OVERTAKING VIOLATIONS IN LEFT-TURN LANES OF RURAL ROADS

Dániel MILETICS
Junior lecturer, PhD student
Department of Transport Infrastructure and Municipal Engineering
Szechenyi Istvan University
Egyetem ter 1
9026 Gyoer, Hungary
Fax: +36-96-503-451
E-mail: mileticsd@sze.hu

Csaba KOREN
Professor
Department of Transport Infrastructure and Municipal Engineering
Szechenyi Istvan University
Egyetem ter 1
9026 Gyoer, Hungary
Fax: +36-96-503-451
E-mail: koren@sze.hu

Abstract: Overtaking is a high risk manoeuvre for road users, still driver often accept this risk, moreover often commit irregular overtaking manoeuvres. The paper gives some overview on traffic violations and irregular overtaking manoeuvres. Left-turn lanes are usual elements of at-grade junctions on two-lane rural roads. In several cases the left-turn lane, built for safety reasons, has the unintended negative effect, it becomes a dangerous spot. The paper analyses overtaking manoeuvres at left-turn lanes on Hungarian rural roads. Typical sites outside built-up area have been identified and selected. Site surveys were completed at the selected intersections and its area. The frequency of irregular overtaking manoeuvres, geometric design, traffic volume, traffic mix and speed characteristics were registered at the intersections. Accident statistics have been collected. Relationships between the frequency of irregular manoeuvres, accident statistics, geometric parameters and traffic data are analysed.

Key words: driver behaviour, left-turn lane, irregular overtaking, site survey, violation

1. VIOLATIONS ON THE ROAD

In considering the human contribution to accidents, psychologists make a distinction between errors and violations; two forms of aberration which may have different psychological origins and demand different modes of remediation (Reason et al., 1990). Three fairly robust factors can be identified: violations, dangerous errors, and relatively harmless lapses, respectively. Violations require explanation in terms of social and motivational factors, whereas errors (slips, lapses, and mistakes) may be accounted for by reference to the information-processing characteristics of the individual.

As a large portion of the violations remains hidden, it is a common method to investigate them by driver behaviour questionnaires (DBQ). One of the most influential studies of the varieties of aberrant driving behaviours has been conducted by Reason et al. (1990). Self-reports of driver errors were collected through the driver behaviour questionnaire from a sample of 520 British drivers. Several other studies followed this in other countries (e.g. Kontogiannis et al. 2002, Gras et al 2006). The most common criticism of self-reported data is the possibility that it suffers from social desirability bias. However, research using the DBQ found that socially desirable responding had a very minimal effect on participants responses (Lajunen & Summala, 2003). Another common criticism of self-report is that there is great variance between what drivers report and their actual behaviour. However, there are also a number of studies that have found self-reported driving behaviour to be significantly related to actual driving behaviour. The most often reported violations in France are shown in Table 1 (Nallet et al 2010).

Table 1. Violations reported to be committed often or fairly often in 2005 in France (Nallet et al. 2010).

	Men (n = 655) %	Women (n = 506) %
Exceeding the speed limit by 10 km/h on a motorway	55.8	48.7
Daytime excess speeding on a road	44.5	34.1
Night-time excess speeding on a road	38.0	22.5
Exceeding the speed limit in a built up area	27.1	21.4
Driving through an amber traffic light	21.6	22.0
…	…	…
Not wearing a seat belt	9.6	5.4
Risky overtaking	**8.5**	**5.3**
Drink driving	5.7	0.9
…	…	…
Driving the wrong way down a one-way street	2.8	0.7
Ignoring a stop sign	2.6	0.8

Among the 21 violations, risky overtaking is at rank 15, drivers report to commit this quite rarely. This is probably because they feel this manoeuvre highly dangerous (see Table 2). It is remarkable however that considering the perception of the risk of punishment for a violation, risky overtaking stands at rank 15 again, indicating that the risk of punishment for this violation is quite low(see Table 3).

Table 2. Perception of the danger associated with the violations in 2005 in France (Nallet et al. 2010).

	Men (%)	Women (%)
Drink driving	87.8	90.4
Ignoring a stop sign	87.6	89.6
Risky overtaking	**89.4**	**86.3**
Cutting in front of another driver	85.0	85.9
Driving the wrong way down a one-way street	84.1	88.2
Telephoning while driving	82.7	88.2
…	…	…
Illegal parking	35.4	36.3
Exceeding the speed limit by 10 km/h on a motorway	31.9	42.1

Table 3. Perception of the risk of punishment for a violation in 2005 in France (Nallet et al. 2010).

	Men (%)	Women (%)
Not wearing a seat belt	79.3	73.7
Drink driving	60.0	71.9
Exceeding the speed limit by 30 km/h on a motorway	57.4	66.5
Ignoring a stop sign	55.7	60.9
Exceeding the speed limit in a built up area	52.4	65.8
…	…	…
Risky overtaking	**19.5**	**25.5**
…	…	…
Failing to indicate	10.6	11.7

2. OVERTAKING STUDIES

Overtaking is a high risk manoeuvres for road users. In the case of a head-on collision, the summarized speed of two vehicles can result a much more severe impact.

As a type of violations irregular overtaking has been observed and analyzed in Saudi Arabia through the actual behaviour of drivers (Ratrout 2004). Irregular overtaking was a frequent cause of accidents with 10 % proportion of all accidents. The goal of Ratrout's study was to quantify the extent of irregular overtakings and to find relationships between different geometric and traffic conditions and the number of irregular overtaking manoeuvres.

Two types of sites were selected for the observations: curves and tangent sections. Overtaking was prohibited in both cases. The prohibition was communicated to the drivers only by road markings, there were no traffic signs posted at any sites. While in case of curves the reason is the restricted visibility, prohibition of overtaking at tangent sections (where anyway the visibility conditions are good) is reasonable by e.g. the desirable avoidance of more risky traffic situations in an intersection area.

It was found, that average percentage of irregular vehicles was higher on straight sections (2.3%), than at curves (1.8%). It seems that there is no correlation between neither the alignment nor the time period and ratio of irregular overtakings. According to the linear regression model given by the study, the number of overtaking vehicles can be predicted by traffic volume, namely the number of irregular overtakings is more affected by the traffic volume in the same direction, than by the traffic volume in the other direction. This model was valid between 650 and 1000 ADT in both directions.

3. DESIGN OF LEFT-TURN LANES

3.1. Hungary

According to the Hungarian design guidelines (HRS 2008), left-turn lanes have to be provided in junctions on rural roads depending on the expected traffic volumes of the two roads. More exactly, left-turn lanes are required, if the product of average annual daily traffic of the two roads is higher than 4.5 million (AADTmajor*AADTminor>=4 500 000).

Left-turn lanes can be implemented various ways according to the traffic volume, class of major road and design speed. The usual geometric design (Figure 1) consists of three sections. First is the lane changing section (L_Z), which is usually implemented by pavement markings only. Second is the deceleration section (L_V), third is the queuing section (L_A). In case of four leg intersection and high left turning traffic, left-turn lanes should be implemented in both directions (HRS 2004).

Following the rules of the guideline, the length of the left-turn lanes can be calculated as a function of the design speed (Table 4). In case of left-turn lanes in both directions, the total length of the two lanes will be between 200 and 400 m. Moreover, if the design speed is 70 km/h or more, this length is more than the half of the minimal overtaking sight distance. These lengths provide opportunity for drivers to overtake in the left-turn lanes even with some feeling of “safety”, as the vehicle in the opposite direction is far away enough. However, this is actually a false feeling of safety.

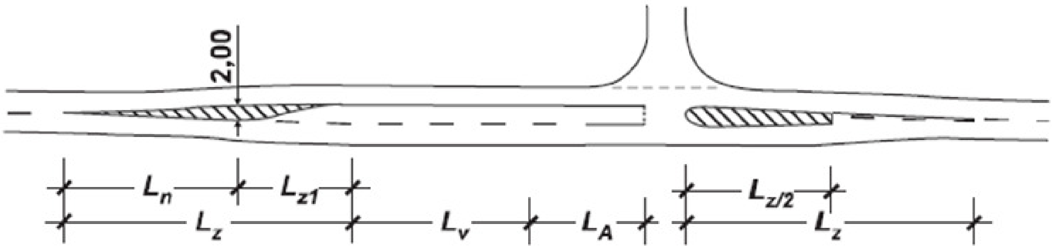

Figure 1. Usual geometric design of left-turn lanes

Table 4. At design speed 70 km/h and more the total length of the two left-turn lanes is higher than the design overtaking length (see **bald** figures)

Design parameters		Design speed (km/h)						
		50	60	70	80	90	100	110
1	Minimal overtaking sight distance, Le_min, m	360	400	440	500	560	640	700
2	Length of lane changing section, LA, m	35	42	49	57	64	71	78
3	Length of deceleration section (if AADT to left>400 PCU), Lv, m	0	20	30	40	55	70	85
4	Length of queuing section, LA, m	20	20	20	20	20	20	20
5	Length of left-turn lane, m 2+3+4 rows	55	82	99	117	139	161	183
6	Total length of two left-turn lanes and intersection core, m	136	190	**224**	**258**	**302**	**346**	**391**
7	Half of the the minimal overtaking sight distance = design overtaking length , m	180	200	220	250	280	320	350

3.1. USA Texas

The terms of application and design parameters are influenced also by traffic volume and design speed. According to the design guideline (TDT 2010) the main reason of implementation of left turn lanes is traffic safety. The length of deceleration section is given with the assumption that the speed of approaching (than left turning) vehicle is already reduced by approximately 15 % before the lane changing section. In this conception the lengths of deceleration section can be reduced.

3.2. Germany

According to the German RAL (FGSV 2008) instead of design speed road design classes are defined, which describes as well geometric parameters as intersection types to use on the given road. The cross section of the studied rural roads in Hungary fits to de German EKL3 (Design Class 3) roads. In EKL3 designed rural intersections with left turn lanes do not have deceleration section at all. Left-turn lanes with three sections are applied only at signalized intersections.

3.3. Austria

In the Austrian design guideline (FGVS 1987) the terms of application and design parameters depend also on traffic volume and design speed. The design parameters in the guidelines arise similar to the Hungarian ones, but much shorter left-turn lanes also can be found on rural roads in Austria. These left-turn lanes are often implemented with raised traffic island in the intersection core and at the lane changing section of the intersection.

4. EFFECTIVENESS OF LEFT-TURN LANES

Installation of left-turn lanes has been the focus of many research studies. Various safety-related impacts have been documented (Harwood et al 2002)

In a synthesis work McFarland (1979) reported that the provision of left-turn lanes at unsignalized intersections, when combined, with installation of curbs, reduced accidents by 70, 65, and 60 percent in urban, suburban, and rural areas, respectively. When the channelization was painted rather than raised, accidents decreased only by 15, 30, and 50 percent in urban, suburban, and rural areas, respectively.

Not all studies, however, have shown that left-turn lanes reduce accidents. Bauer and Harwood (1966) found that left-turn lanes were associated with higher frequencies of both total multiple-vehicle accidents and fatal and injury multiple-vehicle accidents. At unsignalized intersections, McCoy and Malone (1989) determined there was a significant increase in right-angle accidents.

However, at unsignalized intersections on rural two-lane highways, McCoy et al. (1985) found no significant difference in rear-end and left-turn accident rates between intersections with and without left-turn lanes. Poch and Mannering (1985) also found some situations in which accidents of specific types increased with installation of left-turn lanes.

An extensive report of Harwood et al. (2002) presents the results of research that performed a well-designed before-after evaluation of the safety effects of providing left- and right-turn lanes for at-grade intersections. Geometric design, traffic control, traffic volume, and traffic accident data were gathered for a total of 280 improved intersections, as well as 300 similar intersections that were not improved during the study period. The types of improvement projects evaluated included installation of added left-turn lanes, added right-turn lanes, and extension of the length of existing left- or right-turn lanes. An observational before-after evaluation of these projects was performed using several alternative evaluation approaches.

For rural unsignalized intersections with two-way stop control, installation of a major road left-turn lane was found to reduce total accidents at four-leg intersections by 28 percent. The corresponding reduction in fatal and injury intersection accidents was slightly larger, at 35 percent.

For three-leg intersections total intersection accidents decreased by 44 percent with the addition of a major-road left-turn lane at rural unsignalized intersections and by 33 percent at urban unsignalized intersections.

A supplementary analysis addressed the relative safety effectiveness of curbed vs. painted channelization for left-turn lanes. It was found that at rural unsignalized intersections there appears to be a definite indication that left-turn lanes with curbed channelization are more effective than left-turn lanes with painted channelization. This appears to be particularly the case for rural four-leg unsignalized intersections in which channelized left-turn lanes reduced accidents by 57 percent while painted left-turn channelization reduced accidents by only 23 percent. However, the sample sizes for these comparisons are too small for the results to be definitive.

5. SITE SURVEYS

Three intersections have been visited in County Győr-Moson-Sopron in order to observe irregular overtaking manoeuvres at left-turn lanes. The sites are similar to each other in the number of legs, number of left-turn lanes (both directions) and each is on a main road, outside built-up area. They are different in some geometric parameters, like length of left-turn lanes or the alignment of the main road. The overtaking manoeuvres, their length, direction and the type of participating vehicles were registered manually. Traffic volume and traffic mix were also recorded. Investigations were completed at each site in the peak hour (7:00-8:00) and in an off-peak period in the morning (9:00-10:00 or 11:00-12:00), so irregular overtaking manoeuvres could be observed in different traffic conditions. The ratio of free overtaking sections related to the 5 km section before the intersection was also measured. Accident data of years 2000-2010 have been collected. Based on the observations, various types of risky manoeuvres can be identified (Figure 2).

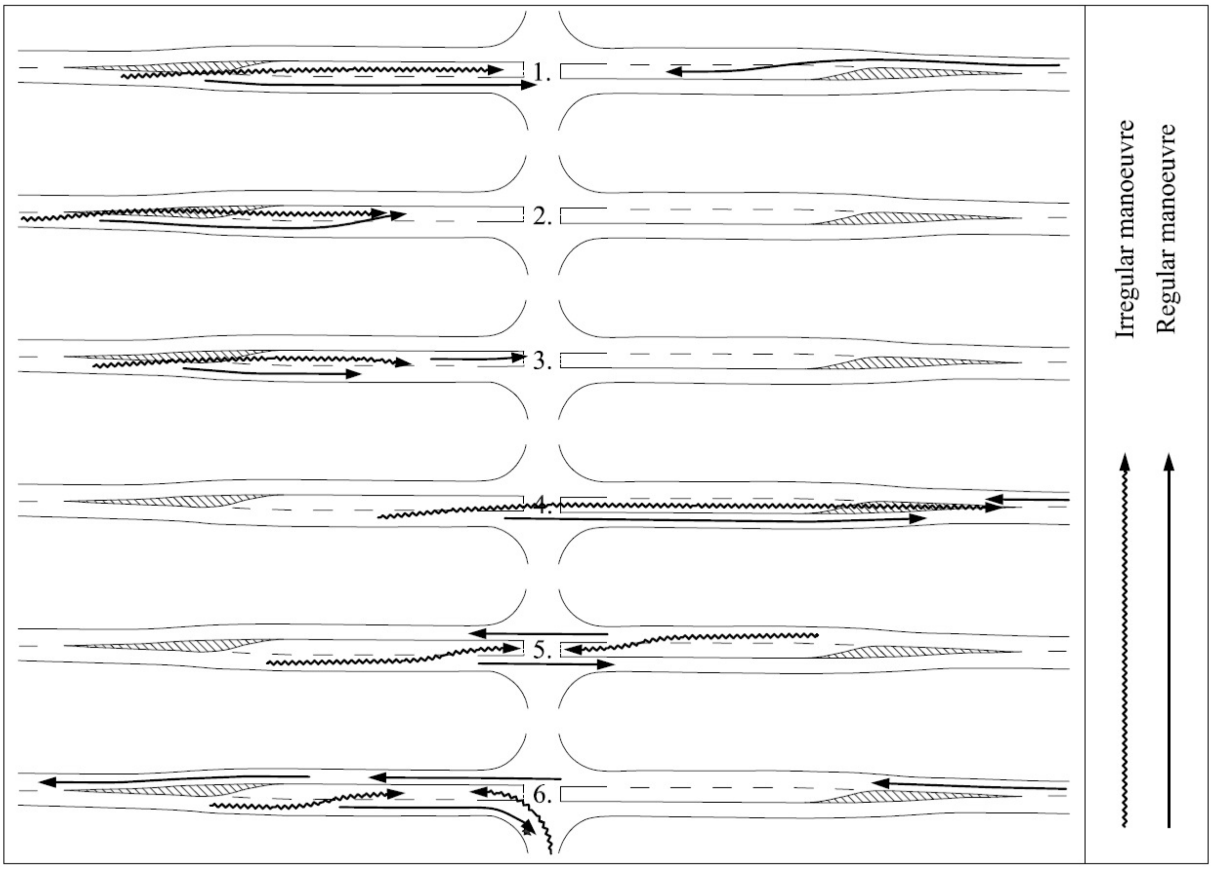

Figure 2. Types of risky manoeuvres

Table 5. Traffic volumes, geometric parameters and irregular overtaking manoeuvres at the three sites.

Site	Period of the survey	Traffic direction	Through traffic, vehicle/h	Ratio of heavy vehicles	Ratio of left turnig vehicles	Ratio of irregular overtaking vehicles	Lenght of left-turne lanes, m	Ratio of free overtaking lenghts before the intersection
1.	7:00-8:00	Győr - Komárom	188	11%	4%	9,6%	400+230	89%
		Komárom - Győr	175	6%	2%	4,6%	230+400	56%
	9:00-10:00	Győr - Komárom	145	15%	4%	4,1%	400+230	89%
		Komárom - Győr	162	9%	4%	0,0%	230+400	56%
2.	7:00-8:00	Győr - Székesfehérvár	144	15%	1%	2,1%	170+140	88%
		Székesfehérvár - Győr	201	16%	0%	1,5%	140+170	73%
	9:00-10:00	Győr - Székesfehérvár	138	20%	13%	0,7%	170+140	88%
		Székesfehérvár - Győr	165	16%	0%	0,0%	140+170	73%
3.	7:00-8:00	Győr - Mosonmagyaróvár	145	11%	11%	1,4%	200+225	87%
		Mosonmagyaróvár - Győr	145	3%	6%	0,7%	225+200	81%
	9:00-10:00	Győr - Mosonmagyaróvár	109	9%	10%	0,9%	200+225	87%
		Mosonmagyaróvár - Győr	112	4%	3%	0,0%	225+200	81%

Site 01 – Road No1: Győr-Gönyű harbour intersection

The intersection is located at the Road No1 in section 114 km + 274 m. Left-turn lanes on the main road serve the left turning traffic in direction Győr-Gönyű Harbour and a railway station. The alignment of the main road is straight, sight distances are ensured from both directions. From the direction of Győr the total length of the left-turn lane is as high as 400 m. It is almost the double of the length specified by the design guideline. It can be explained by the expected high level of truck traffic of the harbour. However the harbour is currently operating with quite low traffic volumes. The length of the left-turn lane in the other direction is 230 m. The speed limit on the main road is 60 km/h in the junction area, some drivers obey others do not the speed limit.

Table 5 shows through and left turning traffic volumes, the ratio of heavy vehicles and the ratio of irregular overtaking manoeuvres. Traffic volumes were quite low as compared to capacity. The ratio of heavy vehicles was higher from 11:00 to 12:00. The ratio of irregular overtaking manoeuvres was much higher in the morning. The total number of irregular overtaking manoeuvres was 26 between 7:00 and 8:00, and 6 from 11:00 to 12:00.

There was difference also between the two directions both in the morning and at noon. More irregular overtaking manoeuvres were taken by drivers from Győr to Komárom (total 24). Except one, all of these manoeuvres were executed by passenger car. The other participant was also PC in 61% of the total actions. All of the manoeuvres happened before the junction, at the "own" left-turn lane. Types of participating vehicles in direction Komárom-Győr were similar. Drivers from this direction used mostly (75%) also the "opposite" left-turn lane to complete their manoeuvre. The ratio of free overtaking distance before the junction is 89% in direction Győr-Komárom, and 56% in the other direction.

The distribution of lengths of irregular overtaking manoeuvres is shown in Figure 3. It is visible that almost all overtakings were completed within 250 m, whereas the length of the left-turn lane is about 400 m.

During the period studied, 2 accidents happened in the area of intersection. In one of them, one person were injured seriously. In the other one, one person was injured seriously three people were injured slightly. Both accidents happened during overtaking manoeuvres.

Site 02 – Road No81. Pér petrol station

The intersection is located near to Pér at Road No81, section 70 km + 876m. The major road connects Győr and Székesfehérvár. The minor road ensures connection to the petrol station northward and to agricultural areas and a fishing lake southward. The alignment of the main road is straight, sight distances are ensured from both directions. From direction Győr, the total length of lane changing section and left-turn lane is 170 m, it is 140 m from the other direction. These lengths fit to the road class and speed limit of 90 km/h.

Table 5 shows through and left turning traffic volumes, the ratio of heavy vehicles and the ratio of irregular overtaking manoeuvres. Traffic volumes were quite low as compared to capacity. The ratio of heavy vehicles was between 15 and 20%. The total number of irregular manoeuvres was 6 in the first and 1 in the second period of observation.

Four of the total irregular overtaking manoeuvres were executed by passenger cars, in three cases by vans. The other participant was PC in four cases and truck in three cases. The distribution of location of the manoeuvres was equal: about half of the overtaking vehicles passed at the "own" turning lane, the other half of the vehicles used the "opposite" turning lane. The ratio of free overtaking distance before the junction is 88% in direction Győr-Székesfehérvár, 73% in the other direction.

All observed overtaking manoeuvres' lengths were equal or shorter than 200 m. During the period studied, 2 accidents happened in the area of intersection. One person injured seriously, number of slight injures is 2. Overtaking played role in the accidents in both cases.

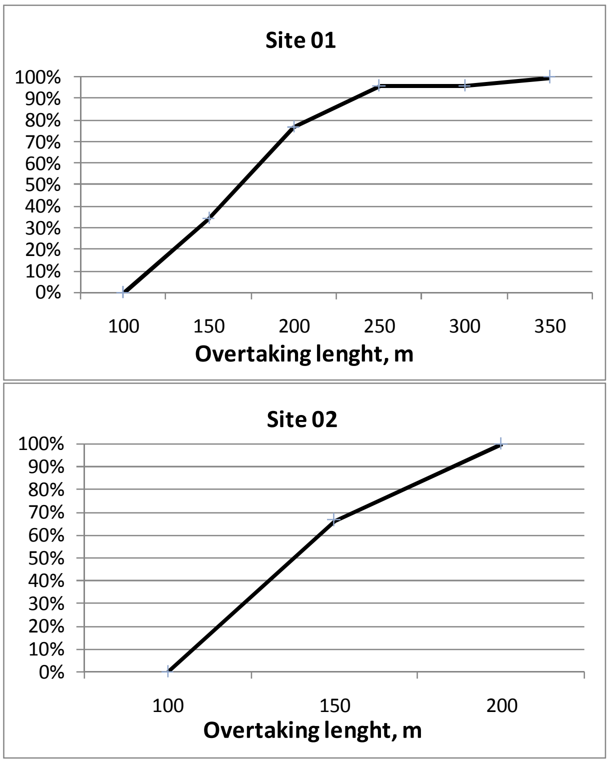

Figure 3. Distribution of overtaking lengths at Site01 and Site 02 7:00-8:00 in the morning

Site 03 – Road No1. Mosonújhely junction

The intersection is located at the road No1 in section 145 km + 165 m. Left-turn lanes on the main road serve the left turning traffic to direction Mecsér and Lébény. The minor road serves as a connection between Road No 1 and the M1 motorway. The alignment of the main road is not straight, the junction is between two curves. Additionally there is also a crest curve. However the radii of the curves and crest curve are relatively big, sight distances are partly restricted by curves and roadside vegetation. From direction Győr the total length of lane changing section and left-turn lane is 200 m, it is 225 m from the other direction. Probably because of former accidents, there is an amber flashing signal device implemented at the intersection on the main road.

Traffic volumes were quite low as compared to capacity. The ratio of heavy vehicles was between 3 and 11%. The ratio of irregular overtaking manoeuvres was 0.0%, 0.7%, 0.9% and 1.4% in the period and directions studied. The number of irregular manoeuvres was 3 in the first and 1 in the second period of observation. All of the irregular manoeuvres were taken by passenger car drivers, the other participants were PCs and trucks. Except one case, vehicles used "own" turning lane for the overtaking manoeuvres. The ratio of free overtaking distance before the junction is 87% in direction Győr-Mosonmagyaróvár, 81% in the other direction (see Table 5).

During the period studied, 8 accidents happened at this site, one person died, three people injured seriously and 21 slightly. Overtaking played no role in these accidents.

6. CONCLUSIONS

At two of the three sites studied, the ratio of irregular overtakings was about 1% of the total number of vehicles passing the junction. At one of the sites, this ratio was significantly higher, 4-5 in average, but as high as almost 10% in some period. The ratio of free overtaking distance before the junctions was over 80% and the traffic volumes were quite low in all cases. Therefore the irregular overtakings cannot be explained by the excessive delays or queuing of drivers.

The length of the irregular overtaking manoeuvres was in most of the cases not more than 250 m at the observed sites. The usual design of left-turn lanes at junction outside built-up areas gives enough space for such overtakings and therefore creates a potential danger, as 1% of the drivers use the opportunity to overtake. If the length of the left-turn lane is more than the minimum length in the guidelines, the ratio of irregular overtakings increases even up to 10% of the drivers. This has to be considered a highly risky situation.

Recommended engineering countermeasures are: a) to reduce the lengths of the left-turn lanes and b) to use traffic islands at the beginning of the left-turn lane and also in the junction core area. Arguments of winter maintenance should not be stronger than safety considerations.

ACKNOWLEDGEMENT

The preparation of this paper was supported by TAMOP-4.2.1/B-09/1/KONV-2010-0003: Mobility and Environment. The Project is supported by the EU and co-financed by the European Social Fund.

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