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# SAFE HIGHWAYS IN INDIA: CHALLENGES AND SOLUTIONS

## A Guidance for Road-Owning Agencies


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# List of Abbreviations

| Abbreviation | Full Form |
|---|---|
| BS | Black Spot |
| CPWD | Central Public Works Department |
| DALY | Disability Adjusted Life Years |
| DMRC | Delhi Metro Rail Corporation |
| EPC | Engineering Procurement and Construction |
| GOI | Government of India |
| HIC | High-Income Country |
| HIV | Human Immunodeficiency Virus |
| IRC | Indian Roads Congress |
| LMIC | Low and Middle-Income Country |
| MDR | Major District Road |
| MoRTH | Ministry of Road Transport and Highways |
| MTW | Motorized Two-Wheeler |
| NH | National Highway |
| NHAI | National Highways Authority of India |
| NHDP | National Highways Development Project |
| NHIDCL | National Highways & Infrastructure Development Corporation Ltd. |
| NMV | Non-Motorized Vehicle |
| O&M | Operations and Maintenance |
| ODR | Other District Road |
| PPP | Public-Private Partnership |
| PRI | Panchayati Raj institution |
| PWD | Public Works Department |
| RO | Regional Officer |
| ROW | Right of Way |
| RSA | Road Safety Audit |
| RSO | Road Safety Officer |
| RTC | Road Traffic Collision |
| RTF | Road Traffic fatality |
| RTI | Road Traffic Injury |
| SCC | Supreme Court Committee |
| SDG | Sustainable Development Goal |
| SE | Safety Engineer |
| SH | State Highways |
| SSA | Safe System Approach |
| ToR | Terms of Reference |
| TSR | Three-wheeled Scooter Taxi |
| VZ | Vision Zero |

# SAFE HIGHWAYS IN INDIA: CHALLENGES AND SOLUTIONS

## A guidance for road owning agencies


### Abstract

The Government of India (GoI) launched a major programme in 2000 to expand and improve highways in India. The upgradation and strengthening of National Highways through various phases of the National Highways Development Project (NHDP). The main motivation behind highway upgradation has been improving inter-city and inter-state connectivity through capacity enhancement of roads. However, with the expansion of highways, road crashes have also continued to increase, in both absolute numbers and deaths per lakh population.

The latest report released by the Ministry of Road Transport and Highways (MoRTH) for road accidents in India (MoRTH, 2023) records 1,68,491 fatalities in road accidents in 2022. Sixty-eight percent of fatalities occurred on highways. Nearly 75% of the fatal crashes involve pedestrians, bicyclists and motorised two-wheeler riders. Despite several measures taken by the National and State governments, the number of fatalities has not reduced. In the same time, several countries have reported reduction in total fatalities despite increase in motorization and population.
An effective sensitization programme of the key stakeholders needs to be implemented as a national priority.

The present study highlights actions that can be taken by highway owning and operating agencies such as NHAI (National Highways Authority of India), MoRTH and the Public Works Departments (PWD) of different states. The report highlights the interventions required to address road safety on highways, and includes two-, four- and six-lane highways and expressways. It also includes the sections of highways that pass through towns and villages and other inhabited areas. While road safety is important for urban areas, this study does not specifically address issues particular to urban road safety. The study proposes specific policy recommendations for road owning agencies (NHAI, MoRTH, and PWDs) and actionable plans for implementation. A roadmap for phased implementation is proposed to address specific traffic safety interventions on highways that can assist authorities in achieving Sustainable Development Goal (SDG) 3.6, which requires countries to reduce road traffic deaths by 50% by 2030.

# 1. Introduction

## Global Trends

The Global Status of Road Safety report,[1] published by the World Health Organisation in 2023, has reported a reduction in road traffic deaths globally for the first time in the history of road traffic crashes. There were an estimated 1.19 million road traffic deaths in 2021 – a 5% drop when compared to the 1.25 million deaths in 2010. This continued decline globally is the result of sustained efforts of experts from various disciplines and other stakeholders over the past 75 years. These efforts include the establishment of independent government agencies to monitor, evaluate and regulate vehicle and road standards and research institutes where multidisciplinary research was conducted to understand the multiple causes of road crashes and the impact of various interventions.

Road traffic safety has been recognized as a public health problem for decades (Gibson, 1961, Haddon, 1963, 1968).[2] Experts have recognized that as a public health problem, road traffic deaths can be treated by methods applied to epidemic diseases, including the detailed investigation of individual incidents and the application of epidemiological techniques. In India, the Indian Roads Congress (IRC) was set up in 1934 and was made responsible for setting standards for road construction, maintenance, and development. The first Motor Vehicle Act was adopted in 1939 and amended in 1988. However, road safety was not recognized as a public health problem. IRC published the first road safety audit guideline in 1999 and the Ministry of Roads and Highways announced a draft road safety policy in 1995.

Prior to 1960, traffic deaths were rising in all countries. However, in most high-income countries (HIC), they declined soon after and have continued to decline over five decades. The decline in traffic deaths occurred despite the fact that vehicle ownership – hence, exposure to the traffic environment – has steadily increased over the last century. In contrast, traffic injuries in most low and middle-income countries (LMIC) are continuing to rise or are stable (Bhalla et al., 2020).[3] The history of traffic safety interventions in HICs suggests that, because of new understanding emerging from scientific evidence and interdisciplinary research, their focus shifted to improved designs of vehicles and roads instead of blaming the individual errors made by road users in the traffic environment. This has important lessons for countries like India, where traffic deaths continue to increase.

1. https://www.who.int/teams/social-determinants-of-health/safety-and-mobility/global-status-report-on-road-safety-2023

2. Gibson, J.J., 1961. The contribution of experimental psychology to the formulation of the problem of safety–a brief for basic research. Behavioral Approaches to Accident Research, 1(61), pp.77-89.

   Haddon Jr, W., 1963. A note concerning accident theory and research with special reference to motor vehicle accidents. Annals of the New York Academy of Sciences, 107(2), pp.635-646.

   Haddon Jr, W., 1968. The changing approach to the epidemiology, prevention, and amelioration of trauma: the transition to approaches etiologically rather than descriptively based. Journal of Public Health and the Nation's Health, 58(8), pp.1431-1438.

3. Bhalla, K., Mohan, D. and O'Neill, B., 2020. How much would low-and middle-income countries benefit from addressing the key risk factors of road traffic injuries? Journal of Injury Control and Safety Promotion, 27(1), pp.83-90.

# The Indian Context

A disproportionately high burden of road traffic deaths and injuries occur in the LMICs. Currently around 90%, it is expected to increase due to rapid urbanization and motorization (WHO, 2023). Road traffic injuries (RTIs) have continued to increase in India, with 168,491 deaths reported in 2022, an increase of 9% from 2021 (MoRTH, 2023). Thirty-six percent of these fatalities were reported on National Highways (NH), 24% on State Highways (SH) and 39% on other roads. The proportion of road traffic collisions (RTCs) on NH, SH and other roads have remained unchanged in the last three decades.

The road network in India had a combined length of 63.32 lakh km in March 2019. The road network consists of NHs, SHs, Districts roads, and Rural and Village Roads. NHs constituted 2.1 percent of the total road length of the country in 2019 (Basic Road Statistics of India, MoRTH). The balance of the road network comprises of State Highways (2.9%). Other roads comprise of District Roads (9.6%), Rural Roads (71%), Urban Roads (8.5%), and Project Roads (5.4%). The construction of roads in India has seen a consistent increase during the 70-year period from 1950-51 to 2018-19.

MoRTH is responsible for the planning, construction, and maintenance of NHs and the administration of various relevant legislative act and rules: National Highways Act, 1956; National Highways Authority of India Act, 1988; National Highways Fee (Determination of Rates and Collection) Rules, 2008; Motor Vehicles (Amendment) Act, 2019; Central Motor Vehicles (Second Amendment) Rules, 2022; Motor Vehicles Act, 1988; and Central Motor Vehicles Rules 1989. MoRTH also formulates policies related to road transport and automotive norms and makes arrangements for movement of vehicular traffic with neighbouring countries. The PWD of each state is responsible for State Highways, whereas district roads are the responsibility of district administration (Zila Parishad). Urban roads are planned and maintained by municipalities and village roads are the responsibility of Panchayati Raj institutions (PRIs). Since 2000, numerous village roads have been constructed and upgraded under the PMGSY (Pradhan Mantri Gram Sadak Yojana) scheme of the Government of India.

There are major initiatives by GoI for upgradation and strengthening of NHs through various phases of the National Highways Development Project (NHDP). In addition to other schemes and projects, the initiative is part of the umbrella program called Bharatmala Pariyojana Phase-I. Seventy thousand kilometres of NH are maintained by the NHAI. Through the NHDP, NHAI is also upgrading nearly 49,000 km of NH, of which 24,000 km have been upgraded. Upgradation includes increasing the number of lanes (e.g., from four to six), converting undivided roads to divided highways, and adding paved shoulders to two-lane roads.

The number of road crashes continues to increase with the expansion of highways, both in absolute numbers as well as fatalities per 100,000 populations, which has increased from 2.1 in 1970 to 12.1 in 2022 (Figure 1). The highway expansion program provides an opportunity to monitor, evaluate and establish robust processes to ensure compliance of safety standards as the new roads are constructed.

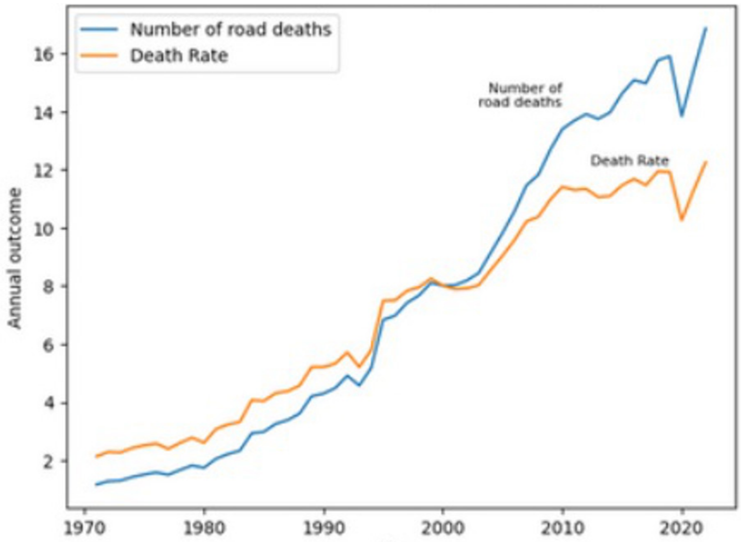


**Figure 1. Road deaths in India from 1971 to 2021 (TRIPC, 2023)**

Source: Tiwari et al, 2023 [add footnote ref '4' in superscript after 2023]

Many different indicators are used to describe road traffic crash problems. Fatalities per 100,000 populations are used for all comparisons because this is a good indicator of the health burden on the population. For example, death due to Malaria and HIV are both represented by deaths per 100,0000 populations. Two other important indicators used to describe traffic crash risk include 'fatalities per 10,000 vehicles' and 'fatalities per 100,000 vehicle kilometres' travelled. 'Fatalities per 10,000 vehicles' explains the probability of a vehicle getting involved in a fatal crash. This is useful for insurance companies, not for suggesting safety interventions. Health professionals also use Disability Adjusted Life Years (DALYs) for expressing the health burden which includes loss of life at a premature age and loss of productivity due to disability.

'Fatalities per 100,000 vehicle kilometre' expresses risk of a fatal crash in the traffic. Based on the availability of reliable data, the use of different indicators is suggested as[5]:

- **Comparing countries**: Fatality rate is used where total fatality is divided by different units capturing the exposure of the road user to the risk of traffic fatality. Some of the common units are fatalities per million vehicle (or person) kilometres, vehicle fleet, road length, population. Non-fatal crashes are underreported therefore not used for comparisons. The most common exposure unit to describe traffic fatality as a health problem is population.
- **Comparing road types**: Fatalities per road type and road length (with a focus on the comparison highway/non highway, for which standard definitions exist). Administration of different road types is the responsibility of different authorities. This indicator is helpful in prioritizing interventions by road type.
- **Comparing transport modes**: Fatalities per vehicle type and per million vehicle-kilometres for comparing risk of using a passenger cars vs motorcycle.
- **Comparing road user groups**: Fatalities per person by age and gender, relative to the population. This analysis is useful for targeting interventions to specific age groups.

4. Tiwari, G. Goel, R. and Bhalla, K. (2023) Road Safety in India: Status Report 2023. New Delhi: Transportation Research & Injury Prevention Centre, Indian Institute of Technology Delhi. https://tripc.iitd.ac.in/assets/publication/RSI_2023_web.pdf
5. Papadimitriou E, Yannis G, Bijleveld F, Cardoso JL. Exposure data and risk indicators for safety performance assessment in Europe. Accident Analysis & Prevention. 2013 Nov 1, 60:371-83.

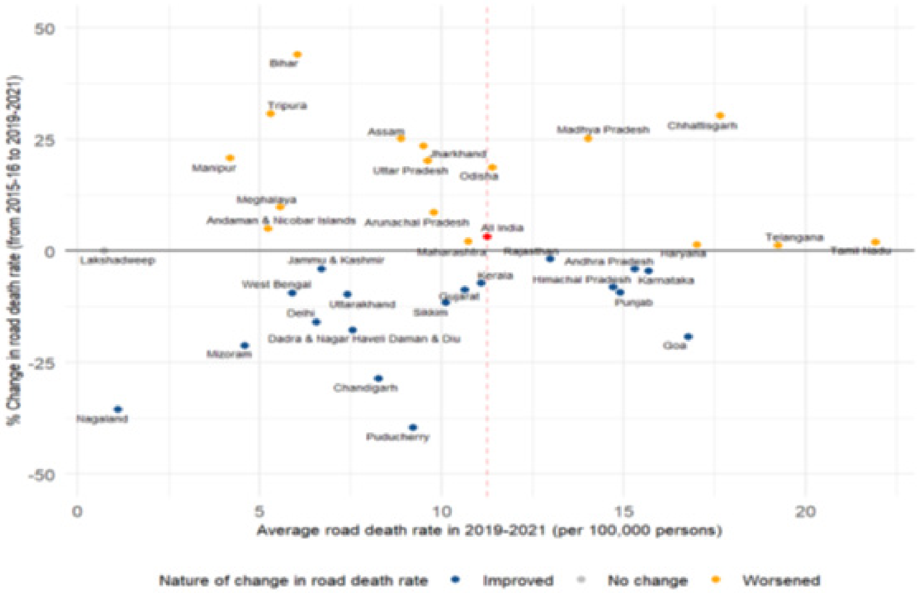


**Figure 2. Change in death rate from 2015-16 to 2019-2021 in States**

Source: Same as Fig. 1

Figure 2 shows that road traffic death rates from 2019-2021 have reduced in many states as compared to 2015-2016. Delhi, Punjab, West Bengal, Kerala, Gujarat and Uttarakhand are some of the states which have reported reduction in road traffic death rates. These states offer lessons for other states for reducing road traffic fatalities. Bihar, Madhya Pradesh, Assam, Odisha and Jharkhand have reported increase in death rates in the same time period.

Figure 3 shows the proportion of road traffic fatalities and length of NH, SH, and other roads in India. Nearly 60% of fatalities occur on highways, both NH and SH combined, which constitute only about 5% of the total road length in India. These are the main arteries carrying inter-city traffic and the presence of motorised traffic is higher on these roads as compared to the traffic on other roads which includes district roads, village roads, urban roads and project roads. Appropriate interventions must be implemented on NH and SH on a priority basis.

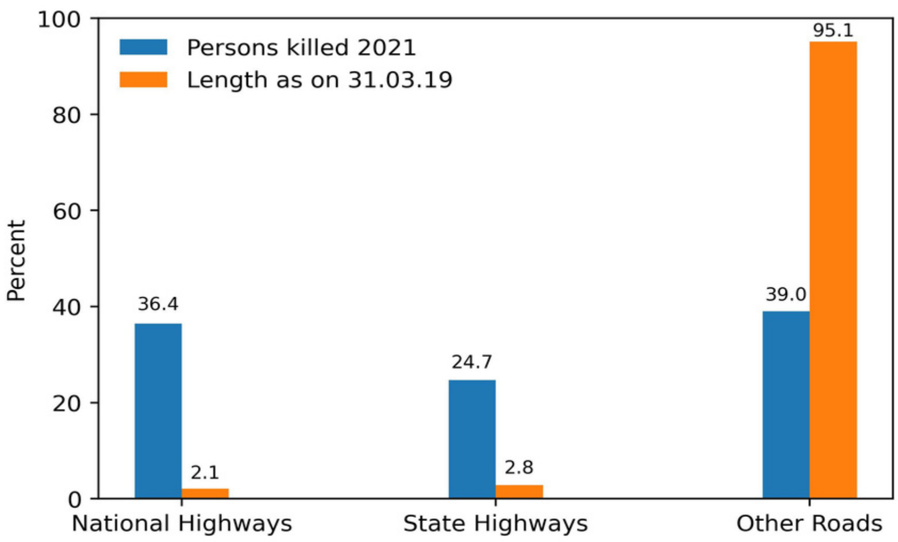


**Figure 3. Proportion of fatalities and road length of NH, SH and other roads in India (MoRTH, 2023)**

Source: Road Accidents in India, MoRTH, 2022

Figure 4 shows the ranking of various diseases measured by DALYs in 2009 and 2019. Road traffic crashes were the 13th largest contributor to health burden (deaths and disabilities) in India. For the working age population (15-49 years), road traffic crashes are the sixth largest contributor to health burden. A study sponsored by the Transport Research Wing of MoRTH reported that the socio-economic cost of road traffic injuries is equivalent to 3.5-5% of the national GDP.[6] Nearly 70% of the socio-economic cost is borne by people in the age group of 18-45 years, and 80% is borne by MTW users and pedestrians.

| S. No. | 2009 RANK | | 2019 rank |
|---|---|---|---|
| 1 | Maternal & neonatal | | Cardiovascular diseases |
| 2 | Cardiovascular diseases | | Maternal & neonatal |
| 3 | Respiratory infections & TB | | Respiratory infections & TB |
| 4 | Enteric infections | | Chronic respiratory |
| 5 | Other non-communicable | | Neoplasms |
| 6 | Other infectious | | Other non-communicable |
| 7 | Chronic respiratory | | Enteric infections |
| 8 | Unintentional inj | | Unintentional inj |
| 9 | Neoplasms | | Musculoskeletal disorders |
| 10 | Nutritional deficiencies | | Mental disorders |
| 11 | Mental disorders | | Diabetes & CKD |
| 12 | Digestive diseases | | Digestive diseases |
| 13 | Transport injuries | | Transport injuries |
| 14 | Musculoskeletal disorders | | Nutritional deficiencies |
| 15 | Diabetes & CKD | | Neurological disorders |
| 16 | Self-harm & violence | | Self-harm & violence |
| 17 | Neurological disorders | | Sense organ diseases |
| 18 | Sense organ diseases | | Other infectious |
| 19 | NTDs & malaria | | Skin diseases |
| 20 | HIV/AIDS & STIs | | NTDs & malaria |
| 21 | Skin diseases | | Substance use |
| 22 | Substance use | | HIV/AIDS & STIs |

**Figure 4. Ranking of various diseases measured by DALYs in 2009 and 2019**

Source: IHME, 2019[7]

Census and population-level sample surveys indicate that the percentage of households owning a car as well as those owning a MTW more than doubled in the ten years from 2008 to 2017. Over this period, about 1.5 million cars and 10 million motorcycles were registered every year — equivalent to 0.6% new households owning a car and 4% owning a motorcycle every year. In 2017, seven percent of the households owned at least one car and 45% owned at least one motorcycle. Bicycle ownership, on the other hand, has stabilised between 40-45 percent. The high level of MTW ownership also results in high usage of MTW, and MTW users face the highest risk of getting involved in fatal crashes in India. MTW riders are not protected like car occupants and are exposed to high-speed traffic. Bhalla et al. (2007) estimated that the fatalities in case of a scenario involving large number of motorcycles is more than those involving large number of cars or buses.[8] Mohan et al. (2020) reported that occupant fatality rates for MTW and TSR occupants are 2–3 times and 3–5 times higher, respectively, than those for car occupants. Given the present trip lengths for each vehicle type, MTW riders are 3–6 times more at risk than car occupants.[9] Increased usage of MTW is likely to increase the road traffic fatality risk for MTW users, who already bear 40% of the traffic injury cost.

6. Study on Socio-Economic Cost of Road Accidents in India, Final Report, DIMTS and TRIPP, sponsored by MoRTH/TRW, 2020
7. IHME. 2020. Global Burden of Disease Collaborative Network. Global Burden of Disease Study 2019 (GBD 2019) Results. Seattle, United States: Institute for Health Metrics and Evaluation (IHME), 2020. Available from http://ghdx.healthdata.org/gbd-results-tool. Accessed 2021-01-11
8. Bhalla K, Ezzati M, Mahal A, Salomon J, Reich M. A risk-based method for modelling traffic fatalities. Risk Analysis: An International Journal. 2007 Feb;27(1):pp.125-36
9. Mohan D, Tiwari G, Mukherjee S. Urban traffic safety assessment: a case study of six Indian cities. IATSS Research. 2016 Mar 1;39(2):pp.95-101.

# 2. Traffic crash risk and crash patterns

The road network of the country is 63.31 lakh km as on 31 March 2019, as reported by MoRTH in Basic Road Statistics 2018-19. Table 1 shows the length of different categories of roads and fatalities reported in 2022. Fatalities per 100 km of road length is the highest on NH with 45 deaths annually. NHs carry 40% of the total vehicular traffic, but this only partly explains the high crash rate. Geometric design, speed compliance and traffic operations play a major role in contributing to high crash rates.

**Table 1. Fatalities on different categories of highways**

| Type of Roads | Length (km) | Fatalities in 2022 | Fatalities/ 100 km |
|---|---|---|---|
| National Highways (including expressways) | 1,32,966 (2%) | 60,038 (36%) | 45 |
| State Highways | 1,83,621 (3%) | 41,012 (24%) | 22 |
| All other roads (district, village, urban, project roads) | 60,15,169 (95%) | 66,441 (40%) | 1 |

Source: Road Accidents in India, MoRTH, 2022

Table 2 shows the crash patterns reported on different types of highways. A majority (68%) of the victims on highways comprise of pedestrians, cyclists, and motorcyclists. Pedestrian and MTW proportions are very high except on six-lane highways where the proportion of truck victims is much higher. The high level of involvement of pedestrians, MTW, and bicyclists in fatal crashes on highways is not reported in most high-income countries. The highway traffic mostly consists of cars and heavy trucks. The presence of pedestrians, bicyclists, and MTW users is negligible on high-speed highways. The highway design standards ensure safe movement of cars, buses and trucks primarily in high income countries. Additional interventions are required on Indian highways to ensure safety of pedestrians, bicyclists and MTW users.

**Table 2. Road Traffic Fatalities by Type of Road User on selected highways**

| Location | Fatalities by type of road user (percent) | | | | | | |
|---|---|---|---|---|---|---|---|
| | Pedestrian | Bicycle | MTW | Car | Bus | Truck | Unknown other |
| Highway locations (1998)[10] | 32 | 11 | 24 | 15 | 3 | 14 | 1 |
| 2 Lane NH 8 (2010-2013)[11] | 20 | 2 | 42 | 14 | 9 | 13 | 1 |
| 4 lane NH 24 (2010-2013)[12] | 27 | 5 | 44 | 8 | 7 | 4 | 4 |
| 4 lane NH 7 (2016-2018)[13] | 24 | 10 | 52 | 8 | 2 | 2 | 1 |
| 6 lane NH 1 (2010-2013)[14] | 34 | 3 | 10 | 6 | 5 | 41 | 1 |
| 6 lane NH 44 (2016-2018)[15] | 40 | 7 | 34 | 8 | 3 | 3 | 6 |
| 6 lane Expressway (2012-2018)[16] | 11 | - | 28 | 29 | 6 | 13 | 12 |

Source: Various, see footnote references

Tables 3 and 4 show the proportion of different types of vehicles involved in fatal crashes, and the pattern of collision types observed on different highways, respectively. Table 3 shows trucks and buses were involved in about 80% of fatal crashes in 1998. Involvement of trucks remained high in 2010-2013 and 2016-2018 as per data obtained from selected highways. Proportion of cars involved in fatal crashes is the highest on expressways.

**Table 3. Types of Vehicles involved in Fatal Crashes on selected highways**

| Location | Vehicles involved (percent) | | | | | | |
|---|---|---|---|---|---|---|---|
| | Truck | Bus | Car | TSR | MTW | Other | Total |
| Highway locations (1998)[10] | 64 | 16 | 15 | 1 | 3 | | 100 |
| 2 lane NH 8 (2010-2013)[11] | 47 | 5 | 17 | 1 | 5 | 25 | 100 |
| 4 lane NH 24 (2010-2013)[12] | 54 | 8 | 9 | 4 | 3 | 22 | 100 |
| 4 lane NH 7 (2016-2018)[13] | 22 | 9 | 50 | 1 | 3 | 16 | 100 |
| 6 lane NH 1 (2010-2013)[14] | 72 | 3 | 12 | 1 | 2 | 10 | 100 |
| 6 lane NH 44 (2016-2018)[15] | 27 | 10 | 30 | 1 | 7 | 25 | 100 |
| 6 lane Expressway (2012-2018)[16] | 26 | 6 | 42 | 0 | 11 | 15 | 100 |

10. Tiwari, G., D. Mohan, and D. P. Gupta. 2000. Evaluation of Capacity Augmentation Projects of National Highways and State Highways. New Delhi: Ministry of Surface Transport, GOI.)
11. Naqvi, H.M., 2019. Establishing Relationship between Elements of Highways on Fatal Crashes on National Highways in India, Ph.D. thesis, Department of Civil Engineering, Indian Institute of Technology Delhi.
12. Ibid.
13. Bisht, Laxman Singh, 2022. SAFETY EFFECTS OF PAVED SHOULDER WIDTH ON INTERCITY HIGHWAYS IN INDIA, Ph.D. thesis, Department of Civil Engineering, Indian Institute of Technology Delhi.
14. Naqvi, H.M., 2019. Establishing Relationship between Elements of Highways on Fatal Crashes on National Highways in India, Ph.D. thesis, Department of Civil Engineering, Indian Institute of Technology Delhi.
15. Bisht, Laxman Singh, 2022. SAFETY EFFECTS OF PAVED SHOULDER WIDTH ON INTERCITY HIGHWAYS IN INDIA, Ph.D. thesis, Department of Civil Engineering, Indian Institute of Technology Delhi.
16. Assessment of fatal rear-end crash risk factors of an expressway in India: a random parameter NB modeling approach (Bisht, L.S., & Tiwari, G. 2023)

Source: Same as Table 2

Table 4 shows that on 4-lane divided roads, head-on collisions comprise 19% of the crashes. Divided 4-lane roads are justified on the basis that these would eliminate the occurrence of head-on collisions. This is probably because tractors and other vehicles go the wrong way when they exit from roadside establishments and the cut in the median is too far away, therefore they prefer to go in the wrong direction. Rear-end collisions (including collisions with parked vehicles) are high on all types of highways including 4-lane highways. This shows that even though more space is available on wider roads, rear-end crashes do not reduce. This is most likely due to poor visibility of vehicles at night, and an inadequate number of truck pull-outs and proper rest areas for long-distance truck drivers, forcing operators to park along the highway shoulders and edge-lanes.

**Table 4. Types of Crashes on selected Highways**

| Highway Type | Crash type (percent) | | | | | | |
|---|---|---|---|---|---|---|---|
| | Overturn | Head-on | Angle | Rear-end | Pedestrian and bicycle | Fixed Object | Other |
| 2 lane with paved shoulder undivided (2010-2015) | 6 | 33 | 6 | 21 | 21 | | 5 |
| 4 lane divided (2010-2015) | 0 | 6 | 2 | 54 | 32 | | 1 |
| 6 lane divided (2010-2015) | 2 | 10 | 9 | 28 | 45 | | 1 |
| 2 lane hill road (2010-2015) | 77* | 4 | | 1 | 4 | | 13 |
| 4 lane NH7 divided (2016-2018) | 0 | 14 | 7 | 39 | 35 | 0 | 7 |
| 6 lane NH44 divided (2016-2018) | 1 | 5 | 9 | 29 | 48 | 3 | 5 |
| 6 lane Expressway (2012-2018) | 3 | 2 | 4 | 49 | 11 | 18 | 13 |

*Run off vehicles 76% and 1% overturn
Source: Same as Table 2

Nearly 18% of the crashes involve hitting a fixed object on expressways clearly highlighting the poor design details. An errant vehicle hitting a fixed object should not lead to fatalities if the design details have been followed correctly. Fixed objects may be a crash barrier, high median, or pole installed for signage.

Figure 5 shows a raised median and incorrect installation of crash barrier (kerb stone in front and low height). An errant vehicle is likely to hit the raised median and turn over or have a tyre burst. Incorrect height of the barrier results in vehicle overturning.

**Figure 5. High median and raised kerb in front of crash barrier (responsible for single vehicle overturning and tyre burst)**

Source: Authors, during field audit in 2021

Figure 6 shows unprotected concrete blocks at a toll plaza (Eastern Peripheral Expressway). An errant vehicle hitting the concrete block is likely to have a very severe injury or fatal crash. The guidelines require these to be protected by a crash attenuator.

**Figure 6. Unprotected concrete blocks at the toll plaza**

Source: Authors, during field audit in 2021

The highest share of crashes based on the type of collision on expressway are rear-end crashes, with 49% of those being fatal. The rear-end crashes are reported due to the collision with a break down vehicle standing on the hard shoulder, and also due to driver "sleepiness". In the case of fatal crashes, "hit pedestrian" crashes are second highest with 11%, followed by "hit median" with 9%, and "hit a guardrail" with 6% share in the total crashes. "Hit pedestrian" crash incidences are being reported in spite of the expressway being access-controlled. Vehicular underpass, cattle underpass, and pedestrian underpass are provided at regular intervals. However, people wait at the entry ramps to board the buses which stop on the expressway near entry and exit ramps as well as near the underpass on the highway.

"Hit median" crashes suggest that the design of the median is not appropriate for a high-speed road. An expressway has a 6 metre wide raised median throughout. The height of the curb is 200 millimetres. Research has established that raised medians are conducive to crashes, hence raised medians must not be permitted on expressways. "Median crossed" crashes indicate the shortcoming or inadequacy of the design. The current standards recommend that the road developer must refrain from using the combination of curb and guardrail; however, in case there is no option other than the combination of curb and guardrail, the height of the curb should not exceed 100 millimetres.

# Black Spots (High-risk locations) on Rural Roads

An accident black spot (BS) is a site that has an abnormally high number of accidents. Most commonly, a black spot is identified based on a higher number of crashes compared to the expected number of crashes on a given stretch of road. This helps in prioritizing interventions. MoRTH notified in October 2015 that States should identify black spots on highways as any stretch of NH/SH/other roads of about 500 metres in length in which (a) either five RTCs occurred during the last three calendar years or (b) 10 fatalities occurred during the last three calendar years. All states have sent a list of black spots to MoRTH. States are required to audit the black spots and suggest long-term and short-term remedial measures. Many states have reportedly initiated the process but information about the number of black spots audited and where the remedial measures have been implemented is not available in the public domain.

A recent study (Bisht et al., 2022)[17] has examined 1100 BS identified between 2016 and 2019 in Uttar Pradesh. The largest number of BS (nearly 94%) were on highway segments passing through settlements or near settlements. Settlements were defined as any inhabited area easily identifiable by dense built-up area on both sides of the road. These could be villages or towns. "Near settlement" was defined as the location which is beyond the built-up area within 500 metres.

Three types of intersections – T, four way and Y – accounted for nearly 82% of the BS. This clearly indicates that special attention is required on the design of junctions and highway segments passing through settlements. The audit study found the presence of informal public transport near most junctions. Other activities such as small eateries, vendors and parked vehicles were observed near public transport stops. The design of the intersection did not accommodate these activities, resulting in the presence of pedestrians and street vendors on the carriageway. The SH and MDR segments did not have any effective speed control measures such as speed humps or rumble strips. Almost 99% of the intersections were without traffic signals, although as per IRC codes they required speed calming measures.

**Table 5. Location of Black Spots in West UP**

| S. No. | Typology | No. of identified blackspots |
|---|---|---|
| 1 | T-junction (through settlement) | 96 |
| 2 | Intersection (through settlement) | 66 |
| 3 | Y-junction (through settlement) | 47 |
| 4 | Midblock (through settlement) | 40 |
| 5 | T-junction (near settlement) | 35 |
| 6 | T-junction | 22 |
| 7 | Midblock (near settlement) | 21 |
| 8 | Staggered junction (through settlement) | 20 |

Source: Bisht et al., 2024

17. Bisht, Laxman Singh and Tiwari, G, 2024. Safety audit of identified black spots: A case study of West Uttar Pradesh Roads-Final Report, supported by Public Works department, Uttar Pradesh.

Nearly 90% of the black spots had informal bus and other public transport stops without safe pedestrian crossing facilities.

Figure 7 shows an undivided MDR (Major District Road) in Shahjanpur district, which was identified as a black spot. Road users present on the shoulders are exposed to high-speed traffic and a minor road joining the main road has no speed control measures.


**Figure 7. Road side hazards on undivided rural road**

Source: Bisht et al., 2024

Detailed data disaggregated at state level is not available in the MoRTH annual report. A TRIP Centre report of 2023 presented data from Chhattisgarh and Haryana. Data from Chhattisgarh, when disaggregated at district level, shows that motorcyclists are the largest group of fatal crash victims – ranging from 41% to 69%. Pedestrians are the second largest group of victims. Trucks and tractors are involved as the striking vehicle in 36% of the cases, whereas 30% cases are single vehicle crashes, where the vehicle may be skidding, tripping or colliding with a fixed object such as a tree or median or pole. Clearly, the presence of roadside hazards has increased the risk of single vehicle crashes (Tiwari et al., 2023)[18].

18. Tiwari, G. Goel, R. and Bhalla, K. (2023) Road Safety in India: Status Report 2023. New Delhi: Transportation Research & Injury Prevention Centre, Indian Institute of Technology Delhi. https://tripc.iitd.ac.in/assets/publication/RSI_2023_web.pdf

# Summary of risk factors

In order to reduce fatalities and serious injuries on the roads the design of roads can be guided by an understanding of road users who face the highest risk in traffic crashes on different categories of roads, of locations where a large number of crashes occur, and crash patterns observed in different category of roads. These aspects are further detailed below:

## High risk road users

Motorised two-wheelers (MTW) and pedestrians and bicycle users account for nearly 70% of the fatal crashes. Proportion of MTW in fatal crashes has been increasing over the years.

**On NH/SH:** MTW, pedestrians and bicyclists are present on all NH and SH. MTW and pedestrians have the largest share in fatal crash victims. MTW are involved in 20-30% single vehicle crashes by hitting a roadside hazard or skidding from the carriageway. Helmet use on NH and SH is less than 20% (SCC audit reports).

**On MDR/ODR:** Proportion of MTW and pedestrians in fatal crashes are high.

**On Expressways:** Limited access expressways are not expected to have pedestrian presence. However, 10% fatal crashes on the Delhi-Agra expressway are pedestrians. MTW are also involved in fatal crashes on expressways, although the proportion of MTW in fatal crashes is less than their presence on NH/SH.

## Crash patterns of fatal cases

Crash patterns vary depending on the type of road.

**On NH/SH:** Six lane and four lane divided NH and SH have a large share of rear end crashes and crashes involving pedestrians and bicyclists. Undivided roads have head on collisions.

**On MDR/ODR:** Single vehicle two wheeler crashes are becoming very common followed by pedestrian and bicycle crashes.

**On Expressways:** Rear end collisions are most common, followed by “hit fixed objects” and roll over crashes. The “fixed objects” include medians, guard rails, bridge parapets and culverts. About 10% of the fatal crashes on expressways involve pedestrians.

# 3. Global best practices and lessons for Indian Highways

A large number of countries have successfully reduced road traffic fatalities since the 1970s. Global Status of Road Safety reported by the World Health Organisation has reported that there were an estimated 1.19 million road traffic deaths in 2021 – a 5% drop when compared to the 1.25 million deaths in 2010. However, RTIs have continued to increase in India, with 168,491 deaths reported in 2022, an increase of 9% from 2021 (MoRTH, 2023). Low- and middle-income countries in African and Southeast Asian regions have reported an increase in road traffic fatalities. Most European countries, plus Australia, Japan and a few Latin American countries, have reported reductions in RTFs as shown in Figure 8.

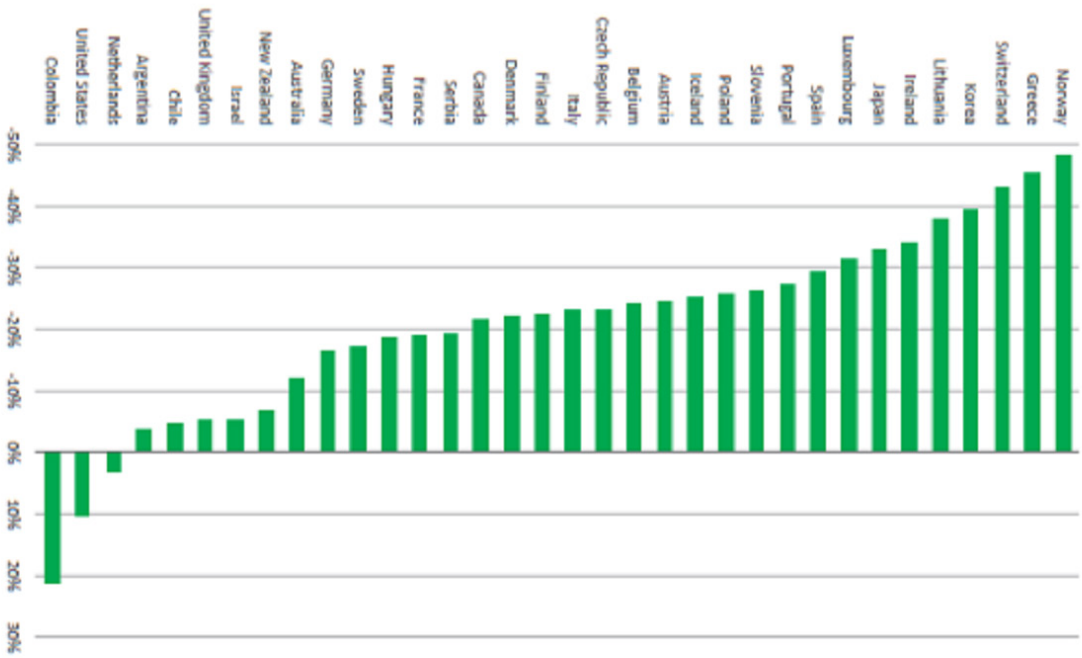


**Figure 8. Change in Road Traffic Fatalities in various countries**

Source: Road Safety Annual Report, 2022, OECD/ITF, 2022, https://www.itf-oecd.org/sites/default/files/docs/irtad-road-safety-annual-report-2022.pdf

## History of Road Safety

Figure 9 shows road traffic fatalities (RTF) per 100,000 population, from 1950 to 2010, for 21 high income countries. The downward trend of RTF from the late 1960s to the early 1970s is noticeable in all countries.

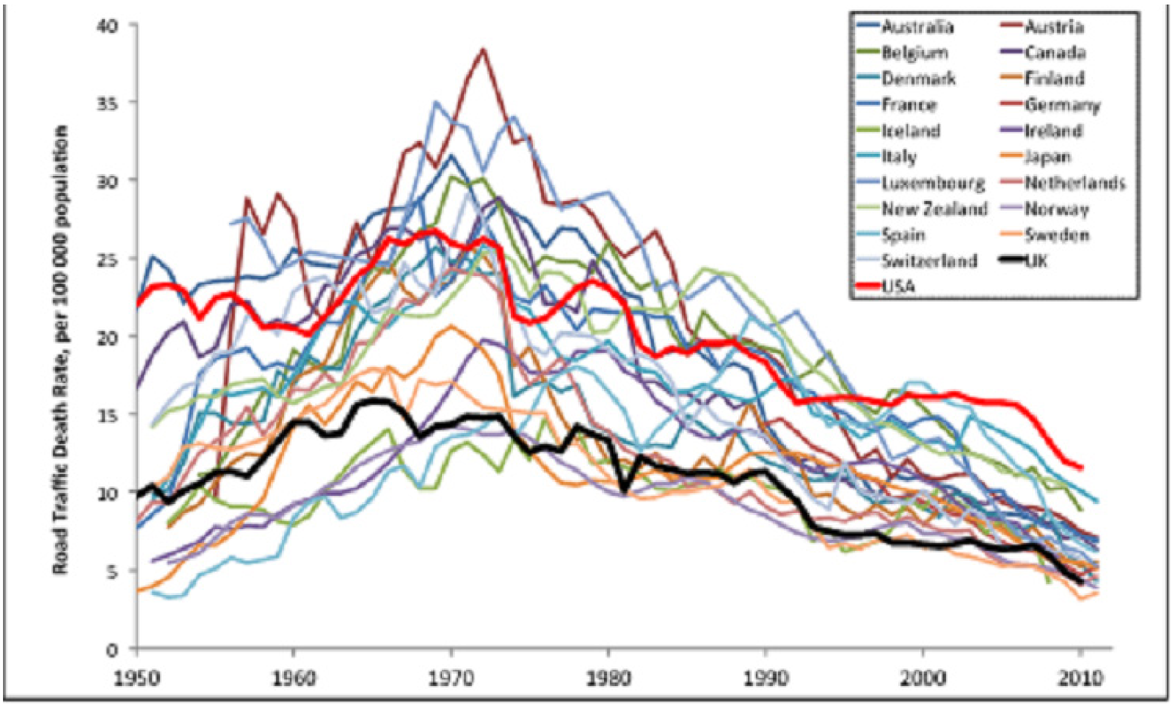


**Figure 9. Road Traffic Fatalities Trend in 21 High Income Countries from 1950-2012**

Source: Bhalla et al., 2020[19]

**Table 6. Time Periods and their characteristic Road Safety Paradigm (OECD, 1997)**

| | **1900-1920** | **1920-1960** | **1950-1970** | **1960-1985** | **1985/1990-Now** |
|---|---|---|---|---|---|
| **Crash** | Chance Phenomena, bad luck | Road devils, accident prone drivers | Road user or vehicle or road | Multicausal approach | Result of integral number of systems |
| **Research** | What | Who | How, the cause | How, which causes, technical improvements | Multi-dimensional economic analysis |
| **Measures** | On an ad hoc basis | Educate, Punish | Choice from 3 E's | Technical solutions for vehicle and roads | Adapt road system to user |

Source: Hagenzieker et al., 2014

Hagenzieker et al **(2014)**[20] studied the history of road safety, divided into five periods, and summarized the changing approach to identifying reasons for crashes, the thrust of research on road safety, and the measures that were recommended in different periods. These are summarised in Table 6.

19. Bhalla, K., Mohan, D. and O'Neill, B., 2020. What can we learn from the historic road safety performance of high-income countries?. International journal of injury control and safety promotion, 27(1), pp.27-34.

20. Hagenzieker, M.P., Commandeur, J.J. and Bijleveld, F.D., 2014. The history of road safety research: A quantitative approach. Transportation research part F: traffic psychology and behaviour, 25, pp.150-162.

In the early periods, the emphasis on road user behaviour and corrective measures focussed on improving behaviour through education, training and strict penalties. As the RTF trend in Figure 10 shows, the RTF rates continue to increase in this period. By the 1960s, the focus shifts from blaming individuals to accepting RTIs as a public health problem. It was understood that injuries are produced by energy interchange and, in principle, etiologically similar to any other disease (Gibson, 1964, Haddon, 1968)[21]. The understanding that traffic injuries result from a complex interaction of sociological, psychological, physical and technological phenomena resulted in the design of safer products, environments, roads and traffic management systems. Once it was accepted that RTI is a public health problem, it helped in initiating a regulatory process and scientific policy for injury control.

New highway standards and vehicle design standards were introduced in these countries resulting in a major reduction in RTIs. However, from the late-1980s onwards, the reduction in RTIs was very small in these countries after implementing the highway design standards and vehicle safety standards.

Around this time, in 1997, the Vision Zero policy, informed by systems thinking, was introduced for the first time in the Swedish parliament. Vision Zero is a landmark safety policy. It was introduced at a time when Swedish roads and transport systems were considered one of the safest in the world. Most countries have traditionally accepted that health losses due to accidents are a major, but to some extent acceptable, consequence of mobility. Contrary to this, the Swedish parliament in October 1997, opined that  the long-term target for the road transport system should be that no one should be killed or receive long-term disablement by the system (Claes Tingvall, 1998; Claes Tingvall & Haworth, 1999)[22]. Vision Zero is an expression of the ethical imperative that "It can never be ethically acceptable that people are killed or seriously injured when moving within the road transport system" (Claes Tingvall & Haworth, 1999). Vision Zero demands that the loss of human life in the road transport system is unacceptable and therefore the transport system should be designed in a way that such events do not occur. This means that safety is a more important issue than other issues in the road transport system (except for health-related environmental issues). Mobility, therefore, should follow from safety and cannot be obtained at the expense of safety.

Over time a large number of interventions were deployed. Regulations to address the most important risk factors were introduced. This included regulating the road environment – design of safe shoulders, clear zones, guard rails, and vehicle standards for safety belts, airbags, strength of bumper, windshield etc. Achieving this required establishing national agencies, giving them legislative authority and financial resources to maintain a trained technical work force, develop interventions, evaluate their effects, and scale up interventions that work as part of an ongoing process of continuing improvement. This is a long-term process.

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21. Gibson, J. J. (1961). The contribution of experimental psychology to the formulation of the problem of safety—a brief for basic research Behavioral Approaches for Accident Research (pp. 77-89). New York: Association for the Aid of Crippled Children.; Haddon, W., Jr. (1968). The changing approach to the epidemiology, prevention, and amelioration of trauma: the transition to approaches etiologically rather than descriptively based. Am J Public Health Nations Health, 58(8), 1431-1438.

22. Tingvall, C., 1998. The Swedish'Vision Zero'and how Parliamentary approval was obtained. In ROAD SAFETY RESEARCH, POLICING, EDUCATION CONFERENCE, 1998, WELLINGTON, NEW ZEALAND, VOL 1., Tingvall, C. and Haworth, N., 1999, September. Vision Zero-An ethical approach to safety and mobility. In 6th ITE international conference road safety & traffic enforcement: Beyond 2000.

Figures 10 show road fatalities in selected countries from 2010 -2021.[23] Most countries have a downward trend of road fatalities from 2010 to 2021.

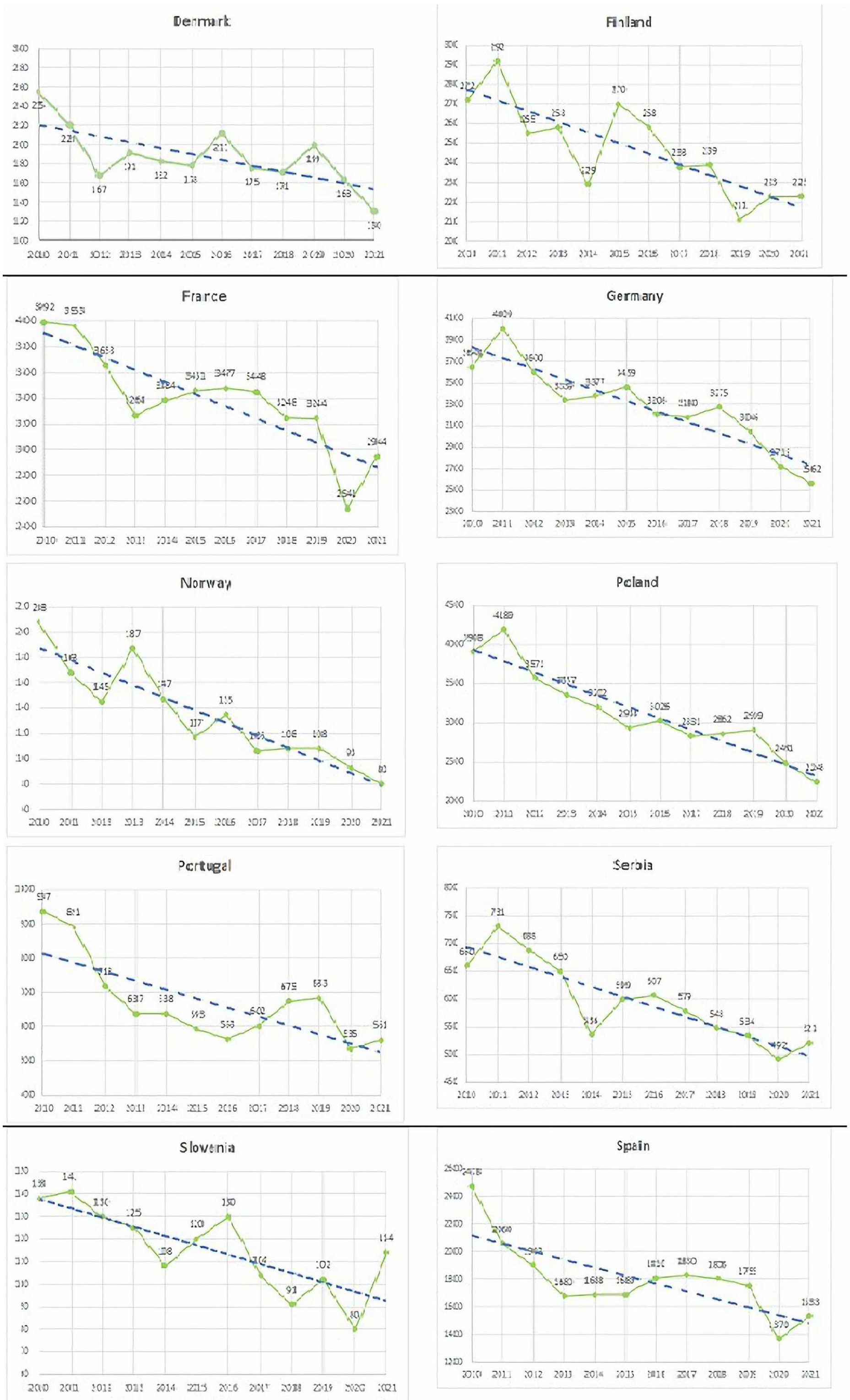


**Figure 10. Road fatalities in selected countries from 2010-2021 (IRTAD, 2022)**

Source: IRTAD road safety annual report, 2022

23. Road Safety Annual Report, 2022, OECD/ITF, 2022, https://www.itf-oecd.org/sites/default/files/docs/irtad-road-safety-annual-report-2022.pdf

Figure 11 shows change in fatalities over the same ten-year period (2010-2021) in South East Asian countries. While some countries like Thailand, Sri Lanka and Myanmar have reported a reduction in fatalities in these ten years, Bangladesh, Nepal and India have reported an increase.

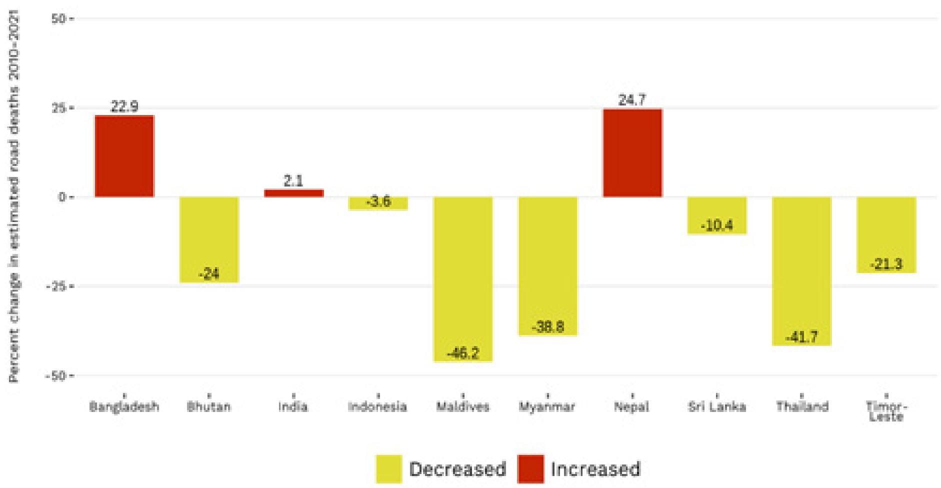


**Figure 11. Percent change in road traffic fatalities in South East Asian countries**

Source: WHO, 2023[24]

# Traffic safety theories

Safety theories to explain the road user/driver behaviour have evolved over the years. R. Elvik et al. (2004)[25] have discussed two important road safety theories that are related to engineering and human behavioural effects. Road safety measures could affect road safety by influencing relevant factors through engineering effect and behavioural adaptation. This suggests that engineering and human behaviour related factors are two important sources of risks. For example, road lighting improves visibility (engineering effect) but road users tend to be less alert (behavioural adaptation). Most factors can be related to either engineering or human behavioural effects. Vehicle related factors can also be explained through engineering effects. For instance compared to cars, large trucks have unique characteristics, most notably high gross weight, long vehicle length, and poor stopping distance, which can be associated with different levels of risk (Chang & Mannering, 1999)[26].

Many other safety theories can be explained based on the engineering and behavioural theories. For instance, drivers can modify their behaviour based on what they see on the road ahead of them (e.g. increasing speed or reducing attention), especially when the lower risk is brought about by a road design countermeasure (Assum, Bjørnskau, Fosser, & Sagberg, 1999[27]. For example, a roundabout breaks the line of sight and the driver reduces speed. This lowers the traffic risk.

24. WHO, 2023. Global status report on road safety. World health Organisation, Geneva.
25. Elvik, R., 2004. To what extent can theory account for the findings of road safety evaluation studies?. Accident Analysis & Prevention, 36(5), pp.841-849.
26. Chang, L.Y. and Mannering, F., 1999. Analysis of injury severity and vehicle occupancy in truck-and non-truck-involved accidents. Accident Analysis & Prevention, 31(5), pp.579-592.
27. Assum, T., Bjørnskau, T., Fosser, S. and Sagberg, F., 1999. Risk compensation—the case of road lighting. Accident Analysis & Prevention, 31(5), pp.545-553.

Physiological theory may be related to both engineering and behavioural theory to some extent. For instance it was suggested that drivers are more likely to fall asleep or feel bored on straight, monotonous, dual carriageway roads with little traffic (Sagberg, 1999)[28]. In this case, drivers changed their behaviour on certain types of roads (e.g. straight and monotonous roads); and on the other hand, road engineers could alter the road environment in order to reduce driver boredom. However, in some cases fatigue or boredom are linked more to the characteristics of the person themselves rather than engineering or behavioural adaption. For instance, it was found that individuals with a higher level of anxiety may be more likely to feel fatigue (Jiang et al., 2003)[29]. In addition, some groups of people (e.g. older people) are inherently more vulnerable than others, thus more likely to be involved in an accident or to be more seriously injured if an accident occurred (Bedard, Guyatt, Stones and Hirdes, 2002)[30].

Safety science has influenced the traffic safety interventions in HICs, primarily leading to the emergence of the Safe Systems approach in The Netherlands and Vision Zero in Sweden.

Vision Zero accepts, as a basic starting point, that human beings make conscious and subconscious mistakes. That is why accidents occur, and the safety work must, in the first instance, be directed at those factors which can prevent accidents leading to death and serious injury. Accidents in themselves are accepted as inevitable, but not their serious consequences, which can be reduced or obviated.

According to Vision Zero, the principal cause as to why people die and are seriously injured is that the energy to which people are exposed in a traffic accident is excessive in relation to the energy that the human frame can withstand. Vision Zero is, among other things, based on the research that the famous American road safety expert William Haddon conducted in the 1960s (Haddon Jr, 1968, 1970, 1973, 1980). Knowledge of energy and tolerance has to a great extent served as a basis for the development of the passive safety characteristics of vehicles and for the development of different protection systems such as child safety seats, helmets, seat belts, etc.

An important consequence of Vision Zero as a general policy for safety work is that the view of knowledge which has served as a basis for the development of a sub-component in the road transport system, namely the vehicle, also has become a general principle for the entire road transport system (Belin, 2016)[31].

According to Vision Zero, it is not the individual road-user who has the ultimate responsibility but rather the so-called system designers. The responsibility for safety is a chain of responsibility that both begins and ends with the system designers (Belin, 2016). The responsibility for safety is thus split between the motorists and the system designers (i.e. infrastructure builders and administrators, the vehicle industry, the haulage sector, taxi companies and all the organizations that use the road transport system professionally). The underlying principles include:

- System designers have ultimate responsibility for the design, upkeep and use of the road transport system, and are thus responsible for the safety level of the entire system.
- Road-users are still responsible for showing consideration, judgment and responsibility in traffic and for following traffic regulations.
- If road users do not fulfil their share of the responsibility, for example due to a lack of knowledge or competence, or if personal injuries occur or for other reasons that lead to risk, the system designers must take further measures to prevent people from being killed or seriously injured.

28. Sagberg, F., 1999. Road accidents caused by drivers falling asleep. Accident analysis & prevention, 31(6), pp.639-649.

29. Jiang, N., Sato, T., Hara, T., Takedomi, Y., Ozaki, I., & Yamada, S. (2003). Correlations between trait anxiety, personality and fatigue: study based on the Temperament and Character Inventory. Journal of psychosomatic research, 55(6), 493-500.

30. Bedard, M., Guyatt, G.H., Stones, M.J. and Hirdes, J.P., 2002. The independent contribution of driver, crash, and vehicle characteristics to driver fatalities. Accident Analysis & Prevention, 34(6), pp.717-727.

31. Belin, M.A., 2016. Vision zero as a new way of thinking. Journal of the Australasian College of Road Safety, 27(3), pp.60-62.

The Safe Systems approach of The Netherlands is based on similar principles as Vision Zero. It is noted in Fred Wegman (2017)[32] that

> "There are two good reasons why the traditional approach (working on reducing spikes in distributions) will become less effective and efficient in countries with mature road safety policies. The first reason lies in the fact that serious road crashes will occur as long as we leave the inherent unsafe conditions in road traffic untouched: the inherent risks come from a combination of the physical vulnerability of the human body and the levels of kinetic energy in crashes (a combination of speed and mass). These inherent risks also stem from the fact that the road transport system cannot be designed from the perspective of the human being as long as it fails to defend against human errors and offenses that can result in crashes".

Further, Wegman compares road safety situation with rail and aviation sectors and notes that

> "...It is remarkable that, while the road transport system puts its faith in individual driving skills, the rail system and the aviation system are designed from a safety perspective—and even well-trained professionals like train drivers and airplane pilots are only allowed to operate under rather strict conditions".

The known interventions about speed control, vehicle design, and road designs dealing with reducing relatively high risks, have become less effective in bringing in the desirable reduction in road risks. A paradigm shift in policies and frameworks addressing traffic risk is therefore required. A strong case must be made for adopting Vision Zero principles and the Safe Systems approach.

Road safety policies around the globe have adopted the Safe Systems approach, which emphasizes that all systems, including road infrastructure, vehicle design, trauma centres, institutions and legislations, have to become safer. If one part of the safety system fails–for example driver makes mistake and goes off the carriageway–the crash barrier should ensure that the vehicle is contained and the people involved do not get serious injuries. This is an example of a forgiving road infrastructure.

Managing speeds of vehicular traffic by making appropriate designs is the most effective intervention for creating safe roads. Road designs must be self-explaining, to guide the driver, and forgiving, to reduce the severity in case of driver error.

Important risk factors, and the interventions which have been successful in addressing these factors, are discussed in the following section.

# Risk Factors and Successful Interventions

There is a broad range of factors affecting road traffic crashes. These factors are usually related to traffic and road characteristics, drivers and other road users, vehicles, and environment. Traffic characteristics (such as traffic flow and speed) and road characteristics (such as road geometry and the quality of infrastructure) might affect road accidents. Factors which seem to have a strong correlation with traffic crashes are discussed below.

32. Wegman, F., 2017. The future of road safety: A worldwide perspective. IATSS research, 40(2), pp.66-71.

# Road characteristics

Engineering theory suggests that road designs - lane width, shoulder presence, number of lanes, median design - influence driving behaviour (operating speeds, lane changes etc.) Therefore, roads themselves play an important role in road safety, and improved geometry design and infrastructure could in turn help to improve road safety. Choice of different operating speeds depending on the context shows that safety is an important goal in highway design (Lamm, Psarianos, & Mailaender, 1999)[33]. Road design standards of lane width, shoulder width, and horizontal and vertical curves, are related to the design vehicle and design speed. Speed itself is the most important risk factor contributing to the number and severity of road crashes.

# Speed

Speed affects road accidents both in terms of accident occurrence and severity (R. Elvik, Peter Christensen, & Astrid Amundsen, 2004)[34]. It seems reasonably safe to assume that increased speed would mean that the accidents that have occurred would be more severe if other factors (e.g., environment and vehicle design) remain the same.  Figure 12 shows the impact of speed and risk of fatalities.[35]

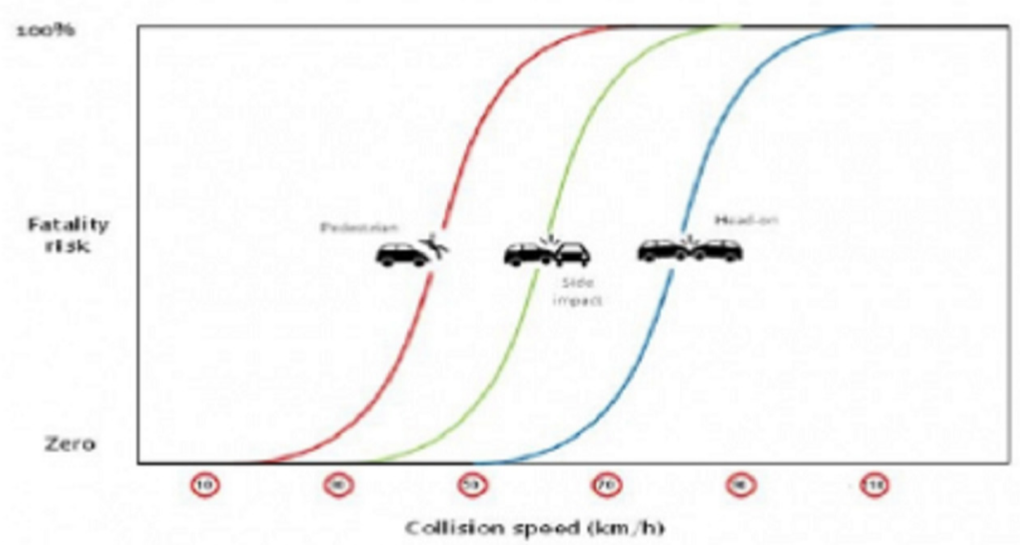


**Figure 12. Impact speed and risk of fatalities**

Source: Based on data from 'Towards Safe System Infrastructure. A Compendium of Current Knowledge', Austroads, AP-R560-18, March 2018, pp.37-9.

33. Lamm, R., Psarianos, B. and Mailaender, T., 1999. Highway design and traffic safety engineering handbook.

34. Elvik, R., Christensen, P., & Amundsen, A. (2004). Speed and road accidents. An evaluation of the Power Model. TØI report, 740, 2004.

35. World Bank Group, Guide for Safe Speeds: Managing Traffic Speeds to Save Lives and Improve Livability. 2024. http://documents.worldbank.org/curated/en/099032224020526401/P175107129f9b401c19e411b9abd824cfd7

A large number of studies have shown the impact of speed both by applying fundamental principles of physics and by analysing empirical data (Ezra Hauer, 2009;[36] Kockelman & Kweon[37], 2002; O'Donnell & Connor, 1996; Shankar, Mannering, & Barfield, 1996). Most studies suggest that increased speed is associated with more accidents or higher accident rates (Aarts & van Schagen, 2006; Rune Elvik, Peter Christensen, & Astrid Amundsen, 2004; Nilsson, 2004; Taylor, Baruya, & Kennedy, 2002). Figure 13 shows that small changes in speed result in large changes in crashes and fatalities[38].

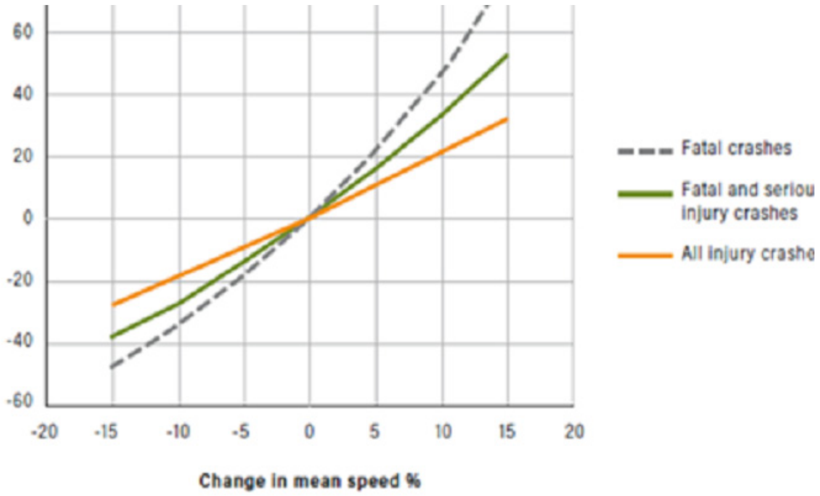


**Figure 13. Relationship between Speed and Fatalities**

Source: Austroads, 2018

Safe speeds on the highway must be ensured by adopting the right design of various geometric features. These include lane width, shoulder width, roadside barriers and median design. These standards are specified in different IRC codes. IRC codes are updated from time to time based on new guidelines and standards published in other countries. The list of relevant IRC codes is given in the Appendix. New guidelines and best practice manuals published by the World Bank and the World Health Organisation (WHO) can guide the road designs of Indian roads. Recommendations for lane width, shoulder widths and clear zones are given in Tables 7 and 8.

**Lane width**: For lower speeds(50km/h), lane width can be 3 m. For higher speeds, lane width can increase to 3.5 m for speeds up to 80 km/h and to 3.75 m for speeds more than 80 Km/h. Lane widths for different roads are specified in IRC SP 33, IRC SP 84, IRC SP 87 and IRC SP 99.

**Table 7. Traffic Lane width for different classes of roads**

| **Primary Class** | **Class I** | **Class II** | **Class III** |
|---|---|---|---|
| 3.5m | 3.5m | 3.5m | 3.25m (3.0m) |
| Traffic lanes should be widened on horizontal curves with radii smaller than 250m to take into account the swept path of long vehicles. | | | |

36. Hauer, E. (2009). Speed and safety. Transportation Research Record: Journal of the Transportation Research Board(2103), pp.10-17
37. Kockelman, K. M., & Kweon, Y.-J. (2002). Driver injury severity: an application of ordered probit models. Accident Analysis & Prevention, 34(3), pp.313-21
38. WHO, Speed Management Manual. 2023. https://cdn.who.int/media/docs/default-source/documents/health-topics/road-traffic-injuries/speed-management-manual.pdf

**Shoulder width/clear Zone**: Rural roads have shoulders, the area beyond the travel carriageway that provides space for emergency maneuvers and break down vehicles. The shoulder width ensures that if a vehicle leaves the carriageway in case of emergency, there should be enough clear space for the vehicle to stop safely without hitting any object. Roads with higher design speed will require wider shoulders. Shoulder/clear zone width may range from 2 m in case of speeds below 50km/h to 10m for 120km/h speed.

**Table 8. Clear Zone widths for different design speed and traffic volumes**

| Traffic Volume | Speed Limit | | | |
|---|---|---|---|---|
| | **50 km/h[39]** | **60 km/h[40]** | **70-80 km/h** | **>/=90 km/h** |
| 0 – 1500 | 2.5m | 3m | 5m | 6m |
| 1500 – 4000 | 3m | 4m | 6m | 7m#[41] |
| 4000 – 12000[42] | 4m | 5m | 7m# | 8m# |
| >12000 | 5m | 6m | 8m# | 10m# |

Figure 14 illustrates clear zone and paved shoulder requirements, and their carriageway placement. Clear zone requirements have not been specified in IRC SP 73, 84 and 87, whereas IRC SP 99 specifies clear zone requirements on expressways. The shoulder widths specified in IRC codes are less than the clear zone requirements. This increases the risk of hitting a roadside pole or tree in case of vehicle leaving the carriageway in an emergency manoeuvre.

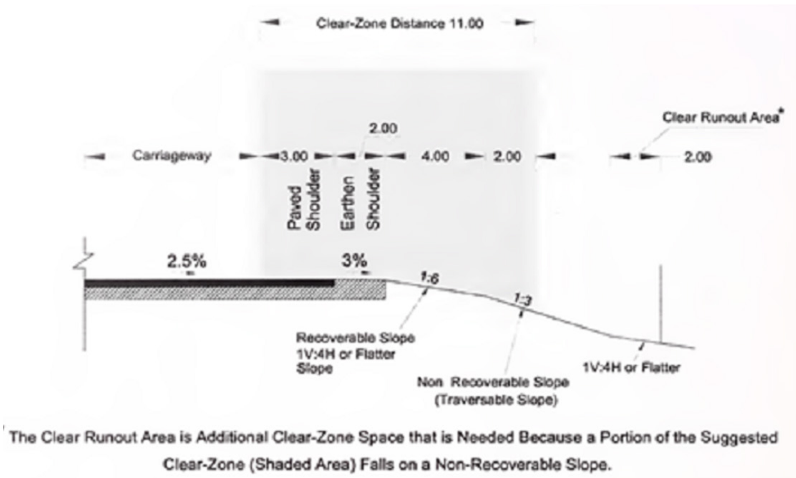


**Figure 14. Clear Zone widths on plain and sloped areas.**

Source: IRC:SP:99-2013

39. Not including urbanised section
40. Lower values are acceptable on tree-lined boulevards
41. # Minimum value of 6m may be acceptable for non-access-controlled roads where provision of the full value is not feasible
42. Traffic volume of 4000-12000 veh/day may be assumed for new and existing roads with no data

**Roadside barriers**: A roadside barrier is installed to ensure that in case of a vehicle leaving the carriageway and insufficient space being available to ensure safe stopping, the errant vehicle can be contained without causing serious injury to the occupant(s). Road-side barriers can be rigid, semi-rigid and flexible. Design of the barrier ensures that the vehicle is directed to the carriage way in case of rigid barrier, and impact energy is dissipated in case of a semi-rigid and flexible barrier. The height of the barrier should ensure that the impacting vehicle does not overturn. The design, height and method of installation of different types of barriers have to be as per specifications, otherwise the barrier itself becomes a hazard for the vehicles. IRC 119 specifies roadside barrier designs and installation details.

**Median design**: Medians in high-speed roads are designed to avoid collisions between vehicles coming from opposite directions. Median barriers are designed to reduce the risk of an errant vehicle colliding with a vehicle travelling in the opposite direction and deflecting the vehicle back into the traffic stream travelling in the same direction or decelerating beyond tolerable occupant limits.

The median must be depressed or flush. As a rule, a depressed median should be provided, except in situations where the availability of ROW is a constraint. An edge strip of 0.75 m width of depressed median adjacent to the carriageway in either direction should be paved as per the same specifications as the adjoining carriageway.

Currently, a median barrier is recommended on all access-controlled, multilane highways with posted speeds greater than 70km/h if the median is less than 15 m wide.

In general, barrier curbs are not desirable for use on freeways and other high-speed roadways. An out-of-control vehicle may overturn or become airborne because of impacting the curb. Curbs are not adequate to prevent a vehicle from leaving the roadway. Curbs are not suitable for use in front of traffic barriers because they can result in unpredictable post-impact trajectories (AASHTO, 1994). Median designs are specified in IRC SP 99 for expressways, IRC SP 87 for six-lane roads and IRC SP 84 for four-lane roads. Height of the median is not specified. MoRTH has issued a circular in January 2020 (see Appendix 2) warning against constructing high medians on highways.

## Roadside Kerbs

Kerbs are not recommended outside built-up areas where traffic speeds exceed 70km/h, as they could cause an errant vehicle to jump or roll over. If kerbs are necessary for drainage purpose, mountable or semi-mountable design should be adopted. Within built-up areas where traffic speed is constrained, it is preferable to adopt near vertical kerbs for footpaths. Table 9 provides guidance on the shapes and dimensions of kerbs. Specifications for kerb designs are not available in the IRC codes.

**Table 9. Recommended Kerb parameters**

| Location | Main Purpose | Shape | Height | |
|---|---|---|---|---|
| Outside built-up areas | Drainage | =/<45$^0$ | 75mm | 100mm |
| Within built-up areas | Footpath and drainage | Near Vertical | 100mm – 125mm | 150mm |

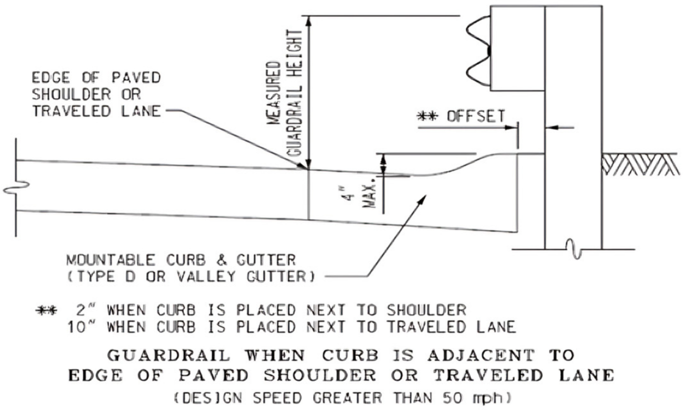


**Figure 15. Guard Rail with mountable kerb**

Source: mdotcf.state.mi.us/public/design/files/englishroadmanual/erdm07.pdf

# Road Markings and signage

Road markings and signages are important to inform the road user. The Convention on Road Signs and Signals, commonly known as the Vienna Convention on Road Signs and Signals (VCRSS), is a multilateral treaty signed in 1968 to standardize the signage system for road traffic (road signs, traffic lights and road markings) in use internationally. Both the Vienna Convention and the earlier Geneva Convention on Road Traffic, 1949, were formed according to the consensus on road traffic signs that evolved in post-World War II continental Western Europe. In order to make it as universal as possible, the VCRSS allows some variations, for example danger warning signs can be triangular or diamond in shape and road markings can be white or yellow. While most UN members, including India, have not ratified the full treaty, the signs and legal principles enshrined in it form the basis of traffic law in a majority of the countries. IRC 67 recommends signage for different situations mostly following VCRSS and IRC 35 recommends road markings following VCRSS.

IRC codes and manuals are expected to guide the site engineers for implementing appropriate designs, signage and markings on the road to ensure safety. The first major problem is non-compliance of current IRC standards in existing roads. MoRTH has issued several circulars[43] with instructions on how the codes have to be followed, how to monitor rectification of Black Spots, process of safety audits, implementation of appropriate signage, markings etc. However, non-compliance of shoulder widths, clear zones, appropriate installation of guard rails, median heights, lack of speed control devises, non-standard signage and markings have been documented in audit reports prepared for the Supreme Court Committee on road safety for twenty states[44]. Similar observations are documented in all audit reports prepared by TRIP Centre as part of the annual road safety training workshop. Other audit reports may have noted the same issues but are not publicly available.

A significant problem is the inadequacy of the IRC codes. The process of updating the code is slow and many details become obsolete with new findings. Many important details are missing, especially related to road safety. The codes are not based on new research from Indian locations because there is no established process for sponsoring studies to evaluate the performance of current standards and update the codes on the basis of primary data from Indian cases. Appropriate processes must be created both for ensuring the compliance of current standards with the IRC codes, evaluating the performance of current standards, and updating codes more frequently based on robust evaluations.

43. https://morth.nic.in/technical_circulars?page=25

44. Consulting Services to Audit the implementation by the States of the directions Issued by the Supreme Court Committee On Road Safety, State reports, 2018-2024, prepared by DIMTS and TRIPC.

# 4. Contractual provisions/ practices for safety

Public highway authorities typically have a duty to maintain their roads and powers to improve them. In principle, the owner/operator of a highway may be held liable for crashes in which a hazardous road environment may be attributed to unsafe road design, deviation from statutory standards, non-implementation of safety systems, or poor maintenance – any of which can result in hazardous road environments. Globally, as pointed out by Forman (2000),[45] claims for vehicular damage and personal injury against those bodies responsible for infrastructure typically focus on:

- policies (design, maintenance and improvement);
- systems (structuring and balancing policy priorities); and
- practice (putting systems into effect).

The underlying liability principles remain similar irrespective of whether road infrastructure responsibilities lie with a public agency or a private entity. The share of the burden of liability can be fixed based on contractual relationships. Even when not mentioned explicitly in contract provisions, road safety can be addressed through provisions relating to design, engineering, construction, and construction quality control.

In most common law jurisdictions such as India, tort liability for road system defects does not hinge only on whether an authority breaches its statutory duty. Claimants can also base their actions on negligence by the authority or indeed nuisance.[46] Unfortunately, courts in India have been reluctant to hold public authorities liable for loss or harm suffered by crash victims because of the public authority's actions, or failure to act in providing safe road conditions.

The safety provisions in the standard contracts of the CPWD, DMRC, NHAI and various state PWDs cover construction zone and construction personnel safety, but, except for NHAI's Standard Engineering, Procurement and Construction (EPC) Agreement, the standard contracts do not provide for post-construction road safety.[47, 48, 49] The NHAI's Standard EPC Agreement requires the contractor to "appoint a safety consultant to carry out a safety audit at the design stage of the Project Highway in accordance with the Applicable Laws and Good Industry Practice"[50] and requires that "[t]he recommendations of the Safety Consultant shall be incorporated in the design of the Project Highway."[51]

45. Forman, P.E. (2000). Managing risks and liabilities in the highways and transport sector. IATSS Research 24(2): pp.28-33
46. Ibid.
47. DMRC (2020) Conditions of contract on Safety and Health for Property Business (PB) contracts.
48. CPWD (2022). Standard Operating Procedures for CPWD Works Manual – 2019.
49. MoRTH (2019). Standard EPC Agreement for National Highways and Centrally Sponsored Road works proposed to be implemented on Engineering Procurement and Construction (EPC) mode of Contract.
50. Ibid. § 10.1 (v)
51. Ibid. § 10.1 (vi)

Public Private Partnerships (PPP) have become common in providing high-quality infrastructure in many countries worldwide, including in India. From 1990 to 2015, governments around the world awarded more than 950 PPP road projects with a total investment of US$ 267 billion.[52] The Ministry of Road Transport and Highways (MoRTH) in India has awarded 68 road projects under the PPP model for a total amount of Rs. 14,122 crore (US$ 1.7 billion).[53]

While Public Private Partnership can take a number of forms, the common and popular ones that have been used for the development of National Highways in India are Build Operate and Transfer (BOT) Toll basis, Build Operate and Transfer (BOT) Annuity basis, and Special Purpose Vehicle (SPV) basis. Regardless of the specific form of the PPP, policymakers argue that road projects developed through PPPs will have better safety outcomes because these projects typically involve upgrading the quality of the roads to improve safety.[54]

Even when not mentioned explicitly in contract provisions, road safety can be addressed through provisions relating to design, engineering, construction and construction quality control. One relatively new tool for this is §198A of the amended Motor Vehicles Act.[55] Section 198A imposes liability for defects:

> [If] "the designated authority, contractor, consultant or concessionaire responsible … [for the design or construction or maintenance of the safety standards of the road, fails] to comply with standards for road design, construction and maintenance [as may be prescribed by the Central Government from time to time, and this failure] results in death or disability, such authority or contractor or concessionaire shall be punishable with a fine which may extend to one lakh rupees … ."

A search of legal databases shows that this provision has not been litigated in any court in India to date. The only mention of §198A in legal proceedings has been in a series of cases in the High Court of Kerala, where the court has invoked this provision to direct the state and local municipal authorities to ensure that pedestrian facilities are kept free of encroachments and otherwise maintained to ensure the safety of pedestrians,[56, 57] and to require highway alignment modifications around religious structures to ensure pedestrian access and safety.[58]

Even if Section §198A does get invoked in legal proceedings, it is unlikely to result in a conviction or fines because of the egregious burden of proof imposed by sub-section (3) of §198A. A designated authority, contractor, consultant or concessionaire may be held responsible for unsafe road design/construction/maintenance resulting in the death or disability of a user but the fine of one lakh rupees is a miniscule amount when compared to the roadway construction costs—about 10 to 15 crore per km to build a four-lane highway and 15 to 20 crore per km for a six-lane highway.

52. The World Bank database.
53. https://morth.nic.in/public-private-participation-ppp
54. Albalate, D., and Bel-Pinana, P. (2019). The effects of public private partnerships on road safety outcomes. Accident Analysis and Prevention, 128, pp.53-64
55. Motor Vehicles (Amendment) Act, 2019
56. Suo Motu vs State of Kerala. 3 February, 2023.
57. H.H. Gouri Parvathi Bayi vs Travancore Devaswom Board. 29 August, 2022.
58. Narayanankutty K vs The Special Devaswom Commissioner. 14 July, 2023.

# Current Status of Existing Contractual Provisions for Road Safety

Although there are provisions in contract agreements for the design/construction/maintenance of highways to meet road safety standards, there are serious implementation issues. Recognizing this, in early 2023, MoRTH laid out a Road Safety Action Plan[59] calling for six interventions to be undertaken by all road owning agencies: (a) Road Safety Audit (RSA) of all NH; (b) development of five stretches of NH as Model Safe Roads in each region; (c) development of five project stretches as Model Safe Construction Zones; (d) a web-based portal/application for monitoring all activities related to RSA; (e) designations of an officer as Road Safety Officer (RSO) under each Regional Officer (RO); and (f) mandatory RSA Certification training for all technical officers of Road Wing, NHAI and NHIDCL up to Superintending Engineer level. As of May 20, 2024, no status update on implementation of these interventions is available from the MoRTH or NHAI websites.

# Recommendations for Contractual Provisions for Enhancing Road Safety

All highway design and construction contracts must include a requirement similar to that in the Standard EPC Agreement of NHAI to "appoint a safety consultant to carry out a safety audit at the design stage of the Project Highway in accordance with the Applicable Laws and Good Industry Practice[,]"[60] and also require that "[t]he recommendations of the Safety Consultant … be incorporated in the design of the Project Highway."[61]

It is crucial that each highway-owning authority develop robust inspection and rectification regimes to be able to identify and rectify road defects on their network. As usage of some highways can deviate significantly from design stage assumptions, O&M contracts must include inspection requirements to identify and rectify defects that 'evolve' over time. This also necessitates that contractual provisions be developed to allow the design and construction of innovative safety elements that may deviate from IRC standards.

Global experience in O&M and PPP contracts shows that including performance-based criteria for road management and maintenance, coupled with well-defined service quality criteria, results in improvement in road safety. Performance standards should define the minimum conditions of the road system, as well as the management and operation of the assets during the entire contract period, leaving it to the contractor as to how to achieve them, as long as they meet the performance standards during the contract period.[62, 63]

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59. MoRTH (2023) Road Safety Action Plan for road engineering interventions on National Highways. Office Memorandum dated 13 Jan 2023.
60. MoRTH (2019). Standard EPC Agreement for National Highways and Centrally Sponsored Road works proposed to be implemented on Engineering Procurement and Construction (EPC) mode of Contract. § 10.1 (v)
61. Ibid. § 10.1.(vi)
62. Zietlow, G. (2007). Performance-Based Road Management and Maintenance Contracts –Worldwide Experiences. International Seminar on Road Financing and Investment. Arusha, Tanzania, April 16-20, 2007.
63. Rangel, T., and Manuel Vassallo, J. (2015). Modeling the effect of contractual incentives on road safety performance. Transport Policy 40(x): pp.17-23.

# Professional Liability

Although contractual provisions are legally binding, professional liability of the engineers and contractors involved in the design and construction must also be in play. Protection of health, safety and welfare of road users must be the highest priority for the public entity which owns the road. As such, there needs to be a push to hold design and construction professionals liable for gross negligence or wilful misconduct. Engineers, construction quality inspectors and safety auditors must also be held liable for any personal injury, wrongful death, or property damage caused by poor or negligent design, poor construction quality, or poor operational safety of a road.

The following is a tentative responsibility matrix based on California's "Designing for Safety" approach:

| **Action** | **Responsibility** | **Institutional/Regulatory Change Needed** |
|---|---|---|
| Training to support implementation of Safe System Approach directed at the project development teams. | Road owning agencies (ROA)– NHAI and various state PWDs | None |
| Enhance the Safety Review process to incorporate the Safe System Approach in project road safety design decision process | Designer & Contractor, with oversight from highway owning agency | Existing regulations need implementation, ROAs need to set up internal mechanisms. |
| Develop project-level communication plans to promote road safety enhancements and improvements in partnership with relevant stakeholders | Officer responsible for the project (Regional officer in case of NHAI) | Create position of in-house Safety Officer with appropriate authority. |
| Improve guidelines for conducting Safety Reviews scope and content throughout Project Delivery (including Bridge Design process & procedures) | Road owning agencies, contractor and construction quality control consultants. | Agencies need to modify the safety audit process to make it a continuous safety review and monitoring process. |
| Develop a template for a formal Safety Review report | Road owning agencies | None |
| Develop criteria for the composition of independent multi-disciplinary Safety Review teams | Road owning agencies | None |
| Develop guidelines for Safety Review applications to appropriate projects | Road owning agencies | None |
| Improve requirements for team member qualifications for Safety Reviews | Road owning agencies | None |
| Update Safety Review procedures | Road owning agencies | None |

# 5. Way Forward for Indian Highways

Indian Roads Congress (IRC) has issued various guidelines and codes of practice for guiding the field engineers. A list of most relevant codes for ensuring road safety is placed in the Annexure. The application of IRC codes should be based on the principles of the Safe Systems approach:

- Principle 1: Recognition of human frailty
- Principle 2: Acceptance of human error
- Principle 3: Creation of a forgiving environment and appropriate crash energy management

Current highway standards for geometric design of highways can be reviewed in the context of these three basic principles. Principle 1 and 2 must recognize that highways in India will have presence of non-motorized vehicles and pedestrians along with motorized traffic. Principle 3 becomes the operational principle for setting appropriate speed limits for ensuring a forgiving environment for all road users. Pedestrians can make mistakes in judging the possible risk in the system and drivers can make mistakes in adopting an appropriate speed.

The design speed governs the design of the horizontal curve, the vertical curve and the safe stopping distance. Several researchers have questioned the conventional practice of keeping design speed higher than operational speed. The design speed must be in line with the requirement of Principle 3, i.e. "Creation of a forgiving environment and appropriate crash energy management". This implies that for setting appropriate design speed, presence of NMVs, presence of activities along the highway, density of built-up area along the highway, and frequency of towns and villages through which the highway passes, must be taken into consideration. Design speed may vary from 30 km/h to 90 km/h with a broad cross-section designed for appropriate crash energy management depending on the surrounding land use along the highway. Design speed of a highway should be based on the understanding of the risk faced by various road users and the function of the road. The current guidance in IRC code mentions only the terrain conditions (plain, rolling, mountainous) for recommending different speeds.

Taking lessons from several studies conducted in the HICs, the most effective measure for speed compliance in India will be through design of active speed control measures. In the context of weak institutional capacity and weak enforcement of legislation, the design of speed control measures – texture change, audible markers, rumble strips, change in geometric standards, median designs, lowering speeds at intersections by introducing roundabouts, raised stop lines and speed humps on minor roads – is likely to be more successful in ensuring speed compliance by all road users, including good drivers, bad drivers, young drivers, knowledgeable drivers, drivers with poor driving education etc. This would ensure compliance with Principle 2.

Many of the current standards for designing the highway cross-section need to be revised (H. Chen & L. Meuleners, 2011; Mohan et al., 2017) in order to comply with Principle 3. Appropriate design of service roads, width of shoulders, and design of medians have to be reviewed to ensure safe designs for NMVs and different kinds of vehicles on the road.

The experience of the HICs shows that standards alone cannot ensure safe roads for all unless the safety performance is evaluated. Vision Zero accepts that it is possible to design a transport system that will not have any deaths and serious injuries. Therefore, to ensure safe highways in LMICs like India, the realization of Vision Zero also requires generation of new knowledge and establishing a process which enables generation of new knowledge. Given the complexity of traffic safety science and its implementation in the field, continuous experimentation is required in LMICs to develop safe highways based on the principles of the Safe Systems approach.

# Recommendations for different road categories:

### Highway safety on different category of roads requires:

1. Identification of non-compliance of road geometry, speed management and roadside hazard management as per the current IRC standards, Action Plan for safety audits, and identification of gaps in the current contract documents with respect to safety compliance.
2. Action plan to ensure compliance of road geometry, speed management and roadside hazard management as per the current IRC standards and Action Plan for implementing and monitoring audit observations.
3. Developing new standards for specific problems where IRC or global standards are not available, documentation of the evaluation of current standards and discussion with IRC committees for developing evidence base standards.
4. Institutional setup: safety section/cell in MoRTH/NHAI/State PWD with permanent trained staff to deliver actions mentioned in 1, 2, and 3 above. The current setup in MoRTH, NHAI and state PWD with very few professional staff and expertise is insufficient to cope up with the magnitude of work. A detailed proposal needs to be developed for institutional restructuring in each organisation.

# Specific recommendations for National Highways, State Highways, District roads, Expressways

Specific recommendations which can be implemented in the current institutional set up in less than 2 years are suggested as short term recommendations. Medium term recommendations are suggested requiring identification of specific research studies and funding for the same. This can be implemented in less than four years. Long term measures will require new institutional set up and may be implemented in less than six years.

# National Highways

NHAI is responsible for planning, building and maintaining the NH network. MoRTH and IRC have issued guidelines and codes for NH, however, NHAI does not have a systematic process of periodical audit, evaluation of various design features and review of current guidelines. NHAI has created a central electronic database—called the Data Lake—which has promise to be a comprehensive data base of highway design features, traffic crashes and traffic volume. The Data Lake can become a reliable data repository which can be used for continuous evaluation of various interventions and impact of geometric features on safety.

**Short Term:** Comprehensive audit of all highways, prioritising highway segments with high crash rates, and preparation of an implementation plan for five years.

i. NHAI already mandates design stage, construction stage, pre-opening, and operation level audits. However, the filed observations show major noncompliance of the current standards. A plan is required to implement speed control in segments passing through habitation with the help of traffic calming as per the recommendations in IRC 99-2018 (Traffic Calming) within a stipulated time period. At grade highway segments passing through habitation should be treated like an urban road, with a maximum speed of 50 km/h and provided with service roads. Where service roads are not feasible, speeds must be restricted to 30 km/h. Rectification of crash barrier installation and median design rectification may be taken up as priority areas on divided highways.

ii. MoRTH has initiated a program of black spot (BS) identification and rectification since 2015 where road owning agencies are required to identify black spots and take remedial measures. Status of BS rectifications by different road owning agencies is available on https://www.blackspot.morth.gov.in/auth/users/login.cshtml. A detailed evaluation of interventions implemented under this program is required to understand the effectiveness of this program. This would guide the future BS rectification scheme.

iii. Advance information to drivers can be provided about the hazardous road conditions or presence of habitation, which requires drivers to reduce speed. This includes both static and dynamic hazardous. Drivers are warned about the fixed hazards such as sharp curve, low bridges, low speed zone ahead and transient conditions like construction ahead, presence of pedestrians, stalled vehicles etc. Advance warning through appropriate signage and electronic messaging can give enough time to drivers to take corrective measures.

**Medium Term:** Initiate research studies to understand specific problems of Indian highways.

Focus on aspects such as impact of various geometric features (lane width, median, shoulder width) on MTW crashes. Activate the Data Lake for sharing data with researchers and prepare dashboards for monitoring safety in each state. Contracts must also be revised to ensure implementation of safety standards during the design, construction and operation of highways.

**Long Term:** Establish a safety cell/section with trained professionals to initiate research studies, fund research and establish reliable database for crashes on highways.

Train safety professionals who can monitor Impact assessment of various geometric features and Revision of highway design standards.

# State Highways

State Public Works Departments are responsible for planning, building and maintaining state highways.

**Short Term:** Annual action plan to implement audit recommendations on high crash corridors initially extending to all corridors.

Revision of speed limits on SH based on surrounding land use and activities. Special attention to speed compliance by design. i.e. traffic calming measures near junctions, public transport stops. Prepare templates to be used in each district for ensuring safety near junctions, public transport stops.

**Medium Term:** Initiate revision of IRC codes, develop detailed process guidance for field engineers and revise the contractual Terms of Reference to ensure better compliance.

**Long Term:** Establish a safety cell/section with trained professionals to initiate research studies, fund research and establish reliable database for crashes on highways.

Train safety professionals who can monitor the impact assessment of various geometric features and revision of highway standards. Revise contracts to ensure compliance with various safety guidelines. Initiate research to study the impact on safety of service road sections in habitations.

# MDR/ODR

Major district road (MDR) and other district roads (ODR) form the secondary road system in State. These are maintained by the state Public Works Departments.

**Short Term:** Annual action plan to implement audit recommendations on high crash corridors initially extending to all corridors.

Revision of speed limits on MDR/ODR based on surrounding land use and activities. Special attention to speed compliance by design. i.e. traffic calming measures near junctions, public transport stops. Prepare templates to be used in each district for ensuring safety near junctions, public transport stops,

**Medium Term:** Initiate revision of IRC codes and develop detailed process guidance for field engineers.

Prepare specific templates for MDR joining SH, NH, MDR joining ODR etc.

**Long Term:** Establish a safety cell/section within PWD for monitoring MDR/ODR with trained professionals to initiate research studies, fund research and establish reliable database for crashes on highways.

Train the safety professionals to monitor Impact assessment of various geometric features and revision of highway standards. Revise contracts to ensure implementation of various safety guideline compliance. Initiate research studies on impact of alternate texture, shoulder design, new markings on safety,

# Limited Access Expressways

India has a total length of 5173 km of expressways. These are controlled access highways where entrance and exits are controlled by the use of clover leaf, trumpet or grade separated interchanges. These expressways are designed for 120 km/h speed limits. Mumbai Pune Expressway is the first 6-lane operational expressway in India started in 2002. Expressways follow standards set by Indian Roads Congress.

**Short Term:** Ensure compliance of current guidelines (crash barrier installation, median designs, implementation of audit recommendations, speed management near exit and entry ramps).

**Medium Term:** Study the impact of speed cameras, alternate median and shoulder designs, and new problems such as locations where pedestrians are present, bus stop locations, frequency of rest areas and monitoring of IPT activities at the entry exit ramps.

**Long Term:** Establish a safety cell/section with trained professionals to initiate research studies, fund research and establish reliable database for crashes on highways.

Train the safety professionals to monitor impact assessment of various geometric features and revision of expressway standards to ensure safe bus stop locations, safety near entry and exit ramps, and MTW lanes. Revision of contracts to ensure implementation of various safety guideline compliance.

To conclude, this paper highlights actions that can be undertaken by the highway owning and operating agencies (NHAI, MoRTH, state Public Works Departments). Unlike many countries, road deaths have continued to increase in India. The major investments in upgrading the highway network in India offers an opportunity and responsibility to road owning agencies for ensuring a safe highway network. The study of historical trends and road safety interventions in countries where road deaths have reduced has highlighted the need for evidence-based interventions. Implementation of road designs that can prevent severe crashes despite errors and mistakes by road users must be prioritized. Compliance of current IRC standards have to be ensured by including new provisions in contract documents. Process of continuous monitoring and evaluation has to be established for updating current standards and proposing new standards. Use of big data and information technology can be utilized both for providing advance information about possible hazards to the driver and a robust data base of scientific evaluations of the interventions implemented by the road owning agencies.

# Annexure: List of Relevant IRC Codes

| S. No. | IRC Code | Description |
|---|---|---|
| 1 | IRC:35-2015 | Code of Practice for Road Markings |
| 2 | IRC:65-2017 | Guidelines for Planning and Design of Roundabouts (First Revision) |
| 3 | IRC:67-2022 | Code of Practice for Road Signs |
| 4 | IRC:79-2019 | Recommended Practice for Road Delineators |
| 5 | IRC:80-2022 | Type Designs for Pick-up Bus Stops on Rural Highways(non urban Highways) |
| 6 | IRC:99-2018 | Guidelines for Traffic Calming Measures in Urban and Rural Areas (First Revision) |
| 7 | IRC:119-2015 | Guidelines for Traffic Safety Barriers |
| 8 | IRC:131-2022 | Identifying and Treating Blackspots |
| 9 | IRC:SP:041-1994 | Guidelines for the Design of At-Grade Intersections in Rural and Urban Areas |
| 10 | IRC:SP:44-1996 | Highway Safety Code |
| 11 | IRC:SP:55-2014 | Guidelines on Traffic Management in Work Zones” (First Revision) |
| 12 | IRC:SP:73-2015 | Manual for Specifications and standards for two laning of highways with paved shoulder |
| 13 | IRC:SP:84-2014 | Manual for Specifications and standards for four laning of highways with paved shoulder |
| 14 | IRC:SP:87-2013 | Manual of Specifications & Standards for Six laning of Highways Through Public Private Partnership |
| 15 | IRC:SP:88-2010 | Road Safety Audit Manual |
| 16 | IRC:SP:99-2013 | Manual for Specifications and Standards for Expressways |