Pap File



DATE: June 13, 1978

REPLY TO ATTN OF: Chief, Hydraulics Branch

SUBJECT: Model Study of Gabion Drop for Block 2 Drains - Navajo Indian Irrigation Project

TO: Chief, Water Conveyance Branch

In accordance with your memorandum of April 12, 1978, a study was performed to develop and test an arrangement of rock gabions to be placed on an inclined canal drop for use in block 2 drains, Navajo Indian Irrigation Project. The study was conceptual in nature and did not represent an exact model of the proposed structure. The information gained from this research will be helpful in designing similar-type structures in the future.

The laboratory model used for this study, consisted of a sheet metal, trapezoidal channel, with 1.5:1 side slopes, 0.15 m (0.5 ft) width across the bottom of the canal. The model was scaled at 12:1 and the 5:1 sloped drop represented drop type 294-10 on the original study drawings. Sections of expanded metal lathe were used throughout the canal to approach a roughness coefficient comparable to that in the field. The rock gabions were modeled out of high density styrofoam. Water was supplied to the model by the laboratory system and discharges were measured by Venturi meters.

Four different arrangements were tested, in each case a maximum discharge of 8.33 $m^3/s$ (294 $ft^3/s$) was observed, as well as lower flows on several different occasions.

Initial observations were made on an unobstructed drop, with a control notch at the beginning of the drop, see figure 1. With this arrangement, a hydraulic jump did not form at the base of the drop, see figure 2. However, the flow was only slightly supercritical and when blocked, a jump formed. Another control notch identical to the one already in place was installed at the lower end of the canal. This raised the downstream water surface and dampened out some of the turbulence; however, no hydraulic jump formed, see figure 3. These observations indicated that any obstruction placed along the length of the drop would slow the flow sufficiently to allow a jump to form at the base of the drop.

1. It was decided to try an arrangement of gabions similar to a baffled apron drop. The gabions used were block 0.23 m x 0.23 m x 0.91 m (0.75 ft x 0.75 ft x 3.0 ft) in size, and placed in an alternating zig-zag pattern on 1.22 m (4.0 ft) centers along the length of the drop, see figure 4. At maximum discharge a hydraulic jump formed at the base of the drop, figures 5 and 6. Turbulence and wave heights resulting from the jump were acceptable, see figure 7. The downstream control notch was installed, again the higher water surface improved and reduced the turbulence, see figure 8. The discharge was reduced to 4.13 $m^3/s$ (146 $ft^3/s$) and the flow conditions were also very good.

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2. The next arrangement tried was a series of 0.15 m (0.5 ft) high, 0.30 m (1.0 ft) wide gabions placed laterally across the canal, see figure 9. At maximum discharge it was evident that the gabions were not high enough to completely intercept the flow. This condition was apparent only over the first five rows of gabions, see figure 10. A hydraulic jump formed at the base of the drop and with the downstream control notch, turbulence and wave height were acceptable, see figure 11.

3. For the third arrangement, the gabion height was raised to 0.30 m (1.0 ft), see figure 12. This improved energy dissipation; however, water still passed over the first three rows of gabions, figure 13. The flow conditions downstream from the drop were similar to the 0.15 m (0.5 ft) high gabions. As seen in figure 14, the flow conditions were acceptable.

4. The gabions were too close together to efficiently intercept and retard the flow, therefore, it was decided to remove every other gabion, leaving them now on 2.44 m (8.0 ft) centers, see figure 15.

With this arrangement plus the downstream control notch, flow conditions were very similar to arrangement 1, at maximum flow, see figure 16. When observed at 4.13 $m^3/s$ (146 $ft^3/s$), small pools formed behind each gabion and energy dissipation was somewhat lessened.

Conclusions:

The tests of the various gabion arrangements led to the following observations. The zig-zag baffle setup appeared to operate better over a wide range of discharges than any other of the arrangements tested. The 0.30 m (1.0 ft) high gabions on 2.44 m (8.0 ft) center, lost some efficiency at discharges less than maximum while the 0.15 m (0.5 ft) and 0.30 m (1.0 ft) high gabions on 1.22 m (4.0 ft) centers lost their efficiency at the maximum flow. The hydraulic jump in each of these configurations was similar and no big difference was noted. The addition of the control notch in the canal downstream from the drop improved flow conditions by raising the water surface and dampening some of the turbulence and waves. Configuration 4 performed satisfactorily over a range of discharges, especially well at the maximum flow, and was chosen as the configuration for block 2 drains.

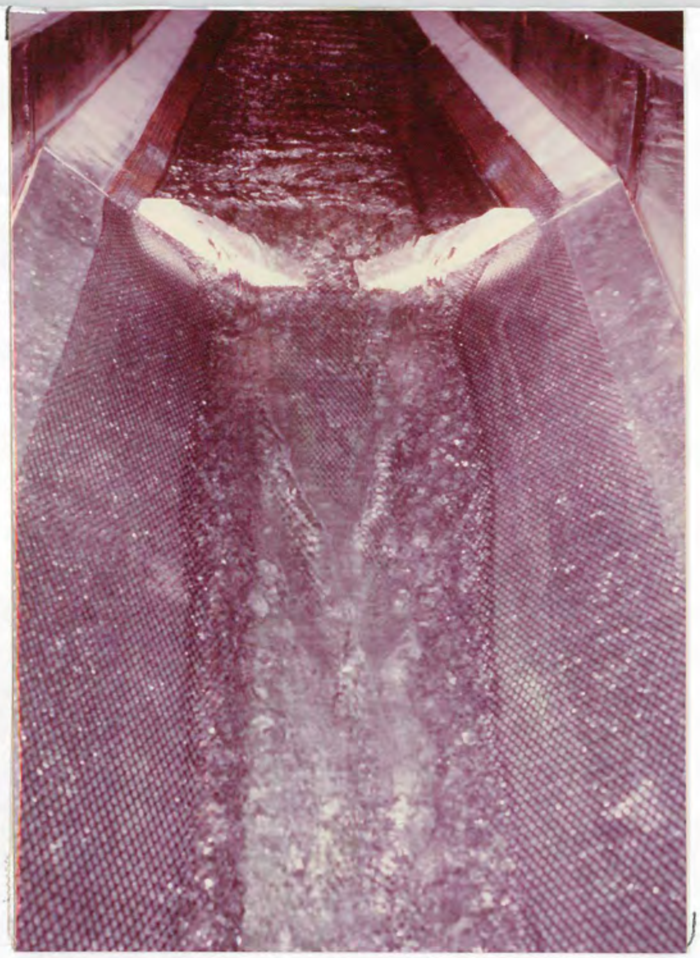

Figure 1 - Unobstructed drop with upper control notch.

Figure 2 - Hydraulic jump not formed at the base of the drop.

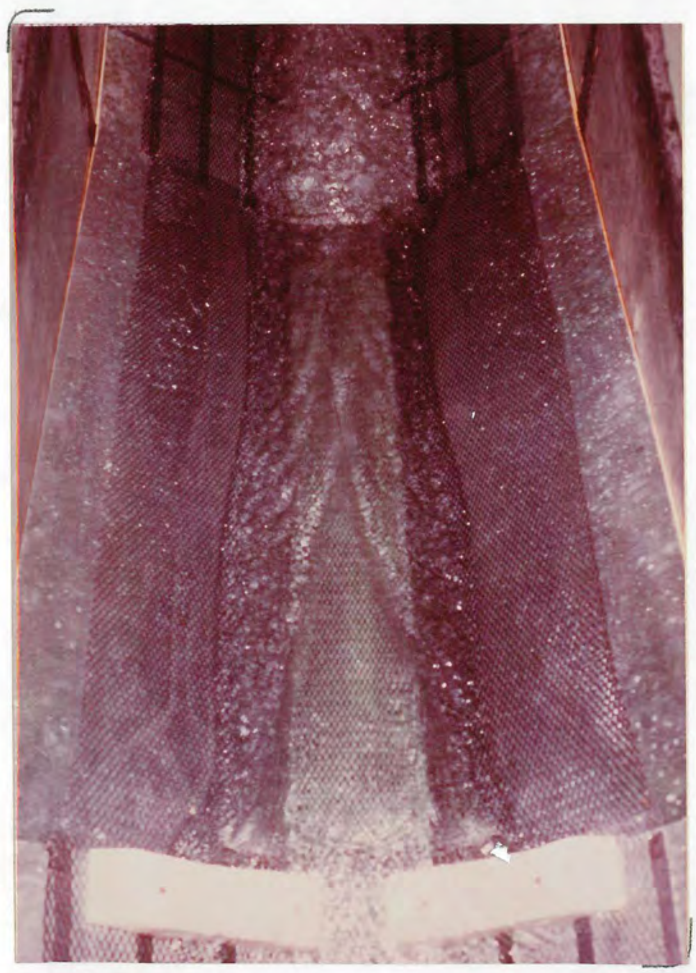

Figure 3 - View of downstream water surface with lower control notch in place.

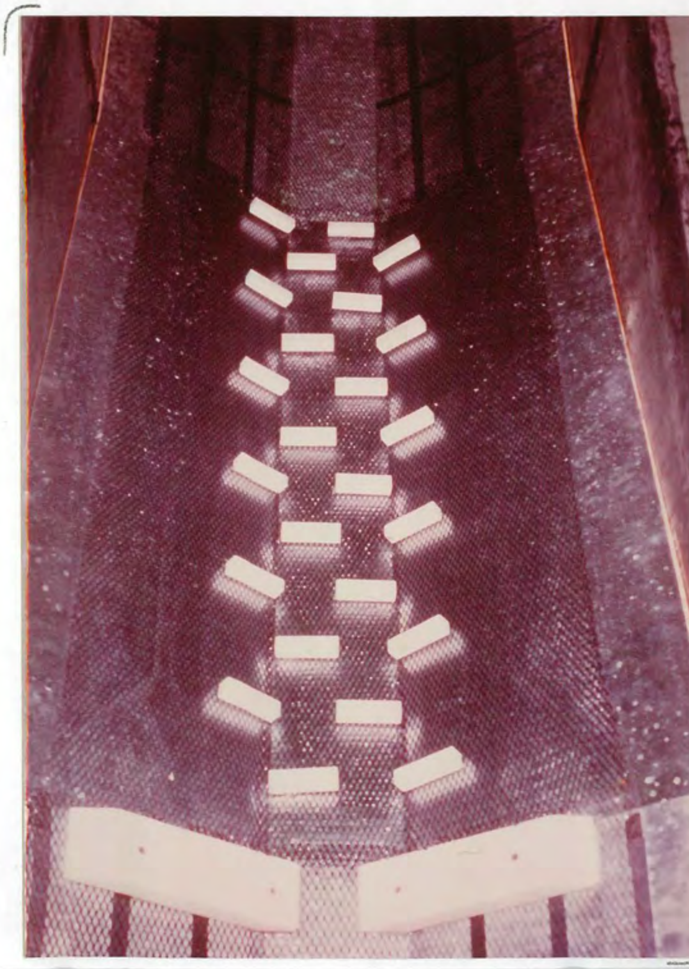

Figure 4 - Zig-zag baffle pattern, gabions on 1.22 m (4.0ft) centers, 0.23m x 0.23m x 0.91m (0.75ft x 0.75ft x 3.0ft) sized blocks.

Figure 5 - Hydraulic jump at base of drop, 8.33 $m^3/s$ (294 $ft^3/s$).

Figure 6 - View of flow conditions on the drop.

Figure 7 - Flow of 8.33 $m^3/s$ (294 $ft^3/s$) with the lower control notch not in place.

Figure 8 - Flow of 8.33 $m^3/s$ (294 $ft^3/s$) with lower control notch in place.

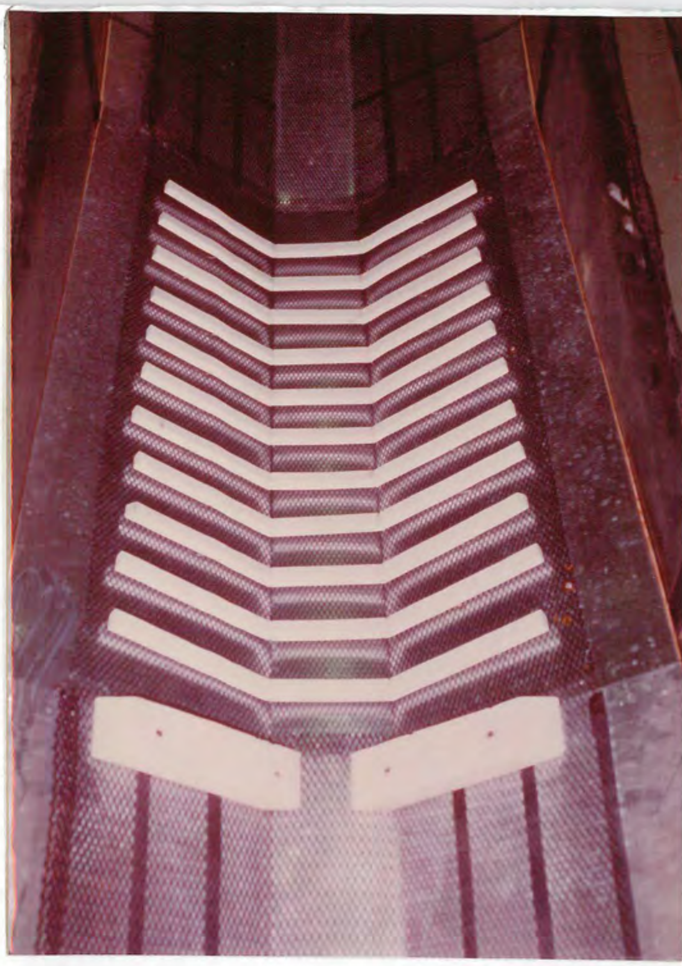

Figure 9 - Configuration 2, laterally placed 0.15 m (0.5 ft) high gabions on 1.22 m (4.0 ft) centers.

Figure 10 - Water passing over first five rows of gabions.

Figure 11 - Hydraulic jump and downstream flow conditions, 8.33 $m^3/s$ (294 $ft^3/s$) lower control notch in place.

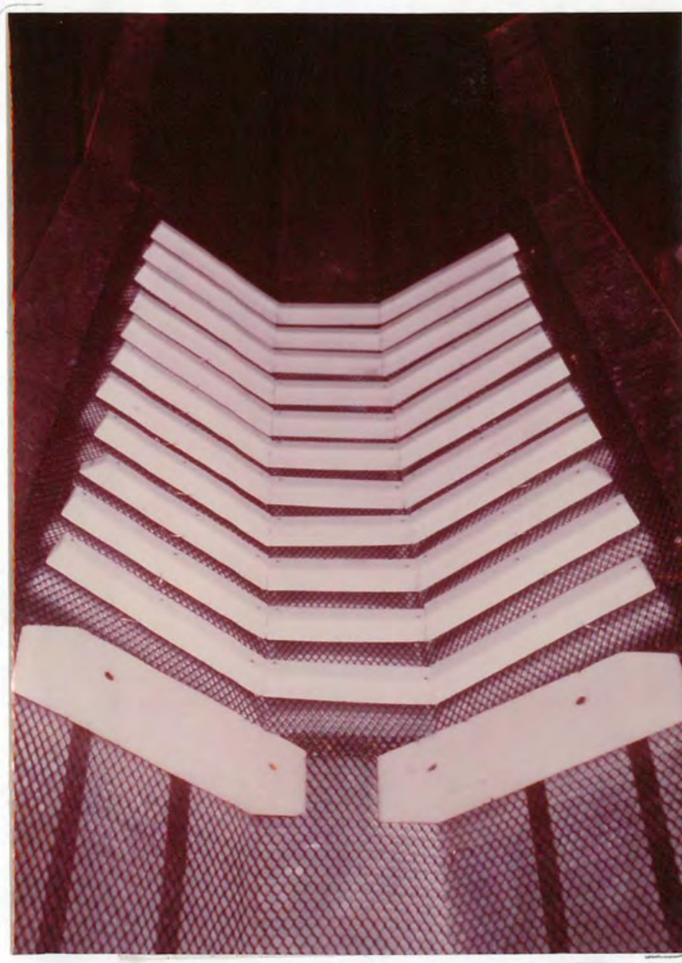

Figure 12 - Configuration 3, laterally placed 0.30 m (1.0 ft) high gabions on 1.22 m (4.0 ft) centers.

Figure 13 - Water passing over the first three rows of gabions.

Figure 14 - Hydraulic jump and downstream flow conditions.

Figure 15 - Configuration 4, laterally placed 0.30 m (1.0 ft) high gabions on 2.44 m (8.0 ft) centers.

Figure 16 - Flow conditions at 8.33 $m^3/s$ (294 $ft^3/s$).