THREATS FOR LIMITATIONS OF VISUAL TRANSMISSION CAUSED BY LACK OF ADAPTATIONS TO EXISTING NEEDS FOR HEAVY TRUCK'S CABIN CONSTRUCTION

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ABSTRACT

In this report are presented results of research concerning widespread and spacing zones around the vehicle (truck categories: N1, N2, N3, i.e. small, medium and heavy) that are visual field of a driver and are bounded by a cabin construction with its equipment. Research method described in UN ECE Regulation No. 46 referring to assessment of provision of visibility by vehicle's mirrors was used in discussed research.

Performed analysis is due to critical situations for tested vehicle. Example analysis was placed on extended intersections with left turn, angular crosscut intersections and on angular railway crossing. A discussed example pointed out that driver has no possibility to observe zones of road, which are crucial for a safe movement of a vehicle. Analysis was performed for vehicles being currently in use and meet current regulations and also more strict regulations, which will be in force due to new European requirements.

For vehicles equipped in accordance to mandatory requirements author pointed out that one of possible direction of decreasing risk of a collision or an accident is to decrease limits in visual transfer of driver – vehicle – surrounding system. It is necessary to consider some modifications of construction and also form of surrounding due to some vehicle and driver constraints.

Regulations compulsory up to now were stringent enough. Complete equipment of vehicles referring to observation possibility were much more lean. Zones that driver can observe in older vehicles are distinctly smaller so threats in older vehicles are much more evident.

This report presents propositions of extending possible observation zones. Also it presents results of investigations for estimation of extended observation zones and of their arrangement after proposed changes in vehicles of different categories. Proposed modifications for in use vehicles and for requirements of vehicle type approval are very basic as a first step.
Keywords: vehicle safety, visibility, proposals.

INTRODUCTION

Although a vehicle meets all requirements referring to visibility, in many cases, not only in the Polish road conditions, a driver has no possibility to take advantage of those car features. Lack of adaptation for surrounding configuration due to limitations of vehicles' cabin construction is a main cause of above mentioned problem.

Advance observation by the driver of some crucial parts of surrounding area is the most important term in case of quick reaction and meeting the possible threats. Factors which affirmatively affect the way of gaining information and which are decisive in case of driver comfort can reduce the level of accident threat.

In some particular roads configuration (e.g. angular crosscut intersections or railway crossings – See Figures 1, 2, 3) possibilities of observing of all area around the vehicle with truck category N1, N2, N3 are not sufficient to undertake proper decisions about continuing the trip safely.

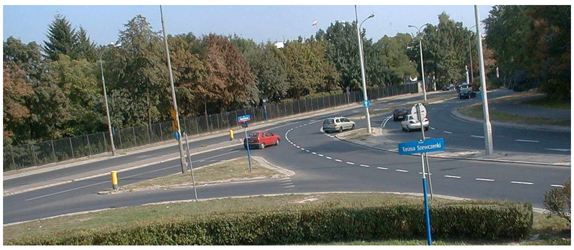


Fig. 1. Situation on the angular intersection with reduced visibility on the right side of the vehicle.

Fig. 2. Commercial vehicle with category N1 at the angular crosscut intersection with tram railways

Fig. 3. Commercial vehicle with category N1 at the angular crosscut intersection with railways

Passenger vehicles are equipped with windows on all sides which gives a driver possibility of observing the whole surrounding of the vehicle. In such condition a driver of the passenger vehicle after turning his head right can observe area through the window in the rear right door and through the rear window. Most of trucks behind the driver's seat have load-carrying space which is not transparent. Mentioned problem causes significant limitation to observation zones. It endangers driver's health due to probable collision effects. The driver in such situation has no possibility to observe surrounding of the vehicle in necessary range.

METHODS

Problem identification was carried out during comparative test of two vehicles: Polonez Caro with M1 category (See Figures 4 and 5) and Polonez Truck with N1 category (See Figures 5 and 6). In discussed problem we assume that front parts of both vehicles towards B pillars are completely the same (taking into account the area of glass surface and arrangement of non-transparent elements). While rear parts beginning from B pillars of those two vehicles are completely different. Assessed vehicles are representation of vehicle categories they belong to.

Fig. 4. Tested passenger vehicle - Polonez Caro

Fig. 5. View from the cabin of passenger vehicle – Polonez Caro

The Polonez Caro has glass surfaces on rear and side walls. The Polonez Truck (See Figure 7) has a barrier behind the first seat row. Behind that barrier is placed non – transparent closed load-carrying body.

Comparison of those two vehicles will allow to identify how large limitation of observing zones is in case of N1 category vehicles.

Fig. 6. Tested commercial vehicle - Polonez Truck

Fig. 7. View from the cabin of commercial vehicle - Polonez Truck

Vehicles of category N2 and N3 (middle and heavy commercial vehicles) also were tested in regard of the arrangement of visible and invisible areas. The vehicle which was chosen as a typical representative regarding vehicles with category N2 is Ford Transit with delivery-van body. The arrangement of all opaque and transparent elements of driver's cabin regarding problem of visibility is typical for vehicles of that category.

Fig. 8. Tested commercial vehicle – Ford Transit

Fig. 9. View from the cabin of commercial vehicle - Ford Transit

The vehicle which was chosen as a typical representative regarding vehicles of category N3 is a truck – VOLVO (See Figures 10 and 11). The arrangement of all opaque and transparent elements of driver's cabin regarding problem of visibility is also typical for vehicles of that category.

Fig. 10. Tested Volvo truck

Fig. 11. View form the cabin of Truck Volvo FH12

All tests referring to observing zones of a driver were conducted in accordance to methods described in Regulation No. 46 and 71 of ECE UN (Economic Commission for Europe of United Nations). Measuring devices used during research met all requirements stated in mentioned regulations [8], [9]. Results of conducted visibility tests are listed below.

RESULTS

Results of conducted test referring all transparent and opaque zones on the level of road surface are presented on Figures 12, 13, 14, 15. Grid lines scale is 1m. Brighter areas on all Figures are transparent zones. Dark areas are invisible. Blue areas present zones which driver can see in rear mirrors.

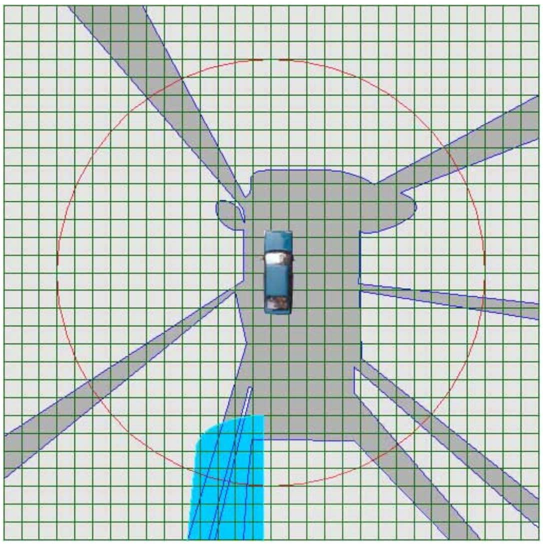


Fig. 12. Measured transparent zones – bright and invisible – dark, on the level of road surface – passenger vehicle Polonez Caro on research circle (diameter 24m)

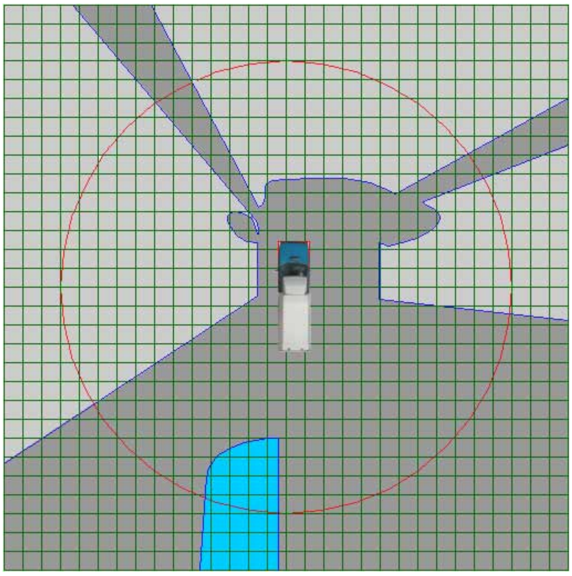


Fig. 13. Measured transparent zones – bright and invisible – dark, on the level of road surface – commercial vehicle Polonez Truck on research circle (diameter 24m)

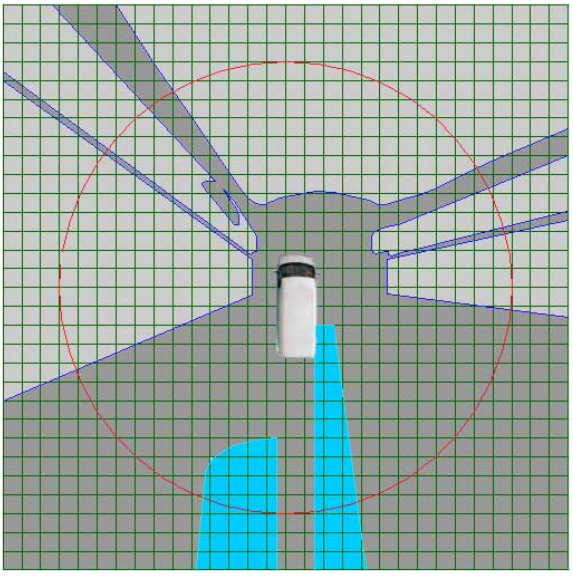


Fig. 14. Measured transparent zones – bright and invisible – dark, on the level of road surface – commercial vehicle Ford Transit on research circle (diameter 24m)

Because of the construction, vehicle limits driver's visibility. There are also road configuration limits and its flap walls (See Figure 16).
Dimensions of visibility field are function of the angle α roads crosscut, distance S between vehicle on a side road and a main road and also angle γ between B pillar and eye-points of vehicle driver, according to (See Figure 17), (analogical angle from left pillar is indicated by β – (See Figure 18).

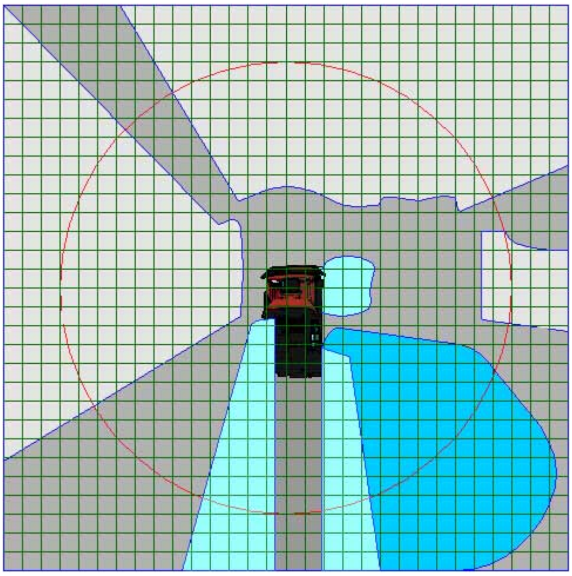


Fig. 15. Measured transparent zones – bright and invisible – dark, on the level of road surface – truck Volvo FH12 on research circle (24m diameter)

Analyzed problem was the influence of variation angle of a cabin right B-pillar, and distance between the car and the intersection and a crosscut intersection angle to length of the observed side main road section on the right side.

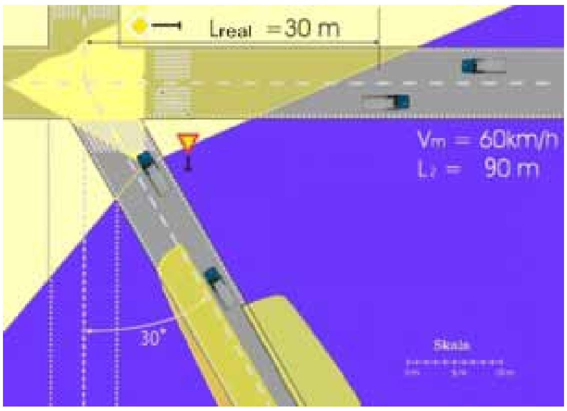


Fig. 16. Situation, stop on the angular intersection - approchement

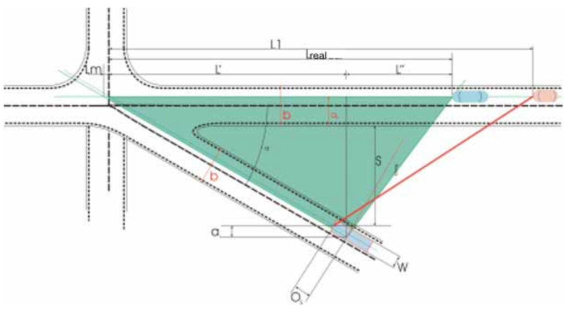


Fig. 17. Area of the real visibility (α = 30°, γ = 7°)

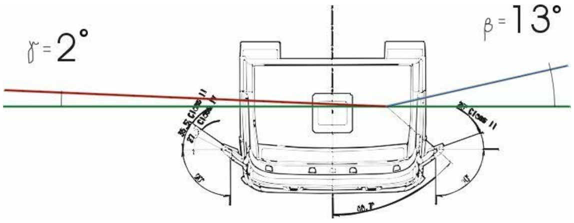


Fig. 18. Characteristic angles of vehicle cabin visibility field

Values, which dimensions knowledge is necessary to point out the range of visibility field are following:

$a = a_1 + a_2$

where $a_1 = \left(o_s + \frac{W}{4 \cdot tg\,\alpha} \right) \cdot \sin\,\alpha$ - distance between eye-points and a tangent crossing by extreme centre point on the front bumper

a_2 *= ¾ b, where b – width of the road*

Vm – flow traffic speed – mean parameter mapping the speed of vehicles on free road traffic, used to determine road elements dimensions value, which on traffic safety consideration should be adjusted to this speed.

L1 – distance measured according to Figure 17, demanded by the traffic regulations while reaching an intersection with a measured speed road.

L2 – distance measured according to Figure 17, demanded by the traffic regulation while start moving to an entry at the intersection with a measured speed road.

$L_{rzecz} = L_{real.} = L' + L'' - L_m$ – real length of visible area from a vehicle, measured like an *L1.*

$L';L'';L_m;$ - values on an intersection screen according to Figure 17.

S – distance between vehicle on a side road and edge of main road,

b – main road width,

α – road's crosscut angle,

W – car width,

Os – distance between eye-points and perpendicular plane, crossing by a front outline of a vehicle,

α Є <25° ÷ 90°> – such range taken, because in situation with obtuse angles, driver does not have any limits from the right and from the left – he can put out his head through a left window. (it is unadvisable – driver switch his sight from a driving course),

S Є <0m ÷ 20m> – maximal distance from the road edge, specified in the traffic regulations,

γ Є <0° ÷ 10°> – such range taken according to testing of trucks category N1, N2, N3

$$L_{rzecz} = \left[S + a_1 + \frac{3}{4} b \right] \cdot \left[ctg\alpha + tg(\alpha + \gamma) \right] - \frac{b}{8 \cdot tg\alpha} \quad (1)$$

Formula (1) describes dependence of real visibility values - $L_{real} = f(s, \alpha, \gamma)$. The results of calculation are illustrated on graphs (See Figures 20, 22).

$$\frac{\partial L_{rzecz.}}{\partial S} = ctg\ \alpha + tg\ (\alpha + \gamma) \quad (2)$$

Formula (2) present sensitivity of visibility L_{real} to variable S describing position of vehicle reaching an intersection with a main road.

$$\frac{\partial L_{rzecz.}}{\partial \alpha} = \left(O_s \cdot \cos\alpha - \frac{1}{4} W \cdot \sin\alpha \right) \cdot \left[ctg\alpha + tg(\alpha + \gamma) \right] + \left(S + O_s \cdot \sin\alpha + \frac{1}{4} W \cdot \cos\alpha + \frac{3}{4} b \right) \cdot \left(-\frac{1}{\sin^2\alpha} + \frac{1}{\cos^2(\alpha + \gamma)} \right) + \frac{1}{8} b \cdot \frac{1}{\sin^2\alpha}$$

(3)

Formula (3) present sensitivity of visibility L_{real} to geometry of intersection (α angle between roads).

$$\frac{\partial L_{rzecz.}}{\partial \gamma} = \left[S + \left(O_s + \frac{W}{4 tg\,\alpha} \right) \cdot \sin\,\alpha + \frac{3}{4} b \right] \cdot \frac{1}{\cos^2(\alpha + \gamma)}$$

(4)

Formula (4) present sensitivity of a visibility L_{real} to geometry of driver's cabin, represented by γ angle.

There is introduced concept of a relative visibility coefficient $(L_{rzecz.} - L_1)/\ L_1$ or $(L_{rzecz.} - L_2)/\ L_2$. The results of calculation are illustrated on graphs (See Figures 21, 23).

The results of sensitivity analysis are illustrated on graphs (See Figures 24, 25, 26).

The driver of a vehicle category N1, N2, N3, in spite of good visibility on the intersection, because of vehicle construction limits, has no chance to take full advantage of provided visibility field.

While reaching an intersection or starting moving on a such intersection (See Figure 19), driver instinctively becomes participant of "risk": he may cross an intersection or he will have an accident.

There are not predicted certain elements of safety system (concerning visibility), indispensable in extreme situations. Although driver satisfies the conditions, vehicle is authorized to traffic, road is according to traffic regulation – driver does not see enough for safe continuation of his ride.

Fig. 19. Situation on extended intersection with a turn to the left and visibility limited by cabin.

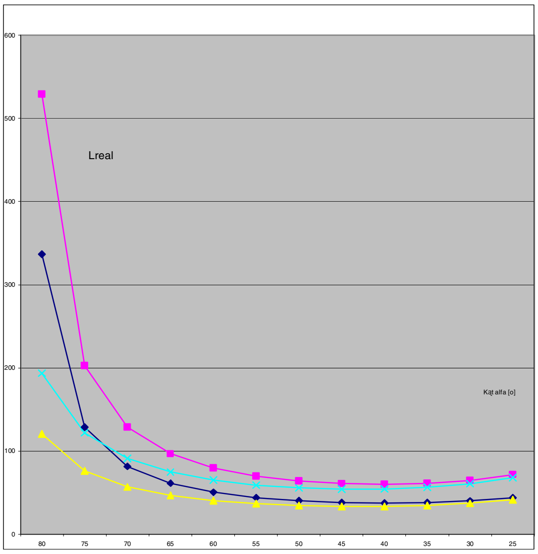


Fig. 20. Real visibility Lreal in function of alfa angle of roads crosscut – approaching, L1 = 120m, Vm = 60 km/h

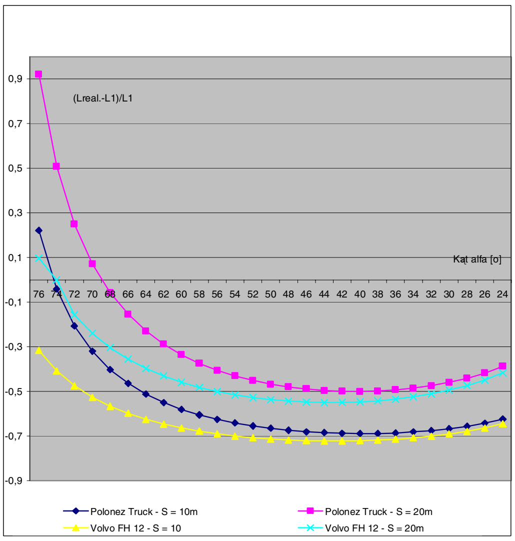


Fig. 21. Relative visibility coefficient (Lreal.-L1)/L1 in function of alfa angle of roads crosscut on intersection – approaching, L1 = 120m; Vm = 60km/h.

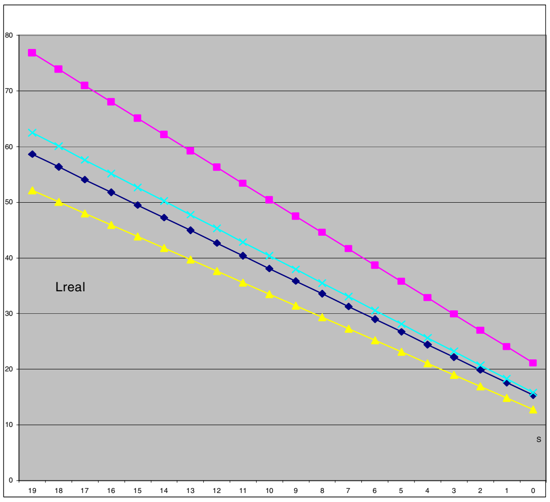


Fig.22. Real visibility on intersection Lreal in function of distance S from road edge – stop, L2 = 90m, Vm = 60km/h.

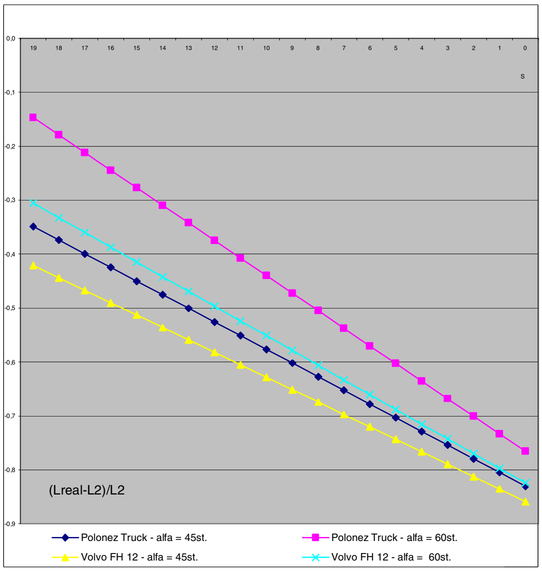
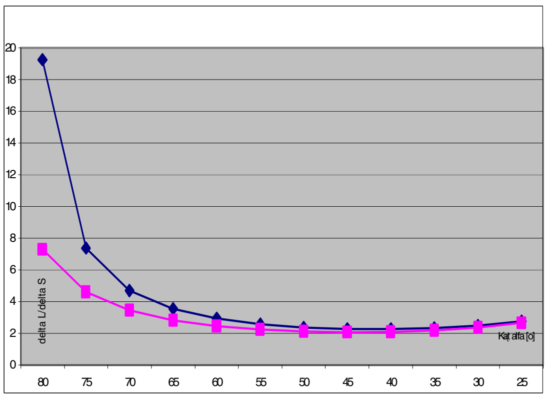


Fig. 23. Relative visibility coefficient on intersection (Lreal-L2)/L2 in function of distance S from road edge – stop, L2 = 90m, Vm = 60km/h.



Rys. 24. Sensitivity of visibility (delta Lreal/delta S) in function of alfa angle

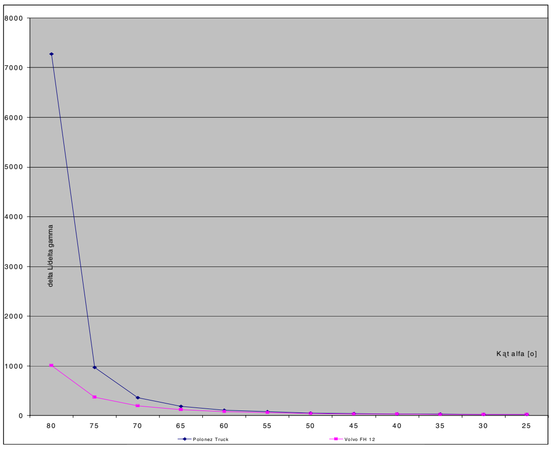


Fig. 25. Sensitivity of visibility (delta Lreal/delta gama) in function of alfa angle.

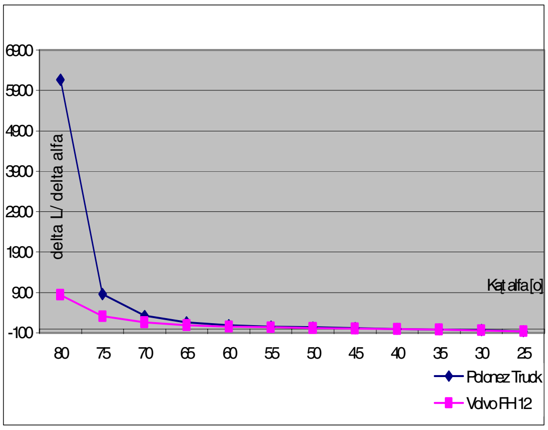


Fig. 26. Sensitivity of visibility (del Lreal/delta del. alfa) in function of alfa angle.

On the Figure 27 is illustrated simulation of real situation of truck on angular railway crossing. Light areas – visible to car driver. Dark areas – invisible. There are areas visible through car mirrors indicated by dark blue colour. Train is in invisible to car driver area.

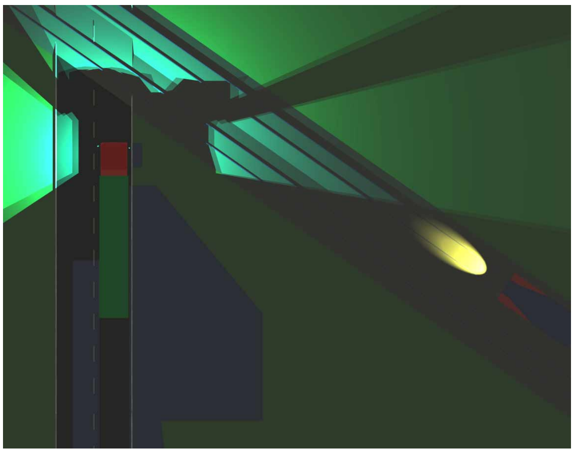


Fig. 27. Schema of the situation before accident.

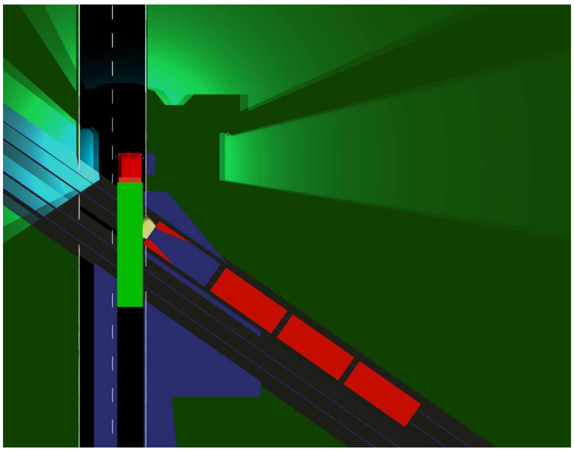


Fig. 28. Schema of the situation where truck is hit by train.

On the Figure 28 is illustrated moment of hit the truck by the train.
On the Figures 29 and 30 are illustrated damages of participants in accident: truck and train.

Fig. 29. Truck after accident.

Fig. 30. Train after accident.

DISCUSSION

From illustrated on the Figures 20 and 22 graphs follow that group of vehicles belonged to category N1, N2, and N3; in compare to passenger car has a large visibility limit, especially on the right side of vehicle. This characteristic is not noticed by traffic regulations authors.

Fig. 31. Extra spherical mirror in vehicle cabin

From obligatory regulations it is seemed that a such projected road does not cause formation of threat. Taking into consideration mentioned matters, projecting and existence of legal angular intersections (without additional elements of safety system) is the reason for accidents.

This consideration about safety of road traffic participants in aspect of visibility from vehicle driver's seat authorize to formulate the following observations and conclusions:

– problems of visibility from vehicle, although noticeable increase of meaning and still increasing formal – regulatory requirements, are still distant from solutions assuring liquidation of road traffic participants threats,
– Polish law standards concerning visibility matters require complex analysis and modification,
– deficiency of regulations follow mainly from lack of its complex treatment in the system Driver-Vehicle – Environment,
– visibility aspects do not have good lay out and are marginal treated in automobile literature.

Fig. 32. Mirror on a road of limited visibility

To help driver I propose to upply extra spherical mirror fixed in cabin on column A.
It allows to observe zone invisible up to now (See Figure 31).

Additionally is recommended to use large spherical mirrors on these intersections (See Figure 32), which enable observation of vehicle surrounding zones, which truck driver does not have possibility to observe without internal mirror.

CONCLUSION AND RECOMMENDATIONS

Indicated problems permit to understand the scale of projects with objective of road traffic safety system improvement. Significant part of these projects may provide meaningful effects – decrease of inhabitants threat and serious accidents indicators.

1. It is important to change urgently requirements of official certification regulations concerning vehicles construction and equipment in objective to assure driver enough visibility from a vehicle on angular intersections.

2. It is urgent to change regulations concerning necessary conditions of assurance of safety on angular intersections taking into account vehicles construction limits.

3. Analysis of sensitivity of real visibility on main road function demonstrate that aberration of α roads crosscut angle from right angle, cause a big variation of length of visible main road section $L_{real.}$ Sensitivity in the angle $\alpha < 75°$ is already not big, but in this case real visibility is distinctly less than required by regulations.
From above follows that α roads crosscut angle, absolutely should not be smaller than 75°.

4. It is appropriate to modify situation on angular intersections already existing with the purpose of eliminate possible threats of road traffic participants, for example by provide intersections with extra installations ensuring standard visibility from vehicles of different categories.

5. It is necessary to equip trucks with extra spherical mirrors located in a cabin, facilitating to driver environment observation.

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