DISCUSSION ON PAPER "USE OF MODEL TO DISCLOSE EFFECTS OF CAVITATION IN PENSTOCK WYE-BRANCH"

By
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The author has described a unique improvised solution to an interesting problem. The added by-pass from the turbine leg to the outlet leg of the branch avoids the unbalanced flow which caused zones of separation with cavitation and vibration in the crotch of the Y. The correction might have been made by simpler design changes had model studies been made prior to instead of following construction.

The writer has been concerned with hydraulic model studies related to symmetrical Y-branches where measurements under unbalanced flow through the Y-branch indicated severe subatmospheric pressures that would cause cavitation and where design changes were made to eliminate these undesirable conditions.

Also, the writer has had experience with a design which required the application of a corrective measure after the field structure had been placed in operation. The hydraulic model tests made to develop the design of this corrective measure are the subject of this discussion.

During initial operations of the outlet works on the Mexican side of the Rio Grande River at Falcon Dam* about 150 miles upriver from Brownsville, Texas, there was a decided vibration in the unsymmetrical Y-branch just upstream from the hollow-jet control valves. The vibration

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*Designs for Falcon Dam were prepared by the office of Assistant Commissioner and Chief Engineer, Bureau of Reclamation, Denver, Colorado.

appeared to originate from turbulent eddy conditions adjacent to the left wall of the left leg of the branch, the centerline of which was at an angle of 45 degrees with the axis of the main conduit and the upstream portion of the right leg. The vibrations were associated with a noise described as strong cavitation sounds, or rather loud and heavy thumping sounds, occurring at 2-~~minute~~ second intervals. The condition was more pronounced when the two valves were discharging simultaneously under high heads and at large openings.

It was theorized that the vibration and noise resulted from pressure fluctuations which caused intermittent subatmospheric pressures in the zone of separation at the left wall of the left leg of the Y-branch where it connected to the truncated conical section of the main conduit. The vibration tendency was noted when similar flow conditions were represented in a 1:15 scale model of the branch and control valves (Figure 1). Because the vibration and noise were associated with highly fluctuating pressures within the branch, numerous piezometers were installed and measurements made of transient pressures with pressure cells and an oscillograph. The shape of the Y-branch, including piezometer locations, ~~are~~ is shown on Figure 2.

Rapid pressure fluctuations up to 60 feet of water (prototype) were recorded at piezometers D and E (Figure 3). Intermittent subatmospheric pressures of about 17 feet were measured at piezometer 5. From the tests it was concluded that pressures in the separation zone of the prototype momentarily reached vapor pressure and that the vapor cavities thus ~~found~~ formed collapsed when subjected to the sudden rises of pressure to cause cavitation with the consequent noise and vibration.

It was reasoned that a solid boundary, shaped roughly to the outer limits of the turbulent separation zone, would do much toward minimizing the pressure fluctuations and thus decrease the cavitation potential of the system. A filler block patterned from previous observations on a transparent model of a similar Y-branch was placed in the zone (Figure 2). This 8.9-inch filler block reduced maximum pressure fluctuations on the left flow surface from 60 to 19 feet of water (prototype). Two additional filler blocks, one larger and the other smaller than the original (10.9" and 6.0"), were tested to ascertain the optimum size. A marked increase in the magnitude of the fluctuations occurred when the block was shortened and only a negligible decrease in the fluctuations occurred with the larger block. It was concluded that the intermediate size gave optimum conditions so the field structure was altered to include this shape. Subsequent observations on the field structure indicated a substantial reduction in pressure fluctuations and the elimination of the rather loud and heavy thumping sounds and vibration in the Y-branch.

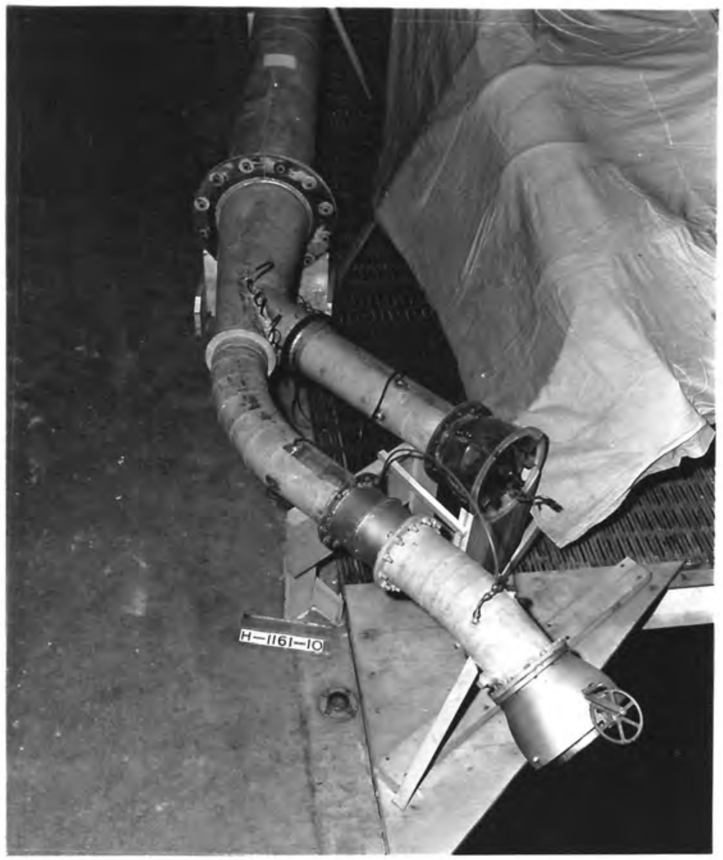
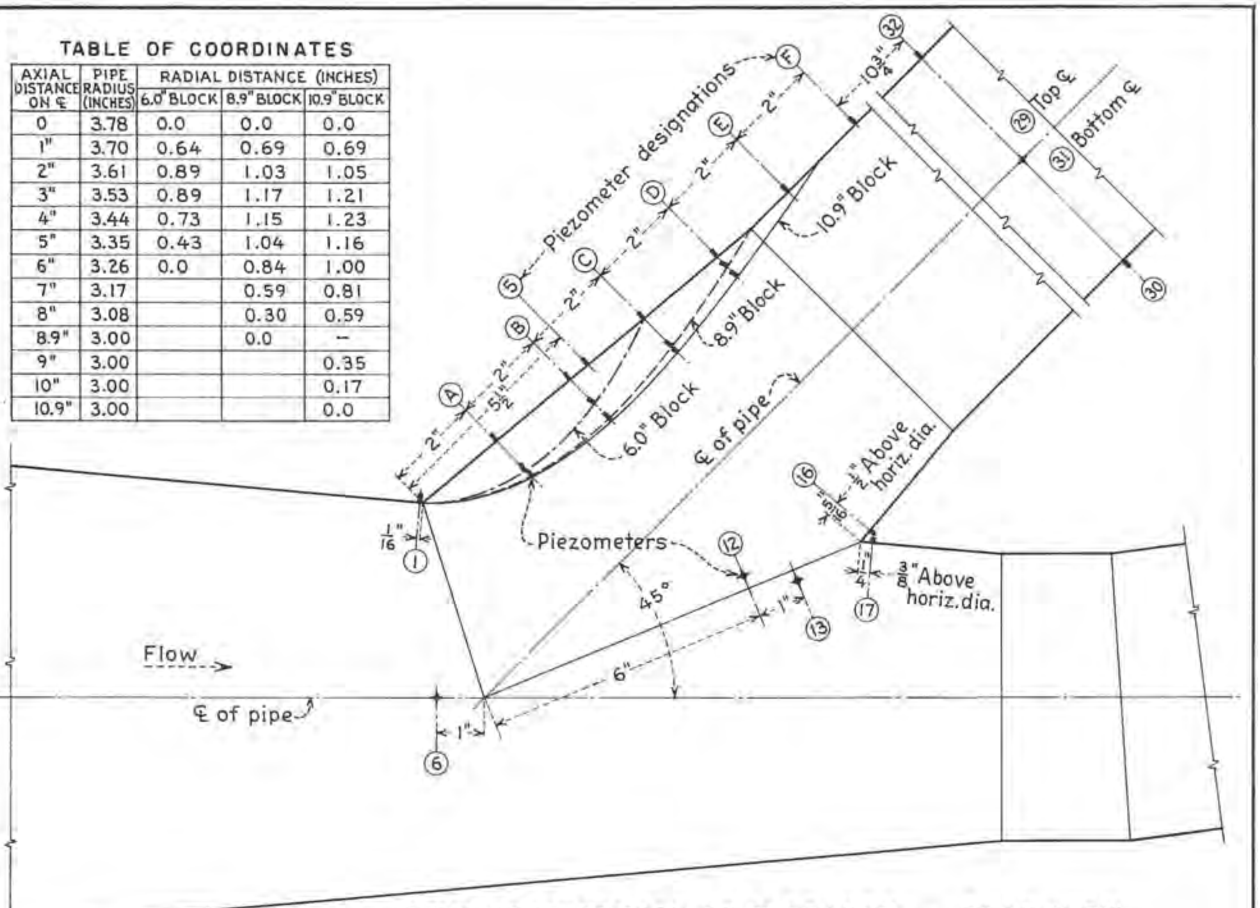


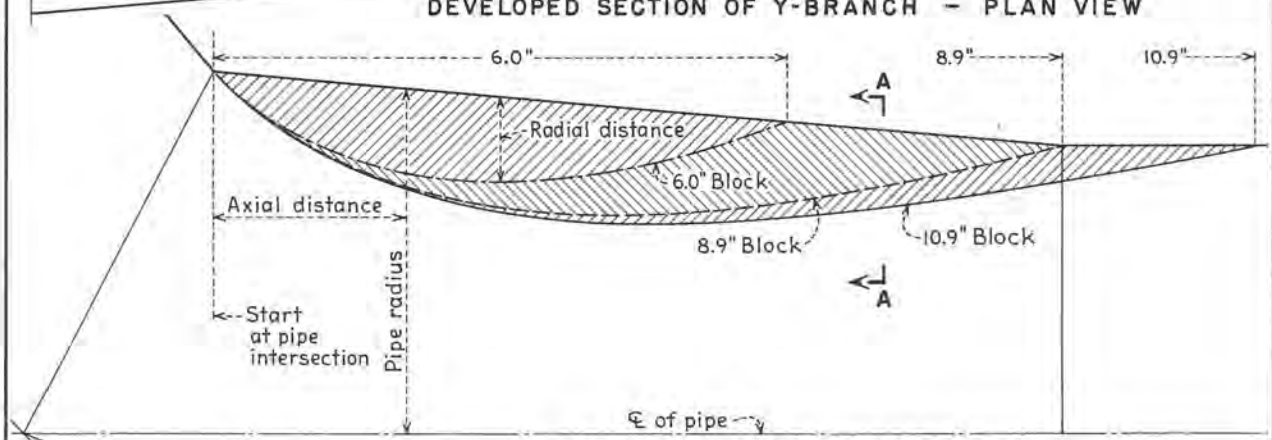
Figure 1, 1:15 Scale Model, Outlet Works, Mexican Side, Falcon Dam.

TABLE OF COORDINATES

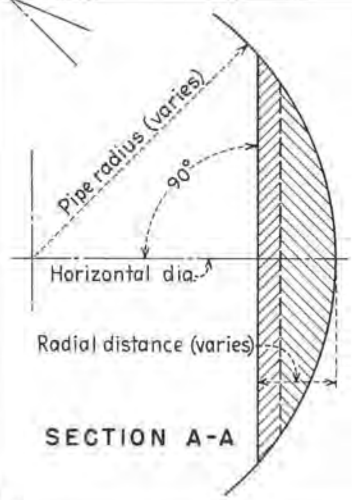
AXIAL DISTANCE ON ℄	PIPE RADIUS (INCHES)	RADIAL DISTANCE (INCHES) 6.0" BLOCK	8.9" BLOCK	10.9" BLOCK
0	3.78	0.0	0.0	0.0
1"	3.70	0.64	0.69	0.69
2"	3.61	0.89	1.03	1.05
3"	3.53	0.89	1.17	1.21
4"	3.44	0.73	1.15	1.23
5"	3.35	0.43	1.04	1.16
6"	3.26	0.0	0.84	1.00
7"	3.17		0.59	0.81
8"	3.08		0.30	0.59
8.9"	3.00		0.0	–
9"	3.00			0.35
10"	3.00			0.17
10.9"	3.00			0.0



DEVELOPED SECTION OF Y-BRANCH - PLAN VIEW



ENLARGED SECTION OF BLOCKS



SECTION A-A

FIGURE 2

FALCON DAM
OUTLET WORKS - MEXICAN SIDE
PRESSURE VARIATIONS IN Y-BRANCH

PIEZOMETER LOCATIONS AND FILLER BLOCKS
1:15 SCALE MODEL

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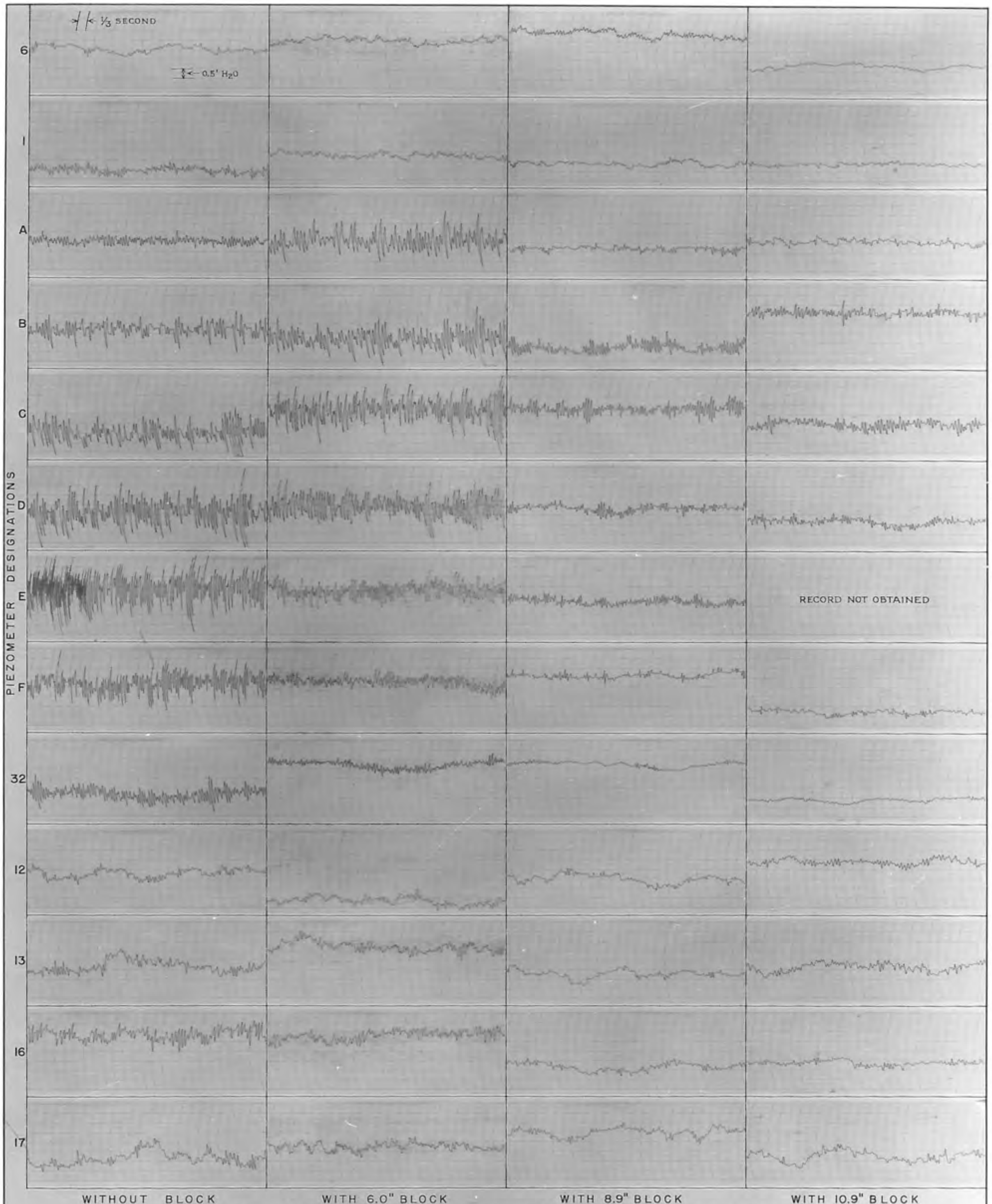
Interior - Reclamation - Denver, Colo.



Horizontal scale:- lines at 1/3 second intervals, Vertical scale:- heavy lines at 0.5' H_2O model intervals

NOTES

See Figure 2 for piezometer locations and block shapes.
Both 90-inch hollow jet valves fully opened - maximum head.
Rate of flow - 6.68 c.f.s. (5 820 c.f.s. prototype)

FIGURE 3

FALCON DAM
OUTLET WORKS — MEXICAN SIDE
PRESSURE VARIATIONS IN Y-BRANCH

PRESSURE TRACES
1:15 SCALE MODEL

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