CLIMATIC REGIONALISM OF LITHUANIAN TERRITORY FROM THE ROAD POINT OF VIEW

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Abstract. Lithuanian climatic, hydro-geological and geological conditions have a large influence on road design, building, repair and maintenance.

Climatic conditions include amplitude and speed of temperature variation, maximum and minimum temperatures, precipitation, wind direction and speed, thickness of snow cover, depth of frozen ground.

In our country, the air temperature is below zero for 3–4 months per year. The longest period of this temperature is in eastern Lithuania, and the shortest period is in western Lithuania. On average, the first snow cover forms from the middle of November and remains until the middle of March. Moreover, in winter thaws are frequent in Lithuania and the temperature fluctuates around zero. There is also high probability of glazed frost, freezing rain and fog.

Instrumental metrological observations were was started in 1770 in the Observatory of Vilnius University. Since meteorological observations in other places of Lithuania were started much later, temperature fluctuations of the last two centuries in Lithuania have been studied according to the observations carried out and being carried out in Vilnius. The temperatures taken in other places of Lithuania closely correlate with the temperatures in Vilnius – r = 0,96…0,98. At present, 21 meteorological stations and 32 posts are in operation in Lithuania, where standard observations are carried out according to the common program: at 03, 06, 09, 12, 15, 18 and 21 h Greenwich Mean Time. Indicators of the air temperature and humidity, precipitation, cloudiness, atmospheric pressure, wind, solar radiation, atmospheric phenomena, snow cover, soil temperature are observed.

In most European countries road weather information systems have been established. The aim of these systems is to reduce the road maintenance costs in winter, to ensure good traffic safety, to inform drivers about poor traffic conditions.

In 1999 Lithuania started to develop the Road Weather Information System (RWIS) based on the meteorological stations located at the roads. The current number of meteorological stations is 45. The main parameters recorded by the RWIS are as follows: air temperature, road surface temperature, subsurface temperature, wind speed and direction, amount and type of precipitation. RWIS collect and store data on extreme changes of the weather conditions on the state road spots mostly impacted by the climate in Lithuania. The road engineer receives all information in a form which enables to use it quickly and take necessary actions. It also enables to collect external data on the weather conditions, which, upon its statistical analysis, can be used for road design, construction, repair and maintenance.

Lithuania territory is regional of meteorological stations by perennial data. This regionalism and data of RWIS system will help to make a Lithuania climatic regionalism from the road point of view.

Introduction

Climatic factors of Lithuania are mostly dependent on geographical location of the territory, solar radiation, air masses movement and the form of terrine. Lithuania is mostly affected by a close neighbourhood of the Baltic Sea and Atlantic Ocean bringing cyclones which determine air temperature variations and precipitation amount. Warming effect of the sea is especially felt on the seashore, getting weaker and weaker eastwards. This is confirmed by the annual amplitude of air temperature – difference between the average temperature of the warmest and coldest temperature of the month. Due to the warming effect of the sea, winters on the seashore are warmer, springs are cooler and autumns are long and warm. The effect of Atlantic Ocean is felt not only on the seashore but also in the whole territory of Lithuania, the climate of which is significantly warmer than of the other continental regions of the same geographical latitudes. In Lithuania the average air temperature in January is almost 10 degrees higher than the average temperature of Middle Russia which belongs to our geographical latitude.

Almost five months per year Lithuanian roads are used under winter conditions; it is true to say that Lithuania belongs to the number of countries experiencing large influences of climatic conditions on road building and maintenance. The main climatic indicators for road maintenance are precipitation, its amount and intensity, number of snowstorms and their duration, air temperature ant the number of its transition over 0 ^{0}C, data on freezing rain.

1. The network of observation stations of the Hydrometeorological Service

Primary meteorological information is the data obtained during the observations of meteorological stations. At present, 21 meteorological stations and 32 posts are in operation in Lithuania, where standard observations are carried out according to the common program: at 03, 06, 09, 12, 15, 18 and 21 h Greenwich Mean Time. Indicators of the air temperature and humidity, precipitation, cloudiness, atmospheric pressure, wind, solar radiation, atmospheric phenomena, snow cover, soil temperature are observed (Statybinė klimatologija 1995). Since 2000 the measurements of frozen ground are being taken in 21 location: in Biržai, Rokiškis, Utena, Ukmergė, Panevėžys, Dotnuva, Šiauliai, Radviliškis, Raseiniai, Telšiai, Tauragė, Šilutė, Vėžaičiai, Kaunas, Trakai, Vilnius, Švenčionys, Kybartai, Marijampolė, Varėna and Lazdijai.

2. Road weather information system (RWIS)

Secondary information obtained on climatic characteristics and weather conditions is data from the Road Weather Information System (RWIS). In 1999 Lithuania started to develop the Road Weather Information System which is based on the meteorological stations installed on the main and national roads. The RWIS allows to measure air temperature and relative humidity, the dew point temperature, number, quantity and type of precipitation, road surface temperature, pavement structure temperature at a depth of 7, 20, 50, 80, 110 and 130 cm, wind direction and speed, visibility, freezing possibility/state and separates data by date, time and stations. It is very important to know a derivative characteristic of these parameters – the number of cycles of the road pavement structure temperature variation over 0 ^{0}C at various depths as well as the total freezing depth. All the obtained data is stored and processed in the data base of the Lithuanian Road Administration under the Ministry of Transport and Communications of the Republic of Lithuania which is added with data several times per year.

The current number of meteorological stations is 45 (Fig. 1) (Laurinavičius *et al.* 2007).

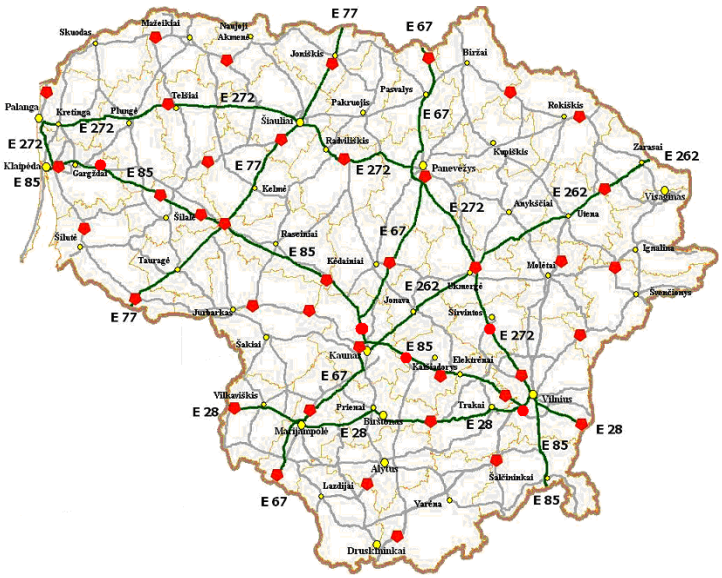

Fig. 1. RWIS stotelių išdėstymas (Laurinavičius *et al.* 2007)

In future the number of meteorological stations should come to 100. In a cold period of the year from 1 November to 31 March data is recorded every 30 min., in a warm period of the year from 1 April to 1 October – every 12 min. This is performed automatically using a data transmission by GSM communications. All the parameters are measured on a continuous basis, every 0,5 s and every selected time interval the average value of the selected parameter is recorded (of most parameters).

3. Regioning of the territory of Lithuania

According to the regularities of hydrothermal regime the whole territory of Eastern Europe is divided into five climatic zones. The territory of Lithuania belongs to the road climatic zone II covering the regions with the characteristic non-snowy winters and frequent thaws, therefore, the most important calculated indices of the Lithuanian road condition are large pavement slippery, migrating moisture and temperature fluctuations from positive to negative – all this makes a large effect on road structures.

Geographical climatic regioning of the territory of Lithuania (Fig. 2, Table 1) is based on the most inherent characteristics of weather conditions. These regions are not related by one or another climatic indicator, for example, temperature, snow cover, precipitation, wind, etc. Therefore, the attempt to divide Lithuanian territory according to climatic factors from the point of view of roads is a must.

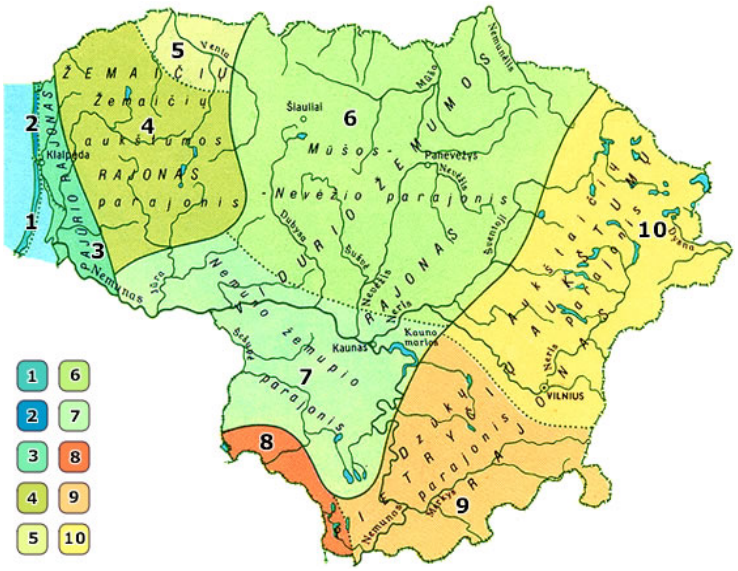

Fig. 2. Regioning of Lithuania by climate (according to K. Kaušyla)

Table 1. Specific features of regions and sub-regions of Lithuania

Region		**Seashore**			**Samogitian (Lower Lithuania)**		**Middle lowland**		**South-eastern highland**		
Sub-regions		**Curronian Spit (1)**	**Seashore (2)**	**Seashore lowland (3)**	**Samogitian highland (4)**	**Venta midstream lowland (5)**	**Mūša – Nevėžis (6)**	**Nemunas lower reaches (7)**	**Sudovia (8)**	**Dzūkija (9)**	**Upper Lithuania (10)**
Thermal conditions (°C)	in summer ΣT>10°	2000-2200	2000	2000 - 2200	1900 - 2000	2000 - 2100	2100 - 2200	2200 - 2300	2100 - 2200	2100 - 2300	2000 - 2200
	in winter T°n(m)*	> -20	> -20	-21 - -22	-22 - -23	-23	-24 - -26	-24	-23 - -24	-24 - -26	-25 - -28
Annual precipitation (mm)		~750	~700	700 - 800	700 - 900	500 - 600	500 - 600	650 - 750	550 - 650	600 - 700	500 - 700
Duration (in days)	with snow cover	75 - 80	65 - 75	75 - 80	90 - 100	80 - 90	80 - 100	70 - 80	80 - 90	85 - 95	100 - 110
	without frost	180 - 190	170 - 180	160 - 170	140 - 150	140 - 150	140 - 160	150 - 160	140 - 150	140 - 150	130 - 150
Main processes causing inter-regional climatic differences		1. Transfer of sea air into the mainland 2. Breeze-type circulation on the coastline			1. Ascent of humid air masses by western highland slopes 2. Effect of local height		1. Adiabatic descent of air masses from adjacent highlands 2. Over-humidity of soils due to a poor water discharge by the flat surface		1. Intensification of turbulent circulation and thermal convection in a more rugged terrain 2. Formation of strong thermal inversions in winter		
* Average minimums of absolute temperature											

Note: Thermal conditions and precipitation amount refers to the period 1961 – 1990, duration of snow cover – 1946 – 1980.

Table 1 gives some peculiarities and differences of the Lithuanian climatic regions and sub-regions. Climatic conditions of the Baltic Seashore region are the most different from the general climatic conditions of the territory. The strong features of coastal climate of this region are analogous to the seashore of Latvia, Kaliningrad district and Poland. Other climatic regions have also their analogues outside the territory of Lithuania. The Middle Lowland region by its climatic conditions is similar to the Middle Latvia, especially Semigallia lowland. The climate of South-eastern highlands region is also characteristic to the adjacent districts of Belarus.

Having processed RWIS data with the Autodesk Land Desktop 3 software it is possible to divide Lithuania into regions from the point of view of roads. Based on the data of RWIS measurements the map was made (Fig. 3) which shows that the lowest depth of frozen ground is found in the Western Lithuania (80-100 cm), the highest – in the South-eastern Lithuania (120-130 cm).

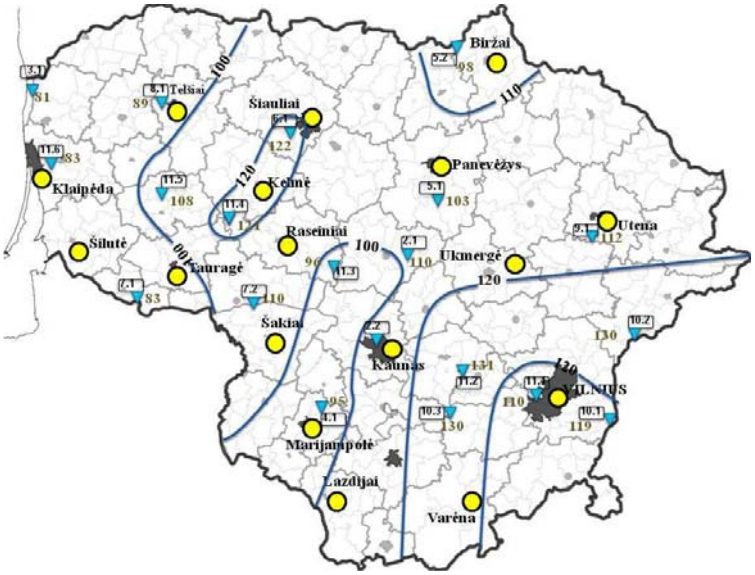

Fig. 3. Distribution of the maximum depth of frozen ground in the territory of Lithuania by RWIS (Juknevičiūtė, Laurinavičius 2008)

The maps on the distribution of the depth of frozen ground according to the data of meteorological stations and of RWIS show that the depth of frozen ground, recorded on the roads and measured in soils, is distributed rather similarly – in the Western Lithuania it is lower, while in the Southern territory of Lithuania – it is higher. We see that according to RWIS the zone of the deepest frozen ground (120-130 cm) covers the larger part of Lithuanian territory – spreading from the Southern part of Lithuania into the South-eastern and Eastern part as well as the Western part of Lithuania around Šiauliai and Kelmė.

A larger depth of frozen ground on the Lithuanian roads could be conditioned by snow cleaning since, when cleaning snow, the surfaces freeze more deep.

The largest number of freezing cycles of road surface (Fig. 4) according to RWIS data could be observed in the South-eastern part of Lithuania (up to 100 times in a cold season).

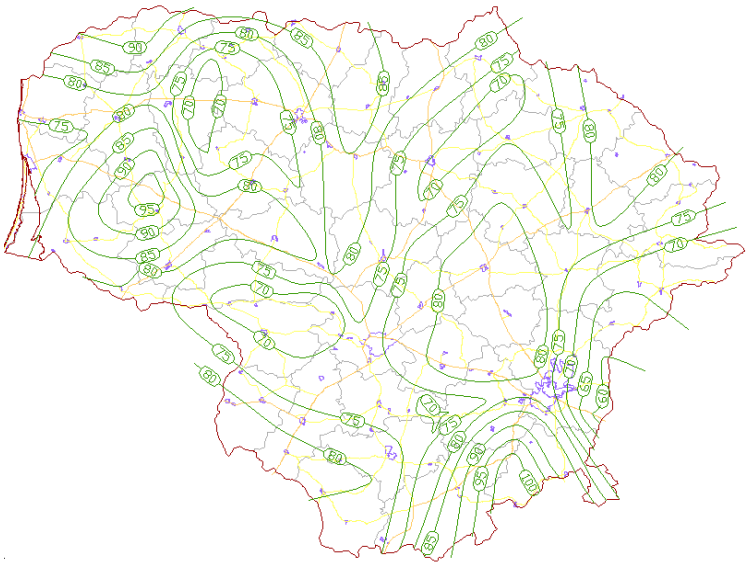

Fig. 4. The map of the number of freezing cycles of road pavement surface according to the average RWIS data of the cold seasons

Conclusions

1. The temperature of air and road pavement recorded by special sensors is important for a technological process of road building and winter maintenance, wind direction and speed – for winter road maintenance (to protect roads from blocking up with snow), depth of frozen ground – for the design of road pavement structures, the number of temperature transition cycles over 0 ^{0}C – for forecasting defects in the road pavement structures, etc.

2. The created special database of RWIS-recorded parameters allows us to analyze the accumulated data and to use it for road design, construction, repair and maintenance.

3. Geographical climatic regioning of the territory of Lithuania is based on the most inherent characteristics of weather conditions. These regions are not related by one or another climatic indicator, for example, temperature, snow cover, precipitation, wind, etc. Therefore, the attempt to divide Lithuanian territory according to climatic factors from the point of view of roads is a must.

4. In order to protect to the best of one's ability Lithuanian roads from blocking up with snow in winter period when predicting the road sections likely to be blocked up with snow it is recommended to use the "roses" of wind direction and speed created by the database for different Lithuanian regions.

5. Data from the map of the number of freezing cycles of road pavement surface in the territory of Lithuania is recommended to be used when forecasting defects in the road pavement structures.

Investigation of climatic regioning from the point of view of roads has been continued and in future the more comprehensive and accurate data will be presented.

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