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"Limiting Factors in Drop Testing Model Rocket Recovery Systems."

Ryan Coleman - NAR #59361

Summary

The purpose of this experiment was to determine some of the factors that limit accuracy in drop testing. The factors tested were accuracy of indoor and outdoor tests on parachutes and streamers. Some factors affecting helicopter model drop testing were also tested. The paper also has points on terminal velocity and finding a high enough place to do accurate drop testing.

One parachute 500 millimeters in diameter was constructed and dropped from indoor and outdoor heights of 4.75 meters. It was timed and the results were reduced to show that parachutes dropped from this height have an accuracy around 10% indoors and 50% outdoors. Clearly, indoor tests are better for parachutes.

One streamer 50 millimeters by 500 millimeters was constructed and dropped from the same height as the parachute at the same location. The streamer tests were shown to have an accuracy of 5% indoors and 15% outdoors from that height. Again, indoor locations seem to produce more accurate results

A rotaroc-type model was constructed and dropped from the same height indoors. However, the model did not reach terminal velocity fast enough and no valuable data was produced.

Future work remains in further clarifying the methods by which accurate data can be produced from drop testing. This report is also designed to aid other researchers in conducting drop tests of their own and getting viable results. This project was done because, although others have used drop tests, no one has shown others what methods to use, and how accurate they can expect their results to be.

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Objective

The objective of this project is to discover some of the factors that limit the viability of drop tests for typical model rocket recovery systems, specifically parachutes, streamers, and helicopters. The objective also includes informing other researchers of the conclusions drawn and ways in which drop tests can be conducted and good scientifically accurate data can be produced.

Approach

One of my first goals was to perform some drop tests of the three types of recovery systems I would be examining and observe the height it takes each device to reach terminal velocity. All of these original drop tests were performed at the local YMCA from a running track positioned 4.75 meters over the gym floor.

A second batch of tests was performed at the same location with only the parachute and streamer devices to determine how accurate the results were indoors. The same number of tests were then performed outdoors at a grandstand from the same height to determine the accuracy of outdoor tests.

Equipment Used

The helicopter model was originally intended for another project, so it was constructed extra long. It had blades of 30 mm by 800 mm. The model was almost a meter long. It was constructed like a typical rotaroc, with Apogee Molded Hinge Hubs, balsa blades, music wire hooks, and rubber bands to pull the blades up. The parachute was technically a hexagonal parasheet 500 mm across from corner to corner. The shroud lines were 1.5 times the diameter of the parachute and ran through a snap swivel. An old key was attached as a small weight to the parachute. The streamer was gold mylar 50 mm by 500 mm and attached to a snap swivel. No weight was added as the snap swivel itself weighed enough.

Other equipment used was a standard stopwatch accurate to the hundredths of a second. I used a measuring device that uses radar to find the distance between the device and the object, in my case, the ground. I used the local YMCA and the grandstands next to my old high school football field for drop tests.

Results and Data

In dropping the helicopter model, I discovered 4.75 meters was clearly not enough height needed for helicopters to reach terminal velocity. The model would slowly rotate around, and then get up to speed, but the immediately hit the ground. It would rotate on its axis for a half-second and the fall to one side. This proved too hard for the model as it eventually broke from the impact.

The parachute reached terminal velocity the fastest of any recovery device. It was dropped by holding the center of the parachute. It would fully inflate and then reach what seemed to be terminal velocity after only falling less than a meter of the 4.75.

The streamer test from 4.75 meters was marginal. The streamer took at least two meters to reach terminal velocity, indicated by a violent flapping of the streamer.

The second and third batches of tests produced results tabulated in the following tables:

	Indoor Parachute Time	Percent Error	Outdoor Parachute Time	Percent Error
Test 1	4.00	29.5%	1.79	119.2%
Test 2	4.34	4.5%	2.41	57.2%
Test 3	4.22	7.5%	3.78	79.8%
Test 4	4.29	0.5%	2.53	45.2%
Test 5	4.33	3.5%	2.44	54.2%
Test 6	4.40	10.5%	3.34	35.8%
Test 7	4.13	16.5%	3.53	54.8%
Test 8	4.41	11.5%	3.12	13.8%
Test 9	4.46	16.5%	3.41	42.8%
Test 10	4.37	7.5%	3.47	48.8%
Average	4.29	10.8%	2.98	55.16%

	Indoor Streamer Time	Percent Error	Outdoor Streamer Time	Percent Error
Test 1	1.44	2.5%	1.09	45.7%
Test 2	1.38	8.5%	1.74	19.3%
Test 3	1.49	2.5%	1.44	10.7%
Test 4	1.53	6.5%	1.53	1.7%
Test 5	1.28	18.5%	1.65	10.3%
Test 6	1.47	0.5%	1.53	1.7%
Test 7	1.47	0.5%	1.41	13.7%
Test 8	1.53	6.5%	1.65	10.3%
Test 9	1.50	3.5%	1.56	1.3%
Test 10	1.56	9.5%	1.87	32.3%
Average	1.47	5.9%	1.55	14.7%

Conclusions from these tests

From these tests, I concluded several things. First, helicopter models need significantly more height than parachutes and streamers to obtain terminal velocity. Helicopter models, because they have more damageable parts, may require padding to land on to prevent damage.

Second, parachutes can reach terminal velocity quickly, less than 1 meter at least. Streamers can take longer, mine took between 1.5 and 2 meters. This may vary depending upon the size of recovery device.

Third, indoor tests of my parachute produced variations within 10.8% with only ten tests. Outdoor tests of the same parachute produced variations within 55.16%. Clearly this shows that outdoor tests cannot be relied upon as much as indoor tests for parachutes.

Fourth, streamer tests produced results like the parachute tests. Indoor tests varied only 5.9% while outdoor tests varied 14.7%. This again shows that indoor tests provide more viable results than outdoor tests.

More Ideas on Drop Testing Recovery Devices

The purpose of this section is to provide some further ideas that could be implemented in drop testing, and to further the conclusions reached from the first section. First, since outdoor tests have been shown to be inaccurate, flight tests should be even more inaccurate do to uncontrollable flight conditions such as whether or not the flight was straight up or arced severely. Also, one model may catch a thermal, while other tests may not, throwing off the results even more. I propose that flight tests be used as a last resort when testing descent times of parachutes, streamers, or helicopters.

Second, the height that the model uses to approach terminal velocity should be ignored. The reasoning is that most of a model's real descent time would be spent at terminal velocity, not approaching it. First, the height that the devices are dropped from could be raised. This would minimize the percent of altitude the device uses to reach terminal velocity. Also, if possible, the time on the device could be started when it passes through a plane at which point it should have reached terminal velocity.

Third, a better way must be found to drop test helicopter models. The height required for parachutes and streamers simply don't give the models time enough to begin spinning. Also, helicopters tend to be more fragile than parachute or streamer on landing. Some padding may be required to insure the models will survive the tests.

Timing also must be considered. I was the only timer for my tests. I was able to observe all the devices all the way through their descent. A better way may be to have two or three timers, like NAR competition rules require. Reducing data is rather easy for tests like these, simple hand calculators are fine, computer spreadsheets like the one I used work great.

Future Work

This project was designed with future work in mind. While attempting a different research project this year, I found no suggestions as to how to go about drop testing. A lot of work both in the art of drop testing and in results from drop testing remains to be done. All of the ideas proposed in the previous section need significant work put into them. Perhaps the primary one of these is to find an acceptable indoor height to test helicopter models and to make parachute and streamer tests more accurate.

Future work is also necessary in tracking down an indoor building with enough height to test any sort of recovery system. Ideas I've had include dropping devices from platforms high above closed sporting arenas. Some hotels in larger cities have indoor balconies hundreds of meters from the floor.

Also, this report may be useful to others conducting drop tests for the first time, or improving the scientific accuracy of them. To my knowledge, streamers have been studied extensively, and parachutes have gotten considerable coverage. Very few experiments in improving helicopter duration models by drop testing has been done, again, to my knowledge.

Project Cost

Item	Estimated Cost
Helicopter Model	
Sheet of 4" by 36" balsa	$2.00
34" BT-5 (from Totally Tubular)	$1.00
Music Wire	$0.15
Apogee Molded Hinge Hub	$4.50
Nose Cones (from BMS)	$1.50
Parachute and Streamer	
Dry Cleaners Bag	$0.25
Thread	$0.05
Snap Swivels (2)	$0.20
Gold 'Trim' Mylar 50 mm width	$0.10
Old Key	$0.05
Other Supplies Used	
Stopwatch	$5.00
Distance Indicator	$15.00
Total	$30.25

Credits

I would like to thank John DeMar for advice and encouragement for this project.