DIMENSIONAL INSPECTION OF BRIDGES BY USING THE LIMNIMETRIC KEY

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ABSTRACT. Designing and building a bridge requires caring out hydraulic calculations, in this respect, topographical, hydrological, geotechnical studies and forecast data on riverbed and water levels being necessary.
Bridges are located, if possible, in a stable and straight portion of the river, avoiding confluence or ramification areas, and, if necessary, corrections to stabilize the riverbed will be taken into consideration.
Sizing bridges is performed in a manner that allows maintaining the capacity to evacuate large amounts of water, by avoiding the emergence of hydraulic resistance.
According to effective national legislation for surface water crossings (bridges, pipelines, power lines etc.) acquiring permits from Romanian Waters National Administration is required, in order to ensure minimum height of the over crossing.
This requires some calculations concerning water flows, areas of different flow sections and hydraulic radius to obtain the limnimetric key using the graphic representation of the relation between water levels and flows for a given section.
To this end, the article aims to analyze the dimensional variation of water's free surface as well as the variation of flow section as to avoid the dangers of hydraulic overload which may occur in case of floods or high flows.

Keywords: water level, limnimetric key, over crossing, hydraulic radius

ПРОВЕРКА НА РАЗМЕРИТЕ НА МОСТОВЕ ЧРЕЗ ИЗПОЛЗВАНЕТО НА ЛИМНОМЕТРИЧЕН КЛЮЧ

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РЕЗЮМЕ. Проектирането и изграждането на мост изисква извършването на хидравлични изчисления, а също така топографски, хидроложки и геотехнически проучвания и прогнозни данни за нивото на водата в речното корито.
При възможност мостовете се разполагат на стабилен и прав участък от реката, като се избягват места на сливане или разклоняване на реки и при необходимост се правят корекции на речното корито за неговото стабилизиране.
Оразмеряването на мостове се прави така, че да осигурява възможност за пропускане на големи количества вода като се избягва появата на хидравлично съпротивление.
Съгласно действащото национално законодателство за наземни водни трасета (мостове, тръбопроводи, електропроводи и др.) е необходимо разрешение от Националната водна администрация на Румъния, за да се осигури минималната височина на наземното трасе.
Необходимо е да бъдат направени изчисления за водните потоци, участъците с различни водни потоци и хидравличния радиус, за да бъде получен лимнометричен ключ чрез използването на графично представяне на връзката между водните нива и потоци в даден участък.
За тази цел докладът цели да анализира вариациите в размерите на свободната водна повърхност, както и вариациите на потоците, за да се избегне опасността от хидравлично претоварване, което може да възникне при наводнения или високи води.

Ключови думи: водно ниво, лимнометричен ключ, наземно трасе, хидравличен радиус

Introduction

Preserving, protecting and improving the aquatic environment in terms of sustainable use of water resources, is based on the principles of precaution, prevention, avoiding damage at source and the polluter pays and must take into account the vulnerability of aquatic ecosystems, as their equilibrium is strongly influenced by the quality of waters.

Main legislation governing the technical aspects of changes to national water bodies are: Law of water no. 107/1996 amended and updated, Decision no. 352/2005 amending and supplementing Government Decision no. 188/2002 for approving rules on conditions for discharge wastewater into the aquatic environment and the Order 799/2012 approving the normative content of the technical documentation required to obtain the water management permit / authorization.

The technical documentation required for obtaining the water management permit makes provisions for measures and work necessary to ensure functioning of existing or under development water usage which could be directly affected by works envisaged such as: water intakes, waste water discharges or bridges and other crossings.

Items needed to compile the technical documentation required for obtaining the water management permit

Issuing permits and authorizations for water management is made on the basis of technical documents whose content must comply with the legal requirements and may be performed only by individuals and legal entities authorized by the Ministry of Environment and Forests, according to the Order 799/2012.

The technical documentation for categories of works performed on watercourses contains the following:

- Water crossing importance class and category, characteristic calculation flow along with the corresponding calculation flows and thalweg levels;
- Hydraulic calculation of surface water crossings outlets;
- Measures to ensure interdependent functioning with ballasts located on the water;
- Works proposed for stabilizing the riverbed in conjunction with existing or projected regularization works;
- Safety measures for securing works to be achieved in high water conditions;
- Longitudinal profile of the studied sector route, indicating the natural ground line, the route's red line, the thalweg of crossed beds;
- Riverbed transversal profile in the crossing area which will include bed thalweg, maximum levels and any aggradations caused by the proposed work;
- Hydraulic and constructive parameters including the lowest superstructure level, maximum water levels in section and connection works (access ramps, routed dams, bank consolidations, etc.)

Case study

Exposition of hydraulic and construction parameters regarding the vehicle access bridge

The team within the Laboratory of Environmental Protection has conducted several activities of compiling documents regarding the acquirement of water management permit / authorization for bridges having vehicle access.

The current paper presents the case study of a bridge made on creek Maleia of Petrosani, for which a series of calculations targeting water flows, areas of different flow sections, as well as hydraulic radius to obtain the limnimetric key were performed.

Characteristic hydraulic and constructive parameters of the bridge in the study are:

- benchmark right bank abutment: 494.60m;
- benchmark left bank abutment: 494.60m;
- right bank / left bank level: 500.37m;
- Water surface level: 497.65m;
- NAE 5% elevation: 498.77m;
- bridge red line level: 500.55m;
- Bridge width: 7.5m;
- Minimum level of superstructure soffit (beam level): 499.70m;
- Total length of the bridge: 11.40m;
- Headroom under the bridge: 2.08m;
- width of minor bed next to the bridge: 7.80m.

On Maleia creek, in the vicinity of the car access bridge, there are no power lines and / or telecommunications cables crossings.

The calculation flow level, riverbed thalweg, immersing depth, water surface, elevation of the superstructure at its most low, the maximum levels of water in section and the connection work is presented in figure 1 (INSEMEX, 2010).

Results and discussions

The extrapolation method using the limnimetric key was applied to estimate the water flow in riverbeds.

According to this method, when the flow measurements do not cover the entire difference of levels that occurred in the period under review, it is necessary to extend limnimetric keys to extreme levels produced both at high waters and shallow waters (Mănescu, 2012).

Choosing the limnimetric key extrapolation method depends on bed shape, size of the observed distance error, the wanted precision and quantity and quality of available material.

One of the extrapolation methods applied uses Chezy's formula (Pişota, 2005). Extrapolation is based on specific parameters: Ω (section), R (hydraulic radius), I (slope) and n (roughness).

Chezy formula was used to obtain the limnimetric key for hydraulic calculations performed:

$$Q = \frac{\Omega \cdot R^{2/3} \cdot I^{1/2}}{n} \quad [mc/s]$$

where:

Q –calculated water flow, mc/s;
Ω – considered cross section area, mp;
R – hydraulic radius;
I – river slope, ‰;
N – roughness coefficient.

The river slope was measured by topographic elevations in 6 points situated upstream and downstream of the bridge.

Through processing data obtained in the field and those presented by literature with reference to hydraulic calculation, values shown in the table 1 were yield.

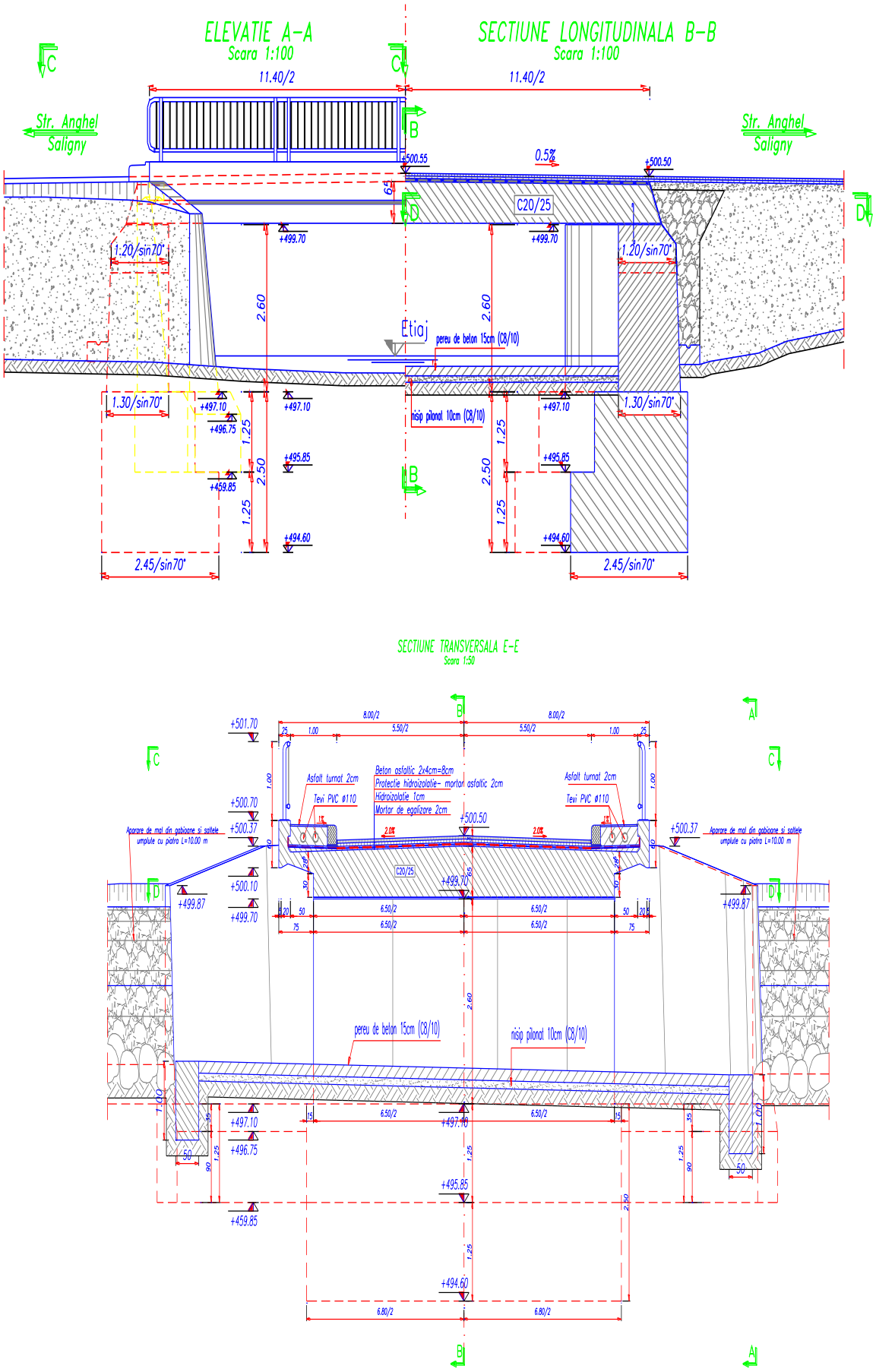

Fig.1. Construction parameters of the car access bridge

Table 1.
Parameters obtained for measuring the dependence between water height and debits

Heights	Areas	Wet perimeter	Hydraulic radius	R^2/3	Slope	Slope^ 1/2	Roughness	Speed	Flow rate
0	0	4,79	0	0	0,019	0,13784	0,04	0	0
0,3	2,358	9,41	0,250	0,39746	0,019	0,13784	0,04	1,369681	3,229709
0,6	5,064	10,01	0,505	0,63490	0,019	0,13784	0,04	2,187878	11,07942
0,9	7,782	10,61	0,733	0,8133	0,019	0,13784	0,04	2,802640	21,81015
1,2	10,51	11,21	0,937	0,95804	0,019	0,13784	0,04	3,301439	34,70473
1,5	13,25	11,81	1,122	1,07993	0,019	0,13784	0,04	3,721472	49,3244
1,8	16,00	12,41	1,289	1,18492	0,019	0,13784	0,04	4,083277	65,36103
2,1	18,77	13,01	1,442	1,27689	0,019	0,13784	0,04	4,400198	82,60053
2,2	19,824	13,23	1,4984	1,309446	0,019	0,13784	0,04	4,512367	89,45317

The results obtained are shown in table 2 and the plotting is shown in figure 2.

Table 2.
Coordinates for the limnimetrical key

h [m]	0	0,3	0,6	0,9	1,2	1,5	1,8	2,1	2,2	1,25
Q [mc/s]	0	3,2297	11,079	21,810	34,704	49,324	65,361	82,600	89,453	40

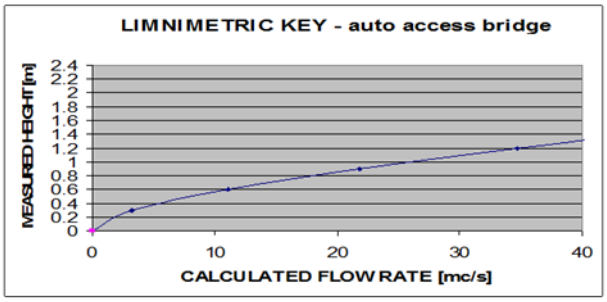

Fig. 2. Limnimetric key

Conclusions

NRDI INSEMEX developed documentations in accordance with the frame content of Order 799/2012 approving the Norms content of the technical documentation necessary for obtaining the water management permit and water management authorization.

Hydraulic calculation for the minimum bridge height was carried out for the maximum flow rate of 40 mc /s with 5% exceeding probability, data provided by the Jiu Craiova Water Department. Distance from thalweg to NAE 5% elevation is 1.15 m. The distance between the bridge beams and NAE 5% elevation is 0.93 m, meeting the safety requirements at maximum flows.

After obtaining the limnimetric key we can conclude that the designed bridge height corresponds to a flow rate of 40 m^3 / s and in case of floods, the bridge over Maleia creek can intake the full amount of water without being structurally affected.

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Recommended for publication by Editorial board.