Project "Catch the rain, stop the pain"

By Andrew And the Optimists

DEM Project
EDSGN100-Section 20
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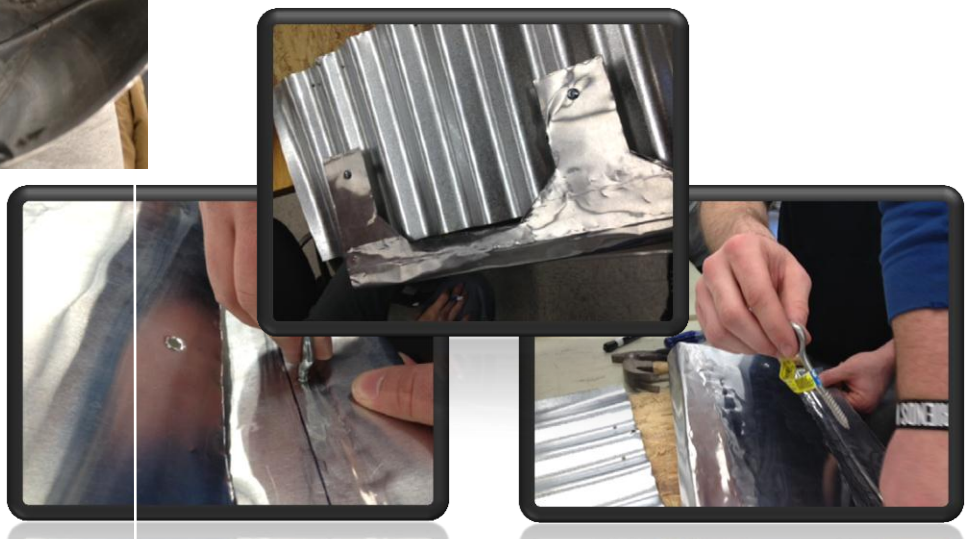
By: Andrew Geil, Greg Frasch, Richard Whitehead, and Aldo Zurita

Final Design



Penn State

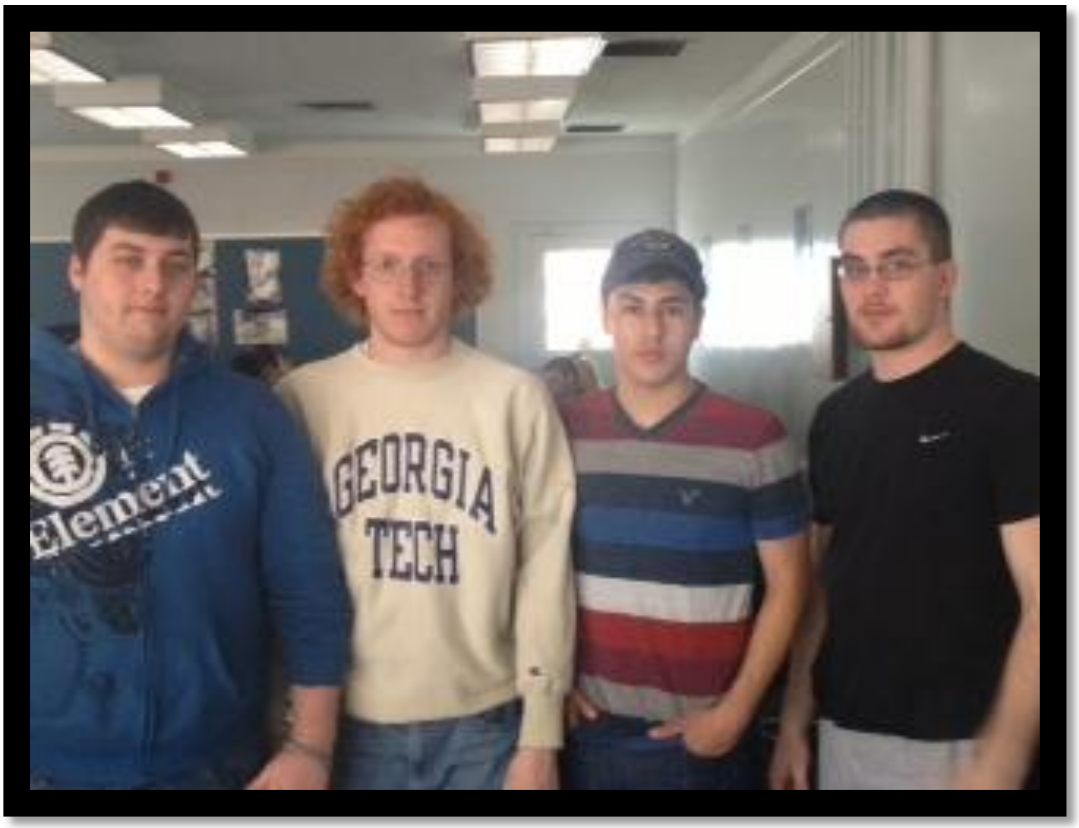
Responsibilities

Aldo Zurita (Historian, Data Collector, Final Editor)
Front Page information, Problem Statement, Concept Development

Greg Frasch (Manufacturing Director)
Testing- Prototype 1

Andrew Giel (Testing Expert)
Design Refinement (Prototype #2) and Testing

Richard Whitehead (Sketch Designer, Background Information Analyst, Final Calculations)
Costing, Lessons Learn



Project "Catch the rain, stop the pain"

The name reflects the purpose of the project.

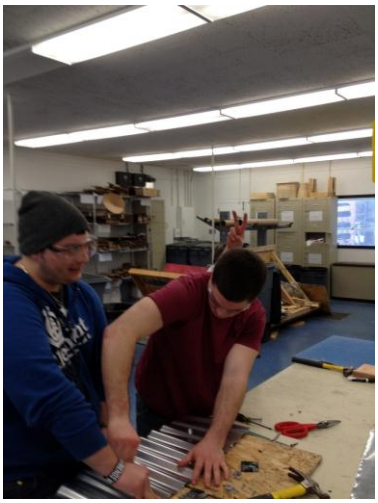
Problem Statement:

The project is centers in the creation of water channels, in this case gutters, that efficiently collect water allowing for the creation of a rainwater harvesting system. The gutter has to be robust, light in weight, easily attachable, and 1$/ meter in cost. A simple design will ensure that the design can be replicated. Additionally, the materials used in its construction should be readily available in the region. The gutter has to be attached with a minimum effort to a tin corrugated roof with readily available tools.

Concept Development:

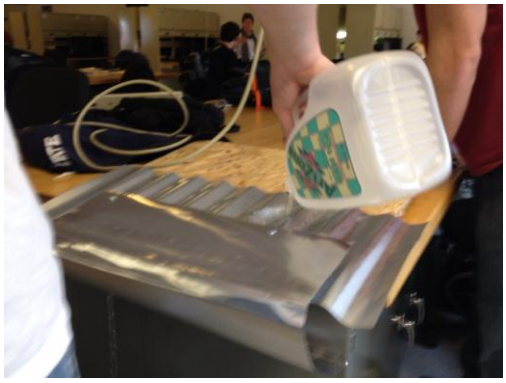
We gathered our date from public online resources ranging from governmental sites, one of them being Open data Kenya and Kenyaspace, to international weather agencies online data. Our region of concentration is the Central Highlands and Great Rift Valley in Kenya, specifically, the Kenyan city of Nakuru. Consider the fourth largest city in Kenya, after Nairobi; the city is located in the south east part of the rift valley province. This area experiences from 1800mm to 2000mm of rainfall annually, with its highest numbers during April and May. Out of the two April has the greatest precipitation.

Prototype #1 Pictures

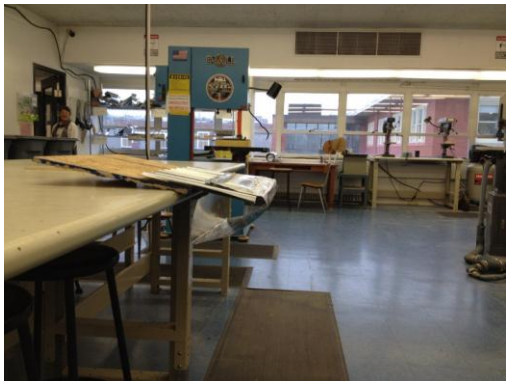


It's necessary to replicate the roof that Kenyan houses have in order to build a realistic prototype.

Water has to be able to run down the roof and into the gutter.



Water can come from different directions, having an impact on the quantity of water collected



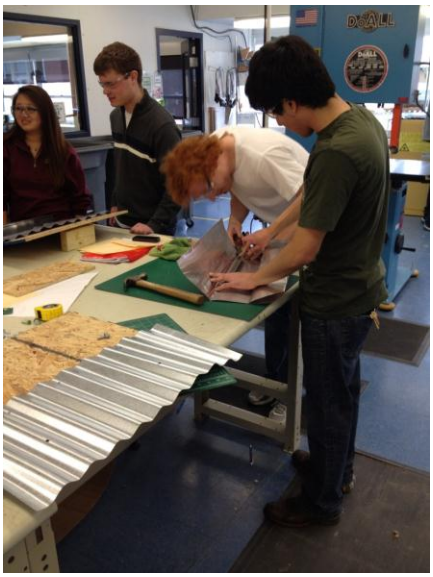
The final model has to be appealing to the senses.

The gutter has to be strongly attached to the roof.

The capacity of the gutter has to be greater than the water precipitated.

The gutter has to be easily attachable to he roof.

The gutter has to be able to adapt to different roof designs.



The design should be simple enough in order to mass produce the product.

Simple tools are used in the construction of the gutter.

Sketches

Provided in Chronological Order of Creation

Testing – Prototype #1:

Our tests for prototype one had a qualitative focus. Rather than obtain actual values, it was more of a pass/fail testing phase. We first poured a significant amount of water onto our roof to look for any leaks or overflow of water. Our first prototype successfully passed this testing. We proceeded to perform the same test, but this time we analyzed whether or not all water would be able to flow into the gutter from the roof. Our design was successful in this area as well. We then wanted to see how strong our design was by viewing the amount the gutter flexed when filled with water. This is where we encountered our first problem: our gutter bowed quite a bit. It forced us to brainstorm and we were able to come up with the solution of creating an attachment both above and below the roof. This ended up being strength of our design, with our gutter now being able to handle copious amounts of water without any problem. We also encountered another problem, the gutter was adaptable to different roof types, but the change we made solved this as well. Through our first round of testing we were able to address a significant problem and we progressively learned how to test more efficiently.

Design Refinement and Testing

After testing prototype one, it was clear that the design still needed work to make it more effective. One of the biggest problems that we saw with our first prototype is that it used up a lot of material and thus made the $1.50/m^2 over our max price. Another design failure that we observed was that the gutter flexed a great deal under the weight of the water. From these two issues, we then proceeded to create as many ideas for solutions as we could. In the end, we came up with three solid ideas for each. For the excess of material flaw, we proposed making the gutter shallow, moving the screw/attachment closer to the edge of the gutter, and only having strips of material on the top side of the gutter to secure it to the roof. Attaching the gutter back up, underneath the roof, to the wall of the house, or using a wire to secure the gutter to the house are all ideas that we as a group came up with as solutions. By using the concept selection matrix, we were able to compare our ideas to see which one was the best for our design. First, we took our design concepts and scored them (1-5, 5 being the highest) on how well they met our design features. When that was done, we took the AHP weights of our design features and multiplied them with the scores we had given the design concepts. By then adding the scores for each design concept, we were able to clearly see a winner. The solution for reducing material was to make the gutter shallow (and by the end of the project, using only strips of material on top of the roof to secure the gutter as well) and the solution for

the flexing of the gutter was to secure the end of the gutter back up underneath the roof. Even when we were discuss the possible solutions, we had a feeling that these design concepts would be the ones chosen; the concept selection matrix agreed with us. During on final testing, we discovered that we had made the correct fixes. The gutter now cost $1.8/m^2$. Also, we were able to eliminate almost all flexing of the gutter by attaching it back to the underside of the roof. Both of the solutions we chose were extremely successful decisions that helped our design to be the best it could be.

Costing

Materials

Equipment	Amount used per meter	Cost per amount	Cost	**Total Cost per m**
Nuts	6.5	$0.054 per nut	$0.35	
Screws	3.25	$0.12 per screw	$0.38	
30 Gauge Sheet Metal	2.23 ft^2	$0.48 per ft^2	$1.07	**$1.80**

We don't expect the installation to require any professional labor as the only part that the owner needs to do is to make half in hole in the roof. We were able to achieve this with only a hammer and nail, which in reality could be replaced by a rock and any hard, sharp piercing object.

Of all the design components that we set out to achieve, easy attachable, durable, use local supplies and catches all rainwater, meeting the cost requirement is the one area we have yet to reach our goals. While we did not reach the goal of $1 per meter our current cost of $1.80 is reasonable for such a strong project. It is important to note that this is just the price we arrived at after two prototypes during which the main concentration was fulfilling other product features, not price. If we had time here are quite a few ideas we were planning on testing that would decrease the amount material and therefore cost. After testing and implementing these ideas, we believe that we could make the $1 per meter require if not, come very close to it.

Lessons Learned

a) Despite only having the opportunity to construct and test two prototypes, we are very confident in and proud of the design we currently have. However, given one or two more prototypes there are a few other significant changes that we would like to test in order to maximize stability and efficiency as well as minimize cost. In order to lower costs there are quite a few tweaks that we would test. First of all, we would try removing the bolt that is on top of the roof and underneath the top lip of the gutter. As long as all the water was still able to pass under the upper lip of the gutter, removing the bolt would greatly lower the cost. Another way to decrease the amount of materials and thus cost, is to the increase the length between the location at which the gutter is attached to the roof. The greater the distance between attachment sites, the less screws and nuts we would use. Finally, we could make the attachment to the roof closer to the edge so that it doesn't require as much material to wrap around and connect underneath. We would have to test to ensure that this change doesn't put too much strain on the roof and still allows the gutter to hold enough water, but if we could find the ideal location we could save on the area of sheet metal needed per meter.

Besides testing different ways of minimizing materials and cost, we also want to test one design change that could make the gutter more durable. The pieces of sheet metal that were removed from the top of the gutter to lower cost were done without much thought behind the shape or amount of metal removed. We would want to test different shaped cut outs to find the right shape that minimizes material, but also is strong enough that it won't weaken or begin to bend over time.

b) The design and construction of the gutter went very well for the team. The design evolved from the original idea on paper to the current prototype as a result of smart insights and constant suggests from all the teammates. Specifically, Greg made a fantastic change in the gutter's underside attachment that made attaching the gutter to the roof possible and quite simple. Big ideas like this, as well as smaller, yet equally important, comments over the course of the design created an active environment for making sure we made the best product we could. Also during the construction of the prototypes in the lab, each member played equal roles in making the product. Aldo and Richie for the most part were in charge of creating the correct bends and shape of the gutter, while Andrew and Greg made the holes in the roof and the screw/bolt attachment. Roles did vary, but everyone was active in assisting in a quick production of the product.

c) While there was great passion about designing and building the product, completing the more tedious and less hands-on aspects of the projects didn't receive the same level of attention from all teammates. Writing test reports as well as doing activities such as sketches or AHP didn't garner the same effort. Some might have been slightly less involved in this part of the project, but all members at one point or another had a minor difficulty putting forth total effort. For example our test results report and our one page hand out at the show case were both edited and completed the class before they were due, when the team agreed to have them completed upon arrival to class.

d) The greenhouse project seemed like a very important problem to solve, yet I think a lot of teams were scared away from it because of its complexity. It appeared as a problem that requires in-depth chemical and materials knowledge in order to successfully pursue and solve. If more background information and guidelines to what the students would experiment with were given with the introduction, I don't think the project would have seemed as intimidating.

Since most of the teams choose the gutter project and ruled out the greenhouse one, it would be beneficial to offer another option that could catch the attention of groups with different interests than the other two projects.

Overall though I think the DEM project was presented and managed perfectly. The gutter problem was presented to the students with just enough information for them to understand what they were trying to solve, but not too much information that would inhibit them from being creative, exploring, taking risks and learning from the process. Also two prototypes was a good amount. After finishing our second prototype, our group wished that we had the opportunity to make one more, but for the most part all the major changes could be made by the second prototype. It could be argued that adding one more prototype would be helpful, but it could require extra or bore the teams with too much time spent on one project.