



CHALMERS
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Design of bicycle crossings in Gothenburg

A study about design of bike crossings in relation to
accessibility and safety for cyclists

Master's thesis in Infrastructure and Environmental Engineering

MATILDA SUNDBERG

MASTER'S THESIS 2016:3

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Department of Civil and Environmental Engineering
Division of GeoEngineering
Road and Traffic Research Group
CHALMERS UNIVERSITY OF TECHNOLOGY
Gothenburg, Sweden 2016

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Abstract

As fossil fuels are getting more expensive and studies one after another show how the global warming is affected by the transport sector, the interest of finding more environmental friendly alternatives of transportation increases. There is much talk about carbon-neutral and bike friendly cities, and bike friendly cities are something highly prioritized by infrastructural planners. Targets and ideas are set of how the cities could be developed to a more environmental friendly society all over the world. In Gothenburg strategies have been developed to increase the cycling as a transportation mode in the city, and the goal of the municipality is to increase the amount of bicycle trips and to be an attractive city for cyclists. To increase the amount of cyclists a traffic system that is both safe and attractive for the users is needed, and for that safe crossings between cyclists and motor vehicle drivers are important. In September 2014 a new regulation in the Swedish law came, dealing with the rules of giving way between cyclists and motor vehicle drivers, where a specific layout of the intersection is required for the rules of giving way.

In relation to the new regulations a possibility to prioritize cyclists in the traffic arose, but the background information of how the new design would affect the road users is inadequate. The aim of this report is to analyze where different type of intersections between cyclists and motor vehicle drivers should be implemented, and to present what changes that need to be made to switch the priority at existing intersections.

As a part of the study, five sites in Gothenburg with bike passages have been analyzed. Along with information from previous studies about the yielding behavior and investigations on different types of design, suggestions of the design of the five sites in Gothenburg are presented and discussed. A clear behavior of the road users could be seen, where many cyclists are given priority on bike passages despite the rules of giving way. The literature study shows that it is common that motor vehicle drivers yield for cyclists, and that the design of the intersection has impact on the yielding behavior. To increase the amount of cyclists it is important to keep a good accessibility, where clear routes, good comfort and security are prioritized. The study also shows that continuity in the design is important, and that a clear difference between bike passages and crossings is necessary.

Keywords: bike path, bike crossing, combined crossing, bike traffic, yield, give way, cyclist, intersection.

Utformning av cykelöverfarter i Göteborg

- En studie om utformning av cykelöverfarter med hänsyn till tillgänglighet och säkerhet för cyklister

MATILDA SUNDBERG

Institutionen för bygg- och miljöteknik

Chalmers Tekniska Högskola

Sammanfattning

I takt med att de fossila energikällorna blir allt dyrare och den globala uppvärmningen lyfts i media, ökar bland annat intresset för miljövänligare alternativ till transport. Det diskuteras bland annat om koldioxidneutrala och cykelvänliga städer. Just cykelvänliga städer är något som ligger högt på önskelistan hos många stadspplanerare, och det sätts mål och spånas idéer över hela världen på hur samhällen ska utvecklas till att bli mer miljövänliga. I Göteborg har man tagit fram strategier för att öka cyklandet i staden, och man har som mål att öka antalet cykelresor och bli en mer attraktiv stad för cyklister. För att öka andelen cyklister krävs ett trafiksystem som är både säkert och attraktivt för användarna och till det hör säkra korsningar mellan cyklister och motorfordonsförare. I september år 2014 infördes en ny reglering i svensk lag som behandlar väjningsplikten mellan cyklister och motorfordonsförare, där det ställs krav på en viss typ av utformning och skyltning av korsningar där cyklister har företräde.

I och med lagtillägget uppkom en ny möjlighet att prioritera cyklister i trafiken, men informationen om hur den nya utformningen ska komma att påverka trafikanterna är bristfällig. Syftet med det här arbetet är därför att analysera olika typer av utformning av korsningspunkter mellan cyklister och motorfordonsförare, och presentera vilka ändringar som behöver göras för att uppfylla kraven för cykelöverfart.

Under arbetets gång har fem platser i Göteborg där det idag finns cykelpassager analyserats. Tillsammans med information från olika rapporter om väjningsbeteende och utvärderingar av olika typer av utformning har förslag på utformning av de fem platserna tagits fram och diskuterats. Ett tydligt beteendemönster hos trafikanterna har kunnat ses, där många cyklister ges företräde på cykelpassager trots gällande regler för väjningsplikt hos cyklister. Litteraturstudien har också visat på att det är vanligt att motorfordonsförare väjer, och att utformningen på korsningen har betydelse för väjningsbeteendet. För att öka andelen cyklister i städerna är det viktigt att hålla en god tillgänglighet, där tydliga stråk, god komfort och säkerhet är prioriterat. Studien visar också att kontinuitet i trafiksystemets utformning är viktigt, och att en tydlig skillnad på utformningen av cykelpassager och cykelöverfarter är behövligt.

Nyckelord: cykelväg, cykelpassage, cykelöverfart, gc-överfart, cykeltrafik, väjning, cyklist, korsning.

Preface

In this Master's Thesis the design and location of intersections between motor vehicle drivers and cyclists are analyzed with regard to accessibility and safety for cyclists. To limit the project the focus has been on five intersections in Gothenburg while comparing the theory with the practise. A large part of the project has been to read and apply the knowledge from studies from Lunds University and the department of Traffic and Road. The project was carried out at the Department of Civil and Environmental Engineering, division of GeoEngineering at Chalmers University of Technology, and at the Traffic and Public Transport Authority in Gothenburg during the autumn 2015.

I would like to thank Malin Månsson at the Traffic and Public Transport Authority for guiding me through the network of people at the office and giving me fresh news of the ongoing work on the subject. A special thanks to Lars-Erik Lundin that has given me answers to many of my questions. Finally a great thanks to Gunnar Lannér and Anders Markstedt at Chalmers University of Technology for all helpful discussions and guiding through the Master's Thesis work.

Matilda Sundberg, Gothenburg, February 2016



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Vocabulary

Cykelbana:	Bicycle path / Bike path
Cykelfält:	Bicycle lane / Bike lane
Cykelöverfart:	Bicycle crossing / Bike crossing
Övergångsställe:	Zebra crossing / Pedestrian crossing
Gångpassage:	Pedestrian passage
Gångfartsområde:	Living street area
Transportstyrelsen:	The Swedish Transport Agency
Trafikkontoret:	The Traffic and Public Transport Authority
Trafikverket:	The Swedish Transport Administration
TRAST, Trafik för en attraktiv stad:	Traffic for an attractive city
VGU, Vägar och Gators Utformning:	The design of roads and streets
SKL, Sveriges kommuner och landsting:	SALAR, Swedish Association of Local Authorities and Regions

Wordlist

- Bike crossing:** A crossing between motor vehicles and bikes where *car drivers* yield. The crossing must be equipped with white transverse markings on the road for bike path, yield markings as well as a sign for bike crossing. Cyclists have priority at this type of crossings, due to new regulations since September 2014.
- Bike passage:** A crossing between motor vehicles and bikes where *cyclists* yield. The crossing can have markings on the road for bike path but do not have any markings for yielding or a bike crossing sign.
- Combined crossing:** An intersection between cyclists, pedestrians and motor vehicle drivers where a zebra crossing and a bike crossing or passage is combined at the same cross point.
- VGU:** A Swedish abbreviation of a document from The Swedish Transport Administration "Vägar och Gators Utformning", containing descriptions, regulations and recommendations of the modelling of roads and streets in Sweden.
- SALAR:** Abbreviation of Swedish Association of Local Authorities and Regions which is an organization that "...represent the governmental, professional and employer-related interest of Sweden's 290 municipalities and 20 county councils/regions." (www.skl.se)
- Yielding:** The rules of giving way says that drivers should slow down before a crossing and give way to cyclists and motor vehicle drivers in, or just entering an intersection.
- Bike path:** A road for cyclists separated from motor vehicles. Bike- and walking paths are often combined in Sweden, sometimes separated by road markings.
- Bike lane:** A part of a road for use by cyclists, clearly marked with color or lines as well as a symbol for cyclists.

Moped drivers: In this report moped drivers are drivers of mopeds class 2 which are allowed to drive on bike paths.

Living street: A street where motor vehicles are allowed to drive but where pedestrians have priority. Drivers should not exceed walking speed and parking is allowed only in designated parking lots (www.transportstyrelsen.se).

1

Introduction

The city of Gothenburg has during the last years come up with goals and strategies for the infrastructural planning in the city. From these traffic strategies a plan for bicycle traffic was made to concretize and give a detailed view of the strategies about bicycling. The city of Gothenburg has a vision of being an attractive city for cyclists, where cycling is a competitive mode of transport (Trafikkontoret 2015). The city also has goals that 75 percentage of the citizens would describe Gothenburg as a good city for cycling, and goals of increasing the bike traffic three times until 2025. In 2015 the city published a program for how to work with planning for cyclists and the bicycle infrastructure. The program, which has the name "Cykelprogram för en nära storstad 2015-2025" contains of strategies and goals for the bicycle infrastructure. One part of the program is a checklist and works as a guide for planners to see if they fulfill the requirements set on different parts of the bike path network (Trafikkontoret 2015).

Two things that affect cycling are security and accessibility, and at crossings with motor vehicles these both categories are jeopardized. The law is difficult to understand, and the design of crossings varies a lot from place to place.

Since the year 2000 the law of giving way has been changed to prioritize pedestrians in traffic. During the process of changing the law the question of giving way for bicycle traffic was raised (Nilson. N. 2009). The question has been raised many times, and discussions about possible changes have led to investigations and analysis about the situation for cyclists in different cities. In the year 2014 the Swedish government implemented a new law affecting cyclists. It is a new type of crossing between bikes and cars where cars have to yield for cyclists. The difference between the new design and the old will be described later in this report.

1.1 Aim

The aim of the project was to investigate where different types of intersections between cyclists and motor vehicle drivers should be implemented, and what changes that need to be made to switch the priority at existing intersections. The study will answer the following questions:

- What is good design?
- Which intersections have a good design and which ones need improvement?

- What kind of design is feasible at the site? Which type of crossing should be used at the site; bike passages or bike crossing?
- How can the intersection be improved?
- What will changes cost?
- What are the advantages and disadvantages with the possible design alternatives?
- How do car drivers and cyclists interact at the studied sites today?

1.2 Limitations

In this project motor vehicle drivers are seen as one group of road users without any division into subcategories such as trucks, personal cars or ambulances. The field study is limited to five sites in Gothenburg, and is only a fraction of all bike passages in the city. The sites are all located at roundabouts or speed reduced three-way crossings.

2

Method

To get a good understanding of the planning and design of bike crossings, a literature study has been done during the process. Sources have mainly been taken from studies at universities in Sweden. A field study has also been conducted where five sites in Gothenburg have been analyzed regarding safety and accessibility for cyclists through the crossing. The locations are:

- Heden/Stensturegatan
- Torpagatan/Munkebacksgatan
- Sprängkullsgatan/Vasagatan
- Övre Husargatan/Linnéplatsen
- Swedenborgsplatsen

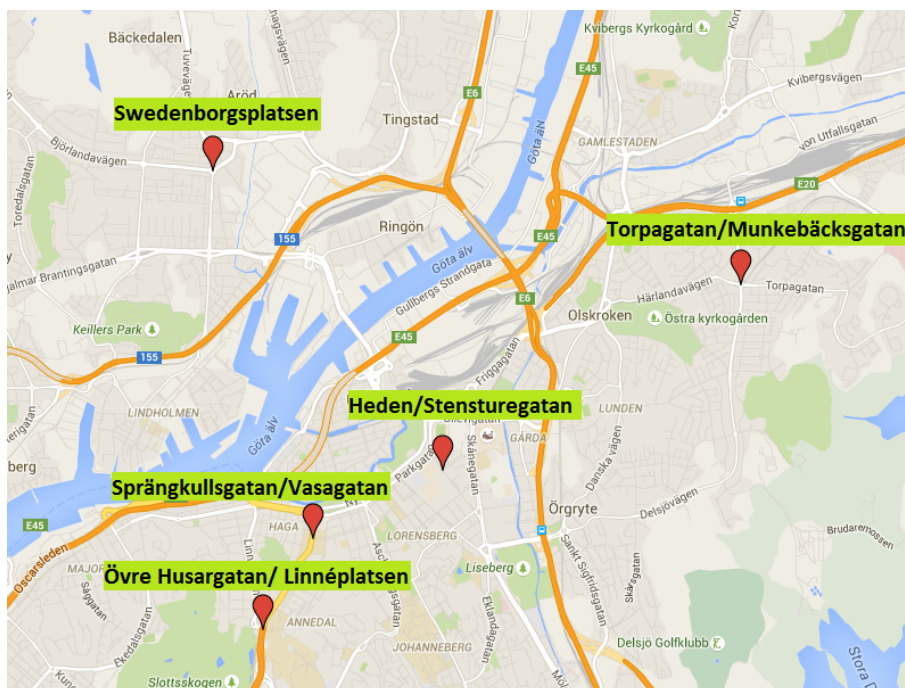


Figure 2.1: Position of the five studied locations in Gothenburg city.

From the field study and knowledge about different layout of bike crossings, design methods are analyzed and discussed, and suggestions of changes or modifications of

2. Method

the crossings are presented.

To analyze if it is to prefer having a bike crossing instead of today's passages the specific locations are inspected. The available space in the crossing, view, amount of traffic and speed have been noticed and classified at each location.

The sites were chosen due to their location in the prioritized bike path network in Gothenburg, as well as their similarity between each other according to traffic intensity. The study results in a short guide for traffic planners about the advantages and disadvantages of different design of intersections between bikes and motor vehicles. The study also results in suggestions of actions for the Traffic and Public Transport Authority in Gothenburg according to the goals of good accessibility and safety for cyclists. While giving the suggestions of design, the recommendations from the Swedish Transport Agency about changes in the new regulation has been used.

3

Law description of bike passages and bike crossings

In the following chapter the law before and after the complementing law from September 2014 will be described.

The rules affecting bike traffic at crossings are the rules of yielding and the responsibility that different categories of road users have. There are two types of unguarded crossings between motor vehicles and bikes; bike passages and bike crossings. The difference between passages and crossings are the rules of giving way, where cyclists yield at passages and motor vehicle drivers at crossings. At combined crossings the motor vehicle drivers should give way to pedestrians but not to cyclists. Before the changes in the law there was one single word for the intersection between bikes and cars, at that time called bike crossings. When the new rules came, the "old" bike crossings changed name to bike passages while the new type was given the name bike crossing.

3.1 Bike passage

A bike passage is a place where cyclists can cross a road with motor vehicles, and can be designed in many different ways though the law does not regulate the design. At bike passages motor vehicles have priority. The description of a bike passage, as it is written in the Swedish law is:

"A part of a road which is intended to be used by cyclists or mopedists to cross a road or bike path and can be painted with markings." (SFS 2001:651 Förordning om vägtrafikdefinitioner)

3.2 Bike crossing

The new bike crossings have a more specified design and cyclists have priority over motor vehicles. A bike crossing is described in the Swedish law as follow:

"A part of a road which is intended to be used by cyclists or mopedists to cross a road or bike path and is painted with markings and has a sign. At a bike crossing the intersection should be designed to secure a speed of vehicles to maximum 30 kph." (SFS 2001:651 Förordning om vägtrafikdefinitioner)

Figure 3.1 illustrates the difference between bike passages and bike crossings. Notice that a bike crossing should be speed secured, which is not shown in the illustration.

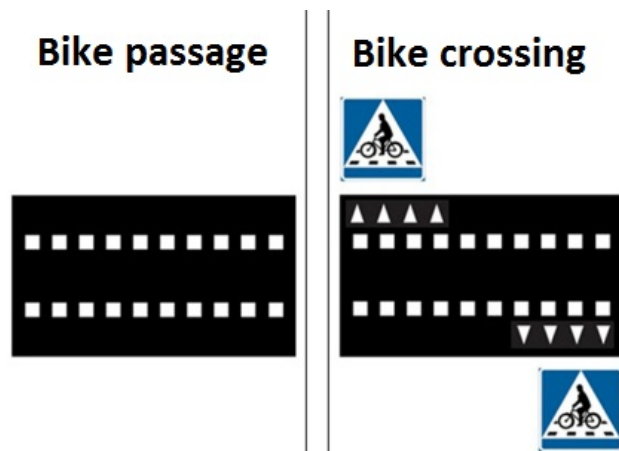


Figure 3.1: Illustration of the difference between a bike passage and a bike crossing (SBK Gatan 2015).

The description of the white square marking, called bike squares, was also changed with the new regulations. The descriptions of the markings are now as follow:

"The marking indicate a bike passage or a bike crossing where the sign B8 is added. If the marking indicates a bike crossing it should be combined with the marking for giving way, M14-Yield marking." (SFS 2007:90 Vägmarkesförordningen)

3.3 A new available yielding signs

Before September 2014 there have been times when it has been necessary to switch the priority between motor vehicles and bikes. One alternative is to use signalized crossings, and it is a common method where the traffic intensity is high. Intersections with many cyclists or many cases of injuries could be regulated without signals as well. That has been done by using the sign and markings for yielding. Today there is another alternative: with the new law a sign for bike crossings was implemented. It is designed to look similar to the sign for zebra crossings, but has a cyclists instead of a pedestrian on the sign. Figure 3.2 shows the sign for bike crossings.



Figure 3.2: Sign B8 for bike crossing (Transportstyrelsen 2015)

The description of the sign for bike crossings is as follow:

"The sign indicates a bike crossing. At bike crossings it is for motor vehicle drivers the regulations in 3 chapter 61 a§ and for cyclists and mopedists the regulations in

6 chapter 6 § the traffic regulation that rules." (SFS 2007:90 Vägmarkesförordningen)

The regulations in 3 chapter 61 a § says:

"At a bike crossing a motor vehicle driver should yield for cyclists or moped drivers that have, or should just enter the bike crossing." (SFS 1998:1276 Trafikförordningen)

The regulations for cyclists in 6 chapter 6 § says:

"Cyclists or moped drivers that should just enter a bike passage shall slow down and take approaching motor vehicles into account and are only allowed to cross the road if it can be done without danger. Cyclists or moped drivers that should just enter a bike crossing should take the distance to, and the speed of approaching motor vehicles into account." (SFS 1998:1276 Trafikförordningen)

Before September 2014 cyclists should give way at all intersections between cars and bikes except two cases; when cars leave a roundabout and when cars are turning in an intersection where the bike path is stretched along the road. The transport agency have made a guide where they illustrates and explain the situations between the rules at passages and bike crossings (Transportstyrelsen 2015). Figure 3.3 illustrates the situation when cars are turning.

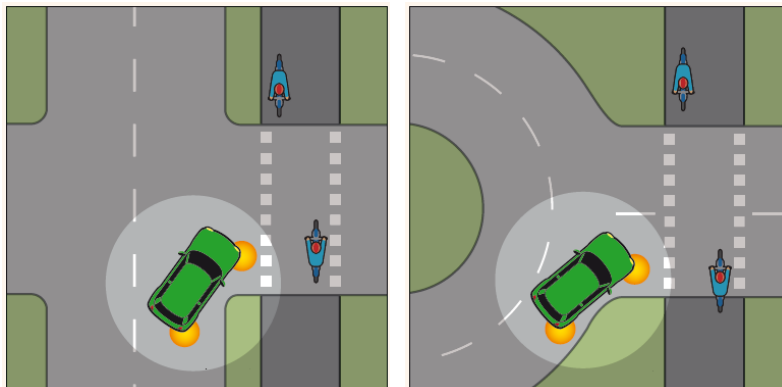


Figure 3.3: Illustration of the situation when cars turn in crossings and should yield (Transportstyrelsen 2015).

3. Law description of bike passages and bike crossings

4

Design of intersections

Intersections between cars and bikes can be designed in many ways, and different examples are easy to find in the same city. Speed bumps, a different color on the bike path and warning signs are some examples. In many cases the bike crossing is combined with a pedestrian crossing, later called combined crossing.

4.1 Speed reducing devices

To ensure a safe passage or crossing for cyclists the speed of the vehicles has a large impact. It is also known that motor vehicle drivers yield in greater occurrence when driving in a low speed. Today there are many methods to decrease the speed of vehicles at the intersection, some more applied than other. In the following text some examples of speed reducing installations will be presented.

Speed bumps

The most common method to reduce the speed of vehicles before a bike- or pedestrian crossing is to install a speed bump before the crossing. The bump forces the car to slow down and makes it easier to stop if necessary. Buses require a higher comfort than cars, and the ramps off the bump on bus roads therefore have a smaller slope (Västtrafik Infra, Vägverket region väst, 2003). Figure 4.1 shows how a speed bump at a combined crossing can be designed.



Figure 4.1: Combined crossing on speed bumps. Photo: Eskilstuna kommun

Narrowing of the road

When making the road narrow cars are forced to keep a lower speed through the traffic place. It also makes the distance shorter for cyclists or pedestrians when crossing the road. The design can be used at bus stops and is a common method to increase the safety for unprotected road users, as seen in figure 4.2 (SKL 2009). The narrowing of the road can be designed in different ways. The example showed on the photo is a design with low and wide refuges on each side of the roadway that have the same level as the sidewalk. Other examples are flower pots which are common in living areas, or refuges with a gap between the sidewalk and the refuge to make it possible for cyclists to pass through the narrowing on the "inside" (Västtrafik Infra, Vägverket region väst, 2003).



Figure 4.2: Narrowing of a road at a bus stop (Trafikverket 2015)

Side moved roads

The side moved roads can be used to make motor vehicles pay attention to a crossing and that something different is coming ahead. The speed of the cars does not decrease that much but can be used where subsidence of the ground makes it impossible to build speed bumps. The design is common in living areas with many unprotected road users. It is a method that can be positive for cyclists when crossing a straight road, but not that effective close to motor vehicle intersections (SKL 2009). In figure 4.3 an example of a side moved road is shown. In this case the traffic place is combined with a narrowing of the road, which is a common solution to slow down the traffic.



Figure 4.3: Side moved road, here with a speed bump. Photo: Vägverket Region Mälardalen

4.2 Sight

The safety and accessibility at a crossing are increased by providing a good sight for all people interacting in the crossing (SKL 2009). Many bike paths are located along roads with many crossings and driveways and are often surrounded with trees or bushes, making it hard for both car drivers and cyclists to see each other well

before the crossing. One way to deal with this is to remove the vegetation that blocks the sight, but also to inform the road users and making them pay attention to the crossing ahead. It can be done by using signs, markings or a special design of the road close to the intersection (SKL, Trafikverket 2010).

4.3 Accessibility

To ensure that cyclists will use the built passage or crossing it is important to keep a good accessibility for cyclists. According to the functionality requirements from the city of Gothenburg there are at least four requirements that should be met. Those are speed standard, good traffic flow, possibility for cyclists to keep different speed and good comfort (Trafikkontoret 2015). It is also important that the design don't make car drivers choose another way because of the design of the crossing. When increasing the priority for cyclists it automatically decreases the priority for other road users, often motor vehicle drivers, and it is therefore important to make the car drivers understand why they have been given lower priority.

4.4 Design with new rules

In relation to the new law for bike traffic the Swedish Association of Local Authorities and Regions (SALAR) presented a publication with suggestions of the design of bike crossings (SKL 2015). Today there are no guides for the design of combined crossings when it comes to the location of the markings and signs. The yield marking that should be in combination with the bike squares would result in a gap between the zebra lines and the bike squares, as described by SALAR in figure 4.4.

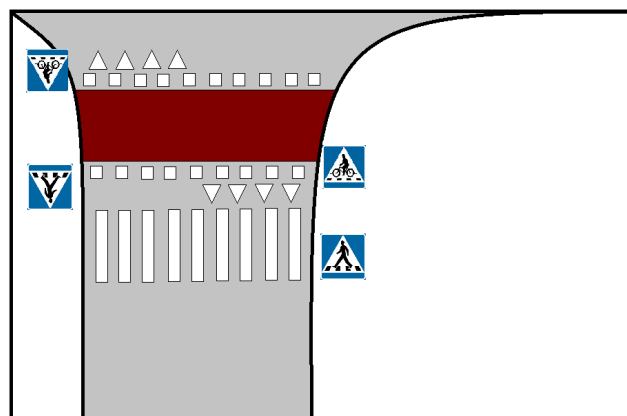


Figure 4.4: Illustration of a combined bike and pedestrian crossing due to the new rules for bike crossings.

In a publication from Gatubolaget recommendations that the combined crossings only have one line of bike squares are given (Gatubolaget 2007). To minimize the number of markings on the road SALAR asks for a combination where the pedestrian crossing acts as one of the bike crossing lines, and where the give way line is

painted before the pedestrian crossing, see figure 4.5.

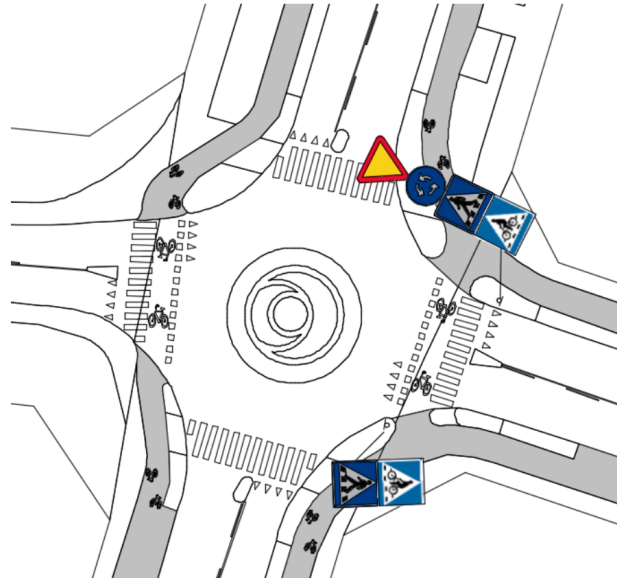


Figure 4.5: Illustration of a roundabout with bike crossing lines in combination with pedestrian crossings (Levander, E. 2015).

It is likely to assume that the same kind of design should be used at bike crossings as at bike passages, and that double lines of bike squares would take up space for no usage. While writing this report there is also an ongoing discussion of how to design the combined crossings. The Swedish Transport Agency has made a recommendation of a change or addition in the regulation making it possible to use only one line of bike squares at combined crossings, and that the yield marking could be painted before the zebra crossing ¹.

In the recommendations from SALAR regarding the changes in the law, they present a design for a roundabout with combined crossings, see figure 4.5. They discuss the possibility to move the combined crossing further away from the entrances to the roundabout, to give space for cars to yield for vehicles in the roundabout without blocking the way for cyclists or pedestrians. In that case two lines for giving way will occur. One for the bike crossing and one for the cars in the roundabout (SKL 2015). This occurs at some places today where the traffic intensity is high.

¹E-mail conversation with Malin Månsson at the Traffic and Public transport authority

5

Accessibility for cyclists

To increase the amount of cyclists in the traffic environment it is important to ensure good accessibility for cyclists. That means good information about routes and directions, road works, type of pavement, distances and goals along the way just to name a few examples (Trafikkontoret 2015). Another important aspect is to let cyclists ride in different speed without making cyclists feel unsafe. This can be satisfied by having wide bike paths without pedestrians where fast and slow cyclists use different parts of the path (Trafikkontoret 2015). The accessibility depends on the amount of information along the bike paths, and on the design of the traffic places. Therefore it is preferable to install road markings and use signs similar to the ones used in the motor vehicle infrastructure (Trafikkontoret 2015). This can be seen by lanes, signs and road markings on bike paths today.

Good accessibility can lead to bad safety if the environment is built to make cyclists ride faster without limiting the speed for motor vehicle drivers. The link between the accessibility and safety is important to keep in mind when planning for cyclists.

The design of signs for directions and distances is one important thing that is under development in Gothenburg and will be updated to give more accessibility for cyclists. There are questions of where the signs should be installed, and how the information should be presented. As seen in figure 5.1 the information is hard to see from all directions. The signs can be designed in many different ways and there is no national standard used. With larger amount of cyclists and goals of increased bike traffic there might be a need for more standardization, such as the destination signs in the bicycle infrastructure.



Figure 5.1: Example of a sign where not all destinations are seen from the same perspective.

The type of bike paths have a large impact on the accessibility for cyclists. Two-way and one-way bike paths have different advantages, and are preferable in different areas. Therefore the traffic and public transport authority present principles of where each type of bike path should be implemented (Trafikkontoret 2015). In the report "Cykelprogram för en nära storstad", the traffic and public transport authority describes that one-way bike paths should be used in the inner city, and that two-way bike paths are preferable in areas where it is long distances and few intersections. It could also be preferable with two-way bike paths where target points are located on only one side of a road (Trafikkontoret 2015).

6

Safety for cyclists

Cyclists are an inhomogeneous group of road users, with different background, knowledge and need of service (SKL, Trafikverket 2010). When dealing with safety and design of the infrastructure it is important to have in mind the spread of different type of road users that will be using the system.

Safety is related to many things in the infrastructural system, and one of them is accidents and injuries from events in the traffic environment. It is proved by examples that it is possible to increase the safety by the design and layout of the infrastructure (SKL, Trafikverket 2008). Severe injuries at intersections between cyclists and car drivers are mostly because of cyclists being hit by cars. Figure 6.1 shows how speed and risk of getting killed in traffic is related. The first curve describes the risk for pedestrians, and is similar to the risk for other unsecured road users. This is well known information for traffic planners and used when deciding the speed limit on different roads. By decreasing the speed both for motor vehicle drivers and cyclists at intersections the safety for cyclists can be increased. The usage of helmets is also known to reduce the amount of accidents leading to death in the traffic (SKL, Trafikverket 2010).

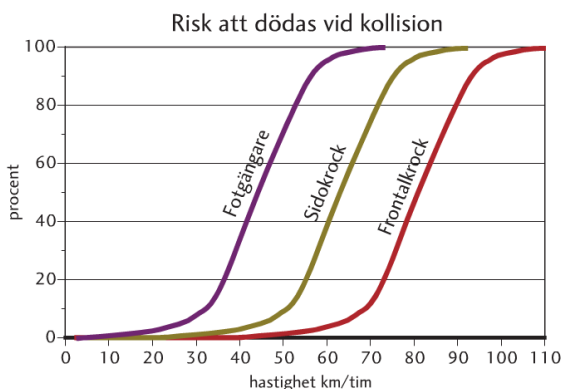


Figure 6.1: Relation between speed and risk of being killed in traffic collisions (SKL, Trafikverket 2008).

Accessibility and safety is linked in some aspects as mentioned in the previous chapter, another aspect is the information given to the cyclists by sign. If the cyclists have time to prepare and plan their route they do not need to be surprised by things that come up along the ride and distract them (SKL, Trafikverket 2008). Examples of this includes lack of warning signs before hidden crossings or pot holes in the bike path that comes as a surprise with a risk for accidents.

Knowing the traffic rules is important for the safety. But because cyclists are an inhomogeneous group of road users with very different knowledge, the traffic rules has to be complemented with practical constructions and physical barriers that increases the safety (SKL, Trafikverket 2010). At bike passages and crossings it is important

that cyclists and car drivers can see and understand each other. At some places, e.g. at Korsvägen and Brunnsparcken in Gothenburg, the traffic place is designed to be indistinct according to the traffic rules to make the road users keep attention and be careful in the intersections. At large intersections where cyclists have to pass many lines the sight can be a problem, and the effort from cyclists for yielding between different lines is large. In Gothenburg they use refuges on pedestrians crossings between the directions of the motor vehicles, and in many cases this method is used for bike passages as well, where there are combined crossings (Teknisk Handbok 2015).

The opposite of the odd design is the importance of having continuity in the bike traffic infrastructure to help road users to know how they should act at a traffic place (Trafikkontoret 2015). One example of this is the design of the bike passages and bike crossings. In Gothenburg today the design varies a lot, and there is no clear theme in the design of different type of intersections. If the bike crossings should be implemented in the city it is even more important to have a clear difference between the two types of intersections so that road users know which traffic rules that should be applied (Trafikkontoret 2015).

7

Investigations concerning bike traffic planning

There are many behaviour studies of car drivers done, and some of them deal with interactions between unsecured road users and motor vehicle drivers. In the following chapters more information about different investigations regarding intersections between cars and bikes is presented.

7.1 Yielding behaviour at bike passages

The department of technology and society at Lund University has done investigations about different design methods for bike traffic and behavior studies between car drivers and cyclists at intersections. Two of the reports as well as a Master's Thesis are presented here.

7.1.1 Design and traffic rules for bike traffic

In a study from Lund University 2007 the behavior of cyclists, cars and pedestrians at different type of crossings were analyzed (Johnsson, Hydén 2007). People working with planning in different cities in Sweden were interviewed and questions about the design of bike crossings were answered. There were disagreements about what design to choose, and different thoughts of the outfall from changing the design. Some of the interviewed persons thought that implementing the bike crossings where cars have to give way may increase the amount of accidents. They meant that cyclists will be less careful if they know that cars should give way. In the study they observed the behavior of cars giving way for cyclists at different design of crossings. They could see that for all types of crossings between cars and bikes the car drivers yield for in average 40 percent of the cyclists at bike passages where cars have priority. The results indicate that designs that decreases the speed of vehicles have a great impact on the priority for cyclists. (Johnsson, Hydén 2007)

7.1.2 Yielding behavior according to position of signs

Two years later another investigation was conducted by the institution at Lund University, analyzing the behavior of giving way at interactions between cyclists and motor vehicle drivers (Pauna et al. 2009). In their project they study six different

types of crossings between cyclists and cars in ten Swedish cities, analyzing the accessibility for cyclists. The crossings were chosen based on the present of yielding signs and lines for motor vehicle drivers, and all crossings were in the same level and color as the roadway.

The result shows that despite the rules for yielding where cars have priority, in average 58 percent of the motor vehicle drivers left the priority to cyclists. When dividing the cyclists in groups of ages, the result is similar except for children which have a significant higher priority than the rest of the cyclists. Many of the sites that they studied were combined crossings, and from the results they could see that the presence of pedestrians increased the amount of drivers giving way for cyclists. They also compared the situation with and without the give-way sign, showing that the presence of the sign is positive for the priority for cyclists. They could also see that at roundabouts the priority for cyclists was depending on the distance between the bike crossing and the entrance to the roundabout. If cars had space to stop between the crossing and the entrance the amount of cars giving way for cyclists increased. In the study they also observed the yielding behavior at the exit of roundabouts and could see that motor vehicle drivers leaving the roundabout gave less priority for cyclists than at the entrance (Pauna et al 2009).

The speed of vehicles in relation to the behavior of giving way was analyzed as well, with the result that cars at lower speed leave priority to cyclists to a greater extent than those driving at higher speed. The study does not take speed reducing installations into account.

The amount of yielding cars is high considering the rules saying that cyclists should give way. Some of the crossings in the study had a situation when both cyclists and car drivers should give way, which makes it confusing both for the people in the interaction and for the traffic police in disputes. This is a design that occurs in the road network, and is kept because of the safety.

7.1.3 Cyclists accessibility on bike crossings

In a Master's thesis from Lund University Sirwan Dabagh studied three types of intersections between bikes and cars to analyze the priority for cyclists (Dabagh 2015). The field study was done before the changes in the law and contained three combined crossings in Malmö, where two of the crossings are bike passages where cyclists should yield. One of them are in the same level as the street with one lane for car traffic in each direction, and the other is speed secured with double lanes for car traffic. The third intersection has reversed priority meaning that cars should yield. It is a speed secured crossing with one lane for car traffic in each direction. The aim was to answer questions about the yielding behavior between cyclists and motor vehicle drivers depending on the rules, the design of the traffic place and the speed of the motor vehicles. In the results from the field study it is shown that the yielding behavior for motor vehicle drivers is high despite the rules of priority in the traffic. In the study the priority for cyclists does not differ much between the

reversed priority and the speed secured passage, where 80 percent versus 75 percent of the motor vehicle drivers gave way at the two intersections. The bike passage in the same level as the road had lowest priority for cyclists in the study, with on average 58 percent of yielding motor vehicle drivers. It is important to remember that the priority for cyclists is high at the bike passages considering the rules, and relatively high for the crossing with reversed priority (Dabagh 2015).

7.2 Traffic rules at intersections

In 2009 the Swedish Transport Agency published a PM with suggestions of changes of the traffic rules at bike crossings and on the bike paths. The purpose of the amendments was to improve the accessibility for cyclists (Transportstyrelsen 2009). In the document the Swedish Transport Agency describe the unclear situation regarding the rules for road users when approaching a bike crossing, which also gives one reason to improve the design and the signs at the crossing. They also mention the importance of keeping and improving the safety for cyclists by regulating the speed limit for the car drivers. With reference to the study from Lund University (Johnsson, Hydén 2007) with information about road users behavior at the crossings, the Swedish Transport Agency present suggested changes in the regulations of the traffic. The suggestions are to change the rules about giving way, so that car drivers have the same obligation against cyclists when approaching an unguarded bike crossing, as against pedestrians at a pedestrian crossing. They also suggest to implement a new sign for bike crossing, similar to the one used at pedestrian crossings.

In the PM the Swedish Transport Agency also mention that crossings along bike paths are always negative for cyclists, both according to accessibility and security. To implement good accessibility from point A to point B in the city there has to be crossings between cars and bikes, and therefore the design of the crossings are important to investigate and evaluate to make the crossing simple and secure (Transportstyrelsen 2009).

7.3 Cykelutredningen - The bicycle investigation

In 2011 the Swedish government made an investigation about cycling in Sweden (SOU 2012). The aim was to look at the rules that affect bike traffic to increase the cycling and make it safer. The subject was analyzed in four categories: planning, bike parking, cycling and public transport and the traffic law. The review resulted in a couple of suggestions of changes (SOU 2012).

The consultant company WSP was part of the investigation and gave suggestions of changes in the design of bike paths and crossings including new signs and road markings. Their assignment was to look at the rules that affect cyclists and the infrastructure planning for cyclists, and analyze if changes in the rules can increase the amount of cyclists and also make the cycling safer (Cykelutredningen part 2

2011).

WSP refers to the Swedish Transport Agency and the PM they published 2009 when discussing suggested changes of rules, and later give suggestion of what changes that should be analyzed further. WSP write about implementing two types of bike crossings where the priority for cyclists is the difference. They discuss implementation of signs and markings brief. The results and recommendations from SOU are at many points based on the PM from the Swedish transport agency when dealing with safety and accessibility at crossings between cars and bikes.

7.4 Traffic for an attractive city

The Swedish Transport Administration together with the Swedish Association of Local Authorities and Region (SALAR) have published a handbook for traffic for an attractive city (TRAST), see figure 7.1 (SKL, Trafikverket 2007). It is mainly a guide for city planners and collects many aspects that planners have to deal with. With basis on TRAST they also made a handbook specific for designing roads and infrastructure for pedestrians, cyclists and mopedists. In the handbook they present the crossings between cars and bikes and mention the importance of designing the crossing so that it is easy to understand the traffic rules for all types of road users (SKL, Trafikverket 2007). They also give advice to reduce the speed to maximum 30 kph to increase the safety in the crossing. In the handbook no specific design solutions are presented, but good examples and ideas about planning for bikes.



Figure 7.1: TRAST (SKL, Trafikverket 2007)

8

Outlook in Europe

When working with infrastructural planning it is good to have knowledge about the planning in other countries. The knowledge from other countries or cities experience can help decision makers in their work. In the following chapter some information about the rules of yielding and common design in The Netherlands, Germany, Denmark and Great Britain are presented.

8.1 The Netherlands

In the Netherlands all cyclists are seen as vehicle drivers and should follow the same rules as motor vehicle drivers. There are some exceptions, e.g. cyclists are allowed to use their phone while cycling, and they do not need to follow the speed regulations for motor vehicles (Jensen 2013). At intersections cars and cyclists from side roads should yield for traffic on the superior road. Turning vehicles should yield for pedestrians and cyclists going straight ahead along the superior road. Cyclists should always yield for pedestrians and are not allowed to cycle on zebra crossings or other types of pedestrian crossings. In the Netherlands there are bike roads (compare with living streets) where cyclists have priority over motor vehicles (Jensen 2013). At signed bike paths cyclists are not allowed to ride on the road but should use the bike path (Urban Movement, Phil Jones Associates 2014). In the city Utrecht in the Netherlands, a well developed bike path network has been built. The network has many links between the main and the general bike paths, and the focus when building the network was hold on the routes (Urban Movement, Phil Jones Associates 2014). In Utrecht three profiles are used when designing the bike paths; visual separation (markings on the roadway), physical separation (different levels on the road or separated paths with grass or parkings between) or a mixed profile where motor vehicles and cyclists share the space (Urban Movement, Phil Jones Associates 2014).

8.2 Germany

Cyclists on bike paths or bike lanes along roads have priority over vehicles from side roads (Jensen 2013). Cyclists on separate bike paths (further away from motor vehicle crossings) should yield for motor vehicle traffic, if nothing else is specified with markings. Cyclists should always yield for pedestrians when cycling on/crossing side walks or walking paths. Where they have bike roads, cars are allowed but have to adept their speed to cyclists. In Munich the bike network is well developed and

has been a part of the infrastructure since the 1970s but now starts to get narrow and crowd (Urban Movement, Phil Jones Associates 2014). Therefore the city has started to rebuild the bike network during the last ten years, taking space from parking lots along the roads and turning them into bike lanes (Urban Movement, Phil Jones Associates 2014). By this the pedestrians are given more space as well, because they don't have to share the sidewalk with cyclists. In Berlin it is common to build bike lanes in the same level as the road, both to reduce costs for building bike paths, but also because of the belief that the safety for cyclists will increase if car drivers easily can see cyclists (Urban Movement, Phil Jones Associates 2014).

8.3 Denmark

When cycling in Denmark you have to yield for motor vehicles when entering a road from a bike paths further away than 6 meter from a longitudinal road with an intersection. The rules are not expected to be known by all road users, and therefore the intersections between cars and bikes are marked with signs or road markings (Jensen 2013). Cycling in Copenhagen in Denmark is an old tradition, and the most common way to travel between home and work (The city of Copenhagen, 2011). Because of the popularity of cycling the infrastructure planners keep developing the bike network by increasing the feeling of safety for cyclists, the accessibility and improving the maintenance. But in the bicycle strategy of Copenhagen (The city of Copenhagen, 2011) they also mention the importance of keeping the good behavior of cyclists, and encourage the cyclists to keep riding their bikes.

8.4 Great Britain

In Great Britain you always have to yield for other road users when cycling through intersections. You are, as a cyclist, seen as a vehicle driver and should follow the same rules as car drivers. In London it is common to paint a bike lane in a different color on the road where cyclists are allowed to ride. Many reports and guides have been made by Transport of London, and in their latest design manual they present how to plan for cyclists in London (Transport of London 2014). The design guide deals with all infrastructural aspects that affects cyclists, and for example, when presenting the alternatives for intersections between cyclists and motor vehicle drivers, they use a table where the traffic amount of different road users gives a preferable solution similar to tables from The Swedish Transport Administration and SKL. In Brighton and Hove the network for cyclists has been growing a lot the last decade. The city uses inspiration and expertise from Copenhagen and the planners have had different focus in projects while building up the network (Urban Movement, Phil Jones Associates 2014). The most common ways of implementing the bike traffic in the city has been to remove space from motor vehicle traffic, but also by allowing cycling on the Undercliff Walk.

9

Effect of changes at intersections

When building a crossing between motor vehicle traffic, cyclists and pedestrians the design of the intersection is developed mostly based on the present situation. Cities change and with that also the amount of traffic. Before making any decisions on what design that is suitable for the specific site, there will be a presentation of possible changes and their effect on the accessibility for cyclists as well as the safety at the intersection.

9.1 Building speed reducing installations

Speed bumps, narrowing of roads or side moved roads are examples of speed reducing installations, as presented in chapter 4. All three types decrease the accessibility for motor vehicles on the road, and each installation is therefore preferable at different types of roads. At bike crossings speed bumps are the most commonly used type to calm down the traffic (Trafikkontoret 2015). Speed bumps can give a false security for cyclists if the design looks safe. The attention to other road users gets worse, and the speed of the cyclists might increase with a secure feeling (SKL, Trafikverket 2010).

9.2 Signalized crossings

When using signal regulated crossings for cyclists it is important that cyclists sees the signals as meaningful. Otherwise it is common that cyclists break the rules and the meaning of using signals is gone. This can occur in situations when cyclists have to wait for green light for a long time and can see an opportunity to ride through the crossing without any complications (SKL 2009). Places where the traffic flow is high both according to motor vehicles and bikes can preferably have signals to help cyclists through the intersection. Where signals are used it is important that the waiting time is short and that the light switch quickly from red to green. For cyclists it is preferable to have some kind of railing to hold on to, or a high refuge to put down one foot on while waiting for green light.

9.3 Changing the priority

Changing the priority in the crossing can lead to more injured cyclists because of the lack of attention for conflicts when knowing that cars should give way (Trans-

portstyrelsen 2009). It can also lead to less accessibility for cars and large queues if the amount of cyclists and pedestrians increases.

9.4 Road markings

Painting one more line of bike crossing squares makes the bike path narrow and might lead to that cyclists use the space for pedestrians as well. It is legal to use the zebra crossing but pedestrians have priority before cyclists there. It is also often built with refuges making it difficult for cyclists to ride there.

The give way line for cars at combined crossings can advantageously be painted at the outer edge of the crossing. This leads to that motor vehicle drivers can yield without blocking the way for cyclists or pedestrians. At crossings near road junctions it is preferable to have space between the crossing and the car intersection to help motor vehicle drivers to get a good view over the intersection. In a British planning guide it is given that five meter is enough for one car and that the space should be adapted to fit one or two cars (TSO 2008). It is important that the distance between the different crossings is enough so that motor vehicle drivers notice the bike crossing or bike passage before they have to prepare for the next crossing.

10

Field study observations

In the following chapters observations from the sites are presented. The sites are all positioned in the city of Gothenburg and have similar traffic flow. All places are, or should be parts of the large bike path network in Gothenburg in the future. In the end of each section there is a suggestion of a layout of the intersection. The position of the yield markings at crossings with speed bumps can vary depending on how long the speed bump is. At old crossings that should be changed into bike crossings, it is preferable to put the yield markings before the markings of the ramp to the speed bump because of the lack of space between the ramp and the passage/zebra crossing.

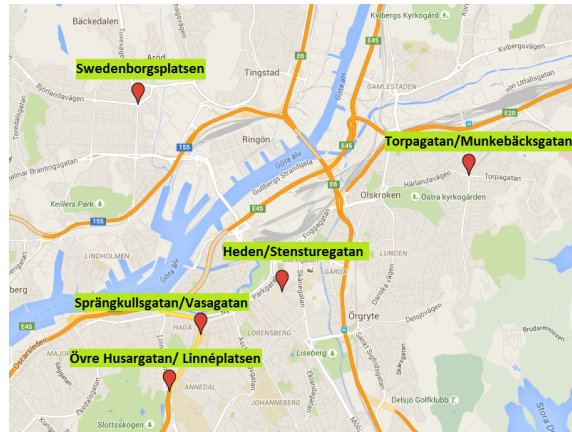


Figure 10.1: Position of the five studied locations in Gothenburg city.

10.1 Sprängkullsgatan/Vasagatan

At the end of Vasagatan is a three way crossing where buses, cars, cyclists and pedestrians interact, see figure 10.2. The intersection is a three-way crossing but looks like a roundabout with an extra crossing in the middle, where buses, cyclists and pedestrians interact, see figure 10.3. The combined crossing is put on a speed bump on the lane where cars drive, and in the middle of the combined crossing there are signals where buses have priority.

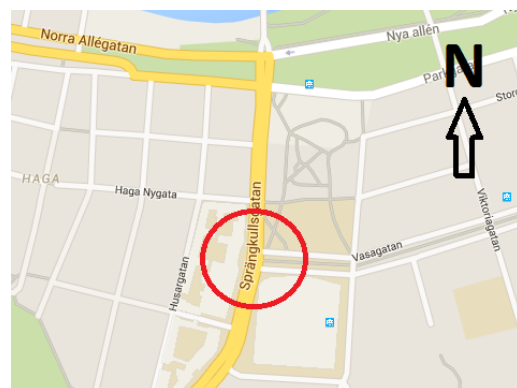


Figure 10.2: Intersection at the west end of Vasagatan.

When watching the situation at the end of Vasagatan it looks busy, and when



Figure 10.3: Intersection at Vasagatan/Sprängkullsgatan.

watching the combined crossing the spontaneous reflection is that cars give way for cyclists. The cyclists have good view over the three lines with refuges between that they have to cross. The buses in north going direction on Sprängkullsgatan have a specific lane with priority regulated by signals for cars, cyclists and pedestrians when they approach. A lot of pedestrians are using the crossing and they walk all over the intersection, both on the zebra lines and on the bike passage, trying to take a short cut over the bike lane. The bike path along Sprängkullsgatan is located very close to the intersection, which gives pedestrians and cyclists in the intersection nowhere to yield for cyclists along the path, see figure 10.4.

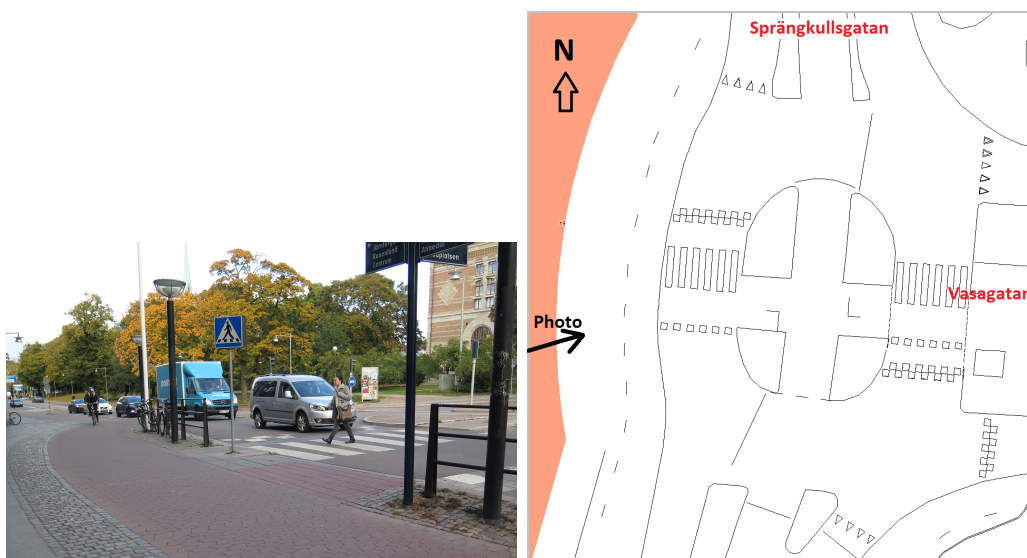


Figure 10.4: The photo shows the bike path on the west side of the intersection. The space between the intersection and the bike path is small, leading to that people from the combined crossing sometimes block the bike path.

At rush hour a lot of cars are driving through the intersection. When the north going buses reach the crossing the cars have to give way. Because of the stop line for cars turning from north to east problem occur when cars and buses going south are

blocked by the turning (waiting) cars when buses comes from the opposite direction. Figure 10.4 illustrates how the intersection is designed today. If the new rules about bike crossings should be implemented at this site, the design of the intersection has to be changed. Markings for giving way before the combined crossing should be added and the new sign for bike crossings should be installed. Perhaps one more line of markings for the bike crossing has to be added between the zebra lines and the bike crossing.

Suggested design

If the combined crossing is moved to the entrance of the roundabout it will look more similar to other places along the way to Linnéplatsen. This will also lead to that cyclists coming from different directions along Sprängkullsgatan have two different intersections to choose between. By installing the combined crossing before the give way line for cars in the intersection the focus will be on cyclists and pedestrians because no cars are interacting at the same time.

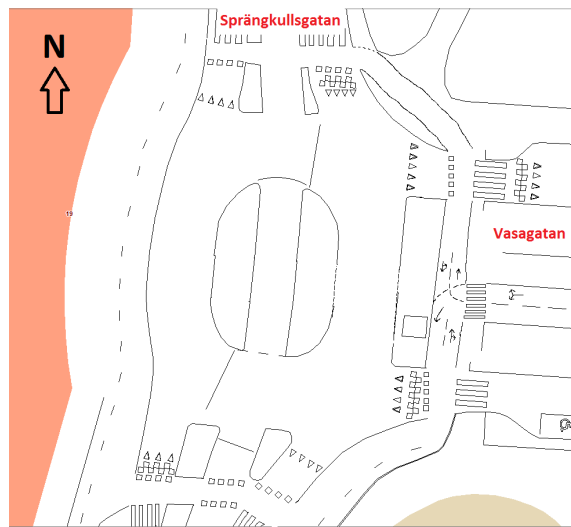


Figure 10.5: Illustration of a suggested layout of the crossing at Vasagatan/Sprängkullsgatan

By keeping the priority to buses in north direction and increasing the priority for cyclists, railings can be installed for cyclists to hold on to when waiting for the bus. It is also important that the signals are quick and turn off when buses have passed. Today some cyclists do not respect the red light because they are slow to switch. Quicker signals will also help the motor vehicle traffic and less queuing will occur.

After observing the situation at this site and also looking at the other intersections along Sprängkullsgatan and Övre Husargatan a suggestion of a new layout was developed. In the new layout the combined crossing is moved to the entrances of the intersection, making it look like a roundabout. The combined crossings are speed secured with speed bumps and equipped with the new markings and signs for bike crossings with priority for cyclists. Figure 10.5 illustrates the new layout. Today there is a fence in the west side of the intersection to keep the pedestrians and cyclists on the combined crossing and not letting them take a shortcut. This fence could be kept, and closed on the middle where the entrance to the combined crossing is located today.

10.2 Övre Husargatan/Linnéplatsen

Close to the bus stop at Linnéplatsen a roundabout is located. At the roundabout combined crossings are located in three entrances and the studied crossing is located on the west side of the roundabout, see figure 10.6. Along Övre Husargatan a bus



Figure 10.6: View of half of the roundabout at Linnéplatsen with the west combined crossing, www.google.se/maps 2015-12-03.

lane is located with priority over all other road users. Cyclists in north-south direction cross the road on a two-way bike lane at a combined crossing. The give way signs for cars are painted just before the entrance to the roundabout and after the combined crossing, see figure 10.7. Cars sometimes stop on the combined crossing because of queues from the upcoming crossing. The traffic flow at Linnéplatsen is quite high, and during rush hour a lot of cars drive through. The combined bike- and pedestrian crossing is speed secured with a speed bump and has a refuge between the in- and outgoing traffic from the roundabout.

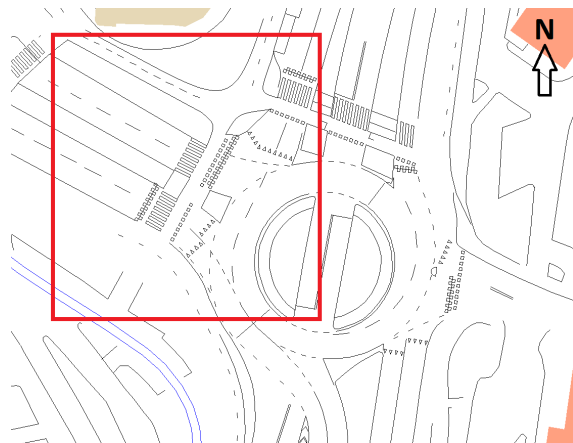


Figure 10.7: The roundabout at Linnéplatsen. The studied crossing is located on the west side of the roundabout.

Suggested design

There are a couple of changes that has to be made if the priority for cyclists at the intersection should be changed. New signs has to be installed, and markings added on the road. By adding a give way line before the combined crossing cars have to stop about ten meters before the roundabout. This leads to bad view for cars, but a better situation for cyclists if they easily can cross the road without any stop. By moving the give way line just before the roundabout forward, one car can wait between the roundabout and the combined crossing without blocking the way for cyclists. A car standing at the entrance of the roundabout is also a sign for cars behind that it is not free way yet. Then cars can stop before the pedestrian crossing and give free way for cyclists while waiting. Giving way for cyclists at this spot might lead to more queues for the cars because of the heavy traffic at rush hour. The safety for cyclists might also decrease because of the lack of attention from cyclists when knowing that they have priority.

To increase the accessibility for cyclists it is preferable to install a combined crossing with priority for cyclists at the roundabout. That would lead to the same rules for the in- and outgoing traffic from the roundabout, and prioritize cyclists in the intersection. At roundabouts it is preferable with two different lines for giving way to ensure that car drivers will have a good sight when entering the roundabout. At the exit it is preferable with space for one car to yield for cyclists or pedestrians and not blocking the way for the traffic in the roundabout. That will also help cyclists and motor vehicle drivers to see each other.

10.3 Heden/Sten Sturegatan

Figure 10.8 illustrates the design of the crossing between Heden and Sten Sturegatan. The intersection is a three way car crossing with a combined bike and pedestrian crossing in the middle. The combined crossing is speed secured with a speed bump and by the roundabout-formation of the traffic place. There are give way lines for cars in all entrances to the intersection, as well as warning signs for upcoming cyclists. When observing the crossing and the people interacting in the crossing, the overall impression is that people act as if cars should give way for cyclists. A large amount of cyclists enter the crossing in high speed because of the slope and the wide bike lanes over Heden, and cars give way for both cyclists and pedestrians. The speed of the cars is low, and all road users have good view over the intersection. Figure 10.9 shows the intersection at the east end of Heden.

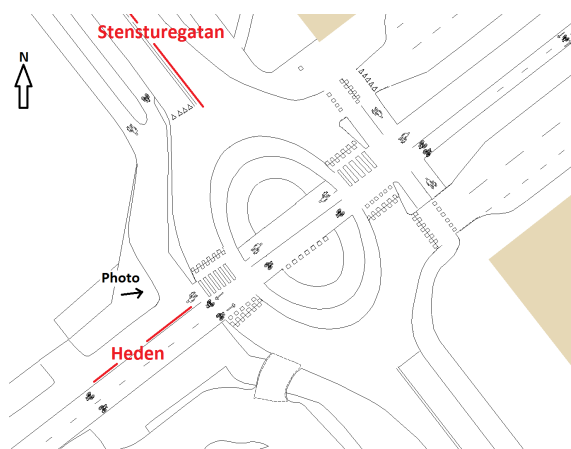


Figure 10.8: Illustration of the crossing at Heden/Sten Sturegatan.



Figure 10.9: Crossing at Heden/Stensturegatan.

Suggested design

Due to the average behavior of the motor vehicle drivers, the combined crossing works as if cyclists have priority. Installing a sign and painting markings on the road might decrease the attention from cyclists if they understand that cars should yield. It is also possible that cyclists will keep a higher speed when coming from

Heden because of the slope, if they trust that cars will yield. Figure 10.10 shows the design of the crossing with the signs and markings for a bike crossing where cars give way. The crossing looks similar to the present intersection and the only thing that differs is the addition of signs and markings. To maintain a good accessibility

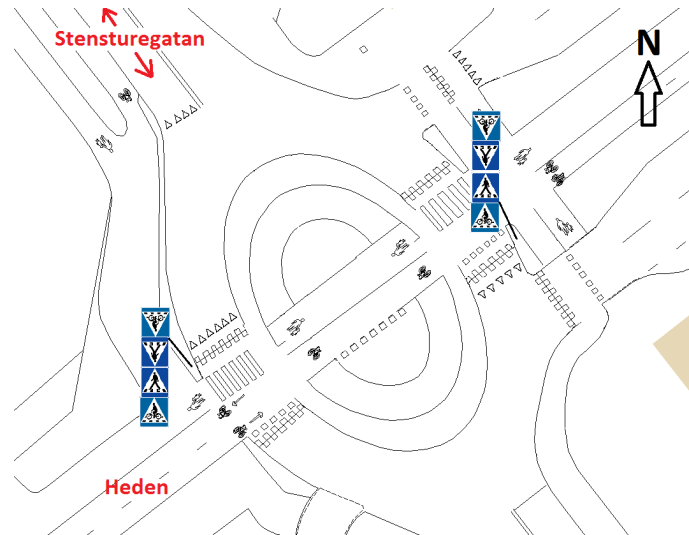


Figure 10.10: Illustration of the crossing at Heden/Sten Sturegatan with give way lines and bike crossing signs.

for cyclists the crossing should be marked as a bike crossing according to the new law. Due to the high speed of the cyclists there could be warning signs or "slow down" signs for cyclists before the crossing. By keeping the difference between the width of the bike path over Heden and over the intersection, the speed of the cyclists from Heden can be kept reduced. Though it is a combined crossing the suggestion is to paint the yield markings before the combined crossing, and to have one line of bike squares. The signs for pedestrian and bike crossings should be installed on the same pole and put before, or in the middle of the zebra crossing.

10.4 Torpagatan/Munkebacksgatan

At Torpagatan a large roundabout with many types of vehicles that interact is located, see figure 10.11. Cars, buses, cyclists, trams and pedestrians interact in the crossing. At two entrances to the roundabout combined bike- and pedestrian crossings are located. The combined crossings are located close to the roundabout but with enough space for a car between the bike passage and the entrance to the roundabout. Larger vehicles block the bike passage if they have to yield at the entrance, a situation that often occurs at the north entrance to the roundabout. The combined crossings are not speed secured and do not have any signals. The crossings stretches over four lanes and have refuges between each lane, see figure 10.11. The bike passages have cyclists going in both directions (two-lane passages).

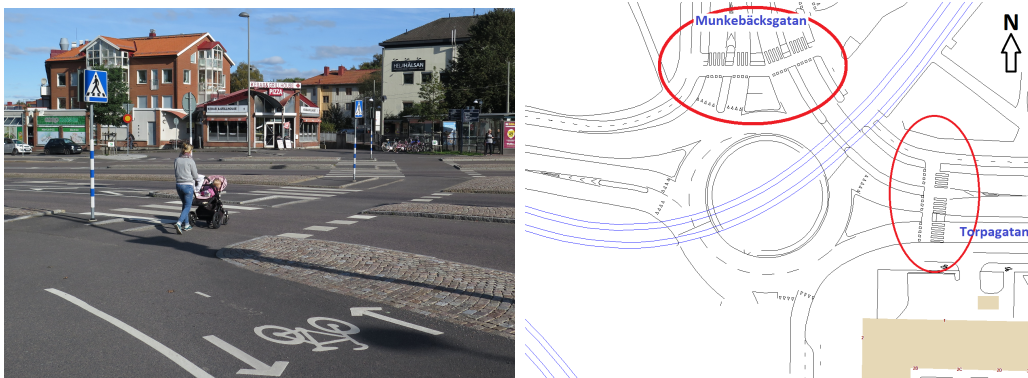


Figure 10.11: Two combined crossings at Torpagatan/Munkebacksgatan. The photo shows the north intersection.

While observing the situation at the roundabout many children ride their bike through the intersection and almost all car drivers gave way. Many cyclists and pedestrians uses the north crossing, heading for the stores or tram stop located on the northeastern side of the roundabout. Cyclists coming from east and heading out on the combined crossing on the north side ride in the same direction as the traffic and have a sharp turn making it hard to see the motor vehicles that they will interact with. Not only cyclists used the bike passage while observing the situation, as seen in the photo. More than one person with a baby carriage chose to walk on the bike passage that has a flat surface.

Suggested design

To improve the priority for cyclists it is preferable to rebuild the combined crossings due to the new regulations. At this site that means installing signs and markings, and to speed secure the crossings. This will also lead to that the space between the bike crossings and the entrances to the roundabout have to be larger. To keep the accessibility for cyclists and not build a detour it is preferable to keep the combined crossings as close as possible to the roundabout and the links in the bike path network around the traffic place. When speed securing it is important to have in

mind the bus traffic as well as the ambulances that use the road. When talking to Lars-Erik Lundin at the Traffic and Public transport Authority in October 2015 the combined crossings are going to be speed secured with speed bumps. This is done to give a safe situations for unsecured road users¹.

10.5 Swedenborgsplatsen

At Swedenborgsplatsen a large roundabout has been built with the formation seen in figure 10.12. All interactions between car drivers and cyclists are at combined crossings with bike lanes in both directions. One of the combined crossings is regulated with signals, and none of the intersection points are speed secured. The give way lines for cars reaching the roundabout are painted just before the entrances to the roundabout and after the combined crossings.

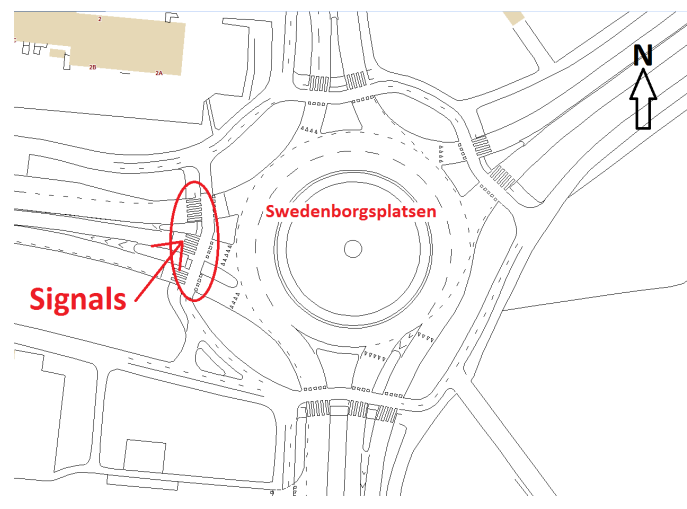


Figure 10.12: Illustration of the roundabout at Swedenborgsplatsen.

While observing the crossing many cyclists used the east and north crossings coming from south and heading for the living area on the northwest side of the traffic place. Cars were mainly coming from east or south, and more than once the bike passage on the east side was blocked by motor vehicles. More motor vehicle drivers than cyclists were using the traffic place while observing the situation, but at rush hour the situation might be different.

Suggested design

The intersection is today similar to the one at Torpagatan/Munkebäcksgatan and to improve the accessibility for cyclists the same type of measurements can be done. That would lead to a higher priority for cyclists but less for motor vehicle drivers. By speed securing the combined crossings the safety for cyclists might increase. Another possible solution is to keep the intersection as a bike passage and paint the

¹Lars-Erik Lundin 2015, e-mail conversation October 12th

bike lanes in red color. That would not change the priority but can affect the security for cyclists if the road users keep attention to the passage. Signals are another alternative to improve the priority for cyclists. The disadvantage of installing signals is that the traffic flow often gets worse when road users have to stop, and according to the large amount of vehicles at Swedenborgsplatsen that would not be preferable.

To increase the accessibility and safety for cyclists it is preferable to speed secure the intersection between cars and bikes with speed bumps. It is also preferable to leave the priority to cyclists to reach the goal of increasing the accessibility at the prioritized bike paths in Gothenburg.

10.6 Costs for changes

The changes that have to be made for making the intersection to be a bike crossing is adding the sign for bike crossing at the poles with the pedestrian crossing sign, and to paint the give way markings before the crossing at two locations. At some places the level of the bike path/crossing will be changed as well. This will of course lead to costs for the society and is an important aspect when considering which intersections that should be changed, and in which order. When talking to Lars-Erik Lundin from the traffic and public transport authority he explains that building a combined crossing today costs about a quarter of a million, and with the new regulations the costs might increase by fifty thousand SEK². Changing the priority on old combined crossings might cost about half the price for the new regulation, twenty five thousand SEK.

²Lars-Erik Lundin 2015, e-mail conversation November 13th

11

Results

A result of the study the questions stated in the introduction of the report will be answered.

- *Which intersections have good design and which need improvement?*
Thinking of the goals of good accessibility and safety for cyclists, there are potential improvements for all studied intersections. The intersections at Swedenborgsplatsen and Munkebäcksgatan which are not speed secured should be prioritized in the maintenance order for cyclists safety. Dealing with the accessibility for cyclists, the priority of maintenance should be firstly on the intersection along Sprängkullsgatan and at Linnéplatsen to improve the flow in the bike traffic.
- *What is good design?*
Good design of intersections between motor vehicles and bikes is about more than thing. The intersection should be safe, secure and have good accessibility for cyclists. The crossing should also not be a barrier for motor vehicles of different types such as buses, ambulances or cars. A good design gives a steady flow of traffic through the intersection, with minimal conflicts.
- *What kind of design is feasible at the site? Which type of crossing should be used at the site; bike passages or bike crossing?*
The conclusion of suitable design results in the recommendation of using bike crossings at sites included in the large bike network in Gothenburg. Bike crossings should be used at places with many interactions between cyclists and motor vehicle drivers where the effort for yielding is higher for cyclists than for motor vehicle drivers. Signalized crossings might be preferable at some intersections as well.
- *How can the intersection be improved?*
The intersections can be improved in different ways because they do not have the same design today. Typical improvements are to change the priority by adding sign and markings for bike crossings.
- *What will the changes cost?*
Because of the unclear situation of which design that should be used, the costs for building bike crossings due to the new regulation are unknown. The expected cost for combined crossings with the new design and priority for cyclists over cars, is approximately three hundred thousand SEK. For changing the priority on old crossings the cost is expected to be about twenty five thousand SEK.

- *What are good and bad with the possible design alternatives?*
All good comes with bad? In this case that might be true because of the shared space where motor vehicle drivers and cyclists interact. Those things that are good for cyclists might be bad for other road users, and one example is the accessibility.
- *How do car drivers and cyclists interact at the studied sites today?*
Typical behavior at intersections today is that cyclists are given priority in most of the cases. Depending on the situation if pedestrians are involved or not, the priority differs with more cyclists given priority when pedestrians are present.

12

Discussion

In this chapter different design alternatives are discussed, their advantages and disadvantages as well as new ideas for the design. The discussion covers details of the physical installations in the infrastructure, as well as the behavior of the road users.

12.1 Limitations

From the questions answered in the result it is good to remember that no comprehensive behavior study has been made for the five sites in Gothenburg. With only five studied sites the results do not show an average behavior for all bike intersections. It is also important to mention that the five crossings in this study only present some of the design alternatives of intersections between cyclists and motor vehicle drivers.

12.2 Shared space for pedestrians and cyclists

In Gothenburg and many other Swedish cities it is common to build combined crossings and combined bike and pedestrian paths. This might be a result of cyclists being directed not to ride on the road. As the amount of cyclists has increased, the need of separating cyclists and pedestrians is higher. Using combined crossings and paths are good in an economic point of view since the building and material costs decrease. It is also preferable in narrow places where it would be impossible to build both a bike path and a separated walking path. With a small amount of cyclists and pedestrians it could be assumed that it would not be a problem with combined paths, but if the speed of cyclists increases it can be a danger to let them share space. With the goals of increasing the amount of cyclists, and the popularity of bike sport, it is preferable to separate cyclists from pedestrians. Both to increase the accessibility, but also to decrease the risk of accidents because of interactions between pedestrians and cyclists.

At intersections between motor vehicle drivers and unsecured road users the combined crossings gives good accessibility for cyclists according to the result from the field study. As mentioned earlier, the presence of pedestrians at the intersection gives higher priority for cyclists. This could be expected as cyclists easily can ride through when motor vehicle drivers have to yield for pedestrians at the crossing. This indicates that the accessibility for cyclists at intersections can be higher at

combined crossings than at separated bike passages or bike crossings where pedestrians are not present.

12.3 Modify combined crossings

At combined crossings close to road intersections, the sight over the upcoming intersection for motor vehicle drivers can be a problem. If drivers have to stop or yield for pedestrians or cyclists, and do not have space to stop between the combined crossing and the road intersection, the accessibility for cyclists often decreases because vehicles block their way. There are a couple of aspects that have to be dealt with when choosing the location for the combined crossing. For example the accessibility for cyclists is depending on the location of the crossing. Which factor is most important? Is it the blocking by vehicles or the location which could give a detour? Another aspect is that the attention from motor vehicle drivers is higher closer to road intersections because they are aware of that they have to interact with other road users when approaching an intersection, they also keep a lower speed which is important for the unsecured road users.

The width of the zebra crossing can perhaps be smaller when they are in combination with the bike crossing. For example the crossing before a roundabout. This leads to a better overview over the crossing for car drivers since it is a shorter distance to the bike crossing.

12.4 Design of long crossings over many lanes

At big junctions often in combination with a roundabout, the number of lanes that pedestrians or cyclists have to cross can be many. Three lines in each direction is common, and it is improbable that all lanes will be empty of cars and safe to cross in one stage. From a cyclist point of view the accessibility decreases if they have to stop in the middle of the intersection to yield for motor vehicles. It could also be unsafe if one car yield for the cyclist, but a car in the next lane can not see the cyclists and do not yield. For cyclists it is easy to see the entire intersection as one crossing that you can cross in one step, but for motor vehicle drivers the focus is mainly on their part of the intersection only including one line. If the rules for yielding should be kept as today it is important to improve the situation for cyclists on the passage. Installing railings to hold on to or a high step to put down a foot on while waiting decreases the effort that cyclists have to give for yielding in the intersection. This could be used at signalized crossings as well, which is a solution that is used in Malmö.

12.5 Design and position of the sign

The sign for bike crossing has the same color and form as the pedestrian crossing sign. There are both positive and negative aspects of having a sign similar to one

already implemented in the traffic system. The positive aspect is that many road users know the rules for yielding at pedestrian crossings, and it is therefore easy to understand the rules at places where the bike crossing sign is installed (as long as they understand that the similar sign has similar rules). One problem when implementing the new sign is the possibility that motor vehicle drivers do not detect the new sign because they assume that it is a sign for a pedestrian crossing. If the signs are on the same pole at combined crossings drivers might observe it because it is two and not one sign.

As an alternative to the bike crossing sign at roundabouts the yielding sign for the motor vehicle drivers at the entrance to the roundabout could be used and a text under the give way sign could be added that says "also applies to cyclists". That would decrease the amount of signs at the entrance to roundabouts where combined crossings are located close to the roundabout. Before the new regulations that was one way to give priority to cyclists.

It is also described in the law that the sign for bike crossings should be just before the crossing. This implies that with the new rules for bike crossings there have to be two yielding signs at combined crossings; one for pedestrians and one for cyclists, and they should be installed just before each part of the combined crossing. At combined crossings in Gothenburg the sign for pedestrian crossings is placed in the middle of the zebra lines where the sidewalk is submerged. To minimize the number of poles it is preferable to place the two signs on the same pole. Today that is a side step from the law since at least one of the signs will not be installed just before the crossing.

12.6 The road markings

When the new regulations came, many planners were confused over how to interpret the regulations. The road markings that should be installed was one of the questions. Today many intersections are combined crossings where the road markings are combined as well, meaning that the bike squares are only painted as one line where the zebra lines are on the other side. As mentioned earlier this is something that the Swedish Transport Agency have made amendments on. It might be favorable to have two lines of bike squares at bike crossings even if they are at combined crossings, helping drivers and cyclists to distinguish between the rules of priority. It could also be preferable to remove the bike squares at bike passages.

Another way to separate the bike crossings from passages is to paint one type in color, and it might be better to paint the bike crossings and leave the passages with as little treatment as possible. In the same way as pedestrians are more observant when they cross a road without a zebra crossing, it is likely to think that a similar behavior will occur for cyclists. The bike path before the intersection also has impact on cyclists behavior and understanding of the upcoming traffic situation. If the bike path is straight and in a clear way continues on the other side of the road, cyclists might be less observant of the intersection. This situation could be avoided

by painting transverse lines on the bike path, writing "Slow down", placing signs for yielding along bike path or building bike path with a small turn to reach the passage (to avoid the straight path). Given that many cyclists have good understanding of the traffic rules, the signs and markings used for motor vehicle traffic can be used for cyclists as well.

12.7 Car or bike tradition

Copenhagen might be one example where you can see that a historical and long tradition of cycling helps building a "good" bike infrastructure as city planners often refer to today. It's maybe hard to turn Gothenburg into a bike city as good as Copenhagen because we have an old car tradition. Maybe in fifty years from now we will have a good start for a bike city because of the next generation. When discussing infrastructural details such as the bike crossings, it is important to remember who will use the system. You probably have to think and design in another way when planning for cyclists that are used to drive cars, than planning for cyclists that always have used their bike to travel.

12.8 What is good design?

The question of what is good design can have many answers depending on who you ask. Infrastructural planners often describe good design with good accessibility, safety and security. But we have to remember the importance of the surrounding of the bike path, such as the view or traffic noise. The bike paths can be perfectly designed to be as safe and secure as possible, but if they are located in industrial areas, close to busy roads or at other unattractive locations, the usage of the system will probably not increase. All aspects are linked together and first when all pieces are working we got a good design. Then of course the good design has to be in every single link, which for the bike crossings would be for cyclists to cross the intersection without stopping, getting harmed or feeling unsafe.

With the new regulation for developing the bike crossings there are many measures for the motor vehicle drivers, but less for cyclists. This means that the good design is mainly depending on the road traffic and that they understand the traffic place. It is hard to develop the design for cyclists and there is a lack of investigations and studies that deals with the area. Even though motor vehicle drivers have a large impact on the safety for cyclists on bike passages or crossings, the behavior of cyclists and the design of the bike path at the crossings are important aspects as well.

13

Conclusions

There are many things in the traffic system that works the same way if you analyze another city or other locations in Gothenburg. The literature study indicated some general behavior of road users based on the actual priority. One conclusion is that cyclists often are given priority at intersections even when the law has given less priority. Here are some general conclusions listed:

- Priority for cyclists is one part of reaching the goal of being an attractive city for cyclists.
- The design of the bike crossings have to be developed and analyzed further but has a good fundamental idea.
- Bike crossings are preferable where bike passages with many motor vehicles are located today, and should be a standard at roundabouts.
- Cyclists knowledge about the risks of riding in high speed or without good control of the surrounding traffic, has to be better.
- The bike path network in cities should have clear routes and continuity to help road users understand the current situation.
- A clear difference between bike passages and bike crossings is needed.

13.1 Further studies

Today it is easy to find behavioral studies of motor vehicle drivers, sometimes with cyclists involved, but seldom studies from a cyclists point of view. There are many investigations of how to slow down the speed of motor vehicle traffic and make the passage over a road safer for cyclists by installing devices for motor vehicles drivers. Studies that focus on measures that could be implemented for cyclists would give the studied area a greater background.

Another study that would be interesting to see is analysis of the implementation of bike crossings in Gävle, which is something they have been doing during the year. In order to see the longterm effect of the installation of changed priority in the traffic

13. Conclusions

it is suitable to do behavioral studies in a couple of years.

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