Verification of the vertical stabilizer effect on a paper airplane

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The purpose

The shapes of paper airplanes that fly well at various official conventions are well studied and are being introduced in websites and books etc. Many of them have a vertical stabilizer, but paper airplanes that currently have world records in distance do not have a vertical stabilizer. Therefore, we examined how the flight distance changes by changing the size of the vertical stabilizer, found the correlation between the size and the result of paper airplane flight, and clarified the "significance of the vertical stabilizer".

Definition

Define the name of the location of each part of the paper airplane as follows.

Figure1

● =Heel

Red line = From the heel fold the tail wing along the red line to make the vertical stabilizer. This line varied from 0cm/5cm/10cm.

Method

① Decide one paper airplane which is the basic form.
② Fold three paper planes of the basic type, one each by three people, and fly them 10 times using the paper airplane launcher .

The condition to fly ;a height of 3.45 m from the ground
an angle of 20 degrees.

Expectation

Vertical stabilizer effect is largely divided into two.

First ; By folding up the vertical stabilizer, the position of the center of gravity shifts to the front and influences the flight distance.

Second ; By folding up the vertical stabilizer, the flow of air around the airplane changes and the stability of the flight distance increases.

Results

*①The length of the vertical
②The length of horizontal
③Flying distance

Basic type	①	②	③
1	14.44	4.45	15.11
2	12.78	3.85	13.34
3	8.41	0.78	8.44
4	10.99	9.20	14.33
5	8.54	0.97	8.59
6	8.46	8.70	12.13
7	8.72	2.24	9.00
8	12.04	1.97	12.20
9	9.34	11.23	14.60
10	10.80	2.73	11.13
average	10.45	4.61	11.89
dispersion	4.02	16.62	5.76

Graph1

Figure2:Basic Type

5cm type*	①	②	③
1	14.39	1.51	14.46
2	10.50	3.34	11.01
3	8.98	5.43	10.49
4	14.33	0.23	14.33
5	10.60	4.94	11.69
6	5.46	1.34	5.62
7	15.44	0.49	15.44
8	8.62	0.88	8.66
9	8.91	2.24	9.18
10	14.40	0.08	14.40
average	11.16	2.05	11.53
dispersion	9.88	3.32	9.00

Graph2

Figure3:5cm Type

10cm type*	①	②	③
1	6.38	8.40	10.54
2	10.48	9.74	14.30
3	15.12	0.06	15.12
4	17.06	3.13	17.34
5	13.86	7.36	15.69
6	6.33	7.87	10.09
7	11.83	8.67	14.66
8	16.18	4.29	16.73
9	10.62	11.13	15.38
10	13.77	4.84	14.59
average	12.16	6.55	14.44
dispersion	12.71	10.33	5.07

Graph3

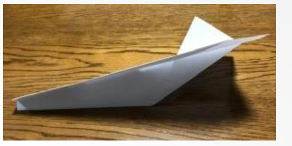

Figure4:10cm Type

Considered

Consider from two viewpoints

①Changes in the position of the center of gravity

Comparing basic type with one whose vertical stabilizer is folded by 5cm(We cannot see folded vertical stabilizer)(Afterwards, we call this form "5cm type").

	flying distance	dispersion	degree
basic type	11.9m	5.76	22°
5cm type	11.5m	9.00	12°

(Greph5 Comparison of basic type and 5cm one)

Considering both flight distance and stability, the basic type is better, but if we consider the flight angle, we see from Gpaph5 that the flight angle of the basic type is larger. In other words, the flight distance of the basic type is larger, but it does not fly straight. This means that we should move the center of gravity forward to make the airplane fly straight.

②Changes in air flow

Comparing 5cm type with 10cm one(We can see folded vertical stabilizer).

	flying distance	dispersion	degree
5cm type	11.5m	9.00	12°
10cm type	14.4m	5.07	30°

(Graph 6 Comparison of 5cm type and 10cm type)

Considering both flying distance and stability, the 10cm type is better. However, like ①,from the viewpoint of the flight angle, the 5cm type is smaller. Therefore, we can see that the protruded vertical stabilizer changed the air flow and although the flight distance has expanded, the deviation increased laterally.

③Summary

The effect that the vertical stabilizer has on the paper airplane is thought to be large depending on the shape with respect to the flight distance and on the position of the center of gravity with respect to the direction.

Reflection

It was difficult to set aside a place to experiment and we could not take the time to experiment as expected, so the number of trials and the types of paper airplanes to try decreased.

Future outlook on research

We haven't decided whether we should continue this experience. However, if we continue, we would like to try further with emphasis on the effect of only moving the center of gravity and the effect of changing only the vertical stabilizer's shape. Moreover, we also want to see if it can be set commonly by increasing the sort of basic type.