CHALMERS

Disturbances of the surroundings in an urban infrastructure project

Master of Science Thesis in the Master's Programme Design and Construction Project Management

PATRIK ANDERSSON
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CHALMERS UNIVERSITY OF TECHNOLOGY
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Cover: Excavator conducting work close to a building at project Hagastråket.

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ABSTRACT

The importance of the urban areas will increase further in the future. This implies that an increasing number of construction projects will face technical challenges with existing buildings and infrastructure, as well as the challenge of interacting with the surroundings in a way that decreases the disturbances. The purpose of this thesis is to identify and map relevant disturbances of the surroundings in an urban infrastructure construction project. As a source of data, a current infrastructure project in the urban area of Gothenburg, Hagastråket, was studied. There, 63 persons were interviewed in connection to the project. These persons were pedestrians, bicyclists, motorists, residents, business owners and representatives, and construction workers. In addition, the case study included observations so that a wider perspective could be considered. In this thesis a disturbance is defined as "a consequence of an event that has an impact that is perceived as negative by those exposed". The selected disturbances are mobility, noise emissions, dust emissions, vibrations, safety of residents, and worker safety during construction. Two additional disturbances, lack of information and idle worksite, were found when interviewing people at the construction site. The results from interviews and observations show that the disturbance that has the largest impact is the lack of information, closely followed by decreased mobility. In addition, the group that was most affected and had the most opinions were the business owners. A conclusion from this study is that it is not possible to do construction work in an urban area without causing disturbances of the surroundings. Another conclusion made, due to the variation in interview responses, is that disturbances are often something perceived and depend on the person exposed. As this thesis is based on a single case study, performed at NCC's project Hagastråket, general conclusions are hard to make.

Keywords: Construction, Disturbances, Surrounding, Infrastructure

Omgivningsstörningar vid ett infrastrukturprojekt i stadsmiljö

Examensarbete inom Design and Construction Project Management

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SAMMANFATTNING

Stadsområdenas betydelse kommer att fortsätta öka i framtiden. Detta innebär att ett ökande antal byggprojekt kommer att möta tekniska utmaningar med redan existerande byggnader och infrastruktur, såväl som utmaningen att interagera med omgivningen på ett sätt som minskar störningarna. Syftet med detta examensarbete är att identifiera och kartlägga omgivningsstörningarna i ett pågående infrastrukturprojekt i stadsmiljö, Hagastråket i centrala Göteborg. 63 personer intervjuades i anslutning till projektet. Dessa personer var gångtrafikanter, cyklister, bilister, boende, näringsidkare eller deras representanter, samt yrkesarbetare. Fallstudien inkluderade även observationer av projektet för att få ett bredare perspektiv. En störning definieras i detta examensarbete som ”en konsekvens av en händelse som har en påverkan som uppfattas negativ av dem som blivit exponerade”. De kategorier störningar som studerats är tillgänglighet, buller, damm, vibrationer, säkerhet för invånare (där alla personer som vistas i anknytning till projektet inkulderas) och säkerhet för byggarbetarna. Ytterligare två störningskategorier framkom under intervjuerna. Dessa två är brist på information och stillastående arbetsplats. Resultatet från intervjuerna och observationerna visar att den störningen som har störst påverkan är brist på information, följt av nedsatt tillgänglighet. Den grupp av människor som påverkades mest och hade flest åsikter var näringsidkare. En slutsats från studien är att det inte är möjligt att bygga i stadsmiljöer utan att orsaka störningar för omgivningen. En annan slutsats som gjorts, utifrån variationen på svaren från intervjuerna, är att störningar ofta är något som uppfattas och beror av individen som utsatts. Därför är det viktigt att kontinuerligt informera närboende och andra som verkar eller förflyttar sig i området om projektet. Eftersom detta examensarbete är baserat på endast en fallstudie, vid NCCs projekt Hagastråket, så är det svårt att dra generella slutsatser.

Nyckelord: Byggnation, Störningar, Omgivning, Infrastruktur

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Patrik Andersson & Annie Johansson

Gothenburg, June 2012

Contents

1 Introduction

1.1 Background

The importance of the urban areas will increase further in the future. Of all countries in the EU, Sweden has the fastest growing urbanization (sverigesradio.se, 2012). Seto & Shepherd, (2009) state that "in 2008, the global urban population exceeded the non-rural population for the first time in history, and it is estimated that by 2050, 70% of the world population will live in urban areas". Hence, a large part of future construction sites will be situated in areas surrounded by existing buildings and infrastructure. In these areas, many people live close to one another and there are consequences for these people and their everyday routines when there is a construction site in the area. In order to avoid unnecessary disturbances to the surrounding, and at the same time increase competitiveness, disturbances need to be acknowledged and addressed. The different disturbances of the surroundings affect the various stakeholders in separate ways, which is important to consider to reduce negative impact.

During the years from 2010 to 2027, major investments will be made to improve public traffic, railways, and roads in the Gothenburg area. This investment is called the West Swedish Solution and includes several different projects at a total cost of 34 billion SEK (Goteborg.se, 2012). As much of this construction work is located in already built urban areas, reducing disturbances will be a great challenge for all involved actors.

1.2 Purpose

The purpose of this master thesis is to identify and map relevant disturbances of the surroundings in an urban infrastructure construction project. The results will form a base for discussions on how to find ways to reduce these disturbances.

Due to a narrow timeframe, limitations are set to identify and map disturbances of the surroundings during the execution phase of one infrastructure project in Gothenburg, Hagastråket. It is run by the contractor NCC Construction Sweden, and the client is Trafikkontoret. Furthermore, this study will not propose necessary actions on how to reduce or minimize disturbances. There exist a large number of disturbances of the surroundings, and the disturbances that are directly perceived by a third person have been selected. Therefore, disturbances that have an environmental or economical affect are not considered in this report. Limitations concerning on what groups to focus the interviews have been made. Hence, motorists that have changed their route and motorists traveling on alternate roads that are affected by the increase in traffic have not been included.

The following main questions will be treated;

- What kind of disturbances of the surroundings are there at the studied case?
- How is the surrounding affected by the different disturbances?
- Which group of people is most affected by disturbances?
- Which of the disturbances has the largest impact?

A case study approach was chosen in order to see what disturbances that affect people and make real life observations. Therefore the results based on interviews and observations are affected by the human perception and by the way that the client and contractor have dealt with planning and early stages of production. The interviews and observations took place at an early stage in production, which also has an effect on interviewees' answers. As this thesis is based on a single case study, general conclusions are hard to make. As a result, the conclusions made in this thesis are affiliated to the project Hagastråket.

2 Literature study

2.1 Disturbances of the surroundings

Disturbances of the surroundings at construction sites are a highly relevant topic, especially when a construction site is located in a densely populated urban area (Pantura, 2011). A disturbance is defined by White & Pickett (1985) as an event in time that disrupts the community or population, and changes resources or the physical environment. Disturbances of residents are mentioned in Swedish law (SFS, 1970:994) as disturbances that are harmful to the residents' health, in accordance with current health protection regulations. As there exists no suitable definitions of disturbances of the surroundings to be found, a disturbance will be defined in this thesis as "a consequence of an event that has an impact that is perceived as negative by those exposed". There still exists little research to be found on disturbances of the surroundings, apart from noise emissions and to some extent also dust emissions. However, 16 disturbances of the surroundings are presented in a report in an EU-project that deals with low-disturbance sustainable urban construction (Pantura, 2011). Five disturbances have been chosen since these affect third person, the focus of this study. The selected disturbances include mobility, noise emissions, dust emissions, safety of residents, and worker safety during construction. Worker safety during construction may seem out of place as it does not concern a third person. However, this study focuses on the worker safety during construction in relation to the surrounding traffic, and not safety due to the way machinery and equipment is handled. An additional disturbance that has been included in this study, but was not mentioned in the Pantura report, is vibrations. The reason for why vibrations is added to this study is that the site manager mentioned that it is a significant part of the risk analysis of the project. The remaining eleven disturbances mentioned in the Pantura report concern environment (e.g., Energy Consumption or Emissions of Greenhouse Gases) or economy (e.g., Life Cycle Costs), are not directly associated to third person behavior and will not be treated in this study.

In the following sections, the selected disturbances will be discussed.

Mobility

According to Pantura (2011), the mobility disturbance is measured by calculating the increase or decrease in travel time affecting pedestrians, bicyclists, and motorists. The time is measured between two points on the travel route that is affected by the construction work. The mobility disturbance causes environmental and economic impact due to the increase in travel time and distance caused by the need of detours, but the focus in this report is the social impact on the satisfaction of affected people.

According to Bootsma et al. (2006), most car travelers choose to still use the car when traveling even though there is a road construction. However, several of them take different routes to try to avoid queues and some decide to change the time of departure.

Noise emissions

Noise affects the health of people and this is often underestimated (Boverket, 2012). When planning and executing construction work, issues that concern health of people are essential, and noise is one of these. In order to minimize disturbances in terms of noise, efforts need to be made during the construction phase. These efforts should be focusing on reducing noise from machines and other vehicles working at the construction site.

According to Hall et al. (1985), the response on noise is different depending on the source of noise, and sometimes a higher noise level is acceptable for some sources. Furthermore, if an activity, especially speech or sleep, is interfered, then the noise causing the interference will be significantly more disturbing. On the other hand, a person can also be disturbed by noise if the presence of the noise is disliked; disregarding the intensity and the interference it creates.

Dust emissions

Dust emissions are defined by Tokmechi (2011) as "the introduction of chemicals, particulate matter, or biological materials that cause harm or discomfort to humans or other living organisms, or cause damage to the natural environment". Tokmechi (2011) adds that it is important to deal with the problem of dust emissions. High emissions of momentary dust are common in road construction and have a large effect on air quality in the area (Chang et al., 1999; Muleski et al., 2005). Moreover, momentary dust emissions from road work are related to work with blasting, ground excavation, and land clearing. Chang et al. (1999) state that dust contributes to the poor air quality in urban areas. Dust particles can cause irritation to eyes, nose and throat but are usually too big to be inhaled (GLA, 2006). Furthermore, a layer of dust may occur on cars, windows and properties and effect the satisfaction of affected people. The indoor air quality in the near area of a construction site could also be affected by dust. In order to protect the health and safety of both workers at site and people in the area, it is important to effectively measure and control dust from any activity that generates dust. Naturally, the drier the climate, the more important this factor becomes.

Safety of residents

According to Glass & Simmonds (2007), construction sites have a negative impact on health and the quality of life to the neighboring community. The main safety impacts stated by Hadi (2001) are; fear of health risks due to pollution and dust, accidents caused by falling materials or potholes, tripping caused by uncovered holes in the road or pavement, falls caused by poor lighting and uneven surfaces, as well as stress caused by the constant noise and disruption. According to Pantura (2011), the safety

of residents is measured by the number of accidents occurring within the area affected by the construction site, such as the number of pedestrian accidents or accidents that include a motorist or bicyclist.

Worker safety during construction

Not only the surroundings become affected by the construction activities, also the construction site as such poses a risk for the construction workers that needs to be considered. Road workers are subjected to the risk of lethal or serious injuries when working close to passing traffic, construction vehicles and machinery (Pratt et al., 2001). However the most dangerous issue is being hit by a third party vehicle (htma.co.uk, 2012). During the years 2003-2007, an average of ten roadwork accidents occurred monthly in Sweden, and numerous studies have shown that nine out of ten workers are worried about passing traffic (arbetsmiljoforskning.se, 2010). In order to avoid roadwork accidents with passing traffic, the Swedish Transport Administration demands that everyone located at a roadwork construction site shall wear fluorescent clothing that fulfills the requirements of the EU commission EN471 (Trafikverket, 2012). In addition, road workers need to be concerned about the behavior of drivers in passing vehicles, as 80 percent of British road workers have been physically and verbally abused by motorists (htma.co.uk, 2012). On the other hand, a study showed that Swedish workers have significantly lower injury statistics than for example Danish workers, when comparing lost-time injuries per million working hours in a cross-nations infrastructure project (Spangenberg et al., 2003). In the Pantura report (2011), worker safety during construction is measured by the number of lost days because of accidents or disease caused by work.

Vibrations

Vibrations consist of wave motions that propagate through the ground. In a construction project there are many sources of vibrations, such as; ground compacting, operating heavy machinery, blasting, and pile driving (Abesiktning Väst AB, 2011). This often causes problems with distraction for business activities, it creates irritation in people, and there is also a risk for damage on buildings (Svinkin, 2004). In addition, the vibration levels increase the higher up in the building a floor is located (Xia et al., 2005). Even though there has been little research on how humans respond to vibration from construction (Hanson et al., 2006), it is clear that the sensitiveness for vibrations is relatively high for humans (Boverket.se). According to Svinkin (2004), there are possible negative effects from construction vibrations and residents should be notified of the influence it has on them. Furthermore, the effects from vibrations are unique to each construction site and depend, among other things, on vibration sources, soil conditions, and layout of surrounding buildings.

3 Methodology

A combination of methods for data collection was used in order to gather as many perspectives as possible. A qualitative research method, which is a method that provides describing data, was used. It is used in order to show the context, and create a deeper understanding for the problem (Olsson & Sörensen, 2007). A case study of an urban infrastructure project was made in order to map disturbances of the surroundings. In order to receive as much information concerning the project as possible, the site manager was interviewed during one hour at the startup of the project. To collect information about what people are disturbed by during construction work in an urban area, 63 persons were interviewed in connection to the project Hagastråket. Some of the interviewees fit into several groups as they for example may be residents, pedestrians and business owners, therefore the total number of interviews are 133. Semi-structured interviews were conducted in order to have flexible interviews and be able to follow up answers with new questions, and therefore create a larger understanding of the interviewees opinions. Every interview lasted for about three to ten minutes. A sheet with questions was prepared prior to the interviews. This was in order to ask everyone the same questions and to easily compare answers among the different groups of people being interviewed. Among the 133 interviews there were road users, such as 38 pedestrians, 8 bicyclists, and 28 motorists, as well as 17 residents, 37 shop and restaurant owners or representatives, and 5 construction workers. People being interviewed were divided into these groups in order to make it easy to see if answers differed between different kinds of people that are affected by disturbances from the construction site. As all the interviewees were informed that they would be anonymous in the report, it allowed them to speak more freely. This was in order to receive a result that is as close to the reality as possible. Moreover, the case study included observations so that a wider perspective could be considered. The case study observations are an explanation of what was seen and experienced at the construction site and the surrounding area. The unstructured observations were made between interviews at locations along the project. This was for the authors to get an own opinion about the disturbances.

A literature study was conducted, based mainly on scientific articles, books, and master theses in order to have a solid foundation when executing the study. During the initial phase of construction, the construction project was mentioned frequently in the local newspapers. These articles concerning Hagastråket have been studied. Furthermore, a work site meeting was attended where part of the meeting concerned the vibrations chapter in the risk analysis.

Analysis of the data collected was made in order to see what conclusions could be made and what answers could be found to the research questions. The answers from the interviews were compared to the literature study to see if there was any connection between what has been said before and what was found in our case study. From this analysis, conclusions could be made and answers could be found to the research questions.

4 Research findings

4.1 Case study at Hagastråket

Hagastråket is an infrastructure project located in the center of Gothenburg, Linnéstaden, along Övre Husargatan and Sprängkullegatan (Figure 1) and is a part of the West Swedish Solution (Goteborg.se, 2012).

Figure 1. Geographic overview of the project 1. Linnéplatsen, 2. Linnégatan, 3. Skanstorget, 4. University of Gothenburg: School of business, 5. Hagakyrkan. © Lantmäteriet permission I2012/0021.

The task is to build traffic lanes for busses, in order to ensure the development of the public transportation that will take place due to the introduction of congestion charges, which is a part of the West Swedish Solution (Goteborg.se, 2012). Furthermore, the street is supposed to be turned into a city street with less traffic (Figure 2). For car traffic, there will be one traffic lane in each direction instead of the former two. The construction of the bus lane is set to be finished in December 2012, prior to the introduction of congestion charges that will take place in January 2013. The whole project will be finished during fall 2013.

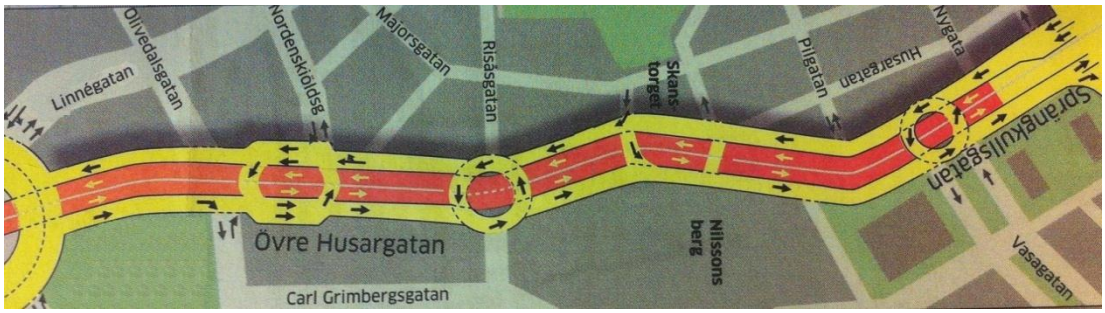

Figure 2. Illustration of the finished project, where red represents the bus lanes and yellow represents car lanes, with north to the right in the picture. © Göteborgs-Posten.

According to the client Trafikkontoret (2011), it is important to decrease disturbances as much as possible, since there are a lot of people living in the area. Furthermore, traffic disturbances should be minimized and the client emphasizes the importance of creating temporary traffic solutions, in order to allow a continuous flow of traffic.

Information was provided by both the client and the contractor to property owners, people living close to the project and business owners, regarding disturbances and other inconveniences due to the construction work (Trafikkontoret, 2011). Before construction began there were already existing problems with traffic noise along Övre Husargatan, and even if there will be less traffic in the future, the vehicles will be of different types and the level of noise will most likely remain the same. Furthermore, most of the noise disturbances that will occur during construction are due to transportation at and to the site.

On the night between Monday the fifth and Tuesday the sixth of March 2012, the traffic was directed to the east side of the road, with one traffic lane in each direction instead of two. The entire west part of the road, stretching from Linnéplatsen to Gothenburg University: School of business, is closed off in order for NCC to work on an area as large as possible. The reason for starting work on the west side is due to the crucial water and sewage connections located there, according to the site manager. When construction on the west side is completed in July-August 2012, traffic will be directed to the west side of the road and the construction work will be executed on the east side (Figure 3).

Figure 3. Timeframe for the project.

As the west side of the road is closed, the area is considered a work site and is fenced off in order to keep people, cars, and bikes out. Though cars and bikes will be using the east side of the road as well as the east bicycle path, pedestrians will be allowed on the west side. This is done by creating a temporary sidewalk lined with crush barriers alongside the facades of the buildings (Figure 4). However, as the construction work proceeds, the temporary sidewalk will be moved away from the facades and out into the working area, in order to allow work being performed alongside the buildings.

In a couple of places, the work site is divided by crossroads and pedestrian crossings that cut through the working area. According to the site manager, the most important crossing, from a safety point of view, is the crossing at Risåsgatan/Brunnsgatan (Figure 4). This is increased by the large number of school children crossing the street daily. In order to make the passage safe, a pedestrian crossing with flashing lights has been installed at the crossing of Risåsgatan. In addition, there is a fenced passage through the working area, and a traffic light crossing lined with speed bumps at the two open lanes of Övre Husargatan.

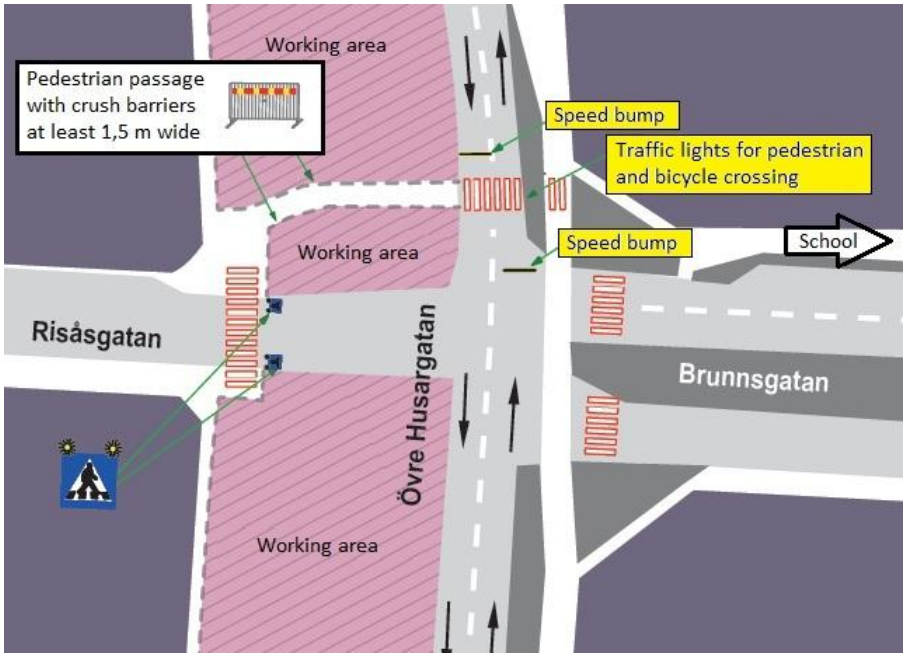

Figure 4. Overview of the pedestrian crossing at Risåsgatan and Brunnsgatan. © Göteborgs stad.

Construction work started with excavators raveling asphalt and removing the street refuges, according to the site manager. Work will simultaneously be conducted in both north and south of Skanstorget, where the site office is located. Excavators normally keep three trucks going every hour so there will be at least nine trucks going through the working area every hour during some stages of production. Waste material will be delivered to different locations, depending on type of waste and the

location of the excavator in the working area. Furthermore, the trucks will drive inside the working area as far as possible. This is to minimize the disturbance of traffic in the area. In order to maintain a tidy and organized working area there will be a small wheel loader assisting the movements of materials.

Hagastråket in newspapers

There have been several articles in the local newspapers in connection to the startup of the project (Figure 5). Several interviewees did not know about the project until they read about it in the newspapers the same day as construction started. When reading the articles, it is clear that several of them have a negative approach to the project, while some are more informative about what is going to happen and what benefits there are going to be in the future.

Figure 5. Articles in the local newspaper Göteborgs-Posten. Headlines state (from left to right); Count on traffic chaos for months (2012-03-06), Customers fleeing the chaos (2012-03-16), Setback for rising district (2012-03-16). © Göteborgs-Posten.

4.2 Case study findings

Mobility

The degree of mobility is limited during the construction time. The excavators started work on the west side of the road. This upset the restaurant owners on the west side since they would not be able to set up tables on the outside of the restaurants as they usually do during summers. Permission to serve outside restaurants is to be approved by Trafikkontoret, who also is the client of the project. Some restaurants got their approval and have already paid for this season but they still will not be allowed to use it. There has been a lack of information provided by the client, and angry restaurant owners have contacted NCC and questioned the decision to begin working with the

west part of the road. The reason why the project started on the west side was because the connections to water and sewage are located on that side, and needed to be handled early on in the project.

The traffic is highly affected by the construction, since two of the four lanes will be removed. On the first day of the project, there were long queues in the morning during rush hours. However, when the new street is finished there will be only one lane in each direction, the difference is that there are new lanes for busses.

Mobility has also been decreased in terms of available parking lots. All space for parking was removed along the west side of Övre Husargatan during the start of the project. Furthermore, shops are affected by the close off with deliveries of goods, since it is not possible to deliver the goods as normally done. There will, during the construction, be a few spots at the intersections where deliveries to shops and restaurants can be made. From there they will have to carry their goods. If the business owners along the road require any other delivery or service, it is possible but then they will have to pay a fee to NCC.

When asking people walking through the area, most of them think that the mobility is as good as before the construction started. They are not at all disturbed by mobility. The sidewalk is not closed, which means that the area for walking is the same as it was before. People traveling with bicycles are more affected since the cycle way on the west side is closed. However, this did not seem to bother them very much. Some had the opinion that there could be more signs in order to make it clearer on where they should go.

One group that was somewhat disturbed by decreased mobility was people going by car. Most of them said that the time to get through was longer now then it was before. Some of them have to take other routes now and the parking lots are a lot fewer than before. Trucks coming to the area to deliver goods to different shops and restaurants now have problems with mobility, according to interviewees. There are a few spots at the intersections where they can park and unload, but some of them have to carry the goods to the shop or restaurant, and the distance is much longer now than before. This is due to the removal of the delivery zones along the main street. Additionally, the recycling trucks have problems with collecting waste in the different properties. People living in the properties now have to carry their waste to containers where the recycling truck is directed to collect it. For some residents this means carrying their disposal more than 100 meters.

When talking to business owners and representatives, they think that mobility has become worse during construction. The thing that is most disturbing to them is that they have fewer customers since their customers have fewer parking lots. According to some business owners their customers do not come because they have read in the newspapers that there are no parking lots, even though there are.

Observations made at site was that mobility for cars and trucks are far worse now than it was before, but for people walking and going by bicycles it is more or less the

same. Problems caused by construction, with having two traffic lanes instead of four, do not seem to be a big issue. The increased travel time due to the removal of two lanes will remain after the completion of the project, since the new road only has two lanes for car traffic. At some places along the close offs, depending on which side the construction site was approached, there were no signs of direction. This could cause some confusion for the road users, especially for bicyclists.

Noise

Main sources of noise at this stage of construction are excavators, transports with trucks, and machines working with packing. There are measurements executed of airborne noise when excavators are working, and additional measures in case of any complaints (Abesiktning Väst AB, 2011). There are regulations on how to manage the measurements and what kind of equipment to use.

Interviewees walking through the area, going by bicycles or cars were not disturbed by noise. However, business owners are somewhat disturbed by it, especially when they have the shop doors opened. These people spend a lot more time in connection to the construction site than people passing through do. Interviewees living in connection to the construction site were not disturbed by noise in general, since the construction work is mainly carried out during hours when people are at work. However, a few residents pointed out that it is disturbing when noisy work starts as early as 06:30.

What could be observed at site was that during certain times of day, the noise was high and it was hard to hear what people said during interviews. However, this was during short periods of time and was not disturbing to a great extent. Most of the time, major part of the noise came from the bypassing traffic.

Dust

When construction work is executed, dust and clay should be avoided on the street and therefore roads that are connected to the working space should be cleaned when needed (Abesiktning Väst AB, 2011).

Dust affects different groups of people in different ways. People, who are passing through the area, either by foot, by bicycle or by car, are not affected by dust from the construction site. The answers when asking people about dust who are working or owning shops and restaurants, differed a lot. Some said that they were disturbed by dust and that they would not be able to have their doors opened due to it. They also thought that it would become even worse when the temperature starts to rise and the climate in the store or restaurant is too warm to have the doors closed. Some people said that it is the same amount of dust now as it was before construction started, and most interviewees were not concerned with dust.

Observations made when asking people about dust were that the answers differed for each person and it did not depend on the geographical position of the store or restaurant, but that different people have different opinions. During one day when observations were made, the weather was sunny, dry and the wind was blowing. This caused a greater amount of dust then the other days of observations (Figure 6). The source of the dust was mainly excavators and trucks.

Figure 6. Dust blowing at the construction site.

Safety of residents

The answers from people interviewed about safety around the construction site differed a lot. Some had the opinion that the safety is better now, since they only have to cross two traffic lines instead of four, and that the cars do not drive as fast as they usually do. Some said that it is worse now because people going by cars do not stop at the pedestrian crossings. A few people think that it is a bit unclear on where they are supposed to cross the street. Several interviewees said that the safety became worse when traffic lights were removed, and that there is just one crossing left where there are lights. Some people said that they had not thought about the safety or are not affected by it. The opinions differed equally among the groups interviewed.

When observing the safety around the construction site, there was an excavator loading a truck over the pedestrian crossing, while people were crossing the street (Figure 7). One worker from NCC, responsible for this task, controlled the situation by stopping the excavator anytime there was someone crossing the street. When asking people who were crossing at this time, all of them felt safe and trusted that the workers knew what they were doing.

Figure 7. Excavator loading over the pedestrian crossing.

Other observations concerning safety were that the close offs made along the project are well done, yet sometimes a bit unclear depending on from where the work site is approached. However, some bicyclists ignored the close offs and signs and could be seen inside the area of construction.

On the 14th of April the local paper Göteborgs-Posten (Lövkvist & Pavlica, 2012) reported on a fatal accident including a truck and a bicyclist at the project Hagastråket (Figure 8). The accident occurred at the intersection of Övre Husargatan and Brunnsgatan, as a truck crossed the bicycle path and the bicyclist ran into the side of the truck (Wallin, 2012). According to Wallin (2012) the police report showed there is no evidence that the cause of the accident was related to the construction site.

Figure 8. Articles in local paper Göteborgs-Posten concerning the accident. Headlines state (from left to right); Fatal bicycle accident in the city's traffic chaos (2012-04-14), Road work increases risks (2012-04-14), No violation of the law behind fatal accident (2012-05-04). © Göteborgs-Posten.

Worker safety during construction

When talking to the construction workers about how they perceive the safety when working with this infrastructure project, most of them thought that the safety is

satisfactory. However, they also said that it is not reasonable to compare an infrastructure project to a house building project, since the safety there is much higher. A few of the workers mentioned that the traffic goes by close to their working space, which is decreasing the safety (Figure 9). They also said that it is hard to trust the people around the working site, especially people going by cars. Therefore, it is important for the workers to watch out for themselves.

As mentioned before, some people going by bicycles were traveling inside the working area, which makes it stressful for the workers. When observing safety for the workers, it seems relatively safe, mainly because the close offs are well executed. However, when traffic is close to the workers, there is always a risk.

Figure 9. The construction worker to the left is working close to bypassing traffic.

Vibration

At project Hagastråket there are different values for what are acceptable levels for different properties (Abesiktning Väst AB, 2011). In order for the levels of vibration to stay acceptable, there will be measurements executed continuously. If there are any complaints on vibrations made to the client, then the client will provide a control measurement of the relevant property. If there for some reason are levels higher than acceptable, then the contractor will make such arrangements that specified levels can be kept. Vibrations due to demolition work can cause damage to certain computers or servers, which are rather sensitive to vibrations (Abesiktning Väst AB, 2011). Therefore, during demolition work at the project, there should be some isolation for

vibrations made on applicable equipment within the range of 75 meters if it is possible.

Vibrations is a disturbance that has not had an impact at this stage of construction. No one of the road users were disturbed by it. Some business owners fear that there will be more vibrations further in the project, but are not disturbed by it at the moment. One resident had the opinion that vibrations are somewhat disturbing, since it made his bedroom vibrate due to a vibrating plate working close by.

Observations that were made could not show that there would be any problems with vibrations at the moment. Machines that were active and working during the observations were excavators, trucks, and vibrating plates, and with exception from the vibrating plate, these machines did not cause much vibration.

Other disturbances brought up by interviewees

Additional disturbances that were discovered during interviews and observations at the construction site were lack of information and idle worksite. These will be discussed briefly.

Lack of information

A discovery that was made was that lack of information was highly disturbing to people in the area, especially to the business owners. Most of them said that they received information between one and two weeks before construction work started, and that they could read about it in the local newspaper the same day the construction began. There was an information meeting ten days before the project started where business owners were invited. When talking to those attending the information meeting they thought that the information was good, but most of them would have liked to get the information about six months earlier in order to be better prepared. Some measures mentioned by the business owners were downsizing or closing for refurbishment. The ones, not disturbed by lack of information were those who had collected the information themselves. A few of the owners of shops and restaurants have been reading and asking about the project earlier, and therefore they were well informed about the construction work. The same day the construction began, sheets with information about the project and the closing of certain areas at the construction site were handed out at one of the pedestrian crossings. This was mostly for children and their parents, since there is a school nearby and they walk through the area every day.

Idle worksite

The other discovered disturbance was when the worksite is idle. This is something, when answered by people interviewed, that is not very disturbing. Just a few of the interviewees said that it is disturbing that NCC have closed off a huge space but are

not working in all areas at the same time (Figure 10). Some thought that it should be possible to close one part at the time, and finish the work in one area before the construction in the next area begins.

Figure 10. A closed off idle worksite.

5 Analysis and Discussion

During the time of observations and the interviews, the construction site was still at an early stage of production. This could have had an effect on the interview responses, as people have not got used to having a construction site in the area. There is a possibility that the acceptance increases as the project advances. The increasing acceptance would probably be among the business owners, as they begin to see an end of the construction work and the improvement to the area that the project hopefully brings. Some business owners did already point this out in their answers, how the short-term decrease in customers will be overshadowed by the long-term gains. Especially when comparing with Linnégatan that has a similar layout, which has turned out to be successful. On the other hand, there is a possibility that people such as residents and road users get tired of having a construction site in the area. Presumably, this will get worse with time. However, the studied case has a narrow timeframe which decreases the risk of people running out of patience. Another point to emphasize is that the answers from the interviewees reflect how they experience the disturbances.

Mobility

As mentioned before, the travel time is affected by the construction work and several people going by car choose to take a different route (Pantura, 2011 and Bootsma et al. 2006). This was something that affects business owners in particular, since their customers take different routes and cannot get there as easy as they did before the construction started. As their source of income is affected by the project, they tend to be disturbed by decreased mobility. When talking to other groups, they are not at all as affected by decreased mobility. People that are going by car have some difficulties with mobility, but not that many of them are disturbed by it. The level of mobility will probably be the same throughout this year. However, when the traffic lanes for busses are completed by the end of the year, the mobility will increase for busses, pedestrians, bicyclists, and residents but not for car traffic. Though, after some time, when people find new routes and accept the new layout of the street, mobility for car traffic will probably not be a problem.

Noise

The work carried out so far consist of excavation work throughout the construction site, soil compacting, as well as transportation with trucks. Future work will include asphalt spreading, which increases the levels of noise and vibrations according to the site manager. Excavators are loud machines and when digging in the ground, noise levels can increase further. Therefore, efforts should be made to reduce the noise from machines and other vehicles working at the construction site (Boverket.se, 2012). However, when observing at the site, the main source of noise was the traffic, which probably is the reason why the interviewees answered the way that they did. This

aligns with Hall et al. (1985), who claim that the source of noise and personal opinions are what determines how people are disturbed. Overall, noise is something that is not very disturbing to people at this moment. A reason for this could be that people tend to accept noise when they see that construction work is progressing or simply that people expect noise at a construction site. In addition, people in the area could be used to noise, due to the loud traffic. Probably, noise will tend to get more and more disturbing when being exposed to it over a long time. Therefore, it is possible to assume that shop and restaurant workers, who are the ones that spend the most time at the construction site, will be more disturbed by noise the longer it goes on.

Dust

Dust is a disturbance where opinions differ a lot between business owners interviewed, some are really disturbed by it, and others have not given it a thought. A reason why they have different opinions could be that some restaurants and shops usually have their doors opened when the temperature is high outside, and some do not. Those who have their doors opened are therefore more affected than those who have them closed. Chang et al. (1999) state that dust contributes to the poor air quality in urban areas, and according to Greater London Authority (2006), the indoor air quality in the near area of a construction site could also be affected by dust. However, when doing observations at the project, there was not much dust at this stage of the project. Probably, there will be much dust around the site if the weather gets really warm and dry, and this would most likely happen during the summer.

Safety of residents

Safety of residents is considering the safety for people who are in the area of the project. Even in this category the opinions differed a lot. Reasons for this could be that different people consider different aspects when thinking about safety. Those who were positive to the safety said that now there are only two traffic lanes to cross instead of four, while those negative to the safety said that the cars do not understand that they have to stop at the pedestrian crossings, since there are no traffic lights there. If all interviewees considered the safety due to traffic lights, then there might be more similar answers. However, no one of the interviewees reflected on the other safety impacts, which Hadi (2001) defined as fear of health risks due to pollution and dust, accidents caused by falling materials or potholes, tripping caused by uncovered holes in the road or pavement, falls caused by poor lighting and uneven surfaces, and stress caused by the constant noise and disruption.

Worker safety during construction

The responses from talking to the construction workers were rather similar for everyone asked. All were satisfied with the safety except that the traffic was passing close to their work site. According to Pratt et al. (2001), road workers are subject to the risk of lethal or serious injuries when working close to passing traffic. During the years 2003-2007, an average of ten roadwork accidents occurred monthly in Sweden (arbetsmiljoforskning.se, 2010). According to several of the workers, they have not received any negative comments from people in the area who seem to think that they are only doing their job, in contrast to what British road workers may be exposed to (htma.co.uk, 2012). However, a few by-passers have expressed some dissatisfaction with the client's way of providing information.

Vibrations

Vibrations are at this stage only disturbing to residents, which live in the buildings along the construction site and according to Xia et al. (2005), the higher up in the building, the worse vibrations get. The reason why some business owners fear that vibrations will get worse in the future could be because they expect vibrations at a construction site, or it could be that some future work will demand machines that cause more vibrations then those that are used today. This is conformably with what Svinkin (2004) stated about vibrations being a distraction for business activities, and that it irritates people.

Lack of information

The disturbance that was most obvious when talking to people and the one that they were most disturbed by is the lack of information. It is possible that this is not a disturbance by itself but when there is a lack of information people tend to be even more disturbed by the other disturbances of the surroundings. However, when interviewing people in the area who were disturbed by the lack of information, they had not necessarily reflected on the other disturbances. This is the reason why lack of information is treated as an individual disturbance.

It seemed that no one of the persons asked in any group had received what they felt were sufficient information about the project, which probably is the reason why we got the answers we got. To compare with those who said that they gathered the information themselves, it is possible this disturbance could be minimized if the communication between the client, contractor and those living, working, and traveling through the area of construction was improved.

Idle worksite

An idle worksite was not disturbing to many of the interviewees. This result could be because those disturbed by it thought that NCC could make smaller close offs and finish the work at small areas at the time. According to NCC, this would take a longer time, and since the schedule is tight and the time is short, it is necessary to work on such large area as possible at the same time.

Further discussion

An observation made when interviewing people were that opinions within the same group of people could differ enormously. People have different backgrounds, different perspectives and attitudes, which most likely is the reason why the answers differed.

Some disturbances are worse than others. Probably, this depends on who the persons are and their perspective and background. Also, some disturbances could have less impact on people and their lives than other, and are therefore more or less acceptable. Table 1 is an evaluation on how much impact the disturbances have had on each target group, based on the authors' assessment of interviewee responses.

	Mobility	*Noise*	*Dust*	*Safety of residents*	*Vibrations*	*Lack of information*	*Idle worksite*	*Total/ group*
Residents	●	●			●	● ●		5
Pedestrians	●			●		●		3
Bicyclists	●			● ●		● ●		5
Motorists	● ●			●		●		4
Business owners	● ● ●	●	● ●	●		● ● ●	●	11
Total/ disturbance	8	2	2	5	1	9	1	

Table 1. An evaluation on how much impact the disturbances have had on each target group (levels of impact are ••• = large impact, •• = medium impact, • = low impact, = no impact).

Lack of information is the disturbance that affects most people and is probably the easiest to minimize. Safety for both residents and workers is of most importance in order to exclude accidents. Some disturbances could be hard to decrease, such as noise and vibrations but it is important to strive at decreasing all disturbances as much as possible. All stakeholders can benefit from decreased disturbances of the

surroundings. The contractor, NCC in this case, could increase their competitiveness if it is known that they consider and try to minimize disturbances of the surroundings. The client would benefit from using a contractor that does not cause too much disturbances, since they are ultimately responsible for the projects and receive most of the complaints. Consequently, everyone in the surrounding of the construction site would benefit from decreased disturbances.

Hagastråket is a project that has been well observed by local newspapers. This causes awareness about the project among people. Moreover, it is possible that people who read the papers get an angled perspective, and in some cases, an incorrect opinion about the project and its disturbances. As an example mentioned before, there are customers who believe that there are no parking lots in connection to the store they tend to visit, even though there are. This could possibly be as a result of the articles in the newspapers. Day one of construction, the local paper Göteborgs-Posten was present with a journalist in order to pick up different opinions from people in the area. Their result that day was that a little more than half of the people had a positive attitude to the project.

A question that occurred was if disturbances could be minimized if people collected information about the project on their own. Since lack of information is disturbing to most people, they would most likely be less disturbed if they gathered information about the project in advance. This is proven when talking to people who have been collecting information themselves, as they are not at all as disturbed as other people.

Another question is if it would be possible to reduce the disturbances of the surroundings if smaller areas of the construction site are cut off, and that they finish the construction work in one area at the time instead of working on a huge area as they do in this project. The risk is that construction time would be significantly longer and that this would increase irritation the longer construction continues.

6 Conclusion

The purpose of this thesis is to identify and map the disturbances of the surroundings in an urban infrastructure construction project.

To collect information about what people are disturbed by during construction work in an urban area, 63 persons were interviewed in connection to the project Hagastråket. In addition, the case study included observations so that a wider perspective could be considered.

Disturbances located at the studied case and that affect third person are mobility, noise emission, dust emission, safety for residents, worker safety during construction, vibration, lack of information, and idle worksite.

This study confirms that it is not possible to do construction work in an urban area without causing disturbances of the surroundings. This is due to the fact that different groups of people are disturbed by different things. Opinions also differ within the groups and this is because different people have different backgrounds and perspective on their environment.

From the results when talking to people and making observations at site, the disturbance that has the largest impact is the lack of information. Therefore this disturbance, in combination with mobility, is of high interest when working on minimizing disturbances. The disturbances that have the lowest impact at this stage of this particular project are vibrations and idle worksite.

The group that is most affected is the business owners. Furthermore, this group is also frequently appearing in media providing their opinions to the public. Therefore the opinions of this group reach more people than other groups' opinions.

The construction workers from NCC had not received any negative comments; most people understand that they are doing their job. Comments have been made regarding the client's way of dealing with information, mostly due to that people did not receive any information until very close to the startup of the project. There was also no one of the interviewed who could think of anything that NCC could do to further reduce the disturbances of the surroundings. A conclusion from this is that the client could improve by providing information earlier than what was made in this project.

A significant conclusion made from the case study, due to the variation in interview responses, is that disturbances are often something perceived and depend on the person exposed. Therefore, the answers from the interviews differ depending on the interviewees' attitudes.

When having a large project in an urban area, there are a lot of people who are affected by it, whether they like it or not. Therefore, it is important that everyone show respect for one another because in the end, the idea is to make the city better for the residents.

6.1 Further studies

Firstly, it would be interesting to continue the studies at the same construction site in a later stage of construction in order to see if there have been any changes in opinion among people interviewed. Moreover, it would be interesting to see if there are disturbances that has increased or decreased in the end of the project.

Another idea for further studies would be to perform the same study in a similar project in order to see if our results are valid or not.

In order to measure the impact of disturbances of the surroundings, it would be interesting to investigate the connection between the disturbances of the surroundings and waste in construction.

With this master thesis as a base, it would be possible to continue to study if there are any possible solutions to reduce how disturbances of the surroundings are perceived.

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