Wind Tunnel Test Report

Testing Date: 7/31/2024

Testing Facility: KOCED Wind Tunnel Center-Jeonbuk National University

Testing Director: Ph.D Seungho Lee, Ph.D Byengcheol Won

Testing Model:

FACTOR	ALDO 50	AEON 50	AEROX60	AEROX40	Z 52/58	D 50	E 50
RIM HEIGHT(mm)	50	50	60	40	52/58	50	50
RIM WIDTH(mm)	32	32	33	31	28	27	32
RIM TYPE	TR	TR	TR	TR	HL	TR	HL
SPOKE COUNT	20/20	20/20	20/24	20/24	24/24	24/24	24/24
SPOKE PATTERN	2-CROSS	2-CROSS	2-CROSS	2-CROSS	2-CROSS	2-CROSS	2-CROSS
SPOKE TYPE	Carbon	Carbon	Steel	Steel	Steel	Steel	Steel
WHEEL WEIGHT(g)	1290	1240	1370	1250	1358	1472	1452

Table 1 Testing model specification (TR:Tubeless Ready, HL:Hookless)

A. Testing Method:

1. Testing Facility

- KOCED wind tunnel(Vertical circulation closed loop)
- Dimension: 5m(W) x 2.5m(H) x 20m(L)
- Wind speed internal: under 1%
- Turbulence intensity: under 1.5%

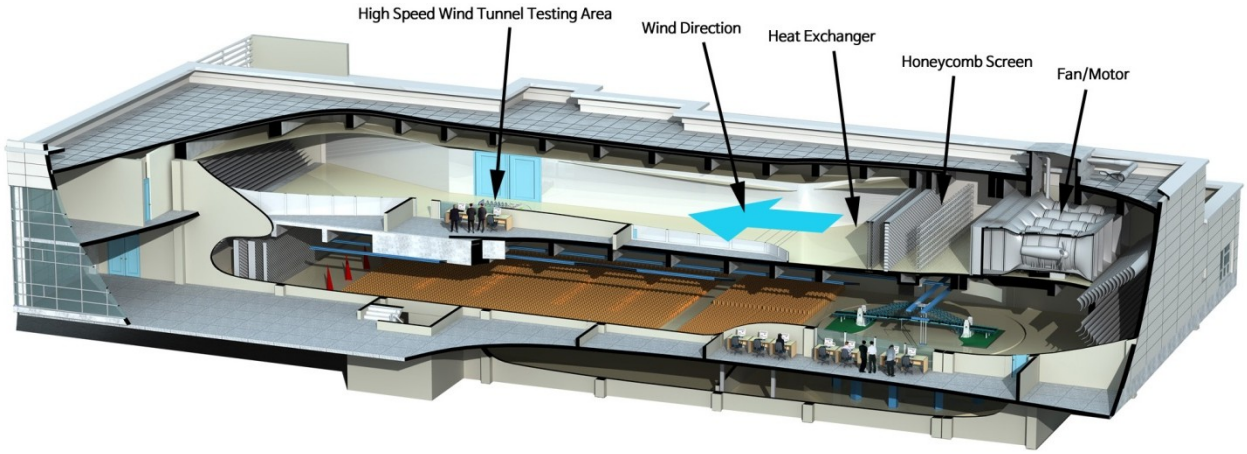


Fig 1 Wind Tunnel Facility

2. Initial Value Setting (mean value)

- Initial setting for measuring the center of gravity of the stand with the wheel before generating wind resistance and the force acting on it
- Data was measured at a rate of 1,000 samples per second (Sampling Frequency = 1000Hz)
- Initial values were measured for 30 seconds per model.

3. Experimental Value Measurement

- Forces and moments were measured from 0° (wheel facing directly) to 20° yaw angle at a wind speed of 11.11 m/s (±0.05 m/s).
- Data was measured at a rate of 1,000 samples per second (Sampling Frequency = 1000Hz).
- Each model was measured for 60 seconds.

4. Wheel Setup

- All wheels were equipped with 26c tires inflated to 80 psi.
- The drum rotating the wheel was set to approximately 1670 rpm, providing a wheel speed of 40 km/h (11.11 m/s), matching the wind speed.

5. Other Equipment Setup

- A special wind barrier was placed on the floor to prevent air resistance from being generated by the drum or other structures
- All equipment, including the drum, motor, and wheel, was mounted on a 4080 aluminum profile attached to a force balance.
- Air resistance generated by the rod holding the wheel was not measured.

Testing Pictures:

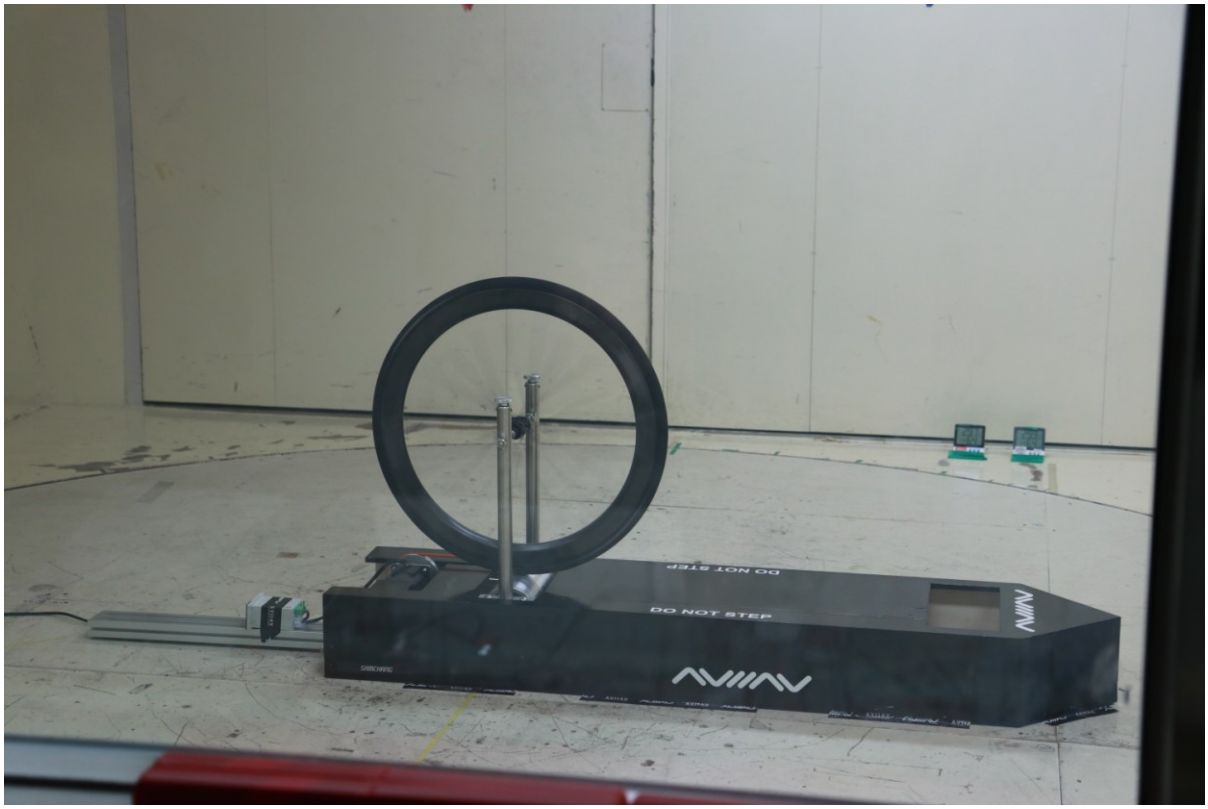


Fig 2 Measuring the ALDO 50 wheel

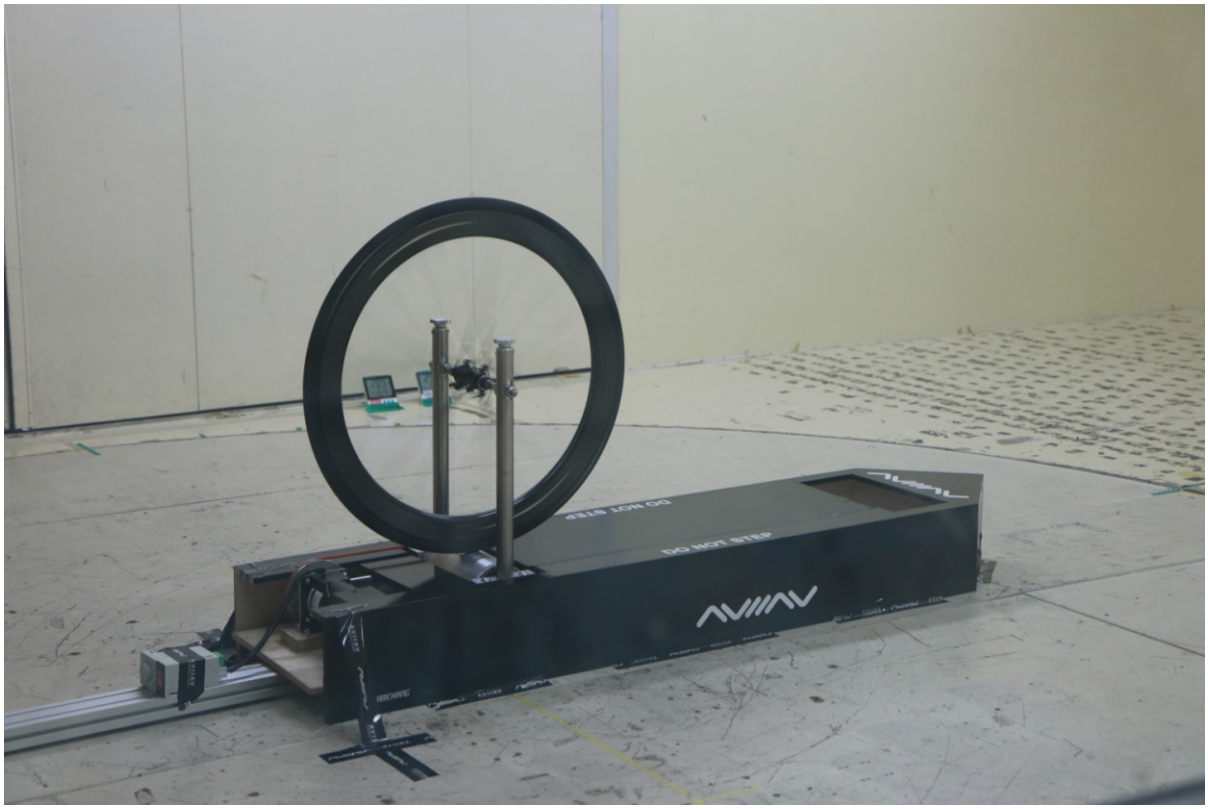


Fig 3 Measuring the AEON 50 wheel

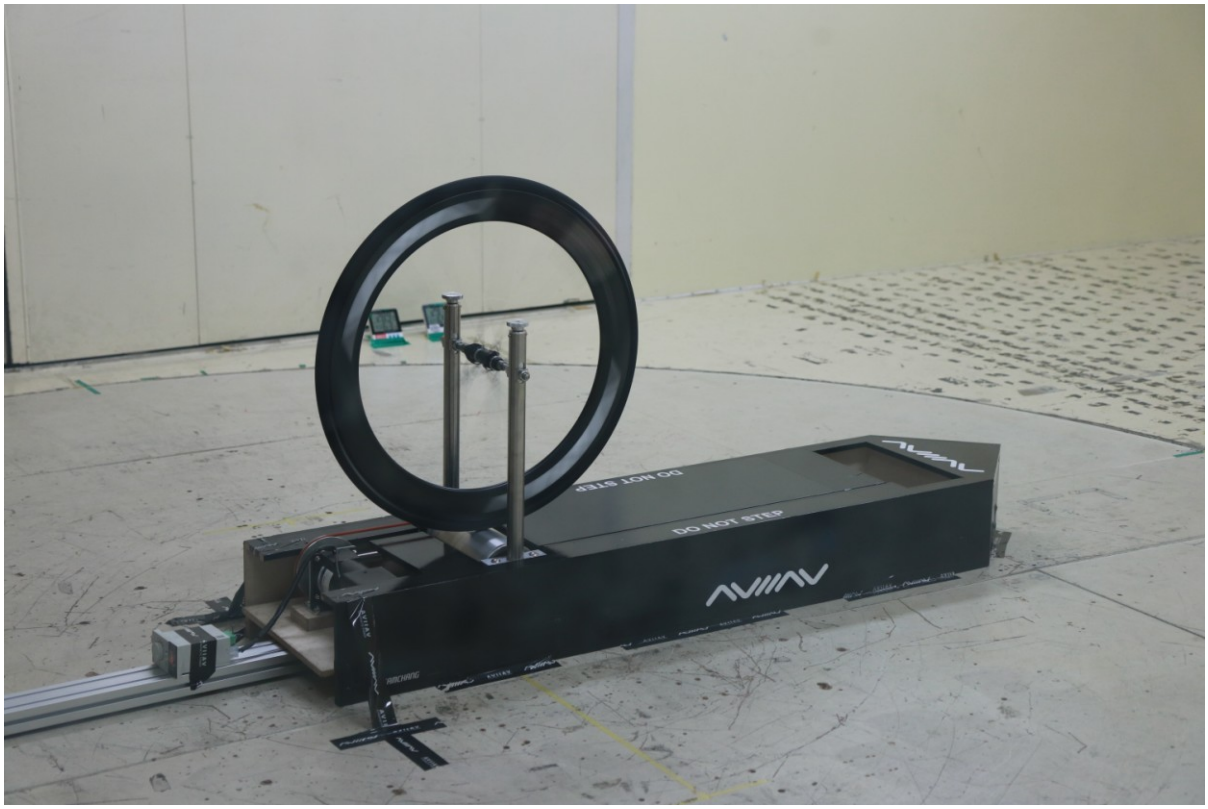


Fig 4 Measuring the AEROX 60

Fig 5 Measuring the AEROX 40

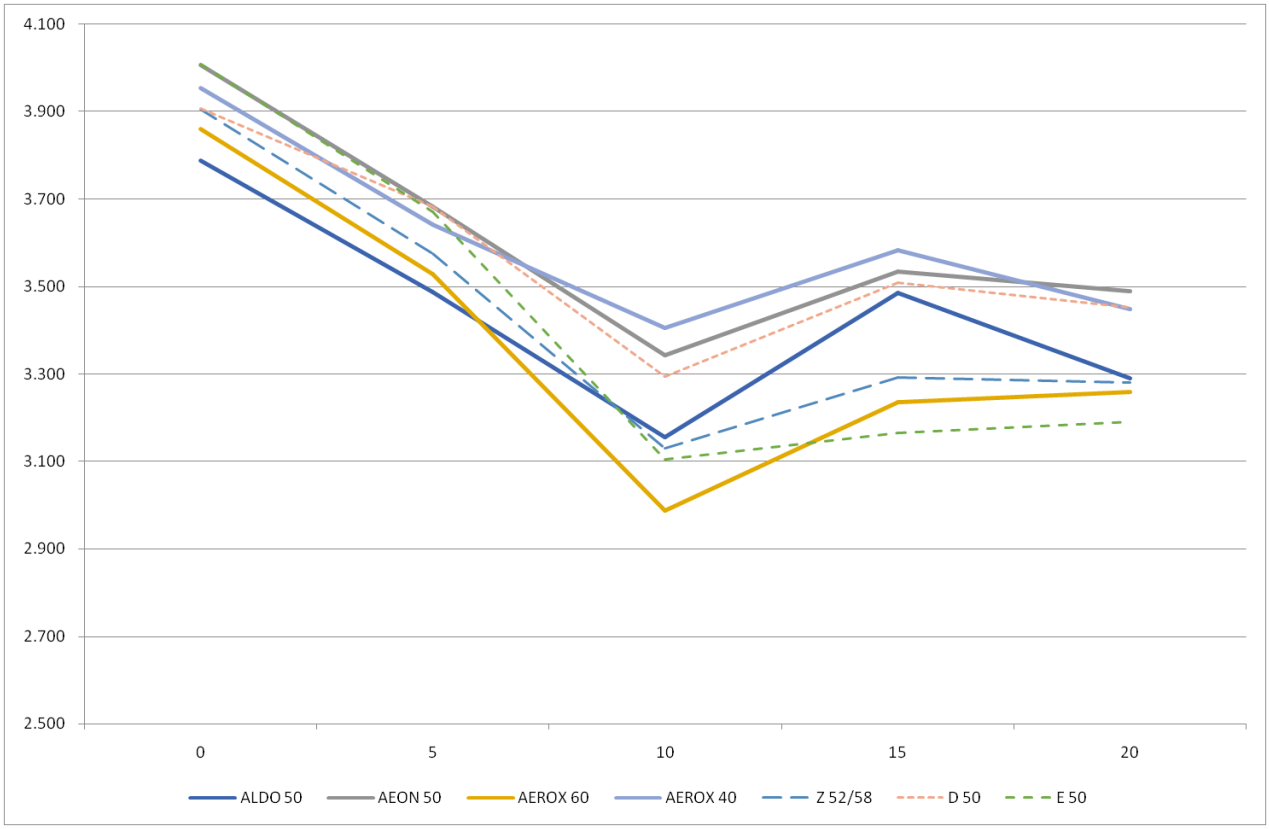
B. Testing Results

- The values below are drag forces corrected by the initial setup values.
- Basic measurement units in Newtons (N).
- Yaw represents in degrees.
- Drag due to the rod holding the wheel was not separately corrected.

1. Fx (Drag forces in the X-axis direction)

Yaw	ALDO 50	AEON 50	AEROX 60	AEROX 40	Z 52/58	D 50	E 50
0	3.788	4.006	3.859	3.952	3.905	3.906	4.009
5	3.487	3.682	3.528	3.641	3.574	3.683	3.671
10	3.156	3.342	2.987	3.405	3.131	3.294	3.105
15	3.485	3.533	3.236	3.584	3.291	3.508	3.165
20	3.290	3.489	3.258	3.448	3.280	3.451	3.190
AVG	3.441	3.611	3.374	3.606	3.436	3.568	3.428

Table 2 Fx forces data



Graph 1 Fx forces data

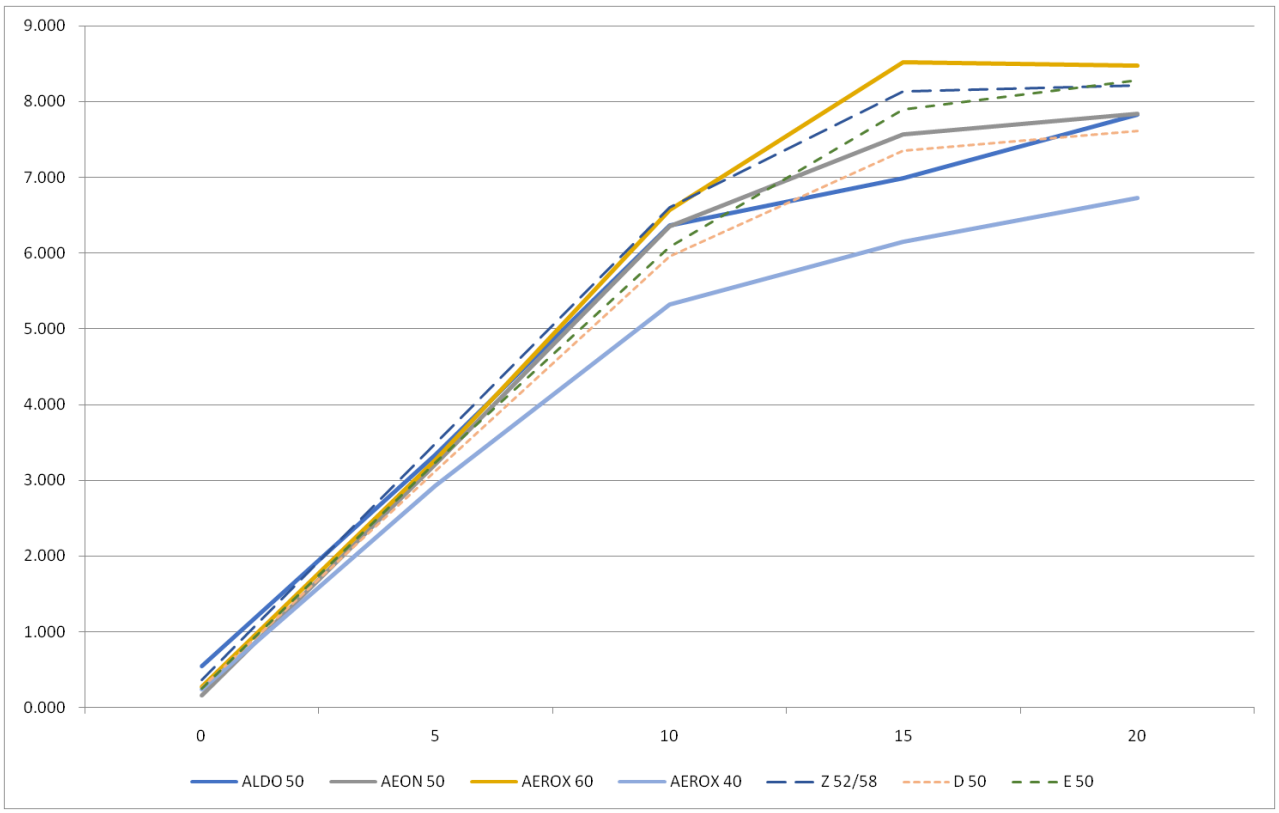
Analysis data:

1. The ALDO wheel showed the lowest drag among the test groups at yaw angles between 0° and 5°
2. Most wheels showed the lowest drag at a yaw angle of 10°, likely due to the bulging profile shape of the rim.
3. The AEROX 60 wheel displayed the best drag performance at 10°, possibly due to its taller rim profile. Wheels from E and Z wheel, with similar rim heights to ALDO, also showed low drag at 10°, with lower drag values in crosswinds compared to ALDO.
4. ALDO's drag increased significantly at a yaw angle of 15°, while wheels from E and Z brands maintained lower drag values with stable performance as the yaw angle increased.
5. At a 20° yaw angle, ALDO ranked fourth in drag performance among the seven wheels tested. The E wheel showed the lowest drag, followed by the E-AX6-Z-ALDO sequence.
6. Overall, ALDO is most advantageous in head-on wind conditions, while the E brand wheel performs better in crosswinds over 10°.

2. Fy(Lateral force in the Y-axis direction)

yaw	ALDO 50	AEON 50	AEROX 60	AEROX 40	Z 52/58	D 50	E 50
0	0.541	0.165	0.278	0.235	0.366	0.256	0.254
5	3.328	3.218	3.272	2.927	3.485	3.117	3.242
10	6.356	6.358	6.565	5.320	6.601	5.960	6.088
15	6.984	7.571	8.518	6.148	8.133	7.350	7.901
20	7.825	7.840	8.475	6.724	8.209	7.617	8.285
AVG	5.007	5.030	5.421	4.271	5.359	4.860	5.154

Table 3 Fy forces data



Graph 2 Fy forces data

Analysis

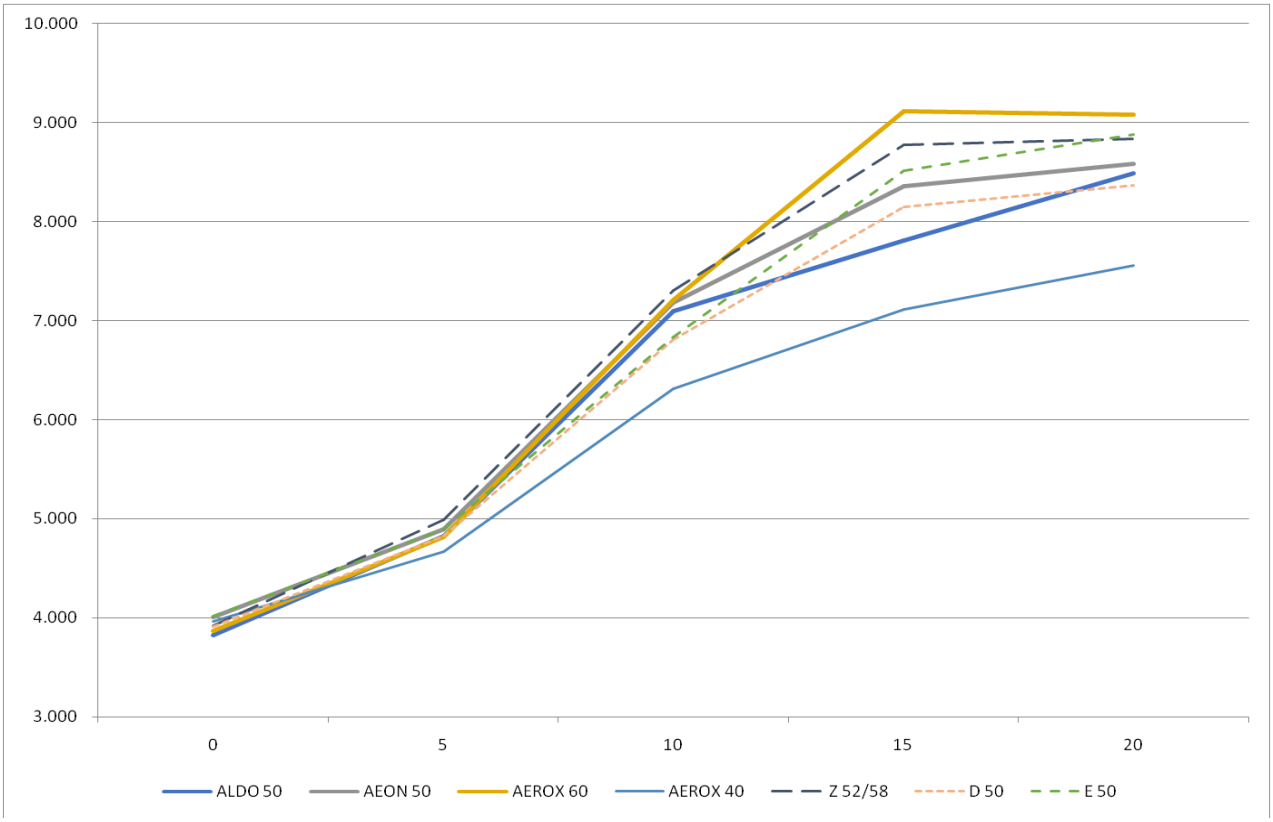
1. Lateral force affects steering stability; higher lateral force makes it harder to maintain direction on a straight course.
2. At 0° and 5°, lateral force is minimal.
3. From 10°, lateral force increases inversely proportional to rim height. The D wheel showed the lowest lateral force at 10° among 50mm profile rims.
4. At 15°, ALDO's lateral force decreased significantly, showing the lowest force among 50mm profile rims.

5. At 20°, the D brand wheel again showed the lowest lateral force, followed by ALDO-AEON-Z-E in order.
6. Unlike drag force, ALDO showed lower values between 15° and 20°, suggesting better steering stability under crosswinds.

3. Fsum(Resultant Force/Vector Sum of Forces)

yaw	ALDO 50	AEON 50	AEROX 60	AEROX 40	Z 52/58	D 50	E 50
0	3.827	4.010	3.869	3.959	3.922	3.914	4.017
5	4.820	4.890	4.812	4.672	4.992	4.825	4.897
10	7.096	7.183	7.212	6.316	7.306	6.810	6.835
15	7.805	8.355	9.112	7.116	8.774	8.145	8.512
20	8.489	8.582	9.080	7.557	8.840	8.362	8.878
AVG	6.407	6.604	6.817	5.924	6.767	6.411	6.628

Table 4 Fsum forces data

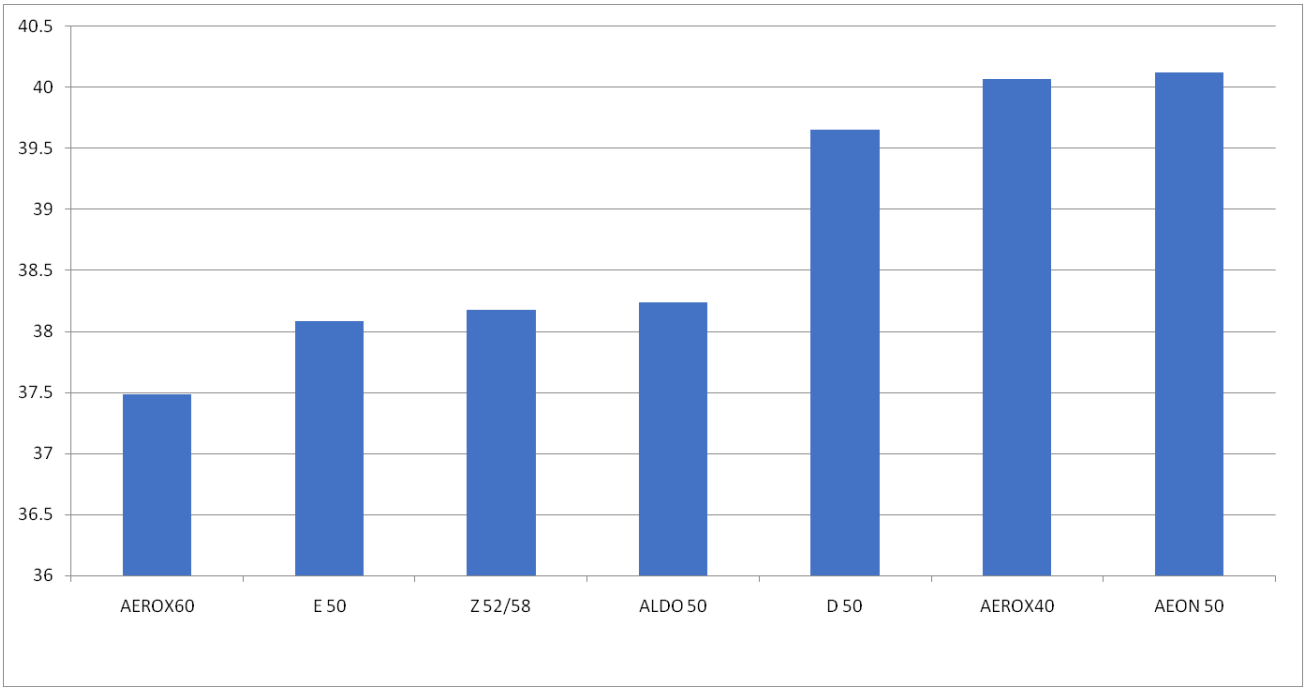


Graph 3 Fsum Forces data

Analysis

1. The AEROX 40 wheel had the lowest average resultant force from 0° to 20°.
2. Among wheels with similar rim heights (ALDO, AEON, Z, E, D), ALDO showed the lowest average resultant force.
3. ALDO's resultant force increased sharply at 10°, unlike other products that increase from 15°, showing a generally low resultant force.

4. Average Drag Force Converted To Watts(W)



Graph 4 Average Drag Forces

Analysis

1. Considering measurement errors, the ALDO2, Z and E wheels exhibited similar average drag values.
2. AEROX 6 showed the lowest average drag, indicating rim height has the greatest impact on drag performance.
3. Comparing 50mm rim heights, the D brand wheel and AEON showed relatively higher drag values, but the difference was about 2 Watts.

C. Conclusion

1. The ALDO wheel maintains low drag due to its unique shape in head-on winds but shows slightly higher drag in crosswinds compared to other wheels. However, it maintains lower lateral force, contributing to better steering stability, making it perform better on strong headwind courses.
2. The AEON wheel, with its typical toroidal rim shape, does not exhibit the lowest aerodynamic drag but demonstrates low weight and excellent balance, showing the lowest My (yaw moment) value with consistent moment values.
3. The AEROX60 (60mm) wheel demonstrates excellent aerodynamic performance and low drag even in crosswinds, confirming that rim height is the primary factor in aerodynamic performance.
4. The AEROX 4 (40mm) wheel provided a good comparison for understanding the effects of low rim height. It was confirmed that a more aero-optimized shape can perform better against head-on air resistance, regardless of rim height.