Chemical sealing of earth dams

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By R. G. Pepper,
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Irrigation and Water Resources Branch

Numerous small holes in the dam batter are caused by ‘piping’ failure.

Leakage is not a major cause of failure of farm dams in the Western Australian wheatbelt, but it is a problem in some districts where it can limit stock carrying capacity. Leaking dams are especially common in the West Midlands, the north-eastern wheatbelt and the ‘jarrah-belt’ which extends from Bindoon, southwards to Manjimup and Mt Barker (see map and Table 1). Some dams which leaked when first built have sealed themselves over the years. Others have been successfully sealed using sodium tripolyphosphate.

Types of leakage
There are three common types of leakage from farm dams.

- Leakage through soil around the excavation. This usually happens in dams constructed just below gravel hills in the mottled and pallid zones of the lateritic soil profile.

- Leakage where quartz-rich zones intersect the excavation. These zones are the original quartz veins which were present in the parent rock. When granite and gneiss weather to form soils these quartz veins are left in the soil. (Granite is a granular crystalline rock of mainly quartz and feldspar; gneiss is a banded rock of quartz, feldspar and mica.)

- Leakage through zones of more permeable soil. These zones are seen as ‘pipes’ or ‘tunnels’ in the empty excavation. They may exist as a few large holes, or as many small holes scattered over the dam floor. ‘Pipes’ or ‘tunnels’ occur mostly on north-eastern and eastern wheatbelt sites where salmon gum and gimlet grew previously.
Leaking dams in the Badgingarra district and 'jarrah belt' are typical of the first two types. Most of these dams are sited just below gravel hills or breakaways. The soils are yellow-brown and orange-brown mottled sandy clay to sandy clay loams in the mottled zone of the laterite profile. The dams in them tend to leak at a constant rate.

Although the clay contents of these soils range from 20 to 40 per cent, most of the remaining fraction is sand. The particle sizes within the sand are poorly graded and the lack of intermediate grades of silt allows seepage through unfilled spaces between sand grains.

**Sealing methods**

Soils can be dispersed and made less permeable by:

- puddling and compaction by livestock;
- compaction by machine; and
- the use of chemical dispersing agents.

A common method of sealing dams involves dispersion of the soil into its primary particles of clay, silt and sand. A dispersed, puddled or remoulded soil conducts water less readily because the soil is more compacted and there is less pore space.
Use of chemicals

Sodium tripolyphosphate (STPP) has been used to disperse soil to reduce excessive seepage from earth dams and ponds by incorporating STPP into the dry batters of the dams. Bulldozers were generally used to incorporate STPP into the dry batters because the steep (1 in 3) batters prevented the use of conventional farm machinery.

An alternative application method is to dissolve the STPP in the dam water. This method has been successful in those dams which leak at a uniform rate. These dams are usually excavated in the mottled and pallid zones of lateritic soils. This application technique leads to a more even distribution of STPP in the walls and floor of the dam and allows a thicker soil layer to be treated. No compaction of the batters after treatment is required.

Sodium tripolyphosphate is dissolved in the dam water by circulating the water through a 200 litre tank in which there is a sieve and a baffle. The STPP is added to the inlet side of the pump for dissolution and the water returns by gravity to the dam. The water is circulated by means of a low-head, high-volume pump, consisting of a boat propellor mounted in a 225 millimetre diameter steel tube, driven by a 6 kW motor. Water is discharged from this pump at 250 cubic metres per hour. The pump and outlet from the tank are placed at the water’s edge so that thorough mixing of the dam water occurs.

Sodium tripolyphosphate is added at a rate of 30 kilograms per hour. When all the STPP has been added, all the water in the dam is circulated through the pump. The position of the outlet should be changed at least once during this operation to ensure thorough mixing and a uniform concentration of STPP in the water.

Rate of STPP used

Soil samples are taken from the dam to be treated. They should be taken from each soil horizon down the front batter for the full depth of the dam. During sampling the soil structure should also be noted and described. A key to such descriptions has been prepared by the Department of Agriculture in Technote No. 5/83—‘Testing soils for dam sites’. If the soil is aggregated to form an open, porous well-structured soil, then there is the risk that this sealing technique will not work. Only those soils that show no structure (called massive soils) can be successfully sealed by using this method.

The degree of dispersion of the soil by STPP is tested on small, air-dried soil crumbs from these samples. These soil crumbs are put in solutions of a range of concentrations of STPP to determine the amount of chemical to dissolve in the dam water. The concentrations of STPP used to test dispersion are: 0.05; 0.1; 0.2; 0.3 and 0.4 grams per litre. These solutions of STPP should preferably be made up by using clear
dam water (muddy water from leaking dams usually settles out within 24 hours) so that dissolved salts present in the dam water will influence the degree of dispersion of the soil. The air-dried soil crumbs are then put in these solutions and rated after 20 hours. A score of 0 to 4 is used to rate the degree of dispersion—0 being nil dispersion and 4 being complete dispersion. A more detailed account of dispersion testing and scoring is given in Technote No. 5/83—‘Testing soils for dam sites’.

The lowest concentration of STPP that gives a score of 2 to 3 is selected. If the STPP solutions cannot be made up in dam water and distilled water is used, the median concentration of STPP that gives a score of 2 to 3 is selected. The median concentration is selected to allow for the suppression of dispersion caused by dissolved salts in the dam water.

If the air-dried soil crumbs completely disperse (score 4), ‘piping’ could occur if that concentration of STPP is used in the dam, and the seepage rate from the dam, after treatment, would increase.

After calculating the volume of water in the dam, enough STPP is dissolved in the dam water to give the required concentration.

**Soil types treated**

Table 2 shows the types of soil in which this treatment has been tried.

Sodium tripolyphosphate has been used mainly in lateritic soils, usually in the mottled or pallid zone of the old laterite profile. The soils are mainly weak, sandy clay loams that do not disperse in distilled water. Adding STPP to these dams, usually at a rate of less than 0.4 g/L, has successfully sealed them.

Dams in sandy loams developed directly from weathering of gneiss have also been sealed successfully.

Dams in hard cemented pallid zones from the north-eastern wheatbelt have not been sealed successfully using STPP.

The STPP technique is not recommended for the sealing of dams in well structured soils because ‘piping’ will result. Seepage from two dams in these soils increased dramatically after treatment. These dams were situated on the tops of gravel hills. The soils were developed from the weathering of granite and had a prismatic structure. However dams in the same position in the terrain have been successfully sealed at Badgingarra where the soils are weathered from sedimentary materials. Those

### Table 2. Description of earth dams treated with STPP

<table>
<thead>
<tr>
<th>Location</th>
<th>Soil type</th>
<th>Rate of STPP (g/L)</th>
<th>Seepage before treatment (mm/day)</th>
<th>Seepage after treatment (mm/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Badgingarra</td>
<td>mottled zone, sandy clay loam</td>
<td>0.8*</td>
<td>3.93</td>
<td>0.61</td>
</tr>
<tr>
<td>Badgingarra</td>
<td>mottled zone, sandy clay loam</td>
<td>1.2*</td>
<td>6.48</td>
<td>2.68</td>
</tr>
<tr>
<td>Badgingarra</td>
<td>mottled zone, sandy clay loam</td>
<td>0.4</td>
<td>2.83</td>
<td>2.0</td>
</tr>
<tr>
<td>Badgingarra</td>
<td>mottled zone, sandy clay loam</td>
<td>0.3</td>
<td>4.94</td>
<td>1.45</td>
</tr>
<tr>
<td>Margaret River</td>
<td>pallid zone, beneath gravel, sandy clay loam</td>
<td>0.2</td>
<td>98.0</td>
<td>4.5</td>
</tr>
<tr>
<td>Narrogin</td>
<td>micaceous sandy loam developed from gneiss</td>
<td>0.4</td>
<td>11.0</td>
<td>2.2</td>
</tr>
<tr>
<td>Jingalup (South of Kojonup)</td>
<td>pallid zone, beneath gravel, sandy clay loam</td>
<td>0.3</td>
<td>8.0</td>
<td>1.0</td>
</tr>
<tr>
<td>Boyup Brook</td>
<td>pallid zone, sandy clay</td>
<td>0.5</td>
<td>26.0</td>
<td>0.5</td>
</tr>
<tr>
<td>Dwellingup</td>
<td>pallid zone, sandy clay loam</td>
<td>0.1</td>
<td>43.0</td>
<td>13.0</td>
</tr>
<tr>
<td>Nyabing</td>
<td>pallid zone, sandy clay loam</td>
<td>0.4</td>
<td>10.6</td>
<td>0.5</td>
</tr>
<tr>
<td>Cleary (West of Beacon)</td>
<td>hard cemented pallid zone, sand clay loam</td>
<td>0.2</td>
<td>56.0</td>
<td>130.01</td>
</tr>
<tr>
<td>Woolbilla Station, Kalgoorlie</td>
<td>hard cemented pallid zone, sand clay loam</td>
<td>0.2</td>
<td>35.0</td>
<td>14.0</td>
</tr>
<tr>
<td>Beacon</td>
<td>hard cemented pallid zone, sand clay loam</td>
<td>0.05</td>
<td>30.0</td>
<td>30.0</td>
</tr>
<tr>
<td>Buniche (East of Lake Grace)</td>
<td>pallid zone, sandy clay loam</td>
<td>0.05</td>
<td>7.0</td>
<td>0.5</td>
</tr>
<tr>
<td>Katanning</td>
<td>mottled zone, prismatic structure</td>
<td>0.3</td>
<td>20</td>
<td>864§</td>
</tr>
<tr>
<td>Wandering</td>
<td>mottled zone, prismatic structure</td>
<td>0.2</td>
<td>17</td>
<td>77§</td>
</tr>
</tbody>
</table>

*Dispersion test to calculate the rate of STPP had not been developed when the treatment was applied.

STPP induced 'piping' failure into this well structured soil.

STPP induced 'piping' failure into this hard cemented soil.

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A key dam treated with STPP now leaks much less water than previously.

The rates of STPP used, up to 0.5 g/L (95 milligrams of phosphorus per litre), do not affect sheep and cattle drinking the water. Water becomes unpalatable to stock only when its phosphorus level reaches 1,000 mg/L.

It was thought that the addition of phosphate to the dam water would cause algal blooms. Blooms can develop when the concentrations of inorganic phosphorus and nitrogen equal or exceed 0.01 and 0.30 mg/L respectively. No algal blooms developed in dams treated with STPP. After the addition of STPP, the concentration of suspended clay in the water increased and sunlight was not able to penetrate the water and encourage algal growth. Low nitrogen concentrations in the water could also limit growth. Most dams were treated in July and August, when water levels were at their highest, and water temperatures were probably too low for rapid algal growth.

Treatment costs

The cost of sealing a dam by dissolving STPP in the dam water ranged from 12 to 48 cents per cubic metre in 1984 for the STPP, excluding the cost of pumping. This cost should be compared to the 75 cents per cubic metre cost of constructing a new dam on a suitable site.

Further reading