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THE CONSTANT ANGLE ARCH DAM

A NEW TYPE OF DAM IN WHICH THE ARCH TAKES THE GREATEST PORTION OF THE LOAD, EVEN CLOSE TO THE FOUNDATION.

THERE is a new type of arch dam to which more than ordinary interest is attached, on account of several new features introduced for the first time in the design. These features accomplish a double purpose. They introduce great economy and they also make it possible for the arch to take the greatest portion of the load acting as an arch even close to the foundation.

So far, the greatest objection of engineers to the use of a pure arch dam has been that this kind of dam as ordinarily built can not deflect enough at and near the bottom to take the load on the arch. Most of the load here has to be taken up by shear and cantilever action, and therefore material sufficient for this purpose must be provided. In the new type of arch the length of the upstream radius decreases at a more or less uniform rate from the crest towards the foundation. In the ordinary type of arch dam this length is kept constant, or in case the upstream face is provided with a batter, this length increases from the crest towards the foundation. That this difference in the length of the upstream radii of the two types has an important bearing upon the economies of the design should be easily realized, when it is considered that the thickness of the arch dam section is proportional to the length of the upstream radius at any elevation and that the crown deflection is practically proportional to the square of the length of the upstream radius. Therefore, the smaller the length of the upstream radius, the smaller the required thickness and the arch deflection. This is of especial importance towards the bottom of an arch dam.

Leaving for a later article the description of two particular dams of this type already in service, the general calculation of arch dams will be given here with especial reference to the type referred to.

In order to obtain a preliminary dam section for any given dam site the simple formula

$$t = \frac{P \times R_u}{q} \qquad - \quad - \quad - \qquad (1)$$

can be used for finding the thickness of a sufficient number of arch slices at different elevations; and by superimposing these slices upon each other the dam section can be formed. In this formula t equals the thickness of the dam in feet at any given elevation; P equals the water pressure in pounds per square foot; R_u equals the length of the upstream radius in feet and q equals the average stress in pounds per square foot of the area of the dam section (Fig. 1).

From (1) it is seen that the thickness, and therefore the area of the dam section varies in direct proportion with the radius. The volume of concrete in any arch dam is equal to the area of the section times the length of the mean arc. The length of the mean arc can be expressed as the length of the mean radius times the subtended angle in terms of

$$\pi \text{ or } V = \text{area} \times R_m \times 2\theta \qquad - \qquad (2)$$

where 2θ is the subtended angle.

The mean radius R_m equals half the width W of the span divided by the sine of half the subtended angle (Fig. 1). Thus

$$R_m = \frac{\frac{1}{2} W}{\sin \theta} \qquad - \quad - \quad - \qquad (3)$$

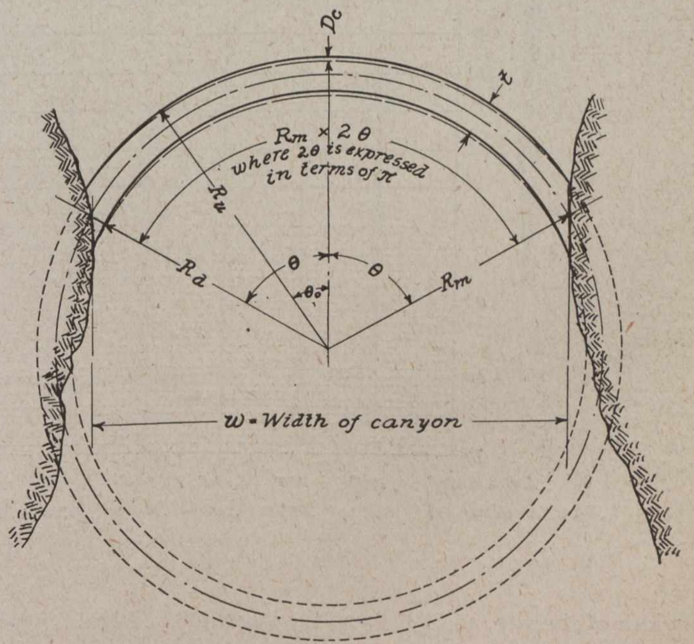

Fig. 1.

As the area of the section is proportional to the radius (both to R_u and R_m), (2), for the volume of masonry can be expressed thus:

$$V = C \times \frac{(\frac{1}{2} W)^2 \times 2\theta}{\sin^2\theta} = \frac{K \times \theta}{\sin^2\theta} \qquad - \qquad (4)$$

where C and K are constants, the latter depending upon the width of the canyon.

According to (4) the volume varies with the term $\frac{\theta}{\sin^2\theta}$. The differential coefficient of this term equated to zero gives the minimum for a central angle of 133°, which means that any horizontal slice of the dam has the least volume when $2\theta \doteq 133°$. In other words, the dam