

The Effect of Blade Curvature and Angle-of-Attack on Helicopter Descent

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Summary

My R&D was to figure out if the helicopter blades on a 4.5 PVC pipe worked better than a helicopter blades on a 1-inch PVC pipe. The first thing that I did was I soaked the blades in ammonia/water and then I taped the blades to the PVC pipes. I then wrapped the taped blades with cloth to hold the curved shape.

When I put on the blades I had to put them on a straight line so they were not twisted. The blades were: the standard blades, rectangular blades, tapered blades, and Allison's Optimum blade shape from her R&D project from 2014. All of those blades were on the 4.5 PVC pipe. The Standard Blade and Allison's Optimum were on the 1 inch PVC pipe. While the blades were drying I started to work on the hub or the place where you put the blades on. My dad helped by building the hub.

The next thing that we did is went to a bridge that was 32 feet 2 inches tall. I dropped the Allison's Optimum and the Standard blade first that were on a 0 degree angle of attack, and the curved on the 1 inch PVC pipe. I dropped them 3 times each. To get the rockets back up we used a hook on a piece of string. Then my dad recorded the data at the bottom of the bridge.

Later I dropped the: Standard, Rectangular, Tapered, and Allison's Optimum on hub that put the blades at 3 degrees angle-of-attack, and was curved on the 4.5-inch PVC pipe. The last thing that I did was drop the: Standard, Rectangular, Tapered, and Allison's Optimum on the 5 degree angle-of-attack, and was curved on the 4.5-inch PVC pipe. My dad timed it and recorded the data. Then I found the average time for all the blades.

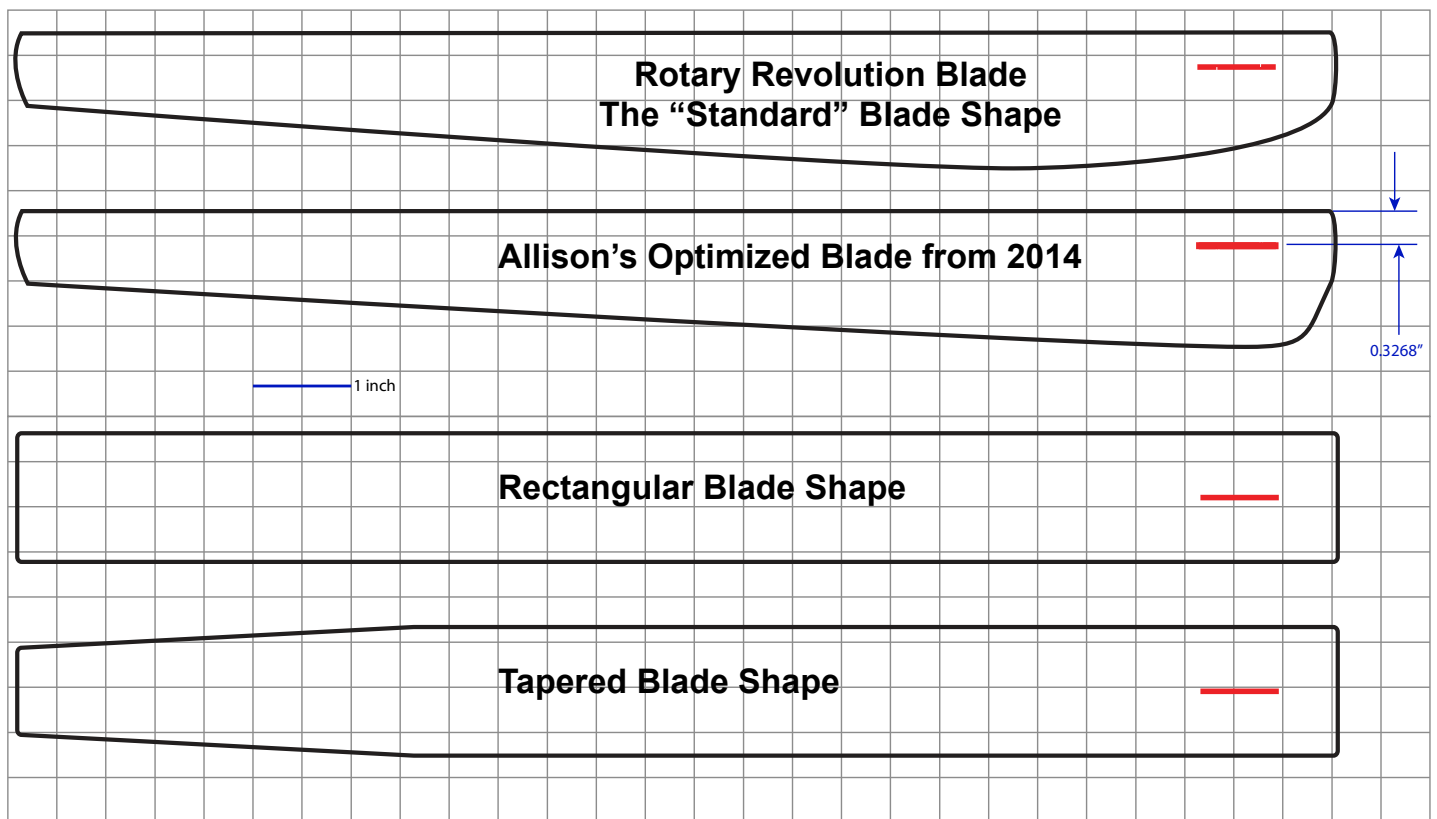
The Objectives of the Work

I got this idea when my dad was talking to Chris Flanigan. He mentioned, that according to his research, blades on a larger pvc pipe would work better than the ones we used in our rockets. So I decided to see if it was true.

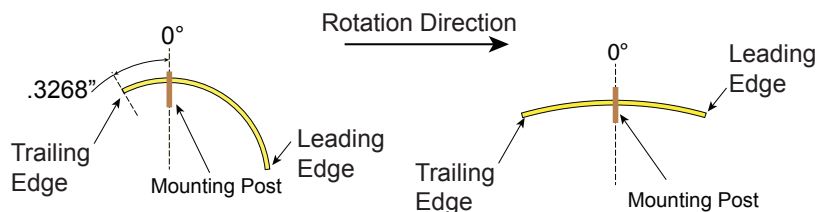
The Approach Taken

Step 1: The first thing I did was to choose which blades I would use for my research project. These blades were: The Standard Blade (which is used on the Rotary Revolution rocket kit from Apogee Components), The Tapered Blade, Allison's Optimum Blade, and The Rectangular Shaped Blade. The tapered blade and the rectangular shape were suggested by Chris Flanigan. The blades were made from 1/32" thick balsa wood.

The different blade shapes used in this experiment



Originally, the Standard Blade and Allison Optimum Blade were on a 1 inch PVC pipe. I used these because they are what I am comparing against. The tapered blade and the Rectangular Blades were on a 4.5-inch



Comparison of blades wrapped around 1" (left) and 4" PVC pipe
Blade curvature at root edge



Blades are wetted, and taped to the pvc pipe.



The curvature of the pvc pipe.



Blades are held in place with a cloth strip.



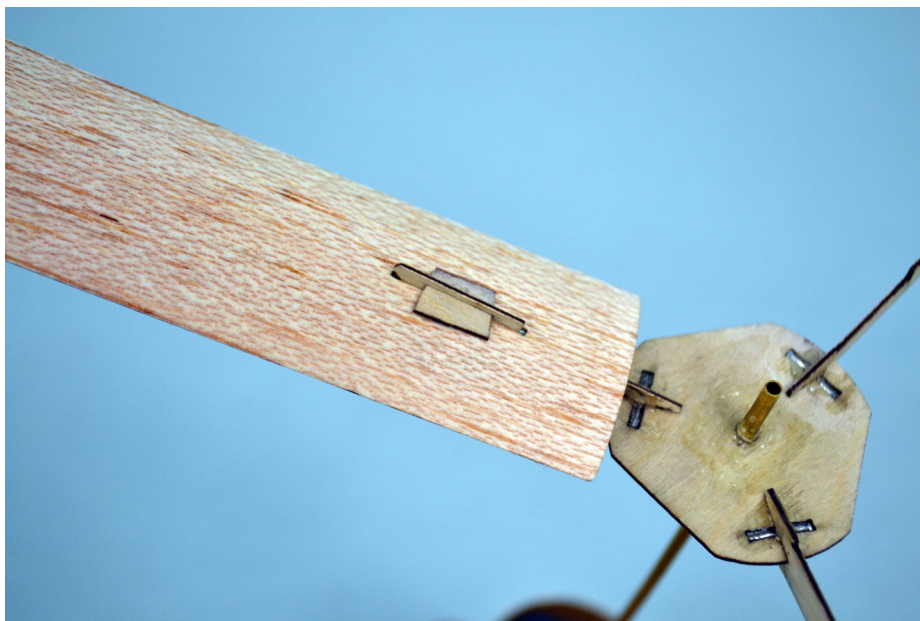
Removing the blades when they are dry.

PVC pipe.

Next I needed to get the blades curved so they would spin better. To get the blades curved I soaked them in ammonia water. Then I had to tape the blades on the PVC pipes because this was the curve I wanted to get. After I taped the blades I wrapped them in cloth. The cloth helps keep the curve and dries the blades (the cloth was a piece of ripped off bedding sheet).

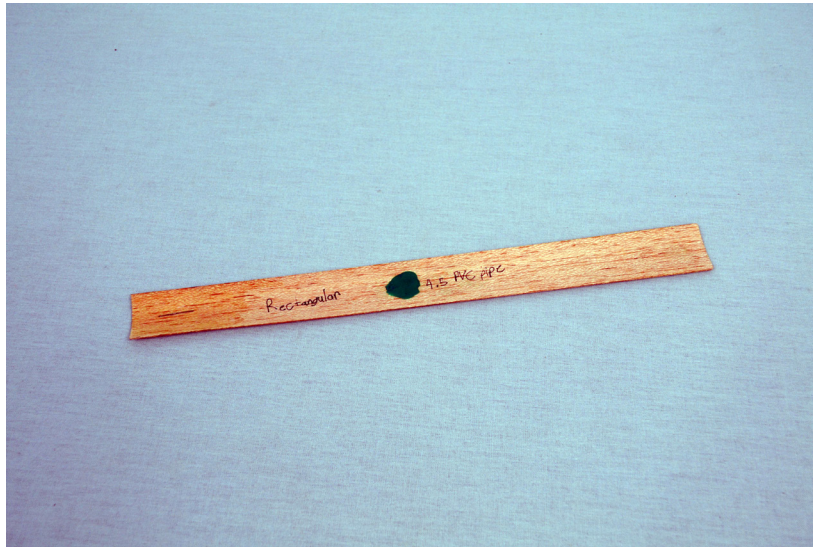
After this I stuck the blades outside in the sun to dry for about 2 hours. I had to do that for the 4.5-inch PVC twice because there was so many blades.

Step 2: The next thing that I did was find the part where the blades are put on, which is called the hub (I used the one my sister used last year for her R&D project). Also, to keep the blades from coming out of where they are I made wedges.



Wedges hold the blades on the hub.

Step 3: Before I went to the bridge for a drop test I weighed each blade. After I weighed each blade I found the heaviest blade of the set. Then I added clay to the lighter blades to make them all equal weight. I did this for each set of blades. I then found the balancing point of each blade. I drew a line to mark the balancing point. I did this for all the blades. I added super glue over the lined area to help the clay stick better to the blades.



Next I put the blades on the hub. I put the blades on a hub set to 0 degrees. I checked to make sure the hub part with the blades weighed 20 grams. I added more clay to equal 20 grams. I used 20 grams, because that is what a competition rocket usually weighs.

Step 4: Now it was time for the drop test. We went to a bridge that was 32 feet and 2 inches high. We mea-



sured this using a string with a weight attached to it.



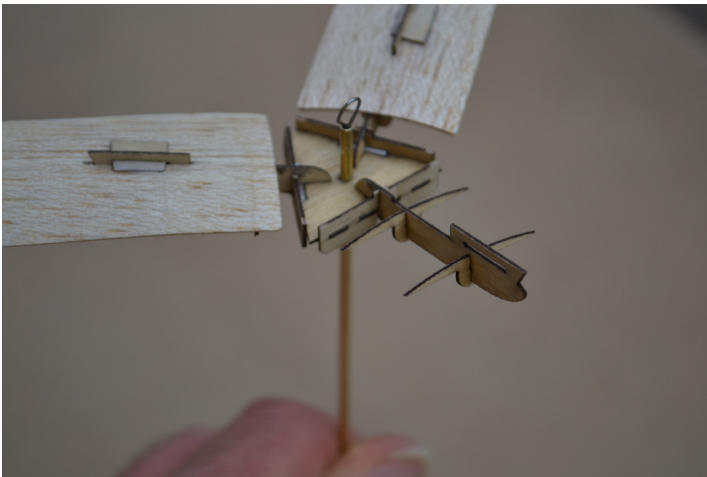
We dropped each of the four different shapes 3 times to see which helicopter blades stayed in the air the longest. If a drop-test hit the bridge we had to redo that test. My dad was timing it while I dropped the rockets. The times were recorded. We dropped it 3 times because I needed to find the accurate time.

Data #1: Blades mounted on arm that was at 0° Angle-of-Attack

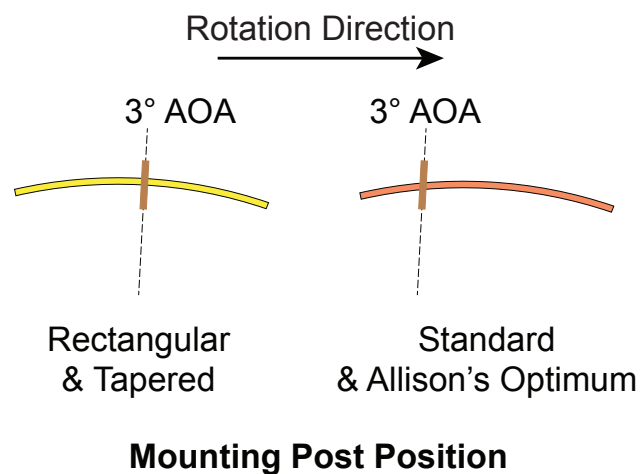
| Blade Shape | Time #1 | Time #2 | Time #3 | Average Time |
|------------------------------------|------------------|-------------------|-------------------|--------------|
| Standard Blade (1" pvc pipe) | 3.34 (Wobbly) | 5.34 | 3.87 | 4.18 |
| Rectangular | 2.8 (no spin) | 3.32 (no spin) | 2.21 (no spin) | 2.78 |
| Tapered | 5.16 | 4.5 | 5.0 | 4.89 |
| Allison's Optimum (1" pvc pipe) | 6.30 | 5.85 | 5.37 | 5.84 |

Drop Height: 32 feet, 2 inches, Time is in seconds.

Step 5: Because the rectangular blade shape didn't spin, my dad suggested that we angle the blade to try to get it to spin. So we came home and my dad built a new hub where the blades would be mounted at a 3 degrees angle. He also put supports under the blades to keep them from rotating on the mounting post.



Step 6: I also realized that if the Standard and Allison Optimum were not on the 4.5-inch PVC then it would not be an accurate test. So I decided that I would put the Standard and Allison Optimum blades on the 4.5-inch PVC pipe, and I made new blades for the second drop test.



Step 7: We went out again and dropped the Rectangular, Tapered, Standard, and Allison Optimum on the 3 degrees angle-of-attack.

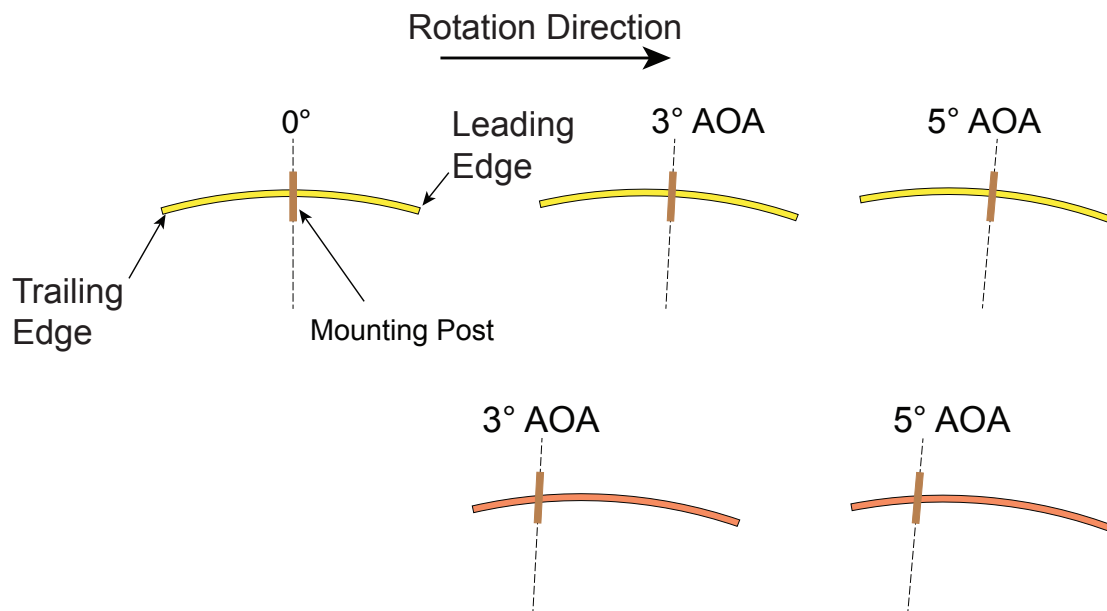
Data #2: Blades mounted on arm that was at 3° Angle-of-Attack

| Blade Shape | Time #1 | Time #2 | Time #3 | Average Time |
|-------------------|-------------------------|------------------------|-----------------------------|--------------|
| Standard Blade | 5.70 | 6.84 | 7.10 | 6.54 |
| Rectangular | (no spin) | (no spin) | (no spin) | - - - |
| Tapered | 2.68 (slow rotation) | 3.0 (slow rotation) | 3.93 (slow rotation) | 3.20 |
| Allison's Optimum | 6.1 (hit bridge) | 4.13 6.1 | 29.31 (caught wind gust) | 11.41 |

Drop Height: 32 feet, 2 inches, Time is in seconds.

Looking at the results the Rectangular still did not even spin, and Allison's Optimum blade did even better with a larger curve and at a 3 degree angle of attack.

Step 8: Since the rectangular blades didn't spin my dad made a new hub tilted at 5 degrees so we hoped the blades would spin. I had to make new blades to fit the new hub. Since the "Standard" blades did not work as well as Allison's Optimum, I decided not to use it.



Mounting Post Position For Allison's Optimum Blade Shape

Step 9: We went out to do our final set of drop tests.



Pulling the helicopter back up after a drop test.

Data #3: Blades mounted on arm that was at 5° Angle-of-Attack

| Blade Shape | Time #1 | Time #2 | Time #3 | Average Time |
|-------------------|--|--|------------------------------|--------------|
| Standard Blade | | | | |
| Rectangular | 2.94 (very little spin) | 3.35 (very little spin) | 3.68 (very little spin) | 3.32 |
| Tapered | 4.53 (took long time to start rotating) | 4.31 (took long time to start rotating) | 5.38 (hit bridge) 3.91 | 4.53 |
| Allison's Optimum | 4.97 (wobbly) | 3.5 (hit bridge) | 3.8 5.28 | 4.39 |

All blades wrapped around the 4" PVC pipe (4.5" diameter). Drop Height: 32 feet, 2 inches, Time is in seconds.

Allison's Optimum shape didn't work the best because I thought it was unbalanced. So the last time the tapered worked the best.

List of Any R&D Reports Previously Entered By Me

None

The Facilities Used

Apogee Components and a bridge

The Money Spent On Project (Budget)

| | |
|-------------------|----------|
| 1/32 balsa wood | \$10 |
| 1/32 plywood | \$5 |
| 1/16 plywood | \$5 |
| kite string | 50 cents |
| Brass tube | \$3 |
| BT/60 | 50 cents |
| Clay | 20 cents |
| 4.5-inch PVC pipe | \$7 |
| 1-inch PVC pipe | \$3 |
| Total = | \$34.20 |

The Conclusion Drawn

As you can see from the data that the Allison's Optimum blades on a 3 degree angle-of-Attack worked the best.

The rectangular work the the worst.

The one question that I couldn't answer was why the Tapered worked but the Rectangular didn't.

References to Previous work done on subject used For Research

"Finding the Best Gyrocopter Blade Shape and Best Place to Attach the Blade" By Allison Van Milligan.
NARAM-56 R&D Project, July, 2014.

The Equipment Used

Stop watch
Scale(In grams)
Super Glue
1-inch PVC pipe
4.5-inch PVC pipe

Clay
BT/60
Brass Tube
Kite String
1/16 Ply Wood
1/32 Plywood
1/32 Balsa wood

Further work

I'd like to find out why the tapered blade rotated, but the rectangular one didn't.