

PART C – SOME COMMON SAFETY CONCERNS ON KARNATAKA’S HIGHWAYS

1. Remembering the safety of road users

Experienced road safety auditors put themselves “into the shoes of the future road users” in an effort to anticipate the road safety concerns of the future road. They understand that humans make mistakes and they take such failings into account during each audit.

For example, inexperienced drivers/riders often find it difficult to judge speed, distance or reaction time. This can lead them to under-estimating their crash risk. Very young pedestrians are more likely to be impulsive, with underdeveloped cognitive skills in judging speeds. Motorcyclists are at high risk of injury or death, but are often the most forgotten road users.

Complying with standards is an excellent starting point for designing safety into a road project. However, ensuring that minimum standards are satisfied is not a guarantee of safety.

A road safety audit goes beyond a compliance check with standards.

An audit is an assessment of how people will use the road once it is opened, and is a report of all the safety concerns in the new road project that could lead to crashes once the road is operational.

A road safety audit helps to achieve a safer new road by checking that it:

- **WARNS** the road users of risks,
- **INFORMS** the road users of conditions ahead,
- **GUIDES** the road users through changing road sections,
- **CONTROLS** priorities, speeds and travel paths, and
- **FORGIVES** the road user’s errant or unsafe behaviour.

WARN, INFORM, GUIDE, CONTROL AND FORGIVE



WARN. Warnings can be given by signs, line markings or rumble strips. The message should be clear and simple.

INFORM. Information is best provided in small amounts, and repeated as necessary. Direction signs and lane direction arrows are good examples of informing drivers/riders of where to go to safely reach their destination, or which lane to use on the approach to a signalised intersection.



GUIDE. If the geometry of the design cannot be improved, one option is to install chevron alignment markers to guide drivers through tight curves. Strong edge lines also assist.





CONTROL. Safe traffic control at intersections is an integral part of any road network. Speed must be managed carefully, and drivers need to be made well aware of the speed limit – no secrets and no surprises!

FORGIVE. Experienced audit teams will check to ensure good roadside safety. Roads with unsafe roadsides may need crash barrier to shield the hazard and to reduce the risk to the occupants of any vehicle that leaves the road. Audit teams need to understand the technical details of barriers, and will also check that the road is to be well delineated too. This road lacks line marking.



A key element of road safety audit is judgement. Decisions about road safety are rarely “black or white”. There are many shades of grey in between. An experienced audit team will go through the checklists for the stage of audit, and the team members will also ask general questions such as:

- Will the design be well understood by the road users?
- Is there a risk that the design could lead to confusion?
- Does it provide adequate visibility from all directions?
- What will happen if a vehicle runs off the road?
- Where will pedestrians cross the road, or walk along the road?
- Will sealed shoulders be provided to assist motorcyclists, pedestrians and animal drawn vehicles?
- Will the signage provide enough information to assist users?

An example of a road safety audit report of a road project in Karnataka is provided below, showing a recommended format for an audit report.

After the audit report, some common safety issues that often arise during road safety audits in Karnataka are outlined. These safety issues are included in this field guide to provide some technical guidance on common safety issues that may assist you in your audit work. The safety tips illustrate many things, one of which is that making a decision in a road safety audit is often a complex interaction of elements. Sound judgement and logical thinking are essential for a road safety auditor.

2. An audit case study from Karnataka

This report provides the results of a preliminary design stage road safety audit of a proposal to duplicate 9km of State highway in SW Karnataka.

Description of the proposal

This report provides the major findings of a preliminary design stage road safety audit of a section of state highway proposed for duplication next year. Included in the task will be the construction of two new bridges (one over a river, one over a railway line), three two-way side roads totalling 1.8km in length, 10 new culverts and one major new intersection. The highway passes through two villages and special attention is being paid in the design to minimise the impact of the new road on these villages.

This road safety audit

This preliminary design stage road safety audit was carried out in accordance with the Road Safety Audit Field Guide for Karnataka. It was undertaken by XXXXX and YYYYY. Both are registered Senior Road Safety Auditors in the Karnataka PWP&IWTD register of road safety auditors. Neither has previously been involved in any aspects of the planning or design of this proposal; each is independent of the project. It is understood that there have been no previous audits of this proposal. The highway was inspected on 12th March (afternoon and night time). The weather was fine and warm during the inspections.

Key safety findings from this preliminary design stage audit

A number of general road safety concerns were detected during this preliminary design stage audit.

Cross section

The standard cross-section for the highway will be:

- (i) Two 7m wide carriageways (each with 2 x 3.50m wide lanes);*
- (ii) A 2m wide central median;*
- (iii) 1.5m unsealed shoulders on the outside of each carriageway;*
- (iv) 0.5m sealed shoulders against the median on each side.*

The first concern is the unsealed shoulder. It will eventually present a maintenance issue for the road authority, it will break up where trucks cross it regularly (such as driveways) and it will get wet and muddy. Pedestrians will walk on the road in preference to muddy shoulders. Drop-offs will develop and these will present a risk for motorcyclists.

The second concern is the narrow median. 2m is insufficient to permit sheltered right turn or U turn lanes to be provided. This means that vehicles slowing to make turns at the openings proposed near Km 19.5, 22.6 and 25.7 will be at risk of being struck from the rear.

The third concern is the cross section on the two new bridges. The drawings indicate there will not be a shoulder across the bridges. It is important for safety to continue the full cross section across the new bridges.

Road side hazard management

With no on-coming traffic there will be less demand on drivers/riders. Higher speeds are expected on the new highway, and more “single vehicle” crashes can be expected unless sound road safety engineering measures are implemented. The existing road side has a number of hazards, including trees, culverts, light poles, bridge end posts, bus shelters and steep side slopes. Internationally recognised clear zone guidelines indicate a clear zone of 9m is appropriate for roads with operating speeds of 100km/h, and traffic volumes of about 20000vpd. The drawings are silent about roadside hazard management.

Crash barriers

Crash barriers are costly to install and maintain. They also represent a hazard to errant road users, especially motorcyclists. During design therefore every effort should be made to eliminate the need for roadside barriers. The drawings show only two lengths of barrier proposed along the highway. However, crash barriers are also considered necessary at five other locations:

- On an embankment at bridge 1 where the slope is greater than 1:6 and the vertical height difference exceeds two metres.
- To shield a sign support plus several large trees which are road side hazards (any fixed object greater than 100mm in diameter) within the agreed 9m clear zone.

The provision of a crashworthy end treatment is required where a crash barrier terminates within the clear zone or where it is likely to be hit by an errant vehicle. The Standard drawings indicate unsafe “fish tail” terminals as standard for the steel barrier. These are dangerous and should not be used.

AUDIT CONCLUSIONS

This road safety audit has identified features of the proposed highway duplication that should be altered, redesigned or removed to improve road safety in this road.

XXXXX

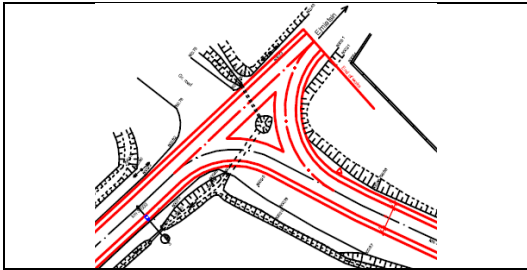
(Senior Road Safety Auditor)

REFERENCES USED DURING THE AUDIT

1. Road Safety Audit Field Guide, 2013.
2. PWP&IWTD Karnataka drawings numbered 01 – 10 for Highway Duplication (Km 18.0 to Km 27.0) (dated March).

NO.	AUDIT FINDINGS	RISK	RECOMMENDATIONS	CLIENT RESPONSE
1 SAFETY CONCERNS WITH THE PROPOSED STATE HIGHWAY DUPLICATION BETWEEN Km 18.70 - 27.70				
1.1	<p>This highway passes through a number of villages. The existing highway is in poor condition with numerous abutting houses and properties. It will be vital to keep speeds to reasonable and safe levels on the new highway through the two villages in this proposal. The duplication and the generous cross sections will increase speeds.</p>	HIGH	<ul style="list-style-type: none"> • Implement traffic calming (Gateway treatments) at the entrance to each village. • Install duplicate 40km/h speed restriction signs at these gateway treatments and at 500m spacings through each village. • Paint large yellow 40km/h signs on the road at these points. 	
1.2	<p>The three median openings (at Km 19.5, 22.6 and 25.7) have no sheltered right turn lane. This means that a vehicle waiting to turn right or to do a U turn is at risk of being struck from the rear. The opening at Km 22.6 in just 50m beyond a small crest meaning that approaching drivers/riders may not see a stationary vehicle in time to stop.</p>	HIGH	<ul style="list-style-type: none"> • Review the proposed cross section. Try to achieve a median that is 6m wide so that sheltered turn lanes (3m wide) can be constructed. • If this is not possible, install warning signs (Median Opening) and suitable lane markings approximately 100m in advance of each opening to alert approaching drivers/riders. • Consider relocating the opening from Km 22.6 to Km 22.7 to increase sight distance to the opening. 	

<p>1.3</p>	<p>The junction in the side road near Km 23.05 has a triangular island in the middle of the intersection. This will permit 2-way traffic on each of the three sides of the triangular island, creating 3 Y junctions and numerous conflict points at this location. Crash risk will thus be increased.</p>	<p>MED</p>	<ul style="list-style-type: none"> • Redesign this intersection to eliminate the triangular island. • Design this as a T junction, with left turning islands as necessary to shelter vehicles and to minimise “corner cutting”. 	
<p>1.4</p>	<p>Both bridges require W beam guardrail to be installed to shield the bridge parapets. At the railway flyover, the guardrail should be extended so that it shields the entire slope that is more than 2m high. The drawings are silent about the use of crash barrier at the bridges.</p>	<p>HIGH</p>	<ul style="list-style-type: none"> • Ensure W beam guardrail is shown on the drawings to shield all bridge abutments. • Ensure that standard drawings are developed that show the safe and correct way to affix guardrail 	
<p>1.5</p>	<p>The right hand curve near Km 26.9 has a much shorter radius than any other curve in this section of the Highway. It will be one of the “sharpest” curves on the entire highway. Some drivers/riders may be caught by surprise at the curve, and run-off-road crashes could result. The drawings are silent about what is intended to address this risk.</p>	<p>MED</p>	<ul style="list-style-type: none"> • Review the design to try to increase the radius of this curve. • If this is not possible, ensure that the outer shoulder is sealed and has a slope to match the superelevation of the carriageway • Ensure that chevron alignment markers are installed around the outside of the curve in addition to the guide posts. 	



The drawing shows this triangular island near Km 23.05. This will create numerous conflict points. It should be redesigned into a T junction.



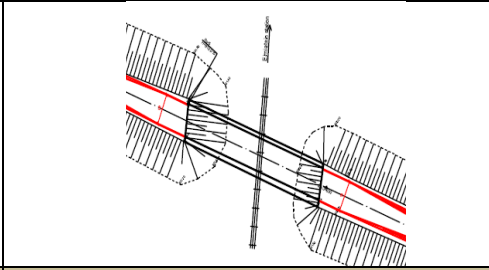
The existing road is in very poor condition. Speeds are less than 20km/h for much of the length. When the highway is duplicated, speeds will increase. This will increase risk for pedestrians especially.



Pedestrians are amongst the largest users of this highway. They warrant special safety attention. Sealed shoulders are recommended.



It is recommended that gateway treatments be developed for each village – comprising flat topped road humps, speed restriction signs, and road markings.



The embankment at the railway flyover is almost 10m high, and an errant vehicle is at high risk if barrier is not correctly installed. With no barriers, the existing bridge is unsafe.



This photo shows W beam barrier firmly attached to a bridge; the posts become more closely spaced to add strength to the barrier close to the rigid abutment.

2 SAFETY CONCERNS WITH VULNERABLE ROAD USERS BETWEEN Km 18.700 – 27.700			
2.1	<p>The existing bus stop in the centre of the first village is a central point for pedestrians. They cross the highway at this point and the bus stop is well used. The proposal is silent about any work at the bus stop and is silent also about how pedestrians are to cross the highway when it is duplicated. The bus stop should be provided with a sealed area, with a good shelter and with a street light for night time security. The volume of pedestrians indicates a set of push button signals should be considered to assist pedestrians to cross the highway safely.</p>	MED	<ul style="list-style-type: none"> • Ensure that the bus stop is fully sealed. • Install a street light at the shelter for night time security. • Consider how best to assist pedestrians to safely cross the highway to access the bus stop. • Push button pedestrian signals are likely to offer the best option but they will require Police enforcement from time to time.
2.2	<p>The drawings show landscaping along the median. It is expected that many pedestrians will use the median to stage their crossing of the highway. The landscaping may obscure sight lines to/from the pedestrians-putting them at risk. Some of the vegetation is shown close to the median openings, where it may block sight lines for turning drivers/riders.</p>	MED	<ul style="list-style-type: none"> • Ensure that the type of vegetation used is a low growing variety that will not hide pedestrians (especially children) and is able to be maintained easily. • Do not plant any vegetation within 50m of a median opening.
2.3	<p>The unsealed shoulders will become wet</p>	MED	<ul style="list-style-type: none"> • Seal the shoulders at least 1.5m wide along

	<p>and muddy during the monsoon. Pedestrians do not like walking along muddy shoulders and many will walk on the road. This will expose them to risk of collision</p>		<p>the length of this highway duplication.</p> <ul style="list-style-type: none"> • Ensure that an edge line is installed to guide drivers/riders 	
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The Audit Team has carried out this preliminary design road safety audit according to the Road Safety Audit Field Guide.

SIGNED:on behalf of the RSA Team by the Team Leader (24th March)

Lessons learnt:

- Ensure an experienced team (2-3 people) undertakes each audit. Good audits depend on the experience and judgement of the audit team in identifying road safety concerns from the drawings.
- Undertake audits at the earliest possible stage within the project schedule. Do not wait until Final Design – by then there are many constraints in place that may prevent some concerns from being fully addressed.
- Site inspections are vital – day time and night time – even for a new road at the preliminary design stage.
- The audit team should set a good example for personal safety – wear safety vests and take all necessary safety precautions while on site.
- Take many photographs of the site, and insert these into the audit report.

3. What to look for when you are on-site

When you are on-site for your audit inspection, try the following tips:

- Park your vehicle well off the road.
- Wear your reflective safety vest – for your own protection and to show that you are serious about safety.
- Look for safety concerns in the geometric design first.
- Move on to intersection layouts and traffic control.
- Think then of signs and line markings. Remember that it is better overall to eliminate a safety concern by better geometric design (if possible) rather than simply using a sign to warn of the problem. Early stage audits are good for this. The later an audit the less chance there is to make geometric changes.
- Remember the needs of pedestrians – not only crossing the road but walking along it. Are paths continuous, obvious, and well separated from high speed traffic? Make sure you walk the proposed road project too!

Cross-section

Look for consistency in cross-section throughout the new road project and also from the old to the new road. Avoid squeeze points and provide consistent lane widths and lane arrangements.

On high speed roads, such as highways, a paved shoulder should be wide enough for a stationary vehicle to be clear of the traffic lanes. A sealed shoulder 2.5 metres wide is desirable, but if this cannot be achieved try to get at least 1.5m sealed shoulders.

It is safest to maintain full pavement width and full shoulders at all culverts, bridges, overtaking lanes and intersections. To reduce the shoulders at these locations creates squeeze points which often catch some road users (especially motorcyclists) by surprise.

Sight distance

Sight distance can be affected by many things including trees, fences, and bus shelters. Sight distance out of side roads can be a major safety concern. Inspect each side road and review restrictions – such as parking or vegetation – that may restrict sight lines to approaching highway traffic.

Intersections

Intersection layouts should be simple and obvious to approaching motorists, motorcyclists and pedestrians. Audit teams should look carefully at intersections with acute angles as these restrict visibility. At left turn slip lanes, aligning the slip lane at 70° to the intersecting road will assist drivers to get a better view of approaching traffic.

Safe road designs provide adequate visibility for emerging traffic. Safe road designs avoid obstructions from street furniture or landscaping, and they provide adequate visibility to traffic control features. Central medians should be wide enough (generally 6m for cars and small vehicles) to provide shelter for crossing vehicles plus right turn lanes for turning vehicles. Medians also serve as refuges for pedestrians and bicyclists to cross one direction at a time (which is safer and easier than judging gaps in both directions at once). Keep landscaping away from intersections.

The traffic control used at an intersection should be clearly understood. Traffic signals need to be conspicuous and easy to understand. Pedestrian signals and audio-tactile facilities are highly desirable to assist pedestrians and the disabled to cross.

Roundabouts are a safe form of intersection control – they must have adequate deflection on entry and they must have the correct signing. For safety, roundabouts should be signed correctly with both regulatory and direction signs. In addition, road users should be made aware to give way on entry to the roundabout.

SAFETY TIPS FOR AUDIT TEAMS – ROADSIDE HAZARDS

Roadside hazards are a major road safety risk on the roads and highways of Karnataka. There is a five step strategy for managing roadside hazards and reducing their risk:

Step 1 - Keep the vehicles on the road

Step 2 - Remove any fixed objects from the roadside (within the “clear zone”)

Step 3 - Relocate hazards from the roadside (outside the “clear zone”)

Step 4 - Alter the hazard to reduce the severity of a collision

Step 5 - Shield the occupants of errant vehicles from the hazard by installing suitable crash barrier

Step 1 - Keep the vehicles on the road.

A combination of good geometrical design, good information for drivers and good maintenance of the road is needed. An early stage of audit (such as the preliminary design stage) can focus on geometric design to minimise the risk of a vehicle running off the road. In later audits, as the design becomes more settled, other safety options to reduce run-off-road crashes such as sealed shoulders, tactile edge lines, warning signs, guideposts and chevron alignment markers may be recommended.

Step 2 - Remove any fixed objects from the ‘clear zone’

Poles and large signs exist along most roads – if a vehicle strikes these at speed the occupants of the vehicle will suffer extremely serious if not fatal injuries. Any fixed object (defined as those with a diameter of 100mm or greater) should be removed from the “clear zone”. The clear zone is an area beside the road – its width is dependent on vehicle speed and volume. Along high speed roads, a clear zone of 9m is desirable. In the clear zone, all side slopes should be flat enough to be “drivable” – that is flatter than 4:1 slopes.



Concrete guide posts are commonly used in Karnataka but they are serious roadside hazards. They should be made highly conspicuous, with reflectors attached to them. When damaged, they should be replaced with white plastic guide posts with large reflective strips on each.

Step 3 - Relocate hazards to a position outside the “clear zone”

The further the fixed object is from the edge of the road, the lower the risk of it being struck. If it is not possible to totally remove a fixed object from a roadside, the next option is to consider relocating it further off the road. Experience and judgement will be necessary in such cases.

Step 4 - Alter the hazard to reduce the severity of a collision

Sign posts, and culverts, can cause serious injuries to the occupants of any vehicle that strikes them. To reduce these injuries, it is possible to place signs on “weakened” posts. It is also possible to install “driveable end walls” at culverts so that the vehicle can ride up and over the culvert, avoiding the savage sudden stop.

Step 5 – Install crash barriers to shield the hazard.

When the first four steps in the strategy have been exhausted, the installation of crash barriers may be a final option. The purpose of crash barriers is to protect the human beings who are inside an errant vehicle from striking a more serious roadside hazard. Remember that a crash barrier is a fixed object, and can cause injury when struck. Try to design the new road to minimise their use. If used - ensure they are correctly designed and installed.

SAFETY TIPS FOR AUDIT TEAMS – SIGNS & MARKINGS

Signs are too often used as a ‘quick fix’ to many safety concerns. They may be an acceptable solution to an existing problem at a small cost however audit teams should debate whether or not erecting a sign is the best solution to a problem. Normally, removing the hazard is the best solution, and should be given priority in design stage audits. If the design does not permit removal of the hazard, or if the cost to remove it is too great, then a sign may be the next best solution. Signs provide a large part of the information needed by drivers. Audit teams should remember the basic principles (the 6C’s) of good signing.





CONSPICUOUS – the sign must be able to be seen. This is a new and reflective sign but has been poorly located and it cannot be seen by drivers/riders. If a sign cannot be seen it cannot be of any use to the road users.



CLEAR – the shape and colour of the sign, as well as the legend/symbol, have to be able to be read from a sufficient distance. This warning sign is not clear and should be replaced.



COMPREHENSIBLE – the sign has to be able to be understood. This confirmation sign is quite clear and easy for drivers to understand.

	<p>CREDIBLE – the message conveyed by the sign has to be believable to the drivers. This sign informs drivers of a diversion 200m ahead. Drivers need good credible information on which to make their driving decisions. In this case they have to prepare to use a diversion on the left.</p>
	<p>CONSISTENT – every sign used for one task should look the same as the other sign(s) for that task. Direction signs are important to assist drivers to find their way to their destination. Consistent shape and colour is important in this regard.</p>
	<p>CORRECT – any sign that is used for be the correct sign for the purpose. It is usually better not to use a sign than to use the wrong sign!</p> <p>This “Keep Left” sign is conspicuous, but it is not the correct sign.</p>
	<p>LINE MARKING - is an important part of a safe road project. Audit teams should closely examine the line marking drawings, trying to anticipate what the road users will make of the new lines. Will they be conspicuous, consistent and correct?</p>

Speed management and traffic calming

High speed is a major contributor to serious road crashes. You should check the drawings to ensure that the operating speeds of the new road can be managed within levels that are appropriate for the design speed of the road.

Firstly, ensure that the design speed and the likely operating speeds match each other. Otherwise some drivers may be caught by surprise at curves.

Secondly, be satisfied that there will be a suitable speed limit imposed. This will need adequate speed restriction signs along the route to remind drivers/riders of the speed limit.

Thirdly, consider the need to reduce operating speeds through “self-enforcing” measures such as traffic calming in towns and villages (such as gateway treatments, raised crossings, road narrowing’s) or by speed enforcement (such as speed cameras).

Night visibility

Roads are used both day and night, and so they should be inspected during day time as well as night time. Some locations look very different at night; they may or may not have street lighting. Some street lighting can create visual deceit (see below). Older people generally have poorer eyesight and this makes reading road signs more difficult than it is for younger people. This is made worse after dark, so particular attention should be paid to night time conspicuity and visibility for the elderly. Perception of widths and distances by older drivers also becomes more difficult at night time.

Visual deceit

Sometimes there are visual cues along a road that give the wrong message to a driver. A long row of trees, or power lines, can give an impression that the road continues straight. But if the road takes a bend, some drivers will be misled by the trees or the power poles – regardless of the number of warning and guide signs used to tell them otherwise. This impression may be so strong that the bend and any warning sign will go unnoticed by some motorists, and run-off-road crashes will result.

SAFETY TIPS FOR AUDIT TEAMS - PEDESTRIANS

Pedestrians are the largest and most vulnerable group of road users in Karnataka. Firstly, control vehicle speeds through villages to reduce crash frequency and severity. Provide sealed shoulders to assist pedestrians who need to walk along the road. Use signalised crossings to give pedestrians time separation from vehicles to cross busy roads. Use medians or refuges to give spatial separation from vehicles. Overpasses or subways are not popular with pedestrians and should only be used as a “last resort” to segregate pedestrians and vehicles on roads with high speed and high traffic volumes.



HIGH RISK PEDESTRIANS - an audit team needs to consider the safety needs of all pedestrians, and in particular the safety needs of high risk groups such as school aged pedestrians, elderly pedestrians, and intoxicated pedestrians.



IN THE SHOES OF THE PEDESTRIAN- the audit team should walk the site day and night to check for pedestrian issues. Pedestrians need to be able to clearly see where they should go. While this may be clear to engineers on a plan, it is not always obvious on the ground.



FOOTPATHS AND SEALED SHOULDERS- in urban areas footpaths are desirable to provide pedestrians with their own space on which to walk. In rural areas sealed shoulders give pedestrians their own space on which to walk. They help motorcyclists also.