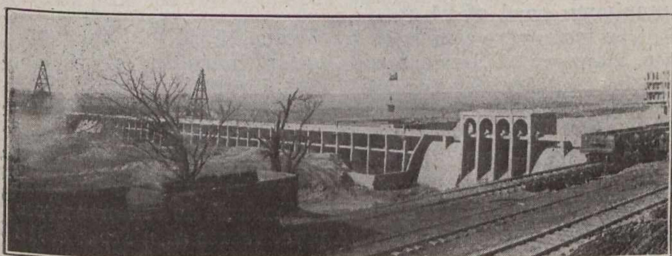
In this connection it may not be out of place to discuss briefly the use of plums, or large stone, in gravity dams. Difference of opinion relative to the advisability of using plums exists among engineers, but a decision in regard to this point usually may be reached by considering the economies of the particular case.

Where the section of the dam is great, and if large stones are available at the dam site, together with proper handling equipment, plums may be used. These, however, should be kept at least one foot from the face or back of the dam, and care should be observed in embedding them to see that no air pockets or hollow spaces exist, especially under the plums. In specifying the use of large stones in gravity dams, it is safe to specify that the plums be limited to about 20% of the volume, and that in proportioning the mixture the plums be considered as so much coarse aggregate.



AMBURSEN BUTTRESS-AND-SLAB TYPE DAM

Simple Arch Dams

Where a high dam is required to close a narrow opening between solid-rock side-hills, a simple arch dam will usually be found most economical. The load is uniform horizontally and exactly known at all points of the height. This enables the engineer to evolve an economical design.

It has been argued that the flow of water over the spillway or through the flood pipes of a dam sets up vibration which in the end proves disastrous. There is, however, little or no data obtained from experience to justify such apprehension.

All types of concrete dams except the gravity type are, of course, reinforced, and the existence of countless reinforced concrete bridges and buildings which are constantly subjected to vibration is sufficient proof of the ability of this material to withstand whatever vibration is set up in dams.

Multiple Arch Dams

The multiple arch type consists of a series of arches with inclined axes supported by buttresses spaced from 30 to 50 ft. apart. The buttresses take the thrust of the arches and are braced horizontally by struts in continuous lines. Some very high dams of the multiple arch type have been constructed and plans are now being prepared for one in California which will have a height of considerably over 100 ft.

This type, as well as the buttress and slab type, is especially adapted to locations where the foundation is rather seamy or unsuited to the gravity type because of the great expense involved in the preparation of the foundations. The footings of the buttress and the lower end of the arches constitute the only points of contact between the foundation and the dam, and these limit unfavorable foundation conditions to relatively small areas, so that these conditions can be easily cared for.

It is apparent that if one of the arches of a multiple arch dam fails, successive failure of the remaining arches of the dam may take place. This possibility can be obviated by constructing every fourth or fifth buttress as a large pier to take the entire thrust of an arch on either side of it, unassisted by the thrust of the adjoining span, or by designing some of the horizontal ties between buttresses to take the thrust of the arches.

The multiple arch type has an advantage over the buttress and slab type in that it affords economy of construction when foundation conditions or great height require that the buttresses or piers be placed at considerable distances apart. In other words, the additional cost of longer spans of the arch type is much less than where concrete slabs are used.

Construction of expansion joints is, of course, a rather difficult problem in multiple arch dams, and it is very doubtful whether they need be constructed at all, since expansion and contraction merely produce deflection of the arch rings.

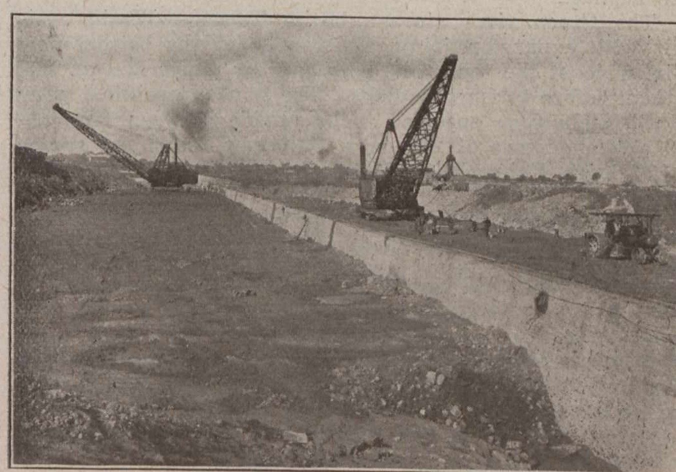
Buttress and Slab Type Dams

This type is especially adapted to long and low dams where the foundation conditions are more or less uncertain. It consists essentially of buttresses or piers, the spacing of which need not be uniform, carrying slabs in an inclined position. The principle, of course, is the same as that of the well-known counterfort retaining wall but the design is much simpler and more accurate, since the thrust of the water is accurately known. In this type of dam, expansion joints are easily constructed and variations in the distance between buttresses to take care of unfavorable foundation conditions at particular points can easily be made. High buttresses should be braced together with horizontal struts or with diaphragms.

Reservoirs

Reservoirs are usually a part of the water supply system. Impounding or natural reservoirs, formed by damming the flow of a stream are common, and the cost of them, in so far as construction is concerned, amounts for the most part to the cost of the dam.

In planning an impounding reservoir, an investigation should always be made of the practicability of impounding more water than is necessary for the supply. The water over and above that required for supply purposes can be utilized to generate power, which will very often justify a much higher and longer dam and the construction of such additional power plant facilities as are necessary. The power so developed may be used for lighting or power purposes in the city served, and is usually a large factor in encouraging the location of manufacturing enterprises, providing sufficient power at a reasonable cost may be had.



CONSTRUCTING EARTH DAM WITH CONCRETE CORE

In addition to large storage reservoirs the distribution of water for a large city will usually require secondary or distribution reservoirs, usually on a hill or high point of the surrounding country.

Prevention of seepage losses from reservoirs is an important item and especially so where the water is pumped into the reservoir. Seepage losses then constitute a constant loss which is directly chargeable to construction and which must be made up in water rates charged. Such losses should be prevented by making the sides and bottom of the reservoir as impervious as practicable. Paving with stones laid in mortar has been resorted to, but it is obvious that concrete linings offer a very attractive and efficient means of preventing seepage losses. Concrete linings are admirably