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Earthen channel lining trials

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ABSTRACT: In many arid parts of the world agricultural activity relies on the transmission and distribution of water via open channel systems. Some of these channels are concrete lined and others depend on soil based liners or even natural compacted soil. Loss of water by seepage from these channels is a major concern, not only for the loss of a valuable water resource, but for the damage that leakage can cause as a result of rising levels of soil salinity. This paper describes field trial applications of numerous different types of geomembrane and other liners in open earthen channels in the Murray – Darling Basin area of South East Australia. This area presents hot and arid conditions with high UV radiation levels. The channels are unprotected so a successful liner must stand up to these conditions as well as the vagaries of wildlife and normal agricultural activity. They were generally installed in 200 m long trial sections of operating channel and were evaluated during installation for cost and installation ease. Their performance was evaluated on the basis of initial ponding tests before the liner was installed and subsequent ponding tests to assess liner performance.

1 INTRODUCTION

In many arid parts of the world agricultural activity relies on the transmission and distribution of water via open channel systems. Some of these channels are concrete lined and others depend on soil based liners or even natural compacted soil. Loss of water by seepage from these channels is a major concern, not only for the loss of a valuable water resource, but for the damage that leakage can cause as a result of rising levels of soil salinity.

Beginning in 2001 and carrying on until 2003 the Australian National Committee on Irrigation and Drainage (ANCID) sponsored field trial applications of numerous different types of geomembrane and other liners in open earthen channels in the Murray – Darling Basin area of South East Australia. This area presents hot and arid conditions with high UV radiation levels. The channels are unprotected so a successful liner must stand up to these conditions as well as the vagaries of wildlife and normal agricultural activity. They were generally installed in 200 m long trial sections of operating channel and were evaluated during installation for cost and installation ease.

Their performance was evaluated on the basis of initial channel ponding tests before the liner was installed and subsequent ponding tests to assess liner performance.

In evaluating what materials were to be trialed consideration was given to previous experiences including the work by the US Bureau of Reclamation at Deschutes Canal, the concrete channels guidance provided by the Department of Natural Resources in Queensland and the current array of established and new geomembrane and other liner materials.

The materials used were the well known HDPE in different thickness, polypropylene (PP) in different thickness and reinforced and unreinforced forms, a Geosynthetic Clay Liner (GCL) and other more unusual materials which are described.

2 FIELD TRIAL PROGRAM

The field trials were carried out at various channel sites operated by Goulburn Murray Irrigation Ltd, Murray Irrigation Ltd, Murrumbidgee Irrigation Ltd and Wimmera Mallee Water.

The materials were supplied and installed on what was essentially a commercial basis, although irrigation authority technical staff often acted as unskilled assistants in order to gain some appreciation of the installation requirements.

The channels were generally 6 to 10 m wide and 2 m deep. The installation plots were nominally 200 m long in order to provide a fairly representative indication of cost and performance. As far as possible sections without bends were chosen for simplicity.

2.1 *Field trials*

The unlined channels were typically rough and unevenly shaped with ponded water, animal tracks and burrows and occasional tree roots. They were prepared for liner installation by removal of standing water, minimal reshaping and tree root removal by an excavator and excavation of anchor trenches as required.

The liners were field seamed and QC tested in accord with normal practice using thermal welding for the thermoplastic materials.

Figure 1. Typical unlined channel.

2.1.1 *HDPE 0.75 mm with soil cover*

This section of channel was approximately 20 m wide and 1200 m long and this was a much larger trial than the other installations. The liner was fully welded and QC tested as per normal practice. The soil cover was material previously overexcavated from the channel bed and stockpiled to each side. It was placed and spread by backblading with excavators.

Figure 2. Soil cover installation over 0.75 mm HDPE.

2.1.2 *Geosynthetic Clay Liner (GCL) with soil cover*

The GCL liner was installed at Tooloondo channel in 2002. Preparation for the GCL also required overexcavation to provide the final soil cover which

Figure 3. GCL installation.

was again placed and spread by excavators. It is to be noted that the soil cover must be placed before the GCL becomes wet as unconfined or premature hydration can permanently damage the GCL. The GCL seams are overlaps with supplementary bentonite.

2.1.3 *Butyl rubber*

It was intended to install a 2 mm Butyl Rubber liner at the Lakeview channel near Griffith but it was passed over in favour of the EPDM which appeared to provided better performance at reduced cost. Commercial quotations were obtained and these are included in the cost comparison.

2.1.4 *EPDM rubber*

Ethylene propylene diene monomer is a synthetic rubber material and arrangements were made to install 1.0 mm EPDM in prefabricated panels into the Lakeview channel near Griffith in 2001 but the installation did not proceed because of an earlier than usual requirement to use the channel for irrigation.

The prefabricated and folded panels were placed in covered storage for a year and the material was found to have bonded to itself ('blocked') such that it could not be used. The commercial costs are included in the cost comparison.

Figure 4. Reinforced PP a1.1 mm.

2.1.5 *Reinforced PP 1.14 mm*

The major advantages expected of reinforced PP are in the form of better thermal stability and hence less thermal expansion/contraction and the potential for better resistance to puncturing by hoofed animals. It was installed at the Finley Main Channel in 2001.

2.1.6 *Unreinforced PP 0.75 mm*

The major feature of 0.75 mm PP is that is able to be prefabricated into large panels such that the trial installation was entirely prefabricated. This does require good advance information on the channel size and profile. It was installed at the Finley Main Channel in 2001.

Figure 5. Unreinforced PP 0.75 mm (Note large crew size).

2.1.7 *Unreinforced PP 1.0 mm*

The unreinforced PP used in this trial was manufactured in 7 m wide rolls which made prefabrication less useful. It was installed at Dahwilly near Deneliquin in 2002.

2.1.8 *Rubberised bitumen emulsion*

The product used was a rubberized bitumen emulsion in a water based carrier. It was applied cold in multiple coatings over a geotextile carrier. Some UV deterioration is expected and a periodic overcoat is recommended for exposed portions every 2-3 years.

Figure 6. Rubberised bitumen emulsion.

2.1.9 *HDPE 1.5 mm*

HDPE 1.5 mm is the most common grade of HDPE and this was installed in the normal way with cross seams. One of the hazards for these installations is the local wildlife and this was well illustrated by the discovery of a dead kangaroo one morning when the installation was almost complete. The surface is extremely slippery and the animals cannot get out.

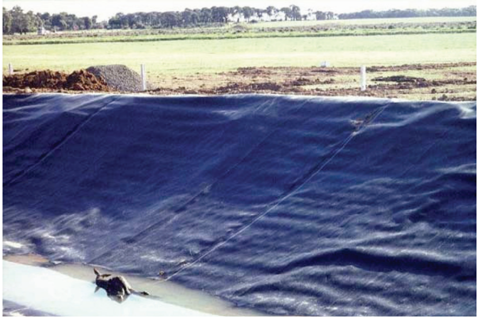

Figure 7. HDPE 1.5 mm (note dead kangaroo).

2.1.10 *HDPE 2.0 mm*

The HDPE 2.0 mm was installed at the Finley Channel in 2003 and a post installation pondage test is yet to be undertaken.

2.1.11 *PE Co-extruded composite*

The PE composite was based on co-extruded blends of LLDPE and the upper layer was a tan layer with additional UV stabilization. It is said to provide better puncture resistance and better control of thermal expansion than a black material.

2.2 *Field trial preliminary results*

The Field trial preliminary results are set out in Table 1.

There are a number of points to be noted about these results:

(a) The apparent efficiency is the ratio of the leakage rate after installation to the leakage rate before installation.
(b) Where a pondage test has not yet been conducted an apparent efficiency of 85% has been used in the comparison
(c) There is some doubt about the efficiency of the end seals used in the HDPE 1.5 mm pondage test since a close inspection found no apparent defects.
(d) There is obviously some variability in the cost data as the HDPE 2.0 mm would be expected to cost more than the HDPE 1.5 mm.
(e) The additional size of the HDPE 0.75 mm trial (24,000 sqm rather than 3000 sqm) means that the HDPE 0.75 mm enjoys a cost advantage of 30 to 50% in this comparison.

Table 1. Field trial preliminary results.

Material	Installed Cost A$/sqm	Seepage Rate $L/m^2/day$	Apparent Efficiency %	Efficiency/ Cost Ratio
HDPE 0.75 mm with soil cover	$7.10	3.8	90%	1.268
GCL with soil cover	$11.91	11.1	87%	0.730
Butyl Rubber	$21.10	na	85%	0.403
EPDM Rubber	$20.14	na	85%	0.422
Reinforced PP 1.14 mm	$16.92	na	85%	0.502
Unreinforced PP 0.75 mm	$11.93	2	71%	0.595
Unreinforced PP 1.0 mm	$15.37	0.5	94%	0.612
Rubberised Bitumen Emulsion	$10.33	1.6	63%	0.610
HDPE 1.5 mm	$13.70	1.1	77%	0.562
HDPE 2.0 mm	$12.20	na	85%	0.697
PE Co-extrusion 1.5 mm	$16.54	0.5	94%	0.568

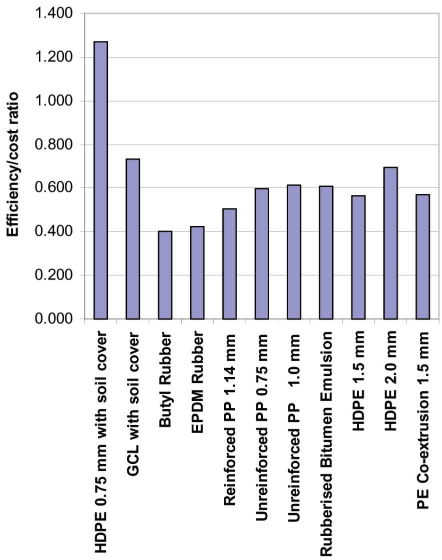

Figure 8. Apparent efficiency/cost.

3 OBSERVATIONS

Since much of the ultimate interest is in longer term performance in the face of wildlife and other interventions it is too early to draw any conclusions and we really need to see results of second and third round pondage tests to see a pattern.

It is apparent that protection from animal life is a substantial issue and that soil covered materials (HDPE 0.75 mm and GCL) seem to show a performance benefit from that protection.

Reference to the work of Sadlier, Frobel and Cowland (2004) which examined potential leakage rates from un-seamed or partially seamed liner systems would indicate that there may be benefit from an examination of unseamed liners with large overlaps and soil cover for these irrigation channel systems. Such systems would be capable of installation without specialist welding skills and could well provide a suitable balance of cost and performance.

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