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PRINCIPLES OF RATIONAL DISLOCATION OF ROAD INFRASTRUCTURE OBJECTS ON THE MAIN AND NATIONAL ROADS

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Abstract. Lithuania has a rather good network of motor roads facilitating transportation of passengers and cargoes. Development of tourism and transit transport requires a rational distribution of hotels, motels, restaurants, cafés, staging posts, filling stations etc. Being now a member of the EU, Lithuania must undertake to improve the network of roads so as to meet the international requirements. Seeking to convert Lithuania into a country of travel, transit and transportation, the roads must be improved to provide all necessary services. The state of pavement, characterised by the indices of cracking and evenness, is an important factor of travelling comfort and safety. Roadsides service objects represent other factors which influence the flows of travellers. Basing on analysis of West European and Russian experience, we recommend to classify the objects and complexes of roadside service and infrastructure into categories *A, B, C, D, E, F,* and *G* depending on the rest time and to arrange them according to the model presented in the article. Having evaluated the questionnaire data and actual distribution of service complexes by the Lithuanian main roads, the authors recommend to space the service objects and complexes at suggested rational distances. The recommendations for improving the roads and their infrastructure represent the novelty of the present work. They will contribute to travelling comfort and contribute to providing the services necessary for travellers and drivers.

Keywords: roads, roadside service and infrastructure objects, rational dislocation, principles of dislocation, transport of passengers and cargoes.

1. Introduction

Lithuania has a rather dense network of good roads, which provide favourable conditions for transport of passengers and cargoes.

The state of pavement, characterised by the indices of degradation and evenness, is an important factor of travelling comfort and safety. The state of road pavement and the services offered to drivers and travellers by the roadsides may influence the flows of travellers. Lodgings for tourists and other travellers in convenient places by the roadsides – motels, hotels, tourist bases, guesthouses, holiday camps, sanatoria, homesteads etc – are one of the most important premises for tourism development. For Lithuania to become a country of travelling and tourism it is necessary to make its roads interesting and attractive for local and foreign tourists. The attractiveness of roads can be strengthened in the following ways:

- by improving the objects of infrastructure and their convenient location,
- by improving the quality of services provided in the objects of infrastructure.

Many researchers in other countries have devoted their works to studies of the possibilities of a better use of roads (with respect to development of services to tourists, holiday-makers and other travellers) [1–12]. Yet this problem is still in embryo [1–4, 8–17]. The solutions of this problem lack objectivity and efficiency because the requests of tourists, holidaymakers and other travellers as to the spacing of roadside service objects and complexes have been neglected. This problem came to notice in Lithuania only in the last few years [13–17].

The aim of the present work is to consider the main principles of a reasoned improvement of roadside service objects and to give recommendations for its dislocation at rational distances along roads.

2. The Lithuanian roads and their necessary properties

Cars are the most frequently used means of communication in Lithuania. Therefore, the improvement of roads should contribute to a regular increase of motor tourists. There were more than 1,63 million vehicles in Lithuania in 2004 (31122004) including more than 1,32 million cars (80,7 % of the total of vehicles). Cars and buses are the main vehicles of foreigners visiting Lithuania. About 3,1 million foreign visitors of the total 4,5 million arrived in our country by cars and buses in recent years. The departing travellers from Lithuania in the period before the country (population 3,5 million inhabitants) was accepted into the EU were for: motor roads – 84 %, railways – 11 %, by air – 3 %, and by sea – 2 %. The given data show that roads are most popular among the visiting and departing travellers.

The process of improvement of Lithuanian roads in the last few decades is shown in Table 1 [18].

The data demonstrate rather high rates of improvement of Lithuanian roads during 1960–2004. They are of sufficient length and their network is of sufficient density. Also they have already been connected to the system of the Western European roads. Two international corridors are crossing the territory of Lithuania from North to South (I corridor) and from East to West (IX corridor).

Main data about the Lithuanian state roads and their infrastructure are in Table 2 [19].

Analysis of completed works [4, 9, 12, 20–22] showed that well equipped and maintained roads with a right system of traffic service objects stimulate the development of tourism and travelling. In many Western European countries [9, 12, 21, 22] the accepted rational distance between staging-posts or places for a nice sight-seeing 13–15 years ago was L = 5–10 km. In Lithuania this distance should be $L \leq 5$ km.

The functional purpose of motor roads is to ensure safe and fuel-efficient traffic transporting passengers and cargoes at an optimal speed in established routes. Recent conversion of Lithuania into a country of international transit, travelling and tourism imparts a new sense to roads. It is necessary now to ensure safe transportation of cargoes and comfortable and safe travelling of tourists and holidaymakers by the international routes (category E) – roads with heavy traffic and roads to the main Lithuanian resorts and visiting places.

For a comfortable and safe travel the pavement of roads must have a strong structure, i e must be even and rough.

Evenness is the main indicator of the state of pavement. It is responsible for comfort and safety of travelling. Therefore the suitability of motor roads for travelling and

Table 1. Total length and density of the motor roads network in Lithuania in 1960–2004 (end of the year)

Year	Total length of roads, km	Roads and their length, km			Proportion of roads with pavement (of the total length of roads), %	Density of the network of roads, km/km^2
		state roads	local roads	city roads		
1960	38 787	16 028	19 735	3024	30,7	0,594
1970	37 403	19 963	13 564	3876	47,4	0,573
1980	36 453	19 984	12 311	4158	66,2	0,558
1990	48 734	20 904	23 273	4557	81,8	0,746
2000	75 517	21 313	48 451	5753	91,3	1,156
2004	79 331	21 345	52 107	5879	88,0	1,215

Table 2. Indices characterising the Lithuanian state roads and their infrastructure in 2005

Indices	Measuring unit	Quantified values
Density of the whole network of roads	km/1000 km^2	326,68
Road length per 1000 persons	km/1000	6,13
Density of paved roads	km/1000 km^2	194,22
Length of paved roads per 1000 persons	km/1000	3,64
Length of roads: category E:	km	1511
Including roads of the 1st category and highways:		554
Including highways		417
Length of the objects of infrastructure by the roadsides:	km	
Foot paths and cycle-tracks		1028
Protective barriers		781
Number of the objects of motor road infrastructure:	km	1125
Mobile stores		
Toilets		409
Bus stages with platform		11 728
Staging posts		383

tourism can be determined according to their evenness. This task has not been fully solved in Lithuania. It is necessary to establish the acceptable values of evenness.

The necessary properties of motor roads could be ensured:

- When designing and building roads, it is necessary to control that the geometrical parameters (width of roadways and roadsides, length of horizontal and longitudinal curves, radii, length of straight road sectors, gradients etc) and other indices (the pavement strength) met the requirements.
- Maintenance of roads must ensure the standard values of evenness and degradation level. This can be achieved through technical inspections and timely repairs of the pavement.

3. Theoretical principles of ensuring the necessary services

Roads must be interesting for travellers and ensure necessary services (rest, catering etc) for tourists, holidaymakers, other passengers and for means of transport (servicing, repair, fuel supply, etc).

Drivers tire less when spaces of various size and form, delineated by groups of trees and shrubs or other vertical forms, intersperse the roads. Greeneries also help integrate the roads into the landscape, emphasise valuable landscape components and shield the unattractive objects. To ensure the traffic safety the roadside greeneries must not reduce the width of the roadway. In highways it is expedient to plant groups or even belts of low shrubs between the lanes with different traffic direction. Such belts prevent from getting dazzled by the car lights from the lane of an opposite traffic. Yet they must not reduce the distance of [15, 20].

Drivers and passengers tire less when roads are integrated into the landscape and properly aesthetically and architecturally designed. This contributes to the traffic safety.

The distribution, dimensions, nomenclature and character of traffic service objects depend on many factors:

- traffic and its composition,
- specific features of the territory,
- average riding speed ensured in the route,
- attraction of traffic service objects and its functions,
- attractiveness of the landscape etc.

When distributing the staging posts it is necessary to plan the number of parking lots in them and to establish the rational average distance between them. The distance between the traffic service objects is established taking into account the minimum needed time of rest necessary for drivers. Well-organised work and sufficient rest time prevent drivers from fatigue and reduce the probability of traffic accidents. According to the safe traffic rules, a driver needs 15 min for rest after 3 working hours and 30 min for rest after 6 working hours. According to medical recommendations drivers must have minimum 30 min for rest after 2 and 4 working hours [9, 12].

Traffic service complexes must have three zones:

- parking-lot zone with entrance and departure drives,
- staging-post zone with an arbour, tables and benches or, in larger complexes, with a motel, restaurant, café, store, etc.
- sanitary zone with a toilet and dumpster.

Larger complexes must have technical maintenance zone with a filling station and a servicing and repair shop. Smaller complexes must have at least a car inspection yard.

The authors formulated the following major principles of classification of traffic service objects and its dislocation along the roads:

- the average distance between the traffic service objects must be 100 km or the distance, which is covered by a vehicle in 2 hours (it is more convenient to take the 100 km distance as a basic one);
- the complexes of traffic services must be classified into categories according to their importance and duration of planned rest time in them;
- service complexes of each category must have the classifying object, which predetermines the critical duration of rest time;
- it is expedient to make the distance between the objects of lower category twice as small as between the objects of a higher category.

It is recommended to group the service complexes and staging posts into categories according to the planned rest time (categories are listed in the sequence of their importance) and dislocate accordingly:

Category *A*, when the planned rest time t is from 1 to 30 days (presence of hotel is a distinctive feature of this category),

Category *B*, when the planned rest time t is from 8 h to one day (the complex must have a small hotel or motel),

Category *C*, when the planned rest time $t = 2–8$ h (the complex must have a restaurant or bistro),

Category *D*, when the planned rest time $t = 1–2$ h (the complex must have a café),

Category *E*, when the planned rest time $t = 0,5–1$ h (the complex must have an arbour),

Category *F*, when the planned rest time $t = 0,3–0,5$ h (the complex must have tables, chairs or benches),

Category *G*, when the planned rest time $t < 0,3$ h (the complex must have a bench, a toilet and a dustbin).

All objects in the service traffic complexes of lower category must be present in the complexes of a higher category. The complexes of categories *A* and *B* must have filling stations. It is desirable that complexes of category *C* should also have them. The complexes of categories *A* and *B* must have technical service station for cars, too.

Taking into consideration theoretical proposals and the results of experimental investigations carried out by the Lithuanian roadsides, we recommend to distribute the service complexes following the given pattern:

- service complexes of categories *A–F* and staging-posts of category *G* should be installed by the main roads,
- service complexes of categories *B–F* and staging-posts of category *G* should be installed along the national roads,
- service complexes of categories *C–F* and staging posts of category *G* should be installed along the regional roads.

Investigation results showed that the distance between traffic service objects along the main Lithuanian roads might be approximated using the normal Gauss' spacing. The spacing depends on the proximity of water bodies and on the picturesqueness of the roadside locality. The spacing usually follows the pattern shown in Fig 1.

The actual distribution of traffic service objects may differ from the most probable average spacing $L \dots L/8$ shown in Fig 1. The higher is the category of traffic service objects, the greater is the distance between them and the index of variation of spacing (the standard deviation σ) may be higher (Fig 1). This proposition is confirmed by actual statistical characteristics of the spacing of traffic service objects of various categories along the main Lithuanian roads.

Following the sanitary and health requirements, the traffic service objects should be built at a greater distance from the roads than they are now in Lithuanian in order to prevent pollution of environment. This requirement has, probably, not been observed because most of travelling tourists reluctantly (very rarely) visit remote service objects.

The distribution of traffic service objects is also predetermined by the time factor: the distance between service infrastructure objects of the same category has been reduced by about 2,4–2,5 times in the last 20–25 years and, if required by customers, maybe reduced even more. For example, the recommended distance between the objects of category *A* in 1975–1980 was 100–120 km [9, 12] and in the last years – 40–50 km [15] (Fig 2).

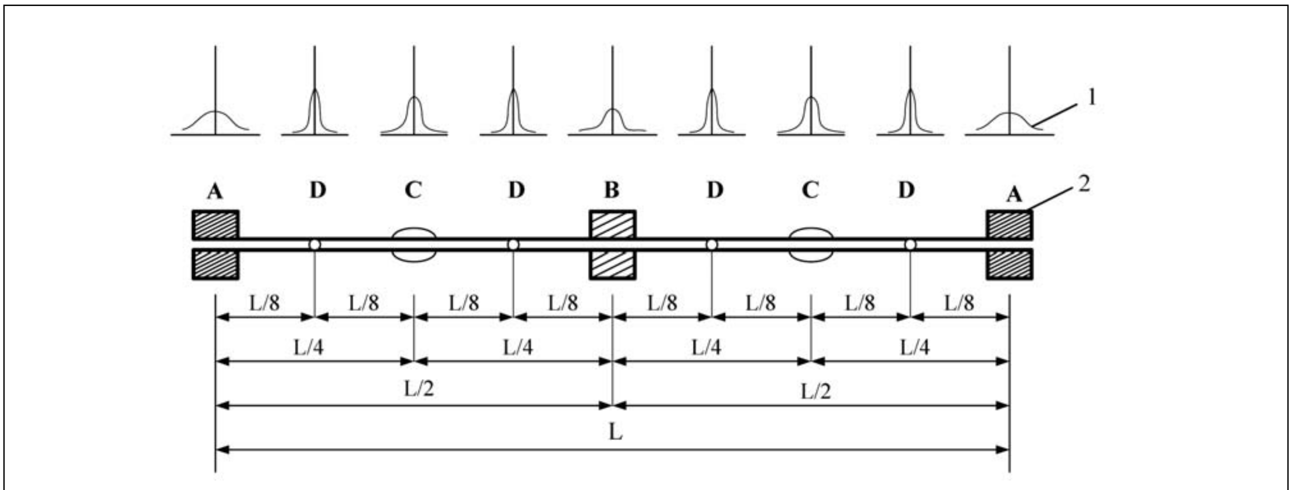

Fig 1. Principal scheme of spacing the traffic service objects of categories *A*, *B*, and *C*: 1 – the most probable places for traffic service objects; 2 – the road and traffic service objects by a roadside

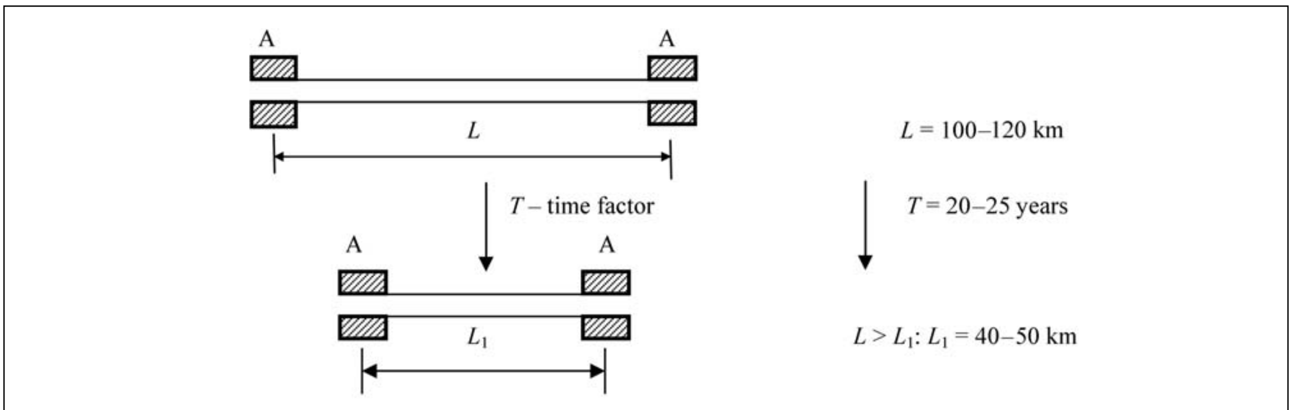

Fig 2. Principal scheme of the influence of time factor T on spacing the objects of service infrastructure

4. The most frequently visited objects of Lithuania and the most important properties of state roads for developing of tourism

The most frequently visited objects in Lithuania were determined on the basis of answers of local and foreign respondents. In the opinion of foreigners, the objects worth visiting in Lithuania are: Vilnius, Trakai, Kaunas, Curonian spit (Nida), Palanga, Druskininkai, Klaipėda, the Hill of Crosses, Rumšiškės Ethnographic Museum, Park of Europe, Aukštaitija National Park, Kernavė, and the Baltic seaside. In the opinion of Lithuanian respondents, such objects are: Trakai, the Old City of Vilnius, Palanga, Kaunas, Nida, Klaipėda, the Hill of Crosses, Druskininkai, Rumšiškės Ethnographic Museum, Kernavė, Anykščiai, Aukštaitija National Park, the Baltic seaside, Curonian spit, the Centre of Europe, Grutas Park, Molėtai lakes, Šiauliai, Stone Museum in Mosėdis, Ignalina NPP ect. The priorities as to the objects worth visiting were comparable in both groups of respondents. The objects to be visited in Vilnius, as pointed by Lithuanians, were: Gediminas Castle, the Cathedral, the Old City of Vilnius, St Ann's Church, TV tower, Aušra Gates, the Hill of Three Crosses, St Peter's and Paul's Church, the Lithuanian National Museum, City Hall, Museum of Applied Arts, Vilnius University, Pilies street, Ethnographic Museum, Seimas Palace, Gediminas Avenue, Jews' Museum, Museum of History, Opera and Ballet Theatre, Verkiai Regional Park etc.

In order to optimise the spacing of service infrastructure objects along roadsides, it is necessary to take into account the requests of local residents and foreign visitors. The data of questionnaires distributed among foreign respondents (249 questionnaires) about the spacing of requested services were processed by mathematical statistical methods and are presented in Table 3.

The data of questionnaires distributed among local residents (1687 questionnaires) about the spacing of requested services were processed by mathematical statistical methods and are presented in Table 4.

The given data (Tables 3, 4) show that both groups of respondents have a rather comparable idea about the spacing of the objects of service infrastructure. The indicated average distances between the objects should be:

- hotels (motels) – every 60,0 km,
- restaurants – every 50,0 km,
- cafés (tea-shops) – every 27,5 km,
- filling stations – every 28,0 km,
- servicing stations – every 30,0 km,
- stores – every 25,5 km,
- parking lots – every 22,5 km.

In the respondents' opinion, the zone of the most important Lithuanian roads lack call-boxes, medical stations, holiday camps, police stations and fire stations, banking services, stalls, pleasure centres etc. Specialists designing the objects of service infrastructure by the roadsides should take this into account.

Basing on the data provided by the Transport and Road Research Institute (TRRI), the authors studied the evenness of the main Lithuanian motor roads Vilnius–Kaunas–Klaipėda (A 1) and Vilnius–Panevėžys (A 2). The study was based on the methods of statistical analysis: using the total of ≥ 200 individual data, the arithmetic mean $\bar{x}$ and standard deviation were calculated. The results showed that the evenness of the main road Vilnius–Panevėžys and the greater part of the main roads Vilnius–Kaunas–Klaipėda measured by International Roughness Index (IRI) satisfies the normal Gauss' law. Analysis of obtained results revealed that almost in all cases the generalised values (arithmetic means) of the evenness of main roads A 1 and A 2 did not exceed the limit values $Y_1 \geq 3,0$ m/km [23]. This implies a rather good condition of the pavement for travelling. The

Table 3. Statistical characteristics of spacing between the objects of service infrastructure along the main Lithuanian roads requested by foreign respondents (the number of individual data $n = 249$)

Statistical characteristics of distance between objects	Information about the evaluated individual data	Objects of service infrastructure						
		hotels (motels)	restaurants	cafés (tea-shops)	filling stations	servicing stations	stores	parking lots
Arithmetic mean $\bar{x}$, km	all data presented	64,306; $n = 216$	50,082; $n = 207$	30,213; $n = 202$	28,061; $n = 214$	32,402; $n = 199$	27,662; $n = 201$	22,251; $n = 203$
	some data are rejected	66,932; $n = 207$	55,595; n =185	32,314; $n = 188$	28,548; $n = 210$	32,551; $n = 198$	30,782; $n = 179$	23,290; $n = 193$
Standard deviation σ, km	all data presented	34,440; $n = 216$	31,417; $n = 207$	16,482; $n = 202$	15,013; $n = 214$	17,474; $n = 199$	17,268; $n = 201$	14,518; $n = 203$
	some data are rejected	32,734; $n = 207$	28,589; $n = 185$	15,097; $n = 188$	14,728; $n = 210$	17,392; $n = 198$	15,667; $n = 179$	14,130; $n = 193$
Variation coefficient V, %	all data presented	53,56 $n = 216$	62,73; $n = 207$	54,55; $n = 202$	53,50; $n = 214$	53,93; $n = 199$	62,42; $n = 201$	65,24; $n = 203$
	some data are rejected	48,91; $n = 207$	51,42; $n = 185$	46,72; $n = 188$	51,59; $n = 210$	53,43; $n = 198$	50,90; $n = 179$	60,67; $n = 193$

results of the evenness were also good – the coefficient of variation of the evenness was $V \leq 33$ % indicating a comparatively low dispersion of actual values.

The special study of the most important (for tourists, holiday-makers and other passengers) Lithuanian roads included specification of the location of traffic service objects and actual distances between them. The obtained results were processed by mathematical statistical methods: from n of individual results the arithmetic means of the distances between the traffic service objects and the standards deviations σ of these distances were calculated. The obtained results are given in Table 5.

The results of Table 5 show that the actual distances between the complexes of traffic service infrastructure by the main Lithuanian motor roads are close to the theoretical model, in which it is indicated that the preferred distance between the staging-posts of a lower category must be almost twice as small as between the staging-posts of a higher category. The average distance between the traffic service objects of different categories are: category *A* – 25–35 km, category *B* – 15–25 km, category *C* – 7–12 km, category *D* – 4–6 km, category *E* – 2,0–4,5 km, category *F* – 1,5–2,5 km.

Table 4. Statistical characteristics of spacing between the objects of service infrastructure along the main Lithuanian roads requested by Lithuanian respondents (the number of individual data n = 1687)

Statistical characteristics of distance between objects	Information about the evaluated individual $\bar{x}$ data	Objects of service infrastructure						
		hotels (motels)	restaurants	cafés (tea-shops)	filling stations	servicing stations	stores	parking lots
Arithmetic mean $\bar{x}$, km	all data presented	53,720; n = 1548	45,469; n = 1488	23,681; n = 1518	23,565; n = 1534	25,873; n = 1488	21,290; n = 1485	20,522; n = 1501
	some data are rejected	56,377; n = 1469	49,922; n = 1345	26,213; n = 1360	25,698; n = 1397	28,069; n = 1361	23,910; n = 1307	23,284; n = 1305
Standard deviation σ, km	all data presented	31,030; n = 1548	30,156; n = 1488	16,103; n = 1518	16,149; n = 1534	16,756; n = 1488	15,068; n = 1485	15,002; n = 1501
	some data are rejected	29,514; n = 1469	28,291; n = 1345	15,114; n = 1360	15,377; n = 1397	15,789; n = 1361	14,209; n = 1307	14,162; n = 1305
Variation coefficient V, %	all data presented	57,76; n = 1548	66,32; n = 1488	67,80; n = 1518	68,53; n = 1534	64,85; n = 1488	70,78; n = 1485	73,10; n = 1501
	some data are rejected	52,35; n = 1469	56,67; n = 1345	57,66; n = 1360	59,84; n = 1397	56,25; n = 1361	59,43; n = 1307	60,82; n = 1305

Table 5. Statistical data about the distances between the objects and complexes of service infrastructure along the main Lithuanian roads

No	Categories of the service objects and distances between them																	
	Category A			Category B			Category C			Category D			Category E			Category F		
	n	$\bar{x}$, km	σ, km	n	$\bar{x}$, km	σ, km	n	$\bar{x}$, km	σ, km	n	$\bar{x}$, km	σ, km	n	$\bar{x}$, km	σ, km	n	$\bar{x}$, km	σ, km
1	Road *Vilnius–Kaunas* (A1)																	
	7	20,81	24,85	7	13,63	14,66	22	3,91	5,85	11	3,16	4,04	9	4,14	3,23	57	2,11	1,31
2	Main motor road *Kaunas–Klaipėda* (A1)																	
	9	29,52	26,12	4	17,68	10,79	36	8,84	8,45	12	4,33	3,01	26	4,77	4,37	39	1,62	1,17
3	The main route to the seaside from Vilnius: main motor road *Vilnius–Kaunas–Klaipėda* (A1)																	
	16	25,71	24,25	11	15,10	13,25	58	6,97	7,46	23	3,77	3,50	35	4,61	4,08	96	1,91	1,25
4	Main motor road *Vilnius–Panevėžys* (A2)																	
	2	32,78	31,57	-	-	-	11	15,40	10,61	3	9,63	3,54	3	5,67	3,28	31	3,95	2,82
5	Main Lithuanian motor roads (A1) and (A2)																	
	18	26,06	25,06	11	1510	13,25	69	8,31	7,97	26	4,45	3,51	38	4,69	4,01	127	2,41	1,64
6	Motor road *Panevėžys–Šiauliai* (A9)																	
	3	22,25	9,43	2	9,98	4,00	5	9,24	9,06	6	3,82	1,98	13	1,72	0,87	68	1,83	1,02
7	Motor road *Šiauliai–Kuršėnai–Kretinga–Palanga* (A11)																	
	2	58,40	68,66	2	58,40	68,66	13	11,76	7,02	5	6,35	8,80	15	1,63	1,18	112	2,15	1,11
8	A very important route to the seaside from Vilnius: *Vilnius–Panevėžys–Šiauliai–Kuršėnai–Kretinga–Palanga* (E272)																	
	7	35,59	31,33	4	34,19	36,33	29	12,71	8,73	14	5,97	4,75	31	2,06	1,25	211	2,31	1,33
9	All studied motor roads: A1, A2, A9, A11																	
	23	28,72	26,81	15	20,19	19,40	87	8,88	7,89	37	4,60	3,98	66	3,40	2,75	307	2,19	1,31

Main principles of development of tourism, recreation and travelling are the following:

- tourism resources must be easily accessible, i e they must have good approaches with information signs and complexes and objects of traffic service infrastructure,
- the available tourism resources must be properly preserved and new ones created,
- touring agencies, companies and other related organisations must prepare exhaustive folders about these resources.

Conditions of travelling and shipment depend on the evenness of roads [24, 25]. The dynamics of the evenness of the main Lithuanian roads is illustrated in Table 6.

The presented data show that due to modern methods of maintenance and repair the pavement of main and country roads has considerably improved (the evenness values according to IRI have been reduced).

Yet other Lithuanian roads are characterised by limit or close to limit values of evenness. Therefore, the travelling conditions are good and very good only in the some main Lithuanian roads, whereas in other main roads and national roads they are only sufficient or marginal. If IRI are improving at the rates given in Table 6, the travelling conditions will become fairly good in all main and national roads in the near future.

5. Principles of improving of roads and their infrastructure

The average annual rates of improvement of evenness values (m/km) since 1992 have been: 0,041 m/km of highways, 0,054 m/km of other main roads, 0,054 m/km of national roads, and 0,049 m/km of all main and national roads. If this trend is continued in the coming 5–10 years, the expected average evenness in 2010 would be: 1,10–1,20 m/km of highways, 2,40–2,50 m/km of other main roads, 3,00–3,10 m/km of national roads, and 2,60–2,70 m/km of all main and national roads. The obtained results show that the standard for evenness should be raised. Table 7 contains the recommended limit values for evenness, which would ensure good travelling conditions by roads.

The recommended limit values of evenness would facilitate travelling comfort and stimulate the development of tourism and recreation.

The following other measures for increasing attraction of tourism and recreation resources are recommended:

- preservation and sustainable development of available tourism and recreation resources,
- relevant marking of the boundaries of tourism and recreation zones,
- management of the environment of recreation zones designed to develop its advantages,

Table 6. Dynamics of the evenness of the main Lithuanian roads according to IRI Y_{IRI} (m/km) in 1992–2005*

Motor roads	Dynamics of road evenness according to IRI Y_{IRI} (m/km) for certain years							
	1992	1993	1994	1995	1996	1998	2000	2005
Main roads	1,93	1,78	1,64	1,50	1,57	1,72	1,60	–
National roads	4,12	4,12	4,13	4,08	4,04	3,92	3,69	–
All studied roads	3,64	3,62	3,65	3,63	3,58	3,43	3,25	3,31**

* TKTI data ** Main roads and national roads

Table 7. Recommended limit values for pavement evenness

No	Group of roads	Recommended limit values of pavement evenness according to IRI Y_{IRI} , m/km
1	Main roads	2,50
2	National roads	3,50

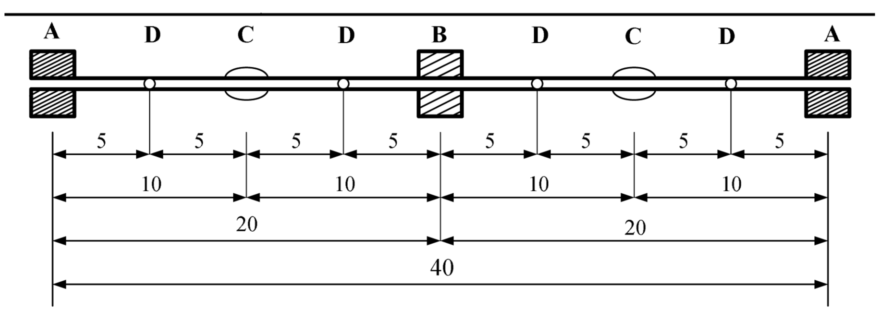

Fig 3. Scheme of recommended distribution in place of traffic service complexes along the main roads (the given values show the average distance between the complexes, km)

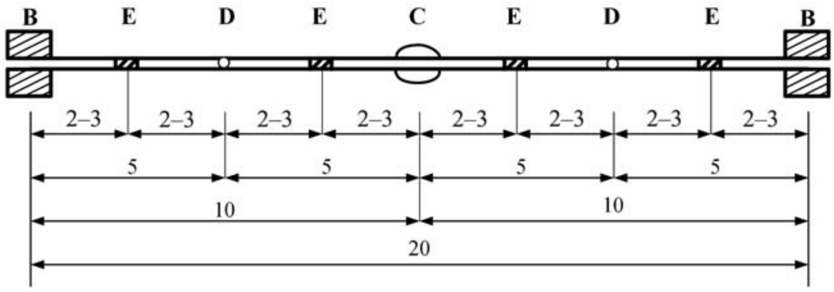

Fig 4. Scheme of recommended distribution in place of traffic service complexes by the national roads (the given values show the average distance between the complexes, km)

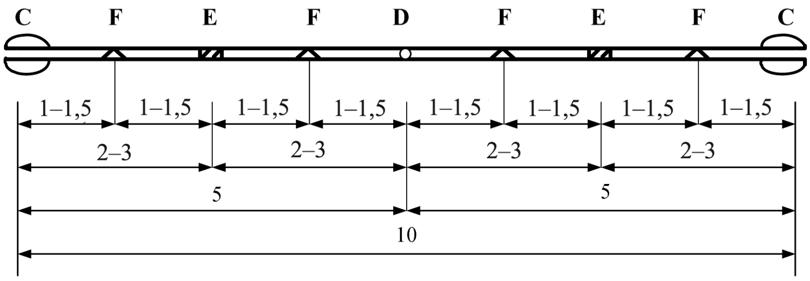

Fig 5. Scheme of recommended distribution in place of traffic service complexes by the regional roads (the given values show the average distance between the complexes, km)

- establishment of staging posts in relevant places by roadsides,
- establishment of beaches, tourism bases and other objects near water bodies,
- establishment of health pathways in the forests, parks and recreation zones.

On the basis of theoretical and experimental data we recommend the schemes of distribution in place of traffic service complexes along the Lithuanian roads. They are given in Figs 3 to 5: *A–D* complexes by the main roads in Fig 3, *B–E* complexes by the national roads in Fig 4, *C–F* complexes by the regional roads in Fig 5.

The complexes of the same category should be distributed at comparable distances by the roads of various ranks. Complexes of category *G* should be distributed at a distance of 0,50–0,75 km from each other.

According to functional design the complexes of service can be subdivided into zones:

Complexes of *A* and *B* categories are subdivided into lodging and catering (passive rest), servicing, breakdown service, parking lot, active rest (category *A* – active rest and pleasure), sanitary and information zones.

Complexes of *C* and *D* categories are subdivided into catering (passive rest), servicing, breakdown service, parking lots, active rest, sanitary, and information zones.

Complexes of categories *E* and *F* are subdivided into passive rest, parking lot, sanitary and information zones.

Complexes of categories *A*, *B* and *C* must provide special sub zones (within zones) designed for the halt of disabled travellers.

Implementation of all given recommendations will create premises for a more intensive development of local and international tourism.

6. Conclusions

1. Lithuania has a rather good network of roads facilitating transportation of passengers and cargoes. In order to convert Lithuania into a country of travel, transit and transportation, the roads must be improved to provide all necessary services. The following ways to enhance the attraction of the objects of service infrastructure are important: improvement of the traffic service objects, distribution in place of the objects of service infrastructure and a high level of services at these objects.

2. After acceptation of Lithuania to the EU there occurred premises for improvement of the Lithuanian roads to match the united system of European roads. Only modern services offered to drivers and passengers and improved evenness of roads will convert Lithuania into a country of tourism, travelling and transit.

3. Properly equipped objects of traffic service infrastructure are one of the main premises of tourism and travelling development: hotels, motels, tourist bases, holiday camps, sanatoria, rural homesteads, restaurants, cafés, arbours, staging-posts, filling stations etc.

4. The value of evenness of roads is indicated among the necessary properties of roads. Evenness is responsible for travelling security, speed, comfort etc.

5. Main principles of achieving attraction and comfort of roads and formation of mandatory service system by the roadsides are discussed.

The objects and complexes of traffic service must be spaced in such a way as the distance between the objects of lower category is about twice as short as the distance between the objects of a higher rank. The critical distance indicating the necessity of rest is 100 km. The distance between objects of category *A* must not exceed this critical value.

6. Investigations revealed that the main parameter of Lithuanian roads responsible for adequate travelling condition – evenness of road pavement – is sufficiently good; therefore travel routes for Lithuanian and foreign tourists may be successfully organised in them.

7. It was determined that different groups of respondents (tourists, holiday-makers and other travellers) recommend very comparable spacing distances for distribution of service objects by the roadsides.

8. The distances between the service objects by the Lithuanian roads are comparable with the recommended distances in the theoretical model. The actual average distance between the objects and complexes of categories *A*, *B*, *C*, *D*, *E*, *F* and *G* are twice and thrice as short as the ones requested by tourists and holiday-makers. Thus, the conditions for development of tourism and recreation in Lithuania are good: the number of service objects is sufficient but the service standard should be conformed to the international level.

9. Improvement of the main Lithuanian roads and objects and complexes of service infrastructure in the roadsides will contribute to modernisation of mandatory services and create premises for activating international cooperation.

References

1. ORNATSKIJ, N. P. Fundamentals of Planning the Arrangement of Service Objects by the Roadsides (Основы расчета вместимости предприятий обслуживания движения на дорогах. Научн. труды МАДИ, 1973, вып. 65), p. 123–132 (in Russian).
2. ORNATSKIJ, N. P. Planning Roadside Facilities on the Basis of the Principles of Architectural-landscape Design (Проектирование благоустройства автомобильных дорог на основе принципов архитектурно-ландшафтного проектирования. Научн. труды МАДИ, 1974, вып. 72), p. 40–60 (in Russian).
3. ORNATSKIJ N, P. A Problem of Systematic Design of Roadside Facilities (Проблема системного проектирования благоустройства автомобильных дорог. Автореф. дис. ... докт. техн. наук: 05.22.03). Moscow, 1977. 32 p. (in Russian).
4. TRESKINSKIJ, S. A.; KUDRIAVTSEV, T. P. Aesthetics of Motor Roads (Эстетика автомобильных дорог). Moscow: Transport, 1978. 200 p. (in Russsian).
5. VINER, J. G.; TAMANINI, F. J. Effective Highway Barriers. *Accident Analysis and Preventions*, 1973, 5, No 3, p. 223–230.
6. CARLSON, R. D.; ALLISON, J. R.; BRYDEN, J. E. Perfomance of Highway Safety Devices. *Transportation Research. Record*, 679. Washington, D.C.,1978, p. 1–8.
7. HAMELIN, P. Les condition temporelles de travail des conducteurs routiers et la sécurité routiere. *Trav. hum*., 1981, 44, No 1, p. 5–21 (in French).
8. BORODINA, S. G. Design of Roadside Facilities by the Roadsides in View of Travelling Safety. Summary of Candidate of Technical Sciences Dissertation (Проектирование сооружений обслуживания на автомобильных дорогах с учетом обеспечения безопасности движения. Автореф. дис ... канд. техн. наук: 05.22.03). Moscow, 1982. 19 p. (in Russsian).
9. ORNATSKIJ, N. P. Organisation of Public Services and Amenities on Motor Roads (Благоустройство автомобильных дорог). Moscow: Transport, 1986. 136 p. (in Russsian).
10. SARDAROV, A. S. Motor Road Architecture (Архитектура автомобильных дорог). Moscow: Transport, 1986. 200 p. (in Russsian).
11. SMIRNOV, J. K. Evaluation of Project Solutions on Two-lane Roads of Health-resorts. Summary of Candidate of Technical Sciences Dissertation (Оценка проектных решений двухполосных курортных автомобильных дорог. Автореф. дис. ... канд. техн. наук: 05.23.14). Moscow, 1987. 19 p. (in Russsian).
12. CHOMIAK, J. V.; GONCHARENKO, F. P.; KOPILEVICH, S. L. Engineering Equipment of Motor Roads (Инженерное оборудование автомобильных дорог). Moscow: Transport, 1990. 232 p. (in Russsian).
13. PETKEVIČIENĖ, B. Improvement of the Functional Design of Lithuanian Motor Roads. *The Geographical Yearbook,* XXXIII (*Geografijos metraštis*), 2000, p. 370–380 (in Lithuanian).
14. PETKEVIČIENĖ, B. Some Regional Aspects of Motor Road Infrastructure Developement. *The Geographical Yearbook,* XXXV (1–2) (*Geografijos metraštis*), 2002, p. 146–153 (in Lithuanian).
15. PETKEVIČIENĖ, B. Geographical Aspects of the Interaction Between the Developement of the Motor Roads Infrastructure and Tourism: Doctoral Thesis (Automobilių kelių infrastruktūros plėtros ir turizmo vystymo sąveikos geografiniai aspektai: Daktaro disertacijos santrauka). Vilnius, 2003. 38 p. (in Lithuanian).
16. PETKEVIČIUS, K.; PETKEVIČIENĖ, B. Geographical Principles of Motor Road Infrastructure Accomodation to Tourism in Lithuania. *The Geografical Yearbook,* XXXVI (2) (*Geografijos metraštis*), 2003, p. 182–191 (in Lithuanian).
17. PETKEVIČIUS, K.; PETKEVIČIENĖ, B. Prospects of Improvement of Roadside Facilities. *Herald of Belarussian National Technical University* (Вестник Белорусского

национального технического университета), No 4, 2004, p. 50–55 (in Russsian).

18. Transport and Communications 2004: Statistical Publication in Lithuanian and English (Transportas ir ryšiai 2004: Statistikos rinkinys lietuvių ir anglų kalbomis). Vilnius, 2005. 156 p.
19. Lithuanian Road Administration (Lietuvos automobilių kelių direkcija). Vilnius, 2005. 24 p. (in Lithuanian).
20. ŠEŠELGIS, K. Environment Protection (Aplinkos apsauga). Vilnius: Mokslas, 1991. 209 p. (in Lithuanian).
21. BAUCHET, P. Les transportes de l'Europe. Paris, 1996. 240 p.
22. CHEVALIER, D. Le transport. Paris, 1997. 276 p.
23. Regulation of Motor Roads STR 2.06.06:2001 (Techninių reikalavimų reglamentas STR 2.06.06:2001. Automobilių keliai). Vilnius, 2001. 80 p. (in Lithuanian).
24. SIVILEVIČIUS, H.; PETKEVIČIUS, K. Regularities of Defect Development in the Asphalt Concrete Road Pavements. *Journal of Civil Engineering and Management*, Vol VIII, No 3, 2002, p. 206–213.
25. BRAGA, A.; ČYGAS, D. Adaptation of Pavement Deterioration Models to Lithuanian Automobile Roads. *Journal of Civil Engineering and Management*, Vol VIII, No 3, 2002, p. 214–220.

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