CEDR Transnational Road Research Programme

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Safety in Non-Urban Areas for VRU (SANA-4U)

WP1 Review of standards and practices for VRU on non-urban roads

Deliverable No (D1.1)

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VTI (Sweden)

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Arup (Ireland)

CEDR Call Safety 2016

Safety in Non-Urban Areas for VRU (SANA-4U)

Deliverable number 1: Review of standards and practices for VRU on non-urban roads

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Glossary of Terms

AADT	Average annual daily traffic (measure of traffic volume).
CEDR	Conference of European Directors of Roads
HF	Human factors (HF) is the application of psychological and physiological principles to the design of products, processes, and systems. The goal of human factors is to reduce human error, increase productivity, and enhance safety and comfort with a specific focus on the interaction between the human and the thing of interest (from Wickens et al., 2004).
MV	Motorised vehicles
NMU	Non-motorised users
NRA	National road authority
NUA	Non-urban areas: Specifies a transition zone which can comprise a road length which is designed between the rural and urban areas.
VRU	Vulnerable Road User: The road user groups defined as vulnerable road users in this project comprises pedestrians and cyclists. Electric bicycles are classes as bicycles if the effect does not exceed 0.250 kW (and speed restricted to 25 km/h). Motorised wheelchairs are included. Electric bicycles with an engine effect > 0.25 kW are classed as mopeds (class 1 or 2 depending on power) or motorcycles if they exceed 4 kW. Neither of these types are classed included in the projects definition of VRU. Equestrian transport or hackneys are not included in this project's definition of VRU.

1 Introduction

The promotion of active transport (cycling and walking) for everyday physical activity is a win-win approach; it not only promotes health but can also lead to positive environmental effects, especially if cycling and walking replace car trips. Cycling and walking can also be more readily integrated into people's busy schedules than, for example, leisure-time exercise. But of course, we must ensure that these activities by cyclists and other vulnerable road users (VRU) can be done in a safe environment.

Promoting safety for VRU is an item which comes back in several initiatives, on national and European levels. Many European Road Authorities focus their design standards on VRU's. But those standards have been developed to be implemented in new road projects, unfortunately not (always) implemented on the existing road network outside urban areas. Within this project, we will review VRU standards across member states, analyse them and develop a "best practice guide" with focus on self-explaining systems for VRU in non-urban areas. Since those roads outside urban areas are increasingly being used to transport goods and services between the larger urban areas while at the same time still being used by local communities, including pedestrians and cyclists, these best practice guidelines will give illustrated examples of self-explaining systems that have proven to be effective in this type of environment.

Work package 1 (WP1) is a review of VRU Standards across CEDR member states. The benefits and need for VRU design guidelines on non-urban legacy road networks comes from the increasing degree of motorised vehicles encroaching on these road networks. The non-urban legacy road networks do not necessarily cater for the needs of VRUs. Local and national governments are increasingly keen that their citizens can utilise secondary (legacy) networks for cycling and walking, whether recreational or for transport/commuting.

2 Project & WP1 objectives

The objectives of this project are to identify improvements on existing standards and guidelines for the design of self-explaining road systems that promote safety for vulnerable road users (VRU) especially in non-urban areas. The non-urban areas of main interest comprise existing legacy road networks in CEDR member states.

The aim of this deliverable for WP1 (D1.1) is the review of standards and encompass all CEDR member states.

The review was undertaken by contacting road authorities directly (using a questionnaire) and through internet searches for relevant standards. This review covers standards and guidelines on geometric design, road safety, human factor design and ITS measures.

3 The Questionnaire

3.1 Method

3.1.1 Questionnaire Objectives

1. To identify which NRA's (National road authority) have existing vulnerable road user standards and if not, use other vulnerable road user standards prepared by other national agencies;
2. To identify the NRA's description of the different types of areas along their road systems (i.e. urban, rural, suburban, semi-rural, small village, etc.) and identify if the standards differ for different types of areas.
3. To identify any difference in standards associated with the new road construction projects and those projects using the existing road network.

The questionnaire was developed within the project and distributed to the CEDR member network via the CEDR project officer. The questionnaire was designed to take as little time as possible from the NRA's while still identify important areas of interest. We were particularly interested in finding the right staff at the respective NRAs and ask about their willingness to participate in follow-up interviews.

The questionnaire template can be found in Appendix 1.

3.2 Results

There are 27 CEDR member countries. There were 13 countries that replied. Table 1 lists the countries that replied and their answer to the question regarding willingness to participate in a follow-up interview. The interviews were then conducted by the project partner that had the best language skills for the respective member countries.

Table 1 lists the CEDR countries that replied and their willingness to participate in a follow-up interview.

	Country	Positive Y/N
1	Estonia	Y
2	Flanders/ Belgium	Y
3	Germany	Y
4	Ireland	Y
5	Netherlands	Y
6	Sweden	Y
7	UK	Y
8	Austria	Y (but no public access)
9	Cyprus	N
10	Italy	N
11	Luxembourg	N
12	Portugal	N
13	Spain	N

As can be seen in Table 1, there were 7 member-countries that were willing to participate in the follow-up interviews and that also had public access for their respective design standards or guidelines.

Table 2: Does your country have road design standards (**compulsory**) for VRU?

Answer	No. of respondents	Percentage (%)
Yes	9	69
No	3	23
Not answered	1	8

(n= 13)

Table 3: Does your country have road design guidelines (**voluntary**) for VRU?

Answer	No. of respondents	Percentage (%)
Yes	9	69
No	3	23
Not answered	1	8

(n= 13)

It should be noted that the frequencies presented in Table 2 and Table 3 reflect that several countries have a combination of compulsory and voluntary guidelines and standards. Although the frequencies in Table 2 and Table 3 had the same tally, they comprised different countries.

The difference between design *standards* and design *guidelines,* is that standards are compulsory but usually with built-in flexibility to be able to e.g. opt-out. The guidelines are recommendations that may in some cases be strongly recommended; or they can be voluntary with no reprisals or negative repercussions if they are not followed.

Table 4: Does your country use best practice policies from other countries/regions?

Answer	No. of respondents	Percentage (%)
Yes	5	38
No	7	54
Not answered	1	8

(n= 13)

In Table 4, the countries and/or regions that were most frequently used were The Netherlands, and Denmark and to a lesser extent France, Germany, UK, Switzerland and Sweden.

Table 5: Local, Regional and National jurisdictions for road **design standards** (**compulsory**) for VRU?

Jurisdictions	Frequency		
	Geometric & road safety design	HF design	ITS measures
Only Local	-	-	-
Only Regional	1	-	-
Only National	2	2	1
Local + Regional	-	-	-
Local + Regional + National	2	-	-
Regional + National	2	1	1
Local + National	2	1	1
No jurisdictions	3	8	9
Not answered	1	1	1
TOTAL	*13*	*13*	*13*

In regard to local, regional and national jurisdictions for road design standards (that are compulsory) for VRU in Table 5, it can be noted that there is a broad scope for geometric and road safety design. However, for human factors (HF) design criteria and ITS measures, there are far fewer standards among the member countries that replied to the questionnaire.

Table 6: Local, Regional and National jurisdictions for road **design guidelines** (voluntary) for VRU?

Jurisdictions	Frequency		
	Geometric & road safety design	HF design	ITS measures
Only Local	-	-	-
Only Regional	-	-	-
Only National	2	1	1
Local + Regional	1	-	-
Local + Regional + National	4	3	2
Regional + National	-	-	-
Local + National	2	2	1
No jurisdictions	3	6	8
Not answered	1	1	1
TOTAL	*13*	*13*	*13*

In regard to local, regional and national jurisdictions for road design guidelines for VRU in Table 6, it can be noted that there is a broad scope for geometric and road safety design and slightly more supporting documents or guidelines pertaining human factors design criteria and ITS measures.

3.3 Summary

In summary, less than half of the CEDR countries that replied to the questionnaire (13 out of 27) regarding the use of guidelines or standards using human factors designs (e.g. self-explaining or human-centred designs) or ITS measures that are aimed VRUs.

Most countries have a mixture of compulsory and voluntary design guidelines, whereas only a few have only compulsory or only voluntary regulations and only one country lacked them all together. The level of jurisdiction between local, regional and national levels was slightly tipped towards a national orientation (or combinations including the national level). The difference between design *standards* and design *guidelines,* is that standards are compulsory but usually with built-in flexibility to be able to e.g. opt-out. The guidelines are recommendations that may in some cases be strongly recommended; or they can be voluntary with no reprisals or negative repercussions if they are not followed.

The replies in questionnaire were used to form the interview guide reported below. 7 of the responding countries agreed to follow-up interviews.

4 The Interviews

4.1 Method

4.1.1 Interview objectives

The aim of the interviews was to gain in-depth information on the infrastructural practices of CEDR members concerning VRU outside urban areas. The objectives were:

1. Provide an overview of the respective country's guidelines/standards in regard to VRU on inter-urban roads.
2. Help find good examples of guidelines/standards in regard to VRU on inter-urban roads that can be used in WP2.

The interviewees were NRA staff (except the Flanders region) that had elected to participate or nominated colleagues to participate in follow-up interviews after having completed the questionnaire (see chapter 3) on road design. There were seven NRAs that were interviewed.

4.2 Results

A synopsis of the 7 countries is provide below and includes excerpts from the interviews and the corresponding documentation. The excerpts contain many other the examples that we aired in the interviews. Many of the tables and figures are in the original languages and are used in this report for illustrative purposes and are intended to highlight some of the examples etc. provided by the NRAs. Links to useful documents or websites, where available, are also provided.

4.2.1 Estonia

It was not possible to interview the Estonian NRA so 20 questions were devised from the interview guide and the answers from the respondent were provided in writing.

4.2.1.1 Excerpts and the corresponding documentation for Estonia

1. *Can you identify possible gaps or holes in the respective guidelines/standards in regard to VRU on inter-urban roads (in Estonia)?*

Yes, we have lack of some specific domestic norms and standards. But in these situations, by a regulation of Minister of Economic Affairs and Infrastructure we can use norms and standards of other European states, located in similar climatic conditions.

2. *Can you identify good examples (in your opinion) of guidelines/standards in regard to VRU on inter-urban roads from Estonia? Please provide images or diagrams if available.*

We have norms that say (Chapter 7.4.5) which crossings should be used (unfortunately in Estonian):

Translations of the text in Table 7 are found below the table.

Table 7: Estonian norms for use of inter-urban crossings and VRUs.

Autoliikluse projektkiirus, km/h	Projekteerimise lähtetase	Maantee ja jalgtee lõikumisviis
≥100	H	
80	H	
	R	
	E	
60	H	
	R	
	E	
40	H	
	R	
	E	

	Tähistatud ületuskoht
	Tähistatud ja ohutussaartega ületuskoht
	Foorjuhitav ületuskoht
	Eritasandiline ületus (tunnel, sild)

Estonia

The letters in Table 7 mean the following: H is good, R is satisfactory, and E is exceptional (should be rarely used).

The colours mean:

White – crossing with appropriate horizontal and vertical signage;

Light Grey - crossing with appropriate horizontal and vertical signage and also a safety island;

Grey – crossing with traffic lights;

Dark Grey – Crossing on another level (viaduct or tunnel)

In addition, there are some more requirements in that chapter.

There are also some guidelines which feature a good way to measure the safety of a crossing. These guidelines are added to this letter.

3. *What is the standard speed in urban areas (UA)?*

50 km/h

4. *What is standard speed in non-urban areas (NUA) (non-highways (2x2 delimited))?*

90 km/h

5. *Can this change? In what circumstances? Does it often happen?*

Yes, this can. According to road environment conditions, hazards, intersections, pedestrian crossings and built-up areas entrance zones.

6. *Is a transition zone from NUA to UA mandatory? What are the dimensions? What infra is necessary?*

By the results of research of different built-up areas entrance types https://www.mnt.ee/sites/default/files/survey/loplik_aruanne_asulavaravad.pdf we started to compile respective instruction.

7. *Do you use a categorisation of roads that takes land use into account? E.g. bigger road with shops alongside, long small roads with housing,…*

We do not have specific norms for that kind of road types, the choice of safety measures depends on local conditions.

8. *Does your categorisation trigger a certain cycle infrastructure?*

N/A

Estonia

9. *Thresholds which require trigger certain requirements for **cars/motorized traffic** e.g. greater than 2,000 AADT requires segregated facilities?*

Traffic safety analysis can trigger this or also our norms have a table that takes into account the class of the road, speed limit on that road and the VRU traffic density.

Table 8: Estonian speed limit on that road and the VRU traffic density

Tabel 7.3

Jalgtee vajadus sõltuvalt eeldatavast liiklussagedusest ja projektkiirusest

Maantee klass	Jalakäijate ja jalgratturite liiklussagedused ≤ ((JK+JR)/ööp.) autoliikluse erinevatel projektkiirustel, km/h		
	60	80	> 80
II	200	100	50
III	250	150	100
IV	300	200	150
V	400	250	200
VI	-	300	200

In addition the road classes are as following.

Table 9: Estonian road classification

Maantee klassid

Maantee klass	Eeldatav aasta keskmine ööpäevane liiklussagedus	
	Füüsiline	Taandatud sõiduautole
	Liiklussagedus a/ööp	Liiklussagedus a/ööp
Kiirtee	üle 40000	üle 45000
I*	üle 14500	üle 18500
II	6000–14500	7200–18500
III	3000–6000	3500–7200
IV	500–3000	1000–3500
V	50–500	100–1000
VI**	Kuni 50	Kuni 100

Märkus: * Liiklussagedusel kuni 20 000 autot ööpäevas võib tee projekteerida kaherajalisena, 5 m laiuste sõiduradadega;

** VI klassi maantee võib projekteerida ka üherajalisena projektkiirusega 40 km/h.

Where a/ööp means AADT, and Kiirtee means motorway.

Estonia

10. *Thresholds which require trigger certain requirements e.g. greater than 50* ***cyclists*** *per day requires segregated facilities? Possibly a combination threshold linked to both the number of cyclists and traffic volume.*

In addition to the previous answer it is said in the norms that on a pathway the bicycle and pedestrian traffic is to be segregated or a separate road is to be built when the DT is more than 300 people or there are more than 30 cyclists in an hour (during a rush hour).

11. *Thresholds which require trigger certain requirements for* ***pedestrians*** *e.g. greater than 50 pedestrian/cyclists per day requires segregated facilities? Possibly a combination threshold linked to both the number of cyclists and traffic volume.*

See the previous answers

12. *A Balanced Approach to Speed: Do you include visual parameters in (re)designing a new road? Confining peripheral vision. Horizontal triggers? New parameters for road design with self-explanatory background?*

N/A

13. *Design speed versus perceived speed. This includes the human factor which influences the landscape.*

We have implemented guidelines on traffic lane width depending (PT III, 1)on the speed that is required. Other than that, we just use signs and in very problematic areas, we use local speed cameras.

14. *Holistic road design and planning: Is there a network for cyclists that is separated from the car network? Do you have different networks for cyclists?*

We have a network (map), but not a very holistic approach unfortunately.

15. *Infrastructure guidelines/****Obstacles and sightlines****: Specifications for limited sightlines for either VRU or motor vehicle drivers for seeing each other?*

We have both in our norms:

The necessary sightlines and the biggest longitudinal gradient on a bicycle path intersection.

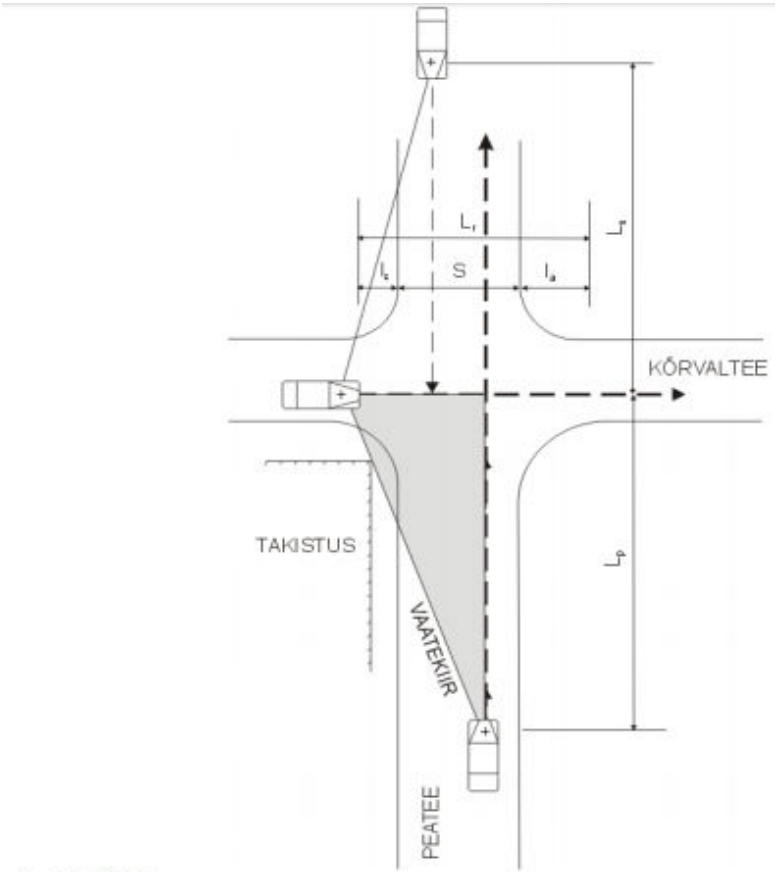
Table 10: Sightlines and the biggest longitudinal gradient on a bicycle path intersection in Estonia

Vajalik nähtavuskaugus ja suurim pikikalle rattateede ristmikel

Näitaja	Hea	Rahuldav	Erandlik
Nähtavuskaugus, m	20	15	10
Pikikalle, %	2	4	6

The letters mean the following: H is good, R is satisfactory and E is exceptional (should be rarely used).

Our norms are also have specific values for sightlines for motor vehicles (point 2.4.6, 2.4.7, 5.2.7):



$L_r = l_s + S + l_a$
L_r – ristmiku ületamise teekonna pikkus;
l_s – peatunud sõiduki kaugus sõidutee serva pikendusest;
S – sõidutee laius;
l_a – sõiduki pikkus;
L_p – nähtavuskaugus paremale;
L_v – nähtavuskaugus vasakule.

Figure 1: Sightlines in Estonia

Estonia

16. Infrastructure guidelines/**Gradients for bicycle facilities**/pedestrian facilities: Specifications?

Guidelines: If the gradient on slope which is situated at a curve is more than 3%, the footpath is to be made 0,5m wider. If it is allowed for a moped to drive on a bicycle path or the longitudinal gradient is more than 3%, the “good” (H) level must be chosen while designing the road.

Table 11: The maximum gradients depend on the longitudinal gradients as following

Rattatee tõusu suurimad pikkused sõltuvalt pikikaldest

Suurim pikikalle, %	Tõusu pikkus projekteerimise lähtetasemel, m		
	Hea	Rahuldav	Erandlik
10	-	-	30
8	-	25	100
6	-	120	200
5	30	200	300
4	100	250	500
3	300	500	1000

The letters mean the following: H is good, R is satisfactory and E is exceptional (should be rarely used).

17. Infrastructure guidelines/**Horizontal and vertical deflections**: Specifications?

N/A

18. Infrastructure guidelines/ **Location and use of street furniture incl. public lighting**: Road crossing and cycle routes crossing roads are usually critical from a safety perspective and may comprise conflict areas between different VRU-groups and/or VRU and motor vehicles; Specifications?

We have guidelines for lighting (unfortunately in Estonian again). Also our norms say the following:

Lighting

(1) Lighting is to mandatory:

1) Separate level junctions, traffic light regulated junctions and roundabouts;

2) crossings with signage;

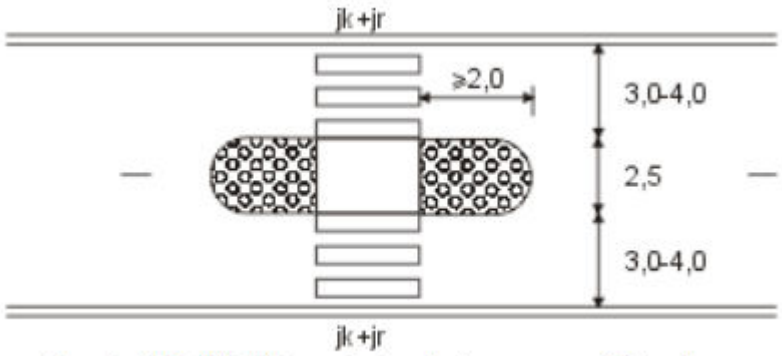
3) rest area and service stations with a lot of users;

Estonia

4) tunnels 24/7;

5) other cases, where it is necessary to guarantee traffic safety.

19. Infrastructure guidelines/ **Crossings**: Specifications?

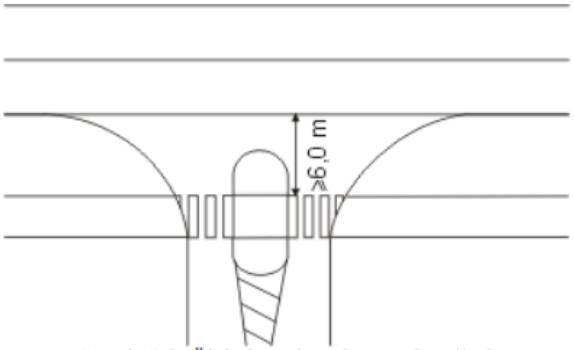


Joonis 7.2. Ülekäiguraja ja ohutussaare mõõtmed, m

Figure 2: Crossings in Estonia

Ohutussaare mõõtmed

	Hea	Rahuldav	Erandlik
	Ohutussaare laius, m		
Jalakäijatele	2,5	2,0	1,5
Jalgratturitele	3,0	2,5	2,0
	Ohutussaare pikkus piki sõiduteed, m		
	4	3	2
Kiiruspiirang	Ülekäiguraja vähim laius, m		
50 km/h	3,5	3,0	2,5
60 km/h	4,0	3,5	3,0



Joonis 7.3. Ülekäiguraja paigutus ristmikul

Figure 3: Crossings and dimensions in Estonia

Estonia

Also some specifications are in the added guidelines.

20. Evaluations of road design: Are there any evaluations of the road designs? Are they published?

We have traffic safety audits (design stage, during building stage and after opening stage) and inspections.

4.2.2 Flanders

The interview and documentation for Flanders was provided by the Department of Mobility and Public Works of the Flanders region. Flanders uses voluntary guidelines and may use best practice from the Netherlands.

4.2.2.1 Excerpts and the corresponding documentation for the region of Flanders

Speed

What is the standard speed in UA?

50km/h

What is standard speed in NUA (non-highways (2x2 delimited))?

70km/h

Can this change? In what circumstances? Does it often happen?

It can be changed:

inside UA to 30km/h in school zones or as required

outside UA to 50km/h with high density building, many bicyclists (>60% and >30% building density on the side of the road, 350 bicyclists per day)

outside UA to 90km/h with low density (<30%), separated cycle lanes, obstacles on distance from road

How is VRU infrastructure defined?

Cycle suggestion lane: lane on the side of the road with no legal status. Goal is to make the car driver aware of bicyclists and narrow the width of the road visually.

Cycle lane (adjacent): delimited with parallel lining

Cycle lane (higher): delimited by height

Separated cycle lane: delimited by distance and lining, bush or parking spaces and lining

Two-directional cycle path: delimited, 2.5m wide cycle path, only along big roads with strong barrier effect.

Flanders

Who is allowed on it?

Signalisation	**Infra**	Speed	Pedestrian	Cyclist	Moped A	Moped B
D7 	**Cycle lane**	50km/h – 70km/h	Not-allowed	Obliged	Obliged	Choice with subsignali-sation
D7 	***Delimited cycle lane***	*70km/h*	Not-allowed	*Obliged*	*Obliged*	*Choice OUA*
D9 	**Delimited walk and cycle lane with white line or different material**	50km/h or 70km/h	Obliged	Obliged	Obliged	Forbidden

Cycle lane/cycle path…

Table 12: Cycle path specifications

Signalisation	Width (cm)	Colour	Marking	Distance from road (cm)	Transitions at crossroads
Cycle suggestion lane	170	Ochre (municipalities can change)	No marking	0	No colouring on junctions with right of way
Cycle path (along road)	150	No colour or Red on conflict points	Parallel marking		Continued at junctions
Cycle path (higher)	150				Lowering at max 2% and
Double direction	200			100	

Flanders

Table 13: Type of bicycle facility (Flanders)

Type of bicycle facility	**Recommended width (cm)**	**Minimum width (cm)**	**Increased**	**Intermediate zone (between road and bicycle facility) (cm)**	**Max. allowed driving speed car traffic (km/h)**
One-way cycle lane (abutting)	≥175	150	x	≥25	≤50
One-way cycle track	≥175	150	/	≥100	>50
Two-way cycle lane (abutting)	Does not apply				
Two-way cycle track	≥250	200	/	≥100	>50
Cycle suggestion lane	170-200	170	/	/	≤50
Cycling route	250-350	250	/	/	/

Excerpt from the vademecum “bicycle facilities” (and translated, since only available in Dutch) of the Flemish Region

Transition zone

Is a transition zone from NUA to UA mandatory? What are the dimensions? What infra is necessary?

No-transition zone, sometimes a vertical change, sometimes a gate effect

Hierarchic road design

Categorisation of roads

Do you use a categorisation of roads that takes land use into account? E.g. bigger road with shops alongside, long small roads with housing,…

No.

Does your categorisation trigger a certain cycle infrastructure?

Primary roads trigger a cycle way.

Categorisation is used in the Spatial Plan of Flanders. This specifies the category roads are in on regional level, not for local roads. Local roads are categorised by the municipalities. The categorisation as such does not trigger certain cycle infrastructure standards.

Flanders

Car intensity (AADT)

Table 14: Thresholds which require trigger certain requirements e.g. greater than 2,000 AADT requires segregated facilities

Amount of cars	Speed	Cycle infra	Mandatory?
No	90	Separated and possibly double direction	Yes
No	70	Separated	No
No	50	Nothing mandatory	No

Pedestrian Traffic Volume

Thresholds which require trigger certain requirements e.g. greater than 50 cyclists per day requires segregated facilities. Possibly a combination threshold linked to both the number of cyclists and traffic volume.

Shops will not trigger walkways, there are no rules for amount of pedestrians.

Along park & ride complexes there are sidewalks to connect everything (bus, parking, train)

Pedestrian Traffic Volume

Thresholds which require trigger certain requirements e.g. greater than 50 cyclists per day requires segregated facilities. Possibly a combination threshold linked to both the number of cyclists and traffic volume.

A Balanced Approach to Speed

Do you include visual parameters in (re)designing a new road? Confining peripheral vision. Horizontal triggers? New parameters for road design with self-explanatory background?

Design speed versus perceived speed. This includes the human factor which influences the landscape.

No, there are minimum widths but no maximum widths to make roads smaller. No vertical necessities when rebuilding a road for smaller peripheral vision. Outside urban areas there are non-mandatory horizontal options for pedestrian crossings, see later.

Minimal width is often used as desired width for new roads.

Flanders

Holistic road design and planning

Alternative routes and their viability for drivers using a holistic view to the whole road network:

- Assessment of transport and mobility needs for the specific road networks
  - VRU groups and
  - Motor vehicle users (private and commercial)
- Traffic density and the road networks capacity

Is there a network for cyclists that is separated from the car network? Do you have different networks for cyclists? How is it constructed?

There is a functional bicycle network that uses parallel roads if possible and if direct enough. There are also recreational routes but these are mostly not near the subject roads of our study. As most Inter Urban roads outside urban area do not have a direct parallel, the infrastructure along these routes is upgraded. The cycle network is getting better at a fast pace since the last year to take away missing links and suboptimal spots.

Infrastructure guidelines

Obstacles and sightlines

Where there are physical objects that might cause increased hazard in a collision (e.g. large stones, hard objects, high verges etc.). Limited sightlines for either VRU or motor vehicle drivers for seeing each other.

Table 15: Obstacles and sightlines in Flanders

Obstacle	Scare width/distance from crossing
Parking spot	If there is no parking spot, a car must leave 1.5m passage on the bank. No parking within 5m from crossing or re-entry of bicyclists. 50cm of scare width should be left between cycle path and parked cars.
Houses (no walkway)	1m
Trees	0.5m
Lighting/pylons	1m
Hedge height	No, practice 50-60cm with many entry points
Obstacles	0.5m
Ditch	1m
lights	No parking 20m before traffic lights

Flanders

Gradients for bicycle facilities/pedestrian facilities

The physical limitations of a cyclist to climb steep inclines…and their ability to stop when descending steep inclines are impacted by the gradient…

Pedestrians:

What is the maximum gradient going up?

5% (<50cm height difference) – 12% (10cm height difference)

> For level differences of up to 10 cm: a slope has to be laid with an incline of maximum 12% with a guide value of 10%. -
>
> For level differences of 10 cm to 25 cm: a slope should be constructed with an incline of maximum 10% with a guide value of 8.3%. -
>
> For level differences of 25 cm to 50 cm, a slope with an incline of maximum 8% with a guide value of 6.25% should be applied. -
>
> For level differences of more than 50 cm: a slope with an incline of not more than 5% should be applied.

What is the maximum difference in height? 2cm for stepping on a walkway

What is the maximum gradient going down?

What is the maximum gradient X-axis on pedestrian facilities?

2%

Cyclists

What is the maximum gradient going up?

2%, the shorter the steeper is accepted

What is the maximum difference in height?

After 3m height difference, use of a rest stretch without gradient.

What is the maximum gradient going down?

What is the maximum gradient X-axis on pedestrian facilities?

2%

Horizontal and vertical deflections

E.g. …the introduction of tight horizontal radii needs to be accompanied by appropriate warning signage on the cycle facility…

Horizontal deflection: Minimal curve/optimal curve/width in curve

Minimum curve for horizontal deflections: 10m

Cycle highways have a minimum radii 35m

Street Furniture

Location and use of street furniture incl. public lighting

Bus stops:

Lighting:

Flanders

Crossroads: takes into account the amount of pedestrians crossing the road.

If there are cycle lanes adjacent to the road or suggestion lanes, the road should be lighted. If a separated cycle lane is crossing a road in a thus far dark location, the junction should be lighted.

Footways, Verges and Strips

Width of edge treatment, 1.5m

When to put a footway? Width? 1.5m

Crossings

Road crossing and cycle routes crossing roads are usually critical from a safety perspective and may comprise conflict areas between different VRU-groups and/or VRU and motor vehicles.

Crossing with pedestrians is done with the highest precaution (see Table 16). If there is a footway, a walking route traversing the road, there will be a pedestrian crossing area. This will have infrastructural changes like an island, speed reduction, different material, lighting, putting the pedestrian forward first. The crossing should be visible from 70m with 50km/h, 120m with 70km/h and 180m with 90km/h. If the amount of cars is lower than 800/h on a crossing, there is no need for a secure crossing. The waiting time is below 10s and will not have unsafe crossing as a result. If there is less than 800 vehicles per peak hour and more than 20 crossing pedestrians near schools, hospitals, public transport stops and nursing home for the elderly there is the possibility to make a secure crossing. In this case there are minimal distances between crossings to be considered. (150m-270m)

Table 16: Pedestrian crossings

Area	*Local road and secondary road type III with 2 lanes*	*Secondary road type I and II and secondary road type III with more than 2 lanes*
core area of a built-up area	*150 m*	*225 m*
built-up area outside of the core area	*210 m*	*315 m*
Transition area	*270 m*	*405 m*

Where do you cross a road with 2-way cycle path? How is signalisation, lighting, priority?

Crossing is outside of priority

Flanders

Where do you cross a road on a normal cycle lane? How is signalisation, lighting, priority?

Right of way

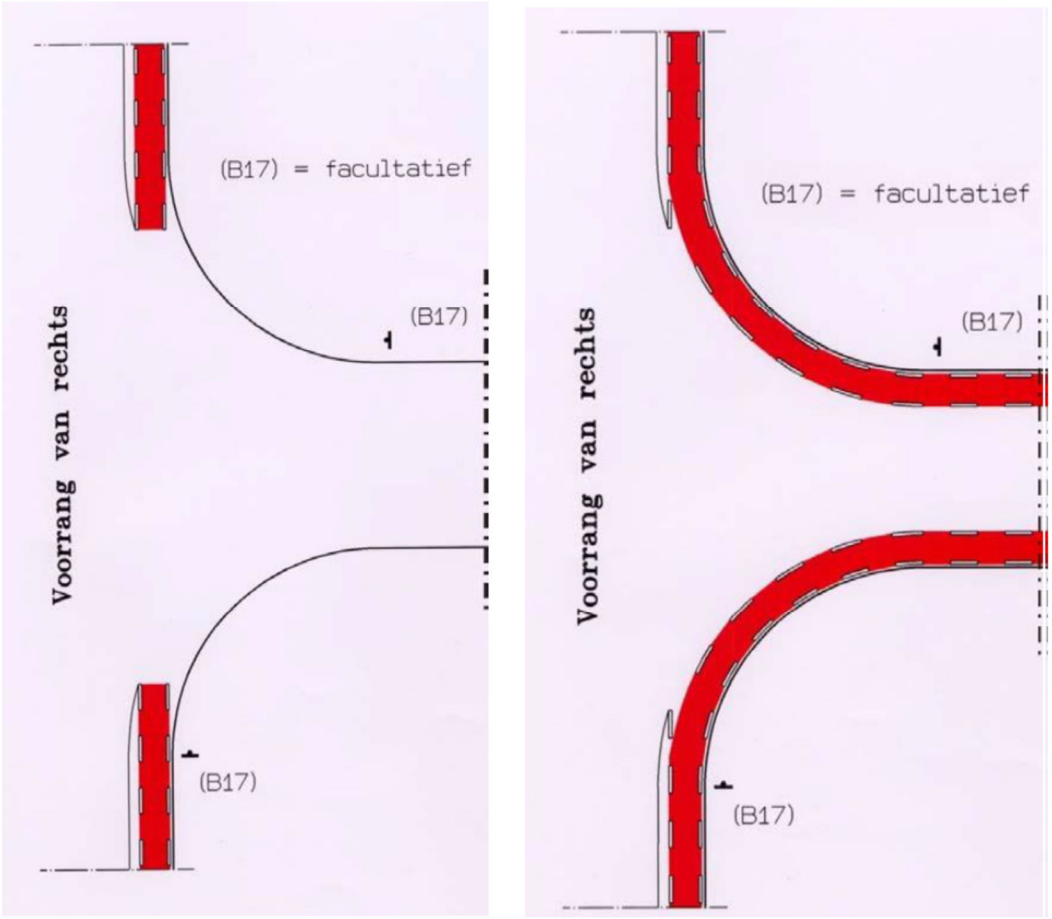
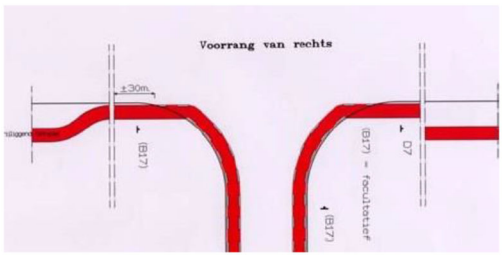


Figure 4: Junctions-1 in Flanders

Flanders



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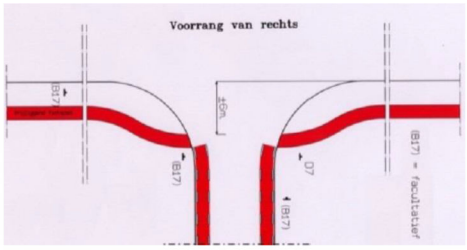
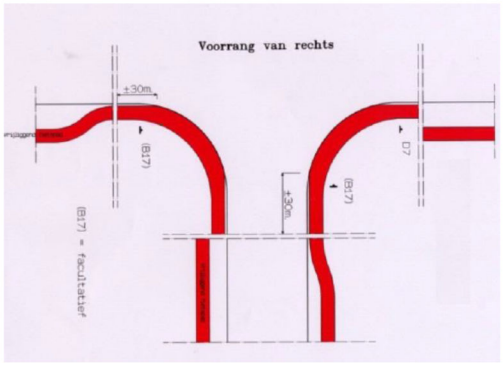


tekening 16



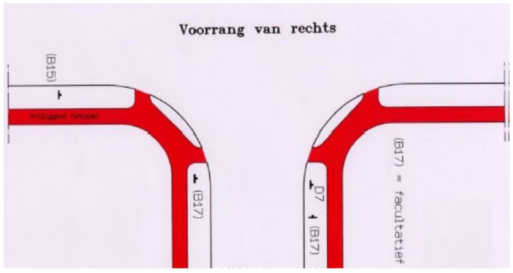
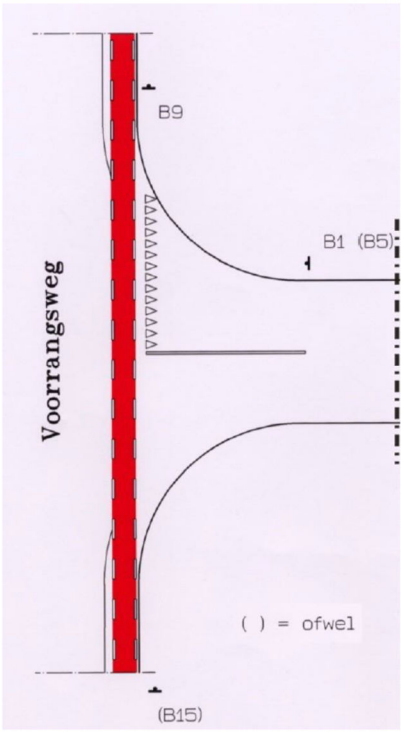


Figure 5: Junctions in Flanders with priority to the right.



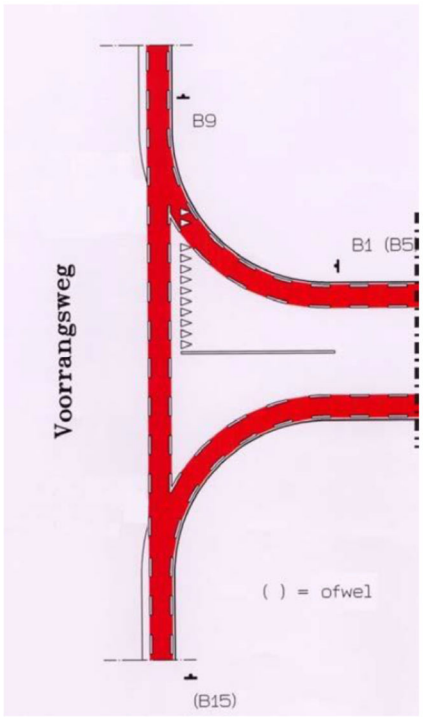


Figure 6: Junctions-2 with priority roads in Flanders

Flanders

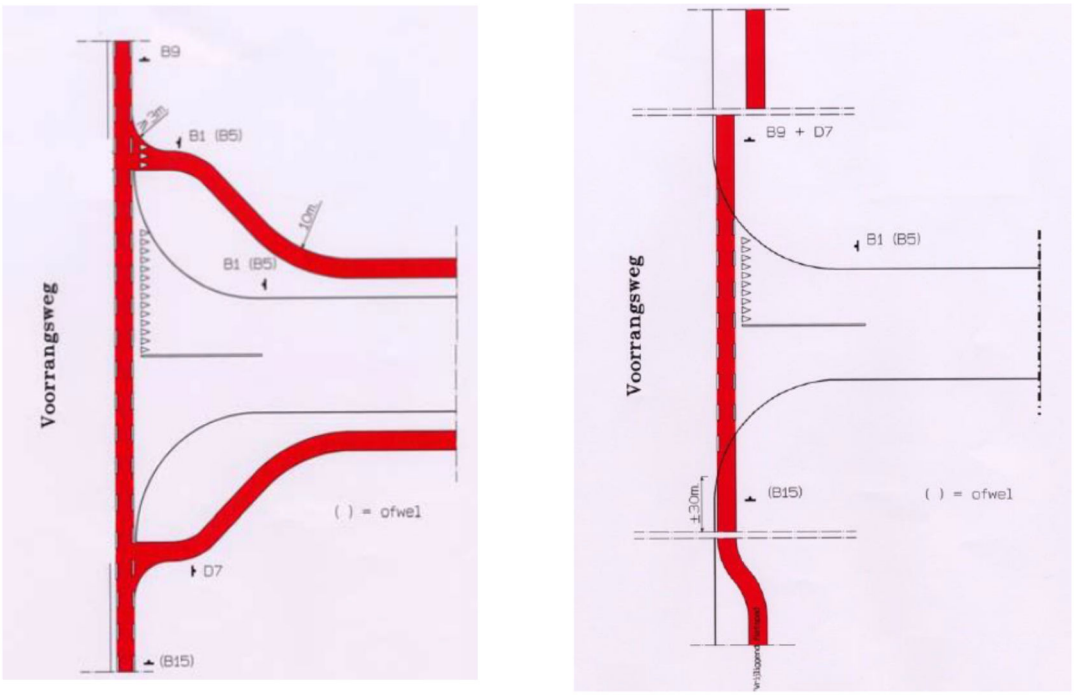


Figure 7: Junctions-3 with priority roads in Flanders

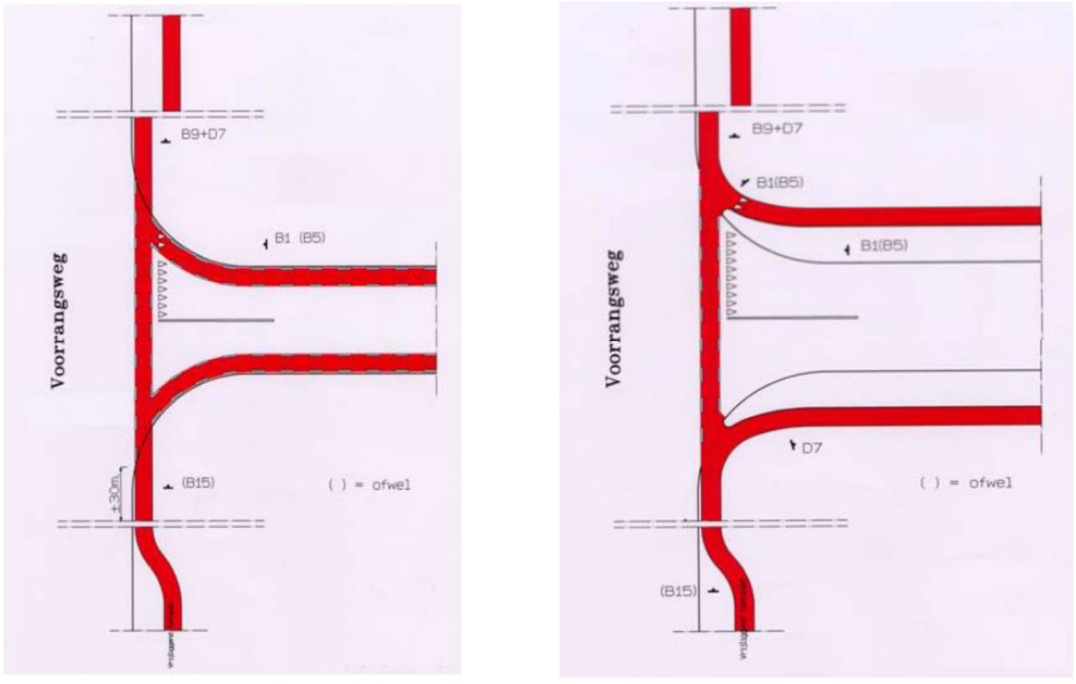


Figure 8: Junctions-4 with priority roads in Flanders

Flanders

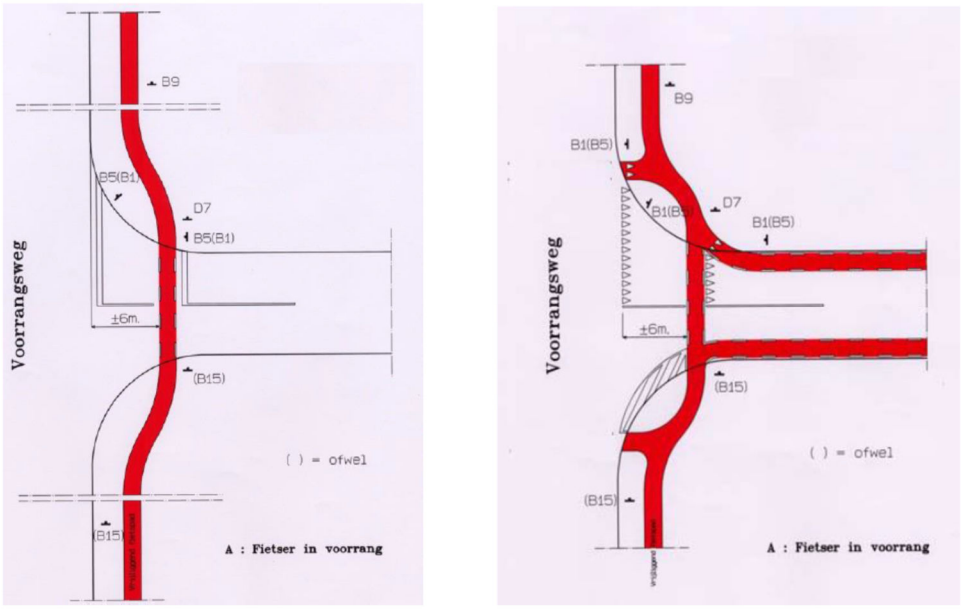


Figure 9: Junctions-5 with priority roads in Flanders

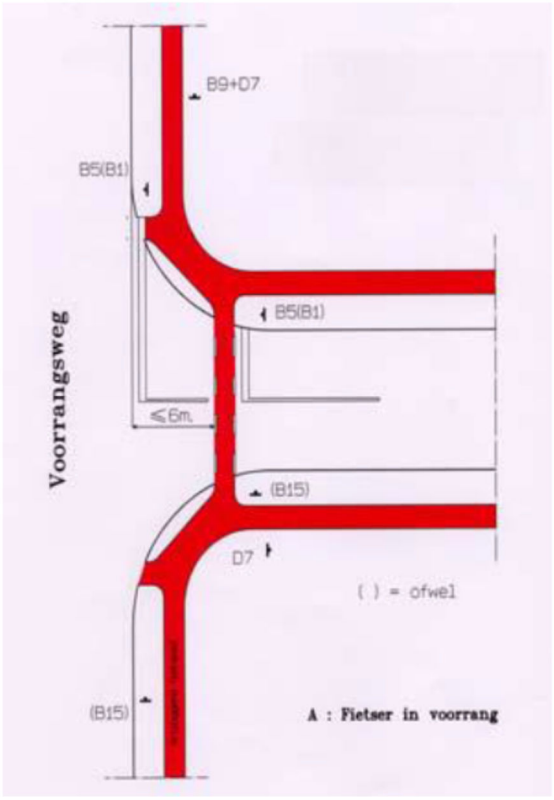


Figure 10: Junctions-6 with priority roads in Flanders

Flanders

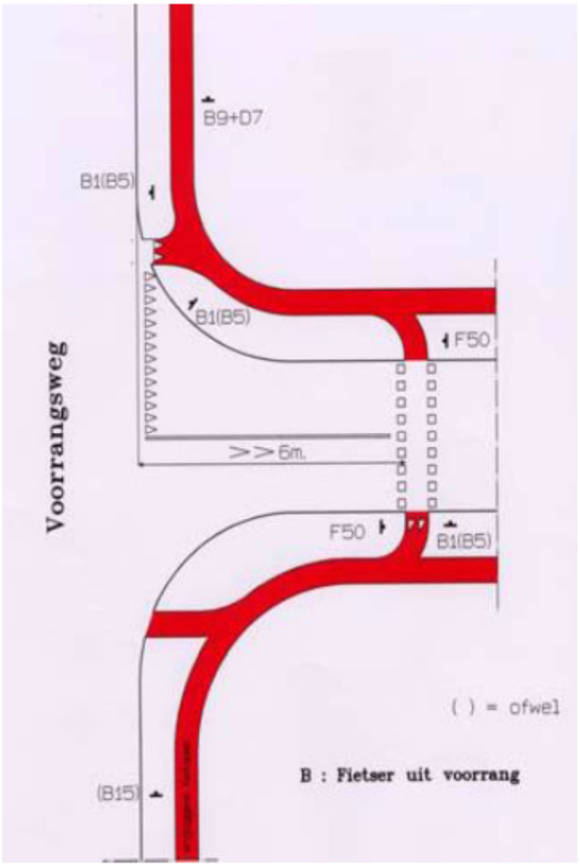


Figure 11: Junctions-7 with priority roads in Flanders

Do cyclists have priority on roundabouts? Cyclists should never be in priority when biking on a roundabout?

Non-priority on roundabouts for cyclists OUA (= Outside Urban Area).

Where do you cross a road with a pedestrian crossing? How is signalisation, lighting, priority?

With speeds of 70km/h or more, speed is expected to be dropped to 50km/h at the crossing. 150m before the crossing these signs are used.

Figuur 3.21 A21 : oversteekplaats voor voetgangers

Figuur 3.22 F49 : oversteekplaats voor voetgangers

Esc min: 40 lux vertical (0.5m & 1.6m) and 80 lux horizontal

Speed 70 : roundabout or lights when 2x2, safety island with speeds (V85)>60km/h)

Local roads, V-Allowed 50 and V85 <60: right of way, normal road crossing, on priority roads: vertical or horizontal speed reduction + visual narrowing (gate effect)

Flanders

Secondary roads: V50 no priority: vertical or horizontal speed reduction

Secondary roads: V50 priority: horizontal speed reduction + visual narrowing

Secondary roads: V70 important junctions: traffic lights or roundabout

Secondary roads V70, not important junctions or outside of crossings: Visual portal + normal road crossing

Secondary roads V90: Traffic lights

How do you cross near bus stops? How is signalisation, lighting, priority?

Bus stop illumination: 20 lux

Special requirements

Design guides available for school zones?

School zones on the regional road, or near a regional road

If a school is on a local road within 100-150m from a regional road, part of that regional road will also be 30km/h with dynamic speed regulation. If the school is located on a regional road the speed will be reduced 100-150m before and after the school.

Bus stops?

Evaluation

Evaluations of road design

Are there any evaluations of the road designs? Check before the plans and after the building?

There are quality advisors, subsidy projects, some legislation, and a mobility decree. Not for regional roads,

Have they been published? Copies available?

Infrastructure measures to reduce single vehicle accidents?

Any infrastructure measures to reduce single sided accidents? Height of entry of cycle lane?

Max 2cm for sidewalk entry, 2% for cycle path ramp.

Always asphalt.

Is there a system to study single vehicle accidents with VRUs?

The organization “Fietsberaad” investigates single bicycle accidents.

4.2.3 Germany

The interview and documentation for Germany was provided by Federal Highway Research Institute (BAST). Germany uses design standards that are compulsory and voluntary guidelines that includes human factor design principles as well as geometric and road safety design.

4.2.3.1 Excerpts and the corresponding documentation for Germany

Speed

What is the standard speed in UA?

50km/h

What is standard speed in NUA (non-highways (2x2 delimited))?

70km/h (if near crossroads, traffic lights, too many accidents or bad shape) or 100km/h

Can this change? In what circumstances? Does it often happen?

How is VRU infrastructure defined?

Cycle suggestion lane: lane on the side of the road with no legal status. Goal is to make the car driver aware of bicyclists and narrow the width of the road visually.

Cycle lane (adjacent): delimited with parallel lining

Cycle lane (higher): delimited by height

Separated cycle lane: delimited by distance and lining, bush or parking spot and lining

Two-directional cycle path: delimited, 2.5m wide cycle path, only along big roads with strong barrier effect.

Who is allowed on it?

Table 17: Cycle lanes in Germany

Signalisation	**Infra**	Speed	Pedestrian	Cyclist	Moped A	Moped B
Combined bicyclists and pedestrian lane		100/70	allowed	allowed	Obliged	Not allowed

Speedpedelec or moped-B cannot use the infrastructure.

Germany

Cycle lane/cycle path…

Table 18: Cycle lane description

Signalisation	Width	Colour	Marking	Distance from road	Transitions at crossroads
Combined bicyclists and pedestrian lane	250	Red if there are safety issues	No marking (only the sign 240StVO)	Minimum 1.75m	No colouring on junctions with right of way

Ausserhalb des Entwässerungsbereiches = a) Outside the drainage area, b) Mit Trennstreifen = b) With separating strips (abmessungen in m) = dimensions in « m » lage und Maße eines gemeinsamen Geh- Radwegs = Location and dimensions of a common bicycle path.

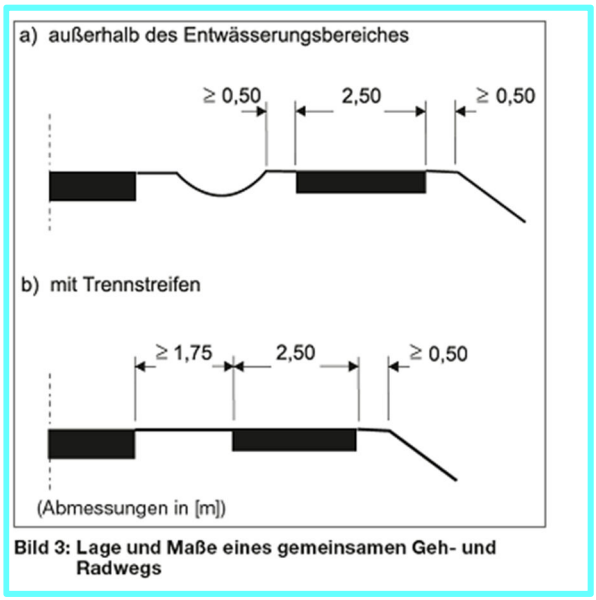


Bild 3: Lage und Maße eines gemeinsamen Geh- und Radwegs

Figure 12: Cycle lane dimensions in Germany

For some types of rural roads, a separated cycle/walkway is mandatory. For other types of rural roads, it is possible.

Transition zone

Is a transition zone from NUA to UA mandatory? What are the dimensions? What infra is necessary?

The transition zone between NUA and UA should be done with a centre island, slowing traffic and make a safe place to enter the road for cyclists when changing to mixed traffic.

Ortseinfahrtbereiche (= local entry areas), slowing down the vehicles. Mittelinsel (= central island) (<3.5m) with offset (<1.75m each side) and 35-55m long or roundabout.

Germany

Hierarchic road design

Categorisation of roads

Do you use a categorisation of roads that takes land use into account? E.g. bigger road with shops alongside, long small roads with housing, …

Does your categorisation trigger a certain cycle infrastructure?

Table 19: Hierarchic road design description-1

Street categories according to the RIN and scope of the RAL (bold outlined)					
group category **connection function level**	Highways	Inter-urban roads	Open main roads	Built-up main roads	Access roads
Continental (0)	AS 0		-	-	-
Large scale (I)	AS I	LS I	-	-	-
National (II)	AS II	LS II	VS II	-	-
Regional (III)	-	LS III	VS III	HS III	-
Local connectors (IV)	-	LS VI	-	HS IV	ES IV ES V
Small scale (V)	-	LS V	-	-	
unproblematic, name of the category problematic not representative or not occurring • planning, if appropriate, based on the RAL					

Table 20: Hierarchic road design description-2

Design classes for highways depending on the street/road category	
Road category	Design class
LS I	EKL 1
LS II	EKL 2
LS III	EKL 3
LS IV	EKL 4

Germany

Table 21: Hierarchic road design description-3

Table 9: Design classes and basic design characteristics										
Design classes	design and operational characteristics					routing on the road				routing in intersections
	planning speed (km/h)	operation mode	Section	safe overtaking sections per driving direction	alignment of bicycle traffic	alignment / layout of the road	recommended range of radii	maximum longitudinal inclination	recommended radius of the camber(/ crest/hilltop) H_k	standard solution for higher priority road
EKL 1	110	motor road	15,5	-40 %	independent of the road	very elongated/stretched	≥ 500	4,5	≥ 8000	merging & pulling out
EKL 2	100	general traffic	11,5+	≥ 20 %	independent of the road or accompanying the carriageway	elongated/stretched	400-900	5,5	≥ 6000	turn into/ turn off/ crossing with traffic lights
EKL 3	90	general traffic	11	No	accompanying the carriageway or on the carriageway	adapted/aligned	300-600	6,5	≥ 5000	turn into/ turn off/ crossing with/without traffic lights
EKL 4	70	general traffic	9	no	on the carriageway	very adapted/aligned	200-400	8,0	≥ 3000	turn into/ turn off/ crossing without traffic lights
Further applications of junction types as a function of the design classes are represented in section 6.3.3.										

Querschnitt: total width of the road.

EKL1: einbahnig with 3 stripes, 3.5m right line (12cm) is outside of this 3.5m, the middle dotted line is half on each side (12cm), full line (12cm) in the middle is not included.

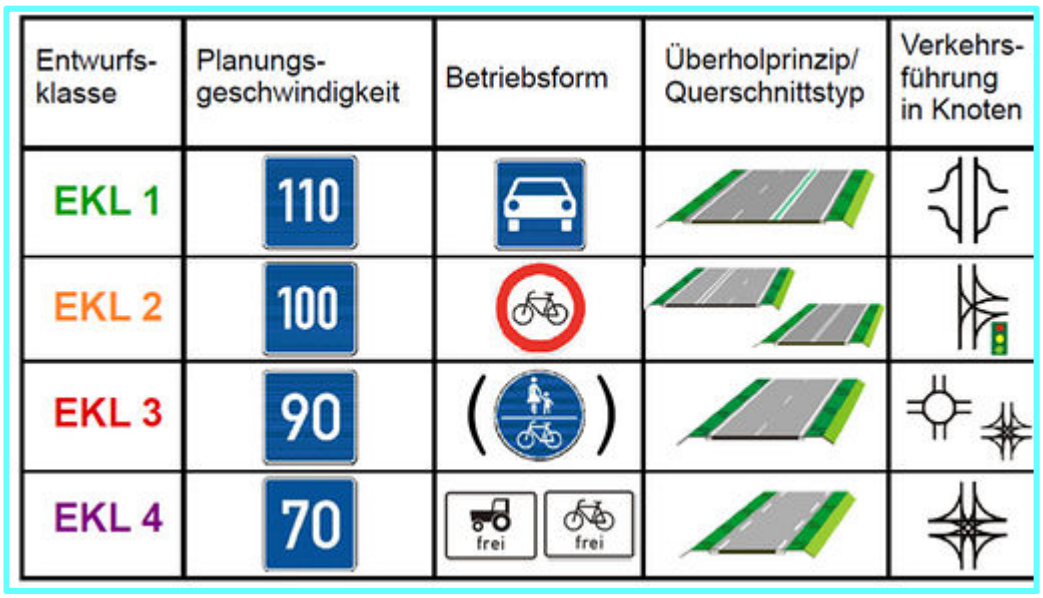
EKL2: einbahnig, 3 stripes on specific locations to prohibit overtaking

EKL3: standard, 1 road with 2 stripes

Germany

Table 22: Speed classification

Design classes	Planning speed	Operation mode	principles of overtaking/cross-section types	Traffic routing in inter-sections



Intensities to trigger separate infrastructure

In Table 23 (table 11 in the original document), daily amount of car traffic is combined with amount of pedestrians and cyclists combined. These numbers determine if a combined walk-cycleway should be built. Cities deal with this matter, it is probably counted.

Germany

Table 23: Intensities to trigger separate infrastructure

Table 11: Reference values for the expedience of a shared use path for pedestrians and cyclists on roads of the EKL 3.	
Average daily motor vehicle traffic [dmt/24h]	Daily load of bicycle and pedestrian traffic [R and F/24h]
2500 – 4000	> 200
4000 – 7000	> 100
7000 – 10000	> 50

Car intensity (AADT) → Germany = speed

Thresholds which require trigger certain requirements e.g. greater than 2,000 AADT requires segregated facilities.

NO

Bicycle Traffic Volume

(See 3.2)

Pedestrian Traffic Volume

See 3.2

A Balanced Approach to Speed

Do you include visual parameters in (re)designing a new road? Confining peripheral vision. Horizontal triggers? New parameters for road design with self-explanatory background?

Design speed versus perceived speed. This includes the human factor which influences the landscape.

EKL4, smaller roads, 5m and 0.5m safety on the side

Germany

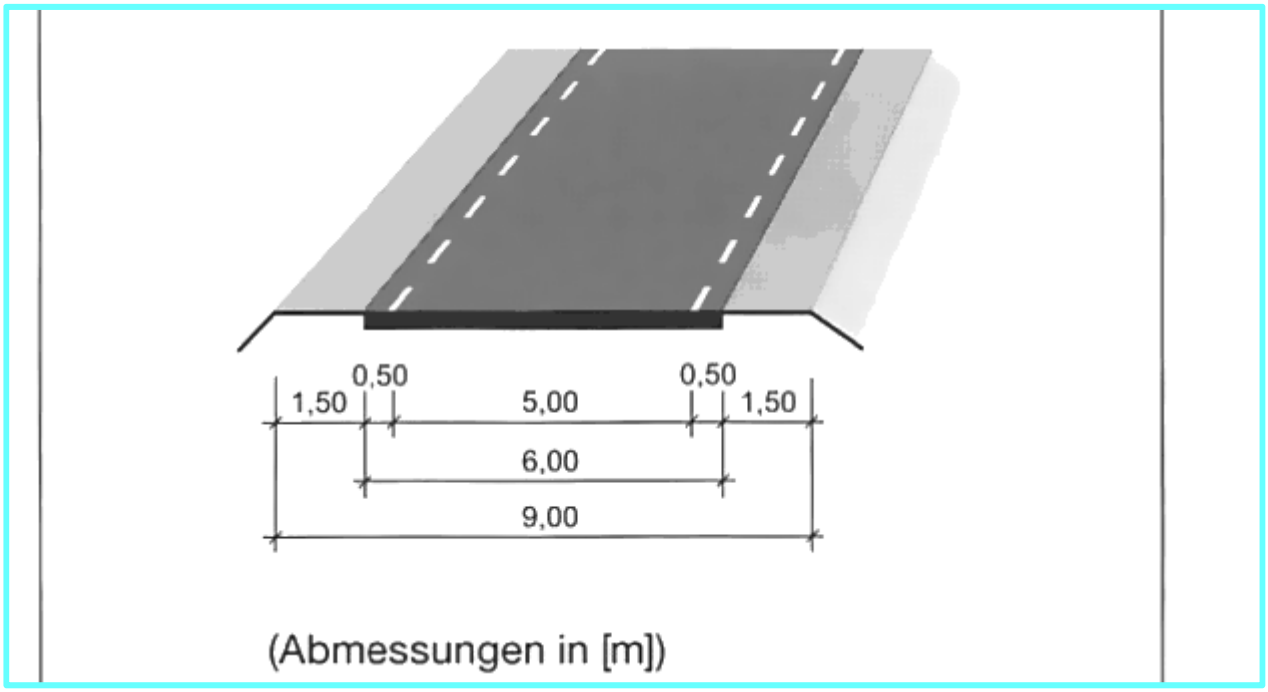


Figure 13: Road dimensions in Germany

Holistic road design and planning

Alternative routes and their viability for drivers using a holistic view to the whole road network:

- Assessment of transport and mobility needs for the specific road networks
  - VRU groups and
  - Motor vehicle users (private and commercial)
- Traffic density and the road networks capacity

Is there a network for cyclists that is separated from the car network? Do you have different networks for cyclists? How is it constructed?

There is a functional bicycle network that uses parallel roads if possible and if direct enough. There are also recreational routes but these are mostly not near the subject roads of our study. As most Inter Urban roads outside urban area do not have a direct parallel, the infrastructure along these routes is upgraded.

Infrastructure guidelines

Obstacles and sightlines

Where there are physical objects that might cause increased hazard in a collision (e.g. large stones, hard objects, high verges etc.). Limited sightlines for either VRU or motor vehicle drivers for seeing each other.

Germany

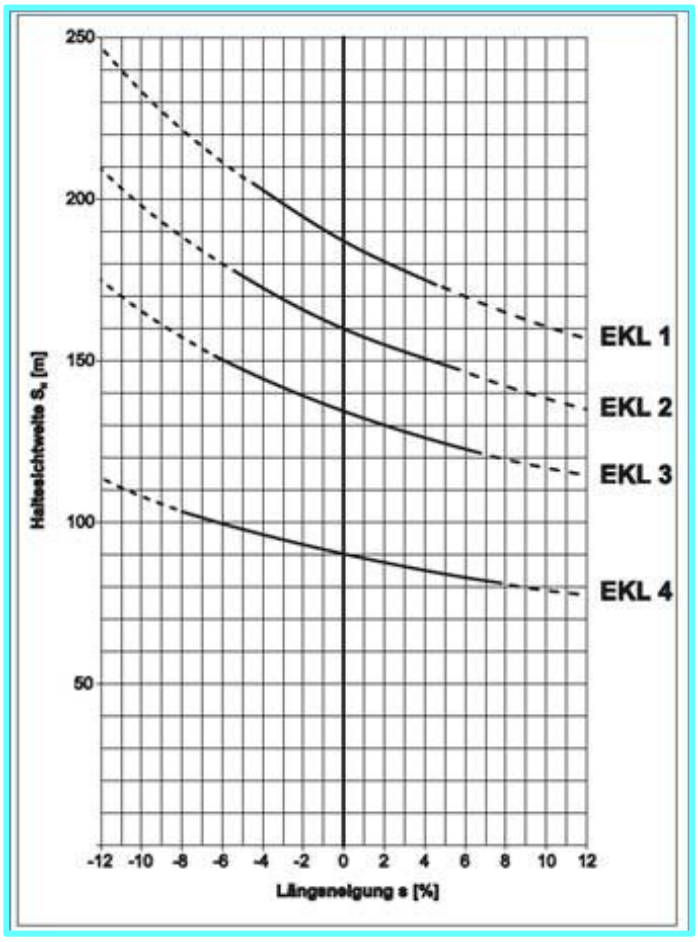


Figure 14: Obstacles and sightlines in Germany. Necessary stopping sight distance S_H as a function of EKL and the longitudinal inclination.

Only trees can be found along rural roads in Germany.

Gradients for bicycle facilities/pedestrian facilities

The physical limitations of a cyclist to climb steep inclines…and their ability to stop when descending steep inclines are impacted by the gradient…

Pedestrians: What is the maximum gradient going up?

What is the maximum difference in height to get on the sidewalk?

2cm for stepping on a sidewalk

What is the maximum gradient going down?

What is the maximum gradient X-axis on pedestrian facilities?

6%

Latitudinal inclination: 2.5%

Cyclists: What is the maximum gradient going up?

Separate cycle infrastructure needed with hills of +5%, longer than 500m, high volume of traffic and dangerous situations. This is in natural hilly locations.

2%, the shorter the steeper is accepted

What is the maximum difference in height?

After 3m height difference, use of a rest stretch without gradient.

What is the maximum gradient going down?

What is the maximum gradient X-axis on pedestrian facilities?

2%

Depending on different boundary conditions. See German recommendations for cycling facilities.

Horizontal and vertical deflections

E.g. …the introduction of tight horizontal radii needs to be accompanied by appropriate warning signage on the cycle facility…

Horizontal deflection: Minimal curve/optimal curve/width in curve

Minimum curve for horizontal deflections: 20m

Street Furniture

Location and use of street furniture incl. public lighting

Bus stops, lighting, crossroads

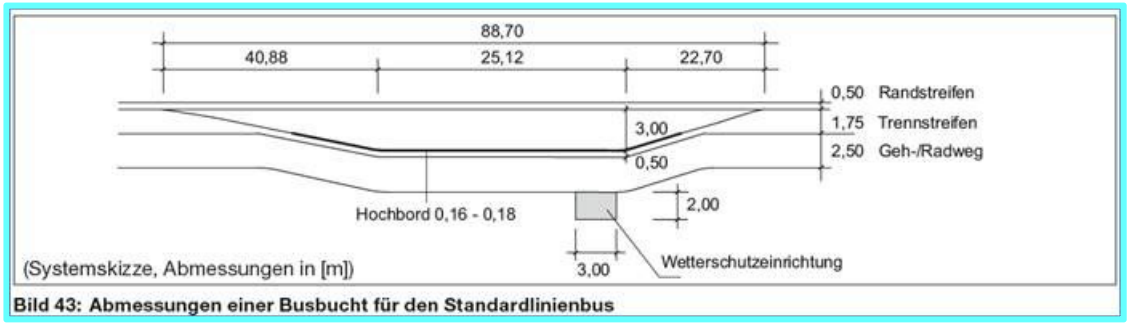


Bild 43: Abmessungen einer Busbucht für den Standardlinienbus

Figure 15: Bus stops in Germany

Near crossroads there can be bus stops but no lighting.

Germany

Footways, Verges and Strips

Crossings

Road crossing and cycle routes crossing roads are usually critical from a safety perspective and may comprise conflict areas between different VRU-groups and/or VRU and motor vehicles.

Where do you cross a road with 2-way cycle path? How is signalisation, lighting, priority?

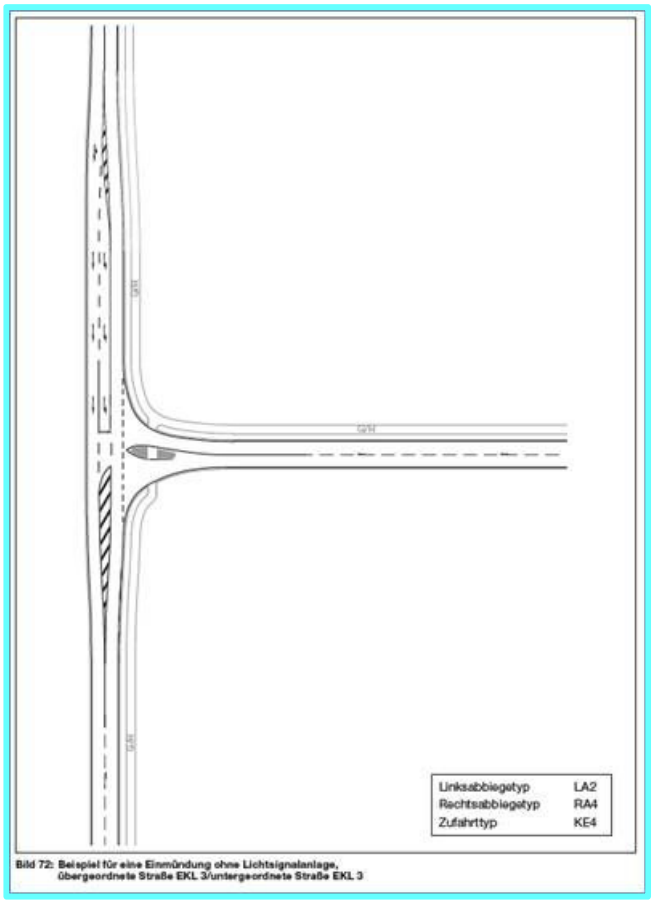


Figure 16: Rural roads-1 in Germany

(Richtlinien für die Anlage von Landstraßen, RAL 2012)

Germany

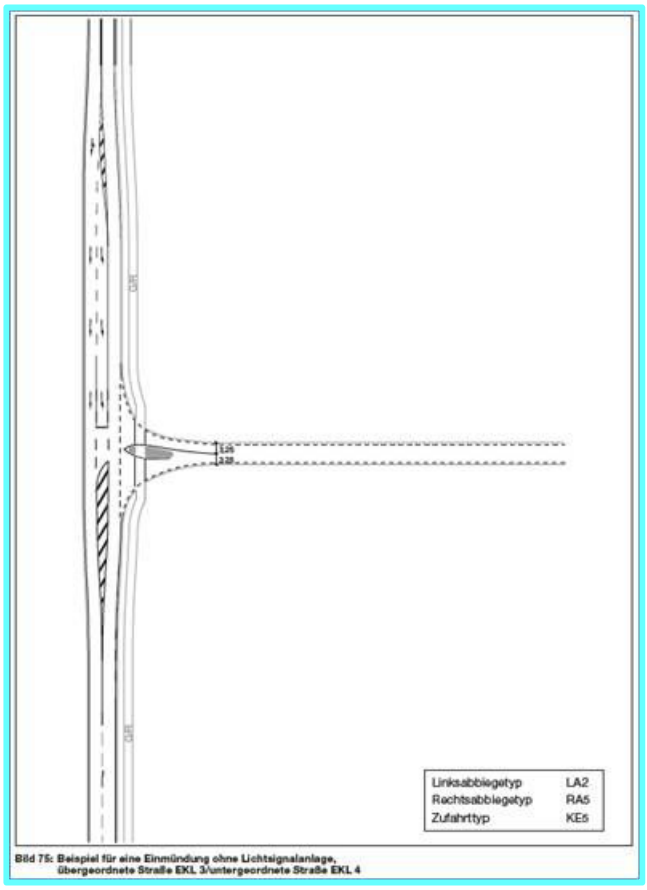


Figure 17: Rural roads-2 in Germany

(Richtlinien für die Anlage von Landstraßen, RAL 2012)

Germany

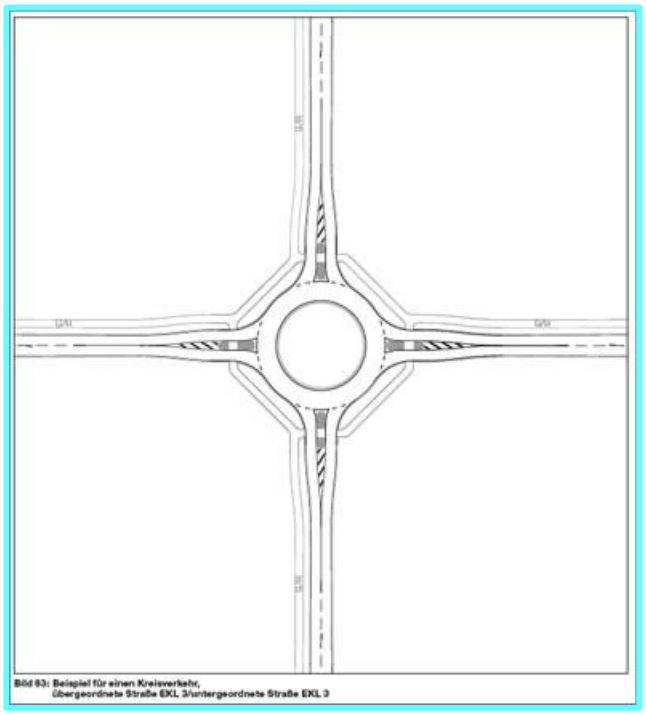


Figure 18: Roundabouts and cycle lanes in Germany
(Richtlinien für die Anlage von Landstraßen, RAL 2012)

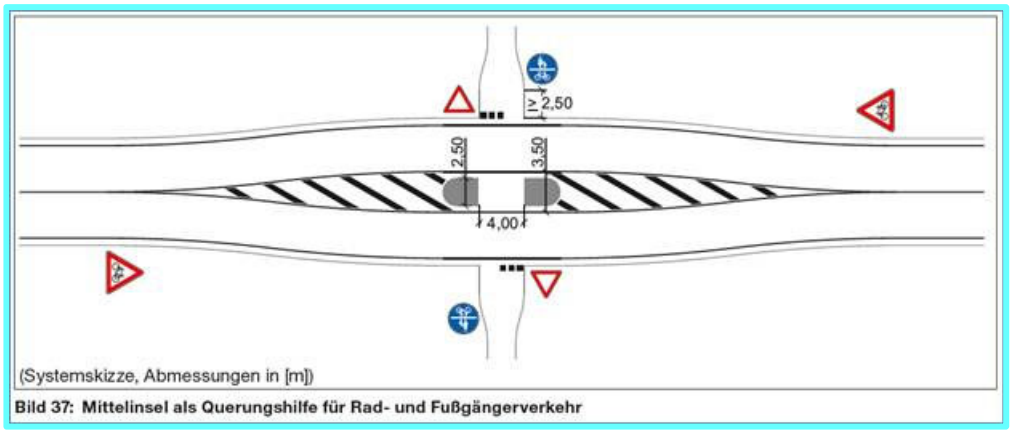


Figure 19: Rural crossings for VRU in Germany
(Richtlinien für die Anlage von Landstraßen, RAL 2012)

Where do you cross a road on a normal cycle lane? How is signalisation, lighting, priority?

Right of way

Germany

Priority road

Do cyclists have priority on roundabouts? Cyclists should never be in priority when biking on a roundabout

Where do you cross a road with a pedestrian crossing? How is signalisation, lighting, priority?

How do you cross near bus stops? How is signalisation, lighting, priority?

Special requirements

Design guides available for school zones?

No schools

Bus stops?

Evaluation

Evaluations of road design

Are there any evaluations of the road designs? Check before the plans and after the building?

Safety audits, auditor is evaluating all the plans. Safety audit after building it, from 2019.

Have they been published? Copies available?

No

Infrastructure measures to reduce single vehicle accidents?

Any infrastructure measures to reduce single sided accidents? Height of entry of cycle lane?

Max 2cm for sidewalk entry, 2% for cycle path ramp.

4.2.4 Ireland

The interview and documentation for Ireland was provided by Transport Infrastructure Ireland (TII). Ireland uses design standards that are compulsory (although there are provisions for flexibility of application) for their national road network. The TII standards for road design contain many VRU considerations, definitions and details that other CEDR countries could benefit from.

4.2.4.1 Excerpts and the corresponding documentation for the Republic of Ireland

Cycle Facilities: Refers to all types of measures which improve conditions for cyclists and include:

i. **Cycleways:** a public road or proposed public road reserved for the exclusive use of cyclists or cyclists and pedestrians.

ii. **Cycle Track:** Part of a road, including part of a footway or part of a roadway, which is reserved for the use of pedal cycles and from which all mechanically propelled vehicles, other than mechanically propelled wheelchairs, are prohibited from entering except for the purpose of access.

iii. **Cycle Lane:** part of the carriageway of a road reserved primarily for use by cyclists. The cycle lane forms part of the road and it is located within the contiguous road surface. A cycle lane can also be referred to as an on-road cycle track.

iv. **Shared Use Cycle and Pedestrian Facilities:** A Cycle Track or Cycleway that is provided for both cycle and pedestrian use.

v. **Shared roads with Motor Vehicles:** A road under low speed/low vehicular traffic flow conditions that is also provided for both cycle and pedestrian use.

vi. **Greenway:** a Cycleway that caters for pedestrian and cyclists in a recreational environment

vii. **Cycle Network:** is a defined collection of routes which connect key origins and destinations in a specified area for cyclists.

The figure below is a cross section example of a cycling facility.

Ireland

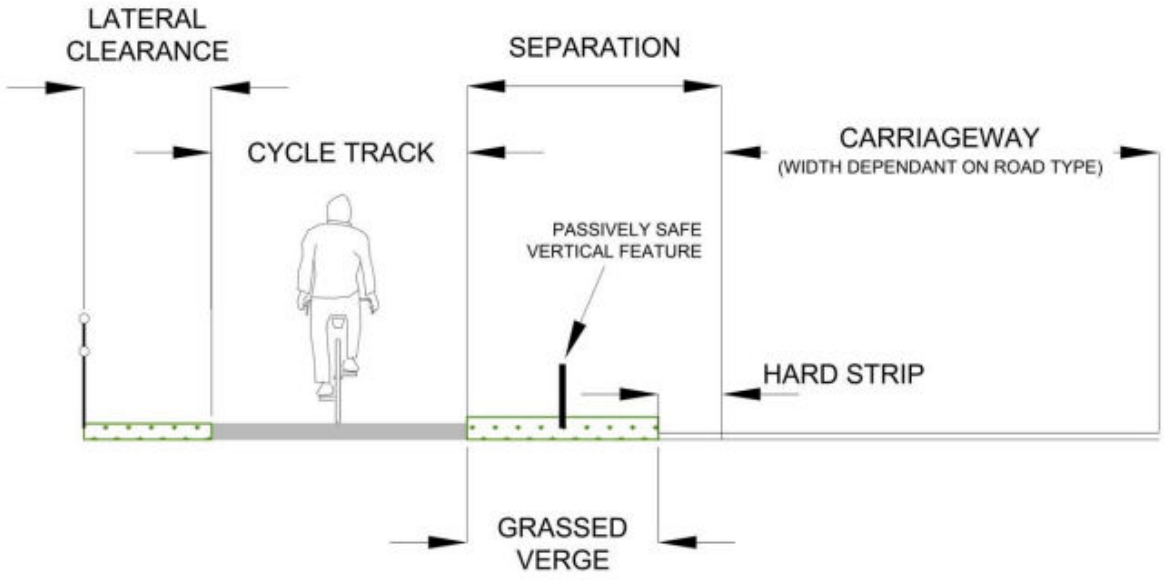


Figure 3.2: Off-Road One-Way Cycle Track

Figure 20: Off-road one-way cycle track. Source DN-GEO-03036

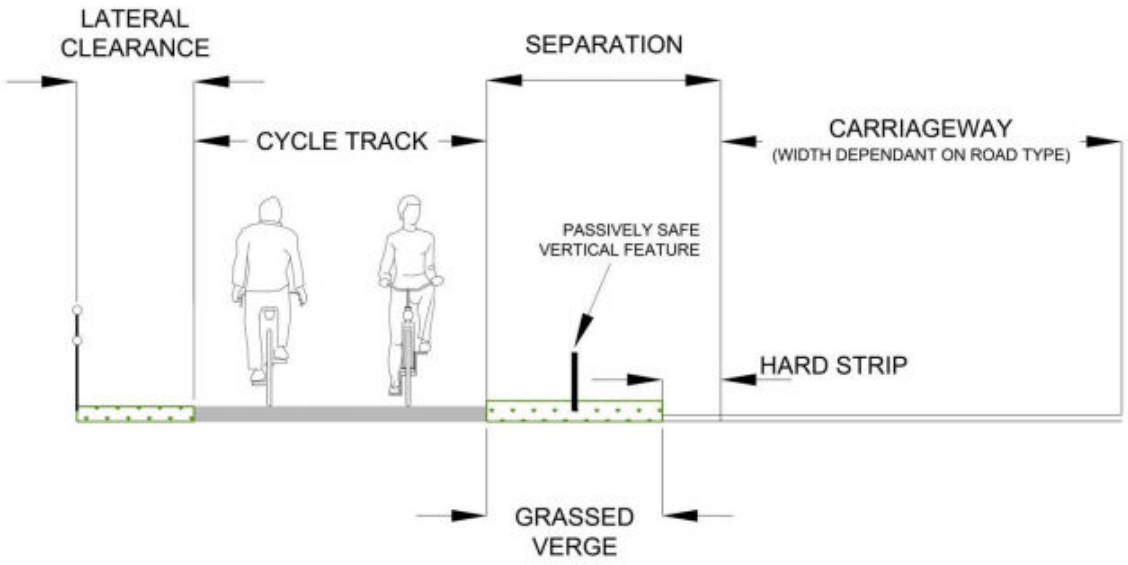


Figure 3.3: Off-Road Two-Way Cycle Track

Figure 21: Off-road two-way cycle track. Source DN-GEO-03036

Design Elements for the Rural Fringe

There should be a gradual change from rural to urban character in the Rural Fringe.

Ireland

A typical rural environment has informal character:

grass verge not mown

hedgerow composed of native species

trees planted in clumps

footpaths usually absent.

A typical urban environment has formal character:

- mown grass verge
- shrubs usually evergreen ground covers
- trees planted as standards in single or double rows
- footpaths usually present.

The following design elements may be considered for inclusion. These are not mandatory but can be considered to supplement measures required by the standards:

Prohibition of overtaking within the Rural Fringe, using formal landscaping, signs, continuous centre line road markings and Gateway treatments as appropriate.

Phasing out of the hard shoulder, using crosshatching road markings inside the carriageway edge line to increase the visual effect.

Narrowing of the carriageway.

Use of signs and landscaping with a vertical emphasis.

Provision of other possible appropriate design elements that may be appropriate to the town or village being treated to give it an individualised sense of identity.

Use of appropriate soft landscape elements such as trees, shrubs, and grass verge treatment, which change in composition and degree of formality along the Transition Zone into the town.

Provision of cyclist and pedestrian facilities.

Use of the town name sign in conjunction with the area speed limit sign in the design of the Gateway itself.

General Design Guidelines for Gateways

The Gateway would normally be located at the extent of the 50km/h speed limit except in towns and villages where there is only a 60km/h zone.

Cyclists may be catered for by means of a cycle track:

- on the roadway
- on the footway
- physically segregated from the roadway by means of a raised kerb, grass verge or similar (shared with pedestrians or exclusive to cyclists).

Ireland

The design must aim to achieve the optimum balance between the safety of cyclists and other road users. In these circumstances, it is imperative that speeds be significantly reduced.

The following specific recommendations should be considered.

Segregated cycle facilities are desirable where high speeds/high volumes of motorised traffic prevail. Removal of cyclists from carriageways at the Gateways is also recommended where this is deemed to be feasible by the Designer.

Consideration should be given, in the vicinity of Gateways, to combining low volumes of pedestrians and cyclists on existing or modified footpaths. The minimum path width required in such situations is 2.0m with a preferred width of 3.0m. Segregation may be achieved using signage, road markings and/or different coloured surfacing.

Inside the speed limit zone, a cycle facility may be continued as part of the traffic calming layout. If this is not possible then any cycle facility provided to “bypass” the Gateway must re-join the main traffic flow using the layout detail shown in Figure 3 below.

Ireland

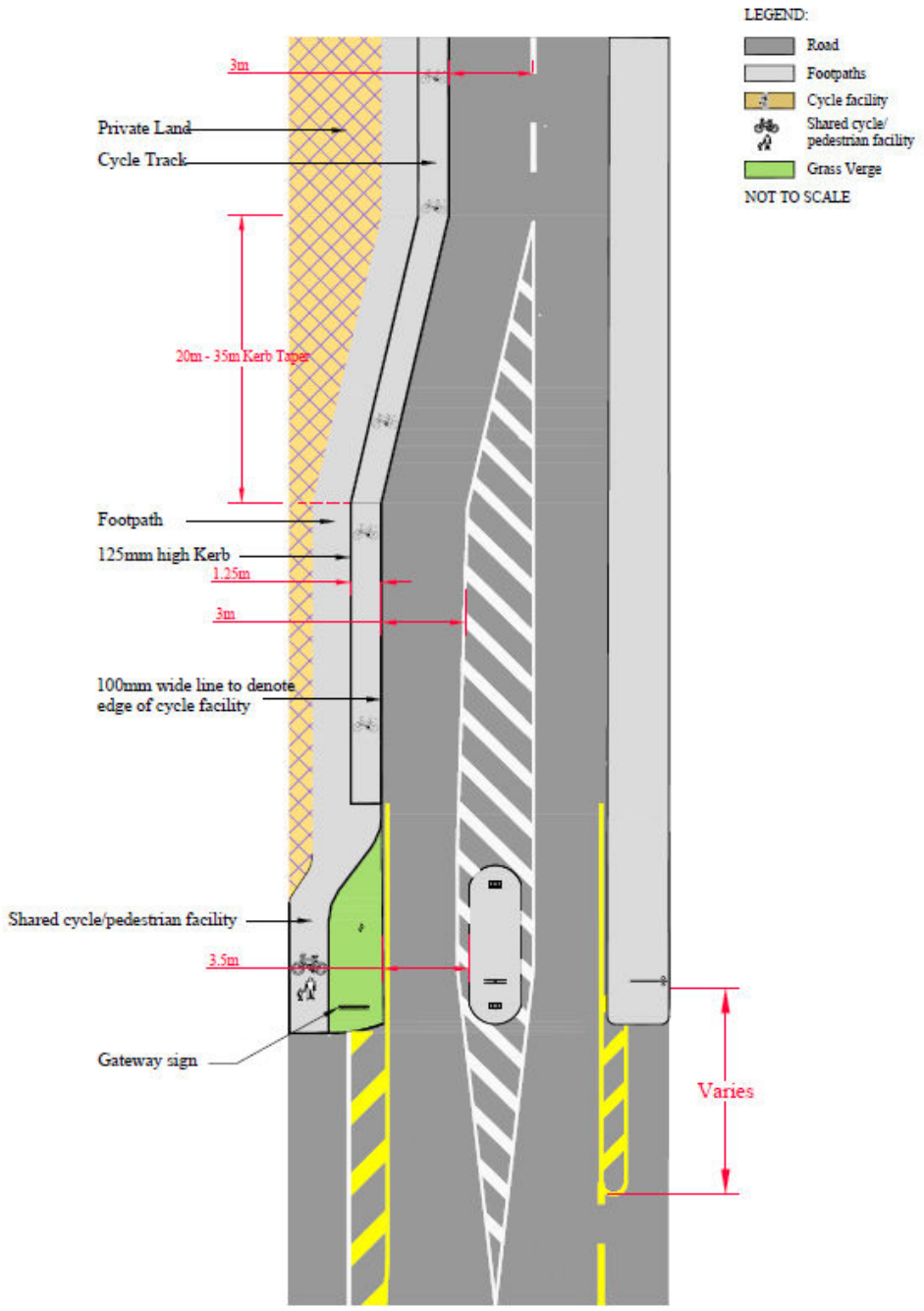


Figure 22: Plan of Cycle Bypass at Gateway Source: DN-STY-00000 (draft)

The Designer should particularly guard against the following:

- imposing sudden deviation from parallel directions of travel on cyclists;
- the cyclist and other vehicular traffic sharing an unsegregated kerb to kerb width of less than 3.5m.

Ireland

Direct Accesses

A cycleway may need to cross direct accesses such as farm and house entrances. As a general objective the priority at these crossings should lie with the cyclists and it is preferable that the alignment of the cycleway is retained past the entrance.

Visibility requirements for motorised vehicles at direct entrances shall be in accordance with the DN-GEO-03060 standard. The 'x' distance shall be measured from the nearside edge of the carriageway without the need to accommodate the cycleway.

Additionally, at direct accesses, the access will require a visibility splay setback of 2.0 m ('x' distance) from the cycleway with a stopping sight distance based on the design speed of the cycleway.

Pavement

Asphalt surfacing is the most popular among cyclists because of its evenness and high skid resistance. It is recommended that an aggregate grading of 0/6 to 0/11 is provided. It is recommended that a closed surface pavement construction should be made up of the following:

a) 20 mm thin surface course macadam

b) 40 mm to 55 mm base course

c) 150 Clause 804 sub-base (machine laid to achieve correct ride quality)

d) Geotextile layer (where necessary)

e) Capping (where necessary)

Lighting

Generally, cycleways will not be illuminated. Lighting should only be considered at crossings and close to and in built-up areas.

4.2.5 The Netherlands

The interview and documentation for the Netherlands was provided by Rijkswaterstaat (RWS) and CROW (Dutch non-profit organisation for roads and other traffic and transport facilities). The Netherlands uses voluntary guidelines that includes human factor design principles, geometric and road safety design and may also include ITS measures.

4.2.5.1 Excerpts and the corresponding documentation for the Netherlands

Speed

What is the standard speed in UA?

50km/h

What is standard speed in NUA (non-highways (2x2 delimited))?

Outside urban area: 60km/h or 80km/h is the standard

Distributor roads (outside urban area) = 80km/h

Through roads and roads of Rijkswaterstaat = 80km/h outside urban area and 100km/h (but VRU aren't allowed on through roads)

Access roads outside urban area = 60km/h

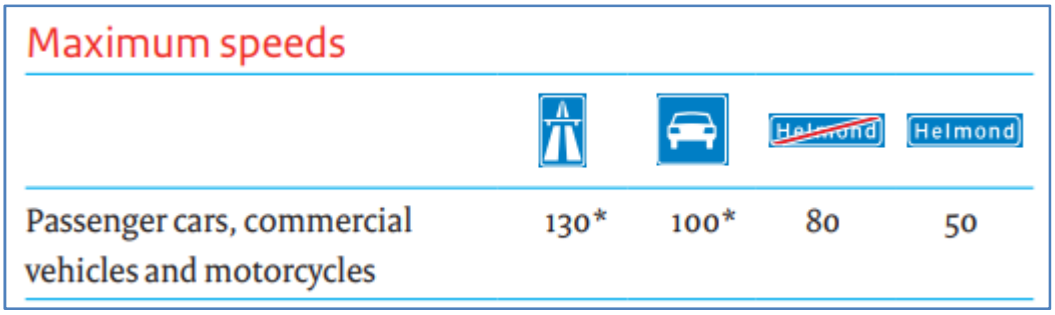


Figure 23: Speed limits in the Netherlands

Can this change? In what circumstances? Does it often happen?

Yes, e.g. on access roads (outside urban area) the speed over a certain length can also be reduced to 30km/h, e.g. on dangerous intersections, in a zone with (frequent) crossing traffic, etc. there the road administrator may decide to set a lower maximum speed (no guidelines about the length of that speed reduction)

80 km/h roads can lower their speed at junctions to 60 km/h

Netherlands

How is VRU infrastructure defined?

For cyclists:

Bicycle infrastructure: always indicated with a traffic sign.

Only "cycle lanes" (red lanes + bicycle symbol) do not need a traffic sign. By making use of cycle lanes, a division is made on the road.

The cycle lane is included in the regulations e.g. motorized traffic is not allowed to stop or park on it but they may drive on it. Cycle lanes are used at distributor roads and access roads.

Access road (in an ideal situation): separate bicycle and car traffic (so separated bicycle paths), but if sufficient space is not available, a cycle lane can also be installed.

Access road (in an ideal situation): low traffic and only destination traffic. No separation of road users.

In practice, some roads do not fit in one or another road “type” ... they are the so-called "gray roads"

A “cycle suggestion lane” does not have a bicycle symbol on the road surface, motorized vehicles may park on it, it is less regarded as a bicycle infrastructure ... sometimes it is not clear for the road users what it exactly means. Cycle suggestion lanes are not included in the legislation and they disappear more and more (also from CROW guidelines) ... The cycle lane did not always have to be colored in red.

E.g. with an available road width of 6 m: suppose that there are many cyclists, so a cycle lane can be considered of 1m 70 on both sides (= minimum size), (6m – (2x 1,70m) = 2,60m) only 2.60 m is left, which is very little ... a cycle lane can still be constructed (limit is 5.8 meters). Under 5.8 meters well-designed cycle lanes are not feasible. In addition to mixed traffic, alternatives aren’t well researched at the moment and we do not know what is better for cyclists (e.g. a cycle street, or e.g. narrower cycle lanes?)

Summary:

Do they occur?

Cycle suggestion lane?: yes, the so called “cycle suggestion lanes”, they are not taken up in the legislation, and are less frequently used.

Cycle lane (adjacent): yes

Cycle lane (higher): not common used, but they occur sometimes

Separated cycle tracks: yes, common used outside urban area

Two-directional cycle track: yes, occur frequently

Netherlands

Other?

In the Netherlands there are both compulsory and voluntary cycle tracks (indicated with a traffic sign)

Who is allowed on it?

Signalisation	**Infra**	Speed	Pedestrian	Cyclist	Moped A	Moped B
 		This is not linked to the speed on this cycle track, but mopeds have to persist a maximum speed of 25km/h	Yes, pedestrians may use it	Yes, obligated	Yes, obligated	No, also speed pedelecs are not allowed
 			*yes*	*Yes*	*Yes*	Yes (also obliged for speed pedelecs)
 G13 Onverplicht fietspad  G14 Einde onverplicht fietspad	E.g. outside urban areas, to indicate recreational cycle track where it is not desirable to drive with an internal combustion engine, or on solitary bicycle tracks	Not linked to speed	Yes	Yes	No	No, also speed pedelecs are not allowed
 G07/G11 Verplicht voetpad en fietspad	Not often used	This is not linked to the speed on this cycle track, but mopeds have to persist a maximum speed of 25km/h	Yes, pedestrians must use it	Yes, mandatory	yes	No, also speed pedelecs are not allowed

Netherlands

Whether or not separate cycling infrastructure is present can also be a decisive factor in the choice of the maximum speed for motorized traffic.

Cycle lane/cycle path…

Signalisation	Width	Colour	Marking	Distance from road	Transitions at crossroads
		Not prescribed in traffic rules, but the use of red color is strongly recommended	Cycle tracks outside urban area: when using bi-directional cycle tracks, the use of well indicated middle-marking and edge markings are strongly recommended but not obliged	See design guide	See design guide

Widths for partition verges (carriageway – cycle track) outside the built-up area:

Road category	Width of partition verge (m)	
	Recommended distance	Minimum distance
District access road	6.00	4.50
Estate access road	> 1.50	1.50

(Design manual for bicycle traffic, Table 18)

Transition zone

Is a transition zone from NUA to UA mandatory? What are the dimensions? What infra is necessary?

Yes, there are recommendations available

Portal, at the boundary of the built-up area, e.g. in the transition zone from 50km/h tot 60km/h, but no hard rules exist.

e.g. mopeds who drove on the road inside urban area must be led to the cycle-moped track outside urban area.

Netherlands

The transition from 80km/h to 50km/h is rather strong, but can be accompanied by a speed bump, an 'axial movement' to alert the divers. Long transition zones (e.g. 100m) with speed reduction does not exist.

Hierarchic road design

Categorisation of roads

Do you use a categorisation of roads that takes land use into account? E.g. bigger road with shops alongside, long small roads with housing, …

Yes, in the Netherlands there are 3 types of roads:

Access roads

Distributor roads

Through roads

Does your categorisation trigger a certain cycle infrastructure?

Yes,

Outside Urban area:

Distributor roads: normally they have separated cycle tracks, no mixed traffic

Access roads: mixed traffic; mixed traffic + cycle lane; sometimes also separated cycle tracks (the so called "gray roads")

In all roads it is customary to have sidewalks inside urban area, except for residential areas where the intention is to mix (pedestrians & other traffic).

Outside urban areas: there is not really a guideline ... where there is a lot of walking it is recommended to build sidewalks.

At occasional bus stops (which are often used), there are also sidewalks outside urban areas, e.g. at a camping.

Car intensity (AADT)

Thresholds which require trigger certain requirements e.g. greater than 2,000 AADT requires segregated facilities.

Yes, that exist even for inside as outside urban areas

Netherlands

Table 24: Selection chart for bicycle facilities on road sections INSIDE built-up areas

				Cycle network category		
road-category	**Maximum speed of motorized traffic (km/h)**		**Intensity of motorized traffic (pcu/day)**	**Basis network ($I_{bycicle}$ <750/24h)**	**Cycle route ($I_{bycicle}$ 500-2.500/24h)**	**Main cycle route ($I_{bycicle}$ > 2.000/etm)**
Access road	Walking space or 30 km/h		< 2.500	Combined traffic	Mixed traffic or cycle street	Cycle street (with priority)
			2.000-5.000		Combined traffic or cycle lane	Cycle track or cycle lane (with priority)
			> 4.000	Cycle lane or cycle track		
Distributor road	50 km/h	2×1 lanes	irrelevant	Cycle track		
		2×2 lanes				
	70 km/h			Cycle-moped track		

Netherlands

Table 25: Selection chart for bicycle facilities on road sections OUTSIDE built-up areas

roadcategory	**Maximum speed of motorized traffic (km/h)**	**Intensity of motorized traffic (pcu/day)**	**Bicycle traffic road section function**	
			Basis network	**(main) cycle route (I_{cycle} > 500/etm)**
Access roads	60 (of 30)	< 2.500	Mixed traffic	Cycle street, if $I_{car} < I_{cycle}$ 1) cycle track or mixed traffic if $I_{car} > I_{cycle}$
		2-000-3-000	Cycle track, eventually cycle lanes	
		> 3000	Cycle track	
Distributor roads	80	irrelevant	Cycle-moped track	

1) + any additional requirements in terms of speed

Bicycle Traffic Volume

Thresholds which require trigger certain requirements e.g. greater than 50 cyclists per day requires segregated facilities. Possibly a combination threshold linked to both the number of cyclists and traffic volume.

Not mandatory but strongly recommended

No link between cycle intensity and type of cycle infrastructure.

There is a link between cycle intensity and the width of cycling infrastructure

Netherlands

Table 26: Desirable pavement width of a cycle track

One-way cycle track		**Bi-directional cycle track**	
Peak traffic intensity in one direction	Width	Peak traffic intensity in two directions	width
0-150	2,00 m	0 – 50	2,50 m
150-750	2,50 – 3,00 m	50 – 150	2,50 – 3,00 m
> 750	3,50 – 4,00 m	150 – 350	3,50 – 4,00 m
	> 350		4,50 m

Table 27: Desirable pavement width of a cycle/moped track

One-way track		**Bi-directional track**	
Peak traffic intensity in one direction	Width	Peak traffic intensity in two directions	width
0-150	2,00 m	0 – 50	2,50 m
75-375	3,00 m	50 – 150	3,00 m
> 375	4,00 m	150 – 350	4,00 m
		> 300	5,00 m

Pedestrian Traffic Volume

Thresholds which require trigger certain requirements e.g. greater than 50 cyclists per day requires segregated facilities. Possibly a combination threshold linked to both the number of cyclists and traffic volume.

Recommendation: Minimum width of sidewalks: obstacle-free zone of at least 1.50 m

Local narrowing over a maximum of 20 m is 1.20 m

Point constriction allowed, but then still 0.90 m left

The preferred width is > 1.80 m, conform the Accessibility Directive (more information: CROW 337 accessibility directive and other publications)

Netherlands

A Balanced Approach to Speed

Do you include visual parameters in (re)designing a new road? Confining peripheral vision. Horizontal triggers? New parameters for road design with self-explanatory background?

Design speed versus perceived speed. This includes the human factor which influences the landscape.

e.g. moped speed bumps to calm down moped riders (when well implemented, cyclists do not suffer from it), not a really comfortable facility for anyone, but they are good at tempering speed. It is often a 'double' speed bump: it goes up / down / up / down

Holistic road design and planning

Alternative routes and their viability for drivers using a holistic view to the whole road network:

- Assessment of transport and mobility needs for the specific road networks
    - VRU groups and
    - Motor vehicle users (private and commercial)
- Traffic density and the road networks capacity

Is there a network for cyclists that is separated from the car network? Do you have different networks for cyclists? How is it constructed?

= yes, the 'solitary cycle track', (see Design guide bicycle traffic (e.g. park and dune areas)

Outside urban areas there are of course also al lot of walkways, but there are other standards for that (e.g. forest paths, paths through fields,)

Infrastructure guidelines

Obstacles and sightlines

Where there are physical objects that might cause increased hazard in a collision (e.g. large stones, hard objects, high verges etc.). Limited sightlines for either VRU or motor vehicle drivers for seeing each other.

Recommendations exist for this.

Outside urban area: **in general 1m of obstacle free zone** along the cycle track

e.g. lighting pole = minimum of 0,90 cm obstacle free zone if the lighting pole is placed on the sidewalk.

Netherlands

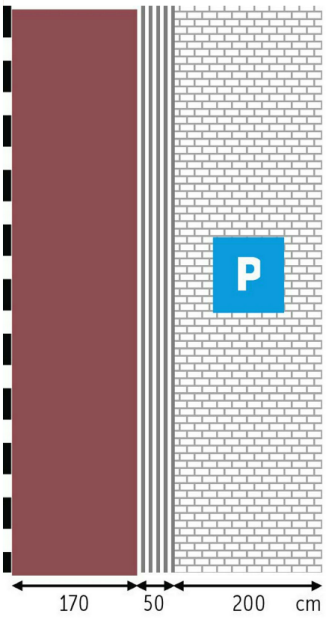


Figure 24: Sightlines and obstacles in the Netherlands

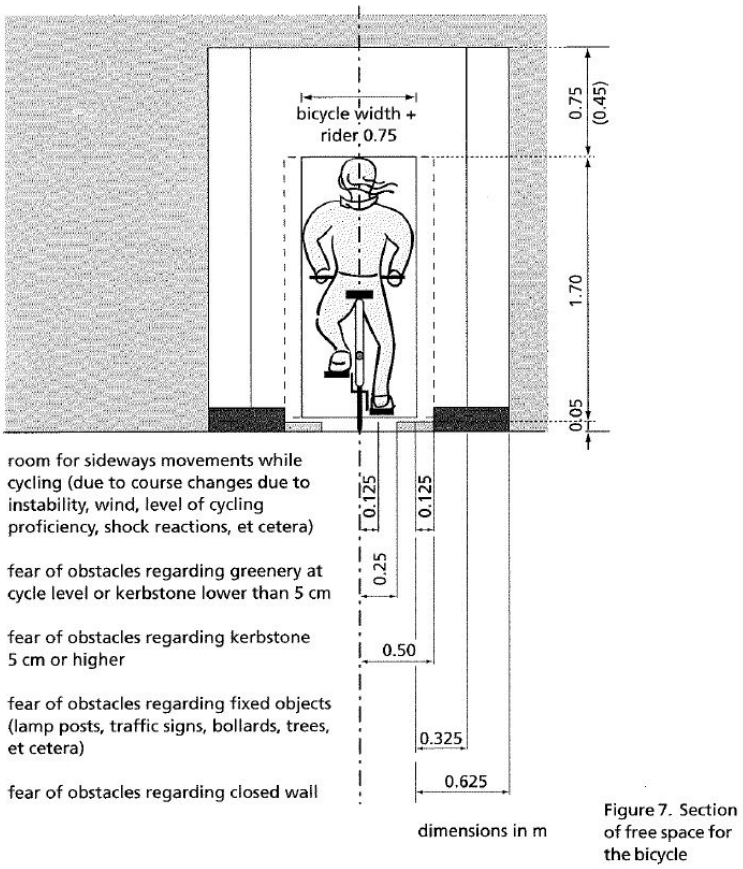


Figure 25: Free space for the cyclist in the Netherlands

Netherlands

Recommendation: minor height differences (e.g. pavement edge) do not have to be protected with a physical element

Table 28: Gradients for bicycle in the Netherlands

Gradients for bicycle facilities/pedestrian facilities

The physical limitations of a cyclist to climb steep inclines…and their ability to stop when descending steep inclines are impacted by the gradient…

Height difference	Gradient percentage
Up to 0,10 m	1 : 10
0,10 – 0,25 m	1 : 12
0,25 – 0,50 m	1 : 16
0,50 – 1,00 m	1 : 20
h > 1,00 m >	1 : 25
(slopes less than 1: 25 aren't considered as a slope but as a 'false flat', so that they can be carried out as a flat pedestrian route)	

Source: ASVV 2012, par.14.1.10

Cyclists

No guidelines (only for bridges and tunnels, not for cycle tracks)

Horizontal and vertical deflections

E.g. …the introduction of tight horizontal radii needs to be accompanied by appropriate warning signage on the cycle facility…

Horizontal deflection: Minimal curve/optimal curve/width in curve

Yes, guidelines exist, but this depends on the 'normative vehicle', allowed on the cycle track

Netherlands

Street Furniture

Location and use of street furniture incl. public lighting

Busstops, lighting, crossroads

Outside urban area: when there are important pedestrian traffic flows (e.g. camping) when more then incidentally

No, according to CROW. General guideline; cycle track must be clearly visible, not always light pole needed. In the outside area probably not.

There are test cases, e.g. "Glow in the dark" markings, dynamic lightings, etc.

Footways, Verges and Strips

Width of edge treatment

When to put a footway? Width?

Crossings

Road crossing and cycle routes crossing roads are usually critical from a safety perspective and may comprise conflict areas between different VRU-groups and/or VRU and motor vehicles.

Where do you cross a road with 2-way cycle path? How is signalisation, lighting, priority?

Table 29: Inter-urban path and road dimensions-1

Table 24. Option table: district access road – estate access road intersection solutions

		Section 2: estate access road or solitary path			
		I_{pcu} < 500 pcu/h			I_{pcu} > 450 pcu/h
Section 1: district access road, with or without (main) cycle route	hourly intensity	no cycle route	cycle route	main cycle route	all situations
	1-1,000 pcu/h	right of way intersection		right of way intersection + supplementary measures or roundabout	roundabout
	800 - 1,500 pcu/h	right of way intersection + supplementary measures			
	1,200 - 1,750 pcu/h	right of way intersection + supplementary measures, roundabout, intersection with TCS or grade-separated intersection (only for main cycle route where appropriate)			
	> 1,500 pcu/h	intersection with TCS or grade-separated (only for main cycle route where appropriate)			roundabout, intersection with TCS or grade-separated solution

Netherlands

Table 30: Inter-urban path and road dimensions-2

Table 25. Option table: district access road – district access road intersection solutions

Section 1: district access road, with or without (main) cycle route	Section 2: district access road, with or without cycle route ($I_2 \leq I_1$)				
		$I_2 < 1{,}200$ pcu/day			$I_2 > 1{,}000$ pcu/day
	hourly intensity (I_1) pcu/h	**no cycle route**	**cycle route**	**main cycle route**	**all situations**
	500 - 1,500		single lane roundabout		roundabout (if necessary with bypass or two-lane) or TCS
	1.200 - 1,750		roundabout (if necessary with bypass or two-lane) or TCS		(multi-lane) roundabout with cycle tunnel in busiest lateral direction (or TCS)
	> 1,500		(multi-lane) roundabout or TCS	(multi-lane) roundabout with cycle tunnel in busiest lateral direction (or TCS)	TCS or grade-separated

If there is regular pedestrian traffic who wants to cross the road, e.g. where maximum speed is 80 km/h, normally there will be taken a measure to make this happen safely, at least a median strip (central reservation) is preferable, if crossing is still difficult (no gaps) a traffic light is needed.

In all cases, the speed must be reduced on the spot. No zebra crossings are built outside the built-up area because this is not safe due to high speeds (no priority will be given to the pedestrian).

Where do you cross a road on a normal cycle lane? How is signalisation, lighting, priority?

Right of way

Outside Urban Areas:

The same priority rules apply to intersections of a solitary cycle track and an access road as for intersections between access roads themselves (all drivers from the right have priority). Both crossroads types can therefore be treated in the same way. However, special attention must be paid to the design at intersections with a solitary cycle track, because the view of the solitary bicycle path is sometimes limited by planting and there can easily be an 'informal' priority behavior.

Netherlands

More concretely: if the traffic on the access road 'overlooks' the solitary cycle track (unconsciously), it is also not intended to give priority to crossing cyclists. Where the chance of such behavior is real, measures must be taken to ensure visibility and equality.

If the solitary cycle track is a main cycle route, the cycle track can have the priority on the access road to be crossed. (The regulation of the priority in favor of the access road is legally not permitted within the built-up area.)

Intersections of solitary cycle tracks with distributor roads can be treated in the same way as intersections between access roads and distributor roads. The traffic on the distributor road is in principle entitled to priority.

If the solitary cycle track is part of the main bicycle network, high demands are placed on a good flow and comfort of the cyclist. A split-level interchange solution is then the safest. If this is not possible, a 'Zwolle bicycle roundabout' can provide a solution within built-up areas. A different way of prioritizing a solitary cycle track when crossing a distributor road is not recommended for road safety reasons.

Priority road

Do cyclists have priority on roundabouts?

General rule: on roundabouts outside urban areas, cyclist do not have priority (on roundabouts inside urban area, they have priority)

Special requirements

Design guides available for school zones?

Bus stops?

Guidelines and recommendations concerning school zones exist, but almost all schools are within the built-up area.

Sometimes existing walking routes are interrupted, because a crossing facility is considered to be too dangerous or too expensive (barrier effect of roads) e.g. when constructing a new ring road around town. In those cases, pedestrians have to walk around what they prefer not to do in practice ('elephant paths' and illegal crossings).

Perhaps this exist in smaller villages?

Only from 60 km/h to 30 km/h the speed can be reduced over certain distances, e.g. crossing traffic, parking, buildings, and dangerous intersections

Normally not at 80km / h roads?

Evaluation

Evaluations of road design

Are there any evaluations of the road designs? Check before the plans and after the building?

Netherlands

Will presumably be arranged differently by different road managers ...

E.g. a few 'key moments' at design stage e.g. environment, spatial quality: probably

Upon completion probably also an evaluation ... but probably no other audits.

Have they been published? Copies available?

In the case of new road layout, the road authority must do this with a traffic decision (legal process) after about 6 weeks, everyone can lodge an objection or something, more than road safety. (on plan)

Evaluation happens in practice (too) little and is not prescribed by default, ... CROW wants to promote evaluations.

If there would have been a pre-and post-examination, this might become available in municipalities ... CROW is sometimes not informed.

Infrastructure measures to reduce single vehicle accidents?

Any infrastructure measures to reduce single sided accidents? Height of entry of cycle lane?

Is there a system to study single vehicle accidents with VRUs?

See: http://www.fietsberaad.nl/?lang=nl&repository=Verkeersveiligheid+van+trottoirbanden

See also: https://repository.tudelft.nl/islandora/object/uuid:a5c5059c-21e0-47eb-87cc-47ee31852e6a?collection=education

Source: Part research 3 - Literature research

Various design proposals follow from the literature review which should be taken into account when designing a bicycle pedestrian combination. The most important requirements are shown below:

- Sufficient road width (> 2m)
- A clear separation between pedestrian and cyclist by means of a white line marking.
- Use of different materials that clearly distinguish the cycle track and the sidewalk, but also characterize it. A consistent design within an urban environment is also important here.
- With a flat edge, a good flat design is also necessary (< 6mm height difference).
- In case of high pedestrian traffic (> 200 pedestrians per hour per profile width), a height difference is recommended.

Netherlands

Design principles:

- E.g. a shoulder must connect well to the cycle track
- Visual separation between cycle track and sidewalk
- Etc.

Does not apply specifically outside urban area: also important is ‘fall prevention’ at sidewalk edges, (e.g. due to poor maintenance of the sidewalks), recommendations are available on quality of sidewalk maintenance.

For more examples see: http://www.fietsberaad.nl/?section=voorbeeldenbank&lang=nl

4.2.6 Sweden

The interview and documentation for Sweden was provided by the Swedish Transport Administration (Trafikverket). Sweden does not use design standards but does have one document that is compulsory for new production of infrastructure on the national/state owned road network. Local levels can be included if they are state roads rather than municipal road (which are predominant roads for VRU).

Municipal roads are owned by local authorities. The Swedish guidelines or *Vägars och gators utformning* (VGU), can be used if they wish. Some of the larger Swedish cities (e.g. Stockholm and Malmö) have drawn up their own version of the VGU, tailoring the specifications. The guidelines are a requirement for Trafikverket contractors (national & regional roads). There are two main sections of the Swedish VGU. 1) Requirements, and 2) advisory. (The advisory documents are more detailed and numerically more.) The VGU is primarily applicable for new production. Legacy road contractors to Trafikverket are to use a common-sense approach to the VGU requirements.

4.2.6.1 Excerpts and the corresponding documentation for Sweden

Speed

What is the standard speed in UA?

The base speed limit in urban areas is 50 km/h and 70 km/h outside of urban areas. Speed limits can however, vary and the incrementations allowed are 30, 40, 50, 60, 70, 80, 90, 100, 110, 120 km/h. Most commonly in urban areas is 30 and 40 km/h. Interurban areas commonly have speed limits between 50 and 60 km/h. The majority or rural roads have a speed limit between 70 and 90 km/h. Dual carriage ways and motorways usually have speed limits between 100 and 110 km/h. A speed limit of 120 km/h is not commonly used.

Sweden

Table 31: Classification of bicycles and e-bikes in Sweden

		E-bike	Motorised bicycle (moped class 2 - max 25 km/h)	Fast E-bike (moped class 1 - max 45 km/h)
				
Max. speed with electric assistance	**Maxhastighet med elassistans**	25 km/h	25 km/h	45 km/h
Engine effect? (continuous effect on wheel)	**Effekt på motor** (kontinuerlig märkeffekt)	Max 250w	250-1000w	Upp till 4000w
No. of wheels?	**Antal hjul**	2 - 4 st.	2 - 4 st.	2 - 4 st.
Requirement for pedalling (electric ass.)?	**Behov av att trampa för att få elassistans**	Yes	No	No
Driving licence requirement?	**Krav på körkort**	No	Yes (car, tractor or provisional licence for mopeds class 2)	Yes (AM – moped class 1 required)
Age limit?	**Åldersgräns**	No	Yes, 15 yrs.	Yes, 15 yrs.
Vehicle number plates	**Registreringsskylt**	No	No	Yes
Third party insurance?	**Trafikförsäkring**	No	Yes	Yes
Helmet requirement?	**Krav på hjälm**	No (if you are under 15 yrs., then helmet required)	Yes (unless there is frame and seatbelts are used)	Yes (Motor cycle helmets required except for children < 7 yrs. (bicycle helmet required)
Passengers/pillion?	**Passagerare**	Yes (if there room. People >15 yrs. can have children <10 yrs. People >18 yrs. can have 2 children ≤6 yrs. on bicycle)	Yes (if the bike is designed for passengers; same rules as e bikes)	Yes (if the bike is designed for passengers; same rules as e bikes)
Driven on a cycle path?	**Cykla/köra på cykelbana**	Yes	Yes (if signposts don't prohibit mopeds class 2)	No

Bicycles have no limit other than the speed limit of the road being used.

What is standard speed in NUA (non-highways (2x2 delimited))?

Urban areas 50 km/h

Non-urban areas 70 km/h although 60-100 km/h is common depending on AADT (cf. Far north and higher speeds despite low road standard)

Can this change? In what circumstances? Does it often happen?

Yes! Depending on AADT, local factors (sight lines etc.), local policy, roadside topography (boulder, trees, run-off zones etc.)

Sweden

How is VRU infrastructure defined?

How is it marked?

D6

Mixed.

D7

Pedestrian on left, cyclists on right.

Cycle lane/cycle path…

Table 32: Cycle lane/ minimum verge width (m) without guard rail > 500 daily pedestrian & bicycle traffic.

Minimum verge width (m) without guard rail > 500 daily pedestrian & bicycle traffic.

	Motor vehicle speed (km/h)			
AADT	80	100	110	120
<1000	3	4	5	13
1000 – 2000	3	5	8	13
2000 – 4000	3	5	8	13
4000 – 8000	4	8	10	13
>8000	5	8	13	13

Sweden

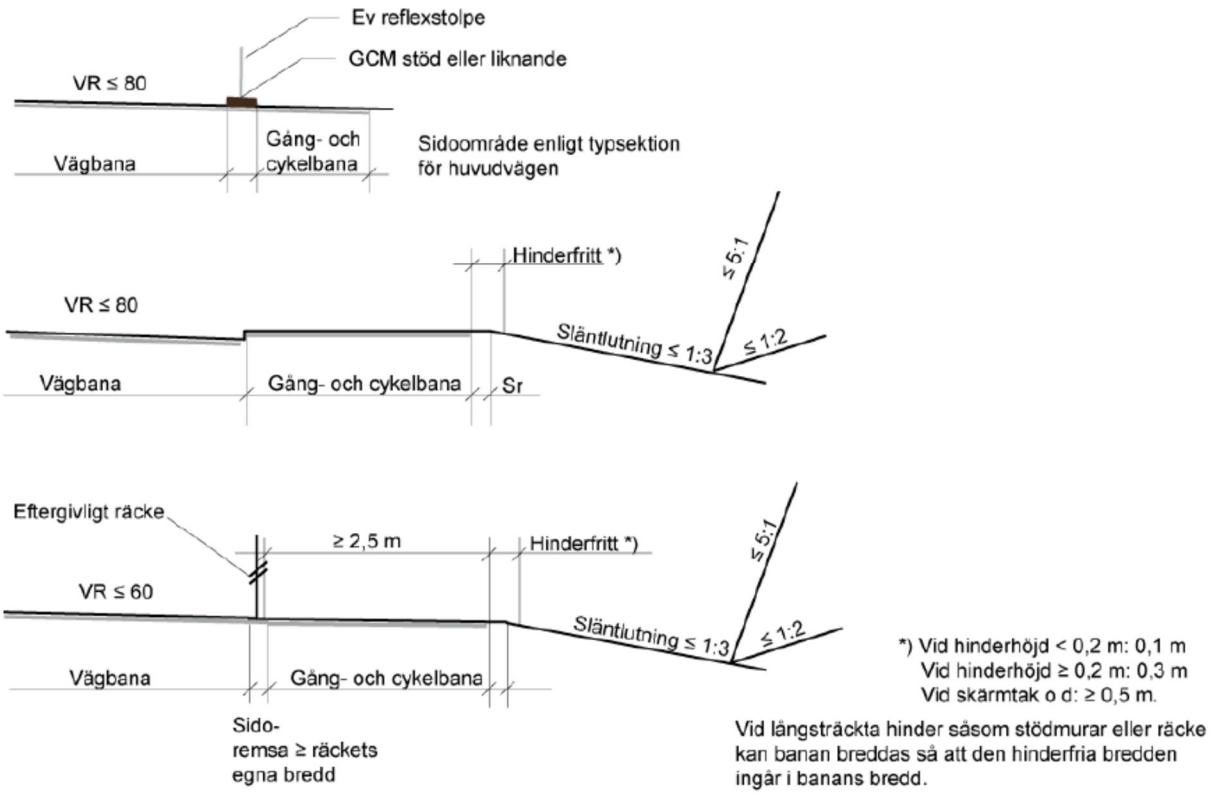


Figure 26: Cross-section view and dimensions for cycle lanes and pedestrian paths with barrier

Table 33: Gradient of the pedestrian and cycle path is mentioned in the VGU Requirements

Tabell 3.2-6 Största lutning på gångbanor/-ytor

Nivåskillnad / Lutning	Gångbana/-yta som dimensioneras för rullstol	Övriga ytor	
		Önskvärd största lutning	Största godtagbara lutning *)
< 1 m	≤ 2 %	5 %	8 %
1 – 2 m	≤ 2 %	5 %	7,5 %
2 – 4 m	≤ 2 %	4,5 %	7 %
4 – 6 m	≤ 2 %	4 %	6,5 %
6 – 8 m	≤ 2 %	4 %	6 %
8 – 10 m	≤ 2 %	4 %	6 %

*) Endast efter väghållarens godkännande

Sweden

Table 34: Gradient for cycle paths only

Level difference/ slope	Pavement/area dimensioned for wheel-chairs	Other areas	
		Greatest preferred gradient	Greatest acceptable gradient*
< 1 m	≤ 2 %	5 %	8 %
1 – 2 m	≤ 2 %	5 %	7,5 %
2 – 4 m	≤ 2 %	4,5 %	7 %
4 – 6 m	≤ 2 %	4 %	6,5 %
6 – 8 m	≤ 2 %	4 %	6 %
8 – 10 m	≤ 2 %	4 %	6 %

*Requires road authority approval

Table 35: Sightlines for stopping are also included.

Sightlines for stopping (m)	Preferred minimum sightlines (m)	Preferred acceptable sightlines* (m)
Dim hastighet 40 km/h	55	45
Dim hastighet 30 km/h	35	25
Dim hastighet 20 km/h	20	15

*Requires road authority approval

Transition zone

Is a transition zone from NUA to UA mandatory? What are the dimensions? What infra is necessary?

Nothing specified.

Hierarchic road design

Categorisation of roads

Do you use a categorisation of roads that takes land use into account? E.g. bigger road with shops alongside, long small roads with housing,…

Does your categorisation trigger a certain cycle infrastructure?

Sweden

New objects are all based on socio-economical calculations and models that can provide a net-benefit, e.g. shorter travel time. Land acquisition etc. is included in the costs/benefit analyses.

Car intensity (AADT)

Thresholds which require trigger certain requirements e.g. greater than 2,000 AADT requires segregated facilities.

The dimensioning factor for roads according to VGU is primarily the speed limit (e.g. VR 60) and not e.g. AADT. The AADT can however, be used when motivating exceptions to the VGU requirements.

Bicycle Traffic Volume

Thresholds which require trigger certain requirements e.g. greater than 50 cyclists per day requires segregated facilities. Possibly a combination threshold linked to both the number of cyclists and traffic volume.

Table 36: Bicycle Traffic Volume

Amount of cyclists	Cycle infra	Mandatory?
"Low" < 360 cyclists/hr./direction	See table 2.4-6 p. 43 in 2015:087 Recommendations	No
"Medium" 360-1440 cyclists/hr./direction	See table 2.4-6 p. 43 in 2015:087 Recommendations	No
"High" > 1440 cyclists/hr./direction	See table 2.4-6 p. 43 in 2015:087 Recommendations	No

Pedestrian Traffic Volume

Thresholds which require trigger certain requirements e.g. greater than 50 cyclists per day requires segregated facilities. Possibly a combination threshold linked to both the number of cyclists and traffic volume.

Sweden

Table 37: Table and figure for minimum verge width (m) without guard rail >500 daily pedestrian & bicycle traffic.

	Motor vehicle speed (km/h)			
AADT	80	100	110	120
<1000	3	4	5	13
1000 – 2000	3	5	8	13
2000 – 4000	3	5	8	13
4000 – 8000	4	8	10	13
>8000	5	8	13	13

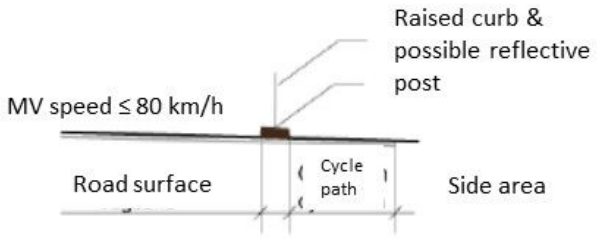


Figure 27: Schematic for road & verge/bicycle lane (m) without guard rail (Source: Page 40 I VGU Krav).

A Balanced Approach to Speed

The setting of speed limits should in theory be in line with the dimensions of the road according to the VGU. For instance, a 13 metre road (high speed road) should not be allocated a low speed if no other design features that reduce perception of driving fast are not included. A reduced speed limit would require e.g. a narrowing of the lanes, traffic calming devises (rumble strips, speed humps etc.), proximity of visual cues can also be used to influence the landscape.

In practice, however, this is not always the case and especially on legacy roads that are also quite often owned and run by municipal councils. Municipalities in Sweden are not required to follow the VGU requirements. Therefore, many roads of this type have received new (lower) speed limits than they were designed for.

New objects are all based on socio-economical calculations and models that can provide a net-benefit, e.g. shorter travel time. Land acquisition etc. is included in the costs/benefit analyses.

The dimensioning factor for roads according to VGU is primarily the speed limit (e.g. speed 60) and not e.g. AADT. The AADT can however, be used when motivating exceptions to the VGU requirements.

Sweden

Holistic road design and planning

Is there a network for cyclists that is separated from the car network? Do you have different networks for cyclists? How is it constructed?

Neither state nor municipal roads (in Sweden) are required to use a holistic design and planning for existing roads. New state-owned roads can seek guidance in the VGU Recommendations but are not required to use a holistic design. New municipal roads planners and designers may use the VGU Recommendations if they wish.

The VGU Recommendations (2016:083) provide guidance on driver behaviour and how it can be applied to road design. The advice is not compulsory.

Road crossing and cycle routes crossing roads are usually critical from a safety perspective and may comprise conflict areas between different VRU-groups and/or VRU and motor vehicles. They are not specified in the VGU per se. Cycle crossings are however regulated by a different government agency in Sweden, the Swedish Transport Agency who writes/interprets road traffic rules and regulations. There is provision for a relatively new phenomenon in Sweden where a special type of unsignalized bicycle crossings (see Figure 28 below) are given a similar status to the pedestrian 'Zebra' crossings (unsignalized). In practice thus far, alignment with the new provision in the law is not followed by local municipalities installing these road/cycle path crossings.

An unsignalized bicycle crossing with priority for cyclists can conceptually be designed similarly to Figure 28 below, and a real-life example. The application in real-life does not, however, follow the guidelines. The guidelines place the cycle-priority crossing in a straight section of road with no other intersections. In the real-life example it has been placed across a secondary road intersection with a main road resulting in more conflicts.

Figure 28: An unsignalized bicycle-priority crossing in Sweden, in theory (left) and an example from real-life (right).

Sweden

Areas that need further attention:

- Moped class 1 (45 km/h) have nowhere to go and are in the way of everyone.
- Evaluations of good and bad designs etc.
- Clear guidelines for threshold values regarding e.g. bicycle and pedestrian path width, cycle lane width etc.
- Rule-exception applications should be evaluated and re-connected to the VGU when they are similar and frequent.

Infrastructure guidelines

Obstacles and sightlines

Where there are physical objects that might cause increased hazard in a collision (e.g. large stones, hard objects, high verges etc.). Limited sightlines for either VRU or motor vehicle drivers for seeing each other.

Bicycle

Obstacle	No, although objects must be marked.
Parking spot	No
Houses (no walkway)	No
Trees	No
Lighting/pylons	Lighting is required.
Hedge height	No
Obstacles	0.4 m I a horizontal curve (e.g. brow of a hill)
Ditch	Yes (depending on the speed of the road/GC path)
Eye level height limit	1.0 m

Gradients for bicycle facilities/pedestrian facilities

The physical limitations of a cyclist to climb steep inclines…and their ability to stop when descending steep inclines are impacted by the gradient…

What is the maximum gradient going up?

What is the maximum gradient going down?

What is the maximum gradient X-axis on pedestrian facilities?

Sweden

Horizontal and vertical deflections

E.g. …the introduction of tight horizontal radii needs to be accompanied by appropriate warning signage on the cycle facility…

Horizontal deflection: Minimal curve/optimal curve/width in curve

Yes

Figure 29: Minimum horizontal curve radius for cycle paths.

Horizontal radius (m)	Preferred minimum horizontal radius	Minimum acceptable horizontal radius*
Dim hastighet 30 km/h	30	20
Dim hastighet 20 km/h	20	10

*Requires road authority approval

Minimum radius for bicycle 5 m (at 10 km/h)

Figure 30: Vertical curves for cycle paths. Long convex vertical curves where the stopping sightline are [top] and are not [bottom] dimensioned according to the VGU requirements (in Table 3.2.4). Source: p. 119-120 I 2015:086 *Krav*.

Convex vertical radius (m)	Preferred minimum radius(m)	Minimum acceptable radius*
Dimensioned speed 30 km/h	600	200
Dimensioned speed 20 km/h	200	

*Requires road authority approval

Concave and short convex vertical curves where the stopping sightline is dimensioned according to the VGU requirements (in Table 3.2.4).

Convex vertical radius (m)	Preferred minimum radius(m)	Minimum acceptable radius*
Dimensioned speed 30 km/h	140	70
Dimensioned speed 20 km/h	60	30

*Requires road authority approval

Street Furniture

Location and use of street furniture incl. public lighting

Bus stops, lighting, crossroads

Sweden

Footways, Verges and Strips

Width of edge treatment

When to put a footway? Width?

Not specified directly in requirements

Crossings

Road crossing and cycle routes crossing roads are usually critical from a safety perspective and may comprise conflict areas between different VRU-groups and/or VRU and motor vehicles.

Where do you cross a road with 2-way cycle path? How is signalisation, lighting, priority?

Not specified in the VGU per se. Cycle crossings are however regulated by the Swedish Transport Agency who writes/interprets road traffic rules and regulations. There is provision for a relatively new phenomenon in Sweden where a special type of unsignalized bicycle crossings are given a similar status to the pedestrian Zebra crossings (unsignalized). In practice thus far, alignment with the new provision in the law is not followed by local municipalities installing these road/cycle path crossings.

Where do you cross a road on a normal cycle lane? How is signalisation, lighting, priority?

Ad hoc

Where do you cross a road with a pedestrian crossing? How is signalisation, lighting, priority?

Ad hoc

How do you cross near bus stops? How is signalisation, lighting, priority?

Ad hoc

Special requirements

Design guides available for school zones?

Bus stops?

Sweden

Evaluation

Evaluations of road design

Are there any evaluations of the road designs? Check before the plans and after the plans?

1. The project officer at TRV will check that the project plan for the object.
2. The building site audit officer (BPU in Swedish) will inspect the site but this is carried out by the same construction company.
3. In some case (e.g. larger objects) an external auditor can be appointed.

This applies to state roads only! Not municipal roads.

Have they been published? Copies available?

No. There could be inspection protocols (somewhere).

Evaluation of the plans

No. No follow-ups are done.

4.2.7 United Kingdom

The interview and documentation for the United Kingdom of Great Britain and Northern Ireland was provided by the UK Department for Infrastructure. The UK uses design standards that are compulsory (although there are provisions for flexibility of application) for their national road network.

4.2.7.1 Excerpts and the corresponding documentation for the United Kingdom

VRU Vulnerable Road Users

Source: HD 42 (DMRB 5.2.5)

Non-Motorised Users (NMUs): Pedestrians, cyclists and equestrians including mobility impaired users as defined below.

1.8 Walking, Cycling & Horse-Riding modes (or users) are primarily defined within this document as:

a) Pedestrians – including mobility impaired and vulnerable pedestrians.

b) Cyclists – including mobility impaired and vulnerable cyclists.

c) Equestrians – including mobility impaired and vulnerable equestrians.

1.9 Other users to be considered as part of this process include (but not limited to):

a) Scooter riders (non-motorised).

b) Cyclists with electrically assisted pedal cycles (where these conform to Department for Transport or other relevant regional regulations and where they may legally be used).

c) Users of powered wheelchairs (where these conform to Department for Transport regulations and where they may legally be used).

Speed

What is the standard speed in UA?

- Town and cities 40 mph (45kph)

What is standard speed in NUA (non-highways (2x2 delimited))?)

- Open Road 50mph (95kph); motorways 70 mph (110 kph)

Can this change? In what circumstances? Does it often happen?

United Kingdom

How is VRU infrastructure defined?

How is it marked? Colour?

- Colour contrast should be used on With-Flow Cycle Lanes (Advisory/Mandatory) and Contra-Flow Cycle Lanes, however no definition on what type of colour is presented or how long the colour section should be.

- signage, line markings, separation distance from the road and other NMU's and kerbs are all features.

Cycle lane/cycle path…

Definitions

Cycle Lane: A lane in the carriageway for use by cyclists.

Cycle Track: A track separate from the main carriageway for use by cyclists.

Bridleway: Highway for use on foot or horseback (unless specifically prohibited, cyclists can also use a bridleway but are required to give way to other users).

Approaches that may be used in the provision of on-carriageway routes include:

- wide nearside lanes;
- with-flow cycle lanes (advisory/mandatory);
- contra-flow cycle lanes;
- with-flow and contra-flow bus/cycle lanes

Transition zone

Is a transition zone from NUA to UA mandatory? What are the dimensions? What infra is necessary?

- n/a

United Kingdom

Hierarchic road design

Categorisation of roads

Do you use a categorisation of roads that takes land use into account? E.g. bigger road with shops alongside, long small roads with housing, …

Rural Roads: All-purpose roads and motorways that are generally not subject to a local speed limit. Refer to **TA 46 (DMRB 5.1.3)**.

Urban Motorway A motorway with a speed limit of 60 mph or less within a built-up area**.**

Urban All-Purpose Road (UAP) An all-purpose road within a built-up area, either a single carriageway with a speed limit of 40 mph or less or a dual carriageway with a speed limit of 60 mph or less.

Does your categorisation trigger a certain cycle infrastructure?

- Categorisation is based on AADT, speed and percentage of HGVs on road as presented in Section 2.2 below.

Figure 31: Information contained in TA 90/05

United Kingdom

Car intensity (AADT)

Thresholds which trigger certain requirements e.g. greater than 2,000 AADT requires segregated facilities.

Amount of cars	Type of road	speed	Cycle infra	Mandatory?
< 8,000 AADT		< 20mph	Cyclists and vehicles share road	
		> 20mph	On carriageway cycle facilities	
< 6,000 AADT		20-40mph	On carriageway cycle facilities	
> 6,000 AADT			Off carriageway cycle facility	
< 1,000 AADT		40-50mph	Cyclists and vehicles share road	
> 1,000 AADT			Off carriageway cycle facility	

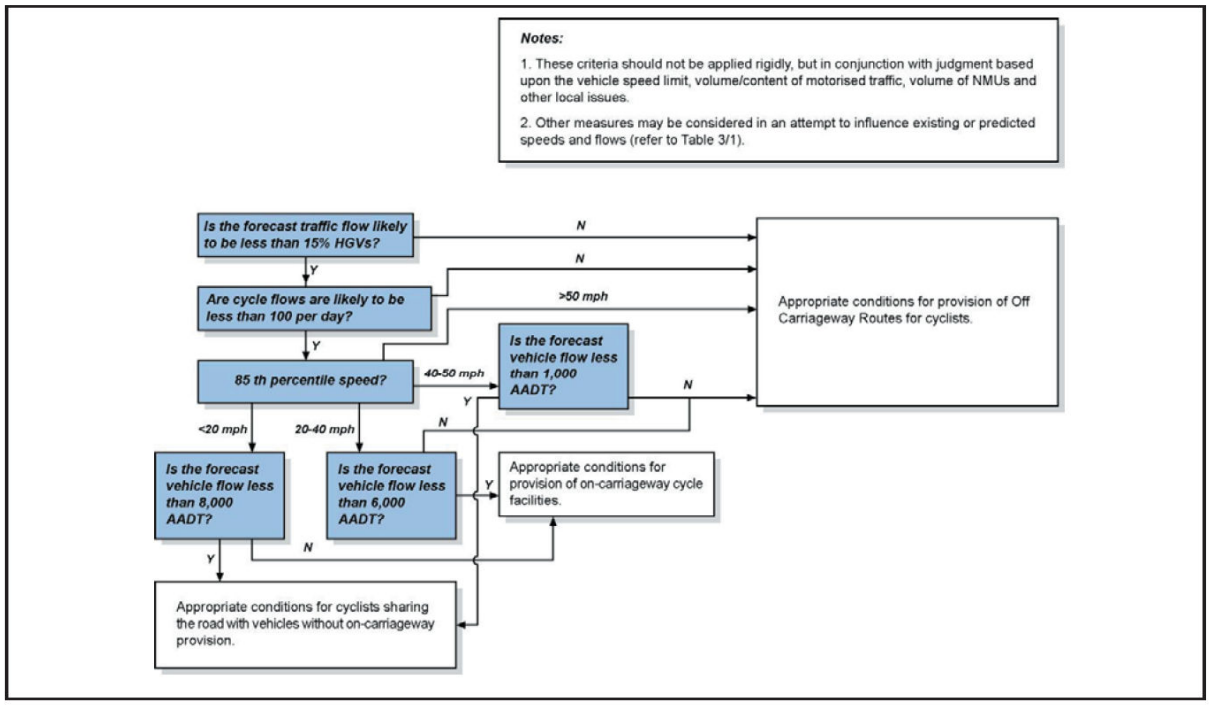


Figure 3/1: Provision of On- or Off-Carriageway Cycle Facilities

Figure 32: Information contained in TA 9/005 page 3/3

United Kingdom

Bicycle Traffic Volume

Thresholds which trigger certain requirements e.g. greater than xx cyclists per day requires segregated facilities. Possibly a combination threshold linked to both the number of cyclists and traffic volume.

Amount of cyclists	Cycle infra	Mandatory?
> 200 NMUs per hour	**Segregated or unsegregated** – combined NMU flows in excess of 200 per hour require specific measures such as kerbs, railings, verge, line marking or different surface textures to denote segregation.	

Source: TA 91/05

Off-Carriageway Cycle Routes

7.5 Table 7.2 provides values for the surfaced widths of unbounded cycle-only routes.

Preferred Width	3.0m
Acceptable Minimum	2.0m

Table 7.2 – Surfaced Widths of Cycle-Only Routes

Where it is not practicable to provide widths of 2.0m for the full length of a route, widths of 1.5m may be provided over short distances.

At gates and where routes are signed for single file use at pinch points, the surfaced width of the route may be reduced to 1.2m.

Sections of off-carriageway cycle route where single file use is unavoidable should be signed accordingly. Single file sections should be no longer than the SSD for the route. Where there are different design speeds on either side of a single file section, the lower value of SSD should be used.

Transitions from one width to another should normally be tapered at a rate no sharper than 1:7 for design speeds greater than or equal to 30kph. For lower design speeds, the taper may be reduced to 1:5.

United Kingdom

Pedestrian Traffic Volume

Thresholds which require trigger certain requirements e.g. greater than 50 cyclists per day requires segregated facilities. Possibly a combination threshold linked to both the number of cyclists and traffic volume.

Amount of pedestrians	Cycle infra	Mandatory?
> 200 NMUs per hour	**Segregated or unsegregated** – combined NMU flows in excess of 200 per hour require specific measures such as kerbs, railings, verge, line marking or different surface textures to denote segregation.	TA 91/05

Source: TA 91/05

Table 7.1 provides values for the surfaced widths of unbounded pedestrian routes. A route is considered unbounded when it is not adjacent to a physical barrier such as a wall or fence at the edge of the route. Where it is not practicable to provide widths of 2.0m for the full length of a route, widths of 1.3m may be provided over short distances.

Preferred Width	2.6m
Acceptable Minimum	2.0m

Table 7.1 – Surfaced Widths of Pedestrian-Only Routes

Shared and Adjacent Use Routes for NMUs

Shared use facilities should generally be restricted to where flows of either cyclists or pedestrians are low, and hence where the potential for conflict is low. Unsegregated shared facilities have operated satisfactorily down to 2.0m wide with combined pedestrian and cycle use of up to 200 per hour. However, the preferred minimum width for an unsegregated facility is 3.0m.

The preferred separation between different types of NMU is 1.0m, with an acceptable separation of 0.5m. Greater verge widths facilitate maintenance. Verges adjacent to field boundaries and existing hedgerows should be a minimum of 0.5m wide to allow hedges to overhang the route without interfering with its use.

United Kingdom

Preferred Minimum	5.0m (3.0m cycle route, 2.0m pedestrian route)
Acceptable Minimum	3.0m (1.5m cycle route, 1.5m pedestrian route)

Table 7.3 – Surfaced Widths of Unbounded Pedestrian/Cycle Routes Segregated by Line

Equestrian Volume

There are very few equestrian-only routes, as in practice most rights of way are shared with other users. Therefore, the cross-section of a route will normally depend upon the likely interaction of equestrians with other users.

Ridden horses can occupy a width of around 1.5m, and a surfaced width of 2.0m should be provided as a minimum to accommodate this. Where horses are expected to pass, a minimum width of 3.0m should be provided.

A Balanced Approach to Speed

Do you include visual parameters in (re)designing a new road? Confining peripheral vision. Horizontal triggers? New parameters for road design with self-explanatory background?

Design speed versus perceived speed. This includes the human factor which influences the landscape.

Yes/No

Holistic road design and planning

Alternative routes and their viability for drivers using a holistic view to the whole road network:

- Assessment of transport and mobility needs for the specific road networks
    - VRU groups and
    - Motor vehicle users (private and commercial)
- Traffic density and the road networks capacity

Is there a network for cyclists that is separated from the car network? Do you have different networks for cyclists? How is it constructed?

- Yes, off carriageway routes use TA 90/05

United Kingdom

Off Carriageway Routes (OCRs)

OCR will need to use a variety of route types along its length, in order to respond to different local constraints. For the purposes of this guidance, the following route types have been identified:

- **Route Type A** – Within trunk road verge;
- **Route Type B** – Land outside, but adjacent to the highway boundary;
- **Route Type C** – Distant from trunk road;
- **Route Type D** – Existing rights of way;
- **Route Type E** – Redundant or bypassed road;
- **Route Type F** – Minor highway;
- **Route Type G** – Other locations such as forestry tracks, canal towpaths, abandoned railway lines and farm tracks. These may be in public or private ownership.

Source: TA 91/05

Infrastructure guidelines

Obstacles and sightlines

Where there are physical objects that might cause increased hazard in a collision (e.g. large stones, hard objects, high verges etc.). Limited sightlines for either VRU or motor vehicle drivers for seeing each other.

Obstacles

Drainage and Manholes

On-carriageway drainage should be outside the effective carriageway area (including the hardstrip).

Ditches and gullies hidden in overgrown verges are a hazard, and should generally be avoided. However, where these are necessary, they should be a minimum of 0.5m back from the edge of the NMU route to avoid hazards in NMUs accidentally leave the route. Regular maintenance is essential.

Drainage grates and utility covers can also cause slipping problems for equestrians. The drainage of equestrian routes may rely on run-off to adjacent land provided this is within the boundary of the facility or road; otherwise, gullies and pipe systems may be required.

Momentary Obstructions regarding visibility

Street furniture, trees and shrubs should be located outside of the envelope of SSD where practical. In particular, trees can obscure pedestrians from approaching cyclists. Isolated objects with widths of less than 300mm are unlikely to have a significant effect on visibility and may be ignored if removal is not practicable. For unmovable obstructions wider than 300mm it may be necessary to provide markings to guide cyclists and equestrians accordingly.

United Kingdom

Obstructions at crossings

Where a cycle or equestrian route is crossed by vehicular accesses to the carriageway, and where there is a risk of obstruction to the NMU route, e.g. by parking or deposition of farm equipment, then protective posts may be used. These may be of wood 150mm square by 1.2 m high, set at 1.8 m spacing across the mouth of the NMU route. Metal or concrete posts may also be considered for urban situations.

Care should be taken to ensure that protective posts are not a hazard. Reflectors should be fitted near the tops of the posts to help cyclists to see them at night. A yellow or white non-reflectorised band may also be provided to help partially sighted pedestrians to see the posts.

Hazards Adjacent to NMU Routes (cross-section)

Where an NMU route is adjacent to hazards such as a ditch (or other water feature) or embankment slopes steeper than 1 in 3, a separation greater than that recommended in paragraphs 7.22 and 7.23 should be considered to minimise the risks. Designers should also consider providing physical barriers, such as dense shrubbery, guardrails or fences. Further information is provided in the Overseeing Organisations' standards for road restraint systems.

The risks described above are heightened at sharp bends, particularly for cyclists at night if the route is unlit. In such circumstances consideration should be given to lighting the bend, increasing the recommended separation and provision of warning signs.

Design Speed

Cyclists

Design speeds for cyclists can vary according to different types of user. The design cyclist types are:

- fast commuter;
- other utility cyclist;
- inexperienced utility cyclist (may travel more slowly than regular cyclists);
- child; and
- users of specialised equipment.

Different authorities in the UK and overseas have used a range of design speeds, from 10 kph to 50 kph. However, cyclists travelling in excess of 30 kph are less likely to be using off-carriageway facilities.

A design speed of 30 kph should be adopted for most off-carriageway cycle routes. However, where a cyclist would expect to slow down (e.g. on the approach to a crossing or a subway) the design speed may be reduced to 10 kph over short distances, with use of 'SLOW' markings.

	Design Speed
Acceptable minimum (over short distances)	10 kph
General off-carriageway cycle route provision	30 kph

Table 2.1 – Design Speed for Off-Carriageway Cycle Routes

Equestrians

There are three basic speeds of travel: walk, trot and canter. The speed is particularly affected by route surface. Grass and wood chip bark can provide adequate surfaces for cantering, whereas routes surfaced with bituminous materials are generally discouraged and would only make walking or a slow trot possible. In areas close to motorised traffic, horses may be walking, or occasionally trotting briskly, to minimise the time spent by a busy road.

Tables 2.2 and 2.3 show design speeds for different circumstances. In Table 2.2 'remote from carriageway' means that the road is either:

- generally not visible due to screening or planting; or
- visible, but more than 6m from the equestrian route.

Situation	Expected Speed
Adjacent to carriageway	Walk
On approach to crossing	Walk
Remote from carriageway (for <50m length)	Walk
Remote from carriageway (for > 50m length)	Trot/Canter

Table 2.2 – Expected Speeds for Equestrian Routes

Type of Use	Design Speed
Trot/Canter	20 kph
Walk	10 kph

Table 2.3 – Design Speeds for Equestrian Routes

Shared Routes

Where routes are shared with other users, the design speed of these routes should be relevant to that of the fastest user (see Table 2.4).

Shared Users	User for determining Design Speed
Pedestrian/Cycle	Cycle
Pedestrian/Equestrian	Equestrian
Cycle/Equestrian	Cycle
Pedestrian/Cycle/Equestrian	Cycle

Table 2.4 – Design Speeds where Use is Shared

Sightlines / Visibility

Visibility to and from NMU Crossing Points

For pedestrians, the preferred “x” distance is 2.0m, to allow for the needs of disabled people and users with prams.

The preferred “x” distance for cyclists is 4.0m, which equates approximately to the length of two cycles.

The preferred minimum “x” distance for equestrians is 5.0 m. Where an “x” distance of 5.0m is not achievable, it may be reduced to a minimum of 3.0m. It should be noted that a horse may view the major route vehicle before the rider.

	Preferred	Acceptable	Minimum for "Jug Handle" crossing
Pedestrian	2.0 m	1.5 m	N/A
Cycle	4.0 m	2.5 m	1.0 m
Equestrian	5.0 m	3.0 m	N/A

Table 3.3 – Minimum "x" Distances for NMUs at Crossings

Minor Route	85th percentile approach speed on mainline	Main Route		
		Mainline carriageway	Off-carriageway cycle route	Equestrian Route
Pedestrian/Cycle	All	As in TD 42 (DMRB 6.2.6)	As in Table 3.1	As in Table 3.2
Equestrian	50kph	135m	As above	
	60kph	168m		
	70kph	211m		
	85kph	270m		
	100kph	345m		
	120kph	At-grade crossing not recommended (See Chapter 9 and TA 91 (DMRB 5.2.4) for further details)		

Table 3.4 – Preferred Minimum "y" Distances for NMU Routes at Crossings

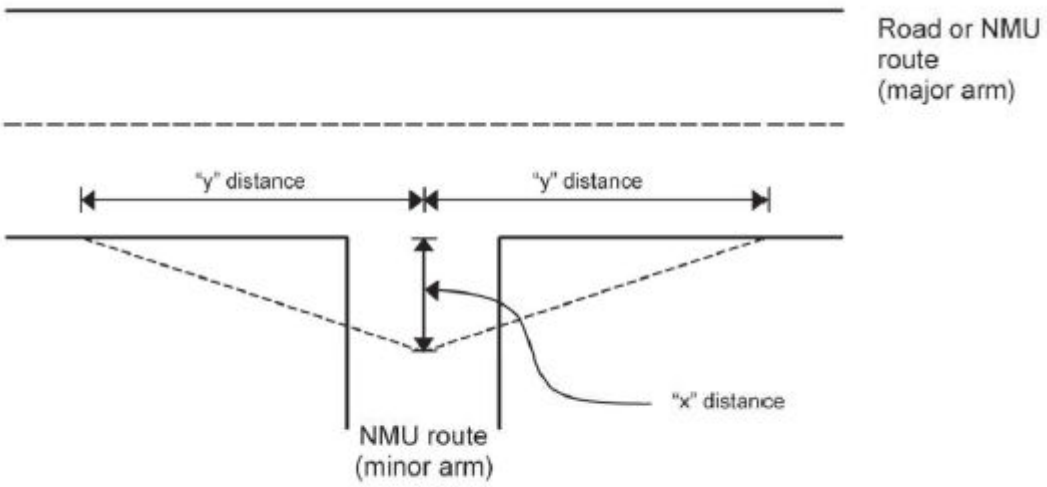


Figure 3.3 – Visibility Splay for NMU Route

United Kingdom

Headroom

Pedestrian Routes

For obstacles longer than 23m, a minimum headroom of 2.6m should be provided. For shorter obstructions this may be reduced to 2.3m.

Off-Carriageway Cycle Routes

For obstacles longer than 23m, a minimum headroom of 2.7m should be provided. For shorter obstructions, such as signs, this may be reduced to 2.4m. In exceptional circumstances, where 2.4m headroom cannot be achieved, signs advising cyclists to dismount will be required.

Equestrian Routes

The desirable headroom for ridden horses is 3.4m, with an absolute minimum headroom for ridden use of 2.8m over short distances, such as at momentary obstructions. If horses are required to be led rather than ridden, the headroom may be reduced to 2.8m over longer distances, such as under bridges. However, this should be avoided wherever possible, as horses can be difficult to control when led. In cases where horses are to be led, mounting blocks should be provided at either side of the discontinuity, together with signs advising riders to dismount.

Gradients for bicycle facilities/pedestrian facilities

The physical limitations of a cyclist to climb steep inclines…and their ability to stop when descending steep inclines are impacted by the gradient…

What is the maximum gradient going up?

What is the maximum gradient going down?

What is the maximum gradient X-axis on pedestrian facilities?

Pedestrian-Only Routes

Gradients along new pedestrian routes are considered in HD 39 (DMRB 7.2.5).

Off-Carriageway Cycle Routes

The preferred maximum gradient for off-carriageway cycle routes is 3%, with an acceptable maximum of 5%. Where new routes are constructed adjacent to the existing carriageway, the gradient will often need to reflect conditions on the adjacent road. As such, where it is not practicable to provide gradients less than 5%, steeper gradients may be considered over short distances. In these circumstances, signs advising cyclists of the need to proceed with care should also be considered.

At the base and top of gradients exceeding 2%, a level plateau at least 5m long is desirable in advance of give way or stop lines.

United Kingdom

Equestrian Routes

Most routes that cater for equestrian use will also be available to cyclists, and as such the advice in paragraph 5.4 will apply. For equestrian routes where cycle use is prohibited, the preferred maximum gradient is 20%.

Where gradients are at the maximum for an equestrian route, the material on this gradient should be non-slip surfacing (refer to HD 37 (DMRB 7.5.2)). On any gradient, the surfacing should be of a consistent material that does not create loose debris; for further information refer to TA 91 (DMRB 5.2.4).

Where the design of an equestrian facility is such that values in excess of those described above are likely to be encountered, provision of steps of height 0.15m and length 2.8m, and with gradients of half of the maximum values quoted, may be considered. However, use of such steps should be avoided where possible.

The Geometric Design of Pedestrian, cycle and Equestrian Routes - TA90/05

Horizontal and vertical deflections

E.g. …the introduction of tight horizontal radii needs to be accompanied by appropriate warning signage on the cycle facility…

Horizontal deflection: Minimal curve/optimal curve/width in curve

Horizontal

The preferred minimum radius for cycle routes is 25m. For sections of the route where the design speed is 10kph, a preferred minimum radius of 4m should be provided and consideration should be given to widening the track and providing warning signs. Table 4.1 summarises the preferred minimum radii for cyclists.

Design Speed	Preferred Minimum Radii
30 kph	25 m
10 kph	4 m

Table 4.1 – Preferred Minimum Radii

Vertical

For comfort, there should be a preferred minimum crest K value of 5.0, and an acceptable minimum crest K value of 1.6, along off-carriageway cycle routes. For the definition of crest K value, refer to TD 9 (DMRB 6.1.1).

United Kingdom

Visibility

Stopping Sight Distances on NMU Routes

Design Speed	Preferred Minimum Stopping Sight Distance
30 kph	30 m
10 kph	10 m

Table 3.1 – SSD for Off-Carriageway Cycle Routes

Design Speed	Preferred Minimum Stopping Sight Distance
20 kph	30 m
10 kph	10 m

Table 3.2 – SSD for Equestrian Routes

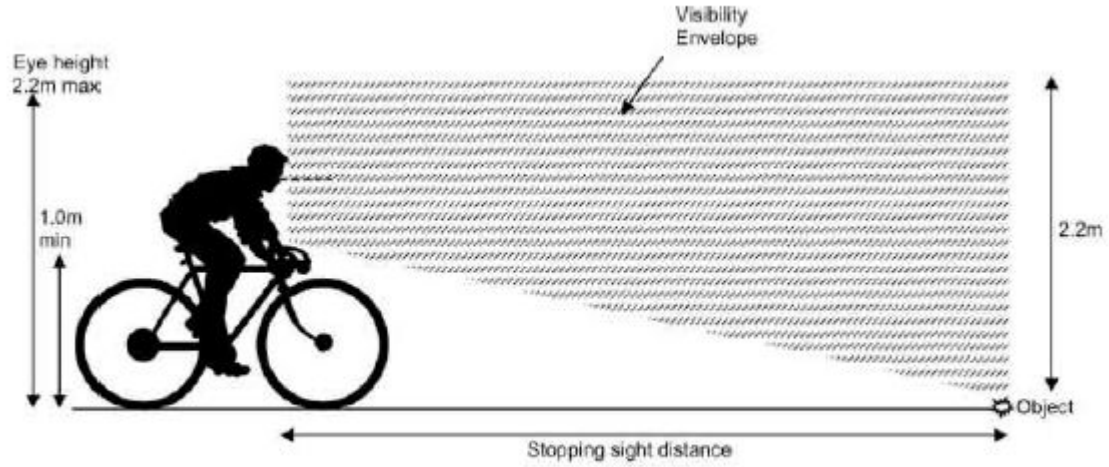


Figure 3.1 – Forward Visibility for Cyclists

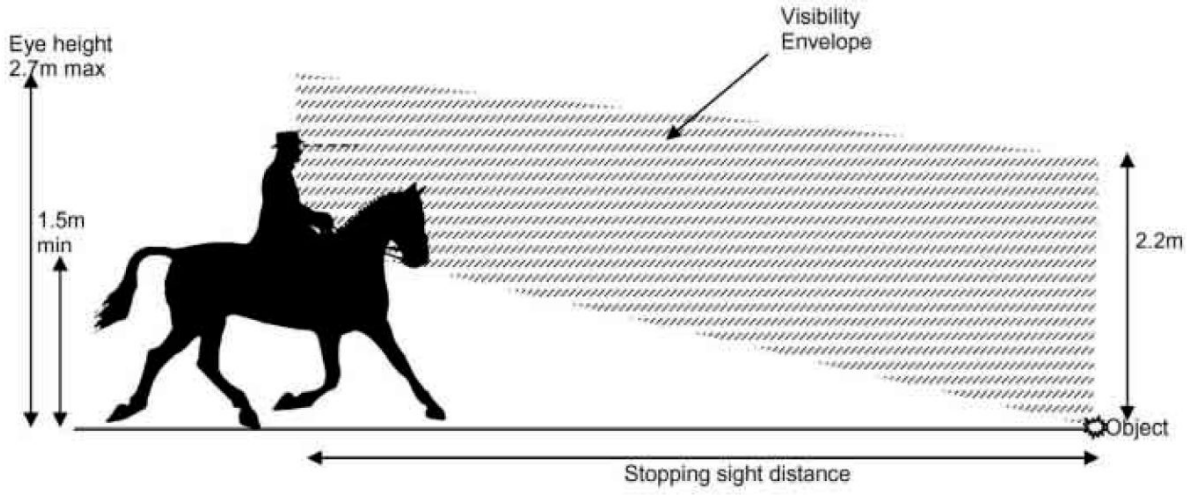


Figure 3.2 – Forward Visibility for Equestrians

United Kingdom

Crossfall

HD 39 (DMRB 7.2.5) considers footway crossfalls. For cycle and equestrian facilities, the values used for footways may be adopted up to a maximum of 5%, as higher values may create manoeuvring difficulties. Crossfalls greater than 3% can create difficulties for cyclists when the surface is icy.

Cross-Section

Pedestrian-Only Routes

Table 7.1 provides values for the surfaced widths of unbounded pedestrian routes. A route is considered unbounded when it is not adjacent to a physical barrier such as a wall or fence at the edge of the route. Where it is not practicable to provide widths of 2.0m for the full length of a route, widths of 1.3m may be provided over short distances.

Preferred Width	2.6m
Acceptable Minimum	2.0m

Table 7.1 – Surfaced Widths of Pedestrian-Only Routes

Off-Carriageway Cycle Routes

Table 7.2 provides values for the surfaced widths of unbounded cycle-only routes.

Where it is not practicable to provide widths of 2.0m for the full length of a route, widths of 1.5m may be provided over short distances.

At gates and where routes are signed for single file use at pinch points, the surfaced width of the route may be reduced to 1.2m.

Sections of off-carriageway cycle route where single file use is unavoidable should be signed accordingly. Single file sections should be no longer than the SSD for the route. Where there are different design speeds on either side of a single file section, the lower value of SSD should be used.

Transitions from one width to another should normally be tapered at a rate no sharper than 1:7 for design speeds greater than or equal to 30kph. For lower design speeds, the taper may be reduced to 1:5.

Preferred Width	3.0m
Acceptable Minimum	2.0m

Table 7.2 – Surfaced Widths of Cycle-Only Routes

United Kingdom

Equestrian Routes

Ridden horses can occupy a width of around 1.5m, and a surfaced width of 2.0m should be provided as a minimum to accommodate this. Where horses are expected to pass, a minimum width of 3.0m should be provided.

Equestrian routes where single file use is unavoidable should be signed accordingly. Single file sections should be no longer than the SSD for the route. Where there are different design speeds on either side of a single file section, the lower value of SSD should be used.

At gates, the likelihood of two equestrians meeting in opposite directions is low. BS5709:2001 specifies a minimum width for bridle gates of 1.525m between posts. A rider would expect to be able to turn 90o after passing through the gate to be able to close it from horseback. Hence, there should be a paved width of 3.0m on either side of the gate for a distance of 5.0m. Fencing for 1.5m each side of a gate should be free of barbed wire and overhanging trees.

There may be a need to turn a horse around at some point on an equestrian route. Designers should ensure that locations are available at intervals of no more than 1 km where this can be easily and safely undertaken. The surfaced width of the route at such locations should be a minimum of 3.0m.

Shared and Adjacent Use Routes for NMUs

Shared use facilities should generally be restricted to where flows of either cyclists or pedestrians are low, and hence where the potential for conflict is low. Unsegregated shared facilities have operated satisfactorily down to 2.0m wide with combined pedestrian and cycle use of up to 200 per hour. However, the preferred minimum width for an unsegregated facility is 3.0m.

The preferred separation between different types of NMU is 1.0m, with an acceptable separation of 0.5m. Greater verge widths facilitate maintenance. Verges adjacent to field boundaries and existing hedgerows should be a minimum of 0.5m wide to allow hedges to overhang the route without interfering with its use.

If the separation described above cannot be provided, segregation may be achieved by use of a post and single rail fence, railings, kerbs or delineator strips.

Table 7.3 provides values for the surfaced widths of pedestrian/cycle routes segregated by line.

Preferred Minimum	5.0m (3.0m cycle route, 2.0m pedestrian route)
Acceptable Minimum	3.0m (1.5m cycle route, 1.5m pedestrian route)

Table 7.3 – Surfaced Widths of Unbounded Pedestrian/Cycle Routes Segregated by Line

United Kingdom

Boundary Treatments

The above widths for pedestrian and cycle routes should be modified in particular circumstances as follows (see Figure 7.1): • for a route bounded on one side (where the boundary height is up to 1.2m), an extra 0.25m should be provided to allow for 'kerb shyness' between the route and the barrier; • for a route bounded on one side (where the boundary height is greater than 1.2m), an extra 0.5m should be provided to allow for 'kerb shyness' between the route and the barrier; and • for a route bounded on both sides, an extra 0.25m or 0.5m should be provided on each side as appropriate.

It is desirable to provide physical separation between NMU routes and carriageways. For pedestrians and cyclists the preferred separation between the NMU route and the carriageway is 1.5m, with an acceptable separation of 0.5m. The higher value of 1.5m should, where possible, be used on roads with speed limits in excess of 40mph. If a hardstrip is provided, this can be considered as part of the separation. Where new routes are introduced, street furniture and all vegetation (except grass) within the separation distance should be removed or the verge widened.

For routes used by equestrians, the separation of the route from the carriageway should be a preferred minimum of 1.8m. If a hardstrip is provided, this can be considered as part of the separation. Where near continuous screening is provided between the equestrian route and the carriageway, gaps should be avoided, as they may unnerve horses.

United Kingdom

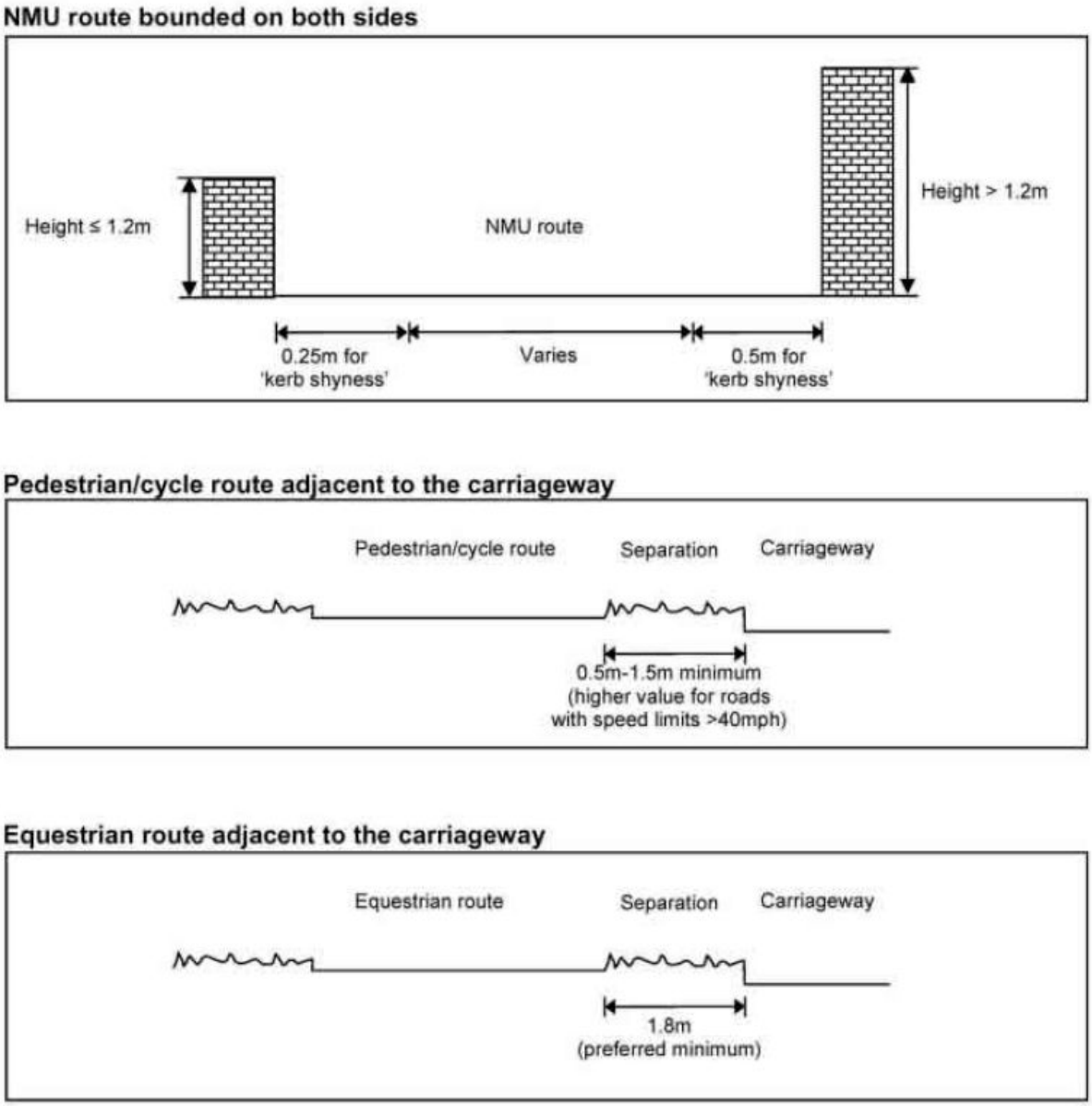


Figure 7.1: Boundary treatments for NMU Routes

Street Furniture

Location and use of street furniture incl. public lighting

Bus stops, lighting, crossroads

- Rural roads not usually lit and do not have many bus stops or street furniture. Where they are provided see the section on obstructions above.

- *United Kingdom*

Footways, Verges and Strips

Width of edge treatment

When to put a footway? Width?

- n/a

Crossings

Road crossing and cycle routes crossing roads are usually critical from a safety perspective and may comprise conflict areas between different VRU-groups and/or VRU and motor vehicles.

Where do you cross a road with 2-way cycle path? How is signalisation, lighting, priority?

- n/a

Where do you cross a road on a normal cycle lane? How is signalisation, lighting, priority?

Cycle Crossings

Where cycle tracks join or cross carriageways or Private Means of Access (PMA), dropped kerbs laid flush with the carriageway should be used as carriageway edging.

Approaches to crossings should normally be at right angles to the carriageway. Where acute crossing angles cannot be avoided, non-slip kerb surfacing should be considered. Where cycle routes are located adjacent to the carriageway and lead to crossing points, 'jug handle' layouts should be used to place the cyclists at right angles to traffic flow (see TD 42 (DMRB 6.2.6)).

Where do you cross a road with a pedestrian crossing? How is signalisation, lighting, priority?

Pedestrian Crossings

The desirable minimum crossing provision where pedestrian routes cross the carriageway is a dropped kerb laid flush with the carriageway, with associated tactile paving. Further advice on dropped kerbs is given in TA 57 (DMRB 6.3.3). Advice on assessing whether increased crossing provision is appropriate can be found in TA 68 (DMRB 8.5.1) and TA 91 (DMRB 5.2.4).

The ramp gradient across the footway to a dropped kerb should be between 1 in 12 and 1 in 20. For narrow footways, the steeper gradient will allow the width of the level strip at the back of the footway to be maximised. This will make it more comfortable for people with pushchairs or wheelchairs who do not wish to use the crossing.

Where do you cross a road with an equestrian crossing? How is signalisation, lighting, priority?

United Kingdom

Equestrian Crossings

For roads where at-grade equestrian crossings are unavoidable, a grassed holding area of 10m wide by 5m long should be provided in the verge. The holding area should be fenced to guide equestrians and highlight the presence of the facility to other users, as shown in Figure 9.1. BS5709:2001 requires structures associated with equestrian routes (i.e. bridle gates and/or horse stiles) to be a minimum of 4.0m from the carriageway.

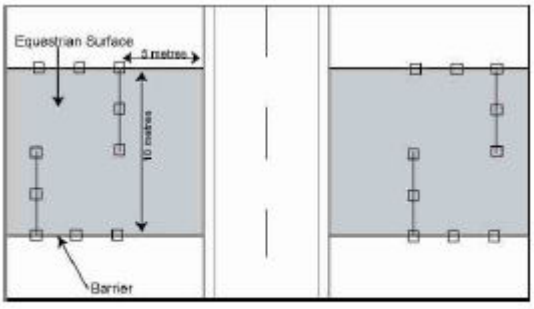


Figure 9.1: Bridleway Crossing with Holding Area

How do you cross near bus stops? How is signalisation, lighting, priority?

Informal at-grade NMU crossings should not be provided on dual carriageways of 3 or more lanes per carriageway.

In addition, informal at-grade equestrian crossings are not recommended on roads with 120kph design speed, or on wide single carriageways.

Road type	AADT flow (two-way)		
	Normally Appropriate	Potentially Appropriate (see paragraph 6.8)	Not Normally Appropriate
Single carriageway	Below 8,000	8,000 to 12,000	Above 12,000
Dual carriageway	Below 16,000	16,000 to 25,000	Above 25,000
Wide single c'way	-	Below 10,000	Above 10,000

In situations where the range is identified in Table 6/1 as 'potentially appropriate', designers should consider in more detail whether an informal at-grade crossing is suitable. This would include:

- site specific factors that may make it easier to cross, e.g. signals upstream of the crossing point, speed limits below national levels;
- potential demand to cross, types of user and types of journey being undertaken;
- overall diversion and delay caused to NMUs on routes that would use the crossing point;
- implications of providing a grade separated crossing (considering design options, environmental impact and possible ways of minimising this);

- any mitigation measures that may be possible in association with an informal at-grade crossing (e.g. speed activated signs).

For any informal at-grade crossing, consideration should be given to warning drivers of possible NMU activity using signs to diagram 562 plated with 'Pedestrians crossing' or 'Cycles crossing'. Detailed guidance can be found in the *Traffic Signs Manual, Chapter 4 (DfT, 2004)*.

Cyclists should normally use the circulatory carriageway for total flows up to 8,000vpd. Where traffic flows are in excess of this, consideration should be given to providing an off-carriageway cycle track around the perimeter of the roundabout, or provision of traffic signals to control the flow of traffic in conjunction with ASLs.

It is recommended that roundabouts with an inscribed circle diameter of over 50m and/or dual carriageway entries… that cyclists are provided with an alternative route such as an off-carriageway cycle track around the perimeter of the roundabout, with signal-controlled crossing of entry and exit arms, or the provision of a grade separated facility.

TA 91/05

Special requirements

Design guides available for school zones?

- n/a

Bus stops?

- n/a

Lighting

NMU routes in rural areas should not normally include lighting unless there are specific requirements, which include:

- high flows of NMUs, particularly on adjacent and shared use NMU facilities;
- routes with intersections with rights of way and both minor and major roads falling below
- geometry standards (lighting used at a specific point to highlight danger);
- routes which form part of an identified school route, commuter route or other route;
- through any underpass (subject to environmental impact).

Where rural OCRs require lighting, it should be continuous along the NMU route. It is also desirable that the lighting has a low environmental impact, and care should be taken at transition points from lit to unlit areas.

At surface level crossings on lit roads after dark, NMUs should always be seen in silhouette, i.e. the lighting source should be close to, but downstream of, the crossing.

United Kingdom

Any lighting columns or bollard lights should be sited a minimum of 0.5m back from the edge of the OCR, so as not to cause an obstruction to NMUs.

Where locations have no existing power supply, the use of solar powered lighting may be considered.

Further information is provided in *'Technical Report Number 23: Lighting of Cycle Tracks'* produced by the Institution of Lighting Engineers and *BS 5489.*

TA 91/05

Evaluation

Evaluations of road design

Are there any evaluations of the road designs? Check before the plans and after the plans?

- n/a

Have they been published? Copies available?

- n/a

Evaluation of the plans

- n/a

Infrastructure measures to reduce single vehicle accidents?

Any infrastructure measures to reduce accidents? Height of entry of cycle lane?

- n/a

Is there a system to study single vehicle accidents with VRUs?

- n/a

5 Summary and next steps

This chapter highlights some of the problems and/or future challenges including what may need to be solved. The same heading structure used in the interviews is applied to the summary.

Speed

Traffic calming measures; there are many different ways of applying traffic calming using road design. This could involve road geometry, physical or technical devises (e.g. speed humps that are only activated if the said passing vehicle is exceeding the mandatory speed limit).

Who is allowed to use it

Avoiding goal conflicts between motorists and VRUs in the road design. The aim for the design guidelines should aim to accommodate for human limitations and performance. It is important that the infrastructure for VRU has, where possible, a dedicated, purpose build space that is free from fast or heavy motor vehicles. It also follows that the VRU infrastructure is clearly defined, maintains a continuity (that the VRU infrastructure doesn't just 'disappear') and legibility (that one can easily perceive what is intended).

Cycle paths/lanes

A common definition of the 'cyclist's dynamic envelope' where consideration to the needs of cyclist, of different ages and abilities is factored in, would benefit particularly those countries who lack said definitions. Common definitions of what is meant by 'safely and safely share' could be developed, including what measures, metrics and threshold values that could be used (cf. Infrastructure Ireland standard, 2014, p.8).

Mopeds class 1 (i.e. mopeds that can have a restricted maximum speed of 45 km/h) are strictly speaking not included in the scope of this project, however, the ramifications of 'rural' and inter-urban moped-infrastructure use in Sweden has direct impact on all other VRU. Moped class 1 (45 km/h) on non-urban roads have "nowhere to go" (Sweden) on many inter-urban and rural roads and are, moreover, "in the way of everyone" (quotes from the Swedish expert). In Sweden mopeds class 1 (45 km/h limited) are not permitted on any cycle tracks or paths. Users of this vehicle-class are usually younger people (from 15 years of age in Sweden). There is deliberation in Sweden to make this rule more flexible, i.e. moped class 1 (max. 45 km/h) should be allowed on non-urban cycle paths, given that the AADT of bicycles is not high and that there is enough space to improve road safety for this VRU-group.

Transitional zones

Transitional zones, defined as a non-urban area which can comprise a road length which is designed between the rural and urban areas, is not always explicitly identified. These areas are however crucial from a VRU safety and attractiveness perspective. Moreover, the term *micro-transitional zones* could also help VRU (mostly cyclists and pedestrians) when being filtered into mixed traffic areas, whether in urban or non-urban areas. Explicitly identify these areas geographically and applying a user-centred design perspective improves the overall design for VRUs.

Holistic road design and planning

The road design guidelines or standards should be 'universal' in each of the respective CEDR country thus avoiding different design criteria and appearance between local or municipal roads and state-owned or national roads (in the same country). Some countries do not require e.g. town planners to follow national design criteria. This discrepancy can cause cognitive dissonance and lack of trust because a road user can encounter exceptions to 'rules' (i.e. subjectively perceived rules) and idiosyncratic traffic solutions. A road system that is predictable and appropriate also supports safety.

If the average road user perceives (for them) an apparently haphazard application of traffic rules and road design. It could undermine conformity with rules and regulations, such as the occurrence of a salient disparity between road design that is perceived as reasonable or unreasonable.

It is importance to underline the conception of creating a road design that supports road users to act 'correctly'. This is especially so for motorised road users who usually are greatest threat to VRUs. Acting 'correctly', however, applies equally to VRUs.

Evaluation

There would appear to be a common lack of evaluation of different road designs. The systematic use of evaluation of tried (but not tested practice) designs would be beneficial in sorting the chaff from the wheat. The evaluations should also be published, perhaps by CEDR, to assistance efficient transfer of knowledge to national road authorities whilst improving road safety for road user groups. Systematic, scientific evaluation of road design and measures is all but missing from all of the countries interviewed. The major benefit from this type of evaluation programme is to be able to identify and distinguish between the successful and effective designs and the ineffective or inappropriate designs. Sorting the wheat from the chaff is especially important for the town/city councils or road authorities that have a limited budget. Finances resources can more easily be put into effective measures rather than wasting money on ineffective or even potentially hazardous measures.

Summary

In summary, it has been noted that developing a forgiving and safe bicycle (urban and non-urban) infrastructure for the cyclist-group of vulnerable road users also benefits other VRU-groups, particularly pedestrians.

It is also important that planners acknowledge that VRU are not a homogeneous group. In fact, they are quite the opposite they are acutely heterogenous, more so even than motor vehicle drivers. Many VRU such as pedestrians or cyclist may only have a very basic understanding of traffic rules and the physical and mental abilities may also vary greatly. Their age range could be anywhere between 1 and 122 years old (the oldest fully authenticated human; to date).

The next steps in the SANA-4U project include the preparation of a 'Best Practise Guide' (WP2); followed by Worked Examples of Best Practice Guide (WP3); and Preparation of Guidelines for Selection of Design of VRU Infrastructure (WP4).

5.1 Highlights for a best practice guide

Some highlights for a best practice guide is provided below as possible input to WP2. This includes possible headings that could be useful when providing a structure.

A best practice guide for VRU on rural roads based on the publications provided by the CEDR members in the interviews should identify some of the following items. The expansion and revision of these items is to be developed in WP2 of this project.

The following items are:

- Applying the vision zero concept of the road owners and infrastructure managers taking responsibility for removing hazards etc. instead of leaving it up to the road users to solve/resolve e.g. design inadequacies.
- Dimensioning the infrastructure for VRU needs
- Street design
- Speed management
- Re-allocation of road space (for VRU)
- Separate cycle lanes
- Shared spaces (all users)
- Path construction
- Rural transitional zones (where separate traffic becomes mixed).
- Rural segregation lanes dependent on AADT
- Inclusion of the MV perspectives and needs

6 References

Infrastructure Ireland standard, (2014). *National Roads Authority Design Manual for Roads and Bridges.* Rural Cycle Scheme Design (including Amendment No. 1) DN-GEO-03047. Volume 6 Section 3, Part 5, NRA TD 300/14. Dublin: TII

Wickens, C.D., Lee, J., Liu, Y. & Becker S.G., (2004). *An Introduction to Human Factors Engineering (2nd Ed)*. New Jersey: Pearson Prentice Hall.

7 Appendix 1

CEDR Project - Questionnaire Octol