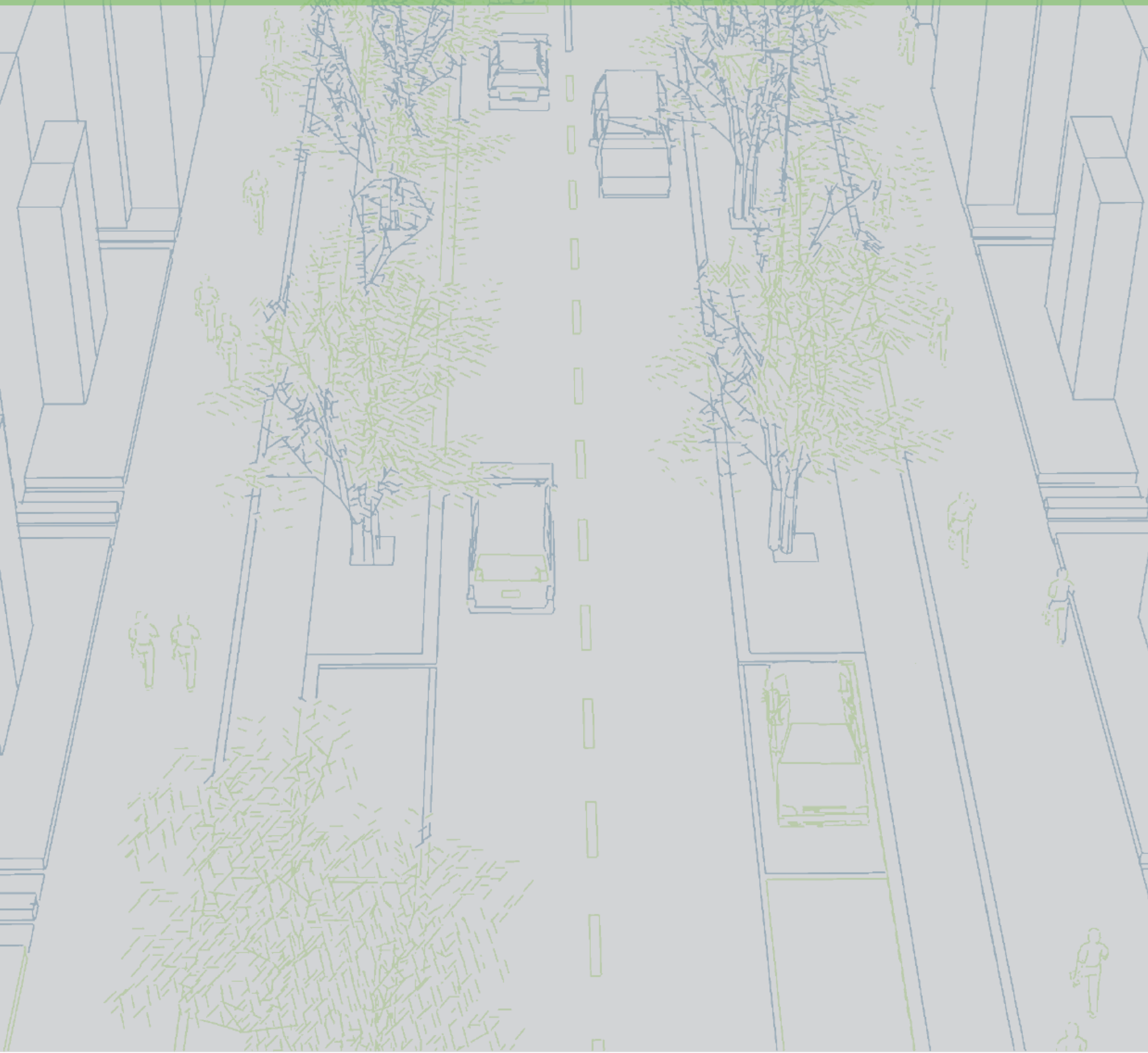
CHAPTER 4 - STREET DESIGN

A more integrated approach to street design can create a 'win-win' scenario, where designers can enhance the value of place whilst calming traffic and improving pedestrian and cyclist comfort. To achieve this outcome, designers need to consider the multi-functional role of the street and apply a package of 'self-regulating' design measures.



4.0 Street Design

4.1 Movement, Place and Speed

4.1.1 A Balanced Approach to Speed

Balancing the priorities *Context* and *Function* creates a shifting dynamic in street design. The UK *Manual for Streets* (2007) illustrates this relationship as a simple graph depicting some well known scenarios (see Figure 4.1). Key to the successful implementation of responsive design solutions is the issue of speed, particularly so with regard to pedestrian and cyclist safety, comfort and convenience (see Figure 4.2). Expectations of appropriate speed will vary greatly from person to person and there is little relevant research on this subject. Intuitively one would expect motorists' tolerance of low-speed journeys to increase in intensively developed areas (i.e. from the *Centres*, to *Neighbourhoods* to *Suburbs*) and according to journey type (i.e. from *Local* to *Link* and to *Arterial* Streets.

Designer must balance speed management, the values of place and reasonable expectations of appropriate speed according to *Context* and *Function*.[1] In this regard:

- Within cites, towns and villages in Ireland a default speed limit of 50km/h is applied.
- Speed limits in excess of 50km/h should not be applied on streets where pedestrians are active due to their impact on place and pedestrian safety.
- Lower speed limits of 30km/h are a requirement of *Smarter Travel* (2009) within the central urban areas, where appropriate.[2]
- Where pedestrians and cyclists are present in larger numbers, such as in *Centres*, lower speed limits should be applied (30-40km/h).
- Where vehicle movement priorities are low, such as on *Local* streets, lower speed limits should be applied (30km/h).

Figure 4.1: Illustration from the Manual for Streets 2 (2010) depicting the relationship between place and movement in regard to some well know scenarios.

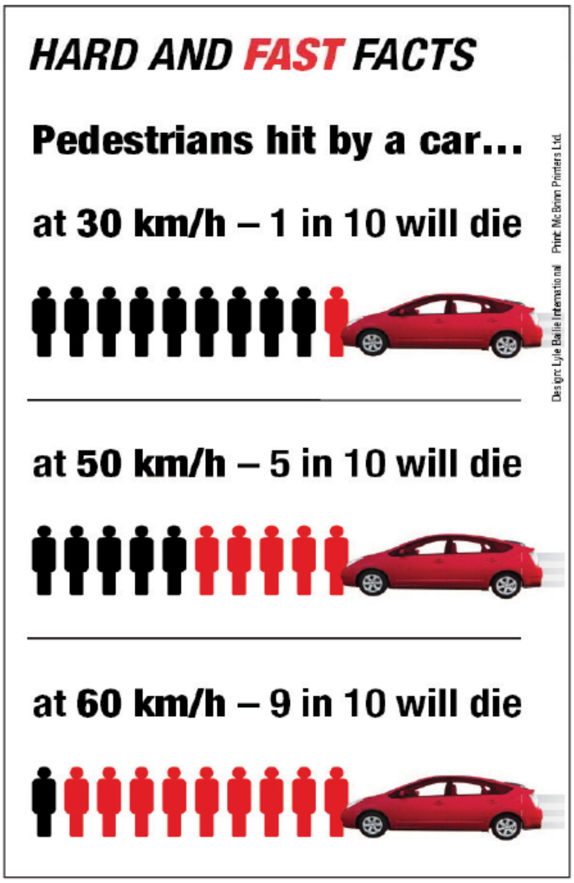


Figure 4.2: Illustration from the Road Safety Authority showing the impact of vehicle speeds on pedestrian fatalities. This is of primary consideration when considering appropriate speeds and levels of pedestrian activity.

1 Further guidance in regard to special speed limits is available from Section 9 of the *Road Traffic Act - Guidelines for the Application of Special Speed Limits (2011)*.

2 Refer to Action 16 of *Smarter Travel (2009)*.

- Local Authorities may introduce advisory speed limits of 10-20km/where it is proposed that vehicles, pedestrians and cyclists share the main carriageway.

Design speed is the maximum speed at which it is envisaged/intended that the majority of vehicles will travel under normal conditions. In this regard:

- In most cases the posted or intended speed limit should be aligned with the design speed.
- In some circumstances, such as where advisory speeds limits are posted, the design speed may be lower than the legal speed limit.
- The design speed of a road or street must not be 'updesigned' so that it is higher than the posted speed limit.

Table 4.1 illustrates the broader application of design speeds according to *Context* and *Function*. Designers should refer to this table when setting speed limits and designing urban streets and urban roads to align speed limits and design speeds.

When applying these limits designers must also consider how effectively they can be implemented, as the introduction of more moderate and/or lower speed limits out of context and/or without associated speed reduction measures may not succeed.

PEDESTRIAN PRIORITY — VEHICLE PRIORITY

FUNCTION	CONTEXT: CENTRE	N'HOOD	SUBURBAN	BUSINESS/ INDUSTRIAL	RURAL FRINGE
ARTERIAL	30-40 KM/H	40-50 KM/H	40-50 KM/H	50-60 KM/H	60-80 KM/H
LINK	30 KM/H	30-50 KM/H	30-50 KM/H	50-60 KM/H	60-80 KM/H
LOCAL	10-30 KM/H	10-30 KM/H	10-30 KM/H	30-50 KM/H	60 KM/H

Table 4.1: Design speed selection matrix indicating the links between place, movement and speed that need to be taken into account in order to achieve effective and balanced design solutions.

4.1.2 Self-Regulating Streets

An appropriate design response can successfully balance the functional needs of different users, enhance the sense of place and manage speed in a manner that does not rely on extensive regulatory controls and physically intrusive measures for enforcement. In short, place can be used to manage movement. Such environments are referred to as being self-regulating. Within this self-regulating street environment the design response is closely aligned with the design speed (see Figure 4.3).

Within Ireland, the *Dublin Traffic Initiative: Environmental Traffic Planning* (1995) was, perhaps, the first strategic document in Ireland to recognise the link between the street environment and driver behaviour. It cited the use of narrow streets and on-street parking as traffic-calming tools. The *Adamstown Street Design Guide* (2010) draws upon research undertaken in regard to the UK *Manual for Streets* (2007) to advance this approach. It cited a combination of place-based psychological measures and integrated them with more traditional physical measures in order to create a self-regulating street environment (see Figure 4.4).[3]

There is no set formula of how a package of psychological and physical measures should be applied. The design team must take into account that:

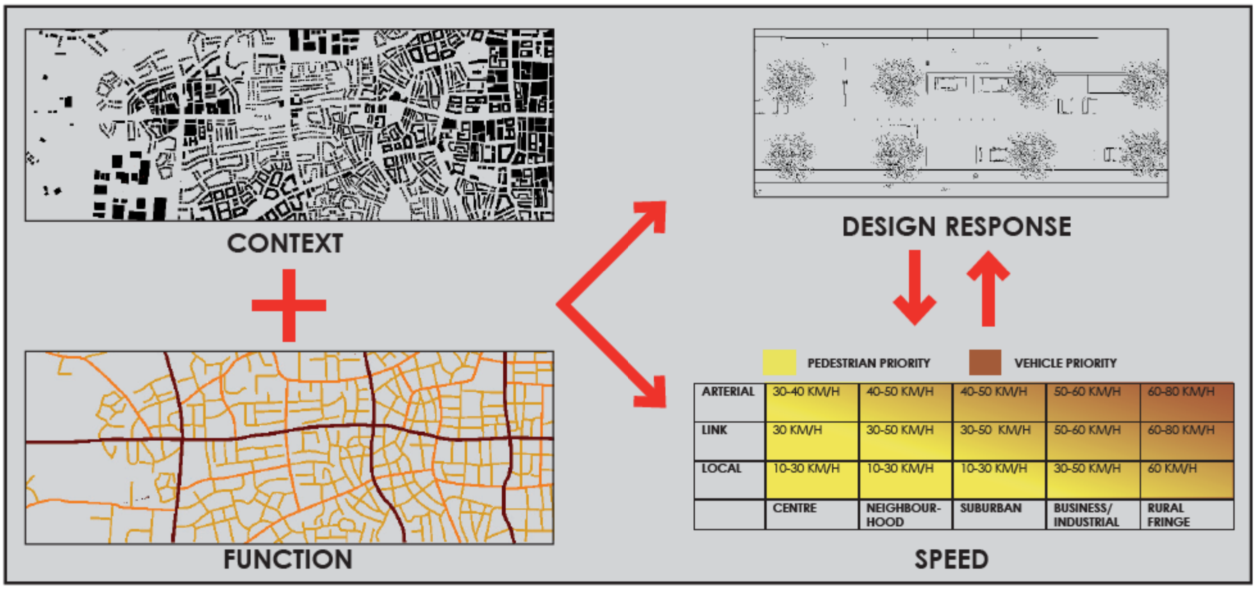
- Physical and psychological measures are most effective when used in combination.[4]

- The more frequently and intensely physical and psychological measures are applied, the lower the operating speed.

Analysis of the Road Safety Authority *Free Speed Survey* 2008, 2009 and 2011, inclusive showed that where there are few psychological and physical measures, average drivers regularly exceeded the posted speed limit. Conversely where these measures are more frequently and/or more intensely applied, driver speeds were lower and compliance with the posted speed limit was greater (see Figure 4.5).

3 Refer also to Section 2.2 'Safe Streets' of the *Adamstown Street Design Guide* (2010).

4 Refer to *Psychological Traffic Calming* (2005).



Figures 4.3: Illustration of the links between place, movement and speed that need to be taken into account in order to achieve effective self-regulating street environments.

Figure 4.4: Extract from the Adamstown Street Design Guide.
Illustration of the psychological and physical, or 'hard' and 'soft', measures that influence driver speeds and may be used to enhance place and manage movement.

Close Proximity of Buildings (left)

Continuous Street Wall (right)

Active Ground Floor Uses (left)

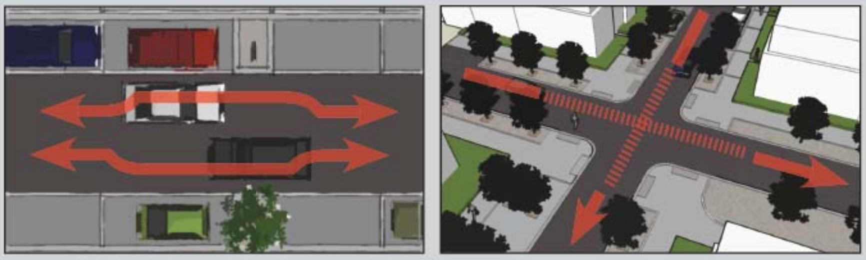
Pedestrian Activity (right)

Frequent Crossing Points and Junctions (left)

Horizontal and Vertical Deflections (right)

Narrow Carriageways (left)

Minimising signage and road markings (right)



Reduced Visibility Splays (left)

On-Street Parking (right)

Tighter Corner Radii (left)

Shared Surfaces (right)

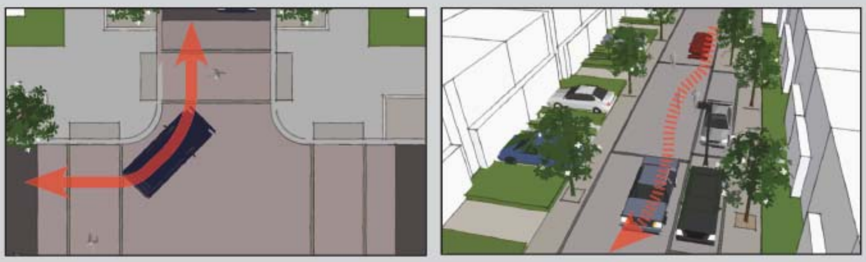


Figure 4.5: Road Safety Authority Free Speed Survey and Street Characteristics

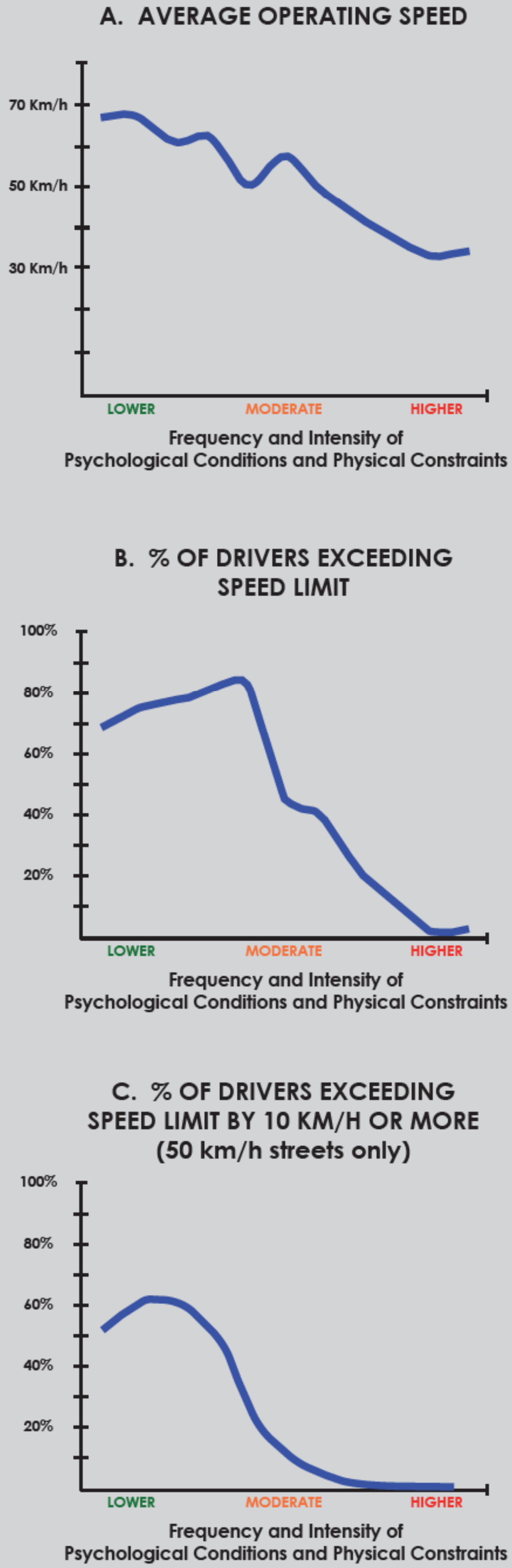
The Road Safety Authority periodically undertakes free speed surveys throughout urban and rural Ireland. In 2008, 2009 and 2011 the speeds of some 9,500 vehicles along 23 streets within metropolitan Dublin were recorded.

An analysis of the characteristics of the street environment at each of the 23 locations was carried out for the preparation of this Manual. This survey recorded the frequency and intensity of psychological and physical design measures that influence driver behaviour, such as those illustrated in Figure 4.4.

The survey results demonstrated that the individual effectiveness of these measures varied. For example, as would be generally expected, the presence of deflections (such as ramps) had a strong influence on reducing speed. Results also showed that other 'softer' measures, such as a sense of enclosure, surveillance and activity created by a continuous line of development fronting directly onto the street, have a strong influence on lowering speed.

Overall, the results demonstrated a strong trend whereby as the frequency and strength of the psychological and physical design measures increased, the lower the operating speed and the greater the level of compliance with the posted speed limit (see graphs A and B). This trend was generally consistent for all road types including those which did not have ramps.

Figure 4.2 illustrates that an increase in vehicle speeds from 50 km/h to 60 km/h nearly doubles the chance of a pedestrian fatality, should they be struck by a vehicle. Graph C is particularly significant in this regard as it illustrates that where there are limited psychological and physical design measures on streets with a speed limit of 50 km/h most drivers will exceed the speed limit by 10 km/h or more. Conversely where the frequency and strength of these measures are high full, or near full, compliance with the speed limit occurred. In many cases the average operating speed dropped below 40 km/h.



In retrofit scenarios, designers must carefully consider the characteristics of the existing street environment prior to implementing self-regulating measures as:

- The measures contained within this Manual should not be implemented in isolation as they may not fully address issues related to inappropriate driver behaviour on existing streets.
- Designers should carry out a detailed analysis to establish the levels of intervention and design measures required in any given scenario (see Figure 4.6).

For example, in many older *Centres* and *Neighbourhoods*, measures such as connectivity, enclosure, active street edges and pedestrian activity are generally strong. In these circumstances the design measures contained within this Manual may be readily applicable. The application of a holistic solution may be more challenging within a more conventional or highly segregated road environments. Under such circumstances a wider package of measures may need to be implemented.

This Manual cannot account for every scenario that a designer will encounter. In addition to those examples contained in the ensuing sections, to assist designers in the process of retrofitting it is intended that a series of 'best practice' case studies will be made available as downloadable content.

Figure 4.6: Examples from Youghal, Co. Cork (left), and Dorset Street, Dublin City (right), of retrofitted design responses that are appropriate according to Context and Function. The narrow, enclosed and lightly trafficked nature of the street within Youghal is highly suited to a shared carriageway. The heavily trafficked nature of Dorset Street makes it highly suited to a Boulevard type configuration.

4.2 Streetscape

4.2.1 Building Height and Street Width

Sense of enclosure is generally measured as a ratio where the height of a building (measured from front building line to front building line) is measured against the width of a street. Consideration needs to be given as to how consistently this ratio applies along the length of the street through the creation of a street wall. The street wall refers to how continuous the sense of enclosure is along the street.

Enclosing streets with buildings helps to define them as urban places, creates a greater sense of intimacy[5] and promotes them as pedestrian friendly spaces that are overlooked. This sense of intimacy has been found to have a traffic-calming effect as drivers become more aware of their surroundings.

Designers should seek to promote/maintain a sense of enclosure on all streets within cities, towns and villages (see Figure 4.7). In this regard.

- A strong sense of enclosure should be promoted in large *Centres*. The most effective way of achieving this is with a building height to street width ratio greater than 1:2 and street wall that is predominantly solid (allowing for intermittent gaps only).
- A good sense of enclosure can also be achieved with a building height to street width ratio of 1:3 and a street wall that is 75% solid, provided a continuous line of street trees are planted along the street. This approach may be more desirable in smaller *Centres* or *Neighbourhoods* where maintaining a more human scale is desirable.
- A strong sense of enclosure may be difficult to achieve where the total street width exceeds 30m wide, such as on *Boulevards*. In such circumstances design teams should emphasise the sense of enclosure with the planting of continuous rows of large closely planted street trees.

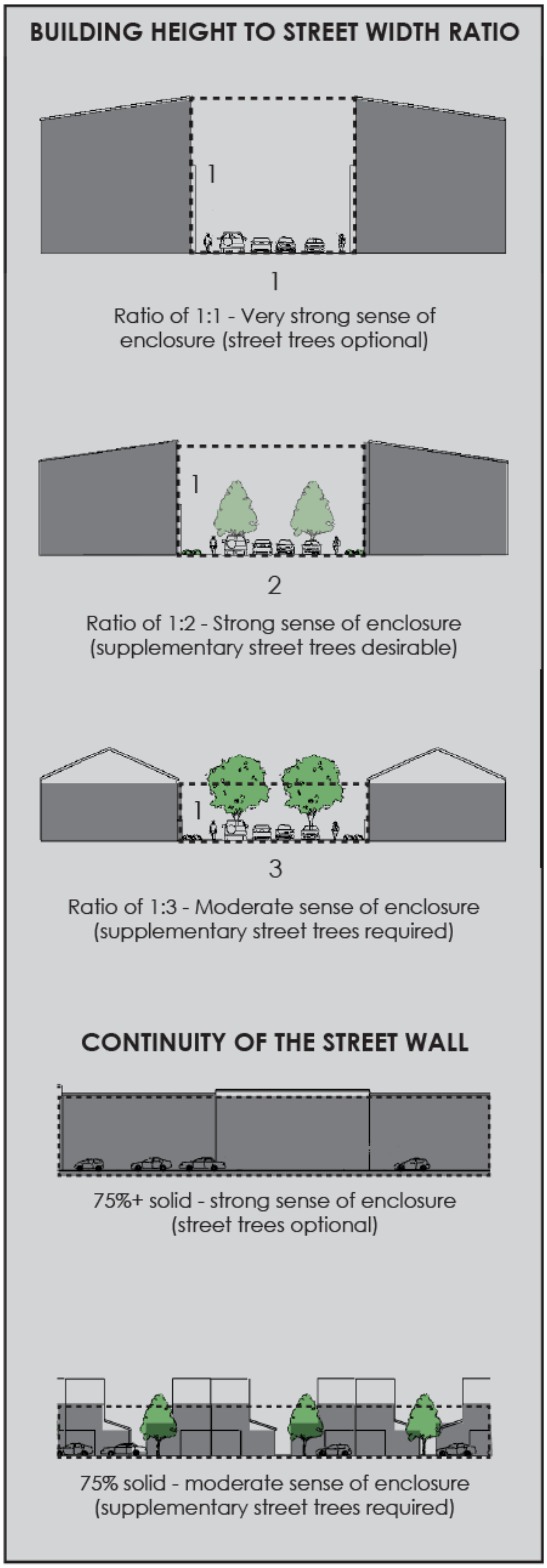


Figure 4.7: Measurements that indicate the sense of enclosure by way of building height to street width ratio and the percentage of the street wall that is solid.

5 Refer to Section 07 of the *Urban Design Manual* (2010).

- Within established areas creating a strong sense of enclosure may result in building heights that would conflict with those of the surrounding area. In such circumstances designers may emphasise enclosure though other design measures, such as the planting of street trees.

- The planting of street trees should also be considered as a retrospective traffic calming measure in existing contexts where levels of enclosure are traditionally weaker, such as in *Suburban* areas.

- The planting of street trees may also be desirable within *Transition Zones* (see Sections 3.4.1 Wayfinding and 3.4.4 Relief Roads), in advance of *Gateways* and within *Rural Fringe* areas as an advance warning to drivers of changing conditions ahead.

The measures illustrated in Figure 4.7 should not be strictly viewed as quantifiable. For example a moderate building height to street width ratio, in addition to a moderate continuity of street wall, does not equate to a strong sense of enclosure. Rather they should be viewed as complementary, i.e. a strong sense of enclosure is created where both elements are strong.

The relationship between building height and street width is also key to creating a strong urban structure, by increasing building heights in proportion to street widths. This will also promote greater levels of sustainability and legibility by placing more intensive development along wider/busier streets, such as *Arterial and Links* streets, to support public transport routes and highlight their importance as connecting routes, respectively (see Figure 4.8).

Additional building height may also be used at junctions to create a 'book end' effect (see Figure 4.9). This approach will assist in slowing vehicles as they approach junctions and will improve legibility by highlighting connecting routes throughout the network.

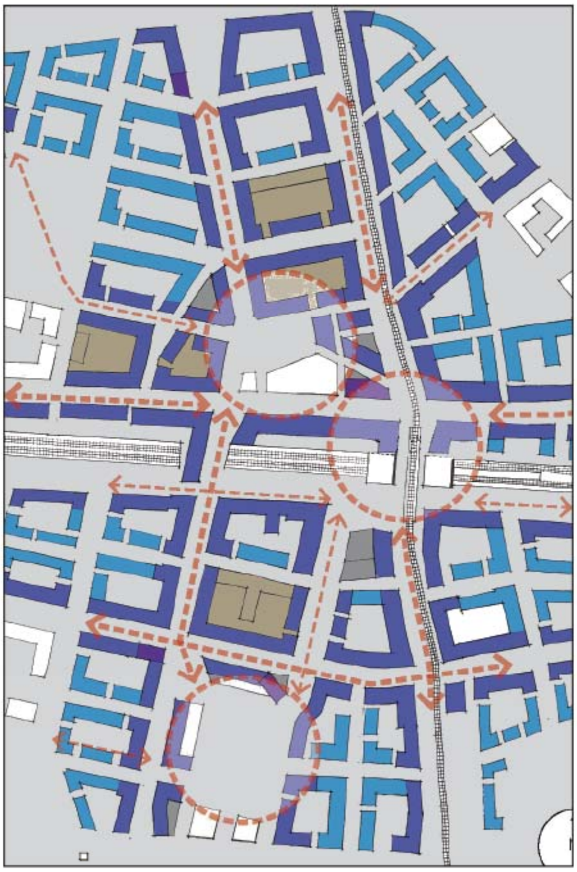


Figure 4.8: Plan illustrating how taller buildings (purple) are placed along busier routes (and around major spaces) to enclose streets and reinforce the structure of the area.

Figure 4.9: Reinforcing junctions with additional building height will assist in slowing vehicles as they approach junctions and will improve legibility by highlighting connecting routes throughout the network.

4.2.2 Street Trees

Street trees are an integral part of street design as they contribute to the sense of enclosure, act as a buffer to traffic noise/ pollution and enhance place. A traffic-calming effect can also be achieved, where trees are planted in continuous rows and their canopies overhang, at least in part, the vehicular carriageway. Street trees can also be used to enhance legibility by highlighting the importance of connecting routes and distinguishing one area from another through variations in size and species selection.

The planting of trees should be considered as an integral part of street design. In general, the size of the species selected should be proportionate to the width of the street reserve. For example (see Figure 4.10):

- Larger species, with a canopy spread greater than 6m will be best suited to wider streets, such as *Arterial* and *Link* streets.
- Smaller species with a canopy spread of 2-6m will be best suited to narrower streets such as *Local* streets.

Designers may seek to vary this approach in keeping with the characteristics of a place. For example:

- Sparse planting may be more appropriate in a *Centre*, enhancing its urban qualities.
- Smaller species may be more appropriate where buildings are located in close proximity to the street edge carriageway (i.e. to take account of overshadowing, growth restrictions).
- Larger species may be desirable within *Suburbs*, to enhance the greener character associated with these places.

To be effective, trees should be planted at intervals of 14-20m. This may be extended periodically to facilitate the installation of other street facilities, such as lighting. Designers should also consider the impact of root growth. Tree roots may need to be contained within individual tree pits, continuous soil planting strips or using other methods to restrict growth under pavements/toward services.

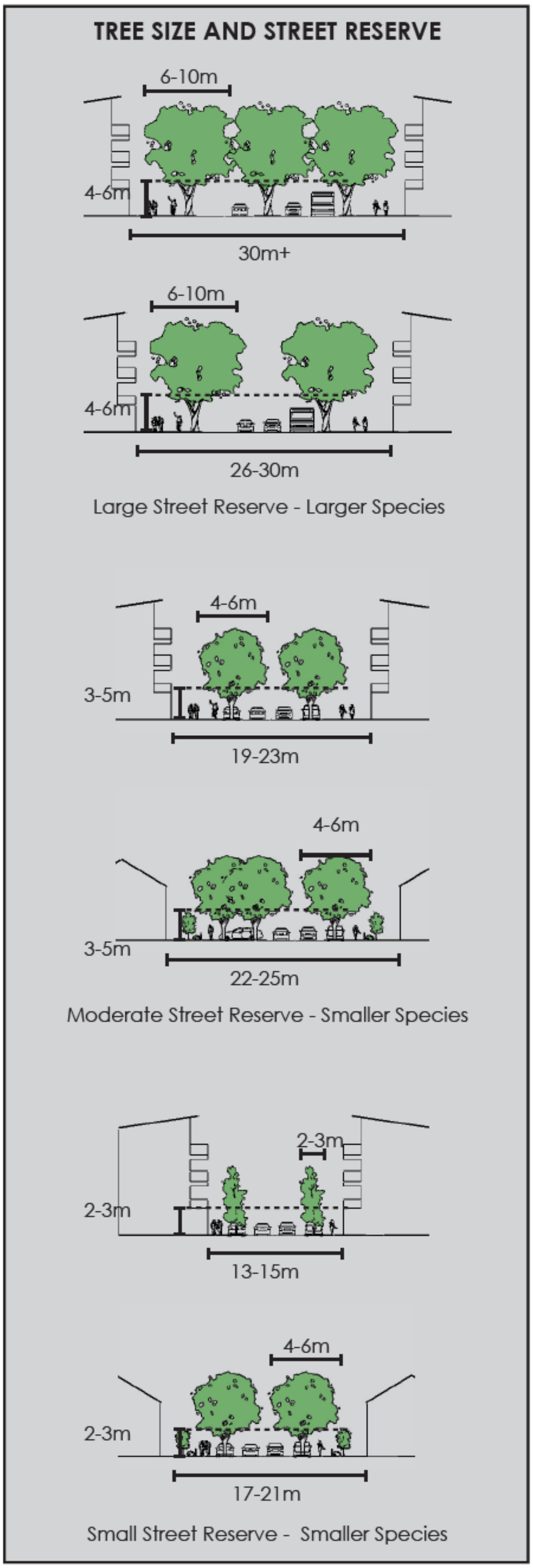


Figure 4.10: General guide to the canopy width and clearance height for street trees.

4.2.3 Active Street Edges

Active street edges provide passive surveillance of the street environment and promote pedestrian activity. This should be a principle aim of the design team. Increased pedestrian activity also has a traffic-calming effect as it causes people to drive more cautiously.[6]

Designers should seek to promote active street edges on all streets within cities, towns and villages. The most effective way to promote pedestrian activity is to place buildings in close proximity of the street (see Section 4.2.1 Building Height and Street Width) with a high frequency of entrances and other openings. In this regard (see Figure 4.11):

- To maximise activity in *Centres* the street edge should be lined with development that promotes a high level of activity and animation such as retail, commercial or other appropriate uses. To maximise the effectiveness of these uses, setbacks should be minimised (for example 0-3m) and a high frequency of entrances provided (for example every 5-10 metres).
- Where larger retail/commercial floor plates are proposed at ground floor level an active street edge may be achieved by creating multiple entrances and/or wrapping them with smaller perimeter units that front on to the street (see Figure 4.12).
- *Arterial* and *Link* streets through intensively developed *Neighbourhoods* may also sustain retail/commercial activity, particularly on corner locations.
- Higher levels of privacy are desirable where residential dwellings interface with streets. This may be provided via a small setback (for example 1-3 metres) which incorporates planted strip that defines public and private space (see Figure 4.13).
- Residential development will also promote on-street activity where individual dwellings (including ground floor apartments) are 'own door' accessed (see Figure 4.14).

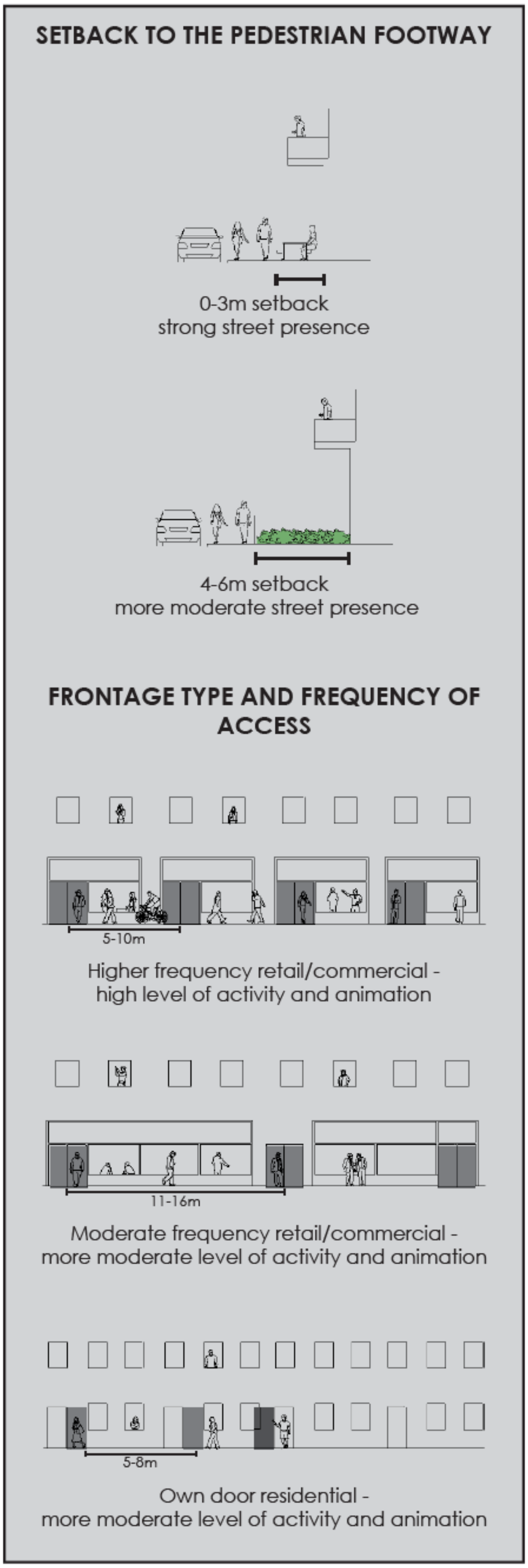


Figure 4.11: Measures that indicate active and animated street interfaces.

6 Refer to Section 2.2.5 of the UK *Manual for Streets* (2007).

- Greater flexibility in regard to setbacks may be needed in existing areas where they are defined by an existing pattern of building lines

- The inclusion of in-curtilage parking within front gardens (i.e. to the front of the building line) may result in large building setbacks that substantially reduce the sense of enclosure. In addition to the above, designers should avoid a scenario where parking dominates the interface between the building and the footway (see Section 4.4.9 On-Street Parking and Loading).

In addition to the above, further advice with regard to the creation of active street edges may also be taken from the *Urban Design Compendium*.[7]

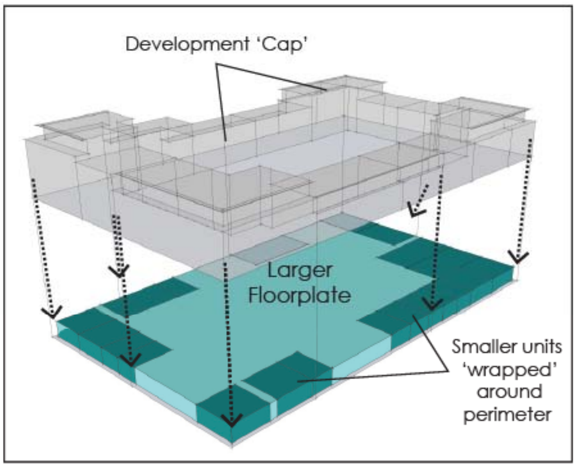


Figure 4.12: Illustration of how a larger retail/ commercial unit can be accommodated within a block whilst promoting an active street edge that is also overlooked from the upper levels.

Figure 4.13: Privacy strip to the front of residential development. The strip provides a buffer and clearly define the private domain from the public.

7 Refer to Section 5.1.2 Building Lines and Setbacks and Section 5.2 Animating the Edge, UK *Urban Design Compendium* (2000).

Figure 4.14: A fine grain residential environment where all ground floor dwellings are directly accessible from the street via 'own door' entrances. Note, in this instance access to upper floors is provided via internal lobby areas.

4.2.4 Signage and Line Marking

The principal source for guidance on signage and line marking is the Department of Transport *Traffic Signs Manual* (TSM) (2010), which categorises signage and road marking into four main categories:

- TSM Chapters 2 and 4: *Information Signs* that give directions and distances to destinations or which provide other information that may be relevant to road users;
- TSM Chapter Section 5: *Regulatory Signs* that give instructions, prohibitions or restrictions which road users must obey and indicate the existence of a Road Traffic Regulation or implement such a Regulation, or both.
- TSM Chapter Section 6: *Warning Signs* are used to alert the driver to a danger or potential danger on the road ahead.
- TSM Chapter Section 7: *Road Markings* are defined as markings on the surface of the road for the control, warning, guidance or information of road users and may either be used on their own or to supplement associated upright signage.

Regulatory Signs can be further divided into three main groups:

- *Mandatory Signs* are used to indicate that a road user must take a certain action. For Example 'Stop', 'Yield' or 'Keep Left'.
- *Restrictive Signs* to indicate a limit must not be exceeded. For Example '50 km/h Speed Limit' or 'Weight Limit 3 tonne'.
- *Prohibitory Signs* to indicate something which must not be done. For Example 'No Right Turn' or 'No Parking'.

The implementation of a self-regulating street environment means that the reliance on signage or line marking to direct or instruct people is significantly reduced. As noted in the *Manual for Streets* (2007)[8], there may also be traffic-calming benefits of a 'less is more' approach to reinforce lower design speeds. For example, the removal of centre line markings has been found to reduce vehicle speeds and the number of accidents.[9] With reduced signage drivers must navigate the street environment with full regard to their own behaviour and the behaviour of others around them. An emphasis on the values of place also requires the visual impact of signage to be considered in order to reduce visual clutter.

The TSM warns against over providing signage and line marking. Section 1.1.10 of the TSM states in relation to signage in general, 'signs should only be erected where there is a demonstrable need, because unnecessary, incorrect or inconsistent signs detract from the effectiveness of those that are required and tends to lead to disrespect for all signs'. There is also a limit to how many signs/line markings drivers can absorb in a short period.

To define where designers are allowed to employ discretion, Section 1.1.12 of the TSM states that:

- 'Shall' or 'must' indicates that a particular requirement is mandatory;
- 'Should' indicates a recommendation; and
- 'May' indicates a permissible option.

8 Refer to Section 9.1.7 of the *Manual for Streets* (2007). Designers should also note that the *Manual for Streets* recommended monitoring streets where little or no signage is used to confirm its effectiveness.

9 Refer to Improving *Traffic Behaviour and Safety Through Urban Design, Civil Engineering* (2005).

Designers should use this discretion with regard to the self-regulating characteristics of streets and the impact of signs/line marking on the value of place when applying the TSM. In this regard:

- Minimal signage is required on *Local* streets due to their low speed nature and low movement function. The generally lightly trafficked nature of these streets means that the use of signage can be minimised, and in some cases eliminated altogether.

- The requirements for signage on *Arterial* and *Link* streets will be higher than on *Local* streets. The use of signage should be kept to the minimum requirements of the TSM, particularly where place values are very high, such as in the *Centre* context.

Designers may have concerns about minimising signage on streets that carry higher volumes of traffic, but there are many successful examples where the amount of signage provided has been significantly reduced (see Figures 4.15 and 4.16).

Figure 4.15: Walworth Road, Central London, UK, before (top) and after (bottom). The street carries over 20,000 vehicles per day and as part of major upgrade signage and line marking were minimised (image source: Southwark Council).

Figure 4.16. Kensington High Street, London, UK, where as part of upgrade works, a major decluttering exercise took place which included removing all guardrails, minimising signage and line marking. It is notable that upon completion of the works, vehicle speeds decreased and the incidence of accidents decreased by 43% (2003-2005). Left image source: Kensington and Chelsea Borough Council.

With regard to signs and line marking more generally (see Figure 4.17):

- Signage structures should be rationalised. Individual sign poles may be better utilised and signs should be clustered together on a single pole.[10]
- Non-regulatory, and in particular *Information Signs*, signage may be embedded within street surfaces or incorporated into other items of street furniture.
- Local authorities should undertake periodic decluttering exercises to remove unnecessary repetitive and redundant signage.[11]
- The size of individual signs should generally be to the minimum specification stated in the TSM for the particular speed limit.
- The use of *Warning* signs should be limited as they are generally not required in built-up areas where potential hazards are clearly legible and vehicles travel at lower to moderate speeds. Warning signs should be installed only if an engineering assessment indicates a specific need for improving road safety for users and it is clear that the sign will be effective.[12]
- Designers should minimise the duplication of signage and/or road marking. Where signage and road markings provide the same function, preference should be given to the provision of road markings only, unless specifically required by the TSM. In general, road markings are more legible for drivers and have less of a visual impact on the streetscape.
- The use of signage and/or road marking that duplicate existing regulations should be avoided and may lead to confusion. For example the use of double yellow lines around corners to reinforce the standard prohibition on stopping within 5m of a road junction may lead to misinterpretation that loading is generally permitted.[13]

Designers should also note that a *Regulatory* sign may not be required as a 'regulation' or a 'mandatory requirement'. Designers may conclude that a *Regulatory* sign may not be needed due to the self-regulating nature of the street and/or in order to reduce the overall amount of signage used.

10 Refer to Action 16 of *Smarter Travel* (2009) which requires the rationalisation of signage poles
11 Refer to UK Department for Transport *Local Transport Note 1/08*. Examples of guidelines are available from www.english-heritage.org.uk
12 Refer to Sections 6.1.17 and 6.1.19 of the *Traffic Signs Manual* (2010).
13 Refer to Section 7.6.5 of the *Traffic Signs Manual* (2010).

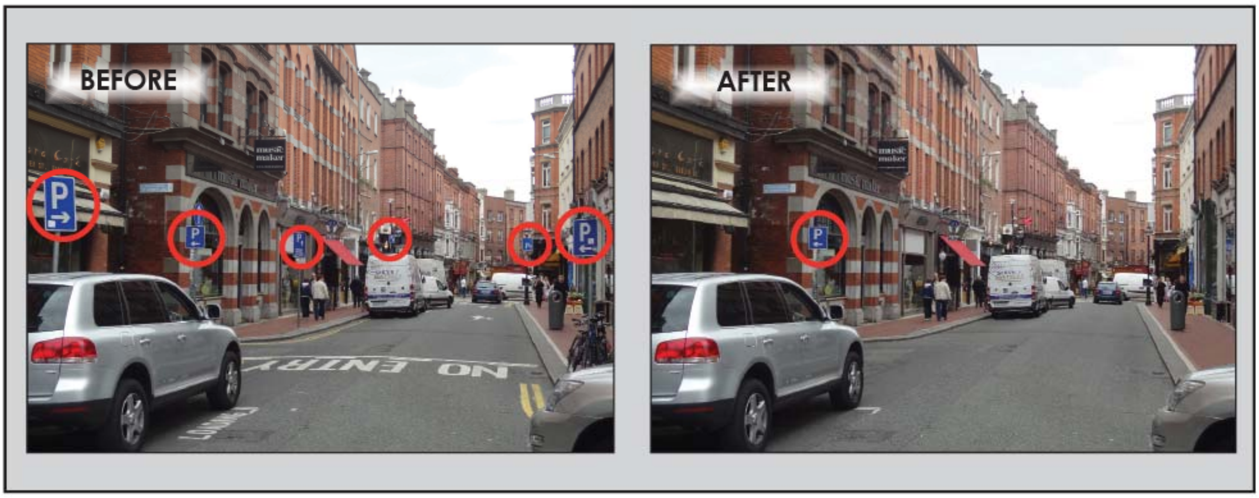


Figure 4.17: Example of the improvements to a streetscape that can be achieved where signage and line marking are substantially reduced. Note all changes have been made within the scope of the TSM.

4.2.5 Street Furniture

Street furniture serves many purposes that relate to both place and function and includes a variety of commonly found items within a street such as public art, lighting, bollards, guardrails, seating and cycle parking. Whilst items such as public art may be of place value only, many other items, if well designed, provide a place and function value (see Figure 4.18).

In general, the provision of street furniture must be considered as part of the overall design of street. In this regard:

- The placement of street furniture should be considered as part of a wider strategy, such as part of an integrated landscape plan or series of street typologies.
- Street furniture should be placed within a designated zone, such as a verge (see Section 4.3.1 Footways, Verges and Strips)
- The items used should be chosen from a limited palette that promotes visual cohesion (see Section 5.2.1 Policy and Plans).
- The number of items used should be balanced with other facilities (including signage and line marking) to reduce clutter.
- Existing items of historic value which promote local character should be clearly identified (see Section 4.2.8 Historic Contexts).

Guardrails

An integrated approach to street design will substantially reduce the need for obtrusive physical barriers such as guardrails. For example, the alignment of crossing points with desire lines will eliminate the need for guardrails to redirect pedestrians (see Section 4.3.2 Pedestrian Crossings)

In this regard:

- Guardrails should not be used as a tool for directing and/or shepherding pedestrians.

Figure 4.18: An example from Drogheda, Co. Louth, where well placed street furniture has a functional role that also provides a major contribution to the streetscape and value of place.

- Guardrails should only by installed where there is a proven or demonstratable safety benefit, for example where people may inadvertently step onto the carriageway (e.g. at a school entrance).[14]

Where the potential need for guardrails is identified (such as via a Road Safety Audit), designers should review their design as this need may highlight inadequacies in the design (such as the failure to take proper account of pedestrian desire lines). Designers should also consider the use of street furniture that may guide pedestrian movement and also contributes to the sense of place and provide amenities (see Figure 4.19).

Authorities should remove unnecessary guardrails on existing streets. The removal of individual sections of guardrails should be the subject of a rigorous and well documented assessment process. Further guidance in regard to the removal of guardrails may be obtained from, UK *Guidance on the Assessment of Pedestrian Guardrail* (2012 update) and UK Department for Transport *Local Transport Note 2/09* (see Figure 4.20). The *National Cycle Manual* (2011) also recommends the removal of guardrail as it poses a safety risk to cyclists.[15] Once guardrails have been removed monitoring should be undertaken to ensure the works have had the desired effect.

Designers may have some concerns in regard to the removal of guardrails on busy streets due to their perception as effective 'crash' barriers. However, guardrails are only effective at stopping vehicles at very low speeds and therefore may provide a false sense of security resulting in pedestrians and vehicles both paying less attention.[16]

Figure 4.19: Items such a bicycle racks, seating and/or bollards are less intrusive elements that can be used to guide pedestrians toward crossing points and reduce illegal kerb mounting.

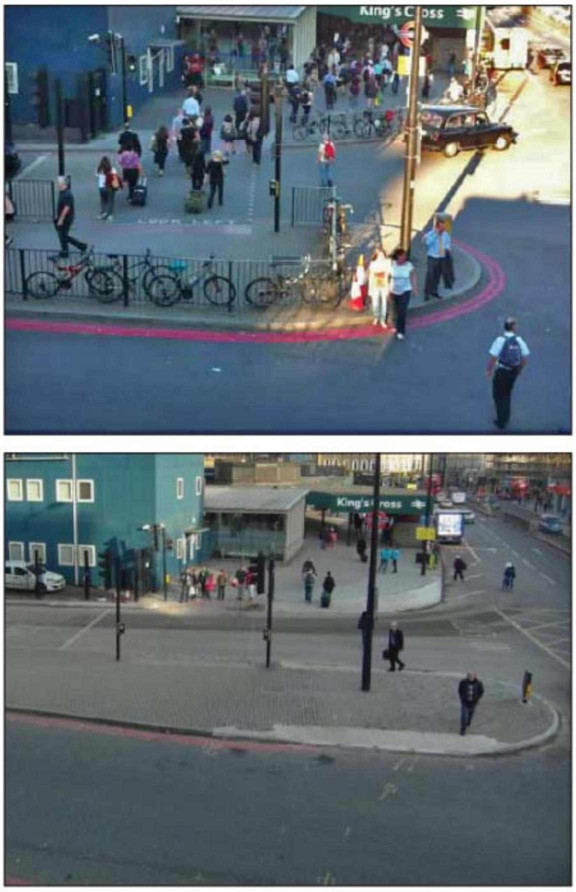


Figure 4.20: Before and after images near Kings Cross station, London, extracted from the TfL document Assessment of Pedestrian Guardrails. TfL have undertaken a wide program of guardrail removal throughout the streets of London.

14 Refer to UK Department for Transport *Local Transport Note 2/09: Pedestrian Guardrailing*, for further guidance.

15 Refer to Sections 1.1.4, 4.4.1.2-4.4.1.4 and 4.4.4 of the *National Cycle Manual* (2011).

16 Refer to UK *Guidance on the Assessment of Pedestrian Guardrail* (2012).

Lighting

Good quality lighting promotes a safer environment by ensuring inter-visibility between users. Poorly illuminated carriageways and cycle lanes can also make it difficult for users to identify potential hazards. The quality of lighting will also have a major impact on perceptions of security. If lighting levels are not sufficient, a place may not be perceived as safe, particularly for pedestrians and cyclists. This may discourage people from walking and cycling, particularly in the winter months when days are shorter, and undermine the viability of public transport.

The standards used for lighting within Ireland are generally taken from *British Standard Code of Practice for the Design of Road Lighting* (BS 5489). Whilst these documents should be referred to in regard to technical details, there are broader design considerations in regard to type of lighting used and the position and design of lighting columns.

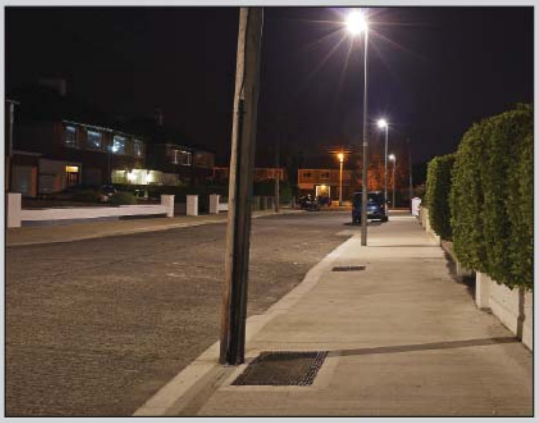
Lighting should be designed to ensure that both the vehicular carriageway and pedestrian/cycle path are sufficiently illuminated. On roads and streets within urban areas white light sources should be used, such as metal halide, white SON, Cosmopolis and LEDs. Where orange (SOX) or softer honey (SON) coloured lights are currently used, they should be replaced with white light as part of any upgrade (see Figure 4.21).

With regard to the height of lighting columns:

- Heights should be sensitive to the scale of the adjacent built environment.
- In city, town and village streets, a lantern mounting height in excess of 8 metres is unlikely to be required.
- On *Local* streets, and in areas of heritage significance, mounting heights should be no greater than 6 metres.
- Where higher numbers of pedestrians are active, such as in *Centres*, consideration should be given to supplementing the traffic route lighting installation with a lower intensity pedestrian lighting lanterns mounted at a lower height on the same columns (see Figure 4.22).

POOR
(Orange SOX)

BETTER
(White SON)



BEST
(Metal Halide)

Figure 4.21: Examples of differing types of lighting and their effectiveness in terms of safety and placemaking.

Lighting installations should be generally located within a verge (see Section 4.3.1 Footways, Verges and Strips) and/or within build-outs that separate bays of on-street parking (see Section 4.4.9 On-street Parking and Loading). Where no verge is available, lighting should be located at the back of footways, to minimise any disruption to pedestrian movement provided:

- They are positioned, where possible to coincide with property party lines to avoid obstructing entrances or windows.
- They are not located in close proximity to properties where they may compromise security.

On narrow streets or streets with narrow footways, consideration should be given to using wall-mounted lanterns

Lanterns should be selected and positioned so as to avoid creating obtrusive light spill on windows, particularly in the case of upstairs residential properties. Internal or external baffle plates can be fitted to lanterns to minimise nuisance light spill. Lights should also be positioned away from trees, which in time may grow to envelop the lanterns or cast shadows which will render the lighting less effective.

Figure 4.22: Example of a light installation that is designed with both the pedestrian and the vehicle in mind and also incorporates signals for a pedestrian crossing (image source: Camden Streetscape Manual).

To reduce street clutter designers should consider combining lighting with other installations (see Section 4.2.4 Signage and Line Marking and as per Figure 4.22). Traffic signal heads, small signs, bus stop signs etc. can be mounted on lighting columns with a degree of co-operation and co-ordination between the relevant authorities and service providers. CCTV columns, which need to be more rigid than lighting columns, can also accommodate lighting and other functions. Ancillary lighting equipment, such as electrical supply pillars, should also be located with a view to minimising their impact on the streetscape, while not creating an obstruction or hazard to pedestrians. Metering cabinets in particular, which may be up to 1.5 metres high, should be located against walls, as unobtrusively as possible, while bearing in mind that they must be accessible for maintenance and meter reading.

4.2.6 Materials and Finishes

The use of materials and finishes is one of the most defining elements of a street, particularly where it is used to define the levels of segregation and integration within a street. The material palette can define space, calm traffic and improve legibility, reducing the need for barriers, signage and line marking in favour of texture and colour. Materials can be used to enhance the value of place and produce more attractive and cost-effective streets.

When choosing surface materials, designers should:

- Use robust surfaces (such as natural stone, concrete block paving or imprinted asphalt) extensively throughout *Centres* and around *Focal Points* to highlight the importance of place, calm traffic and alert drivers of higher levels of pedestrian activity (see Figure 4.23).

- Use robust surfaces and/or changes in colour around *Gateways* and *Transitional Zones* to alert drivers of changing driving conditions (see Section 3.3.4 Wayfinding).

- Choose items from a limited palette to promote visual cohesion (see Section 5.2.1 Policy and Plans).

- Apply a hierarchical approach to the application of materials. Altering the palette according to the street hierarchy and/or importance of place will assist in way finding.

- Use of contrasting materials and textures to inform pedestrians of changes to the function of space (i.e. to demarcate verges, footway, strips, cycle paths and driveways) and in particular to guide the visually impaired (see Section 4.3.4 Pedestrianised and Shared Surfaces).

The layout and colour of tactile paving used to assist the visually impaired in navigating the pedestrian environment should ensure that a consistent logic is applied. This includes the cumulative impact of tactiles with other material choices. For example, the use of strong red or yellow tactile paving may not be appropriate to avoid visual clutter associated with too many surface types or colours. In such instances the use of a more varied palette or contrasting tones is preferable (see Figure 4.24). Further guidance on the use of tactile paving may also be taken from Section 13.3 of the *Traffic Management Guidelines* (2003) and the UK *Guidance on the use of Tactile Paving Surfaces* (2005).

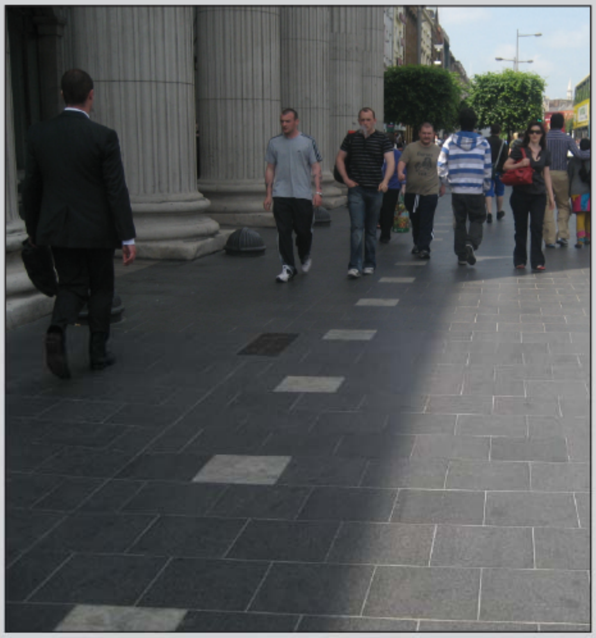


Figure 4.23: O'Connell Street, Dublin. The high place status, intensity of activity and low design speed (30 Km/h) is highlighted by high quality and robust materials, such as granite paving.

Designers may have concerns in regard to the initial costs associated with using higher specification materials and their ongoing maintenance. The use of higher quality materials has wide economic benefits. For example, in relation to shopping streets, research in the UK has shown that streets finished with better quality materials result in better market prices, better rents and better retail sales.[17] Capital costs should also be measured against savings that result from a reduction in the need for barriers, signage, line marking and longer term costs related to durability and maintenance. Further guidance may be obtained from the *Natural Stone Surfacing - Good Practice Guide* (SCOTS Guide) (2004) .

The quality of materials may also be selected to ensure that more robust and higher quality materials are used where they are most needed and appreciated. Figure 4.25 from the *Adamstown Street Design Guide* (2010) provides an overview of how the standard of materials may be applied with regard to amenity, density and activity. When applied systematically it directs the designers to use the highest specifications of materials in the *Centres* and along streets which are the most active, such as *Arterial* and *Link* streets. It will also direct the use of higher specification materials to the vicinity of *Focal Points*. Good results may also be achieved on lower budgets, provided material selection has the desired effect of supporting other measures aimed at calming traffic and defining place (see Figure 4.26).

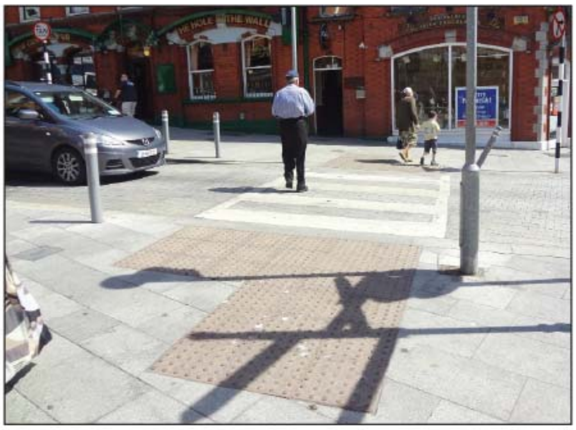


Figure 4.24: Example form Drogheda, Co. Louth, of red tactile paving at a zebra crossing which has been toned down to balance the degree of contrast with higher specification materials.

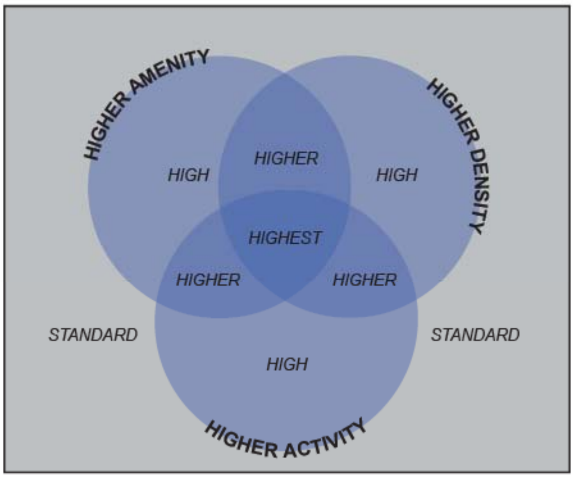


Figure 4.25: Diagram illustrating a hierarchical and cost-effective approach to the specification of materials on streets.

Figure 4.26: Fade Street, Dublin City Centre. To reduce the overall cost of work in remodelling the street, lower budget materials such as HRA with coloured aggregate chips and epoxy resin bound surfaces were used on the carriageway and footpath, respectively.

17 Refer to *Paved with Gold* (2007).

4.2.7 Planting

Planting is generally located in areas such as medians, verges, build-outs and privacy strips. Landscaping is traditionally used to add value to places though visual enhancement. There are many approaches that can be taken with regard to planting, for example:

- Within *Centres* a greater emphasis may be placed on using 'harder' landscape elements that define them as urban, allow greater freedom of movement and are able to withstand higher level of pedestrian traffic (see Figure 4.27).

- In *Neighbourhoods* and *Suburbs* a greater emphasis may be placed on the use of planted materials to promote 'softer' landscape elements and a greener 'living' character (see Figure 4.28).

Other key considerations include the ongoing maintenance and size of street trees/planting at maturity. Quality and maintenance should be viewed in a similar regard to the application of materials and finishes (as per Figure 4.27) with a hierarchical approach that promotes the use of higher quality planting within *Centres* and along streets which are the most active, such as *Arterial* and *Link* Streets, and around *Focal Points*.

Figure 4.27: Example from Dundalk of an area with higher activity, the use of planted materials will be more sparsely and selectively applied in favour of more robust and durable materials.

Figure 4.28: Example of a residential character, a rich palette of planted materials will enhance green qualities.

Designers should also consider the size of trees, shrubs and other landscape elements at full maturity. In general designers should avoid planting that will grow to obstruct movement and surveillance. There are exceptions to this, for example overgrown medians can help reinforce narrower carriageways and tall shrubs may deflect sightlines reducing forward visibility.

Streets also support an important drainage function within built-up areas. The shift toward sustainable forms of development has seen the emergence of Sustainable Urban Drainage (SUDs) systems. SUDs consist of a range of measures that emulate a natural drainage process to reduce the concentration of pollutants and reduce the rate and volume of urban run-off into natural water systems (and thus the pollutants it carries). The incorporation of SUDs elements into the fabric of the street itself can also serve to increase legibility and add value to place (see Figure 4.29). Further advise with regard to the use of SUDs may be found in the *Greater Dublin Strategic Drainage Study* (2005).

Figure 4.29: Examples of Sustainable Urban Drainage incorporated into a street in the form of a small 'swale' (top) and larger linear basin (bottom). These treatments not only assist in containing urban surface water run-off but also contribute to the sense of place by adding a unique feature.

4.2.8 Historic Contexts

Additional design considerations must be taken into account in areas of historic significance that are highly sensitive to interventions. Historic features help reinforce an areas character/place value and may also play a role in managing speeds (see Figure 4.30). The most appropriate course of action should be to minimise any level of intervention to existing historical features.

Elements of street furniture associated with the historic use of the street should be identified and protected, where appropriate (see Figure 4.31). Significant historic features may also include the street surface itself (as per Figure 4.30)[18] and any features set into it such as coalhole covers, weighbridges, pavement lights, cellar doors etc.

An 'assessment of significance' should be prepared when dealing with interventions within historic core areas. This is seen as addressing/acknowledging essential elements of the historic urban environment which may have architectural, historical and technical significance. For example when dealing with an established street layout and associated materials a distinction is drawn between three levels of significance:

1. Undisturbed areas of existing historic streets, which have the highest value and bear witness to the skill of historic craftsman;

2. Areas where streets have been altered or reconfigured using the original design/ material;

3. Reinstated street areas re-using salvaged material from other places.

The mechanism for the protection of historic areas is based on statutory protection. If an area lies within an Architectural Conservation Area (ACA) or forms part of the setting of a protected structure (or a number of protected structures), development policies will be set out in the relevant County/City Development Plan, as well as active planning control.[19]

18 *Refer to Paving: the Conservation of Historic Ground Surfaces.* Forthcoming in 2013. Department of Arts, Heritage and the Gaeltacht.'

19 Refer also to the *Architectural Heritage Protection Guidelines for Planning Authorities* (2011).

Figure 4.30: The stone sett paved carriageways of Temple Bar, Dublin, are of historical significance, enhance the areas value as a cultural corner and calm traffic by creating a sense of shared space.

Figure 4.31: An example of a historic water fountain in Newcastle, Co. Dublin. Such features are integral of local identity and should be retained.

4.3 Pedestrian and Cyclist Environment

4.3.1 Footways, Verges and Strips

A strong sense of enclosure and active street edges contribute to a pedestrians/cyclists sense of security and comfort by creating streets that are overlooked, animated and sheltered from inclement weather conditions. Studies have found that providing wider and better quality walking facilities can lead to an increase in walking.[20] Well designed footpaths are free of obstacles and wide enough to allow pedestrians to pass each other in comfort. For this purpose the footpath is divided into three areas (see Figure 4.32):

- Footway: this is the main area along which people walk.
- Verges: These provide a buffer between pedestrians and the vehicle carriageway and provide space for street furniture and street trees as well as overflow space for pedestrian movement (see Figure 4.33).
- Strips: These spaces, provided directly to the front of a building, may be occupied by activities generally associated with retail/commercial uses such as stalls or outdoor seating. Strips may be incorporated into the private space of a dwelling (as per Figure 4.13).

20 Refer to Section 5.1 of the UK *Manual for Streets 2* (2010).

Footways

Minimum footway widths are based on the space needed for two wheelchairs to pass each other (1.8m). In densely populated areas and along busier streets, additional width must be provided to allow people to pass each other in larger groups. In this regard:

- The width of footways should increase from *Suburbs* (lower activity), to *Neighbourhood* (moderate activity) and to *Centres* (higher activity) and as development densities increase.
- The width of footways should increase according to function from *Local* (lower activity), *Link* (moderate activity), to *Arterial* streets (moderate to higher activity) as connectivity levels increase.
- The footway should be maintained at a consistent width between junctions and should not be narrowed to accommodate turning vehicles.

Figure 4.34 illustrates the space needed for pedestrians to comfortably pass each other with reference to the anticipated levels of activity within a street. These standards should be used to formulate the minimum footway widths.

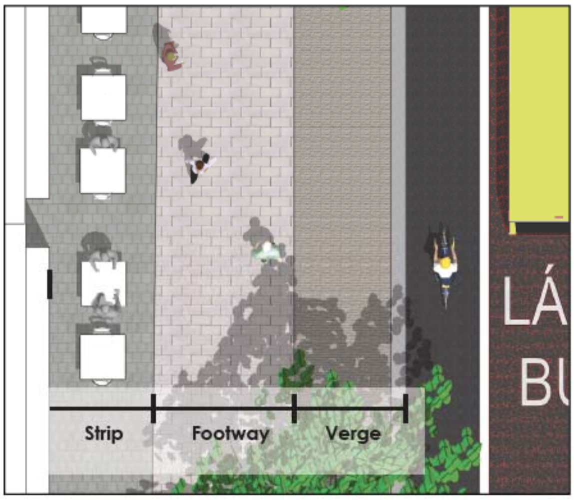


Figure 4.32: Illustration of the area generally thought of as the footpath. This area should be viewed and designed as three areas of activity.

Figure 4.33: Example from Castlebar, Co. Mayo, where the verge acts a designated space for street furniture, lighting facilities and planting of trees, keeping the footway clear of obstacles.

In areas of particularly high pedestrian activity, such as shopping streets or close to major nodes (such as a train station) more complex modelling may be needed to determine footway widths. In such cases designers may refer to the UK *Pedestrian Comfort Guidance for London* (2010) for further guidance in regard to footpath widths based on the volume of pedestrians per hour (provided these do not fall below the thresholds in Figure 4.34). This guidance may also be of particular assistance in assessing pedestrian comfort levels on existing footways.

In a retrofit situation increasing footpath widths should be a priority for designers and where appropriate, accommodated by narrowing vehicular carriageways (see Section 4.4.1 Carriageway Widths). Increases in width should also be considered as part of a package of facilities, including the provision of cycle lane/tracks, on-street parking and other street facilities (including street trees).

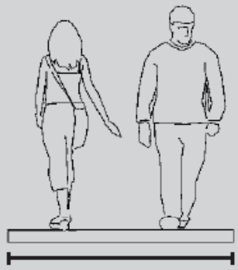
Designers should also ensure that the design of vehicle crossovers clearly indicate that pedestrians and cyclists have priority over vehicles. There should be no change in level to the pedestrian footway and no use of asphalt (which would incorrectly indicate vehicular priority across a footpath). Large or busy driveways (i.e. access to large car parks) may, however, be demarcated by a change in surface materials, such as contrasting paving and/or coloured concrete (see Figure 4.35). Designers should also refer to Section 5.4 - Entrances and Driveways of the *National Cycle Manual* (2011) for further design guidance where cycle tracks are present.

Verges

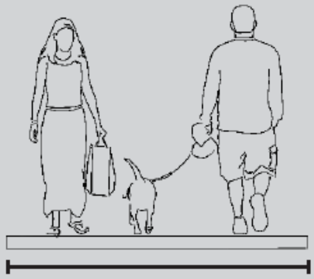
The need and size of the verge will largely be dependent on the function of the street and the presence of on-street parking. In general:

- On *Arterial* and *Link* streets with no on-street parking a verge of 1.5-2m should be provided as a buffer and to facilitate the planting of large street trees and items of street furniture.

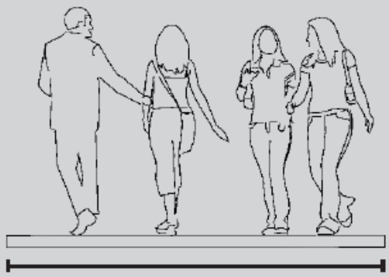
PEDESTRIAN ACTIVITY AND FOOTWAY WIDTH



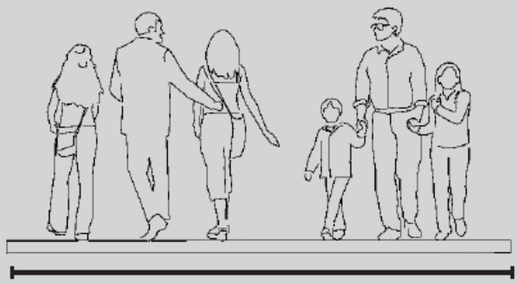
1.8m
Minimum space for two people to pass comfortably. Areas of low pedestrian activity



2.5m
Desirable space for two people to pass comfortably. Areas of low to moderate pedestrian activity



3.0m
Minimum space for small groups to pass comfortably. Areas of moderate to high pedestrian activity



4.0m
Minimum space for larger groups to pass comfortably. Areas of high pedestrian activity

Figure 4.34: Diagram showing the amount of space needed for pedestrians to pass each other with regard to pedestrian activity levels.

- There is no minimum requirement for verges on *Local* Streets, but designers may need to provide space to prevent any encroachment of street furniture into the footway.
- Where on-street parking is provided, a verge (and change in kerb line) may be needed on approaches to junctions to enforce the visibility splays (see Section 4.4.5 Visibility Splays). In such cases the width of the verge will generally correspond to the width of car parking spaces.
- A verge should be provided where cycle tracks are located adjacent to parking spaces (see Section 4.3.5 Cycle Facilities)
- A verge (minimum of 0.3m) should be provided in areas of perpendicular parking where vehicles may overhang the footway (see Figure 4.36)

Strips

Strips may be provided as a designated zone that further animates the street and, in the case of a residential property, provide a buffer between the footway and the private residence.

With regard to areas of commercial activity:

- Where outdoor seating is provided the minimum width of a strip should be 1.2m.
- Outdoor seating may also be provided within a verge area, where the footway runs between the shop front and seating area.
- There is no recommended maximum size of a strip, but the design team should consider the impact of larger setbacks on the sense of enclosure of the street if a large area is proposed.
- A designated strip may also be considered within *Centres* on shopping streets to provide additional space for window shopping.

For residential areas designers should refer to Section 4.2.3 Active Street Edges, with regard to the width of privacy strips.

Figure 4.35: Example from Dublin where pedestrian priority across driveways is indicated by maintaining footway levels and surface treatments.

Figure 4.36: An example where a narrow verge is provided to ensure that vehicle overhangs do not intrude on the footway.

4.3.2 Pedestrian Crossings

Crossings are one of the most important aspects of street design as it is at this location that most interactions between pedestrians, cyclists and motor vehicles occur. Well designed and frequently provided crossings are critical to the balancing of movement priorities. The design of crossings, and the frequency at which they are provided, will have a significant impact on pedestrian/cyclist mobility and comfort and the flow of vehicular traffic.

Crossing Selection

Crossings are referred to as controlled, such as zebra or signalised crossings or uncontrolled.[21] Uncontrolled crossings include less formal types such as courtesy crossings and/or those identified by a drop kerb. At junction locations the type of crossing used will generally be determined in conjunction with the form of junction control that is used to manage traffic (see Section 4.4.3 Junction Design). More generally, designers should be guided by pedestrian demands, safety and vehicle flows. In this regard:

- In general, signalised crossings should be provided on busy *Arterial* and *Link* streets and/or where cyclists are likely to cross.
- Zebra crossings provide greater pedestrian priority and may be used on *Arterial* and *Link* streets within lower speed environments, such as *Centres* (see Figure 4.37).
- Zebra crossings are also highly effective where both levels of pedestrian and vehicular activity are more moderate[22] and may also be used more generally, such as on Link streets in *Suburban* areas.
- Courtesy crossings, which are generally defined by a change in material and/or vertical deflection (see Section 4.4.7 Horizontal and Vertical Deflections) allow pedestrians to informally assert a degree of priority over drivers and are particularly effective at promoting pedestrian priority. They may be used in lower speed environments (and will also assist in making such environments self regulating, see Figure 4.38)
- *Local* streets, due to their lightly-trafficked/low-speed nature, generally do not require the provision of controlled crossings. The provision of drop kerbs will generally suffice. However zebra crossings or courtesy crossing should be considered where pedestrian demands are higher such as around *Focal Points*.

21 Refer to Section 12.3-12.4 of the *Traffic Management Guidelines* (2003).

22 Refer to Section 12.3 of the *Traffic Management Guidelines* (2003).

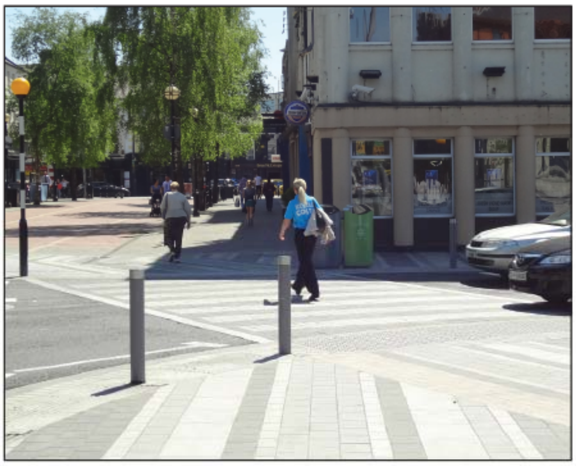


Figure 4.37: Example of a Zebra crossing within the town centre of Dundalk, Co. Louth. Zebra crossings promote greater levels of pedestrian priority as drivers must give way to pedestrians once they have commenced the crossing.

Figure 4.38: Example of an informal 'courtesy' crossing in Westport, Co. Mayo. Drivers stop and wait for pedestrians to cross as a courtesy.

Crossing Locations

The location and frequency of crossings should align with key desire lines and be provided at regular intervals. Within larger areas this may need to be addressed via a spatial analysis and supporting plan (see also Section 5.2.1 Plans and Policies). Methods that rely on absolute figures, such as the system of warrants, should not be used. More generally, designers should:

- Provide pedestrian crossing facilities at junctions and on each arm of the junction.
- Minimise corner radii so that crossing points are located closer to corners on pedestrian desire lines (see Section 4.3.3 Corner Radii).
- Provide regular mid block crossings in areas of higher pedestrian activity, such as *Centres*, where the distance between junctions is greater than 120m.
- Locate mid-block crossings at strategic locations where pedestrians are likely to cross, such as adjacent to bus stops and *Focal Points*, or to coincide with traffic-calming measures on longer straights (see Section 4.4.7 Horizontal and Vertical Deflections).

Crossing Design and Waiting Times

Smarter Travel (2009) requires that pedestrian movement at signalised crossings be given priority by timing traffic signals to favour pedestrians instead of vehicles by reducing pedestrian waiting times and crossing distances at junctions.[23] To achieve this objective, designers should:

- Optimise pedestrian movement, with pedestrian cycle times of no more than 90 seconds at traffic signals.
- Allow pedestrians to cross the street in a single, direct movement (see Figure 4.39). Staggered/staged crossings should not be used where pedestrians are active, such as in *Centres, Neighbourhoods* and *Suburbs* (except where stated below).
- Where staggered/staged crossings currently exist they should be removed as part of any major upgrade works. This should include realignment works to slow vehicle movements, such as reduced corner radii and/or carriageway narrowing (see Figure 4.40 and Section 4.3.3 Corner Radii)

23 Refer to Action 16 of *Smarter Travel* (2009).

Figure 4.39: Example of a wide streets with a crossing that allows pedestrians to cross in a direct manner and in a single movement. The median acts as a refuge island for those users who cannot cross the street in a reasonable time.

Designers may have concerns regarding the omission of staggered/staged crossings on wide streets (i.e. with four or more lanes and a median) on the grounds of safety and traffic flow. With regard to safety these concerns may be overcome by:

- Ensuring enough green time is provided for pedestrians to cross in a single movement.
- Removing flashing amber lights phases where vehicles may move forward not realising pedestrians are still on the median or far side of the crossing.
- Providing build-outs, where possible, to reduce the crossing distance.
- Providing a refuge island (minimum of 2m) for those who are unable to make it all the way across in a reasonable time. Under such circumstances a Push Button Unit (PBU) and the required signals must be provided within the refuge.

Safety concerns regarding pedestrian crossings should also be viewed in the context of pedestrian behaviour. Research has found that pedestrians are less likely to comply with the detour/delay created by staggered crossings, leading to unsafe crossing behaviour.[24] It will generally be more desirable, from a safety point of view, to provide a direct single phase crossing.

With regard to traffic flow on wide streets a more flexible approach may be taken where traffic modelling confirms that junctions would become overly saturated for long periods if designed with single phase/direct pedestrian crossings. A judgement will need to be made as there may be circumstances where it is acceptable to saturate junctions in order to prioritise/promote more sustainable travel patterns (see Section 3.4.2 Traffic Congestion) In these circumstances designers may also consider:

- A straight ahead two stage crossing within lower speed environments where the median is sufficiently wide to clearly distinguish each arm of the crossing.
- Increase pedestrian cycle times up to 120 seconds for short or intermittent periods (i.e. when saturation is likely to occur).
- Implement more conventional staggered crossings where the balance of place and movement is weighted toward vehicle movement such as on *Arterial* streets in *Suburban* areas or more broadly in *Industrial Estates* and the *Rural Fringe*. Where applied, the width of the central area for pedestrian circulation should be a minimum of 2m.

24 Refer to *Pedestrian Crossing Behaviour at Signalised Crossings* (2008).

Figure 4.40: Example from Kensington High Street, London, of a left hand turning slip point was removed and replaced with a safer single phase crossing which also slowed vehicle turning movements (image source: Hamilton Baillie).

When determining the width of crossings designers should refer to Section 7.16 of the *Traffic Signs Manual* (2010) which contains maximum and minimum design specifications for pedestrian crossings. In this regard (see Figure 4.41):[25]

- Within *Centres* and on *Arterial* streets, all crossings should generally be a minimum of 4m wide.
- The minimum width of all other pedestrian crossings should be 2m.
- The minimum width for Toucan crossings should be 4m.
- In determining the optimal width of a pedestrian crossing, designers may refer to Figure 4.34 to ensure that pedestrians are able to pass each other in comfort.
- On crossings where very high numbers of pedestrians and/or cyclists cross, a width in excess of those above may be required, to a maximum of 10m.

It is also an objective of *Smarter Travel* (2009) that level grade crossings (i.e. those that are aligned with the height of footways) be provided for pedestrians across junctions.[26] These are highly recommended in areas where pedestrian flows are high such as in *Centres*. They are also an effective measure for calming traffic and enforcing lower speeds (See Section 4.4.7 Horizontal and Vertical Deflections).

Figure 4.41: Standard crossing widths to be used in most circumstances across the main carriageway of Access or Link streets and across side junctions with Local streets.

25 Refer to Section 7.16 of the *Traffic Signs Manual* (2010) which contains maximum and minimum design specifications for pedestrian crossings.
26 Refer to Action 16 of *Smarter Travel* (2009).

4.3.3 Corner Radii

Reducing corner radii will significantly improve pedestrian and cyclist safety at junctions by lowering the speed at which vehicles can turn corners and by increasing inter-visibility between users (see Figure 4.42). Reduced corner radii also assist in the creation of more compact junctions that also align crossing points with desire lines and reduce crossing distances.

Corner radius is often determined by swept path analysis. Whilst swept path analysis should be taken into account, designers need to be cautious as the analysis may over estimate the amount of space needed and/or the speed at which the corner is taken. Furthermore, such analysis also tends to cater for the large vehicles which may only account for relatively few movements.

Designers must balance the size of corner radii with user needs, pedestrian safety and the promotion of lower operating speeds. In this regard designers must consider the frequency with which larger vehicles are to be facilitated as follows (see Figure 4.43):

- In general, on junctions between *Arterial* and/or *Link* streets a maximum corner radii of 6m should be applied. 6m will generally allow larger vehicles, such as buses and rigid body trucks, to turn corners without crossing the centre line of the intersecting road.[27]

27 Refer to Sections 6.9, 9.3 and 10.4 of the *Traffic Management Guidelines* (2003).

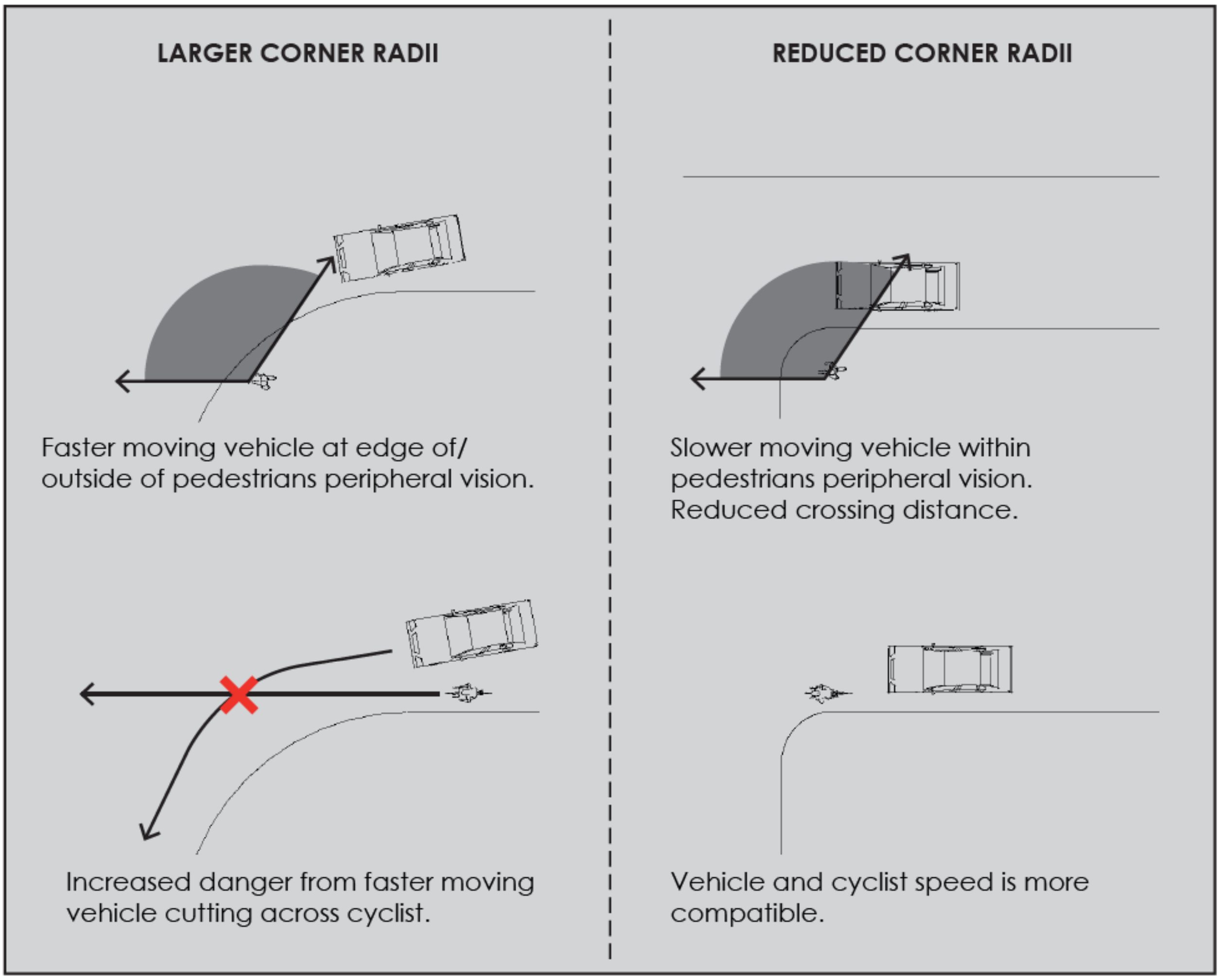


Figure 4.42: Illustration of the benefits of reduced corner radii on pedestrian and cyclist safety (images based on Figures 6.3 and 6.15 of the UK Manual for Streets (2007)).

- Where turning movements occur from an *Arterial* or *Link* street into a *Local* street corner radii may be reduced to 4.5m.

- Where design speeds are low and movements by larger vehicles are infrequent, such as on *Local* streets, a maximum corner radii of 1-3m should be applied.

- In circumstances where there are regular turning movements by articulated vehicles, the corner radii may be increased to 9m (i.e. such as in *Industrial Estates*).

Designers may have concerns regarding larger vehicles crossing the centre line of the intersecting street or road. Such manoeuvres are acceptable when turning into/or between *Local* or lightly trafficked *Link* streets as keeping vehicle speeds low is of higher priority. Where designers find it difficult to apply the radii referred to above, or to further reduce corner radii where pedestrian activity is high (such as within centres) designers may also:

- Increase the carriageway width at junctions to provide additional manoeuvrability without signalling to drivers that the corner can be taken at greater speeds (see Figure 4.44).

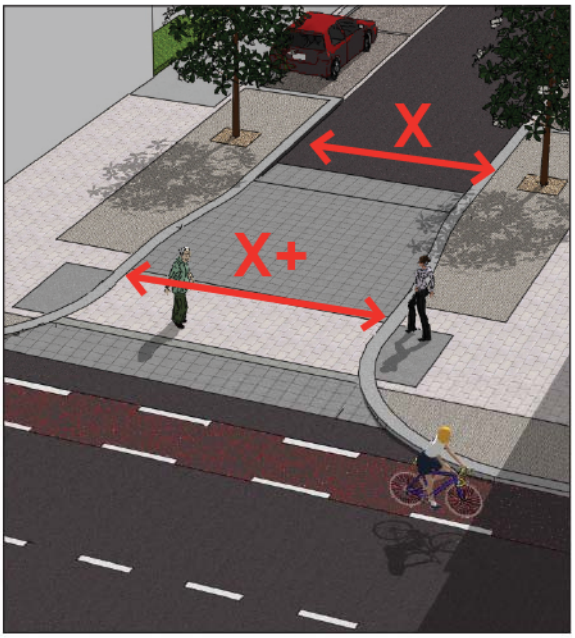


Figure 4.44: Illustration of how tighter corner radii can be applied to a junction, with additional manoeuvrability for larger vehicles provided by widening the street entrance.

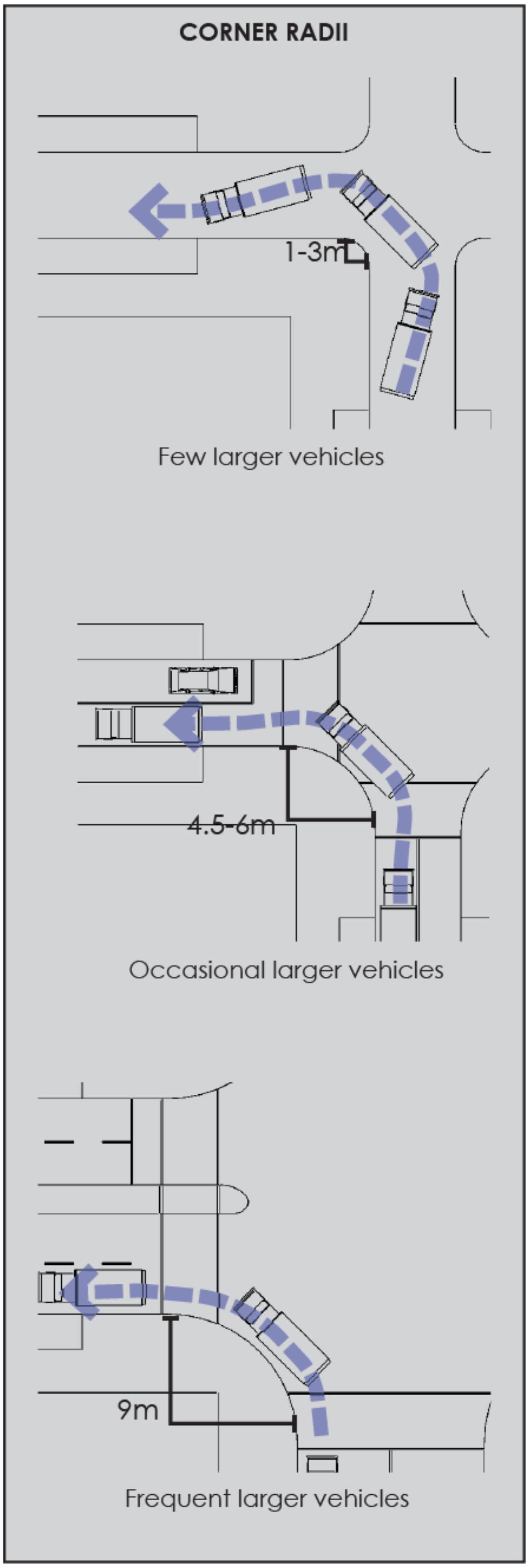


Figure 4.43: Approaches minimising corner radii according to level of service by larger vehicles.

- Apply setback vehicular stop lines at signalised junctions to allow turning vehicles to cross the centre line of the intersecting street without conflicting with oncoming movements (see Figure 4.45 and Section 4.4.2 of the *National Cycle Manual* (2011)).

- Designers should also consider the use of setback stop lines on *Arterial* and *Links* streets within centres to further reduce corner radii.

- Keeping corners clear of obstacles (or removing obstacles such as guardrails) to allow emergency vehicle overrun.

Figure 4.45: Setback stop lines allow for additional vehicular manoeuvrability for larger vehicles at signalised junctions without the need for larger corner radii.

4.3.4 Pedestrianised and Shared Surfaces

Pedestrianised and shared surfaces are an effective way of promoting place and providing pedestrians and cyclists with a more enjoyable experience, particularly in areas of historic significance. These streets operate as linear 'squares' or corridors of public open space.

Pedestrianised streets fully segregate pedestrians and cyclists from motor vehicular movement (although emergency access is possible and limited access may also be provided for service vehicles). They are generally only appropriate in areas where higher levels of activity can be sustained throughout the day and into the evening period, as the removal of vehicular traffic will reduce surveillance levels. They are best suited to the *Centres* around areas of retail, commercial and cultural activity (see Figure 4.46).

Shared surface streets and junctions are integrated spaces where pedestrians, cyclists and vehicles share the main carriageway. This may include streets where the entire street reserve is shared (see Figure 4.47) or where designated sections may provide for pedestrians and/or cyclists use only with a shared surface carriageway along part of the street (see Figure 4.48). Shared surface streets may also periodically transfer from pedestrian only spaces to shared spaces at different times of the day (as per Figure 4.47).

Shared surface streets and junctions are particularly effective at calming traffic. Research has found that shared carriageways perform well in terms of safety and there is also evidence to suggest that well designed schemes in appropriate settings can bring benefits in terms of visual amenity, economic performance and perceptions of personal safety.[28]

Shared surface streets and junctions are highly desirable where:

- Movement priorities are low and there is a high place value in promoting more livable streets (i.e. homezones), such as on *Local* streets within *Neighbourhood* and *Suburbs*.

Figure 4.46: Fully pedestrianised street within a Centre. Activity is sustained by a mix of retail, commercial and cultural activities.

Figure 4.47: Street in Waterford City Centre which changes from a pedestrianised space to a shared surface area at different times of the day.

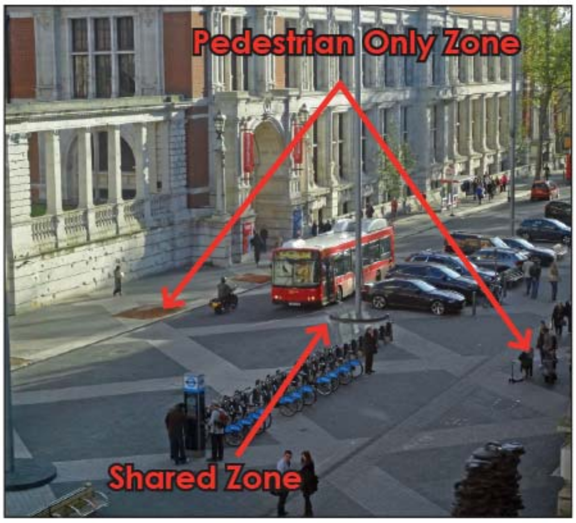


Figure 4.48: Exhibition Road, London, an example where distinct zones that delineate pedestrian only space from shared space have been created (image source architects).

28 Refer to UK Department for Transport *Shared Space Project Stage 1: Appraisal of Shared Space* (2009).

- Pedestrian activities are high and vehicle movements are only required for lower-level access or circulatory purposes. This include streets within *Centres* where a shared surface may be preferable over full pedestrianisation to ensure sufficient activity occurs during the daytime and the evening period.

The application of shared surfaces may also be desirable on a wide variety of streets and junctions. The implementation of shared surfaces in the UK and internationally has evolved from lightly-trafficked areas to include heavily-trafficked streets and junctions (as per Figure 4.48 and Figure 4.49). Where designers consider the use of shared surfaces on more heavily-trafficked routes the location must be the subject of a rigorous analysis that assesses the suitability of a street for such purposes.

The key condition for the design of any shared surface is that drivers, upon entering the street, recognise that they are in a shared space and react by driving very slowly (i.e. 20km/h or less). To ensure this, designers should:

- Use a variety of materials and finishes that indicate that the carriageway is an extension of the pedestrian domain (such as paving: see Section 4.2.6 - Materials and Finishes).
- Avoid raised kerb lines. Any kerb line should be fully embedded within the street surface (see Section 4.4.8 Kerbs).
- Minimise the width of the vehicular carriageway and/or corner radii (see Sections 4.3.3 Corner Radii and 4.4.1 Carriageway Widths).

Shared surface streets can be very intimidating for impaired users. Visually-impaired users in particular usually rely on kerb lines to navigate streets. To assist navigation and movement through shared spaces, designers should apply design measures such as:

- Sections of tactile paving that direct movement along the street or across spaces (see Figure 4.50).
- The creation of distinct zones that delineate pedestrian only space from shared space (as per Figure 4.48).
- Flush kerbs, drainage lines and/or sections of tactile paving to assist guide dogs and indicate movement from a pedestrian only space to a shared carriageway (see Section 4.4.8 Kerbs).

Figure 4.49: Shared surface junction in Ashford, Kent, UK, carries significant amounts of traffic and challenged conventions regarding traffic volumes along shared surfaces. An informal zebra crossing has also been marked adjacent to the junction to provide a place for less confident pedestrians to cross.

- Verges that act as refuge zones allowing pedestrians to step on and off the carriageway to let cars pass (see Figure 4.51).

Further information regarding the design and application of Shared Surfaces may also be sought from the UK Department for Transport *Local Transport Note 1/11* and supporting research volumes.[29]

Figure 4.50: Examples from Cork city of the use of tactile paving that assist the visually impaired by guiding movement across a shared space.

Figure 4.51: Examples from Adamstown, Co. Dublin, where a verge is provided as refuge that pedestrians can hop on and hop off as cars slowly pass.

29 Refer to *Designing the Future: Shared Space: Qualitative Research* (2010).

4.3.5 Cycle Facilities

This Manual and the *National Cycle Manual* (2011) (NCM) promote cycling as a sustainable form of transport and seek to rebalance design priorities to promote a safer and more comfortable environment for cyclists. To achieve these goals, the NCM recognises the importance of slowing vehicular traffic within cites, towns and villages, and advocates many of the measures contained within this Manual, such as narrower vehicular carriageways and tighter corner radii.

The principle source for guidance on the design of cycle facilities is the NCM published by the National Transport Authority. The NCM provides designers with a comprehensive set of design measures aimed at achieving an overall quality of service that is appropriate to user needs.

Figure 4.52, from the NCM, provides an overview of the integration and segregation of cycle traffic within the carriageway based on vehicle speeds and traffic volumes. For example:

- On lightly-trafficked/low-speed streets, designers are generally directed to create *Shared Streets* where cyclists and motor vehicles share the carriageway
- On busier/moderate speed streets, designers are generally directed to apply separate cycle lanes/cycle tracks.

Designers must also have regard to the measures contained within this Manual when applying the NCM. For example:

- To minimise the width of vehicular carriageways from kerb to kerb, preference should be given to the implementation of *Raised Cycle Lanes* or *Raised Cycle Tracks* over those design solutions where cyclists and vehicles are at grade.

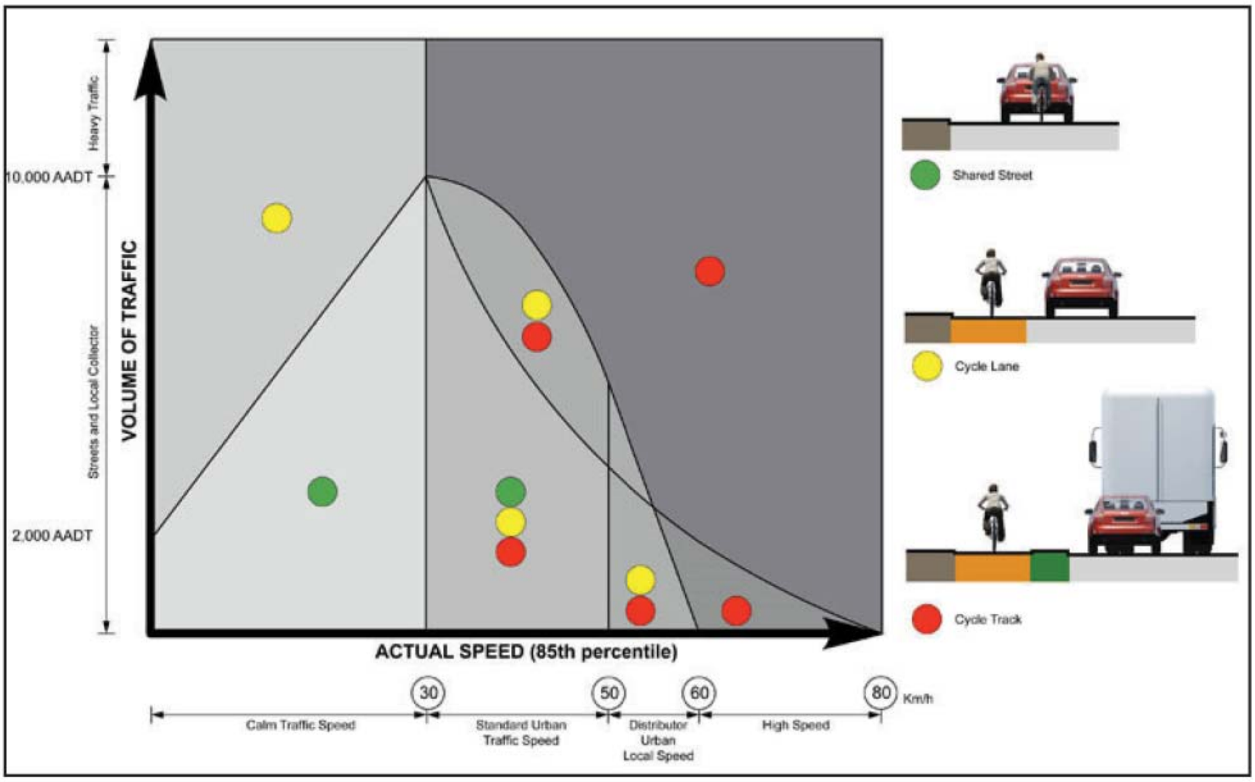


Figure 4.52: Extract from the National Cycle Manual (2011) which illustrates the appropriate use of integrated or segregated cycle facilities according to the volume and speed of traffic.

- Cycle facilities on most streets within *Centres*, *Neighbourhoods* and *Suburbs* will need to be integrated with on-street parking. Pages 138-139 and 149 of the NCM illustrate how this can be achieved with Cycle Lanes. Figures 4.53 and 4.54 illustrate this with regard to a Cycle Track.

- To reduce clutter, the use of hatching, bollards and signage associated with cycle facilities should be minimised within areas with a higher place value such as *Centres*, *Neighbourhoods* and *Suburbs*. A similar logic may be applied in respect of the requirements for signage and line marking within the NCM as with the application of the *Traffic Signs Manual* (2010), refer Section 4.2.4 Signage and Line Marking.

The NCM also makes several references to the *Traffic Management Guidelines* (2003). As the *Traffic Management Guidelines* precede this Manual many of these references may no longer be relevant and designers should refer to the corresponding principles, methods and standards contained within this Manual.[30]

Figure 4.53: Example of a narrow verge between a cycle track and on-street parking. This verge provides a buffer that protects cyclists from opening doors.

30 For comparison between the road classification system used within the *National Cycle Manual (2011)* and *Traffic Management Guidelines (2003)* designers should refer to Table 3.1.

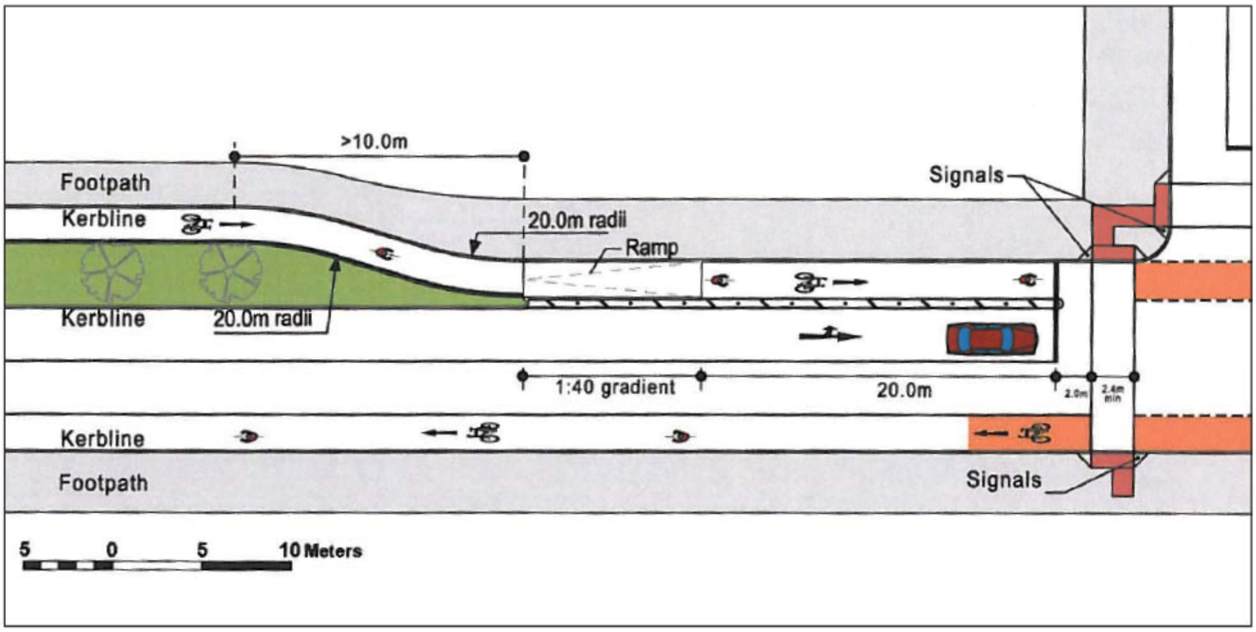


Figure 4.54: Extract from page 86 of the National Cycle Manual illustrating how to re-establish from an Off Road Cycle Track to Cycle Lane on approach to a junction. This design can be adapted to cater for on-street parking by placing spaces within the green area or verge between the vehicular carriageway and Cycle Track.

4.4 Carriageway Conditions

4.4.1 Carriageway Widths

Research from the UK has found that narrow carriageways are one of the most effective design measures that calm traffic.[31] The width of the vehicular carriageway is measured from kerb to kerb or from the outside line of a Cycle Lane or from the edges of parking spaces (where the latter facilities are provided).

Designers should minimise the width of the carriageway by incorporating only as many lanes as needed to cater for projected vehicle flows and by reducing the size of individual lanes to meet predominant user needs (see Figure 4.55). In this regard:

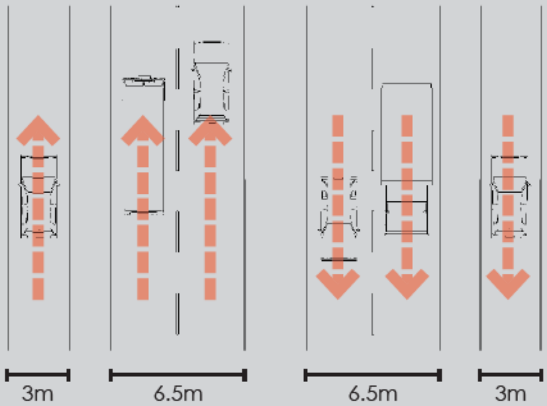
- The standard lane width on *Arterial* and *Link* Streets should be 3.25m.
- Lane widths may be increased to 3.5m on *Arterial* and *Link* streets where frequent access for larger vehicles is required, there is no median and the total carriageway width does not exceed 7m.
- Lane widths may be reduced to 3m on those *Arterial* and *Link* streets where lower design speeds are being applied, such as in *Centres* and where access for larger vehicles is only occasionally required.
- The standard carriageway width on *Local* streets should be between 5-5.5m (i.e. with lane widths of 2.5-2.75m).
- Where additional space on *Local* streets is needed to accommodate additional manoeuvrability for vehicles entering/leaving perpendicular parking spaces, this should be provided within the parking bay and not on the vehicle carriageway (see Section 4.4.9 On-Street Parking and Loading).
- The total carriageway width on *Local* streets where a shared surface is provided should not exceed 4.8m.

On heavily-trafficked *Arterial* and *Link* streets with multiple lanes (see Section 3.4.5 Noise and Air Pollution) in urban areas designers should consider the street as *Boulevard* with a median that is no less than 2m wide to provide areas of pedestrian refuge and allow for the planting of large trees.

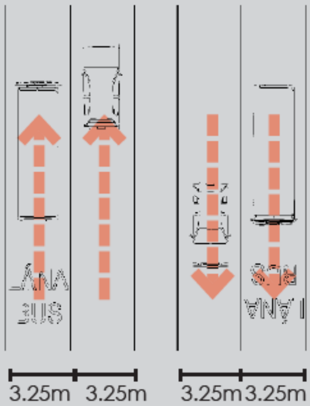
When carrying out upgrades, or traffic-calming works on existing streets, the first priority of authorities should be to narrow existing carriageways where they exceed those standards listed above. This will not only calm traffic, but will free up additional space within the street reserve to widen footpaths, insert cycle lane/tracks, provide bus lanes, street trees and on-street parking (all of which will further contribute to traffic calming).

31 Refer to Figure 7.16 of *UK Manual for Streets* (2007).

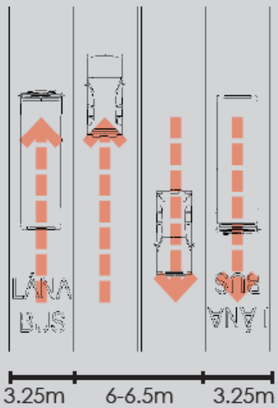
FIGURE 4.55: CARRIAGEWAY WIDTHS
(note: Illustrations do not include cycle facilities)



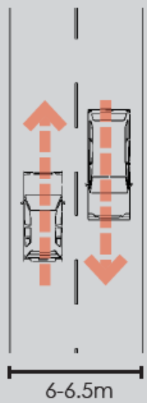
Carriageway widths for heavily-trafficked *Arterial* and *Link* streets in boulevard configuration. Main carriageway suitable for moderate design speeds. Includes access lanes with a lower design speed.



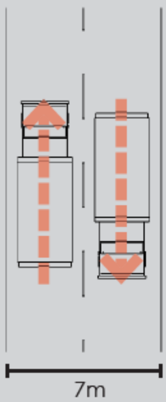
Standard lanes widths for multi lane carriageway for *Arterial* and *Link* streets in boulevard configuration, including bus lanes.



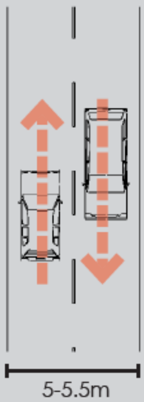
Standard lane/carriageway widths for multi lane *Arterial* and *Link* streets, including bus lanes. Range for low to moderate design speeds.



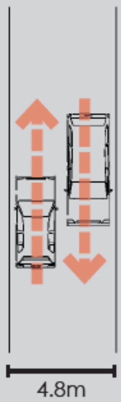
Standard carriageway widths for *Arterial* and *Link* streets. Range for low to moderate design speeds.



Carriageway width for *Arterial* and *Link* streets frequently used by larger vehicles.



Standard carriageway width for *Local* streets



Carriageway width for *Local* streets with a shared surface carriageway.

4.4.2 Carriageway Surfaces

The material, texture and colour of the carriageway are important tools for informing drivers of driving conditions. Research has found that the use of robust surface materials (such as block paving) can reduce vehicle speeds by 4-7 km/h alone.[32] The use of paving, imprinted or looser materials (combined with no kerbing, see Section 4.4.8 Kerbs) is one of the clearest ways of reinforcing a low-speed environment and of signalling to all users that a the main carriageway is to be shared (see Figure 4.56). The use of such surfaces also adds value to place, particularly in historic settings.

Figure 4.56: Example from Adamstown, Co. Dublin of a shared surface 'homezone' adjacent to a school. Paving materials, combined with embedded kerbs encourage a low speed shared environment.

With regard of surface types:

- The use of standard materials, such as macadam/asphalt should generally be confined to streets with moderate design speeds (i.e. 40-50km/h).
- Where lower design speeds (i.e. 30km/h or less) are desirable changes in the colour and/or texture of the carriageway should be used, either periodically (30km/h) or for the full length of the street (below 30km/h).

The use of robust finishes may also be used, on all streets, for the full carriageway where large numbers of pedestrians congregate. Such treatments should be considered in *Centres* (i.e. along shopping streets), in all urban areas around *Focal Points* and adjacent to schools, squares, parks and other areas where vulnerable pedestrians are present (see Figure 4.57).

Figure 4.57: Example from Chapelizod, Co. Dublin, where the carriageway has been paved adjacent to a square in a village centre to add value to place and calm traffic in an area of higher pedestrian activity.

Designers should also consider the use of at-grade material changes (up to 25mm in height) such as at crossings, particularly on streets with more moderate speeds and where the aim is not to require large reductions in speed but to alert drivers of a change in driving conditions ahead (see Figure 4.58).

Figure 4.58: Examples from Tallaght, Co. Dublin of a robust surface material (including a slight vertical deflection) designed to add value to place and increase pedestrian safety by alerting/slowing vehicles on approach to the crossing.

32 Refer to Section 7.2.15 of the UK *Manual for Streets* (2007).

4.4.3 Junction Design

Junction design is largely determined by volumes of traffic. As noted in Section 3.4.2 Traffic Congestion, the design of junctions has traditionally prioritised motor vehicle movement. Designers must take a more balanced approach to junction design in order to meet the objectives of *Smarter Travel* (2009) and this Manual. In general designers should:

- Provide crossings on all arms of a junction.
- Reduce kerb radii, thereby reducing crossing distances for pedestrians and slowing turning vehicles (see Section 4.3.3 Corner Radii).
- Omit left turn slips, which generally provide little extra effective vehicular capacity but are highly disruptive for pedestrians and cyclists. Where demand warrants, they may be replaced with left tuning lanes with tighter corner radii (see Figure 4.59).
- Omit staggered crossings in favour of direct/single phase crossings (see Section 4.3.2 Pedestrian Crossings).
- Omit deceleration lanes. These are not required in low to moderate speed zones (i.e. up to 60km/h).
- Include pedestrian, cyclist and bus passenger delays in the optimisation of traffic signal phasing and timings. This will almost certainly lead to a reduction in cycle times.
- Minimise waiting with pedestrain cycle times of no more than 90 seconds at signalised junctions (see Section 4.3.2 Pedestrian Crossings).

Designers should also have regard to *Context* and *Function* when selecting junction types (see Figure 4.60). Junction design will also need to be considered in conjunction with crossing types and ratio of flow to capacities (see Sections 4.3.2 Pedestrian Crossings and 3.4.2 Traffic Congestion).

Figure 4.59: Left turning slips (left) generally offer little benefit in terms of junction capacity and increase the number of crossings pedestrians must navigate. They also allow vehicles to take corners at higher speeds, exposing pedestrians and cyclists to greater danger. Where a large number of turning movements occur, left turning lanes (right) with tighter corner radii should be used.

Traffic Signals

These can provide a wide range of capacities depending on the widths of the approaches, the presence of bus lanes on approach, cycle times and turning traffic flows. Traffic signal junctions can include pedestrian phases and advanced stoplines for cyclists, thus making them safer. Traffic Signals should generally be used at all junctions between *Arterial* and *Link* streets. Where pedestrian activity is particularly high (such as within a *Centre* or around a *Focal Point*), designers may apply all-round pedestrian phase crossings with diagonal crossings.

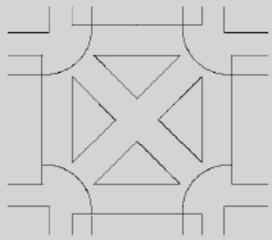
Roundabouts

These have a wide range of capacities depending on the size and geometry of the roundabout, its approaches, and turning traffic flows, but are generally lower than signalised junctions. Large roundabouts are generally not appropriate in urban areas. They require a greater land take and are difficult for pedestrians and cyclists to navigate, particularly where controlled crossings/cycle facilities are not provided, and as such, vehicles have continuous right of way.

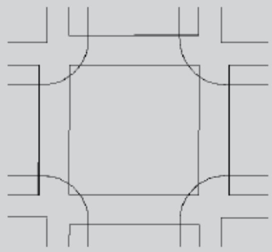
The use of large roundabouts (i.e. those with radii greater than 7.5m) should be restricted to areas with lower levels of pedestrian activity. Where large roundabouts currently exist, road authorities are encouraged, as part of any major upgrade works, to replace them with signalised junctions or retrofit them so that are more compact and/or pedestrian and cycle friendly, as is appropriate.

The use of more compact roundabouts (i.e. those with a radii of 7.5m or less) may address many of the issues highlighted above and may also be useful as a traffic-calming measure. These may be considered where vehicle flows are not sufficient to warrant full signalisation, such as on *Links*, and pedestrian activity is more moderate, such as in *Suburbs* and *Neighbourhoods*, provided they are appropriately fitted with the appropriate pedestrian crossings.

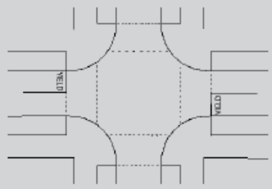
JUNCTION CONTROL



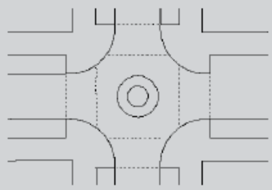
Signalised junction with all-round pedestrian phase crossing. Areas of high pedestrian and vehicular activity.



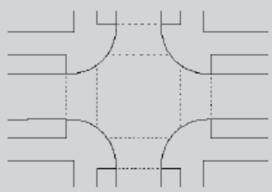
Standard Signalised Junctions. Areas of moderate pedestrian/high-moderate vehicular activity.



Priority Junction. Areas of lower/moderate pedestrian and vehicular activity.



Mini or shared roundabouts with informal crossings. Areas of low pedestrian activity.



Uncontrolled Junctions. Areas of lower/moderate pedestrian and vehicular activity.

Figure 4.60: General junction selection based on the optimising pedestrian and cyclist movement whilst also balancing the needs of motor vehicle users.

Section 4.8 of the *National Cycle Manual* (2011) also contains further guidance on the design and use of roundabouts to make them more pedestrian and cycle friendly. With regard to the application of these models.

- Where compact roundabouts are proposed, designers may apply the *Mini* or *Shared* roundabout models.

- The use of large roundabouts, such as the *Segregated Track on Roundabout* or *Fully Segregated Roundabout,* should be restricted to areas where pedestrian activity is low (as noted above). The application of these models may be acceptable where it is proposed to retrofit an existing roundabout to make it more pedestrian and cycle friendly.

Designers may also consider the use of shared space/informal roundabouts within low speed environments, such as *Centres*. These junctions incorporate the design characteristics of a shared space junction (i.e. no kerbs, paved surfaces etc) with circular features placed at the centre and edges. Examples of roundabout type features (sometimes referred to as 'roundels') have been successfully implemented in the UK on heavily trafficked junctions with the effect of enhancing place, calming traffic and increasing cyclist/pedestrian mobility (see Figure 4.61).

Figure 4.61: Examples from Ashford, UK (top) and Poynton, UK (bottom). The placement of a circular features with the shared space/ traffic calmed environment creates an informal roundabout with fewer restrictions pedestrian/ cyclist movement when compared to more conventional types (image sources: Hamilton-Baillie Associates and Ashford Borough Council).

Priority Junctions (i.e. Stop and Yield junctions).

These generally have low capacity and are appropriate for low to medium flows. They should generally be applied where *Local* streets meet *Arterial* or *Link* streets.

Uncontrolled Junctions

These generally have low capacity and rely on informal communication between drivers. They should generally be used where vehicle flows are low, such as those between *Local* streets. Designers may also consider the use of shared space junctions at busier junctions within low speed environments, such as *Centres*. There are also examples of uncontrolled shared space junctions which cater for higher flows without signalisation (see Figure 4.62 and Section 4.3.4 Pedestrianised and Shared Surface Streets).

Figure 4.62: Example from Coventry, UK of a shared surface uncontrolled junction. The level of traffic using the junction would normally warrant some form of control, however, its traffic calmed nature allows for drivers to communicate with each other and pedestrians to establish movement priorities (image source: Hamilton-Baillie Associates).

4.4.4 Forward Visibility

Forward Visibility, also referred to as Forward Sight Distance (FSD), is the distance along the street ahead which a driver of a vehicle can see. The results of research carried out by Transport Research Laboratory UK (TRL) for the UK *Manual for Streets* (2007) found that reducing forward visibility is one of the most effective measures used to increase driver caution and to reduce speeds.[33]

The minimum level of forward visibility required along a street for a driver to stop safely, should an object enter its path, is based on the Stopping Sight Distances (SSD). The SSD has 3 constituent parts:

- Perception Distance: The distance travelled before the driver perceives a hazard.
- Reaction Distance: The distance travelled following the perception of a hazard until the driver applies the brakes.
- Braking Distance: The distance travelled until the vehicle decelerates to a halt.

The perception and reaction distances are generally taken as a single parameter based on a combined perception and reaction time. The formula for the calculation of SSD is:

$$SSD = vt + v^2/2d$$

33 Refer to Section 7.4.4 of UK *Manual for Streets* (2007) and *UK Manual for Streets: Redefining Residential Street Design* (2006).

Where:

v = vehicle speed (m/s)
t = driver perception-reaction time (s)
d = deceleration rate (m/s^2)

SSDs have generally been applied according to those contained within the NRA DMRB TD 9 which where derived from the UK DMRB Manual of the same name using a perception reaction time of 2 seconds, and a deceleration rate of 0.25g, or 2.45 m/s^2. TRL found these SSD values to be overly conservative as they underestimated driver reaction times, deceleration rates and did not take into account actual road design details.[34] Based on this research, a driver perception-reaction time of 1.5 seconds, and a deceleration rate of 0.45g, or 4.41 m/s^2, should be applied with design speeds of 60 km/h and below. For larger vehicles such as HGVs and buses, a deceleration rate of 0.375g, or 3.68 m/s^2 should be applied.

A revised set of reduced SSDs, based on the parameters included in the UK *Manual for Streets* (2007), are presented in Table 4.2. The reduced SSDs should be applied according to the design speed of a street (see Section 4.1.1 A Balanced Approach to Speed) at junctions and along the alignment of a street (see Sections 4.4.5 Visibility Splays and 4.4.6 Alignment and Curvature, respectively).

34 Refer to *Manual for Streets: Evidence and Research (TRL Report 661)* (2007).

SSD STANDARDS

Design Speed (km/h)	SSD Standard (metres)
10	7
20	14
30	23
40	33
50	45
60	59

Forward Visibility

Design Speed (km/h)	SSD Standard (metres)
10	8
20	15
30	24
40	36
50	49
60	65

Forward Visibility on Bus Routes

Table 4.2: Reduced SSD standards for application within cities towns and villages. Reduced forward visibility increases driver caution and reduces vehicle speeds.

4.4.5 Visibility Splays

Visibility splays are included at junctions to provide sight lines along the intersected street to ensure that drivers have sufficient reaction time should a vehicle enter their path. Visibility splays are applied to priority junctions where drivers must use their own judgement as to when it is safe to enter the junction. Junction visibility splays are composed of two elements; the X distance and the Y distance.

- The X distance is the distance along the minor arm from which visibility is measured. It is normally measured from the continuation of the line of the nearside edge of the major arm, including all hard strips or shoulders.
- The Y distance is the distance a driver exiting from the minor road can see to the left and right along the major arm. It is normally measured from the nearside kerb or edge of roadway where no kerb is provided.

The procedure for checking visibility splays at junctions is illustrated in Figure 4.63. An additional check is made by drawing an additional sight line tangential to the kerb, or edge of roadway, to ensure that an approaching vehicle is visible over the entire Y distance.

Longer X distances allow drivers more time to observe traffic on the intersected arm and to identify gaps more readily, possibly before the vehicle comes to a stop, thus allowing increased vehicle speeds through junctions. Furthermore, a longer X distance may encourage more than one vehicle on the minor arm to accept the same gap even where it is not ideal that they do so. Neither circumstance is desirable in urban areas. The attention of a driver should not solely be focused on approaching vehicles and the acceptance of gaps. The pedestrian/ vulnerable road users should be higher in the movement hierarchy

For this reason, priority junctions in urban areas should be designed as Stop junctions, and a maximum X distance of 2.4 metres should be used. In difficult circumstances this may be reduced to 2.0 metres where vehicle speeds are slow and flows on the minor arm are low. However, the use of a 2.0 metre X distance may result in some vehicles slightly protruding beyond the major carriageway edge, and may result in drivers tending to nose out cautiously into traffic. Care should be taken to ensure that cyclists and drivers can observe this overhang from a reasonable distance and manoeuvre to avoid it without undue difficulty.

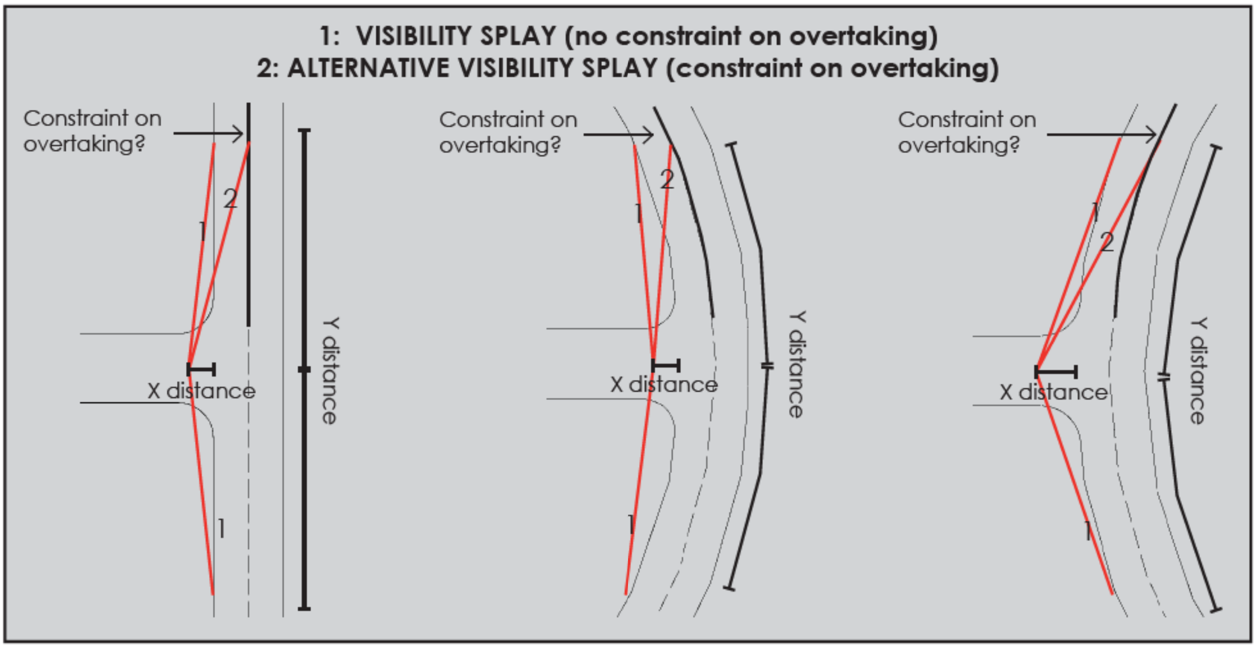


Figure 4.63: Forward visibility splays refer to an X and Y value. The X value allows drivers to observe traffic on the intersected arm. The Y value allows the driver of a vehicle to stop safely should an object enter its path, and is based on the SSD value.

The Y distance along the visibility splay should correspond to the SSD for the design speed of the major arm, taken from Table 4.2 while also making adjustments for those streets which are frequented by larger vehicles. For example, within *Industrial Estates* and/or on *Arterial* and *Link* streets with higher frequency bus routes.

In general, junction visibility splays should be kept clear of obstructions, however, objects that would not be large enough to wholly obscure a vehicle, pedestrian or cyclist may be acceptable providing their impact on the overall visibility envelope is not significant.

Slim objects such as signs, public lighting columns and street trees may be provided, but designers should be aware of their cumulative impact.

- Street furniture, such as seats and bicycle stands may also be acceptable, subject to being sufficiently spaced.
- Splays should generally be kept free of on-street parking, but flexibility can be shown on lower speed streets with regard to minor encroachments.
- Pedestrian guardrails can cause severe obstruction of visibility envelopes, and the use of guardrails should be avoided (see Section 4.2.5 Street Furniture).

Designers should also check the visibility envelop in the vertical plane on approach to junctions (see Section 4.4.6 Alignment and Curvature, Figure 4.67)

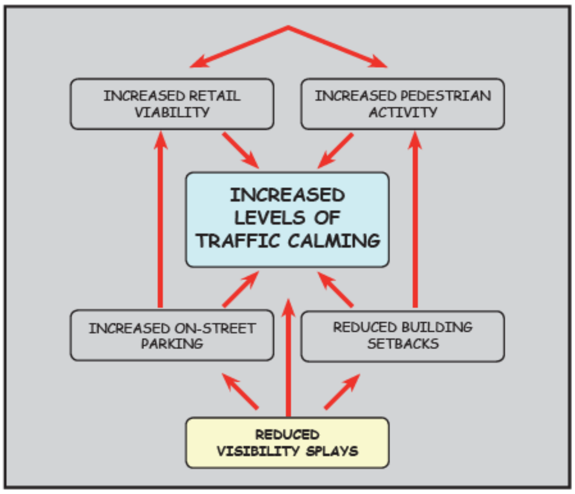


Figure 4.64: Flow diagram showing the inter-linked traffic calming and place making benefits of reduced visibility splays.

Designers may have concerns about reducing visibility splays at junctions that carry higher volumes of traffic at more moderate speeds. This issue was addressed further in respect of research carried for the UK *Manual for Streets 2* (2010). This included 'busy radial roads', many of which included bus routes within a variety of 20, 30 and 40 mph environments.[35] The research concluded that there is no evidence that reduced SSDs are directly associated with increased collision risk, as shown on a variety of street types at a variety of speeds. The *Manual for Streets 2* (2010) also refers to research where it was found that higher cycle collision rates occurred at T-Junctions with greater visibility.[36] The research concluded that this was because drivers were less cautious where greater visibility was provided.

Designers must also take a holistic view of the application of reduced forward visibility splays. As illustrated in the *Adamstown Street Design Guide* (2010), there are other place making and traffic calming benefits that can be implemented by reducing forward visibility splays at junctions (see Figure 4.64).

35 Refer to 10.4 of *UK Manual for Streets 2* (2010) and the report *High Risk Collision Sites and Y Distance Visibility* (2010).

36 Refer to *Layout and Design Factors Affecting Cycle Safety at T-Junctions* (1992).

4.4.6 Alignment and Curvature

Changes in the alignment of roads and streets are generally referred to in the horizontal and vertical sense. When these changes occur, the FSD, is reduced and, as noted above, this is one of the most effective measures used to increase driver caution and calm traffic (see Figure 4.65).

Figure 4.65: Example from Clongriffin, Co. Dublin where a change in the alignment of the street calms traffic as drivers proceed cautiously due to the uncertainly of what lay ahead (image source: Google Street View).

Horizontal Alignment

The horizontal alignment of a street consists of straight sections and curves. Whilst changes to the horizontal alignment calms traffic, this needs to be balanced with safety concerns. To prevent abrupt changes in direction minimum FSD required along a street should correspond to the minimum SSD appropriate to the design speed. FSD is checked at horizontal curves by measuring between points on the curve along the centreline of the inner lane (see Figure 4.66).

Frequent changes to the horizontal alignment should also be balanced with permeability and legibility. Overuse of changes in the direction of streets may disorientate pedestrians and increase walking distances between destinations. In this regard:

- Designers should avoid major changes in the alignment of *Arterial* and *Link* streets as these routes will generally need to be directional in order to efficiently link destinations.
- Major changes in horizontal alignment of Arterial and Link streets should be restricted to where required in response to the topography or constraints of a site.
- There is greater scope to use changes in horizontal alignment on *Local* streets to promote lower speeds and a more intimate sense of place (see Section 4.4.7 Horizontal and Vertical Deflections)
- Designers should not rely on curvature alone to reduce vehicle speeds. Changes in horizontal alignment should be combined with contextual measures that reduce forward visibility, such as building lines and on-street parking.

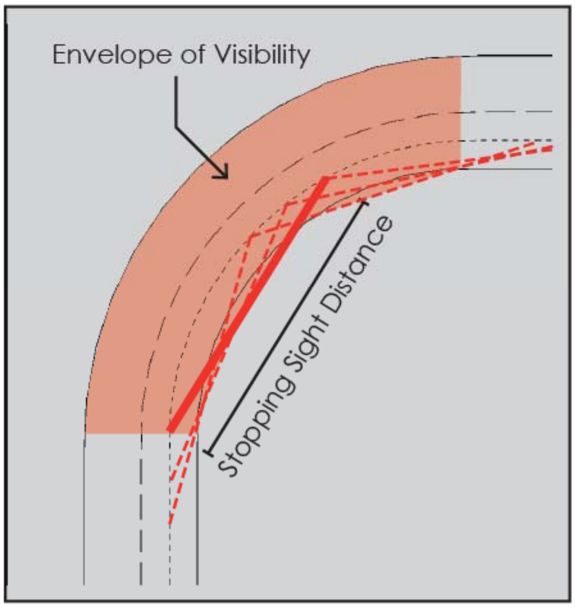


Figure 4.66: Forward visibility at horizontal curves need to take account of SSD values

Horizontal Curvature

At a horizontal curve, the centrifugal force a vehicle travelling around that curve is generally counteracted by a combination of 2 factors: friction between the tyres and the road surface, and superelevation of the carriageway, where the carriageway is constructed such that the outside carriageway edge is higher than the inside carriageway edge. Traditionally, the design approach has been to combine these factors to ensure that a vehicle can travel around a bend without reducing speed or without causing significant discomfort to the occupants of the vehicle. Where a horizontal alignment along a street requires changes in direction, the curves between straight sections should have radii in accordance with Table 4.3.

Crossfall

Designers should also consider superelevation where one side of the road is designed to be higher than the other in order to resist the centrifugal effect of turning a corner. As the aim of superelevation is to assist drivers to maintain higher speeds around curves, its use is inappropriate where the design is intended to achieve a moderate or low speed environment. As also noted in the *Manual for Streets 2* (2010), superelevation is also difficult to implement in urban areas with frequent junctions and points of access.[37]

However a crossfall of 2.5% is generally provided on carriageways to assist in drainage, which would tend to result in adverse camber at horizontal curves. Consequently, in order to assist in achieving lower vehicle speeds through a more restrictive horizontal alignment, there is a need to provide sharper horizontal curves that do not have the benefit of high levels of superelevation to counteract the centrifugal force. Designers should refer to Table 4.3 for minimum radius with adverse camber of 2.5%.

Where the introduction of radii less than those for minimum radius with adverse camber of 2.5% is unavoidable, a reasonable level of superelevation may be introduced to eliminate adverse camber and introduce a favourable crossfall. Minimum curve radii for a superelevation rate of 2.5% are also presented in Table 4.3, and may be used in such circumstances.

HORIZONTAL CURVATURE

Design Speed (km/h)	10	20	30	40	50	60
Minimum Radius with adverse camber of 2.5%	-	11	26	56	104	178
Minimum Radius with superelevation of 2.5 %	-	-	-	46	82	136

VERTICAL CURVATURE

Design Speed (km/h)	10	20	30	40	50	60
Crest Curve K Value	N/A	N/A	N/A	2.6	4.7	8.2
Sag Curve K Value	N/A	N/A	2.3	4.1	6.4	9.2

Table 4.3: Carriageway geometry parameters for horizontal and vertical curvature.

Vertical Alignment

A vertical alignment consists of a series of straight-line gradients that are connected by curves, usually parabolic curves. Vertical alignment is less of an issue on urban streets that carry traffic at moderate design speeds and changes in vertical alignment should be considered at the network level as a response to the topography of a site.

The required envelope of forward visibility in the vertical plane is illustrated in Figure 4.67 below. The envelope should encompass the area between a driver eye height in the range of 1.05 metres to 2.00 metres, and an object height in the range of 0.6 metres to 2.00 metres

Vertical Curvature

Where changes in gradient are required along an alignment, vertical curves are introduced, such that the appropriate SSDs are achieved, and an adequate level of driver comfort is provided. Ordinarily in urban areas where it can be expected that vehicle speeds will reduce in response to changes in alignment, it will be sufficient to design vertical curves such that the minimum SSD is provided.

Vertical curves can take the form of Crest or Sag curves, the length of a vertical curve, L, is the critical design parameter, and is determined by multiplying the K Values set out in Table 4.3 by the algebraic change of gradient expressed as a percentage, that is:

$$L = Ka$$

Where:

K = The constant of curvature
a = The algebraic change in gradient.

Vertical Crest Curve Design

At crest curves visibility can be obstructed by the road surface itself. Crest curve, accordingly, should be designed such that the curvature is sufficient to maintain an adequate FSD and SSD for a driver. In urban areas, where vehicle speeds are low and gradients are generally modest, the design of vertical crest curves can be simplified as follows:

- For very low design speeds (i.e. less than 40 km/h), and where the algebraic difference in gradient between straight sections is less than 12%, it will generally not be necessary to specifically design a vertical crest curve; however the carriageway should be shaped to avoid an abrupt change in vertical alignment.
- For design speeds of 40 km/h and above, and again where the algebraic difference in gradient is modest, up to a maximum of 12 %, it will normally be sufficient to provide a vertical curve with a length determined using the K-values presented in Table 4.3.

In exceptional circumstances where the algebraic difference in gradient exceeds these limits, it will be necessary for the designer to determine a crest curve length suitable for the circumstances from first principles.

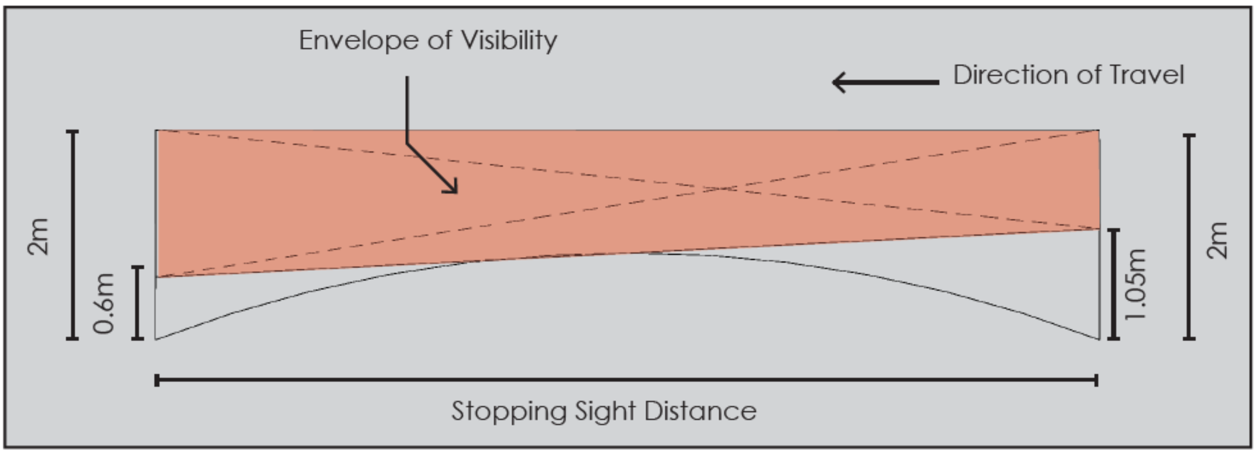


Figure 4.67: Visibility envelope in vertical plane.

Vertical Sag Curve Design

When designing vertical sag curves, there are three potential design parameters that need to be considered:

- Driver Comfort.
- Clearance from Structures.
- Night-time Conditions.

In urban areas, the obstruction of visibility due to structures (overbridges, gantries etc.) is likely to be an uncommon occurrence, and night time visibility only becomes an issue on unlit roads. Therefore the sag curve K values presented in Table 4.3 are based on the driver comfort parameter, and have been derived using a comfort criterion of 0.3m/s2 maximum vertical acceleration.

Maximum and Minimum Gradients

In urban areas, it is likely that the comfort of vulnerable road users will be the determining factor for desirable maximum longitudinal gradients on streets. Part M of the building regulations advises that access routes with a gradient of 1:20 or less are preferred. Therefore a maximum gradient of 5% is desirable on streets where pedestrians are active.

In hilly terrain, steeper gradients may be required but regard must be had to the maximum gradient that most wheelchair users can negotiate of 8.3%, although this should be limited to shorter distances A designer may need to consider mitigation measures, such as intermediate landings, to ensure that pedestrian routes are accessible. This also needs to be considered at the network level and as a response to place making.

The inclusion of streets that exceed these gradients may not be significant within a network where there are alternative routes that can be taken between destinations and where steeper gradients may in fact have placemaking benefits.

A minimum longitudinal gradient of 0.5% is desirable to maintain effective drainage on streets. Care needs to be taken at vertical curves, and in particular at sag curves, to ensure that there is provision at level points of curves to allow surface water to run off the carriageway.

4.4.7 Horizontal and Vertical Deflections

Horizontal or vertical deflections are changes that occur within the alignment of the carriageway to slow vehicles by requiring drivers to slow and navigate obstacles. Deflections include chicanes (horizontal) or ramps (vertical). The use of such physically intrusive measures is not necessary within a self-regulating street environment. Less aggressive features, such as junction offsets (see Figure 4.68), raised tables and changes to kerb lines, can be used strategically as supplementary measures which calm traffic and assist pedestrian movement by allowing them to cross at grade (see Section 4.3.2 Pedestrian Crossings).

Raised tables, or platforms, may be placed strategically throughout a network to promote lower design speeds, slow turning vehicles at junctions and enable pedestrians to cross the street at grade. Key locations where these should be considered include:

- On longer straights where there is more than 70m between junctions.[38]
- At equal priority junctions.
- At entrance treatments where Local streets meet *Arterial* and *Link* streets (see Figure 4.69).
- Outside *Focal Points* and areas of civic importance (such as schools).
- At pedestrian crossings.
- To reinforce a change between design speeds (such as at entrance treatments).

As raised tables are primarily designed to reinforce lower speed environments, their use should generally be limited to *Local* streets and/or the *Centres*. The use of raised tables more broadly across *Arterial* and *Link* streets (excluding those within *Centres*) should be limited to sections where speeds are to be lowered for a particular purpose (i.e. adjacent to *Focal Points* and/or key pedestrian crossings).

The principal aim of the designer should be to slow vehicles without causing undue discomfort. In this regard:

- An entry slope of 1:20 will allow most vehicles to cross at moderate speeds
- An entry slope of 1:15 is more appropriate for lower speeds.
- The minimum length of level section of the table should be 2m (to allow a pedestrians to cross).
- The height of a raised table should generally correspond with that of the adjoining kerb. Where buses operate the maximum height should be 75mm to reduce passenger discomfort.

38 Refer to Section 7.4.3 of the UK *Manual for Street* (2007).

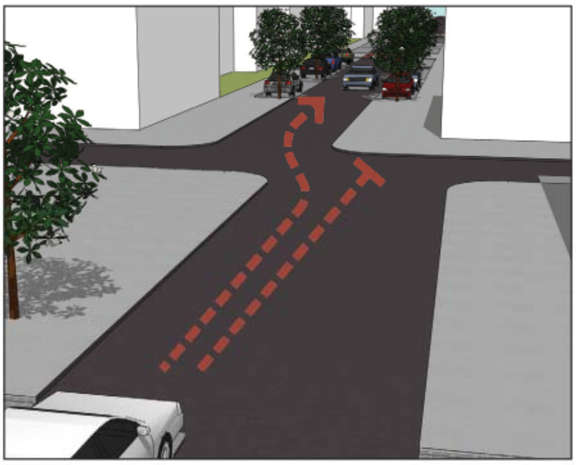


Figure 4.68: illustration of how off-setting junctions can create a change in alignment (without reducing permeability or legibility) and reduce forward visibility.

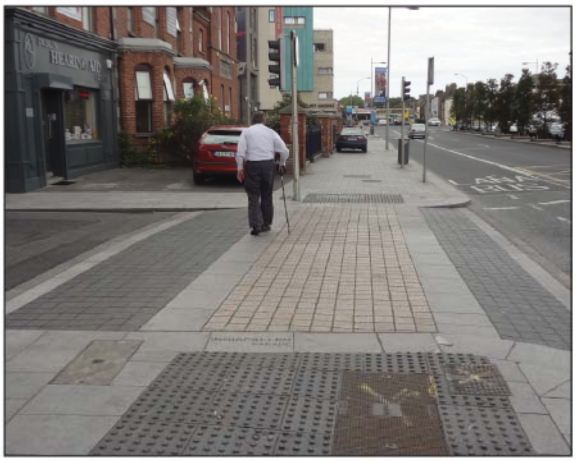


Figure 4.69: Example from Dorset Street, Dublin, where the carriageway has been raised and paved to slow turning vehicles and enhance the pedestrian crossing.

Horizontal deflections are particularly effective when considered at the network level and used in combination with restrictions in forward visibility (see Section 4.4.6 Alignment and Curvature and Figure 4.70). When deployed throughout a network on *Local* streets they can also be used to discourage through traffic (see Section 3.4.1 Vehicle Permeability). Deflections can be created by varying the kerb line/street alignment causing the carriageway to broaden and narrow and/or creating a series of directional adjustments. Car parking may also be used to similar effect (see Section 4.4.9 On-Street Parking and Loading). Other methods that may be considered at the network level include off-setting junctions to create a 3 Way Off Set Network (See Section 3.4.1 Vehicle Permeability).

Singular treatments include pinch-points that narrow the width of the carriageway over a short section of the street. These can be used in combination with raised tables at key locations on *Local* streets and/or within the *Centres* (see Figure 4.71). To be visually effective a pinch point should seek to reduce the width of the carriageway by a minimum of 0.5m for a minimum length of 6m.[39]

39 A minimum of 3.7m (3.1m at 'gateways') is required for fire vehicle access as per Table 5.2 of the *Building Regulations* 2006 (Technical Guidance Document B – Fire Safety).

Figure 4.70: Examples from Poundbury, Dorchester, UK, where changes in the kerb line and carriageway alignment calm traffic by limiting forward visibility, creating pinch points and requiring multiple changes in direction.

Figure 4.71: An example from Ingress Park, Kent, UK, of how the path and speed of a vehicle is altered within a low speed environment through the use of vertical and horizontal deflections (and material changes).

4.4.8 Kerbs

Kerbs traditionally provided a street drainage function but have more recently come to define the pedestrian domain from the vehicular carriageway. In so doing kerbs are key to establishing the level of segregation or integration which is to occur within a street. Lower kerbs, or lack thereof, can therefore create a greater sense of shared space and can be used to calm traffic. Lower kerb heights are also easier for pedestrians to negotiate, particularly for the mobility impaired.

With regard to the height of kerbs:

- The standard height for kerbs is 125mm and this provides a clear definition of a segregated street environment. These should be used on all streets where design speeds and pedestrian activity are more moderate, such as on *Arterial* and *Link* streets.

- Lower kerbs of 50-75mm or less are more appropriate in areas of higher pedestrian activity and where lower design speeds are applied, such as on all streets within *Centres*, around *Focal Points* and on *Local* streets (see Figures 4.72 and 4.73).

- Where a shared surface is proposed a kerb should not be used. Designers may consider embedding a kerb line or drainage channel (see Figure 4.74) into the carriageway to indicate an area of pedestrian refuge. This is particularly important for visually-impaired users who feel less comfortable on shared surfaces and also require a kerb line for navigation (see Section 4.3.4 Pedestrianised and Shared Streets).

Changes to kerb lines can also be used to slow drivers at critical points by changing the alignment of the carriageway to create pinch-points, build-outs and horizontal deflections (see Section 4.4.7 Horizontal and Vertical Deflections). Build-outs should be used on approaches to junctions and pedestrian crossings in order to tighten corner radii, reinforce visibility splays and reduce crossing distances (see Sections 4.3.2 Pedestrian Crossings and 4.4.5 Visibility Splays).

Figure 4.72: Example of a low kerb from Drogheda, Co. Louth, which is used to reinforce lower design speeds and create a greater sense of shared space.

Figure 4.73: Example from Clongriffin Co. Dublin, where the footpath, kerb line and vehicular carriageway are at the same level. Whilst pedestrian and vehicular space are still clearly defined, a greater sense of shared space is still created.

Figure 4.74: Example of an drainage channel on Exhibition Road, London. The kerb line indicates an area of pedestrian refuge and is used to guide the visually impaired.

4.4.9 On-Street Parking and Loading

One of the principal objectives of this Manual is to promote the use of more sustainable forms of transport. Whilst a place-based approach to street design will reduce car dependency, as noted in the Urban Design Manual,[40] people may wish to own and park a car, even if it is not used on a regular basis. On-street parking and loading refers to spaces that are directly adjacent to and accessible from the main vehicular carriageway. On-street parking, when well designed can:

- Calm traffic by increasing driver caution, visually narrow the carriageway and reduce forward visibility.
- Add to the vitality of communities by supporting retail/commercial activities that front on to streets through the generation of pedestrian activity as people come and go from their vehicles.
- Contribute to pedestrian/cyclist comfort by providing a buffer between the vehicular carriageway and foot/cycle path.
- Reduce the need or temptation for drivers to kerb mount and block foot/cycle paths.
- Provide good levels of passive security as spaces are overlooked by buildings.

The quantity of on-street parking that is needed in a given area depends on a number of factors, but is most closely related to proximity to *Centres*, the availability of public transport and the density, type and intensity of land use. Notwithstanding these factors, on-street parking has a finite capacity, depending on the per unit parking requirements. For example in residential areas:

- On-street parking alone can generally cater for densities up to 35-40 dwellings per ha (net).
- Once densities reach 40-50 dwellings per ha (net) the street will become saturated with parking and reduced parking rates (a max of 1.5 per dwelling) and/or supplementary off-street parking will be required.
- For densities over 50 dwelling per hectare, large areas of off-street parking, such as basements, will generally be required.

Getting the balance right presents a challenge to designers. If parking is over provided it will conflict with sustainability objectives and can be visually dominant. Conversely, if parking does not cater for user needs or is under provided it may encourage poor parking practices (including illegal ones) such as kerb mounting, parking on footpaths and within areas of open space.

Whilst off-street parking may form part of a design response, the first priority of a designer should be to locate parking on-street as follows:

- On *Arterial* and *Link* streets on-street parking spaces should be provided in a series of bays that are parallel to the vehicular carriageway.
- Perpendicular or angled spaces may be provided in lower speed environments such as *Local* streets. They may be applied more generally in *Centres* to cater for increased demands around shopping areas.
- On-street parking on public streets should not be allocated to individual dwellings. This allows for a more efficient turnover of spaces and, as such, fewer spaces are needed overall.
- Loading facilities should preferably, be provided off street. However, this is not always possible or desirable within older centres and/or where it would lead to an excessive number of access points to driveways.

There are a number of measures that should be used by designers to ensure that parking and loading areas are well designed (see Figures 4.75 and 4.76):

- To reduce the visual impact of parking the number of parking spaces per bay should generally be limited to three parallel spaces (including loading areas) and six perpendicular spaces.

40 Refer to Section 11 of the *Urban Design Manual* (2010).

- Perpendicular parking should generally be restricted to one side of the street to encourage a greater sense of enclosure and ensure that parking does not dominate the streetscape.

- To reinforce narrower carriageways (particularly when spaces are empty) each parking/loading bay should be finished so that it is clearly distinguishable from the main carriageway.

- Kerb build-outs, or similar treatment, should be provided to separate each bank of parking/loading. These will enable space for the planting of street trees and other street facilities (such as lighting or bike racks).[41]

- Kerb build-outs should also be provided on the approach to junctions to facilitate visibility splays (see Section 4.4.5 - Visibility Splays), reduce corner radii (see Section 4.3.3 Corner Radii) and ensure a clear line of sight between vehicles and pedestrian crossings.

Figure 4.75. Example from Ballymun, Co. Dublin (top) and Leixlip, Co. Kildare (bottom) where kerb build-outs and contrasting materials are used to separate and define bays of parking from the vehicular carriageway, reduce corner radii and facilitate planting or landscape treatments.

41 Refer to page 186 of the *National Cycle Manual* (2011).

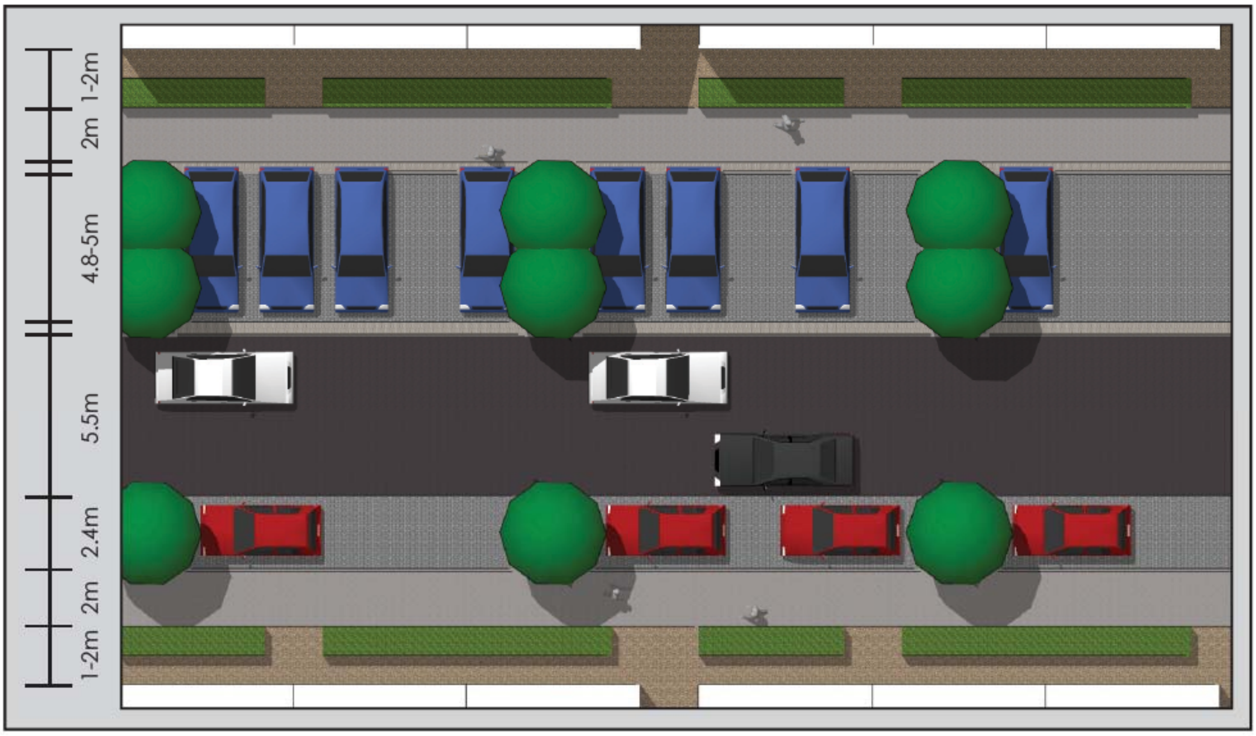


Figure 4.76: Extract from the Newcastle LAP (South Dublin County Council) illustrating the layout of a Local street with a uniform mix of parallel and perpendicular parking.

- Where on-street parking is provided adjacent to cycle paths/lanes a verge should be provided to allow additional space for opening doors (see Section 4.3.5 Cycle Facilities).

Parking may be added to existing streets where the carriageway is excessively wide as a means of narrowing it (see Figure 4.77). However, as noted in Section 4.4.1 Carriageway Widths, the first priority of designers should be to improve facilities for pedestrian and cyclists, prior to the addition of on-street parking.

A range of less formal or alternative parking arrangements may be used where design speeds are lower, particularly on *Local* streets and within Centres. A diverse range of parking types may be provided to create more intimate spaces, reduce the amount of line marking/constructed elements and/or reinforce the low speed environment. Such measures may include the following:

- Horizontal deflections may be produced by switching the location of parking bays from one side of the street to the other, or from the side of the street to the centre (see Figure 4.78).

Figure 4.77: Example from Fettercairn, Co. Dublin where a 'distributor' style road was narrowed by adding bays of parallel parking as part of a package of works aimed at calming traffic and improving the sense of place.

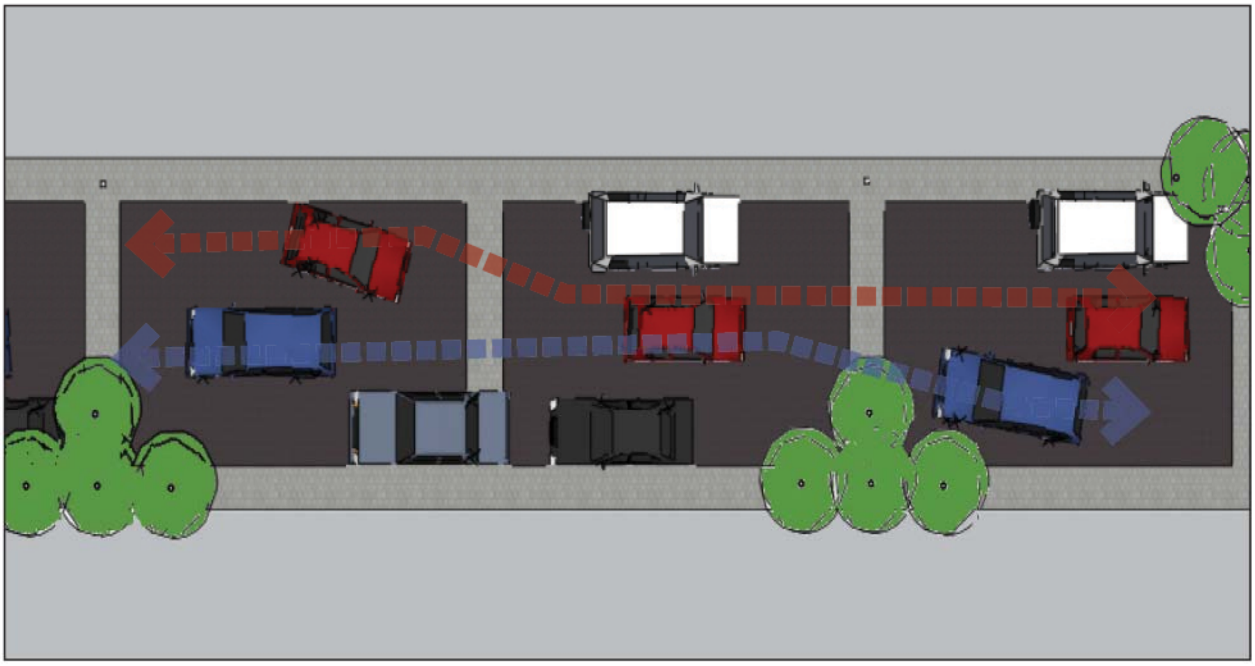


Figure 4.78: Illustration of informal on-street parking distributed to form a series of horizontal deflections and pinch points to reinforce a low speed environment.

- Parking bays may be less formally defined for example, the presence of the street tree embedded into the carriageway will also indicate where to park (see Figure 4.79).

- On-street and in-curtilage spaces may be integrated to reduce the overall amount of parking that is on-street and create a 'mews' like environment (see Figure 4.79.)

- Placing parking within the central area of a street to provide a greater level of surveillance.

- Loading areas may be provided at grade with footpath areas (i.e. within a verge), so that when not in use they revert back to pedestrian use (see Figure 4.80).

In areas of high demand, parking may be provided within the central areas of street as well as the edge of the carriageway to create an on-street parking courtyard (see Figure 4.81). Such spaces should be limited in size, well planted and landscaped to ensure that the courtyard is not overly dominated by parked vehicles.

Designers may also refer to the *Urban Design Manual* (2010)[42] and UK *Parking: What Works Where* (2006), for further guidance.

With regard to the design of individual parking/loading spaces:

- The standard width of a space should be 2.4m.

42 Refer to Chapter 11 of the *Urban Design Manual* (2010).

Figure 4.79. Example from New Hall, UK where a variety of in-curtilage and on-street parking is provided. On-street parking is provided semi-informally (indicated by the planting of trees). The parking of vehicles further calms traffic by providing a series of horizontal deflections.

Figure 4.80: Example from Walworth Road, London, UK, where a loading bay, provided within a verge, can revert to pedestrian space when not used.

- The standard length of a space should be 6m (parallel spaces).
- The standard depth of a perpendicular space should be 4.8m (not including a minimum 0.3m overhang, see Section 4.3.1 Footways, Verges and Strips).
- The depth of angular parking should be 4.2m for 60° angle parking and 3.6m for 45° angle parking.
- The dimensions of a loading bay should be 2.8 x 6m to cater for large vans. Facilities for larger vehicles, such as trucks, should be located off-street.

There are additional design considerations associated with perpendicular or angled spaces to ensure that they do not result in excessively wide vehicular carriageways. Perpendicular spaces generally require a minimum carriageway width of 6m, which is generally too wide for *Local* streets. Where additional space is needed, manoeuvrability should be provided within the parking bay itself and kerb build-outs should extend forward of each bank of parking to narrow the carriageway. Alternatively, additional manoeuvrability can be provided by designing wider spaces. For example, if the width of parking spaces is 2.6m, the carriageway may be reduced to 5m (see Figure 4.82).

Figure 4.81: Examples from Belmayne (top) and Ballycullen (bottom), Co. Dublin of a well landscaped parking court integrated within a street environment .

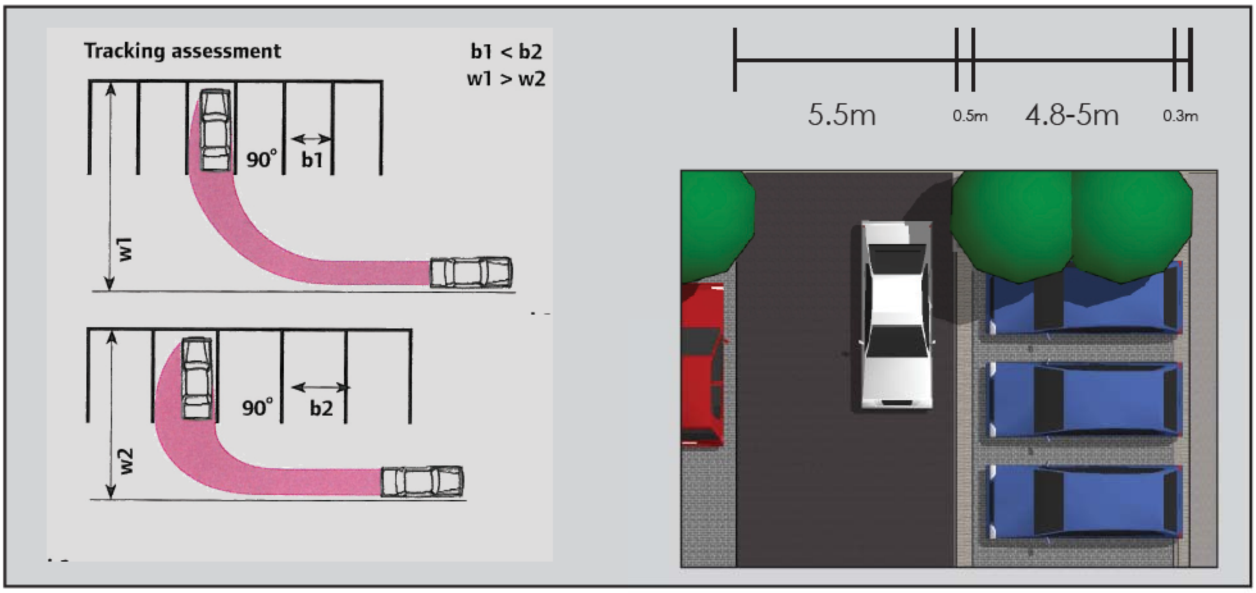


Figure 4.82: Example of how additional manoeuvrability may be provided for vehicles in areas of perpendicular parking whilst minimising carriageway widths. The images to the left are extracted from the Manual for Streets (2007) and illustrate the provision of wider spaces. The image to the right also shows the use of small verges.