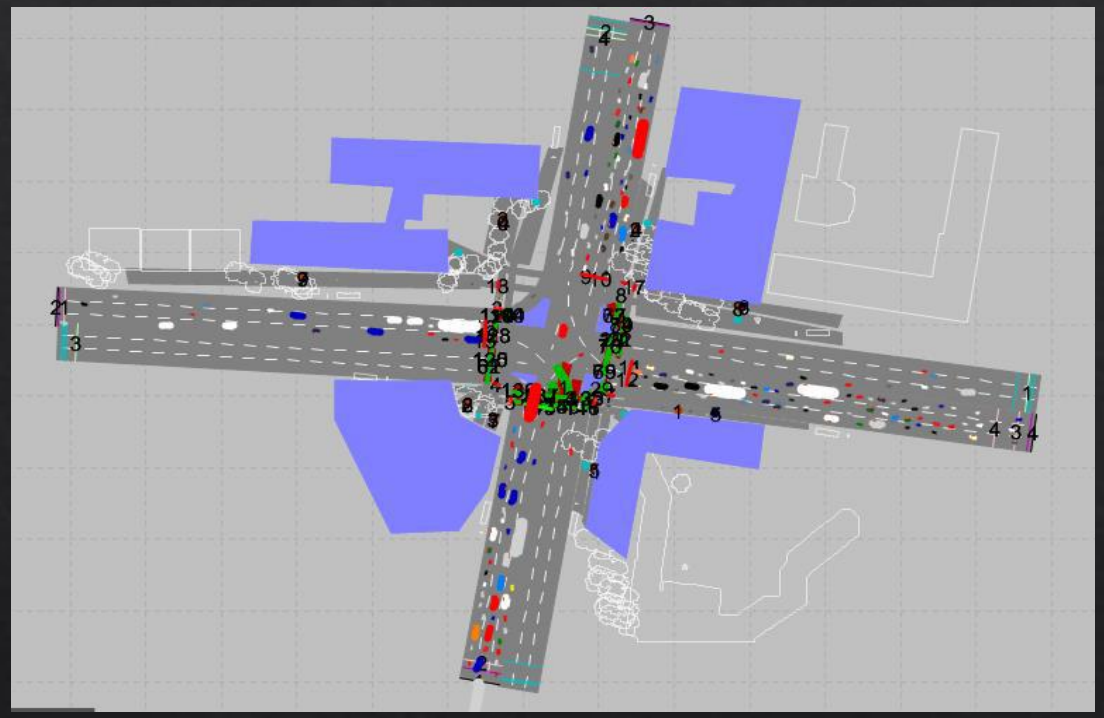
$$dp = \frac{1\ (e2*187 - 2*\ 187 - 1)}{2}$$

$$= 503\ s$$

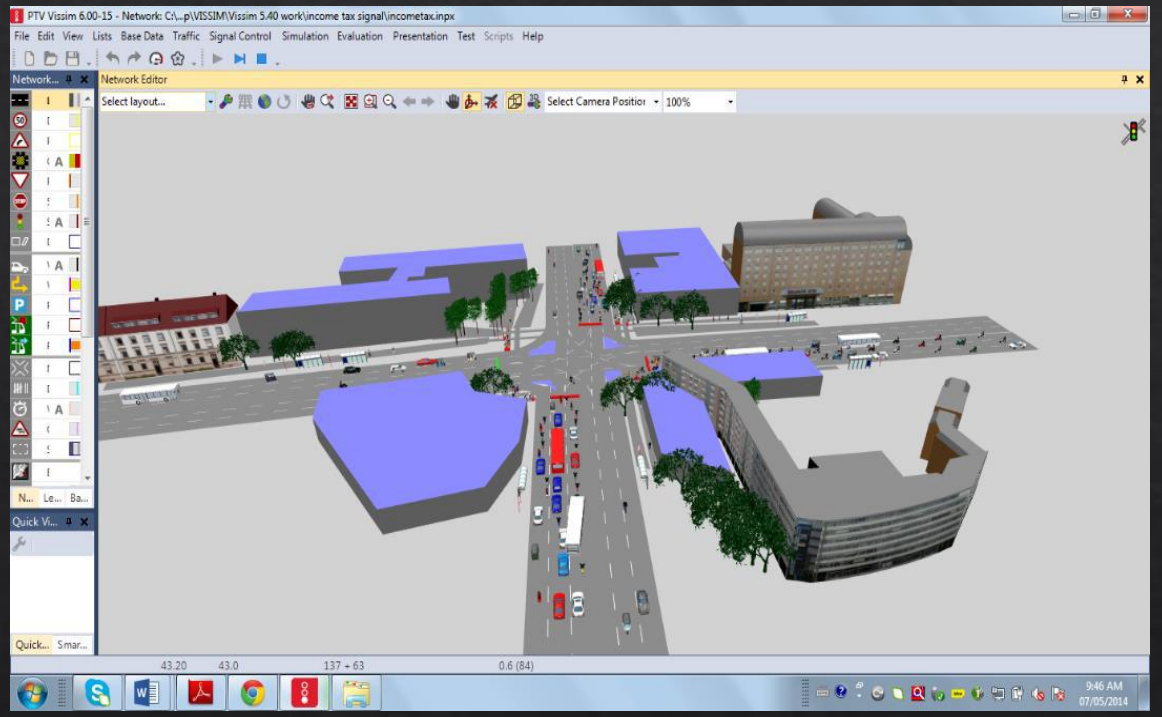
LOS criteria for Pedestrians at Unsignalised Section (Mid-block)

LOS	Average Delay/ Pedestrian(s)	Likelihood of Risk-Taking Behavioural
F	>45	Very High

Data Analysis by VISSIM

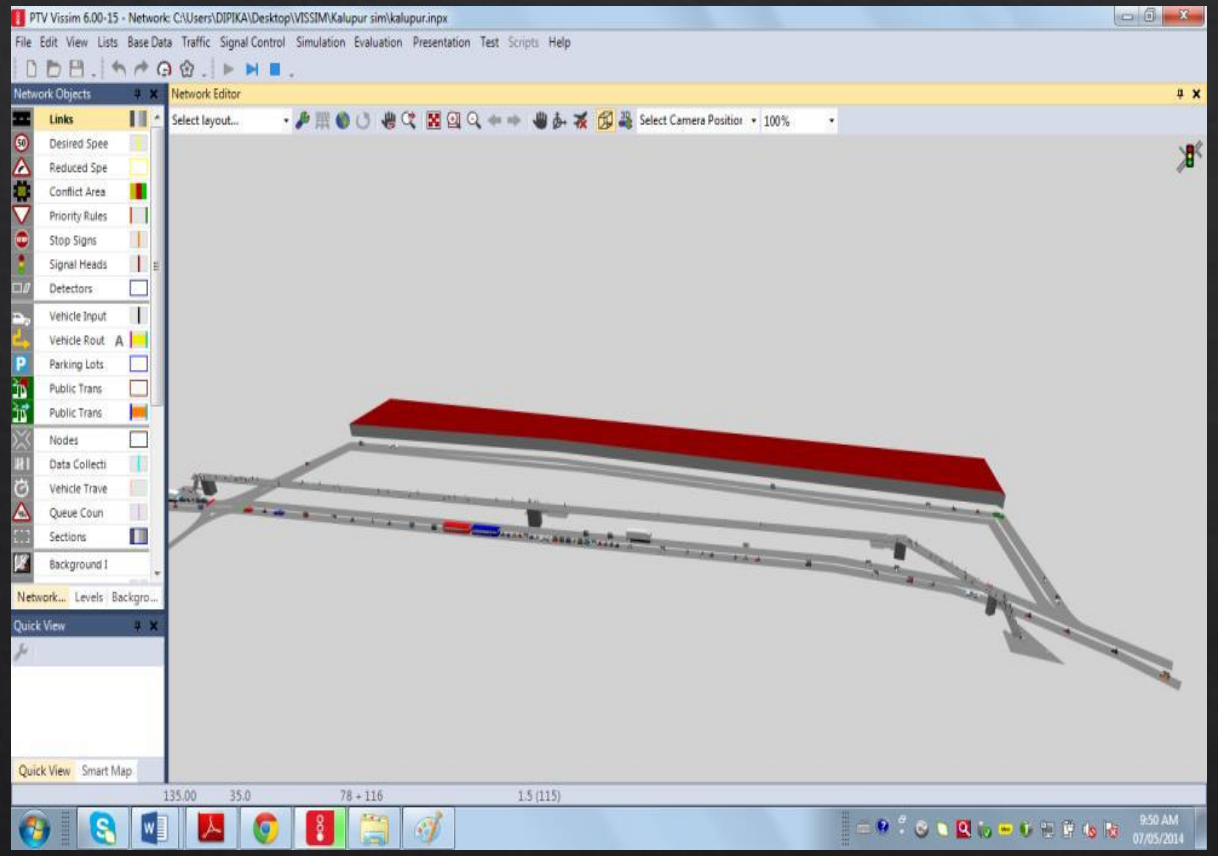


Snap shot of Income Tax Intersection during Simulation run (2D)

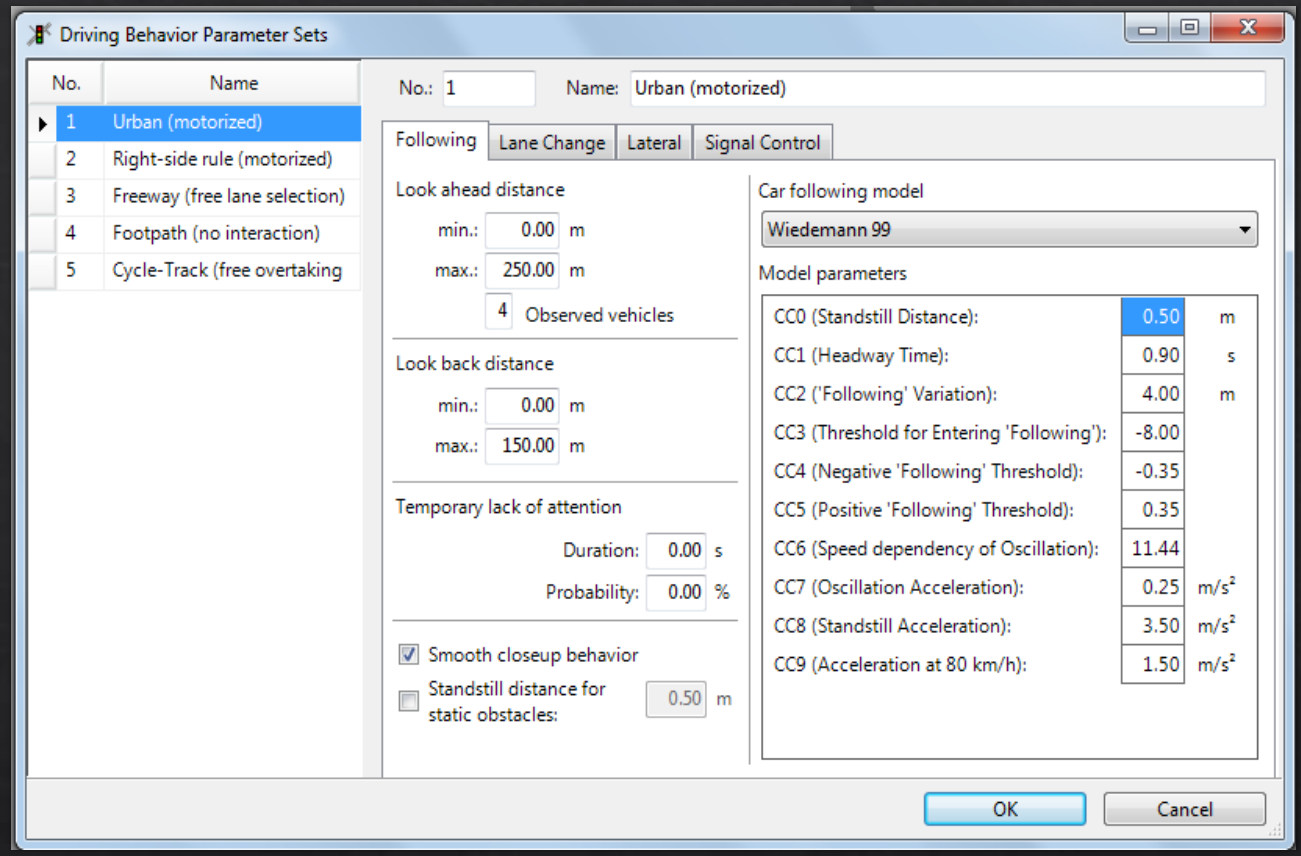


Snap shot of Income Tax Intersection during Simulation run (3D)

Analysis Cont…

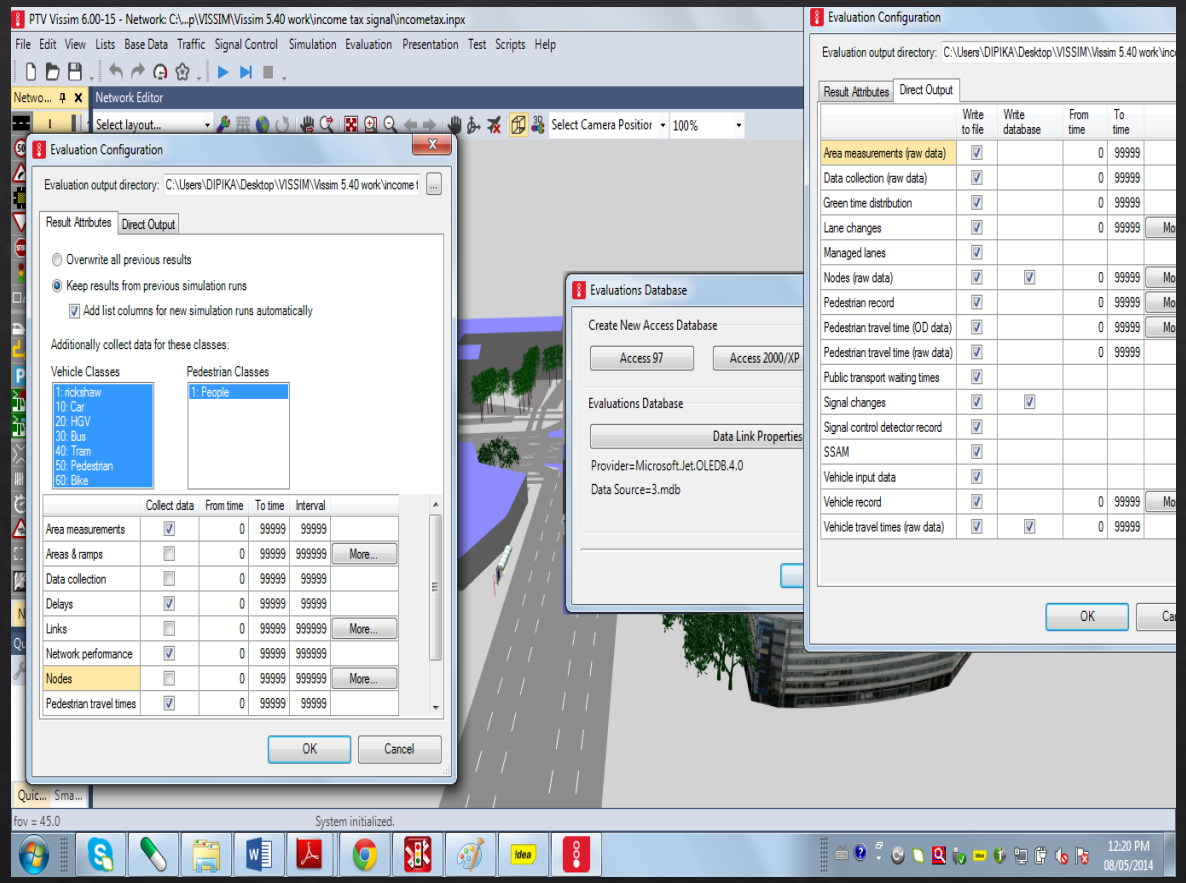


Snap shot of Kalupur Railway Station during Simulation run (3D)



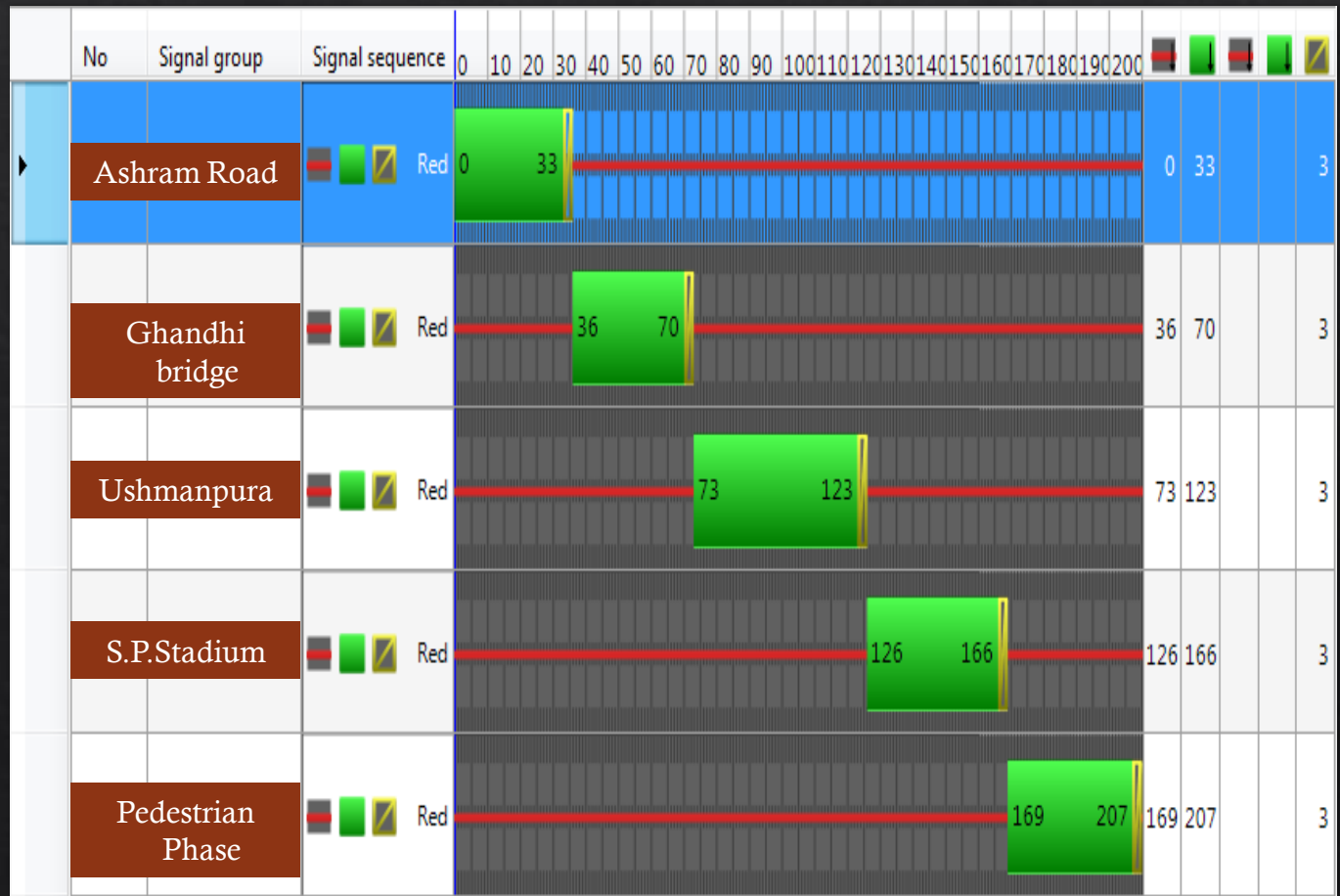
VISSIM - Driving Behavior Parameter Set Window – Wiedemann'99

Analysis Cont…

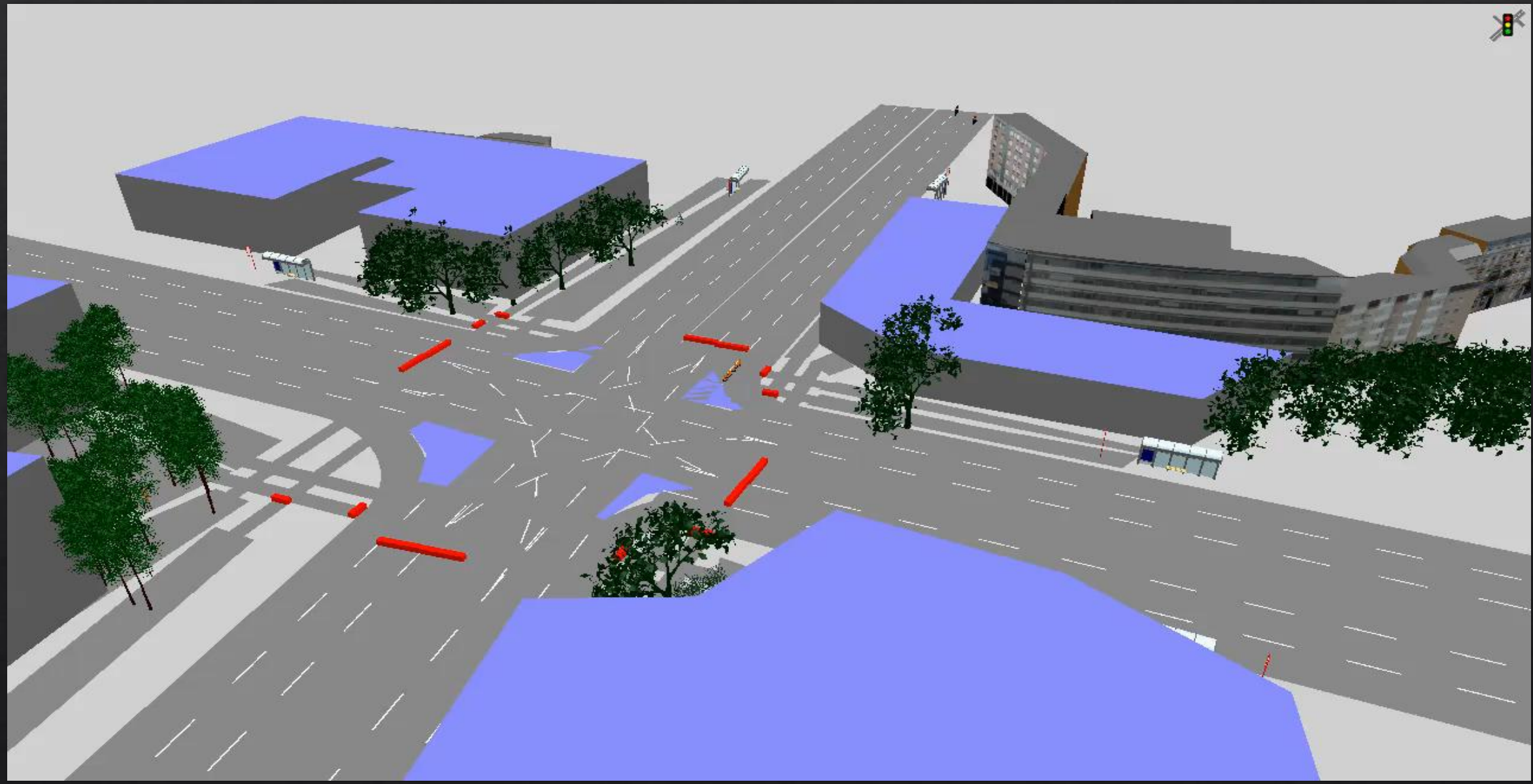


VISSIM Window - Collecting Simulated Data

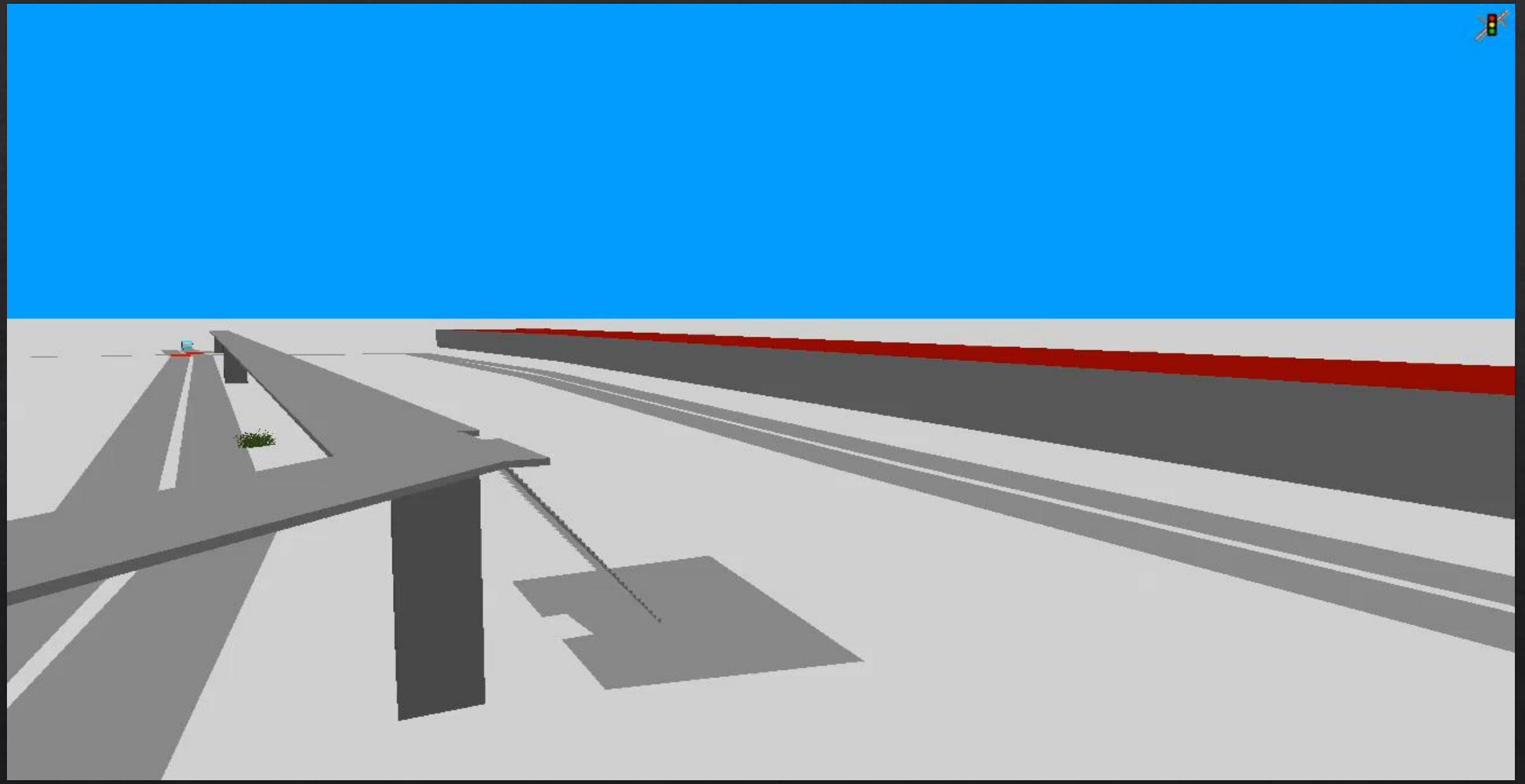
Signal program of Income tax Intersection in VISSIM



Video of Income Tax Intersection during Simulation run (3D)



Video of Kalupur Railway Station during Simulation run (3D)



Delay observed by VISSIM at Kalupur Railway Station

Vehicle /600 sec	Vehicle Delay(sec)	Pedestrian Delay(sec)
42	50.38	0.200
49	50.32	0.374
59	40.92	0.476
64	3.11	0.546
66	48.81	0.598
74	21.64	0.639
98	53.11	0.668
115	23.11	0.689
123	7.12	0.708
129	29.92	0.732
132	7.07	0.759
134	50.53	0.787
136	69.74	0.813
147	58.50	0.837
160	44.20	0.856
161	38.67	0.871
162	42.57	0.879
165	47.43	0.880
182	71.97	0.880
186	65.08	0.884
195	65.86	0.893
203	19.89	0.904
205	61.93	0.918
208	20.14	0.929
209	64.53	0.933
210	35.41	0.933
211	61.62	0.933
213	59.56	1.082
217	46.00	1.116
218	27.23	1.170

Delay observed by VISSIM at Income Tax Intersection

Vehicle /600 sec	Vehicle Delay(sec)	Pedestrian Delay(sec)
737	172.16	6.08
726	169.62	8.22
738	173.15	4.37
762	162.55	9.52
724	174.21	9.66
742	173.47	10.81
741	169.26	15.96
771	156.28	20.11
745	172.82	24.26
766	162.56	25.41
753	170.22	27.56
776	156.83	28.71
747	175.87	31.86
760	165.91	33.01
774	157.07	34.16
761	171.57	38.31
765	157.86	39.46
787	143.59	41.61
773	161.13	42.76
768	165.77	48.91
782	153.90	46.06
789	148.94	49.20
791	124.99	57.21
818	1.74	58.33
795	142.61	59.36
830	0.23	60.00
798	134.07	62.32
829	5.47	64.43
810	117.02	65.00
785	148.81	67.89

Analysis Cont…

Calibrated model Result for selected area

AREA	PEDESTRIAN DELAY	
	Actual Delay (s)	Simulated Delay (s)
Income Tax Intersection	44	36
Kalupur Railway Station	503	.8

Justification of Warrants for Grade Separated Pedestrian Facility- Skywalk Warrants

- Provision of a grade separated pedestrian facility may be warranted according to the IRC 103-2012 at locations where one or more of the following conditions may exist :

1) Volumes of pedestrian and vehicular traffic are so large that insertion of an exclusive pedestrian phase will increase the cycle time for traffic signals beyond 120 seconds.

-The Selected location of this study resulted in higher volume of both pedestrian and vehicular traffic which will increased the cycle length about 181.4 seconds that is beyond 120 seconds.

2) Vehicular traffic demands uninterrupted flow as associated with major arterial roads are expressways.

3) Control at-grade pedestrian crossing decisively falls to mitigate the problem pedestrian- vehicle collision. Viability of a grade separated pedestrian facility must be checked against delay for both pedestrian and vehicle. Through the accident study reflects that pedestrian- vehicle collision is too high and there must be taken necessary steps to over come from this situation.

Design Facilities for Skywalk at Income Tax Intersection

Component	Sub component	Design Standards and requirement
1) Need criteria	>15 m Roads	Skywalk should be provided at Junction locations on roads of 17 m or more for each Lane. If provided, requirements 2 to 5 mention below (location and design criteria) must be met.
2) Location criteria		Should be located at Intersection aligned with: 1. Areas with pedestrian attractors with busy area like Public transport location, shopping areas, schools, key civic areas, residential areas, etc. 2. Mid block transit/Bus stop locations. 3. Long blocks (Generally>150m).
3) Engineering Feasibility		i) Min Width of Skywalk: - Skywalk only for pedestrians: 1.8 -3.00 m ii) Min Width of staircase: 2.0m iii) Vertical clearance: - A height of 6.5 m must be kept free above Roadways iv) Skywalk should span the entire carriageway such that one can cross safely.

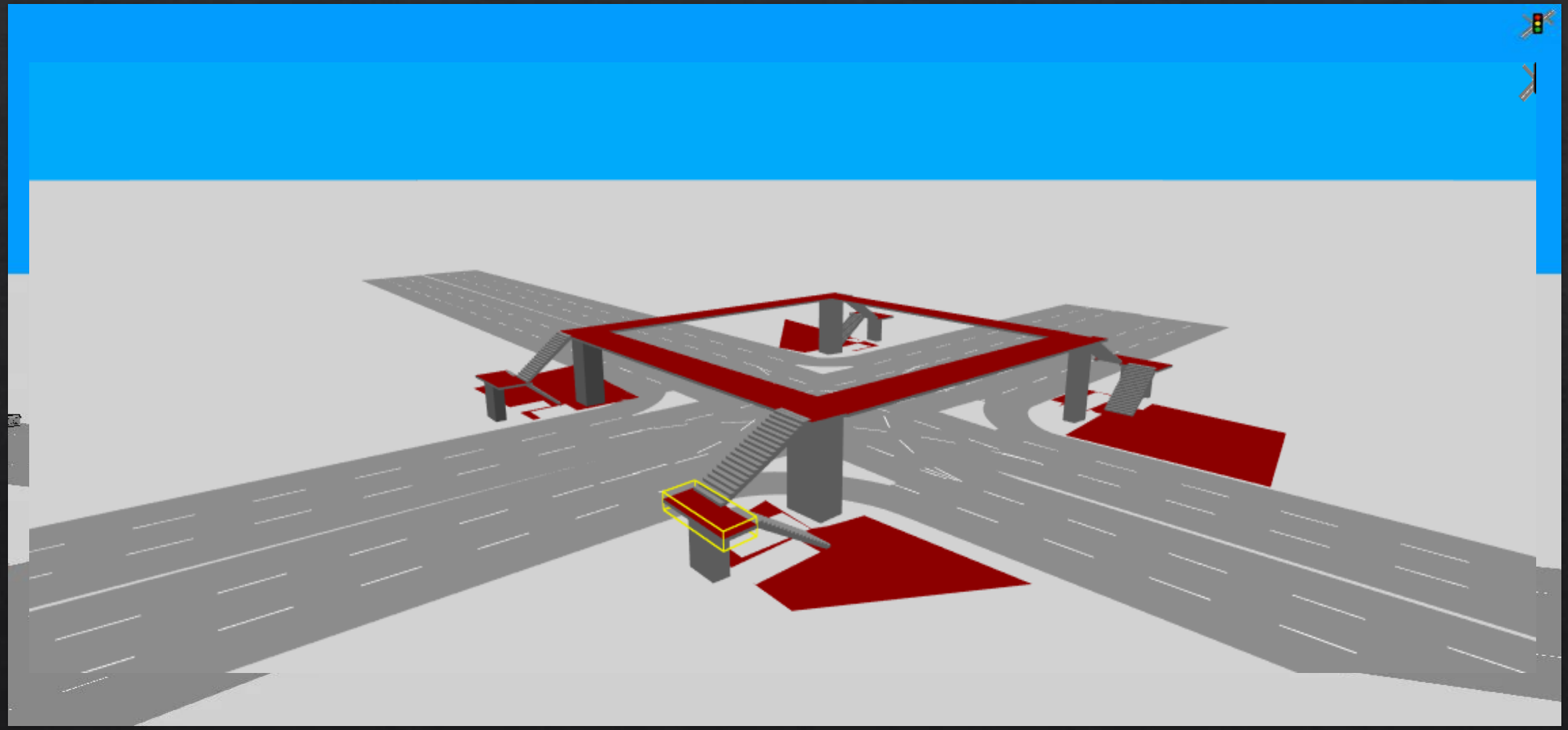
Design Cont…

Component	Sub component	Design Standards and requirement
3) Engineering Feasibility		v) A slope of 5% (1 in 20) on Skywalk ramps, with appropriate resting place or landing, maximum height of a flight between landings shall be 1200 mm. vi) Flights and landing should have a clear unobstructed width of at least 1000mm. vii) The rise between landings should not exceed 1200mm viii) Uniform risers of 150 mm and tread of 300 mm shall be adopted for the stairs. ix) The steps should have unrestricted width of at least 1200 mm. x) The rise of each step should be no greater than 150 mm, consistent throughout the path.
4) Usability	All year round weather protection	Skywalk must provide partial shelter from the elements at least along one edge of the Skywalk. This is most relevant during extreme weather conditions.
	Lighting for safety and visibility	Skywalk at intersection(junction) must deliver a sense of security and safety even during evening/night. Adequate lighting must be provided at both access points and along the Skywalk.

Design Cont…

Component	Sub component	Design Standards and requirement
4) Usability	Seating	Resting places and seating must be provided at minimum two locations along the skywalk.
	Garbage Disposal	Garbage bins must be located adjacent to both access points.
	Way Finding/information maps	Where appropriate, particularly near pedestrian attractors, way-finding / information maps must be provided
5) Quality and type of construction	Structural system	Light-weight, easy and quick to erect and space efficient structural systems are recommended. Structures which will dismantled in future and reassembled are highly recommended.
	Quality	Robust and vandalism-proof materials and furniture/fixtures should be used

Layout of Skywalk at Income Tax Intersection in VISSIM



Design Facilities of Skywalk at Kalupur Railway Station Road

Component	Sub component	Design Standards and requirement
1) Need criteria	>80m Roads	Skywalk should be provided at mid-block locations on roads of 90 M or more for people to cross safely and conveniently. If provided, requirements 2 to 5 below (location and design criteria) must be met.
2) Location criteria		Should be located at Mid Block Locations aligned with: 1. Areas with pedestrian attractors with mid block entries like Public transport location, shopping areas, schools, key civic areas, residential areas,etc. 2. Mid block transit/Bus stop locations. 3. Long blocks (Generally>150m).
3) Engineering Feasibility		i) Min Width of Skywalk: - Skywalk only for pedestrians: 2.50 -3.00 m ii) Min Width of staircase: 2 m iii) Vertical clearance: - A height of 6.5 m must be kept free above Roadways iv) Skywalk should span the entire carriageway such that one can cross safely.

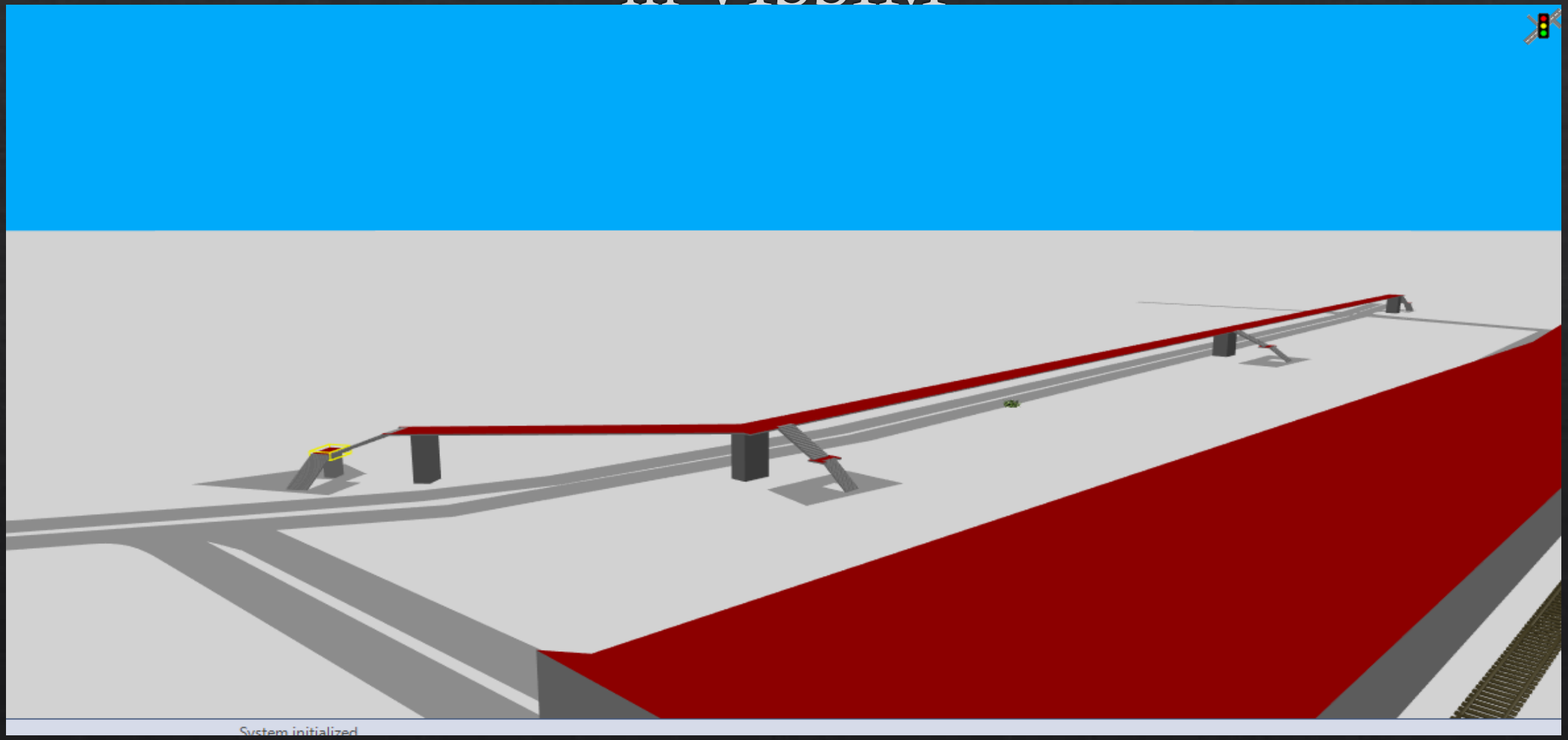
Design Cont…

Component	Sub component	Design Standards and requirement
3) Engineering Feasibility		v) A slope of 5% (1 in 20) on Skywalk ramps, with appropriate resting place or landing, maximum height of a flight between landings shall be 1200 mm. vi) Flights and landing should have a clear unostructed width of at least 1000mm. vii) The rise between landings should not exceed 1200mm viii) Uniform risers of 150 mm and tread of 300 mm shall be adopted for the stairs. ix) The steps should have unrestricted width of at least 1200 mm. x) The rise of each step should be no greater than 150 mm, consistent throughout the path.
4) Usability	All year round weather protection	Skywalk must provide partial shelter from the elements at least along one edge of the bridge. This is most relevant during extreme weather conditions.
	Lighting for safety and visibility	Skywalk must deliver a sense of security and safety even during evening/night. Adequate lighting must be provided at both access points and along the Skywalk.

Design Cont…

Component	Sub component	Design Standards and requirement
4) Usability	Seating	Resting places and seating must be provided at minimum two locations along the skywalk.
	Garbage Disposal	Garbage bins must be located adjacent to both access points.
	Way Finding/information maps	Where appropriate, particularly near pedestrian attractors, way-finding / information maps must be provided.
5) Quality and type of construction	Structural system	Light-weight, easy and quick to erect and space efficient structural systems are recommended. Structures which will dismantled in future and reassembled are highly recommended.
	Quality	Robust and vandalism-proof materials and furniture/fixtures should be used.

Layout of Skywalk at Kalupur Railway Station in VISSIM



Conclusion

1. Traffic simulation is one of the cost efficient operative tool for estimating the further traffic, traffic planning and designing, pedestrian estimation, testing different alternatives and evaluating traffic management schemes. However ,VISSIM utilizes links and connectors for building links and intersections, which permit to code the road stretches of the study area.
2. This study is concluded after carrying pedestrian opinion survey and accident survey across Income Tax Intersection and Kalupur Railway Station.
3. For a stretch of Kalupur Railway Station, the average delay to pedestrian after simulation come as .8 sec which is negligible. Hence it is fairly represent that after providing Skywalk across Kalupur Railway station, pedestrian will feel safe and convenient to use this facility.
4. For Income Tax Intersection ,the average delay to pedestrian after simulation comes as 36 sec. After providing separate signal phase for pedestrian, vehicular traffic have to wait for long periods. It is then taken into consideration that there must be accommodation of Skywalk. So that pedestrian will able to cross a lane safely and convenient from their bus stand, taxi stand to the another lane.
5. Warrants for Grade separated pedestrian crossing which is Skywalk are fulfilled. The design of Skywalk on both location is satisfied.

Future Scope of the Study

1. Economic evaluation of design of Skywalk.
2. Comparing the design cost of Skywalk with the fuel cost of vehicular traffic.
3. Comparing cost of accident to the nation with cost of design of Skywalk.
4. Pedestrian delay result obtained through VISSIM can be compared with the other microsimulation tools.

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Thank you