ISSN 1822-427X print
ISSN 1822-4288 online

THE BALTIC JOURNAL
OF ROAD AND BRIDGE ENGINEERING

http://www.bjrbe.vgtu.lt

2006, Vol I, No 4, 167–175

ROAD CLIMATOLOGY: DETERMINATION OF CALCULATED VALUES OF METEOROLOGICAL CHARACTERISTICS

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Abstract. Practically all the road-related questions are solved with the consideration of climatic factors. Besides, the meteorological characteristics of the region, where the road objects are located, are taken into account, as well as their calculated values. This paper describes a methodology for determining these values. The examples are given on how to calculate the main meteorological characteristics of the percentage of integral probability, which are used in designing, constructing and maintaining roads.

Keywords: climatology, meteorology, solar radiation, air temperature, atmospheric precipitation, snow cover, fog, wind, cloudiness, meteorological information.

1. Introduction

Climatology is a science based on the observation data of many years and focused on the mean values. Besides, the statistical methods are widely used for processing data from weather stations, which are collected continuously according to an established system.

Climatology is mainly influenced by the dislocation of weather stations, type and character of installations and devices to be used, a long-term and uninterrupted operation under stable conditions. For generalisation of data of observations the statistical data processing methods (method of average values) are widely used and up-to-date estimation systems.

Based on the observation data of weather stations, the average values of many years are calculated as well as their recurrence by month of the indicated meteorological elements.

The main idea of the method is to achieve a full comparability of the calculated average and other data. This is the background for all the methods of calculation and the use of average values of many years, reduction of observation results to the same level and to the same period of time, etc. Data, having been systemised by this method, is mapped and further serves for climatological generalisation. Table 1 gives the levels of processing meteorological information [1].

When designing, conctructing and maintaining roads, it is necessary to solve various tasks, taking into account climatic indicators, which could be divided into 3 groups: indicators of temporary structure, non-periodic changes and complex evaluation of meteorological elements.

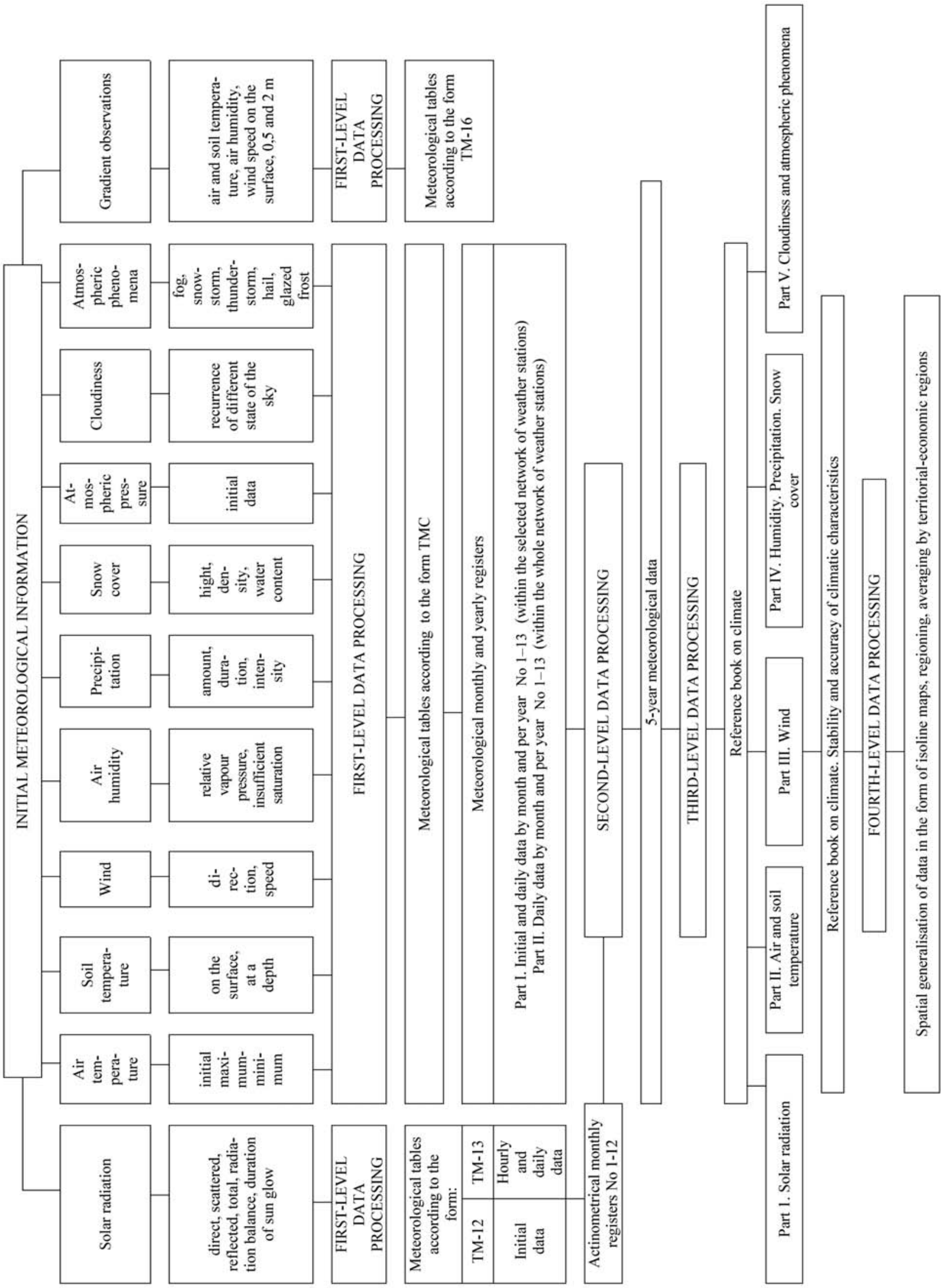
2. The main meteorological characteristics

In order to identify climatic features of a certain locality, the meterological characteristics are used [2], the probability of which is determined by the methods of mathematical statistics. Depending on the purpose, the calculated indicators of one or another characteristic could be assumed with a different probability, related to their influence on certain objects and the processes of road infrastructure [3].

1. Indicators of temporary structure – periodical changes of the element in time, ie daily (24 hours), ten-day, monthly and annual changes of parameters, characterised by the amplitude and the moment of occurance of extreme and other values of the element (by the average data and recurrence).

2. Indicators of non-periodic changes of the element, interrelation between the series, daily variability, continuous

Table 1. The levels of processing meteorological information



duration of the element values above or below the given level – correlation coefficient between the neighbouring members of a series; average value of daily changes; root-mean-square deviation of daily changes; average continuous duration of the values above or below the given value (level); number of periods of continuous duration of the values above (below) the given level; recurrence and accumulated recurrence of different values of continuous duration above (below) the given level.

3. Indicators of complex evaluation of meteorological elements – recurrence and accumulated recurrence of combination of values of the constituent elements; correlation coefficient of the constituent elements; correlation ratio.

All the main meteorological indicators are of a probability origin; therefore, the methods of mathematical statistics are used for their determination, ie to determine [4]:

- recurrence of different values of the element;
- accumulated recurrence;
- average mathematical value;
- boundary (maximum, minimum) values;
- variability indicators;
- indicators of asymmetry and kurtosis of a distribution curve.

Road organisations have to apply different meteorological indicators, which sometimes must be considered in road design, technological and organisational works. The following indicators [5] could be used for the determination of:

solar radiation – the level of solar radiation; the level of solar radiation of the given accumulated recurrence; slope angle of the locality (of a study surface) in relation to the Sun rays; geographical latitude;

air temperature – average air temperature; average daily temperature; average monthly temperature; average yearly temperature; average temperature of many years; average temperature of the coldest period of the year; average maximum temperature of the hottest month; average amplitude of daily temperature flunctuations, absolute maximum; absolute minimum; dew point; duration of a period with an average daily temperature of more than t °C; duration of a period with an average monthly temperature of less than t °C; average duration of temperature of different gradiuation; average temperature of a period with an average monthly temperature of less than t °C; vertical gradient of temperature; number of days with the temperature transition across 0 °C;

soil (pavement) temperature – soil temperature on the surface; soil temperature at a depth h; depth of zero isotherm; maximum depth of zero isotherm; average yearly soil temperature; capacity of a seasonaly frozen soil layer;

wind impact – prevailing wind direction; average wind speed; dynamic pressure; velocity head;

air humidity – vapour pressure; absolute humidity; specific humidity; relative humidity; deficit of humidity of the given accumulated recurrence; intensity of water evaporation; duration of the period of water evaporation; dew point;

atmospheric precipitation – average amount of precipitation; amount of precipitation in a number of days with the precipitation of more than h MM; average rain intensity; number of rains of n-percent of accumulated recurrence; duration of precipitation of n-percent of accumulated recurrence;

snow cover effect – height of snow cover; average ten-day height of snow cover; snow cover lying duration;

atmospheric pressure – force, acting on a unit of horizontal surface (mm Hg; Pa; mb); dynamic pressure;

fog – physical conditions of formation; synoptical conditions of formation; recurrence of fogs; aggregation state of water drops and ice pellets; temperature distribution in fog; water content in fog;

cloudiness – microstructure of clouds; water content of clouds; height to a lower boundary; vertical extent; amount of clouds;

other atmospheric phenomena – average number of days with a thunderstorm; average number of days with snowstorm; transparence of atmosphere (coefficient); meteorological range of horizontal visibility.

Specific features in interpreting and estimating numerical values of meteorological characteristics will be described in the examples below.

Solar radiation (MJ/m^2) depends on a geographical position of a study locality, time of the year and cloudiness. Solar radiation is direct, scattered and total. It is determined on horizontal and vertical surface, also on a vertical surface of a corresponding orientation (southern, south-western, south-eastern, eastern, western, northern, north-western, north-eastern).

Data on solar radiation and radiation balance are presented in the reference books on climate and were obtained on the basis of actinometrical observations.

The complex of actinometrical observations includes measurements of direct and scattered radiation on an active surface; radiation, reflected from an active surface; radiation balance of this surface. Active surface is the surface of soil, water and vegetation which directly absorbs solar and atmospheric radiation and removes emission into the atmosphere. Solar radiation, getting on an active surface in the form of a bundle of parallel rays, sent out directly by the Sun, is called direct solar radiation. Actinometrical stations measure a direct solar radiation, getting on the surface S, perpendicular to the Sun rays.

The amount of direct solar radiation, getting on a horizontal surface S, depends on the solar altitude above the horizon and can be obtained from the relation:

$$S' = S \times \sin h_{\Theta}, \quad (1)$$

where h_{Θ} – angle of solar altitude above the horizon.

Part of solar radiation, getting on an active surface of the Earth from all points of the vault of heaven after scattering into the atmosphere is called scattered radiation *D*. Actinometrical stations measure a scattered solar radiation, which gets on a horizontal surface.

Direct and scattered radiation belongs to a short-wave part of the spectrum (with the wave length from 0,17 to 4 μm). In fact, the Earth's surface is reached by the rays with the wave length from 0,29 μm.

Total amount of solar radiation on a horizontal surface, consisting of direct and scattered radiation, is called total radiation *Q*:

$$Q = S' + D\,. \tag{2}$$

The intensities and sums of radiation are related to a horizontal surface or the surface perpendicular to the Sun rays. Based on this data it is possible to estimate the intensities and sums of direct radiation, and approximately – the sums of scattered and total radiation, getting on the vertical and sloping surfaces of any orientation.

Direct radiation on a vertical and sloping surface is estimated by the following formula:

$$S_V = S \times \cos h_\Theta \times \cos(A_\Theta - A); \tag{3}$$

$$S_{Sl} = S_E \times \sin\alpha + S'\cos\alpha\,, \tag{4}$$

where S_V – direct solar radiation, getting on a vertical surface; S_{Sl} – direct solar radiation, getting on a sloping surface (S_V and S_{Sl} have the same azimuth); *S* – direct solar radiation, getting on the surface perpendicular to the Sun rays; S' – direct solar radiation, getting on a horizontal surface; h_Θ – solar altitude; A_Θ – azimuth of the Sun; *A* – azimuth of the normal to a vertical surface; α – steepness of slope.

3. Practical methods for estimating the values of meteorological characteristics

The level of solar radiation of the given accumulated recurrence is determined according to the data of many years for a certain month or a certain locality. For example, in order to estimate maximum total radiation of 5 % accumulated recurrence, it is necessary to carry out sampling of 30–50 years period. Data is arranged in a descending order (Table 2).

Table 2. Estimation of maximum total radiation

Maximum solar radiation, MJ/m^2	Ordinal number	Maximum solar radiation, MJ/m^2	Ordinal number
750	1	…	…
748	2	620	45
745	3	618	46
730	4	615	47
728	5	611	48
725	6	609	49
…	…	602	50

Maximum solar radiation is approximated up to 5 MJ/m^2 and an average ordinal number is determined:

750	1,5	…	…
745	3	620	45,5
730	4,5	615	47
725	6	610	48,50
…	…	600	50

Integral probability is defined by the following formula:

$$P = 1 - \frac{m_a - 0{,}3}{n + 0{,}4}\,, \tag{5}$$

where m_a – average ordinal number; *n* – number of the members of a series.

In the result:

$P_{1,5} = 0{,}98$ ...

$P_3 = 0{,}95$ $P_{45,5} = 0{,}10$

$P_{4,5} = 0{,}92$ $P_{47} = 0{,}07$

$P_8 = 0{,}89$ $P_{48,5} = 0{,}04$

... $P_{50} = 0{,}01$

Using these data it is possible to construct a graph, based on which the unknown value is determined:

$$P_{5\%} = 610 \text{ MJ/m}^2\,.$$

Average daily air temperature is determined as the average arithmetical value based on systematic measurements of temperature in the weather stations, which are carried out every 3 hours (in 0; 3; 6; 9 etc).

Example. The following data were determined when measuring the air temperature in the weather station N: 10; 10,1; 10,2; 12,3; 14,5; 16,2; 14,1; 11,4.

Based on this data, the average daily temperature is:

$$T_{da} = \frac{\sum T_h}{n} = \frac{98{,}8}{8} = 12{,}4 \text{ °C}.$$

Average monthly air temperature is determined as the average arithmetical value based on the average daily temperatures.

In the weather station „Minsk" the following average daily temperatures were determined in April:

5,3	6,3	5,9	4,3	5,3	3,8	7,6	6,4	6,9	5,2
5,6	4,8	6,1	6,0	5,8	6,5	7,9	4,6	5,6	4,3
7,4	6,6	7,0	5,4	5,6	4,9	6,2	6,1	4,8	8,1

Average monthly temperature is:

$$T_{\mathrm{ma}} = \frac{\sum_{i-1}^{30} T_{\mathrm{da}}}{30} = \frac{176{,}3}{30} = 5{,}91 \ \ ^\circ\mathrm{C}.$$

Average annual air temperature is determined as the average arithmetical value based on the average monthly or average daily temperatures [6].

Example. Average monthly air temperature in Gomel region is: – 6,9; – 6,3; – 1,8; 6,3; 13,7; 16,9; 18,6; 17,4; 12,5; 6,4; 0,6; – 4,3.

In this case the average annual temperature:

$$T_{\mathrm{ya}} = \frac{\sum_{t=1}^{12} T_{\mathrm{ma}}}{12} = \frac{73{,}4}{12} = 6{,}1 \ \ ^\circ\mathrm{C}.$$

Air temperature of the coldest day. The coldest days in a study period (ten-day period, month, year) are those the temperature of which has the average arithmetical variable of a minimum value.

Thus, in the example of average monthly air temperature, the temperature of the coldest day (6 April) was equal to 3,8 °C.

Analogically, air temperature of the warmest day is defined. In the above example 30 April was equal to 8,1 °C.

Absolute maximum (minimum) of air temperature.

The absolute maximum (minimum) is the highest (the lowest) temperature, measured within a study period of time. The average of annual absolute maximum (minimum) is defined as the arithmetic mean in a number of years.

Probability of the temperature below or above the absolute minimum (maximum) is determined when dividing the number of the members of a series, outside a study interval, by the total number of the members of a series.

Data on the weather conditions in the town of Minsk, based on observations of many years, is given in Table 3.

Air temperature of the coldest day and of the coldest five-day period in a long-time duration.

Based on the data of monthly weather observations, the sampling is carried out of the temperature of the coldest day and the coldest five-day period in 30–50 years. Table 4 gives the summary data in a descending order.

Then, the temperature approximation is carried out to an accuracy of 0,5 °C. Each value is given an average ordinal number. In this example:

Table 4. Data on the temperature of the coldest day and the coldest five-day period

The coldest day		The coldest five-day period	
temperature, °C	ordinal number	temperature, °C	ordinal number
– 33,2	1	– 28,5	1
– 33,1	2	– 26,2	2
– 32,4	3	– 26,0	3
…	…	…	…
– 13,0	28	– 12,4	28
– 13,1	29	– 10,3	29
– 12,4	30	– 10,1	30

– 33,0	–	1	– 28,5	–	1
– 32,0	–	2	– 26,0	–	2
– 32,5	–	3	– 26,0	–	3
…	–	…	…	–	…
– 13,0	–	28	– 12,5	–	28
– 13,0	–	29	– 10,0	–	29
– 12,5	–	30	– 10,0	–	30

Integral probability is estimated by the formula (5).

Integral probability is:

$$P = 1 - \frac{1{,}5 - 0{,}3}{30 + 0{,}4} = 0{,}96 \qquad P = 1 - \frac{1{,}0 - 0{,}3}{30 + 0{,}4} = 0{,}98$$

$$P = 1 - \frac{3{,}0 - 0{,}3}{30 + 0{,}4} = 0{,}91 \qquad P = 1 - \frac{2{,}5 - 0{,}3}{30 + 0{,}4} = 0{,}93$$

... ...

$$P = 1 - \frac{28{,}5 - 0{,}3}{30 + 0{,}4} = 0{,}07 \qquad P = 1 - \frac{28{,}0 - 0{,}3}{30 + 0{,}4} = 0{,}09$$

$$P = 1 - \frac{30 - 0{,}3}{30 + 0{,}4} = 0{,}02 \qquad P = 1 - \frac{29{,}5 - 0{,}3}{30 + 0{,}4} = 0{,}04$$

Based on the obtained data, integral curves are plotted in logarithmic coordinates (on the ordinate – logarithmic scale of air temperature, on the abscissa – double logarithmic scale of integral probability) (Fig 1).

Based on the curve of integral probability, the temperature of the coldest day and the coldest five-day period of the given integral probability is identified.

Average duration of air temperature of different gradation.

Table 3. Probability of the temperature below or above the absolute minimum

Absolute maximum, °C	≥ 28	≥ 29	≥ 30	≥ 31	≥ 32	≥ 33	≥ 34
Probability, %	95	90	75	50	25	10	5
Absolute minimum, °C	≥ (–36)	≥ (–33)	≥ (–30)	≥ (–27)	≥ (–25)	≥ (–21)	≥ (–20)
Probability, %	5	10	25	50	75	90	95

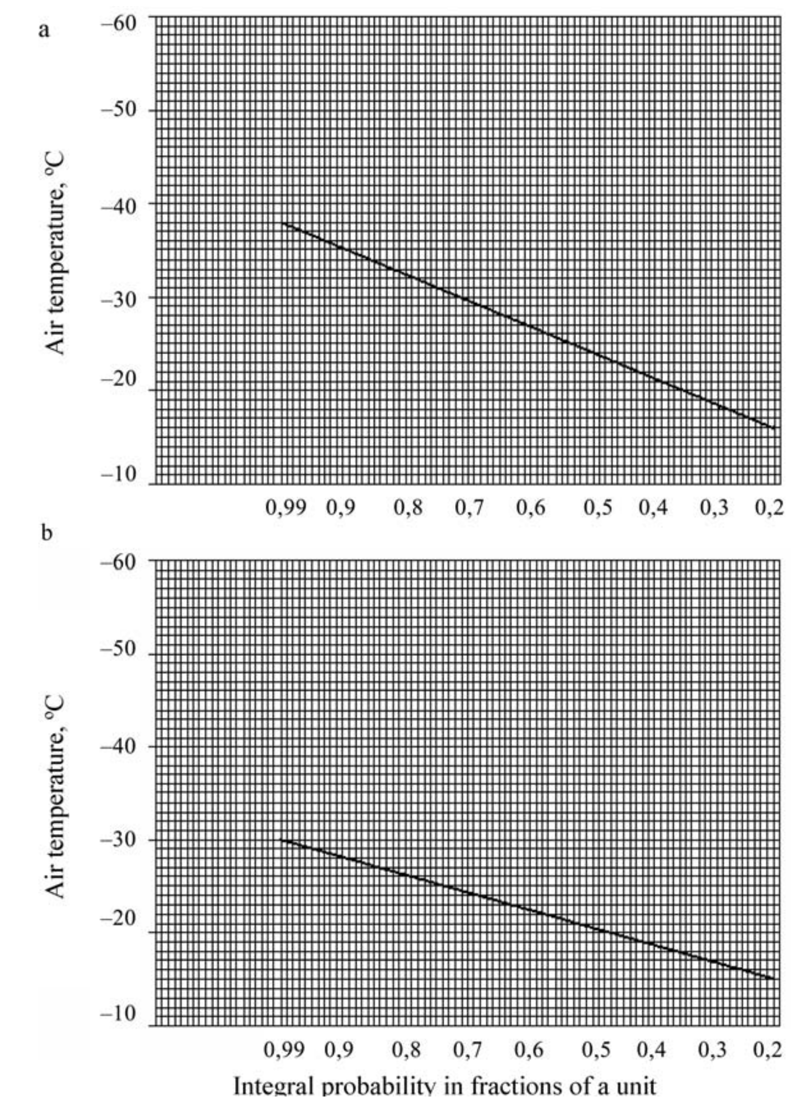


Fig 1. Integral curves of air temperature: a – of the coldest day; b – of the coldest five-day period

Initial information is the air temperature of a certain day of observations (usually – starting from 0 hour and further – every 3 hours).

Data on the average duration of air temperature of different gradation is a statistical set of numerical values of air temperature t_i in the form of statistical distribution. It is included into the group of numerical values of air temperature according to certain gradations (mid-gradation $t_1, t_2, ..., t_k$) and calculation of absolute ($m_1, m_2, ..., m_k$) and relative ($P_1, P_2, ..., P_k$) frequency of each temperature gradation.

Absolute frequency is a number of cases when the air temperature values get into one or another gradation, and $\sum m_i = n$, ie equal to the number of observations. A relative frequency of gradation is expressed by the ratio $P_i = \frac{m_i}{n_i}$, and $\sum P_i = 1$.

Statistical set in the form of distribution enables to get the first view on the main regularities of air temperature regime of many years, the most frequent values of air temperature and the range of its changes.

Accumulation of frequency is obtained by summarising absolute or relative frequencies. The expression of accumulated frequencies, at the number of gradations k, is:

not more than t_i: not less than t_i:

$$m \le t_i = \sum_1^i m_j, \qquad m \ge t_i = \sum_1^k m_j, \tag{6}$$

$$P \le t_i = \sum_1^l m_j, \qquad P \ge t_i = \sum_1^i P_j. \tag{7}$$

Sometimes the accumulated relative frequencies are calculated by using a sorted series (when the numerical values of the members of a series are arranged in a descending or ascending order) by the following formula:

$$D \le t \ = m_i(n+1) \ , \tag{8}$$

where m_i – ordinal number of the member of a series; n – statistical series.

Example. The following data were obtained as the result of air temperature observations:

t	0	5	10	15	20	25	30	
recurrence m_i	4	6	8	12	15	10	5	Σ60

Absolute frequencies in this case will correspondingly be equal to 4, 6, 8 etc. Their sum will make 60.

Relative frequencies will be obtained from the expression $P_i = m_i/n$. In the given example:

$P_0 = 4/60 = 0{,}06$; $P_{20} = 15/60 = 0{,}25$;
$P_5 = 6/60 = 0{,}10$; $P_{25} = 10/60 = 0{,}17$;
$P_{10} = 8/60 = 0{,}14$; $P_{30} = 5/60 = 0{,}08$;
$P_{15} = 12/60 = 0{,}20$; $\Sigma P_i = 0{,}06 + 0{,}10 + \ldots + 0{,}08 = 1{,}00$.

Accumulated frequencies in this case can be presented as:

Absolute frequency $m = 18$ of temperature $t < 15$ °C;
$m = 5$ of temperature $t > 25$ °C;
Relative frequency $P = 0{,}3$ of temperature $t < 15$ °C;
$P = 0{,}08$ of temperature $t > 25$ °C.

Relative frequency of the temperature change from 10 to 25 °C makes $P = 0{,}62$.

Number of days with the temperature transition across 0 °C. Air temperature measurements with maximal and minimal thermometers enable to record its extreme values, ie the highest and the lowest temperature. If the maximum temperature is positive and the minimum – negative, a transition of air temperature across 0 °C takes place.

The settled average daily temperature being subzero, the fact of temperature transition into a positive area shows the period of a warmer weather. And, on the contrary, the average daily temperature being positive, the appearance of negative temperatures on a minimal thermometer shows the frost.

Temperature transition across 0 °C makes a negative effect on road pavement condition; sometimes the road construction works are impossible under such conditions.

Calculated air temperature of an integral probability. The calculated air temperature is necessary to be known when defining an optimum size of road slabs, their longitudinal stability, the depth of thawing of road bases etc. Depending on a concrete task, the calculated temperature is usually selected from the list of temperatures, presented in the reference books on climate. The list gives the average monthly, average annual, absolute maximum and minimum, average maximum air temperatures of the hottest month of the year, also the temperature with 0,92 and 0,98 integral probability for the coldest day and the coldest five-day period and the average temperature of the coldest period in different sites of a locality.

Calculated temperature must be assumed as maximum (minimum) air temperature of the study month of the year within the study period of a service-life of the object. In case of road pavement with the calculated service-life of n years, the integral probability of the calculated air temperature p is assumed as $n^{-1} \cdot 100$ %.

In order to solve the task of this formulation, the calculated maximum (minimum) air temperature of the day, having the integral probability p %, $t_{a\,p\%}^{\max\,(\min)}$, can be assumed as being equal to the sum of the average maximum (average minimum) air temperature and the standardised positive (negative) addition to it $\pm\Delta t_{a\,p\%}$:

$$t_{a\,p\%}^{\max\,(\min)} = t_{a\,p\%}^{\max\,(\min)} \pm \Delta t_{a\,p\%} \, . \tag{9}$$

In this formula the sign "+" is assumed for the determination of maximum, the sign "–" – minimum daily air temperature of p % integral probability.

Temperature designations are given in the list below: t_a – air temperature; t_{ma} – average monthly air temperature; A_{ma} – average monthly amplitude of air temperature; $t_{a\,mid}^{\max\,(\min)}$ – average maximum (average minimum); $\Delta t_{a\,\mathrm{mid}}^{\max\,(\min)}$ – average temperature deviation from $t_{a\,mid}^{\max\,(\min)}$; $t_{a\,i}^{\max\,(\min)}$ – i-number of temperature deviation from $t_{a\,mid}^{\max\,(\min)}$; $t_{a\,\mathrm{abs}}^{\max\,(\min)}$ – absolute maximum (minimum); $\Delta t_{a\,p\%}$ – standardised (positive or negative) temperature addition to $t_{a\,mid}^{\max\,(\min)}$; $t_{a\,p\%}^{\max\,(\min)}$ – the calculated air temperature of integral probability p %.

A calculation scheme, corresponding to the real observations, is given in Fig 2 together with the necessary explanations.

In fact, in order to solve this task, it is necessary to find out the regularity of deviation of the calculated temperatures from the average temperatures of many years – average maximum or average minimum temperatures. Also, it is assumed that the process of temperature changes with respect to their average maximum (average minimum) values is random, stationary and ergodic. Solving this task, the regularity of temperature random deviations of one month of the year is the same as of this month in all years of service-life; therefore, there is no necessity to consider it when calculating variations of average monthly temperatures in different years.

In the above formula the parameter $t_{a\,mid}^{\max\,(\min)}$ is assumed according to the reference data and, in case if it is absent, it is determined by the following equality:

$$t_{a\,mid}^{\max\,(\min)} = t_{ma} \pm \frac{1}{2} A_{ma} \, . \tag{10}$$

The check of this equality for the objects, situated

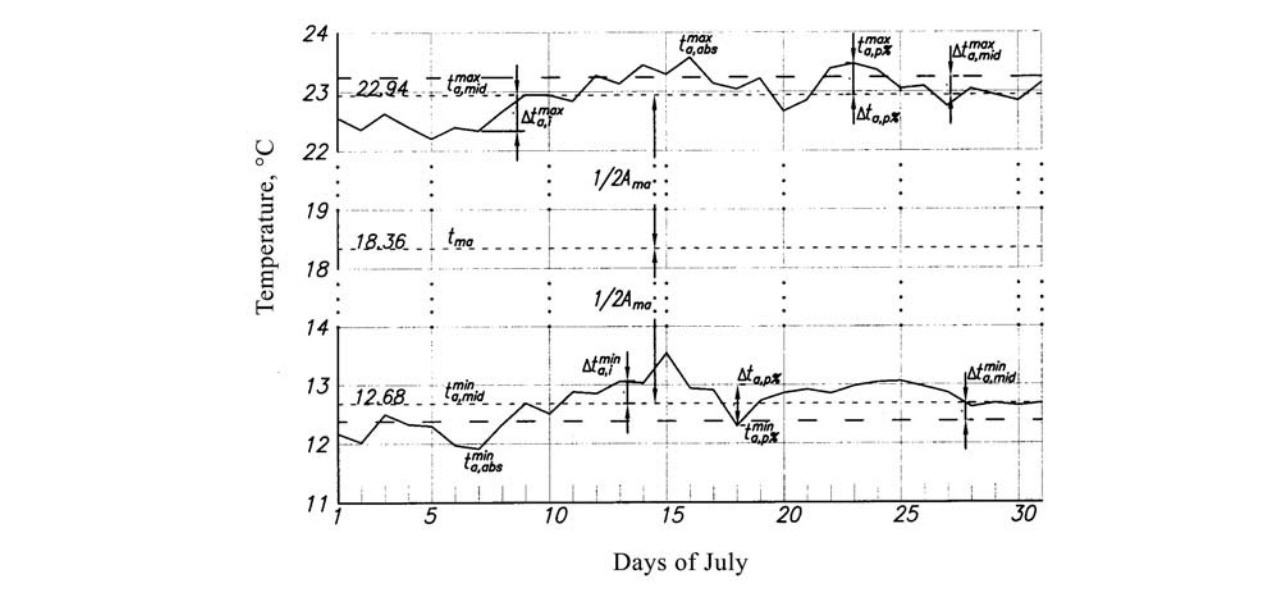


Fig 2. Monthly variation of maximum and minimum daily air temperature in the town of Minsk (July 2004). Calculation scheme for determining the air temperature with the integral probability p %

under different environmental-climatic conditions, showed that its accuracy ranges within the limits of the decimal fractions of a degree. When using data from СНиП 2.01.01-82 and other reference books on climate, the parameters $t_{a\,mid}^{\max\,(\min)}$, t_{ma} and $\frac{1}{2}A_{ma}$ must be assumed for the same month of the year in every case, taking into consideration that July is not necessarily the hottest month.

Depth of a zero isotherm. With the help of extended termometers, which are located at a depth of 20, 40, 80, 160 and 320 cm from the Earth's surface, the soil temperature is determined every day. It is assumed that the temperature changes uniformly according to the depth. A zero isotherm is determined by a linear interpolation method.

For example, during a usual measurement it was defined that the temperature at a depth of $h_{20} = -5$ °C, at a depth of $h_{40} = -3$ °C. The task is to determine the depth of a zero isotherm.

Let's make a relationship:

$$\frac{|t_{20}|}{x} = \frac{|t_{40}|}{20 - x}. \tag{11}$$

It follows that

$$x = \frac{20 \cdot t_{20}}{t_{40} + t_{20}} = \frac{20 \cdot 5}{3 + 5} = 12{,}5.$$

The depth of a zero isotherm is:

$$h_o = 20 + 12{,}5 = 32{,}5 \text{ cm}.$$

Analogically, the depth of a zero isotherm per month or per year is determined. Average values of many years are estimated on the basis of the yearly data. Besides the average values of temperature 0 °C penetration in soil or ground, the highest and the lowest values are selected from the whole number of observations.

Height and duration of a snow cover [7]. Height of a snow cover is determined by two criteria: the average biggest ten-day height and the biggest from the biggest ten-day height. The average biggest ten-day height of a snow cover of the winter is estimated as the average arithmetic value of the biggest ten-day values in every year of observations, irrespective of the month and of a ten-day period of its occurence.

Duration of a snow cover – is a time interval from the date of formation of a stable snow cover until its destruction. However, a stable snow cover is that which lies for 30 days period with the breaks of no more than 3 days one after another; a destroyed snow cover is the cover when less than 60 % (less than 6 points) of the locality is covered with snow.

Wind speed is determined at a 10–12 m height and at a distance from the surrounding objects equal to 10–20 times height. A measuring interval is set according to Regulations for the Weather Stations (1965) 8 times per day. All the calculations are carried out as average arithmetical, average daily, average monthly, average yearly and average of many years.

Recurrence of wind speed is calculated as a ratio between the number of winds of a given gradation and the total number of the values recorded. Gradation is usually assumed as:

0–1	6–7	12–13	18–20
2–3	8–9	14–15	21–24
4–5	10–11	16–17	

Actual values are approximated according to this gradation, by the rules of approximation.

Recurrence could be calculated for the different hour of the day and also as the average daily, average monthly, average yearly and average of many years.

Continuous duration of the wind of different speed (number of gradations) is determined on the basis of meteorological observations. Gradation of speeds can be different, but mostly with the intervals: 0–1, 2–5, 6–9, 10–13, 14–17 etc.

Gradation of wind duration is: 1–5, 6–10, 11–15, 16–20, 21–24, 25–36, 37–48, 49–72, >72.

Recurrence of various wind directions and calm weather (in percent) is determined for a certain time (average monthly, average of a certain hour of the day per month, average yearly etc.) Reccurence in all these cases will be a ratio between of the number of occurences of the given gradation and the total number of the members of a study series. Wind is classified according to F. Beaufort.

Air humidity. The following variables are used to characterise the air humidity in a different hour of the day and to calculate average, maximum and minimum values in a certain period: water vapour pressure, relative humidity, shortage of saturation etc. Like for any other meteorological elements, it is possible to calculate average arithmetic values, to determine extreme values (maximum and minimum) and recurrence of one or another value.

Range of visibility. Day and night visibility is distinguished. Range of day visibility – limited distance at which a remote object becomes inseparable from the surrounding background (sizes to be visible). Range of light visibility – the distance at which a dotted luminous source of a certain force sizes is percepted by a human eye.

Meteorological range of horizontal visibility in a daytime is defined according to the formula:

$$S_m = \frac{1}{\alpha} \ln \frac{K_o}{\varepsilon}, \qquad (12)$$

where α – indicator of reduced visibility per length unit; K_o – initial contrast between the object and the background; ε – indistinguished with a human eye, relative difference between the brightness of a sufficiently large object and the background ($\varepsilon \approx 0{,}02$).

Resistance to the air-space. A moving vehicle falls under the effect of an air-space. Aerodynamic force of resistance can simply be expressed by the following formula:

$$W_p = CS\frac{\rho v^2}{2}, \qquad (13)$$

where C – coefficient of aerodynamic force (of any resistance), depending on the shape of vehicle and smoothness of its surface; S – frontal surface of the vehicle, m^2; v – driving speed with respect to the air, m/s; ρ – air tightness, kg/m^3.

When solving the other engineering tasks, where meteorological characteristics should be taken into consideration, the other type of data could be necessary. In order to obtain this data, it is purposeful to use the fundamental theories of meteorological analysis and statistics.

4. Conclusions

1. A proper decision in the field of road design, construction and maintenance could be made in case if the whole set of meteorological characteristics of a given region is taken into consideration.

2. Meteorological characteristics, even for one region, usually varies within the significant limits; therefore, their calculated value could be determined on the basis of observation data of many years, processed by the methods of mathematical statistics.

3. The methods of mathematical statistics should be necessarily used for processing information, effectively collected in the road weather stations, the network of which has been expanded every year.

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Submitted 24 Sept 2006; accepted 4 Dec 2006