

ENGINEERING DESIGN STANDARDS TO ENSURE ROAD SAFETY: EXPERIENCES FROM INDIA

Atul Kumar¹

ABSTRACT

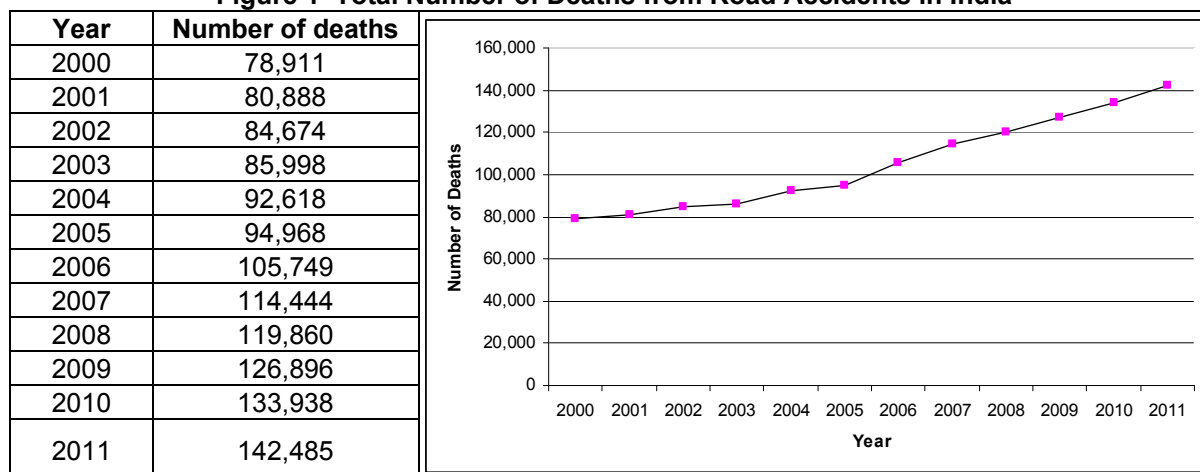
The primary goal of designing roads with adequate standards is to achieve a safer transport facility for both motorized and non-motorized road users. However, the responsibility of road safety has traditionally been placed on the individual road user rather than on the designers of the system. Thus in practice, the upgrading of roads results in increasing accident rates, despite attempts by engineers to follow the appropriate standards.

Drawing on experiences from India, this article deals with the key aspects of the causes of road accidents from the viewpoint of design standards. It highlights best practices from the aspect of design, which if applied can help to reduce road accidents and fatalities. The design aspects dealt with in this article looks especially at the eradication of road injuries for non-motorized transport and vulnerable road users.

INTRODUCTION

The road safety record on Indian roads has steadily worsened over the past decade. As can be seen from Figures 1 – 3 below, the number of persons killed or injured in road accidents has been steadily rising since 2000. It is a matter of serious concern for all stakeholders. One issue of particular concern is that around 60% of victims are Vulnerable Road Users (VRUs) such as pedestrians, bicyclists and so on.

Figure 1 Total Number of Deaths from Road Accidents in India



Source: Ministry of Road Transport and Highways, Government of India

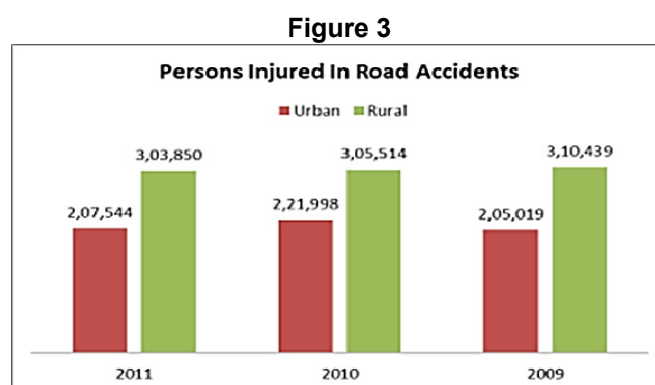
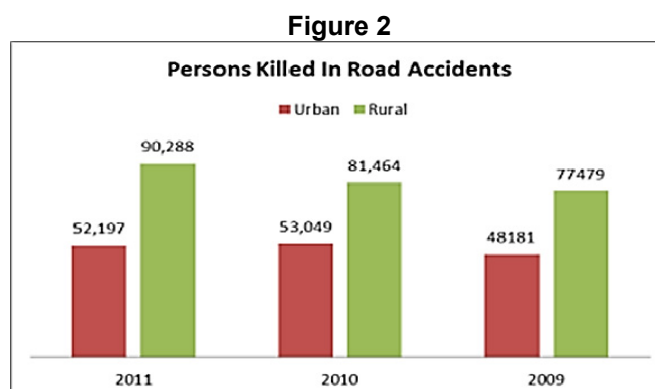
There are many reasons for the rise in traffic fatalities. Among them, the following are three major causes of road crashes in India:

- Though mobility has been improved, Vulnerable Road Users (VRUs) are sharing the same road space and the roads have inadequate safety measures for VRU.

¹ The author is a Civil Engineer and M-Tech from IIT, Delhi with over 35 years professional experience in India and the Middle East. He has been participated as a speaker in many international conferences and was deputed to the International Monetary Fund (IMF) and the World Bank.

- Inadequate enforcement of traffic rules and lack of awareness by the road users.
- Engineering measures to upgrade the highways are inadequate.

Figures 2 and 3 show the number of persons killed and injured in urban and rural areas between 2009 and 2011. This data suggests that road safety in both types of areas is poor, but there are more people affected in rural areas.



It is an accepted norm that whenever a highway is upgraded in terms of width and other engineering features, one of the primary considerations is that it should become safer for users. However, this may not be the case if the engineering measures adopted are not done with due diligence and are not suitable for local requirements. In fact, in many cases, it has been observed that the accident rate increased after highways are upgraded, in spite of good enforcement of regulations and a large proportion of relatively new automobiles.

I. HIGH ACCIDENTS DUE TO INADEQUATE ENGINEERING MEASURES

Since 2000, India has undertaken a massive highway up-gradation programme, the “National Highway Development Programme (NHDP)”, totaling 55,528 km of highways. As of October 2013, over 21,000 km of highways had been upgraded/constructed and over 12,000 km was under construction in different stages. The highways have been upgraded to international standards. However, the existing road accident scenario on Indian highways is very grim and is increasing exponentially.

Table 2 shows monthly accident data collected from the Concessionaire for a recently completed national highway in South India, the NH 9 from Hyderabad to Vijayawada, shows that where mobility has been improved, the total number of accidents has also gone up. In the Indian context, causes like contra-flow and speeding, which is associated with lack of enforcement of highway regulations, are usually involved.

Table 2 Accident Totals in a Recently Upgraded 4-lane Highway (180 km)

Months	Fatal	Grievous Injury	Minor Injury	Total Accidents
2012 December	27	15	48	65
2013 January	13	36	53	52
2013 February	9	44	64	10
2013 March	23	16	79	59
2013 April	7	15	67	69
2013 May	21	42	130	107
2013 June	13	27	63	98
2013 July	14	16	48	73
2013 August	6	26	73	79
2013 September	6	17	67	66
2013 October	11	31	117	89
	150	285	809	767

Source : Concessionaire, M/S. GMR Hyderabad Vijayawada Expressways Pvt. Ltd. & Independent Engineer, ICT Pvt. Ltd.

It is worth noting that these accidents have been caused despite high standards for the new highway. In this regard, it is necessary to look at some of the most important areas where there may have been faults in the engineering design.

II. BEST PRACTICES IN ENGINEERING DESIGNS FOR ROAD SAFETY

The Ministry of Road Transport and Highways² and the National Highway Authority of India (NHAI)³ of the Government of India has circulated the examples of good practices for road safety. The ten most important areas which require attention are:

- 1) Geometry of the road
- 2) Segregation of local traffic
- 3) Pedestrian facility
- 4) Bus bays
- 5) Illuminations
- 6) Development of Junction
- 7) Signage
- 8) Traffic calming & Safety Management Measures
- 9) Bridges/CD structures
- 10) Road Safety Audit

1) Geometry of the Road:

Geometry of the road can be said to be the most important element in the road design. Faulty design/engineering measures will result in "Black Spots" i.e. areas of high accidents. Following aspects are key to good design:

² Letter No. RW/NH-35072/04/2004-S&R® dated 27th April, 2010 as a follow-up of 4th IRF Regional Conference Recommendations "Accident Prevention : Road Safety Measures"

³ Circular No. NAHI/2008/Road Safety/IRF/588 dated 12th July, 2010.

- (a) **Width:** In urban areas, all through lane should be of normal width (3.5m) except the approaches through the junctions where the speed is expected to be very low, the lane width can be reduced to a minimum of 3.1metre [Indian Road Congress Code] for a length of at least 50metre in approach road. It is desirable to keep lateral clearance along multi-lane highway of at least 1.5m width from the edge of the carriageway without any obstacles. When a permanent object cannot be removed, provision of fenders and hazards markers with reflectors, frangible lighting column and speed posts need to be used for minimizing severity in case of collision.



*Hazard protected from collision on urban roads.
Photo No- 1*

- (b) **Slope:** For green field projects of high speed highway/expressway for ensuring effectiveness of recovery zone a slope of 1:4 is required to be provided, and slopes steeper than 1:4 shall be provided with W-beam crash metal carrier.



Steep Side Slope with Guard Rail

- (c) **Median & crash barrier:** Wherever adequate land is available, it is preferable to provide wide depressed median having width of 12m or more and in any case not less than 1.5 to 2m with W-beam metal crash barriers at the edge of the median.

In the case of narrow medians, 2m or less wide, are generally provided in urban areas, New Jersey type concrete crash barriers should be used along with anti-glare screen.

In the case of raise median, it is essential to provide W-beam metal crash barriers in the median along both the carriageways.

When two carriageways are at different levels, the median edge of the higher carriageway shall be provided with a W-beam metal crash barrier. Whenever embankments height is 3m or more, the W-beam metal crash barrier must be provided at the edge of the formation.



Depressed Median

2) Segregation of Local Traffic:

For safety of traffic operation, in cases of all multi-lane highways, local traffic has to be separated/segreated from the through traffic plying on the carriageway by service roads (minimum 5.5m wide) with safety fence, railing, etc. of robust and vandal proof design. Wherever service roads cannot be provided due to space constraints, then to protect the traffic it is essential to provide an additional width of paved shoulder with edge marking and ribbed pavement of at least 0.25m width. Adequate cattle underpasses, pedestrian underpasses and vehicular underpasses, truck lay-by should be provided at the important locations.

3) Pedestrian Facility

In urbanized sections, adequate pedestrian facilities are to be provided so that the pedestrians are not required to enter the main carriageway. All pedestrian underpasses wherever provided shall have a minimum 7m width, with a vertical clearance of 3.5m.



Lane marking

4) Bus bays

Suitably design bus bays at desired locations shall be provided along the main carriageway by using extra width together with approach and exit transition lanes. In no case, pedestrian should be required to enter in the main carriageway for cross-over or even to move along the highway. The safety features such as pedestrian foot over bridges, underpasses, etc. should be provided wherever required.

5) Illuminations

Stretches of highways in urban built up areas, underpasses and foot bridges shall be adequately illuminated so that a minimum 40 lux is available with 24 hours power supply, if required, supported by solar power.

6) Development of Junction

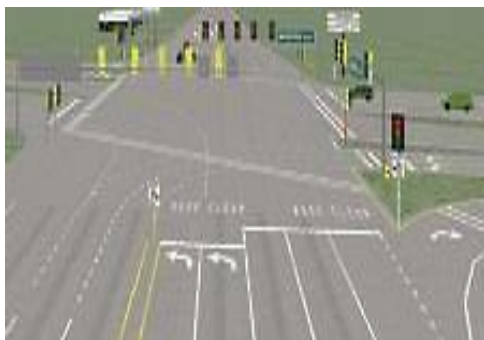
The crossing of a multi-lane highway by a primary road (National Highway/State Highway) shall preferably be through a grade separator. In case of other categories of roads (Major District roads, village roads), the excess should be preferably provided through service road.

When cross roads are to be brought to level of the service road and flared for appropriate length, stop/yield line and center markings shall be preferably provided. Rumble strips/speed breaker shall be provided on each cross road with warning sign and road marking. At all entry and exit, to and from the high speed highway, the merging and the diverting shall be only through suitable design acceleration lanes.

7) Signage

All signs preferably shall be of retro-reflective type. All curves with radius <math><750\text{m}</math> be delineated on outer side of the curve from both the directions (for RH curve it will be on shoulder and for LH curve it will be on median) by chevron signs. The W-beam metal crash barriers will be fitted with delineating reflectors when they are installed on embankments with 3m or above.

In embankments and flat curves, where crash barriers are not provided, these need to be delineated by 1.5m high reflectorized delineators. One-way reflective road studs shall be provided on edge lines and lane lines on approach to inter-section or high level bridge/culvert/ROB etc. with high embankments and along the sharp curves.



Lane Marking at Junctions



Traffic Calming Measures

8) Traffic Calming & Safety Management Measures

Whenever a multi-lane highway passes through built-up areas, design should be such to bring about reduction in speed to the level of 60/70 km for which repeated bar markings with hot applied retro-reflective thermoplastic. White paint lines can also be provided at the approaches to such built-up areas.

9) Bridges / CD Structures

In the approaches to the to & exist form, bridges and other CD structures, W-beam metal crash barrier shall be provided in continuation of the parapet on both the carriageways for at least 30m in addition to hazard sign marking.

10) Road Safety Audit

A Road Safety Audit should be carried out at all stages of road development viz. planning, design, construction and operation. Black spots (locations of high accidents) should be identified and removed. All road safety audit recommendations should be implemented and followed religiously.

III. CONCLUSION

In the 2011 report “Road Accidents in India”, the Government of India acknowledges that “road accidents are a human tragedy.”⁴ In this regard, it recognizes that “data and analysis on road accidents contained in this volume will help create awareness and assist in informed decision making in the area of road safety”. It is encouraging to see that under the 12th Five Year Plan, the Government has incorporated road safety audits as well as training of both engineers and road safety auditors as part of its strategy to design safer roads.

⁴ <http://morth.nic.in/writereaddata/mainlinkFile/File835.pdf>