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FACULTY OF TRANSPORTATION SCIENCES

Bc. Jakub Matějček

MODIFICATION OF CROSSROADS ON ROADS III/0063 AND III/2384 AT VELKÁ DOBRÁ

Master thesis

2019

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Bc. Jakub Matějček

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Vedoucí diplomové práce: **doc. Ing. Jiří Čarský, Ph.D.**
Ing. Josef Filip, Ph.D.

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L. S.

Ing. Martin Jacura, Ph.D.
vedoucí
Ústavu dopravních systémů

doc. Ing. Pavel Hrubeš, Ph.D.
děkan fakulty

Potvrzuji převzetí zadání diplomové práce.

Bc. Jakub Matějček
jméno a podpis studenta

V Praze dne ..... 17. prosince 2018

Preface

Here I would like to thank to all the people, who supported me and helped me to successfully complete this master thesis. To my supervisors, who helped me all the way through my studies in Prague up to this point, where I am putting my Master Thesis forward. To doc. Ing. Jiří Čarský, Ph.D. for professional guidance of my master thesis and for being helpful with administrative matter throughout my studies. To Ing. Josef Filip, Ph.D. which always put me in the right direction when working on my thesis. To my colleague at work Ing. Milan Tesař, who willingly became my mentor and his experience and expert knowledge helped me to produce this project with a very high level of precision. And last, but not least the most important thanks belong to my family for a moral and material support I have received throughout my studies.

Declaration of independent work

I hereby submit for my assessment and defense a master thesis elaborated at the end of my studies at the CTU in Prague, Faculty of Transportation Sciences.

I declare that I have elaborated the submitted work independently and that I have stated all used information sources in accordance with the Methodological Guidance on Ethical Preparation of University Final Theses.

I have no serious reason against the use of this school work within the meaning of Section 60 of Act No. 121/2000 Coll., on copyright, on rights related to copyright and on amendment to certain acts (Copyright Act).

In Prague, 28. May 2019 .....

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Prohlášení

Předkládám tímto k posouzení a obhajobě bakalářskou práci, zpracovanou na závěr studia na ČVUT v Praze Fakultě dopravní.

Prohlašuji, že jsem předloženou práci vypracoval samostatně a že jsem uvedl veškeré použité informační zdroje v souladu s Metodickým pokynem o etické přípravě vysokoškolských závěrečných prací.

Nemám závažný důvod proti užití tohoto školního díla ve smyslu § 60 Zákona č.121/2000 Sb., o právu autorském, o právech souvisejících s právem autorským a o změně některých zákonů (autorský zákon).

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Bc. Jakub Matějček

CZECH TECHNICAL UNIVERSITY IN PRAGUE

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MODIFICATION OF CROSSROADS ON ROADS III/0063 AND III/2384 AT VELKÁ DOBRÁ

Master thesis

May 2019

Bc. Jakub Matějček

Abstract

Presented master thesis deals with a layout of two intersections at north and south entrance to the municipality Velká Dobrá. Issued intersections are 4-leg intersection of road III/0063 and ramp to a freeway D6 (in direction to Karlovy Vary) and 5-leg intersection of local streets and roads III/2384 and III/2385. Both intersections are located on the border of town residential area and rural area and due to the proximity of freeway D6 are strongly affected by transit traffic. The thesis deals with the analysis of the current situation and based on surveys made in the area, proposal of suitable adjustments in both areas is suggested.

Abstrakt

Předkládaná diplomová práce se zabývá prostorovým uspořádáním dvojice křižovatek na severním a jižním vjezdu do obce Velká Dobrá. Předmětné křižovatky jsou čtyřramenná křižovatka komunikace III/0063 a nájezdové rampy dálnice D6 (směr Karlovy Vary) a pětiramenná křižovatka místních komunikací a komunikací III/2384 a III/2385. Obě křižovatky se nacházejí na rozhraní intravilánu a extravilánu a vzhledem k bezprostřední blízkosti dálnice D6 jsou silně ovlivněny tranzitní dopravou. Diplomová práce se zabývá analýzou stávajícího stavu a na základě provedených dopravních průzkumů je vytvořen návrh vhodných úprav pro obě lokality.

Key words

Intersection, roundabout, municipality, entrance gate, urban area, rural area.

Klíčová slova

Křižovatka, okružní křižovatka, obec, vjezdová brána, intravilán, extravilán.

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List of abbreviations

LS	Local street
ČSN	Czech technical standard
TC	Technical conditions
N	North
E	East
S	South
W	West
NTC	National Traffic Counting
ADT	Average daily traffic
HGV	Heavy goods vehicle
ALF	Agriculture land fund
MP	Martial property
UM	Unit of measure
veh	vehicle

1 Introduction

1.1 History of the general research area

Transport is a dynamic field, that has always been an essential part of every society. No difference in place or time, there has always been the need to transport from one place to another no matter where and when was it. What set the difference with the stream of time was the way we transport things or ourselves from point A to B. Each time there had been a new form of transportation, it had an enormous impact on the whole society. More specifically, from our point of view, on the road network. With the invention of coaches, crooked, narrow, bumpy footpaths became more straight paved paths suitable for the needs of a vehicle with wheels. Similar transition began with the invention of a car. Paths became wide roads with firm surface and streets in cities suffered a dynamic transformation. Cities designed ultimately for walking became unsustainable. Streets changed from one level continuous area to segregated space with designated areas for pedestrians and vehicles how we know it today.

With the fast development of car industry over the last 100 years, the influence of car and its indispensability led the way we design cities. Cars became faster, roads wider and sidewalks narrower. Together with the rising level of urbanisation, degree of automobilization was going up as well and the situation in large metropolitan areas became unbearable. The number of accidents was rising, air pollution was high, and the quality of life was affected in a significant way. The need for change was inevitable. At the end of the last century, cities began to realize that they need to change the way they look at the design of cities and started to think about calming and restricting the traffic.

The term “Traffic calming” arose in the 90s and by that time a lot of cities had already begun to calm and restrict traffic in urban areas. Generally, traffic calming included physical measurements on local streets, calming of main and through roads, restrictions at the entrances to city centres, reduction of traffic and measurements at the entrance to the city.

1.2 Current state of the general research area

This thesis deals with two traffic calming fields that are connected together. Namely, calming of through roads and traffic calming measurements at the entrances to cities.

To justify the chosen research area, it is important to know the process most of the cities go through. Cities usually begin with the effort to calm the traffic down in city centres and historical areas. And then they move their focus steadily through the most

problematic areas inside of the city. Nowadays there is a large number of cities, that already have managed to understand the importance of those measurements, but they forget to deal with one of the most important things. They forget to calm the traffic, that is coming from outside of the city.

1.3 Objectives of this thesis

Objective of this thesis is to suggest and design a suitable traffic calming measurement at the entrance to the municipality Velká Dobrá. This suggestion will be based on a thorough analysis of the current situation and a meeting with the representatives of the municipality itself. Outcome of this thesis will be a convenient proposal that will aim to improve the traffic situation at the entrances to the urban area.

The outcome of this thesis should serve as a good basis for higher degree documentations.

2 Basic specification

2.1 Identification of the project

Subject to this thesis is a study of suitable adjustments of intersections in two areas of the municipality Velká Dobrá. Initiative to work out this project came from the municipality itself. It is dealt with intersections of very busy roads with a high importance for the whole region. The reason for this paper is such that the current design of those junctions is executed in an unsuitable way. Objective of this project is to design suitable adjustments in mentioned areas that would lead to a situation which is generally better arranged and clearer for drivers. Throughout the process of finding the right adjustments, there was an effort to come up with a solution optimal not only in terms of transport, but also from the urban point of view of a quality of the public area.

2.2 Localisation

Velká Dobrá is a municipality in the Central Bohemian Region in the district of Kladno, 4 km south-west from the city of Kladno. It spreads over the area of 8,42 km^2 and has around 1 800 inhabitants /1/. Both areas that are subject to this thesis are situated in the cadastral area of Velká Dobrá (cadastral territory 778303) on the northern and southern part of the urban area.

GPS coordinates of the middle of concerned areas are:

- North entrance (Rozdělovská x Kladenská): 50.1136211N, 14.0778006E
- South entrance (Berounská x D6): 50.1071331N, 14.0775539E

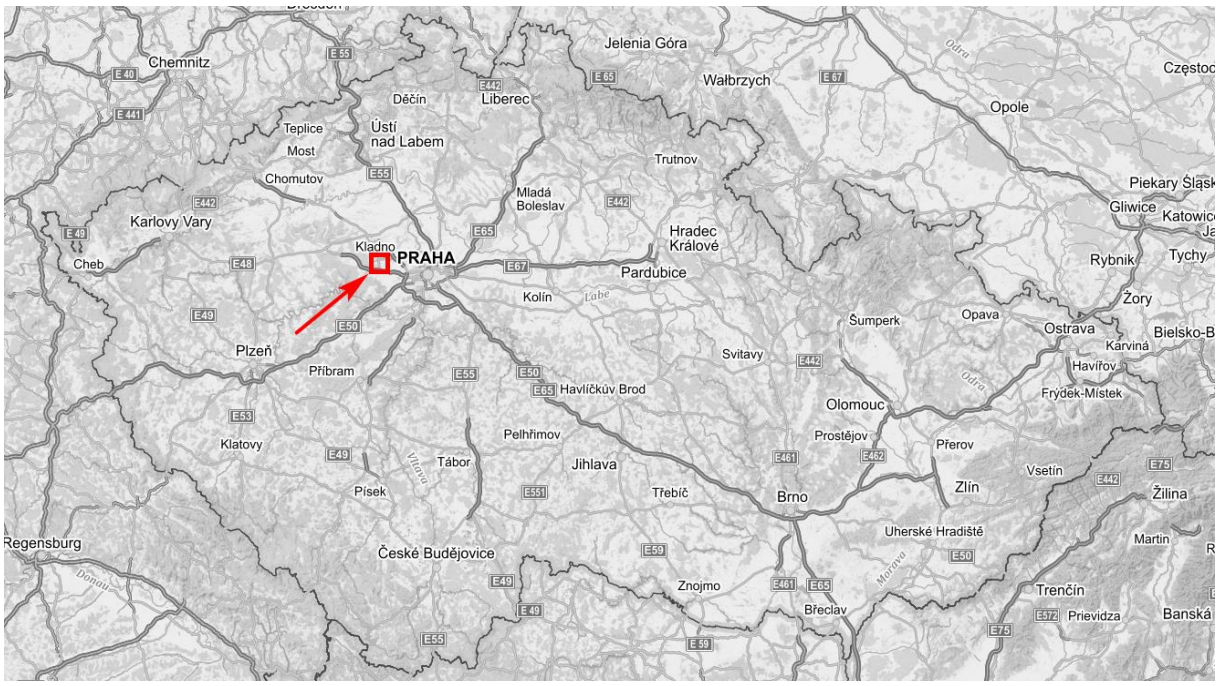

Figure 1 – Location of Velká Dobrá within the Czech Republic (source: /2/)

2.3 History of Velká Dobrá

The oldest written record is dated back to 1328, where Bohuslav from Dobrá is mentioned. For centuries there had been two villages, each with its own fortress. They were around 800 metres apart. One village, located in the south-west part of today's municipality, was from the 15. century called the Velká (Great) or also Hořejší (Upper) Dobrá. Whereas the second, situated in the north-east from Velká Dobrá was called Malá (Small) or Dolejší (Lower) Dobrá. Big increase of the population thanks to the development of mining industry in the area led to merging of both villages together. The administrative merging under the name of Velká Dobrá came in 1935. Over the last two decades, there has been a gradual development of new houses. /1/

It is noticeable from historical maps, that the street net of the area went with stream of time through a significant change. Particularly in terms of transverse permeability of the municipality. Based on the difference of two historical cadastral maps below, the influence of cars on the configuration of streets can be deduced. In the first picture, the main streets (paths) are coming from all directions together in the centre of the area creating a free space (square) for business and meeting of people. In the second picture, there is already noticeable the influence of motorised vehicles and the effort to segregate space, including the city centre. Interesting fact is that today's routing of roads in the surrounding areas of Velká Dobrá is exactly the same as the historical routing of pathways.

Figure 2 - Historic cadastral map from 1840 (source: */3/)*

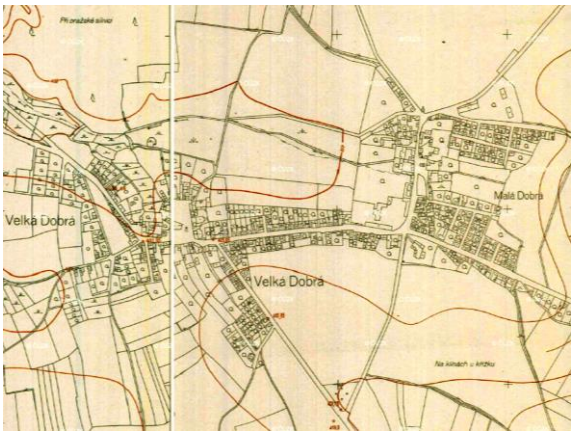

Figure 3 - Historic cadastral map from 1959 *(source: /3/)*

3 Background material

- Local investigation (December 2018)
- Speed survey (September 2016, May 2017, February 2019)
- Cadastral map ČÚZK
- Zoning plan of the municipality Velká Dobrá
- ČSN 73 6102. Projektování křižovatek na silničních komunikacích, Czech
- ČSN 73 6110 - Projektování místních komunikací, Czech
- TP 65. Zásady pro dopravní značení na pozemních komunikacích, Czech
- TP 85. Zpomalovací prahy, Czech
- TP 103. Navrhování obytných a pěších zón, Czech
- TP 133. Zásady pro vodorovné dopravní značení na pozemních komunikacích, Czech
- TP 135. Projektování okružních křižovatek na silnicích a místních komunikacích, Czech
- TP 170. Navrhování vozovek pozemních komunikací, Czech

4 Current state

4.1 Surrounding areas relationships

This thesis devotes to areas that are situated in the municipality Velká Dobrá. Velká Dobrá is very well accessible and well connected to the road network of the region, since it is in immediate proximity of a freeway D6, which offers fast connection with the capital city. It is also well connected with two direct roads with Kladno, which is the administrative centre of the district.

In terms of public transport there are 2 bus lines going from Prague and 2 bus lines going from Kladno. There is no railway going through Velká Dobrá, so residents depend on the road network of the area.

Intersections that are subject to this thesis are located at north and south entrance to the urban area of Velká Dobrá. On the north entrance, it is dealt with five-leg intersection of streets Rozdělovská, Lipová, Pod Zahrady, Kladenská and road III/2385. On the south entrance is the focus on intersection of Berounská street, exit of the freeway D6, road III/0063 and Unhošťská street. For easier identification, intersections are going to be referred to as intersections in the locality North and South (see figure 4).

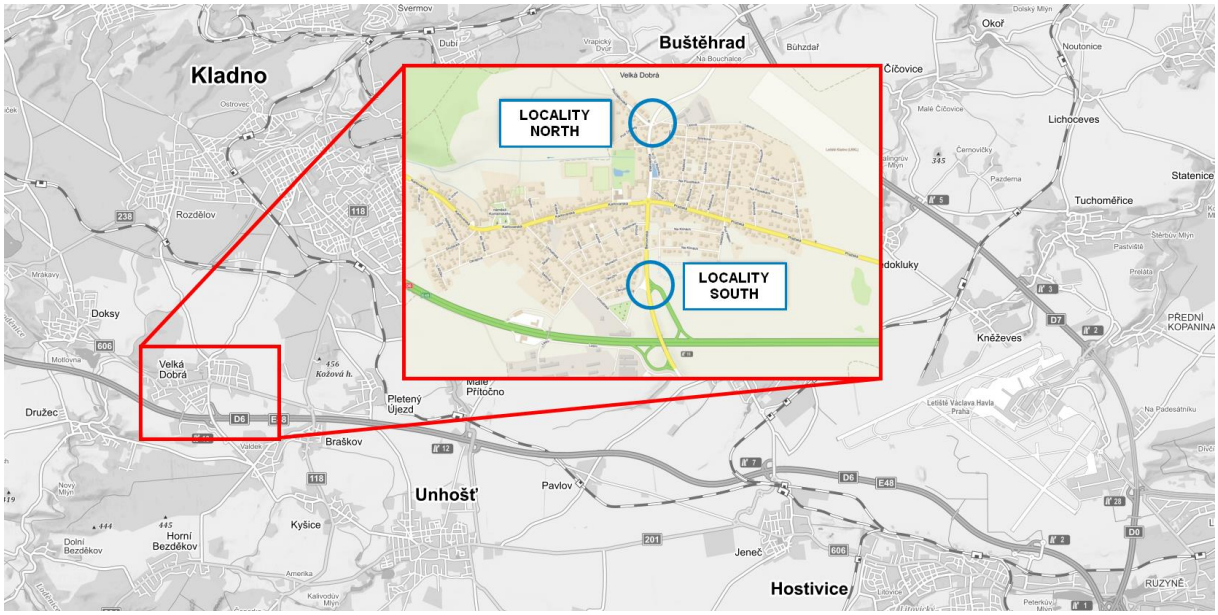

Figure 4 – Location of intersections within the municipality (source: /2/)

The figure above shows, how the city is divided with four through roads into four parts. These four streets that meet in the middle of the municipality are the most important and frequented streets in Velká Dobrá. Both intersections have therefore great importance for the city itself, since in between them leads the north-south through road.

Both junctions are also very important for the whole district, as inhabitants of nearby municipalities, particularly Kladno, are going through them to/from the freeway D6.

4.2 Spatial layout

4.2.1 Locality North

Intersection at the north entrance is located at the very border of rural and urban area. Junction is therefore kind of an entrance gate to the municipality, where there is a relatively distinct contrast between compact build-up area on one side and extensive fields on the other side. This contrast is unfortunately this strong only from the aerial photo (figure 5, 6).

Figure 5 – Aerial photo of the north entrance to the municipality (source: /3/)

Figure 6 – Vastness of the intersection (source: /3/)

From the point of view of the driver and pedestrian there is, because of the vastness configuration of the intersection, the impression of continuous continuation of the rural character. The driver is therefore not motivated to adapt his speed, which would be suitable for the urban character and the road leading to the city centre creates a barrier for pedestrians. This is clear from the pictures below (figure 7, 8).

Figure 7 – View at the entrance to the municipality (source: author)

Figure 8 – View at the way out from the municipality, direction to Kladno (source: author)

In the current configuration, the intersection has 5 legs that have following attributes:

a) The northern leg is at the entrance to the intersection 15 m wide with 3 lanes and has ditches and shoulders on both sides. Surface of the road is asphalt and is in a good condition.

Figure 9 – N leg, direction in (source: author)

Figure 10 – N leg, direction out (source: author)

b) The eastern leg is at its entrance 10 m wide with ditch and shoulder on one side and strip with bushes and sidewalk on the other side. Surface of the road is asphalt and is in a solid condition. Surface of the sidewalk is concrete pavement.

Figure 11 – E leg, direction in (source: author)

Figure 12 – E leg, direction out (source: author)

c) The southern leg is at its entrance 18 m wide with 3 lanes and sidewalks on both sides. On one side there is also green strip with couple of trees. Surface of the road is asphalt and is in a good condition. Surface of the sidewalk is concrete pavement.

Figure 13 – S leg, direction in (source: author)

Figure 14 – S leg, direction out (source: author)

d) The western leg is at its entrance 6 m wide with sidewalk on one side and green strip on the other side. Street has a short asphalt strip in a poor condition, which shortly turns into gravel and sidewalk is made of concrete pavement also in a very poor condition.

Figure 15 – W leg, direction in (source: author)

Figure 16 – W leg, direction out (source: author)

e) The north-west leg is at its entrance 10 m wide with gravel on one side and sidewalk on the other side of the road. Surface of the road is asphalt and is in a good condition. Surface of the sidewalk is concrete pavement.

Figure 17 – NW leg, direction in (source: author)

Figure 18 – NW leg, direction out (source: author)

4.2.2 Locality South

Intersection at the south entrance to the municipality has a quite different character. There is no direct connection to a build-up area, since the junction is outside of the border of the municipality (the sign of the beginning of Velká Dobrá is 70 m north from the middle of the intersection). Also, the houses located west from the junction are hidden behind a line of high trees. So, the intersection has a pure rural area character, which is noticeable from the aerial photo below. But that is with respect to the immediate proximity of the urban area not optimal. Absence of traffic calming elements is obvious from the photo in figure 22.

Figure 19 – Aerial photo of the south entrance to the municipality (source: /3/)

Figure 20 – Vastness of the intersection (source: /3/)

Safety issue here is worse distinguishability of the intersection. It means that it is hard to see the area of the intersection ahead of time when the driver is approaching. It is complicated for the driver to know what is coming, because the southern arm of the intersection finds itself an arch and drivers are not warned about the upcoming intersection. Similar situation is on the east arm (by the exit from freeway D6), which ascents and the junction is hidden behind the horizon. When putting together the proposal of changes, it is necessary to take these facts into account.

Figure 21 – Vastness of the intersection (source: author)

Figure 22 – Absence of traffic calming elements *at the entrance to the municipality (source: author)*

Figure 23 – Arch on the south arm before the intersection (sourc*e: author)*

Figure 24 – Ascending road at the exit from *freeway D6 (source: author)*

In the current configuration, the intersection has 4 legs that have following attributes:

a) The north leg is 16 m wide with 3 lanes at the entrance to the intersection with ditches and shoulders on both sides.

Figure 25 – N leg, direction in (source: author)

Figure 26 – N leg, direction out (source: author)

b) The eastern leg is 8 m wide with 2 lanes at the entrance to the intersection with ditches and shoulders on both sides.

Figure 27 – E leg, direction in (source: author)

Figure 28 – E leg, direction out (source: author)

c) The southern leg is 12 m wide with 3 lanes at the entrance to the intersection with shoulders on both sides. Also, there is a ditch on the right side and a footpath for pedestrians on the left side of the arm in the direction to the centre of the intersection.

Figure 29 – S leg, direction in (source: author)

Figure 30 – S leg, direction out (source: author)

d) The western leg is 8 m wide with 2 lanes at the entrance to the intersection with shoulders on both sides. Then there is a ditch on the right side and a sidewalk on the left side of the arm in the direction to the centre of the intersection.

Figure 31 – W leg, direction in (source: author)

Figure 32 – W leg, direction out (source: author)

4.3 Traffic volumes analysis (NTC)

To get a basic idea about traffic volumes in the area, data from National Traffic Counting (NTC) 2010 and 2016 were examined. The data showed that there is quite a big share of heavy goods vehicles in both localities. Mainly because of the location of the municipality, that finds itself in between freeway D6 and the city of Kladno, the biggest city in the district.

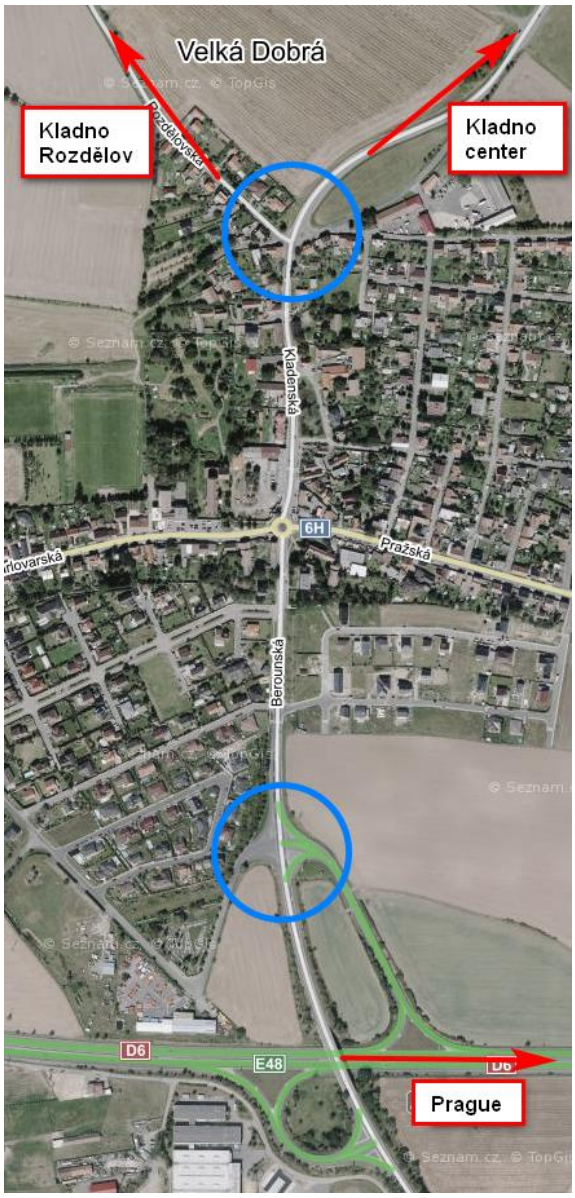

Figure 33 – Main destinations of transit in the area (source: /2/)

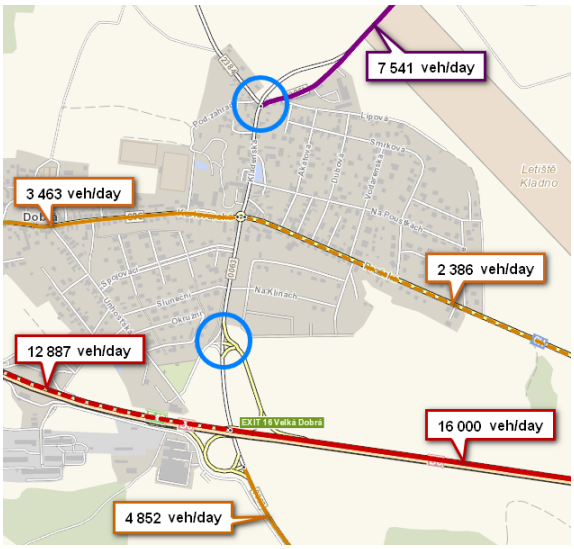

Figure 34 – Traffic volumes on chosen roads according to NTC 2010 (source: /4/)

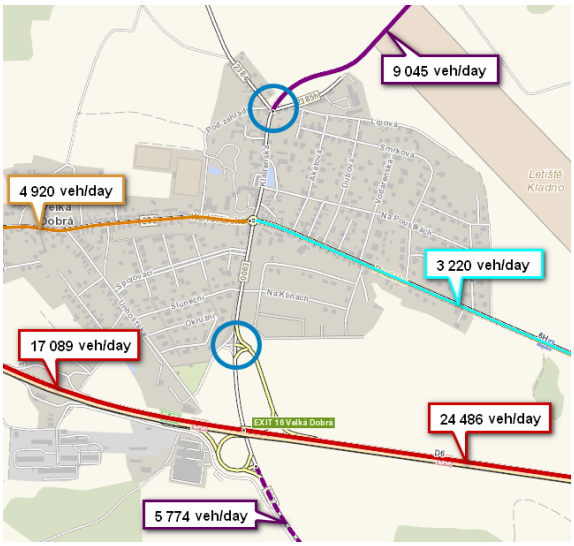

Figure 35 – Traffic volumes on chosen roads according to NTC 2016 (source: /4/)

On the road III/2385 in direction to Kladno centre was according to the NTC 2010 counted ADT 7541 veh/day, from which 10,1% was the share of HGVs. In 2016 the ADT counted was 9045 veh/day with the same share of HGVs. Remaining roads and streets, leading to the two intersections, that are subject to this thesis, were not taken into account in NTCs.

From the figures that are shown above, the upward trend of the total volume of traffic is clear. Traffic volumes raised from 2010 to 2016 in average by 34%. The share of HGVs remains still the same, which means around 10% from the total.

4.4 Traffic volumes analysis (own survey)

To have exact overview of traffic volumes and directions of traffic streams on both intersections, own survey was made. The survey took place on Tuesday 13. 11. 2018 from 6:00 to 21:00 in both localities. For having accurate results of the analysis, cameras were installed, and the video samples were afterwards examined and vehicles counted.

Unfortunately, there was a traffic closure on a ramp of the freeway D6 (direction Prague) during the survey, which may have an impact on the results of the survey. The closure started in summer 2018 and still lasts, so there was no way around it.

Vehicles were sorted according to 7 vehicle categories, so that we know about vehicle composition as well. (see next chapter)

4.4.1 Locality North

III/2385 x III/2384										
13.11.2018	Total number of vehicles									
Tuesday	Car	Van	Light truck	Heavy truck	Articulated lorry	Bus	Motorcycle	vehicles	% from total	Public transport
06:00 - 07:00	516	34	11	12	0	1	1	575	5,4	5
07:00 - 08:00	915	71	17	43	0	0	2	1 048	9,9	6
08:00 - 09:00	574	70	19	26	0	1	0	690	6,5	7
09:00 - 10:00	552	71	18	35	0	0	0	676	6,4	4
10:00 - 11:00	415	39	17	39	0	0	0	510	4,8	3
11:00 - 12:00	444	33	22	33	0	2	1	535	5,0	5
12:00 - 13:00	509	51	13	25	0	0	0	598	5,6	1
13:00 - 14:00	586	43	26	42	0	0	0	697	6,6	5
14:00 - 15:00	719	93	17	12	6	9	3	859	8,1	0
15:00 - 16:00	864	99	15	12	6	4	1	1 001	9,4	0
16:00 - 17:00	959	64	10	9	2	5	1	1 050	9,9	0
17:00 - 18:00	866	6	2	5	2	5	0	886	8,4	0
18:00 - 19:00	648	5	1	5	4	1	1	665	6,3	0
19:00 - 20:00	497	4	0	0	1	2	0	504	4,8	0
20:00 - 21:00	296	1	0	3	1	1	0	302	2,9	0
Σ	**9 360**	**684**	**188**	**301**	**22**	**31**	**10**	**10 596**	**100,0**	**36**

Table 1 – Results of traffic volumes survey in locality North

From the table above, following results can be deduced:

- Total amount of vehicles 10 596 (without PT)
  from that: motorcycles 10
- Slow vehicles 542 (without PT)
- Peak hour 16:00 – 17:00 1 050
  9,9% from total amount (without PT)

The survey provided us with traffic volumes of vehicles according to 7 vehicle categories that we distinguished. From the data acquired we can calculate the share of heavy goods vehicles:

$$HGV = \frac{0{,}1 * van + 0{,}9 * light\ truck + 2{,}0 * heavy\ truck + 2{,}3 * articulated\ lorry + bus}{0{,}01 * total\ amount\ of\ vehicles}$$

According to the formula, the share of HGVs in locality North is 8,41%.

4.4.2 Locality South

ramp D6 x III/0063										
13.11.2018 Tuesday	Total number of vehicles									
	Car	Van	Light truck	Heavy truck	Articulated lorry	Bus	Motorcycle	vehicles	% from total	Public transport
06:00 - 07:00	579	11	20	6	14	4	1	635	6,0	0
07:00 - 08:00	786	46	19	19	13	8	2	893	8,4	0
08:00 - 09:00	553	60	21	20	12	10	2	678	6,4	1
09:00 - 10:00	503	50	24	20	19	10	0	626	5,9	0
10:00 - 11:00	401	30	28	18	21	6	0	504	4,7	0
11:00 - 12:00	454	38	16	17	15	5	1	546	5,1	0
12:00 - 13:00	481	42	9	5	7	7	1	552	5,2	0
13:00 - 14:00	587	45	17	21	13	9	1	693	6,5	0
14:00 - 15:00	737	68	19	9	8	13	0	854	8,0	0
15:00 - 16:00	916	67	14	10	7	10	1	1 025	9,6	0
16:00 - 17:00	997	36	18	6	11	12	0	1 080	10,2	0
17:00 - 18:00	970	6	5	4	12	6	0	1 003	9,4	0
18:00 - 19:00	707	6	2	2	11	1	0	729	6,9	0
19:00 - 20:00	482	5	3	0	3	1	0	494	4,6	0
20:00 - 21:00	310	1	1	0	4	1	0	317	3,0	0
Σ	**9 463**	**511**	**216**	**157**	**170**	**103**	**9**	**10 629**	**100,0**	**1**

Table 2 – Results of traffic volumes survey in locality South

From the table above, following results can be deduced:

- Total amount of vehicles 10 629 (without PT)
  from that: motorcycles 9
- Slow vehicles 646 (without PT)
- Peak hour 16:00 – 17:00 1 080
  10,2% from total amount (without PT)

The survey provided us with traffic volumes of vehicles according to 7 vehicle categories that we distinguished. From the data acquired we can calculate the share of heavy goods vehicles:

$$HGV = \frac{0{,}1 * van + 0{,}9 * light\ truck + 2{,}0 * heavy\ truck + 2{,}3 * articulated\ lorry + bus}{0{,}01 * total\ amount\ of\ vehicles}$$

According to the formula, the share of HGVs in locality South is 9,76%.

4.5 Vehicle composition

Vehicle compositions of traffic flows are very similar in both localities. The dominance of cars is from the figures below obvious. The second highest share have vans followed by light trucks and heavy trucks. The only significant difference can be seen in the share of articulated lorries, where near the freeway is the share 1,6% and in locality South only 0,2%.

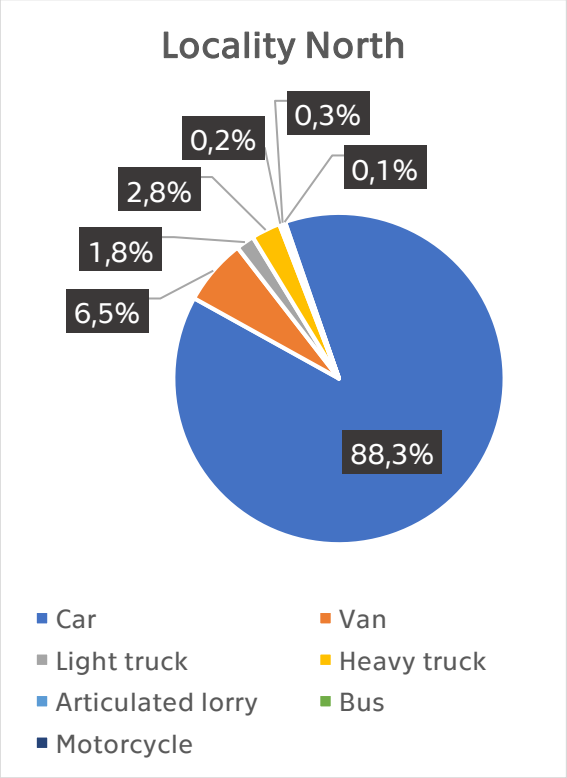

Figure 36 – Vehicle composition during survey in locality North (source: author)

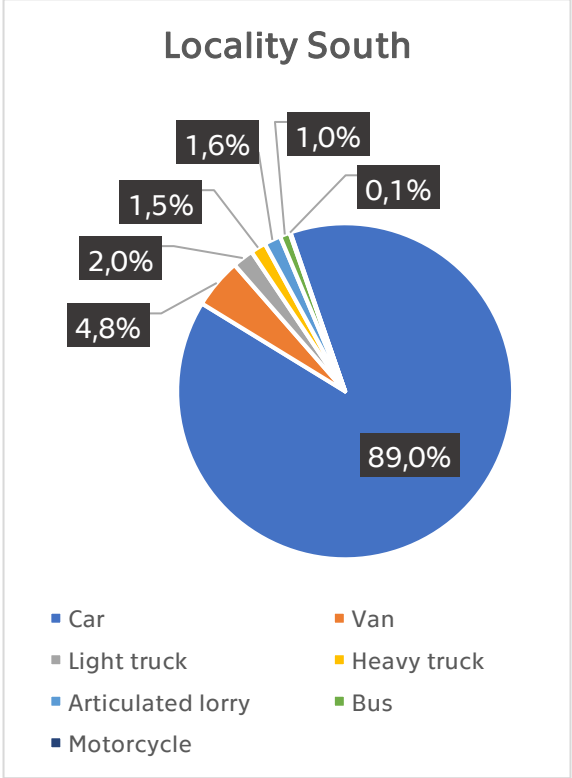

Figure 37 – Vehicle composition during survey in locality South (source: author)

4.6 Traffic flows

4.6.1 Locality North

From the figure below, that shows directions of travel of all vehicles, is clear that the flow of vehicles is strongest between southern and northern arm. These high numbers are created by people from Kladno going to and from freeway D6. It is important to mention that the western arm (here as III/2384 (S)) was during the time of the survey closed at the entrance to Kladno. So, the results are influenced by this, because this arm is based on the information from local people much busier than what does the diagram show.

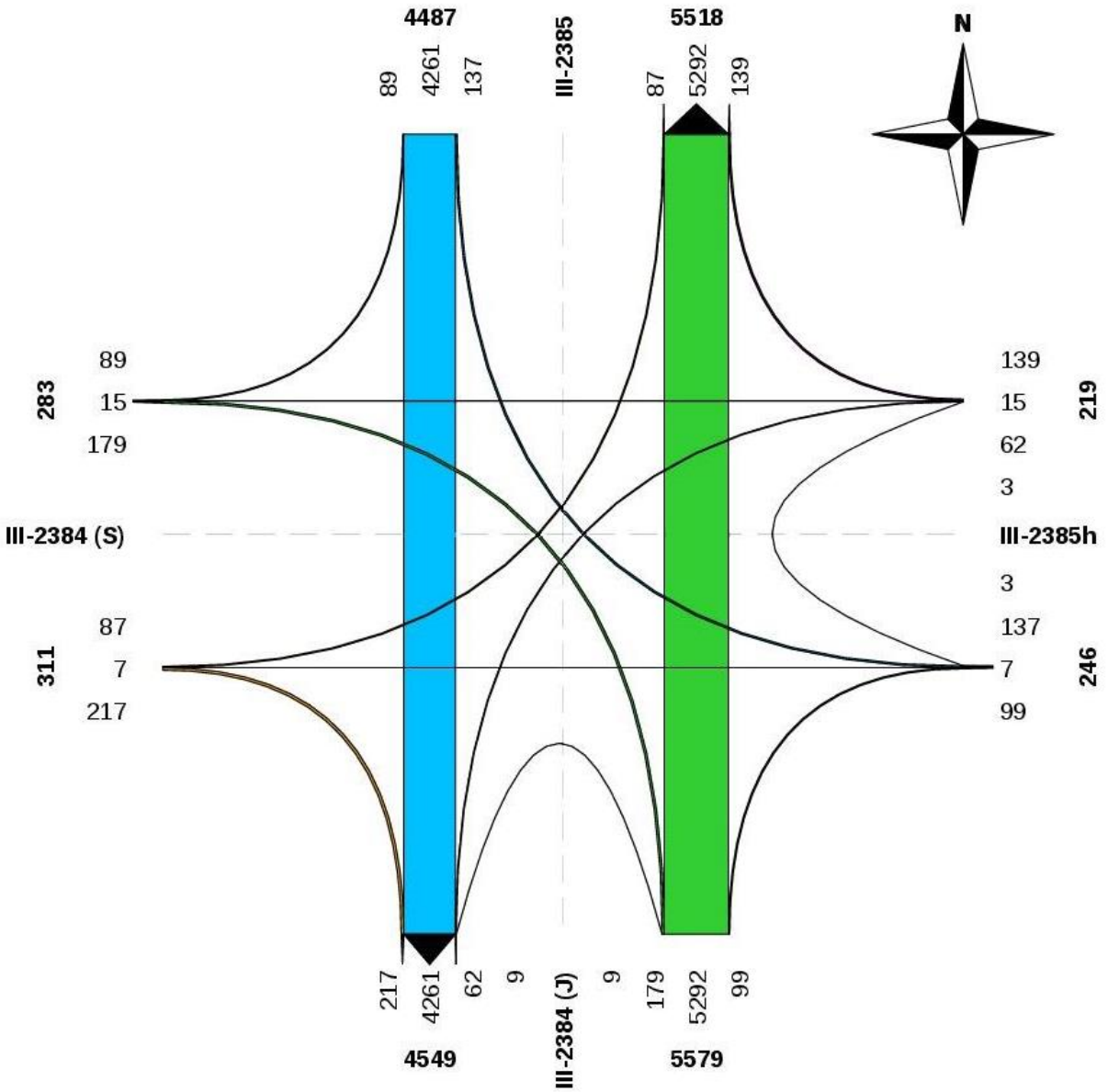

Figure 38 – Traffic flows of all vehicles during survey in locality North (source: author)

The next figure shows traffic flows of heavy goods vehicles. The strongest traffic flow remains the same. But it is noticeable that even though the western arm was closed at its end, there are still some HGVs going to and from this direction. That is mainly because there is building supply store located in this direction.

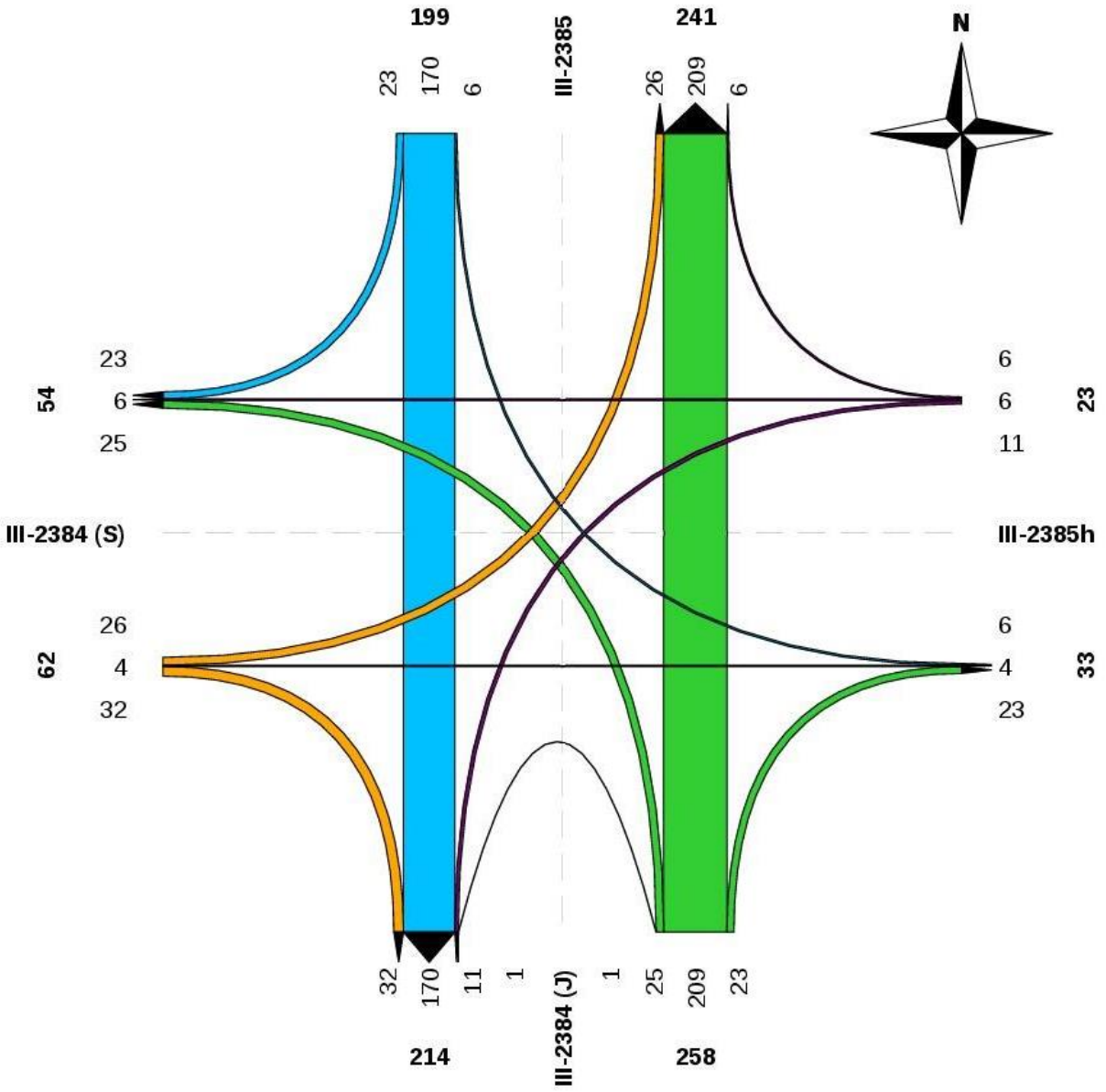

Figure 39 – Traffic flows of HGVs during survey in locality North (source: author)

4.6.2 Locality South

In locality South is the situation different. The strongest flow of vehicles is from the ramp of the freeway D6 (direction from Prague) to the centre of the municipality. That is mainly because of the people going from Prague to Kladno. The opposite direction is much weaker, since not a lot of people use the opposite direction of the freeway (direction to Karlovy Vary). The second strongest flow is from north to south mainly created by cars going from Kladno to the second ramp of the freeway D6 (direction to Prague). Even though the ramp was closed during the survey, people were still going in this direction to get to the next ramp in a neighbouring municipality.

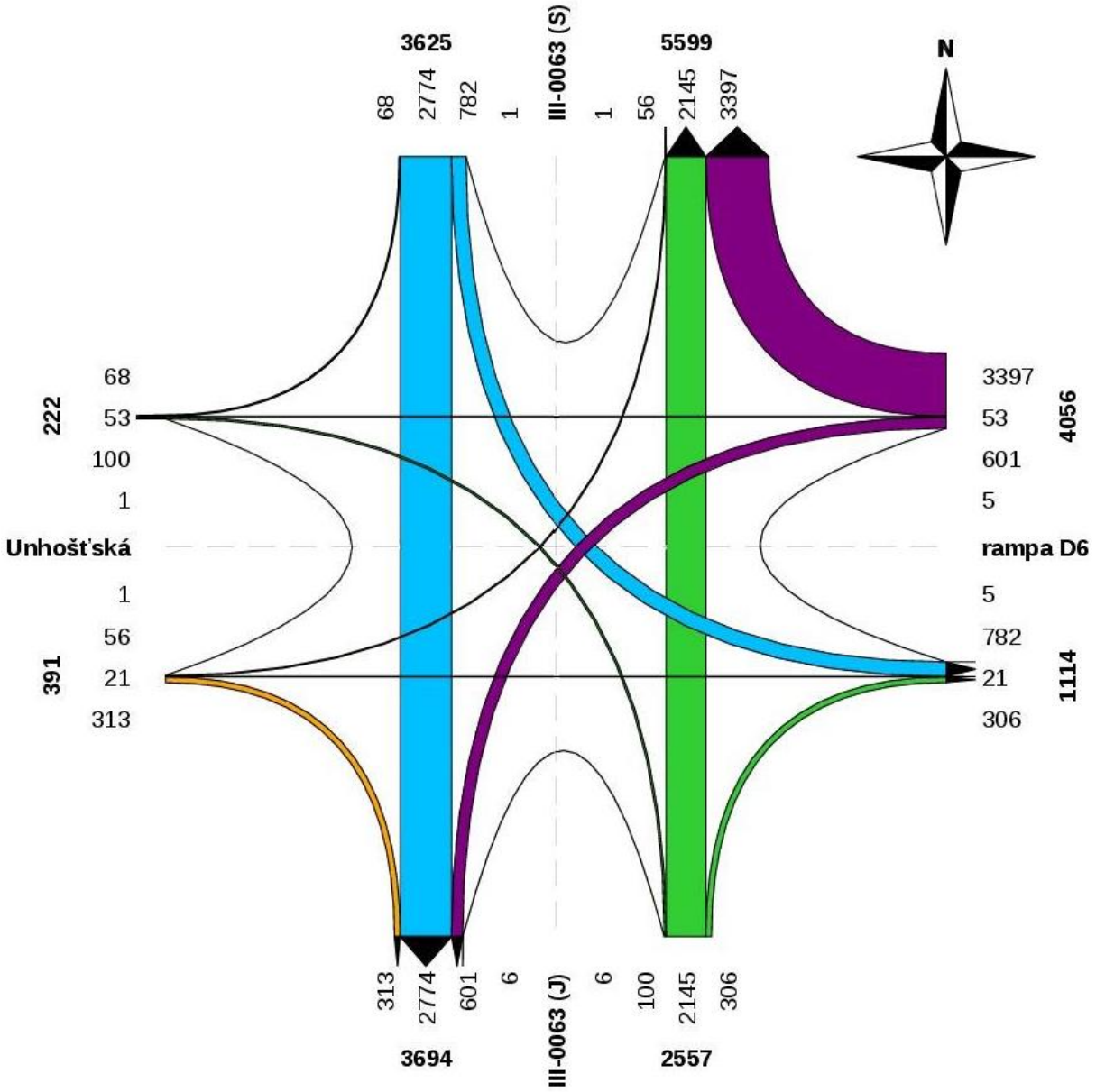

Figure 40 – Traffic flows of all vehicles during survey in locality South (source: author)

The figure below shows traffic flows of heavy goods vehicles in locality South. The diagram is very similar to the previous one. The only significant difference is that larger percentage of vehicles goes to the freeway in direction away from Prague.

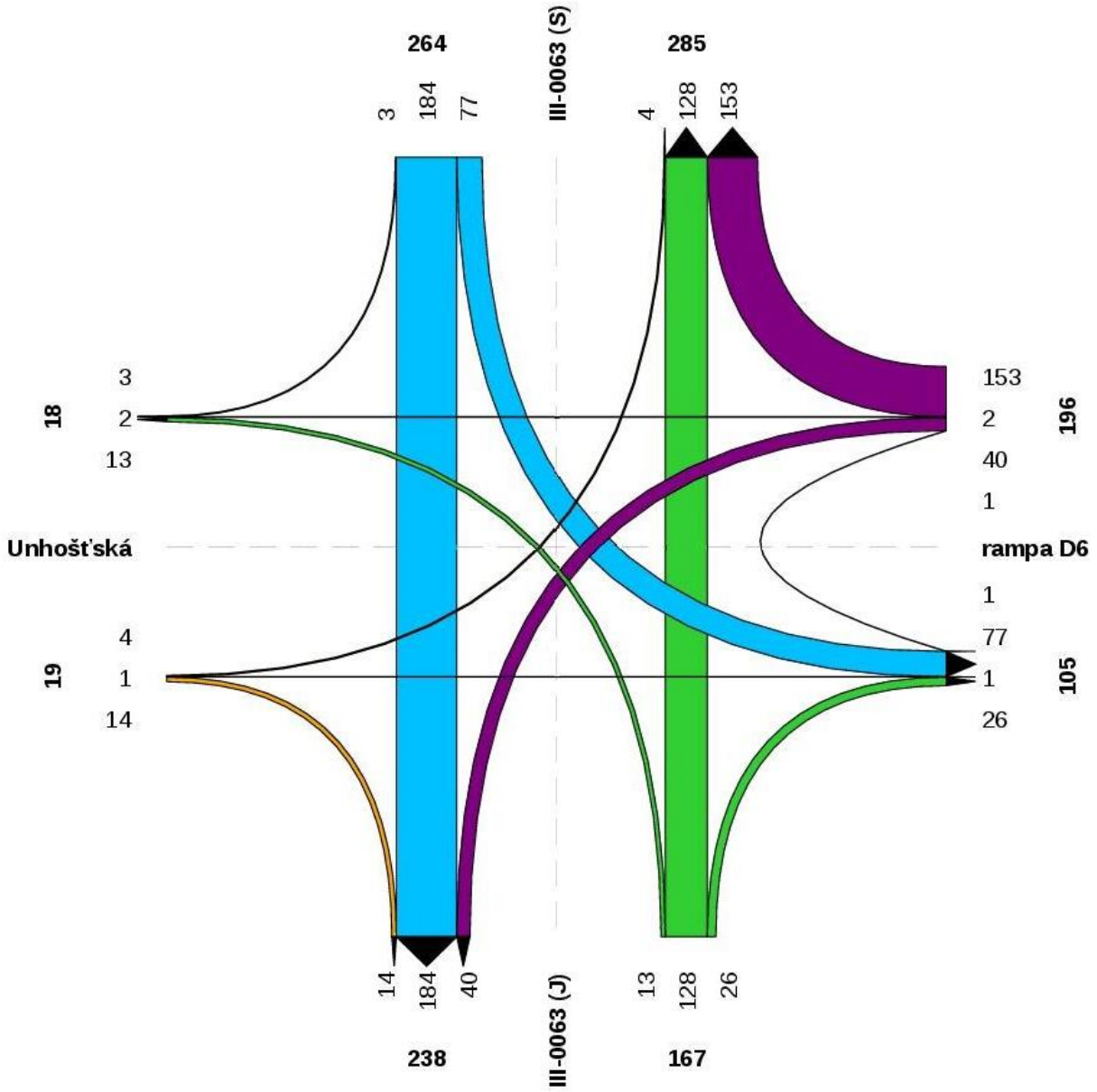

Figure 41 – Traffic flows of HGVs during survey in locality North (source: author)

4.7 Analysis of traffic accidents

Both localities have been checked in terms of traffic accident analysis. For this purpose, statistics of the Police of the Czech Republic available from the website www.jdvm.cz/pcr were used.

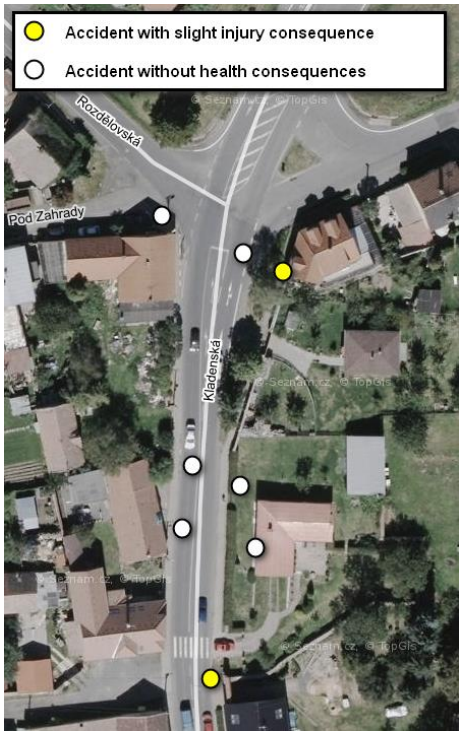

Figure 42 – Traffic accident analysis in locality North (source: /2, 5/)

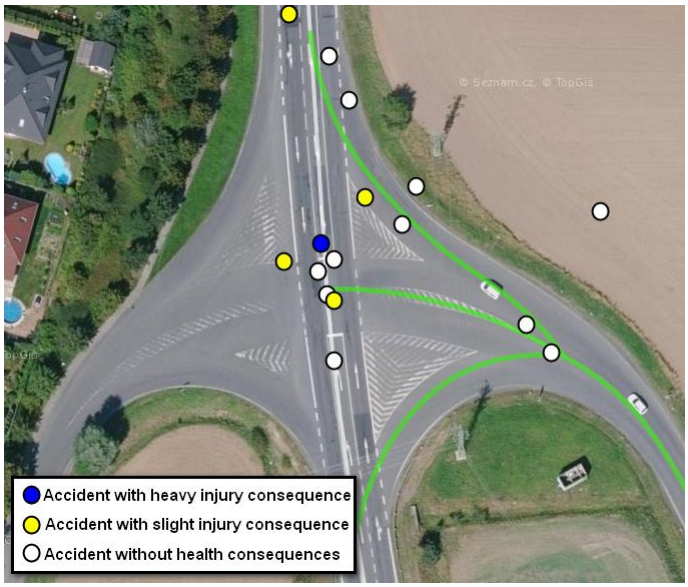

Figure 43 – Traffic accident analysis in locality South freeway D6 (source: /2, 5/)

4.7.1 Locality North

Locality North does not show high number of traffic accidents. From 2007 to 1. 2. 2019 (so, period of 12 years), there has been 8 traffic accidents recorded in total. In all those cases, the offender was the driver of a motorized vehicle. From the total amount, 6 accidents were without health consequences and 2 had a slight injury consequence of a 3 people in total. The main causes of all accidents are different. Examples given:

- Speed not adjusted to the condition of the road,
- Improper U-turn,
- Not being fully focused on the driving of the vehicle.

So, based on traffic accident analysis, there is no clear lead, what is the main safety issue on this intersection.

4.7.2 Locality South

Locality South shows much higher number of traffic accidents. During the same period like in locality North, 16 traffic accidents with following consequences had been recorded:

- 1 heavy injured person
- 4 slightly injured persons

Causes of the traffic accidents were mainly:

- Left turning manoeuvre (4 accidents)
- Not respecting traffic sign "Give right of way" (4 accidents)
- Not respecting the safety distance (3 accidents)

From the figure with traffic accidents it is clear that the most dangerous spot is where axes of all four arms of the intersection meet in the middle. And then the right turning arm of the exit from the freeway D6 in the direction to the municipality. This analysis shows, on which parts should be especially focused on when putting together the new layout of the intersection.

4.8 Speed analysis

Since both localities are located near the entrance to Velká Dobrá, it is important to know, what is the current situation when it comes to speed of vehicles entering the municipality. In both localities traffic flow was monitored in a defined profile by static radar SR4 (see figures below). This radar measures speed, traffic volumes and vehicle composition. In this chapter, the main focus is speed, because other measurements were already described in previous chapters. It was technically ensured that the radar is not recognizable by drivers, so the measurement is not influenced by this.

Figure 44 – Static radar SR4
(source: author)

Figure 45 – Measured profiles of roads
(source: /2/)

The speed limit standard in rural areas is 90 km/h and in urban areas 50 km/h (if not stated else by traffic signs). And it is clear, that the municipality is aware of the fact that there is a high chance of speeding, because they installed radar speed signs on both entrances.

Figure 46 – Radar speed sign on the north entrance (source: author)

Figure 47 – Radar speed sign on the south entrance (source: auth*or)*

4.8.1 Locality North

In the traffic accident analysis, there has been mentioned that there is no clear lead on what the main safety issue on this junction could be. But looking again on the figure with the location of traffic accidents, it can be noticed that all of them are located on the through road close to the beginning of the municipality. That may indicate there is some speeding issue with vehicles not slowing down enough when entering the municipality. Another fact supporting the hypothesis of drivers not observing the speed limit is that the road is descending towards the municipality.

Figure 48 – Radar on the traffic sign post (source: author)

Figure 49 – Radar behind the entrance to the municipality (source: author)

To find out, whether drivers observe the speed limit or not, speed radar was installed at the entrance to the intersection or more precisely the municipality. The radar was installed from 28 .2. 2019 to 1. 3. 2019 and has been located on a post of a traffic sign behind the entrance to the municipality.

There are no traffic signs reducing the speed limit, so all vehicles approaching the intersection should not be going faster than 50 km/h.

The radar measures speeds of vehicles in both directions of travel, but for our purpose, only vehicles arriving to the municipality were filtered.

24-hour sample from the collected data was examined and the result of the speed analysis is represented in the figure below. In the pie chart, vehicles were divided into speed groups and distinguished by colours.

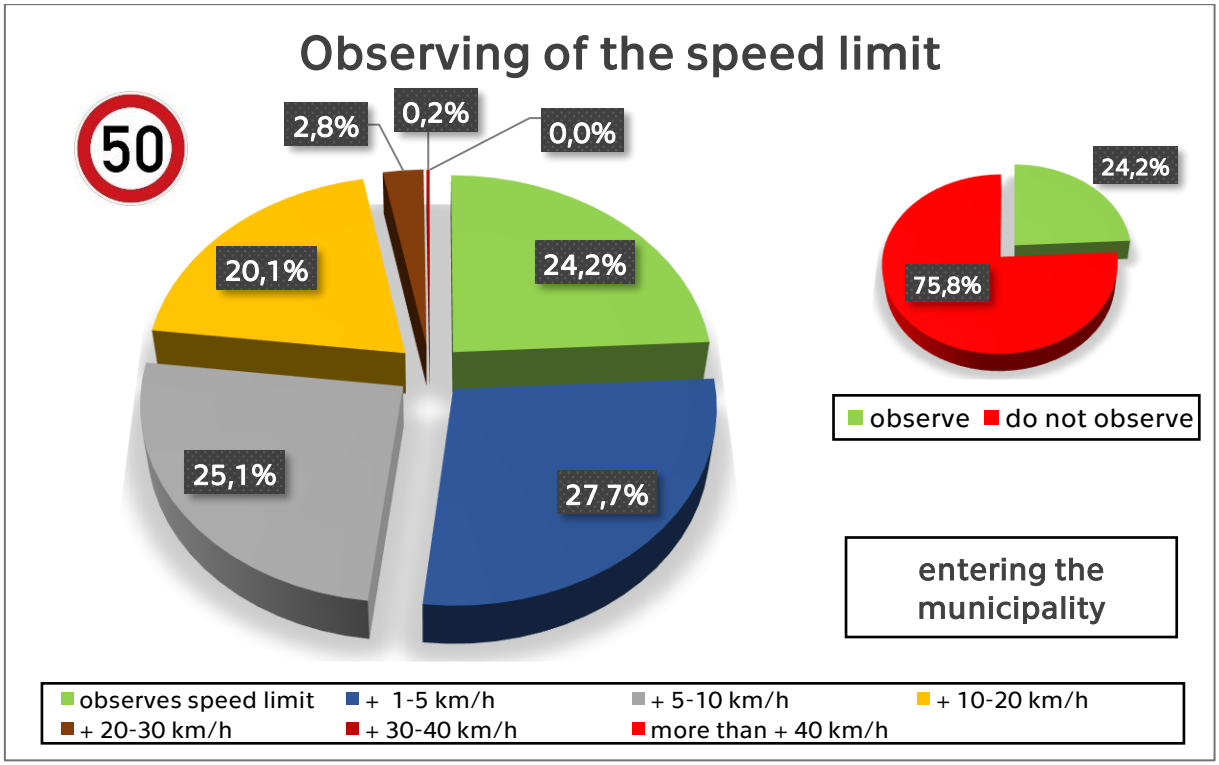

Figure 50 – Pie chart of speed analysis on the road III/2385, north entrance to Velká Dobrá (source author)

The results of this analysis are rather disturbing. We can see at a first sight that we have 4 similar shares of different speed groups. But the bad news is that the share of vehicles observing the speed limit has neither the highest, nor the second highest share. It is on the third place with a share of 24,2% The most common speed drivers are going with is in between 50 and 55 km/h (27,7%). Altogether throughout the whole one-day sample, 76% of the drivers are going faster than 50 km/h, which is the permitted limit.

The speed analysis showed us disturbing results of the current speeding situation. Three quarters of drivers arriving to the municipality are going with a speed above the permitted limit. Moreover, the highest recorded speed was 91 km/h. This analysis showed the urge to make changes in the current layout of the intersection. More specifically, to suggest a solution that would make driving at the speed of 91 km/h behind the entrance to the municipality impossible.

Below is a bar chart showing the distribution of vehicle speeds divided into intervals of 5km/h.

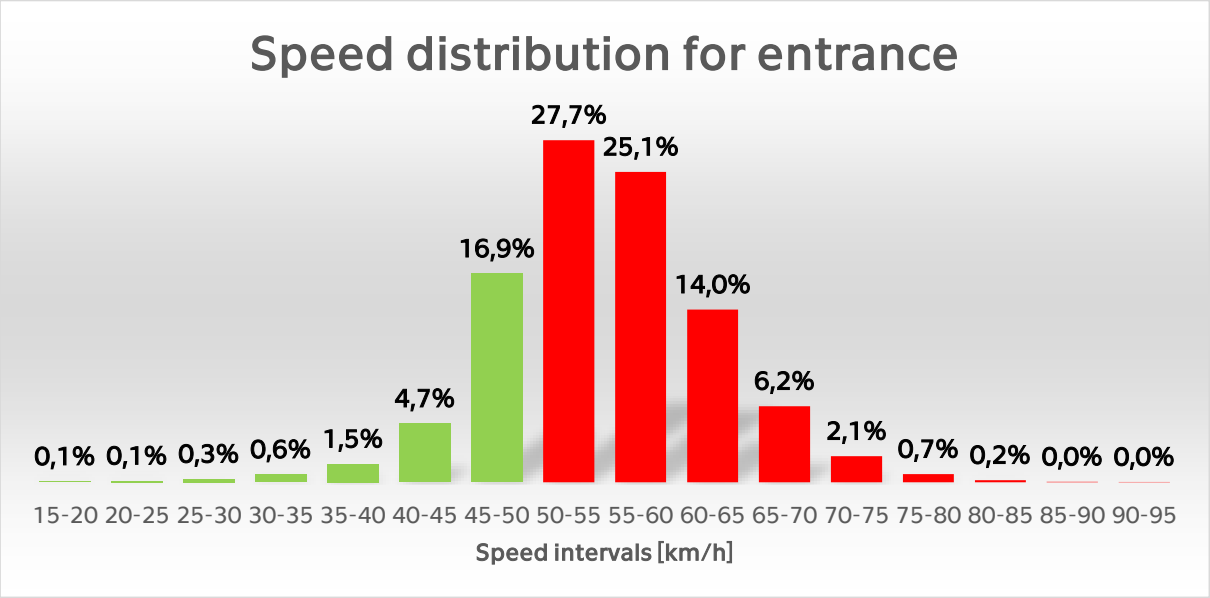

Figure 51 – Bar chart of speed analysis on the road III/2385, north entrance to Velká Dobrá (source author)

4.8.2 Locality South

In the traffic accident analysis, there has been a significant lead on what part of the intersection should we focus on in the further analysis. Most of the traffic accidents and the most severe ones occurred in the middle of the intersection. Taking into account the current layout of the junction and very bad visibility, it can be deduced that turning manoeuvres within the intersection are quite dangerous, especially the left turning manoeuvre from the main road. It is clear, that bad visibility is one of the main factors we should focus on, but the question now is, whether its visual dangerousness is also supported by high speed.

To find out, whether drivers observe the speed limit or not, speed radar has been installed at the entrance to the municipality behind the intersection. The radar was installed from 4. 5. 2017 to 5. 5. 2017 and was located on a post of a traffic sign behind the entrance to the municipality (see figures below). It was put on a traffic sign

"pedestrian crossing" to find out about the dangerousness for pedestrians as well. Fact supporting the possibility of drivers not observing the speed limit is that the road is descending towards the municipality.

There are no traffic signs reducing the speed limit, so all vehicles approaching the intersection should not be going faster than 50 km/h.

Figure 52 – Radar behind the entrance to the municipality (source: *author)*

Figure 53 – View on part of the road *where the speed was measured (source: author)*

24-hour sample from the collected data was examined and the result of the speed analysis is represented in the figure below. In the pie chart, vehicles were divided into speed groups and distinguished by colours.

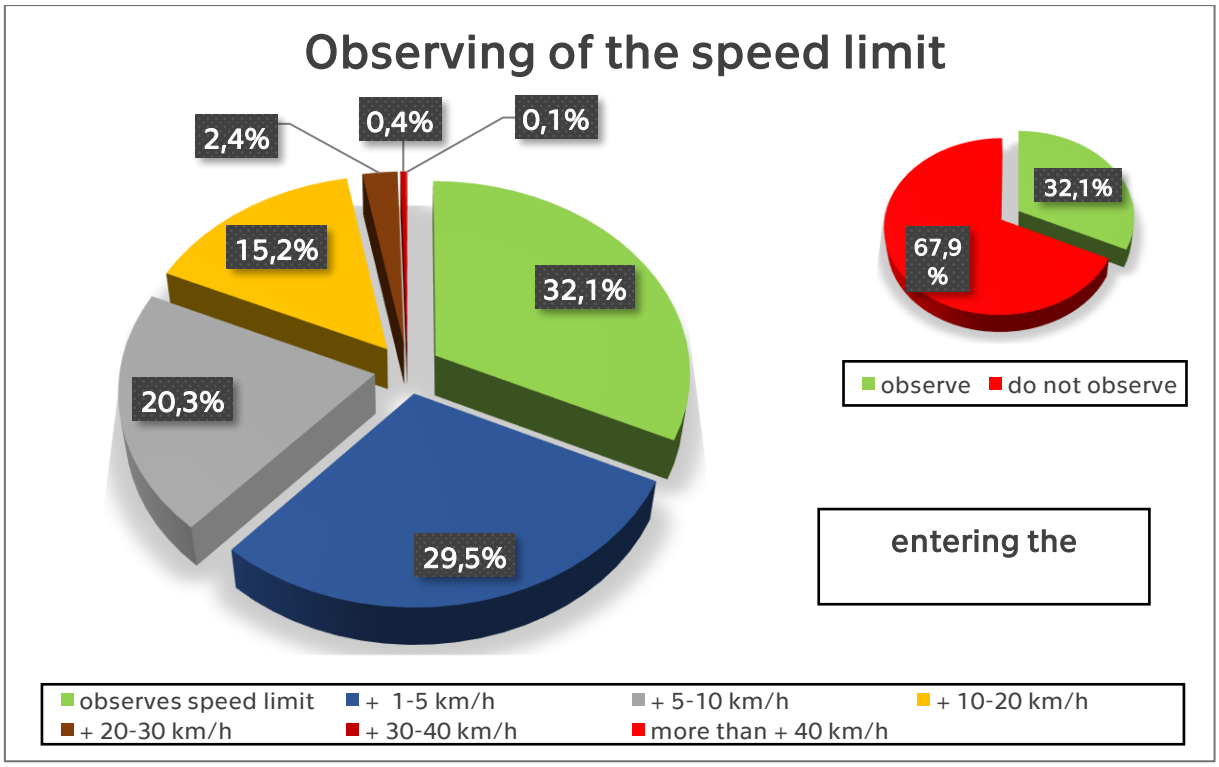

Figure 54 – Pie chart of speed analysis on the road III/0063, south entrance to Velká Dobrá (source: author)

The results shown are much better than in locality North, but still can be hardly considered as a satisfying result in terms of safety. The share of vehicles that observe the speed limit is highest from all speed groups distinguished, but 32,1% is still too low. Drivers are also very often going with a speed in between 50 and 55 km/h (29,5%). Altogether throughout the whole one-day sample, 68% of the drivers are going faster than 50 km/h, which is the permitted limit.

The speed analysis showed us results of the current speeding situation. Almost 68% of drivers arriving to the municipality are going with a speed above the permitted limit. Moreover, the highest recorded speed was 114 km/h, which is even worse considering the fact, it was recorded right in front of the crossing for pedestrians. This analysis showed the urge to make changes in the current layout of the intersection. More specifically, to suggest a solution, that would make driving at the speed of 114 km/h behind the entrance to the municipality and in front of the pedestrian crossing impossible.

Below is a bar chart showing the distribution of vehicle speeds divided into intervals of 5km/h.

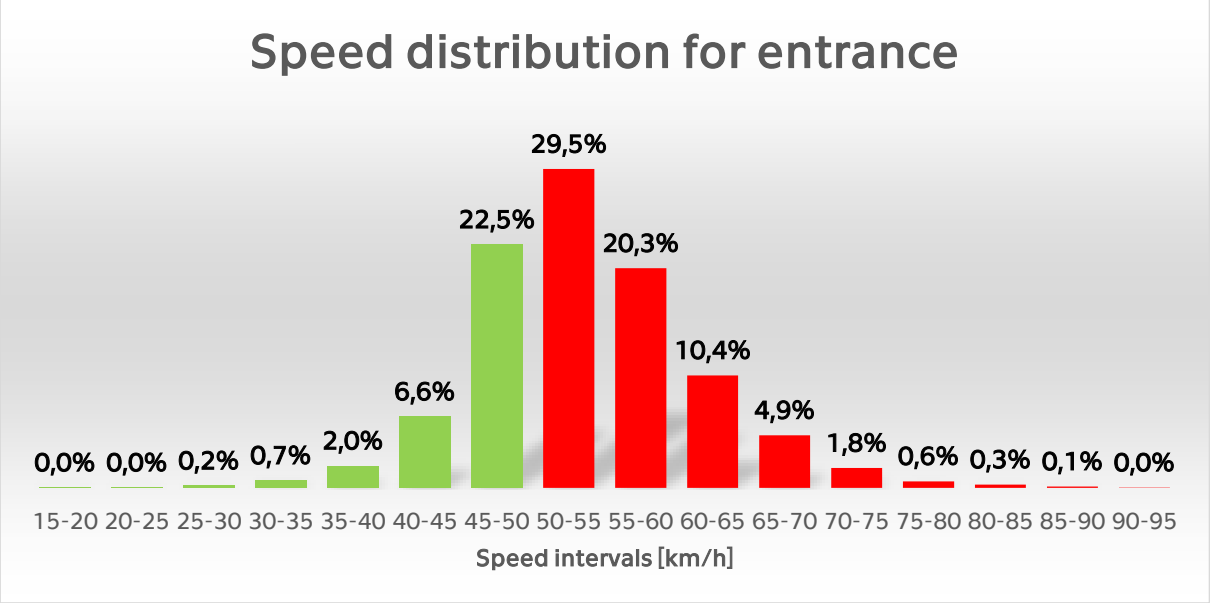

Figure 55 – Bar chart of speed analysis on the road III/0063, south entrance to Velká Dobrá (source: author)

4.9 Pedestrian traffic

4.9.1 Locality North

Locality North is currently oriented mainly on transport of motor vehicles and pedestrian traffic is sidelined. In terms of pedestrian traffic, the main characteristics are narrow pavements with a width of 1,0 – 1,6 m, railings and insufficient connection across the through road leading through Kladenská street. The bad connection is illustrated in the figure below. If pedestrians do not want to run across the busy road and they choose the proper way to go to the other side of the street, they need to walk all the way to the pedestrian crossing. But this option is much longer, to be exact 8 times. Moreover, the crossing for pedestrians is improperly situated in front of the entryway to a private property. This results in pedestrians dangerously running across the intersection using it as a shortcut.

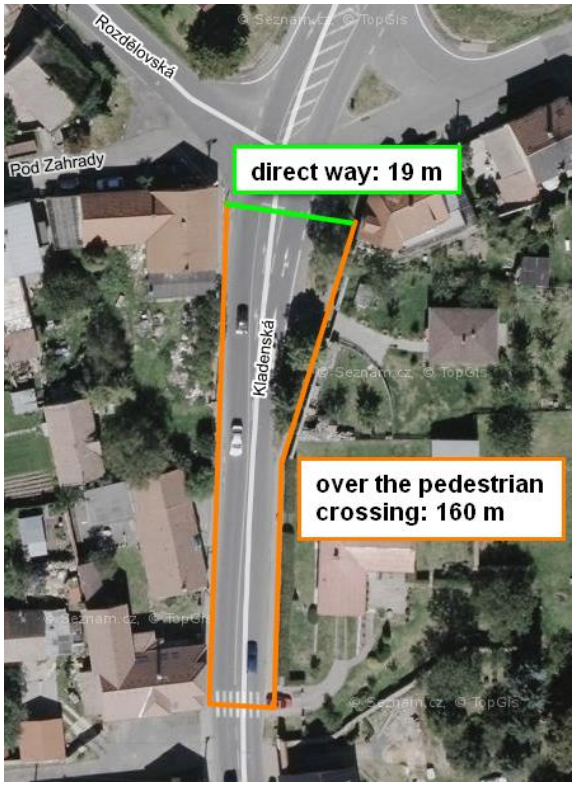

Figure 56 – Absence of the ped. crossing (source: /2/)

Figure 57 – View on part of the road where the speed was measured (source: author)

In the area between northern and western arm of the intersection, there is a historical object wayside shire (see figure 50).

The main deficit is the quality of public space in general. Kladenská street leads through the municipality and therefore creates potential for meetings of inhabitants from both sides of the municipality. But such a place is unfortunately missing.

Figure 58 – Bench with a view on the *intersection and wayside shire (source:* author*)*

Figure 59 – Sidewalk narrowed down to a 1,0 m accompanied by railing (source: author)

The analysis of the infrastructure for pedestrians showed more problems this locality is dealing with. Its current layout is designed mainly for the comfort of cars and is not attractive and comfortable for pedestrians. Proposed solution should therefore focus on improving the current situation.

4.9.2 Locality South

One arm of the intersection in locality South is connected directly to the freeway D6 and therefore together with the fact that it is located outside the border of the municipality is the dominance of motorized transport logical. Despite this, there is still a sidewalk lining the built-up area of the municipality. This sidewalk is connected to a brand-new pathway built last year. This pathway goes next to the northern arm of the intersection leading to the neighbouring municipality.

Figure 60 – Sidewalk lining the built-up area (source: author)

Figure 61 – New pathway leading to a neighbouring municipality (source: author)

The infrastructure for pedestrians is given the area relationships sufficient.

5 Space syntax analysis

To prove the importance of both intersections, space syntax analysis of the area was made. Space syntax is a set of techniques for analysing spatial layouts and human activity patterns in buildings and urban areas. It is also a set of theories linking space and society. Space syntax addresses where people are, how they move, how they adapt, how they develop and how they talk about it. /6/

5.1 DepthMapX

DepthMapX is a single software platform to perform a set of spatial network analyses designed to understand social processes within the built environment. It works at a variety of scales from building through small urban to whole cities or states. At each scale, the aim of the software is to produce a map of open space elements, connect them via some relationship (for example, intervisibility or overlap) and then perform graph analysis of the resulting network. The objective of the analysis is to derive variables, which may have social or experiential significance. /7/

Map of all roads and paths using DepthMapX software was made and is depicted below.

Figure 62 – Network of roads (source: author)

5.2 Choice

Choice measures how likely an axial line or a street segment it is to be passed through on all shortest routes from all spaces to all other spaces in the entire system or within a predetermined distance (radius) from each segment. /7/

Figure 63 – Choice analysis (source: author)

For the choice analysis radius of 5 km was used. The result of the analysis showed us interesting results that can be seen in the figure above. Warmer colours show segments that are most likely going to be chosen for a trip and colder colours streets that are least likely going to be chosen.

In locality North are all the streets generally depicted in warmer colours and it is therefore very important for the intersection where they all meet to be designed in a better way than it is now. Moreover, Kladenská street (the only one depicted in a red colour) is most likely going to be chosen for a trip and regarding choice analysis is it the most important street.

In locality South are segments generally depicted in colder colours. Reason for that is that the analysis was focused on the municipality itself and therefore segments connected to the freeway are not likely to be chosen for a trip within the municipality.

5.3 Integration

Integration measures how many turns have to be made from a street segment to reach all other street segments in the network, using shortest paths. If the number of turns required for reaching all segments in the graph is analysed, the analysis is said to measure integration at radius 'n'. The first intersecting segment requires only one turn, the second two turns and so on. The street segments that require the fewest turns to reach all other streets are called 'most integrated' and are usually represented with hotter colours, such as red or yellow. Integration can also be analysed in local scale instead of the scale of the whole network. /8/

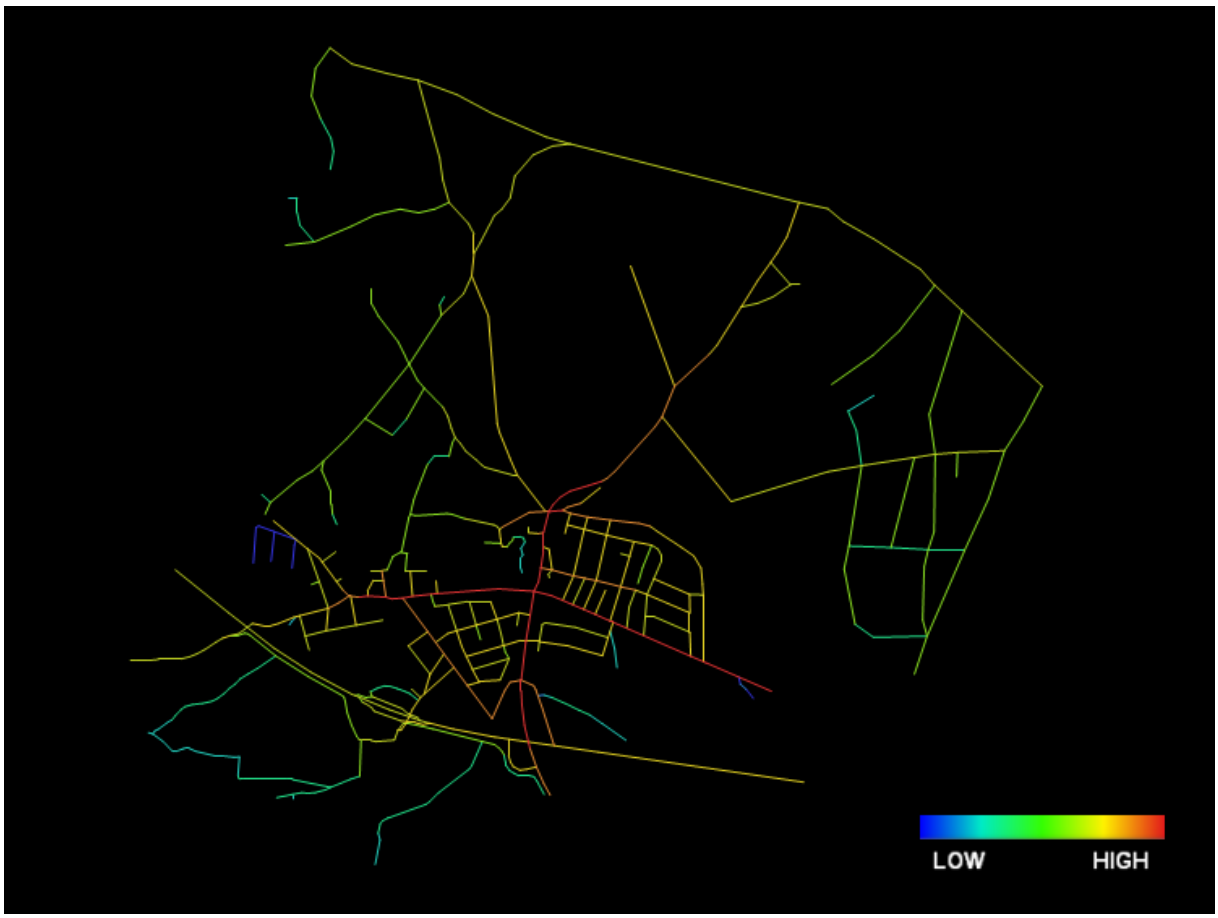

Figure 64 – Integration analysis (source: author)

Integration analysis again showed even more interesting results. From the result above can be clearly seen red cross of 4 through roads, that are best integrated to the map of segments within the municipality. It is also clear that in both locality South and North meet streets that are very well locally integrated in the area. More precisely, are together with the intersection in the centre, where all 4 through roads meet, the most important intersections in terms of integration rate.

6 Zoning plan

According to the current zoning plan valid from January 2015, there is no change expected for the current layout of both intersections Also, there was no limitation found in a close proximity of both localities, which would significantly restrict possibilities and spatial demands of a new proposed design.

In the locality South, there is planned a new quarter of family houses. The new quarter will be located in the north-east quadrant of the intersection. In the figure below it is depicted in a pink colour with the label Z49. Furthermore, there is a new shopping zone planned. The shopping zone will be located in the south-west quadrant of the intersection and in the figure below it is depicted with a chequered light blue and has a label Z50. So, the transformation in the surrounding area of the intersection is clear and it is important to take this into consideration when putting together the new design of the intersection.

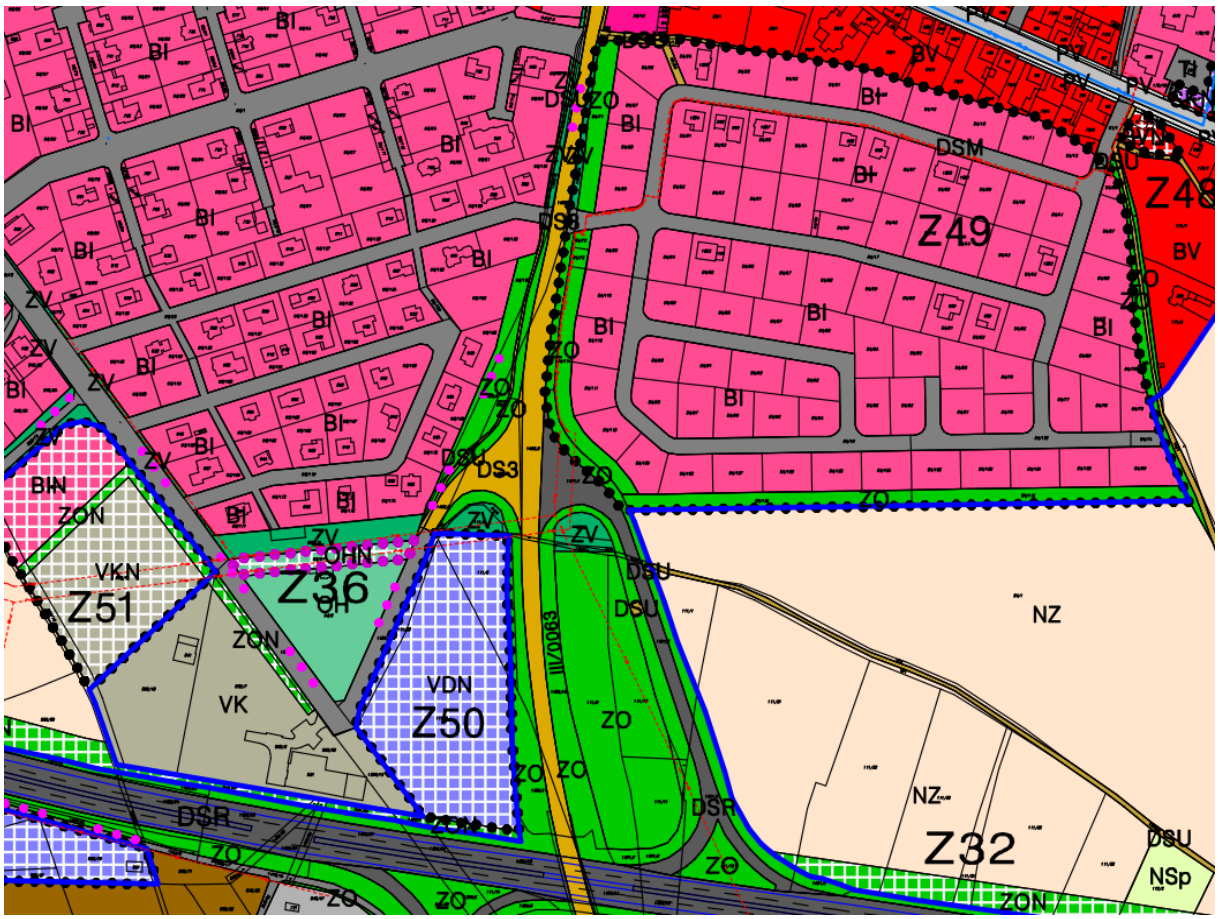

Figure 65 – Zoning plan of the surrounding area of the locality North (source: /9/)

In locality North there are also some new houses planned in Pod Zahrady street.

7 Deficits and goals

For having a clear overview of deficits of the current state and goals we want to achieve, table of deficits and goals for both localities is provided below. Also, the idea about how do we want to solve deficits mentioned is provided in the column action objectives.

7.1 Locality North

Deficits	Goals	Action objectives
Poor conditions for people with limited movement and orientation	Have good conditions for people with limited movement and orientation	Adding dropped kerbs, raised kerbs, signal strips, warning strips
Missing connection for pedestrians	All directions for movement of pedestrians comfortably accessible	Adding missing crossing for pedestrians
Bad location of pedestrian crossing	Not having pedestrian crossing in front of an entryway	Removing pedestrian crossing and moving it
Bad quality of public space	Have a good public space that encourages people to walk and meet each other	Adding benches and trees, creating living street
Narrow sidewalks	Sidewalks are wide enough	Widening of sidewalks
Missing traffic calming measurements	Having a suitable set of traffic calming elements that drivers have to respect	Designing roundabout with splitter islands on entrances
Poor organisation of traffic streams within intersection	Having a clear separation of traffic streams. Intersection is easy to understand.	Designing roundabout with splitter islands on entrances and one lane on the circulatory roadway
No clear separation of urban and rural area at the entrance to the municipality	Having a clear separation of urban and rural area at the entrance to the municipality	Designing roundabout at the entrance to the municipality
Large asphalt areas	Having carriageways only in places, where vehicles actually ride	Removing access asphalt areas

Table 3 – List of goals and deficits in locality North

7.2 Locality South

Deficits	Goals	Action objectives
Missing traffic calming measurements	Having a suitable set of traffic calming elements that drivers have to respect	Designing roundabout with median strips and splitter islands on entrances
Poor organisation of traffic streams within intersection	Having a clear separation of traffic streams. Intersection is easy to understand.	Designing roundabout with splitter islands and median strips on entrances and one lane on the circulatory roadway
Bad visibility of the intersection from some directions	Knowing about the upcoming intersection well in advance	Designing median strips and splitter islands and putting high trees in the middle of the intersection.
No clear separation of urban and rural area at the entrance to the municipality	Having a clear separation of urban and rural area at the entrance to the municipality	Designing roundabout at the entrance to the municipality
Large asphalt areas	Having carriageways only in places, where vehicles actually ride	Removing access asphalt areas
Purely transport character	Having area, where traffic and nearby living function are balanced	Adding green vegetation areas with trees.

Table 4 – List of goals and deficits in locality South

8 Concept of the proposed solution

8.1 Generally

The goal of the thesis is to propose such solution that will fulfil not only its transport task but will as well provide a good urban solution. The aim is to reduce the barrier effect at the entrance to through roads. Also, the solution is based on findings from the current state, already mentioned in previous chapters. The proposal also uses information from recommendations provided in Technical Conditions of the Ministry of Transportation.

8.2 Reasons for reconstruction

Current design of entrances to the municipality and through roads breaks the coherence and character of a cohesive settlement. Municipality is therefore nowadays divided into quadrants, whose interface are through roads, which create a barrier for the inhabitants. Their straight routing and generous design of entrances literally attracts high speed. One of the most important things of calmed character of through roads in general are the sections at the entrance/exit to/from the municipality. To start the process of changes in the layout of through roads at the intersections that are located at the entrance to the municipality is therefore logical step.

Figure 66 – Through roads divide the municipality into quadrants (source: /2/)

8.3 Chosen parts from guidelines

8.3.1 Measurements at the entrance to the municipality according to Technical Conditions 132

Configuration of the entrance (so called gate) to the municipality should according to TC 132 be designed in a way to disable drivers to continue with a high speed from rural area to the urban area. Without implementation of major construction or combination of construction and psychological measurements is the speed generally higher at the beginning of the municipality than in the following sections.

Typical measurements at the entrance to a municipality are:

- directional lane deflection in the direction to the municipality, installation of middle traffic island;
- **application of roundabouts;**
- physical narrowing of a street – narrower driving lanes, dividing traffic islands, locally widened sidewalks, beginning of sidewalks (cycle paths);
- optical narrowing of road (with horizontal marking, green vegetation areas, large trees, paved sides of the road);
- reinforcement of green vegetation elements, that remind the presence of life and encourage drivers to reduce the speed;
- supporting of the effect of preceding elements by a different surface of the road (for example paving of colour distinguishing).

8.3.2 Measurements at the entrance to the municipality according to Technical Conditions 145

Entrance to the municipality has according to technical conditions 145 special effect for those, who are arriving from the rural area. Here on the border of the municipality is decided at which speed will the driver drive through the urban area. And it is mainly the construction layout, which makes drivers to slow down. The speed that is then chosen after the entrance is decisively influenced by a suitable layout of the road itself.

The layout of the entrance (so called gate) to the municipality should be designed in a way that prevents drivers from continuing with a high speed from rural to urban area. Without execution of major construction or combination of construction and psychological measurements is the sped generally higher at the beginning of the municipality than in the following sections. That is given by both technical and psychological factors.

Typical measurements at the entrance to a municipality are for example:

- directional lane deflection in the direction to the municipality, installation of middle traffic island;
- physical narrowing of a street
    - local – with the help of dividing traffic islands or locally widened sidewalks on sides of the roadway (rare),
    - liner – transition to narrower lanes inside of the urban area (common);
- optical narrowing of road (with horizontal marking, green vegetation areas, large trees, paved sides of the road);
- roundabouts are perfect and effective measurement, which ensures contrast as well as safe transition between sections with different characteristics. This measurement can be used only if there is intersection at the border of the municipality, which is suitable to be transformed to a roundabout. This case is very common. Mostly it is intersection, where traffic streams turn into different parts of a municipality. More and more common is a connection of big shopping centres that are being built on the edges of municipalities. In all cases is a roundabout able, if correctly dimensioned, provide effective distribution of traffic streams as well as reduction of speed at the entrance to a municipality;
- strengthening of green vegetation elements, that remind the presence of life and encourage drivers to reduce their speed, for example planted trees that create the effect of a gate (quite simple, but useful measurement could also be a placement of a flower box near the traffic sign "beginning of the municipality";
- supporting of the effect of preceding elements by a different surface of the road (for example paving of colour distinguishing).

9 Proposal of the solution

9.1 Locality North

On the north entrance to the municipality, the five-leg intersection was transformed to a four-leg roundabout. The reason was the need to generally calm down the traffic coming from the rural area, because the speed analysis showed disturbing results, which made the need for change urgent. The goal was to make the whole intersection more clear and easier to understand and having a clear separation of traffic streams. From all the possible measurements mentioned in previous chapter, it is the most suitable one. Furthermore, the mayor of the municipality itself favoured this option the most.

Because of the effort to make the intersection clearer, there was a reduction in the number of arms. The reason why it was possible is that the fifth arm, which is Pod Zahrady street, is not very busy since it is a dead-end street and serves only to four houses. This street was therefore connected outside of the circulatory roadway to the arm in Rozdělovská street.

The proposal is based on the idea that in the very centre of the municipality, where through roads meet themselves, exists already a roundabout. The idea is then to create a logical continuity of cross-adjustments that will create a sense of unity and order.

The new type of this intersection is a roundabout with one lane on the circulatory roadway. The roundabout has following dimensions:

- inscribed diameter 26 m,
- central island diameter 8,2 m,
- apron width 2,3 – 3,3 m,
- circulatory road width 5,6 – 6,6 m.

The reason for changing dimensions of two parts of the intersection is that there is an effort to slow down the traffic coming to the municipality more than traffic going out. For that reason, is the central island egg-shaped, which influences also the width of the circulatory road.

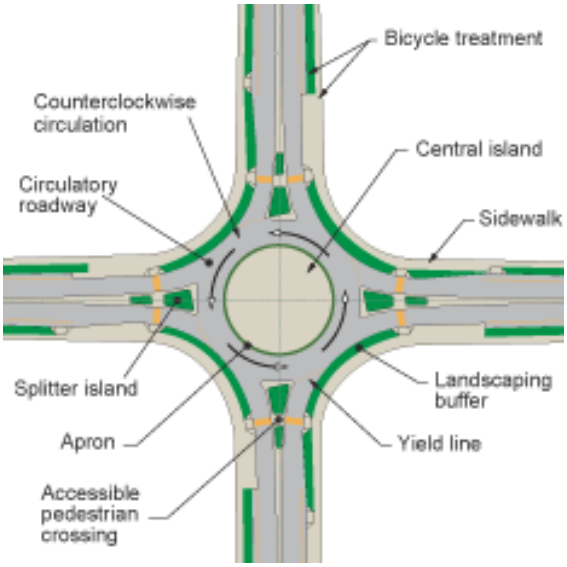

Figure 67 –Parts od a roundabout (source: /10/)

All possible manoeuvres within the new design of the intersection were verified with swept path analysis of the largest vehicles that may possibly drive through this

intersection. Those design vehicles are articulated bus, articulated lorry and garbage truck.

Also, there has been analysis of sight distance according to TC 135. Based on sight distance analysis, the proposal of planting of trees was made. Trees cannot be planted inside of sight visibility triangles of the roundabout. Because of the smaller diameter of the central island, it was necessary, taking into account determined sight distances, to keep the island clear from any obstacles, so that drivers are able to see behind the island.

Together with the design of the new roundabout all arms of the previous junction went through a major change in their layout. Common elements of the new design are widening of sidewalks, enlargement of green vegetations areas and adjusting entryways to private properties to a more comfortable way. List of main changes in all arms of the intersection follows:

- On the **northern arm** (road III/2385) there is a reduction from three to two lanes. Instead of the left turn lane, there is a median strip of a width of 2,5 m, which warns drivers before the beginning to the municipality about the upcoming change in the character of the road.
- **Eastern arm** (Lipová street) connected to the roundabout was designed in a clearer way by narrowing the opening of the arm to the intersection and tilting the street axis to the middle of the intersection. The opposite traffic lanes are at the neck of the arm separated by a short splitter island, which is partly lowered to allow drivers from private properties to comfortably enter the intersection. Because in the Lipová street ale located three companies using articulated lorries to transport goods, it was necessary to design truck aprons to offer comfortable passage through the junction. There is also a widened sidewalk from previous 1,5 m to 1,95 – 3,0 m.
- In the **southern arm** (Kladenská street) there is a reduction to one lane for each direction and there is also designed currently missing comfortable connection for pedestrians in the northern part of this street. Instead of the left turning lane, there is now a 2,5 m wide splitter island, which also serves as a refugee island, since it has an integrated pedestrian crossing in it. There are sidewalks widened in the whole part of the street, that is designed as a part of this master thesis, locally up to 5 m. In the southern part of the drawings the position of the pedestrian crossing is moved beyond the entryway to a private property.

Green vegetation with trees taken away on the western part of the street is replaced with new green vegetation with trees on the opposite side of the road.

- **Western arm** (in Rozdělovská street) is tilted, so that the axis of the arm aims to the centre of the roundabout. There is also splitter island that is lowered in the middle in order to allow vehicles to turn to and from Pod Zahrady street. Also, the sidewalk going alongside this arm has been connected to newly created area in Pod Zahrady street, so pedestrians can now move in the area in a more comfortable way.
- Pod Zahrady street serves only four houses, it is not connected to the roundabout as a fifth arm. Instead it has been for its low utilization rate connected to Rozdělovská street. The traffic mode of this street is also changed to a living street. The designed area is now in one level, where the part where cars are expected to go is made from a different surface.

In the area between Kladenská and Pod Zahrady street is expected as a part of the new living street to create public area with trees and benches. This place is in a direct connection to the newly designed pedestrian crossing which connects both sides of Kladenská street. The area should serve as a place for meeting of inhabitants and

9.2 Locality South

On the south entrance to the municipality, the four-leg cross intersection was transformed to a four-leg roundabout. The reason for transformation was similar like in the northern entrance. There was a need to calm the traffic down and to warn drivers coming from the rural area and the freeway D6 about the upcoming change of traffic mode. Also, the intersection needed to be made much clearer, since the area of the junction is in the current situation for some directions hidden behind the horizon. Those deficits are proven by a higher number of traffic accidents and by a speed analysis, which showed that majority of the drivers coming from the intersection to the municipality are not observing the speed limit. Another factor that influenced the choice of a new form of the intersection was a fact that one of the arms is directly connected to a freeway D6. It was therefore advisable to propose a more convenient form of connection of all four arms than it is now.

From all the possible measurements mentioned in previous chapter, it is the most suitable one. Furthermore, the mayor of the municipality itself favoured this option the most.

Building a roundabout offers an effective solution to all the deficits the locality is facing. Also, together with the proposal in locality North and the already existing roundabout in the city centre will help to create a compact system of three roundabouts on the north-south through road through the municipality.

The new type of this intersection is a roundabout with one lane on the circulatory roadway. The roundabout has following dimensions:

- inscribed diameter 33,5 m,
- central island diameter 19,5 m,
- apron width 1,5 m,
- circulatory road width 5,5 m.

All possible manoeuvres within the new design of the intersection were verified with swept path analysis of the largest vehicles, that may possibly drive through this intersection. Those design vehicles are articulated bus and articulated lorry.

Also, there has been analysis of sight distance according to TC 135. Based on sight distance analysis, the proposal of planting of trees was made. Trees cannot be planted inside of sight visibility triangles of the roundabout. Because of the larger diameter of the central island, it was necessary to put some obstacles in the central area of the island given by sight distance analysis. According to TC 135, central islands of larger diameters are supposed to have obstacles on them to make sure drivers will not see through the central island on the opposite side of the roundabout. To accomplish that, planting of trees is suggested in the middle of the central island.

Together with the design of the new roundabout all arms of the previous junction went through a major change in their layout. Generally, there is a reduction in asphalt areas previously used for right turning manoeuvre. Those areas are replaced with green vegetation with trees. List of main changes in all arms of the intersection follows:

- **Northern arm** (Berounská street) is narrowed down to one lane for each direction of travel and instead of the left turning lane in the middle, there is a splitter island. Thanks to the narrowing of the arm, there is a free area on both sides of the arm, which is used for green vegetation with trees. Trees are proposed to be planted in a form of an alley, that would line the entrance road to the municipality on both sides. The idea behind this is that this alley of trees will optically narrow down profile of the road and will create the impression of an entrance gate to the municipality. Another reason for planting trees is that there is a quarter of

family houses planned (see chapter 6). Trees would therefore help to create a visual barrier between busy road and living quarter.

- In the **eastern arm** (exit from the freeway D6) there is a significant reduction in the width at the entry to the intersection. The gained area on both sides was used for new green vegetation with trees for the same reason like on the northern arm. In the middle of the eastern arm is a new splitter island that contributes to a clearer arrangement of the junction.
- **Southern arm** (III/0063) finds itself in an arch and the visibility on the area of the intersection is therefore bad for drivers arriving to it. For that reason, there is a long median strip designed to warn drivers about the upcoming intersection.
- **Western arm** (Unhošťská street) went recently through a major change as a part of already realized project of pathway from Velká Dobrá to a neighbouring municipality Braškov. As a result of this project, there is a new pathway alongside the southern arm and a place for crossing of pedestrians together with a refugee/splitter island on the western arm. As a part of this project, part of the asphalt area of the intersection was already transformed to a green vegetation. Because of the proposal put forward by this thesis, the splitter island is made a little bit shorter and there are trees on both sides of the arm.

Thanks to the different layout of the intersection, the whole character of the locality has changed. The area of the junction is reduced, the intersection is more clear, drivers are forced to drive slower and safety is increased. That will be achieved by a raised level of the central island with trees on it. Those trees can be seen even from behind the horizon, so together with median strips and splitter islands the drivers will know about the intersection when approaching it. Free areas between arms of the intersection created by a reduction of the asphalt area will provide room to extend the vegetation area like it already happened in the NW quadrant of the intersection, thanks to a recently realized project. All the changes aim to reduce the purely transport character of the site and thus create more motivating environment for residents of both municipalities to use this pedestrian connection.

Another positive of the proposed change is that it follows the effort of the city to generally calm down the traffic on the southern entrance to the municipality. Before this project, in 2016, the municipality ordered another study that designed traffic calming elements on the southern through road from the beginning of the municipality to

the roundabout in the city centre. The new design of the intersection proposed by this thesis would therefore logically complete the system of traffic calming elements at the entrance to the municipality.

10 Dewatering

10.1 Locality North

For dewatering in locality North, the arms will be two side sloped carriageways with the camber of 2,5%. With this camber, the water will flow to street inlets located alongside the carriageways or to ditches. New paved areas of sidewalks will be dewatered by a one side slope with the camber of 2,0%. The water will flow either to the adjacent vegetation, where the rainwater will soak naturally, or to a carriageway where the water will flow to ditches or street inlets.

Because of the proximity of a private property in the north-west quadrant of the intersection, the ditch needs to continue into a drainage pipe that leads into a bottom part of a mountain gully. From here the water flows with another drainage pipe to a current sewerage system. In this section above ground is to solve the dewatering installed concrete channel, which ends in a mountain gully.

10.2 Locality South

Dewatering in locality South is much easier. The arms will be two side sloped carriageways with the camber of 2,5%. With this camber, the water will flow to ditches and green areas around arms and the area of the intersection. New paved areas of sidewalks will be dewatered by a one side slope with the camber of 2,0%. The water will flow either to the adjacent vegetation, where the rainwater will soak naturally, or to a carriageway where the water will flow in a way already described.

11 Proposed solution for people with limited movement and orientation

11.1 Solution for people with limited movement

Height difference of sidewalks and carriageways in places for crossing of pedestrians is solved with dropped kerb +2 cm above the carriageway. In other places, where sidewalk meets the carriageway is the kerb +10 cm above the level of the carriageway.

Longitudinal slope and camber for people with limited movement will nowhere exceed the maximal limits given by the guidelines.

11.2 Solution for visually impaired people

Natural lines to guide blind people on new sidewalks are underpinnings of fences or perimeter walls of buildings. On places where the guiding line is missing is added raised kerb 6 cm above the level of sidewalk. All traffic signs have to be located away from those

routes. Potential street furniture (benches, trash cans et cetera) have to be located in a way that does not create an obstacle for blind people.

Dropped kerbs on places for crossing of pedestrians and places for possible entry of pedestrians to the road (places of entryways to private properties) are lined with a 0,4 m wide tactile warning strips. In front of pedestrian crossings is to warning strip also added signal strip that is perpendicular to the warning strip. Its function is to lead blind people from the guiding line to the warning strip and also to signalize in which direction the pedestrian crossing is.

12 Utilities

Courses of the technical equipment of the territory by utilities was obtained based on a request from individual administrators. The drawing of utilities is shown in appendixes 1.3 and 2.3.

12.1 Locality North

In the area of the new proposed design in locality North are utilities listed in the table below. Included are administrators in brackets and lengths of possible relocations of utilities.

Utility type	Length of relocation [m]	Total
Medium pressure gas pipeline (INNOGY)	310	310
Underground metallic cable (CETIN)	319	319
Above ground low voltage lines (ČEZ DSO)	252	252
Underground low voltage lines (ČEZ DSO)	91	
Sewerage (municipality Velká Dobrá)	210	210
Water pipeline (SVAS)	387	387
Total	**1569**	**1531**

Table 5 – List of utilities and length of possible relocations in locality North

12.2 Locality South

In the area of the new proposed design in locality South are only above ground high voltage lines operated by ČEZ DSO. Total length above the new design is 53 m.

Utility type	Length of relocation [m]	Total
Above ground high voltage lines (ČEZ DSO)	53	53
Total	**53**	**53**

Table 6 – List of utilities and length of possible relocations in Locality South

13 List of land owners

13.1 Locality North

In locality North occupies the proposed solution according to cadastre 12 different lands with a total area of 2 729 m^2. From that are 9 lands with total area of 2 665 m^2 state-owned or owned by the municipality itself and 3 lands private-owned. So, if the proposal was successfully approved, the municipality would have to contact those owners and settle conditions and accounts for parts of their lands occupied. Table with detailed description of all lands follows below.

Cadastral area	Parcel number according to cadastre estate	Owner – address (groundsman)	ALF (yes/no)	Land occupation [m2]	Total land area [m2]	Form of usage	Type of land	Number on property sheet
Velká Dobrá [778303]	400/33	Czech Republic **Right to manage state property:** State land office, Husinecká 1024/11a, Žižkov, 13000 Prague 3	yes	3898	26060		fertile ground	10002
Velká Dobrá [778303]	1430/1	Central Bohemian Region, Zborovská 81/11, Smíchov, 15000 Prague 5 **Right to manage state property:** Regional administration and maintenance of roads, funded organisation, Zborovská 81/11, Smíchov, 15000 Prague 5	no	326	17016	road	other area	455
Velká Dobrá [778303]	400/30	MP Drábek Petr and Drábková Jaroslava, Rozdělovská 557, 27361 Velká Dobrá	yes	18	747		fertile ground	988
Velká Dobrá [778303]	1421	Central Bohemian Region, Zborovská 81/11, Smíchov, 15000 Prague 5 **Right to manage state property:** Regional administration and maintenance of roads, funded organisation, Zborovská 81/11, Smíchov, 15000 Prague 5	no	1441	23771	road	other area	455
Velká Dobrá [778303]	1475	Municipality Velká Dobrá, Karlovarská 15, 27361 Velká Dobrá	no	80	103	other road	other area	10001

Cadastral area	Parcel number according to cadastre estate	Owner – address (groundsman)	ALF (yes/no)	Land occupation [m2]	Total land area [m2]	Form of usage	Type of land	Number on property sheet
Velká Dobrá [778303]	1411/3	Municipality Velká Dobrá, Karlovarská 15, 27361 Velká Dobrá	no	147	458	watercourse through natural of modified	water area	10001
Velká Dobrá [778303]	1411/1	Czech Republic **Right to manage state property:** State land office, Husinecká 1024/11a, Žižkov, 13000 Prague 3	no	283	5012	other road	other area	10002
Velká Dobrá [778303]	1465	Municipality Velká Dobrá, Karlovarská 15, 27361 Velká Dobrá	no	73	86	other road	other area	10001
Velká Dobrá [778303]	1454/3	Municipality Velká Dobrá, Karlovarská 15, 27361 Velká Dobrá	no	128	677	other road	other area	10001
Velká Dobrá [778303]	1454/2	Municipality Velká Dobrá, Karlovarská 15, 27361 Velká Dobrá	no	333	395	other road	other area	10001
Velká Dobrá [778303]	51/6	Municipality Velká Dobrá, Karlovarská 15, 27361 Velká Dobrá	no	133	133	other road	other area	10001
Velká Dobrá [778303]	17/1	MP Brynda Pavel and Bryndová Jitka, Kladenská 344, 27361 Velká Dobrá	no	86	1164		built-up area and courtyard	557
Velká Dobrá [778303]	51/1	Kabát Jiří, Kladenská 563, 27361 Velká Dobrá; MP Kabát Jiří and Kabátová Eleonora, Kladenská 563, 27361 Velká Dobrá (share 1/2)	no	3	730		garden	512
Velká Dobrá [778303]	1454/5	Municipality Velká Dobrá, Karlovarská 15, 27361 Velká Dobrá	no	4	60	other road	other area	10001

Table 7 – List of land owners in locality North

13.2 Locality South

In locality South occupies the proposed solution according to cadastre 9 different lands with a total area of 7 370 m^2. Positive information is that all lands are state-owned or owned by the municipality itself. So, there should be no problems regarding land ownership. Table with detailed description of all lands follows below.

Cadastral area	Parcel number according to cadastre estate	Owner – address (groundsman)	ALF (yes/no)	Land occupation [m^2]	Total land area [m^2]	Form of usage	Type of land	Number on property sheet
Velká Dobrá [778303]	1405/1	Central Bohemian Region, Zborovská 81/11, Smíchov, 15000 Prague 5 **Right to manage state property:** Regional administration and maintenance of roads, funded organisation, Zborovská 81/11, Smíchov, 15000 Prague 5	no	233	2851	road	other area	455
Velká Dobrá [778303]	1405/14	Municipality Velká Dobrá, Karlovarská 15, 27361 Velká Dobrá	no	10	675	other road	other area	675
Velká Dobrá [778303]	1405/8	Czech Republic **Right to manage state property:** State land office, Husinecká 1024/11a, Žižkov, 13000 Prague 3	no	2247	2867	other road	other area	10002
Velká Dobrá [778303]	1405/5	Czech Republic **Right to manage state property:** State land office, Husinecká 1024/11a, Žižkov, 13000 Prague 3	no	1046	2115	other road	other area	10002
Velká Dobrá [778303]	1405/6	Municipality Velká Dobrá, Karlovarská 15, 27361 Velká Dobrá	no	145	563	other road	other area	563
Velká Dobrá [778303]	1491/1	Czech Republic **Right to manage state property:** Road and Motorway Directorate of the Czech Republic, Na Pankráci 546/56, Nusle, 14000 Praha 4	no	1905	3201	other road	other area	678
Velká Dobrá [778303]	1405/9	Municipality Velká Dobrá, Karlovarská 15, 27361 Velká Dobrá	no	27	71	other road	other area	71
Velká Dobrá [778303]	1405/10	Central Bohemian Region, Zborovská 81/11, Smíchov, 15000 Prague 5 **Right to manage state property:** Regional administration and maintenance of roads, funded organisation, Zborovská 81/11, Smíchov, 15000 Prague 5	no	1738	5122	road	other area	455
Velká Dobrá [778303]	1405/11	Czech Republic **Right to manage state property:** State land office, Husinecká 1024/11a, Žižkov, 13000 Prague 3	no	19	1839	other road	other area	10002

Table 8 – List of land owners in locality South

14 Meeting with responsible authorities

On 13. 1. 2019 a meeting with responsible authorities took place. The meeting was held in municipal office of the district town Kladno. The co-ordination meeting was negotiated based on the project this thesis is dealing with. Authorities from all representative bodies involved in this project were present, in total 11 representatives from 6 different representative bodies.

Authorities were presented proposals of a new design of both intersections with all the details and reasons for changes made compared to the current state. After the presentation, discussion followed, where all representatives commented on presented drawings. Generally better accepted was the intersection designed in locality South and for the design in locality North, there were some remarks contrary to the proposal. As a result of the discussion, there is a list of things that should be taken into account

- Higher level of documentation for roundabout at the **northern entrance** to the municipality is recommended to work out, if following points are observed:
  - increasing the roundabout diameter to at least 30 m;
  - keeping the kerb of a splitter island at the western arm of the intersection throughout its whole length;
  - shortening of the raised section of the splitter island on the northern arm;
  - either connection Pod Zahrady street to the intersection as a fifth arm or closing it and solving the entrance to this street from its other side
- Higher level of documentation for roundabout at the **southern entrance** to the municipality is recommended to work out, if following points are observed:
  - shortening of the raised section of the median strip on the southern arm;
  - consider concrete surface of the splitter island on the eastern arm of the intersection;
  - extend streetlamps from the edge of the municipality to the area of the roundabout.

After the meeting, scheme of changes for locality North was made. For designing the drawing scheme, all the comments mentioned in the meeting were taken into account. Comments on the intersection in locality South did not have a significant influence on the proposed solution.

15 Indicative calculation of investment costs

To know about the financial costs of both proposals, indicative calculation of investment costs was made. According to this indicative calculation would realisations of proposals cost:

- roundabout in locality North 5,33 million Czech crowns
- roundabout in locality South 8,95 million Czech crowns

Detailed calculations of all budget items follow below.

15.1 Locality North

Item description	Amount (measurement)	UM	Unit price	Total (CZK)
Preparation of the area				
Bushes removal	25,00	m²	100,00	2 500,00
Cutting down broad-leaved trees 10-30 cm	1,00	pcs	980,00	980,00
Cutting down coniferous trees 10-30 cm	2,00	pcs	920,00	1 840,00
Cutting down broad-leaved trees 30 - 50 cm	2,00	pcs	1 100,00	2 200,00
Cutting down coniferous trees 30 - 50 cm	2,00	pcs	1 000,00	2 000,00
Kerbs removal	350,00	m	200,00	70 000,00
Demolition of road construction layers	383,00	m²	350,00	134 050,00
Milling the roadway asphalt layer 4 cm thick	2 986,00	m²	400,00	1 194 400,00
Dismantling of pavement	423,00	m²	150,00	63 450,00
Removing railing with concrete base	38,00	m	400,00	15 200,00
Removing traffic signs	6,00	pcs	370,00	2 220,00
Adjusting and cleaning of current ditches	317,00	m	200,00	63 400,00
Total				**1 552 240,00**
Earthworks				
Adding humus and sowing	190,00	m³	90,00	17 100,00
Embankments from imported soil	85,00	m³	750,00	63 750,00
Total				**80 850,00**
Construction layers				
Bituminous roadway - all layers	485,00	m²	1 800,00	873 000,00
Bituminous roadway - reconstruction of asphalt layer	2 070,00	m²	300,00	621 000,00
Multipurpose belts, truck aprons, islands - granite paving - using current bottom layers	201,00	m²	2 160,00	434 160,00
Entrances - interlocking pavement	111,00	m²	1 500,00	166 500,00
Roadway - interlocking pavement	229,00	m²	1 500,00	343 500,00
Sidewalk - interlocking pavement	758,00	m²	1 375,00	1 042 250,00
Warning and signal strips for blind people, 34 cm thick made of paving for blind people	46,00	m²	1 260,00	57 960,00
Total				**2 094 660,00**

Item description	Amount (measurement)	UM	Unit price	Total (CZK)
Other constructions and works				
Traffic signs on the construction - temporary - set	1,00	pcs	24 000,00	24 000,00
Traffic sign C4a	4,00	pcs	890,00	3 560,00
Traffic sign C1	4,00	pcs	890,00	3 560,00
Traffic sign P4	1,00	pcs	850,00	850,00
Traffic sign IZ5a	1,00	pcs	1 490,00	1 490,00
Traffic sign IZ5b	1,00	pcs	1 490,00	1 490,00
Traffic equipment Z4b	1,00	pcs	650,00	650,00
Post 1,0 m	4,00	pcs	150,00	600,00
Post 3,5 m	9,00	pcs	550,00	4 950,00
Installation of 1 road sign including post	13,00	pcs	1 600,00	20 800,00
Road marking of width 0,125	264,00	m	30,00	7 920,00
Road marking of width 0,25	620,00	m	55,00	34 100,00
Road marking of width 0,50	61,00	m	108,00	6 588,00
Drainage DN 400	14,00	m	2 500,00	35 000,00
Connections to drainage	1,00	pcs	750,00	750,00
Concrete channel 60 cm wide	39,00	m	570,00	22 230,00
Drainage of ditch DN 315	36,00	m	3 000,00	108 000,00
Green areas (sewing only)	190,00	m^2	150,00	28 500,00
Streetlamps for pedestrian crossing (pair)	1,00	pcs	50 000,00	50 000,00
Total				**276 538,00**
Reserve 10%				**400 428,80**
TOTAL				**4 404 716,80**
21% VAT				924 990,53
Costs including VAT				**5 329 707,33**

The indicative calculation does not include costs related to the induced necessity of relocation of the utilities!!! Calculation of these costs is necessary to consult with individual administrators.

Table 9 – Calculation of investment costs in locality North

15.2 Locality South

Item description	Amount (measurement)	UM	Unit price	Total (CZK)
Preparation of the area				
Kerbs removal	*7,00*	*m*	*200,00*	*1 400,00*
Demolition of road construction layers	*1 766,00*	*m²*	*350,00*	*618 100,00*
Milling the roadway asphalt layer 4 cm thick	*6 821,00*	*m²*	*400,00*	*2 728 400,00*
Total				**3 347 900,00**
Earthworks				
Adding humus and sowing	*1 766,00*	*m³*	*90,00*	*158 940,00*
Embankments from imported soil	*706,00*	*m³*	*750,00*	*529 500,00*
Total				**688 440,00**
Construction layers				
Bituminous roadway - reconstruction of asphalt layer	*4 748,00*	*m²*	*300,00*	*1 424 400,00*
Multipurpose belts, truck aprons, islands - granite paving – using current bottom layers	*407,00*	*m²*	*2 160,00*	*879 120,00*
Sidewalk - interlocking pavement	*5,00*	*m²*	*1 375,00*	*6 875,00*
Warning and signal strips for blind people, 34 cm thick made of paving for blind people	*7,00*	*m²*	*1 260,00*	*8 820,00*
Total				**2 303 520,00**
Other constructions and works				
Traffic signs on the construction - temporary - set	*1,00*	*pcs*	*24 000,00*	*24 000,00*
Traffic sign C4a	*3,00*	*pcs*	*890,00*	*2 670,00*
Traffic sign C1	*4,00*	*pcs*	*890,00*	*3 560,00*
Traffic sign P4	*2,00*	*pcs*	*850,00*	*1 700,00*
Traffic sign Z3	*4,00*	*pcs*	*580,00*	*2 320,00*
Traffic sign IZ1a	*1,00*	*pcs*	*2 850,00*	*2 850,00*
Traffic sign E3a	*1,00*	*pcs*	*850,00*	*850,00*
Post 3,5 m	*5,00*	*pcs*	*550,00*	*2 750,00*
Post 1,0 m	*7,00*	*pcs*	*150,00*	*1 050,00*
Installation of 1 road sign including post	*12,00*	*pcs*	*1 600,00*	*19 200,00*
Road marking of width 0,125	*342,00*	*m*	*30,00*	*10 260,00*
Road marking of width 0,25	*956,00*	*m*	*55,00*	*52 580,00*
Road marking (areas)	*100,00*	*m²*	*475,00*	*47 500,00*
Planting trees	*43,00*	*pcs*	*5 000,00*	*215 000,00*
Total				**386 290,00**
Reserve 10%				**672 615,00**
TOTAL				**7 398 765,00**
21% VAT				1 553 740,65
Costs including VAT				**8 952 505,65**

The indicative calculation does not include costs related to the induced necessity of relocation of the utilities!!! Calculation of these costs is necessary to consult with individual administrators.

Table 10 – Calculation of investment costs in locality South

16 Conclusion

Based on local investigation and analysis of the current situation, proposal of a solution of southern and northern entrance gate to the municipality of Velká Dobrá was made. The output of this thesis, that is being put forward is optimal and suitable solution of problems both localities are dealing with at the moment. Pair of proposed roundabouts fulfils the request to generally calm down traffic at the entrance to the municipality. Also, it creates conditions for subsequent traffic calming measurements on through roads that lead from roundabouts to the city centre. New form of crossing of roads creates in both localities optimal transition from the character of rural area to urban area and aims to homogenize the behaviour of traffic flows into an optimal form.

In both localities were successfully reduced asphalt areas and were replaced with materials more suitable for urban areas. In locality North is the reduction 19% and in locality South even 31%. That means 780 m^2 more mainly for green areas and sidewalks at the north roundabout and 3 235 m^2 for green vegetation areas or traffic islands.

	Asphalt area reduction [%]	Gained area [m^2]
Locality North	19	780
Locality South	31	3 235

Table 11 – Reduction of asphalt areas

Following the change in the use of these large areas, a significant reduction in purely automotive character was achieved in both locations. In this way, the role of pedestrians changes fundamentally. They should be in this newly designed state much more motivated to use walking as an equal form of transportation within the municipality.

I hope that findings and conclusions resulting from this thesis will serve as a good source for the municipality itself and that proposed solutions will one day hopefully be implemented.

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