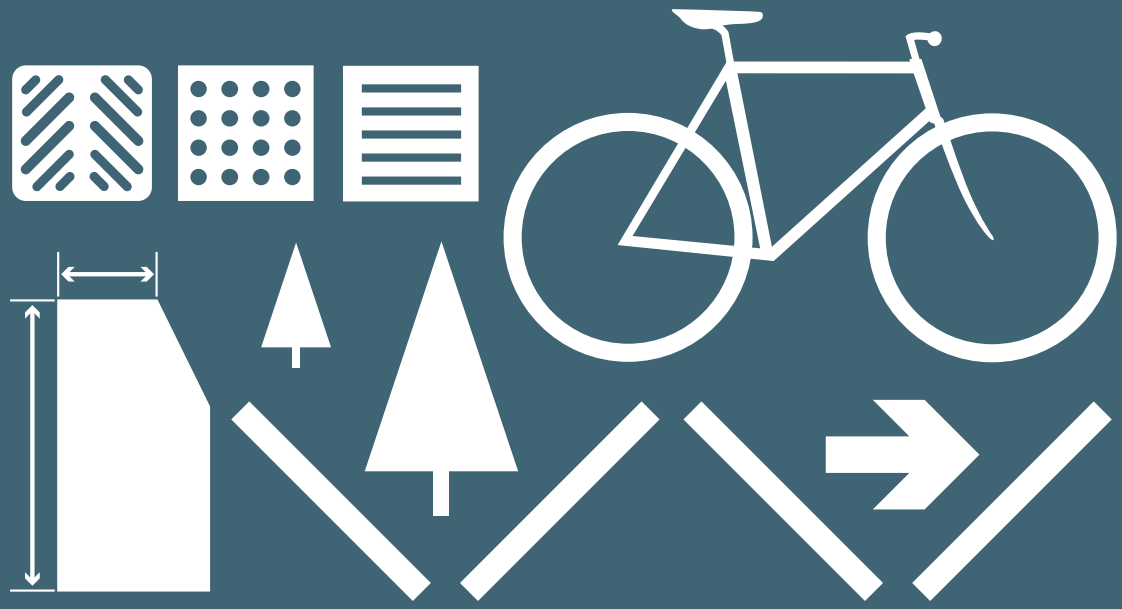
7. Construction, including surfacing

This chapter covers aspects of construction and maintenance that are vital for making cycle infrastructure as safe, comfortable, attractive, accessible and durable as possible.



Version control

Version 1 (Dec 2014) – Published

Version 2 (Sept 2016) – Minor amendments following publication of TSRGD (2016)

7. Construction, including surfacing

7.1 General requirements

7.1.1 Responding to context

Streetscape issues need to be considered in all aspects of design and construction. Cycle schemes should seek to reinforce the distinctive character of places and neighbourhoods and to improve environmental quality by lessening the predominance of motor traffic and traffic-related street furniture.

Street designers are directed to chapter 3 of this document and to the TfL Streetscape Guidance as well as borough streetscape guidance documents and streetscape-related supplementary planning documents.

The sections below set out general advice to inform design development. In all cases, the highway authority and its standard details for carriageway and footway construction should be consulted. This is particularly important wherever the authority is expected to adopt the facility: non-compliance with the relevant standards could lead to rejection.

Quality of construction for cycle infrastructure is covered by the Cycling Level of Service assessment, as shown in figure 7.1.

Figure 7.1 Key construction considerations in CLoS

Factor	Indicator	Relates in this chapter to
Directness: **Directness**	Deviation of route	Major infrastructure such as bridges and tunnels to make direct connections
Comfort: **Surface quality**	Non cycle friendly ironworks, raised/sunken covers and gullies	Machine-laid sealed surfacing, flush kerbs at crossings and transitions, drainage design and road marking materials
Coherence: **Surface material**	Construction	
Attractiveness: **Greening**	Green infrastructure or sustainable materials incorporated into design	Use of permeable surfaces as appropriate

7.1.2 Lighting

An appropriate level of lighting is important for all cycle routes; the highway authority's lighting unit will need to be consulted on all lighting proposals. This may entail upgrading existing lighting or the provision of new lighting in open spaces, particularly where there are concerns for personal security. In some areas lighting units may be targeted and damaged by vandals, so this will need to be taken into account in the provision. Where vandalism is an issue, piped music has proved to be effective in some locations as a deterrent.

For aesthetic and conservation reasons, lighting may not be acceptable through parks and other green corridor areas. Low-level timed, motion-sensitive or solar stud lighting may be considered in such circumstances. Further guidance on providing adequate lighting in sensitive areas may be found in Sustrans' Technical Information Note 29: Lighting of cycle paths (2012) and the Campaign for the Protection of Rural England's (CPRE) report, Shedding Light (2014). If adequate lighting is not feasible on routes away from the highway then alternative night-time routes should be provided.

7.1.3 Construction principles

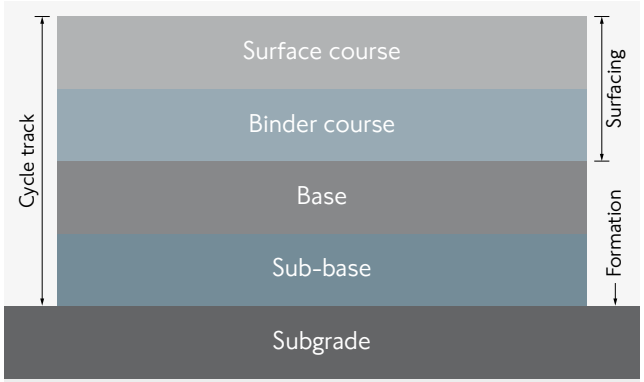
Practicalities such as cost, consideration of future maintenance and availability of materials have a significant bearing on decisions about construction of paths, tracks and cycle lanes. However, from the perspective of the user, the riding quality and reliability of the surface are the most important construction considerations (see section 7.2 below). This means providing machine-laid surfacing, effective drainage and disposal of surface water, and well constructed dropped kerbs and transitions.

A standard carriageway construction is appropriate for all cycling infrastructure on carriageway. Some modifications to the surface may be required to incorporate cycle lanes, advanced stop lines, or traffic speed control measures (traffic calming). Dimensional tolerances should follow normal highway standards, and when a new cycle route is installed a check should be carried out to confirm that this is the case.

Off-carriageway, cycle tracks and shared paths will have a similar construction to footways or footpaths, but they will generally have few vehicle loading requirements. Depending on ground conditions, different construction approaches may be considered in locations where there is only occasional use by motorised vehicles, very often for maintenance.

For cycle tracks, a maximum gradient of 3 per cent is recommended but this can rise to 5 per cent over a distance of up to 100 metres. Where it is unavoidable, a gradient of up to 7 per cent over a distance of no more than 30 metres is acceptable. In some circumstances, steeper gradients than 7 per cent over short distances on a cycle route may be preferable to failing to provide the route at all.

Typical off-carriageway facility



Typical cycle track construction. Diagram from Mineral Products Association, Asphalt applications: construction and surfacing of footways and cycleways using asphalt (2009)

7.1.4 Basic contruction requirements

For all types of construction, the surface is built up in a number of layers – typically surface course, binder course, base and sub-base. The binder, base and sub-base should be chosen and applied in accordance with the local authority's highway design standards, and in a manner appropriate to the context. When considering what depth of construction to adopt, it should be borne in mind that one of the most common reasons why some cyclists use the main carriageway, in preference to a cycle track alongside the road, is that the riding quality of the main road carriageway is better.

> The riding quality of any cycle track should be at least as good as that of the adjacent road. Refer to local design and streetscape guidance for more details.

The depth of each layer will depend on the materials and local ground conditions – the presence of tree roots, for example, may require a deeper construction depth. Indicatively for a cycle track, a surface course may be around 25mm, the binder and base course may be another 50mm and the sub-base 125-225mm. Away from the highway, a higher grade binder course with an increased laying depth may be considered rather than separate surface and binder layers.

In all cases, consideration should also be given to:

- The impact of construction and the choice of materials on drainage
- Responsible sourcing and re-use of construction products (bearing in mind that certain types and colours of aggregate, for example, may not be local and will need to be transported over a long distance)
- Local character, and selection of materials appropriate to the context, as covered in local design or streetscape guidance
- Reducing use of bituminous materials away from the highway by applying a surface dressing, or using alternative materials such as resin-bonded gravels

The porosity of surface, binder and base materials should be a consideration for any integrated approach to sustainable drainage.

Any new carriageway construction should be to normal highway standards unless there is kerb segregation of the cycle lane. Carriageway construction depth depends on ground conditions and expected loadings – indicatively, this may be around 600mm. This can entail the relaying and/or protection of utilities plant (electricity, gas, water, foul and surface water drainage, telephone, cable TV, tram cables etc).

Edge restraints

For cycle tracks and shared footways, adequate edge restraint should normally be provided in the form of edging to restrict the deformation and erosion of the facility. Standard 50mm wide, 150mm deep concrete edging is normally suitable, which can be laid flush to allow water run-off, or raised as a low (50mm) kerb if adjacent to a pedestrian way if required.

Alternatively 125x150mm kerbs, either bull-nose, battered or half-battered, can be used. For some towpath environments, timber edge restraint may be more appropriate to the context. On cycle tracks across open spaces, parkland and old railway alignments, edge restraints may be omitted to reduce the impact of a sealed surface path.

Maintenance considerations

Maintenance of the riding surface to match the original standard and colour after construction is essential to ensure the facility delivers a high level of service. This includes proper reinstatement following works by statutory undertakers. Close attention to drainage is necessary so that ponding is avoided as this provides a poor level of service and can result in cyclists moving into positions where conflict with other traffic is more likely to occur. To avoid this, surfaces should be machine-laid for all new-build facilities and where extensive repair works are undertaken.

7.1.5 Drainage

Gully location and levels are critical for cyclists to ensure good route drainage. This is particularly important where cyclists join or leave the carriageway, at all at-grade crossings, where there is physical separation or where current levels of provision are known to be problematic.

Acceptable gully characteristics are as follows:

- No gaps between the frame and cover wider than 15 mm
- Transverse bars or ‘portcullis’ type bars on the cover
- Recessed gully frames raised to be flush (tolerance +/- 5mm) with the surface
- Suitable for their location to take public highway loadings
- Open in a manner suitable to be cleansed by a normal gulley cleansing or jetting machine under the relevant highway authority contract

Dished and other gratings unsuitable for cycling across should be replaced. Side-entry gullies or perforated kerb type gullies (such as Beany Blocks) may be suitable in some circumstances, particularly where there is restricted width and where cyclists will be close to the kerb. Drainage on cycle lanes and tracks may need additional gullies as well as appropriate falls to facilitate run-off. A minimum grating size of 300 x 300mm is recommended, as the smaller size gully gratings that are sometimes used in off-carriageway situations tend to get blocked.

Perforated kerb gullies, as used in a cycle track

Grates should be perpendicular to direction of travel

Non-slot 'pedestrian style' gratings should be used wherever possible, particularly in and around crossings or shared public realm. Alternatively, the orientation of slots should be perpendicular to the expected direction of travel, which removes the possibility of cycle wheels sticking in gullies.

Falls of at least 1:40 cross-fall and 1:200 longitudinal are preferred. With non-machine laid surfaces steeper longitudinal falls will be required. Falls on roads (including 'summit and valleying') often get reduced or removed during re-surfacing, and so may need to be corrected. Any areas of ponding on a cycle route that will have an adverse effect on cyclists should be addressed, including where splashing from a carriageway onto an adjacent cycleway occurs.

Problems caused by ponding

Off-carriageway drainage

For cycle tracks and off-road routes, drainage requirements are best served by ensuring that the design of the path sheds water away from the centre of the track or path. The crossfall should be between 1 and 2.5 per cent to ensure adequate drainage but avoid creating discomfort for disabled users.

Additional stone grips or French drains may need to be considered to help achieve this. Drainage should be designed to feed new or existing ponds, develop new wetland habitats or simply soak away, rather than be fed back into existing piped systems. Raised delineators may need regular gaps to allow surface water to drain away.

7.1.6 Kerb construction

Low kerbs at least 50mm high can allow better use of restricted space by maximising effective width – allowing cyclists to travel closer to them without risk of catching pedals on the kerb. Dropped kerbs need to be provided to allow comfortable access for those for whom a 50mm upstand will still be an obstacle, such as people with mobility scooters, prams or buggies.

It is important that people using guide dogs or long canes are able to detect a kerb edge. One study by the University College London Accessibility Research Group (Childs et al 2009) showed that a 60mm upstand was readily detectable by all participants but recommended that further research be undertaken to establish whether 50mm, being a more common dimension and being well received by many users, might be a more practical minimum.

Angled kerbs

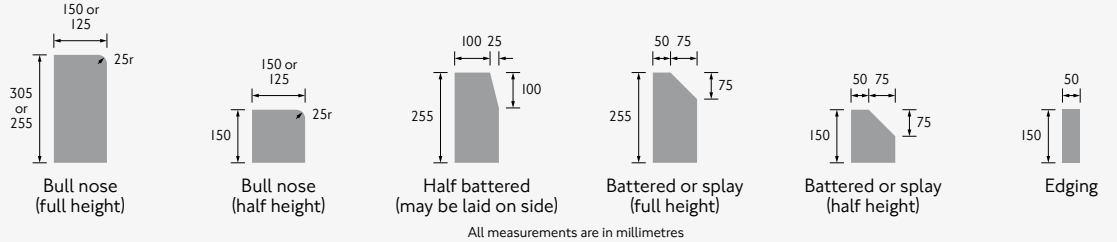
Angled kerbs – splayed, battered (45-degree faces) or half-battered – can also be used to help maximise effective width, and are more comfortable for disabled cyclists to negotiate than low, square-faced kerbs. Red-brick and block-battered units are also available. Transitions from angled kerbs to other profiles can be complex to construct and so it is recommended that angled kerbs are used consistently on a link and that any island should be specified with angled kerbs on all sides.

It is recommended that design decisions on use of low or angled kerbs should be a site-specific analysis of current patterns of movement, by consultaion with access groups and by an Equality Impact Assessment, as appropriate.

Dropped kerbs

All dropped kerbs should be specified as flush, within a tolerance of +/-6mm of the adjacent surfaces, to provide a comfortable surface for cyclists and people in wheelchairs. Particular care is needed with channel levels to ensure that ponding does not occur at crossing points. Upstands of anything over 10mm, parallel to the direction of travel, can destabilise cyclists if struck. Upstands cannot be safely and comfortably traversed by all cyclists when approached at right angles if more than 15mm high, or by wheelchair users if more than 6mm high.

Angled kerbs as used in London, above and the Netherlands, below. Note that block paving should only be used over short distances, if at all, because it can be uncomfortable to ride over



Typical kerb profiles

7.1.7 Kerbed island construction

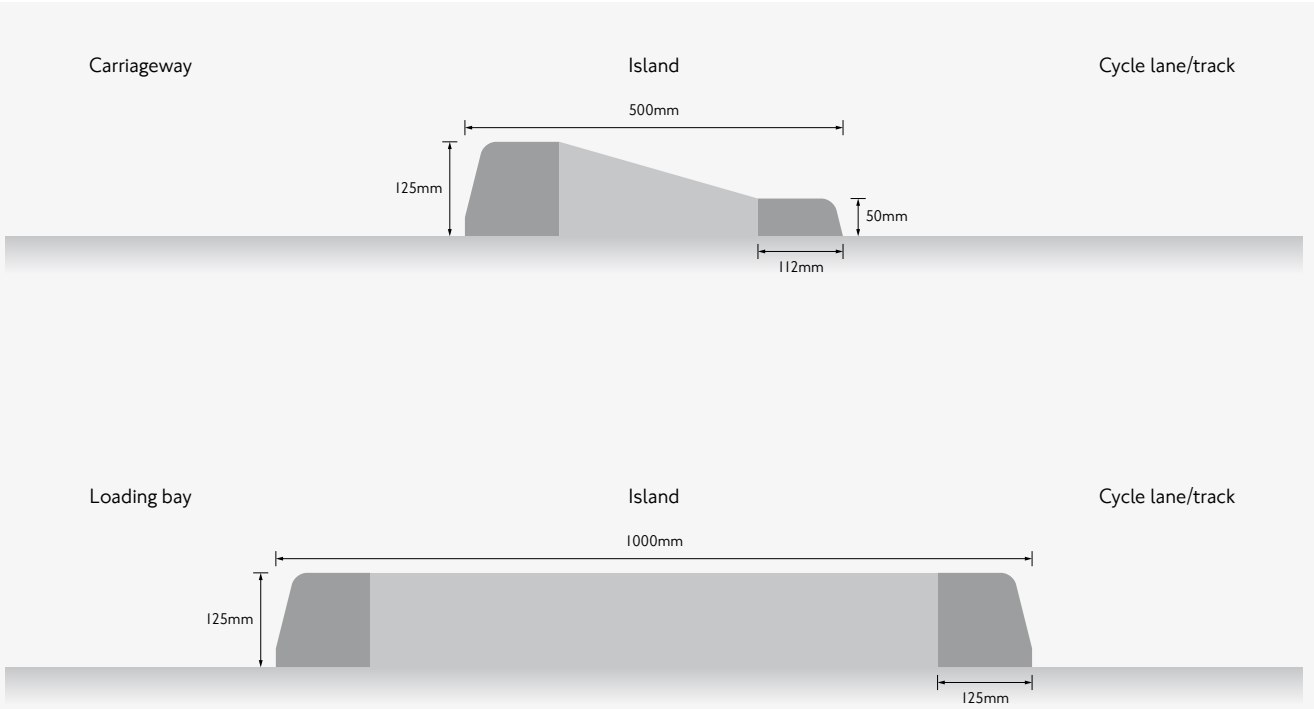
The edges of cycle tracks and segregated lanes need to be detailed so as to provide clear but safe delineation between carriageways and footways. Depending on width and on context (particularly in conservation areas), suitable materials for the edge strip or segregating island may include: paving slabs, block paving, granite setts, or coloured surfacing. Any change in material should be laid with a flush edge to the adjacent surface

A strip or island installed to create segregated cycling facilities may also incorporate parking bays, lighting columns and other street furniture. Features such as low walls and planting may be appropriate to either protect the cycling area or improve the ambience.

Where the island incorporates cycle parking, its dimensions should take into account the need to accommodate longer cycles, allowing them to turn safely and be stored without overhanging the kerb.

Guard railing and crash-barriers can create dangerous squeeze points, particularly where heavy goods vehicles turn, so they should be used only with caution, and with consideration for impact on cycling provision on-carriageway.

The segregating strip should be visually differentiated from the cycle lane or track by using a contrasting material. Paved strips with granite kerbs may be appropriate in more central urban settings but grass verges may also be suitable. They



Angled kerb sections for segregating islands not used by pedestrians and segregating island next to loading bays

are relatively easy to maintain and provide suitable space in which to take avoiding action in case of an emergency.

Any planting should be designed with consideration of safe and effective operation of the cycling facility. Plant height and growth, for example, should not affect forward visibility, and thorny bushes should be avoided adjacent to the edge of the cycling facility. Planting needs to be regularly maintained, particularly between March and October, to ensure that the cycle facility remains fully usable and that there is no reduction in effective width and overall visibility.

Refer generally to TfL Streetscape Guidance and relevant borough street design guidance and standard construction details for more information on kerbs.

7.2 Surfacing

7.2.1 Basic requirements

Good surface riding quality is essential for cyclist safety and comfort. This is the case whether cycling is on- or off-carriageway. Cyclists need a smooth riding surface, which should not be undulating and should have skid resistance appropriate to the location.

- The surface should be machine-laid, avoiding changes of level or 'steps' of more than 6mm, as these destabilise cyclists and are a significant factor in cycle safety
- Inspection covers and transitions between on- and off-carriageway must be flush, within a tolerance of 6mm
- The surface should be laid on adequate, well compacted base materials so that subsequent settlement does not occur
- Pot-holes, rutting and other defects must be rectified immediately through patching, resurfacing or deeper trench reinstatements as necessary
- Where anti-skid surfacing is used, it should continue over ironwork particularly where cyclists are likely to be changing direction

7.2.2 Surfacing materials

This section sets out the most common materials that are used to create a good quality surface for cycling, whether on carriageway, on a dedicated track or on a shared use path – see figure 7.2 below. The road network in urban areas is primarily a machine-laid bituminous or asphalt surface. Surfacing for the cycling network should be of the same standard, except for off-carriageway locations where a bound surface would be inappropriate.

Types to be avoided for general cycling use include:

- Paving slabs/flags – lower wet skid resistance and risks of trips and rocking
- Cobbles (pebbles in concrete) – uncomfortable surface with poor skid resistance
- Ungraded aggregate such as shingle, ballast or scalping – poorly graded materials will be too rough and cycle wheels will sink in

Where cobbles need to be retained as a heritage feature, it may be possible to lay 'paths' in different surface material through such areas in order to enable better access for cycles, wheelchairs and other mobility aids.

Figure 7.2 Surfacing materials and surface-applied treatments

Surfacing material	
Asphalt	This should be the default provision for cycling, in the form of asphalt concrete or a thin surface course system, hot laid as specified in BS594987. Hot-rolled asphalt, historically used for carriageways, is not recommended. (See 'asphalt surfacing' below).
Micro asphalt surfacing	A cold-applied, low-carbon alternative to conventional surfacing treatments, this is not suitable for general use on-highway but could be applied to cycle infrastructure off-highway or to specific low-use areas on-highway. It provides similar finishes to hot mix 6mm and 10mm dense bitumen macadam surfacing but is unlikely to have the same stiffness. It seals the surface, improving visual quality and skid resistance.
Concrete	Historically used on estate roads and can be useful where large numbers of HGV or bus turning movements take place. Good for cycling if the joints and slabs are in good condition, but surface markings tend not to be clearly visible. Avoid tamped finished surfaces as this creates a bumpy / uneven ride. Brushed finishes are better.
Brick or block paving	Acceptable for cycling on over relatively short stretches but skid resistance can be low on some brick paving types and so not so cycle-friendly when wet, particularly when turning movements need to be made. Can be beneficial where high cycling speeds are not appropriate. Can be uneven leading to ponding or unseen edges and so maintenance requirements may be high.
Natural stone blocks	May be suitable if bedded on mortar/concrete and surface is not uneven or smooth, and has good skid resistance.
Granite setts	Too rough and uneven for some cycles, but if laid flush can be acceptable in limited areas. Can polish with use and be slippery when wet.

Surface-applied treatments	
Surface dressing	An even spray application of an emulsion bituminous binder through a purpose-built spray tanker onto an existing road or path surface followed immediately by the even application of aggregate chippings to 'dress' the binder – for example, pea shingle or granite stone. This seals the surface, improving visual quality and skid resistance. It can be a good choice off-highway, having the appearance of loose gravel but in the form of a bound surface. It can be used to change the colour or texture of a surface, provided that it is applied to a surface that is already well constructed and in good condition.
Slurry sealing	A cheap maintenance layer, suitable for temporary cycling use only.
Self-binding surfaces	Often used for rural paths, but remain loose and dusty, have poor skid resistance, are not very durable and not therefore recommended anywhere for utility cycling other than some environmentally sensitive areas where a bound surface would not be acceptable. Includes limestone fines to dust, Coxwell gravel (which has a reddish colour) and hoggin (a well-graded mixture of sand, gravel and clay). Requires a 100mm aggregate base.
High-friction surfacing (anti-skid), cold applied	Normally acceptable for cycling but laying methods resulting in ridges should be avoided (ie lay in longitudinal strips rather than transversely).
Coloured veneer coat	Specialist coloured surfaces in blue, green, red, etc laid onto wearing courses, normally anti-skid.

Paths with bound surfaces in Kingston: Skerne Walk (top) and Thames Path (bottom)

7.2.3 Off-carriageway surfacing

Surface materials should be chosen to fit the context. For routes across parks or commons, polymer-bound materials are preferred, to ensure that a smooth and durable surface is provided.

Sealed surfaces tend to be more expensive to construct but last longer, so the level of service for cycling is significantly better and whole-life costs are usually much lower. Self-binding surfaces and surface dressings are chosen in some circumstances away from the highway, where machine-laid bituminous or asphalt surfaces cannot be applied. See Sustrans, Cycle path surface options, technical information note no.8 (2012) and Sustrans, Handbook for cycle-friendly design (2014).

It may be appropriate to omit formal concrete or timber edging and allow the edge to gradually deteriorate and become overgrown. This will result in a loss of edge width and this needs to be planned for in designing effective width. Alternatively, treated timber edge restraints may help maintain the durability of the path and sub-base but still be sympathetic to the environment.

7.2.4 Asphalt surfacing

The typical choice for the carriageway, and for many footways, is an asphalt surface. Asphalt used for roads and paths contain bitumens and aggregates which give a durable, joint-free surface that is relatively straightforward to construct and maintain.

Different products are available, each with their own properties. The main variables are the aggregate size, aggregate content, binder content and binder grade, which have an effect on stiffness, resistance to cracking and other physical properties of the asphalt. The smoothness of the riding surface tends to be dictated by the texture depth of the asphalt – the higher the texture depth, the rougher the surface and vice-versa.

Asphalt surface treatments for carriageways, cycle tracks and footways generally come in one of three forms:

Asphalt concrete (also known as bitmac or dense bitumen macadam)

A close-graded, 6mm asphalt concrete is a good choice for footways and cycle tracks as it gives a consistent and smooth surface finish. Designers should also consider porous asphalt concretes to help reduce surface, water, spray and ponding.

TSCS, a thin surface coarse system
This is often applied to carriageway surfaces, typically using a 10mm or 14mm aggregate, although 6mm is an option for footways. The advantage of using TSCS is that these materials come in a variety of texture depths and also colours. The use of clear bitumens and coloured aggregates allows these materials to be used as decorative asphalts. However this is not recommended in areas of load unless assurances are sought from material suppliers. Note that proprietary types of TSCS have replaced generic stone mastic asphalt (SMA).

HRA, hot-rolled asphalt, (with or without pre-coated chippings)

HRA is not recommended for cycle infrastructure. Its use has been in decline due to its positive texture, which means it generates more noise than some other treatments, and time and complexity of construction. For HRA with pre-coated chippings, hard-stone (often granite) chippings are rolled into the asphalt surface course while it is still hot. They add texture to the surface and therefore increase its skid-resistance properties. The chippings are pre-coated with a binder, which can contain coloured pigment if necessary. They must be hard-wearing but with a high polished stone value (PSV), so that they are durable and do not polish over time.

The use of all these materials is described in the European Standard Specification EN13108 and thicknesses should be specified using the British Standard BS594987: 2010, Asphalts for roads and other paved areas – specification for transport, laying compaction and type testing protocols, in conjunction with the local highway authority's design and construction standards. Full guidance on using the British Standards is provided in PD 6691 Guidance on the use of BS EN 13108 Bituminous Mixtures - material specifications (BSI, 2010).

Sustainable drainage

In selecting a suitable type of asphalt for a given location, consideration should be given to the wider approach to sustainable drainage – specifically the extent to which the surface material may contribute to run-off into gullies and drains, or may be capable of holding water in situ during a rainfall event and allowing it to permeate slowly into the ground or on highway drainage systems.

The porosity of TSCS and HRA is very low but open-graded asphalt concrete, where finer particles are eliminated from the aggregate mix, is more porous and more suitable as part of a SUDS-led approach.

7.2.5 Coloured surface treatments

See section 6.2.6 for guidance on where coloured surfacing may be appropriate. In London, where colour is used for marking cycling facilities, it should be deep chrome green (No 267 BS381C: 1988) or blue on Cycle Superhighways (RAL5015).

The colour of asphalt surfaces depends largely on the colour of the aggregate used. This can be emphasised by using a clear binder – often a synthetic or vegetable-based binder. Coloured pigment can also be added but the colour of the aggregate endures much longer than any added colour, which tends to fade over time as the bitumen is worn from the riding surface. Coloured aggregate may cost up to twice as much as the standard shades of black/grey.

In conservation or other sensitive areas, natural stone-coloured chippings on HRA or natural stone-coloured asphalt concrete can be used. These colours can have longer life and better colour retention than other colours, but are often less conspicuous and less likely to have an enhanced driver awareness benefit compared to blue or green.

7.2.6 Comparison of surface materials

Among the most important considerations in choosing an appropriate surface material are cost (and variation by colour), durability and skid resistance. Polished stone value (PSV) gives a measure of skid resistance. A PSV of 55 is normally acceptable for road skid resistance.

Figure 7.3 shows, indicatively, a comparison of different surface materials and treatments according to these criteria. Only materials costs are included here. Laying costs can vary considerably depending on the area (m^2) and the required traffic management arrangements – difficult and restricted access, in particular, is likely to increase costs. The cost per square metre will also be higher for smaller areas. In each case, more accurate figures should be obtained from suppliers.

Figure 7.3 Surface treatments and indicative costs

Surface Material	Life (years)	Skid resistance (PSV)	Indicative cost per square metre (£)		
			Normal	Red	Blue/Green
6mm asphalt concrete	20	60+	8	12	25
Coloured TSCS, 30-50mm thick	20	55+	-	25+	25+
Block paving	20	55	20-30	20-30	-
Brick paving	20	-	-	20-40	-
Concrete paving flags	10	-	20-30	-	-
Tactile paving	10	-	30-40	-	-
York stone flags	20	-	160	-	-
Granite paving flags	20	-	100	-	-
Thermoplastic High-Friction Surfacing	4-6	70+	13	16	16
Resin High-Friction Surfacing	8-10	70+	15	18	18
Cycle Track Veneer (thermoplastic slurry)	5	55+	8	8	8
Cycle Lane Veneer (polymer binder)	10	55+	10	12	12
Slurry Seal (poor colour and life)	5	55			
Surface Dressing – Granite Stone (bituminous binder)	20	60+			
Surface Dressing – Granite Stone (clear binder colour enhance)	20	60+			
Surface Dressing – Pea Shingle Stone	20	50			

7.2.7 Road marking materials

A consistent standard of road markings is required, as described in TSRGD and the Traffic Signs Manual, chapter 5. For cycle symbols to diagram 1057, pre-formed markings are preferred.

Re-surfacing works can be an opportunity to review, address and upgrade various aspects of construction quality (falls to prevent or address ponding, gulley positions, grating types, chamber covers) and provision for cyclists (lane widths, pinch-points, corner radii, road markings).

Where extensive re-surfacing requires the removal of existing red or yellow line markings, highway authorities should consider providing replacement lines at the minimum permitted width. In addition to reducing visual intrusion and saving on materials, this can help to visually accentuate the width of cycle lanes or coloured surfacing and reduce the risk of cyclists skidding on road markings in the wet. 50mm line width is technically acceptable for design speeds of up to 30mph, and 100mm above this. Design teams should take account both of enforcement requirements and reasonable consistency of appearance.

Road studs, or cat's eyes, are an authorised marking, primarily a means of illuminating other road markings. These must comply with the requirements of TSRGD (2016), Part 2, Item 7 and may only be used in conjunction with those markings stipulated. This does not currently include diagram 1049B mandatory cycle lane markings. Any proposal to use them on cycle lane markings would need to be raised with DfT and trialled.

7.3 The pedestrian environment

7.3.1 Guidance on design for pedestrians

The main general sources of advice in this area are TfL's Streetscape Guidance and London Pedestrian Design Guidance and relevant borough street design and accessibility guidance.

In any interaction with cycle infrastructure, the layout of pedestrian facilities should be as simple and logical as possible and be consistent along a route. In particular, the needs of people with mobility and visual impairments and those with learning difficulties must be a priority in the design of footways and footpaths.

Specific advice on the provision of surface textures to assist pedestrians with visual impairments can be found in DfT's Guidance on the use of Tactile Paving Surfaces (2007). The following documents also provide useful guidance on general issues and those specifically related to integration with cycling facilities.

- CABE, Sight Line (2010)
- RNIB, Building Sight (1995)
- Joint Committee on Mobility of Blind and Partially Sighted People (JCMBPS), Adjacent Facilities for Pedestrians and Cyclists (2004)

7.3.2 Accessibility requirements

Tactile paving must be applied to street environments to ensure they can be used comfortably and reliably by people with visual impairments. For cycle facilities, this refers particularly to crossings, where separate but adjacent facilities are provided for cycling and pedestrians, and for any shared infrastructure. This section covers each of these scenarios.

Consideration for users is the most important principle. National guidance should be followed, in order to maintain legibility and consistency, but always with common sense in mind. The characteristics of a place, and the movement patterns it gives rise to, will dictate whether a given arrangement is fit-for-purpose. Design needs to be as supportive as it can be, while avoiding over-complication, illegibility or confusion.

Over-provision of tactile paving will cause confusion and discomfort, disbenefit streetscapes and be costly. Where possible, the street environment should be designed so that minimal tactile paving is required.

Tactile paving depth

Tactile paving should be provided so that all users can detect it and therefore needs to be no deeper than the length of the longest likely stride.

Research undertaken in 2010 by University College London concluded that 'the blister profile is readily detectable when it is 800mm wide', leading TfL to make a recommendation that the minimum width for longitudinal blister tactile paving on TLRN should be reduced from the 1200mm recommended in national guidance to 800mm, ie two rows of 400x400mm flags.

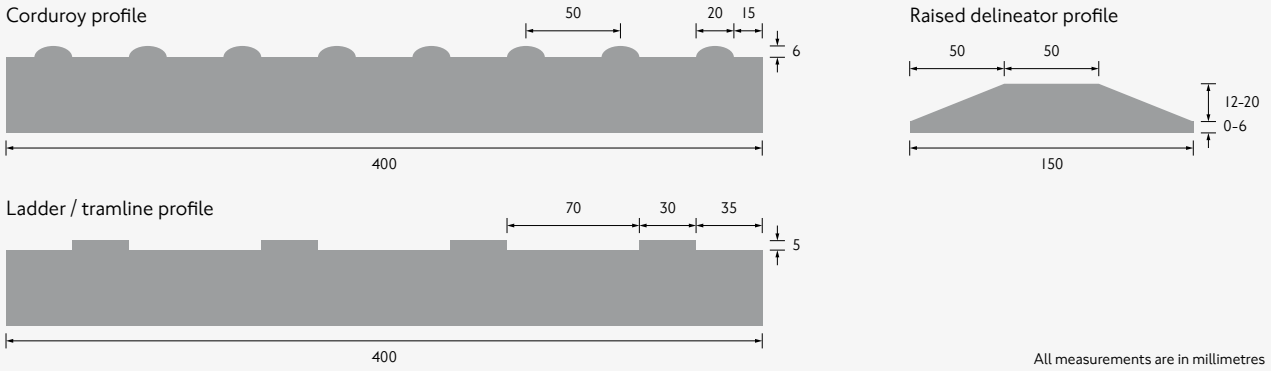
It may be reasonable to assume that, where any kind of tactile paving is intended to be understood only by pedestrians, the minimum depth should be 800mm, and to apply this logic to types such as ladder and tramline. TfL intends to undertake further research to test this.

Seeking to rationalise the amount of tactile paving used in a scheme makes sense from the perspective of legibility and comfort.

Moving across many types of tactile paving can be uncomfortable for both pedestrians and cyclists and therefore they should, ideally, be used sparingly.

Figure 7.4 Summary of tactile paving types used with cycle infrastructure

	Description	Use
Blister	Paving with parallel rows of flat-topped 'blisters': 25mm diameter, 5mm high domes. Available in red, buff or various shades of grey. Usually provided as 400x400 modular paving with 6x6 or 7x7 domes.	800mm depth at controlled and uncontrolled crossing points where the footway and carriageway are level with one another. Controlled crossings also have 800mm deep tactile tails of blister paving.
Ladder and tramline	Flat-topped ribs, 30mm wide, 5mm high, spaced 70mm apart. Available in light or dark grey, buff, or green, so that a consistent colour background can be achieved. Usually provided as 400x400 modular paving with 4 ribs.	National guidance sets out 2400mm depth to show a transition between an area shared between cyclists and pedestrians and an area separated between the two. As set out above, it is proposed that this may be reduced to 800mm minimum. Forthcoming TfL research will explore this proposition. On the cycling side, the 'tramline' tactile is aligned with the direction of movement. On the pedestrian side, it is laid transversely in a 'ladder pattern' – across the direction of movement.
Corduroy	Rounded ribs, 20mm wide, 6mm high, spaced 50mm apart. Buff, grey or charcoal colour tactile paving is available to match the footway.	800mm depth to warn visually impaired people of the presence of specific hazards such as steps, level crossings or on-street light rapid transit platforms. Also used where a footway or footpath joins a shared route, conveying the message 'hazard: proceed with caution'.



Comparison of corduroy and ladder/tramline tactile paving, in profile

7.3.3 Tactile paving at crossings

The advice in figure 7.4, taken from Guidance on the use of Tactile Paving Surfaces (2007) and Inclusive Mobility (2005), applies to pedestrian crossing of cycle tracks as well as crossing the carriageway. The most important principles for use are:

- Red blister tactile at controlled crossings (zebra crossings or signal-controlled crossings), with a tail to enable the crossing to be located
- Buff-coloured blister tactile, or a tone that provides clear visual contrast with the surrounding footway, at uncontrolled crossings (red should never be used at uncontrolled crossings)
- In some exceptional circumstances, such as Conservation Areas, a strongly contrasting grey may be acceptable at controlled crossings

Local streetscape guidance should be consulted for site-specific requirements.

At controlled crossings, 800mm-wide 'tails' run between the blister paving at the crossing-point and the back of the footway or building line. Appropriate tail lengths should ideally be derived from understanding pedestrian movement at each crossing, ensuring that the tail is perpendicular to the predominant pedestrian flow. For further details and examples, consult Guidance on the use of Tactile Paving Surfaces (2007).

7.3.4 Tactile paving at shared use areas

As figure 7.4 describes, Guidance on the use of Tactile Paving Surfaces (2007) recommends that ladder-and-tramline tactile paving should be applied to shared use areas to allow people, particularly those with visual impairments, to detect a transition between a shared area and separate spaces for pedestrian and cycle movement. Cyclists should be able to recognise when they leave a dedicated area and enter a shared area: there is an even greater obligation to act with care and courtesy in such environments.

Appropriate signing should also be provided: the sign to diagram 956 of TSRGD for shared use and to diagram 957 where a footway or footpath is divided between users. This should be adequate without needing surface markings although it can be helpful to provide these in some circumstances as inlaid tiles (see section 6.3.4). Where cyclists and pedestrians are separated but at the same level, the 20mm raised delineator strip to diagram 1049.1 of TSRGD should be used.

TSRGD diagram 956

TSRGD diagram 957

Red blister tactile paving used at controlled crossings. Note the buff blister tactile at the uncontrolled crossing of the cycle tracks, bottom

Legibility and coherence

Designers need to consider the legibility of the street environment and the desirability of minimising sign clutter when it comes to signing shared use areas. Over-use of tactile paving and signing can lead to unattractive, incoherent and confusing provision.

- It is more or less impossible to account for every direction or angle of possible pedestrian movement – this makes it difficult to provide tactile paving that is fit-for-purpose
- Cyclists can slip on tramline tactile paving, particularly in wet or freezing conditions – their wheels can become deflected by the longitudinal grooves
- It is recommended that all other alternatives should be explored before relying on tactile paving to distinguish between different areas preferably, this should include clear physical – and/or visual distinction between an area for cycling and a shared area

Where a cycling scheme appears to require a large amount of tactile paving and signing to diagrams 956 and 957, this usually indicates that the design solution is not fit-for-purpose and it should prompt a re-design.

If cyclists cannot be accommodated in safety and comfort on the carriageway, or vertically separated from pedestrians off-carriageway, then fully shared use is often preferable to short, 'stop-start' sections of separated use at footway is level.

Ladder and tramline

Where ladder and tramline is provided, Guidance on the use of Tactile Paving Surfaces advises that 2400mm depth should be used. TfL is proposing that this may be reduced, potentially to a minimum of 800mm, in line with conclusions about depth of blister paving, and will undertake research to test this.

It is possible to use tramline tactile paving on its own at the start of a cycle track and accompanied by cycle track sign TSRGD diagram 955, or at the start of a segregated path with the sign to diagram 957. However, it is preferable that other visual cues should be used to identify a facility as a track or path for cyclists before resorting to tactile paving.

Ladder and tramline at 2400mm depth (left) and 1200mm (right)

Corduroy

Where a footway or footpath joins a shared route, Guidance on the use of Tactile Paving Surfaces advises that 800mm depth of corduroy tactile paving be used at the transition. Corduroy, which is normally used at steps or other changes of level, is similar to ladder/tramline but its ribs are rounded and more tightly spaced and so it feels different underfoot. It is important not to confuse these two types of tactile paving and corduroy should never be laid in line with cycle movement as it can destabilise riders.

Corduroy tactile paving material has also developed a 'variant' use (ie one not described in DfT guidance) as substituting for a kerb edge in schemes where a level surface treatment has been applied. This is in order to help blind and partially sighted pedestrians find the edge and is intended to assist cane users in particular. Whether this treatment is appropriate will depend on the overall design for a street. It should not be applied without broader consideration of the needs of all users as part of a scheme and without assurances from user groups that it will convey the intended message.

Corduroy paving used instead of a kerb edge at Bexleyheath

7.3.5 Pedestrian guardrailing

The Mayor's Manifesto (2012) said: 'The capital has too many guardrails, restricting the movement of pedestrians and also presenting a hazard for cyclists.' TfL has produced Guidance on the Assessment of Pedestrian Guardrail (2012), based on the experience of analysing and removing pedestrian guardrail at around 150 junctions and 200 staggered crossings in central London.

The assessment procedure should include a road safety audit, starting from the assumption that all the guardrailing is to be removed. Guardrails can be especially hazardous for cyclists as they block a potential escape route in the event of collision. Removal of guardrail does, however, reduce opportunities for informal cycle parking and at least an equivalent number of stands should be re-provided in the vicinity.

7.4 Maintenance and asset management

7.4.1 Why maintenance is important

The maintenance of cycle routes and cycle facilities is essential if they are to encourage cycle use. Attention to maintenance for cycle routes should be higher than generic highways standards described in DfT Roads Liaison Group, Well-maintained highways (2005) and elsewhere. Even minor defects can unseat a rider and poor surface quality can increase the effort required to cycle to the extent that it deters cycle use.

Highway authorities should consider obligations under the Equality Act (2010) with regard to level of service and disabled cyclists. Poor maintenance affects non-standard cycle users disproportionately. Any user of a cycle with more than two wheels cannot avoid pot-holes without putting themselves at increased risk. For those who use their cycle as a mobility aid, damage to their cycle can negatively affect quality of life.

Relevant to effective maintenance are ownership issues and the New Roads and Street Works Act, 1991. NRSWA provides a legislative framework for street works activities by all undertakers, with the aim of coordinating them efficiently for the benefit of all road users. In some instances, certain responsibilities under the Highways Act (1980) and NRSWA are devolved to contractors.

7.4.2 Maintenance regimes

Importantly, cycle routes need to be inspected and resurfaced regularly. Occurrences of any of these defects should be rectified in order to maintain the comfort level of service rating. It is recommended that each highway authority should:

- Integrate routine inspection of cycle facilities into its in general highways maintenance regime
- Integrate consideration of cycle facilities into planned road maintenance programmes – for example, identifying what improvements for cycling can be made as part of planned resurfacing
- Make use of the local cycling community in identifying road faults, obstructions and maintenance issues (smartphone technology can contribute to this)

Winter maintenance needs to be considered separately, due to the additional risks that this presents to cyclists and likelihood of people being deterred from cycle use during the winter months. Cycle lanes and tracks can become unusable without adequate salting or gritting. However, excessive grit accumulating by the road, in cycling facilities, is also a problem. Snow and ice cleared from the carriageway should never be allowed to accumulate in cycle lanes. Issues identified in regular inspections should be raised with the relevant borough winter maintenance manager, or equivalent.

Consideration of maintenance routines needs to include ensuring that there is access for the use of maintenance vehicles to all parts of the cycle network, and that such vehicles are appropriate for winter use and snow and ice clearance. Segregated lanes, for example, are likely to need small sweepers.

Visual inspection by cycle and on foot are the simplest methods but cycle- or motor vehicle-mounted equipment can be a useful additional tool in measuring surface quality on a regular basis.

Maintenance hierarchy

TfL has developed the following hierarchy based on cycle flows and the relative importance of designated routes:

Prestige
Policy priority route, with very high flows (>2500 cyclists/day) and/or part of the Cycle Superhighway or Quietway network

Primary
High flows (1000 to 2500 cyclists/day) and/or sites that are part of other designated cycling routes

Secondary
Medium / low flows (<1000 cyclists/day) and/or local access and links

Cyclists excluded
Any section of highway from which cyclists are legally excluded

7.4.3 Surface quality

Uneven surfaces can affect the balance and stability of bikes, or generate swerving manoeuvres, which can contribute to the risk and seriousness of injury. As set out in section 7.1 above, to ensure cycle safety and comfort, upstands of over 10mm parallel to the direction of travel and over 15mm at right angles need to be avoided for any cycle facility. These should inform the thresholds for intervention for each of the surface quality issues set out in figure 7.5.

Some streets are more sensitive than others to the negative effects of surface defects and, through maintenance regimes, should be prioritised. These sensitive streets include feeder access routes to schools and parks, or any other street often used by children, older people or people carrying children on cycles.

Figure 7.5 Typical maintenance issues affecting cyclists

Standing water due to uneven or slack gradients, blocked gullies, rutting of surface or leaking water valves

Surface cracking or excessive rutting (top) Worn/smooth manhole covers (bottom)

Unsuitable road gullies: dished, with longitudinal waterway gaps or with frame set below adjacent surface

Missing surface material or failed reinstatement

Standing water

Standing water is a risk as it results in an unnecessarily slippery surface and cyclists swerving to avoid spray from passing vehicles. It needs to be treated as a priority all year round and not just in cold weather. It can also conceal other hazards, such as broken glass or a pot-hole, or indicate a drainage problem. Blocked gullies or inadequate drainage should be identified and rectified during normal maintenance routines. Leaking water valves are the responsibility of the water authority and NRSWA coordinator.

Ironwork

Ironwork should be checked during routine inspections so that skid resistance is compatible with that of the surrounding road surface, particularly where surface coatings have been applied. Covers sitting low or loose in frames can be a source of discomfort or even a safety risk for cyclists where they need to swerve to avoid the cover.

Most inspection covers (other than gullies and other surface water chambers) are the responsibility of service providers: replacement covers must be 'badged' identifying the owner (as set out by NRSWA, 1991). These companies may have their own intervention levels but these may not adequately meet the needs of cyclists.

Highway authorities may replace covers but may not be able to recover costs.

Poor maintenance practices can result in the tops of gullies being set unnecessarily low, which is not only a problem for cyclists but also results in vehicle impact loading and early failure. To avoid this issue, contract specifications should address materials and construction details, and supervision of work is required.

7.4.4 Debris and other obstructions

Some maintenance issues will need to involve relevant borough street cleansing and refuse collection teams in a programme of inspection and checking, or in the identification of problem areas such as spillages from refuse vehicles. Inspections should focus on typical problem locations, such as the areas around bus stops and petrol stations.

Broken glass or other debris often blown across by motor traffic can cause danger to cyclists trying to avoid it. This can be a particular problem when segregated cycle lanes are introduced and debris ceases to be deflected by the normal flow of vehicles. Any changes to the cleansing contractor's schedule will need to be notified and agreed, and should be recorded in case cleansing problems arise.

Obstructions such as skips, hoardings, scaffold and building materials left on cycle lanes and tracks should be identified in inspections and reported to the relevant borough licensing team for highway works. Effective planning, programming and supervision of works is required to avoid contractors and statutory and private utility companies obstructing cycle infrastructure with compounds, machinery, plant and equipment. Obstructions caused by advertising material or other unofficial street furniture, or by persistent parking, should be dealt with through enforcement and reported to the borough NRSWA team.

Building materials left on cycle track

Contractors obstructing cycle route

7.4.5 Landscape growth

Growth of adjacent planting over the edges of cycle lanes and tracks can seriously reduce the width available to cyclists. It can reduce sight lines to create blind spots, sometimes giving rise to social safety issues. Cyclists can find it harder than pedestrians to avoid branches due to their speed, and their height off the ground.

Vegetation needs to be kept in check by regular trimming, typically using mechanical hedge cutters, and by periodic major pruning. Light pruning will not address the creeping forward of the main trunks of shrubs and trees in locations such as canal towpaths. The mowing or hedge pruning zone needs to be kept clear of obstructions, to allow machines to be used for this maintenance.

Inspections need to be proactive and enforcement letters issued to private owners (under section 154 of Highways Act, 1980) before the problem becomes unacceptable. The authority must have in place a procedure for inspecting the works in default of a notice and a regime for their own trees. Issues around grass encroaching on cycle tracks should be addressed to the relevant borough street cleansing manager, or equivalent.

Stinging nettles, brambles and other trimmed-back thorn bushes need to be thoroughly removed after cutting to ensure that punctures do not result. (Wherever possible, avoid cycle tracks and such plants in close proximity).

Consider proximity of trees and bushes when planning and maintaining signs

7.4.6 Street furniture, signing and lighting

Maintenance inspections should highlight where any street furniture close to the kerb represents an obstruction for cyclists. This includes permanent, temporary or fly-posted signs attached to poles and lighting columns. Any missing or damaged signs should also be noted during inspections and reported to the relevant borough highway engineering manager.

Damaged sign obstructing cycle track

Obstruction by street furniture

Signs can be rotated, removed unofficially, not replaced after collision damage, or made illegible with graffiti. Problems such as these can give the impression of a route with issues of social safety as well as indicating lack of importance given to cycling by the managing authority. Anti-rotational brackets should be fitted to appropriate signs, particularly 'finger' direction signposts – see section 6.3.7. Square-profile posts can also help to remove this problem.

Surface markings are likely to become worn, and may be removed by trench digging or by resurfacing. These defects should be rectified as soon as they become illegible. Markings can also become difficult to read if they have been part-reinstated. Contractors should be instructed to repaint the whole of any road marking, rather than just the part directly affected by their works.

Inadequate lighting of cycling facilities ideally needs to be addressed through proper design and/or improvement schemes. Frequent inspections can help identify issues, which should be raised with the relevant borough highway engineering manager or equivalent.

7.5 Structures

7.5.1 Overview

Making difficult connections can often only be done by taking cycling facilities over or under other features such as highways, railways and waterways. Because these usually require cyclists to deal with gradients, and because they are likely to be costly, a strong case will need to be made for their construction. However, bridges and subways can play an important role in cycling networks, and they can offer a high degree of safety and directness.

Opportunities should be taken to improve access generally with investment in cycling infrastructure, which can help contribute to the business case. Structures should therefore enable better pedestrian access and improved access for people with visual and mobility impairments, in line with duties under the Equality Act (2010).

7.5.2 Bridges

White House Lane bridge, Hackney – before and after. Conversion to a fit-for-purpose cycling link

New bridges should allow for comfortable and direct cycle and pedestrian movement. Although separation may be considered for wide structures, subject to the advice given in sections 4.5 and 4.6, shared use is likely to be practical. It also works better where any turns need to be made by cyclists as this will be difficult to achieve while staying one side of any separation.

Consideration should be given to the likely growth in cyclist numbers due to network improvements and making a new link locally. It is recommended that new pedestrian/cycle bridges in urban areas should be built with at least 4 metres' clear width.

Gradient

Bridges for cyclists' use should be designed so as not to require cyclists to dismount and use steps, which is usually best achieved through access ramps. Ramps should have a shallow gradient – generally be no greater than 1 in 20 (5 per cent). A 1 in 12 (8 per cent) gradient over short stretches with flat landings every 10-15 metres may be preferable to a long or convoluted 1 in 20 ramp.

Where multiple ramps are needed, they should preferably avoid 90- or 180-degree angles where they turn. Turning circles of larger cycles and of mobility scooters need to be taken into account in the design of ramps and landing areas (see section 3.2.3).

A ramp as steep as 1 in 12 is likely to be difficult to negotiate for many other users. DfT's Inclusive Mobility guidance recommends that gradients up to 1 in 20 (5%) are acceptable only over short distances for manual wheelchair users. Should a bridge have a ramp exceeding 5%, it should be provided with a lift, to specifications set out in section 8.2.1, enabling access for people with larger models of cycle who may not be able to use a steep ramp.

Bridges with separate pedestrian and cycling facilities in Stockholm (left) and Minneapolis (right)

Ravensbury Park shared use bridge, Merton

Access ramp, Richmond

Parapet height

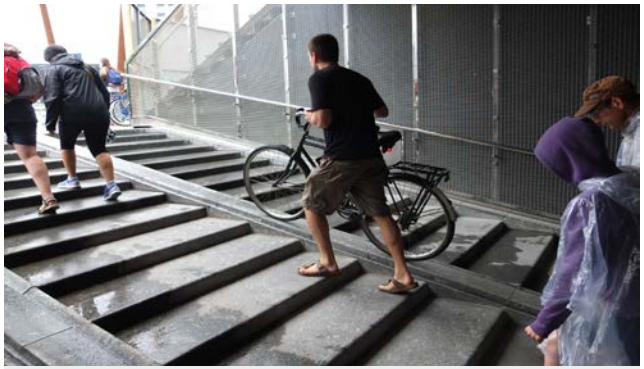
On footbridges intended for shared pedestrian and cycle use the minimum parapet height stipulated by DMRB, section BD 29/04 is 1.4 metres. Where pedestrian and cycle use is separated, this requirement only applies to the cycle side. On other structures and situations it is recommended that a risk assessment be carried out to inform design options. The Sustrans guide, Parapet heights on cycle routes: Technical information note no. 30 (2012), includes guidance on undertaking such a risk assessment.

High bridge parapets

7.5.3 Wheeling ramps

Where steps are unavoidable at bridges and subways, or as a short-term, low-cost measure pending replacement, concrete or steel-section wheeling ramps on one or both sides of steps should be considered, giving cyclists an alternative to using lifts or carrying their cycle. Retrofitting wheeling ramps should be considered whenever bridges, railway stations and underpasses are refurbished. Steel-section ramps, with a high-friction surface for the ramp channel, should be at least 100mm wide and 50mm deep, and mounted at least 200mm away from the wall.

Wheeling ramps are of limited use to those with non-standard cycles and are not a substitute for step-free access, which will generally need to be served by providing a lift. If step-free access cannot be secured, signing ahead of the bridge or subway is needed to indicate this and to provide alternative, step-free directions.



Concrete wheeling ramp, Netherlands

Pedestrian accessibility issues

In fitting wheeling ramps, care needs to be taken to avoid compromising the accessibility needs of pedestrians, particularly young children, older people and people with mobility impairments, all of whom may need to rely on close proximity to the handrail. Ideally, a sufficient number of handrails should be provided at the edges and at the centre of the steps to allow for two sides to be dedicated to pedestrian use and two to cyclists.

Where this is not achievable, a wheeling ramp may be installed directly below a handrail so that they do not interfere with one another. This requires enough space for the cycle to be wheeled without catching the handlebars on the handrail. Angling the channel of the wheeling ramp outwards may help. Otherwise, a wheeling ramp for cyclists on one side only may be the best solution.

Wider stone or brick infill sections for wheeling cycles are often easier to use, and can also offer some assistance to people with prams and pushchairs. For the above reasons, these should only be used if users still have full, close access to handrails (on another part of the steps).

Wheeling ramps

7.5.4 Tunnels and subways

A dedicated cycle tunnel or subway, or one shared with pedestrians, may be a viable option as part of an urban cycling network. It can help:

- Avoid circuitous, possibly motorised traffic-dominated routes
- Give protection from weather and, provided it is not used by other vehicles, a good riding surface
- Offer consistent provision where the tracks join off-carriageway facilities on either side

A well designed tunnel or subway could become an attractive, distinctive and memorable part of any cycling route. However, this will require good lighting, high standards of maintenance and ramps to provide access to and from the facility, so construction and maintenance costs are likely to be high. Angled approach ramps can create blind corners and lead to social safety concerns so, wherever practical, subways designed to give good through-visibility are preferred.

Design considerations

Due to the probable need to turn corners, shared use is likely to be preferable to separation and sufficient widths should be provided to retain comfortable movements for all users. Noting the need to provide for growing numbers of people walking and cycling, a working minimum of 4 metres should be applied wherever possible, widening on busier sections of path or where separation of users is considered to be necessary.

DMRB section BD 78/99 sets out tunnel design requirements for vehicular traffic, much of which also applies to tunnels for cycle and/or pedestrian use only. The DMRB definition of a road tunnel is 'a subsurface highway structure enclosed for a length of 150 metres, or more'. Most of the basic design and management requirements set out in DMRB are assumed to apply to tunnels largely dedicated to cycling.

Headroom through tunnels and subways should be a minimum of 2.4 metres for cyclists (DMRB, section TD 36/93) and 2.1 metres for pedestrians. In many cases, such as on canal towpaths, this cannot be achieved because of structural constraints. Reduced headroom should be highlighted using an explanatory sign with appropriate text (such as 'Cyclists beware – low headroom'), and stating the actual height available. Existing structures that have headroom less than 2.4 metres should not be precluded from inclusion within a cycle network, and should be signed appropriately.

Sustrans' Technical Information Note No.29, Lighting of cycle paths (2012) provides further information on design considerations for tunnels, underpasses, subways and bridges.

Subway for cycle crossing of busy road, Netherlands

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