Australasian Road Safety Research, Policing & Education Conference 2012
4-6 October 2012, Wellington, New Zealand

SNOW TYRES
EMERGENCY BRAKING & CORNERING PERFORMANCE
COMPARISON WITH CONVENTIONAL TYRES

Senior Constable Cory Ubels, NZ Police
Serious Crash Unit
Eastern Police District
cory.ubels@police.govt.nz

ABSTRACT

The use of snow tyres in New Zealand is becoming more common due to lower priced late model second hand passenger cars being imported fitted with older half worn snow tyres. Inappropriate use of snow tyres has been anecdotally linked to a number of serious and fatal crashes nationally. A primary consideration for crash investigators is to establish whether or not the use of the snow tyres contributed to the cause of those crashes.

This paper describes comparative testing of snow tyres and conventional tyres for both wet and dry road surfaces. Testing was undertaken for both cornering and straight line emergency braking. The tests were performed by NZ Police Serious Crash Unit staff.

Preliminary test results indicated a significant reduction in traction for snow tyres when compared to conventional car tyres during cornering manoeuvres, and a considerable increase in stopping distances on wet surfaces under emergency braking situations.

An analysis of the results from initial testing showed a reduction in cornering (lateral) traction of around 6.0% on a dry road and 9.2% in the wet. Regarding stopping distances under emergency braking, in the dry there was a reduction in stopping distance of around 13.1%, but an increase in stopping distance in the wet of 16.0%. This equates to an increase in stopping distance on a wet road surface of about 2.6 metres at 50km/h and about 10.6 metres at a speed of 100km/h.

The research, although limited in extent, show that snow tyres do not offer as much grip as can be achieved with conventional tyres, particularly in wet conditions and also during cornering in wet or dry road conditions. Further testing is required to determine if the age of the snow tyres and/or the road surface type will have an effect on the results (asphalt, bitumen chip etc). This testing should clarify the relationship between tyre type, tread depth and friction.

1 INTRODUCTION

The emergency braking and cornering performance of snow tyres is an aspect explored by crash investigators in relation to their causative influences in the circumstances of a crash. This paper describes comparative testing performed by NZ Police Serious Crash Unit staff, and outlines the findings of those tests. The purpose of this research was to determine the effectiveness of snow tyres in comparison to conventional tyres on both dry and wet road surfaces.

Some of the terminology the author uses throughout this paper may appear vague from a pure engineering standpoint. Please take into consideration this paper has been written from the perspective of a crash investigator detailing the results of physical tests undertaken as opposed to being written from an engineering perspective as a technical paper.

Snow (or winter tyres as they are sometimes referred to as) are designed for driving on snow and ice, and in temperatures below 7°C. They are constructed from a specific softer compound of rubber and they can be distinguished by their deep square-patterned tread blocks.

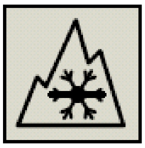
It is important to note that snow tyres should not be confused with all-season tyres referred to as ‘mud & snow’ tyres, which are often marked with the letters ‘M+S’ on the sidewall.

Fig 1: Snow Tyre Tread

Snow tyres have a distinctive tread pattern. It consists of deep square patterned tread blocks that have small zig-zag grooves called sipes which allow the blocks to flex in order to maintain grip.

In addition to the distinctive tread pattern, winter tyres usually have one or both of the following markings:

- A snowflake and mountain symbol marked on the sidewall of the tyre.



- The word 'Studless' on the side wall of the tyre.

For a very small number of drivers who regularly drive on snow and ice and in cold temperature, snow tyres may be appropriate. In these cases the snow tyres should be fitted in sets of four, and changed at the end of the snow conditions. Most New Zealand motorists don’t need specialised snow tyres on their vehicles.

Although NZ has areas where the climate seasonally supports the use of snow tyres, due to the increase in imported cars coming into the country fitted with snow tyres, these specialised tyres are being used in conditions where their use may not be appropriate.

Recent legislation in New Zealand restricts the use of snow tyres by ensuring that there is no mixing of snow and conventional tyres. If snow tyres are to be used, then all four tyres have to be snow tyres. The minimum tread depth was also increased from 1.5mm to 4.0mm. Providing those two restrictions are adhered too, snow tyres can be used on any road surface in any weather conditions.

The question being asked in this research is how safe are used snow tyres when compared to used conventional tyres where the snow tyres are being used outside of their optimum climate conditions.

2 RESEARCH OBJECTIVES

The objective of the original tests was to undertake a tyre comparison as part of a live crash investigation where a Holden Commodore sedan that had been involved in a fatal crash, had mud grip all-terrain tyres fitted to the rear axle of the vehicle.

The intention of those original tests was to establish a lateral traction comparison between mud grip tyres and conventional passenger car tyres. Once this testing was completed it was decided to expand the testing to include the comparison with snow tyres using the same site. This allowed the author the ability to capture useful data which may assist in future crash investigations where snow tyres were being considered as a causative factor in the crash.

Based on the results of those snow tyre tests, the research objective was modified in order to determine if there was a safety and/or performance issue with the use of snow tyres on New Zealand roads.

To the author's knowledge, there has been no published research completed in New Zealand specifically detailing a comparison between snow tyres and conventional passenger car tyres.

This research attempted to compare like with like in that the conventional tyres and the snow tyres used both had tread depths of around 4.0mm. An important issue to be considered though is due to a lack of available resources at the time, the snow tyres used for these tests were over 11 years old and the conventional tyres were only 3 years old.

Further testing of younger and/or new snow tyres will need to be completed in order to determine if the degradation of the tyre material due to age would be a significant factor when comparing the results of testing between the two types of tyres.

3 METHODOLOGY

The snow tyre comparison tests were completed on two types of road surface in both wet and dry conditions. These tests were predominantly undertaken under straight line emergency braking situations but also whilst cornering in order to compare lateral traction under the same conditions.

3.1 Lateral Traction Tests - Napier Airport

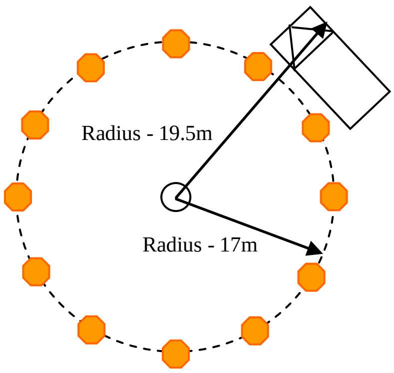
The test site was set up on the tarmac in front of the fire rescue building at the Napier Airport. Cones were set up in a circle with a radius of about 17m which was pre-determined in order to have a critical curve[1] speed of about 45km/h. This speed was considered appropriate in order to complete the tests safely with little or no damage to property.

Fig 2: Airport Lateral Traction Test Site

The vehicle used for these tests was a 2006 VZ Holden Commodore. The test vehicle was driven by the author, with a passenger seated in the front passenger seat.

The passenger monitored a GPS speedometer which sampled at a rate of 100Hz. As the vehicle was accelerated faster and faster around the circle of cones, the passenger read out the speed from the GPS hand held display.

Fig 3: Lateral Traction Test Setup



Once the critical lateral friction (traction) was exceeded and the vehicle started to slide out, the speed at which this occurred was recorded.

The speedometer of the vehicle was not used for these tests due to the inaccuracy of a speedometer when the tyres of the vehicle begin to slip on the road surface.

Three tests were completed whilst travelling in a clockwise direction and then three tests in an anti-clockwise direction. These tests were repeated on a dry and a wet road surface.

A Vericom VC3000PC accelerometer was also used to determine the peak lateral friction of each test. The peak lateral friction values were obtained after downloading the test data into a Vericom Computers Incorporated software programme called 'Profile', Version 3. The Vericom VC3000PC is a gazetted brake testing device used internationally to determine vehicle performance.

[1] *Critical Curve Speed - Is a speed above which a particular highway curve, or a curve demanded by the driver, could not be negotiated by a motor vehicle without all the wheels side slipping.*

The Vericom is a dual axis high precision accelerometer that measures motion as a rate-of-change of speed (acceleration and deceleration). By inference, the lateral and longitudinal measurements are taken as simply a numeric representation of the forces measured as a percentage of gravity (9.81m/s^2).

Fig 4: Vericom VC3000PC Set Up

The device is mounted on the test vehicles windscreen and can be activated externally from the brake lights or internally by the deceleration of the test vehicle which in turn is directly related to the braking force.

The Vericom was used during this research to not only determine peak lateral friction values, but also to determine the drag factor[2] of the road surfaces during the emergency braking tests.

The result that this device produces is sometimes referred to as the 'Co-efficient of Friction'. The Drag factor and Co-efficient of Friction will be equal in cases where all wheels are locked and sliding on a level road surface.

These tests were completed using the same vehicle, the same weight and on a reasonably level surface, and with all the wheels locked so the term drag factor will be used through-out this paper.

3.2 Emergency Braking Tests - Napier Airport

A number of straight line emergency braking tests were also completed at the same location as where the lateral traction tests had been completed.

These tests were undertaken using the Vericom along with the same vehicle, the same conventional tyres and the same snow tyres as were used for the lateral traction tests. A passenger was also seated in the front passenger seat during all the tests in order to balance the weight of the vehicle.

All straight line emergency braking tests were completed at a speed of around 50km/h to ensure not only safe testing practices were being adhered too, but also to ensure that the tyres being tested did not degrade to the point where they could no longer be used for further testing.

Fig 5: Airport Emergency Braking Test Site

The anti-lock braking system (ABS) was de-activated during these tests so that all four tyres would lock and slide across the surface.

3.3 Emergency Braking Tests - Irongate Road East

The second location used for testing was on Irongate Road East, Hastings. This is a stretch of well used arterial road which had been blocked off as a result of a new expressway splitting the road through the middle.

The same vehicle, conventional tyres, snow tyres, Vericom and driver were used for these tests as was used for the tests completed at the Airport. A passenger was also seated in the front passenger seat.

Fig 6: Irongate Road East Test Site

[2] *Drag Factor:* *A term used by crash reconstructionists to represent the acceleration or deceleration of a vehicle or other body as a decimal fraction of the acceleration of gravity (9.81m/s^2).*

By using the same variables for these tests, it ensured a more consistent and therefore comparable result when comparing the emergency braking tests undertaken at the Airport.

These tests were completed on a dry road surface, and then the local fire service wet down the road so that wet surface testing could also be completed. A further series of wet road surface testing was completed at the same location on a different day whilst it was raining.

The extra wet surface comparison was considered important in order to determine whether or not the method of wetting the road surface affected the results.

4 TYRES USED FOR THIS RESEARCH

The set of four snow tyres that were used for these tests were donated for the purpose of this research. The same set of snow tyres were used for all the relevant tests both at the Napier Airport test site and at the Irongate Road East test site.

4.1 Snow Tyre

Dunlop Grasspic DS-1 195/55 R15
Tubeless Steel Belted Radial
Studless
Average Tread Depth - 4.0mm
Date of Manufacture - 4700 (November 2000)
Made in Japan
Tyre Pressure: 32psi

Fig 7: Dunlop Grasspic Snow Tyre

The set of conventional tyres used were from an older style VZ series Holden Commodore Police patrol vehicle. The same conventional tyres were used for all the relevant tests involved in this research.

4.2 Conventional Tyre

Bridgestone Turanza ER30 225/60 R15
Tubeless Steel Belted Radial
Average Tread Depth - 4.0mm
Date of Manufacture - 0209 (January 2009)
Made in Australia
Tyre Pressure: 36psi

Fig 8: Bridgestone Conventional Tyre

5 TEST SITE ROAD SURFACES

The two test site locations had quite different types of textured surfaces. The Airport surface was quite smooth compared to the normal New Zealand road surface, hence why further tests were completed at the Irongate Road East site which was a more appropriate road surface.

5.1 Napier Airport

The Airport road surface was a mix 10 asphaltic concrete which was estimated at about 5 years old. The macrotexture was about 0.5mm MPD (*mean profile depth*) and the aggregate was greywacke. It appeared that the bitumen had been worn off the surface aggregate.

The asphaltic concrete surface was similar to that used in urban areas. It is often used with a larger aggregate size in high stress areas such as intersections.

Fig 9 & 10: Napier Airport Test Surface

The low macrotexture means this type of surface should not be used in higher speed areas. This particular surface is lightly trafficked which appears to have resulted in the aggregate not being significantly polished to a lower skid resistance.

5.2 Irongate Road East, Hastings

This test site has a grade three chip seal which was moderately worn. The macrotexture was between 1.7mm and 2.0mm MPD. The aggregate was also greywacke and the surface was moderately polished.

Fig 11 & 12: Irongate Road East Test Surface

The chip seal is representative of tar sealed chip aggregate used widely in New Zealand. Asphaltic concrete in the full range of mix types is used in more heavily trafficked areas and more common in urban areas where noise is of concern.

6 ANALYSIS RESULTS

6.1 Napier Airport - Lateral Traction Tests

The original data results were split into three separate sections, conventional tyres inflated to 36psi, snow tyres inflated to 44psi and snow tyres inflated to 32psi. Tests were completed using snow tyres at 44psi (which is the maximum inflation pressure for these particular snow tyres) in order to determine if a difference in tyre pressure affected the results.

The advisory tyre pressure for these snow tyres is about 32psi, so for the purpose of this analysis, only the tests completed at 32psi have been detailed in the data results. The comparison between the different snow tyre pressures is discussed later in the paper.

The speed at which these tests were undertaken was deliberately low due to safety concerns with the area where the tests were being conducted.

The lateral friction test results as detailed in Table 1 combine both clockwise and anti-clockwise direction tests on a dry road surface.

As shown in Table 1, there was a reduction of 6% in the cornering traction of the snow tyres when compared to the conventional tyres.

The results also show that if the average of 6.0% reduction in lateral traction is applied to critical curve speeds of 70km/h & 90km/h using conventional tyres, then the speed the snow tyres should lose traction on the same dry road surface would be around 65km/h and 84km/h respectively.

Table 1: Lateral Traction Dry Surface Test Results & Analysis

Tyre Type	psi	Dry / Wet	Speed	Lateral Friction	Average Lateral Friction	Critical Speed at 70km/h	Critical Speed at 90km/h
Conventional	36	Dry	43	0.923	0.921	70.0 km/h	90.0 km/h
Conventional	36	Dry	44	0.936			
Conventional	36	Dry	45	0.898			
Conventional	36	Dry	45	0.923			
Conventional	36	Dry	44	0.913			
Conventional	36	Dry	43	0.935			
Snow	32	Dry	41	0.814	0.815	65.8 km/h	84.6 km/h
Snow	32	Dry	40	0.757			
Snow	32	Dry	39	0.826			
Snow	32	Dry	43	0.882			
Snow	32	Dry	41	0.847			
Snow	32	Dry	41	0.761		-6.0%	

Further lateral tests were completed on a wet road surface. Again, these test results included clockwise and the anti-clockwise tests combined in one table.

Table 2: Lateral Traction Wet Surface Test Results & Analysis

Tyre Type	psi	Dry / Wet	Speed	Lateral Friction	Average Lateral Friction	Critical Speed at 70km/h	Critical Speed at 90km/h
Conventional	36	Wet	45	0.906	0.875	70.0 km/h	90.0 km/h
Conventional	36	Wet	44	0.850			
Conventional	36	Wet	43	0.922			
Conventional	36	Wet	39	0.860			
Conventional	36	Wet	39	0.853			
Conventional	36	Wet	40	0.857			
Snow	32	Wet	35	0.706	0.722	63.6 km/h	81.8 km/h
Snow	32	Wet	37	0.714			
Snow	32	Wet	36	0.648			
Snow	32	Wet	38	0.788			
Snow	32	Wet	38	0.738			
Snow	32	Wet	36	0.736		-9.2%	

As shown in Table 2, the reduction in lateral friction between conventional tyres and the snow tyres increases from 6.0% in the dry to 9.2% on a wet road surface.

If the same consideration used for the dry surface analysis is also used for the wet surface, with a 9.2% reduction in lateral friction applied to a speed of 70km/h and 90km/h, the speed the snow tyres would lose traction on the same wet surface would be around 63km/h and 81km/h respectively.

As previously discussed, some of the lateral traction tests were conducted with snow tyres inflated to 44psi in order to determine if tyre inflation is likely to be a factor to consider when analysing the safety of snow tyres. The result indicated a further reduction in lateral friction from 6.0% to 7.2% on a dry road surface and a further reduction from 9.2% to 11.2% on a wet road surface. This clearly shows that the tyre inflation level of snow tyres does need to be considered when determining their suitability for use outside of their optimum climate conditions.

6.2 Napier Airport - Emergency Braking Tests

These tests were originally conducted as an after thought, as the site was set up specifically to test the lateral traction between different types of tyres. A decision was made on the testing day to test the emergency braking ability of snow tyres also. As a result, only one dry road surface test using conventional tyres was undertaken before the road was wet in order to continue with wet road surface testing.

The data obtained from the dry road surface testing produced surprising results, in that the snow tyres out performed the conventional tyres on the same surface.

Each of the analysis results as detailed in the following tables refer to stopping distances at 50km/h and 100km/h. These results have been calculated using an average drag factor taken from the data obtained during the tests as a variable in a widely used distance formula: *d = Velocity* ^{2}*/(2*9.81*Drag factor)*

As shown in Table 3, an increase of 13.1% in friction value alone is considerable, but when that result is applied to a speed of 50km/h and 100km/h, the reduction in stopping distance could mean the difference between serious or minor injuries in a crash. It is important to keep the fact only one dry test using conventional tyres was completed, so it is possible that the difference between the types of tyres may have been over or under stated.

Table 3: Emergency Braking Dry Surface Test Results & Analysis (Napier Airport)

Tyre Type	psi	Dry / Wet	Drag Factor	Speed	Slide Distance	Avg Drag Factor	Difference	Stopping @ 50km/h	Diff @ 50km/h	Stopping @ 100km/h	Diff @ 100km/h
Conventional	36	Dry	0.674	50	14.5 m	0.674	n/a	**14.6 m**		**58.4 m**	
Snow	32	Dry	0.761	43	9.5 m				**-1.7 m**		**-6.7 m**
Snow	32	Dry	0.772	44	10.2 m	0.762	**13.1%**	**12.9 m**		**51.7 m**	
Snow	32	Dry	0.753	45	10.8 m						

The next set of tests was undertaken on a wet road surface in the same area to where the dry road surface tests had been completed. The surface was wet down by the Fire Rescue staff between each set of three tests.

Unfortunately due to these emergency braking tests not being pre-planned, the snow tyre tests were only undertaken with an inflation pressure of 44psi and not at the recommended pressure of 32psi.

Table 4: Emergency Braking Wet Surface Test Results & Analysis (Napier Airport)

Tyre Type	psi	Dry / Wet	Drag Factor	Speed	Slide Distance	Avg Drag Factor	Difference	Stopping @ 50km/h	Diff @ 50km/h	Stopping @ 100km/h	Diff @ 100km/h
Conventional	36	Wet	0.705	44	11.1 m						
Conventional	36	Wet	0.720	43	10.2 m	0.710	n/a	**13.9 m**		**55.4 m**	
Conventional	36	Wet	0.706	45	11.3 m						
									2.6 m		**10.6 m**
Snow	44	Wet	0.593	44	12.9 m						
Snow	44	Wet	0.582	45	14.4 m	0.597	**-16.0%**	**16.5 m**		**66.0 m**	
Snow	44	Wet	0.615	43	12.7 m						

The results shown in Table 4 show a clear turn around compared to the dry road surface tests with an <u>increase</u> in stopping distance between the snow tyres and the conventional tyres of about 16%.

The extra inflation pressure is likely to result in a slight decrease in stopping distance under emergency braking conditions; therefore this is going to impact slightly on the results of these tests. However if the data is taken on face value, an increase in stopping distance of about 2.6m at 50km/h and 10.6m at 100km/h would be considered very unsafe.

6.3 <u>Irongate Road East, Hastings</u> - Emergency Braking Tests

These tests were planned and designed specifically to provide data to assist in determining if the type of road surface would have an effect on the results obtained during the tests conducted at the Napier Airport. They were conducted in both directions and on the same section of road in order to provide double the amount of data available for analysis. All the test data has been combined within the tables shown.

The results as detailed in Table 5 show similar results to the dry road surface results obtained during the emergency braking tests at the Napier Airport.

Table 5: Emergency Braking Dry Surface Test Results & Analysis (Irongate Road East)

Tyre Type	psi	Dry / Wet	Drag Factor	Speed	Slide Distance	Avg Drag Factor	Difference	Stopping @ 50km/h	Diff @ 50km/h	Stopping @ 100km/h	Diff @ 100km/h
Conventional	36	Dry	0.649	49	14.2 m	0.652	n/a	**15.1 m**	**-1.7 m**	**60.4 m**	**-6.7 m**
Conventional	36	Dry	0.673	48	13.2 m						
Conventional	36	Dry	0.630	43	11.6 m						
Conventional	36	Dry	0.652	51	15.1 m						
Conventional	36	Dry	0.656	47	12.8 m						
Snow	32	Dry	0.719	48	12.3 m	0.733	**12.4%**	**13.4 m**		**53.7 m**	
Snow	32	Dry	0.712	47	12.3 m						
Snow	32	Dry	0.746	46	10.9 m						
Snow	32	Dry	0.748	42	9.3 m						
Snow	32	Dry	0.730	46	11.2 m						
Snow	32	Dry	0.742	46	11.2 m						

During these tests, the snow tyres out performed the conventional tyres with an average of 12.4% reduction in stopping distance, equating to 1.7m at 50km/h and 6.7m at 100km/h.

The wet road surface testing results as shown in Table 6 were obtained by using the local fire service to wet down the road before each set of three tests were completed. These results were not as dramatic in comparison to the Airport wet road surface tests, but they did confirm that conventional tyres out perform snow tyres on wet road surfaces.

Table 6: Emergency Braking Wet Surface Test Results & Analysis (Irongate Road East)

Tyre Type	psi	Dry / Wet	Drag Factor	Speed	Slide Distance	Avg Drag Factor	Difference	Stopping @ 50km/h	Diff @ 50km/h	Stopping @ 100km/h	Diff @ 100km/h
Conventional	36	Wet	0.607	42.0	11.9 m	0.584	n/a	**16.9 m**	**1.0 m**	**67.5 m**	**4.0 m**
Conventional	36	Wet	0.612	42.1	12.3 m						
Conventional	36	Wet	0.620	45.1	13.7 m						
Conventional	36	Wet	0.536	43.3	14.4 m						
Conventional	36	Wet	0.566	42.1	13.0 m						
Conventional	36	Wet	0.560	43.6	14.2 m						
Snow	32	Wet	0.566	42.5	13.2 m	0.551	**-5.6%**	**17.9 m**		**71.5 m**	
Snow	32	Wet	0.565	41.9	12.7 m						
Snow	32	Wet	0.543	42.0	13.5 m						
Snow	32	Wet	0.546	44.0	14.4 m						
Snow	32	Wet	0.547	44.0	14.5 m						
Snow	32	Wet	0.538	43.5	14.6 m						

A further set of tests were conducted on a different day whilst it was raining as opposed to the previous tests being conducted using the local fire service to wet down the road. The purpose was to determine if the method used to wet the road surface affected the results.

Although there was a slight increase in stopping distance between the two different methods used to wet the road surfaces, the data suggests that the method used to wet the road surface and the resultant difference in the temperature of the road, appears to make very little difference to the overall results.

What the results do highlight is the fact that snow tyres take longer to stop on a wet road under emergency braking conditions when compared to conventional tyres.

7 CONCLUSION

Snow tyres are a specialised tyre designed for driving in snow conditions (on snow and ice, and in temperatures below 7°C) and there appears to be little consideration given in New Zealand as to how safe snow tyres are in weather outside of those conditions.

Passenger cars are being imported into New Zealand (mainly from countries such as Japan) with used snow tyres fitted. Providing the vehicle meets New Zealand entry inspection vehicle standards and warrant of fitness criteria, e.g., 4mm tread depth and all four tyres being snow tyres, then the snow tyres are considered legal on the vehicle.

This situation is exacerbated by the fact that unsuspecting people who are sold snow tyres because they are relatively cheap, do not necessarily have the experience to assess the problems or the knowledge to know how to deal with the loss of control. It is also likely that people purchasing imported vehicles and/or used snow tyres will not realise that they need to purchase a full set of four snow tyres with a minimum of 4.0mm tread depth.

This research determined that snow tyres under perform considerably during cornering tests compared to conventional tyres on both dry and wet road conditions. The reduction in lateral friction between the types of tyres, particularly on a wet road surface, is concerning. This subject needs further investigation and testing to determine the exact extent of the issue.

In relation to emergency braking, snow tyres also under performed conventional tyres on wet road surface tests. It was expected that snow tyres would under perform in the wet due to a lack of drainage within the tyre tread combined with the tyres softer compound.

These results tended to confirm that statement; however in contrast, snow tyres out performed conventional tyres during dry road surface emergency braking testing. The low macrotexture of the surface would also tend to favour the conventional tyres in the wet but the snow tyres in the dry.

It is important to put these conclusions into perspective though, as there are a number of other factors that need to be considered when determining the reliability of the results obtained from this research. These factors may include the types of snow tyres available, the brand and the age of the tyres, as well as different tyre pressures and the different types of road surfaces available within New Zealand.

Testing was also only completed at about 50km/h for safety reasons and to ensure the tyres used for the testing did not degrade to the point where they could not be used for further testing. However, there is a school of thought that suggests that during wet road testing, the friction value can decrease as the speed of the testing is increased. The resultant decrease in friction does not appear to be overly significant but it would be worth while considering all the same.

It is possible that the age of the snow tyres used for this research may have affected the results of the analysis as the tyre material is likely to have degraded to some degree. Therefore these results may not be representative of a younger or new snow tyre. However, there does not appear to be any record kept of the average age of snow tyres on vehicles being imported into NZ, so it is also possible that older snow tyres are being used on NZ roads.

Further research will need to be completed to determine the average age of snow tyres being fitted to late model second hand vehicles being imported into New Zealand. The result of that research may necessitate further comparative testing using younger or possibly even new snow tyres to determine if the age of the tyre is a significant safety and/or performance issue when snow tyres are being used outside of their optimum climate conditions.

8 REFERENCES

NZTA, (2011) Tyres and Wheels Rules, Pamphlet - www.nzta.govt.nz/resources/rules/tyres-and-wheels-2001-index.html

Brown, E, NZ Police (2005) - Developments in traffic crash investigation

Stables, M, NZ Police (2011) - The use of winter (snow) tyres in New Zealand

RNZPC, NZ Police, (2005) - Vericom VC3000 Instruction and Procedures Manual (Modified for NZ Police)

Road Accident Investigation Services Pty Ltd, (2010) - Identify and Gather Evidence Training Manual

Rod Cross, Physics Department, University of Sydney, NSW, (2006) - Increase in friction force with sliding speed

9 ACKNOWLEDGEMENTS

The author wishes to acknowledge and thank David Cook, New Zealand Transport Agency, for his involvement during the early stages of the practical testing and also for his advice and guidance during the preparation of this paper.

The author also wishes to acknowledge and thank Inspector Mark Stables, National Manager Police Crash Investigation, for his contribution in providing relevant and very useful research material, and for his support in the preparation of this paper.

The author would also like to thank 'Mudgway Partsworld' in Hastings for donating the snow tyres that were used for this research.

Finally the author would like to thank Senior Constable Chris Pye and Senior Constable Tim Rowe for their assistance during the practical testing phase of this research.

10 DISCLAIMER

The views expressed in this paper are of the author and do not necessarily represent the views of the New Zealand Police.

11 AUTHOR BIOGRAPHY

The author, Cory Ubels, is a serving member of the New Zealand Police and the officer in charge of the Eastern District Serious Crash Unit. He has over 18 years experience including 15 years as a crash reconstructionist/analyst.

He holds a number of university certificates in collision investigation, forensic mapping and adult education and training. He is also an approved NZ Police instructor for the basic crash investigation course.