The Basileia Barrel

EDSGN 100

Section 21

Spring 2015

Instructor: Jesse McTernan

Bolun Lu, Liang Wang, Conley Oster, Mitchell Storm

Mission Statement

Our mission is to recycle the waste materials of ArcelorMittal, a global steel manufacturer. Our solution utilizes the 50 gallon drums to create an artificial reef, a man-made underwater structure. An artificial reef provides a surface for undersea life to grow, which in turn attracts other aquatic life. Our goal is to create a structure that supports an aquatic ecosystem and can be safely and accurately dropped into a body of water.

Summary

Recently an industry leader in steel production and mining, ArcelorMittal, approached our Engineering Design class with a problem that needed an economical, viable, and logical solution. Being that ArcelorMittal is in steel production as well as being one of the largest companies in the world; they unwillingly produce a lot of waste. So as a class split into teams we had to figure out a way to either recycle or reuse one or more of four possible waste products; these products were: 50 gallon steel drums, 50 gallon plastic drums, refractory brick, and large palletized chemical containers all used in the steel making process. The process or product had paramount importance of turning items currently being thrown away into profit.

Background

In the last few decades, mankind has destroyed over 35 million acres of coral reefs. Reefs of 93 countries have been damaged by human activity. If the present rate of destruction continues, 70% of the world's coral reefs will be killed within our lifetimes (Yip, 1). With growth rates of 0.3 to 2 centimeters per year for massive corals, and up to 10 centimeters per year for branching corals, it can take up to 10,000 years for a coral reef to form from a group of larvae (Barnes, 2). At this rate it could take eons to replenish the coral humans have already damaged. This startling statistic led marine biologists and maritime engineers to pioneer other ways to foster small marine growth. The coral itself is not nearly as important as the structure it provides for other marine animals. Small barnacles, baitfish, and large game all prefer a structured environment. The structure fosters barnacle growth by giving a hard surface to latch to, this in turn provides food for the small baitfish and legged marine life to feed off; it also gives them hiding places from larger predators to procreate and foster large school growth. Without structure the bottom two components of the oceanic food chain would seize to exist. With a booming small fish population the tertiary consumers are given a vast amount of food to eat without the possibility of them overeating the area due to the vast numbers. This allows for a healthy food pyramid to be in play around the artificial reef, which in turn allows commercial fishing to continue (with fewer seasonal fish bans) continuing to stimulate the regional and national economy. The booming marine activity around artificial reefs also attracts commercial driving expeditions, snorkelers, and recreational fisherman.

In the state of Florida there are currently 2879 man-made artificial reef structures in the ocean (FWC). In order to drop a structure in the ocean off of the Floridian coast (or most coasts) you must either sell your Coast Guard approved structure to the Coast Guard or the Florida Fish and Game Conservation. From 1979 through fiscal year 2011-2012, Florida's artificial reef program provided at least $15,253,084 in state and federal funding to local coastal governments for public reef construction projects. Another $3,082,524 has gone toward statewide artificial reef research projects, $1,417,256 toward reef monitoring and $479,853 toward four regional reef socioeconomic studies (FWC). The research aspect of the funding has led to resounding confirmations of the artificial reefs' success. Although the structures may not exceed the natural coral reefs inhabitant numbers, they get extremely close, as seen in table 1.

	Artificial Reef		**Natural Reef**	
	Species	**Individuals**	**Species**	**Individuals**
January 1972	- Reef built -			
February 1972	29	143	38	368
April 1972	51	251	58	760
August 1972	56	674	46	687
February 1973	43	337	37	377
August 1973	44	992	40	1027
February 1974	35	563	39	753
April 1974	27	776	33	929
August 1974	48	921	48	948

In accordance with their saltwater success the artificial reefs are equally (if not more) successful in freshwater fishing. Structure in freshwater is slightly different than saltwater. Rather than fostering small barnacle and microorganism growth, they are almost purely places for game fish to nest and raise their young. Competitive Largemouth Bass Fishing is currently a 3 billion dollar industry and structures are as important to many Bass Fisherman as the lures they cast. Bass fishing has had a second wind over the last decade overthrowing the nostalgic "grandpa-esque" feeling that it had prior. Science, engineering, and tested results are helping smaller companies push past the larger stockholders in the

industry. With fishing structures selling better in the last half decade than ever before and competitors running upwards of $500, there is a vast area for a cheaper product and large profits.

Table 1

TABLE 1: "Artificial Reefs." *Artificial Reefs*. Sbg.ac, 3 Aug. 1998. Web. 29 Apr. 2015.

Yip, Maricela. "An Overview of Artificial Reefs." *Artificial Reefs*. Dr. A. Goldschmid, 22 Nov. 1998. Web. 29 Apr. 2015.

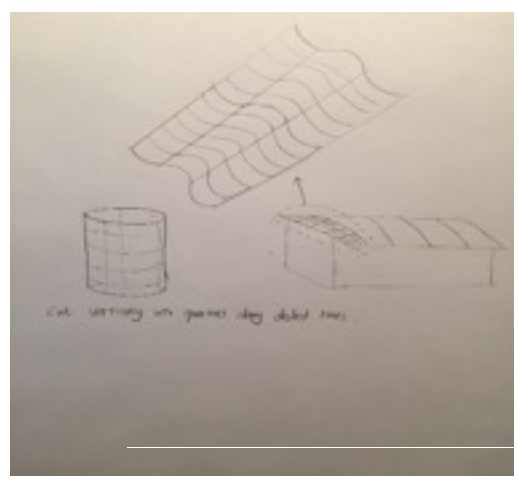
Barnes, Ryan. "Corals." *NOAA National Ocean Service Education*:. 12 Mar. 1987. Web. 29 Apr. 2015.

"While Artificial Reefs Generally Enhance Local Economies, They Can Have Both Positive and Negative Effects on Ecosystems." *What Effects Do Artificial Reefs Have on the Natural Environment and the Economy?* NOAA, Web. 29 Apr. 2015.

"Artificial Reef Program." Artificial Reef Program. FWC, Web. 29 Apr. 2015.

Selection Matrices

The way that we began our search to find a good idea is brainstorming things that can be used to re-use or recycle the waste material including drums, refractory bricks and pallets and make good use of it. We brainstormed and find three ideas in total. The first idea was called Roof cladding; basically, the barrels would be cut into half and welded together. This roof cladding can be used in highly array area to collect water. Another idea is to use drums to carry mine water. This idea is straightforward and profitable. The last idea is to cut the drums into some specific pattern and then used as an artificial reef, which is a human-made underwater structure built to promote marine life.



All of these three ideas are good ideas and it is really hard to say which idea is better than the other's. Idea one focuses more on humanitarian while idea two focus on profit and practical applicability. Idea three focus on both profit and environmental sustainability. We felt that all of these three ideas were strong in that area and there was no need to factor that in as much as the other aspects that varied in strength among these three concepts. Therefore we decided to use selection matrix to help us choose which idea we were going to use.

	Price	Safety	Efficiency	Usefulness	Duribility	Public Image	sum	**weight**
Price	1.0000	1.0000	1.0000	0.3333	0.5000	2.0000	5.833333333	**15%**
Safety	1.0000	1.0000	1.2000	1.2000	1.5000	1.0000	6.9	**17%**
Efficiency	1.0000	0.8333	1.0000	1.0000	1.5000	0.8333	6.166633333	**16%**
Usefulness	3.0000	0.8333	1.0000	1.0000	2.0000	1.0000	8.833333333	**22%**
Durability	2.0000	0.6667	0.6667	0.5000	1.0000	0.5000	5.333333333	**13%**
Public Image	0.5000	1.0000	1.2000	1.0000	2.0000	1.0000	6.700048002	**17%**
						total	39.76668134	

After seeing that the Artificial Reef plan weighted higher than the other two plans, we finally decided to continue on with the artificial reef plan.

		Concepts							
		Cleaning and melting		Roof cladding		Carry mine water		Artificial reef	
Selection Criteria	Weight (%)	Rating	Weighted Score	Rating	Weighted Score	Rating	Weighted Score	Rating	Weighted Score
1. Price	15%	3	0.45	4	.6	4	.6	4	0.6
2. Safety	17%	3	0.51	3	0.51	2	0.34	2	0.34
3. Efficiency	16%	3	0.48	2	0.32	3	0.48	4	0.64
4. Public Image	17%	3	0.51	4	0.68	3	0.51	4	0.68
5. Usefulness	22%	3	0.66	4	0.88	4	0.66	4	0.88
6. Duribility	13%	3	0.39	4	0.52	4	0.39	4	0.52
	Total Score	3		3.51		2.98		3.66	
	Rank	3		2		4		1	
	Continue?							Yes	

Table 2: Selection Weight

Prototyping

<u>Prototype 1-</u>

Figure 2: SolidWorks design of

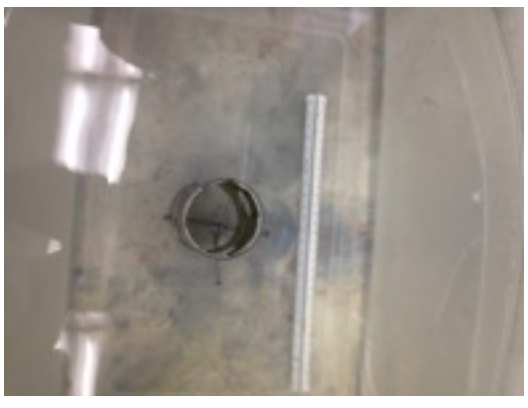
Before making our first prototype, we created a design in SolidWorks. As seen in figure 2, our design maps out the cuts we are going to make into the material representing the barrel. The cuts need to allow aquatic life inside the structure and have different ways for aquatic life to exit so as to not trap it inside.

User Need / Feature / Requirement	Describe Test	What is “pass”?	Materials / tools needed to run tests
1.Accuracy of drop	Drop prototype in a bucket of water; measure if it falls in the acceptable drop zone	Falling within 2 inches of desired drop zone	Tub of Water, Target
2. Orientation after drop	Drop prototype in water horizontally and vertically; observe if it lands in the desired orientation	Landing in the correct orientation	Tub of Water
3. Motion in current	Place prototype in moving water; measure movement from original position	Staying within 2 inches of its original position	Tub of Water, Target

4.Supporting growth	Place prototype in pond water; observe any growth	Does algae grow	Pond Water

Test	Attempt #1	Attempt #2	Attempt #3
1.Accuracy of drop	Vertically: 0.75 inches- Pass Horizontally: 2.5 inches- Fail	Vertically: 1.25 inches- Pass Horizontally: 2.125 inches- Fail	Vertically: 0.25 inches- Pass Horizontally: 3 inches- Fail
2. Orientation after drop	Vertically: Pass Horizontally: Pass	Vertically: Pass Horizontally: Pass	Vertically: Pass Horizontally: Pass
3. Motion in current	Vertically: 12 inches (end of tub)- Fail Horizontally: 12 inches (end of tub)- Fail	Vertically: 12 inches (end of tub)- Fail Horizontally: 12 inches (end of tub)- Fail	Vertically: 12 inches (end of tub)- Fail Horizontally: 12 inches (end of tub)- Fail
4.Supporting growth	Pass	N/A	N/A

The first test measured how accurately the prototype fell into the water. The full sized artificial reef would need to be relatively precise when being dropped in the water so it can be marked on maps and not hit other structures or land in a useless location. The second test revealed if the prototype would land in the correct orientation. An artificial reef cannot be built to trap fish, so it would need to land properly to provide the safest environment for undersea life. The third test showed if the prototype could withstand motion in the water. The reef would need to stay stationary when actually submerged to provide a safe habitat and not move due to any currents or other forces in the water. The final test was the most important in relation to usefulness of the reef. An artificial reef needs to support growth of aquatic and plant life to create a desirable habitat and growing algae proves if the barrel is a suitable surface for growth.



Prototype 1 failed the first test when dropped horizontally, as shown in figure 3, falling just over 2 inches away from the drop zone. It passed the first test when dropped vertically, as show in figure 4, only falling a quarter of an inch away from the drop zone. When dropped, both vertically and horizontally, prototype 1 landed in the correct orientation, passing test 2. Prototype 1 failed test 3 and was completely swept away in moving water. Test 4 took 2 weeks, but the prototype supported algae growth and passed the test. Figure 5 shows the prototype sitting in pond water at the start of the test and figure 6 shows the growth of the algae after 2 weeks.

After testing the first prototype, we learned that the prototype needs to sink faster and more accurately. The prototype supported growth and landed in the correct orientation, but did not pass any drop related tests and did not fare well in moving water. The next design needs to be heavier so the barrel can withstand motion in the water and sink faster so it does not aimlessly float before reaching the bottom of the tub. The biggest surprise was how buoyant the prototype was. It was very light under the water and as it floated to the bottom it drifted around the tub.

Tests will remain the same for prototype 2. The tests gave accurate representation of challenges faced in dropping an artificial reef and gave essential feedback for the redesign of prototype 1. We will remove the testing of life growing on the prototype because the material of the barrel will not change for prototype 2. The system of

measuring where the prototype landed will also be upgraded. We obtained all necessary information from our initial testing and can proceed to the designing of prototype 2.

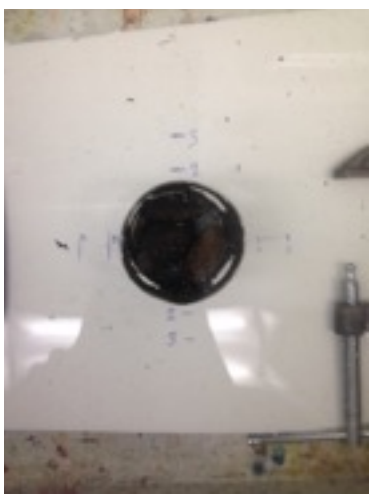
Prototype 2-

User Need / Feature / Requirement	Describe Test	What is “pass”?	Materials / tools needed to run tests
1.Accuracy of drop	Drop prototype in a bucket of water; measure if it falls in the acceptable drop zone	Falling within 2 inches of desired drop zone	Tub of Water, Target
2.Orientation after drop	Drop prototype in water vertically; observe if it lands in the desired orientation	Landing in the correct orientation	Tub of Water
3.Motion in current	Place prototype in moving water; measure movement from original position	Staying within 2 inches of its original position	Tub of Water, Target

Test	Attempt #1	Attempt #2	Attempt #3
1.Accuracy of drop	0.125 inches- Pass	0.25 inches- Pass	0.125 inches- Pass
2.Orientation after drop	Pass	Pass	Pass
3.Motion in current	0.25 inches- Pass	0 inches- Pass	0.125 inches- Pass

The tests for prototype 2 served the same functions as the tests for prototype 1. We tried to create tests that would simulate challenges faced when trying to drop the artificial reef from a boat to the seafloor. The main problem with prototype 1 was how heavy the structure was and this problem was remedied by adding a metal mesh to the bottom of the can to hold weight, displayed in figure 7. The weights used were rocks and could be rocks in the actual design. Prototype 2 was also only dropped vertically. Dropping the prototype horizontally resulted in too much surface area for the water to act against when sinking.

As shown in figure 8, the first change made to testing for prototype 2 was the device used to measure underwater movement. Prototype 2 landed nearly in the center of the bull’s-eye each time it was dropped as shown in figure 9. Test 2 was also successful for prototype 2, the rocks did not cause any shifting that would cause the structure to fall over. Figure 10 shows a whirlpool we created and prototype 2 remaining stationary at the center of the bull’s-eye. The prototype passed test 3 no matter how strong the current was.



The testing of prototype 2 went much better than prototype 1. The added weight created a steadier descent into the water and a more stable structure when sitting on the bottom of the tub. The prototype landed in the center of the target when dropped and did not move when current acted on it. The rocks stayed contained within the can and did not cause any shifting once it landed. The design of prototype 2 was much more successful during testing than the design of prototype 1. The addition of rocks on the bottom of the barrel would not create additional costs and would add a natural element to the artificial structure.

Business Case

Here is the table of our costs and profits. The cost to cut the drum will depend on the cost of labor or machinery if cutting is done on site. The cost of transportation varies based on the destination of the Artificial Reef.

Service/ Material	Wire Netting	Cutting Fee	Labor	Transportation
Cost	$25 per one	about $25	Depends	Depends on Location
Total	$50			
Selling	$400 each			
Total Profit	$350 each			

Assumptions:

1. The cost of decontamination is not included. The drums previously had chemicals inside, but these do not seem to be harmful to aquatic life, so we will assume cost to be $0
2. The drums are free materials since they were previously thought of as waste.
3. We do not include the taxes of making and selling.
4. No discount for selling in bulk.

We summarize all of the assumptions and potential costs, which should be within $100 per drum, so the total profit would decrease to $300 per drum. If the artificial reefs are produced in large numbers the cost of transportation will be less of a factor due to higher quantities of products being sold.

Lesson Learned

a. If a third prototype were created, we would try and create something closer to the actual size and weight of the 50 gallon drums. The first two prototypes were much smaller and lighter which would change results for testing in water if they were actual size. Our tests could also be improved on a larger scale. Two main factors would need to be expanded upon, a deeper tank for dropping the prototype, to simulate an ocean drop much better, and the ability to create more complex and uniform current flows. Larger scale tests would provide data more accurate to an actual ocean drop. Also, more time to see results of testing would give more accurate results. We could place other marine life in with the prototype to see how they interact, and see if the prototype rusts and becomes uninhabitable after a certain amount of time. These newer tests would be along the same lines as the original tests, just on a larger scale.

b. Our team worked very well together. We followed a schedule and each member had different roles in the project. Each of us had different ideas of recycling and we collectively choose an artificial reef as the final project. We created models for our designs in SolidWorks, but actually creating the models was a bit more difficult and required us to utilize our machine-shop skills. Work on the final report and presentation was divided evenly amongst group members and led to very efficient out of class meetings because roles and expected work was already agreed upon beforehand. This project helped us improve our technical and communications skills.

c. Communication was hard at times among the group because we have two Chinese members. Sometimes we needed to spend more time on explanations about our current task and on discussions about work that was expected of us. Also, prototypes 1 and 2 do not differ in materials or size, to more accurately represent the final product. We had difficulties finding suitable materials for testing and creating our prototypes and eventually settled on aluminum cans. We could have decided earlier on materials we needed instead of looking for whatever was available when we needed to make our prototype. Time was not always used efficiently either. Most of the creation of the prototypes and testing only required 2 people, which left 2 other group members standing by watching. These two group members worked on other jobs that needed to be done for the most part, but at times there was no other work to be done.

d. This project as a whole could be improved if less importance was placed on prototyping and more importance was placed on the business plan itself. Many of the ideas proposed did not have very innovative designs that would need more than an explanation to ArcelorMittal, who would be much more interested in the waste that gets used and the money they either make or need to spend. The project would be improved if more focus was on how these plans would be followed or carried out rather than what materials are needed or what the designs look like.