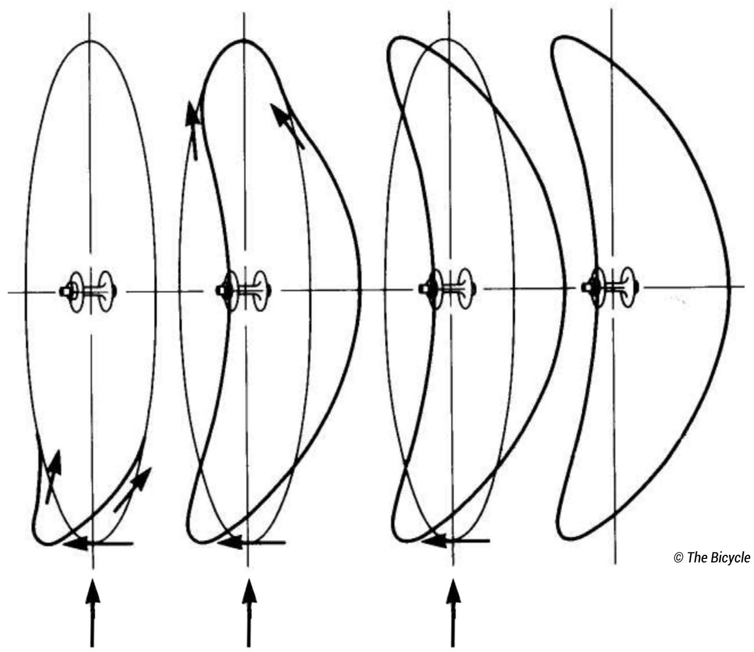
IN-DEPTH STIFFNESS TESTING ON DYNAMIC LOADS, SPOKE PRETENSION AND POWER EFFECIENCY



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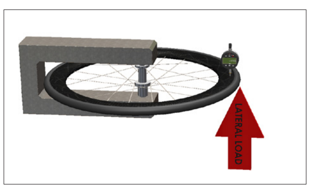
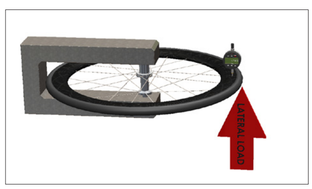
TEST 1



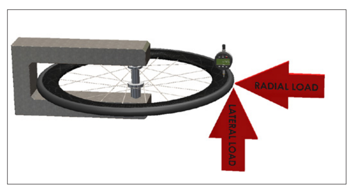
CONVENTIONAL
DRIVE SIDE

TEST 2



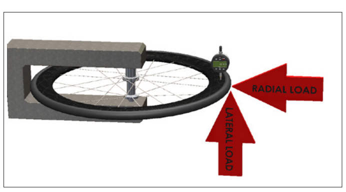
CONVENTIONAL
NON-DRIVE SIDE

TEST 3 - RIDING SITUATION



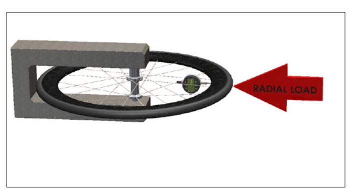
LATERAL LOAD FROM
DRIVE SIDE

TEST 4 - RIDING SITUATION



LATERAL LOAD FROM
NON-DRIVE SIDE

TEST 5



RADIAL LOAD

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ADVANCED WHEEL STIFFNESS TEST

TEST ACCEPTANCE FORM

TEST DATA

Customer:	Nippelshop	Nippelshop
Test date:	Oct-10-2019	Oct-10-2019
Wheel Type:	Asphalt55 D	Asphalt55 D
Spoke Type:	Competitor: 4,3g / 2,0-0,9*2,2-2,0 Conventional Bladed Aero Spoke, 272mm, SP	Pillar PSR Wing 20, 4,3g Fully Ovalized Airfoil Shape, 272mm, Straight Pull
Hub Type:	Syntace Straight RS	Syntace Straight RS
Axle Standard:	142*12	142*12
Nipple Type:	Internal	Internal
Spoke quantity:	24	24
Spoke Pretension	115kgf (+/-0,25)	115kg (+/-0,25)
Rim Type:	55mm Carbon TLR Clincher 445g	55mm Carbon TLR Clincher 445g
Test type:	Premium***	Premium***
Standard/custom protocol?	Standard	Standard
Custom requests:	No	No

Lateral load range (over preload)	This is a safe non-destructive load range	0-20kg
Radial load	Reflects a wheel load including bumps and radial braking and cornering forces	60kg
Lateral + Radial Load application to wheel	This stiffness test combines radial and lateral loads at the same time, simulating realistically the dynamic forces applied to the wheel when sprinting and cornering	By roughed contact surface pressed in 2 directions to tire
Radial Load application to wheel	This is a radial stiffness test of the wheel. The load simulate stiffness when subjected to bumps, cobbles, etc.	By roughed contact surface pressed to tire
Lateral Load application to wheel	This test is a static test, compared to the conventional unloaded testing method.	By PTFE strip pressing to rim edge over length equal to tire contact surface
Lateral preload at 0 gauge set	Eliminating hub bearing clearance and all other play	2kg
Radial preload at lateral only test	To avoid radial movement of PTFE	13kg
Axial fix screw torque set	Set by a torque wrench for identical hub holding force	10Nm
Tensiometer	Measured at the spoke that is in-line with radial load	Digital DT-like meter
Tire Pressure:	Interacting with spoke pretension on clinchers	6.0 bar
Test inner tire type:		Conti regular race inner tire
Test tire type:		Conti Ultra Sport foldable 28mm

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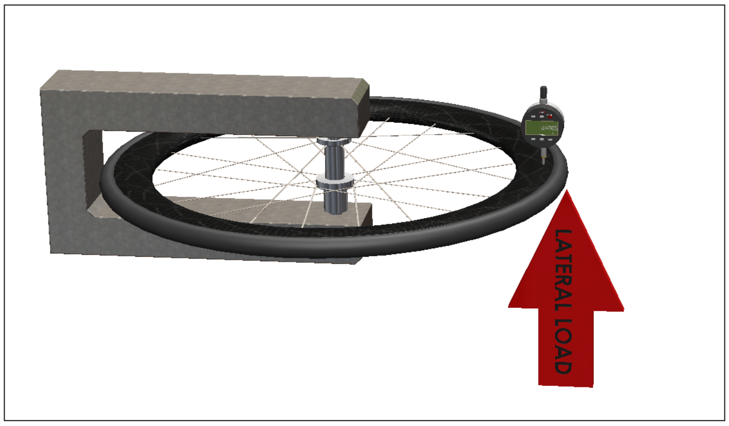
ADVANCED WHEEL STIFFNESS TEST

TEST 1 - CONVENTIONAL DRIVE SIDE

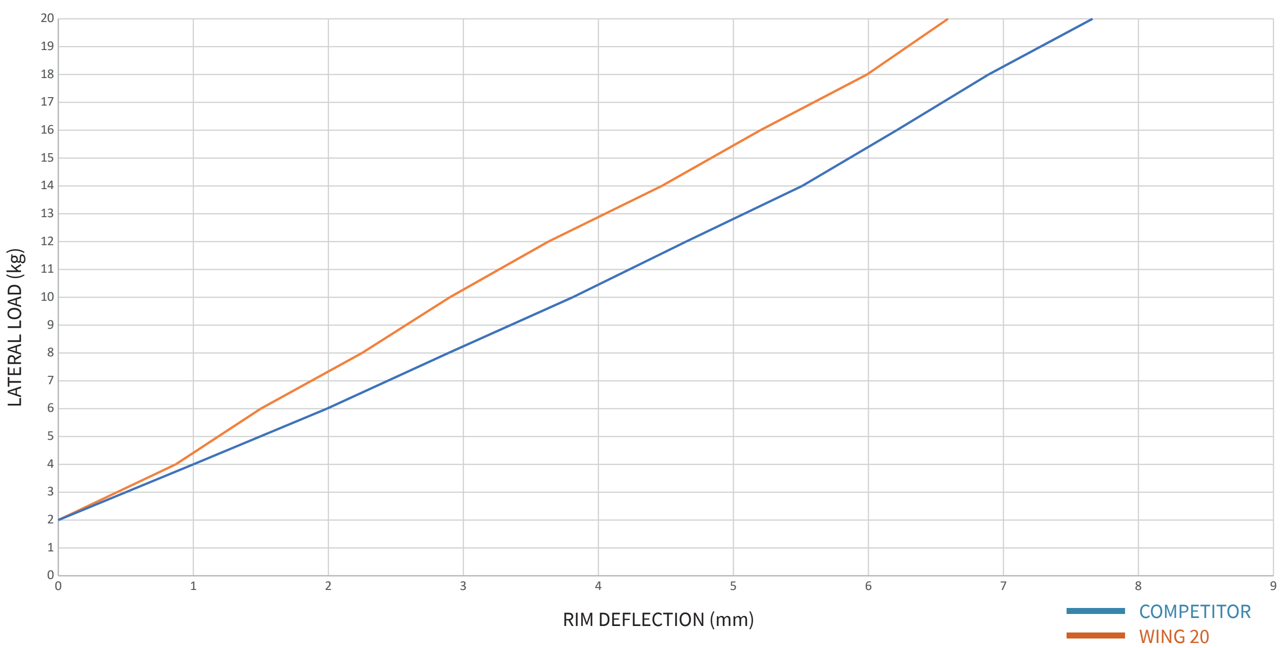
• **LATERAL LOAD: 0 - 20 kg**



LATERAL FORCE (kg)	DISPLACEMENT (mm) COMPETITOR	WING 20
2	0	0
4	1,00	0,87
6	1,99	1,50
8	2,89	2,25
10	3,81	2,90
12	4,65	3,63
14	5,51	4,47
16	6,21	5,20
18	6,89	5,99
20	7,66	6,59

TEST RESULTS

	COMPETITOR	WING 20
MAX. RIM DEFLECTION (LOWEST = STIFFEST)	7,66 mm	6,59 mm
RELATIVE STIFFNESS (N/mm)	25,61 N/mm	29,77 N/mm
SUPERIORITY IN %		16,24 %
SUPERIORITY IN N/mm		4,16 N/mm



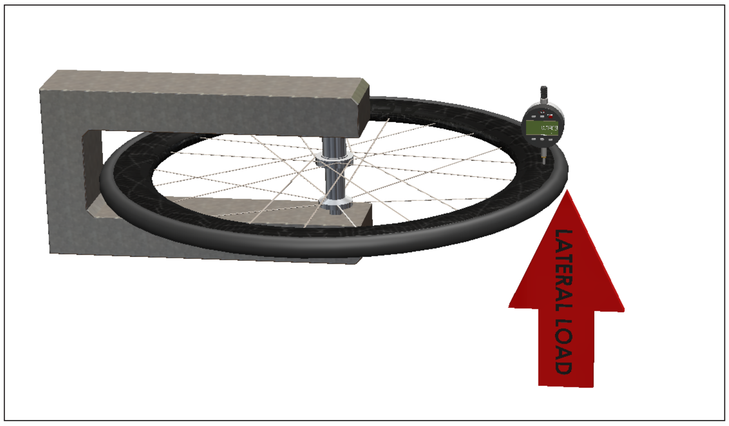
COMMENTS

This test is equal to any conventional static lateral stiffness test. Test can be done with or without tire.
The main reason we also test in this conventional way, is to expose the result differences to the more realistic lateral + radial testing method as it does not picture the realistic load situation when riding the bike.

ADVANCED WHEEL STIFFNESS TEST

TEST 2 - CONVENTIONAL NON-DRIVE SIDE

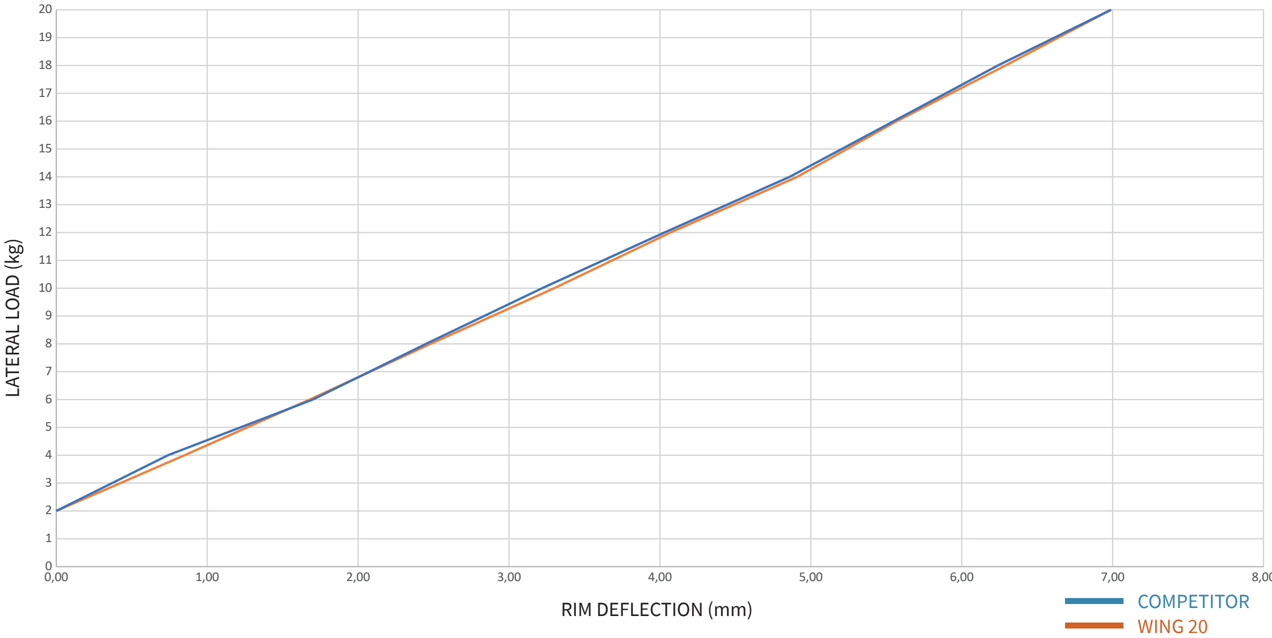
• **LATERAL LOAD: 0 - 20 kg**



LATERAL FORCE (kg)	DISPLACEMENT (mm) COMPETITOR	WING 20
2	0,00	0
4	0,74	0,85
6	1,70	1,68
8	2,45	2,48
10	3,22	3,30
12	4,03	4,07
14	4,86	4,91
16	5,55	5,57
18	6,24	6,29
20	6,99	6,99

TEST RESULTS

	COMPETITOR	WING 20
MAX. RIM DEFLECTION (LOWEST = STIFFEST)	**6,99 mm**	**6,99 mm**
RELATIVE STIFFNESS (N/mm)	**28,07 N/mm**	**28,07 N/mm**
SUPERIORITY IN %		**0,00 %**
SUPERIORITY IN N/mm		**0,00 N/mm**



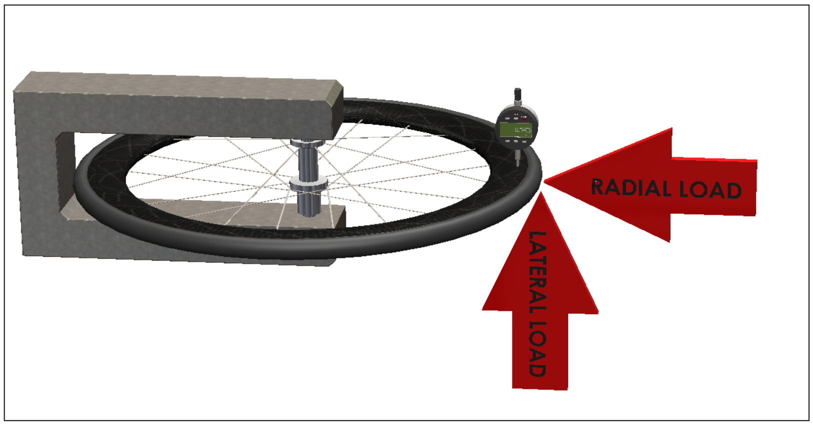
COMMENTS

As with Test 1, this test does not reflect any loads and deflections occuring in a real world situaton but remarkably test results are identical. Reason is that the NDS - spoke angle superimposes spoke type effect.

ADVANCED WHEEL STIFFNESS TEST

TEST 3 - RIDING SITUATION
LATERAL LOAD FROM DRIVE SIDE

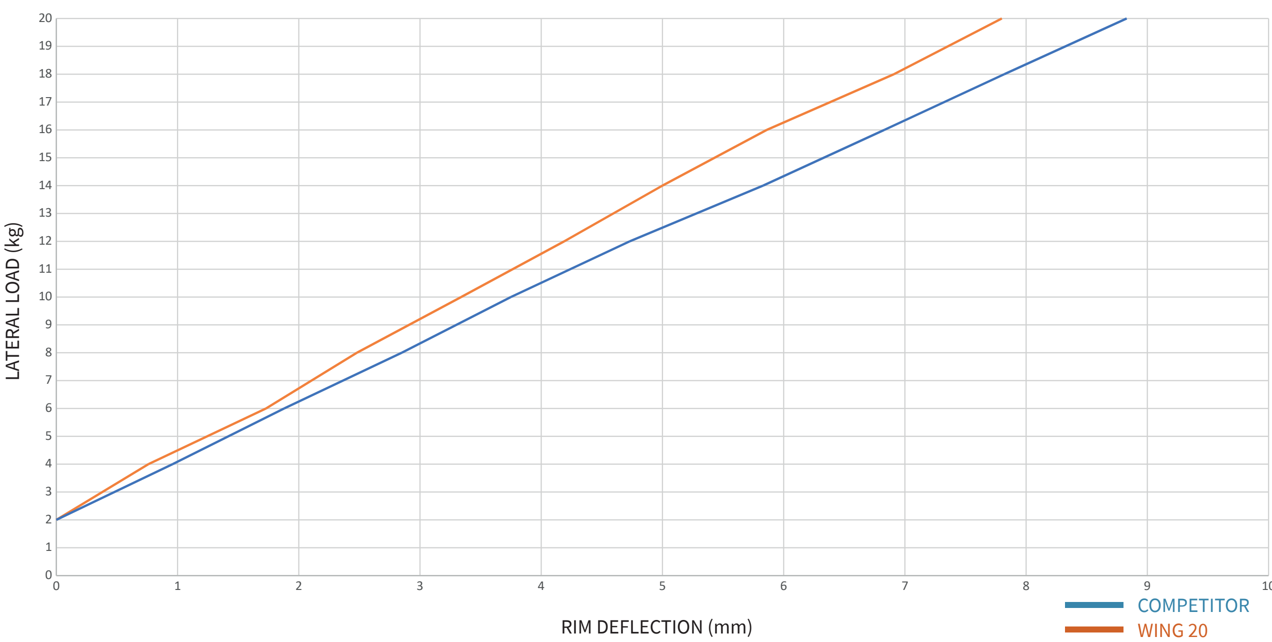
- **LATERAL LOAD: 0 - 20 kg**
- **RADIAL LOAD: 50 kg STATIC**



LATERAL FORCE (kg)	DISPLACEMENT (mm) COMPETITOR	WING 20
2	0	0
4	0,96	0,76
6	1,88	1,73
8	2,85	2,48
10	3,75	3,34
12	4,73	4,19
14	5,83	5,00
16	6,83	5,86
18	7,82	6,91
20	8,83	7,80

TEST RESULTS

	COMPETITOR	WING 20
MAX. RIM DEFLECTION (LOWEST = STIFFEST)	8,83 mm	7,80 mm
RELATIVE STIFFNESS (N/mm)	22,22 N/mm	25,15 N/mm
SUPERIORITY IN %		13,21 %
SUPERIORITY IN N/mm		2,93 N/mm



COMMENTS

This test simultaneously applies the loads that occur in dynamic situations like criterium cornering, descents and sprinting. Because of the radial load, spoke tension drops and the actual realistic (dynamic) lateral stiffness is measured. Load is applied through a contact surface, pressing on the tire.

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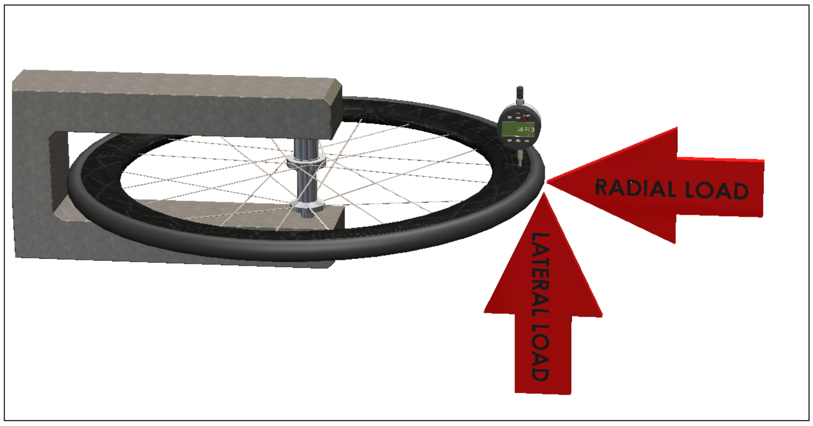
ADVANCED WHEEL STIFFNESS TEST

TEST 4 - RIDING SITUATION
LATERAL LOAD FROM NON-DRIVE SIDE

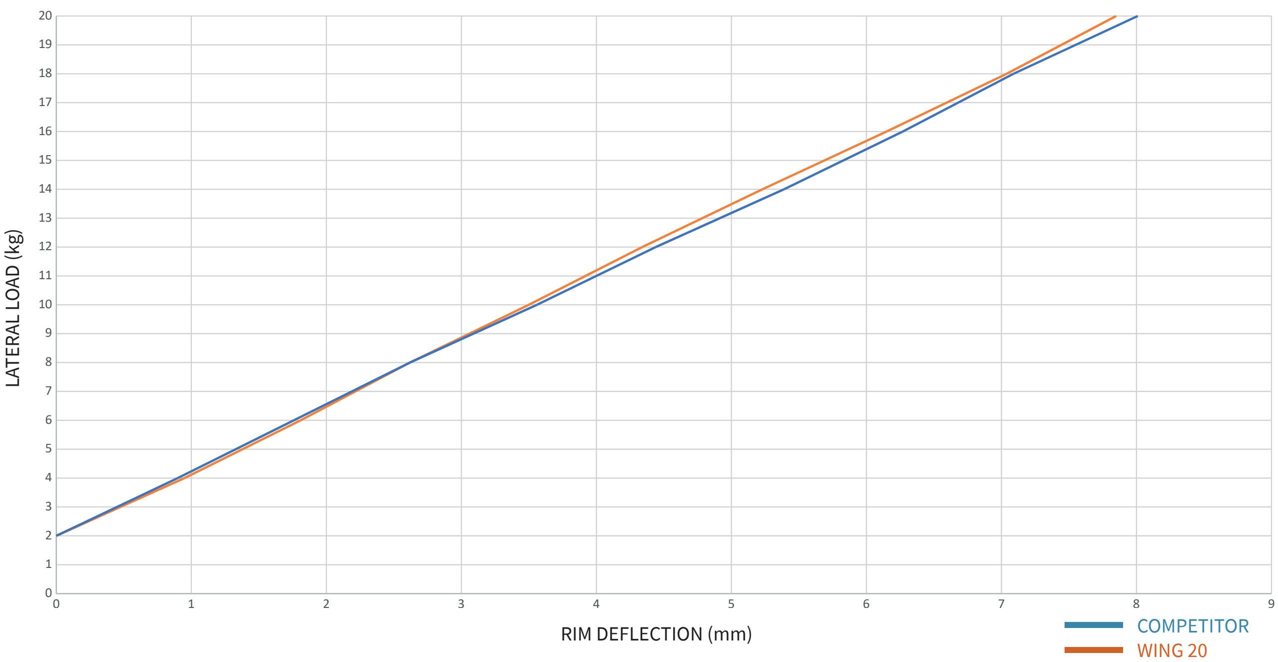
- **LATERAL LOAD: 0 - 20 kg**
- **RADIAL LOAD: 50 kg STATIC**



LATERAL FORCE (kg)	DISPLACEMENT (mm) COMPETITOR	WING 20
2	0	0
4	0,9	0,95
6	1,76	1,81
8	2,62	2,62
10	3,56	3,50
12	4,44	4,34
14	5,39	5,23
16	6,27	6,15
18	7,09	7,04
20	8,01	7,85

TEST RESULTS

	COMPETITOR	WING 20
MAX. RIM DEFLECTION (LOWEST = STIFFEST)	8,01 mm	7,85 mm
RELATIVE STIFFNESS (N/mm)	24,45 N/mm	25,15 N/mm
SUPERIORITY IN %		2,69 %
SUPERIORITY IN N/mm		0,66 N/mm



COMMENTS

This test simultaneously applies the loads that occur in dynamic situations like criterium cornering, descents and sprinting. Because of the radial load, spoke tension drops and the actual realistic (dynamic) lateral stiffness is measured. Load is applied through a contact surface, pressing on the tire.

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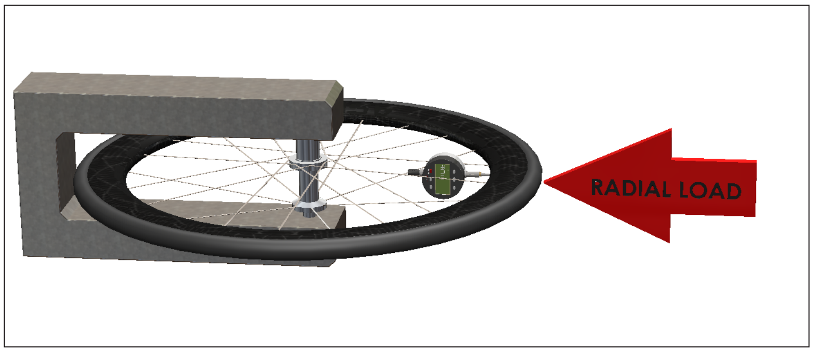
TEST 5 - RADIAL LOAD TEST

• **RADIAL LOAD: 50 kg STATIC**



RADIAL FORCE (kg)	DISPLACEMENT (mm) COMPETITOR	WING 20
50	0,12	0,13

COMMENTS

In this test we measure the radial stiffness of the wheel (also referred to radial comfort). Because of spoke tension drop due to tire pressure, the load is applied through a contact surface.

DYNAMIC SPOKE TENSION BEHAVIOUR

FOR ALL TEST ROUTINES

NO LOAD

	COMPETITOR	WING 20
TENSIOMETER VALUE DS (MM)	1,85	2,66
DIFFERENCE DS (%)		
TENSIOMETER VALUE NDS (MM)	1,44	2,11
DIFFERENCE NDS (%)		

TEST 1 - CONVENTIONAL DRIVE SIDE

	COMPETITOR	WING 20
TENSIOMETER VALUE DS (MM)	2,35	3,27
DIFFERENCE DS (%)	*27,03%*	*22,93%*
TENSIOMETER VALUE NDS (MM)	0,33	1,07
DIFFERENCE NDS (%)	*-77,08%*	*-49,29%*

TEST 3 - RIDING SITUATION
LATERAL LOAD FROM DRIVE SIDE

	COMPETITOR	WING 20
TENSIOMETER VALUE DS (MM)	1,11	1,77
DIFFERENCE DS (%)	*-40,00%*	*-33,46%*
TENSIOMETER VALUE NDS (MM)	2,01	2,87
DIFFERENCE NDS (%)	*39,58%*	*36,02%*

TEST 4 - RIDING SITUATION
LATERAL LOAD FROM NON-DRIVE SIDE

	COMPETITOR	WING 20
TENSIOMETER VALUE DS (MM)	1,75	2,57
DIFFERENCE DS (%)	*-5,41%*	*-3,38%*
TENSIOMETER VALUE NDS (MM)	1,33	1,98
DIFFERENCE NDS (%)	*-7,64%*	*-6,16%*

COMMENTS

During all tests, spoke tension drop or increase is measured. This visualizes the dynamic behavior of the spokes during loads. Visualizing these behavior can be useful for example to improve spoke fatigue failure resistance and many more abilities.

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FINAL TEST RESULT

ENERGY/POWER LOSS

	COMPETITOR	WING 20
SPRINT DURATION	20 sec	20 sec
PEDAL FREQUENCY	120 rpm	120 rpm
PEDAL STROKES PER SPRINT	80	80
ENERGY	1,184 J	1,132 J
POWER LOSS / WHEEL	94,68 W	90,53 W

POWER SAVED 20SEC SPRINT WITH WING 20: **4,05 WATTS**

POWER SAVED P.SEC. WITH WING 20: **0,203 WATTS**

COMMENTS

Those values are valid for the tested rear wheel, front wheel savings have not been tested yet but do exist as the front wheel also deforms under load! Power (W) is related to total consumption of energy the wheel looses or uses when forced to spin. This loss is determined mechanically by the total stiffness of the wheel and refers to the fact that all "Pulling-Spoke-Wheel-Designs" in general are torsional springs.
The calculation is based on hypothetical test parameters, that can be filled in according customer preference.

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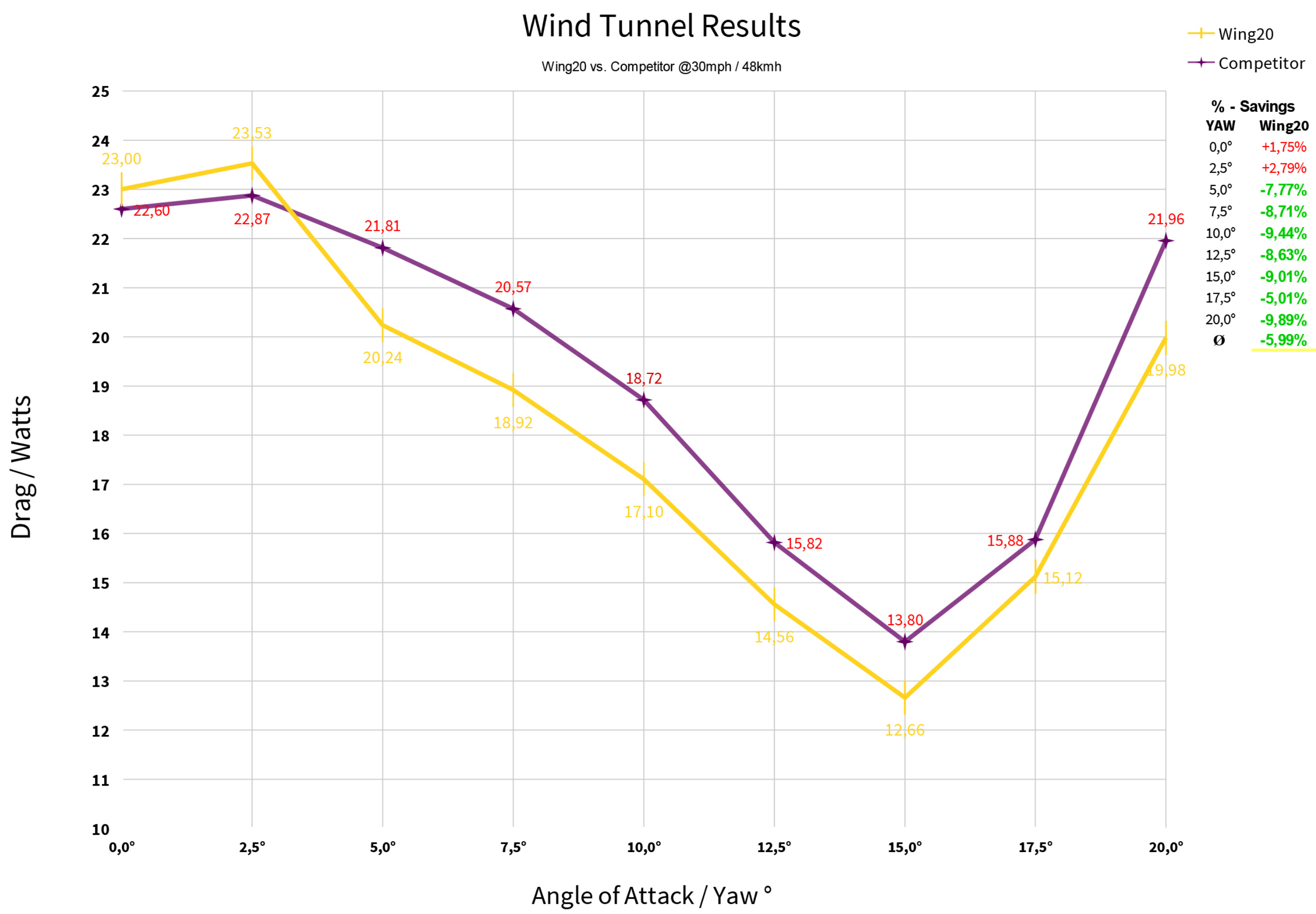
ADVANCED WHEEL STIFFNESS TEST

AERODYNAMICS

Conventional bladed spokes are flat and wide following the model of laminar air flow happening in a wind tunnel; yet in the real world air-flow is different. I'ts a giant vortex, like a swirl!
In this fully turbulent environment you need a spoke profile handling multiple yaw- angles better thus still having lowest drag.
Proven through research, the design of a missile cone head is most efficient. The shade of the all new developed Wing Spoke directly derives from this design. Its fully ovalized shape has been tested in some of the industries leading wind-tunnels resolting in ~3 Watts saving per wheelset compared to the best conventional 0,9*2.2mm bladed spoke.



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