Nic Cage Fan Club presents:
Pallet Pavilion

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Mission Statement:
Our Goal with this project is to minimize the waste of ArcelorMittal. To accomplish this we designed Pallet Pavillion, a low cost pavilion made of repurposed pallets, leftover after being used by ArcelorMittal. Pallet Pavillion is a 10ft by 20ft structure made almost entirely of wood from pallets. The goal for our product is that it will be low cost for consumers compared to what is currently on the market, durable enough to withstand the elements, easy to manufacture and be look appealing to the general public. The primary market for our product is ArcelorMittal. The secondary market is the consumers who will eventually buy Pallet Pavilions from ArcelorMittal. We hope our product will be a good way to recycle pallets and consumers with but Pallet Pavilion instead of other pavilions on the market.

About ArcelorMittal:
ArcelorMittal is the world’s leading steel and mining company with 119 million tons of annual production capacity. ArcelorMittal is a major supplier of steel for the automotive, construction, household appliance and packaging industries on a global scale. In 2014 they produced 93.1 million tons of crude steel and shipped 85.1 million tons of steel. Dedicated to “Transforming Tomorrow,” ArcelorMittal’s mission is not only to create high quality steel but also to do so in a safe environment while researching ways to create stronger and lighter steel in a sustainable way. In 2014 alone 375 million dollars were allocated to environmental and energy improvements. Among many improvements some include a new 75 million dollar, energy efficient boiler and committing 175 million in research to help reduce air pollution$^{[1]}$.

Selection Matrices:

![Selection Matrix](image)

Figure 1: The screening matrix shows preliminary scoring of possible concepts ready to be expanded upon.
In figure 1 there are four concepts we decided to explore regarding the recycling of old pallets. Concept A is a plan that includes using recycled pallets to create indoor and outdoor furniture that can be sold to the public for a profit. Concept B is an outdoor structure plan that involves creating sheds, pavilions, or pergolas out of recycled pallets that can also be sold to the public. Concept C would include grinding and chopping old pallets into much or fine pieces that can be used to create plywood. Concept D does not involve recycling old pallets but rather cuts off the source of the problem. Reusable pallets would stop the production of short term use pallets by creating long term use pallets that can be easily recycled. Reusable pallets are a long term solution.

![Table: Scoring Matrix]

**Figure 2:** The scoring matrix shows a numerical approach to picking the type of project to pursue.

Each concept was scored according to six selection criteria shown in figure 2. Each criteria was weighted according to importance deemed by ArcelorMittal’s goal of creating a safe and sustainable world. Furniture was used as a reference for scoring which means all other scores given were based on the relative strengths of the furniture concept. Outdoor structures scored higher than furniture due to a higher demand for outdoor pallet structures and a higher expected durability. Mulching scored the highest overall due to demand and overall material used and construction difficulty. This
The concept was not used however because of the high start up costs associated with creating mulch by grinding pallets into chips via a mulching machine. Reusable pallets was ruled out because of a low demand for a universal change to reusable pallets. Overall, we chose to design an outdoor structure because of its high demand and the amount of recycled material it would consume.

Prototype One:

<table>
<thead>
<tr>
<th>User Need / Feature / Requirement</th>
<th>Describe Test</th>
<th>What is “pass”?</th>
<th>Materials / tools needed to run tests</th>
<th>Pass?</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Ease of building</td>
<td>Build the scale model</td>
<td>The structure can be built in a reasonable amount of time (sub 30 min)</td>
<td>Popsicle sticks, glue, tape</td>
<td>Yes</td>
</tr>
<tr>
<td>2. Appearance</td>
<td>Take a survey (10 people) regarding the appearance of the structure</td>
<td>70% of people surveyed agree that it is appealing (out of 10 people)</td>
<td>10 people</td>
<td>Yes</td>
</tr>
<tr>
<td>3. Weight durability</td>
<td>Place weights in increments of 1 lb on the top of the roof to test for weight of snow.</td>
<td>2 lbs</td>
<td>1 lb weights</td>
<td>No</td>
</tr>
<tr>
<td>4. Wind test</td>
<td>Blow box fan at highest power on the structure from a top view, and two side views, 90° from top</td>
<td>Joints stay intact and structure does not move.</td>
<td>1 box fan</td>
<td>Yes</td>
</tr>
<tr>
<td>5. Rain test</td>
<td>Pour 1 liter of water in 1 min</td>
<td>Structure’s joints are intact after “rain”</td>
<td>1 liter of water and stopwatch</td>
<td>Yes</td>
</tr>
<tr>
<td>6. Protection from sunlight</td>
<td>Shine light simulating sunlight to see how much shade is provided</td>
<td>At least 50% of the area underneath the pavilion has shade</td>
<td>Flashlight</td>
<td>No</td>
</tr>
</tbody>
</table>

Figure 3: Testing plan shows descriptions of each test performed on prototype one, what qualified as a “pass” and whether or not it passed.
We first tested to see how long it would take to build our prototype. We timed how long it would take to build, and it took around 25 minutes. Our goal was under 30 minutes, so the prototype passed the test. This is an important test because workers are going to have to be paid to build these pavilions, and we want to minimize that cost in order to maximize profits.

We surveyed a group to see how they felt about our design. Out of ten people, eight said they would put our design in their backyard. Based on these results, our prototype passed this test. If no one finds our design appealing, no one is going to buy it, which is what makes this test important.

For our next test we tested how much weight our prototype could hold up. We felt that two pounds was a reasonable amount of weight for the scale of our design. After putting three cell phones weighing a total of approximately a pound on the roof of our prototype, we determined that it couldn’t hold any more weight, meaning it did not pass the test. Since it could snow in areas where our product is sold, the pavilion must be able to hold a substantial amount of weight.

Figure 4: Construction of prototype one.
In order to test the prototype’s resistance to wind, we took a box fan at max power and pointed it at the prototype, testing it from all sides to make sure it was stable. The prototype did not move and it held together, so it passed this test. This is an important test to pass because these pavilions could be sold in all sorts of areas, and these areas could potentially have strong wind.

Figure 5: “Rain” test for prototype one.
We used water to test how well the structure would hold up in rain as well as how sheltered someone would be from the rain. The water did cause some of the beams that acted as a roof to fall (mostly due to the fact that glue was holding it together and not something more secure), but the structure itself did not collapse, which is what we were testing. The structure passed the test, but some adjustments could be made in order to make sure the roof doesn’t collapse on the people under it. From a shelter standpoint, the roof we designed is not efficient at protecting from rain. People are probably not going to be as likely to buy a pavilion if they are not protected from the elements, so it is important for it to pass this test.

![Figure 5: Protection from sunlight test.](image)

For our final test we went into a dark area and used a flashlight to test how much shade the roof creates. From most angles, there is a lack of shade, so our prototype did not pass this test. People are going to be more likely to buy a pavilion that shades you from the sun over one that has only partial shade.

Based on these results, we have concluded that our first prototype does not serve much purpose other than to be aesthetically pleasing. It is not a great spot to sit under, but it is a good place to put plants and such, as vines can grow along the roof. These tests revealed that our pavilion’s roof is not very practical, so we definitely will want to change that for prototype two. Also, if our prototype fails a test structurally we cannot say it completely failed, because glue and tape aren’t exactly the strongest way to hold things together (A final product would likely have screws or nails).
We were surprised that the people we surveyed said they would be willing to buy our product despite the roughness of our prototype. It was also surprising that it held together under the amount of water we dumped on it.

Based on how well our tests worked on prototype one, we are not going to add or remove any tests when testing prototype two. After dumping water on our prototype, we realized we could have expanded upon our description of what constitutes as a “pass”. While we tested to make sure the structure could hold up in the rain, we should also test to see if any water collects under the pavilion.

Prototype Two:

Figure 6: Several views of prototype two after complete construction.
Upon considering the results of the tests we performed on prototype 1, we decided that it would be beneficial to change the overall design of our project by adding a full roof, instead of the partial roof. This is because we felt that it would be more attractive to customers if our pavilion could protect from sunlight and rain. We also added more supports so that the pavilion would be more structurally sound, as seen in figure 6 above. After building prototype 2, with the aforementioned changes, we ran the same gauntlet of tests as we performed on prototype 1.

![Figure 7: Rain test of prototype two.](image)

The next test we performed was the water test. This time our project passed with flying colors. Not only did the newly added roof protect from water much better than in prototype 1, but there was no popsicle sticks falling off afterwards, which means that we did a better job in attaching the sticks together to make the roof. Only a few drops of water were able to pass through the roof, but this problem would be alleviated in the full scale model because the planks would be attached with screws, not hot glue, allowing for a better fit with less gaps.
The next test we ran was the sunlight test. After performing the test the same way we did for prototype one, we found that yet again the new roof improved the results dramatically. The full roof protects against sunlight at all angles immensely better than prototype one's roof. This means that prototype two, yet again, passed this test much more easily than our previous model.
Much like the wind test from the first prototype the structure held firm passing the wind test. With a closed roof design we noticed that the roof, while it may be minimal, was working to redirect some of the wind over the pavillion which is more that prototype one did with an open roof design.

![Prototype Image](image)

**Figure 10:** Strength reinforcements are shown by arrows on prototype two.

As for the weight test we managed to stack a max weight of 4 pounds on our pavillion before the legs started to give way. This is a great improvement from our last prototype, which was only able to hold about one pound. We added only a few additional reinforcements to the structure which proved to increase the strength by a factor of four. These reinforcements are marked in figure 10.

**Business plan:**
In order to reduce the amount of wasted pallets and acquire revenue simultaneously, leftover pallets that are still in usable condition can be taken apart and the wood repurposed to build pavilions. This could be done either in-house or by hiring another
company. These pavilions could then be sold to the public for a price of $1000. To determine this price, we took the average number of planks on a pallet (12) and divided the amount of planks used in a pavilion (about 330) by this. Multiplying this quotient by the cost of one pallet ($14) the total came to $490. To this, we added the estimated cost of wood not found on pallets, screws and labor and arrived at a final cost of $1000. This would be appealing to customers because these would be much cheaper to buy than a pavilion using all new materials. On the market pavilions can cost upwards of $6000 such as the Del Norte Outdoor Kitchen Pavillion[2]. These could also be advertised as good for the environment because they use 100% recycled materials.

Lessons learned:
Add or change anything if there were a prototype 3?
Add or change tests?
What went well?
What did not go well? -- How would it be fixed?
How could overall project be changed for the better?

Citations:

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