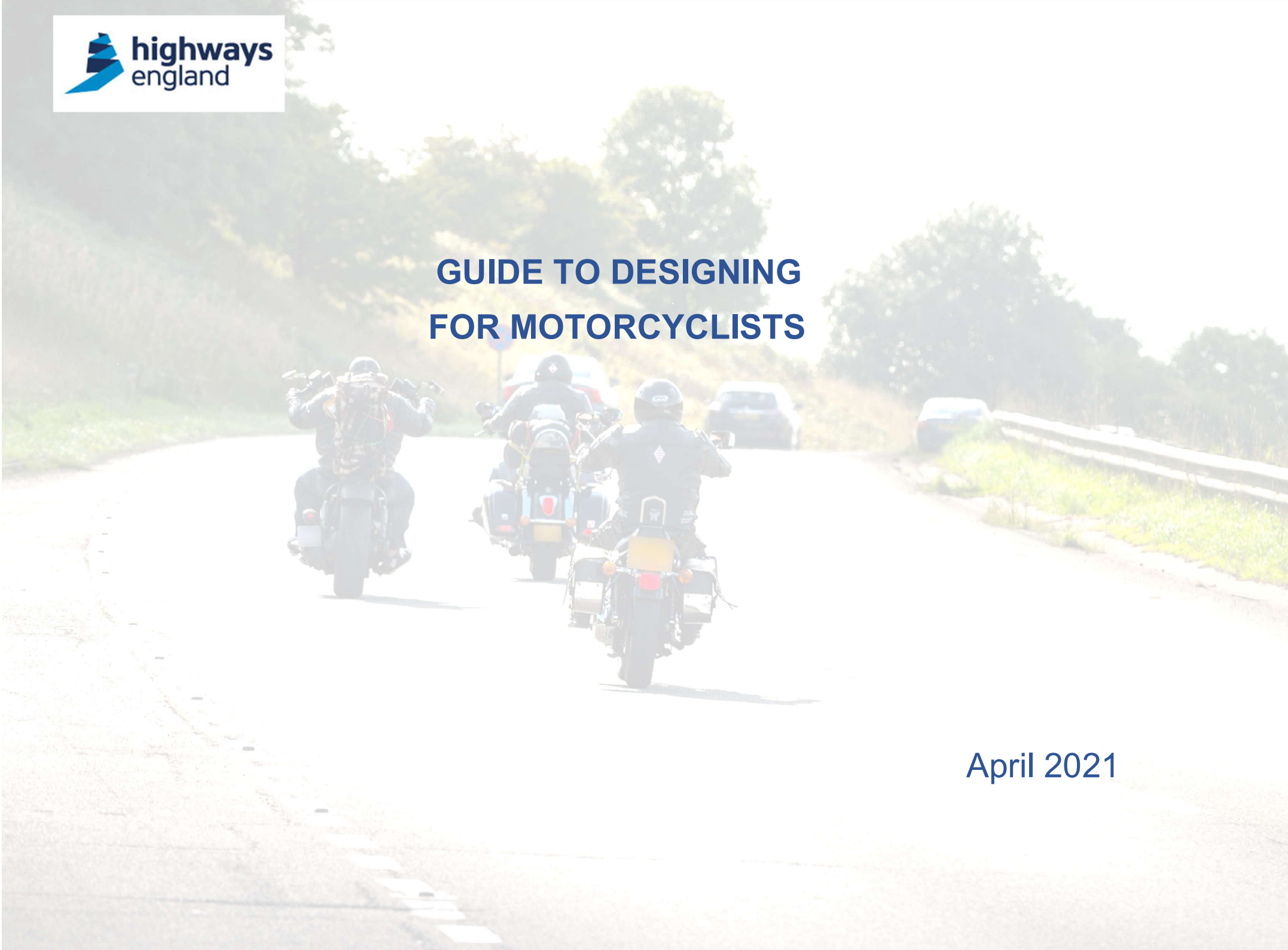
highways england

GUIDE TO DESIGNING FOR MOTORCYCLISTS



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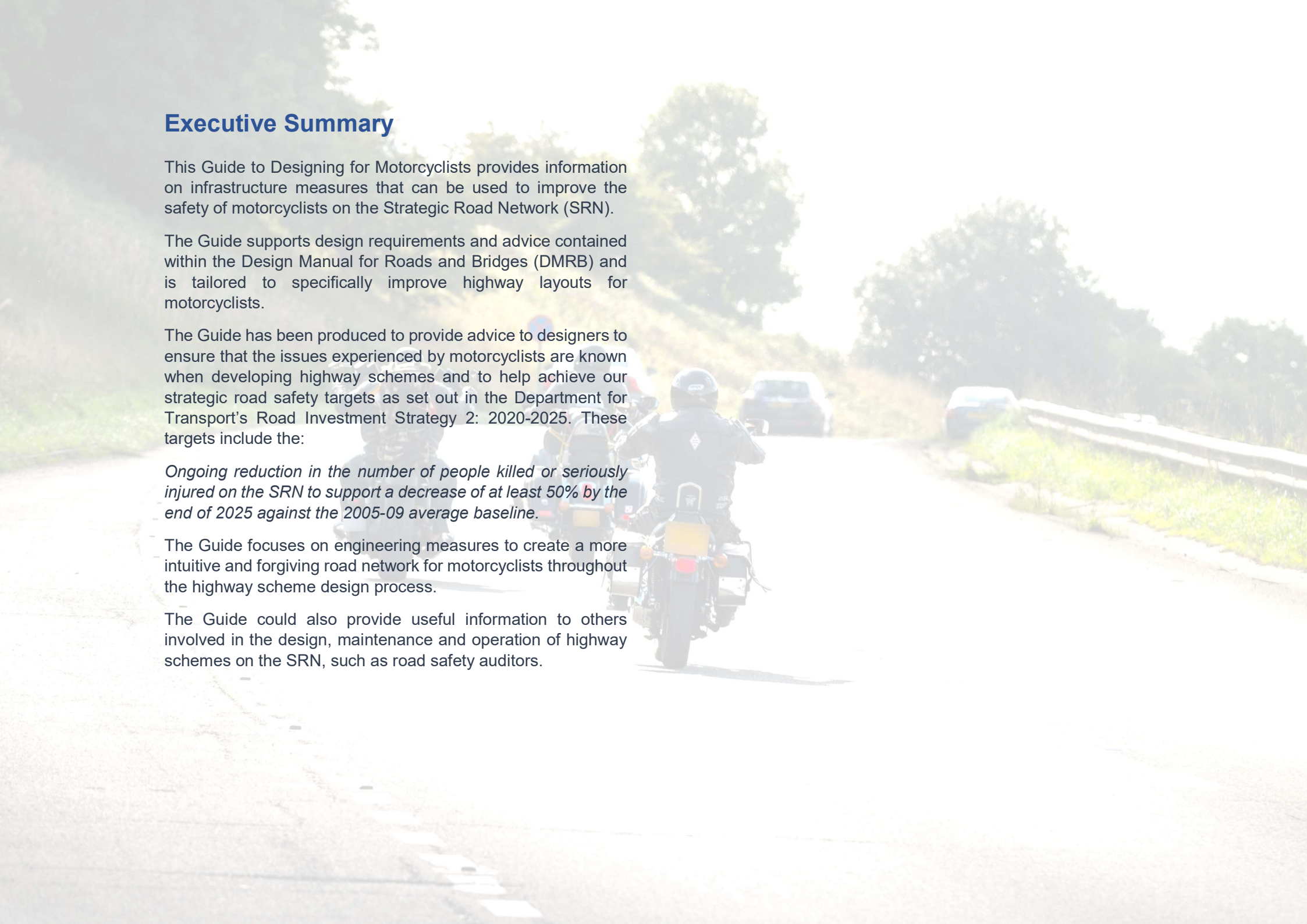
Contents



Executive Summary

This Guide to Designing for Motorcyclists provides information on infrastructure measures that can be used to improve the safety of motorcyclists on the Strategic Road Network (SRN).

The Guide supports design requirements and advice contained within the Design Manual for Roads and Bridges (DMRB) and is tailored to specifically improve highway layouts for motorcyclists.

The Guide has been produced to provide advice to designers to ensure that the issues experienced by motorcyclists are known when developing highway schemes and to help achieve our strategic road safety targets as set out in the Department for Transport's Road Investment Strategy 2: 2020-2025. These targets include the:

Ongoing reduction in the number of people killed or seriously injured on the SRN to support a decrease of at least 50% by the end of 2025 against the 2005-09 average baseline.

The Guide focuses on engineering measures to create a more intuitive and forgiving road network for motorcyclists throughout the highway scheme design process.

The Guide could also provide useful information to others involved in the design, maintenance and operation of highway schemes on the SRN, such as road safety auditors.

Background

Highways England has made a commitment to improve safety for motorcyclists across our network. As a result of working collaboratively with motorcycle and road safety groups, Highways England has identified a range of engineering issues that can impact motorcycle safety. This Guide draws on some of these issues and presents designers with ideas of how to mitigate them.

Highways England goals and targets

The Department for Transport's Road Investment Strategy 2: 2020-2025 sets out the vision to continue towards the goal of 'Zero Harm', aiming to bring the number of people killed or seriously injured on the SRN to a level approaching zero by 2040.

One of the key performance indicators of the strategy is the ongoing reduction in the number of people killed or seriously injured (KSI) on the SRN to support a decrease of at least 50% by the end of 2025 against the 2005-09 average baseline.

This is supported by a set of performance indicators (PIs) which will help capture performance, including 'the number of non-motorised and motorcycle users killed or seriously injured on the SRN.'

Motorcyclist collisions

Data from 2019 highlights that motorcyclists can be vulnerable in a collision and that they remain over represented in collision data on the SRN when the proportion of motorcyclists on the network is taken into consideration.

In 2019:

- there were 668 recordable collisions reported on the SRN involving a motorcycle which resulted in:
    - 30 motorcyclists killed,
    - 305 motorcyclists seriously injured, and
    - 359 motorcyclists slightly injured.
- motorcyclists accounted for 380 million vehicle miles travelled on the SRN out of a total of 96.8 billion vehicle miles;
- motorcyclists accounted for 0.4% of total vehicle miles travelled per year on the SRN;
- motorcyclists accounted for 14.3% of fatalities and 17.2% of KSI casualties on the SRN; and,
- the motorcyclist KSI rate was 88.16 casualties per hundred million vehicle miles.

This emphasises the importance that designers understand the issues faced by motorcyclists so that this user group is not disadvantaged by design decisions.

Introduction

Purpose of the Design Guide

The purpose of the Guide is to provide a central location for motorcycling-specific road safety advice to aid designers when preparing schemes for implementation on the SRN.

The Guide provides advice to designers that is specific to motorcycling safety; the aim being to ensure that issues faced by motorcyclists are known when highway schemes are designed. The Guide is divided into three sections providing information on the following highway features:

- **Features on the carriageway** – carriageway features can include utility covers, road markings and surface treatments, all of which can affect motorcycle stability.
- **Roadside features** – these are physical objects in the verge that can increase the severity of a collision such as trees, vegetation, posts and vehicle restraint systems.
- **Highway features** – these are specific elements of the highway such as bends and junctions where motorcyclists may be vulnerable to a collision.

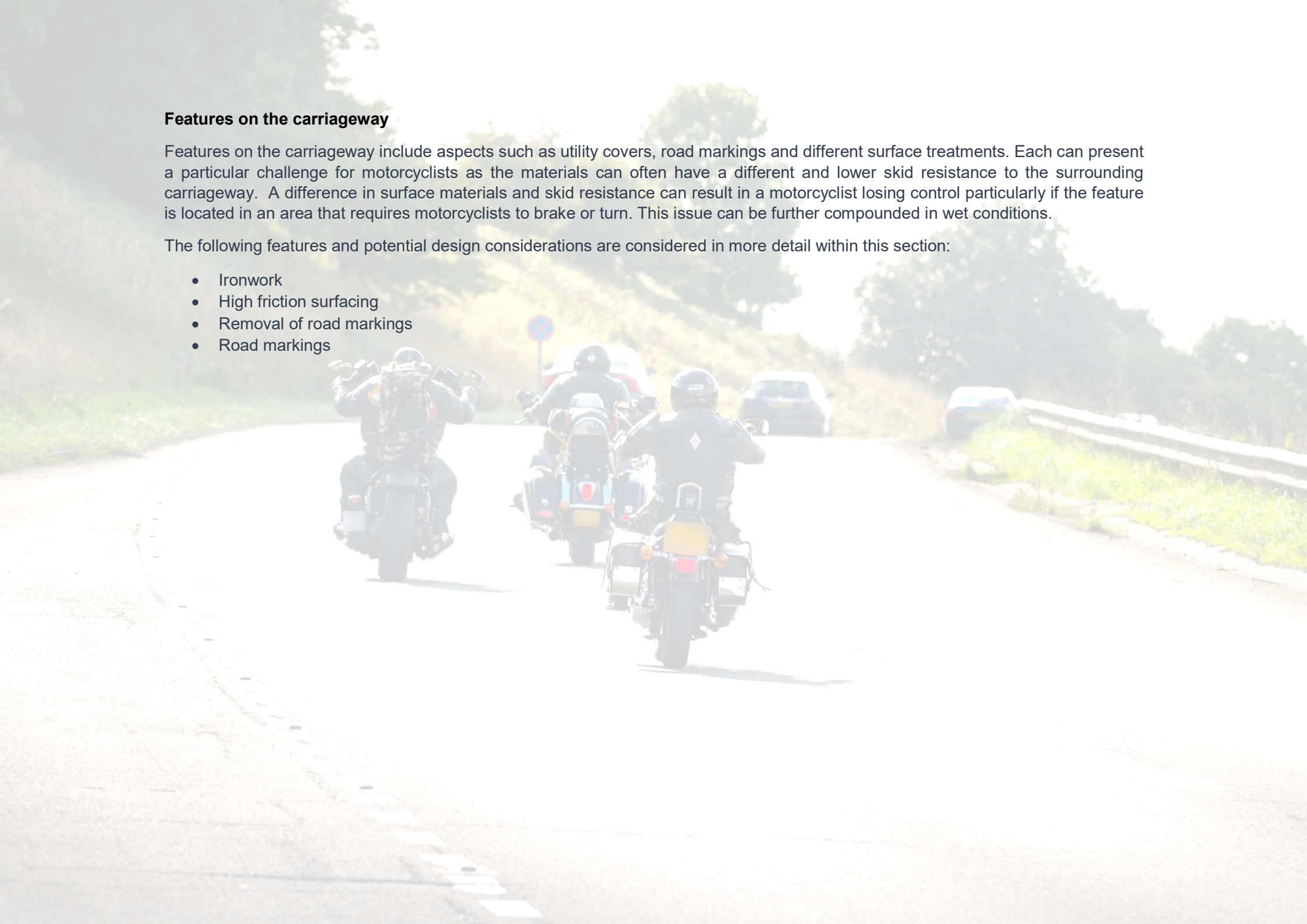
Within these sections various issues are described that impact on motorcycle safety. Relevant mitigation measures are then identified that can help reduce the risk to motorcyclists.

Features on the carriageway

Features on the carriageway include aspects such as utility covers, road markings and different surface treatments. Each can present a particular challenge for motorcyclists as the materials can often have a different and lower skid resistance to the surrounding carriageway. A difference in surface materials and skid resistance can result in a motorcyclist losing control particularly if the feature is located in an area that requires motorcyclists to brake or turn. This issue can be further compounded in wet conditions.

The following features and potential design considerations are considered in more detail within this section:

- Ironwork
- High friction surfacing
- Removal of road markings
- Road markings



Ironwork

Issue:	Motorcyclists are vulnerable to skidding on ironwork as the ironwork can have a lower skid resistance than the surrounding carriageway. Where there is a sudden change in road surface properties, such as on ironwork, this can lead to stability issues for motorcyclists. The locations that are most problematic are where a cover is located within the riding line in areas where a motorcyclist is likely to brake, turn, accelerate and/or change lane. This can be a particular issue on bends and at junctions and roundabouts.
Treatment:	Historically ironworks were located within the carriageway. However, DMRB CD 534 Chamber tops and gully tops for road drainage and services now stipulates that, '*New chamber tops shall not be installed in carriageways including hardstrips, hard shoulders and central reserve crossovers of motorways and all-purpose trunk roads.*' Designers need to comply with this requirement ensuring that the location of ironworks is carefully considered during initial design stages. DMRB CD 534 also provides requirements and advice when chamber tops are already located in the carriageway, stating that these should be relocated where practicable. However, if it is an all lane running scheme involving hard shoulders being used as running lanes then existing chamber tops shall be removed.  Where there are existing chamber tops that cannot be practically moved, then the polished skid resistance value (PSRV) should match the surrounding carriageway and not be less than 60 PSRV.
Design considerations:	Do not position ironwork in the carriageway. Relocate ironwork where practicable. Where a chamber top is retained within the carriageway, the cover should be skid resistant to a value that matches the surrounding carriageway and not be less than 60 PSRV.
References:	DMRB CD 534 Chamber tops and gully tops for road drainage and service.

High friction surfacing

Issue:	High friction surfacing (HFS) is a surface treatment that provides an enhanced level of skid-resistance and is typically applied on the approaches to signal controlled junctions, roundabouts, tight radius bends and pedestrian crossings. Where there is a transition from a high friction surface to a standard road surface, motorcyclists will experience a reduction in grip between the tyres and the carriageway. This may not be a problem on straight sections of carriageway but, if the HFS ends on a bend, a change in the road surface friction can destabilase a motorcyclists. Where HFS is terminated is partly down to engineering judgement therefore it is important that the surfacing extends to a point where the hazard has diminished. An example of this is on the exit from a bend where the extension of the HFS by a matter of metres can move the transition point beyond the bend and onto a straight section of carriageway. This can be a simple but effective measure to assist motorcyclists.
Treatment:	Designers need to specify appropriate friction characteristics for carriageway surfacing depending on the nature of the road environment at each location. This includes where motorcyclists and other road users are accelerating, braking and cornering. DMRB CD 236 Surface course materials for construction provides information on the permitted surface course for given intervention levels (IL), traffic flows and site categories. HFS is permitted at the following site categories subject to given IL and traffic flows: • approaches to and across minor and major junctions, approaches to roundabouts and traffic signals • approaches to pedestrian crossings and other high-risk situations • gradients greater than 5% and longer than 50m • bend radii less than 500m on carriageways with one-way traffic or two-way traffic To note, HFS is not permitted on the circulatory sections of roundabouts, even if traffic signal controlled. DMRB CS 228 Skidding resistance provides information on the minimum application lengths of HFS on the approach to a hazard. This length can be extended when justified by local characteristics which includes extending the surfacing beyond the bend.
Design considerations:	Follow the requirements for the use of HFS in CD 236 and CS 228, and ensure the HFS is applied beyond the bend.
References:	DMRB CD 236 Surface course materials for construction. DMRB CS 228 Skidding resistance.

Removal of road markings

Issue:	As highway layouts change, road markings are repeatedly renewed or surface dressing is applied over old markings. This can lead to an accumulation of road markings and surface dressing treatments which can destabilise motorcyclists particularly if this results in standing water. Similarly, masking of redundant markings can also result in a higher upstand and create areas of surfacing with different skidding resistance. Designers and maintenance organisations should be aware that Regulation 10 of the Traffic Signs Regulations and General Directions states that no road marking may project above the surface of the adjacent carriageway by more than 6mm at any point except where a provision to that effect is made elsewhere in the Regulations.
Treatment:	When introducing, amending or renewing road markings it is best practice to remove the previous road markings entirely to eliminate the risk of a build-up of material. Removal of road markings should be in accordance with Series 1200 of MCHW.
Design considerations:	Avoid the build-up of surfacing and road markings which can result in raised areas within the carriageway.
References:	Series 1200 of MCHW The Traffic Signs Regulations and General Directions 2016. BS EN 1436:2018 Road marking materials – Road marking performance for road users and test methods.

Road markings

Issue:	Road markings on the carriageway can destabilise motorcyclists because they can have a lower skid resistance than the adjacent carriageway. Extensive coverage of road markings, particularly at complex decision points such as roundabouts or junctions, can create a skidding risk to motorcyclists as they are often located where motorcyclists are accelerating, braking or turning.
Treatment:	When introducing road markings it is good practice to locate them away from where motorcyclists are likely to be accelerating, braking or turning. Road markings with an improved skid resistance similar to that of the adjacent carriageway could be considered where the road marking is considered necessary. Methyl Methcrylate (MMA) road markings offer a number of benefits over thermoplastic road markings including an improved skid resistance, durability at high stress locations such as roundabouts and junctions and higher visibility at night. There are some disbenefits around application of MMA, including 'greying' of the marking over time due to trafficking and the retroflective performance.  Designers need to take a balanced approach when considering road markings and use different types of road marking dependent on the site and the potential skidding risk to motorcyclists.
Design considerations:	Minimise or avoid large areas of road markings. Consider the use of road markings with a higher skid resistance value.
References:	The Traffic Signs Regulations and General Directions 2016. BS EN 1436:2018 Road marking materials – Road marking performance for road users and test methods.

Roadside features

Roadside features are objects in the verge such as trees, vegetation, posts and vehicle restraint systems which can present a hazard to motorcyclists. This is often because motorcyclists become separated from their vehicle in the event of a collision or loss of control and are then at risk of coming into conflict with a feature in the roadside.

Collision data for the SRN between 2015 and 2019 inclusive, indicates that 60% of all collisions which involved a motorcyclist colliding with a feature in the roadside, such as signs, lighting columns, telegraph or electricity poles and trees, resulted in fatal or serious injuries. For the same period, collisions involving cars colliding with a roadside feature resulted in 30% fatal or serious injuries. This demonstrates the vulnerability of motorcyclists when roadside features are present.

Designers need to understand and apply good road safety practice to manage roadside risks for all road users. The following steps are a useful design tool to ensure that the concerns of motorcyclists are included when a roadside feature is being considered:

Remove the hazard

Relocate the hazard

Reduce the hazard

Protect the hazard

The following features and potential design considerations are considered in more detail within this section:

- Features in the verge - vegetation
- Features in the verge - signs and other road furniture
- Vehicle restraint systems

Features in the verge - vegetation

Issue:	Whilst vegetation is often planted when trees and hedgerows are saplings, eventually they will mature and become an immovable object. As such, vegetation in the verge can create a serious and fatal hazard for motorcyclists in the event that they lose control and leave the carriageway. Between 2015 and 2019, 11 motorcyclists collided with trees, 9 of which resulted in the motorcyclist being killed or seriously injured. This highlights that although the occurrences are small in number, the impact can be severe. Mature vegetation can also impact on visibility splays and sight lines and restrict other road users view of approaching motorcyclists and/or limit road users awareness of the approaching road layout.
Treatment:	Road landscapes should aim to fit with the local landscape character, and this will include reflecting the predominant vegetation patterns and species. This is important not only for reducing the impact of the road corridor on the landscape but also in benefiting the road user experience. However, planting design also needs to take into account safety requirements as well as longer term maintenance, management of these areas, the nature of the road corridor that it is intended for, and operational requirements. DMRB LA 117 Landscape design provides requirements and advice for the planting of shrubs and trees adjacent to the highway and advises that: • shrubs used in edge planting are not planted within 4.5m from the edge of the carriageway • medium size trees (tree girth less than 450mm) no closer than 7m from the edge of the carriageway (i.e. Malus sp, Prunus sp) • larger trees (tree girth greater than 600mm) not within 9m from the edge of the carriageway (i.e. Quercus sp, Fagus sp.) Therefore designers should try and ensure that the immediate area adjacent of the carriageway is free from vegetation which could result in serious or fatal injuries to motorcyclists.
Design considerations:	Follow the advice of LD 117 Landscape design for the planting of shrubs and trees.
References:	DMRB LD 117 Landscape design

Objects in the verge - signs and other road furniture

Issue:	Verges can have signs, lighting columns and other road furniture within them which if poorly located can result in injuries if struck by a motorcyclist. Introducing these structures as passively safe can provide an important tool in reducing the severity of vehicle related collisions, however the standard for testing passively safe features does not take into account motorcycles or motorcyclists. BS EN 12767:2019 Passive safety of support structures for road equipment, which includes the test method for determining the performance of road equipment support structures, dictates that the test vehicle is a standard passenger car. Consequently, locating a traffic sign on the outside of a bend and specifying that it will be passively safe is likely to reduce the consequences for an errant vehicle leaving the carriageway and then striking the sign. However, if that vehicle is a motorcycle and the motorcyclist is the object striking the sign then it is likely to result in an injury collision. As a result, designers need to take into account that passively safe road furniture may not perform in the same manner when hit by a motorcycle or motorcyclist. These structures may not shear or deflect, potentially resulting in higher severity injuries for this group of road users. The use or need for this infrastructure should be carefully considered.
Treatment:	When developing highway schemes that incorporate roadside furniture the positioning of these features needs to be carefully considered. Designers need to understand and apply good road safety practice to manage roadside risks for all road users. The principle of remove, relocate, reduce and protect the hazard ensures that the concerns of motorcyclists are included when introducing road equipment support structures into a design.
Design considerations:	Remove or minimise the occurrence of objects in the verge. Position signs and other road furniture as far back as possible in the verge. Consider the use of passively safe road furniture. Avoid placing road furniture on the outside of bends.
References:	BS EN 12767:2019 Passive safety of support structures for road equipment. Requirements and test methods. DMRB CD 377 Requirements of road restraint systems DMRB CD 354 Design of minor structures

Vehicle Restraint Systems

Issue:	The objective of installing a vehicle restraint system (VRS) is to contain and redirect errant vehicles so that they do not cross central reservations into the path of other vehicles, or impact/enter into roadside hazards. Motorcyclists are vulnerable to injury when they strike post and rail VRS because the gap beneath the beam can allow a motorcyclist to come into contact with the unprotected VRS posts. Although motorcycle traffic only makes up 0.4% of traffic, they account for 13% of all fatal VRS collisions. Furthermore, between 2015 and 2019 (inclusive) there were 166 motorcycle collisions involving VRS, 71% of which resulted in fatal or serious injuries.
Treatment:	Designers need to apply good road safety practice to manage roadside risks for all road users. This includes applying the principle of remove, relocate, reduce and protect the hazard to ensure that the risks to all road users are mitigated as far as practicable in a design. With the first consideration being, can the hazard that requires VRS to be installed be removed or avoided entirely? Where a VRS is identified as required for a new scheme, and where there are specific risks to motorcyclists, it is important that the type of VRS chosen minimises the risk to these road users. Where specific risks to motorcyclists have been identified, 'add on' motorcycle protection to post and rail type VRS is recommended to minimise the risk of injury.  The provision of an add on vehicle restraint is a risk-based approach usually evidenced through collision data or where other mitigation measures cannot be introduced. The Design Organisation must check with the VRS manufacturer that any such proposed protection will not invalidate the certification on the system. Such 'add on' products need to be compatible with the restraint system to which it is being attached.
Design considerations:	Can the hazard be removed entirely? If not, consider the use of motorcyclist protective features on VRS and/ or use other measures, such as high friction surfacing, to reduce the likelihood of a collision.
References:	DMRB CD 377 Requirements for road restraint systems. MCHW Series 400 and the associated Notes for Guidance (Series NG 400). PD CEN/TS 17342:2019 Road restraint systems. Motorcycle road restraint systems which reduce the impact severity of motorcyclist collisions with safety barriers.

Highway features

Highway features such as bends, priority junctions and roundabouts are potentially more hazardous for motorcyclists because these are locations where accelerating, braking and turning manoeuvres are involved. Visibility at these locations is key as motorcyclists present a relatively small frontal view which makes them more vulnerable to being missed or temporarily obscured by other vehicles, road furniture or vegetation. Collision data for the five year period 2015 to 2019 inclusive, indicates that 36% of all motorcyclist collisions at junctions on the SRN (crossroads, T or staggered, roundabout, or mini roundabout) resulted in fatal or serious injuries compared to 14% for collisions involving cars.

The following location-specific highway features and potential design considerations are considered in more detail within this section:

- Bends
- Junctions
- Roundabouts
- Mini roundabouts

Bends

Issues:	On bends, motorcyclists will generally adopt a line that follows the vanishing point. However, if a roadside object such as a tree or field gate interrupts the vanishing point then motorcyclists may veer towards that object. This can then result in a loss of control collision and as already highlighted within the guide, when a motorcyclist is involved in a collision with a roadside feature on the SRN it can result in fatal or serious injuries. In order to reduce this risk, motorcycle trainees are often taught that 'Where You Look Is Where You Go' (WYLIWYG).
Treatment:	Where there are safety concerns of road users losing control on a bend, the WYLIWYG principle can be introduced. WYLIWYG uses a series of hazard marker posts to draw the focus of motorcyclists and drivers to the vanishing point of the bend and prevents distraction by road side objects. Hazard marker posts are placed in the verge at regular intervals, extending both around the bend as normal, but also for some distance after the bend until the vanishing point starts to move away from the rider's view, into the subsequent straight. WYLIWYG is most commonly introduced on unlit rural roads. Designers need to give due consideration to the passive safety and BS EN 12767 when proposing the installation of hazard marker posts. Providing hazard marker posts can have maintenance implications, since it is essential that the posts remain visible to maintain their effectiveness. 
Design considerations:	Consider the use of verge marker posts and the WYLIWYG concept.
References:	BS EN 12767:2019 Passive safety of support structures for road equipment. Requirements and test methods Traffic Signs Manual. Highways England Guide to Road Safety Route Treatments.

Junctions

Issue:	The main challenge for motorcyclists at junctions is motorists failing to register an approaching motorcyclist. This is often because of the small frontal aspect that a motorcyclist presents head on and other road users poor judgement of motorcycle approach speeds. Collision data for the period 2015 to 2019 inclusive indicates that 47% of all motorcyclist collisions at priority junctions on the SRN (crossroads, T or staggered) resulted in fatal or serious injuries. This can be compared to car collisions at priority junctions which resulted in 22% fatal and serious injuries.
Treatment:	To reduce the risk to motorcyclists, clear visibility splays need to be maintained at junctions so that driver sight lines are optimised and motorcyclists do not become 'masked' by roadside features. This includes restricting parking on the approaches to junctions and positioning road furniture/vegetation out of the visibility splay. Inter-visibility between drivers and motorcyclists can be improved by the minor approach of a junction being perpendicular to the major road. This also helps to reduce the likelihood of the view of the driver being obscured by the vehicle's door pillar and consequently increasing the risk that the driver fails to see an approaching motorcycle.
Design considerations:	Follow the requirements of CD 123 Geometric design of at-grade priority and signal controlled junctions.
References:	DMRB CD 123 Geometric design of at-grade priority and signal controlled junctions.

Roundabouts

Issue:	Roundabouts can present a number of hazards for motorcyclists since accelerating, braking and manoeuvring are all necessary. As highlighted earlier within the guide, this can be compounded when there are large amounts of road markings and ironwork in the carriageway which can introduce variations in skidding resistance. Collisions at roundabouts typically involve; drivers failing to giveway, drivers looking but failing to see a motorcyclist, misjudgement of motorcyclist's speed and tight bends on entry. Collision data for roundabouts indicates that 29% of all motorcyclist collisions result in fatal or serious injuries compared to 9% fatal or serious injuries for car occupants.
Treatment:	Motorcycle collisions at roundabouts can be partly mitigated by clear signing and marking, by limiting visibility to the right until 15m before entry using suitable screening, and by ensuring that the layout is self-explanatory. Designers should avoid providing tight bends on roundabout entries as these can cause loss of control collisions for motorcyclists. Designers should also ensure that surfacing materials and road markings have suitable skidding resistance.
Design considerations:	Follow the requirements of DMRB CD 116 Geometric design of roundabouts. Avoid tight bends on entry and use the correct entry path curvature to help reduce vehicle approach speeds. Follow the requirements for the use of HFS in CD 236 and CS 228 to ensure it is applied in such a way to benefit motorcyclists by providing good braking surfaces. Follow the requirements for the positioning of ironwork in CD 534. Minimise or avoid large areas of text road markings by locating them in advance rather than within the roundabout. Limit visibility to the right at entry using suitable screening.
References:	DMRB CD 116 Geometric design of roundabouts.

Mini Roundabouts

Issue:	Motorcyclists are vulnerable at mini roundabouts particularly when making tight right turns which can result in stability problems. Furthermore, mini roundabouts may be provided because there is insufficient visibility for a priority junction however, this can increase the risks for motorcyclists with other drivers 'looking but failing to see'. As highlighted for roundabouts, mini roundabouts require motorcyclists to brake and turn. The use of excessive road markings and the positioning of ironworks within the carriageway can create a skidding risk. This is particularly pertinent at mini roundabouts due to the extent of the coverage in relation to the size of the junction. The number of collisions at mini roundabouts on the SRN is low, this is partly due to the relatively small number of them on the network. However, despite this, 6% of the recorded collisions at mini roundabouts still involved motorcyclists which appears significant when taking into account that motorcyclists account for 0.4% of traffic on the SRN.
Treatment:	Mini roundabouts are only permitted on roads with a speed limit of 30mph or less, hence their occurrence on the SRN is low. Where they are introduced, designers should provide advance warning of the junction type and ensure that the appropriate visibility is provided. Large areas of road markings should be avoided as motorcyclists making tight right turns can have stability issues, particularly if there are variations in skidding resistance between road markings and the carriageway surfaces. Ironworks should be relocated from the carriageway.
Design considerations:	Follow the requirements of CD 116 Geometric design of roundabouts. Remove existing ironwork which is located along the line a motorcyclist might be expected to take. Remove irregular surface features on the approaches to, and within the junction. Remove existing channels and changes in crossfall if they are likely to destabilise motorcyclists. When a mini roundabout is constructed, the entire junction should be considered for resurfacing to prevent problems at the joint between the old and new road. Minimise or avoid large areas of road markings by locating them in advance rather than within the roundabout.
References:	DMRB CD 116 Geometric design of roundabouts.