College of Engineering
Department of Mechanical & Industrial Engineering

College of Engineering
School of Electrical Engineering & Computer Science

To Predict ▶ To Design ▶ To Perform

ME, ECE Capstone Design Programs

Team# 5 : Rapidly Deployable, Modular Flood Barrier

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LSU COLLEGE OF ENGINEERING

Objective Statement

To design a rapidly deployable and modular flood prevention system that can protect a structure against flood water, and adapt to multiple terrain

Significance

A onetime flood can cause a lifetime in damage and financial strain. Many of these existing flood barriers do not protect flood waters that reach 5 ft. and expensive compared to the flood water height and the linear feet they protect against. The goal for this project is to create a flood protection system which can protect residents from standing and receding flood waters, as well as water traveling back through drains and to remove any water that has accumulated inside of the flood barrier.

Functional Requirements

1) System must be rapidly deployable
2) System must be modular
3) System must protect from hydrostatic and dynamic forces
4) System must be able to adapt to uneven terrain
5) System must prevent backflow through pipes caused by flood
6) System must be able to remove accumulated water inside perimeter

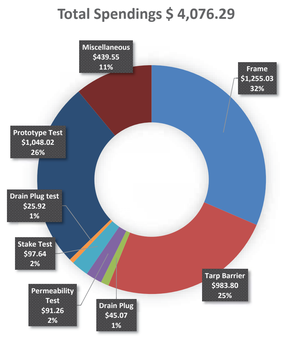
Engineering Specifications

Engineering Specifications	Target	Achieved
1) Rapidly Deployable	100 Linear feet/hour	107 Linear feet/hour
2) Working Time	7 Days	X
3) Cost	15,000	$ 24,500
4) Storage Space	11 ft (wide) x 12 ft (long) x 6 ft (tall)	9 ft (wide) x 11.5 ft (long) x 5.3 ft (tall)
5) Fit uneven Terrain	linear foot	X
6) Modularity	20 Parts/panel	38 Parts/panel
7) Flood Water Height	60 Inches	43 Inches
8) Hydrostatic Force	3,200 Pound Force (lbf.)	1,600 Pound Force (lbf.)
9) Water Velocity	2 ft/second (ft/s)	2 ft/second (ft/s)
10) Leak Rate Through Panel	0.06 GPM	3.2 GPM
11) Pipe Head of Drain plug	5 ft	13 ft

Manufacturing and Budgeting

Parts Name/Panel	Quantity	Dimension
3" PVC Frame	2 frames	8 ft (wide) x 6 ft (tall) x 3 ft (deep)
22 oz Vinyl Tarp	1 pcs	10 ft (tall) x 9 ft (wide)
Velcro	1 pcs	2 inches (wide) x 10 ft (tall)
# 15 Big Zip Zipper	1 pcs	(2 inches (wide) x 10 ft (tall)
Metal Cam Straps	18 pcs	(2 inches (wide) x 1 ft (tall)
Eurmax Galvanized Stakes	32 pcs	

	Dimension	Price
1 Panel of Flood Barrier	8 ft (wide) x 6 ft (tall)	$ 700
35 Panels of Flood Barrier	280 ft (wide) x 6 ft (tall)	$ 24,500

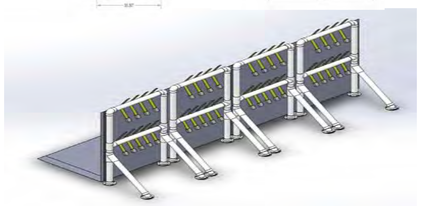


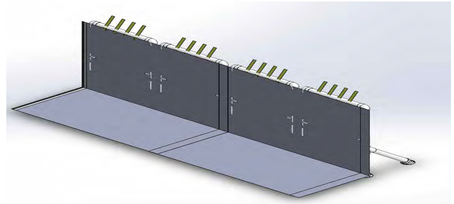
System Description

System	Subsystem	Components
1) Flood Barrier	1.A) Frame 1.B) Tarp	Frame Stakes Tarp Straps Zipper Water Proof Tape
2) Water Removal System		
3) Drain Plug		

https://www.libertypumps.com/Category/stormcell

https://www.zoro.com/shaw-plugs-mech-expansion-plug-nuts-rite-2-52005/i/G3530025/





Engineering Analysis

Drain Plug

$$\frac{P_1}{\rho g} + Z_1 = \frac{P_2}{\rho g} + Z_2$$

$$P_1 = \rho g Z_1 + P_{atm}$$

$$P_2 = P_{atm}$$

$$\frac{\rho g Z_1 + P_{atm}}{\rho g} + Z_1 = \frac{P_{atm}}{\rho g} + Z_2$$

$$Z_2 = \frac{\rho g Z_1 + P_{atm}}{\rho g} + Z_1 - \frac{P_{atm}}{\rho g}$$

$$Z_2 = 2 \times Z_1 + \frac{P_{atm}}{\rho g} - \frac{P_{atm}}{\rho g} = 2 \times Z_1$$

$$Z_1 = 5\ (ft) \rightarrow Z_2 = 10\ (ft)$$

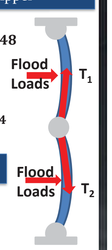
Tarp, Buckle, Zipper

$$SF = \frac{2{,}500\ lbf}{1{,}562.5\ lbf} = \mathbf{1.63}$$

$$SF_1 = \frac{\sigma_{y\,max}}{\sigma_{y1}} = \frac{33{,}593.75\ psi}{5{,}053.006\ psi} = \mathbf{6.648}$$

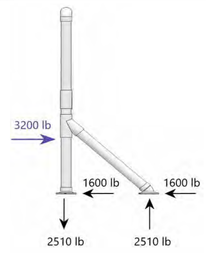
$$SF = \frac{16{,}380\ psi}{7{,}813\ psi} = \mathbf{2.09}$$

$$SF_2 = \frac{\sigma_{y\,max}}{\sigma_{y2}} = \frac{33{,}593.75\ psi}{24{,}433.192\ psi} = \mathbf{1.374}$$



Frame, Stakes

FBD (static loading): Hydrostatic loading for 5ft of water on a frame. The stakes carry the horizontal reactions and the downward reaction at the front feet.



Testing and Validation

Test	Qualitative Specifications
Permeability	Determine the combination for joining the tarp
Drain Plug	Determine and recommend suitable drain plug
Stake	Determine which stake is easiest to drive while providing enough strength
Storage Space	Determine what preassemble frame combination requires the least amount of storage space
Frame Assembly	Determine the time it takes to assemble different preassembled frame combinations
Deployment	Determine the time it takes to set up 4 frames and 2 tarp sections
Prototype	Determine the strength of all sub-systems and prove engineering concept of the barrier.

Testing Results Analysis

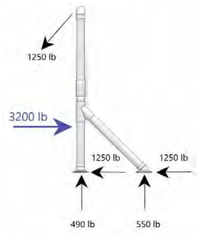
3:50 PM	4:00 PM(Just Before Failure)

Discussion on The Design

The design failed to meet the requirements of water height and cost. The frame failed during the prototype testing. This was due to the stakes on the front legs being lifted out of the ground. The requirements of time to set up and storage were met. The engineering specifications of water velocity, and the ability to fit uneven terrain were not able to be quantified due to testing limitations. Qualitatively the design was able to handle velocity and uneven terrain.

Discussion on The Testing Setup

The prototype testing set up had several issues. The pool used in testing was not able to handle the loads caused by the testing; this caused the pool to shift. The issue of sealing the tarp to the wall of pool liner caused higher stress on the tarp and side frames and contributed to the leak rate recorded.



Proposed FBD (static loading): With front end tie down

Improvements and Recommendations on Design	
Add an auger off the front side of frame (front end tie down)	It would cause the vertical reaction forces on the feet to be supported by the ground instead of stakes
Look into using a more flexible/lighter tarp	It would allow the weight of the water to create a better seal with the ground under lower pressure
Add a heavy portion to the front of apron (Ex: water bladder, water sock)	It would allow the bottom of tarp to be placed into position easier
Remove the flap containing the Velcro on the apron	The Velcro did not provide acceptable resistance to leaking; Would save approximately $2.25 per linear foot

Improvements and Recommendations on Testing	
Create an enclosed barrier	It would remove the problem of sealing the tarp to a wall (and address the problem with the pool shifting if that path is used)

September – Preliminary concept; Preliminary design

October – Engineering Analysis; 3D Drawing

November – Testing Concept; Material Selection

December – Procurement; Fabrication Preparation

January – Permeability Test; Barrier Fabrication

February – Drain plug Test; Prototype Setup Preparation

March-April – Stake Test; Prototype Test; Removal System Selected

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Instructor: Dr. Keith Gonthier