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THE SECURITY SPILLWAY WITH CONJUGATED SILLS

FOR BISSORTE DAM

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by D. J. Hebert

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The model experiments made in the Hydraulic Laboratories of the Neyrpic Company for studying the hydraulic shape of a flood spillway for Bissorte Dam have highlighted a new type of structure, the principle of which may be applied in similar terrain, which is economical and effective.

In August 1935, due to an exceptionally large flood which greatly exceeded the predictions, the Molare Dam in Italy failed. A tremendous waterspout with enormous blocks entrained in it descended the slope, engulfed the small village of Oveda, pushed over houses as if they were straws, and caused the death of many people. This catastrophe caused by a local storm of extreme violence attracted the attention of numerous hydroelectrical societies who wondered if similar tornadoes could happen in other places. It was known that such floods had been observed in the Sierra Nevada and in the Cevennes where the topography of the location resembled that of Molare. That is, a spur of the steep mountains was exposed to the storm winds and to sudden storms. For this reason, the Hydroelectric Society of Savoy decided to take preventive measures for Bissorte Dam whose proximity to that of Molare, despite a certain difference in arrangement, made an analogous peril a possibility.

The Research

This society decided to add a security weir to the main spillway. After examination of the problem the capacity was set at 180 m^3/sec and it seemed reasonable to adopt a value of 1.5 meters for the thickness of the weir nappe. The configuration of the terrain as well as the existing work dictated that the shape of the auxiliary spillway should be a tunnel fixed in location, for the most part, should convey the flow with a free surface and discharge downstream from the dam. Finally, it was decided that the spillway be located on a rock buttress which would be the most suitable spot.

The shape of the weir crest was made to conform with the shape of this promontory. The presence of a zone of slides on each side of the rock buttress restricted the width. According to the restrictions, the weir was given the form of a semielliptical bowl. Theoretical considerations led to the prediction of a "crete de cog" (louse-wort) (liquid bump) in the center of the structure which was confirmed by experience. The meeting of the fluid filaments produced a violent eddy which caused an undesirable decrease of velocity at the tunnel entrance and lowered the capacity. It was necessary to find a means of suppressing this central bump which was troublesome.

For this purpose the velocities of the filaments were slowed down for better control. The weir crest was extended by a platform located at one side. This maintained critical flow over the crest and preserved the discharge coefficient. The water can, thus, lose velocity. The liquid filaments converge and boil up at the downstream end of this landing before falling down another chute towards the tunnel. By varying the respective proportions of the platform and the lateral walls of the spillway, it was possible to avoid the breaking up of the stationary wave and to calibrate perfectly the shape of the jet to the tunnel section.

Thanks to this new principle the liquid jet, without walls, without guiding, molds itself in space and glides in transparent form, very stable and well-shaped into the tunnel where it penetrates without an expensive transition.

Naturally, it was only after numerous trials with the model, which are indicated above, that we arrived at this solution. Since that time we have applied this principle to numerous spillways where only the form was different. Although not applicable universally, this elegant solution retains its supremacy for certain configuration of the terrain, as proven by its realization at Bissorte.

Construction

Situated in the Alps at an elevation of 2,000 meters on a tributary of the Arc River, the Bissorte Dam supplies under a head of 1,150 meters a hydroelectric plant consisting of three Pelton turbines of 38,000 cv. These turbines of the single-nozzle type are among the most powerful in Europe.

In the beginning, flood evaluation was assured by a structure located on the right bank consisting of:

a. Two sluices, 2.30 m. wide, each equipped with a gate 4 meters high and designed to pass 140 cm^3/sec.

b. Four self-priming siphons, each equipped with an automatic device controlled by the level upstream and designed to pass about 30 m^3/sec.

These predictions appeared to be adequate until the security weir was constructed according to the model findings. Because the latter offered greater security, the S.H.E.S. decided to use it as principal spillway. The shape permitted construction in (pierres appareillees non gelives) (ruble masonry) which is well adapted to a dam at high altitudes. Its elegant structure shows up favorably against modern accomplishments in reinforced concrete.

Comparison Between the Initial Proposed Scheme and the Final Project

Since 1937 the final structure with the bowl and double sill has functioned very satisfactorily during many minor floods. As for future floods, even the most violent ones, it has our entire confidence. It is both an original and economical solution. Flow conditions in the initial proposal whose classical form is shown in the first plate, showed the superiority of the final solution:

a. From a hydraulic viewpoint, the remarkable way which it operates to distribute the velocity in the tunnel demonstrates a new hydraulic phenomenon and it has many advantages.

b. From a civil engineering viewpoint, the following comparative data show the economy realized:

Construction	Initial	Final
Volume of masonry	1,500 m^3	800 m^3
Volume of spoil	2,300 m^3	2,100 m^3

This example shows clearly the importance of model studies. As yet, the theory of spillways does not permit in every case a complete mathematical determination of the profiles. The scale model for the purpose of determining the shapes of a structure is an indispensable tool of the engineer, who must combine an ever-alert intuition with a well-developed hydraulic sense.

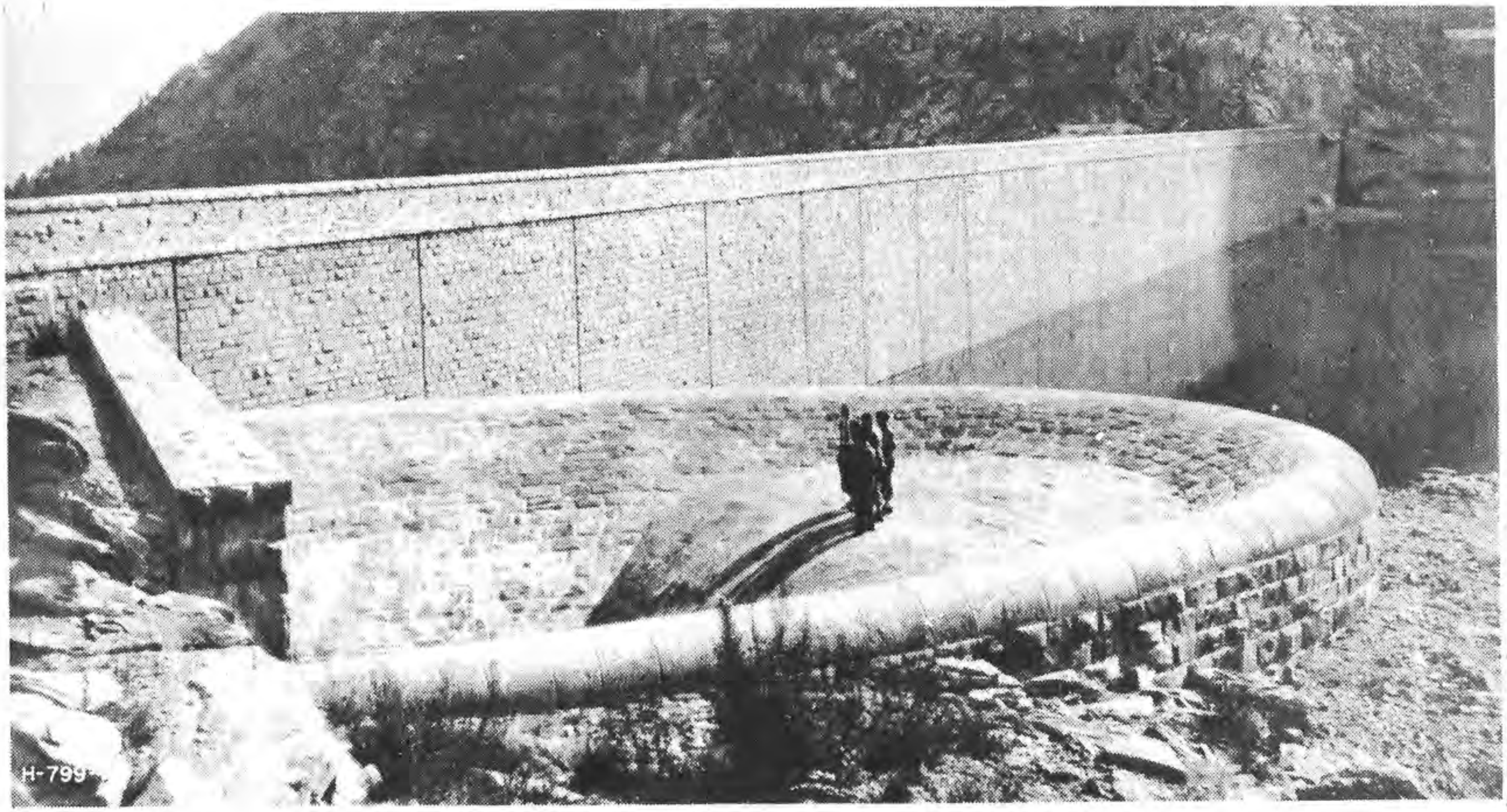
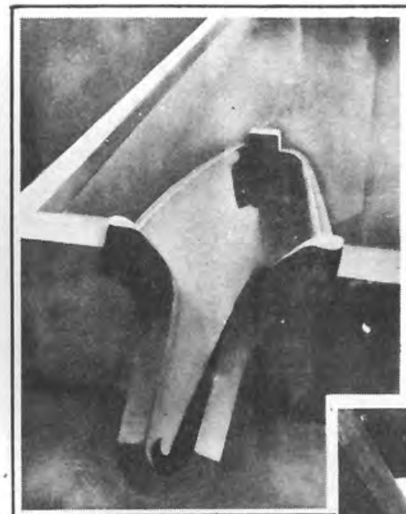


FIGURE 1

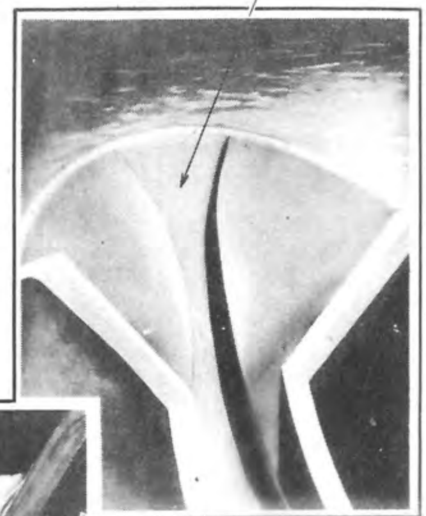
DAM AND WEIR

FIGURE 2

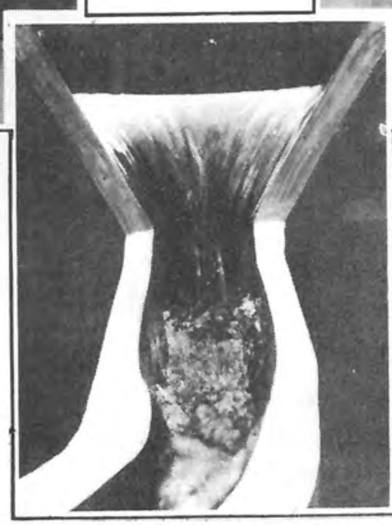
TRIAL DESIGNS



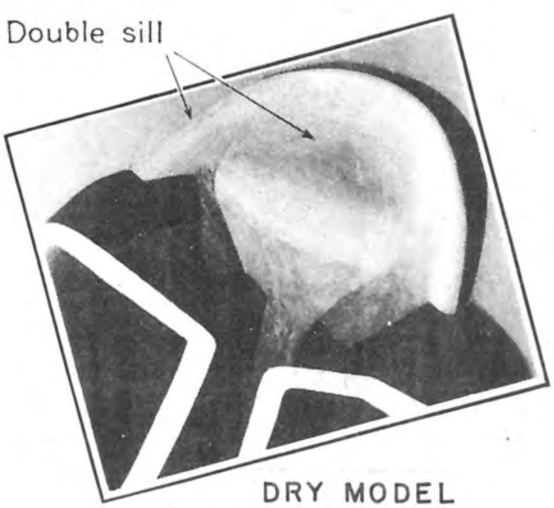
INITIAL PROPOSAL



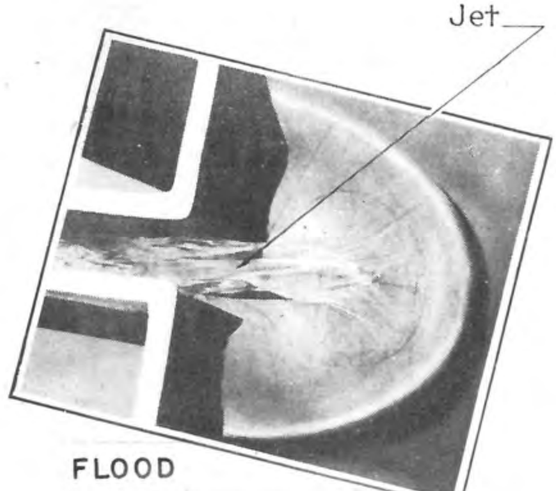
CHANNEL



SEMI-CIRCULAR BOWL



DRY MODEL



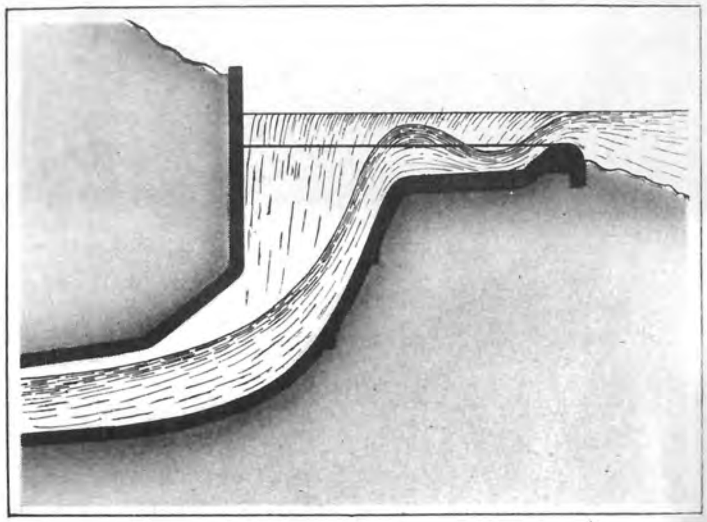
FLOOD

100 cu. m. per sec.

FIGURE 3

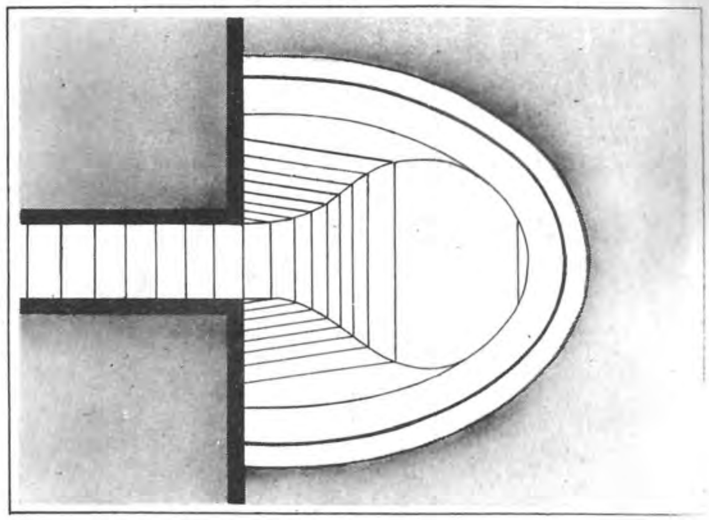
FINAL DESIGN

SECTION
FLOOD - 180 cu. m. per sec.



CONJUGATE SILLS

Concentration & swelling of the nappe causes acceleration.



PLAN
CONTOUR LINES

FLOOD
180 cu. m. per sec.