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TRAFFIC ORGANISATION PROBLEMS AT NON-SIGNALISED INTERSECTIONS – CASE STUDIES OF VISIBILITY DISTANCE AND ‘GIVE WAY’ AND ‘STOP’ ROAD SIGNS

Summary. The paper analyses traffic organisation at non-signalised intersections. In such locations, the use of correct road signs is crucial. Traffic engineers should consider a balance between traffic fluency and safety. Sometimes, limited visibility necessitates the use of a ‘stop’ sign. The paper includes case studies for selected intersections in the Silesia Province, Poland.

Keywords: visibility distance, ‘give way’ and ‘stop’ road signs, road safety

1. INTRODUCTION

Every day on our roads, we may observe intensive road traffic generated by commuters especially in large cities and urban agglomerations. [1, 10]. Traffic control is unavoidable if we are to prevent accidents and reduce the number of injured people and fatalities [3]. Additionally, road incidents translate into the cost of emergency service interventions, delays at work, the cost incurred by drivers due to congestion, and cost related to mental health

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disorders. Relevant traffic control enables road users to avoid incidents and facilitates the efficient flow of vehicles at intersections, particularly in core city centres.

Regarding road safety, the lack of appropriate signage is a serious problem. In many instances in Poland, the development of road signage falls behind the increase in traffic [1]. Moreover, drivers frequently ignore road signs, which leads to road incidents making travelling burdensome. Since every location in the road network has different parameters, it is necessary to adjust safety measures to the actual traffic [11-13, 16]. Although, road incidents most often happen due to human error, the surrounding or adverse traffic conditions impacts on drivers' judgements [8]. Therefore, it is important to provide relevant roads signs that are straight-forward and not misleading for drivers and do not pose a threat to road traffic safety, and consequently, do not stimulate decisions that may compromise safety and contribute to road accidents [2]. Not only does the appropriate signage help to avoid dangerous situations on our roads, but it also reduces the cost of dealing with the aftermath of accidents. In Poland, rules pertaining to road signs and traffic management are defined in relevant laws, including [5, 6, 8].

2. ROAD SIGNS AND VISIBILITY DISTANCE AT NON-SIGNALISED INTERSECTIONS

The road traffic organisation is based on a set of rules for vehicles and pedestrians to observe. The traffic organisation is one of the major responsibilities of a traffic management body. The goal is to ensure traffic fluency and guarantee safety in a given area of the road network. An indispensable component of the traffic organisation is road signage, both vertical and horizontal, and traffic lights [9, 14].

Traffic organisation is particularly important in locations with likely potential collisions involving traffic participants. It is possible to reduce the number of prospective collisions by applying relevant traffic measures. This, however, is not always possible. An intersection, where roads cross or connect, is usually a place of the largest number of accidents [4].

Visibility at intersections can be defined using such parameters as the visibility area, referred to as the visibility triangle, and the stopping visibility distance. The latter is the minimum distance for the driver to see a road sign, warning or danger and react early enough to avoid a road incident. The visibility area is defined depending on the permitted speed at a given road, curve radius and building facilities situated along the road. The 'Regulation of the Minister of Transport and Maritime Economy of 2nd March 1999 concerning technical conditions to be met by public roads and their locations' [5] provides minimum values of the visibility distance for various road types. Below, Figure 1 presents the visibility area for a car approaching an intersection and minimum sight distances [5, 9, 15]. Figure 2 shows the visibility area for a vehicle moving from the place it stopped and minimum sight distance values [5]. An important aspect of traffic organisation is that signage needs to be adjusted to in accordance with the features of its surrounding.

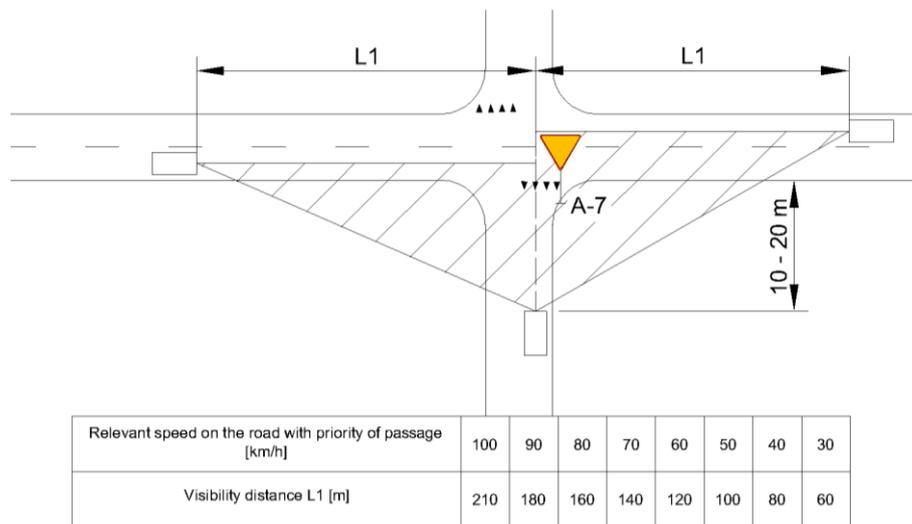


Fig. 1. Visibility area while approaching an intersection based on [5]

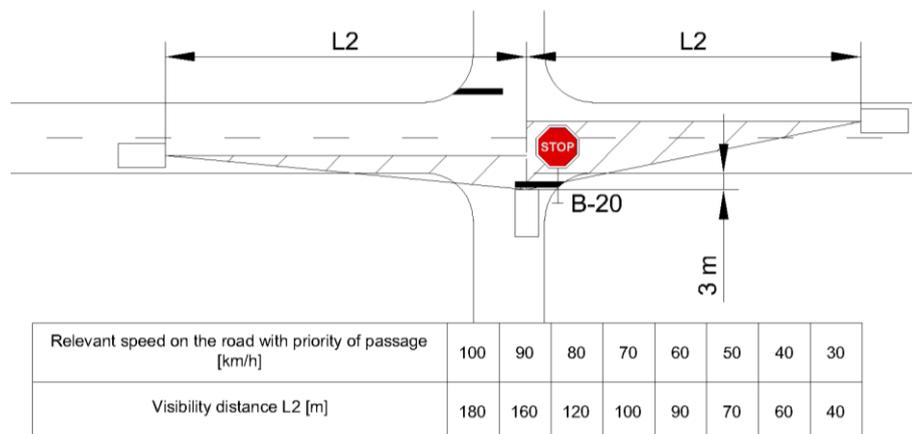


Fig. 2. Visibility area while moving from stop location based on [5]

At intersections without traffic lights, either A-7 or B-20 sign is set at the connecting road. In the case of the A-7 ‘Give Way’ sign, vehicles stop when a car is approaching along the road with right of way, whereas in the case of the B-20 ‘Stop’, vehicles are obligated to stop, which automatically increases their safety before they merge with the traffic. The B-20 ‘Stop’ sign is more restrictive for drivers than A-7 ‘Give Way’. From the viewpoint of traffic fluency, the less restrictive solution (A-7) is more justified. However, in a number of instances, especially in the case of poor visibility, that sign should be replaced with the B-20 sign which is more unambiguous in defining driver’s behaviour.

3. CASE STUDY

For the purpose of the study, the analysis covered four locations with major visibility issues at their intersections with the right of way roads. Each of those locations was

thoroughly examined at the site with driver's behaviour observed as well. The locations were also analysed for road incidents and frequency while taking into consideration the traffic volume. Finally, changes in the traffic organisation were proposed to improve safety. The analyses covered the following locations:

- #1 intersection of Opatowicka and Opolska streets in Tarnowskie Góry.
- #2 intersection of Pukowca and Bocheńskiego streets in Katowice.
- #3 intersection of Łagiewnicka, Krzyżowa and Świętochłowicka streets in Bytom.
- #4 intersection of 9 Maja and Karola Miarki streets in Chorzów.

3.1. Current situation

At each intersection, the Give Way sign (A-7) was set at the connecting street. The analysis of the actual situation revealed visibility issues at each intersection. At some intersections, other problems were noted as well.

Case #1

The intersection is situated in Tarnowskie Góry and shortens the travelling distance for drivers using the ring road and for the inhabitants when travelling to the city centre. The A-7 sign was set at Opatowicka Street. Due to a very small angle between Opatowicka and Opolska streets (ca. 20°) and poor stopping visibility distance, the sign should be replaced by the 'Stop' sign (B-20) according to principles defined in the Regulation on technical conditions for public roads and their locations. The situation is presented in Figure 3. The observation showed that drivers approaching the intersection from Opatowicka Street, desiring to turn right needed to rotate their heads significantly to make sure that they give way to vehicles moving along Opolska Street. While doing so, they were not able to pay attention to the immediate surrounding in front of their cars, which frequently required them to brake abruptly to avoid collision with a preceding vehicle if it moved at a smaller speed. The intersection with Opatowicka Street lacks horizontal signs indicating the right of way.

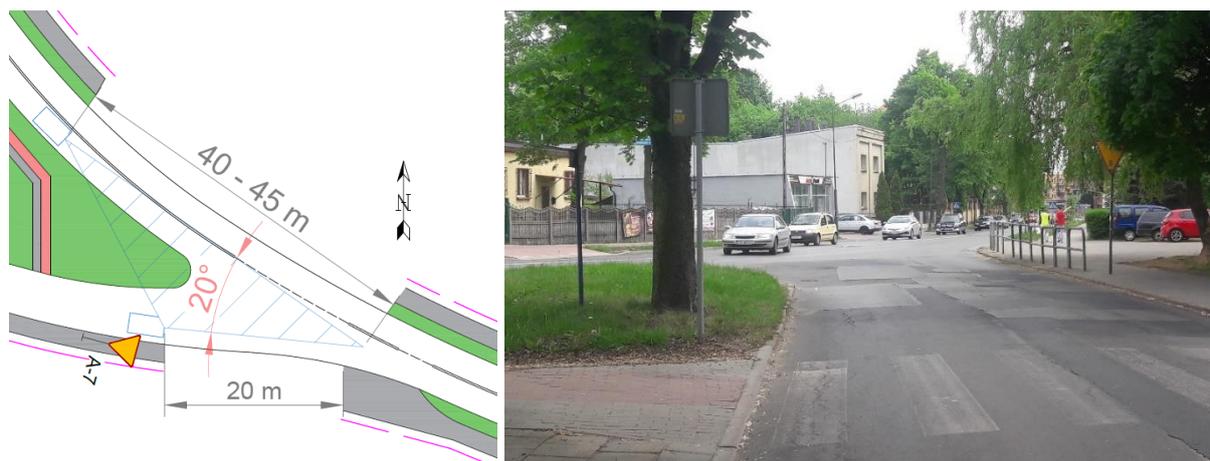


Fig. 3. Traffic organisation and stopping visibility distance at the intersection with Opatowicka Street (case #1)

Case #2

The intersection is situated in the north-west part of Katowice. It plays the role of the connecting point. Bocheńskiego Street is one of the major streets in the city connecting with

the A4 motorway situated 1 km away from the intersection. The street enables for fast travelling to the city centre. Although at the merging point with Bocheńskiego Street a 'Give Way' (A-7) sign has been placed, the arrangement of Pukowca Street and Bocheńskiego Street causes the situation of reduced visibility. Another issue is the lack of a merging lane along Bocheńskiego Street (for vehicles driving along connecting roads), which combined with the shortage of horizontal signage may be misleading for drivers. This has been confirmed by the observation of drivers at the superior connecting road. They had to brake suddenly when someone failed to give them right of way and also drivers moving along Pukowca Street had to brake at the very last moment before merging with the main traffic. Traffic organisation and visibility field at Pukowca Street are presented in figure 4.



Fig. 4. Traffic organisation and stopping visibility distance at Pukowca Street (case #2)

Case #3

The intersection without traffic lights is situated in the southern part of Bytom. The street with the right of way connects the Łagiewniki District with the city centre. Increased traffic at the intersection can be seen mainly during the morning and midday peak hours. Numerous trees and bushes growing along the road disrupt visibility for drivers moving along the subordinate road which has the A-7 sign set close to the intersection. Drivers merging with the traffic from Krzyżowa Street find it difficult to see other vehicles on the right of way street. It is particularly dangerous in the case of drivers turning left when cars at the subordinate connecting point must give way to cars moving along each of three lanes. The traffic organisation and stopping visibility distance at the intersection are presented in Figure 5. The observation revealed two types of hazardous behaviour among drivers coming from the subordinate connecting road and turning left. On one hand, drivers turning left at Krzyżowa Street often merge with the traffic after they are sure of no incoming vehicle along Świętochłowicka Street, but at the same time, they ignore cars on the connecting Łagiewnicka Street. While on the other hand, drivers approaching the intersection without reducing their speed, had to brake sharply to avoid collision with cars coming along the right of way road when they noticed it at the very last moment.

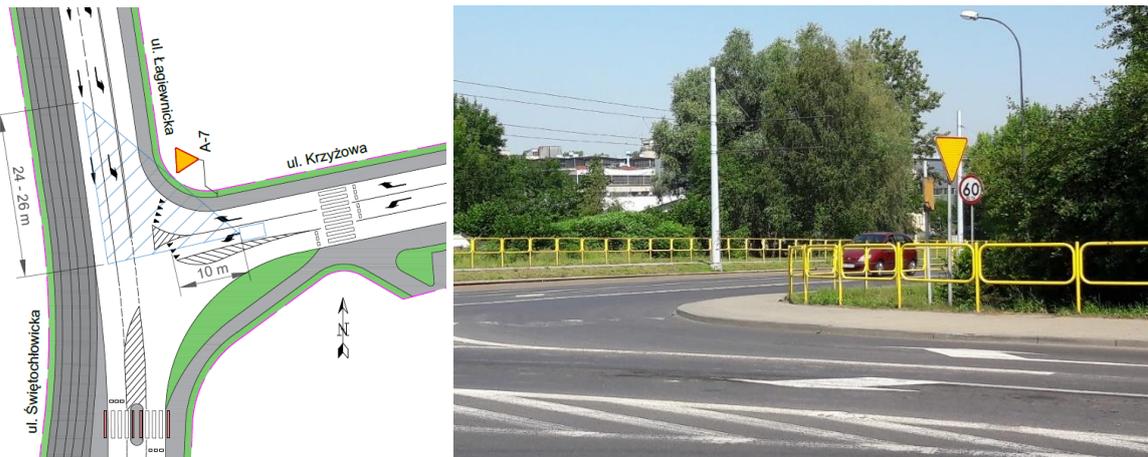


Fig. 5. Traffic organisation at the intersection and stopping visibility distance at connecting Krzyżowa Street (case #3)

Case #4

The final case study involves an intersection without traffic lights in the centre of Chorzów. The intersection connects 3 Maja Street, which is one of main east-west city highways, and Karola Miarki Street, which is a major road connecting the northern districts of Chorzów with the city centre. Moreover, 3 Maja Street also conveys the tramway traffic. The intersection is situated in the dense build-up residential area. Traffic from the subordinated connecting road is controlled by the A-7 sign. However, the dense residential development significantly reduces visibility for drivers coming from the subordinated connecting road and turning right as well as those turning left. Visibility is further limited by cars parked along 3 Maja Street, in the immediate vicinity of the intersection. Traffic organisation and stopping distance visibility at the intersection are presented in Figure 6. The observation showed that drivers coming along the subordinated connecting road, find it difficult to see cars approaching along the right of way street. This frequently leads to failure to give way. The situation is particularly dangerous for cars turning left since they need to give way to vehicles moving along the 2 lanes and the tram as well.

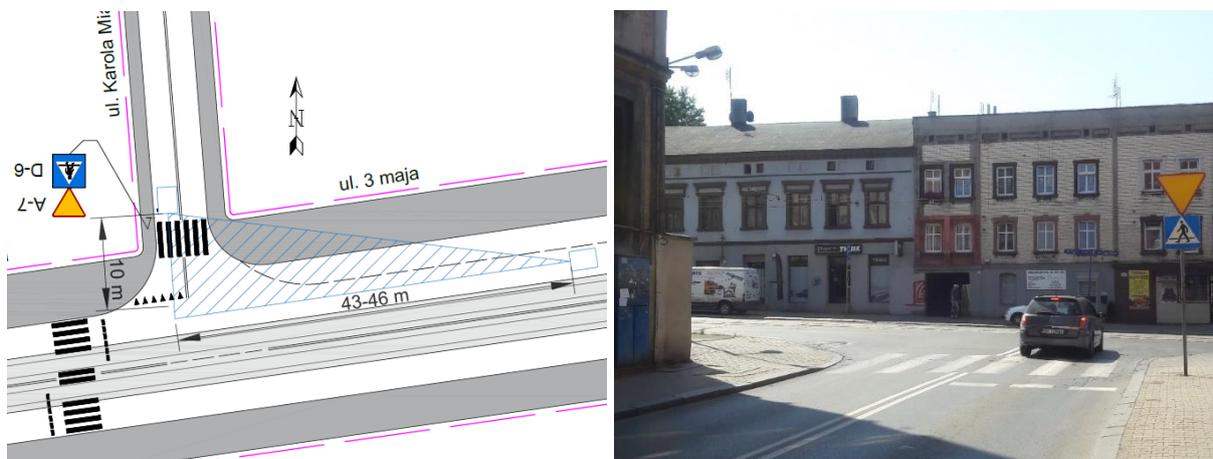


Fig. 6. Traffic organisation at the intersection and stopping visibility distance at T-junction with Karola Miarki Street (case #4)

3.2. Causes of road incidents

The analysis covered data for selected intersection concerning the number of road incidents. Data originated from relevant police records and the SEWiK system (Accident and Collision Register). Table 1 includes 2016 and 2017 data with a breakdown of causes of incidents. As observed, the main causes include the failure to give way and failure to keep a safe distance between vehicles. In the last case (#4), inappropriate turning was a major cause.

Tab. 1

Road incidents in 2016 and 2017 at intersections examined.

Cause	#1		#2		#3		#4	
	2016	2017	2016	2017	2016	2017	2016	2017
Failure to give right of way			4	3	4	3	1	1
Failure to keep safe distance	2	3	4	2	1		2	1
Inappropriate turning			1				1	3
Inappropriate passing		1		1				
Inappropriate reversing				2				
Inappropriate overtaking	1							
Failure to observe road signs and other signals			1					
Inappropriate change of lane			1					
Poor health						1		
Driving into road hole						1		
Failure to give way to pedestrians							1	
Unknown	1							
TOTAL	4	4	11	8	5	5	5	5

It should be noted that the main causes of incidents might be related to poor visibility when merging with the traffic from a road with right of way. Due to poor visibility, drivers fail to give way or need to brake abruptly or brake too late and risk a collision with a preceding car on the road.

3.3. Proposed improvements

The analysis of the actual situation, information about incidents, and observations on those intersections helped in developing proposals for improvements. In each of the cases, it was suggested that the A-7 sign should be replaced with the B-20 sign to deliberately force drivers to stop at the connecting road. This may cause loss of time at the intersection during off-peak hours (when traffic volume is reduced on roads with the right of way). However, in the opinion of the authors, the change can improve safety at intersections. The changes for particular cases are described below.

Case #1 – Proposed changes

A suggested solution that would improve traffic safety involves replacing the A-7 sign with the B-20 sign. Moreover, the intersection design should ensure that the angle between streets is close to 90° with a 20° tolerance. This improves visibility for drivers approaching the intersection and it gives them the opportunity to react faster in case of danger [9]. For the reason, of solving the problem of the small angle between Opolska and Opatowicka streets, and improve the visibility area as well, it is suggested that the connection with Opatowicka Street be rebuilt and the angle with Opolska Street reconstructed closer to a 90° orientation (Figure 7).

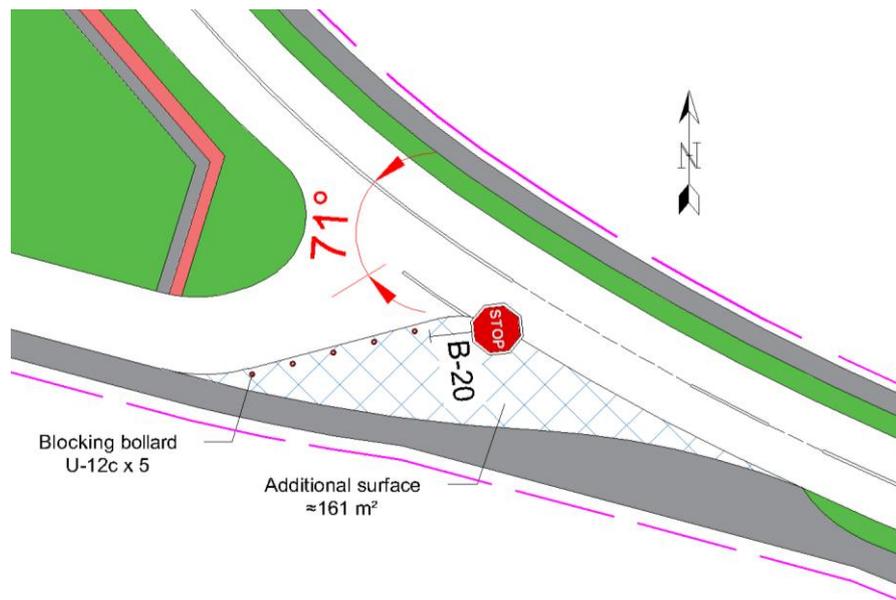


Fig. 7. Proposed rebuilding of intersection of Opolska and Opatowicka streets (case #1)

Case #2 – Proposed changes

It is advised that the vertical sign A-7 ‘Give Way’ be changed to the B-20 ‘Stop’ sign. Additionally, horizontal signs should be placed for the B-20 sign to clearly set the stop point for a car before entering the possible conflict zone with cars enjoying the right of way (Figure 8). Application of the suggestion can stop misunderstanding between drivers as they would be sure to give way and approach merging lane without confusion. These suggested changes do not necessitate the rebuilding of the road infrastructure.

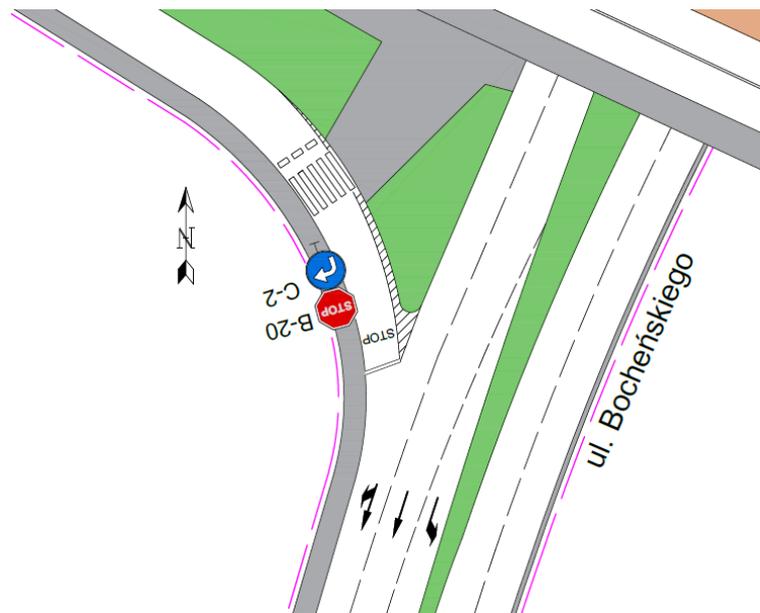


Fig. 8. Suggested traffic organisation at the connection with Pukowca Street (case #2)

Case #3 – Proposed changes

It is suggested that road signs be changed (Figure 9). Again the proposal is to replace the A-7 sign with the B-20 sign to force drivers to stop and give way if necessary. This should help drivers to cross the intersection safely. The solutions suggested, requires drivers to stop before entering the intersection, however, principally the proposed changes in road signs increase the stopping visibility distance.

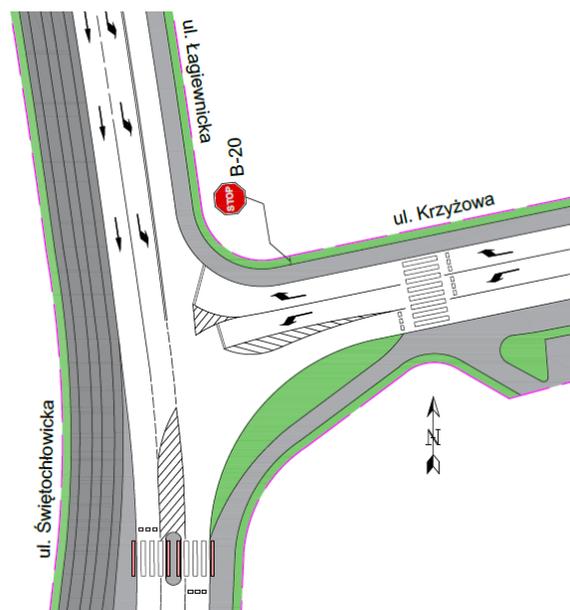


Fig. 9. Suggested traffic organisation at the connection with Krzyżowa Street (case #3)

Case #4 – Proposed changes

In this particular case, we suggest replacing the vertical A-7 ‘Give Way’ sign with the B-20 ‘Stop’ sign and reducing the number of parking places as well as fitting posts that prevent drivers from parking close to the intersection (Figure 10). The change partially improves visibility at the connecting road and at the same time enhances the certainty that the right of way is respected by drivers moving along roads without right of way.

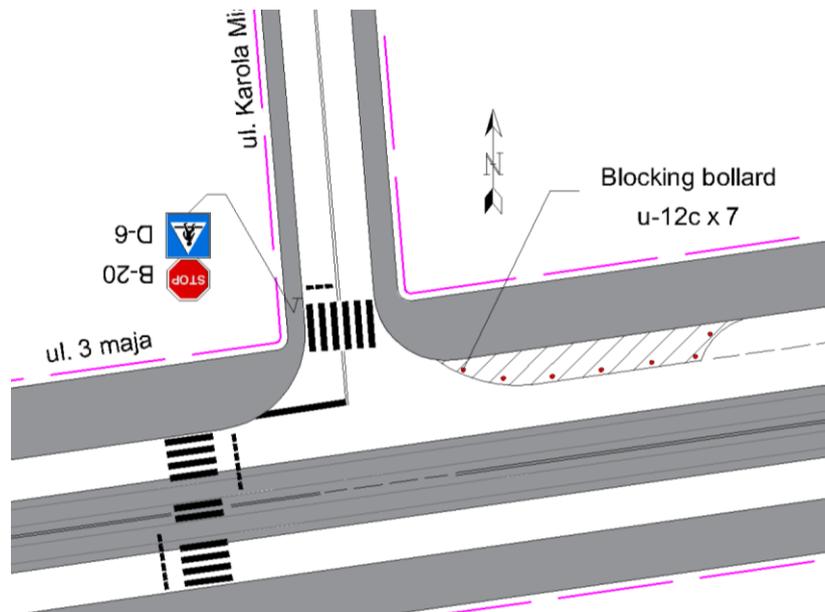


Fig. 10. Suggested traffic organisation at the intersection of 3 Maja and Karola Miarki streets (case #4)

4. CONCLUSION

Traffic organisation is one of the basic elements of transport infrastructure which is decisive regarding safety at intersections. Due to different configurations of the surrounding, every intersection requires an individual approach as regards organisational measures. In the case of a non-signalised intersection, proper visibility is particularly important, since at the access road without right of way a driver makes an individual decision to go through the intersection (no traffic lights). The use of a Stop sign, as proposed in the article, forces drivers to stop at the connecting point. On one hand, a drawback of the solution is time lost at the connection point, since the car needs to stop there. On the other hand, the solution provides clear information to the driver to give way and necessitates the driver to examine the actual traffic on the right of way street.

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