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Yellowtail Dam Issue Evaluation – Jet Erosion Tests of Breccia Core Samples

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Yellowtail Dam Issue Evaluation – Jet Erosion Tests of Breccia Core Samples

Pick-Sloan Missouri Basin Project, Montana
Great Plains Region

Tony L. Wahl

Prepared: Tony L. Wahl
Hydraulic Engineer, Hydraulic Investigations and Laboratory Services, 86-68460

Robert F. Einhellig

Technical Approval: Robert F. Einhellig, P.E.
Acting Manager, Hydraulic Investigations and Laboratory Services, 86-68460

Kathleen H. Frizell   6/18/09

Peer Review: Kathleen H. Frizell   Date
Hydraulic Engineer, Hydraulic Investigations and Laboratory Services, 86-68460

REVISIONS					
Date	Description	Prepared	Checked	Technical Approval	Peer Review

Introduction

Two jet erosion tests were conducted March 24, 2009 on core samples obtained from the vicinity of Yellowtail Dam. The tests were performed in the hydraulics laboratory using a jet test apparatus constructed by Reclamation in accordance with ASTM D-5852, *Standard Test Method for Erodibility Determination of Soil in the Field or in the Laboratory by the Jet Index Method*. This test uses measurements of the scour caused by an impinging hydraulic jet to quantify the erodibility of soil materials. A schematic diagram of the test setup is shown in Figure 1. In recognition of the fact that the samples being tested were likely to be very erosion resistant compared to the soil specimens typically tested with the apparatus, water was supplied from a head tank providing approximately 235 inches (approx. 20 ft) of driving head to the submerged jet, a much larger head than is typically used for such tests (18-60 inches).

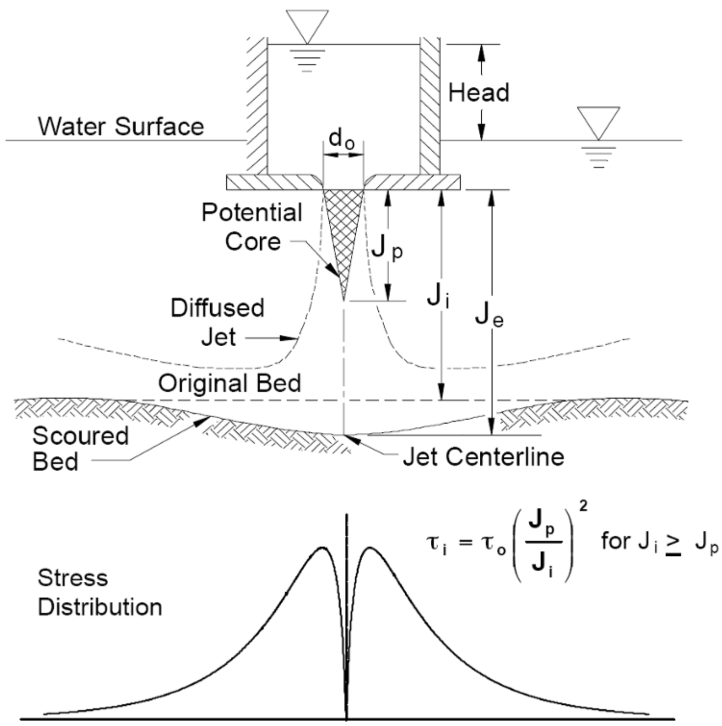

Figure 1. — Schematic of circular submerged jet test (from Hanson and Cook 2004).

There is interest in knowing the potential for developing piping erosion through the breccia material, and thus, hole erosion tests (HETs) were initially considered. However, on the basis of research conducted by Reclamation (Wahl et al. 2008), the likelihood for producing erosion that could be measured and analyzed seemed quite remote for this material. Reclamation's research did offer the possibility for performing jet erosion tests (which can be applied to more erosion resistant materials) and using the results to infer HET erosion indices.

Eight potential test specimens were cut from core samples obtained from two drill holes. From these, two specimens were selected for initial jet testing. Details of each test follow.

DH07-4, 26.63 ft to 27.0 ft

This sample was tested in an inverted position (jet impinging on the 27.0-ft depth surface). The ¼-in. diameter submerged hydraulic jet was positioned initially 0.158 ft above the sample surface, producing a computed peak hydraulic shear stress against the surface of 336 Pa (7.0 psf). The impingement velocity against the specimen was about 29.5 ft/s. Measurements of the scour depth below the jet were made at increasing increments of test time: 2, 5, 20, 60, 131, and 212 minutes.

There was immediate removal of breccia fragments around the top perimeter of the specimen when the test was started, as the jet washed away fragments that had been pre-existing or were produced by cracking that occurred during the coring operation. It should be noted that if the sample had been confined in a tube or soil mold as is typical with soil specimens tested in the submerged jet apparatus, most of these fragments probably would have remained in place. Directly beneath the impinging jet, where scour depth measurements were made during the test, there was absolutely no erosion throughout the test period. In fact, over the course of the test, the elevation of the top surface increased by 0.01 ft (about 1/8 in.), indicating that the specimen was swelling as it became saturated, figure 2.

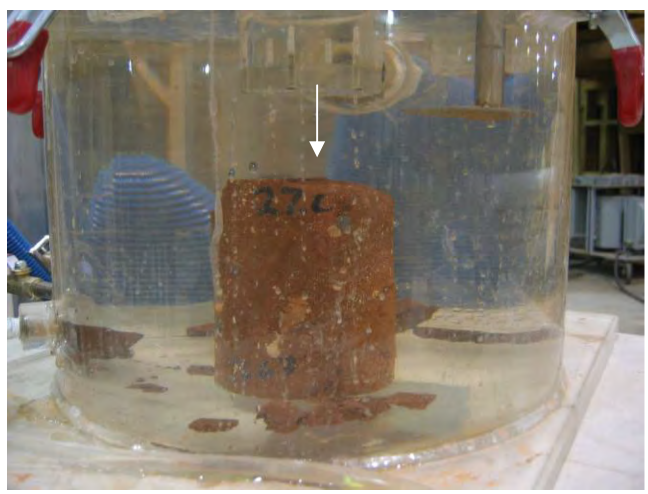

Figure 2. — DH07-4 specimen before (left) and during test. In the right hand photo, note erosion of breccia fragments from around top perimeter of specimen, but no downward erosion of the specimen at the center (beneath the impinging jet location, indicated by the arrow).

At the end of the test, the tank was drained and the sample carefully removed from the tank. Despite the care exercised, the bottom part of the specimen crumbled loose when the specimen was picked up. Some of the pieces that came loose could be further broken down by hand and their texture and tendency to cloud the water remaining in the tank suggested the presence of small amounts of silt and clay. Figure 3 shows the specimen after it had been air-dried overnight.

Figure 3. — DH07-4 specimen after jet test. Loose fragments from the bottom of the specimen are being used to prop it up for viewing.

No quantitative analysis of this test is possible, because the swelling of the specimen caused negative erosion to be calculated beneath the impinging jet. Although material was removed from around the perimeter of the specimen, the initial detachment of this material appears to have been driven simply by the wetting processing, not by the applied hydraulic stress. The impinging jet did remove this material once it became detached, but the stress applied by the jet did not drive the detachment process. Thus, the detachment rate coefficient and threshold shear stress needed for detachment cannot be determined. The fact that no erosion was observed directly beneath the jet shows that on a very small scale, the breccia material is more erosion resistant than any soil-like material, but on a larger scale at which joints, cracks, and discontinuities come into play, the material can be quite erodible. As a result, this material should be resistant to piping erosion, but very susceptible to scour caused by free surface flow or impinging jets that attack unconfined surfaces exhibiting joints and cracks.

DH07-5, 52.83 ft to 53.2 ft

This sample was also tested in an inverted orientation with the jet impinging on the 53.2-ft depth surface. The ¼-in. diameter submerged hydraulic jet was positioned initially 0.161 ft above the sample surface, producing a computed peak hydraulic shear stress against the surface of 324 Pa (6.8 psf). The impingement velocity against the specimen was about 29.0 ft/s. Measurements of the scour depth below the jet were made at test times of 5, 49, and 121 minutes. No significant erosion of this sample was observed during the test, but the scour depth measured at the 5-minute mark did show a scour depth of 0.001 ft (smallest measurable amount), which is probably indicative of removing the thin layer of material from the surface that was disturbed when the specimen was cut from the original core. For the remainder of the 2-hour test period, the specimen was completely stable. This specimen did not swell during the test like the DH07-4 specimen, and when it was removed from the apparatus at the end of the test it was completely intact, with no loose fragments on any part of the specimen, figure 4.

Figure 4. — Photos of DH07-5 test specimen before (left) and after submerged jet testing. Note that the depth interval shown on the paper label is incorrect.

Conclusions

The submerged jet erosion tests performed on two samples of breccia material from the vicinity of Yellowtail Dam showed that they do not erode in a soil-like manner, but behave in a manner typical of rock-like materials. The submerged jet test (and the hole erosion test which was also considered for these samples) do not measure the erodibility of rock, but the test performed on the specimen from drill hole DH07-4 does suggest qualitatively that in zones that are already fractured, this material can be eroded if the already-detached fragments are unconfined so that they can be transported away by the flow. In a piping erosion situation, where the material is confined, the breccia is likely to be very resistant to the development of piping. If a hole erosion test could be performed, this material would certainly be in the most erosion-resistant classification, HET group 6.

Based on past experience with a variety of soil materials and these tests, there is no possibility that hole erosion tests could be successfully performed or would provide any additional meaningful information. Further submerged jet testing is also unlikely to be of additional value.

References

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