Bicycle infrastructure design standards and modal choice

A comparison between Gothenburg, Copenhagen and Amsterdam.

Master's thesis in infrastructure and environmental engineering

Oskar Sköld

Department of Architecture and civil engineering, Division of Geo Engineering, Road and Traffic Research Group

CHALMERS UNIVERSITY OF TECHNOLOGY

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ABSTRACT

The aim with this project was to identify and compare the bicycle infrastructure design standards and existing bicycle network in the cities of Gothenburg, Copenhagen and Amsterdam. By comparing the design standards their impact on the bicycle modal share were to be analyzed. No consideration was taken to whether the design standards are fulfilled in the cities or not. A literature study and interviews with representants from the different cities were performed to achieve a satisfying result. Further, a statistical analysis was completed to identify how a crossing over the river Göta älv in the city of Gothenburg affect the modal choice in the city.

The result achieved indicate that there are minor differences when comparing the design standards on a small scale but more prominent when comparing them on a large scale. Copenhagen design standards tends to at some situation reduce the traffic security to increase the traffic safety. It is hard to say to what extent the design standards alone affect the modal share, but a proper designed bicycle infrastructure is vital for a city to increase the bicycle modal share. The creation of a bicycle infrastructure is important, but it does not increase the bicycle modal share without being marketed and maintained in a proper way. Further, a city with a great mix of residential and business areas where the average trip length is considered short are a good prerequisite for a higher bicycle modal share.

The bicycle network quality is similar in the three cities, the more varied topography in the city of Gothenburg however entails in problem with creating a continuous and easily oriented bicycle network. According to the statistical analysis the river barrier in the city of Gothenburg affect the modal choice in a prominent extent. Individuals are more likely to travel by bicycle if they not crossing the river. However, additional analyzes must be made to ensure this conclusion. To increase the bicycle modal share, the city of Gothenburg should encourage officials to prioritizing the bicycles and start target the creation of bikeways through green areas.

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PREFACE

This master thesis is intended for people working with city planning and mobility. The master thesis is written at Chalmers technical university and the Danish consultancy Ramboll. The project was conducted at the Mobility department at Ramboll Göteborg and at the Department of Architecture and civil engineering, Road and Traffic at Group at Chalmers University of Technology, Sweden.

The project was supervised both by Ramboll and Chalmers. M.Sc. Linda Andersson was supervising from Ramboll and assistant professor Ivana Tasic from the Department of Architecture and civil engineering. Help was also given from officials in the cities of Amsterdam, Copenhagen and Gothenburg by posting an interview helping to achieve greater knowledge within the study area.

Oskar Sköld 2018

WORDLIST

Bicycle box – Design solution at an intersection which allows additional space for cyclists at red light and increases the passability at green light.

Bikeway – A term used to describe the area cyclists traveling on.

Detour factor – The actual travel distance between two locations divided with the straight line between the locations.

Green wave – Several intersections interact with each other to give a specific road user green light when traveling through all of them with constant speed.

Phase cycle – At a signalized intersection a phase is when all the different signal modes that may occur have been run.

Road users – All stakeholders utilizing the road. Pedestrians, cyclists, motorists and public transit.

Security – The perceived safety an individual experience when utilizing the infrastructure.

Safety – How safe the infrastructure really is.

1. INTRODUCTION

Global warming is one of the greatest challenges for the modern society. (United Nations, 2018). To decrease the environmental impact, people should strive to live a more sustainable life. A way to motivate this is to plan cities in a way that encourages such behavior. In Sweden, transportation is responsible for about 30% of the total emissions of greenhouse gases. (Trafikverket, 2017). Further, motorized traffic contributes to cognition and decreased passability in the cities. A way to reduce the congestion, improve the passability and counteract global warming is to reduce the trips done by motorized transportation. This could be done by encouraging people to travel by alternative modes, such as bicycles, instead.

The city of Gothenburg, Sweden, has adopted a program to increase the bicycle modal share. The goal is to make people consider Gothenburg a bicycle-friendly city and triple the number of trips done by bicycle. Travelling by bicycle should be considered as a fast, accessible, enjoyable, safe and healthy experience. By increasing the modal share of bicycles, the urban environment will be improved in consideration to pollutions, noise and area occupation. Further, the public health increases if citizens start to travel by bicycle. (Göteborgs stad Trafikkontoret, 2015). One way to increase the bicycle modal share is to develop an attractive bicycle infrastructure. Studies approve that a well-developed bicycle infrastructure increases the bicycle modal share. (Dill & Carr, 2003). (Hull & O´Holleran, 2014).

Today, 8% of all trips in Gothenburg is done by bicycle. (Göteborgs stad Trafikkontoret, 2015). Compared to Copenhagen and Amsterdam, which has a corresponding modal share of 29% and 36%, it is considerably low. (City of Copenhagen, 2017). *(City of Amsterdam, 2016).* Factors affecting the bicycle modal share are safety, security, travel distance, traffic properties, topography and the weather conditions. (Weber, 2017).

Based on previous, it is possible to compare the three cities design standards, policies and guidelines on bicycle infrastructure to understand how Gothenburg should develop the bicycle infrastructure to improve the bicycle modal share in the city.

1.1 Aims and goals

The aim of this report is to:
- Characterize the qualities of good bicycle infrastructure and compare the existing bicycle network in the city of Gothenburg, Copenhagen and Amsterdam.
- Compare the bicycle infrastructure design standards for Gothenburg, Amsterdam and Copenhagen to see how they affect the bicycle modal share.
- Study the impact from factors affecting the modal choice in the city of Gothenburg by creating a statistical model.

1.2 Limitations

The following limitations are set for the report:

The design standards for rural areas has not been investigated.
The historical impact has been investigated in limited extent.
The bicycle infrastructure investment in the different cities has not been considered.

1.3 Purpose + Issue

The purpose with this report is to give engineers and student within the study area an insight in how an attractive bicycle infrastructure can be created. The report is written as the last statement on the master program Infrastructure and environmental engineering at Chalmers technical university in the city of Gothenburg, Sweden.

2. BACKGROUND

2.1 History

Copenhagen and Amsterdam are in many surveys considered two of the most bicycle friendly cities on the planet. (Copenhagenize, 2017). The two cities have a long tradition of cycling in common. (Pucher & Buehler, 2007).

After the invention of the bicycle during the latter half of the 19th century the modal share of the new invented vehicle started to increase rapidly due to its accessibility and freedom of movement for everyone. The modal share for bicycles increased until around 1960 when the working-class families started to afford buying cars. During the 1960s the city planning took a more car-oriented agenda and the bicycles became marginalized. (Ruby, 2018).

During the 1970s and the 1980s, in Copenhagen, the car and bicycle interest started to get into conflicts. Political ideas of building highways through natural areas and the number of cyclists killed in traffic accidents were some of the underlying causes. The politicians realized that the city areas had to be shared between the different stakeholders. Since then, investment to create a safe and integrated bicycle infrastructure has been regular in Copenhagen. As the question about climate change recently has been highlighted, so has the question about the bicycle as a transportation mode. The largest cities in Denmark has started large campaigns to make more of their citizens consider the bicycle as an attractive travel mode. (Ruby, 2018). (Cycling embassy of Denmark, 2012).

In figure 2.1 the historical development of trips done by cars and bicycles in the central parts of Copenhagen are presented. In the graph the decrease in bicycle modal share in the 1960s and 1970s can be observed.

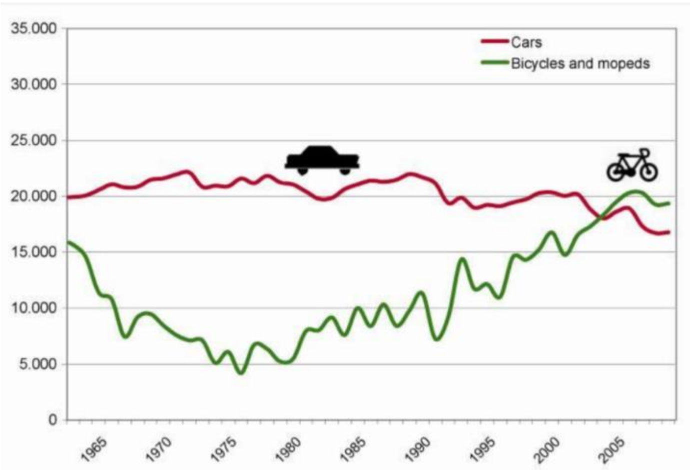


Figure 2.1: Graph presenting the historical development of journeys done by cars and bicycles in the central parts of Copenhagen. (City of Copenhagen, 2009).

Similarly to Copenhagen, Amsterdam experienced a decrease in bicycle modal share in the 1960s. During the 1970s large protest towards the increasing number of deaths, specially of children, caused by traffic accidents between motorists and cyclist took place. The bicycle had been marginalized in favor for motorized vehicles the last years and when the oil crisis came in 1973 the politicians realized that they had to find a less energy demanding source to run the society. The government discarded the motorized vehicle centric policies and started to invest in an infrastructure integrating the different road users which lead to the modal share of bicycles increasing with 30-75% around the Netherlands. (Pucher & Buehler, 2007). (Wagenbuur, 2011). In figure 2.2 the historical development for transportation modes modal share in Amsterdam are presented.

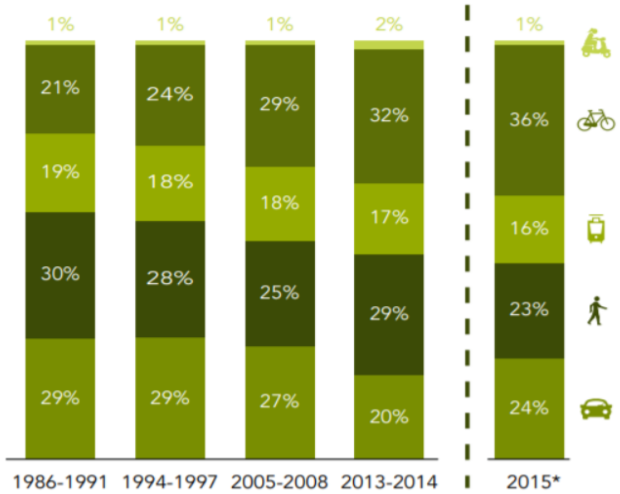


Figure 2.2: Diagram describing the development of modal share of all trips in the city of Amsterdam during a working day. (City of Amsterdam, 2016).

During the 20th century the cities in Sweden developed in a similar way as Copenhagen and Amsterdam. In larger infrastructure project it was not certain to involve an expanding bicycle network at all. Protest were raised to attain a safer traffic environment. (Johansson & Lagercrantz, 2013). Swedish traffic officials then developed a design standard called SCAFT. SCAFT was based on ideas to differentiate and separate different road users to improve traffic safety. The idea was to create an infrastructure based on simplicity, which did not demand so much concentration from the travelers, and to plan the cities so its citizens should not have to cross city barriers to often. (Statens planverk, 1968). Since motorized traffic were most commonly prioritized this resulted in a marginalization of the bicycles. (Hagson, 2004). Recently, the bicycle as a mode of transportation has gotten more attention in Sweden. For instance, the city of Gothenburg has since the nineties adopted different strategies to emphasize the importance of a good bicycle infrastructure. Compared to Copenhagen and Amsterdam however, the modal share in the city of Gothenburg is markedly smaller, 8% compared to 29% and 36%. (Göteborgs stad Trafikkontoret, 2015). (City of Copenhagen, 2017). *(City of Amsterdam, 2016).* The minor modal share for Gothenburg could be a result of neglecting the development of the bicycle infrastructure for decenniums and focusing on the wrong city planning policies.

2.2 Infrastructure

The infrastructure of a city are the facilities used to serve the different areas within the city. For instance, it could be the water supply, the power supply or the road network of a city. The main purpose with the road network of a city is to improve the accessibility and transportation opportunities for its citizens and business. (Investopedia, 2018). For decades the city planning has been centered on motorized vehicles passability within cities. Recently, the city planning has been more focused on creating a sustainable environment. (Newman & Kenworthy, 2000). City planners should encourage people to travel in a more sustainable way than with automobiles, like with bicycles e.g. A well-accepted theory is that investments improving the bicycle infrastructure gradually increases the bicycle modal share. (Dill & Carr, 2003). (Hull & O´Holleran, 2014). To meet the requirement of modern bicycle infrastructure, cities and countries has developed design standards to adopt when designing the city infrastructure. The design standards contain requirements and design solutions to implement in the city planning to achieve well-functioning bicycle infrastructure. (Dufour, 2010).

2.3 Bicycle Priority

When designing a city infrastructure, different road elements may get in conflict with each other and the planners must therefore prioritize the different road elements considering their passability. Engineers may marginalize the bikeway in favor for other road elements considered of a higher prioritization. (Stockholms stad, 2013). The bikeway passability affects the attractiveness to travel by bicycle. The prioritization of the bikeway when designing a street therefore affect the modal share of bicycles. (Landis, Vattikuti & Brannick, 1997).

Prioritization could either be passive or active. Passive prioritization is actions that does not involve system detection of a road user, such as: (Vägverket & SK, 2004).

- Physical configuration.
- Location of public transit stop.
- A well-planned route.
- The green time share for a road user. A time set can be customized for the prioritized traffic.

Active prioritization is when detection is used to distinguish the prioritized vehicles from the others. Active prioritization can be actions such as: (Vägverket & SK, 2004).

- Extending running green times.
- Shorten the adverse traffic green time if prioritized vehicle arrives at an intersection.
- Skip phases to get the prioritized vehicles phase to run earlier.
- Ad a phase that only run during the time a prioritized vehicle arrives at the intersection. Used at railroad tracks, bridge openings or with emergency vehicles for instance.

The active prioritization actions above are commonly combined to allow the prioritized vehicle to always have green light when arriving at the intersection. (Vägverket & SK, 2004).

When utilizing active prioritization, the following limitation needs to be considered: (Vägverket & SK, 2004).

- The shorten of adverse traffic green light is limited to minimum times such as the time pedestrians require to cross the road.
- If the adverse traffic flow is high the prioritization can entail traffic congestion.
- Prioritization of different road users can counteract.
- Physical obstacles at an intersection.
- A high flow of prioritized road users increases the accompanied problem.

3. METHODOLOG

To be able to compare the bicycle infrastructure design standards and policies in the different cities a literature survey was performed. The main objective was to define what factors that are important to create an attractive bicycle infrastructure and compare the standards of those factors. Interviews with representants from the different cities were then performed to attain deeper knowledge. The bicycle network comparison was performed in QGIS with data collected from the websites of the municipalities. Further, a statistical model comparing the impact from different factors on the bicycle modal share in the city of Gothenburg was created.

Amsterdam and Copenhagen were selected as cities to compare Gothenburg with since they in many surveys are considered two of the best bicycle cities in the world. (Copenhagenize, 2017).

3.1 Literature survey

The literature survey was based on documents containing the design standards for the three cities. Since the design standards for the cities has a deficiency of information they were supplemented with additional documents. In 3.1, the most used documents are given a short introduction.

Table 3.1: Table describing the documents mainly used in the literature review.

Gothenburg	
Title	**Topic**
Technical manual, the city of Gothenburg.	The design standards for the city of Gothenburg. It is edited by the traffic department of Gothenburg and contains guidelines when designing the traffic infrastructure. It should be used complemented with VGU.
VGU, Vägar och gators utformning, Swedish transport administration & SKL.	VGU is a document created by the municipalities and Traffic administration in Sweden. The recommendations are mandatory for the Traffic administration employees, municipalities can use them as guidelines.
Copenhagen	
Title	**Topic**
Cykelfokus, Københavns Kommunes retningslinjer for vejprojekter.	A document containing guidelines when designing bicycle infrastructure in the city of Copenhagen. It is edited by the municipality of Copenhagen and should be used as a complement to additional sources.
Idékatalog för cykeltrafik, Cycling embassy of Denmark.	A document containing recommendations and information on how to design the bicycle infrastructure in Denmark. The municipality of Copenhagen do refer to it in their guidelines.

Amsterdam	
Title	**Topic**
Leidraad Centrale Verkeerscommissie, Gemeente Amsterdam.	The design standards for the municipality of Amsterdam.
Design manual for bicycle traffic, CROW.	A Dutch design manual describing how to create an attractive bicycle infrastructure and how to maintain it.

3.2 Interviews

In addition to the literature study, qualitative interviews were performed with representatives from the different cities to get deeper knowledge on the subject. The interviews were performed with the following interviewees:

- Malin Månsson, transportation planner, Traffic department, Gothenburg.
- Casper Wulff, transportation planner, Raw Mobility, Copenhagen.
- Gerrit Faber, Cycling expert, Amsterdam. Gerrit worked for the Dutch cycle union between 2010 and 2016.

The interviewees were selected because they had many years of experience in urban bicycle planning in their cities. The interviews were of the qualitative type to get a deeper knowledge of the subjects discussed.

During the interviews the following were discussed:

- What factors that are considered when designing the bicycle infrastructure.
- How the representative defines bicycle prioritization and how they consider the bicycle priority in their city.
- Why there are differences in the design standards.
- How officials in their city consider the theory of creation of an attractive bicycle infrastructure increases the bicycle modal share in a city.
- What has been prioritized in the city planning the last decades.
- Pros and cons with different design solutions.
- In the interview with the representant from the city of Gothenburg, the impact from the topography of the city when designing the bicycle infrastructure were discussed. This was done since Gothenburg is more undulating than Copenhagen and Amsterdam.

3.3 Modal choice in the city of Gothenburg

To be able to determine the impact from different factors on the modal choice in the city of Gothenburg a multinomial logit model was created. The model was developed together with the supervisor at Chalmers university.

3.3.1 Multinomial Logit Model

A Multinomial Logit Model (MNL) is a type of discrete choice modelling method. Discrete choice modelling methods are used when modelling a group of individuals each selecting an option from a finite set of independent alternatives. A discrete choice model results in a probability of making a particular choice among a set of choices provided to an individual in the population. (Dios Ortuzar & Willumsen, 2001).

A discrete choice model requires that: (Dios Ortuzar & Willumsen, 2001).

- All individuals observed belong to a population q. Every individual is perfectly informed about the different options and selects the option which maximizes their personal utility.

- The utility for an individual from an alternative is calculated with explanatory variables describing their characteristics. Each explanatory variable has specific impact on the total utility. A disturbance term can be added in the utility calculation since the observer does not possess all information about the individuals.

- Every individual is characterized with a set of explanatory variables x_i and must select one option from the finite set of alternatives A. The explanatory variables could be describing the characteristics of the traveler(sex, age etc.), the journey(travel time, distance etc.) or the transport facility(comfort, security etc.). The explanatory variables could either be continuous, ordinal or nominal. A continuous variable can be given as a fixed number(Age, Income etc.), an ordinal variable as an answer on a scale ranking("from a scale of 1 to 5, how do you?") or a nominal variable as a property(Travel mode, Gender etc.). (Lærd Statistics, 2018).

- Explanatory variables in the utility function are not correlated with each other.

In discrete choice modelling the individuals can be modeled as a group, aggregated model(AM), or as single individual, disaggregated model(DM). (Dios Ortuzar & Willumsen, 2001). In this report a disaggregated discrete model were created.

The following advantages have been stated with disaggregated modelling: (Dios Ortuzar & Willumsen, 2001).

- DM can be used to analyze populations at all aggregation levels.
- DM are stable when transferred between time and space.
- A DM is less likely to be affected of ecological correlation. Dios Ortuzar & Willumsen(2001) explains the concept by ecological correlation as when aggregating information, unidentified parameters may be hidden in the aggregated data and the result might therefore be misleading.
- The number of individuals selecting a specific option equals the sum of the probabilities of every individual selecting that option.
- The probability of a set of individuals choosing a specific option equals the product of every individual selecting that option.

3.3.2 Mathematical framework

Multinomial logit modelling calculates the probability of an individual selecting a specific option as the exponential of the chosen option utility divided by the summary of the exponential for all options utility. This is described with the formula: (Dios Ortuzar & Willumsen, 2001).

$$P_1 = \frac{\exp(V_1)}{\exp(V_1) + \exp(V_2) + \cdots + \exp(V_n)} \quad (3.1)$$

Where

P = Probability of choosing the option.

V = Utility of a travel mode.

The utility V is calculated according to the formula:

$$V = \theta_1 x_1 + \theta_2 x_2 + \theta_n x_n \quad (3.2)$$

Where

x_i= explanatory variables.

θ = coefficient which denote the weight from each explanatory variable.

The values of the coefficients θ are estimated according to the maximum likelihood estimation method(ML). The ML method is used to estimate parameters in a probability distribution of a given data set. The values of θ are estimated so that the utility V achieve in its maximum value for a given set of explanatory variables. This is done by creating a log-function l(θ) and maximize it to find the optimal value of θ. (Dios Ortuzar & Willumsen, 2001). The outcome of *n* individuals selecting a travel mode among *i* options are presented in table 3.2. The probability *P* for an individual *q* to select a specific travel mode among *i* and the explanatory variables x_{iq} for every individual are listed in the table.

Table 3.2: Table describing how the probability is connected to the explanatory variables.

Observation q	Mode choice P_{iq}	x_{1q}	x_{2q}
1	P_{i1}	x_{11}	x_{21}
2	P_{i2}	x_{12}	x_{22}
…	…	…	…
n	P_{in}	x_{1n}	x_{2n}

To create the log-function, a likelihood function of the data above are first created. The likelihood function is given as the product of the probability of every individual selecting the transportation mode they select. I.e.: (Dios Ortuzar & Willumsen, 2001).

$$L(\theta) = P_{i1} * P_{i2} * \ldots * P_{in} = \prod_{i=1}^{n} P_i \quad (3.3)$$

The loglikelihood-function l(θ) can then be written as:

$$l(\theta) = \log(P_{i1}) + \log(P_{i2}) + \cdots + \log(P_{in}) \quad (3.4)$$

P_{in} is then expressed in terms of θ, simplifications of 3.4 give:

$$l(\theta) = \log\left(e^{\theta x_{11}} + \cdots + e^{\theta x_{n1}}\right) + \log\left(e^{\theta x_{12}} + \cdots + e^{\theta x_{n2}}\right) + \cdots + \log(e^{\theta x_{13}} + \cdots + e^{\theta x_{n3}})$$
(3.5)

The derivate of the loglikelihood-function is then set equal to zero to find the maximum value of $l(\theta)$ and thereby the optimal value on θ. θ has then the value which result in the largest utility for a specific transportation mode with the given set of explanatory variables. Therefore, this value of θ are used as the coefficient. (Dios Ortuzar & Willumsen, 2001).

3.3.3 Software SPSS

The commercial software SPSS was used to calculate the utility of the transportation modes and the probability of an individual selecting a specific transportation mode.

SPSS is a software used to analyze statistical data. It has a built-in function for multinomial logit regressions which allow the user to calculate coefficients for a given dataset according to the mathematical technique described in 3.3.2. To understand the result in SPSS the concept *statistical significance* is of high importance. Statistical significance is a value 'p' indicating whether a result is obtained because of randomness or not. The value 0.05 is often set as the threshold for statistical significance. If 'p'<0.05, 'p' is said to be statistically significant and therefore not a result of randomness. (Lærd Statistics, 2018). The threshold for 'p' was set to 0.05 in this report.

The result in SPSS is presented as different tables: (Lærd Statistics, 2018).

- Model fitting table: A table providing information whether the explanatory variables statistically significantly improve the model compared to the intercept alone or not.
- Likelihood ratio table: A table providing information whether the explanatory variables are statistically significant or not.
- Parameter estimates table: A table presenting the estimated values on the utility for each explanatory variable and whether they are statistical significant or not.

The result from the SPSS simulation are imported as print screens into the result part of the report.

The probability of an individual with a given set of explanatory variables choosing a specific option are then calculated with the values given in the Parameter estimates table. The table provide a parameter(coefficient) *B* for each explanatory variable and a constant factor called *intercept* representing the properties not considered in the explanatory variables. The intercept and *B* for every explanatory variable are then summarized to the total utility. Then equation 3.1 can be used to calculate the probability for the individual choosing a specific travel mode.

3.3.4 Input data

The input data for the Multinomial logit model were collected through an online questionnaire created in Google form. The questionnaire was posted in a Facebook group called Yimby which members living in the city of Gothenburg. By posting the formula in Yimby, answers from a diverse spread of individuals within the city were achieved. 146 individuals were answering the questionnaire. The questions were designed to obtain answers which satisfied the requirement for explanatory variables presented in 3.3.1. The questions were considering:

 - Characteristics of the traveler such as gender, age, poses of diver license and access to a car.
 - Characteristics of the trip such as the distance, travel time and whether the individual crossing Göta älv or not and if they consider crossing the river to be a problem.
 - Characteristics of the transport facility such as the rating of the bicycle infrastructure, weather impact on modal choice and distance to public transit.

A question about how the topography affecting the modal choice was decided not to be included in the questionnaire since the affect from the topography on the bicycle infrastructure in Gothenburg were discussed during the interview with Malin Månsson. However, the intercept added in SPSS symbolize the impact from variables not included in the model, including the topography. The questionnaire can be found in appendix I.

To be able to run the multinomial logit model in SPSS the intervals of the input data had to be change since the program could not run it without error for the interwall given in the online survey. The following changes were done to get it to work:

- The travel mode option ‘walking’ had to be removed since too few individuals had chosen the option.
- The question about whether and individual had a driver license or not were erased since a large majority of the individuals had a driver license.
- The question about how many cars an individual had were change to a “Yes or No question” about whether the individual had access to a car or not.
- The rating on the bicycle infrastructure category 4 had to be merged into category 3.
- The weather impact category 1 had to be merged into category 2.

By implementing the steps above the questions and answer intervals presented in table 3.3 were created and used as input data in SPSS. Question number four were added to investigate if an individual living on the mainland were choosing another modal option than an individual, with same characteristics, living on Hisingen. Hisingen is an island which constitute the northern part of Gothenburg.

Table 3.3: Questions and answers used in SPSS.

Question	**Answer**
Gender?	Male Female
Age?	20-29 30-39 40-49 50-59 Older than 60.
Travel mode?	Car Public transit Cycling
Do you live on Hisingen or the Mainland?	Hisingen Mainland
Do you cross Göta älv when commuting to work?	Yes No
Do crossing Göta älv poses a problem for you?	Yes No

	I don’t cross
How far is it to your work?	<3 km 3-6 km 6-10 km 10-20 km >20 km
How long time does it take to reach your work?	0-20 min 21-40 min 41-60 min >60 min
How far is it from your home to the closest transit?	0-200 m 200-400 m 400-600 m >600 m
How do you rate the bicycle infrastructure between your home and your work?	Very bad Bad Okay Good
How large impact does the weather have on your choice of transportation?	Not at all Slightly Much Very much
Do you have a car?	Yes No

The input data were compiled in an excel document and then imported into SPSS with the configuration presented in Figure 3.1.

Gender	Age	Travel_Mode	H_or_M	Crossing	Problem	Distance	Time	Transit	Rating	Weather	Nr_of_cars
Female	30-39	Bike	Mainland	No	No	<3 km	21-40	0-200 m	Ok	Not at all	0
Female	40-49	Car	Mainland	Yes	No	10-20 km	0-20	0-200 m	Bad	Very much	1
Male	20-29	Car	Mainland	No	Not crossing	3-6 km	0-20	0-200 m	Ok	Very much	1

Figure 3.1: A table describing how the input data were configurated in SPSS. The example is for three of the individuals in the population.

3.3.5 Final multinomial logit model

To be able to utilize a multinomial logit model the explanatory variables must be independent. SPSS has a built-in function to investigate if any variables correlate with each other. By using this function, a final model was created in which four of the explanatory variables which did not correlate were used. The final model was then verified by checking if it was statistically significant compared to the intercept. Further, each of the four variables used were verified by checking if they were statistical significant. This is verified in the results presented in SPSS.

The variables selected to be included in the model were the age of the traveler, whether the traveler is crossing Göta älv or not, the travel distance and in what extent the traveler consider the weather to affect its modal choice.

3.3.5 Verifying the model

To verify the model and get an idea of how crossing over Göta älv affect the modal choice, the model was tested for two made-up individuals with the characteristics listed below. The results are discussed in chapter 5.

Person 1 characteristics:
Age: 25 year
Crossing the river: Yes
Travel distance: 15 km
Weather impact: 4

Person 2 characteristics:
Age: 25 year
Crossing the river: No
Travel distance: 15 km
Weather impact: 4

4 RESULTS

In this chapter, good bicycle infrastructure is first defined. Followed by an overview of the bicycle network in the different cities. Then the design standards and policies for bicycle infrastructure identified during the literature study and interviews are presented. The last part of the chapter is presenting the result of the multinomial logit model.

4.1 Attractive bicycle infrastructure

Göteborgs stad (2015) stated that an attractive bicycle infrastructure requires the following characteristics:

- The bicycle network should be direct and allow travelling in desired speed.
- The bicycle network should be continuous and well connected throughout the city.
- The bicycle network should be safe.
- The bicycle network should be secure.
- It should be easy to navigate in the bicycle network.
- It should be comfortable to travel on the bicycle network.

The Dutch organization CROW (2016) define bicycle friendly infrastructure with five concepts:

- *Cohesion*: A cohesive bicycle network should connect all locations a cyclist may consider travel between. A network cohesion is defined by the grid size which is the distance between parallel bikeways in a network. The lower grid size, the more cohesive network.
- *Directness*: A cyclist should be able to travel as direct as possible between different locations. The ability to reach destinations faster by bicycle than by car are desirable.
- *Attractiveness*: All road users has different views of what the attractiveness of a bicycle infrastructure is. However, some prominent factors are: bikeways through green areas, high traffic safety, even surfaces, proper designed junctions, good signage and low interaction with motorized traffic.
- *Safety*: The bicycle infrastructure should guarantee traffic safety for all road users. Well visible edge markings, smooth transitions, limited number of bollards on bikeways, well defined bikeways, separation of different road users, enough width on bikeways and prevention of interaction between motorized vehicles and cyclists are factors affecting the safety.
- *Comfort*: The bicycle infrastructure should entail as low nuisance and delay for the cyclists as possible. Additional factors affecting the comfort of a bikeway is the slope and the evenness of the surface.

4.2 Bicycle network

All three investigated cities divide their bicycle network into different sub-networks. The design standards on a network depends on the type of sub-network being constructed. In this chapter the bicycle network for each city are presented.

4.2.1 Gothenburg network

The city of Gothenburg divides their network in the following sub-networks: (Göteborgs stad, 2018).

- Commuter bicycle network: To connect remote locations, distance >5 km. Constructed for higher speed travelling.
- Overall bicycle network: Connections between locations along the commuter bicycle network.
- Local bicycle network: Routes that connect the cyclist to their destination.

A recommended mesh distance between the bikeways in the city of Gothenburg is not given in the design standards. A detour factor of 1.25 is set for the commuter network. (Göteborgs stad, 2018). Figure 4.1 present the bicycle network of Gothenburg.

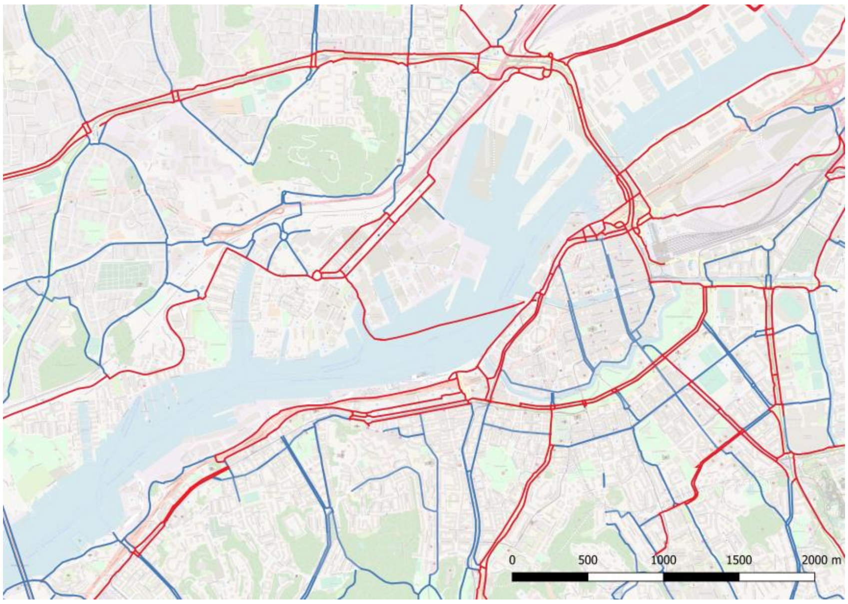


Figure 4.1: The bicycle network in the city of Gothenburg. The red lines indicate the commuter network and the blue lines the overall network. (Trafikkontoret, 2018).

Gothenburg is more undulating than both Amsterdam and Copenhagen which both can be considered flat. In figure 4.2 the combination of a shape-file over the bicycle network of the city and a topography DEM-file in QGIS are presented.

Figure 4.2: Bicycle network and topography over the city of Gothenburg. Yellow indicates the commuter network and black the overall network. (Trafikkontoret Göteborgs stad, 2018).

4.2.2 Copenhagen network

The city of Copenhagen divides their network in the following sub-networks: (København kommunes, 2013)

- Standard bicycle routes.
- Grønne cykelturer: Bikeways through attractive areas on which the traveler should appreciate the bicycle ride.
- Supercykelsti: The Danish commuter network, used to travel longer distances by bike.
- PLUSnet: A selection of bikeways, Grønne cykelturer and Supercykelstier with increased standard.

The mesh distance for the bicycle network in Denmark is set to 400-500 m but could be minor in central urban high traffic areas. (Celis Consult, 2014). Figure 4.3 present the bicycle network of Copenhagen.

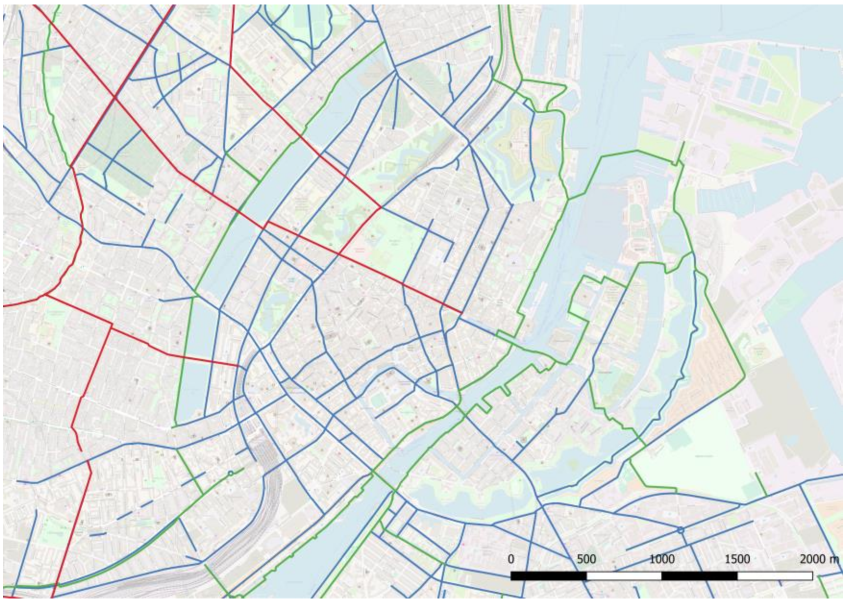


Figure 4.3: The bicycle network in the city of Copenhagen. The blue lines indicate standard bicycle routes, red lines "Supercykelstier" and green lines Grønne cykelturer.

4.2.3 Amsterdam network

The city of Amsterdam divides their network in the following sub-networks: (Gemeente Amsterdam, 2016).

- Plusnet fiets: The basic bicycle network of Amsterdam. Used on neighborhood scale.
- Hoofdnet fiets: The main cycle network used to connect important locations in the city. Maximum quality standards are required.
- Bicycle highways: Used to commute quick between far located positions, 5-30 km. Should make the bicycle considered as a good option to traveling by car.

The grid size in Amsterdam is set to 300-500 meters for urban areas and 1000-1500 meter for rural areas. The detour factor is set to 1.2 for the main cycle network and 1.3-1.4 for the rest. (CROW, 2016). Figure 4.4 present the bicycle network in Amsterdam.

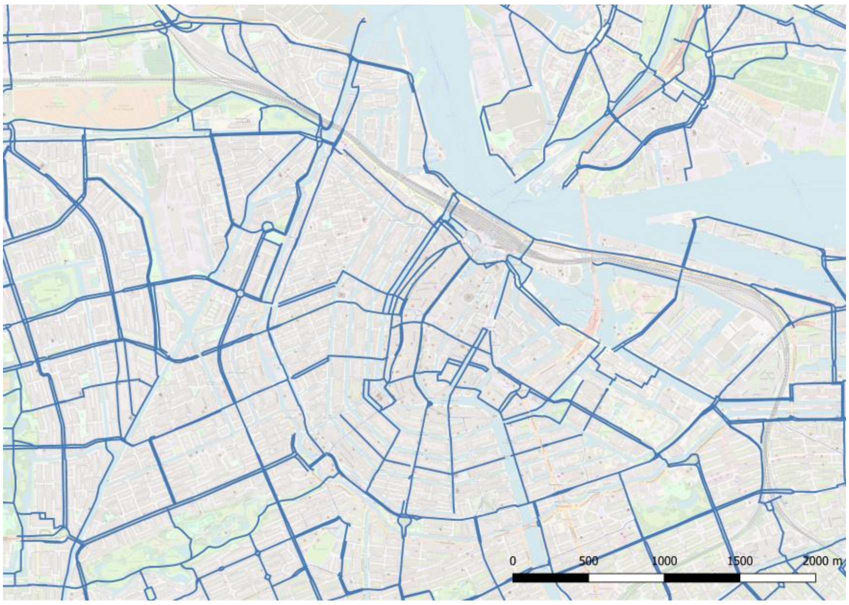


Figure 4.4: The bicycle network in the city of Amsterdam.

4.3 Bikeways

The bikeway is the part of the street allocated for the cyclists. It can either be integrated with the motorized traffic or physically separated from it. (NACTO, 2018). In this chapter different types of bikeways are presented.

4.3.1 Bicycle path

A bicycle path is a travel area reserved for cyclists physically separated from motorized traffic. A bicycle path could either be reserved for cyclists only or utilized by both cyclists and pedestrians. In the latter case separation between the road users are advantageous. Mandatory signs can be put up at special occasions, for instance where a lot of children or elderly occupying the route. (Trafikverket & SKL, 2010).

A bicycle path could either be one-directional or bidirectional. From a safety perspective it is desirable to construct one-directional bicycle path on each side of the road. (CROW, 2016).

According to CROW(2016) bidirectional bicycle path may be used where:

- A logical connection on the bicycle network can be achieved.
- A bidirectional bicycle path can prevent carriage way crossings by cyclists.
- There is a lack of space to implement a one-directional bicycle path on both sides of a street but enough room for a bidirectional on one side.

In the design standards for the city Gothenburg, Amsterdam and Copenhagen implementation of bicycle paths over bicycle lanes are recommended motivated by increased safety. (Göteborgs stad Trafikkontoret, 2018). (København kommunes, 2013). (Gemeente Amsterdam, 2016). This is because bicycle paths are located further away from the carriage way than bicycle lanes. Further cyclists are not exposed to as much emissions while traveling on bicycle paths. (CROW, 2016).

In 4.5, 4.6 and 4.7 a typical streetscape according to the design standards for the different road users for each city is presented. The scale in the figures are the same. (Göteborgs stad Trafikkontoret, 2018). (København kommunes, 2013). (Gemeente Amsterdam, 2016).

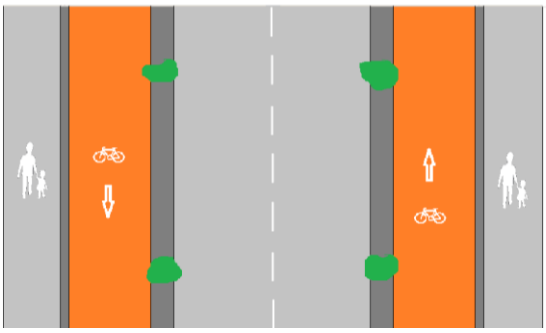


Figure 4.5: A streetscape in Amsterdam.

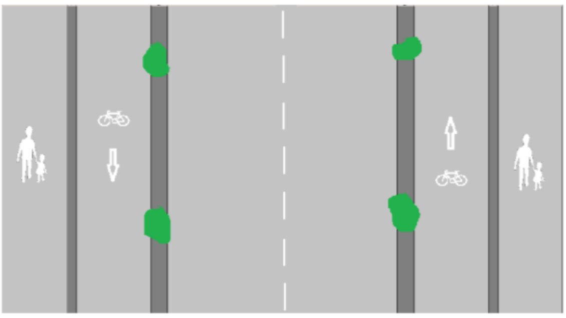


Figure 4.6: A streetscape in Gothenburg.

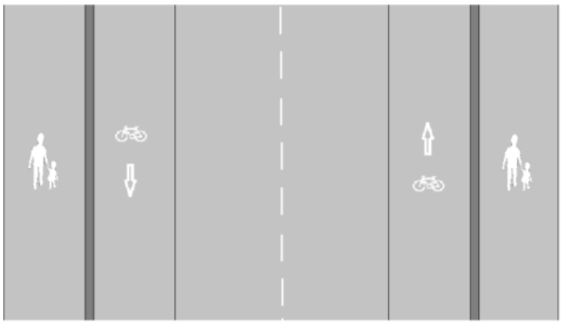


Figure 4.7: A streetscape in Copenhagen.

4.3.2 Bicycle lane

A bicycle lane is an additional lane on a street, next to the motorized vehicle lane, reserved for cyclists. Since they are not separated from the carriage way with more than a line, they are less safe than bicycle paths. In Sweden bicycle lanes can be used if the reference speed is minor to 80 km/h. (Trafikverket & SKL, 2015). They are commonly used where the reference speed is set between 40-50 km/h. The travel direction on a bicycle lane is always one-directional. (Trafikverket & SKL, 2010).

In the city of Gothenburg bicycle lanes should only be implemented when there is a lack of space to implement bicycle paths. (Göteborgs stad Trafikkontoret, 2018).

Bicycle lanes are on some occasions used in Copenhagen since it is cheaper and easier to implement than bicycle paths. It is desirable however that the bicycle lanes are designed so they can be upgraded to bicycle paths in the future. (København kommunes, 2013).

In the Netherland, safety, available space and exposure to emission are factors to consider when deciding to implement bicycle lanes or bicycle paths. Bicycle paths are preferred in terms of safety and exposure to emissions. Bicycle lanes may be used where the available space is limited. (CROW, 2016).

4.3.3 Bicycle street

Where there is a high number of cyclists compared to motorized traffic, bicycle streets can be implemented. A bicycle street is a street where the space is completely shared between the motorists and cyclists. The speed limit is set to the bicycle speed and cyclists have the right of the road over motorized vehicles. (Trafikverket & SKL, 2015).

In the city of Gothenburg bicycle streets may only be implemented when there is a lack of space to implement bicycle paths. Recommended speed limit is 30 km/h. (Göteborgs stad Trafikkontoret, 2018).

In Copenhagen bicycle streets with a reference speed of 40 km/h has been implemented. With low motorized vehicle flow and low reference speed it has worked well for cyclist to travel on bicycle streets. The reference speed however has been questioned by the Danish police department. (København kommunes, 2013).

The Design manual for bicycle traffic from CROW(2016) list advantages with bicycle streets such as they require less space to implement than separated lanes for all road users, reduces the risk of accidents between cyclists and motorists and increasing the accessibility. Recommended speed limit in the Netherlands is 30 km/h.

4.3.4 Bicycle highways

To commute between far located destinations in a short time, bikeways of higher standard have been developed. In Copenhagen the bikeways with the highest standard are called Supercykelsti (translated: Super bicycle path). (København kommunes, 2013). The Netherlands has bicycle highways that utilize the same function. (CROW, 2016). These types of bikeways have been developed to attract citizen outside the cities to commute by bicycle by offering them a fast, safe, comfortable and accessible alternative travel mode. (København kommunes, 2013). In table 4.1 the design standard of the width and the speed for a one-way Danish Supercykelsti, Dutch bicycle highway and the commuter network in Gothenburg is compared.

Table 4.1: Design standards of bicycle highways. (Göteborgs stad Trafikkontoret, 2015), (København kommunes, 2013), (Vejdirektoratet, 2016), (CROW, 2016).

City	Gothenburg	Copenhagen	Amsterdam
Width	2.0-3.0 meter	2.5-3.0 meter, 3 meter on the PLUSnet.	3.0 m
Design speed	30 km/h	35 km/h	30 km/h

4.3.5 Mixed traffic

One option to the ideas above is to let vehicles run in mixed traffic. I.e. the vehicles are sharing the same area. The city of Gothenburg only recommends this solution if it can be ensured a speed limit of 30 km/h. (Göteborgs stad Trafikkontoret, 2018). Amsterdam use it as the standard solution on street with a speed limit of 30 km/h. (City of Amsterdam, 2014). In Copenhagen, the highest speed limit is set to 40 km/h. On one-way mixed traffic streets in Copenhagen and Amsterdam, a bicycle lane may be implemented to allow cyclists to travel in the opposite direction. (København kommunes, 2013).

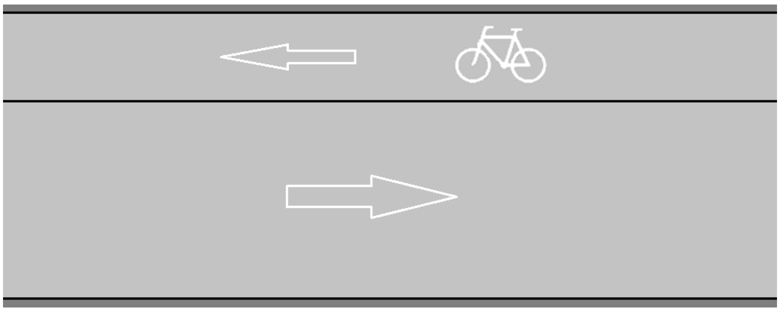


Figure 4.8: One-way street with mixed traffic allowing cyclist to travel in the opposite direction on a bicycle lane.

4.3.6 Special situations

When travelling on a bikeway conflicts with other transportation modes are sometimes inevitable. Design solutions at public transit stops and plazas are presented in this section.

4.3.6.1 Bus stops

On bikeways running along bus routes bottlenecks may arise at bus stops when pedestrians exiting the buses need to cross the bikeway to reach the sidewalk or if a bus need to cross a bicycle lane to reach the bus stop. Trafikverket & SKL(2010) list different design solutions for bus stops, these are presented in figure 4.9.

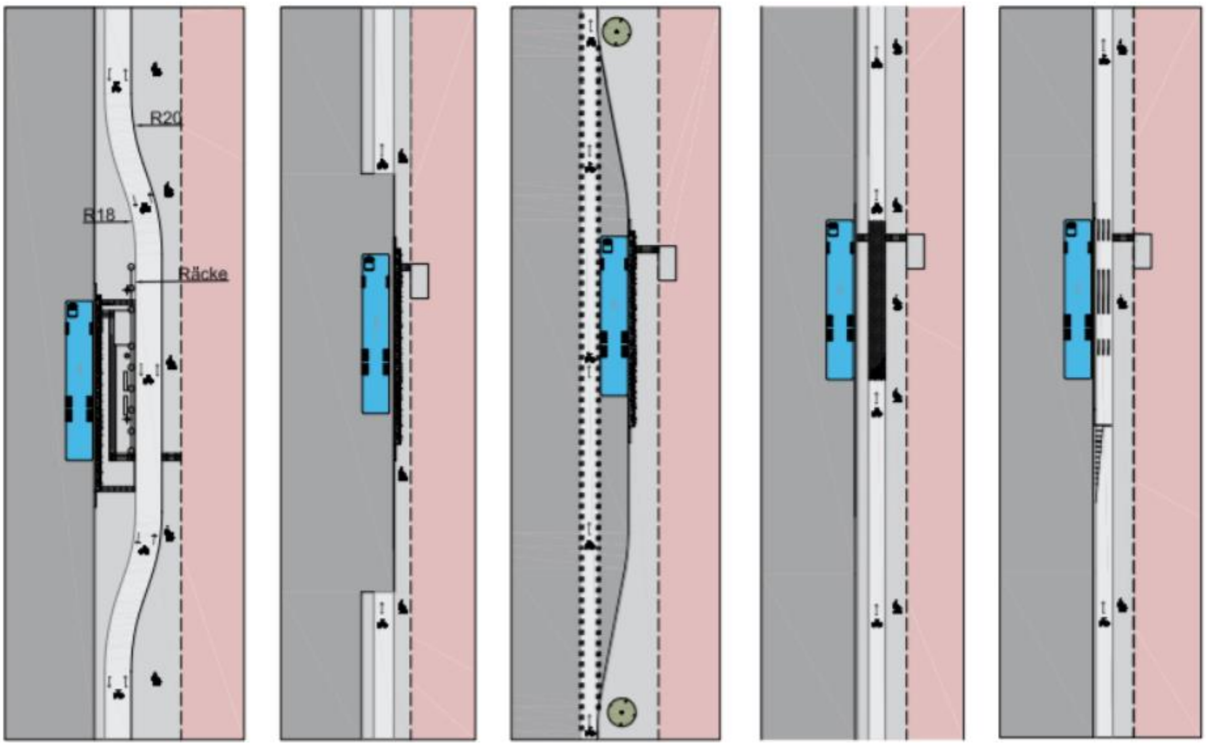


Figure 4.9: Different design solutions at bus stops. from left to right: bicycle path behind the bus stop, mixed traffic along the bus stop, a bus bay within the bicycle lane, bicycle path in front of the waiting area, bicycle path in front of the waiting area with raised safety measures. (Trafikverket & SKL, 2010).

At a bus stop, the Swedish recommendation is to locate the bicycle path behind the bus stop. In case this is not possible, actions need to be taken to achieve a good interface between the bus travelers and cyclists. Solutions such as tapering the bicycle path before a bus stop or use different material on the bikeway can be implemented. (Trafikverket & SKL, 2015).

In Copenhagen the recommendation is to create a platform for exiting bus travelers. However, bus stops where travelers exiting the bus straight to the bicycle path do exist. (København kommunes, 2013). Travelers entering or exiting the bus should give way for the cyclist. If there is no bus present the cyclist should give way. (Celis Consult, 2014).

In the Netherlands a bus can either be stopping on the road, or at a bus bay. In case of bicycle lane, the bus bay should be wide enough to allow a bus to fit in it without blocking the bicycle lane. If separated bicycle paths are used the recommendation is to let them run around the bus stops. A bicycle path running behind a bus stop can be elevated to warn the cyclist and pedestrians about eventual conflicts. (CROW, 2016).

4.3.6.2 Tramway

In the Dutch design standards, the possibility to combine the bikeway and the tramway are presented. The idea could be used to maximize the use of available space in the streetscape but is not recommended due to reduced traffic safety for the cyclists. (CROW, 2016).

4.3.6.3 Shared space

Shard space are utilized in areas which all road users may utilize. For instance, shared space can be implemented at plazas. Motorized and nonmotorized traffic are mixed and the priority is spontaneously determined rather than establish by traffic rules and regulations. Shared space should not be implemented in areas with high traffic flow, larger than 3000-4000 vehicles/day. (Vejdirektoratet, 2014). The motorized traffic can be directed with polls to marginalize their area of movement on a plaza. The maximum speed is set to 15-30 km/h. It is unclear how a shared space affect cyclists security. (Trafikverket & SKL, 2010).

4.4 Intersections

Many of the severe accidents involving cyclists occur at intersections with motorized vehicles. The most ideal option would be to grade separate the different road users but due to economy, this is usually not possible. The function of an intersection is to improve the accessibility of the bicycle network. Having to densely distributed intersections however, decreases the traffic safety and increases the travel time in a network. (CROW, 2016). An intersection with motorized vehicles, cyclist and pedestrians can be designed in various of ways. They can be either signalized or unsignalized. (Trafikverket & SKL, 2010). In this chapter, different design solutions for intersections are presented. The drawings are done to present the configuration of the intersection and are not in scale.

4.4.1 Unsignalized crossings

In Sweden there are two types of unsignalized bicycle crossings where interaction with motorized traffic occur in the same plane. Bicycle passages and bicycle overpasses. (Transportstyrelsen, 2015). The design standards and obligations from the different road users at the different type of crossings are presented below.

On bicycle passages cyclists must give way for the motorized vehicles. However, the motorized vehicles should pay attention to the traffic on a passage and drive carefully to show consideration to them. It is common to design a passage so its configuration reduces the motorized vehicle speed. This could be done by elevating the passage. If this is not possible a speed bump can be constructed in front of the passage. Another option is to decrease the width of the motorized vehicle lane at the crossing. There is also signalized bicycle passages to manage the safety problem. A bicycle passage can be used at 3-way intersections, 4-way intersections, roundabouts or crossings over carriage ways. (Transportstyrelsen, 2015). The layout of a bicycle passage is presented in figure 4.11a.

On a bicycle overpass the right of the road rules are different. On a bicycle overpass the motorized vehicles must give way to the cyclists. (Transportstyrelsen, 2015). Bicycle overpasses should be apparent highlighted, so the road users easily can distinguish them from bicycle passages. The traffic sign for a bicycle overpass is presented in figure 4.10. The layout of a bicycle overpass is presented in figure 4.11b.

Figure 4.10: The Swedish bicycle overpass sign. (Transportstyrelsen, 2018).

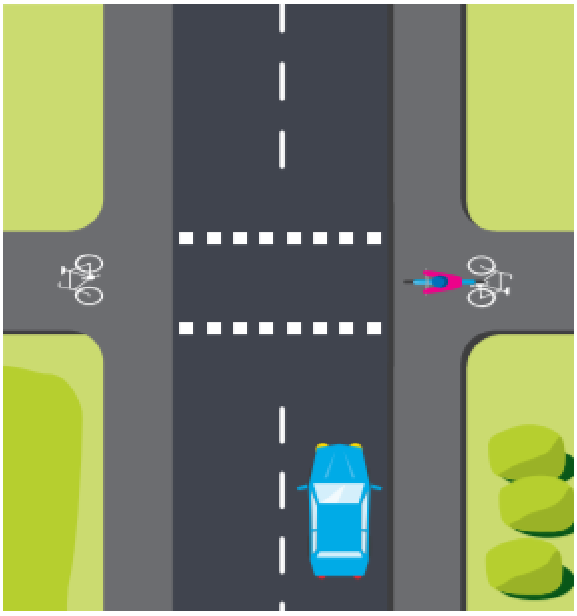


Figure 4.11a: A Swedish bicycle passage. (Transportstyrelsen, 2015).

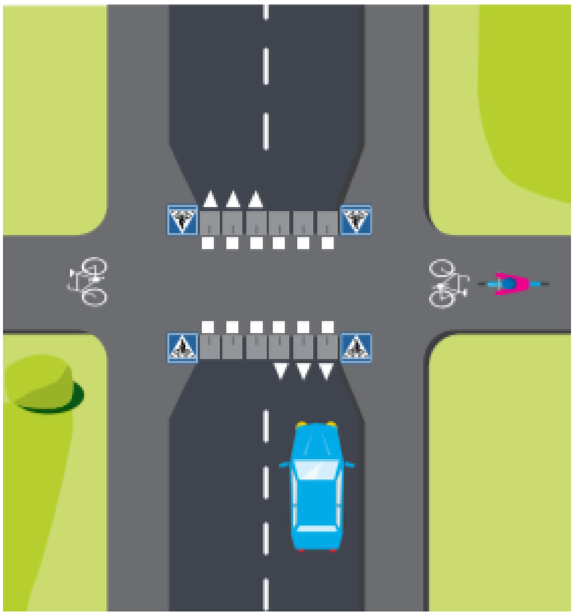


Figure 4.11b: A Swedish bicycle overpass. (Transportstyrelsen, 2015).

In Denmark and the Netherlands, no distinguish is done between bicycle passages and bicycle overpasses. Instead, there are traffic rules indicating who should give way. This is informed by traffic signage and markings as presented in figure 4.12. (Cycling embassy of Denmark, 2012). (CROW, 2016).

Figure 4.12: At the bicycle crossing to the left the cyclists are obligated to give way to motorized traffic. At the bicycle crossing to the right the cars are obligated to give way to the cyclists.

At an intersection where connecting traffic flow is low and the bicycle flow high along the distributor road, a pervading bicycle path can be implemented. On a pervading bicycle path, the motorized vehicles on the connecting street must give way to the cyclists on the bicycle path. (Göteborgs stad Trafikkontoret, 2018). (Københavns Kommune, 2013). (CROW, 2016). The city of Gothenburg recommend that a pervading bicycle path is constructed by letting the curbstones along the carriage road proceed through the intersection across the connecting street, i.e. the bicycle path should continue through the intersection. No traffic signs must be put up at the intersection since the bicycle path is considered as a part of the distributor road. (Göteborgs stad Trafikkontoret, 2018).

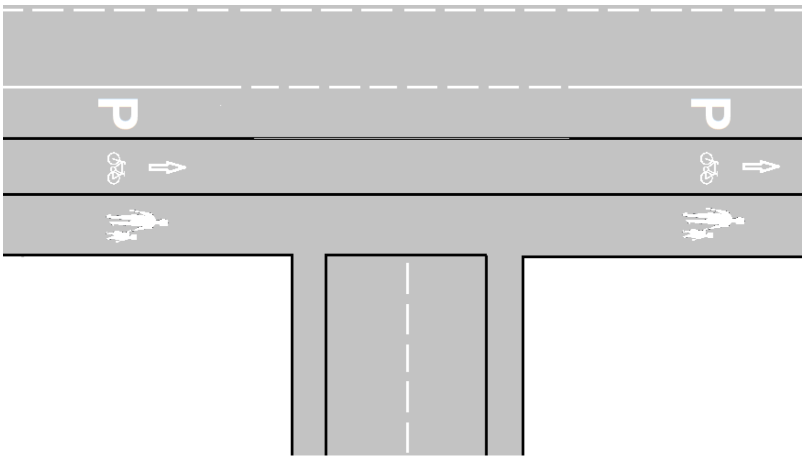


Figure 4.13: The principle configuration of a pervading bicycle path.

4.4.2 Signalized intersection

In this chapter, design solutions for 4-way signalized intersections will be presented according to the design standards of the three different cities. Further, additional design solutions used at intersections are presented.

In figure 4.14, 4.15 and 4.16 the recommended configuration of a 4-way signalized intersection in the different cities with one-way bicycle paths are presented. The reference speed is 50 km/h. (Gemeente Amsterdam, 2016). (Trafikverket & SKL, 2015). (København kommunes, 2013). The connecting streets to the left and the right in the Copenhagen intersection has been designed with different design solutions than the standard. These solutions are however utilized around the city. (København kommunes, 2013). The solutions are presented in detail later in the chapter.

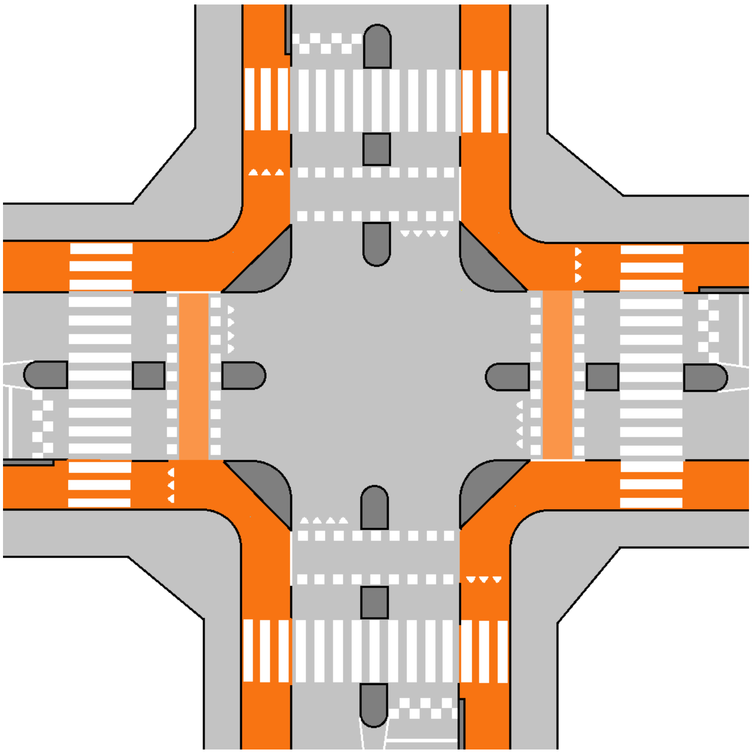


Figure 4.14: The recommended layout of a 4-way intersection in Amsterdam with separated bicycle paths.

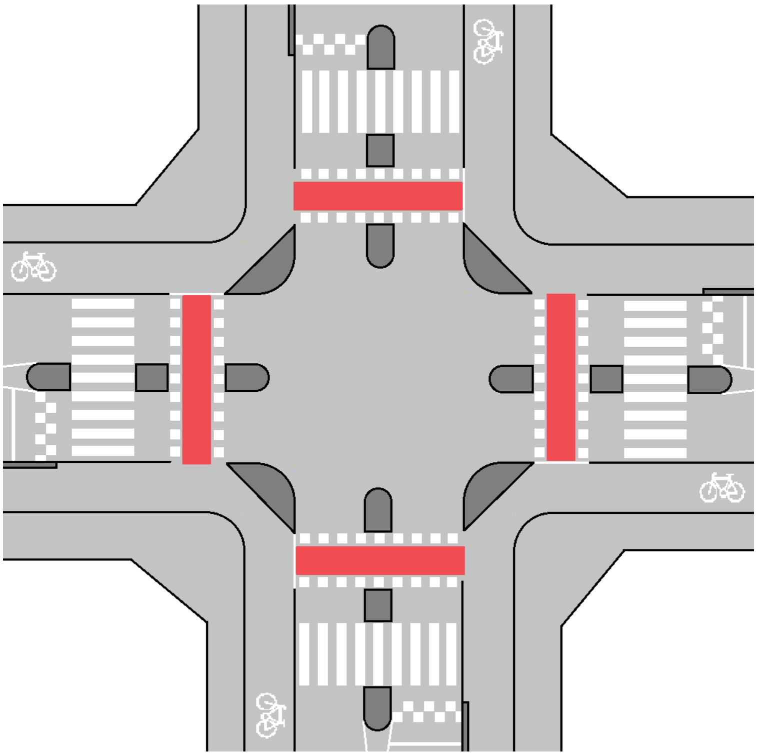


Figure 4.15: The recommended layout of a 4-way intersection in Gothenburg with separated bicycle paths.

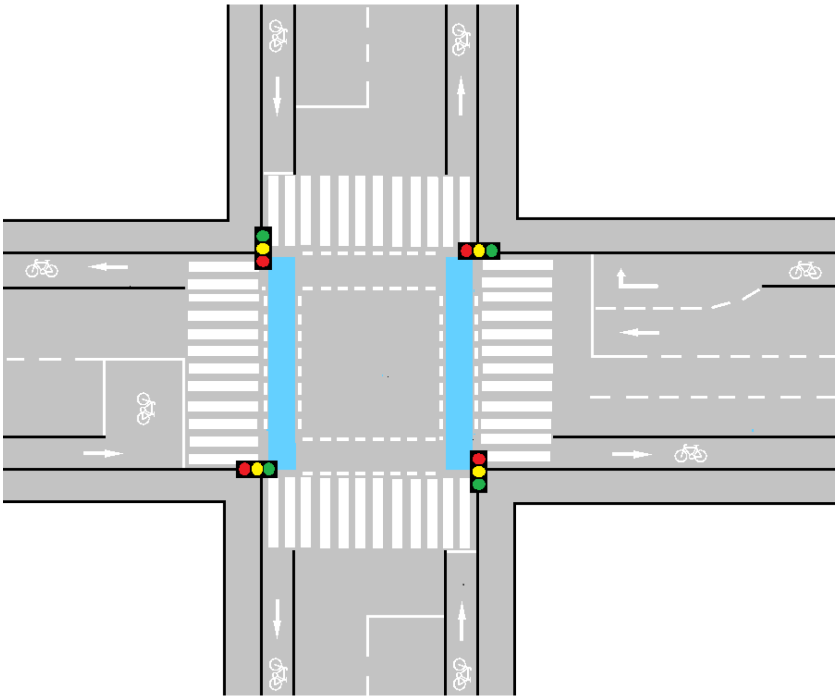


Figure 4.16: The recommended layout of a 4-way intersection in Copenhagen with separated bicycle paths. The connecting street at the left has been equipped with a bicycle box. The connecting street on the right has been designed with a shortened bicycle path.

When utilizing signalized intersections, the prioritization of different road users must be regarded. In a signalized intersection it is possible to prioritize different road user with consideration of passability, accessibility and safety. This is done by controlling the green time and the order of the traffic light phases for the different road users. The green time can be extended for a user or if there is an incoming prioritized vehicle, the system can break the phase cycle and give the prioritized vehicle green light. (Vägverket & SK, 2004). Recently, interest in prioritization of pedestrians and cyclists has got more attention. Modern traffic signal systems have made it possible to make different intersections interact with each other. With this technique green waves can be created. A green wave allows a transportation mode to meet green light through several intersections along a stretch when traveling with a constant speed. By implementing green waves, the passability of a transportation mode can be prioritized over others. (Copenhagenize, 2014). On Norrebrogade in Copenhagen implementation of green waves for cyclist has been tested on a two-kilometer stretch. The travel speed is set to 20 km/h. The effect on the bicycle travel time was positive but on the expense of public transit mobility. (Hoegh, 2007).

If the bicycle flow is high at a signalized intersection, a common improvement is to implement a bicycle box between the motorized vehicle stop line and the pedestrian walk. A bicycle box improves the passability as a group of cyclists can leave the stop line at the same time, instead of in a line, which allow cars to turn right earlier at green light. Further, the implementation of a bicycle box increases the safety and security at an intersection. The design concept of a bicycle box is shown in figure 4.17. (Københavns Kommune, 2013).

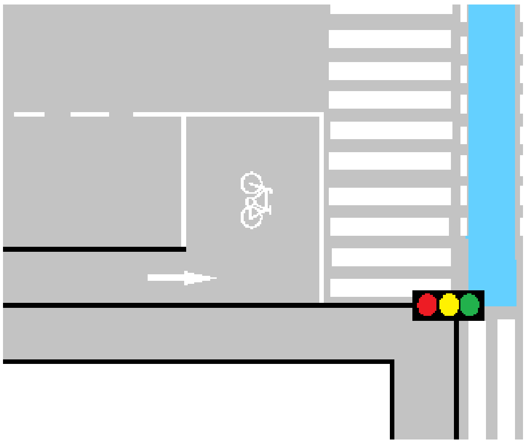


Figure 4.17: Configuration of a bicycle box at a signalized intersection.

In the design standard for the city of Gothenburg recommendations to implement bicycle boxes on bikeways with a high bicycle flow are suggested. Further the city wants to implement green waves for cyclist with a traveling speed of 20 km/h. (Göteborgs stad Trafikkontoret, 2015).

According to the design standard for the city of Copenhagen the stop line for the motorized vehicles should be located 5 meters behind the pedestrian crossing to create a bicycle waiting area at the intersections. Implementation of bicycle boxes are common. If the cyclists utilize a separate traffic signal it is advised to turn it green before the right turning traffic to reduce the risk of conflicts between cyclist and motorists. The bicycle path should have its normal width until the stop line. (Københavns Kommune, 2013). To improve the passability in an intersection a shortened bicycle path can be designed. (Københavns Kommune, 2013).Right turning traffic and cyclists are then led into mixed traffic 15 to 25 meters before an intersection. Cyclists going straight can then locate themselves on the left side of right turning traffic. (Celis consult, 2014). The solution is presented in figure 4.18.

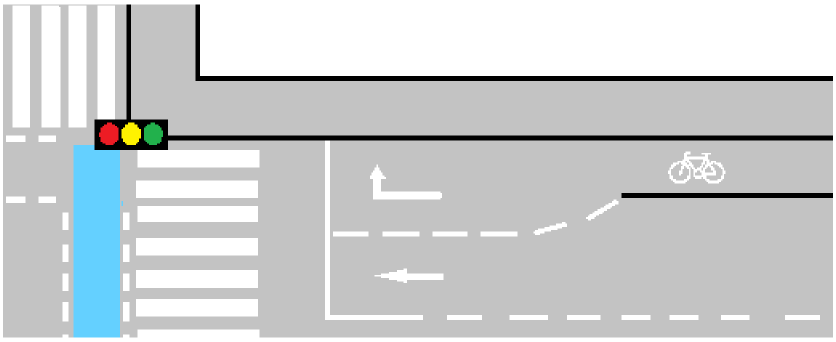


Figure 4.18: Shortened bicycle path combined with right turning traffic.

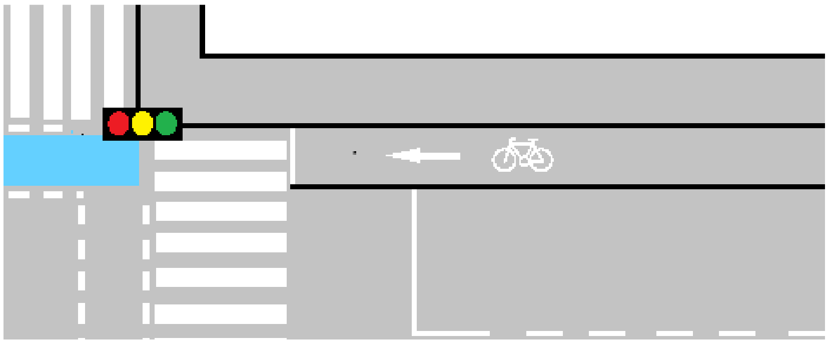


Figure 4.19: Standard solution at signalized intersections in Copenhagen.

The Dutch design standards are suggesting the following solutions at intersections. For right turning cyclists, separate “right turn through red” paths or separate “free to turn right” lanes can be implemented. The “right turn through red” solution is presented in figure 4.20. For bicycle traffic traveling straight a separate bikeway are desired to run parallel with the motorized vehicle lanes. The stop line for the cyclists are recommended 2-3 meters ahead of the stop line for the motorized vehicles to prevent accidents between cyclists and motorists. The same idea as the one presented in figure 4.19. Left turning cyclist solutions depends on the bicycle flow. A separated bicycle lane or a stacking space for left turning cyclists can be implemented. The configuration of a stacking space for left turning cyclists are illustrated in figure 4.21. To prioritize left turning cyclist it is suggested to make two green phases follow each other since left turns require two operations from a cyclist. If the left turning bicycle flow is considerably high a phase with green light for the bicycle traffic in all direction can be considered. The traffic sign for an intersection with green light for bicycles in all direction is presented in figure 4.22. (CROW, 2016).

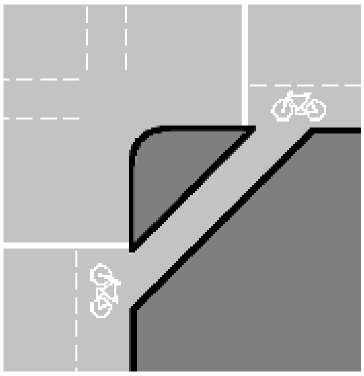


Figure 4.20: Right turn through red.

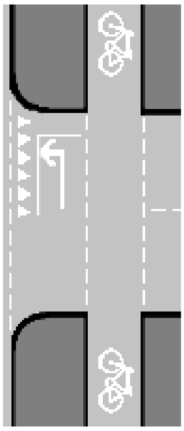


Figure 4.21: Stacking space for left turning traffic.

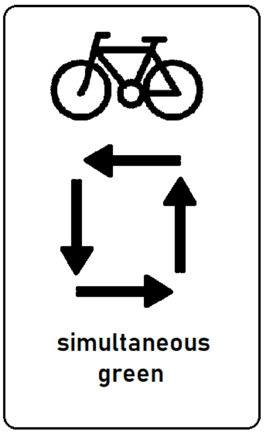


Figure 4.22: Sign indicating intersection with a green light for cyclist in all direction phase.

4.4.3 Roundabouts

When the traffic flow is high, an alternative solution in intersections is to construct roundabouts. According to CROW(2016) a roundabout decreases the conflict points between the road users significantly and thereby improve the traffic safety. However, the cycling embassy of Denmark(2012) states that the safety for motorized vehicle increase but this do not apply to cyclists. Figure 4.23 comparing the conflict points at an intersection and a roundabout with one lane traffic. Grey dots indicate conflict points between motorists and pedestrian or cyclist. *(Glæver & Tvelt, 2006).*

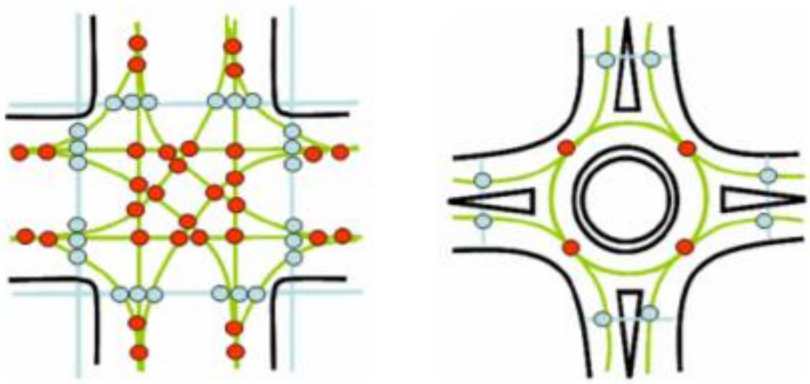


Figure 4.23: Conflict points comparison between an intersection and a roundabout. (Glæver & Tvelt, 2006).

The layout of a roundabout is depending on what type of bikeway that is connecting to it and the motorized vehicle flow. If the motorized vehicle flow is low the cyclist may utilize the same area as the motorists. If the motorized vehicle flow is high, bicycle paths are recommended at roundabouts since bicycle lanes reduce the traffic safety. Crossings can be located a distance into a connecting street to create an area for cars exiting a roundabout to stop while giving way for cyclists. (CROW, 2016). The typical configuration of a roundabout paths in Amsterdam with separated bicycle are presented in figure 4.24. (Gemeente Amsterdam, 2016). The bicycle paths are one-directional since bidirectional crossings at roundabouts reduce traffic safety. (CROW, 2016).

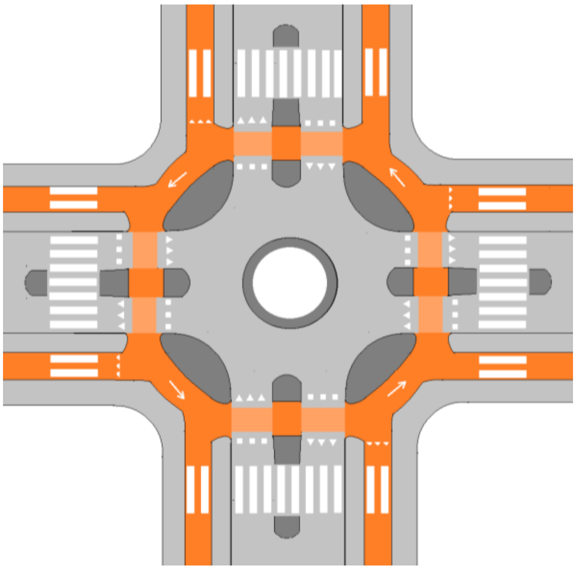


Figure 4.24: The typical configuration of a Dutch roundabout. (Gemeente Amsterdam, 2016).

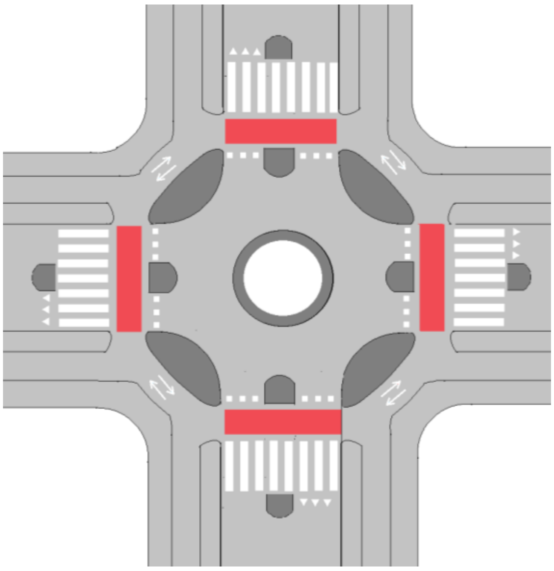


Figure 4.25: The typical configuration of a Swedish roundabout. (Trafikverket & SKL, 2015).

The city of Gothenburg recommends a design speed of 30 km/h for roundabouts when cyclist and motorized utilize the same space. (Göteborgs stad Trafikkontoret, 2018). The Swedish design standards recommend bidirectional bicycle paths to be implemented around the roundabout. *(*Vägverket & SK, *2004).* The configuration of a roundabout with separated bicycle paths in Gothenburg is presented in figure 4.25. (Trafikverket & SKL. 2015).

In Copenhagen roundabouts is used very sparsely. The city of Copenhagen refers to the document "*Idékatalog for cykeltrafik 2012"* from the Cycling embassy of Denmark as their roundabout design standard (København kommunes, 2013). In "*Idékatalog for cykeltrafik 2012"* it is written that a roundabout requires bicycle lanes which make the design solution space demanding and therefore not optimal in urban environment. Further, it is stated that implementation of roundabouts increases the number of traffic accidents for cyclist. Mini roundabouts with a capacity of 15.000 vehicles/day and speed limit of 30-50 km/h are however used at some locations. The configuration of such roundabout is presented in 4.26. The cyclists are led into the roundabout with bicycle lanes and then utilizing a colored one-directional bicycle lane through the roundabout. (Cycling embassy of Denmark, 2012).

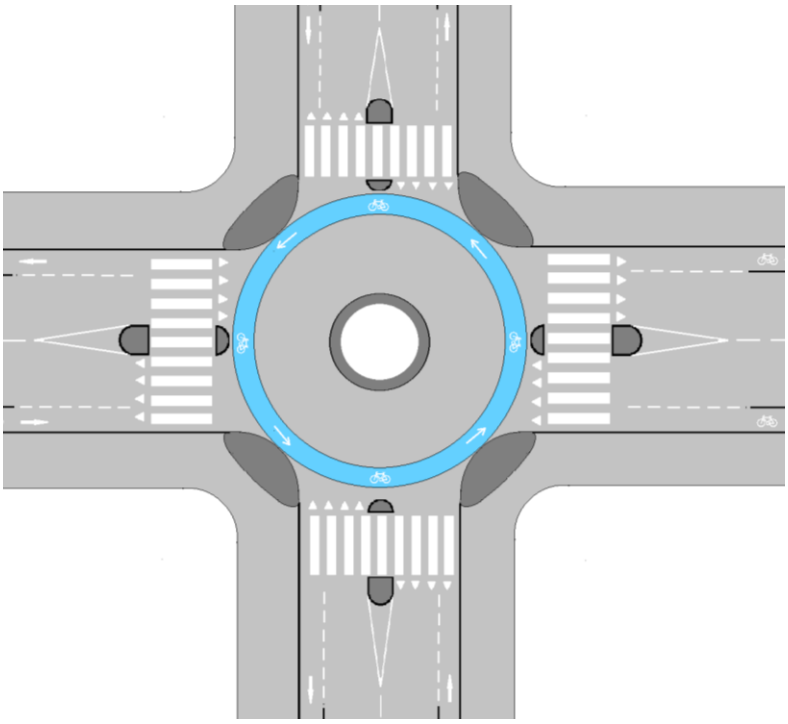


Figure 4.26: Typical configuration of a Danish urban roundabout. The drawings are done to present the configuration of the intersection and is not in scale.

4.5 Signs

In this chapter the most important signs concerning bicycle traffic are presented. In figure 4.27 the sign indicating a bicycle path is presented. It can be shared with the pedestrian walk; either separated or integrated.

Figure 4.27: Mandatory signs in Denmark specifying the traffic type on the path ahead. (BedreBilist.dk, 2018).

On a one-way street in the Netherlands cyclist may not enter as long as no additional sign allowing it is added. In figure 4.28 the additional sign in the Netherlands indicating that the prohibition sign not applies on cyclists are presented. Uitgezonderd is dutch for except. In Gothenburg and Copenhagen the sign for prohibition of motorized traffic presented in figure 2.29 are used instead.

Figure 4.28: One-way street with additional sign allowing cyclist to travel in opposite direction. (Informatiebord.nl, 2018).

Figure 4.29: Sign prohibiting motorized traffic. (Transportstyrelsen, 2018).

In 4.30 the Swedish sign for a bicycle overpass is presented. *(Transportstyrelsen, 2018).* Since Denmark and Netherlands not distinguishing between bicycle passages and bicycle overpasses they do not have a corresponding sign. Instead the road users use the signs for right of the road and give way. Some example of them are presented in 4.31. (CROW, 2016).

Figure 4.30: Swedish sign indicating a bicycle overpass. (Transportstyrelsen, 2018).

a.  b. 

Figure 4.31.a.b: Standard traffic signs used to indicate the right of the road at intersections in the Netherlands and Denmark. (BedreBilist.dk, 2018).

4.6 Markings

In this chapter different types of markings used in the bicycle infrastructure are presented.

4.6.1 Pavement markings

The give way triangle in figure 4.31a are often supplemented with "shark teeth"-markings on the ground as in figure 4.32a. This indicate the line at which vehicles should stop and give way before crossing. The markings in 4.32b are used to indicate a bicycle passage or a bicycle overpass. The symbol indicating a bikeway can be marked on the ground as in 4.33. (Transportstyrelsen, 2018). (CROW, 2016).

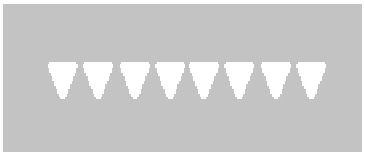


Figure 4.32a: Give way triangles marked on the ground making the traffic aware on what rules to obey.

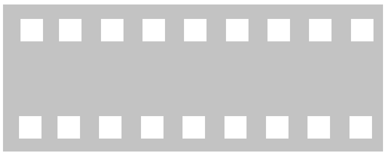


Figure 4.32b: Standard swedish bicyle passage and bicycle overpass markings in Sweden.

Figure 4.33: Bikeway marking on the ground.

4.6.2 Traffic separation

The traffic safety for cyclists increases depending on what level the bikeway is separated from the motorized traffic. Further, well planned separation changes people attitude to use bicycle as a transportation mode. (Bagloee, Sarvi, & Wallace, 2015).

In Gothenburg the most common way to separate cyclist from pedestrians is to create a verge of irregular material or as a white line between the mentioned. If the flow of pedestrian is high, irregular material could be applied to the whole pedestrian area or a wider separation(>0.5m) can be installed. Between cyclists and motorized traffic, a verge separation(>0.5 m) is recommended(see figure 4.6). The verge can be created as a line of trees or curbstones. (Göteborgs stad, 2018).

In Copenhagen and Amsterdam similar techniques are used to separate the road users. In Copenhagen however, no verges are created between the motorists and cyclists. Further, in Amsterdam the bicycle paths and lanes are colored with red asphalt to inform the traffic where the bikeway is. (CROW, 2016). Copenhagen use the idea with color to but not on entire bikeways. The bicycle crossings and bicycle boxes are often blue. However, no more than two crossings in an intersection are colored since this reduce the traffic safety. (Cycling embassy of Denmark, 2012). The car parking along a street also work as a safety barrier for the cyclists. (København kommunes, 2013).

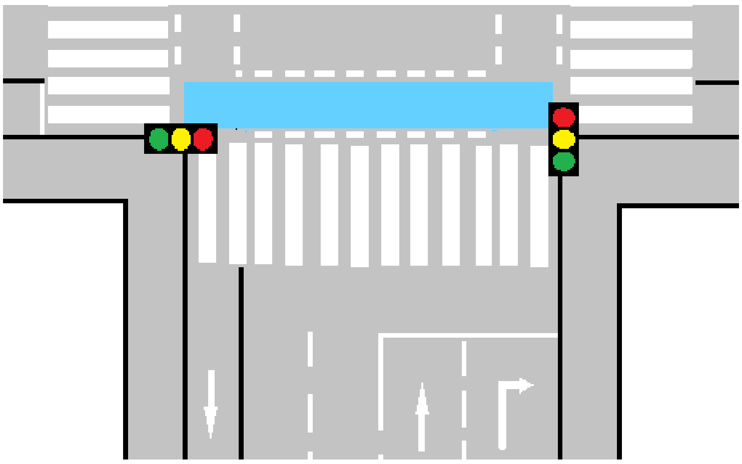


Figure 4.34: A colored Danish bicycle crossing.

4.7 Infrastructure facilities

In this chapter the most important facilities for an attractive bicycle infrastructure are presented.

4.7.1 Lights

In all the design standards the importance of lighting along bikeways are mentioned. Lighting is used to ensure comfort for the travelers, increase bicycle flow capacity, make travelers aware of unsafe situations and emphasize the vehicle road. (CROW, 2016). On a correctly lit path the traveler should easily perceive changes in the environment and easily navigate in the road network. The lighting should make the traveler aware of potential obstacles ahead. The present of good lighting increases the security for individuals utilizing the infrastructure. (Trafikverket & SKL, 2010). The requirement of lighting on a bikeway for the three different cities are presented in table 4.2.

Table 4.2: Bicycle infrastructure lighting requirement in Gothenburg, Copenhagen and Amsterdam.

City	Requirement
Gothenburg	Bicycle paths should always be well lit. Cautions should be taken so no trees or bushes cover the light. At tunnels the sight must be good. Tunnels longer than 20 meters are recommended to be lit all day around to increase the security for the traveler. (Göteborgs stad Trafikkontoret, 2018).
Copenhagen	As a rule, the required lightning along a road should be equal for all road users. The users should be convinced that the municipality do care about their safety. (København kommunes, 2013).
Amsterdam	Lighting is always recommended on the main cycle network. On the basic network the street lights are often enough. (CROW, 2016).

4.7.2 Bicycle storage

A vital part in the bike infrastructure is the possibility to store the bicycles. Surveys indicate that accessibility of bicycle parking affect the number of commuters. (Beuheler, 2012). The requirements on the parking facility depends on for how long cyclists park their bicycles. For shorter errands bicycle racks with the possibility to lock a bicycle to are enough. For a full day storage, it is recommended to raise a ceiling over the bicycle racks. For long time storage, facilities which only the bicycle owner have access to should be considered. Constructing large bicycle garage underground have become more common in cities. (Trafikverket & SKL, 2010).

The different cities have established standards for how many bicycle parking that are required. The standards for each city are presented below. The bicycle parking design standards for Gothenburg are the presented in table 4.3. In Gothenburg every resident must have access to store one bicycle indoors. (Göteborgs stad Trafikkontoret, 2017).

Table 4.3: Required bicycle parking in Gothenburg.

Type of building	**Bicycle parking per 1000 m^2**	
	Living/Working	Visitors
Residence	25	10
Offices (central part of Gothenburg)	13	2

The bicycle parking design standards for Copenhagen are the presented in table 4.4. (Københavns Kommune, 2018).

Table 4.4: Required bicycle parking in Copenhagen.

Location	**Demand of parking**
Housings	4 per 100 m^2
Youth housings	4 per 100 m^2
Retirement home	1.5 per m^2
Workplaces	4 per 100 m^2
Educational institutes	0.5 per student/employee
Shops	4 per 100 m^2

The city of Amsterdam does not have any requirements of bicycle parking according to specific properties. The city however expanding their bicycle parking network since it is running on its full capacity. Between 2012 and 2020, parking facilities for additional 50.000 bicycles are planned in the city. (City of Amsterdam, 2014).

4.8 Bicycle infrastructure design standards

In this section measures on the bicycle infrastructure design standards will be presented.

4.8.1 Width

The width of the bikeway affects the safety and attractiveness to travel by bicycle. (CROW, 2016). (Fu & Farber, 2017). The width requirements are depending on what type of bikeway being constructed. The width requirements for three different kind of bikeways in Gothenburg, Copenhagen and Amsterdam are compared below. The type of bikeways compared are:

- Bidirectional bicycle path, normal condition, separated from the traffic with a wider strip. Separated from pedestrians.
- One-way bicycle path separated from pedestrians.
- One-way bicycle lanes on the right side of the motorized vehicle lanes.
-

Table 4.5 comparing the width for bidirectional bicycle paths in the different cities: (Göteborgs stad, 2018), (København kommunes, 2013), (Gemeente Amsterdam, 2016).

City	Gothenburg	Copenhagen	Amsterdam
Width	2.4-4.8 m 2 m minimum	3.5 m 3.0 m minimum	4.0 m minimum

Table 4.6 comparing the width for one-way bicycle paths in the different cities: (Göteborgs stad, 2018), (København kommunes, 2013), (Gemeente Amsterdam, 2016).

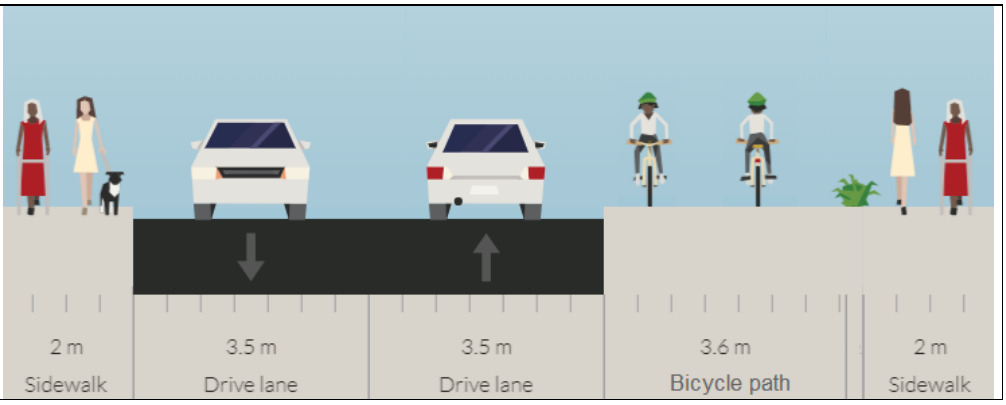
City	Gothenburg	Copenhagen	Amsterdam
Width	1.6-3.0 m 1.2 m minimum	2.5 m 2.2 m minimum	2.5 m minimum

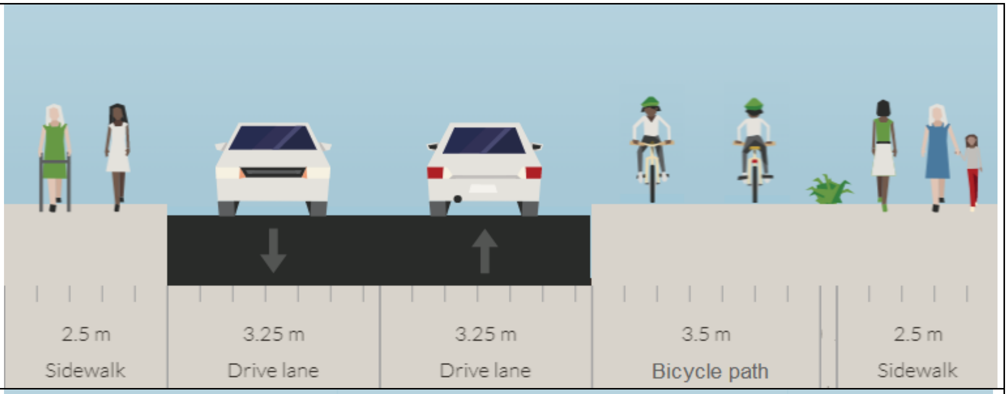
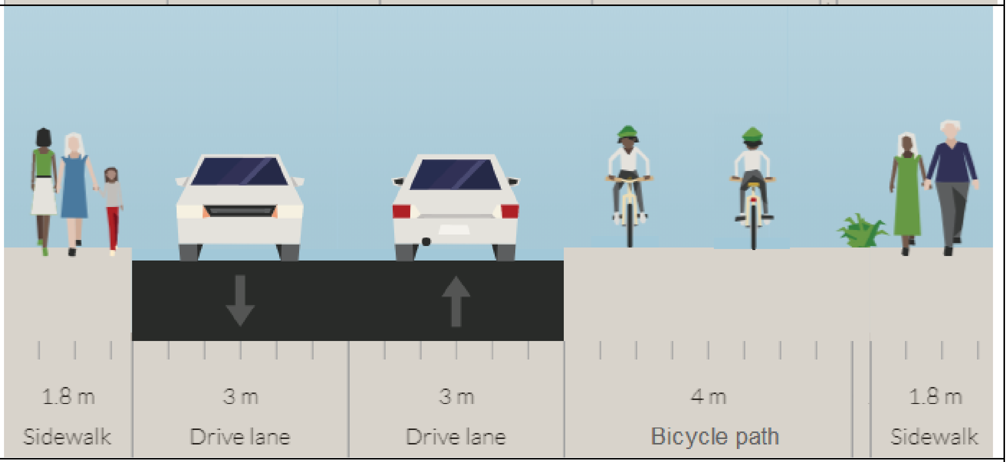
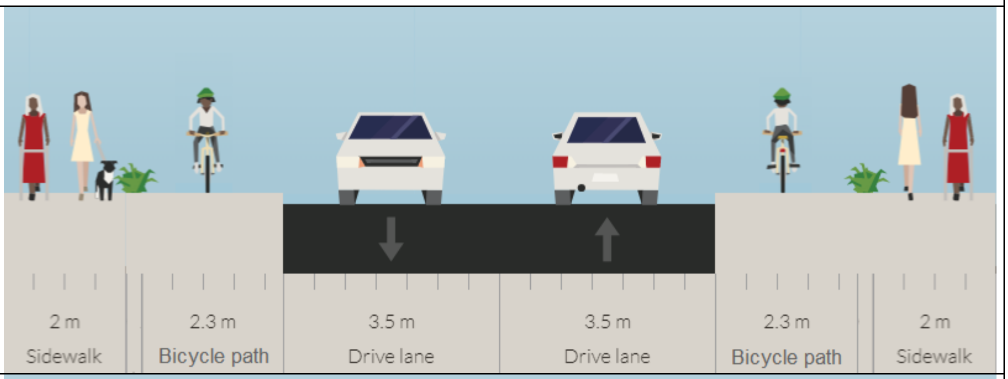
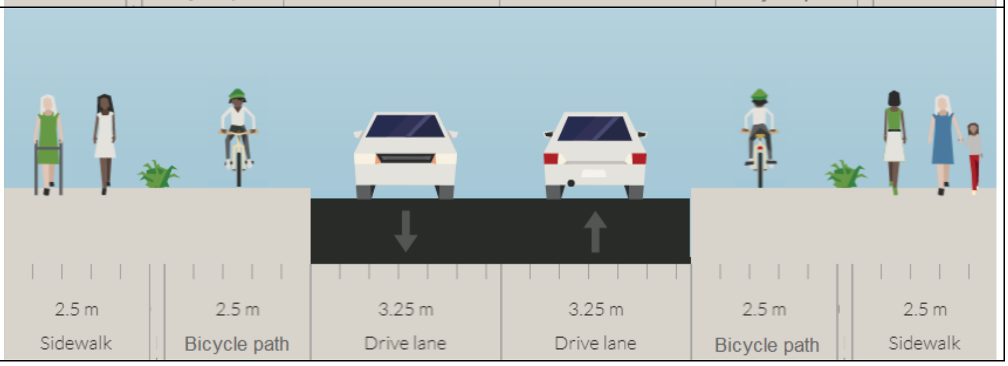
Table 4.7 comparing the width for bicycle lanes in the different cities: (Göteborgs stad, 2018), (København kommunes, 2013), (Gemeente Amsterdam, 2016).

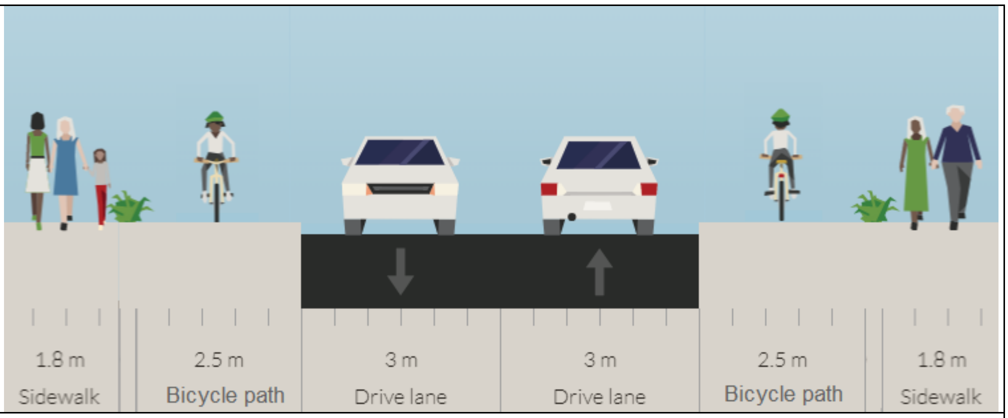
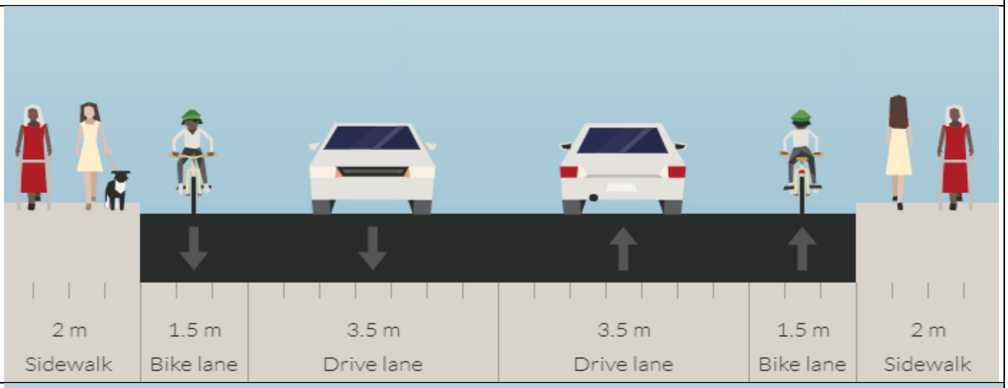
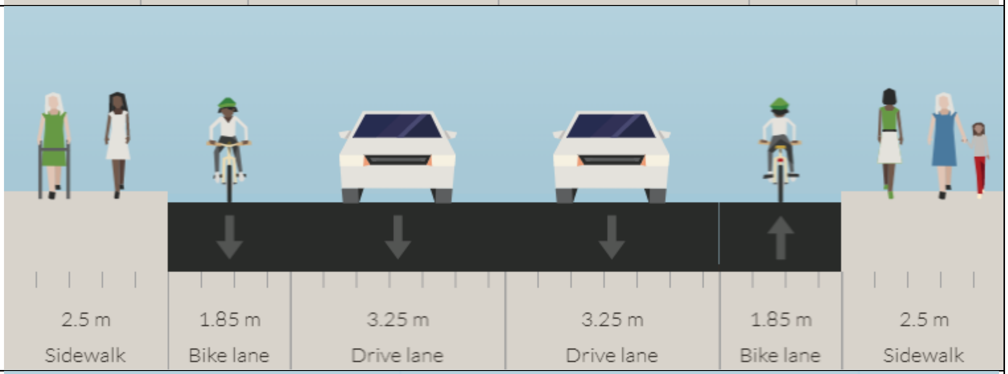
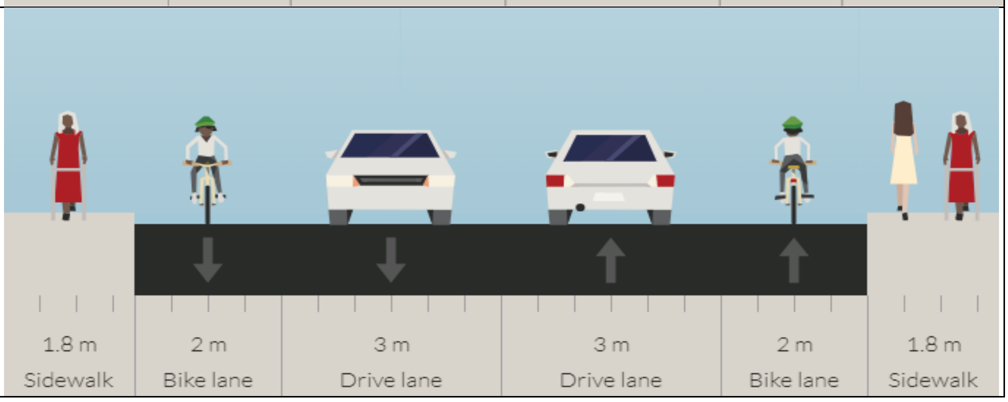
City	Gothenburg	Copenhagen	Amsterdam
Width	1.2-1.75 m	1.5-2.2 m	2.0 m minimum

Section views of a typical streetscape in the three cities are presented in table 4.8. The width of the motorized vehicle route and the sidewalk is set as the standard width in the different cities. When the bikeway width is given as an interval the average width is chosen. (Göteborgs stad, 2018), (København kommunes, 2013), (Gemeente Amsterdam, 2016).

Table 4.8: Section views of a typical streetscape in the three cities.

Gothenburg – Bidirectional bicycle path on one side of the street.	

Copenhagen – Bidirectional bicycle path on one side of the street.	
Amsterdam – Bidirectional bicycle path on one side of the street.	
Gothenburg – One-way bicycle paths on both sides of the street.	
Copenhagen – One-way bicycle paths on both sides of the street.	

Amsterdam – One-way bicycle paths on both sides of the street.	
Gothenburg – One-way bicycle lanes on both sides of the street.	
Copenhagen – One-way bicycle lanes on both sides of the street.	
Amsterdam – One-way bicycle lanes on both sides of the street.	

4.8.2 Inclination

The inclination of a bikeway affects the comfort for cyclists while travelling on it. According to the Gothenburg design standard the inclination is given as a function of the difference in elevation. In Denmark the inclination is given as a function of the length of the slope. In table 4.9 and 4.10 the desired inclination in the two cities is presented.

Table 4.9: Gothenburg inclination requirements. (Göteborgs stad Trafikkontoret, 2018).

Difference in elevation in meters.	Inclination in %, high standard route.	Inclination in %, less good route.	Inclination in %, low standard.
<0.5	<4	4-8	>8
0.5-1.0	<2.5	2.5-5	>5
1.0-2.0	<2.5	2.5-5	>5
>2.0	<2.5	2.5-4	>4

Table 4.10: Danish inclination requirements. (Celis Consult, 2014).

Length of slope in meters	Inclination in %
50	5
100	4.5
200	4
300	3.5
500	3

In the Netherlands the inclination properties are given with a severity of the slope factor instead. Severity of the slope is a measure describing how a cyclist will experience traveling on the slope. The severity of the slope is given by the formula: (CROW, 2016).

$$S = \frac{H^2}{L}$$

where

S = Severity of the slope.

H = Difference in elevation between start and end.

L = Length of the slope.

I.e. by knowing the height difference and a targeted severity factor the length and gradient of the inclination can be calculated. (CROW, 2016).

The gradient is calculated as:

$$\frac{H}{L}$$

4.8.3 Speed

The design speed for a bikeway is an important parameter when creating a bicycle network. A higher design speed allows the cyclists to reach a specific destination in a shorter time. I.e. a higher design speed makes the bicycle competitive towards other modes of transportation. (CROW, 2016). The design speed during normal conditions for the different cities are presented in table 4.11.

Table 4.11: The design speed in the different cities.

City	Gothenburg	Copenhagen	Amsterdam
Design speed	20 km/h, overall network. (Göteborgs stad Trafikkontoret, 2018).	30 km/h. (København kommunes, 2013).	30 km/h (CROW, 2016).

4.8.4 Pavement surface

The surface material on the bikeway affecting the comfort, safety and security for cyclists traveling on it. Evenness, good skid resistance, good drainage and low rolling resistance are characteristic for a good surface. (CROW, 2016). Another color can be used on the bicycle paths and lanes to highlight them and make it easier for the traffic to distinguish between the different vehicle lanes. (Trafikverket & SKL, 2010). In table 4.12 the recommendations for surface materials in the different cities are presented.

Table 4.12: Recommendation of surface materials in the different cities.

City	Gothenburg	Copenhagen	Amsterdam
Surface	The standard surface material for bicycle path is asphalt. At crossings it is common to use red asphalt, red concrete or red SF-stones. The surface should be at least as smooth as the carriage way. (Göteborgs stad Trafikkontoret, 2018).	Asphalt is highly recommended. Thermoplastics is used to highlight the bikeway. When thermoplastics are used it must be good friction on it. (København kommunes, 2013).	Asphalt or concrete are preferable. Red asphalt is used on most bikeways. (CROW, 2016)

4.9 Interviews

In this chapter the result from the interviews is presented.

4.9.1 Interview Malin Månsson, Gothenburg

The interview with Malin Månsson at Trafikkontoret started with a discussion about who the bicycle infrastructure is designed for. Malin explained that everyone should be able to travel by bicycle and the traffic safety is of high importance when designing the bicycle infrastructure. Since the safety factor is important we do not see solutions like the one presented in figure 4.18 in Gothenburg even if it improves the passability since Malin consider it less safe than the Swedish standard. Further, Malin talked about the influence on the design standards from the number of cyclists. Since both Amsterdam and Copenhagen have a higher bicycle modal share than Gothenburg the “Safety in numbers” concept can be utilized in the cities. This might be a reason why the design standards are different. Malin also mentioned that Copenhagen compared to the other cities tend to treat the bicycle as an own transportation mode in a larger extent.

Malin consider the Swedish idea of using bicycle overpasses and bicycle passages to cross a street confusing. She favorize the idea to use the “give way” signs and markings as they do in the other countries.

The topography in Gothenburg Malin explained needs to be considered when designing the bicycle infrastructure. The topography complicates the work with creating a continuous and easily orientable bicycle network since the bikeways may have to be located around ascents.

In *Cykelprogram för en nära storstad 2015-2025* Trafikkontoret(2015) list factors affecting the appealing of the bicycle infrastructure(see 4.1). Compared to CROW(2016) the factor Attractiveness are not mentioned. One criterion to satisfy the Attractiveness factor is to create bikeways through attractive areas. Malin explained that the city of Gothenburg needs to focus on creating a well-functioning bicycle infrastructure before starting to consider attractive routes such as the “Grønne cykelturer” in Copenhagen. According to Malin the city of Gothenburg has green routes already, but the city is not as good on marketing them as the city of Copenhagen. Recently however, the politicians stated that the city green areas must be more available and that the possibility to tourist by bicycle in the city should be improved. This may result in green routes soon starting to be targeted as a goal for the city Gothenburg.

Malin stated that even if the design standards are important when designing the bicycle infrastructure, officials must remember that they are not superior. For instance, it may be acceptable to decrease the width of a bikeway if it entails in a better continuity of the bicycle network. The problem for the city of Gothenburg however is that the bicycle network fulfills neither of these criteria. Further Malin explained that this may be a result of that officials in Gothenburg have been to focused on separating and differentiating different road users during its development and now it is hard to upgrade the infrastructure with integrated traffic as Copenhagen and Amsterdam.

The idea that investment in the bicycle infrastructure will increase the bicycle modal share Malin said is not approved by all officials in the city of Gothenburg. Officials also has prejudices that by prioritizing bicycles may upset large groups of people when it in the end may results in positive attitudes towards the bicycle priority solution.

For future work, Malin recommended to investigate how the other cities experiencing to what extent the bicycle is prioritized in the city planning and how they define bicycle prioritization. She recommends to study how the city of Gothenburg have been developing their traffic infrastructure during the 20th century which briefly was explained in chapter 2.1.

4.9.2 Interview Casper Wulff, Copenhagen

Casper explain that Copenhagen has a long tradition of cycling and that the main reason why Copenhagen started to invest in the bicycle infrastructure was the oil crisis in the 1970s. The idea was to separate the cyclists from the pedestrians to make more people to travel by bicycle. He explained that the theory of creating an attractive bicycle infrastructure will increase the bicycle modal share is approved by officials in Denmark. As evidence for the theory, he mentioned an district in Copenhagen called Fredriksberg which had a neglected bicycle infrastructure 15 years ago and a low bicycle modal share. After investments in the bicycle infrastructure in Fredriksberg the number of cyclists has increased. One reason is that parents did not let their children travel by bicycle when the infrastructure was unsafe.

Casper explained that mixed traffic is used very sparsely in Copenhagen and the general idea is to separate the different transportation modes. Exceptions are done at intersections. When we discussed the design solution presented in figure 4.18 Casper explained that the security may be reduced with this solution, but it does not mean the traffic safety decreases. Instead cyclists will be more observant of their surroundings when running into mixed traffic. The solution in 4.19 are considered secure but may result in cyclists running forward without observing their surrounding and therefore traffic safety may be reduced even if the situation feels safe.

The theory discussed with Malin that other cities may use different design solutions since they can use the concept of safety in numbers Casper consider partially true. The number of cyclists often peak at specific hours during the day and if the infrastructure is designed for these bicycle flows it may have consequences for cyclists traveling outside these hours. A design solution must be safe even during the hours with a minor bicycle flow.

The level of bicycle prioritization in Copenhagen Casper consider to be high. As an example, he mentions a street named Norrebrogade where only public transit, cyclist and pedestrians are permitted. However, he explains that consideration of all transportation modes always must be taken, even the bicycle should not be superior. A common conflict between the bicycle interests and the motorized vehicle interests are the parking spaces since this is where the bikeways are located.

4.9.3 Interview Gerrit Faber, Amsterdam

Gerrit explained that the modern city planning of Amsterdam are based on the concept Sustainable safety. Sustainable safety is a concept developed in the Netherlands during the 1990s to attain improved traffic safety and reduce severe traffic accidents. The concept is based on the following five ideas:

- *Functionality*. The road network should be divided into different subnetworks with different functions. Through roads with high traffic volume, Local roads to connect people with their end destinations and Distributor roads to connect the Local roads with the Through roads.
- *Homogeneity*. Different road users must be separated with consideration to their speed, mass and vulnerability.
- *Predictability*. The road network should be consistent so that road users easily can understand what street they are traveling on.
- *Forgivingness*. The road network must be forgiving when an accident unfortunately occurs. It could be done with calming streetscape designs.
- *State awareness*. Road users need to be educated of the properties of different transportation modes.

The Sustainable safety concept has resulted in Amsterdam designing their road network according to two types of roads in the highest possible extent. Those with a speed limit of 50 km/h with separation between the road users and those with a speed limit of 30 km/h with mixed traffic. There are however exceptions. There are still some streets important for both motorized traffic and unprotected road users, like streets to narrow to divide between the different road users sufficiently. The city should be designed in a way encouraging bicycle transportation. For instance, large shopping malls with car parking lots are rarely seen in Amsterdam since the idea is to create residents where people can buy what they desire in their neighborhood. Further, it is desired to mix residential and business areas to allow people to travel to work by bicycle.

According to Gerrit, the bicycle has high priority in Amsterdam. Right now, the city working with indirect bicycle priority. For instance, by increasing the parking fees for cars and by organizing the city so that if you travel by car you might have to take detours when crossing it. To highlight a problem with the bicycle infrastructure Gerrit mention the possibility to park your bicycle in the city. Today the city has a lack of space for citizens to park their bicycles. This must be counteracted by the city planners. For instance, by creating more space for pedestrians and cyclists. This is done by removing car parking in the city center and reserving areas for bicycle parking to prevent bicycles to be park all over the public spaces. Further, additional bicycle parking facilities are being built, both indoor and underground.

The theory that the creation of bicycle infrastructure increases the bicycle modal share Gerrit agrees with. However, he points out that it is important to not only construct the bicycle infrastructure. Officials need to work with marketing the bicycle as an attractive transportation mode as well to get people to start utilizing the infrastructure. One way is to discourage car traffic with the action described earlier.

Gerrit think next step for Amsterdam should be to try to attract people living outside the city center to travel by bicycle. Many people with foreign background live in these areas. Bicycle traveling is not as common in these groups, why they constitute a good potential cyclist group. The bicycle infrastructure in the suburbs are often better than the one in the central parts but there is still too much space for motorized traffic.
The city planning to construct two bridges cross the river Ij to allow people living in the northern part of the city a better connection to the central part of the city. Today the crossing is done by ferries.

When discussing the different design standards at intersections, Gerrit explained the importance of that city planners can relate to cyclists. Since cyclists chose to travel in the way they consider the most logic. Therefore, the designed infrastructure most always be the most logical travel route. In Amsterdam distinguishes are done between different intersections. At minor intersections, cyclists turning left can do it in one signal phase with a well programmed signal system instead of with two maneuvers as in Copenhagen. In major intersections the cyclist must wait 2 phases, the system is programmed in a way reducing the second waiting time.

Finally, Gerrit has been cycling in Gothenburg and consider the bicycle network to be good. However, he noticed that the bikeways were located on a few street whilst in Amsterdam almost every street has an idea of how you should be able to travel by bicycle on them. Personally, he prefers to travel on bikeways through attractive areas, something he think the city of Gothenburg should strive to create in a larger extent.

4.10 Multinomial logit model

In this chapter the results from the multinomial logit model analysis in SPSS are presented. The answers on the online questionnaire are presented in appendix II.

When checking the correlation between the explanatory variables in SPSS the matrix in figure 4.30 was achieved. If two variables are highly correlated(Sig-value<0.05), then only one of them was included in the statistical model specification. The “Travel_mode” variable can however corelate with an explanatory variable since it was the dependent variable investigated. (Lærd Statistics, 2018).

		Gender	Age	Travel_Mode	H_or_M	Crossin	Problem	Distance	Time	Transit	Rating	Weather	Nr_of_cars
Gender	Pearson Correlation	1	,243**	-,080	-,073	,047	,155	-,004	,047	-,087	,060	,028	,112
	Sig. (2-tailed)		,004	,348	,390	,583	,069	,966	,582	,306	,484	,746	,188
	N	139	139	139	139	139	139	139	139	139	139	139	139
Age	Pearson Correlation	,243**	1	,041	-,043	,067	,113	,112	,023	,100	,045	-,028	,273**
	Sig. (2-tailed)	,004		,631	,619	,433	,185	,190	,787	,244	,602	,740	,001
	N	139	139	139	139	139	139	139	139	139	139	139	139
Travel_Mode	Pearson Correlation	-,080	,041	1	-,069	-,175*	,052	-,264**	-,293**	-,041	,150	-,311**	-,155
	Sig. (2-tailed)	,348	,631		,417	,039	,546	,002	,000	,628	,077	,000	,068
	N	139	139	139	139	139	139	139	139	139	139	139	139
H_or_M	Pearson Correlation	-,073	-,043	-,069	1	,213*	,112	-,112	-,010	,135	-,047	-,005	-,214*
	Sig. (2-tailed)	,390	,619	,417		,012	,191	,190	,906	,114	,581	,951	,011
	N	139	139	139	139	139	139	139	139	139	139	139	139
Crossin	Pearson Correlation	,047	,067	-,175*	,213*	1	,641**	,119	,339**	,079	-,017	,093	-,069
	Sig. (2-tailed)	,583	,433	,039	,012		,000	,163	,000	,356	,841	,278	,420
	N	139	139	139	139	139	139	139	139	139	139	139	139
Problem	Pearson Correlation	,155	,113	,052	,112	,641**	1	-,021	,113	-,043	,096	,065	-,120
	Sig. (2-tailed)	,069	,185	,546	,191	,000		,810	,187	,619	,263	,449	,159
	N	139	139	139	139	139	139	139	139	139	139	139	139
Distance	Pearson Correlation	-,004	,112	-,264**	-,112	,119	-,021	1	,410**	,269**	-,158	,003	,184*
	Sig. (2-tailed)	,966	,190	,002	,190	,163	,810		,000	,001	,063	,972	,030
	N	139	139	139	139	139	139	139	139	139	139	139	139
Time	Pearson Correlation	,047	,023	-,293**	-,010	,339**	,113	,410**	1	,195*	-,231**	,064	,154
	Sig. (2-tailed)	,582	,787	,000	,906	,000	,187	,000		,022	,006	,456	,070
	N	139	139	139	139	139	139	139	139	139	139	139	139
Transit	Pearson Correlation	-,087	,100	-,041	,135	,079	-,043	,269**	,195*	1	,011	,059	,011
	Sig. (2-tailed)	,306	,244	,628	,114	,356	,619	,001	,022		,896	,491	,899
	N	139	139	139	139	139	139	139	139	139	139	139	139
Rating	Pearson Correlation	,060	,045	,150	-,047	-,017	,096	-,158	-,231**	,011	1	-,086	,018
	Sig. (2-tailed)	,484	,602	,077	,581	,841	,263	,063	,006	,896		,316	,835
	N	139	139	139	139	139	139	139	139	139	139	139	139
Weather	Pearson Correlation	,028	-,028	-,311**	-,005	,093	,065	,003	,064	,059	-,086	1	,114
	Sig. (2-tailed)	,746	,740	,000	,951	,278	,449	,972	,456	,491	,316		,181
	N	139	139	139	139	139	139	139	139	139	139	139	139
Nr_of_cars	Pearson Correlation	,112	,273**	-,155	-,214*	-,069	-,120	,184*	,154	,011	,018	,114	1
	Sig. (2-tailed)	,188	,001	,068	,011	,420	,159	,030	,070	,899	,835	,181	
	N	139	139	139	139	139	139	139	139	139	139	139	139

Figure 4.30: Matrix describing the correlation between the explanatory variables.

After comparing the different explanatory variables and tested their statistical significance in a multinomial regression in SPSS the final model where set to be depending on the following explanatory variables:

- The age of an individual. The variable can have the value of 0, 1, 2, 3, 4 or 5 which correspond to the group categories 10-19 years, 20-29 years, 30-39 years, 40-49 years, 50-59 years or 60-69 years. The variable will help analyze how modal choice change according to the age of an individual.
- Whether an individual is crossing Göta älv or not. The variable can have the value of 1 which means crossing or 0 which means not crossing. This variable will help analyze how a crossing over Göta älv affect the modal choice.

- The distance from the home of an individual to its work. The variable can have the value of 1, 2, 3, 4 or 5 which correspond to the distance interval <3 km, 3-6 km, 6-10 km, 10-20 km and >20 km. This variable will help analyze how the length of a trip affect the modal choice.
- The impact from the weather on the modal choice. The variable can have the value of 2, 3, 4 or 5 which correspond to what extent an individual considers the weather affect its modal choice. This variable will help analyze how the weather affect the modal choice for an individual in the city of Gothenburg.

After running the multinomial regression in SPSS for the four variables the tables presented below were achieved.

In the model fitting information table presented in figure 4.31, the “Final”-row has a “Sig.”-value of 0.000. This means that the model statistically significantly calculates the probability of an individual choosing a specific travel mode better than the intercept-only model. (Lærd Statistics, 2018).

	Model Fitting Criteria	Likelihood Ratio Tests		
Model	-2 Log Likelihood	Chi-Square	df	Sig.
Intercept Only	223,310			
Final	161,752	61,558	22	,000

Figure 4.31: Model fitting table.

The Likelihood ratio tests table presented in figure 4.32 indicates that all the chosen explanatory variables are statistical significant and therefore not a result of randomness. (Every value in the “Sig.”-column are below 0.05). (Lærd Statistics, 2018).

	Model Fitting Criteria	Likelihood Ratio Tests		
Effect	-2 Log Likelihood of Reduced Model	Chi-Square	df	Sig.
Intercept	161,752[a]	,000	0	.
Age	176,426	14,674	6	,023
Crossin	175,233	13,481	2	,001
Distance	180,277	18,525	8	,018
Weather	180,714	18,962	6	,004

Figure 4.32: Likelihood ratio tests table.

In the parameter estimated table presented in figure 4.33 the B-column is of highest interest since these values are used to calculate the total utility for a transportation mode. The probability calculations for the two made-up persons are presented below.

Travel_Mode[a]		B	Std. Error	Wald	df	Sig.	Exp(B)	95% Confidence Interval for Exp (B)	
								Lower Bound	Upper Bound
Car	Intercept	3,739	1,634	5,236	1	,022			
	[Age=1]	-,386	1,057	,133	1	,715	,680	,086	5,397
	[Age=2]	-,577	1,003	,331	1	,565	,561	,079	4,011
	[Age=3]	-,042	,844	,002	1	,961	,959	,184	5,014
	[Age=4]	0[b]	.	.	0	.	.	.	.
	[Crossin=0]	-,275	,711	,150	1	,699	,759	,188	3,060
	[Crossin=1]	0[b]	.	.	0	.	.	.	.
	[Distance=1]	-4,804	1,629	8,696	1	,003	,008	,000	,200
	[Distance=2]	-3,736	1,377	7,364	1	,007	,024	,002	,354
	[Distance=3]	-3,294	1,383	5,671	1	,017	,037	,002	,558
	[Distance=4]	-2,274	1,365	2,775	1	,096	,103	,007	1,494
	[Distance=5]	0[b]	.	.	0	.	.	.	.
	[Weather=2]	-2,704	,947	8,153	1	,004	,067	,010	,428
	[Weather=3]	-2,299	1,039	4,899	1	,027	,100	,013	,769
	[Weather=4]	-,924	,886	1,087	1	,297	,397	,070	2,254
	[Weather=5]	0[b]	.	.	0	.	.	.	.
Public traffic	Intercept	3,367	1,455	5,355	1	,021			
	[Age=1]	1,880	,748	6,313	1	,012	6,551	1,512	28,382
	[Age=2]	1,534	,730	4,414	1	,036	4,635	1,108	19,382
	[Age=3]	,380	,765	,246	1	,620	1,462	,326	6,547
	[Age=4]	0[b]	.	.	0	.	.	.	.
	[Crossin=0]	-1,630	,477	11,700	1	,001	,196	,077	,498
	[Crossin=1]	0[b]	.	.	0	.	.	.	.
	[Distance=1]	-2,399	1,264	3,602	1	,058	,091	,008	1,082
	[Distance=2]	-2,164	1,239	3,052	1	,081	,115	,010	1,302
	[Distance=3]	-2,964	1,295	5,236	1	,022	,052	,004	,654
	[Distance=4]	-2,190	1,351	2,627	1	,105	,112	,008	1,582
	[Distance=5]	0[b]	.	.	0	.	.	.	.
	[Weather=2]	-2,023	,636	10,124	1	,001	,132	,038	,460
	[Weather=3]	-1,329	,684	3,774	1	,052	,265	,069	1,012
	[Weather=4]	-1,743	,736	5,604	1	,018	,175	,041	,741
	[Weather=5]	0[b]	.	.	0	.	.	.	.

a. The reference category is: Bike.

b. This parameter is set to zero because it is redundant.

Figure 4.33: Parameter estimates table.

<u>Probability calculation for person 1:</u>

Utilities:

$$U_{car} = 3.739 - 0.386 - 3.294 - 0.924 = 0.155$$

$$U_{public\_transit} = 3.367 + 1.880 - 2.190 - 1.743 = 1.314$$

$$U_{bicycle} = 1$$

Modal choice probabilities:

$$P_{car} = \frac{\exp(U_{car})}{\exp(U_{car}) + \exp\left(U_{public\_transit}\right) + \exp(U_{bicycle})} = 15.3\%$$

$$P_{public\_transit} = \frac{\exp(U_{public\_transit})}{\exp(U_{car}) + \exp\left(U_{public\_transit}\right) + \cdots + \exp(U_{bicycle})} = 48.9\%$$

$$P_{bicycle} = \frac{\exp(U_{bicycle})}{\exp(U_{car}) + \exp\left(U_{public\_transit}\right) + \exp(U_{bicycle})} = 35.7\%$$

<u>Probability calculation for person 2:</u>

Utilities:

$$U_{car} = 3.739 - 0.386 - 0.275 - 3.294 - 0.924 = -0.12$$

$$U_{public\_transit} = 3.367 + 1.880 - 1.630 - 2.190 - 1.743 = -0.316$$

$$U_{bicycle} = 1$$

Modal choice probabilities:

$$P_{car} = \frac{\exp(U_{car})}{\exp(U_{car}) + \exp\left(U_{public\_transit}\right) + \exp(U_{bicycle})} = 20.5\%$$

$$P_{public\_transit} = \frac{\exp(U_{public\_transit})}{\exp(U_{car}) + \exp\left(U_{public\_transit}\right) + \cdots + \exp(U_{bicycle})} = 16.8\%$$

$$P_{bicycle} = \frac{\exp(U_{bicycle})}{\exp(U_{car}) + \exp\left(U_{public\_transit}\right) + \exp(U_{bicycle})} = 62.7\%$$

5 DISCUSSION

When defining what a good bicycle infrastructure is, the city of Gothenburg, unlike Copenhagen and Amsterdam, do not mention the goal of creating bikeways through attractive areas in their bicycle program. During the interview with Malin Månsson, she explained that this is because Gothenburg first need to focus on creating a well-functioning bicycle infrastructure. This could be an indication that Copenhagen and Amsterdam are further ahead with the development of their bicycle infrastructure.

After comparing the bicycle network, it seemed to be well coherent in all the cities. The river in Gothenburg and Amsterdam could be spotted as potential barriers towards bicycle use. This was why a Göta älv river crossing effect on modal choice was investigated in the multinomial logit analysis. The multinomial logit model fortified this theory, the made-up individuals in the probability calculation had 62.7% probability to choose bicycle if not crossing the river and 35.7% probability when crossing the river. A decrease of 43%. Copenhagen has many bridges connecting the south side of the city with a north. The municipality of Copenhagen(2017) list on their website the advantages constructing connections across the harbor. E.g. they present that one of their bridges saves 1400 km driven by car every year, which correspond to 87 000 kg of CO_2. This should motivate the other cities to construct bridges in the highest possible extent as well.

An important difference between the cities is that the topography of Gothenburg is more varied than the topography of Copenhagen and Amsterdam which both could be considered flat. This aggravates the creation of a continuous and orientable bicycle network. In the multinomial logit model, the additional error factor was considerably large which indicates that some factors affecting the modal choice in a high extent were missing in the model. This could partially be the impact from the topography. In the future however, as the use of electrical bicycles increases, I believe the topography will be a minor excuse for not travel by bicycle. Many bikeways in Gothenburg stretches through areas that are not noticeably elevated either(see figure 4.2), which should reduce the impact from the topography even further. The possibility to bring the bicycle on public transit should be expanded in the city of Gothenburg to simplify travel uphill.

After comparing the bicycle infrastructure design standards in the cities, it was found that they are similar when comparing each criterion separately, on a small scale. The similarities indicate that Gothenburg officials know how to create an attractive bicycle infrastructure but are behind Amsterdam and Copenhagen in bicycle modal share for other reasons. Like the development of the bicycle infrastructure and the marketing of it. The development of the bicycle infrastructure is behind because Swedish officials have been focusing on the ideas of traffic separation and differentiation presented in SCAFT for long while the other cities started to integrate the bicycle in the infrastructure already in the 1970s. Further, the ideas of separation and differentiation have resulted in problems when upgrading the existing infrastructure to a bicycle friendly one. How Gothenburg should work with the marketing of the bicycle as a transportation mode are suggested as future work.

When comparing the bicycle infrastructure on a larger scale, at intersections, roundabout or the configuration of a streetscape more distinct differences can be observed. My observations are that Danish officials seems to at some situations reduce the traffic security and argue that this improve the traffic safety since the cyclists will be more observed of their surroundings.

Like the situation presented in figure 4.18. Even if the traffic safety seems to decrease on the expense of passability in the solution, it does not have to be the case. Reduced traffic security may result in more observant cyclists and in turn increase the traffic safety. Similarly, a secure traffic situation can be unsafe, e.g. at the Danish standard solution presented in figure 4.19 cyclist may run straight at the intersection without observing their surrounding since they feel secure. To draw conclusions from this I investigated what seemed to be the “acceptable” level of severe injuries on the bicycle network. All cities aiming to keep the severe accidents as low as possible, but accidents do always occur. Copenhagen has set a goal for 2025 of no more than 35 severe injuries because of bicycle accidents. (Københavns Kommune, 2016). 2017 the number of severe injuries was 79 and two cyclists died. (Danmarks statistik, 2017). In Gothenburg the number of severe accidents were 50 and zero cyclists died the same year. (Göteborgs stad, 2017). The total number of accidents involving cyclists in the cities were 150 in Copenhagen and 252 for Gothenburg. (Danmarks statistik, 2017). (Göteborgs stad, 2017). By considering these numbers, it can be determined that the number of severe injuries is lower in the city of Gothenburg. However, since there is more cyclist in Copenhagen it is hard to say if this is a consequence from less safe design solutions or not. The concept of safety in number and the number of cyclists wearing helmets also have an impact on these statistics. In Amsterdam the annual bicycle accidents resulted in hospital visits in 2012 was 441. (Panneman, 2014). No information was found on how many that were severe. However, about 10 to 20 fatal accidents occur in Amsterdam every year of which 20 to 30 percent are cyclists. (I Amsterdam, 2017). Based on previous, I think additional investigations should be made to see at what traffic situations accidents occur to investigate how the decrease and increase of traffic security affect the traffic safety.

Prejudices that prioritizing bicycles result in complaints occur in Sweden while it in fact may have a welcoming effect in the long run. Further, some Swedish officials believe that investments in bicycle infrastructure not result in an increased bicycle modal share. Danish officials do not agree, the theory can be strengthened with the example from Fredriksberg Casper Wulff presented. Officials should therefore be encouraged to prioritize the bicycles. Gerrit Faber however emphasized that the investment in the bicycle infrastructure must be followed with proper marketing and maintenance of the infrastructure if the bicycle modal share should be improved.

Both Amsterdam and Copenhagen have a longer tradition of cycling than Gothenburg which has resulted in a greater bicycle modal share. The greater number of cyclists in Amsterdam and Copenhagen may be another reason why the design standards are different in the cities. The goals in “Cykelprogram för en nära storstad 2015-2025” edited by the city of Gothenburg hopefully marks a breakthrough of the bicycle as a transportation mode in the city.

The Dutch idea of coloring the entire bikeway is something I think should be used in Gothenburg to at some locations since it may improve the security and safety and therefore the attractiveness of the bicycle as a transportation mode. It may also have a positive impact to get pedestrians not to walk on the bikeway. The idea of connecting the central parts of a city with the outskirts by creating a bicycle highway connection I believe is a great example of smart bicycle infrastructure which can attract potential cyclists.

I agree with that one directional bicycle paths should be desired from a safety and passability perspective. By drawing a bicycle conflict point figure for an intersection like the one for cars at roundabouts in figure 4.23 it is noticed that the conflict points between cyclists are reduced with 75% at intersections when utilizing one directional bicycle paths. This is presented in figure 5.2.

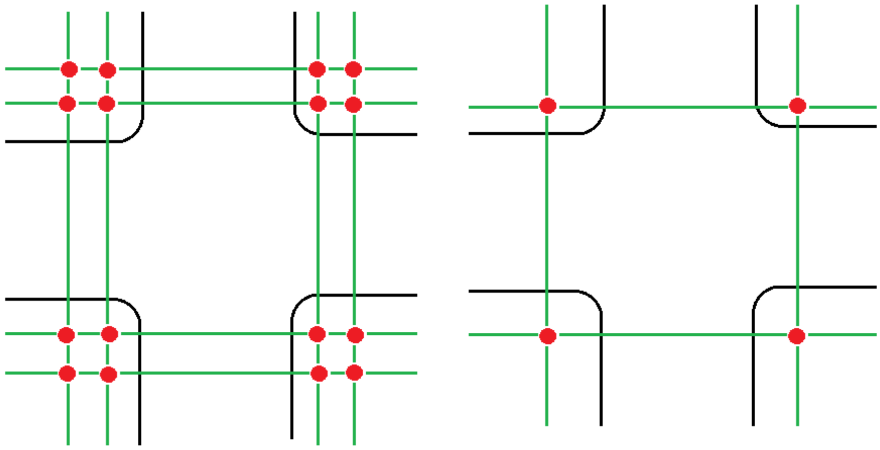


Figure 5.2: Conflict points between cyclists at a bidirectional bicycle path intersection and at a one directional bicycle path intersection.

In figure 5.1 two print screens from Google street view, one from Gothenburg and one from Amsterdam, are presented. The print screens are taken at the entrance to a one-way street where cyclists can travel the opposite direction. On the Dutch street, cyclists have much easier to understand where to locate themselves. The bicycle lane clarifies where the cyclists should locate themselves. The design solution was presented in figure 4.8. This I believe is another good example of how to create an easy understandable and attractive bicycle infrastructure. Gerrit Faber explained that you often must consider the limitation of car parking when prioritizing bicycles. On one-way streets with a potential high bicycle flow, I think the cyclists should be prioritized above parking lots.

Figure 5.1a: Andra Långgatan in Gothenburg where cyclist allowed to travel opposite direction against one-way street. (Google, 2018).

Figure 5.1b: Haarlemmerstraat in Amsterdam where cyclist allowed to travel opposite direction against one-way street. (Google, 2018).

The idea Gerrit Faber presented that there should exist an idea on how cyclists should travel on every street in Amsterdam I believe is something Gothenburg should implement to. Further, the Dutch focusing on creating a forgiving bicycle infrastructure. This is briefly mentioned in the documents from Gothenburg to, but I think it is something that deserves more attention. (Göteborgs stad Trafikkontoret, 2015).

People often emphasize the impact from the weather on the modal choice. The multinomial logit model analysis motivates that the extent an individual considers the weather when choosing transportation mode reduces the chances to travel by bicycle. This conclusion is made by analyzing the variable *B* for each value on the weather impact variable in the Parameter estimates table(figure 4.33). Comparing car to bicycle, *B* goes from -2.023 to 0. Comparing public transit to bicycle however the chances of choosing public transit first increases but then decreases when choosing the value of 4. The annual precipitation in Gothenburg is 491.6 mm, Copenhagen 312.4 mm and Amsterdam 549.7 mm. The average temperature varies between 0-17°C in Gothenburg, 1-18°C in Copenhagen and 4-18°C in Amsterdam. (Timeanddate, 2018). Since the weather conditions are similar in the cities it should not have a significant impact the differences on modal share in the cities.

The age of an individual and how far the individual travel also reduces the probability of choosing to travel with bicycle compared to car. When comparing public transit and bicycle, the probability of choosing bicycle reduces the older you get. The impact from the distance may be misleading since it reduces the probability of choosing bicycle if the distance is between 3-6 km(*B*=-2.164) and increases the probability if the distance is between 6-10 km(*B*=-2.964). It is not reasonable that the probability of traveling by bicycle increases with the distance.

The input data for the Multinomial logit model was based on answers form 146 people living in the city of Gothenburg. The bicycle modal share from this sample was 44.9%(see appendix II). In Gothenburg however, Trafikkontoret(2017) estimated the bicycle modal share to 8%. This may indicate that the model does not reflect reality and additional investigations with a larger sample should be made. What can be learn from this report however is how to create a multinomial logit model to analyze modal choice.

It is hard to say in what extent the design standards affect the modal share. In this project the plan was to investigate how the bicycle infrastructure rating from an individual affect its modal choice. When the rating of the bicycle infrastructure was used as input in the multinomial logit model the result were not statistical significant which in turn meant that it could not be ensured that an increase or decrease in probability of a transportation mode were a result of randomness or how the individuals rated the infrastructure.

During this research information about additional factors that may affect the bicycle modal share in a city was found. Due to a limited time frame they will just briefly be discussed below. It could be considered as an introduction to future work.

In this report, no consideration on how much money the municipalities are investing in the bicycle infrastructure were taken. The investments will differ and should have an impact on the bicycle modal choice in the cities. In what way the money is invested also have an effect. Investment can be made in the solid infrastructure, maintenance work or as marketing the bicycle as a transportation mode.

By comparing the average trip length in Gothenburg, Amsterdam and Copenhagen, table 5.1 can be created. Information about Copenhagen travel distance were not found, hence statistics of Denmark are used. (Göteborgs stad Trafikkontoret, 2017). (City of Amsterdam, 2016). (Larsen, 2010).

Table 5.1: Average trip length for Gothenburg, Amsterdam and Denmark.

	Car	Public transit	Bicycle	Walking
Gothenburg	17 km	20 km	3.9 km	1.3 km
Denmark	12.2 km	17.3 km	2.0 km	0.7 km
Amsterdam	49 km	36 km	1.0 km	<1 km

Table 5.1 indicate that car and public transit users in Amsterdam are traveling further distances than in Gothenburg. This together with the lower average bicycle trip distance motivates that Amsterdam have a city planning according to what Gerrit stated, with a great mix of residential and business areas to allow citizen to live close to their errands. Since the statistics for Copenhagen is given for the whole country of Denmark it is hard to draw any conclusions from it. The values should however be minor in a large city than for the whole country and therefore the average cycle trip should be shorter in Copenhagen than Gothenburg to. This could indicate that denser cities have a higher bicycle modal share.

Many surveys fortify that the density of a city population have an impact on the bicycle modal share in a city since it reduces the travel distance. (Pucher & Buehler, 2005). (Cervero & Radisch, 1996). In figure 5.3 a graph with values of the density and the bicycle modal share for some cities are plotted. (City Clock, 2014). (World Population Review, 2018). (NYC, 2018). (London datastore, 2018). (Tokyo metropolitan government, 2015). (City of Sydney, 2016). No specific relationship can be seen between the variables and the trendline indicate a very slow modal share increase with increased density. However, the density may have an effect if other city properties are advantageous. Factors such as how a city is mixing residential and business areas or in what extent the city has a developed bicycle infrastructure. In this project there was not enough time to investigate this, but it is suggested as further studies.

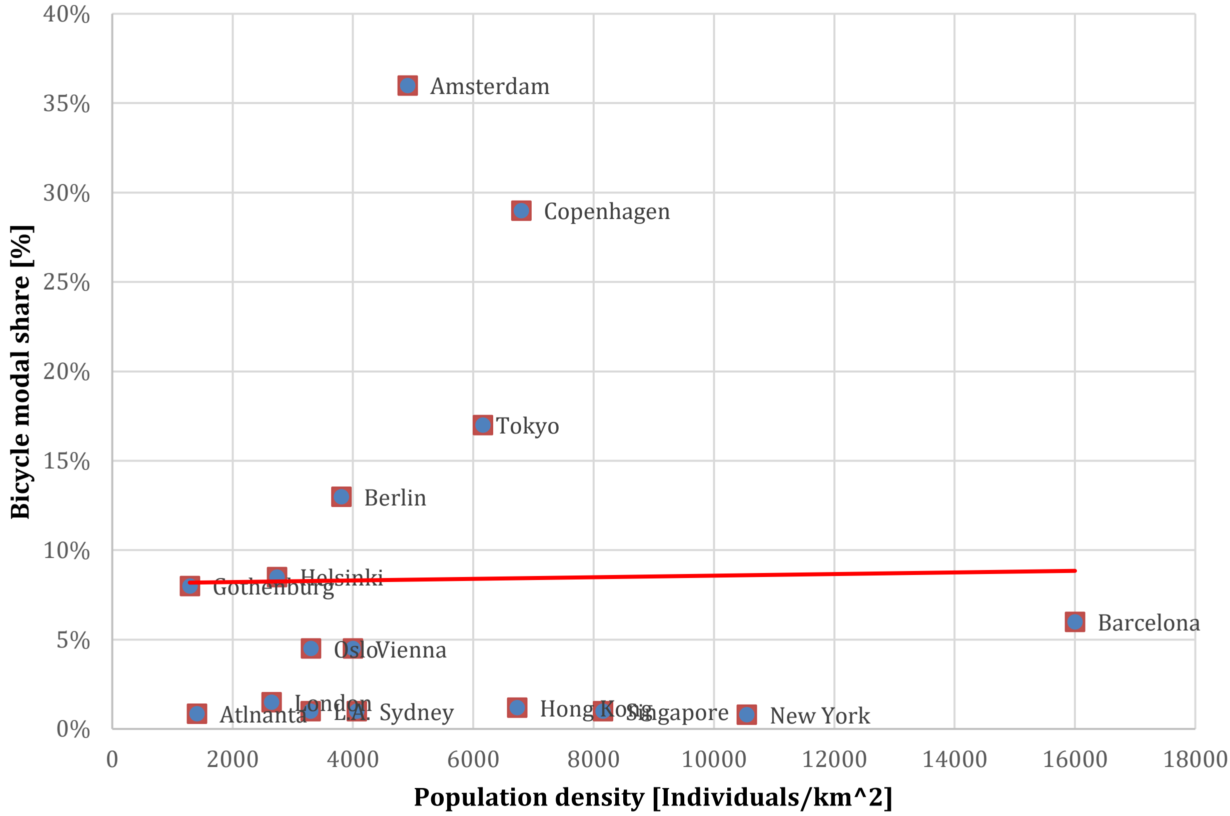


Figure 5.3: Modal share and population density relationship for some cities around the world. The red line indicates the trendline for the relationship.

6 CONCLUSION

The design standards are similar when comparing them on a minor scale. When compared on a major scale, differences can be observed.

Swedish long-term design standards focusing on separating and differentiating the road users have made the bicycle infrastructure in the city of Gothenburg neglected.

The differences in the design standards are partially a result of a higher bicycle modal share in Copenhagen and Amsterdam.

The bicycle network does not differ significantly between the three cities in terms of cohesion and directness. The topography in Gothenburg do aggravate the creation of a continuous and orientable bicycle network.

The bicycle infrastructure is vital for the bicycle modal share even in dense cities. The creation of a bicycle infrastructure however, will not increase the bicycle modal share without being marketed and maintained in a proper way.

A river crossing has a notable impact on the modal choice in the city of Gothenburg. However, a multinomial logit analyze with a larger sample are suggested to ensure conclusion.

Gothenburg should keep investing in the bicycle infrastructure, work on the marketing of the bicycle as a transportation mode, create a plan on how people should be able to travel by bicycle on every street and the creation of bikeways through attractive areas.

7 FUTURE WORK

Investigate how bicycle modal share are calculated in different cities since it might be calculated in different ways. Such an investigation could find guidelines to find a standard procedure to calculate transportation modal share.

Compare the population densities and how the mix of residential and business areas are in the different cities. This might have an impact on the bicycle modal share.

Investigate how much that are invested in the bicycle infrastructure and compare whether investment in marketing, solid infrastructure and maintenance has different impact on modal share.

Investigate the most advantageous way Gothenburg should market the bicycle as a transportation mode.

Investigate to what extent the cities fulfill their bicycle design standards.

Compare statistics of accidents involving cyclists between the cities at location where the design standards differ.

Perform a Multinomial logit analysis for the cities of Amsterdam and Copenhagen to find out if a river crossing in these cities affect the modal choice in the same extent as Gothenburg. In Copenhagen the impact from a river cross should be less since Copenhagen has more bridges cross the harbor.

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APPENDIX I

Travel mode choice questionnaire:

Gender?

- ◯ Male
- ◯ Female

How old are you?

Ditt svar

How do you commute to work/school?

- ◯ Car
- ◯ Public traffic
- ◯ Bicycle
- ◯ Walking
- ◯ Other

Do you live on Hisingen or the mainland?

- ◯ Hisingen
- ◯ The Mainland
- ◯ Övrigt:

Do you cross Göta älv when commuting to work/school?

- ◯ Yes
- ◯ No

Do the crossing over Göta älv poses a problem for you to travel by bike?

- ◯ Yes
- ◯ No
- ◯ I do not cross Göta älv

How long is your trip to work? (Enter the amount of kilometers, e.g. "4.2")

Ditt svar

How long time does it take for you to get to work? (Enter the amount of minutes, e.g. "40")

Ditt svar

Estimate how far it is from your home to the closest public traffic stop? (Enter the amount of meter, e.g. "350")

Ditt svar

How do you rate the bike infrastructure between your home and work? (5=very good, 1=very bad)

1	2	3	4	5
○	○	○	○	○

How much does the weather affect your travel mode choice? (5=very much, 1=not at all)

1	2	3	4	5
○	○	○	○	○

Do you have a driver licence?

- ○ Yes
- ○ No

How many cars do you have in your household?

- ○ 0
- ○ 1
- ○ 2
- ○ More than 2

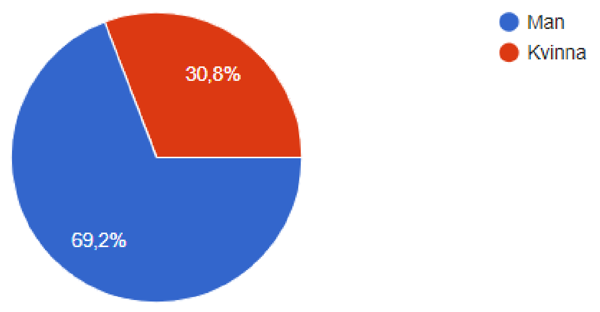
APPENDIX II

Travel mode choice questionnaire answers:

The questionnaire was given in Swedish since it was done in a Swedish town.

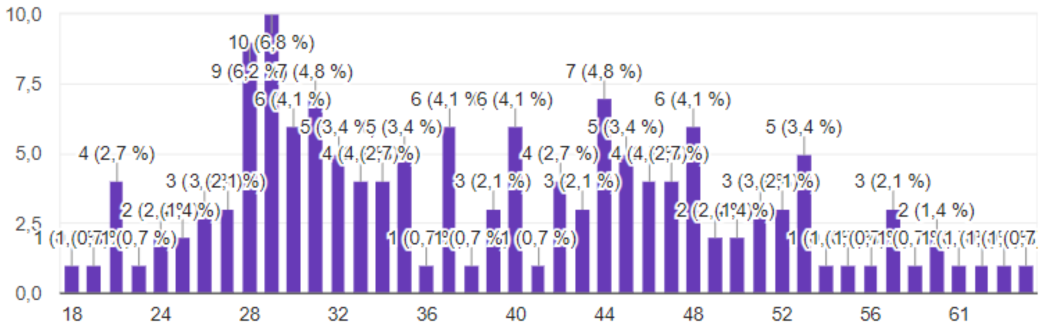
Är du man eller kvinna?

146 svar



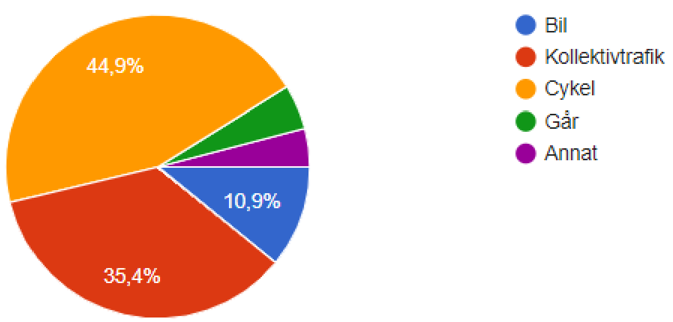
Hur gammal är du?

146 svar



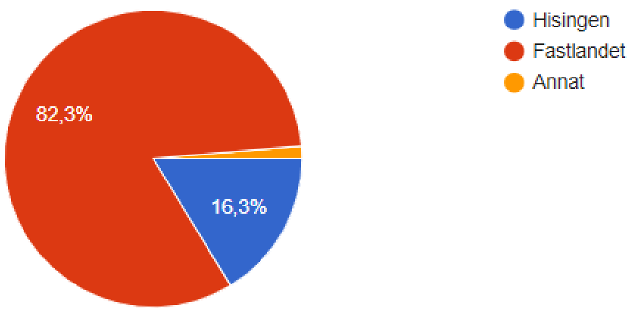
Hur tar du dig till jobbet/skolan?

147 svar



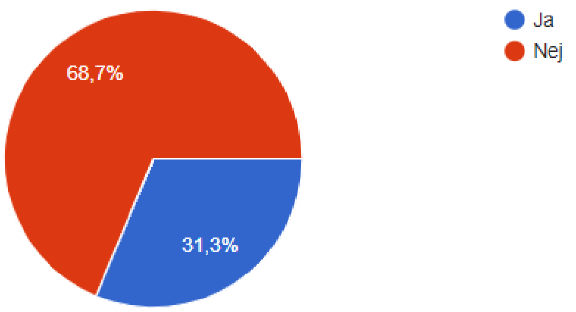
Bor du på Hisingen eller fastlandet?

147 svar



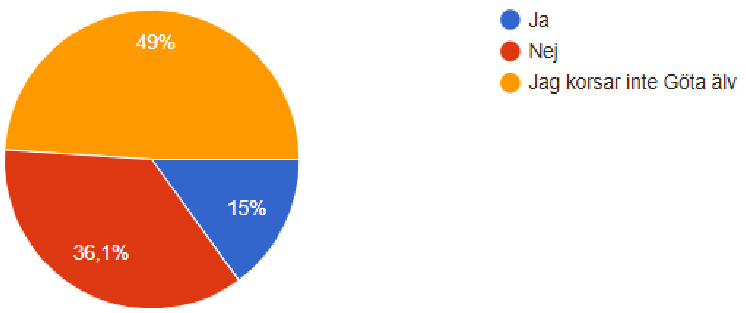
Korsar du Göta älv när du reser till jobbet/skolan?

147 svar



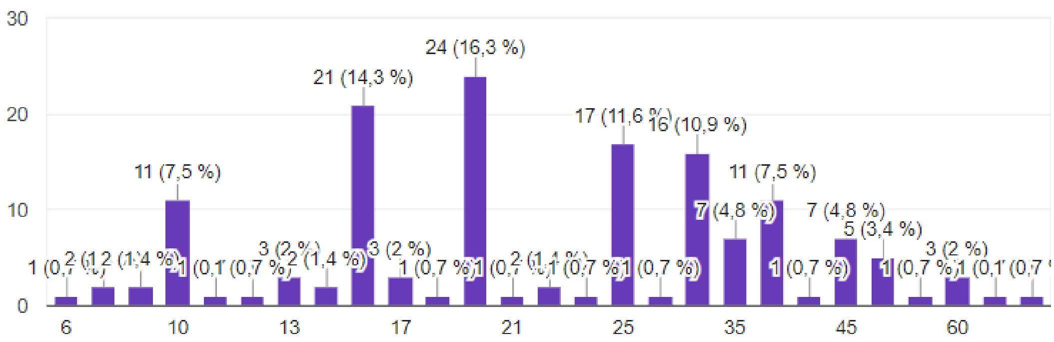
Medför en korsning över Göta älv ett hinder för dig för att resa med cykel?

147 svar



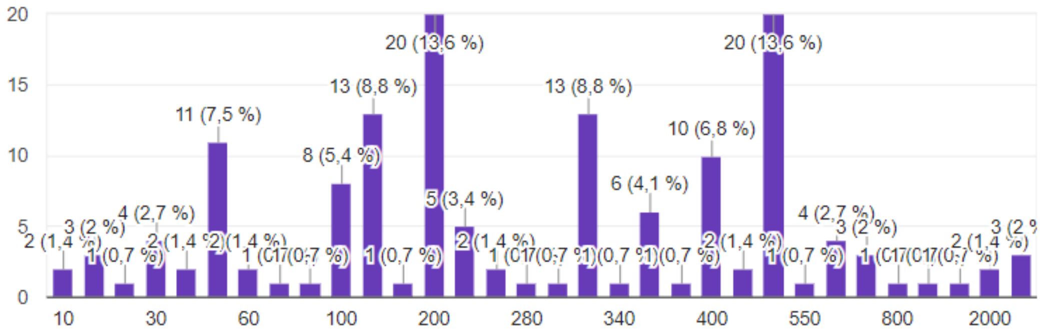
Hur lång tid tar det för dig att komma till jobbet? (ange svar i minuter, tex "40")

147 svar



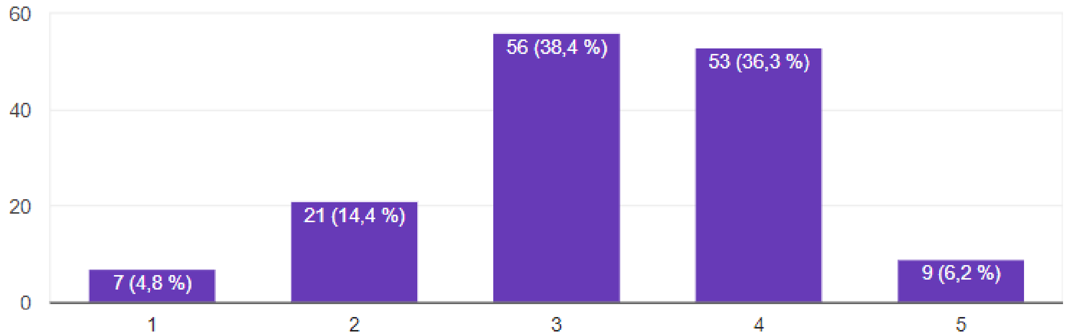
Hur långt är det från din bostad till närmsta stop för kollektivtrafik? (ange svar i meter, tex "450")

147 svar



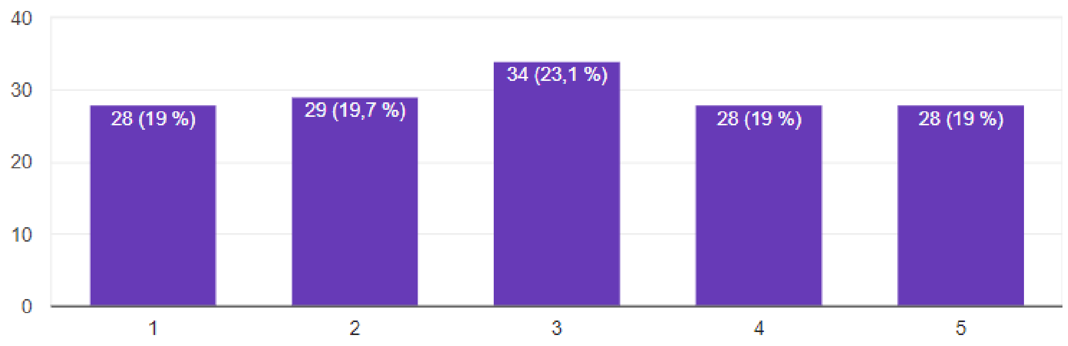
Hur betygsätter du cykel-infrastrukturen mellan din bostad och ditt jobb? (5=mycket bra, 1=mycket dålig)

146 svar



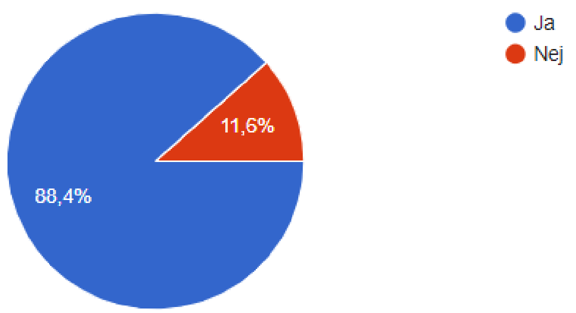
Hur mycket påverkar vädret ditt val av färdmedel? (5=väldigt mycket, 1=ingenting)

147 svar



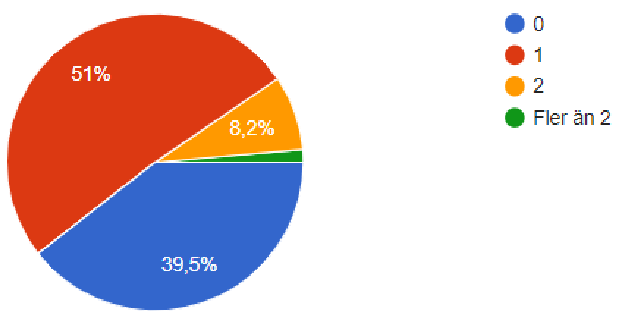
Har du körkort?

147 svar



Hur många bilar har ni i ert hushål?

147 svar



Hur lång är din resa till jobbet/skolan? (ange svar i kilometer, tex "1.5")

145 svar

4 (13)
5 (12)
3 (11)
8 (6)
2 (5)
6 (5)
7 (5)
9 (4)
10 (4)
15 (3)
30 (3)
1.5 (3)
3.5 (3)
3.8 (3)
11 (3)
4.5 (3)
20 (3)
12 (3)
7.5 (3)
1 (2)
3.0 (2)
13 (2)
2.5 (2)
0.8 (2)
18 (2)
23 (2)
1.2 (2)
40
10.9
9
5.3
0.6
10.2
6.9
4.2

1.3
4.4
3.2
1.7
25
27
6.5
0.9
3.9
9.1
8.7
8.6
16
45
5.6
5.7
2.4
6.2
120
9.4
12.6
8.8
14
4.3
2.1
4.8