Concrete Lined Irrigation Channels – Crack Repairs

1 Overview

Crack repair will not always be necessary in concrete channel linings, but when the presence of cracks permits serious water loss, something must be done. The requirement for action may be prompted by consideration of the value of the water lost, by damage it is doing to the channel foundation soils as it escapes, or by the nuisance it presents on adjoining property.

This section considers the measures to be taken in the repair of cracks, a process undertaken (in this context) solely to prevent the passage of water. If the cracks are numerous enough, or so disposed, to threaten the integrity of the channel lining, then other measures will be more appropriate. These might include patch repair, re-lining or complete replacement.

If a repair is to be successful in the long term, it is important that various steps are taken, in the correct order, towards its implementation.

First, the nature and cause of the crack(s) must be identified and any consequent damage to the supporting soils determined. Correction of any such consequent damage must then be undertaken before repairs can be started.

If this process is ignored or skimped, then the repair is likely to fail in short order and the money and resources employed will have been wasted.

A second step is to determine whether or not the crack is inert. Truly inert cracks are rare, as some degree of thermal movement is practically inevitable, but the less movement there is, the more likely it is that a rigid repair material will work.

Once the above steps have been completed (ie a proper condition survey has been undertaken) suitable repair materials can be selected. This will entail matching the characteristics and requirements of the repair materials or system to the conditions at the repair site, considering likely future crack movement, time available to effect the repair, difficulty of drying the concrete, etc.

The concrete itself must then be properly prepared for the repair process. Incorrect or inadequate preparation for a particular process is the most common cause of repair failure.

Given all of the above, then the repair must be implemented correctly and cured properly before success is likely. The manufacturer's recommendations for the use of proprietary materials and systems are based on knowledge and experience and must be followed closely for best results.

All of the above comments will apply, whether the crack repair consists of filling a fine crack, sealing a large (or enlarged) crack, or making an elastic join (bridging the crack with a flexible sealing material).

2 Issues to be Considered

It is assumed that the causes of the cracking have been determined and that any consequent damage has been remedied. This could include backfilling any voids outside the lining, relieving any pressure on the lining, or using slabjacking techniques to re-align lining panels.

For the purposes of the following discussion, a definition of crack widths is appropriate. Table 1 below sets out a definition of crack widths likely to be experienced in the field. These definitions were obtained from a report by the Department of Land & Water Conservation – Murrumbidgee Irrigation on the Lake View Branch Canal near Griffith in New South Wales.

Table 1 – Definitions of Crack Widths

CRACK TYPE	CRACK WIDTH
Small Crack	1 – 5 mm
Normal Crack	5 – 25 mm
Big (or Wide) Crack	25 – 75 mm

2.1 Crack Stability

An assessment must then be made of whether or not the crack is likely to move again. Some degree of movement in response to thermal changes is almost inevitable, but the likelihood of recurrence of the degree of movement that caused the crack should be estimated.

Pure shrinkage cracks with no associated ground movement can be expected to be fairly stable, as can accidental cracks once the cause has been neutralised. Cracks caused by (or later affected by) ground or water pressure, soil movement, etc, are more likely to continue to move, as are those exposed to constant thermal variations.

It is very important that rigid repair methods such as filling with mortar or grout, sealing with bitumen or injecting with epoxy are **not** used if further crack movement is likely. Any subsequent movement will either disrupt the repair material or cause a second crack adjacent to the first.

2.2 Concrete Preparation

Poor or inadequate preparation of the parent concrete is the single most common cause of failure in crack repairs. Repair materials cannot bond successfully to weakened, deteriorated or dirty concrete. Many repair materials cannot bond to wet or damp concrete, either.

In general, the repair area will have to be cleaned thoroughly with a high-pressure water blaster or a grit blaster, then blown with compressed air to remove all dust and loose material while drying the concrete.

Depending on crack width and materials, this regime may have to be applied to the concrete faces within the crack itself, as well as to its edges and the surrounding concrete.

Skimping on preparation could negate the whole repair, so the process required for a given repair material must be carefully considered at the planning stage. If the channel cannot be emptied and dried properly, for instance, it may be worthwhile considering the extra expense of a material that can be applied in wet conditions, or even underwater.

2.3 Material Application

Correct application of most modern repair materials is crucial to their success, and certainly crucial to any performance guarantee offered by the manufacturers.

With the more complicated technologies, it may well be worth the expense of having the work done by experienced and/or approved applicators, partly for the increased likelihood of a successful repair and partly to take full advantage of any guarantees.

Direct labour personnel can execute simpler repairs, but the work should still be implemented in accordance with the manufacturer's recommendations. The points likely to prove critical include the degree of cleanliness and/or dryness required at the repair site, the correct use of suitable primers, the maximum or minimum size of crack to be repaired and the quantities of material to be used.

These recommendations should be followed carefully for best results, unless prior experience or testing has provided proof that variations will work successfully.

2.4 Curing

All repair materials have specific curing requirements and should be cured in accordance with their manufacturer's recommendations for best results, as these have been found by test to be most effective in establishing good repairs.

Unfortunately, this aspect of the work is often the least well executed, especially as it comes at the end of the repair process, when time constraints are likely to be at their worst.

Some materials require long wet cures, some need initial moisture only, and others must be kept dry for a specific time. It is crucial that these requirements are noted and properly implemented if the best performance and service life are to be obtained from the repairs.

3 Repair Options

The appropriate crack repair options for any given case will depend on whether the crack to be repaired is considered stable (inert) or likely to move (active). The choice will also depend on the repair type – filling, sealing or bridging the crack.

Crack filling is only appropriate when the crack width is small. For wide cracks (or cracks which have been routed out to widen them) sealing compounds can be applied as for a normal joint groove. Most cracks can also be bridged over with a suitable membrane, with or without a reinforcing tape.

3.1 Crack Filling

Crack filling usually consists of injecting a suitable material into the crack via entry ports drilled into the crack after sealing across the crack face with tape or putty. The material to be injected must have an appropriate viscosity, chosen to match the crack width, and appropriate properties after curing. It is also possible, with cracks in horizontal surfaces, to run the filling material into the crack by gravity.

If the crack is inert, suitable filling materials include epoxy resins, polyurethane grouts and even cementitious grouts.

Cementitious grouts can be run or injected into medium cracks and can fill them well, but are brittle when hardened and will fail if movement occurs later. They are relatively cheap, but not recommended for most situations.

Epoxy injection is very good for structural repairs, but generally requires extensive preparation, including flushing out and drying the cracks. Most hardened epoxy resins are not tolerant of movement and should not be applied to active cracks, as subsequent movement will cause a new crack to form adjacent to the repaired one.

Like epoxy injection, filling cracks with polyurethane grout is a time-consuming and expensive process, but these materials cure on exposure to moisture, can adhere to damp concrete and are flexible. They will seal cracks even after some movement has occurred.

Crack filling, with epoxy or with polyurethane, requires expert knowledge and techniques. It is best left to experienced applicators and will probably be found to be too expensive to contemplate for a large number of cracks.

3.2 Crack Sealing

This method involves routing, or enlarging, the crack along its exposed face (inside the channel) and filling with a joint sealant. Wider cracks can be sealed directly, providing their edges are sound enough to provide a permanent bond to the sealant.

As with crack filling, modified cementitious mortars and epoxy compounds can be used for crack sealing, but they are both intolerant of movement and should only be selected for inert cracks.

Where some movement is anticipated, flexible materials such as silicone, polyurethane, or polysulphide should be used. Acrylic sealants are generally not recommended for continuous immersion in water.

The degree of preparation, cleanliness and dryness required in the crack will vary from product to product, and should be checked and included in cost comparisons. Requirements for the application of primers also vary, with most manufacturers specifying them for many of their products. Tests by the US Bureau of Reclamation, however, have shown that the use of primers can impair performance unless done properly, and that many products perform perfectly well without primers (see References).

Some sealants are designed to swell on contact with water to ensure a tight, leak-free joint. These materials should be used with caution, as the swelling pressure in some instances may be enough to cause disruption of thin concrete channel linings.

3.3 Crack Bridging

In this technique, a narrow strip of flexible waterproof membrane is placed (or formed) over the crack and stuck to the concrete at either side. Depending on crack width and membrane thickness, some form of backing may be required, such as a fibreglass tape over the crack to support the membrane.

At the expensive end of the scale are specialist systems designed for bridging and sealing cracks and joints with large expected movements. These typically consist of a specially-reinforced flexible waterproof tape and an adhesive system by which the tape is glued to the concrete at either side of the crack or joint.

On a simpler level, some Irrigation Authorities have achieved good results with a liquid waterproofing membrane applied across the crack, sometimes as a multi-layer system incorporating reinforcement fabric. The ultimate life of this option is not yet known, but the membrane is an acrylic formulation that is not usually recommended for constant immersion in water.

These crack-bridging systems are, of course, totally dependent on obtaining a good bond to the concrete surface at either side of the crack. The quality of this bond depends very much on the cleanliness of the concrete surface, and so relies on excellent surface preparation.

4 Installation Considerations

Many installation considerations have been mentioned in conjunction with the relevant type of repair and material. In general, however, most of the materials and systems described depend on good bond to concrete for their continued effectiveness.

This usually entails thorough cleaning of the crack and/or the concrete adjacent to it, removal of all loose or unsound material and often complete drying of the concrete surface or the interior of the crack.

When the manufacturers recommend these preparations, it is folly to skimp on them, as a few dollars (or days) saved can totally negate the repair and waste all the money spent on it.

When a primer is to be used on the concrete before application of the repair material, it is essential that the primer is applied correctly, or it can become a debonding agent.

Although trials elsewhere have indicated that some materials perform well without primers, in unusually wet conditions, underwater, or with no preparation, the adoption of such practices should be approached with caution. Consultation with the material manufacturer and local trials would be wise precautions before implementing a full repair programme on the basis of less-than-rigorous preparation.

Most of the chemicals used in the modern range of sealants and grouts are relatively innocuous if handled carefully, but typical precautions include not inhaling vapours, avoiding contact with the skin, and the use of eye protection when mixing components.

Reference should always be made to the manufacturer's literature for recommended safety precautions when handling these substances, and adequate measures taken to comply. Particular hazards such as inflammable components or dangerous fumes are rare, but will be marked on containers when they exist.

5 Summary and Recommendations

It is recommended that all cracks be treated as active unless there are compelling reasons to do otherwise. They should, therefore, be repaired with materials that can tolerate some movement.

Crack sealing or crack bridging techniques are likely to be more cost-effective than crack filling or injection techniques. If dealing with a few isolated cracks requiring repairs with maximum effectiveness and service life, however, the cost of crack filling could be well worthwhile.

Polyurethane materials seem to be the best all-round bet for filling and sealing cracks. Unless alternative approaches have been well documented or proven by testing, rigorous implementation of recommended crack preparation procedures is advised.

6 References

"Guide to Concrete Repair and Protection", published jointly by Standards Australia, Standards New Zealand, CSIRO and the Australian Concrete Repair Association.

"Elastomeric Canal Sealants: Air-Water-Heat Study", Report R-93-09, US Department of the Interior, Bureau of Reclamation, May 1993.

"Elastomeric Canal Sealants: Application to Wet Concrete", Report R-93-18, US Department of the Interior, Bureau of Reclamation, December 1993.

"Lake View Branch Canal – Investigation for Reconstruction - Mirrool", Department of Land & Water Conservation, Murrumbidgee Irrigation, October 1995.