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INVESTIGATING AMOUNT OF LEAKAGE, SEDIMENT AND DURABILITY IN GEOSYNTHETIC COVER OF PUMPING CHANNEL 3 AT IRRIGATION NETWORK OF MOGHAN

INVESTIGAÇÃO DA SEDIMENTAÇÃO E DURABILIDADE NA COBERTURA GEOSINTÉTICA DO CANAL DE BOMBAGEM 3 NA REDE DE IRRIGAÇÃO DE MOGHAN

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ABSTRACT
Controlling the losses of water leakage from channels and reservoirs is essential in order to protect the limited water resources of country. Yet, several methods have been used to control leakage and nowadays using the geosynthetic covers, such as geomembrane sheets, have been considered. The purpose of this research is to evaluate the leakage rate of channel with geosynthetic layer. In this research, at first the existing problems in different stages of designing and implementing the geomembrane covers in canals were studied. Then, the leakage rate of this type of covering was investigated in different conditions by using the input-output method. After investigating the sources, among the channels with geosynthetic covers in the Moghan irrigation network (it is in Iran), the Moghan pumping channel 3 was selected due to importance and technical features, and field and laboratory studies was done in terms of hydraulic properties, control of leakage, durability and reviewing the executive issues. Based on the results of experiments, the average of leakage discharge rate was reported 46.86 liters per day and per square meter. This leakage rate is moderate in compared with other studied geosynthetic covers in other places (14-69 liters per day and per square meter). However, it seems necessary to investigate leakage rate in different parts of network and to determine its time changings for proper maintenance and using the geosynthetic materials is recommended to prevent water loss from similar channels.
Keywords: Geomembrane; Irrigation Canal; Leakage Control; Water Resources.

INTRODUCTION

Due to the growing increase of water consumption and limitation of available water resources, water conservation and reduction of losses from water transmission and distribution channels, especially in arid and semi-arid areas, have importance. One of the important factors in the optimal use of water and soil resources is to use the suitable channels in order to transfer and to distribute safely the water from source to place of use. In this case, covering channels and reservoirs can effectively contribute to improve the water efficiency (SCHULTZ and DEWRACHIEN, 2002). Therefore, covering the channel in irrigation networks, which is usually carried out by using large investments, has importance.

Bahramlo (2012) has stated that Preventing the leakage losses and increasing the transmission and distribution efficiency is the purpose of using good material in irrigation channels coverage. Therefore, channel coating is very important in irrigation networks. The evidence shows that the traditional methods of using hard coverage for decreasing the leakage from irrigation channels was not practical and in most cases because of the channel leakage the drainage problems have increased. The traditional methods of running channels like dense clay coating or impenetrable concrete is not effective in many soils as plaster soil, sandy soil, locked up soil, divergent soil.

Therefore, the soil replacement costs are high. It can be damaged by the environmental factors and bring up the maintaining costs in the system of utilization period. Then we must use special materials for certain coatings. You can not use one type of channel coating for every situation. Using materials that are cheap and transportable is one of the options. We can use materials that are simply accessible and have high leakage control with proper durability. Rahimi *et al.* (2008) has stated that recently geosynthetic materials are used in channels coverage, storages and pools. A geomembrane is a type of geosynthetic that is made from polymer and because of its nature it is very popular in the flow control structures in developing countries. These materials are used for purposes as arming, separation, moisture insulation, erosion control, filtering and drainage. Scheirs (2009) has stated that the permeability of geomembrane PVC and HDPE are in the range of $10^{-15}\,{cm}/{s}$ and $10^{-12}\,{cm}/{s}$.

GEOMEMBRANES

Geomembranes are a subset of geosynthetics that are significantly impenetrable. The main ingredient of geomembrane is artificial polymer and blocking the passing water is their main job. Elzein and Bowey have stated that the geomembrane layers can control the hydraulic stream at the lowest level. The combination of geomembrane and concrete has a great efficiency (95%). the geomembrane will play the role of dam in this system and the concrete will protect it from mechanical destruction and weathering. The maintenance operation will be carried out only on the concrete coatings.

Divya *et al.* (2019) stated that maximum deformation of geomembranes and maximum curvature of its layer in the permeation area prevents the permeation of water through the cracks. Shahrokhnya (2014) has stated that the average leakage in Daaraab's irrigation channels were 197.7 milliliters per day per square meter. These statistics have been decreased to 16.3 after the concrete coating. Movahhedan and Abbasi according to researches, HDPE geomembranes with 1 to 2.5 millimeters width are the most used materials for coating the water storage tanks (agricultural, industrial, recreational) in Iran because of the great features of these types of geomembranes.

The results of studies about the Chitgar Lake master plan showed that it's better to use other methods of sealing because of the high level and the sensibility of geomembrane coating. Geosynthetic methods are growing constantly. From an economical and technical point of view, using them like other building materials has been expanding steadily. Specifications of some major projects carried out in Iran is shown in Table 1. According to USBR researches, channels that are not coated will lose 50% of their transitional water from leakage.

Table 1: **Specification of some implicated channels with geosynthetic materials**

Project Title	Places of implicating	Type of used materials	Specification of materials	Rate of usage (m^2)	year of implicating
Covering the channel of water transfer	Isfahan Province: Zarin Shahr, Borkhar, Meimeh and Zarrin Shahr	Geomembrane	HDPE 0.75 mm	12000	2003 and 2004
Insulating the concrete channel	Isfahan province: Waterfall irrigation network	Geomembrane	Butyl Rubber 0.75mm	100000	1975-1977
Covering the channel of water transfer	Ardebil province, Moghan, Khodaafarin project	Geothextile	Concrete pan	25000	1997
Covering the channel of water transfer	Khuzestan Province: Shahid Chamran Channel, Ahvaz, Abadan Suburb	Geomembrane	HDPE 0.75,1mm PP 300gr/m^2	32000	2003 and 2006

Movahhedan *et al.* (2011)

METHODS AND MATERIALS

The purpose of this research is to measure the durability and efficiency of geosynthetic materials in coating irrigation channels that transport the water to the Moghan

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plains. Then, with field and laboratory researches, measuring the durability of these materials and executive issues and their performance was investigated.

Measuring the level of leakage in pumping irrigation channels of Moghan, comparing the amount of wasted water to the similar channels and measuring the geosynthetic coating in certain channels in order to decrease the water loss is the purpose of this research.

SPECIFICATION OF THE RESEARCH LOCATION (MOGHAN REGION)

The fertile plain of Moghan is in the northeast of Ardebil province. From the north and west to the Aras river, from the east to Iran and Azerbaijan borders and from the south to the Sabalan mountain. This plain is located between 47-25 to 48-25 northern tropics and 39-25 to 39-42 eastern meridian. The area of Moghan plain is about 300 to 350 thousand hectares. The development plan for the exploitation of Aras River water resources has been implemented in 90 thousand hectares of this region (AKHAVAN, 1999). The position of Moghan region is shown in Figure 1. Moghan's irrigation and drainage network was built with providing water purposes for 90 thousand hectares of low-level plains. Currently this water network can provide the water requirements of 64000 hectares of land for agriculture companies, Moghan and Pars industry and the private sections.

The length of the main channel of the network is 176 kilometers with a capacity of 80 cubic meter per second. The main channel isn't coated and it's earthy. The optimization plan of coating operations for second- and third-degrees channels was started recently. Currently most of the second degrees channels have been coated. Also, a great part of the third-degree channels (42000 hectares) have been optimized with precast concrete channels. It means that nearly half of the Moghan sub network land (90400 hectares) is developed by precast channels. You can see the geographical position of Moghan region in Figure 1.

SPECIFICATION OF MOGHAN'S IRRIGATION AND DRAINAGE NETWORK

The irrigation and drainage network of Moghan was designed and developed in 1355-1362. After descending and a ten years exploitation period, the channel's floor and walls were cracked and damaged. Because of these problems, the exploiting operation became difficult. In 2001 three critical areas of 8 kilometers were repaired and restored. After less than two years of operation, severe damages were reclaimed in the modified areas. In addition to the removal of damaged bottom soil, the channel has been geotextiled with geomembranes and flushing water. Eventually it will be great with concrete channel lining. Specification of the station and channel's coat is shown in Figures 2 and 3, Table 2 and 3.

All the studies have been carried out in a 900 meters channel developed and maintained by geomembrane materials. The areas of geomembrane pumping channel lining are shown in Figure 2. After descending and a ten years exploitation period, the floor and walls of channel were cracked and damaged. Because of these problems, the exploiting operation became difficult. In 1379 three critical areas of 8 kilometers were repaired and restored which is shown in Figure 3 (SATTARI *et al.*, 2009). 1.5 years after the maintenance operation, damages in forms of cracks, leakages and displacement of the concrete coatings were reclaimed in the modified areas. Eventually the exploiting operation became difficult.

Figure 1: Geographical location of Moghan region

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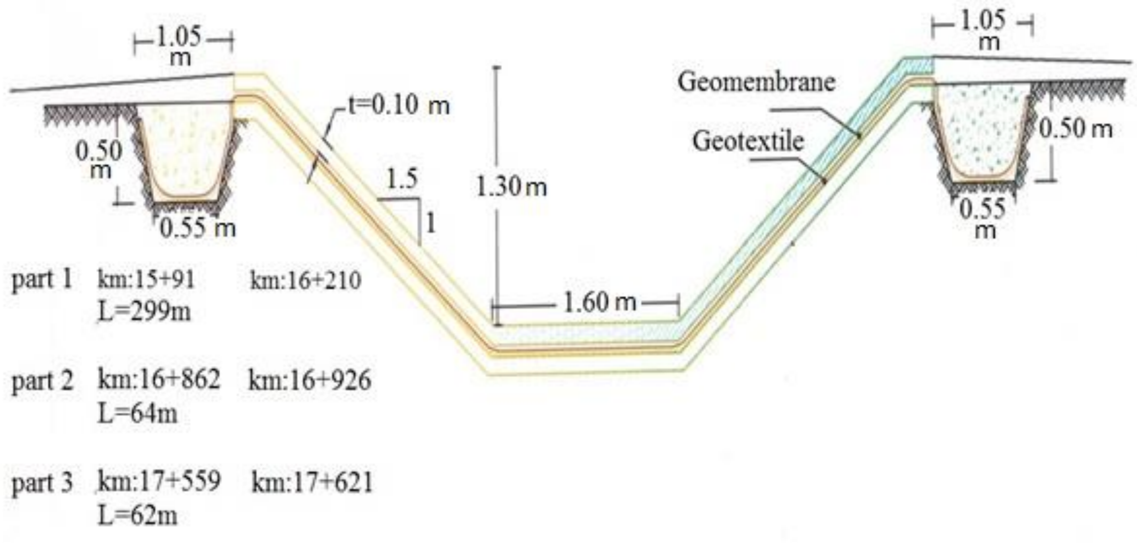

Figure 2: Lining sections of the geomembrane of the pumping channel 3

Figure 3: The destruction of pumping channel 3

Revista Geoaraguaia
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Table 2: **General specification of pumping station 3**

Number of installed pumps	4 Devices
Total volume of watering	3.6 Cubic meter
Thrust height	60 meters
Length of transmission line to storage pond	600 meters
Water volume of storage pond	2500 Cubic meter
Power of device	2.760 MW
Impure land	4400 Hectare
Pure lands	2650 Hectare
Year of operation	1360
Length of channels transmission line	31000 meters

Table 3: **General specification of geosynthetic cover in the studied channel**

Parameter	Specifications
Type of coverage	A geotextile and geomembrane layer and concrete cover
Geotextile features	Non-woven geotextile, white color, made of inside with a weight of 500 grams per square meter
Geomembrane features	HDPE, black, smooth with thickness of 1.5 mm, made of outside
Covered length	3454 meters

In order to find out the reasons of destruction and developing a modified method for pumping channel 3, geotechnical studies of bottom soil channel were conducted in several stages. The purpose of this research is to measure the durability and efficiency of geosynthetic materials in coating irrigation channels. With field researches, measuring the durability of these materials and executive issues and their performance was investigated. By measuring the level of water channel in a certain period and evaporation of the basin (using the aerology data), the total amount of evaporation channel is obtained. The status of probable sediment deposition and the strength and durability of used materials in the channel will be investigated by field inspections along the channel route.

With considering that purpose of present study is to evaluate the durability and effectiveness of geosynthetic materials in the coverage of irrigation water channels in Moghan plain, it was tried to study the durability of these materials and their executive and operational issues through field and laboratory studies. At first, information was collected about the usage of geosynthetic materials in irrigation networks of region. According to the obtained information, geosynthetic material was implemented in the irrigation channel under operation of pumping 3 in Moghan network and in the main channel of existing under construction network in domain of Khodaafarin at Moghan. Pumping channel 3 was chosen as the location of this research and about one kilometer of this channel were selected for testing by frequent visiting and investigating the conditions. With beginning the irrigation season and sealing the

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channel, the following studies were carried out to evaluate the hydraulic and technical properties of geosynthetic covers. Measurement of water losses through leakage from body and wall of channels was done by using the input-output method.

Figure 4: Flow measurement to determine the leakage rate by ultrasonic device

Although the pond test has a higher accuracy than this method, but the input-output method was selected due to the need to interrupt in operation of channel and closing the channel at the beginning and the end of the considered domain. Thus, the difference between the amount of entered water to a domain of channel and amount of released water from it is considered as leakage losses. For this purpose, a domain of 1900 meters was selected and amount of leakage in this domain was measured and averaged in different discharges and with three replications in each discharge. It was noted that the flow discharge rate in the channel was measured by using an ultrasonic flow meter. By measuring the water level of channel in desired domain and evaporation from pan (by using weather data), the total amount of evaporation from channel was obtained.

IMPLEMENTATION ISSUES

The length of geomembrane sheets will change significantly because of the thermoplastic behavior (their length will change according to temperature). HDPE geomembrane has a high thermal expansion coefficient, therefore due to the heat, some wrinkles or called waves that is shown in Figure 5 will occur. Then connecting the geomembrane sheets should be done at the right temperature. Connecting the geomembrane sheets on hot and sunny days is inappropriate and it will cause the rise of geomembranes in the upper parts of the slope.

The sun radiation during the installation of geomembranes makes them upwardly curved in a certain position and will make waves. In fact, these waves or topical elevations of geomembrane sheets cause it to separate from the substrate. Although this separation will be decreased with vertical pressure but according to Koerner and Soong (2007), it will remain even at 1100 kpa vertical pressure.

MAINTENANCE ISSUES

Like every project, proper maintenance is one of the most important factors of stable utilization in geomembrane coating. This factor is very vital in hypaethral projects. In these projects, preventing the mechanical damages (intentional or unintentional) has a fundamental role in great performance of this type of coating. Due to the sensitivity of geomembrane coverage to the intentional destructions (cutting, burning, rubbing, impact), these problems can significantly decrease the coverage efficiency in controlling leakage.

RESULT AND DISCUSSION

Leakage rate

Based on the average of measurements, leakage rate per surface unit in this channel was 46.86 liters per day and per square meter. The comparison of the amount of obtained water leakage from channel with available values in sources indicates the leakage rate of channels with different covers includes a lot of changes by depending on type of cover, depth of flow, quality of implementation, operation and maintenance, and life of cover.

In Table 4 the leakage rate from channel was calculated by input-output discharge method. This leakage rate is moderate in compared with other studied geosynthetic covers in other places (14-69 liters per day and per square meter). However, it seems necessary to investigate leakage rate in different parts of network and to determine its time changings for proper maintenance and using the geosynthetic materials is recommended to prevent water loss from channels and destruction of concrete channels (because of cracks in concrete and leakage from seams).

Figure 5: Implementation of Geomembrane Lining

Table 4: **Determining the average rate of water leakage from channel by input-output method**

Average of input discharge (lit/s)	1335.6
Average of output discharge (lit/s)	1328.4
Length of selected domain	1900
Discharge of total losses	7.2
Average depth of flow	128
Average wetted perimeter	6.24
Average wetted area in domain	11856
Total losses in domain	622.08
Water surface area of channel	6650
Total losses due to evaporation	66.5
Leakage per surface unit	46.86

Sediment Status

Assessment of sediment condition. The investigation of the probable sediment deposited in the channel showed that, since the channel was refilled by the pool after the lake sequestration, the water in the channel had no sediment, except in certain cases where algae was observed.

Measuring the Material Durability

Field inspections: regular field inspections are performed to audit the effect of climate parameters (sunlight, extreme heat and cold, rain, humidity, wind, melting and freezing) and mechanical damages caused by people, animals and machinery. There is not any sign of destruction since the geomembrane layer is located below the concrete layer.

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CONCLUSION

Regarding the importance of water leakage issue from water storage and transportation systems in low water countries like Iran, controlling the water losses in these systems is essential. Due to the unique features of geosynthetic covers, especially geomembranes, in sealing the channels and other advantages, such as quick and easy implementation, the usage of this kind of cover in the country is expanding rapidly.

On the other hand, geomembrane covers, like any other materials, need to observe considerations in designing, implementing and operating. But there are not comprehensive studies about efficiency of these types of covers. Logical development, proper usage and optimal investment in this way require a comprehensive assessment of undertaken projects. The results of this study show the efficiency of well-implemented geomembranes cover in short-term water losses control is acceptable. Therefore, geomembrane covers can be effective in improving the agricultural water productivity, if they are acceptable for sealing, through reducing significantly water losses.

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