

# Laboratory Testing of Flood Fighting Structures



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# Laboratory Testing of Flood Fighting Structures

## Outline

- *Laboratory Facility*
- *Testing Protocol*
- *Laboratory Testing*



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# Laboratory Testing of Flood Fighting Structures

*Laboratory Facility*



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# Unique Test Facility

- 115 ft by 185 ft basin, 4 ft deep
- Modified with an 8-ft-diameter sump
  - Wing walls extend from rear wall of basin on both sides of sump
  - Test structure ties into wing walls to seal off in front of sump
- Full Instrumentation



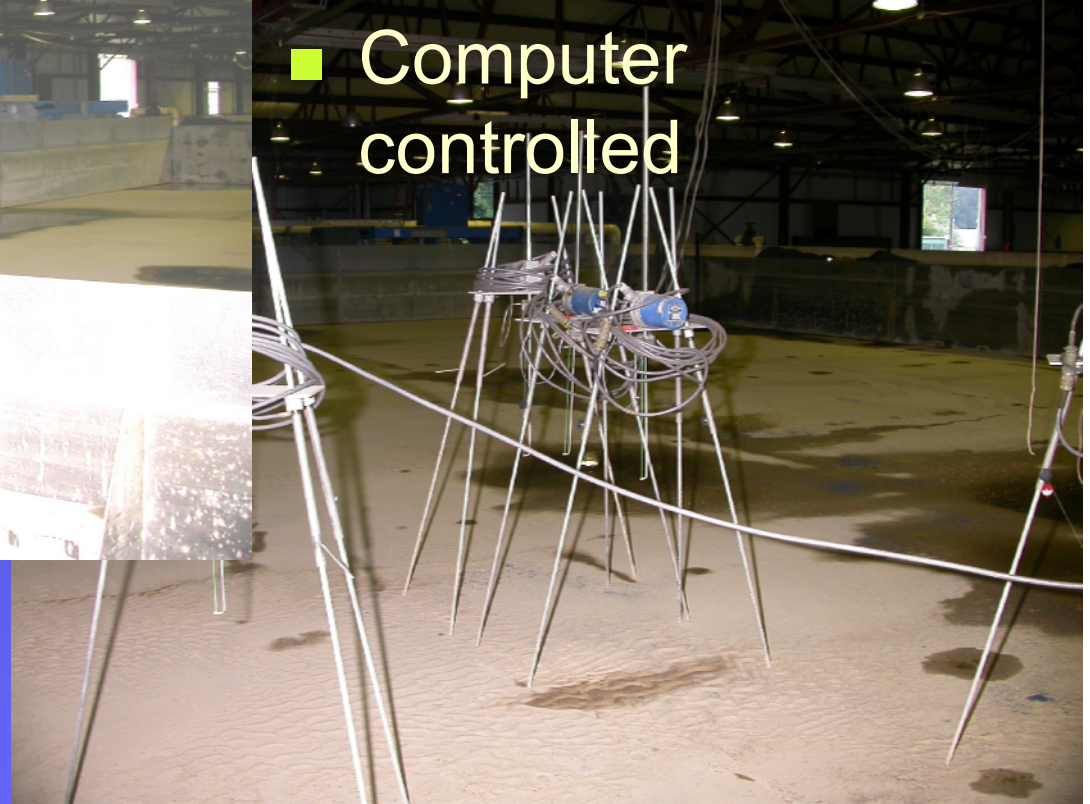
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# Three 25-ft-wide wave generators



- Synchronized
- Spectral or monochromatic
- Computer controlled



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# 8-ft-diameter sump



- Two 4-in pumps
- Two diesel pumps



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# Impact Tests

- 12-in and 16-in-diameter logs
- 5 mph



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# Instrumentation

- Wave gauges
- Laser displacement measurements
- Pool elevation
- Pump discharge
- Webcams



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# Laboratory Testing of Flood Fighting Structures

## *Test Protocol*



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# Standardized Test Protocol

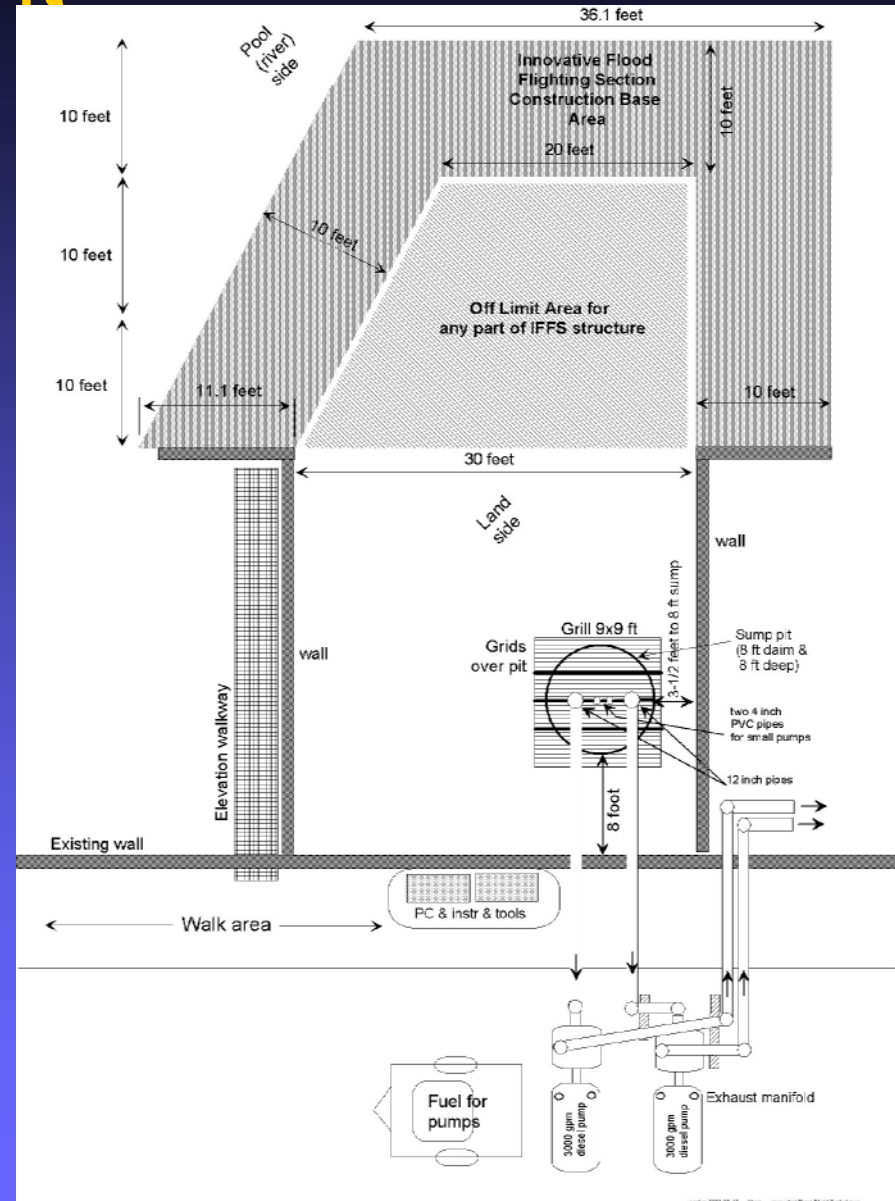
- Construction, Repair, Removal
- Static Head
- Dynamic Wave
- Overtopping
- Debris Impact
- Reusability
- Environmental Evaluation



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# Construction Footprint

- One 90 degree angle
- One 60 degree angle
- Tie into one wall perpendicularly
- Tie into one wall at angle



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# Construction and Removal

- Total man-hours
- Equipment used
- Materials and supplies



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# Static Head Tests

- Test cases:
  - 1 ft head
  - 2 ft head
  - 95% of design height
  - 22 hrs each
- Measurements
  - Seepage rate
  - Displacement
  - Damage



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# Dynamic Wave Tests



- 2 inch Waves for 7 hours
- 6-8 inch Waves for 30 min
- 10-12 inch Waves for 10 min
  
- All waves at 67%H and 80%H



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# Overtopping Test

- 1 inch Head for 1 hour
- Damage and Survivability Test



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# Debris Impact Test

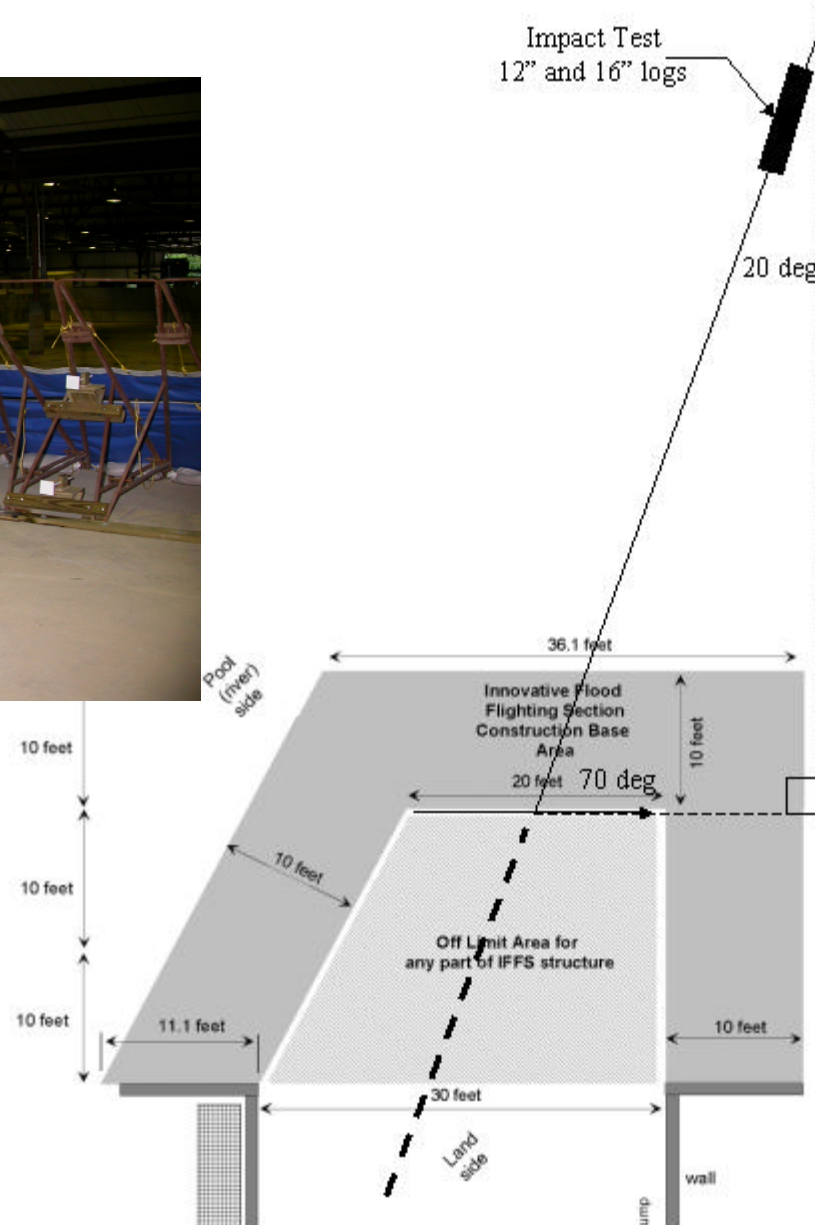
- 12-in-diameter log, 5 mph
- 16-in-diameter log, 5 mph



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# Impact Tests



# Repairs

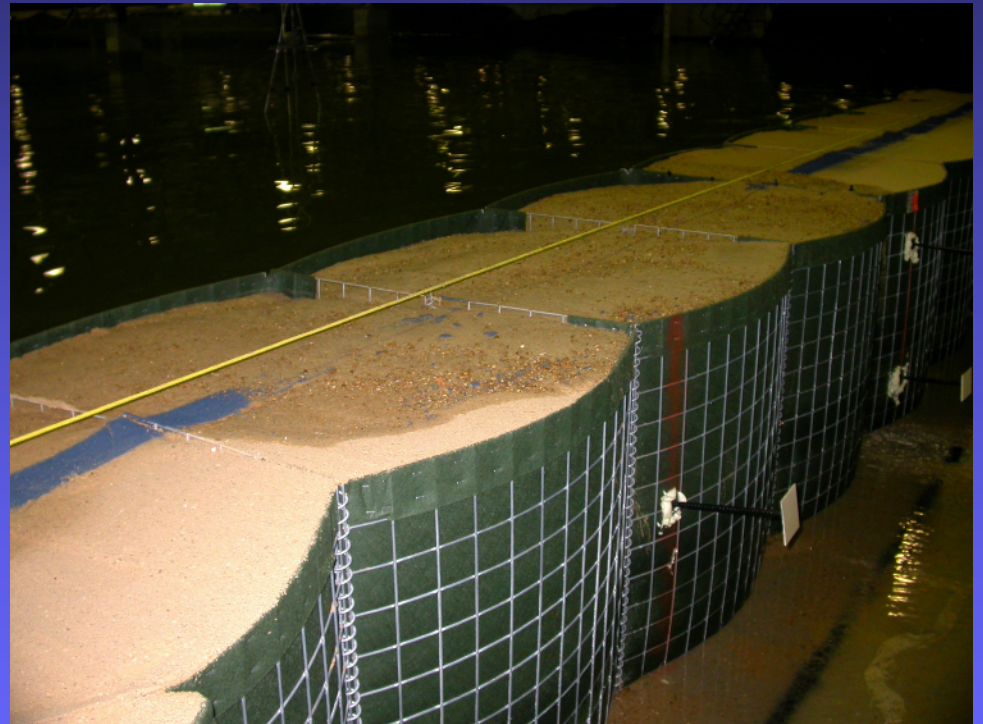
- Up to three repairs allowed
- 30 minute maximum
- 4 person maximum
- Only at conclusion of specific tests



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# Reusability

- Special equipment needed to clean unit
- Time needed for clean up unit
- Damages of structures
- Storage needed





# Environmental Evaluation

- Disposal Concerns
- Contamination



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# Laboratory Testing of Flood Fighting Structures

*Laboratory Testing*



# Test Parameters

- Constructability
- Hydrostatic Load
- Wave-induced Hydrodynamic Load
- Overtopping
- Debris Impact
- Repairs to Flood-Fight Structures
- Removal of Structures
- Reuseability
- Environmental Evaluation



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Structures Evaluated

Sandbags

Hesco-Bastion Container



Geocell Systems RDFW



Portadam



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# Sandbag Levee - Construction



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# Sandbag Levee - Construction



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# Sandbag Levee - Static



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# Sandbag Levee – Overtopping



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# Sandbag Levee – Overtopping



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# Construction and Removal Summary

## Construction:

- 205.1 Man-hours
- Equipments:
  - Front-end loader
  - Manual sandbagger
  - Cones
- Materials
  - Sandbags
  - Sand

## Removal:

- 9 Man-hours
- Front-end loader



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# Repair Summary

- Repair 1: 2.0 Man-hours
  - Repaired wave damage
  - Levelled top surface
- Repair 2: 2.0 Man-hours
  - Repaired wave damage
- Repair 3: 2.0 Man-hours
  - Repaired wave damage
- Rebuild: 44 Man-hours
  - Placed heavier, tied sandbags on surface



# Hesco-Bastion Concertainer Construction



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# Hesco-Bastion Concertainer Construction



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# Hesco-Bastion Concertainer Construction



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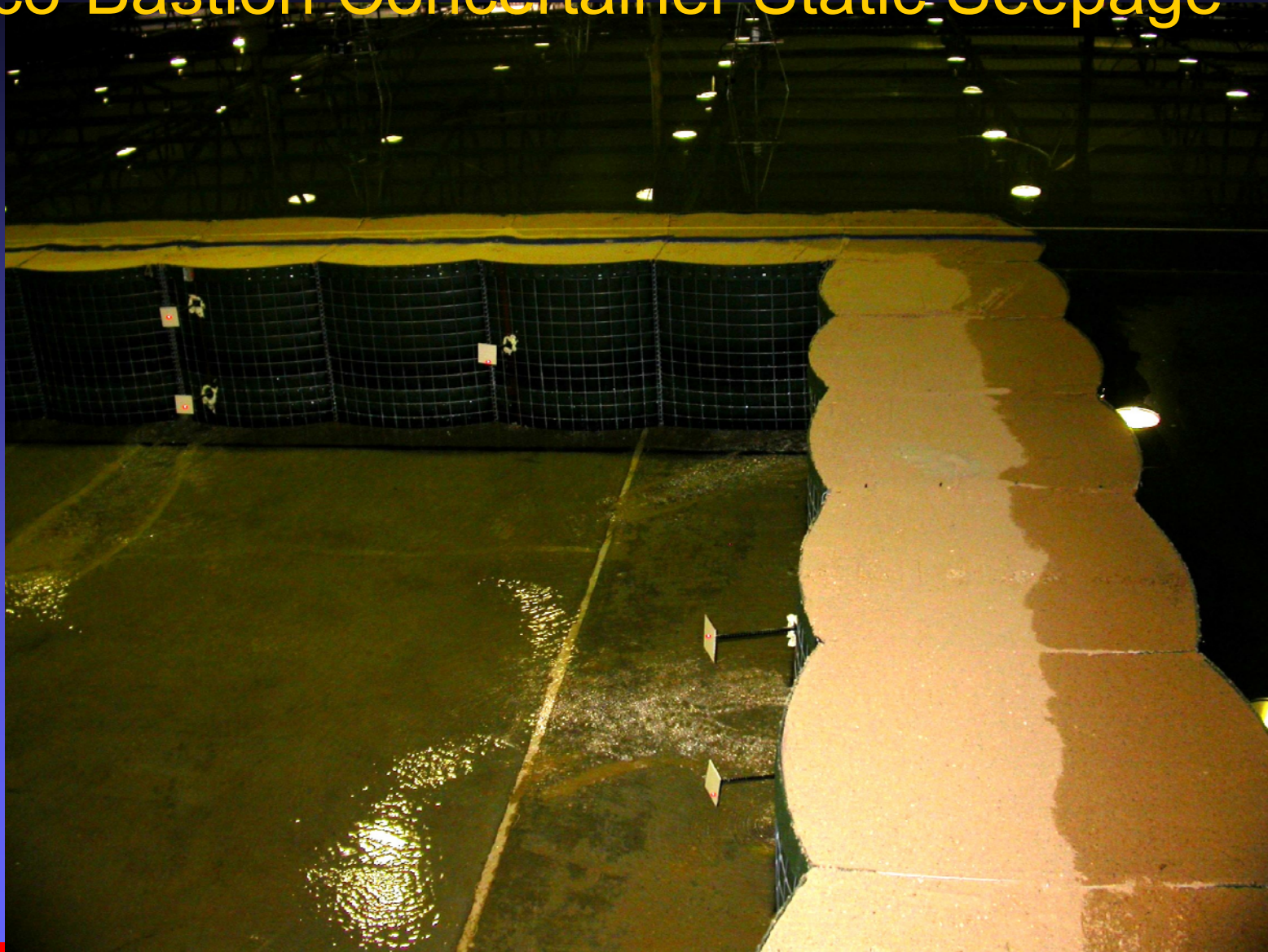
# Hesco-Bastion Concertainer Construction



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# Hesco-Bastion Concertainer Static Seepage



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# Hesco-Bastion Concertainer – Wave Damage



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# Hesco-Bastion Concertainer – Cover Installation



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# Hesco-Bastion Concertainer – Overtopping



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# Hesco-Bastion Concertainer – Removal



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# Hesco-Bastion Concertainer – Removal



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# Construction and Removal Summary

## Construction:

- 20.8 Man-hours
- Equipments:
  - Front-end loader
- Materials
  - Concertainers
  - Sand, 5 Sandbags
  - Insulating Foam
- Comments
  - 6-man crew took 3 hr 28 min

## Removal:

- 13.4 Man-hours
- Front-end loader



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# Repair Summary

- Repair 1: 1.6 Man-hours
  - Added membrane over surface
- Repair 2: 0.2 Man-hours
  - Placed sandbags along toe
- Repair 3: N/A



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# Geocell RDFW – Construction



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# Geocell RDFW – Construction



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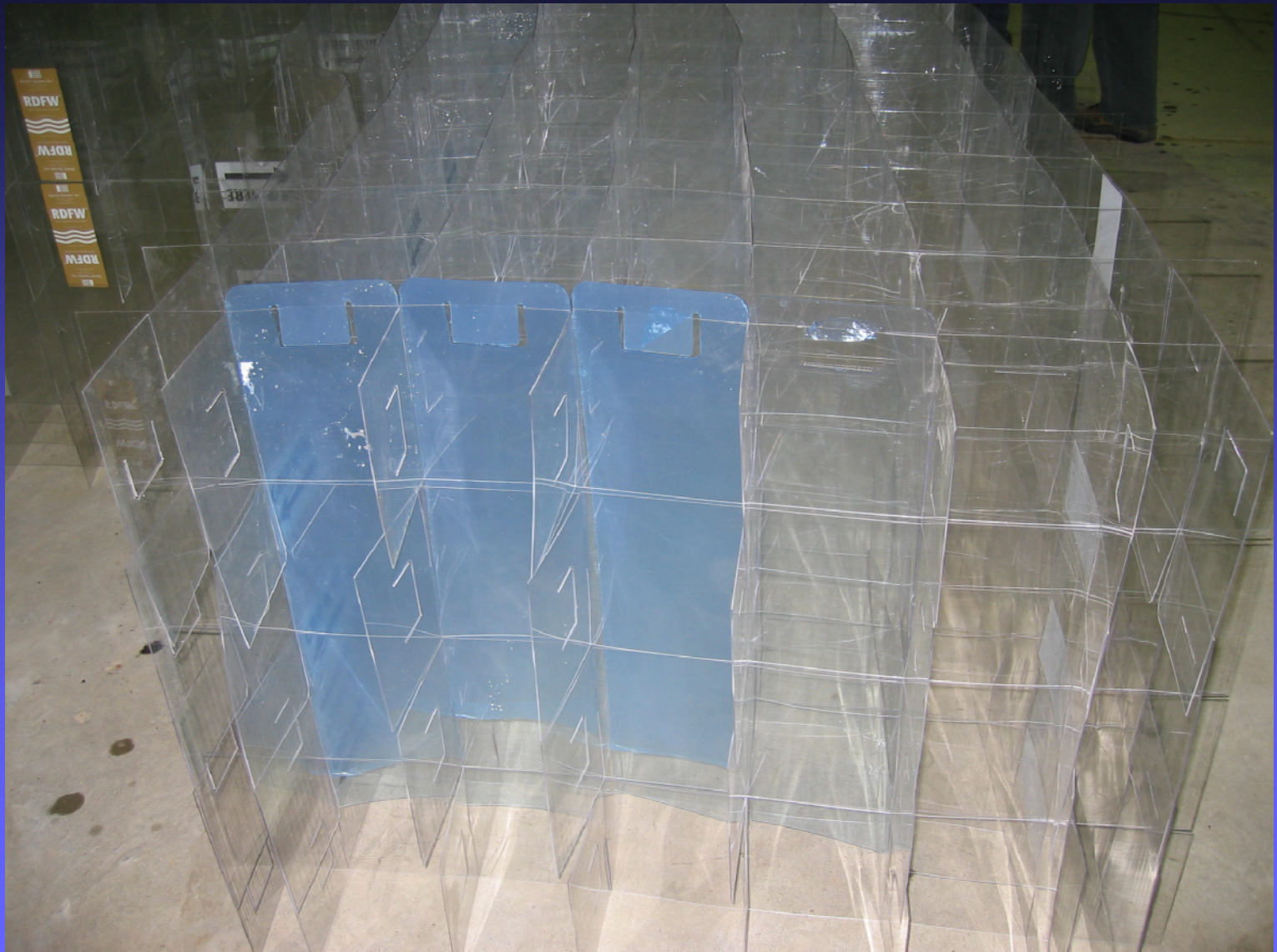
# Geocell RDFW – Construction



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# Geocell RDFW – Construction



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# Geocell RDFW – Construction



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# Geocell RDFW – Construction



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# Geocell RDFW – Static Damage



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# Geocell RDFW – Wave Action



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# Geocell RDFW – Wave Damage



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# Geocell RDFW – Repair



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# Geocell RDFW – Log Impact



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# Geocell RDFW – Damage



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# Geocell RDFW – Removal



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# Geocell RDFW – Removal



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# Geocell RDFW – Removal



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# Geocell RDFW – Removal



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# Construction Summary

- Construction:
  - 32.8 Man-hours
  - Equipments:
    - Front-end loader
    - Bobcat
    - Forklift
  - Materials
    - RDFW Units
    - Sand
    - Cement
  - Comment
    - 6 man-crew, took 5 hr 28 min
- Removal:
  - 
  - 42 Man-hours
    - Bobcat
    - Forklift
    - Shop vacuums



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# Repair Summary

- Repair 1: 1.9 Man-hours
  - Added sand along top surface
- Repair 2: 0.7 Man-hours
  - Added reinforcing strips
- Repair 3: 1.9 Man-hours
  - Added additional sand



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# Portadam - Construction



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# Portadam - Construction



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# Portadam - Construction



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# Portadam - Waves



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# Portadam - Overtopping



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# Portadam – Log Impact Damage



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# Portadam - Removal



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# Construction Summary

- Construction:
  - 24.4 Man-hours
  - Equipment:
    - Hyster Forklift
  - Materials
    - Portadam frames and cover
    - Sand bags and sand
    - Insulating foam
    - Tape, Rope
  - Comments
    - 6-man crew, 2 only filled sandbags

- Removal:
  - 4.4 Man-hours
  - Equipment:
    - Hyster Forklift



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# Repair Summary

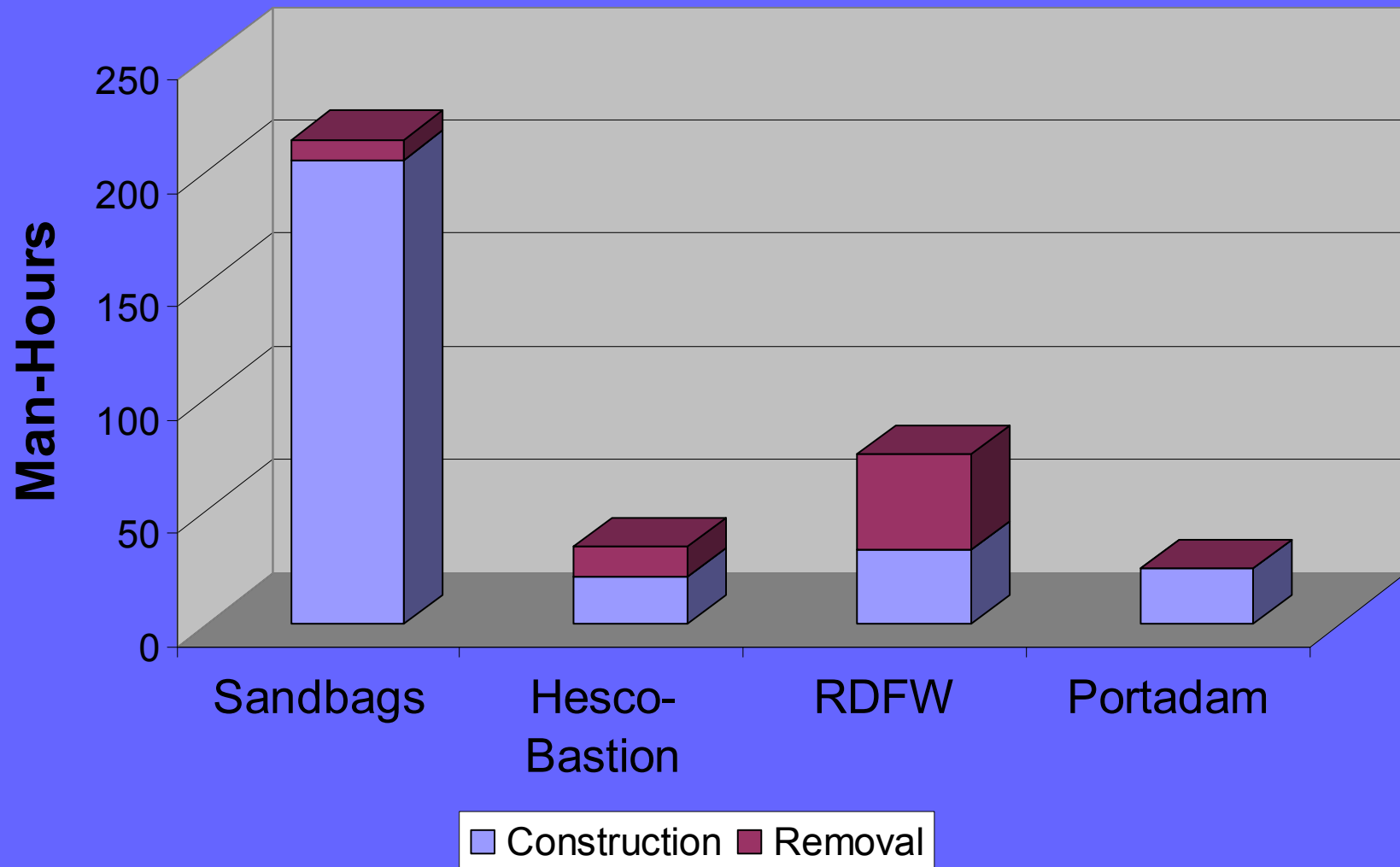
- Repair 1: 0.5 Man-hours
  - Placed sandbags over bubbles under skirt
- Repair 2: 1.5 Man-hours
  - Improved seal along wall
- Repair 3: N/A



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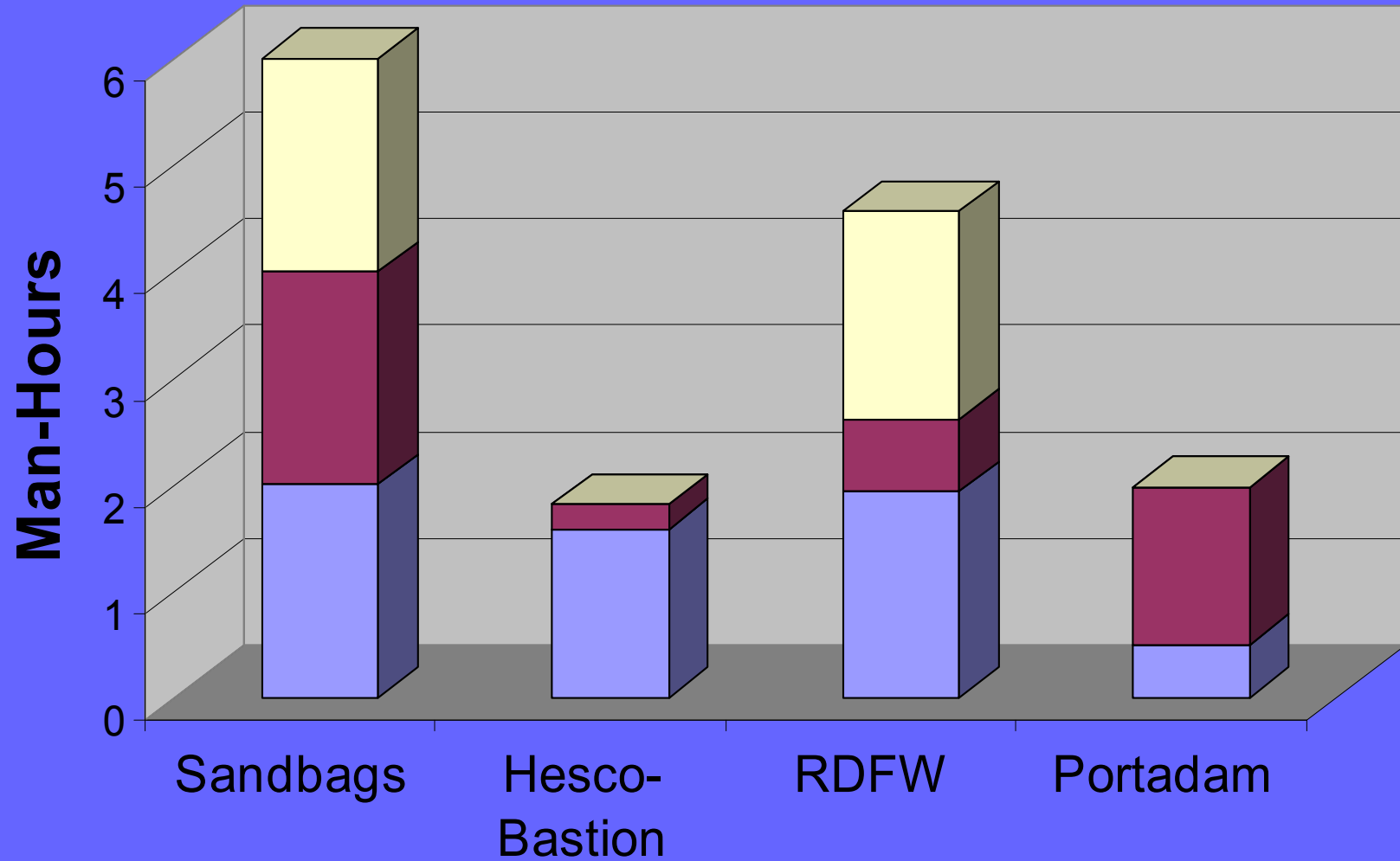


# Construction and Removal Summary



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# Repair Summary



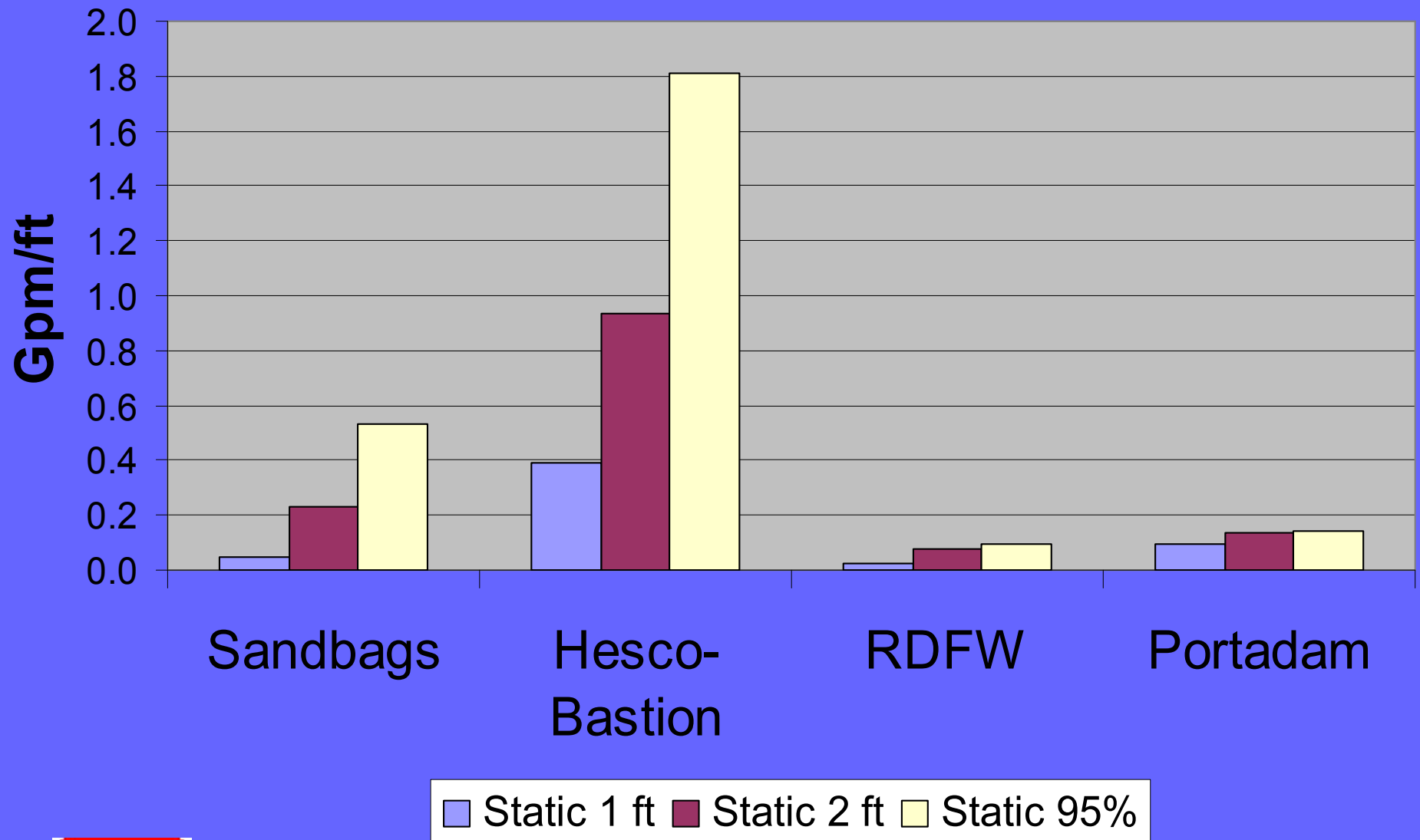
Repair 1 Repair 2 Repair 3



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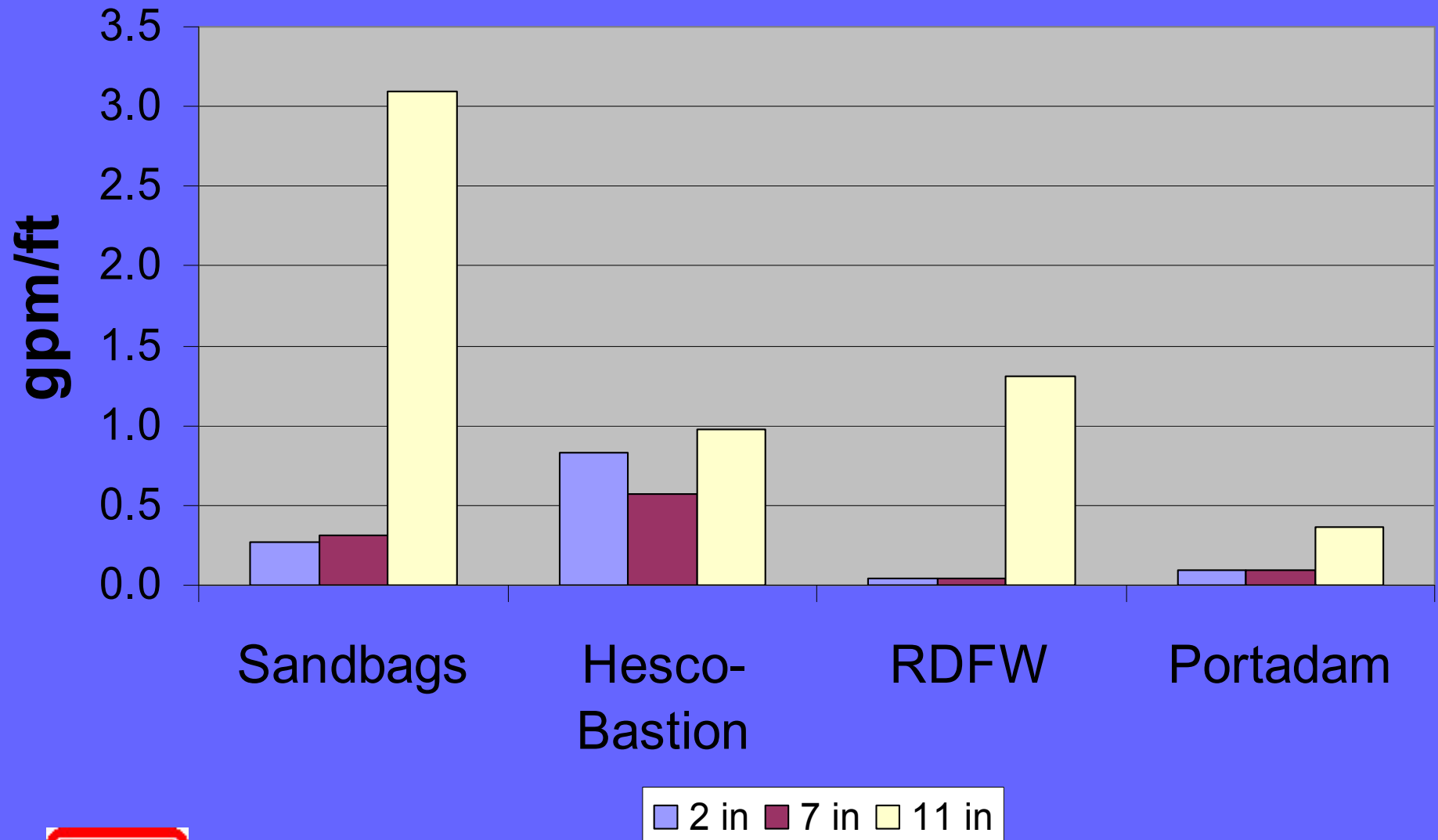


# Static Head Seepage Rates Summary



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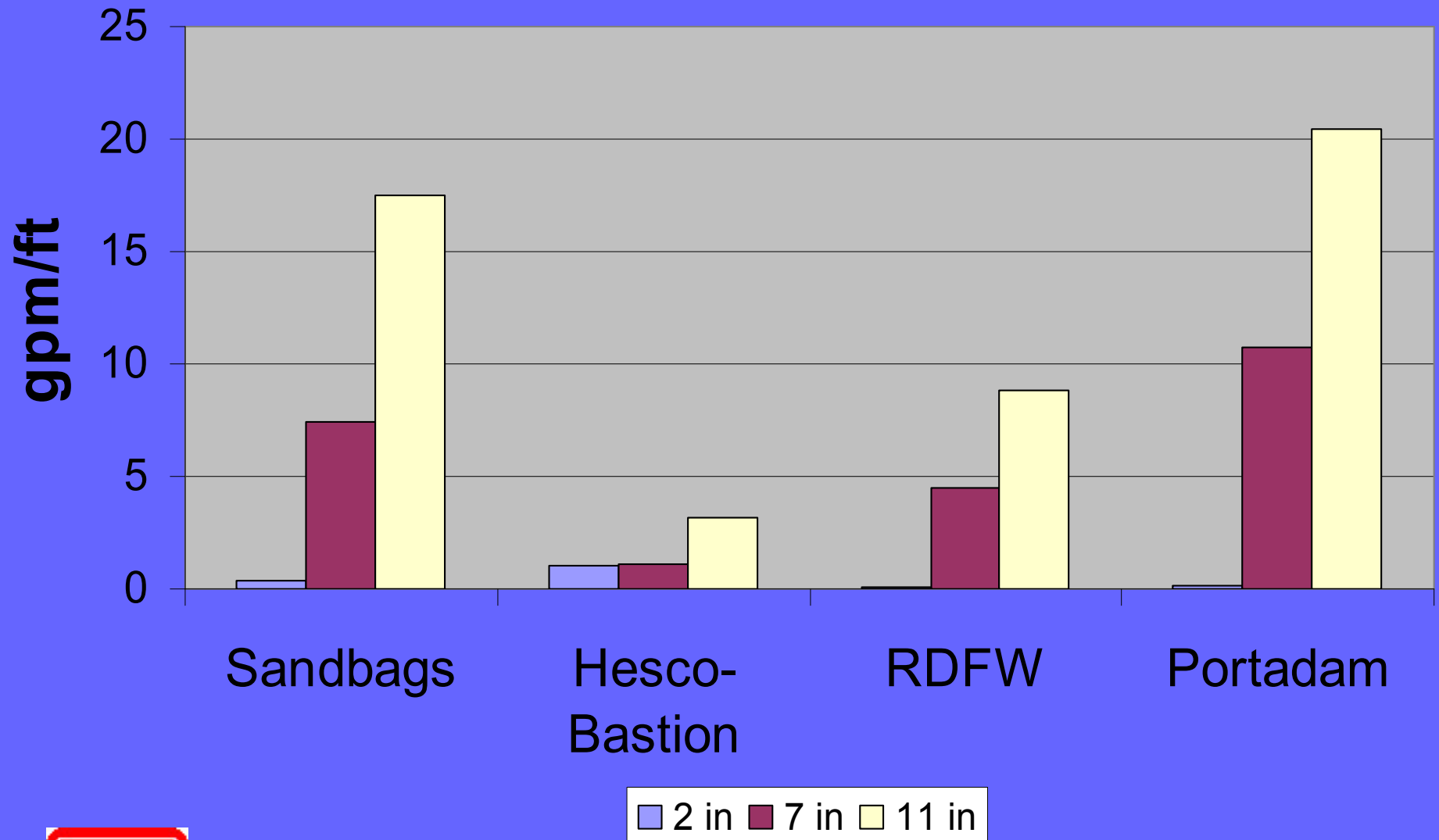
# Dynamic Wave Loading at 67%H Seepage



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# Dynamic Wave Loading at 80%H Seepage



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# Damage Summary

- Sandbags
  - Repeatedly damaged by waves
  - Failed during overtopping
- Hesco-Bastion Concertainer
  - Some sand settling and washout (minor)
  - Wire bent by log impact





# Damage Summary (concluded)

- Geocell Systems RDFW
  - Minor sand settling
  - Significant washout along edges and toe
  - Toe damaged during large waves or overtopping
  - 10% of structure broken
- Portadam
  - Fabric torn during impact tests



# Reusability

- Sandbags

- Possible, but not practical
- Entire structure discarded



- Hesco-Bastion Concertainers

- Reusable
- May be difficult to clean muck from fabric
- End pieces must be replaced



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# Reusability (concluded)

- Geocells Systems RDFW
  - Reusable
  - Structure can be hosed off
  - Replace broken pieces – time consuming
- Portadam
  - Reusable
  - Hose off fabric
  - Designed for rental use – reused many times
- Disassembly times did not include times to prepare for reuse



# Test Summary

## Observed Product Strengths and Weaknesses

| Product       | Strengths  | Weaknesses  |
|---------------|--|---|
| Sandbags      | 1. Low Cost – generally constructed by volunteer labor | 1. Very labor intensive and time consuming to construct |
|               | 2. Conforms well to varying terrain                    | 2. Not reusable   |
|               | 3. Low seepage rates                                   |   |
|               | 4. Can be raised if needed                             |   |
| Hesco Bastion | 1. Low Cost  | 1. Significant ROW required due to granular fill        |
|               | 2. High degree of reusability                          | 2. Highest Seepage Rates                                |
|               | 3. Can be raised if needed                             |   |
| RDFW          | 1. Low seepage rates                                   | 1. Significant ROW required due to granular fill        |
|               | 2. High degree of reusability                          | 2. High cost  |
|               | 3. Can be raised if needed                             | 3. Most difficult to remove                             |
| Portadam      | 1. Ease of Construction (time, manpower, equipment)    | 1. Punctured during laboratory debris impact test       |
|               | 2. Low seepage rates                                   | 2. Can't be raised in a typical application             |
|               | 3. No required fill                                    |   |
|               | 4. High degree of reusability                          |   |
|               | 5. Least ROW required                                  |   |





# Questions?



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