

*transportation safety, problem "to see and to be seen",  
safety on crosswalks, analysing of different situations,  
application of safety elements – reflective eye, their visibility*

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## INCREASING THE TRANSPORTATION SAFETY, NEW POSSIBILITIES

The article describes possibilities for improvement of road users visibility in places, where happen to concentration of automobile transport - higher traffic accidents probability - and in places, where automobile transport intersects with pedestrians and bikers. For pedestrians safety on crosswalks is valid the same principle, like for whole traffic on surface routes, namely "to see and to be seen".

## ZWIĘKSZENIE BEZPIECZEŃSTWA TRANSPORTU, NOWE MOŻLIWOŚCI

Artykuł opisuje możliwości usprawnienia widoczności użytkowników w miejscach, gdzie pojawiają się stężenia ruchu samochodowego – większe prawdopodobieństwo wypadku samochodowego – oraz w miejscach, gdzie transport samochodowy krzyżuje się z ruchem pieszym i rowerowym. Dla pieszych bezpieczeństwo na pasach obowiązuje w myśl takiej samej zasady, jak dla całego ruchu na drogach naziemnych, to znaczy „widzieć i być widzianym”.

### 1. INTRODUCTION

One of the item, according demand „to see and to be seen“ is undoubtedly of course the vehicle colour or the dress. From speed of sense point of view even peripheral seeing is the most important contrast between vehicle colour and environment .in which is moving just now, or standing. The environment is very changeable factor – not only during seasons but the differences are also between urban municipal and open air.

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The most actual for visualisation of vehicles (the all number of colours) is lightening. The light is visible at once, namely in summer time. The strong lightening effect had been proved (namely to pedestrians) in Czech Republic some years ago. Transport Enterprise of Prague tested switching up of trams through the whole year. Positive effect has been at once. The number of accidents visibly dropped down.

From statistic of accidents point of view in Czech Republic resulting (in 2001) two third of accidents number at day time and very good visibility conditions have happened. To these accidents devolve 45% of fatal accidents. Importance of these accidents is lower then average values in CZ.

Transport accidents rate in CZ – proportional to visibility – 2001 year

Table 1

Visibility	Accidents number	%	Number of killed users	%	Accidents importance = number of killed to 1000 accidents
DAY good	117 908	63,5	554	45,4	4,7
DAY decreased – sunrise, sunset	6 001	3,2	67	5,5	11,2
DAY decreased– fog, snowfall	19 553	10,5	120	9,8	6,1
NIGHT – place of street lightening	18 661	10,1	119	9,8	6,4
NIGHT – place of street lightening - decreased	5 534	3,0	42	3,4	7,6
NIGHT – place without street lightening	13 613	7,3	257	21,1	18,9
NIGHT – place without street lightening-decreased	4 074	2,2	60	4,9	14,7
Undetected	320	0,2	0	0,0	0
<b>SUMMARY</b>	<b>185 664</b>	<b>100</b>	<b>1 219</b>	<b>100</b>	<b>6,6</b>

The most important accidents at night time and in places without of street lightening, have happened.

Approx. 80 % of accidents (time and place – the most important accidents) in rural zone have happened. That is why in some countries (Netherlands, Denmark, Belgium, etc.) street lightening is carry out (exposed roads) also in rural zone. By divide for drivers it means night traffic is no more safe and calm. It is fact, traffic intensity is lower but risk is higher.

Some situation exists when accident danger is not from visibility decrease but from effect of road users view limit. It could be case, in town is four lanes road, in right one is bus and behind this bus (left ride lane – headway) is motorcar. The bus driver sees pedestrian ready to enter on crosswalk and begins to brake. He brakes in enough headway before the crosswalk. At present motor car driver does not see neither pedestrian nor vertical traffic sign. The bus in right lane covers these ones. Motor car driver doesn't need to observe the crosswalk (bad climate conditions, bad keeping up of horizontal signs).

In the next part of this contribution, the disposal design for traffic safety increasing will be presented.

## 2. THE CROSSWALK FOR PEDESTRIANS ON FOURLANES MUNICIPAL ROAD

Let come back to the a.m. situation (in right traffic lane is the bus, in the left traffic lane, headway – motorcar). We will suppose, both drivers are diving on allowed speed limit 50 km.h<sup>-1</sup>. The bus driver is seeing pedestrian on the crosswalk and he begins to brake in adequate distance before the crosswalk.

In this moment, motor car driver can not see neither pedestrian, nor vertical sign. He even can not see crosswalk existence (e.g. owing to the bad climate or technical conditions). As far the driver sees breaking of the bus, he can suppose existence of bus stop. In left traffic lane, driver of motor car has no reason for breaking and drive farther.

As far pedestrian begins cross the road in this situation, the crash to motor car is probable. In such a case is impossible to define the guilty detachment. Both users are proceeding acc. traffic regulations.

For described situation simplification, we suppose longitudinal road gradient equal to zero. Pedestrian is ready to enter on crosswalk. The bus driver begins stop before the crosswalk, proportionally to stop sight distance, acc. to Std ČSN 73 6110 ( $D_z = 35$  m). The sight distance is enlarged for 5 m, so that the bus will stop before crosswalk safely (acc. regulations in CZ valid [3]).

The case a.m., rather starting situation is given on Fig.1. The sight beam for bus is broken line. Motor car is at this moment e.g. 65 m from the crosswalk. The car driver does not see neither pedestrian, nor vertical traffic sign. The sight beam for motor car is unbroken line.

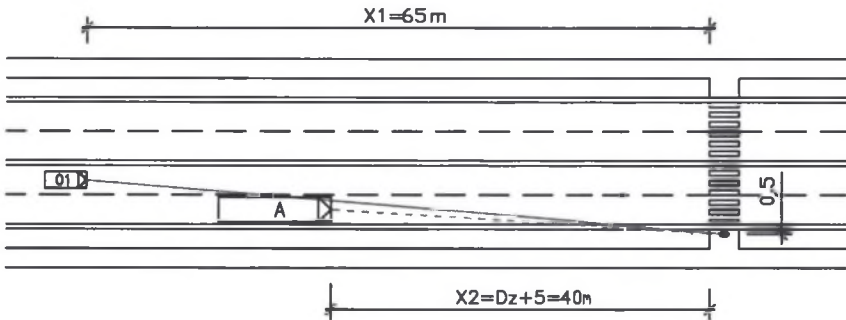


Fig.1. The bus driver in the right traffic lane begins stop before the crosswalk

For situation analyse the a.m., next realities are supposed. Motor car driver will drive in uniform straight motion on speed at maximum  $50 \text{ km.h}^{-1} = 13.889 \text{ m.s}^{-1}$ . After his bad analyse of situation (driver is not guilty), he will pass the drive way in time  $t$ ,  $s_T = v_o \cdot t$ .

Bus driver moves on initial speed  $v_o = 50 \text{ km.h}^{-1} = 13.889 \text{ m.s}^{-1}$ . When he get view of pedestrian, he decides to stop. Motion of vehicle can be determined up to full stop, from calculation of basic sigh stopping distance  $D_z'$  (acc. Std CZ – ČSN 73 6101, appendix B, time of driver reaction for stopping on municipal roads is 1 s).

Sign distance for stopping of bus is sum of distance moved in driver time reaction and breaking distance:

$$s_2 = D_z' = s_2' + s_2'' = 13,889 + 17,557 = 31,446m \quad (1)$$

The application of general physical formulas for steady deceleration motion is transformed the value of average bus deceleration  $a = 5,494 \text{ m/s}^2$ . The necessary time for bus stopping is than  $t = 2,528 \text{ s}$ .

For better understanding is next process divided to detached seconds. Situation of vehicles before the crosswalk is in Tab.2.

Way of vehicle before crosswalk

Table 2

Time $t$ since process beginning (bus stopping before crosswalk)	Distance of motor car		Distance of bus	
	From place of process beginning $s_1 = v_0 t$	From crosswalk $X_1 = 65 - s_1$	From place of process beginning $s_2 = 1,0 \cdot v_0 + \left( v_0 t - \frac{1}{2} a t^2 \right)$	From crosswalk $X_2 = 40 - s_2$
(s)	(m)	(m)	(m)	(m)
0,000	0,000	65,000	0,000	40,000
1,000	13,889	51,111	13,889	26,111
2,000	27,778	37,222	25,031	14,969
3,000	41,667	23,333	30,679	9,321
3,528	49,000	16,000	31,446	8,554

Demonstration of detached part of process before crosswalk is given on Fig. 2 – 4. From figures is evident, the driver of motor car (in left lane), all the time has no chance to see any pedestrian. By this the distance between motor car and crosswalk is only less 3 seconds (beginning of the process) than necessary distance for safely stopping this vehicle (see Fig. 4).

From transport safety reason should not be suitable to carry out crosswalk in situation, when is necessary for pedestrians to cross two lanes of road in one driving direction.

In places, where is impossible the other arrange of crosswalk, such a crosswalk should be controlled by semaphore. Here are two ways of solution. One is classical - the a.m., vehicles breaking when intensity of pedestrians is low. The second one could be application of electronic sensor for monitoring of pedestrian, incoming on crosswalk. (e.g. sheet display above road – „Pedestrian on crosswalk“).

Next possibility, it could be application of the above described safety element – Reflective Eye. This element gives chance for incoming driver to safely enroll crosswalk and adapts his behaviour to this situation (see Fig.7).

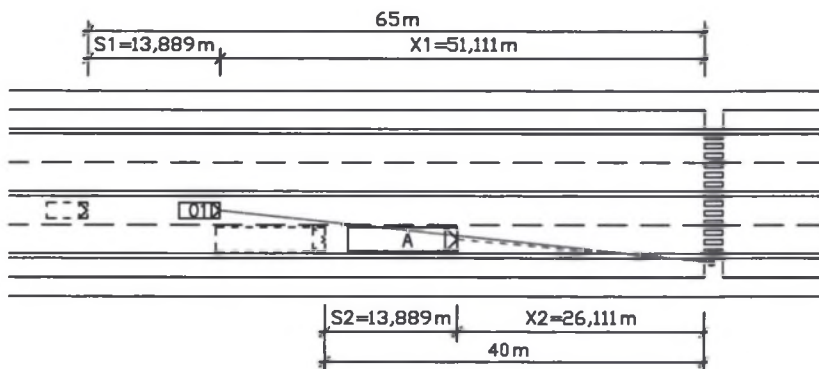


Fig.2. The situation before crosswalk 1 second after the bus stop beginning

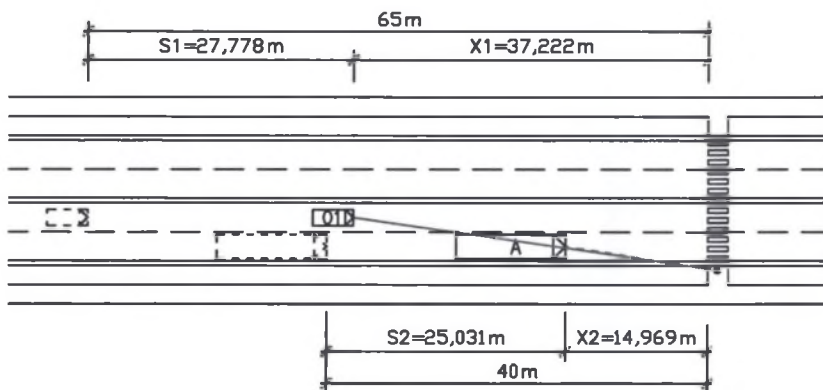


Fig.3. The situation before crosswalk 2 seconds after the bus stop beginning

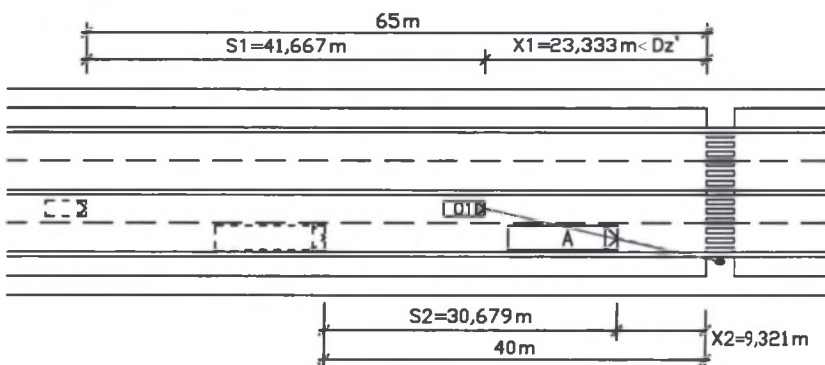


Fig.4. The situation before crosswalk 3 seconds after the bus stop beginning



### 3. APPLICATION OF SAFETY ELEMENT – REFLECTIVE EYE

The actual application on the roads in Czech Republic, on the base of abroad experience, has been recommended „Omnidirectional – Retroreflective Eye for enhance of Road Kerbs” (in Czech – reflective eye). Recommendation for this element is also from French lab LCPC.

Reflective eye is an element which by vehicle lighting gives sharp of lanes bounder, pedestrians island, crosswalk and the other structures. Product is closed glass hemisphere with reflective flats in inner part. This hemisphere is in rubber mantle settled and rubber mantle is in bored hole of road kerb. Product acc. to the results of tests is safety. Element is changeable and installation is very simply at place. Installation could be carry out also in rainy day.

The places with installed reflective eyes are visible from each course and in night and in case of limited vision. Reflective eye needs not any power supply. Energy of exposition is glareless light and not effected to the other drivers of passing vehicles.

Possible spreading of this element could be e.g. side sharpening of crosswalks (namely in cities where are roads with more lanes), circuses, etc. In municipal traffic is also possible to apply this element with power supply on crosswalks.

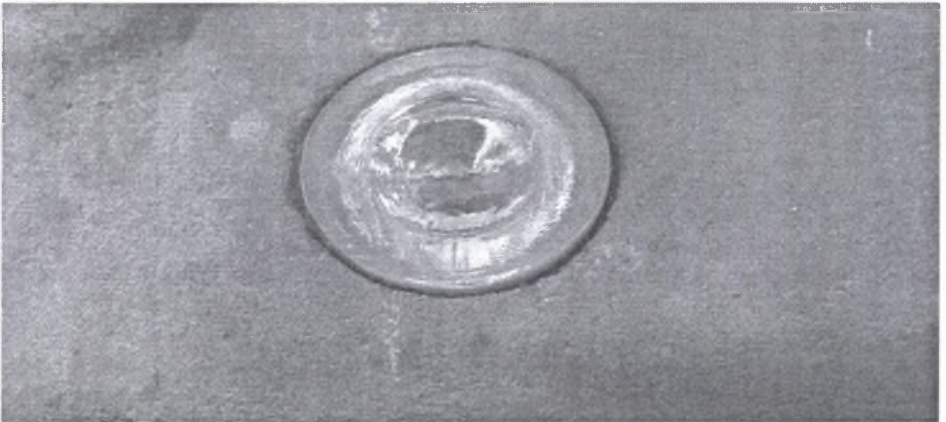


Fig.5. Reflective eye - installed into road kerb

Within tested pilot program of Ministry of Transport Prague – „Snall circuses”, reflective eyes have been installed in :

- Hradec Králové – road I/11 Hradec Králové – Plačice,
- road I/11 Hradec Králové – Kukleny,
- road I/14 Rychnov nad Kněžnou,
- road I/35 a I/16 – Úlibice,
- road I/57 Nový – Jičín, street Jeremenko.

Also installation in :

- outer side of crossing (in circuses – outer bounder),
- central island of circus,
- pedestrian islands.

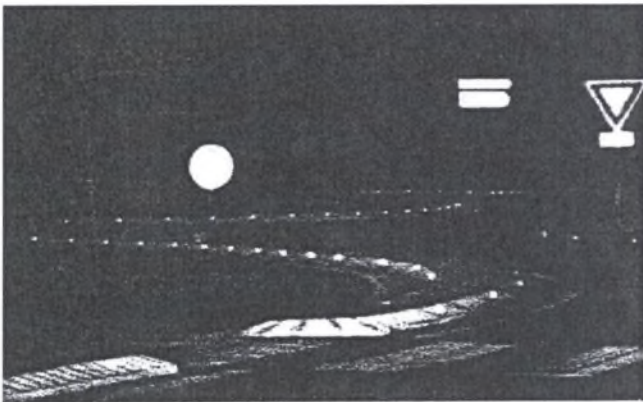


Fig.6. Highlight of communication route



Fig.7. Highlight of crosswalk

The results prove stability and function of the a.m. safety element. A little bit complicated could be function during the winter (snow, higher level of roads keeping up).

From complex rating point of view, visibility of reflective eyes have been tested by motor car Renault Laguna. Measurement has carried out on circus at Nový Jičín (road I/57 and street Jeremenko), 8. 3. 2004 at time 18.00 - 19.45. Visibility –low, owing to the weather – rain and snow, temperature 2° C, windy. Height of car lights 0,65 m, height of driver eye 1,2 m, horizontal length between car lights and driver eye 2,2 m.

Table 3

Visibility distance measurement of reflective eyes from car lights

Length of view m	Retroreflective of eye by dipped lights A/N	Retroreflective of eye by distance lights A/N	Designed speed km/h
30	A	A	40
40	A	A	50
45	A	A	-
55	A	A	60
60	A	A	-
70	A	A	-
75	A	A	70
80	N	A	-
90	N	A	-
100	N	N	80

Reflective eyes are visible from distance 90 m (distance lights) and 75 m (dipped lights), which is acc. to Std. ČSN 73 6101 proportional to the distance of view for vehicle stopping by designed speed 70 km.h<sup>-1</sup>. Their visibility is decreasing to sedimentation of salt, mud, etc. (higher requirements to winter maintenance and spring washing).

Also situation during glare of oncoming vehicles, has been studied. No effect has been found.

#### 4. CONCLUSION

The contribution describes some new safety elements which could be distinguished for increasing of traffic safety mainly in municipal areas. The authors co- operate with Central Traffic Research of Brno in research program BESIDIDO CZ. Program devotes to theoretical and practical problems of traffic in region of northern Moravia. The common plan is decreasing of traffic accidents in Czech Republic.

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