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REHABILITATION OF HYDROTECHNICAL WORKS OF AN IRRIGATION PLOT, BABADAG AREA, BABADAG COUNTY, TULCEA

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Abstract

This paper illustrates the current situation of the CA1 adduction canal, the possible technical solutions, the technical comparison between two waterproofing variants, the presentation of the rehabilitation works, as well as the main technological stages of the waterproofing of the canal in the Babadag area, county of Babadag. Tulcea. The two solutions that will be analysed are the following: the first solution consists in restoring the CA1 channel to its original dimensions and waterproofing it using the following technical solution: waterproofing using 235 g/m2 geotextile + 0.75 mm HDPE geomembrane + C20/25, 8 cm concrete slabs, reinforced with welded mesh, and the second solution is restoring the CA1 channel to its original dimensions and waterproofing it using the following technical solution: waterproofing using EPDM geomembrane reinforced with polyester mesh.

The extension and rehabilitation of the irrigation infrastructure in Romania is expected to have a significant economic impact on the economic viability of farms, increase the competitiveness of farmers, but also support the agricultural sector to be able to face the long-term challenges of climate change, in particular those related to drought, as well as to ensure food stability and security in adverse climatic conditions. In the project we aimed to rehabilitate the hydrotechnical works of an irrigation plot in the Babadag area, we analysed the situation of the whole, we proposed general valid solutions for the condition of the hydrotechnical works and we customised to the situation and technical solutions suitable for the CA1 canal. We have analysed its transport capacity, finding that, if it is decolmated, it meets the flow conditions required for operation, but with a higher water level at the required flow rate.

***Key words**: adduction, canal, geomembrane, geotextile, irrigation, land reclamation, waterproofing.*

INTRODUCTION

In order to ensure sustainable economic development in rural areas, the analysis of the current situation in Romania shows that it is necessary to accelerate the process of modernisation/structural adjustment of agriculture, land improvement and rural development.

Romania's rural economy is dominated by agriculture, but is not yet well integrated into the market economy.

In Romania, the territory totals 23.8 million ha and the agricultural area of the country is 14.7 million ha (61.7%), of which about 2/3 of this agricultural area suffers from drought, excess moisture and soil erosion, causing damage to agriculture every year.

Land improvement works aim at eliminating the negative effects of climate change as described above and are classified into: works to eliminate soil water deficit by means of irrigation; works to prevent and combat soil erosion; works to prevent and combat excess water: dyking, drainage-drainage and regularisation of watercourses.

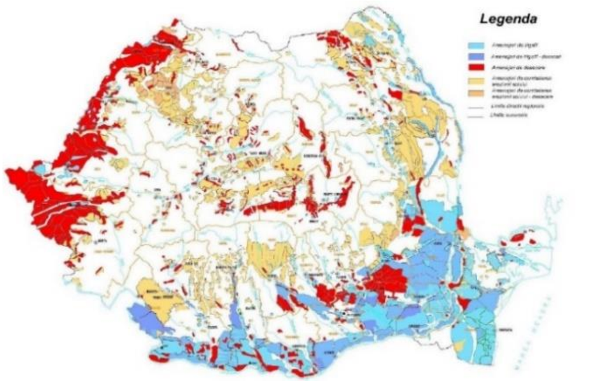

Figure 1. Situation of functional, contracted and irrigated areas during the period 2006 – 2018

Irrigation development Babadag, jud. Tulcea, planning code 350, with a total area of 24,449 ha, of which 21,028 ha declared viable, its location is on the territory of the following municipalities: Mihail Kogălniceanu, Mihai Bravu, Nalbant, Sarichioi, Frecăței and the town of Babadag in Tulcea county.

Figure 2. Pumping station building, Babadag, county Tulcea

As a source of water supply for irrigation, Lake Babadag is a lake located north of Babadag, Tulcea County and west of Lake Razim. Its surface area, including the Sărătura and Cotului liman is 2,370 ha. The length is 8.75 km, the maximum width is 3.40 km and the maximum depth is 3.1 m. The maximum frost depth characteristic for the area analysed is 0.80-0.90 m from the land surface, according STAS 6054-77.

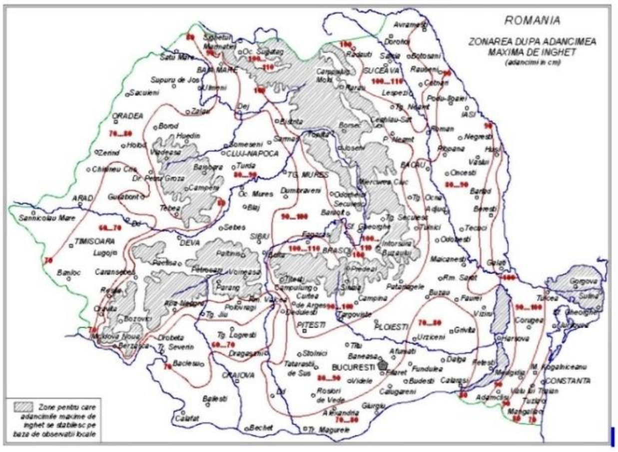

Figure 3. Zoning by maximum frost depth

According to P100-1/2013, the peak design acceleration value for earthquakes with mean recurrence interval IMR = 100 years is ag = 0.20g and the corner period of the response spectrum is Tc = 0.70

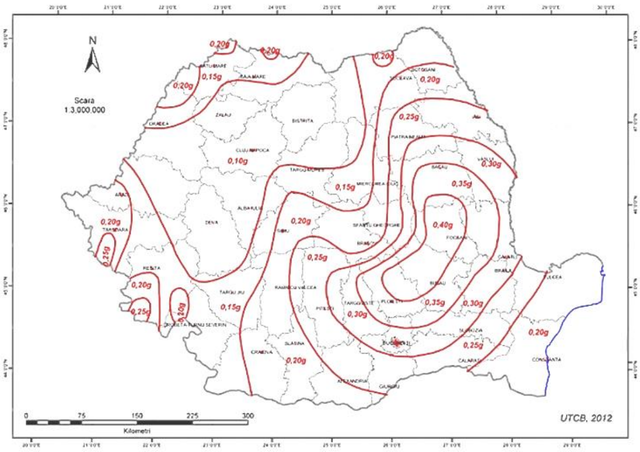

Figure 4. Zoning of peak ground acceleration values for design ag

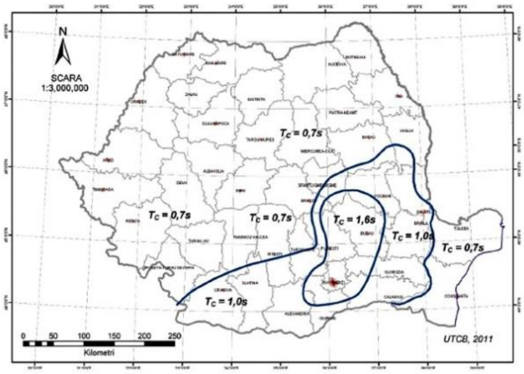

Figure 5. Zoning of the territory in terms of response spectrum control period (Tc)

The following types of irrigation systems are used in large irrigation systems: lined earthen canal systems; unlined earthen canal systems; gutter systems; low pressure pipe systems; high pressure pipe systems; indoor systems for bivalent irrigation and buried pipes; other types of irrigation systems.

Indoor irrigation systems can be considered as: classic (open, non-impermeable channels) and modern, the networks are designed in such a way that energy and water losses are reduced to very low values.

The main purpose of crop irrigation is to achieve high, efficient and stable yields provided that soil fertility is maintained or improved.

The main watering methods and their characteristics: sprinkler watering method; surface run-off watering method; drip watering method; underground watering method; submersion watering method. For proper operation, the irrigation system must be equipped with the following main facilities:

water intake; the conveyance, distribution and irrigation network; the collection and disposal network; the constructions and installations on the canal network and special constructions and installations.

According to their degree of technical sophistication, irrigation systems can be divided into three categories: rudimentary, semi-rudimentary and advanced.

According to the method of water transport, irrigation systems are divided into: open (with open channels), closed (with pipes) and combined (large open channels and small closed channels).

Irrigation systems are further classified according to the method of receiving water: gravity-fed, mechanically lifted and mixed irrigation systems.

In terms of operating time, irrigation systems are divided into: permanent irrigation systems; periodic irrigation systems.

The canal network of the irrigation system is intended to provide: water supply and distribution to the irrigated land to compensate for moisture deficit and other uses; collection and discharge of surplus water from the irrigated land and other uses.

The irrigation system includes two categories of canals: the adduction and irrigation network; the collection and drainage network for desiccation.

The adduction and irrigation network is designed to convey water from the water source to the irrigated land, where the transition from the current state to the wet state will take place.

A system's network of supply and irrigation canals is divided into: permanent network and temporary network. The issue of waterproofing irrigation canals depends on a number of objective requirements, such as: the need to minimise water losses due to seepage; prevent silting of adjacent land and reduce drainage costs; reduce the size of canals and the cost of engineering works; reduce maintenance and operating costs.

The lining of water storage ponds and irrigation channels can be done with different types of sheeting (membranes), protected with concrete slabs, which is the solution unanimously accepted by experts.

Geomembranes are thin, flat, polymeric products in the form of sheets with very low permeability, used for waterproofing (sealing) in contact with soil or other materials.

Geomembranes are successfully used in: waterproofing of waste water treatment, storage and purification basins; waterproofing of water reservoirs, ponds and artificial lakes; waterproofing of canals, earth dams and tunnels; hydro-engineering and water management constructions; land improvement constructions, etc.

MATERIALS AND METHODS

From a technical point of view, each of the options has a number of advantages and disadvantages, which are summarised in the table below:

Table 1. Technical comparison between variants

Nr. Crt.	**Varianta**	**Avantaje**	**Dezavantaje**
1	geotextil 235 g/m^2 + geomembrană din PEID 0,75 mm + dale din beton C20/25, 8 cm, armat cu plasă sudată	- rezistență chimică excelentă; - îmbinare ușoară prin încălzire și extrudere; - cost redus; - gamă largă de grosimi; - poate avea ambele fețe netede sau poate să fie rugoasă pe o față sau pe ambele fețe; - rezistență remarcabilă la radiațiile UV; - poate fi instalată în condiții diverse; - are proprietăți de frecare excepționale.	- suprafață lisă cu frecare redusă; - sensibilă la fisuri din solicitări; - contracție/ dilatare termică mare.
2	geomembrană din EPDM întărit cu plasă de poliester	- comportare bună la factorii climatici; - greutate redusă când se realizează dintr-un singur strat; - bună rezistentă la fisurarea la rece; - rezistentă chimică bună.	- performanțe slabe la temperaturi ridicate; - presupune echipament special pentru îmbinare; - repararea pe șantier este dificilă.

Proposed rehabilitation works

<u>Canal CA1 – L= 4.035 m</u>

Technical characteristics of the adduction canal CA1:

Length (m)	4.035,00
Surface (m2)	33.268,50
Debit (m3/s)	12,32
Slope invert (%)	0,1
Raft width, b (m)	2,5
Inner buttress	1:1,5

1) Recalibration of the channel section by clearing overgrown vegetation on the embankments and channel invert and removing debris down to the existing slabs; Once the

spoil has been removed, it will be deposited on the left bank, filling in the existing soil wave.
2) Filling voids in existing slabs with sand and repairing sharp edges in the existing wall with repair mortar;
3) Waterproofing of the channel using 235 g/m2 geotextile + 0.75 mm HDPE geomembrane + C25/30 concrete slabs, cast in place 8 cm, 6 m slab length, reinforced concrete with welded mesh D=4 mm. The new wall on the slabs will exceed the top of the existing wall by 25 cm.
4) 2 cm/8 cm backfill filled with sand (4 cm) and modified bitumen mastic with added rubber or equivalent (4 cm);
5) The 5 areas of collapse (km 1+870, km 2+612, km 2+644, km 3+168, km 3+408) will be remedied by removing unstable slabs, filling with local material from borrow pits without topsoil, creating twinning steps and compacting them to the level of the existing slabs.
The dismantled slabs will be transported to a landfill site chosen by the beneficiary for reuse or to a landfill for construction waste.
6) In the vicinity of hydrotechnical constructions, the geotextile and geomembrane shall be anchored as follows:
- a trench 25 cm deep and 1.5 m wide shall be dug along the entire length of the channel cross-section, the area of the tiled wall, up to the base of the hydrotechnical construction;
- place the geotextile and geomembrane;
- pour the concrete up to the level of the new slabs, resulting in a total thickness of 25 cm + 8 cm.
7) The 5 areas with breaks in the earth wave protecting the channel (km 2+644, km 3+168, 3+283, km 3+360, 3+868) will be repaired. The repair consists of completing the earthworks to restore the wave profile.
8) The culvert at km 0+306 will be cleared.
9) The storm water discharge area at km 1+505 will be closed and the section of pipe perpendicular to the canal in the ANIF management area will be decommissioned.
10) Concrete repairs at spillway km 3+990;
11) The slopes above the new concrete wall;

Main technological stages of sewer waterproofing

- the marking of the channels, with the placement of concrete kilometre and hectometre markers;
- manual and/or mechanical clearing;
- clearing of channels of deposits and vegetation;
- spreading the resulting soil on the existing protective wave / filling in the gaps in it;
- finishing the slopes above the wall area;
- excavations for anchoring geotextile and geomembrane above existing slabs;
- filling the missing spaces between existing slabs with sand;
- grinding the surfaces of existing slabs with repair mortar in order to avoid sharp edges in the geosynthetic backing layer;
- laying the geotextile across the channel with the associated overlaps and anchoring;
- laying and installation of the geomembrane, including wind protection measures and the establishment of traffic restrictions on the installation materials;
- careful placement of reinforcement mesh using spacers that do not affect the geomembrane and concrete casting, including in anchors;
- watering the concrete in the wall and protecting it;
- treatment and closure of joints;
- grassing of channel slopes above the concrete wall.

Calculation of transport capacity

I checked the carrying capacity of the existing section to see if recalibration was needed.
b = 2,5 m (the bottom width of the canal)
h = 2,1 m (height/depth of water in the canal)
hguard = 0,75 (existing slab) + 0,15 (elevation) = 0,90 m
m = 1,5 (embankment slope)
n = 0,034 (roughness)
i = 0,1% (hydraulic slope)
$P = b + 2 \times h \times \sqrt{1 + m^2}$ (wetted/wetted perimeter, m)
P = 10,07 m
$\omega = h \times (b + m \times h)$ (flow section, m2)
ω = 11,87 m2
$R = \frac{\omega}{P}$ (hydraulic radius)
R = 1,18 m
$v = C \times \sqrt{R \times i}$ (flow speed, m/s)
$C = \frac{1}{n} \times R^{1/6}$ (Chézy's coefficient, m0,5/s)

C = 30,23 m0,5/s
v = 1,04 m/s
Q = ω × v => Q = 12,32 m3/s
In the existing channel it is sufficient to return to the original section by dewatering with the proviso that the maximum water level will be raised, which makes it necessary to raise the water level of the section on the slopes.

Channel exfiltration for different hypothesis
The numerical modelling of the flow process in a porous medium beneath the CA1 channel slopes was carried out using the calculation program called SEEP/W, from the GEOSLOPE 7 software package - developed by the University of Saskatchewan - Canada, specialized in the study of flow through porous media.
We initially defined all existing material types and assigned all material types:
- Loess (orange), with permeability k = 10-7 m/s
- Geotextile (black), with permeability k = 6 x 10-2 m/s and thickness 1,4 mm.
- Geomembrane (yellow) with permeability k = 10-14 m/s and thickness 2,2 mm.
- Concrete (grey), with permeability k = 10-9 m/s
- Water (blue)
-

Results obtained and their interpretation
We considered 3 situations of lining with:
1) Geomembrane (proposed solution)
2) New concrete wall
3) Degraded/porous wall (initial solution)
For each of the 3 situations we obtained the following:
<u>Situation 1 - with geomembrane: 1,06 x 10-20 m3/s.ml</u>

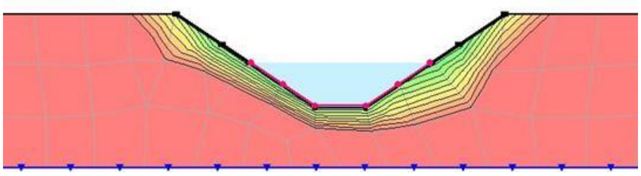

Figure 6. Equal hydraulic load lines

<u>Situation 2 - new concrete wall: 2,32 x 10-17 m3/s.ml</u>

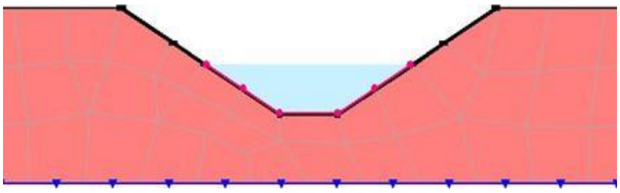

Figure 7. Equal hydraulic load lines

<u>Situation 3 - existing degraded/porous wall: 2,65 x 10-15 m3/s.ml</u>

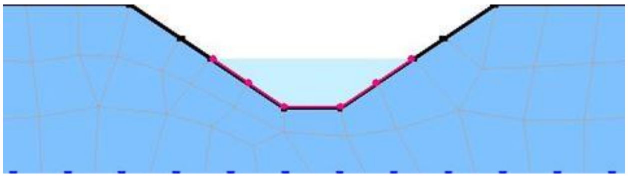

Figure 8. Hydraulic equal load lines

RESULTS AND DISCUSSIONS

Comparing the flow values obtained by summing the flows on the elements composing the channel contour, I find that the difference between the proposed solution and the initial solution is 5 orders of magnitude, which means that the exfiltrated flow in the variant using the new concrete wall is 100 times lower than the existing situation (with degraded wall), and if I use the solution with geomembrane waterproofing, the exfiltrated flow decreases by 100,000 times.

CONCLUSIONS

Consequently, the solution I advocate is to maintain the channel at its original dimensions, waterproofing using the following technical solution: waterproofing using 235 g/m2 geotextile + 0.75 mm HDPE geomembrane + C20/25, 8 cm concrete slabs, reinforced with welded mesh.
The benefits and advantages of these rehabilitation works are numerous, such as: optimal flow carrying capacity, reduction of drainage costs and prevention of silting of adjacent land, water lost through exfiltration is reduced to the maximum, maintenance and operation costs are reduced, an important factor, but also macroeconomic effects that will be generated thanks to the rehabilitation of the main irrigation infrastructure. These consist of a net income increase compared to the previous rehabilitation situation due to improved land

productivity, improved cropping plan structure and higher average production per hectare.
In conclusion, the project I have submitted to you will, through all the benefits mentioned, lead to sustainable agriculture.

CONTRIBUTIONS

Under the guidance of coordinating professor Assoc. Prof. PhD Eng. Augustina Tronac, the author conducted the research described in this paper in the Irrigation Laboratory of the Faculty of Land Reclamation and Environmental Engineering.

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