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Legislation and road safety

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ABSTRACT
Traffic accident statistics point out that the most dangerous fault of drivers is the fact of not adapting the speed of their vehicles. Many of them often do not realize the fact that it is necessary to comply with the allowed speed not only for their own travel safety but also because of other road users ability to respond to them. In this case the driving speed is an essential assumption to handle a situation not only in a populated urban area but also on the open road. The quality and condition of the road surface has a significant impact on the driving safety. Drivers are often unaware of the fact that with increasing speed also their kinetic energy increases, which is converted into braking heat then and the braking distance of their vehicles gets longer. The text provides some model situations of these effects.

KEYWORDS: traffic accident, driving safety, reaction time, vehicle, safe distance, legislation

1. Introduction

Any restriction in the legislation is supported by the physics and its goal is not to make the driver´s life difficult, but mainly to reduce the risk of accident and of the associated consequences.

1.1 Driving speed

Most drivers consider the reduction of speed from 60 km/h to 50 km/h as a special kind of injustice which slows their movement and causes the loss of their time. This negligible loss of time is balanced by increasing road safety. If the vehicle captures pedestrian at speeds of 60 km/h, the probability that the pedestrian will be as a result killed is about 75%. This probability drops to 40% by the reduction of the crash velocity to 50 km/h. Drivers or pedestrians are unaware of crash energy, which must be absorbed by their bodies during the collision. More comprehensible is the recalculation of crash kinetic energy to the potencial´s energy. If the vehicle captures pedestrian at speeds of 60 km/h, this collision has the same devastating potential as a fall from a height of 14,2 m. If the crash velocity is reduced to 50 km/h, it is an equivalent to a fall from a height of 9,8 m. The driver mostly brakes before collision, thus he is able to reduce the speed to 40 km/h. In this case, the fall from a height of 6,3 m would be an equivalent to the crash. It is significantly less, but a reasonable person should not risk or a fall from this height. Even crashes in much lower speeds are a source of potential serious danger to pedestrians. Fig. 1 is obtained from cameras which are monitoring the traffic in the USA.

Fig. 1 . The vehicle catches the pedestrian

This figure shows the situation of pedestrian after he was caught by the vehicle. The vehicle was moved relatively slowly, only by 16.7 km/h, but the view of pedestrian was probably different. This is because the crash energy increases with the square of the speed. But this is only one of the reasons why it is necessary to respect the speed limit when driving in village. The speed limit in the village is not only because of the crash energy. The reason is also to ensure that the road users will be able to react on a moving vehicle. An example might be an older man who wants to cross the road. Older people are not movable as young people, they see and hear much worse. It can be supposed that a grandmother showed on fig. 2, is able to move at a speed of 1 m / s.

Fig.2. **Pedestrian crossing road**

If she wants to cross the road with width of 10 meters, it will take her 10 seconds. One more second to look to the left and right side should be added to this time. If such a person decides to cross the road, he has worry to the whole movement. Such person is no longer able to control the situation on the road and the change of speed of its movement is not possible at all. The distance vision varies with the speed of incoming vehicles. The table 1 shows how the necessary view is changing according to the speed of oncoming vehicles.

Table 1. The outlook distance of pedestrian which is moving at a speed of 1 m / s, when crossing the street with width of 10 m, in dependence on the speed of incoming vehicle

The speed of incoming vehicle [km/h]	The outlook distance of pedestrian [m]		
	Left side	Right side	Total
50	153	153	306
60	183	183	366
70	214	214	428
80	244	244	488
90	275	275	550

It is obvious, that not every pedestrian is able to see on distance of 153 m if the vehicle goes by speed of 50km/h. Pedestrian even doesn´t see on distance of 275 m if the vehicle goes by speed of 90 km/h. The driver is relative safe during the collision with pedestrian because the weight of vehicle is in disproportion with weight of pedestrians. However, the situation changes if the vehicle crashes with a fixed barrier, or collides with an oncoming vehicle. If vehicles have the same weight, their speeds are averaged and each of them has to absorb the same energy. In case that one of them had a speed of 50 km/h and the second one had a speed of 30 km/h, the average speed is 40 km/h. Every object tends to maintain its state of motion, i. e. it tries to move by original speed toward the original direction, as long as any power will not stimulate to change its state of motion. The vehicle stops on the deformation track front of the vehicle after the crash. Unbelted transported people and things are moving further and hit the dashboard at the original speed. The idea that the passenger is able to resist the crash by simple force of his hands is naive. If the vehicle´s deformation zone is 0,5 m, the vehicle slows on this distance from crash velocity. The passengers of vehicle must suffer the slowdown of 123,5 m/s^2. It means that the driver, but also passanger or carried object multiplies its weight 12,6 times. If the safety seat belt should hold the motion of body weighing 100 kg, the force which acts on it is similar if it held the weight of 1260 kg. Between the seat belt and the body of a passenger shall not be a space. This space could cause that the body will crashes the seat belt with particular speed. Consequently it could cause an injury of passanger and the break of seat belt. Then the seat belt would failed to fulfill its mission. A frequent mistake is to claim that if there are airbags in the vehicle, the seat belts are unnecessary. The role of a safety belt is to hold the body of the passenger, in order to avoid its approximation to the dashboard and than provide important time and space to the expansion of the airbag. The airbag extends by the speed of 200 km/h. The movement of unbelted passanger is opposite what could mean the serious injury or death of such unbelted passanger.For comparison, the boxer knocks his rival in the ring with speed of 40 km/h. The speed of drive also raises a formation of so called tunnel vision (fig. 3).

Fig.3. The impact of vehicle´s speed to the creation of pedestrian´s tunnel vision [4]

A person is able to perceive the environment in wide angle, but the details can recognize only in a narrow angle. This angle of sharp vision is even narrower with the increase of driving speed. Figure 3 shows this effect. We can see exactly the change of view in dependence of change in perception of details needed for correct decision-making and reaction of responsible driver. At a speed of 90 km/h, the driver almost does not recognize that he is coming to the crossroads nor a pedestrian walking on the left side of the road. Also this fact has an influence to the speed reduction in the village from 60 to 50 km/h

1.2 Distance for vehicle stopping

If the unexpected barrier or another serious reason to brake appears in front of the vehicle, the vehicle will not stop immediately, but on the distance entitled the distance for vehicle stopping. This distance consists of a distance passed by the vehicle during the driver´s reaction and of a braking distance. The stopping distance incorporates the distance passed by the vehicle during the delay of braking (vehicle is moving at an unchanged) speed), the distance passed during the braking deceleration (vehicle deceleration increases from zero up to a mean fully developed deceleration) and simple braking distance. The distance of braking delay and rise of braking deceleration depends on the construction of brakes and their technical condition. The distance of effective braking depends on the speed and the road surface conditions (dust, snow, ice, texture, material).

Fig. 4 shows the action which must happen in the brain of the driver while he makes decision about braking the car.

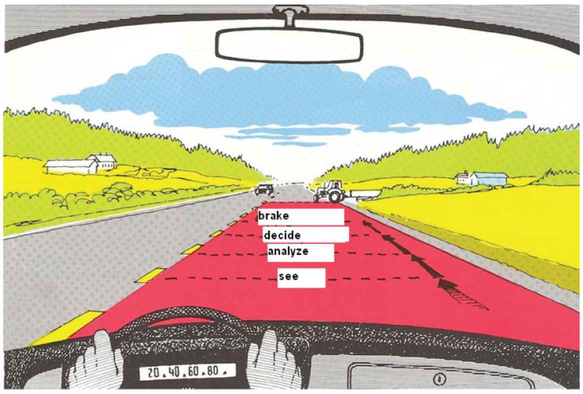

Fig.4. Pedestrian crossing road [own work]

During this decision-making process the car is being moved with the original speed and direction. Time that is necesary for making decision is depented on the state and the concentration of the driver. The concrete information about the reaction time of the driver and the lane he passes with the car during this time with the speed 90 km/h are shown in the table 2.

Table 2. The lane that the car passes wit the speed 90 km/h during the reaction of the driver [own work]

The state of driver	The average time of the reaction [s]	The lane the car passes [m]
attentive, concentrated, he expects the signal	0,65	16,25
attentive, but he doesn´t expect the signal	0.8	20
he concentrates his attention to others activities that is related to driving (gear change, forego, observation of the side roads)	1.1	27,5
not attentive, he talks with his fellow-travellers	1.6	40
indisposed because of tiredness or illnes, he is drunk	2,0	50

The difference in the lane that is passed by car, which is driven by concentrated or indisposed driver is 33,75 m. Let´s assume, that the car from time, when the driver touch the controller of brake until the time when he stop he will move with the full average centred braking deceleration about 7,5 m/s^2 . If the driver in the first case is able to stop in front of the barrier closely, in the second case he will crash to the barrier with the speed 81 km/h. If the barrier is a pedestrian, it will have the same result as the fall from the height 25,8 metre. The driver very often underestimate the fact that they have cold. While in some countries people don´t go out without the protective guise on their face, in Slovakia nobody cares about it either during driving. Although to sneeze means that people close their eyes subconsciously and for about 1 second he doesn´t perceive the surroundings. Next he is situated in the role of the driver, who was speaking with his fellow-travellers and then he has to get back his view about the surroundings. This means that his car is moved 2,6 seconds without the corection of the speed and direction. With the speed 90 km/h it means the lane 65 metres. If we use the previous example, the driver won´t realize that he must brake and he crash to the barrier – pedestrian with the unchanged speed 90 km/h. The statistics show, that if the car hits the pedestrian with the speed 80 km/h the posibility that the pedestrian will die is closed to one. Very often the lorry drivers have the idea that their cars have higher number of tyres than car so it means that they can better brake. However they must know that not every car is able to brake with the same intensity. If on the same surface and with the same speed (80km/h) the lorry and car brake, the lorry will have longer braking distance (12 metres). If full centred braking deceleration 7,5 m/s^2 , it means, that while the first car stops before the barrier, then the second one crashes to the barrier with the speed 48 km/h.

Table 3 shows the effect that has the influence on the speed of the ride to the stop of the car

Table 3. The speed of the ride and the lane that is need for braking the car [own work]

The speed of ride [km/h]	The lane during the reaction of the driver [m]	The braking lane of the car [m]	The speed of crash [km/h]	The equivalent of the fall from the height [m]
20	5,6	2,1	-	-
30	8,3	4,6	-	-
40	11,1	8,2	-	-
50	13,9	12,9	-	-
60	16,7	18,5	39,9	6,3
70	19,4	25,2	58,6	13,5
80	22,2	32,9	74,0	21,5
90	25,0	41,7	87,8	30,3
100	27,8	51,4	100,0	39,3

Let´s assume, that in front of the driver the barrier will appear in the distance of 27 metres, the car is in the perfect technical condition and it´s able to slow down with the full centred braking deceleration 7,5 m/s^2. The driver´s reactional time will be 1 second. For the demonstration the last column shows the height of the fall for the energetic equivalent of the crashed energy. While the driver that drives with the speed 50 km/h is able to stop in front of the barrier, the driver who drives with the speed 60 km/h crashed to the barrier with the speed 39,9 km/h. Another important fact is related to the speed. If the car wants to slow down e.g. about 20 km/h, with the same deceleration it will pass different distance. The table 4 shows this information relatively clearly.

Table 4. The lane that is need for the change of speed with of 20 km/h during the slowing down 7,5 m/ s2 [own work]

Slowing down		The passed distance
from speed	**to speed**	
100 km/h	80 km/h	18,5 m
80 km/h	60 km/h	14,4 m
60 km/h	40 km/h	10,3 m
40 km/h	20 km/h	6,2 m
20 km/h	0 km/h	2,1 m

The deceleration of the car is not constantly like we considered in the table 4, but it differs with the speed and on the wet surfance it changes very strongly with the depth of the groove of the tyre profile. The change of adhesion which is consider to be the „synonym" of the braking deceleration of the car is shown in the figure 5.

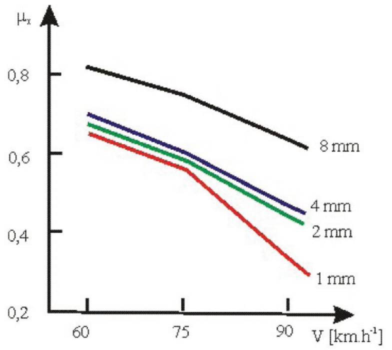

Fig. 5. The change of the adhesion of the wheel on the wet surfance in dependence of the depth of the tyre profile and the speed of driving [5]

So the difference in the lane that is need for braking is more distinct on the wet surfance. With the new tyre (8 mm) the decrease of ability to brake in dependence from spped is about 10 %, the tyre with the groove of the tyre profile 2 mm will lost about 30 % and 1 mm of tyre profile means the decrease of more than 50 %. What is more, it is possible to see the breakage in the ability to transfer the force with the speed 75 km/h. These are the reasons why is the minimum groove of the tire profile of the summer tyre determined to 1,6 mm.

2. Conclusion

In this article we would like to highlight the need to address road safety and possible solutions have to be found in a wide range of circumstances that may affect road safety.We wanted to highlight the fact that the legislation related to road safety is fully justified and should help to meet the 2020 target to reduce the number of fatalities on the roads to the half of the number from 2010. Therefore, from the point of view of traffic safety we should not neglect any of these factors.

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Bibliography

[1] ONDRUŠ, J.: Faktory vplývajúce na bezpečnosť v cestnej premávke, In: Transport 2011 – Bezpečnosť cestnej premávky, pp. 80-88. ISBN 978-80-554-0439-4. (2011)

[2] CABAN J., VRÁBEL J., DROŹDZIEL P.: Stan bezpieczeństwa transportu drogowego w Polsce i na Slowacji w porównaniu z innymi krajami UE, In: Autobusy; Technika, eksploatacja, systemy transportowe. pp. 1129-1138. ISSN 1509-5878. (2013)

[3] KALAŠOVÁ, A., ČERNICKÝ Ľ., HAMAR M.: A new approach to road safety in Slovakia, In J. Mikulski (Ed.): TST 2012, CCIS vol. 329, pp. 277–290, Springer, Heidelberg (2012)

[4] Brezník at all: Dober voznikom bom Univerzitetna knjižnica Maribor 2010, ISBN 978-961-91400-7-9

[5] http://continental.com (date of access: July 02, 2013)