ANNEX X
to SWOV report
Safety effects of road design standards
R-94-7

Bicycles at intersections in the Danish road standards

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R-94-7 X
Published by: SWOV Institute for Road Safety Research, Leidschendam, The Netherlands

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Notice to the reader

This volume is one of the annexes to a main report on safety effects of road design standards which was compiled by SWOV in collaboration with other European partners, in 1993-1994.

The project was carried out with financial support of the Commission of the European Union. However, no authority of the European Union has responsability for the contents of this publication.

The main report is a composition of contributions from various authors, edited by SWOV and published in both English and French. The annexes were not re-edited but were published in the form in which they were furnished by the authors. SWOV is not responsible for the contents of annexes that were produced by authors from outside the institute.

The full publication consists of the following volumes.

Main report: Safety effects of road design standards
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Annex I: Road classification and categorization
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Annex II: Assumptions used in road design
M. Slop; SWOV Institute for Road Safety Research, Leidschendam, The Netherlands

Annex III: Methods for investigating the relationship between accidents, road user behaviour and road design standards
G. Maycock & I. Summersgill; Transport Research Laboratory, Crowthorne, England

Annex IV: International organizations and road design standards
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Annex V: National road design standards
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Annex VI: Road cross-section
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Annex VII: Road design standards of medians, shoulders and verges
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Annex VIII: Design features and safety aspects of exit and entry facilities on motorways in the EC (in German)
J. Steinbrecher; Aachen, Germany

Annex IX(E): Curves on two-lane roads
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T. Brenac; Institut National de Recherche sur les Transports et leur Sécurité, Salon-de-Provence, France

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1. INTRODUCTION

This report summarize how the subject "Bicycles at intersections" is handled in the danish road standards, distinct between urban and rural areas.

The report include a detailed summary of the standards regarding the subject. This description has been limited to the extract of standards specifically dealing with the subject "Bicycles at intersections" i.e. The conflicts between cardrivers and cyclists.

The conflicts between cyclists/cyclists, cyclist/mopeds and cyclists/pedestrians are included in the standards but excluded from this summary except the requirements of sight at path crossings which has been described in addition to tunnels and bridges in chapter 5.

The more general parts of standards i.e. contents concerning all categories of road users, has been excluded with few exceptions.

The extent to which traffic safety has determined the standard is described. A great part of the traffic safety considerations which have determined the standards is described in the standard itself and has been summarized as an integrated part of the standard summary. Supplementary traffic safety considerations has been added marked as "italics" type.

The status of standards is described in chapter 2.

The philosophy behind the danish road standards has been explained in chapter 3.

References to the bibliography is marked by figures in brackets.

2. RECOMMENDED GUIDELINES

Stating prescriptive standards for existing areas is difficult as the physical reality will often provide only limited possibilities for the application of such standards. Therefore all the instructions in the Danish road standards are, in general, non-compulsary, i.e. recommended guidelines which may be relaxed, if appropriate.

Some of the instructions concern subjects that are also described in other road standards and associated provisions, such as "Road Standards for Road Marking" and "Road Standards for Traffic Lights", and the Ministry of Justice's Order and Circular concerning the marking of roads. Wherever an instruction is stated in these road standards as compulsory requirement this status is explicitly mentioned and marked on a dark background.

3. THE PHILOSOPHY BEHIND THE DANISH ROAD STANDARDS FOR URBAN AREAS

The philosophy behind the danish road standards for urban areas is based on a fundamental road and speed classification system, in which traffic safety is of prime importance.

Two road classes

In accordance with the municipal plan's distinction between a main road network and local traffic areas, these road standards divide roads into only two classes, namely

- traffic roads and
- local roads.

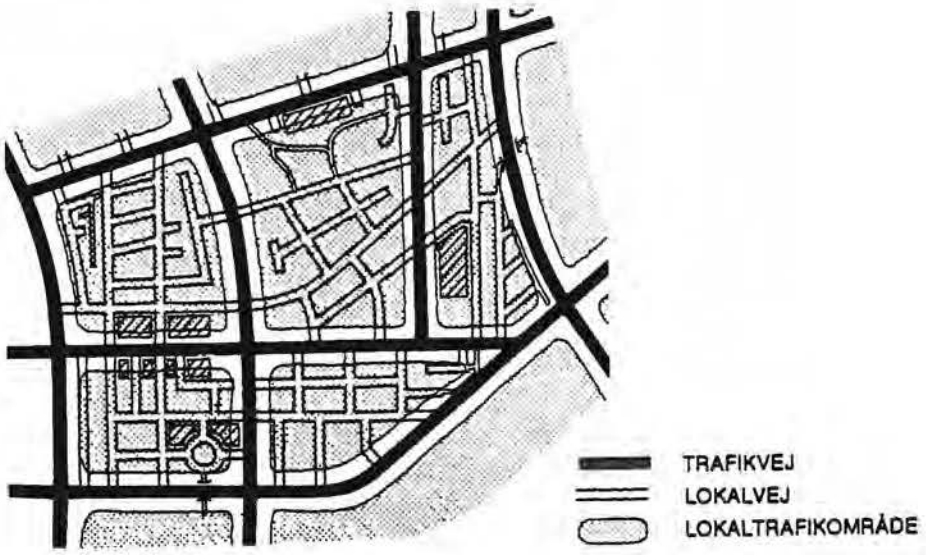


Figure 3.1 The road network.

Traffic roads

The traffic roads are the roads that constitute a municipality's main road network. They serve the through-traffic, traffic between the municipality and the region, traffic between towns, and between individual neighbourhoods or quarters of large towns.

Local roads

All other roads in the municipality are designated local roads. They serve local areas, neighbourhoods and houses, workplaces, institutions, and shops.

Two path classes

Also the light road users' traffic network can be divided into two classes, namely

- main paths and
- local paths.

The main paths, i.e. the light road users' main traffic network as defined in the municipal plan's main traffic structure, serve the main pedestrian, bicycle, and moped traffic in a given area.

Just as important, however, is the distinction between three main types, i.e.

- separate paths
- cycle tracks along roads
- main routes using local roads.

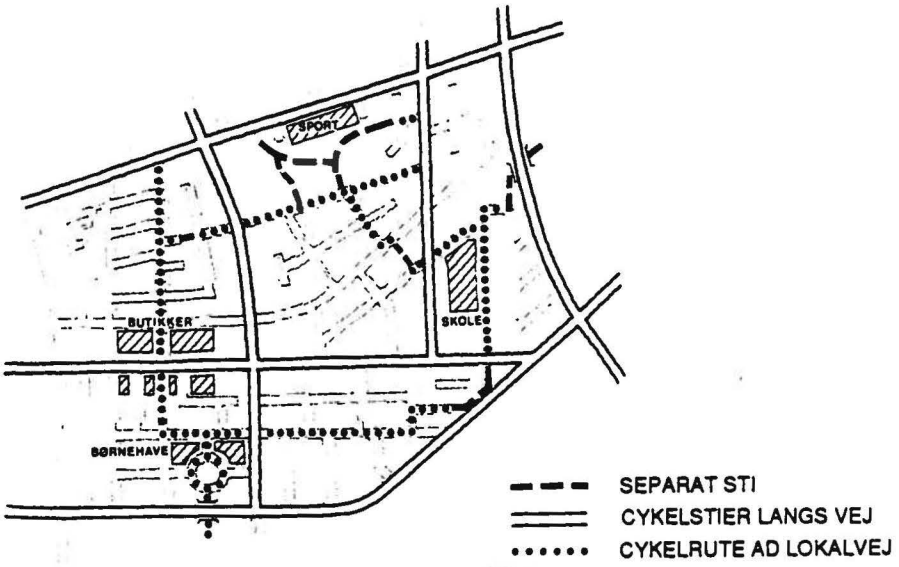


Figure 3.2 Path network.

The importance of speed

As mentioned the regard for traffic safety is of prime importance in the planning of urban traffic areas, and it has been proved through thorough investigation that speed adjustments according to the traffic context are essential for traffic safety.

All things being equal, low speed means fewer accidents, and also less damage and personal injury in the case of accident.

Whereas the concept of safety designates something measurable, i.e. the number of accidents and the resulting damage, the concept of security describes safety as experienced by people. There is not always a one-to one relationship between safety and security, but it has been proved in various investigations that the feeling of security also improves considerably when car speeds are reduced.

The fence effect of a road is the obstructing effect caused by the road and the traffic. It can be described in terms of the number of road users actually crossing the road compared to the desired or needed number of crossings, in terms of the delay caused, and in terms of people's feeling of security before and during the

crossing. As for safety and security the fence effect is also markedly changed for the better at lower speeds.

Noise impact on the surroundings drops at lower speeds. However, the noise level may increase if the lower speed results in many accelerations and decelerations, and so it is important to aim at a constant speed profile. At high speeds the noise from tyres is the major problem and at lower speeds the engine noise. The relation between speed and traffic noise also depends on the distritution of the traffic between small and large vehicles.

The more cars and the light road users such as pedestrians and cyclists, children and elderly people share the same road, the more important it is to consider the above-mentioned relation between on the one hand car speed and on the other safety, security, fence effect and noise.

Therefore the basis of road design varies substantially from the relatively few urban areas where car traffic can be effectively separated from other traffic and from the urban functions as such, and to the many existing areas where each road serves many different functions and where, accordingly, the various groups of road users must be mixed.

Desired speed

The philosophy behind the concept of desired speed is as follows:

As part of the traffic planning for a town or an urban area each individual road or stretch of road is assessed for a number of parameters:

Vehicle traffic: road class (traffic road or local road). Present and future traffic flow. Distribution on types of vehicles.

Pedestrian and bicycle traffic: road function - possibly also as a constituent part of the light road users' main traffic network. Present and future traffic flow for light road users along or across the road. Existing cycle tracks or possible construction of cycle tracks.

Bus traffic: present or future bus services along roads.

Other functions: the road as a shopping street, housing access road, etc. and as a public area.

Geometry: road alignment and profile. Free width. The possibilities of redesign.

On this basis it is decided which vehicle speed should be preferred for the road - the desired speed.

In the detailed planning and design of the road the planners should subsequently ensure that car drivers will respect this speed.

This is achieved by determining the length of the individual road stretches, when carrying out the detail design, and when designing the individual elements of the road, if necessary by incorporating speed reducing measures, and by a deliberate and consistent use of marking, planting, street layout and materials.

Also the surroundings of the road should be designed to the degree possible en accordance with the desired speed.

Four speed classes

As a basis for deciding the desired speed for each individual road the following four speed classes are applied:

High	(desired speed 70-80 km/h)
Medium	(desired speed 50-60 km/h)
Low	(desired speed 30-40 km/h)
Very low	(desired speed 10-20 km/h)

These four speed classes are used as a basis for a range of instructions in the volumes of the "Urban Traffic Areas" series. (1)

Speed on traffic roads

On traffic roads the speed classes High, Medium, or - locally and under special circumstances - Low can be used as a basis for the geometrical design.

High speed is only used in special cases. The conditions are

- that light road users, if any, are separated from motor car traffic by at least a kerb line,
- that the need for communication across the road is insignificant or can be established at another physical level,
- that no buildings have road frontage or that there are only few road exists.
- that the roadside usage is of such a kind or that roadside functions lie at such a distance from the road as not to be sensitive to the impact from high-speed traffic.

Medium speed, which is the general speed limit for urban areas, is normally used. In certain cases it may be necessary to make sure that this speed is respected by means of various kinds of speed reducing measures. At medium speed cyclists and pedestrians should generally be separated from the car traffic by at least a kerb line.

Low speed is used

- where there are many cyclists and no cycle path
- if many light road users need to cross the road
- where schools, institutions, shops, etc. have road frontage, or
- where visibility distances require it.

To ensure that this speed is respected it will often be necessary to establish various kinds of speed reducing measures.

Speed on local roads

On local roads Medium, Low, or Very Low speeds are used as the basis for the geometrical design.

Medium speed can be used when certain conditions are fulfilled, i.e.:

- where no buildings have road frontage or where there are only few road exits
- where there are only few light road users
- where visibility distances and the general road design allow it.

Otherwise *Low speed* is used. Under some circumstances it may be necessary to control speeds by means of speed reducing measures.

Very Low speed, however, is used

- where roads are designed as shared areas in accordance with §40 of the Danish Road Traffic Act
- in pedestrian streets
- in particularly sensitive areas generally, i.e. in certain squares and open spaces.

Requirements to the path system

The path system shall serve the needs of two groups of road users: the pedestrians and the two-wheeled traffic. In planning the path system the following items should be considered:

- safety and security
- accessibility
- direct routes
- connection
- clearness of layout
- environmental experiences, and
- climatic conditions.

Traffic safety is the most essential of these considerations. The others, however, are important in their own right, and contribute to attracting traffic to the path network, thereby contributing to traffic safety.

Safety and security

Safety is best ensured by constructing separate paths. In existing urban areas, however, it will often be impossible to establish separate paths that are placed and aligned so that they will be properly used.

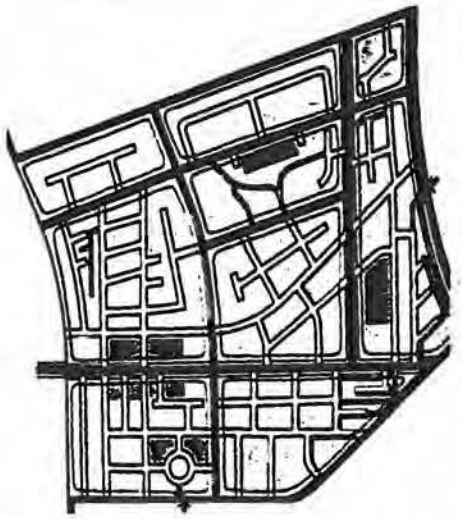
Therefore, where light road users are forced to share the ordinary road system, they should be protected by

- construction of cycle tracks along busy roads
- adjustment of car speed
- careful securing of spots where light road users cross motor traffic and
- securing of spots where there is a conflict within the group of light road users, e.g. at bus stops on roads with cycle paths.

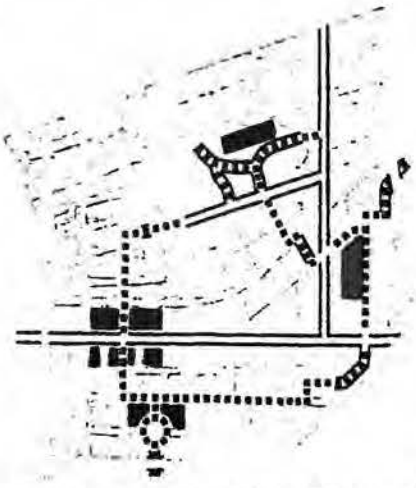
Not only safety but also the feeling of security should be a main objective in the planning of the path system. One should remember in this connection that the feeling of insecurity may be caused both by the risk of traffic accidents and by the fear of various forms of criminal action. Most importantly, separate paths should therefore be designed very carefully and special attention should be paid to unrestricted visibility, lighting and alignment along trafficked routes.

Identification of main intersections and crossing points

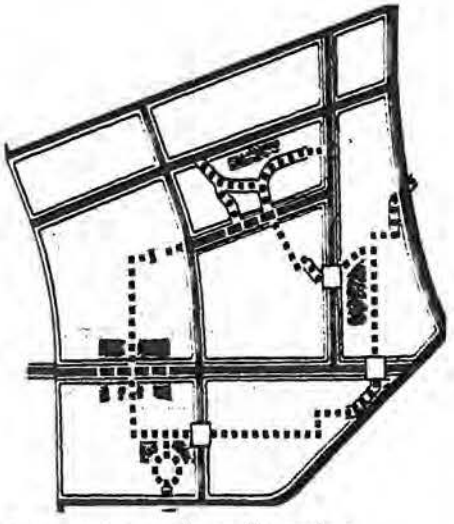
The combination of the functional classification and speed classification of the road network together with the description of the light road users' main routes lead to the identification of points of intersection.



The classified road network.



The light road users' main traffic network.



Intersections and crossing points.

4. BICYCLES AT ROAD INTERSECTIONS IN URBAN AREAS

4.1 Road safety

Consideration for road safety must be a primary condition when locating a new intersection, when choosing the type of intersection and in the detailed design of an intersection and its surroundings.

Driving over an intersection usually involves complicated manoeuvres, in which road users must perform many evaluations, eg of the position of other road users, their speeds, etc. It is decisive for road safety that road users have sufficient time to understand their situation and adapt their speed accordingly.

In urban areas and when reconstructing roads, the design of the intersections will normally be of decisive significance for the permitted speed. It can therefore be necessary to augment the desired reference speed with physical and optical measures at the intersections.

A road user who approaches an intersection shall first and foremost be able to see the intersection from a sufficient distance, in order to prepare for the necessary changes in driving. Road users on the secondary road must be warned to give way within such a distance that this is, in fact, possible, and road users on the primary road must also be given clear notification of who has right of way, at a reasonable distance from the intersection.

All road users must have a clear view, especially from the secondary road to the primary road, along the primary road (for primary road users turning left) and to the rear (for primary road users turning right).

Drivers must be able to position themselves in good time before the intersection and it must be easy to select a direction and the appropriate lane when at the intersection.

Moreover, special care must be given to light road users, ie pedestrians, cyclists and moped riders. Partly, this is because the accident risks of these road users are particularly high and the degreee of injury is usually greater. Partly, their style of travelling is less predictable than that of vehicle traffic and even small inconveniences, in the form of detours or suchlike, can cause inappropriate behaviour on their part at intersections.

In the Road standards for urban areas, a number of general requirements based on safety considerations are ennumerated, ie the location, marking and design of intersections. It will often be difficult to satisfy these requirements in urban areas. For this reason, it can often be necessary to apply the requirements "in reverse", ie by removing intersections and junctions that are unsuitably located or that cannot be given a reasonable form.

4.2 Types of intersections

The table of Fig. 4.1 shows a guide to the combinations of the main types of intersections and reference speeds.

	Speed class			
Type of intersection	Very low (10-20 km/h)	Low (30-40 km/h)	Medium (50-60 km/h)	High (70-80 km/h)
Intersection controlled by traffic lights		X	X	(X)
Priority F-junction not controlled by traffic lights		X	X	(X)
Priority T-junction not controlled by traffic lights		X	X	X
Exit construction from side road	X	X	X	(X)
Roundabout		X	X	X
Non-priority crossing	X	X		

Figure 4.1 Combinations of type of intersection and the reference speed of the major road.
The combinations marked with "(X)" are not to be recommended and should therefore not be used in new constructions.

4.3 Traffic lights

Traffic lights for the sake of cyclists

Traffic lights can be established for the sake of cyclists where:

- there is a special risk of accident
- there are many cyclists and/or pedestrians

the total average hourly traffic of pedestrians and cyclists who cross the road in the four peak traffic hours - not necessarily consecutive - exceeds 200, when the total average hourly traffic driving on the road they must cross exceeds 600 in the same period. Where there are traffic islands the latter figure can be increased to 1000 vehicles. Close to schools, old-peoples homes, etc., special circumstances may apply (large number of vulnerable road users, but for short periods).

In this context, a warning is appropriate against excessive reliance on the safety-promoting effects of traffic lights. In cases where many accidents occur between motorists due to crossing and turning, traffic lights can reduce the accident count but they will very often increase the number of tail collisions, accidents when turning left in front of traffic from the opposite direction and accidents between light road users and turning traffic.

Cyclists traffic lights

Cyclist traffic lights are an auxiliary aid, which is significant only to cyclists and moped riders, for whom they replace normal traffic lights.

Cyclist traffic lights can only be used where there is a cycle path and then only if the signaling for cyclists differs from the signaling for vehicles, eg if cyclists are given an early green light.

Cyclist traffic lights should be erected at the stopline or, where circumstances make it desirable and where there is absolutely no doubt about the stopping point, within 5 m of the stopline. They shall be located to the right of any main traffic lights controlling the same direction. Their location shall be such that it is impossible to confuse the two sets of traffic lights.

Apart from the above, the cyclist traffic lights can be repeated as directly as possible in the field of view of the waiting cyclists.

Cycle detectors

Cycle detectors should operate automatically.

However, where special circumstances apply, manually-operated detectors (push-buttons) can be used. In such cases, they shall incorporate indicator lamps that catch the eye of cyclists and that apply obviously to the relevant stream of cyclists.

Traffic lights. Safety periods

The safety periods between opposing sets of traffic lights shall be long enough to ensure a reasonable degree of safety. On the other hand, excessive safety periods can easily be considered unacceptable and can therefore diminish the respect of road users for the traffic lights.

As a rule, the safety period between two arbitrary opposing sets of traffic lights are set so that the road users just avoid each other, when the parameters (dimensioning values) of the table below are used.

When all potential for conflict has been investigated, the safety periods are determined on the basis of the most dangerous situations, ie those that demand the longest safety period.

	Earliest road user		Latest road user	
Guiding dimensioning values for calculation of safety period	Speed v^s	Passage time before green	Speed v^r	Passage time after green
Vehicle (8 m long) (0 m with respect to pedestrians)	13 m/s	0 s	13 m/s	3 s
Bicycles with respect to drivers	8 m/s	0 s	5 m/s	2 s
Bicycles with respect to pedestrians	10 m/s	0 s	5.5 m/s	0 s
Pedestrians	2.5 m/s	0 s	1.5 m/s	0 s

Figure 4.2 Note: the figures in the table must only be considered as dimensioning values, which experience shows usually give reasonable safety periods, regardless of whether or not they are completely reflect reality. (6)

Speed measurements on cyclists in signalized urban intersections have shown that the speed of "the latest cyclist towards car" on 5 m/sec is too high (6, 12).From the measurements (12) it is suggested to reduce this basical speed value to 3.5 m/sec) for safety reasons.

The recommended values on "Passage time after green" is based on 20 year old information on road user behaviour and must be reconsidered

4.4 Individual elements

Lanes

<u>At intersections without traffic lights</u>

Right-turn lanes for vehicles are normally only recommended on primary roads where there is heavy vehicle traffic and a cycle path. Right-turn lanes remove the pressure on drivers turning right to turn too early, thereby possibly colliding with cyclists.

Omitting to establish a right filter lane can have the effect of slowing traffic.

Roads at roundabouts should only have a single access lane and a single exit lane to ensure the safety and security of light road users.

The widths of access lanes where bicycle traffic is only insignificant should normally be kept within the intervals shown in the table of Fig. 4.3. In cases where cyclists use the straight-ahead lanes extensively their width should be increased by 0.75 m, on roads with speed class "Medium" or, exceptionally, "High".

The addional 0.75 m to the lanewidth in cases with high volumen of cycle traffic is for the reason that forcing of cyclists resulting in safety and security problems shall be avoided.

Lane	Speed class			
	Very low (10-20 km/h)	Low (30-40 km/h)	Medium (50-60 km/h)	High (70-80 km/h)
Straight-ahead lane at intersection with traffic lights or on primary road at priority intersection	2.50*)-2.75	2.75-3.00	3.00-3.25	3.50
Pure turning lane at intersection with traffic lights or left-turn lane on primary road at priority crossing		2.50*)-3.00		
Access lane on secondary road at priority crossing		2.50*)-3.50		

*) A lane width of 2.50 m should only be used where vehicles with a breadth of more than 2.20 m are encountered only rarely. Otherwise, the lane breadth should be at least 2.75 m. The marking of lanes narrower that 2.75 m requires dispensation from the compulsory requirements in Road Standards governing lane marking and from Circulars governing road marking.

Figure 4.3 Lane widths (m), traffic lanes with only insignificant cycle traffic

Cycle paths

Intersections with cycle paths on one or both roads should be given appropriate facilities for cyclists, according to the following principles.

When determining the routes of cyclists at intersections, detours should be avoided as far as possible and short cuts should be made difficult or prevented - but without reducing the view.

Cycle tracks and cycle lanes should only be conducted round the corners of intersections where cyclists never turn left or ride straight ahead.

At intersections with traffic lights, cycle paths should be located immediately adjacent to the vehicle lane in the access area, partly to limit the total area of the intersection and partly to enable drivers to see the cycle path in their right-hand mirrors.

Cycle tracks and lanes can be continued to the stopline. However, this can diminish safety conditions, especially for moped riders.

Instead, the cycle track or lane can be interrupted at some distance from the stopline, which makes it possible for cyclists, moped riders and right-turning vehicles to mingle in a lane marked with right-turn arrows.

However, if cycle traffic is to be controlled independently, it is necessary to bring the cyclists up to the stopline.

The general experiences from danish and nordic research during the last years say that the safest solution in signalized urban intersections is to let cyclists approach the intersection so close to the cars moving in the same direction that the two road users can easily observe each other.

This can take place on a shared right turn lane (although cyclists feel much less safe here), on a cycle lane (painted) or on a cycle track, on which special attention - enhancing and separation securing arrangements have been installed. (9, 10, 11)

The ongoing danish research project on "safety of cyclists in urban areas" managed by Danish Road Directorate include research on these last mentioned arrangements. (10)

Conversely, inherently unsafe designs are intersection layouts like a cycle track through the intersection at some distance from the roadway, say about 3 metres at the intersection road, and like wise the usual Danish curbed cycle track right up to the stopline. (9, 11)

At intersections without traffic lights, a cycle track can be interrupted or continue through the crossing (junction of side road with exit construction) and, in the latter case, it can also be relocated closer to the secondary road (staggered cycle track); see Figs. 4.4, 4.5 and 4.6.

There is no basis for choosing between the three principles out of consideration for the conditions of cyclists. In the case of moped riders, an interrupted cycle path is safest.

Where a cycle track passes through a crossing (Fig. 4.5), it should be immediately adjacent to the vehicle lane, so that the drivers of trucks can see in their right-hand mirrors cyclists approaching from behind.

Where a cycle track is staggered (Fig. 4.6), the degree of staggering should be so great that cyclists can be observed through the side windows of vehicles turning right and so that a private car can wait for the cycle-path traffic, without the driver feeling compelled to start too soon by vehicles driving straight ahead. Nevertheless, the cycle track shall be an considered and integral part of the crossing. Staggering by between five and seven m will normally serve this purpose.

At roundabouts, cycle paths shall be located immediately adjacent to the vehicle lane. Along the access and exit lanes, the cycle paths shall extend right up to the circulation area, so that cyclists are not crowded by right-turning vehicles.

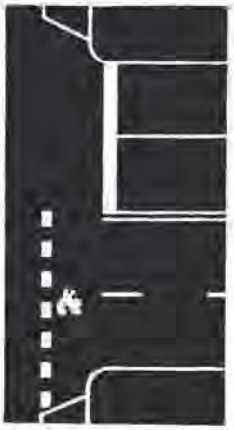
Figure 4.4 Interrupted cycle track.

Figure 4.5 Cycle track continuous through crossing.

Figure 4.6 Staggered cycle track.

Cyclists overpasses

S 21



Where a cycle path is interrupted and where it is considered that there is a need to draw attention to conflicts between cyclists and motorists, the cyclist overpass should be demarcated by a broad broken line, possibly supplemented with cycle symbols, cf Statutory Orders and Circulars on marking.

Statutory order on marking of roads, Paragraph 48 S 21 "Cyclist overpasses"
Areas in crossings that indicate that cyclists and moped riders must use the relevant part of the road. Such areas are marked with a broken broad line, with line sections and breaks of equal length, or with a blue surface. V 21 "Cycle symbol" shall always be marked in the area.

Circular on marking of roads, Paragraph 48, S21 "Cyclist overpasses"
185. Cycle areas shall be marked as "cyclist overpass" where it is considered that there is a need to draw attention to conflicts between cyclists and motorists.

Cyclist overpass must not be established for cyclists and moped riders that must give way or must turn right.

Cyclist overpass must be marked with broad broken lines extending to the separation between opposing traffic lanes of the road that crosses. If the lane width of the road that crosses is less than 5.5 m, the line should extend right through the crossing. Only the left-hand edge of the cyclist overpass should be marked. The line shall be marked with 50-cm long, 30-cm broad markings.

V 21 "Cycle symbol" shall always be marked in the area.

In more complex intersections, the line can pass right through the intersection and the right-hand edge of the cyclist overpass can be marked with a broken broad line. Where the right-hand edge of the cyclist overpass is bounded by another marking, eg a pedestrian area or give-way line, the broken line at the right-hand edge of the cycle area can be omitted.

186. At more complex intersections, the entire cyclist overpass can be marked in blue as a supplement to, or replacement for, broad broken lines. This type of marking should be used where the risk of accident to cyclists and moped riders is especially great, eg where such paths extend bi-directionally over a side road or bi-directionally through an intersection controlled by traffic lights, or where turning in

V 21

the same direction across the cycle-path crossing is permitted from more than one lane, or where it is not possible to gain a reasonably free sight between the vehicle lanes and cycle path before the intersection. Blue is the only colour used for marking of cycle passes at intersections.

If a cyclist overpass is not marked in blue it has the same colour as the surface of the vehicle lane. The cycle-path surface can be used in the cyclist overpass if a long, contiguous path system has special surfacing, such as red, to emphasise the structure of the path system.

If the path surface extends through the crossing, a cyclist overpass shall be marked with a broken broad line and cycle symbol.

Bi-directional cycle tracks

Where a bi-directional cycle track crosses a traffic road, the crossing should either be controlled by traffic lights or, possibly, a roundabout should be constructed.

Where it crosses a local road at an intersection without traffic lights, the cycle track can cross the road at the pavement level.

Bi-directional cycle tracks shall always extend right up to the crossing.

It will normally be advantageous from the standpoint of the safety of cyclists if right-turn lanes are constructed at the intersection.

The strip separating the vehicle lane and bi-directional cycle track shall be not less than 1 m and not more than 6 m broad. However, if there is a right-turn lane, the width of the separating strip can be reduced to 0.5 m or it can be replaced by a raised kerb. Where vehicles turning right and cyclists travelling straight ahead share a common period of the green light, the breadth of the strip must not exceed 0.5 m.

The value on 0.5 m width is for the reason that right turning cardrivers and straight ahead going cyclists approaching the intersection shall drive so close that they can easely observe each other and thereby avoid accidents in signalized intersections.

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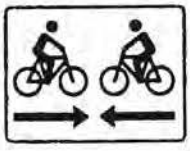
B 11

B 13

UB 11,2



A Circular on road marking contains the following on cycle tracks at crossings.

The bi-directional cycle track shall be marked with a broken narrow line, with line sections and breaks of equal length. The line shall extend across side roads and driveways.

At side roads, both sides of the line shall be marked with V 21 "Cycle symbol". Sign B 11 "Give way unconditionally" shall be erected at side roads and exits from which road users cross a bi-directional cycle track. However, this does not apply to exits from individual properties that are not visited by many road users who lack a knowledge of the local area. The sign shall also display the UB 11.2 supplementary sign.

If sign B 13 "Stop" is present, supplementary sign UB 11.2 shall be placed below it.

Where cyclists and moped riders cross the vehicle lane at the start or end of a bi-directional cycle track, warning sign A 21 "Cyclists", with supplementary sign "Cyclists crossing", should normally be erected.

Statutory order on marking of roads, UB 11.2 "Bi-directional cycle track"
The supplementary sign indicates that the road that crosses has a cycle track, along which travel is permitted in both directions.

This sign can be mounted below signs B 11 and B 13.

Circular on marking or roads, UB 11.2 "Bi-directional cycle track"

UB 11.2 shall be mounted below B 11 and B 13 if road users approaching from the side road can cross the bi-directional cycle track that crosses the side road.

UB 11.2 shall also be mounted if a bi-directional cycle track starts or ends at the relevant side road.

When driving out from a road crossed by a bi-directional cycle track in an urban area, the "give-way" line shall be marked with S 11 "Give-way line" and B 11 "Give way unconditionally" at the right-hand side of the secondary road.

Marking with B 11 also applies if traffic at a four-pronged intersection can cross a cycle track on the opposite side of the intersection.

Circular on the establishment of bi-directional cycle track along roads

As the number of cycle paths and side roads is significantly lower outside urban areas, and as the side roads, etc., often carry less traffic than in the towns, there will often be potential for establishing bi-directional cycle tracks along arterial roads outside urban areas.

A. Bi-directional cycle tracks outside urban areas.

1) There should not be heavily-trafficked side roads along the stretch. Where a bi-directional track crosses a heavily-trafficked road outside a intersection, the intersection should be constructed at another level, controlled by traffic lights or interrupted by staggered cycle gates.

3) The establishment of right-turn lanes before side roads has safety value for path users. When right-turn lanes are constructed, the dividing strip towards the vehicle lane should be narrowed down to 0.5 m or be replaced by a kerbstone boundary.

The dividing strip shall be correspondingly narrowed at traffic-light controlled intersections, cf Item c 2.

4) The dividing strips should have a maximum breadth of 6 m. The sight of the intersection shall be sufficient to ensure that vehicle drivers who shall give way to cyclists when crossing the path can, in fact, do so.

6) Bi-directional cycle tracks should, to the greatest extent possible, be terminated at road junctions where road users can be expected to be prepared for crossing road users. At the ends of tracks, cycle gates, fences, railings

or other measures should be established that can induce cyclists riding on the left-hand side of the road to reduce their speed. Paths must not end on stretches where right is restricted.

Any cycle gates, etc., at the ends of paths shall be illuminated.

7) Where a bi-directional track running alongside a primary road crosses a small side road and the track is used mainly by cyclists, the track can pass over on an exit construction across the side-road junction. Such exit constructions must not be used at major road junctions or at intersections controlled by traffic lights.

C. Bi-directional cycle tracks at intersections controlled by traffic lights.

1) Regardless of the traffic intensity, the manner in which they shall behave in the intersection must be clear to all permitted streams of cycle traffic. Thus, the way in which turning is permitted shall be clearly and unambiguously indicated to all streams of cyclists turning into or from the bi-directional cycle track. The directives must only demand behaviour that can be expected of cyclists.

If a turning cycle stream is not controlled separately, the sequence of signals issued by any signaling system with more than two phases must be considered "natural." The sequences used must not be so unexpected that cyclists undertake the turn at an unsuitable point in any sequence.

2) When a bi-directional cycle track is located to the right of a vehicle lane with right-turning traffic, and the two traffic streams share a common green period, the breadth of the bi-directional cycle track over a suitable distance before the stopline must not exceed 3 m and that of any dividing strip towards the vehicle lane must not exceed 0.5 m.

3) The two opposing streams of a bi-directional cycle track shall receive the green light at the same time. Moreover, the cyclists shall receive the green light at the same time as a pedestrian area beside the cycle track. However, small deviations resulting from differences in time taken to leave the area can be tolerated.

4) Conflicts between right-turning motorists and cyclists travelling in the opposite direction, and between left-turning motorists and cyclists travelling in the same direction, can be resolved through separate control of the turning vehicles or through separate control of the cyclists. If this is not the case, the motor vehicles' turns must be undertaken from a single vehicle lane, which must not be used by vehicles travelling straight ahead. Moreover, such conflict situations shall be apparent under all conditions. In all situations, there shall be clear markings with traffic signs and lane markings and the cycle track shall at least be illuminated in accordance with the Circular of September 26, 1979, on road illumination, Paragraph 2.1.7, Item 4, and Paragraph 2.2.4.

5) If cyclists from a bi-directional cycle track are controlled by separate sets of lights, there shall be a minimum of two sets of special cyclist lights for each direction. Only normal traffic lights shall be erected when cyclists from a bi-directional cycle track can ride straight ahead at the same time as motor vehicles can turn, unless there is a particular reason for cyclist lights governing the relevant direction to operate in a sequence other than that of the main traffic lights. Thus, different types of lantern can be used for each stream of the cycle track.

6) After taking a bi-directional cycle-path crossing controlled by traffic lights into operation, and in the event of any subsequent change in the traffic conditions of such a crossing, especial care must be taken to check that traffic flows with a reasonable degree of safety. Especially in the case of major intersections, it may be found necessary to erect clearer markings than were originally considered necessary or to use traffic lights to control potential conflicts, if such conflicts incur greater risks than were originally expected.

Stoplines

In conjunction with traffic-light control, stoplines are normally located 0.1 to 0.5 m from the pedestrian zebra crossing, cf Road Standards for marking of lanes. However, out of consideration for the safety of pedestrians against vehicles that start too early, and for cyclists against right-turning vehicles, consideration should be given to whether the stopline should be located between 4 and 5 m from the pedestrian zebra crossing. Regardless of this, stoplines on cycle paths should be located immediately adjacent to the area.

Safety effects on recessed stoplines for car traffic in signalized urban intersections has recently been documented in the ongoing danish research project on "Safety of cyclists in urban areas". (10)

Traffic Islands

The break in the cycle path shall be of the same breadth as the path and without any raised kerbstone.

Geometry of roundabouts

Out of consideration for the safety and security of light road users, only a single access lane and a single exit lane should be constructed on each of the adjacent roads.

Where cycle paths are established, their minimum width shall be 1.7 m, including the edge line or kerbstone.

Where it is considered necessary to reduce the speed of vehicles, humps can be located in the approach, about 5 to 10 m from the circulation area, or else the roundabout's cycle path and pavement can be pass the road fork as an exit construction.

Pedestrian crossings and cycle tracks or lanes should normally be located directly adjacent to the circulation area. The give-way line on the access road should be located before the pedestrian crossings.

Recessed pedestrian crossing and/or cycle track crossing can be justified by the unacceptable risk of queuing back into the circulation area or by the special circumstances prevailing when a bi-directional track passes a roundabout.

A recessment of pedestrian/cyclist crossings should be at least 10 to 15 m and should be accompanied by an unconditional obligation to give way to right-turning traffic, possibly supplemented with a cycle gate.

If the degree of staggering is too great there may, in certain cases, be a risk that cyclists use the vehicle lane instead of the cycle path around the roundabout.

There is insufficient knowledge on accidents at roundabouts to choose between cycle lanes, cycle tracks or neither in the circulation area.

The construction of cycle tracks demarcated by kerbstones can be justified by:

- greater security for the cyclists
- less risk of crowding from vehicle traffic
- less inclination to cut corners on the part of cyclists

- natural continuation of the cycle path along one or more of the road forks
- narrower construction and appearance, which results in reduced vehicle speed.

Where there is only limited traffic, cycle paths and pavements can pass a road fork as an exit construction;

Where a cycle track or lane is constructed at a roundabout, it should be continued some distance along any road forks that otherwise lack cycle tracks or lanes. This is especially important on the approach.

Where there is a cycle track or lane alongside the circulation area, it should be marked as a cycle area where it passes the road forks. The cycle-area marking shall either be coloured blue or comprise two concentric broken lines (0.5-0.5). Moreover, it shall be marked with cycle symbols that are clearly visible to motorists entering and leaving the roundabout.

The danish road standards on roundabouts are in general based upon special attention to safety of cyclists. The conflicts between circulating cyclists and entering and exeting cardrivers cause high risk situations to cyclists in urban roundabouts.

The speed reducing design of roundabout leave time enough for the cardrivers to observe cyclists and give right of way for circulating two-wheelers with the purpose to reduce risk and encrease the feeling of security.

The ongoing research project "Safety of cyclists in urban areas" also include analysis on road users behaviour in roundabouts related to different design solutions.

Narrowing

The traffic lane can be narrowed, where it is desired to construct crossings so that they help to reduce the speed of vehicle traffic.

On roads of speed class "Low" and "Very low", which have only low traffic intensity, the traffic lane can be narrowed in the immediate vicinity of the intersection to a single lane shared by the traffic from both directions. The lane breadth should be at least 3.5 m, out of consideration to cyclists, but in other respects should be suited to the turning area required by the dimensioning vehicle.

Raised areas and humps

Where it is desired to construct intersections so that they have a speed-reducing effect on vehicle traffic, on roads with a reference speed of 50 km/h or less, raised areas and ramps can be constructed, or humps can be located close to the access and

exit routes. The design of speed reducers is described in detail in Volumen 7 in the Road Standards of urban areas. (1)

Change of road surface

This can be used as a supplementary speed-reducing measure or for the marking of areas that are wholly or partly reserved for particular groups of road user or types of vehicle.

The advantages of establishing such areas should be weighed in each individual case against the accompanying inconvenience, in the form of poor friction, drainage difficulties, maintenance difficulties, noise and inconvenience to light road users.

Exit constructions

Exit constructions should be constructed as a raised level with a differing surface, as an extension of the strip and/or pavement of the major road, or as an unbroken pavement and/or cycle track along the major road.

The difference in level between the exit construction and vehicle lane of the major road should be between 10 and 12 cm and, out of consideration for efficient reduction of the speed of right-turning vehicles, the gradient of the ramp should be as much as 30%. However, consideration for cyclists and invalids can require a lower ramp gradient; see the table of Fig. 4.7.

The difference in level towards the vehicle lane of the side road can be less and, in this case, the ramp gradients shown in the table of Fig. 4.7 should be applied, out of consideration for cyclists.

The use of cobble-stones as surfacing for exit constructions should be avoided out of consideration for cyclists.

Ramp height	Ramp gradient
6 - 8 cm	30 %
8 - 10 cm	20 %
10 - 12 cm	25 %

Figure 4.7 Dimensioning parameters for ramps between an exit construction and the vehicle lane of a side road.

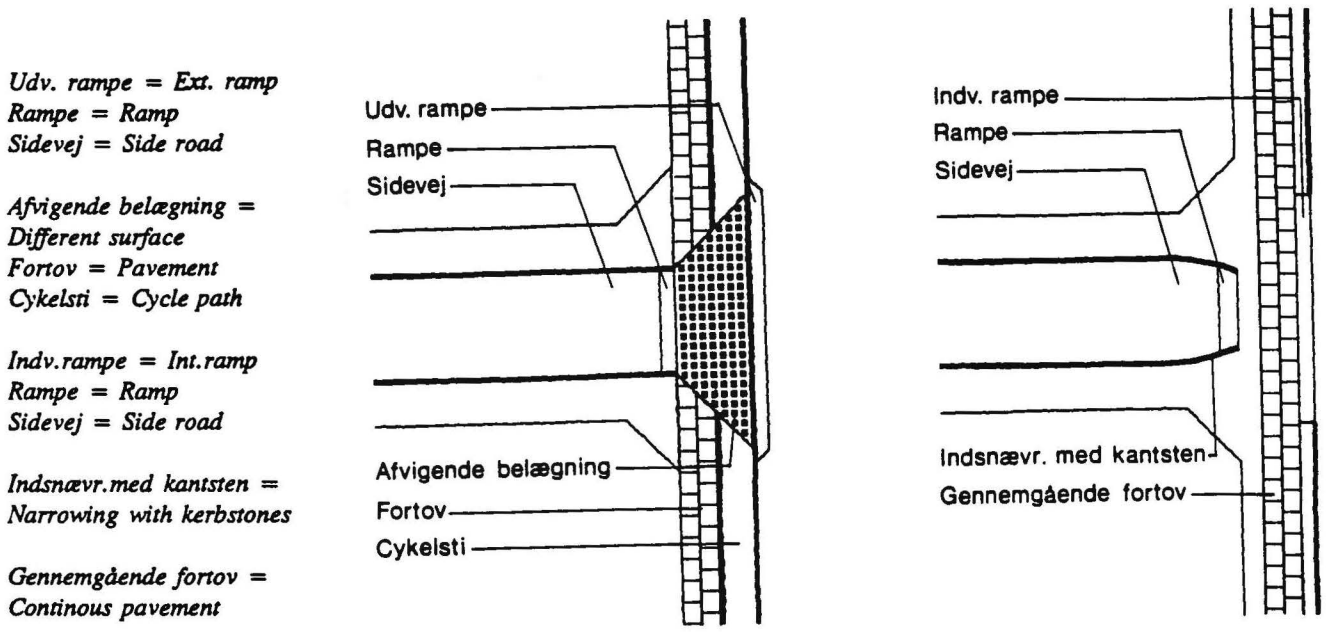


Figure 4.8 Schematic drawing of exit construction.

Exit constructions have a positive safety effect on cyclists, documented by research.

Railway crossings

Railway crossings, ie crossings of rails and vehicle lanes or cycle paths, should be constructed with an incline of between 70° and 110°.

4.5 Signt at intersections

Sight area

There must be a clear sight from the stop position of the secondary road at all intersections where there is an unconditional obligation to give way. There should be a clear sight from this point to the vehicle lane of the primary road and to any cycle path on the primary road.

The necessary sight of the cycle path will often fall within the area of sight needed for a sight of the vehicle lane. In other cases, an additional triangle may be needed, as shown in Fig. 4.9.

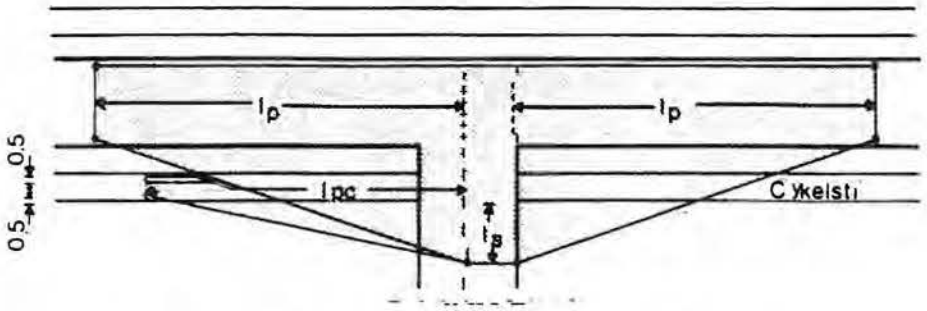


Figure 4.9 Sight area, intersection with cyclists on primary road.

Where it is especially difficult to arrange sufficient sight, l_s can be calculated from the vehicle lane, instead of from the edge of the cycle path, as far as the sight of the vehicle lane is concerned; see Fig. 4.10.

In the case of bi-directional cycle tracks along the primary road, sight shall be provided to the right and to the left. Where uni-directional cycle paths are, in practice, used as bi-directional, it can also be of relevance to provide a sight of both sides.

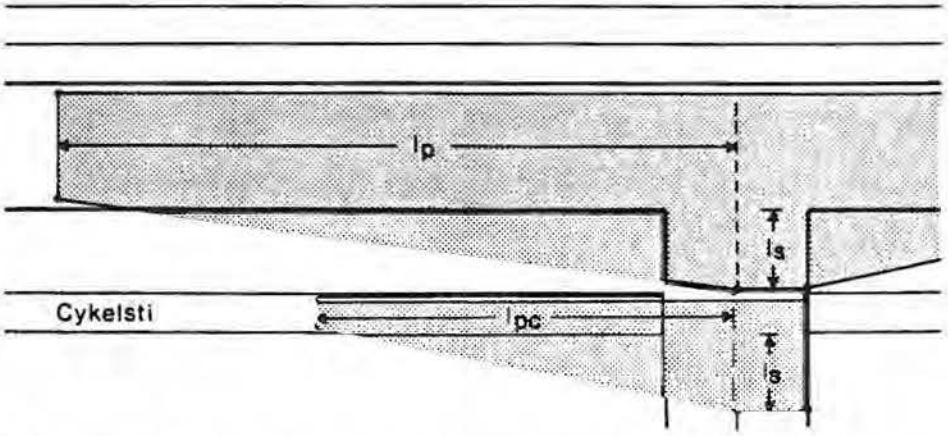


Figure 4.10 Sight area, intersection with cycle track on primary road, complex conditions.

In the case of new constructions and whenever possible elsewhere, the sight lengths l_s and l_p should satisfy the following requirements:

l_s: 2.5 m

This distance corresponds to the normal eye position of the users of the secondary road.

The distance l_p along the primary road should be of at least the value shown in Fig. 4.11.

Reference speed (km/h)	80	70	60	50	40	30
Sight distance l_p (m)	175	145	120	95	75	55

Figure 4.11 Sight distances along primary road.

The distance l_{pc} along the primary road's cycle path should be at least:

cycle path with moped traffic: 45 m
cycle path with cyclists only: 33 m

Conditions

The above signt distances promote safety for both vehicles and cyclists when crossing or turning under the following conditions:

speed, vehicles on primary road:	reference speed
speed, mopeds:	30 km/h
speed, cyclists:	25 km/h
orientation time for road users from secondary road:	2.5 s
braking reaction time:	2.0 s
deceleration, vehicles:	3.5 m/s^2
stopping distance, mopeds:	25 m
stopping distance, cyclists:	16 m

Higher speeds, lower deceleration rates, etc., can also be encountered but, in practice it is assumed, for instance, that higher speed on the part of cyclists will be compensated by greater attentiveness and/or better brakes.

Sight before intersections

In the case of new constructions, there are normally no requirements on sight before intersections, ie of and for secondary road users approaching the crossing.

Height of sight space

With consideration for snow, grass, etc., vehicle lane areas, cycle paths and pavement areas, traffic islands, dividing islands and shoulders within the sight area shall be at least 0.2 m below the sight space. The same applies to road equipment within the sight area.

Sight for road users turning left

Left-turning road users shall have sufficient sight to ensure a safe crossing of the opposing vehicle lane and of any cycle path.

Thus, care must be taken that two opposing road users do not obstruct each other's view when turning left simultaneously.

The sight distance along the traffic lane for road users waiting to turn left should, therefore, be as shown in Fig. 4.12.

Reference speed (km/h)	80	70	60	50	40	30
Sight distance (m)	135	115	100	85	65	50

Figure 4.12 Sight distances along traffic lane with turning to left.

The sight distances towards an opposing cycle path should be: 70 m.

The above distances ensure that a truck can cross the opposing vehicle lane or cycle path, respectively, without necessitating braking on the part of a road user approaching from the opposite direction.

Sight for road users turning right across cycle path

Right-turning road users should have a sight sufficient to ensure a safe crossing of the cycle path.

Because of blind angles and insufficient side mirrors, conflicts between right-turning vehicles (especially vans and trucks) and cyclists travelling straight ahead (especially mopeds) are particularly frequent. To reduce the risk of such conflicts, the vehicles shall be given the possibility to drive immediately adjacent to and parallel with the cycle path, for a distance of 20 to 25 m.

An unobstructed view of 70 m to the rear ensures that a truck can cross the cycle path, without a moped rider needing to brake.

5. BICYCLES AT PATH/ROAD CROSSINGS IN URBAN AREAS

5.1 General comments on road safety, etc., concerning crossings between paths and roads.

Road safety

Significant risks of accident are linked with the crossing of roads by cyclists and pedestrians. In the case of accidents between vehicles and light road users attempting to cross, moreover, the degree of injury is usually severe.

Consideration for road safety must, therefore, be a primary condition for the location of crossings between roads and paths, for the choice of type of crossing and for the detailed design of the crossing and its surroundings. First and foremost, care must be taken that the attention of road users on the road and path is drawn to prevailing rights-of-way, cf the Road Traffic Act.

Vehicle drivers and cyclists on the road must be able to see the crossing from a distance sufficient to ensure that they can prepare themselves for the necessary changes in driving behaviour at the crossing. Pedestrians and cyclists who wish to cross the road shall be motivated to use the safe crossing and their attention shall also be drawn to the risks involved in crossing the road.

Light road users must have a clear view of the vehicle lane and vehicle drivers must have a clear view of the crossing itself and of approaching light road users.

Where it is not possible to provide sufficient visibility, this should be compensated by the establishment of physical measures, which sharpen the attention, reduce speed and, possibly, compel drivers to stop.

Location, marking and design

Crossings shall first and foremost be located so that they will be used by the greatest possible number of pedestrians and cyclists who wish to cross the road. They shall, therefore, be located close to any path system and with consideration for the most important pedestrian destinations along the road.

Crossings should, moreover, be located at low points if possible and, under no circumstances, at convex vertical curves. They should preferably be located on straight stretches and, under no circumstances, at sharp horizontal curves.

Finally, a crossing should not be located close to localities that complicate recognition of the crossing. Thus, crossings should not be located adjacent to crossroads, ie closer than 30 or 40 m.

Road/path crossings and not least, their surroundings, shall be designed so that they are clearly and visibily differentiated from the rest of the road.

General requirements on design

- the choice of crossing type shall be made on the basis of the intensities of the road and path traffic
- the design shall be in accordance with the reference speed of the road
- crossings between roads and paths shall be more or less at right angles
- great importance shall be attached to the interplay of the individual elements that comprise crossings
- crossings shall comprise only a few, recognisable elements.

The following can be used, where a crossing is intended to have the effect of reducing the speed of vehicles:

- ramps
- humps
- central islands
- staggering
- narrowing and
- traffic-controlled lights.

The location of road equipment, signs and traffic-lane markings should be an integrated part of the geometric design of crossings.

Basic traffic parameters for cycles and mopeds

The dimensioning speeds and associated braking distances shown in the table of Fig. 5.1 are used for cycle and moped traffic. The cycle speeds have been chosen so that 85% of cyclists will cycle more slowly than the stated speeds.

Faster cyclists are presumed to compensate through greater attentiveness and improved braking.

Traffic conditions	Cycle traffic		Moped traffic	
	Dimensioning speed (km/h)	Stopping distance (m)	Dimensioning speed (km/h)	Stopping distance (m)
Crossing without right of way	25	16	30	25
Crossing with right of way	10	4	10	6

Figure 5.1 Dimensioning speeds and stopping distances for cycle and moped traffic.

5.2 Main types of path/road crossing

	Speed class			
Type of crossing	High (70-80 km/h)	Medium (50-60 km/h)	Low (30-40 km/h)	Very low (10-20 km/h)
Path tunnel	X	X		
Path bridge	X	X		
Ordinary signalized crossings	(X)*)	X	X	
Crossing with flashing light for school patrol		X	X	
Crossing with speed reduction		X	X	X
Ordinary pedestrian crossings, etc.		X	X	
Other crossings where vehicle traffic must give way			X	X
Path junctions	X	X	X	X

*) For speed class "High", control by traffic lights should only be used where the reference speed is 70 km/h and should not be used for new constructions.

Figure 5.2 Guiding combinations of reference speed and type of crossing.

A compulsory requirement in Road Standards for traffic lights say:

A signalized path crossing shall not be established on roads with permitted speed on 70 km/h or higher.

Level crossings should normally be used except, however, on roads of speed class "High".

Tunnels and bridges

From the standpoint of safety, tunnels and bridges are to be preferred as they provide complete separation of light and heavy road users - when they are, in fact, used.

However, these solutions require space, are costly, make some road users feel insecure, involve climatic problems and normally also cause difficulties in overcoming differences in elevation over relatively short distances.

Crossings on different levels should therefore mainly be established in new urban developments, where the path system is separated from the roads and where the topograph permits it.

Tunnels shall be illuminated and there should be an unobstructed sight through the tunnel.

Tunnels should be broader than the paths entering and leaving them. The longer the tunnel, the greater the breadth increase should be. Tunnels should not be narrower than 3 m.

Between paths in connection with tunnels, crossings shall be located so that sufficient sight can be provided.

Sight at path crossings

The sight area shall be determined at sight distances l_p and l_s along the primary and secondary paths, respectively; see Figs. 5.3, 5.4 and 5.5.

l_s should satisfy the following requirements:

moped traffic, continued driving:	6.0 m
cycle traffic, continued driving:	4.0 m
cycle traffic, dismounting:	1.5 m
pedestrian traffic:	1.5 m

The distances 6.0 and 4.0 m ensure safe braking from a previously reduced speed of 10 km/h to 0 km/h, before the moped rider/cyclist reaches the primary path.

l_p (l_{pc} and l_{pg}) should satisfy the following requirements:

moped traffic:	24 m
cycle traffic:	20 m
pedestrian traffic:	12 m

The distances 24, 20 and 12 m ensure that cyclists crossing the primary path at a speed of 10 km/h can pass, without forcing a moped, cyclist or jogger to slow down from a speed of 30, 25 or 15 km/h.

The above values also ensure that path users on the primary path can, if necessary, stop before the crossing, even in the event of wet or newly-gravelled asphalt.

In this context, attention should be drawn to the fact that riders of modern cycles can cycle as fast as mopeds for which reason, cycle speeds in excess of 25 km/h will often be encountered.

Within the sight area, there must be no fixed objects or plants higher than 0.5 m above a surface determined by the centre line of the two paths, ie with consideration for the longitudinal profiles of the paths.

However, bushes lower than 0.5 m can be recommended, out of consideration for the visual environment and to obviate short cuts with reduced sight.

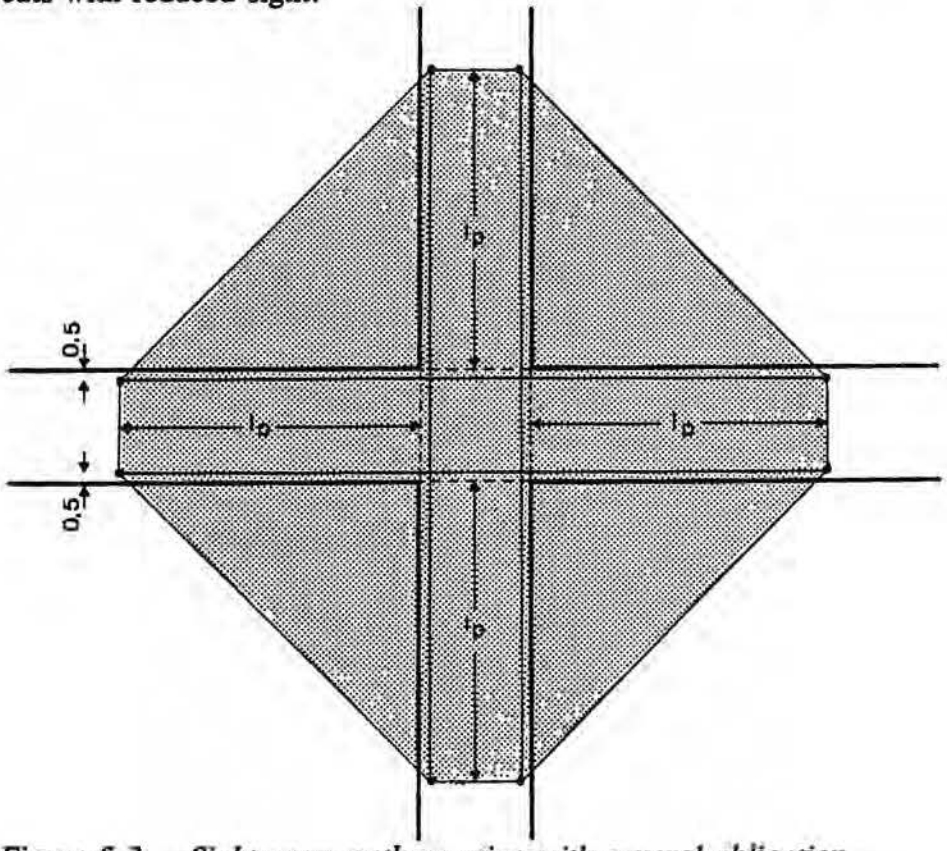


Figure 5.3 *Sight area, path crossing with general obligation to give way to right-hand traffic.*
"Cykel- eller fællessti" = Cycle or shared path.

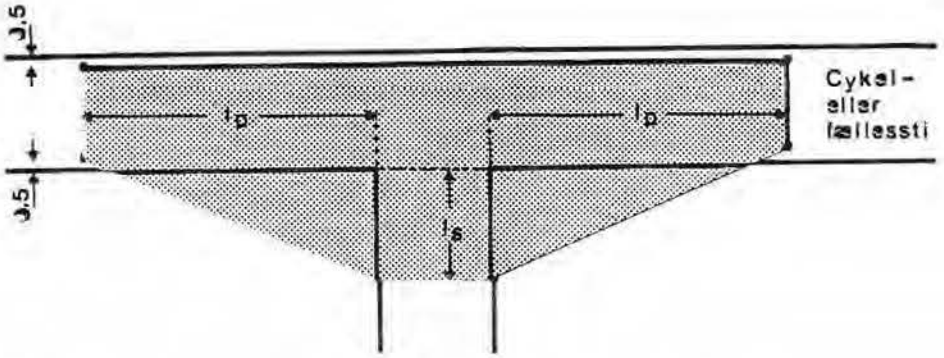


Figure 5.4 *Sight area, path crossing with unconditional obligation to give way, with a cycle/moped or shared path as the primary path.*
"Cykelsti" = Cycle path
"Gangsti" = Pedestrian path

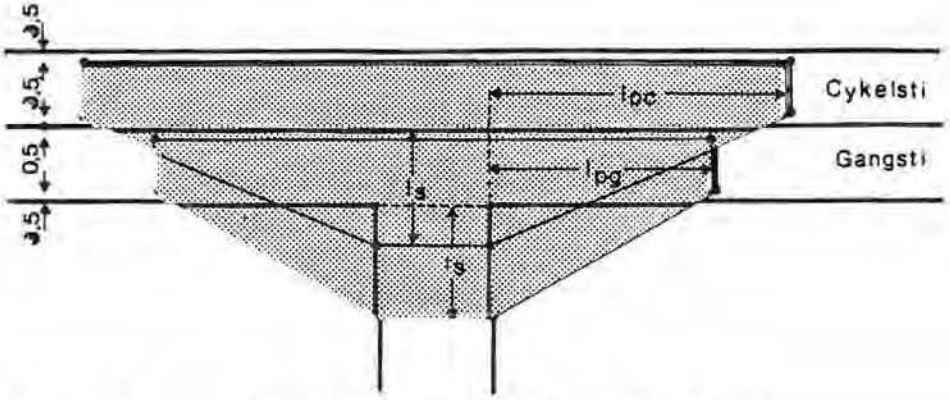


Figure 5.5 *Sight area, path crossing with unconditional obligation to give way, with separate cycle and pedestrian paths as primary paths.*

Traffic lights

Traffic-light controlled crossings should only be used where the desired speed is 50 km/h or less. In addition, at least one of the following conditions must be fulfilled:

- particular risk of accidents
- high traffic flow of light road users
- long waiting times for light road users
- coordination with other signals needed
- speed reduction needed.

It should be noted that traffic-light control of crossings does not automatically result in improved safety.

Crossings with speed reduction

If lower vehicle speed is desired at and near a crossing, perhaps in connection with speed reduction over the whole of the road stretch in question, the crossing can be provided with speed-reducing measures.

Speed reduction can be achieved by means of:

- humps before and after the crossing
- placing the crossing on a raised area
- staggering of lanes
- narrowing of lanes.

In all cases, the horizontal traffic provisions should be augmented with vertical provisions, such as plant beds, hedges, bollards, road signs and, possibly, a change of surfacing.

At this type of crossing, cyclists must always give way to traffic on the road, unless the road is marked with lines obliging the road traffic to give way.

Where separate paths cross a road, it is especially important to draw the attention of cyclists and moped riders to their duty to give way. This should be marked with give-way lines or ramps leading up to the pavement and it should be reinforced by ending the path surfacing at the crossroads. Cycle gates or suchlike possibly could also be installed.

The design of speed reducers is described in detail in Volumen 7. (1)

Ordinary pedestrian crossings

When constructing ordinary pedestrian crossings, an obligation should be placed on vehicle drivers to give way to pedestrian traffic, but not to cycle traffic. Thus, where separate paths cross a road, care must be taken to ensure that the attention of cyclists is drawn to their obligation to give way. This should be marked with give-way lines or ramps leading up to the pavement and it should be reinforced by ending the path surfacing at the crossroads. Cycle gates or suchlike possibly could also be installed.

Right-of-way for path traffic

In crossings where a separate main path intersects a local road with little traffic and low speeds, and where cycle and pedestrian traffic is substantial, a right-of-way can be imposed on road traffic for the benefit of path users.

The crossing path should, before and after the crossing, be constructed as a split path. The cycle path should extend unbroken through the crossing.

The compulsory requirement on "Cyclists overpasses" has been described in chapter 4.4.

Path junctions

Where a path joins a road and where there are only few path users use the crossing, a path junction can be established without a zebra crossing or any other type of intersection facility.

5.3 Individual elements

Traffic lanes

On roads with speed classes of "Low" and "Very low", where a path crossing is constructed as a speed-reducing measure, two lanes on a free stretch can be narrowed to one through the crossing. However, this should only be done where the peak-hour traffic is less than 500 vehicle units.

Guiding breadths for two-lane roads can be found in the table of Fig. 5.6.

	Speed class	Traffic-lane breadth
High	(70 - 80 km/h)	3.50 m
Medium	(50 - 60 km/h)	3.00 - 3.25 m
Low	(30 - 40 km/h)	2.75 m
Very low	(10 - 20 km/h)	2.50 m

Figure 5.6 Guiding breadths of traffic lanes.

The breadths of traffic lanes that are used to a significant extent by cyclists should be increased by 1.00 m on roads with speed classes "Medium" and "Low". Cyclists should not be placed in the vehicle lanes of roads with speed class "High", and on roads with speed class "Very low", widening is unnecessary.

Where a two-lane road is narrowed to a single lane through a crossing, the lane breadth should be at least 2.75 m, for speed class "Low", and 2.50 m, for speed class "Very low". In cases where the traffic lane is used to any significant extent by cyclists, its breadth should be increased by 1.0 m.

Cycle paths along roads

Where there are cycle tracks or lanes along a road included in a intersection, they should normally continue through it. If the crossing path has right of way, however, the path along the road should be interrupted.

The breadths of the cycle paths should be the same as on the free stretch.

Cyclist overpass

Cyclist overpasses (marked with cycle symbols) that cross a road must only be established in connection with traffic-light controlled intersections and crossings at which vehicles must give way.

Moreover, they must only be established in connection with demarcated pedestrian crossing.

The breadth of the cyclist overpass should be at least 2.5 m; see Chapter 4.

Ramps and humps

In cases where it is desired to install special visual markings at a road/path crossing, and to design for reducing the speed of vehicles, on roads with a reference speed of 50 km/h or less, a raised surface can be constructed, with ramps towards the traffic-light lane or with a circular hump before (and after) the crossing.

The detailed design of humps and raised traffic surfaces with ramps, staggerings or narrowings, is described in Volumen 7, on speed reducers. (1)

Traffic islands

Traffic islands in connection with road/path crossings should be demarcated by kerbstones and should normally have a breadth of at least 2.0 m, measured from kerbstone to kerbstone. Their lengths should correspond to the width of any pedestrian crossing (+ any cyclist overpass) + at least 1.0 m on each side of this.

Openings for cyclists should be without raised kerbstones.

Narrowings

The lane width at narrowings can be found in Fig. 5.6.

However, if the lane is used by cyclists and vehicles on roads with speed class "Low", its breadth should be increased by 1.00 m.

Cycle gates, etc.

Where cycle paths open onto roads, physical provisions should be established that draw the attention of cyclists to the new conditions.

Depending on their purpose, such provisions can take the form of:

- staggering, constructed with cycle gates or plant beds
- ramps leading up to the level of the pavement
- inclination of the final section of the path.

Staggering should be designed so that the cyclists face the vehicle traffic.

Gates for cyclists are used for safety reasons only.

Fig. 5.7 shows specifying dimensions for a staggered cycle gate which, when cycling slowly, can be passed by a cycle. A maximum distance of 2.5 m between the two gates applies for cycles with trailers. If the 0.6 m dimension is reduced to 0 m, the 2.5 m value can be reduced to 2.0 m.

Illumination of cycle gates is recommended. Illumination of the termination of a bi-directional cycle path is compulsory required.

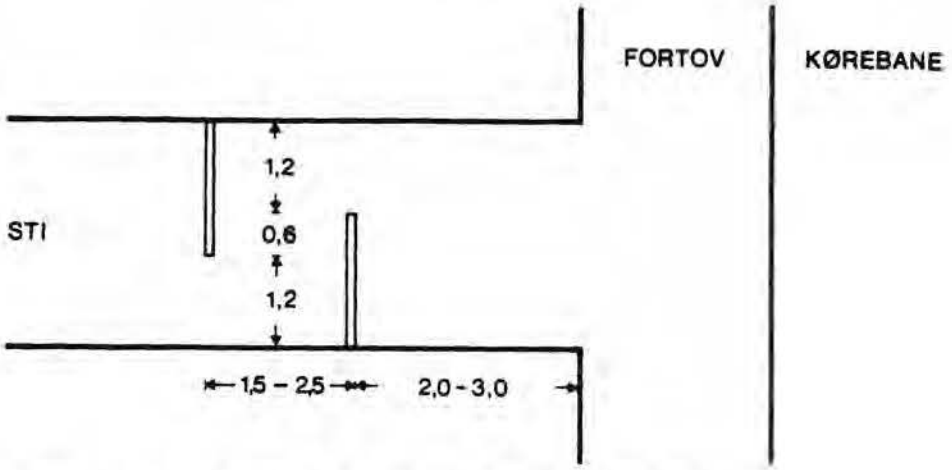


Figure 5.7 Cycle gates on paths, schematic diagram.
Sti = path
Fortov = pavement
Kørebane = traffic lane

5.4 Sight at path/road crossings

Sight distances for path users

Pedestrian crossings are dimensioning on paths with cycle traffic.

On road/path crossings not controlled by traffic lights, where the path traffic must give way to vehicle traffic, the path traffic should have a clear sight of the crossing road as shown in Fig. 5.8.

Crossing with traffic-lane breadth	Reference speed (km/h)							
	80	70	60	50	40	30	20	10
4 m	90	80	65	55	45	35	20	10
6 m	135	115	100	85	65	50	35	15
8 m	180	155	135	110	90	65	45	20
10 m	220	195	165	140	110	85	55	30
12 m	265	235	200	165	135	100	65	35
14 m	310	270	235	195	155	115	80	40

Figure 5.8 Sight distances for path users (m).

Sight for vehicle traffic

At road/path crossings where vehicle traffic is unconditionally obliged to give way to pedestrian and cycle traffic, an sight area should be established, with the sight distances l_{pc} along the path and l_s along the road, as shown in Fig. 5.9.

In the case of new constructions, and where otherwise feasible, the sight distances l_{pc} and l_s should satisfy the following requirements:

l_s: 2.5 m
l_{pc}: 45 m, for paths with moped traffic
l_{pc}: 33 m, for paths with only cycle traffic.

The magnitude of l_s corresponds to the normal eye position of a waiting vehicle driver.

The magnitude of l_{pc} ensures that a cyclist or moped rider can brake in time to avoid a vehicle that fails to give way on the road, under the following conditions:

speed, mopeds:	30 km/h
speed, cycles:	25 km/h
orientation time for vehicle driver:	2.5 s
stopping distance, mopeds:	25 m
stopping distance, cycles:	16 m

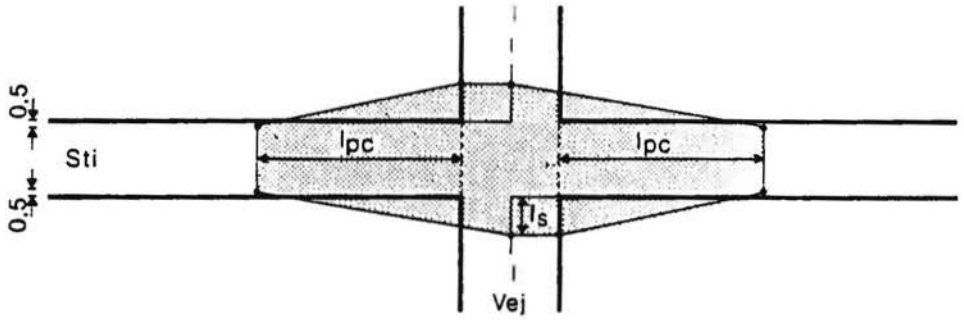


Figure 5.9 Sight area at road/path crossing where vehicle traffic must give way.

There must be no fixed objects with a height greater than 0.5 m, above a surface determined by the centre lines of the path and road, within the sight area. This applies also to road equipment, such as signs, etc.

6. BICYCLES AT ROAD INTERSECTIONS IN RURAL AREAS

6.1 Road safety

Consideration for road safety shall be one of the main conditions for the location of road intersections, for the choice of type of intersection and for the detailed design of intersections.

Thus, it shall be easy for road users to recognise intersections and the prevailing right of way, there shall be a clear view of other road users and it shall be easy for road users to orient themselves and choose their driving directions.

Finally, special consideration shall be given to light road users: pedestrians, cyclists and moped riders.

Light road users set special requirements on geometric design.

Their behaviour is less predictable than that of vehicle traffic and even small inconveniences, in the form of detours or suchlike, can cause undesirable behaviour.

Moreover, the speed of vehicle traffic on highways is considerably greater than that of light road users. The risk to these vulnerable road users of severe personal injury is therefore very high.

A clear sight of cyclists approaching from the rear must therefore be ensured for drivers of vehicles turning right.

6.2 Traffic islands and turning lanes for vehicles.

The construction of left-turn lanes is recommended out of consideration for vehicles, cycles, mopeds and pedestrians.

Primary traffic islands and left-turn lanes

The situation is apparent at intersections with primary traffic islands and left-turn lanes and cyclists, mopeds and pedestrians have a better chance of being observed. Moreover, protected refuges for light road users can be established in the shelter of the primary traffic island. This counteracts especially pedestrian accidents and accident situations 322, 410, 510 and 650, with cycles/mopeds and vehicles as the two parties.

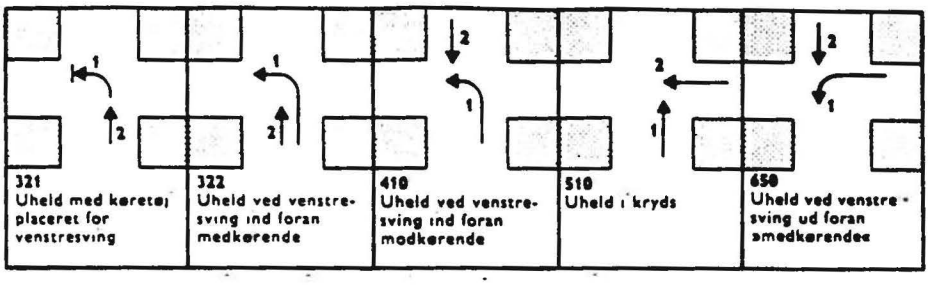


Figure 6.1 Accident situations, Nos. 321, 322, 410, 510 and 650.

The three designs of **primary traffic island**, with kerbstones, without kerbstones and as a painted island, are all to be recommended. The kerbstone-demarcated primary traffic island reduces the potential for avoiding action. On the other hand, painted islands do not offer the same "protection" for cycles and mopeds.

Triangular traffic islands

When constructing triangular traffic islands with right-turn lanes on the primary road, there is a risk of tempting vehicles to drive at higher speeds than are really feasible. The establishment of triangular traffic islands can make conditions difficult for cycles and mopeds travelling straight ahead.

Right-turn lanes

Similarly, the establishment of right-turn lanes will make conditions difficult for cycles, mopeds and pedestrians and cannot, for that matter, be shown to be of any safety-promoting value.

6.3 Cycle paths.

When designing junctions, special consideration should be given to the safety of cyclists and moped riders.

The best approaches can, however, be very costly for which reason, the expected total accident figure must also be taken into consideration when choosing a design.

Crossing conflicts and, therefore, risks of accident, occur where streams of vehicles cross streams of cycles and mopeds. The higher the traffic intensity, the more frequent and serious the conflicts.

Criteria for establishment of cycle paths

Where cycle paths run along a road that leads into a intersection, the path shall be continued through the intersection. The criteria for establishing paths along stretches of road are given in

"Katalog over vej- og stityper i åbent land" ("Catalogue of road and path types in open landscapes").

It is not possible to give exact criteria for the establishment of paths at road intersections, where paths do not run along the stretches of road involved. However, the following verbal criteria can be used as a rule of thumb.

Where there are especially frequent or serious conflicts, cycle and moped traffic should be conducted along cycle paths in the vicinity of the junction and roads and paths should intersect on two levels.

Where there are fewer and less serious conflicts, cycle and moped traffic should similarly be conducted along cycle paths in the vicinity of the junction but roads and paths can intersect on a single level.

Where cycle paths are only established in the vicinity of the junction, they shall continue throughout the channalisation stretch, with junctions around the point at which widening begins. However, cycle paths can possibly be omitted along the secondary road.

There is no need to establish cycle paths where the occurrence of conflicts is insignificant.

The following can be said on the design of the various types of path.

Intersection on two levels

Where roads and paths intersect on two levels, care must be taken to ensure that cyclists and moped riders are not tempted to use the roads through the crossing. The path shall follow a line that is as direct as possible and short cuts through the crossing should be made difficult or, if possible, prevented.

Intersection on a single level - general

Detours should also be limited to the minimum at intersections on a single level and any possible short cuts should be made difficult or physically prevented without, however, diminishing sight.

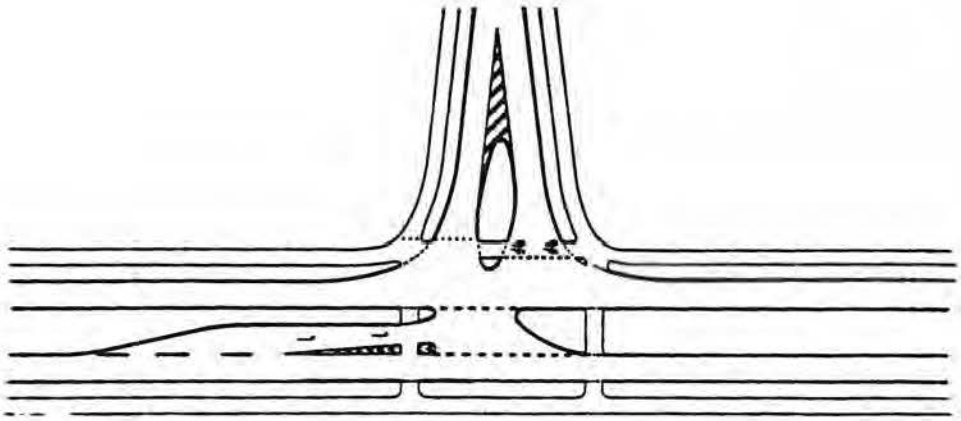


Figure 6.2 Intersection on single level, cycle paths direct through crossing.

Intersections between cycle paths and secondary roads can be marked as shown in Fig. 6.2. The cycle path should possibly be conducted over a secondary traffic island that is at least 3 m broad (including breadth of kerbstones), so that it is possible to cross the secondary road in two stages.

The intersection between the cycle path and primary road should be as close to the secondary road as possible, but without significantly extending the length of the crossing due to rounding of the junction corners.

Cyclists and moped riders should be able to cross broad primary roads in two stages, with a refuge at a primary traffic island which should, therefore, be at least 3 m wide, including the breadth of the kerbstones at this point.

Traffic islands demarcated by kerbstones offer the best protection to cyclists and moped riders.

The establishment of paths along the secondary road, and their alignment is of decisive significance for whether or not cyclists choose to cross the primary road via the refuge at the primary traffic island.

Cyclists paths along the primary road can either be routed directly through the crossing or as staggered paths.

Cycle paths routed directly through crossing

Figs. 6.2 and 6.3 show cycle paths that are routed directly through a crossing. This method has the follow advantage over staggered cycle paths:

Right-turning vans and trucks are given a reasonable chance of seeing in their right-hand mirrors cyclists or moped riders who

are travelling straight ahead. In this respect, the approach shown in Fig. 6.3 is slightly better than that of Fig. 6.2.

Cyclists and moped riders travelling straight ahead maintain their direction of travel through the entire crossing and, therefore, do not give right-turning vehicle drivers false reason to believe that they will turn right.

Cyclists and moped riders need make no, or only insignificant, detours.

Only a small area is required.

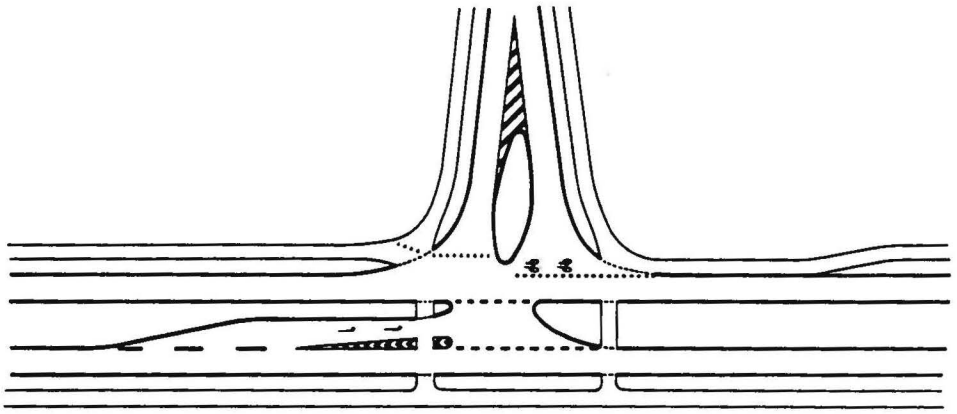


Figure 6.3 Intersection on single level, cycle paths pass directly through crossing, immediately adjacent to vehicle lane.

Staggered cycle paths

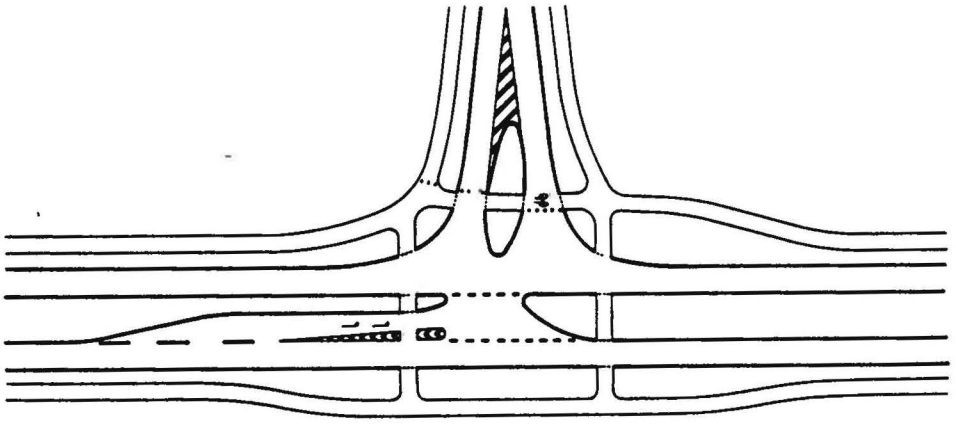


Figure 6.4 Intersection on a single level, staggered cycle paths

Fig. 6.4 shows a T-junction with staggered cycle paths. At the intersection with the secondary road, the cycle paths are staggered by between 5 and 7 m from the edge of the vehicle lane of the primary road. This method has the following

advantages over cycle paths that pass directly through the crossing:

- cyclists and moped riders are motivated to reduce their speed
- vehicles turning right are reminded of the obligation to give way to cyclists and moped riders travelling straight ahead
- vehicles waiting to turn right do not obstruct the way for users of the primary road who are travelling straight ahead.

Fig. 6.4 also shows a staggered cycle path along the primary road crossing the secondary road. This simplifies recognition of left-turning cyclists for vehicles that are travelling straight ahead and vice versa.

Bi-directional cycle tracks

When crossing a bi-directional cycle track on driving out from a road outside built-up areas, the right-hand side of the secondary road should be marked with S 11, "Give-way line", and B 11 "Give way unconditionally".

Marking with B 11 also applies where it is possible to cross a cycle path on the opposite side of a four-pronged crossroads.

The compulsory requirements on bi-directional cycle tracks is described in chapter 4.4 for urban and rural areas together.

6.4 New road standards for rural areas

During the next years a new serie of volumes concerning Road Standards for rural areas will be developed. The aim is to create two parallel sets of Road Standards for "Urban Areas" and "Rural Areas".

The danish Road Standards will continuesly be adjusted and further developed depending on new experiences and knowledge from research and practice.

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