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EXPERIMENTAL REBUILDING OF A CROSSING WITH TRAFFIC LIGHT SYSTEM INTO A ROUNDABOUT IN SZÉKESFEHÉRVÁR

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Abstract

This article is about a new experiment and its results. The aim of this experiment was to analyse and compare the traffic stream in two different traffic control systems (a crossing with full mask traffic light system and a compact roundabout). The comparability condition was that the conditions, which have an effect on traffic stream, had to be permanent, and only the traffic control system, had to be changed. The rebuilding of the crossing was made during the night, so the function of the crossing in the road network, the traffic flow, the number of arms, the visibility and the environment of the crossing did not changed.

W2e point out that we planned to make these changes on a location, where the rebuilding was not a pressure of circumstances, so both the traffic light system and the roundabout was acceptable. We believe that in practice decision should have been made to choose from these two traffic control methods by making complex evaluation of all the major factors.

Keywords: roundabout, rebuilding of a crossing.

1. Introduction

The novelty of this experiment can be compendiated in three thoughts:

- We rebuilt a well-built and well-controlled crossing, where the regional traffic is essential. The crossing is not very dangerous, only one accident with human injury happens a year. The traffic flow and its distribution are so that from the permeability's point of view both traffic control methods are perfectly convenient. Travellers know the crossing and the traffic light system (full mask) well, so the quality parameters of the traffic flow (number of stops, waiting times, time

loss of crossing, crossing speed) can be measured, and the values are typical of the crossing and the control method.

- There are considerable differences between the two traffic control methods in the field of the quality parameters of the traffic flow, the environment aspects (noise pollution), and the crossing size. Our aim was to define these differences by measurements, and this was also the novelty of this experiment, because this way the traffic light system and the roundabout are comparable in the same traffic flow and environment.

- Referring to investment costs the roundabout is a slowly growing crossing type in our country. Unfortunately, there are some bad, disadvantageously built roundabouts in places where there was no reason for building them. Therewith the big sized roundabouts are common, use a lot of unneeded space and are disadvantageous for traffic safety. The experimental crossing is a good example of building an optimal sized roundabout at relatively low cost, with the reduction and use of the actual asphalt. With this idea we would like to blow away the misbelief which says that the roundabout requires a lot of space and it is too expensive.

The most difficult part of the experiment was to find a traffic light controlled crossing, where there was no island, there was no underpass approach and was enough place for a compact roundabout. After preliminary conferences we have chosen the crossing of Horváth I. and Deák F. Streets which is under administration of the 'Fejér megyei Közútkezelő KHT' on Road 70 in Székesfehérvár.

At first we designed the roundabout using the actual riding-surface inside the kerb boundary by the national prescription 'Design guide of roundabouts'. We defined the traffic signs and the road surface signs strivingly to the maximal safety (*Fig. 1*). We constrained the superfluous riding-surface and created the central island recycling used truck tires.

Our design was different from the national design specifications in two points. First the location of the pedestrian crossings (at two arms) was less than the desired 4 meters; this happened because of the provisional rebuilding. The other things were the arrows, which were drawn on the side of the tire made rotary island; these were there to show the way of turning. We thought that we might help the people who use the crossing for turning left.

The rebuilding was made in the night between the 10–11th of September in 1997. The professionals of the organization (Public road maintainer company of Fejér county) did the constructing work. On top-side views of the crossing (*Fig. 2*) it is visible that the roundabout needs less space than the traffic light controlled crossing.

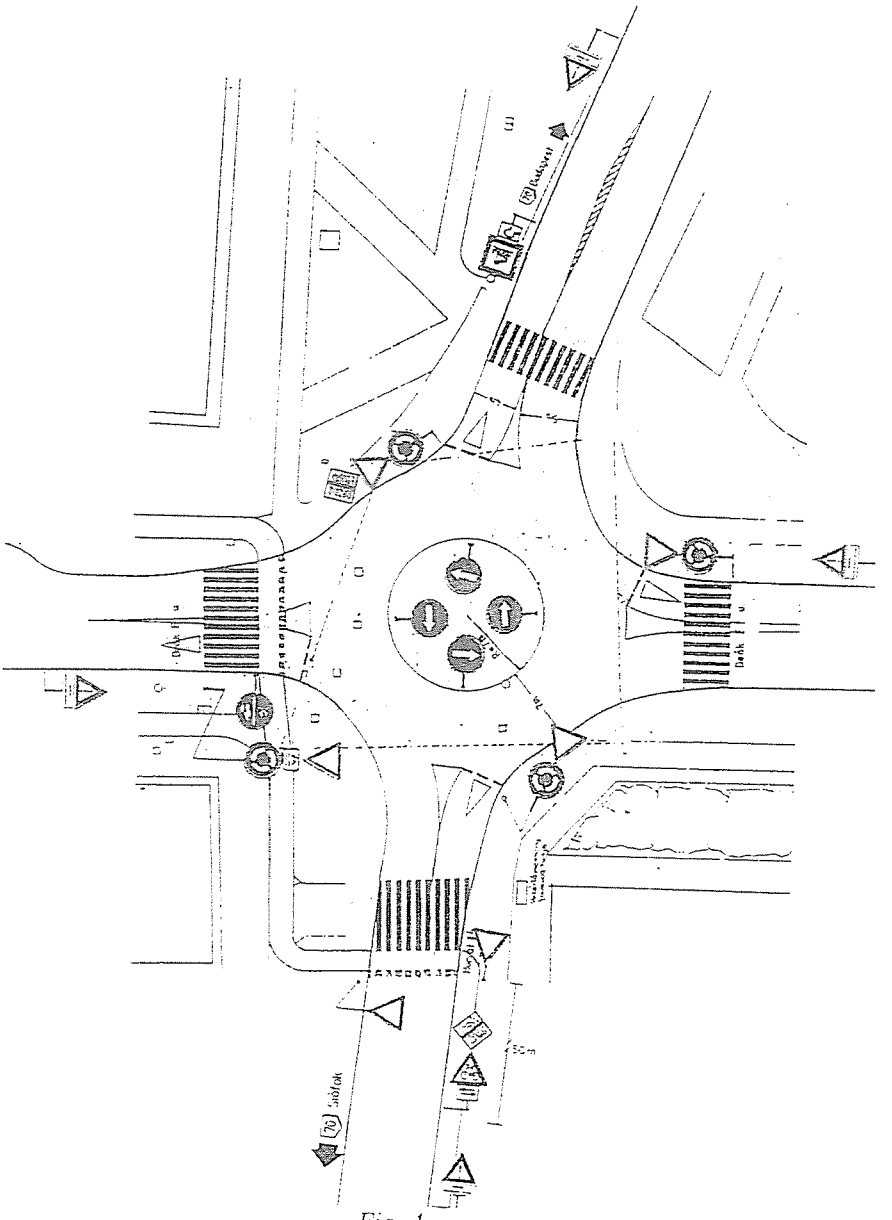

Fig. 1.

2. The Measurement Method of the Quality Parameters of the Traffic Stream in the Crossing

One of the most difficult things was to select the appropriate measurement method, because we had to record the traffic flow of all directions and the

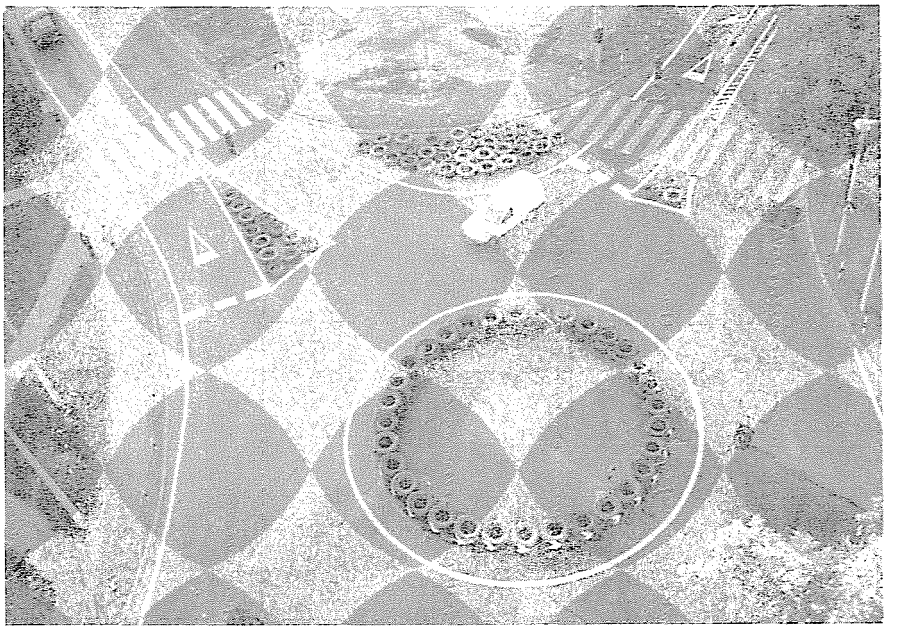

Fig. 2. The view of the crossing before the rebuilding

parameters of the traffic stream. We used a combined measurement method; on one hand, we recorded the arriving vehicles with wide-angle lens cameras to enable the posterior verification and data processing. On the other hand, on one arm of the crossing we recorded the traffic flow and the loss times onsite, with a portable small computer. We programmed the small computer and we recorded the beginning of slowing of the vehicles and the crossing-entering time of the vehicles. The time loss of the vehicles before entering the crossing itself is the difference of these two times.

At the traffic light system we could differ the vehicles by the blanes, so the right turning and the straight going vehicles were in the same category. We recorded the beginning and the end of the green-time to be able to measure the number of vehicles, which were not able to cross in one period.

For the roundabout we needed a different computer program. Just like in the case of the traffic light system we recorded the beginning of decreasing of the vehicles and the crossing-entering time of the vehicles and we distinguished three vehicle categories (cars+vans, lorries, long vehicles). In the same time we recorded the vehicles, which were leaving the roundabout at the same arm, and the vehicles passing in front of the arm in the circle lane, but have not distinguished categories. This way we got the time losses of the vehicles in function of the main traffic (running in the circle lane) and the disturbing traffic (going out at the same arm).

The traffic matrix was producible only afterwards with the help of the

VHS recording.

Because of our measurement method we have not distinguished how many times a vehicle stopped, but we distinguished the straight going vehicles from the stopping ones. The limits of our measurement method appear only in saturated traffic, when the end of the vehicle queue is not visible. This has not occurred during our measurements.

3. The Demonstration of the Results of the Measurement

A very important part of the work was the before-after study. Before (full mask green traffic light system) and after (roundabout) the experiment we studied:

- the quality parameters of the traffic stream
- the noise pollution
- the traffic behaviour of drivers, especially to the observance of priority laws

We mainly wanted to study the quality parameters of the traffic stream, therefore we made comparisons arm by arm with the following parameters:

- specific waiting loss times (s/veh)
- geometric delay (s/veh)
- crossing speed (km/h)

We made the measurements in the following times:

Test: Friday, 20th June 1997
14:45–16:30 (BEFORE)
Mes. Nr.1.: Tuesday, 9th September 1997
6:00–9:00, 14:00-16:30 (BEFORE)
Mes. Nr.2.: Wednesday, 15th October 1997
6:00-9:00, 14:00-16:30 (AFTER)
Mes. Nr.3.: Wednesday, 12th November 1997
6:00-9:00, 14:00-16:30 (AFTER)

In all measurement times the weather conditions were fine and dry and the visibility was also good.

The main traffic flow of the crossing is the line of Horváth I. Street. Here the 89% of the traffic coming from Budapest and the 79% of the traffic coming from Siófok is going straight through the crossing. In the two peak traffic matrices (Sheets 1–2) it is visible that the traffic flow is stronger in the morning from Siófok and from the railway station, and in the afternoon from Budapest and from the direction of Deák F. Street.

Sheet 1 The morning peak traffic matrix

		TO				
		Budapest	Siófok	Railway station	Downtown	SUM:
F	Budapest	0	356	59	6	421
R	Siófok	466	0	96	39	**601**
O	Railway station	77	43	0	113	233
M	Downtown	62	86	38	0	186
	SUM:	605	485	193	158	1441

Sheet 2 The afternoon peak traffic matrix

		TO				
		Budapest	Siófok	Railway station	Downtown	SUM:
F	Budapest	0	486	60	0	546
R	Siófok	378	0	18	84	480
O	Railway station	60	6	0	54	120
M	Downtown	34	99	67	0	200
	SUM:	472	591	145	138	1346

We made the full analysis with the data of the morning session. From these sheets it is visible that there is not a real difference between the morning and the afternoon sessions, the traffic flows are each other's reflection. The global peak hour traffic flow of the four arms is relatively low, it stays under 1500 veh/h.

4. The Calculation of the Vehicle Times Loss

For the calculation of the vehicle delays we recorded the approaching vehicles' arrival times to the crossing, from the moment when they had to slow down because of the red sign of the traffic light system (for the left turning considering the straight going interfering vehicles) or because of the vehicles travelling in the circle lane or the pedestrians crossing at the zebra crossing. The leaving of the crossing we defined when there was not any circumstance that could delay the vehicles. The traffic flow and the vehicle delay times are shown on *Fig. 3* for the Budapest arm and on *Fig. 4* for the Siófok arm. In the interval between 9th September 1997 and 12th November 1997 the nature of the traffic stream was not changed substantially, so vehicle delay times are comparable.

Figs. 3–4 show: at the roundabout at both cases (October, November), the specific vehicle delay times are almost at the same level, mostly between 2 and 5 seconds. In case of the traffic light system these times are between 9 and 25 seconds. In *Fig. 5* it is noticeable that at almost doubled traffic flow (7:15–7:45) the vehicle delay times were dropped to the half or quarter after the building of the roundabout.

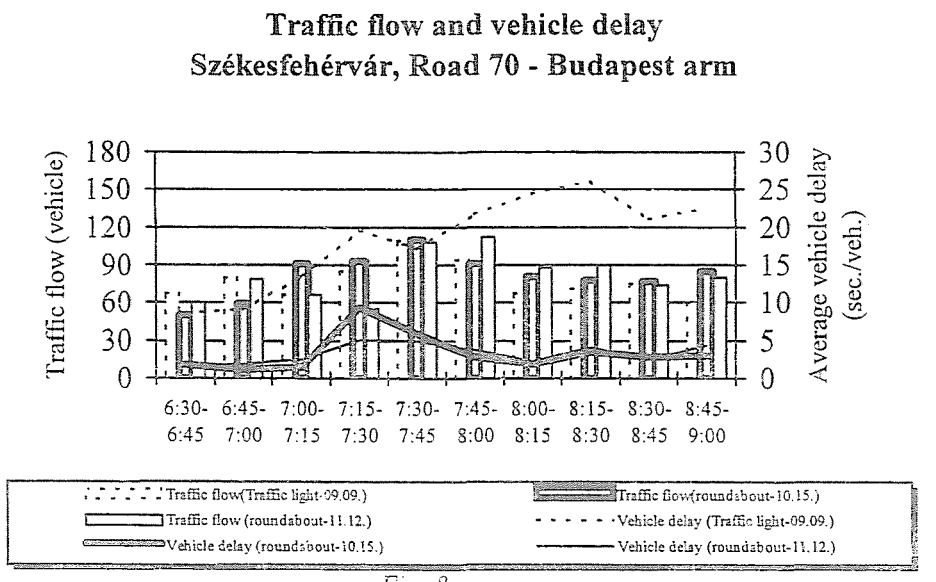

Fig. 3.

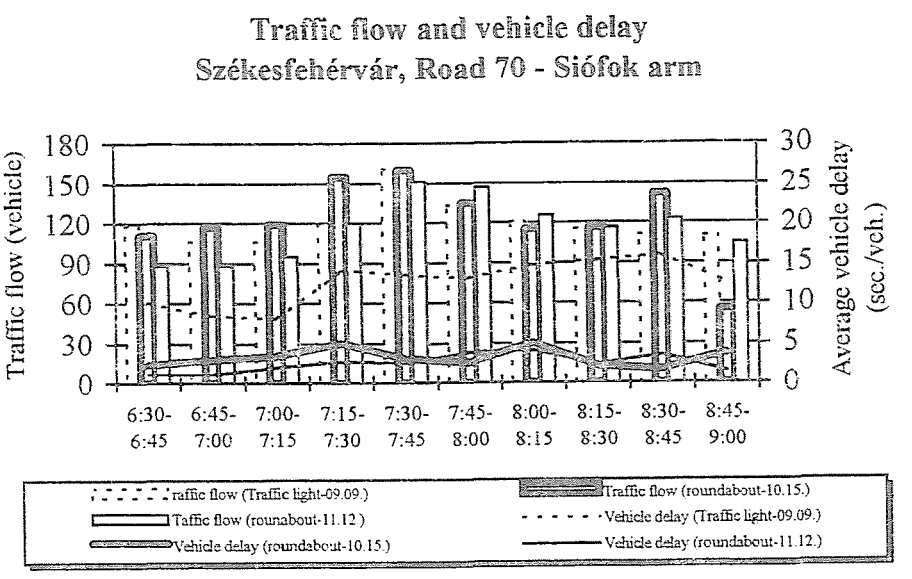

Fig. 4.

Fig. 6 shows the building and decreasing of the vehicle queue of the Siófok arm. The vehicles arriving in groups from the neighbouring Lövölde Street – Budai Street crossing are forced to queue again in this crossing, because of the traffic light system (this crossing is not synchronised with the neighbouring traffic light systems). It is visible how the traffic light

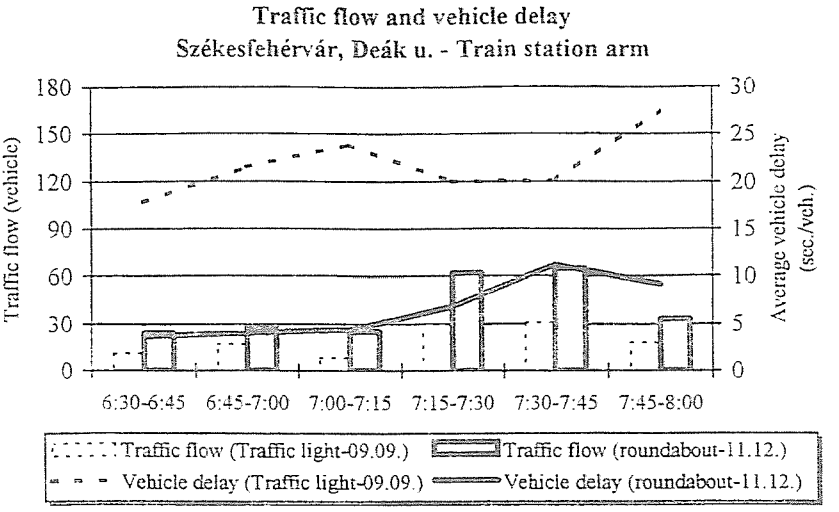

Fig. 5.

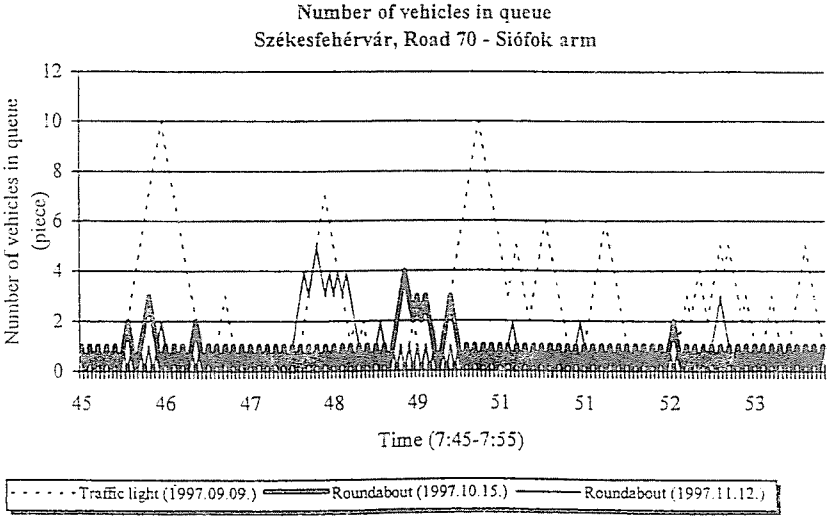

Fig. 6.

system is collecting the vehicles; it happened that after several periods the queue still could not build down. At the roundabout the traffic stream was continuous; in October only in 2, in November only in 5 cases happened that more than 3 vehicles were queuing. In case of the traffic light system

in the end of the periods at least 6–10 vehicles were recorded in the queue.

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INQUIRY FORM

1. How do you use the crossing mostly?
A ☐ as a driver
B ☐ as a cyclist
C ☐ as a pedestrian

1. How often do you come to this crossing?
A ☐ daily
B ☐ weekly
C ☐ rarely, then weekly

3. Drivers, cyclists:
Approaching the crossing
A ☐ it is easily detectable that this is a roundabout.
B ☐ the type of the crossing is hardly detectable

Pedestrians:
What do you think about the safety of using the pedestrian crossing in the roundabout?
A ☐ safe
B ☐ a bit dangerous
C ☐ very dangerous

4. Drivers, cyclists:
Who has right of way in the roundabout?
A ☐ the vehicle running in the circle lane
B ☐ the entering vehicle

Pedestrians:
What do you think about crossing in the roundabout than in the traffic light system?
A ☐ better
B ☐ no difference
C ☐ worse

5. Which system is better in this crossing in your opinion?
A ☐ the roundabout
B ☐ the traffic light system
C ☐ a crossing with road-signs (STOP-sign or Give way sign)

6. In comparison with the traffic light system
A ☐ I need less time to cross
B ☐ I need the same time to cross
C ☐ I need more time to cross
in the roundabout.

Fig. 7.

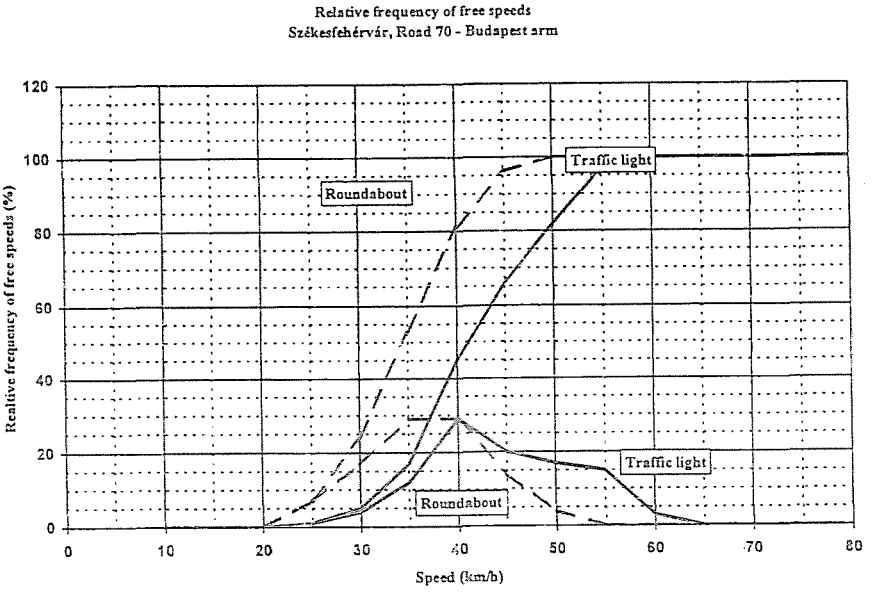
Relative frequency of free speeds
Székesfehérvár, Road 70 - Budapest arm
Realtive frequency of free speeds (%)
120
100
80
60
40
20
0
Roundabout
Traffic light
Traffic light
Roundabout
0
10
20
30
40
50
60
70
80
Speed (km/h)

Fig. 8.

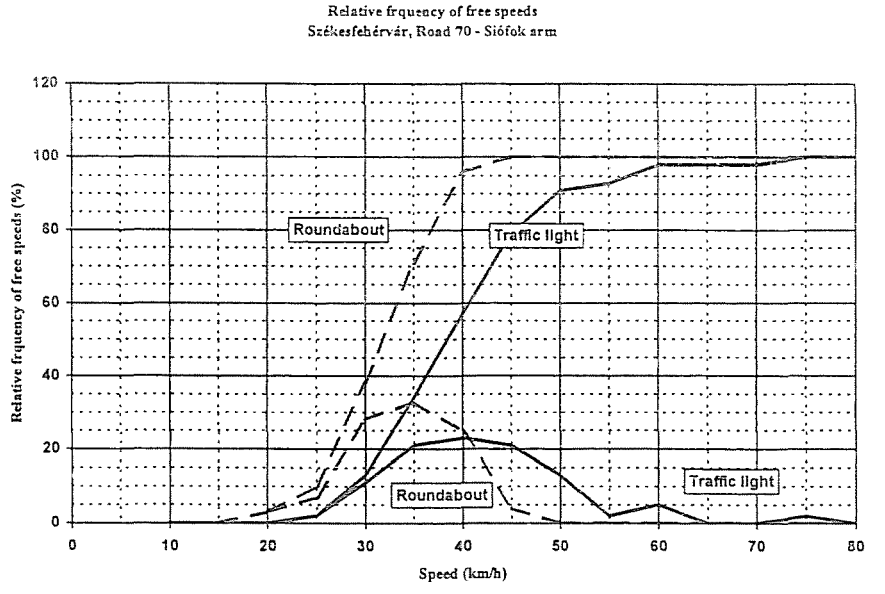
Relative frquency of free speeds
Székesfehérvár, Road 70 - Siófok arm
Relative frquency of free speeds (%)
120
100
80
60
40
20
0
Roundabout
Traffic light
Roundabout
Traffic light
0
10
20
30
40
50
60
70
80
Speed (km/h)

Fig. 9.

5. The Calculation of the Geometric Times Loss

Beside the waiting loss times we considered the change of the geometric delay times as well. The geometric loss time is the delay time which the crossing vehicle suffers – independently from the traffic flow, only because of the geometric shaping of the crossing – during arrival, crossing, and acceleration. We made the calculation of the geometric delay times for the straight going vehicles, because the difference is the biggest in this case; for turning right the speed and distance actually was not changed. In the FROM-TO sheets it is visible that the straight going stream is dominant and the proportion of the left turning traffic is minimal. We calculated the differences between the geometric delay times – at each arm – from the average speeds and the additional distances (going straight: 17 meters at the traffic light system and 22 meters in the roundabout, because of the circle lane), BEFORE and AFTER the rebuilding. At the traffic light system the geometric delay times were 0.8–2.4 second less per vehicle than in the roundabout.

The significant differences in the specific stopping and waiting times were not changed, even considering the geometric delay times.

6. The Results of the Inquiry Forms

We made an inquiry form to get to know the opinion of people using the crossing. The inquiry was done on 27th and 28th November 1997 where people (33 pedestrians, 12 cyclists, 17 drivers) living in the neighbouring houses answered our questions. The translated inquiry form is presented in *Fig. 7.*

From the answers to Question 2 appears that 93% of the questioned are using the crossing regularly (80% daily, 13% weekly).

The Question 3 was about the recognizability of the rebuilt roundabout. The answers were unequivocally favourable, in spite of that the traffic lamps stood darkly on their place. (The 97% of the questioned answered that the roundabout was finely visible.) The arrows drawn on the side of the tire made rotary island with fluorescent 3paint made a good job. The fluorescent prisms and deflectors made by SZTRÁDAKOLOR, which are excellent optical guidance for the entire traffic stream, are efficient especially in dark.

In the second part of Question 3 we would like to know the safety feeling of the pedestrians using the crossing. Sadly, only 48% of the pedestrians using the crossing daily think that the crossing is safe and 28% said that using the pedestrian crossings is dangerous. Most of the weekly using people found the crossing less dangerous, and 67% of the people using the crossing rarely than weekly think that the crossing is safe.

Question 4 was about the rule of the road knowledge of the drivers.

They all knew the most important rule drivers using the circle have right of way. Sadly, the travellers are not clear about the way of using the indicator lights at the entry and the exit. The regulation for the indication – written in the national traffic regulations (KRESZ) – is different from the West-European practice, needs modifications, and does not help the spread of the roundabouts. We investigated, how many percent of the drivers use their indicator entering and leaving the roundabout as described in the traffic regulations. Entering the roundabout is similar to turning, therefore – related to the traffic regulations – while entering, the drivers have to use the indicator lights, but have to turn it off going round the rotary island. On the 21st November 1997 we made a perception on the Budapest arm with the strongest traffic flow. The results are shown in Sheet 3. Most of the drivers (41.5%) did not, 32.5% only at the exit, 3% only at the entry use the indicator lights. Only the 23% of the drivers used the indicators regularly (while entering and exiting). The national traffic regulations should regulate the usage of the indicator lights separately for the roundabout.

Sheet 3

Indicating	Right turning	Straight going	Left turning	Sum:
as entering	2	4	7	13 (3.0 %)
as exiting	6	122	12	140 (32.5 %)
as entering and exiting	17	43	38	98 (23.0 %)
Not indicating	8	163	8	179 (41.5 %)

In the second part of Question 4 we wanted to know the opinion of the pedestrians. According to the pollees, the majority of them (56%) found the crossing in the roundabout better, 9% found no difference, 35% thought it was worse to cross in this case.

From the answers to Question 5 it is unequivocally visible that the new crossing type is more popular for the drivers. 83% of them, 58% of the cyclists, and 55% of the pedestrians thought that the roundabout was better. We looked at this question from another aspect: how does the frequent usage of the crossing influence the opinion of the pollee. People who regularly use the crossing vote for the roundabout, the others vote for the traffic light system.

Question 6 asked the times loss of the travellers. It is unequivocal that the drivers need less time to cross the roundabout, but the opinion of the pedestrians and the cyclists is also favourable. Most of the people using the crossing save time. Only the 14% of the pollees judged the crossing at the roundabout disadvantageously.

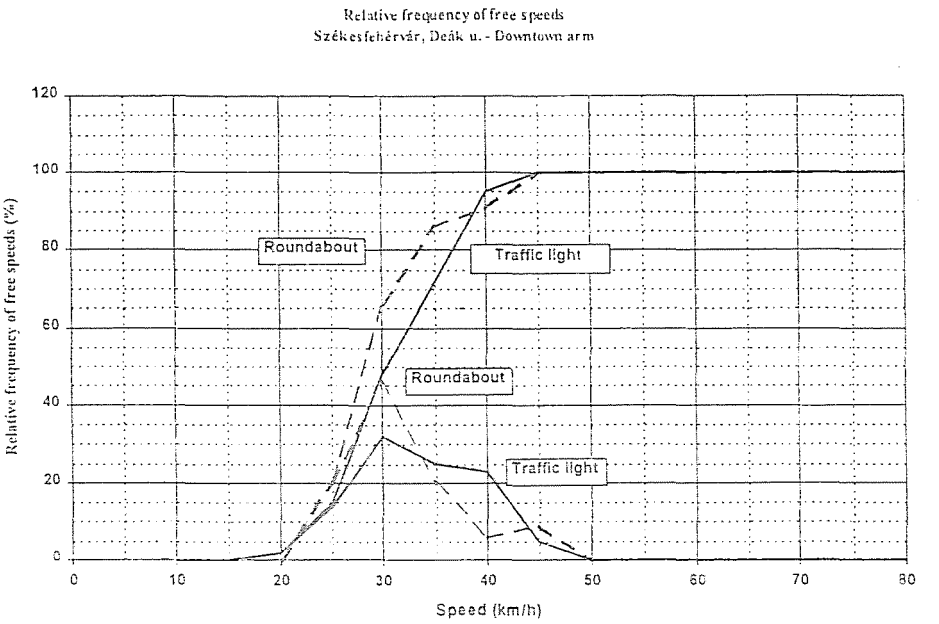

Fig. 10.

7. The Evaluation of Speed Measurement

We analysed whether the speed of the vehicles was changed after the rebuilding of the crossing. We made speed measurements BEFORE (traffic light system) and AFTER (roundabout) the rebuilding on all arms of the crossing. The measurements were made with the FÁMALASER II. laser-beam radar system. For the documentation the device is integrated with a video camera. We succeeded to find places for the radar where the drivers could not see us.

We recorded the speed of the exiting vehicles at the line of the pedestrian crossings. During the evaluation period we calculated only with the free speeds, so the vehicles following the slower ones were left out from the sample.

Figs. 8 and *9* picture the relative frequency and the cumulative relative frequency of the free speeds recorded on the Road 70. It is visible from the cumulative relative frequency curves that the average reduction of the speed was 10 km/h in all speed ranges. From the drivers going to the direction of Budapest, in the roundabout 82% and in the traffic light system only 45% kept the prescribed speed limit – 40 km/h – indicated with traffic signs. It is clear that owing to the roundabout the speeding drivers have to slow down on the pedestrian crossings.

The frequency of the free speed values has normal distribution. The

most frequent speed values are 35 km/h in the roundabout and 40 km/h in case of the traffic light system. In *Fig. 9* are well visible those very high speed values (77 and 60 km/h), which are very dangerous in this crossing, because the surroundings are densely inhabited and a school and a kindergarten are located in the area. The reason for these high speeds is well known: the drivers can see the lights from afar, so they accelerate to catch the green light and cross under it. Of course with this full mask system the straight going drivers cannot meet the pedestrians – because they are not allowed to cross at that time – but the left and right turning vehicles endanger the people crossing on foot.

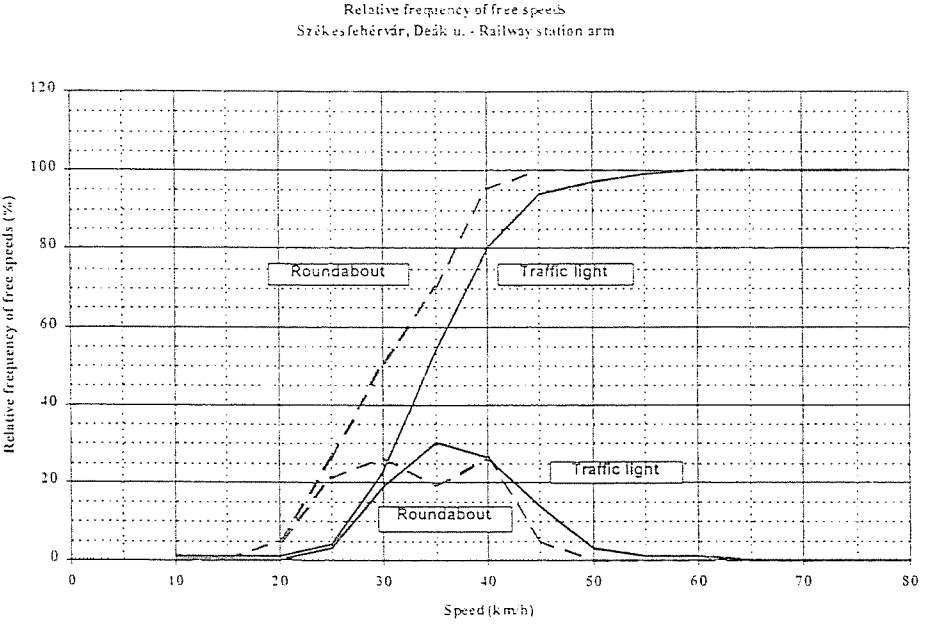

Fig. 11.

In *Figs. 10* and *11* we pictured the relative frequency and the cumulative relative frequency of the free speeds recorded in the Deák Ferenc Street. The reduction is visible from the cumulative relative frequency curves, in all speed ranges. The reduction is smaller than in the Road 70, because the original speed was also smaller under the traffic light system. (The traffic flow coming from the Road 70 is dominant.)

In *Fig. 12* we highlighted the speed values belonging to the 85% point of the cumulative relative frequency curve, which showed 10 km/h decrease on both arms of the Road 70 after the rebuilding. The difference between the highest and the lowest values was 13 km/h under the traffic light system and only 5 km/h in the roundabout.

It is also visible from *Fig. 12* that the difference between the speed

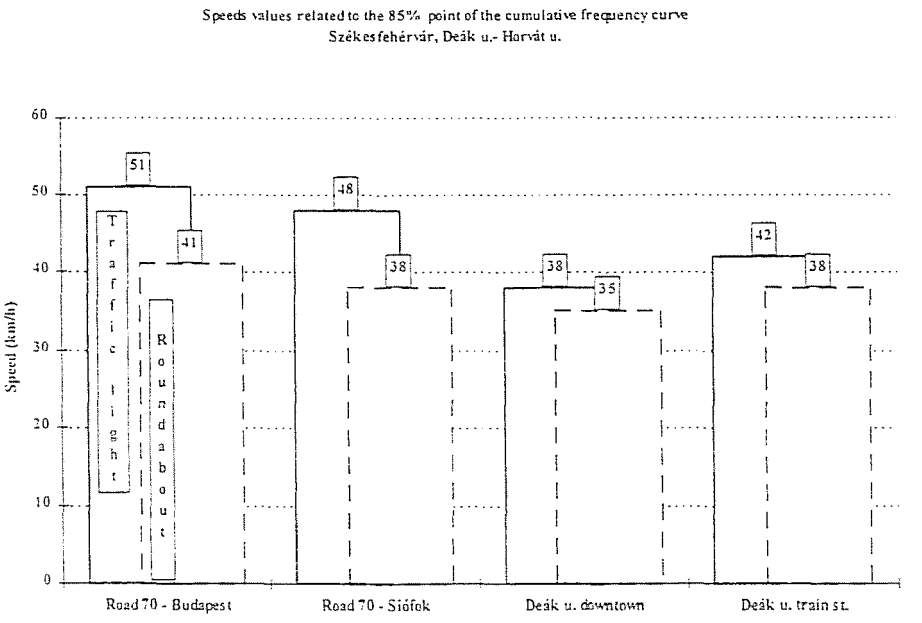
Speeds values related to the 85% point of the cumulative frequency curve
Székesfehérvár, Deák u.- Horvát u.
Speed (km/h)
60
50
40
30
20
10
0
51
41
48
38
38
35
42
38
Traffic light
Roundabout
Road 70 - Budapest
Road 70 - Siófok
Deák u. downtown
Deák u. train st.

Fig. 12.

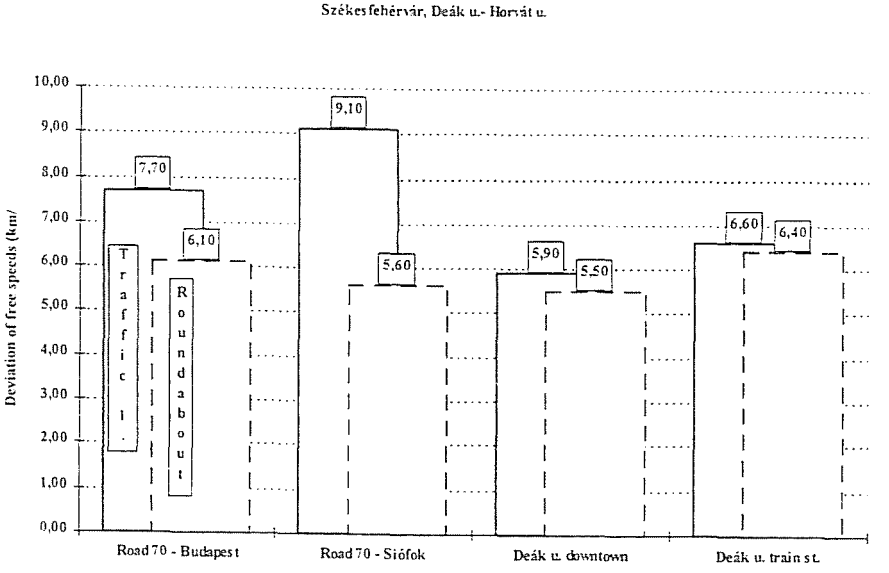
Deviation of free speeds
Székesfehérvár, Deák u.- Horvát u.
Deviation of free speeds (km/
10,00
9,00
8,00
7,00
6,00
5,00
4,00
3,00
2,00
1,00
0,00
7,70
6,10
9,10
5,60
5,90
5,50
6,60
6,40
Traffic l.
Roundabout
Road 70 - Budapest
Road 70 - Siófok
Deák u. downtown
Deák u. train st.

Fig. 13.

values of each arm decreased, so the speed distribution got more homogeneous. The more inhomogeneous the speed distribution, the higher the risk of accident, not just because of the vehicle – vehicle conflicts, but also because of endangering the pedestrians. (The pedestrian waits for the passing of the slower vehicles, steps to the road in front of the next, faster vehicle, underestimating its speed.) The deviation of the recorded values (*Fig. 13*) shows that the roundabout significantly helps the formation of a more homogeneous speed distribution.

8. The Evaluation of Noise Measurement

We carried out the measurement I and II at the reference point allocated near the crossing at the same time of the day. The traffic flow was running in the crossing with a lower utilisation of permeability, accordingly both under traffic light system and both in the roundabout the acceleration of the vehicles leaving the crossing was not influenced by any cause of traffic. The analysed quarter-hour traffic flow, and also the percentage of heavy vehicles were the same during the two measurement periods, therefore the quarter-hour equivalent noise level (dBA) values were actually identical. The deviation of the noise level was firstly cause of the deviation of the accelerations, secondly was due to fluctuation of the traffic flow. Because of inconsiderable entry traffic flow with the building of the roundabout caused neither any improvement nor disimprovement. By higher entry traffic flow in the roundabout the average speed of the crossing vehicles changed only by a small amount, therefore the vehicles leave the crossing with acceleration, so the noise level is increasing with logarithmic scale of the traffic flow. With the traffic light system the similar noise level was recorded as in the roundabout with the same inconsiderable traffic flow.

The microphone position of the noise measurement was 18.3 meters far from the geometric central of the crossing, 7.5 meters far from the centreline of the Road 70, by the street lighting lamp-standard at the height of 1.2 meters. The type of the noise-level meter: BK 2230 a precision-type integrating noise-level meter.

The times of the noise measurements:

I. measurement: 10th September 1997

11:05–12:00 (traffic light system)

The cycle times are indicated on *Fig. 14*

II. measurement: 15th October 1997

11:05–12:00 (roundabout)

Sheet 4. Meas. I. (Before)

	Deák F. Street			Horváth I. Street (Road 70)			Equivalent noise level
	I. cat	II. cat.	III. cat.	I. cat.	II. cat.	III. cat.	Leq [dBA]
11.05-11.20	54	7	4	154	24	8	68.7
11.20-11.35	59	5	5	149	12	9	68.4
11.35-11.50	47	4	3	139	10	7	67.9
11.50-12.05	41	2	2	127	4	3	67.7

Sheet 5. Meas. II. (After)

	Deák F. Street			Horváth I. Street (Road 70)			Equivalent noise level
	I. cat	II. cat.	III. cat.	I. cat.	II. cat.	III. cat.	Leq [dBA]
11.05-11.20	45	7	3	130	13	9	69.9
11.20-11.35	55	5	4	138	15	9	69.5
11.35-11.50	48	1	2	154	10	6	68.6
11.50-12.05	40	2	3	118	15	7	69.0

The phase times for all arms of the traffic light system (sec):

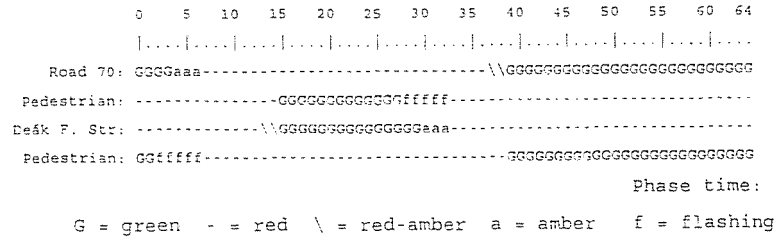

Fig. 14

Acoustical vehicle type categories:

I. category: passenger car + light lorry

II. category: two-axle lorry

III. category: three-axle lorry

The results of traffic count and noise measurements are shown in Sheets 4–5. We counted the traffic flow of both directions and the proportion of turning vehicles was the same during measurement I and II.

9. Summary

During our experiment we did planned set of measurements to get to know the characteristic of traffic stream in two different traffic control systems.

In Székesfehérvár at the crossing of Deák F. and Horváth I. Streets the rebuilding of the full mask traffic light system into a roundabout was a very good experience. The level of traffic stream unequivocally got better,

both in peak and in other periods. By determination of prestation level of a crossing we used the average at the average times loss. On all arms occurred at least one level improvement, but on Road 70 at the Budapest arm occurred a two level (C–A) improvement. This is considerable also because in the roundabout the old main arm loses priority, so in balanced (symmetric) traffic the traffic stream of the secondary arm theoretically got better by disadvantage of the main arm. In this crossing, where the global peak hour traffic flow was under 1500 veh/h, the improvement of the traffic stream was unequivocal in all arms, therewith the average speed of the vehicles decreased and the speed distribution got more homogeneous.

The opinion of the questioned drivers has mirrored this advantageous improvement, sith they voted the roundabout. The judgement of the pedestrians and the cyclists is not unequivocally advantageous. Although most of the pedestrians and the cyclists (54,6% and 58,3%) find the roundabout a better system, 48% of the pedestrians find it secure, 26% find it a bit dangerous and 26% find it very dangerous to cross. Out of accordance with the expectations the pedestrians do not think unequivocally that the change was disadvantageous. The international experience is that after a year it is worth to make another interrogation, when the collaboration of drivers and the pedestrians is hardened. In our country the pedestrians still need psychical defence of the green light, but the incompletion of the regulation of roundabouts, the inexperience in knowing the regulations and the small number of roundabouts make the situation harder.

According to the experiences and the result of the query form questioning we have to keep an eye on the security of pedestrian crossings. There are two solutions for this problem: on the one hand, the sizes of separation islands between the entry and exit lanes by the pedestrian crossing have to be bigger, on the other hand, to reduce the speed of the vehicles more on Road 70 lane offsetting and deflection with bigger radius should be used.

In summary it is observable that the experiment described above brought advantageous results, it proved true that the compact roundabouts which need small space, have a raison d'être.

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