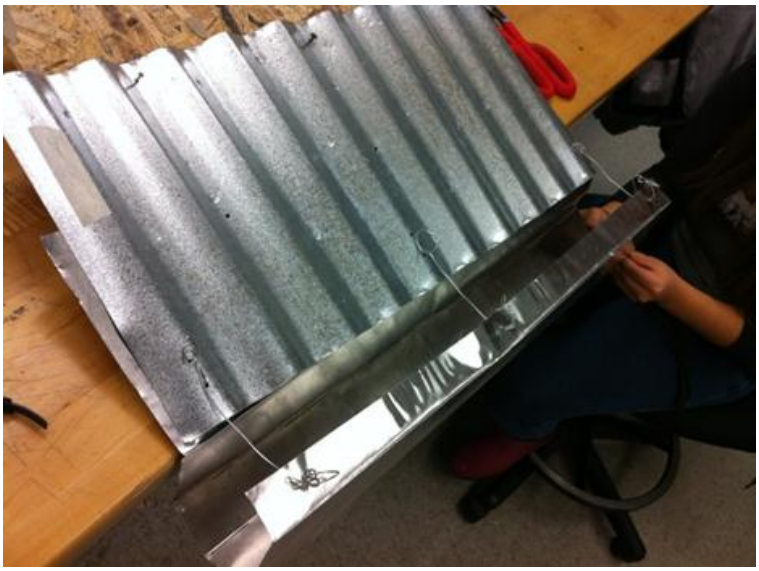
Gutter, Water Obtaininator



Aesha Kewalramani- Problem Statement, Concept Development

Brendan Bishop- Cost, Final Editor

Jeremick Agudelo- Lessons Learned

Terry Kim- Testing, Design Refinement

EDSGN100 Sec 20 Liz Kisenwether

Problem statement:

To make an effective rainwater harvesting system for the houses in rural Kenya using gutters that will be attached to a corrugated tin roof.

Concept development (Prototype #1)

Background information (societal, economic, history) about rural Kenya

Our team distributed the work amongst our teammates and each member of the team did research on different aspects of the country which we compiled. The results were as follows:

1. Economic:

   The economy of Kenya is unstable at best. The long term success of their economy is in question though, due to the lack of investment in infrastructure and corruption within the government. They have a high unemployment rate of 40% (Heritage, CIA). The inflation rate is currently 14% but is decreasing. 50% of the population is currently under poverty level. (CIA)

2. Climate:

   Kenya's climate varies across the country. The coast is very hot and humid, the inland experiences cool weather, while the north suffers from dry heat. On an average, the temperate ranges from 20-30 degree Celsius. During April and June, Kenya experiences long rains, and short rains from October to December.

3. Infrastructure:

   In rural Kenya, buildings vary greatly in design and architectural material. Some walls are made of bricks, others concrete, stone, mud, iron sheets, a few of glass and even paper bags and cardboards. Mud houses are more common in rural Kenya.

Desired features for prototype #1:

1. We wanted to attach the gutter and the roof at an angle which would result in the minimum wastage of water. (the roofs in rural Kenya vary in their angle of inclination so we could not decide a solid angle because it would change depending on how steep the roof is)
2. Cheap and durable holder to prevent the gutter from bending out. (We chose metal wires)
3. Let the gutter be at a slanted angle that is one side be lower than the other to avoid puddles in the gutter. Also to enable water to flow out from one side only.

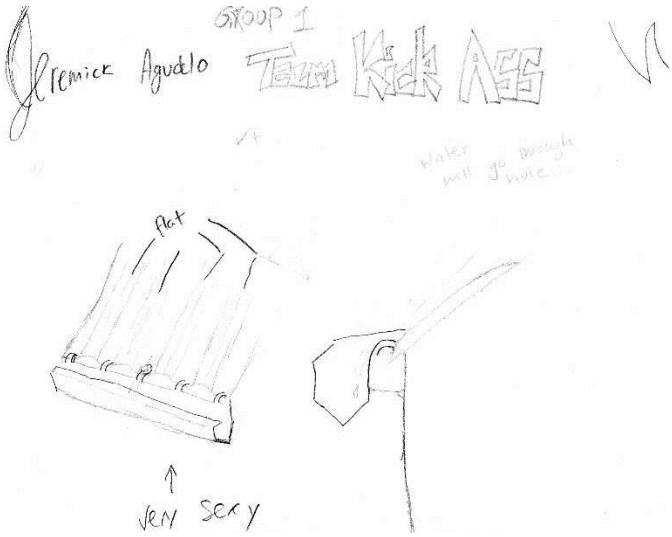
The team's AHP (Analytic Hierarchy Process) table with weights

	Safe	Cheap	Compatibly	Hold gutter at max.
Safe	1	0.5	0.7	1.8
Cheap	2	2	1.4	0.6
Compatibility	1.43	1.43	1	0.8
Hold gutter at max. capacity	0.556	0.556	1.25	1
Min. spillage	1	1	0.66	0.714
Easy to replicate	0.83	0.83	0.83	0.625
Easy to install	0.5	0.5	2.5	1.11
0.0874	0.0874	0.0874	0.0874	0.0874

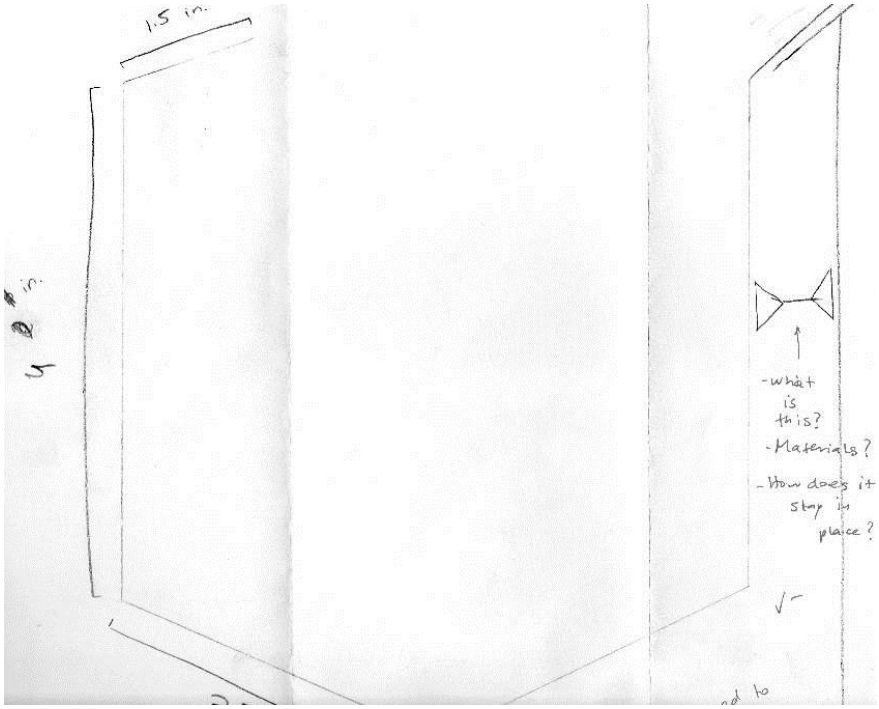
Optimize water collection	Min. spillage	easy to replicate	easy to install	Total	Weight
1	1.2	2	1.6	9.8	0.1349
0.5	1.3	0.3	1.4	8.5	0.1171
1.5	1.2	0.4	0.8	7.3	0.1005
1.4	1.6	0.9	1.7	10.073	0.1387
1	1	0.4	1.4	8.174	0.1126
1	1	0.3	1.2	6.554	0.0903

2.5	3.33	1	1.6	15.87	0.2185
0.0874	0.0874	0.0874	0.0874	0.0874	0.0874

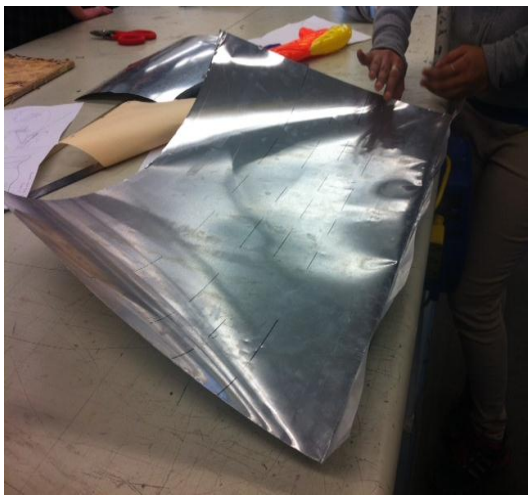
Early design sketches:

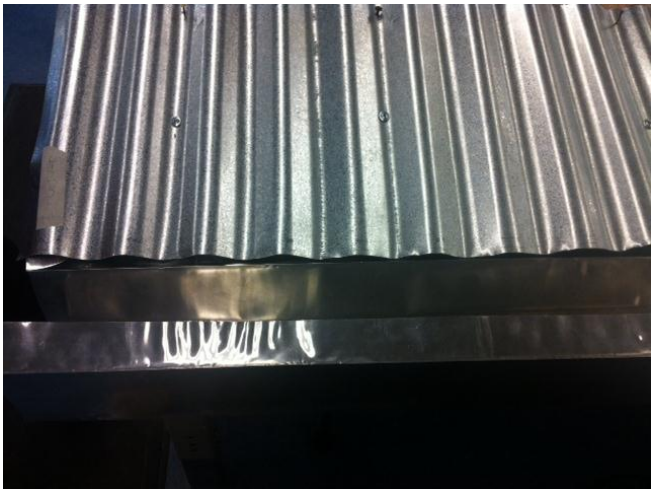


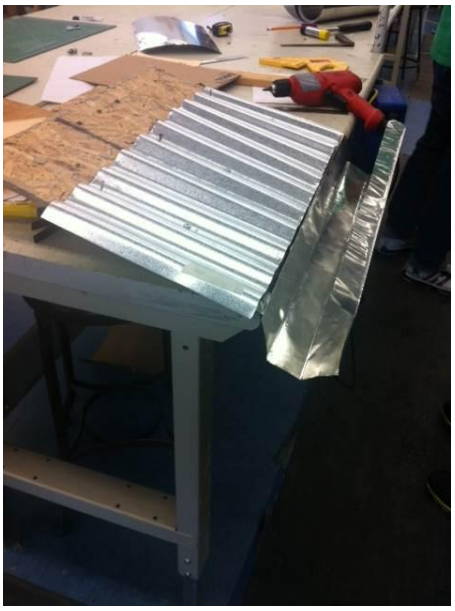
Final design sketch:

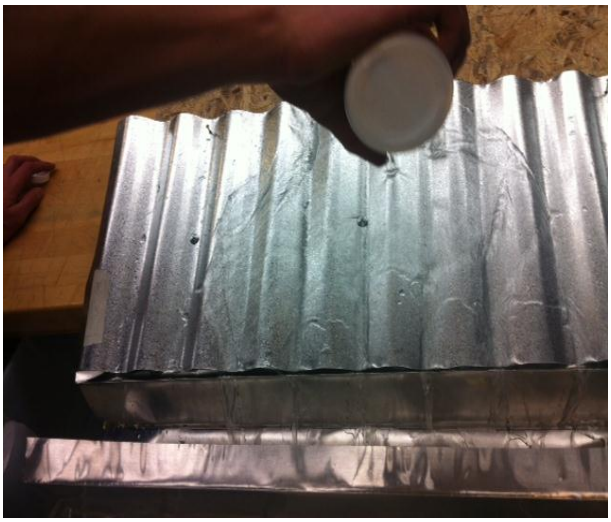


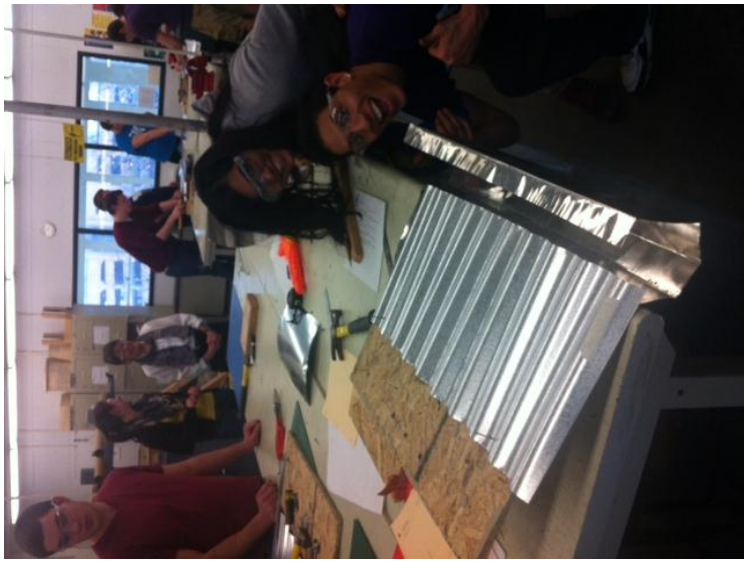
Prototype #1 photos:











Product name:

GUTTER WATER OBTAINATOR - FTK(For the Kenyans)

The main purpose of our project was to design a channel (gutter) for a rainwater harvesting system for rural Kenya. These channels will then guide rainwater into a tank or irrigation system. Therefore we think the name that we chose is very appropriate and conveys our design idea which is basically a gutter used to collect water for the houses in rural Kenya.

Testing – Prototype #1:

What were the test results for prototype #1? Did the prototype #1 test results impact the team's redesign? What other information, experiences or insights impacted prototype #2 design?

While testing prototype #1 by constantly pouring 1.75L (1750mL) of water with the average water rate of 260mL/s on the roof as a demonstration of rainfall, we observed that the 0.03mL/cm^2 of water was being caught in between the roof and the gutter. This was because the angle that the gutter was folded, which was about 80 degrees, was too close to the base of the tin roof. Also, a self-tapping screw was screwed into both tin roof and the gutter, which was a temporary method of gutter attachment and caused a tight squeeze between the roof and the gutter than we did not intend. Moreover, water was flowing out of the both ends of the gutter, and the gutter was bending out easily (approximately 0.00286 degrees/mL of water poured) with the heavy rainfall. There were about 0.001mL/cm^2 of water remaining on the gutter itself, but we determined that if we fix the gutter to make the water to flow out to one way, this problem would go away. The water we collected from the plastic box after we poured down the roof and the gutter was approximately 1.71L (1710mL) and the rate of water flowing out of the gutter was 123mL/cm^2 in average from one side of the gutter. The prototype #1 test results revealed several problems that our team had to fix and redesign the prototype to fit the rural Kenya's need better. Our team went back to AHP table and created a design selection matrices to see what design modifications we can put on prototype #2 to minimize the cost and maximize the stability and capacity of the gutter at the same time.

Design Refinement (Prototype #2) and Testing

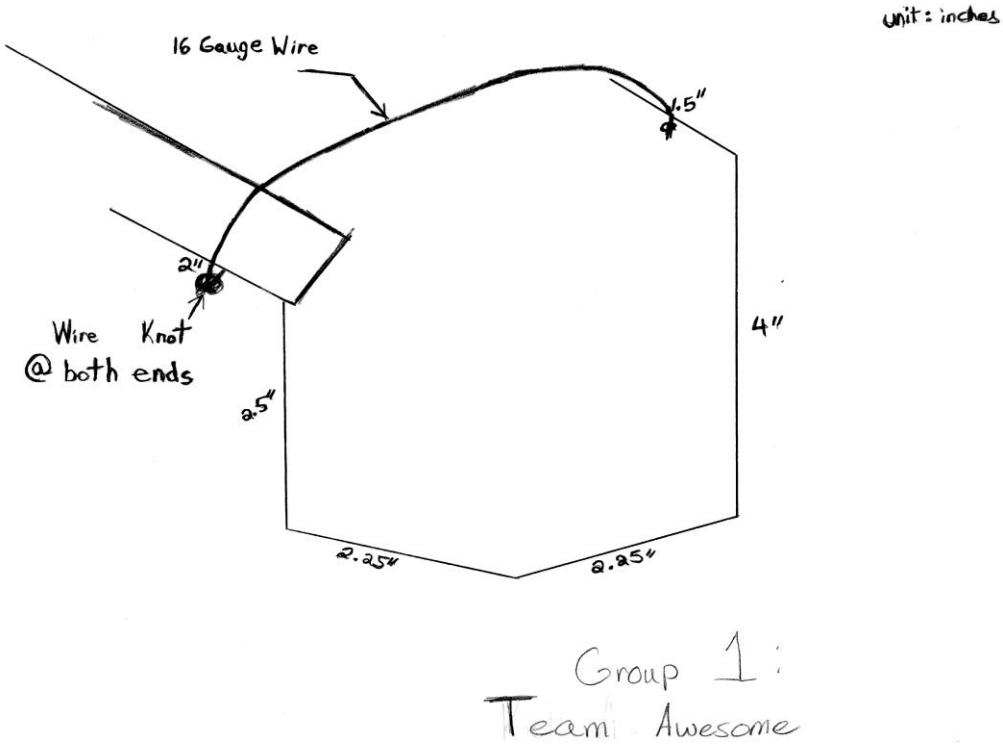
Describe how the team used the AHP and selection matrices (screening and scoring) to guide prototype #2 construction.

Before we jump into brainstorming modification ideas for the prototype #2, we wrote down our design factors and determined whether if each design factor is a feature or a constraint in prototype #1. We recorded what kind of test was done to test each design factors and the results of each test. After we have ranked the problems in the order that needed to be fixed first with the prototype #1, we started researching for the ideas of what we can do to minimize the current

problems. There were some design factors that contrasted each other such as the cost and durability or capacity. We went back to our AHP table and decided which design factor is prior and more desirable for the environment of rural Kenya. AHP table helped us choose the design factors that we ultimately needed to focus on for our final product.

Then, we worked on the selection matrices by coming up with three design concepts and weighted scores for each design factor and design concepts. The three design concepts were attaching the metal wire between the roof and the outer side of the gutter, replacing the makeshift screws with bolts, and attaching the magnet on the inner side of the gutter to hold the gutter and tin roof together. As a result, attaching the metal wire scored the highest. The selection matrices helped us choose which design concept fits our design factors best and which concept was the best for the rural Kenya's need. For the prototype #2, we made modifications by taking out the self-tapping screws and making two holes on both the roof and inner side of the gutter at three different places: one on the left edge, one on the middle, and another on the right edge of the roof and the inner side of the gutter horizontally. The first hole was placed on 2.4cm from the end of the roof and there were 1.5cm vertical gap in between two holes. Holes were drilled on the outer side of the gutter as well at three different places. Then, we made knots with metal wires on each end. The metal wire on the far most right side of the gutter was tied the tightest, so that the water flows only to one side.

Provide either a hand-sketch (clearly drawn with very dark lines) or CAD images. In either case, provide overall dimensional



information.

Include one or more photos of prototype #2

Report on success (or failure) in at least two tests of the final prototype.

Prototype #2 was tested by constantly pouring 1.75L (1750mL) of water with the average water rate of 260mL/s on the roof as a demonstration of heavy rainfall, which is the same condition that the prototype #1 was tested. As a result, we

observed that the 0.000123mL/cm^2 of water was being caught in between the roof and the gutter, which was a lot less than the prototype #1 and we determined that it is negligible. The water was flowing out of only one end of the gutter, and the metal wire was holding the gutter sturdily anchored to the tin roof when the heavy rainfall was demonstrated (approximately 0.000571 degrees/mL of water poured). There were about 0.0000315mL/cm^2 of water remaining on the gutter itself, and the water we collected from the plastic box after we poured the water down to the roof was approximately 1.749L (1749mL). These test results implied that our gutter maximizes the capacity and water collection. The rate of water flowing out of the gutter was 134mL/cm^2 in average from one side of the gutter. The maximum weights capacity that the gutter held was 0.412L/m^2 when it was tested with sand bags, and this result proved that our gutter is durable and safe because the maximum amount of rain fall in Kenya is about 15mm/day during long raining season. Our final product cost was $0.33/meter in US$, which meets the material cost goal of <$1/meter. Overall, our prototype #2 showed tremendous improvements from our prototype #1. The only constrain design factor that needs to be worked on prototype #2 is the easy replication.

Costing

For the actual gutter tin material the cost is $4.07 for a standard length of roof at 32 linear meters. The hanging material for this 32 meters is a total of $0.63. The total price for the materials then is $10.60 and then $0.33 per meter. With the labor costs being at $9.16 for two days of work the total cost comes in at $19.76. I feel like that is a fairly reasonable cost especially when the labor cost is probably a slight overestimate for when the skilled laborers get accustomed to building these, the process should be faster.

Lessons Learned

We feel if there was a prototype three then there would be a couple changes we would like to include. Clearly, if we had more time, we would be able to perfect our model a bit more and improve it. The first change we would do would be adding more of a tilt to our gutter. Though it already has a small angle to it, I think we would be able to increase it by a small percentage to make sure that no water escapes. Another aspect that I think we should work on is the method of folding

our sheet of tin. The way we accomplished this was by folding it and then we hammered it down, but this process caused a slight difficulty in pulling apart. This method left a slight pinch of the metal at all the corners. We are not sure if there are any machines in Kenya that are able to do this for us, but if not, we feel that this style will suffice. A test we would like to perform would involve a scenario in which there was an extremely heavy rainfall, to see how the gutter would withstand the force of the water. A couple of tests that we think are important, but do take time to test, would be testing the time it takes to install the gutter, and the difficulty of installing it. We would find people that know average knowledge of tools and construction and time them perhaps ask them questions on how the installation went.

We really believe that the price of our gutter came out to a nice reasonable total cost. We were able to keep our costs low by using minimal materials, and using the materials that were commonly found in all areas of Kenya. Another aspect of our gutter that we enjoyed was the extra bent on the far side of our gutter. This extra bent will prevent splashing water from escaping the gutter and maintaining all within. This last feature that we only came up with near the end was the method in which we are keeping the far side of the gutter from bending outward. At first we used thick electrical wires to hold it in place, but then we found a thinner wire that was easier to tie in a knot. We punctured a hole on the extra bent, tied a knot, and then punctured another hole on the roof tying another knot. This we feel will effectively prevent the far side to bend outward.

The one feature we feel could improve would have to do with the main way of securing the gutter, which we just screwed in. After some time they might get loose and the gutter might fall. Furthermore, we believe that our work ethic could have improved in the beginning, at the start we did not use our time wisely. As time progressed we started to work more efficiently and used our time to the fullest. As far as the roles of everyone, we feel that everyone contributed to the fullest and were great assets to the team. I do not believe anyone slacked off, but were able to pull their weight.

I really enjoyed working on the DEM project, it was a really fun and interesting topic to get us thinking like engineers. This not only was exercise for what we might be doing in the future, but we had a chance to help people less fortunate than us, which made this project that much more important. With that in mind, I do not believe there is much to change with the DEM project. Perhaps if we had a layout of all the materials available in Kenya, so we knew right away what we can and cannot use, so we did not have to waste time realizing that they were not available. Another thing that might need work on is the showcase; there was not much order to it. The projects were scattered and some teams were not able to stay because it was during another class. Maybe if the showcase was at a later time, possibly when most classes are over, then everyone would be able to show up.