Optimum Use of Geomembrane Materials in Irrigation Canal Lining

The geosynthetics industry, over the last four decades has developed a wide range of materials that are used in the construction of irrigation and drainage projects. Professionals and agencies dealing with the use of geomembranes are often confronted with the appropriate choice of these materials. Dr. Ian D. Peggs, President of I-CORP INTERNATIONAL, Inc., USA, specializing in geosynthetic materials performance provides some practical tips in selection and use of the geomembrane material in irrigation canal lining through his vast experience in this field.

A few years ago, I was privileged to visit the Tarim Basin in north-west China on behalf of The World Bank to report on geomembrane manufacturers and their on-site installation protocols for high density polyethylene (HDPE) liners in new irrigation canals. While "HDPE" is almost synonymous with "geomembrane", and is the most preferred material, there are many other candidate geomembrane materials, each with its own advantages and disadvantages in different environments. There are even several different HDPEs with differing mechanical and weathering durabilities – a function of the co-polymers and additive package formulations proprietary to each resin and geomembrane manufacturer.

All geomembrane materials, like HDPE, Linear low density polyethylene (LLDPE), Polyvinyl chloride (PVC), Flexible polypropylene (fPP), Chlorosulphonated polyethylene(CSPE), Ethylene-propylene diene monomer (EPDM), bituminous geomembrane (BGM)), and Polyurea (PU), are effective in reducing water seepage/ leakage and allow increased flow rates. However, in practice, they may not be totally leak-tight. They differ in their abilities to lay and remain flat as temperatures change, in their abilities to conform to rough subgrades and differential settlement without impacting durability, in their tolerance of installation damage, UV radiation and oxidation, and in their abilities to be easily installed and repaired. The US Bureau of Reclamation (USBR) has brought out a useful reference document based on the experience of a ten year study on performance of many different geomembrane materials (Swihart, J. and Hayne. J, "Canal Lining Demonstration Project, Year 10 Final Report" R-02-03, November 2002).

There are six basic considerations for the selection of a geomembrane material, viz, (1) New canal or lining of existing unlined canal, (2) Roughness of sub-grade, (3) Weather during installation, (4) Experience of installation personnel, (5) Covered or exposed installation, and (6) Cost of installation.

A new canal may have a well-compacted smooth subgrade that is more suitable for HDPE. Due to its susceptibility to stress cracking the HDPE should only be used as a barrier, not as a load bearing member of the lining system, and not on rough subgrades or where differential settlement might occur. In such situations other materials with higher "yield" strains (LLDPE, fPP) or no yield feature (PVC, EPDM, PU) in the stress/strain curve are preferred.

While reinforced geomembranes such as RPP, PVC alloys, and CSPE (Hypalon) have higher strengths, they have much lower elongations at break; therefore have less ability to conform to rough subgrades. Ductility in a geomembrane is often a far more important parameter than strength.

Leak location surveys have shown that approximately 25% of leaks are caused during installation, mostly at welds. The bulk of the damage occurs when the cover layer is placed on the geomembrane. Thus it may be beneficial to leave a liner uncovered and to minimize the number of seams made in the field. Materials such as HDPE and LLDPE, typically in 7 m roll widths, require all welds be made in the field by specially trained operators. However, materials such as PVC, PP, EPDM, and CSPE can be welded into large panels in the controlled environment of a prefabrication plant thereby minimizing the number of field seams besides reducing installation time. This has also made possible the installation of geomembrane liners without the need to de-water the canal. The availability of spray-applied liners, such as PU, allows the on-site application of a liner without seams, but requires experienced spray personnel. On the other hand, a BGM can be welded by locally trained personnel.

A BGM, essentially a custom engineered composite geomembrane, is heavier than most single layer and reinforced thermoplastic/ elastomeric geomembranes and therefore needs less ballasting against uplift in windy environments. It has zero thermal expansion coefficient and therefore does not expand, wrinkle or contract and pull taut, as do the homogeneous materials. The HDPE has a high coefficient of linear thermal expansion so can generate significant wrinkles when it experiences temperatures over 80°C in summer sunshine after being installed at lower temperatures. Wrinkles make HDPE difficult to protect with poured concrete or with precast concrete slabs. The expansion coefficient of fPP is approximately one half that of HDPE, while that of RPP, being reinforced, is effectively zero.

As the HDPE is quite notch sensitive, particular care must be taken against mechanical damage while installing any cover. Such damage is not as critical in the more amorphous and more flexible geomembranes, unless exposure to UV, high temperatures, and stress, has caused additives to be consumed or leached out. Thus, PVC and LLDPE should not be left exposed unlike other materials.

Section of the 50 year-old canal of the Quincy-Columbia Basin Irrigation District, Washington State, USA repaired in 2003 with composite Ethylene-Vinyl Acetate (EVA) liner (0.5 mm) between two non-woven geotextiles.
The composite liner was covered with 75 mm poured concrete.
Side slopes are 1.5H: 1V. Photos taken of the same section during repair (a) and when the canal back in service (b) *[Photo courtesy: Huesker Inc.]*

The conventional geomembranes are typically attached and sealed to concrete structures using stainless steel batten strips and neoprene gaskets. An improved alternative is to cast an extruded profiled strip made of the same resin as the geomembrane, into the concrete, to which the geomembrane can be welded. The HDPE can be treated in a fluorine gas autoclave so that it can be bonded to a concrete with an adhesive. The BGM can be bonded directly to a bituminous coating applied to the surface of concrete. A PU can be sprayed directly on to a concrete surface. However, while the BGM develops a leak-tight seal the bond has limited strength so is typically reinforced with a batten strip. Conversely, HDPE welded to a cast-in HDPE anchor strip is rarely additionally supported. However, since extrusion welds are subject to mechanical grinding and oxidation during welding it is important to design the adjacent liner/subgrade geometry to minimize the stress in the liner at the weld.

In summary, a geomembrane material can be found to suit any combination of subgrade, environmental, and operating conditions. All geomembranes do not have equal performance characteristics in all conditions. For optimum performance the material should be selected based on technical merit with cost being the last consideration. After all, the geomembrane is the key component of the lining system, and the cost differential between geomembrane materials, in order to ensure optimum service, is a small fraction of the overall cost of the project.

For more information on geosynthetics, please visit www.geosynthetica.net and www.geosindex.com or contact Dr. Ian D. Peggs on icorp@geosynthetic.com.
