Laboratory Testing

Laboratory testing of Portadam, HESCO Bastion concertainer, RDFW, and sandbag structures was conducted in a wave research basin at ERDC. The products were tested in a controlled laboratory setting but under conditions that emulate real world flood fighting. The structures were tested consecutively under identical conditions. Stringent construction, testing, and removal protocols were developed for the laboratory. The protocol for the laboratory testing included both performance parameters (hydrostatic testing, hydrodynamic testing with waves and overtopping, and structural debris impact testing with a floating log) and laboratory setting operational parameters (time, manpower, and equipment to construct and disassemble, suitability for construction and disassembly by unskilled labor, fill requirements, ability to construct around corners, disposal of fill material, damage, repair, and reusability).

The laboratory testing included the construction of skewed u-shaped structures. Each structure had an approximate length of 85 ft. Due to the restrictive height of the research basin walls, the height of each structure was limited to approximately 3 ft. Laboratory testing of the structures was initiated in March 2004 and completed during August 2004. The sandbag structure was tested first in the laboratory followed in order by the HESCO Bastion concertainer structure, the RDFW structure, and finally, the Portadam structure.

Laboratory Testing – Results

Tables 1 through 3 present a summary of pertinent laboratory testing results. The results show that as expected, the sandbag structure took much longer (205.1 man-hours) to construct than the other three structures. Only Portadam was removed in less time than required to remove the sandbags, largely because all structures other than sandbags were largely reusable and required care in their removal. The sandbag levee was the only structure to fail during any of the tests. Table 1 gives a summary of man-hrs to construct and remove each structure. Details of the construction are given in Table 4, and details of the removal are given in Table 5.

Each structure was allowed a maximum of three repairs at specified times during the testing sequence, with each repair limited to a maximum of four man-hrs. In addition, one rebuild of the structure was allowed. Only the sandbag levee required a rebuild. A summary of the man-hrs required for repairs on each structure is given in Table 1, and details of each repair are given in Table 6.

Seepage rates through the sandbag levee were very low during the one foot hydrostatic head test because the sandbag levee is wide at the lower portion of the levee. Seepage rate increased through the sandbags as the water elevation rose and the levee became narrower. Sandbags had a particularly high “seepage” rate during dynamic tests with large waves because waves were able to run up the sloped face of the levee and overtop the structure. Seepage rates during the static head tests are given in Table 2.

Seepage rates for both RDFW and Portadam were generally much lower than for the sandbag levee. Seepage rates for HESCO Bastion were considerably higher than sandbags, with most of the seepage flowing through the junction between adjacent units. It was later determined that the local HESCO office was not familiar with HESCO-recommended construction techniques for use of the concertainers as a flood barrier that should significantly reduce the seepage between units.

Table 1
Effort Required to Construct, Repair, and Remove The Flood-Fighting Structures

Structure	Construction (man-hrs)	Repairs (man-hrs)	Removal (man-hrs)
Sandbags	205.1	4.0	9.0
HESCO Bastion	20.8	1.8	13.4
RDFW	32.8	4.6	42.0
Portadam	24.4	2.0	4.4

Table 2
Seepage Rates During Static Head Tests

Structure	1 ft Head (gpm/ft)	2 ft Head (gpm/ft)	95% Head (gpm/ft)	Average (gpm/ft)
Sandbags	0.05	0.23	0.54	0.27
HESCO Bastion	0.39	0.94	1.81	1.05
RDFW	0.02	0.08	0.10	0.07
Portadam	0.10	0.14	0.14	0.13

Note: gpm/ft = gallons per minute per linear foot of structure.

Table 3
Structure Damage During Laboratory Testing

Structure	Observed Damage
Sandbags	Repeatedly Damaged By Waves Failed During Overtopping
HESCO Bastion	Minor Sand Settling and Washout Some Bending of Wire During Debris Impact
RDFW	Minor Sand Settling Significant Washout Along Edges and Toe Toe Damaged During Large Waves or Overtopping 10% of Structure Broken
Portadam	Impermeable Liner Torn During Debris Impact

Table 4
Construction details

Structure	Time	Equipment	Materials	Comments
Sandbags	205.1 man-hrs	Manual sand bagging machine, Cat® 916 front-end loader	Sandbags, sand	Placed as USACE District, Vicksburrg, method. 17 full-time, 4 part-time laborers. 5 laborers worked sand bagging machine, 6 filled bags by hand, 1 equipment operator, rest carried and stacked sandbags.
HESCO Bastion Concertainer	20.8 man-hrs	CAT® 916 front-end loader	Sand, aerosol foam (used to seal structure to wing walls)	One HESCO supervisor, 4 laborers unfamiliar with product, one equipment operator
RDFW	32.8 man-hrs	CAT® 916 Front-end loader	Sand, Portland cement (mixed with sand in structure toe and adjacent to wing walls)	One RDFW supervisor, 4 laborers unfamiliar with product, one equipment operator
Portadam	24.4 man-hrs	Hyster® forklift	Sandbags, tape (apron was taped to concrete floor, tape was covered with sandbags)	One Portadam supervisor and one laborer assembled framework while three laborers filled sandbags, then supervisor and two laborers installed apron, one equipment operator. Laborers were unfamiliar with the product.

Table 5
Disassembly details

Structure	Time	Equipment	Comments
Sandbags	9.0 man-hrs	CAT® 916 Front-end loader	2 laborers, 1 equipment operator. All materials disposed of.
HESCO Bastion Concertainer	13.4 man-hrs	CAT® 916 Front-end loader	One HESCO supervisor, 3 laborers, one equipment operator
RDFW	42.0 man-hrs	Bobcat® front-end loader, Hyster® forklift, 2 portable vacuum cleaners	One RDFW supervisor, 4 laberors, one equipment operator
Portadam	4.4 man-hrs	Hyster® forklift	1 Portadam supervisor, 2 laborers, one equipment operator

Table 6
Details of repairs

Structure	Repair 1	Repair 2	Repair 3	Re-Build	Comments
Sandbags	2.0 man-hrs after low water, high waves dynamic tests. Repositioned sandbags, added new sandbags.	2.0 man-hrs after high water, high waves dynamic tests. Repositioned sandbags, added new sandbags.	n/a	44.0 man-hrs after overtopping test. Rebuilt failed portion of levee.	Small front-end loader used to carry sandbags for repairs.
HESCO Bastion Concertainer	1.6 man-hrs; prior to high water dynamic tests. Added cover to units.	0.25 man-hrs; prior to overtopping test. Added sandbags adjacent to wing walls	n/a	n/a	Repairs used cable ties to attach fabric cover, sandbags.
RDFW	1.9 man-hrs; prior to 95% hydrostatic test. Added sand to top of structure.	0.7 man-hrs; prior to high water dynamic tests. Added sand along structure crest; added reinforcing strips to joints between units.	2.0 man-hrs; prior to overtopping test. Added sand along structure crest.	n/a	Repairs used small front-end loader, shovels, buckets, and vacuum device
Portadam	0.5 man-hrs after first hydrostatic test. Removed air bubbles under apron.	1.5 man-hrs prior to overtopping. Improved seal to wing walls.	n/a	n/a	UGL Drylock Fast Plug™ added to apron at wing walls