
ROAD SAFETY AUDIT OF MUMBAI METRO RAIL CORRIDOR

JULY 2013

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1 Introduction

1.1 Background

A safety audit is a systematic method of checking the safety aspects of new road projects or rehabilitation projects in order to detect potential safety hazards before the road is opened to traffic. The principle behind it is that 'prevention is better than cure'. Road user error is a major contributing factor to road accidents, but defects in the road environment (poor alignment, inadequate signing, dangerous obstacles, etc.) also contribute in many cases. Remedying these defects at the design stage is an economical and effective way of reducing road accidents.

A road safety audit assesses how the road will function and focuses on the safety of all users - pedestrians, cyclists, motorcyclists, truck and bus drivers, car drivers, etc. The audit takes into consideration the abilities, knowledge and demands of the users. It is based on how road users behave, not how they are supposed to behave.

The principles of safety audit are established through application of knowledge and experience of effective accident remedial programmes, planned studies of the influence of design and traffic management on safety, and of the factors contributing to the occurrence of accidents.

The outcome of the audit is the identification of potential problems. The audit team then make recommendations on how those issues may be addressed in order to minimise or remove the problems. An audit can be undertaken at fixed points in the progress of a road project. The main aim of safety audit is to ensure that all new road schemes operate as safely as possible.

Road safety audit is a natural element in the quality management of road administrations. It can be used for new road as well as road improvement projects.

1.2 Introduction to project site

The Mumbai metro corridor extends west to east from Versova to Ghatkopar over a distance of 11.07km. This phase of the metro includes 12 stations And a maintenance depot which is located at DN Nagar close to Versova station. The location of the metro line is shown in Figure 1.

The metro is constructed as an elevated line along the centreline of exiting road corridors of Jai Parkash (JP) Road and Mathuradas Vasanji (MV) Road. The width of right way is variable throughout the corridor from 32m to less than 16m.

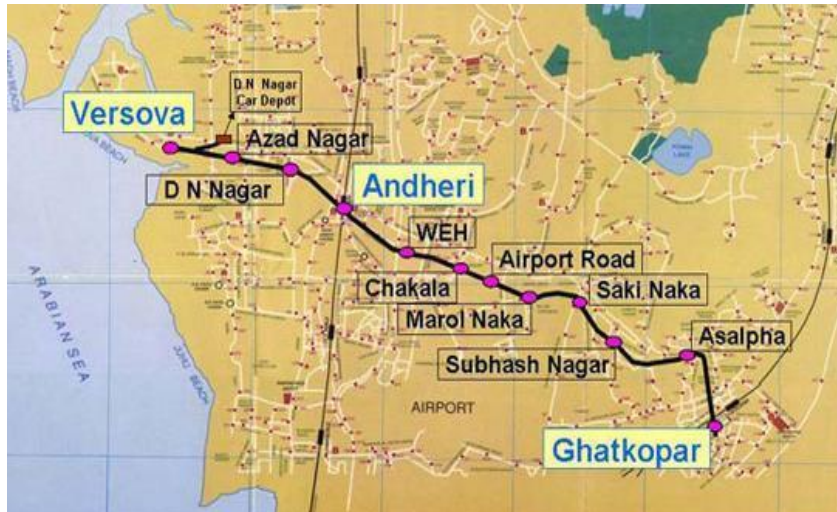


Figure 1: Metro line

Both JP Road and MV Road have concrete surface through the metro corridor with an approximately 2m wide parking strip of block paved construction. Generally the concrete surface of the road changes to block paving on the approach to junctions.

1.3 Structure of report

The report is divided into two sections, general problems and recommendations; and specific problems and recommendations. The general section contains issues that pertain to all, or a large section of the corridor. The specific issues section contain issues specific to a location on the corridor. In some cases, multiple issues may be shown in one drawing, and labelled suitably.

The recommended treatment is listed immediately after each issue. Some issues may have more than one recommendation.

2 General recommendations

2.1 Sidewalks

Problem

The design aims at providing sufficiently wide sidewalks all along the corridor by narrowing down the carriageway. This is very commendable. At some points for example under stations where stairs and escalators come down sidewalks are quite narrow.

The challenge is that at some points the sidewalk is blocked by trees, street vendors or fixed objects forcing pedestrians out on the street.

In the design ramps are provided at all level changes, but in some cases the ramps are blocked by objects so that wheelchairs cannot pass.

At some places it is possible to find informal vendors placed on the sidewalks. This is a problem as they are often an obstacle that may induce pedestrians to walk in the traffic lanes. When these vendors are placed near gates or any access to private areas they may also affect the visibility of vehicles that are leaving the area to access the main road.

Recommendation

It is very important to keep the high priority of wide and unobstructed sidewalks. Especially near stations where large flow of pedestrians will move after a train arrives, the area of the sidewalk should be checked to ensure a sufficient level of service to prevent pedestrians from walking in the vehicle lanes. It could be considered narrowing down the vehicle lanes at such points to 3m. This would also have a speed reducing effect and the added risk from having varying lane widths is considered much lower than the benefit from providing sufficient space for pedestrians.

Where at stations it is possible for pedestrians to cross the central reserve a guardrail should be installed along the sidewalk. This will also prevent illegal parking on the sidewalk.

The vendors should be relocated to appropriate places and enforcement may be necessary to ensure that they will respect the defined areas for their activities.

The design should be checked to ensure that fixed objects on the sidewalks do not obstruct the movement of wheelchairs especially near ramps.

2.2 Bus stops and pedestrian crossings

Problem

At some instances bus stops are placed just before a pedestrian crossing. This reduces the visibility of pedestrians from vehicles passing the bus stop.

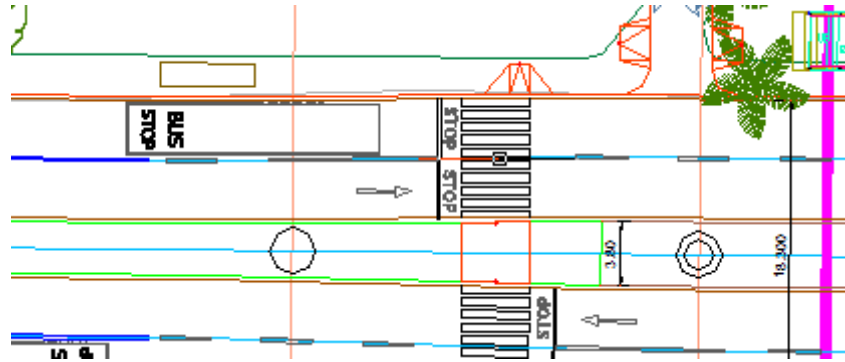


Figure 2: Bus stop before pedestrian crossing

Recommendation

Bus stops should be placed after pedestrian crossings.

2.3 Provisions for parking

Problem

The introduction of the Metro line implies many changes in the use of the road. One of the major changes is that provisions for parking are greatly reduced. The demand for parking, however, is high and illegal parking for example along the central reserve was observed. Parked vehicles obstruct visibility and increase hazards especially for crossing pedestrians.



Figure 3: Vehicles parked at central reserve

Recommendation

A survey on demand for parking should be undertaken and possibilities for satisfying a reasonable amount of this demand should be provided as dedicated (marked) parking along the corridor or on adjacent streets.

2.4 Property accesses

Problem

At accesses to properties the sidewalk is cut off so that the access is at street level. This means that accesses work as side roads and vehicles can turn at some speed. Also, the sidewalk is often interrupted and does not provide safe passage for pedestrians.

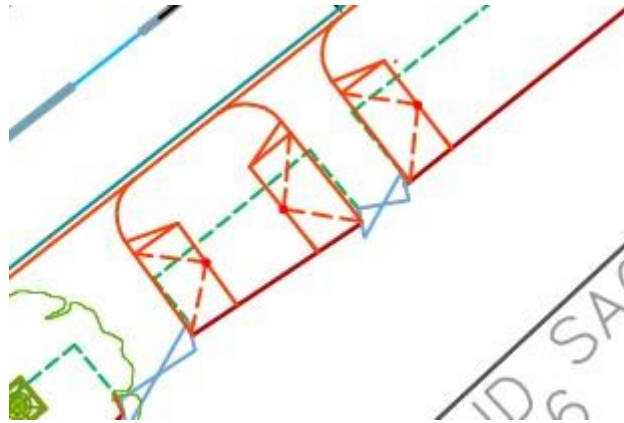


Figure 4: Changes in sidewalk level due to gates close to each other

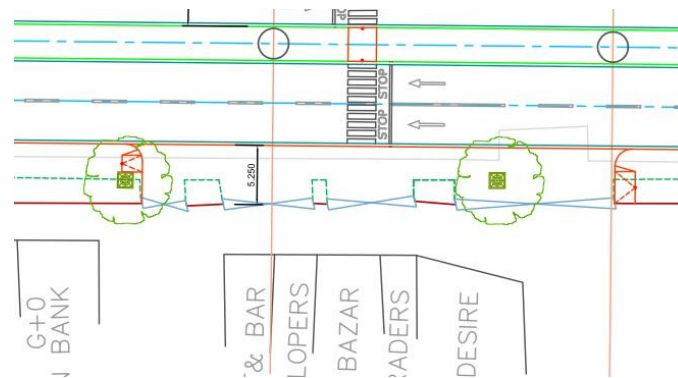


Figure 5: Sidewalk at street level over a longer distance

Recommendation

The sidewalk should be kept at the same level between side roads along the corridor, prioritizing pedestrians. A raised sidewalk will reduce the speed of turning vehicles. Where this recommendation cannot be followed accesses should be reconsidered to ensure sufficient visibility, width of and access to ramps.

2.1 U-turns

Problem

The design includes a solid central barrier along the corridor. This will greatly reduce conflicts with turning vehicles. But it will also increase the demand for U-turns along the corridor. U-turns in junctions increase conflicts and add to congestion.

Recommendation

It could be considered to arrange for a U-turn prior to a junction taking the U-turn out of the junction area. Some issues should be taken into consideration:

- U-turns of large vehicles demand a large sweeping area and it may be necessary to widen the carriageway at the U-turn
- U-turns should be placed near speed reducing measures such as a raised pedestrian crossing or a signal-controlled junction.
- U-turns should be placed so the columns of the metro do not obstruct visibility.
- Where U-turns are placed near junctions a no-U-turn regulation in the junction should be enforced.

2.2 Ramps with different widths

Problem

Ramps are designed with varying widths. Some of them seem to be too narrow to allow for a wheelchair to use it.

Recommendation

All the ramps of the project should be designed according to national standards allowing any user that may need the ramps to access the sidewalk.

2.3 Safety during construction

Problem

A construction site along a busy road induces risks for both road workers and road users. The construction sites at the metro corridor are not marked and no guidance or protection is provided for any road users. This is especially a problem for pedestrians passing under the coming stations. They have to walk in the vehicle lanes and the forward visibility is very poor.



Figure 6: During construction pedestrians are forced out in the vehicle lanes

Recommendation

National standards for safe management of construction sites should be in place and followed at any construction site.

2.4 Mid-block pedestrian crossings

Problem

At a number of places in the design pedestrian crossings are suggested mid-block or at minor unregulated junctions. The respect for pedestrian crossings is very low and will in themselves not provide any safety for pedestrians.

Recommendation

All non-signalised pedestrian crossings should be constructed as raised crossings or be provided with a hump before the crossing to secure low speeds of vehicles.

2.5 Maintenance

Problem

It was often observed that the pavement was in a poor state of maintenance. This poses a risk especially for two-wheelers.



Figure 7: Pavement in poor condition

Recommendation

It is assumed that the corridor will be given a new overlay after construction works finish, but if that is not the case repairs should be undertaken where conditions pose a risk to the road users.

2.6 Trees in inappropriate places

Problem

It was noticed that some trees shown in the project are not in appropriate places. Some of them are in front of ramps, property gates or even in the middle of the street. It was not clear if they are going to be removed or if they are going to be kept in the project.

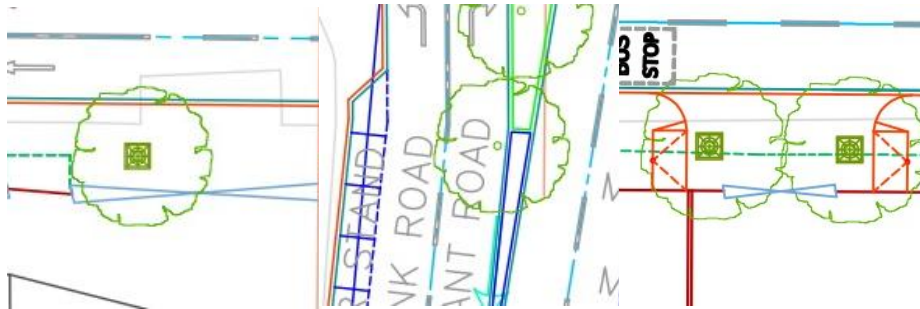


Figure 8: Trees in front of a gate, in the middle of the street and in front of the ramps

Recommendation

The trees should not be an obstacle to pedestrians or other road users. If the project includes the trees, the infrastructure around them should be planned and built in a way that will not be obstructed by the trees. Otherwise, they should be removed.

2.7 Traffic signs

Comment

It was not clear which traffic signs will be used, and where they will be applied. They should be consistently used all along the corridor and side roads to guide drivers and pedestrians together with road markings.

2.8 Turning radius

Problem

At some intersections or near the property gates, the turning radius is too wide. This should be avoided, as vehicles are likely to use higher speeds to turn instead of decelerating, which would be the safer way to turn.

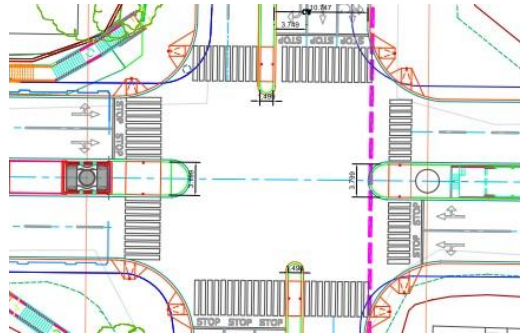


Figure 9: Intersection with large turning radii

Recommendation

To ensure that vehicles make the turning movements at lower speeds, the turning radius should be as small as possible. This can be done through the widening of sidewalks and extension of the central medians.

2.9 Visibility under the stairs

Problem

Under some stairs on the stations there are property gates. Vehicles leaving the gates may not have appropriate visibility of the street and oncoming vehicles and pedestrians due to these stairs, and they may also not be seen by the main road users.

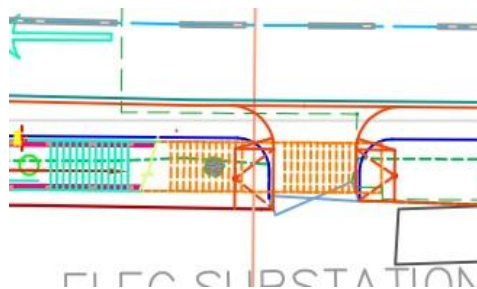


Figure 10: Property gate under the station's stairs

Recommendation

The property gates under the stairs should be properly signalled, to alert drivers on the street about the vehicles leaving the gate. The approach should also allow drivers leaving the gate to have an appropriate visibility of the main road and pedestrians crossing the area in front of the gates.

3 Specific design issues

3.1 Pedestrian crossing in an inappropriate place

Problem

Location: J.P. Road, in front of Peary Palace

The pedestrian crossing in front of Peary Palace is aligned to a property gate. It may create conflicts between pedestrians and vehicles arriving or leaving the property.



Figure 11: Pedestrian crossing aligned to a property gate

Recommendation

The pedestrian crossing should be moved in order to lead pedestrians to safe sidewalks. The bus stops should be kept close to the crossings.

3.2 Junction between J.P.Road and Harmind Singh Road

Problem

The junction is very skew and not signal-controlled. Vehicles from Panth Road drive against traffic to go south on J.P.Road. Many drivers also make a U-turn from J.P.Road to Panth Road but space is not sufficient for large vehicles.



Figure 12: Trucks cannot make U-turn into Panth Rd.

Recommendation

It should be considered to change the junction to a roundabout. The layout should be as tight as possible to avoid vehicles moving in opposite direction in the roundabout. Overrun areas (for example a circle of cobblestone) can be placed at the perimeter of the central circle.

Even with a narrow roundabout some vehicles may still go from Panth Rd. against traffic. If possible Panth Rd. should be changed to one-way away from J.P.Road.

3.3 Property gate at intersection

Problem

Location: J.P. Road with Vasvani Road

There is a property gate at J.P. Road, close to the intersection with Vasvani Road. It may create conflicts between vehicles using the main road and vehicles leaving the property. Two trees on the sidewalk blocks visibility.

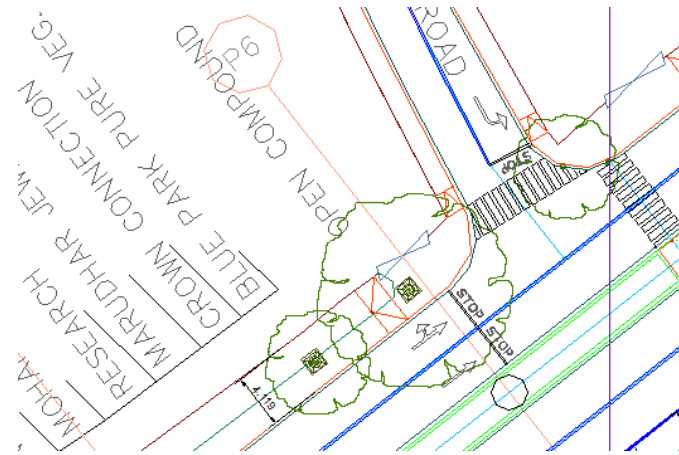


Figure 13: Property gate too close to the intersection and near trees

Recommendation

This property gate should be moved to the side road or to a place further from the intersection.

3.4 Distance between bus stops and pedestrian crossing

Problem

Location: J.P. Road, P12

Near the bus stops in front of Shopping Center there are no pedestrian crossings installed. It means that passengers will be tempted to cross the main road far from the crossings, without any protection. This problem gets even worse as the shopping is likely to attract more people to this area.



Figure 14: Bus stops far from the pedestrian crossing

Recommendation

Bus stops should be moved closer to the regulated pedestrian crossings and guardrails should be installed to guide pedestrians to the safe crossing points.

3.5 Conflicts at intersection

Problem

Location: J.P. Road, P22

The geometry of the junction is complicated because of the column in the middle. Right-turning vehicles were seen passing on either side of the column from both directions. U-turns are also performed from all directions.

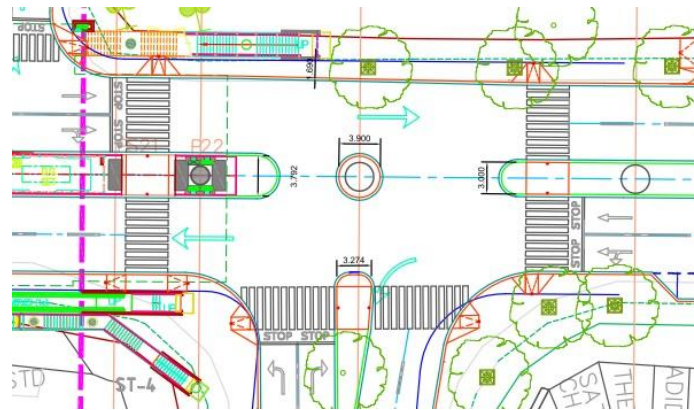


Figure 15: Intersection of J.P. Road and Balasaheb Sawant Road

Recommendation

It is recommended to close the central reserve at this point.

3.6 Bus stops

Location: J.P. Road, P32 to P34

Problem

On the northern side there are bus stops on either side of the pedestrian crossing. On the southern side the bus stop is placed before the pedestrian crossing. Placing bus stops before a pedestrian crossing reduces visibility of crossing pedestrians and their sight distances.

Recommendation

As there is only one stop on the southern side it seems that bus traffic can be managed at one stop on the northern side as well. The stop before the pedestrian crossing should be removed. On the southern side the bus stop should be moved to after the pedestrian crossing.

3.7 Wide junction

Location: J.P. Road, P35 to P36

Problem

The junction area is very wide leading to many conflicts and difficulties for pedestrians to cross.

Traffic from north has two lanes but the southern arm is only marked for one lane – although wide.

There is an access to a parking lot where the pedestrian crossing ends to the west in the junction.

Recommendation

The junction should be narrowed down through build-outs at corners and extension of the central reserve from east. Pedestrian crossings at east and south should be moved closer to centre of junction. The access from north should have only one lane for going straight across the junction and one left-turn lane. The width on the southern exit should be reduced to one lane.

The access to the parking area should be closed.

3.8 Bus stop

Location: J.P. Road, P37

Problem

The bus stop at this location is placed before the pedestrian crossing which may reduce visibility.

The pedestrian crossing ends at street level on the northern side. If the recommendation of using raised crossings at mid-block pedestrian crossings is followed the crossing should have a ramp. This would complicate the passage of vehicles for the property gate.

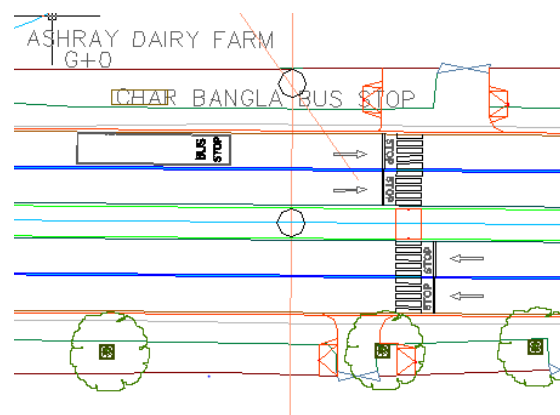


Figure 16: Bus stop in front of pedestrian crossing

Recommendation

To keep consistency along the project, the bus stop and the pedestrian crossing should shift place. This would allow vehicles to have a better visibility of pedestrians crossing the main road. This would also solve the access problem.

3.9 Ramp width

Location: J.P. Road, P41

Problem

The ramps at the pedestrian crossing in the side road seem to be very narrow.

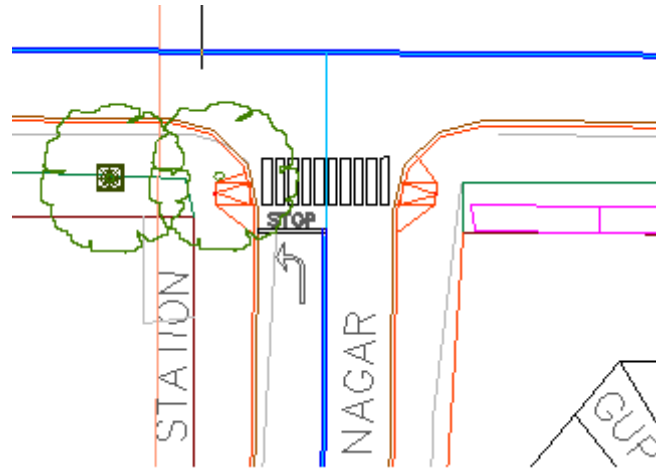


Figure 17: Narrow ramps at pedestrian crossing

Recommendation

Check that the width of the ramps is in accordance with Indian standards.

3.10 Ramp ends in tree

Location: J.P. Road, P48

Problem

The ramp at the southern end of the pedestrian crossing ends in a tree trunk.

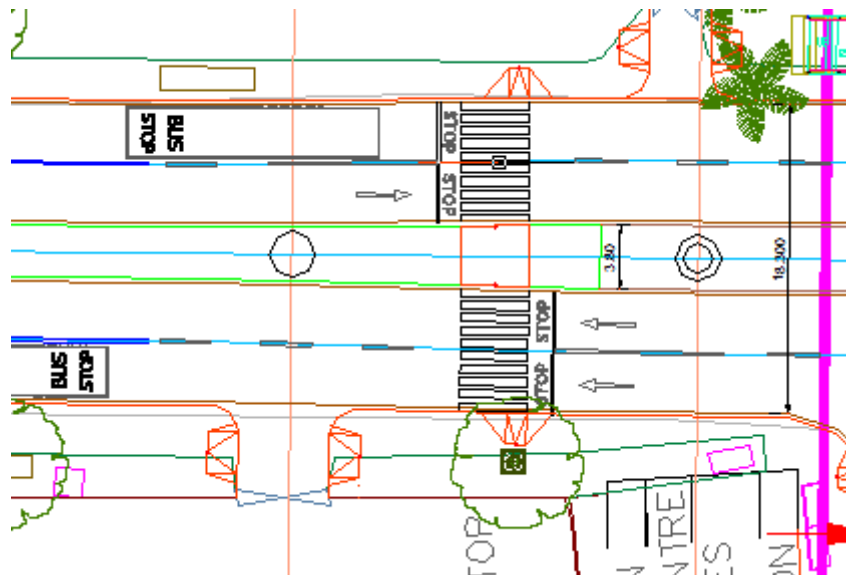


Figure 18: Ramp ends in tree

Recommendations

Move the ramp to other side of pedestrian crossing.

3.11 Allowed movements

Problem

Location: J.P. Road, P63

At the intersection of J.P. Road and Bazar Road an arrow in the left lane indicates that the vehicles are only allowed to move straight. Apparently, this lane should allow access to Bazar Road as well.

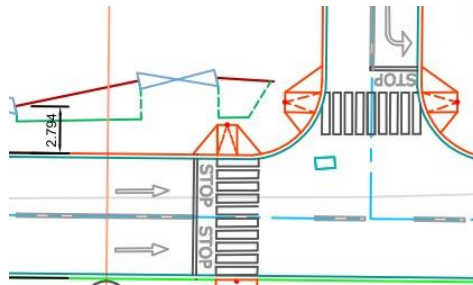


Figure 19: Lane markings indicating straight movements only

Recommendations

If left turning movements are allowed at this point, which would not present any safety problems, this arrow should also indicate this movement as a possibility to vehicles approaching to the intersection.

3.12 Bus stops far from pedestrian crossings

Problem

Location: J.P. Road, P65

There is a bus stop placed at this point, but there are no pedestrian crossings near it. This is a problem, as bus passengers don't have safe conditions to cross the main road after alighting or when attempting to access the bus stop.

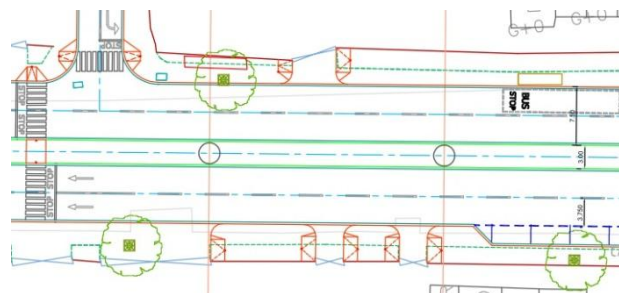


Figure 20: Bus stop far from pedestrian crossing

Recommendation

To allow passengers to cross the main road safely, bus stops should always be installed near pedestrian crossings.

3.13 Markings of turning movements

Problem

Location: J.P. Road, P69

Markings on the southern half of J.P.Road indicate a right turn lane and a lane for going straight. The central reserve does not allow right turn and the side road seems to be bidirectional allowing for left turns.

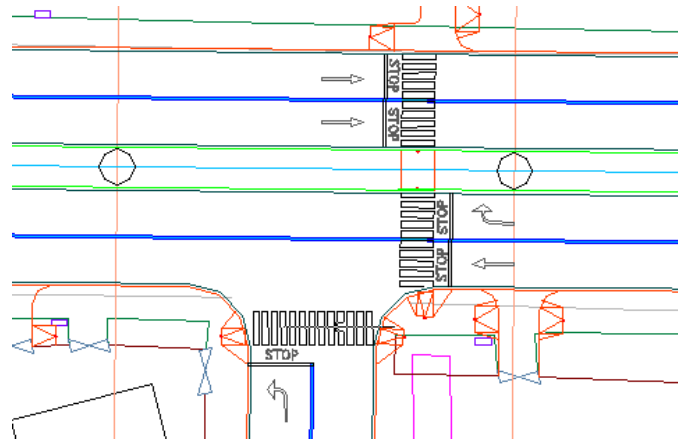


Figure 21: Marked turning movements

Recommendation

Replace the markings with a straight arrow in the right lane and a combined straight/left arrow in the left lane.

3.14 Access to high school

Location: J.P. Road, between P72 and P73

A high school is placed at the southern side of the corridor with its main gate at this location. There are no provisions for pupils to cross safely.

Recommendation

A pedestrian crossing should be installed here to facilitate safe crossing.

3.15 Pedestrian crossing in front of property gate

Problem

Location: J.P. Road, between P79 and P80

In front of a property gate, there is a pedestrian crossing (see *Pedestrian crossings in front of a property gate*). This crossing is also far from the bus stop and the stairs of the metro station.

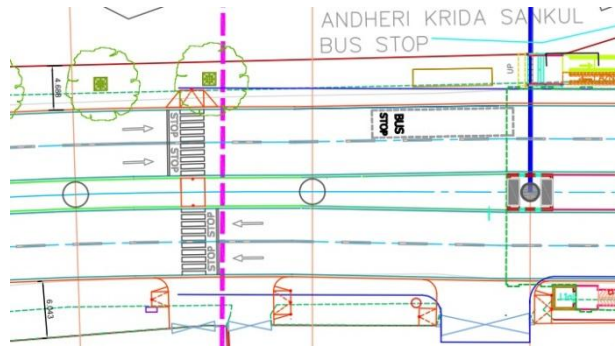


Figure 22: Pedestrian crossing in front of property gate

Recommendation

The location of the pedestrian crossing should be carefully designed. The crossing should be placed as close as possible to the bus stop and the stairs of the metro station, taking into consideration that pillars may obstruct the visibility of pedestrians waiting to cross. Guardrails should be placed to help guide pedestrians to the crossing.

3.16 Allowed movements

Problem

Location: Veera Desai Road

The arrow drawn in one of the lanes of Veera Desai Road indicates that it is allowed to turn right to access the main road, which may create many conflicts between vehicles making this movement and the ones already using J.P. Road.

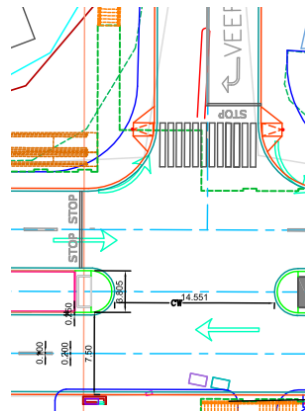


Figure 23: Arrow indicating allowed right turning

Recommendation

If the right turning access to the main road is allowed, this intersection should be signal-controlled and the arrow should indicate both right and left turning. Otherwise, the central reserve should be closed and the arrow should indicate left turning instead.

3.17 Narrow sidewalk in front of pedestrian crossing

Problem

Location: J.P. Road, between P88 and P89

At the second part of the crossing, the sidewalk is too narrow due to the stairs of the metro station. This sidewalk is also too close to a property gate under the stairs, which may obstruct the visibility of vehicles.

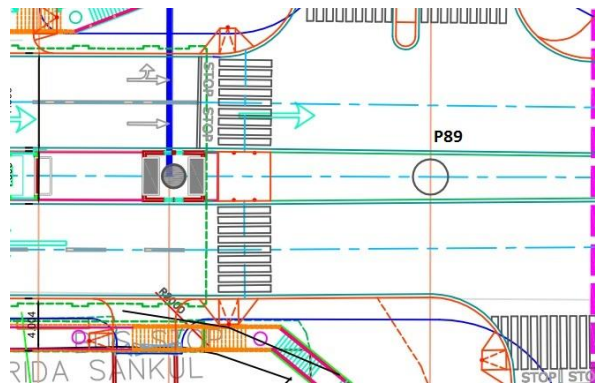


Figure 24: Pedestrian crossing in front of narrow sidewalk

Recommendation

The second part of the sidewalk should be staggered to a wider part of the sidewalk (closer to P89).

3.18 Access of two vehicles to the main road at the same time

Problem

Location: J.P. Road, P89

The markings at the two side roads indicate that vehicles at both lanes should turn left and access the main road. If two vehicles try to access J.P. Road at the same time, they may not have an appropriate visibility of the other vehicles at the main road.

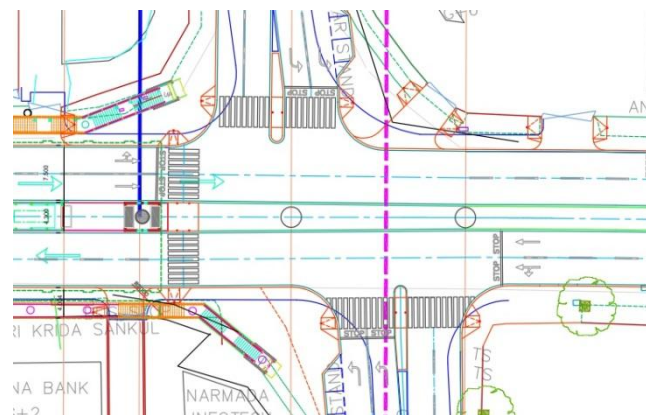


Figure 25: Arrows in side road indicating left turning

Recommendation

If the junction is not signal-controlled, it is recommended to allow only one vehicle at a time to access the main road. This can be done by extending the sidewalks and central islands.

3.19 Allowed movements at intersection

Problem

Location: J.P. Road, between P94 and P95

The arrows in the drawing indicate that right turning is allowed from the main road to access the side road. Right turning may create many conflicts between vehicles in different lanes. There are no arrows indicating which movements are allowed to vehicles leaving the side road.

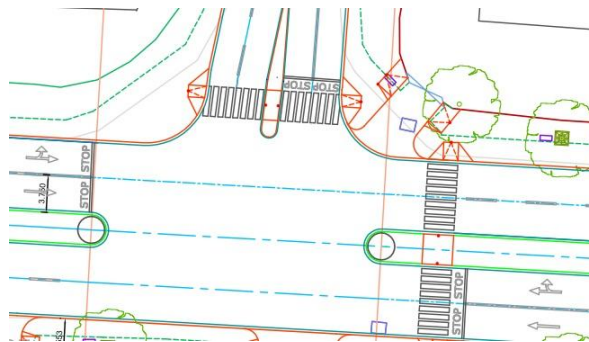


Figure 26: Arrows in main road indicating right turning to access the side road

Recommendation

If right turning is allowed from J.P. Road to access the side road, this intersection should be signal-controlled. Otherwise, the arrow in the main road should be changed to one indicating straight movements and the central reserve on the western side should be extended to the middle of the junction.

Road markings should be applied to inform the allowed movements to drivers coming from the side road. Right turn movements should not be allowed unless the junction is signal-controlled.