INVESTIGATING GEO-SYNTHETIC (GEO-MEMBRANE) COATINGS AND PREFabricated MOISTURE BARRIER (INSULATION) IN IRRIGATION NETWORK CANALS AND DRAINAGE OF ARAYEZ PLAIN OF SOUTHEASTERN IRAN

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ABSTRACT

To prevent waste and pollution of freshwater and to deliver right amount of water at the right time to the right place, have always been one of the subjects in scientific water resource management. In channels, seepage loss of irrigation water is checked by adopting various options of lining, including concrete and geosynthetics. Geosynthetics are composed of compressed polyethylene materials. These are by and large chemically inert and are little affected due to weather action if adequately protected from exposure to atmosphere. That is why use of polymer covers and prefabricated humidity insulation in irrigation and drainage channels have been considered as best alternative to traditional methods by those involved in development projects around the world. In this study, the characteristics and methods of geomembrane and insulation were explained. In addition, these covers and their application in construction of irrigation and drainage channels in Arayez plain were presented, along with their advantages and disadvantages.

Keywords: geosynthetic, irrigation and drainage channels, Arayez plain

1. INTRODUCTION

In Low Rainfall Zones (LRZ) such as of Khuzestan, the issue of water supply has always been one of the most important problems. Farm irrigation systems are designed to supply the demanded agriculture water with minimal losses. Water losses may occur due to infiltration during conveyance, deep percolation out of the root zone, runoff and evaporation. The performance of an irrigation system is measured through the efficiency of water storage in reservoirs, water transfer efficiency to farms, in-the- farm water use efficiency, adequacy, and uniformity of water distribution in the farm. The use of geo-membranes in the past three decades has had exponential growth. Geo-membrane is the long-term solution to the problem of leakage from reservoirs and canals. Today, with the increasing demand for water and scarcity of new sources, the importance of water conservation has been highlighted as a vital matter. The evidence suggests that conventional methods of using hard coatings to reduce leakage from irrigation canals do not have the expected performance and in most cases, drainage problems have exacerbated due to leakage losses from the available canals. The purpose of this article is a technical review of geo-synthetic (geo-membrane) and prefabricated moisture barrier (insulation) in irrigation network canals and drainage of Arayez Plain of southeastern Iran.

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In a study on the Moghan Plain, Mousavi Jahromi et al. (2006) studied the factors and causes of damage to the canals in irrigation network and drainage of Moghan. According to studies from different parts of the damage, it was found that the overall process of work in terms of research principles, design, implementation, quality of execution, and the materials used is appropriate and flawless, and the greatest reason of destructions is lack of proper understanding of the engineering properties of clay soils such as dispersion, solubility, and these soils being gypseous. In a study in the area of Jozam, Isfahan, Islamian et al. (2007) evaluated the advantages and disadvantages of using precast concrete canals in the construction of sub-networks. In the studies, it was found that the use of precast concrete canals has been very effective in terms of solving the problem of concrete corrosion by sulphate soils. Bahramloo et al. (2006) in a study in Bahar Plain of Hamadan aimed to determine the major barriers in the efficient use of water resources and management of technical issues in the canals. Duct canal and track facilities, issues, and the problems were studied and the efficiency of water transport in a number of canals with different coatings and uncoated ones were measured. The results showed that transfer efficiency in stone covering is 93.5%, in canals with concrete cover is 70.8%, and in canals without covering, it is 52.14%. USBRP Institute in 1974 considered the major network problems due to leakage of canals walls, water evaporation, social, economic, and quantitative problems of the facilities. In studying the degradation of Saveh irrigation canals in sandy soils, Rahimi et al (2002) evaluated the canals degradation with three elements of canal design, quality of execution, and geotechnical properties of the bed. Among these, the role of geotechnical factors that is the presence of sand veins, the suitable conditions of erosion, attrition and removal the abutment cavities of concrete canal were considered as the most important factor of damaging the coverage. In a study, Pourmohammadi (2006) expressed that construction of irrigation systems in arid and semi-arid areas for conveyance and distribution of agriculture water is an inevitable component of development.

2. METHODS

The evidence suggests that conventional methods of using hard coatings to reduce leakage from irrigation canals do not have the expected performance and in most cases, drainage problems have exacerbated due to leakage losses from the canals. Adoption of new construction technologies in irrigation and drainage projects using geo-synthetic is a promising technology addressing the water leakage problem.

2.1 Irrigation canal and drainage network in Arayez Plain

This project is located in southwestern Iran, Khuzestan, to the west of the Karkheh River. Arayez Plain contains seven Development Units where units 2 and 3 have an area of 6295 ha hectares. Its start is 70+480 km of the main canal of Payepol Plains, which is about 120 km away from Andimeshk. The total project area is 28285 hectares, of which 11465 hectares with 170 million cubic meters of water use per year is in use, 5340 hectares with a water requirement of 79 million cubic meters is under construction, and 11 480 hectares with water demand of 170 million cubic meters per year is ready to run. Table 1 shows the overall climatic characteristics of the study area. Studies show that frost rarely happens in the project area.

<table>
<thead>
<tr>
<th>Description</th>
<th>Unit</th>
<th>Annual average</th>
<th>Absolute maximum</th>
<th>Absolute minimum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rain</td>
<td>Mm</td>
<td>229.7</td>
<td>January 30</td>
<td>Summer 0</td>
</tr>
<tr>
<td>Temperature</td>
<td>°C</td>
<td>28</td>
<td>August 49.5</td>
<td>January 2</td>
</tr>
<tr>
<td>Evaporation</td>
<td>Mm</td>
<td>3313</td>
<td>Summer 1544.8</td>
<td>Winter 8.278</td>
</tr>
<tr>
<td>Relative humidity</td>
<td>%</td>
<td>64</td>
<td>September 99</td>
<td>August 21</td>
</tr>
</tbody>
</table>

Table 1. Climatic features of the project area
Canal route is mainly in the excavation and sediment of the route is mainly composed of silty sand that changes into clay and silt in some parts of the route. According to the results of geotechnical excavations carried out in the Development Unit, subsurface conditions of the canals and drainage is composed of sandy and clay sediments. Moreover, silty sediments have sometimes been encountered. In order to investigate the divergence phenomenon, double hydrometer, chemical, and pinhole tests were carried out. The results of the soil showed that, it is divergent and in some cases has moderate divergence potential. The results of studying the swelling of soils of the region indicate low swelling potential of the region. Moreover, in some areas moderate to high soils have locally been encountered.

2.2 Methods of implementation of geo-membrane and prefabricated moisture barrier (insulation)

In canals where geo-membrane was applied, the executive operations conducted were as follow:

- Digging of hydraulic cross-canal
- Tune up and repair of floor surfaces and canal bed to create a suitable bed
- Spreading polymer membrane rolls in the direction of canal width
- Connecting the edges of the adjacent rolls
- Installation of metal castings instead of a stencil and concreting canal cover

2.3 Methods of implementation of prefabricated moisture barrier (insulation)

- Given that prefabricated moisture barrier was done on a trial basis in the range of 200 meters in the canal, its method of implementation has been investigated.
- Excavation of the canal and tune up of and canal bed cover
- Thin Concrete (Slim)
- Prefabricated moisture barrier (insulation)
- Concreting of concrete cover of the canal

![Figure 1: Geo-membrane cover being implemented in Arayez Plain](image-url)
3. RESULTS AND DISCUSSION

The purpose of implementing coating is to prevent water loss, soil erosion, reducing canal maintenance costs, and preventing weed growth in canal. Administrative costs per square meter of concrete lining and geo-membrane-concrete are almost equal. Therefore, in similar circumstances, the advantage of using geo-membrane covers is to prevent water loss or higher efficiency of transfer. Table 2 shows average leakage discharge achieved in different canals covering.

Table 2: Leakage of water from canals with different cover

<table>
<thead>
<tr>
<th>Row</th>
<th>Type of canal lining or coating</th>
<th>Leakage in area unit (l. Day.m$^2$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Natural base</td>
<td>462</td>
</tr>
<tr>
<td>2</td>
<td>Construction Brick</td>
<td>91</td>
</tr>
<tr>
<td>3</td>
<td>Sandy bed</td>
<td>163-3170</td>
</tr>
<tr>
<td>4</td>
<td>Loamy ground</td>
<td>183-1368</td>
</tr>
<tr>
<td>5</td>
<td>Plastic</td>
<td>3-12</td>
</tr>
<tr>
<td>6</td>
<td>Canal without cover</td>
<td>194-216</td>
</tr>
<tr>
<td>7</td>
<td>Concrete canal</td>
<td>37-86</td>
</tr>
<tr>
<td>8</td>
<td>Canal coated with 2.5 mm thick HDPE</td>
<td>69-14</td>
</tr>
</tbody>
</table>

One of the inherent characteristics of geo-membranes is very low permeability to a wide range of gases, vapors, and liquids. Intact and without damage geo-membranes are virtually impermeable to fluids penetration (Weber, 2008).

The use of these coatings, in addition to preventing the waste of chemical solutions available in canals, due to having the environmental license, will prevent pollution of water and soil resources. On the other hand, the use of HDPE as a substitute for clay or concrete lining will prevent destruction of canal bed and walls due to corrosion of the substrate soil and guarantee the decades-long durability without the need for repairs, or soil replacement in unsuitable soils such as gypsum, lime, and sulphate.

There are two solutions to build canal in exposure to unsuitable soils: 1. Replacement of the soil with suitable soil, 2. the use of geo-membrane covers, and 3. the use of moisture barrier (insulation). According to analyses, in the ranges of the canal, which
pass from the gypsum and erodible sandy soil and canal trapezoidal prism is in a combination of excavation and embankment, the cost and duration of the implementation of prefabricated moisture barrier, compared to geo-membrane, especially in soil-replacement, is less.

Moreover, due to lack of executive experience in the use of artificial composite geo-membrane, like HDPE, PVC, and so on and contractors’ familiarity with installing moisture, building insulation sheets in the canal of the project seems more logical. It is noteworthy that in implementation of this cover in case of non-observance of the following, undesirable results are achieved.

1. Lack of proper implementation of geo-membrane and lining
2. Not using of the proper product
3. Soil settlement
4. Inaccuracy in the installation of geo-membrane
5. Lack of proper containment of geo-membrane
6. Using concrete except under the geo-membrane lining

The most important part about geo-membrane layer is related to sealing and welding geo-membrane panels in place, because if leaks occur in these locations, the project loses its efficiency and targets will not be met. Altogether, in the projects implemented with geo-membrane about 15% economic savings occur compared to other projects that do not use geo-membrane.

4. CONCLUSIONS

- Use geo-membrane will prevent the waste of liquid of chemical solutions available in canals, and due to having the environmental license, will prevent pollution of water and soil resources.
- The use of HDPE as a substitute for clay or concrete lining will prevent destruction of canal bed and walls due to corrosion of the substrate soil and guarantee the decades-long durability without the need for repairs, or soil replacement in unsuitable soils such as gypsum, lime, and sulphate.
- At intervals where the canal passes from the gypsum and erodible sandy soil and canal trapezoidal prism is in a combination of excavation and embankment, the cost and duration of the implementation of prefabricated moisture barrier compared to geo-membrane, especially in soil-replacement, is less.
- In projects implemented with geo-membrane, about 15% economic savings occur compared to other projects that do not use geo-membrane.
- According to the results, it appears that selecting prefabricated concrete canals for irrigation water conveyance compared to in situ concrete canals would be a better option.

ACKNOWLEDGMENTS

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