1965 - 2005

IHIE | INSTITUTE OF HIGHWAY INCORPORATED ENGINEERS

# IHIE GUIDELINES FOR MOTORCYCLING

## improving safety through engineering and integration

version 1.1

# CHAPTER 4 ROAD DESIGN AND TRAFFIC ENGINEERING

## 4.1 Key Points

**4.1.1** Many of the current road design and traffic engineering practices are suitable for all road-user groups but the particular dynamic stability needs of the motorcycle need special consideration.

- Designers need to "think bike".
- Getting input from a suitably trained and experienced rider to inform this thinking at an early stage and prevent the inadvertent inclusion of design features that increase the risk to riders.
- The relationship between the road and braking/steering/accelerating on motorcycles needs to be a design consideration.
- Using this understanding to pick up on good design points.
- Exploring new possibilities by considering allowing motorcycles into bus lanes and to use Advanced Stop Lines.

## 4.2 Context

**4.2.1** Road designers and traffic engineers need to take into consideration the specific needs of motorcyclists. Some features, benign to other road users, can present a hazard to motorcycles. When considering engineering measures on existing roads it is recommended that any accident data analysis is supplemented by comments from a suitably qualified and experienced rider in order to gain an understanding of real-life causation factors.

## 4.3 Road Design

### Overview

**4.3.1** It may be of value to the non-riding road designer to briefly explain how motorcycles are different:

- The consistency of grip between tyres and the road surface is critical to motorcycle stability, especially when leaning over for cornering or when braking or accelerating.
- Most braking effort and all steering control for a motorcycle is through the front tyre which means that riders avoid combining braking and steering whenever possible to reduce the likelihood of overwhelming front tyre grip as it attempts to deal with conflicting forces. Any change in this grip, and in particular a sudden decrease, can lead to loss of control during the manoeuvre as the front wheel slides away. Loss of front tyre grip on a bend almost invariably leads to a crash.
- All accelerating force is through the small patch of the rear tyre in contact with the road. A sudden lessening of the grip available, for example because of a surface change part-way through a bend, can cause the rear tyre to slip sideways and cause loss of control.
- Motorcycle riders adopt a different line through bends than drivers of twin-track vehicles, traversing the width of the lane in order to maximise grip through minimising steering

Motorcycle taking up position to left from a right hand bend.
*Keith Sharples Photography.*

Bends with street furniture in the "clear zone".
*Keith Sharples Photography.*

Where you look is where you go (before).
*Buckinghamshire County Council.*

Where you look is where you go (after).
*Buckinghamshire County Council.*

inputs. This keeps the machine as upright as possible, and maximises forward visibility and safety. Anything that forces riders to choose a less-than-optimum riding line through a bend increases the risk of loss of control.

## Surface grip and consistency

**4.3.2**

- Motorcycles have a much greater need for a consistent and high coefficient of friction from the road surface than twin-track vehicles, especially on wet surfaces and in areas requiring braking and steering.
- Riders adopt an angle of lean to negotiate a corner that is related to speed and bend radius - any change in grip between tyres and surface can destabilise the machine.
- Any deviation from a consistently level surface in the same areas can seriously impair the motorcycle's road-holding ability.
- A sudden change in surface level rapidly loads and unloads the suspension, thus reducing the grip between front wheel and road surface. In other words, the wheel rebounds upwards and in severe cases can lose contact with the surface.
- Unpredictable changes in the road environment that call for rapid deceleration or braking while cornering can cause the motorcycle to "sit-up" and take a tangential line away from the bend.

## Bends

**4.3.3** There is anecdotal evidence that riders who are losing control of their machine on a bend tend to "fixate" on what seems to be the object in their path most likely to hurt them - typically a tree or signpost. The argument goes that, once this "target fixation" occurs, the rider will usually hit that object. Whether or not target fixation is a genuine phenomenon, research indicates that a significant percentage of motorcycle fatalities (17% in GB in 2003) involve collision with road side objects (unpublished DfT STATS19 data, see also ATSB 2000, quoted in MCC 2002). Wherever possible, any highway furniture or signage should not be positioned on the outside of bends, creating a "clear zone" in higher speed rural situations, to minimise this problem. Other options are:

- Site the signs back as far as possible; falling riders quickly lose speed on open verges (Fox *et al* 1979, quoted in VicRoads 2001).
- On right-hand bends with sufficient forward visibility, position the signs on the inside of the bend.
- A site-specific engineering solution was implemented by Buckinghamshire County Council on one particular bend where there had been three motorcyclist fatalities in five years and a number of serious injuries, including car drivers. The principle behind the scheme is called "where you look is where you go" WYLIWYG and works on the basis that if you can "hold" the rider's/driver's eye around a bend then they are likely to successfully negotiate it. Filming of this and similar bends had indicated that chevron signs could misrepresent the radius of the bend, especially at night.

Hazard marker posts were positioned on the outer edge of the bend, at a closer spacing than normal, to concentrate the rider's eyes on the "vanishing point". The owner of adjacent land removed bramble overgrowth so there was visibility across the inside of the bend. This low-cost measure appears to have been successful, with no injury accidents more than two years after completion.

### Visibility

**4.3.4** Drivers often do not "see" motorcyclists because of the relatively small frontal area presented by their machines, the presence of other road vehicles and roadside obstructions. Junction design should ensure that drivers do not have their sight lines obscured.

### Rural roads

**4.3.5** The higher speed potential on rural roads, especially those that are attractive to leisure riders, means that many of the aspects covered in this section have greater importance for casualty reduction on these roads.

### Safety barrier

Street furniture can obscure sightline to right, on exit from side road.
*Keith Sharples Photography.*

**4.3.6** Research in Australia has shown that the probability of a falling rider being killed doubles in a collision with safety barrier systems. Injuries were less severe from impact with the beam or the face of a concrete safety barrier system, compared to collisions with the posts used in the system or the roadside posts being protected by the safety barrier (Gibson and Benetatos 2000). Falling riders, as they slide along the road surface, are most likely to be at risk of added injury from the unprotected barrier support posts and projecting surfaces or by sliding underneath barriers (FEMA 2004). Riders often express concern at the perceived dangers of wire rope safety fence, but the Government's Advisory Group on Motorcycling concluded that this form of safety fence appears, from the limited research completed so far, to be no more hazardous than other types of post-and-rail barrier. There is general agreement that more research is required on the effects of different types of fence on falling riders and on the posts that cause the most severe injuries to riders when they hit safety fence (AGoM 2004).

Wire Rope Safety Fence and support posts.
*Keith Sharples Photography.*

**4.3.7.1** Pending further research it seems that retro-fitting impact mitigation measures to posts and some means of preventing dismounted riders from passing under rails would improve secondary safety for falling riders in safety barrier collisions. TD 19/06 Requirement for (Vehicle) Road Restraint Systems(DMRB Vol 2 Sec 2) advices designers tthat "at high risk sites it is recommended to use an 'add on' motorcycle protection system to post and rail type safety barrier to minimise the risk of injury to motorcyclists.

### Priority junctions and roundabouts

**4.3.8** Important considerations at priority junctions and roundabouts are to optimise sight lines and provide good braking surfaces for all users. This will mitigate the problem of drivers not

Motorcycle on roundabout with narrow entries.
*Keith Sharples Photography.*

responding to motorcyclists' presence - even when the latter have priority. The relatively small frontal aspect of motorcycles makes this particularly important. Low entry angles on roundabout approaches mean riders in the circulatory area can be obscured by the central pillar on emerging cars. Entry angles that are too high can lead to excessive speed on approach and tail-end collisions. Wide entries encourage drivers to pull up on the offside of the rider, especially if the latter is on a low-powered machine. Both of these potential problems are mitigated with entry angles between 30° and 40° and entry widths no greater than absolutely necessary - and these measures should also have the effect of reducing entry speed. A balance will need to be struck between capacity and safety. The positioning of street furniture and vegetation at junctions is critical for good sight lines. A very high proportion of collisions between motorcycles and cars in urban situations are due to emerging drivers failing to see the oncoming motorcycle. The higher speed of traffic on rural roads requires that designing for adequate sight lines is even more important.

### Light Rapid Transit systems

**4.3.9** The rails of on-street Light Rapid Transit (LRT) systems can have a destabilising effect on motorcycles and cycles. Ongoing research at Nottingham University into the effects of tram infrastructure on cyclists is awaited. Discussion with recent LRT providers indicates that flush rails with high-PSV surrounding surfaces offer the best compromise between tram utility and the safety of other road users, including riders of mopeds or motorcycles. Seek out the experience of earlier LRT projects such as Manchester, Sheffield, West Midlands, Nottingham and Croydon.

### Design Points

**4.3.10** To reduce the need for sudden variations in steering or braking and to minimise the consequences of any loss of control, consider these points:

- Consistent horizontal alignment - for example avoiding bends that tighten after entry - minimises the need for change of steering angle, and hence angle of lean, especially in a critical situation, such as a road surface compromised by water, detritus or leaf fall. Chapter 8 deals with vertical and horizontal alignment in the specific circumstances of traffic calming. Chapter 9 looks at this issue in a Road Safety Audit context.

- Cross-sectional design consistent with the speed of the road and the radius of the bends. This is more of a problem for roads that have"evolved" over time, rather than new-build, but adverse camber or inadequate super-elevation can be a problem for all motor vehicles, but with worse consequences for motorcyclists.

- Wherever possible a motorcycle should be able to brake and stop while upright, travelling in a straight line and on a consistent grip surface. Clear and adequate sight lines to pedestrian crossing facilities minimises the need for last

Approaching a pedestrian crossing.
*Keith Sharples Photography.*

minute reactive behaviour. This means keeping formal crossing facilities away from bends where possible and where pedestrian desire lines permit.

- Consistent skid resistance, including that of extra surface features, such as coloured patches. This is especially important on bends, given the rider's need to vary position across the lane to maximise safety and provide maximum forward visibility.

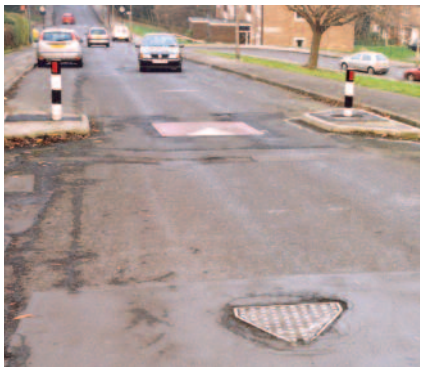
- Use high friction surfacing at junctions with a history of drivers emerging against priority into the path of motorcyclists. This maximises the rider's chances of braking safely.

Avoid thermoplastic marking on bends.
*Keith Sharples Photography.*

- Terminate high friction surfacing on straight sections. Sudden changes in road surface properties on bends and at junctions, especially skid resistance, can lead to stability problems as the rider tries to cope with the sudden change in the dynamics and response of the motorcycle.

- Avoid using different surfaces, for example granite setts, to emphasise a change in circumstances, at turning points such as priority junctions and small roundabouts where motorcycles may be destabilised by their use.

- Thermoplastic markings rarely have the same skid resistance properties of the surrounding road and their skid resistance deteriorates faster than the road surfacing. Arrows and destination markings on bends or roundabouts are of concern to riders as the motorcycle may be leaning over or may be accelerating or braking. Consistent and informative advance warning and direction signs should minimise the need for such surface signing. Careful thought should be given before using large areas of hatching.



Poor road surface on approach to traffic calming.
*Keith Sharples Photography.*

- Specifications for and positioning of in-road and roadside furniture, including impact characteristics when struck by a fallen or sliding body. The principle should be to minimise the number of obstacles, especially on higher speed bends, and to use supports that do not shear off leaving jagged or sharp remnants or that have protrusions that could snag a fallen rider. On higher speed roads consideration must also be given to the swept path of the rider leaning into bends, something that is not of concern for twin track vehicles.

- Gentle changes in vertical alignment to minimise potential for loss of tyre adhesion and to optimise drainage, both of which have a greater effect on motorcycles than on twin track vehicles.

- Allow for the higher eye level of riders when positioning street furniture or planting vegetation, especially at junctions. Consider the full growth of trees and shrubs, along with leaf fall characteristics and maintenance.

- Where it is absolutely necessary to use kerbs in rural areas,


Poorly located utility cover.
*Keith Sharples Photography.*

Added warning of hazardous bend.
*Keith Sharples Photography.*

Shared use of an ASL.
*MCIA.*

use battered kerbing to minimise potential injury to a sliding body.

- When redesigning an existing layout consider the position and level of utility covers, especially on bends and within braking or steering areas. Avoid forcing riders to over-run them whenever possible. If it is unavoidable, use covers with a skid resistance similar to the surrounding road surface.

- Consistent signing along a route so that rider expectations are met. This links to the concept of 'self-explaining roads', where the level of signing and marking is proportionate to the severity of the hazard and this proportion is the same along the whole route. If the road can "deceive" then warnings are required - a tightening radius or a horizontal deviation immediately over a crest are examples where advanced warning is appropriate.

- Consider the role that probable future levels of maintenance of the design may have on continued safety. Avoid including design features that require higher levels of maintenance than the road is realistically going to receive, which could in turn lead to future safety problems.

## 4.4 Traffic Engineering

### Shared use of Advanced Stop Lines (ASLs)

**4.4.1** The use of Advanced Stop Lines (ASLs) for cyclists at signal junctions is now widespread. They are intended to provide a safe location for waiting cyclists, especially those wishing to make a right turn at a junction. The Traffic Signs Regulations and General Directions (2002) (DfT 2002) clarified the legal position of such ASLs making it an offence for other vehicles to cross the first stop line and wait in the reservoir between the stop lines, except if unable to stop safely otherwise.

**4.4.2** The shared use of specifically designed ASLs by cyclists and motorcyclists could provide similar benefits to motorcyclists as those experienced by cyclists:

- They offer a head start over other traffic, reducing the potential for conflict especially where turning movements are possible.
- They allow motorcycles to be visible away from and in front of other traffic.

**4.4.3** There is an obvious potential safety benefit to cyclists themselves. Motorcycles are generally capable of greater acceleration than other motor vehicles; the risk of conflict is that much greater if motorcycles are placed directly behind them.

**4.4.4** However, cycling representatives have raised concerns, arguing that the shared use of ASLs would detract from the convenience and safety of making a trip by bicycle and that the facilities would no longer be being used for the purpose for which they were intended. This implies that motorcyclists are less vulnerable than cyclists and do not need priority measures. Such

concerns led to trials in the London Borough of Newham of shared use of ASLs. These trials, monitored by the Transport Research Laboratory (TRL), have included attitudinal surveys both before the installation of the facilities and after, and a video survey. The surveys showed significant illegal use of ASLs by a range of vehicles including motorcycles. Conflict between pedal cycles and motorcycles was not identified as a problem although the trial sites only provide a limited range of conditions and there were few right turning manoeuvres.

**4.4.5** The trials have highlighted a number of design issues regarding the shared use of ASLs, especially the provision of separate filter lanes for motorcycles providing direct access to the protected area. There were particular concerns with motorcyclists rejoining other traffic as the signals change. The early results of these limited trials have been encouraging (Tilly, A & Huggins, P 2003):

- Before the trial of the shared use of ASLs a majority of motorcyclists (77%) and cyclists (51%) were supportive of motorcyclists using ASLs.
- After implementation 73% of motorcyclists thought the layout was an improvement along with 48% of cyclists.
- 80% of cyclists surveyed thought that the layout was better or unchanged and only 5% believed it had become worse.
- Across all sites the number using the new ASL filter lane "after" was greater than the number that filtered on the outside "before".
- The number of motorcyclists filtering between the nearside kerb and queuing traffic fell from 13% to 6%.
- There was no change in the number of cyclists managing to reach the front of the traffic queue.
- The percentage of motorcyclists managing to reach the front of the traffic queue rose from 40% 'before' to 53% 'after'.
- Conflict between motorcyclists and cyclists did not arise.
- Overcrowding was not an issue.
- Motorcyclists would tend to wait on the right hand side of the ASL reservoir, cyclists on the left. Conflict could arise, however, between left turning motorcyclists and right turning cyclists. This was not an issue as the majority of movements were straight ahead.

**4.4.6** In view of the limited number of trial sites included in this study and the limitations on layout and traffic mix, there is a clear need for further trial sites, with local authorities being encouraged to apply for trial sites in their areas. In doing so the following points should be considered:

- A consistent approach should be adopted on a route so that both cyclists and motorcyclists know they share the facility and so that drivers will expect motorcyclists to filter to the ASL.
- Motorcyclists are more likely than cyclists to access the feature from other than the nearside position. Access from the offside is feasible, given appropriate signing to inform all drivers and riders. The positioning of road-centre street furniture needs careful consideration in order to avoid last minute steering/braking corrections from riders.
- Adequate and prominent advance signing is needed to alert both riders and drivers of the facility.

- Supplementary surface signing should be used sparingly - previous advice above about surface treatment and road markings is relevant.
- All non-standard signs and markings require special authorisation from the appropriate authority.

### Shared use of bus lanes

**4.4.7** In the present situation, a typical urban road layout with a bus lane and a single all-purpose lane, during congested periods motorcyclists use the legal manoeuvre of "filtering" or passing to the right of stationary traffic. This presents three possible hazards:

- Potential conflict with oncoming traffic.
- The risk of colliding with the opening door of an inattentive car driver or passenger if the rider tries to reduce the above risk by keeping close to stationary traffic. Car occupants often use stationary periods in traffic to drop off passengers, check the vehicle and so on.
- Potential conflict with pedestrians crossing through stationary traffic. Many pedestrians, having crossed an empty bus lane and a stationary traffic lane, assume their next hazard is traffic from the other direction, and do not look for filtering motorcycles.

**4.4.8** Therefore the possible safety benefits of allowing motorcycles into bus lanes can be summarised as:

- Eliminating the potential for conflict with oncoming traffic while the rider is using the bus lane.
- Reducing the potential for conflict between motorcycles and other traffic. Even if a car occupant opens a door on the nearside, they are more likely to check for permitted vehicles in the bus lane and in any case the motorcycle is likely to be in the centre of the bus lane, not close to the stationary traffic.
- Reducing the potential for conflict with pedestrians because they will check for permitted vehicles before crossing the bus lane.

Shared use of a bus lane.
*MCIA.*

**4.4.9.1** Bus lane access by motorcyclists was first granted by Avon County Council in Bristol in the mid-1990s. Since then an increasing number of local authorities have allowed the shared use of bus lanes by cyclists, taxis and motorcycles. In 2007 The DfT produced a Traffic Advisory Leaflet~ TAL 2/07 The use of Bus Lanes by Motorcycles. This revised the previous advice contained in Keeping Buses Moving (DETR 1997), against motorcycles normally being allowed into bus lanes and now recommends that local authorities consider such access.

**4.4.9.2** Signs permitting the use of bus lanes by motorcycles are not allowed without specific authorisation. Department for Transport (DfT) working drawings NP 958.4 and 959.4 give sign design details and special authorisation for signs will continue to be required until the additional variants are prescribed in any update to TSRGD".

**4.4.10** Proposals to introduce shared-use bus lanes will often be met by objections. The arguments usually revolve around conflicts with cyclists, who are usually permitted to use bus lanes, and to a

lesser extent reduction in benefits to buses. Concerns may also be raised over possible conflicts with pedestrians. For cyclists the concern would seem to stem from the differential speeds of bicycles and motorcycles; the smaller frontal profile of motorcycles, especially compared to buses, and the higher levels of traffic in bus lanes giving rise to at least the perception of greater risk and a less attractive cycling environment. For pedestrians, higher speeds and lower conspicuity underlie perceived safety concerns.

**4.4.11** Experience of shared-use bus lanes in Bristol and subsequent trials by Transport for London (TfL) would seem to indicate that shared use of bus lanes can be introduced with little or no detrimental effect for other road users (TfL 2004). Interim data from these trials indicates:

- Reductions in motorcycle accidents between 0% and 31% at the trial sites, with no increase in overall accidents at any site.
- Reductions in motorcycles using general traffic lanes of between 31% and 40% at the trial sites. There was no adverse effect on bus journey times.
- In surveys 44% of cyclists reported that collisions and near misses they experienced when using bus lanes involved cars - this increased by 1% during the trial, and compared with 3% involving motorcycles, which again increased by 1% during the trial. The number of cars illegally using bus lanes fell during the trial, probably due to increased enforcement.

**4.4.12** The work has taken place against a background of the introduction of the London Congestion Charge, which has lead to an increase in motorcycles within the charge zone, along with a reduction in motorcycle accidents (TfL 2003). The Government's Motorcycle Strategy recognises that *"although these studies have not finally concluded, the evidence so far suggests that there are no apparent safety disbenefits from allowing motorcycles to use bus lanes"* and DfT will include consideration of the position on motorcycles as part of the review of LTN 1/97 in the light of the results of the research.

### Road markings

**4.4.13** The use of road markings needs careful consideration, especially within steering or braking zones. Used inappropriately they can force riders off the safest line, or if poorly designed or laid they can collect and divert water, adding to the problem of providing consistent grip. The reduction in skid resistance over time or in wet conditions causes problems for motorcyclists. Direction arrows and destination markings are of particular concern. Often they are used on bends when, if they are needed at all, they could be better placed in an advanced position on a straight section of the road. Also they are likely to be re-laid on maintenance schedules, leading to layering and a significant up-stand from the surrounding surface; most road markings over 6mm in height are illegal with few exceptions, for example mini-roundabout domes. Blacking-out redundant markings rather than burning or planing them off creates a higher up-stand with the added hazard of reduced skid resistance. In general, well positioned roadside

## Sponsors

bmf better biking

County Surveyors' Society

Department for Transport

HIGHWAYS AGENCY

The Motor Cycle Industry Association

Transport for London