How to measure the capacity of farm dams

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AT some time or another nearly every farmer needs to be able to measure the capacity of an ordinary farm dam of the "excavated earth tank" type and many requests are made for a method of calculating this volume. This article describes how this can be done.

In its simplest form the farm dam can be regarded as a prismoid.

A prismoid is a solid bounded by two parallel planes and by sides which are plane surfaces extending from one end plane to the other.

On reasonably level country the volume of a dam is given by the prismoidal formula which is—

\[ V = \frac{D \times (A_1 + 4A_m + A_2)}{6} \]

where \( V \) = volume in cubic feet
\( D \) = depth in feet
\( A_1 \) = area of top surface in square feet
\( A_m \) = middle area in square feet
\( A_2 \) = area of bottom in square feet.

To convert to gallons, multiply by 6\(\frac{1}{4}\) and to convert to cubic yards, divide by 27.

As an illustration of the use of the formula consider the dam in Fig. 1 with the following dimensions:

- Top length ... 90
- Top width ... 70
- Bottom length ... 30
- Bottom width ... 10
- Depth ... 10
- Slope of sides ... 3 : 1

Area of top ... \(90 \times 70 = 6,300\) sq. ft.
Area of bottom ... \(30 \times 10 = 300\) sq. ft.

The slope or batter of the side of the dam is 3 : 1. This means that there is a horizontal displacement of 3 relative to a vertical distance of 1.

At a depth of 5 ft. at the centre of the dam there will be a horizontal displacement of 15 ft. This occurs on both ends of the dam so that the length of the middle section is \(30 + 15 + 15 = 60\) ft. Similarly the width of the middle section is \(10 + 15 + 15 = 40\) ft. Therefore, the area of middle section = \(60 \times 40 = 2,400\).

Substituting these values in the formula:

\[ V = \frac{10 \times (6,300 + 4 \times 2,400 + 300)}{6} \]

\[ = \frac{10 \times 16,200}{6} \text{ cubic feet} \]

Fig. 1.—Dam with regular sides
162,000
cubic feet

\[
\frac{27,000}{6} = 27,000 \text{ cubic feet}
\]

\[
\frac{27,000}{27} = 1,000 \text{ cubic yards}
\]

\[
27,000 \times 6\frac{1}{2} = 168,750 \text{ gallons}.
\]

A word of warning is necessary here: It is necessary to ensure that all measurements are in the same unit—in this case feet and cubic feet. To compute the middle area it is wrong to take the average of the top and bottom areas.

The estimation of the middle area involving the batter of the dam may prove awkward to those who are not used to calculations. However the formula can be used in the following modified form:

(1) Multiply the length by breadth of the top area.

(2) Multiply the length by breadth of the bottom area.

(3) Multiply the sum of top and bottom lengths by the sum of the top and bottom widths.

(4) Add these results together; multiply by the depth and divide by 6 as before.

Reverting back to Fig. 1.

Area of top .......... 90 ft. \times 70 ft. = 6,300 sq. ft.

Area of bottom .......... 30 ft. \times 10 ft. = 300 sq. ft.

Sum of top and bottom lengths 90 + 30 = 120 ft.

120 \times 80 = 9,600 sq. ft.

Total = 16,200 sq. ft.

\[
V = \frac{10 \times 16,200}{6} = 27,000 \text{ cubic feet}
\]

**Dam with Irregular Sides**

For a dam with irregular sides the same method is followed, except that in this case it is necessary to find the average lengths and average widths of the different areas. The procedure is:

(1) Add together length of top of both sides and divide by two for the average top lengths.

(2) Add together the widths of both ends at the top and divide by two for the average top width.

(3) Add together length at bottom of both sides and divide by two for the average bottom length.

(4) Add together width of both ends at the bottom and divide by two for the average bottom width.

(5) Multiply the average top length by the average top width.

(6) Multiply the average bottom length by the average bottom width.

(7) Multiply the sum of the top and bottom average lengths by the sum of the top and bottom average widths.

(8) Add the last three results together; multiply by the depth and divide by 6 for cubic feet.

The procedure is illustrated in the example in Fig. 2.

Average top lengths \frac{90 + 92}{2} = 91 ft.

Average top widths \frac{90 + 70}{2} = 80 ft.

Average bottom length \frac{30 + 32}{2} = 31 ft.

Average bottom width \frac{10 + 20}{2} = 15 ft.,

Average top length \times \text{Average bottom width} (91 \times 80) = 7,280 \text{ sq. ft.}

Average bottom length \times \text{Average bottom width} (31 \times 15) = 465 \text{ sq. ft.}

Sum of average top and bottom lengths \times \text{Sum of average top and bottom widths} (122 \times 95) = 111,495

Total sum 7,280

\[
\frac{465}{11,590} = 19,335
\]

Then \[
V = \frac{19,335}{6} \times 10 \text{ cubic feet}
\]

= 32,225 cubic feet

= 1,193.5 cubic yards

= 201,406 gallons

Where a dam is built on a considerable slope care should be taken to take the top measurement along the line of water level. However, slopes are rarely great enough to affect this measurement appreciably.
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