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STUDY OF DRIVERS' BEHAVIOR IN URBAN ROAD TRAFFIC

Summary. The main aim of the research was to diagnose drivers' behavior in urban road traffic. It was preceded by careful observation and testing of drivers' behavior in terms of the violations assumed to be observed. It was taken into account, inter alia, aspects such as failure to comply with road signs and signals, behavior at the rail-road crossing, or offenses occurring in the pedestrian-driver relationship. During the observations, the assumption was to capture negative behaviors of drivers, but each time attention was also paid to positive behaviors related to road culture. The analysis of the results allowed the researchers to identify the most common mistakes made by drivers. This can help not only to better enforce regulations at selected measurement sites but also lead to improved education about these specific violations.

Keywords: drivers' behavior, urban road traffic, traffic measurements, traffic volume, traffic regulations, road safety

1. INTRODUCTION

Road safety is one of the important parameters determining the quality of the urban transport network. Moreover, this parameter has a direct impact on the number of fatalities, the number

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of injured and the number of road collisions. Therefore, it is even more important to maintain an appropriate level of education, not only at a young age or while obtaining a driving license but also in the following years of life. For example, in Poland 2,245 people died as a result of road accidents, and 26,415 people were injured in 2021 [1].

Each participant of the road traffic (driver or pedestrian) must obey the rules of the road. They may differ from country to country [2], but it is these regulations, as well as road signs and signals, that are designed to increase safety and possibly facilitate traveling on the road network. In Poland, road traffic regulations are regulated by the Road Traffic Law [3].

Navigating the road network is a dynamic task. During its implementation, the driver registers various stimuli, selects them, processes and evaluates them, makes decisions, and finally performs some action [4]. Driving a car is the most challenging activity. The basis of drivers' activity in urban road traffic is the observation of the road and its surroundings. Moreover, it is extremely important to observe other road users (road users) and collect data important for driving a car [4]. The most important data are road signs and signals, recorded by drivers using their eyesight.

Driver behavior is a factor contributing to more than 90 percent of road accidents [5]. Many researchers focus on the way, how to improve road safety and which traffic rules are more respected and why. It is necessary to have a holistic approach to the road safety problem [6], but more microscopic analysis may show problems in specific groups or places. As pedestrians are the unprotected road users, it is pedestrians who are at risk of injury or loss of life [7], [8]. Sometimes research is connected only with one group of drivers, like van drivers [9], or motorcycle drivers [10]. Sometimes analysis selects a specific type of road, like in [11] or divides drivers based on age [12].

This article presents and discusses the issues of drivers' behavior in urban road traffic, and analyzes and interprets the results obtained during field tests. There is also a summary of the main research results and conclusions drawn after the analysis of the obtained results.

2. MEASUREMENTS METHOD

The observations carried out in individual places of the road and street network were preceded by their prior inventory, e.g., with regard to the choice of the location of the camera, in order to ensure the best quality and transparency of the recordings.

The research material was collected empirically directly in selected places of the road network through observations combined with live image recording with the use of a car video recorder or a camera placed on a tripod, depending on the possibilities and spatial conditions in a given place. Observed drivers' behavior and the times of their occurrence were recorded on an ongoing basis. Then, the received notes were verified with the recorded video material. The behavior of other road users, namely pedestrians and cyclists, was also observed. In addition to the main offenses assumed for the study, other potentially dangerous situations involving drivers of vehicles at a given observation site were also mentioned.

After the research in a given place, the received video material was archived each time and saved on a portable disk. Then, collective forms were created in a spreadsheet, transferring data from paper notes and recording the intensity of vehicle and pedestrian traffic in a given place. Depending on the behavior studied in a given place, other information was also compiled, such as the speed of the vehicle on the road section or the time elapsed from the moment the red light came on until the offense of driving a red light was committed. On the basis of electronic sheets, a graphical interpretation of the obtained results was made in the form of charts and tabular

summaries. During the analysis of the video material obtained during the field tests, the traffic intensity in a given place was estimated each time.

In the literature other examples of driver behavior observation can be found, like in [13]. Authors collected data about crossing the intersection during red light signal. The current paper's main aim is to collect data about different kinds of violations committed by drivers. Before starting the field observation, the main violations committed by drivers, analyzed during the research, were assumed. They were:

- ignoring the B-20 "Stop" sign and not stopping the vehicle in the designated place,
- exceeding the permissible speed on a given road section,
- overcoming a rail-road crossing with a red signal transmitted by a signaling device,
- crossing a red-light intersection,
- failure to comply with road signs and signals at the intersection with traffic lights - turning back in an illegal place and not stopping the vehicle due to the "green arrow" (signal allowing entry in the direction of the arrow) that determines the right turn,
- refusing to give priority to pedestrians at a crossing without signaling,
- enforcement of the right of way by drivers entering a roundabout intersection.

During field tests, other violations and potentially dangerous situations were also recorded in places selected in terms of the above violations.

A two-hour measuring period was adopted, divided into eight 15-minute intervals. For all selected places in the road and street network, an identical division of the generic structure of vehicles was made, which was divided into the following 9 groups: SO - passenger cars, SD - vans, A - buses and coaches, AP - articulated buses, SC - trucks, SCP - trucks with a trailer, M - motorcycles, R - bicycles, OTHER - e.g., agricultural tractors, four-wheelers.

The speed was estimated on the basis of a comparison of the times the vehicle exceeded successive road sections. For this purpose, the sections L_1 and L_2 and the distance s between them were determined for each site (Figure 1). Then the formula (1) was used:

$$v = \frac{3,6*s}{t_2 - t_1} [km/h] \quad (1)$$

Where:

V – velocity [km/h],

s – distance [m]

t_1 – moment the vehicle crosses the auxiliary section L_1 [s]

t_2 – moment the vehicle crosses the auxiliary section L_2 [s]

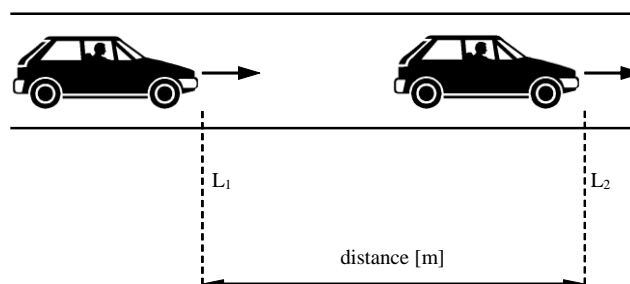


Fig. 1. Scheme of traffic situation with auxiliary sections to estimate velocity

3. PLACES OF MEASUREMENTS AND OBSERVATION

The sites of the road and street network of the city of Jaworzno with different characteristics were selected for field research. Most of these tests were carried out in the afternoon rush hours (between 2 p.m. and 5 p.m.), and the measurement lasted at least 2 hours. Only tests on the pedestrian crossing were carried out outside rush hours due to the specific location of the crossing and the intensity of pedestrian traffic on it. Each time, drivers' behaviors were observed in terms of various infringements, such as crossing a red-light crossing, ignoring the B-20 "Stop" sign, or refusing to give priority to pedestrians.

When selecting sites for measurement and observation, the following factors were taken into account:

- high traffic volume during rush hours - based on own experience and information from online map services, as well as the presence of traffic generators in the vicinity of a given place,
- the possibility of placing the camera in an inconspicuous place in order to prevent drivers and other road users from feeling watched,
- number of road incidents in a given place (based on the SEWiK database),
- spatial discrepancy - places located in different parts of the city were selected,
- atmospheric conditions - the tests were carried out on days when there was no rainfall and the temperature allowed for convenient observation,
- day of the week - the tests were carried out on working days in the afternoon rush hours, with the exception of the pedestrian crossing at Armii Krajowej Street, where due to greater pedestrian traffic in the morning, the tests were carried out on a working day between 9:00 and 11:00.

Case #1 – Intersection without traffic lights

The intersection selected for the research was the intersection of Martyniaków - Dąbrowszczaków streets in the western part of the city (Figure 2). It is a three-entry intersection without traffic lights, where the section of Martyniaków street with an increased speed limit up to 70 km / h has priority. The inlet of Dąbrowszczaków Street is the inlet subordinated to the sign B - 20 "Stop". Bus stops and pedestrian crossings are designated at the subordinate inlet and at Martyniaków Street towards the intersection with Wojska Polskiego Street. Opposite the inlet of Dąbrowszczaków Street there is a road leading to a large workplace. The intersection at the beginning of 2022 underwent modernization, during which the asphalt surface was replaced and road markings were repainted. In the area of the intersection, there is tall greenery (trees) and low greenery in the form of a lawn.

Case #2 – Road section

The section of road selected for analysis was the section of Szczakowska Street located in the northern part of the city (Figure 3). It is a busy street with a speed limit of 40 km / h. More than 13,000 cars use it daily. A large part of them move at greater than the allowable speed. Along the street, on both sides, there are single and multi-family houses as well as public utility buildings. The road surface is uneven, there are periodic losses of asphalt and cracks. The width of the lanes is about 3.5 meters. There is a pedestrian crossing near the place from which the observation combined with live image recording was carried out.

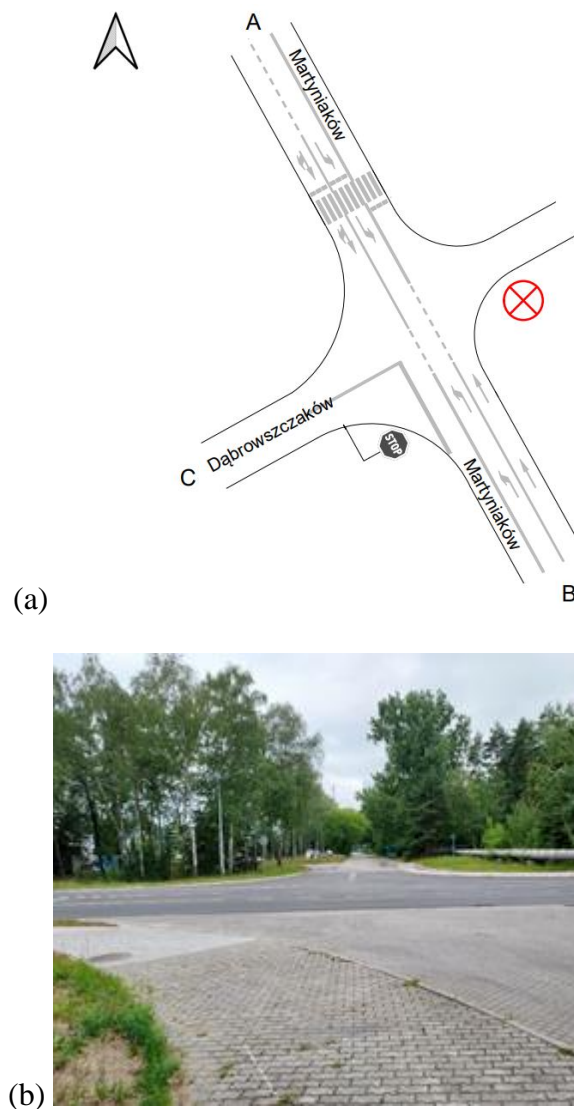


Fig. 2. Intersection without traffic lights – Martyniaków - Dąbrowszczaków streets:
(a) scheme (x symbol means observer's position), (b) view from the observer's position
(case #1)

The scheme (Figure 3) shows an 18-meter auxiliary section with a blue line, according to which the approximate speed of vehicles was estimated later in the study. Line L_1 is the road section at the beginning of the auxiliary section, while line L_2 is the road section at the end of the section.

Case #3 – Railroad crossing

The third place chosen to observe drivers' behavior was the railway crossing at Stefan Batory Street (Figure 4) in the northern part of the city, near the border with Sosnowiec. It is a category B crossing, public use, equipped with automatic traffic lights and half barriers. It is a one-level intersection of railway line No. 667 with a road. The crossing is located outside the built-up area, there are forest areas on both sides of the Stefan Batory Street road.

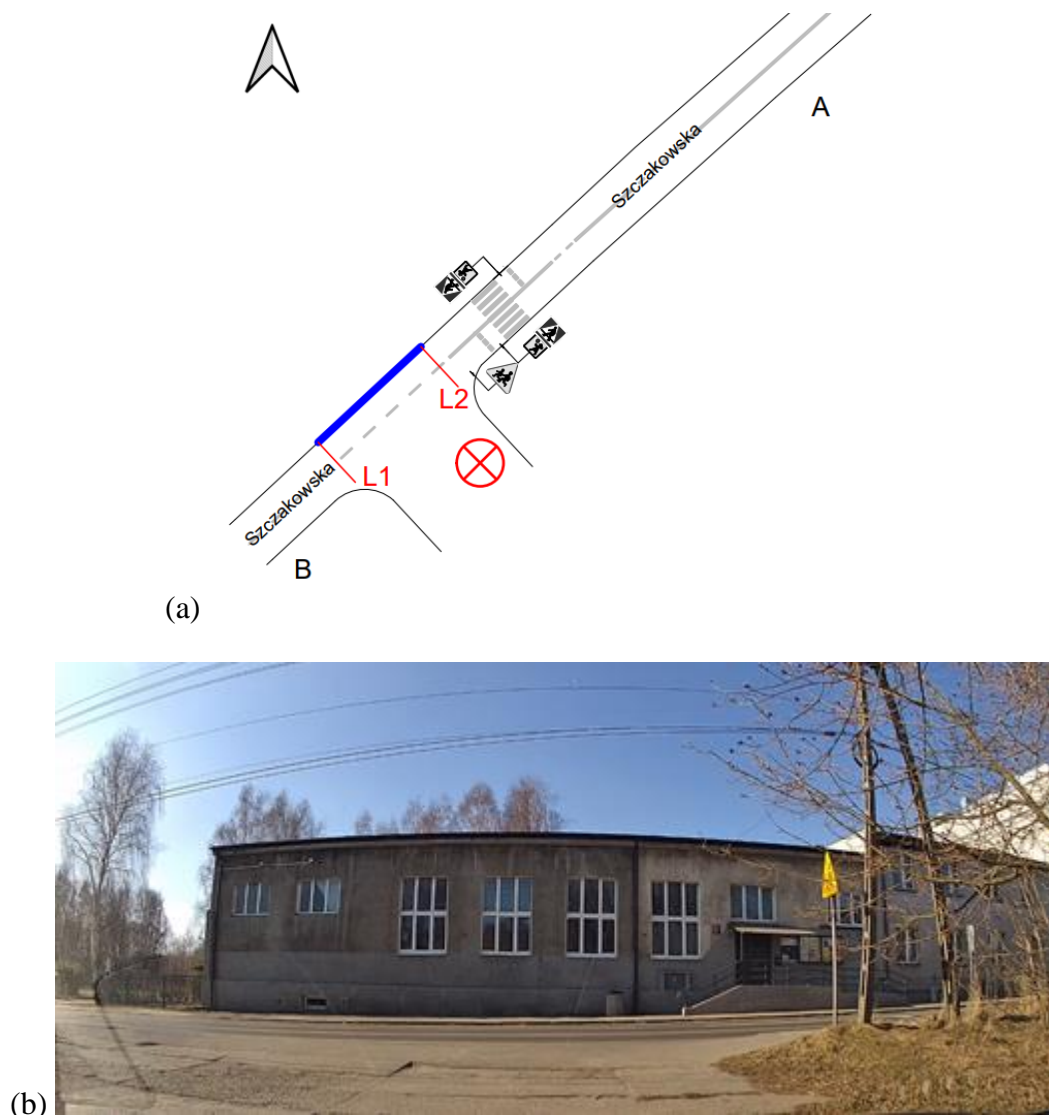


Fig. 3. Road section Szczakowska Street: (a) scheme (x symbol means observer's position), (b) view from the observer's position (case #2)

Case #4 – Intersection with traffic lights I

The drivers' behavior was tested at two intersections with traffic lights, but for different violations. First, the observations were made at the intersection of Wojska Polskiego - Martyniaków - Wisława Szymborska streets, located in the area of the industrial zone in the western part of the city (Figure 5). It is a four-leg junction with traffic lights operating in acyclic mode. The section of Wojska Polskiego street with an increased speed limit up to 70 km / h has priority. The inlet of Martyniaków and Szymborska streets are subordinate inlets. There are crossings for pedestrians and cyclists at the subordinate inlets and at the inlet of Wojska Polskiego Street towards Katowice. The national road No. 79 runs through the intersection, it is characterized by heavy traffic, especially during rush hours.

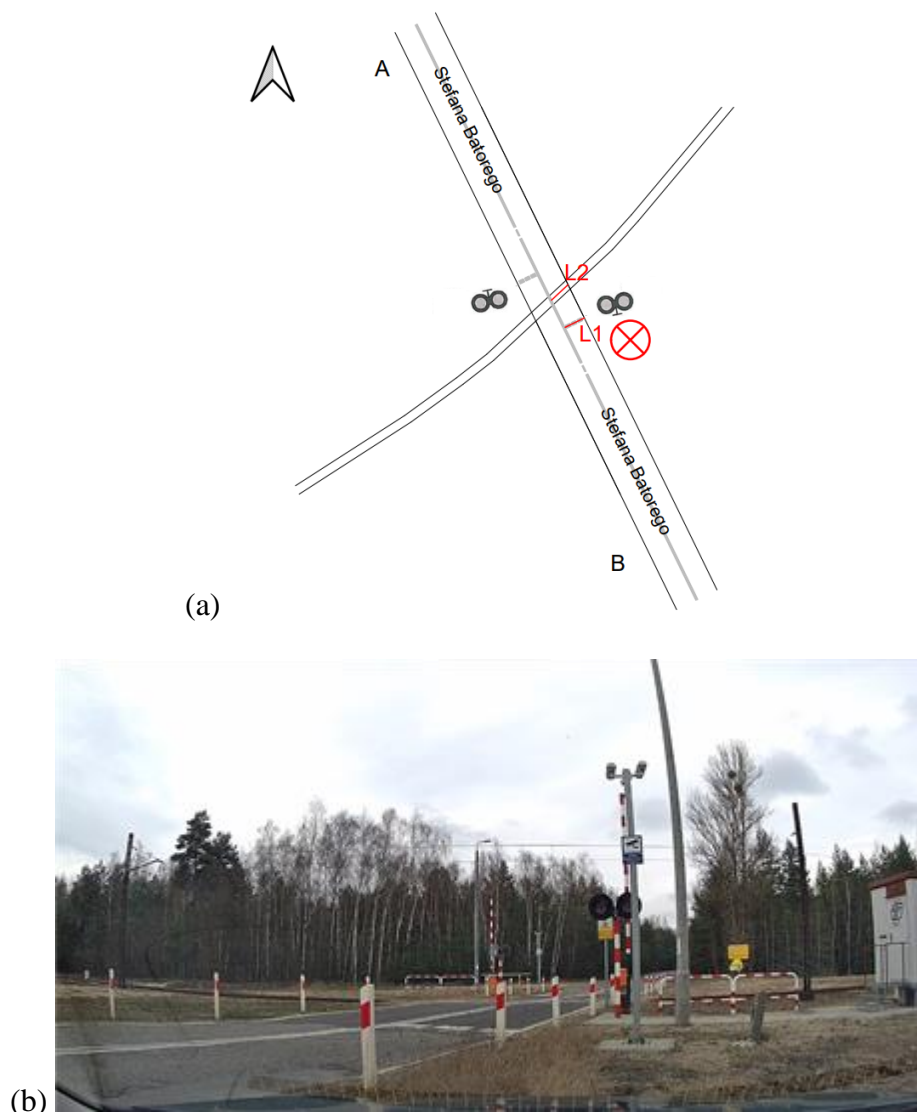
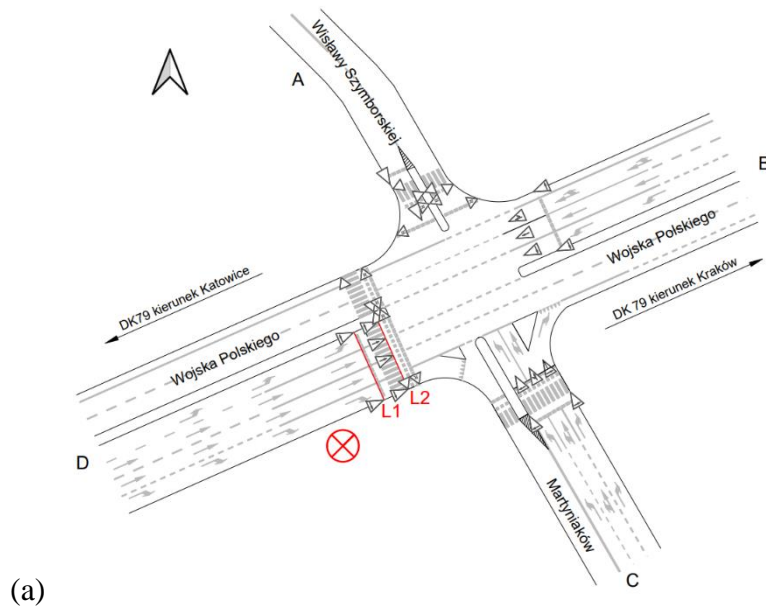


Fig. 4. Railroad crossing at Stefan Batory Street: (a) scheme (x symbol means observer's position), (b) view from the observer's position (case #3)

Case #5 – Intersection with traffic lights II

Another place with similar characteristics was the intersection of Grunwaldzka - Szczakowska - Steczkowskiego Streets (Figure 6). It is a four-leg crossing with traffic lights operating in accommodative mode. Priority is given to the section of Grunwaldzka Street with an increased speed limit of up to 70 km / h. The inlets of Szczakowska and Steczkowskiego streets are subordinate inlets. There are pedestrian crossings at the subordinate inlets and at the entrance of Grunwaldzka Street from Krakow to the city. The signaling works as a four-phase one, the duration and sequence of individual green signals are determined by the reports of traffic participants on the detectors. The crossing of Grunwaldzka Street is carried out without dividing it into two stages. The national road No. 79 runs through the intersection of Grunwaldzka - Szczakowska - Steczkowskiego Streets. Around the intersection there are parking spaces, shops, residential buildings, workplaces and bus stops.



(a)



(b)

Fig. 5. Intersection with traffic lights I - Wojska Polskiego - Martyniaków - Wisława Szymborska Streets: (a) scheme (x symbol means observer's position), (b) view from the observer's position (case #4)

Case #6 – Pedestrian crossing

Another place analyzed in this study was the pedestrian crossing at Armii Krajowej Street in the Osiedle Permanent district (Figure 7). It is located between two intersections, namely Stefania Sempołowska Street and Aleja Tysiąclecia Avenue. The passage is made horizontally, marked with horizontal painting and marks D-6. There are no traffic lights, the width of the passage is 4 meters, and the length - 7 meters. The crossing is characterized by heavy pedestrian traffic in the morning hours due to the nearby shopping pavilions, service points, an educational institution, and a church. It is also located on the way to the nearby allotment gardens.

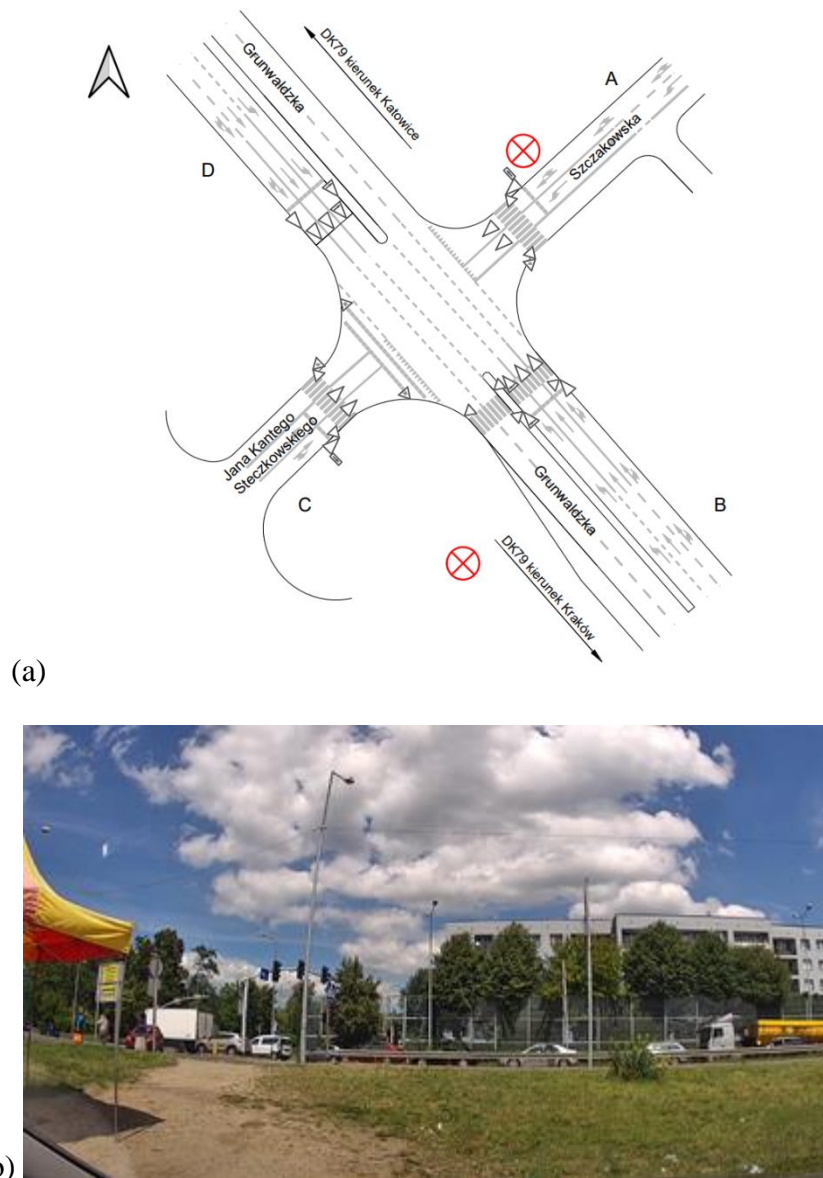


Fig. 6. Intersection with traffic lights II - Grunwaldzka - Szczakowska - Steczkowskiego Streets: (a) scheme (x symbol means observer's position), (b) view from the observer's position (case #5)

Case #7 – Intersection with a circular movement

The last site where the research was conducted was a circular intersection. It is a single-lane roundabout located at the intersection of Jana Pawła II and Jana Matejki Streets (Figure 8). It has four main inlets and is designed with all possible by-lanes, i.e., additional lanes intended for right-turning vehicles. The advantage of their use is the reduction of vehicle queues and the loss of time at individual inlets, which is particularly important during rush hours. Right-turning drivers can change lanes in good time and do not need to use the main road of the roundabout around the center island. It is the main entrance to the city center. According to the SEWiK database, 20 road incidents took place in 2017-2021. The reason for 70% of them was the failure to grant the right of way.

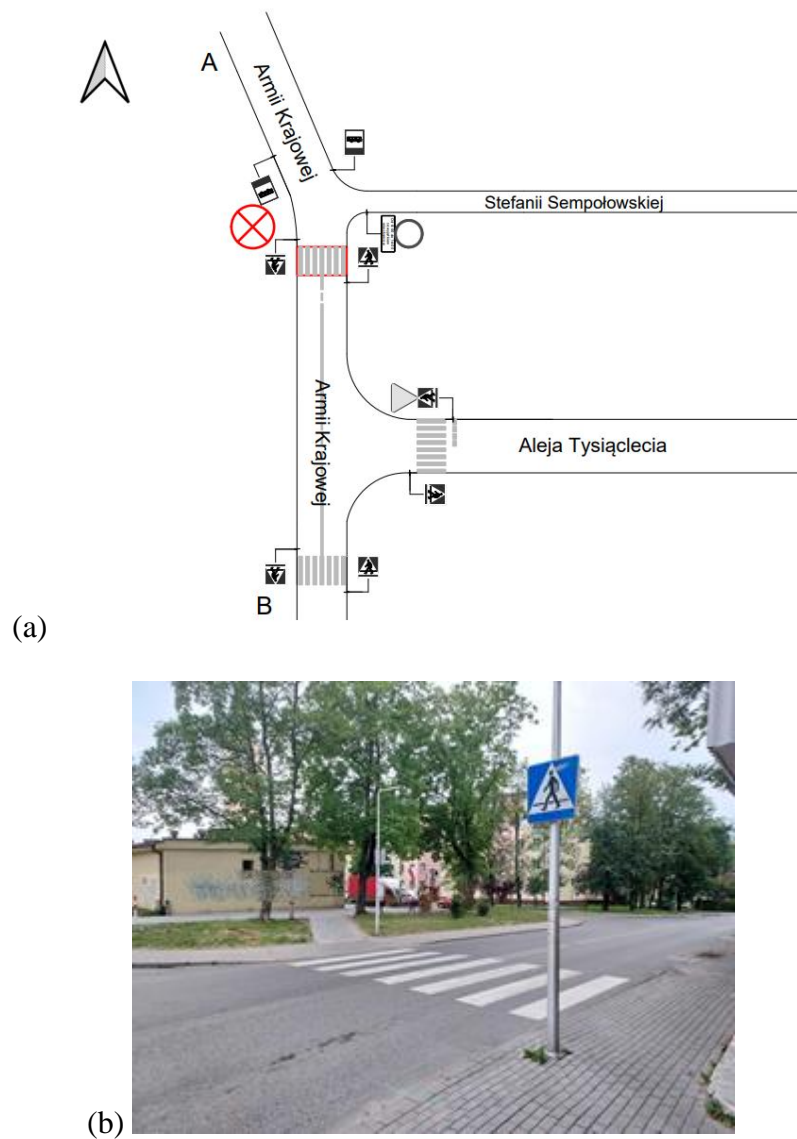


Fig. 7. Pedestrian crossing at Armii Krajowej Street: (a) scheme (x symbol means observer's position), (b) view from the observer's position (case #6)

4. RESULTS

The chapter presents the most important results of measurements and observations for subsequent measurement sites.

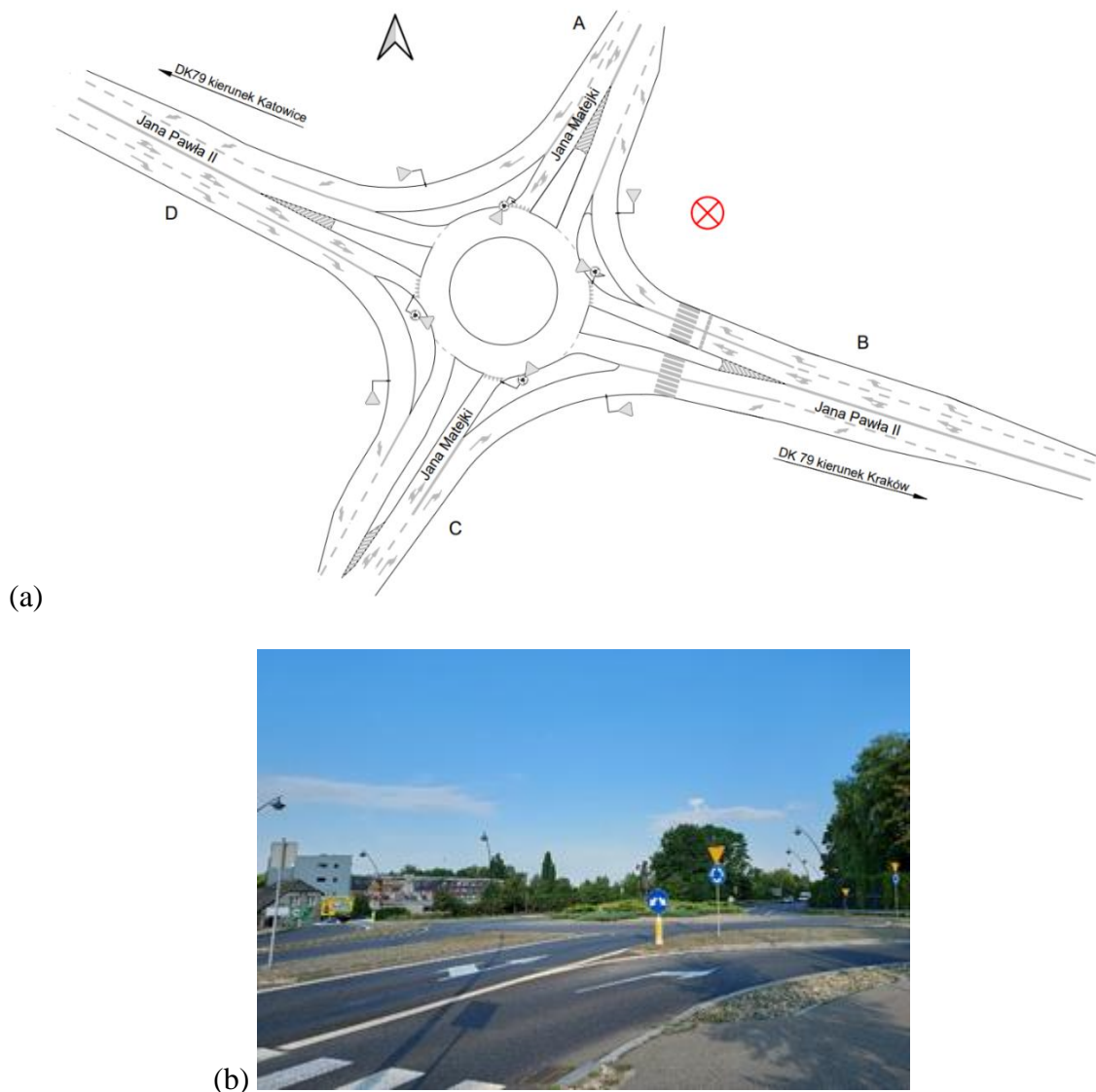


Fig. 8. Intersection with a circular movement at the intersection of Jana Pawła II and Jana Matejki Streets: (a) scheme (x symbol means observer's position), (b) view from the observer's position (case #7)

Case #1 – Intersection without traffic lights

At the intersection without traffic lights, observations were made for violations consisting in not stopping the vehicle in connection with the sign B - 20 "Stop". The observation concerned the C inlet (Figure 2). The weather conditions prevailing during the study did not have a negative effect on traffic safety by hindering the visibility, visibility and passability of the intersection for drivers. The inventory of the intersection showed that the B-20 sign is clearly visible, visible from a distance, not obscured by vegetation. The clearly visible, freshly painted P-12 absolute stop line also informs drivers about the place where to stop the vehicle. There was an almost equal division of drivers obeying and not obeying the rule on the order to stop the vehicle in a designated place after the B-20 "Stop" sign (Table 1).

During the measurement, it was observed that when sequences of vehicles moving with each other were approaching the stop line, drivers more often ignored the rule that each of them should stop on this line.

Tab. 1

The number of violations depending on the traffic volume (case #1)

Interval	Traffic volume	Number of vehicles that did not stop at sign B - 20	Percentage of rule violators
14:00 - 14:15	63	28	44,4%
14:15 - 14:30	78	40	51,3%
14:30 - 14:45	67	34	50,7%
14:45 - 15:00	48	28	58,3%
15:00 - 15:15	29	12	41,4%
15:15 - 15:30	64	31	48,4%
15:30 - 15:45	59	29	49,2%
15:45 - 16:00	27	9	33,3%
Total	435	211	48,5%

Referring to the traffic directional structure to compliance with the regulations, it should be noted that out of 374 right-turning vehicles, only 165 stopped at the designated place. In the case of left-turning drivers, those who obey the rules have a clear advantage. Out of 61 vehicles turning left, only 2 did not stop at the designated spot.

Case #2 – Road section

The test was carried out for an infringement consisting of exceeding the speed limit. The weather conditions prevailing during the study did not adversely affect the researcher or traffic safety. The speed limit in the place under control is 40 km / h, which is informed by the B-33 sign, located approximately 500 meters from the observation point. Frequent police checks also pay attention to the current speed limit.

During the measurement with the road section, 1,275 vehicles traveled. The results presented in the table clearly show that most of the vehicles traveled along the tested road section at a speed higher than the permitted speed (Table 2). Table 3 provides information on the number of vehicles exceeding the speed limit in certain ranges. The violation ranges are the same as the values in the valid tariff of fines.

Tab. 2

The number of violations depending on the traffic volume (case #2)

Interval	Traffic volume	Number of vehicles exceeding speed	Percentage of rule violators
14:00 - 14:15	113	105	92,9%
14:15 - 14:30	152	143	94,1%
14:30 - 14:45	167	163	97,6%
14:45 - 15:00	142	132	93,0%
15:00 - 15:15	159	141	88,7%

15:15 - 15:30	166	164	98,8%
15:30 - 15:45	200	188	94,0%
15:45 - 16:00	176	137	77,8%
Total	1275	1173	92,0%

Tab. 3
Estimated values of the approximate velocity of vehicles (case #2)

Number of vehicles traveling at the speed limit (correct ≤ 40 km/h)	Number of vehicles exceeding the speed limit by:						
	Less than 10 km/h	11 - 15 km/h	16 - 20 km/h	21 - 25 km/h	26 - 30 km/h	31 - 40 km/h	41 - 50 km/h
102	370	330	196	147	71	55	4
8,00%	29,02%	25,88%	15,37%	11,53%	5,57%	4,31%	0,31%

Only 8% of the surveyed group of drivers drove their vehicle at a speed not exceeding 40 km/h. The largest group of drivers exceeded the speed limit by a value not exceeding 10 km / h. Four drivers traveled over 80 km / h.

Figure 9 presents a comparison of the number of vehicles depending on the approximate speed with which they were moving. Most vehicles moved along the tested road section at a speed of about 52 km/h.

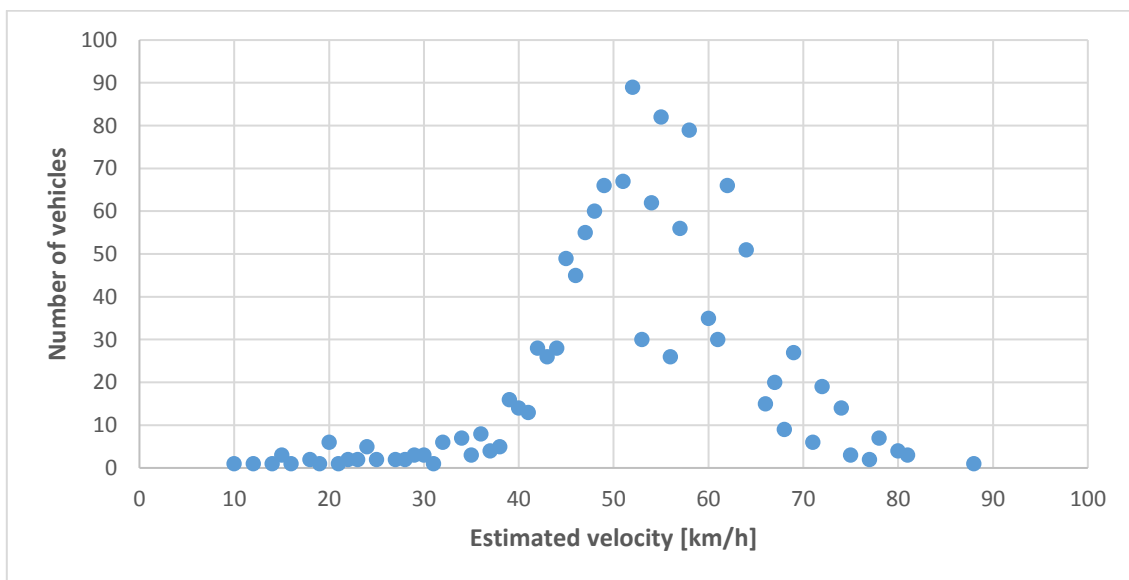


Fig. 9. Number of vehicles traveling at a given speed during the measurement period (case #2)

Case #3 – Railroad crossing

The test was carried out in terms of violating the ban on entering the traffic light at the red signal by the vehicle driver at the railway crossing.

Table 4 includes the number of violations. During the observation, 5 red light runs were noticed. Table 5 shows that the approximate speeds of the vehicles at the time of entering the track with the red light on were not high. This shows that the drivers slowed down before crossing, but nevertheless broke the law.

Tab. 4

The number of violations depending on the traffic volume (case #3)

Interval	Traffic volume		Number of violations (red light runs)	
	Direction		Direction	
	Sosnowiec	Jaworzno	Sosnowiec	Jaworzno
14:00 - 14:15	18	36	1	0
14:15 - 14:30	87	77	1	0
14:30 - 14:45	61	77	0	0
14:45 - 15:00	66	79	0	0
15:00 - 15:15	56	72	1	2
15:15 - 15:30	63	79	0	0
15:30 - 15:45	51	80	0	0
15:45 - 16:00	64	65	0	0
Total	466	565	3	2

Tab. 5

Type and estimated velocity of vehicles which run during red light (case #3)

No.	Direction	Type of vehicle	Time after read light turned on [s]	Estimated velocity [km/h]
1	Sosnowiec	SO	1,9	18
2	Sosnowiec	SCP	4,1	16
3	Sosnowiec	SO	1,9	14
4	Jaworzno	SO	0,7	9
5	Jaworzno	SD	1	8

Case #4 – Intersection with traffic lights I

The test at the first intersection of this type was carried out for a red-light violation. The weather conditions prevailing during the observation did not adversely affect traffic safety by obstructing the visibility and passability of the intersection for drivers.

During the entire measurement, 19 cases of running red light were recorded (Table 6). In details, these 19 cases were described in Table 7. Most of the violations were committed shortly after the red signal was started. There was at least one red light run in each measurement interval.

Most of the drivers driving straight ahead with red light run at speeds higher than the permissible speed (70 km / h).

Tab. 6

The number of violations depending on the traffic volume (case #4)

Interval	Traffic volume	Number of violations (red light runs)	Percentage of rule violators
14:00 - 14:15	285	2	0,7%
14:15 - 14:30	288	1	0,3%
14:30 - 14:45	313	3	1,0%
14:45 - 15:00	260	3	1,2%
15:00 - 15:15	383	3	0,8%
15:15 - 15:30	297	2	0,7%
15:30 - 15:45	299	2	0,7%
15:45 - 16:00	297	3	1,0%
Total	2422	19	0,8%

Tab. 7

Type and estimated velocity of vehicles which run during a red light with dependence on direction (case #4)

Left turn				Stright				Right turn			
No.	Type of vehicle	t [s]	v [km/h]	No.	Type of vehicle	t [s]	v [km/h]	No.	Type of vehicle	t [s]	v [km/h]
1	SO	1,5	29	1	SO	0,4	61	1	SO	0,2	31
2	M	0,8	25	2	SO	0,2	81	2	SO	0,3	32
3	SO	1,1	29	3	SO	0,1	95	3	SO	1,4	28
				4	SO	0,1	88	4	SCP	0,3	39
				5	SO	1,2	108	5	SO	0,1	29
				6	SO	0,2	108	6	SO	2,3	31
				7	SO	0,8	88	7	SO	0,6	33
				8	SO	0,3	69				
				9	SO	0,6	74				

During the observation, it was also noticed that drivers turning left often turned back at the intersection. This is an infringement because the intersection investigated is a non-collision with a left turn warrant and a back-turn is not allowed there. The registration of this type of behavior of drivers was an inspiration to conduct tests, typically in terms of it, but at a different intersection with traffic lights.

Case #5 – Intersection with traffic lights II

The test at the second intersection with traffic lights was carried out for violations consisting in turning back in an illegal place and, additionally, in not stopping the vehicle due to the passage indicated by the "green arrow" (the signal authorizing entry in the direction indicated by the arrow). The total recorded number of unauthorized back-turns accounted for over 3% of the left-turning traffic flow (Table 8). In five cases, vehicles turning in a prohibited place took the right lane of Grunwaldzka Street, which forced sudden braking on vehicles turning right at the same time from Steczkowskiego Street on a conditional green arrow. In this way, the traffic flow at the intersection was temporarily disturbed.

Tab. 8

The number of violations (illegal back turning) depending on the traffic volume (case #5)

Interval	Traffic volume	Number of violations (turning back in an illegal place)	Percentage of rule violators
14:00 - 14:15	38	1	2,6%
14:15 - 14:30	29	2	6,9%
14:30 - 14:45	31	0	0,0%
14:45 - 15:00	64	3	4,7%
15:00 - 15:15	31	2	6,5%
15:15 - 15:30	38	0	0,0%
15:30 - 15:45	57	1	1,8%
15:45 - 16:00	46	2	4,3%
Total	334	11	3,3%

The total number of vehicles turning right into Grunwaldzka Street was 534 vehicles. Of these, 180 vehicles performed this maneuver while displaying a conditional "green arrow" signal. As many as 160 vehicles (almost 90%) passed during this time without stopping (Table 9).

Tab. 9

The number of violations (passing the „green arrow" signal without stop) depending on the traffic volume (case #5)

Interval	Traffic volume	Number of violations (passing "green arrow" signal without stop)	Percentage of rule violators
14:00 - 14:15	26	23	88,5%
14:15 - 14:30	30	26	86,7%
14:30 - 14:45	16	14	87,5%
14:45 - 15:00	29	26	89,7%
15:00 - 15:15	13	12	92,3%
15:15 - 15:30	21	19	90,5%
15:30 - 15:45	17	15	88,2%
15:45 - 16:00	28	25	89,3%
Total	180	160	88,9%

Case #6 – Pedestrian crossing

The examination was carried out for the violation of not giving priority to pedestrians. Weather conditions did not have a negative effect on traffic safety by preventing drivers from seeing pedestrian crossings. Inventory showed that it is clearly visible, with clearly painted stripes and the D-6 sign placed in a visible place.

During the measurement period, 259 pedestrians used the crossing (Table 10). Most in the sixth interval - 43 people. The smallest number in the second interval - 20 people. In the remaining periods, the number of pedestrians at the crossing ranged from 26 to 39.

Tab. 10

The number of violations (not giving priority to pedestrians) depending on the traffic volume (case #6)

Interval	Traffic volume	Number of violations (not giving priority to pedestrians)	Pedestrian volume
9:00 - 9:15	39	1	26
9:15 - 9:30	56	0	20
9:30 - 9:45	56	1	39
9:45 - 10:00	51	1	32
10:00 - 10:15	50	0	39
10:15 - 10:30	48	4	43
10:30 - 10:45	49	0	32
10:45 - 11:00	52	0	28
Total	401	7	259

The violations occurred when single people waited at the crossing. In situations where a larger group of pedestrians appeared at the crossing, vehicle drivers immediately gave them priority.

Case #7 – Intersection with a circular movement

The examination was carried out for a violation consisting of forcing the right of way by a vehicle entering the roundabout. Weather conditions did not have a negative effect on traffic safety.

During the observation at the roundabout entrance, 4 cases of forcing the right of way by drivers joining the roundabout were noticed. All of them took place in the last measurement interval (15:45 - 16:00), in which a total of 101 vehicles were turned on from the examined entrance to the roundabout (30 left the intersection using a separate lane intended for turning right). Each of the violations was committed by drivers of passenger cars. In three cases, violations forced drivers on the roundabout to brake suddenly, and in one even to stop completely to avoid a collision.

The observation also concerned the determination of the real signaling of the exit from the roundabout (Table 11). The lack of this signal disrupts traffic and generates dangerous situations.

Tab. 11

The number of violations (exit from a roundabout without a proper signal) depending on the traffic volume (case #7)

Interval	Traffic volume	Number of violations (exit from roundabout without proper signal)	Percentage of rule violators
14:00 - 14:15	106	9	8,5%
14:15 - 14:30	119	15	12,6%
14:30 - 14:45	104	6	5,8%
14:45 - 15:00	133	42	31,6%
15:00 - 15:15	121	20	16,5%
15:15 - 15:30	130	28	21,5%
15:30 - 15:45	122	25	20,5%
15:45 - 16:00	123	24	19,5%
Total	958	169	17,6%

5. DISCUSSION

As part of the study, observations and measurements of drivers' behavior were carried out in seven selected places (intersections, road sections, pedestrian crossings) in the city of Jaworzno. The summary list of the types of violations is included in Table 12.

Tab. 12

The number of violations (exit from a roundabout without a proper signal) depending on the traffic volume (case #7)

Measurement place	Type of violation	Total traffic volume (during 2 hours)	Number of violations	Percentage of rule violators
Intersection without traffic lights (inlet)	Ignoring the sign B - 20 "Stop"	435	211	48,5%
Road section	Exceeding the speed limit	1275	1173	92,0%
Railroad crossing	Running on a red light	1031	5	0,5%
Intersection with traffic lights (inlet)	Running on a red light	2422	19	0,8%
Intersection with traffic lights (inlet)	Illegal back turning	334	11	3,3%
Intersection with traffic lights (inlet)	Vehicle not stopping due to "green arrow"	180	160	88,9%
Pedestrian crossing	Failure to give priority to pedestrians	401	7	1,7%

Intersection with a circular movement (inlet)	Priority enforcement	824	4	0,5%
Intersection with a circular movement (exit)	Failure to use the turn signal	958	169	17,6%
Total		7860	1759	22,4%

The scale of dangerous driving behavior observed during field tests was varied depending on the place of observation. However, it should be remembered that their examination each time only covered a period of two hours. Many more would probably occur over a longer period of follow-up. While preparing the work, a group of 7,860 drivers was analyzed in terms of negative behavior. The results summarized in Table 12 indicate that 22.4% of drivers violated the road traffic regulations, but they differed depending on the place of observation. The vast majority of the drivers tested did not comply with the speed limit on the road section and did not stop on the green arrow marked at the signaling device. There was also a large share of drivers ignoring the B-20 sign and a noticeable group not using the right indicator when leaving the roundabout.

According to [1], in 2021 no priority given and the failure to adjust speed to traffic conditions were the two main causes of accidents due to drivers' fault. Hence, the high value for speeding on straight stretches of road observed during testing is a major road safety concern. Such behavior can be reduced through frequent police checks or traffic engineering solutions. Violation of not stopping due to "green arrow" signal in Poland could be caused by a few changes of road traffic law during the last decade. In the case, and in case of a lack of turn signals on roundabouts, it is necessary to improve proper information transfer and education.

6. CONCLUSION

The conducted research allowed an illustration of the scale of violation of road traffic regulations in relation to the most common infringements.

There are various reasons why drivers ignore traffic regulations. One should distinguish here absent-mindedness, lack of training and conscious breaking the rules. It is important to consistently implement communication education in society, one of the goals of which is to shape and modify behaviors while using roads and vehicles. A good driver, apart from knowing the rules of the road, should be aware of the risks and have the ability to correctly perceive himself and other road users.

Other ways to better enforce traffic regulations include an increase in the number of inspections of relevant services, but also more frequent use of solutions that force the use of certain behaviors, such as the use of a calm traffic zone in a given area or road shaping in such a way as to physically prevent a given maneuver. An attempt to select methods for specific types of breaking the rules of the road will constitute the authors' future research.

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