FloodWalls™ Summary of Laboratory Testing

By Don Ward, ERDC-CHL, April 10, 2008

The FloodWalls™ units are large quasi-cylindrical bags made of a heavy-duty rubberized fabric (Figure 1). The units are manufactured in the Czech Republic by Rubrena Corporation and available in the United States through FloodWalls, Inc.

Figure 1. FloodWalls™ flood fighting barrier.

A common problem with cylindrical water-inflated bags is that increasing water pressure from rising water on the pool side of the bags will cause the bags to roll away from the pool. To counter this effect, the FloodWalls™ units are constructed with an internal baffle that runs the length of the unit. The baffles effectively prevent the units from rolling when flooded on one side.

Flaps at the ends of the units have grommet-reinforced holes that can be used to tie adjacent units together before filling as a further protection against movement of the units.

An 80-ft barrier of FloodWalls™ units was laid out and ready for filling by two people in 41 min with no special equipment or machinery, or about 1 man-min per ft. The units could have been placed more quickly if they were being placed as a series in a straight line, which would be a more common application. With a single 1-1/2 in. fill line, filling the units took 2 hr, 22 min or about 1 min, 45 sec/ft. A fire hydrant with 2-1/2 in. line or a good pump could reduce the fill time considerably.

The units are rated for a depth of 31.5 in. (H). In hydrostatic tests the seepage rate varied from approximately 0.04 gallons per minute per linear foot of wall (gpm/lft) at a depth of 1 ft to about 0.18 gpm/lft at a depth of 0.95H.

At a depth of 0.67H, the structure withstood tests with small, medium, and large waves (2 in., 6-8 in., and 10-12 in., respectively) without any problems. At a depth of 0.80H, the small and medium waves had minimal effect on the structure. However, one of the units did move substantially during the test with large waves.

Unit C was at the middle of the barrier and oriented parallel to the incident wave crests such that the waves struck the unit along its entire length at the same time. The force of the large 10- to 12-in. waves pushed one end of Unit C inward towards the pit area. After one end had moved several feet, Unit C was no longer oriented parallel to the incident wave crests. The waves then reached the opposite end of the unit and gradually progressed along the unit rather than striking along the entire length at one time.

The end of Unit C moved completely off the end of Unit D, but remained in contact with the lee side of Unit D. The barrier did not breech or fail, and none of the units were damaged. The units are manufactured with flaps at the ends of the units designed for tying the units together to prevent movement, but the units were not tied together for these tests.

The units were reinstalled in a straight line to simulate a segment of a long installation on top of a levee, and this time the units were tied together at the ends. The units were struck by both a 12-in.-diam and 16-in.-diam log with no damage to the units.

Although the protocol tests were completed, additional tests were conducted to demonstrate the capabilities of the units. An additional unit was installed perpendicular to the straight row of units to provide additional support. With the additional support, the barrier wall did not fail during tests with large waves or water depth 33 percent greater than design maximum depth. Seepage between units during the high-water tests was quickly reduced by placing a tarp over the junction between the units on the pool side.

Average seepage rates during the tests are listed in Table 1.

Table 1. Seepage rates during tests with FloodWalls™.

	Average Seepage	Comments
Hydrostatic		
1 ft Head	0.04 gpm/ft	Leaks most at seams and wall
2 ft Head	0.09 gpm/ft	Leaks most at seams and wall
0.95H Head (2.85 ft)	0.18 gpm/ft	Leaks most at seams and wall
Hydrodynamic		
0.67H depth		
Small Wave	0.10 gpm/ft	No overtopping
Medium Wave	0.10 gpm/ft	No overtopping
Large Wave	0.12 gpm/ft	No overtopping
0.80H depth		
Small Wave	0.10 gpm/ft	No overtopping
Medium Wave	0.11 gpm/ft	No overtopping
Large Wave	1.96 gpm/ft	Overtopping with each wave
Log Tests		
12in Log	n/a	No damage
16in Log	n/a	No damage
27.67 in. Depth T-Wall		
Large Wave	2.20 gpm/ft	Overtopping with each wave
Overtopping to 42.58 in. T-Wall		
Over topping	20.00 gpm/ft	Bags lifted but held

The barrier wall was quickly taken down by two men without any special equipment or machinery. After the wall was taken down and the units were rolled and ready to be packed, a small forklift was used to provide additional

drainage of the units and to aid in placing the units in shipping crates. Use of the forklift was more of a convenience than a necessity.

In summary:

- FloodWalls™ units were very quick and easy to install and remove without special equipment or machinery.

- FloodWalls™ units did not completely eliminate seepage but had seepage of approximately 0.04, 0.09, and 0.18 gpm/lft for pool elevations of 1 ft, 2 ft, and 29.9 in. (0.95H), respectively.

- At a depth of 0.67H, waves up to 10- to 12-in. high caused no damage to the FloodWalls™ barrier.

- At a depth of 0.80H, 6- to 8-in. waves caused no damage to the barrier but 10- to 12-in. waves caused one unit to move until it was no longer directly oriented with the wave crest. The structure did not fail, and no units were damaged.

- The debris impact tests did not damage the structure.

- Additional tests demonstrated that the barrier could be reinforced by tying the units together and/or adding additional support units on the lee side. The reinforced barrier withstood the large 10- to 12-in. waves and water levels up to 33 percent higher than the maximum design water level.

- The internal baffles worked well to prevent the units from rolling due to hydrostatic or hydrodynamic forces. As the pool elevation increased, the units rolled a few inches until an equilibrium position was reached with the baffles redistributing the load through the units.

Costs

The following costs were provided by FloodWalls, Inc., in January 2007. All costs are FOB Baltimore, MD. At the request of USACE, costs are provided both for individual units and as a cost per 1,000 ft using units of different lengths. Although the cost per 1,000 ft decreases with longer units, the longer units are

heavier and may require mechanized equipment to place the units. Weights of the units are therefore provided. In addition to the Type A5 units tested herein, prices and specifications are provided for other lengths of Type A units, Type B units, and Type C/120 and C/140 units. Additional information on the different units may be found on the company website or is available by contacting the company.

Table 2. Costs and specifications of FloodWalls™ Type A units.

Item	A2	A3	A4	A5	A10	A15	A20
Part #	610034	610033	610032	610031	610030	610029	610028
List	$998	$1,193	$1,395	$1,569	$2,981	$4,259	$5,520
$/ft	$153.57	$121.34	$107.27	$98.07	$93.17	$86.91	$84.92
$/1000'	$130,531	$103,135	$91,182	$83,358	$79,195	$73,873	$72,185
Material Weight (lb)	63	95	125	154	308	472	626
Length (ft)	6.5	9.8	13.1	16.4	32.8	49.2	65.6
Wt/ft	9.6	9.6	9.6	9.6	9.6	9.6	9.6
Volume (gal)	730	1,103	1,459	1,796	3,592	5,500	7,296
Water Weight (lb)	5,399	8,165	10,798	13,290	26,581	40,702	53,992
Total Weight (lb)	5,462	8,260	10,924	13,444	26,889	41,173	54,618
Protected Height (in.)	31	31	31	31	31	31	31

Table 3. Costs and specification of FloodWalls™ Type B units.

Item	B2	B3	B4	B5
Part #	610079	610078	610077	610076
List	$1,164	$1,424	$1,616	$1,829
$/ft	$179.02	$144.83	$124.34	$114.32
$/1000'	$152,168	$123,102	$105,685	$97,170
Material Weight (lb)	67	101	134	165
Length (ft)	6.5	9.8	13.1	16.4
Wt/ft	10.3	10.3	10.3	10.3
Volume (gal)	730	1,103	1,459	1,796
Water Weight (lb)	5,618	8,496	11,236	13,829
Total Weight (lb)	5,685	8,598	11,370	13,994
Protected Height (in.)	31	31	31	31

Table 4. Costs and specification of FloodWalls™ Type C/120 units.

Item	C2/120	C3/120	C4/120	C5/120
Part #	610291	610292	610293	610294
List	$1,318	$1,455	$1,629	$1,933
$/ft	$202.80	$147.97	$125.31	$120.80
$/1000'	$172,378	$125,775	$106,517	$102,676
Material Weight (lb)	110	158	180	253
Length (ft)	6.5	9.8	13.1	16.4
Wt/ft	16.9	16.1	13.8	15.8
Volume (gal)	730	1,103	1,459	1,796
Water Weight (lb)	5,618	8,496	11,236	13,829
Total Weight (lb)	5,728	8,654	11,416	14,082
Protected Height (in.)	48	48	48	48

Table 5. Costs and specification of FloodWalls™ Type C/140 units.

Item	C2/140	C3/140	C4/140	C5/140
Part #	610295	610296	610297	610298
List	$1,995	$2,376	$2,800	$3,238
$/ft	$306.85	$241.75	$215.38	$202.39
$/1000'	$260,825	$205,484	$183,077	$172,028
Material Weight (lb)	264	310	383	462
Length (ft)	6.5	9.8	13.1	16.4
Wt/ft	40.6	31.5	29.5	28.9
Volume (gal)	730	1,103	1,459	1,796
Water Weight (lb)	5,618	8,496	11,236	13,829
Total Weight (lb)	5,882	8,806	11,619	14,291
Protected Height (in.)	60	60	60	60

Other Factors

The units were 100 percent reusable with no apparent environmental concerns. Because no special equipment or machinery is required, the units could be placed in an area with a minimum right-of-way or over surfaces not suited to heavy equipment.

Although constructed of reinforced material, the units are capable of being punctured, either accidentally or through vandalism. If a unit fails, it should be possible to place additional units behind the failed unit to repair the barrier. Punctured units could also be patched with underwater patches and then refilled.

No attempt was made to stack units to raise the working depth of the barrier. If the pool in front of an installed barrier is in danger of exceeding the maximum design depth of the units, it may be necessary to install a second row with units designed for greater depths. The manufacturer suggested that sandbags may be

placed over the units to provide additional weight if the pool depth becomes greater than the design maximum, and the manufacturer has special sandbags for this purpose, but the sandbag option was not tested herein.

The units are available in custom sizes and lengths and appear to be a very quick and economical means of raising a levee or other structure in danger of being overtopped. Within the range of depths tested, the units performed very well with hydrostatic forces and wave height up to 6- to 8-in. when installed without additional supports or being tied together. If large waves are expected, the units should be tied together and in extreme cases should be supported on the lee side with additional units.

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