

## SAFE ROAD INFRASTRUCTURE DESIGN FOR HIGHWAYS

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### ABSTRACT

Road safety has become a global issue of concern and concerted efforts need to be initiated at the ground level to avoid the thousands of lives being lost in road crashes around the world. Considering Road Safety as an area of immediate concern around the world, the United Nations (UN) has declared Decade 2010-2020 as the Decade of Action for Road Safety. The International Road Federation (IRF) has also taken many initiatives towards road safety, such as the development of the Road Accident Data Recorder (RADAR) which will help in the systematic storage of data and scientific analysis of accidents.

One of the most important measures for the reduction of fatalities is to put in place a good infrastructure regime. By comparing desirable standards for Safe Road Infrastructure Design with undesirable standards for each of the key elements, engineers can play a crucial role in building safer roads. Uniformity of standards is a key element in design of safe roads. Developing country engineers can also learn from proven practices of Safe Road Infrastructure Design from developed countries.

### INTRODUCTION

Global facts and figures on the road safety scenario around the world reveal some startling statistics. More people die on the world's roads each year than the total number of people who die from malaria. The WHO estimates almost 1.3 million people die each year, equivalent to six jumbo jet crashes every day. However, while the crash of a single jumbo jet makes headlines in the media, road fatalities, even in such large numbers, do not get the same attention. Worryingly, death by road accidents is the No.1 cause of death for young people worldwide, and the economic cost to the global economy is estimated to be a staggering \$1.2 trillion a year.

Furthermore, 50 million people are injured annually, many of whom are left disabled. As shown in Figure 1, Road Traffic Injury (RTI) is the highest cause of global injuries. Ninety per cent of these casualties occur in developing countries. With the number of annual deaths occurring from road accidents forecast to rise to 1.9 million by 2025 (Figure 2), there is an urgent requirement to act now to prevent unnecessary deaths from road accidents in the future.

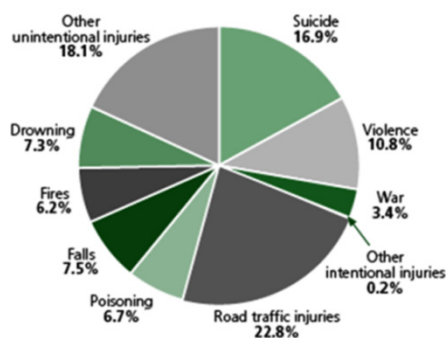


Figure 1: World-wide Cause of Injuries

Source : World Report on Road Traffic Injury Prevention (WHO).

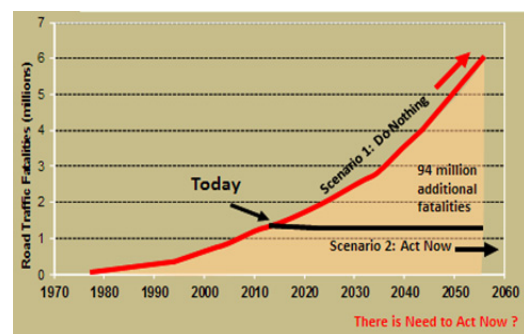


Figure 2: Projection of Global Road Traffic Fatalities

Source: Report on Safe Roads by Guria, J (2009).

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In response to these trends, the United Nations declared 2011 to 2020 as the Decade of Action for Road Safety. It aims to save 5 million lives by 2020. One of the five “pillars” of the Decade is on “Safer Roads and Mobility”.



## SAFE ROADS FOR ALL

The International Road Federation, or IRF, has several major road programmes on road safety in different regions of the world. Its Regional Offices provide training programmes on road safety, each different but complimentary to each other. For example, in collaboration with the UN Economic Commission for Africa and other international agencies, the IRF supports the Trans-African Highway Network. In Africa, the IRF also provides help and technical assistance on public-private partnerships, road safety, and Statistical Data Collection and Training. In the Mediterranean region, IRF designs personalized training seminars and regional conferences. The IRF Geneva Programme Centre develops customized training and visual materials such as videos.

Another major initiative under the IRF is the Road Accident Data Recorder (RADAR) developed by IRF is an innovative and scientific crash data collection and reporting system, designed as an application for use in a tablet with Android OS.<sup>4</sup> It provides paper-less digital accident data collection from the accident site/scene, and a device free delivery of the application to the customers. RADAR application is equipped to use the GSM Network, GPS, and digital camera facilities of the tablet.

The output from the Reporting Tool of RADAR Application can be used by all concerned actors connected to Road Accidents/Crashes, such as policy-makers, politicians, lawyers, road engineers, enforcement agencies, education and awareness groups, health professionals, researchers, insurance companies, vehicle manufacturers, and NGOs and community groups. This system for secured and scientific data on road accidents is expected to revolutionize road safety engineering and all other aspects of road safety across all boundaries.

### I. ENGINEERING ASPECTS OF SAFE ROAD INFRASTRUCTURE DESIGN

In general, it can be said that the “5Es” of Safe Road Operations are:

- **Engineering** – Defining the Built Environment including the road design and vehicle design.
- **Enforcement** – Strict application of law.
- **Education** – Teaching good road behavior through awareness campaigns.
- **Encouragement** – Rewarding people for good road behavior.
- **Emergency Care** – Road side medical care and access to para-medics in the “Golden Hour”, or the hour immediately following a road accident during which the provision of first aid can greatly enhance the prospects of the accident victim’s survival.

In this regard, the role of engineers is paramount to ensuring roads are as safe as possible. From an engineering perspective, road safety can be enhanced by Highway Engineers into various stages of road projects, as follows.

- **Planning Stage** - through land use control policies; providing by-passes for congested towns and linking them by spurs; and creating Self Contained zones to avoid nonessential traffic in the neighborhood
- **Design Stage** - designing “Self Explaining Roads” and “Forgiving Road Side” by selecting the most desirable design standards (and NOT the minimum standards) involving:

<sup>4</sup> Further information about the Road Accident Data Recorder (RADAR) can be found on the IRF’s website at: <http://www.irfnet.ch/index.php>.

- i. Design speed
  - ii. Horizontal and vertical geometry
  - iii. Cross-sectional elements
  - iv. Design of at-grade and grade separated junctions
  - v. Provision of service roads for segregation of slow and fast traffic
  - vi. Designing effective road furniture, vis-à-vis guard rails, traffic signage, road-side illumination provisions, etc.
- **Construction Stage** - Proper separation of the construction zone through effective barricading; construction of proper traffic diversions; provision of road signage; environmental controls for reducing noise, dust, etc.
  - **Maintenance and Operation Stage** - providing an Automated Traffic Management System (ATMS) for safe operation of Traffic and Incident Management. This includes providing Mobile Communication Systems, Variable Message Signs, Weigh-in-Motion System, and Central Control Room.

The key to Safe Road Infrastructure Design is consistency of standards so that road users do not encounter unexpected situations. While road crashes are overwhelmingly caused by human failings, the greatest untapped potential to prevent death and injury is through the roads themselves. For example, there has to be a clear distinction between inter-urban roads for high speeds and urban roads for lower vehicle speeds and priority for vulnerable road users.

By making the roads more predictable, consistent and forgiving, we can produce a long-term solution that helps save lives and reduce injuries. For example, between 1980 and 2000, in Sweden, the Netherlands and the United Kingdom, infrastructure treatments combined with speed management measures reduced the number of deaths of vulnerable road users by around a third. In this regard, it is important for all road engineers to acknowledge the key elements of safe road infrastructure design.

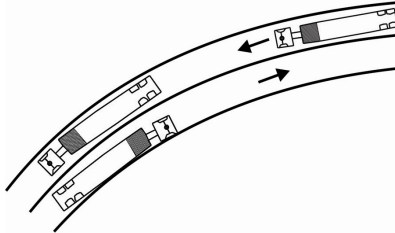
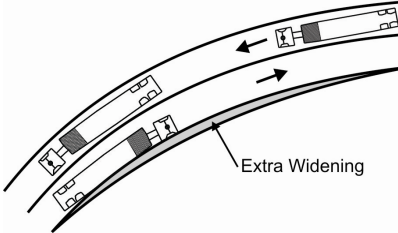
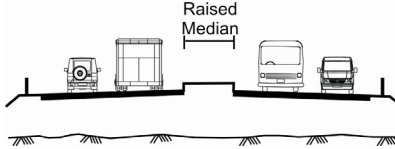
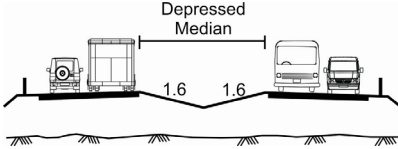
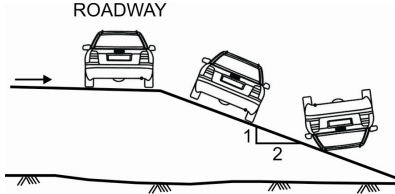
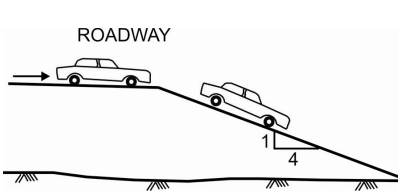
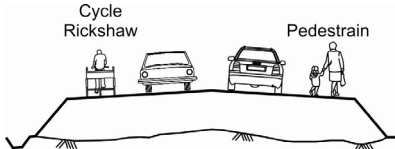
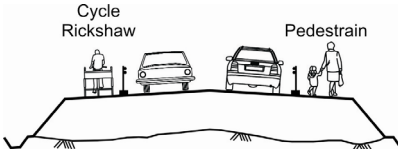
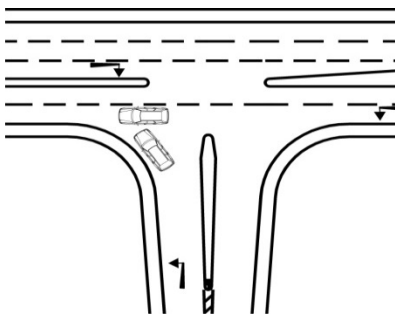
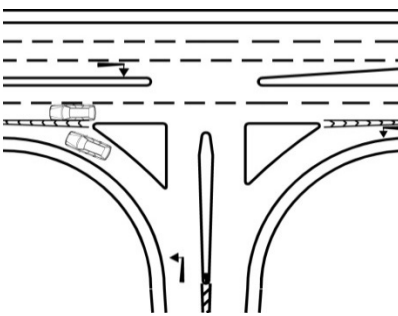
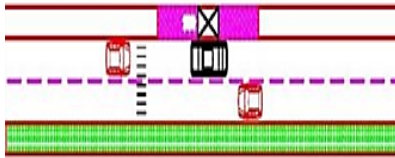
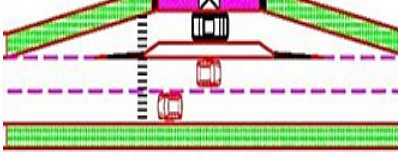
## II. KEY ELEMENTS OF SAFE ROAD INFRASTRUCTURE DESIGN

Some of the key elements of Safe Road Infrastructure Design are given in Table 1 below and are further illustrated in the table below.

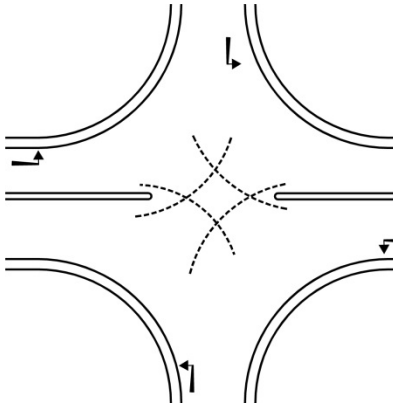
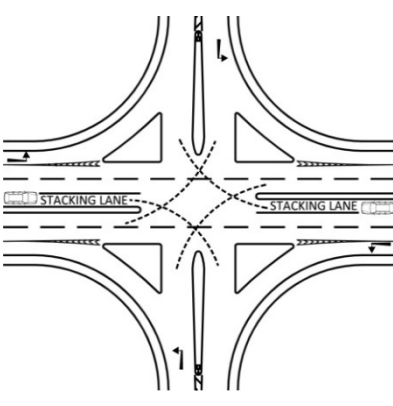
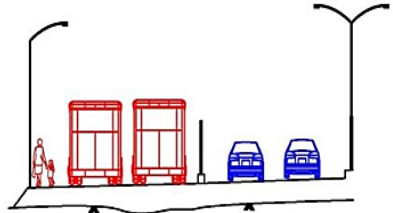
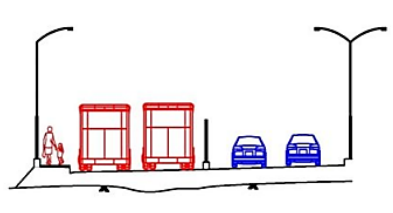
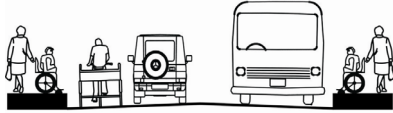





- a) Major arterials and expressways should bypass major towns which should be connected by spurs. There should be clear zones identified for linear land use control.
- b) Consistency of horizontal geometry avoiding monotonous straight lines or abrupt change of speed.
- c) Adequate off-set distance from natural road side features.
- d) Undivided carriageways designed for Overtaking Sight Distance.
- e) Wider lane widths and shoulders for High Speed Roads.
- f) Inside widening for sharp curves.
- g) Recoverable slopes for out-of-control vehicles.
- h) Segregation of the slow moving non-motorized traffic from fast moving traffic.
- i) Provision of raised footpath for pedestrians in Urban Areas.
- j) Barriers should be designed to deflect the vehicle and not crash it.
- k) Road Signs should be standardized throughout the country.
- l) Properly designed traffic calming measures like the speed humps, rumble strips, small roundabouts, etc.
- m) Entry / Exit only through Slip Lanes with proper Acceleration and Deceleration Lanes.



Table 1. Key Elements of Safe Road Infrastructure Design

Design/ Planning Element	Undesirable	Desirable	Principle applied
Alignment Selection and Land Use			Major arterials and expressways should bypass major towns which should be connected by spurs. There should be clear zones identified for linear land use control
Horizontal Geometry			Consistency of horizontal geometry avoiding monotonous straight lines or abrupt change of speed.
Horizontal Geometry			Adequate off-set distance from natural road side features.
Vertical Geometry			Undivided Carriageways designed for desirable Overtaking Sight Distance (OSD)
Cross-sectional Elements			Wider lane widths and shoulders for high speed roads

Design/ Planning Element	Undesirable	Desirable	Principle applied
Cross-sectional Elements			Inside widening for sharp curves
Cross-sectional Elements			Wider depressed median for high speed roads to prevent glare and jumping of vehicles
Cross-sectional Elements			Recoverable slopes for out of control vehicles
Cross-sectional Elements			Separate slow moving non – motorized traffic (cycles, rickshaws, etc.) from fast moving traffic
Entry/ Exit			Entry Exit only through slip lanes with proper acceleration and deceleration lanes
Passenger Transit			Separate Lay bye for buses and taxis to facilitate segregation and improve visibility



Design/ Planning Element	Undesirable	Desirable	Principle applied
Junction Design			Channelization, provision of stacking lanes, adequate turning radii
Pedestrian Facilities in Urban Areas			Provision of raised footpath for pedestrians in Urban Areas
Facilities for differently abled	 Road Crossing Location	 Road Crossing Location	Footpath merging in a slope with a cross street, bus bays flushed with foot boards etc.
Barriers			Barriers should be designed to deflect the vehicle and not crash it.
Road Signs			The road signs should be standardized throughout the country

Design/ Planning Element	Undesirable	Desirable	Principle applied
Traffic Calming	 <i>Non-standard Hump</i>	 <i>Standard Hump</i>	Properly designed traffic calming devices like speed humps, rumble strips, small roundabouts

### III. EXAMPLES OF GOOD PRACTICES IN SAFE ROAD INFRASTRUCTURE DESIGN

Around the world, there are many examples of good practices in Safe Road Infrastructure Design. Some of these are elaborated below and illustrated in Figure 3.

- Mild Slope Treatment (Forgiving Road Side Treatment) to absorb impacts of vehicle turnover
- Recovery Zone (Hard Shoulder) to allow Safe Recovery
- Road Side Feature (Protected with guardrails)
- Recoverable Fill Slope (for adequate protection)
- Rock face Cutting (Shielded with safety barrier)
- Roundabout (At grade with Non-Motorized Mode of Segregation)
- Grade separation at busy intersection (with segregated passage for pedestrians and local traffic)
- Depressed Median (Prevent run-off accidents)
- Speed Camera/Radar Photo (Speed control)
- Speed Limit on the Asphalt (to limit the speed)
- Speed Calming Measures (to limit the speed)
- Adequate Design for Non-Motorized Traffic
- Adequate Refuge for Pedestrians

**Figure 3: Examples of Good Practices of Safe Road Infrastructure Design**



*Forgiving Road Side Treatment*



*Recovery Zone (Hard Shoulder)*



*Recoverable Fill Slope*



*Rock Face Cutting (Shielded with Safety Barrier)*



*Roundabout  
(At Grade with Non-Motorized Mode Segregation)*



*Speed Humps: Speed Calming Measures*



*Grade Separation at Bust Intersection*



*Speed Camera/Radar (Speed Control)*

#### IV. CONCLUSIONS

The road fatality trajectory is going up alarmingly around the world. Following the example of developed countries, where road fatalities through infrastructure safety and other educational and enforcement programs have drastically reduced the number of accidents, developing countries need to put in place a good regime of Safe Road Infrastructure Design to improve road safety scenario and reduce road casualties/fatalities.

Immediate implementation of successful road safety models in some regional countries may also require institutional reforms/change in legislation. However, safety engineering can be carried out without any structural change in existing implementation framework. To improve infrastructure safety, the major steps which need to be implemented are:

1. Road Agencies to adopt road safety audit in all stages of road development and to make them mandatory.
2. Training and Capacity Building to enhance Safety Engineering Expertise.



3. Revise Codes and Manuals for improved vehicle technology and prevailing road user behavior.
4. Initiate Peer-to-Peer Program at National Level and establish Center of Excellence and Road Safety Auditor's Accreditation system.