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PROBLEMATIC TURNING OF BUSES ON WRONGLY DESIGNED INTERSECTION

PROBLEMATICKÉ ODBOČOVÁNÍ AUTOBUSŮ NA CHYBNĚ NAVRŽENÉ KŘIŽOVATCE

Abstract

The paper deals with problematic turning of buses on selected intersection with use of video analysis of conflict situations. This paper also describes a new attitude to division and marking of conflict situations and also one of the methods during video analysis of conflict situations by the evaluation of inappropriately designed building elements on intersections.

Keywords

Video Analysis, Conflict Situation, Intersection.

Abstrakt

Článek se zabývá problematickým odbočováním autobusů na vybrané křižovatce s využitím videoanalýzy konfliktních situací. Článek také popisuje nový přístup při členění a označování konfliktních situací a rovněž jeden z postupů při provádění videoanalýzy konfliktních situací při hodnocení nevhodně navržených stavebních prvků na křižovatkách.

Klíčová slova

Videoanalýza, konfliktní situace, křižovatka.

1 INTRODUCTION

Every road, or its construction, has to comply with rigorous criterions for safety and continuous road traffic. The reliability of this construction is influenced by load: partly by load which is cause by vehicle weight (risk of rutting) and partly by so called traffic load, i.e. by volume of traffic flows. Great traffic volumes can cause sub-standard behavior of participants of road traffic and also increased number of danger situations. These situations can lead to traffic accident. The accident can be caused by wrong vigilance of driver (participant of road traffic) or by "wrong infrastructure" (wrong designed road, intersection, pedestrian crossing etc.) which can cause wrong behavior of driver and consequent problem (conflict situation or traffic accident).

The conflict situation is such a situation when arises, for some traffic participants, more than usual degree of risk. It can be said, that the conflict situation is a potential accident situation which may result to an accident or not [1]. Every conflict situation is marked by symbol – its innovative form for analysis of inappropriately designed building elements on intersections is showed on Fig. 1.

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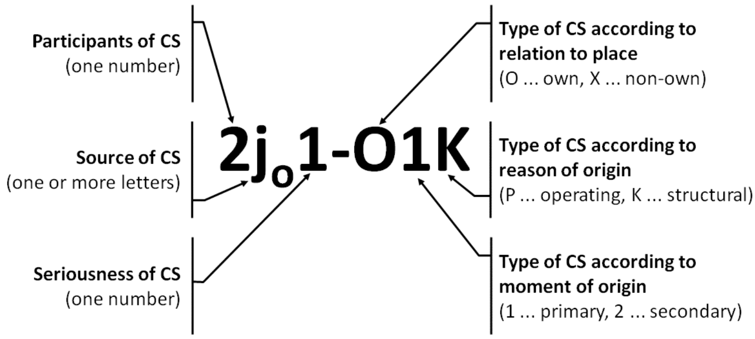

Fig. 1: Innovative classification symbol for marking of conflict situation (CS)

The first number marks participants of conflict (2 = isolated vehicle, 6 = couple or group of vehicles). The source of conflict is marked by letter or letters (also with subscript), for example: $j_{ř}$ = ride wrong turning lane, j_{so} = ride over visual island, j_{o} = ride near the curb etc. Seriousness of conflict situation is marked by number: 1 = potential conflict situations, 2 = conflict situations when one or more participants are restricted, 3 = conflict situations when one or more participants are endangered and 4 = traffic accident (for details see [1] and [2]).

According to relation to place the situations were divided to two groups (the mark for use in classification symbol is in parenthesis) [2]:

- “own” conflict situation (O) – a conflict situation which is related to traffic on the roundabout, its construction etc.,
- “non-own” conflict situation (X) – a conflict situation which is influenced by other conflict situation in the vicinity.

The next conflict situations emerge as influence of the other situations. For example: the driver of the first vehicle has to unexpectedly rapidly slow (e.g. before pedestrian crossing, where the careless pedestrian was suddenly entered) and the driver of the second vehicle has to also rapidly brake to avert crash. The second situation is dependent on the first situation. Conflict situation according to moment of origin were divided to [2]:

- “primary” conflict situation (1) – a conflict situation which isn’t caused by other conflict situation,
- “secondary” conflict situation (2) – a conflict situation which is caused by other conflict situation.

Reason of origin of conflict situation isn’t caused only by wrong behavior of driver (or the other participant of traffic), but also by inappropriately designed building elements on intersections. The conflict situations were divided to:

- „operating“ conflict situation (P) – a conflict situations which is caused only by driver (or the other participant of traffic),
- „structural“ conflict situation (K) – a conflict situations which is caused not only by driver, but also (usually) by inappropriately designed building elements

The video analysis of conflict situations can help designer of transport construction to prevent wrong design of intersections etc. This video analysis can be also use during safety inspection on the road (see Law No. 13/1997 [3]).

The results which are showed in this article were obtained with financial contribution of research project [4] and they are original (next results of this project were published e.g. in [5] and [6]). The classification of conflict situation and innovative classification symbol is made also largely by new way (partially see [2]).

2 DESCRIPTION OF INTERSECTION AND POSITIONS OF CAMERAS

For our needs the intersection *Průběžná – obratiště autobusů – parking Globus* in Ostrava-Poruba was chosen (near Faculty of Civil Engineering, VSB – Technical University of Ostrava – see Fig. 2). The major streets have the turning lanes and the minor street which (leg C) has pedestrian crossing with refuge island.

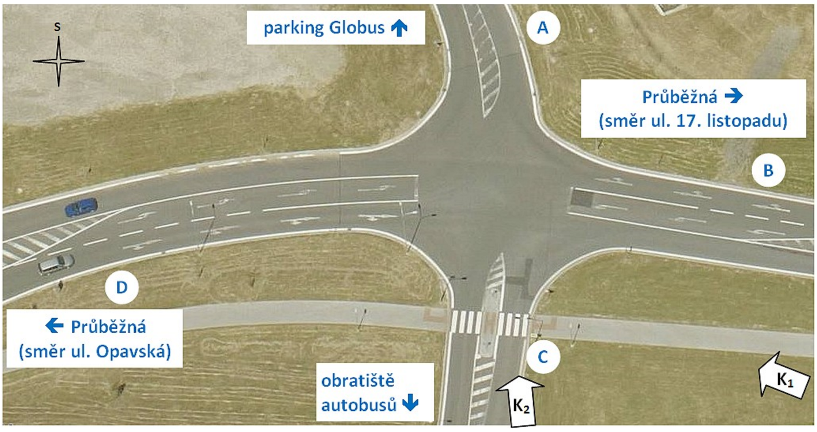

Fig. 2: Monitored intersection *Průběžná – obratiště autobusů – parking Globus* in Ostrava-Poruba

The Fig. 3 shows the exact positions of cameras. The camera K_1 („top" camera) was situated on the 6th floor of building of Faculty in distance about 130 m from center of intersection (illustration see Fig. 4-a). The camera K_2 („down" camera) was situated in distance about 35 m from pedestrian crossing on leg C. There was relatively good view for recording of ride near guide strip (line) or curbs. If necessary the camera was turned to the left part of crossing (see illustration on Fig. 4-b) or to the right part of crossing (see illustration on Fig. 4-c).

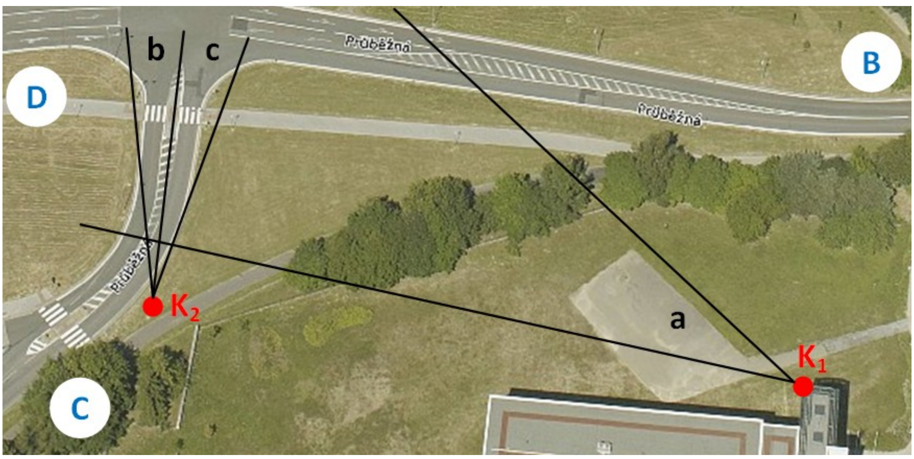

Fig. 3: Positions of cameras for monitoring of conflict situations (a, b, c – see Fig. 4)

Fig. 4: Illustration views from cameras: from K_1 see (a) and from K_2 see (b) and (c)

3 SELECTED CONFLICT SITUATIONS

On monitored intersection occurred group of conflict situations (CS): on the one hand the operating conflict situation (e.g. violation of rule “yield to ...”) and on the other hand the structural conflict situation (e.g. ride near to curb due to its inadequate radius, ride wrong turning lane for control safety turn maneuver etc.).

Some conflict situations was classify to category of operating or structural CS according to culprit: wrong ride or driver or inappropriately designed building elements of intersection. For example: the ride to the opposite direction by driver of passenger car going from leg A to B was evidently the mistake of this driver (i.e. operating CS). The ride to the opposite direction by driver of bus going e.g. from leg C to B was caused by small radius of curb, when the driver try to avert driving onto curb by rear wheel (i.e. structural CS).

Due to limited scope of this paper we will concentrate only on description of selected conflict situations, i.e. the situations which arise during turning of buses from leg B (or D) to leg C: i.e. CS marked as $2j_{ř}1$-O1K, or $6j_{ř}2$-O1K (its numbers see Tab. 1) and also $2j_{so}1$-O1K and $2j_{o}1$-O1K.

Tab.1: Numbers of conflict situations

Mark of CS	Time of measuring						SUMA
	13^{30}- -13^{45}	13^{45}- -14^{00}	14^{00}- -14^{15}	14^{15}- -14^{30}	14^{30}- -14^{45}	14^{45}- -15^{00}	
$2j_{ř}1$-O1K (B→C) (incl. $6j_{ř}2$-O1K)	4 (1)	2 (1)	3	4	4 (1)	1	18 (3)
$2j_{ř}1$-O1K (D→C) (incl. $6j_{ř}2$-O1K)	2	0	1	3 (2)	0	1	7 (2)

During conflict situation $2j_{ř}1$-O1K (or $6j_{ř}2$-O1K, when the other participant is restricted or endangered) the driver have to drive by next turning lane (see Fig. 5).

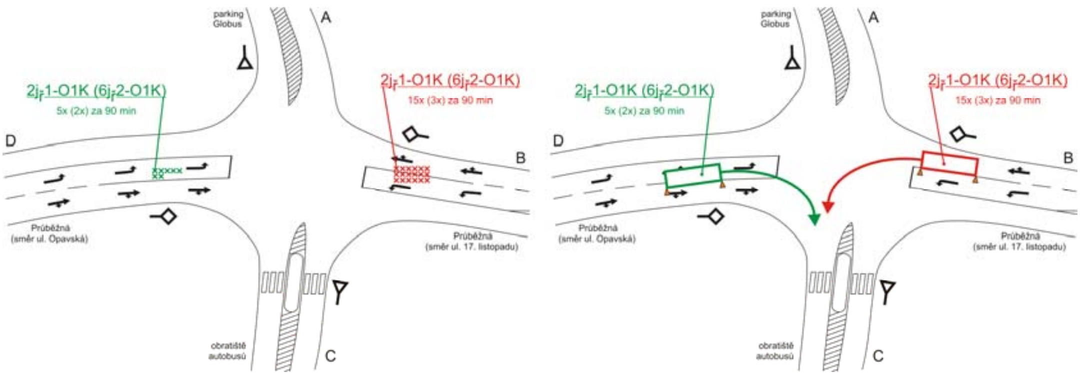

Fig. 5: Scheme of origin and localization of conflict situation $2j_{ř}1$-O1K (or $6j_{ř}2$-O1K)

There were the buses going to leg C in the direction of the bus stop *Opavská*, i.e.:

- either to the left from leg B to C (see Fig. 6 or 8), when the driver drive by running lane,
- or to the right from leg D to C (see Fig. 7 or 9), when the driver drive by left turning lane.

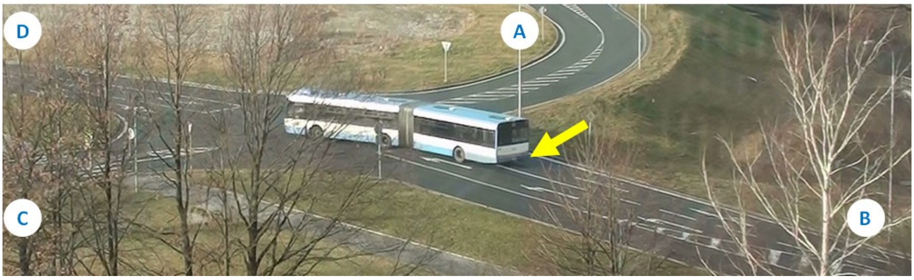

Fig. 6: The bus driving by running lane during turning to the left (conflict situation $2j_{\check{r}}1$-O1K)

Fig. 7: The bus driving by left turning lane during turning to the right (conflict situation $2j_{\check{r}}1$-O1K)

The reason of this behavior is following: the bus drivers have problem to go into space between refuge island and right curb (see exit C on Fig. 2). In case of drive from leg B to C (the left turning) the buses usually drive over visual island (i.e. conflict situation $2j_{so}1$-O1K) and then near the curb (i.e. conflict situation $2j_{o}1$-O1K) – see Fig. 8. The vehicles going from leg D to C (the right turning) then drive near the curb (i.e. conflict situation 2jo1-O1K) – see Fig. 9. This way of drive can moreover endanger pedestrians which are near pedestrian crossing.

Fig. 8: The bus driving over visual island (conflict situation $2j_{so}1$-O1K), or near the curb of refuge island (conflict situation $2j_{o}1$-O1K); the left picture shows driving over guide lane by left wheel of the second axle, the right picture shows the third axle the same bus

Fig. 9: The bus driving near the curb of refuge island (No. 1; conflict situation $2j_{o}1$-O1K);
2 ... driving by left profile of the bus over guide strip

We can state, that the drivers to prevent situation $2j_{o}1$-O1K and $2j_{so}1$-O1K have to cause the situation $2j_{\check{r}}1$-O1K or $6j_{\check{r}}2$-O1K – and contrariwise. By driving by wrong lane the other participants of road traffic can be restricted or endangered (i.e. conflict situation $6j_{\check{r}}2$-O1K – see Fig. 10).

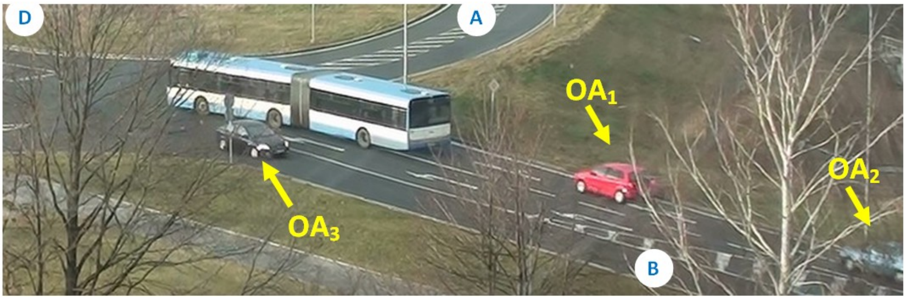

Fig. 10: The restriction of the other vehicles (OA_1 and OA_2) by bus turning to the left (giving way to vehicle OA_3) and driving over running lane (conflict situation $6j_{\check{r}}2$-O1K)

We can also say, that the driver of bus turning to the right (from D to C) in quest to prevent drive onto curb by right wheels can contrariwise drive onto curb of refuge island by the left wheels (or they drive by bus profile over guide strip – see Fig. 9, arrow 2) – analogically for bus driver turning to the left (from B to C).

The curb between entry D and exit C isn’t damaged, however the curb of refuge island on leg C is damaged – see Fig. 11.

Fig. 11: The damage curb of refuge island on leg C

4 RUPTURE CURVES

The rupture curves are used to verify of passage through directional elements of roads. We can use relevant standard (TP 171 [7]) or special software AutoTURN. On the figures in the following text is used green color for representation of rupture curves of the front wheels, dark-blue color for the rear wheels, violet color for profile of vehicle and gray color for route. It’s certainly that they are only theoretical trajectory of vehicle motion. During maneuver the driver changes, in the event, vehicle speed, turning of steering wheel and passage of given place is depend also on knowledge of this place and drivers experiences. There was used the vehicles which was found out as the most large.

4.1 Turning from leg B to C

As the first problem will be describe the *left* turning from Průběžná street (*leg B*) in the direction to bus stop on leg C, when the articulated bus used the left turning lane. On Fig. 12 we can see, that this type of bus has already in low speed (10 km/h) relatively problem with exit to leg C (where the refuge island is). However, the bus don’t go neither by front nor by rear wheels onto curb, but only onto visual island. The details on Fig. 13 show the same situation, but for greater speeds (15, 20 and 25 km/h). During speed 20 km/h the vehicle already drives near the curb of refuge island, during speed 25 km/h the bus even drive onto the curb by the right wheel.

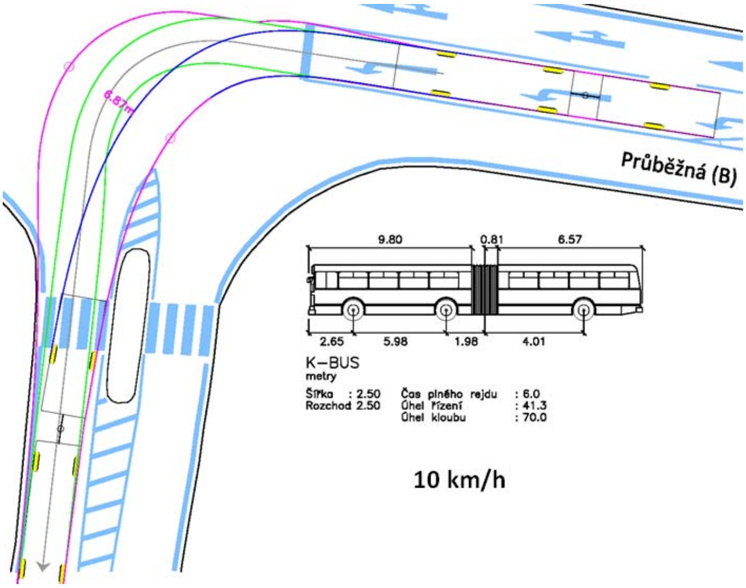

Fig. 12: The rupture curves (AutoTURN) for turning from leg B to leg C
with use of the left turning lane (speed 10 km/h)

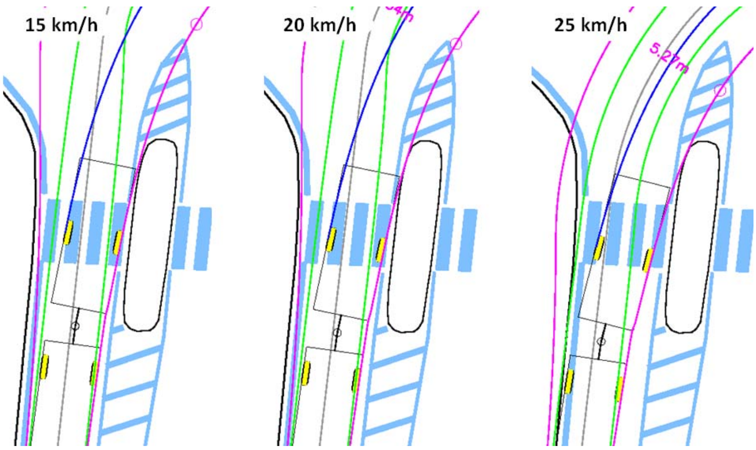

Fig. 13: The rupture curves (AutoTURN) for turning from leg B to leg C
with use of the left turning lane (speeds 15, 20 and 25 km/h)

On Fig. 14 is showed the situation, when the articulated bus don't use the left turning lane, but the next lane (for drive strait and on the right) – there is situation for speed 10 km/h. This bus don't drive neither onto guide strip nor visual island (even if with minimal or zero reserve). The details on Fig. 15 show the same situation, but for greater speeds (the situation is logically more problematic).

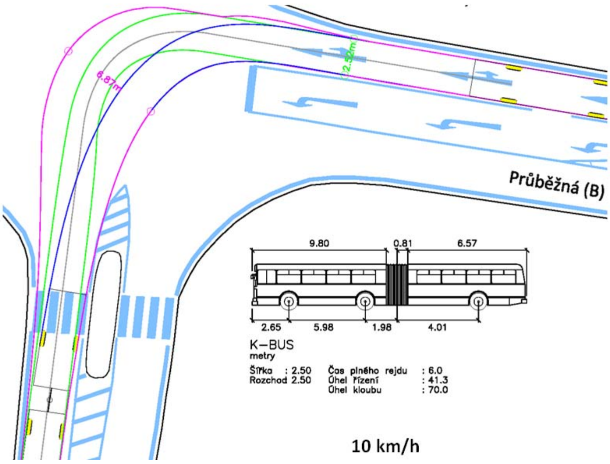

Fig. 14: The rupture curves (AutoTURN) for turning from leg B to leg C without use of the left turning lane (speed 10 km/h)

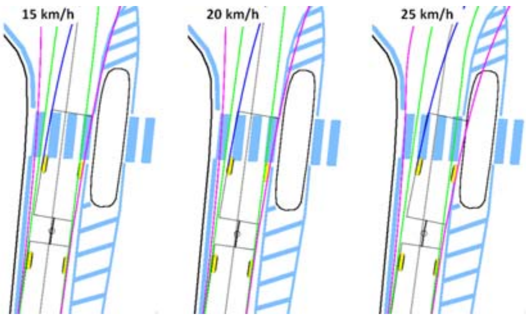

Fig. 15: The rupture curves (AutoTURN) for turning from leg B to leg C without use of the left turning lane (speeds 15, 20 and 25 km/h)

4.2 Turning from leg D to C

As next problem will be describe the *right* turning from Průběžná street (*leg D*) in the direction to bus stop on leg C, when the articulated bus used the left turning lane. The buses (here only 12-metre vehicles) have to drive by the next left turning lane for prevent driving onto curb or refuge island. Fig. 16 (left) shows situation, when the bus is driving only partly through this lane, Fig. 16 (right) shows situation, when the bus is driving through this lane by whole width. This maneuver is problematic already for speed 10 km/h.

3 CONCLUSION

How to successfully deal with conflict situation in road traffic is a very difficult issue. We can say that the main part of conflicts is caused by irresponsibility of drivers (or the other participants of road traffic) – so called operating conflict situations. However, there are the conflict situations which are cause by wrong infrastructure – so called structural conflict situations. In the both events we can use the video analysis very advantageously (it is possible to stop, slow or repeat the sequences of video recording for exact and objective appraisal of the conflict situation. Monitoring of conflict situations in road traffic has certainly well-founded significance. To prevent problems (i.e. here traffic accident) is better than then to deal with negative repercussions (usually of serious character – i.e. death, injury, damage).

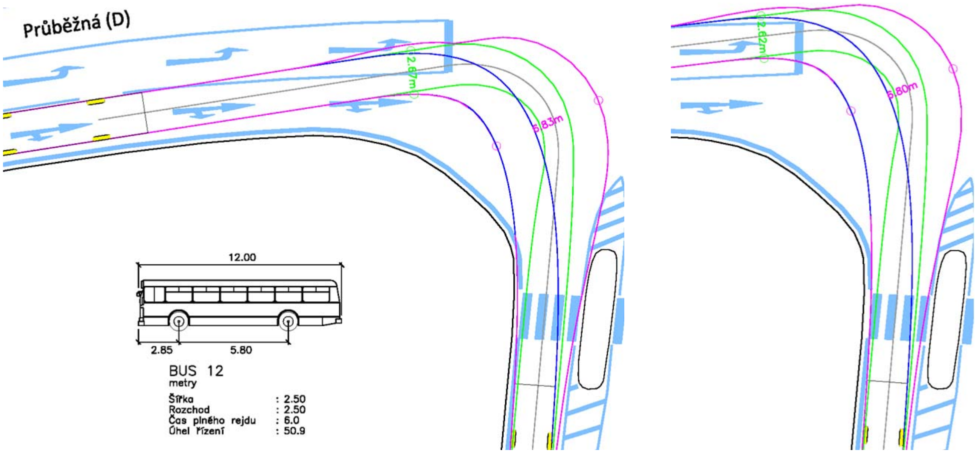

Fig. 16: The rupture curves (AutoTURN) for turning from leg D to leg C with partial (left) and full use of the next turning lane (speed 10 km/h)

This article brings one of new view for use video analysis of conflict situations and concentrates on inappropriately designed building elements on selected intersections. It's logical that the damage may occur not only regularly, but due to isolated event (e.g. traffic accident, damage during winter maintenance etc.). The video analysis of conflict situations can reveal this periodicity.

The video analysis of conflict situations we can also very good use for safety inspection according to Law No. 13/1997 [3]. The profitable use of this method for analysis of inappropriately designed building elements on roundabouts is showed in [8] and [9].

The use of software AutoTURN proved to be very appropriate for verify of passage through directional elements of roads by rupture curves. The problems showing by AutoTURN were confirmed by video analysis of conflict situations. It follows that both tools should be used together. It's certainly that they are only theoretical trajectory of vehicle motion (with use AutoTURN or TP 171 [7]). During real maneuver the driver changes, in the event, vehicle speed, turning of steering wheel and passage of given place is depend also on knowledge of this place and drivers experiences.

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