平成26年度研究調査プロジェクト（H2652）

# インドにおける交通安全のための
# コミュニティデザインに関する研究調査

# 報 告 書

平成27年3月

公益財団法人 国際交通安全学会
International Association of Traffic and Safety Sciences

# 研究組織

## プロジェクトリーダー

土井 健司
 大阪大学大学院 工学研究科 教授

## プロジェクトメンバー

大口 敬
 東京大学 生産技術研究所先進モビリティ研究センター 教授

北村 友人
 東京大学大学院 教育学研究科 准教授

西本 幸正
 (株)本田技術研究所 二輪 R&D センターマネージャー

井上 勇一
 東京都市大学 国際部担当部長

武内 和彦
 東京大学 国際高等研究所サステイナビリティ学連携研究機構 教授・機構長

Dinesh Mohan
 Indian Institute of Technology Delhi, Biomedical Engineering, Professor

Sudipto Mukherjee
 Indian Institute of Technology Delhi, Mechanical Engineering, Professor

Geetam Tiwari
 Indian Institute of Technology Delhi, Civil Engineering, Professor

Girish Agrawal
 Shiv Nadar University, Professor

（所属・役職は当時）

# 目　次

# インドにおける交通安全のためのコミュニティデザインに関する研究調査

## 1. はじめに

### １．１　プロジェクトの目的

インドにおいては，目覚ましい経済および都市の発展とモータリセーションにより，交通死亡事故の増加に歯止めがかからず，極めて憂慮すべき状態にある。2012 年時点の統計によれば，世界の交通死亡事故の約 1 割がインドで発生し,交通事故の 6 件に 1 件がインドで発生している状況にある。過去 10 年間で，交通事故による死者は約 120 万人，重傷者は 550 万人にのぼる。新興国市場では自動車販売台数が増え続ける一方，交通事故による死者数が減少しつつあるのが一般的であるが，インドは例外であり過去 10 年間の死者数は増加の一途にある。

本プロジェクトでは，急増するインドの交通死亡事故の実態を把握し原因を解明するために，まず人口 100～200 万人の中規模都市群から事故率の異なる 6 つの都市を抽出し，詳細な事故記録の収集を行う。そして，疫学的アプローチや GIS 分析に基づき原因の解明を行い，道路利用者（車両別）の事故死亡リスクの評価および対策案の検討を行うものである。その上で，道路利用に関わる市民のニーズや社会習慣を踏まえた安全なコミュニティのための道路設計ガイドラインを日印共同で作成し，研究成果をインドの地域社会に還元することを目的としている。期待される具体的な成果は，自治体による安全な道づくりを支援するためのガイドライン”Safe Streets for Agra: Street Design Guidance for Urban Roads”および中央政府向けのガイドライン“Streets for Safe Communities”の作成である。

なお，本プロジェクトは，海外の研究組織と IATSS との連携強化を目的とした「海外展開プロジェクト」の３年目として，H2429 および H2540 プロジェクトの成果を受け継ぎ，総括のためのプロジェクトとして実施されたものである。また，そうした成果の発信および共有のために，アグラでのコミュニティリーダー会議およびデリーでのシンポジウムの開催にも注力した。

### １．２　プロジェクトの実施体制

本年度も過年度のプロジェクトと同様に，日本・インド間の共同研究体制の下で研究調査を実施した。日本側のメンバーは都市計画，交通工学，環境学，教育学および機械工学の専門家から構成され，インド側もそれに対応してインド工科大学デリー校（以下，IITD）の都市計画，交通工学，機械工学および法律学の専門家から構成されている。

なお，本年度はアグラでのコミュニティリーダー会議およびデリーでのDSDSシンポジウムの開

催のために，以下の様なメンバーにも参画を依頼した。

・アグラ開発庁コミッショナー，アグラ地区コミッショナー，行政長官，交通警察長官

・The Energy Research Institute(TERI）エネルギー研究機構

　　Mr.S.Sundar, Distinguished Fellow

　　Ms.Megha Kumar, Research Associate, Sustainable Habitat Division

・Asia Injury Prevention Foundation　アジア傷害予防財団

　　Mr.Colin Delmore, International Development Director

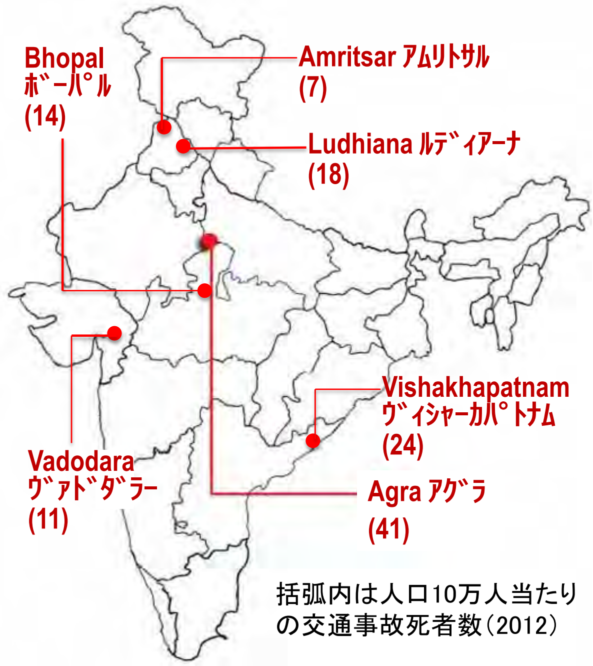
・Institute for Global Environmental Strategies(IGES)（公財）地球環境戦略研究機関

　　Prof.Hironori Hamanaka, Chair of the Board of Directors

## ２．事故記録の収集に基づく実態把握と原因分析

### ２．１　交通死亡事故の実態

図１に示す６都市をスタディエリアとして選定し，交通死亡事故の詳細な実態把握と原因分析を実施した。6 都市での 5 年間の交通事故記録を収集し，統一規格でのデータ整備および GIS 化を行った。この事故データの分析から，全交通事故死者数の中で歩行者と自転車が約５割，自動二輪車が 3～4 割を占めるという犠牲者の状況が捉えられた。また，これらの犠牲者の多くは，トラックとの事故に起因したものであることが明らかにされた。6 つの都市間で交通事故死亡率には差はあるものの（図１中の括弧内の数値参照），こうした傾向は一致している。




| 都市 | 州 | 人口（2011） | 交通事故死者数 |
|---|---|---|---|
| アーグラ | ウッタル・プラデーシュ | 1,574,542 | 606 |
| アムリトサル | パンジャーフ | 1,198,841 | 80 |
| ボーパル | マディア・プラデーシュ | 1,756,718 | 254 |
| ルディアーナ | パンジャーブ | 1,706,069 | 294 |
| ヴァドーダラー | グジャラート | 1,516,108 | 172 |
| ヴィシャーカパトナム | アーンドラ・プラデーシュ | 1,057,146 | 414 |

図１　プロジェクトの対象都市の概要

## ２．２　時間的および空間的特徴

事故の発生時間帯に注目すると，歩行者および自動二輪車の交通死亡事故は夜間に高いピークが存在し，自転車は朝の９時頃にピークが見られる（図２）。また，GIS 分析の結果から事故多発地点は，幹線道路や高速道路の大型変形交差点，多様な車両が混在する都市内幹線道路，および沿道環境の未整備な郊外部の新規道路区間であることが確認された。都市間での比較を行うと，事故率の低いルディアーナやヴァドダラーでは放射＋環状の道路ネットワークが体系的に整備されつつあるが，事故率の高いアグラにおいては，高規格の環状道路を備えておらず，東西および南北方向に走る幹線道路やアクセス制限のない高速道路を通じて通過交通が市街地に流入する状況を招いている。

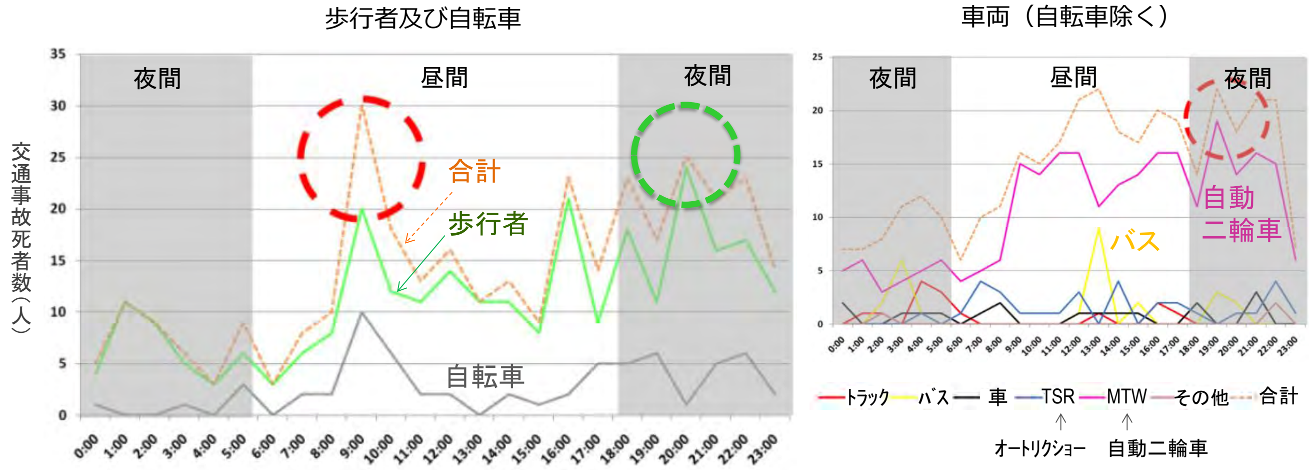


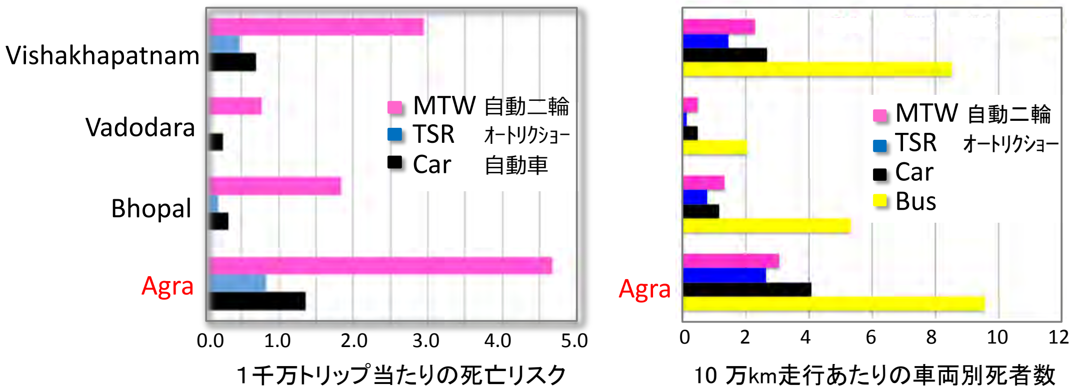

図２　アグラにおける交通死亡事故の時間変動

## ２．３　交通手段別の交通事故死亡リスクの評価

交通死亡事故リスクを交通手段別に評価するために，パーソナルリスク(Personal Risk)と社会的リスク(Societal Risk with Exposure)を以下のように定義し，定量化を試みた。

$$PR = \frac{\text{各手段の交通事故死者数}}{\text{各手段のトリップ数} \times \text{平均乗員数}} \qquad SRE = \frac{\text{各手段に絡む交通事故死者数}}{\text{各手段の走行台キロ}}$$

パーソナルリスクについては自動二輪車が突出して高い値を示し，特にアグラにおいて高い結果が示された。自動二輪車や自動車に比べてオートリクショーのパーソナルリスクは低い。社会的リスクについてはバスが最も高い値を示し，自動車，自動二輪車が続く。オートリクショーは社会的リスクにおいても最も低い値を示している(図３)。




➤ **自動二輪車>自動車>TSR** ➤**バス>自動車>自動二輪車>TSR**

図３　交通手段別のパーソナルリスクと社会的リスク

## ２．４　アグラにおける詳細分析

### （１）分析の方法

全 14 の警察署から 2007～2011 年の道路交通死亡事故の被害届（FIR）の写しを収集し、データのコード化を行うと共に，発生現場の詳細が分かっている事例をアグラの地図上に表示した。

協力警察署

マントラ，ニュー・アグラ，M.M.ゲート，　エトマッドゥラー，ナイ・キ・マンディ、シカンドラ，ロハ・マンディ，シャーガンジ，ラカブガンジ，タージガンジ，ハリ・パルヴァット，チャッタ，サダール，ジャグディシュ・プラ

また、交通死亡事故の多発する下記の道路沿いで交通流と走行速度の測定を行った。

1.　国道 2 号線
2.　国道 11 号線
3.　マハトマガンジー（MG）道路

上記の現場では夜間に照度の測定も行っている。

また，収集した交通死亡事故データと交通流等の観測データを照合し，以下の分析を行った。

- 道路利用者タイプ/衝突車両別の死亡者数
- 時刻/道路利用者タイプ別の交通事故死亡者数
- 移動 1000 万回あたりの乗員の死亡率（人的リスク）
- 各種車両が関連する死亡者数
- アグラで発生した実際の死亡事故現場（自動車と自動車以外）

さらに，同市を碁盤目状に分割する（緯度と経度に基づき）と，各碁盤目状区画で発生した交通事故死亡者数は，各種道路の長さや，その碁盤目状区画内の交差点の数と相関関係が見られた。狭い緩衝地域（半径 0.01 度の円形地域）の死亡者数は，道路の幅，路肩が舗装されているか未舗装

か，中央分離帯/防護策の有無，人口密度，土地利用パターンなどの構築環境パラメータと相関関係が確認された。

（２）夜間に多発する交通死亡事故の発生原因

交通事故死亡率およびリスク値の最も高いアグラを対象として，交通死亡事故と道路種別・構造・施設，昼夜間の交通量および周辺土地利用との関連性を分析した。分析の結果，国道 2 号線（NH2），11 号線（NH11）およびマハトマガンジー道路（MG Road）が特に交通死亡事故の多い道路として抽出された。前二者は都市を貫く都市間高速道路であり，MG Road は都市内の幹線道路である。

3 つの道路における昼間と夜間の車種別の走行速度の比較を示したところ, NH2 においては, オートリクショーや自動二輪車をはじめとして, 車両の走行速度は昼間より夜間の方が低い傾向にある。NH11 においては昼夜間での明確な速度の差違は見られない。他方，都市内の幹線道路であるMG Road においては，各車両とも夜間の走行速度の方が高い傾向が捉えられた。以上の走行速度の分析から, 夜間の走行速度の速さが夜間の交通死亡事故の発生に影響を及ぼしているとは結論づけられない。しかし，その一方で，NH2 や MG Road においては，夜間における自動車交通量の増加が夜間の交通死亡事故の増加に寄与していることが推察される。MG Road においては，夜間に自動車の割合が 17%増加（昼間：32%→夜間：49%），自動車の平均走行速度は 7km/時以上も増加しており，その多くは通過交通という実態である。

（３）夜間の道路・沿道環境

次に, 対象道路における実際の照度と基準値とを比較するとともに, 街灯の設置状況を調査した。NH2 や NH11 においては, 平均照度は 10～12lux と基準値の 30lux を大きく下回っている状況にあり, NH11 では街灯の設置間隔が 50m と長く, 街灯から 7m 離れると 1lux にまで低下することが判明した。中心市街地を走る MG Road では平均照度は 20lux と基準値を上回っているものの,街灯の設置間隔が長く，街灯から離れた場所では照度が大きく低下していることが確認された。上記の街灯の設置間隔に加え，その稼働状況を見ると，多くの街灯が機能していない状況が散見された。

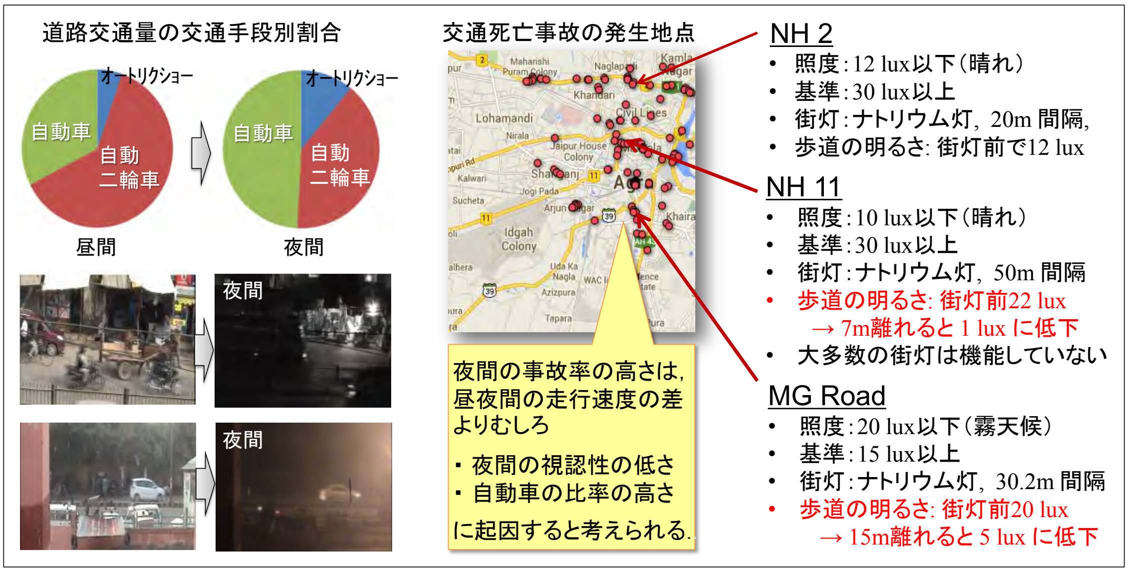



図４　アグラにおける交通死亡事故の発生地点と夜間の道路・沿道環境

## 3．交通安全のためのコミュニティデザインの実践

### ３．１　コミュニティリーダー会議の設立とワークショップの開催

アグラ都市圏の主要なステイクホルダーを集めたコミュニティリーダー会議を設立し，コミュニティの交通安全に関する意識，改善ニーズを把握した上で，プロジェクト成果の共有化と地域社会への還元を試みた。ここでいうコミュニティリーダーとは，政務官，市長，自治会代表，行政（都市開発・高速道路・交通局），医療専門家（医師会やトラウマセンター），自販組合会長，バス協会代表，NGOs，メディアなどの地域を代表する主体である。

日時：2014 年 6 月 20 日　 10:30 – 14:00
会場：アグラ市内トライデントホテル
会議のプログラム

表１　アグラでの交通・安全ワークショップ

| | | |
|---|---|---|
| 10:30 | 開会の辞 | Geetam Tiwari 教授, IIT デリー |
| 10:45 | 参加者紹介 | |
| 11:00 | 日本側からの趣旨説明 | 土井健司教授, IATSS,日本 |
| 11:10 | アグラ側からの代表挨拶とプロジェクトレポートの提出 | Pradeep Bhatnagar，アグラ開発庁コミッショナー／委員長 |

| | | |
|---|---|---|
| セッション I　司会 ：Indra Vikram Singh，アグラ自治体組織コミッショナー | | |
| 11:25 | 道路安全に関する研究成果発表 | Geetam Tiwari 教授および<br>Dinesh Mohan 教授, IIT デリー |
| 12:00 | 討議 | 参加者全員 |
| 12:10 | 休憩 | |
| 12:30 – 12:50 セッション II　司会: A.K. Tripathi，アグラ交通警察長官 | | |
| 12:30 | 車両設計と安全性 | Sudipto Mukherjee 教授, IIT デリー |
| 12:40 | 討議 | 参加者全員 |
| 12:50 – 13:10　セッション III　司会: Pankaj Kumar，アグラ地区行政長官 | | |
| 12:50 | 交通・安全の法制度 | Girish Agarwal 教授，シヴナダル大学 |
| 13:00 | 討議 | 参加者全員 |
| 13:10 – 13:40　セッション IV 司会: A.K. Kulshreshtha，チーフメディカルオフィサー | | |
| 13:10 | 救急医療とファーストエイド | Mathew Varghese 医師，聖ステファン病院 |
| 13:25 | 議論 | 参加者全員 |
| 13:35 | 討議と提案取りまとめ | |
| 13:50 | 閉会の辞 | Pankaj Kumar，アグラ地区行政長官 |

### ３．２　コミュニティにおける交通・安全の認識と改善要望

コミュニティリーダー会議においては，まず参加者に対して，コミュニティ自身による交通安全の現状評価，交通事故原因に対する認識に加え，財源制約下での交通改善（交通安全改善を含む）の優先順位，交通安全対策に関する優先順位，および交通安全啓発活動に関するヒアリングを実施した。参加者数は 58 名である。

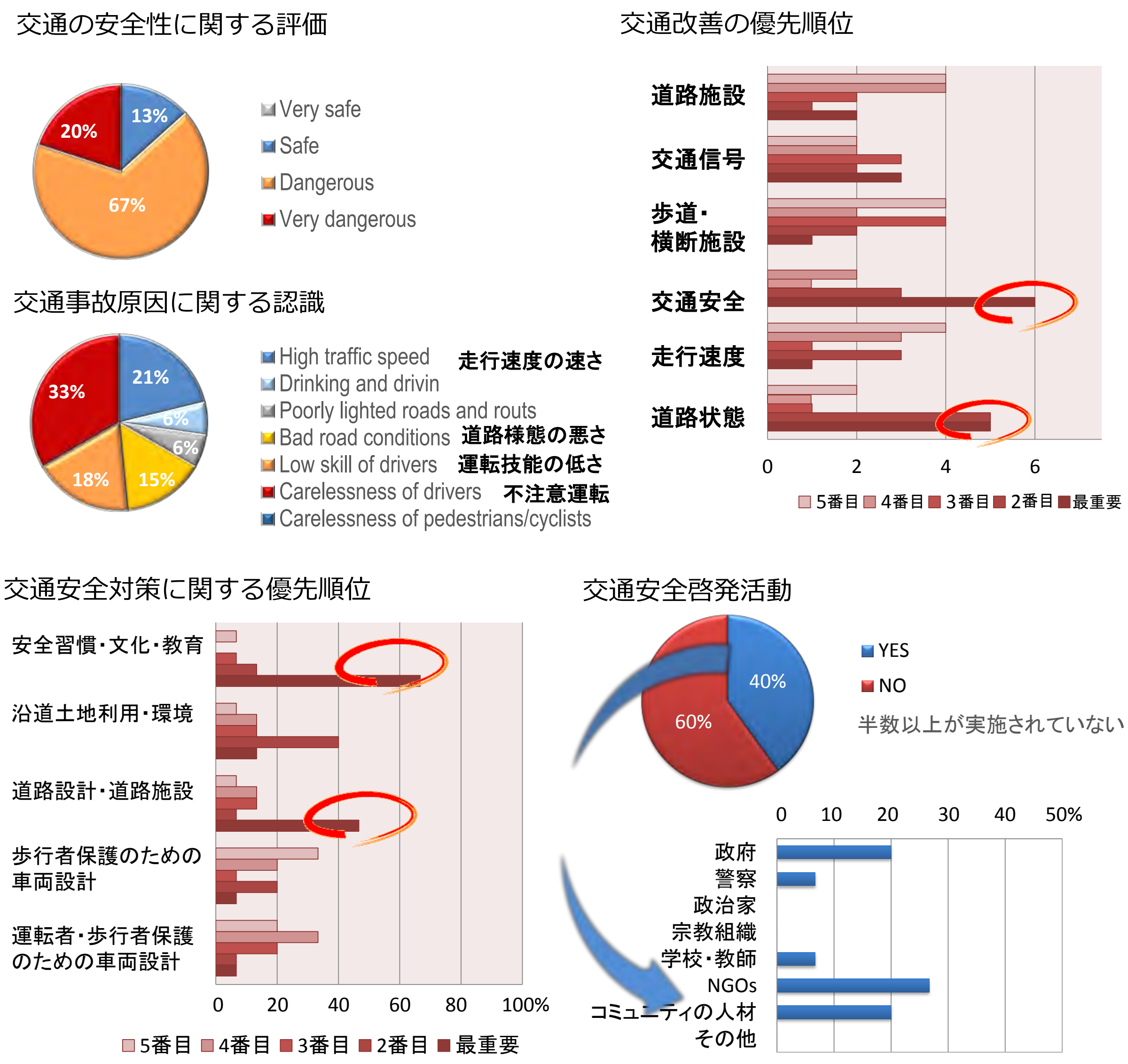



図５ アグラでの現状評価と住民ニーズに関するヒアリングの概要

図５にヒアリング結果の概要を示す。現在の安全性の評価においては，回答者の 87%が危険な状況と捉えており，その危険を生み出している要因として，不注意運転（33%），走行速度の速さ（21%），運転技能の低さ（18%），道路性能の低さ（15%）が挙げられた。また，交通改善への要望については，交通安全対策，道路改善への要望が高い優先度を示している。さらに交通安全対策については，安全習慣・文化・教育とともに道路設計・道路施設の改善への要望が高い優先度を示している。また，現行の交通安全啓発の取り組みにおいては，NGO やコミュニティの人材が大きな役割を担っていることが把握された。

なお，ヒアリングのための調査票は以下の通りである。

# Questionnaire for Stakeholders in the Communities

1. Sex: ___Male ___Female

2. Age: ____________

3. Current job status: ______________________________________________________________

4. Educational background (Last educational level you finished):

   ___Primary education
   ___Lower secondary education (junior high school)
   ___Upper secondary education (high school)
   ___Higher education (college/university)
   ___Graduate level (Master's and Doctoral studies)

5. What kind of roles you have been playing in your community?
   (The term "your community" hereinafter refers to the community you are currently living. Therefore, "people in your community" means those neighbors living in the area where you reside and it includes not only people in the same socio-economic status as yours but also those people in different socio-economic statuses.)

   ________________________________________________________________________________

6. How long have you lived in this area?

   ________________________________

7. What mode of travel do people in your community most often use?

   ________________________________________________________________________________

8. Do people in your community use local transit/public transport?

   _____Yes _____No

   => **<u>If Yes</u>,** public transport is used by:

   ____Everyone in the community
   ____More than half
   ____Half
   ____Less than half

9. If people in your community do not currently use public transport, what prevents you from using it?
   ________________________________________________________________________________
   ________________________________________________________________________________

10. Overall, how would you rate the following transport system in this area?

| | | | | |
|---|---|---|---|---|
| Condition of roads | ___ Excellent | ___Good | ___Fair | ___Poor |
| Traffic speed | ___ Excellent | ___Good | ___Fair | ___Poor |
| Traffic safety | ___ Excellent | ___Good | ___Fair | ___Poor |
| Footpaths/Pedestrian Crossings | ___ Excellent | ___Good | ___Fair | ___Poor |
| Traffic signal system | ___ Excellent | ___Good | ___Fair | ___Poor |
| Street furniture* | ___ Excellent | ___Good | ___Fair | ___Poor |

*Street furniture includes traffic barriers, street lamps, traffic signs, bollards, and bus stops, etc,

11. If you had control over the transport budget, how would you rank the following in importance?

(Please **put the number from 1** being most important **to 5** being least important.)

____Condition of roads
____Traffic speed
____Traffic safety
____ Footpaths/Pedestrian Crossings
____Traffic signal system
____Street furniture

12. How would you rate the situation of traffic accidents in this area?

____Very safe
____Safe
____Dangerous
____Very dangerous

13. In your understanding, what are the causes of traffic accidents (hit by a car) in this area? (Please choose the **maximum of two items** below.)

____High traffic speed
____Drinking and driving
____Poorly lighted roads and routes
____Bad road conditions
____Low skill of drivers
____Carelessness of drivers
____Carelessness of pedestrians/cyclists

14. Of the roads and routes that your community has, which is **used most often**?

____Paved road
____Dirt or unpaved road
____Paths
____Train (railway route)
____Other, what? ____________________________________________

15. In your opinion, since 2009 (last 5 years) the roads and routes:

____Have improved
____Have gotten worse
____Stayed the same

16. What benefits would your community receive if the roads in this region were improved? (Please choose the **maximum of two items** below.)

____Easier access to markets
____Better opportunities to work
____Lower the prices of consumer goods
____Could have more doctors
____Could have more teachers
____Expansion of cultivated areas
____Other, what? ____________________________________________

17. What are the **2 principal problems** with the service of public transport?

____Insufficient buses
____Buses in bad condition
____Public transport is bad
____The routes are far away
____Don't keep to the schedules
____Poor service at night
____Other, what? ____________________________________________

18. For the improvement of traffic safety, how would you rank the following in importance? (Please **put the number from 1** being most important **to 5** being least important.)

____Vehicle design for driver and passenger protection
____Vehicle design for pedestrian protection
____Road design and street furniture
____Roadside land use and built environment
____Safety habits, culture and education

19. What persons or institutions are currently assisting or have assisted the local authority in your community in order to improve the transport systems and road conditions? (Please choose **all applicable items** below.)

____The government
____The police
____The politicians
____The religious groups
____The school/teachers
____NGOs
____People from the community
____Other, What? ______________________________________________

20. Does your community organise awareness-raising activities for residents about the risks of traffic accidents?

____Yes ____No

=> **If Yes**, what persons or institutions organise such activities? (Please choose **all applicable items** below.)

____The government
____The police
____The politicians
____The religious groups
____The school/teachers
____NGOs
____People from the community
____Other, what? ______________________________________________

★Finally, please describe your opinion on how community should be involved to enhance traffic safety in your area.

______________________________________________________________________

______________________________________________________________________

３．３　コミュニティデザインの展望と提言書

ワークショップにおいては，多様なステイクホルダーとの対話において，日本が経験した交通戦争と安全対策および IATSS の役割を伝え，アグラが目指すべき都市交通政策の方向を図６のように俯瞰的に示した。その上で，安全なコミュニティのための“Streets for Safe Communities”に関する提言書をリーダーらに提出した。この提言書は，「安全な社会空間」としての道路を実現するための道路利用者の優先順位を明記し，優先すべき安全対策を示した道路設計ガイドラインである。

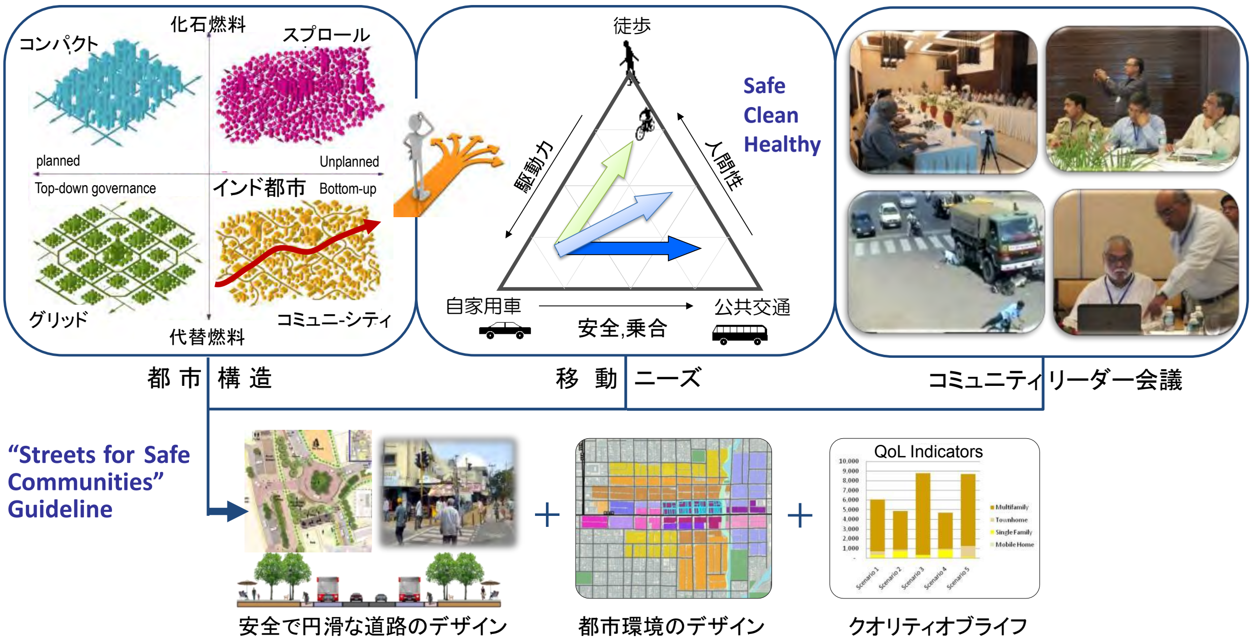



図６　交通死亡事故の抑制のための総合的アプローチ

上記のガイドラインにおいては，具体的な対策事例として，事故リスクの高い大型変形交差点の改良とコンパクト化，既存のラウンドアバウトの再整備，社会的ユーザビリティの観点からの歩行者や自転車が利用しやすい道路横断施設の整備，自動車・バイクと歩行者・自転車との混在を抑制しオートリクショーを安全に活用するための道路空間の整備，および夜間の道路・沿道環境の改善策を盛り込んでいる。ガイドラインに示された具体的な知見と示唆は以下の１０項目に纏められる。

① アグラの広幅員道路や幹線道路では衝突事故率が高い。中心市街地を通過する現状の道路位置や設計基準では危険性が高く，高架化や市街地を迂回するバイパス整備を検討するとともに，より安全な設計基準に発展させることが望まれる。

② 全ての道路交通手段において，死亡事故のリスクは夜間の方が相対的に高い。

③ バスやトラックの大型車両と交通死亡者数との関連性が高い。

④ 自動二輪車乗員は高い交通死亡事故リスクにさらされている。

⑤ 自動二輪車乗員のヘルメット使用や自動車乗員のシートベルト使用の義務化，速度制限の

強制，飲酒運転の取り締まりにより，死亡者数の削減に大きな効果が期待される。

⑥ 夜間には歩行者と自動二輪車との衝突事故率が高い ― 道路照明と飲酒。

⑦ 道路の舗装状態が劣悪な地域に比べ，舗装状態が良い地域では事故件数が多い。舗装状態が良いほど走行速度が速くなるため，速度の取り締まりが必要である。

⑧ 道路には，自転車の専用空間や適切な歩行者用の施設の設置が必要であり，補助幹線道路や街路では交通静穏化が必要である。

⑨ アグラでは現在，オートリクショーが主要な公共交通手段。より安全かつ効率的で利便性に優れたものにすることが求められる。

⑩ オートリクショーや自動二輪車が歩行者や自転車との衝突事故に関与していることから，交通弱者に対しもっと優しい設計に改善すべき。

### ３．４　本プロジェクトのコミュニティデザインの特徴

本プロジェクトにおいては，コミュニティデザインを都市および地域コミュニティの社会的構造を踏まえた上で，多様な住民のニーズや社会習慣に即した実用的なデザインおよびそれを生み出す行為と定義する。住民のニーズについては３．２の図５にまとめた通りであるが，道路空間の利用に関わる社会習慣については、インドでの運転経験者へのヒアリングから，以下の様な特徴が抽出された。

１）「自分の身を守るために前方のみ注視」

⇒ 左右や後方の確認は自分の責任ではないとの意識。その意識を反映して，クルマのサイドミラーもとってしまうという行動。

２）「常に周りに対して自分の存在を示す」

⇒ クラクション（=自分の存在）を鳴らし続けるという行動習慣。その行動を反映して，インド販売車のステアリングは特別仕様との実態がある。

３）「チャンスがあれば自由に走行する」

⇒ 逆走も厭わない　→ ラウンドアバウトの走行において特に危険な状況を生み出している。

少しでも前方へ　→ レーン無視，車間距離なしという実態。

バスの全速走行　→ 高いリスクを抱えるバスの存在。

４）「女性を始めとした運転技能の低さ」

⇒ 今後、女性の社会進出が進み女性ドライバーの増加が予測される中で，大きなリスク要因と受け止められる。女性への安全運転教育の必要が指摘される。

こうしたニーズや社会習慣を踏まえた上で，本プロジェクトではコミュニティデザインを図７に示すように道路・車両デザインおよび都市環境デザインに対する第３のデザインとして位置づけて

いる。図中においては，道路・車両デザインを「セーフティ」に，都市環境デザインを「アクセシビリティ（接近可能性）」に対応させており，コミュニティデザインを「社会的ユーザビリティ」すなわち社会の多様な利用者にとっての使いやすさ（実用性）に対応させている。

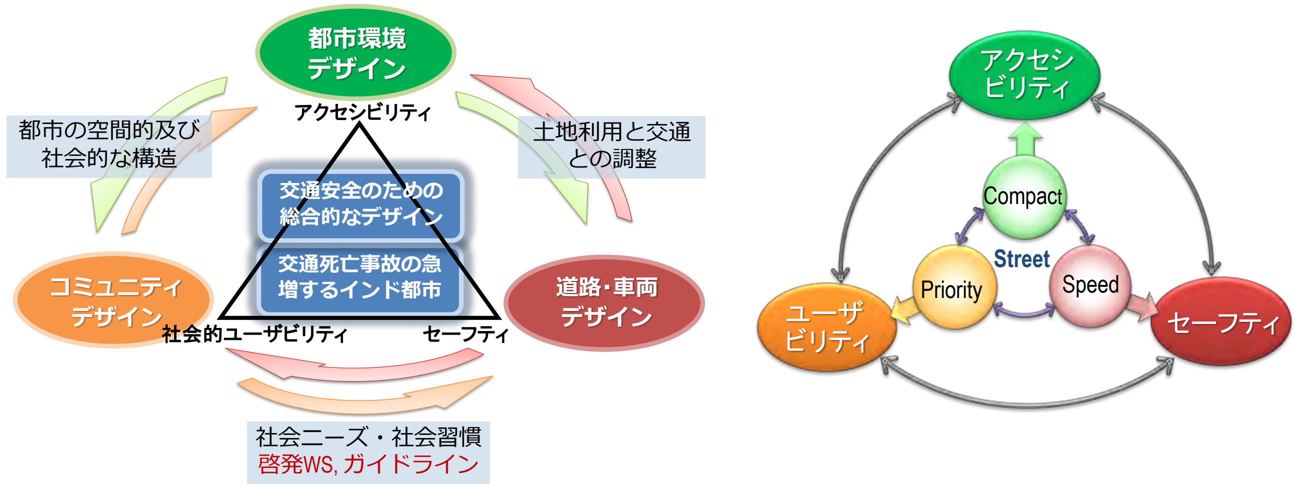



図７　交通・安全に関わるコミュニティデザインの位置づけ

## ４．おわりに

３年間のプロジェクト期間を通じて，世界最悪と言われるインドの交通死亡事故の実態把握と原因分析を行い，事故抑制のための日印共同提言書（ガイドライン）を作成するに至った。このガイドライン“Streets for Safe Communities”は，対象地域アグラだけでなく中央政府に対する提言書としても取り纏め，提出する運びとなった。2014 年 5 月に誕生したモディ新政権は，年間の交通事故死者数の 20%減といった目標を盛り込んだ 5 ヵ年計画を打ち出し，道路法規に対する 1947 年以来の最大規模の改訂へと踏み込もうとしている。本ガイドラインは，その根拠と改善の方向性を提供しうるものと期待される。

また，国際展開プロジェクトとしての本プロジェクトは，その総括として 2015 年 2 月に国際サミット Delhi Sustainable Development Summit での分科会“Safe and Clean Transport for Sustainable Cities”において成果を公表し，広く情報発信を行う機会を得た。当分科会は IATSS と IITD が主催したものであり，交通の安全と持続可能性に跨る初の取り組みとして大いに注目を集めた。こうした情報発信を機に，IATSS がアジア地域にとどまらず将来的にはアフリカ等の新たな国々との間にも連携体制を構築し，図８に示す

ような Safety，Resilience，Sustainability，そして国際的な連携・協調の下での地域主体の実践的な交通文化としての Glocal Culture (*Gloculture*)を創造するための国際展開のプロセスが拓けつつあると思われる。

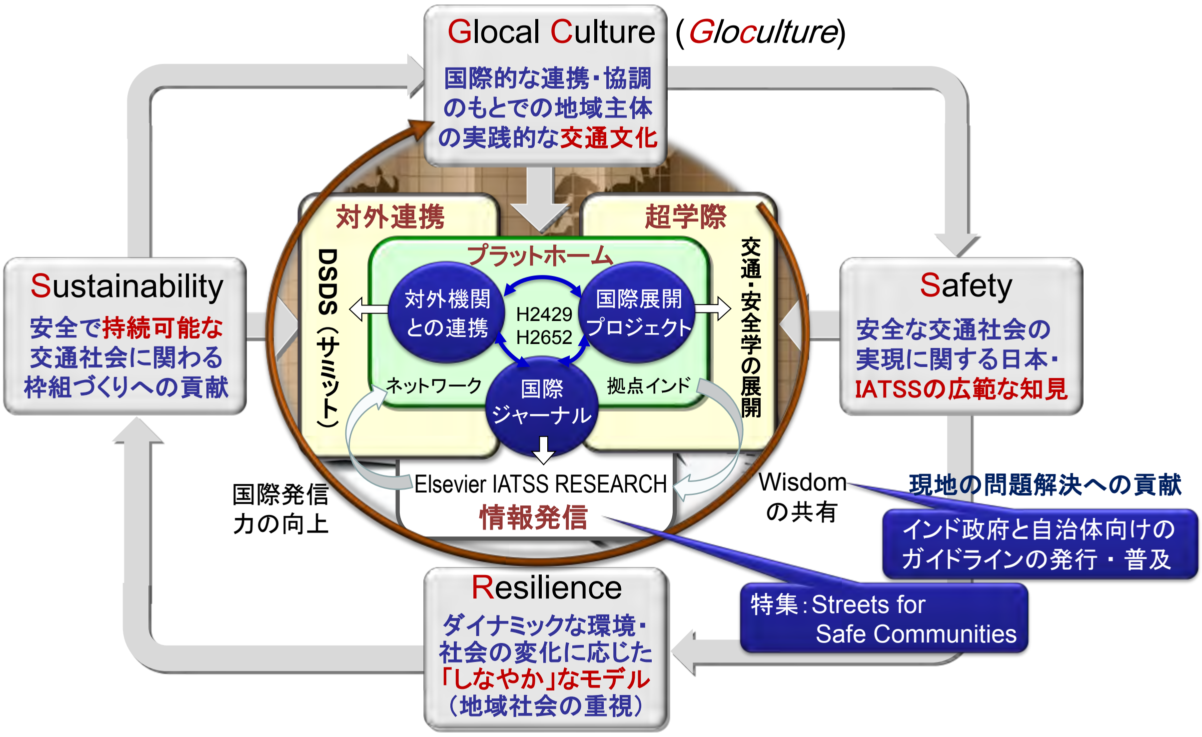




図８　国際展開プロジェクトの総括と *Gloculture* 創造へのプロセス

# 付　録　IITD 側での三か年の作業レポート

# A STUDY ON COMMUNITY DESIGN FOR TRAFFIC SAFETY

## FINAL REPORT 2012-2015


INDIAN INSTITUTE OF TECHNOLOGY DELHI

March 2015

# A STUDY ON COMMUNITY DESIGN FOR TRAFFIC SAFETY

**Final Report (2012 – 2015)**

**The International Association of Traffic and Safety Sciences (IATSS)**

**Dinesh Mohan**
**Geetam Tiwari**
**Sudipto Mukherjee**

March 2015

**Transportation Research and Injury Prevention Programme**

**Indian Institute of Technology Delhi**

*Mohan, D., Tiwari, G. & Mukherjee, S. (2015) A STUDY ON COMMUNITY DESIGN FOR TRAFFIC SAFETY. Final Report for The International Association of Traffic and Safety Sciences (IATSS). (Confidential). New Delhi: Transportation Research and Injury Prevention Programme, Indian Institute of Technology Delhi.*

# CONTENTS

# A STUDY ON COMMUNITY DESIGN FOR TRAFFIC SAFETY

## OBJECTIVE

1. To study the epidemiology of road traffic injury (fatal) patterns in six cities of India differentiated by population size and high and low rates of fatalities per unit population.
2. To understand the modal share of victims and vehicles involved in crashes and to estimate risk functions associated with different road users.
3. Detailed plotting of crashes for all six cities.
4. To obtain a preliminary understanding of road design from an engineering perspective, design of the built environment from a land-use perspective, and community design in a broader sense for control of road traffic fatalities in urban areas. Understanding reasons for differences in high crash rates in one city with low crash rates in one city.
5. Estimate running speeds of different vehicle types in daytime and measure luminance/darkness on the road and the road side.
6. Detailed analysis dividing into day and night or into hours of a day of the personal risk and the social risk that were reported in the last year project for one city.
7. Organise a meeting with community leaders of one study city to discuss findings and possibilities for future action.
8. Development of detailed urban road design and street furniture guidelines for Agra to maximise safety.
9. Streets for safe communities document based on the above experience.
10. Organise a high level stakeholder meeting on urban traffic safety in India.

## RESEARCH TEAM – TRIPP IIT DELHI

**<u>Indian Institute of Technology Delhi</u>**

1. Professor Dinesh Mohan. Ph.D. in Bioengineering, University of Michigan, Ann Arbor, Michigan, USA.

2. Professor Geetam Tiwari. Ph. D. In Transportation Planning, University of Illinois, Chicago, Illinois, USA

3. Professor Sudipto Mukherjee. Ph.D. in Mechanical Engineering, Ohio State University, Columbus, Ohio, USA.

## TIME FRAME

Three years: 1 APRIL 2012 – 31 MARCH 2015

## RESEARCH DESIGN AND METHODS

### Selection of study sample

Six cities were selected in India for the study (Figure 1).


**Figure 1. Cities selected for the study.**

**Table 1. Population and road traffic fatality data for six cities selected for the study.**

| | CITY | | | | | |
|---|---|---|---|---|---|---|
| | Agra | Amritsar | Bhopal | Ludhiana | Vadodara | Vishakhapatnam |
| Population 2011 Census | 1,574,542 | 1,132,761 | 1,795,648 | 1,613,878 | 1,666,703 | 1,730,320 |
| Fatalities in 2011 | 653 | 70 | 254 | 294 | 172 | 416 |
| Fatalities per 100,000 persons | 41 | 6 | 14 | 18 | 10 | 24 |

Table 1 shows the population and road traffic fatality data for the six cities selected for the present study (Census of India, 2012, NCRB, 2012).

It was decided to select 6 cities to get a proper representation of the situation in India. Travel patterns can vary from city to city in the use of bicycles, paratransit modes, mopeds and official public transport. The six cities have very different fatality rates per 100,000 persons. These cities represent the growing urban agglomerations of India where high growth rates are expected in the next decade. An analysis for these cities would be useful as our findings may influence future directions for road safety policies in high growth cities in India.

## Sources of data

Data were collected from different police stations in each city, transportation departments, and municipalities of the selected cities.

## Collection and coding of Data

Research assistants specially employed for the project were sent to Agra, Amritsar, Bhopal, Ludhiana, Vadodara and Vishakhapatnam to obtain primary data on vehicle registration and road traffic fatality cases and other data available in the city from secondary sources (e.g.: transportation and city development plan studies commissioned by respective city governments).

Different police stations in each city were visited and a request placed for obtaining copies of First Information Reports (FIRs) of fatal road traffic crashes for the previous five years (example in Appendix 1). The data from the records so obtained were coded on to a special accident recording form (Appendix 2). The data from these forms were then entered in spread sheets for computer analysis.

## Data Analysis Strategies

The data recoded into the IITD form and vehicle registration data are expected to give us information on the following variables:

- Age (not for all) and sex of victims
- Month, day and time of crashes
- Road user type and type of associated crash vehicles
- Type of road where crash occurred
- Crash at junction or mid-block
- Vehicle manoeuvre
- Proportions of vehicles in use in the city

a. The above data have been used to prepare cross-tabulations for all variables to develop an understanding of the epidemiology and spatial distribution of traffic crashes in these six cities. These data have been used to determine significant differences in these cities that might be leading to the differences in crash rates.

b. In addition, a risk-based method for modelling traffic fatalities will also be attempted for each one of the cities. This method has been described by Bhalla et al ( 2007). In this method it is assumed that crash rates between different road users are proportional to their roadway use and this can be used to estimate case fatality ratios (CFRs) for the different vehicle-vehicle and vehicle-pedestrian combinations. The CFR, the probability of fatality in the event of a crash, depends on precrash variables that describe the characteristics of vehicles and victims, the crash variables, and the postcrash victim care. These include:

- Vehicle characteristics (e.g., size, mass, and shape) and safety design technology (e.g. availability and use of seat belts and airbags);
- Victim attributes including age, sex, height, and weight;
- Crash conditions including vehicle speed, direction of vehicle travel, crash avoidance manoeuvres, weather conditions, and roadway infrastructure;

- Post crash medical care including response time of emergency medical services, and quality of on-site and trauma care.

In our study all the details may not be available, and therefore, we might have to make some educated assumptions establish pairwise CFRs in for different road users, represented as a matrix with the threats (impacting vehicles) listed in columns and the victims listed in rows. We will establish a CFR Matrix using for each city using a methodology similar to that employed by Bhalla et al ( 2007).

## Detailed analysis

The following analyses were conducted:

1. Vehicle registration comparison
2. Vehicle ownership patterns for each city
3. Fatalities by road user type
4. Fatalities by road user type and struck vehicle
5. Road traffic victims by estimated age groups (Vadodara only)
6. Road traffic fatalities by time of day and road user type
7. Road traffic fatalities by road user type and location (junction or mid block) – Ludhiana and Vadodara only.
8. Occupant risk per vehicle (Agra, Bhopal, Vadodara, Vishakhapatnam)
9. Fatalities associated with different vehicle types (Agra, Bhopal, Vadodara, Vishakhapatnam)
10. Estimate of fatalities associated with different vehicle types per 100,000 km (Agra, Bhopal, Vadodara, Vishakhapatnam)
11. Estimate of personal fatality risk per 100 million trips
12. Road users killed based on type of road and location (Vadodara)
13. Actual location of fatalities in all cities.

## Detailed plotting of crashes for all six cities

Detailed plotting of all crashes was completed for all the cities. Location information of crashes as recorded by the police report were used for plotting the same on detailed maps for each city with details of victim type and impacting vehicle included in the data. This work required searching the police recorded locations on Google maps and then locating them on GIS maps. This work was very labour intensive.

## Understanding reasons for differences in high crash rates in one city with low crash rates in one city

One low rate city (Ludhiana) and one high rate city (Agra) were selected for this comparison. The differences in these cities were evaluated for the following variables:

a. Population density

b. Road structure

c. Proportion of arterial roads and national highways in the city

d. Differences in victim type and impacting vehicles

e. Road widths and facilities on high incidence roads in the city

f. Location of crashes in the two cities

## Research of the running speed different vehicle types in two cities

a. Three locations were selected in Agra for study of speeds and traffic flow in the day and night with high rate of night-time crashes. The same procedure was followed for Ludhiana.

b. At each location a video camera was set up to record traffic flow and traffic flow recorded.

c. The video data obtained has been analysed to calculate speeds of every vehicle passing by: motorised two wheelers, cars, three-wheeled scooter taxis, buses and 6 trucks. The number of vehicles included in the sample was such that the mean speed of each group of vehicles stabilised within 5 per variance.

d. Comparisons have been made for different time periods and different types of vehicles for mean speeds, 10 percentile and 90 percentile speeds.

## Research of the luminance/darkness on the road and the road side

Luminance measurements have been made at three locations in Agra. The same was done in Ludhiana.

## Development of detailed urban road design and street furniture guidelines for Agra to maximise safety

A sample of road stretches were identified for proposing redevelopment. The criteria for selection of these streets were:

a. High concentration of road traffic crashes.

b. Relative importance pertaining to mobility in the city.

c. Including three different road classes: main arterial, arterial, local streets.

Stages of street redesign included the following activities:

a. Preliminary site visit

b. Preparation of Base Map. (Source : Google Earth)

c. Understanding the existing street design through its geometry and preliminary photographic enquiry, the macro scale - location of intersections and land use abutting these roads.

d. Based on the analysis, 5 km of road length in total was asked surveyed to prepare typical cross sections and general alignment drawings.

e. A survey team was employed to undertake total station survey of 5 km of road length. This included: (i) Mahatma Gandhi Road - 3.5 km (ii) National Highway 2 - 1.0 km (iii) Hospital Road - 0.5 km.

f. Activity Survey

g. Design Development

- After the surveys, the following steps were undertaken based on standard documents, best international practices and experiences of working on other Indian cities:
- Preparation of typical cross sections - allocating R OW as per road type and design speed.
- Design of intersections.

- Introduction of road infrastructure components like bus stops, short term bays, street furniture, and integration of feeder systems.
- Integration of road marking and signage.

h. Final Design: The development drawings and cross sections were finalised after in-depth discussions with the full research team.

## Publication of Traffic and Safe Communities document

The experience gained in analysis of safety statistics in the project cities, detailed analysis of speed and road characteristics in Agra and Ludhiana, and development of alternate safe designs for three road stretches in Agra were sued to design and publish the following two documents:

a. *Safe Streets for Agra*
b. *Streets for Safe Communities*

## Organise a high level stakeholder meeting on urban traffic safety in India

IIT Delhi and IATSS collaborated with TERI to organise a special Thematic Track on 'Safe-and-Clean Transport for Sustainable Cities' at the 15th Delhi Sustainable Development Summit on 6$^{th}$ February 2015 in Delhi.

## Ethics and Human Subjects Issues

1. No human subjects are involved.

2. Names and addresses of all road traffic crash victims will be not be included in any of the data files maintained at TRIPP to maintain the confidentiality of the victims.

# Results

## Background information on cities[1]

### Agra


Agra (27°12' N and 78°12' E) is located on the banks of the river Yamuna in the northern state of Uttar Pradesh, India, 363 km west of state capital, Lucknow and 200 km south of the national capital Delhi.

Being centrally located on the national map traffic by rail and road going south passes through Agra thus making it a major transport node at the regional level as well as at the national level.

| Year | Population | Decadal growth rate |
|---|---|---|
| 1961 | 462,000 | - |
| 1971 | 591,000 | 28% |
| 1981 | 781,000 | 32% |
| 1991 | 978,000 | 25% |
| 2001 | 1,275,000 | 30% |
| 2011 | 1,574,000 | 23% |

The population of Agra city was 1,574,000 persons in 2011 with a decadal growth rate ranging from 25% to 32% in the last five decades. The growth rate was lowest in the last decade. The present density of the city is 84 persons per hectare. Sex ratio in urban region of Agra district is 857 as per 2011 census data. Child population (0-6 years) of Agra district is 13 % of total urban population and average literacy rate 73%.The city is divided into 80 wards but the distribution of population is non-uniform in the city. Wards 26, 43, 50 and 66 have high concentration of population whereas the wards 36, 40 and 47 have lower population

The economy of Agra city is based on small scale industries, commerce, trade and tourism. Major crops are Wheat, Paddy, Bajra, Mustard, Patato etc. Over 7,200 small scale industrial units are spared all over the district. Agra city is also known for leather goods, handicrafts, stone carving and inlay work.

---

[1] All data for cities has been obtained from the respective City Development reports prepared in the period 2006-2008, and Census of India 2011. Definitions for road lengths may differ across cities and city boundaries may have changed in the 1961-2011 period.

## Amritsar


Amritsar (31.63° and 74.85° E) is located on the north-west corner of the sate of Punjab 28 km for the border of India with Pakistan. National Highway (NH) 1 connects the city to Jallandhar through Beas towards the Eastern side and NH 15 links the region with Tarn Taran District towards Southern side. These two national highways connect the city to other nearby urban centres. The city also has a good linkage to Lahore, Pakistan through Wagha Border towards the west direction.

The population of Amritsar city was 1,132,761 persons in 2011 with a decadal growth rate ranging from 26% to 42% in the last five decades. The growth rate was lowest in the last decade. The present density of the city is 81 persons per hectare.

| Year | Population | Decadal growth rate |
|---|---|---|
| 1961 | 390,055 | 16% |
| 1971 | 454,805 | 17% |
| 1981 | 594,844 | 31% |
| 1991 | 708,835 | 19% |
| 2001 | 1,011,327 | 42% |
| 2011 | 1,132,761 | 12% |

Female to male sex ratio in urban region of Amritsar district is 880 as per 2011 census data. Child population (0-6 years) of Amritsar is 10 % of total urban population and average literacy rate 85%.

The road network of the Amritsar City is radial-cum- circumferential covering an area of 139 sq. km. The total road length is about 525 km. According to an estimate about 50,000 people visit Golden temple every day. All these have impact over the socio-economic context of the city.

Trading sector absorbs 59% of the workforce. The major commodities for trade include various silk products, woollens, traditional embroidery, blankets, carpet, copper, brass utensils, dry fruit and tea. Apart from textile manufacturing, Amritsar is also one of the biggest grain markets in Punjab. The important items include wheat, maize, gram, rice .

## Bhopal

Bhopal (23.25° N, 77.42° E) is the capital of the Indian state of Madhya Pradesh and the administrative headquarters of Bhopal District and Bhopal Division. The major regional Road network comprises of NH 12 connecting Hosangabad and Narsingarh and a number of State Highways linking Indore, Sagar, and Jabalpur.


| Year | Population | Decadal growth rate |
|---|---|---|
| 1961 | 222,000 | - |
| 1971 | 384,000 | 73% |
| 1981 | 671,000 | 75% |
| 1991 | 1,062,000 | 58% |
| 2001 | 1,433,000 | 35% |
| 2011 | 1,796,000 | 25% |

The population of Bhopal city was 1,796,000 persons in 2011 with a decadal growth rate ranging from 25% to 75% in the last five decades. The growth rate was lowest in the last decade. The present density of the city is 86 persons per hectare.

Female to male sex ratio in urban region of Bhopal is 911 as per 2011 census data. Child population (0-6 years) of Bhopal is 12 % of total urban population and average literacy rate 85%.

Bhopal is located on hilly terrain within the Malwa Plateau and the National Highway 12 (Beora – Jabalpur road), which links the city to many large cities in the north – west and the south – east. State Highways connect Indore and Sagar.

The economic base of Bhopal City mainly depends on industrial sector, while the service sector is becoming increasingly important which provides the majority of employment in Bhopal because it being capital of state. The sectors that reported to be growing fast in Bhopal are housing, banking & insurance and education.

The total road length of the city is 1,020 km. The city is distinctly divided into two parts, the old city housing most of the trading and commercial activities and the newly developed area with mainly administrative, institutional and residential activities.

## Ludhiana

Ludhiana (30.91° N, 75.85° E) is the largest city in Punjab, both in terms of area and population. The city is spread over an area of 159 sqkm. It is one of the prime industrial and educational centres of northern India


The population of Ludhiana city was 1,615,000 persons in 2011 with a decadal growth rate ranging from 26% to 67% in the last five decades. The growth rate was lowest in the last decade. The present density of the city is 88 persons per hectare.

| Year | Population | Decadal growth rate |
|---|---|---|
| 1961 | 251,000 | 26% |
| 1971 | 401,000 | 60% |
| 1981 | 606,000 | 51% |
| 1991 | 1,042,000 | 67% |
| 2001 | 1,395,000 | 38% |
| 2011 | 1,615,000 | 16% |

Female to male sex ratio in urban region of Ludhiana is 845 as per 2011 census data. Child population (0-6 years) of Ludhiana is 11 % of total urban population and average literacy rate 85%.

The city is very well connected in terms of roadways and railways. NH1-Grand Trunk road passes through the city, which connects it to Indian capital city Delhi and to other important cities of Punjab like Jalandhar, Amritsar, Wagha Border etc. NH95 connects the city to Chandigarh in southeast direction and Ferozpur in southwest direction. Other important State highways and major roads also connect the city to various towns of Punjab.

The economy of the city is based on various areas of manufacturing industry including bicycles, sewing machines, textile and other industries. Others include commercial establishments, financial and banking services, public services and places of religious importance.

A total of 1356 km of road network exists. The city has built 2.3 km long elevated road cutting across the city to facilitate through traffic movement. Traffic problems are severe, especially in major commercial areas. At present no city bus services are being operated in the city.

## Vadodara


Vadodara (22.30° N, 73.19° E), formerly known as Baroda, is the third largest and most populated city in the Indian State of Gujarat, after Ahmedabad and Surat. The city is spread over an area of 149 sqkm. The city is on the major rail and road arteries joining Mumbai with Delhi and Mumbai with Ahmedabad. National Highway No. 8 passes through the city.

The population of Vadodara was 1,666,700 persons in 2011 with a decadal growth rate ranging from 27% to 77% in the last five decades. The growth rate was lowest in the last two decades. The present density of the city is 99 persons per hectare.

| Year | Population | Decadal growth rate |
|---|---|---|
| 1961 | 298,000 | - |
| 1971 | 468,000 | 57% |
| 1981 | 735,000 | 57% |
| 1991 | 1,031,000 | 40% |
| 2001 | 1,306,000 | 27% |
| 2011 | 1,666,700 | 28% |

Female to male sex ratio in urban region of Vadodara is 923 as per 2011 census data. Child population (0-6 years) of Vadodara is 9% of total urban population and average literacy rate 92%.

The State Road Transport (STC) of Vadodara links it with a number of towns in Gujarat. The STC buses connect Vadodara with the different destinations in Gujarat, northern part of Maharashtra and western region of Madhya Pradesh.

Vadodara is one of India’s foremost industrial centres with dominant groups of chemicals and pharmaceuticals, cotton textiles and machine tools. The city witnessed a sudden spurt in industrial activity with the establishment of the Gujarat refinery in 1962. Various large-scale industries such as Gujarat State Fertilizers and Chemicals (GSFC), Indian petrochemicals Corporation Limited (IPCL) and Gujarat Alkalis and Chemicals Limited (GACL) have come up in the vicinity of the Gujarat Refinery.

## Vishakhapatnam

Vishakhapatnam (17.00° N, 83.00° E) is a port city on the southeast coast of India. It is the second-largest city in the state of Andhra Pradesh and the third-largest city on the east coast. The city is spread over an area of 530 sqkm. It is one of the prime industrial and educational centres of northern India


The population of Vishakhapatnam city was 1,6730,320 persons in 2011 with a decadal growth rate ranging from 26% to 67% in the last five decades. The growth rate was lowest in the last decade. The present average density of the city is 33 persons per hectare.

| Year | Population | Decadal growth rate |
|---|---|---|
| 1961 | 251,000 | 95& |
| 1971 | 401,000 | 72% |
| 1981 | 606,000 | 66% |
| 1991 | 1,050,000 | 74% |
| 2001 | 1,320,000 | 26% |
| 2011 | 1,615,000 | 30% |

Female to male sex ratio in urban region of Vishakhapatnam is 977 as per 2011 census data. Child population (0-6 years) of Vishakhapatnam is 9 % of total urban population and average literacy rate 83%.

The city has 1,220 km of roads dominated by three major arteries, one along beachfront, another along the Northern Hill flank and the third which runs through the city. NH- 5 and NH – 43 of the National Highway (NH) network and the State Highways connect the city area to the vast hinterland. Around 8 % of the total area is covered by roads.

The sectors contributing to city’s economic growth are agriculture and fishing, large, medium and small scale industries and services that include trade and commerce, transport, education, etc. It has experienced rapid industrialization with the onset of major industries: oil refinery, fertilizer factory, Hindustan Zinc Smelter and Visakhapatnam Steel Plant. The construction of the outer harbour and steel plant have considerably changed the character of the city.

## Transportation data

1. Vehicle ownership data has been obtained from four cities:

- Agra
- Bhopal
- Vadodara
- Vishakhapatnam

We were not successful in sourcing reliable and accurate data from Ludhiana, and none from Amritsar. Based on the limited data available from Ludhiana we have made some estimates of vehicle populations.

2. The official vehicle registration numbers are overestimated for private vehicles, as they are not required to pay any taxes annually. Private vehicles pay a lifetime registration tax at time of purchase, and therefore the official number represents a cumulative total over a number of years. The actual numbers of vehicles on the road are estimated to be approximately 65% of the official number (CRRI, 2007; Expert Committee, 2002). This fact may be kept in mind when examining the numbers presented in this section.

### Vehicle registration

Table 2 shows the official vehicle registration figures for the five study cities. Statistics for Amritsar are not available and Ludhiana is estimated. It is expected that they will be available before the end of November.

**Table 2. Vehicle registered in Agra, Bhopal, Ludhiana (estimated), Vadodara, and Vishakhapatnam in 2010.**

| Vehicle | City | | | | |
|---|---|---|---|---|---|
| | **Agra** | **Bhopal** | **Ludhiana** | **Vadodara** | **Vishakhapatnam** |
| **MTW*** | 568,470 | 497,735 | 866,392 | 817,379 | 453,847 |
| **TSR+** | | 11,500 | 14,562 | 33,239 | 21,994 |
| **Car** | 76,544 | 60,095 | 158,263 | 106,475 | 50,910 |
| **Taxi** | | 13,635 | 1,701 | 7,116 | 6,331 |
| **Bus** | 1,791 | 3,275 | 2,588 | 3,717 | 3,234 |
| **Truck** | 18,160 | 14,433 | 35,487 | 33,337 | 18,163 |
| **Tractor** | 37,121 | 14,977 | 48,571 | 4,779 | 3,001 |
| **Total** | **702,086** | **616,578** | **1,127,564** | **1,008,679** | **558,704** |
| **Population** | 1,574,000 | 1,796,000 | 1,615,000 | 1,666,000 | 1,615,000 |

** Motorised two-wheelers* *+ Three-wheeled scooter rickshas*


**Figure 2. Examples of three-wheeled scooter rickshas which serve as para-tarnsit transport modes in all six cities.**

Figure 2 shows examples of three-wheeled scooter rickshas. Figure 3 shows the proportions of vehicles registered in 5 study cities. In relative terms, Agra has a larger proportion of motorized two-wheelers, and Vishakhapatnam a greater proportion of three-wheeled scooter rickshas. Ludhiana and Vadodara seem to be similar in their vehicle proportions. Vehicle ownership pattern for 5 cities is shown in Figure 4. Relative to other cities, Vadodara and Ludhiana have a higher proportion of car and motorised two-wheeler ownership.

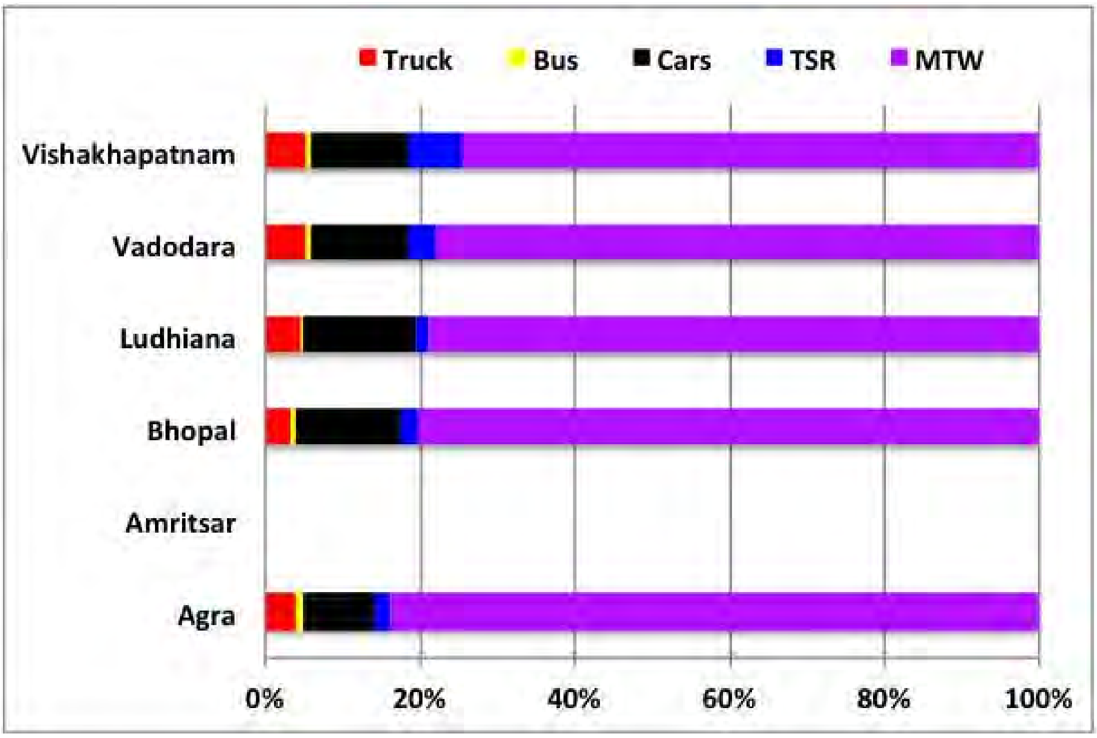



**Figure 3. Official vehicle registration data for 5 study cities, vehicle proportions of total in each city (MTW - Motorised two-wheelers, TSR - Three-wheeled scooter rickshas).**

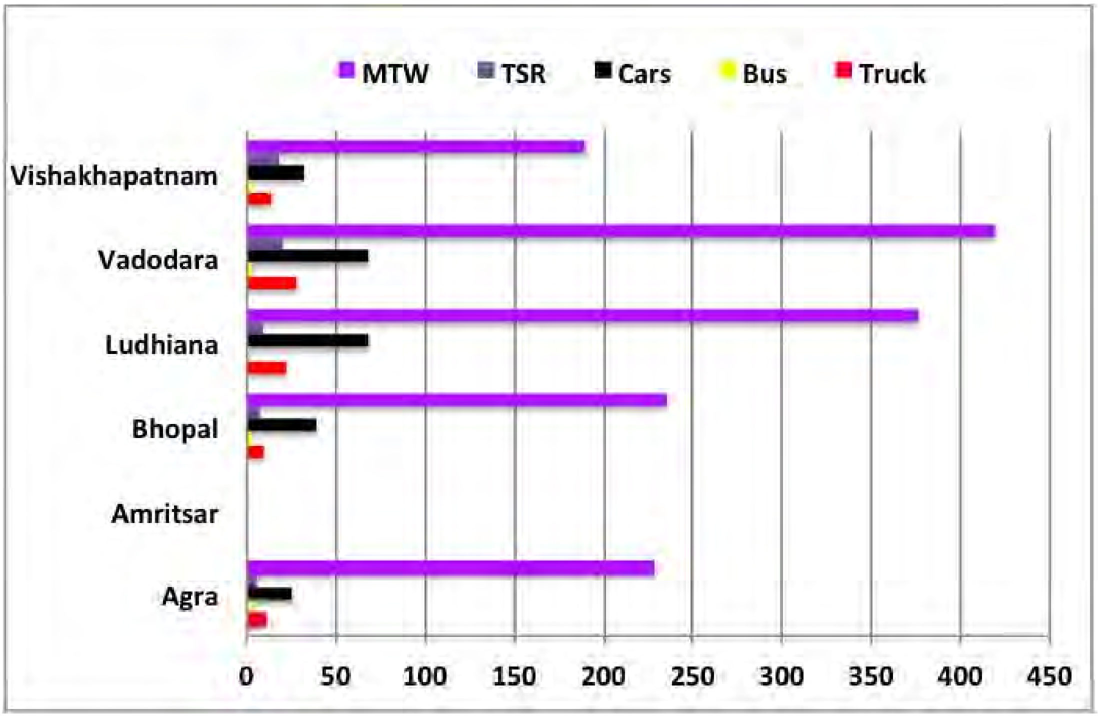



**Figure 4. Official vehicle registration per 1,000 persons data for 5 study cities.**

## Road traffic injury (RTI) fatality data

### Progress

**Table 3. Details of records collected, coded and analysed for road traffic fatal crash data from six study cities in India.**

| City | Fatal crash records obtained | Data coding | Data analysis |
|---|---|---|---|
| Agra | 674 | Completed | Completed |
| Amritsar | 265 | Completed | Completed |
| Bhopal | 685 | Completed | Completed |
| Ludhiana | 651 | Completed | Completed |
| Vadodara | 684 | Completed | Completed |
| Vishakhapatnam | 1164 | Completed | Completed |

Table 3 shows the summary of progress on the field study of fatal road traffic crash patterns in 6 study cities in India. The following may be noted:

1. A total of 4,23 hard copies of fatal accident police records (FIR, see example in Appendix 1) were obtained from six cities and brought to Delhi for coding and analysis.
2. The details from these records were translated and coded into a special form developed for this project (Appendix 2) and the same transferred into computer spreadsheets for analysis.
3. As decided in the First Interim Meeting in Delhi, we selected two cities for a more detailed analysis – Ludhiana and Vadodara.

### Fatalities by road user type

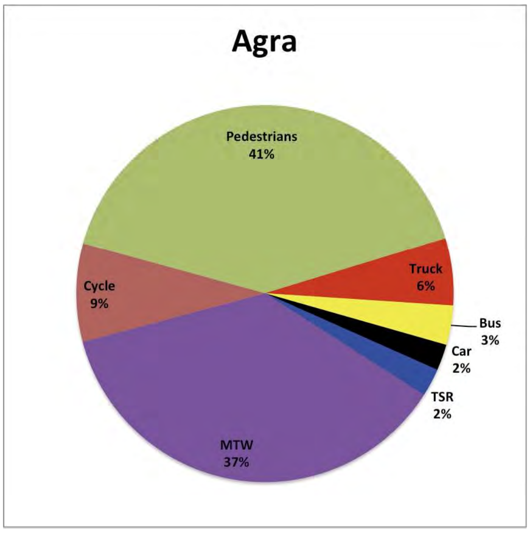



**Figure 5. . Road traffic fatalities by road user type – Agra.**

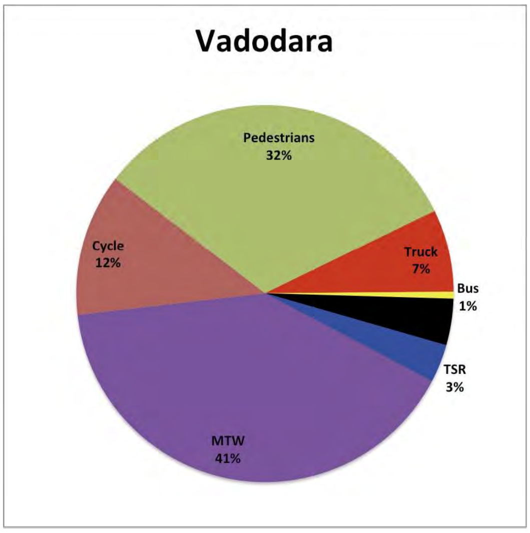



**Figure 6. Road traffic fatalities by road user type – Vadodara.**

**(MTW - Motorised two-wheelers, TSR - Three-wheeled scooter rickshas)**

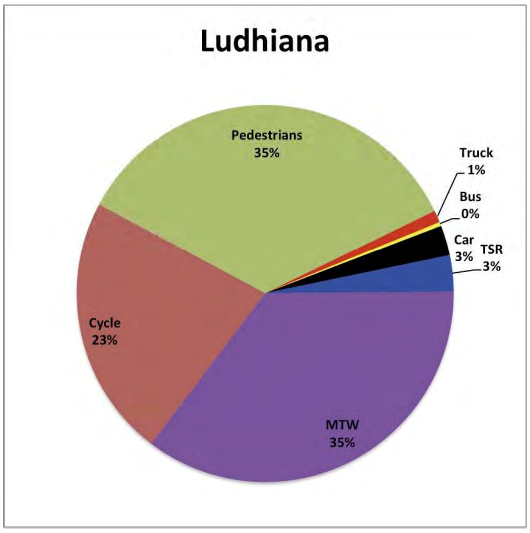



Figure 7. Road traffic fatalities by road user type – Ludhiana.

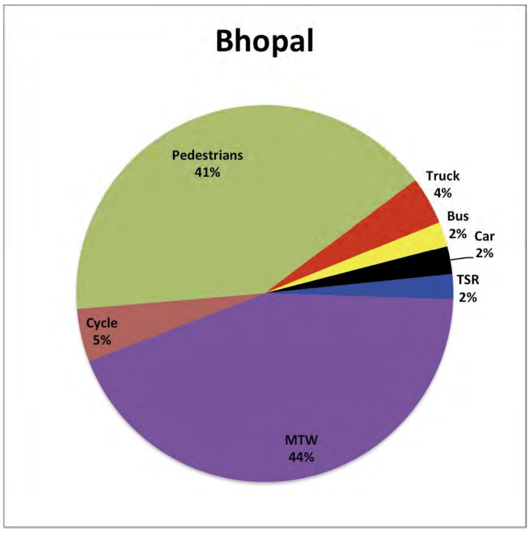



Figure 8. Road traffic fatalities by road user type – Bhopal.

Figures 5-10 show the distribution of fatalities by road user type in the six study cities. Agra and Vadodara have similar populations with a RTI fatality rate higher in Agra (41 per 100,000 persons) compared to Vadodara (10 per 100,000 persons). Agra, which is a major tourist destination, has a higher proportion and a higher number of bus and pedestrian fatalities than Vadodara.

Ludhiana and Bhopal have similar populations but Ludhiana (18 fatalities per 100,000

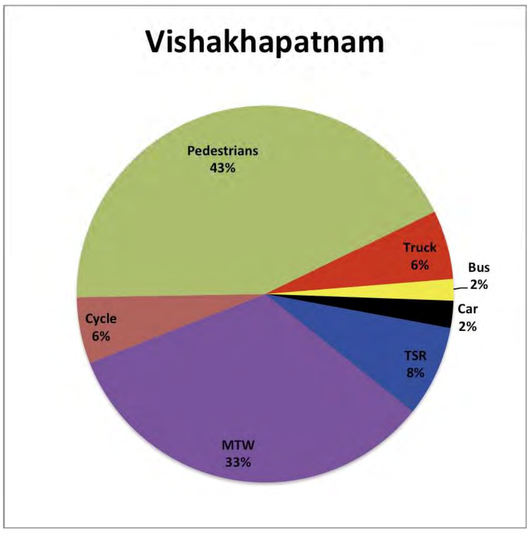



Figure 9. Road traffic fatalities by road user type – Vishakhapatnam.

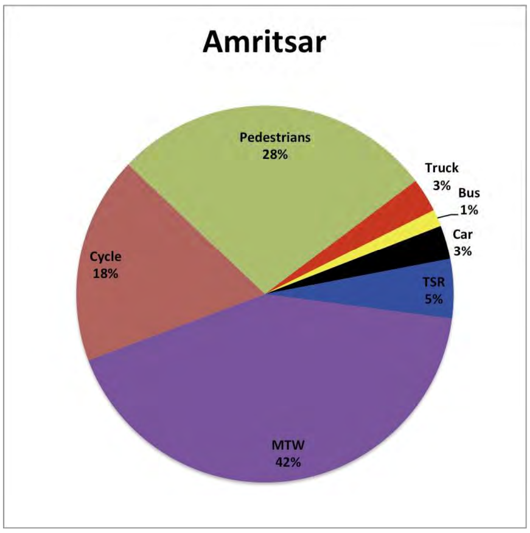



Figure 10. Road traffic fatalities by road user type – Amritsar.

persons) has a slightly higher RTI fatality rate than Bhopal (14 fatalities per 100,000 persons). Ludhiana has a much higher rate for bicyclists and Bhopal is higher for MTWs

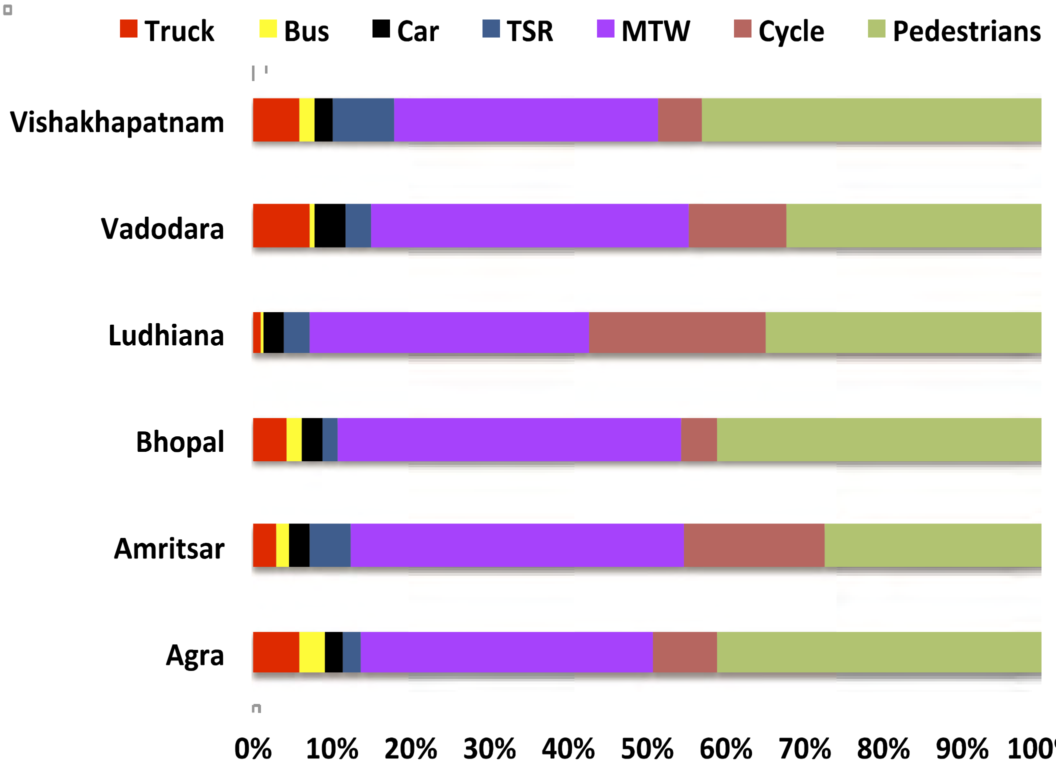



**Figure 11. Proportion of RTI fatalities by road user type in six study cities (MTW - Motorised two-wheelers, TSR - Three-wheeled scooter rickshas).**

The RTI fatality rate in Vishakhapatnam (24 per 100,000 persons) is much higher than Amritsar (6 per 100,000 persons), and the former has a higher proportion of pedestrian and three-wheeled scooter ricksha deaths. In all the cities vulnerable road users (VRU - pedestrians, bicyclists, and motorised two-wheeler occupants constitute more then 80 per cent of all fatalities irrespective of the overall death rate. Car occupants less constitute than 4 per cent of fatalities in all cities and TSR occupants less than 5 per cent, except in Vishakhapatam where the proportion for the latter is 8 per cent. Cycler occupants have the highest proportions in Ludhiana and Amritsar (23 per cent and 18 per cent respectively).

## Traffic fatalities: victim type vs impacting vehicle/object

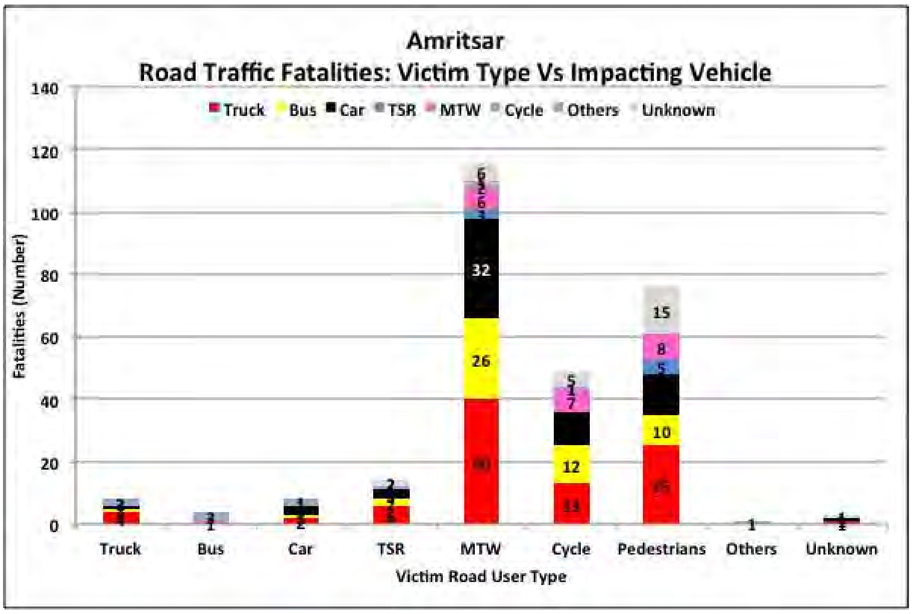



**Figure 12. Traffic fatalities: victim type vs impacting vehicle/object in Amritsar (MTW - Motorised two-wheelers, TSR - Three-wheeled scooter rickshas).**

Figures 12-17 show the distribution of road traffic fatalities by road user category versus the respective impacting vehicles/objects for all the six study cites. In all the cities the largest proportion of fatalities for all road user categories are associated with impacts with trucks

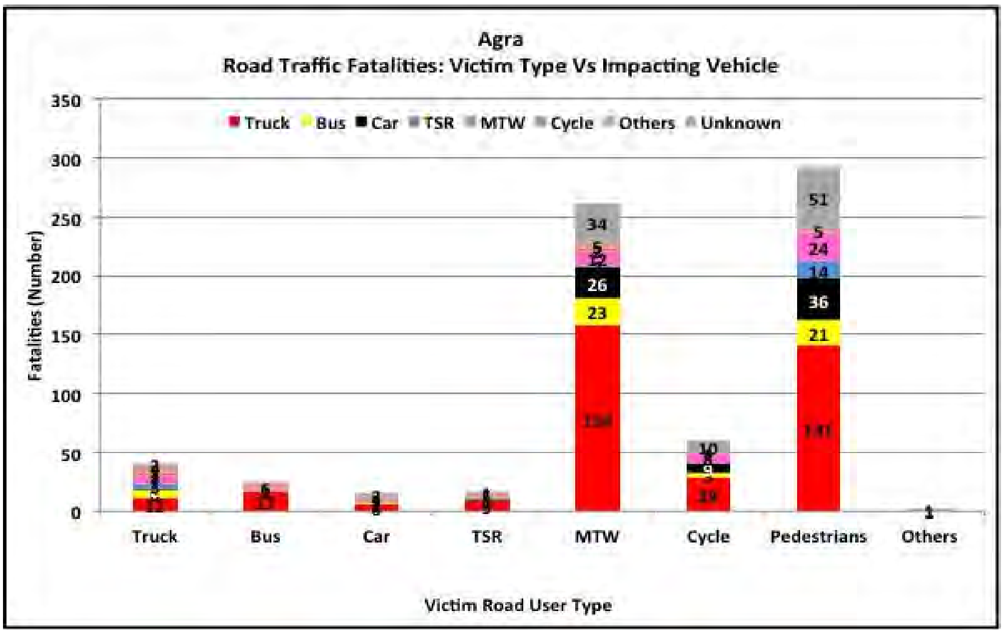



**Figure 13. Traffic fatalities: victim type vs impacting vehicle/object in Agra.**

and then cars. Amritsar has the highest proportion of fatalities involving buses as impacting vehicles. The reason for this is not clear. The most interesting feature emerging from this analysis is the involvement of motorised two-wheelers as impacting vehicles in VRU in all the six cities. The proportion of pedestrian fatalities associated with MTW impacts ranges from 8 to 25 per cent of the total. The highest proportion was observed in Bhopal. The involvement of MTWs as impacting vehicles in VRU fatalities may due to the fact that pedestrians and bicyclists do not have adequate facilities on arterial roads of these cities and they have to share the road space (the curb side lane) with MTW riders.

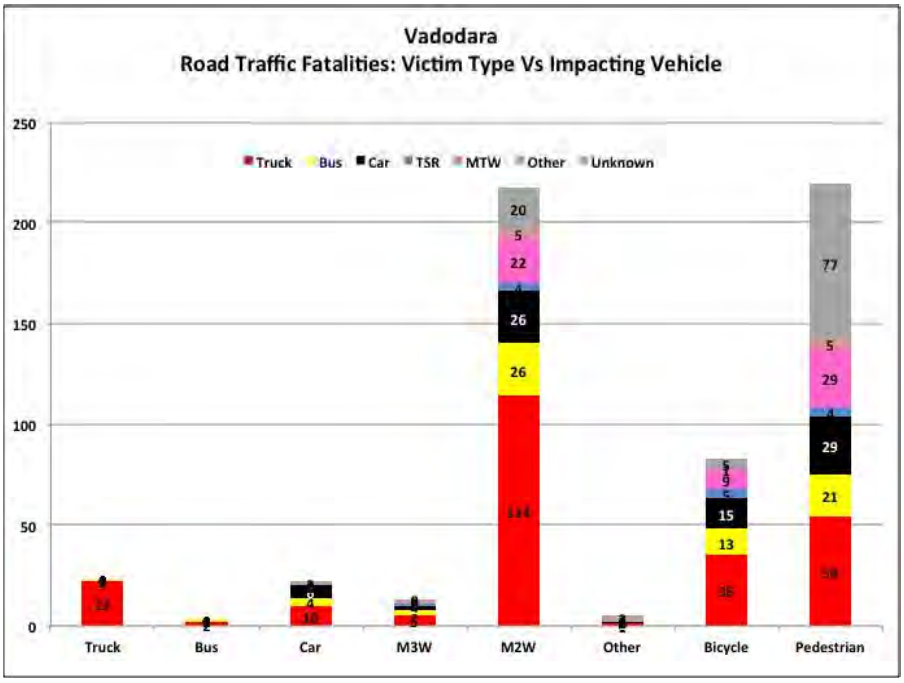



**Figure 14. Traffic fatalities: victim type vs impacting vehicle/object in Vadodara (MTW - Motorised two-wheelers, TSR - Three-wheeled scooter rickshas).**

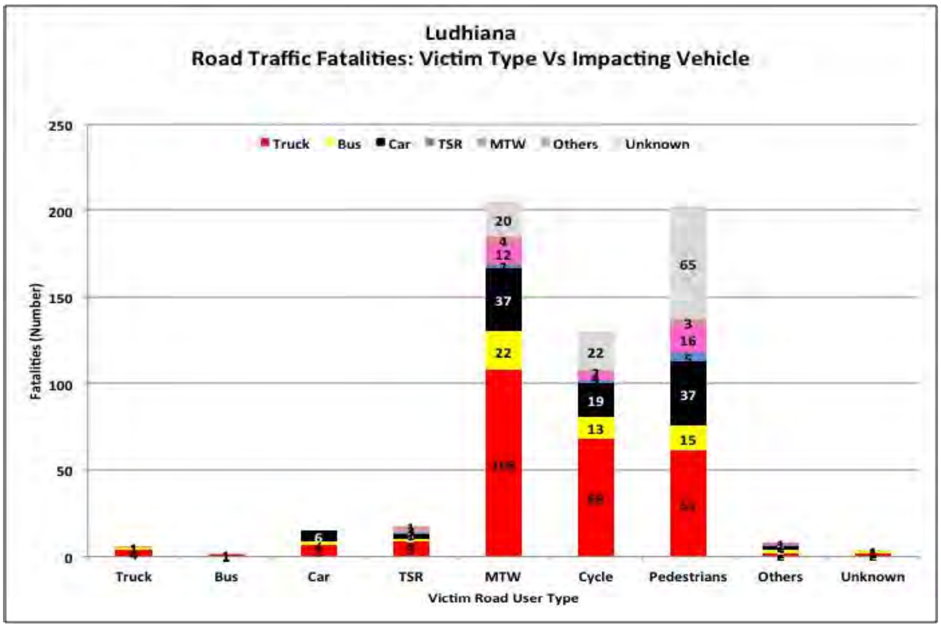



**Figure 15: Traffic fatalities: victim type vs impacting vehicle/object in Ludhiana.**

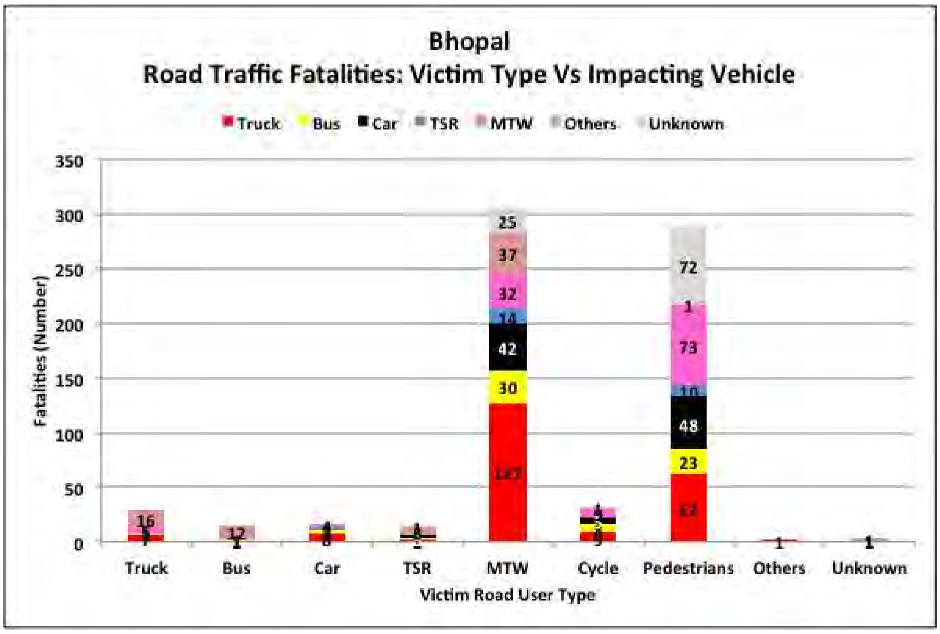



**Figure 16: Traffic fatalities: victim type vs impacting vehicle/object in Bhopal (MTW - Motorised two-wheelers, TSR - Three-wheeled scooter rickshas).**

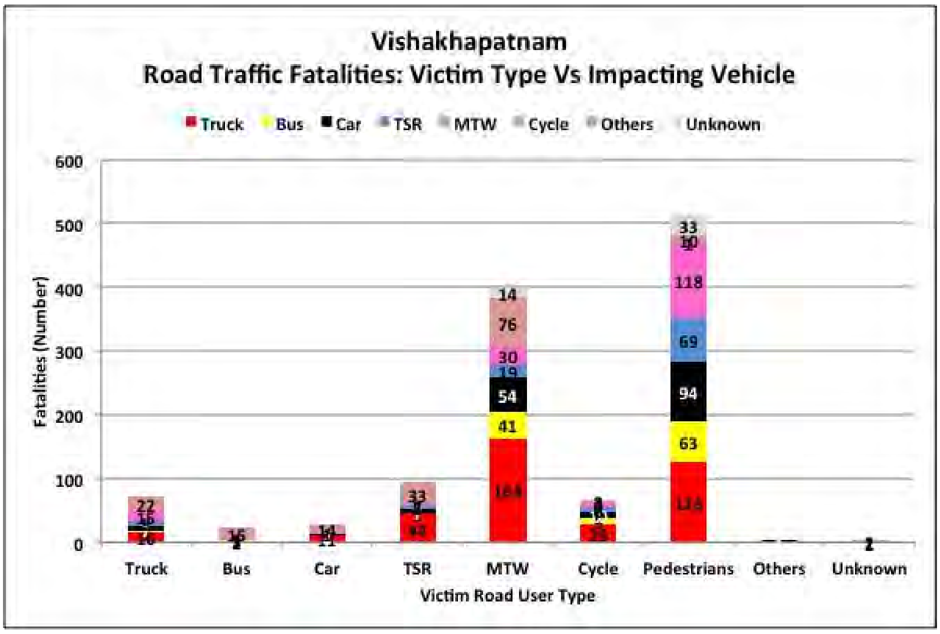
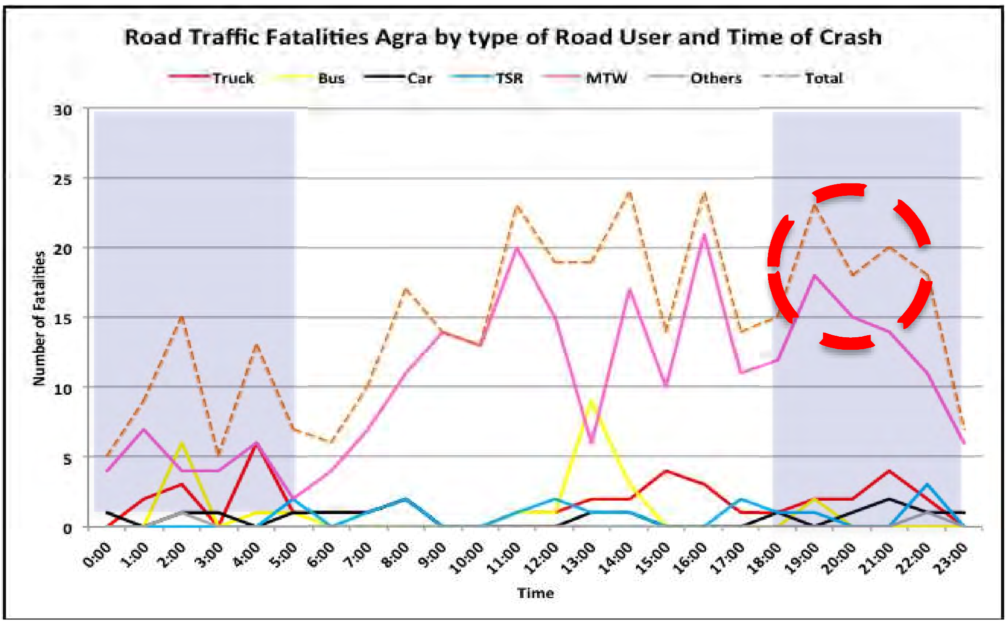



**Figure 17. Traffic fatalities: victim type vs impacting vehicle/object in Vishakhapatnam.**

## Road traffic fatalities by type of road user and time of crash



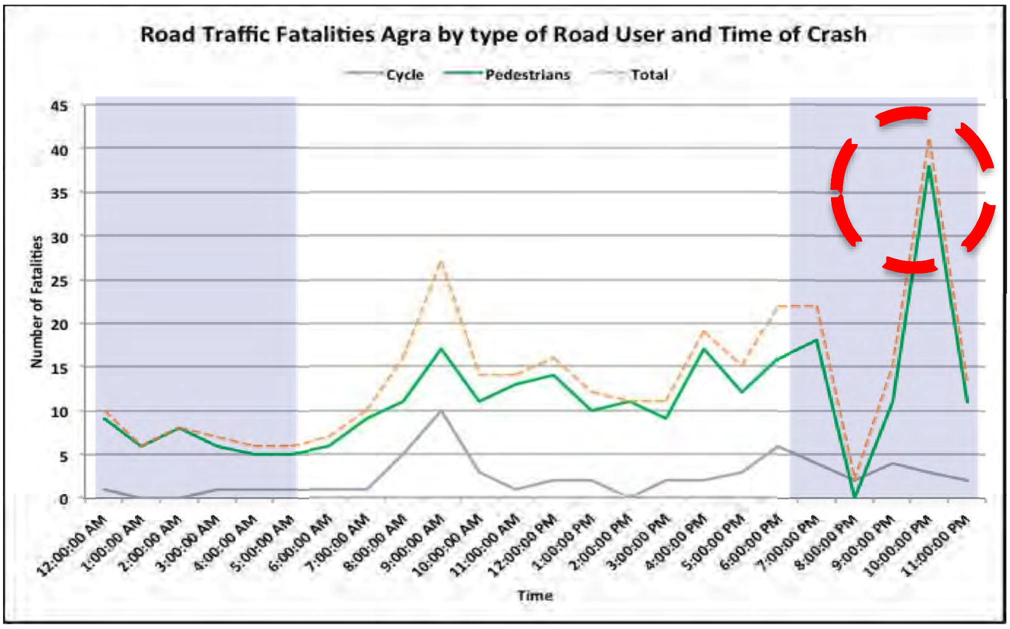




**Figure 18. Road traffic fatalities in Agra by time of crash.**

Figure 18 shows the fatalities by road user category and time of day in Agra. Pedestrian and bicycle fatalities peak somewhat earlier in the morning than the motor vehicle fatalities. This may be because this class of road users start for work earlier than those using motorised transport. The total fatality rate remains somewhat similar between the hours of

10:00 and 18:00 and a strong bimodal distribution is not observed. This could be because school and working timings are reasonably staggered. Schools start around 08:00 in the morning and close at 14:00 and some of them have a second shift, private offices open between 08:00-09:00, government offices between 09:00-10:00 and shops around 11:00. Most shops stay open up to 21:00 and restaurants up to 23:00. The data also show that MTW and pedestrian deaths are relatively high at 22:00-23:00 when we would expect traffic

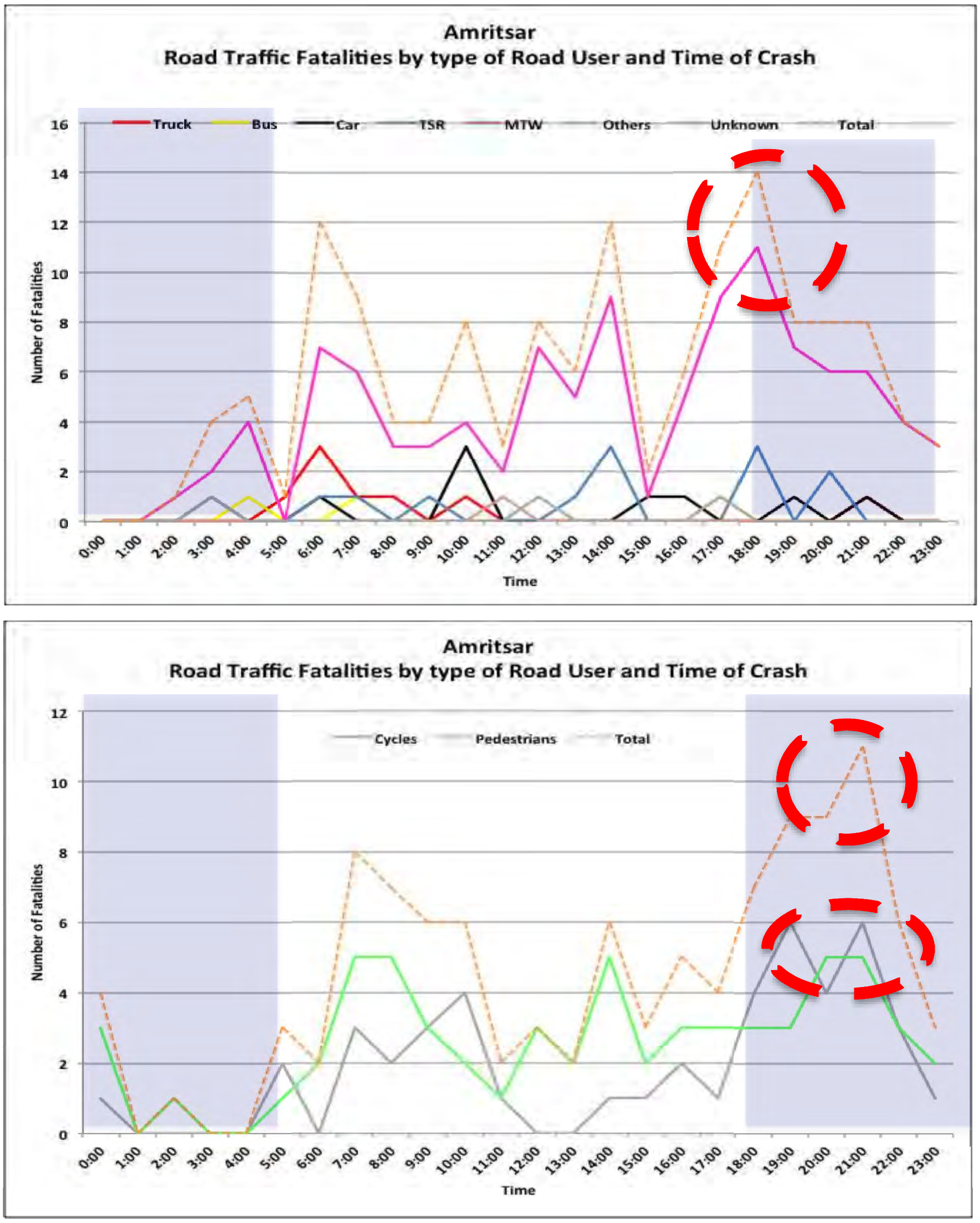
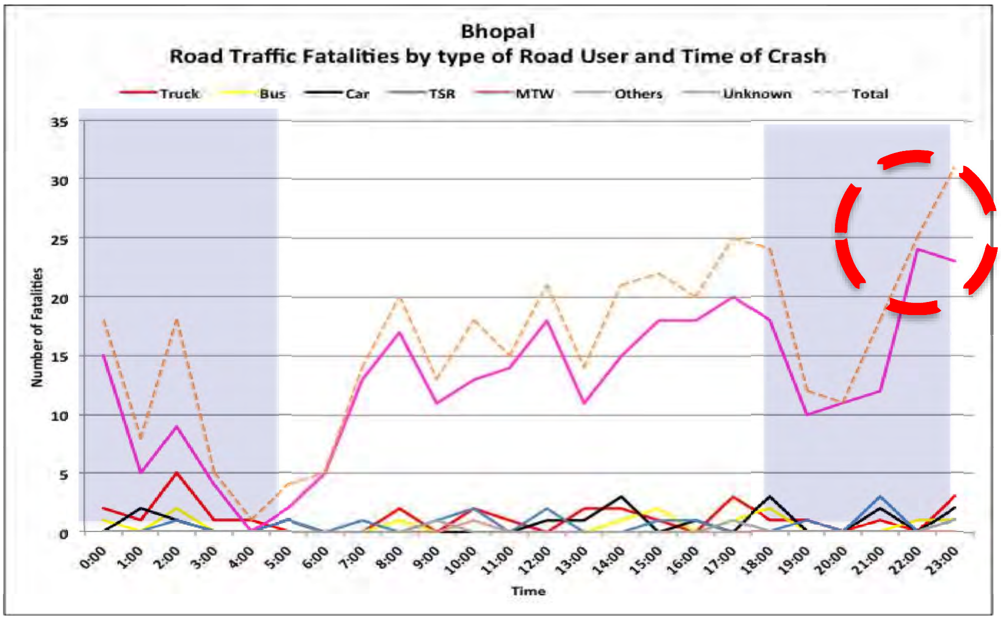



**Figure 19. Road traffic fatalities in Amritsar by time of crash.**



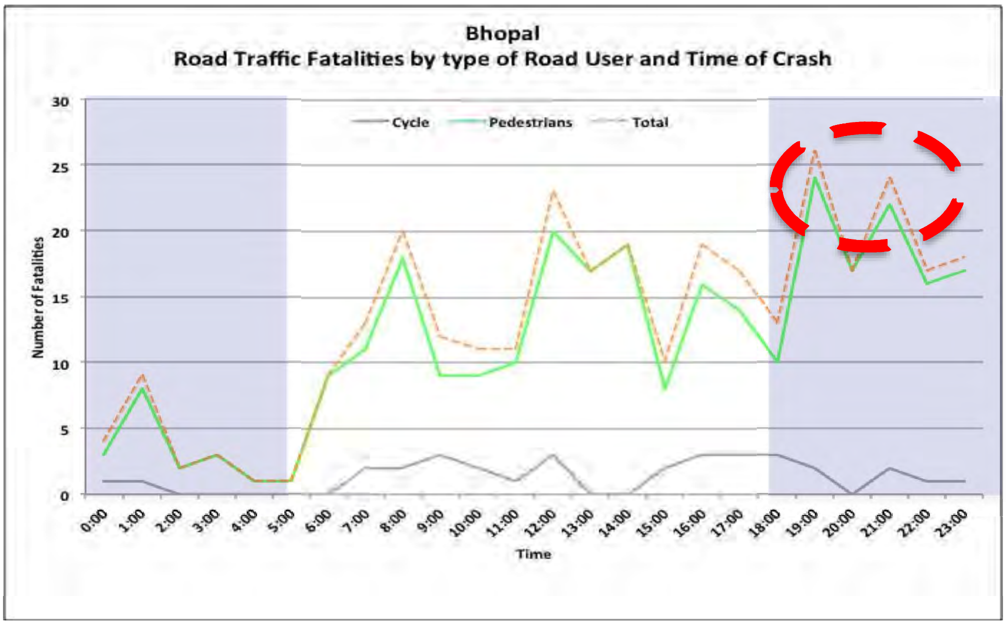




**Figure 20. Road traffic fatalities in Bhopal by time of crash.**

volumes to be low. Details regarding the associated causes for these crashes are not available but the risk factors could include high speeds, driving under the influence of alcohol, and limited visibility. Figure 19 shows road traffic fatalities by time of day in Amritsar. The pattern is similar to that observed in Agra in the previous figure.

Figure 20 shows road traffic fatalities by time of day in Bhopal. The pattern is similar to the previous two cities, except that pedestrian and bicycle crashes do not show as high a rate at

22:00-23:00 hours. However, the pattern of MTW fatality rates at night are similar to the previous two cities.

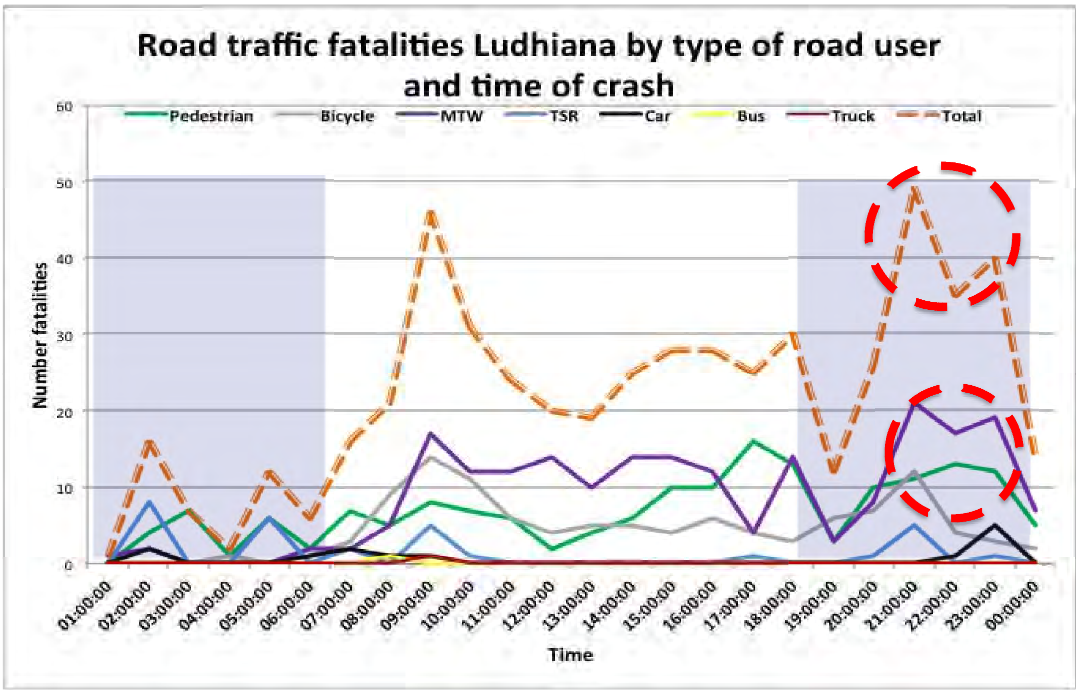



**Figure 21: Road traffic fatalities in Ludhiana by time of crash.**

The crash patterns by time of day in Ludhiana are similar to the previous cities (Figure 21), but those in Vadodara seem to have a slight difference in night-time crashes. Pedestrian and MTW peaks are not seen at 22:00-23:00 hours. This could be because Vadodara is located in the sate of Gujarat, which is a dry state by law, and sale of alcohol is prohibited. However, we do not have the necessary epidemiological data to verify this.

The general pattern of crashes by time of day in Vishakhapatnam is similar to the previous five cities, except that the relative increase in pedestrian deaths at night appears to be higher than the other cities. The details available with us do not permit us to offer any reliable explanation for this.

In summary, the data from the six cities indicate that crashes rates between 20:00-23:00 hours are relatively high in all the cities when traffic volumes would be relatively lower. This points to risk factors including high velocities, alcohol involvement and lack of visibility.

## Age of victims

Age of victims was not recorded in the First Information Reports (FIR) made available to us for a vast majority of the cases. However, for the city of Vadodara, we made estimated the age of the victims in 3 broad groups: 0-19 (young adults and children), 20-59 (working age), and ≥ 60 years (elderly). The estimates are shown in Figure 22. These data indicate the proportion of young individuals involved in fatal road traffic crashes is relatively small. Anecdotal evidence suggests that a large proportion of young individuals walk and bicycle to school, and many are transported as passengers on motorised two-wheelers. Figure 23 shows the age distribution of fatal road traffic crash victims for the country as reported by the police. These data also indicate that the 0-14 age group is under represented in proportion to their share in the population. Lower exposure rates may account for this, however, this explanation does not seem to be adequate enough to explain these very low rates, especially children on motorcycles. This phenomenon needs further study.

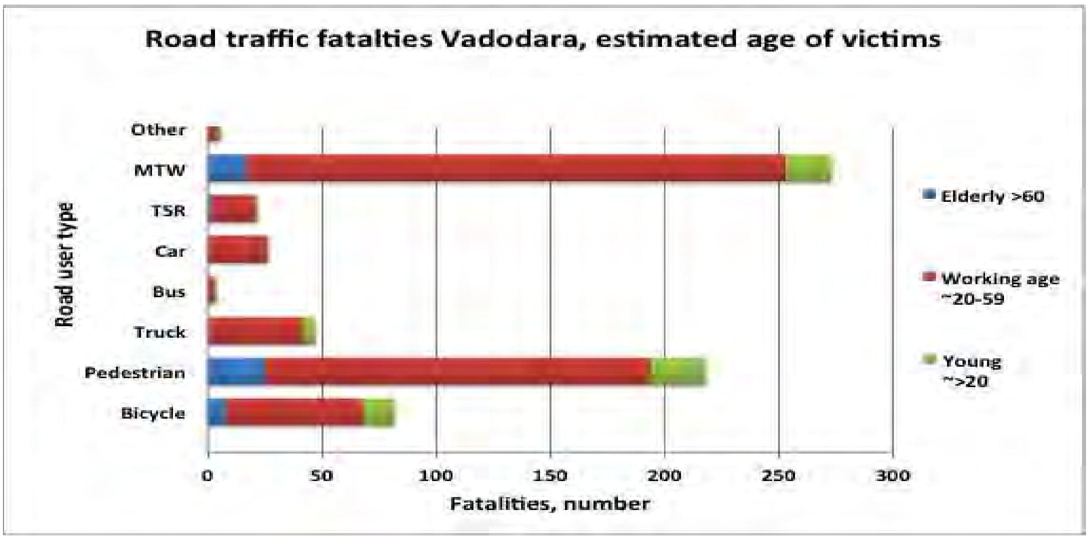



**Figure 22: . Estimated age distribution of road traffic crash fatalities in Vadodara**

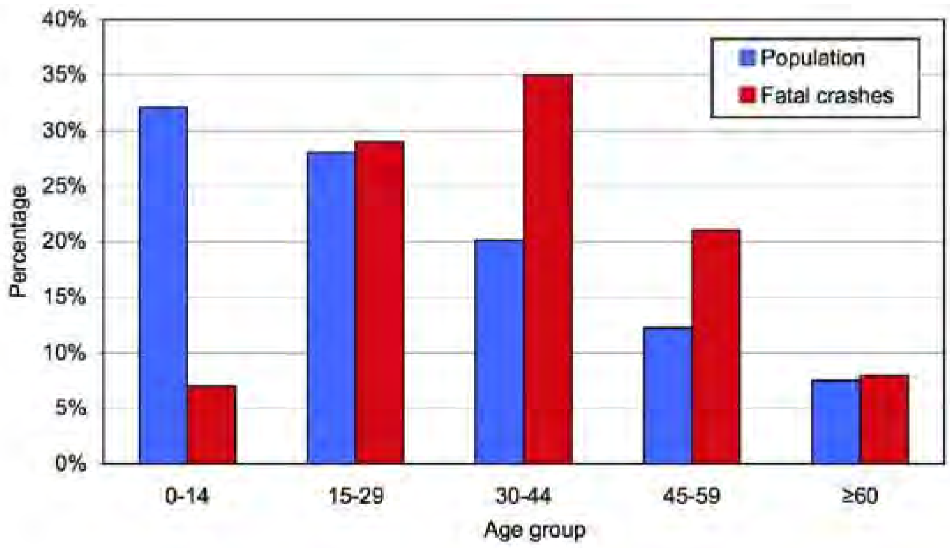



**Figure 23: . Age distribution of road traffic crash fatalities in India (NCRB, 2012).**

## Road traffic fatalities by type of road user and location of crash

Figure 24 shows the distribution of road traffic fatalities in Vadodara and Ludhiana at junctions and mid-blocks. In the case of Vadodara, the junction definition included a distance of 50 m upstream of all the roads meeting at the junction. For Ludhiana the location was recorded as mentioned in the police FIR/. These data indicate that a majority of the fatal crashes take place mid-block rather than at junctions. The Vadodara data shows a higher proportion at junctions as compared to Ludhiana. This could be because of the more inclusive definition adopted for Vadodara. A vast majority of the fatal crash victims comprise VRUs. In the absence of adequate pedestrian and bicycle facilities on arterial roads of all six cities studied, the left side of the road (curb side lane) has to be shared by pedestrians, bicyclists, MTWs, buses and trucks. In addition, vehicle speeds would tend to be higher in mid block locations. This may be one reason why a majority of fatalities take place mid-block.

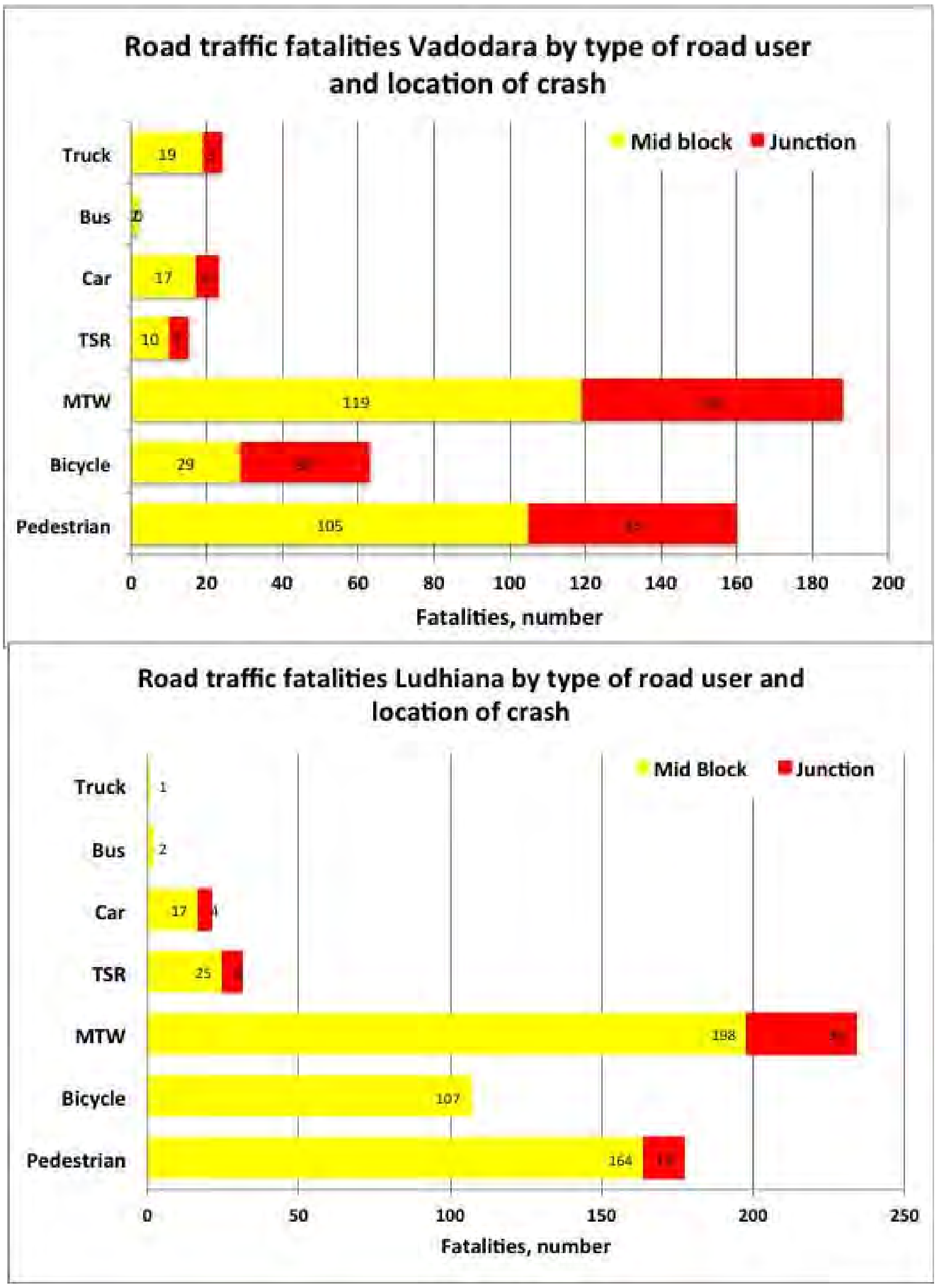



**Figure 24: Road traffic fatalities by location of crash**

## City structure, arterial roads and location of crashes

The city structure and location of main arterial roads and highways passing through the city was studied by examining the map of each study city. In addition, all fatal crashes were plotted (for cases where location details could be identified) for two cities: Ludhiana and Vadodara. In the case of Agra, we were able to plot cases for one year. The results of this study are included below.

**a. AGRA (high crash rate)**

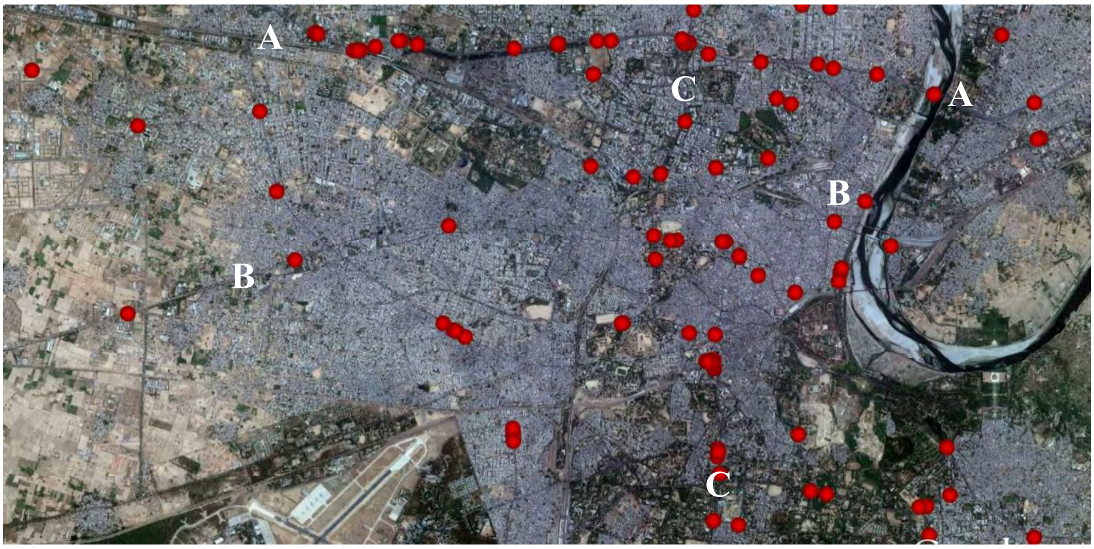



**Figure 25. Fatal crash locations (one year) identified in Agra city.**

Figure 25 shows the fatal crash locations in Agra city. A majority of the fatal crashes are located on the arterial roads of the city and not on the local and connector roads. Some of the highest concentrations take place on three highways passing through the city: (a) A-A is a six lane national highway, which runs east-west and seems to have the higher velocities; (b) B-B is a state highway also running east-west, which is 2- 4 lanes; (c) C-C is a state highway running north-south, which connects to cities south of Agra (Figure 26). The road has heavy mixed traffic including with very inadequate pedestrian/bicycle facilities. All these roads have heavy traffic throughout the day, and velocities can be above 50 km/h at night. Figure 27 shows traffic on the National Highway (A-A) in Agra. This is major highway constructed through the city over the past decade. This highway is a major east-west corridor for inter city traffic and is used by large proportion of buses and trucks. There are almost no convenient faculties for VRUs to cross this highway. In addition, a very large number of workshops, trading and transport companies, and shops are located on both

**Figure 26: Traffic on national highway A-A in Agra**

sides of the highway. A highway like this constructed through the city seems to result in high crash rates along its length.

Figure 27: . Traffic on road C-C in Agra

**b. AMRITSAR (low crash rate)**

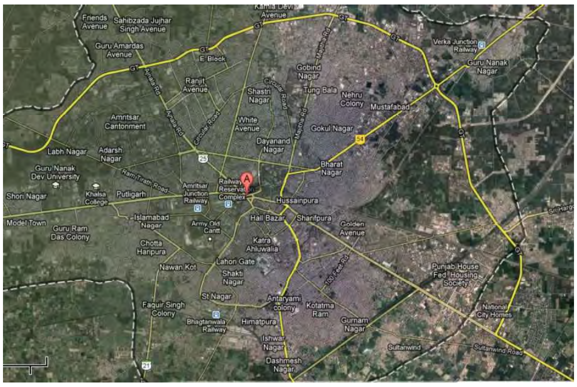



Figure 28: Arterial roads in Amritsar.

Amritsar is a city in the north-west of India about 30 km from the border with Pakistan. As a result there are no major national highways that have to carry intercity traffic through the city. Most of the roads in the city are congested. Crash locations were not identified for Amritsar. According to official statistics the city has the lowest road traffic fatality rate among the six studies included in this project.

**c. BHOPAL (low crash rate)**

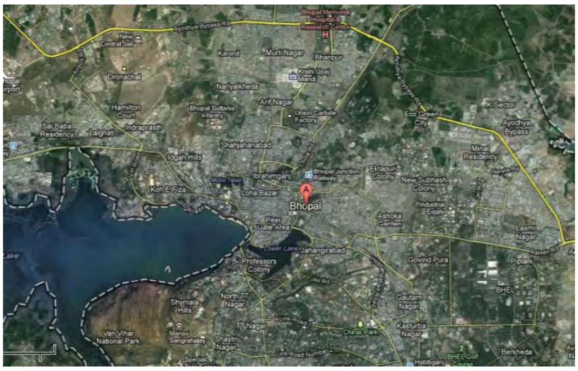



Figure 29: Arterial roads in Bhopal.

Crash locations have not been identified for Bhopal. The city has no major highways crisscrossing the city. In addition the city has a large lake within the city and a hilly residential area. Most of the arterial roads in the city are congested in the daytime hours with mixed traffic. Bhopal has a lower fatality rate as compared with Agra, Vishakhapatnam and Ludhiana.

**d. LUDHIANA (high rate)**

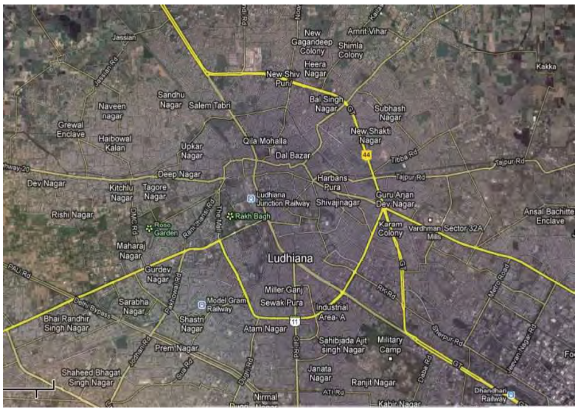



Figure 30: Arterial roads and highways in Ludhiana.

Figure 30 shows the arterial roads and highways passing through Ludhiana. An important National Highway that connects the capital Delhi with the border city Amritsar passes through Ludhiana, going from the southeast side to the northwest. Another national highway comes into the city form the southwest and a state highway from the south. A bypass has been constructed connecting these highways encircling the city in the north, east and the south sides.

**Figure 31: Traffic on highways passing through the city in Ludhiana.**

The highways passing through the city also serve as arterial roads of the city. The type of mixed traffic including trucks operating on these roads is shown in Figure 31. Bicyclists and pedestrians in large numbers also use these roads but adequate and safe facilities for them do not exist in these roads.

The location of pedestrian, bicycle and MTW fatalities is shown in Figure 32. As in Agra, a large proportion of fatalities take place on the highways and major arterials. The red dots represent impacts by trucks, blue dots impact by buses and red dots impacts by cars. Truck impacts are the most frequent on the highways.


**Pedestrian fatalities**


**Bicycle fatalities**


**MTW fatalities**

**Figure 32: Location of pedestrian, bicyclist and MTW fatalities in Ludhiana.**

**e. VADODARA (low rate)**

Figure 33 shows the arterial and highway layout in Vadodara. There is no major highway that goes through Vadodara, there is bypass for intercity traffic which skirts the western side of the city from the north ton the south. Arterial roads connect the central parts of the city to this bypass.

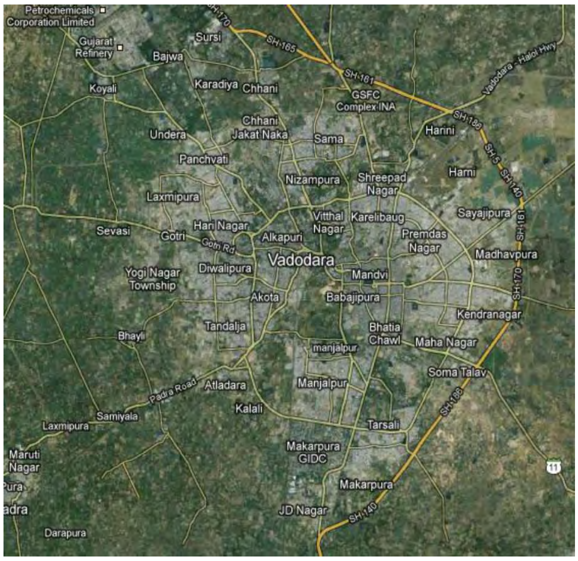



**Figure 33: Arterial roads and highways in Vadodara.**

Figure 34 shows the locations of the fatal crashes in the city. All the main arterials leading out from the city and the circular road inside the bypass have a concentration of crashes.

The western bypass also has a higher concentration and crashes are located all through its length. Type of traffic operation on the bypass is shown in Figure 35.

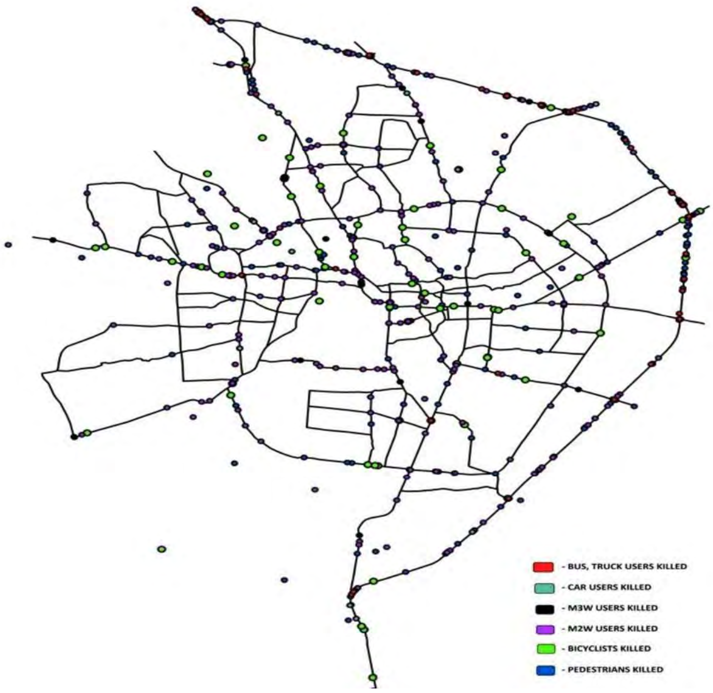



**Figure 34: Location of fatal crashes in Vadodara.**


Figure 35: Traffic on the bypass in Vadodara.

Mixed modes, relatively high speeds and sharing of the road by VRUs with heavy vehicles results in high crash rates. However, the overall fatality rate in Vadodara is less than that in Agra, Ludhiana and Vishakhapatnam as the main roads inside the city are congested.

**f. VISHAKHAPATNAM (high rate)**

Vishakapatnam is a port city with the eastern headquarters of the Indian Navy, and it hosts heavy industry factories in different locations of the city. National highways lead out of the city and different sectors of the city are connected with roads that can have relatively high speeds. The city has a high fatality rate.

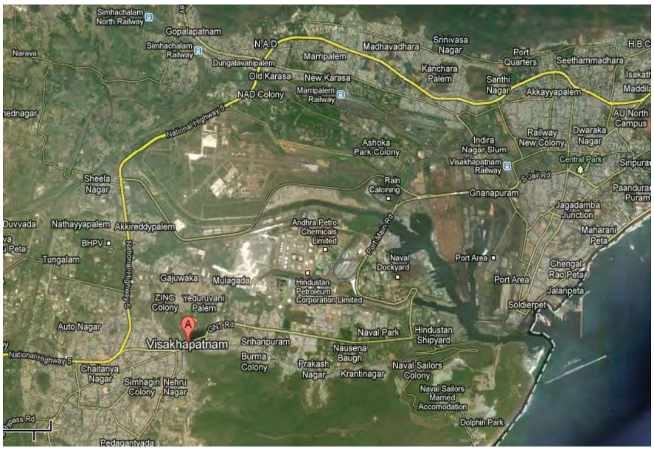



Figure 36: Highways and arterial roads in Vishakhaptnam

**Figure 37: Traffic on the main arterials of Vishakhaptnam.**

Fatality locations have not been identified in Vishakhapatnam. Figure 37 shows the traffic on main arterials of the city. Existence of wide roads and flyovers with mixed traffic may be one of the factors associated with high road traffic fatality rates in the city.

## Road user risk analysis

Risk of fatality has been calculated using different indices to understand the role of different motor vehicles, personal risk per trip by different modes and the risk different vehicles present to society.

### Occupant risk per 100,000 vehicles

Figure 38 shows the number of motor vehicle occupant fatalities per 100,000 vehicles. This has been obtained by dividing the total number of occupant fatalities for each vehicle type divided by the specific number of that vehicle type registered in the city (corrected for overestimates). These data show that occupant fatalities per vehicle decrease in the following order – bus:truck:TSR:MTW:car. It is difficult to

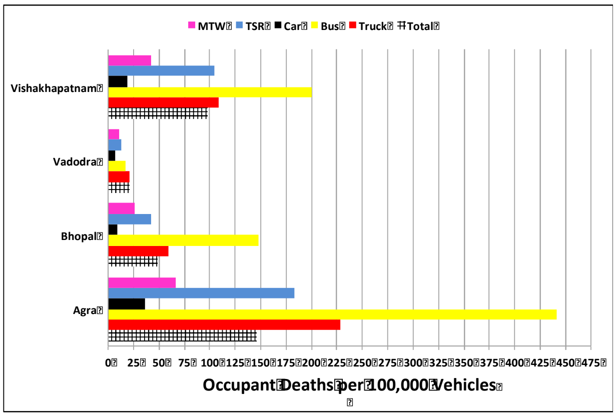



**Figure 38: Motor vehicle occupant fatalities per 100,000 vehicles.**

account for the bus and truck figures, as the total number of fatalities is divided by the number of these vehicles registered in the specific cities only. However, the actual number of trucks and buses operating in the cities would include those passing through these cities but not registered there. If these extra vehicles were accounted for, then the indices for occupant fatality rates for buses and trucks would be lower.

Occupant fatality rates for MTW and TSR occupants are 2-3 and 3-5 times higher that for cars respectively. The high rates per vehicle for TSRs would also be because they carry a much larger number of passengers in the day as compared to MTWs and cars. This effect is accounted for in the section on personal risk in a following section.

## Fatalities associated with each vehicle type

Figure 39 shows all the fatalities that each vehicle type is associated with. This includes fatalities of road users other than the vehicle occupant. For example, if a motorcycle hits a pedestrian and the pedestrian dies, then the pedestrian death will also be associated with the motorcycle. This index gives a rough idea of the total number of fatalities you can expect for each vehicle type given the present traffic conditions and mode shares.

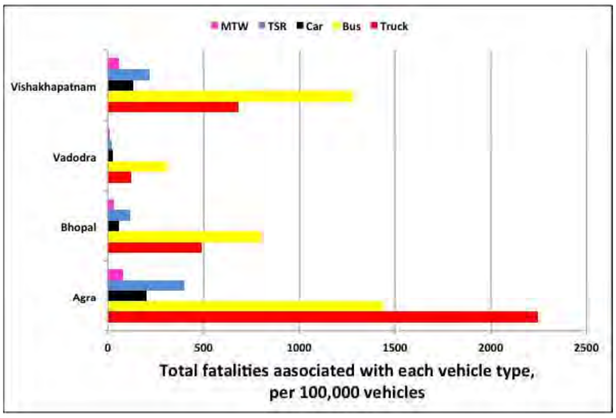



**Figure 39: Fatalities associated with specific vehicle types per 100,000 vehicles.**

These indices again show that buses and trucks have the highest rates in all the cities. The usual caveat applies that the actual number of buses on the roads in these cities would be higher than the number registered in the city. This would mean that the absolute index for buses and trucks would be lower than that shown in Figure 39. In all cities except Agra, buses appear to have a higher number than trucks. Whatever, the real index for these vehicles, the data in figure 41 does point to the fact that buses and trucks have a disproportionate involvement in urban fatal crashes. Since a majority of the victims associated with these crashes are VRUs, these figures strengthen the need for much better facilities for VRUs so that they do not have to share the curbside lanes with these heavy vehicles. If buses and trucks were designed to have safer fronts for impacts with pedestrians, then this number would reduce. At present there are no pedestrian impact standards for buses and trucks.

These data also show that each TSW is associated with more fatalities than the car and each car is associated with more fatalities than a MTW. However, the differences between the car and MTW are not very large. What these data tell us is that at the city societal level a motorcycle does not do as much harm, though it is more hazardous for its own occupant than the car or TSR. This index also points us to the need for improvement in TSR designs and need for crashworthiness standards. These numbers give us an indication of the situation at present operating levels and exposure has not been taken into account. This is done in the next section.

## Fatalities associated with each vehicle type accounting for exposure

Figure 40 shows us the estimates for all fatalities associated with specific vehicle types per 100,000-vehicle km per day. The following values have been assumed for distances travelled per day.

Bus: 150 km
Car: 50 km
TSR: 150 km
MTW: 25 km

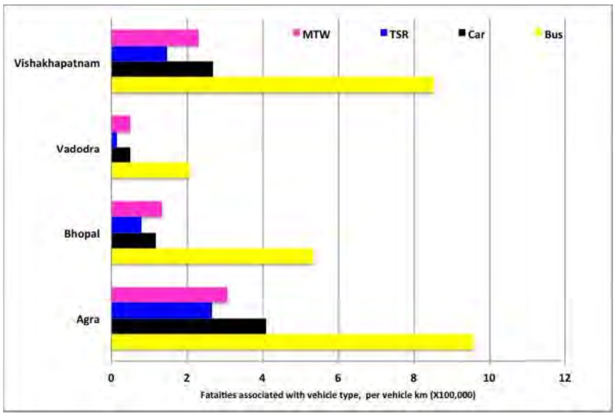



**Figure 40: Fatalities associated with specific vehicle types per 100,000-vehicle km.**

These figures basically indicate that the relative higher rate for TSRs as compared to cars as shown in the previous section was due to the higher exposure of TSRs. These indices appear to indicate that per km of travel TSRs, MTWs and cars are very roughly equally harmful for society under present conditions. Out of these three vehicles it is very important to improve the safety performance the MTW for its occupants (helmet use and daytime running lights). TSRs need improvement for safety of occupants as well as the VRUs it impacts. The fatalities associated with the can be decreased mainly by speed control and reduction in drinking and driving.

## Personal fatality risk per 10 million trips

The personal fatality risk has been calculated by dividing the vehicle specific occupant fatality rate by estimates of average number of occupants carried by each vehicle per day. The numbers assumed are: MTW – 4, TSR – 60, Car – 7. The results of these calculations are shown in Figure 41.

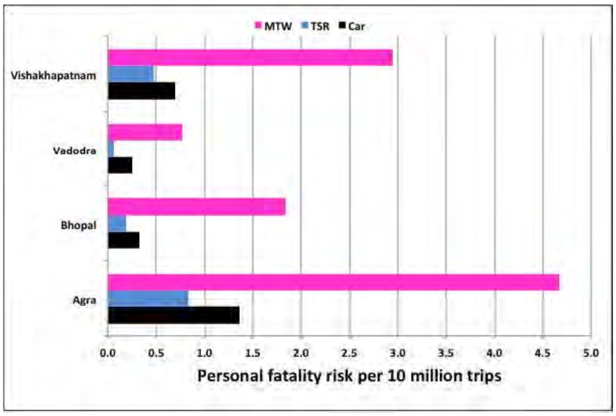



**Figure 41: Vehicle specific personal fatality risk per 10 million trips.**

It is clear that given the present trip lengths for each vehicle type, the MTW rider is 3-6 times more at risk than a car occupant. The MTW fatality rates per trip in Agra and Vishakhapatnam are much higher than the other three cities. The reasons for this are not known at present. At a personal level, risk per trip seems to be lowest for TSR occupants in all the cities. These estimates are true for present modal shares and assumed trip rates.

Helmet use and daytime running lights are not mandatory for MTW riders in any of the cities studies. The implementation of just these two measures is likely to reduce the personal fatality risk by about 50%.

## Effect of the built environment on traffic safety in urban areas

All roads in the two cities were represented by line type objects. For the purpose of analysis, the city was divided into 30 areas based on lat/long:

Latitudes and longitudes were divided in intervals of 0.025°

The software ArcGIS 10.0 was used to determine length of all roads in the cities of Agra and Ludhiana. The mid-point of each line was used to classify which area a particular road belonged to. The function "*Calculate Geometry*" was used to determine length of each line in the shapefile.

- Roads were classified highways, arterial roads and minor roads.
- Width of lanes: Wide, Medium and Narrow

- Data on: Median presence, Average width of paved/unpaved shoulders, Number of traffic lights per unit length (km), Number of street lights per unit length (km), Moderate curves per unit length (roads bent by 20-30 degrees), Sharp curves per unit length (km), Adequacy of road markings, Number of access points per unit length (km), Pavement Quality/Sidewalk provision, Population density of nearby area, Land-use pattern of nearby area.

Table 4 shows the results of the surveys conducted in Agra and Ludhiana regarding the built environment attributes in the two cities.[2] Negative Binomial Regression was performed using IBM SPSS Statistics 20. The dependent variable was the number of fatalities in each grid in the city. Initially, the independent variables were length of minor roads, length of arterial roads, length of highways and number of intersections in the corresponding grid. But later, the insignificant variables were removed to get the final model. The main conclusions drawn are as follows:

- Regression Model is significant as indicated by Likelihood Ratio Test
- **Length of highways and arterial roads** is significant at 95% confidence interval
- With 1 km increase in length of highway, the log(expected number of accidents) **increases** by **0.6**
- With 1 km increase in length of arterial roads, the log(expected number of accidents) **increases** by **0.2**
- Number of intersections and length of local roads is insignificant.

[2] Detailed data and modelling results are available with the authors.

**Table 4. Overview of survey conducted regarding  built environment parameters in Ludhiana.**

| AGRA | | | |
|---|---|---|---|
| **Parameter** | **Min** | **Max** | **Average** |
| Regions Covered | | | 27 |
| Total Readings | | | 57 |
| Lanes per direction | 0.5 | 3 | 1.516 |
| Width of Lanes | Narrow = 30 | Wide = 6 | Medium = 21 |
| Median Presence | 1or 2 = 34 | 3 or 4 = 10 | 5 = 13 |
| Safety Barrier Presence | 1 or 2 = 55 | 3 or 4 = 1 | 5 = 1 |
| Paved shoulder width | None = 35, Narrow = 10 | Wide = 4 | Medium = 8 |
| Unpaved shoulder width | None = 22, Narrow = 16 | Wide = 4 | Medium = 15 |
| Traffic Lights per km | 0 | 10 | 0.62 |
| Street Lights per km | 0 | 100 | 60.4* |
| Moderate curves per km | 0 | 50 | 7.78 |
| Sharp curves per km | 0 | 50 | 2.92 |
| Road Markings | Inadequate = 42 | Adequate = 15 | |
| Access points per km | Low = 15 | High = 22 | Medium = 20 |
| Pavement quality | Poor = 23 | Good = 15 | Medium = 19 |
| Sidewalk provision | Poor = 39 | Good = 7 | Medium = 11 |
| Population Density | Low = 15 | High = 20 | Medium = 22 |
| Land Use | Residential = 20 | Industrial = 7 | Mixed = 27, None = 3 |

| LUDHIANA | | | |
|---|---|---|---|
| **Parameter** | **Min** | **Max** | **Average** |
| Regions Covered | | | 30 |
| Total Readings | | | 62 |
| Lanes per direction | 0.5 | 4 | 1.387 |
| Width of Lanes | Narrow = 27 | Wide = 16 | Medium = 19 |
| Median Presence | 1or 2 = 34 | 3 or 4 = 8 | 5 = 20 |
| Safety Barrier Presence | 1 or 2 = 59 | 3 or 4 = 3 | 5 = 0 |
| Paved shoulder width | None = 34, Narrow = 12 | Wide = 7 | Medium = 9 |
| Unpaved shoulder width | None = 31, Narrow = 10 | Wide = 9 | Medium = 12 |
| Traffic Lights per km | 0 | 2 | 0.274 |
| Street Lights per km | 0 | 100 | 32.41 |
| Moderate curves per km | 0 | 5 | 1.677 |
| Sharp curves per km | 0 | 3 | 0.403 |
| Road Markings | Inadequate = 51 | Adequate = 11 | |
| Access points per km | Low = 33 | High = 14 | Medium = 15 |
| Pavement quality | Poor = 24 | Good = 12 | Medium = 26 |
| Sidewalk provision | Poor = 38 | Good = 9 | Medium = 15 |
| Population Density | Low = 33 | High = 15 | Medium = 14 |
| Land Use | Residential = 7 | Industrial = 8 | Mixed = 32, None = 15 |

- Paved shoulder presence, low access points, footpath presence, low population density, residential land use and traffic lights per km are significant at 95% confidence interval.

- As compared to NO Footpaths, presence of footpaths decreases log(expected number of accidents) in the region by ~1.4. This result is intuitive because presence of footpaths decreases exposure of pedestrians to traffic.

- As compared to HIGH population density, LOW population density decreases log(expected number of accidents) in the region by 2.2. This result is also intuitive because low population density decreases exposure.

- As compared to OTHER Land Use (mostly forests), Residential Land Use decreases log(expected number of accidents) in the region by 2.6. The possible reason for this observation is that less traffic is observed in residential areas during non-peak hours.

The main conclusions drawn are as follows:

- Median presence, presence of road markings, good pavement quality, low/medium population density, residential land use and traffic lights per km are significant at 95% confidence interval

- As compared to NO Median, presence of median increases log (expected number of accidents) in the region by 1.1. This observation raises questions on the design of the medians. Raised medians on highways where speeds greater than 50 km/h are a liability. This is because several fatalities occur due to vehicles colliding with them at high speeds.

- As compared to NO road markings, presence of road marking decrease log(expected number of accidents) in the region by 2.7. Road markings help to delineate slow moving and fast moving traffic. Lack of road markings is the most important reason why fatalities are high on Indian roads.

- As compared to POOR Pavement Quality, GOOD Pavement Quality increases log(expected number of accidents) in the region by 2.573. Higher speeds are observed on better pavement quality. This requires presence of several safety measures like safety barriers, road markings, signs, etc. However, due to their absence, better pavement quality leads to more accidents.

- As compared to HIGH population density, LOW population density decreases log(expected number of accidents) in the region by 2.1. This result is intuitive because low population density decreases exposure.

- As compared to HIGH population density, MEDIUM population density decreases log(expected number of accidents) in the region by 2.8. This result is also intuitive because exposure is still low.

**Table 5. Velocity profiles at 3 locations in Agra (TST- Three-wheeled scooter taxi, MTW-Motorised two-wheeler)**

| Location | Day velocities km/h (10%, Mean, 90%) | Night velocities km/h (10%, Mean, 90%) |
|---|---|---|
| Location 1 | TST 14.5, 26.4, 38.3<br>MTW 17.8, 32.2, 46.6<br>Car 10.2, 29.3, 48.4<br>Truck 16.1, 26.0 36.0 | TST 13.7, 21.6, 29.5<br>MTW 14.9, 27.7, 40.5<br>Car 11.0, 26.9, 42.9<br>Truck 12.7, 23.4, 34.2 |
| Location 2 | TST 22.0, 32.1, 42.2<br>MTW 19.3, 32.7, 46.2<br>Car 20.3, 29.4, 38.5 | TST 17.4, 28.3, 30.0<br>MTW 19.6, 33.0, 34.7 |
| Location 3 | TST 5.5, 12.0, 18.4<br>MTW 7.6, 13.6, 19.6<br>Car 6.6, 13.0, 19.4 | TST 7.5, 15.7, 23.8<br>MTW 9.1, 17.9, 26.7<br>Car 11.5,20.5,29.5 |

## AGRA

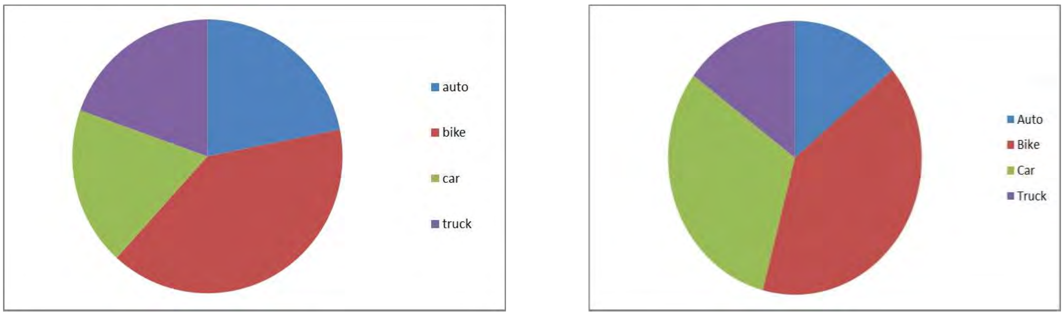
Traffic volume data was collected by taking videos of traffic at 3 locations:

- Location 1: Janki Emporium (from 1st Floor of a building) on National Highway 2
- Location 2: Housing Complex (from 2nd Floor), National Highway 11
- Location 3: S N Medical College (from 1st Floor), MG Road

Video recording of traffic was made from an elevated location in the day and night times. The data for speeds in the day and night are given in the Table 5.

Location 1 observations

- The number of TSTs have decreased at night-time.
- The proportion of cars has increased at night time from 19% to 31%
- The proportion of 2-wheelers and trucks remains almost constant.
- In terms of vehicle speed on NH-2 an overall decrease is noted during night (approximately 10-12%).
- Overall traffic volume is almost the same

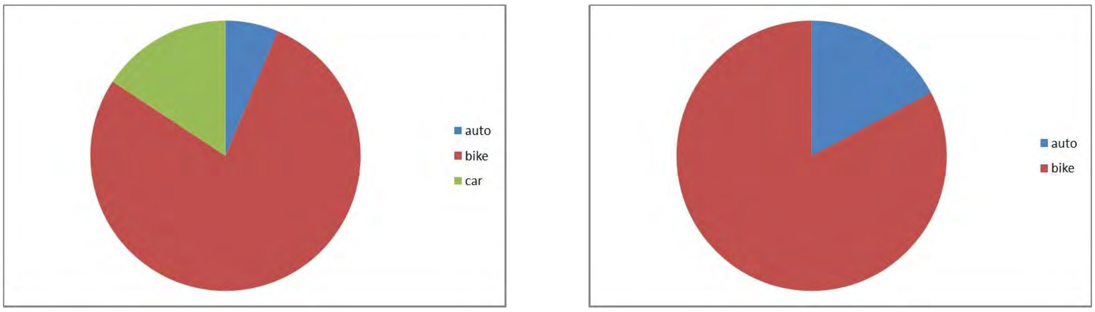



Day Night

**Figure 42: Modal share of vehicles at location 1 in Agra**

<u>Location 2 observations</u>

- NH-11, has a very high portion of MTW traffic.
- During the night time, the proportion of cars in the location drops from 16% to almost zero.
- The proportion TSTs in the area increases at night from 6% to 17%
- No decrease is observed during the night-time, the traffic travels with almost similar 90% and mean limits.
- Overall traffic volume remains unchanged, but is lower than NH2.



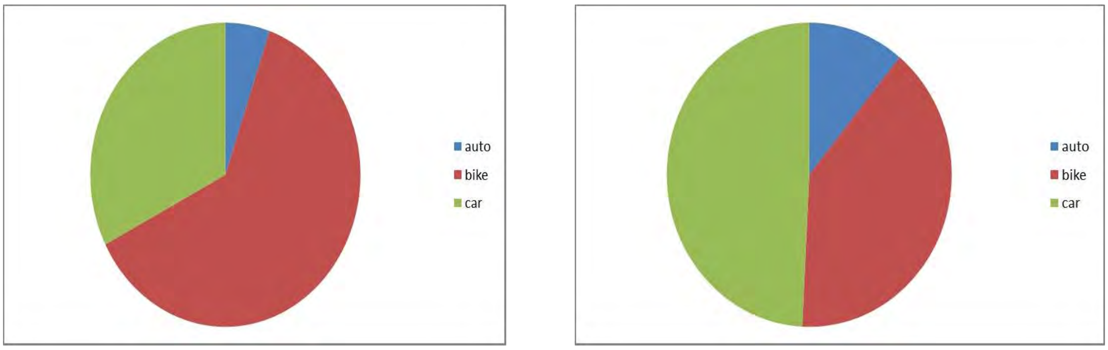

Day Night

**Figure 43: Modal share of vehicles at location 2 in Agra**

<u>Location 3 observations</u>

- Proportion of cars in traffic has increased from 32% to 49%, with a decrease in number of "bikes", from 62% to 40%

- The number of TSTs has also increased.
- Higher speeds are observed all throughout the traffic for night time with greater variation in data.
- This can be explained by the good quality of road in the area and drastic drop in traffic from 54 to 16 vehicles per minute.




Day Night

**Figure 44: Modal share of vehicles at location 3 in Agra.**

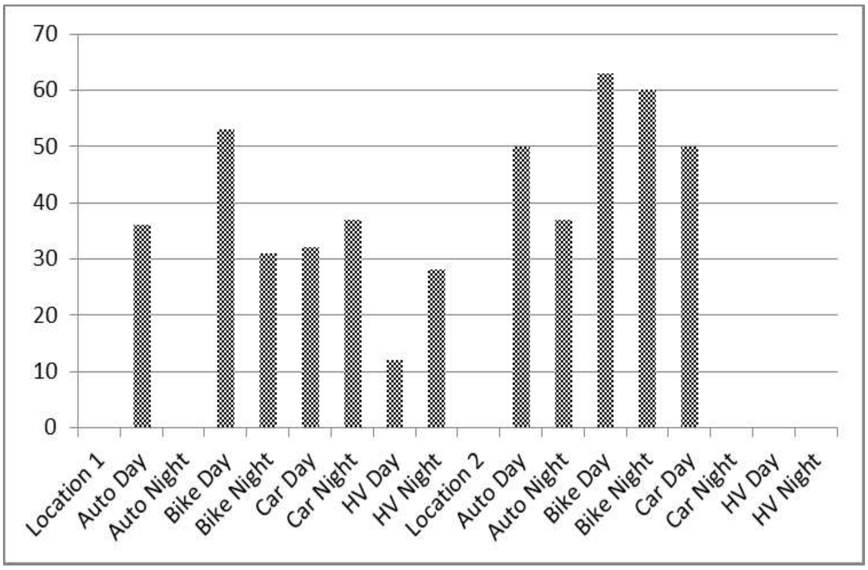



**Figure 45: Proportion of vehicles with velocities greater than 30km/hr at three locations in Agra.**

Figure 45 shows little significant change in the readings after normalizing for traffic volumes in both day and night. The only significant change as can be seen is found on NH2 where the percentage of vehicles going above 30km/h goes up from 12% to 28% which is a direct causality as heavy vehicles contribute 53% of the impacting vehicles (excluding hit & run cases marked impact vehicle: unknown).

**LUDHIANA**

Traffic volume data was collected by taking videos of traffic at 3 locations:

1. Site 1: In front of the State Bank of Patiala branch, Jasdev Nagar, SH11

2. Site 2: In front of Apollo hospitals, NH1

3. Site 3: Opposite Hyatt Regency Hotel, NH95

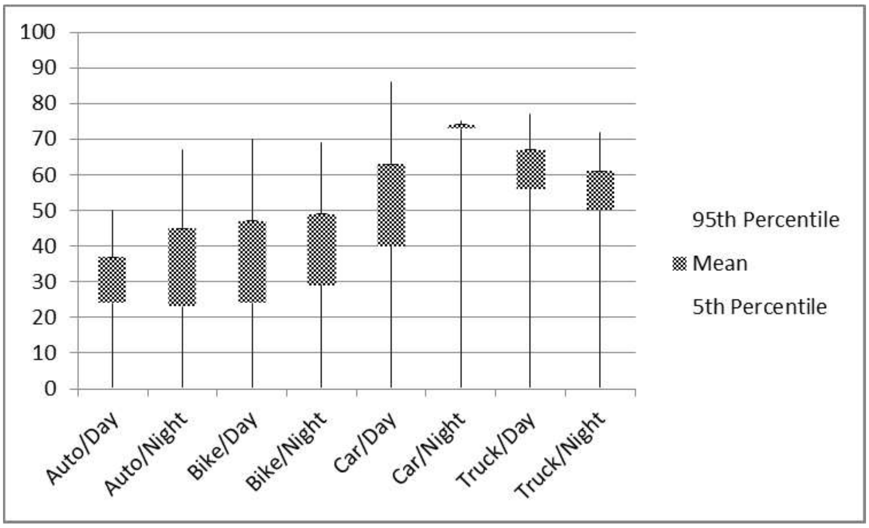
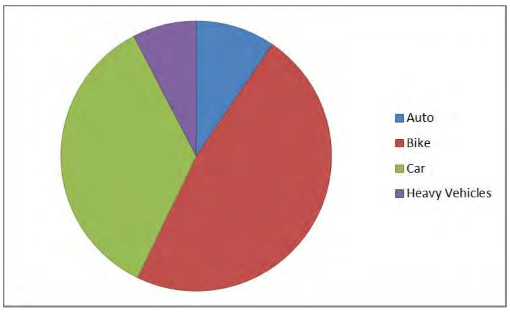
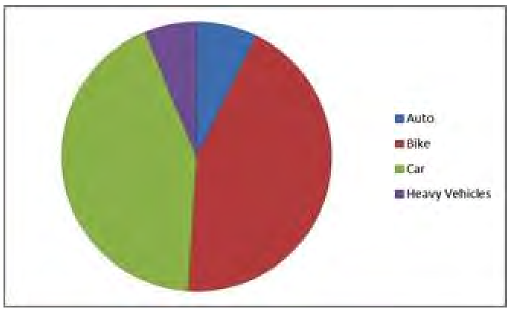



**Figure 46: Speed profile of vehicles at location 1 in Ludhiana.**

Figure 46 shows the 5th, 95th percentile and mean speeds for vehicles at location 1 in Ludhiana and Figure 47 the modal shares.




Day




Night

**Figure 47: Modal share of vehicles at location 1 in Ludhiana.**

Figure 48 shows the 5th, 95th percentile and mean speeds for vehicles at location 2 in Ludhiana and Figure 49 the modal shares.

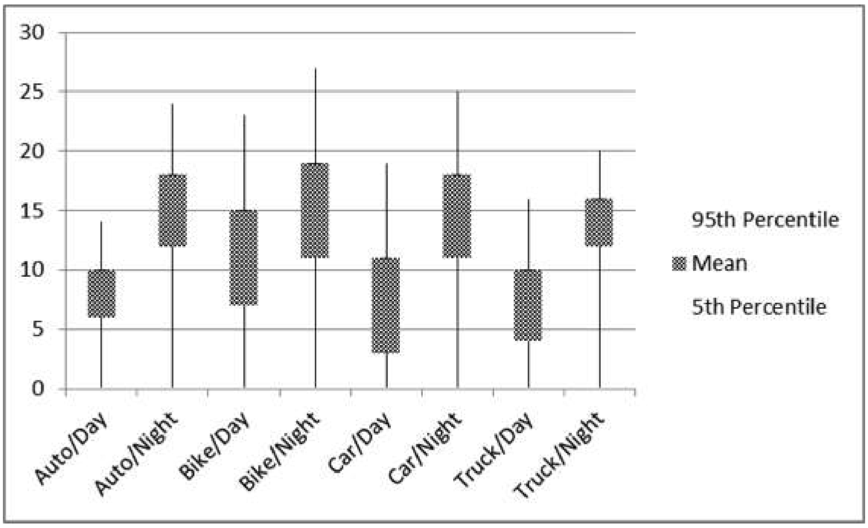
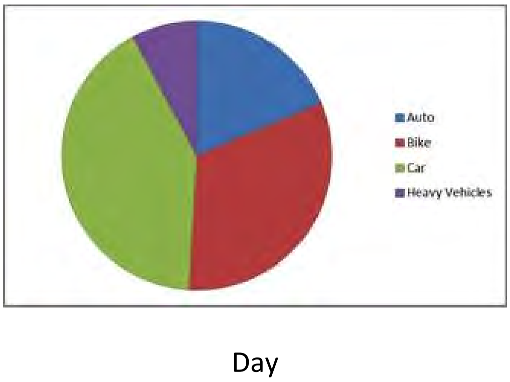



**Figure 48: Speed profile of vehicles at location 2 in Ludhiana.**



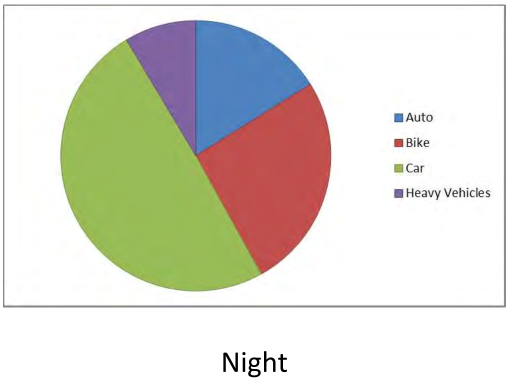




**Figure 49: . Modal share of vehicles at location 2 in Ludhiana**

Figure 50 shows the 5th, 95th percentile and mean speeds for vehicles at location 3 in Ludhiana and Figure 51 the modal shares.

The above data show that in general a shift exists in the pattern of traffic at day and night time. During night the proportion of vehicles travelling at higher speeds were observed to be higher and the proportion of cars increases and three-wheeled vehicles (auto) reduce at night. These two factors may contribute to the high fatality rates at night.

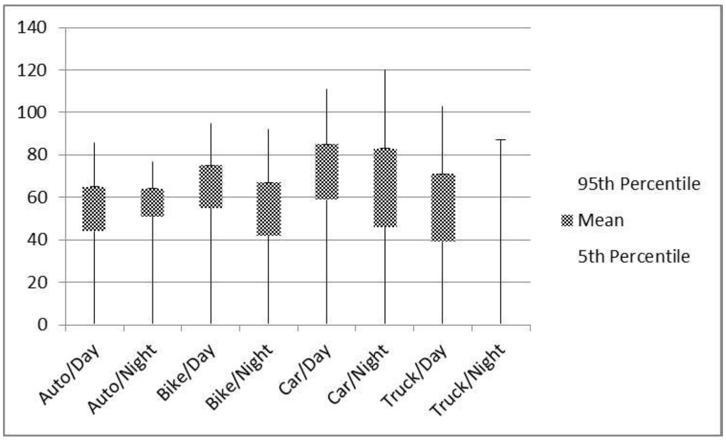



**Figure 50: Speed profile of vehicles at location 3 in Ludhiana.**

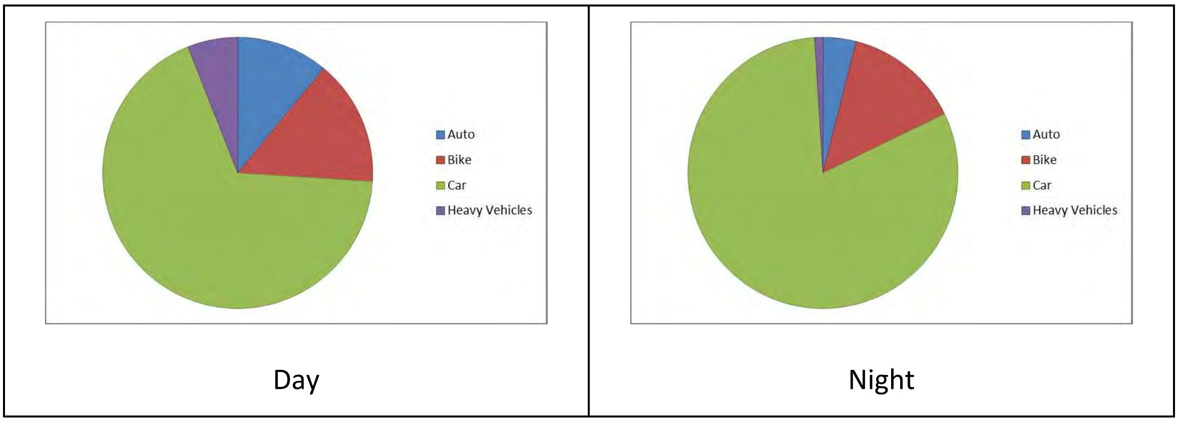



**Figure 51: Modal share of vehicles at location 3 in Ludhiana.**

## Research of the luminance/darkness on the road and the road side

Luminescence data was measured by assembling three light metres orthogonally and mounting them on a tripod (Figure 52).

**Figure 52: Assembly of 3 light meters mounted on a tripod.**

**AGRA**

NH2 Observations

- Conditions: Highway, Clear weather, Mid-Block Section
- Type of Luminaire: Na Vapor Lamp, 20m spacing, (neighboring street light non-functional)

- No value in any direction greater than 12 lux compared to Road Class: A1, average recommended luminance is 30 lux.
- Overall Uniformity = 1 (but values 2/2) > 0.4
- Longitudinal Uniformity= 0.5 < 0.7
- Surround Footpath Values (direct): 12 lux
- Many extra posts exist, but lights on many non-functional

MG Road Observations

- Conditions: Highway, foggy weather, mid-block section
- Arrangement: Opposite
- Type of Luminaire: Na Vapor Lamp, 30.2m spacing, neighbouring street light non-functional
- No value in any direction greater than 20 lux, Road Class: A2, average luminance by code 15 lux.
- Overall Uniformity = 1 (but values 2/2) > 0.4 ok
- Longitudinal Uniformity= 1.0 > 0.7
- Surround Footpath Values (direct): 20 lux in front of post
- Surround value drops to 5 lux 15m from the post

NH 11 Observations

- Conditions: Highway, Clear weather, Mid-Block & Intersection
- Arrangement: Opposite
- Type of Luminaire: Na Vapor Lamp, 50m spacing, neighbouring street light non-functional
- No value in any direction greater than 10 lux, Road Class: A1, average luminance by code 30 lux

- Overall Uniformity = 0.25 < 0.4
- Longitudinal Uniformity= 0.5 < 0.7
- Surround Footpath Values (direct): 22 lux front of post
- Surround value drops to 1 lux 7m from the post
- A large number of lights non-functional leading to low U values.

Luminescence values suggest that lighting conditions on all roads are much lower than that recommended by national and international standards.

**LUDHIANA**

Location 1 observations:

This location in the outer of SH11, lacked relevant infrastructure and any street lighting.

Location 2 observations

| | |
|---|---|
| Weather | Clear |
| Location | NH1 (Sherpur Chowk) |
| Section | Mid-Section |
| Configuration | Opposite Sided Configuration |
| Luminaire | Na Vapor Lamp |
| Comments | Due to construction work rubble was lined up on the side corridor |
| Class of Road* | A1 |
| Spacing | 30m |
| UO | 0.66 |
| UL | 1.0 |
| Eav | 25 lux |

Location 3 observations:

| | |
|---|---|
| Weather | Clear |
| Location | NH95 (Front of Hyatt Regency) |
| Section | Mid-Section |
| Configuration | Opposite |
| Luminaire | LED (low power) |
| Comments | A lot of ambient light was observed from the mall nearby |
| Class of Road* | A1 |
| Spacing | 35m |
| UO | 1.0 |
| UL | 1.0 |
| Eav | 20 lux |
| Surround | ~7 lux |

The data from Agra and Ludhiana suggests that the high rate of night-time crashes may be also due to low visibility conditions at night and a higher proportion of four-wheeled vehicles. This could be particularly true when a vast majority of the victims are vulnerable road users. The probability of fatalities for pedestrians increases for about 10 per cent at impacts of 30 km/h to over 70 per cent at 50 km/h.

## Meeting with community leaders of one study city to discuss findings and possibilities for future action

A Stakeholder Workshop for Road Safety in Agra was organised at the Trident Hotel in Agra on 20 June 2014.

- Forty six persons participated in the meeting
- All participants were provided the following documents
    - Traffic Safety in Agra - A Report

- Essential Ideas from Safety, Sustainable and Future Urban Transport
- When Someone is Hurt
- Dealing with Traffic - a guide for young people
- Ten Years of TRIPP
- TRIPP Bulletin

Professor Geetam Tiwari opened the Workshop with introductory remarks regarding the work done by TRIPP IIT Delhi in collaboration with IATSS to assess the road safety situation in Agra along with a background on TRIPP. This was followed by introduction by all the participants.

Professor Kenji Doi gave Opening Remarks and then Mr. Pradeep Bhatnagar, Commissioner Agra division (the administrative unit which includes Agra district), and Chairman, Agra Development Authority, inaugurated the Workshop and released the report, *Traffic Safety in Agra.* He congratulated the organisers for conducting such a detailed study of traffic safety in Agra. He requested the stakeholders present to study the report and suggest ways to improve traffic conditions in Agra. He also assured government support for any further studies to be done by TRIPP IITD in Agra and that the government will give more importance to provision of facilities for pedestrians in the future. However he requested that any suggestions that are made be practical from the point of implementation according to the prevalent conditions in Agra. The Commissioner stated that there was no real shortage of funds to implement practical solutions.

The TRIPP IITD team made 5 presentations:

- Dinesh Mohan: *Road Safety in Agra – Study results*
- Geetam Tiwari: *Road Safety in Agra – Road and Street Design*
- Sudipto Mukherjee: *Vehicle Design and Safety*
- Girish Agrawal: *Road Safety and the Law*
- Mathew Varghese: *Emergency Care and Pre-hospital care programme*

Salient points raised during discussions:

- Regional Transport Officer mentioned the problems faced by them in checking errant vehicles due to shortage of manpower.
- Virendra Gupta, Chairman Transport Chamber Welfare Association, suggested that if the Ring Road and Northern Bypass projects were implemented then many of the commercial vehicles would not have to enter Agra city. This should result in a reduction of road traffic injuries in Agra.
- Mr. A. K. Tripathi, Superintendent of Police, Traffic, informed the gathering that the Agra Police Department was planning to install red light and speed checking cameras in Agra and connect its systems to the national vehicle registration register so that out of state vehicles could be identified for traffic violations. He also said that in future they planned to record the lat-long coordinates for road traffic accidents to make it easier to do black spot analysis. He also felt handicapped by shortage of staff and suggested that automation that made it difficult for drivers to violate laws like seat-belt and helmet usage might help.
- Rajiv Garg, Head of Department, Civil Engg Department, Anand College of Engineering, and Prof.V. K. Gupta, Hindustan College of Science & Technology mentioned that their students and staff were very aware of safety issues, especially in the vicinity of their institutions. They suggested that in future some of their students could be involved in traffic and safety studies in Agra.

A copy of the report *Traffic Safety in Agra* distributed to all the participants is include in Appendix 3

## Development of detailed urban road design and street furniture guidelines for Agra to maximise safety

Detailed guidelines for designing safer streets for Agra have been prepared based on a detailed survey of three road types:

- National highway traversing the city
- Arterial road in the city

- Local street (with commercial activity) in the city

The draft full report including these guidelines is included in Appendix 4.

A final version of this report will be reformatted, and re-edited and printed for public distribution in April.

## Traffic and Safe Communities document

The experience gained from this project has been used to prepare a document titled *Streets for Safe Communities*. This document is intended to familiarise policy makers and interested professionals with principles associated with planning a safe city. Printed and pdf versions of this document will be available in the public domain.

The draft version of this document is included in Appendix 5.

A final version of this report will be reformatted, and re-edited and printed for public distribution in April.

## High level stakeholder meeting on urban traffic safety in India

IIT Delhi and IATSS collaborated with TERI to organise a special Thematic Track on 'Safe-and-Clean Transport for Sustainable Cities' at the 15th Delhi Sustainable Development Summit on 6$^{th}$ February 2015 in Delhi. The background note on the Track is given below.

### Background note on safe and clean transport for sustainable cities

Most cities in the world are grappling with issues concerning sustainable transportation and safety on the streets. The more complex the issue, the more there is a tendency to focus on the simpler and more technical aspects of the problems. Sustainable transport solutions are frequently reduced to those concerning cleaner vehicle emissions, provision of public transport and 'encouraging' walking and bicycling. The reasons why people and governments don't or cannot follow many of the prescribed goals get less attention. Complex issues involving the interaction of urban structures, urban layout, street design and architectural forms and their influence on human behaviour in transportation choices get neglected by many planners.

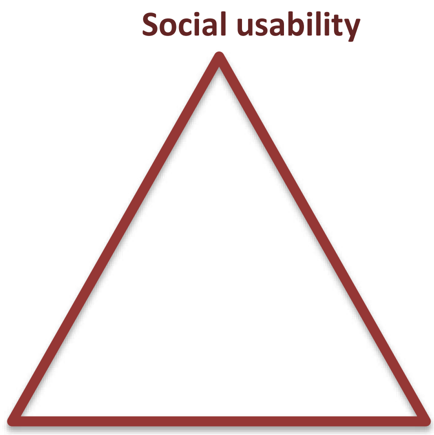
This thematic track is proposed on the back of Japan-India collaborative research carried out through International Association of Traffic and Safety Sciences (IATSS) and Indian Institute of Technology Delhi (IITD). Japan experienced a serious problem of traffic fatalities that was referred to as "Traffic War" around 1970, and IATSS was established to cope with the problem, specifically by an interdisciplinary approach in 1974. In the first part of the track, after introducing "Community design for traffic safety in India" as an interdisciplinary research approach, some successful cases and histories in reducing traffic fatalities in Japan and other countries will be explained.

Although travel patterns vary from city to city in the use of bicycles, paratransit modes, mopeds and official public transport, these cities represent the growing urban agglomerations of India where high growth rates are expected in the next decade. However, these modes will not look attractive unless people perceive them to be safe. In the second part of the track, experiences gained from a detailed study of traffic safety in 6 Indian cities will be used to demonstrate how street designs can be altered to make our cities inherently safer. Among these 6 cities, the study team paid special attention to Agra as it has one of the highest fatality rates in India, and proposed an integrated program of road space design from an engineering perspective, built environment design from a land-use perspective, and community design from a social and cultural perspective to enhance urban transport sustainability. A move toward designing safer streets and neighbourhoods has to become an integral part of our efforts to move toward a more sustainable future.

Human beings are strongly influenced by structures and systems they operate in, solutions based on individual behaviour change are not very successful in most situations. The more complex the system, the less freedom individuals have in changing their own behaviour. Here we focus our attention on how a city can be made safer, independent of enforcement and policing activities. This in the belief that unless people feel safe from crime and traffic accidents they will not willingly walk, bicycle or use public transport. Therefore, urban safety becomes a necessary though not sufficient condition for the promotion of sustainable urban futures. In this context, broader concept of sustainability of urban transport is discussed in our thematic track with emphasis on road traffic safety, environmental and health impact, and community resilience.

To cope with growing traffic fatalities and injuries worldwide, the UN General Assembly adopted a resolution on "Improving global road safety" in April 2014. The WHO has warned that road traffic crashes are on a path to becoming the fifth leading cause of premature mortality by 2030, in many emerging economies. A large majority of the victims of traffic accidents are pedestrians, cyclists and motorcyclists who account for over two thirds of road traffic fatalities.

Traditionally, road traffic safety policies aim to reduce the risk of a crash by improving road infrastructure, by educating road users, and to reduce the injury outcome of a crash by improving vehicle technology and enforcing seatbelt and helmet usage by law. Furthermore, a rapid increase in traffic fatalities in early stage of motorization is associated with the development of road infrastructures deficient in design and increase in speed of vehicles.




Urban form in the structure of its street layout and types of roads have a determining influence on traffic safety. Cities with the same socio-economic characteristics can have very different road traffic fatality rates. Local street and junction design can have a strong influence on promoting safety. Until today vehicle speeds have been a low priority area in urban road design. The best way forward in the short run is to develop strategies where infrastructural measures like traffic calming are combined with vehicle measures to control vehicle speeds.

Placing public transportation where it is equitably responsive to community needs and encourages links to vibrant centres is valuable. Community involvement and comprehensive approaches and multiple sectors working together is essential for designing safer streets. Effective and safe road design and transport planning has to address a set of conflicts implicit in the social context within which roads are built and transport is provided. Social usability, safety and accessibility are interlinked and interdependent. All three aspects have to be considered in design of safe and livable cities. An interdisciplinary approach is therefore necessary.

Safety of pedestrians and bicyclists must be taken up urgently in all Indian cities. This requires serious commitment by city authorities and municipalities. It is possible to retrofit city streets by introducing traffic calming, small roundabouts segregated cycle tracks and pedestrian paths on arterial roads to create a safe city wide network for pedestrians and bicyclists.

## Programme for the Thematic Track

3:15– 3:30 PM: Introduction to the track by Co- Chairs :

- Mr S Sundar, Distinguished Fellow, TERI
- Prof. Kazuhiko Takeuchi, IATSS Executive Vice President (Director and Professor, Integrated Research System for Sustainability Science (IR3S), Todai Institutes for Advanced Study (TODIAS), The University of Tokyo)

3:30-3:40 PM: Presentation - 'Research Framework on Community Design for Traffic Safety'

- Prof. Kenji Doi, Professor, Department of Global Architecture, Graduate School of Engineering, Osaka University

3:40-3:50 PM: Presentation - 'Achieving Safe Road Traffic Experience in Japan'

- Prof. Takashi Oguchi, Professor, Institute of Industrial Science, The University of Tokyo.

3:50-4:05 PM: Presentation by IITD on 'Safe Transport and Sustainable Cities'

- Prof. Dinesh Mohan, Volvo Chair Professor Emeritus, Transportation Research & Injury Prevention Programme, Indian Institute of Technology Delhi

4:05-4:20 PM: Presentation by TERI – ''Making public transport safe and clean - Focus: public transport provided by private operators'

- Ms Megha Kumar, Research Associate, Sustainable Habitat Division, TERI

4:20-4:30 PM: Presentation

- Mr Colin Delmore, International Development Director, Asia Injury Prevention Foundation

4:30-4:40 PM: Presentation

- Prof. Hironori Hamanaka, Chair of the Board of Directors, IGES

4:40-4:50 PM Special Address

- Dr R. K. Pachauri, Director- General, TERI

4:50-5:10 PM: Open House

5:10-5:15 PM: Vote of Thanks

## Acknowlegement

This project could not have been undertaken without financial support from IATSS.

IATSS staff and memebers: DOI Kenji, TAKEUCHI Kazuhiko, OGUCHI Takashi, KITAMURA Yuto, YOKOYAMA Toshio, OMAE Hideyuki, KAKINUMA Toru, KAJITA Tomoyuki, SASA Hideko.

Assistance in data analysis has been provided by Pankaj Prajapati, Gaurav Pandey, Abhay Jha, Rahul Goel.

Assistance in obtaining data from various cities by Mahesh Gaur and Sumit Gupta.

Assistance in data transcription and coding by Amrendra Kumar, Arla Sagar, K. Guru Prasad, K. Madhavi, Kamal Preet Singh, Poojari Yugendar, Sunil Sharma, Vijendra Kumar.

Assistance in preparing *Safe Streets for Agra* and *Streets for Safe Communities*: Ruchi Verma and Alokeparna Sengupta

## References

Bhalla, K., Ezzati, M., Mahal, A., Salomon, J. & Reich, M. 2007. A risk-based method for modeling traffic fatalities. *Risk Analysis*, 27, (1) 125-136.

Census of India. 2012. *Provisional population totals 2011* [Online]. New Delhi: Office of the Registrar General and Census Commissioner. 2012].

CRRI 2007. *Annual Report 2007*. New Delhi: Central Road Research Institute

Expert Committee on Auto Fuel Policy. 2002. *Urban road traffic and air pollution in major cities: Volume 1*. New Delhi: Government of India.

NCRB 2012. *Accidental Deaths & Suicides in India - 2011*. New Delhi: National Crime Records Bureau, Ministry of Home Affairs.

## Appendix 1 – Sample of police First Information Report (FIR)

CIPA-R1.11 00

**FIRST INFORMATION REPORT**
**(Under Section 154 Cr.P.C.)**

1. District: AMRITSAR CITY P.S.: Maqboolpura Year: 2011 FIR No.: 68 Date: 26-12-2011

2. Act(s): Section(s):
   (i) IPC 1860 304A/279
   (ii)
   (iii)
   (iv)

3. Occurrence of Offence:
   (a) Day: Monday Date From: 26-12-2011 Date To: 26-12-2011
   Time Period: Time From: 18:30 hrs Time To:
   (b) Information received at P.S: Date: 26-12-2011 Time: 20:05 hrs
   (c) General Diary Reference: Entry No.: 29 Time: 20:05 hrs

4. Type of Information: WRITTEN

5. Place of Occurrence:
   (a) Direction and Distance from P.S: West/1.0 Km. Beat No.: 01
   (b) Address: RAM TALAI CHOWK, AMRITSAR
   (c) In case, Outside the limit of the Police Station:
   Name of P.S: District:

6. Complainant/Informant:
   (a) Name: RAJAN SHARMA (S/O) ASHWANI KUMAR
   (b) Birth Year: Nationality: INDIA
   (c) Passport No. Date of Issue: Place of Issue:
   (d) Occupation:
   (e) P R/o ,
   C R/o H.NO 33 GALI NO 3 PAWAN NAGAR BATALA ROAD ASR,

7. Details of Known/Suspect/Unknown accused with full particulars(attach separate sheet if necessary):
   (i) KASHMIR SINGH (S/O) NIRANJAN SINGH
   P R/o ,
   C R/o VILL BHINDER PS KHALCHIAN ASR (R),
   (ii)
   (iii)

8. Reason for delay in reporting by the complainant/informant: NO DELAY

9. Particulars of the properties stolen/involved(attach separate sheet if necessary):

| Sl.No. | Property Type(Description) | Est. Value(Rs.) | Status |
|---|---|---|---|
| (i) | | | |
| (ii) | | | |
| (iii) | | | |

-- 1 --

District: AMRITSAR CITY   PS: Maqboolpura   Year: 2011   FIR No.: 68   Date: 26-12-2011

10 - Total value of property stolen:

11 - Inquest Report/U.D Case No., if any:

12 - F.I.R Contents(attach separate sheet,if required):

ਬਿਆਨ ਅਜਾਨੇ ਸ਼੍ਰੀ ਰਾਜਨ ਸ਼ਰਮਾ S/o ਸ਼੍ਰੀ ਅਸ਼ਵਨੀ ਕੁਮਾਰ ਕੌਮ ਬ੍ਰਾਹਮਣ ਵਾਸੀ H.no 33 ਗਲੀ ਨੰ 3 ਪਵਨ ਨਗਰ ਬਟਾਲਾ ਰੋਡ ਅੰਮ੍ਰਿਤਸਰ ਉਮਰ ਕਰੀਬ 27 ਸਾਲ ਬਿਆਨ ਕੀਤਾ ਕਿ ਮੈਂ ਉਕਤ ਪਤੇ ਦਾ ਰਹਿਣ ਵਾਲਾ ਹਾਂ ਅਤੇ ਮੈਂ ਨਗਰ ਨਿਗਮ ਅੰਮ੍ਰਿਤਸਰ ਵਿਚ ਠੇਕੇਦਾਰੀ ਦਾ ਕੰਮ ਕਰਦਾ ਹਾਂ ਅਤੇ ਅੱਜ ਵਕਤ ਕਰੀਬ 6.30 ਵਜੇ ਸ਼ਾਮ ਨੂੰ ਆਪਣੀ ਮਾਰੁਤੀ ਕਾਰ ਨੰਬਰੀ CH01-L-1380 ਸਵਾਰ ਹੋ ਕੇ ਬੱਸ ਸਟੈਂਡ ਅੰਮ੍ਰਿਤਸਰ ਤੋਂ ਆਪਣੇ ਘਰ ਨੂੰ ਜਾ ਰਿਹਾ ਸੀ ਅਤੇ ਮੇਰੇ ਪਿਤਾ ਅਸ਼ਵਨੀ ਕੁਮਾਰ ਆਪਣੇ ਮੋਟਰਸਾਈਕਲ ਨੰਬਰੀ ਟੈਂਪਰੇਰੀ PB02-BM-4236 ਹੀਰੋ ਹਾਂਡਾ ਸਪਲੈਂਡਰ ਰੰਗ ਕਾਲਾ ਤੇ ਸਵਾਰ ਹੋ ਕੇ ਮੇਰੇ ਅਗੇ ਅਗੇ ਜਾ ਰਹੇ ਸੀ ਜਦੋਂ ਮੇਰੇ ਪਿਤਾ ਅਸ਼ਵਨੀ ਕੁਮਾਰ ਰਾਮਤਲਾਈ ਚੌਕ ਤੰਦਰਾਂ ਵਾਲਾ ਤੇ ਤੰਦਰਾਂ ਵਾਲੀ ਸਾਈਡ ਪਹੁੰਚੇ ਤਾਂ ਮਗਰੋਂ ਬੱਸ ਸਟੈਂਡ ਅੰਮ੍ਰਿਤਸਰ ਵਲੋਂ ਇਕ ਬੱਸ ਬਹੁਤ ਤੇਜ਼ ਸਪੀਡ ਆਈ ਜਿਸ ਨੂੰ ਇਕ ਸਰਦਾਰ ਡਰਾਈਵਰ ਚਲਾ ਰਿਹਾ ਸੀ ਜਿਸ ਨੇ ਮੇਰੇ ਪਿਤਾ ਤੋਂ ਥੋੜੀ ਅਗੇ ਬੱਸ ਕੱਢੀ ਤੇ ਮੇਰੇ ਪਿਤਾ ਨੂੰ ਬੱਸ ਦੀ ਸਾਈਡ ਮਾਰੀ ਜੋ ਮੇਰੇ ਪਿਤਾ ਦਾ ਮੋਟਰਸਾਈਕਲ ਸੜਕ ਤੇ ਡਿੱਗ ਪਿਆ ਅਤੇ ਮੇਰੇ ਪਿਤਾ ਦਾ ਸਿਰ ਸੜਕ ਤੇ ਵੱਜਾ ਤੇ ਖੂਨ ਲੱਥ ਪੱਥ ਹੋ ਗਿਆ ਤੇ ਮੈਂ ਆਪਣੀ ਕਾਰ ਖੜੀ ਕਰਕੇ ਰੌਲਾ ਪਾਇਆ ਅਤੇ ਬੱਸ ਦਾ ਨੰਬਰ PB09-8125 ਜਿਸ ਦੀ ਸਾਈਡ ਤੇ ਪਿਆਰ ਬੱਸ ਸਰਵਿਸ ਲਿਖਿਆ ਸੀ ਜਿਸ ਦੇ ਡਰਾਈਵਰ ਦਾ ਨਾਮ ਬਾਅਦ ਵਿਚ ਪੱਤਾ ਲੱਗਾ ਕੇ ਕਸ਼ਮੀਰ ਸਿੰਘ S/oਨਿਰੰਜਣ ਸਿੰਘ ਕੌਮ ਜੱਟ ਸਿੱਖ ਵਾਸੀ ਭਿੰਡਰ ਥਾਣਾ ਖਲਚੀਆ ASR ਦਿਹਾਤੀ ਚਲਾ ਰਿਹਾ ਸੀ ਜੋ ਮੇਰੇ ਪਿਤਾ ਦੇ ਤੇਜ਼ ਰਫਤਾਰ ਉਕਤ ਡਰਾਈਵਰ ਨੇ ਉਕਤ ਬੱਸ ਦੀ ਸਾਈਡ ਮਾਰੀ ਤਾਂ ਮੇਰੇ ਪਿਤਾ ਦੇ ਸੜਕ ਵਿਚ ਡਿੱਗ ਕੇ ਸਿਰ ਵਿਚ ਗੰਭੀਰ ਸੱਟ ਲਗਣ ਕਾਰਨ ਮੌਕੇ ਤੇ ਮੌਤ ਹੋ ਗਈ ਤੇ ਮੈਂ ਆਪਣੇ ਰਿਸ਼ਤੇਦਾਰ ਨੂੰ ਫੋਨ ਕਰਕੇ ਮੌਕਾ ਤੇ ਬੁਲਾਇਆ ਸੜਕ ਤੇ ਲੋਕਾਂ ਦੀ ਭੀੜ ਹੋਣ ਕਰਕੇ ਡਰਾਈਵਰ ਕਸ਼ਮੀਰ ਸਿੰਘ ਉਕਤ ਮੌਕਾ ਤੋਂ ਬੱਸ ਛੱਡ ਕੇ ਭੱਜ ਗਿਆ ਮੈਂ ਆਪਣੇ ਪਿਤਾ ਦੀ ਲਾਸ਼ ਕੋਲ ਸੰਨੀ ਸ਼ਰਮਾ S/o ਸ਼੍ਰੀ ਵਿਨੋਦ ਕੁਮਾਰ ਕੌਮ ਬ੍ਰਾਹਮਣ ਵਾਸੀ H.no 33 ਗਲੀ ਨੰਬਰ 3 ਪਵਨ ਨਗਰ ਬਟਾਲਾ ਰੋਡ ਅੰਮ੍ਰਿਤਸਰ ਛੱਡ ਕੇ ਆਪ ਪਾਸ ਇਤਲਾਹ ਦੇਣ ਜਾ ਰਿਹਾ ਸੀ ਆਪ ਮਿਲ ਗਏ ਹੋ ਕਾਰਵਾਈ ਕੀਤੀ ਜਾਵੇ ਬਿਆਨ ਸੁਣ ਲਿਆ ਠੀਕ ਹੈ Sd/- Rajan Sharm ਤਸਦੀਕ ਪ੍ਰਮਜੀਤ ਸਿੰਘ ASI PS ਮਕਬੂਲਪੁਰਾ ਅੰਮ੍ਰਿਤਸਰ ਮਿਤੀ 26-12-11 ਕਾਰਵਾਈ ਪੁਲਿਸ:- ਅੱਜ ਮਨ ASI ਸਮੇਤ HC ਸਤਨਾਮ ਸਿੰਘ 2976 HC ਜੋਗਿੰਦਰ ਸਿੰਘ 2528 SPO ਅਜੈਪਾਲ 1068 ਬਾਏ ਗਸ਼ਤ ਅਤੇ ਤਲਾਸ਼ ਭੈੜੇ ਪੁਰਸ਼ਾਂ ਦੇ ਸਬੰਧ ਵਿਚ ਪ੍ਰਾਈਵੇਟ ਵਹੀਕਲਾਂ ਦੇ ਸਬੰਧ ਵਿਚ ਥਾਣਾ ਮਕਬੂਲਪੁਰਾ ਤੋਂ ਗੋਲਡਨ ਐਵੀਨਿਊ ਅੰਮ੍ਰਿਤਸਰ ਨੂੰ ਜਾ ਰਹੇ ਸੀ ਜਦ ਮੋੜ ਗੋਲਡਨ ਐਵੀਨਿਊ ਪੁੱਜੇ ਤਾਂ ਸ਼੍ਰੀ ਰਾਜਨ ਕੁਮਾਰ S/o ਅਸ਼ਵਨੀ ਕੁਮਾਰ ਉਕਤ ਨੇ ਮੇਰੇ ਪਾਸ ਹਾਜ਼ਰ ਆ ਕੇ ਆਪਣਾ ਉਕਤ ਬਿਆਨ ਤਹਿਰੀਰ ਕਰਾਇਆ ਬਿਆਨ ਲਿਖ ਕੇ ਪੜ੍ਹ ਕੇ ਸੁਣਾਇਆ ਗਿਆ ਜਿਸ ਨੇ ਆਪਣਾ ਬਿਆਨ ਠੀਕ ਮੰਨ ਕੇ ਆਪਣੇ ਬਿਆਨ ਹੇਠ ਅੰਗ੍ਰੇਜ਼ੀ ਵਿੱਚ ਦਸਖਤ ਕੀਤੇ ਜਿਸ ਦੀ ਮੈਂ ਤਸਦੀਕ ਕੀਤੀ ਬਿਆਨ ਬਾਲਾ ਤੋਂ ਸਰੇ ਦਸਤ ਜੁਰਮ 304A/279 IPC ਦਾ ਹੋਣਾ ਪਾਇਆ ਜਾਂਦਾ ਹੈ ਕੰਟਰੋਲ ਰੂਮ ਪਰ ਇਤਲਾਹ ਦਿੱਤੀ ਜਾਵੇ ਬਿਆਨ ਹੱਥੀ SPO ਅਜੈਪਾਲ 1068 ਥਾਣੇ ਭੇਜਿਆ ਜਾਂਦਾ ਹੈ ਮੁਕੱਦਮਾ ਦਰਜ ਕਰਕੇ ਨੰਬਰ ਮੁਕਦਮਾ ਤੋਂ ਜਾਣੂ ਕੀਤਾ ਜਾਵੇ ਮੈਂ ਸਮੇਤ ਸਾਥੀ ਕਰਮਚਾਰੀਆਂ ਮੌਕਾ ਪਰ ਮੁਸ਼ਰੂਫ ਤਫਤੀਸ਼ ਹਾਂ Sd/- ਪ੍ਰਮਜੀਤ ਸਿੰਘ ASI PS ਮਕਬੂਲਪੁਰਾ ASR 26-12-11 ਅੱਜ ਬਰੰਦ - ਮੋੜ ਗੋਲਡਨ ਐਵੀਨਿਊ at 7.00 pmਅੱਜ ਥਾਣਾ :- ਇਸ ਵਕਤ ਉਕਤ ਫਰਦ ਬਿਆਨ ਮੌਸੂਲ ਥਾਣਾ ਹੋਣ ਤੇ ਮੁਕੱਦਮਾ ਉਕਤ ਬਾ ਜੁਰਮ ਉਕਤ ਦਰਜ ਰਜਿਸਟਰ ਕਰਕੇ ਅਸਲ ਫਰਦ ਬਿਆਨ ਮਹਿ ਨਕਲ FIR ਹੱਥੀਂ ਅਰਿੰਦਾ ਕਰਮਚਾਰੀ ਨਿਯਦ ASI ਪਾਸ ਮੌਕਾ ਪਰ ਭੇਜਿਆ ਜਾਂਦਾ ਹੈ ਕੰਟਰੋਲ ਰੂਮ ਤੇ ਮੁੱਖ ਅਫਸਰ ਥਾਣਾ ਬਜਰੀਆ ਟੈਲੀਫੋਨ ਇਤਲਾਹ ਦਿੱਤੀ ਗਈ ਪੂਰਤੀ ਰਪਟ ਨੰਬਰ 31 ਸਮਾਂ 9.05 PM

13 - Action Taken(Since the above information reveals commission of offence(s)u/s as mentioned at item No.2:

(i) Registered the case and took up the investigation OR

(ii) Directed(Name of the I.O): PARAMJIT SINGH Rank: ASI
No.: 1146 to take up the investigation, O

(iii) Refused investigation due to:

OR

(iv) Transferred to P.S(name): District:
on point of jurisdiction.

F.I.R read over to the complainant/informant, admitted to be correctly recorded and a copy given to the complainant/informant, free of cost:

R.O.A.C:

14 .

Signature / Thumb Impression of The Complainant/Informant:

Signature of Officer
Name: PRITAM PAL
Rank: SI No.: 783

15 - Date and Time of despatch to the court:

## Appendix 2 - Accident Recording Form

| Road Accident Recording Form | | | |
|---|---|---|---|
| **Accident Information** | | | |
| **Form No.** | | | |
| **Filled By** | | Date filled (dd/mm/yyyy) | / / |
| **Police Report Available** | 0=No 1=Yes | | If yes, FIR No. |
| **City/Town/Village Name** | | | |
| **Time of Accident** | | | |
| **Date** | **(DD)** | **(MM)** | **(YYYY)** |
| **Day** | 01=Monday 02=Tuesday 03=Wednesday 04=Thursday 05=Friday 06=Saturday 07=Sunday 08=Unknown | | |
| **Holiday** | 0 = No 1 = Yes 9=Unknown | | |
| **Hit and Run** | 0 = No 1 = Yes 9=Unknown | | |
| **Accident Severity** | 1=Damage Only 2= Injury 3=Fatal 9= Unknown | | |
| **No. of Fatalities** | | | |
| **No. of Injured** | | | |
| **No. of Vehicles Involved** | | | |
| **Collision Type** | | | |
| 01 = Hit pedestrian | 02 = Vehicles head on | 03 = Vehicle hit from back | |
| 04 = Vehicle hit from side at right angle | 05 = Sideswipe (same direction) | 06= Vehicle Sideswipe (opposite direction) | |
| 07 = Overturn | 08 = Vehicle hit fixed object | 09 = Run off the road | |
| 10= Others | 99 = Unknown | | |
| **Collision Spot** | 01 = On straight road 02 = Road junction 03 = Other 09 = Unknown | | |

**Type of Road** 0= Un-metalled 01=Metalled (Black topped/Concrete) 02=Others 09=Unknown

**Divider** 1=Two-Way without median 2= Two-way with median 3= One-way 9= Unknown

**Location** 1=Urban 2=Rural 3=Semi-Urban 4=Other 9=Unknown

**Light Condition** 1=Day light 2=Dark 3= Dark but lighted 4= Dawn 5= Dusk 9= Unknown

**Road Category** **RURAL:** 1= State Highway 2= National Highway 3= PMGSY

**URBAN:** 4=Arterial 5= Sub-Arterial 6= Local Street 7= Local 8= Other 9= Unknown

**Distance** Km post. In the absence of Km post - from the nearest urban centre ( (m)

**From**

**Global Position** (latitude) (longitude)

**Road 1** **Road 2**

**Road 3** **Landı**

**Brief Description of Accident**

## Vehicle Information

**Form No.** **Vehicle**

**Type**

01 = Multi-Axle Heavy Goods vehicle 02 = 2-Axle Heavy Goods vehicle 03=Light Goods Vehicle 04 =Mini Bus

05= Bus 06 = Car/van/jeep/taxi 07= Ambulance 08= Fire Fighting Vehicle

09= Three Wheeler Passenger 10=Three Wheeler Goods 11 =Thela 12=Electric Cycle

13 = Tractor without Trailor 14= Tractor with Trailor 15 = Cycle Rickshaw 16 = Motorcycle/Scooter/Moped

17 = Animal drawn vehicle 18=Bicycle 19=Pedestrian 20=Others 99=Unknown

**Maneuver of Vehicle at Crash Time**

01 = Proceeding straight 02 = Turning 03 = Reversing 04 = Overtaking 05=Parked/Stopped

06 = Other 07= Going wrong way 08= Making U turn 09 = Unknown

**Loading** 1=Normal 2= Overloaded 3= Others 9= Unknown

**Disposition** 0=Not Roadworthy (needs to be towed away) 1= Roadworthy ( can drive away ) 9 = Unknown

**Mechanical Failure** 0=No 1=Yes 9=Unknown

**Hazardous Cargo** 0=No 1=Yes 9=Unknown

**Fire** 0=No 1=Yes 9=Unknown

**Impact-Vehicle/Object**

Vehicle type (If another vehicle impacted this vehicle) 11=Pedestrian 12=Tree

13=Kerb/Median 14= Pole 15= Other 99=Unknown

**Make-Model**

**Model-Year**

**Form No.** **Vehicle**

**Type**

01 = Multi-Axle Heavy Goods vehicle 02 = 2-Axle Heavy Goods vehicle 03=Light Goods Vehicle 04 =Mini Bus

05= Bus 06 = Car/van/jeep/taxi 07= Ambulance 08= Fire Fighting Vehicle

09= Three Wheeler Passenger | 10=Three Wheeler Goods | 11 =Thela | 12=Electric Cycle

13 = Tractor without Trailor | 14= Tractor with Trailor | 15 = Cycle Rickshaw | 16 = Motorcycle/Scooter/Moped

17 = Animal drawn vehicle | 18=Bicycle | 19=Pedestrian | 20=Others | 21=Unknown

**Manoeuvre of Vehicle at Crash Time** ☐

01 = Proceeding straight | 02 = Turning | 03 = Reversing | 04 = Overtaking | 05=Parked/Stopped

06 = Other | 07= Going wrong way | 08= Making U turn | 09 = Unknown

**Loading** 1=Normal 2= Overloaded 3= Others 9= Unknown ☐

**Disposition** 0=Not Roadworthy (needs to be towed away) 1= Roadworthy ( can drive away ) 9 = Unknown ☐

**Mechanical Failure** 0=No 1=Yes 9=Unknown ☐

**Hazardous Cargo** 0=No 1=Yes 9=Unknown ☐

**Fire** 0=No 1=Yes 9=Unknown ☐

**Impact-Vehicle/Object** ☐

Vehicle type (If another vehicle impacted this vehicle) | 11=Pedestrian | 12=Tree

13=Kerb/Median | 14= Pole | 15= Other | 99=Unknown

**Make-Model** ☐

**Model-Year** ☐

## Victim Information

**Road User** 1= Passenger, 2= Driver, 3= Pedestrian, 4=Cyclist, 9= Unknown ☐

**Occupant Vehicle** ☐

01 = Multi-Axle Heavy Goods vehicle | 02 = 2-Axle Heavy Goods vehicle | 03=Light Goods Vehicle | 04 =Mini Bus

05= Bus | 06 = Car/van/jeep/taxi | 07= Ambulance | 08= Fire Fighting Vehicle

09= Three Wheeler Passenger | 10=Three Wheeler Goods | 11 =Thela | 12=Electric Cycle

13 = Tractor without Trailor | 14= Tractor with Trailor | 15 = Cycle Rickshaw | 16 = Motorcycle/Scooter/Moped

17 = Animal drawn vehicle | 18=Bicycle | 19=Pedestrian | 20=Others | 21=Unknown

**Seating Position** 01= Front 02= Back 03= Other 09= Not Applicable for Cyclist/Pedestrian ☐

**Location of Non-occupant** ☐

**Age** In years, 99 if unknown ☐

**Sex** 1 = Male 2 = Female

**Injury** 0 = No injury 1= Injured 2 = Fatal 9 = Unknown

**Pedestrian/Vehicle Impact**

**Mode of Treatment**

0=None 01=First aid only 02=Discharge after casualty ward treatment 03=Admitted to hospital 08=Others 09=Unknown

**No. of Days in Hospital** Days, Unknown- 999

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Injury 1** | | | | | | | **Injury Severity 1** | |
| **Injury 2** | | | | | | | **Injury Severity 2** | |
| **Injury 3** | | | | | | | **Injury Severity 3** | |
| **Injury 4** | | | | | | | **Injury Severity 4** | |
| **Injury 5** | | | | | | | **Injury Severity 5** | |
| **Injury 6** | | | | | | | **Injury Severity 6** | |
| **Most Severe Injury** | | | | | | | **ISS** | |

# Appendix 3: Traffic safety in Agra

# TRAFFIC SAFETY IN AGRA

Dinesh Mohan
Geetam Tiwari
Sudipto Mukherjee

Transportation Research & Injury Prevention Programme
Indian Institute of Technology Delhi
New Delhi 110016

June 2014

*Suggested citation*

Mohan, D., Tiwari, G., Mukherjee, S. 2014) *Traffic Safety in Agra.* New Delhi: Transportation Research & Injury Prevention Programme, Indian Institute of Technology Delhi.

# CONTENTS

## ACKNOWLEDGEMENTS

The International Association of Traffic and Safety Sciences (IATSS), Japan, supported this work. Appreciation is extended for useful suggestions and help provided throughout the project by Prof. Kazuhiko Takeuchi, Prof. Kenji Doi, Prof. Takashi Oguchi, Mr. Toshio Yokoyama, Dr. Yuichi Inoue, and Prof. Yuto Kitamura. Thanks are due to Mr. Hasegawa, Ms. Hideko Sasa, Mr. Hideyuki Omae, Mr. Hosokawa, Mr.Tanigawa, Mr. Tomoyuki Kajita, Mr. Toru Kakinuma, Ms. Uchiyama for support from the IATSS secretariat.

Assistance in data analysis was provided by Abhay Jha, Ankit Malhan, Sudatta Mohanty, Abhinav Kumar, Rahul Goel, and Deepty Jain.

Assistance in obtaining data from Agra and management of project logistics by Mahesh Gaur.

Assistance in data transcription and coding by Akhil Das, Kamalpreet Singh, Suman Dwivedi, Mahesh, Amrendra Kumar, Sunil Sharma, and Vijendra Kumar.

Appreciation is extended to officials from the Police Administration and Department of Transport Agra for cooperation in collection of data from Agra.

## INTRODUCTION

This document, *Traffic Safety In Agra*, aims to provide policy makers and citizens of Agra details regarding fatal road traffic crashes in the city and suggestions regarding possible countermeasures that may be put place to reduce the incidence of such crashes. The Transportation Research and Injury Prevention Programme at the Indian Institute of Technology Delhi conducted the study with support from the International Association of Traffic and Safety Sciences (IATSS).

Injuries and deaths due to road traffic have become a serious public health problem in India. According to the National Crime Records Bureau 139,091 persons were killed in road traffic crashes in 2012. The fatality rate increased from 36 per million persons in 1980 to 125 per million persons in 2012 (Figure 1).

In Agra road traffic fatalities increased from 89 in 2011 to 653 in 2011. The population of Agra city increased from 462,000 in 1961 to 1,574,000 persons in 2011 with a decadal growth rate ranging from 25% to 32% in the last five decades. The growth rate was lowest in the last decade. The present density of the city is 84 persons per hectare. Sex ratio in urban region of Agra district is 857 as per 2011 census data.

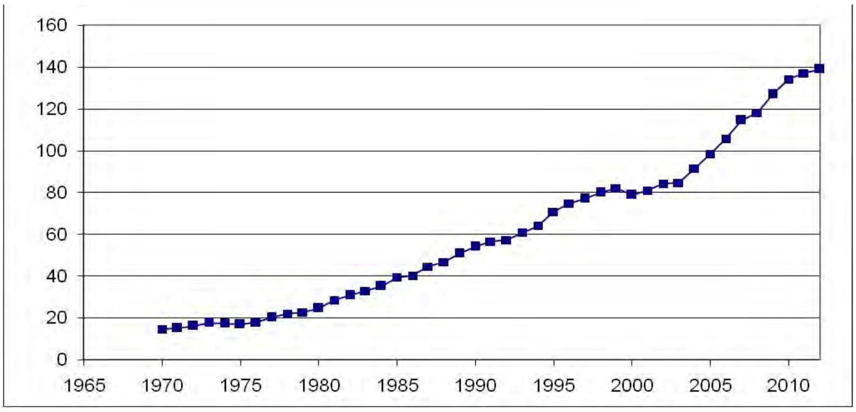



**Figure 1: . Traffic Fatalities in India 1970-2012 (Source: NCRB)**

# METHOD

Reasearchers from TRIPP visited Agra to collect data from police stations, transportation departments, and municipality.

Copies of FIRs for fatal road traffic crashes for the years 2007-2011 were collected from 14 police stations (Table 1) and data coded for analysis at IIT Delhi.

The cases for which details of loaction were available were plotted on the map of Agra.

Traffic flow and speed measurements were done on the following locations:

1. National Highway-2
2. National Highway-11
3. M G Road

Light intensity was measured at the above locations at night.

**Table 1: List of police stations in Agra used for data collection**

| | |
|---|---|
| Mantola | New Agra |
| M. M. Gate | Etmaddullah |
| Nai Ki Mandi | Sikandra |
| LohaMandi | Shahganj |
| Rakabganj | Tajganj |
| HariParvat | Chatta |
| Sadar | JagdishPura |

The following analyses were conducted:

- Fatalities by road user type and struck vehicle
- Road traffic fatalities by time of day and road user type
- Occupant fatality (Personal Risk) per 10 million trips
- Fatalities associated with different vehicle types
- Actual location of fatalities in Agra (motorised and non-motorised)
- The entire city was divided into grids (based on latitude/longitude) and the number of traffic fatalities in each grid correlated with the lengths of different types of roads and the number of intersections in that grid. Number of fatalities in small buffer regions (circular regions of 0.01 degree radius) was correlated with built environment parameters such as width of roads, paved/unpaved shoulders, median/safety barrier presence, population density, and land-use pattern.

# RESULTS

## VEHICLE POPULATION

**Table 2. Vehicle population in Agra 2011.**

| Vehicle | Number | Percent |
|---|---|---|
| Motorised two-wheeler (MTW) | 5,68,470 | 81.4 |
| Auto rickshaw (TSR) | 8,724 | 1.2 |
| Car and jeep | 60464 | 8.7 |
| Taxi | 3,853 | 0.6 |
| Bus | 1,791 | 0.3 |
| Truck | 18,160 | 2.6 |
| Tractor | 37,121 | 5.3 |
| **Total** | **6,98,583** | **100** |

- Earlier research studies indicate that the actual number of personal motor vehicles in use in Indian cities is 55%-65% of the number registered.[1-3] This is probably because owners of personal vehicles pay a lifetime tax when they buy a vehicle and neglect to have the vehicle de-registered when it goes out of service.
- In all analyses in this study a reduced estimate of personal vehicles will be used for all calculations.
- Agra has two major national highways going through the city (NH2 and NH3) and is a major tourist destination. The number of buses and trucks registered in the city may not represent the actual number of buses and trucks on the roads in Agra.
- Motorised two-wheelers (MTW) comprise a vast majority of vehicles in Agra. This would influence the pattern of road traffic fatalities in the city.

**TRAFFIC FLOW**

To understand traffic flow and street lighting conditions in Agra, data was collected from three roads with high incidence of fatal crashes:

1. National Highway-2, (Class A1 road, NLC-2010)
2. National Highway-11 (Class A1 road, NLC-2010)
3. M G Road (State Highway, Class A2 road, NLC-2010)

Traffic was video recorded in the daytime and at nigh time at midblocks on all three locations from the first floor of buildings on the road. The data recorded was analysed to calculate traffic flows and velocities of vehicles.

**Table 3. Traffic flow data from 3 locations in Agra.**

| Location 1 - NH 2 | Day | Night |
|---|---|---|
| Total Flow in vehicles/h | 1296 | 1098 |
| Auto | 22% | 14% |
| MTW | 40% | 40% |
| Car | 19% | 31% |
| Heavy Vehicle | 20% | 15% |

| Location 2 - NH 11 | Day | Night |
|---|---|---|
| Total Flow in vehicles/h | 737 | 735 |
| Auto | 6% | 19% |
| MTW | 78% | 91% |
| Car | 16% | 0% |
| Heavy Vehicle | 0% | 0% |

| Location 3 - MG Road | Day | Night |
|---|---|---|
| Total Flow in vehicles/h | 3240 | 997 |
| Auto | 5% | 11% |
| MTW | 62% | 40% |
| Car | 33% | 49% |
| Heavy Vehicle | 0% | 0% |

Table 3 shows that:

- Motorised two-wheelers comprise the largest proportion of motorised road users on the three roads surveyed both in the day and night.
- The proportion of heavy vehicles and cars is highest on National Highway 2 running across the city.
- Proportion of car traffic increases at night on NH2 and MG road
- MH 11 remained very congested both in the day and night.
- Volume of traffic is the highest in the daytime on Mg Road.
- Traffic flow generally reduces in volume at all three locations.

There were no safe and convenient facilities for pedestrian and bicycle traffic along on any of the roads surveyed. Neither were there safe places for these road users to cross the road at convenient intervals.

Research studies show that the probability of fatal pedestrian crashes increases dramatically from about 10% at vehicle impact speeds of 30 km/h to about 80% at 50 km/h.

Figure 2 shows the proportion of TSR, MTW, cars and heavy vehicles travelling at speeds greater than 30 km/h at two locations in Agra. These data show that MTWs have the highest proportion in the daytime and cars and trucks have higher velocities at night on NH2. Velocities seems to reduce at night at the location of the survey on NH 11. However, it is possible that some of these observations would be different at other locations and roads in the city.

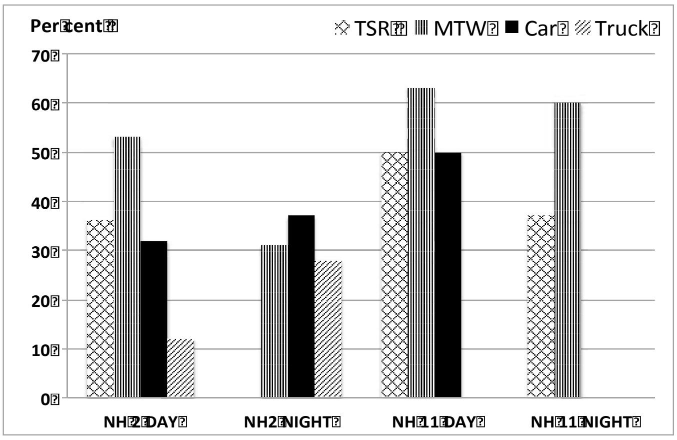



**Figure 2: Percent of vehicles with velocities greater than 30 km/h at in day and night at three locations surveyed in Agra**

Average Illuminance was measured with light meters at the three locations at night with a special instrument fabricated at IIT Delhi. Data was collected on the side of the roads at 1.5m. The Average value of Illuminance ($E_{av}$) should be 30 lux for reasonable visibility at night time on urban roads. The measured values at all three locations varied between 10-20 lux.[4]

The observations show that conspicuity of pedestrians and bicyclists was compromised at all locations because of inadequate visibility (Figure 3). At these locations, very often the infrastructure was present for the provision of streetlights but either the spacing between light poles was greater than desired and/or the lights not being functional.

**Figure 3: . Picture of lighting conditions at night on NH11.**

## PATTERN OF FATAL CRASHES

Agra had a fatality rate of 41 persons per 100,000 persons in 2011. This compares with rates of 11 in Delhi, 10 in Vadodara, and 24 in Vishakhapatnam. Agra has among the highest fatality rates in Indian cities.

<u>Road user type</u>

Figure 4 shows the distribution of fatalities by road user type.

- Vulnerable road users (pedestrians, bicyclists and motorised two-wheeler (MTW) riders comprise 88% of all fatalities.
- Auto rickshaws (TSR) occupants are only 4% of all fatalities.

Figures 5 and 6 show the fatalities during day and night respectively

- Vulnerable road users dominate both during day and night.

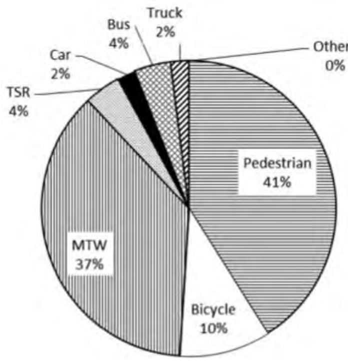



**Figure 4: Fatalities by road user type over the whole day in Agra (TSR – Auto rickshaw, MTW – Motorisewd two-wheeler)**

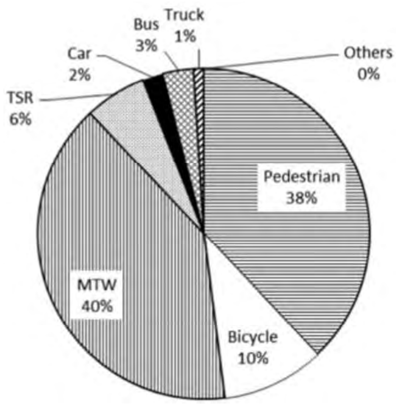



**Figure 5: Fatalities by road user type O6:00-18:00 hours (daytime) in Agra.**

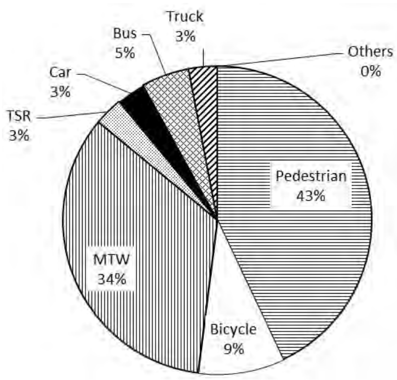



**Figure 6: Fatalities by road user type 18:00-06:00 (night time) in Agra.**

- Auto rickshaw fatalities are much more during the day because they do not operate late at night and during early morning hours.
- Pedestrian fatalities are slightly higher at night.
-

<u>Striking vehicles and type road user victims</u>

- The largest proportion of fatalities for all road user categories is associated with impacts with trucks and cars.

- An interesting feature emerging from this analysis is the involvement of motorised two-wheelers as impacting vehicles in VRU crashes. This is probably because of the mixing of pedestrians and bicyclists with MTW traffic
- Trucks and buses striking MTWs is greater during the day.
- Proportion of car impacts with pedestrians is greater during the day.

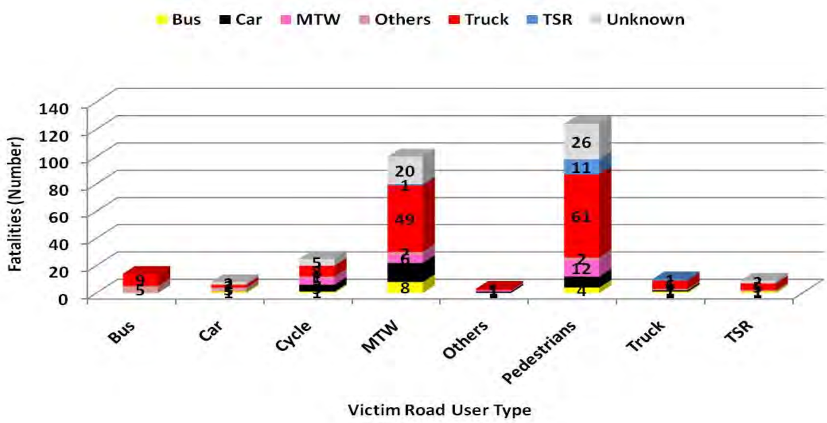



**Figure 8: Fatalities in the night time by road user type and striking vehicles.**

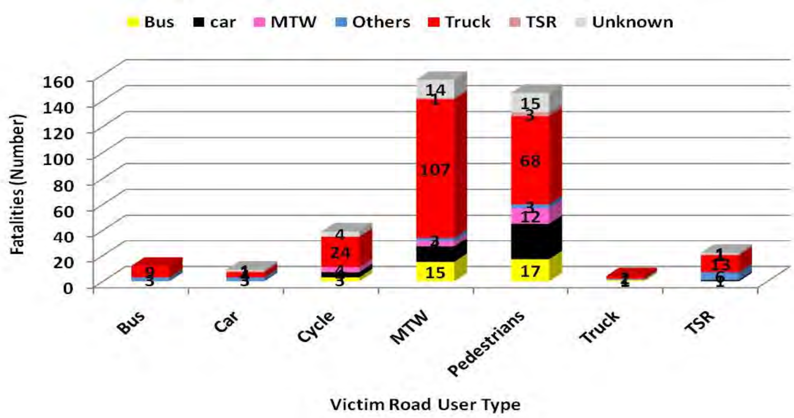



**Figure 7: . Fatalities in the daytime by road user type and striking**

Time of day

Figures 9 and 10 show the fatalities by road user category and time of day in Agra.

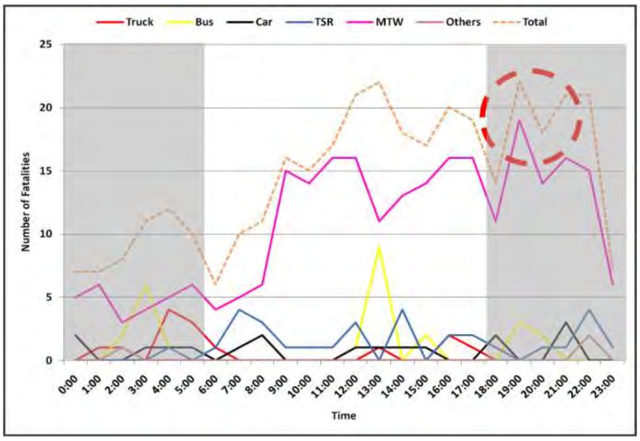



Figure 9: Road traffic fatalities by time of day for truck, bus, car, TSR and MTW occupants

- Pedestrian and bicycle fatalities peak somewhat earlier in the morning than the motor vehicle fatalities. This may be because this class of road users start for work earlier than those using motorised transport.
- The total fatality rate remains somewhat similar between the hours of 10:00 and 18:00 and a strong bimodal distribution is not observed. This could be because school, commercial and government working timings are staggered.
- MTW and pedestrian deaths are relatively high at 22:00-23:00 when we would expect traffic volumes to be low. Drinking and riving data are not available, but this cojuld be a major factor
- Proportion of pedestrian and bicycle fatalities remain high during the hours after sunset when their numbers are lower than that in the daytime.
- Traffic flow data shows that proportion of trucks and cars at speeds greater than 30 km/h is higher at night (especially on NH2) and level of street lighting is less than recommended by national standards. These two factors may account for high rate of pedestrian fatalities at night.

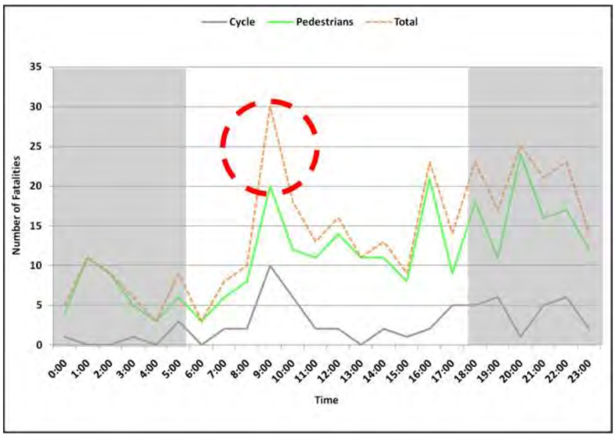



Figure 10: Road Traffic fatality by time of day for bicyclists and pedestrians.

**RELATIVE RISK OF FATAL CRASHES**

- The personal fatality risk as shown in Figure 11 has been calculated by dividing the vehicle specific occupant fatality rate by estimates of average number of occupants carried by each vehicle per day. The numbers assumed are: MTW – 4, TSR – 60, Car – 7.

- Helmet use and use of daytime running lights is not compulsory in Agra. These two measures jointly have the possibility of reducing the MTW fatality rate by about 50%.[5]

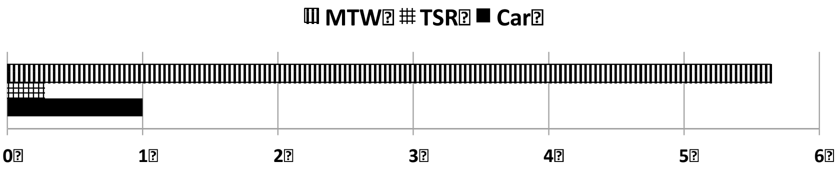



**Figure 11: Relative personal risk of fatal crashes for occupants of motorised two wheelers (MTW), auto rickshaws (TSR) and cars per 10**

- Enforcement of seatbelt use by car occupants can decrease car occupant fatality rates by 30%-50%.[5]

Figure 12 shows the relative to society of all the fatalities in collisions associated with MTWs, TSRs and cars. These data suggest that special attention need to be given to vulnerable road user collisions associated with TSRs and cars.

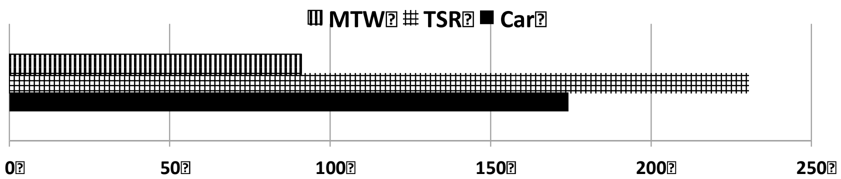



**Figure 12: Deaths associated with motorised two-wheelers (MTW), auto rickshaws (TSR) and cars per 100,000 vehicles per year.**

**CITY STRUCTURE AND ROAD DESIGN**

Figure 13 shows that a majority of fatal crashes take place on the national highways passing through the city and on the major arterial roads of the city. Regression analysis provides the following results for the effect of built environment on as predictors for road traffic fatalities.[6]

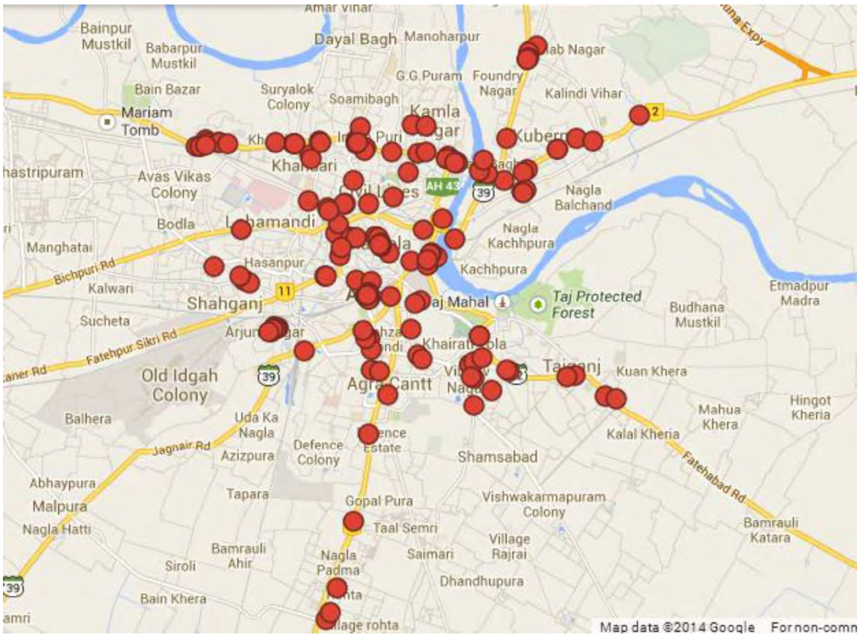



**Figure 13: Location of fatal crashes in Agra for the years 2009-2011 for the cases when could be ascertained.**

- As compared to no road markings, presence of road markings decrease expected number of fatal crashes in the region.
- as compared to poor pavement quality, good pavement quality increases expected number of fatal crashes in the region. This is probably due to higher speeds on better pavement quality.
- Presence of raised mediums increases the probability of fatal crashes. This is probably because roads with raised medians may have heavier traffic volumes and presence of heavy motor vehicles, and of more impacts with medians.

## CONCLUSIONS

- Wide roads and highways in Agra have high crash rates . Current location and design of highways in Agra is unsafe. Safer design criteria need to be evolved including the possibility of elevated national highway and bypasses in the city.
- Association of buses and trucks with fatalities is high.
- Motorcycle occupants have high risk.
- Relative risk for all groups is higher at night.
- Enforcement of provisions in the Motor Vehicles Act regarding mandatory helmet use by motorised two wheeler riders, seat belt use by motor vehicle occupants, enforcement of speed limits and control of drinking and driving will have a very significant effect in reduction of road traffic fatalities in Agra.
- TSR and MTW crash involvement with pedestrians and bicyclists of concern – design implications.

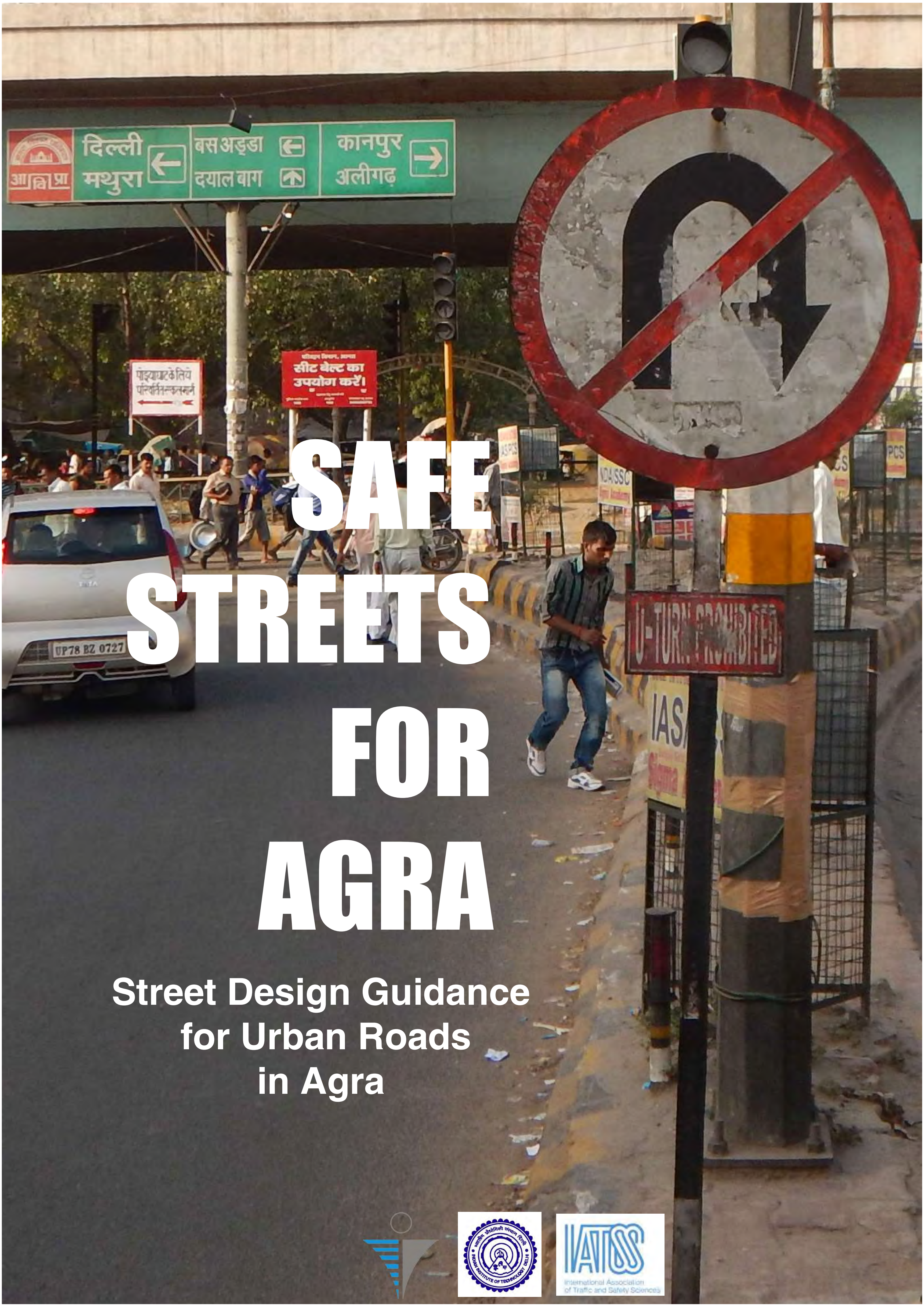
- Presence of road markings decrease expected number of crashes .
- High rate of pedestrian MTW crashes at night – alcohol and lighting is an issue.
- Presence of median increases expected number of accidents in the region. This observation raises questions on the design of the medians.
- As compared to poor pavement quality, good pavement quality increases expected number of accidents in the region. Higher speeds are observed on better pavement quality. This requires presence of speed control measures.
- Arterial roads need provision of segregated bicycle paths and adequate pedestrian facilities.
- Traffic calming required on local arterials and streets.
- Safer and more efficient paratransit facilities should be supported.

# REFERENCES


1. Mohan D. Moving around in Indian cities. *Economic & Political Weekly* 2013;XLVIII(48):40-48.
2. CRRI. Annual Report 2007. New Delhi: Central Road Research Institute, 2007.
3. Expert committee on auto fuel policy. Urban road traffic and air pollution in major cities: Volume 1. New Delhi: Government of India, 2002:1-395.
4. Malhan A. Night time crash-rate studies in Agra and Ludhiana. B. Tech. Thesis. Indian Institute of Technology Delhi, 2014.
5. Peden M, Scurfield R, Sleet D, Mohan D, Hyder AA, Jarawan E, et al. *World report on road traffic injury prevention*. Geneva World Health Organization 2004.
6. Mohanty S. Effect of built environment on road traffic crashes in India. B.Tech Thesis. Indian Institute of Technology Delhi, 2014.

# Appendix 4: Safe Streets for Agra

-




# SAFE STREETS FOR AGRA

## Street Design Guidance for Urban Roads in Agra

Indian Institute of Technology, Delhi 2014

Mohan, D., Tiwari, G. & Mukherjee, S. (2014) A STUDY ON COMMUNITY DESIGN FOR TRAFFIC SAFETY, PHASE III : Interim Report for The International Association of Traffic and Safety Sciences (IATSS). (Confidential). New Delhi: Transportation Research and Injury Prevention Programme, Indian Institute of Technology Delhi. November 2014.

# Acknowledgement

The Safe Streets for Agra Planning and Design guideline has been produced under a sponsored project of The International Association of Traffic and Safety Sciences (IATSS) by the Transportation Research and Injury Prevention Programme at the Indian Institute of Technology, Delhi. The project team at TRIPP, IIT Delhi, has worked closely with team from SGArchitects, New Delhi. We thank Mr. Shiv Raj Singh, Agra Development Authority to provide us with facts and vision of Agra city.

# Contents

# Foreword

Agra is known for the Taj Mahal. However, Agra is more than the Taj. With heritage mouments of great importance, rich cultural history and bustling markets, the people of Agra are engaged into small scale industries, trade and tourism. Agra is the 20th most populous city in the country. (Metropolis Indian Cities: Managing Urban Growth).With the growth of the city as well as its importance on the national map of tourism, transport within the city gains focus. People living in Agra use the available road network to commute for work and leisure by using various modes. They use these streets as a vital public space. Streets promote both social as well as economic activity.

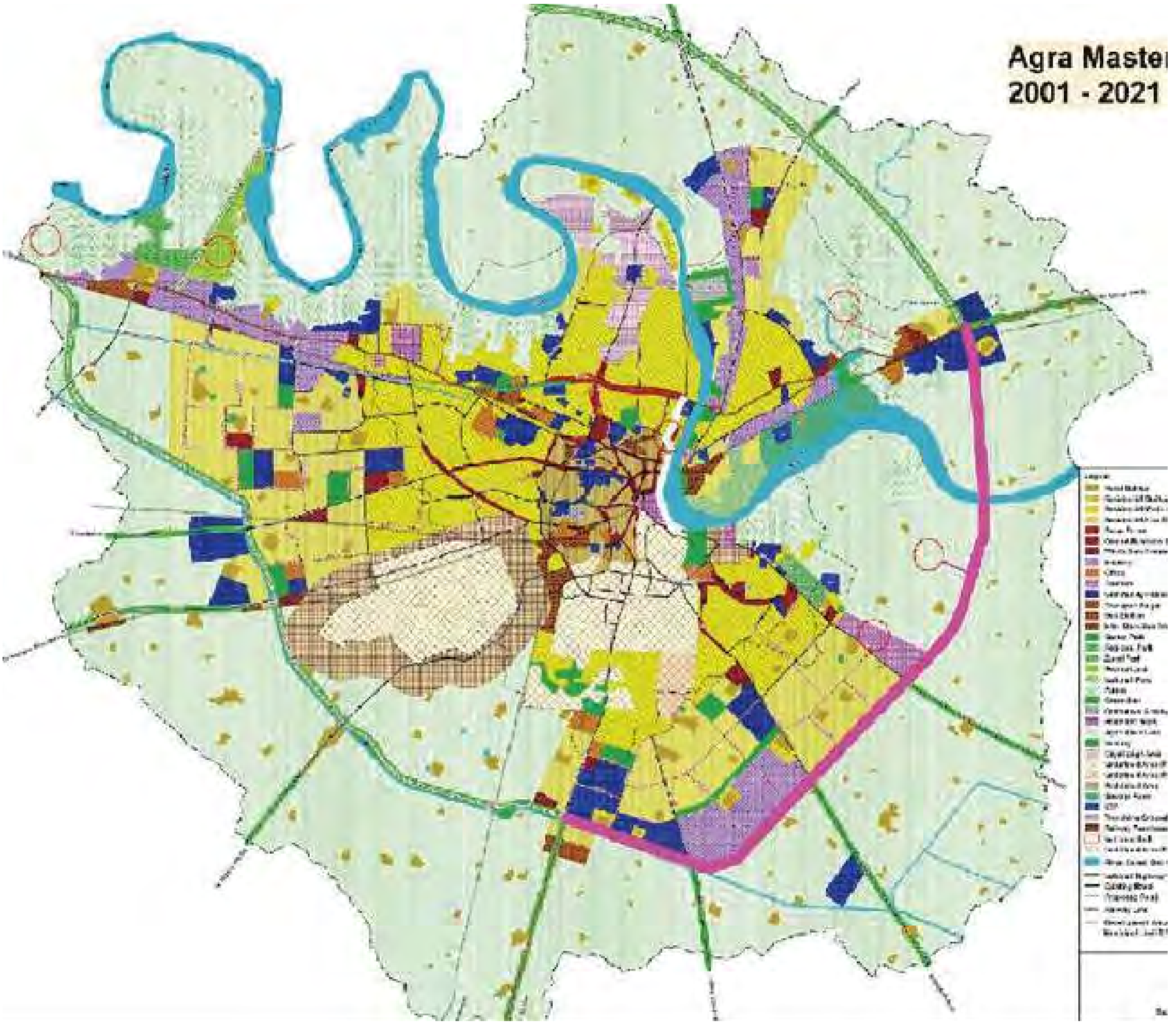
However, the condition and safety of the streets needs to be upgraded to promote high quality of life and livability. The fatality rate in Agra is one of the highest in the country. The road environment needs to be redesigned and made much more safer to bring down the fatality rate. The roads environment needs to be designed for people and not vehicles.

Safe Streets for Agra paves the way to design complete streets i.e. safe and inclusive streets for all types of road users and modes. It promotes sustainable safety and prioritizes vulnerable road users like pedestrians and cyclists. It provides the methods to deliver high quality design of various street typologies in synchronisation with international best practices and indian policies.

Dr. MPS
GROUP OF INSTITUTIONS
Leading
Youth
Scholarship
Placement
9359090501
9359090502
SSC
KEITSER
INSTITUTE
A11 NEW AGRA
Ph. 4041555
लाल बत्ती का सम्मान करें।
यातायात पुलिस, उत्तर प्रदेश


PETER ENGLAND
HOTEL

**Figure 1:** MasterPlan 2021
Source : Agra development Authority



# 1.0

# Introduction

Agra (27°12' N and 78°12' E) is located on the banks of the river Yamuna in the northern state of Uttar Pradesh, India, 363 km west of state capital, Lucknow and 200 km south of the national capital Delhi. Being centrally located on the national map traffic by rail and road going south passes through Agra thus making it a major transport node at the regional level as well as at the national level.

Agra comes under category B as million plus city and has also importance of being a world-class architectural heritage site. For a city with million plus population that has grown at more than 25% in last thirty years, the infrastructure development has failed to keep pace with population growth. The population of Agra city was 1,574,000 persons in 2011 with a decadal growth rate ranging from 25% to 32% in the last five decades. The growth rate was lowest in the last decade. The present density of the city is 84 persons per hectare.

The city is divided into 80 wards but the distribution of population is non uniform in the city. Wards 26, 43, 50 and 66 have high concentration of population whereas the wards 36, 40 and 47 have lower population. The economy of Agra city is based on small scale industries, commerce, trade and tourism.

The city of Agra has several such deficiencies and there is a need to make substantial improvement in basic infrastructure prevailing in the city to raise the standard of health, sanitation, urban environment keeping pace with rapid urbanization and growing population. The importance of Agra city as a leading tourist destination has to be kept in view while designing the system to make the city beautiful, attractive to the tourists visiting the city

The positive role of urbanization has often been over-shadowed by the deterioration in the physical environment and quality of life in the urban areas caused by widening gap between demand and supply of essential services and infrastructure. It is further associated with many problems, such as high levels of poverty, environmental stress, risks to productivity, high health costs, and lack of access to basic services,

**Figure 2:** Regional Setting of Agra
Source : CDP, Agra


**Table 1: Agra Fact sheet**
**Source: CMP, Agra**

| Fact Sheet | |
|---|---|
| Population Density | |
| | 9000 persons per sq. km. |
| Decadal Population Growth Rate | |
| | 30.37% |
| Average Trip Length | |
| | 4.9km |
| Area under Traffic and Transportation | |
| | 10% |

**Table 2: Population growth in Agra**

| Year | Population | Decadal Growth Rate |
|---|---|---|
| 1961 | 462,000 | - |
| 1971 | 591,000 | 28% |
| 1981 | 781,000 | 32% |
| 1991 | 978,000 | 25% |
| 2001 | 1,275,000 | 30% |
| 2011 | 1,574,000 | 23% |

such as water supply, sanitation, and housing.

The total road length of 1724 km in Agra Nagar Nigam area (including pucca road, semi pucca road, kaccha road) hasn't increased in last three years (since 2003)[1]. (Source : CDP, Agra 2006).According to Agra Master Plan 2021, 10.79% of the area will be covered under Traffic and Transportation. But the road network of the city offers poor level of service affecting safety, efficiency and economy of traffic operation within the city. However, recent data shows that Agra has recorded increase in road fatalities from 89 in 2001 to 653 in 2011. Agra had a fatality rate of 41 persons per 100,000 persons in 2011. This compares with rates of 11 in Delhi, 10 in Vadodara, and 24 in Vishakhapatnam. **Agra has among the highest fatality rates in Indian cities.**

A clear difference can be seen in the provision of infrastructure for the pedestrians and the car owners. Roads have been widened, relaid, etc for smooth movement of vehicular transport to ensure comfort to the car user.

• Crossing the road is dangerous and difficult. Current road design is promoting exclusivity and islolation.

• The deteriorating condition of the road infrastructure, missing or lack of footpaths, lighting etc has made the pedestrians and the cyclists prone to crashes.

• Increasing air and noise pollution has ill effects on the health of citizens of the city. It is leading to respiratory infections, obesity, etc.

Agra needs to focus on providing for its people and not the vehicles. With over 78% of people using modes other than private vehicles of which 37% are purely walk, (all trips are walk trips for some part of the journey), it is imperative to provide for pedestrians, non motorised transport and public transport. They are the major stakeholders of road users on the streets.

1 CDP, Agra

**Figure 2: Agra Fact sheet**
**Source : Agra Master pLan 2021**

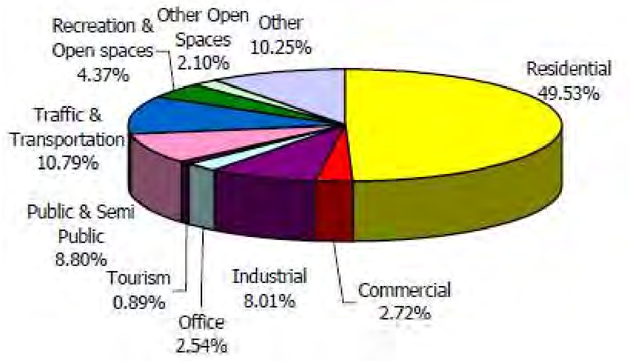



**Figure 3: Hostile environment for pedestrians and cyclists**

**Figure 4: Roads are only for vehicles**

# 2.0
# Why Safe Streets?

Sustainable transport needs inclusive streets. Inclusive streets ensure not only safe mobility – reduced risks of traffic crashes – but also reduced street crimes and better social cohesion, and makes public transport, bicycling and walking attractive, and the preferred choice for commuting. Hence, Safe streets are complete streets. They ensure door to door mobility for all road users in a safe and seamless manner. They foster a community spirit since residents use streets to meet, access public spaces and socialize. There is strong evidence that sustainable urban mobility planning raises the quality of life in an urban area.[1]

**Safe Streets put pedestrians first.** They prioritize vulnerable user groups like pedestrians and cyclists. Any type of streets, any width of streets needs to address the prerequisites of a pedestrian and a cycle. The approach is people centric and not car centric. The multi-dimensional experiences of the pedestrian, cyclist and passenger must all be considered as one, at the 'eye-level' of humans in the city.

**Safe streets are forgiving in nature.** The road environment allows the road users to make 'mistakes'.

**Safe streets are more secure street.** Newly emerging research confirms that the presence or fear of violence impedes activity levels and the ability to move outside freely, especially among populations that are more vulnerable to violence such as children, women, people with disabilities, and older adults.[2] Safe streets are inclusive and provide 'eyes on street'. Integrating spaces for hawkers and vendors not only provide

**Safe streets are for ALL**: Design of inclusive streets gives a safe environment to all age groups and segregates population from high speeds and prevents injuries. Safe streets do not discriminate the elderly and the differently abled.

**Safe streets give clean air.** The increased dependence on personal transport leads to high emissions. The more people use public transport or just walk and cycle, the cleaner the air.

**A move towards designing safer streets and neighbourhoods has to become an integral part of our efforts to move towards a sustainable future.**

Figure 5: Times Square, New York (Before)
Source: Jeff Rissom

Figure 6: Times Square, New York (After)
Source: Jeff Rissom

1 EU mobility
2 larry cohen, carolina guzman, sana chehimi, anna realini.

# 2.1

# How safe are Agra streets?

Non motorised transport dominates the modal share in Agra. Over 75% of the modal share is accounted by walk (37%) , cyclists (17%) and public transport and para transit transport. Motorised transport accounts to about 22% out of which 81% are motorised two wheelers. Motorised two-wheelers (MTW) comprise a vast majority of vehicles in Agra. This would influence the pattern of road traffic fatalities in the city.

Reasearchers from TRIPP visited Agra to collect data from police stations, transportation departments, and municipal government sources. Copies of First Information Reports (FIRs) for fatal road traffic crashes for the years 2007-2011 were collected from 14 police stations and data coded for analysis at IIT Delhi.

The cases for which details of location were available were plotted on the map of Agra. Traffic flow and speed measurements were done along National Highway-2, National Highway-11 and M G Road.

**Increase in Speed:** Research studies show that the probability of fatal pedestrian crashes increases dramatically from about 10% at vehicle impact speeds of 30 km/h to about 80% at 50 km/h. Figure 9 shows the proportion of TSR, MTW, cars and heavy vehicles travelling at speeds greater than 30 km/h at NH2 and NH11 in Agra. These data show that MTWs have the highest proportion in the daytime and cars and trucks have higher velocities at night on NH2. Velocities seems to reduce at night at the location of the survey on NH 11. However, it is possible that some of these observations would be different at other locations and roads in the city.

**Fatalities in Agra:** Vulnerable road users (pedestrians, bicyclists and motorised two-wheeler (MTW) riders comprise 88% of all fatalities. Auto rickshaws (TSR) occupants are only 4% of all fatalities.

- Vulnerable road user fatalities dominate during day and night.
- Auto rickshaw fatalities are much more during the day because they do not operate late at night and during early morning hours.
- Pedestrian fatalities are 4% higher at night.

Figure 7: Modal Split for Agra City
Source : CMP Agra

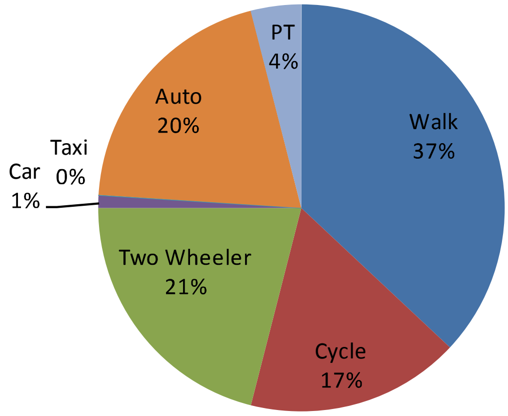



Figure 8: Vehicle population in Agra 2011

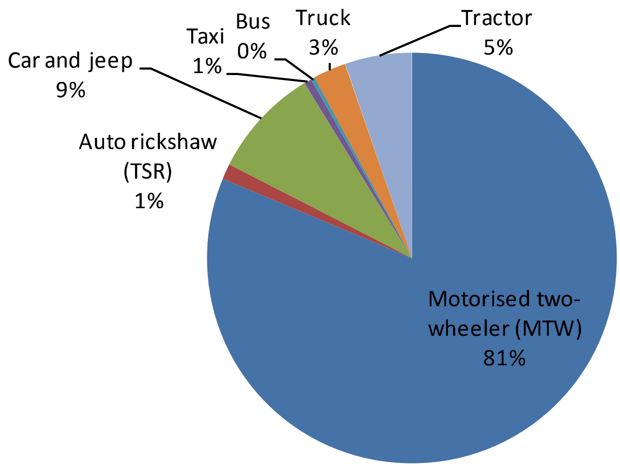
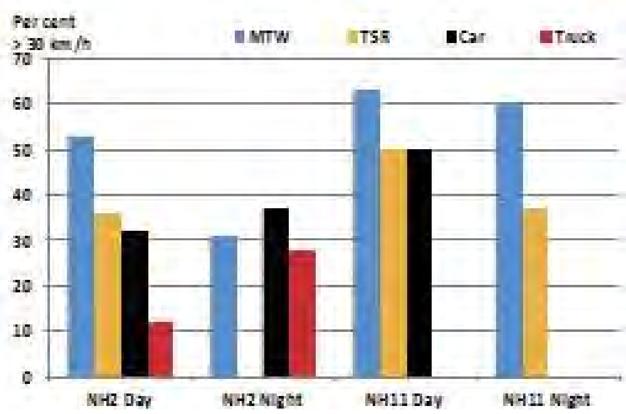



Figure 9: Per cent of vehicles with velocities greater than 30 km/h at in day and night at three locations surveyed in Agra



• Pedestrian and bicycle fatalities peak somewhat earlier in the morning than the motor vehicle fatalities. This may be because this class of road users start for work earlier than those using motorised transport.

• The total fatality rate remains somewhat similar between the hours of 10:00 and 18:00 and a strong bimodal distribution is not observed. This could be because school, commercial and government working timings are staggered.

• MTW and pedestrian deaths are relatively high at 22:00-23:00 when we would expect traffic volumes to be low. Drinking and riving data are not available, but this cojuld be a major factor

• Proportion of pedestrian and bicycle fatalities remain high during the hours after sunset when their numbers are lower than that in the daytime.

**Impacting vehicles :** The largest proportion of fatalities for all road user categories is associated with impacts with trucks and cars. There is a high involvement of motorised two-wheelers as impacting vehicles in VRU crashes. This is probably because of the mixing of pedestrians and bicyclists with MTW traffic. Trucks and buses striking MTWs is greater during the day. Proportion of car impacts with pedestrians is greater

**Figure 10: Road traffic fatalities by time of day for truck, bus, car, TSR and MTW occupants**

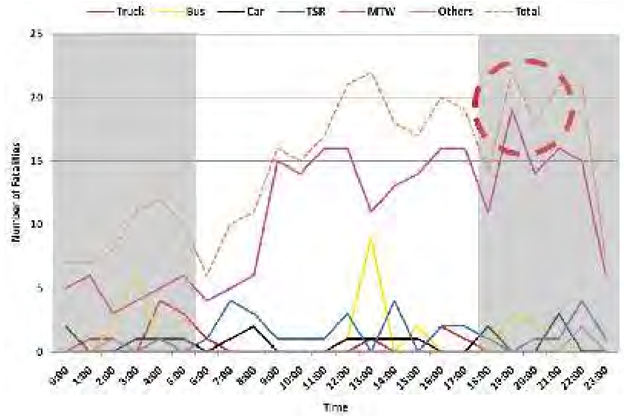



**Figure 11: Road Traffic fatality by time of day for bicyclists and pedestrians.**

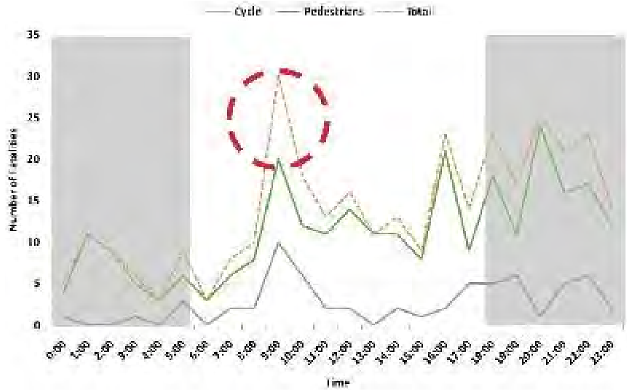
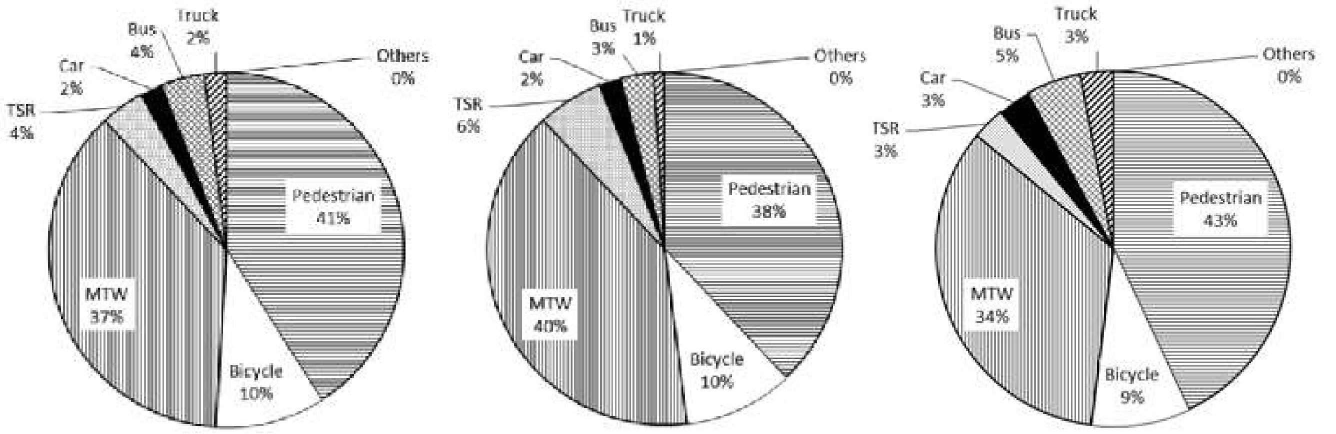



**Figure 12: Fatalities by road user type**

Fatalities by road user type over the whole day in Agra (TSR – Auto rickshaw, MTW – Motorised two-wheeler)

Fatalities by road user type O6:00-18:00 hours (daytime) in Agra.

Fatalities by road user type 18:00-06:00 (night time) in Agra.



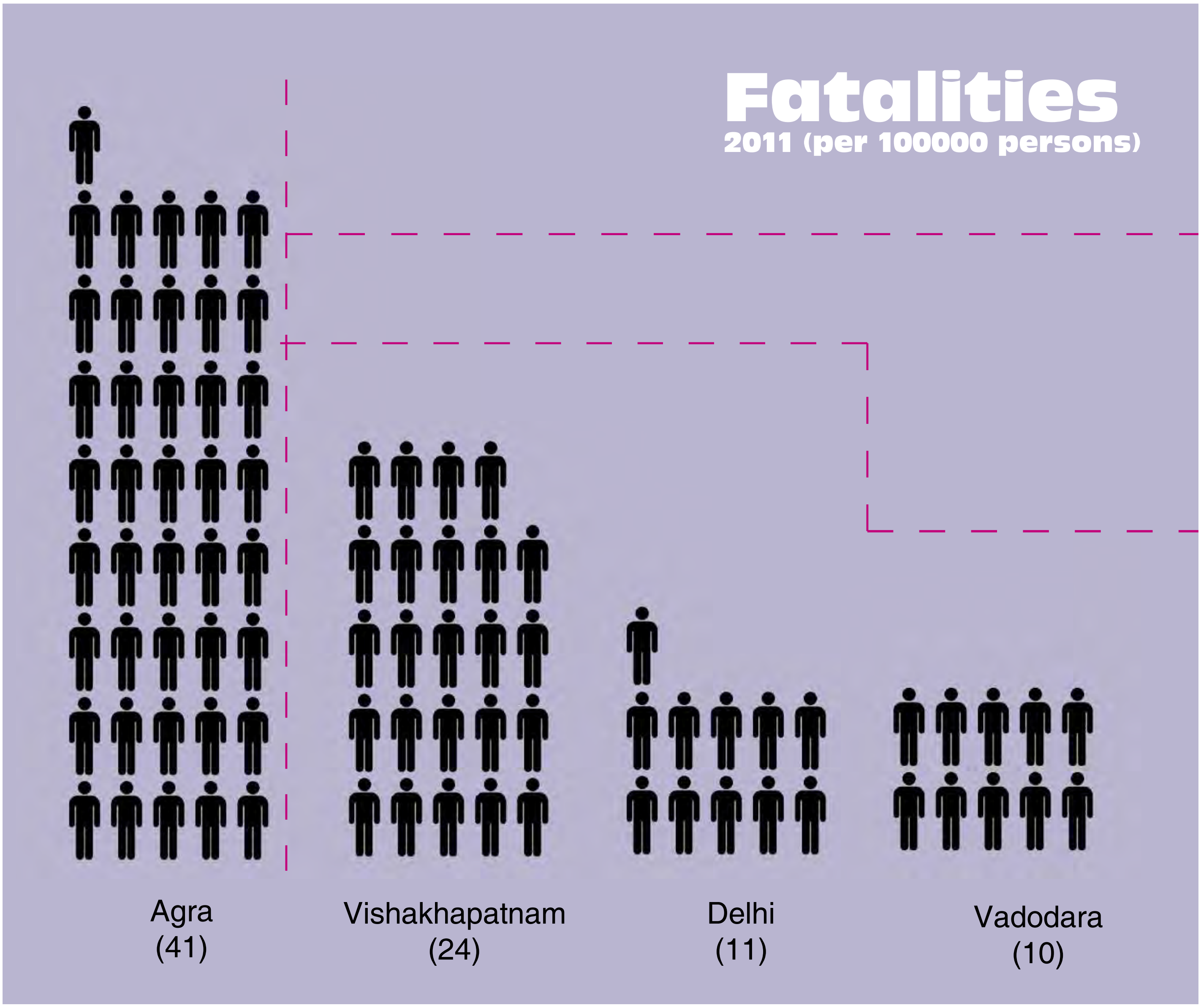



Figure 14: Fatalities in the day time by road user type and striking vehicles.

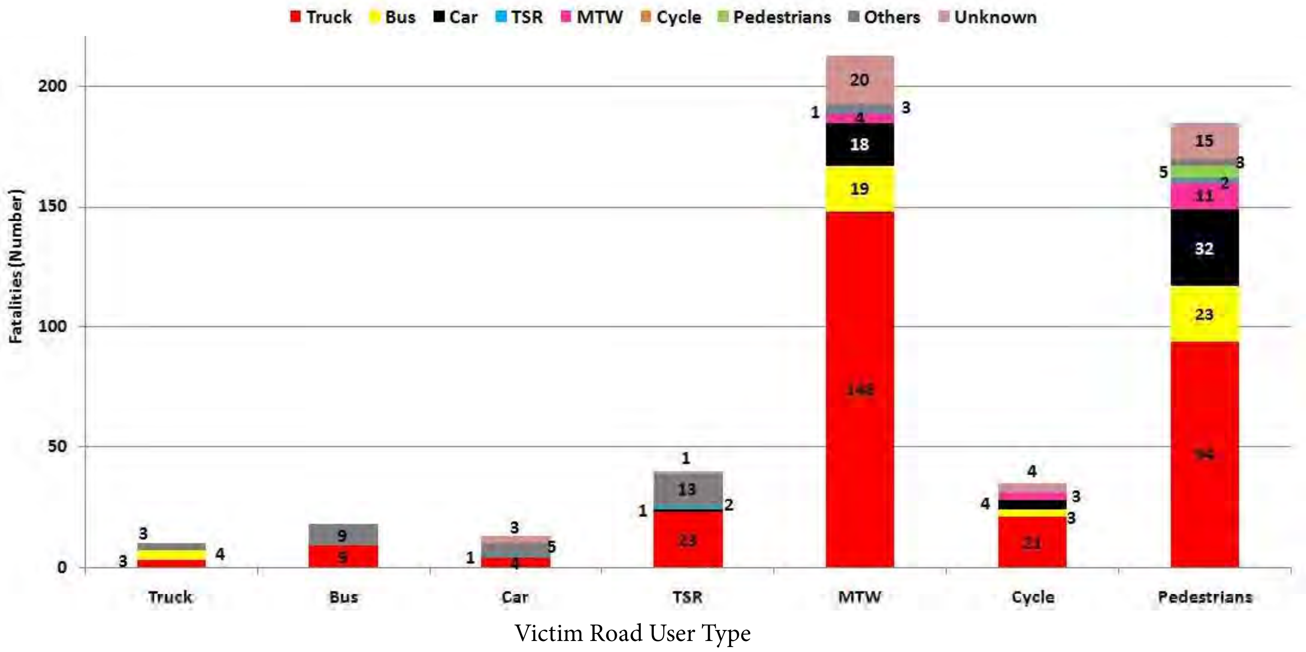


Figure 13: Fatalities in Agra (2011)

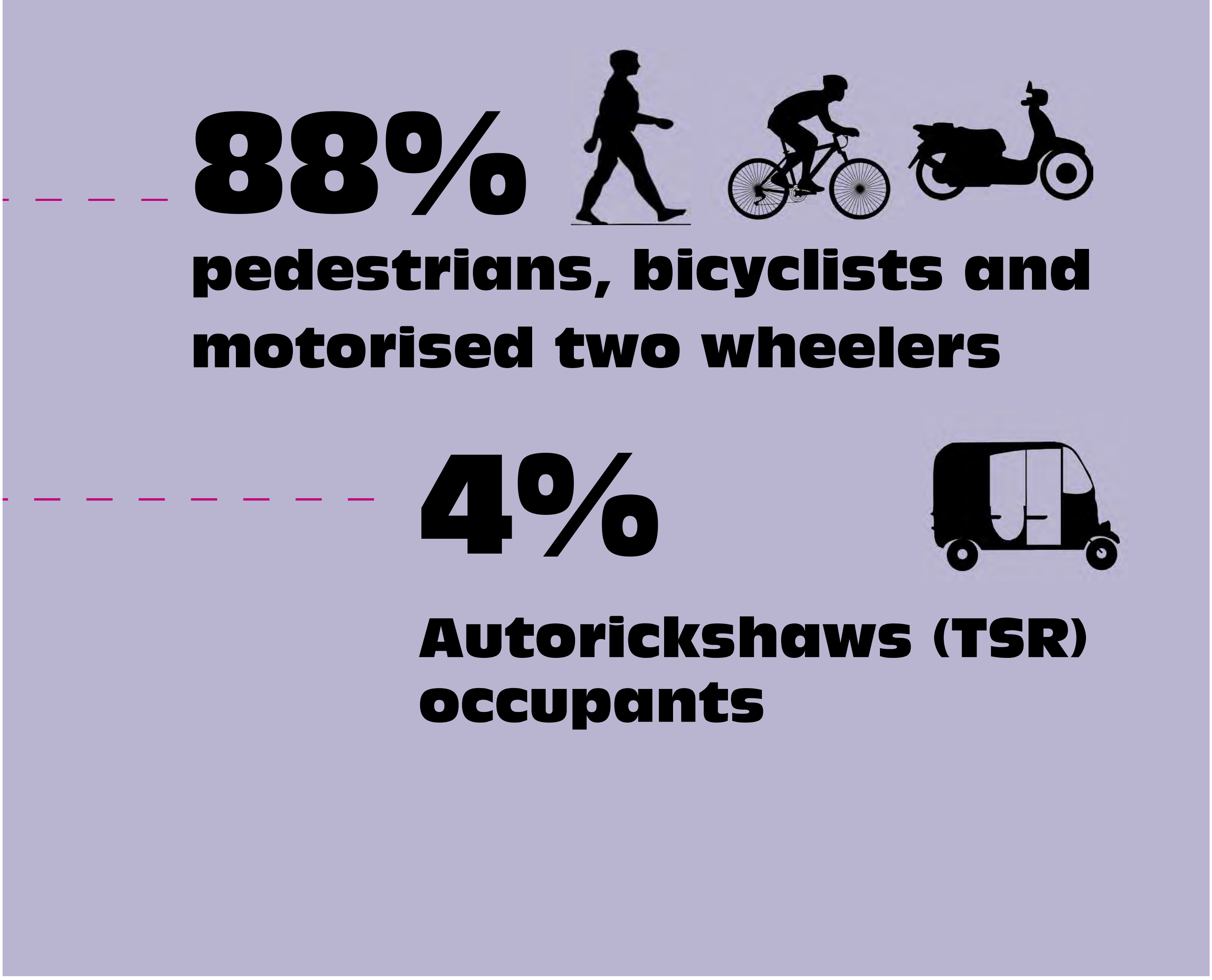
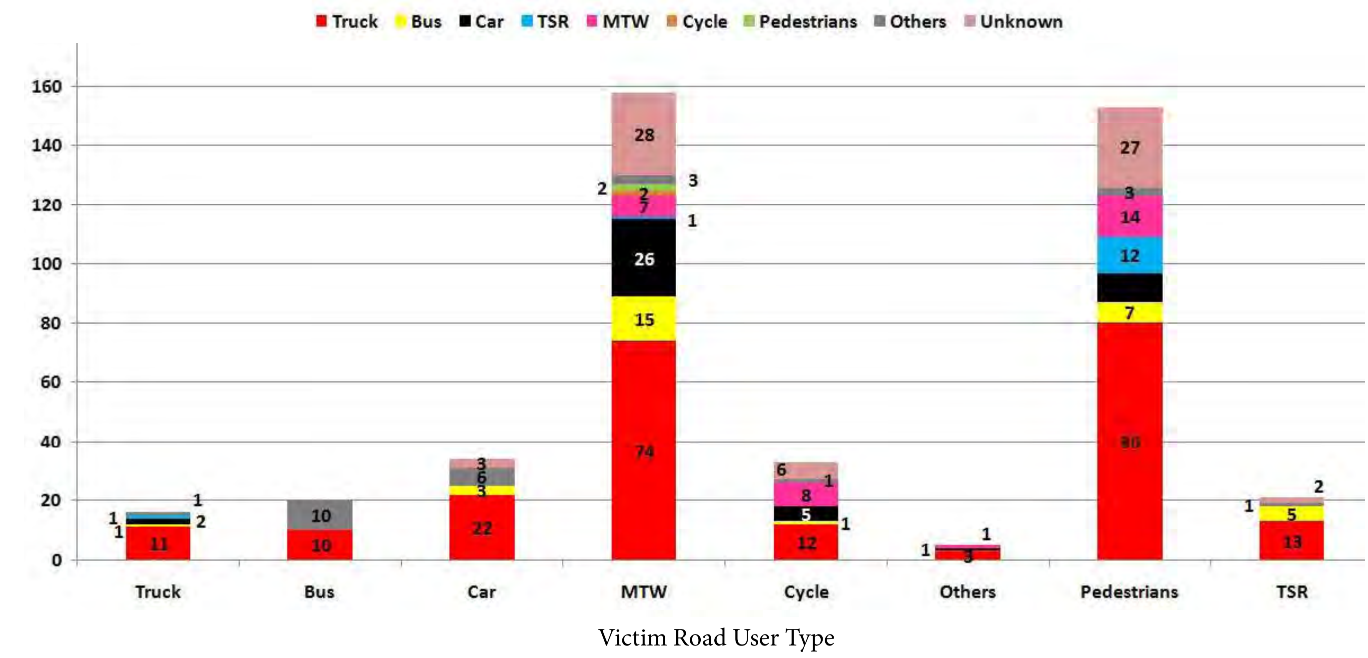



Figure 15: Fatalities in the night time by road user type and striking vehicles.



| | |
|---|---|
| Fatalities in 2011 | 653 |
| Fatalities per 100,000 persons | 41 |

Figure 16: Location of fatal crashes in Agra for the years 2009-2011 for the cases when could be ascertained.

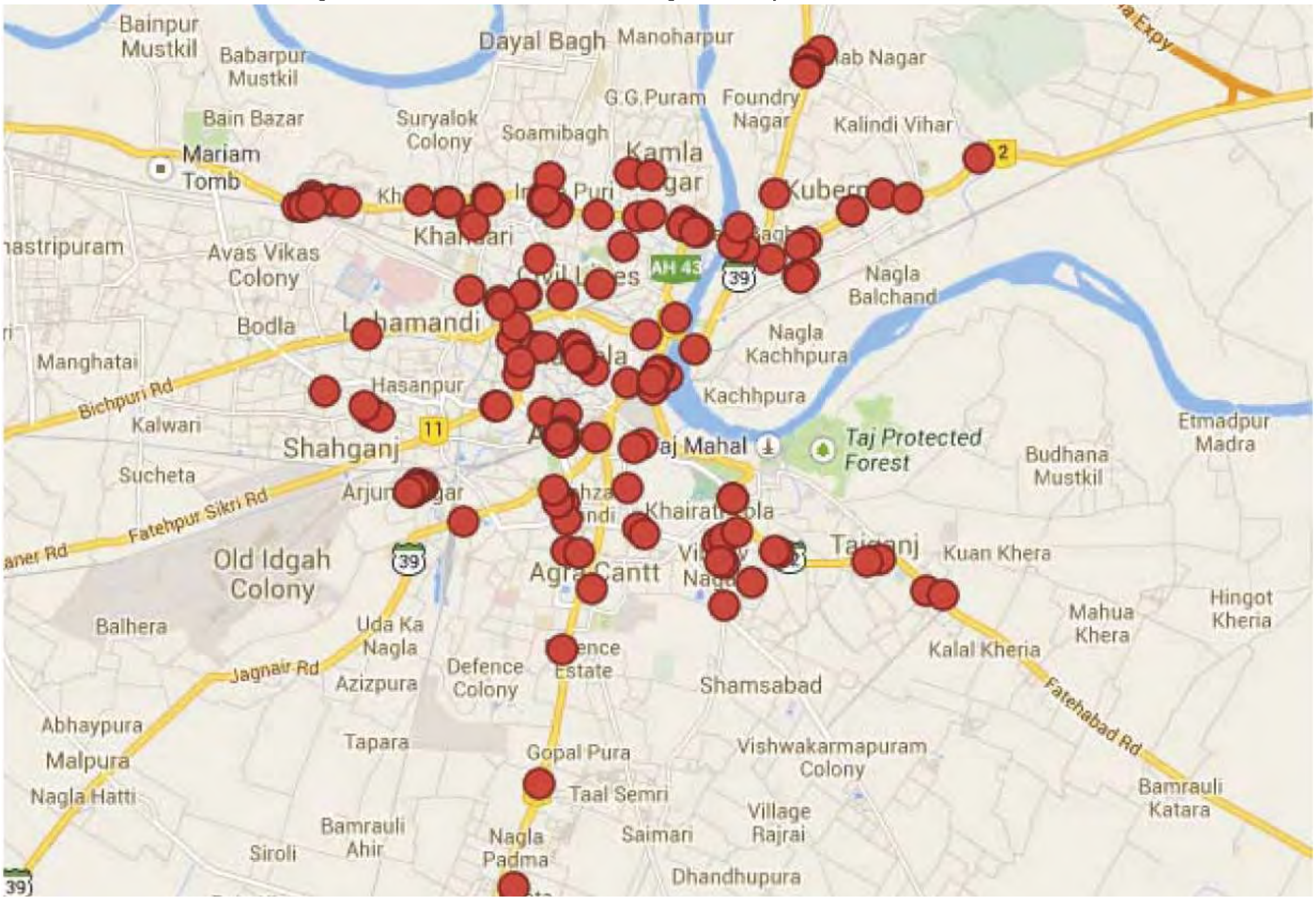



Figure 17: Poor lighting and non segregated infrastructure on NH2, Agra.

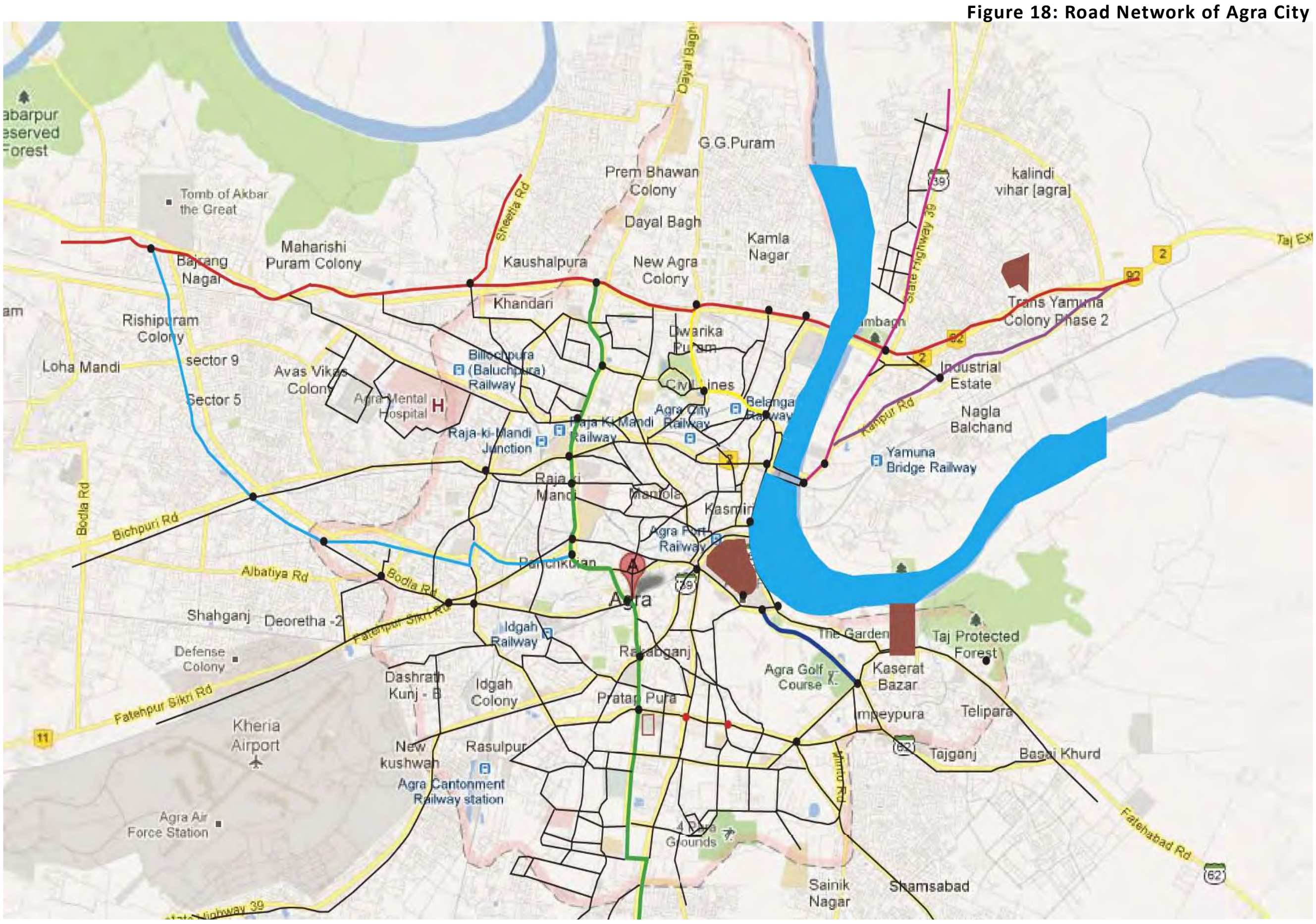
during the day.

• Traffic flow data shows that proportion of trucks and cars at speeds greater than 30 km/h is higher at night (especially on NH2) and level of street lighting is less than recommended by national standards. These two factors may account for high rate of pedestrian fatalities at night.

Some of the conclusions highlighted in the study are as follows:

• Wide roads and highways in Agra have high crash rates . Current location and design of highways in Agra is unsafe. Safer design criteria need to be evolved including the possibility of specially designed elevated national highways and bypasses going around the city.

**Figure 18: Road Network of Agra City**




• Enforcement of provisions in the Motor Vehicles Act regarding mandatory helmet use by motorised two wheeler riders, seat belt use by motor vehicle occupants, enforcement of speed limits and control of drinking and driving will have a very significant effect in reduction of road traffic fatalities in Agra.

• TSR and MTW crash involvement with pedestrians and bicyclists is an issue of concern. Designs need to be more VRU friendly.

• High rate of pedestrian MTW crashes at night – alcohol and street lighting is an issue.

• Presence of median increases expected number of accidents in the region. This observation raises questions on the design of the medians.

• Arterial roads need provision of segregated bicycle paths and adequate pedestrian facilities.

• Traffic calming required on arterials and collector streets.

• Auto rickshaws are the main mode of pubic transportation in Agra at present. Therefore, it is important that special attention be given to their operations to make them safer, more efficient and convenient

• Presence of raised mediums increases the probability of fatal crashes. This is probably because roads with raised medians are likely to have heavier traffic volumes and presence of heavy motor vehicles. Many crashes also involve impacts with medians.

# 2.2
# Design Issues

• **Absence of Pedestrian Paths** : The road are mostly devoid of any safe infrastructure like footpaths or refuge space. The road has only been asphalted to allow for movement of motorised vehicles.

• **Parking Encroachments**: Heavy encroachment of two wheelers and car parking on pedestrian infrastructure. This makes the pedestrian infrastructure unusable and forces the pedestrians to use the carriageway alongside motorised traffic.

• **Insufficient widths**: Many footpaths were not wide enough to ensure smooth and comfortable walking.

• **Obstructions**: The other obstructions apart from vehicular parking include encroachments due to extension of abutting property, trees, locations of bus stops, signages on the walking path.

• **Lack of amenities like toilets, kiosks, etc.** Toilets have been located but they are not enough. They abruptly discontinue the pedestrian path. The design of the toilets and making them accessible for all needs to be relooked into.

• **Lack of designated parking spaces:** The entire road stretch has few spaces designed for parking. Most of the on street parking is free of charge.

• **No integration of feeder service**: Auto rickshaws, e-rickshaws, cycle rickshaws ply on MG road. There is no provision of integrating bus stations for commuter convenience.

• **No provision for safe cycling**: Presence of cyclists, passenger cycle rickshaws and goods cycle rickshaws was observed on this road. However, all the above three modes are moving in unsafe conditions in a high speed corridor. With no available prerequisites of bicycle infrastructure, cyclists travel with motorised

Figure 18: Absence of continuous pedestian paths

Figure 19: Vehicular Parking encroaching pedestrian paths

Figure 20: Rickshaws share carriageway in unsafe conditions on high speed roads

vehicles, risking their lives.

• **Unsafe and inaccessible pedestrian crossing**: Crossing facilities in the city are abysmal. Pedestrians and cyclists need to cross 6 lanes of traffic. The medians lacks refuge island spaces.

• **Obsolete street infrastructure**: All of street infrastructure needs to be universally accessible. The bus shelters have been designed without any consideration for people on wheelchair. Signages, proper lighting, accessible ramps, use of tactile paving, easy boarding and alighting, route informations etc should be components of state of the art bus stations.

• **Design of integrated spaces for hawkers/ vendors**: A lot of informal activity is present on the roads. The vendors stand along the road providing service to bus commuters, cyclists and pedestrians. Though they are seen as encroachments by authorities, they provide security on our roads. The need to integrate them in the road design is critical.

• **Lack of planning to integrate service and utilities**: Light poles, electricity poles come abruptly in the pedestrian path and road edges. These are obstructions but also indicate a lack of planning to integrate the utility in the road design so that they can be easily maintained in future without disturbing pedestrians and cyclists. Proper drainage has been not provided. This leads to waterlogging and puddling, adding to inconvenience to people on the sidewalks and road edges.

• **Missing street infrastructure, signs and road marking**: There is a lack of resting places like seats, benches etc. These not only provide comfort but make the road attractive. This a prime commercial street. Adding street furniture will add to the attractiveness of already existing formal and informal commercial stretches. Signages and marking play a critical role to inform road users.

**Figure 21: Poor design and unsafe pedestrain crossing**

**Figure 22: High medians - unsafe and accident prone.**

**Figure 23: Street light located in the middle of the corridor.**

• **Need for Safe Intersection design:** The current intersections comprise of signalised crossings and roundabouts. However, there are basic flaws in the current geometry. They do not make the traffic slow down and are not able to assist in safe crossings of vulnerable user groups.

• **Missing traffic signals:** The junctions are also unsafe since traffic signals are absent or are not in a working condition.

• **Signages:** There is lack of road signs for each road user. Also, lack of standardization of signs and non-compliance to signs recommended by Indian Road Congress was observed.

• **Marking:** Only some pedestrian crossings were painted. There are other types of markings that complement signages and inform road users of the road environment. This was absent.

**Figure 24: Bus Stop near an open garbage bin.**

**Figure 25: Lack of coherent path for pedestrians.**


**Figure 26: Poor intersection design. .**

**Figure 27: School children cycle in unsafe conditions.**

# 3.0
# Vision

Figure 27: Safe Streets for Agra : Vision


Agra being one of the most unsafe cities in India. The city government needs to take up immedate action to bring down the fatalities in all user groups especially VRUs. Therefore, the first step is to outline a vision that promotes safety and mobility to the road users. The vision shall not only directly affect the number of fatalities but also improve the quality of life of the city.

**The main aim is to bring down the road fatalities of the city considerably. Therefore, aiming at a 20% reduction of deaths annually in all road users will bring down deaths between 50% - 70% in an incremental manner over next 5 years..**

A roll out plan needs to be prepared for the next five years targeting road safety and safe streets. This shall not only include infrastructure amendments but legal & enforcement as well. Important indications for previous study are:

- Enforcing use of helmets.
- Presence of functional street lighting
- Introduction of traffic calming and speed control.

It is important that all tiers of the urban local body coordinate and combine an integrated structure to achieve the vision.

Table 3: Difference bewteen traditional approach and vision zero
Source: http://www.visionzeroinitiative.com

**Vision Zero, Sweden**

**Any loss of life in traffic is unacceptable**

| Traditional thinking | Vision Zero |
|---|---|
| Focus on accidents | Focus on fatalities and serious injuries |
| Perfect human behavior | Integrate the failing human in design |
| Individual responsibility | Shared responsibility between system and design |
| Industry must be forced | Industry can be stimulated |
| Saving lives is expensive | Saving lives is cheap |

**2006 : National Urban Transport Policy, India**

**... to recognize that people occupy center-stage in our cities and all plans would be for their common benefit and well being.**

There are various policies and visions that showcase major shift in the approach to road safety thinking.

• The **National Urban Transport Policy** (NUTP, 2006) envisions a focus on movement of people and goods rather than vehicles as the paradigm of transport planning leading to equitable allocation of road space with priority to public transport and non-motorized transport.

**• Vision Zero Initiative, Sweden (1994)**

The Vision Zero is the Swedish approach to road safety thinking. It is based on the simple fact that we are human and make mistakes. The road system needs to keep us moving. But it must also be designed to protect us at every turn. It aims reduce fatalities and serious injuries to zero by 2020.

Transport systems are traditionally designed for maximum capacity and mobility, not safety. This means road users are held responsible for their own safety. The Vision Zero Initiative takes the opposite approach. The main burden for safety is on system design and recognise human weaknesses and low tolerance to mechanical force. No one should die or suffer serious injury in traffic. [1]

**• Sustainable Safety Vision (1990s)**

Sustainable Safety vision aims to prevent (serious) crashes from occurring and if this cannot be done, to prevent severe injury. Sustainable Safety is a pro-active approach. [2]

**• NYC Vision Zero (2014)**

New York's families deserve and expect safe streets. The City of New York must no longer regard traffic crashes as mere "accidents," but rather as preventable incidents that can be systematically addressed. No level of fatality on city streets is inevitable or acceptable. This Vision Zero Action Plan is the City's foundation for ending traffic deaths and injuries on our streets. (http://www.nyc.gov/html/visionzero/pages/home/home.shtml)

1 visionzeroinitiative

2 www.swov.nl

**Figure 28: Vision examples from various countries**

**SWEDEN**

Source: http://www.visionzeroinitiative.com/en/Concept/

**1997 :"No one shall be killed or seriously injured within the road traffic system."**

**THE NETHERLANDS**

Source: SWOV Fact Sheet (www.swov.nl), July 2013

**Sustainable Safety Vision**

**...the infrastructure must be adapted to the capabilities and limitations of humans...**

**NEW YORK, USA**

Source: http://www.nyc.gov/html/visionzero/

**2014 : "... death and injury on city streets is not acceptable and that we will no longer regard serious crashes as inevitable."**

# 3.1 Principles

## 1 Sustainable Safe Traffic System

Congestion continues to get worse as more and more people give up walking, cycling, and using public transport, which are better for the environment. A well functioning road infrastructure must meet the needs of all road users. [1] The sustainable safe traffic system is based on the five principles on which the vision is based: functionality, homogeneity, predictability, forgivingness, and state awareness.

It focuses on three main points:

- **a road environment with an infrastructure adapted to the limitations of the road user:** Designing a forgiving road environment is key. The guideline focuses predominantly on this factor.

- vehicles equipped with technology to simplify the driving task and provided with feattures that protect vulnerable and other road users

- road users that are well informed and adequately educated.

## 2 Social Usability

Streets are not only important for mobility but are vital public spaces of the city. As mentioned earlier, streets are tools for social cohesion. Streets are used by people to meet each other, do outdoor activities and access other public spaces of the city. This is an important component which separates a street from a road. This is where the ' human factor ' influences. Detailing such as continuity, traffic calming, street furniture, lighting, shade, etc make the street more attractive and encourage usage.

1 Tiwari, G. 2002, "Returning Streets to the People", British Medical Journal, 324:1164

Figure 29: Sustainable Safety

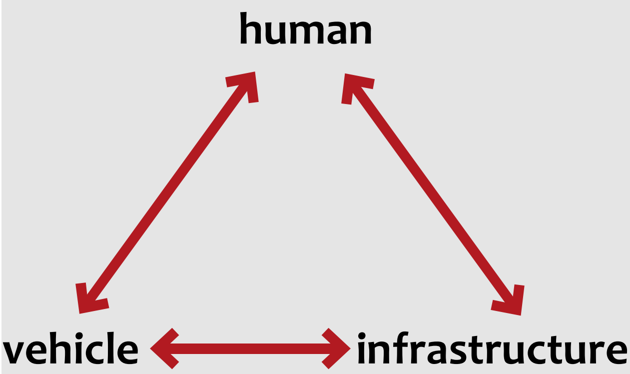



Figure 30: Social Usability of Streets.

Urban Village, Delhi

Popular Street, Seoul

Figure 31: Cheonggyecheon Greenway, Seoul
Source:

# 3 Universal Accessibility

The integration of the concept of universal design has been completely missing from our streets. Street design has to answer inclusivity and accessibility for ALL. Pedestrians, therefore includes everybody i.e. differently-abled people, hawkers and street vendors, people carrying luggage, pregnant women, children, people travelling with infants either in hand or in stroller, etc. Invariably, the physical profile of a pedestrian covers all age groups and gender.

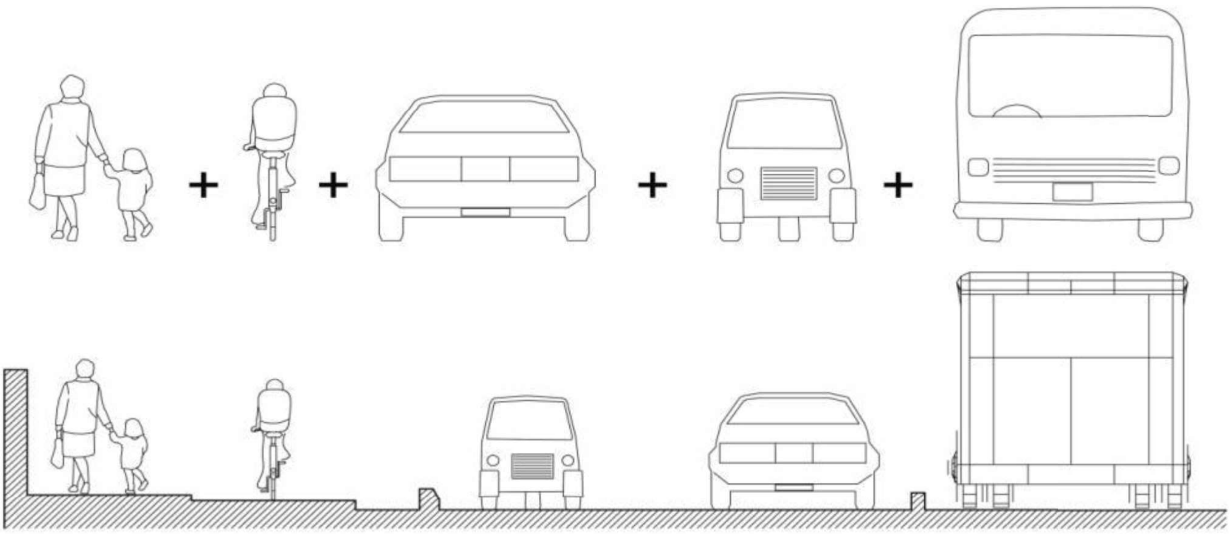
Figure 32: Improper ramps bring dicomfort to differently abled.

# 4 Captive Users

Indian cities, with their high population densities, mixed land use and short trips have an environment which naturally encourages walking. Added to that, high rates of poverty make the ownership of any type of vehicle, often even a bicycle, unaffordable. Even if a vehicle is owned by a household of 4-5 persons, it may typically only be used by one person and the others may resort to other, less expensive means of transport like walking or IPT or Public transport, depending on their trip length. Very few people, who walk in the Indian cities, do so out of choice. Streets must be returned to pedestrians, not only because pedestrians make up the

Figure 33: Captive users

Figure 23: Different design components of the Road for different road users
Source : Code of Practice -I(Institute of Urban Transport, 2013)



majority of road users, but also because the efficiency of the overall system, including the performance of motorised vehicles, depends on meeting the demand of "captive pedestrians."

Travel patterns of people living in informal housing or slums are very different from residents in formal housing. Generally, bicycles and walking account for 50-75% of the commuting trips for those in the informal sector. The formal sector is dependent on buses, cars and two wheelers. This implies that despite high risks and a hostile infrastructure, low cost modes exist because users of these modes do not have any other choice. They are captive users of these modes. [2]

# 5 Equitable Allocation of Road Space

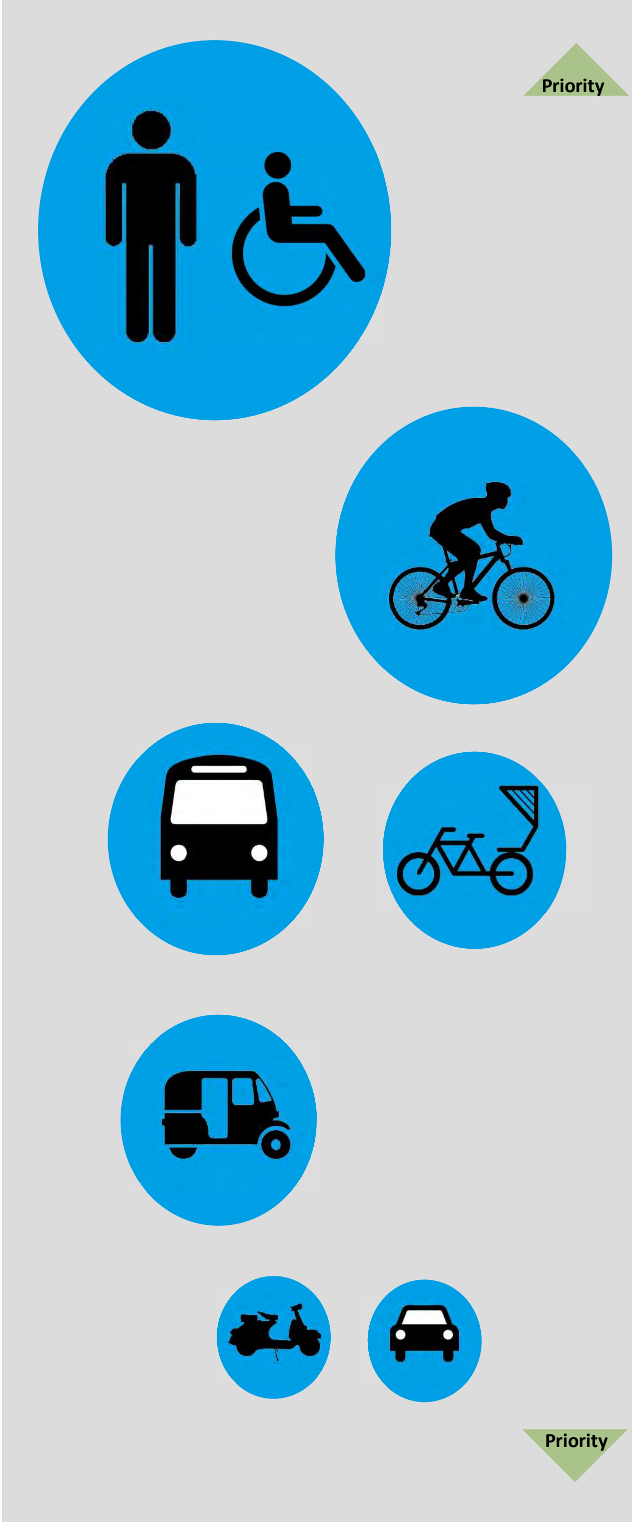
Urban roads in India have a heterogeneous mix of traffic. These include the pedestrians, slow moving vehicles like bicycles, rickshaws both for passenger and freight movement and fast motorized vehicles like motorcycles, scooters, three wheelers, cars and public transport vehicles. The space occupied by each of these vehicles, accelerations and deceleration characteristics and possible maximum speeds by each user is variable. Therefore space allocation to different vehicles has to be carefully ensured according to their design speed to achieve a smooth and safe flow of traffic.

# 6 Modal Hierarchy

Pedestrians, non motorized users and the public transport users in urban areas form the basis of sustainable transport systems. Therefore designing a road space for these three user groups in priority is of utmost importance.

2 Geetam Tiwari 2007, "Urban Transportation Planning" Seminar, No. 579, 45-49

Figure 34: Modal Priority for Safe and Sustainable Roads



# 3.2 Design Process

## 1 NETWORK PLAN

• Identify the road hierarchy including arterials, distributor and access roads.

## 2 SELECT CORRDIORS & AUDIT THE EXISTING CONDITION

• Select segments/ corridors on basis of priority, safety, bottlenecks, etc.
• Audit the present condition using relevant checklist using Urban Road Safety Audit Toolkit. (MoUD, 2012)

## 3 CONDUCT SURVEYS TO UNDERSTAND THE SCOPE OF INTERVENTION

• Surveys required : total station survey, activity survey, accident data, parking survey.
• Analyze the data and outline the scope of intervention on the basis of Right of Way (ROW) and design speed of the road type.

## 4 ADDRESS PRINCIPLES THROUGH DESIGN INTERVENTIONS

• Design ROW components by cross-section and intersection design by prioritizing modal hierarchy
• Integrate features that render the street as safe and a social space.
• Integrate green buffers and Tree lines at appropriate places for shade and attractiveness.

## 5 MEASURE EFFECTIVENESS OF PROPOSALTHROUGH AUDIT

• Audit the proposed design again using same checklist (selected earlier) using Urban Road Safety Audit Toolkit. (MoUD, 2012)

## 6 IMPLEMENT ON SITE

• Preparation of development plan including bid process, construction, operation as well as maintenance
• Safety of road users need to be taken into consideration at the time of road construction and maintenance work. Compliance with Work Zone Safety Guidelines including preparation of Traffic Management Plan's.

## 7 ENGAGE COMMUNITY GROUPS / CIVIL SOCIETY GROUPS

• Participate with the community at various stages. This includes audits, design proposals and knowledge dissemination.
• This also ensures faster outreach of the vision and instills a sense of ownership of community to environmental safety.

# 3.3
# Implementing Safe Streets

Moving in the city has become a nightmare especially for people who walk, cycle and take public transport for work. As mentioned in the revised bicycle master plan of Delhi, (Tiwari & Jain, 2008), a well functioning bicycle infrastructure is the key to a longer lasting safe road-traffic system.

A network plan should be prepared and well-integrated along with the master plan document of the city which includes recommendations on the network of arterial roads i.e. links for which segregated cycle tracks and pedestrian footpaths are needed, distributor roads - the links for which traffic calming is needed and access roads, where minimum interventions are required.
For major impact across the road network, it is important to understand the following:
i. Arterial roads – These are the most critical. With large ROW and high speed, most fatalities take place on these roads.
ii. Collector roads – With design speed 30km/hr and minimum interventions, risk can be reduced
iii. Access roads (by lanes) – least critical for intervention.

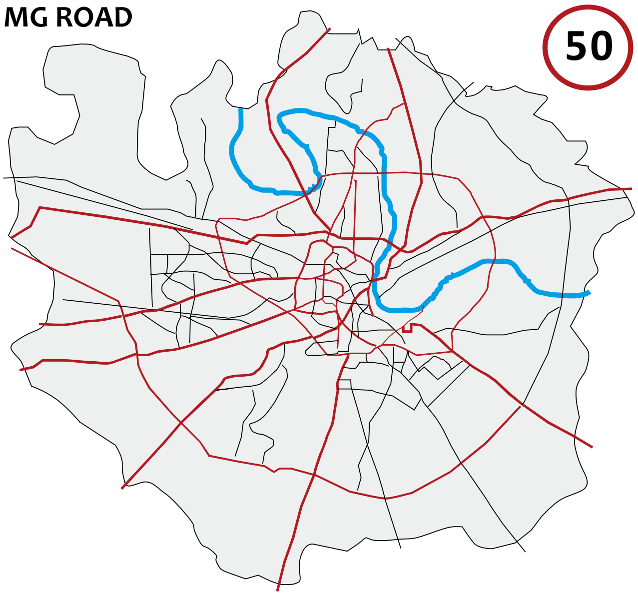
Since arterial roads are most critical, a huge impact can change the safety conditions on our roads as well as provide a robust network for walking and cycle for both captive and potential users.The implementation of the safe streets can be done in a phased manner and can be implemented in a time span of 5 years in total. The proposedphases are as follows:

Phase I: Radials, MG Road and all major highways within the city. These are major roads above the width of 30 m ROW which carry fast traffic.

2. Identify the remaining arterials (above 24m ROW) and demarcate cycle lanes to reserve space for cyclists

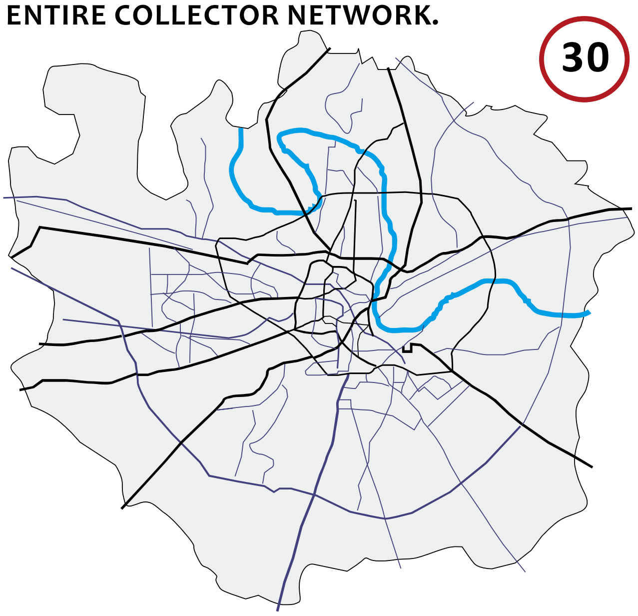
3. Initiate implementation of design on all remaining arterials. Collector Network - Demarcate cycle lanes and introduce traffic calming measures along the entire distributor network.

**PHASE I: AUDITING AND IMPROVING PRIME ARTERIAL NETWORK - RADIAL, HIGHWAYS and MG ROAD**




**PHASE II - IDENTIFY THE REMAINING ARTERIALS AND DEMARCATE CYCLE LANES ON ALL OTHER ARTERIALS TO RESERVE SPACE FOR CYCLISTS**

**PHASE III - COLLECTOR NETWORK. INTRODUCE TRAFFIC CALMING ALONG ENTIRE COLLECTOR NETWORK.**



# 4.0
# Road Network

Urban transport in Indian cities reflects the heterogeneity in the socio-economic and land use patterns. It is dominated by walk trips, non motorised modes such as bicycles and rickshaws, and motorised para transit and public transport depending on the size of the city. A well functioning road infrastructure must fulfill the requirements of all road users. If the infrastructure design does not meet the requirements of these elements all modes of transport operate in sub-optimal conditions.

The road network is used by at least seven categories of motorized and non-motorised vehicles. Vehicles ranging in width from 0.60 m to 2.6 m, and capable of maximum speeds ranging from 15 km/h to 100 km/h, share the same road space. All these vehicles which have varied dynamics and static characteristics share the same carriageway. Thus traffic is characterised by a lack of effective channelisation, mode segregation or control of speeds. To a formally trained planner, it looks like chaos moving towards total gridlock. Yet the people and goods keep getting through and may, by some measures, actually be faring better than in some controlled conditions.[1] To allocate widths, it is important to understand the space required by each vehicle type. Planning and Design Guideline for Cycle Infrastructure provides the dimensions of all non motorised vehicles seen on the streets.

**Presence of Urban Freight :** Freight and goods delivery is an important part of Agra's streets. There are both motorised transport and goods cycle rickshaw present that are used to transport the goods within the city.

**Figure 35: Road Users in Agra**
**Source :**

1 (Tiwari, G. 2000, "Encroachers or Service Providers?", Seminar, 401, 26-31 ).

## Road Typology

The infrastructure requirements for each depends upon the road type and road design speed. As mentioned in Code of Practice : Design of Urban Roads (Institute of Urban Transport and Ministry of Urban Development), the classification of urban road type is as follows:

A. **Arterial Roads** : They are the primary roads for ensuring mobility function. They carry the largest volumes of traffic and longest trips in a city. These roads have the maximum right of way amongst the four categories and cater to a speed limit of 50 km/h and a ROW of 50-80 m.

B. **Sub Arterial Roads**: This is context specific and is based on the function and the land use development it passes through and caters to a speed limit of 50 km/h(same as arterial roads ) .The ROW of this category of roads varies from 30-50 m.

C. **Distributor/Collector Roads**: As the name suggests, these are connector roads which distribute the traffic from access streets to arterial and sub arterial roads. They are characterized by mobility and access equally. They are characterized by a design speed of 30km/h and have a ROW midway of access streets and two types of arterials i.e. 12-30m.

D. **Access Streets** : They cater to a design speed of 15-30km /h and have a road right of way of 15m-30m. They carry relatively lower volumes of traffic at low speeds. They are characterized by access predominantly; they can be used for collector functions.

Based on the road type an appropriate design speed is adapted. The design speed governs the geometric design of the right of way and the cross section elements of the road.

| Road Typology | Right of Way-ROW (m) | Design speed (km/hr) |
|---|---|---|
| Arterial Roads | 50-80 | 50 |
| Sub Arterial Roads | 30-50 | 50 |
| Collector Roads | 12 - 30 | 30 |
| Access Streets | 6 - 15 | 15 |

**Figure 36: Hospital Road, Agra (Access Street)**

## Prerequisites : Planning

**Coherence and directness (Connectivity)**

• To make the total city pedestrian and cycle friendly, the entire network needs to be cohesive. The lower the travel time, the higher the directness. At network level, a cohesive network would involve minimal detours for cyclists and pedestrains accessing it.

• Higher directness can be achieved not just within the NMT network but also on public transport corridors by using walking, cycles and rickshaws as feeders and providing parking and transfer infrastructure at stations to minimize delays. Hence, there should be a complete NMT network connecting all destinations integrated with public transport lines and road networks.

**Attractiveness and Comfort**

• Plan some activities and break the monotony of the route and introduce visually and spatially attractive elements more apt to the scale of NMT users instead of stark, monotonous, long, barren walls.

• Eliminating traffic bottlenecks, steep gradients, nuisance caused by traffic noise and emissions, bad riding quality, presence of obstructions resulting in frequent braking or slowing down, etc.

**Safety and Security**

Pedestrians and cyclists are very vulnerable in the case of crashes. In common practice of increasing non motorised safety is to segregate them from motorized vehicles in time and space. For captive users, segregation by time is not a viable option as the journey between work and home is undertaken at almost the same time as other (motorized) modes (especially for shorter trips). Here, the most effective option would be to segregate users into separate tracks or paths along the road network, (especially if the speed limit for MV is over 30 Km/hr). On other streets there is a need to reduce their speed difference by traffic calming without affecting directness or coherence.

## Prerequisites : Design

**Coherence**

• Segments in the network should look similar to improve the legibility and usability of the bicycle infrastructure and there is provision of good connectivity between all origins and destinations.

• Constant width ensured through design with adequate widening at turns and rendering the same texture for typical scenarios across the network.

• Elimination of any missing links as well as standardization of intersections i.e. the shape, size and form of each category of junction solution.

**Directness**

Directness of bicycle infrastructure has to do with the amount of time and effort required by a pedestrian and a cyclist to undertake a journey. Therefore, major detours from their natural path should be avoided. As mentioned in the 'Design manual for bicycle traffic' (CROW, June 2007), directness has two components: in terms of distance and time.

**Attractiveness**

• To ensure attractiveness, care should be taken that the path of the cyclist should be clean and devoid of any dumped material that blocks movement.

• Location of spaces for hawkers and vendors, well integrated bus shelters, green areas, resting spaces, etc. and shaded NMT infrastructure are factors that are definitely attractive.

**Safety and Security**

• Prevention of collisions and reducing the conflicts and their impact will result in a safer travel.

• Provision of adequate and uniform lighting ensures enhanced usability as well as safer streets. Integration of spaces for hawkers and vendors, support facilities provides security and the necessary eyes on street.

• Safer Intersections can be provided by minimizing conflicts (and sub-conflicts), introducing traffic

**Comfort**

• Walking and riding comfort ensures usage. It is important that proper drainage should be provided with regular maintenance.

# 4.1
# Cross Section Design

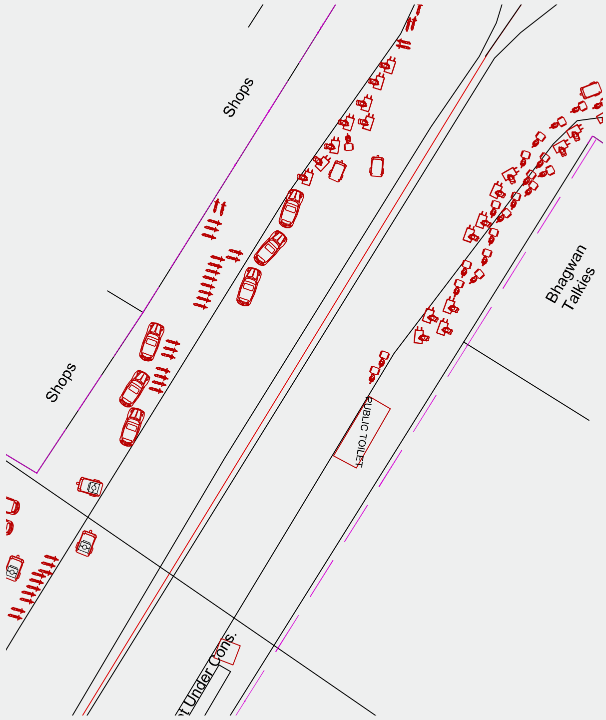
## Data Collection

**Geometric Survey** - A total station based geometric survey of the entire ROW along the length of the road is a basic requirement to undertake safe street design. A total station survey will give complete topographical data of existing underground and overhead features like services and utilities, the existing landscape, buildings and structures.

**Activity Survey** - An activity survey allows an understanding of the user requirements and behaviour, which cannot be reflected by a geometric survey. It records dynamic, formal and informal activities at the site, such as parking, hawking, service activities, etc.

**Traffic, Parking and Accident Surveys**- Traffic surveys provide an assessment of current vehicular (motorized and non-motorized) as well pedestrian traffic demand on the corridor. Parking surveys record the current usage of land at different times of the day by parking– both formal and informal.

**Figure 37: Typical survey drawing with activity survey, MG Road**




• Also at intersections, traffic nuisances should be minimum.
• Segregation for VRUs terminating up to the stop line at high speed roads or high volume distributor will ensure cyclists that their Right Of Way (ROW) is not obstructed by vehicular traffic.
• It is necessary to accommodate utility services along and across the roads. The laying design of utilities has to be done to ease maintenance and operations but keeping in mind that it will affect the traffic flow and conflict with other services to the minimum.

## Cross Section Design

The street selected for planning is divided into various segments based on its function, form and use from the surveys mentioned earlier. The minimum and most available ROW conditions are selected for each stretch from the total station survey drawing, for the development of the cross section designs. The main elements of a cross section design are given in Table 4.

The type and character of each urban road needs to be carefully detailed to respond to the functions it performs, i.e. providing mobility or access or both. Safety of road users is a major concern now because the number of traffic accidents and fatalities on urban roads has continued to increase in the past few years. Therefore application of appropriate geometric design standards on urban roads is essential to ensure the safety to all road users. A design of the entire road cross-section holds considerable importance, as
• It governs the design speed of vehicles
• Reflects prioritization in space allocation
• Introduces concepts of universal design and traffic calming.

Following are examples of MG Road, NH2 and Hospital road redesigned according to Table 4.

Figure 38 : Cross Section Design according to road type
Source : Planning and Design for Cycle Infrastructure, TRIPP, 2014

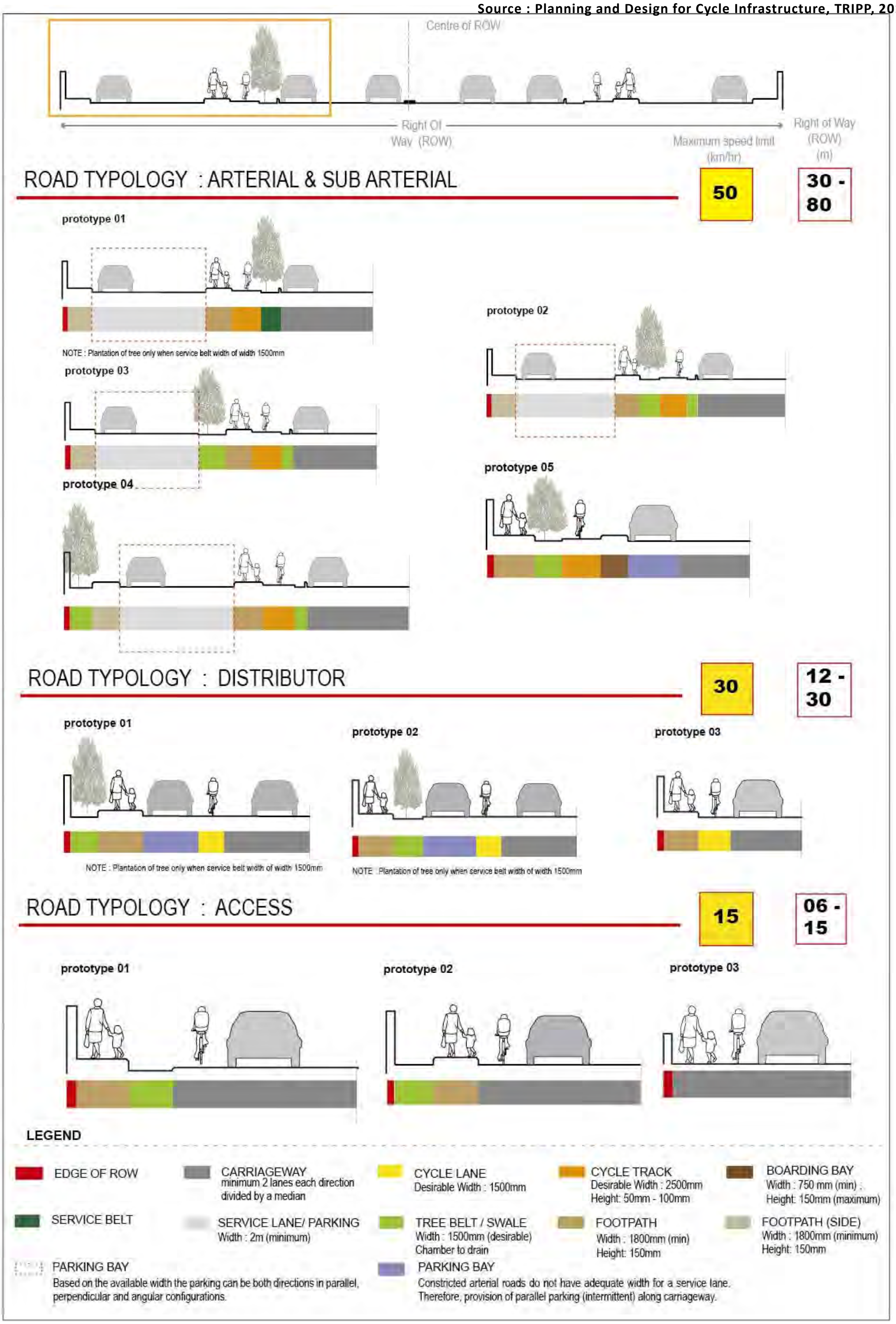


**Table 4 : Cross Section Design according to road type**
**Source : Planning and Design for Cycle Infrastructure, TRIPP, 2014**

| | Arterial Roads | Sub Arterial Roads | Collector Roads | Access Roads |
|---|---|---|---|---|
| **Carriageway** | | | | |
| Criteria | 50 km/h | 50 km/h | <=30km/hr | <= 15 km/hr |
| ROW | 50m – 80m | 30m – 50m | 12m – 30m | 6m – 15m |
| | | | | |
| Gradient | 2% | 2% | | |
| Number of lanes | Maximum 6 to 8 lanes divided (using a raised median); | Maximum 4 to 6 lanes divided (using a raised median); | Maximum 4 lanes of 3.0m width each (excluding marking) or 2 lanes of 2.75m to 3.1m width each (excluding marking) with or without an intermittent median | 1 to 2 lanes, (undivided); of 2.75 to 3.0m width each |
| Maximum Width for car lane | 3.0 to 3.3m width each (excluding lane marking) | 3.0 to 3.3m width each(excluding lane marking) | 3.1m width each | 2.75 to 3.0m width each |
| Maximum Width for bus lane / Mixed lane | 3.3m - 3.5m | | | |
| (segregated ) excluding lane marking | 3.3m - 3.5m (segregated ) excluding lane marking or painted lane | Mixed traffic | | |
| | Mixed | | | |
| Levels | 0.0m | 0.0m | 0.0m | 0.0m |
| Note - In special cases, there are conditions on arterial and sub arterial streets where the ROW gets constricted to a minimum of 24m. In such conditions, the continuity of the NMT and pedestrian infrastructure is important without creating a bottle neck in the arterial/sub arterial flow. A segregated cycle track and footpath can be easily achieved with 2 lanes in both directions. | | | | |
| **Non Motorised Vehicle** | | | | |
| | Segregated Cycle Track | Segregated Cycle Track | Cycle Lane | Mixed \traffic |
| Location | Between Carriageway or street parking and footpath on either edge of the carriageway | Between Carriageway or street parking and footpath on either edge of the carriageway | On the edge of the carriageway, adjacent to the footpath or parking. | |
| Gradient | 1:12 – 1:20 (min) | 1:12 – 1:20 (min) | 1:12 – 1:20 (min) | 1:12 – 1:20 (min) |
| Desirable | | | | |
| Lane width | 2.5 to 5.0m | 2.5 to 5.0m | 1.5 to 2.5m | Mixed with motorized vehicular traffic |
| Level | +50mm to +100mm | +50mm to +100mm | 0.0m | 0.0m |
| Minimum Width | 2.2 for a two lane cycle track and 3m to 4m for a common cycle track and footpath (not more than a length of 40m. | 2.2 for a two lane cycle track and 3m to 4m for a common cycle track and footpath (not more than a length of 40m). | 1.2m painted cycle lane. | Mixed condition |
| **Pedestrian Paths** | | | | |
| Gradient | 1:20 | 1:20 | 1:20 | 1:20 |
| Level | +150mm | +150mm | +150mm | 0.0m |
| Lane width | 2.5m (including curbs) to 5.5m each side. However where secondary footpaths are available along service lane, the minimum width of secondary paths can be 1.5m minimum(including curbs) | | | |
| *Based on site observation, if required, the secondary/side footpaths could equal or larger than the primary path | 2.5m (including curbs) to 5m each side. | 2.5m (including curbs) each side. | 0-2.5m (including curbs) each side. | |
| Minimum Width | 1.8m | 1.8m | 1.8m | 1.8m |
| * To be applied on both directions of ROW for streets which have uni-direction vehicular traffic | | | | |
| **Green Belt / Utility Zone** | | | | |
| Width | 0.75m (min) desirable = 1.5m | | | |
| Location | Primarily between carriageway and cycle track. Secondary between cycle track and pedestrian path. In addition tree planters may be provided between parking bays on the service lane. | | preferably located between cycle lane and pedestrian path | preferably located between carriageway and pedestrian path |
| **Parking** | | | | |
| Width | Parking width can vary from 2.5m (parallel parking) to 5.0m (perpendicular parking) along with adequate width of access road. | 1.8 to 2.5m width (parallel parking) | Non defined, mixed function with motorized vehicular traffic | |
| Location | Service lane only | Service lane only | Along carriageway between cycle lane and footpath | preferably be located between carriageway and pedestrian path |
| Levels | 0.0m | 0.0m | 0.0m | 0.0m |

Speed Limit (km/h)

50

# Arterial Streets

They are the primary roads for ensuring mobility function. They carry the largest volumes of traffic and longest trips in a city. These roads are characterized by mobility and cater to through traffic with restricted access from carriageway to the side. In such cases, special provisions should be introduced to reduce conflict with the through traffic. These roads have the maximum right of way amongst the four categories and cater to a speed limit of 50 km/h and a ROW of 50-80 m.

Figure 39: National Highway 2 - Existing Cross section AA

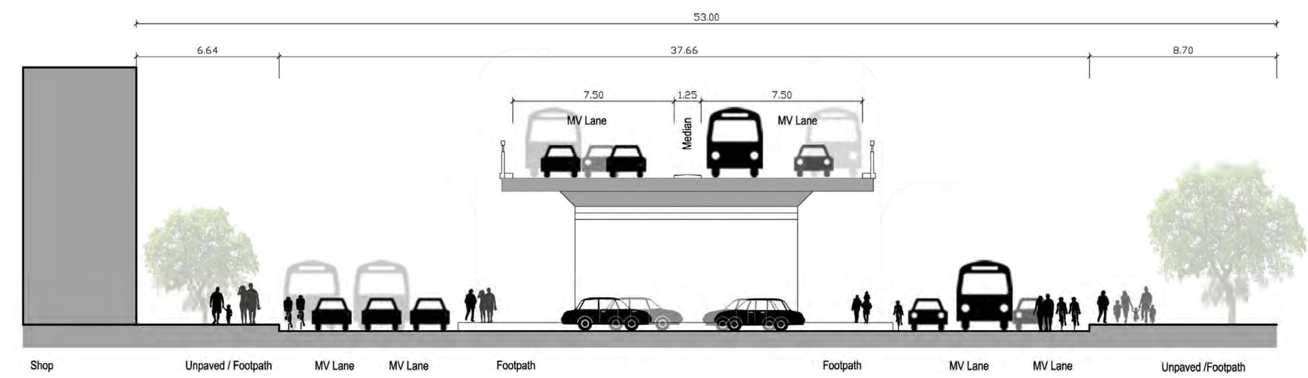



Figure 40 : National Highway 2 - Existing Cross section BB (at foot of

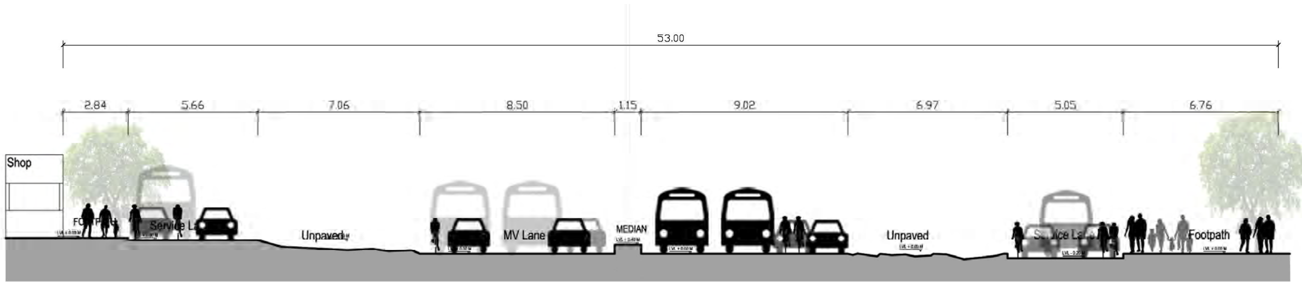



Figure 41 : National Highway 2 - Existing Cross section CC

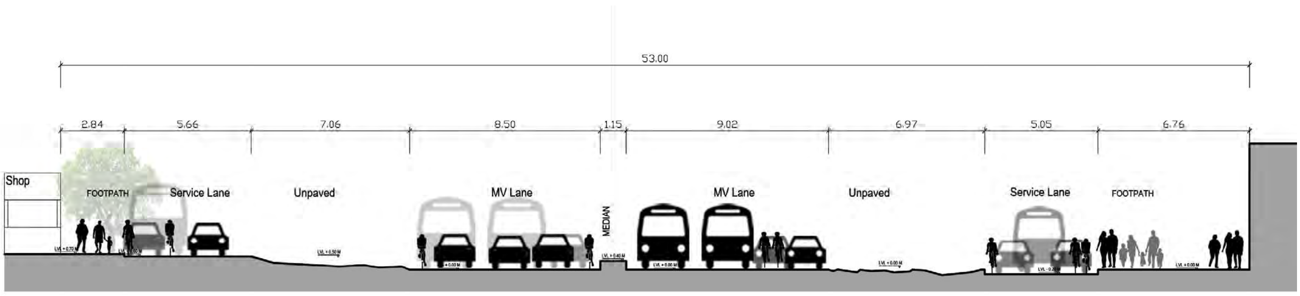


Figure 42: National Highway 2- Proposed Cross Section AA

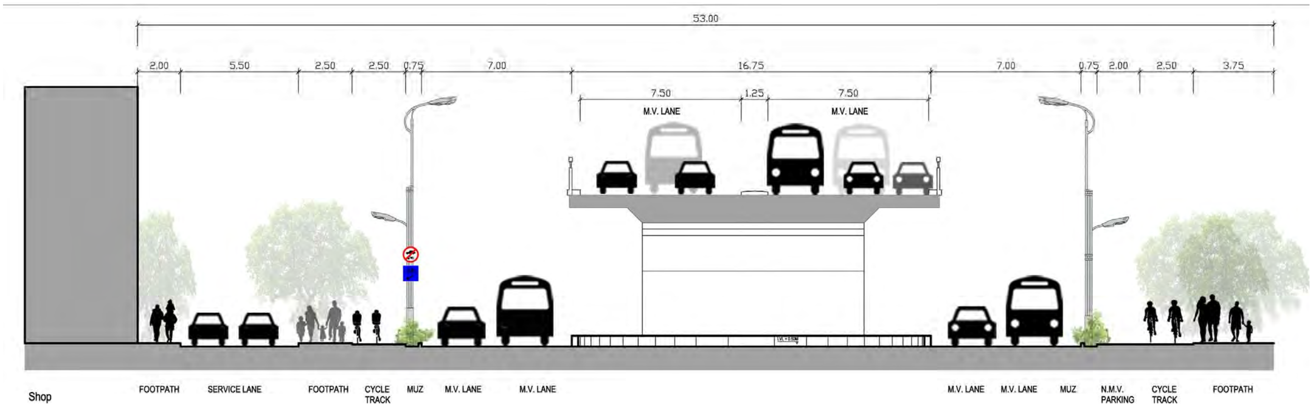



Figure 43: National Highway 2- Proposed Cross Section BB

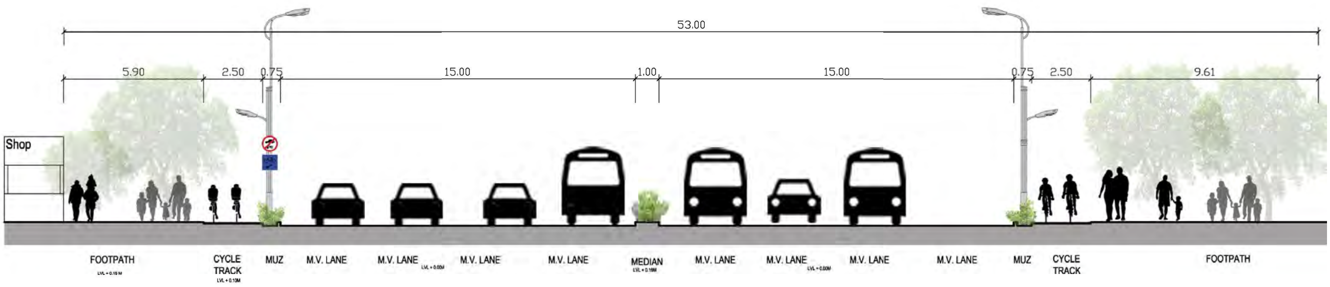
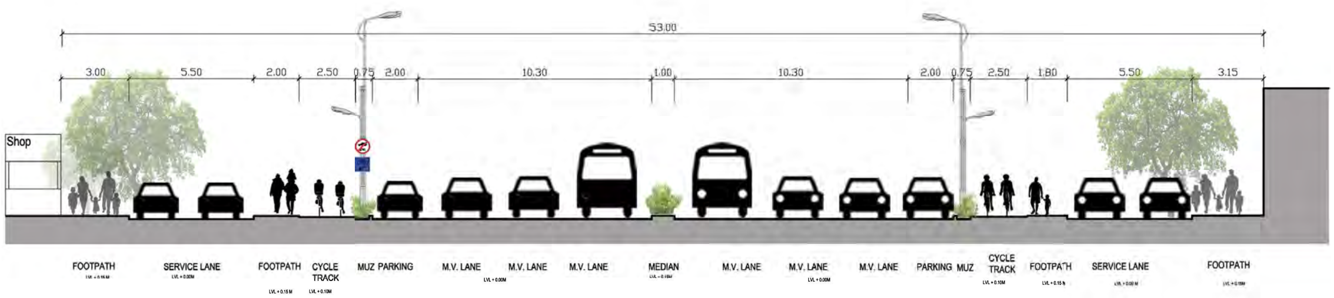



Figure 44: National Highway 2- Proposed Cross Section CC



Speed Limit (km/h)

**50**

# Sub-Arterial

This category of road follows all the functions of an Arterial Urban road and are characterized by mobility, and cater to through traffic with restricted access from carriageway to the side. It carries same traffic volumes as the arterial roads. Due to its overlapping nature, Sub arterial roads can act as arterials. This is context specific and is based on the function and the land use development it passes through and caters to a speed limit of 50 km/h(same as arterial roads ) .The ROW of this category of roads varies from 30-50 m.

**Figure 45: Existing Cross section - MG Road**

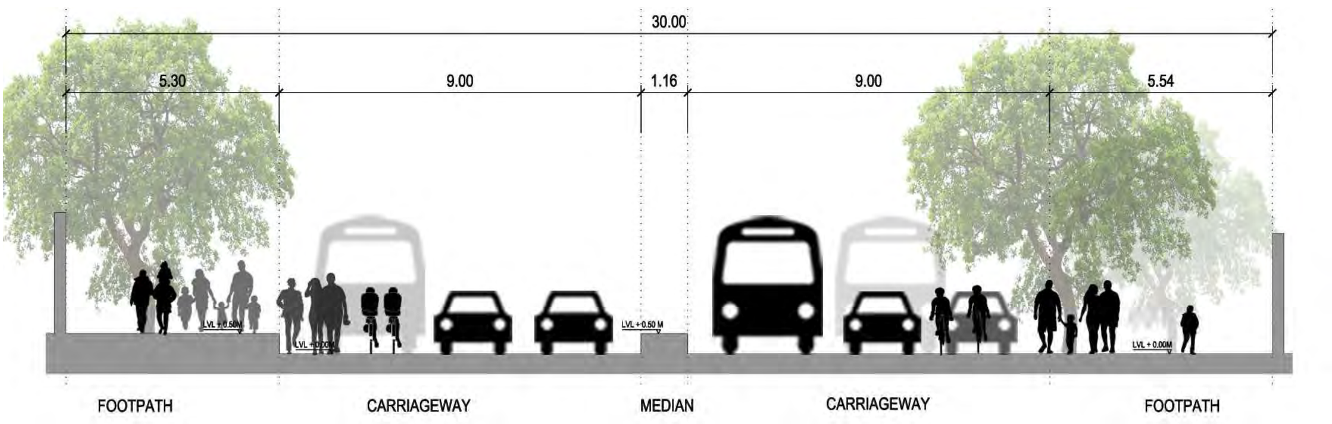



**Figure 46: Arterial Road (existing)**
**Source : SGArchitects, New Delhi**

**Figure 47: Arterial Road (Proposed)**
**Source : SGArchitects, New Delhi**

Figure 48: Proposed Typical Cross Section - Mahatma Gandhi Road

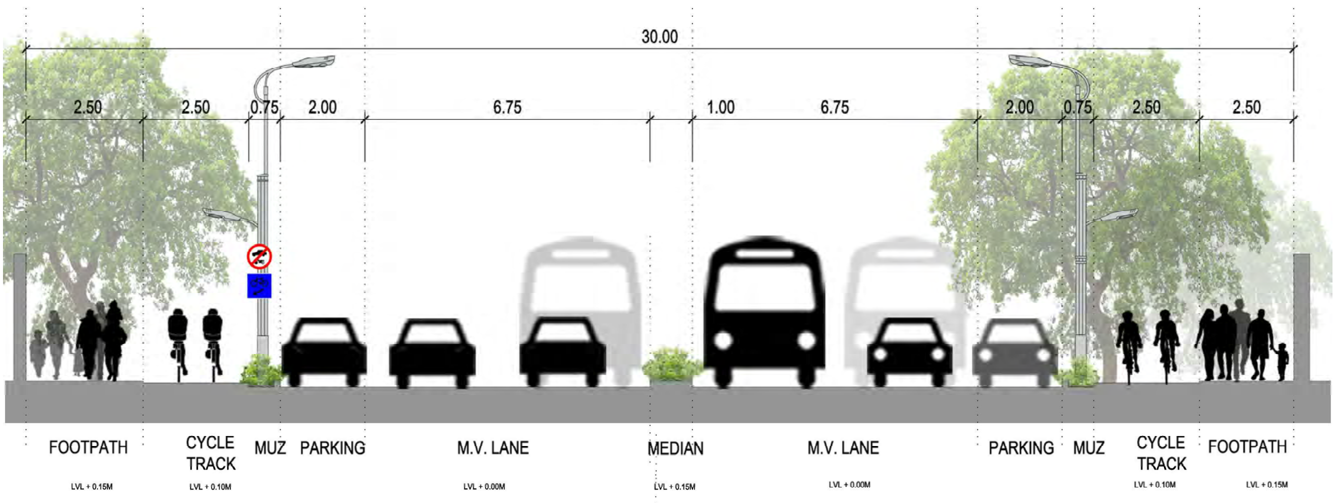



Figure 49: Sub-Arterial Road (existing)
Source : SGArchitects, New Delhi

Figure 50: Sub-Arterial Road (Proposed)
Source : SGArchitects, New Delhi

# Collector Streets

Speed Limit (km/h)

**30**

As the name suggests, these are connector roads which distribute the traffic from access streets to arterial and sub arterial roads. They are characterized by mobility and access equally. They are characterized by a design speed of 30km/h and have a ROW midway of access streets and two types of arterials i.e. 12-30m. It carries moderate traffic volumes compared to the arterial roads. Due to its overlapping nature, distributor roads can act as an sub arterial and as access streets, depending upon the function and the land use of the surroundings.

**Figure 51: Collector Road - Existing Cross section**

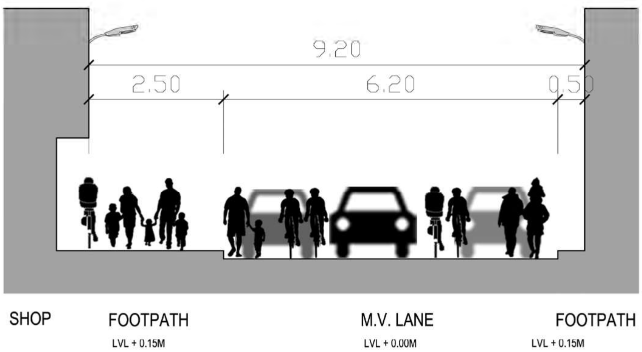



**Figure 52: Collector Road : Proposed Cross Section**

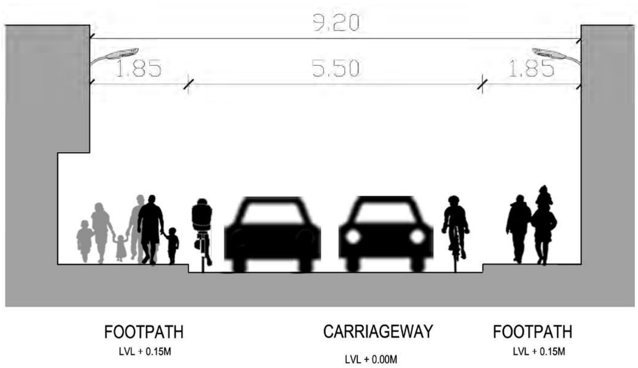



**Figure 53: Collector Road (existing)**
**Source : SGArchitects, New Delhi**

**Figure 54: Collector Road (Proposed)**
**Source : SGArchitects, New Delhi**

# Local Streets

Speed Limit km/h

**15**

These are used for access functions to adjoining properties and areas. A majority of trips in urban areas usually originate or terminate on these streets. They cater to a design speed of 15-30km /h and have a road right of way of 15m-30m. They carry relatively lower volumes of traffic at low speeds. They are characterized by access predominantly; they can be used for collector functions.

**Figure 55: Hospital Road - Existing Cross section**

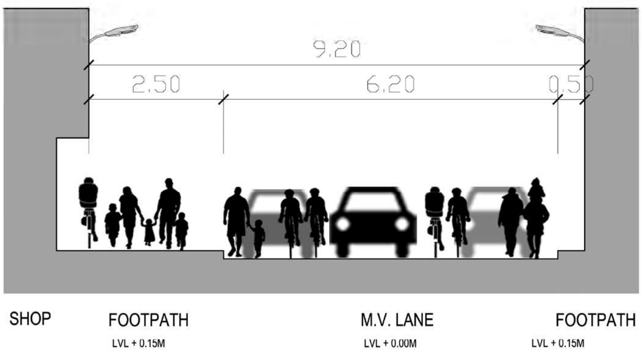



**Figure 56: Hospital Road : Proposed Cross Section**

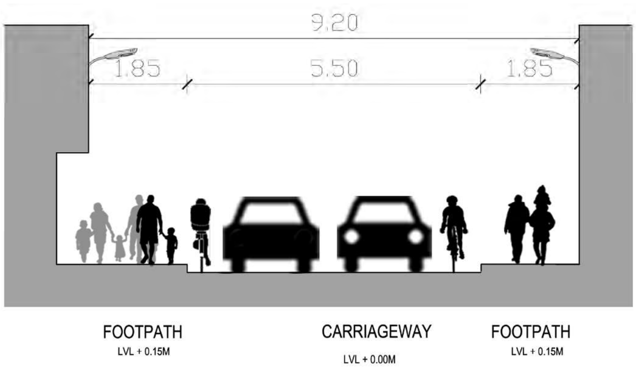



**Figure 57: Access Road (existing)**
**Source : SGArchitects, New Delhi**

**Figure 58: Access Road (Proposed)**
**Source : SGArchitects, New Delhi**

# 4.2
# Intersection Design

Intersection functions to control conflicting and merging traffic and to achieve this, intersections are designed on certain geometric parameters and are broadly classified into three main heads. Designers are often faced with tough choices of prioritizing the conflicting requirements of one mode over another. Here the key is to apply the most appropriate solution based on the type of junction as well site conditions/ constraints.

The three main types of junction solutions are:
1. Un signalized intersection,
2. Signalized Junctions
3. Roundabouts

Different combinations of the intersection type is determined primarily by the number of intersecting legs, the topography, the character of the intersecting roads, the traffic volumes, patterns, and speeds, and the desired type of operation.

Types of intersection depending on the geometric forms are as follows
3- Leg Junction, 4- Leg Junction, Multi-Leg Junction
**Grade Separated Facilities:** There are various solutions possible between junctions of different road types. Grade separation of intersecting motorized vehicle carriageway (flyovers, etc) is a high cost intersection design solution, which may be suitable for use on highways or expressways. Such solutions are not desirable within the built up areas or urban limits due to their adverse impact on accidents, pollution, etc. However, grade separation of cycle and pedestrian traffic across high-speed and high volume motorized vehicle carriageway may often be advisable to ensure safety of cyclists and pedestrians.

Wide roads and grade-separated junctions divide the urban landscape into separate zones. It becomes very difficult for people to cross these arteries on foot or using other non-motorised modes. This has the effect of discouraging public transport use, as all commuters using buses have to cross the road at least two times for every round trip at the origin or the destination. The area occupied by grade separated intersections is much greater than ordinary intersections. The location of bus stops at grade separated intersections is often changed from the present location which is close to the intersection to the foot of the flyover. (Tiwari, G. 2001, " Traffic Segregation: A Case for Bus Priority Lanes with Segregated Cycle Tracks - Case Study Delhi", Workshop on Transportation, Landuse, and The Environment, Pune, December 3-4.)

There are various aspects of intersections including signaling and detailing.

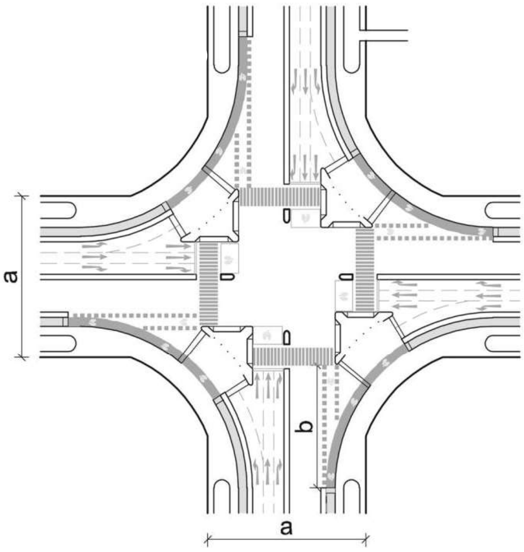
More Info:
1. Code Book - 2 : Intersections
2. Planning and Design Guideline for Cycle Infrastructure

**Figure 59: Best Practise - Raised Crossing (Unsignalised)**

**Figure 60: Signalised Intersections - Unsafe and improper design**

**Figure 61: Signalised Intersections - Unsafe and improper design**
**Source : Design of Urban Roads: Intersection**

Roundabout




Signalised Intersection

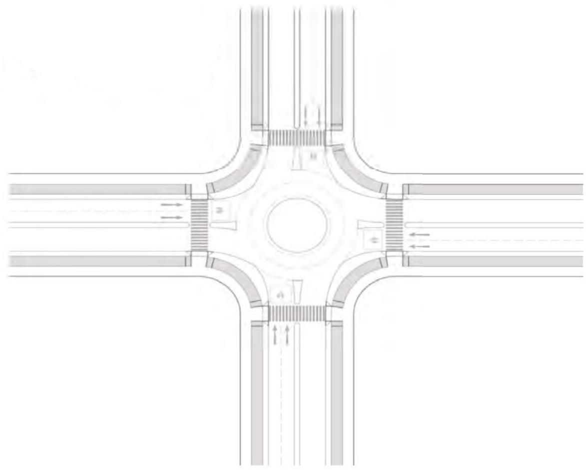


**Table 5: Comparison between Roundabout and Signalised Junction**
**Source : Code of Practice II, IUT, 2013**

## Roundabout

**Pros**

- Reduces the number of conflicts to eight as against 32 in un-signalized intersections.
- Ensures safety through speed reduction by design. This is particularly useful at late night hours when speeds are high and compliance of signals and traffic rules is low.
- Minimal or no delays for all road users including cyclists.

**Cons**

- Roundabouts are not very effective for more than two circulatory lanes. They have capacity limitations and may not be able to handle a very high volume of traffic.

## Intersection

**Pros**

- Signalized intersections can handle high traffic volumes. This can be achieved by accommodating wider carriageway with more number of lanes.

**Cons**

- Four times the number of conflicts than the roundabout.
- Safety is ensured by eliminating conflicts through signalization – high dependence on enforcement.
- Higher delays for all road users including cyclists.

# Crossing the Road

The distance between two junctions should be 500m – 700m each, to offer commuters a comfortable walking distance. In case the distance is more, a signalized crossing needs to be added at a mid block to facilitate safe at grade crossing.

Figure 66 showcases proposed crossings and junction typology for MG Road, Agra. Only, if it is not possible to introduce a new crossing due to high speed traffic on a highway/expressway grade separated crossing facilities should be provided which comply with universal accessible principles.

In order of preference, half subways preceed footoverbridges in a grade separated facility.

## 1. At Grade

Figure 62: At Grade Crossing , Delhi

## 2. Half - Subways

Figure 63: Half Subway

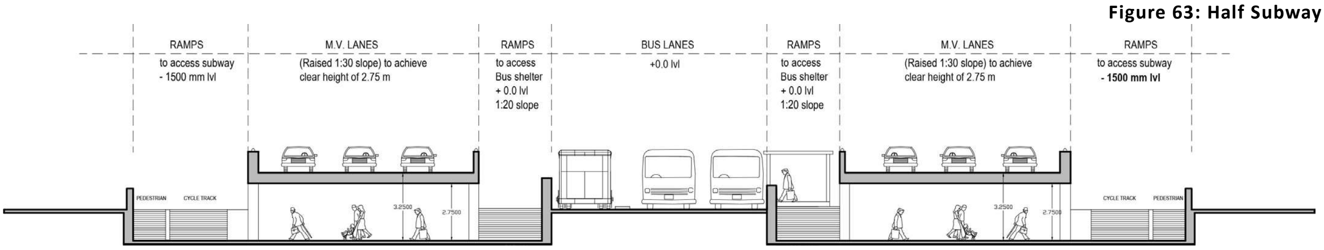
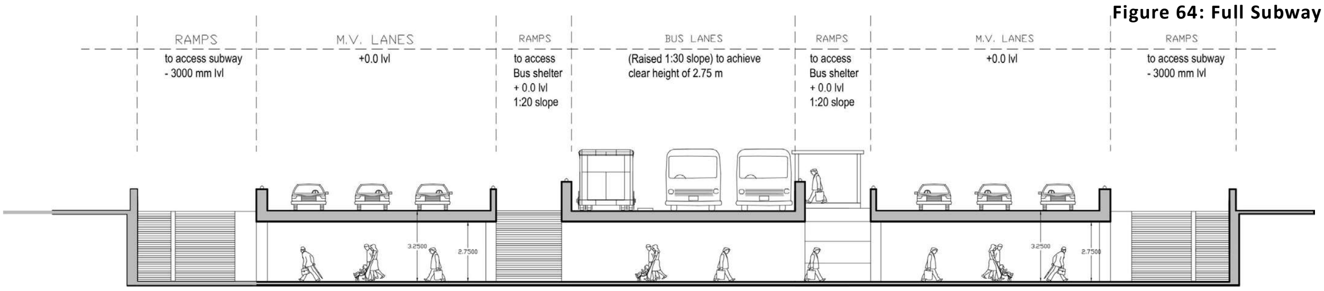



Figure 64: Full Subway

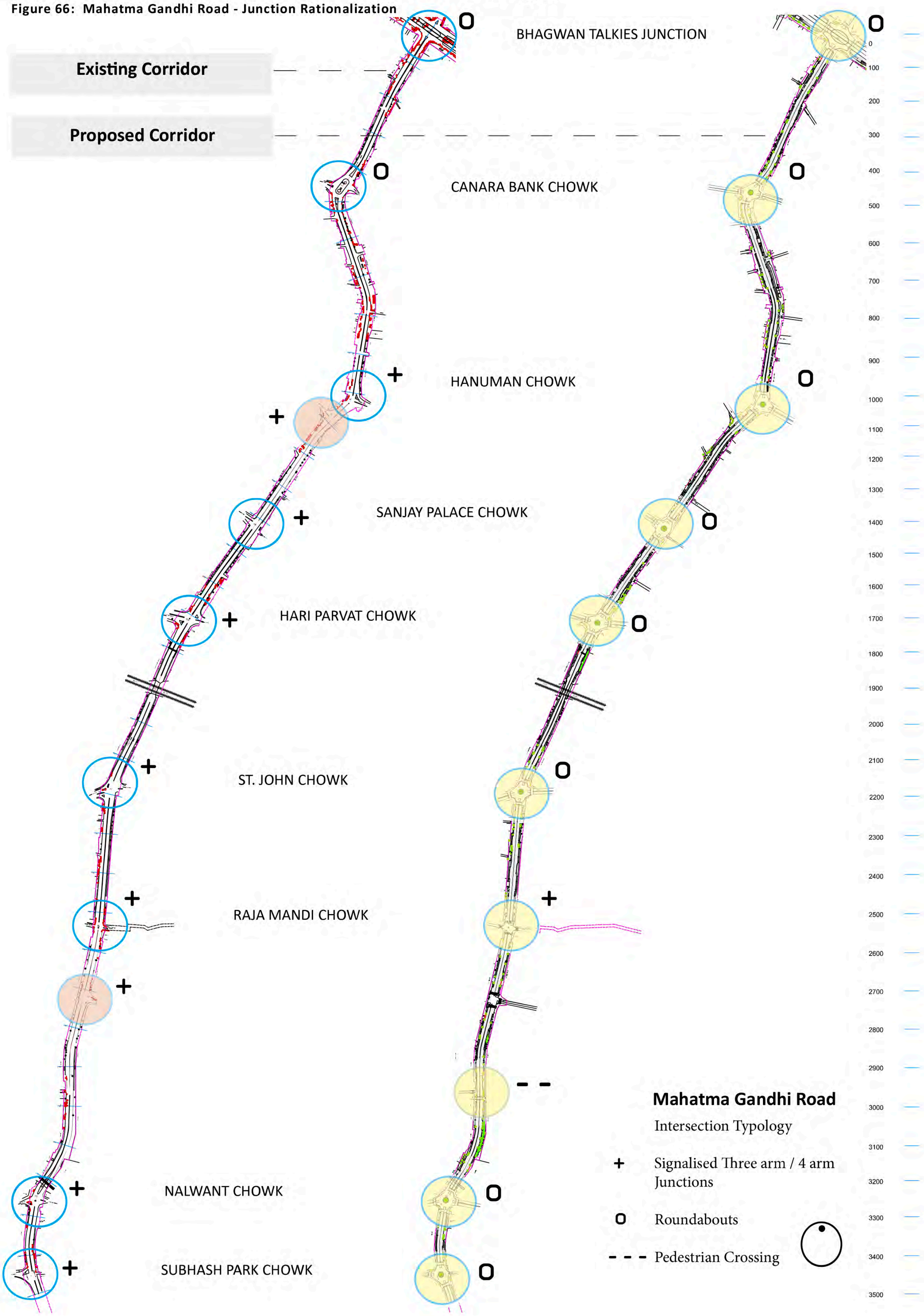



## 3. Foot over Bridges

Figure 65: Existing Foot Over Bridge at MG Road, Agra


More Info:
1. Bus Rapid Transit Design Guideline, 2014

Figure 66: Mahatma Gandhi Road - Junction Rationalization



# 4.3
# Street Infrastructure

Figure 67: Streets as public spaces in Agra


People use streets as social spaces. All components of road design and various road users interact in a such a manner that it creates an urban system. This urban system fosters public spaces.

For eg. at a bus shelter, one may find hawkers, autos, rickhsaws, some area where cars drop/ pick commuters. Similary at the corner of an intersection, there are places where toilet blocks for better visibility and also advertisements are placed for revenue generation. Infront of colleges, universities, offices, one may find hawkers and para transit modes that are service providers to students and people coming/ going to offices. People meet on streets and look for places to sit. In scorching summer months, it is a tree line that makes commute a bit easy.

In order to generate public activity on roads, it is vital to integrate such conditions at the same location as today.

Some key components to be integrated are:

• Bus Shelters – When curb side shelters are installed on the road, it needs to be connected to the pedestrian path.

• Hawker Spaces – Presence of hawkers and street vendors provides security and services to road commuters. Allocation of a dedicated space shall also make the street more lively and interesting.

• Para Transit – TSR and Cycle rickshaw are feeder services and need to be integrated in the cross section as well as intersections at critical locations to enhance seamless multi-modal accessibility.

Apart from the above, toilets, other public amenities, resting areas and seating are also important. They provide comfort and rest areas for both pedestrians and cyclists. They can help in identifying an area of different function. The use of street furniture definitely assists in improvement of the urban quality of road infrastructure. In addition to its aesthetic quality, street furniture plays a role in segregating spaces and adding facility for different users.

The following should be taken into consideration while adding street furniture:

- Vandal-Proof. All street furniture should be vandal-proof.
- Easy to install.
- Requires little or no maintenance.
- Attractive design.
- Economical design.
- Ease in production.

Use of dustbins and location of amenities such as public toilets, kiosks, information booths are other types of street furniture that make the infrastructure more attractive.

An attractive tree line and shade makes the entire street attractive. Use of hedges and green belts is recommended.

More Info:
1. Bus Rapid Transit Design Guideline, 2014
2. Planning and Design Guideline for Cycle Infrastructure, 2014

## Hawker Spaces

Bicycles, pedestrians and bus traffic attracts street vendors. Often the side roads and pedestrian paths are occupied by people selling food, drinks and other articles, which are demanded by these road users. Vendors often locate themselves at places, which are natural markets for them. A careful analysis of location of vendors, number of vendors at each location and type of services provided them shows the need of that environment, since they work under completely "free market" principles. If the services provided them were not required at those locations, then they would have no incentive to continue staying there.

However, road authorities and city authorities view their existence illegal. Highway design manuals recommends frequency and design of service area for motorized vehicles. Street vendors and hawkers serve the same function for pedestrians, bicyclists and bus users. As long as our urban roads are used by these modes, street vendors will remain inevitable and necessary. All modes of transport move in sub-optimal conditions in the absence of facilities for pedestrians and non-motorized vehicles. ncase no provision is facilitated and no integration by design is undertaken, there is bound to be an encroachment on to the infrastructure provided for other users.

**Figure 68: Integarted Hawker space, Delhi**

## Location of Bus Shelter

Bus Shelters need to be located every 500-700m. Also the junctions are rationalized on the same principle. However, in the current scenario bus shelters have been located at a greater distance or away from the junctions. This increased the access length of a commuter to the bus shelter or to his/her destination. Also, it can be seen from the activity survey that in the vicinity of the bus shelter, hawkers, cycle rickshaws, e-rickshaws etc are present.

The bus shelters have been proposed to be located between 20m - 40m at the near-side of the junctions which are also proposed as roundabouts. There are two advantages :
1. Bus Stop slows the traffic approaching the intersection.
2. The Right of Way (ROW) of the roundabout is better used.
3. Bus Commuters have to walk less distance.

Design features that have been introduced are:
1. Dedicated spaces for NMV Parking, TSR Parking and Short term car parking bays. Table Tops to facilitate safe crossings. Addition of rumble strips prior to table top crossing to slow traffic.

**Figure 69: Existing scenario at Bus Shelters**

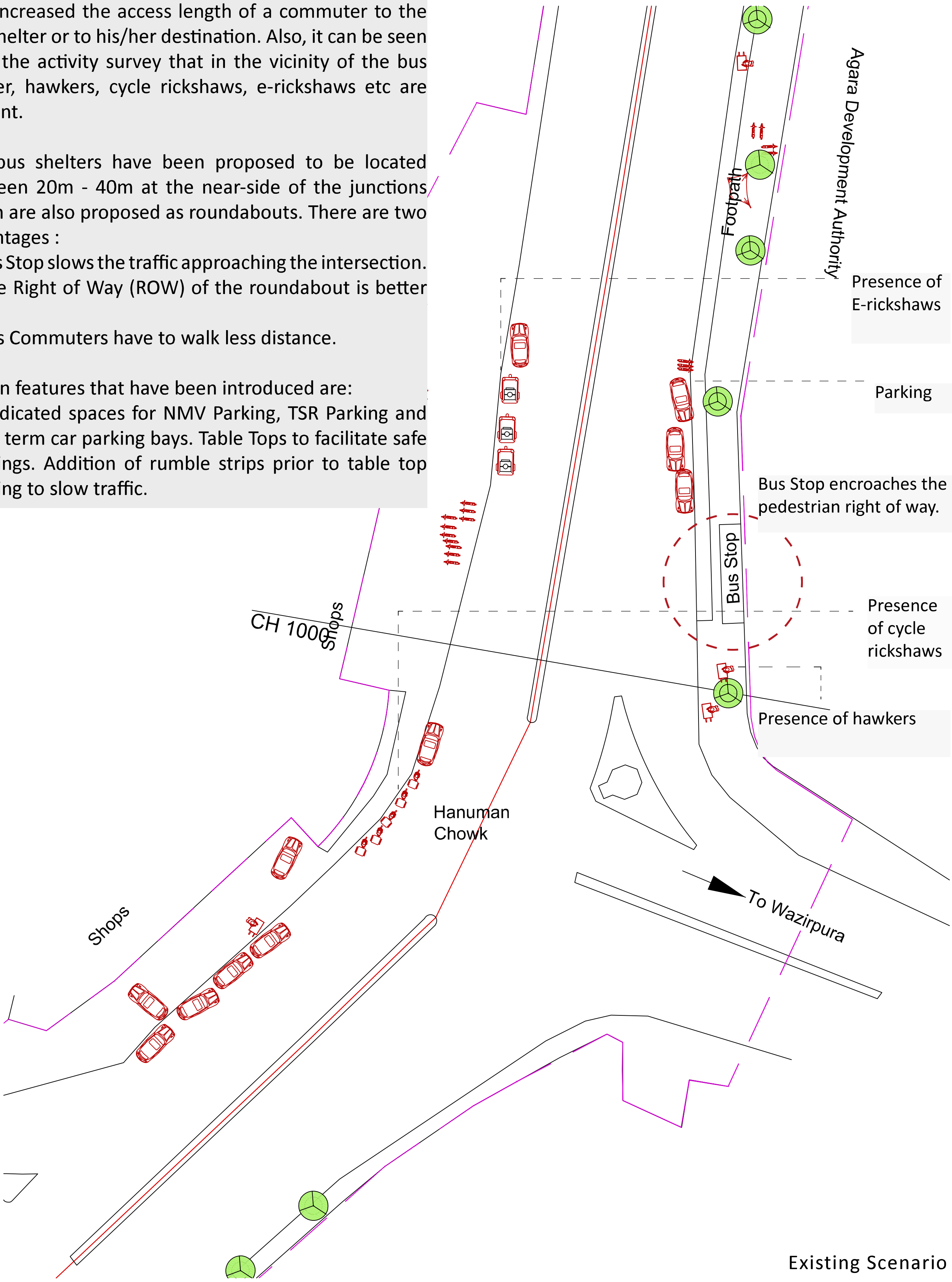
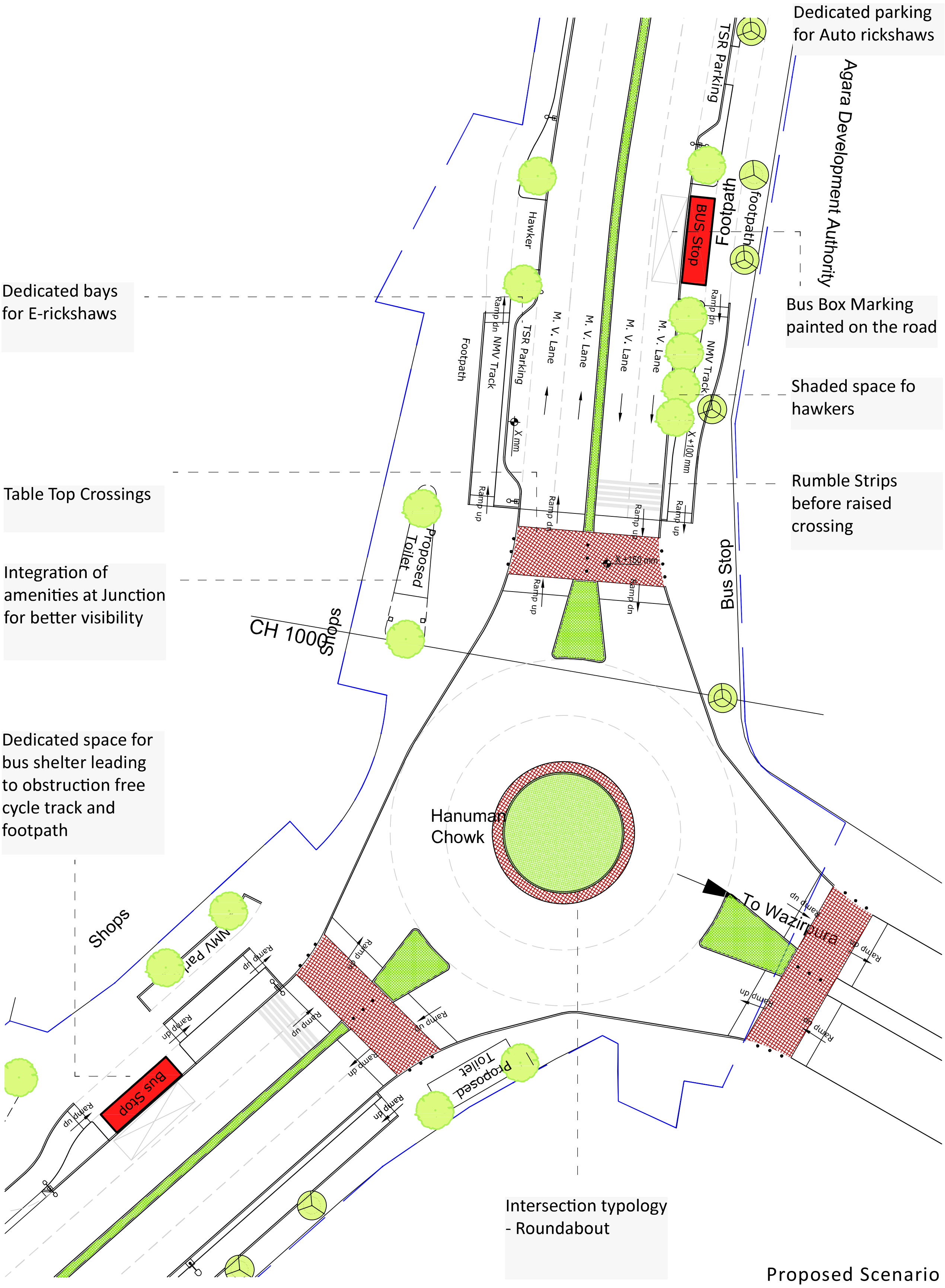


**Figure 70: Proposed scenario at Bus Shelters and integration with junctions**




Proposed Scenario

## Integration of Feeder Service

(as per activity survey)

Commercial stretches also have a high presence of hawkers and vendors. Since markets are also destinations, one can see rampant on-street parking as well as presence of cycle rickshaws, e-rickshaws bringing people and also acting as feeder to bus transportation. Much of this encroaches pedestrian infrastructure and also creates high friction with other modes.

Space needs to be allocated while planning and integrate feeder infrastructure, vendors and hawkers as close to their previous location.

**Figure 71: Existing scenario of feeder services and vendors**

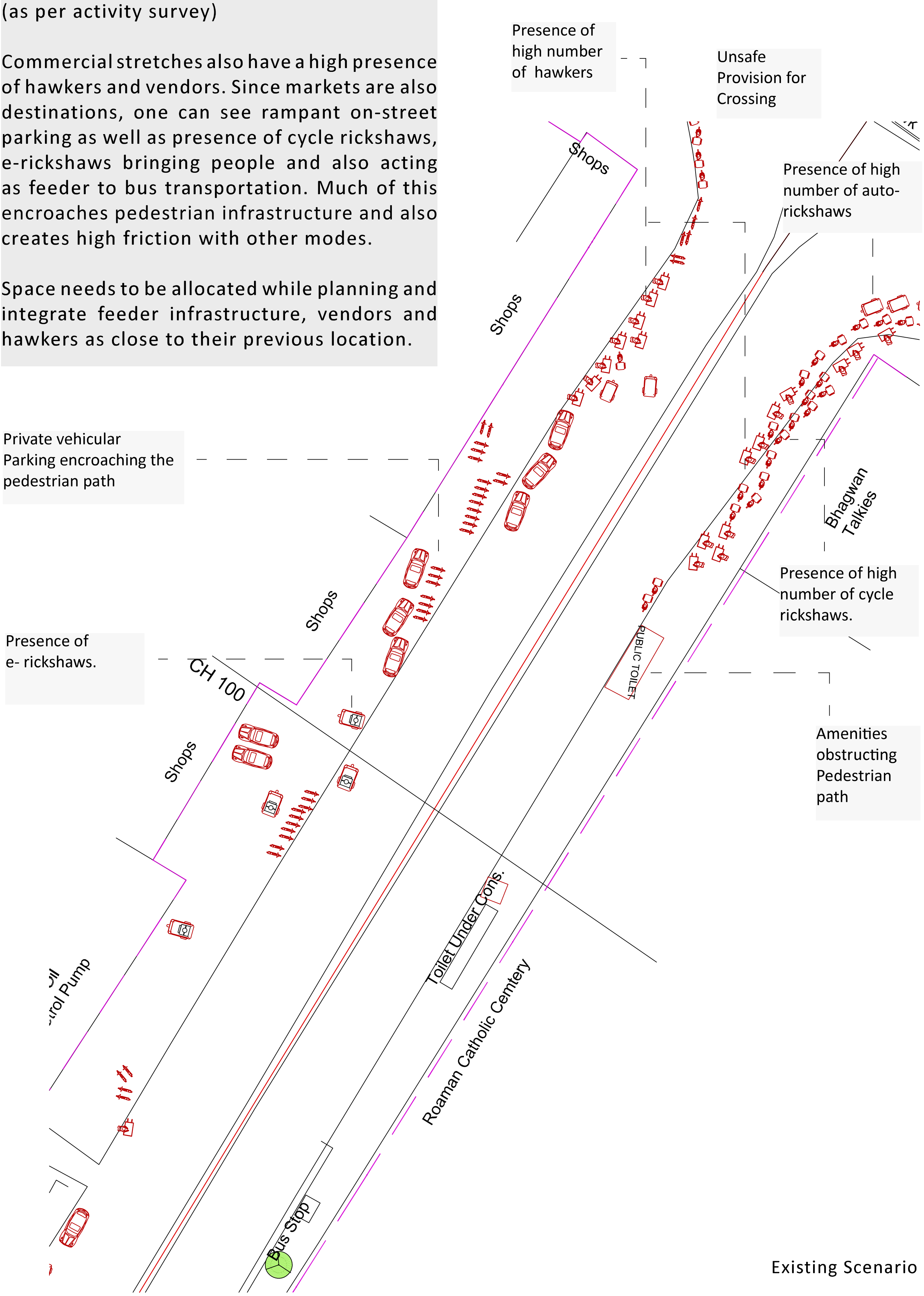
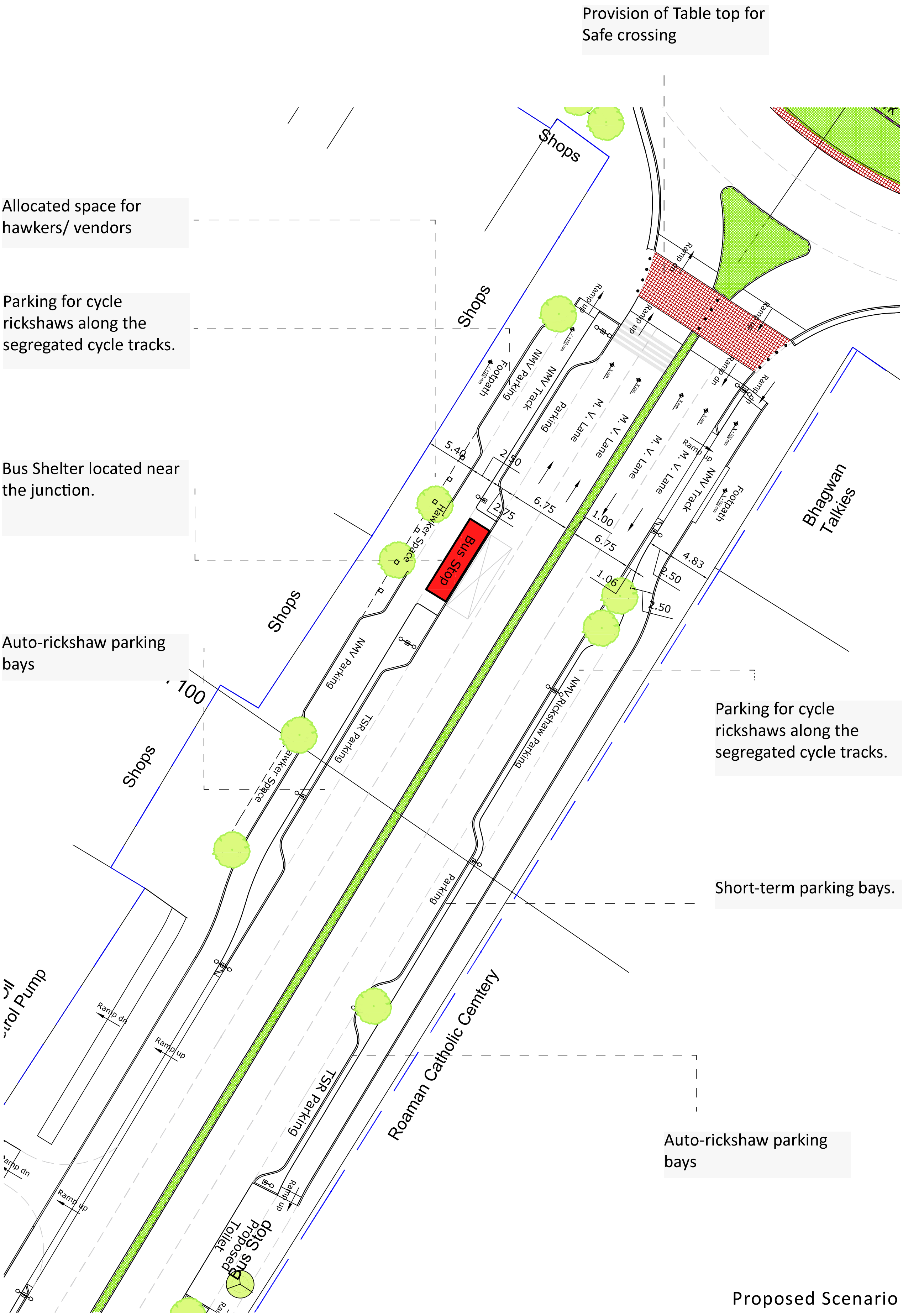


Figure 72: Proposed scenario of feeder services and vendors



# 4.4
# Services, Signage & Marking

**Drainage :** Improper design of gully gratings, water collection on streets creates incovenience for all road users especially the pedestrians and the cyclists. It should be taken care that no services that require regular maintenance should be laid below the cycle track. The green verges should have the provision of gratings that take surface water from the carriageway as well as the cycle track (slope 2%). Water travels through a pipe to the storm water drain. For distributor and access streets placing a collection grating along the edge of the footpath can be placed. A bell mouth arrangement to collect water is not recommended. The grating should be flush with the floor of the carriageway and the cover should not hamper the movement of cyclists. The cover of the grating should be perpendicular to the direction of the travel of bicyclists so that the tyre does strike it.

**Other Utilities:** There are various utilities running longitudinal and across the ROW of any category road. These include storm drains, underground and overhead electrical lines, gas pipelines, optical fibre cables and others. Usually it is seen that an annual maintenance is required which involves roadwork and therefore disruption of movement of traffic for a temporary period. In such a case, the location and depth of laying these utilities is of utmost importance. The important point is to rationalize all available existing and proposed services in order of their maintenance works and see that they do not come in the way of the efficiency and functioning of streets.

**Lighting:** Street lighting makes the available space legible for each road user. The illumination of a street is governed by the posted design speed. Lighting also adds to the comfort and is required for visibility of a roadway and it adds to the safety of all features of a road design. In fact, lighting is the basic street furniture required in the functioning of the safe streets.

Location of Poles is decided depending upon the category of the road. It could be the central verge or at the sides where a segregated cycle facility is available. Two luminaries can be mounted on a pole

Figure 73: Utlity Belt along the carriageway, BRT Delhi

located between the carriageway and the cycle track at different height to light the required area with the required lux levels. This would also reduce the number of poles required and the vertical clutter on any given road.

**Color of Light:** Street lighting should produce enough intensity required for face recognition and objects from a particular sight distance. Especially for the purpose of social safety, women and children are a special group for whom the color of light is of added importance. White light is a preferred choice. The advantages of white light are as follows: In a segregated facility, it easily distinguishes between the fast and slow moving zones. It creates contrasts for pedestrians with tactile paving provided for the differently-able and the visually impaired.

**Signage:** The importance of a signage is that it keeps the road user informed of the following:

- Important destinations and routes
- Unexpected conditions
- Traffic laws
- Facilities like Public conveniences and Parking areas.
- Differently-abled environments, facilitated by the following elements:

**Inclusive Signages:** combination of easily recognisable symbols using contrasting colors, Audible Signals or Auditory Signals along with a Braille marking and International symbol of Accessibility (ISA). The international symbol of access (ISA) also known as the International Wheelchair Symbol. It is used as an informatory sign with blue background and image of a person using a wheelchair overlaid in white.
- Guiding and Warner Tactile Blocks
- Railings wherever necessary

Signage is a comprehensive system of Regulatory, Informatory and Warning messages corresponding to the information for all road user groups. Refer IRC 67: code of practice 3.

**Marking:** Road markings are essential to guide the road users and to ensure a smoother flow of traffic. Markings have to be of standard color and dimensions and should be marked at appropriate places so as to optimize their visibility and effectiveness.

Road surface marking is any kind of device or material that is used on a road surface in order to convey official information. Road Markings are defined as lines, patterns, words or other devices, applied to or attached to the carriageway or kerb or to the objects within as well as the adjacent to the carriageway, for controlling, warning, guiding and informing all the road users.

More Info:
1. Code Book - 1 : Cross Section Design
2. Code Book -3 : Road Marking
3. Code Book - 4: Signages
4. Planning and Design Guideline for Cycle Infrastructure, 2014
5. Bus Rapid Transit Design Guideline, 2014
6. IRC 67

Figure 74: Road Signs and Marking

# 5.0 Audit

Audits can be used in any phase of project development from planning to construction. The main aim of an audit is to minimize the risk and severity of road crashes; to minimize the need for remedial works after construction; and to reduce the life costs of the project (Austroads, 2002).

It is intended to minimize the risk of a traffic crash and ensure that measures to eliminate or reduce identified urban roadway problems are fully considered. An audit case may refer to city, station area network, route or corridor etc.

## City

For a city level audit, a sampling methodology needs to be undertaken. In the "Toolkit for preparing Low-carbon Comprehensive Mobility Plan (UNEP, 2012), a sampling methodology was undertaken to evaluate a city. A sample should include about 10% of the entire road network of the city covering all type of roads. The sampling methodology needs to be applied for household surveys and information about infrastructure inventory.

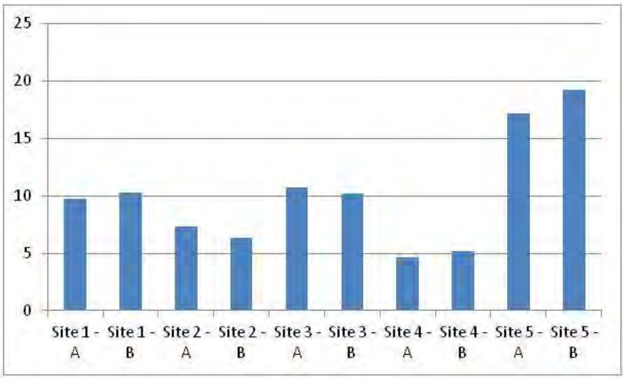
## Corridor/Route

When a corridor or route is desired to be audited, the audit can be conducted for cycling infrastructure independent of the context or in relation to the context. In the Urban Road Safety Audit Toolkit (MoUD, 2012), the audit selection is based upon road type and context.

## Transit Stops

The Public Transport Accessibility Toolkit ((MoUD), 2012) can be conducted either during the construction of a new public transport facility or in redesigning an existing facility. It is necessary to understand different access modes and plan for each and every one of these and potential access modes to ensure accessibility to PT. This helps in identifying the access modes for which intermodal connectivity need to be provided in Indian cities. 5 types of modes were thus identified as pedestrian, cyclists, IPT users, bus users and private motor vehicle users. The area in which the audit has to be carried out is dependent on the type of road user.

**Figure 75: Audit Results on 5 roads for pedestrian infrastructure using URSA Toolkit. Survey conducted at TRIPP. in 2014**




Maximum Score : 22

**Figure 76: Sample Checklist from Public Transport Accessibility Toolkit**

| Direction: Location B – SB Marg – Max meuller Marg | | | | | | |
|---|---|---|---|---|---|---|
| Indicators | (A) Present: 1 pt / Absent: 0 pt | (B) Quality Good (1 pt) | Fair (0.5 pt) | Poor (0.2 pt) | (C) (A)X(B) | Remark |
| **Comfort of Pedestrian / Quality of Footpath** | | | | | | |
| 1)Pavement type | | Concrete/ Interlocking block/ Paver blocks/ Tar/ Asphalt | Tiles | Unpaved/ non metaled surface | 1 | |
| 2) Width of footpath | | 1.7 to 5.0m (including curbs) | 1.5 - 1.7m | < 1.5m | 1 | |
| 3) Height of footpath | | < 100mm (4") | 100mm (4") – 300mm (12") | Very user unfriendly (>300mm) | 0.5 | |
| 4) Cleanliness and maintenance of footpath | | Well maintained footpaths | Need better maintenance and cleanliness | Foot paths are not maintained | 0.5 | |
| 5) Provision of amenities (lighting, Hawkers exclusive zone, cover from sun and rain, etc.) | | Pedestrians provided some good amenities and feel safe | Limited number of provision for pedestrians and slightly uncomfortable at late nights | No amenities and Unsafe | 0.2 | There were no hawkers, sitting places and 75% street was shaded. |
| 6) Provision of Disability friendly Infrastructure (tactile flooring, audible signals, railing, ramps) | | Infrastructure for disabled is present | Some infrastructure is available | Mostly absent | 0.2 | |
| 7) Degree of obstructions on footpaths (obstructions such as trees, parking vehicles, hawkers and vendors etc. should be absent) | | There are no obstructions | Pedestrians has to slow down sometimes | Pedestrian has to slow down most of the time | 0.5 | |
| 8) Signage for Pedestrians | | Frequently and Visible | At some points | Very rarely or not visible | 0.5 | |
| Overall | | | | | 4.4/8.0 | |
| **Safety of pedestrians** | | | | | | |
| Speed of Motor Vehicles | | < 30 km /hr | 30-40km /hr | > 40 km/hr | 0.2 | |
| 2) Light after dark (Visibility to walk after dark) | | Light poles at every 20 m and lighting intensity of 40 lux along the road and 50 lux at crossing | Light poles at every 20 m with lighting intensity of 20-40 lux Or Light poles at every 40 m with lighting intensity of 40 lux. | Average distance between Light poles distance is >40 m Or Intensity of light less than 20 lux. | 0.2 | |
| Overall* | | | | | 0.4*2 0.8/4.0 | |
| Total score for pedestrian accessibility | | | | | 5.2/12.0 | |

More Info:
1. Planning and Design Guideline for Cycle Infrastructure, 2014
2. Urban Road Safety Audit Toolkit
3. Public Transport Accessibility Toolkit

## BIBLIOGRAPHY


WHO COLLABORATING CENTRE

**Transportation Research & Injury Prevention Programme Indian Institute of Technology Delhi New Delhi 110016**

**http://tripp.iitd.ernet.in**

## Appendix 5: Streets for Safe Communities

# STREETS FOR SAFE COMMUNITIES

## GUIDELINES

INDIAN INSTITUTE OF TECHNOLOGY DELHI

# STREETS FOR SAFE COMMUNITIES

## GUIDELINES

Transportation Research & Injury Prevention Programme

Indian Institute of Technology Delhi

New Delhi 110016

January 2015

**Project Team**

Geetam Tiwari, Alokeparna Sengupta, Dinesh Mohan and Ruchi Verma

## Acknowledgements

This work was supported by The International Association of Traffic and Safety Sciences (IATSS).

Suggested citation

TRIPP (2015I. Streets for safe communities guidelines. New Delhi: Transportation Research & Injury Prevention Programme, Indian Institute of Technology Delhi.

# Table of Contents

## INTRODUCTION

## CITY FOR ALL

**The genius loci of Indian cities is its vibrancy and diversity, visible in all aspects of urbanity, but especially so within its street life.**

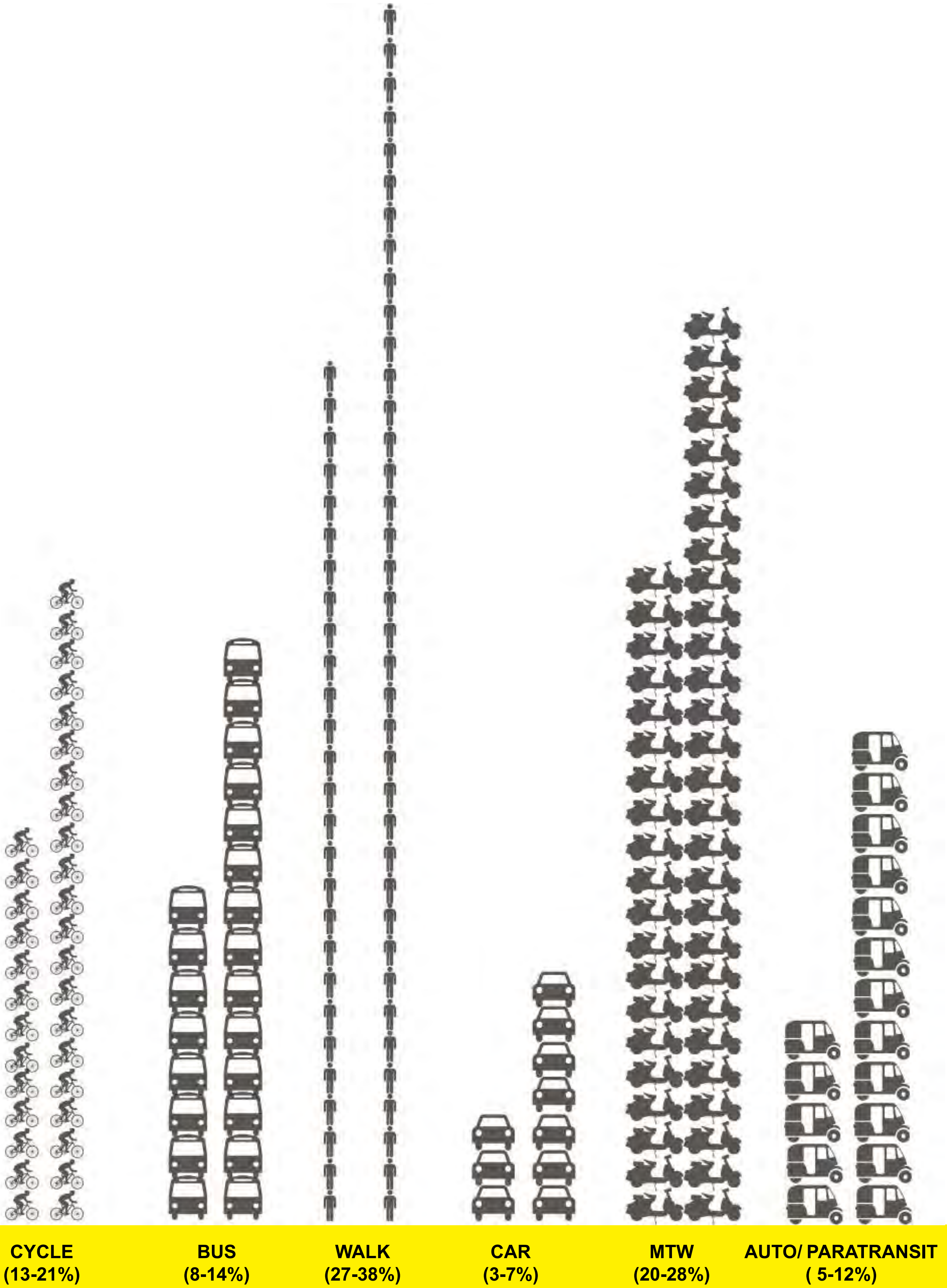
The demographic diversity of cities is reflected within its public spaces. Enabling the urban environ to accommodate these diverse activities in a safe way, asks for creating an unique modality of operations. City design needs to acknowledge the existance of diverse situations and build capacity to contain them.

It is important to promote activities like walking to the local grocery store, cycling to work or taking a bus to a distant part of the city, amongst all income and age groups. Inorder to do so, these options should be made viable, through safe and comfortable infrastrcutural provisions. Though most Indian cities show high percentage of non-motorised transport usage - both for modes and capita, the actual quality (and hence viability) of these spaces is questionable.

This is evident in the high percentage of non-motorised transport (NMT) users being involved in accidents in Indian cities - indicating the unsafe navigation condition. Pedestrians and cyclists are the most vulnerable group in our cities, due to the absence of proper footpaths and almost nil existance of cycle tracks. They have to share road space directly with cars, buses and trucks, with no buffer or grade separation provisions. Navigating in Indian cities, is more of a trade-off between affordability and forced choices, rather than decision making based on safety and comfort.


Unsafe crossing situation. Location : Delhi, Source : Author


No space allocation for pedestrains and cyclists. Typical condition of urban roads in Indian cities Location : Agra, Source : Author




Modal share in medium and large Indian cities.
Source : Tiwari & Jain, 2008

Note : Each unit represents 1%

The present structure of our large and medium scale cities which is progressing more and more towards a dispersed state, interspersed with poor transport infrastructure, presents a challenging situation with respect to minimising travel distance or accessibility to opportunities of higher education and work. Faced with neglible or poor connectivity via public transport, such challenges are overcome with private transport modes. Such modalities of access, cuts off a large group of people to these opportunities, who are not able to afford car ownership and car-pooling charges.

Ironically, a major part of these unacknowledged strata of citizens bring vibrancy and life to our city streets, in their quest for earning a livelihood through hawking, street merchandise and informal trade. They are also the ones who almost singlehandedly contributes to sustainable soft mobility modes - walking and cycling, in their quest to be mobile.

While international examples of bike friendly cities depict cyclists who may be rich, middle income or poor, in Indian cities, it is more of a circumstantial selection, in the face of unaffordable choices of private transport and negligible provisions of continuous connectivity through public transport .

Slow and fast modes in the same space gives rise to higher chance of conflict and crash. Location: Delhi, Source: Authors

*People in middle-and-low income countries are forced to walk or use public means of transportation as a consequence of living in informal sectors with substandard housing, poor basic infrastructure, and few economic resources to afford private transportation. Many transportation policies [...] neglect the access and transportation demands of the more economically disadvantaged groups of society, who rely mostly on public transportation, walking and cycling. ( Andres Villaveces in Mohan, D. 2012 )*

Despite a large number of trips being made by cycles, very few roads in India have basic amenities such as cycle tracks.
Location : Delhi, india, Source: Anvita Anand

Apart from the streets of the old and historic parts of most Indian cities, the human-scale of our urban environments has progressively decreased since the 1960s. A comparative study of the historic and the modern streets of Indian cities, brings out the lack of comfortable and safe navigation, in the latter context. Being constantly exposed such conditions, acitivites like walking at the edge of carriageways in the absence of footpaths have become a normal and accepted affair.

Enabling the viability and liveability factor in our cities, means creating a sensitive communication between the “built - enclosed ; built - open ; semi-built - open” urban spaces. While the built - enclosed ( i.e. our homes, offices, shops, schools, colleges etc. ) and semi-built - open ( i.e. public parks ), are vital for the realization of our work and life, it’s the built - open spaces ( streets, roads, pavements) which are pivotal in getting us to our destinations.

Girls walking in the middle of the road due to absence of pavements. Location: Agra, Source: Authors


Cyclist stuck amidst cars on the road and cars parked on pavements. Location: Delhi, Source: Authors

It is also crucial, that the conjunctive spaces - the common edges of land use and streets, which accommodate our vibrant street life in the form of hawkers along with the most vulnerable groups of street users i.e the pedestrians and cyclists be included in our planning. The current structure of our street planning focuses solely on moving vehicles. It ignores the spaces for walking, cycling and affordable public transit infrastructures. People first rather than vehicles will foster safe and accessible mobility for all users, since the focus starts from the grass roots level , thereby accommodating all instead of a few.

Make-shift food stalls and hawkers, provide affordable refreshments and resting spots to commuters and are also the first ones to help out accident or street crime victims. Location : Delhi Source: Anvita Anand

Broken and dilapidated footpaths discourage usage and force pedetrains to walk on the carriageway thereby compromising their safety. Location: Delhi, Source: Author

*Key to this people first approach is recognizing that walking is the most universal form of transport. All cyclists, public transit riders and motorists begin their journey as pedestrians and therefore the transit and automobile network can only be as good as the pedestrian network that brings them to other modes of transit ( Jeff Rissom, in Mohan, D. 2012 )*

The daily commute and interaction that connects us from one destination to another, is a vital part of our well being. Enabling the built - open configuration to contain the existing street life in a safe and equitable manner, is also a step towards creating vibrant communities. However, a walk through any street of an Indian city will show, that a majority of the street users are highly unempowered in terms of accessibility and safety.

Be it an old man crossing the street by himself, a cyclist / street hawker confronted with navigating over a flyover , or a mother and child walking at the edge of a road ( due to the absence of pavements) - the evidences in our daily lives are numerous and startling. Is navigating within the relatively safer realm of a car , the only option left for our city users? If so, then can we say that our cities belong to all its citizens ?


Navigating a flyover on a cycle is strenous and compromises on health due to excessive strain caused during pedalling. Location: Delhi, Source: Authors

Walking direclty on a carriageway, alongside motorized traffifc, makes pedestrains, especially aged people, most vulnerable to crashes. Location: Delhi, Source: Authors

The street life of our cities is a representation of a wide range of vocations and livelihoods.

The organic nature of organisation of street trades and vocations in our neighbourhoods, around schools, marketplaces, bus stands etc inspite of attempts at banishing them through nil space allocation, provokes us to take a closer look at their transitory occurrence, and their contributions in supporting the city life. Supporting them through proper infrastructure like pedestrain paths, hawker zones, cycle tracks, and public transit affordable for all, are indeed crucial and of outmost necessity


Cycle tracks are rendered useless and discourages cyclists from cycling, due to small obstructions.
Location: Pune, Source: http://www.mid-day.com/

***The transportation system and the way road spaces are allocated in the cities, is a clear indication of a societal attitude and mind-set. Transport planning is clearly car-oriented, with cars having priority on the high speed road stretches, at the intersections which minimize their waiting time, at flyovers that allow them to avoid the congestions, at market places that give them large parking spaces,and the list goes on. While the authorities may apologize for badly maintainedroads, they would never think of apologizing for the broken pedestrian paths,non-existent bicycle lanes and dilapidated bus shelters and the inefficient public transport now in place.***
***( Ravi, R. TRIPP Bulletin 2005)***

No buffer space for a bus-stop located on a major arterial road, makes the waiting paasengers exposed to fast moving traffic, thereby creating high risk, unsafe situations. Location: Outer Ring Road, Delhi. Source: Authors

## SAFE STREETS.

Sustainable transport needs inclusive streets. Inclusive streets ensure not only safe mobility – reduced risks of traffic crashes – but also reduced street crimes and better social cohesion, and makes public transport, bicycling and walking attractive, and the preferred choice for commuting. Hence, safe streets are complete streets. They ensure door to door mobility for all road users in a safe and seamless manner. They foster a community spirit since residents use streets to meet, access public spaces and socialize.

Safe streets include all user types by allocating spaces for each - a pedestrian, a cyclist, a hawker, a car user and a public transport user. Also, streets by themselves can't be safe, unless and until, a continuous dialogue between landuse edges and streets is created. Active and passive interaction with passers by, well lit pathways and cycle tracks, insterspersed with rest areas and bus-stops prevent creation of lonely and desolate spaces which encourage crime and unsafe situations.

***The sidewalk and street peace of cities is not kept primarily by the police [...]. It is kept primarily by an intricate, almost unconscious network of voluntary controls and standards among the people themselves, and enforced by the people themselves. Jacobs, J (1961)***

An urban village. Location: Hauz Khas, Delhi Source: Authors

***There must be eyes upon the street, eyes belonging to those we might call the natural proprietors of the street. Jacobs, J (1961)***

Span of streets should foster easy visibility and visual reference from both sides of the street. Location: Bidhan Sarani,Kolkata, Source: www.wikimedia.org

A street becomes a public space and increases the vibrancy of the neighborhood, when pedestrians are given priority. Location : Times Square, New York. Source : Jeff Risom

## SAFE STREETS.

Segregated tram lanes and interaction with pedestrains. Location: Kolkata Source: www.wikimedia.com

**Safe Streets put pedestrians first.** Prioritizing vulnerable groups like pedestrians and cyclists, who are the most affected by speeding vehicles and street crimes, is needed during the design and planning of streets.
Any type of streets, any width of streets, needs to address the prerequisites of a pedestrian and a cyclist. Safe streets are built for people and not cars. The multi-dimensional experiences of the pedestrian, cyclist and the motor vehicle passenger must all be considered as one, at the 'eye-level' of humans in the city. Visual contact amongst all street users foster a sense of safety, public pride and 'right to the street' and prevents actions like speeding of vehicles and rash driving due to a sense of 'being watched'.

'Right to the street'. Location: Delhi Source: www.flickr.com

**Safe streets are forgiving in nature.** Human nature is prone to making mistakes. Mistakes range from crossing streets without noticing the red light,ignoring speed limits, taking a left turn where it is not allowed, forgetting to switch on headlights or indicator, the list goes on and is numerous. Each of these mistakes maybe harmless individually, but can lead to fatal or near-fatal accidents, depending on the context of the road. Design of streets, should lessen the impact of human error. Forgiving street enviornment discourages speeding and encourages soft mobility modes to use streets with confidence and reduces fear of harm.

Slowing of vehicle speed through traffic calming measure like raised table top crossing.Location: Delhi Source : www.itdp.com

## SAFE STREETS.

**Safe streets are secure streets.**
Addressing the needs of all user groups, results in a succesful system / network design. Human and mechanical dynamics meet and interact within any given street enviornment. Designing for a robust street system, enhances security through an interplay of “voluntary controls”( Jacobs, 1961), enhanced by visibility and interaction. Newly emerging research confirms that the presence of fear of violence impedes activity levels and the ability to move outside freely, especially among population that are more vulnerable to violence such as children, women, people with disabilities, and older adults.(Cohen, et al., 2013). Presence of fear of violence also fosters distrust and unwillingness to nteract or aid another street user.
A woman walking on a lonely isolated street is less likely to help another person. She is more likely to hurry up to her destination, than stop and an aid another in need due to fear of dupe and attack. While in a busy market, she would be more likely to aid and also call others to assist. Safe streets provide ‘eyes *and a helping hand* on street’.

Street as a system where all components have been allocated space. Location: New York Source : *Active Design Supplement : Promoting Safety, AIA, New York*

**Safe streets are inclusive.** Design of inclusive streets gives a safe environment to all age groups and segregates population from high speed and prevents injuries. An inclusive approach, gives power to the most vulnerable street users through design. Bus and bicycle lanes, pedestrian islands, signalized and redesigned intersections, curbs and sidewalks, frequent and safe crossing oppurtunitiesare detail which when incorporated creates inclusive streets. These details also keep a NMT user well involved in the street enviornment and helps them predicting of driver behaviour and speed, thereby increasing their chances of protecting themselves

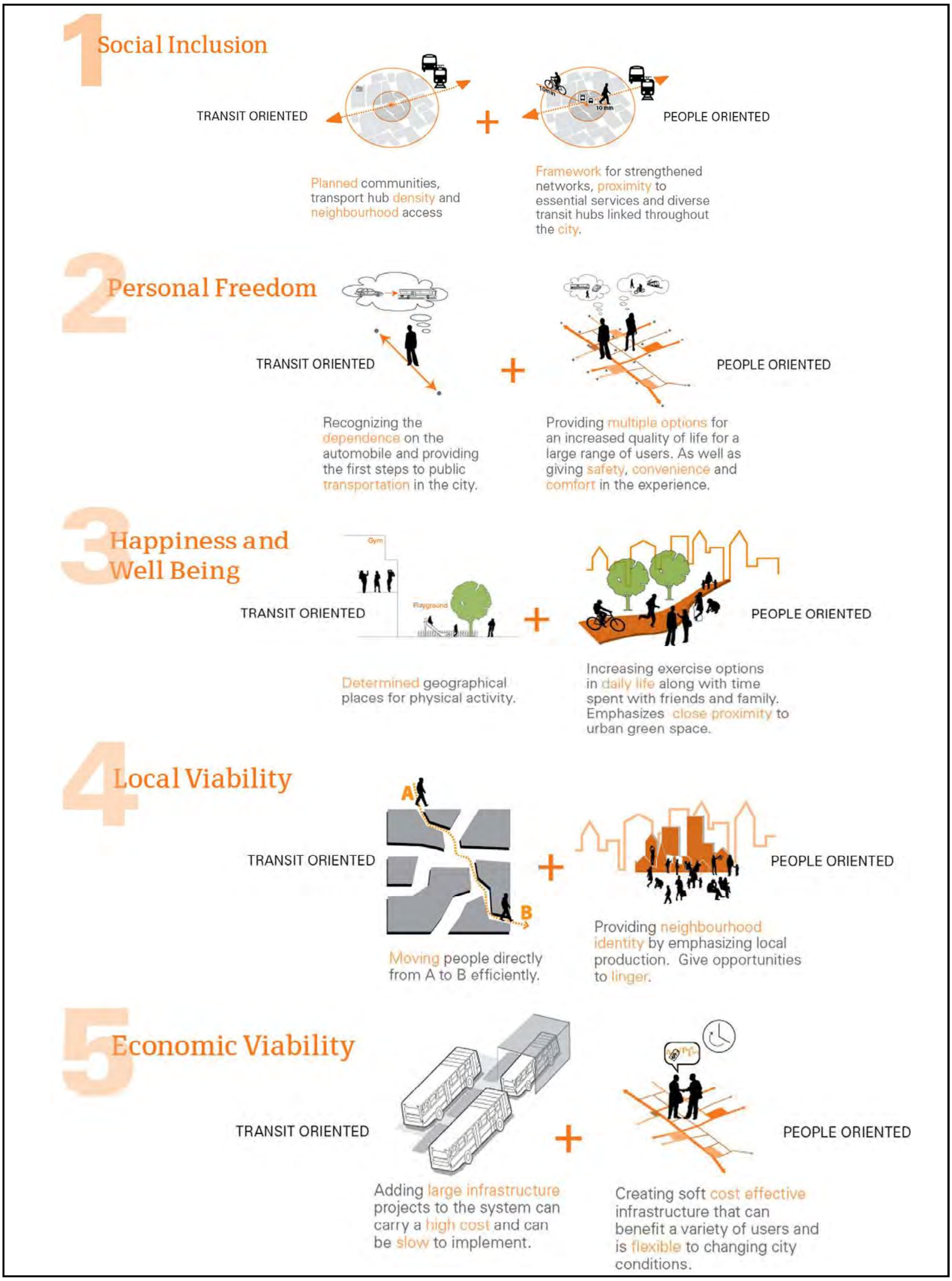
Pedestrains at the top of modal hierarchy. Location: Number One Oxford Street London Source : www.bbc.co.uk

**Safe streets give clean air.** The increased dependence on personal transport leads to high emissions. Comfort of commuting by car can hence lead to a heavy price of breathing in noxious fumes and developing respiratory problems over a period of continuous exposure - for eg. daily commute to work. The more people use public transport or just walk and cycle, the cleaner the air.

Public transport also provides an opportuity to include urban greens Location: Kolkata Source: facingkolkata.wordpress.com

## SAFE STREETS.

A complete system of mobility within a city encourages a sense of equality among its citizens. When successfully incorporated into the grain of the city, public transportation, pedestrian walkways, and bicycle lanes, are usable by all because of their low cost and convenience. In this sense, People First Mobility fosters democracy as well as a sense of individual importance ( Gehl 2010).




Ibidem

## SAFE STREETS

### SOME INDICATIONS AND GUIDELINES

Urban Transport is a means of access and not mobility. Non Motorised Transport (NMT) can offer increased mobility to large parts of the population, safeguard the accessibility of otherwise congested cities and provide freedom of movement to rich and poor, young and old. NMT not only offers environmental advantages but provides a holistic range of benefits to both the individual and the city. This includes health, equity, better air quality, poverty alleviation, road safety, liveable cities and equal opportunities to all irrespective of their socio-economic background. However, there has been a decline in the use of NMT as a result of rising income levels and hostile conditions on roads resulting in a greater dependency on privately owned motorised transport. This not only increases the volumes of traffic on our roads leading to congestion and pollution but also increases our vulnerability to various health issues. (TRIPP, 2013)

***" 98%of Central Government Grants under JNNURM have been used by the Govt. of NCT Delhi in expansion of roads, construction of flyovers and parking projects and in spite thereof there are cars, cars and cars and nothing else. The roads are bursting on the seams due to cars. [...] and since in a democracy it is not to physically possible to seize cars and destroy them, the only democratic solution would be to dedicate road space for buses, which would move quick and fast and this would act as an incentive for people to switch over to public transport."***
***( Delhi High Court , 2012)***

Traffic Congestion , Delhi . Source: https://www.wikipedia.org


Traffic Congestion , Mumbai . Source: https://www.flickr.com

## PRINCIPLES OF SAFE STREETS

### SUSTANAIBLE SAFE TRAFFIC SYSTEM

a road environment with an infrastructure adapted to the limitationsof the road user.

### SOCIAL USABILITY

Apart from being, spaces of navigation, streets our also spaces of meeting, trade and an extension of the urban public spaces. Waiting areas, hawker zones, public amenities like toilets, increase the usability and acceptabilty of streets as spaces of interaction and gives citizen a space to be proud of.

### UNIVERSAL ACCESSIBILITY

The integration of the concept of universal design has been completely missing from our streets. Street design has to answer inclusivity and accessibility for ALL.

### EQUITABLE ALLOCATION OF ROAD SPACE

Pedestrians, non motorized users and the public transport users in urban areas form the basis of sustainable transport systems. Therefore designing a road space for these three user groups in priority is of utmost importance.

### CAPTIVE USERS

Pedestrians, non motorized users and the public transport users in urban areas form the basis of sustainable transport systems. Therefore designing a road space for these three user groups in priority is of utmost importance.


## CURRENT LIMITATIONS OF URBAN TRANPORT

Broadly speaking, three issues are important in confronting the current limitations of the urban roads in Indian cities :

### OVERCOMING MYTHS

Currently the usage of NMT modes and public transport,suffer certain myths, which further detriment their popular usage. Identifying these myths is essential for overcoming them and building  NMT inclusive road infrastructure design .

### SAFE AND COHERENT NETWORK

The success of an urban transport infrastructure depends on the functionality of the network as a whole. Each aspect like bus routes, cyclist tracks, pedestrian pathways, crossings and intersections function as parts of a whole system. Isolated focus on each or any wouldnt be effective in providing any benefits to the user and would sooner or later lead to shift to privatev vehicles or unsafe trapped usage conditions.

### CORRIDOR PLANNING

While being part of a larger network, each cross-section of road falls under a specific typology anfd demands specific design solutions and details to make it work efficiently and safely. While the coherence of the whole network is of utmost importance, it wouldnt be possible without a succesfull detailed intervention at the micro- scale of the road space

# MYTHS ABOUT CYCLISTS AND CYCLE USAGE

### CYCLE SHOULD BE ONLY BE USED IN INTERNAL ROADS

**FACT** : India has a high share of current users and they will prefer using the road network which is more direct and faster

### SEPARATE TRACKS ARE NEEDED ONLY WHEN VOLUME OF CYCLISTS IS HIIGH

**FACT** : Separate cycle tracks are needed for all roads with and above 30m right of way inorder to prevent conflict

### CYCLE IS USED PREDOMINANTLY BY MEN

**FACT** : A large number of women of all age groups use the bicycle nd rrickshaw for work and commute

### IN METROPOLITAN CITIES TRIP LENGTHS ARE LONGER, PEOPLE HAVE TO TRAVEL LONGER DISTANCES

**FACT** : Nearly seventy percent of the trips are shorter than 10kms regardless of city size. There are about a million cyclists in metropolitan cities like Delhi. The average trip length is about 10km

# MYTHS ABOUT CYCLISTS AND CYCLE USAGE

## NMT = BICYCLE

**FACT** : NMT also covers tri-pedal rickshaws and four wheeled vendor trolleys apart from others used for inclusive mobility

## THERE IS NO SPACE FOR CYCLE INFRASTRUCTURE

**FACT** :There is a lot of wasted space on the road. Equitable road space allocation can be easily done according to the classification of road to provide usable and safe cycle infrastructure

## CYCLING AS A MODE OF COMMUTE IS FOR LOWER CLASS ( ECONOMICALLY WEAK ) PEOPLE

**FACT** : The two pictures above show a sharp contrast between the cyclists. While the former is using a low cost cycle in normal work clothes, the latter is using an expensive cycle, along with safety helmet. Apart from the marked difference in the economics of cycling, the pictures show that commuting by cycling can be practicised by all - either rich or poor.

# MYTHS ABOUT BUS USAGE

## INDIAN ROADS AREN'T WIDE ENOUGH FOR BUS LANES

**FACT** : The above two pictures clearly depict that dedicated bus lanes can function quite well even in a 2 lane and 4 lane condition.

## DEDICATED BUS LANES CREATE CONGESTION


**FACT** : The above example clarifies that bus lanes, instead of creating congestion, clears out chaos caused by a mixed mode situation. This chaos is largely responsible for adding to the traffic congestion, along with high volume of cars

# MYTHS ABOUT PEDESTRIANS

### DISABLED PEOPLE ARE TAKEN CARE OF, THEY DONT NEED TO BE ALONE ON THE STREET

**FACT** : Disbaled people are not able to navigate on the streets independantly, as footpaths are not universally accessible and they have to share the same road space as cars and buses.

### FOOT-OVER BRIDGES ARE THE BEST WAY TO CROSS ROADS

**FACT** : At grade crossing is the most comfortable way of crossing for pedestrians.

### THERE IS NO SPACE FOR FOOTPATHS, DUE TO HIGH VOLUME OF CARS

**FACT** :Street edges lack proper thought and design , thereby wasting a lot of space, which if properly designed, can provide ample space for footpaths

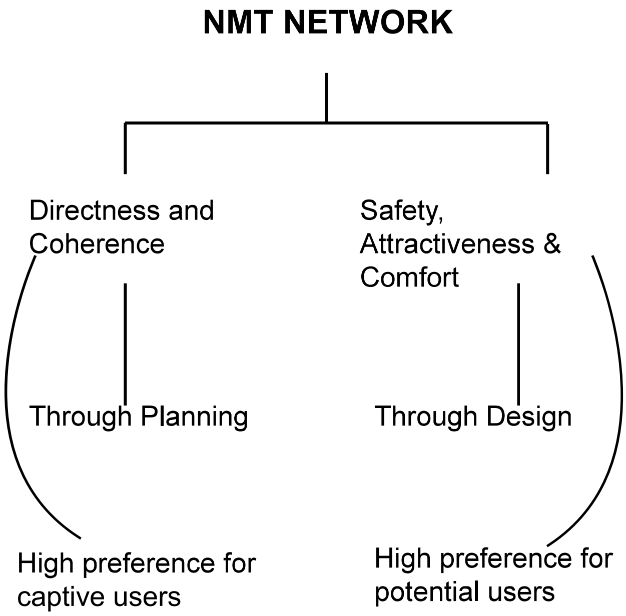
### STREET HAWKERS CREATE UNSAFE AND CHAOTIC ENVIORNMENT

**FACT** : Even if they are an integral part of urban life and economy, their existance is actually ignored when it comes to planning and designing of infrastructure, thereby leading to chaos.

### SAFE AND COHERENT NETWORK

The planning for NMT modes cannot be carried out in isolation but needs an integrated approach addressing the needs of all road users. Planning for cycle and pedestrian paths, bus lanes and stops, integrating with metro station access, on-street parking, para transit stands, hawkers; etc. all require to be integrated in the planning process to ensure that the NMT infrastructure functions as planned.

*At a network level, the NMT network is far denser than the MV network and the public transit network. While they overlap, the NMT network needs to be fine-grained with the highest connectivity – in effect there may be streets which are NMT only, but all MV and PT networks should have NMT integrated in their plans.*




Equitable space allocation and grade separation for all user types leads to a safe and coherent network. Delhi BRT ; Source :TRIPP

Continuous cycle tracks without obstructions contribute to coherence . Location : Delhi, Source : Authors

The three major components needed for an efficient urban transportation network are explained below.

**Coherence and directness (Connectivity)**
Cyclists and pedestrians use a given infrastructure only if it provides a continuous connection between their origin and destination. The lower the travel time, the higher the directness. At network level, a cohesive network would involve minimal detours for cyclists accessing it

Footpaths interspersed sitting areas and resting zones offer comfort and increase attractiveness of the infrastructure. Location : Delhi, Source : Authors

**Attractiveness and Comfort**
Due to their slower speed compared to motorists, pedestrians and cyclists are sensitive to microenvironments on the streets and this may affect their route choice or decision to walk or cycle.

*Factors adversely affecting the comfort of NMT users by choice are: traffic bottlenecks, steep gradients, nuisance caused by traffic noise and emissions, bad riding quality, presence of obstructions resulting in frequent braking or slowing down, etc.*

Facilties like low floor buses not only enable universal accessibility, but also provides additional safety to aged people and pregnant women.Location : Delhi, Source : Authors

**Safety and Security**
NMT users are very vulnerable in the case of crashes. In common practice of increasing NMT safety is to segregate them from motorized vehicles in time and space. The most effective option would be to segregate users into separate tracks or paths along the road network, (especially if the speed limit for MV is over 30 Km/hr). On other streets there is a need to reduce their speed difference by traffic calming without affecting directness or coherence.

## CORRIDOR PLANNING

For identifying what is wrong and lacking from our urban streets, it is important to know the various types of streets and their related modal space allocation.

**The arterial and sub-arterial roads** ( colloquial term- main roads) have usual right of way ROW ( total span of space between land use on either side ) of 50 - 80m. Arterial and sub-arterial road can easily have dedicated bus lanes upto a maximum of 6-8 lanes for the former and 4-6 lanes for the latter. Lanes can have a width of 3.3 - 3.5 m . Segregated cycle tracks and pedestrian footpaths of 2.5- 5 m should be provided.

*These are the roads, where we see the highest concentration of all the different modes and hence the probability of accidents which are fatal, is also very high. Also, due to their ample width, they encourage speeding, if proper design measures havent been taken during planning and implementation phases, to slow down speeding instincts. These roads are important in defining the coherence at a macro scale, in the sense that they are the dominant players in giving a language, form and identity to the entire road network of a city.*

**Distributor streets** a ROW of 12 -30m and can have a maximum of four motor lanes of 3.0m width each. Cycle lanes on the edge of carriage way, adjacent to footpaths and parking of 1.2 m width, painted on asphalt is sufficient on these roads. They connect our so called main roads to our close knit alleys of residences and commerce. These carry moderate volume of traffic, at a relatively slower speed.

*These streets form the buffer between are neighborhoods and the main traffic roads , and hence play an important role in bringing us out of our intimate narrow streets to the hustle and bustle of bi-directional fast moving traffic. Traffic calming is important here, as these streets contain movement of kids, young adults and old people at a larger volume than the main roads. Neighborhood kids cycling in groups during evening play time, old people walking to the neighborhood community centres / religious buildings, are the most prone to accidents on these roads. The distributor street spaces should be well complemented with outdoor furnitures like benches and drinking water and foster a sense of community interaction.*

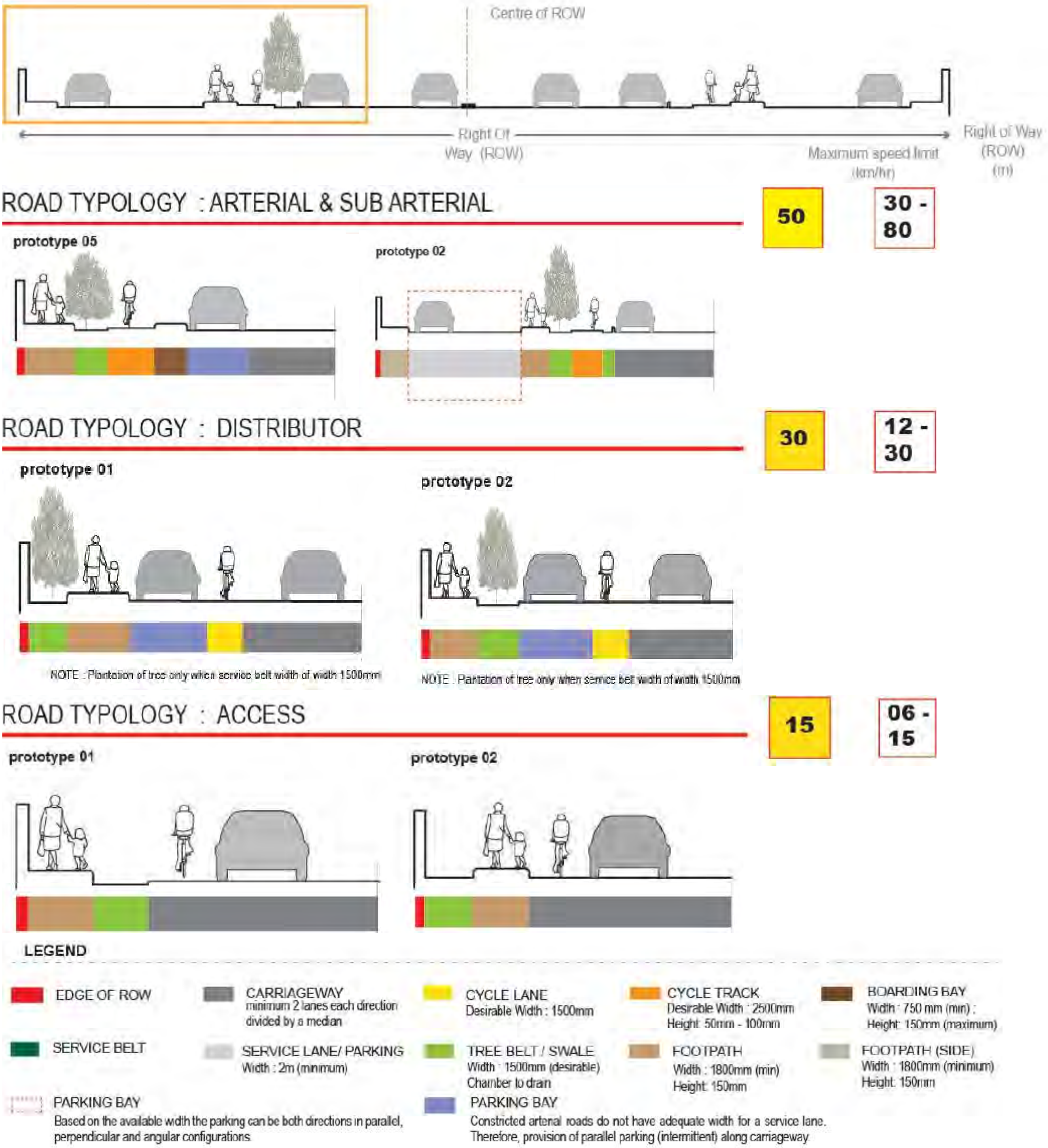
**Access streets** are the streets, on which we directly step out from our residential buildings ( sometimes local street shops / offices ). These carry very low volume of traffic, at very low speeds. They have a ROW of 6-15 m and have 1-2 lanes of 2.75 - 3m width. They contain mixed traffic ( motorized and cycle), while footpaths of 1.8 - 2.5m can be separately

*These streets are literally an extension of our living quarters, and should imbibe in the citizen, a sense of nurturing and responsibility for these spaces. They can be well interspersed with tot-lots, parks and greens, which act as neighborhood interaction spaces. Ample street lighting and outdoor furnitures makes these streets liveable and vibrant*

The correct design of any stretch of road, depends upon understanding the function and typology of the cross-section in question. An efficient urban road network follows a hierarchy. The hierarchy is based on the function that the road is expected to perform, the type of traffic and the road users present on the road. The design speeds, road widths and other geometric features are adapted to suit the road function. (MoUD, 2012)

## Cross- Section Design

| Road Typology | Right of Way-ROW (m) | Design speed (km/hr) |
|---|---|---|
| Arterial Roads | 50-80 | 50 |
| Sub Arterial Roads | 30-50 | 50 |
| Distributor/Collector Roads | 12 - 30 | 30 |
| Access Streets | 6 - 15 | 15 |



## Intersection and Approach Design

The intersection design forms an integrated part of the overall route for a NMV user. As mentioned in the design requirements, all principles need to be applied in intersections as well. Based on the types of roads intersecting,junctions can be classified as a signalized intersection, an un-signalized intersection or a roundabout.

Intersections created within and between each road type presents varying challenges to directness, safety, comfort and the attractiveness of NMV infrastructure.

Roundabouts: Safety of cyclists and pedestrians negotiating a roundabout can be ensured by reduced vehicular speeds and geometric designs, ensuring adequate segregation and visibility for slow moving users. Modern roundabouts allow better capacity without compromising safety.

Signalized Junctions: At signalised intersections, expected delays for cyclists are considerably longer than other junction solutions. Therefore, a flexible approach to adapt a single or combination of crossing methods should be adopted.

Segregation at or Near Intersection ensures safety and directness for cyclists.

Bicycle Boxes or Waiting Spaces for cyclists are required for waiting cyclists on the near side of junctions.

Provision of Left turning Traffic: Additional turning pocket for left turning vehicles may be provided on the near side of the junction but a segregated lane should be avoided.

At intersections where heavy left turning traffic is expected, to reduce any expected delays for motorized traffic, introducing a two-phase pedestrian and bicycle signal coupled with traffic calming in the form of speed table or raised crossing for cyclists and pedestrians, can be implemented.

Traffic Calmed and Un-signalized Junctions: For minor intersections, it is recommended to apply traffic calming such as mini roundabouts, humps, table tops to keep the speed of motor vehicles in check.

Traffic calming through raised table top crossings. Location : Delhi, Source : Authors

Bicycle boxes reduce chances of conflict and crashes. Location : Delhi, Source : Authors

Segregated routes for motorised and non-motorised traffic ( in construction ). Location : Chandigarh, Source : Authors

## Special Conditions : Streets as Public Spaces

People use streets as social spaces. All components of road design and various road users interact in a such a manner that it creates an urban system. This urban system fosters public spaces.

Apart from serving its purpose to foster navigation, streets are also places of waiting , places of meeting , places of resting , places of protest and places of festivity. In short they are as public ( if not more) as any public park, fair grounds or sports clubs. More so, they are the most affordable places to loitre, drink tea, or relish street food.

Common scenarios from our street life clearly portray the enjoyment and relaxation that the 'public'ness of these spaces provide. They are places of informal trade, hence contributing to providing a market for a number affordable products. Keeping these very 'humane' condiions of our streets edges and waiting areas , its fundamental to incorporate them through space allocation and inclusive design

Bus-shelters are also used as waiting and resting spaces. Location : Delhi, Source : Authors

**BUS SHELTERS**

Bus Shelters need to be located every 500-700m. Also the intersections are rationalized on the same principle. However, in the current scenario bus shelters are located at a greater distance or away from the intersections. This increases the access length of a commuter to the bus shelter or to his/her destination. In the vicinity of the bus shelter, hawkers, cycle rickshaws, e-rickshaws etc are mostly present to capitalize commuter needs and provide feeder connectivity

**HAWKER SPACES**

Bicycles, pedestrians and bus traffic attracts street vendors. Often road sidesv and pedestrian paths are occupied by people selling food, drinks and other articles, which are demanded by these road users. A careful analysis of location of vendors, number of vendors at each locationand type of services provided them shows the need of that environment, since they work under completely "free market" principles.


Alongwith providing necessary services, street side trades provide spaces of meeting, waiting and loitering, thereby enforcing the " publicness" of our streets. Location : Delhi, Source : Authors

## INTERVENTIONS ON EXISTING INFRASTRUCTURE

Insertion of table top crossing , facilitating slow down of motorised vehicles and safe crossing with universal accessibility.
Delhi BRT ; Source :TRIPP


Optimum utilization of existing roads by insertion of cycle tracks and zebra crossing

## INTERVENTIONS ON EXISTING INFRASTRUCTURE


**Acess Roads** : Typical conitions in Indian cities . How soft intervenions can alter the quality of the space with equitable space allocation for all modes. Source : SGA architects.

**Arterial Roads** : Typical conitions in Indian cities . How soft intervenions can alter the quality of the space with equitable space allocation for all modes. Source : SGA architects.

WHAT CAN COMMUNITIES DO ?

## AUDITS AND PRIORITISE

## Why should communities play an active part ?

**Communities have strengths and assets that can provide an enviornment that promotes health and well being**

**A communnity approach minimizes “blaming the victim”**

**A community approach means that fewer people have accidents / fatalities, not just more people are safe**

**A community approach builds on what is already working within cultures and is tailored to the community’s strengths**

**A community approach approach enables communities to develops solutions that benefit all**

**A community approach strengthens the overall enviornment of the community**

**Adopted from Prevention is Primary ( Cohen et al, 2007)**

## When can Public Transport Accessibility Audit be conducted?

Public Transport Accessibility Audit can initially be conducted either during the construction of a new public transport facility or in redesigning an existing facility.
It can later be conducted once every year across the city to ensure that public transport is still accessible to its users.

## How can citizens Audit city infrastructure ?

Walking on city roads comes as naturally to citizens as going to work or education or market places. It is the means of pursuing any particular want to be mobile. Talking to neighbors of different age groups, understadning the needs of each and checking whether a particular existing street has the capability to address those needs is the first step to understanding what is requirred and what is absent. Based on this know-how citizens can then organixe themselvss and ask city officials to provide them with proper infrastrcuture which meets their needs and right to mobile in a safe way

## REFERENCE LINKS


Cohen, L., Guzman, C., chehimi, S. & Realini, A., 2013. Essential Ideas from Safety, Sustainability and Future Urban Transport. Delhi: Eicher Group. *http://tripp.iitd.ernet.in/publications/other_pub/urbanmobilty.pdf*

MoUD, 2012. Design of Urban Roads, Code of Practice -1 : Cross section. s.l.:MoUD.
*http://moud.gov.in/sites/upload_files/moud/files/Part_I_Cross_Section.pdf*

MoUD, 2012. Design of Urban Roads, Code of Practice -2 : Intersection. s.l.:MoUD.
*http://moud.gov.in/sites/upload_files/moud/files/Part_II_Intersections.pdf*

MoUD, 2012. Design of Urban Roads, Code of Practice -3 : Signage. s.l.:MoUD.
*http://moud.gov.in/sites/upload_files/moud/files/Part_III_Road_Marking.pdf*

MoUD, 2012. Design of Urban Roads, Code of Practice -4 : Road Marking. s.l.:MoUD.
*http://moud.gov.in/sites/upload_files/moud/files/Part_IV_Signages.pdf*

MoUD, 2012. Design of Urban Roads, Code of Practice -5: Traffic Calming. s.l.:MoUD.
*http://moud.gov.in/sites/upload_files/moud/files/Part_V_Traffic_Calming.pdf*

TRIPP, 2014. Planning and Design Guideline for Cycle Infrastructure. Delhi: Shakti Foundation
*http://tripp.iitd.ernet.in/publications/other_pub/Planning%20and%20Design%20Guideline%20for%20Cycle%20Infrastructure.pdf*

UNEP, I. D., 2012. Toolkit for preparing Low carbon Comprehensive Mobility Plan (LCMP), s.l.: UNEP.
*http://www.unep.org/transport/lowcarbon/PDFs/CMPToolkit_revised.pdf*

WHO COLLABORATING CENTRE

Transportation Research & Injury Prevention Programme
Indian Institute of Technology Delhi
New Delhi 110016

http://tripp.iitd.ernet.in

非売品

H2652 プロジェクト
インドにおける交通安全のためのコミュニティデザインに関する研究調査
報 告 書

発行日　　平成 27 年 3 月
発行所　　公益財団法人 国際交通安全学会
東京都中央区八重洲 2-6-20 〒104-0028
電話/03(3273)7884　　FAX/03(3272)7054

IATSS

公益財団法人 国際交通安全学会

International Association of Traffic and Safety Sciences