Field research of the ice regime of the Karasuk River in the Novosibirsk region

Fomicheva Nyailya Nikolaevna
Candidate of Technical Sciences, Associate Professor
Siberian State University of Water Transport
Vasilenko Dmitriy Sergeevich
Student
Siberian State University of Water Transport

Abstract. The article presents data from field studies of the ice regime of the Karasuk River in Novosibirsk region: the results of measurements of the thickness of the ice cover, snow on ice, and air temperature. The data on the strength of winter ice obtained from the compression tests of specimens are also given, and the structure of the ice is described.

Keywords. Ice regime, congestion, ice thickness, ice strength, ice structure.

Ice phenomena on the rivers: congestions, gales are classified as hazardous hydrological phenomena. In Western Siberia, catastrophic floods occur mainly during the spring flood, when ice jams occur. In order to take proactive measures to prevent or reduce the risk and damage from such natural phenomena, it is necessary to draw up long-term and short-term forecasts. This problem can be solved only by relying on an extensive database for monitoring certain hazardous phenomena [1]. Today, mathematical models of the development of unfavorable events are being drawn up. But they also require specific initial data for the sections under consideration [2].

The sources of the initial data are both systematic observations of the ice regime and expeditionary field work in individual sections of the river.

The impact of ice on hydraulic structures (bridges, piers, etc.) is associated with the study of the dynamic impact of ice masses. The force of the impact of a moving ice field can be determined by the formula [1]:

$$P = k_{ср} \cdot \sigma_{л} b t_{л}, \text{ mH}, \quad (1)$$

where $k_{ср}$ – structure aspect ratio;

σ_c – compressive strength of ice, MPa;

b – width of the structure, m;

$t_л$ – ice field thickness, m.

For structures of a sloping type, knowledge of the ultimate strength of ice during bending will be required. This issue has been studied in detail and is reflected in the literature [3,4,5].

The purpose of this work is to conduct field studies of the ice regime on the Karasuk River, Novosibirsk region.

The tasks include: measuring the increase in the thickness of the ice cover and assessing the influence of meteorological conditions on this process; compressive strength testing of ice samples; study of the structure of winter ice.

Table 1 shows the results of measurements of the increase in the thickness of the ice cover on the Karasuk River. The measurements were carried out at different points: near the bank and in the middle of the river, while the measurement points were coordinated. Measurements of the thickness of the snow on the ice were also carried out. To assess the influence of meteorological factors on the formation of the ice cover, the air temperature was measured.

Table 1 – Results of field studies to measure the thickness of ice and snow cover on the Karasuk River in 2020–2021.

Indicators / Date		19.12. 2020	06.01. 2021	16.01. 2021	31.01. 2021	14.02. 2021	23.02. 2021	06.03. 2021	14.03. 2021
h_{ice}, cm	middle	29.5	34.0	51.0	55.0	56.0	65.0	87.0	70.0
	by the coast	25.0	45.0	41.0	51.0	52.0	52.0	78.0	45.0
h_{snow}, cm	middle	6.0	16.0	15.0	12.5	11.5	17.0	11.0	15.5
	by the coast	13.5	40.0	24.0	27.0	30.0	30.0	14.0	43.0

The increase in the thickness of the ice cover is shown in fig. 1.

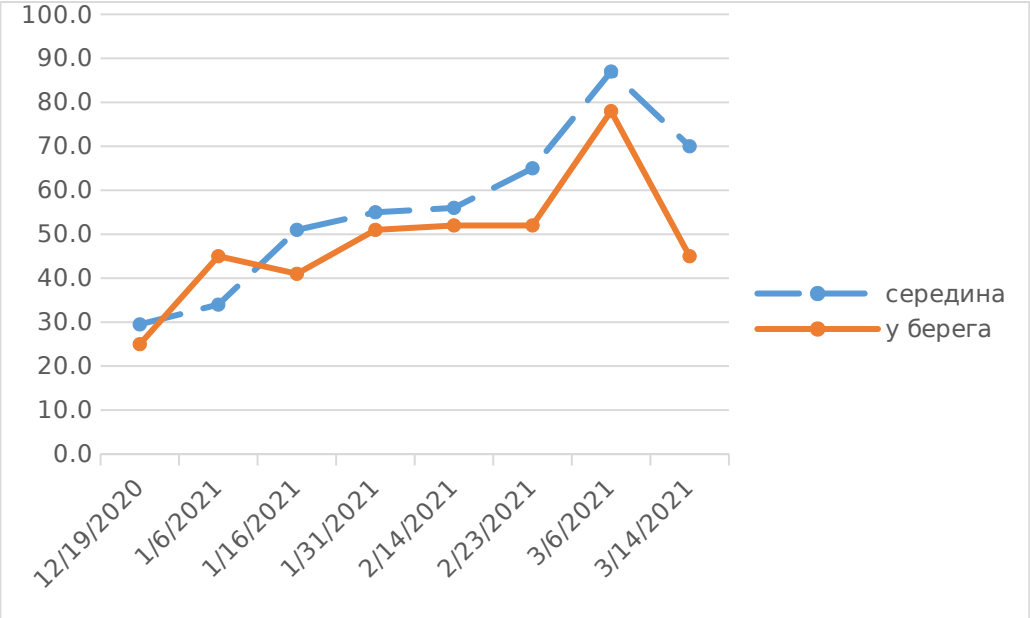

Fig. 1. Ice thickness at the coast and in the middle of the course of the Karasuk River

Figure 2 shows the course of air temperature during the period of field studies.

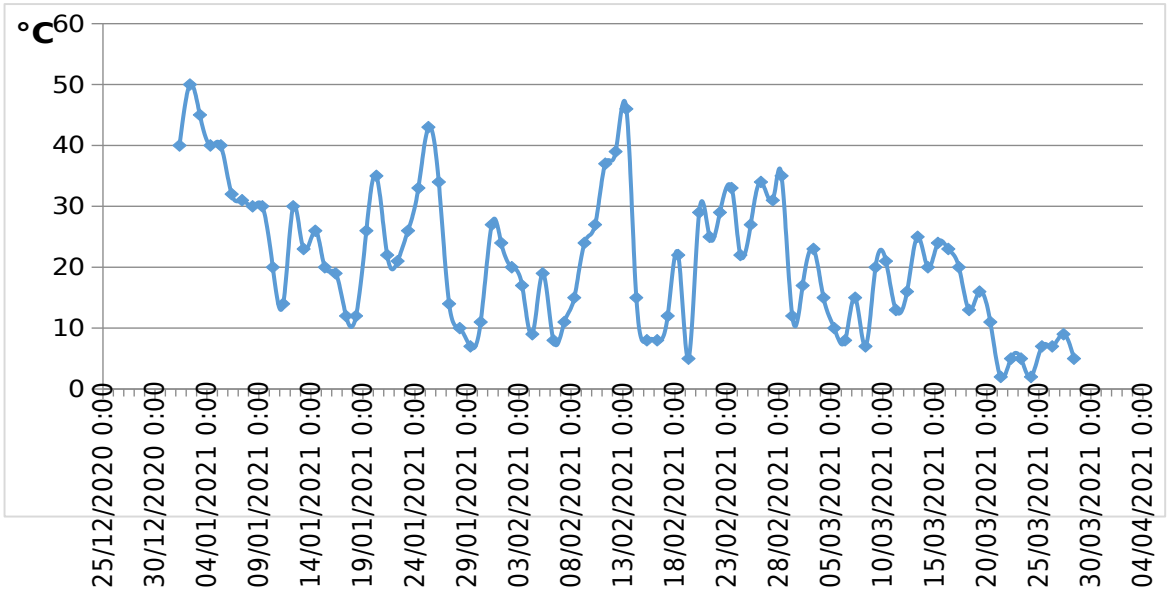

Fig. 2. Graph of air temperature changes in the study area

The intensity of the increase in the thickness of the ice cover, as can be seen from the above results, is on average: for points near the coastal strip - 0.70 cm/day; for the middle flow - 0.76 cm/day.

The structure of the river ice cover is shown in fig. 3. The sample has a non-uniform structure. The upper layer is snow ice of about 10 cm, then dense water ice (90 cm) and the lower layer is turbid with inclusions of solid particles and significant roughness at the base. For comparison, the ice structure of the Novosibirsk reservoir is shown [4].

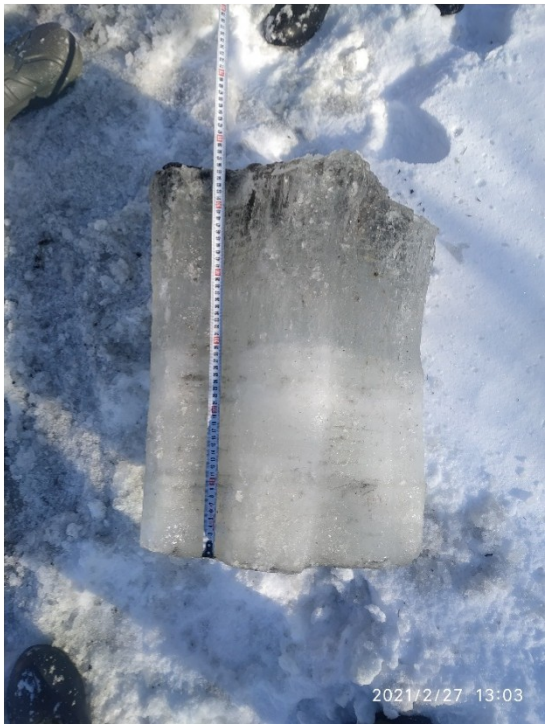

Fig. 3. Structure of winter ice of the Karasuk river

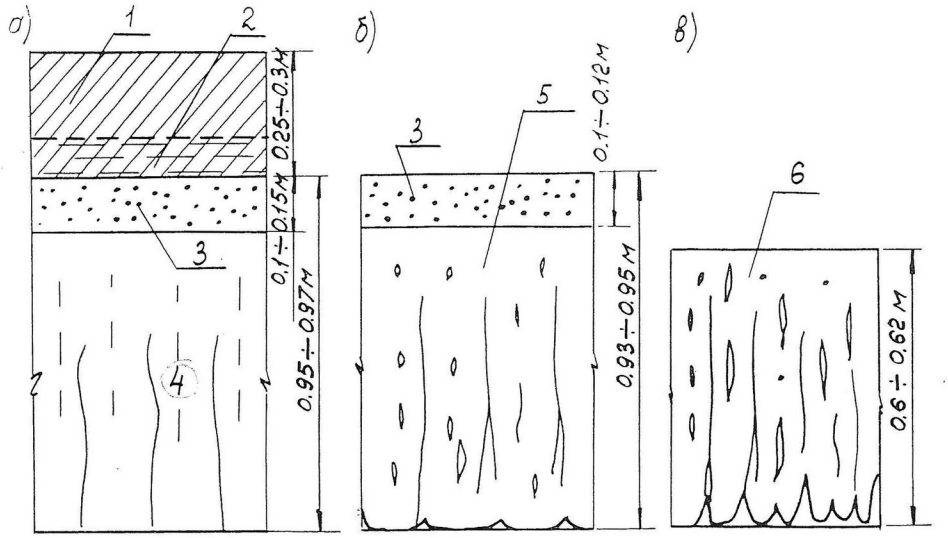

Fig. 4. Ice structure of the Novosibirsk reservoir in the area of the willage Borovoe

a) 4.04.82, b) 11.04.82, c) 15.04.82

1 – snow; 2 – water; 3 – cloudy ice; 4 – transparent ice; 5 – transparent ice with bubbles air; 6 – transparent ice with vertical channels filled with water

Strength tests of ice samples were carried out on a P-125 hydraulic press (fig. 5). The samples were 10x10 cm in size and were cut from different layers of ice. The results obtained are shown in Table 2.

Table 2. Results of testing samples for strength

№ of the sample	1	2	3	4	5
Compressive strength, MPa	2.76	3.88	2.35	1.41	1.64

Fig. 5. Test of ice cubes for strength

The table shows that the strongest is water ice, which is located at a depth of 10-30 cm from the surface.

Research results and analysis of literature data [3] allow for the approximate period from compressive strength to tensile strength in bending to recommend the graphs shown in fig. 6.

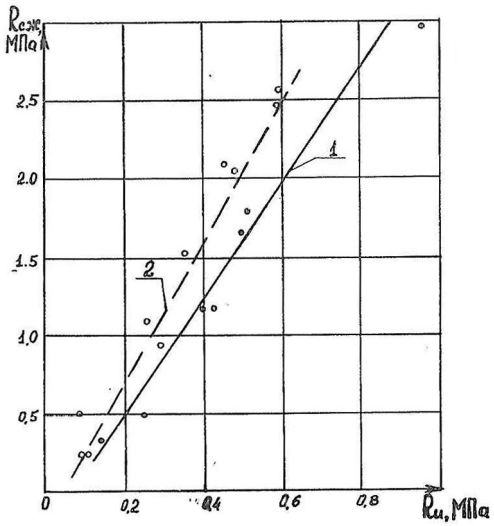

Fig. 6. Averaged graphs of the relationship between the tensile strength in bending of cantilever specimens and the compressive strength obtained when testing specimens with a size of 8x8x8 cm^3: 1 – winter ice; 2 – spring ice

Conclusions:

1. Full-scale studies of the increase in the thickness of the ice cover of the Karasuk River in the Kochkovsky region of Novosibirsk region in the winter period of 2020-2021 have been carried out.

2. The results show the intensity of the increase in the thickness of the ice cover, which is 0.70-0.76 cm/day.
3. Compression tests of ice cover samples were carried out. The ultimate strength was 1.4÷3.9 MPa for various layers of winter ice.

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