EVALUATION OF ROAD SAFETY ON THE NATIONAL HIGHWAYS

A PROJECT REPORT

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BONAFIDE CERTIFICATE

This is to certify that the project report entitled **EVALUATION OF ROAD SAFETY ON THE NATIONAL HIGHWAYS** is the bonafide record of project work done by **INDHUJA.M (17CER065), HARISHKUMAR.S (17CER063), JEEVANAND.A (17CER069)** in partial fulfillment of the requirements for the award of the Degree of Bachelor of Engineering in Kongu Engineering College of Anna University, Chennai during the academic year 2020 - 2021.

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EXAMINER I **EXAMINER II**

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We affirm the project titled **EVALUATION OF ROAD SAFETY ON THE NATIONAL HIGHWAYS** being submitted in partial fulfillment of the requirements of the award of Bachelor of Engineering in the original report carrying out by us. It has not formed part of any other project report or dissertation on the basis of which the degree or award was conferred on an earlier occasion on this or any other candidate.

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I certify that the declaration made by the above candidates is true to the best of my knowledge.

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ABSTRACT

Road safety is vital that must be followed in any respect times to ensure the security of the drivers, passengers and pedestrians. Road accident is the major reason behind demise among individuals aged 18-30 years. Nearly one million individuals lost their lives yearly because of accident. Road accident price most countries three percent of their Gross Domestic Product. Road user Safety performance could be a foremost concern for growing countries likes South Asian region. Good quality safety information is required to enhance road safety. Numerous techniques are gone through to evaluate and improve safety.Road safety Audit is the technique to examine the road accident severity and safety execution within the conditions of planning, rehabilitation, enhancements and maintenance in active road network. Road Safety Division investigates the infrastructure deficiencies which will influence crash occurrences and suggest guidelines for suitable improvement measures. Roadways should be designed to reduce the need for driver decisions and to reduce unexpected situations.Traffic rules and pointers ought to be in situ and strictly followed so injuries are averted.

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LIST OF ABBREVIATION

RSA	Road Safety Audit
DEA	Data Envelopment Analysis
ISA	Intelligent Speed Adaptation
TSMS	Traffic Safety Management System
NRA	Network Risk Assessment
SEM	Safety Environmental Management
MORTH	Ministry Of Road Transport And Highway
TJA	Traffic Jam Assist
RSI	Road Sign Information
SSD	Stopping Sight Distance
RPM	Raised Pavement Marker
LOS	Level Of Service
ROS	Right Of Speed
LTOL	Left Turn Only Lane
RTOL	Right Turn Only Lane

CHAPTER 1

INTRODUCTION

1.1 GENERAL

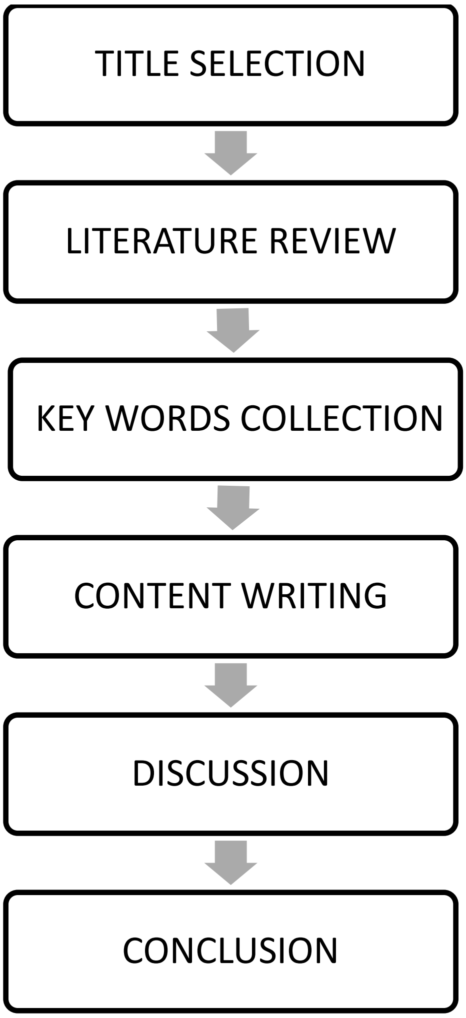
Road safety is an issue of national concern, considering its magnitude and gravity and the consequent negative impacts on the economy, public health and the general welfare of the people. Today, Road Traffic Injuries are one of the leading causes of deaths, disabilities and hospitalizations, with severe socioeconomic costs, across the world. Road traffic safety constitutes the safety measures to be taken up to prevent the road users from being killed or injured. Road users are typically drivers, passengers, cyclists, pedestrians, etc. The road safety system's strategy is to ensure that in an event of a crash, the impact is not so much as to cause death or any serious injury. Any road accident is all the more depressing as the victims are very healthy just before the crash. More than one million people die on the road ever year according to the WHO and road traffic injuries are the leading cause of death among young people, aged 15–29 years.

In India, for the first time in two consecutive years, it was reported that there was a 2.9% decline in the number of road accidents, the number of persons killed and the number of persons injured in road accidents. Road traffic accident (RTA) fatality remains one in each of the foremost pressing problems inside this time. For example, in line with the info of the Association for Safe International Road Travel, yearly worldwide in RTAs about 1.3 million persons die and from twenty to fifty million persons are gashed and lose work capability on the average. In India, some 400th of road user accidents fatalities occur on four-lane rural highways (MORTH, 2016). Safety performance of highways is of great importance at intervals the country primarily owing to relatively poor road geometrics associate degreed indivisible by traffic from two opposite directions that finally conclude in an extremely higher kind of accidents with high severity.

The foremost step undertaken for proposing any accident hindrance strategy for the most part focuses on distinctive the basis causes, so as that eradicating it'll stop future accidents. The quest for effective countermeasures has impressed many accident investigation studies globally. However, in India, sometimes the road accident records unit not maintained properly, and so the speed of underreporting is improbably high for low severity accidents. Further, there is little or no coordinated effort at intervals the road agencies to assemble and maintain info on road inventory, geometric vogue, traffic regulation and management, making accident modelling rather powerful. Here, we will be going to study the various assessment methods used to evaluate and improve the road user safety in the National highways especially.

CHAPTER -2

METHODOLOGY



CHAPTER – 3

LITERATURE REVIEW

(NCHRP, 2004) RSA was first conducted in the United Kingdom in 1980. However, RSA was not adopted in many developed countries including the United States until 1996 . Through the 1990s, RSA was introduced to other countries such as Denmark, Canada, the Netherlands, Germany, Switzerland, Sweden and South Africa. By the early '90s RSA was adopted in Australia and New Zealand.

Pikunas and Pumputis (2005) They deliberated the need of the RSA system in Lithuania. The authors suggested including RSA as an essential tool into the national road safety strategy can benefit the road sector to a greater extent. In recent years, RSA has been actively implemented in countries such as Singapore and United Arab Emirates beside, several developing countries such as Malaysia, Bangladesh, India, and Mozambique. Presently, the World Bank and European Transport Safety Council are actively promoting RSA as part of national road safety programs (FHWA, 2006).

Ahmed et al. (2013), compared the contents of safety guidelines of seven countries, in which the documents were critically reviewed under seven parameters. Individual RSA document was studied methodically, and the parameters were compared meticulously, so that limitations or strengths of any guideline document could be easily identified. This method enabled to identify the shortcomings and any potential improvements of the guideline documents that could be recommended through this study. Importance was given to study the checklist 3910 Sudipa Chatterjee et al. / Transportation Research Procedia 48 (2020) 3908–3923 Chatterjee, Bandyopadhyaya and Mitra / Transportation Research Procedia 00 (2018) 000–000 3 or forms attached to the guidelines. It was found that the qualifications of auditors or the requirements of the team were not highlighted equally in the documents and even the legal liability aspects were not given any emphasis in three of the seven guideline documents.

Vardaki et al. (2014) elaborated on the method followed in RSA of Attica Freeway in New York. The RSA team not only focused on identifying potentially dangerous roadway environment but also discussed on misleading or missing information on the road. The major safety issues identified by them were grouped into specific areas such as signage, roadside hazards, issues related to cross sections, stopping sight distance, decision sight distance, driver behavioral issues and issues related to vulnerable road users.

Pietrantonio and Bornsztein (2015) conducted an exploratory study on signalized intersections in the city of São Paulo, Brazil. The performance of RSA application is evaluated using weighted indices of concordance and disagreement. The ratings for the observations gathered in the accident analysis at the intersection were complemented by statistical analysis of the influence of selected covariates on these scores. The conclusions were useful for the selection of alternative RSA procedures in agencies responsible for promoting or enforcing RSA and in professional teams carrying out RSA tasks.

Gashi et al. (2016) argued that a combination of factors causes road accidents, there is less understanding of the relationships between accidents and those factors causing them, or contributing to the causes. The authors carried out their study for the Western Balkan Countries (WBC), which are among the worst road safety performers in Europe based on road fatalities per population. The study gave a general idea of the current road safety conditions from the design point of view in Western Balkan Countries with a focus on the road network of Albania and Kosovo, the two nations with significant number of fatalities. A section of recently constructed dual carriageway in Kosovo was studied where significant deficiency of design in terms of road safety was noticed. A few more road sections in these two countries were analysed where safety was not incorporated in the design.

Huvarinen et al. (2017) emphasized that the mere observance of road design and construction standards does not guarantee the safety of traffic. The authors applied RSA to the risks outside the framework of standards and codes, and found the process to be cost-effective. Moreover, the authors found that RSA has the potential for improving the intra-industry cooperation besides decreasing the accident rate. The thorough traffic safety audit performed at all the phases of the road construction and operation helps in determination and elimination of errors at an early stage. The study proposed that the safety audit should be combined with the experience of the road sector and other field's experts for making the design of future roads in Russia more user-friendly. This would confirm to higher traffic safety levels due to the prevention of errors in road users' behaviour, making it more predictable and safer.

Jovana et al. (2017) in a recent study collected most common road safety deficiencies identified by the authors in the context of South Eastern Europe. It was found that in different South-Eastern Europe countries RSA, Road Safety Inspection (RSI), as well as Black Spot Management (BSM) were utilised effectively. Typical road safety engineering deficiencies have been presented in 8 different subsections, based on PIARC (World Road Association) RSA approach. This paper presents collected common road safety difficulties with relevant illustrations of associated accident risks.

Development of Safety Audit Methodology for Existing Roadway Sections(2002) India has just started realizing the importance of RSA. At present there is no formal qualification in Safety Audit or Road Safety Engineering and only a few training programs are designed and conducted to produce Road Safety Auditors. The first RSA was carried out by CRRI in 2000 on Indore Bypass. In the year 2002, the Ministry of Road Transport and Highways (MoRTH) sponsored the project on "Development of Safety Audit Methodology for Existing Roadway Sections". Thereafter, the National Highway Authority of India (NHAI) thereafter entrusted CRRI to carry out RSA of engineering design for construction packages under on NH-2. Gradually it was recognized that RSA is to be undertaken for all road types. With the number of fatal road accidents increasing in India, the International Road Federation (IRF) has emphasized the need for regular RSAs, which has been made mandatory by the Ministry of Road Transport and Highways. Although RSA is much talked about in seminars and workshops in India, an appropriate RSA policy is missing at the National and State levels.

Chatterjee, Bandyopadhyaya and Mitra (2018) The first RSA guidelines were produced in 2003 and revised in 2009 by CRRI. However, still there is a need to make highway professionals aware and knowledgeable in making roads safer and the highway authorities would need to commit themselves much more seriously on road safety aspects. As per the recently approved road safety manual the experts must carry out safety audits, not just during the design and implementation phases of the projects, but also in the post operation period to identify and rectify deficiencies.

Rao et al. (2003) carried out an accident study between Anakapalli and Visakhapatnam of NH-5. The RSA revealed that the main reason for a high number of crashes on the four-lane divided highways is the direct access of the local traffic to the NHs. Moreover, median openings at a frequent interval resulted in wrong maneuvering by the road users. The analysis also indicated that vehicle drivers are mostly responsible for the accidents as they fail to perceive the situation ahead because of poor reflexes, fatigue, inexperience or intoxication. The RSA team suggested appropriate traffic guidance and control systems and adequate infrastructural facilities to guide road users, ensuring safety. In 2010, a comprehensive manual on RSA, IRC: SP:88 was published in India. It is a guideline for RSA to the decision makers, engineers, and technicians in road sectors, providing procedures for applying quality assurance to road project from the road safety perspective. This manual is under revision for further improvement.

Jain et al. (2011), the authors aimed to evaluate the RSA of a section of four-lane divided NH-58. The study focused on evaluating the benefits of the proposed actions that have emanated from deficiencies identified through the audit process. The RSA team found that truck parking on highways reduced the effective width of carriageway and creates traffic hazards to highspeed moving traffics. Unauthorized median openings were another potential threat identified in the audit. The Vulnerable Road User (VRU) such as pedestrians and cyclists needed to be facilitated on priority. However, no design related deficiencies emerged from the study.

Kumar and Chowdary (2018) made a case study on the four-lane NH-65 indicated that road markings, condition of the shoulder, condition of the carriageway and median opening are the significant contributing factor for accidents. It was also observed that the moderately moving vehicular traffic, that generally occupies innermost lane of the highway, creates traffic glitches for the fast-moving vehicular traffic. The need for service road along the highway to segregate the slow-moving vehicular traffic from fast moving vehicular traffic was evident from the study. The RSA report insisted that all the illegal median gaps should be closed and necessary provisions such as foot-over bridges must be provided for the local neighborhood to cross the highway on a priority basis. The undeveloped minor and major crossings along the road should be developed with necessary lighting provisions to reduce the accident rate. Footpath for the pedestrian should be developed and maintained near the habitant areas, industries, educational institutions and guard rail to be provided along the entire length of the footpath. The authors suggested the development of special facilities for the differently abled people at bus stops.

Chatterjee and Mitra (2019) attempted to identify critical safety issues on two-lane highways in India through a combined proactive-reactive approach. Several risk factors were identified using the principles of RSA, and were mapped with the available crash data analysis to develop a risk matrix. This systematic development of risk matrix was found to be helpful in the selection of countermeasure design in a more scientific way, targeting the frequent crash types and severities expected to result at the high crash sites.

Gibbs et al. (2006) suggested in a study that publishing RSA case studies can provide local and state agencies with examples and offer further guidance which can assist them in implementing RSAs and proposing countermeasures at their jurisdictions facing similar safety issues. However, most of the studies conducted in India give a general overview of the RSA procedure. Only a few studies attempted to discuss on the risk factors identified from the RSA but they mostly focused on four-lane highways. There are very few if any studies related to the identification of risk factors for two-lane Indian highways from RSA. The traffic operation on a four-lane highway is very different from a two-lane highway; as a result, the safety issues are also different and more critical when compared. Keeping that in mind, the object the study is to discuss the RSA findings of 2 two-lane highways in eastern India and elaborate on the safety issues identified through the audit process. Methodology of the Study RSA is a recognized technique for safety assessment of accident prone locations. RSAs can be conducted at five stages to ensure that the needs of all road users are considered during each phase of project development – (i) planning phase; Sudipa Chatterjee et al. It was found that the qualifications of auditors or the requirements of the team were not highlighted equally in the documents and even the legal liability aspects were not given any emphasis in three of the seven guideline documents.

Sze and Wong (2007) applied logistic regression in order to investigate the influence of contributory factors on the probability of fatality and sever injury. In pedestrian – vehicle crashes young (under 19 years) and older pedestrians (over 60 years) are more likely to be involved in fatal accidents than other age groups

(Al-Ghamdi, 2002) Parameters that significantly influence the severity of the pedestrian injuries are the: vehicle type; drivers' or pedestrians' alcohol involvement and age (over 65 years), (Zajac and Ivan, 2003). The elderly are more vulnerable, higher speed limits lead to higher injury severity, accidents at signalized intersections are less severe and darkness leads to higher injury severity (Eluru et al., 2008). There is also an influence of personal and environmental characteristics on pedestrian severity in pedestrian-vehicle crashes. The environmental conditions should be examined more thoroughly and be an important consideration when planning urban areas (Clifton et al., 2009). Walking with company and presence of high level pedestrian traffic flow in a street can increase the road safety level.

Jacobsen (2003) concluded that doubling the pedestrian volume results to 32% reduction of traffic crashes with injuries. This can be explained because drivers are aware of pedestrians' presence and adapt their driving behavior. Higher vehicle speeds increase both the likelihood of a pedestrian being struck by a car and the severity of injury (Rosen and Sander, 2009).

(NHTSA, 2015) Most pedestrian deaths occur in urban areas, non-intersection location and at night (NHTSA, 2015). In 2013 4,735 pedestrians were killed in traffic crashes in the United States. This averages to one crash-related pedestrian death every two hours (NHTSA, 2015). Additionally, more than 150.000 pedestrians were treated in emergency departments for non-fatal crash-related injuries in 2013 (CDC, 2015).

(Beck et al., 2007) Pedestrians are 1.5 times more likely than passenger vehicle occupants to be killed in a car crash on each trip (Beck et al., 2007). In 2013, 5,712 pedestrians were killed in road accidents in the EU, which is 22% of all fatalities.

(ERSO, 2015) In the last decade, in the European Union pedestrian fatalities were reduced by 37%, while the total number of fatalities was reduced by almost 45% (ERSO, 2015). Citizens desire to live in a city where they will be able to walk with safety and convenience. Cities that are suitable to walking (walkable city) have many benefits for their citizens in terms of road and personal safety, convenience, accessibility to destinations, combined transportation and increased health level.

(Lund, 2003; Southworth, 1997; Saelens et al., 2003) The definition of walkability is not specific but can be explained as the suitability that the urban road environment offers to pedestrians .The walkability level differs among urban areas and cities. There are many differences related to economic, cultural and topographical factors. Pedestrians should be able to walk in the entire urban road network in order to reach their destinations. Promotion of walkability can improve the quality of life in urban areas and raise the sustainability footprint of the city. There are major benefits from the promotion of walking both in urban and regional revel. Pedestrians do not consume fuel to travel, pollute the air or create noise. In urban areas the choice to walk depends on many factors.

Shay et al. (2003) propose two groups of factors that influence walking: ability and motivation. The "motivation" factors relate to personal or social characteristics. Only with the presence of the ability factors can be the motivation factors operational in order to promote walking among citizens. The distance and the time that is necessary for a commuter to reach his destination are major factors in order to travel on foot .

(Mackett, 2001) Pedestrians travel slowly, resulting to a limited distance of 1÷2 km they can reach conveniently. Issues more than road safety and mobility, like personal image and value of time are usually critical factors for citizens to select walking. Especially, highly paid workers cannot afford losing working time selecting to travel on foot or with public transport modes.

(Easton and Smith, 2003) Personal safety is also a major factor for many citizens to walk (Easton and Smith, 2003). Especially women avoid walking during night time selecting another transport mode or choosing not to travel. Many parents consider that their children face not only problems for their road but also personal safety when they walk (Jones and Bradshaw, 2000).

Tegge et al., 2010 The literature review which summarizes recent research on TSMS can be divided into three sections which are safety performance function (SPF), crash hot spots, and optimization methodology for safety management system. In order to improve safety, it is important to understand why crashes occur. There is a significant number of researches modeled crash occurrence.

Abdel-Aty and Radwan (2000) studied the modeling of traffic accident occurrence and involvement. The results showed that annual average daily traffic (AADT), speed, lane width, number of lanes, land-use, shoulder width, and median width have statistically significant impact on crash occurrence.

Tegge et al. (2010) studied SPFs in Illinois and found that AADT, access control, land-use, shoulder type, shoulder width, international roughness index, number of lanes, lane width, rut depth, median type, surface type, number of intersections have a significant impact on safety.

Cafiso et al. (2010) developed comprehensive accident models for two-lane rural highways and found that section length, traffic volume, driveway density, roadside hazard rating, curvature ratio, and number of speed differentials higher than 10 km/h increased crash occurrences significantly. Highway safety manual (HSM) provides the safety performance functions for the roadways divided into rural two-lane two-way roads, rural multilane highways, and urban and suburban materials.

(AASHTO, 2010) The safety performance functions provide the predicted total crash frequency for roadway segment base conditions. More accurate predicted crash frequency can be measured considering the CRFs from the geometric design and traffic control features. Researchers have utilized different approaches to establish the relationship among crash occurrences, geometric characteristics, and traffic related explanatory variables using statistical models of multiple linear regression, Poisson regression, Zero-

Inflated Poisson (ZIP) regression, Negative Binomial (NB) regression, and Zero-Inflated Negative Binomial (ZINB) regression.

Jovanis and Chang (1986) studied why multiple linear regression is not appropriate for modeling crash occurrence since accident frequency data did not fit well with the basic assumptions underlying the model. The major assumption with linear regression models is that the frequency distribution of observations must be normally distributed. Most crash frequency data violates this assumption. It was also observed that crash frequency data possesses special characteristics such as count data and overdispersion.

Miaou and Lord (2012) studied on the performance evaluation of Poisson and Negative Binomial regression models in modeling the relationship between truck accidents and geometric design of road sections. This research recommended that the Poisson regression or ZIP model could be the initial model for relationship establishing because of the crash frequencies. But in most crash data, the mean value of accident frequencies is lower than the variance, which is termed as overdispersion .

(Saha et al., 2015) If overdispersion is present in crash frequency data, NB or ZINB would be appropriate models since they account for overdispersion. In most accident data, crash frequencies show significant overdispersion and exhibit excess zeroes, in which the ZINB regression model appears to be the best model There are 12 crash hot spot analysis techniques discussed in HSM.

(AASHTO, 2010) These techniques basically rank the sites with potential safety issues. The criteria for raking the sites are based on average crash frequency, crash rate, relative severity index, critical crash rate, level of service of safety, and predicted crash frequency. Some states have their own identification methods in addition to the 12 HSM crash hot spot analysis techniques. Moreover, a significant amount of researches have been performed to identify crash hot spots using different identification methodologies and screening methods such as sliding scale analysis, empirical Bayesian (EB) method, Kernel density estimation (KDE), Moran's I Index method and Getis-Ord Gi

(AASHTO, 2010) The most accurate technique can be selected based on two considerations, which are accounting for regression-tothe-mean bias and estimating of a threshold level of crash frequency or crash severity .Among the available techniques, the EB method should be the standard approach in the identification of crash hot spots. for safety management system Identification of safety projects within limited budget is an important element for transportation planning. Crash hot spots should be identified, because not all of these spots can be selected for implementing safety countermeasures due to fund limitations.

(Mishra et al., 2015) In order to identify the best set of crash hot spots within budget, optimization techniques provides the best approach over project prioritization. The TSMS is a multi-objective optimization problem for three reasons, first, engineers or decision makers want to minimize overall crash frequency within budget; second, fatal-and-injury crashes should be minimized; the third, high traffic volume roadways should have higher priority when selecting safety projects. The problem has been characterized as a multi-objective optimization in many researches.

(Saha and Ksaibati, 2015) Optimization techniques are commonly used for resource allocation in operation research, transportation, management, finance and manufacturing. In transportation, optimization technique has been applied to PMS and they can also be implemented in TSMS. In TSMS, optimization usually involves minimizing predicted crash frequency comprising a set of decision variables subject to various constraints such as budget and risk. There are different optimization techniques, linear, integer, nonlinear and dynamic programming.

(Mishra et al., 2015) Optimization techniques in TSMS include both linear and integer programming This section presents the formulation of TSMS model used in this research. The primary parameter of this model, crash hot spots identification, is discussed briefly. Identifying crash hot spots requires crash data analysis which is followed by field investigation to identify appropriate treatment types. The algorithm for identifying the best combination of safety projects This process consists of two main steps which are identification of crash hot spots and potential countermeasures and allocation of funding.Traffic crashes are rare and random events having a tendency to cluster together at certain locations. The straightforward process of plotting crash map reveals clustering characteristics of crash occurrence. Road conditions, weather condition, horizontal alignment of roadway, grade and lighting conditions are the most contributing factors of crashes.

(Koyuncu and Amado, 2018) As the most frequent visual aids in roadways, traffic signs provide safer traffic environments through regulating, warning, or guiding the road users. The goal of installing key traffic signs, such as stop signs, yield signs, and speed limits, is to increase traffic safety. However, traffic signs are only effective when clearly visible. By incorporating sheeting made of retroreflective material, even signs that arenot illuminated by external lights are still visible at night. Retroreflection works by redirecting light from the sign face back to the source .

(McGee, 2010) To ensure that drivers are able to comprehend traffic signs, the U.S. Congress introduced standards for minimum levels of sign retroreflectivity to the secretary of transportation in 1992 (United States Department of Transportation, 1992). To fulfill that mandate, in 2009, the manual on uniform traffic control devices (MUTCD) established minimum retroreflectivity standards for traffic signs, including an obligation for agencies to replace signs that were not in compliance with these levels. The coefficient of retroreflectivity, RA, commonly referred to as retroreflectivity, is the ratio of a sign's luminance to its illuminance (FHWA, 2012).

(Balali et al., 2015; Khalilikhah and Heaslip, 2016) The MUTCD outlined five methods that would guide agencies in achieving and maintaining minimum RA levels. These methods included assessment methods (visual nighttime inspection and sign retroreflectivity measurement) and management methods (expected sign life, blanket replacement, and control signs). In general, assessment methods tend to evaluate each individual sign of the inventory on a periodical follow-up basis to assess sign retroreflectivity compliance. In contrast, sign attributes, such as sheeting type, color, age, and geographic conditions are utilized in management methods to categorize signs and predict their retroreflectivity without inspecting each in-service sign. Over the course of the past few years, transportation agencies have aggressively developed methodologies to meet the MUTCD mandate.

(Re and Carlson, 2012) In 2011, the Utah Department of Transportation (UDOT) sponsored field investigations by a team to investigate the compliance of traffic signs with the guidelines set forth by the 2009 MUTCD. At the completion, the attributes of 1683 inservice traffic signs were measured in the field. Of all the assessment and management methods, the expected sign life has been selected most often as a primary or secondary method .

(Evans et al., 2012) Using the expected sign life method, signs are replaced before their retroreflectivity degrades below the minimum levels. However, the expected life of a sign has been shown to exhibit discrepancies, depending on the manufacturer, sheeting type, color, and geographic location .In this study, after reviewing recent studies and discussing our collected traffic sign data, the authors begin our analysis with assessing the association between inservice sign age and retroreflective performance. Then, the effects of damage on sign visibility are quantified. Next, various damage forms are compared in terms of their impact on traffic sign visibility. Finally, a sign replacement plan is suggested based on our findings.The minimum retroreflectivity levels established by the MUTCD require transportation agencies to implement an assessment or management method that is designed to maintain sign retroreflectivity at or above the established minimum levels. After adopting final revisions to the MUTCD in 2012, the three original target compliance dates for minimum retroreflectivity levels were changed (FHWA, 2012). However, federal and state funds can still be effectively allocated to fund efficient sign assessment and management methods.

Khalilikhah et al., 2015 In the past, multiple studies were performed, focusing on assessment and management of traffic signs .A simulation of the sign inspection process to optimize sign management was conducted. In addition, a risk-based approach for agencies to follow when checking for retroreflective sign compliance was developed. There have also been studies focused on long-term deterioration of traffic signs, with special attention given to color. One such study showed that sheeting age was one of the most significant variables affecting sign performance. Other researchers have analyzed the retroreflective characteristics and deterioration of sheeting materials based on sign age . A study discussed the uncertainty in sign retroreflectivity measured by handheld devices discussed traffic sign vandalism. However, little research exists in the current literature quantifying the effects of sign damage.

Kuemmel et al. (2001) performed a 5 year research to “assess the public’s perceptions of pavement improvement strategies and to develop customer-based thresholds of satisfaction” in a three phased study. In the first phase, 381 responses were considered to evaluate the corresponding state Department of Transportation pavement policies. Analysis of 400 telephone interviews on improvement policy trade-offs such as satisfaction, trust, improvement issues, and construction delays for each state were considered in phase two. Phase three involved recruiting 2300 participants that were contacted by phone and asked to drive on selected rural highway segments and explain their satisfaction with the road segments to evaluate the roughness and distress levels which are tolerated by the public. The study also attempted to determine the IRI value that 70% of drivers are satisfied with. According to the results, at least 70% of drivers were satisfied with the pavement condition when the IRI value was 0.7 m/km in asphalt concrete pavement and 1.1 m/km in concrete pavement .

Shafizadeh and Mannering (2002) examined road users’ perception of road roughness in Washington, USA. A total of 56 participants were included in the study and each participant evaluated 40 segments of highways and 2180 separate observations were collected. Driver-perceived roughness ranking and evaluation of the acceptability were collected. ANOVA was used to evaluate the significance of the difference between vehicle types and start location and ordered probability models were used to link roughness rankings to variables such as vehicle, road, and driver characteristic.

(Shen et al., 2015) Road safety index is one of the important indicators in terms of road safety performance. The multidimensional structure and complexity of the road safety show that policy makers should apply various influential factors to the road safety. Introduction of a composite road safety index could be useful to reduce the dimensions of the problem. However, determining the weight of sub-indicators or various factors affecting the road safety is challenging. Sensible judgment is needed to specify the weight of the factors affecting the road safety.

(Hassan, 2004), A simpler approach to evaluate design consistency can be based on the alignment indices, which are quantitative measures of the general character of an alignment in a section of road. Examples of alignment indices include average radius (AR), ratio of maximum to minimum radius (RR), average rate of vertical curvature (AVC) and the CRR that is defined as the ratio of radius of a single horizontal curve to the average radius of the entire section. Analyses of collisions on the two-lane rural highways have shown that a significant relationship exists between collision frequency and alignment indices.

(Muchuruza and Musa, 2004).In South Carolina, 45 mph is the minimum posted speed limit along all interstate routes, except for a short segment of Interstate 26 (I-26) near the terminal end in Charleston. The minimum speed limit posted along this segment is 35 mph on a 50 mph posted maximum speed limit. Although the minimum speed limit is uniform in many parts of the state, the maximum speed limits vary in multiples of 5 mph from 55 to 70 mph as shown in Fig. 1. This creates the posted differential speed limits ranging from 10 to 25 mph with an exception of a short segment of I-26 near Charleston where differential speed is 15 mph (i.e., 50 mph posted maximum speed limit and 35 mph minimum speed limit). The existence of such posted differential speed limits, especially within the same interstate, is one of the main reasons why the relevance of the minimum speed limit is being called into question.

(Russo et al., 2015) The main objective of this paper is to evaluate the significance of the currently posted differential speed limits on traffic operation and safety along interstate highways in South Carolina. This paper defines the posted differential speed limit as the difference between the posted maximum and minimum speed limits. For example, for the maximum posted speed limits of 70 mph and the minimum speed limit of 45 mph, the DSL is 25 mph. specifically; this paper uses field collected vehicle speed data and traffic crash data to evaluate the effectiveness of the posted differential speed limits in reducing traffic crashes on interstate highways. It is worthwhile mentioning that the focus of this paper is not on the differential speed limits between trucks and sedans. There is sufficient literature that exists on the effectiveness of the differential speed limits between trucks and sedans.

Forbes et al. (2012) report, selecting an appropriate speed limit for a facility can be a polarizing issue for a community. Authors indicated that residents and vulnerable road users generally seek lower speeds to promote quality of life for the community and increased security for pedestrians and cyclists while motorists seek higher speeds that minimize travel time. On the other hand, despite the controversy surrounding the maximum speed limits, it is clear that the overall goal of setting the speed limit is almost always to increase safety within the context of retaining reasonable mobility (Forbes et al., 2012). Thus, establishing speed limits has always been the sole responsibility of the state and local governments except for when the U.S. issued the national maximum speed limit in 1974. This maximum speed limit law, set forth by President Nixon, was mandated to force Americans to drive at speeds that were considered more fuel-efficient, which were at 55 mph and below; therefore, lowering oil consumption since many issues were surrounding the Arab owned oil (TRB, 1984).

Muchuruza and Mussa (2006) conducted a mail-out survey in the United States to unveil the state-of-practice related to the posting of minimum speed limit signs on the interstate freeway system. The analysis of the survey results revealed that, at the time of the survey, half of the country (25 states) posted the minimum speed limit on the interstate freeways. The most common posting being 40 mph, but a few states had 45 and 55 mph in some sections on the interstate freeways. The survey results also discovered that many states raised the maximum speed limits on interstate freeways as a consequence of the National Highway System (NHS) Designation Act of 1995 without revising or studying the effect of the existing minimum speed limits on traffic operation.

(Wang et al., 2016), MTWs exhibit a contrast from the motor vehicles in many aspects, like lower operating costs, ease of use, easier maintenance, lesser pollution, more power to weight ratio, more complex manoeuvres, etc. The use of MTWs can save a lot of time in traffic jam conditions, and they acquire lesser spaces on the roads as well as in the parking lots as compared to motor vehicles. But since they have only two wheels, they are unstable as compared to their four-wheeled counterparts. In a heterogeneous traffic condition, they typically tend to filter through the traffic, get ahead of the halted vehicles in a traffic signal, very poor lane discipline, etc. Other factors that may increase crash likelihood include abrupt detection of animal or other objects on the road, which is typically found in some developing countries including India. All of these imply that the MTWs are very different from the cars. Hence there is a need to conduct research specifically for MTWs to cater to the operational and safety requirements.

Ettema (2013) indicated that experience of road conditions, socio-demographics has an impact on travel satisfaction. Besides, roadside furniture, including another amenity, road signage etc. of road services can improve the road user satisfaction. Karnataka State Highway Improvement Project (2004) carried a study where respondents are asking to give their satisfaction level based on a 5-point Likert scale. The result found that the quality of road surface and roadside signage has a high satisfaction level. Least satisfaction has found in air and noise pollution. National Road User Satisfaction Survey in the UK found that road users are mostly satisfied with their quality. In summary, it can represent that excellent road services can retain and increase the level of
satisfaction of road .

CHAPTER-4

ROAD SAFETY ASSESSMENT

4.1 INTRODUCTION:

Road Safety Assessments (RSAs), also referred to as Road Safety Audits in safety literature, are a proactive approach to improving road safety. An RSA is a formal assessment of the safety performance of an existing or planned road segment or an intersection. It is carried out by an independent multidisciplinary RSA Team that typically consists of representatives from local law enforcement, road safety education, road/traffic engineering, emergency medical response, and an expert in human factors. The step-by-step procedure of an RSA can be performed during any or all stages of a project, including planning, preliminary or final design, traffic control planning, construction, pre-opening, and on existing roads. They can also be used on any sized project from minor intersection and roadway retrofits to large transportation projects. An RSA can be a tool for public agencies to improve road safety and communicate to the public on how the agency is proactively addressing road safety concerns.

It is relatively recently that public agencies in the United States have begun to focus on RSAs. Several US states have begun to incorporate RSAs along with their existing efforts to improve road safety. However, RSAs have been applied successfully in countries such as England, Australia and New Zealand since the 1990s. The RSA concept has proven to be highly effective in these countries for identifying and reducing crash risks on public roads. The European Union now has a RSA requirement for all roads in EU nations. A program by Pennsylvania DOT has successfully implemented RSAs in the design phase. The New York DOT has integrated RSAs within their pavement overlay program. The Iowa DOT has implemented RSAs in resurfacing projects. An RSA program launched by the Arizona DOT in 2006, has led to a number of RSAs across the state. The state’s 2007 Strategic Highway Safety Plan includes RSAs. The 2005 MAG Strategic Transportation Safety Plan also identified RSAs as a strategy to improve road safety

The focus of the assessment is to calculate decrease within the activity of road safety measures for the impact space of the planned road. This can change the estimation of the quantity of points in step with the adopted criteria for every variants, and institution of the ranking of variants. To strengthen road safety of the road web there are variety of strategies offered to evaluate road safety. Selecting the foremost appropriate one is the key to achieving the required outcome in road safety. There's presently restricted steerage offered on the various strategies to assess road safety and that technique to use for a given project or state of affairs. This technique embody the followings as below.

4.2 TYPES OF ROAD SAFETY ASSESSMENTS

As per in the literature review road safety evaluation is done by using below types of road safety assessments. which are discussed as below,

Fig 4.2 Types of Road Safety Assessment

4.3 ROAD SAFETY STRATEGY

The aim of the strategy is to provide a commitment from all United Nations organizations to a single vision and an agreed set of objectives and actions to reduce the number of road traffic crashes involving United Nations personnel and vehicles and associated losses in a systematic and comprehensive manner. The strategy embraces the ethical imperative that ‘no road users, including pedestrians, should be killed or seriously injured in road crashes involving United Nations vehicles.’ The United Nations organizations hereby commit to “Vision Zero.” The United Nations is engaged in developing a pro-active, forward-looking approach to road safety, which requires managing the interaction between speed, vehicles, road infrastructures and road user behaviours in a holistic manner. In addition, the strategy supports a paradigm shift in the way road safety is viewed and the strategies used to address it. This shift involves moving from traditional road safety policies to an integrated approach, in which road safety management becomes a “safesystem”8 and serious outcomes from crashes are reduced and eventually eliminated. The goal of a safe system is to ensure that crashes do not result in serious human injury.

In line with the Sustainable Development Goals and the United Nations Global Plan of Action for the Decade on Road Safety, the Road Safety Strategy for the United Nations system aims at reducing the level of road traffic fatalities and injuries caused by the United Nations vehicles through managing the interaction between speed, vehicles, road infrastructure and road-user behaviour in a holistic manner. This strategy is based on a renewed partnership within organizations of the United Nations system; between organizations as employers and their personnel as road users; between organizations and their interlocutors in local governments; and, fInally, collaboration with the private sector. Collaboration and partnerships will be essential to leverage knowledge, existing initiatives and ultimately benefit from economies of scale.

The action plan is built on the following five main pillars:
1. Road Safety Management
2. Safer Vehicles
3. Safer Road Users
4. Post-crash Response
5. Safer Road Environments

The strategy will be achieved by adhering to the ambitious yet feasible target for reduction of road fatalities identifed in the Sustainable Development Goals. The number of United Nations personnel or other road users killed or seriously injured as a result of road crashes involving United Nations vehicles should be reduced by 50 percent by 2020. The action plan, defned within the fve key areas, will provide a global road safety programme for the United Nations system-wide, and will take into account existing organizations' initiatives and road safety programmes. All organizations of the United Nations system should develop or review their internal action plan, to make sure it is aligned with the Strategy.

While there are roles and actions United Nations organizations will take to make the Road-Safety Strategy work, ultimately the responsibility for the strategy lies with all United Nations personnel. This safe-system approach requires everyone to do their part to make vehicles and road use safer. The strategy's goal is that death and injury will in the future no longer be an inevitable part of road-use by United Nations personnel. To achieve this, the strategy has outlined a safe-system approach with 12 key actions spread across five pillars that will address major road safety issues for United Nations personnel. The strategy seeks to demonstrate a balance between the inputs received, resources available and what research shows can have an impact. United Nations organizations will work to introduce the strategy and to improve road safety, but all personnel are urged to make safety a top priority when using roads. This will allow United Nations personnel to have safer journeys and deliver programmes and activities through a safe road system.

It is an idea to guide efforts in reducing fatal and high injury accident for all transport users and pedestrians across an outlined road network. The aim is to determine a desired forthcoming ways with actions and targets designed to attain specific results. The strategy set up is made on the subsequent five main element: Safety Management on road, Safer automobile. Safer Users, Post-crash Responses , Safer Road Environments. These five set up can give a world road safety program for the Nations and can take under consideration existing organizations's initiatives and road safety programmes. All organizations of the Nations system ought to review their internal action set up, to form certain it's line up with the Strategy. It considers skilled and community input. It's managed by a certified team of professionals. An idea is made.

4.4 NETWORK RISK ASSESSMENT

It is an assessment of lane safety threat across an outlined road network. The intention is to spot general areas of unsafe in road safety for all users of road. It's considered that network operations and road characteristics should contain crash history. First stages to search out a sub-set of variables, among the foremost necessary factors associated with road safety for the calculation of the danger Index. The projected integrated approach relies on the identification of the subsequent six categories of things, which may contribute to accident incidence. The factors are following :Historical accident information are a crucial measure of safety enforcement of road for spotting high rate accident locations. Density of intersections entrance on the road section. Direct acquire to roads will considerably increase accidents. Pavement purity and abnormality issues associated with horizontal road signs and vertical road signs. lack of the margin and safety barrier. Evaluating the danger Index and informing drivers concerning about the danger associated to the road section travelled, so as to create the transportation system with lot of safe. It's managed by skilled |a certified professional. A report is created.

4.5 ROAD SAFETY EVALUATION

Many attempts have been made to develop theories designed to predict or explain the findings of road safety evaluation research. Reviewing these theories would detract from the main objective of this paper. It will suffice it to note that none of the theories proposed so far, in particular Wilde's theory about risk homeostasis, or various theories of human behavioural adaptation to road safety measures are widely applied in road safety evaluation research or enjoy widespread approval among road safety evaluation researchers. In reviewing the extent to which road safety evaluation research is based on behavioural theory, It notes that most of this research is not based on behavioural theory, and mostly refers to it only informally or not at all.

The following functions that behavioural theory could ideally serve in road safety evaluation research are listed

1. Serve as the basis for designing roads and vehicles that are optimally adapted to human limitations with respect to perception, the possibility of making errors and the consequences of erroneous action,

2. Serve as the basis for regulating human behaviour within a given technical system in a way that is conducive to road safety, 15th ICTCT workshop theoretical issues and strategies

3. Propose hypotheses about human behaviour to be tested in studies designed to evaluate the effects of road safety measures,

4. Specify the behavioural mechanism through which road safety measures are intended to affect safety, and

5. Specify possible unintended behavioural adaptations to road safety measures, which may in part or in whole offset the effects of those measures on safety.

It is argued that most road safety measures have to influence human behaviour in order to be effective. Seat belts must be worn in order to protect from injury; headlights must be turned on in order to make the car more visible; drivers must stop at red traffic signals for these to function as intended, and so on. It is, however, not always the case that human behaviour needs to be influenced for a road safety measure to be effective. Road lighting, for example, does not require road users to change their behaviour in any way. Guardrails and other energy absorbing structures fitted to roads or vehicles protect road users from injury, while not requiring that road users modify their behaviour in any way. Logically speaking, a road safety measure must influence one or more risk factors that are associated with accident occurrence or injury severity in order to affect the number of accidents or the severity of injuries.

The concept of a causal chain was introduced in order to describe the process through which a road safety measures affects safety. In its simplest form, the causal chain through which a road safety measure influences road safety can be modelled like this: Road safety measure Î Risk factor or factors Î Final outcome (accidents, injuries) There are three basic shortcomings in using this simple model as a basis for developing a theory intended to explain the findings of road safety evaluation studies:

1. The number of risk factors that influence road accidents, and that can be influenced by road safety measures, is very large. There is a need to develop a typology of these risk factors.

2. Very many road safety evaluation studies do not explicitly identify, let alone measure, the risk factors that are influenced by a road safety measure.

3. Some road safety measures lead to behavioural adaptation among road users, that is, they influence not just the risk factors that are the target for the road safety measure, but other risk factors as well. The two first of these points both suggest a need to reduce the multitude of

risk factors influencing road accidents and injuries to a simple typology, stated in abstract and general terms. The third point, the issue of behavioural adaptation, has been extensively discussed in the research literature. The most lucid contribution from a theoretical point of view has been made by Leonard Evans , who suggested that a road safety measure normally influences road safety by way of two causal chains: (1) The engineering effect (2) Human behavioural feedback to engineering changes.

4.6 TRAFFIC SAFETY MANAGEMENT SYSTEM (TSMS)

This presents the formulation of TSMS model used in this research. The primary parameter of this model, crash hot spots identification, is discussed briefly. Identifying crash hot spots requires crash data analysis which is followed by field investigation to identify appropriate treatment types. The algorithm for identifying the best combination of safety projects is illustrated in this Figure1. This process consists of two main steps which are identification of crash hot spots and potential countermeasures and allocation of funding. Each step is discussed in detail in the following subsections.

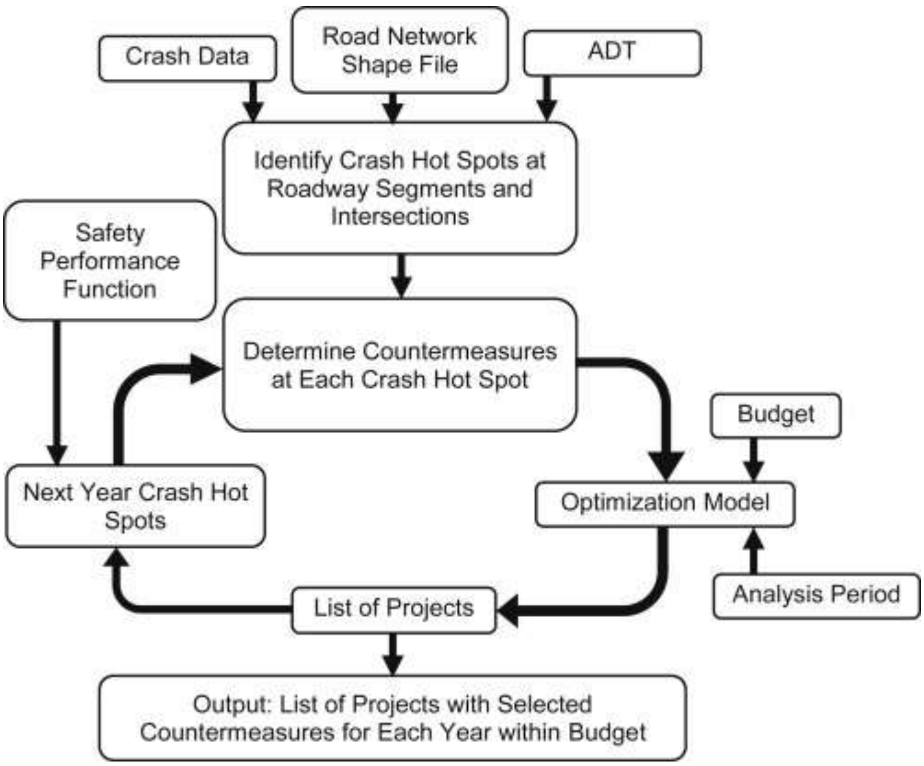


Fig 4.6 steps involved in TSMS

1. Identification of crash hot spots

Traffic crashes are rare and random events having a tendency to cluster together at certain locations. The straightforward process of plotting crash map reveals clustering characteristics of crash occurrence. Road conditions, weather condition, horizontal alignment of roadway, grade and lighting conditions are the most contributing factors of crashes. In this research, crash frequency was calculated for each segment using five years of crash data . As the length of each segment is different, the crash frequency was normalized by one mile, so that the segments can be compared. In order to identify crash hot spots, the EB method has been implemented.

In this method, the expected crashes were calculated using the SPF of two-lane two-way roadways from HSM. Sometimes, decision makers or engineers might have different objectives to improve the safety of the network, such as reducing overall crash frequency and reducing severe crashes. This research considered both of the objectives to identify the best combination of safety improvement projects. In the process of identifying the projects, priority was given to the hot spots that were involved with fatal-and-injury crashes.

2. Funding allocation strategy

After identifying crash hot spots, the next step is to conduct field evaluation to identify safety countermeasures. A list of the possible low-cost safety countermeasures associated with unit cost for county paved roads are summarized .The WYT2 /LTAP uses these low-cost safety countermeasures to enhance the safety of county paved roads. When a major safety improvement is needed, it is normally combined with other major pavement rehabilitation projects. At each location, the best countermeasure is chosen based on CRF and cost with consideration of the overall safety budget. It's an optimization method where the objective function is to minimize the predicted crash frequency within budget by selecting the best combination of safety improvement projects on roadways with higher ADT.

4.7 INTELLIGENT SPEED ADAPTATION (ISA)

ISA refers to system that didn't permit the vehicle to cross the safe limit or wrongfully enforced speed. In a speeding situation, the vehicle speed is accordingly reduced (active method) or the driver could be alerted (passive method). ISA helps the drivers to maintain a legal and safe speed along the driving time. Passive method (such as beeps, buzzers, and optical and aural messages) had outlined with a definite effect on drivers' speed limits conformity. Studies according vital reduction in vehicles rate following active ISA's like as Active Accelerator Pedal (AAP). Moreover, motorist belief AAP as a convenient idea. Determining the effect of ISA on traffic accidents is difficult. Because the portion of ISA installed vehicles in studies were relatively small. Moreover, it is show that effects depends on ISA type.

4.8 DATA ENVELOPMENT ANALYSIS (DEA)

DEA is the nonparametric approaches maintains a mechanism of many raw data and result for the estimation of risk .It's a direct programming method for computing the comparative presentation of units of a similar pattern. In this conception, while calculating endanger in the road safety area, the decreased quantity has been taken as the border of safety. During the appliance of the DEA model, patois computer code was used (programming-based),which made the probability values for every Resolution Making Unit termed as (RMU).DEA was introduced by investigators within the province of traffic safety by distribution weights for the enhancement of composite performance indicators then, for the examination of traffic safety rankings, a endanger price was computed. That endanger rate was based on outcome and feed in considering road fatalities per million inhabitants . Further, an improvement was tested within the model by testing it along side six inputs: liquor, speed, protecting systems, infrastructure, vehicles, and trauma management. The implementation of rule enforcement agency during this manner any inspired the usage of varied inputs and result, and it absolutely was then tested with thirteen raw data and four result.

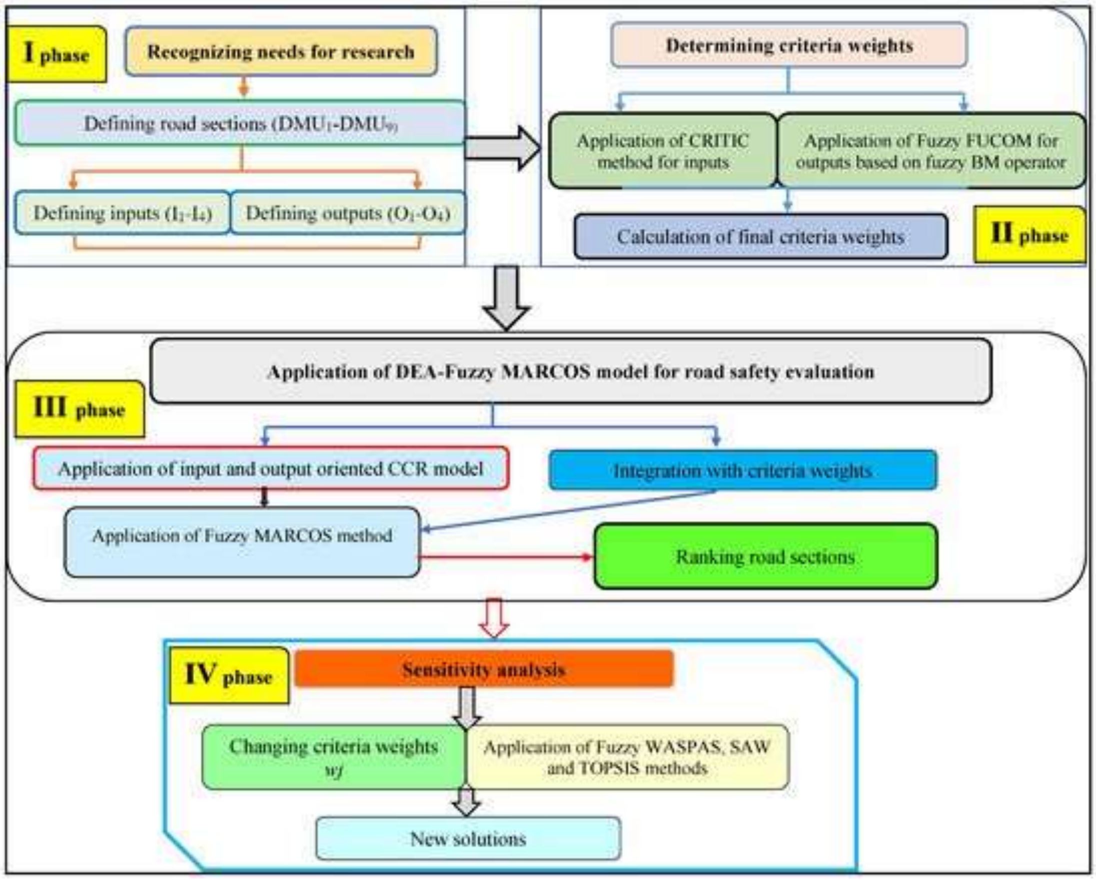


Fig 4.8 DEA stages

Since DEA offers some benefits to other approaches such as:

(1) DEA is able to handle multiple inputs and outputs;

(2) DEA does not require a functional form that relates to inputs and outputs;

(3) DEA optimizes each individual observation and compares them against best practice observations;

(4) DEA can handle inputs and outputs without knowing a price or weights and;

(5) DEA produces a single measure for every DMU that can be easily compared with other DMUs, and also have some limitation as:

(1) DEA only calculates relative efficiency measures; and

(2) As a nonparametric technique, statistical hypotheses tests are quite difficult .However, Partial Least Square-Structural Equation Model (PLS-SEM) offers frequent benefits to researchers as it is efficient with: (1) abnormal data; (2) small sample sizes; and (3) formative measured constructs . PLS is characterized as a technique most suitable where the research purpose is a prediction or exploratory modeling. In general, covariance-based SEM is preferred when the research purpose is confirmatory model. Furthermore, it has the ability to model multiple dependents as well as multiple independents, ability to handle multi collinearity among the independents, robustness in the face of data noise and missing data, and creating independent latent variables directly on the basis of cross-products involving the response variable(s), making for stronger predictions. However, “PLS is less than satisfactory as an explanatory technique because it is low in power to filter out variables of minor causal importance”.

4.9 ROUTE SAFETY REVIEW

Multi-disciplinary safety reviews of key transport routes. These reviews involve extensive investigation and consultation including in-depth analyses of the routes crash history, route inspections, community workshops, reporting and program development. The reviews also place emphasis on further improving the coordination and integration of road improvement projects and ensuring the best safety outcome through an integrated program. Route safety review programs are holistic approaches aimed at reducing the road toll by targeting works at identified road safety problems and effective road safety engineering measures combined with complementary behavioural and enforcement programs. These are undertaken by a multidisciplinary team of road safety engineering, behavioural and enforcement professionals from both within and outside the road authority. A comprehensive report is produced with a comprehensive program of works.

4.10 COMMUNITY FOCUSED ROAD SAFETY PLAN

It is a formal process for reviewing the road safety across a defined community area for all road users. The intention is to identify road safety issues and risks and to promote or establish community based strategies and actions to enhance the road safety for that community. It considers all current and proposed strategies, plans and works within the community (for example, pedestrian access and mobility plans). It is led by the community and managed through a steering committee involving road authorities. The plan ensures integration of existing and proposed strategies along with future road upgrades.

4.11CRASH INVESTIGATION & SPEED ZONE REVIEW

It is a detailed analysis of road crashes over a number of years along an existing road. The intention is to identify and analyse crash clusters, fatal and injury crash sites, common crash characteristics and types and develop appropriate treatments. It is conducted by a road safety professional. A signed report is produced.

Speed zone review is a formal assessment of speed limits along an existing road to provide an appropriate level of safety while allowing for mobility and amenity on public roads. It considers the road function, roadside development, and road and traffic characteristics. It is conducted by a qualified road safety professional. Formal documents are produced.

4.12 ROAD SAFETY CHECK & SAFETY BENEFIT AND IMPACT CALCULATION

Road safety check is an assessment of potential road safety risks for a proposed or existing road from the perspective of all road users. It is applied where the overall risks are low (for example design and installation of an indented bus bay along an existing road). The intention is to identify road safety risks . It considers crash history and road and traffic characteristics and is conducted by a road safety professional. As it is a less formal approach a response is produced.

Safety benefit and impact calculation is an assessment of the impact on road safety of proposed work on an existing road. The intention is to identify treatments for specific works which offer the highest benefit for road safety. Or the intention is to compare the impact on road safety of each proposed work to assist in prioritising a program of works. It considers crash history and treatment options. It is undertaken by project managers. A road safety impact index is produced.

CHAPTER -5

ROAD SAFETY AUDIT

Road Safety Audit is a formal, systematic, independent assessment of the potential road safety problems associated with a new road scheme or road improvement scheme. The assessment should involve the placing of equal emphasis on all road users. Road Safety Audit (RSA) is carried out as per on the guidelines given in IRC: SP: 88-2010 (Road Safety Manual). The procedure includes three key players such as: Client, Designer, Auditor and the Road User. The Road Safety Audit is based on standard checklist developed in IRC: SP: 88-2010(RSM). These checklists cover planning, alignment, cross section, junction, link road, traffic sign, road marking, road lighting, road side hazards, road side furniture, vulnerable road users, cross-drainage structure etc. The Road Safety auditor visits the sites for identifying the deficiencies from safety angle of the safety stretch suggests the remedial measures. The auditor checks the planning, vulnerable road users signs, markings and lighting also road side hazards,(IRC:SP: 88-2010).

5.1 OBJECTIVES OF ROAD SAFETY AUDIT

The main objective of safety audits is to ensure that highway schemes operate as safely as possible, i.e. to minimise the number and severity of occurring accidents. This can be achieved by avoiding accident-producing elements and by providing with suitab,b accident-reducing elements. The purpose of safety audits is to ensure that 'mistakes' are not built into new schemes. Other specific aims of the Road Safety Audit are :

• To minimise accident risk on the network adjacent to new schemes;

•To lay emphasis on safe design practice and increase the awareness of everyone involved in planning, design, construction, and maintenance of roads;

• To highlight the importance of taking into consideration the needs of all types of users;

• To reduce the whole-life cost of the schemes, by minimising the need of future corrections ; In order for a safety audit to be successful, some certain factors should be taken into consideration. The key factors that contribute to the efficiency of the safety audit may refer to the organisation and the selection of the audit team (AT): With respect to safety audit organisation, support and commitment of senior management is necessary. Safety audits should be an integral part of an agency's overall program. Local authorities often use a Road Safety Plan as a framework in which the RSA is placed. By doing so, the RSA is part of the overall safety management strategy . With respect to the auditing team:

• The team should include specialised safety engineers with experience in accident investigation and analysis.

• In order to ensure that the procedure is as objective as possibIe, the auditors should be independent of the design team. This is insisted on by the Department of Transport.

• Attention should be paid to all road users; pedestrians, (espec'Jally children), bus drivers and passengers, cyclists as well as motorists, especially for urban schemes; and their needs should be considered . In order to achieve this, the auditors should take the role of all users and try to predict/visualise, as precisely as possible, the way different users will perceive the scheme ('drive, ride, walk' concept) .

• Consultation with experts outside the auditing team (such as traffiic signals engineers, the Police) may be necessary

Audit Stage

The Audit is being carried for Stage 6 i.e. Existing Road Audit Stage.The road safety audit conducted aimed at assessing the prevalence of safety hazards on the road stretch with respect to the following,

i. Road Alignment & Cross Section

ii. Auxiliary Lanes

iii. Intersection

iv. Traffic Signs & Lighting

v. Markings & Delineation

vi. Pedestrians

vii. Miscellaneous

Each category presented in the following formats:

i. Observation : Problem Observed.

ii. Reasons for Concern : The safety concerns have mentioned, supported with pictures from the site, to support the gravity of the issue.

iii. Recommendations : The Audit recommends road safety engineering measures for the observed problem and its priority of implementation.

iv. Conclusion : The audit has conducted for the Existing stage and deficiencies have noticed. Therefore, suggested measures need to implement.

5.2 RSA TEAM

Road Safety Audits are undertaken by a Road Safety Audit Team which must be independent to the engineering team that have designed the works. The Road Safety Audit Team comprises of a minimum of two persons with appropriate levels of training, skills and experience in Road Safety Engineering, Collision data analysis and an understanding of highway design principles and best practice.

Audit Team Training, Skills and Experience

The most appropriate candidates for Audit Team Leader and Audit Team Member are individuals whose current employment involves Collision Investigation or Road Safety Engineering on a regular basis. This should ensure that auditors are well versed in the most recent practices and developments in the field. Those candidates who have the recommended experience in Collision Data Analysis or Road Safety Engineering experience but who have not undertaken such work on a regular basis in the previous two years are unlikely to be acceptable.

Candidates who carry out Road Safety Audits full time to the exclusion of general Collision Data Analysis or Road Safety Engineering work are unlikely to be acceptable as they may lack the appropriate and recent Collision Data Analysis or Road Safety Engineering experience.

It is the responsibility of the Highway Authority/Overseeing Organisation to approve the Audit Team as part of the approval of the Audit Brief. They must be satisfied that the proposed Audit Team Leader, Audit Team Members and any Observers have adequate and relevant training, skills and experience. The Audit Team Leader, Audit Team Member and Observer's Curriculum Vitaes are normally submitted for approval and should consist of no more than three pages of information for each. The CV should demonstrate that their previous experience of Road Safety Audit, Collision Data Analysis and Road Safety Engineering is relevant to the scheme to be audited, in terms of scheme type and complexity. The Continuing Professional Development (CPD) record included on the CV should also focus on Road Safety Audit, Collision Data Analysis and Road Safety Engineering. It should mention any other relevant CPD, covering areas such as highway design, traffic management and highway maintenance. Teams comprising highway design engineers with no experience of road safety work are not suitable.

Road Safety Auditors should also have an understanding of how best practice highway design principles may benefit road safety. It is not intended that Road Safety Auditors have extensive detailed design knowledge. However, they should have a reasonable understanding of design standards and best practice design principles, and how the application of these can minimise collision risk.

The following list gives guidelines on acceptable training, skills and experience for Audit Team Members:

Audit Team Leader

A minimum of 4 years Collision Data Analysis or Road Safety Engineering experience. Completion of at least 5 Road Safety Audits in the past 12 months as an Audit Team Leader or Member. In order to become an Audit Team Leader the auditor will already have achieved the necessary training to become an Audit Team Member. However, they should also demonstrate a minimum 2 days CPD in the field of Road Safety Audit, Collision Investigation or Road Safety Engineering in the past 12 months.

Audit Team Member

A minimum of 2 years Collision Data Analysis or Road Safety Engineering experience. Completion of at least 5 Road Safety Audits as Audit Team Leader, Member or Observer in the past 24 months. The Audit Team Member should have attended at least 10 days of formal Collision Data Analysis or Road Safety Engineering training to form a solid theoretical foundation on which to base practical experience. They should also demonstrate a minimum of 2 days CPD in the field of Road Safety Audit, Collision Data Analysis or Road Safety Engineering in the past 12 months.

Observer

A minimum of 1-year Collision Data Analysis or Road Safety Engineering experience. The Observer should have attended at least 10 days of formal Collision Data Analysis or Road Safety Engineering training.

Specialist Advisors

As part of agreeing the Audit Brief the Design Organisation and the Audit Team should consider if there are any particular features of the project, such as complex signal controlled junctions, highway design, traffic management or maintenance issues that warrant the appointment of Specialist Advisors to advise the Audit Team. Appointment of Specialist Advisors is subject to the approval of the Highway Authority/Overseeing Organisation. A Specialist Advisor is not a member of the Audit Team but advises the team on matters relating to their specialism.

Certificate of Competency

At least one individual within the Road Safety Audit Team undertaking Road Safety Audits on the motorway or trunk road network must hold a Certificate of Competency in Road Safety Audit, acquired in accordance with Appendix G of GG119 contained within the Design Manual for Roads and Bridges.

With regard to local roads, the relevant Local Highway Authority guidelines should be checked to see whether audits need to be undertaken in accordance with Highways England standards in GG119 (formerly HD19/15) of the Design Manual for Roads and Bridges or if the Local Highway Authority have specific local standards that should be applied. The standards to be applied should be clearly set out within the Road Safety Audit Brief.

PRE- AUDIT MEETING

Before the field inspection, a commencement meeting was held in which the RSA team, the operator staff and a police officer participated. The meeting was necessary for the operator to become familiar with the audit process and for the audit team to obtain the necessary background for the project and receive information regarding road safety concerns and problems, issues and constraints requiring specific consideration.

DATA COLLECTION

The data which were provided to the audit team included: & The design standards that were used. & Traffic volumes. & Horizontal and vertical alignment plans (1:5000 scale). & Ortho photomaps (1:2000) & Previous road safety audit reports from the pre-opening stage. & Sign plans (1:5000). & Freeway plans “as built”. & Crash data. & Route mapper software. .

FIELD INSPECTION & CHECKLIST

When inspecting a design or a newly constructed project, road safety auditors must first consider who might be hurt in a collision on a particular part of the highway and how that might occur. The auditors must then consider how the potential for such a collision can be reduced or how its consequences might be limited . The Road Safety Audit team conducted the RSA with the goal to identify potentially dangerous roadway or traffic features of the freeway operating environment, as well as potentially misleading or missing information by the application of safety principles of positive guidance and self-explaining roads while recognizing the potential influence of human factors such as road users’ limitations in capabilities or unfamiliarity. The RSA audit lasted approximately one month. The RSA team developed checklists for the specific project, as was requested by the operator. They were based on a review of the relevant material and were tailored to the specific freeway. The freeway was inspected in daylight and at night-time in wet and dry conditions and included all movements at each interchange. The inspection was undertaken from the point of view of all road users.

Motorcyclists accounted for a considerable share of crashes, as was evident from the data provided to the RSA team, while older drivers displayed difficulties at certain locations. During the road inspection emphasis was placed on how drivers might perceive or adjust their behavior to the features of the roadway, allowing the identification of any aspects of the roadway where drivers’ expectations about the road and traffic might be violated or where the layout fails to give the right message . The RSA team checked issues regarding recognizability, early warning and guidance, particularly at locations where drivers make complex decisions and/or perform complex maneuvers . The road was reviewed on the basis of the adequacy of time available to drivers in order to decide and perform maneuvers, the conformity of road layout to driver expectancies ,checking potential violations of expectancies related to roadway design. Inspections were scheduled during typical or representative traffic conditions, allowing the RSA team to understand how usual traffic conditions and road user behavior may affect safety during the daytime and at night . RSA was partly based on a research study on performance assessment and self-assessment in which active older drivers participated in an on-road trial on the freeway in question . A method of performance assessment was developed which was based on observations of driving behavior and task analysis. Task analysis is a process tool, useful in revealing the interaction between task demands and users’ capabilities . The route appeared to have complexities at certain locations where drivers had to choose directions and maneuver in short sequence or inside tunnels, following rather complicated signs at relatively high speeds and in considerable traffic . The RSA findings were recorded in the RSA report together with recommendations for implementation.

5.3 STEPS FOR ROAD SAFETY AUDIT PROCEDURE

There are four different stages of a Road Safety Audit each forming their own independent report but with reference to earlier stages, with each stage detailed below:-

Stage 1

Stage 1 Road Safety Audits are undertaken at the completion of preliminary design and normally before planning consent is granted, as this is usually the last occasion at which land requirements may be increased and the basic design principles can be altered. At the Road Safety Audit Stage 1 all team members shall visit site together and examine the existing highway layout or features and where the new highway improvement scheme ties into the existing highway.

Stage 2

Stage 2 Road Safety Audits are undertaken at completion of the detailed design stage of the works. The Audit Team will be able to consider issues such as the layout of junctions, position of signs, carriageway markings, lighting provision and other issues. At the Road Safety Audit Stage 2 all team members shall visit together and examine the existing highway layout or features and where the new highway improvement scheme ties into the existing highway.

Stage 3

The Stage 3 Road Safety Audit should be undertaken when the Highway Improvement Scheme is substantially complete and preferably before the works are open to road users. The Audit Team will examine the scheme site during daylight and during the hours of darkness so hazards particular to night operation can also be identified. For Stage 3 Road Safety Audits it is a mandatory requirement for the Audit Team Leader to invite representatives of the Police and Maintaining Authority to accompany the Audit Team on the site visit, to allow them to participate and offer their views.

Stage 4 - (Monitoring)

Following the first year a Highway Improvement Scheme is open to traffic, a check should be undertaken of the personal injury incidents that have occurred, so that any new patterns or trends that may be associated with the works are identified and remedial actions taken where necessary. Stage 4 monitoring reports shall be prepared using 12 months of incident data from the time the scheme became operational.

The collision records shall be analysed in detail to identify:

- Higher than anticipated numbers of incidents that have occurred since the scheme became operational compared to control data;
- Locations at which incidents have occurred;
- Incidents that appear to arise from similar causes or show common factors or trends.

The analysis should include identification of changes in the incident population in terms of number, types, and other incident variables, with comparisons made with control data. Where the Highway Improvement Scheme is an on-line improvement then the incident record before the scheme was built should be compared with the situation after opening.

If incident records are not sufficiently comprehensive for detailed analysis, the police may be contacted to ascertain whether additional information can be provided that may aid the analysis.

The Stage 4 Road Safety Audit report should identify any road safety problems indicated by the data analysis and observations during any site visits undertaken. The reports should make recommendations for remedial action.

Road Safety Audit (RSA) Response Report

For Stage 1-3 Road Safety Audits it is necessary to produce a RSA Response report. The Design organisation would normally produce the report, with collaboration from the Highway Authority/Overseeing Organisation.

The RSA Response Report must respond to each of the problems raised, either by:-

- accepting the RSA problem and recommendation, or
- accept the RSA problem but suggesting an alternative solution, or
- disagreeing with the RSA problem and recommendation, giving justifiable reasons for their rejection.

The responses to each problem must then be agreed with the Highway Authority/Overseeing Organisation, with the actions to be taken recorded in a decision log, which would form part of the final RSA Response report.

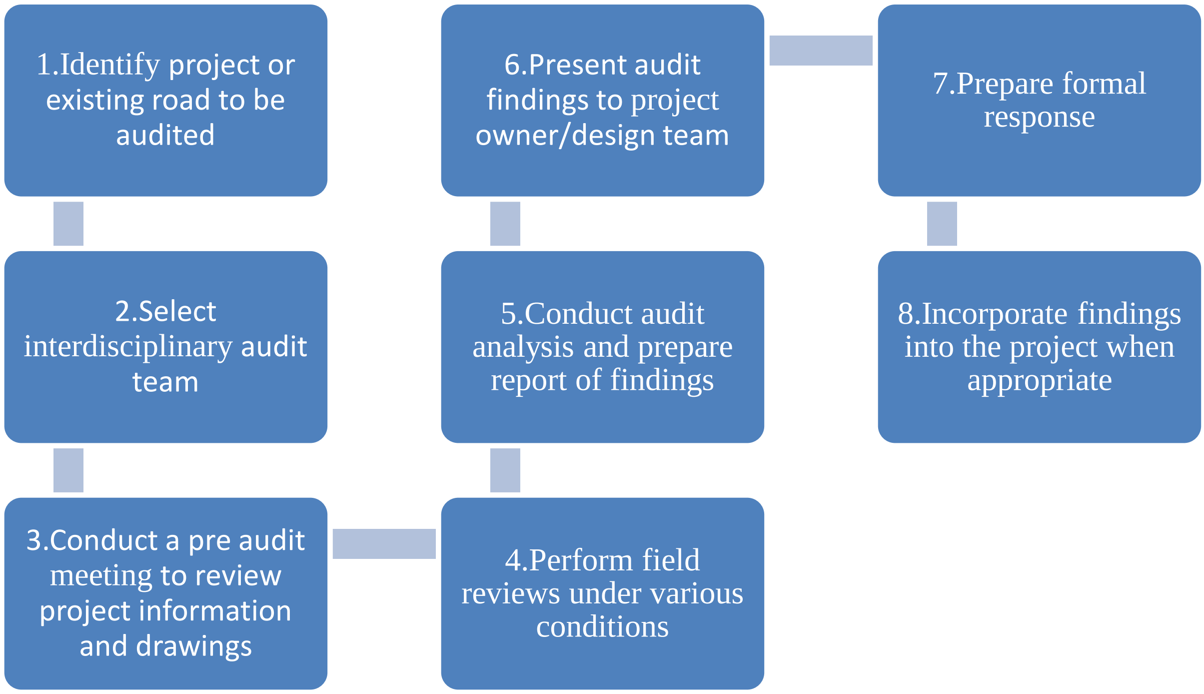


Fig 5.3 Steps for road safety Audit Procedure

5.4 RSA FINDINGS AND RECOMMENDATIONS

Markings

The road marking was faded at certain locations, while old markings controlling temporary traffic had not been removed effectively . Improvement of road markings was recommended since ineffective markings could cause course deviation and driver behavior problems especially in a high speed environment as a result of inadequate warning and guidance. The use of a high-quality retroreflective material effective in rain and darkness with adequate skid resistance characteristics was recommended. Priority of implementation was recommended for horizontal curves and transition points.

Roadside hazards

The RSA team identified locations where the roadside barrier was interrupted for a short distance. This would cause an errant vehicle entering the unprotected zone to be “trapped”, with no possibility to retain control and crash into roadside obstacles behind the barriers. In addition, there were sometimes no safety barriers in front of roadside obstacles such as lighting columns, pipes in tunnels and electrical and mechanical installations. Such features cannot be removed, while at these locations maintenance activities by technical personnel take place regularly. The team recommended the installation of restraint systems to fill the short gap between consecutive barriers – ensuring safety-barrier continuity – and in front of road equipment . During the RSA, the team identified some locations where bridge abutments are almost in contact with the restraint system. Similarly, there was almost no space between the safety barrier and the bridge column Selected safety issues Topic areas Safety issues Recommendations Signage Faded road markings Improved road markings Old road markings Removal of old road markings Roadside hazards Unprotected road equipment (lighting columns, pipes in tunnels, electrical and mechanical installations) Installation of roadside barriers Short gaps between road side barriers Extension of barriers Bridge abutments and columns Installation of safety barrier special treatment Cross-sections Variability of emergency lane width/excessive width Constant width of emergency lane Stopping sight distance (ssd) Limited ssd on horizontal curves (vegetation, guard rails, tunnel concrete wall) Elimination of plantation (New Jersey) Improvement of road surface skid resistance Warning sign (danger)/VMS Lower speed limit Automatic speed cameras enforcement Decision sight distance Restricted sight distance due to upstream horizontal/ vertical curvature Improvement of road surface skid resistance Advance warning signs Improvement of road delineation/markings Crash cushion at noses (ends of barriers) Speed limit sign Automatic speed cameras enforcement Driver behavior Operating speeds exceeding speed limit in tunnels and direction choice points Improvement of road surface skid resistance Improvement of road delineation/markings Speed limit signs in tunnels (Rumble strips before decision points) Encroachment on delineated areas Use of rumble strips Advance warning signs (gantries) Special considerations for vulnerable road users Protection of motorcyclists Addition of a skirting to road restraint systems, especially on tight curves Older drivers' hesitation upstream of exit locations .In the case of a vehicle collision with the restraint systems there would be not adequate space allowing effective absorption of the kinetic energy. The installation of a concrete barrier of appropriate height and length and special treatment of transition areas between the different types of restraint systems was recommended. 3.3 Cross section The emergency lane had variable width and at some locations drivers might use it as an ordinary lane. The application of constant width along the emergency lane was recommended along with appropriate transition between variable widths.

Limited stopping sight distance

During the inspection, the RSA team identified horizontal curves with limited sight distance. A comparison between the available sight distances and the required stopping sight distances (calculations based on the speed limit) on curves identifies where there were visibility restrictions in the left lane due to the height of vegetation (i.e. the case of the median concrete barrier on left horizontal curves) or the height of the guardrail as well as in the right lane mainly due to the tunnel wall. Suggestions of the RSA team included decreasing the speed limit, placement of appropriate warning signs, elimination of plantation on horizontal curves, improvement of road surface skid resistance and speed limit enforcement. In order to increase speed limit compliance, the RSA team proposed the use of automatic speed cameras. It is worth noting however that speeding should be treated with a combination of measures including roadway treatments and behavioral countermeasures. The RSA team proposed for pilot awareness campaigns to promote the acceptance by the public of the use of automatic speed cameras .

Decision sight distance

The RSA team identified restricted visibility in locations where complex maneuvers are carried out, during which drivers have to choose directions and/or maneuver in short sequence or inside tunnels, following rather complicated signs at relatively high speed and in considerable traffic. The particular layouts were considered uncommon, potentially violating drivers' expectancies [11].

Freeway split with an optional lane

A freeway split is located downstream from an entrance and a sight-restricting horizontal curve Lane drop Drivers on a two-lane ramp connecting road have to follow directions to the mainline. As they approach they are warned about the exit which is located downstream from a sight-restricting vertical curvature. In addition, they usually have to change lane to follow the Fig. 2 Short break in guard rails Bridge column in contact with guard rail Optional lane split to mainline direction, merging into the left fast lane. Consecutive maneuvers Approaching consecutive exits, located downstream from a sight-restricting vertical curvature, drivers have to make directional choices and maneuvers in short sequence following directional signs inside a tunnel. Due to high operating speeds, the available visibility distances to these locations were less than the sight distance needed to decide and complete the maneuver they were almost sufficient at driving speeds within the speed limit . RSA recommendations included improvement of road surface skid resistance and installation of advance warning signs within tunnels. In addition, since additional safety issues were identified at these locations, the team suggested appropriate measures such as improved road delineation and elimination of old markings, installation of a crash cushion at gores or split points, installation of speed limit signs and speed limit enforcement.

Driver behavior

Operating speeds exceeding speed limit The RSA team observed driving behaviors related to driving speeds exceeding the speed limit along sections where limited sight distances were identified, specifically on horizontal curves with limited stopping sight distance due to the presence of plantation or a guardrail on the restraint system and the concrete wall inside tunnels. Relatively high driving speeds were also observed in proximity of freeway exits or split points where complex maneuvers are carried out. The team recommended improvement of road surface skid resistance and improvement of road delineation and markings, as well as speed management measures such as installation of speed limit signs in tunnels, as well as rumble strips before decision points and enforcement of speed limits. Among the measures suggested was the monitoring of speeds and skid resistance in these areas in order to identify, as early as possible, the need for relevant interventions.Encroachment on delineated areas Observations of drivers' behavior revealed that at certain locations drivers encroached on delineated areas. In order to discourage this unintended use, the team recommended the use of rumble strips in these areas and installation of advance warning signs on gantries.

Motorcyclists

Accident data revealed a significant proportion of accidents involving motorcyclists. In particular, motorcycles represent 3 % of traffic while their share in road deaths is 60 %. The RSA team recommended addition of a “skirting” to road restraint systems , especially on tight curves, for guidance and protection especially for motorcyclists.

5.6 ROAD SAFETY AUDIT REPORT

At all Stages the Road Safety Audit Team shall prepare a written report. A stage 1, 2 and 3 Road Safety Audit Report shall include:

a. Identification of the Road Safety Audit stage including a unique document reference number and the status of the Road Safety Audit Report.

b. A brief description of the proposed Highway Improvement Scheme including details of its location and its objectives.

c. Details of who supplied the Road Safety Audit Brief, who approved the Road Safety Audit Brief and who approved the Road Safety Audit Team.

d. Identification of the Road Safety Audit Team membership as well as the names of others contributing such as the Police, Maintaining Agent and Specialist Advisors.

e. Details of who was present at the site visit, the date and time period(s) when it was undertaken and what the site conditions were on the day of the visit (weather, traffic congestion, etc.).

f. The specific road safety problems identified, supported with the background reasoning confirming who may be affected and the type of incidents that could occur.

g. Recommendations for action to mitigate or remove the road safety problems.

h. A location map based on the scheme plan(s), marked up and referenced to problems and if available, photographs of the problems identified.

i. A statement, signed by both the Road Safety Audit Team Leader and the Road Safety Audit Team Member(s).

j. A list of documents, drawings and any other information reviewed for the Road Safety Audit.

Problems and Recommendations

The report shall contain a separate statement for each identified problem describing the location and nature of the problem and the type of incidents considered likely to occur as a result of the problem.

Each problem shall be followed by an associated recommendation. The Audit Team should aim to provide proportionate and viable recommendations to eliminate or mitigate the identified problems.

Recommendations to 'consider' should be avoided. Recommendations to 'monitor' should only be made where a need to supplement the scheduled Stage 4 monitoring is specifically identified in terms of frequency and incidence of particular vehicle manoeuvres or incident causation factors, and the monitoring task can be specifically allocated.

The use of the word ‘must’ shall also be avoided in Road Safety Audit recommendations, as this may be misinterpreted as an instruction from the Road Safety Audit Team.

5.7 ROAD SAFETY AUDIT DEFINTIONS

Within this page we have put together several definitions of key words relating to a Road Safety Audit and the Road Safety Audit Team.

Collision Data Analysis

The examination of historical collision data over a period of time in order to identify patterns, common trends and factors which may have contributed to the incidents. This could also include the detailed forensic investigation of single collisions.

Audit Brief

The instructions to the Road Safety Audit Team defining the scope and details of the Highway Improvement Scheme to be audited, including sufficient information for the audit to be undertaken.

Audit Report

The report produced by the Audit Team describing the road safety related problems identified by the Audit Team and the recommended mitigation to those problems.

Audit Team

A team that works together on all aspects of the audit, independent of the Design Team and approved for a particular audit by the Highway Authority/Overseeing Organisation. The team shall comprise a minimum of two persons with appropriate levels of training, skills and experience in Road Safety Engineering and/or Collision Data Analysis. The members of the Audit Team may be drawn from within the Design Organisation or from another body.

Audit Team Leader

A person with the appropriate training, skills and experience who is approved for a particular audit by the Local Highway Authority/Overseeing Organisation. The Audit Team Leader has overall responsibility for carrying out the audit and managing the Audit Team.

Audit Team Member

A member of the Audit Team with the appropriate training, skills and experience necessary for the audit of a specific scheme reporting to the Audit Team Leader.

Audit Team Observer

A person with the appropriate training, skills and experience accompanying the Audit Team to observe and gain experience of the audit procedure. The Audit Team Observer is encouraged to contribute actively to the audit process but is not a member of the Audit Team.

RSA Response Report

A report that is normally prepared by the design organisation in response to the recommendations made in the Road Safety Audit. The report must then be agreed with the Local Highway Authority/Overseeing Organisation, with a decision log included confirming the agreed actions taken in response to each of the problems and recommendations.

Design Organisation

The organisation(s) commissioned to undertake the various phases of scheme preparation.

Design Team

The group within the Design Organisation undertaking the various phases of scheme preparation.

Highway Improvement Schemes

All works that involve construction of new highway or permanent change to the existing highway layout or features. This includes changes to road layout, kerbs, signs and markings, lighting, signalling, drainage, landscaping and installation of roadside equipment etc.

Interim Road Safety Audit

The application of Road Safety Audit to the whole or part of a Highway Improvement Scheme at any time during the preliminary and detailed design stages. Interim Road Safety Audit is not mandatory or a substitute for the formal Stage 1, 2 and 3 Safety Audits.

Overseeing Organisation

The organisation responsible for the Highway Improvement Scheme to be audited. This would typically be the Local Highway Authority for works on local roads or Highways England for works to the Strategic Highway Network (Trunk Roads and Motorways).

Road Safety Audit

The evaluation of Highway Improvement Schemes during design and at the end of construction (preferably before the scheme is open to traffic) to identify potential road safety problems that may affect any users of the highway and to suggest measures to eliminate or mitigate those problems. The audit process includes the collision monitoring of Highway Improvement Schemes to identify any road safety problems that may occur after opening. This Stage 4 Audit will include the analysis and reporting of 12 months of completed personal injury incident data from when the scheme became operational.

Road Safety Engineering

The design and implementation of physical changes to the road network intended to reduce the number and severity of incidents involving road users, drawing on the results of Collision Data Analysis.

Specialist Advisor

A person approved by the Overseeing Organisation to provide specialist independent advice to the Audit Team should the scheme include complex features outside the experience of the Audit Team Members, e.g. a complex traffic signal controlled junction.

5.8 BENEFITS OF RSA

An increasing number of countries focuses on Road Safety Auditing. One of the positive ideas behind RSA is its preventive character. 'Getting it right the first time' is one of the factors that makes this RSA an appealing idea, for it seems that money and victims can be saved. Nevertheless RSA does not stand on its own. Besides knowledge of accident investigation techniques there should be some sort of 'natural audit environment'. This implies a few things. First there should be a top-down management commitment and bottom-up adaptation of the ideas for enthusiastic cooperation. Secondly it implies that there should be a political statement about accident reduction goals convenient for allocating resources. Some of the benefits of RSA

- May help produce designs that reduce the number and severity of crashes.
- May reduce costs by identifying safety issues and correcting them before projects are built .
- Help promote awareness of safe road design practices.
- Help integrate multimodal road safety concerns.
- Help identify key human factor considerations.

CHAPTER -6

DISCUSSION

The focus of the assessment is to calculate the decrease within the level of highway safety measures for the impact space of the planned road. This may modify the calculation of the quantity of points in keeping with the adopted criteria for every of the variants, and institution of the ranking of variants. Road safety strategy could be a attempt to guide efforts in reducing fatal and high injury crashes for all users across an outlined road network. The intention is to determine a desired future direction with actions and targets designed to realize specific results. Network risk assessment it's purpose is to spot general areas of endanger in road safety for all tranport users. It take into accounts network operations and road characteristics and will consider crash history. Safety strategy could be a formal examination of the potential Associate in Nursing actual road safety risks for an existing road from the attitude of all road users. The purpose is to spot road questions of safety and risks that have or may cause to road crashes or damage to folks. TSM is the recognition of crash spots to spot plant disease EB methodology is enforced and result comes within the sort of fatal and non-fatal crashes. Funding allocation strategy associate by choosing the best combination of safety improvement comes on main road with higher ADT. Intelligent speed adaptation (ISA) measure to any method that failed to permit the transport to increase the safe or wrongfully enforced speed.In a rushing state of state, the motorcycle speed is mechanically reduced (active) or the driving force may well be alerted (passive). ISA helps the drivers to keep up a legal and safe speed on the driving time. DEA is a applied mathematics technique for measurement the relative execution of entities or units of the same pattern. during this conception, whereas shrewd risk within the traffic safety field, rock bottom level has been thought of because the frontier of safety.Road Safety Audit is also a proper, systematic, freelance assessment of the potential road questions of safety associated with a replacement road theme or road improvement theme. . The RSA team evolution checklists for the actual project, as was requistion by the operator. The list are road Alignment, Auxilliary lanes, Intersection, Traffic signs & lighting, Marking& delinations, pedestrians and miscellaneous.

CHAPTER – 7

CONCLUSION

As per the discussion created, we tend to conclude ,RSA may be a extremely economical and efficient engineering tool for improvement of safety on roads. RSA is that the most efficient speculation a Road officials will undertake. Road Safety deals with the event and management of road infrastructure, provision of safer vehicles, legislation and enforcement and concrete land use coming up with etc. The key objective of the RSA is to decrease the chance of accidents occur in the future. There are variety of strategies offered to assess road safety on a road network. Supported the expertise gained from the appliance of RSA within the operative stage, it ought to be stressed that the participation within the RSA team of members with information of living factors is taken into report advisable for an efficient result. RSA will gift and highlight problems in safety engineering, showing the safe and dangerous practices in Road safety maintenance like Route Signs, Interchange signs, Exit signs, Miscellaneous info signs, Road Markings etc. Self-Explaining Roads and Forgiving Roads will save the lives of driver and traveler. RSA applied to the risks outside the framework of standards and codes, to confirm safety and instructed measures may be enforced to confirm safety to the vehicles.

CHAPTER – 8

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