DAMS IN ITALY CONSTRUCTED FOR EARTHQUAKE RESISTANCE

by Carlo Semenza*

In continuance of what Professor Raphael and Professor Oberti have said regarding the behavior of dams under the action of earthquakes, this paper presents some of the main dams built in Italian seismic areas by the writer's company and by others. Among these are: the Comelico dam on the Piave River, built in 1929-1931; those on the Isonzo River; the Lumiei Dam which was for a few years the highest arch dam in the world; the Pieve di Cadore Dam on the Piave River; and the Val Gallina Dam. Construction of the Vajont Dam has just begun in the same area, which will be 800 ft. high, the highest arch dam in the world--at least for a few years.

All Italian territory is more or less subject to earthquakes, particularly the northeastern section of the Alps in the Veneto region. We might of course desist from building dams in seismic areas, but this would mean foregoing the development of many natural resources. In fact, reservoirs are necessary in Italy, as hydraulic resources are rather limited and must, therefore, be exploited with the greatest possible efficiency for the production of electric power as well as for irrigation and other purposes. Our rivers have extremely variable flows, with very low levels at times. Consequently, proper storage of water must be provided for satisfactory exploitation.

In consideration of this, it was necessary to face the problem of constructing the dams to withstand seismic shocks of a certain intensity. Most of the Veneto dam sites are in rather narrow erosion gorges cut in excellent rock formation and are particularly suited to the construction of arch dams. Most of the dams referred to in this paper are in limestone gorges, the various formations of which have proved to be excellent for the support of arch dams.

The problem was to determine the behavior of arch and dome dams under the action of earthquakes, even of great intensity. Up to a short time ago, the problem had only been tackled in a preliminary fashion, starting with the method adopted for gravity dams. During the International Congress on Large Dams recently held in Paris, several ideas were advanced, among them the suggestion by the writer and further stated by M. André Coyne, that the worst stress condition for an arch dam is probably the one resulting from a seismic acceleration towards the chord. Calculations have now fully confirmed this intuitive conception.

A visit to Algeria after the Paris technical meetings, to some hydraulic structures badly damaged in the Orleansville earthquake, has convinced the writer of the necessity of a thorough examination of the problem.

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When the first arch dams were built in the Veneto region, among which were the Lumiei, the Pieve di Cadore, and the Val Gallina dams, local seismic features suggested the occurrence of earthquakes of "average intensity." Designs were prepared with cautious factors of safety. In actual fact, these dams were subjected to, and successfully resisted, earthquakes up to Intensity 8 on the Mercalli scale. For the Ambiesta Dam, which is now being built and is situated near the Carnia epicentral zone, provisions are being made for seismic shocks of the highest intensity, as it may have to stand earthquakes up to, and perhaps over Intensity 10 on the Mercalli scale. The location was investigated thoroughly by geophysical methods and the dam was designed very carefully with the aid of model tests.

We have availed ourselves of the services of the I.S.M.E.S. of Bergamo for testing the effects caused by seismic shocks of every possible characteristic and intensity on model structures, especially dams. The writer is partly responsible for this important laboratory, which is directed by Prof. Oberti, a responsibility which can be borne with relative ease and tranquillity. The tests described earlier by Prof. Oberti have assured us, as much as is possible within the limits of human knowledge, of the future behavior of the Ambiesta Dam.

What Mr. Brunnier stated concerning "overdesign" was of great interest. We Italians agree with his conceptions, and it is for this very reason that we spare no pains to get as exact an idea as possible of the actual stress conditions of our dams. The importance of models for the saving of construction costs is indicated by the fact that the cost of a large scale static model is generally one percent of the cost of the concrete used in a large dam, which in most cases corresponds to a thousand or, as a maximum, a few thousand yards of concrete. It is clear that a concrete yardage saving of the same order may be achieved easily through an accurate study. Under the worst circumstances, the results obtained through the model pay for its full cost, even disregarding the advantage of the factor of safety and tranquillity gained by designers and constructors, the value of which is actually inestimable. In most cases, however, the saving is much more than the model testing cost, reaching very high percentages of the total estimated cost. As an example, the model of the Pieve di Cadore Dam persuaded us to adopt the arch-gravity type dam, saving nearly 25% on the total cost when compared with the best of other solutions.

Fig. 2 Vajont Bridge

Fig. 1 Ponte Racli Dam

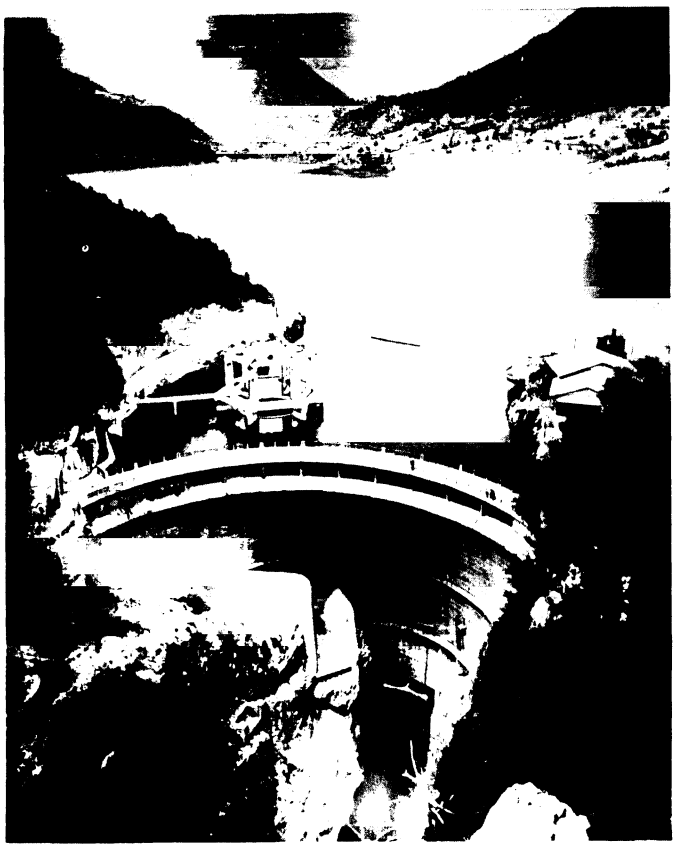

Fig. 3 Barcis Dam

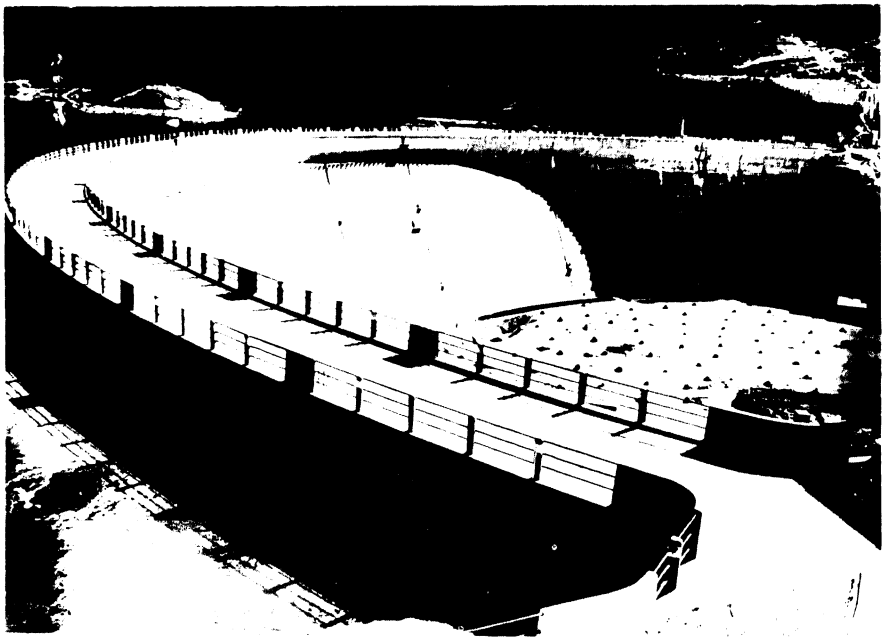

Fig. 4 Pieve di Cadore Dam

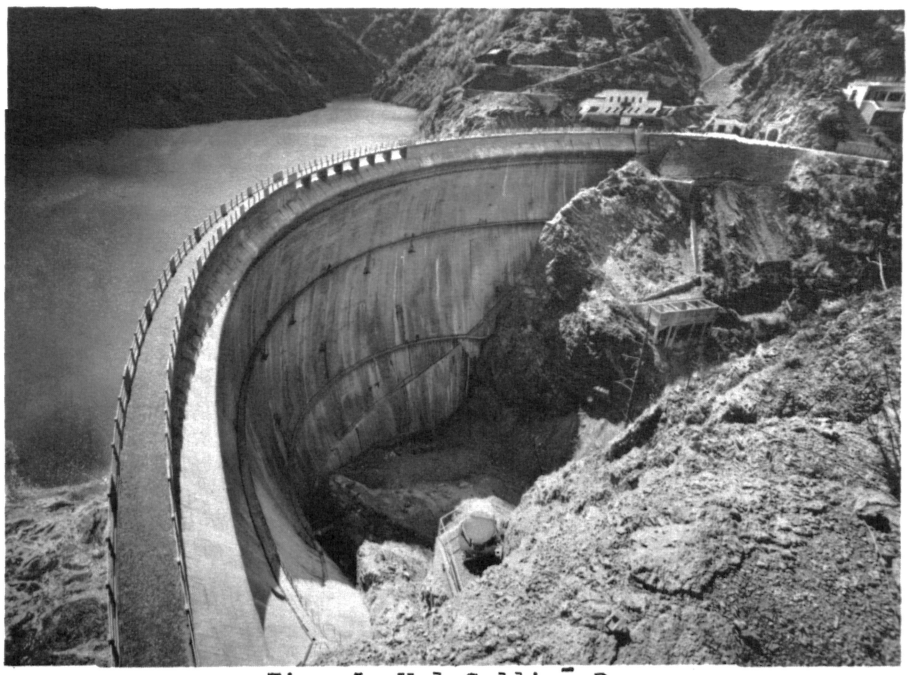

Fig. 5 Val Gallinā Dam

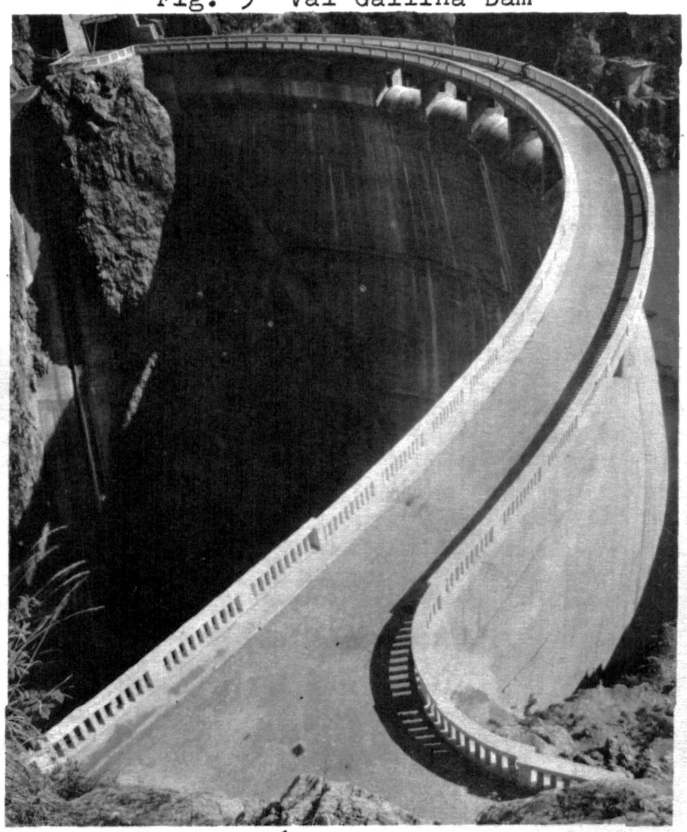

Fig. 6 Lumiei Dam