UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

EROSION TESTS ON FOUR EARTH MATERIAL SAMPLES FROM THE SITE OF THE PROPOSED OAHE CANAL--OAHE UNIT--JAMES DIVISION--MISSOURI RIVER BASIN PROJECT

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RESEARCH AND GEOLOGY DIVISION

BRANCH OF DESIGN AND CONSTRUCTION
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Laboratory Report No. 298
Hydraulic Laboratory
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Subject: Erosion tests on four earth material samples from the site of the proposed Oahe Canal--Oahe Unit--James Division--Missouri River Basin Project

PURPOSE

To determine the erosion resistance of the above cited soft earth samples when subjected to flowing water.

CONCLUSIONS

Hole 5--Dept 5 to 6.5 feet.

Excessive erosion occurs at a water velocity of 1.25 feet per second. The erosion occurs as a continual removal of material from the surface and with a tendency for the material to soften and "melt" at the edges and corners (Figure 2B).

Hole 5--Depth 9.5 to 11 feet, Hole 8--Depth 9.5 to 11 feet, and Hole 9--Depth 3.5 to 5 feet.

These fragile samples crumbled when the shipping cases were removed (Figures 3, 4, and 5), and no erosion tests could be conducted on them. It was apparent, however, that excessive erosion would occur in the laboratory tests at a water velocity of 1.25 feet per second.

INTRODUCTION

The Oahe Unit consists, in the main, of Oahe Dam and Power Plant, a pumping plant for raising water from the Oahe Reservoir to the Oahe Canal, about 40 miles of unlined canal leading east from the dam to Blunt Reservoir, and about 85 additional miles of unlined canal leading to the fields to be irrigated in the James Valley. Oahe Dam will be located on the Missouri River about 4 miles upstream from Pierre at the approximate center of South Dakota.

For economic reasons it is desirable to make the main canals of the system as small as possible in cross section and to use the maximum allowable water velocities. However these unlined canals pass through earth material which is so easily eroded by flowing water that care must be exercised to prevent excessive damage. As an aid to determine the maximum allowable water velocities over these materials, four undisturbed samples were procured from representative sites along the canal and shipped to the Hydraulic Laboratory in Denver for laboratory erosion tests.

This report concerns the method of conducting the erosion tests on the samples and the results obtained from these tests.

DESCRIPTION OF THE SAMPLES

Hole 5--Depth 5 to 6.5 feet.

Silty clay, slightly moist, somewhat plastic, and nonlayered (Figure 2).

Hole 5--Depth 9.5 to 11 feet.

Sand and gravel, dry, poorly graded, and nonlayered (Figure 3).

Hole 8--Depth 9.5 to 11 feet.

Fine to medium sand with some small gravel, dry, moderately graded, and somewhat layered (Figure 4).

Hole 9--Depth 3.5 to 5 feet.

Fine to medium with some clay and small gravel, slightly moist, moderately graded, and somewhat layered (Figure 5).

APPARATUS AND TESTS

A schematic diagram of the erosion test apparatus is shown in Figure 1. Water was supplied through a 6-inch standard pipe and a transition section to the 16-inch wide by 66-inch long test chute. A valve was provided to regulate the discharge and a flow straightener was placed downstream from the valve to insure smooth, straight flow into the test section. The water entered the chute in a uniform stream 2 inches deep and the slope of the chute was adjusted to maintain this depth over the full length of the sample. The velocity of the water over the test sample was determined by measuring with a Venturi meter the quantity of water flowing and dividing this quantity by the cross sectional area of the flowing water in the chute. The water discharged freely from the end of the chute and was returned to the supply channel by a trough. The floor of the test box was adjustable to permit moving the sample to keep its top surface level with the chute floor as the material was washed away. To avoid surges and excessive velocities over the sample when the flow was started, an obstruction was placed across the downstream end of the channel, the chute flooded to a depth of 2 inches, and the control valve slowly opened while the obstruction was being removed. A final adjustment of the valve established the desired water velocity over the sample.

Visual means were used to judge the erosion on the samples, and photographs are presented to show the condition of samples at the completion of the tests because no feasible method of determining the quantity of material removed in the erosion process has been developed to date. Weight, volume, and collection measurements could not be made because of large changes in moisture content during testing, swelling of certain materials (particularly clay) when water is absorbed, and the lack of filtering equipment capable of holding the small particles washed off the sample and still capable of handling the large quantities of water used.

The restrictions imposed by laboratory investigations upon the size and shape of the samples used in the erosion tests permits only an approximation of the field erosion conditions. In the laboratory the samples are relatively small, are subjected to a stream of clear water flowing with a high velocity gradient near the sample surfaces, and are not continuous but are affected by the necessary corners and edges in the flow surfaces of the test apparatus. The results presented in this report must therefore be regarded as qualitative only and must be used with care to predict the erosion velocities in the field.

Previous to procuring the material samples, the field inquired as to the most desirable sample size. They were instructed to obtain samples 12- by 12- by 18-inches instead of 12 inches wide, 18 inches long, by 12 inches deep, thus it was necessary to place the samples upright, exposing only a 12- by 12-inch test surface, in order that the water would flow over the material in the proper direction (Figure 2A).

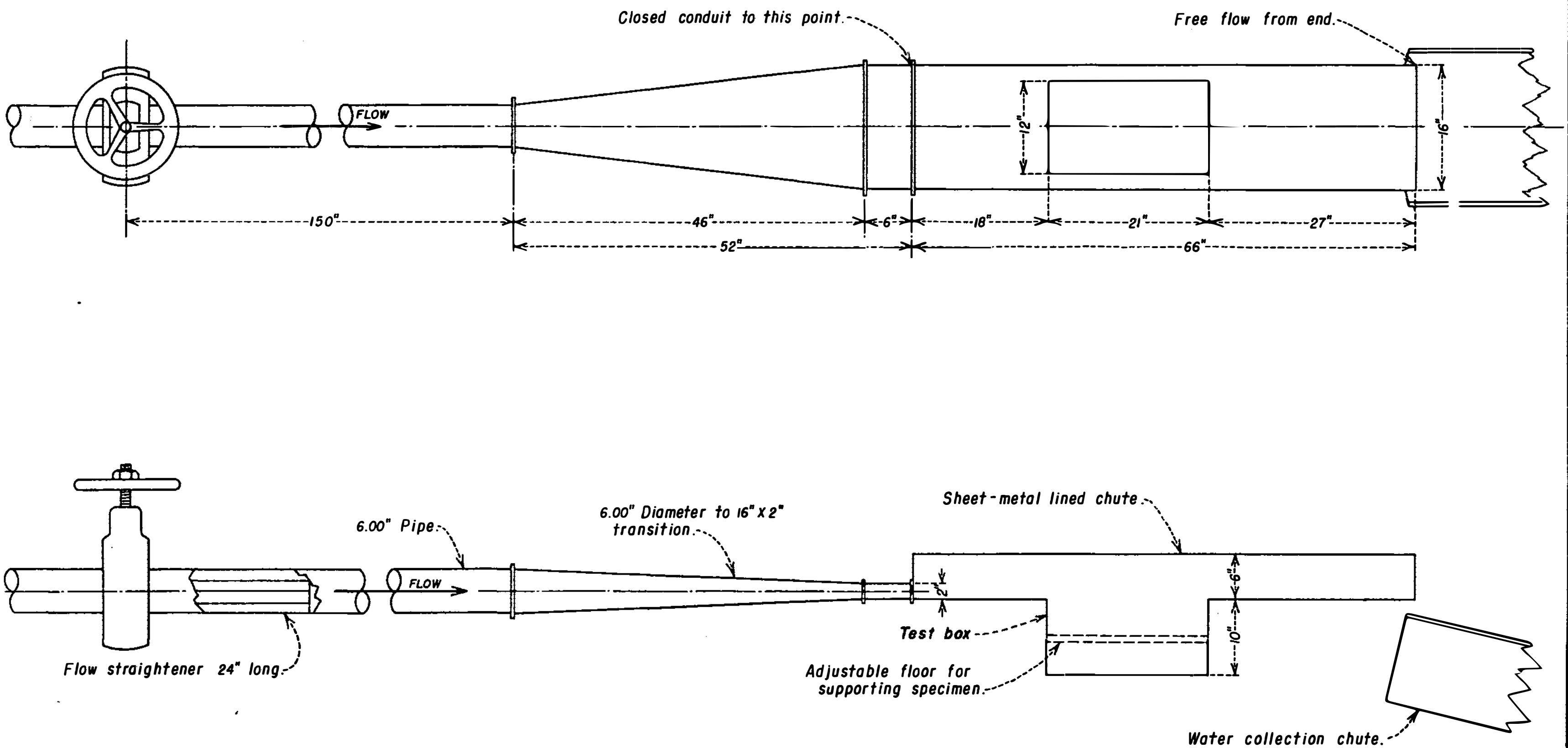
TEST RESULTS

Hole 5--Depth 5 to 6.5 feet.

Water was passed over the sample at a velocity of 1.25 feet per second and almost immediately loose material was swept from the top surface in quantities great enough to make the water opaque. After about a minute the rate of material removal decreased sufficiently for the water to clear. Subsequent action consisted of continuous erosion over the full surface of the sample with the washed-off particles ranging in size from silt to clumps three-eighths of an inch in diameter. The corners of the sample, which were subjected to unavoidable eddies, appeared to soften and "melt." This was particularly noticeable at the downstream corners. At the end of 20-minutes, the water flow was stopped. During the 20-minute test period so much material was removed from the top surface that the sample was raised a total of 1-1/2 inches while maintaining the top level with the chute floor. The sample was examined and photographed (Figure 2B). The surface material was found to be soft mud which offered almost no resistance to the penetration of the blunt end of a pencil to a depth of one-fourth inch. Further tests seemed useless on this material and the program was halted.

Hole 5--Depth 9.5 to 11 feet, Hole 8--Depth 9.5 to 11 feet, and Hole 9--Depth 3.5 to 5 feet.

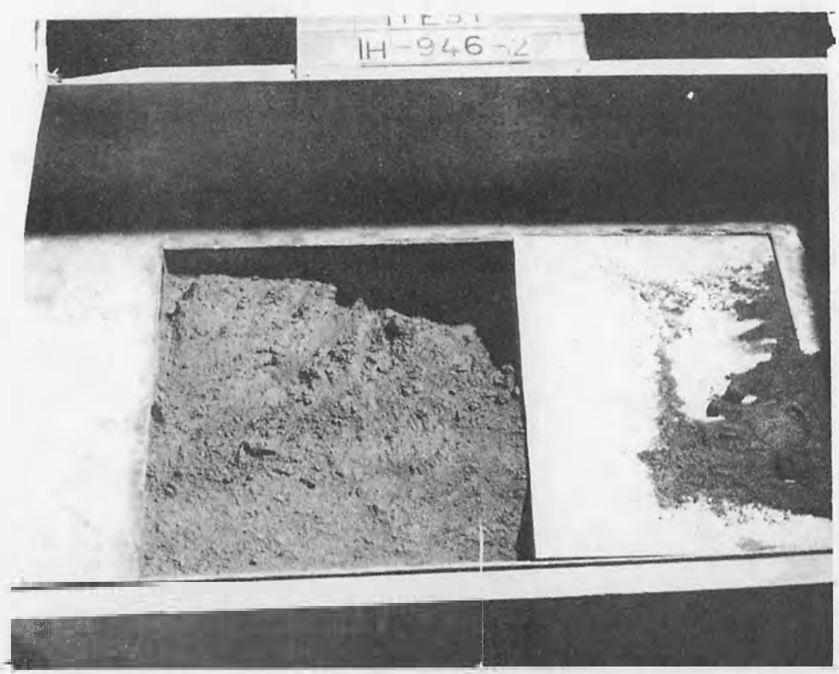
Particular care was taken to avoid jarring these three samples while removing the packing cases because the material descriptions forwarded with the samples indicated that they were fragile. While the cases were being removed, severe crumbling and cracking occurred in the earth material, and photographs were taken to record the sample conditions (Figures 3A, 4A, and 5A). After the cases were removed to the extent that they offered no support to the sides or ends of the sample, further crumbling and cracking occurred (Figures 3B, 4B, and 5B). The samples from Hole 5 and Hole 8 were unsuitable for erosion tests. An attempt was made to place a portion of the sample from Hole 9 in the test apparatus, but the material crumbled as soon as it was moved. It was therefore not possible to run tests on any of these three samples. It is reasonable to assume, however, that from the nature of the materials the erosion rate would be at least as high as for the sample tested.



ERОSION TEST APPARATUS

FIGURE 1

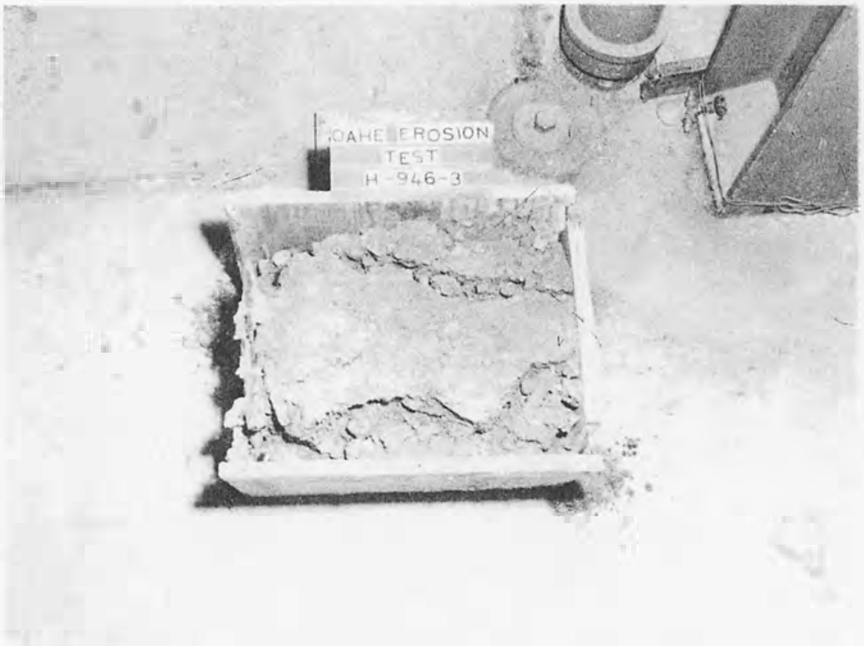
A. Sample in place in the test apparatus before the test.



B. Sample after 20 minutes exposure to a water velocity of 1.25 feet per second. Flow from left to right.

Sample taken from Hole 5 at a depth from 5 to 6.5 feet

Oahe Erosion Tests



A. Containing box partially supporting the sample. The top of the sample is at the right.

B. Containing box removed from the sides and top of the sample. Top is in right foreground.

Sample taken from Hole 5 at a depth from 9.5 to 11 feet.

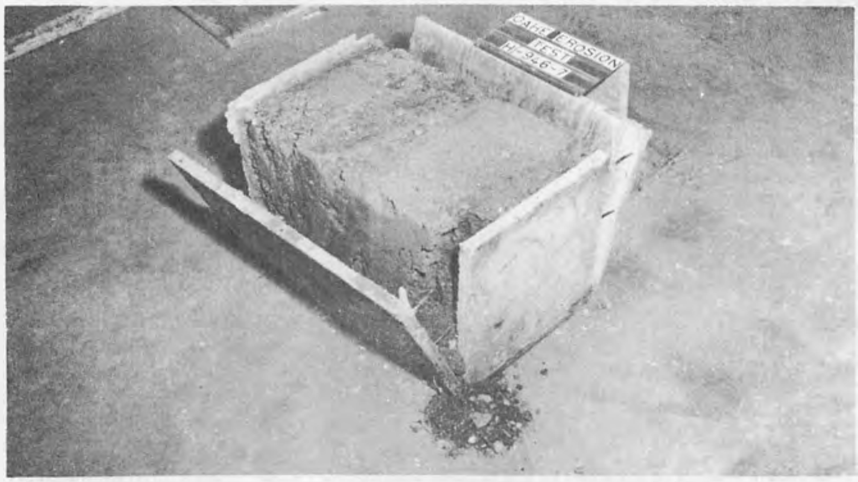
Oahe Erosion Tests

A. Containing box partially supporting the sample. The top of the sample is at the right.

B. Containing box removed from sides and top of the sample. Top is in right foreground.

Sample taken from Hole 8 at a depth from 9.5 to 11 feet.

Oahe Erosion Tests



A. Containing box partially supporting the sample.

B. Box removed from the sides and top of the sample.

C. The material crumbled as soon as an attempt was made to move it. Top of the sample is in right foreground.

Sample Taken from Hole 9 at a depth from 3.5 to 5 feet.

Oahe Erosion Tests