Red Oak Hail Test Ice Cannon Project Report #1

Summary

The goal of this experiment was to understand how an assortment of Class IV shingles would perform under various simulated hail conditions with respect to each other. Differences in damage were observed when accounting for variations in the size of the projectile, the distance it was fired from and how much force was used to fire it. The top three best performing shingle tested were the Malarkey Legacy, F-Wave, and the Atlas Storm Master. The worst performing shingles were the Mystery Shingle, Tamko Heritage IR, and the IKO Nordic (see figure 4). Another finding of note is that the OC Duration Storm and Flex both performed very similarly.

Final Ranking- By Average Damage (Best Performance to Worst)

1. Malarkey Legacy
2. F-Wave
3. Atlas Storm Master
4. CertainTeed landmark IR
5. OC Duration Storm
6. OC Duration Flex
7. IKO Nordic
8. Mystery Shingle
9. Tamko Heritage IR

Analysis

A total of 63 projectiles were fired from the ice cannon. The PSI of the chamber prior to launch was recorded and rounded to an interval of 5 (5,10,15 PSI etc…) the average pressure of the cannon at the time of firing was 50 PSI. Figure 1 below is a histogram of the entire set of projectiles launched to better understand the distribution of firing.

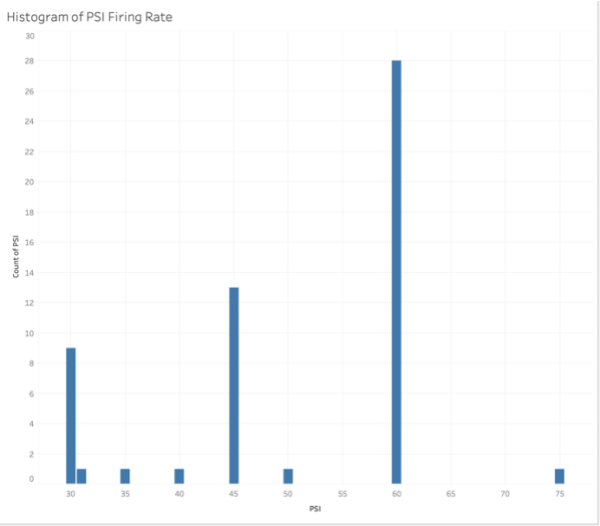

Figure 1: Histogram of PSI firing Rate

The histogram above demonstrates that there was a reasonable distribution of PSI firing rates. Namely a low end (30 PSI), medium (45 PSI), and a high value (60). In future experiments it will be best to stick two only two levels a low and a high which will enable us to perform more complex and informative statistical analysis such as an ANOVA analysis (Analysis of Variance).

Next, average damage vs PSI was analyzed to verify the hypothesis that a faster moving piece of ice results in more damage.

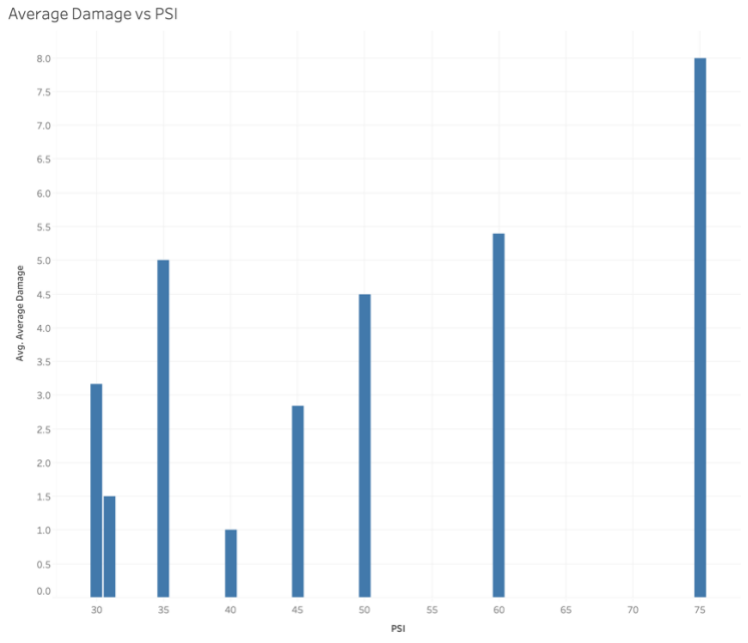

Figure 2: Average damage vs PSI

The above Figure 2 confirms, visually, that a higher PSI generally resulted in more damage to the surface. Again, we do not have a larger enough data set to assert with statistical significance

that this was due to causation rather than correlation. Although it does appear to be a reasonable assumption.

Results

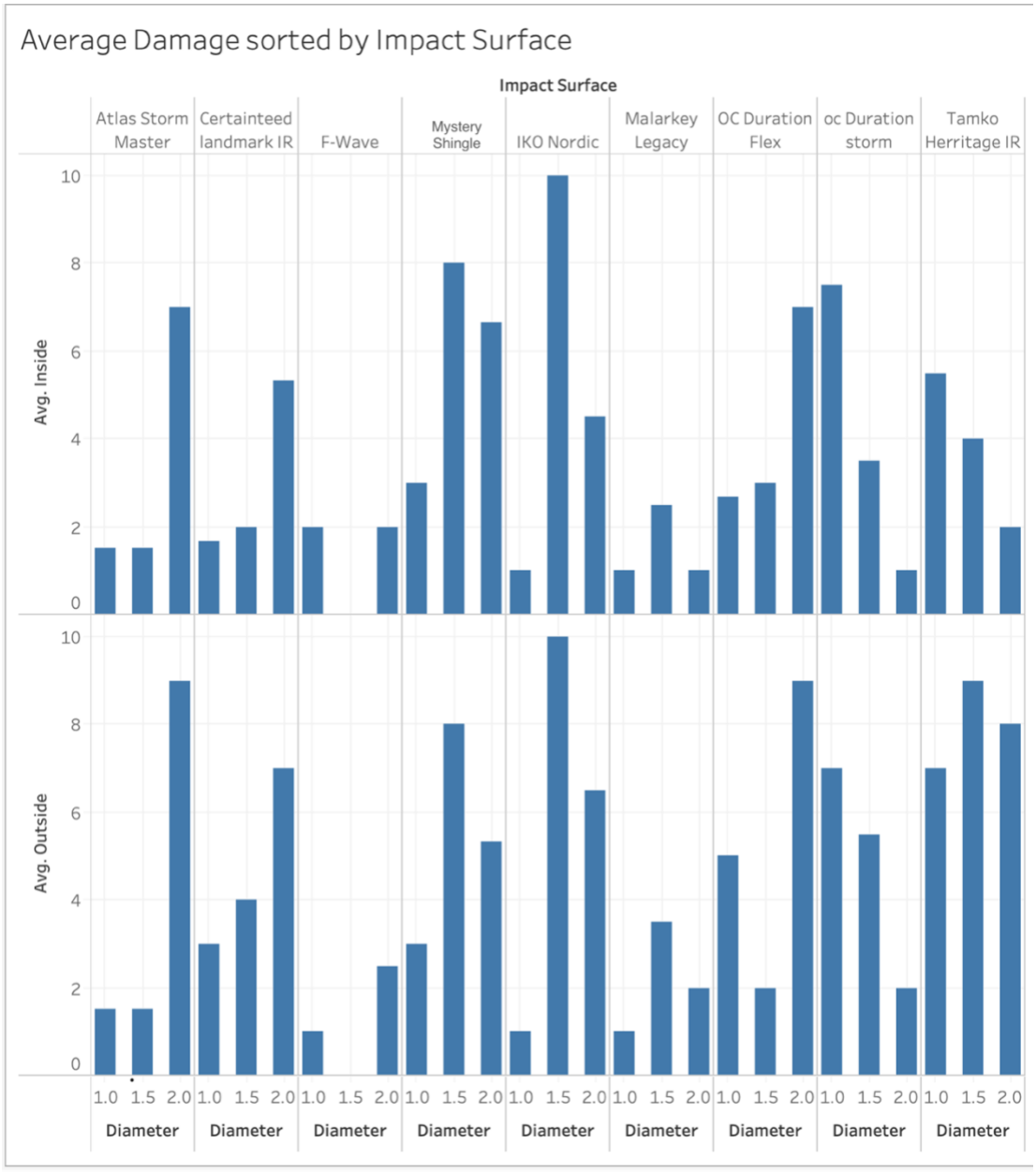

Figure 3: Average damage for inside outside with diameter resolution

A surprising finding during the analysis is that the 1.5 diameter ice generally did the most damage. This requires further investigation to explain, however one hypothesis is that 1.5 inches is the perfect balance between large impact and ability to reach a damaging velocity.

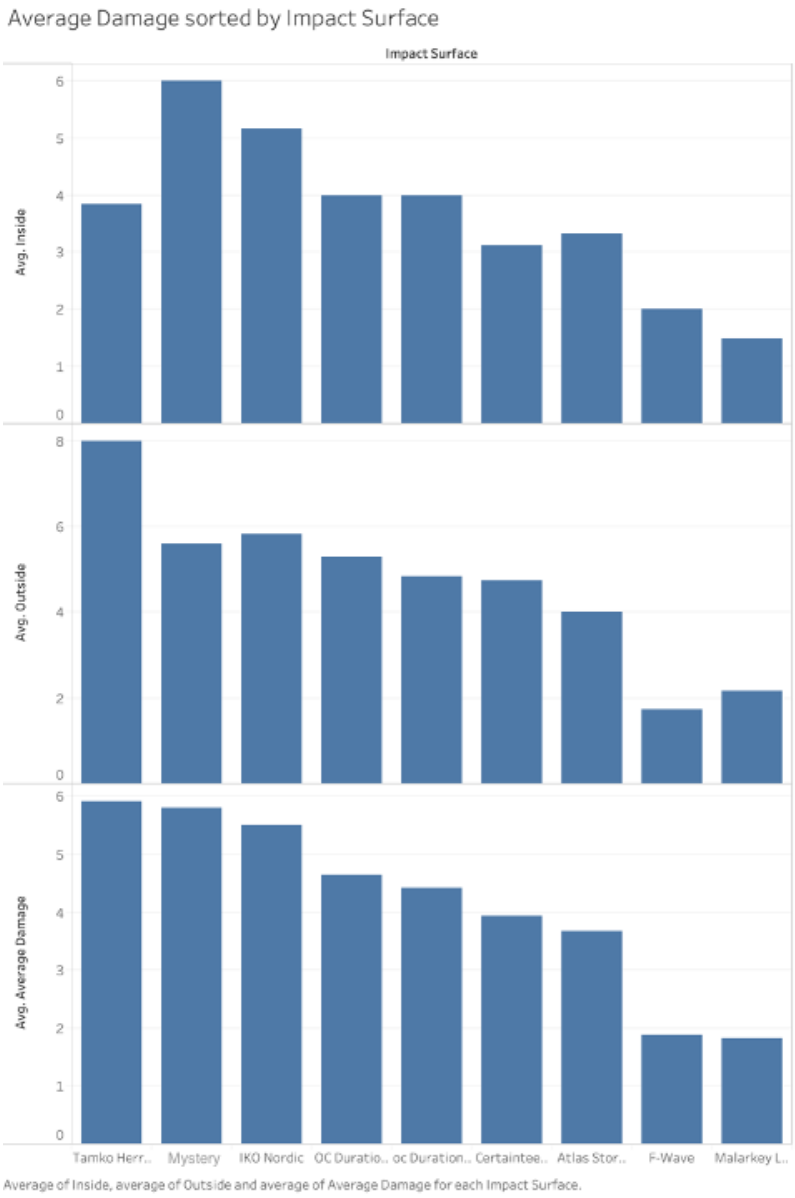

Figure 4: Average Damage by Impact Surface.

This above graph is very interesting, It shows the average damage for all nine surfaces that were tested. A lower number indicates better performance, so the top three performers were F-Wave, Malarkey, and Atlas Storm.

Methodology

A cannon was designed to shoot projectiles of ice at three different diameters (1 inch, 1.5 inch and 2 inch). It was informed by the ASTM International Testing E1038 Protocol for measuring impact on photovoltaic cells. Although in these trials we did not test a PV module, the experimental design will allow us to do so in the future and compare results accordingly.

First the cannon was designed and verified to shoot projectiles in the desired range of speed. The desired range was between 25 m/s and 92 m/s which simulate the range of actual hail impact when accounting for variations in size, angle and windspeed.

Data was collected on September 24th and 25th 2020, with temperatures ranging between 70-90 degrees Fahrenheit. The distance between the cannon and the impact surface was recorded as was the PSI of the cannon, the diameter of the projectile, the impact surface and resultant damage. The speed of the projectile was not directly recorded, but many of the trials have a slow-motion recording that could be used to calculate the velocity. Additionally, the PSI of the cannon should serve as a proxy for velocity and can be used to extrapolate velocity. A total of 63 trials were run with a total of 8 data points removed because they were outliers. Examples of outliers occurred when the impact hit an already damaged section of shingle or if the shingle was not properly resting on the panel. Each trial was scored by the damage done to the outside and the inside of the shingle on a 1-10 scale.

This study has a few limitations, primarily proving statistical significance with so few trials is not possible. However, there is definite validity to some of the findings specifically, that there is a large range in how much force it requires to damage a class IV shingle. Additionally, for a higher resolution and better analysis the experiment should be done with more consistent processes, (like accounting for how long the projectile sits in the barrel) and other environmental conditions like humidity and temperature.