Repair/Replacement of Concrete Lined Irrigation Channels

Case Study

Geomembrane Lining

Mareeba Dimbulah Irrigation Area
State Water Projects, Queensland

1. General

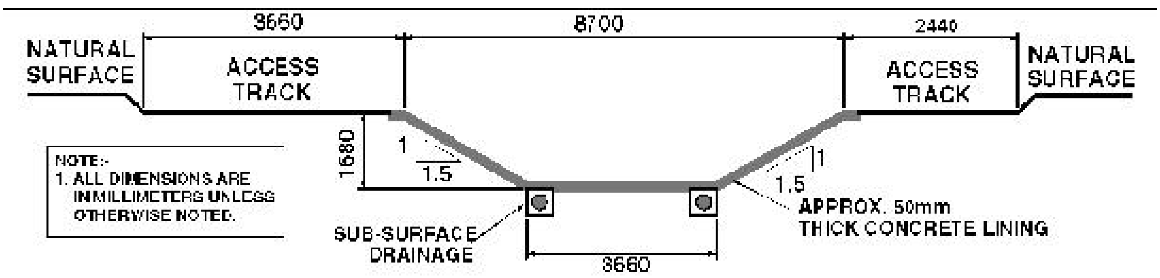
1.1 Background

Tinaroo Dam was constructed in the mid 1950's on the Barron river near Atherton in North Queensland. It was built to supply irrigation water to the Mareeba - Dimbulah Irrigation Area and the Barron Falls hydro-electric power station near Kuranda. Construction of the channel system to supply the Mareeba - Dimbulah Irrigation Area began in 1958 and was effectively completed by 1970. The distribution system consists of about 180 km of open channels and about 190 km of pipelines.

Some channels & pipelines are now 40 years old and in need of major maintenance. This paper discusses the rehabilitation carried out on about 5 km of concrete lined, trapezoidal open channel.

1.2 Extent of Problem

The section of channel discussed in this paper crosses high permeability sandy soils and as such was originally concrete lined to limit water losses. The concrete is nominally 50mm thick and un-reinforced. Sub-surface drainage was installed in the bed of the channel, prior to the placement of the concrete lining so as to relieve any natural ground water and any minor channel leakage.



TYPE CROSS SECTION

Constant seepage into the sub-surface drainage lines over many years has produced piping problems within the earthworks beneath the concrete lining. The resultant loss of integrity of the subgrade has resulted in significant joint displacement and cracking of the un-reinforced concrete lining. In some cases large voids have formed causing collapse of lining.

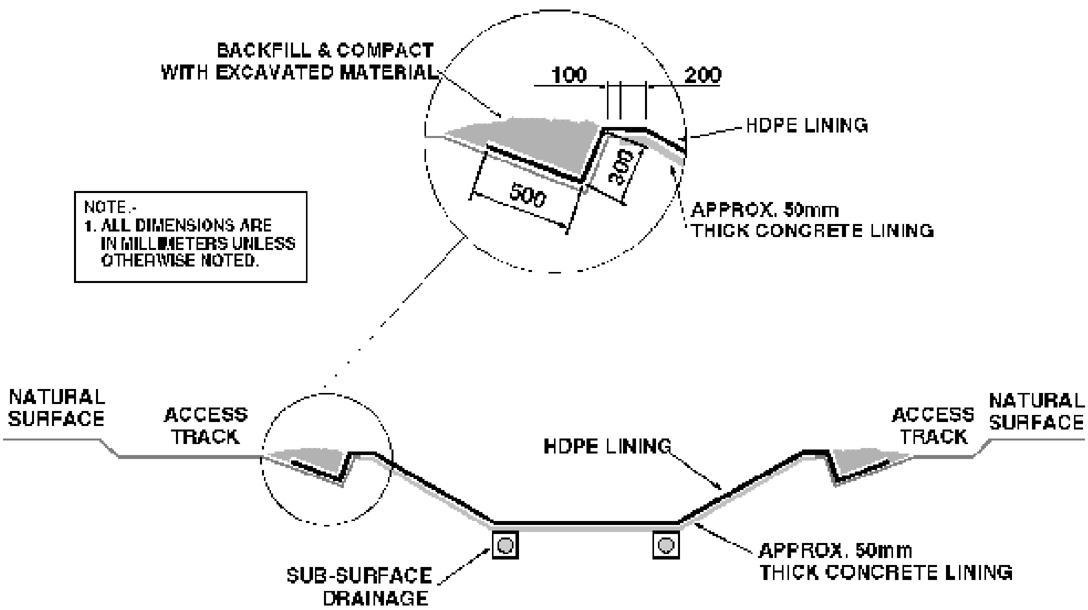
The discharge from the sub-surface drainage was measured using a temporary V notch weir. It was assumed that the measured discharge of 7Ml per day was all channel leakage. The value of the lost water was used to justify the capital expenditure of remedial works.

2. Adopted Solution

The practice of repairing cracks & joints with cement or epoxy-based products or flexible sealants has been ongoing for many years in the MDIA. Such repair methods are of limited success and are at best a temporary solution. A more permanent solution was required. Removal of the existing lining and replacement with a new concrete lining was too expensive. In any case, replacement with a new version of the old system is likely to give the same poor result.

About twelve months prior to the start of this project, a 400m section of smaller channel in a different location was lined with 2mm thick HDPE lining as a trial. This had followed a 10 year accelerated weathering test under tensile load at the Allunga exposure laboratory.

ANCHOR TRENCH DETAIL



TYPE CROSS SECTION

The existing concrete lining was retained as a foundation for the plastic liner. This trial section is now 2 years old and is performing well. Although 2 years is insufficient time to comment on UV exposure performance, the installation process went well. The trial section was quite small (1090m2) and was relatively expensive at about $24/m2.

On the strength of the trial section results, it was decided to proceed with the much larger project discussed in this paper. The project required 55,000m2 of lining and cost around $9.00/m2. The rate per square meter was significantly less than for the earlier trial section. This is mainly due to economies of scale, but also due to a particularly keen contract price at the time. It is suggest that a cost of $10/m2 - $12/m2 be used for budget purposes for a project of similar size. As most lining materials are imported, the cost varies considerably depending on foreign exchange rates. As material costs account for about 75% of the total project costs, more detailed cost estimates should be based on current material costs obtained from suppliers.

2.1 Preparation

The channel was drained, desilted and cleaned with high pressure sprays. Any badly broken bays were patched with concrete. Any open joints or large cracks with sharp edges were filled and smoothed over with cement mortar so as to limit the potential for puncturing of the lining. The channel was then refilled due to customers irrigation demands.

2.2 Laying the Liner

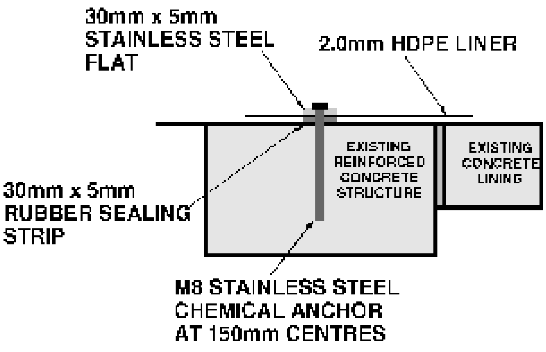
A grader was used to cut a "V" shaped anchor trenches along each bank at the top of the channel batter. This work was done before draining the channel for liner installation. To limit the effect on customers, the lining was installed in 2 separate 5 day shut down periods with a 9 day watering period between channel closures. After re-draining and re-cleaning, the liner was rolled out over the existing concrete lining and into the anchor trenches. The anchor trenches were partly backfilled at regular intervals so as to avoid wind gusts lifting the loosely placed liner. The width and length of liner on each role depends on the supplier. However, roles are typically about 7 meters wide and about 100m long in the case of 2mm HDPE.

2.3 Joining

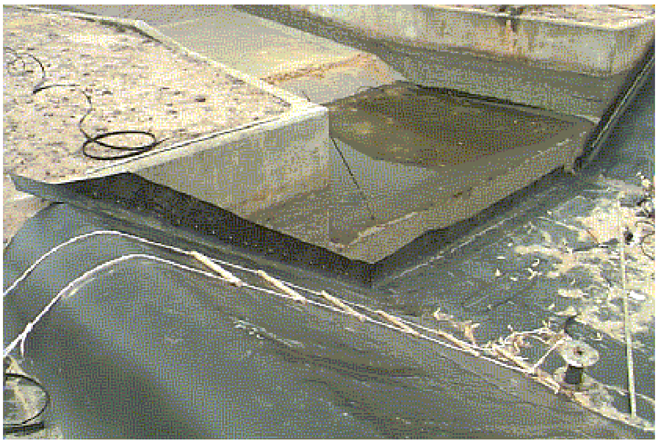
Sheets were lapped and joined using a twin track, hot wedge welding machine. The welding machine is self propelled. It passes a heated metal wedge between overlapping sheets to soften the plastic and then presses the softened sheets together between rollers. This welding technique produces two parallel seams about 10mm wide each and about 10mm apart. The double seam gives extra security against leakage and also provides a sealed tube between the two seams that can be pressure tested to ensure an adequate seal has been achieved. Any minor welding required to fit the lining around structures was done using extrusion welding techniques, were a bead of molten plastic is extruded onto the lapped sheets to fuse them together. The use of extrusion welding is unavoidable in some circumstances but should be avoided were possible as the heat generated in the welding process can contribute to brittle crack problems in the future.

2.4 Fixing at Structures

The lining was sealed around concrete structures using with a neoprene rubber strip placed between the concrete and the liner. A 30mm wide stainless steel strap was then placed on top off the liner an fixed into the concrete structure with 8mm chemical anchors at 150mm centres.



CONCRETE STRUCTURE
FIXING DETAIL



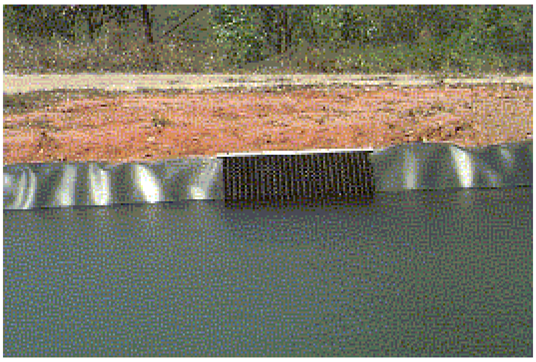
As HDPE has a relatively high thermal expansion coefficient, it tends to expand and wrinkle up a little in the middle of the day, contracting to a smother flatter appearance at night. Due to this characteristic is important that final fixing of liner at the ends and around offtake structures is under taken while the liner is in its coolest state. For this reason, cutting and fixing of liner around structures is done very early in the morning. It is extremely import that the lining not be smoothed out and fixed during the heat of the day as it will contract overnight at tear away from its fixings.

3. Conclusions

The lining project has been completed for over twelve months. So far there have been no major problems. The discharge for sub surface drainage has effectively stopped. Installation was very quick. This is important if annual maintenance shut down periods are short or non existent. The liner has not been installed long enough to prove it's longevity. However, HDPE liners in exposed applications have been used in Australia for about 12 years and in the US for over 50 years. Most suppliers of HDPE will provide a guarantee for 15 to 20 years exposed. Based on accelerated exposure tests, it has been suggested that a life of up to 50 years is possible.

If you are intending to use HDPE liners you should also be aware of the following issues that may be of concern. HDPE has been know to suffer environmental stress cracking problems especially in colder climates. If the portion of the liner above the water level is not free to expand and contract on a daily basis, internal stresses can build up over time resulting cracking of the liner.

Potential fire damage is also an issue that needs careful consideration. Most plastic liners will melt severely if exposed to fire. As such it is important to ensure the edges are kept clean and clear of dead grass were fires are likely. Sterilisation of the anchor trench backfill should be considered.



HDPE liner is also very slippery and may result in a safety hazard. If someone falls into a lined channel, it is very difficult to climb out. Wild life falling into the channel and drowning is also a problem. In order to address this issue, rubber escape mats were installed at 100m intervals along the length of channel. The rubber mats seem to have reduced the number of animals drowning in the channel. At this stage there has been no damage to the liner from animals. However, hard hoof animals such as deer have been a problem in the US.

4. Other Options

There are many different types of plastic liners available on the market, each with their own strengths and weaknesses. Some of the materials that you may come across include High Density Polyethylene (HDPE) as discussed in this study, Linear Low Density Polyethylene (LLDPE), Very Low Density Polyethylene (VLDPE), Polyvinyl Chloride (PVC), Chlorosulphonated Polyethylene CSPE, Polypropylene (FPP) and Ethylene Interpolymer Alloys (such as XR-5).

A university degree in polymer chemistry is required to fully understand the different properties and behaviours of the different materials. However, it is fair to say that HDPE has a good, long term record in exposed applications. HDPE is also relatively inexpensive.

Although relatively new on the market and slightly more expensive than HDPE, FPP liners should also be considered as an alternative in an exposed application. Lab tests indicate FPP will have similar or better performance exposed to UV to that of HDPE. It has better multi-axial strain properties than HDPE and as such it has a greater capacity to stretch over minor obstructions without rupture than HDPE. Environmental stress cracking problems are also significantly reduced for FPP.

Provided budgetary constraints allow, a plastic liner covered with earthworks or concrete would be the best solution. This approach is recommended by ongoing studies and trials by USBR. If covered, the choice of lining material expands greatly as problems associated with UV exposure, environmental stress cracking, fire and animal damage are significantly reduced. To provide a soil or concrete cover will be considerably more expensive than an exposed liner. However a significantly longer functional life could be expected. A whole of life economic analysis should be undertaken to determine the best option.

New and improved lining materials are entering the market all the time and as such it can be a little difficult to keep up with geosynthetic technology. The success or otherwise of a plastic lining project depends greatly on the correct choice of material and correct installation procedures. It is therefore important that a specialist consultant be engaged to design a system suitable for your application. There are several consultancies in Australia that specialise in geosynthetic design. There are also many experienced installation contractors capable of successfully installing these materials. Taking advantage of these specialist services is strongly recommended.

5. References

'Deschutes – Canal-Lining Demonstration Project: Year 5 Durability Report' Report R-97-01, US Department of the Interior, Bureau of Reclamation, January 1997.

Further Information

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