City of Hamilton

Review of Red Hill Valley Parkway Friction Test Results

Final Report

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Table of Contents

List of Figures

1. Introduction

The Red Hill Valley Parkway (RHVP) is a municipal expressway within the City of Hamilton (the City) that connects the Lincoln M. Alexander (LINC) to the QEW.

In the Summer of 2019, the City completed pavement resurfacing and rehabilitation of all the northbound and southbound lanes of the RHVP. In association with the repaving, the City had friction testing completed on the new pavement by September of 2019.

Upon completion of this friction testing, the City requested CIMA+ to conduct a review of the new friction test results. Specifically, CIMA has been requested to provide responses to the following questions:

- *In light of the September 2019 RHVP friction data collected by ARA, are any changes needed to the recommendations in the previous CIMA reports*[1] *to the City regarding safety on the RHVP?*
- *In light of the September 2019 RHVP friction data collected by ARA, and the speed limit and enforcement measures recently taken, are any safety measures or monitoring steps on the RHVP recommended to the City?*

As part of this review, CIMA was provided with data from friction testing that had been carried out on the RHVP in previous years. It is noted that CIMA had previously commented on these earlier friction testing results from the RHVP. In February of 2019, CIMA provided a memo commenting on the results of friction testing collected in 2013 by Tradewind Scientific Ltd. Also in February of 2019, CIMA provided a memo commenting on friction testing that had been collected between 2008 and 2014 by MTO.

This report focuses on the 2019 friction data collected after the repaving. It also references the other friction datasets described, to assist in a contextual analysis and to help assess how friction data on the RHVP might best be monitored moving forward.

The following sections provide the details of the assessment methodology and our findings.

2. Field Measurement Methodologies

Prior to discussing the collected friction data, it is essential to understand the different field measurement methodologies that have been used to collect the friction data on the RHVP, in the time periods described above.

Friction testing data can be acquired from a range different measurement methodologies and devices. These are variously described as; locked wheel, side force, fixed slip, and variable slip methods[2]. Each method of measuring friction has its own advantages in both the collection

[1] Road safety assessments completed for the RHVP in 2015 and 2018.
[2] Henry, J. J. (2000). NCHRP Synthesis 291 Evaluation of Pavement Friction Characteristics: A Synthesis of Highway Practice. Transportation Research Board, Washington, DC.

methodology and the ability to measure the friction of the surface. It is important to note that the friction values determined by any one method are specific to that method. While each method measures friction values, the results from one method may not be directly comparable to results from another method.

The various datasets examined in this review were collected using two different methods, the locked wheel method and the fixed slip methods. The different methods are discussed below.

2.1. Locked Wheel

The locked wheel method is the most common method of friction measurement used in North America. As suggested, it uses a vehicle wheel tire that is mounted on a trailer towed behind a vehicle. The wheel turns as is travels over the surface. An operator 'locks' the wheel of the trailer and the friction between the tire and pavement surface is then measured.

The locked wheel approach is recognized by the American Society for Testing and Materials (ASTM) and, in accordance with ASTM E 274 developed in the 1960s, measurement results are standardized for the test. The method simulates emergency braking without anti-lock brakes. As part of the measurement procedure a truck carrying water tank deposits a known film thickness of water onto the road surface, ahead of a locked wheel trailer it is towing. In this way the test simulates wet road surface conditions.

The resulting "skid number" is a measure of friction acting between the locked wheel tire and the pavement surface. Other parameters including the speed at which the testing is being done and the air temperature is recorded at each test location[3,4].

This method has been used for many years in North America. One significant advantage of this method is that it operates at near to highway speeds, enabling the measurement of large sections of roadway without the need for lane closure or other intrusion onto the roads that are in operation.

Locked wheel friction measurements are referenced in various North American publications, including the National Cooperative Highway Research Program (NCHRP) Guide for Pavement Friction, as Friction Numbers (FN)[5].

2.2. Fixed Slip

The fixed slip friction measurement systems more closely replicate the action of modern vehicles in an anti-lock braking situation. The test wheel rotates with a constant slip, i.e., the wheel is lightly braked to provide a difference in velocity between the test wheel and the speed

[3] Kandhal, P. S., Parker, F., and Mallick, R. B. (1997). Aggregate Tests for Hot Mix Asphalt: State of the Practice. NCAT Report 97-06. National Center for Asphalt Technology, Auburn University, Alabama
[4] Lu., Q. and Steven, B. (2006). Friction Testing of Pavement Preservation Treatments: Literature Review. California Department of Transportation, California
[5] Hall, J. W., Smith, K. L., Titus-Glover, L., Wambold, J. C., Yager, T. J., & Rado, Z. (2009). Guide for pavement friction. Final Report for NCHRP Project, 1, 43.

of the towing test vehicle. The slip ratio is usually between 10 and 20 percent. This is usually accomplished by incorporating a gear reduction of the test wheel drive shaft from the drive shaft of the host vehicle, or through hydraulic retardation of the test wheel. One advantage that the method has is that the fixed slip method can be operated continuously over the test section without excessive wear of the test tire, as compared to the locked wheel method which can wear bald sections on a tire, impacting results.

An example of a fixed slip testing device is the GripTester. This specific product is commonly used in Europe. The GripTester can either be manually pushed by an operator (<5 km/h) or, more commonly, towed behind a vehicle at higher speeds (50+ km/h). The friction value from this test method is typically referred to as a Grip Number (GN).

3. Correlation between Testing Method

There are currently no applicable reference standards or guidelines in North America with which to directly compare data collected by fixed slip friction measurement equipment, such as GripTester, with locked wheel methods.

There have been numerous efforts by different countries and agencies to better understand the relationship and behavior of different friction-testing devices and the influence of texture, speed, and other external conditions on these measurements.

The Permanent International Association of Road Congresses (PIARC) conducted a series of experiments to compare texture and friction measurements. In 1992, PIARC undertook an experiment across 54 sites in Belgium and Spain with the intention of comparing and harmonizing texture and skid resistance between a range of measurement methods including locked wheel, fixed-slip and other methods[6]. Based on the modeling exercise, the International Friction Index (IFI) was then developed to allow for the harmonizing of friction measurements taken with different equipment and/or at different slip speeds to a common calibrated index[7].

Theoretically, the IFI values should be the same for tests conducted at the same location, speed, and weather conditions. However, several studies in North America found discrepancies in the IFI values. In 2009, a study focused to compare measurements obtained with different types of equipment on 24 pavement sections with a wide range of textures[8]. Data were collected with two locked-wheel skid trailers, a GripTester, and a dynamic friction tester, and the relationship between friction and speed for the different pavement sections and devices was studied. Even though all steps included in the specifications derived from the experiments by the PIARC were followed, the results obtained were not satisfactory.

[6] Henry, J. J. (2000). NCHRP Synthesis 291 Evaluation of Pavement Friction Characteristics: A Synthesis of Highway Practice. Transportation Research Board, Washington, DC
[7] ASTM E1960-07. (2015). Standard practice for calculating international friction index of a pavement surface
[8] Flintsch, G. W., Izeppi, E. D. L., McGhee, K. K., & Roa, J. A. (2009). Evaluation of international friction index coefficients for various devices. Transportation research record, 2094(1), 136-143

A more recent study aimed to compare the friction data measured by the ASTM Brake force trailer and the Findlay Irvine brand of GripTester on a 100 km section of a highway in Ontario[9, 10]. During the field testing, approximately 600 Friction Number (FN) and over 200,000 Grip Number (GN) values were measured. While the difference between the two measurements were found to be around 14.4%, the general correlation between the two values was poor, with the model R^2 of 16% for the asphalt surface conditions.

The findings are not overly surprising. Different test methods measure different aspects of pavement friction. Even when the same tire or slider is used, other details may vary, such as speed, mode of operation, and water film control. The research shows that there is no simple ‘conversion’ available to obtain a one-to-one correlation between friction measurement results from different types of testers.

The reasons for this lie mainly in the complexities of the friction behavior of rubber and tires during the testing process, which has been extensively discussed in the literature[11, 12].

Based on the discussions above, a direct comparison between the friction values obtained from the two different testing methodologies that have been used at different times on the RHVP would not be recommended.

In this report, CIMA has undertaken a review of the temporal and geographical comparison of friction test data where data was collected using the same testing method. This assessment can provide valuable insights regarding the performance of the surface pavement under wet weather conditions at different locations and time periods. Such approach was utilized for comparing the friction test data over a range of years for the pavement that existed prior to the 2019 repaving. The evaluation of changes that did occur over time with the ‘old’ pavement is useful in providing context for the evaluation of 2019 friction data from the ‘new’ pavement.

4. Friction Data

As noted above, the friction testing surveys were conducted using two different sources and testing methods: locked wheel tester methodology conducted by both Applied Research Associates Inc. (ARA) and MTO and fixed slip surveys using GripTester instruments completed for Golder by their subcontractor, Tradewind Scientific Ltd (Tradewind).

It is noted that details of the exact testing protocol(s) that were used by MTO and ARA were not available for our review. It is our understanding that both used locked wheel methods, and thus

[9] The name of the highway was not given in the study
[10] Khanal, S., Eng, P., Hein, D. K., Schaus, L. K., & Engineer, S. P. (2015). Assessment and Effective Management of Pavement Surface Friction. In TAC 2015: Getting You There Safely-2015 Conference and Exhibition of the Transportation Association of Canada, Ottawa, Canada
[11] Kogbara, R. B., Masad, E. A., Kassem, E., Scarpas, A. T., & Anupam, K. (2016). A state-of-the-art review of parameters influencing measurement and modeling of skid resistance of asphalt pavements. Construction and Building Materials, 114, 602-617
[12] Lu., Q. and Steven, B. (2006). Friction Testing of Pavement Preservation Treatments: Literature Review. California Department of Transportation, California

could not be compared to the Tradewind protocol which used the fixed slip method. We have assumed that the ARA and MTO methods are alike enough to compare.

The details of each data source are discussed in this section.

4.1. Locked Wheel Tester Data

The friction testing using the locked wheel testers were conducted along the RHVP during both before (i.e., 2008, 2009, 2010, 2011, 2012, and 2014) and after roadway resurfacing in 2019. This data is separate from the friction testing data which was collected in 2013 by Tradewind Scientific.

The surveys were completed along a 4 km stretch of roadway. Where available, the City provided geo-coded survey results in a spreadsheet format. The following common attributes were listed in the test data for the “before” period:

- Date and time;
- Direction of travel;
- Lane number;
- Testing speed;
- Average, minimum and maximum friction number; and
- Air temperature.

It is noted that all tests were completed on a wet surface condition and using the left-wheel of the testing vehicle, traveling at approximately the posted speed limit of 90 km/h at the time of testing. Exact GPS coordinates for the testing location were only available for the testing completed in 2014.

The friction testings for the “after” period were conducted from September 26 to 28, 2019 and included the following additional attributes comparing to the “before” period discussed above:

- Testing wheel (for both left and right);
- Standard deviation of calculated friction numbers during test;
- Peak calculated friction number during test;
- Standard deviation of speed during test;
- Average flow rate of sprayed water in gallons per minute; and
- Surface temperature.

It is important to note that in contrast to the testing completed prior to the roadway resurfacing, the testing speed values in the ’after’ period ranged from 65 to 90 km/h. This variation is important, because the friction numbers measured are known to decrease as the traveling speed increases.

4.2. Fixed Slip Data

The Tradewind data was reported in January 2014 and summarizes the friction testing surveys completed along the RHVP on November 20, 2013[13]. The report indicated that the GripTester Friction measurements were completed given the testing speed of 50 km/hr, with the depth of 0.25 mm water film applied on the surface. Five test runs were completed on the RHVP in the right-hand wheel path of each lane in both directions as well as a single reference centreline run in the right-hand lane. The friction numbers were reported for each 100 m of the roadway segment. Other reported variables were the temperature (7 degrees), weather condition (clear), and wind condition (calm).

5. Exploratory Analysis

5.1. Locked Wheel Tester Data

Our exploratory analysis involved preliminary observations from friction testing results to capture the underlying trends prior to the more robust statistical analysis. It is important to note that pavement friction can be expected to change over time due to environmental and traffic related wear to the pavement surface. Variations of surface friction over time is a way to assess pavement deterioration[14]. This is a normal aspect of the degradation of roadway infrastructure over its lifespan. It is desirable that pavement exhibit sufficient friction levels over the service life of the surface withstanding the seasonal fluctuations and long-term wear.

Figure 1 to Figure 4 shows the distribution of measured friction numbers from 2008 to 2019 for different lanes and directions of travel. For direct comparison, the friction numbers in the figures below represent the 90 km/h testing speeds for both before and after roadway resurfacing periods.

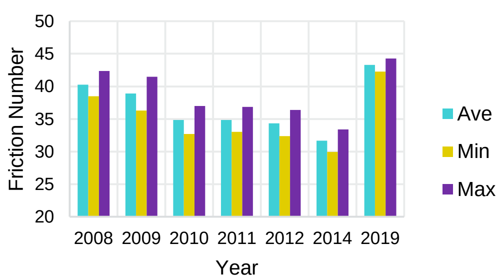


Figure 1: Friction Numbers (Lane 1 Southbound)

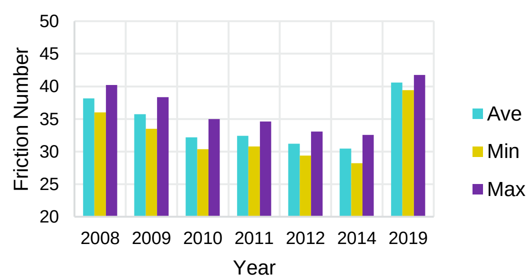


Figure 2: Friction Numbers (Lane 2 Southbound)

[13] Friction Testing Survey Summary Report, Lincoln Alexander & Red Hill Valley Parkways (Hamilton), Tradewind Scientific Ltd., November 20, 2013
[14] Transportation Association of Canada, Pavement Design and Management Guide, Ottawa, Ontario, 1997.

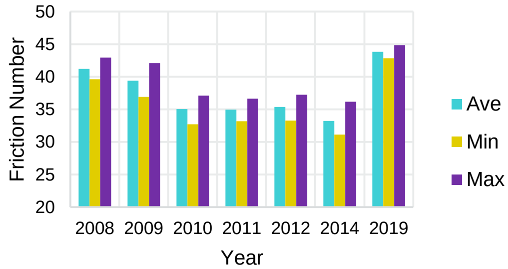


Figure 3: Friction Numbers (Lane 1 Northbound)

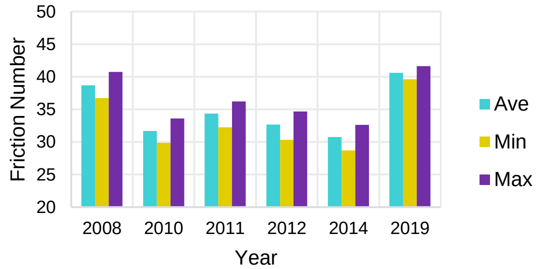


Figure 4: Friction Numbers (Lane 2 Northbound)

Based on the above figures, the average friction numbers were indicated to range from 38 to 41 along the RHVP in 2008. These values, Friction Numbers (FN), are assumed to be able to be compared directly to frictions values (f) used in design. FN numbers which use a scale of 0 to 100, can be correlated to friction values (f) of 0.38 to 0.41 as defined in the Transportation Association of Canada Geometric Design Guide for Canadian Roads (TAC-GDGCR), which uses a scale of 0 to 1.0.

These numbers were above the design parameters used in the road design for stopping distance, which are f=0.29, corresponding to a roadway with a design speed of 100 km/h, such as RHVP[15].

It is clear from the data that friction values changed over time. A review of the temporal changes in values indicate an approximate 20% reduction from 2008 to 2014, with the reported average friction numbers ranging from 30 to 33 in 2014. While it is known that the deterioration of pavement friction is inevitable as infrastructure ages, the change in the data also highlights the importance of ongoing evaluation of pavement friction levels over time.

In 2019, after pavement resurfacing was completed the friction values increased. The data shows average friction numbers ranging from 40 to 44 in 2019. We note that the 2019 values for the 'new' pavement are in a similar average range to the values from 2008, with the average friction numbers ranging from 38 to 41 noted above. Both sets of data are using the locked wheel method of testing.

5.2. Fixed Slip Data

The Tradewind testing from 2013 refers to friction testing results using the GripTester. Values were reported as Grip Numbers (GN), a measurement of friction. The Golder report has expressed the Tradewind Grip Numbers (GN) numbers as Friction Numbers (FN). Figure 5

[15] Readers are referred to the Red Hill Valley Parkway - Pavement Friction Testing Results Review study, submitted to the City on February 4, 2019 for the detailed definition and discussions of pavement friction in design and operation

shows the distribution of these values for different lanes, denoted as “L” (left) and “R” (right) and directions of travel (i.e., “NB” for northbound and “SB” for southbound).

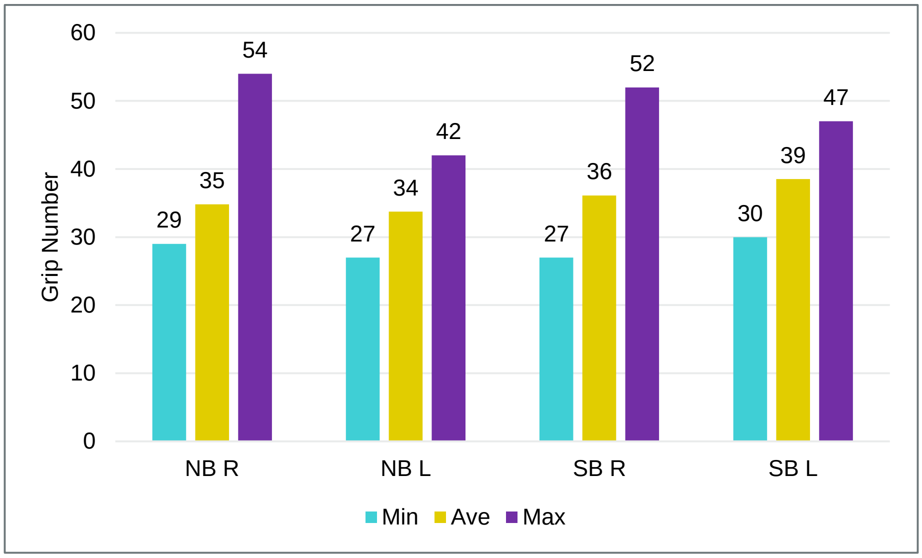


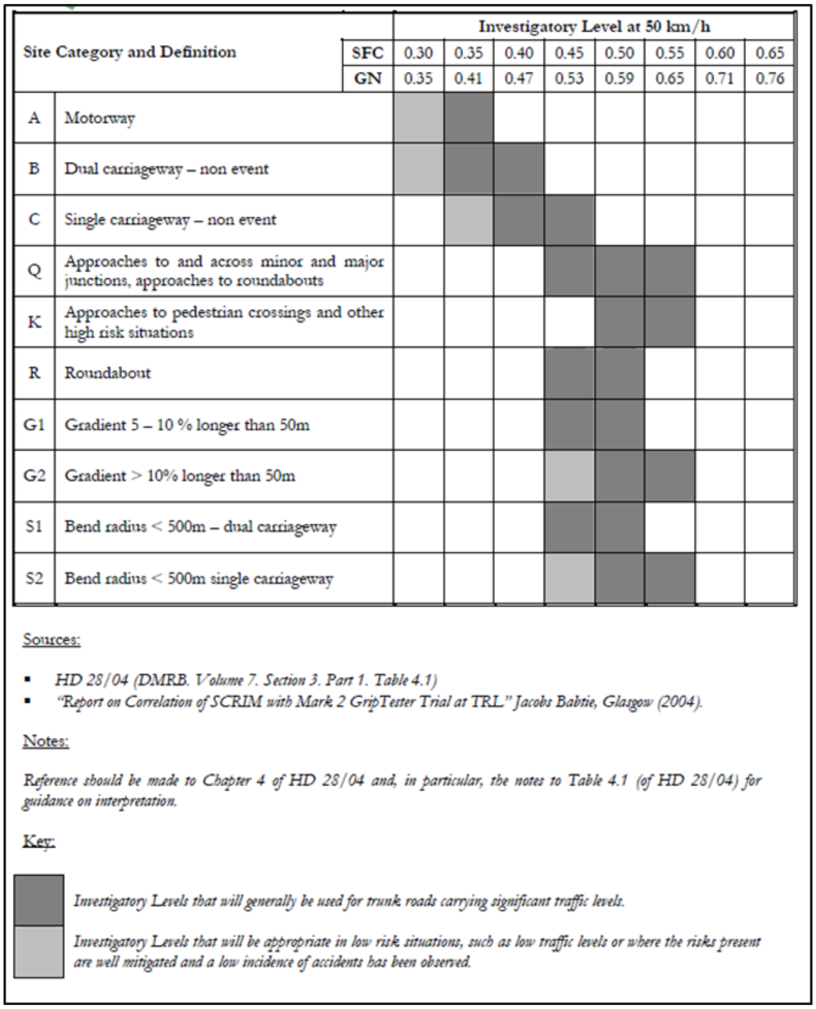
Figure 5: Grip Numbers Reported by Tradewind in 2013

In contrast to airport runways, there are currently no directly applicable reference standards or guidelines in North America with which to compare the above data collected by continuous friction measurement equipment, such as GripTester, for roads and highways.

In the United Kingdom transportation authorities have developed a reference ‘Investigatory Level’ table for GripTester measurements on roadways. It is our understanding that the purpose of the investigatory level is to set a threshold at which a flag would be identified that further testing should be considered for more detailed assessment.

The Tradewind report included a reference table showing investigatory levels. However, the table used in their report is different from the reference table that is typically applied. The reference more broadly used for determination of investigatory levels is the table from the United Kingdom Pavement Management (UKPMS) publication for interpretation of Grip Tester data[16], shown in Figure 6. Therefore, the reported friction values in Figure 5 were assessed using the UKPMS table.

[16] United Kingdom Pavement Management System, Volume 3, Chapter 11, Machine Data Collection for UKPMS – GripTester, Table 1, August 2005



Site Category and Definition			Investigatory Level at 50 km/h							
		SFC	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65
		GN	0.35	0.41	0.47	0.53	0.59	0.65	0.71	0.76
A	Motorway									
B	Dual carriageway – non event									
C	Single carriageway – non event									
Q	Approaches to and across minor and major junctions, approaches to roundabouts									
K	Approaches to pedestrian crossings and other high risk situations									
R	Roundabout									
G1	Gradient 5 – 10 % longer than 50m									
G2	Gradient > 10% longer than 50m									
S1	Bend radius < 500m – dual carriageway									
S2	Bend radius < 500m single carriageway									

Sources:

- *HD 28/04 (DMRB. Volume 7. Section 3. Part 1. Table 4.1)*
- *"Report on Correlation of SCRIM with Mark 2 GripTester Trial at TRL" Jacobs Babtie, Glasgow (2004).*

Notes:

Reference should be made to Chapter 4 of HD 28/04 and, in particular, the notes to Table 4.1 (of HD 28/04) for guidance on interpretation.

Key:

Investigatory Levels that will generally be used for trunk roads carrying significant traffic levels.

Investigatory Levels that will be appropriate in low risk situations, such as low traffic levels or where the risks present are well mitigated and a low incidence of accidents has been observed.

Figure 6: UKPMS Site Categories and Investigatory Levels

Tradewind reported that the friction testing results were 'below or well below' the investigatory levels for dual carriageways, with similar roadway characteristics to the RHVP. When assessed against the UKPMS table, it was found that the average friction numbers were closer to the threshold levels of 41 to 47, than indicated by Tradewind. It is important to note that the UKPMS categories were intended to indicate the need for further investigation.

It is important to know that, while research does confirm a correlation between lower pavement friction levels and collisions, this correlation is not automatically confirmation of collision causation. Interpretation of the fixed slip GripTester pavement friction data, or the locked wheel testing method, as they relate to safety requires greater consideration.

Road sections that have lower friction measurements may indicate a need to undertake review of the location because of the potential that collision risk may be elevated. However, friction measurements that are at investigatory levels are in no way a definitive indication that a location is 'unsafe'.

The research for the development of the investigatory level thresholds states that for some sites, where friction numbers are below 35, collision risk *may* increase, but it also notes that for many sites with the same readings, collision risk will not exist. Thus, further investigation of conditions is needed[17].

In short, the friction values measured by the Tradewind are in the range that the UKPMS would identify as ‘investigatory’ and would suggest a need for additional review of the roadway as a whole. The Golder / Tradewind report made a similar overall conclusion from the data, albeit using a different reference table. These findings were also reported in our February 04, 2019 memo.

6. Statistical Analysis

Regardless of the testing methodology utilized, friction values measured can be influenced by a wide range of factors. We have noted there are clearly changes over time in the data collected using the locked wheel method. But the changes in the friction values cannot be compared using only a single factor statistical comparison (i.e., t-test paired comparisons). In this review, we have undertaken a more detailed analysis of the changes over the various years that data was collected by including a multi-factor design approach that examines a range of parameters that were also recorded during the testing periods and for which inputs could be considered. Factors include; speed, year, temperature, direction, and lane position.

Regression technique acts as the backbone of this friction data analysis. Following this technique, the main effects and interactions of different contributing factors were statistically examined. It is noted that the statistical analysis was conducted using the MTO / ARA test data for 6 years of the 7-year timespan. It is noted that the data in 2013 from the Tradewind slip fixed testing methodology was not used in this regression analysis as the testing method and results can not be directly compared to the locked wheel values.

The potential for trends in the data was reviewed using various model alternatives. Linear regression (straight-line projection), was assessed as was non-linear regression. A linear function was found to have the best fit, statistically.

The structure of the statistical model is as follows:

$$FN = \alpha_0 + \alpha_1(Period) + \alpha_2(Year) + \alpha_3(Dir) + \alpha_4(Speed) + \alpha_5(Dist) + \alpha_6(Lane2) + \alpha_7(Lane3)$$

Where:

α_0 to α_7: Model parameters

FN: Average measure of friction value estimated for a given observation

$Period$: A dummy variable with a given value of 0 for “before” period and 1 for “after” period

$Year$: The year of the friction testing

[17] Accidents and the Skidding Resistance Standards for Strategic Roads in England. (2005). TRL Report TRL622, H. Viner, A Parry, Page 6.

Dir:	A dummy variable with a given value of 0 for northbound direction of travel and 1 southbound
$Speed$:	Testing speed
$Dist$:	The distance in kilometres from the start of the testing location on either side of the road
$Lane\ 2$:	A dummy variable with a given value of 1 if the test was conducted in Lane 2 of the roadway; otherwise zero
$Lane\ 3$:	A dummy variable with a given value of 1 if the test was conducted in Lane 3 of the roadway; otherwise zero[18]

It is our understanding that the friction testing results were conducted in relatively similar environmental conditions (temperature and environmental conditions), and therefore, the impact of air temperatures was not found to be statistically significant and excluded from the modeling exercise.

The calibrated regression model with 95% confidence interval and R^2 of 0.63 is as follows:

$$FN = 2861 + 14.6\ (Period) - 1.39\ (Year) - 3.32\ (Dir) - 0.27\ (Speed) + 0.45\ (Dist) - 2.35\ (Lane2) - 2.61\ (Lane3)$$

The following observations can be made from the above model.

All the included variables were statistically significant at 95% significance level or higher.

The estimated model R^2 of 0.63 is quite reasonable considering the number of independent variables and was deemed acceptable for this comparative analysis.

The positive coefficient of 14.6 for the "$Period$" variable indicates that the friction numbers were higher after roadway resurfacing in 2019 and the difference was found to be statistically significant compared to the “before” period.

7. Summary and Discussion

This study was aimed to conduct a review of the friction test results on ‘new’ pavement on the RHVP from 2019 and to assess those results in the context of data available from the ‘old’ pavement, gathered from 2008 to 2014. The earlier data offers insight as to how, on the ‘old’ pavement friction values changed over the time period. The friction data generated from the two testing methodologies were also reviewed.

The findings of the analyses were then supplemented by the statistical modeling to using the MTO / ARA tester data for the 2008 to 2014 time period. Data from 2013 that used a different

[18] If the friction test was conducted on Lane 1, a value of zero was given to both dummy variables (i.e., Lane 2 and Lane 3)

testing method was not incorporated in the analysis and is not used in the discussion of findings relative to the 2019 data on the 'new' pavement.

The above analyses provided insights in answering the two questions:

Question 1)

In light of the September 2019 RHVP friction data collected by ARA, and the speed limit and enforcement measures recently taken, are any safety measures or monitoring steps on the RHVP recommended to the City?

Answer 1)

CIMA had made several recommendations regarding the roadway safety on the RHVP. Having reviewed the 2019 friction data collected by ARA, we have not identified any information that would change our recommendations in our previous reports completed in 2015 and 2018.

The CIMA reports were prepared prior to the roadway 2019 resurfacing. They noted that there was a high proportion of collisions on the RHVP occurring in wet road conditions. We indicated that the issue may be related to the pavement surface skid resistance (surface friction) and high vehicle operating speeds. Our recommendations included multiple actions directed to these two elements, including increased speed enforcement, installation of larger speed signs, undertaking a review of pavement friction testing, and installation of 'slippery when wet' signs.

As expected, the ARA data confirmed that the friction number was increased after roadway resurfacing. Our findings suggest that the 2019 are in a range consistent with the friction values gathered in 2008. These values are above the GDGCR thresholds for stopping distance (f=0.29).

Having said that, a detailed review of the historical friction values on the 'old' pavement indicate an approximate 20% reduction in friction values from 2008 to 2014, which was prior to the road resurfacing. Some individual measured values in 2010, 2011, 2012, and 2014 had friction values that were lower than the stopping distance design numbers.

In addition to the MTO and ARA report, the friction values measured by the Tradewind using a different methodology in 2013 were lower than the investigatory levels set by UKPMS and would suggest a further investigation.

Assuming other relevant factors remain unchanged, lower friction levels result in longer stopping distances. Multiple countermeasures were previously recommended by CIMA and have been implemented to mitigate for the conditions identified considering the 'old' pavement on the RHVP. The recent lowering of the speed limit for portions of the RHVP adds to those countermeasures.

We have reviewed the recommendations in our 2015 and 2018 reports in light of the testing data. Our reports had recommended pavement friction testing. We had also identified countermeasures that targeted elements that interact with pavement friction, specifically speed.

Given that resurfacing was completed in 2019 and the pavement friction values exceed the GDGCR, we have no changes to our recommendations. Having said that, our review identified that friction on the RHVP changed over time from 2008 to 2014. While those findings were in conditions that included the 'old' pavement, other elements remain essentially unchanged such as traffic volumes and, possibly, speeds. Our conclusion is that the ongoing monitoring of friction values during the operating life of a roadway should be considered to assess potential degradation of the roadway infrastructure and friction values over time.

While our previous reports recommended friction testing in the context of the ‘old’ pavement, we would continue to recommend monitoring of friction values on ‘new’ pavement going forward to assist in the overall determination of when the infrastructure may approach the end of its lifecycle or require rehabilitation.

Question 2)

In light of the September 2019 RHVP friction data collected by ARA, are any changes needed to the recommendations in the previous CIMA reports[19] to the City regarding safety on the RHVP?

Answer 2)

The new surface exceeds the friction parameters used in the geometric design of the road. Our previous reports recommended friction testing in the context of the ‘old’ pavement and we would continue to recommend monitoring of friction values on ‘new’ pavement going forward to assist in the overall determination of when the infrastructure may approach the end of its lifecycle or require rehabilitation.

The CIMA reports included several options that were recommended for consideration to improve safety on the RHVP. A number of those recommendations have been implemented and others are in progress or being further evaluated.

We see no need for changes to the recommendations provided in the earlier reports other than to continue to suggest that ongoing performance monitoring relating to vehicle speeds and collisions be carried out going forward.

[19] Road safety assessments completed for the RHVP in 2015 and 2018.