BEST PRACTICES IN SUPPORT OF VULNERABLE ROAD USER PROTECTION IN SOUTH AFRICA

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ABSTRACT

Vulnerable road user fatalities continue to make up the bulk of road traffic related deaths in South Africa. Safe System-based measures aim to improve the safety of the road environment for all road users including vulnerable road users. Safe System-based measures are primary mitigation measures that focus on reducing the severity of accidents while supporting techniques and measures that focus on reducing the number of accidents. Road Restraint Systems (RRS) form a vital part of the road planning and design process in support of minimising the severity of accidents, including accidents involving vulnerable road users.

The uptake of best practices relating to the provision of safe and forgiving roads that can mitigate the severity of injuries in South Africa, has been poor. This research paper considers the plight of vulnerable road users in the South African road environment and provides practical evidence/examples of existing scenarios where roadside risk for vulnerable road users such as non-motorised transport users can be addressed through the provision of correct and crash tested RRS that contribute to making the road environment inherently safe and more forgiving.

1. BACKGROUND

Vulnerable road users (VRUs) are defined as non-motorized road users, such as pedestrians and cyclists, as well as motorcyclists and persons with disabilities or reduced mobility and orientation (Eltis, 2015). Globally, Vulnerable Road Users (VRU) are overly impacted by road deaths. The Global Road Safety Facility (GRSF, 2021) state that globally road traffic deaths for pedestrians and cyclists is estimated to be in the region of 26% and another 28% estimated to be two- and three-wheeler motorcyclists. Globally VRU deaths make up 54% of road user deaths. Regionally on the African continent, pedestrian and cyclist deaths make up 44% of road deaths (Global Road Safety Facility, 2021).

The South African National Household Travel Survey (2020) indicated that in the seven days preceding the survey, 41.7% South Africans walked all the way to their destination, followed by 25,7% of individuals who made use of taxis (25,7%) and 14,9% of road users who used a car/truck as a driver. Indications are that VRU deaths (pedestrian and cyclists) contributed to 40% of the total road deaths between 2019 and 2021 (Road Traffic Management Corporation, 2021).

Humans are physically fragile, especially in relation to the masses and speeds encountered in traffic. Any approach to safety must account for human frailties. In-car technology (e.g., air bags, crumple zones) can provide a measure of protection for vehicle occupants, but pedestrians, bicyclists, and motorcyclists will always be vulnerable. Roads should be designed to eliminate the possibility that anyone is exposed to fatal forces (Kerksieck, 2016).

VRUs lack protection in traffic and as such should receive special attention in road safety policy and practice (Ptak, 2019). VRUs are particularly prone to injuries and fatalities because they are not protected by any external vehicular body and their vulnerability is higher in mixed traffic conditions (Agyemang, 2021). VRU safety is affected by factors such as vehicle design, road and pavement layout, legislation (e.g., speed limitations), and active and passive safety systems such as a car's camera/LIDAR/RADAR or a cyclist's helmet (Ptak, 2019).

The primary road environment safety objective is to reduce crashes and casualties when roadway departure crashes occur. This can be achieved by improving the road environment (together with traffic management). Interventions recommended for adoption to improve safety in the road environment include roadside and central barrier systems, medians, infrastructure to support appropriate operational speed for road users, pedestrian footpaths, and crossings, separated bicycle and motorcycle facilities, and traffic signs and line markings including audio-tactile line markings. Safety barriers have been found to reduce severe injuries by between 70% to 80% (Turner et al., 2021).

2. PURPOSE OF THIS PAPER

This paper highlights that roadside protection for VRUs is globally considered a priority. However, South African guidelines and specifications to address roadside safety for VRUs are lacking. The paper considers available guidelines and current practices and concludes with recommendations pertaining to roadside devices that can be considered for more efficient VRU protection along the side of the road in South Africa.

3. SAFE SYSTEM APPROACH IN SUPPORT OF FORGIVING AND SAFE ROADSIDES

3.1 Introduction

South Africa adopted the Safe Systems Approach (SSA) in 2011. ISO 39001: the Road Traffic Safety Management System, forms the basis of the National Road Safety Strategy 2030. Central to the SSA is the recognition that road users are fallible and will make mistakes, even if alert and intending to comply with the road rules (World Health Organisation, 2021). The SSA encourages road authorities and designers to provide a safe environment and to consider all facets that comprise the system as contributors to accidents, rather than the traditional approach that blamed the road user for human casualties. Shared responsibility for road safety is a principle of the SSA and as such the planners and designers have a responsibility to provide inherently safe and forgiving roads and road environments while the onus rests on users to comply with road regulations and proper road safe behaviour. The design of the roadside and ancillary features can either adversely affect road safety or contribute to a safer environment for all road users (Road Traffic Management Corporation, 2022).

The SSA advocates the need to adopt the viewpoint that roads and roadsides should be *forgiving,* and that fatal and serious accidents should not occur as result of driver error (Global Road Safety Facility, 2021). Fundamental to the SSA is designing a road network that recognises the limited tolerance of the human body to kinetic energy changes that occur during an impact, to eliminate fatalities and serious injuries.

Countermeasures (such as a reduction in speed limits) need to reduce crash severity to survivable limits and/or eliminate or compensates for the human error. Safe system-based measures aim to improve the safety of the road environment and can be considered as ‘primary’ mitigation measures with the focus on reducing the severity of accidents while with ‘supporting’ techniques, the focus is on reducing the number of accidents. Vehicles and road infrastructure need to be designed to discourage errors and protect against the consequences (damage and injury) when errors do occur.

Designing within the Safe System approach, requires consideration in terms of *functionality*, *homogeneity, predictability, forgivingness of roads, as well as status of awareness of road users* (Signor et al., 2018; Kerksieck, 2016).

Kiersieck (2016) states that the principle of predictability is based on the theory, that risk of error increases when drivers must react to unexpected situations. Predictable road designs add simplicity in decision-making and risk of driver error increases as decisions become more complex, even if the traffic situation is anticipated.

Design implications include a recommendation for pedestrian crossing islands; favouring 2-lane, as opposed to multilane, roads; and protected left turns over permitted left turns because of how they simplify crossing decisions for pedestrians and motorists. To the principle of forgivingness – based on the theory that humans will continue to make mistakes, both intentionally and unintentionally – this thesis add the principle of restrictiveness. While forgivingness aims to lessen the risk of serious injury after a mistake has been made, restrictiveness aims to prevent people from the making the mistakes or they are inclined to make in the first place.

3.2 Roadway Departures and Road Restraint Systems

The Federal Highway Administration (FHWA, 2020) defines a roadway departure (RwD) crash as a crash which occurs after a vehicle crosses an edge line or a centre line, or otherwise leaves the travelled way. Road safety equipment and how it is used under different road and traffic conditions influences its functionality and safety (Antoniuk, 2017). It is important to study these areas and use the results to formulate modern methods for the design, construction and operation of road infrastructure giving sufficient emphasis to the role of the equipment in ensuring the safety of road infrastructure. Road safety devices can be divided into two groups:

- Active devices are designed to handle the impact of out-of-control vehicles, including collisions and crashes (Antoniuk, 2017). Active devices such as road restraint systems are specifically designed to minimise the consequences of such events, especially those involving people (injury or death).

- Passive devices including Automatic Emergency Breaking (AEB), Forward Collision Warning (FCW) or Lane Departure Warning (LDW), do not come into direct contact with vehicles involved in a crash and is used to organise and control road traffic, prevent disruptions to traffic and inform motorists and other road users in advance about safety risks or traffic delays (Budzynski, 2019).

Road Restraint Systems (RRS) forms a vital part of the road planning and design process in support of minimising the severity of accidents if a vehicle leaves the travelled path and constitutes an important life-saving device available to authorities and road operators (European Road Federation, 2008). RRS protect motorists from hitting an obstacle or physically prevent vehicles from leaving the road in the case of steep embankments. RRS are active road safety devices and used if the consequences of a crash or accident were greater than those caused by crashing into a barrier or oncoming traffic. However, RRS can pose a risk, especially if poorly designed and built (Budzynski et al., 2019).

RRS should not be treated as elements of traffic layout or only considered at the last stage of the design when safe solutions can no longer be applied (Antoniuk, 2017). Designs for RRS are based on parameters such as vehicle type, as well as specific requirements (speed, containment level, working width, angle of impact and vehicle trajectory). Effective RRS are designed to successfully handle vehicle impact as the main purpose of a RRS is to protect road users (and roadside users) from fatal and significant injury (Antoniuk, 2017). RRS as the basic active road safety device **should respond to the level risk** to traffic safety and roadside hazards, taking in consideration the road environment, traffic, and operating speeds.

4. INTERNATIONAL GUIDELINES AND STANDARDS FOR RRS

4.1 Introduction

The European Norm (EN) 1317 and the Manual for Assessing **Safety** Hardware (MASH)norm represent the highest international standards for safety barriers and define common testing and certification procedures (Stopel, 2021). To be installed, safety barriers must meet the requirements of the EN 1317 or MASH and must successfully pass crash tests, whose parameters and acceptance criteria are defined by these norms (Amato, 2013). Both norms define guidelines for crash tests of safety barriers and specify evaluation criteria for assessing test results.

EN 1317 and MASH enable containment level comparison of different systems. Classifying safety barriers not only according to their ability to restraint errant vehicles but also according to risk of injury to vehicle occupants and vulnerable road users (Impact Severity Level) and space requirements in case of vehicle impact (Working Width). As such these norms enable:

- Professional, easy, and independent classification of safety barriers based on performance.
- Comparison with different suppliers and achieve the best return on investment.
- Increased safety barrier quality and reduced number of deaths on roads.

4.2 European Standards

4.2.1 European Standard 1317 for Road Restraint Systems

The European Norm 1317 for Road Restraint Systems was created in 1998 and lays down common requirements for the testing and certification of road restraint systems in all countries that adopts standards from the European Standards Committee (CEN), (Hernández, 2018). As of 1 January 2011, all RRS sold within the European Union (EU) need to be certified with a CE marking (CE appear on products that are traded on the single market in the European Economic Area or EEA). This is an obligation stemming from provisions of the European Constructions Products Regulation (305/2011/EU-CPD) as stipulated in Annex ZA of EN 1317-5. The entry into force of the Regulation meant an end to the three-year transition period during which the EN 1317 and respective national norms coexisted. The introduction of EN 1317 represents a meaningful change in terms of safety and quality for European drivers insofar that it establishes an EU market based on performance, replacing previous ‘prescriptive based systems based on empirical experience’. In practical terms, this means first, that new barriers placed on European roads can offer guaranteed levels of safety and secondly, that the level of guarantee is the same across the whole of the EU, i.e., a single market for safety barriers. Conformity assessment requirements for restraint systems like safety barriers, crash cushions are specified in EN 1317 standard (Stopel, 2021).

4.2.2 European Union standard (EN) 12767

EN 12767 specifies a method for assessing the passive safety properties of supporting structures such as lighting poles, signposts, supports for road signs, structural elements, foundations, and any other components used as roadside equipment. EN 12767 specifies performance requirements and defines levels in passive safety terms intended to reduce the severity of injury to the occupants of vehicles impacting with the permanent road equipment support structures. Consideration is also given to other traffic and pedestrians. Three energy absorption types are considered and test methods for determining the level of performance under various conditions of impact are given. This European Standard excludes vehicle restraint systems, noise barriers and transilluminated traffic bollards. It also excludes temporary traffic control devices (Stopel, 2021).

4.3 United States of America Guidelines

4.3.1 Manual for Assessing Safety Hardware and National Cooperative Highway Research Programme Report 350

The United States of America’s Manual for Assessing Safety Hardware (MASH) is an update to and supersedes National Cooperative Highway Research Programme (NCHRP) Report 350, *Recommended Procedures for the Safety Performance Evaluation of Highway Features*, for the purposes of evaluating new safety hardware devices. NCHRP 350 contains recommended crash-testing procedures for evaluating a variety of roadside safety hardware, including traffic control devices that are used in work zones. MASH testing procedures allows for testing of road restraint systems against heavier vehicle impacts, not necessarily addressed in EN1317.

4.3.2 AASHTO Roadside Design Guideline (2011)

The fourth edition of the American Association of State Highway Transportation Officials (AASHTO) Roadside Design Guideline (2011) presents a synthesis of information and operating practices related to roadside safety. The Roadside Design Guideline forms the basis of a written policy that needs to be prepared by each state highway agency for designing roadsides that incorporate wide clear zones, traversable drainage structures, and breakaway sign and lighting support structures in new construction and reconstruction, to the extent practicable. The roadside policy should also describe how other hazards may be relocated, modified, shielded, or delineated. There is currently a process underway to update the guideline (5^{th} addition) to ensure a focused approach to roadside safety.

5. SOUTH AFRICAN GUIDELINES AND STANDARDS FOR RRS

5.1 South African National Standard (SANS) 51317 - Road Restraint Systems

South Africa adopted the European Standard (EN 1317:2010) published in 2022 as South African National Standard (SANS) 51317. The purpose of the standard is to provide guidance on the improving and maintaining roadside safety where the design of safer roads requires, on certain sections of road and at locations, the installation of road restraint systems. These road restraint systems are designated to redirect errant vehicles with a specified performance level and can provide guidance for pedestrians or other road users. The standard identifies test methods and impact test acceptance criteria that the products for road restraint systems need to meet to demonstrate compliance with the requirements. The design specification, for road restraint systems entered in the test report, identify important functional site conditions in respect of the test installation. The performance range of the products for road restraint systems, designated in this standard, enables national and local authorities to recognise and specify the performance class to be deployed. The three main criteria in EN 1317 or SANS 51317 are Containment Level, Working Width, and Impact Severity Level.

5.1.1 Containment Level

The standard classifies Vehicle Restraint Systems into Containment Levels which express the ability of the restraint system to hold vehicles back. The Containment Level, along with the Working Width and Impact Severity, is determined with up to three crash tests with defined weights, speeds, and impact angles for the test vehicles. The EN 12767 standard states that crash tests should be carried out in the range of two velocities and that the choice of velocity classes are 50, 70, and 100 km/h[1]. The velocity class should be selected appropriately to the place of application of the designed structure. For each of the selected velocity classes, the level of impact energy absorption is determined separately. For the speed class of 100 km/h-1, crash tests at 35 and 100 km/h-1 should be carried out. The standard defines three classes of energy absorption namely:

- NE – no energy absorption.
- LE – low level of absorption.
- HE – high level of absorption.

Contrary to what it might seem, the highest level of safety according to the provisions of the standard is ensured by structures that do not absorb the impact energy. They should be the smallest obstacle for the vehicle, which is equipped with active passenger safety systems. It is the opposite assumption in relation to road restraint barriers, which are to prevent vehicles from leaving the track. The basis for assessing the needs should be the crash experience of the immediate area and the specifics for the cause(s) of the crashes (Amato, 2013). Table 1 provides detail on containment level tests and the conditions where tests may be applicable. There may be times when no causative factor can be isolated, and sound engineering judgment must be applied.

Table 1: Containment levels (TMH24, 2022; Butāns et al., 2015)

Containment Level		Test	Vehicle Type	Mass (Kg)	Speed (Km/h)	Angle (degrees)	Application
LOW ANGLES	T1	TB21	Car	1300	80	8	N/A. * Vehicle mass not representative
LOW ANGLES	T2	TB22	Car	1300	80	15	N/A. * Vehicle mass not representative
LOW ANGLES	T3	TB41 + TB21	SU + Car	10000 + 1300	70 + 80	5 + 8	Roadworks 80 km/h urban arterials
Containment Level		**Test**	**Vehicle Type**	**Mass (Kg)**	**Speed (Km/h)**	**Angle (degrees)**	**Application**
NORMAL	N1	TB31	Car	1500	80	20	Roads with speeds limit ≤ 80 km/h, except locations where heavy vehicle risk has been identified
NORMAL	N2	TB32 + TB11	Car + Car	1500 + 900	110 + 100	20	Roads with speed limits > 80 km/h, except locations where heavy vehicle risk has been identified
Containment Level		**Test**	**Vehicle Type**	**Mass (Kg)**	**Speed (Km/h)**	**Angle (degrees)**	**Application**
HIGH	H1	TB42 + TB11	SU + Car	10000 + 900	70 + 100	15 + 20	Roads with speed limits <80 km/h at locations where truck risk has been identified, but articulated trucks are not expected
HIGH	H2	TB51 + TB11	Bus + Car	13000 + 900	70 + 100	20 + 20	Special applications at locations where heavy buses have been identified as dominant design vehicle
HIGH	H3	TB61 + TB11	SU + Car	16000 + 900	80 + 100	20 + 20	Locations where truck risk has been identified and where large articulated trucks are not expected
VERY HIGH	H4a	TB71 + TB11	SU + Car	30000 + 900	65 + 100	20 + 20	Special applications at locations where 30t rigid heavy vehicle type is dominant
VERY HIGH	H4b	TB81 + TB11	Articulated truck + Car	38000 + 900	65 + 100	20 + 20	Locations where heavy truck risk has been identified, e.g., bridge piers

* Test facilities will use cars that is available to them. Since it is not possible to test all cars on the road the most normal car or everyday car will be used for the test.

5.1.2 Working Width

The working width (W) measures the space needed behind the barrier for the system to function properly in case of impact. W is the distance between the front side of the undeformed barrier and the rearmost part of the deformed barrier after impact.

TMH 24 states that Working Width is the dynamic deflection of a test vehicle during the test procedure. The Working Width of a barrier at a roadside feature should be specified to avoid a collision between vehicles and the feature that is being protected (Table 2).

Table 2: Working width

Category	Deflection
W1	W </ 0.6 meters
W2	W </ 0.8 meters
W3	W </ 1 meters
W4	W</1.3 meters
W5	W</1.7 meters
W6	W</2.1 meters
W7	W</2.5 meters
W8	W</2.5 meters

5.1.3 Impact Severity Level

The Impact Severity Level assesses the risk of injury to the occupants of a passenger car during impact with a barrier. It is determined based on values calculated from data provided by sensors on the test vehicle during the 100 km/h impact. Impact Severity is calculated by assessing the acceleration Severity Index (ASI), the Theoretical Head Impact Velocity (THIV), and the Post-impact Head Deceleration (PHD). Both EN 1317 and EN 12767 classify the construction to a proper safety class according to the values of ASI and THIV parameters and vehicle velocity loss (Stopel, 2021). In a crash test, the combination of these results gives a severity grade A, B or C (Table 3).

Level A indicates higher safety for vehicle passengers than level B, and B higher safety than level C (Stopel, 2021). If ASI exceeds 1.0 and 1.4 then it is considered that the impact event has dangerous or lethal consequences for the passengers. For THIV, the occupant head is a freely moving object that, as the vehicle changes its speed during contact with the road barrier, continues moving until it strikes a surface within the interior of the vehicle. The PHD describes the head deceleration after this impact. In this scale, grade A means low severity, with the THIV, ASI and PHD parameters lying below the human injury limits (Neves, 2018). Grades B and C implies higher severity injuries or even lethal consequences to the car occupants.

Table 3: Severity Index (Neves 2018)

Severity Grade	Severity Parameters
A	ASI ≤ 1.0
B	1.0 < ASI ≤ 1.4 T HIV ≤ 33km/h P HD ≤ 20g
C	1.4 < ASI ≤ 1.9

5.2 Draft Standard Specifications for Road and Bridge Works for South African Road Authorities Chapter 11: Ancillary Road Works (4) Road Restraint Systems

The Committee of Transport Officials (COTO) Draft Standard Specifications for Road and Bridge Works for South African Road Authorities (DSS, 2020), *Chapter 11: Ancillary Road Works, Section 11.4 Road Restraint Systems* provide guidance in terms of the “supplying, installing and maintaining of various types of Road Restraint Systems (RRS) at locations in accordance with the specifications and details, dimensions and design shown on the drawings; or specified by the Engineer; or as specified by the performance based system manufacturer” (Committee of Transport Officials, 2020). There are two types of RRS, namely Vehicle Restraint Systems (VRS) and Pedestrian Restraint Systems (PRS), these systems may either be rigid, semi rigid, or flexible, with transitions between types of RRS. Vehicle Restraint systems are divided into systems that are based on:

a) Method specification timber post systems with elements conforming to SANS 1350 (provision of guardrails) and other SANS compliant material requirements and installation specifications; or concrete barrier systems detailed in the Contract Documentation; or

b) Performance based systems where the installation shall conform to EN 1317 (Parts 1 to 8) and/or AASHTO MASH or NCHRP350 as alternative where no MASH product is available.

5.3 South African Road Restraint Manual (TMH 24, 2022)

5.3.1 Theoretical Basis

Technical Methods for Highways (TMH) 24, published in 2022 is part of the South African Road Safety Manual (SARSM) series of documents that have been developed to assess or audit road safety conditions, identify areas that require improvement and provide guidance to improve road safety on the South African road network, including the installation of RRS. The guidelines (TMH 24) are currently under review in accordance with the Committee of Transport Officials (COTO) process. Technical Methods for Highways (TMH 24) consists of two volumes compiled under the auspices of the Committee of Transport Officials (COTO). TMH (24), aims to prescribe a uniform approach for the assessment and the treatment of roadside risk through the provision of roadside hardware that can minimise the occurrence of fatal and severe injuries. TMH 24 Volume II provides detailed design parameters for different RRSs that fall under South African National Standards (SANS) 51317 which is based on the European Norm (EN) 1317:2010.

Volume I offers an overview of assessing and addressing roadside hazards and the protection of road users. On existing roads, improvement of roadside-safety includes removing or treating hazards that may result in a crash or contribute to the severity of a crash into of hazards in the adjacent-to-existing-road environment that need to be considered strongly for removal, especially trees. In the case of new roads, a safer roadside is achieved by ensuring that an adequate clear zone is provided immediately adjacent to the road. This clear zone is free of obstacles and designed so that drivers can regain control of their vehicles.

Volume II provides guidance on standards that any RRS must comply with and the requirements that they need to fulfil. Volume II provides detailed design parameters for different RRSs that will fall under the proposed South African National Standards (SANS) 51317 which is based on the EN1317:1998 and the current SANS 1350: Guardrails for roads (W-section) standards.

5.3.2 Risk Assessment Procedure for South Africa (TMH 24, 2022)

The Risk Assessment Procedure for South African (RAPSA) is based on the NetSafe Highway Safety Model (2019) developed as a safety model and implemented by SANRAL in the South African Road Design System. The NetSafe model utilises a model for the estimation of accident rates and frequencies. The accident rates are modelled in terms of various road and environmental characteristics. These are not the only factors that affect accident rates, but for highway evaluation and analysis, a proportion of the accident rates can be explained in terms of these road-related factors. RAPSA, was developed as part of the TMH 24 to conduct risk assessments on either uniform sections of a road project or single positions on the road network. RRS systems ruled by the policy are first implemented during the design process, followed by analysing the remainder of situations via the RAPSA.

6. GUIDANCE ON ROADSIDE PROTECTION OF VULNERABLE ROAD USERS IN SOUTH AFRICA

6.1 Vulnerable Road User Protection

Guard rails should be used where there is a reasonable possibility of an errant vehicle encroaching into an unprotected area used by pedestrians. South African authorities and planners define the safety barrier performance level on facts like application (temporary, permanent, highway, bridges etc.), local conditions (traffic intensity, speed limits, percentage of trucks etc.) and the available space. However, current practice dictates that most off the road agencies designs, and typical drawings only refer to guardrail to be used and this leaves the design engineer with little to work with. In most cases this will become an afterthought and the designer will just specify guardrail as a protective system between pedestrians and vehicles. Standard drawings from the South African National Roads Agency Limited (SANRAL) that date back to the 1950’s are used to inform the development of specifications. However, this standard does not consider containment level and working width. In addition, standard drawings only make provision for guardrails that deflects vehicles 1.9 meters with no consideration towards vulnerable road users placed directly behind the guardrails (steel W beams).

SANS 51317 and Chapter 11: Ancillary Road Works (4) Road Restraint Systems provide information and guidelines regarding the implementation of RRS. However, the designer of the road determines the threshold of the level of risk as well as performance based systems criteria which are specified in the specifications, measurement, and payment section of contracts/tender. The predefined specification obligates the Contractor responsible for execution of the work to provide a road restraint system which is fully compliant with performance based specifications of EN1317 and/or AASHTO MASH and more recently SANS 51317. In addition, Chapter 11 does not yet consider pedestrian restraint systems and pedestrian protection are currently covered by standard drawings which do not take suitability of the barrier into account. Chapter 11.4.5. indicates that temporary work zone protection devices need to be crash tested however in practice, the bill of quantities and traffic accommodation drawings make no provision for protecting road workers.

6.2 Examples of Current Practice

Many countries lack clear regulations and standards on RRS. Stopel (2021) indicates that the specifications are usually defined in tender documents according to mechanical and geometrical properties like height, shape, and material.

Examples how safety barriers would be specified within tender documents according to EN 1317 are:

- H2 | W2 | ASI B for central reserve applications.
- H4b | W2 | ASI B for bridge applications.
- T3 | W2 | ASI A for temporary work zone applications.

Guardrails as per standard drawings on most road agencies, is on wooden posts, this design came out in 1956 and is tested to a N2 W7 if the wooden post is installed as per crash test. The illustrated method of installing a kerb and then guardrail is an incredibly old and costly method and will not protect the VRU against most vehicles using the road, to give them the best chance of staying save new and approved ways of analysing and designing sidewalks.

Guardrail on wooden post as installed in Figure 1 is standard practice because all the drawings state this system and means of installation. If a designer analysed the crash test of a guardrail having a containment level of N2 and a working with of W7 you will find that N2 is a 1500kg car traveling at 110 km/h and impacting the system at a 20 degree angle, this relates to 82kJ of kinetic energy impacting the system. This brings the practitioner to the working width of W7, where there is a collision a 1500kg car will move the system 2,5 meters under these crash test conditions, Figure 1 shows that the pedestrians will be seriously injured and planning to protect VRUs should be a priority.

Figure 1: Defective guardrail installation - offering no protection to VRUs

A proper road audit needs to be conducted, which will indicate the type of vehicles that use the road. With this information a proper design can be implemented with the proper working width and containment level being considered and then installing the correct crash tested VRS, as indicated in Figure 2.

Figure 2: Examples of correct crash tested and installed VRS that offer protection to VRUs

The next figures will show some alternative methods of thinking about VRU protection.

Figure 3: DB80 VRS and crash tested steel systems

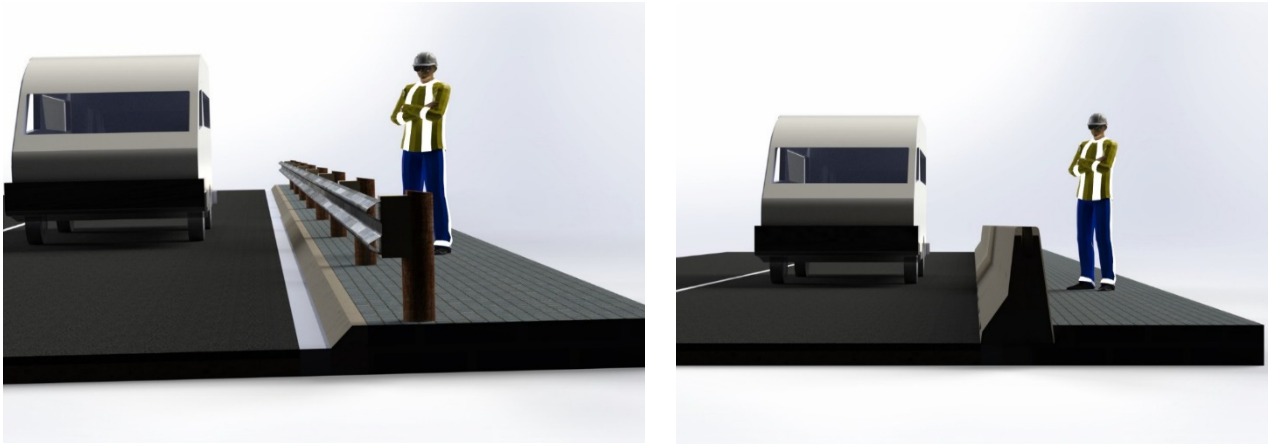

Figure 4: Guardrail N2 W7 vs DB80AS without Kerb H1 W1

7. CONCLUSION

It is accepted in road design that no road is entirely safe because, inherent to the driving task, there is the constant risk of damage to property or injury to persons. The aim of RRS is to contain and redirect errant vehicles to avoid injury to occupants and reduce the damage to vehicles and infrastructure (SARRSM, 2022). RRS (both vehicle and pedestrian restraint systems) forms a vital part of the road planning and design process and requires detailed knowledge of civil, transportation and traffic engineering, and road safety principles. A reasonable engineer needs to practically analyse a road and all road hardware and obstacles to make the best decision to keep the road user safe and plan for all potential accidents that may occur. Protecting pedestrians should, in line with the Safe System Approach be a priority for any consulting engineer.

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