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WORKING DESIGN

Amendment under Art. 154 according to the Spatial Development Act

SITE: "INCREASE OF THE HYDRAULIC CONDUCTIVITY OF R. TSAPAREVSKA ON THE TERRITORY OF THE VILLAGE OF MIKREVO, MUNICIPALITY. FLOWED BY INNOVATIVE METHODS FOR WATER MANAGEMENT (GEOCELLS)"

ASSIGNOR: MUNICIPALITY OF STRUMYANI

CONTRACTOR: GEOCONSTRUKT LTD.

PART: HYDROTECHNICAL AND CONSTRUCTIVE

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1. INTRODUCTION

The project development updates the project originally prepared in 2016. The Assignor provided a cadastral basis with regulatory boundaries and a geodetic basis reflecting the condition of the riverbed and the banks of the Tsaparevska River in the regulation of the village of Mikrevo. The aim of the project is to ensure the trouble-free conduct of high waters by cleaning the riverbed and designing flexible correction measures on both banks of the river in the regulation of the village of Mikrevo. In the spring of 2013, the high waters of the Tsaparevska River caused a partial excavation of the slopes of the river banks. In combination with the deposition of large dragged sediments on the bottom, the high waters have caused an emergency situation with the danger of flooding residential buildings in the lower part of the village. After the fall of the waters, the bottom and the banks are not cleaned and strengthened, which does not guarantee the conduct of further high waters. It is necessary to clean individual areas along the riverbed from large sediments, to perform appropriate re-mowing and to strengthen the slopes.

This project was developed at the request of the Contracting Authority - Municipality of Strumyani and based on the need for changes in the originally adopted and approved project in 2017 . The Assignor provided a cadastral basis with regulatory boundaries and a geodetic basis reflecting the condition of the riverbed and the banks of the Tsaparevska River in the regulation of the village of Mikrevo. After comparison with the initially prepared project documentation, it was established that the regulatory boundaries for the Tsaparevska riverbed are reduced in size and route, which partially does not coincide with the existing position of the riverbed and requires the formation of a new riverbed and dikes. The aim of the project is to ensure the trouble-free conduct of high waters by cleaning the riverbed and designing flexible correction measures on both banks of the river in the regulation of the village of Mikrevo.

After excavation in the contour of the regulatory boundaries, it was established that along the new route there is the presence of heavy earth soils - alluvial deposits represented by boulders and large gravels with sandy aggregate. Alluvial deposits established on site are a good ground base for foundation facilities. The bearing capacity of the alluvial deposits significantly exceeds that of the sandy-clay materials on the banks of the old river route. This allows to reduce the height of the geocellular system without risking compromising it. The change in the route also requires a change in the planned construction and installation works, as the main problems are imposed by the presence of a significant amount of boulders that need to be removed, several increases in embankment materials and several reductions in excavation materials. This requires the supply of suitable material for the construction of the fence dikes and the supply of material for filling the geocellular system.

The site is the first category according to art. 137 of the Spatial Development Act, Ordinance 1, Art. 2 §7.

2. HYDROLOGICAL DATA FOR THE TSEPAREVSKA RIVER IN THE PART OF THE VILLAGE OF MIKREVO

The Tsaparevska River is a right tributary of the Struma River and flows into it below the village of Mikrevo. It collects its waters from the southeastern slopes of the Malishevska Mountain, starting below Golak Peak (1538.7 meters). About 2 km below the village of Tseparevo, the river receives its left main tributary, the Goremska River.

The area of the catchment area near the village of Mikrevo is F = 76 km^2. The parameters of the river flow are given in the table below.

№	Parameters	Unit	Value	Secured p=50%	Secured p=75%
1	2	3	4	5	6
1	Catchment area	km2	76,0		
2	Average altitude	m	964,0		
3	Outflow module	1/sec/km2	9,0	9,0	6,4
4	Outflow rate	1/sec		684	486
5	Coefficient of variation	-	0,5	0,5	0,5
6	Average year water mass	mil. m2		21.5	15.3
7	High water 1% security	m3	48		
8	High water 1% security	m3	27		

For the purposes of the project it is essential to determine the high waters, authoritative for the sizing of the correctional flexible systems of the Tsaparevska River.

In the specific case for the correction in the settlement according to the norms for the sizing of the correction of the high waters it is performed for carrying out Q1,0% = 48m3 / s.

3. HYDRAULIC SIZING OF THE HIGH WATER CONDUCTING CROSS SECTION

Hydraulic models and analyzes

• Initially, the capacity of characteristic sections of the river route in the studied section was determined;

• Hydraulic model selected - 2D model

• Topographic data - data describing the shape of the riverbed and the adjacent flood terraces. This information is represented by photographed cross-sections, together with information about their location along the river.

• Information on the location of existing hydro-technical facilities and elements of the technical infrastructure along the river and data on their geometry.

- Selection of roughness coefficient, after analysis of the morphological characteristics and grain size of the bottom in the section for the area of the main river bed (bottom of the gorge) and for the area of the river terrace (slopes of the gorge).

For the needs of the project, design solutions have been developed to increase the permeability of the gorge section and at the same time to prevent the removal of particles from the bottom and the surrounding terrains (slopes) in the studied area. Where necessary, measures are envisaged for the construction of hydraulic facilities along the river in the section provided for correction. The structure of the project development follows established in the practice of the company "Geoconstruct" Ltd., in solving such tasks, sequence:

Calculations of allowable speeds in the trough. The calculations are in accordance with the characteristic shapes along the route (zones of vorticity, removal and accumulation), flow velocities and particle size;

If necessary, sizing of the facilities for strengthening the banks, which according to the specific geotechnical and hydraulic conditions are:

- Different types of facing materials on a geosynthetic basis;

- Introduction of the main flow of the water flow in a pre-sized trough;

- And other.

All calculations in the Hydraulic Engineering section are in compliance with the requirements of the current regulations and those specified in the item REGULATORY BASE, including the "Basic geotechnical facilities" Building norms and rules 2.02.02-85,1988.

Following the approach described above, two hydraulic models were made:

- In existing condition;

- In design condition.

After the analysis of the model in the existing state, the critical areas in need of correction in order to conduct the sizing water quantity are determined. Based on it, a model was drawn up in a design state ensuring the implementation of the sizing water quantity. The characteristics of the sections in the individual sections are presented in the graphic appendices. The project section has the following design parameters:

- Width of the bottom - 3.50 meters;

- Slope slope - 1: 1.25;

- Average slope of the bottom - 1.90%

- Length of the section - 1212 m ';

- n = 0,0225- roughness coefficient;

- Height of the current h = 1.50 m ';

- Estimated stock of VC 1% - 0.50 m ';

The study was conducted at a sizing water quantity Q = 1.0% = 48m^3/s, which is the sizing of high water correction in this project. Detailed calculations and analyzes for the selected water quantity are presented in the attached explanatory note in the Hydrology section.

- **Existing position**

At present, the project section has impaired conductivity. There are sections with greatly reduced cross-section (due to the accumulation of branches, trees, etc. solid runoff), which leads to increased speeds and excavation of the banks and the bottom after the respective section. The slopes are of variable height, which in combination with variable slope of the bottom can lead to overflow upon receipt of water quantities with security in accordance with the regulatory requirements. After analyzing the data obtained from HEC-RAS in the previous design for the section and geometry of the existing riverbed, the conclusions were confirmed that the section cannot carry out the sizing water quantities and corrective (shore protection and conductivity) measures are needed.

- Hydraulic calculations

After analysis of the obtained data and the geometry of the existing riverbed, the project section is divided into two sub-sections - Subdivision I (planned for implementation in Stage 1 - phase 1 and phase 2) and Subdivision II (planned for implementation in stage 2 - phase 1 and phase 2). The geometry of the design profiles is chosen so as to ensure the implementation of the dimensional water quantity of Q1,0% = 48m^3/s.

The calculations are according to Shezi's formula for currents in open beds, and the optimal design parameters are determined after iterative analysis when changing the input data for bottom width, slope and roughness:

	m=	1.24		m'=	1			
	n=	0.022						
b	h	ω	χ	R	C	J	Q_1	Q_1
m	m	m^2	m	m	√m/s	-	m^3/s	l/s
0	0.00	0.00	0.00	0.0000	0.00	0.0000	0.00	0.00
3.50	0.25	0.95	4.30	0.2217	35.36	0.019	2.19	2186.01
3.50	0.50	2.06	5.09	0.4045	39.09	0.019	7.06	7059.13
3.50	0.75	3.32	5.89	0.5641	41.32	0.019	14.21	14212.74
3.50	1.00	4.74	6.69	0.7089	42.92	0.019	23.61	23612.49
3.50	1.10	5.35	7.00	0.7638	43.46	0.019	28.01	28011.97
3.50	1.20	5.99	7.32	0.8174	43.95	0.019	32.78	32784.44
3.50	1.30	6.65	7.64	0.8696	44.41	0.019	37.94	37935.77
3.50	1.40	7.33	7.96	0.9209	44.83	0.019	43.47	43472.23
3.50	1.50	8.04	8.28	0.9711	45.23	0.019	49.40	49400.41
3.50	1.60	8.77	8.60	1.0206	45.61	0.019	55.73	55727.13
3.50	1.70	9.53	8.92	1.0693	45.96	0.019	62.46	62459.35
3.50	1.80	10.32	9.23	1.1173	46.30	0.019	69.60	69604.18

b - width of the bottom;

h - current height;

ω - area occupied by the water quantity;

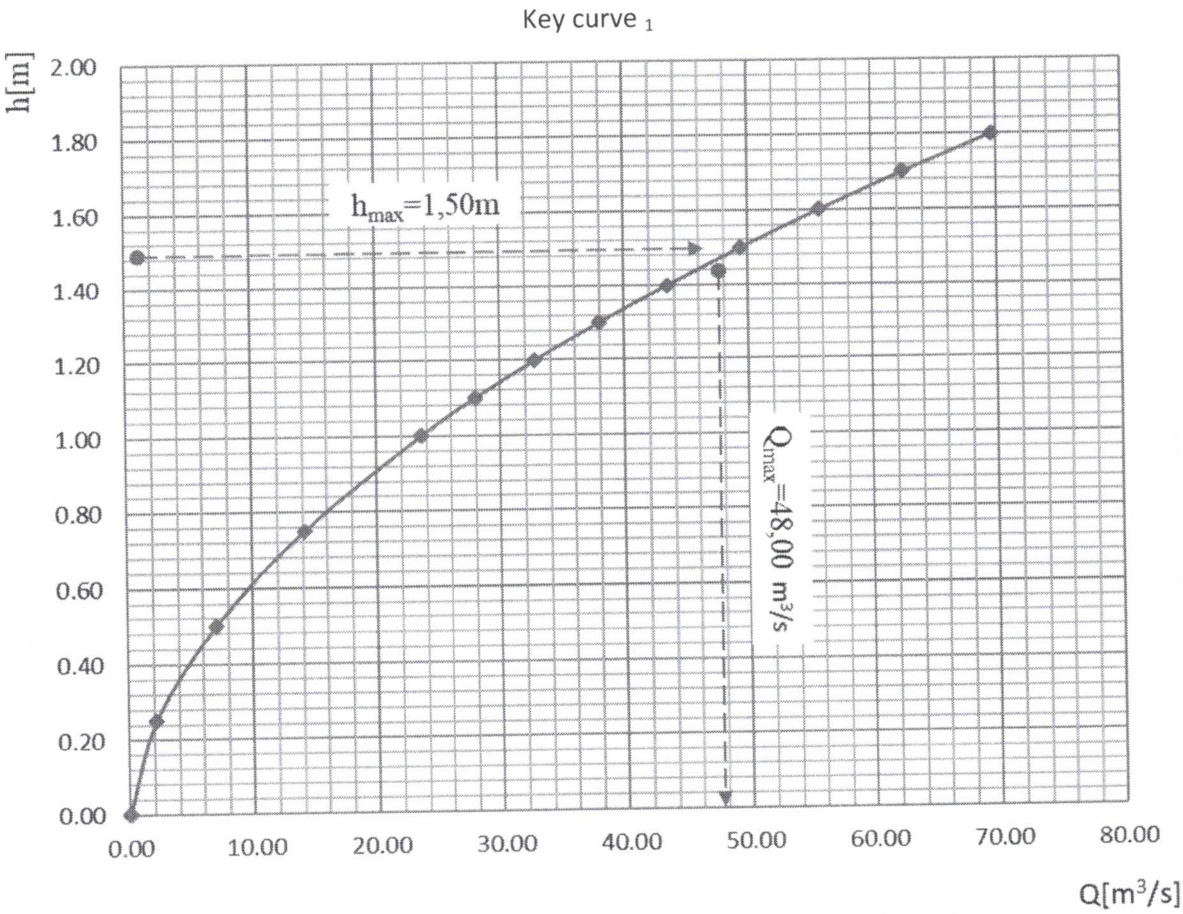
χ - wet perimeter;

R - hydraulic radius;

C - speed coefficient of Shezi;

J - slope of the bottom

Q - conducted water quantity;



From the transverse profile shown below it is clear that the newly selected geometry of the corrected bed of the Tsaparevska River within the village of Mikrevo is good enough to absorb high waters, which would be formed at Q1.0% = 48m^3/s. The same results are observed for all cross sections of the model.

4. DESIGN SOLUTION

The section is compared with the regulatory boundaries provided by the municipality of Strumyani and our team has strived for maximum adherence to the planned contour.

The main parameters and the amendments of the project under art. 154 of the Spatial Development Act, compared to the initially approved ones, are indicated in tabular form. The changes are dictated by two factors:

- Adherence to the regulatory limits adopted by the General Streaming;

- Establishing the presence of boulders along the route after clearing the vegetation and starting the excavation works

Parameters	Approved project in 2017та	Working project under para.154
Length of the corrected section	L=1212 m	L=1212 m
Dimensional water quantity	$Q_{1,0\%}$=48m^3/s	$Q_{1,0\%}$=48m^3/s
Changes in structural elements along the route	Not envisaged	Not envisaged
Depth of current	h=1,25m	h=1,50m
Roughness coefficient	n=0,0225	n=0,0225
Excavation of earth masses	V=10391 m^3	V=8155 m^3
Excavation and breaking of rock fragments	V=0 m^3	V=2050 m^3
Embankment of earth masses	V=10818 m^3	V=15165 m^3
Bottom width	b=10,0m	b=3,5m
Width at the crown	B=15,3m	B=8,5m

Longitudinal slope	i=1,4%	i=1,9%
Geocellular system	H=20cm	H=10cm
Number of st.b. thresholds	4 pcs.	2 pcs.

In order to ensure the indicated roughness coefficient, the stability of the shores and respectively the conduction of the water quantities in relation to the contours provided according to the regulation, the use of a geocellular system is envisaged. The geocells are h = 10 cm high.

Before forming the project profile, the bottom of the river is excavated to an elevation 53 cm lower than the project. Geotags are laid on the slopes. For their permanent fixing, the laying of L-shaped skewers and distribution bearing polyethylene ropes is provided. Concrete C16 / 20 is partially (in the lower 1/2) for filling the geocells. After laying the concrete, backfilling of the bottom is performed. The upper part is filled up to 5 cm with local material, and the surface 5 cm is filled with clay, which is subsequently compacted. After laying the clay, the slope is grassed. The work in the riverbed will be performed in separate sections for the left and right banks, as the waters divert to the opposite slope.

In the project development is attached a detail for the laying and filling of the geocells, which should be strictly observed during the implementation. Additionally, the technology is explained in item 6 of this note.

5. CONCLUSIONS FROM THE HYDRAULIC INVESTIGATIONS CARRIED OUT

• The studied section of the Tsaparevska River within the village of Mikrevo is 1212 m long. The aim is to determine the conductivity of the high water section with a security of 1%.

• In extensive hydrological studies, a sizing water quantity of Q1,0% = 48 m^3/s was obtained.

• After analysis of software modeling of the existing position of the Tsaparevska riverbed, within the village of Mikrevo, it becomes clear that the current geometry is not sufficient to conduct the dimensional water quantity and will lead to excavation of river banks and danger from flooding of residential buildings within the village.

• Hydraulic calculations of the existing position of the riverbed have shown the need for a complete correction of the studied area.

• It is clear from the hydraulic model that the newly selected geometry for the corrected section is sufficient to conduct high waters with a 1% security if necessary.

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6. CONSTRUCTION OF CORRECTIONAL ACTIVITIES

There are different engineering approaches to strengthening river banks, especially when the problem involves improving the hydraulic conductivity of rivers. The development of scientific technologies and technical capabilities in the manufacturing industry has allowed, in hydraulic engineering practice, the application of flexible structures that can more easily absorb the uneven deformations caused by hydrodynamic forces arising in the cross section of the riverbed. The main problem here is the control of water quantities and respectively the allowable speeds in the riverbeds. Last but not least in the implementation of projects are the technological aspects. The integrated solution of the technical challenges in hydraulic engineering leads in a direct way to an ecological effect. The ecological effect is not only a consequence, but also during the technology and the materials used in it.

In this regard, the technical proposal provides for the use of category A geocells or those with equivalent characteristics. The technology allows the reversal of the riverbeds and the achievement of hydraulic characteristics of the riverbed depending on the accepted in the calculations. This refers to the fact that geocells can be laid extremely quickly and can be filled with either local material and grassed or filled with concrete.

The project envisages the implementation of corrective activities on the profile of the riverbed, which are mainly divided into two groups:

➢ Soft measures

• Cleaning and deepening of the bottom;

• Forming slopes;

• Construction of protective dikes in separate sections

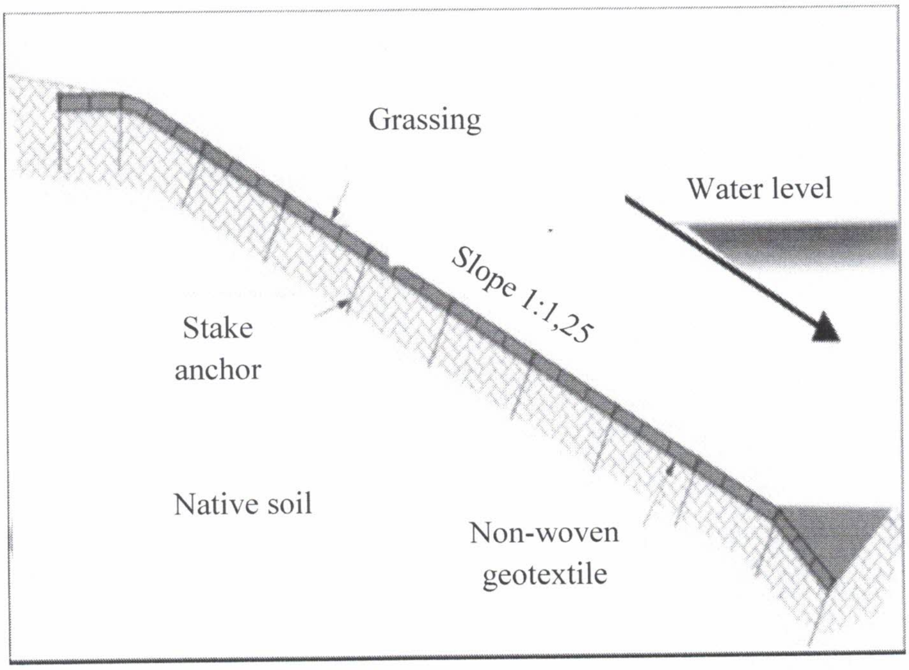
➢ Force measures

• Laying of flexible systems for strengthening the riverbed - geocells with height h = 10.0 cm;

• Fixing of the geocells with rigid J-shaped anchors N14 and polypropylene ropes (N> 0.9kN) to the slopes;

- Filling the geocells with concrete C16 / 20 to 1/2 of the height of the slopes;
- Subsequent filling of the free section of the geocells with earth-rock material from the excavation activities;
- Laying a clay seal with a thickness of d = 5cm;
- Execution of hydroseeding on the slopes;

Figure 6. Detail of the application technology



The anchoring length in the crown of the slopes of the flexible reinforcement system is l = 1.00 m ', and in the heel of the slope l = 0.90 m'. The typical anchoring lengths are illustrated in the graphic appendices to the project.

The technology allows the restoration of natural plant species above the elevation of filling with concrete.

The static calculations to ensure the stability of the reinforcing layer are presented in text annex 1.

The technological sequence in the execution of construction works consists of:

- Delivery and unloading of the necessary materials to the sections of the site;
- Preparation of the river bed and the soil base;
- Preparation of the ridge of the slopes;

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- Laying of geotextiles;

- Anchoring on the ridge of the slopes;

- Stretching of the sections along the slope and anchoring;

- Anchoring the ends of the sections in the bed of the river;

- Laying a filling layer of concrete C16 / 20;

- Applying a filling layer of local materials;

- Landscaping (clay sealing and grassing / hydroseeding)

The project also envisages the construction of 2 bottom concrete thresholds, in order to prevent the receipt of large slopes in some subsections, which would lead to an increase (reaching unacceptable) of the excavation flow velocities. They are illustrated in Graphical Annex No. 2.1 and No. 4.3.

In view of the characteristic hydraulic features of the Tsaparevska River and the purpose of the project, the design team structurally divides the project into a two-phase implementation. Phase 1 includes construction of facilities described above in a more urbanized area of the village of Mikrevo to the bottom concrete threshold No. 2. The section is 635 m long. Phase 2 covers the section from the bottom concrete threshold No. 2 (inclusive) to the end of the section planned for correction (ie until the confluence with the Tsaparevska River in the Struma River). The section is 577 m long. Phase 1 envisages the execution of construction and installation works, only and exclusively in Section I, and Phase 2 envisages the execution of construction and installation works in Sections I and II. This approach of phase separation is taken on the basis of the differences in the conditions of organization of construction in phase 1 and phase 2, respectively. This is due to the different development in the sections of the two phases.

It should be borne in mind that in phase 1 during the execution of construction and installation works the activities and the organization of construction will be performed in a part with higher construction, while in phase 2 the execution of construction and installation works is easier.

The implementation of construction and installation works in phase 1 is planned to be carried out in two stages. The first stage starts with point 1 and ends with point 20, as the section is 365 m long. The second stage has the beginning of item 20 and the end of point 32 / beginning of phase 2 /. The length of the section at stage 2 is 270 m.

Gradual division is aimed at facilitating the process of realization of the site and the possibilities for financing the planned construction and installation works.

The implementation of construction and installation works in phase 2 is planned to be carried out in two stages. The first stage has the beginning of point 32 and the end - an existing bridge at point 47, as the section is 291 m long. The second stage begins with point 47 and ends with the connection with the Struma River. The length of the section at stage 2 is 286 m. The same step-by-step division is aimed at the peculiarities of the construction at stage 2, where in addition to all accompanying construction works in stage 1, it is envisaged to form by geocellular system the connections of the riverbed with the foundations of the existing bridge at item 47 and the Struma river.

The necessary mechanization and tools are:

Standard construction tools (optional)

- Hand tools - shovels, rakes, hammers and nails, model knives, wooden planks;

- Power tools - drills, saws, hammers;

- Concrete plasters - trowels, sealants;

- Hand tools - levels, tripods, levers, laser signalization, receivers, props, twine.

Mechanized construction equipment

For connection when laying the sections - pneumatic stapler and 1/2 "(13mm) galvanized staples and air compressor and generator (60psig / 4bar pressure) & pneumatic hammer with guide head (optional).

In the process of filling and compaction, the use of concrete pumps and conventional digging machines is recommended. It is possible to use trucks, conveyors, inverters and gutters for the filling process;

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