DESIGNING A HORIZONTAL DRAINAGE SYSTEM

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Abstract. This paper aims to design a network of horizontal drainage for the area being studied, in order to eliminate the excess humidity due to infiltrations and input of ground and exfiltrated water. The topographical plan of the area for which the drainage network is designed was used to make the cross-sections. As a result of the analysis the transversal scheme of drain pipes location was applied and the calculations/results for this paper corresponding to the sizing of the collector and the absorbent drain pipes, the flow rate, the volumes of soil excavation / filling and the volumes of the materials used, are included in a report that represents the basis for implementing this system in the field.

Keywords: horizontal drainage, sizing, absorbent drain pipe, collector drain pipe, volumes

INTRODUCTION

Drainage works are used to prevent and to remove the excess water from the surface of the land and within the soil, in order to assure favorable conditions for land use. These types of arrangements include collecting, transportation and evacuation works of the excess water into an emissary (The Law for Land Improvements No. 138 of 2004). Within the field of land improvements, drainage works occupy a special place with due to their hydroameliorative role. The purpose of subsurface drainage is to lower the water table and, therefore, the water pressure to a level below that of the potential failure surfaces. Methods that can be used to accomplish subsurface drainage are: subsurface drainage blankets, trenches, horizontal drains, relief wells, drain wells and stone columns, wellpoints and deep wells and drainage galleries (https://www.iitbhu.ac.in/faculty/min/rajesh-rai/NMEICT-Slope/lecture/c8/l13.html). Land drainage means eliminating water through a network of drain pipes. According to Dîrja and Budiu (2006), a network of horizontal drainage, which enables the abstraction and evacuation of excess water and the reduction of the level of ground water, contains, functionally speaking, absorbent and collector-emptying drain pipes.

Within a drainage system, the absorbent drain pipes are placed in parallel rows, which for the most part are equidistant, perpendicular or at an angle in relation with the collecting drain pipe. The location for the drainage network can follow several placement schemes on the plan, which are: longitudinal, cross-cut and intermediary. Special constructions and devices such as evacuations holes, falling chambers, visiting and control manholes and protection works ensure that the drainage network works as intended.

MATERIALS AND METHODS

The studied area is located in Băbuțiu, Vultureni commune, Cluj county, Transilvania, near the county road DJ 109A (Figure 1.).

Figure 1. The frame of the studied area
(image source: www.openstreetmap.org, Google Earth Pro)

The topographical plan of the area for which the drainage network is designed was used to determine the natural slope and to make the transversal profiles, the necessary elements, namely the elevations (Table 1) and distances being established with the use of AutoCAD functions.

Table 1

Elevations used to create the characteristic cross-sections

Line 1		*Line 2*		*Line 3*		*Line 4*		*Line 5*	
Point Code	*Elevation*	*Point Code*	*Elevation*	*Point Code*	*Elevation*	*Point Code*	*Elevation*	*Point Code*	*Elevation*
216	383.55	1139	383.08	1170	382.82	1224	382.03	1246	381.95
218	382.95	1138	383.17	1172	382.65	1227	382.10	1250	381.70
219	382.93	1136	382.62	1173	382.70	1228	381.87	1266	381.26
220	383.01	1135	382.53	1174	382.40	1229	381.66	1272	381.01
221	383.08	1134	382.53	1175	382.28	1230	382.03	2810	379.81
222	383.05	1133	382.56	1176	382.23	1231	382.29		
223	383.10	1132	382.51	1177	382.30	1232	382.35		
224	383.13	1131	382.55	1178	382.32	1233	382.41		
225	382.96	1130	382.66	1179	382.47	1234	382.21		
226	383.15	1129	382.78	1180	382.63	1235	382.24		
227	383.28	1128	382.83	1181	382.66				
228	383.33	1127	383.47	1182	382.81				
229	383.41								

The directions for the cross-sections have been established with the help of five lines. Each line went through the surveyed points in the field. The elevation for the points of interest was known due to the graphical representation in the consulted DWG file. Moreover, after consulting the DWG file it becomes apparent that the slope is below 0.005 units, which implies recommending a transversal scheme to the drainage network.

Therefore, in order to eliminate the excess humidity from the study area a horizontal drainage network is proposed, which will enable collecting and eliminating the exces water as well as lowering the groundwater level. From a functional point of view the drainage network will be composed of absorbent drainage pipes and collector - eliminator drainage pipes.The drainage network will be composed from two sectors:

- The first sector - drainage intake pipe to collect the excess water due to the infiltrations through the shore/dam.
- The second sector - drainage intake pipe with absorbent pipes, to evacuate the excess water due to seepage and groundwater.

The evacuation of the water will take place in a nearby emissary, which in this case will be the nearby stream, which surrounds the site from the East to the North. The stream flows from the South to the North, and respectively from the East to the West.

The best solutions towards designing the drainage network were chosen after a rigorous analysis upon with the help of the cross-sections. The design of the network (the drawn part) was made in AutoCAD 2012, by applying ***the transversal scheme*** of drain pipes location. The calculations for this paper were made with the help of Microsoft Excel.

RESULTS AND DISCUSSION

According to water sources that cause the excess humidity on the surface where the drainage network will be implemented, two collector drain pipes have been proposed: a collector drain pipe to abstract / evacuate water infiltrations into the neighbouring lake and a collector drain pipe with the role of evacuating the excess water due to the input of ground and exfiltrated water. Moreover, 26 absorbent drain pipes have been proposed, 80 - 100 m long, arranged at an angle of 59° from the collector drain pipe (Figure 2). A horizontal drainage system is proposed, which is composed of drains from pipes → corrugated pipes.

Covering the tubes will be made using filtrating materials which will enhance the penetrating hydraulic conditions for the water and will also have a protective role. Therefore, the material chosen was geotextile. As for the sizing of the collecting drains as well the absorbent drains, several key elements are imposed, such as length, width, depth and slope. With the help of these elements we can determine the width of the excavation, ballast, depth of the ballast, depth of the filing with soil as well as the afferent cross-sections (total excavation cross-section, filling cross-section for the ballast and soil). The sizing parameters for the drainage system components as well as the measuring units are shown in Table 2 and Table 3.

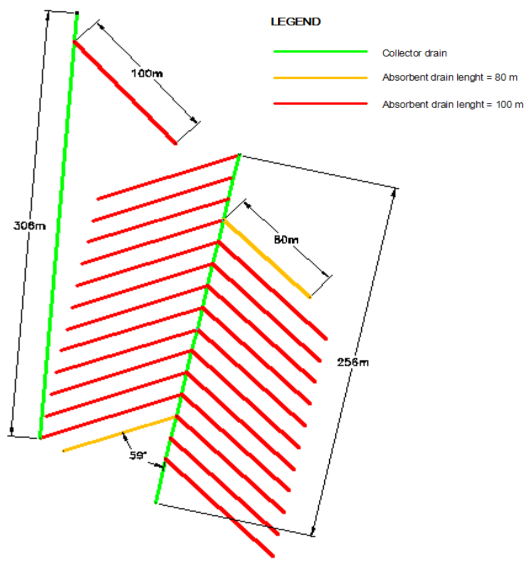


Figure 2. The position of the collector and absorbent drain pipes

Table 2

Imposed data for sizing the collecting drains

Excavation shape - rectangular				
Parameters	Collector drain - role of evacuating the excess humidity due to the input of groundwater		Collector drain - role of evacuating the excess humidity due to water infiltrations and groundwater	
Collector drain length (m)	256		306	
	Start	Finish	Start	Finish
Base Width (m)	0.30	0.30	0.30	0.30
Depth (m)	1.00	1.25	1.00	1.30
Collector drain slope	0.001		0.001	
Data				
Excavation opening (m)	0.30	0.30	0.30	0.30
Ballast opening (m)	0.30	0.30	0.30	0.30
Ballast Depth (m)	0.50	0.50	0.50	0.50
Soil Filling Depth (m)	0.50	0.75	0.50	0.80
Total Excavation Section (m^2)	0.30	0.38	0.30	0.39
Ballast Filling Section (m^2)	0.15	0.15	0.15	0.15
Soil Filling Section (m^2)	0.15	0.23	0.15	0.24
Geotextile Perimeter (m)	1.60		1.60	

Table 3

Imposed data for sizing the absorbent drains

Excavation shape - rectangular		
Parameters	Absorbent drain L = 100 m	Absorbent drain L = 80 m
Absorbent Drain Length (m)	100	80
	Start	Finish
Base Width (m)	0.30	0.30
Depth (m)	1.00	1.25
Collector drain slope	0.0025	
Data		
Excavation opening (m)	0.30	0.30
Ballast opening (m)	0.30	0.30
Ballast Depth (m)	0.50	0.50
Soil Filling Depth (m)	0.50	0.75
Total Excavation Section (m^2)	0.30	0.38
Ballast Filling Section (m^2)	0.15	0.15
Soil Filling Section (m^2)	0.15	0.23
Geotextile Perimeter (m)	1.60	1.60

The evacuation flow for which the drain diameter is established, is calculated from the specific drainage flow and the collecting surface of the drain. The most common diameters for PVC corrugated tubing are 50, 65, 80, 90 and 100 mm (Dîrja and Budiu, 2006). In this study case, the values for the drains are presented in Tab. 4. Depending on the drainage type, the quality of the filtration material and the nature of the soil, the speed of the water may vary. For the present case, the imposed speed is between 0.2 and 0.3, having a specific value of 0.26 m/s (Table 4).

Table 4

Calculating the specific flow values for the drains

Elements	
Corrugated pipe diameter- collector drain (m)	0.10
Corrugated pipe diameter- absorbent drain (m)	0.08
Imposed speed (m/s)	0.26
Specific flow (m^3/s) – First sector collector drain	0.002
Specific flow (m^3/s) – Second sector collector drain	0.002
Specific flow (m^3/s) – Absorbent drains	0.001

For the absorbent drains, whether their lenght is 100 m or 80 m, the imposed distance between them is 16 m, and the surface served by them is 4.10 hectares.

Table 5

Calculating the collected flows by the proposed drains and the served area

Absorbent drains		
Distance between the drains (m)	Drain Length (m)	
16	100	80
Absorbent drain served area (ha)	0.16	0.13
Collected flow by the drain (m^3/s to ha)	0.0003	0.0002
First sector collected flow by the drain (m^3/s)	Served area (ha)	
0.003	1.25	
Second sector collected flow by the drain (m^3/s)	Served area (ha)	
0.003	1.24	

Table 6

Absorbent drain zone volumes calculus

Determined data	*L = 100 m*	*L = 80 m*
Number of absorbent drains (pieces)	24	2
Absorbent drain length (m)	100	80
Excavation volume for 1 absorbent drain (m^3)	34.00	27.00
Total excavation volume for different length drains (m^3)	816	54
Total excavation volume for 26 absorbent drains (m^3)	**870**	
Geotextile area for 1 absorbent drain (m^2)	160	128
Geotextile area for different length drains (m^2)	3840	256
Total geotextile area (m^2)	**4096**	
Corrugated pipe for different length drains (m)	2400	160
Total corrugated pipe length (m)	**2560**	
Ballast volume for 1 absorbent drain (m^3)	15.00	12.00
Ballast volume for different length drains (m^3)	360	24
Total ballast volume (m^3)	**384**	
Soil filling volume for 1 absorbent drain (m^3)	19.00	15.00
Soil Filling volume for different length drains (m^3)	456	30
Total soil filling volume (m^3)	**486**	
Total superelevation soil filling volume (m^3)	48.6	
Total soil filling volume including the superelevation (m^3)	**534.6**	

The volumes for the ballast and soil filling with/without superelevation of 10% were determined both for the zone with absorbent drains (Table 6) as well for the one with the collector drains (Table 7).

Other key elements necessary in designing the drainage network are presented in Table 8. The manholes are made from different materials or prefabricated elements, having a either a square or circular cross-section and a diameter between 0.70 and 0.80 m.

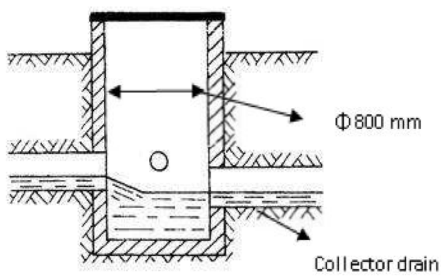
Table 7

Collector drain zone volumes calculus

Number of collector drains (pieces)	*1*	*1*
Determined data	Collector drain	Collector drain
Length (m)	256	306
Excavation volume (m^3)	87.00	106.00
Total excavation volume for 2 collector drains (m^3)	**193.00**	
Geotextile area for 1 collector drain (m^2)	409.6	489.6
Total geotextile area (m^2)	**899**	
Corrugated tube length (m)	256	306
Total corrugated tube length (m)	**562**	
Ballast volume for 1collector drain (m^3)	39.00	46.00
Total ballast volume (m^3)	**85.00**	
Soil filling volume for 1 collector drain (m^3)	48.00	60.00
Total soil filling volume (m^3)	**108.00**	
Total superelevation soil filling volume	10.8	
Total soil filling volume including the superelevation (m^3)	**118.8**	

Table 8

Other necessary elements

	Necessary	Observation
Manholes (pieces)	2	
Connections (pieces)	26	Prefabricated elements or overlaped
Emissary evacuation holes (pieces)	2	
Corrugated PVC tubing intake – outtake manholes (m)	4	

CONCLUSION

The identified elements are presented in a supporting report that contains the main aspects concerning the designed drainage network and that represents the basis of the implementation in the field. For the area with absorbent drain pipes, the results have been the following: a volume of excavation of 870 m^3, the surface of geotextile – 4096 m^2, the length of the rifled tube – 2560 m, the volume of the ballast – 384 m^3, the volume of the soil loading with a cant (10%) – 534.6 m^3. For the area with collector drain pipes, the results have been the following: the volume of excavation – 193 m^3, the surface of geotextile – 899 m^2, the length of the rifled tube – 562 m, the volume of the ballast – 85 m^3, the volume of the soil loading with a cant (10%) – 118.8 m^3.

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