ERDC Report to Sponsor

US Army Corps of Engineers®
Engineer Research and Development Center

Evaluation of HESCO-Bastion Concertainer SL4836™ Flood Fighting Barrier

Glenn B. Myrick and Donald L. Ward
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Executive Summary:

The Concertainer SL4836™ flood fighting barrier by HESCO Bastion, Inc., consists of 15-ft-long “Concertainers™” each divided into five wire-mesh baskets partially lined with geotextile. Each basket is 48 in. in height, 36 in. in width, and 36 in. in length. Adjacent Concertainers™ are joined together with pins, and the resulting barrier is filled with sand. For the tests reported herein, the barrier was wrapped with a sheet of plastic from partway under the baskets, up the outer side (water side), and across the top.

The units fold flat for shipping, and the entire 75.3-ft-long barrier was shipped on a single pallet. Installation of the roughly 75.3-ft-long barrier took a crew of 3 men 10.1 man-hrs, including one person on a skid-steer loader to fill the baskets with sand. Construction of a similarly-sized sandbag barrier took more than 200 man-hrs.

Static water seepage rates at basin depths of 1 ft, 2 ft, and 3.8 ft were 0.04, 0.09 and 0.13 gpm/ft, respectively. At each depth the seepage rate was significantly lower than that of a comparably sized sandbag barrier.

The barrier was undamaged by waves, overtopping, or debris impact.

The units are designed for easy disassembly and can be recovered. However, for testing purposes of expediency, the wire panels were cut with bolt cutters to allow access to the sand and the units were discarded after removal.

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Unit Conversion Factors

Multiply	By	To Obtain
degrees (angle)	0.01745329	radians
feet	0.3048	meters
inches	0.0254	meters
$feet^2$	0.0929	$meters^2$
gallons (U.S. liquid)	0.003785412	cubic meters
gallons (U.S. liquid) per minute per foot	0.00020699	cubic meters per second per meter
pounds (mass)	453.59237	grams
pounds (force)	4.448222	Newtons

1 Introduction

Background on Testing Program

Early in 2004, Congress tasked the U.S. Army Engineer Research and Development Center (ERDC) to "devise real-world testing procedures for … promising alternative flood-fighting technologies…." Through the General Investigation Research and Development Program, ERDC conducted research and developed a laboratory procedure for the prototype testing of temporary barrier-type flood-fighting structures intended to increase levels of protection during floods.

The test facility was laid out along the perimeter wall of a reservoir with dimensions of 115 ft by 185 ft by 4 ft deep (Figure 1). The test facility was reconfigured specifically for innovative flood-fighting experiments by allowing levees to be constructed against two wall abutments with a 30-ft opening between the walls (Figure 2). A geometric testing zone footprint was laid out on the concrete floor and all levees are required to be constructed within this given footprint. One side of the footprint abuts the concrete wall at a 90-deg angle, and the other side abuts the concrete wall at a 63-deg angle (Figure 3). The purpose for having two different angles is to simulate real-world geometric variability and demonstrate constructability and geometric flexibility of each vendor's product. Additionally, the unsymmetrical geometry allows wave loading variability during hydrodynamic testing, and causes an apparent current along the 63-deg wall.

Inside the test area (leeward side of the levee), an 8-ft diameter by 8-ft-deep circular pit was installed to catch any seepage or overflow water from the structure (Figure 3). Two 4-in.-diam pumps were installed in the seepage pit to pump the accumulated water back into the wave basin. Two 12-in.-diam pumps (12 in. intake and 10 in. output) were also installed to pump excess water out of the seepage pit when the capacity of the 4-in. pumps was exceeded.

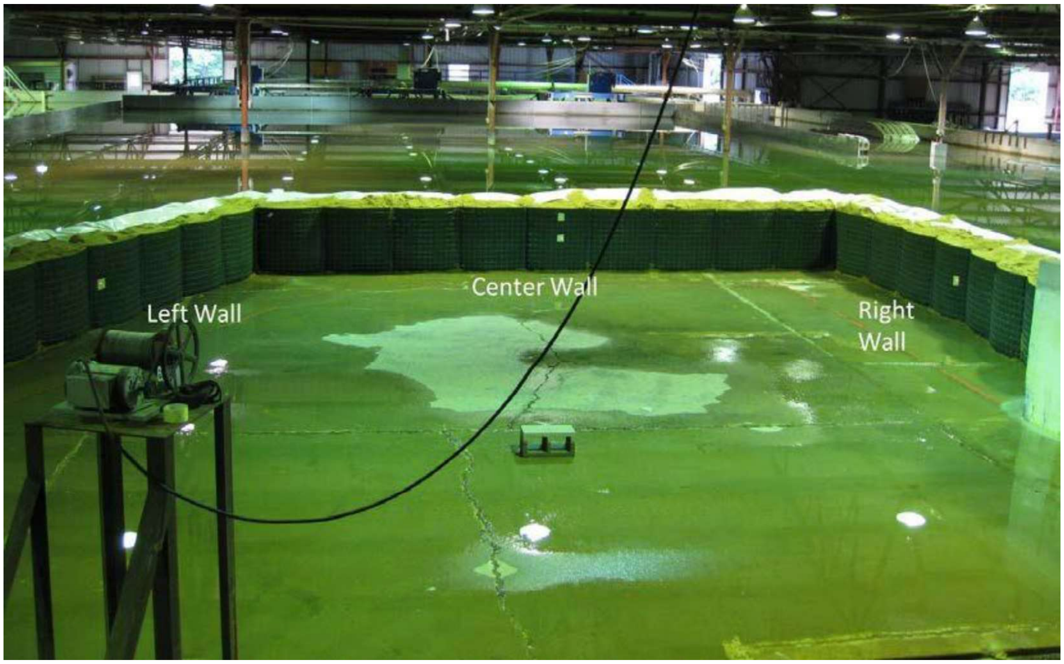

Figure 1. Looking into the research basin from the test area. The wave machines are at the far end of the basin, the winch for the debris impact test is front left, and the front edge of the sump for measuring seepage is to the lower right.

Figure 2. Looking into the test area of the research basin. The vertical white pipes extend down into the seepage pit.

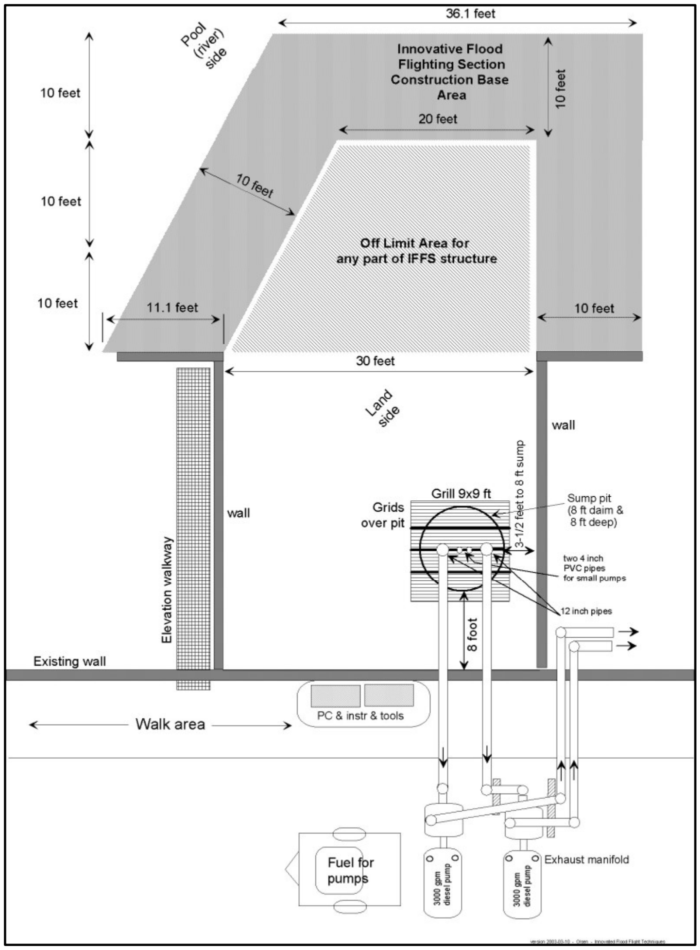

Figure 3. Layout of test area within research basin.

The test area was instrumented with a series of lasers to measure any movement of the flood-fighting barrier, a laser to measure changes in water surface elevation within the seepage pit, and an additional laser to measure water surface elevation within the basin.

In the research basin tests, products were tested in a controlled laboratory setting but under conditions that emulated an impending flood overtopping a levee along a riverbank with moderate flow. Vendors were required to arrive at the test facility with all equipment and supplies required to erect their product prior to testing. The Vendor could use his own people or ERDC personnel (after receiving training from the vendor) to construct the barrier. The ERDC testing engineer did not assist with the

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construction but observed and documented the selected protocol-defined metrics associated with the construction including time required to install the test walls and any special equipment requirements. After construction, the Vendor was not allowed to adjust the structure during any of the tests specified in the protocol. The protocol does allow the Vendor access to the structure a maximum of three times between tests for a limited length of time if such access is required. Any such access to the structure was recorded.

A copy of the standard testing protocol is available at http://chl.erdc.usace.army.mil/chl.aspx?p=s&a=PUBLICATIONS;243

Concertainer SL4836™ Product Description

A Concertainer™ is a series of wire mesh baskets that are partially lined with a geotextile fabric and joined together into a single unit (Figure 4). With the Concertainer SL4836™, each of the baskets are 36 in. wide by 36 in. long and 48 in. high, and there are 5 baskets joined together in each 15- ft-long Concertainer™. "SL" stands for Storm Lined and refers to how each basket is lined with geotextile. The geotextile lines all sides of the baskets and extends across the bottom a distance of about 6 in. from the side. The basket bottom is therefore mostly open but has enough fabric area around the sides that the weight of the sand on the fabric will hold the unit in place. The wire mesh is made of 4 mm wire, welded and galvanized.

Wire mesh panels of a basket are held together by a wire coil through the ends of the panels. To join together two Concertainers™, the coils at the end of each unit are overlapped, and a pin is placed through the two coils.

Delivery

All the units required for the test barrier were shipped to ERDC on two pallets. A third pallet contained bentonite and fabric for sealing the transition area to the walls. A pickup truck arrived with the necessary tools, supplies, and personnel. Sand to fill the units was delivered and stockpiled outside the test building prior to tests (Figure 5).

Figure 4. Concertainer SL4836™ barrier assembled.

Figure 5. Sand Delivery.

2 Testing Procedure and Results

Assembly

The HESCO-Bastion Concertainers™ were shipped to ERDC on two pallets, with tools and supplies arriving in a pickup truck with HESCO personnel. The HESCO personnel had rented a Bobcat™ skid-steer loader equipped with both a front load bucket from a local rental company; the Bobcat™ was delivered prior to the arrival of the HESCO personnel.

The barrier was constructed by two men on the ground plus one man operating the Bobcat™. While the two men on the ground set up the barrier walls, the Bobcat™ operator began moving sand from the stockpile outside the basin and placing it in a pile inside the basin close to the flood barrier.

A Concertainer™ would be lifted from the pallet and dragged to the approximate location for the barrier (Figure 6), the two men would then open the unit to its full size.

Figure 6. A Concertainer™ being dragged into position and unfolded.

Individual baskets of the Concertainers™ were then modified or removed as necessary to fit the required layout of the test. For the left wall, the

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basket that fitted against the wingwall was re-shaped by cutting through the wires of the front and back panel to form a roughly trapezoidal shape that matched the 63 degree angle to the wall; the end panel was then reattached to the sides with the wire coils (Figure 7). Similarly at the far end of the left wall, the end basket was modified to fit the angle joining the left wall to the center wall (Figure 8).

Figure 7. The left wall abuts to the wingwall at a 63 deg angle. The end basket is reshaped by cutting out sections of the panels to fit the connection.

Figure 8. The basket at the end of the left wall that connects to the center wall is reshaped to fit the 63 deg angle. Panels are held together by coils, then a pin is inserted through adjacent coils to make the final shape.

The center wall and right wall were formed simply by removing baskets from one of the Concertainers™ in each wall. The final barrier then consisted of 9 baskets in the left wall with the basket at each end re-shaped to fit the angle of the wall, 9 baskets in the center and 8 baskets on the right walls (Figure 9).

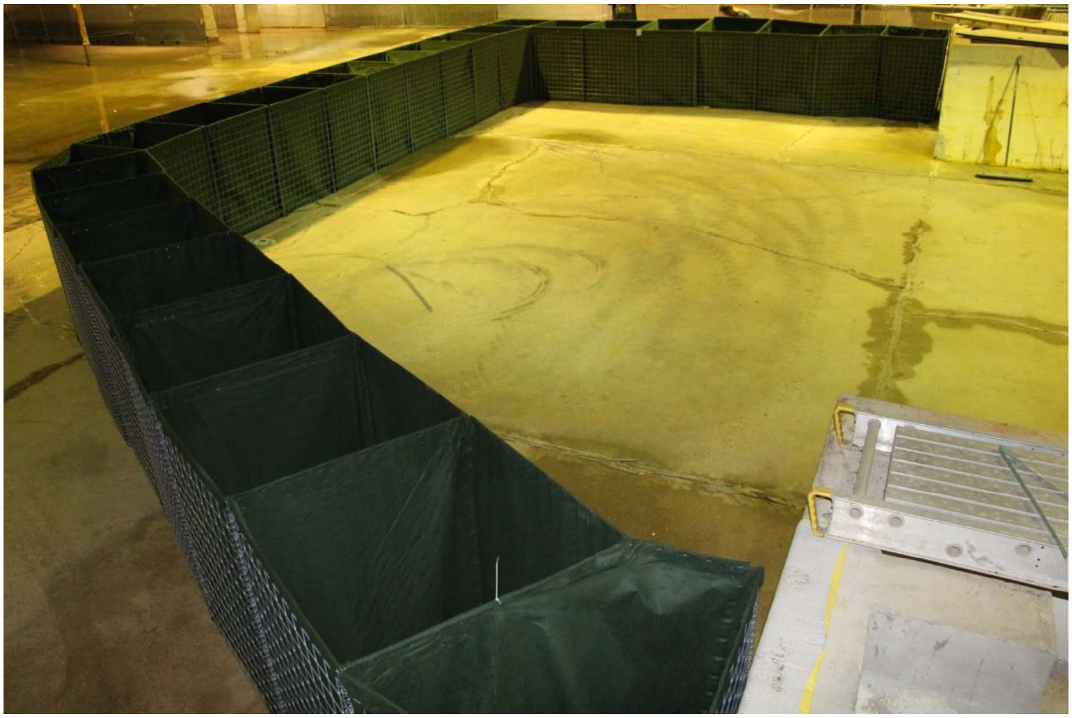

Figure 9. Final Layout of Concertainers™.

To connect the Concertainers™ to the wingwalls, bentonite had been pre-mixed with water to form malleable cylinders about 3 in. diameter and 8 in. long. The cylinders were placed at the bottom of the wingwall to form a fillet. A sheet of bentonite-laced fabric was placed on the wall and over the fillet. The end basket of the Concertainer™ was forced into the fillet and against the sheet of bentonite-laced fabric (Figure 10).

Figure 10. Pre-moistened cylinders of bentonite are placed at the base of the wingwall then a bentonite-impregnated fabric is placed over the wingwall. The Concertainer™ will abut to the fabric.

A line of dry bentonite was placed around the perimeter of the wall a few inches in from the outer wall. Prior to making the final connection the wall and filling with sand, a reinforced rip-stop sheet of plastic was placed under the front edge of the Concertainers™ and against the wall. (Figure 11).

The baskets were filled with sand brought over with the Bobcat™ (Figure 12). The units were overfilled to allow for settlement; the plastic sheeting was then wrapped up over the front of the baskets and across the top (Figure 13). It was intended that the plastic sheeting would cover the top of the barrier, but apparently it had been placed too far under the baskets and did not reach all the way across the top.

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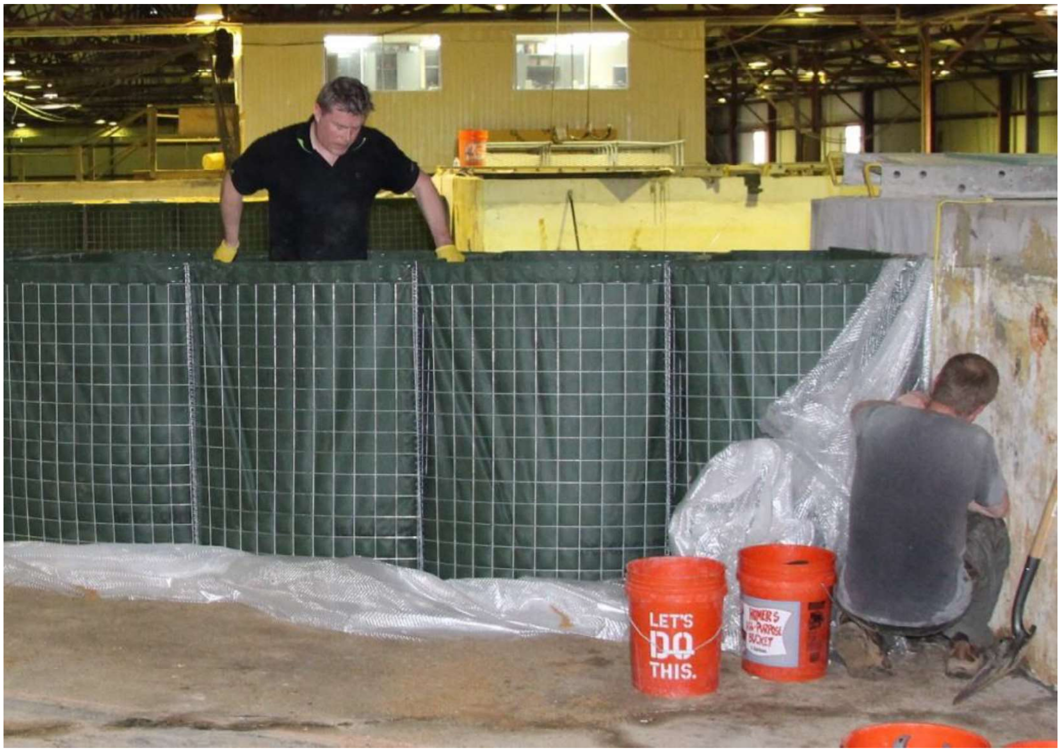

Figure 11. Plastic sheeting placed at wall and under the edge of the Concertainers™.

Figure 12. With baskets in place, they are filled with sand.

Figure 13. After the baskets are filled with sand, the plastic sheet is wrapped up over the front of the barrier and secured with tie wraps to the top of the baskets.

Measured along the centerline on top of the barrier, the total length of 75.3 ft.

The barrier was constructed by 3 men over a total assembly time of 10.1 man-hrs. Time taken for breaks is not included in the total in order to fairly compare construction times for barriers constructed in cool weather to those constructed in the heat of summer where additional breaks are required for safety.

Equipment used during the assembly included a Bobcat™ skid-steer frontend loader, shovels, 5 gallon buckets, bolt cutters, utility knives, and a sand tamper. Supplies used included the sand fill, bentonite, bentonite mats, duct tape, Gorilla™ tape and reinforced plastic sheeting.

Hydrostatic Tests

One Foot Depth

Seepage

The pumps were turned on at 17:20 on 24 March 2018 and a depth of one foot in the basin was reached at 18:57. Seepage and movement data was collected for the next twenty-two hours. The average seepage of the test was 0.04 gpm/ft (Figure 14), which included some minor floor crack leaks. Actual measurements of the floor crack leaks were not taken at this depth as they were visibly minor. Still, it can be reasonably assumed that there was at least a small increase in seepage due to water intrusion from beneath the basin floor.

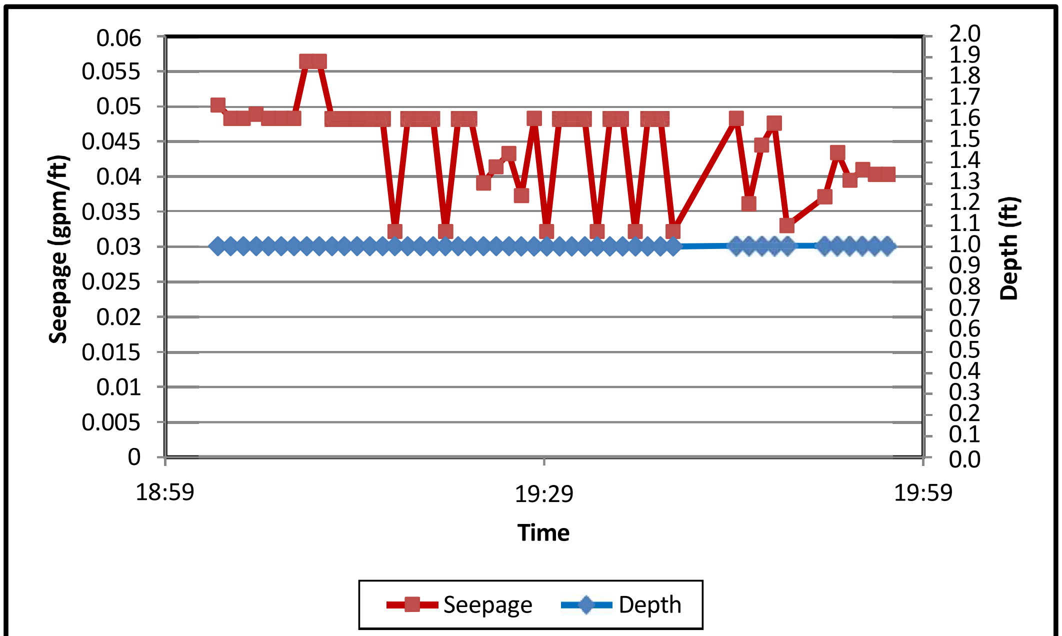

Figure 14. Seepage rates near the end of the one-foot depth hydrostatic test.

Movement

Distance-measuring lasers were aimed near the center (vertically and horizontally) of each of the three walls of the barrier to record any movement of the barrier. Minor movement is usually expected: as the sand fill settles or becomes saturated the walls of the baskets can expand outward slightly, as the basin depth increases water pressure on the barrier walls can cause the baskets to lean inward, or water pressure can cause the baskets to slide. The lasers cannot differentiate the cause of the movement; they only record if the inside wall of the barrier has moved. In the movement figures, distance to the barrier is subtracted from the original (pre-flooding) location of the barrier. Movement into the test area will therefore yield a positive value while movement out into the basin will yield a negative number.

By the end of the test, there was no significant measurable movement from the pre-flood location (Figure 16).

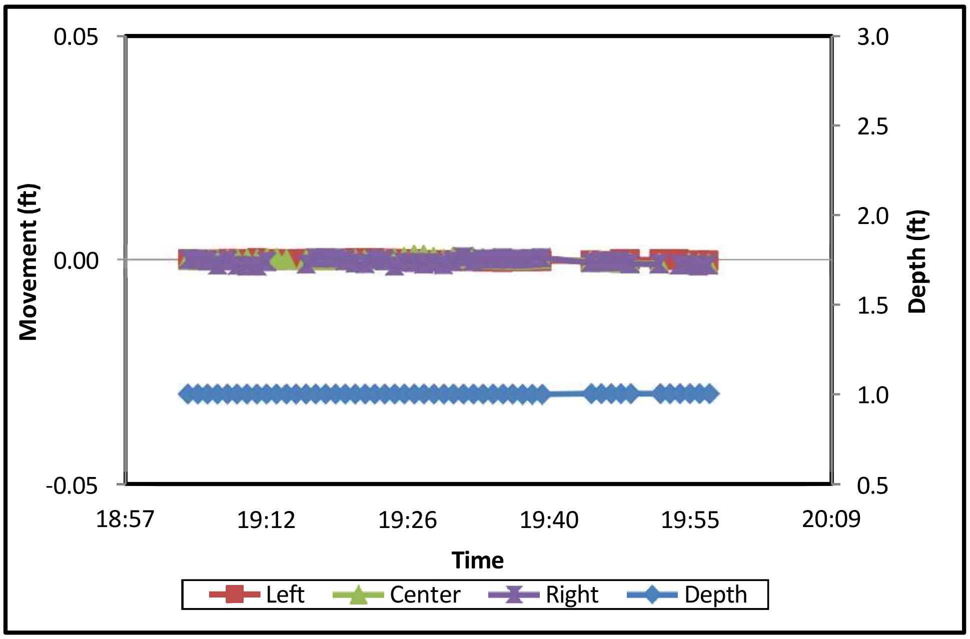

Figure 15. Movement of barrier walls during the one-foot depth hydrostatic test.

Two Foot Depth

Basin Floor Seepage

Cracks in the basin floor had not been cleaned and sealed since 2014. Prior to testing, there was an attempt to clean and seal the most noticeable cracks, but time constraints prevented a complete repair. Testing exposed more floor and wall seepage than was observed during the 2014 tests. (Figure 17). There was no significant seepage through the floor observed

at a basin depth of 1 ft, but seepage at a basin depth of 2 ft through some of the cracks could be measured. At a depth of 3.8 ft the seepage through cracks in the floor were significant and a large crack on the right wall produced a high volume of water. The floor seepage was measured as accurately as possible, then adjusted to account for smaller seepage holes that were observed but too small to measure. Total seepage through the floor at a basin depth of 3.8 ft was estimated at 0.010 gpm/ft. In this report, floor seepage at a basin depth of 1 ft will be neglected, floor seepage at a depth of 2 ft will be estimated at 0.051 gpm/ft, sand seepage at a basin depth of 3.8 ft will be assumed to be 0.275 gpm/ft.

Figure 16. Upward flow through cracks within the test area.

Floor seepage rates were used to adjust the actual seepage collected.

Seepage

Seepage increased as the water level in the basin was raised from one foot to two feet. The average seepage of the test was 0.09 gpm/ft. Figure 17 shows the seepage and depth during the final two hours of the two-foot hydrostatic test.

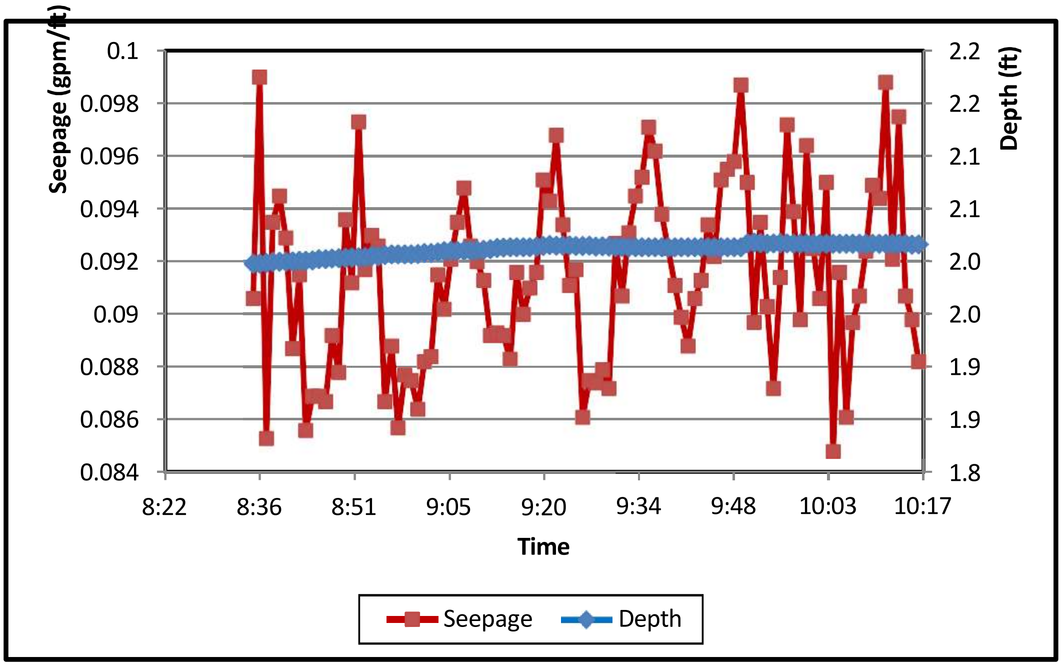

Figure 17. Seepage rates during final two hours of two-foot depth hydrostatic test.

Movement

Figure 18 shows movement of the barrier during filling to a basin depth of 2.0 ft and during the first hour of the test. The center wall moved from about 0.011 ft at the start of filling to 0.016 ft by the end of the day. Both the left wall and right wall remained within 0.005 ft of the start of the test series.

Figure 21 shows movement during the final two hours of the test. The left wall is 0.059 ft inward, center wall has moved to 0.051 ft, and the right wall is 0.090 ft inward.

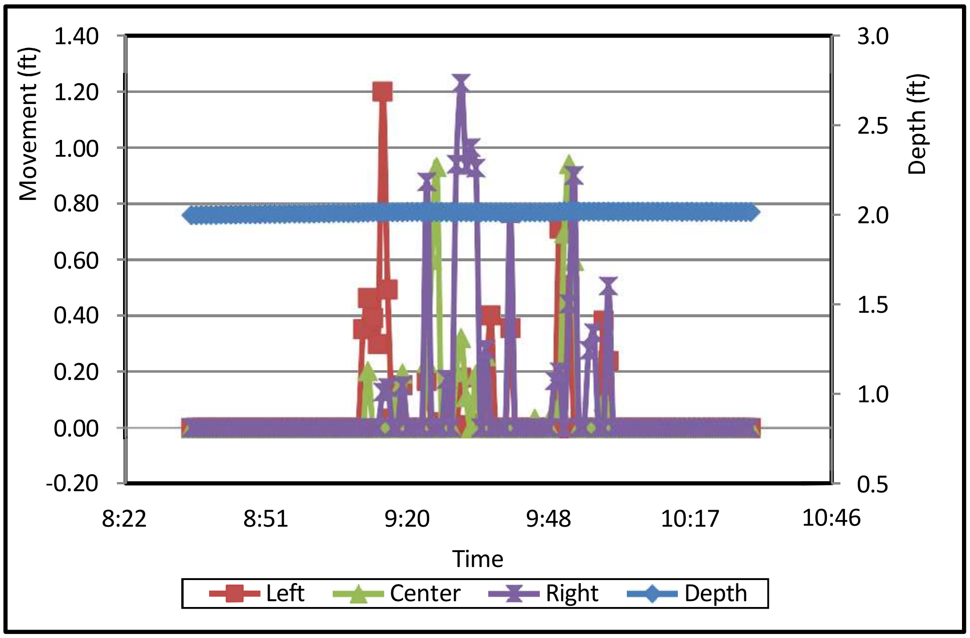

Figure 18. Movement of barrier during final two hours of two-foot hydrostatic test.

95% Depth

Seepage

A third static water test was conducted at a basin depth of 95% of the structure design height. The Concertainer SL4836™ is designed for a working height of 4 ft; therefore the test was conducted at a basin depth of 3.8 ft or 45.6 in. (Figure 19). The average seepage was 0.13 gpm/ft (Figure 20).

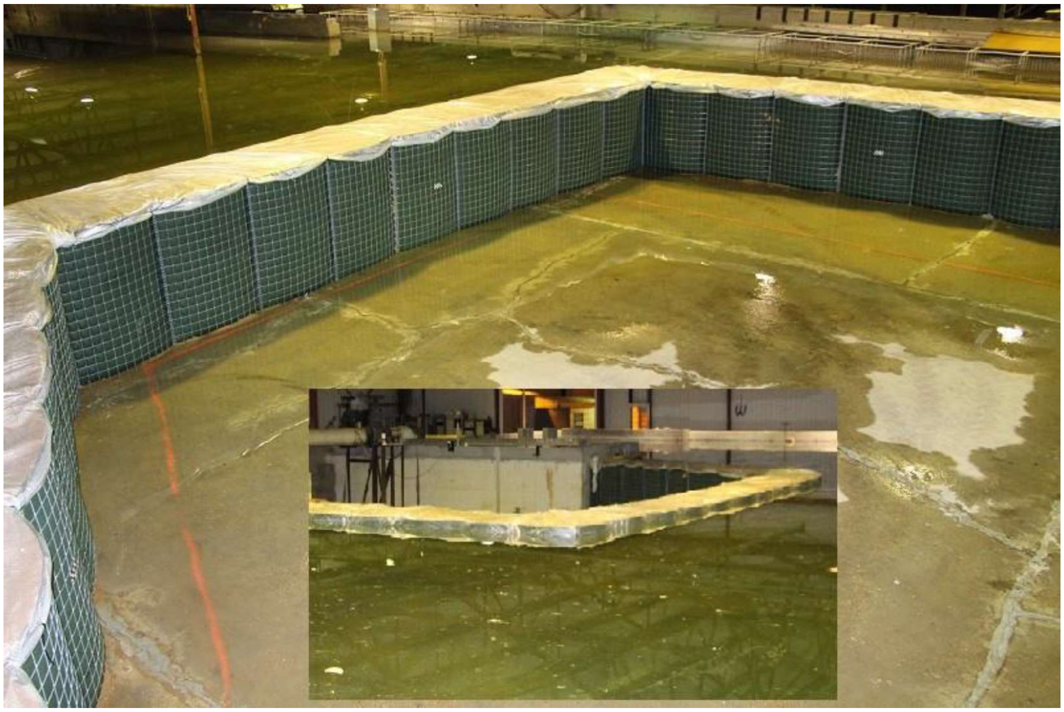

Figure 19. Barrier holding back water at 95 percent of structure height. Insert shows the view from the outside wall.

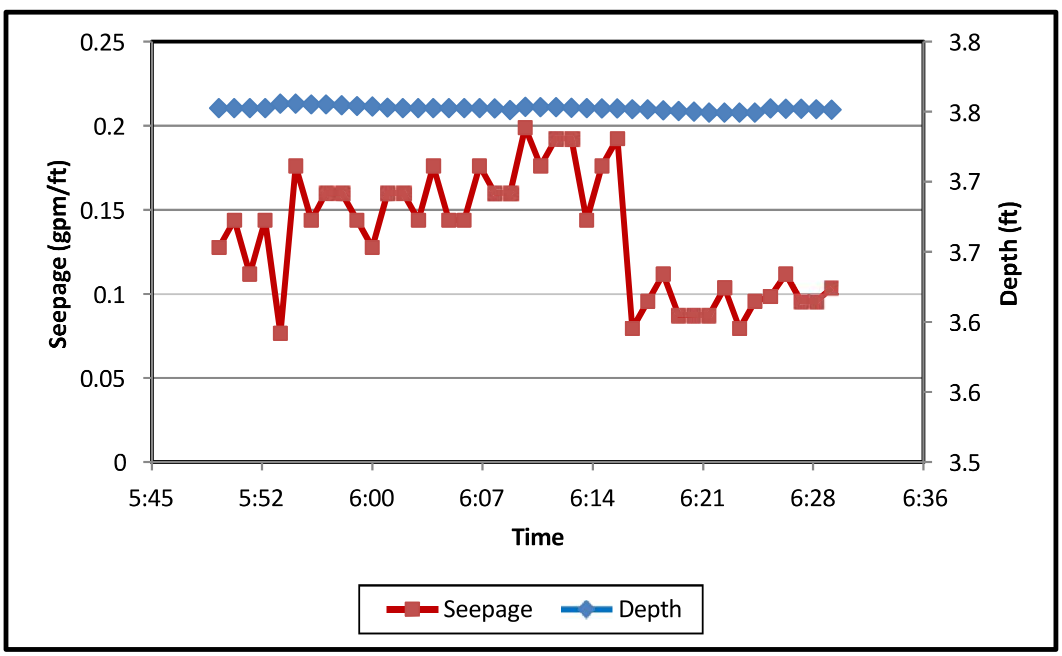

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Figure 20. Seepage rates during final two hours of 95 percent depth hydrostatic test.

Movement

Movement of all three walls was measured when the basin was filled to a depth of 3.8 ft. Surprisingly, there was no significant movement to note. (Figure 21).

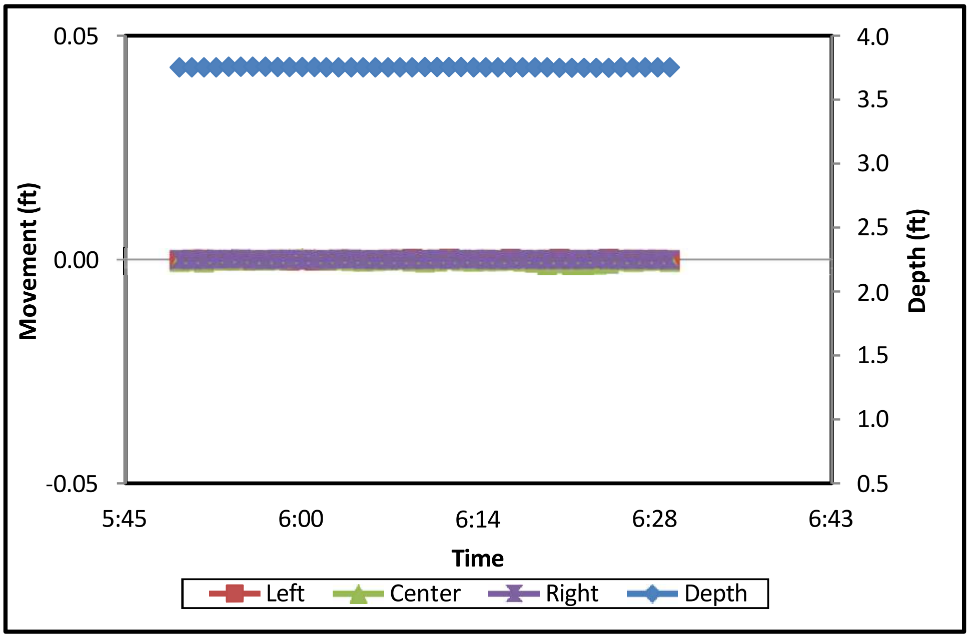

Figure 21. Movement during the end of 95 percent depth hydrostatic test.

Repair 1

On March 25, at 14:40, the sponsor began repairs to a small hole in the plastic liner located on the upper outside of the left wall. Upon completion, the sponsor chose to add a small layer of bentonite along the outside edge of the barriers at each connection (Figure 22).

The repair took one person 21 minutes to complete, or 0.35 man-hrs.

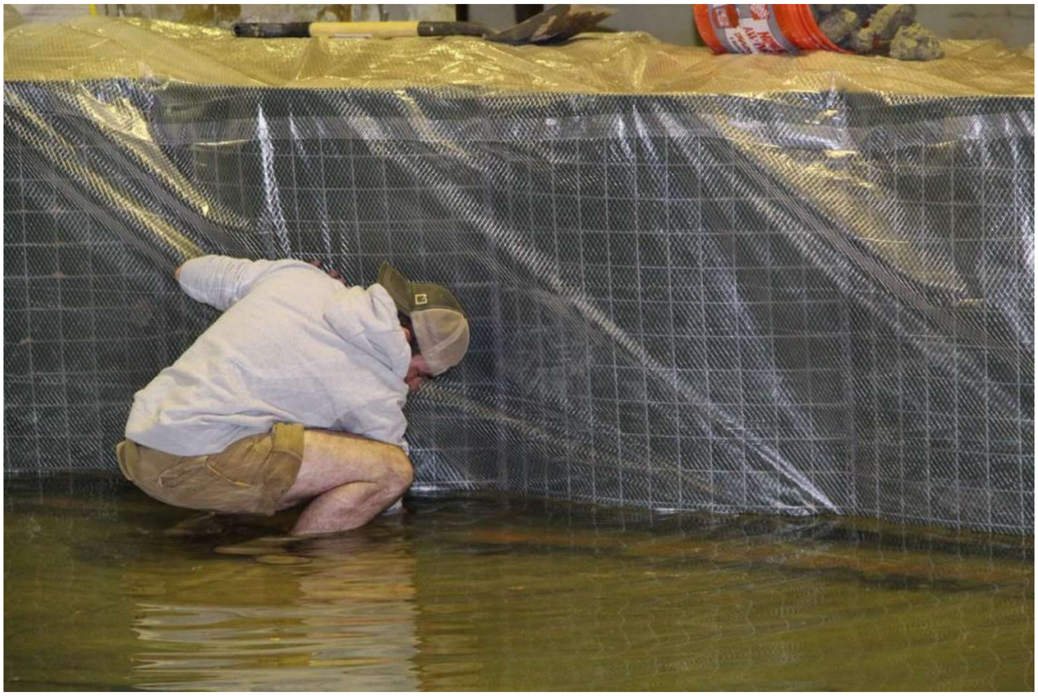

Figure 22. Repair 1: Repairing small puncture in plastic sheeting and adding bentonite to barrier connections along the outside edge.

Hydrodynamic Tests

Hydrodynamic tests included tests with waves and an overtopping test. The wave tests included small (2 in.), medium (6- to 8-in.), and large (10- to 12-in.) wave heights, all with a 2-sec wave period. All wave heights were run at low water (67% of structure design depth) and repeated at high water (80% of structure design depth). For the Concertainer SL4836™, 67% of structure design height was 2.67 ft or 32 inches, and 80% was 3.2 ft
or 38.4 inches.

There are instances when tests produce wave-induced resonance in the basin which subjected the structure to much higher wave energies and much higher overtopping than structures which had been tested previously. Every basin has a natural frequency that is a function of depth and length. In the test basin, there is a natural frequency based on depth and the distance between the barrier and the wave generator. In some instances, incident and reflected waves can combine to produce very sharp wave crests and high overtopping rates.

Placement of the barrier in this test was such that the incident waves (2 sec period or 0.5/sec frequency) were a harmonic of the natural frequency, which initially resulted in resonance. This was also observed during the testing of the HESCO Concertainer SL3636™.

Because of the similarities the Concertainer SL3636™ and Concertainer SL4836™, some resonance was anticipated. During the 80% wave testing some resonance appeared to be producing waves larger than 2”. Adjustments were made to the wave program to reduce the board stroke for the 6” and 11 inch waves, thereby correcting the issue.

The minor variabilities had no noticeable effect on the performance of the structure.

Low water, small waves

Small, 2 in. wave were run for a total of seven hours at a basin water depth of 2.67 ft. The first 45 minutes were run the night of 28 March, but were interrupted during a power outage caused by damage to the power grid during a severe thunderstorm. The remaining 6 hrs and 15 mins were run the following day (Figure 23).

The average seepage was 0.05 gpm/ft (all values adjusted for floor seepage).

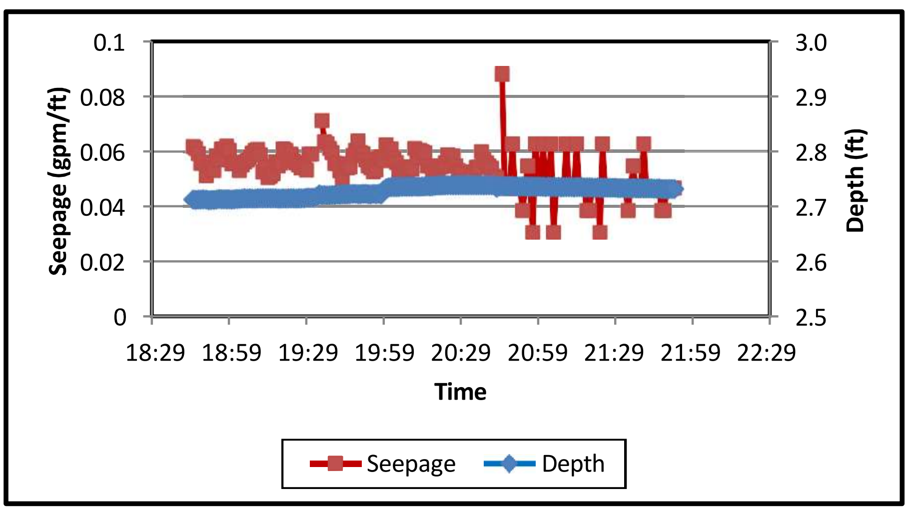

Figure 23. Seepage rates during test with small waves at water depth of 67 percent of structure design height.

There was no overtopping and no noticeable movement of the structure. The left laser was accidently bumped causing the unusual movement captured in Figure 24.

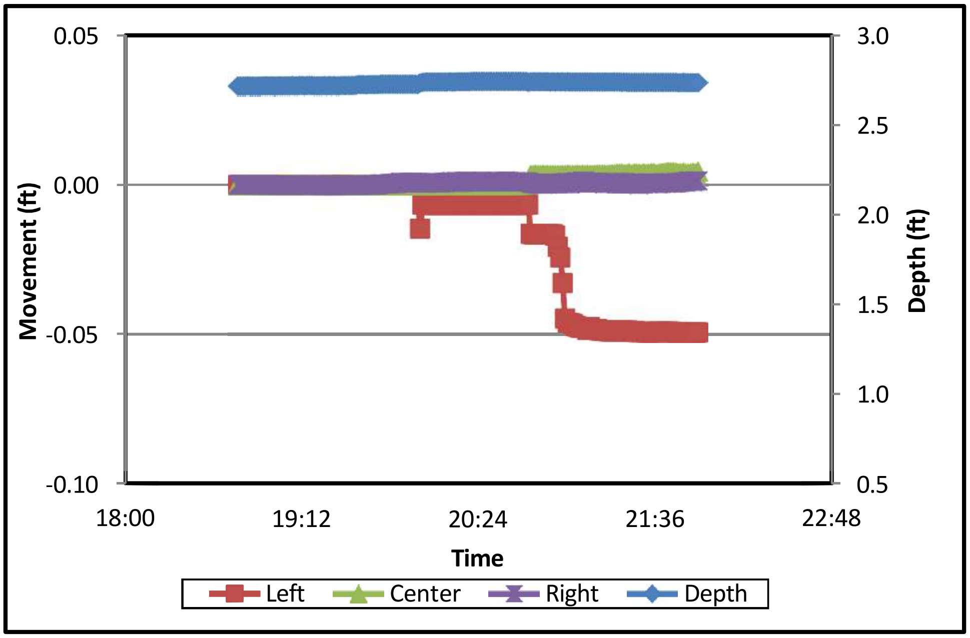

Figure 24. Movement of barrier during test with small waves at low water depth.

Low water, medium waves - Overtopping observed

The medium waves were generated for three 10-min runs with a stilling period between runs to allow the wave energy to dissipate and minimize wave energy buildup. Due to the wave-induced resonance, the Concertainer™ was subjected to significant overtopping.

The three runs can be seen in Figure 25 by the sudden increase in "seepage" rates caused by the overtopping (the test basin cannot distinguish between water flowing under, through, or over the barrier and simply reports the total flow rate as seepage). The medium waves were run for ten minutes each.

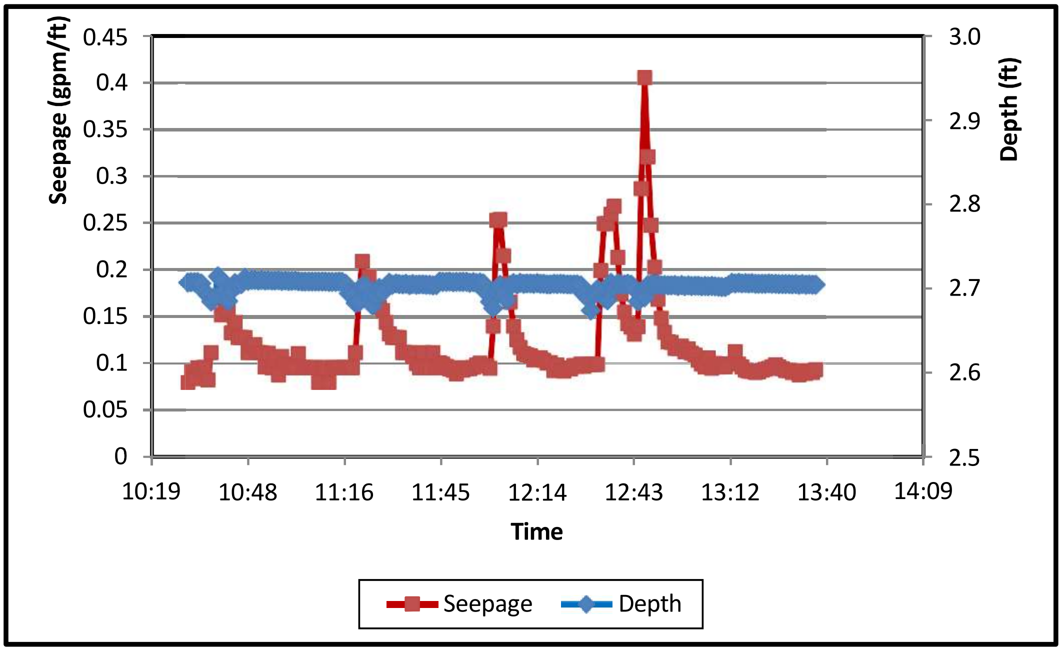

Figure 25. Seepage plus overtopping rates during tests with medium and large waves at water depth of 67 percent structure design height.

Waves overtopped the center wall near the left center the left wall near the wingwall; no overtopping of the right wall was observed. Average seepage rates (including overtopping) were 0.07 gpm/ft. Figure 25 does not reflect the adjustment for floor seepage.

There was no noticeable movement of the barrier walls (Figure 26). Gaps or outliers in the recordings of the lasers on the walls were caused by people walking in the test area and crossing between the wall and the laser. This is noticed through the various data collection conditions.

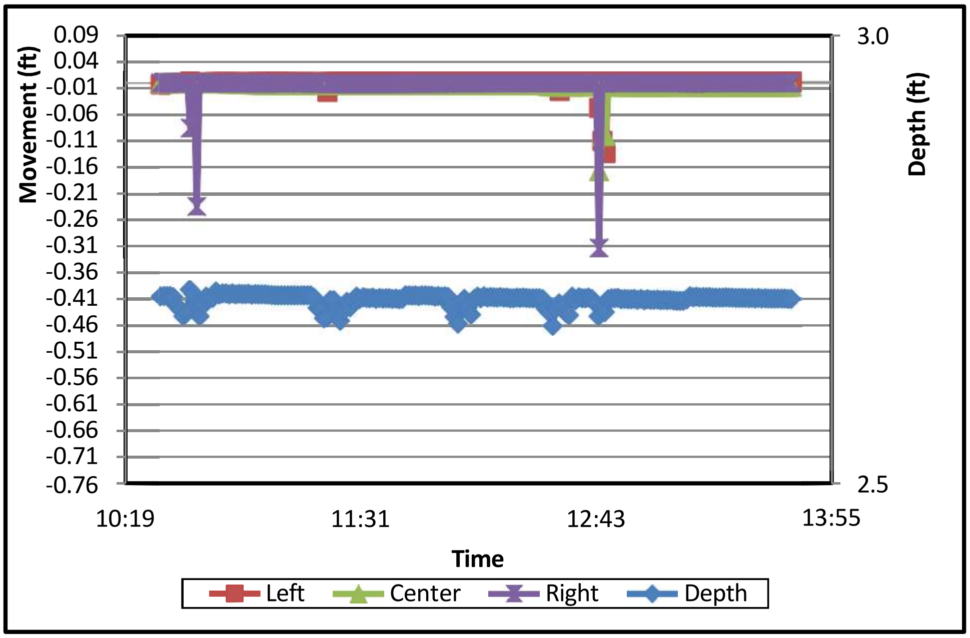

Figure 26. Movement of barrier during tests with medium and large waves at water depth of 67 percent of structure design height.

Low water, large waves – Overtopping observed

The large waves were generated for a single 10-min run starting at 11:23 (Figure 27). The wave-induced resonance observed with the medium waves was again produced, just larger. Overtopping was spread along the entire width of the center wall and along most of the left wall (Figure 32). "Seepage" rate averaged 0.27 gpm/ft, adjusted for the basin floor seepage. The center wall moved inward another thousandth of a foot; there was no noticeable movement of the left or right walls.

At the end of the test the basin water level was raised to 80% of the barrier height.

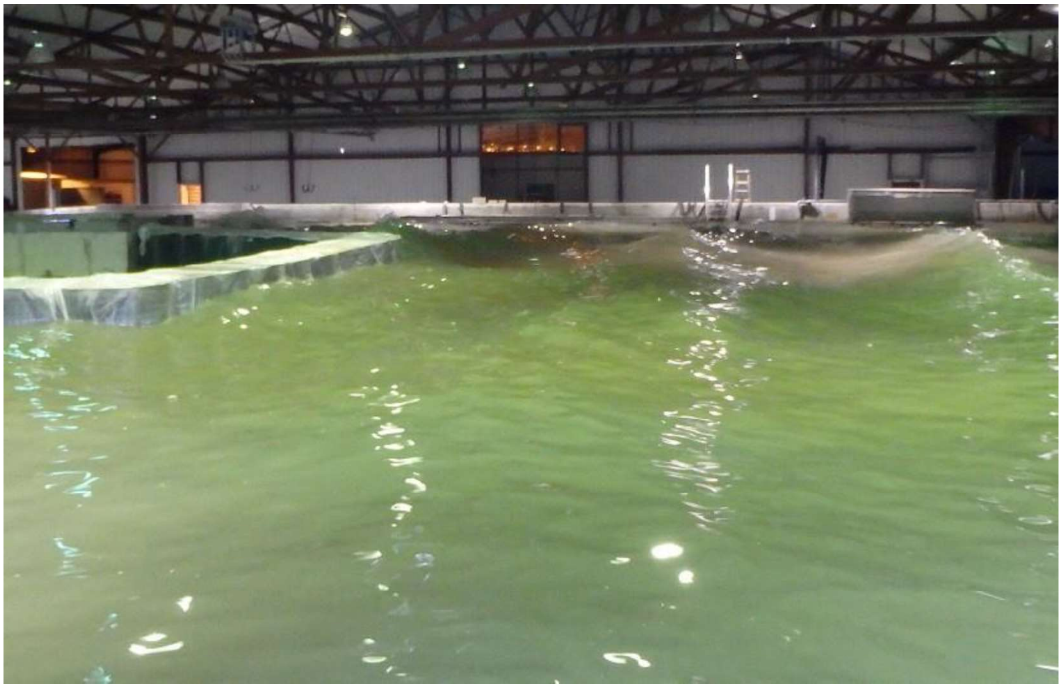

Figure 27. Overtopping during the test with large waves at low water.

High water, small waves

The water level was raised to the 80% structure height of 3.2ft or 38.4 in. on 30 March 2018. High water tests were included in the protocol to insure that there would be some overtopping of the structure due to the wave action. The original protocol called for the small waves to be run for another 7 hrs (as they were for the low water level), but this seemed unnecessary for structures that were not affected by the small waves. The protocol was therefore modified such that small waves at high water would be run for a minimum of one hour, and could be run for up to seven hours at the discretion of the testing engineer. If the engineer had any questions about the effects of the small waves on the structure, he could continue the tests for up to the full 7 hours. However, if the waves were having no effect on the structure, he could end the test after a minimum of one hour. For the Concertainer SL4836™, the small waves had no noticeable effect on the structure and the test was run for only one hour.

The small waves were started at 20:31 (Figure 28). Average seepage rate was 0.06 gpm/ft (adjusted for floor seepage). There were no noticeable effects to the structure, and no noticeable movement (Figure 29).

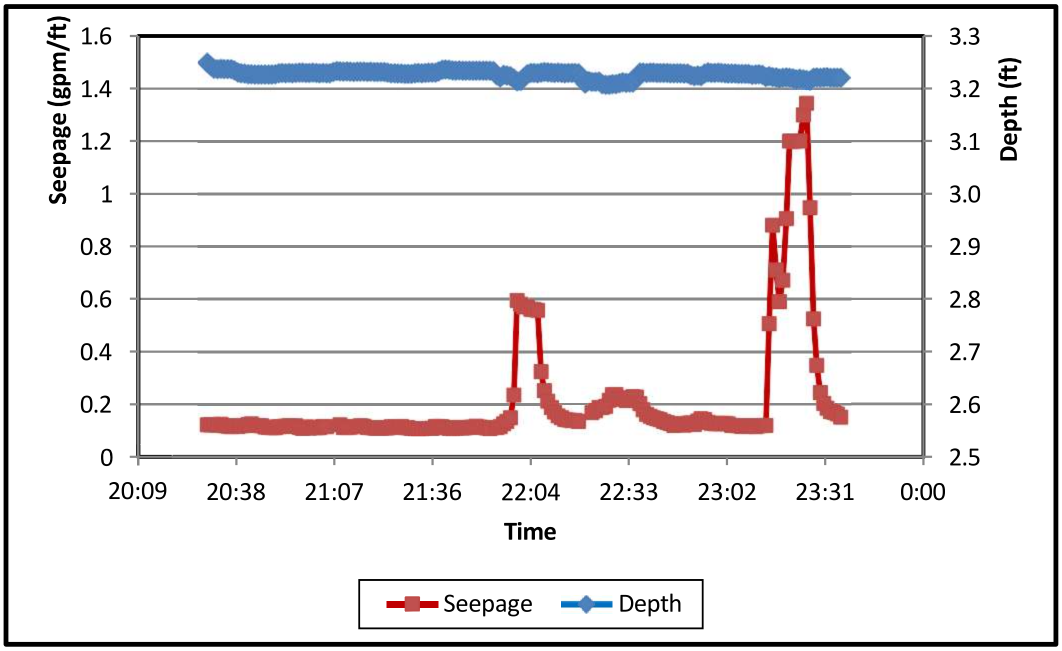

Figure 28. Seepage rates during tests with small, medium, and large waves at high water.

High water, medium waves

The three runs of medium waves (approximate 6 in. wave height) were run for 10 minutes each with an approximate 20 minute stilling period between each (Figure 29).

The peak measured overtopping rates (one-minute average) was 0.6 and the average overtopping rates for the 10-min runs was 0.20 gpm/ft. Resonance was not evident during the medium wave tests.

Figure 29. Overtopping during the test with medium wave heights at high water.

Although no movement of the barrier was observed during the tests, the data show a slight movement inward for the center wall. At the end of the third run the total movement was 0.013 ft (center wall). The medium waves had little effect on the left or right walls (Figure 30).

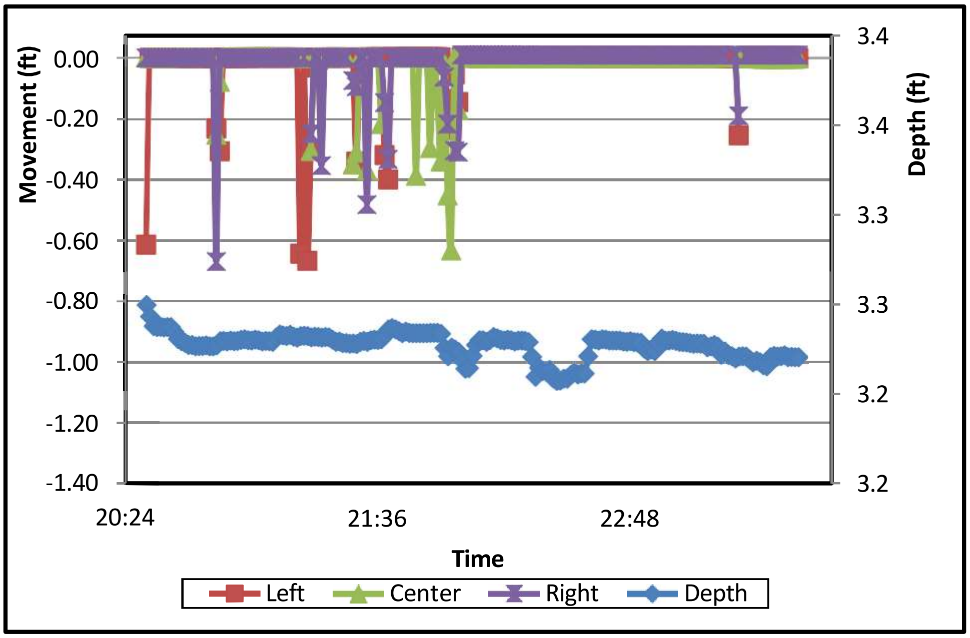

Figure 30. Movement of barrier during tests with small, medium, and large waves at high water.

High water, large waves

The large waves were started at 23:14. Overtopping occurred along the entire center section and along the left wall nearest the abutment (Figure 31). The overtopping reached a peak of over 1.3 gpm/ft and averaged 1.01 gpm/ft.

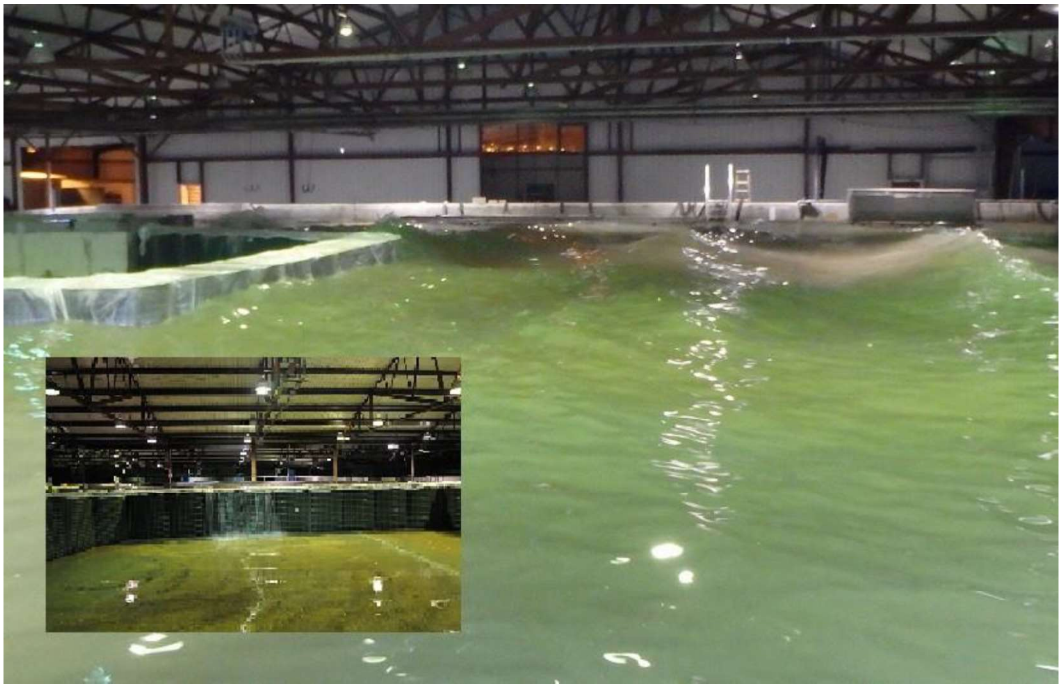

Figure 31. Wave overtopping during test with large waves at high water. Insert shows view from the inside of the barrier.

Overtopping

The overtopping test was conducted by raising the water level in the basin until water was flowing over the barrier at an average depth of 1 in. Because the containers had been overfilled to account for settlement, the crest elevation of the sand varied which caused some areas of overtopping to be greater than others, while some areas had no overtopping. The test engineer estimated when the overtopping reached an average depth of one in., then stopped filling the basin and allowed the water to overtop the barrier for one hour before opening the drain and lowering the water level in the basin (Figure 32).

The first noticeable overtopping occurred at 10:25 at a basin depth of 4.26 ft. An average of one in. overtopping was estimated to be reached at 10:50 at a basin depth of 4.4 ft. At this point, two problems arose. The first was that the laser data was no longer collecting information as the data collection system crashed. Secondly, the pumps were not initiated in time to avoid the sump area from becoming overfilled too quickly. A failure by the second pump caused the center area to become completely swamped

Evaluation of HESCO-Bastion Concertainer SL4836™ Flood Fighting Barrier, US Army Engineer Research and Development Center Coastal and Hydraulics Laboratory, Glenn B. Myrick and Donald L. Ward, September 2018.

approximately 30 minutes into the tests. Eventually, the water was cleared and the testing completed. Throughout the test, the Concertainers™ retained structural integrity and suffered no noticeable damage.

Figure 32. Overtopping of right and center wall during overtopping test.

Debris Impact Test

To test flood fighting structures for their ability to withstand impact from debris carried by the current in an actual flood, a debris impact test is included as part of the Standardized Testing Protocol. The debris impact test involves towing two logs into the barrier with a winch located inside the test area (Figure 33). On 31 March 2018, the logs were towed in at a 20-deg angle at a speed of 5 mph (7 ft/sec), and power to the winch was cut just prior to impact with the structure. Both logs were 10-ft-long and cut from a creosote-coated telephone pole. The smaller log was 12 in. diameter and weighed 610 lbs dry; the larger log was 16.5 in. diameter and weighed 790 lbs dry. Both logs had been soaking in water for 1-1/2 weeks prior to testing and undoubtedly had increased in weight.

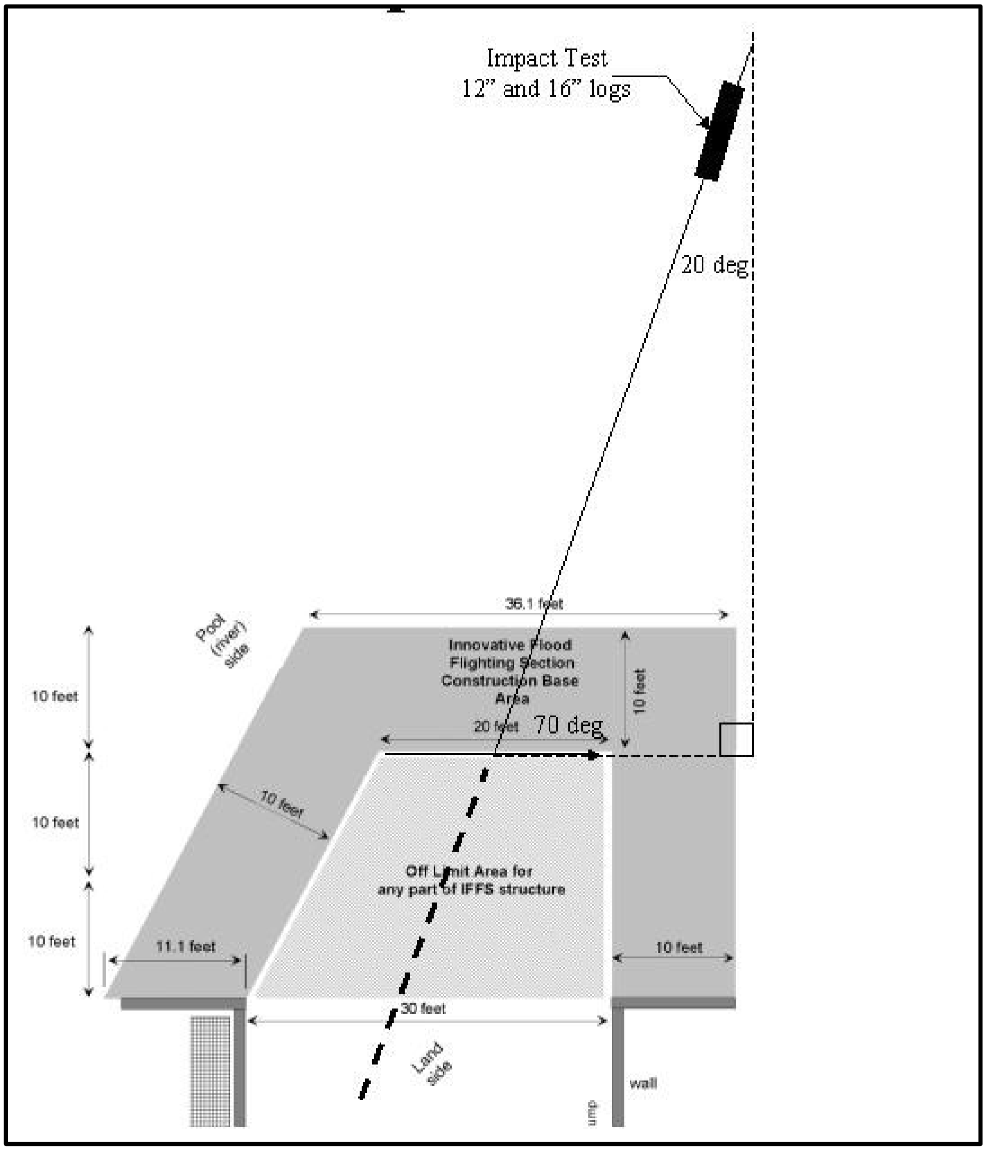

Figure 33. Setup for debris impact tests.

The two logs were towed into the structure one at a time, the smaller log first (Figure 34). The first log struck on a coil joining adjacent baskets together and caused some scuffing of the plastic sheeting covering the front of the barrier, but did not penetrate the plastic (Figure 35). The second log hit the front panel of a basket leaving little evidence of a collision (Figure 36). Neither impact test damaged the Concertainers™.

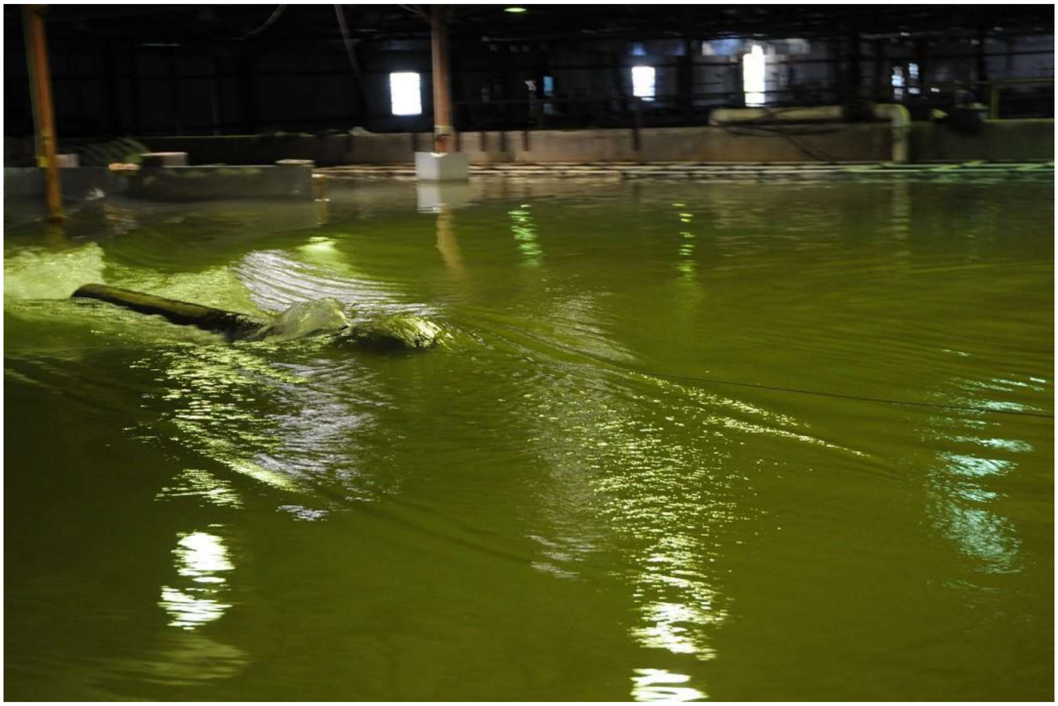

Figure 34. Small log approach during debris impact test.

Figure 35. Log point of impact.

Figure 36. Impact area of large log test.

The debris impact tests were conducted at a water depth of 67% of structure design depth, or 2.67 ft.

Disassembly

Removal of the barrier was accomplished by three people including one person on a Bobcat™ skid-steer loader.

The Concertainers™ are designed to be recoverable. However, rather than try to save the barriers for future work, the sponsor chose to cut the wire and fabric and sacrifice the units to demonstrate how quickly the assembly could be removed and cleaned.

To accomplish this, the cover sheet of plastic was first cut along the floor and pulled over the top. This was followed by cutting the wire mesh and fabric vertically at each individual gabion intersection on both the front and back sides (Figure 37). This allowed easy access to the fill sand and disposal of the remnants of the Concertainers™.

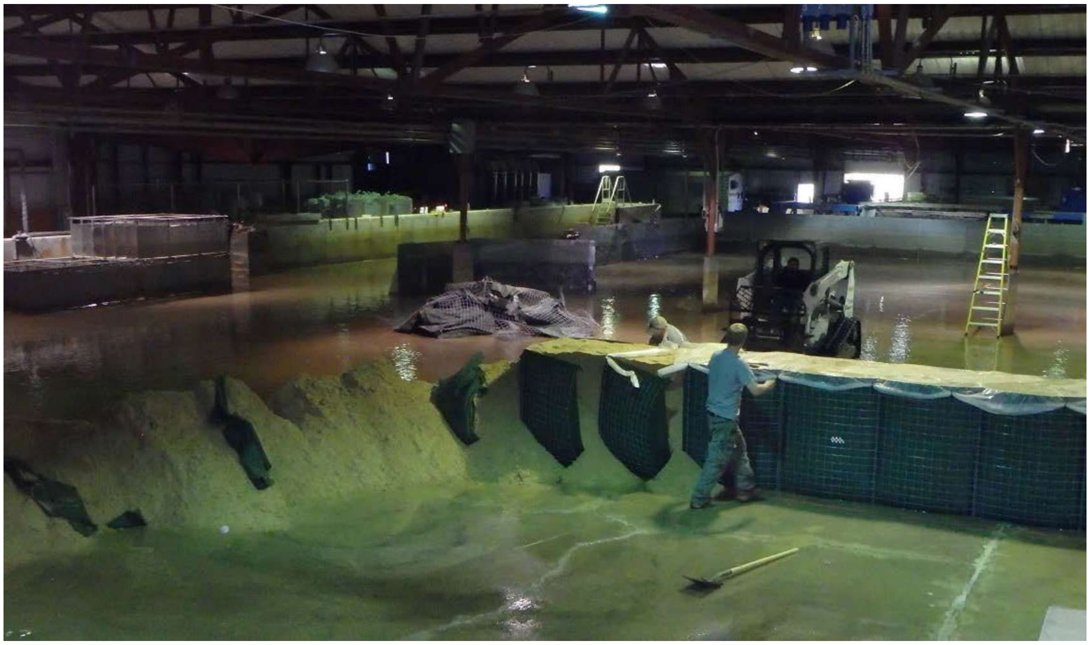

Figure 37. Removal of Concertainers™ by cutting wire and fabric.

Figure 38. With the outer and inner panels open, the Bobcat™ removed the gabion remnants using the forks prior to changing to the bucket for sand

removal.

It is probable that much of the barrier could have been reused if additional time was taken in the disassembly. However, in this test the entire barrier was sacrificed during disassembly.

The remnants of the Concertainers™ were removed with the Bobcat™ fork attachment prior to changing to the bucket attachment for sand removal (Figures 38 and 39).

Figure 39. Sand removal during cleanup.

Removal of all units and sand took 1.1 hr, or 3.28 man-hrs. Equipment used included the Bobcat™ skid-steer loader with fork and front bucket attachments, bolt cutters, shovels, push brooms, and utility knives.

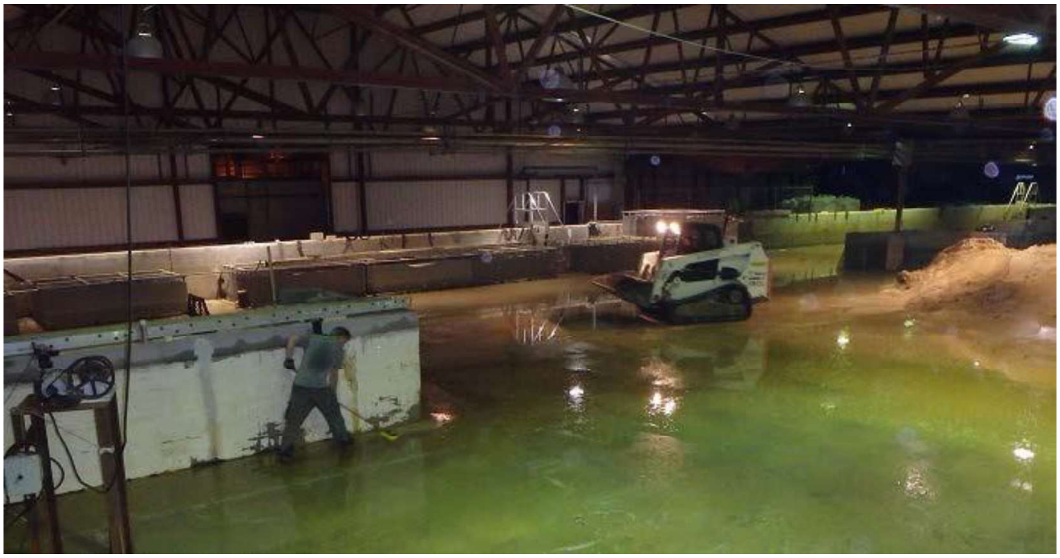

Figure 40. Final cleanup of test area.

3 Summary

Construction Times and Seepage

Times for construction, repair and disassembly, and seepage rates are shown in Table 1.

Table 1. Summary of Tests with Concertainer SL4836™ flood fighting barrier.

Test	Measurements
Construction/Repairs/Disassembly	
Construction (man-hrs)	10.1
Repair 1 (man-hrs)	0.35
Disassembly (man-hrs)	3.3
Hydrostatic Seepage Rates (gpm/ft)	
1 ft Head	0.04
2 ft Head	0.09
3.8 ft Head	0.13

The seepage rates listed are the average over the last two hours of the hydrostatic tests.

Other Factors

Constructability and Re-usability

No large power equipment was needed to construct the barrier indicating that it is suitable for areas where heavy equipment may not have access. The only power equipment used for assembly or disassembly was a Bobcat™ skid-steer loader. In the event that larger equipment has access to the site, the barrier could have been filled and removed in less time with a larger front-end loader. Other equipment were simple hand tools, including shovels, bolt cutters, utility knives, and a broom.

Supplies used included bentonite, bentonite sheets, duct tape, Gorilla™ tape and plastic sheeting.

The barrier is designed to be largely recoverable, but was destroyed for the sake of time during the disassembly. Had more time been taken during disassembly, the wire baskets could have been preserved and much of the geotextile line could have been cleaned and re-used. The plastic wrapping was considered expendable.

The barrier was constructed on a flat concrete floor. In a real application, the welded wire mesh panels may inhibit the units from conforming to irregularities in the ground, although the bottom of the panels can be cut to allow the units to be placed over obstructions.

The barrier was able to easily handle a 90 degree angle and a 63 degree angle in planform, and to abut perpendicularly to a vertical wall and to abut at an angle to a vertical wall.

The barrier should be placed on ground that is even from the inside of the barrier to the outside of the barrier so that the inner and outer walls are vertical. However, the barrier should be able to run straight up and down a mild slope, just not across the slope.

Environmental

Because the main parts of the barrier are recoverable, the environmental impact is minimal. If not re-used, the geotextile and the wire baskets can be recycled. However, if the flood waters are carrying pollutants or contaminants, these may be retained by both the sand and the fabric. Special disposal may be required depending on the contaminants.

Additional Information

The unit tested at ERDC was a 48-in.-high basket called the Concertainer SL4836 Recoverable™, where the SL stands for Storm Lined and the 4836 is for 48 in. high and 36 in. wide. Storm Lined units are also available in 24 in. by 24 in. baskets (SL2424) and 36 in. high by 36 in. wide baskets (SL3636). Each size is available in both standard or recoverable units.
Additional information is available on the Vendor's website at www.hesco.com .

Comparison to Sandbags Baseline Data

Table 2 compares measured parameters from the Concertainer SL4836™ flood fighting barrier tests reported herein to baseline data collected in 2004 with a sandbag barrier following the same protocol. The sandbags took 30 times the man-hrs to construct and had 5 times the seepage at the deepest depth tested (hydrostatic tests). In addition, sand was washed out of the sandbags during the waves test causing significant damage that had to be repaired, then the sandbags failed during the first minutes of the overtopping test when the top layer of bags was washed off the crest of the barrier then damage progressed further down into the sandbag mound with additional bags being washed off into the test area (Pinkard et al., 2007)[1]. In contrast, the Concertainer SL4836™ withstood all tests without damage.

Damage and Seepage

There was no damage to the barrier during any of the tests. During the 2014 testing of the SL3636 units, some sand was washed out from overtopping by waves or during the overtopping test when the water got beneath the plastic cover. Improvements to the plastic cover placement resulted in no loss of sand during the current tests.

The barrier was destroyed during disassembly.

Maximum seepage rate during hydrostatic testing was 0.13 gpm/ft at a basin depth of 3.8 ft. None of the dynamic tests (waves, overtopping, debris impact) appeared to have any effect on the rate of seepage under or through the barrier.

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[1] Pinkard, F., T. Pratt, D. Ward, T. Holmes, J. Kelley, L. Lee, G. Sills, E. Smith,

P. Taylor, N. Torres, L. Wakeley, and J. Wibowo. 2007. "Flood Fighting Structures Demonstration and Evaluation Program: Laboratory and Field Testing in Vicksburg, Mississippi," ERDC Technical Report TR-07-3, July 2007. 306 pp.

Table 2. Comparison of Concertainer SL4836™ Flood Protection Barrier to sandbag baseline data.

	Concertainer SL4836™	Sandbags
Install/Remove	Man-hrs	
Construction	10.1	205.1
Repair 1	0.35	2.0
Repair 2	N/A	2.0
Repair 3	N/A	2.0
Disassembly	3.25	9.0
Depth (ft)	Seepage (gpm/ft)	
1.0	0.04	.05
2.0	0.09	.23
3.8	0.13	.53

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4 Conclusions

The HESCO Bastion Concertainer SL4836™ barrier system proved to be an expedient and effective flood barrier. Compared to the baseline sandbag barrier of comparable length and height, the Concertainer™ barrier system was faster to construct and remove with fewer people and less equipment, had less seepage, and was more resilient to waves and overtopping. Under the conditions required by the Standard Testing Protocol, the Concertainer SL4836™ outperformed or met the performance of the baseline sandbag test in every way.

Tests were conducted on a flat, even surface. Use of the Concertainers™ on an irregular or sloping surface was not tested.