SWOV Fact sheet

SWOV INSTITUTE FOR ROAD SAFETY RESEARCH

Crossing facilities for cyclists and pedestrians

Summary
More than half of all serious crashes (with fatalities or inpatients) in which cyclists or pedestrians are involved occur while crossing the road. An estimated 32% of these crashes occur on crossing facilities, in spite of the huge numbers of people crossing there (data 2006). Crossing locations are, therefore, relatively safe.
There are many different designs and layouts for crossing facilities, which causes a lack of clarity for those crossing, but also for approaching drivers. What is expected of them? Crossing facilities must be understandable for everybody, especially by means of an unequivocal layout. For this reason the Netherlands have provisional layout requirements for pedestrian crossing facilities according to Sustainable Safety. There should be only one priority rule at facilities used by both pedestrians and cyclists: both have priority, neither have priority, or both have traffic lights. Where they do have priority, this must be indicated by triangular priority marking and by extended speed bumps to ensure a low approaching speed. Crossing facilities at intersections that are only for cyclists should be raised.
What precisely makes a crossing facility safe and understandable needs more research.

Background
In the terminology of sustainably safe road traffic, crossing the road could cause a 'lateral conflict'. These should only be allowed to happen if the speed differences are small. This is the case on access roads: in general separate crossing facilities are not necessary there. In exceptional cases, such as in the vicinity of schools or at locations where a lot of the elderly cross over, crossing facilities on access roads are also advisable.
Crossing on distributor roads should only be permitted at intersections, preferably via a crossing facility. The driving speeds of motor vehicles at that intersection may not be faster than 30 km/h; at a roundabout this is usually the case.
The driving speeds of motor vehicles on road sections of distributor roads are too fast to permit crossing. If, in spite of this, there are good reasons for facilitating crossing on a road section (many or vulnerable people crossing, long detour via intersection), this should be done with a fully-fledged crossing facility, especially with a speed inhibiting effect on motor vehicles.
This fact sheet only discusses crossing facilities. For information about pedestrians and cyclists you may consult the SWOV fact sheets *Cyclists* and *Pedestrians*.

Which are the Sustainable Safety requirements for crossing facilities?
The provisional Dutch layout requirements for a sustainably safe pedestrian crossing in a road section have been drawn up by CROW (2000). There are as yet no such detailed requirements for cyclists. More research is needed for definite layout requirements with regard to what precisely makes a crossing facility safe and understandable for everybody.
The provisional requirements for the sustainably safe pedestrian crossing are:
- a speed reducing effect with a horizontal speed inhibitor, such as a narrowing, or a vertical speed inhibitor, such as a speed hump or a raised junction;
- zebra marking (the stripes) parallel to the carriageway;
- zebra marking continued over separate parallel bicycle tracks;
- a road sign 'pedestrian crossing' before the zebra crossing;
- the same road sign floodlit above the zebra crossing mounted on a gantry;
- good lighting in a different colour;
- ribbed tiles on the pedestrian route towards the zebra;
- studded tiles at the beginning and end of the zebra, and on sloping access curbing if the zebra is not on an extended speed hump;
- the zebra has a minimum width of 4 metres;
- an as short as possible crossover length, possibly with refuge.

A sustainably safe pedestrian crossing should only be constructed on an urban distributor road with a speed limit of 50 km/h and 2x1 lanes (in Sustainable Safety there are, in principle, no 1x2 lane roads).

The most characteristic of the requirements is the speed inhibitor; a motor vehicle should only be allowed to approach a sustainably safe pedestrian crossing at a maximum speed of 30 km/h.

What types of crossing facilities are there in the Netherlands?
Very little is known about the current number or the locations of crossing facilities for cyclists and pedestrians in the Netherlands. An inventory which was made several years ago (VIA, 2001) showed a great variety in their layout, and De Langen (2003) concluded that there was not much system in this variety. She analyzed 47 different features of three types of crossing facilities (pedestrians only, cyclists only, cyclists and pedestrians) and ascertained that there was no connection between them (e.g. width, speed inhibitor, 24-hour traffic volume, driving speeds, signing, marking).

How safe is it to cross the road and how safe are the crossing facilities?
In addition to their numbers or locations, practically nothing is known about the use of crossing facilities in the Netherlands. Without a doubt there are large numbers of users, but without quantitative data, nothing can be said about the *risk* of a crash at a crossing facility in comparison with such a risk at a location without facilities.
An additional limitation for a safety analysis is that crossing conflicts are not explicitly described as such in the crash statistics. And particularly for cyclist conflicts it is not accurately coded whether a crash occurred at a crossing facility. In spite of this we will attempt to discuss the hazards of crossing as thoroughly as possible. This we restrict to the conflicts between motor vehicles and 'slow traffic' (bicycles, mopeds, light-mopeds or pedestrians). These crashes usually have serious consequences.

Casualties on 50 km/h and 80 km/h roads
We first examined the data of crashes at locations with a speed limit of 50 km/h or 80 km/h (*Table 1*). These road types are the most relevant for the category distributor roads. In 2008, approximately 28% of all road deaths and inpatients[1] occurred in a conflict between a motor vehicle and slow traffic.
In general, there are fewer casualties of this conflict type on 80 km/h roads than on 50 km/h roads. The conflicts on 80 km/h roads are more severe; there are relatively more fatalities.

In conflicts between *pedestrians* and motor vehicles on 80 km/h roads, most of the fatalities and inpatients are on road sections and not on intersections. This is also the case for 50 km/h roads, but to a lesser extent. In crashes between *bicycle* or *(light) moped* and motor vehicle on both 50 km/h and 80 km/h roads, more of the casualties occur in intersection crashes than in road section crashes.

Motor vehicle crashes with:	50 km/h speed limit				80 km/h speed limit				Total	
	Road section		Junction		Road section		Junction			
	N	%	N	%	N	%	N	%	N	%
Pedestrian	225	*2,2*	149	*1,5*	26	*0,3*	8	*0,1*	407	*4,1*
Bicycle	311	*3,1*	946	*9,4*	69	*0,7*	133	*1,3*	1.459	*14,5*
Light moped	46	*0,5*	121	*1,2*	6	*0,1*	12	*0,1*	185	*1,8*
Moped	185	*1,8*	390	*3,9*	51	*0,5*	84	*0,8*	710	*7,1*
Total	767	*7,6*	1.606	*16,0*	152	*1,5*	236	*2,4*	2.761	*27,5*

Table 1. *Number of registered fatalities and inpatients in the Netherlands at locations with 50 km/h and 80 km/h speed limit resulting from crashes between a) motor vehicles and b) pedestrians, cyclists, or (light-)moped riders: absolute numbers and percentages of total numbers of fatalities and inpatients, annual averages in 2006-2008 (2.761) (Source: Transport Research Centre/Centre for Transport and Navigation).*

Crashes when 'intersecting' or 'crossing'
In the Dutch crash statistics, crossing conflicts are only to be found in pedestrian crashes with 'crossing' as manoeuvre type. The safety of crossing the road for cyclists and (light-)moped riders can be derived from crashes with the manoeuvre type 'intersecting with or without turning off'. These latter ones are not always 'pure' crossing crashes. For conflicts between motor vehicles and slow traffic, a distinction is made between these manoeuvres in *Table 2*.

[1] The numbers of registered inpatients in this fact sheet are only an approximation of the real numbers. Some of the casualties are not registered at all and the information about whether or not there has been a hospital admission is not always correct.

More than half of all serious crashes involving pedestrians, cyclists, or (light-)moped riders are of the manoeuvre type 'intersecting' or 'crossing'. This share is 52-78% in serious crashes between *pedestrians, cyclists* or *(light-)moped riders* and motor vehicles. The crashes of this manoeuvre type are more often fatal for *pedestrian and cyclist* conflicts than for conflicts with *(light-)moped riders*. Cyclists are the largest group of slow traffic in conflict with motor vehicles with manoeuvre type 'intersecting' or 'crossing'.

Motor vehicle crashes with:	All manoeuvre types		Manoeuvre intersecting (with and without turning off) or crossing		
	A	*%*	B	*%*	*% of A*
Pedestrian	520	*5,8*	271	*7,2*	*52,1*
Bicycle	1.788	*20,0*	1.385	*36,6*	*77,5*
Light moped	223	*2,5*	164	*4,3*	*73,7*
Moped	870	*9,7*	616	*16,3*	*70,8*
Total (all conflicts, also without slow traffic)	8.947	*100,0*	3.782	*100,0*	*42,3*

Table 2. *Number of* ***fatal and inpatient crashes*** *in the Netherlands between a) motor vehicle and b) pedestrians, cyclists, moped or light-moped riders by manoeuvre type. All manoeuvre types and manoeuvre types 'intersecting (with or without turning off)' or 'crossing' during conflicts in 2006-2008 (source: Transport Research Centre/Centre for Transport and Navigation)).*

Crashes at crossing facilities
For the year 2006, we analyzed the serious crashes with the manoeuvre 'intersecting' or 'crossing' to see how many conflicts occur on a (pedestrian) crossing, i.e. as far as this was coded as such in the crash statistics. Of all *bicycle* conflicts with this manoeuvre (1215), approximately 28% of the fatal and 31% of the inpatient crashes happened on a crossing facility (32 and 337 crashes respectively).Of all *pedestrian* crashes with this manoeuvre (274), an estimated 33% of all fatal crashes and 42% of all in-patient pedestrian crashes took place on crossing facilities (12 and 100 crashes respectively). All in all, 32% of the serious 'crossing' conflicts with pedestrians and cyclists happen on a crossing facility. Furthermore, the statistics showed that nearly all pedestrian conflicts at crossing facilities happened at locations with a 50 km/h speed limit. This is most probably because there are many more crossing facilities on 50 km/h roads than on roads with other speed limits.

How safe are the various types of crossing facilities?
In the 1980s, extensive experiments with various types of *pedestrian crossing facilities* on road sections and intersections of major roads were made in the Netherlands. SWOV assessed some of these facilities (Bos & Dijkstra, in Dijkstra, 2000).
The total number of injury crashes on all types of crossing facilities declined by 6% (corrected for developments in control areas) as a result of the measures. However, the number of crashes with pedestrians increased by 23% (also corrected). The number of killed and injured pedestrians even increased by 34%. If we look at the studied types separately, we see the bad scores especially on the crossing facilities at road sections. For this reason, three of these are no longer included in the Dutch recommendations for urban traffic facilities (CROW, 2004).
Berends & Stipdonk (2009) have, among other things, investigated the safety of separate bicycle tracks in Zones 30. In the Netherlands, cyclists on these tracks usually have priority at the intersections. This causes cyclists being involved in crashes more frequently; the number of conflicts is a factor of 5 higher than expected. The Directorate-General for Public Works and Water Management (to be published) has recently carried out a study of crashes with cyclists crossing. The results of this study will soon be published.

A Swedish study (Gårder et al., 1998) describes the effects of *raised bicycle crossings* on six urban intersections. The cyclist crash reduction was 33% (corrected for other influences such as an increase in the number of passing cyclists). Nielsen et al. (1996) reported the results of constructing urban *bicycle lanes* in Denmark. These lanes intersect with 217 side streets; traffic from a side street must give priority to traffic (including cyclists) on the main road. Based on the developments at 227 control locations (comparable intersections), the number of injury crashes with cyclists was expected to have increased from 7 to 10 if the lanes had not had any effect. The actual number, however, increased to

26. The total number of injury crashes also increased considerably, from 24 to 55 (and not to 25, as was expected). It must be observed that the effect of these bicycle lanes on road sections is completely different: the number of injury crashes involving cyclists declined by about 35% (Herrstedt et al., 1994).

Schnüll et al. (1992) compared various types of *cyclist crossing facilities*. The research material consisted of 575 intersection branches without traffic lights on which 375 crashes with cyclists going straight ahead were registered. An intersecting bicycle path with marking only had the highest crash frequency (number of crashes per intersection branch per year), irrespective of the number of passing cyclists. The further from the carriageway the bicycle path is situated, the higher the crash frequency. A raised cycle path at the intersection had a much lower crash frequency. The crash frequencies for cyclist facilities on a lane or on the carriageway were the lowest, irrespective of the number of cyclists passing. In a comparative Netherlands study (Welleman & Dijkstra, 1988), the crash rates (number of crashes per passing cyclist) were studied at intersection branches where the cyclist crosses the side street on a lane, a path, or on the carriageway. In this study, the bicycle lanes had the highest bicycle crash rate, and the crash rates for bicycle paths and bicycles on the carriageway did not differ. The results were different for the moped crashes: bicycle paths had the highest moped crash rate, and bicycle lanes and mopeds on the carriageway had the same crash rate.

De Langen (2003) collected data from 121 *crossing facilities only for cyclists, only for pedestrians*, and *for both groups*. The selected crossing facilities had a wide variety of features concerning layout, signing and marking, and use. On crossing facilities used by both cyclists and pedestrians, they sometimes had different priority regulation, for examples: pedestrians do and cyclists do not have priority, or pedestrians have traffic lights and cyclists do not. This is very confusing for both those crossing as well as for the approaching motor vehicle drivers.
De Langen (2003) studied the priority behaviour on crossing facilities that had a sustainably safe layout and on those that did not. She concluded that pedestrians at a sustainably safe pedestrian crossing have less confidence in being given priority correctly than pedestrians at a non-sustainably safe pedestrian crossing. On the other hand, this also results in fewer potential conflict situations. No explanation can be given for this unexpected result. De Langen (2003) also ascertained that the approach speed at a sustainably safe pedestrian crossing was slower than at a non-sustainably safe pedestrian crossing, which leads to a safer situation. The speed at a sustainably safe pedestrian crossing is still higher than 30 km/h, the speed at which the mixing of traffic types is permitted.

A study by the AA Foundation (1994) determined how often *pedestrians* walk along various urban road types) *main road, distributor road, and residential street*), how often they cross the road there, and at what types of crossing facilities they used to do so. With this exposure data they then calculated the casualty rate (number of pedestrian casualties per distance walked or per crossing). The number of pedestrian casualties (killed, severely injured, slightly injured) per 100 million pedestrian kilometres on distributor roads was three times higher and on main roads six times higher than on residential streets. The number of pedestrian casualties per crossing on distributor roads was nearly five times higher, and on main roads more than nine times higher than on residential streets. The number of pedestrian casualties per crossing on a zebra crossing (irrespective of road type) was half that of the number at locations where there are no crossing facilities. On main roads in particular, this ratio was much higher: there the zebra crossing was hundred times safer than at locations without crossing facilities.
In general, there are nearly four times more pedestrian casualties per crossing at locations with pedestrian traffic lights (Pelican type crossings) than at locations without crossing facilities. However, it is striking that on main roads there are half the pedestrian casualties per at a Pelican crossing than at locations without crossing facilities. Pedestrian facilities evidently have a positive safety effect on crossing busy (main) roads.

Zegeer et al. (2001) studied the difference in safety between 1,000 *marked pedestrian crossing facilities* (various marking types including zebras) and 1,000 locations without any markings but where pedestrians cross the road.
The safety level (number of crashes per million crossing pedestrians) of both location types was the same when the 24-hour traffic volume is less than 10,000 motor vehicles. When the traffic volume is larger than this, locations without markings were *safer!* Zegeer et al. (2000) assume that this result is due to the fact that motorists hardly react to a marked crossing facility and that pedestrians wrongly

assume that such a facility offers extra safety. They base these assumptions on a number of detailed behavioural studies that were carried out earlier within the framework of this study.
In contrast to those in the United Kingdom (AA Foundation, 1994), marked crossing facilities in the United States (Zegeer et al., 2001) have no positive effect on busy/busier roads. There is as yet no explanation for this.

How much do crossing facilities cost?
The only information about the costs of Dutch crossing facilities can be found in a publication by Infopoint Sustainable Safety (2001). This publications mentions that the price of a pedestrian crossing facility on a road section of an 80 km/h distributor road costs €5,500 (price level 2001). An extended speed hump on a 50 km/h distributor road costs €16,000.

Conclusions and recommendations
More bicycle crashes occur at locations where bicycle lanes intersect with side streets than where there are no bicycle facilities. Raised crossing facilities for cyclists at intersections have a positive safety effect; 33% fewer cyclist crashes in Sweden (Gårder et al., 1998).
Crossing facilities at intersections have a more positive effect on the number of crashes involving pedestrians than crossing facilities on road sections. Crossing locations with traffic lights on main roads are twice as safe, per crossing pedestrian, as locations without any facilities. Other types of crossing locations (zebra crossings) are also safer than locations without any facilities. The Dutch crash data also shows that crossing locations are generally relatively safe. About 32% of serious crashes involving cyclists or pedestrians crossing happen on a crossing facility, in spite of the large numbers of people crossing there. An estimated 41% of serious crashes involving pedestrians take place at a crossing location. At priority intersections with separate bicycle tracks in Zones 30, cyclists are more often involved in crashes than is to be expected.

It is important to introduce a greater uniformity in pedestrian crossing facilities by using the (provisional) Sustainable Safety implementation requirements. In addition, further research is necessary of how a crossing facility can be made safe and understandable for everybody. This is important because a) a considerable share (41%) of severe pedestrian crashes still occurs at crossing facilities, b) there often is no correct priority giving, and c) there is an enormous diversity of crossing facilities. This diversity also makes it less clear what is expected from those crossing and the approaching drivers.

Furthermore, it is recommended that only one priority rule for both pedestrians and cyclists is used at facilities: either both have priority, neither have priority, or both have traffic lights. Where they do have priority, this can be indicated by triangular priority marking just in front of the crossing facility, combined with an extended speed hump to ensure a low approach speed. A rather long speed hump would slightly increase drivers' comfort because they can position the whole vehicle on the speed hump just in front of the crossing facility.
Crossing facilities at intersections that are only for cyclists had best be raised.

Publications and sources
(SWOV reports in Dutch have an English summary)

AA Foundation (1994). *Pedestrian activity and accident risk*. AA Foundation for Road Safety Research, Basingstoke, Hampshire (UK).

Berends, E.M. & Stipdonk, H.L. (2009). *De veiligheid van voetgangers en fietsers op 30km/uur-erftoegangswegen*. R-2009-6. Stichting Wetenschappelijk Onderzoek Verkeersveiligheid SWOV, Leidschendam.

CROW (2004). *ASVV Aanbevelingen voor verkeersvoorzieningen binnen de bebouwde kom*. Publicatie 110, CROW kenniscentrum voor verkeer, vervoer en infrastructuur, Ede.

CROW (2006). *Veilig oversteken? Vanzelfsprekend! Toepassing en ontwerp van oversteekvoorzieningen voor voetgangers*. Publicatie 226. CROW kenniscentrum voor verkeer, vervoer en infrastructuur, Ede

Dijkstra, A. (2000). *Veiligheidsaspecten van verkeersvoorzieningen in stedelijke gebieden*. R-2000-5. Stichting Wetenschappelijk Onderzoek Verkeersveiligheid SWOV, Leidschendam.

Gårder, P., Leden, L. & Pulkkinen, U. (1998). *Measuring the safety effect of raised bicycle crossings using a new research methodology*. In: Transportation Research Record 1636. Transportation Research Board, Washington D.C.

Herrstedt, L., et al. (1994). *Safety of cyclists in urban areas: Danish experiences*. Danish Road Directorate DRD, Copenhagen.

Infopunt DV (2001). *Maatregel-wijzer verkeersveiligheid: "er is meer dan je denkt…"*. Infopunt Duurzaam Veilig Verkeer, Ede.

Langen, A.C.B. de (2003). *Veiligheid van enkele typen oversteekvoorzieningen in stedelijke gebieden*. R-2003-23. Stichting Wetenschappelijk Onderzoek Verkeersveiligheid SWOV, Leidschendam.

Nielsen, E.D., Andersen, K.V. & Lei, K.M. (1996). *Trafiksikkerhedseffekten af cykelbaner i byområder*. Rapport 50. Vejdirektoratet, Copenhagen. [In Danish].

Rijkswaterstaat (to be published). *Oversteekongevallen met fietsers; het effect van infrastructuurkenmerken op voorrangskruispunten.* Directoraat-Generaal Rijkswaterstaat, Dienst Verkeer en Scheepvaart, Delft.

Schnüll, R., et al. (1992). *Sicherung von Radfahrern an städtischen Knotenpunkten*. BASt Nr. 262. Bundesanstalt für Straßenwesen BASt, Bergisch Gladbach.

VIA (2001). *Verkeersveiligheidsaspecten oversteekvoorzieningen; Inventarisatie*. In opdracht van de SWOV. VIA BV, Vught.

Welleman, A.G. & Dijkstra, A. (1988). *Veiligheidsaspecten van stedelijke fietspaden*. R-88-20. Stichting Wetenschappelijk Onderzoek Verkeersveiligheid SWOV, Leidschendam.

Zegeer, C.V., et al. (2001). *Safety effects of marked versus unmarked crosswalks at uncontrolled locations; analysis of pedestrian crashes at 30 locations*. In: Transportation Research Record 1773. Transportation Research Board, Washington D.C.