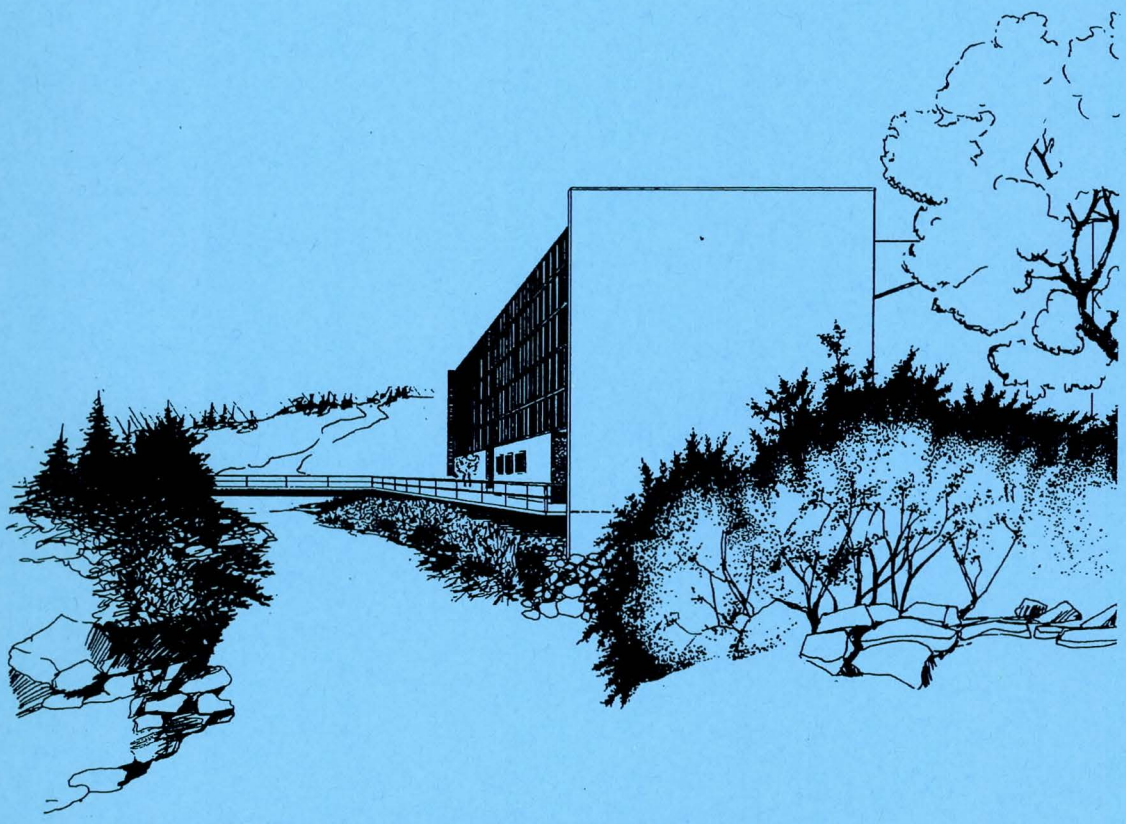
High Velocity Flow Testing Between Parallel Verdura 40 and Verdura 60 Block Retaining Walls.

May 2003

Soil Retention

Prepared By: Blake P. Tullis, Ph.D.



UTAH WATER RESEARCH LABORATORY

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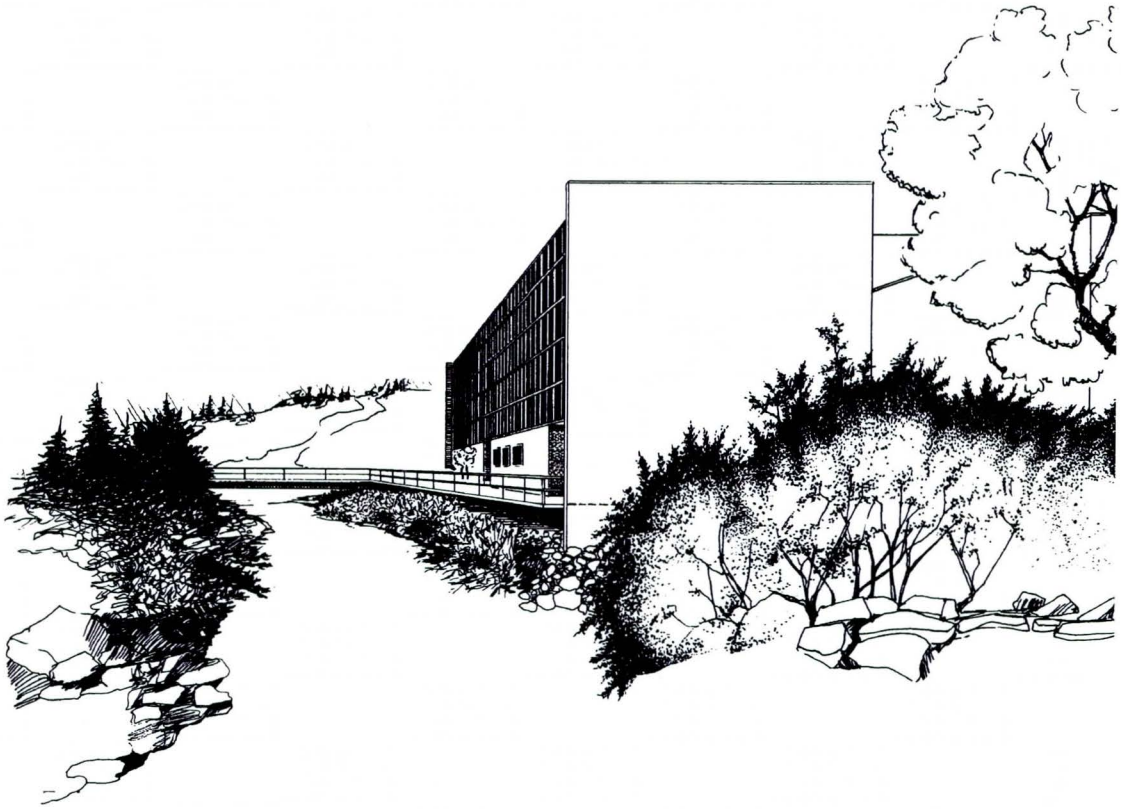

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Client:

Soil Retention
Dean Sandri
2501 State Street
Carlsbad, CA 92008
Ph: 760-966-6090

Test Conducted By:

Blake P. Tullis, Ph.D.

May 2003

Utah Water Research Laboratory
Utah State University Foundation
Logan, Utah 84322-8200

Hydraulics Report No. 1355

Introduction

The Soil Retention retaining wall system is a gravity retaining wall that utilizes its weight and optional soil anchors to resist lateral earth pressure. The blocks are assembled with a 1-horizontal to 4-vertical slope, as successive rows of blocks stack on top of and behind the preceding row of block.

Soil Retention, Inc. contracted with the Utah Water Research Laboratory at Utah State University to conduct a high velocity test flow test with Verdura 40 and Verdura 60 blocks. The objective of the testing was to determine the stability of retaining wall, built with Verdura 40 or 60 retaining wall blocks, when subjected to a high-velocity jet flowing parallel to the retaining wall. The Soil Retention contact for this testing was Dean Sandri, P. E. The details of the testing and the test results are presented in this report.

Facilities, Procedures, and Test Results

General Description

All of the tests were conducted in an indoor concrete flume at the UWRL. The flume, which is 8 feet wide, 6 feet deep, and 570 feet long. The flume is hydraulically connected to a supply reservoir via a 4-foot diameter pipeline and provides approximately 35 feet of head.

Each block type was tested separately. Figure 1 shows the block configuration for the high-velocity flow test. The two parallel walls were approximately 35 feet long. The upstream ends of the walls curved into the sides of the laboratory channel. A slotted bulkhead was placed at the downstream end of the walls to hold the structure in place. Sand bags and geo-textile fabric were integrated into the wall and fill material at the upstream and downstream ends to minimize the loss of backfill material due to end effects. A layer of window screen mesh and chicken wire were attached to the slotted bulkhead to provide additional support. 3/4-inch, washed gravel was used as backfill material. A sieve analysis of the backfill material is included in Table 2.

The walls were spaced 9 inches apart at the bottom. For the Verdura 60 test, 5 rows of Verdura 60 were installed. A sixth row of blocks was placed on each wall using Verdura 40 block. The purpose of the sixth row was to provide a deeper channel for flow containment. The sixth row was not considered part of the test wall and its performance was not documented. For all tests, the rows are identified with row 1 being the bottom row and the row numbers increase sequentially as you move up.

For the Verdura 40 test, the test wall included 6 rows of Verdura 40 block, with an additional two rows of Verdura 40 (total of 8 rows) at the upstream ends. The extra rows were used to contain the flow in the channel, and to minimize the amount of water splashing over the wall in to the backfill material.

The high-velocity jet was produced using a nozzle built into the end of a 48-inch pipe. The nozzle matched the shape of the channel, whoever, slightly undersized. The nozzle included a

rounded approach upstream. The nozzle is detailed in Figure 2. Flow through the nozzle was control using a 48-inch butterfly valve located approximately 4 pipe diameters upstream from the nozzle. A 48-inch ASME flow, traceable to the National Institute of Standards and Technology (NIST) by weight, was used to determine the flow rate through the nozzle.

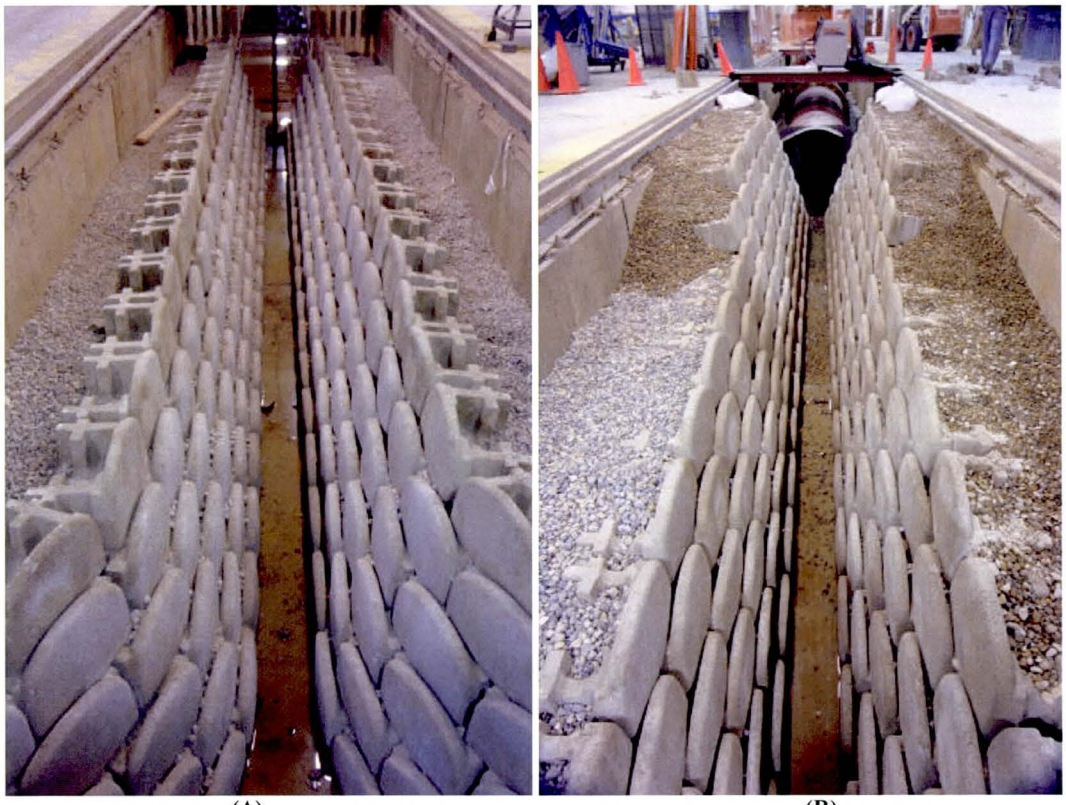
The velocity data reference in this report are the flow velocity exiting the nozzle, which were calculated by dividing the measured flow rate by the cross-sectional area of the nozzle. Due to the magnitude of the test velocities, the flow velocities in the retaining wall block channel could not be directly measured with the instrumentation available. Based on the fact that the nozzle area and the retaining wall block channel area were similar in shape and size, and that the majority of the discharge was contained in the channel, we conclude that the nozzle exit velocity closely approximate the actual velocity in the retaining wall block channel.

Prior to flow testing, the position of every fourth block on the bottom and third rows were determined by measuring from a vertical reference line (created by attaching an angle iron to a cart that rides on rails above the channel) to a spot on the face of the block. The block measurement point was at the vertical centerline of the block and near the bottom. The measurement location was identified using a black marker so that the measurements could be repeated to the same location after the flow test. Rows1 and 3 were selected because they did not have anchors tying them back to the concrete wall of the laboratory channel.

Two tests were conducted with each block type. A velocity in the range of 20 to 25 fps (23.3 fps for the Verdura 60, and 25.0 fps for the Verdura 40) was maintained for 15 minutes. The flow was shut off and the walls inspected for failure. Obvious block movement or backfill material removal through the walls would constitute a failure condition. As no failures were observed with either block type, a flow velocity of approximately 30 fps was set and maintained for 30 minutes. Following the 30-minute test, the walls were again inspected for visual failure and the position of the reference blocks were measured. **No movement of the blocks could was detected as a result of high-velocity flows**. The distance measurements appear in the appendix. The small differences in before and after measurements are within the accuracy of the measurement method. The velocity data are presented in Table 1. Figures 3 and 4 show the Verdura 40 wall during and after the high-velocity tests. Figures 5 and 6 show the Verdura 60 walls during and after the high-velocity tests.

Appendiix

Report Figures and Tables



(A) (B)

Figure 1 Overview of Verdura 60 (A) and Verdura 40 (B) pretest setups. Photo A is looking upstream. Photo B is looking downstream.

(A)

(B)

Figure 2 Discharge nozzle detail. Photo A shows the quarter-round transition approaching the nozzle. Photo B shows wall extensions on the downstream end of the nozzle.

Figure 3 Verdura 40 Block during 30.5fps flow test.

Figure 4 Verdura 40 walls following high velocity testing.

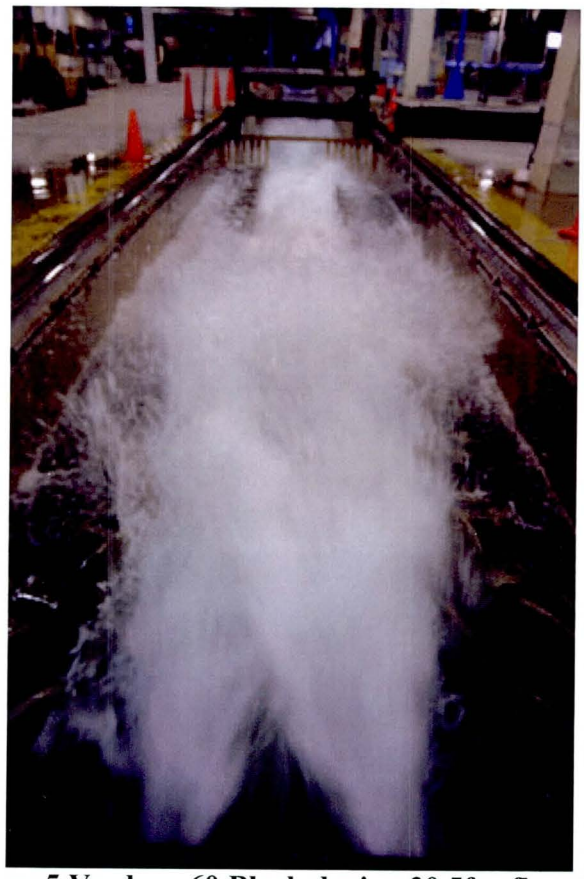


Figure 5 Verdura 60 Block during 30.5fps flow test.

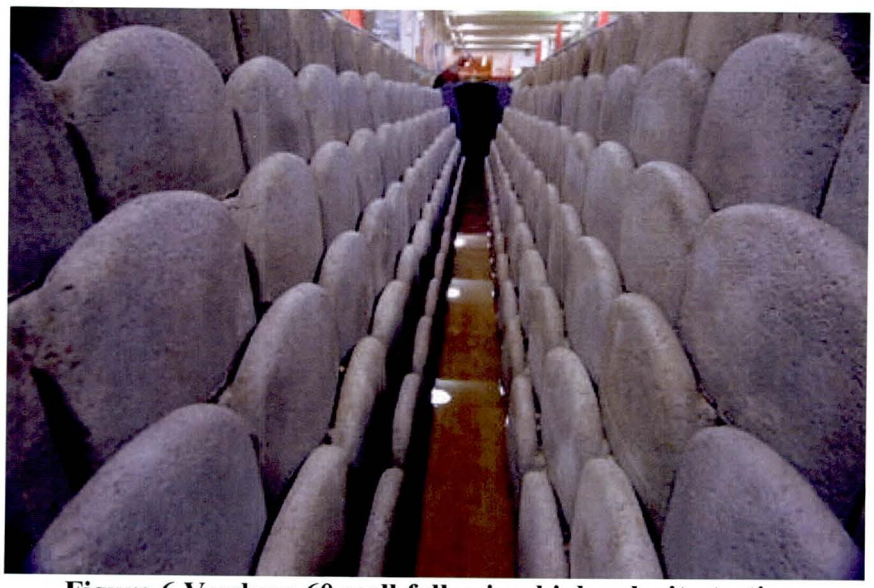


Figure 6 Verdura 60 wall following high velocity testing.

Table 1. Velocity data for each block type

Block Type	15-minute Test Velocity	30-minute Test Velocity
Verdura 60	23.3 fps	30.4 fps
Verdura 40	25.0 fps	30.5 fps

*Note: See discussion on how velocities were determine

Table 2. Sieve Analysis of Retaining Wall Backfill Material

Coarse Aggragate Seve Analysis (ASTM C136)
Location: USU Concrete Lab
Description of Soil: Well Sorted, Washed Gravel
Tested by: Everett W. Taylor Date: May 5, 2003

Mass of dry sample + Dish (lb)	26.1
Mass of dish (lb)	2.3
Mass of Dry sample (lb)	23.8

Sieve Size (in)	Mass Weighed (lb)	Mass retained (lb)	% Retained	% Passing
1.5	0	0	0.00%	100.00%
1	0	0	0.00%	100.00%
0.75	5.1	2.8	11.97%	88.03%
0.5	14.6	12.3	52.56%	35.47%
0.375	9	6.7	28.63%	6.84%
0.187	3.5	1.2	5.13%	1.71%
Pan	2.7	0.4	1.71%	0.00%
	Sum Mass Ret. (lb)	23.4		

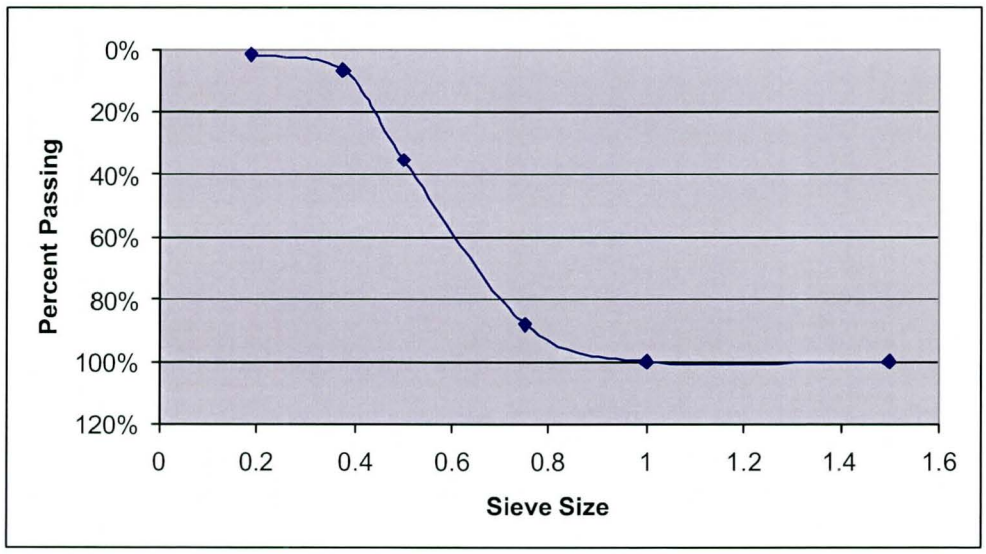


Table 3. Measured block locations both pre- and post-test for the Verdura 60 and Verdura 40 block tests.

Client: Soil Retention
Test Block: Verdura 60
Date Tested: 4/3/03

	Left Wall			Right Wall	
Block	3	1	Rows	1	3
2	10.30 in	4.80 in	Pre-Test	3.90 in	9.60 in
6	10.50 in	5.10 in		3.70 in	9.40 in
10	10.30 in	4.90 in		3.90 in	9.65 in
14	10.30 in	5.00 in		3.80 in	9.60 in
18	10.50 in	5.00 in		3.80 in	9.30 in

	Left Wall			Right Wall	
Block	3	1	Rows	1	3
2	10.30 in	4.90 in	Post-Test	3.90 in	9.55 in
6	10.50 in	5.05 in		3.70 in	9.40 in
10	10.30 in	4.90 in		3.90 in	9.65 in
14	10.30 in	5.00 in		3.80 in	9.60 in
18	10.50 in	5.00 in		3.80 in	9.30 in

	Left Wall			Right Wall	
Block	3	1	Rows	1	3
2	0.00 in	-0.10 in	Difference	0.00 in	0.05 in
6	0.00 in	0.05 in		0.00 in	0.00 in
10	0.00 in	0.00 in		0.00 in	0.00 in
14	0.00 in	0.00 in		0.00 in	0.00 in
18	0.00 in	0.00 in		0.00 in	0.00 in

Test Block: Verdura 40
Date Tested: 4/22/03

	Left Wall			Right Wall	
Block	3	1	Rows	1	3
2	8.73 in	4.55 in	Pre-Test	2.90 in	7.23 in
6	9.50 in	5.12 in		3.50 in	8.10 in
10	9.67 in	5.26 in		3.58 in	7.95 in
14	9.08 in	5.10 in		3.66 in	8.31 in
18	8.80 in	4.68 in		3.70 in	8.45 in

	Left Wall			Right Wall	
Block	3	1	Rows	1	3
2	8.78 in	4.59 in	Post-Test	2.91 in	7.18 in
6	9.48 in	5.22 in		3.45 in	8.12 in
10	9.70 in	5.29 in		3.60 in	7.93 in
14	9.08 in	5.13 in		3.64 in	8.30 in
18	8.81 in	4.70 in		3.63 in	8.38 in

	Left Wall			Right Wall	
Block	3	1	Rows	1	3
2	-0.05 in	-0.04 in	Difference	-0.01 in	0.05 in
6	0.02 in	-0.10 in		0.05 in	-0.02 in
10	-0.03 in	-0.03 in		-0.02 in	0.02 in
14	0.00 in	-0.03 in		0.02 in	0.01 in
18	-0.01 in	-0.02 in		0.07 in	0.07 in

Notes:

1 Left and right are relative to looking downstream
2 Rows are numbered with the bottom being Row 1
3 Rows 2 and 4 were tied to the channel wall using anchors supplied by Soil Retention
4 Blocks numbered relative to Block 1 being the farthest downstream block on the row.