A comparison of low rolling resistance tyres with standard tyres on New Zealand roads

Report prepared for
EEOA
Energy Efficiency and Conservation Authority
Te Tari Tiaki Pūngao

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Executive Summary

Central Laboratories has carried out an on-road test programme for the Energy Efficiency and Conservation Authority (EECA) to compare the rolling resistance and wet emergency braking stopping distance of two makes of “low rolling resistance” tyres with two makes of standard tyres. While proven technology overseas, this on-road testing programme sought primarily to investigate if low rolling resistance tyres could offer fuel saving benefits on New Zealand road surfaces.

With regard to rolling resistance, the research confirms that low rolling resistance tyres can enable fuel savings on fine and coarse textured New Zealand chipseal road surfaces compared with standard tyres. However, the potential fuel savings of different makes of low rolling resistance tyres may differ. One of the low rolling resistance tyre sets tested had better (lower) rolling resistance than the other set of low rolling resistance tyres.

With regard to wet emergency braking stopping distance, there was no significant difference between the low rolling resistance tyres and standard tyres when tested on fine textured chipseal at 50km/h or at 70km/h, or when tested on course chipseal at 50 km/h. However, there was a slight difference in performance between the tyres when tested on course textured chipseal at 70km/h, in favour of standard tyres. This may indicate that a slight trade-off exists between reduced rolling resistance and wet emergency braking stopping distance on the tested coarse chipseal surface.

Disclaimer

The on-road testing programme only considered the performance of the selected tyres with regard to rolling resistance and wet emergency braking stopping distance. These two performance attributes were selected because they are the two main attributes that will be part of the European Union tyre labelling scheme from November 2012.

There are various other performance attributes that have not been tested, but which consumers may wish to consider before making a tyre purchase. Such factors include, but are not limited to, durability, wet lateral grip, dry grip, and noise.

This report is generally an exploratory investigation to test the likely transferability of European findings about low rolling resistance tyres to the New Zealand context. Consumers are advised to seek advice from a qualified automotive professional to help them make an informed decision considering all performance attributes when in the market for new tyres.

This testing programme only compared mid-range quality tyres, and did not include any low cost budget tyres or high-end performance tyres. This report should not be read as an endorsement or criticism of the particular tyres tested.
1.0 Background

Several tyre manufacturers claim to make “low rolling resistance” tyres, and some of these are available for sale in New Zealand. These tyres do have the potential to provide significant fuel savings. However, the test measurements on these tyres have largely been confined to low textured bituminous mix and concrete road surfaces.

Accordingly, there is a need to verify these fuel saving claims in regard to coarse textured chipseal surfaces that make up a large proportion of the New Zealand roading network, as hysteretic losses are greater on such surfaces. The following on-road test programme was developed to compare these “low rolling resistance” tyres against conventional tyres of the same size and, except for rolling resistance, similar performance. The on-road testing involved comparative measurements of, (a) tyre rolling resistance, and (b) emergency braking stopping distance (wet).

Please note that this test programme was not intended to provide coefficients of rolling resistance and ABS braking. The use of the “coastdown” and ABS braking methods were simply to provide comparative data so that the performance of the tyres at the same speeds on different chipseal surfaces could be evaluated.

2.0 Site Selection

Two sites were required for the testing, a coarse textured chipseal, and a fine textured chipseal. These needed to be relatively straight, flat, at least 1km long, and have a surface texture as consistent as possible along the entire length.

Various sites in the Wairarapa were assessed, and two of these were chosen for the testing. These were both on Kahutara Road, which extends south from State Highway 2 towards the south Wairarapa coast.

Figure 1 shows a panoramic view of Site 1 (fine textured chipseal), while Figure 2 shows a view of the surface. The site was not completely flat, having slightly sloping sections at the start and in the middle of the site. Sandpatch tests on this site indicate a generally consistent texture depth of around 1.3mm along the entire length of the site.

Figures 3 and 4 show the corresponding views of Site 2. This site did have two sections of chipseal, apparently laid at different dates, which are visibly different in colour. However, sandpatch tests on this site indicated a generally consistent texture depth along the entire length of the site of around 3.2mm.

Previous research performed by Opus Central Laboratories has determined that texture depth rather than surface type is a key determinant of rolling resistance (Cenek, 1994), hence the emphasis on the sites having consistent texture depth.
Figure 3: Panoramic View - Site 2

Figure 4: Surface View - Site 2
3.0 Test Vehicle

Toyota New Zealand kindly provided a vehicle for the testing. This was a 2011 Toyota Corolla sedan (Reg FTJ744) running on 205/55 R16 tyres. It had ABS (Anti-lock Braking System) installed as standard. For all of the testing the vehicle was driven by a trained member of the New Zealand Police. Figure 5 shows a view of the vehicle.

Figure 5: Test Vehicle

4.0 Test Tyres

Two tyre manufacturers were asked to provide a standard mid-range tyre and a low rolling resistance tyre each, of the same size and, except for rolling resistance, similar performance.

Note that for reasons of commercial sensitivity the tyres are referred to in the remainder of the report as Standard Tyres 1 and 2 and Low Rolling Resistance Tyres 1 and 2.

These brand new tyres were each fitted to identical standard alloy rims, balanced and inflated to the standard manufacturer’s inflation pressure of 32psi. Each set of four tyres were then installed on the test vehicle and driven for a minimum of 25km to remove the manufacturer’s lubricant and run the tyres in.

5.0 Vehicle Instrumentation

The vehicle was instrumented as follows for each of the two different types of testing.

(1) Coastdown Testing

A data acquisition system was installed in the test vehicle. This was connected to (1) a rotary encoder (300 pulses/revolution) that could be attached to the left rear wheel so that distance could be accurately measured, and (2) a cup and vane anemometer unit that could be installed above a sign mounted to the vehicle’s tow bar. Figure 6 shows a view of
the rotary encoder attached to the vehicle’s wheel, and Figure 7 shows a view of the cup and vane anemometer unit mounted on the vehicle. The data acquisition system was set to record data at a frequency of 20Hz, and also had an event marker that could be used to accurately mark the start and end of the tests.

Figure 6: Rotary Encoder mounted on the test vehicle

Figure 7: Cup and vane anemometer unit mounted on the test vehicle

(2) ABS Braking Tests

A Vericom VC3000 vehicle computer was kindly provided by the New Zealand Police. This is an accelerometer based unit that can be attached to a vehicle’s windshield by suction cups. Figure 8 shows a view of the Vericom attached to the windshield of the test vehicle.
When the braking mode is selected, data recording is triggered when a deceleration level of -0.25g (g = 1 gravity = 9.8m/s$^2$) is exceeded. During a braking event the Vericom unit records data at 100Hz, and provides summary information on the test run when the vehicle has come to a full stop. This information includes (1) the elapsed time, (2) the speed at which braking was initiated, and (3) the distance travelled.

6.0 Test Methodology

(1) Coastdown Testing

Comparative measures of rolling resistance were made for each of the four sets of tyres using the “coastdown” method in dry conditions. This involved accelerating to a constant speed, engaging neutral gear, and measuring the distance taken to coast to a complete stop, or to a specific speed, without braking.

The coastdown tests on Site 1 (fine textured chipseal) were conducted on the 18th June in a northbound direction. The coastdown tests on Site 2 (coarse textured chipseal) were conducted on the 27th June in a northbound direction. Both series of coastdown tests were filmed by Mike Rathbone of Video NZ Ltd.

Each set of tyres was fitted to the vehicle, and driven a minimum of 10km to warm the tyres up. During the warm ups, the opportunity was taken to set the cruise control to the appropriate speed of 50km/h, 70km/h or 100km/h. The tyre pressures were also reset to the standard manufacturer’s inflation pressures of 32psi.

The vehicle was then accelerated to a constant speed, and the gear selector engaged in neutral at the chosen start point. The same start points were used for all of the different
tyres and speeds at each test site. The vehicle was then allowed to coast to a complete stop with no braking. Both the start and end points were event marked in the data recording. In addition, coloured stakes were used to mark each stopping point so that simple visual comparisons of repeatability could be made. For the first set of tyres at 50km/h on the fine textured chipseal the coastdowns were repeated five times. As the repeatability was considered to be reasonable, it was decided to limit the number of tests for each tyre and speed to three. The same methodology was used for each set of tyres.

Note that Site 2, the coarse chipseal site, was around 1km long. The 50km/h and 70km/h coastdown tests could be accommodated within this length. However, for the 100km/h runs the test vehicle reached the end of the site still moving. Accordingly, the data for these runs was processed to provide measures of the distance taken for the speed to drop from 100km/h to 50km/h.

(2) ABS Braking Tests

The ABS braking tests were carried out on both sites on the 20th June. The original intention was to apply water using a water truck to simulate wet road conditions. However, this was not initially required as rain had earlier wetted the sites. Towards the end of testing on Site 1, the weather improved. Before significant drying occurred it was decided to begin wetting the road using the water truck to ensure the road was consistently wet. For the testing on Site 2, the water truck was used to wet the site for each set of speeds.

As for the coastdown tests, each set of tyres was fitted to the vehicle, driven to warm the tyres up, and the tyre pressures checked. The vehicle was then accelerated up to the desired test speed of either 50km/h or 70km/h, and emergency braking to a stop was initiated. All the braking tests involved ABS braking. A total of five braking tests were carried out along the length of the site for each speed. All of the ABS braking tests were again filmed by Mike Rathbone of Video NZ Ltd.

7.0 Test Results

(1) Coastdown Testing

The results of the coastdown tests are listed in Table 1. This table lists the average distance travelled for each tyre. No results for the 70km/h tests on the fine chipseal have been provided because the results for this speed were considered to be affected by a slightly sloping section in the middle of the test site. The results for the 100km/h tests on the coarse chipseal show the distance for the speed to drop from 100km/h to 50km/h. This is because of the shorter length of the test site.
Table 1: Average Coastdown Distances (LRR – Low Rolling Resistance)

<table>
<thead>
<tr>
<th>Initial Speed (km/h)</th>
<th>Tyre</th>
<th>Fine Chipseal Distance (m)</th>
<th>Coarse Chipseal Distance (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>50</td>
<td>Standard Tyre 1</td>
<td>559.6</td>
<td>467.7</td>
</tr>
<tr>
<td></td>
<td>Standard Tyre 2</td>
<td>579.4</td>
<td>506.4</td>
</tr>
<tr>
<td></td>
<td>LRR Tyre 1</td>
<td>701.4</td>
<td>595.6</td>
</tr>
<tr>
<td></td>
<td>LRR Tyre 2</td>
<td>621.8</td>
<td>496.9</td>
</tr>
<tr>
<td>70</td>
<td>Standard Tyre 1</td>
<td>N/A</td>
<td>733.1</td>
</tr>
<tr>
<td></td>
<td>Standard Tyre 2</td>
<td>N/A</td>
<td>818.2</td>
</tr>
<tr>
<td></td>
<td>LRR Tyre 1</td>
<td>N/A</td>
<td>974.9</td>
</tr>
<tr>
<td></td>
<td>LRR Tyre 2</td>
<td>N/A</td>
<td>786.3</td>
</tr>
<tr>
<td>100</td>
<td>Standard Tyre 1</td>
<td>1277.5</td>
<td>705.6(^1)</td>
</tr>
<tr>
<td></td>
<td>Standard Tyre 2</td>
<td>1296.9</td>
<td>759.0(^1)</td>
</tr>
<tr>
<td></td>
<td>LRR Tyre 1</td>
<td>1617.0</td>
<td>910.7(^1)</td>
</tr>
<tr>
<td></td>
<td>LRR Tyre 2</td>
<td>1424.4</td>
<td>773.0(^1)</td>
</tr>
</tbody>
</table>

\(^1\) – based on the distance taken for speed to decrease from 100km/h to 50km/h.

Figures 9 and 10 show plots of the individual coastdown distances against the initial speed for the fine textured and coarse textured surfaces respectively.

Figure 9: Coastdown Distances – Fine Textured Chipseal
The following points should be noted from the recorded data, as well as observations made during the testing:

(1) Specific performance comparisons between the tyres should only be made for the same speeds on the same site. However, the variations with speed on each site are generally consistent.

(2) On the fine chipseal surface, the measured coastdown distances for the 70km/h speed were considered to be affected by the sloping section in the middle of the test site. Accordingly, the test results for this test have been disregarded as the absolute differences between the tyres for this speed are likely not to be robust.

(3) Wind conditions for the coastdown tests on both sites were consistent through the testing. On Site 1 the wind conditions were very light northwesterly winds of around 10km/h or less. On Site 2 the wind conditions were moderately southwesterly winds averaging around 20km/h.

(4) On the coarse chipseal surface, because of the limited site length, the results for the 100km/h tests, which give the distance for the speed to drop from 100km/h to 50km/h, may not necessarily reflect exactly the same relative performance of the different tyres had the coastdown tests been to a standstill.

(5) Table 1 and Figures 9 and 10 do show that the LRR Tyre 1 did consistently perform better than the other three tyres by a significant margin at all three test speeds, and on both the fine and coarse textured chipseal. The LRR Tyre 2 performed slightly better than either of the standard tyres on the fine textured surface, most notably at 100km/h. It also performed slightly better than the standard tyres on the coarse chipseal at 100km/h, but not for the lower speeds of 50km/h and 70km/h.
(2) ABS Braking

The results of the ABS braking tests are listed in Table 2, and plotted in Figure 11.

Table 2: Average ABS Braking Distances

<table>
<thead>
<tr>
<th>Initial Speed (km/h)</th>
<th>Tyre</th>
<th>ABS Stopping Distance (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Fine Chipseal</td>
</tr>
<tr>
<td>50</td>
<td>Standard Tyre 1</td>
<td>11.42</td>
</tr>
<tr>
<td></td>
<td>Standard Tyre 2</td>
<td>11.48</td>
</tr>
<tr>
<td></td>
<td>LRR Tyre 1</td>
<td>11.39</td>
</tr>
<tr>
<td></td>
<td>LRR Tyre 2</td>
<td>11.65</td>
</tr>
<tr>
<td>70</td>
<td>Standard Tyre 1</td>
<td>21.63</td>
</tr>
<tr>
<td></td>
<td>Standard Tyre 2</td>
<td>22.12</td>
</tr>
<tr>
<td></td>
<td>LRR Tyre 1</td>
<td>21.71</td>
</tr>
<tr>
<td></td>
<td>LRR Tyre 2</td>
<td>22.60</td>
</tr>
</tbody>
</table>

The results show that on the fine textured chipseal there was very little difference between all four of the tyres tested. On the coarse textured chipseal the low rolling resistance tyres performed slightly worse on average than the standard tyres by between 5-10%, corresponding to an increase in stopping distance of around 1.5m or less, or around 1/3 of a car length at 70km/h. This may indicate that a slight trade-off exists between reduced rolling resistance and wet emergency braking stopping distance on the tested coarse chipseal surface.

Figure 11: ABS Braking to Stop Distances
Acknowledgements

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References