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HYDRAULIC LABORATORY REPORT NO. 153

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# MODEL STUDIES OF THE INITIAL REGULATION OF FLOW AT ANDERSON RANCH DAM, BOISE PROJECT

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By

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UNITED STATES
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Branch of Design and Construction
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Laboratory Report No. 153
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Subject: Model studies of the initial regulation of flow at Anderson Ranch Dam - Boise Project, Idaho.

1. The original design of the penstock at Anderson Ranch Dam provided for the flow of water to the turbines and to a branching line which lead to four 72-inch hollow-jet valves. At the reservoir end of the penstock a bulkhead-type gate was provided to allow for unwatering the penstock when necessary. The hollow-jet valves would have provided for passing discharges up to 10,000 second-feet. Larger flows which could not be stored in the reservoir would have been discharged over the spillway. Due to the present emergency, it was not possible to obtain the valves and to regulate the flow accordingly. To conserve water and later pass it downstream to the power plants during the dry season, it was necessary to change the bulkhead gate to a regulating gate and operate the penstocks as ordinary outlets through the dam.

2. The regulation of flow with the temporary arrangement was expected to begin in 1944, at which time it was expected that the water level in the reservoir would be at elevation 4050. During the 1944 season and part of the 1945 season the revised gate at the penstock was to be used for regulation of the flow. At some time during 1945 it was expected that the reservoir would have stored sufficient water to raise the level to plus or minus 4105, thereby creating sufficient head to make it impractical to use the gate as a regulating device. At this point it was planned to place one of the 84-inch Boulder needle valves in the conduit for the regulation of flow and

the slide gate was to be returned to its original use as an emergency bulkhead.

3. The use of the gate as a regulating device presented a problem in cavitation which was further complicated by the fact that at no time during the release of water by this method was the conduit expected to flow full. Further, the intake was considerably above the horizontal part of the conduit (figure 1), which would necessitate two sharp turns in the flow before it reached the outlet. It was expected that this turning of the flow in the upper reaches of the conduit would cause parts of the conduit to become filled near the intake, with the result that severe subatmospheric pressures and the resulting pitting would be obtained.

4. A 1:40 hydraulic model was constructed to determine the capacity of the air vents and a suitable location for them. Preliminary tests with the arrangement shown on figure 1 indicated that satisfactory operation could be obtained by connecting an air-vent pipe between the penstock immediately downstream from the 45-degree bend and the upstream end of the transition. As the horizontal part of the penstock did not flow full, the vent pipe would have allowed air from this region to flow into the cavity formed in the transition and would prevent any severe subatmospheric pressures.

5. The intake center line of this scheme was at elevation 3969.16 (figure 1). As several earth slides in the reservoir area of the prototype have already occurred, it appeared advisable to raise the intake to elevation 4000.00 to eliminate the danger of clogging by some future slide or submerged trash.

6. In the new arrangement the center line of the intake was placed at elevation 4000.00, and the connection to the present installation was effected by a vertical drop to a 90-degree bend at the beginning of the horizontal part of the penstock (figure 2). The first test with this arrangement showed that the water flowing under the gate

continued across the vertical section of the conduit and was deflected back and forth across the conduit as it dropped down to the horizontal section, causing a siphon action which would have lowered the pressures in the prototype to the vapor pressure of water. These pressures were relieved, and the siphon action was partly broken by placing a 30-inch air vent in the top of the transition downstream from the gate; however, the pressures on the bottom of the transition were still sufficiently low to cause pitting. This condition was remedied by placing a step and another vent in the transition and also changing the former 30-inch vent to 20 inches in diameter (figure 3).

7. With this arrangement it would have been necessary to remove the step when conditions made it unnecessary to use the gate as a regulating device. To overcome this objection the step was changed to a recess (figure 3) having the same vent system. This scheme was tested for regulation of flow with the gate and under the normal operating conditions of the completed project. There were no negative pressures for normal operation. The recess and the vents did not have any adverse effects on the flows, indicating that it would not be necessary to fill or plug them after they had served their purpose. Some negative pressures still prevailed when the gate was used as a regulating device; however, they were not serious enough to warrant the additional cost to alleviate them, inasmuch as the arrangement was to be temporary. The piezometric pressures converted to prototype, for aeration with the step and the recess, are shown on figure 4. They apply when the gate is used for regulating the flow.

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CREST DETAIL
Detail D
Section B-B
HALF SECTION E-E
Inlet structure
See Detail G
Reservoir level
Reference line
Constr joint
SECTION C-C
SEE DETAIL D
Scale in feet
NOTE
REFERENCE DRAWINGS
PRELIMINARY MAY NOT BE USED
ANDERSON
OUTLET WORKS
INLET STRUCTURE
CONCRETE OUTLINE
DRAWN J.E.S.
TRACED
CHECKED

DETAIL "A"
HALF ELEVATION "C"
ELEV. E-E
SECTION E-E
DETAIL "D"
HALF SECT. ELEV. "B"
SECT. L-L
DETAIL "P"
SECTION G-G
HALF SECTION M-M
DETAIL "M"
DETAIL "K"

Note:
= Piez. locations for recess in floor
= Piez. locations for contraction in floor

| DISCHARGE C.F.S. | HEAD ON ℄ GATE FT. WATER | PIEZOMETER NUMBER | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| 10400 | 102.0 | -6.0 | 39.2 | 4.0 | 4.0 | -1.6 | -14.6 | -13.6 | -4.0 |
| 8000 | 102.5 | -8.8 | 4.6 | 3.6 | -1.6 | -5.2 | -12.0 | -11.6 | -4.0 |
| 5880 | 102.4 | -8.4 | 52.4 | 14.4 | -8.0 | -8.0 | -8.9 | -8.4 | -1.0 |
| 4000 | 105.5 | -4.6 | 60.8 | 20.0 | -5.6 | -7.2 | — | -4.4 | -4.0 |
| 10170 | 49.7 | -9.0 | 12.0 | -1.40 | 3.8 | -1.2 | — | -12.0 | -4.5 |
| 8200 | 51.7 | -2.4 | 18.0 | 1.00 | 3.4 | -1.2 | — | -8.8 | -3.0 |
| 6080 | 49.3 | -3.2 | 21.6 | 2.80 | 1.8 | -2.4 | — | -7.6 | 0.0 |
| 4000 | 50.8 | -7.4 | 28.0 | 6.40 | -1.4 | -4.4 | — | -4.0 | 0.2 |
| 3250 | 49.8 | -3.6 | 28.8 | 10.8 | -.20 | -4.0 | — | -2.8 | 0.2 |

PIEZOMETRIC PRESSURES FOR DESIGN 2
(Step in bottom of transition)

| DISCHARGE C.F.S. | HEAD ON ℄ GATE FT. WATER | PIEZOMETER NUMBER | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| 10270 | 104.0 | 17.8 | -0.4 | 38.8 | 0.6 | -1.8 | -8.4 | -12.2 | -10.4 |
| 8800 | 102.5 | 19.8 | -2.0 | 43.2 | 3.0 | -1.8 | -6.2 | -6.2 | -10.4 |
| 8200 | 103.2 | 20.6 | -1.2 | 50.4 | 5.0 | -1.2 | -6.2 | -6.2 | -9.4 |
| 6070 | 106.6 | 25.0 | -7.4 | 57.6 | -4.6 | -6.6 | -4.2 | 4.8 | -8.2 |
| 3745 | 102.0 | 3.8 | -1.2 | 20.4 | -15.2 | -4.8 | 0.0 | 0.0 | 0.0 |
| 10590 | 48.9 | 8.2 | 1.6 | 8.8 | -0.6 | -0.2 | -5.0 | -8.0 | -4.2 |
| 8100 | 48.4 | 9.8 | 0.4 | 14.8 | -0.2 | -0.2 | -4.0 | -6.4 | -5.0 |
| 5980 | 55.6 | 11.2 | -1.8 | 26.2 | 3.4 | -0.6 | -2.4 | -0.4 | -4.0 |
| 3240 | 47.2 | 11.0 | -2.4 | 27.2 | 9.0 | 7.0 | -2.0 | -1.4 | 0.0 |

PIEZOMETRIC PRESSURES FOR DESIGN 3
(Recess in bottom of transition)

Note: For piezometer locations see figure

FIG 4