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Flat batter dams suit difficult sites

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Flat batter dams suit difficult sites

In south coastal districts a unique method of catching and storing water on farms has been developed where deep sandy-surfaced soils and low-intensity falls of rain make conventional dam filling from surface runoff difficult or impossible.

These deep sandy soils make roaed catchments economically unattractive, and they often suffer rilling and silting problems if they are made very wide and steep as is necessary on deep overburden sites.

The existence and nature of the sub-soils offers a solution to the problem of filling dams built in this deep sand country.

Why not create a catchment by spreading the clay from the dam excavation over the surrounding sandy soil surface? This has proved a practical answer. The result is the flat batter dam.

Such dams usually are circular in plan. The sandy topsoil is used to form a circular saucer around the proposed dam, then clay from the
dam excavation is spread over this sandy saucer to form the catchment.

The circular shape now used for most flat batter dams makes construction easier, since there are no corners to build up as in the case of the earlier square flat batter dams. A road grader can work in a continuous circular motion, moving outwards from the dam, thus spreading the clay on the catchment during construction. This also makes subsequent maintenance easier.

**Ratio of catchment area to dam volume**

A fixed ratio of catchment area to dam volume is often used for easy design purposes. Thus, in south coastal districts where average annual rainfall is greater than 400 mm, a ratio of $5 \text{ m}^2$ (square metres) of catchment per $1 \text{ m}^3$ (cubic metre) of excavation or $1 \text{ ha}$ of catchment per $2000 \text{ m}^3$ of excavation, is an adequate 'rule of thumb'. However, this criterion will not normally produce the most efficient farm water supply in terms of dollars outlayed per livestock unit.

*Cross section through a circular flat batter dam.*

Experience in the south coastal districts has shown that flat batter dams yield at least as much runoff as roaded catchments made from the same type of clay. Thus, if efficient, least-cost water supplies are required, the same principles of design for flat batter dams can be used as are used for conventional dams and roaded catchments. These principles are described in detail in Farmnote No. 44/76, and Technote 4/76, and are based on the findings of a computer simulation model of dam size, catchment size, drinking rate, rainfall and evaporation rates.

**Sites for flat batter dams**

Flat batter dams can succeed in catching and storing water where no other design would be suitable. When the sandy topsoil is deeper than 0.4 m or a proposed site has too little slope for a conventional dam and roaded catchment, flat batter dams are ideal, especially in south coastal areas.

Flat batter dams can be built on sites with quite deep overburden but the depth of overburden which can be accepted for a practical site depends on the size of the dam excavation. Table 1 gives the minimum size of dam and catchment that can be constructed in soils with a particular overburden. This table shows that catchment size is governed by dam size and that as overburden depth and dam size increase, the ratio of catchment area to dam size decreases. However this catchment limitation can be overcome by sinking both dam and catchment below ground level to obtain enough soil to construct the catchment.

Another method of obtaining enough soil for the catchment is to have a 'borrow pit' around the outside circumference of the catchment. Soil is pushed from this borrow pit into the catchment area to build it up. This method should be cheaper than sinking the whole dam and catchment below ground level, because the soil is moved through a shorter distance. Conventional dams and roaded catchment sizes are independent of one another and can be varied at will. However one disadvantage of conventional dams and roaded catchments is that they are not compact units and at times cause difficulty with cropping and stock operations.

**Construction**

The catchment is prepared using a scraper and road grader. The sandy overburden is pushed out to form a

<table>
<thead>
<tr>
<th>Capacity $m^3$</th>
<th>Top excavation radius m</th>
<th>Bottom excavation radius m</th>
<th>Depth m</th>
<th>max. depth of overburden m</th>
<th>Outer catchment radius m</th>
<th>Total area ha</th>
<th>Ratio of total area to excavated volume $ha/1000m^3$</th>
</tr>
</thead>
<tbody>
<tr>
<td>500</td>
<td>11.79</td>
<td>5.90</td>
<td>1.96</td>
<td>0.46</td>
<td>35.7</td>
<td>0.40</td>
<td>0.80</td>
</tr>
<tr>
<td>1000</td>
<td>14.83</td>
<td>7.43</td>
<td>2.47</td>
<td>0.81</td>
<td>45.0</td>
<td>0.64</td>
<td>0.64</td>
</tr>
<tr>
<td>1500</td>
<td>17.00</td>
<td>8.50</td>
<td>2.83</td>
<td>1.06</td>
<td>51.5</td>
<td>0.83</td>
<td>0.56</td>
</tr>
<tr>
<td>2000</td>
<td>18.71</td>
<td>9.36</td>
<td>3.12</td>
<td>1.28</td>
<td>56.7</td>
<td>1.01</td>
<td>0.56</td>
</tr>
<tr>
<td>2500</td>
<td>20.15</td>
<td>10.08</td>
<td>3.36</td>
<td>1.45</td>
<td>61.10</td>
<td>1.17</td>
<td>0.47</td>
</tr>
<tr>
<td>3000</td>
<td>21.42</td>
<td>10.71</td>
<td>3.57</td>
<td>1.63</td>
<td>64.9</td>
<td>1.32</td>
<td>0.44</td>
</tr>
<tr>
<td>3500</td>
<td>22.55</td>
<td>11.28</td>
<td>3.76</td>
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<td>68.4</td>
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<td>4000</td>
<td>23.57</td>
<td>11.79</td>
<td>3.93</td>
<td>1.92</td>
<td>71.5</td>
<td>1.60</td>
<td>0.40</td>
</tr>
</tbody>
</table>
Stage I, establishment of the circular pattern and scrub clearing.

sloping, saucer-shaped depression surrounding the dam site, with a slope of 1 to 1.5 per cent towards the dam site. Then clay from the excavation is pushed out radially to cover this sand. The clay-covered catchment is then smoothed with a road grader and rolled.

In the construction of a flat batter dam it is advisable to push up a circular embankment of clay around the edge of the excavation. Then water can be directed safely through this embankment from the catchment into the dam via a pipe. This helps reduce siltation of the dam. Also it can be used to increase the depth of storage by pumping over the wall if salty groundwater or rock limit the depth of the excavation.

Potential in northern areas
Because flat batter dams have been so successful in south coastal districts, farmers and researchers are interested in the potential for their use in other parts of Western Australia where farm water supply problems exist. Two particular areas of interest are the West Midlands and the north-eastern wheatbelt.

The Department of Agriculture constructed a flat batter dam at Badgingarra Research Station in 1978 to supplement the research station water supply and to demonstrate the technique in a district where this had not been done before. The site chosen sloped considerably (greater than 2 per cent), which involved more earthmoving in the flat batter construction than would a site of less slope.

This dam is very successful but its cost per cubic metre of water stored was 50 per cent more than the estimated cost of a similar sized conventional dam—roaded catchment combination, mainly because of the sloping site. However, in south coastal areas flat batter dams compare favourably in cost to the same sized conventional dams with roaded catchments because roaded catchments are very costly on deep overburden sites.

It is likely that the Badgingarra flat batter dam will be more reliable and require less frequent maintenance than a conventional dam and roaded catchment combination. These advantages may be regarded as worth the extra outlay.

Compared to south coast requirements, farm dams and improved catchments in the north eastern wheatbelt must be bigger to cater for a given number of sheep. This results from the combined effects of the greater water requirements of livestock, greater evaporation losses from water storage, and less annual runoff yield per hectare of improved catchment in the north-eastern districts. The greater water requirement of sheep in northern areas is related partly to the longer period on dry feed each year, and partly to higher summer temperatures.

The flat batter dam technique therefore will cost more to apply in the north-eastern districts, where there is a need to make each water conservation unit bigger. The extra size means that earth must be moved over longer distances to create the bigger storages and flat batter catchments. By comparison, the cost of conventional dams and roaded catchments is not as sensitive to increase in size. This is mainly because roaded catchments consist of a series of individual catchments linked by a common collecting drain. Adding more individual catchments (roads) adds very little to the cost of the existing catchment. In contrast, a flat-batter catchment is a single unit, and any additional catchment will require proportionally greater cost than the original catchment.

Success rates also are in doubt. Already, two round flat-batter dams in lower rainfall areas (the north-eastern wheatbelt and the Nullarbor plain) have failed to achieve their expected performance levels.

In both cases, the owners had anticipated much better runoff, considering the catchment slope and surface preparation.

It appears that in such areas, soil type, rainfall intensity or both can adversely affect the runoff potential of flat-batter dams.

From the above points and experience to date Departmental officers believe it unlikely that the flat batter technique will be suitable for the north-eastern wheatbelt. Flat batter dams are likely to cost more than conventional dams plus roaded catchments, and technical difficulties are more likely to arise in their application. In the West Midlands, the technique can be applied where the topography is suitable.