160 km/h on the Highway

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Abstract The speed limit on the highways of Slovak Republic is 130 km/h. It is recently considered the increase of this speed on some sections to the 1600 km/h. However this increase brings with it a substantial negative impacts. On the basis of its evaluation appears to increase this speed to 160 km/h as inappropriate

Keywords Speed limit, highway, car accident, consumption, braking distance

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1. Introduction

The legislation allows in Slovak Republic the following speeds limits unless local treatment by traffic signs provide otherwise: 50 km/h in town, 90 km/h outside of town and 130 km/h on expressways and highways. It raises recently the question about the increase of the speed limit on certain sections to 160 km/h. It occurs in discussion the opinions that agree or disagree with this increase of speed limit. This problem can be viewed from multiple angles.

One of the basic arguments to increase the maximum speed is saving time. We compare the saving time for section Zilina – Bratislava in the length of 200 km. On this journey is on the section Trnava – Bratislava the running speed limited to 110 km/h, 50 km in length. Assume that the traffic volume is so small that the vehicle could go through the whole section at a constant speed and provided that the area is not restricted measures such as road works, the reduced number of lanes, etc. The vehicle running speed of 130 km/h needs to overcome this section the time of 1 hour 36 minutes and 30 seconds. At a speed of 160 km/h vehicle overcomes this section for 1 hour 23 minutes and 31 second. In the aim would be about 12 minutes and 59 seconds before. This time saving of one vehicle will bring also some negative.

2. Quality of Traffic

The most sections of highways in Slovakia is built as a two-lane and a cars on the straight section must drive at least the speed of 80 km/h and trucks over the 3500 kg and vehicle combinations have a limited maximum speed to 90 km/h. For the slow moving vehicles is added a third lane. Permissible intensity of traffic on dual belt without speed limits according STN 73 6101 is shown in table 1.

Table 1. Permissible intensity of traffic on dual belt without speed limits [1]

The quality level	Permitted traffic intensity outside of the village on the direction of three – lane road [vehicle/h/direction]			Permitted traffic intensity outside of the village on the direction of dual-lane road [vehicle/h/direction]		
	Ratio of trucks [%]			Ratio of cars [%]		
	0	10	20	0	10	20
A	1620	1530	1440	1080	1050	1020
B	2970	2805	2640	1980	1925	1870
C	4050	3825	3600	2700	2625	2550
D	4860	4590	4320	3240	3150	3060
E	5400	5100	4800	3600	3500	3400
F	-	-	-	-	-	-

The same standard classes level of the quality service.

Level A: Free movement of traffic low within compliance its free speed. Vehicles are not limited in its movements inside of the traffic low. Road users are very rarely affected by other participants. The gap between the vehicles is length up to 26 vehicle (about 160 m).

Level B: The movement of the traffic flow and ability to maneuver is within the traffic flow slightly reduced. The need to adapt the speed is barely noticeable.

Level C: Maneuvering of the vehicles is severely limited, changing of lanes require the increased attention of the driver. Smaller incidents in the traffic flow will resolves themselves in the partial local deterioration of movement.

Level D: Free movement speed begins to fall. Freedom to maneuver within the traffic flow is significantly reduced. All participants of traffic must bear the transport constraints because in almost every lane changes the conflict situation.

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Level E: The traffic flow moves on the capacity. It is not able disperse and maneuverability of the vehicles is quite limited. Vehicles moving at low speed, mainly in the columns. Each change of speed causes the disturbance spreading the movement of vehicles.

Level F: It is characterized by degradation of traffic flow of vehicles, such as in a car accident. The number of passing vehicles is greater than that can pass through the monitored segment.

The latest counting of traffic on the ground of the Slovak Republic took place in 2010. To determine the intensity of traffic on the highway D1 we selected counting section 87090 in Nové Mesto nad Váhom and section 87020 at Senec. Intensity of traffic shows the Table 2.

Table 2. Intensity of traffic of census 2010 [2]

Section	87020 Senec	87090 Nové Mesto nad Váhom	87120 Trenčín
Number of lanes	3	2	2
Trucks	9 267	8 592	10 115
Ratio [%]	18,38	38,91	32,72
Cars	41 114	22 081	20 797
Motorcycles	51	0	0
Together	50 432	30 673	30 912
Development index [3]	1,116		
View to year 2015	56 282	34 231	34 497
Real cars./ hour/ direction	2 345	1 426	1 437

Comparing the data in the table 2 and 1, we find that the quality of traffic is at the level of B and we can assume that at peak hours reached a level C, while the assessment is for speed 110, respectively 130 km/h. Increase in speed would lead to the deterioration the quality of the traffic and the vehicle traveling speed 160 km/h would be forced to frequently change direction and speed of its drive.

3. Consumption of the Vehicle

The road transport is one of the main emitters of greenhouse gases. The main representative is carbon dioxide CO_2. When it burns a litre of gasoline is released into the atmosphere 2.5 kg of CO_2. Not quite the last indicator is the economy. One litre of the diesel costs 1.13 €. For the comparison, we use a car with weight 1320 kg with a transmission efficiency of 91%, the size of the frontal area of 2.1 m^2, coefficient of aerodynamic drag 0.3 and coefficient of rolling resistance f = 0.011. Engine efficiency is 35 % and heat of combustion of the fuel is 42 040 kJ and density of the fuel is 0.75 kg/m^3. Comparison of the consumption shows the Table 3. We will assume again that the driver is not restricted. The efficiency of the engine remains unchanged. The consumption resulting from the sum of rolling resistance and air resistance.

3.1. Air Resistance

Unless the vehicle is moving, always is present the air resistance. Its size can be determined using the following equation:

$$O_v = \frac{1}{2} \cdot \rho \cdot v^2 \cdot c_x \cdot S \qquad (1)$$

Where,
v – a speed of the vehicle [m/s],
c_x – coefficient of air resistance [-],
S – the size of the frontal area [m^2],
ρ – instantaneous air density [kg/m^3]. Providing immediate air density corresponding to the particular conditions we can calculate using the following equation:

$$\rho = \rho_n \cdot \frac{273}{273 + t} \cdot \frac{p}{p_n} \qquad (2)$$

Where,
ρ_n - air density at the temperature 0°C and pressure 0.101325 MPa. Under these conditions achieves the value 1.29 kg/m^3,
t - the actual temperature of the air [°C],
p - the actual pressure of the air [MPa],
p_n - the normal pressure of the air [0.101325 MPa].
This indicates that the size of the air resistance changes proportionally with the speed of the travel and the pressure and inversely with the temperature.

3.2. Rolling Resistance

It is the second driving resistance which is always present as long as the vehicle is moving. The size can be determined using the following equation:

$$O_f = f \cdot m \cdot g \cdot \cos\alpha \qquad (3)$$

Where,
m – the weight of the vehicle [kg],
g – the acceleration due to gravity [9,81 m/s^{-2}],
α – the angle of runner plane [°],
f – the coefficient of rolling resistance [-]. It varies with the speed using the equation:

$$f_v = f \cdot \left[1 + 0{,}0065 \cdot (V - 80)\right] \qquad (4)$$

Where,
f_v - the coefficient of rolling resistance for calculated speed,
f - the basic coefficient of rolling resistance,
V – the calculated speed [km/h].

Table 3. The vehicle consumption and emissions

Section	Trnava - Bratislava	Žilina - Bratislava	Žilina - Bratislava
Speed [km/h]	110	130	160
Length [km]	50	150	150
Air resistance [N]	381	532	806
Rolling resistance [N]	170	189	217
Consumption [litre]	2.77	10.89	15.45
Price [€]	3.134	12.305	17.459
Produced CO2 [kg]	6.935	27.223	38.625

Such ease of comparison it can be shown that the increase on speed limit can caused increasing costs to consumption of 5.145 € and it will produce about 11.02 kg of CO_2 over at a speed of 130 km/h. The difference would be ever higher in the practice because the vehicle travelling speed of 160 km/h, in view to traffic situation, it had to brake repeatedly and accelerate again.

4. Connecting the Combinations of the Vehicle

Motorways in Slovakia are constructed as two-lane and under the legislation outside village is the driver required to drive in the right lane, unless it does not prevent the obstruction or traffic congestion. It means that the vehicles driving with the speed 160 km/h could drive in the right lane. To the continuous lane want include also the vehicles from the connecting strips from petrol stations, car parks or roads of lower classes and of course trucks and road trains. It needs to increase its speed in the connection traffic lane and its maximum speed is 90 km/h. According the tests carried out by the magazine Trucker 40 toned combination with the trailer Mercedes Actros 1842 needs to accelerate from speed of 60 km/h to 85 km/h the time 28.9 seconds. During this time passing combination of about 400 m, while the vehicle approaching at a speed of 160 km/h will pass 1270m. Don't limit the vehicle, the driver of the vehicle combination would have to monitor the situation behind the vehicle at a distance of 870m and it is impossible using thought mirrors.

5. Overtaking

Legislation commands slowly riding driver to give way to faster vehicles reassignment to the right lane. Vehicles able to run at a higher speed result in a range of vehicles run at a speed of 90 km/h. When vehicles want to continue in driving at a higher speed they would have to increase its speed. A vehicle with an engine power of 125 kW would increase the speed to 110 km/h took six seconds and to 130 km/h 10 seconds. It does not become an obstacle to sudden vehicle running at a speed of 160 km/h, the driver of vehicle would have to keep overview on the road at the distance of 267m, respectively 444 m. On the motorways is also moving the vehicles with less powerful engines and buses which also have the opportunity to overtake slower cars. Clearly, any such maneuver is associated with risk.

6. Braking Distance

According to valid legislation the driver may only drive at a speed that was able to stop the vehicle on the distance to which he has sight. In this area occurs a significant shift. The tires ability to transmit power varies with speed, see Fig 1, where μ_p superior adhesion of tires and μ_s is adhesion of tires at 100 % slip. Based on the achieved parameters of the adhesion of tires on asphalt, while simplyfying, at speed above 100 km/h will not fall the adhesion of tire, we can compare the braking distance of the vehicles. At a speed of 130 km/h will the braking distance of vehicle 88,61 m and from the speed 160 km/h will increase the braking distance of vehicle at 141.25 m, what is 1.594 times. If we made this comparison for loved wheels, the braking distance of vehicle from the speed 130 km/h would be 144.47 m, but from a speed of 160 km/h will be up to 300m, which is 2.077 times. Comparison of braking distance spee aks a clear language.

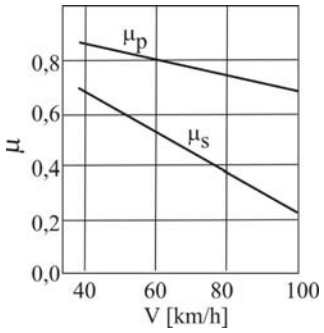

Figure 1. Change of the tire adhesion on the asphalt surface [5]

Compare the required braking distances of vehicles in the event, that the driver of bus would make a mistake and he will rank in front of oncoming vehicles. Buses are allowed to drive a speed of 100 km/h. We must also consider with the reaction of the driver 1 second. To slow down the speed of 130 km/h the vehicle needs the distance 77.08 meters, from a speed 160 km/h this distance to 138.83 meters. As to the driving speed on the highway accessing EU countries is evident from the table 4.

Table 4. Speed limits in km/h [6]

State	Build up area	Outside build up area	Motorway
Belgium	30 - 50	90 - 120	120
Bulgaria	50	90	130

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Czech	50	90	130
Denmark	50	80	130
Germany	50	100	(130)
Estonia	50	90 - 110	-
Ireland	50	80 - 110	120
Greece	50	90 - 110	130
Spain	50	90 - 110	120
French	50	80 - 110	110 – 130
Croatia	50	90 - 110	130
Italy	50	90 - 110	130
Cyprus	50	80	100
Latvia	50	90	110
Lithuania	50	70 - 90	110 – 130
Luxemburg	50	90	110 – 130
Hungary	50	90 - 110	130
Malta	50	80	-
Holland	50	80 - 100	130
Austria	50	100	130
Poland	50 - 60	90 - 120	140
Portugal	50	90 - 100	120
Romania	50	90 - 100	130
Slovenia	30 - 50	90 - 100	130
Slovakia	50	90	130
Finland	40 - 50	80 - 100	100 – 120
Sweden	50	70	110
Great Britain	32 - 48	96 - 112	112

Notes: GB, IE, CY a MT traffic drives on the left of road. It drives in others member states on the right side (Sweden from 3.9. 1967). The values in the GB are given in miles per hour. The table refers in the column "outside build-up area" speed limit on dual carriageway, which is not motorway.

Speed limits:
GE: Motorways: No general speed limit, recommended speed limit is 130 km/h (More than half of the road network has a maximum speed of 120 km/h or less).
FR: Dual carriageway 110 km/h. If the path is wet: highway 110 km/h, dual carriageway 90 km/h, in other un-build area 80 km/h.
IT: 150 km/h on certain motorway 2x3 if the operator so requests.
FI: In winter 100 km/h on motorways, 80 km/h on other roads.
PL: Build-up areas: 50 km/h from 05 hour to 23 hour, 60 km/h from 23 hour to 05 hour.

7. Conclusions

From previous results is apparent that allow the running speed 160 km/h on the roads of Slovakia is inappropriate thought. It would significantly increase the risk of serious traffic accidents at high speeds. Unsuitability to increase the risk of accidents is also evident from the fact that on the roads of Slovakia in the last two years has been arise in the number of fatalities.

Table 5. The number of fatalities per year 2013

Order	State	Number of fatalities 10 mil.person/ km
1.	Sweden	24
2.	Great Britain	28
3.	Holland	33
4.	Denmark	36
5.	Germany	37
6.	Ireland	40
7.	Finland	40
8.	France	41
9.	Slovenia	50
10.	Spain	53
11.	Italy	55
12.	EU	56
13.	Austria	61
14.	Luxemburg	66
15.	Belgium	66
16.	Estonia	72
17.	Cyprus	74
18.	Latvia	77
19.	Portugal	78
20.	Malta	79
21.	Greece	91
22.	Slovakia	92
23.	Czech	101
24.	Hungary	114
25.	Bulgaria	117
26.	Croatia	141
27.	Latvia	153
28.	Poland	158
29.	Rumania	232

Equally inappropriate is the introduction this speed also in terms of increased production of greenhouse gases. Consider this speed is only possible to fully fledged tree-lane sections where would be the last lane reserved for driving at over 130 km/h. If the Slovak driver is sufficiently prepared for increased travel speed shows the Table 5 too, in which is stated the order of states based on the number of killed people in car accidents, calculated on person/km. This indicator best reflects the intensity of use of the vehicles.

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