Engineering surveys for the rebuilding of culverts considering construction requirements

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Abstract. The main stage of the survey is a field survey as a result of which a decision is made on the need for reconstruction work. The object of the study is culverts on the section of the Ust-Ishim-Zagvazdino highway, which runs along the River Irtysh. During the inspection, defects in the culverts were identified and decisions were made for reconstruction. Calculations of the new pipe diameter were carried out and modern materials were selected.

1 Introduction

A highway is a complex of complex engineering structures that ensure safe and comfortable movement of vehicles.

All year round, roads are exposed to numerous natural and climatic factors (snow, fog, surface and ground water, etc.) which must be taken into account during design, construction and reconstruction. A mandatory stage in the preparation of project documentation is carrying out survey work. The types of surveys carried out are selected depending on the technical specifications and characteristics of the objects.

Engineering and hydrometeorological surveys should ensure the study of the hydrological and meteorological conditions of the construction or reconstruction area to obtain materials on the hydrology of land, seas and river mouths and materials on meteorology and climatology, as well as to assess possible changes in the hydrometeorological conditions of the territory and water area under the influence of the construction and operation of the projected structures [1-3].

2 Problem statement

The object of the study is a section of the Ust-Ishim-Zagvazdino highway, which runs along the River Irtysh in the northwest of the city of Omsk. The section of the road under consideration runs along the left side of the Irtysh River catchment area at a distance of 1.3 - 3.9 km from the edge. The reconstructed section of the highway crosses 3 watercourses along its length; all watercourses are temporary watercourses and are represented by runoff hollows (Figure 1). To pass water from the territory under consideration, pipes of various diameters are provided in the body of the road.

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The type of groundwater regime in the culvert area is riverine; in the approaches and areas for concentrated soil reserves, it is terraced. The level regime of groundwater in the riverine zone is hydraulically related to fluctuations in water in the river and depends on the water level in the river. The average annual amplitude of level fluctuations is 1.2 m on average.

The maximum predicted level position is expected during periods of high water, spring snowmelt and heavy rainfall. The groundwater level during the maximum period, considering the seasonal adjustment (August - 1.4 m) to the measured level.

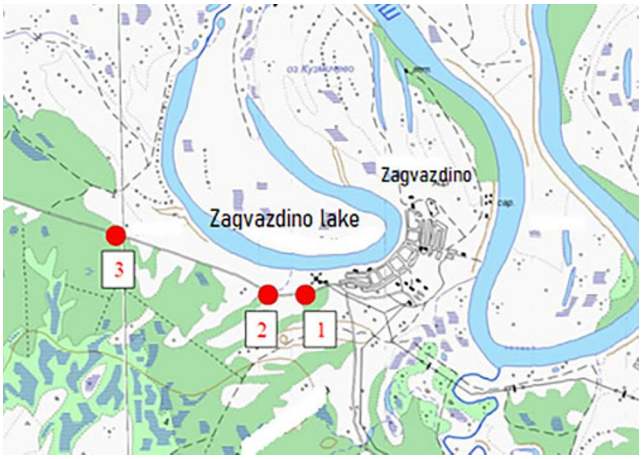

Fig. 1. Survey site diagram.

Information about watercourses crossed by the reconstructed section of the road is given in Table 1.

Table 1. Morphometric characteristics.

Watercourse, site	Length of watercourse from source, km	Square catchment area, km^2
1 - drainage depression km 56+850	0.6	1.04
2 - drainage depression km 57+460	1.1	5.27
3 - drainage depression km 59+780	1.4	4.44

All watercourses belong to the Irtysh River basin and, in general, are in the same physical and geographical conditions. The area under consideration is located in a forest zone, most of the catchment area is swampy [4,5].

3 Materials and methods

The main stage of the research is a field survey, as a result of which a decision is made on the need for reconstruction. The information obtained is also used when performing the required calculations, selecting the type and size of reconstructed structures [6-8].

3.1 Culvert at 56+850 km

The designed highway route crosses a hollow, the flow from which downstream acquires a pronounced bed of a b/n stream flowing into Lake Zagvozdinskoye. The hollow is a

depression with a flat overgrown bottom, mainly shrubs and herbaceous vegetation. The width of the valley at the entrance at the top is 15 - 25 m, the height of the slopes is up to 1 m. At the entrance to the pipe, the hollow is not pronounced, with standing water in the depressions. At the exit from the pipe, the hollow is cut in and takes on pronounced shapes. The width of the hollow at the top is 15 - 25 m, the slopes are moderately steep, 2 - 3 m high. To pass runoff from the territory through the highway, a steel pipe with a diameter of 500 m is laid in its body. There are no portal walls at the entrance and exit, destruction of the road slopes is observed. The outlet head of the pipe is littered with debris and branches, and deformation of the culvert is observed. The general condition of the pipe is unsatisfactory (Figure 2).

Fig. 2. Culvert at 56+850 km.

Fig. 3. Culvert at 57+460 km.

Fig. 4. Culvert at 59+780 km.

3.2 Culvert at 57+460 km

Within the survey area, the hollow above the road is flat, poorly traced, and is a depression with a slight slope, smoothly turning into the adjacent area. The depression is swampy, at the time of the survey there was standing water above and below the road, there was no drainage through the pipe at the time of the survey. Below the road, the hollow is relatively flat, slightly incised. The vegetation on the site is represented mainly by shrubs and dense moisture-loving herbaceous vegetation. In this section, a steel pipe with a diameter of 1200 mm was laid across the highway. The pipe has no portal walls. The inlet and outlet heads are cluttered and

destroyed. There are gullies on the side of the road (Figure 3). The general condition of the pipe is unsatisfactory.

3.3 Culvert at 59+780 km

In this section, the highway route crosses a drainage depression, which is a weakly expressed, flat, swampy depression, with a slight slope of the terrain. Visually, the hollow as such is not visible, overgrown with forest. A culvert with a diameter of 800 mm is laid in the body of the road (Figure 4). Above and below the highway on the site in depressions there is standing water. The pipe has no portal walls, the inlet and outlet ends are not cluttered or blocked. The inside of the pipe is silted. The general condition of the pipe is unsatisfactory.

According to the data obtained, the studied culverts need reconstruction. During the inspection of the structures, the following defects were identified: erosion of the road embankment slopes, lack of strengthening of the road embankment slopes, mechanical damage to culverts [9-11].

4 Results and discussion

As a result of mechanical damage to culverts, it is necessary to calculate a new pipe diameter and select modern materials.

The diameter of the pipelines is selected based on the results of calculations of the pipes' capacity to operate under various hydrological conditions.

The minimum design diameter of pipes is determined by the equation:

$$d_p = [\left(\frac{Q}{\theta g^{0.5}}\right)]^{0.4,M}$$

where Q – estimated flow rate, m^3/sec., $\theta g^{0.5}$ - flow rate considering gravity acceleration.

The estimated Q water flow was determined based on the maximum annual flow data for the studied watercourses. The maximum calculated flow rates are observed during the spring flood period and are recommended for use in design. The calculation results are shown in Table 2.

Table 2. Estimated maximum water flows.

Watercourse, site	Maximum water flow, m^3/s				
	provision, %				
	1	2	3	5	10
1 drainage basin 56+850 km	1.73	1.43	1.29	1.14	0.90
2 drainage depression 57+460 km	3.56	2.95	2.66	2.27	1.71
3 drainage depression 59+780 km	2.33	1.93	1.73	1.48	1.12

The calculated flow rate for determining the minimum diameter is taken to be the flow rate of the wettest year (1% of the supply).

The results of calculating pipe diameters are given in Table 3.

Table 3. Culvert diameters.

Settlement area	Estimated flow rate, m^3/sec	Pipe diameter, mm
1 drainage basin 56+850 km	1.73	1300
2 drainage depression 57+460 km	3.56	1700
3 drainage depression 59+780 km	2.33	1500

The diameter of the pipes is designed to allow flow through during the spring flood period.

5 Conclusion

To replace destroyed culverts in all study areas, it is recommended to use corrugated pipes with a corrugation of 130x32.5 mm (without an inlet head with a cut perpendicular to the axis of the pipe, with a smooth tray along the bottom, occupying ⅓ of the inner perimeter of the pipe, thickness = 0.05 m with a slope it = 0.01), which are currently widely used in transport construction.

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