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To cite this article: Robert Ziolkowski 2017 *IOP Conf. Ser.: Mater. Sci. Eng.* **245** 082047

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Investigations of Section Speed on Rural Roads in Podlaskie Voivodeship

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Abstract. Excessive speed is one of the most important factors considered in road safety and not only affects the severity of a crash but is also related to the risk of being involved in a crash. In Poland the problem of speeding drivers is widely common. Properly recognized and defined drivers behaviour is the base for any effective activities taken towards road safety improvements. Effective enforcement of speed limits especially on rural road plays an important role but conducted speed investigations basically focus on spot speed omitting travel speed on longer sections of roads which can better reflect driver's behaviour. Possible solutions for rural roads are limited to administrative means of speed limitations, installations of speed cameras and police enforcement. However due to their limited proved effectiveness new solutions are still being sought. High expectations are associated with the sectional speed system that has recently been introduced in Poland and covered a number of national road sections. The aim of this paper is to investigate section speed on chosen regional and district roads located in Podlaskie Voivodeship. Test sections included 19 road segments varied in terms of functional and geometric characteristics. Speed measurements on regional and district roads were performed with the use of a set of two ANPR (Automatic Number Plate Recognition) cameras. Conducted research allowed to compare driver's behaviour in terms of travel speed depending on roads' functional classification as well as to evaluate the influence of chosen geometric parameters on average section speed.

1. Introduction

According to the European Transport Safety Council, unadjusted and excessive speed is the main cause of one third of all fatal accidents [1]. The same reason is pointed in official safety statistics published yearly in Poland [2]. The higher the speed, the higher the risk of an accident and the severity of its consequences should be expected. Reducing average speed by 5% leads to 10% reduction in accidents causing injuries, 15% reduction in accidents causing serious injuries, and 20% reduction in accidents involving fatalities. Knowledge of driver's behaviour and especially travel speed are the basement for taking effective actions towards road safety improvements [3, 4]. In Poland the consideration of driver's speed focuses mainly on instantaneous speed investigations conducting on national roads [5, 6] while lower class roads are much less interested although a significant number of accidents is there recorded [2, 7, 8, 9].

Spot speed doesn't fully reflect driver's behaviour along a segment of a road and hence in certain occasions may lead to erroneous conclusions related to the interpretation of causes for road accidents.



Investigations conducted for this study focused on section speed measurements and included 19 sections of regional and district roads located in Podlaskie Voivodeship, a region in north-eastern Poland. Main criteria considered during road sections selection included: roads with an increased number of accidents, functional and technical classification, shoulder and driving lane width and road curvature. The main objectives of this study were to evaluate average travel speeds depending on road functional and geometric parameters.

Research area and speed measurements

Research area included chosen segments of regional and district roads located in Podlaskie province. The list of all tested sections with basic geometric characteristics is provided in table 1. The parameters considered for roads selection were:

- functional classification of roads,
- number of accidents registered on roads in Podlaskie Voivodeship in years 2011-2015,
- lane width from,
- road curvature.

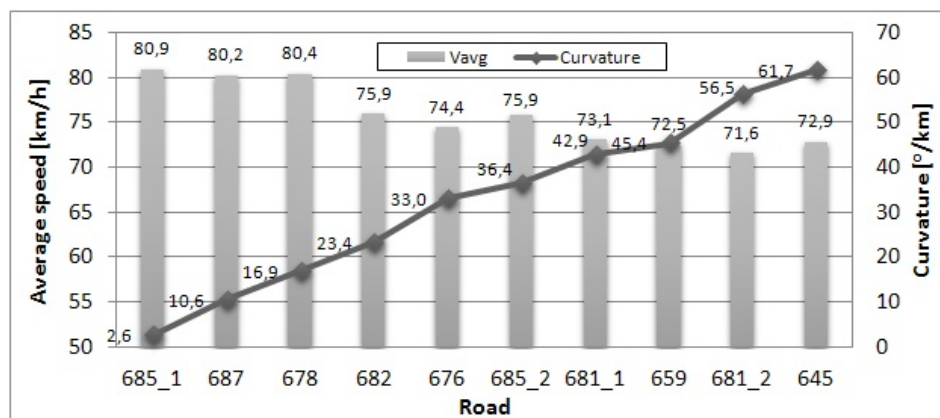
All of the sections were single carriageway, two-directional rural roads with administrative speed limit of 90 km/h. In two cases (road no. 645 and 685_1) the speed limit was lowered to 70 km/h as roads were passing through small villages. Speed measurements on the investigated sections were performed using a set of two ANPR cameras installed on the check points. Vehicles passing through the check points located at the beginning and end point of every measured section were detected and recorded by video-cameras. A camera read the vehicle's number plate and encrypted it using the cryptology methods. When the vehicle exited the section the number plate was again read and matched to the plate captured at the beginning of the section. Using these two data records and the elapsed time between them, the system calculated the average speed based on the length of the section. The length of the section depended on the local conditions – generally an analysed section stretched between two consecutive built-up areas and the cameras were placed in the outskirts of those areas.

Table 1. Geometric characteristics of investigated roads.

Road no.	Curvature [°/km]	Length of a section [km]	Lane width [m]	Shoulder width [m]
Regional roads				
685_1	2.64	3.60	3.25	1.00
687	10.59	3.62	3.00	1.10
678	16.91	2.64	3.0	1.00
682	23.40	3.01	3.25	1.25
676	33.05	3.32	3.00	1.25
685_2	36.36	9.59	3.00	1.00
681_1	42.89	3.22	3.00	1.25
659	45.39	3.84	2.75	1.00
681_2	56.47	3.22	3.00	1.00
645	61.70	7.76	3.25	1.25
District roads				
P1575B_1	6.69	2.97	2.50	0.50
P1601B	8.03	8.38	2.75	0.75
P1629B	17.51	3.67	2.75	0.50
P1483B	33.54	4.30	3.00	0.75
P1575B_2	34.12	2.80	2.50	0.50
P1507B_1	41.82	4.71	2.75	0.50
P1483B	45.58	4.37	3.00	0.75
P1508B	58.00	3.32	2.50	0.50
P1507B_2	71.54	3.66	2.75	0.50

2. Results discussions

As a result a number of individual speed records were gathered and average section speed values were calculated. The results presenting average section speeds in relation to road's function and curvature are presented in figure 1 and 2.

**Figure 1.** Average section speed in relation to road's curvature for regional roads

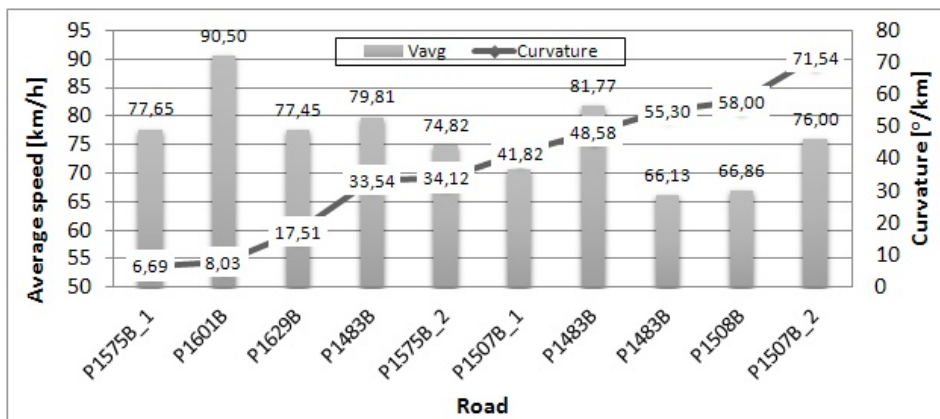


Figure 2. Average section speed in relation to road’s curvature for district roads

Based on the data presenting average section speeds registered on regional roads (figure 1) the relationship between speed and curvature is quite distinct. Higher values of average speeds are accompanied by the lower curvature of the road section. Average speed remains on a constant level of approximately 80km/h as long as the curvature does not exceed 25o/km and behind that value the speed decreases and the lowest speed (72,9km/h) was registered on a road with a curvature of 61,7o/km. Correlation analyses confirmed the existence of dependency on a very high level ($R^2=0.8671$, $p=0.00009$) even though the difference in extreme speeds doesn’t exceed 10%. Opposite situation can be observed on district roads (figure 2). Although extremes of speeds vary from $V=90.5$ km/h on a road with a curvature of $8,03$ o/km to $V=66.9$ km/h (25% difference) on a road with a curvature of 58 o/km there is no statistically significant correlation between average speed and curvature ($R^2=0.3064$, $p=0.122$). The highest average speed (90,5 km/h) was recorded on a road P1601B with a curvature of 8 o/km and the lowest value was recorded a road P1483B with a curvature of 55.30 o/km. Figure 3 presents scatterplots of correlations between road curvature and average speeds for regional (figure 3a) and district roads (figure 3b).

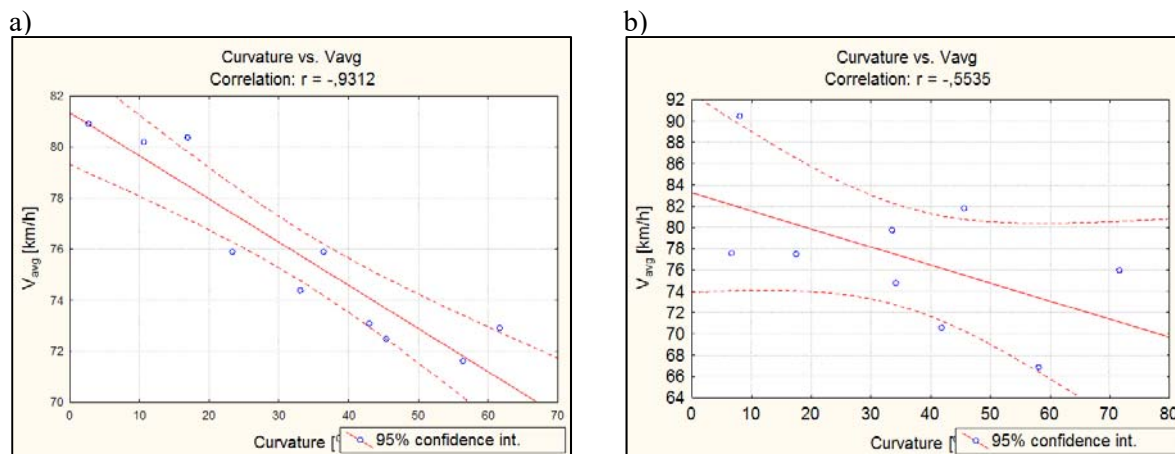


Figure 3. Scatterplot for a) regional roads and b) district roads

An important part of traffic safety analyses is investigation of basic characteristics of speed such as an average speed, 85th percentile (V_{85}) or percentage of speeding drivers ($U\%$). Those data are given in table 2.

Table 2. Characteristics of speed parameters.

Road no.	Average speed	V ₈₅ [km/h]	U% [%]
Regional roads			
DW_685_1	80.9	93.1	78.0 ^a
DW_687	80.2	89.4	24.7
DW_678	80.4	93.5	21.3
DW_682	75.9	84.9	6.7
DW_676	74.4	84.1	5.5
DW_685_2	75.9	88.4	21.4
DW_681_1	73.1	84.6	6.7
DW_659	72.5	84.1	9.9
DW_681_2	71.6	86.7	5.9
DW_645	72.9	84.1	94.4 ^a
District roads			
P1575B	77.6	86.8	7
P1601B	90.5	102.2	57
P1629B	77.5	91.5	22
P1483B	79.8	88.7	18
P1575B	74.8	85.5	10
P1507B_1	70.6	79.0	4
P1483B	71.8	91.0	6
P1508B	66.9	76.0	0
P1507B_2	76.0	87.8	9

^a Road segments with speed limit of 50 km/h.

From table 2 it appears, as expected due to higher geometric parameters, that average section speed on regional roads (75.8km/h, excluding segments with 50 km/h speed limit) comparing to district ones (72.3km/h) is higher but the difference is not excessive (less than 5%) and is not statistically significant ($p = .2236$). The explanation for a lack of the significance difference between those two types of roads is differentiation in individual's speed. That heterogeneity is clearly visible in figure 4 which presents histograms of sectional speeds registered on both regional and district roads. In both cases the range of travelling speed is similarly large and the difference between slowest and fastest vehicles extends from 55km/h to 105km/h. Such a phenomena may cause an increased risk on the roads especially on roads with higher curvature.

Considering average speed and 85th percentile values it's a remarkable fact that average speeds on almost all investigated roads, except of road P1601B, remain significantly below existing speed limit. In case of 85th percentile recorded values are also in most cases below speed limit. Comparing achieved results of sectional speeds with instantaneous speed recorded on other but of similar geometric characteristics regional and district roads [3] it occurs that instantaneous speeds is on a considerably higher level. Average spot speed values was 84km/h on regional roads and 80km/h on district roads.

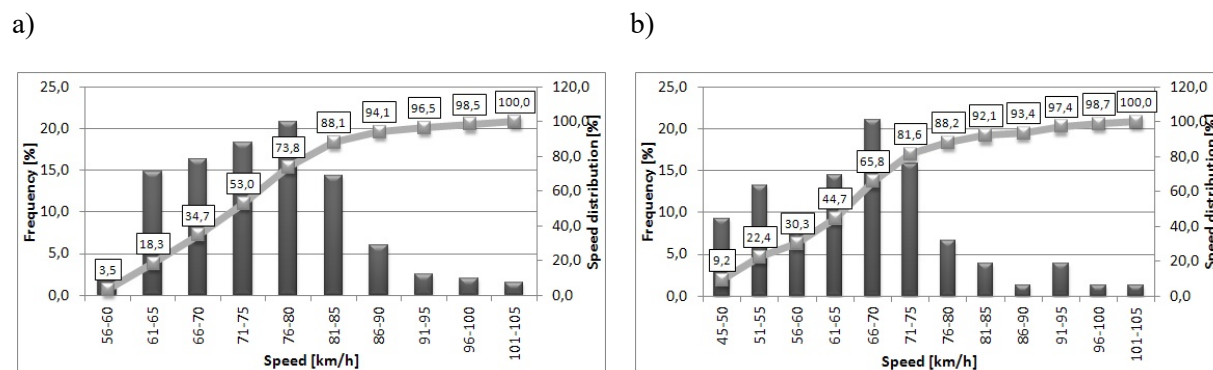


Figure 4. Speed distribution a) regional road and b) district road

Table 3. Characteristics of speed parameters.

Regional roads		District roads	
Lane width	Average speed	Lane width	Average speed
2.75	72.5	2.50	73.1
3.00	76.0	2.75	78.6
3.25	76.4	3.00	75.9

Analysing data presented in table 3 reflecting average speeds in relation to the lane width it appears that in case of regional roads the increase of the lane width corresponds to higher speed values although to a small extent. The lowest average speed value was recorded on roads with a lane with 2.75m (72.5km/h) and it was only 5% lower than an average speed recorded on roads with a lane width 3.25m (76.4km/h). In case of district roads the increase of a driving lane width from 2.5 to 2.75 resulted in 7% increase in average speed but further increase of a lane width has resulted in an opposite tendency and 3.4% drop of speed was observed.

3. Conclusions

Commonly conducted research and speed analyses focus on roads constituting main road network, namely national roads. At the same time official police statistics have been emphasizing for many years a fact that a great number of accidents occurs due to excessive speed regardless the class of a road.

The paper presents results of section speed investigations performed on regional and district roads located in Podlaskie Voivodeship and also refers them to average instantaneous speeds. Based on obtained results it may be stated, unexpectedly somehow, that average section speed recorded on regional roads is insignificantly higher than average speed measured on district roads although the latter characterize with lower geometric parameters. At the same time those values are essentially lower than instantaneous speed measured on other but similar in geometric characteristics regional and district roads. In both cases average values of section speeds were almost 10% lower than average spot speed values. The same applies to the percentage of speeding drivers - their number is distinctly higher if spot speed is considered.

Those observations are essential in scope of traffic safety analyses. Excessive speed being a dominant reason in police statistics doesn't have to be a suitable explanation of increased risk on regional and district roads in terms of sectional speed considerations. As speeding drivers remain on a relatively low level the reasons for inappropriate driving may be more related to road characteristic and heterogeneity than speed.

Considering geometric parameters and their influence on travel speed in case of regional roads curvature and width of driving lane are more related to the speed than in case of district roads where there was no such a correlation.

Acknowledgment(s)

The research was supported by the Project No S/WBiIS/1/15 and it was financially supported by Ministry of Science and Higher Education, Poland.

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