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CONCEPT AND EXECUTION OF WATER SYSTEM IN ARBORETUM AREA

Vasile TIGANASU

Scientific Coordinators: Assoc. Prof. PhD Eng. Augustina TRONAC, Lect. PhD Eng. Tatiana OLINIC

University of Agronomic Sciences and Veterinary Medicine of Bucharest, 59 Mărăşti Blvd, District 1, 011464, Bucharest, Romania, Phone: +4021.318.25.64, Fax: + 4021.318.25.67, Email: vasile.tiganasu@gmail.com

Corresponding author email: vasile.tiganasu@gmail.com

Abstract

The water system from arboretum is part of a complex project of landscaping (improvement) into the University of Agronomical Sciences and Veterinary Medicine of Bucharest (UASVMB) campus area. The aim is to valorise the park by harmonizing the natural space with the anthropogenic one. The water system consists of two reservoirs at different levels. Those are connected by a channel with a trapezoidal section and a pipeline that transports the water from the downstream lake to the upstream lake using a pump for water recirculation. *The lack of natural water sources and the local soil high permeability imposed a waterproofing solution in order to reduce water loss. The channel path intersects an alley used by pedestrians and having auto traffic. For overpass it, there was built a bridge of reinforced concrete. The project in its entirety improves the landscape and social life of both students and employees of UASVMB and also of the people who visit the park for recreation.*

Key words: *imitate natural, hydraulic sizing, channel, sinuous and curved line, waterproofing*

INTRODUCTION

The water system in arboretum is part of a complex project of landscaping the UASVMB campus area whose basic idea is to value the garden by harmonizing the natural space with the anthropogenic one. It was thought to create a landscape setting that wants to imitate natural forms, the lines are sinuous and the chosen shape are irregular (Gedeus, 2016). Thus, it is found that the ensemble fits on the free technique of landscape composition.

Since the project is complex it was thought in stages, at the beginning the upstream lake already existed and it was functioning as a reservoir.

To build the water system it was necessary to design, construct, put into commission and monitoring in exploitation of the downstream lake and channel that mimics the natural course of a river, the connecting pipe and pump system, essential in obtaining a closed circuit.

MATERIALS AND METHODS

The work involves stages of design, construction and operation. The design required a hydraulic sizing of the channel and of the pipeline so that the circuit avoids to heighten the water level in the lake upstream in the case of a small water level in the channel, but also in the case of a excessive draining of the lake downstream, in the case of a massive pumping. Then the two routes of the constructions were established, the channel for aesthetic reasons and for the protection of vegetation, the pipeline trying to track the route with minimal length, but also preserving valuable elements of the arboretum. The hydraulic isolation solutions for the components are then defined as part of the final solution. The next phase is establishing the execution technology taking into account dimensions and the constructive solutions agreed upon, with supplementary constraints about the costs of execution or available materials.

It has been designed, staggered the proper execution by phases and time moments in correlation with resources and it is constantly providing maintenance of water system components, depending of climate changes and operational conditions.

RESULTS AND DISCUSSIONS

The first stage of the work was to establish the channel route. The route was made based on topography and vegetation in the park in order to not change the existing landscape. Drawing the channel axis (riverbed line) was made in a sinuous and curved line so it would have a natural look; in the field that was made through pickets stuck in the ground. In every picket topographic measurements were made from the ground elevation for conducting longitudinal profile and establish the ground slope. Left and right of the channel axis, at distances of about 30 cm, were manually excavated two trenches with a depth of 10 cm, for delimitation of mechanized excavation area.

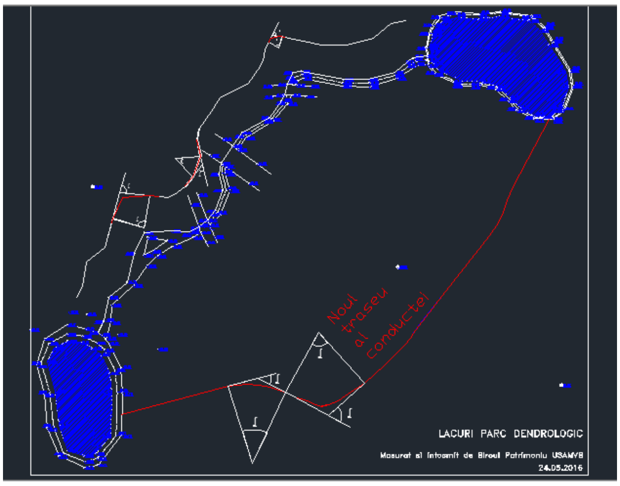

Figure 1. Water system plan view

For stage two, there were made calculations for the hydraulic sizing of the channel, of the pipe also and have determined the pumping plant characteristics.

The slope of the bottom channel is the ground slope.

It was imposed the channel bank to be covered in gravel and to have 1:2 slope for stability reasons relating to the ground put above the sealing layer.

The value of the upper limit of the speed of water flow in channels lined with gravel is 0.9 m/s.

Figure 2.Channel axis – execution stage

The channel section was chosen to be trapezoidal, with the bottom base of 50 cm, slope on the bank of ditch 1:2 and height of water column 10 cm in the channel, to which it is added a safety height of 15 cm.

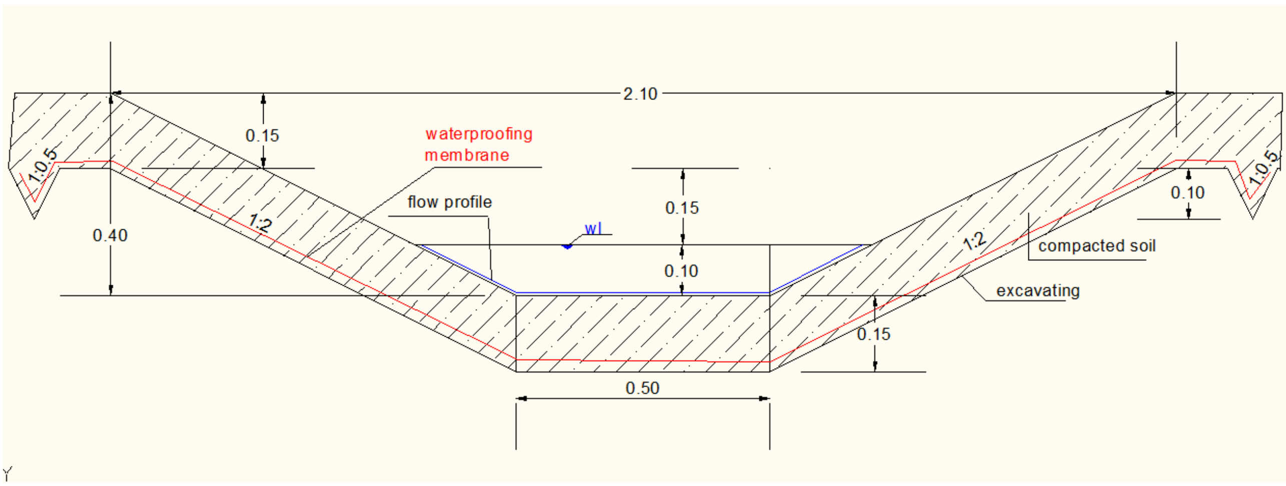

Figure 3.Typical main cross section of the channel

On the channel route, for avoiding a tree, there was designed a channel split in two branches, also with trapezoidal section, each with the bottom base of 25 cm and slope on the bank of ditch 1:1, so that the sum of that 2 sections area to be equal with the main section area.

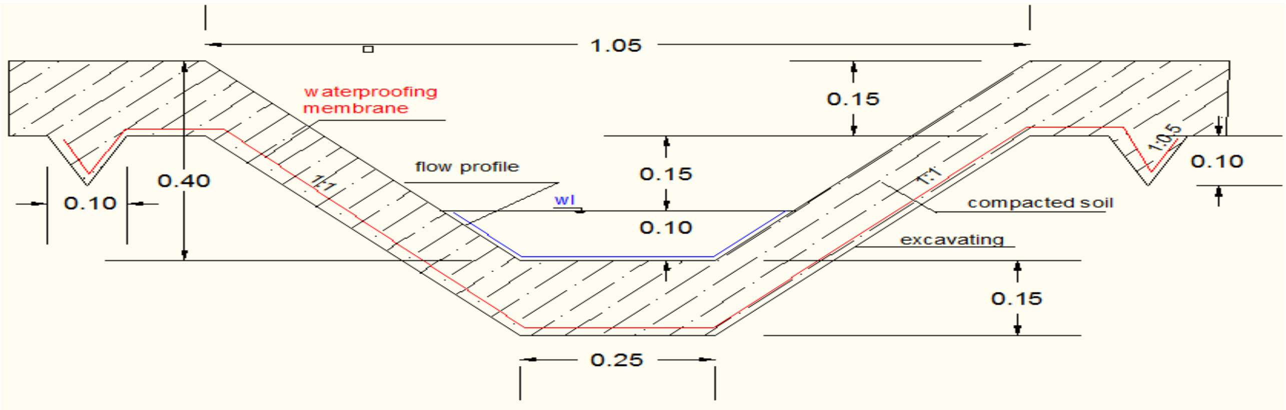

Figure 4.Typical cross section of the branch channel

The water speed was calculated using the Chezy formula that describes the flow movement in open channel:

$v=C\sqrt{R*i}$

where:

v- flow velocity

C- Chezy coefficient, C= (1/n)*R0.16

R- hydraulic radius

n- Manning's roughness coefficient

i- bottom slope

The water flow was calculated using the equation:

$Q = \dot{\omega} * v$

where:

$\dot{\omega}$= cross-sectional area of flow.

The calculations were conducted as in Table 1.

For the pipeline route it was chosen the minimum distance between the lakes, so they do not disturb protected areas of the park. Sizing calculations for the pumping system were made for 100 m of HDPE pipe length with diameter of 90 mm, buried at 1.5 m depth and accessories mounted on the network (bends, valve, connection elements). In calculation it is used Altchul formula for determination of the friction loss factor:

$\lambda=0.11*(De/D)^{0.25}]$

where:

λ- friction loss factor

De- relative roughness

D- pipe diameter

For friction losses it is used Darcy-Weissbach equation:

$h_d= \lambda*(L*v^2)/(D*2*g)$

where:

h_d- friction losses

L-pipe length.

v- velocity

g- acceleration of gravity

For local losses it is used the general formula:

hl = ζ*v2/(2*g), where

ζ- local loss coefficient

v- velocity at the section exit point

g- gravitational acceleration

It is used a pump of 25 m3/h and discharge head of 10 m water column, already existing. The calculations for friction loss and local losses were conducted as in Table 2 and Table.3.

The total head loss (discharge head) it is resulting as a sum of the friction losses, local losses and level difference between pump enter in point and exit pipe point (Mocanu, 2015):

Ht=hd+hl+hg

where:

Ht – pumping head

Hg - level difference

Level difference is about 1.50 m.

The second row concerns the actual situation, due to the fact that the pump equipment, already existing, has the following characteristics: Hp = 10 m, Qp = 25 m3/h.

Table 1. Hydraulic sizing of channel cross section

	Water height h(m)	Water slope i	Cross section slope m	Channel base b(m)	Water area ὡ(m2)	Water perimeter P(m)	Hydraulic radius R	Chezy coefficientC	Water velocity v(m/s)	Water flow Q	
										(m3/s)	(m3/h)
channel	0.1	0.0032	2	0.5	0.045	0.947	0.048	15.045	0.186	0.008	28.88
branches	0.1	0.0032	1	0.25	0.0225	0.533	0.042	14.753	0.171	0.004	13.89

Table 2.Calculations of friction loss

Qchannel=Qpipe		Flow velocity v(m/s)	Flow area ὡ(m2)	Pipe diameter D(m)	Relative roughness De	Reynolds number Re	Friction loss factor λ	Pipe lenght l(m)	Friction losses hd(m)	Comment (Qpump = 25 m3/h)
(mc/s)	(m3/h)									
0.008	28.8	1.258158	0.006359	0.09	0.007	112113	0.0582	100	5.22	Qpipe>Qpump
0.0069	24.84	1.085162	0.006359	0.09	0.007	96698	0.0582	100	3.88	Qpipe≈Qpump

Table 3.Calculations of local loss

	α	R(m)	v(m/s)	l(m)	De	λ	ζ90	ζ	hl(m)
curve 1	45	10.12	0.15	7.9442	0.007	0.058	0.88	0.74454	0.00085
curve 2	70	11.87	0.15	14.495	0.007	0.058	1.02	0.79246	0.00091
hl(bend1)	90		0.15		0.007			0.15	0.00017
hl(bend2	90		0.15		0.007			0.15	0.00017
hl(valve)			0.15		0.007			1.7	0.002
hl(divider)			0.15		0.007			2	0.002
hl(exit)			0.15		0.007			1	0.001
								Σhl	0.047

The discharge head of the pump resulted Ht= 5.427 m.

The lack of silt from the two lakes and a regular maintenance allows operation system in optimal conditions.

Stage three consisted in excavation for the channel and trench for the water recycling pipe and was made mechanized and manually.

Channel excavation section is greater than the determination of the hydraulic section, as is required by the waterproofing solution. (Figures .3-4).

Mechanized excavation was done at the depth calculated in stage two, depth to which were added 15 cm, meaning layer of soil that coated the waterproofing membrane.

Manual excavation was carried out to achieve the required slope on the bank of ditch, having slope of 1:2, and for the execution of the trench in which was embedded the waterproofing membrane. The embedded trench had a triangular section with a depth of 15 cm and a slope of 2:1.

For an easier way to work on arranging the riverbed it is recommend using a trapezoidal frame with the desired dimensions to be made.

For the recycling pipe was excavated a trench with the width of 30 cm and depth of 1.5 m and a pit with a unit square section and width of 1.50 m, where was mounted an inspection chamber. The inspection chamber is from polyethylene with a circular section, radius of 1.00 m, and height of 1.20 m. Inside it was fitted a butterfly valve and a divider device.

Figure 5. View within the mechanised excavation stage

Figure 6. View within bank of ditch arrangement

For the bridge abutment there were dug manually two tranches of 1.00 m depth, 0.30 m width and 3.20 m length.

Figure 7. Bridge abutment tranche - view

There were used two types of materials: polyethylene film and bentonitic geocomposite. The polyethylene film was placed first and over it there was laid the bentonitic geocomposite.

The settlement of the waterproofing system in the trench channel was made by placing the pieces upstream over downstream ones on a length of 30 cm. The width of the two materials was cut so that it covers 90% of the embedment trench. At the exit point of upstream reservoir, the channel waterproofing membrane was placed 70 cm under the lake waterproofing; at the discharge point into the downstream reservoir the channel waterproofing membrane was placed 70 cm over the lake waterproofing.
For step Four, the waterproofing membrane was mounted and coated with a layer of soil.
After the membrane was placed there was put over a layer of soil, which has reached a thickness of 15-20 cm after compaction. It was used the soil obtained from channel excavation and a borrow pit. For compaction, after laboratory tests conducted before execution stage (Proctor test), it was determined that the soil needed to be moistened. Laboratory tests are intended to simulate the field process and to indicate the most appropriate compaction moisture for achieving the maximum dry density for soil (Ivasuc, 2012). The calculations were conducted and are present in Table 4.

Table 4.The optimum moisture content

Optimal water content	%	17
Maximum Dry density	g/cm^3	1.7

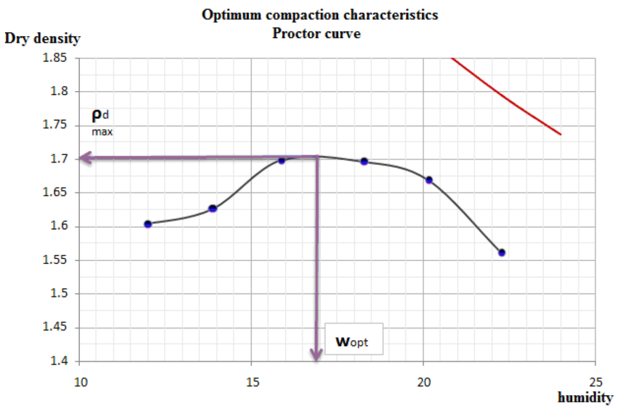

Figure 8.Proctor curve

Compaction was done with a compactor plate, first on the shoulders slope, to embed the hydro isolation, after that, the trench floor and finally it was compacted the slope soil. At the end, it was placed a layer of gravel with thickness of 4 -5 cm, sort 16/31.

Figure 9. View of soil ready for compaction

Figure 10. Channel sector finished - view

In step Five, since the water intersected the main alley of the park, alley used both by pedestrians and the machinery of the administration of the park, the project required the construction of a reinforced concrete bridge in length of 4.00 m.
The concrete use was Bc 30.
The concrete placement was performed continuously and thus obtaining a monolithic structure supported on two abutments with a small elevation.

Figure 11. Preparing for concrete placement - view

Figure 12. View of concrete placement

CONCLUSIONS

UASVMB campus would like to have the title of “greatest campus in Romania”, so it benefits from a complex landscaping project.
Staging of the project has led to sequential water system works and adopting solutions used less.
It was conceived a river stream to humanize the surrounding place, leading to an idyllic area with a minimum financial effort and maximum aesthetic effect.
It was obtained a meandering stream with variable flow sections. The project did not disturb the existing vegetation in the park and creates the impression of naturalness.
The technical solution based on engineering dimensioning and appropriate technologies accompanied by the need to protect existing vegetation valuable, lead to a development scheme that improves the quality of life of students and employees of UASVMB and also generates a major recreational context which attracts visitors of all ages any time of day or of year.

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