Road Safety Requirements

Manar M. Nassef *1

[1] Department of Civil Engineering, Delta Higher Institute for Engineering and Technology, Egypt.
Email: manar.nassef2@gmail.com

Abstract

Frequent and severe traffic accidents have become a major concern because they hinder the sustainable development of society. Elements of roadway design play an important role in determining the risk of traffic accidents. Where, the geometry of the road has an effect on both the severity and frequency of road accidents. Road safety is affected by a variety of factors related to the behavior of drivers and the quality of the infrastructure. Some solutions need to be provided in order to reduce the number of traffic accidents, and safety performance functions (SPFs) are essential to the implementation of science-based road safety management. This is because it is preferable to provide preventative protection than to deal with the after-effects of an accident. The ability to address this issue is also dependent on having information about the safety conditions of the road network as well as the amount of finances that are available for the implementation of new road safety initiatives. It also requires the prioritization of the various interventions that may generate benefits, increasing safety, while ensuring that reasonable steps are taken to remedy the deficiencies detected within a reasonable timeframe. Roadside accidents are often considered to be among the "most merciless" types of accidents. It is possible to significantly lessen the severity of collisions by designing roadsides to be more "forgiving". A roadside design that is more forgiving has a limited effect on lowering the overall number of accidents, but it has a significant impact on reducing the severity of collisions, which in turn reduces the number of fatal and injury accidents.

Keywords: Road safety; Safety performance functions; Roadside Safety

1. Introduction

The rise in both the population and the number of people who own cars has resulted in an increase in the amount of traffic, the number of traffic accidents has also climbed dramatically. Around 50 million individuals are seriously injured each year due to traffic accidents, and an additional 1.24 million lose their lives [1]. Egypt has one of the highest rates of fatalities caused by road traffic accidents in the Eastern Mediterranean area, with a rate of 42 deaths per 100,000 persons caused by road traffic accidents [1]. According to Ismail and Abdelmageed [2], the total cost of traffic accidents in Egypt was over 10 billion Egyptian Pounds in 2008, with an average cost per accident of 500,000 Egyptian Pounds. Each year, Egypt loses almost 6.90 billion Egyptian Pounds [3] due to these accidents.

Traditionally, the idea of the three Es has served as the foundation for road safety efforts. Engineering, education, and enforcement are the three Es in this phrase. The field of engineering is now split into two subfields: designing safe vehicles and designing safe roadways. When it comes to education, the idea centres on two aspects: first, the education that is required of drivers in order to earn a licence, and second, the education that is required of the general public in order to raise awareness about the dangers of driving. While the focus of enforcement is on regulating and influencing the behaviour of drivers in order to make roadways safer [4].

Doi: https://doi.org/10.54216/IJBES.050205
Received: May 18, 2022 Accepted: August 11, 2022

Some developed countries , such as the United States and Australia, have come to the realisation that increasing behavioural safety and vehicle safety is a difficult undertaking that accomplished over a lengthy period of time. The researchers began by analysing the causative mechanism of roadside accidents. They then explored the risk factors that affect the frequency and severity of roadside accidents [5]. These researchers have implemented corresponding measures to improve roadside safety and reduce roadside accident losses, such as driver management, vehicle review, and road optimization design [6].

Since crash prediction models are the primary instruments used in evaluating treatment effects and predicting crashes, there has been significant progress made in their development over the past decade. It is common knowledge that these models represent safety performance functions (SPFs). At its most fundamental level, the SPF is a mathematical function that establishes a relationship between the average crash frequency at a site and a number of explanatory variables [7]. These explanatory variables typically include the volume of traffic at the site as well as other site characteristics (such as the pavement width, shoulder width, segment length, etc.). Table 1 presents safety measures to reduce accidental rates [8].

Table 1: Safety measures to reduce accidental rates

Geometric Deficiency	Safety Measures
Narrow shoulders and lanes	• Raised pavement markers • Post delineators • Pavement edge marking
Narrow Bridge	• Warning signs and markings • Transitional protection barriers at bridge approach • New or rehabilitated bridge rails
Roadside Obstacles / Steep side slopes	• Remove obstacles such as trees, poles • Pavement markings • Flatten side slopes up to 3:1 or steeper
Sharp horizontal curves	• Widening carriageway • Use of roadside barriers • Raised pavement marking • Pavement anti-skid treatment • Appropriate superelevation
Hazardous intersection	• Use of roundabouts • Traffic control signalization • Traffic control devices • Speed controls
Poor sight distance	• Traffic control device, signs and markings • Shoulder widening • Remove fixed danger obstacles
Edge drop shoulders	• Paving shoulders at critical points • Tapering pavement edge shape
Lack of skid resistance	• Apply "antiskid" treatment at pedestrian crossings and potential junctions • Providing skid resistance during the programme of maintenance • Retexturing and surface dressing

Doi: https://doi.org/10.54216/IJBES.050205
Received: May 18, 2022 Accepted: August 11, 2022

2. Road Infrastructure Safety Management (RISM) system

The Road Infrastructure Safety Management (RISM) system consisting of five different supporting procedures [9]:

- Road Safety Audit (RSA)
- Road Safety Impact Assessment (RIA)
- Black spot treatment (BST)
- Network Safety Management (NSM)
- Road Safety Inspection (RSI)

A Road safety Impact Assessment is a process that may be used to evaluate how different proposals would affect road safety. This may include construction of a new bridge or major road works. A RIA can also be concerned with a broader scheme, which means that it might be meant to generate plans for the improvement of the overall safety level of a network or a region [10]. An RSA is carried out during the design phase in order to guarantee that new road projects will function in the safest possible manner for all user groups of roads. The Road Safety Audit (RSA) is a study of road projects that takes place throughout the various stages of project development, beginning with the preliminary design and continuing up until before or soon after a road is opened to traffic [11, 12].

The safety level of an existing road may be increased by a variety of procedures once the road has been brought up to full operating status. These operations include the remediation of dangerous places, the management of network safety, and road safety inspections. A black spot is any location that has a higher number of crashes than other similar sites as a result of local risk factors. Black spot treatment consists of the identification, analysis, and treatment of black spots. Network safety management is the process of identifying, analysing, and treating dangerous road sections. A hazardous road section is any part of a road that is predicted to have a greater anticipated number of collisions and a more severe nature than other road sections that are equivalent [13]. In contrast to the treatment of black spots, network safety management focuses on longer road sections, often ranging from two to ten kilometres in length, whereas black spots are typically no longer than half a kilometre. Both of these are reactive processes.

The Road Safety Inspection (RSI) is a preventative technique for finding safety hazards on existing roads that are in operation. It consists of a regular, systematic, on-site inspection that covers the whole road network and is carried out by qualified safety expert teams [14]. The factors that are known to be risk factors for crashes or injuries are the elements that will be addressed in these RSI. These risk factors include the quality of traffic signs, road markings, and road surface characteristics, as well as adequate sight distances and the presence of roadside traffic hazards [14]. The General Assembly of the United Nations declared March 2010 to be the beginning of a Decade of Action for Road Safety (2011-2020). The notion that underpins the UN's operational framework is the successful safe system method. As can be seen in figure 1, the structure is comprised of five distinct pillars [15].

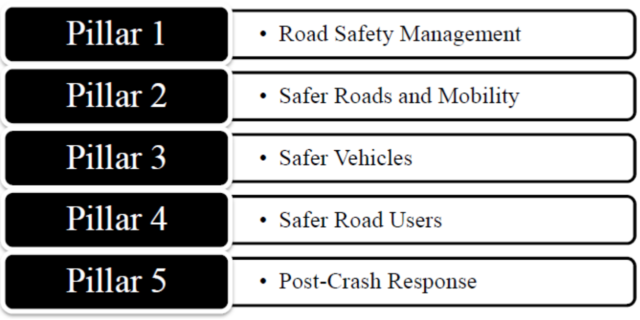

Figure 1: Five pillars of road safety

Doi: https://doi.org/10.54216/IJBES.050205
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3. Safety performance functions (SPFs)

Crash data analysis, which is used to evaluate the safety of a transportation facility (such as a highway, arterial road, or intersection), is one of several fields within the broader discipline of traffic safety research. Crash frequency studies and their limitations were systematically reviewed by Lord and Mannering [16]. Similar research on the topic of damage severity was undertaken by Savolainen et al. [17]. Analytic methodologies employed in these two fields were outlined by Mannering and Bhat [18], who also included future directions. Finding the association between a wide range of different factors and the occurrence of crashes or the severity of those crashes is the primary objective of the majority of these researches. Crash prediction models are referred to as Safety Performance Functions. Essentially, they are mathematical formulae that connect the number of accidents of different categories to site characteristics. These models always take into account the traffic volume (AADT), but they may also take into account site characteristics such as the width of the lanes, the width of the shoulder, the radius of horizontal bends, traffic management at junctions, and the presence of turning lanes [19]. Safety performance functions, often known as SPFs, are essential to the implementation of any science-based approach to the administration of road safety, such as the procedures outlined in the Highway Safety Manual [20]. SPFs are statistical models that are applied in order to estimate the crash frequency that may be predicted for a facility [21]. The quality of organizing data into homogenous units, also known as the segmentation approach, is a critical factor in determining whether or not the use of an SPF for road segments would be successful [22]. When segmentation is based on a number of different criteria, the end result may be very short homogeneous segments [23]. For instance, when adopting the segmentation strategy advised by the Highway Safety Manual (HSM), Very small segments impede reliable statistical inference for a variety of reasons. The most crucial are the imperfect identifiers of the locations of accidents, which are often acquired from the reports filed by the police [24]. Increasing the length of the segments in order to circumvent these issues will result in the loss of homogeneity. Ogle et al. [25] showed that studying the collision in a short portion of less than 160 metres produces uncertain results.

The Highway Safety Manual (HSM) [20] recommends adopting homogenous segments in terms of AADT, curvature, number of lanes, outer and inner lane width, shoulder width, clear zone width, and median width. A minimum segment length of 0.16 kilometres has been recommended, despite the fact that there is no predetermined minimum segment length for the use of predictive models. The development of safety performance functions (SPFs) for important rural arterial highways in Egypt was presented by Elagamy et al. [26]. A constant section length of one kilometre (S1), homogenous sections (S2), following the recommendation of the highway safety manual (HSM), variable sections with respect to the presence of curvatures (S3), and variable sections with respect to the presence of both curvatures and U-turns (S4) were utilised during the development of the SPFs (S4). For the development of SPFs, the generalised linear modelling approach was utilised, and the stepwise strategy was applied, with or without the time impact being taken into consideration (i.e. year-to-year variation). The calibrated SPF model that is based on the S3 segmentation technique and uses the time-trend model form performs better than other SPFs that are calibrated based on other segmentation methods when it comes to total crashes. While S1 and S4 segmentation approaches, which did not include the time-trend model form, provided the greatest SPFs for "death and injury" accidents and property damage only crashes, respectively. In addition, the findings demonstrated that the likelihood of a collision occurring may be reduced by broadening the pavement, the shoulder, and the median of the roadway.

4. Road side clear zone (RCZ)

On roads that already exist, potential hazards can be identified either through road safety inspections or by referring to collision records. It is possible to identify potential hazards by taking into account factors such as the volume and speed of traffic, road geometry, surface characteristics, and the severity of expected collisions. During the planning process for new road projects, it is important to recognize and take into account any potential risks that may exist once this is done. In most cases, a Clear Zone (also known as a safety zone) is an acceptable solution.

Doi: https://doi.org/10.54216/IJBES.050205
Received: May 18, 2022 Accepted: August 11, 2022

Thompsonet et al. [27] define a roadside as the land that is outside the carriageway's boundary. In Figure 2, we see a cross section of a typical road with some of the components seen along the sides of the road. The roadside in this diagram is the space outside of the travel lanes (or carriageway). Therefore, the shoulders constitute a part of the roadside since the lane markers delineate the limits. The road designer must take into account the slopes, the clear zones (sometimes called safety zones), and the tree to create a more "forgiving" roadside.

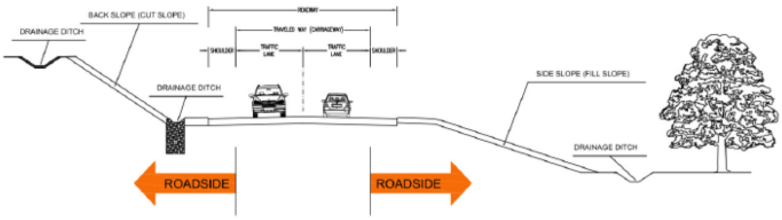

Figure 2: Roadway cross section accompanied with illustrations of roadside clearance areas

Research in the topic of roadside safety [28] focuses on the following three aspects:

(1) The frequency of roadside accidents: utilising the data collected from roadside accidents, a variety of statistical analysis models are utilised in order to investigate the risk variables that have an effect on the number and frequency of roadside accidents.

(2) The severity of roadside accidents: The risk factors that influence the severity of roadside accidents are identified by analysing the risk of occupant injuries and applying statistical analysis models, based on roadside accident data. This is done in order to determine the severity of roadside accidents.

(3) Roadside safety design: elements of this design include the width of the RCZ, the roadside slope, the design of the roadside guardrail, the protection and optimization design of roadside traffic facilities, and the method of setting the RCZ based on a cost-benefit analysis.

The CEDR report categorises Roadside Hazards under the following headings [29]:

1. Single Fixed Obstacles
   - Fencing at an angle to travel direction, within the Clear Zone
   - Headstones
   - Rocks and boulders
   - Safety barrier terminals and transitions
   - Trees
   - Utility poles and lighting posts

2. Continuous Hazards
   - Curbs
   - Ditches
   - Embankments and slopes
   - Pavement edge
   - Permanent water bodies
   - Road restraint systems

3. Dynamic roadside hazards
   - Bicycles
   - Parking
   - Pedestrians
   - Temporary advertising signs on timber posts or trailers

Doi: https://doi.org/10.54216/IJBES.050205
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5. Improve roadside safety

To improve roadside safety [29]:

1- Removing and relocating obstacles
2- Modifying roadside elements
3- Shielding obstacles

The provision of a Clear Zone, often known as an area that is devoid of obstacles and has land that is level and gently sloped, can be the most beneficial kind of roadside enhancement. In the event that a driver loses control of their car and goes off the road, this gives them space and the chance to get it back under their control. Objects that cannot be removed completely should be moved outside the Clear Zone [30]. Breakaway devices have the benefit of a decreased likelihood of impact damage and injury, but they have the drawback that a falling pole can be a hazard to surrounding traffic, pedestrians, and property [31]. Slip base poles are distinguished by the fact that when they are hit at normal traffic speeds, they are generally displaced from their initial position, as seen in Figure 3. Because of the way the pole is constructed, it will be able to tip over and collapse to the ground in the event of a collision [31].

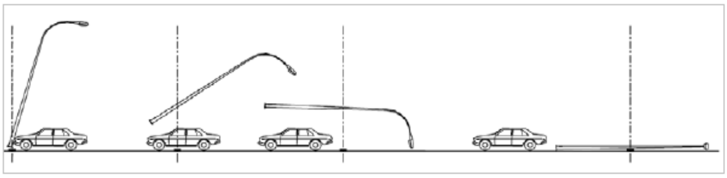

Figure 3: Vehicle impacting a slip base pole

It is not possible to remove or alter potentially dangerous objects that are located along the side of a road in many instances. The third treatment that is advised involves sheltering hazardous items using road restraint systems (RRS) to prevent vehicles from colliding with these things. This is done in order to prevent collisions between vehicles and these objects (RRS). Errant vehicles will be forced to crash into the RRS, while these treatments would appear to be dangerous things in and of themselves, the severity of crashes would be far worse if RRS weren't there. The most crucial category of RRS is the safety barriers. These restrict vehicels from leaving the route, which in turn reduces the chance of collisions with dangerous objects. It is possible to place safety barriers on either side of the road, or in the median [29]. Safety barriers are categorised in the following three groups [32]: Rigid; Semi-rigid; Flexible

6. Conclusion

• New road plans have always prioritised safety first and foremost.

• It is important to develop effective plans and implement them to ensure the safety of all drivers. This may be done with the help of a thorough Road Safety Audit / Road Safety Inspection programme, as well as the creation and implementation of relevant standards and procedures for road design.

• To reduce the frequency and severity of run-off-road collisions, roadside safety management works to provide a forgiving area on both sides of the roadway. When designing a road, it is important to ensure that the roadside features reduce the likelihood of fatalities or injuries of a serious nature in the event that a vehicle veers off the roadway.

• The decided recommendation for road safety include

a) reducing the possibility of vehicles leaving the roadway (e.g. through improved delineation).

b) ensuring that there is sufficient room for vehicles to recover in the event that they do off the roadway

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c) making sure that if a crash does occure in the roadside, it's only cause minimal damage to the vehicle and its occupants if they collide (no fatal or serious injury outcomes).

Funding: “This research received no external funding”
Conflicts of Interest: “The authors declare no conflict of interest.”

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