SWOV Fact sheet

Bicycle facilities on distributor roads

Summary
A sustainably safe road environment requires bicycle facilities that separate motorized traffic from relatively vulnerable road users like cyclists. Research indicates that on distributor roads the road sections with adjoining or separate bicycle tracks are safer than the road sections without any bicycle facilities. Furthermore, roundabouts with separate bicycle facilities are safer than roundabouts without such facilities. Other intersection types require speed reduction measures to reduce the number of crashes.

Background and content
Bicycle facilities in the form of lanes and paths are intended to separate bicycle traffic from motorized traffic. In a sustainably safe road traffic such a separation is necessary when motorized traffic travels at speeds exceeding 30 km/h. Rural distributor roads usually have an 80 km/h speed limit and limits on urban distributor roads are usually 50 km/h and sometimes 70 km/h. Physically separating motorized vehicles from other road users at road sections of distributor roads prevents large differences in speed on the same carriageway.
This fact sheet will first look at cyclist safety on distributor roads. Then it will go into the different bicycle facilities on distributor roads and their safety effects. More general information about cyclists can be found in the SWOV Fact sheet *Cyclists.* SWOV Fact sheet *Crossing facilities for cyclists and pedestrians* discusses crossing facilities.

How many cyclist fatalities are there on distributor roads?
In the years 2007-2009 and for all road types together, an annual average of 143 fatalities among cyclists was registered. This is 21% of the total number of registered road fatalities. For 53% of the road fatalities among cyclists the registration form reported a 50 km/h speed limit and for 25% the reported speed limit was 80 km/h. These percentages are probably an overestimation, as 50 and 80 km/h are often ticked off as the limit when the actual limit is 30 or 60 km/h (Braimaister et al., to be published). *Tables 1 and 2* contain the registered numbers of road fatalities among cyclists on 50km/h roads and 80km/h roads subdivided by crash opponent and by intersections and road types. The data for bicycle-bicycle crashes and for single bicycle crashes[1] are underestimations, because these crashes are not registered as well as crashes involving a motorized vehicle (Weijermars, Goldenbeld & Bos, 2009). Insufficient data is available about serious road injuries among cyclists on 50 and 80 km/h roads, because the Dutch National Medical Registration does not indicate the road type.

On 50 and 80km/h roads, almost two thirds of the fatal bicycle crashes happen at intersections. This is due to the fact that there are more possible conflict points at intersections than on road sections. There are more than twice as many road fatalities on 50km/h roads than on 80km/h roads; the explanation being that the number of cyclists is higher in urban areas. On both 50 and 80km/h roads most cyclist fatalities occur in crashes involving motorized vehicles. Particularly at road sections on 50km/h roads a number of fatalities is the result of single bicycle or bicycle-bicycle crashes.

[1] No road user other than the cyclist is involved in a single bicycle crash, but the cyclist falls or crashes into, for example, a tree, a post or the kerb.

Crash opponent (50 km/h)	Road fatalities among cyclists per year (average 2007-2009)			Share of all fatalities among cyclists (%)		
	Intersection	Road section	Total	Intersection	Road section	Total
Passenger car	26	10	36	18%	7%	25%
Lorry	13	3	16	9%	2%	11%
Delivery van	5	3	7	3%	2%	5%
Single vehicle crash	1	4	5	1%	3%	4%
Bicycle	0	2	2	0%	1%	2%
Other	5	4	9	4%	3%	7%
Total	**51**	**25**	**76**	**35%**	**17%**	**53%**

Table 1. *Number of registered road fatalities among cyclists at intersections and road sections of 50km/h roads with different crash opponents and percentages of the total number of fatalities among cyclists (average of 143 per year in 2007-2009).*

Crash opponent (80 km/h)	Road fatalities among cyclists per year (average 2007-2009)			Share of all fatalities among cyclists (%)		
	Intersection	Road section	Total	Intersection	Road section	Total
Passenger car	14	6	20	10%	4%	14%
Lorry	1	0	2	1%	0%	1%
Delivery van	5	3	8	3%	2%	5%
Single vehicle crash	0	3	3	0%	2%	2%
Bicycle	0	0	0	0%	0%	0%
Other	2	1	3	2%	1%	2%
Total	**23**	**13**	**36**	**16%**	**9%**	**25%**

Table 2. *Number of registered road fatalities among cyclists at intersections and road sections of 80km/h roads with different crash opponents and percentages of the total number of fatalities among cyclists (average of 143 per year in 2007-2009)..*

The road crash registration in the Netherlands contains only limited information about the traffic facilities at the crash location. Additional (crash) studies are nearly always required to provide insight in the unsafety of the different types of bicycle facilities (e.g. Schepers & Voorham, 2010). It is registered, however, whether the cyclist was using a bicycle track or lane prior to the crash. On road sections of roads with a 50km/h limit, 11 of 25 (45%) fatalities among cyclists had a bicycle track or lane as a starting point, on 80km/h roads the number was 4 of 13 fatalities (33%).

Which bicycle facilities can be found on road sections of distributor roads?
The main types of bicycle facilities on road sections are (by increasing level of separation): non-compulsory lane, bicycle lane, adjoining bicycle track and separate bicycle track. The design guidelines for these different bicycle facilities are laid down in the publication *Design manual bicycle traffic* (CROW, 2006). The most important characteristics can be found in *Table 3*. Non-compulsory lanes are only advised for access roads; bicycle lanes only for access roads (both urban and rural) and for urban distributor roads.

A separate bicycle track is preferable for distributor roads, because the large degree of separation offers the best possible protection against the large speed differences between motorized traffic and cyclists. Not only the separate bicycle track, but also the measure *Moped on the carriageway* is a way to separate fast and slow traffic, mopeds and bicycles in this case. This measure, which has been operational since late 1999, involves mopeds using the carriageway on roads with a speed limit lower than 70 km/h. Another guideline for the application of bicycle facilities (CROW, 2006) is that they should not be located adjacent to parking spaces so that conflicts between parking vehicles (manoeuvres, doors opening and passengers getting out) and passing cyclists are avoided. Finally, a one-way bicycle track is to be preferred to a two-way bicycle track (CROW, 2006). A crash analysis carried out by the Dutch Centre for Transport and Navigation DVS (Schepers & Voorham, 2010) shows that the risk of an intersection crash is also greater on a two-way bicycle track than on a one-way track. When a two-way track is indeed chosen, compensatory measures like speed humps are required at those locations where bicycle tracks cross the carriageway (CROW, 2006).

Bicycle facility	Recommended characteristics
Non-compulsory lane (Access road)	– Width: 1.5–2 metres – Not in the colour red – Preferably in combination with a parking ban
Bicycle lane (Urban access and distributor roads)	– Width: 1.5–2.5 metres – In the colour red, with a bicycle symbol – Preferably not in combination with lay-bys
Bicycle track, separate or adjoining (Distributor road)	– Width: 2–4 metres, dependent on bicycle intensity and one-way or two-way – Preferably with a closed surface and in the colour red – Only for separate tracks in rural areas: verge between carriageway and bicycle track a minimum width of 4.5 m and preferably 6 m

Table 3. *Most important characteristics of urban and rural bicycle facilities (adapted from CROW, 2006)*.

The extent to which the different bicycle facilities have indeed been applied to distributor roads has been illustrated by Doumen & Weijermars (2009). They carried out a survey among road authorities to make an inventory of which bicycle facilities had been constructed on distributor roads with a 50km/h limit at the end of 2008. The results are given in *Table 4*. When this data is combined with the crash data in the previous paragraph, it can be concluded that relatively few crashes seem to occur on roads with bicycle facilities. More than 80% of the 50km/h roads have a bicycle facility, while no more than 45% of the fatalities occur on roads with a bicycle facility.

Bicycle facility	Share of bicycle facility on 50 km/h distributor roads (%)
None	17%
Non-compulsory lane/bicycle lane	24%
Separate bicycle track, moped on bicycle track	14%
Separate bicycle track, moped on carriageway	45%

Table 4. *Presence of bicycle facilities on 50km/h distributor roads, end of 2008 (Doumen & Weijermars, 2009).*

In rural areas bicycle traffic is sometimes combined with slow motorized traffic (including agricultural vehicles; see SWOV Fact sheet *Road safety aspects of agricultural traffic*) and local traffic. In those cases no separate bicycle track is constructed, but do cyclists use the service road.

Which bicycle facilities are found at intersections of distributor roads?

Intersections of two distributor roads preferably should be roundabouts, but intersections with or without traffic signals also occur. Driving speeds should be lower at an intersection than on the connecting road sections. In the case of roundabouts the driving speed will automatically be rather low. At other intersection types a lower speed must be enforced by speed reducing measures, like traffic humps just before the intersection or a raised junction. However, these measures are not yet used much in actual practice (Doumen & Weijermars, 2009).

Priority intersections are to be preferred at intersections between access roads and distributor roads; for rural intersections roundabouts may be considered. A T-intersection is preferable to a full intersection (CROW, 2006). An alternative for a T-intersection is a bayonet connection which consists of two T-intersections a short distance apart; see *Figure 1*. A bayonet construction prevents cyclists from having to cross the main traffic flow at a right angle. The ‘left’ bayonet is preferable to the ‘right’ bayonet because the intersecting bicycles need not take a left turn on the main road (CROW, 2006). However, Schepers & Voorham (2010) advise against using a bayonet connection, because they believe cyclists have a higher risk on two the two T-intersections than on one four-arm intersection. Also on these four-arm intersections a lower speed can be enforced by, for instance, road humps and raised intersections. The Schepers & Voorham (2010) crash study, which takes account of the volumes of motorized traffic and bicycle traffic, indicates that in urban areas the number of crashes on intersections with speed reduction measures is lower than that on intersections without speed reduction measures. More information about intersections can be found in the SWOV Fact sheet *Types of junctions*.

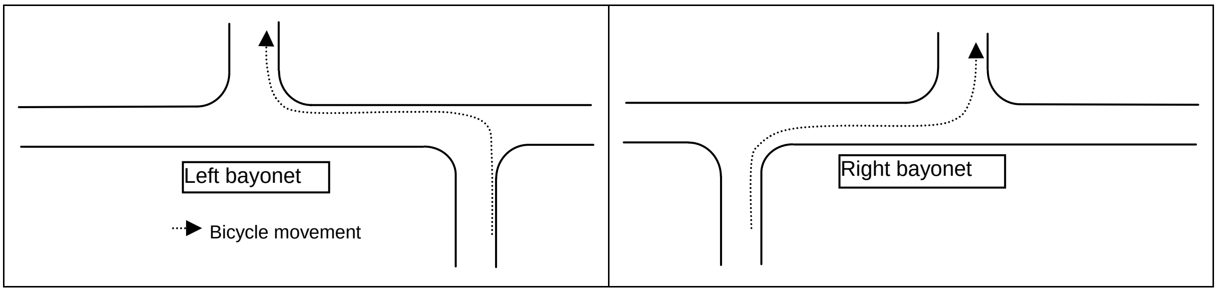

Figure 1. *Example of a left and of a right bayonet connection.*

Different bicycle facilities can be applied at intersections. The most important are:
- A *median guardrail* or a *median island* enables cyclists to cross a busy road more safely. On wider urban distributor roads a median island with a waiting space for cyclists only is safer than the situation in which cyclists have to make use of a left-turn section for motorized traffic (Schepers & Voorham, 2010). At quieter urban distributor roads (with a single carriageway and two lanes) it is better to be reluctant about the construction of median islands.
- The *stacking area*, the *storage lane* or the *expanded bicycle lane* at traffic lights are intended to position cyclists in such a way that they do not obstruct other traffic. An expanded bicycle lane could also help to prevent blind spot crashes.
- With an *inward or an outward curve of the bicycle track* the bicycle track curves towards the carriageway or indeed away from it. This increases the cyclist's visibility on the intersection. A bicycle track with an outward curve allows a vehicle to position itself between the bicycle track and the main carriageway. The earlier mentioned DVS crash study by Schepers & Voorham (2010) indicates that the risk of a crash for crossing cyclists in urban areas is smallest on roads with a separate one-way bicycle track that is positioned at a 2 to 5 m distance from the road. When the distance is larger, the number of crashes increases. However, this increase is smaller than it would be for an adjoining bicycle track. The DVS study therefore recommends not to give bicycle tracks an inward curve, but a slight (2 to 5 m) outward curve.
- The measure *'Right turn allowed when red'* at signal-controlled intersections is intended to prevent waiting time for cyclists, to provide a better fit with the actual traffic behaviour, and to prevent enforcement problems.

The implementation of the above facilities is mainly determined by the amount of passing traffic (motorized vehicles and cyclists) and by the presence of (bicycle) facilities at adjoining road sections. Little is known presently about the actual usage of the different types of bicycle facilities at intersections in actual practice. The *Design manual for bicycle traffic* (CROW, 2006) gives guidelines for the design of different types of intersections and the application of different bicycle facilities.

How do cyclists behave on distributor roads?

The presence of bicycle facilities does not guarantee that cyclists use these as they are intended or in accordance with the law. No studies are known, however, that focus on cyclist behaviour on distributor roads from this point of view. We know from experience that such undesirable behaviour does indeed occur, also when a bicycle facility is present, e.g. large groups of cyclists blocking a bicycle track, many cyclists beside each other, or cycling on the carriageway although a bicycle track is present. Cyclists using a bicycle track in the wrong direction are a specific problem as they cause an unpredictable situation. However, no data is available about the extent to which this behaviour occurs and the risks it causes.

How safe are the different types of bicycle facilities on distributor roads?
From *Table 4* we already concluded that bicycle facilities appear to have a positive road safety effect on road sections of urban distributor roads. No recent data, however, is available about the safety level of the different types of bicycle facilities on these road sections. On the basis of research from the 1980s (Welleman & Dijkstra, 1988) and taking account of the fact that mopeds no longer use the bicycle track, Wijnen, Mesken & Vis (2010) estimate that the construction of a separate bicycle track results in a 4,4% reduction in the number of injury crashes. This refers to a reduction in all types of crashes (also those not involving cyclists), and to urban distributor roads with a separate bicycle track as opposed to the types of road without a separate bicycle track or parallel road. Welleman & Dijkstra (1988) furthermore concluded that bicycle lanes were less safe than no bicycle facility. Unfortunately it is not known whether this is still the case and whether this applies to all construction types of bicycle lanes. There are indications that for busy rural distributor roads with many connections it is safer to construct a parallel road than a bicycle track, but this requires further investigation (Godefrooij et al., 2008).

Roundabouts have now been constructed on many intersections of through roads. Dijkstra (2005) established that roundabouts with separate bicycle tracks are safer than roundabouts without any bicycle facilities (cyclists in the carriageway) and roundabouts with bicycle lanes. Dijkstra (2005) also found that it is safer on roundabouts with separate bicycle tracks to the give right of way to motorized traffic entering or exiting a roundabout and not to cyclists. Furthermore, the DVS crash analysis (Schepers & Voorham, 2010) indicates that a slight outward curve (2 to 5 m) for bicycle tracks at priority intersections is preferable to an inward curve or ending the bicycle track at some distance from the intersection. After correction for the intensities, the number of crashes in urban areas involving crossing cyclists is indeed higher at intersections with bicycle lanes and adjoining bicycle tracks.

There has also been international research into the safety of different types of bicycle facilities. Elvik et al. (2009) have included many of these in a meta-analysis. The international effect estimates, however, are not entirely applicable to the situation in the Netherlands which is rather unique due its many bicycle facilities and high daily bicycle use.

Not only should bicycle facilities be constructed, they should also have a safe design and layout and they must be maintained well. Schepers (2008) found that the infrastructure's design, layout and maintenance play a role in approximately half of the cyclist-only crashes.

Conclusion
During the period 2007-2009, there have been an annual number of 143 registered road fatalities among cyclists; this is 21% of the total number of registered road fatalities. Approximately three quarters of the fatal crashes involving cyclists occurred on distributor roads. In a sustainably safe road traffic, separate bicycle tracks alongside distributor roads ensure a good separation between motorized vehicles and the other traffic. A study carried out in 1988 indicates that roads with bicycle tracks are safer than roads with bicycle lanes and that roads with bicycle lanes are less safe than roads without bicycle facilities. However, the group of bicycle lanes in that study was rather diverse and the study is fairly dated. At intersections of distributor roads a roundabout is to be preferred. At intersections where no roundabout has been constructed, speed reduction measures for motorized traffic should be taken, and bicycle tracks slightly curving away (2 to 5 m) from the carriageway are to be preferred to tracks curving towards the carriageway.

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