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# A Case Study on Road Safety Audit from Vizag to Araku Road

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**ABSTRACT**

Road safety is a collective responsibility that requires the involvement of government, civil society as well as businesses from both the public and private sector. It requires a well-planned strategy and an associated plan. However, despite the impact of poor road safety on societies and economies around the world resulting in an annual loss of Gross Domestic Product (GDP) in the order of 2%–5%, only a limited number of countries follow coordinated approaches to road safety management. Unfortunately, the countries that suffer the most are those in need of development. For example, according to the Road Safety Report by the World Health Organization, Malaysia recorded 25 deaths per 100,000 population which is among the world's highest figure, compared to a regional figure of 17.9 deaths per 100,000 population. This has caused negative social and economic effects and an estimated economic loss of about MYR 79 billion since 2004.

## 1. INTRODUCTION

Moreover, the institutional road safety management worldwide and primarily in LMICs has been weak, leading to failure to reduce road traffic accidents in these countries. There are issues associated with (a) the identification of appropriate institutional management functions and (b) interventions and achievement of results. There is a need therefore to investigate how road safety is affected at institutional level and this study seeks to provide such a systematic approach using Malaysia as a case study.

It has been stated that there is a correlation between the amount of investment in road safety and its positive impact and that many countries have failed to ensure that road safety plans are delivered successfully since they have been forced to cut down their road safety actions because of lack of funding and weak commitment from the stakeholders. These findings further supported by a study by Batool et al. who found that in LMICs, governments tend to value road safety low, and, as a result, the budget for road safety is compromised whenever the government reduce their yearly spending. For example, in Malaysia the budget for road safety campaigns allocated to the in 2015 was only MYR 2 million compared to MYR 8 million received in 2014. This is about a 75% decrease and it is being considered as worrying. This agrees with Zietlow who stated that insufficient and unsustainable funding conditions are the most important and necessary issues that need to be addressed to improve road safety. To this end, this study focused on the funding issues of road safety and in connection with the success (or failure) of conventional funding mechanisms..

Furthermore, the strengthening of institutional road safety management and the appointment of one lead government agency to guide the national road safety actions are two other important measures recommended by the World Health Organization (WHO). Their implementation ensures the effectiveness of road safety management, a well-planned road safety strategy and associated plan. In addition, three important related elements should be considered:

(a) The institutional management functions

(b) The interventions needed

(c) The consequent results.

### *1.1. OVERVIEW OF ROAD SAFETY AUDIT*

#### *1.1.1. Road Safety Audit*

Road safety audit is a systematic and formal process of checking the safety aspects of road schemes before they are built. The objective is to identify potential safety problems, so that, where possible, the design can be changed to eliminate or reduce them. The audit is carried out by trained and experienced auditors who are independent of the scheme designers.

Road safety auditing follows the principle of "prevention is better than cure". An audit conducted at the planning or design stage allows a line on a plan to be changed, which is much cheaper than having to alter asphalt or concrete once the scheme has been built. Most countries have experience of having to make major alterations to a newly built road because a significant safety problem was designed into the road. This can be avoided if all schemes are

audited before construction. Experience from other countries suggests that at least a third of crashes can be prevented or their severity reduced by conducting road safety audits and acting on the findings. Road safety audits are appropriate for all kinds of road construction, including rehabilitation and upgrading, as well as new build. They can also help in assessing the safety of:

Arrangements for traffic control and signing at roadworks management schemes

Major roadside building development (e.g., shopping malls, car parks, leisure centers, etc.)

Existing roads the earlier a road scheme is audited within the design and development process the better.

For road construction projects there are four main audit stages:

1. Feasibility Study Audit
2. Preliminary Design Audit
3. Detailed Design Audit
4. Pre-opening Audit

### *1.1.2. Road Defects as a Cause of Accidents*

Although road defects are not the major cause of road crashes, efforts to improve road design, construction and maintenance are often highly cost-effective – and much easier than trying to improve the skills and attitudes of drivers. Research shows that there are three contributing factors to road crashes: human factors (involved in about 95% of crashes)road and road environment factors (involved in about 28% of crashes) vehicle factors (involved in around 8% of crashes)

### *1.1.3. Road Safety Engineering*

All road authorities must have an on-going road safety engineering programmed. This will comprise 'crash reduction" activities, such as accident blackspot programmers, and "crash prevention" activities, such as road safety audits. Experience shows that it is necessary to put at least three times more effort into blackspot programmers than auditing. The lessons learnt from the evaluation of blackspot schemes will be fed into the audit system. And experience from safety auditing will feed into the revisions of design standards. In this way the road authority will be acting both pro-actively and reactively to improve the safety of the nation's roads.

### *1.4. Limitations of Design Standards and International Consultants*

Why should audits be needed when the road authority employs the best international consultants and insists on the use of high design standards? There are several answers to this question, including standards do not guarantee safety – although conformity with standards and guidance as the Ministry's Road Design Manual (Road safety revision)) will help make the design safe, there will inevitably be many situations that are not covered by the standards – moreover a number of individual elements, all designed to standard, may, when combined, be unsafe. foreign consultants tend not to take full account of the local operating environment –

They sometimes produce designs that would be adequately safe in their home country, but are often unsuited to the very different operating environment that exists in Uganda.

**1.2 Different Audit Stages** Road Safety Audits should be implemented throughout the design and construction process. Typically, schemes shall be audited over a 3/4 stage process. These stages are:

•Stage F: Route Selection Stage

Stage 1: Preliminary Design Stage

2: Detailed Design Stage

3: Construction

4: Post Construction/Monitoring

- Route Selection Stage
- Required prior to route choice on large scale road schemes such as motorways.
- A feasibility assessment on road safety grounds
- Identifying any potential safety concerns at an early stage

**Stage 1 Preliminary Design:**

- Assessment of early design stages to identify any potential safety concerns and confirm land acquisition boundaries.
- This requires a site visit and photo survey undertaken by two individuals, with the consideration of preliminary design and background data.

**Stage 2: Detailed Design:**

- A safety assessment of the detailed aspects of the design, operation and servicing.
- This requires a site visit and photo survey undertaken by two individuals, with the consideration of detailed design drawings, standard details, specification of road works, Traffic Impact Assessment Reports.

This RSA Stage must occur in advance of tender of construction contract. Design & Build stage 2 RSAs must be carried out in accordance with the contract requirements.

If, for any reason, a Stage 1 Road Safety Audit has not been carried out (for example, where a scheme is of such a scale that no preliminary design has been necessary and the scheme has progressed directly to detailed design with agreement of the appropriate Road Authority) Audit Stages 1 and 2 can be combined at Stage 2 to provide a Stage 1/2 Road Safety Audit.

**Stage 3: Construction:**

- Audit undertaken upon completion of construction, ideally prior to opening of scheme to traffic.
- Determines whether contractor has constructed the works correctly, i.e. trip hazards, poor surfacing, ponding, visibility, appropriate signs etc.
- Identify any safety concerns that could not be identified until complete.
- Usually involves a site visit undertaken by two auditors, and potentially a member of A Garda Siochana and a Local Roads Authority / Regional Roads Design Office Representative.
- Site visit also undertaken during hours of darkness.
- If, for any reason, a Stage 1 Road Safety Audit has not been carried out (for example, where a scheme is of such a scale that no preliminary design has been necessary and the scheme has progressed directly to detailed design with agreement of the appropriate Road Authority) Audit Stages 1 and 2 can be combined at Stage 2 to provide a Stage 1/2 Road Safety Audit.

**Stage 4: Post Construction:**

- Audit undertaken upon completion of construction
- Issued to determine whether contractor has constructed the works correctly, i.e. trip hazards, poor surfacing, ponding, visibility etc.
- Identify any safety concerns that could not be identified until complete
- Usually involves a site visit undertaken by two auditors, a member of the Highway
- Authority and a member of the local constabulary
- Site visit also undertaken during hours of darkness

**Stage 5: Monitoring:**

**TO DO: INCLUDE COMMENTS & COSTS**

- Collision Investigation
- Collision Reduction
- Collision Prevention
- Road Safety Education and Training
- Road Safety Research and Evaluation
- Road Safety Impact Assessment
- Road Safety Planning
- Road Safety Management / Network Safety Management
- Road Safety Strategy and Policy Formulation
- Road Safety Campaigning and Marketing
- Road Safety Consultation including Public Consultation

## 2.0 GENERAL

### *LITERATURE REVIEW*

The below literature review discuss about the different road lengths and the points they considered at their location and any points need to be considered to become advanced in the signaling and segregating the traffic and improving the latest techniques for avoiding the accidents.

### *2.1 LITERATURE REVIEW*

MANASA SR published in 2020

In recent years, the road accident has become a global problem and marked as the ninth prominent cause of death in the world. Due to the massive number of road accidents every year, it has turn-out to be a major problem. Consequently, to handle this overwhelmed situation, a precise analysis is required. In India there is road network of 33 lakh kilometers of which nearly 65% of the cargo activity and 80% of traveler movement is on the Highways constitute around 1.7% of the road network but carry about 40% of the aggregate or road networks. National ad traffic. Number of vehicles has been increasing at a normal pace of 10.16% for every annum during the most recent five years. Road safety audit is formal procedure for assess in accident potential and safety performance in the provision of new road schemes, the improvement of existing road and in maintenance of roads. Accident prevention and accident reduction are the two main strategies in the road safety. In this case study we analyses the NH75 which is the major highway connecting Bangalore Mangalore. The highway conveys substantial and volume of traffic throughout the day and it has number of conflict points such as villages, industries. Detailed analysis of NH75 will be carried out from the point of view of safety and geometric design asp deficiencies, improving design aspects, enhancing credibility of the roads. acts will be performed. This paper aims to identify He tram sharma Dr sheetal Agarwal in 2015

The Road Safety Audit (RSA) is a technique to investigate the road crashes potential and safety performance in the provision of new road planning's, rehabilitation, improvements and maintenance in existing road network. This investigates the road infrastructure deficiencies that may influence crashes occurrence and suggests the guidelines for appropriate improvement measures. The present study aimed to evaluate the Road Safety deficiencies and improvements on existing road network. NH-12 (Durgapur Bus Stand to India Gate) (total length= 10.500Km)), for present study the accident data were collected at

identified road stretch and black spots namely India Gate, Headlight Marg and Pinjrapole Goshala were identified. The road safety deficiencies such as improper intersection designing's width of carriage way low maintenance of road markings, road sign, unauthorized median openings, unavailability of Bus- Stops, confusing behavior of Pedestrian etc., were overserved at identified location. It was found that the public transport system including minibus and low floor bus shared a major part of carriageway width and creating the traffic hazards to the other fast-moving vehicles. Further, Improper vehicle tuning movements and unauthorized median openings at road intersections, were also responsible for accidental crash.

Tummala Bharat Kumar in 2020

In India there is road network of 33 lakh kilometers of which nearly 65% of the cargo activity and 80% of traveler movement is on the road networks. National Highways constitute around 1.7% of the road network but carry about 40% of the aggregate road traffic. Number of vehicles has been increasing at a normal pace of 10.16% for every annum during the most recent five years. Road safety audit is the formal methodology for getting accident potential and safety potential in the development of new road schemes and the schemes for the improvement and maintenance of the existing road facilities. Accident prevention and accident reduction are the two main strategies in the road safety. In this case study we analyses the NH-65 which is the major highway connecting VIJAYAWADA and HYDERA-BAD from the 270thKM to 247th KM. The highway carries considerable amount of traffic throughout the day and it has number of con-flict points such as villages, industries. Detailed analysis of NH-65 will be carried out from the point of view of safety and geometric design aspects will be performed. This paper aims to identify deficiencies, improving design aspects, enhancing credibility of the roads.

Arun S Bagi1 in 2012

Road safety audit is formal procedure for assessing accident potential and safety performance in the provision of new road schemes, the improvement and rehabilitation of existing road & in maintenance of roads. The role of auditor is to provide independent advice in the form of written recommendations. The designer or client then considers the advice and formal decision is made by them on whether to adopt each of the recommended safety alterations. The primary role of audit team is to identify the potential problems of a highway project by conducting the site inspection & collecting data from various agencies. The objective of the study is the identification of accident-prone areas on the road from FIR, to study the effect of roadway geometrics and traffic conditions on the road stretch and development of statistical relationship between accident rates and various factors causing accidents. The scope of the study is to

reduce accidents on road network, reducing severity of accidents and the need for costly remedial work is reduced. The road selected for the study is Bannerghatta road (12 km). The accident analysis is done from four years data. The V.F. Babkov's analysis is done by collecting geometric features of the road. Pedestrian safety analysis also done. Accident prone locations are identified by the all analysis.

Ravi Saharan in 2017

Now a days, in each ten minutes, we tend to lose one human life because of road accidents. Within the world, Bharat has world's largest weighty traffic and accidents too it's necessary to provide the safety to roads. Road Safety Audit (RSA) could be a practice or methodology within which identification of existing or future road on basis of questions of safety and provision of safety remedial measures on that. Road Safety Audit (RSA) is a formal method for assessing accident potential and safety performance within the provision of latest road schemes and schemes for the improvement and maintenance of existing roads. In this study, the section of road from "Balsam and – Hisar Bypass Road (MDR 107)" is undertaken. Road taken having appreciable traffic throughout day time and a few black spots on the road wherever accidents could happen and in-depth analysis of road from "Balsam and – Hisar Bypass Road (MDR 107)" is administered on the premise of information assortment like traffic behavior study, road safety signs and symbols, etc. The purpose of study is to examine the road within the terms of the security measures, road situation, any kind of flaws and to counsel the alleviative and preventive actions for the chosen section of road for audit.

K. Durga Abhishek in 2011

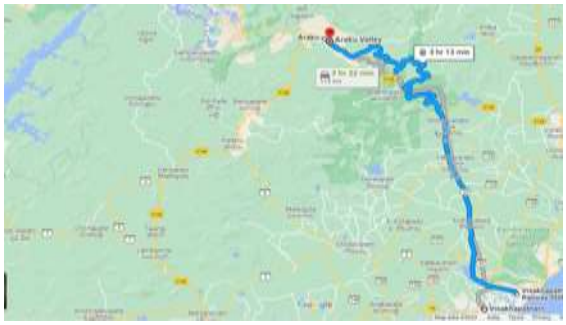
Road Safety Audit (RSA) gives scope for the reduction of accidents and helps us to provide safe, self- explaining and efficient roads. Analysis: The road safety audit was done for a stretch of 10 km from Kelambakkam Junction to VIT Chennai located at Kelambakkam to Vandalur Road- SH 121 in India. In this Road safety audit, the accident analysis was done by considering geometric features of the road, pedestrian safety, and accident-prone locations. The accident data for past 4 years 2015 – 2018 was considered and compared the RSA data with various identified accident case studies in that stretch. Findings: After conducting RSA, it was found that the effective width of carriageway was reduced by the trucks, which were parked on highway, and creating traffic hindrance to high speed moving vehicles. Numbers of streetlights are not enough and most of the Street lights are not working properly throughout the stretch. Median openings were found at unauthorized places which should be immediately closed, Access and service lanes are also deficient which requires immediate improvement. Growth of uncontrolled vegetation on either side of the road should be removed. Road and median markings which

are found missing should be corrected and speed signs should be indicated at various places. This study will be more useful if the RSA data would be updated, and the reason behind each accident, are recorded and corrective measures taken. Application: This research can be used by the government officials to monitor and alter the road conditions as per IRC codes. It aids in rectifying and reducing the future accidents.

Michael Karantanos in 2018

18 Road Safety Audit (RSA), as a formal system of checking roadway schemes for safety 19 problems, was originally adopted in Great Britain and spread to many countries throughout 20 the world. RSA is considered the major and most cost-effective proactive road safety 21 measure. Several national guidelines have been published providing guidance and 22 information on how the RSA process should be carried out. 23 The present paper focuses firstly on a comparative review of the three main current RSA 24 guidelines internationally: those published by Austroads in 2009: those published by the 25 British Institution of Highways and Transportation (IHT) in 2008 and those published in the 26 USA in 2006, by the Federal Highway Administration (FHWA). Relevant legislation and 27 standards were also taken into account while undertaking this comparative review. More 28 specifically both the European Commission"s Directive 2008/96/EC on Road Safety 29 Infrastructure Management, issued in 2008, as well as the British standard HD 19/03 for 30 Road Safety Audits, issued in 2003, were considered. 31 A survey was also carried out in order to determine the approach of highway designers in 32 Greece to this –recently introduced in the country– safety measure. In-depth interviews with 33 designers were carried out on the basis of a questionnaire set up in advance by the authors. 34 The findings of this paper may contribute to the enhancement of the existing RSA guidelines, 35 as well as to the development of relevant guidelines in countries such as Greece, where the 36 RSA is to be introduced.

## 3.1. SAFETY AUDIT OBSERVATIONS:



Overall, the VSKP-ARAKU corridor planning and construction is generally found to be satisfactory. The following observations, however, need to be considered.

**Corridor: VSKP TO ARAKU:**

In this corridor, road width provided for VSKP-ARAKU bus lane at corner junction, the zone unsafe for rapid moving buses in opposite dire

**Observation 1:** Transverse rumble strips are placed very close to signalized intersections. It is inconvenient for road users and reduces the overall performance of intersection at bus stop. Sparaco officials explained that close spacing of rumble strips is only atemporary measure that has been taken to habituate the drivers for safe movement at intersections.

**Observation 2:** At most of the intersections, pedestrian crossings on both roads are aligned except few locations as shown in the figure below. Lack of connectivity in pedestrian crossing makes very difficult and risky for handicapped pedestrians to cross the road at bus stop. It is desirable to have the straight alignments for pedestrian crossing wherever it is practically possible.

**Observation 3:** Unwanted openings in barricading and median opening at will increase pedestrian vehicle conflict and affect the performance of traffic.

**Observation 4**: Safety issues at junction (T junction)

(i) Absence of road markings and channelization to segregate the movement of buses andother types of vehicles.

(ii) Absence of bus lane sign board

(iii) Improper pedestrian crossing facilities, like pedestrian signals, markings etc., at…. junction.

(iv) Absence of bus lane signal

The junction improvement measures must be implemented as per the details given in VSKP-ARAKU design drawings.

**Observation 5:** Bus station markings and bus lane edge line markings are quite unclearat …. bus stop.

**Observation 6:** Pavement surface leveling difference/undulation on the service lane near

**Observation 7:** Absence of traffic segregation in terms of lane markings and signs.

**Observation 8:** Incomplete ramp construction and seating facilities at bus station

**Observation 9:** Pedestrian accessibility to bus station from alternative sides

**Observation 10:** Major obstruction on the corridor, absence of bus lane markings.

**Observation 11:** Unwanted Midblock opening. These openings should be closed before traffic operations.

**Observation 12:** Level difference/discontinuity in pedestrian zebra crossing near busstations (unsafe for physically challenged people)

**Observation 13:** No separate signal for at Next to bus station.

**Observation 14:** Unfinished bus station access ramp.

**Observation 15:** Absence of exclusive pedestrian.

**Observation 16:** Absence of bus bay markings at Bus stations

**Observation 17:** Rumble strip is placed on the bus lane without specific purpose. It will reduce the performance of traffic.

**Observation 18:** Few observations made related to bus station facilities

(i) Lack of seating arrangements/ incomplete seating arrangement

(ii) Automatic door installation is still pending at the bus stations throughout the lane.

**Observation 19:** Absence of segregation through marking and information signs at starting/ending point of the corridor which can cause merging/diverging conflicts near.

**Observation 20:** Mixed traffic zone forming bottle neck .

**Observation 21:** No Side edges or any traffic signals gudeilines at the extreme turn as the forward moving vehicle cannot be knowing about the opposite side vehicle.

**Observation 22:** Absence of cat eyes/reflectors, footrule and lack of lighting facilities. Down lighters need to be provided here.

**Observation 23**: Absence of bus lane markings and reflectors

**Observation 24:** Improper lighting facility on the Foot over Bridge

**Observation 25**: Unwanted mid-block opening near 1st Bus station at…. This allows vehicles to take U turns and pedestrians to cross the road, thus results more conflict points and affect traffic movements.

**Observation 26:** Absence of proper marking/sign boards at location where other vehicles are merging.

**Observation 27:** Absence of marking to guide buses to access bus station andabsence of information sign.

**Observation 28:** Nonstandard bus station sign. This bus station sign should be according to IRC 67: 2012.

**Observation 29:** Improper pedestrian crossing facilities around 1set Bus station at (absence of pedestrian signal crossing markings etc.)

**Observation 30:** Absence of platform or flooring for pedestrian movement (difficulty for physically challenged).

**Observation 31:** At 1set Bus station, improper alignment of dividers can cause obstruction for the smooth movement, unnecessary rumble strips and chevron, bus lane markings are missing.

**Observation 32:** There is no possibility of getting information about bus arrival at bus stations

## OBSREVATIONS BY FIGURES

Fig : Observation 1

Fig : Obseravtion 2

Fig : Observation 3

Fig : Obseravtion 4

Fig : Observation 5

Fig : Observation 6

Fig : Observation 7

Fig : Observation 8

Fig : Observation 10

Fig : observation 11

Fig : observation 12

Fig : Observation 13

Fig : Observation 14

Fig : Observation 15

Fig : Observation 16

Fig : Observation 17

Fig : Observation 18

Fig : Observation 19

Fig : Observation 20

Fig:Observation21 :

Fig : Observation 22

Fig : Observation 24

Fig : Observation 26

Fig : Observation 23

Fig:Observation25

## 4.1 STUDY FINDINGS:

On performing the safety audit for VSKP-ARAKU corridor included in the 115 km stretch few common issues came out which can be checked and specifically targeted on. These observations are based on actual execution of work at the time of visit and have been listed below:

- At most of the intersections we spotted lack of pedestrian crossing sign, markings, proper signal system (that is VSKP-ARAKU signal) to make pedestrian aware of VSKP- ARAKU as well as service lanes. (Example: Pendurthi crossroad junction). Most of the marking, signs shown in the VSKP-ARAKU junction designs have not been implemented on field yet.
- At certain stations pedestrian phasing is properly done like NAD there are few junctions where this is still not been implemented and should be taken care of before commencing VSKP-ARAKU operation.

- Though at many places the facilities for physically disabled people have been taken care of, but few places have been spotted with lack of proper facilities and hence, proper action is needed. That is absence of raised platforms, presence of cement base bollards creating obstructions, improper bollard gaps etc. (Example: Bus station at NAD)
- Improper or absence of VSKP-ARAKU barricading and presence of median openings along the corridor. (Example: Median opening at NAD)
- The longest stretch of VSKP-ARAKU seems to be incomplete in terms of construction that is, crucial activities like bus station construction, proper barricading, proper signal system and sign boards etc. are pending.
- At few places (NAD) due to long stretches of lanes with no segregation for VZG-ARAKU, mix-traffic zones can be formed creating bottle necks for smooth traffic flow.
- Improper leveling of the service lane or pathways making movement difficult particularly for the physically handicapped pedestrians. (Example: near District Home Guard Junction)
- In VSKP-ARAKU corridor, construction of lane separator is incomplete.
- Proper marking/highlighting at bus stations missing. (Example: NAD)
- Automatic door installation is still pending at the bus stations throughout the
- VSKP-ARAKU lane. (Example NAD bus station)
- Common bus station facilities like installation of bus station sign board and information board of VSKP-ARAKU is missing. Incomplete construction of Bus station facilities like seating area, ramps etc. (Example: District home VSKP-ARAKU junction)
- Lack of visibility of buses approaching towards the bus stations. (Example: Bus station at VSKP-ARAKU junction)
- Accessibility for riders/pedestrian between subways and VSKP-ARAKU bus stations should be improved at few locations. At some place's subway construction is pending or going on. (Example: VZG-ARAKU)
- No proper segregated lane/sign boards/information board for VZG-ARAKU, provided at the start and end points on the lanes which can cause merging or diverging conflicts. (Example: Starting point of VZG-ARAKU)
- Improper lighting facilities, markings/highlighting or cat eyes at bus stations for nighttime.
- Missing/improper median marking (Example: Home guard junction)
- No warning/direction sign board to give alert to the BRT driver. (Example: VZG-ARAKU)
- Absence of speed limit signs along the VSKP-ARAKU corridor.
- Improper road surface at few places on the VSKP-ARAKU corridor (Example: near VSKP-ARAKU junction bus station)

## 4.2 MAJOR SAFETY CONCERNS AND DISCUSSIONS

**Issue 1:** Improper pedestrian facilities at intersections including bus stations

Fig

***Discussion:***

- Assume red block indicates a pedestrian attempting to cross the road. Due to lack of proper signal system, pedestrian after crossing the leftmost service lane can lose focus on VSKP-ARAKU lane and accident can occur.
- Similarly, riders after getting down from the bus station shown by green block will cross VSKP-ARAKU corridor and will have to very quickly encounter another road crossing, which can be risky without any signal, sign board or markings.
- Considering a situation where pedestrians are crossing from both the sides without proper signal system, with the intention of crossing quickly, collisions can happen between pedestrians or with vehicles.

- By using proper signal systems, signboards, pedestrian crossing platform and markings at intersection can be made safer.

***Issue 2: Safety measures at general intersections***

Figure 2

If the intersections are not properly designed there can be conflicts between VSKP-ARAKU and other modes. Improperly or un-designed intersections will create chaos between all the modes, VSKP-ARAKUand pedestrians causing congestion, reducing efficiency and increasing chances of accidents. High speed moving VSKP-ARAKUand vehicles trying to change lane at intersections can cause conflict if proper markings, directions to maintain segregation is not done. Example of such a kind of unplanned intersection is the one present near mental corner junction. Intersections can be designed with proper signal / markings/ round or square about to keep traffic organized and mitigate risk. All pedestrian facilities should be paid attention to by involving pedestrian crossing platform, sign boards, signals etc.

***Issue 3: Improper/ absence of barricading***

Figure : 3

Figure : 4

***Discussions***

- This open barricading can be used by pedestrians for crossing or for reaching thebus station quickly, which can be unsafe.
- During the time of high traffic congestion or traffic jam, vehicles can enter theVSKP- ARAKU corridor through this which can cause accidents if VSKP-ARAKUis active.
- Vehicles may enter the corridor causing mixed traffic zones.

**Issue 4: Absence of Rumble Strips on Service Lanes near Intersections**

***Discussions:***

High speed VSKP-ARAKUmoving in the same direction as of other vehicles which can prove to be very dangerous. At the start or the end point of VSKP-ARAKUcorridor, the buses move towards a mixed traffic zone. In order to avoid conflicts between high speed running. Bus and other vehicles on the road, rumble strips should be provided at the end point ofthe corridor or near junctions on the two service lanes for slowing down the speed of other vehicles before entering the mix traffic zone with VSKP-ARAKUbus. VSKP-ARAKUcorridor start orend sections require special treatment for smooth entry and exit of buses. Markings as shown by red arrow can be made to guide the VSKP-ARAKUso that it remains close to median even while travelling in the mix zone.

***Issue 5: Lack of Subway lane Accessibility Discussions:***

Pedestrians approaching from subway to the bus stations don't have easy access. The pedestrians will have to cover extra distance to reach till crossing if they prefer subway. In such a case, most of them may opt direct road crossing near junction rather using subway thus negating the purpose of subway. Currently, there is an obstruction present in the VSKP-ARAKU lane parallel to the subways without any warning sign board or marking, which can be dangerous for VSKP-ARAKU operations. During nighttime, to make the obstruction distinctly visible warning sign board becomes more necessary.

A third arm of the existing subway can be developed in the VSKP-ARAKU lane which is connected to the bus station by a pedestrian pathway with proper barricading and markings.

## ROAD SIGNAGES AND MARKINGS

Signs and road markings are main guiding factors for the road users which are essentially required to be adequate and placed at appropriate places on the road. The road signs are designed scientifically keeping in mind the movement of vehicle maneuver expected at the succeeding intersection catering to different types of road users. Based on this, the signs should be designed and placed at VSKP-ARAKU corridor. Advance Direction Signs should be posted at the corridor at each of the approach arms of the intersections.

Further, regulatory signs such as 'Speed Limit' and 'Keep Left and 'Keep Right' signs also need be placed at appropriate locations in the vicinity of all the existing bus shelters. Typical 'Speed Limit', 'Keep Left' and 'Keep Right' signs and 'Bus Stop' and other important signs as per

,IRC:67 (2012): Code of Practice for Road Signs' should be designed and installed on the ground before commencement of operation. The details about the signs and their images are given below:

(i) **Give way to buses exiting bus lay-by ahead:**

The sign shall be used to inform vehicles about Give way to Buses exiting from a bus lane ahead. The sign can be placed at the beginning of such area.

(iii) **Maximum Speed Limit:**

Speed is the single most important causal factor in road accidents that result in a road fatality. We recommend a maximum design speed of 40 kmph for any road upon which a VSKP-Arikis developed. As far as possible, this speed should be induced through road design, rather than relying on signage and/or enforcement.

These design features include narrower lanes, speed tables, chicanes, etc. It is important to note that in the urban context, achieving a high midblock speed has very little impact on total journey time. This is because of the frequent need to slow down or stop at intersections, which are present at a much more frequent interval than in the context of a regional highway. Further, a slower and more consistent speed, may also improve the capacity of the road. This is because the safe gap or headway required between vehicles is less for slower moving traffic.

The sign shall be located at the beginning of the section of the road or area displaying speed restriction, with numerals indicating the speed limit in km per hour. The Speed limit should be marked in multiples of 5 km per hour. Separate speed limit signs for VSKP-ARAKUbuses and other vehicles should be provided.

**(iv) Over taking prohibited (VSKP-ARAKU lanes):**

The sign shall be erected at the beginning and at intervals within VSKP-ARAKU lanes, at sections where overtaking will be hazardous. The sign may be dispensed with pavement markings as per IRC provided for ,No Overtaking Zones'. The ,No Overtaking' sign should be erected on each side of the road at the start of the affected length and should be supplemented by repeating signs at intervals not exceeding 400 m.

**(v) Restriction Ends Sign:**

This sign shall indicate the point at which all prohibitions notified by prohibitory signsfor moving vehicles ceases to apply.

**(vi) Bus Way/ Buses only:**

The sign shall mean that only buses are allowed and the other traffic is not allowed onthis road/ carriageway. The sign may be supported by supplementary plate with, BUSES ONLY' written on Pavement surface. (The background color should be as perthe code.)

**(v) Right/ Left hand curve (VSKP-ARAKU lane)**

These signs are to be used, whenever there is a need for reduction of speed due to change of direction of alignment and radii of the curvature are below the specified limit.These signs are intended to warn the driver to reduce the speed and proceed cautiously. The warning signs are to be used sparingly. If a road has certain curves where vehicles cannot be allowed to negotiate with the absolute speed limit or the general operating speed established for the road, such curves shall be provided with curve warning signs on both approaches. The left hand curve sign should be used to mark curves bending tothe left and right hand curve sign for curves bending to the right.

**(vi) Chevron sign:**

At the curved alignment of a roadway, the chevron signals shall be used to inform the drivers about sharpness of curve. The chevron sign shall be a vertical rectangle and shall be installed always on the outside of a turn or curve, in line with and at approximately right angle to the approaching traffic. Spacing of chevron signs should be such that the road user always has at least two signs in view, until the change in alignment eliminates the need for the sign. Depending upon the sharpness of the curve, Single Chevron, Double Chevron Sign and Triple chevron sign can be installed.

**(vii) Bus Lane:**

This sign is installed to inform the drivers about the presence of reserved bus lane in the carriageway. The operation of bus lane is supported by appropriate markings on the pavement to delineate the lane indicate the bus only lane markings. These are generally mounted overhead with appropriate support.

## I. PEDESTRIAN FACILITIES:

As bus users, people have to cross the road prior to boarding or after alighting from the bus. This would be true for all commuters whether buses are in the central or curb side lanes. Since people live and work on both sides of the road at least half the passengers have to cross the full width of the road in the case of the curb side lane. In the case of the central lane, only half the width of the road has to be covered on foot, the latter arrangement requires a shorter red light signal phase for cars, which increases safety all round.

Improvement in pedestrian facilities can be made by providing proper signals at intersections, sign boards and enhancing VSKP-ARAKU user experience by establishment of informative sign boards, handicapped user friendly facilities, convenient accessibility design. The sign should be erected in advance on both approaches of the uncontrolled pedestrian crossings. This sign establishment is absolutely essential when visibility of the crossing is impaired by a bend or hump in the road. If required, the sign can be repeated at a short distance ahead of the pedestrian crossing.

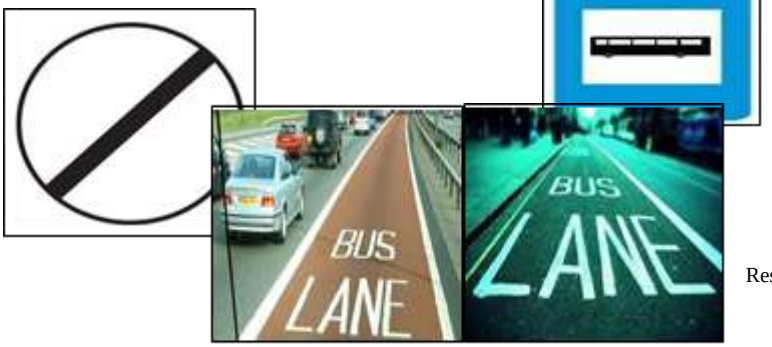
We recommend a minimum footpath width of 3 meters for an urban corridor. The recommended footpath kerb height is 0.10 meters. We recommend that all the pedestrian crossings should be signal controlled. We further recommend that the crossings should be supplemented with speed tables, in order to induce other vehicle users to drive at the design speed.

Figures :


Give way to the Buses


Speed Limit

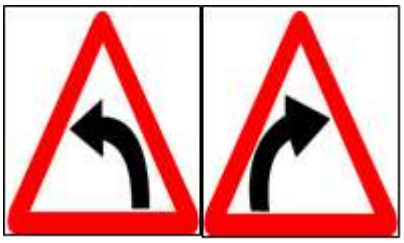
Over Taking Prohibited




Restriction End Signs

Busway

Buslanes



Right/ Left Hand Curve

Chevron Sign

Pedestrain Facilities

We strongly recommend that the phases of successive pedestrian crossing signals be synchronized, to reduce the probability that vehicles will have to wait at more than one signal in the same midblock. We do not recommend pedestrian actuated signals in the Indian context; as such signals are only useful when there is a low and infrequent crossing demand.

Speed tables Since, traffic discipline in most Indian cities is poor; motorists may not always respect pedestrian signals. This can be extremely dangerous, especially if the vehicle in the lane closer to the footpath stops at the signal, while the vehicle away from the footpath doesn't stop. Here, the stopped vehicle in the leftmost lane creates s sense of security forthe crossing pedestrian and blocks his/her view of the oncoming vehicle in the other lane. This can lead to a fatal collision.

We thus recommend that all signalized pedestrian crossings signs should be placed on top of speed tables. This is an added safety feature to slow down vehicles at the pedestrian crossing, and to induce them to drive at a safe speed. For our design, we have used a gentle speed table of the following dimensions:

Table 1

| | |
|---|---|
| Length of Up-slope ramp | 1 meter |
| Length of table-top (pedestrian crossing width) | 3 meters |
| Length of down-slope ramp | 1 meter |
| Height of table-top | 0.1 meters |

We do not recommend abrupt speed bumps on any urban arterial. Speed bumps force vehicles to come to a complete stop. We recommend the provision of pedestrian refugesbetween the mixed traffic and BRT lanes in order to accommodate slow-moving pedestrians which may get stranded at the end of a pedestrian green phase. We also recommend that the pedestrian crossing width must be at least as wide as the footpath, which in our case is 3 meters.

## II. MITIGATING THE BUS-TO-PLATFORM GAP

The photos below show excessive gaps found during normal operations in VSKP-ARAKU systems in other large cities in Asia and the America. During trial run of Pune VSKP-ARAKUS, this aspect should be considered carefully. Excessive gaps require passengers to carefully watch the gap when they board or alight, causing delays and creating the risk of injuries as well as line delays. Excessive bus-to-platform gaps at VSKP-ARAKU stations can make boarding and alighting more difficult for all passengers and especially for children, elderly and physically challenged people.

As per the information shared by VSKP-ARAKU officials the gap observed during pilot run on level boarding is shown below:

Reduce the space between bus and platform to nominal size for all passengers, through different methods of gap reduction. A 10 cm horizontal gap is the absolute maximum and smaller horizontal gaps are highly desirable. Vertical gaps should be minimized as much as possible and it should be no more than 1-2 centimeters. Doors should be operated by sensors to prevent people from getting hit by buses. The doors should only open when a bus arrives, and all buses stops should be in perfect alignment with the shelters. Automatic doors should be installed for all the bus stations.

## III. VSKP-ARAKU LANES AND DIVIDER

A divider marking of minimum 0.5 meters width between VSKP-ARAKU lanes is observed in most of sections and the same is recommended for whole stretch. This vacant space is needed to ensure the full utilization of the adjacent traffic lanes. This is because vehicles tend not to drive very close to a visible vertical obstruction, and thus enough space is needed on both sides, so that both the VSKP-ARAKU bus makes full use of their respective traffic lanes. It is preferable to have physical divider with the height of 0.15 meters for more safe operations.

The width selected for the VSKP-ARAKU lane is recommend being 3.5 meters. This is consistent with the recommended width for VSKP-ARAKU lanes across the world. It is done to ensure that the VSKP-ARAKU bus can drive safely at a reasonably good speed, without running with the risk of colliding with the guardrails or a bus approaching from the opposite direction.

## IV. MID BLOCK OF VSKP-ARAKU

In general, pedestrians are at risk when they cross the corridor away from designated crossings. The risk is particularly high near VSKP-ARAKU stations, as passengers will oftenattempt to cut across the bus lanes to go in or out of the station. This suggests that station access design can play a key role in improving safety on bus corridors, along with better provision for pedestrian mid- block crossings.

Pedestrians may have to cross both the VSKP-Araucana and the mixed traffic lanes at one go. This is not necessarily dangerous, if the crossing is signalized. However, in the absence of working pedestrian signals, this can lead to a high number of pedestrian fatalities.

## V. INTERSECTIONS

As a general principle, minor streets must not be allowed to cut across at VSKP-ARAKU corridor; that is, it is better to terminate the minor street into a T-intersection, rather than introducing 4-arm intersection, because of lesser number of conflict points.

We, therefore, recommend eliminating the possibility of right turns, either from the minor street into the Vskp-Araku, or from the VSKP-ARAKU corridor, in to the minor street. We recommend, instead, facilitating a combination of a U-turn and a left turn to complete this maneuver

Right turns, for mixed traffic on a VSKP-ARAKUcorridor, have huge safety implications, if designed incorrectly. This is due to the positioning of the VSKP-ARAKU lanes along the central lanes of the road. As a result, traffic on the VSKP-ARAKUcorridor that needs to make a right turn, must do so by cutting across the BRT lanes. This can be dangerous, because the VSKP-ARAKU buswill, typically, need to move straight, through the intersection. Thus, there is a risk that the right-turning vehicles may collide with the straight-moving VSKP-ARAKU bus.

VSKP-ARAKUin different cities have adopted various measures to counter this safety risk. One alternative is to terminate the segregation of the VSKP-ARAKU lane a few meters before the intersection, and allow right-turning vehicles to merge into the VSKP-ARAKU lane, so that they make the right turn form the same lane that the bus continues straight. This can be a safe solution if the merging of the right-turning traffic into the VSKP-ARAKU lane is signalized, or if there is adequate merging length and sight distance. However, if none of these features are present, then itmay simply result in creating the collision risk from the intersection to the point before the intersection, where the merging happens. Another design alternative is to continue the segregation of the VSKP-ARAKUlane till the intersection, but have separate signal phases for mixed traffic right turns, and VSKP-ARAKUstraight movement

## VI. VSKP-ARAKU LANES TURN INTO MIXED-TRAFFIC ROUTES

VSKP-ARAKUcorridors should be designed for the dual function of throughput mobility and local accessibility. In this context, much lower speed is essential in order to ensure safety of all road users. Traffic safety issues should be taken care of while the VSKP-ARAKUbus lane is merging and diverging with heterogeneous traffic. Thus, at the merging and diverging zones, to provide segregation, markings, arrows, median directions etc. should be used. This can be used at 900m long stretch mix traffic zone present in VSKP-ARAKUcorridor and at the stretch near intercity bus terminal.

## VII. APPLICATION OF INTELLIGENT TRANSPORTATION SYSTEM MEASURES

Bus signal preference and preemption: In future, preferential treatment of buses atintersections can involve the extension of green time or actuation of the green light at signalized intersections upon detection of an approaching bus. Intersection priority can be particularly helpful when implemented in conjunction with bus lanes or streets, because general-purpose traffic does not intervene between buses and traffic signals.

Improved facilities and amenities: The operational and travel time benefits resulting from the separation of buses from general-purpose traffic can be augmented with improved amenities such as bus shelters and stations. These facilities provide protectionfrom the elements and can also be equipped to furnish information such as printed routes and schedules or electronically transmitted real time schedule data. Space can also be leased to commercial convenience services.

Automatic vehicle location systems – This will enable transit agencies to track their vehicles in real time and provide them with information for making timely schedule adjustments and equipment substitutions.

Passenger information systems – Such systems give passengers the means to make informed decisions about their transit travel. Of the many technologies now available for passengers to access this type of information, the APTS applications most appropriate for Bus Rapid Transit are in-vehicle information systems. These systems automatically announce approaching bus stops, allowing disembarking riders to position themselves near the doors prior to arriving at their stops, and speeding up the unloading and loading operation.

Fare collection system that speeds up the boarding process – This system would decrease dwell time and improve overall system efficiency.

## VIII. TRAINING FOR VSKP-ARAKU PERSONAL

The design solutions mentioned above are enhanced by proper training of bus driversto avoid sudden starts and stops, to reduce speed before going around curves, and to drive carefully for the sake of all passengers. Public outreach programs and safety campaigns for public is also recommended.

## IX. ENFORCEMENT

On-street parking is a typically witnessed on the road stretch causing so much interference traffic on the lane on both directions of travel. Since this is more of an enforcement issue, it can be strictly controlled through law enforcement.

## CONCLUSION

Safety audit of the pilot VSKP-ARAKU corridor was successfully done. Overall, the planning and design aspects of pilot VSKP-ARAKUcorridor are satisfactory. Through this study we find out the few safety issues for vehicles as well as pedestrians and we have given effective solutions to improve the performance with minimum disruption to the flow of VSKP-ARAKUbuses. The study reveals that no major demolition, construction is warranted at this stage of auditing. The improvement measures suggested are easy to implement and low cost in nature which could be completed without difficulty. These measures must be implemented before commencement of VSKP-ARAKU operations. We have also provided solution for pedestrian crossing issues and physically challenged people to use VSKP-ARAKU service. We also suggest, it is a good idea to conduct safety audits at different stages like (I) during planning and design stage (ii) during construction stage (iii) pre-opening stage of the remaining VSKP-ARAKU corridors proposed.

But unless there is proper connectivity to VSKP-ARAKU routes, it is difficult to visualize it as a successful system. Only when this has been achieved will the VSKP-ARAKU be able to attract many users. It should be kept in mind that opening day is not a good time to assess what the system will be like a week or a month later, when lessons that are learned can hopefully be put into practice to improve the system. We recommend that the problems identified and finding observed should be shared with the officials. For example, if bus drivers are stopping too far from the platform edge, it will be legit to request the VSKP-ARAKUmanagers to provide them with better training.

Traffic police and other security personnel need to back and help the Municipal Corporation and other levels of government organizations to effectively operate the proposed VSKP-ARAKU system. Targeted public education campaigns should be conducted to involve the user community. Road users are expected to incur maximum use of this facility by following the laws and rules sincerely A systematic investigation of the second-generation funding model and its variants are beyond the scope of this paper and may be found elsewhere. However, the model and its associated concepts seem to address satisfactorily the needs of better road safety management and financing as outlined in the case study. By implementing a second generation road fund model (or a variant of it) using a systematic approach, and both international experience and local knowledge, the funding resources for road safety could become sufficient and sustainable and this in turn would increase the transparency and accountability of road safety management. Support by the road safety stakeholders, road users and ultimately the society could be enabled. Fragmentation of decision- making procedures would be minimized together with political interference. This would ultimately increase the effectiveness in delivering road safety and the efficiency of the resources available.

**REFERENCES**


1. AASHTO 1993 “AASHTO guide for design of pavement structures”, American Association of state highway and transportation officials, Washington, D.C.
2. IRC: 37-2001 “code of guideline for the design of flexible pavement “, Indian Road Congress, New Delhi 2001.
3. IRC: 58-2002 “code of guideline for the design of plain joined rigid pavement for highway “, Indian Road Congress, New Delhi 2002.
4. Anandakrishnan, M. and Dhaliwal, S. S. (1996), “Effect of Various Constructions of sodium chloride and calcium chloride on the pore pressure parameters and on strength parameters of Black Cotton soil”, Research Report, Dept. of civil., IIT, Kanpur, India.
5. Agarwal, K.B and Joshi, D.K., Dynamics of Mechanism of Swelling in Expansive soils, Proc. Of the 1st National Symposium on Expansive Soils, HBTI-Kanpur, India,1997.
6. Abouleid, A.F., Foundations on Swelling Soils, Proc. Of seminar of foundation problems in Egypt and Northern Germany, Cairo, Egypt, 1985.
7. Addams, M.et al., Reinforced Soils for Bridge Support Applications on Low Volume Roads, TRR-1652, TRB, 1999.
8. Babu shanker n. (1986), “What Techniques other than under reamed piles have? Proven to be Effective in Minimizing Foundation problems in Black Cotton Soils’’, IGC-86, New Delhi, Vol, pp.155-158.
9. Bansal, R.K., Pandey, P.K. and Singh, S.K (1996), “Improvement of a Typical Clay for Road Sub grades with Hydrated Lime’’, proc. of National Conf. on Problematic Subsoil Conditions, Terzaghi-96, Kakinada, India, pp-193-197.
10. Bell, F.G. (1993): “Eng. Treatment of Soils”, E&FN Spon Pub. Co.
11. Basma, A.A. and Tuncer, R.E. (1991). “Effect of Lime on volume Change and Compressibility of Expansive Clays”, TRR-1295, pp.52-61.

12. Bhattacharya, P. and Bhattacharya, A., Stabilization of Bad Banks of Railway Track by Lime Slurry Pressure Injection Technique, proc. of IGC-89, Visakhapatnam, Vol.1 , 1989,pp.315-319

13. Broms, B. B. and Boman, P., Stabilization of soil with Lime Columns, Design Handbook, Second Edition, Royal Institute of Technology, Sweden,1978.

14. CBRI. (1978). "Handbook on Under-reamed and Bored Compaction Pile Foundation", Jain Printing press, Roorkee, India.

15. Chandrashekar, B.P., Prasad Raju, G.V.R., Ramana Murthy, V. and Hari Krishna, P.