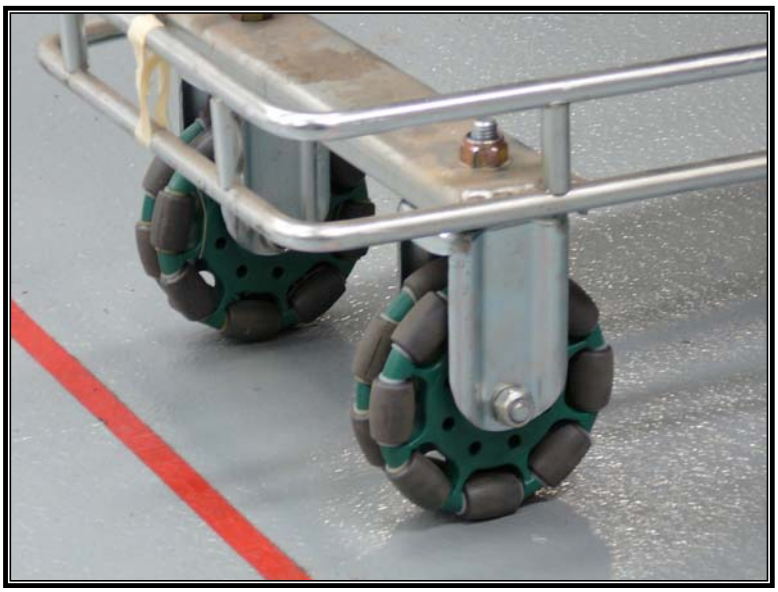
Testing of Shopping Trolley Castors



Performed for Rotacaster® Wheel Limited

Testing and Results

Testing performed by
IAG Research Centre.

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Introduction

IAG Research Centre was approached by Rotacaster® Wheels Limited to perform some testing on Rotacaster® shopping trolley wheels. The aim of this testing was to compare the characteristics of Rotacaster® shopping trolley wheels with those of standard shopping trolley wheels. The characteristics that were tested for were directional control, speed control and incline behaviour.

Test Procedure

Three types of investigations were performed on the two sets of trolley wheels:

i) Speed Control

This testing aims to determine the rolling resistance of Rotacaster® wheels by measuring their deceleration. In this testing the trolley was propelled by a pendulum device at 10 km/h and the deceleration over a 10m distance measured. The test was repeated 3 times for each condition and for each set of trolley wheels.

The 4 test conditions were as follows:

a) Rotacaster® trolley wheels with a 0kg shopping trolley load

b) Rotacaster® trolley wheels with a 45kg shopping trolley load

c) Standard trolley wheels with a 0kg shopping trolley load

d) Standard trolley wheels with a 45kg shopping trolley load

Images of the set-up for these tests can be seen in Appendix 2

ii) Directional Control

This testing aims to compare the force required to maintain the direction of the shopping trolley in a constant arc. Figure 1 shows a schematic of the testing procedure used for this investigation.

In this testing the trolley was propelled with a constant force (F_C) and the required lateral pulling force on one side on the handle to keep the trolley travelling in a prescribed arc (F_L) was measured by use of a hand held scale. The test was performed for 3 different diameter arcs and also repeated in the both the clockwise and counter clockwise directions for each condition and for each set of trolley wheels.

The 3 arc diameters (D) were as follows:

a) 2.065m representing the tightest turning circle as measured in a supermarket

b) 2.965m representing the average turning circle as measured in a supermarket

c) 3.865m representing the widest turning circle as measured in a supermarket

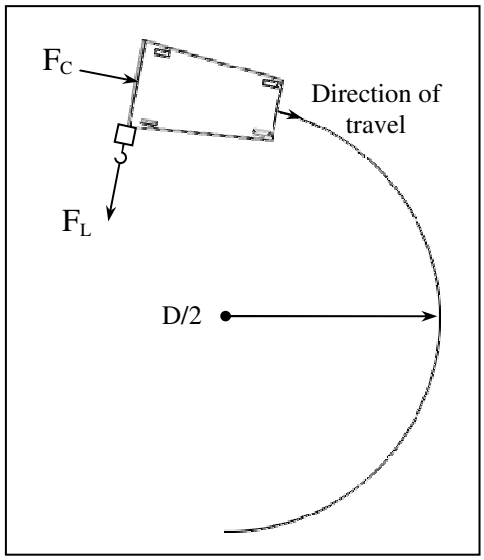


Figure 1. Directional Control Procedure.

The 4 test conditions were as follows:

a) Rotacaster® trolley wheels with a 0kg shopping trolley load

b) Rotacaster® trolley wheels with a 45kg shopping trolley load

c) Standard trolley wheels with a 0kg shopping trolley load

d) Standard trolley wheels with a 45kg shopping trolley load

iii) Incline Behaviour

This testing aims to determine the incline angle at which Rotacaster® wheels overcome static friction compared to standard shopping trolley wheels. The method used for testing this phenomenon was to place the shopping trolley on a horizontal ramp in a series of angles in relation to the axis of the ramp. The end of the ramp was then raised until the trolley started to roll down the ramp. The incline at which this occurred was then measured for each test angle and condition. Each test was repeated three times.

The 7 test angles were as follows:

a) 0^o (ie parallel to the axis of the ramp)

b) 10^o

c) 20^o

d) 30^o

e) 45^o

f) 60^o

g) 90^o (perpendicular to the axis of the ramp)

The 4 test conditions were as follows:

a) Rotacaster® trolley wheels with a 0kg shopping trolley load
b) Rotacaster® trolley wheels with a 45kg shopping trolley load
c) Standard trolley wheels with a 0kg shopping trolley load
d) Standard trolley wheels with a 45kg shopping trolley load

Images of the set-up for these tests can be seen in Appendix 2

Test Results

Graphs in Appendix 3 show the results from the testing performed on the Rotacaster® and standard shopping trolley wheels.

Discussion

i) Speed Control

The table below summarises the speed control results for the testing of standard and Rotacaster® wheels.

Wheel Type	Grocery Load	Velocity After 10m
Standard	0kg	1.72 m/s
	45kg	1.85 m/s
Rotacaster ®	0kg	1.65 m/s
	45kg	1.60 m/s

From the speed control testing it was observed that the trolley fitted with the Rotacaster® wheels decelerated quicker than the trolley fitted with standard wheels. For instance with a 0kg grocery load, the trolley fitted with Rotacaster® wheels was 4% slower after a distance of 10m. Correspondingly, when the trolleys were loaded up with 45kg of groceries, the trolley fitted with Rotacaster® wheels was nearly 14% percent slower after 10m.

Another factor observed during this testing was that the trolleys fitted with Rotacaster® wheels were less susceptible to rotational forces and consequently travelled in a straighter and more predictable manner.

ii) Directional Control

The table below summarises the directional control results for the testing of standard and Rotacaster® wheels.

			Required Force F_L (grams)		
Wheel Type	**Load**	**Direction**	**Minimum Radius**	**Maximum Radius**	**Average Radius**
Standard	0kg	Clockwise	698	471	699
	0kg	Counter clockwise	712	429	605
Rotacaster ®	0kg	Clockwise	1759	1229	1695
	0kg	Counter clockwise	1851	1376	1811
Standard	45kg	Clockwise	1272	1014	1068
	45kg	Counter clockwise	1267	1041	1066
Rotacaster ®	45kg	Clockwise	2488	1543	2186
	45kg	Counter clockwise	2624	1656	2165

From the directional control testing it was observed that the trolley fitted with the Rotacaster® wheels required a higher lateral force (F_L) under the tested conditions to maintain its direction around the prescribed arc than the trolley fitted with standard wheels. For instances with a 0kg grocery load, the trolley fitted with Rotacaster® wheels required between 156% and 190% more force to maintain its direction around the test arc. Correspondingly, when the trolleys were loaded with 45kg of groceries, the trolley fitted with Rotacaster® wheels required between 56% and 104% more force to maintain its direction around the test arc.

The following table summarises the increase in the force required to maintain the arc as a result of changing the grocery load for both standard and Rotacaster® wheels.

			Average Required Force (grams)		
Wheel Type	**Load**	**Direction**	**Minimum Radius**	**Maximum Radius**	**Average Radius**
Standard	0kg	Combined	705	450	652
Standard	45kg	Combined	1269.5	1027.5	1067
Increase in force required (0kg-45kg)			564.5	577.5	415
% Increase (0kg - 45kg)			**80%**	**128%**	**64%**
Rotacaster ®	0kg	Combined	1805	1302.5	1753
Rotacaster ®	45kg	Combined	2556	1599.5	2175.5
Increase in force required (0kg-45kg)			751	297	422.5
% Increase (0kg - 45kg)			**42%**	**23%**	**24%**

The above table indicates that the percentage force increase as the grocery load increases is less for the Rotacaster® wheel equipped trolley than that for the standard castor equipped trolley.

It should be noted that this testing only determines the lateral pulling force on one side of the handle to keep the trolley travelling in the prescribed arc and as such any forces in other directions have not been measured. Further testing on directional control with instrumentation to measure the two components on each end of the trolley handles (4 forces in total) could more accurately quantify the required force to maintain the trolley's direction.

This testing was also designed to measure the forces required to maintain the trolley's direction once initiated. Further testing could be carried out to determine the different forces that would be required to initiate travel in the prescribed arc.

iii) Incline Behaviour

The table below summarises the directional control results for the testing of standard and Rotacaster® wheels.

	Ramp Angle (Degrees)			
Trolley Angle	**Standard Wheels – 0kg Load**	**Standard Wheels – 45kg Load**	**Rotacaster® Wheels – 0kg Load**	**Rotacaster® Wheels – 45kg Load**
0^o	1.28	2.15	2.67	2.45
10^o	1.05	1.72	2.71	2.44
20^o	1.18	2.12	2.70	3.26
30^o	1.31	2.15	4.28	4.76
45^o	2.02	2.16	4.69	3.20
60^o	2.42	2.14	4.92	5.55
90^o	2.75	3.42	6.03	7.02

From the incline behaviour testing it was observed that the trolley fitted with the Rotacaster® wheels required a greater incline angle to overcome static friction and roll down the ramp than the trolley fitted with standard wheels. For instance with a 0kg grocery load, the trolley fitted with Rotacaster® wheels required an incline angle of between 103% and 227% greater than the standard wheeled trolley to roll down the ramp. Correspondingly, when the trolleys were loaded up with 45kg of groceries, the trolley fitted with Rotacaster® wheels required between 14% and 159% more incline to roll down the ramp unaided.

Conclusion

At the request of Rotacaster® Wheels Limited, the IAG Research Centre performed a series of comparative tests on a set of standard trolley wheels and Rotacaster® wheels. These tests aimed to determine the performance of Rotacaster® wheels in the following areas:

i) Speed Control
ii) Directional Control
iii) Incline Behaviour

With respect to speed control, it was found that the Rotacaster® wheels decelerated quicker once the force pushing them was removed, being up to 14% slower at the end of the 10m test track.

Directional control testing indicated that when the trolley was fitted with Rotacaster® wheels it required considerably more force to maintain the trolley's arc in a prescribed circuit; in some cases almost three times higher. This testing was used to test the lateral pulling force on one side of the handle to keep the trolley travelling in a prescribed arc. As such any other forces involved in maintaining the motion of the trolley in the prescribed arc have not been measured and could be determined with further investigation. Also the forces required to initiate the angular motion (turning) of the trolley could be measured with additional testing.

The incline behaviour testing showed that the ramp angle required to initiate movement down the ramp was between 14% and 227% greater for the trolley fitted with Rotacaster® wheels than when fitted with standard trolley wheels, depending on grocery load and trolley angle on the ramp.

To fully quantify the forces involved with cornering the shopping trolley it is recommended that further testing be performed. Such testing should involve the following:

a) Measurement of all forces required to propel and turn the shopping trolley. This would entail a rig containing 4 sensors to be attached to the trolley to measure all force components.
b) Measurement of the forces required to initiate and also maintain the angular motion of the trolley.
c) The testing should be performed at varying speeds and also ideally with differing grocery loads to enable the casters' performance to be measured over numerous operating conditions.

Appendices

Appendix 1. Shopping Trolley Wheel Images

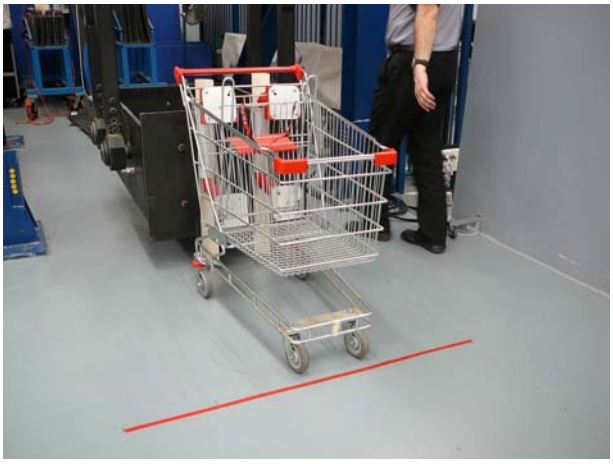
Standard Shopping Trolley Wheels.

Rotacaster Shopping Trolley Wheels

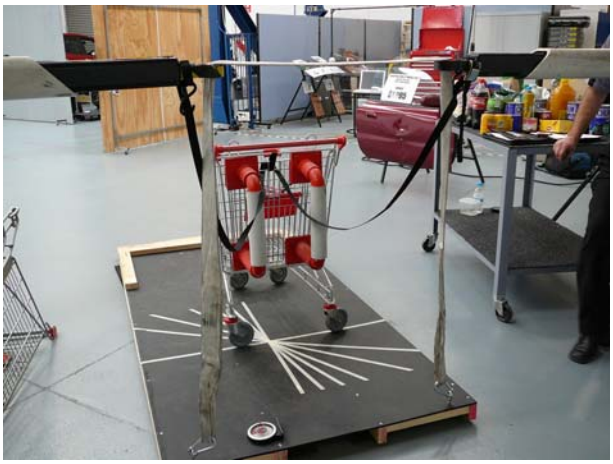
Appendix 2. Testing Set-up

Speed Control Setup

Speed Control Testing - Rotacaster Wheels with Full Grocery Load



Speed Control Testing - Standard Wheels with No Grocery Load

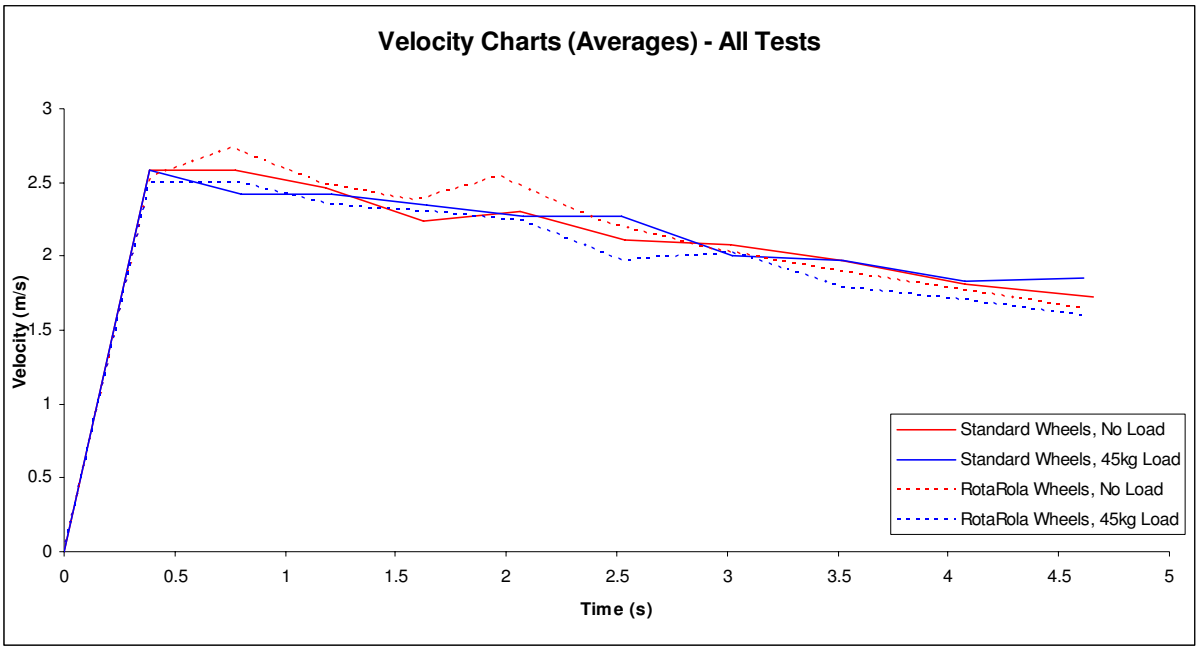


Incline Behaviour Setup

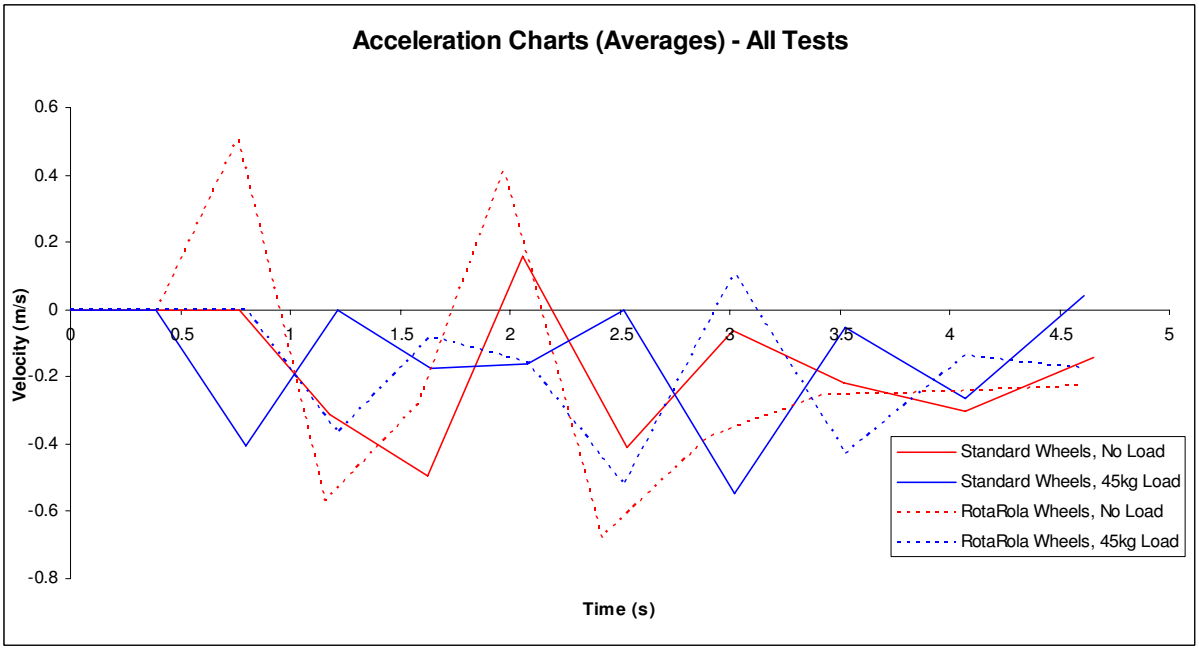
Incline Behaviour Testing - Rotacaster Wheels with No Grocery Load

Incline Behaviour Testing - Rotacaster Wheels with 45kg Grocery Load

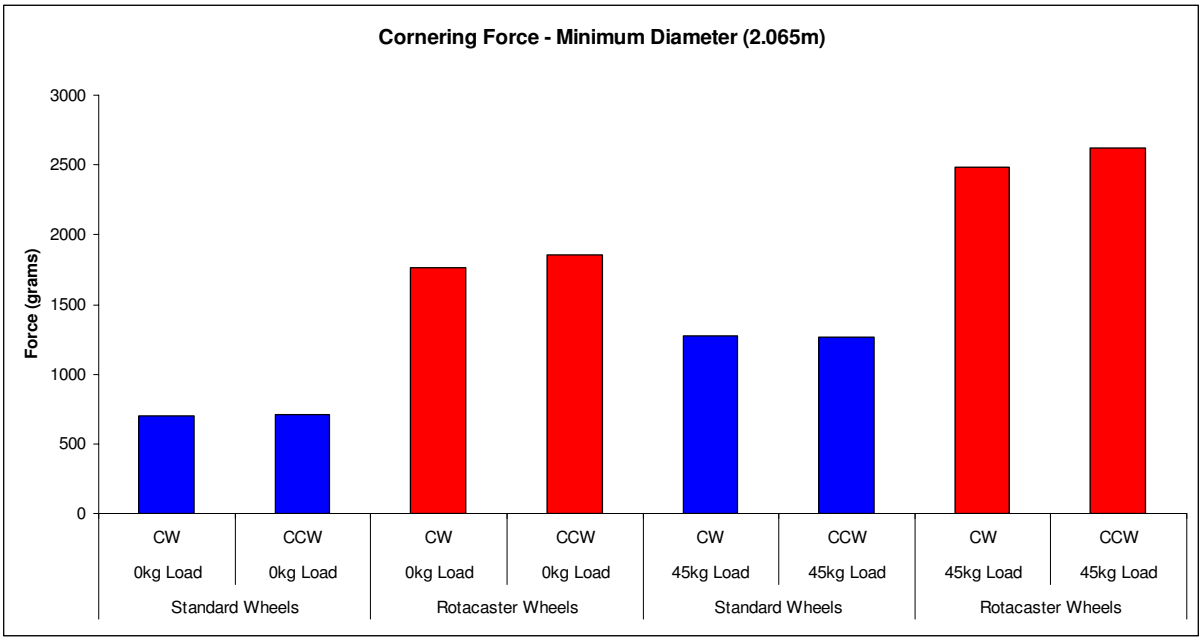
Appendix 3. Results



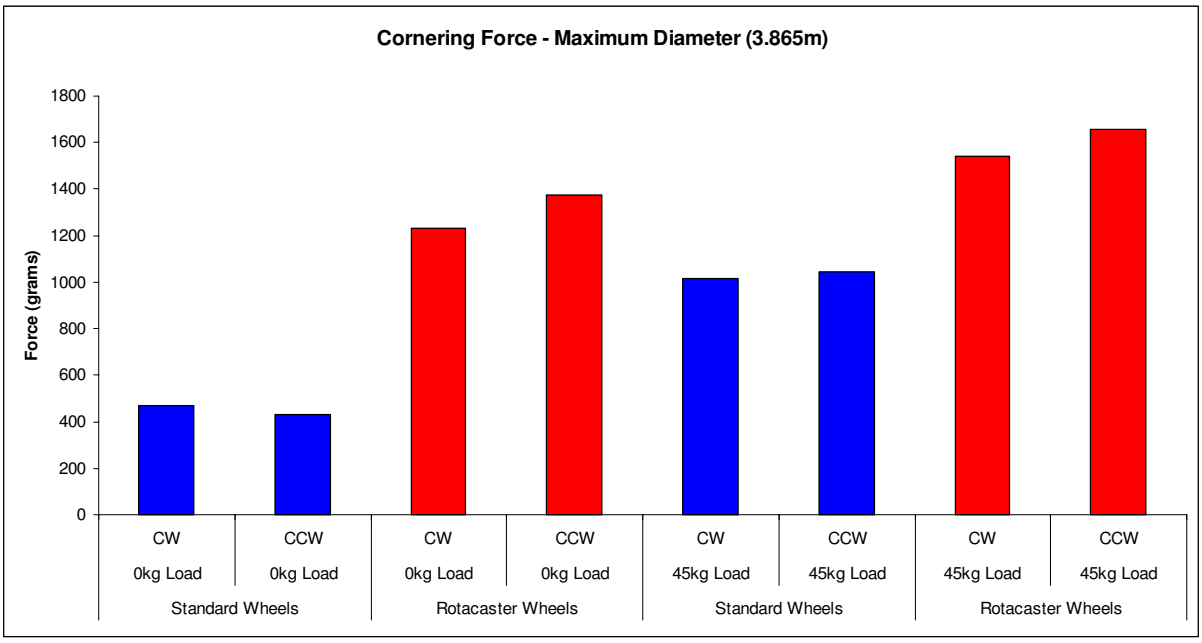
Speed Control Testing Summary Results - Velocity



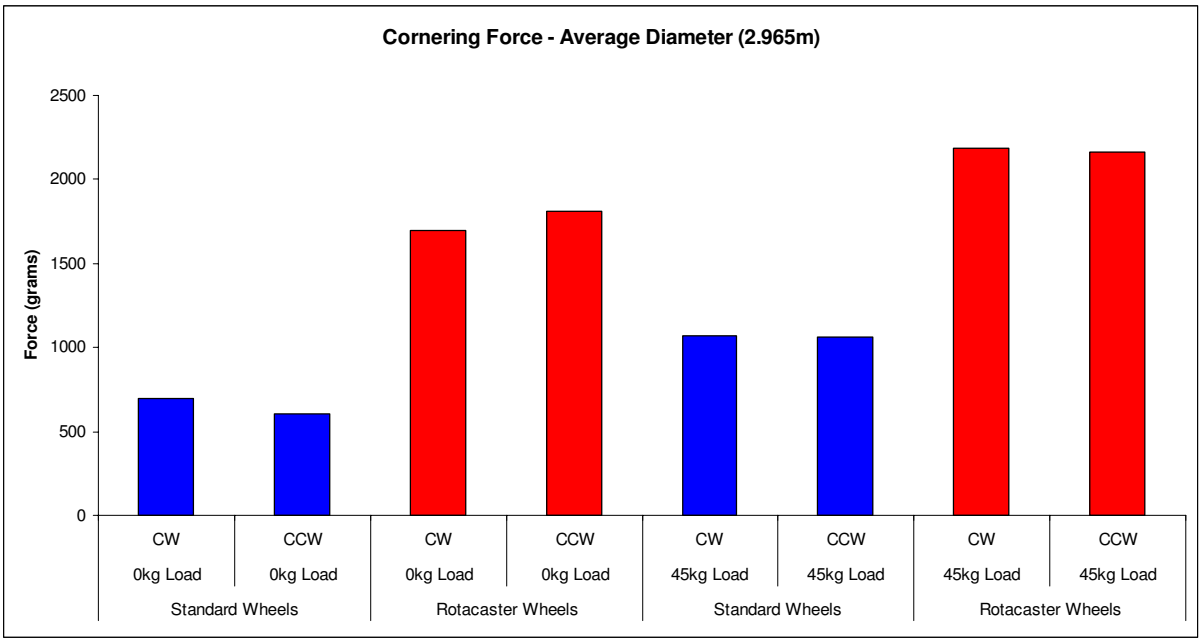
Speed Control Testing Summary Results - Acceleration



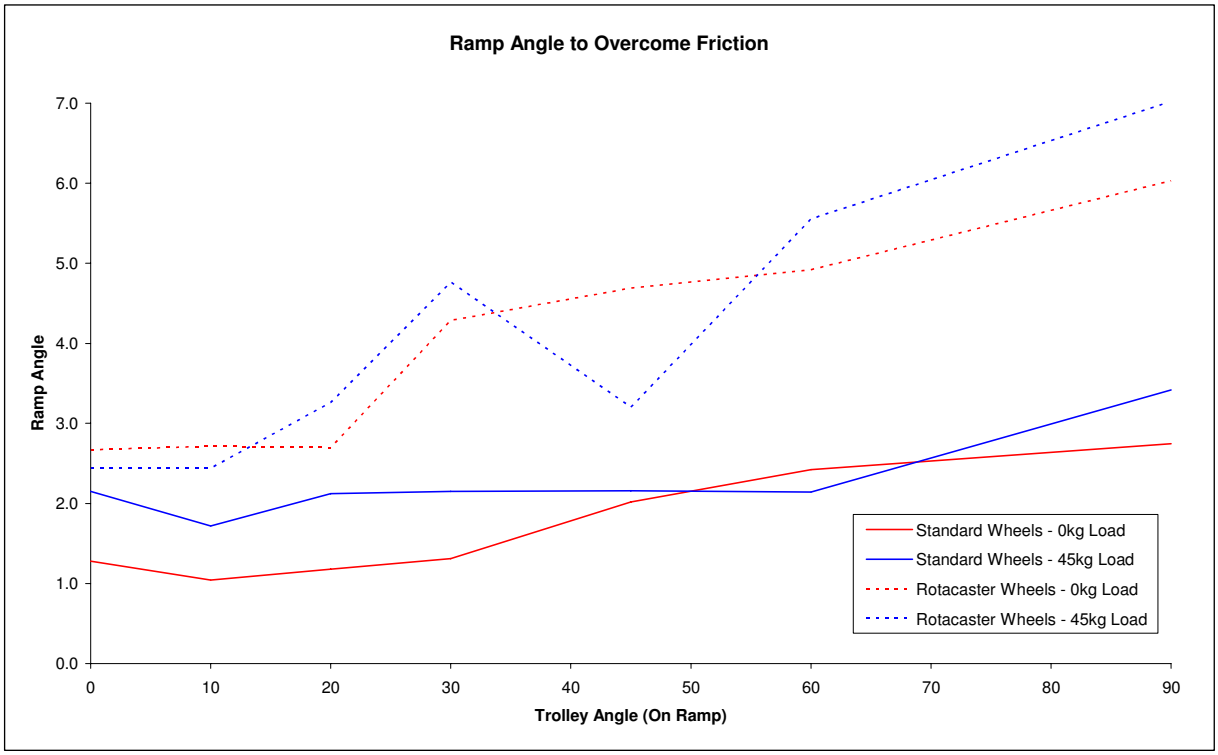
Directional Control Testing Summary Results – Minimum Corner Diameter



Directional Control Testing Summary Results – Maximum Corner Diameter



Directional Control Testing Summary Results – Average Corner Diameter



Incline Behaviour Testing Summary Results