EPDM RUBBER LINING SYSTEM CHOSEN TO SAVE VALUABLE IRRIGATION WATER

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ABSTRACT

The distribution of valuable irrigation water using some type of conveyance such as a canal has been in use for thousands of years. Due to excessive seepage loss, many types of lining systems have been used since early times including soil liners, paving bricks, bitumen and clay. With the development of polymers and the expansion of the plastics industry in the 1940's, 1950's and 1960's, sheet materials such as Polyethylene, Polyvinyl Chloride (PVC-soft), Butyl and EPDM Rubber became popular in agricultural applications (Comer et.al, 1999). With the rapid development of the geomembrane industry in the 1970's and 1980's polymeric sheet materials were developed specifically for many civil applications including the waterproofing of distribution canals. EPDM rubber sheeting has proven to be one of the most durable and cost effective exposed synthetic lining system for use in canal rehabilitation.

As a successful example of recent installations, the Tulelake Irrigation District (TID) located in Northern California installed over 4 miles of EPDM rubber lining under the guidance of the U.S. Bureau of Reclamation. Historically, the TID has faced loss of deliverable water due to high seepage rates in unlined canals and laterals, approaching 50 percent in some cases. This, in addition to the drought conditions here and in other western and southwestern irrigation districts, has prompted the federal government to initiate a program for the selection and installation of low cost, low tech synthetic canal lining systems.

This paper will focus on the selection, cost, installation methods and effectiveness of EPDM rubber canal lining systems as used in the TID emergency seepage control program. In addition, a Texas case history will illustrate the use of EPDM rubber for the repair of old, deteriorated concrete lined canals.

INTRODUCTION

One of the major early uses for flexible membrane liners or geomembranes has been in the waterproofing of canals and laterals used in water distribution for agricultural irrigation and their use has been documented as early as the late 1930's in the western U.S. Early lining systems included bitumen coated burlap and

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eventually thermoset elastomeric liners such as Butyl Rubber (IR) and Ethylene Propylene Diene Monomer (EPDM) which were also being used in the lining of canals and water containment reservoirs (Comer, et.al, 1999). In fact, according to Staff (1984), rubber linings were even used prior to the 1930's for the containment of water and Polyvinyl Chloride (PVC-soft) was used in the 1940's in buried applications. Thus, the use of synthetic polymers for canal lining is nothing new and has been a viable alternative to much costlier concrete.

Earth Lined Canal Rehabilitation – Tulelake Irrigation District (TID), California

The Tulelake Irrigation District (TID) supplies valuable agricultural water to the over 25,500 hectares (63,000 acres) of otherwise dry but fertile lands of the northern California counties of Siskiyou and Modoc as well as Klamath County, Oregon. It is one of 18 districts in the U.S. Bureau of Reclamation Klamath Project which is one of the oldest irrigation projects in the Western United States. Irrigation water has always flowed to the approximately 800 farms using a vast network of over 390 km (242 miles) of main canals, laterals and ditches, some of which date back to the turn of the century.

Historically, the irrigation district has faced loss of deliverable water due to high seepage rates in unlined canals and laterals, approaching over 30 and sometimes as high as 50 percent. This, in addition to the drought conditions here and in other western irrigation districts, prompted the federal government to intitiate a program for the selection and installation of low cost, low tech lining systems that can be 100 percent installed and maintained by the irrigation district personnel without the need for specialized installers or contractors. Materials must be capable of being installed in harsh, rough soils conditions, resist animal traffic and be left exposed in excess of 20 years.

The M-2 Lateral

In June of 2001, the U.S. Bureau of Reclamation, Mid Pacific Region, issued a Request for Proposals (RFP) to supply a synthetic lining system to line the M-2 lateral of the Tulelake Irrigation District from sta 0 + 00 to sta 121 + 92 or approximately 3.7 km (2.3 miles). The request specified an exposed geomembrane system that could be installed, seamed, repaired and maintained by irrigation district personnel. The maximum panel size was limited to 9.14 m x 61 m (30 ft x 200 ft) with a minimum thickness of 1.14 mm (45 mils). The geotextile required for extreme rocky outcroppings was a minimum 340 gm/sq m (10 oz/sq yd) nonwoven protection fabric. The government required that a review panel select the geomembrane system based on the following evaluation criteria:

1. Technical Capability
   a. Ease of Installation (Delivery, Placement, Seaming by TID)
   b. Damage Resistance (During Placement and Operation)
   c. Ease of Repair (Repair by TID over life of the lining)
   d. Expected Life (Manufacturer 20 year warranty for exposed conditions)
   e. Seepage control (Effective barrier material)
   f. Descriptive Literature addressing the above
2. Past History and Performance
3. Price

The final selection of a supplier was based primarily on technical merit, the opportunity for installation by TID personnel using their own equipment and characteristics of the geomembrane material as well as low cost. Thus, the lowest bid price was not the principal determining factor in the final selection of the system.

The canal section to be lined was a canal that was originally earth-lined and built in 1942. It has some rocky reaches and known high seepage loss in excess of 30 percent. Technical characteristics included the following:

Q = 2 cms (72 cfs)
V = 0.4 m/s (1.32 fps)
D = 1.22 m (4.0 ft)
S = .00015

Side slopes were an average of 1.5H : 1V and base width varied between 1.8 m and 2.4 m (6 - 8 ft). Total width of the section including flat runout anchors at top of slope was 9.14 m (30 ft). Thus, geomembrane panels delivered to the site were required to have a 9.14 m (30 ft) width with no longitudinal seams. Seaming in the field was to be at panel ends only and across the width of the canal section.

EPDM Chosen for Superior Technical Characteristics and Low Cost

The U.S. Bureau of Reclamation, Mid Pacific Region awarded the project to a material supplier of 1.14 mm (45 mil) thick Ethylene-Propylene-Diene-Monomer (EPDM) rubber geomembrane based on the above technical evaluation factors and low cost. EPDM geomembranes have been in use worldwide for over 40 years in a wide variety of containment applications including large and small irrigation canals. EPDM was chosen for the Ochoco and Talent Irrigation Districts in Oregon to line canal sections with extreme water seepage. Both of these projects utilized the irrigation district crews for soils preparation, EPDM installation, seaming and connections to structures.

EPDM Geomembrane Placement by the Tulelake Irrigation District

EPDM factory panels were manufactured in custom sizes for the TID M-2 Lateral. Each panel was 9.14 m (30 ft.) in width by 61 m (200 ft.) in length, folded along the length and then rolled for delivery and handling on site. Once the rolls of panels were delivered to the site, the TID deployed the panels using their own equipment and a crew of eight workers. District personnel fabricated a custom lifting bar which was suspended by cable from the bucket of an XL4100 Gradall. The rolls of EPDM were lifted from a flatbed truck, positioned in the channel bottom and unrolled along the channel by advancing the XL4100 Gradall along the channel access road.

Once the panels were unrolled and unfolded up the side slopes, they were positioned and placed into the anchor benches on both sides of the channel section. The ends of the panels were then overlapped a minimum of 150 mm (6 in.) and the overlap area was cleaned and primed. The overlap area was then tacked without wrinkles and an adhesive tape seam system was applied by the TID crew. The field-fabricated seams were composed of prefabricated 150 mm (6 in.) wide rolls of partially vulcanized cover strips with adhesive backing. Once the strip was placed and centered on the overlap, it was pressed down onto the two adjacent panels with constant hand roller pressure to ensure complete adhesion. Advantages of using the patented tape seam system include:

- Designed for remote areas and can be installed in cold temperatures
- No specialized welding equipment, hot air guns or supporting electric generator equipment is required
- Components are simple and can be stored at irrigation district shops for future use
- Seaming requires no specialized training (TID crew received 15 minutes of instruction)
- Resultant seam is a continuous 75 mm (3 in.) bond to panel edge with high peel and shear strength. Seam area will resist movement under load of over 300 percent without affecting the waterproof integrity
- The same seam methods are used for repair patches by TID maintenance crews.

During the placement of panels, it was noted that the EPDM sheet material was not susceptible to wind uplift even by high winds which are a frequent occurrence at this site. The EPDM rubber sheet conforms readily to the subgrade, lays flat and adheres to the soil due to surface friction, unit weight and flexibility (intimate subgrade contact and conformance).

Once the panels were in place and seamed, the TID crew placed soil cover on the anchor benches and compacted the material at top of slope with dozer or motor grader wheel loading. It was noted that during soil placement and grading on the top of the channel that some large angular rocks in excess of 34 kg (75 lbs) were displaced and rolled down the EPDM slopes. No puncture damage or marks were noted on the EPDM due to rock fall. Although there is no requirement for soil cover on the bottom of the channel, sediment, upper slope soils and wind blown soils will accumulate over time providing a deposited soil cover.

Concrete Lined Canal Rehabilitation - Harlingen Irrigation District (HID), Texas

The Harlingen Irrigation District (HID) No. 1 is located within the boundaries of Cameron County, the southernmost county in Texas. The District extends approximately 32 km (20 miles) north from the Rio Grande River and approximately 13 km (8 miles) north of Harlingen, Texas and maintains 3309 irrigation accounts. The District obtains water from the Rio Grande as authorized through the Texas Commission of Environmental Quality (TCEQ) which includes 98,232 acre-feet of irrigation water as well as municipal water. The District has 64.3 km (40 miles) of earth lined canals constructed between 1905 and 1915, 41.8 km (26 miles) of concrete lined canals constructed in the 1950's and 1960's and 250 km (155 miles) of pipelines extending from the canal systems. Approximately 25% of the water diverted from the Rio Grande is lost to seepage. The District intends to conserve water by lining the larger capacity canals with geomembrane liners and converting some of the smaller canals to pipelines with funding coming from a variety of State sources as well as the North American Development (NAD) Bank, Water Conservation Investment funds.

The Wyrick Canal

The HID project improvements include the rehabilitation of 15 km (9 miles) of existing concrete lined canals that have been severely damaged due to excessive ground movement. Repair will be implemented by placing an exposed geomembrane lining system directly on the damaged concrete sections, thus eliminating the need for removal. Lining will be limited to the large capacity canals with flows greater than 2.3 to 4.0 cms (80 to 140 cfs).

In July, 2003 the HID purchased 1.14 mm (45 mil) thick EPDM rubber for the exposed geomembrane system to be placed on the Wyrick canal. The Wyrick canal's original concrete lining was cracked throughout and excessive seepage in excess of 20% was noted. The canal section is trapezoidal in shape with 1.5:1 side slopes and base width varying between 1.8 and 2.4 m (6 and 8 ft) and total prism width averaging 5.0 m (16.4 ft).

The HID selected EPDM rubber as the geomembrane system based on the following evaluation criteria:

1. Technical Evaluation
   a. Installation (Placement, Seaming, Maintenance by HID)
   b. Resistance to Damage (Placement and Operation)
   c. Repair by the HID over the Life of the Lining
   d. Life Expectancy (20 year minimum)
   e. Effective and Proven Seepage Control
   f. No Requirement for Geotextile Underlayment
   g. Flat Surface Installation (no wrinkles)
2. Texas Valley Prior History and Performance
3. Low Installed Price and Low Maintenance Costs

The EPDM geomembrane panels delivered to the site were custom sized 6.10 m (20 ft) in width and 30.5 m (100 ft) in length. The panels were folded along their length and then rolled on a core for delivery and handling on site. As with the TID, the HID personnel placed and field seamed all panels using their own equipment. Anchoring at the top of slope was provided by a 450 mm (18 in.) deep "V" trench cut in close to the top edge of the concrete and later backfilled with the excavated soil. The upstream and downstream ends of the EPDM lined section were anchored into the concrete section by placement into a 300 mm (12 in.) wide groove cut 450 mm (18 in.) deep across the entire width of the concrete section. The ends of the panels were placed into the groove and then the groove was backfilled and flush finished with concrete thus forming the transition from concrete to rubber lining.

Once the rolls were delivered to the site, the HID deployed the panels using their own equipment and a crew of 6 workers. District personnel pre-fabricated a metal lifting bar that passed through the core of each roll for lifting from a flatbed transport truck. Each roll was lifted by a large backhoe from the truck, positioned across the channel bottom and then unrolled down the channel by advancing the backhoe along the channel access road. After unrolling, the panels were unfolded and pulled up the side slopes, positioned flat with no wrinkles and placed into the "V" shaped anchor trenches. Overlap seaming was accomplished by district personnel using the same techniques described in the TID installation. Final installation was smooth and wrinkle free due to the conformability, unit weight and flexible properties of synthetic rubber membranes.

SUMMARY

The TID and the HID successively installed an exposed EPDM geomembrane system using custom manufactured panels, district personnel for installation and seaming and district equipment for the soils preparation and backfilling. The combination of low cost and user friendly materials that can be installed by irrigation district personnel with minimal training and no specialized equipment is an outstanding alternative to other systems and an excellent method for old canal lining rehabilitation.

EPDM rubber geomembranes are an outstanding alternative for use in the rehabilitation of old canals and laterals of western irrigation districts for the following reasons:

- Minimal preparation of the channel section or concrete surface using district equipment and personnel.
- User-friendly ease of panel installation with district equipment and personnel.
- User-friendly low tech seaming and repair methods by district personnel.
- Mechanical properties to resist installation and operation stress in an exposed environment (puncture/impact resistance, working strain to over 500 percent)
- Attachment to concrete and steel structures (gates, turnouts, pipes, etc.) using special waterproof adhesive systems, conventional batten bar attachment or simplified ballast attachment.
- Lay flat (soil friction and unit weight) characteristics to resist wind uplift/displacement.
- Lay flat wrinkle free installation over concrete.
- High UV / weathering resistance backed by decades of exposed installations including installations in the desert areas of the southwest.
- Repair and maintenance by irrigation district using simple low-tech seaming techniques and repair kits.
- Custom panel sizes for differing channel sections.
- Installation and seaming in cold winter weather conditions (usually off-season October to March in northern climates).
- Resistant to animal traffic including deer and elk in remote areas.

The TID and the HID are typical of many irrigation districts in the western United States where conveyance channels are unlined or deteriorated with many losing between 30 and 50 percent of the deliverable water to seepage during the irrigation season. With water costs increasing and available water in short supply (especially during dry years or federally mandated allocation restrictions), irrigation canals and laterals are being evaluated for lining rehabilitation with exposed geomembrane systems. There are over 10,000 km (16,100 miles) of main canals and over 16,760 km (27,000 miles) of laterals in the western United States alone (Comer, et.al, 1999). Of these, only approximately 15 percent are lined. Although all reaches of canals or laterals do not need lining, the potential of those that will need lining or rehabilitation to save valuable irrigation water in the very near future is indeed large.

REFERENCES

Comer, A., Haynes, J. and Frobel, R. (1999), "Canal Lining Systems in the Next Millennium", Proceedings 13th Annual GRI Conference – Geosynthetics in the Future, Geosynthetic Institute Publishers, Philadelphia, PA, pp 204-219.

Staff, C.E. (1984), "The Foundation and Growth of the Geomembrane Industry in the United States", Proceedings International Conference on Geomembranes, Denver, CO, IFAI Publishers, St. Paul, MN, pp 5-8.