*J. Appl. Environ. Biol. Sci.*, 6(7)45-50, 2016

ISSN: 2090-4274
Journal of Applied Environmental and Biological Sciences
*www.textroad.com*

# A Review on the Application of Geomembranes in Hydraulic Structures

**Esmaeil Teymourei*[1], Khosro Hoseini[2]**

[1] PhD Student in Civil Engineering, Hydraulic Structures, Semnan University, Semnan, Iran
[2] Civil Engineering, Hydraulic Structures, Semnan University, Semnan, Iran

*Received: January 13, 2016*
*Accepted: April 22,2016*

## ABSTRACT

Geomembranes are a member of geosynthetics family with a high level of impermeability and they are used in variety of hydraulic applications such as dam construction, canals, pipes, landfills, reservoirs, etc. They have drawn a high level of attention due to their special usages and high efficiency. However, specific precautionary and conservational issues should be taken into account when they are used in the hydraulic structures. The present study was formulated in order to review the application of this geosynthetic material in hydraulic structures and briefly mention specific issues in the application of geomembranes in these structures.
**KEYWORDS:** geomembrane, dam, reservoir, landfill, pipe, canal.

## 1- INTRODUCTION

Geosynthetics are materials produced along with progress in petrochemical industry by using different kinds of polymers and they are enthusiastically used as novel materials in water and soil projects. Generally, geosynthetics is a comprehensive issue to describe thin and flexible plates embedded in soil mass or soil materials for different purposes such as arming, separation, moisture insulation, prevention from erosion, filtering, drainage, etc. In many cases, the plates render a combination of the mentioned roles (Rahimi et al., 2004). Geosynthetics consist of geotextiles and Geomembranes(Novak et al., 2007).

Geomembranes are a member of geosynthetics family with a considerable level of impermeability. Their most important characteristic is that they are considered a protective material against fluid passage. Their extensive application relies on their marvelous properties regarding their weight. They have various applications in civil projects; they are used as protective shield in internal surfaces of canals, tanks, and water pipes; they avoid buried trash seepage into soil; they are applied to control soil erosion, among others (Niazkhani, 2011).

Giroud (1984) classified geomembranes into two main groups on the basis of their manufacture process; the first are those which are made in the construction site and the second are those which are made in a factory. He further classified each group into two more categories: the geomembranes which are reinforced by using a fabric and those which are not reinforced (this type is also called “homogenous”). The fabric reinforcement is applied in order to increase stability of the compound during the manufacture process, add dimensional stability to compounds to have higher level of flexibility in different temperatures, prevent from any damage during handling and installation and resist against design stresses, and to enhance modulus so as to reduce geomembrane’s elongation in face with stresses (Giroud, 1984). Fig. 1 shows this classification.

* **Corresponding Author:** Esmaeil Teymourei, PhD Student in Civil Engineering, Hydraulic Structures, Semnan University, Semnan, Iran. E-mail: Teymourei@yahoo.com

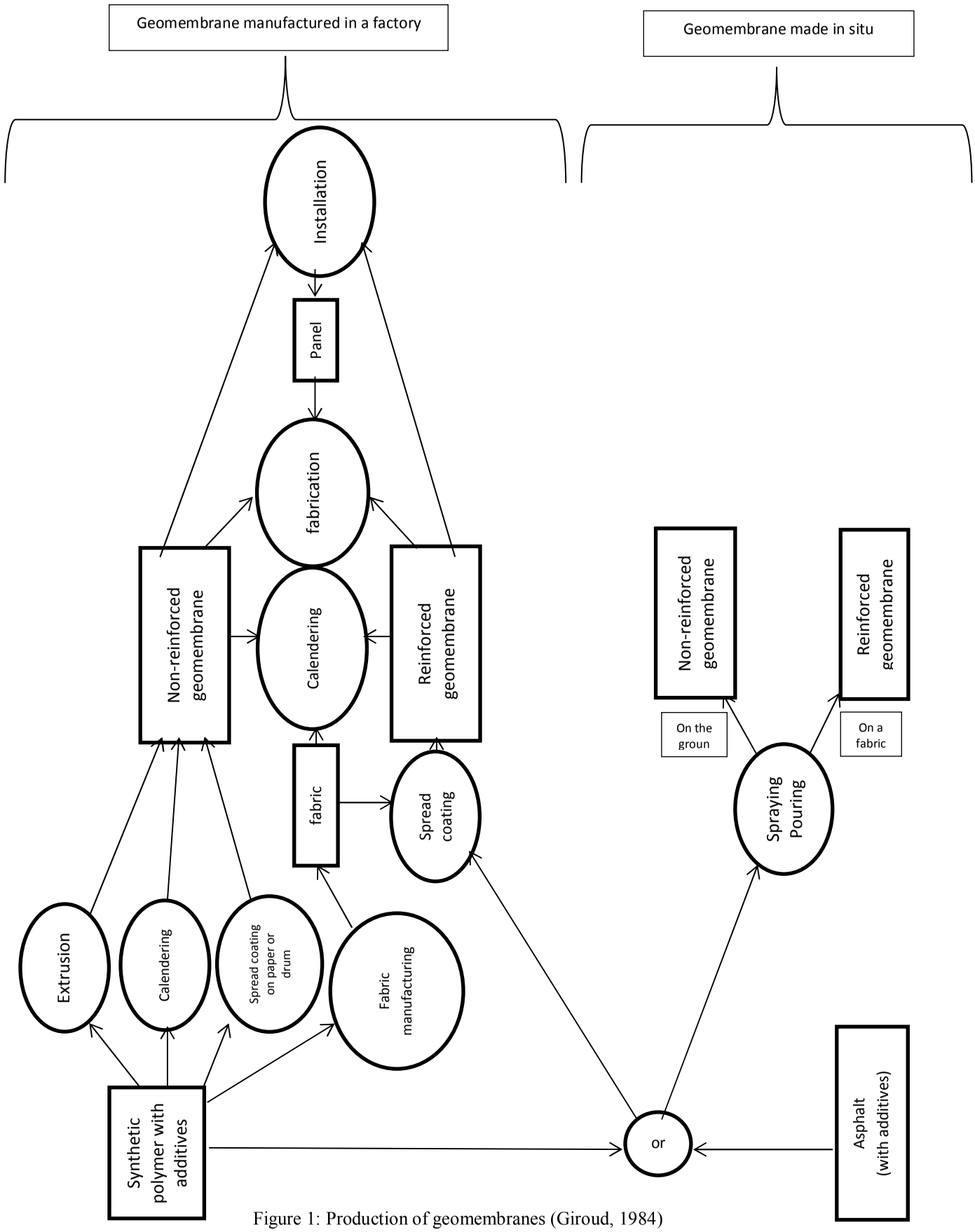


Figure 1: Production of geomembranes (Giroud, 1984)

What follows is a review of application of geomembranes in hydraulic structures plus a part dedicated to performance considerations and conclusion.

## 2- Geomembranes in dam engineering

Onset of application of geomembranes as lining system in dams can be traced in two civil projects (Bouazza et al., 2002). The first project was forContradaSabetta Dam, Italy (Cazzuffi, 1987) and another project was in the TerzaghiDam, Canada (TerzaghiandLacroix, 1964) in the late 1950's.

Geomembranes are of great importance in dam engineering because they have a great role in increasing durability of dams. They can be used in both construction and rehabilitation projects. Application of Geomembranes in dam started in 1970. Geosynthetics have several usages in dam engineering; they are known as impermeable membranes with a thickness of 3-4 mm; they are adopted as drainage filters to control seepage; they are intended for reinforcement of earth, for example they are used to increase stability of slopes; they are very helpful to control surface erosion; finally, they are used to separate the interlayers in dams (Novak et al., 2007).

Whitfield (1996) reported use of geomembrane in order to enhance the water tightness of a roller compacted concrete dam. However, he mentioned that there were some challenges in the way of using this geosynthetic material in the dam. Therefore, he proposed some recommendation in order to make a better use of this material:

(1) Employment of expert geosynthetic personnel in order to help with development of specifications in the project, methodology of construction, and development of a material-specific plan;
(2) A full supervision on all details of construction including delivery and handling of the material;
(3) Instruction and qualification of geomembrane installers;
(4) Education of constructors and contractors about conservation of geomembrane;
(5) Consultation with an adept geomembrane consultant before construction and installation (Whitfield, 1996).

## 3- Geomembranes in reservoirs

He et al. (2009) reported that application of geomembrane to control seepage in the water reservoir of Tai'an pumped storage power station was successful. They claimed that the reservoir worked perfectly for four years without a major problem and the seepage was very low and negligible. They also mentioned that use of geomembrane in this project could save a great deal of money and decreased construction period by 4-6 months.

Blanco et al. (2012) evaluated effectiveness of three different types of geomembranes, i.e. plasticized poly vinyl chloride (PVC-P), high density polyethylene (HDPE), and ethylene-propylene-dienic monomer (EPDM), as coating systems in a reservoir in Spain. They performed this evaluation in terms of thicknesses, tensile properties, dynamic and static puncture, foldability at low temperature, shore hardness, and joint strength (shear and peeling test). Results obtained conclude with a long-term durability of geomembranes, independently of their macromolecular nature. They found that regardless of their macromolecular nature, all three types of geomembranes showed high capability in reservoir lining.

Breul et al. (2008) adopted bituminous geomembrane in order to provide a leakage-resistant coating in a water reservoir. They have chosen this type of geomembrane because, as they claimed, it can be readily laid on any mineral bottom and there is not necessity of using an extra sand layer, it can be easily exposed to the mineral sealing layer since its thermal expansion coefficient is suitable, and its installation in very low temperatures, e.g. -30˚C and therefore, its installation is not greatly affected by climatic conditions.

It is also very important to use geomembranes in mountain reservoirs. Mountain reservoirsare used as a water stock for ski resorts and they are mostly intended for making artificial snow. These reservoirs can be very susceptible to different risk factors because they are normally built in high altitudes. Therefore, it is very important to protect the geomembranes using a cover layer and consider very carefully the support layers as well as drainage under the geomembranes in mountain reservoirs (Poulain et al., 2011).

## 4- Geomembranesfor landfills, pipes, and canals

Geomembranesare extensively used as a liner system to prevent contamination of subsurface in waste containment facilities. They do this by reduction of movement of waste constituents into the environment under the surface. Such protective layer should possess the following characteristics: resistance to the stress caused by construction and replacement of waste; resistance to such damages as puncture and tearing; flexibility to future placements with the potential of cost reduction; high capability of drainage; and tolerance against various landfill operations (Reddy et al., 1996).

In landfills, the fluid is collected beneath the landfill as a result of accumulation of wastes. The fluid gradually precipitates into the surrounding soil and causes environmental adverse effects. In order to prevent this precipitation, the floor and walls of landfills are coated with geomembranes. Geomembranes are also adopted to cover the surface

of landfills because they efficiently resist against ups and downs caused by irregular sedimentation of wastes (Sadrianzadeh, 2004).

Geomembranescan be used in different ways to provide a coating for landfills to avoid infiltration of seepage into soil texture. One method to use geomembranes is to incorporate them in into a double liner system. In this system, there is a granular layer in the top and two clay liners. There is a geomembrane coating between the granular layer and the first clay liner and also there are drainage layer and geomembrane layer between the two clay liners (Fig. 1, Bouazza et al., 2002).

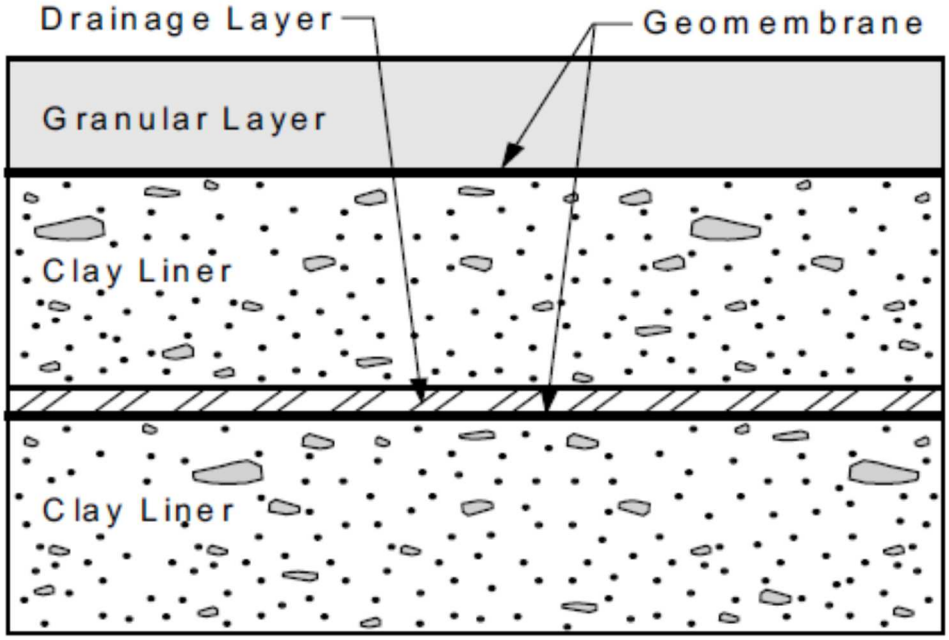


Figure 1: Cross section of double liner systems (Bouazza et al., 2002).

Nevertheless, Buazza et al. (2002) proposed that for achieving the best result in landfills, a composite system using geomembranescan be the most appropriate choice (Fig. 2). This system inhibits percolation of water into the underlying waste; this allows prevention from the conveyance of landfill pollutants and impurities into the groundwater.

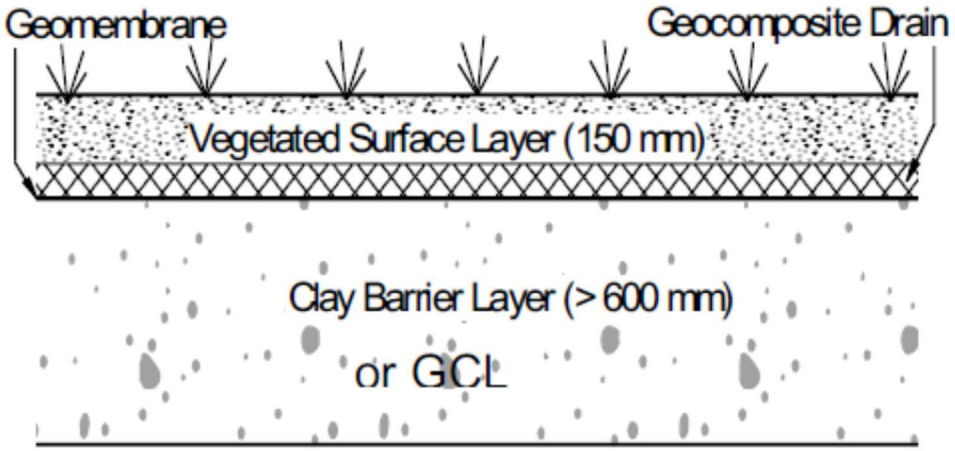


Figure 2: Composite lining system using geomembranes for landfills (Bouazza et al., 2002).

Irrigation canals are bound to take water to local farms. They are prone to some adverse conditions such as unfavorable soil conditions, lack of required materials, and limitation of necessary resources. Also, they should have an efficient coating, they should be able to perform for long periods of time, and also they should be plausible in terms of costs. When the soil in an area is poor, canal bed might be in hazard due to water and wastewater leakage.

Given the high costs of conventional lining methods such as compacted clay, concrete coating or a combination of them, geomembranesare strongly recommended in order to provide an efficient and economical coating for the canals (Firouzi and Najdi, 2011).

Swihart and Haynes (2002) reported that seepage loss can be reduced to 90-95% in canals by using geomembrane liners. Also, Zornberg and Weber (2003) claimed that in a long term period, construction costs for canals can be recovered by using geomembranes in order to prevent from water and seepage loss.

Role of geomembranes in providing coating for canals is very imperative because conventional concrete linings for the canals might be inefficient in different climatic, soil, water, and executional conditions. Also, some kinds of soils are susceptible to water such as expansive soils, dispersive soils, collapsible soils, and liquefiable soils. Therefore, geomembranes are very important in order to avoid any leakage into soil, especially because some soils contain high levels of water-soluble substances such as salts and plaster (Totonchi and BalighJahromi, 2009).

Although geomembranes have been showed to be an appropriate alternative for conventional lining systems such concrete coating, there seems to be an investigational gap to analyze possible damages and maintenance and mending considerations. In hydropower canals, there should be a special attention that even a small tearing along the geomembrane lining cannot be neglected since it brings waterproofing of the system under question and besides, it might cause damage in turbines (Schäfer, 2006).

## 5- Performance considerations and conclusion

If geomembranes are to be used in slopes or perpendicular surfaces where there is a risk of sliding, geomembranes should have special peg-like nodules to go through the lining and prevent geomembranes from sliding. Also, special attentions should be given to avoid any rupture and abrasion on the surface of geomembranes since these ruptures and abrasions will profoundly reduce resistance of lining. Geomembranes are commercially available in rolls and boards. Sometimes two or more layers of geomembranesare stuck on a surface. Sticking process is performed by using special glues; however, sometimes, a solute is adopted to stick two geomembranelayers which result in solution of the layers (Sadrianzadeh, 2004).

Overall, geomembrane is one of the most imorptantgeosynthetic materials and it can be used in variety of applications from dam construction to canals and landfills. However, precautionary considerations should be taken into account in the construction and installation of geomembranes. Also, conservational attempts should be standardized in order to provide an appropriate protective framework in order to make a long-lasting use of geomembranes in hydraulic structures.

## REFERENCES

Blanco, M., Castillo, F., Soriano, J., and Noval, A.M. (2012). Comparative study of three different kinds of geomembranes (PVC-P, HDPE, EPDM) used in the waterproofing of reservoirs. *5th European Geosynthetics Congress*, Valencia, Spain.

Bouazza, A., Zornberg, J.G., Adam, D. (2002). Geosynthetics in waste containment facilities: recent advances. *Geosynthetics - 7 ICG - Delmas, Gourc& Girard (eds), Swets&Zeitlinger, Lisse*, 445-507.

Breul, B., Huru, M., Palolahti, A. (2008). Use of Bituminous Geomembrane (BGM) Liner for Agnico Eagle Mine InKittila (Finland). *Proceedings of the 4th European Geosynthetics Conference*, Paper number 245, Scotland.

Cazzuffi, D. (1987). The Use of Geomembranes in Italian Dams.*International Journal of Water Power and Dam Construction*, 26(2): 44-52.

Firouzi, O., Najdi, M.H. (2011). Lining of Irrigation Canal Using Prefabricated Bituminous Geomembrane (PBGM) (Case Study: Arayez Irrigation and Drainage Project - Khuzestan- Iran). *ICID 21st International Congress on Irrigation and Drainage*, Tehran, Iran.

Giroud, J.P. (1984). Geotextiles and Geomembranes.*Geotextiles and Geomembranes*, 1, 5-40.

He, S.,Wu, Y.,Li, H. (2009). Application of geomembrane in seepage control technique in upper reservoir of Tai'an pumped storage power station. *Advances in Science and Technology of Water Resources*, 29 (6), 78-82.

Niazkhani, E. (2011). The Role of Textile Industry in the Reduction of the Municipality's Developmental Costs. *Iranian Journal of Urban Economy*, 10 (special issue), 47-58.

Novak, P., Moffat, A.I.B., Nalluri, C., Narayanan, R. (2007). *Hydraulic Structures*.Taylor& Francis, Fourth edition.

Poulain, D., Peyras, L., Meriaux, P. (2011). Feedback and guidelines for geomembrane lining systems of mountain reservoirs in France. *Geotextiles and Geomembranes*, 29 (4), 415-424.

Rahimi, H., Ghobadinia, M., Ahmadi, H. (2004).Application of Geosynthetics as Drainage under Canal Covering.*Iranian Workshop on Drainage System under Canal Covering, Iranian National Committee on Irrigation and Drainage*, 113-134.

Reddy, K.R., Bandi, S.R., Rohr, J.J., Finy, M., and Siebken, J. (1996). Field Evaluation of Protective Covers for Landfill Geomembrane Liners under Construction Loading. *Geosynthetics International*, 3 (6), 679-546.

Sadrianzadeh, M. (2004).An Introduction on Geosynthetics and their Application in Civil Engineering. *The 11th Conference of Civil Engineering Students in Iran*, Hormozgan University, Hormozgan, Iran.

Schäfer, P. (2006). Basic Research on Rehabilitation of Aged Free Flow Canals with Geomembranes. *Lehrstuhl und Versuchsanstaltfür Wasserbau und Wasserwirtschaft der Technischen Universität München*.

Swihart, J., and Haynes, J. (2002).*Canal-Lining Demonstration Project Year 10 Final Report*.Rep. No.R-02-03, Bureau of Reclamation, US Department of the Interior, Denver, CO.

Terzaghi, K., and Lacroix, Y. (1964). Mission Dam: An Earth and Rockfill Dam on a Highly Compressible Foundation. *Geotechnique*, 14(1): 13-50.

Totonchi, A., Baligh Jahromi, P. (2009). Determination of Ways to Mend Damaged Concrete and Increase Water Resistance in Metal Structures and Water Canals in Maroun and Behbahan in Khuzestan Province. *The Bational Conference on Water Crisis Management, Islamic Azad University*, Marvdasht Branch, Marvdasht, Iran.

Whitfield, B.L. (1996). Geomembrane Application for an RCC Dam.*Geotextiles and Geomembranes*, 14, 253-264

Zornberg, J.G., and Weber, C.T. (2003). Geosynthetic Research Needs for Hydraulic Structures. *Proceedings of the GRI-17 Conference "Hot Topics in Geosynthetics"*, GII Publications, Folsom, PA.