Bicycle Infrastructure – Planning to Implementation
Lessons Learnt: Case Study Delhi

AUTHORS:

Mr. Sandeep Gandhi
Transportation Research and Injury Prevention Program,
Indian Institute of Technology,
Hauz Khaz, New Delhi
INDIA
Email: gandhi.sandeep@gmail.com

Dr. Geetam Tiwari
Transportation Research and Injury Prevention Program,
Indian Institute of Technology,
Hauz Khaz, New Delhi
INDIA
Email: geetamt@gmail.com

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Indian cities are dominated by bicycle users. They are mainstream commuters, and in the absence of any dedicated infrastructure are forced to share the road space i.e. left most lane on the carriageway with heavy transport vehicles, effectively increasing their risk of fatal accidents. Despite concerns to their safety cyclists constitute 8% of the total trips made in Delhi as they are captive riders and cannot even afford a subsidized public transport system.

The issue of cyclist safety and the need for dedicated bicycle infrastructure has been ignored by the concerned authorities. Efforts made by TRIPP to implement bicycle Master plan for Delhi (submitted in 1998) and to integrated bicycle specific designs on existing roads have been met by stiff resistance from road engineers and bureaucrats on account of contradictions with existing road development guidelines. Guidelines such as the Indian Road Congress (IRC) specifications do not include precise information on bicycle infrastructure design and are motor vehicle specific. On the contrary, it states, '… wherever the streets are very congested or on arterial roads with pedestrian and motor vehicles as the main road users, it is desirable to **prohibit the slow moving traffic** either totally or for a limited period of the day when traffic is at it's peak.'[1]

The paper shows how international design specifications contextualized to meet local needs can be used to convert a hostile street for cycling into a bicycle friendly corridor. It presents location specific examples of bicycle infrastructure design details and solutions, evolved for an arterial road in Delhi.

[1] IRC: 70-1977

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With the growth of economy new road infrastructure development projects are gaining momentum in India. This increases the urgency for uniform case sensitive guidelines for NMV infrastructure. The planning and design of High Capacity Bus System (HCBS) and NMV infrastructure undertaken by TRIPP in various Indian cities has generated an opportunity to develop detailed designs and specifications for bicycle infrastructure.

Guidelines for Bicycle Infrastructure in Indian Cities

Cyclists in India are found on all major roads. The main cycling routes in the city are along the important arterial and ring roads. For these routes to be bicycle friendly, a continuous, safe, direct and attractive infrastructure with a *recognizable uniform planning features, so the route will be clearly recognizable over its whole length* (CROW 1994: 69)*,* needs to be integrated with the road system. Existing Indian guidelines fail to acknowledge the existence of main stream cycle commuter and address the issue by suggesting that **w*herever feasible*** *fully segregated cycle track should be provided along segregated traffic corridor* (DDA 2005: 95)*.* Hence concerns for increased congestion induced by reduced carriageway width for motor vehicles, is cited as the main reason by planners, for not providing segregated bicycle infrastructure.

However, even when cyclists risk their lives in existing mixed traffic situations on fast roads, motor vehicles loose on usable road space as even a low cycle volume prevents motorists from using the curb side lane of the carriageway (Tiwari, G. 1999). It is suggests that continuous and segregated bicycle lanes be provided on both sides of the carriageway where peak vehicular speeds exceed observed peak speed of 50 km/hr. The specifications of segregated bicycle infrastructure based on lessons learnt from proposed/executed projects, and analysis of International as well existing Indian guidelines have been drafted under the following categories:

- **Location, Segregation and edge treatment**
- **Entry/exit treatment**
- **Width of bicycle lanes**
- **Service Providers**
- **Parking**

Location, Segregation and Edge Treatment

Internationally bicycle tracks are segregated wherever the need exists to increase the attractiveness of bicycling by, making their journey safe, comfortable and fast, along highways or high speed urban roads. In such situations the design of the segregation needs great attention to maintain, the directness and the attractiveness of the cycle path. Although the scale of the segregation directly affects the safety of cyclists on high-speed roads, *it is also possible however that because of the increased scale the attractiveness of cycling is reduced* (CROW 1994: 71). Careful planning is required to achieve the right balance between safety and attractiveness. Since cyclists constitute 8 to 40% of total trips in Indian Cities, the concern of segregation is mainly for their safety. However since cyclists are main stream commuters, and travel time as well comfort is more important to them than the concern for their safety, they seldom trust lanes or paths which are away from carriageway or likely to be poorly maintained (TRIPP 2005: 14). Ignoring this issue, the current Indian standards states; *"cycle tracks should be located beyond the hedge, tree or footpath* (IRC11 1962: 5)*"*. This is one of the main reasons why existing service lanes segregated from the carriageway, by tree line, footpath and/or railing, in central parts of Delhi, are ineffective in attracting cyclists, when demarcated as cycle lanes.

It is important to understand the fact that safety of cyclist cannot be achieved at the cost of actual or perceived risk to their mobility and comfort. Based on this the following specifications for location, segregation and edge treatment of cycle track are suggested:

Location of Cycle Path

- A single path for non motorized vehicles such as cycles and cycle rickshaws should be provided between motor vehicle lanes and the pedestrian path for each direction of traffic on both sides of the road and be should preferably be 0.05 to 0.10m above the carriageway level.

Segregation from Pedestrian Path should be achieved as following:

- NMV lanes should be visually and physically segregated from pedestrian paths to make a clear distinction between the areas to be used by each user.
- Pedestrian paths should be preferably raised from the NMV lanes by 0.05 to 0.08m. The edge could be maintained by curbstones which remain flushed with pedestrian path paving.
- NMV lanes can be combined with pedestrian paths at locations where the right of way is less than 28m. (at stretches with bus shelter) to 25m. (at stretches without bus shelter). Such stretches should preferably not be longer than 40m. At such locations no visual or physical edge need to be defined between pedestrian paths and NMV lanes.
- At locations where providing service lane is advisable and limitations of right of way lead to combining of service lane, parking and pedestrian facilities such that level of service lane is raised to 0.15m above the carriageway level and approx. 0.05 to 0.08m above the NMV lane level; the bicycle track should be segregated from the service lane using bollards, benches, planters etc., with a clear gaps of between 0.45m to 0.65m and a maximum permissible height of 0.65m. each.

Segregation from MV lane should be achieved as following:

- Segregation between MV lanes and cycle tracks should be designed to allow the cyclists to leave the cycle path at any time with little or no difficulty.
- On streets where fast moving MV traffic is expected (i.e. observed peak speed of more than 50 km/hr) it is desirable to have 0.6 to 0.75m wide segregation between MV lanes and the cycle track (refer figure 1).
- Such segregation may be created using curb stones with the maximum height of the edge facing MV lanes as 0.15m.
- Such segregation between MV lanes and cycle track may be used as buffer for providing services such as storm water collection chambers and light poles. The level of such a surface

should be 0.02 to 0.05m below the level of the carriageway, shielded from the carriageway by a single row of 0.15m thick curbstones (max height from road surface to be 0.15m).

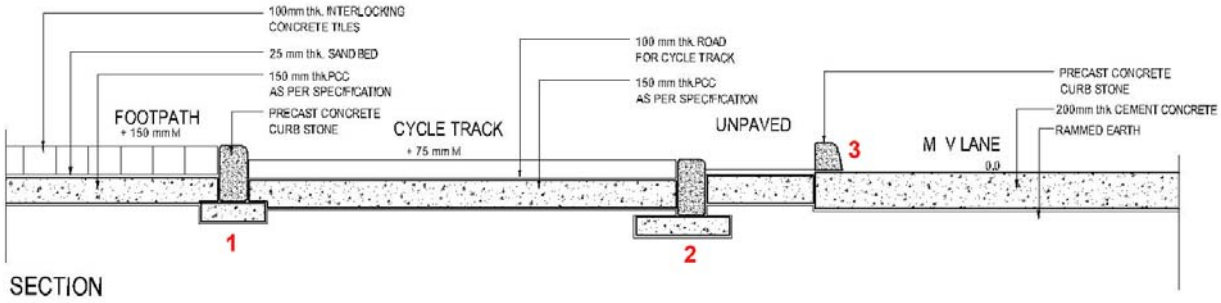

Figure 1: Detail section showing segregation between cycle track and MV lanes

- In case of narrow road right of way the segregation between cycle track and MV lanes can be reduced to a 0.15m high (from MV lanes), 0.3m wide, median. The level of the cycle track may be raised so as the vertical edge (of the curb stone) from cycle track is only 0.08 to 0.05m high.
- In areas where extreme constriction of road right of way forces the cycle track to be combined with pedestrian path, the surface of cycle track and MV lane should be on and continuous segregated with a single row of bollards, maximum of 0.65m high, min. 0.15m wide and with a maximum clear gap between them as 1.25m. This arrangement though is not advisable for a continuous length of more than 40m, and should only be considered where right of way is less than 28 to (at stretches with bus shelter) 25m (at stretches without bus shelter) (refer figure 2).

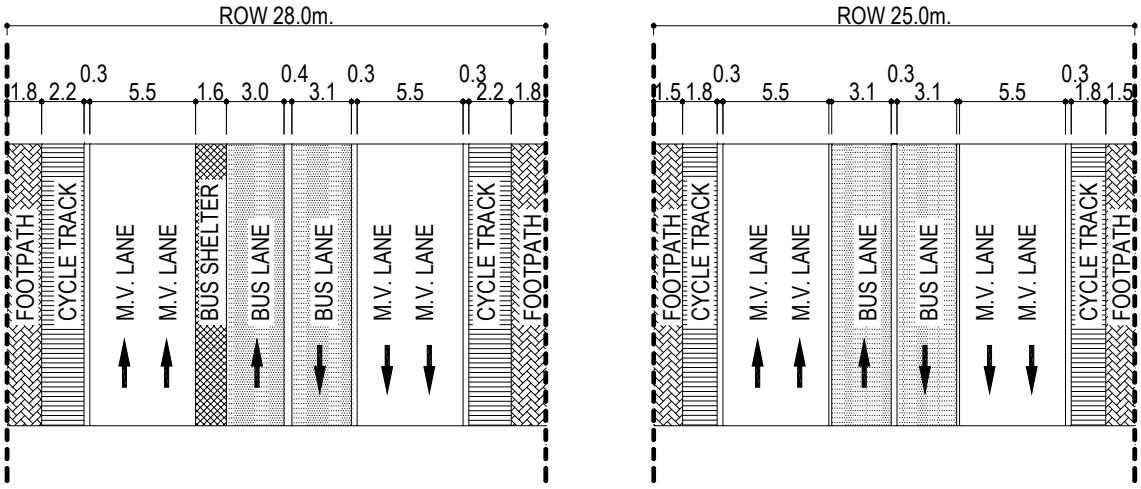

Figure 2: Layout for segregated bicycle tracks on road sections with right of way 28m and 25m.

- In areas of extreme constriction where observed peak motorized traffic speeds (in mid-sections) is restricted to less than 50 km/hr, cycle lanes may be segregated from vehicular lanes by pavement marking and/or texture, in a manner that the continuity of cycle path is evident to both the cyclist and the motorist.

Entry/Exit Treatment

Though international guidelines recommend that bicycle tracks be physically segregated along fast moving urban roads (CROW 1994: 80), lack of space on constrained road sections may not allow a continuous separation. Detailed design of entry/exit to physically segregated lanes and visual segregation of cycle path between them is important to maintain the continuity and directness of the cycle route. In places where profile with physical separation passes into a mixed profile, motorists must be forewarned that the cross section profile is changing and cyclists must be offered protection (CROW 1994: 125). Though existing Indian guidelines suggest provision of segregated tracks in patches along a route (wherever feasible) (DDA 2005: 95), no guidelines exist for their entry/exit treatment. Lack of detailed entry/exit design is one of the reasons why the 4km long Pankha Road cycle track in West Delhi, fails to attract any bicycle use (refer figure 3).

Figure 3: Cycle track at Pankha Road, Delhi

Entry/exit treatment for cycle path at intersections require careful detailing, as it must be avoided that junctions become bottleneck in the route, and it is particularly at junctions where bicycle traffic can gain a lot of time (CROW 1994: 149). Existing Indian guidelines though do not give any details for entry/exit to cycle lanes (at intersections), suggest; where a cycle track crosses a road, the carriageway should be marked with appropriate road markings (IRC11 1962: 6).

Bicyclists need to undertake a range of turning and straight movements at signalized junctions. Since traffic volumes at busy four arm junctions do not allow dedicated signal phase for NMVs, cyclists need to undertake these maneuvers with motor vehicles, which require merging motorized and non motorized traffic at junctions. International guidelines argue between removing and continuing segregation at the junctions (and in case of continuous segregations; bending the bicycle track in or out) (CROW 1994: 157), to balance between safety of cyclists and to improve their efficiency at the junction. Since the motorized traffic in Indian cities comprises of large two wheeler volumes; international, bicycle specific junction details may not be applicable for Indian conditions. The proposed specifications suggest design details to improve bicycle safety and efficiency at signalized junctions by; 1) preventing encroachment by left turning vehicles, 2) providing safe opportunities for right turning and straight moving cyclists. We suggest the following specifications for entry/exit to bicycle facilities at intersections and mid-sections:

- Entry/exit to NMV lanes should be physically and visually aligned to the bicyclist movement in mixed or visually segregated lanes on the carriageway at intersections as well mid-sections, should be clearly marked and signed and should be free of any obstructions.
- NMV lanes need to be punctured at the junctions and at entrance to properties/ side lane or access to service lane to allow access by cyclists and cycle rickshaws.
- Existing free turns for motor vehicles at intersections should be signalized to provide safe opportunities for bicyclists.
- Bollards should be used at all entry and exit points to cycle track with 1.25m to 1.3m as the clear distance between them as 1.25 m and a maximum height of 0.65m, to prevent encroachment by motor vehicles and TSRs.
- Segregated cycle tracks on the ‘on side’ of the junction shall be brought down to the level of the carriageway using ramp with a minimum gradient of 1:10 at a distance of 50 to 100m before the vehicular stop line (depending on the expected queue length at the junction).
- Segregation between the cycle track and the MV lane should continue till the junction (from the ramp) in the form of curbstones angles obliquely from cycle track, so as cyclists intending right turns at the junction can leave cycle track with little or no difficulty.
- The clear (perpendicular) gap between the curbstones should be 1.25m to allowing cycle rickshaw to leave the cycle track.

- The segregation should end at the stop line so as cyclists could wait ahead of the traffic queue (in cycle boxes).
- Left turning movement for cyclists should not be signalized as left moving cyclists face little or no friction from crossing pedestrians.
- At junctions (on the 'off side' of the junction), the segregation between NMV and MV lane should be setback by a minimum of 30m. Independent bollards or curbstones spaced at an interval of 1.5 to 2.0m should be used to define the cycle path for this length. This would give the cyclists (released in groups after each red light) the flexibility to enter the NMV lane along the edge, if the entrance is congested by slow moving rickshaw traffic.
- At all entrance/exit points to NMV tracks other than those at signalized intersections, the entrance exit area should be raised to a level of 0.15m above the carriageway, and accessed by a ramp with a maximum slope of 1:10 from all sides.

Cycle Track Width

International recommendations on the desirable bicycle path width relate to the size of the cycle lane for minimum width and, existing/projected demand and the capacity of the path, for the maximum width. Because existing Indian guidelines suggest the required bicycle path width as 5m for each direction (segregated from the carriageway by a 1m verge) (IRC70 1977: 4), planners avoid compromising 12m width from the available right of way. Hence planners/engineers either prohibit the slow moving traffic either totally or for a limited period in the day (IRC70 1977: 4), or demarcate existing service lanes or footpaths as bicycle lanes.

In the Netherlands, the capacity of a 2.50m-wide one-way cycle path has been calculated at 6,500 cyclists per hour. In practice, examples have been recorded of more than 5000 cyclists per hour on a cycle path 1.80m wide (HPF, I-CE, VNG 2000: 21). Since peak bicycle demand in most Indian cities is less than 5000 cyclists the proposed draft specifications for bicycle infrastructure proposes to rationalize the width of bicycle path so as it not only becomes usable by passenger as well goods rickshaw but also discourages encroachment by motor vehicles for parking and thoroughfare. Analysis of 5 to 8m wide bicycle path developed at Pankha Road, show that wider paths lead to its misuse by motorized vehicles. Trucks, buses and taxis use this path for parking, discouraging cyclists from using it (I-CE 2004). The following specifications are proposed taking into account these factors:

The width used by each cycle track user is as following:
Bicycle – 0.75m
Passenger cycle rickshaw – 0.95m
Goods Cycle Rickshaw – 1.20m
Based on these the minimum and the comfortable width required to allow two way traffic for is given in table 1.

Table 1: Width of cycle track with respect to its usage.

S.No.	Used by?	Min. Width	Comfortable Width
1.	Bicycles only	1.5m	1.8m
2.	Bicycles and Passenger Rickshaws	1.8m	2.0m
3.	Bicycles and Goods Rickshaws	2.0m	2.2m
4.	Passenger and Goods Rickshaw	2.2m	2.5m
5.	Heavy Goods Rickshaw traffic	2.5m	3.0m

In case of cycle volumes of more than 5000cyclists per hour (for both direction traffic) cycle track width, wider than 2.5 to 3.0m may be required. However for lower volumes it is not advisable to have widths of cycle tracks less than 1.5m or more than 2.5. A lower width will discourage bicycle use; a higher width would encourage encroachment by other functions such as parking and through two wheeler traffic.

- Clear width of NMV lanes should preferably be 2.5m.
- Where road right of way is constrained, the NMV lane width can be reduced to 1.8m
- In case of severe constriction of right of way, NMV lane width can be reduced to 1.5m but this width should not be consistent over large lengths of the lane.

- At locations where right of way widths do not permit segregated bicycle tracks, bicycle track may be combine with pedestrian path (with a total minimum width of 2.0m) for short stretches. The level of this stretch (10 to 40m long) should be the same as carriageway and should be segregated from MV lanes using a row of bollards with a clear gap of between 1.25 to 1.3m; allowing cycle rickshaw access.
- At constrained right of way locations where the combined minimum width of NMV lanes and pedestrian paths can be between 2.5 to 3.5m and the total length of the constrained stretch is not more than 10m, the bicycle path may be raised using ramps with min. gradient of 1:10 to the level of the footpath for combining the two at both ends of the constrained stretch.

Service Providers

Informal commercial activities in the form of hawking are dominant in Indian Cities. Since hawking is predominant in developing countries, examples of specifications addressing this function do not exist in western guidelines. This issue is not addressed in Indian guidelines as well. Thus provision is not made for hawking along Indian streets. Hawkers occupy the service lane, pedestrian path, and on left lane on the carriageway (near bus shelters) since no dedicated space is provided for them. Hawker spaces were developed at four locations along with cycle tracks and bus shelters for Delhi Transport Corporation during 2001, in West Delhi. Specifications for the design of this space were derived from the study of existing demand. The area was designed keeping in mind the physical requirement of three different types of hawkers i.e., hawkers which conduct business directly on pavement, hawkers which use, wheel carts, hawkers which operate from temporary kiosks. The space was divided into three different levels specific for each hawker type. Subsequent study of these zones revealed that only a fraction of hawkers remained within the prescribed space, the remaining encroached upon cycle and pedestrian path to conduct their business (refer figure 4). The reason for this behavior has been attributed to restricted space, multiple levels and lack of shade. It is understood that the space requirement for hawkers is specific to the business conducted; however the minimum required area for a single hawker is 4 sq.m. Demand exists for three types of vendors; 1) serving pedestrians near bus shelters, important landmarks and nodes; 2) serving motorized two wheelers as helmet sellers; 3) serving cycle and rickshaw traffic in the form of repair shops and water trolleys.

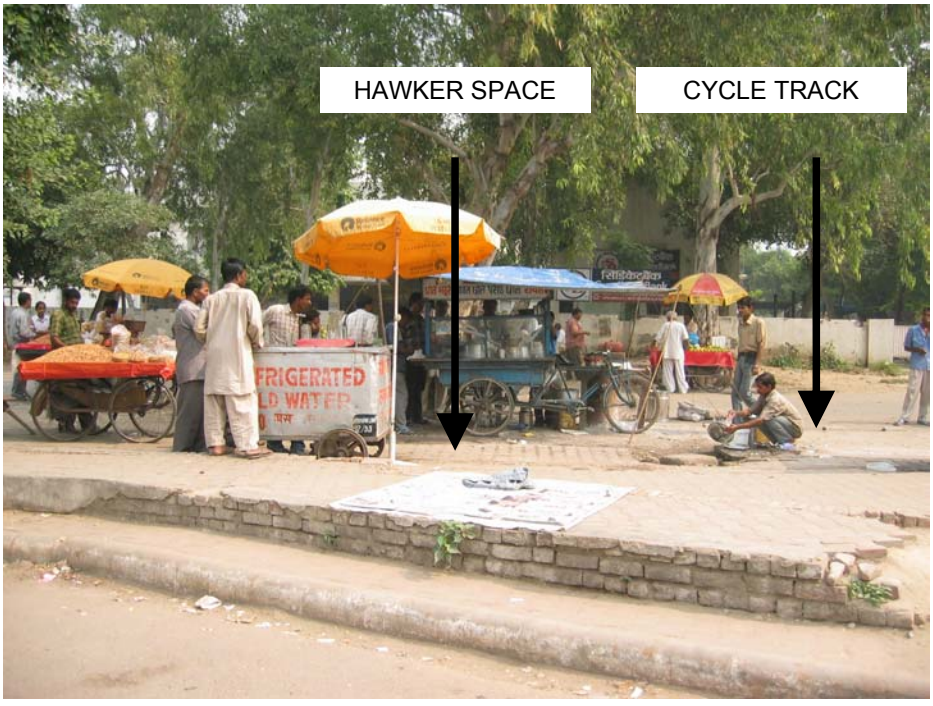

Figure 4: Hawker space and cycle track at Wazir Pur Depot Bus Shelter, Delhi

Hawkers on Indian streets are important service providers. It is understood that unless addressed and provided for in the streetscape, hawkers are likely to encroach dedicated bicycle infrastructure. The following specifications for the detailed design and planning of hawker are suggested to integrate these service zones with dedicated bicycle infrastructure:

- A location, which is ideal and proposes a promising business as per the user should be assigned. Such locations can be determined by studying existing demand of hawkers. Hawkers prefer nodes where there is a lot of moving human traffic and complement the other activities. Other important locations include bus shelters, important institutions and places of worship.
- Another criterion is shelter i.e. at places where there is a lot of shade. This can be ensured by planting more trees/ planters.
- It should be at the same level as that of the pedestrian path
- The space requirement should be on the basis of the existing land use and the new usage pattern should not be very different from the old usage.
- The minimum width required per hawker is 2m. The minimum area required for a hawker to sell and do business is 4sq.m. (though space should be allocated as per existing demand).
- It can be segregated from the pedestrian path, visually by providing bollards spaced at a clear distance of 1.25m – 1.3m and providing different texture/ flooring pattern, which demarcates the space from main pedestrian path.
- These lines of bollards also prevent the three-wheelers from using the space for parking.
- The design of the bollard is at the discretion of the designer which makes this space more attractive.
- Apart from its surface texture and pattern, this urban space has to be detailed out with street furniture like a sitting area/bench, signage, dustbins, lightning, and drain point. A detailed study of the various hawkers and their requirement should be done in order to minimize waste of space and increase the efficiency should carefully place the street furniture (refer figure 5).

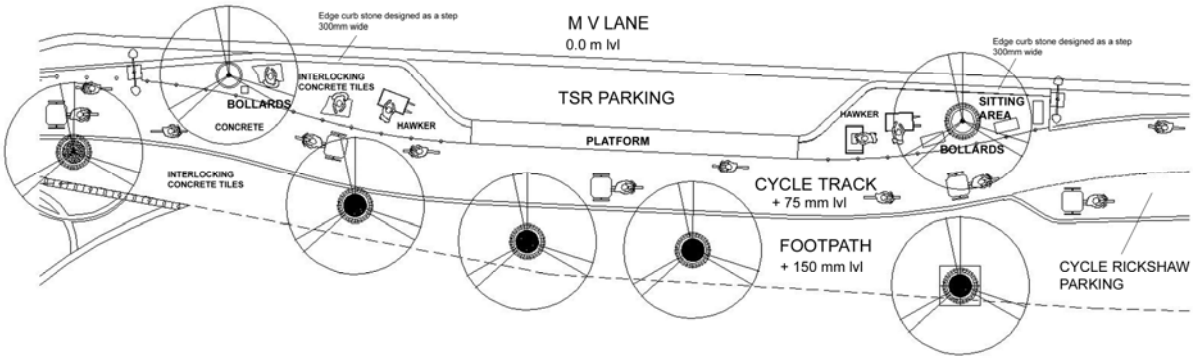

Figure 5: Proposed design of hawker space adjacent to cycle tracks.

- The entire space should be attractive. It should be vandalism proof and require low maintenance.
- Hawker spaces serving bicyclists should be at the same level as that of the cycle track and located either between the MV lane and cycle track, or between footpath and the cycle track.
- Hawker space can be defined using bollards spaced at a clear distance of 1.25m – 1.3m and by providing a different texture/flooring pattern which demarcates the space. The bollards should be placed at an offset of 0.3m from the edge of the cycle track, and should not be higher than 0.65m.
- The edge between hawker space and MV lane should be 0.3m – 0.45m wide and 0.15m high from the MV lane. The level of hawker zone should be 0.08m from the M V lane, i.e. at grade with bicycle path.

Parking

International guidelines prescribe for the availability of good cycle storage facilities to stimulate bicycle-ownership and use (CROW 1994: 240). Low cost of owning and maintaining a cycle in India has encouraged very high ownership and use. As cyclists here are main stream commuters their parking requirement is usually met at the residence or workplace and they seldom need to park along the route.

However, high parking demand exists for cycle rickshaws, which ply on main roads and serve as feeder service to public transport. Street space usage survey conducted to understand existing usage patterns on proposed HCBS corridors in Delhi show that demand exists for cycle rickshaw parking near bus shelters and important nodes. However existing Indian guidelines for NMV infrastructure do not include any reference to parking facilities for cyclists and cycle rickshaws. On the contrary, it states, *"… wherever the streets are very congested or on arterial roads with pedestrian and motor vehicles as the main road users, it is desirable to* ***prohibit the slow moving traffic*** *either totally or for a limited period of the day when traffic is at its peak* (IRC70 1977: 4)."

It is important to understand that provision of formal safe parking spaces for rickshaw which have provision for parking of bicycles (including rails and stands for locking) will encourage both bicycle and rickshaw as feeder modes to public transport. Thus the following specifications for the planning and design of parking faculties for cycles and cycle rickshaw are proposed:

- Cycle rickshaw parking should be provided adjacent to cycle tracks (at the same level) as 1.5m to 2.5m deep bays (for parallel or perpendicular parking),near pedestrian crossings, bus shelters, important nodes, and landmarks attracting heavy pedestrian traffic; or wherever existing demand is observed.
- Cycle rickshaw parking should be close to pedestrian crossings at intersections preferably on the 'on side' of the junction.
- The capacity of cycle rickshaw parking should be as per existing demand at that location.
- Cycle rickshaw parking should include, features such as sign boards, light poles, stands, rails (for locking bicycles) etc.

Conclusion

The draft specifications for bicycle infrastructure have been used to integrated dedicated bicycle infrastructure designs with the proposed High Capacity Bus System corridors in Delhi. The detailed alignment drawings for the bus corridor including designs and specifications for NMV infrastructure in the form of alignment drawing, edge details, details for mixed areas, parking spaces, hawker spaces, specifications for materials used, etc. (refer figure 6 and 7), has been prepared for a total road length of 50km in Delhi and 4.5km in Pune. The phased construction of the first corridor (14.5km in length) from Ambedkar Nagar to Delhi Gate, Delhi, is expected to start in March 2006.

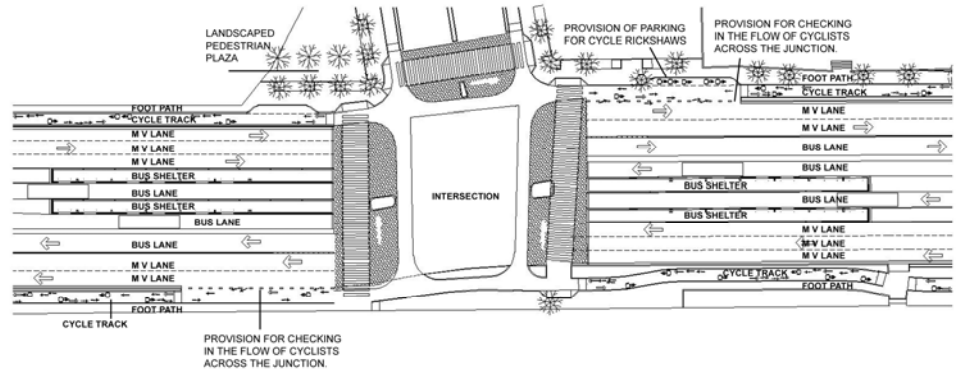

Figure 6: Plan showing entry exit to cycle track at junctions

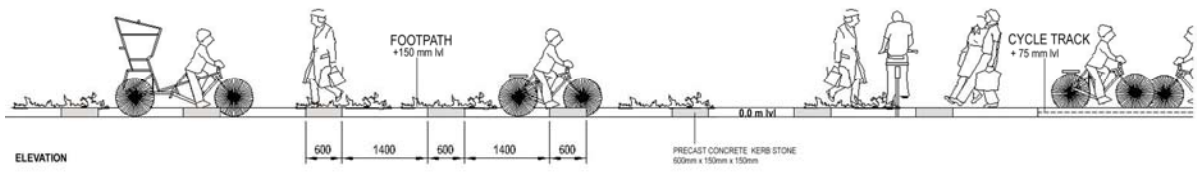

Figure 7: Detail elevation of cycle track entry at (on the off side of) junction.

Acknowledgement: The author would like to acknowledge the contribution of Ms. Ruchi Verma, TRIPP, IIT, Delhi, in preparation of sketches and drawings for this paper.

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