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Telephone +44 1524 63175 Fax +44 1524 848340
E-mail: Editorial: <ecologic@gn.apc.org> Business Manager: <pascal@gn.apc.org>

Pedestrian infrastructure in the city transport system: a case study of Delhi

Geetam Tiwari

Address for correspondence
Geetam Tiwari
Transportation Research and Injury Prevention Programme, Indian Institute of Technology-Delhi, Hauz Khas, New Delhi-110 016, India.
<gtewari@ee.iitd.ernet.in>

Abstract

Walking and non-motorised vehicles are the principal modes of transport for most of the urban poor in Asian cities. For a large number of people even subsidised public transport (buses) and low cost bicycles are beyond their means, so that a significant proportion of the population falls into the category of 'captive pedestrians'. Captive pedestrians and public transport users together form the largest group of road users. Yet their need for a safe and convenient infrastructure continues to be ignored. This has two major impacts on city traffic and travel patterns. Pedestrian and public transport trips as a percentage of total journeys have declined over the years, though they are not expected to disappear in the near future. Pedestrians are present on the roads despite hostile infrastructure designs and motor vehicles are forced to share the road space with them; this creates sub-optimal conditions for all road users. A reversal of this trend is possible. It is possible to create pedestrian, bicycle and public transport friendly urban roads without increasing the right of way of existing arterial roads in Delhi. The guiding principle of such a design is re-assigning priorities to various road users and by meeting the needs of pedestrians, cyclists and public transport commuters in that order.

Keywords

Delhi transport, non-motorised vehicles, Pedestrian infrastructure, urban transport, walking.

Introduction

Walking and non-motorised vehicles are the principal modes of transport for most of the urban poor in Asian cities. Walking and non-motorised vehicles provide access to economic opportunities, health services and other social services essential for their survival and well being. Unlike high income countries, walking is the only option for commuting to work, even for long distance trips in these countries. For a large number of people, even subsidised public transport (buses) and low cost bicycles are beyond their means. Therefore, a significant proportion of the population falls into the category of 'captive pedestrians'. This segment of the population is dependent on walking to access various activities and facilities in the city. In addition, public transport users are walkers at least four times each day when they access and exit public transport systems. Captive pedestrians and public transport users together form the largest group of road users. Yet their need for a safe and convenient infrastructure continues to be ignored. In pursuit of development, cities continue to invest in infrastructure which makes the environment for the pedestrian even more hostile than at present.

Socio-economic profile of captive pedestrians

In most Asian cities increasing numbers of poor, working class, people live in informal settlements or colonies without basic water supply, sanitation and transport services; they represent a large proportion of the population in cities. Many are migrant labourers from neighbouring states seeking better employment and higher income opportunities. Due to the acute scarcity of land, shelter and infrastructure, many construct their homes on public and other vacant land (termed 'Jhuggi Jhopri', 'JJ clusters' or 'Jhuggies'). In Delhi, it is presently estimated that there are at least 1500 unauthorised colonies and 1200 JJ clusters without civic amenities and as much as 60% of the population live in sub-standard housing. The population living in Jhuggies is estimated to be well over 3 million people

Table 1. Modal shares of journeys to work by low income households in Delhi (1999)

Mode	Shares of low income households (average monthly income Rs.2000~US$40)
Cycle	38.87
Bus	31.43
Car	0
Scooter/Motorcycle	2.48
3 wheeler taxi	0.96
Taxi	0
Rail	1.79
Others	2.34
Walk	22.12
Total	100

Source: IIT-Sajha Manch(1999)

and is projected to increase to more than 6 million people by 2020 (Hazard Center, 2001). Captive pedestrians belong to the low income households residing in Jhuggies, slums and unauthorised residential settlements in Delhi. Table 1 shows the distribution of journey to work trips by different modes of people residing in JJ clusters and low income housing.

Table 2 shows the changing modal share of trips (excluding walk trips) in Delhi. It is noteworthy that the travel statistics do not have any record of walking before 1994. In 1994, nearly 32% of trips are walk trips. The share of public transport (road based), including chartered buses, is 42% of all trips. Of the total trips around 11% are by slow modes like cycles and rickshaws, 5% of trips are by car and 12% by two-wheeled motor vehicles (TWMV).

Table 3 shows the estimated average modal share for the whole city in 1999 which is very different to modal shares from 1957-1994. The two most important factors contributing to this change may be the rapid increase in poor residents along with major changes in the city bus system. The introduction of private buses, which are more expensive than public buses and may be beyond the means of many people, results in declining shares of bus trips and an increase in bicycle trips. The decline in walking trips, despite the increase in low income households, is noticeable.

JJ clusters and low income housing are spread all over the city so that captive pedestrians are on all major travel corridors. Since access to public transport requires a walking trip to the bus stop, all public transport users are also pedestrians. Despite large increases in private car and scooter ownership, 34% of all trips are by public transport. Therefore ,public transport pedestrians together with other pedestrians form the largest group of road users. Yet road design and traffic management policies cater to the convenience of car users, often to the detriment of pedestrians, public transport users and other road users.

The basic infrastructure

The road network in Delhi is based on a notional hierarchy of roads, ranging from arterial roads designed to carry fast through traffic, to collector and residential roads. However, the lack of transport choices results in a pedestrian presence on all roads, regardless of the hierarchy and designated functions.

The existing road design does not cater for the needs of pedestrians, cyclists, or other slow moving traffic. Service roads if present, are not well maintained. Footpaths are either not present or poorly maintained. Furthermore, there are no specific facilities, other than shelters, provided for buses. Approaches to bus shelters, bus priority lanes, continuous pedestrian paths, and lanes for slow vehicles like bicycles and rickshaws have not been included in the road network designs. Consequently, all road users have to share the carriageway. This often leads to unsafe conditions for pedestrians and slow moving vehicles and congested conditions for motor vehicles. The per capita availability of roads in Delhi in 1997 was 2.6 metres per person. It must also be noted that almost 66% of the vehicle fleet in Delhi consists of TWMV which (when parked) take up less road space than cars and buses. Despite this, average speeds have fallen over the years. Peak hour traffic on arterial roads (most of which are three-lane dual carriageways) crawls through bottlenecks at major intersections. However, the extensive road network has not been developed to serve the mixed traffic presently using the roads.

State authorities and 'experts' continue to plan infrastructure which ensures fast movement of car traffic at the expense of pedestrians and non-motorised vehicles. The basic needs of pedestrians are not recognised as a key part of the urban transport infrastructure. In a recent study, pedestrians were observed at selected junctions on a major arterial road in Delhi (IIT, 2000). The study shows that nearly 70% of pedestrians cross the road when it is safe for them to cross, i.e. either it is green for pedestrians or green for right turning vehicles which makes half the crossing safe. The number of pedestrians waiting at the median is more than those waiting on the side of the road, even though there is no pedestrian island in the median. The road median does not provide any convenient space for waiting and indeed restrictive measures for pedestrians are instituted such as high

Table 2. Modal share in Delhi, 1957-1994

Mode	1957	1969	1981	1994	1994 *
Cycle	36.00	28.01	17.00	6.61	4.51
Bus	22.40	39.57	59.74	62.00	42.00
Car	10.10	15.54	5.53	6.94	4.74
Scooter/Motorcycle	1.00	8.42	11.07	17.59	12.00
3 wheeler taxi	7.80	3.88	0.77	2.80	1.91
Taxi	4.40	1.16	0.23	0.06	0.04
Rail	0.40	1.23	1.56	0.38	0.26
Others	17.90	2.19	4.10	3.62	2.47
Walk					31.77
Total	100.00	100.00	100.00	100.00	100.00

Source: ORG(1994) * including walk trips

medians (30-50 cm) and guard rails. Often, the construction of pedestrian subways and footbridges is to ensure that pedestrians do not obstruct motor traffic. These pedestrian subways continue to have low usage rates not only because of poor location, but also because they are often locked at night due to safety concerns. This leaves no option for pedestrians but to either break the median fences or run across at the risk of losing their lives.

The road improvement plan for the city includes the following:

- Construction of 40 new grade-separated junctions / flyovers;
- Construction of subways to facilitate pedestrians; and
- Widening of arterial roads.

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 by 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 twice for every round trip at the origin or the destination. The area occupied by grade-separated intersections is much greater than ordinary intersections and the location of bus stops at these intersections is often changed from the previous location (close to the intersection) to the foot of the flyover. Consequently, commuters have to walk a greater distance – at least 200 metres extra when changing bus routes. This can discourage those who own private motor transport from using public transport. In addition, because of the increase in walking distance and road widths, pedestrians and commuters are exposed to higher accident risks. This further discourages use of public transport by children, disabled people and other vulnerable road users.

Pedestrians have to contend with narrow pavements, often made narrower to increase the width of the road to reduce congestion for cars and other motor traffic. Pedestrians are expected to walk among parked cars, street furniture such as electricity poles, telephone poles, traffic signs, litter bins, redundant phone boxes and commercial waste. The situation is made worse as a result of poor public management of streets and public spaces, including litter and uneven pavements. It is not wrong to say that our urban streets are characterised by an absence of design.

The presence of diverse socio-economic groups in the city is reflected in the wide variety of transport modes present on all roads. This also results in the emergence of a range of activities by different road users.

Roadside vendors & services for road users

Bicycles, pedestrians and bus traffic attract street vendors. Often, the side roads and pedestrian paths are occupied by people selling food, drink and other in demand goods. If the wares on offer were not required at those locations, then the vendors would have no incentive to remain there. However, road authorities and city authorities view their existence as illegal. Often the argument is made that road capacity is reduced by the presence of street vendors and hawkers. If we apply the same principle that is applied for the design of the road environment for motorised traffic, especially private cars, then vendors have a valid and legal place in the road environment. Highway design manuals make recommendations on the frequency and design of service areas for motor vehicles. Street vendors and hawkers serve the same function for pedestrians, cyclists and bus users. As long as our urban roads are used by these modes, street vendors, inevitably, will remain.

Pedestrian safety

In Delhi, pedestrians, cyclists and TWMV constitute 75% of the total road traffic fatalities (Tiwari, 1993). Because cyclists and pedestrians continue to share the road space in the absence of infrastructure specifically designed for non-motorised vehicles, they are exposed to higher risks of being involved in a road traffic accident. Figure 1 shows road traffic fatalities in Delhi from 1990 to 1999. Pedestrians make up the largest share in total fatalities. The most alarming trend is that this share has been increasing over the years compared with those of other categories of victims, which have either remained constant or show a decline. Buses and trucks are involved in more than 60% of the fatal

Table 3. Estimated modal shares for 1999

low income population @	60%		50%	
Mode	Total trips	%	Total trips	%
Cycle	5.71	24	4.87	21
Bus	7.80	33	7.91	34
Car	2.65	11	3.32	14
Scooter/Motorcycle	3.09	13	3.72	16
3 wheeler taxi	0.30	1	0.32	1
Taxi	0.00	0	0.00	0
Rail	0.25	1	0.21	1
Others	0.33	1	0.27	1
Walk	3.26	14	2.78	12
Total	23.39	100	23.39	100

Source: Tiwari (2000)

Note: There are no reliable census figures for the low income population in Delhi. Therefore, the two columns show estimated modal shares when the low income population is 60% & 50% respectively

crashes. All modes of traffic use one, two and three lane roads. Traffic laws do not segregate bicycle traffic and speed limit enforcement is minimal.

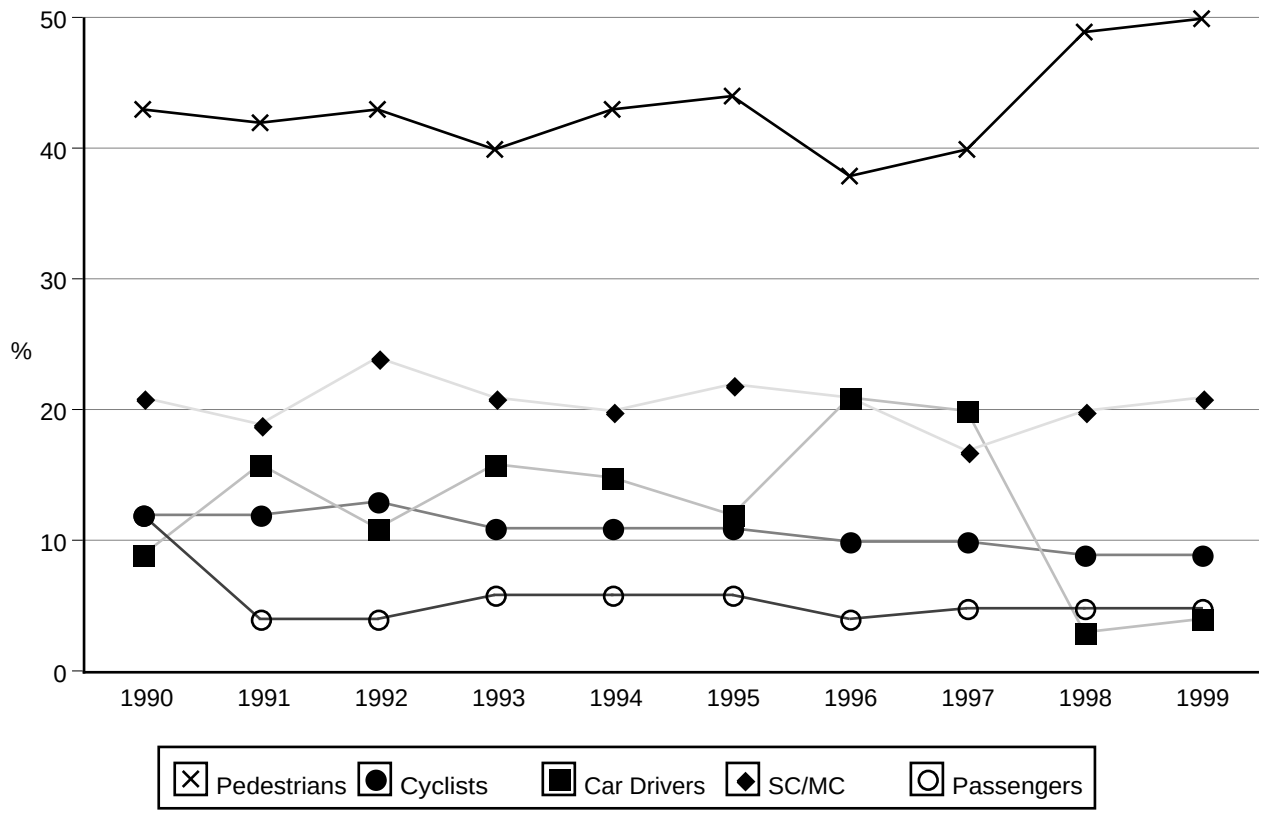
A study of mid-block conflicts presents information about the use of road space by different road users. The fourteen sites studied show that maximum mixing of pedestrians and non-motorised vehicles with motor vehicles occurs at the stops (Tiwari *et al*.,1998). Their interaction with motor vehicles is minimal at other locations. Natural segregation takes place on three- and two-lane roads. On three-lane roads, motor vehicles use two lanes and the kerbside lane is used by non-motorised vehicles. Vehicles of one group tend to interact mostly with other vehicles of the same group. Though *de facto* segregation takes place on two- and three-lane roads, an unacceptable danger exists to pedestrians and cyclists because of the impact of motor vehicles.

The data show that bicycle fatalities on two and three lane roads are relatively high when motor vehicle volumes are low, but the level of conflicts between motor vehicles and non-motorised vehicles shows little correlation with fatalities during peak flows. In these locations of 'integrated' traffic on two- and three-lane roads, fatalities during peak hours are low but not eliminated. On the other hand, during non-peak hours vehicles travelling at speeds around 50 km/h or greater kill a large number of pedestrians and cyclists (Tiwari, 1993). The top ten locations for the highest number of fatal accidents in Delhi are on major arterial roads, comprising both mid-block and intersections and are predominantly pedestrian fatalities (Delhi Traffic Police, 1999).

Speed influences energy consumption, pollution, noise, vehicle and road maintenance costs, stress on road users and safety. In general, higher speeds have an adverse influence on all these factors. Increase in speed is associated with a disproportionate increase in the number of fatalities. Also, the safe speed for car occupants is much higher than for pedestrians and cyclists. Safety of road users is influenced both by the absolute speed of vehicles and by the variation in speeds among vehicles on the road (Noguchi, 1990). Other factors remaining constant, higher speeds increase the probability of a crash taking place and the severity of injury in a crash, whereas a greater variation in speeds of vehicles only increases the probability of the event. Small reductions in travelling speed result in large reductions in injuries and fatalities both in urban and rural areas because the stopping distance of a vehicle when braking is proportionate to the square of the original velocity and the damage to human beings is related to the square of the impact velocity.

In Delhi there seems to be a major conflict between speed and fatality trends. Average speed has been

Figure 1. Road traffic Fatalities in Delhi, 1990-1999



declining over the years. Congestion on Delhi roads is worsening despite several local road improvement programmes. Average speeds during peak periods range from 10 km – 15 km / h in central areas and 20 km – 40 km / h on arterial roads.

Delhi does not lack road infrastructure. However, problems arise as a result of the wide variety of vehicle types including bicycles, mechanical, human-powered and animal-drawn vehicles sharing the same road space. A much better picture can be expected only if the road space available can be used efficiently by all vehicles present. Reduced average speeds should result in fewer fatalities. The number of total fatalities does show a marginal decline; however, the share of pedestrian fatalities continues to rise. The decline in the average speed of motor vehicles and the increase in pollution levels in the city seem to be the two most important driving forces influencing the type of investment in road infrastructure. The safety and mobility needs of the majority of the road users, i.e. pedestrians and bus commuters, are not considered for future improvement plans. This has two major impacts on city traffic and travel patterns.

1 Pedestrian and public transport trips as a share of total trips have reduced over the years. In both cases the only people who continue to walk and use public transport, despite the hostile environment, are those who do not have any other option.
2 Given the socio-economic context of our cities, pedestrians are present on the roads despite hostile infrastructure designs and motor vehicles are forced to share the road space with them, which creates sub-optimal conditions for all road users.

Since pedestrians, bicycles and other non-motorised vehicles use the left side of the road, buses are unable to use the designated bus lanes and are forced to stop in the middle lane, often 4 m – 6 m away from bus stops. The carriageway between the bus and the bus stop is occupied by waiting commuters, parked rickshaws and hawkers. Not surprisingly, government surveys find 50% of the road space in Delhi 'encroached on' by non-traffic activities. This disrupts traffic in all lanes and makes walking and cycling even more hazardous. Motor traffic does not use the kerbside lane even when pedestrian and bicycle densities are low. Providing a pedestrian friendly path and separate bicycle track would make more space available for motorised modes and would make walking and cycling less hazardous. All modes of transport move in sub-optimal conditions in the absence of facilities for pedestrians and non-motorised vehicles.

Future directions

A well-functioning road infrastructure must fulfil the requirements of all road users. In the context of the present socio-economic realities in most developing

Figure 2. Conflict between cyclists, bus users, buses & other motor vehicles conspire to keep buses away from bus stops

countries, pedestrians, cyclists and other slow moving vehicles cannot be eliminated from the urban landscape. The needs of pedestrians have been ignored in conventional planning strategies and have been assigned lower importance compared with other vehicles on the road. However, the experience from environments where 'captive pedestrians' are present makes a very strong case for re-thinking the conventional hierarchy of road users. It is clear that present investment patterns focussed on improving conditions for cars are not giving the desired results. Congestion continues to worsen along with a shift away from walking, bicycles and public transport – the desirable modes for sustainability. A reversal of this trend is possible. It is possible to create pedestrian, bicycle and public transport friendly urban roads without increasing the right of way of existing arterial roads in Delhi. The guiding principle of such a design is meeting the needs of pedestrians, cyclists and public transport commuters in that order.

The proposed network must enable direct and safe walking and bicycle travel within a coherent system. The proposed routes must guarantee a coherent network, minimise trip length (directness) and minimise encounters between cyclists and motor vehicles. The success of bicycle / non-motorised vehicle route design depends upon meeting not only the requirements and convenience of bicycles and non-motorised vehicles but pedestrians as well. Otherwise, all road users are obliged to share space with motor vehicles resulting in sub-optimal conditions for all.

Conclusion

Given that there is not much space available to expand existing roads, future mobility needs are best met by increasing the capacity of the existing road network. This can only be achieved by encouraging modes which are more efficient in terms of space utilisation. If pedestrian friendly paths are constructed, together with a separate segregated lane for bicycles, the kerbside lane (which is currently used by cyclists) becomes available to motorised traffic. This relatively small investment in pedestrian and bicycle friendly infrastructure offers multiple benefits.

Motor vehicles benefit because of increased road capacity and speed improvements. Major beneficiaries of speed improvement are buses and TWMV because the kerbside lane becomes available to them without interference from pedestrians and slow vehicles. By providing an exclusive cycle track, estimates of a typical arterial road in Delhi (Tiwari, 1999) show increases in corridor capacity of 19% – 23%. Utilising the full capacity of the corridor (i.e. by providing a high capacity bus lane in the left-hand lane) can lead to a capacity increase of 56% – 73%. In terms of congestion, re-planning junctions to include separate pedestrian paths, non-motorised vehicle lanes and bus priority lanes can bring an 80% improvement over the present level of delays. The cost of this measure is 25 times less than grade-separated junctions (Kartik, 1998) which are currently being constructed at an average cost of US$2m – $6m.

There would be safety benefits too. By creating segregated pedestrian paths and bicycle lanes and re-designing intersections, conflicts between motor vehicles and pedestrians and cyclists can be reduced substantially, leading to a sharp decrease in the number of accidents and fatalities for pedestrians, cyclists and TWMV. Safety benefits estimated for a typical arterial in Delhi show a 46% reduction in accident costs. This is because segregated facilities reduce injury accidents by 40% and fatalities by 50%.

Finally, there would be wider health benefits from the construction of pedestrian friendly paths and segregated cycle lanes. Motor vehicles are reported to be the single largest source of air pollution causing 67% of the total air pollution in Delhi (MOE, 1998). This is a serious concern to cyclists, pedestrians and motorists as air quality is worse in or near built up roads. A better pedestrian and bicycle infrastructure can play an important role in increasing the modal share of pedestrians and bicycles and thus in reducing the adverse health effects of pollution.

References

Delhi Traffic Police (1999) *Road accidents in Delhi* Delhi Traffic Police, Delhi.

Hazard Center (2001) *Manual for people's planning: a view from below of problems of urban existence in Delhi* Hazard Center, Delhi.

IIT (2000) *Road user behaviour and traffic violations in Delhi*, report for SIAM, TRIPP, Indian Institute of Technology, Delhi.

Kartik, V. (1998) *Comparison of alternate measures at AIIMS intersection*, B.Tech Thesis, Department of Civil Engineering, Indian Institute of Technology, Delhi.

MOE (1998) *White paper on pollution in Delhi with an Action Plan* Ministry of Environment and Forests (MOE), Government of India, New Delhi.

Noguchi, K. (1990) 'In search of optimum speed: from the users' viewpoint' *Journal of the International Association of Safety Sciences*, 14, 1.

Tiwari, G., Mohan, D. & Fazio, J. (1998) 'Conflict analysis in mixed traffic conditions' *Accident Analysis and Prevention*, 30, 2, 207-215.

Tiwari, G. (1993) 'Pedestrians and bicycle crashes in Delhi' 2nd World Injury Conference, Atlanta, GA.

Tiwari, G. (1999) 'Planning for non-motorised traffic – a prerequisite for a sustainable transport system' *IATSS Research*, 23, 2, 70-77.