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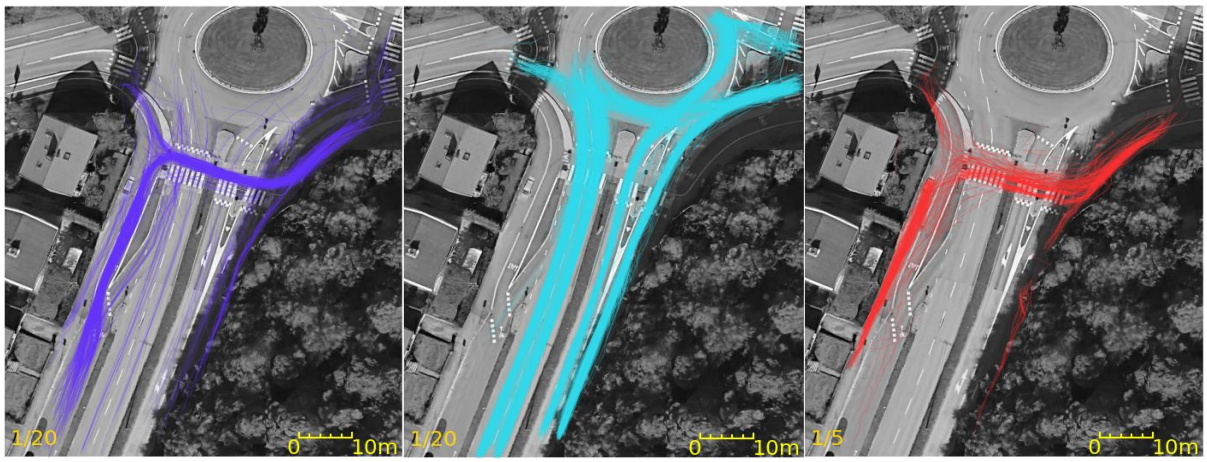

Road users' behaviour at bicycle passages

A case study in Gothenburg performed by video analysis and interviews

Master's thesis in Infrastructure and Environmental Engineering

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Master's Thesis ACEX30-18-100

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Cover:
Tracks of road users from the video analysis performed in this report, from the left: cyclists, vehicles, pedestrians

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Abstract

Gothenburg has a vision of a more sustainable traffic system where more people use other ways to travel than the car, and wants to make it easy and safe to take the bike. Therefore, new bicycle paths are planned to be built and many of the current bicycle paths are planned to be rebuilt. With this in mind, this thesis examines road users' behaviour at bicycle passages and which road user that gives way in practice. When a cyclist is about to cross a road, there could be either a bicycle crossing or a bicycle passage. Simplified, cars must give way at bicycle crossings and cyclists must give way at bicycle passages, this cause confusion among the road users since they experiencing it difficult to distinguish between passages and crossings.

The methods used was video analysis and quantitative interviews. The video analysis was used to observe the road users' behaviour in an objective way and the interviews were used to examine the knowledge in the applying traffic rules. To do this, a bicycle passage by a roundabout in Gothenburg was chosen as a study area.

The result from the video analysis showed that car drivers brake as much for pedestrians as they do for cyclists. This indicates that many car drivers give way for cyclists, while the majority of the cyclists shows no intention to give way for the cars. Further, the interview result showed that over 60 % of the cyclists had perceived the rule at bicycle passages wrongly, and also act accordingly. Moreover, many of the respondents experienced the rules as unclear. Finally, the conclusions of this thesis is that the traffic rules at bicycle passages need to be clarified, more bicycle crossings could advantageously be introduced in Gothenburg and that the video analysis tool worked good with interviews.

Key words: bicycling, bicycle crossing, bicycle passage, road safety, give way, roundabout, traffic legislation, video analysis

Trafikanters beteende vid cykelpassager
En studie i Göteborg genomförd med videoanalys och intervjuer
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Sammanfattning

Göteborgs stad har en vision att ha ett mer hållbart trafiksystem, där fler väljer andra transportmedel än bilen och vill göra det enkelt och säkert att använda cykel istället. Därför planeras för att byggas fler cykelbanor och flera av de nuvarande ska byggas om. Med detta i åtanke har denna uppsats syfte varit att studera trafikanters beteende vid cykelpassager och vilken trafikant som ger företräde för vem i praktiken. När en cyklist ska korsa en bilväg kan det antingen vara en cykelpassage eller en cykelöverfart. Förenklat ska bilister ge företräde för cyklister på cykelöverfarter, medan på cykelpassager är det cyklister som ska väja. Detta orsakar förvirring hos trafikanterna eftersom de upplever det svårt att skilja på passager och överfarter.

Metoderna som användes var videoanalys och kvantitativa intervjuer. Videoanalysen användes för att observera trafikanterna på ett objektivt sätt och intervjuerna för att utreda regelkunskaperna hos cyklister. För att göra detta valdes en cykelpassage i Göteborg som studieområde.

Resultatet från videoanalysen visade att bilisterna bromsar lika mycket för cyklister som för fotgängare, vilket kan indikera att många bilister ger företräde för cyklister medan en majoritet av cyklisterna inte visar någon intention att väja för motorfordonen. Vidare visade resultatet från intervjuerna att över 60 % av cyklisterna hade missuppfattat reglerna vid cykelpassager och beter sig utifrån det. Många av respondenterna upplevde även reglerna som oklara. Slutligen är slutsatsen av denna uppsats att trafikreglerna vid cykelpassager behöver förtydligas, mer cykelöverfarter skulle med fördel kunna introduceras i Göteborg och att videoanalys har fungerat bra som metod i kombination med intervjuer.

Sökord: cykling, cykelöverfart, cykelpassage, trafiksäkerhet, väjning, cirkulationsplats, trafikregler, videoanalys

Acknowledgements

In this study, road users' behaviour at bicycle passages has been investigated. Video analysis and live interviews has been performed at a roundabout in Gothenburg. The thesis has been carried out at the department of Architecture and Civil Engineering, Road and Traffic Research Group at Chalmers University of Technology from March 2018 to August 2018. The study has been a cooperation with ÅF Infrastructure, Viscando Traffic Systems and Traffic and Public Transport Authority in Gothenburg. Following persons deserves a thanks from the authors of the thesis:

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The thesis would not have been possible without Viscando Traffic Systems, who was responsible for the video analysis. They have shown a lot of interest and put a lot of time and effort in the project. Special thanks to their CEO Amritpal Singh for giving input during the project and to Mikhail Bolbat who did the algorithm work.

The Traffic and Public Transport Authority in Gothenburg have supported the project, financially when installing the video analysis equipment. Further, they have also contributed with knowledge in the current traffic situation for cyclists in Gothenburg, by their co-workers Malin Månsson and Lars-Erik Lundin.

The opponent Oskar Sköld, who gave valuable response on the report and the presentation.

Hanna Lundborg
Emma Wallberg

Gothenburg, September 2018

Glossary of terms

Bicycle path	a path that is intended for people who riding bicycles
Bicycle passage	where cyclists should give way for vehicles
Bicycle crossing	where vehicles should give way for cyclists
Give way	to allow other road users to go past before you move further
Roadway	the part of the road on which vehicles drive
Unsupervised intersection	an intersection that has no traffic lights
Give way-behaviour	how road users behave in situations when some road user must give way

English - Swedish translations

Traffic and Public Transport Authority in Gothenburg	Trafikkontoret, Göteborgs stad
Swedish Transport Administration	Trafikverket
Swedish Transport Agency	Transportstyrelsen
Swedish National Road and Transport Research Institute	VTI
Swedish Association of Local Authorities and Regions	Sveriges kommuner och landsting, SKL
Median barrier	mitträcke
Vulnerable road users	oskyddade trafikanter

Contents

1 Introduction

Traffic planning has traditionally been done with a focus on cars and other motorized vehicles. However, recent years changes have happened in order to create more sustainable traffic systems. Many cities state visions to reduce the motor traffic and get people to travel with other transport modes. The good effects if people start to walk, take the bike or public transport instead of the car are, for example, that the emissions of carbon dioxide would decrease as well as the air pollutions. Furthermore, it would have good effects on the public health and traffic congestion. A conversion to a more sustainable traffic system with more cyclists and pedestrians is of course not entirely unproblematic. When the different road users have to share the same space, more conflicts and accidents could possibly happen. The interactions between the different road users can also create irritation. As an example, cyclists think that car drivers drive too fast and careless, and that pedestrians walk on the bicycle paths. On the other hand, car drivers think that cyclists and pedestrians are inattentive.

1.1 Background

When planning for a traffic system involving different road users, it is important to consider the safety of each transport mode, not only the car drivers. When discussing safety, it is also important to talk about security and distinguish between those two concepts. Security is about the perceived risk, if the road user feels that the traffic situation is safe or not. Safety on the other hand is about the actual risk, if accidents occur. A traffic situation can be experienced as insecure, even if the road safety is high and few accidents happen. Contrariwise, a situation that actually is unsafe can be experienced as secure. With this in mind, it is essential that the safety is greater than the security in traffic planning.

One thing that can cause insecurity is if the road users are unsure of which traffic rules applies, or if they feel that other road users are lacking in knowledge about the rules. Furthermore, it is also a problem if road users think that they know the rules and act accordingly, even if they have misunderstood the rule. Since one not needs a driving license to bicycle, and since the rules for cyclists maybe is not as well-known as for car driver, it is possible that insecurity is more common among cyclists. In 2017 the *Swedish National Road and Transport Research Institute*, hereinafter shortened VTI, published a study on formal and informal rules among cyclists. According to that study (Björklund, Forward, Janhäll & Stave, 2017), a situation that many cyclists experienced as unclear was "bicycle crossings or other places where cyclists and other road users' ways are crossing".

In Sweden, the normal situation when a bicycle path is crossing a road is that there is a bicycle passage, which means that the cyclist must give way and not the car driver. The bicycle passages are often placed side by side with a pedestrian crossing, where the car driver must give way versus the pedestrian. This is something that possibly can lead to confusion and misunderstandings. If the bicycle passage is placed by a road crossing or a roundabout, the rules are stated a bit differently, which possibly can cause even more confusion.

1.2 Aim and objectives

The aim of this master thesis was to investigate the behaviour of different road users; pedestrians, cyclists and car drivers, at bicycle passages. Traffic rules regarding bicycles that are crossing a roadway are, according to several studies, experienced as unclear by road users, especially when the passage is placed next to a roundabout or roadway crossing. This thesis was examining which road user that gave way in practice, both

with automated video analysis and with interviews. In addition, the road users' knowledge of the traffic rules in such situations was examined. To be able to fulfil the aim, a case study has been made, this is further explained in the next chapter.

1.2.1 Background to the study

As this master thesis was done at Chalmers University of Technology in Gothenburg and as the infrastructure in Gothenburg is planned to expand a lot in coming years in terms of developed public transport and bicycle paths, it was naturally to place the case study there. The City of Gothenburg has, as many other cities, the vision of a more sustainable traffic system, where more people use other ways to travel than the car. According to the City of Gothenburg (Trafikkontoret, 2014a), one of the main goals is that at least 35 % of all travels should be done by bike or foot in 2035, which is a doubling compared to today. To make that possible, different actions have been or will be done in the next few years. New bicycle paths are built and many of the current paths are rebuilt to be able to meet the political visions. Furthermore, so-called bicycle crossings will be built at some places, which should make it easier for bicycles to cross a road.

The specific traffic junction studied in this thesis is a roundabout located at the intersection between Margretebergsgatan and Slottsskogsgatan in the district Majorna-Linné in Gothenburg. A satellite photo of the roundabout can be seen in Figure 1.1. The site was chosen together with the *Traffic and Public Transport Authority in Gothenburg* and the company Viscando, who was responsible for the automated video analysis. The site was chosen due to the relatively high flows of both cyclists, pedestrians and cars in the area. Furthermore, a reconstruction of the junction is planned in the future, whereupon the city has an interest in an analysis of today's traffic situation. In addition, the junction is designed in a way that makes video analysis possible.

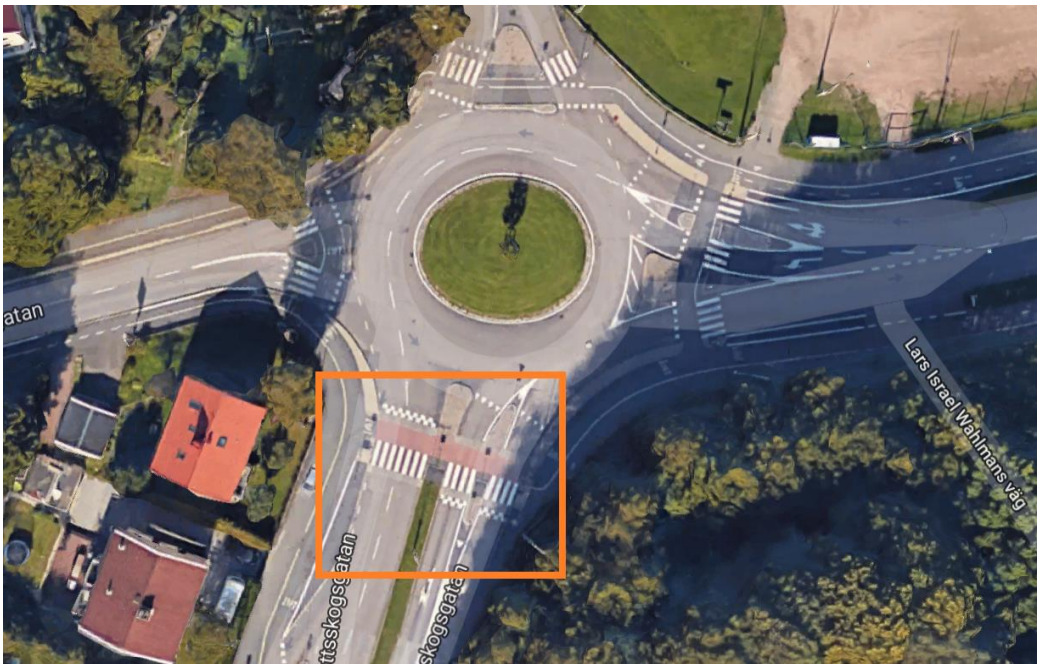

Figure 1.1 The chosen spot to study, a roundabout in Majorna by the big park Slottsskogen. The area inside of the orange mark is the part of the roundabout that was analysed (Google Maps, 2018b).

1.2.2 Problem and question formulation

To fulfil the aim, the project was divided into three parts:

1) In the first part, a literature study was done, which explains the main background information necessary for the project, about e.g. current traffic legislation in Sweden, bicycles trends and theory of road safety.
2) In the second part, an automated video analysis was performed to see the actions of the road users. General information about the road users' velocities, tracks etc. were examined. Moreover, it was analysed how the cars brake for cyclists.
3) In the third part, interviews were performed with cyclists and pedestrians in the study area. The questions investigated their knowledge about the traffic rules and their own behaviour.

Those three parts was then compared and discussed in the final chapter.

1.2.3 Hypothesis

The hypothesis was that a lot of road users, both cyclists and car drivers, lack in knowledge about the traffic rules at bicycle passages. Furthermore, the road users who are aware of the rules, do not often follow the rules either. This because cyclists do not like to stop and loose speed, and car drivers do not want to cause an accident. As a comparison, the knowledge about rules applying for pedestrians was assumed to be better than for cyclists.

1.3 Delimitations

This thesis has had a focus on Swedish traffic conditions and rules, and the case study was placed in Gothenburg. Only one part of the roundabout was studied, this due to the complexity of the junction and the capacity of the video analysis equipment. At the studied section, cyclists and pedestrians cross four car lanes, two in each direction, as shown in Figure 1.1 earlier in the chapter. This part was mainly chosen due to that the traffic flows of both motor vehicles, cyclists and pedestrians were expected to be the highest there. Further, it is the most complex part of the roundabout as cyclists and pedestrians are crossing four car lanes and the seight conditions are partly not satisfactory enough.

The automated video recording was done from the 22nd of May 2018 to 25th of May 2018, for around 65 hours in total. Traffic flows for cyclists in Sweden are varying a lot over a year, due to weather conditions. Therefore, the dates were chosen with this in mind, so that the flows could be expected to be relatively high. The measurements were performed during a "normal week" without any public holidays or major events and before the summer vacations started.

The interviews were performed at separate times between the 28th of May 2018 to the 18th of June 2018, in total 130 interviews were done. Due to the difficulty to stop car drivers, interviews were executed with only cyclists and pedestrians. The possibilities of interviewing car drivers in other ways were discussed, but due to limitations in time and risk of getting low response rate, it was chosen not to. Mopeds of class 2, skateboarders, inline skates etc. that are using the bicycle path or pedestrian path is not included in the study, due to the low proportion of them compared with cyclists and pedestrians.

1.4 Overall methodology

In this thesis, different methods have been used to be able to fulfil the aim. To receive explanations for the theoretical parts, a literature study on current traffic legislation, bicycle trends etc. was performed.

To be able to study the behaviour of the road users, an automated video analysis was done. The use of automated video analysis in traffic analysis has been more common in recent years, as the technology behind it has developed and become more accurate. When using video analysis, the behaviour can be studied in a more objective way. Further, it is more discrete and does hopefully not affect the road users to the same extent as human observers would do. Another advantage with video analysis is that different types of road users; cars, cyclists and pedestrians, can be measured at the same time but be separated from each other when performing the analysis.

In order to get public opinions, cyclists and pedestrians passing the studied roundabout were interviewed. This to get more understanding on how cyclists who often utilize the junction perceive it. The questions were few and short so people could answer them quickly. The result from the interviews was then compared with the result from the video recording analysis to examine the similarities and differences in the results. More detailed description of the methodology behind the video analysis and the interviews is presented in chapter 3.

2 Literature study

To be able to follow this study in an accurate way, background information about traffic legislation, traffic rules, cycling in Sweden and some other theory are presented in the following chapter. The traffic rules in give way-situations are explained, which is of importance when investigating the behaviour of road users at bicycle passages.

2.1 Traffic legislation in Sweden

The main purpose of traffic rules is to increase traffic safety and decrease traffic accidents. The current traffic legislation in Sweden is very common with traffic legislation in other countries since it is based on an UN-agreement from 1968 (Transportstyrelsen, n.d.a), the general traffic rules can be found in "Trafikförordningen" (1998:1276). In addition, the municipalities and county administrative boards decide about local traffic regulations. It is important to have in mind that different traffic rules apply to different transport modes. The following subchapters describe the traffic rules necessary for this study, starting with a short historical background.

2.1.1 Historical background on traffic rules and safety

The first victim of motorized traffic accidents in Sweden was killed in 1908, this prompted the first traffic rules and in the year 1924 Sweden had 12 traffic rules (Trafikverket, n.d.a). In the mid-20th century, there were a lot of children that were killed in traffic accidents, the worst year was 1964 when over 200 children were killed. The theory back then was that it was the children that behaved wrong in the traffic, whereupon traffic education was introduced in schools. The purpose was that the children should get knowledge about the traffic rules applied and act in a way that reduced the accidents. The school was held responsible for children's road safety through education. During 1980's research showed that the accidents increased with increased number of cars and the responsibility for children's road safety were now put on the municipality through building and traffic planning.

Due to the high number of killed persons, not only children, the traffic legislation was considered during the 1960's and 1970's (Brüde, U., n.d.). Before this, the roads were left-hand trafficked and several roads had no speed limit. Requirements of seatbelt in the front seat of the cars, speed limitations, wearing helmet during motorbiking and right-hand traffic were some traffic rules that were implemented during the 1960's and 1970's (Brüde, U., n.d.). In 1971, VTI was founded in order to deepen the research on roads, vehicles and road users. Traffic legislation in Sweden have been continuously developed since then and will, for sure, keep on developing in the future.

Vulnerable road users, cyclists and pedestrians, has in a historical point of view had the responsibility in traffic situation when interacting with cars. In the 1980's a change was made in the Swedish legislation and now car driver had to "pay particular attention to cyclists at bicycle passages" (Trafikverket, 2017b), the same rule for car drivers versus pedestrians was introduced a bit earlier. The rule that car drivers should give way for pedestrians at a pedestrian crossing was introduced in 2000, the same kind of rule was then discussed for cyclists but were not introduced due that is was not considered as traffic safe enough. However, in 2014 bicycle crossing was introduced in Swedish traffic legislation but still has not had its breakthrough.

2.1.2 Traffic rules for cyclists

In Sweden, bicycles are classified as vehicles which means that cyclists must follow the same rules as other vehicles. However, there are some rules that only apply to cyclists. One rule is that a cyclist shall use the bicycle path if there is one. If there is no cycle path, the cyclist shall use the roadway instead, if it is wide enough. (Notation: there has been a change in regulation just before this thesis was published, but when the study was made this was the current rule) If the cyclist is about to cross the roadway on a bicycle path two different rules can apply; bicycle passages and bicycle crossings, where the most common today is bicycle passages. At a bicycle passage, the cyclist must give away, while the car driver must adjust the speed when approaching the passage so it does not endanger cyclists who are using it. This may seem contradictory, but the idea is if both cyclists and car drivers pay attention, the safety increases. The passage is designated with road markings and can sometimes be raised to slow down traffic.

The rules at a bicycle crossing are stated differently than at a bicycle passage. Cyclists should pay regard to the proximity and speed of vehicles approaching, but the car driver must give way. The crossing shall be designed to ensure that the speed of the vehicles does not exceed 30 km/h. Bicycle crossing was introduced in Swedish traffic legislation in 2014 and after that is has been up to the municipalities whether to use it or not (Sveriges Kommuner och Landsting, 2017). In chapter 2.2, further reading about bicycle crossings can be found.

2.1.3 Traffic rules for pedestrians

Generally, there are not that many traffic rules applying for pedestrians, most of them say that the pedestrian should be aware of the rest of the road users. By definition, the category pedestrians also comprise people who travel with e.g. inlines, skateboard and kick bike, as well as for those who are using wheelchairs or leads his or her bike or motorbike. The most relevant rule for this study is that pedestrians should walk on the pavement and cross the road at the pedestrian crossing. Moreover, cars should give way for pedestrians but pedestrians should observe the speed of, and distance to the car before crossing the pedestrian crossing (NTF, n.d.).

2.1.4 Traffic rules for motor vehicles in a roundabout

Roundabouts are a common alternative to a signal-regulated crossing. The intersection is used to lower the speed and decrease severe accidents, they are easy to understand and contributes to a more even traffic flow. Accidents in roundabouts still happen, but the damage is almost always mild like damage to the plate and almost no injury. This due to the low speed and that crashes occur in an oblique angle. Since the 1990's, roundabouts have become more common in Sweden, as an example the number of roundabouts in Sweden increased from 1 500 in 2005 to over 2 500 in 2010 (Silvano, A & Linder, A, 2017).

Cars that are about to drive into the roundabout should give way for cars that already are inside it. If it is a pedestrian crossing next to the roundabout, car drivers should also give way pedestrians, both when entering and exiting the roundabout. If there is a bicycle passage next to the roundabout, it is the cyclist that must give way when the car driver is entering the roundabout. When a car driver is exiting a roundabout, the rule is stated a bit different and says that "the driver must drive at a low speed and give cyclists who are on or about to enter the passage an opportunity to cross", see Figure 2.1. When a car has turned in an ordinary intersection and is supposed to cross a bicycle passage, the rules are stated the same as when a car is exiting a roundabout, see Figure 2.2.

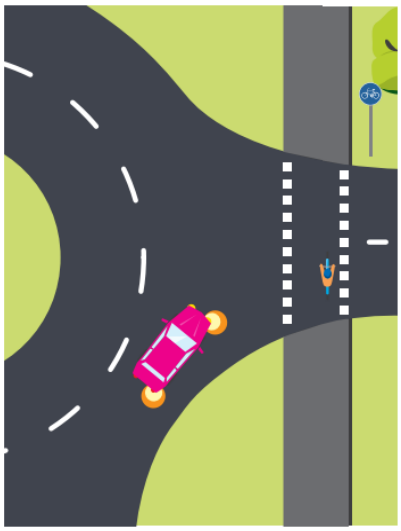

Figure 2.1 When a car is exiting a roundabout the driver must drive at a low speed and give cyclists who are on or about to enter a bicycle passage an opportunity to cross (Transportstyrelsen, 2015a).

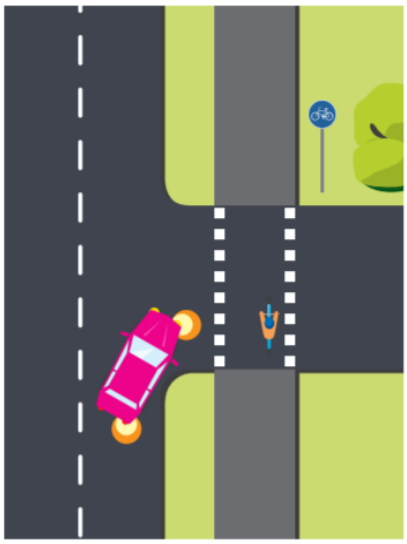

Figure 2.2 When a car has made a turn in an intersection and shall pass an unsupervised bicycle passage, the driver must drive at a low speed and give cyclists who are on or about to enter a bicycle passage an opportunity to cross (Transportstyrelsen, 2015a).

2.2 Cycling in Sweden and Gothenburg

To create a more sustainable transport system, the bike has been more and more highlighted as a substitute for the car the last decades. The advantages with cycling are e.g. that it has good effects on the public health and for the environment in general. However, to get people to choose the bike, infrastructure must be more suited for cyclists and it must feel like a safe option. The following chapters give an insight on the current situation for cyclists in Sweden in general and more specifically in Gothenburg.

2.2.1 General trends for cyclists

In Sweden, around 600 million bike-travels are done every year, which in other words means that an average day, around 800 000 people are using a bike (Trafikverket, 2017a). The amount of travels by bike has been, more or less, the same during the last 10 years. According to *Swedish Transport Administration*, a trend is that the length of the average bike trip has increased, especially for those that are made by people in the age of 25 years and older (Trafikverket, 2017a). This can be explained by the increased number of people taking the bike to work, another reason can be the increasing number of electrical driven bikes. Another trend is that young people tend to take the bike in a lesser extent than before (Trafikverket, 2017a).

Every year the *Traffic Public Transport Authority in Gothenburg* publishes a report on the traffic and travel development in the city. Between 2011 and 2017 the number of bicycle trips is estimated to have increased by 20 % (Trafikkontoret, 2018a). However, the last year the development has moved in the other direction and the number of bicycle trips has decreased slightly. The city has stated a vision that the bicycle trips shall be tripled between 2015 and 2025 and with the current development the goal will not be reached. In Figure 2.3 the distribution of the different transport modes is shown.

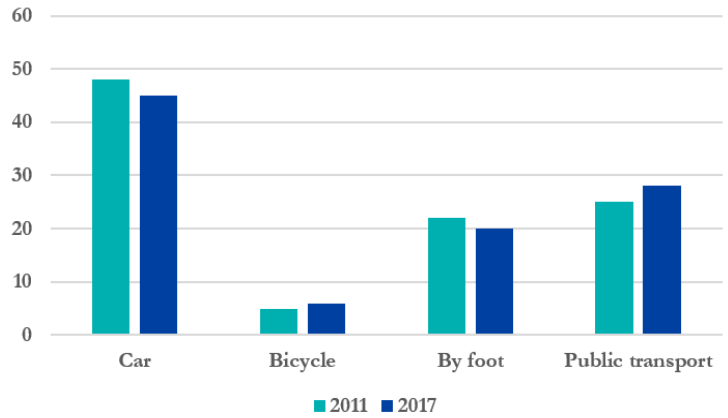

Figure 2.3 The distribution in different transport modes in year 2011 and 2017, adapted from (Trafikkontoret 2018a).

2.2.2 Road safety for cyclists & cyclists' behaviour

When talking about road safety, cyclists are often forgotten, although cyclists are the group of road user that stands for most severe accidents in Sweden (Trafikverket, 2014a). In 2012 almost 2 000 of the 4 500 severe injured in traffic accidents were cyclists. In 2013 VTI published a statistical report over the reported accidents with cyclists in Sweden between 2007 to 2012. During these years, 153 cyclists were killed and over 44 000 were injured so difficulty that they had to seek health care (Niska & Eriksson, 2013).

Around 80 % of the bicycle accidents were single-bicycle accidents and 10 % bicycle-motor vehicle accidents. On the other hand, if just the fatal accidents are studied, almost 70 % of them were in collision with a motor vehicle. Niska and Eriksson (2013) state that the main actions for reducing the severe accidents are improved ice removal, winter tires for bikes and use of cycle helmet. For reducing the severe accidents, helmets are even more important, as well as prevent collisions with motor vehicles by e.g. means of segregation and safe bicycle passages.

Further, Niska and Eriksson (2013) say that most accidents happened during the summer months, May - September, which relates to the increased amount of bicycle flows. During the day, most accidents happen between 7 am and 9 am in the morning and between 3 pm and 6 pm in the afternoon, even this is connected to the higher flows. During night time, 11 pm to 1 am, relatively many accidents also occur which often can be related to alcohol impact.

According to the bicycling program for the years 2015-2025 in the city of Gothenburg, the number of killed and severely injured cyclists in Gothenburg decreased a lot during the 1990's and early 2000's, but in 2011 it was a change. Of all accidents involving cyclists, around 75 % were single accidents. The city tries to improve the safety by separation between the different transport modes and create a forgiving traffic environment, where it is okay to make mistakes. In Gothenburg, the increase of cyclist travels between 2011 and 2017 was around 20 %, while the accidents increased by over 50 % during the same period (Trafikkontoret, 2018a).

The majority of the inhabitants in Gothenburg experience the city as bicycle friendly, but according to the attitude survey for the year of 2016, many people also experience the road safety for cyclists as low (Göteborgs Stad, 2016). In 2015 the survey also examined why the respondents thought the safety was low and even if 80 % of the bicycle accidents were single-accident, it was the interaction with other cyclists that was experienced as most unsafe, together with obscurity (Trafikkontoret, 2015b). In order to increase the road safety for cyclists, operation and maintenance during the whole year need to be improved and the infrastructure for cyclists need to be designed based on the cyclists need.

According to a study from VTI, cyclists stated that roundabouts are a traffic situation where the traffic rules are unclear (Björklund, et al., 2017). Traffic rules for cyclists were also experienced as unclear in bicycle crossings and other situations where roads for cyclists and other road users are crossing each other. The study also confirms that cyclists who are in a rush often ignore the traffic rules and for example use pavements or roadways to reach their destination faster. Also, the cyclists do not always stop at red lights or at stop signs (Björklund, et al., 2017). According to the same study, the majority of the people try to choose a stretch with as few obstacles as possible and further, the majority of the people are not breaking any traffic rules with purpose.

2.2.3 Bicycle passages and the introducing of bicycle crossings

"Cyklingsutredningen" is an investigation performed with the purpose to increase the cycling and make it more safe. As a result of the investigation, bicycle crossings were introduced in Swedish legislation in 2014. The purpose of the introduction of bicycle crossings was to increase the accessibility for cyclists and make the rules more uniform and clear. The rule change was carried out without any recommendations in the design of the bicycle crossings, which meant it was up to each road owner to interpret the legislation. In practice, this has led to that only a few bicycle crossings have been implemented around Sweden, at the end of 2016 around 90 crossings had been implemented (Trafikverket, 2017b). It may also have led to confusion among road users.

Due to the few bicycle crossings implemented, it has been hard to draw any clear conclusion about the effect. The only town that has implemented bicycle crossings in a larger scale is the town Gävle. The *Swedish Transport Administration* did an analysis in 2017, mostly based on the crossings in Gävle, and it showed that the number of accidents per bicycle crossing and year was halved after the implementation (Trafikverket, 2017b). However, due to the low amount of bicycle crossings and the relatively short time they have been implemented, the result is not statistically reliable.

In Gothenburg, the first bicycle crossings were introduced in Autumn 2017. Before bicycle crossings were built, *Traffic and Public Transport Authority in Gothenburg* did a pilot study on the accessibility, obscurity and road safety of the existing bicycle passages. The aim of the study was to examine the current traffic situation and the interplay between cyclists and car drivers. As methods, both interviews and automated video analysis were made. The results showed that car drivers generally experience more obscurity and security than cyclists (Göteborgs Stad, 2017). One reason for that could be that cyclists are more physically vulnerable than car drivers. Another reason could be the knowledge of traffic rules and design of the road.

2.2.4 Design of bicycle passages and bicycle crossings

It is desirable that bicycle passages and crossings should be constructed the same in different municipalities around Sweden. Differences in terms of traffic signs, road markings and coatings should be avoided in order to facilitate the road users. To favour this, *Swedish Association of Local Authorities and Regions* (SKL) have performed a municipal practice for bicycle crossings and bicycle passages. The configuration should make it clear for road users, both cyclists and other, what traffic rules apply for the intersection. Below, Figure 2.4 and 2.5 describes the drawings that SKL have performed for bicycle passages and bicycle crossings. As can be seen in the figures, cars should give way for cyclists on a bicycle crossing due to the yield triangles both in the ground and on the traffic signs. In a bicycle passage with a pedestrian crossing, it is only a yielding sign for pedestrians and not for cyclists. To reach good standard, the broadness of a bicycle passage and a bicycle crossing should be 3 meters, and for low standard 2 meters (Sveriges Kommuner och Landsting, 2017).

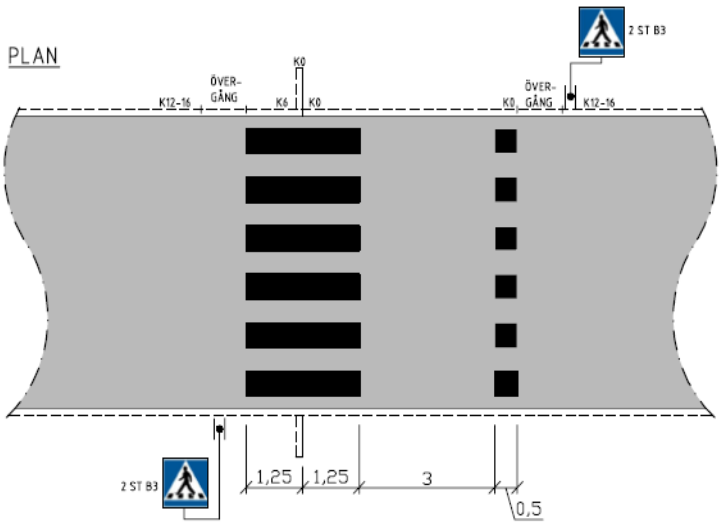

Figure 2.4 Drawing of how a bicycle passage should be designed (R Falk, 2017a). Descriptions in the figure are in Swedish.

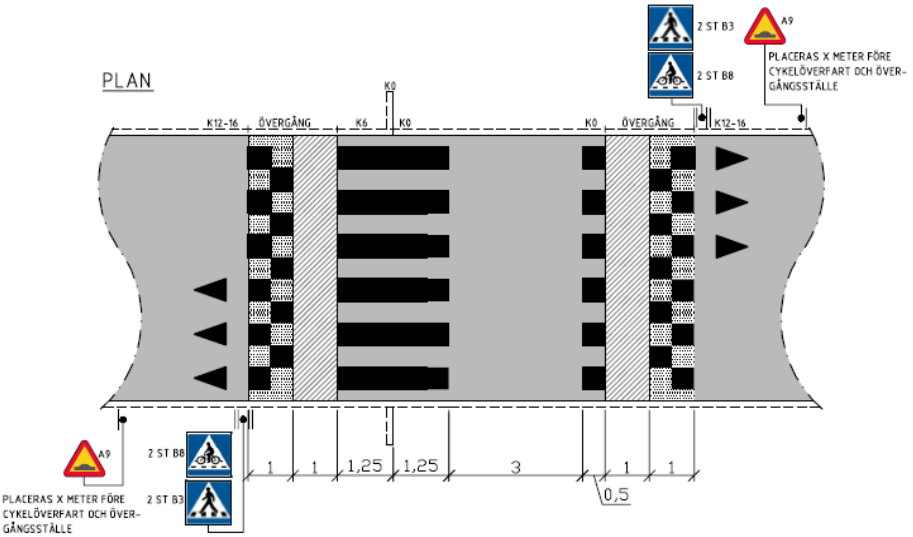

Figure 2.5 Drawing of how a bicycle crossing should be designed (R Falk, 2017b). Descriptions in the figure are in Swedish.

According to standards of the city of Gothenburg, it should be safest to have overpasses intersections in Gothenburg but due to aspects like economy and security, it is not always possible (Teknisk Handbok, 2018a). With the aspect security means that overpasses intersections for example could lead to a tunnel for pedestrians and cyclists, which may not be appreciated during dark hours and therefore it would not be fully used. For intersections in one plane, there are some rules, for example should a bicycle passage be designed so that the road users' attention increases and the speed decreases. Moreover, elevation of the passage and crossing can be used on a road with low speed limit but if the intersection is signalised or highly trafficked it should be avoided (Teknisk Handbok, 2018a).

2.3 Theories of road safety and accidents

When studying road safety, history of accidents is often the only data source and also the main data source in many studies. Even though accidents are an obvious safety indicator, it comes with some important limitations. Sometimes the traffic accidents as an indicator are not very well representative and lifelike due to the following concerns:

- To collect enough amount of data takes a long time since traffic accidents are rare events.
- Lack of reporting of accidents.
- Near-accidents are not reported and they cause a feeling of insecurity.
- Accidents are random and the expected number of accidents is hard to estimate.
- The process of the accident development is often unwell described in the accident reports.

With this in mind, this chapter describes some theories and concept of road safety, which are of interest for this thesis.

2.3.1 The difference between road safety and security

When talking about road safety it is important to distinguish between security and safety. Safety deals with the actual risk, if dangerous situations and accidents occur. The speed limit on a road for example, depends on safety. The criteria for safety depends on how a human being can take violence from a collision. For

instance, at a road with median barrier the speed limit is 70 km/h, whereas at a road where vulnerable road users and cars meet the limit is 30 km/h (Teknisk Handbok, 2018b). On the other hand, security is about the perceived risk, if the road user feels that the traffic situation is safe or not. Security is a complex concept and is not necessarily related to the actual risk, and that is why the concepts security and safety should be separated. Street lighting, good overview and clean areas are factors that can increase security (Teknisk Handbok, 2018c).

In traffic planning, the concepts of safety and security are very essential and strongly connected to each other. The actual risk may differ a lot from the perceived risk and the rule in traffic planning is that the safety has to be greater than the security. This can be exemplified by a person that feels insecure probably act carefully and thereby safe. On the other hand, a situation can be unsafe if a person feels too secure that he or she become inattentive.

2.3.2 Vision Zero & STRADA

In 1997 the Swedish parliament took the historical decision to make the so-called Vision Zero serve as a basis for all traffic safety activities in Sweden. The focus in the vision is that no one should get killed or severely injured in the traffic. In other words, the main problem is not that accidents happen, it is about the consequences of the accidents. A main part in Vision Zero is the fact that road users always will make mistakes and that the traffic system therefore should be designed with that in mind. Since the introduction of Vision Zero, the number of people killed in traffic accidents has decreased. In the late 90's around 500 people were killed every year, in 2017 the same number was 253 (Transportstyrelsen, 2018). The decrease can be explained by, e.g., better cars, better hospital care, median barriers, more roundabouts, alcolocks and speed cameras.

In the same period as Vision Zero was introduced, the database STRADA (Swedish Traffic Accident Data Acquisition) was developed. The database is used to collect information about traffic accidents and the data comes from both the police and hospitals. The police give information from the accident site on what happened, while the hospitals give information on how severe the injuries were. An advantage with the information from the hospitals is that even accidents where the police are not present are reported, which often is the case with accidents involving just cyclist and/or pedestrians (Transportstyrelsen, n.d.b).

2.3.3 The Swedish traffic conflict technique

Traffic safety has traditionally been described in numbers of accidents, which, as described earlier, comes with some limitations. With this as a background, the Swedish traffic conflict technique has been developed. The concept is based on that traffic process can be seen as a number of elementary events, where the events have different degree of severity (Laureshyn & Várhelyi, 2018). The frequency of the events then stands in relation to the severity, which is easiest explained by the "safety pyramid" shown in Figure 2.6.

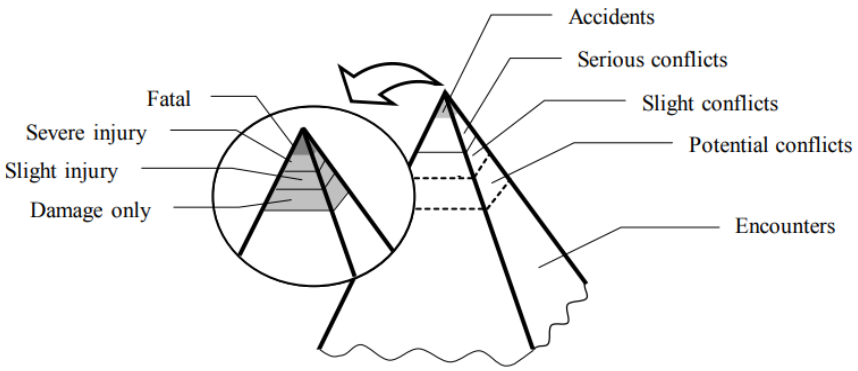

Figure 2.6 The "Safety pyramid", where the top of the pyramid represents the most severe events (Laureshyn, 2010).

Simplified, the concept can be used to estimate the number of accidents, and thereby the traffic safety, by studying the number of conflicts. In earlier days, this was mainly done by human observers, but the last decade it has been more common to use automated video analysis (Laureshyn & Várhelyi, 2018). The concept has been criticised, mainly due to that the relationship between the number of conflicts and accidents cannot be seen in the statistics. As well, according to the Vision Zero the problem is not the number of accidents in general, it is about the number of severe and fatal accidents.

2.3.4 Safety in Numbers

The last years, the theory "Safety in Numbers" has been more and more common in reports and debates on traffic safety, especially when talking about cyclists and pedestrians (Koucky & Partners, 2015). The theory says that with an increased number of cyclists and pedestrians, the relative risk for one person to get involved in an accident decrease. The concept became globally spread in 2003 when a study showed that a collision between a motorist and a cyclist or pedestrian is less likely to appear if more people are walking or bicycling (Jacobsen, 2013). "Safety in Numbers" is widely used as an argument for increasing cycling, although some researcher states that the concept is not scientifically substantiated enough.

3 Method

In this study, video analysis was used as a method in order to study the behaviour of road users. This method can be seen as a developed human observation and is an effective tool for objective observations. Additionally, a quantitative study, in terms of interviews, was another method used to perform the research. This chapter describes the methods further.

3.1 Automated video analysis

A video analysis of the traffic environment provides a lot of information. The challenge is to collect the interesting and useful information and then transfer it to usable data. In automated video analysis, the road users are detected by cameras, but the video is not necessarily recorded. This subchapter further describes the concept of an automated video analysis and how it was used in the studied area.

3.1.1 The use of video analysis

To analyse road users and their behaviour in traffic, data needs to be collected in terms of indicators. It is of importance that an indicator is validable and reliable, which usually requires numerous large-scale studies performed in various conditions. Reliability is the accuracy of the measurements and the methods used to measure the indicator, validity is whether an indicator describes the quality that it is intended to represent. Most of the indicators used in traffic behaviour studies can be retrieved from automated video analysis. The traffic environment is recorded by one or several cameras that are mounted a few meters above ground level to get a birds-eye-view in order to be able to catch as big area as possible. The system can provide detailed description of the movement of different transport modes over an area large enough to cover some kind of intersection or other traffic infrastructure. It can also study periods that last for months or years, in order to collect reliable information about rare traffic events. The digital video is then processed by algorithms that are trained to detect different transport modes and analyses different parameters like speed, size and orientation.

The output from the video analysis describes each road user in terms of speed, position, direction etc. with a certain time frequency and in a certain time span, during the road users' appearance in the camera view. The system makes it possible to sort the output data in the way that suits a specific study, as an example can all the right turning cyclists or all cars with a speed of 50 km/h or more be sorted out. The outcome gives a better understanding on how different transport modes interact and what factors affect the interaction at different stages. The camera used in this study is a OTUS3D, see Figure 3.1. OTUS3D can detect different road users in the same system and is designed to handle the unpredictable way pedestrians and cyclists move. This system is developed by the company Viscando in Gothenburg.

Figure 3.1 OTUS3D, the camera used in this study.

3.1.2 Installation of the system and recording in the study area

The video analysis system described in the previous subchapter were used in this study. The cameras were mounted Tuesday 22nd of May and dis-mounted Friday 25th of May by a hired company that had the tools necessary for mounting, such as TMA-cars and skylift, see Figure 3.2. Three cameras were mounted on an existing lamp post and were positioned at different directions, see Figure 3.3. Since one lane in each direction on the roadway needed to be partly secluded during the installation of the system, a so-called "TA-plan" needed to be approved by the Traffic and Public Transport Authority in Gothenburg before the mounting.

Figure 3.2 The cameras were mounted by a skylift.

Figure 3.3 Three cameras mounted, circled in orange on a lamp post in the studied area.

Figure 3.4 shows the catchment area for each camera, represented by different colours. The two cameras with the catchment areas in red (western direction) and blue (eastern direction) were directed towards the roundabout to register the traffic there. The third camera, with a catchment area painted in light blue (southern direction), was directed in the opposite direction. The reason is that it should register the speed and braking of cars and other vehicles that were travelling into the roundabout. Further, the camera with the southern direction could also log the travelling pattern for cyclists and pedestrians that were about to travel through the roundabout. The different lines represent how reliable the different road users were logged in the system:

- The dotted line closest to the cameras represents the area where all different transport modes were logged reliably.
- The second dotted line represents the area where cars were logged reliably and pedestrians/cyclists were logged but not fully reliable.
- The solid line represents the area where pedestrians and cyclists could not be logged and cars could be logged but not fully reliable.

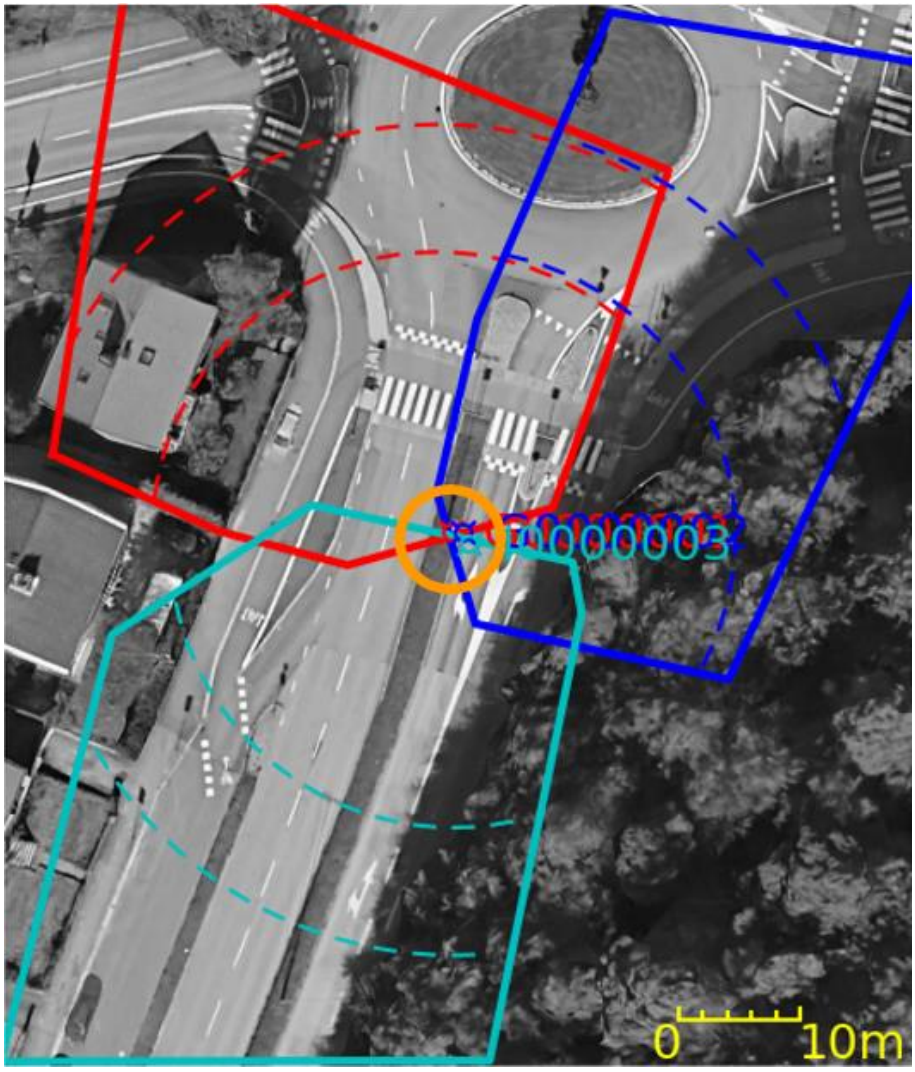

Figure 3.4 Catchment areas for the three cameras, marked with red, blue and turquoise. The cameras were placed at the orange circle.

The three cameras registered the pattern of the road users, and also the speed and interactions between road users. The cameras were also capable of saving video of the spot, but due to Swedish law, one person needed to be present with a sign that informs the road users that they were surveilled. In the recorded video, road users and how they were moving in the area could clearly be seen, but register plates and faces were impossible to distinguish and therefore, identifications were impossible to do. During the period that the cameras were mounted, the intersection was surveilled at two occasions; Wednesday 23rd of May at 8 am-10 am and Thursday 24th of May at 3 pm-5 pm. The occasions were chosen in order to get the flows during rush-hours, but also to get some video when the flows increased and decreased. The view from each camera is shown in Figure 3.5.

Figure 3.5 The view from each camera, where the direction is marked in the orange circles.

3.1.3 The development of data and behaviour in give way-situations

At first, the basic data about tracks, speed and flows of the different road users was received from the system. From this information, it was necessary to develop a method to examine the give way-behaviour in the study area. The video analysis company had not done this before, in the way that was desirable for this study. Therefore, different ways of examining the give way-behaviour were discussed to find the most suited method.

After the discussion, it was decided that the best way to examine the give way-behaviour was by study how and when the cars were braking when driving towards the roundabout. The vehicles that were about to exit the roundabout were not included due to low speed. In that way, it was possible to see how the car drivers' behaviour varied depending on the situation. It was of interest to know whether a cyclist or pedestrian was

crossing the roadway at the same time as the car, or if the car had free passage. To make this possible, zones for cyclists and motor vehicles respectively were defined, see Figure 3.6. When defining the zones, seight conditions and the time and distance to the middle of the passage were held in mind. Therefore, the zones for vehicles were larger than the zones for cyclists and pedestrians, but also due to the higher speed a vehicle can reach. Also, the road for the vehicles is straight and the bicycle and pedestrian path is curvaceous which may affect the speed of the road users since it is easier to reach a higher speed at a straight road.

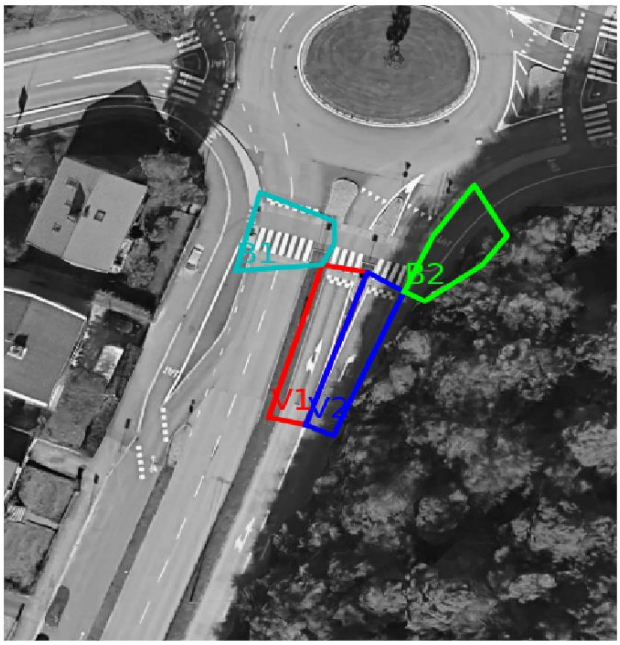

Figure 3.6 Zones that were defined during the study. V1 & V2 are zones for vehicles and B1 & B2 are zones for bicycles and pedestrians.

Firstly, data about the vehicles that were about to enter the roundabout without any interaction with other road users needed to be filtered out. To make this possible, the system was programmed to sort out the vehicles that fulfilled following requirements:

- Did not have any other vehicles in front of them that affected the drivers' reaction. The program lets the algorithm control that no other vehicle was in the same zone when the vehicle first showed up in one of the vehicle zones (V1 or V2).
- No cyclist or pedestrian was near the pedestrian crossing or bicycle passage, thus, the zones B1 and B2 were empty.

For the vehicles that fulfilled the requirements, a speed profile as a function of the distance to the passage was produced.

Thereafter, the system was programmed to sort out the vehicles that were interacting with cyclists and/or pedestrians. Cyclists and pedestrians that crossed the road on the passage were matched with vehicles that were on their way into the roundabout. For the vehicles that were interacting with a road user that was in zone B1 or B2, two speed profiles were produced, one for interaction with cyclists and one for interaction with pedestrians. If the car was interacting with both cyclists and pedestrians, that vehicle was included in both graphs. Lastly, both curves were plotted together and then compared to each other.

3.1.4 Analysis of the recorded videos

At two occasions during the period that the video analysis equipment was installed, the study area was surveilled and video could be saved. Those videos, around 4 hours in 3 directions, were studied as a complement to the video analysis, which can be compared to human observers. When the videos were studied, it was found that the camera directed to the South was not very useful for human observing. Hence, the videos from that camera were not further studied. The other two cameras on the other hand, gave some useful information. The videos that finally were watched were recorded the 23rd of May between 08.00-10.00 (towards Botaniska trädgården) and the 24th of May between 15.00-17.00 (towards Kungsladugårds-gatan), those were chosen in order to get the highest flows.

The videos were studied in order to complement the data for the give way-behaviour. The morning rush was studied from the western camera and the afternoon rush from the eastern. The analysis was made from the cyclists' perspective and it was noticed which of the road user (cyclist or car) that gave way or if the cyclist had free passage. The pedestrians were excluded due to low flows. Everything was noticed and analysed together with the numbers that the data system gave. Additionally, if some cyclists' itineraries deviated from the normal pattern, this was noticed as well.

3.1.5 Video analysis-limitations

The system comes with some limitations, and so does the chosen intersection. The camera cannot separate motorcycles from cycles which means that motorcycles were registered as bicycles. This may affect the result and therefore, neither the cyclists or motorcyclists that were travelling on the roadway were included in this study. Moreover, it is a guidance sign that was blocking the cameras' sight to the West, see Figure 3.7. Due to the blocking plate, the cameras could not register road users that moved right behind it, which may be noticed in the result.

Figure 3.7 A sign in the area that limits the catchment area for the western camera.

3.2 Interviews

As a complement to the video analysis, interviews have been performed to examine the road users' knowledge of the applying traffic rules and their own and others behaviour. The interviews were executed after the video recording was made, since the result of the video analysis was assumed to be more accurate if the road users did not know that a study was performed in the area. In this chapter, one can read about the interview procedure and the developing work with the questions.

3.2.1 The development of the interview procedure and questions

The selection of the respondents was divided by age, road user type and whether the person had a driving license or not. The division was made in order to see if the answers were split by age and whether the possession of a driving license affected the answers or not. Moreover, respondents that looked like they were younger than 15 years were not asked to attend the interview. In order to avoid that people got bored and to maximize the number of respondents, four questions with yes- or no-answers were formed. It was assumed that it would be easier to get more numerous and more honest answers if the interview were made quickly and easily. Also, the quicker the interview went, the more answers could be collected and a more reliable result could therefore be expected.

Before the final interviews were performed, test-interviews were done in order to develop the questions and the interview method. The test-interviews were performed close to a roundabout in Gothenburg, but not the roundabout studied in this report. After the test interviews, some improvements were made. For instance, it was decided to ask the question about whether the respondents had a driving license or not at the end of the formula. This was done since some of the respondents got confused and answered the questions as they were car drivers and not as cyclists or pedestrians. Moreover, it was noticed that some of the questions were difficult to speak orally which led to rewording.

After some developing work with the interview questions that are described in the chapter above, this is the final version:

1. Who must give way?
2. Do you follow the traffic rules?
3. Do other road users follow the traffic rules?
4. Do the marks and signs evidence what traffic rules apply?

Additionally, the respondents were asked about age and whether they had a driving license or not. The whole questionnaire can be found in Appendix A.

3.2.2 The interview procedure

The interviews were performed at five occasions in the end of May and the beginning of July, around 1-2 hours each time. The exact times for the interviews can be seen in Appendix B. People that passed the roundabout by foot or by bicycle were randomly asked if they could answer some short questions. The answers were logged in a Google Drive document by tablets. In total, 130 interviews were performed, where 107 were cyclists and 23 were pedestrians. This corresponds to 12 % of the cyclists and 15 % of the pedestrians passing the crossing a normal workday, according to the measured flows.

3.2.3 Analysis of the interview result

After the interviews were performed, the information was transferred to Microsoft Excel, where the result was analysed. Firstly, the basic information on the selection was analysed; the respondents' age and whether they had a driving license or not. Further, the result on the four asked questions was analysed, where the answers from the cyclists and pedestrians were separated to see if it was a difference in the answers. Moreover, whether the age and driving license had an impact on how the respondents answered was analysed. In addition, it was studied how many of the respondents that did not know the rules but said that they followed them, which means that they follow the wrong rule.

3.2.4 Interview-limitations and selection method

The interviews were early decided to only be executed with people who passed the roundabout, by bike or by foot. It was decided that it would be too hard to include car drivers, since it would be difficult to stop them in a safe way. It was also discussed to note the license plates of the cars passing and then contact the owner of the vehicle, but due to the limited time of the project this was chosen not to be included in the method.

When the interviews were performed, people that passed by on the pedestrian and bicycle path were stopped and asked the interview questions. The roundabout is well trafficked during rush-hours and the area is limited. Due to the accidental risks during rush-hours, the interviews have not been made at that time. Moreover, it should have been harder to make people stop and dedicate their time during rush-hours due to stress and high flows.

Another selection aspect was the weather and while the weather was rainy, no interviews were performed. During the major part of the period that this study was made, the weather was sunny and warmer than normal, which is good conditions for cyclists and the flows were therefore high. However, just a few days were rainy and lower flows were expected. Further, it was assumed that fewer people were interested to stop and answer questions during bad weather conditions and therefore no interviews were made during the rainy days. The result was not expected to be affected by weather conditions or rush-hour-traffic.

People that clearly were out running or cycling as exercise were not asked, as well as people traveling with small children. If a cyclist and a pedestrian were passing at the same time, the cyclist was given priority since the answers from cyclists were seen as more interesting, partly due to higher flows of cyclists. Due to this, more cyclists than pedestrians were interviewed over all.

4 Study Area

To be able to meet the aim of this thesis, a case study has been performed. The chosen intersection is situated in the Western part of Gothenburg. The existing bicycle paths in the studied area are planned to be reconstructed before 2025, probably earlier. The reconstruction will comprise broadening and introduction of bicycle crossings. To get a better understanding of the task, the areas Högsbo and Majorna and the actual roundabout are described in the following chapter.

4.1 The area around Högsbo and Majorna

In the Western part of Gothenburg, the districts Högsbo and Majorna are located, see Figure 4.1. The roundabout between Slottsskogsgatan and Margretebergsgatan separates the two districts from each other, see Figure 4.2. The boundary is in the very middle of the roundabout which means that the roundabout is located in both districts. The area around the intersection consists largely of residential. Just 100 meters Northeast of the intersection, one of the oldest, largest and most popular parks in Gothenburg, Slottsskogen, is located. In Slottsskogen one can find playgrounds, big areas of grass, a zoo and a lot of cafés and restaurants. The park is also a popular motion centre with established exercise trails and outdoor gyms. Further, Slottsskogen is a park that gets full of people during sunny days and is also frequently used for public events like the race Tough Viking and the festival Way out West.

Figure 4.1. The orange circle marks where the roundabout is located in Gothenburg (Google Maps, 2018a).

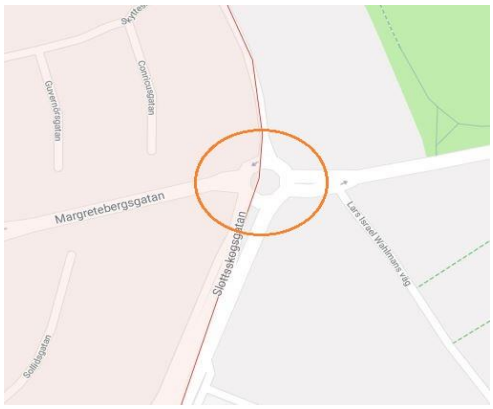

Figure 4.2. The red line shows where the boundary between the districts goes, the orange circle marks out the roundabout (Google maps, 2018b).

In the Southeast part, a big sports center is located, where both the athletic arena Slottsskogsvallen and the ice hockey arena Frölundaborgs Isstadio can be found. Also, the sports covenant of Gothenburg is located there. Further, the annual half-marathon Göteborgsvarvet, with thousands of participants, has its start and stop at Slottsskogsvallen. Moreover, the University hospital Sahlgrenska is located approximately 2 kilometers from the intersection. When it comes to traffic, the large main roads Högsboleden and Dag Hammarskjöldsleden can be found in the nearby area. Because of this, both Margretebergsgatan and Slottsskogsgatan are used as transport distances between these main roads, see Figure 4.3. It is also worth to mention that approximately 3 kilometers in the other direction the trafficked bridge Älvsborgsbron is located.

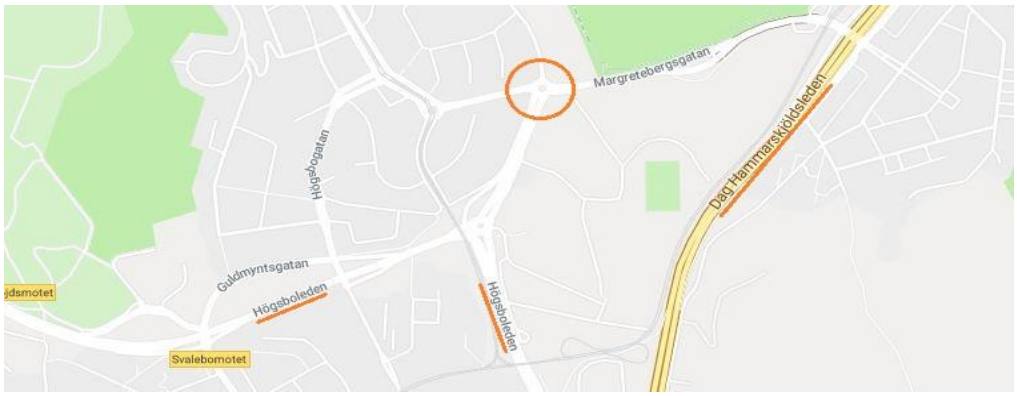

Figure 4.3. A map where the main roads are marked out, the circle marks the studied roundabout, (Google Maps, 2018a).

The mentioned conditions above makes the roundabout between Margretebergsgatan and Slottsskogsgatan highly trafficked during some parts of the day, both by cars and bikers. The traffic flows in the area are further described in chapter 4.3. During popular events that are arranged in the area several times per year, the traffic increases further, both in terms of cyclists, pedestrians and car drivers. During some events, for example Göteborgsvarvet, Margretebergsgatan between Dag Hammarskjöldsleden and the studied roundabout is fully secluded, see Figure 4.4.

Figure 4.4. An aerial photo of the studied roundabout during Göteborgsvarvet, Gothenburg (Powerphoto, 2010). Reprinted with permission.

4.2 The design of the roundabout

The intersection between Margretebergsgatan and Slottsskogsgatan is regulated as a roundabout and it involves both pedestrians, cyclists and vehicles. Due to the local traffic regulations, both Margretebergsgatan and Slottsskogsgatan, between Högsboleden and Margretebergsgatan, are major roads.

The roundabout has two lanes and is a separated roundabout which means that the bicycle and pedestrian paths runs parallel and outside the roadway, see Figure 4.5. In a separated roundabout, the transport modes are separated from each other and only interact when cyclists and pedestrians need to cross the road. In the studied roundabout, the pedestrian crossing is unsupervised and the bicycle path differ in material, colour and height just where the passage is, see Figure 4.6. It is allowed to bicycle in both directions over the passage which requires the car drivers to pay attention to cyclists that comes both from the left and from the right at the same time. The middle part of the roundabout consists of grass and is approximately 18 meters in diameter. The sight conditions are good when drivers come from the East (1) and North (4), bad when they come from the West (3) and semi-good when they come from the South (2). The same goes for cyclists.

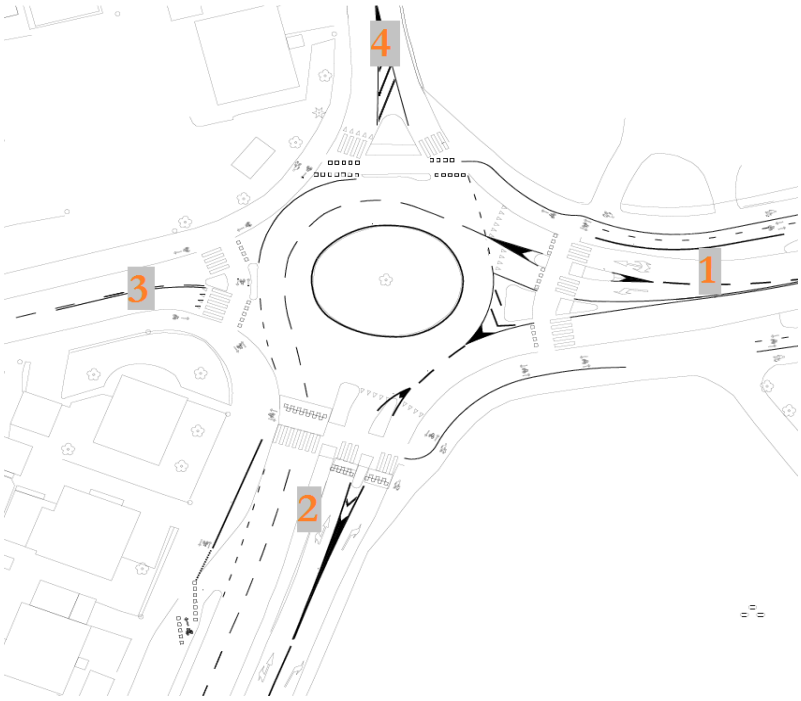

Figure 4.5. A drawing of the studied roundabout. Modified drawing, given by the *Traffic and Public Transport Authority in Gothenburg*.

Figure 4.6. The bicycle path that differ in material where it turns into bicycle passage.

4.3 Traffic flows in the area

The traffic flows for motor traffic at the roads into the intersection has been measured by the *Traffic Public Transport Authority in Gothenburg,* and is presented in table 4.1 below (Trafikkontoret, 2016a) (Trafikkontoret, 2016b). When it comes to flows of cyclists and pedestrians, no measurements have been done.

Table 4.1 Measured data on the traffic flows during one day, next to the roundabout. Data from (Trafikkontoret, 2016a) (Trafikkontoret, 2016b).

Part of the road	**Vehicles/work day**
East of the roundabout (1), at Margretebergsgatan	11 100
South of the roundabout (2), at Slottsskogsgatan	13 200
West of the roundabout (3), at Margretebergsgatan	4 600
North of the roundabout (4), at Slottsskogsgatan	3 600

At the studied part of the roundabout, the South part, the flow varying as seen in Figure 4.7 and Figure 4.8 below.

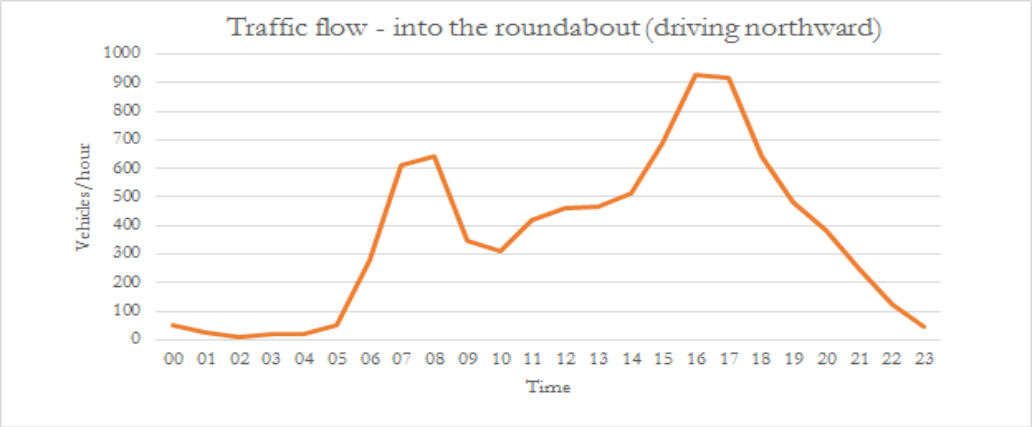

Figure 4.7. Variation of the traffic flow from the South into the roundabout, over one day. The traffic data is given by the *Traffic Public Transport Authority in Gothenburg.*

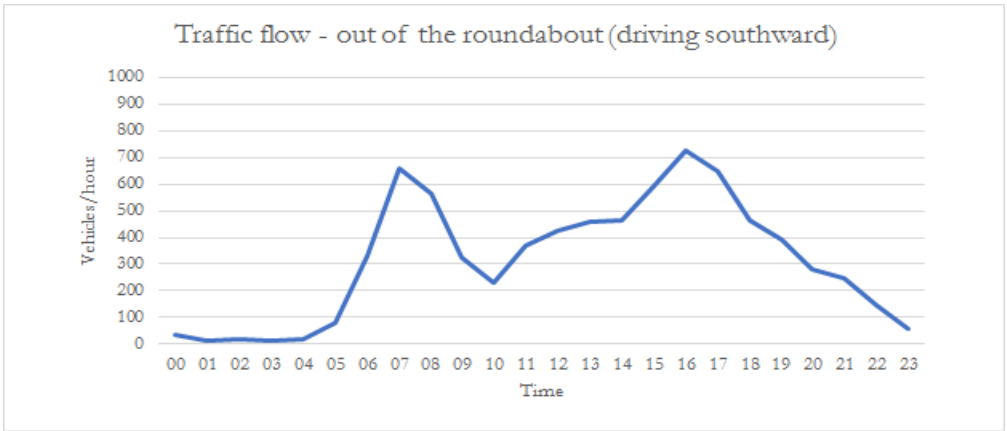

Figure 4.8. Variation of the flow out of the roundabout, driving South, over one day out of the roundabout. The traffic data is given by the *Traffic Public Transport Authority in Gothenburg.*

4.4 Reported traffic accidents in the area

Threw the database STRADA, the reported traffic accidents during the last 10 years in the area were studied. The exact period was the 1st of January 2008 to 31st of May 2018. A total of 19 accidents have been reported; 1 fatal accident (where the dead person probably was acute sick), 5 moderate accidents, 5 slight accidents, 1 doubtful and 7 undamaged. 6 of 11 of the reported accidents, that ended up damaged, included a cyclist and a car. 1 of those 11 accidents happened on a straight road and 10 of them inside the roundabout.

5 Result & Analysis

The result is divided into two parts; the video analysis and the interviews, both performed at the studied roundabout in Gothenburg. An analysis of the results is added to most of the results. The results and analysis are then further discussed in the next chapter.

5.1 Video analysis results

The measurements at the study area started at 16:37 Tuesday 22nd of May 2018 and ended at 09:14 Friday 25th of May 2018, which means that the recordings lasted for 2 days, 16 hours and 37 minutes. During the recordings, unexpected errors happened two times due to problems with the batteries on the camera directed to the West. These errors lasted between 00:14 and 03:23 on the 23rd of May and between 15:15 and 16:03 on 24th of May. Therefore, some data is missing from these periods.

As mentioned earlier in the report, the camera cannot separate motorcycles from bicycles, why the cyclists and motorcyclists that are travelling on the roadway are excluded from the results. This delimitation was confirmed to be reasonable, from the recorded video and when doing human observations, since the number of motorcycles that passed the roundabout was few, compared with other motor vehicles.

5.1.1 The road users tracks and traffic flows at the study area

From the video analysis, the different road users' choice of track was produced. Those are presented in Figure 5.1; where the purple tracks represent cyclists, the turquoise tracks motor vehicles and the red tracks pedestrians. To make the figures more visually clear, only every twentieth cyclist and motor vehicle is visualised. Because the number of pedestrians was fewer, every fifth pedestrian is visualised. Further, it can be noticed that the pattern for vehicles is visible further away than for pedestrians and bicycles, this is due to the capacity of the cameras.

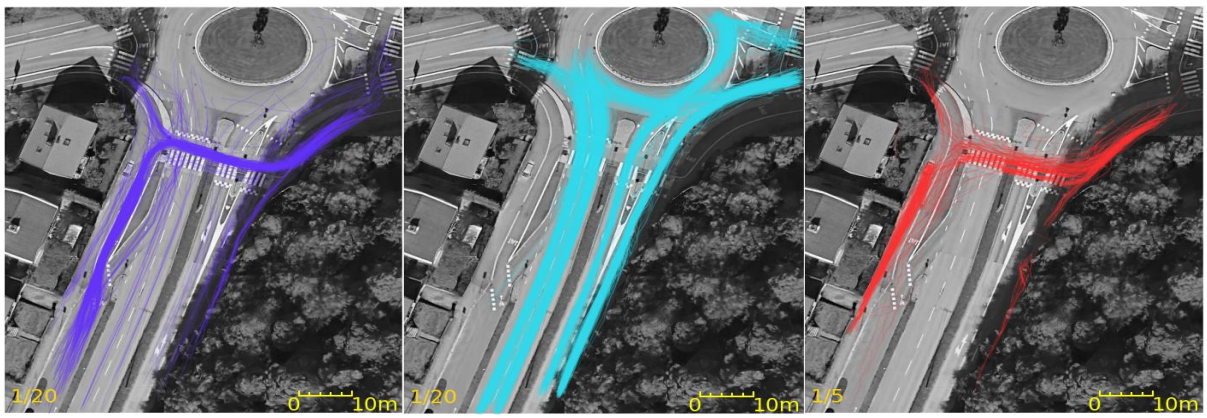

Figure 5.1 The tracks that the different road users took. From left; cyclists, motor vehicles and pedestrians.

When looking at these figures, it can be noticed that the pattern for pedestrians is a bit irregular in the West part of the pedestrian crossing. This is because of the guidance plate that was blocking the cameras' sight. With a bit of imagination, the pattern can be assumed at the missing part anyhow. However, the outcoming data is affected by this, due to lack of data in terms of velocities behind the plate.

During the period that the equipment was installed, around 4 600 cyclists, 800 pedestrians and 42 600 motor vehicles passed the studied area. The number of passages of motor vehicles was measured a bit South of the pedestrian crossing/bicycle passage, while the passages were counted in the middle of the crossing for

cyclists and pedestrians. This is also visualised in Figure 5.2, where the different road users' travelling directions are defined as well. Furthermore, the average daily flows have been calculated as a mean value of the flows during the two whole days that the equipment was installed, the Wednesday and Thursday, and are presented in Table 5.1 and Table 5.2.

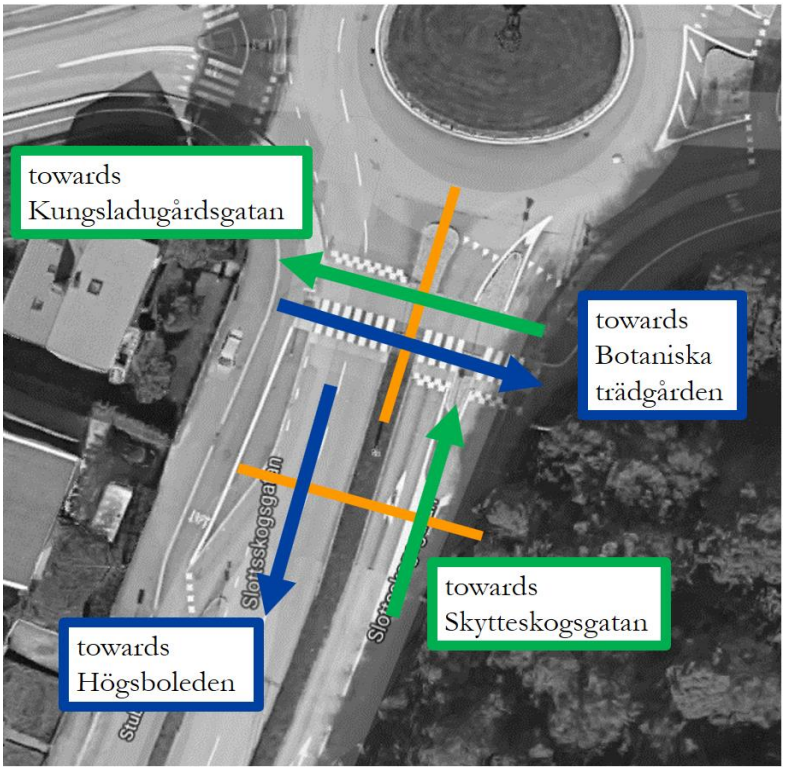

Figure 5.2 A map of the studied area. The orange lines represent the points where the number of passages was measured and the blue and green arrows represent the travelling directions.

Table 5.1 The mean number of passages by bike and foot at the crossing, in each direction and in total, presented as passages per day.

	towards Botaniska trädgården	**towards Kungsladugårdsgatan**	**Total**
Cyclists	1 037	691	1 727
Pedestrians	144	180	324

Table 5.2 The daily flows of motor vehicles on the road, in each direction and in total, presented as passages per day.

	towards Skytteskogsgatan	**towards Högsboleden**	**Total**
Motor vehicles	9 128	7 615	16 743

To get a deeper understanding on how the number of passages varies over the day, the following three figures present traffic flows of the different transport modes during the entire period the cameras were mounted. Figure 5.3 shows the flows of cyclists that pass the bicycle passage, divided in travelling directions. From the result presented in Table 5.1, it is known that more cyclists were travelling towards Botaniska

trädgården than Kungsladugårdsgatan, which also can be seen in the figure. Additionally, that figure shows that in the morning, most cyclists were travelling in the eastern direction, towards Botaniska trädgården. In the afternoon, it was more even between the travelling directions, but some more travels were made in the western direction, towards Kungsladugårdsgatan.

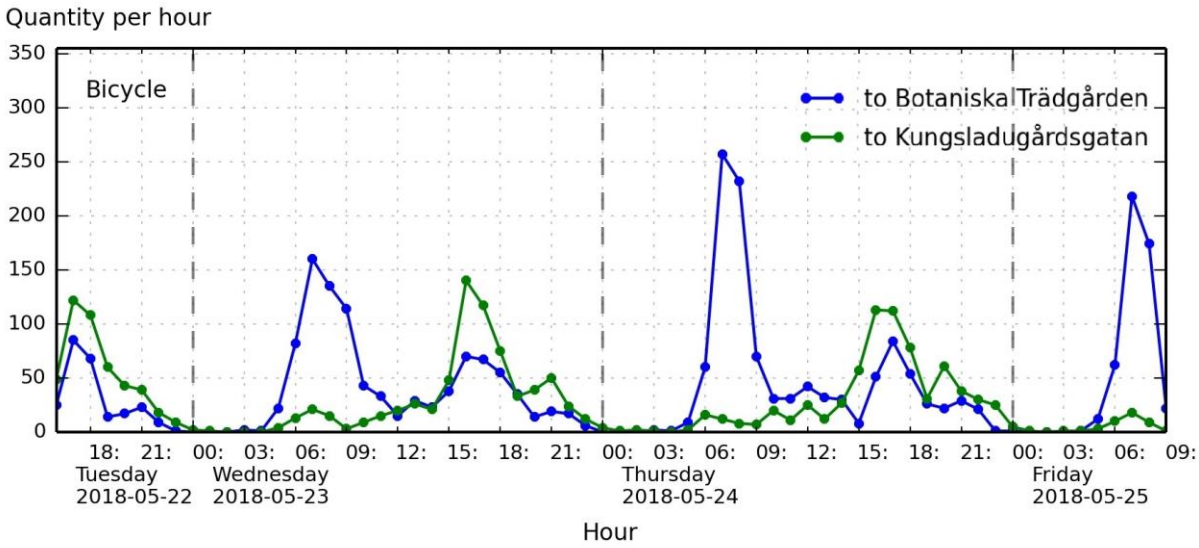

Figure 5.3 Passages of bicycles per hour during the measuring period. The green line shows those travelling to the West (towards Kungsladugårdsgatan) and the blue line them travelling East (towards Botaniska trädgården).

In Figure 5.4 the traffic flows of motor vehicles on the road is shown, where the green line represents the vehicles driving into the roundabout and the blue line represents the vehicles exiting it. During night-time and in the mornings, it seems like approximately the same number of vehicles were travelling out of as into the roundabout. Instead, during the mid-day and in the afternoon, more vehicles travelled into the roundabout. Also, it can be noticed that the flows peaked in the afternoon.

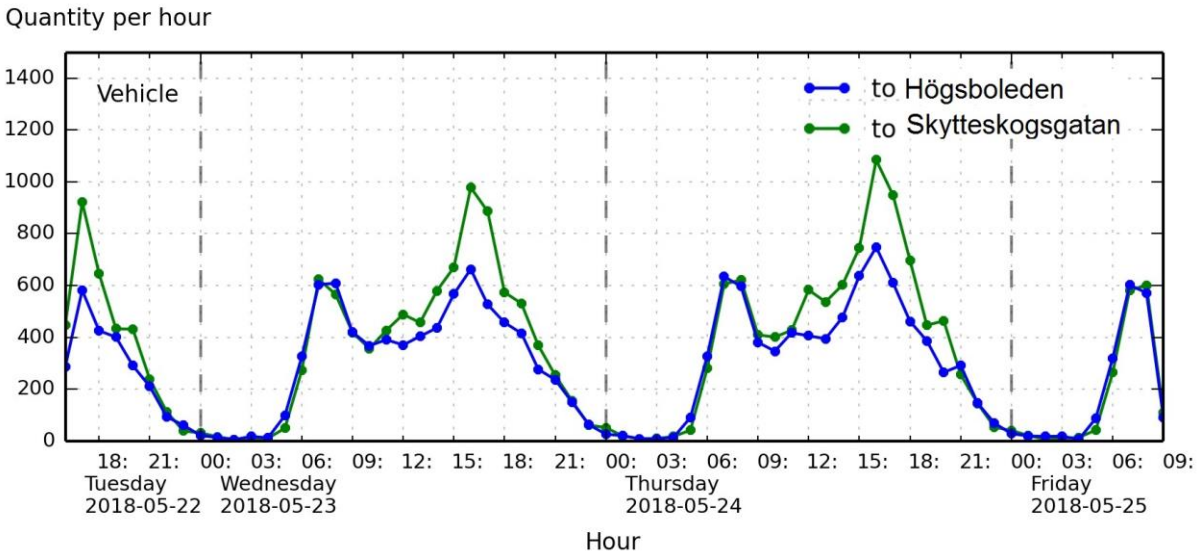

Figure 5.4 Motor vehicles per hour during the measuring period. The green line is the vehicles driving into the roundabout (towards Skytteskogsgatan), while the blue line is the vehicles exiting (towards Högsboleden).

Finally, Figure 5.5 presents the traffic flows of pedestrians crossing the road. When analysing the graph for pedestrians, it can be seen that the flows are irregular from day to day and do not have any clear peak, which tells that pedestrians are crossing the roundabout every now and then during the day. Probably because many pedestrians do not walk by with work or school as a destination, instead they could be out walking as exercise etc.

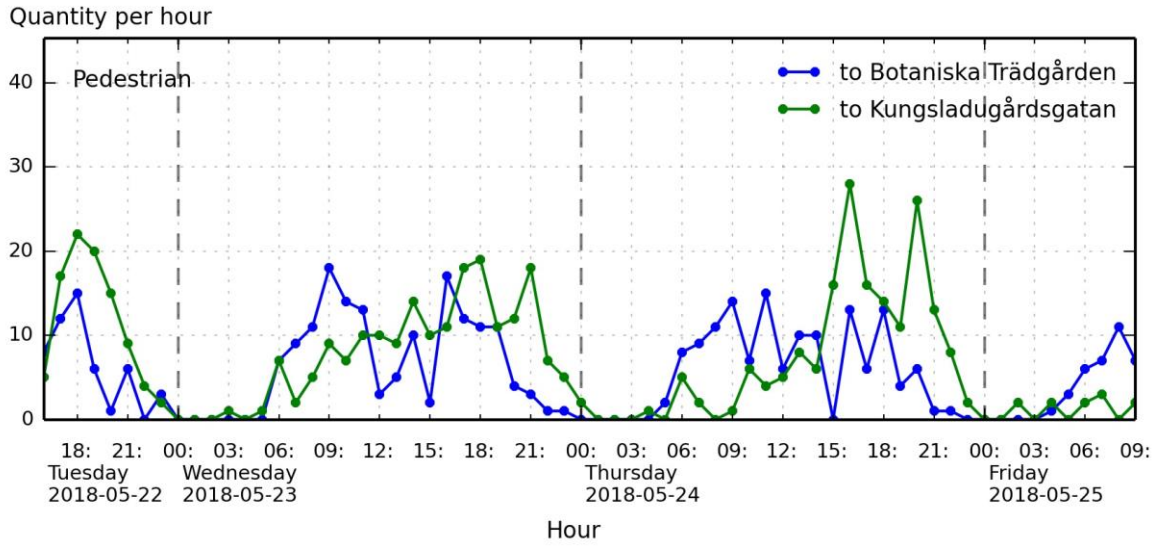

Figure 5.5 Pedestrians per hour during the measuring period. The green line represents those walking to the West (towards Kungsladugårdsgatan), while the blue line represents them walking East (towards Botaniska trädgården).

In summary, it can be noticed that the flows for motor vehicles were more evenly distributed than for cyclists. It looks like many of the cyclists tend to travel during rush-hours in the morning and afternoon, and not during mid-day and in the evening. In comparison, car drivers also tend to travel between the rush-hours and in the evening.

5.1.2 Velocity of the road users

Something that also can be extracted from the video analysis is the velocity of the different transport modes, which can be presented in different ways. In Table 5.3, the velocities are presented as the mean value and the 85th percentile. The measurement of the speed of cars was performed when they were on their way into and out of the roundabout, and for bicycles the measurement was made when they were crossing the road in both directions, at the same spots as shown in Figure 5.2. More detailed description of these measurements and graphs can be found in Appendix C. The velocity for pedestrians have assumed not to be of any interest to this report.

Table 5.3 The mean speed and the 85th percentile for bicycles and vehicles.

	Bicycle [km/h]	**Vehicle [km/h]**
Mean	12.7	30.9
85th percentile	15.7	40.8

In addition, the mean speed at different parts of the studied area can be extracted from the video analysis, as shown in Figure 5.6 and Figure 5.7. The reason that Figure 5.6 looks a bit "dotted" and that many cyclists are travelling on the roadway is, that motorcyclists also are logged as cyclists, and can therefore be neglected.

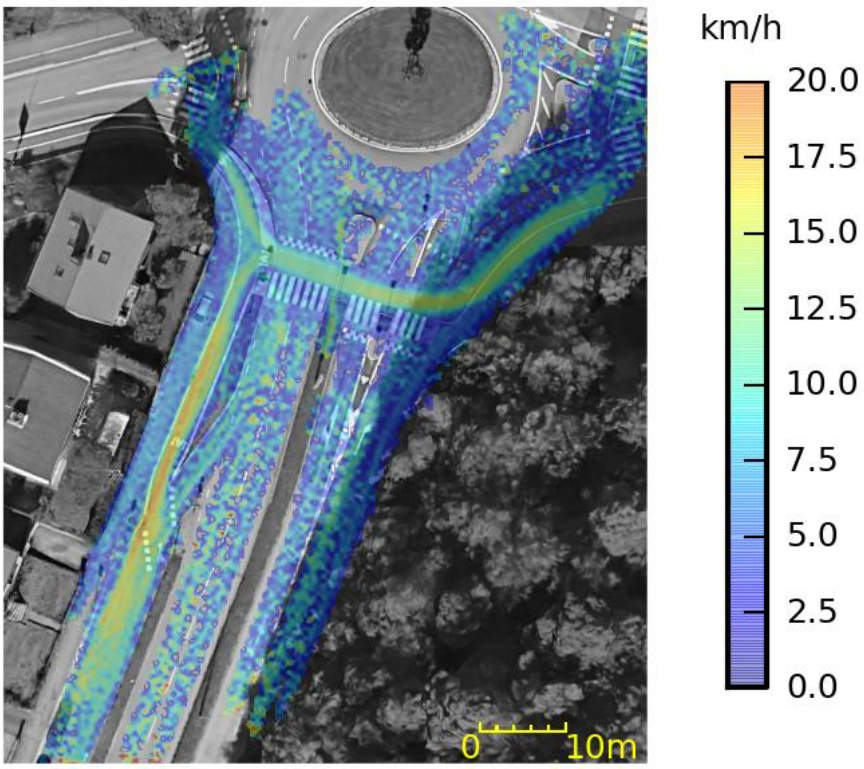

Figure 5.6 The average speed for cyclists at different parts of the studied area, in km/h.

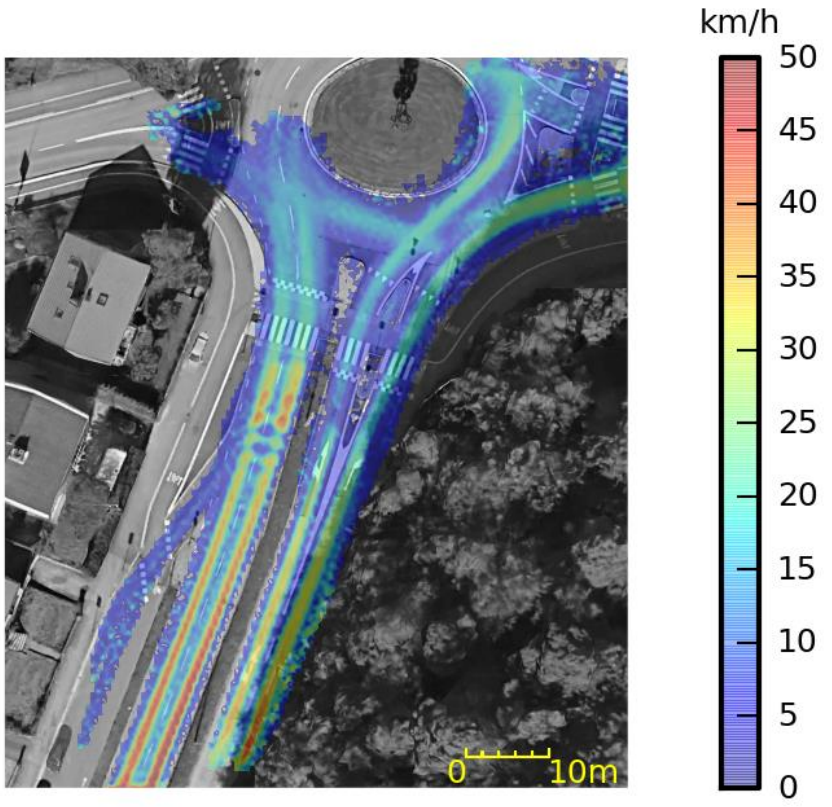

Figure 5.7 The average speed for motor vehicles in km/h, at different parts of the studied area.

The result shows that cyclists highest speed were at the straight path at Slottsskogsgatan and the lowest speed on the West part of the roadway crossing. It can also be noticed that the speed when cyclists were crossing the roadway was relatively low as well. The speed on the eastern side of the roadway crossing was lower than on the West side, but higher than the speed over the bicycle passage. This indicates that cyclists lower their speed when they are about to cross the roadway and easily increases the speed when they bike on a straight path again, whilst the speed increases less when the path is curvaceous, probably due to lower speed from the start.

For vehicles, the highest speed was measured to be when they drove out of the roundabout and it seems like the car drivers increased the speed right after they passed the pedestrian crossing. As can be seen in Figure 5.7, some car drivers were turning right, into the small street that runs parallel with Slottsskogsgatan. It probably explains why there is a part where the average speed is lower just before they were turning. When the vehicles are about to enter the roundabout, the result shows that the speed starts to decrease a couple of meters before the pedestrian crossing. Further, the average speed when vehicles passed the pedestrian crossing and the bicycle passage was low, so was the speed when the vehicles were inside the roundabout.

5.1.3 Analysis of the motor vehicles' braking behaviour

To study how and when the cars were braking when driving into the roundabout, speed profiles as a function of the distance to the pedestrian crossing/bicycle passage have been made, see Figure 5.8. The different profiles represent how the car drivers behaved when they had free passage versus when interacting with cyclists or/and pedestrians. It is noticeable that if the car interacts with a cyclist and a pedestrian at the same time, the brake of the car will be present in both curves.

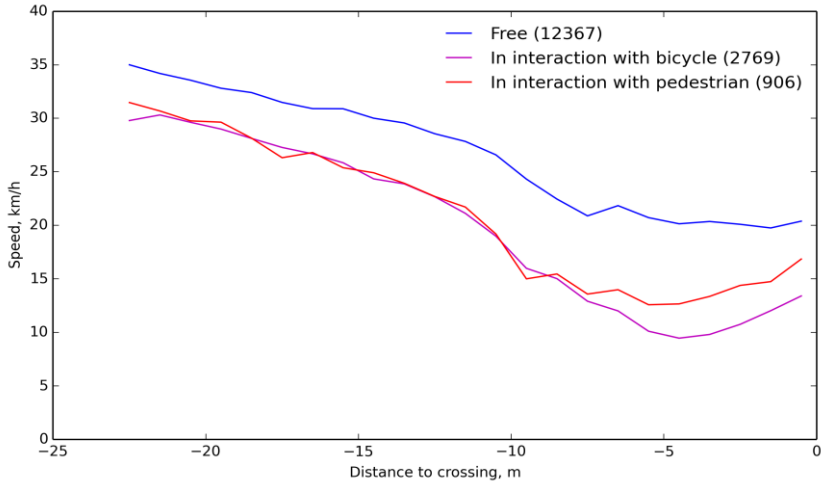

Figure 5.8 Speed of the motor vehicles that were about to enter the roundabout. The blue line presents the cars that had free passage, the purple line the cars that were interacting with cyclists and the red line interacting with pedestrians.

When looking at the figure above, it is obvious that the braking of cars differs between free flow and interaction flow. Already at the start of the comparison, about 22.5 meters from the crossing, the speed differs 5 km/h between the free vehicles and the ones in interaction with vulnerable road users. That indicates that the car drivers started to adjust their speed relatively far away from the interaction point. Up to 10 meters before the crossing, the car drivers seem to have acted quite similar if there were a cyclist on the passage or a pedestrian. However, when comparing the two lines for interaction with bicycles and pedestrians, from 10 meters to the crossing, it can be noticed that cars braked more for cyclists than they

did for pedestrians. This discovery will be more discussed in the next chapter since the result should be the other way around according to the traffic rules.

5.1.4 Human observations from the recorded video and from site

From the recorded videos, the cyclists give way-behaviour was studied. The result is presented in Table 5.4. The watched video towards Botaniska trädgården was recorded the 23rd of May between 08.00-10.00 and towards Kungsladugårdsgatan the 24th of May between 15.00-17.00 in order to get the highest flows. One can see that the total flow is similar for the different directions but it is different distributed between the different cases. Another similarity is that situations where cyclists give way is rare. The differences that can be seen is that the video recorded in the morning shows several free passages and fewer situations where car drivers give way and in the afternoon, the opposite is shown. This can be explained by Figure 5.3 where one can see that the flows of bicycles is higher towards Botaniska trädgården in the morning and towards Kungsladugårdsgatan in the afternoon.

Table 5.4 The bicycle trips divided into four categories and two directions, compiled in the end.

Travel direction	**Free passage**	**Cyclist give way**	**Car driver give way**	**Special cases**
Towards Botaniska trädgården	108	11	69	3
Towards Kungsladugårdsgatan	34	12	107	10
Total	142	23	176	13

The special cases consisted of:

- When a cyclist crossed two lanes with cars in both, one of the cars gave way for the cyclist and the other one did not.
- The cyclist drives zigzag between the cars.
- The cyclist stops in order to give way for the car, puts down his/her foot on the ground but the car stops as well and let the cyclist pass.
- The cyclist does not seem to intend to give way and neither does the car, it ends up with the car suddenly having to stop.

Among those cyclists that gave way, two types of situations were noticed. Some of the cyclists clearly stopped to give way for the car. However, in some situations it was difficult to see if it was the car driver or the cyclist that gave way for one another. The video where the cyclists were travelling towards Botaniska trädgården, 38 cyclists perceived as a school class passed. This large number of cyclists passing in such short time were not counted in the flows since it would have affect the result to a large extent and it was considered as a deviation in the measurements.

In addition, when studying the recorded videos and when observing the roundabout live some other interesting observations were made. For example, one thing that could not be seen in the automated video analysis was that some cyclists used the roadway in the roundabout instead of the bicycle path. This was observed, both on site when surveilling the roundabout during recording and when doing interviews. The cyclists that did this mostly came from West travelling to the East.

5.2 Results from the interviews

The following weeks after the video analysis equipment was dismounted, interviews were performed at the same site. The interviews were done with both cyclists and pedestrians, but the focus was on getting the cyclists' view. This chapter presents the results from the interviews, where some of the answers have been combined with each other in order to get the information interesting for this study.

5.2.1 The selection of respondents

In total, 130 interviews were done at the study area. Since the hypothesis was that cyclists feel more unsure on applying traffic rules than other road users, more cyclists than pedestrians were interviewed. Moreover, the number of cyclists passing the crossing was more than pedestrians. This is shown in Figure 5.9 below, as well as the respondent' variation in age and whether they had a driving license or not.

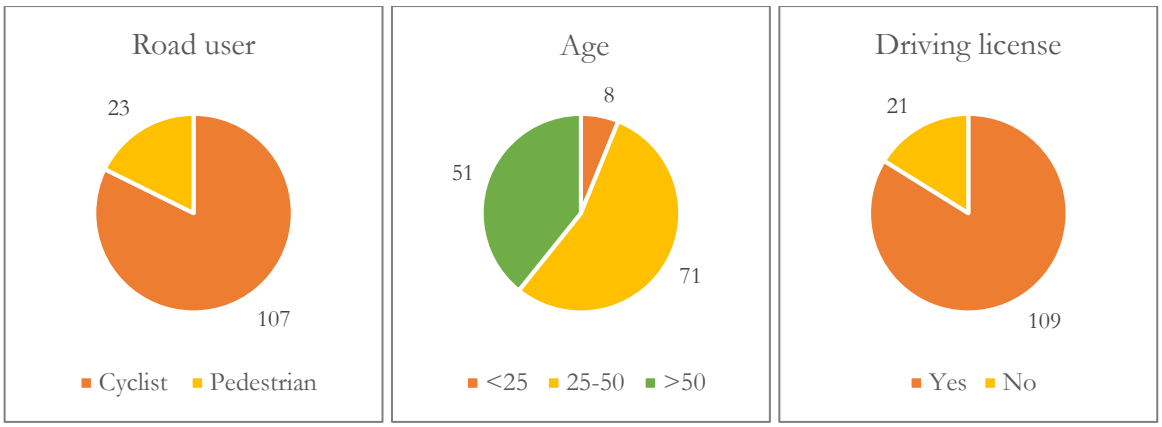

Figure 5.9 From the left; transport mode, the respondents age and if they had a driving license or not.

5.2.2 Result and analysis of the respondents' answers

The first question the respondents had to answer was which road user that must give way and not at the studied area. Among the pedestrians, almost everyone, 22 of the 23 respondents, did know that it is the car driver that must give way at a pedestrian crossing. Among the cyclists, it was just 40 of 107 that knew that it is the cyclist that must give way for motor vehicles at a bicycle passage. The answer was considered as correct both if the respondents answered that cyclists always must give way, or if they explained the rule in the totally correct way, which few did. The result is shown in Figure 5.10.

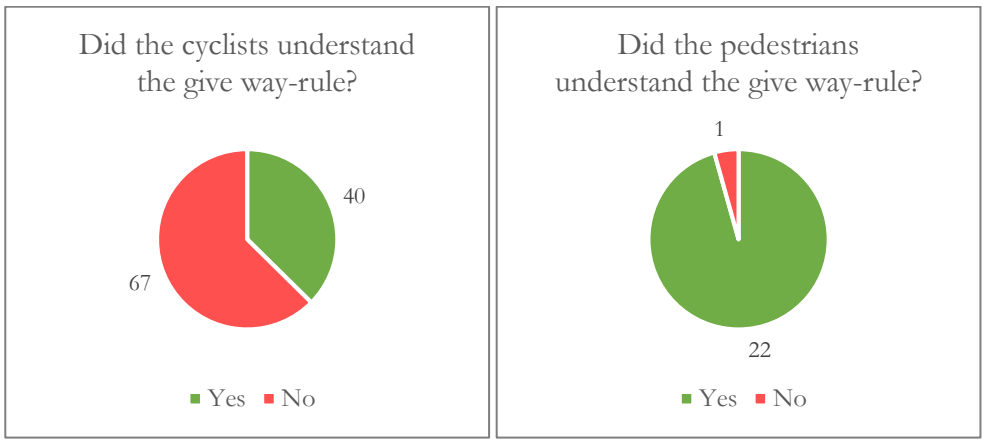

Figure 5.10 The respondents' knowledge in the give way-rule, at bicycle passages/pedestrian crossings respectively.

The next question was if the respondents thought that they normally follow the traffic rules at intersections, as a cyclist or a pedestrian. Some answered this question a bit vaguely, but if they said that they follow the rule most of the time, it was considered as a yes in the statistics. The result shows that the majority of the road users think that they are following the applying rules, the result is presented in Figure 5.11. As one can see in the figure, cyclists tend to break the traffic rules to a larger extent than pedestrians.

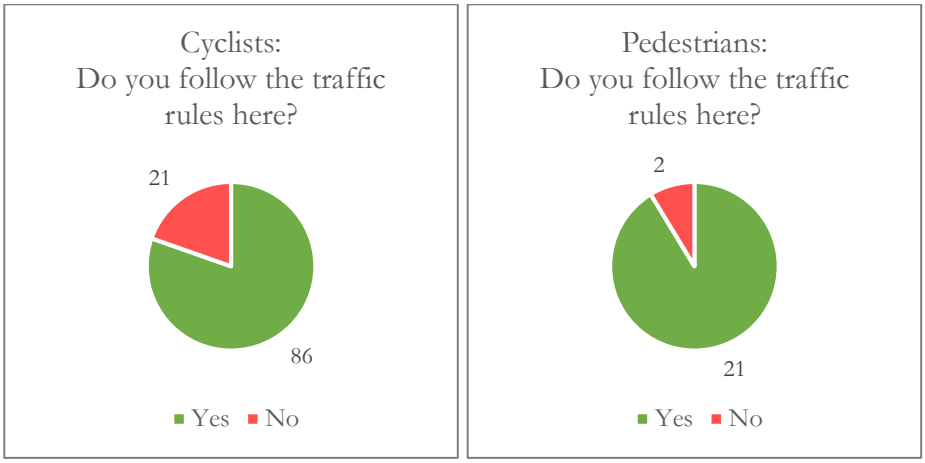

Figure 5.11 The charts show whether the cyclists and pedestrians thought that they normally followed the traffic rules.

In the following question, contrariwise, the respondents answered if they thought that the car drivers normally follow the rules. The result shows that over three-quarters of the pedestrians thought that the car drivers normally follow the rules, among the cyclists, the proportion was two-thirds. The result is shown in Figure 5.12.

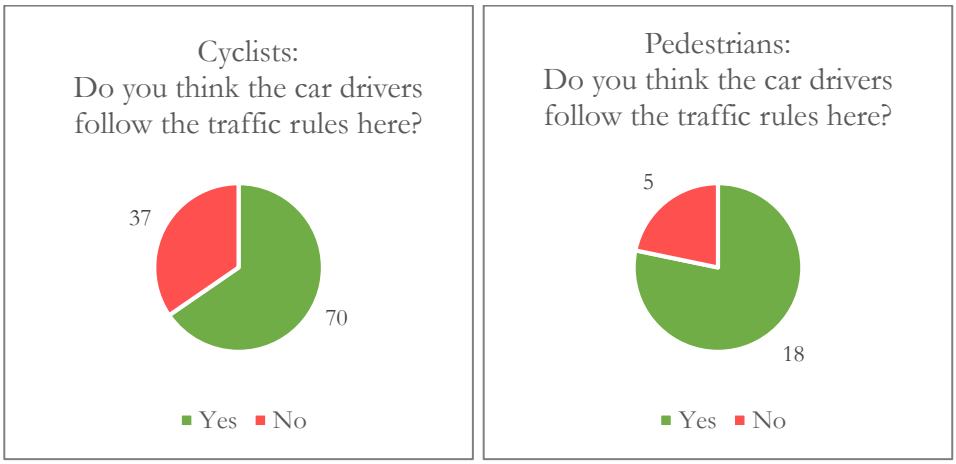

Figure 5.12 The respondents answered the question on how well they thought the car drivers follow the traffic rules at the studied roundabout.

Lastly, the respondents were asked about how well they thought marks and signs evidence what traffic rules apply in the area. The answers here varied a lot between cyclists and pedestrians. Among the cyclists, the majority thought that the marks and signs did not represent the rules, whereas among the pedestrians, a clear majority thought that the marks and signs were good enough. Figure 5.13 presents the result of this question.

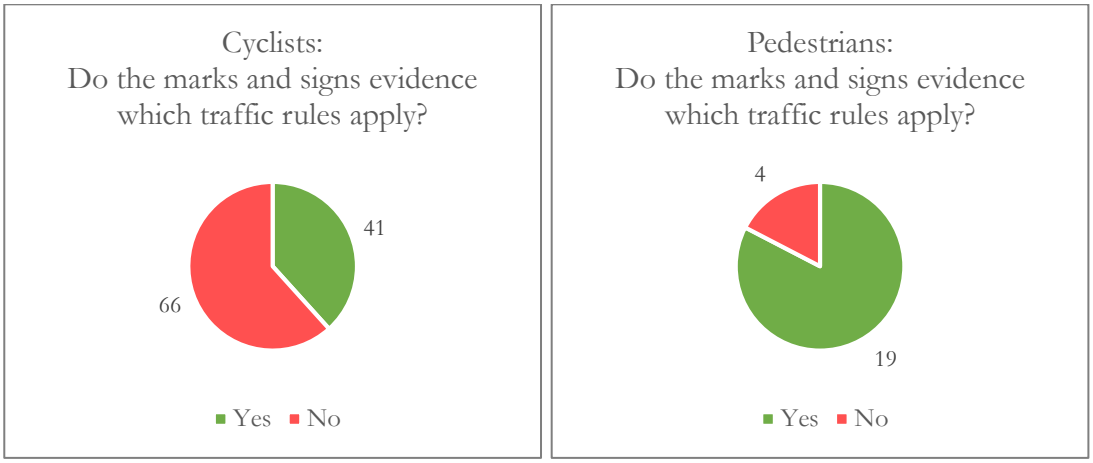

Figure 5.13 The cyclists and pedestrians answer if they thought the marks and signs evidence the traffic rules apply in the area.

5.2.3 The importance of the respondents' age and driving license among cyclists

A conjecture was that the knowledge about the traffic rules may differ between cyclists who have a driving license and not. The result, presented in Figure 5.14, shows that the knowledge is slightly better among those who have a driving license. However, just 17 cyclists had not got a driving license, whereupon it is hard to say how much that factor has impacted the result. The difference between the answers, among those who had a driving license or not, further combinations of the answers are presented in Appendix D.1.

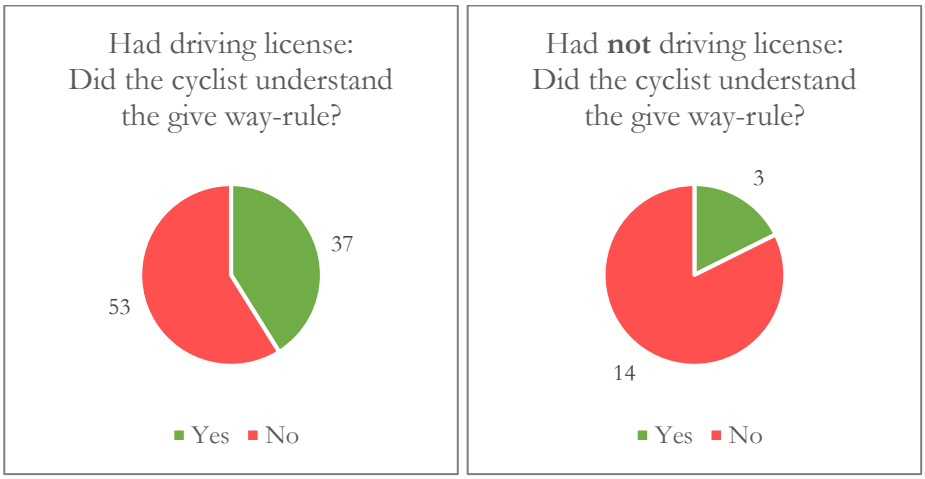

Figure 5.14 The chart to the left shows the knowledge in the traffic rule among those who had a driving license, while the chart to the right shows the result for those who had not.

Another factor that may affect the respondents' answers is their age. The interviews show that the respondents over 50 years old were those who had the best knowledge. Only 6 of the cyclists were under 25, and none of them knew the give way-rule. But to get a more reliable result, more interviews would have

been necessary, especially with people under 25. The result of this question is presented in Figure 5.15; further combinations of the answers are presented in Appendix D.2.

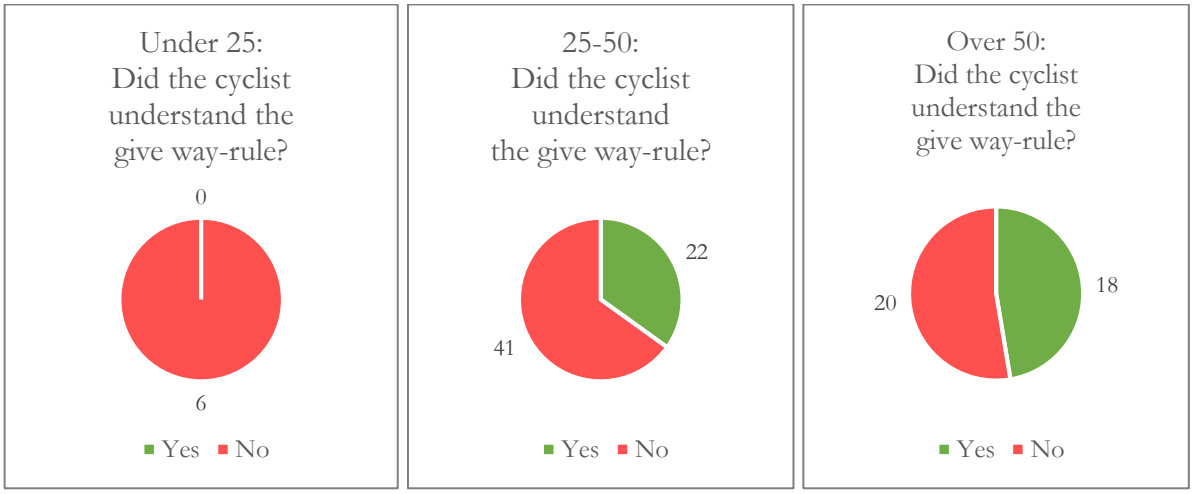

Figure 5.15 The knowledge about the traffic rule, divided into age-categories.

5.2.4 The road users' knowledge compared to their behaviour

When comparing if the respondents thought they followed the applying traffic rules, between those who actually knew the give way-rule and those who did not, the results look quite alike, see Figure 5.16. The results say that 53 of all the interviewed cyclists do not know the give way-rule and also say that they follow the traffic rules. This is something that will be further discussed in the next chapter.

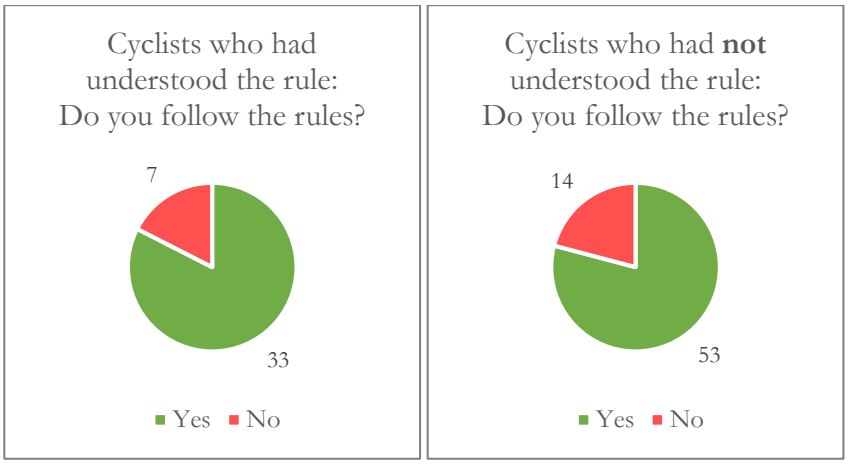

Figure 5.16 Shows the result of the question "Do you follow the rules?", divided into those who knew the rule and those who did not.

6 Discussion & Conclusions

In this chapter, the results, as well as the used methods, are discussed and the results are compared with parts of the literature study. As the aim of this master thesis was to investigate the behaviour of different road users, particularly in give way situations, this will be discussed. Moreover, the hypothesis that the knowledge in the applying traffic rules at bicycle passages is lacking and that the knowledge is better for pedestrians than for cyclists, is also discussed and further, final conclusions are made.

6.1 Discussion of the used methods

To be able to meet the aim of this study and examine the give way-behaviour at bicycle passages, video analysis and interviews were used as methods. The advantages and disadvantages of the methods are further discussed below, as well as limitations and improvements.

6.1.1 Video analysis as a method

The time span that the equipment was installed has a great impact on the outcome of the analysis. In this study, the period was assumed to be relatively representative for the normal traffic situation in the study area. However, the bicycle flows were, most probably, a bit higher than normal due to the good weather conditions during May 2018. The higher flows affected the results in a positive way, since it gave more interaction-moments between vehicles and cyclists. The equipment was mounted for almost three days, which was assumed to be a period long enough to get the amount of data needed. Of course, if the equipment had been installed for a longer time, the amount of data would have been even greater and the result more reliable.

To confirm that the flows of vehicles were representative, the measured flows of vehicles were compared with data from previous measurements, given by *Traffic and Public Transport Authority in Gothenburg*. The video analysis says that 16 700 vehicles drove in or out of the roundabout a normal workday. Comparatively, the previous measurements say that 13 200 vehicles pass a normal day. The explanation for the lower number in the previous data is most probably that the measurement was done at a spot a bit more to the South. That means that the vehicles driving directly to the small street, that runs parallel with Slottsskogsgatan, after exiting the roundabout was not included in the given data. The given data is also a few years old, and therefore, the traffic situation in the area could have changed.

The method used to study the give way-behaviour, by looking at how and when the cars were braking before entering the roundabout, was developed by the video analysis company and authors of the thesis. Therefore, some weaknesses in the method can be noticed, and to confirm the reliability of the method, more similar studies would have been preferred. For instance, the zones that were created could be more developed and better designed if some deeper research of the spot were performed. To study the braking of cars out of the roundabout, before they pass the pedestrian crossing, would not have been that interesting due to the low velocities inside the roundabout. Nevertheless, the outcome result seems to be reliable and confirms what was observed at site and the hypothesis of the master thesis.

When developing the method mentioned above, it was also discussed to study how the cyclists behaved near the passage, instead of studying how the cars were braking. However, since the cyclists' ground speed is lower than motor vehicles, it is harder to study the differences in speed for cyclists. Instead, as a complement, it was decided to study the cyclists' behaviour from the recorded videos. When looking at the videos it is possible to play the video back and forth, which makes it possible to look at tricky situations

several times. In that way, doing human observations by looking at a recorded video gives a more reliable result than observing at site.

The earlier mentioned guidance sign which is blocking some of the road users could be avoided by placing the camera in another angle. The blocking is assumed to not have affected the result in a large extent, more than visually. An improvement would be to place the camera looking to the West in a way so that the cyclists who are coming from there could be captured further away from the roundabout, since those cyclists have higher speed due to the existing slope. This improvement would have required some other type of attachment than the lamp post since the camera would have needed to be in another position.

To conclude, the use of video analysis as a method have many advantages when comparing to human observers. Firstly, a lot of time could be saved since the cameras can be mounted for a longer time and no human needs to be present. As the cameras are hard for the road users to detect, a normal behaviour can be expected from the road users and that is desired in a study like this. Further, different types of road users can be measured at the same time but be separated from each other when performing the analysis. Lastly, more advanced and detailed data can be produced and the system gives the opportunity to obtain data a long time after the video recording was performed. The disadvantages with the method are that it is complex and requires knowledge in both traffic management and about the advanced data system. Moreover, this is a more expensive tool than human observers.

6.1.2 Interviews as a method

That the car drivers were excluded from the interviews is a limitation since that would have given a larger understanding of the subject. It was discussed to try to interview the car drivers, in different ways, but none of them were feasible within the framework of the thesis. If these interviews would have been done, it could have been stated whether the car drivers knew how the give way-rule works or not. It would have been interesting to see if the car drivers actually do not know how the rule at bicycle passage works, or if they know but still let cyclists pass to avoid accidents, which is believable in many cases. It was discussed to do online-interviews in addition to the interviews. An interview-form would then have been sent out on e.g. Facebook, this to get more respondents. But due to limited time, and that the number of respondents were considered as enough, this was not done. Also, it would have been hard to get the respondents even distributed, it would have been difficult to get different road user to answer the questions. On the other hand, answers from car drivers would have been easier to collect this way.

In order to facilitate the analysis of the interview result, the questions were formed so that only two different answers could be registered, yes or no. Some of the respondents wanted to answer e.g. "maybe" or "sometimes", but were then asked to change the answer to a yes- or no-answer. The questions could instead be formulated as; "on a scale of 1 to 5, how well do you think the sign evidence the applying traffic rules?". That would have given another kind of result, but the analysis of the result would have been more difficult to perform and would have taken longer since more options of answers probably require more attended respondents. Therefore, the result of this study is slightly simplified but due to the time limitation of the study it would have been difficult to make it in any other way.

Due to practical issues, the interviews were not performed in rush-hours. This may have affected the result slightly since the cyclists that are travelling in rush-hour presumably use the bike often and therefore maybe have a better understanding of the rules. But when doing the interviews, the impression was that even cyclists that said that they are using the bike often lack in knowledge about the give way-rule at bicycle passages. Therefore, this has probably not affected the result to a large extent.

Finally, interviews as a method have been a good complement to the video analysis. The interviews enabled the knowledge in traffic rules to be confirmed in a way that the video analysis could not provide. The fact that the age etc. of the road users could be investigated made the result more profound. Moreover, the ability to be present at the study area has given insight into how people behave in different situations at the site, which has contributed to the result as well.

6.2 Discussion of the results

The video analysis and the interviews provided different types of results that complement each other, and together they reflect reality. Moreover, results were provided from observations at site and are discussed below, together with results from video analysis and interviews.

6.2.1 The outcome of the video analysis and human observations

The western camera was out of order two times; once at night-time and once in the afternoon. The power break that happened at night has not affected the result to a particularly large extent since the flows were low, especially for cyclists and pedestrians, and the other two cameras were working. However, the other power break that occurred in the afternoon did presumably affect the result relatively much since the flows are highest during this time. When looking at Figure 5.3, 5.4 and 5.5, it can be noticed that the flows differ at 15.00 the 24th of May for both cyclists and pedestrians, when comparing to the 23rd of May. For cars, this change is not seen, since the western camera does not measure the motor vehicle passages.

When studying the result for give way-behaviour, it can be noticed that cars brake more sharply for cyclists than for pedestrians. According to the applying traffic rules, when a car is about to drive into a roundabout with a crossing bicycle passage, the bicycles should give way for cars in that situation. Hence, it seems strange that the result shows that in the reality the behaviour is the opposite. This is probably due to that several of both car drivers and cyclists have not got knowledge about the traffic rules, but also on the fact that some of the cyclists do not care about the give way-rule. In some situations, it is possible that the car drivers know about the give way-rule, but they also know that many cyclists often pass the roadway without giving way for cars and therefore, car drivers may brake for cyclists anyway.

During the time that the cameras were recording the video, the roundabout needed to be surveilled and the road users had to be informed about it, due to Swedish law. When the roundabout was surveilled, some observations were made. In addition, further observations were made when watching the recorded video, which were a valuable complement to the final results. One thing that was observed was that many cyclists have a high speed when entering the roundabout and it looks like many of them do not intend to stop before the passage to give way for the cars. This may be the reason that it looks like many car drivers drive carefully in and out of the roundabout, maybe they feel that the cyclists are unpredictable. Another reason for some drivers' supervised behaviour could be that they are not sure of which traffic rules apply.

When observing, another type of car driver was identified; them who apparently know the rules and want to claim. Many of these drivers keep a low speed but they almost never stop for cyclists unless they are really close to a collision. These drivers were, during the observation, perceived as being irritated at the cyclists but anyhow they do not want to cause an accident. Maybe the irritation car drivers feel about cyclists is more justified than irritation the other way around according to the traffic rules. Even though the rules say another thing, car drivers are afraid of getting the blame if they collide with a cyclist.

During rush-hours, the cars rarely have free passage, especially when driving into the roundabout. There are often other motor vehicles in front of them or a pedestrian at the crossing, which means that they need

to slow down. When they have done that, it is quite natural for them to also let the cyclists pass. On the other hand, for those vehicles that are about to exit the roundabout, queues may occur behind them in the roundabout and the accessibility deteriorates.

6.2.2 Observations when performing the interviews and the result of them

From the result of the interviews, the main thing that can be said is that extremely few of the cyclists knew the exact rules at bicycle crossings next to a roundabout/intersection. Those few, less than 5 people, gave the impression of being well informed. In total, 40 of 107 of the respondents knew that it is the cyclist that must give way. When the interviews were held, the respondents did not receive the correct answer about the give way-rule until the interviews were over. Hence, many people stated that they followed the rules even though they had explained the give way-rule wrongly. Very many of the respondents were unsure and it was perceived as they were guessing. It was also noticed that several of the cyclists were very sure that they were right when they claimed that the rule was that car drivers should give way for the cyclists in the studied situation. It is probably them who are dangerous in the traffic, the road users that think they know the rules and act that way, but they have perceived the rule wrongly, no matter if it is pedestrians, cyclists or car drivers.

The design of the bicycle passage is something that made many of the respondents think that the car driver must give way. This because the passage is red and a bit elevated. It was also several respondents that had heard of the new rule of bicycle crossings, where the car driver must give way, and thought that it is applied at passages with red markings or everywhere. Since there must be a yielding-sign that informs the car to give way for cyclists at a bicycle crossing, the studied roundabout is not wrongly designed but the design can still be discussed. The red colour and the elevation of the bicycle passage confuses many road users. This study can only confirm the confusion for cyclists, but from the human observation, it can be assumed that many car drivers are confused about the rules as well. Some researchers say that the uncertainty in traffic rules leads to a safe traffic environment, since it gives more observant road users, while other claims that it leads to irritation and frustration in the traffic which can lead to accidents.

Some of the respondents answered that they thought the right-hand rule applies next to a roundabout. Which means they thought that whether the car driver must give way or not depends on the direction from where the cyclist is coming from. The impression was that mostly people over 50 years thought so, which indicate that those kinds of rules may applied back in the days when they had their driving license.

The importance to consider both the actual safety and the security when studying traffic safety is something that has been mentioned earlier in the report. When analysing the interview result, it was interesting to study how many of the respondents that did not know how the give way-rule, but said that they were following the applying traffic rules. The result showed that 53 of all the interviewed cyclists did not know the give way-rule, but at the same time, they claimed that they followed the traffic rules. This may mean that they felt secure, but can put themselves into dangerous situations since it is a "false security".

The result from the interviews confirms the hypothesis that pedestrians have better knowledge in traffic rules applying in a bicycle passage than cyclists. The reason for this is probably that the rules for pedestrians are more clear than for cyclists and further, the rules for pedestrians are not so many and have not been changed at the latest. The conclusion is that traffic rules for cyclists need to be clearer and better implemented for all road users.

6.3 The future development of bicycling in Gothenburg and Sweden

As mentioned in the literature study, the vision for Gothenburg is that the bicycle trips shall be tripled between 2015 and 2025. As bicycling increases, the infrastructure for cyclists needs to be developed and the safety needs to increase, otherwise, accidents may increase as well. Moreover, it is possible that with an increase of cyclists, the traffic rules need to be clarified so all road users know what applies. However, the statistic of accidents says that not so many accidents involving vehicles and cyclists occur. It can be discussed whether it depends on shown consideration from both sides or on lacking knowledge in traffic rules. Presumably, it may also depend on careful car drivers that do not want to hit cyclists that think they have precedence. On the other hand, even if just 10 % of all the accidents involving cyclists happened in collision with a motor vehicle, it is those accidents that is the most severe. According to the Vision Zero, it is the fatal and severe accidents that must decrease in order to improve the traffic climate.

Bicycle crossings is a current topic. In Gothenburg, it only exists a few of them at the time of writing but more are planned to be built. It can be discussed whether the bicycle crossings will make it safer or if it will make cyclists more inattentive. In the area studied in this report, the bicycle passage almost works as a bicycle crossing, since the car drivers give way for the cyclists to a large extent. If the number of cyclists increases as stated in City of Gothenburg vision, even more cyclists will pass the passage, which probably will make cars give way to an even larger extent.

6.4 Subjects that can be studied further

In the beginning of the work with this thesis, it was discussed to study previous court cases and how "crime" against the traffic rules is seen juridically. For instance, who was found guilty in situations where a cyclist was hit by a car, at a crossing where the cyclist must give way. However, due to lack of juridical knowledge and time, this was excluded from the report but is something that would have been interesting to study further. If a similar study is performed in the future, the juridical part would have been desirable to include.

The video analysis could provide a lot more data that can be used for further studies, e.g. by the *Traffic Public Transport Authority in Gothenburg* or future thesis work.

6.5 Final conclusion

Among cyclists, the knowledge in traffic is varying due to differences in age and experience. Also, the fact that no driving licence for bicycling is required, affects the traffic climate. The traffic rules at bicycle passages are experienced as unclear, and can lead to misunderstandings and misinterpretations. Therefore, it should be of importance to have traffic rules that are easy to understand, for all road users. One option to solve the problem could be to change the bicycle passage into a bicycle crossing and at the same time formulate the rules so they will be easy to understand.

Since the design of the roundabout apparently makes people believe that the passage is a bicycle crossing, it can be discussed to change the rules there. The result shows that many road users act like it is a bicycle crossing, regardless if they know what rules applies or not. Also, it has been discovered that several cars have to stop and wait for the vehicle in front of them to drive, or give way for pedestrians or cars inside the roundabout and when that happens, they can just as well let the cyclists pass too. To conclude, since many the road users act like the passage is a bicycle crossing, it can just as well be regulated as one.

During the project process, it has become obvious that it is difficult to observe and study behaviour in traffic in a totally objective way, since the human factor always is present and cannot be neglected.

Therefore, it seems hard to get observations and analysis fully automated with today's technique, since many definitions need to be done and people have different opinions. However, as mentioned before, video analysis together with human observations seems like a good concept for now.

The conclusion of this study confirms the hypothesis pretty well, and the overall knowledge in traffic rules at a bicycle passage is lacking. In order to create a more safe and secure traffic environment, the following should be held in mind:

- Clear traffic rules
- Introduce more bicycle crossings
- Video analysis works good with interviews

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Appendix A

The questionnaire used in the interviews can be seen below. Due to that, the authors and most of the respondents were Swedish speaking it was done in Swedish.

Trafikant
- ❑ Fotgängare
- ❑ Cyklist

Körkort
- ❑ Ja
- ❑ Nej

Ålder
- ❑ <25 år
- ❑ 25-50 år
- ❑ >50 år

1. Är det du (cyklist/fotgängare) eller bilisten som har väjningsplikt?
   - O Har förstått
   - O Har inte förstått
2. Tycker du att du följer reglerna (som fotgängare/cyklist)?
   - O Ja
   - O Nej
3. Tycker du att bilister följer reglerna?
   - O Ja
   - O Nej
4. Tycker du att det är tydligt vilka trafikregler som gäller här?
   - O Ja
   - O Nej

Appendix B

Table B.1 shows when the interviews were performed and how many that was performed at each occasion.

Table B.1 The dates, times and number of interviews.

Day	**Time**	**Number of interviews**
Monday 28/5	9.10 - 10.20	42
Thursday 31/5	19.30 - 20.10	18
Friday 8/6	9.50 - 11.00	18
Thursday 14/6	14.00 - 15.00	12
Monday 18/6	8.30 - 10.00	40

Appendix C

Figure C.1 and C.2 presents the variation in speed of cyclists and motor vehicles in cumulative share.

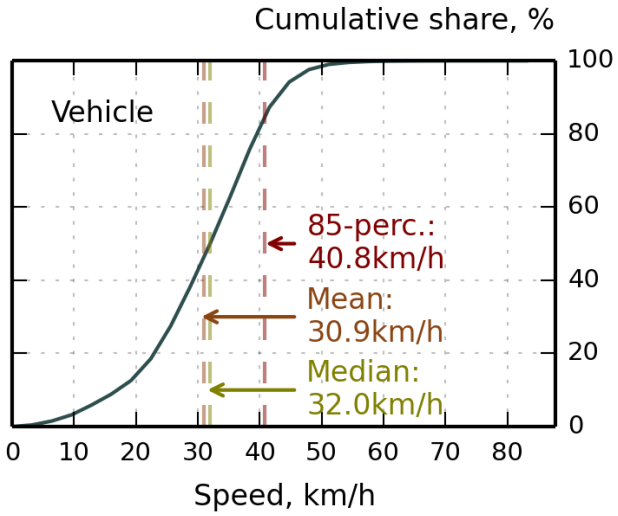

Figure C.1 Variation in speed for the motor vehicles.

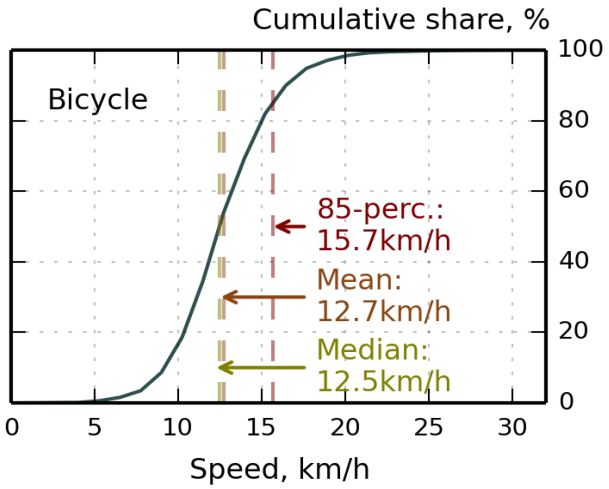

Figure C.2 Variation in speed for the bicycles.

Appendix D

Appendix D, Figure D.1 – D.6, contains results from the interviews.

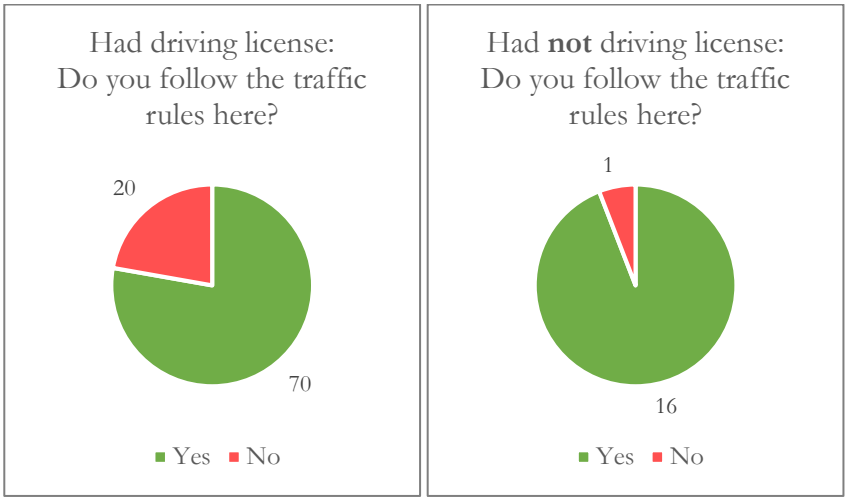

Figure D.1.

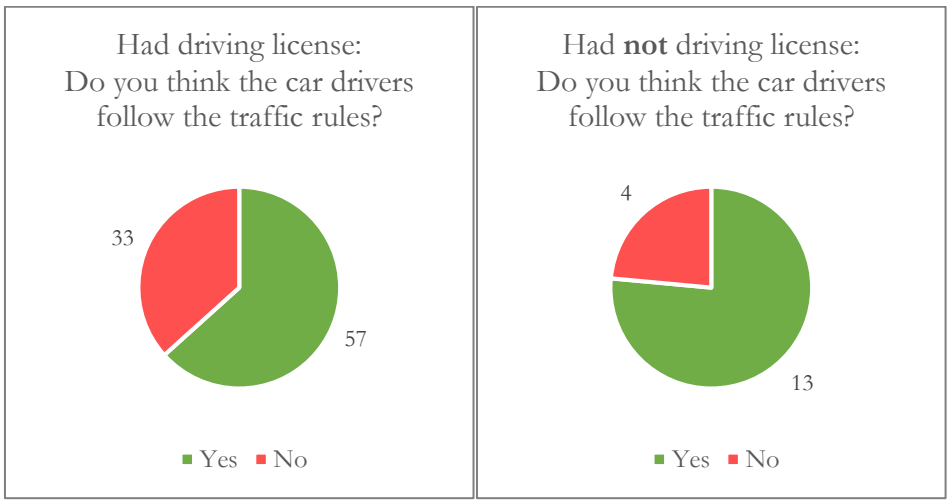

Figure D.2.

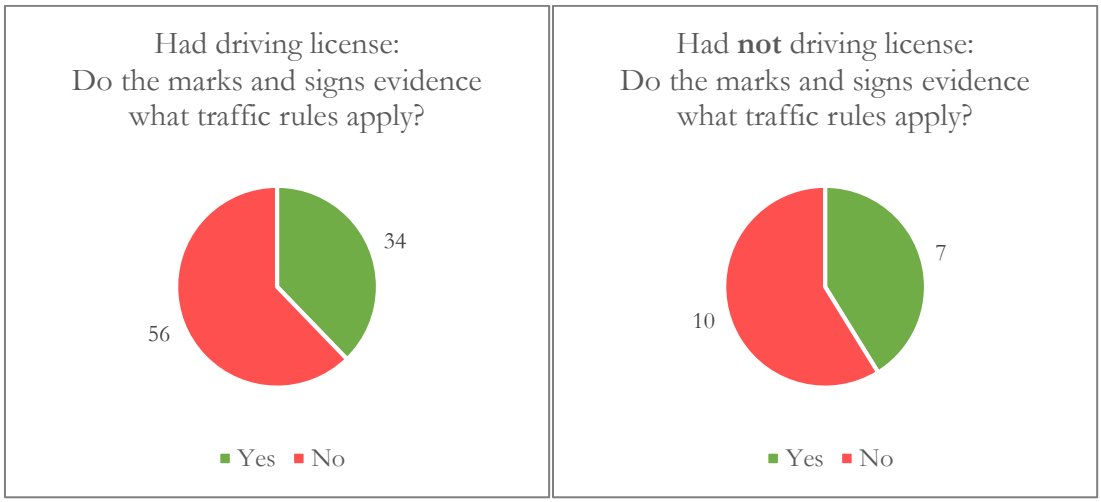

Figure D.3.

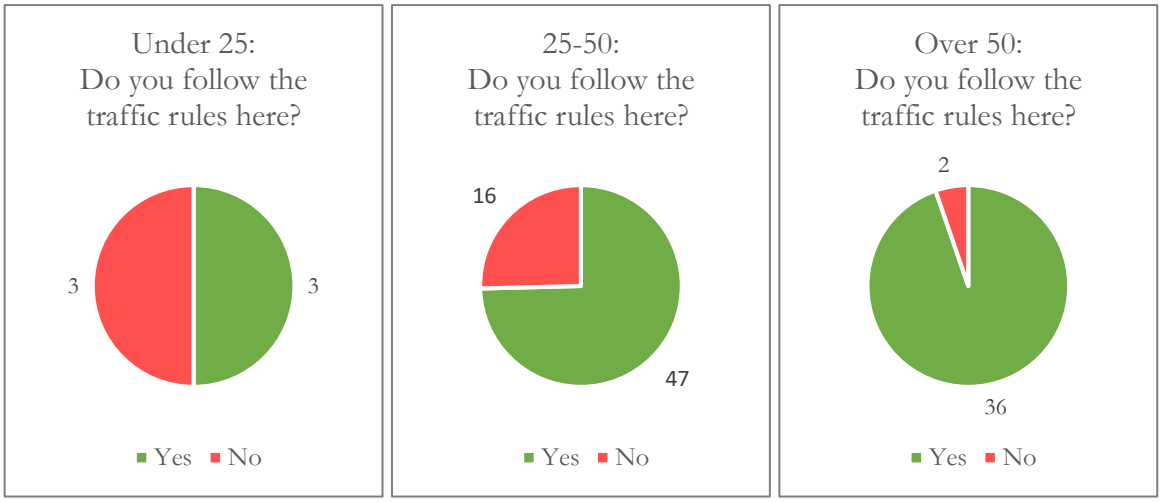

Figure D.4.

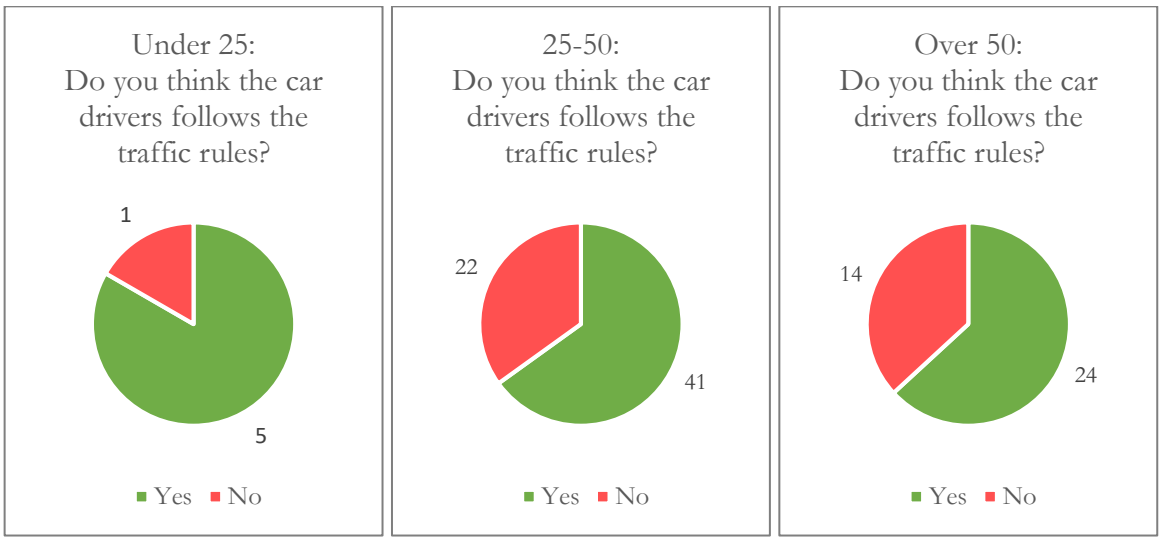

Figure D.5.

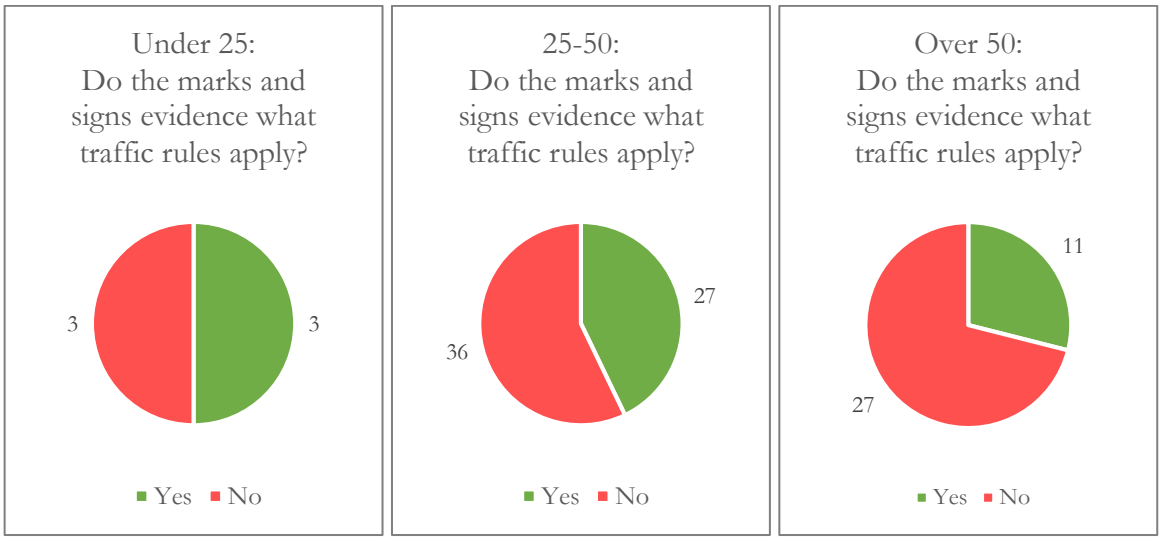
Under 25:
Do the marks and signs evidence what traffic rules apply?
3
3
Yes
No
25-50:
Do the marks and signs evidence what traffic rules apply?
36
27
Yes
No
Over 50:
Do the marks and signs evidence what traffic rules apply?
11
27
Yes
No

Figure D.6.