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Rolling Resistance Measurements at the MnROAD Facility, Round 2

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16. Abstract (Limit: 250 words)

The Minnesota Department of Transportation and Minnesota State University, Mankato, contracted with the Technical University of Gdańsk, in Poland, for a second time to conduct rolling resistance at the MnROAD facility near Albertville, Minnesota. Rolling resistance testing was conducted on most of the cells of the MnROAD mainline and the low-volume road. A relative ranking of rolling resistance among the difference surfaces at MnROAD was developed.

The research team from Poland conducted the testing for a week in early May 2014. The rolling resistance data collected were analyzed and are presented in this report. Additional analyses that were conducted include a relative comparison of fuel consumption predicted with the different rolling resistance coefficients measured at MnROAD, with standard concrete and asphalt pavements as references.

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Final Report

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EXECUTIVE SUMMARY

The Minnesota Department of Transportation and Minnesota State University, Mankato, contracted with the Technical University of Gdańsk, in Poland, to conduct a second round of rolling resistance at the MnROAD facility near Albertville, Minnesota. The testing was conducted on the cells of the MnROAD mainline and low-volume road by the research team from Poland over several days in May 2014. The testing program included three standard reference tires operated at speeds of 50, 80 and 110 km/h (31, 50, and 68 mph, respectively). The low-volume road cells were only tested at the two lower speeds.

Data analysis was conducted to compute the rolling resistance of the surfaces, as well as to estimate the relative impact on energy consumption by each surface. Comparisons were also made with the first set of rolling resistance measurements conducted in 2011 on the same surfaces at MnROAD. The collected rolling resistance data were analyzed and are presented in this report.

Chapter 1. INTRODUCTION

Measurements of tire rolling resistance were performed at Minnesota's Cold Weather Road Research Facility (MnROAD) by the team of the Technical University of Gdańsk, Poland (TUG) in the first week of May 2014.

During the measurements the Polish test trailer "R^2 Mk.2" was used. The trailer was transported to the USA by air and delivered to Monticello in Minnesota. The trailer is presented in Figure 1. This trailer is highly modified version of trailer R^2 that was used during measurements at the MnROAD Facility in 2011 *(1)*. The rolling resistance trailer was developed by Dr. Ejsmont and his research team over several years.

Figure 1. Rolling Resistance Test Trailer R2 Mk. 2.

Rolling resistance force is about one percent of the vertical load acting on the tire. The most important problem facing the construction of a successful vehicle for rolling resistance measurements is to eliminate the influence of mechanical parts misalignment and cross-talk (electronic interference) of the sensors. In addition, acceleration/deceleration and road grades generate forces acting on the system that interfere with the measurements. Trailers of the type "R^2" designed and built at TUG use the *vertical arm* principle of measurements that was used for the first time in the trailer build by the Belgian Road Research Centre (BRRC). Despite using the same measuring concept, the R^2 Mk.1 and Mk.2 trailers use very different mechanical solutions than the BRRC trailer. Vibrations of the measuring arm are damped by Foucault currents brake (see item 2 in Figure 2). The influence of inertia and grade forces acting on the test wheel and measuring arm is compensated by a specially designed counterbalance system patented by TUG. The trailer position is measured over the road surface by the laser system and the grade of the road is measured by a precision altimeter. Signals from all sensors, including air, tire, and pavement temperatures are send to the computer via a National Instruments acquisition system. The authors are aware only four specialized trailers in the world for measuring rolling resistance of passenger car tires. One trailer is used by BASt (Federal Highway Research Institute) in Germany, one by BRRC in Belgium and two trailers of the R^2 type by TUG. R^2 type trailers differ from the other two very much and make it possible to obtain much more efficient measurements.

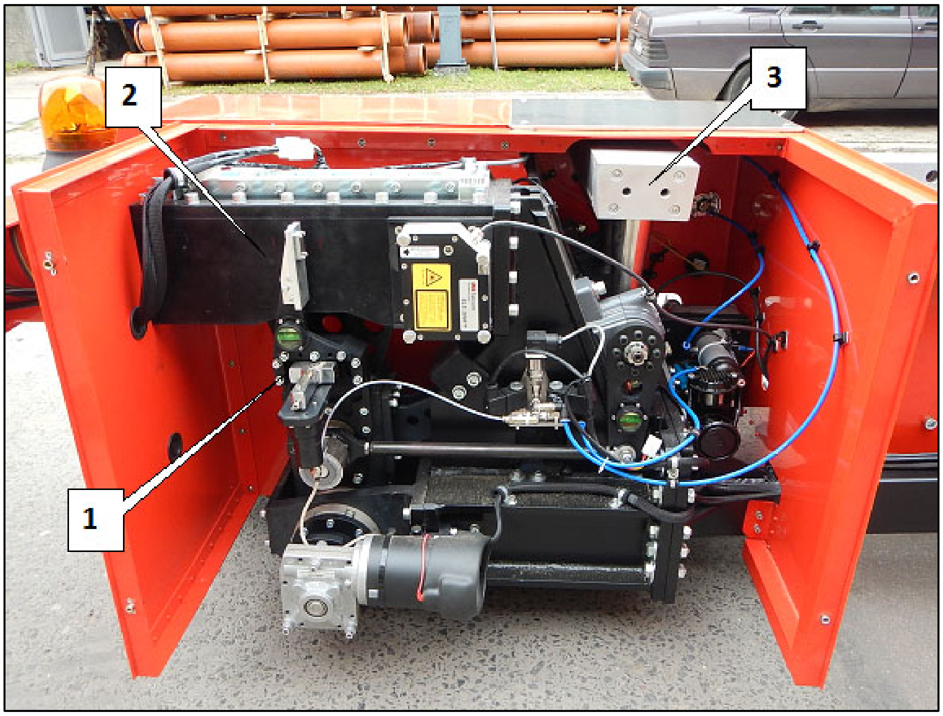

Figure 2. Measuring system of the R2 Mk.2 trailer.

Chapter 2. TEST CONDITIONS AND PROCESSES

During the MnROAD rolling resistance measurements three passenger car tires were used. They are presented in Figure 3 and described in Table 1. It must be noted that although tires AAV4 and SRTT have the same designations as those used during the testing performed in 2011, they are only nominally the same (that is they are of the same type, but were manufactured much later). Replacement of the tires was necessary due to the aging processes in the rubber, and to maintain compliance with testing standards. In 2011 the third tire was Michelin Energy Saver ME16 but by 2014 this tire was replaced by Michelin Primacy HP designated as MCPR that recently was chosen by TUG as the third "TUG reference" tire.

During the measurements the tire load was 4000 N (900 lb) and regulated tire inflation was 210 kPa (30.5 psi). Before measurements were conducted, the tires were warmed by not less than 20 minutes of driving. During the tests each tire was tested at speeds of 50 km/h (31 mph) and 80 km/h (50 mph). On cells located at the MnROAD mainline tires were also tested at 110 km/h (68 mph).

On cells located at the Mainline tests were performed on the right wheel track (RWT), between wheel track (BWT) and left wheel track (LWT). For each path two runs were performed – eastward and westward. Data from both directions were averaged to eliminate the effects of roadway grade. On the Low Volume Road (LVR) tests were performed on the inner and outer lanes in the left wheel track and between wheel track (two runs at each speed, track and lane). During tests on inner lane direction of driving was clockwise and on outer lane – anticlockwise.

Figure 3. Test tires AAV4 (left), SRTT (center), MCPR (right).

Table 1. Characteristics of Test Tires.

Tire	Manufacturer	Tread	Size	Load index	Speed index	Hardness [Sh]
SRTT	Uniroyal	Tiger Paw	P225/60R16	97	S	71
AAV4	Avon	AV4	195R14C	106/104	N	70
MCPR	Michelin	Primacy HP	225/60R16	98	V	68

Road Surfaces

Measurements were conducted on the road cells at the MnROAD Facility both on the Mainline and the Low Volume Road. Table 2 gives a summary of the test cells and their surface types. A shaded background in the Surface Type column indicates that the pavement surface differs from its condition when it was tested in 2011 – not only due to wear but also due to intentional changes (treatment, reconstruction, resurfacing, etc). Appendix A has a more detailed description with photos of the actual pavement surfaces.

Table 2. Description of the Road Surfaces.

Cell	SubCell	Experiment	Surface Type
1			Original HMA
2		SemMaterials FDR Study	Ultra Thin Bonded Wearing Course
3		SemMaterials FDR Study	Ultra Thin Bonded Wearing Course
4		SemMaterials FDR Study	12.5 mm Dense Graded SuperPave
5	505, 605		Transverse Broom
	305, 405		Longitudinal Tine + Conventional Grind
6	306, 406		Longitudinal Tine + Turf
7		5 year design PCC – Widened lane – PASB – longer panel	Innovative Diamond Grind
8		5 year design PCC – Widened lane – PASB – Supplemental Steel	Conventional Diamond Grind
9		5 year design PCC – Widened lane – PASB	Ultimate Diamond Grind (2008)
160		Thin Bonded Concrete Overlay of HMA – 5 inch – sealed	Turf; whitetopping (fibers and transverse drag)
161		Thin Bonded Concrete Overlay of HMA – 5 inch – unsealed	Turf; whitetopping (fibers and transverse drag)
162		Thin Bonded Concrete Overlay of HMA – 4 inch – sealed	Turf; whitetopping (fibers and transverse drag)
163		Thin Bonded Concrete Overlay of HMA – 4 inch – unsealed	Turf; whitetopping (fibers and transverse drag)
96		Thin Bonded Concrete Overlay of HMA – 5 by 6 panels	Conventional Diamond Grind
70		SHRP II Composite Pavement Study – DL Doweled, PL Not Doweled	12.5 mm Dense Graded SuperPave
71		SHRP II Composite Pavement Study – Diamond Grind Surface	2010 Ultimate Diamond Grind (Driving) Conventional Diamond Grind (Passing)

Table 2 continued. Description of the Road Surfaces.

Cell	SubCell	Experiment	Surface Type
72		SHRP II Composite Pavement Study – EAC Surface	Exposed Aggregate
12		10 year design PCC – Drained base	Transverse Tine
13	513, 413, 313, 213, 113	PCC Thickness Optimization – 5 inch – Flat Plate Dowels – 12 and 15 foot panel lengths	Longitudinal Turf Drag
14	914, 814, 714, 614, 514, 414 314, 214, 114		Longitudinal Broom Drag
15		Warm Mix Asphalt Overlay	12.5 mm Dense Graded SuperPave
16		Recycled Unbound Base Study, Warm Mix Asphalt Surface	12.5 mm Dense Graded SuperPave
17		Recycled Unbound Base Study, Warm Mix Asphalt Surface	12.5 mm Dense Graded SuperPave
18		Recycled Unbound Base Study, Warm Mix Asphalt Surface	12.5 mm Dense Graded SuperPave
19		Recycled Unbound Base Study, Warm Mix Asphalt Surface	12.5 mm Dense Graded SuperPave
20		Low Temperature Cracking, RAP Study	12.5 mm Dense Graded SuperPave
21		Low Temperature Cracking, RAP Study	12.5 mm Dense Graded SuperPave
22		Low Temperature Cracking, RAP Study	12.5 mm Dense Graded SuperPave
33		Polyphosphoric Acid Study	12.5 mm Dense Graded SuperPave
34		Polyphosphoric Acid Study	12.5 mm Dense Graded SuperPave
35		Polyphosphoric Acid Study	12.5 mm Dense Graded SuperPave
36		LVR design PCC – SUBGRADE R70 subgrade – doweled	Transverse Tine
37		LVR design PCC – SUBGRADE R70 subgrade – undoweled	Conventional Diamond Grind (TS3) 2007 Innovative Diamond Grind (TS 1 and 2) 2010 Diamond Grind (TS 5) Transverse Tine (TS 4 and Inside Lane)
38		LVR design PCC – Standard base – doweled	Transverse Tine

Table 2 continued. Description of the Road Surfaces.

Cell	SubCell	Experiment	Surface Type
39		Porous Concrete Overlay Experiment	Pervious Overlay; diamond grooved
40	140, 240	LVR design PCC – 7-5.5-7 inch Trapezoidal – undoweled	Overlay 6x6 foot panels; fibers, longitudinal tining and drag
24		Aging Study, WMA Control	12.5 mm Dense Graded SuperPave, Fog seals each year in 100-ft sections
85		Pervious Concrete Experiment – Low Volume Road – Sand subgrade	Pervious Concrete
86		Porous HMA Study	Porous Hot Mixed Asphalt
87		Porous Pavement Study – Control Section	12.5 mm Dense Graded SuperPave
88		Porous HMA Study	Porous Hot Mixed Asphalt
89		Pervious Concrete Experiment – Low Volume Road – Clay subgrade	Pervious Concrete
27		Geocomposite Capillary Barrier Drain	Chip Seals (FA-2 and FA-3)
28		Stabilized Full Depth Reclamation	Double Chip Seal
77		Fly Ash Study, Polyphosphoric Acid Study	12.5 mm Dense Graded SuperPave
78		Fly Ash Study, Polyphosphoric Acid Study	12.5 mm Dense Graded SuperPave
79		Fly Ash Study, Polyphosphoric Acid Study	12.5 mm Dense Graded SuperPave
31		2004 LVR Taconite SuperPave	12.5 mm Dense Graded SuperPave
32		LVR design PCC – Thin Slab	Diamond grooved
52		5 year design PCC – Load testing – FRP dowels	Longitudinal Turf Drag
53		60-year PCC	Transverse Broom
54		PCC mix experiment – Mesabi Select aggregates	Longitudinal Turf Drag

Chapter 3. ROLLING RESISTANCE RESULTS

All rolling resistance test runs were recorded by the data acquisition system using LabView and analyzed at TUG in May and June 2014. The results refer to the Coefficient of Rolling Resistance (CRR) that is defined as:

$$CRR = \frac{F_R}{L} \quad (1)$$

Where:

F_R = Rolling Resistance Force, and
L = Tire Load.

The final CRR values averaged for all runs and both directions, are presented in Appendix B, in the following tables.

- Table B-1. Coefficients of Rolling Resistance for tire SRTT on Mainline.
- Table B-2. Coefficients of Rolling Resistance for tire SRTT on Low Volume Road.
- Table B-3. Coefficients of Rolling Resistance for tire AAV4 on Mainline.
- Table B-4. Coefficients of Rolling Resistance for tire AAV4 on Low Volume Road.
- Table B-5. Coefficients of Rolling Resistance for tire MCPR on Mainline.
- Table B-6. Coefficients of Rolling Resistance for tire MCPR on Low Volume Road.

A temperature correction used for evaluations was applied as specified in ISO 28580 according to the equation:

$$CRR_t = CRR(1 + K(t - 25)) \quad (2)$$

Where:

CRR_t = Coefficient of Rolling Resistance corrected for temperature,
CRR = Coefficient of Rolling Resistance at temperature t,
t = temperature, °C, and
K = coefficient of temperature correction K=0.008.

Figures 6 through 8 show the influence of speed on CRR for different cells and different tires. It must be stressed that the length of test cells was in some cases too short for making reliable measurements at speeds over 80 km/h, due to transients on cell joints. This implies that results for 110 km/h are not as reliable as results for 80 km/h.

In Figure 9, differences between different lateral positions of measurements are presented for tire MCPR at 80 km/h.

In order to reduce the size of the data the results for all three test tires and test speeds 50 and 80 (70) km/h were averaged. Using the average values, the ranking of surfaces was established. The ranking is presented in Figure 10 for the current set of data (measured in May 2014).

Individual results for each tire are presented in Appendix B, and averaging was used only for ranking of road surfaces as shown in Figure 10.

The ranking is presented in this way since there is no standard for making road measurements of rolling resistance. The SRTT tire is an *all season* type, while AAV4 is a *winter* type and MCPR is a *summer* type. For evaluation of surface ranking it is desirable to use an average tire that may be representative for all typical conditions thus the results were averaged. For the evaluation of energy consumption, in the next chapter, it is better to consider an "average" tire.

The spread between the averaged Rolling Resistance Coefficients evaluated during the measurements is between CRR_t = 0.0094 (PCC, Longitudinal Turf Drag, Cell 52) and CRR_t = 0.0117 (Porous Hot Mixed Asphalt, Cell 88). The relative difference between surfaces with the lowest and the highest CRR is 24%.

Using the CRR values over the 64 Cell/Surface combinations, the following comparisons are made between surface types. The information in Figure 4 shows that there is no distinction between the CRR values of concrete or asphalt surfaces when only considering the material type.

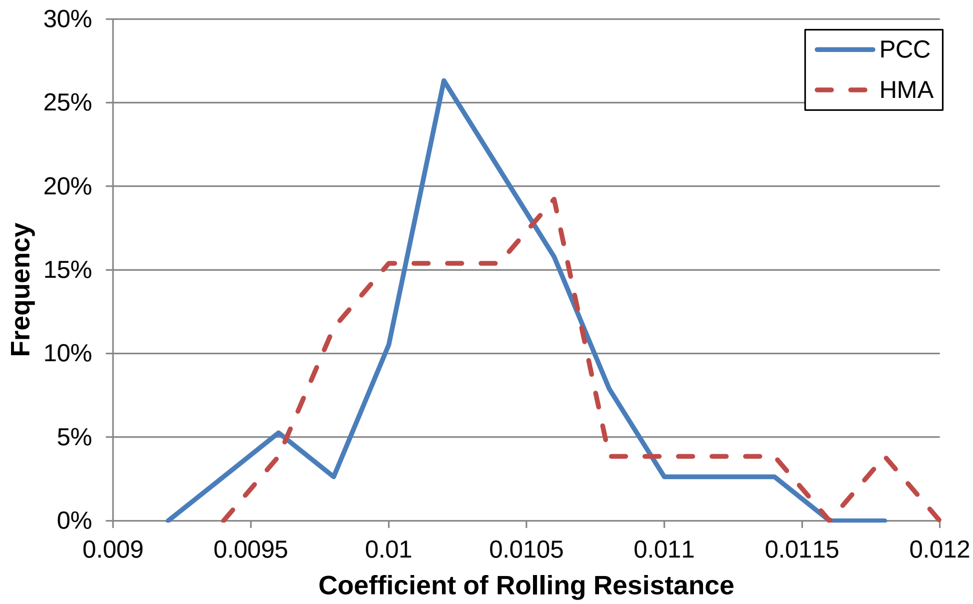

Figure 4. Distribution of CRR of concrete and asphalt surfaces.

There is more of a difference, although not statistically significant, when comparing surfaces categorized as "high texture" and "low texture" as shown in Figure 5. In this figure, "high texture" includes pavement surfaces with open graded, conventional diamond grinding, porous materials, etc. The "low texture" surfaces include dense graded asphalt, innovative grinding (with a flat surface and no "fins" contributing to the texture), and longitudinal turf or broom drag.

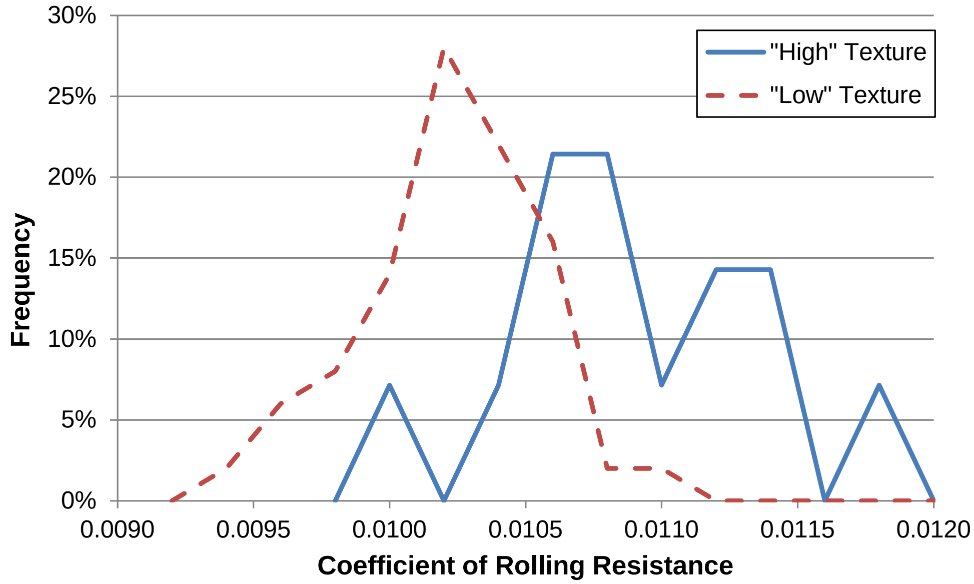

Figure 5. Distribution of CRR of surfaces with "high" and "low" texture.

For further purposes of comparison, Figure 11 shows the same 2014 measurements as Figure 10, with the addition of the rolling resistance measurements from 2011. The data in Figure 11 are ranked in the order of the 2014 measurements, and the 2011 data are added to each relevant cell. Some cells had been reconstructed, or otherwise modified between the two sets of measurements. In these cases, the 2014 data are kept in the plot, but no 2011 data are given for comparisons. As mentioned in Chapter 2, the tires used in the 2014 measurements are not the identical tires as used in 2011. In the case of the SRTT and AAV4 they are different samples of the same type. The third tire is of a different type from the same manufacturer, since they changed the style of reference tire.

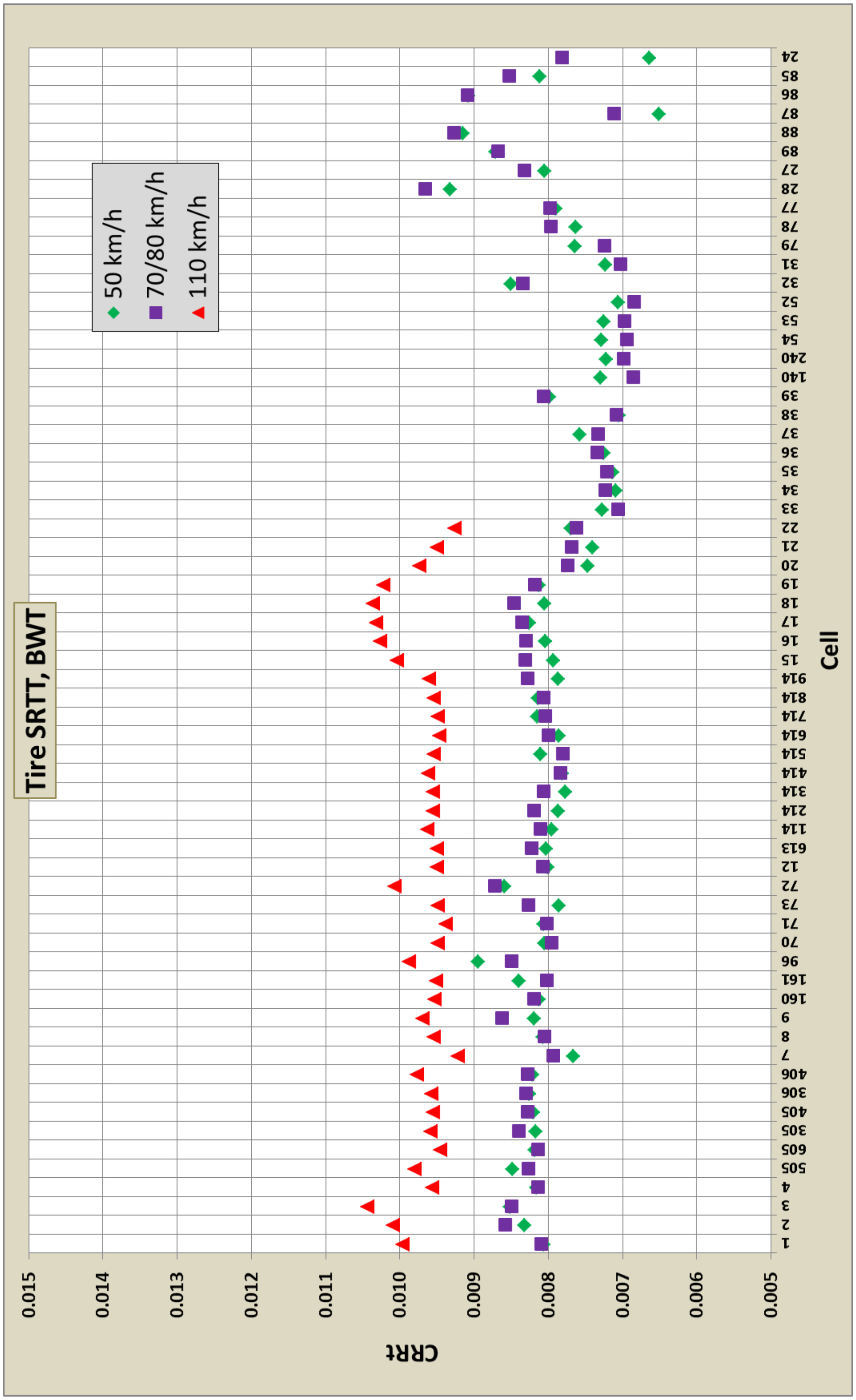

Figure 6. Speed influence for tire SRTT.

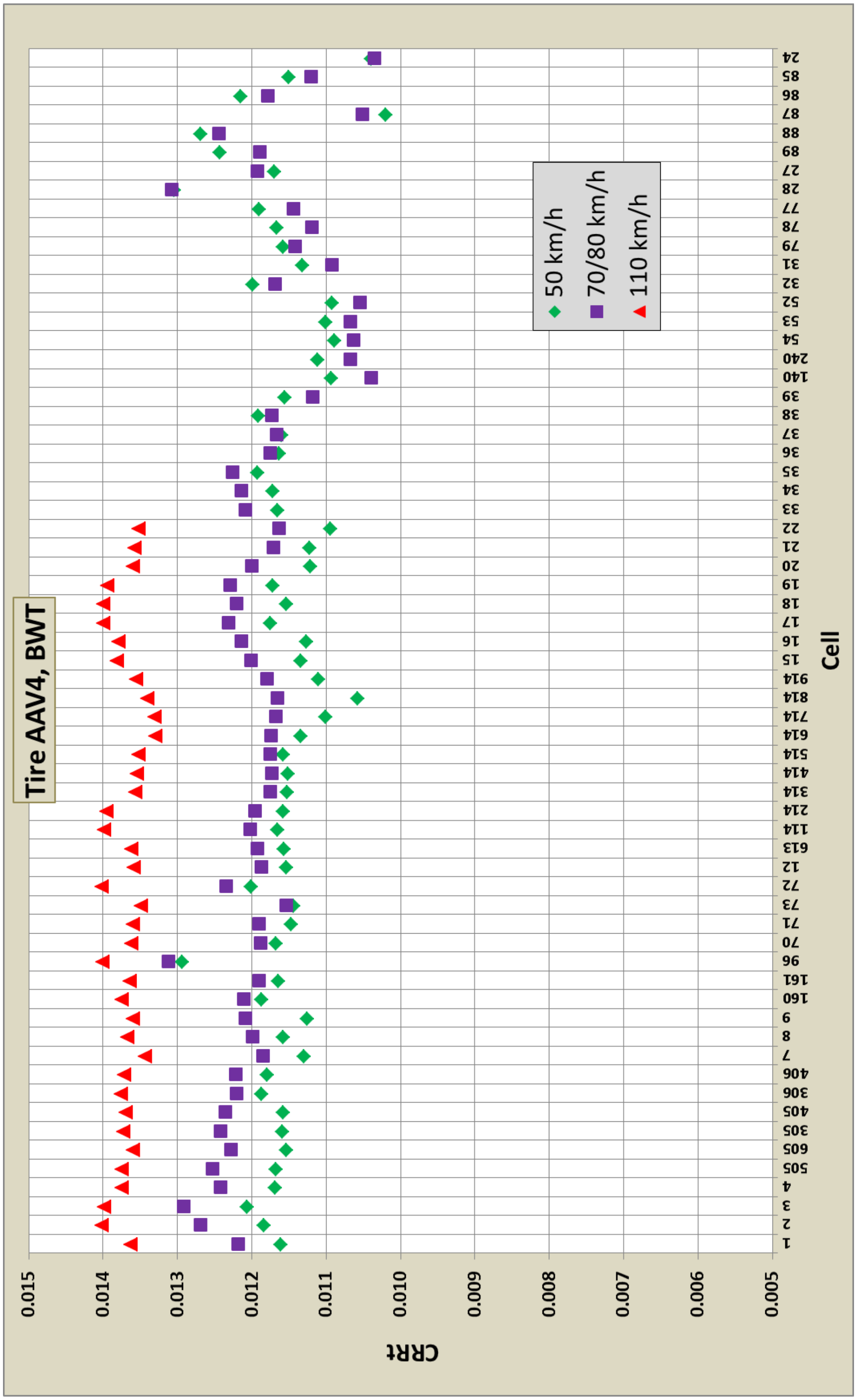

Figure 7. Speed influence for tire AAV4.

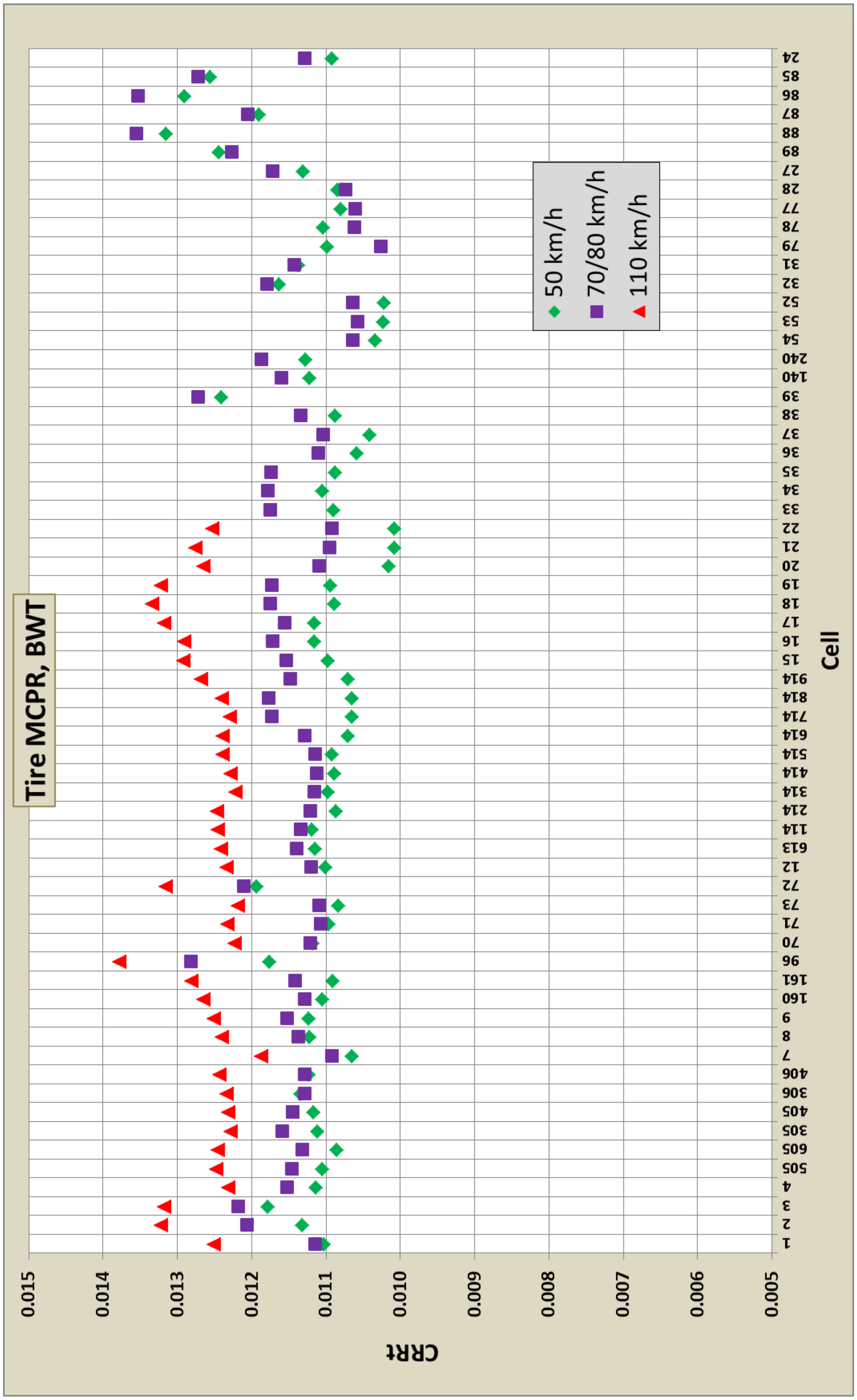

Figure 8. Speed influence for tire ME16.

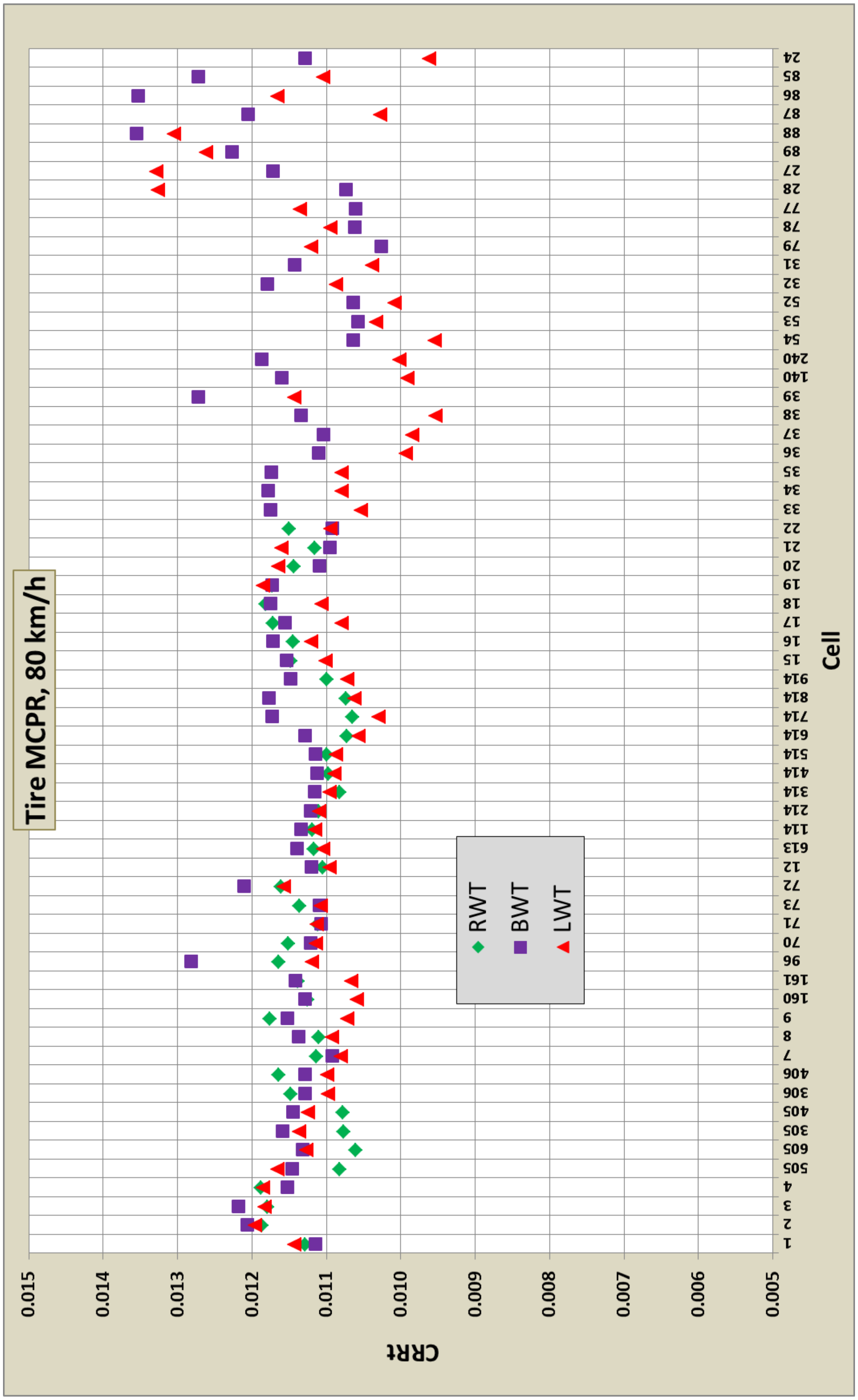

Figure 9. Influence of lateral position on CRR for tire MCPR at 80 km/h.

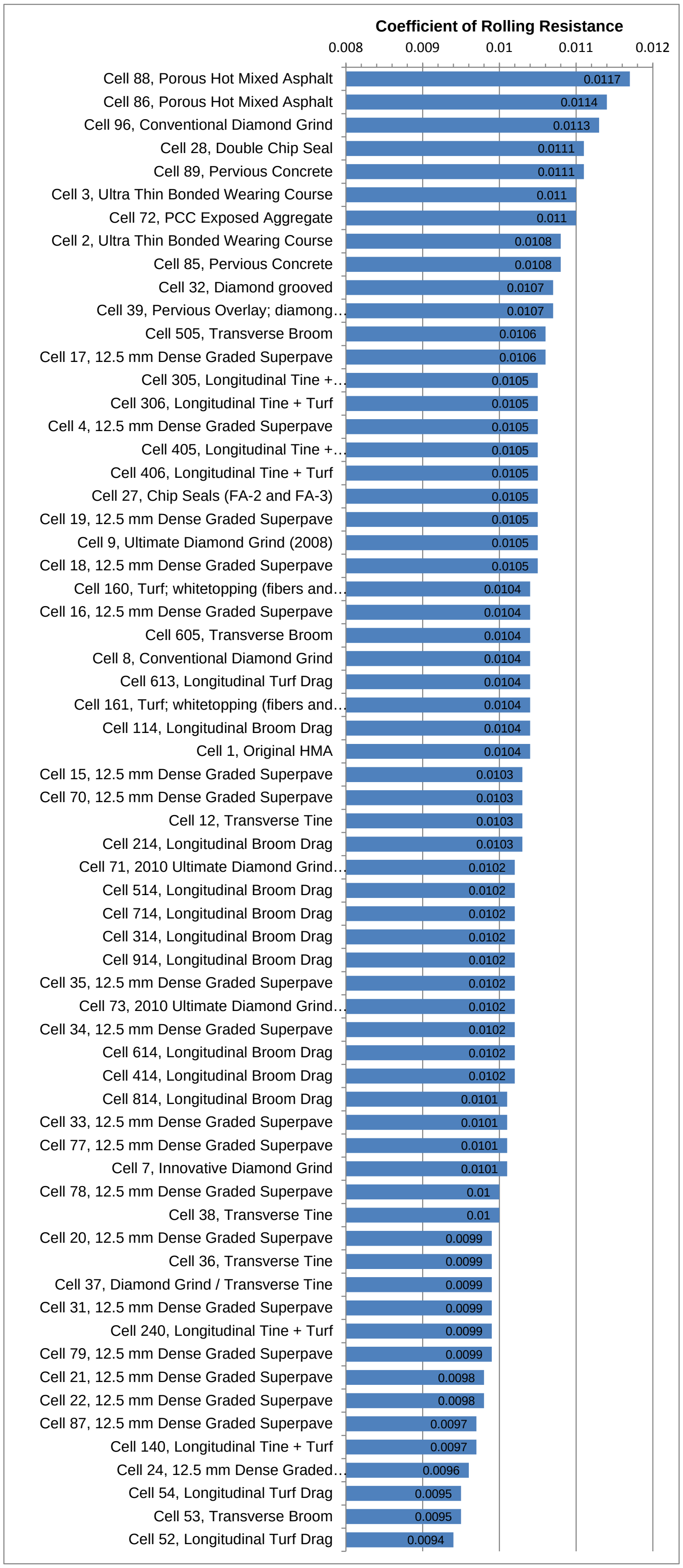

Figure 10. Surface ranking based on averaged CRR, 2011 measurements.

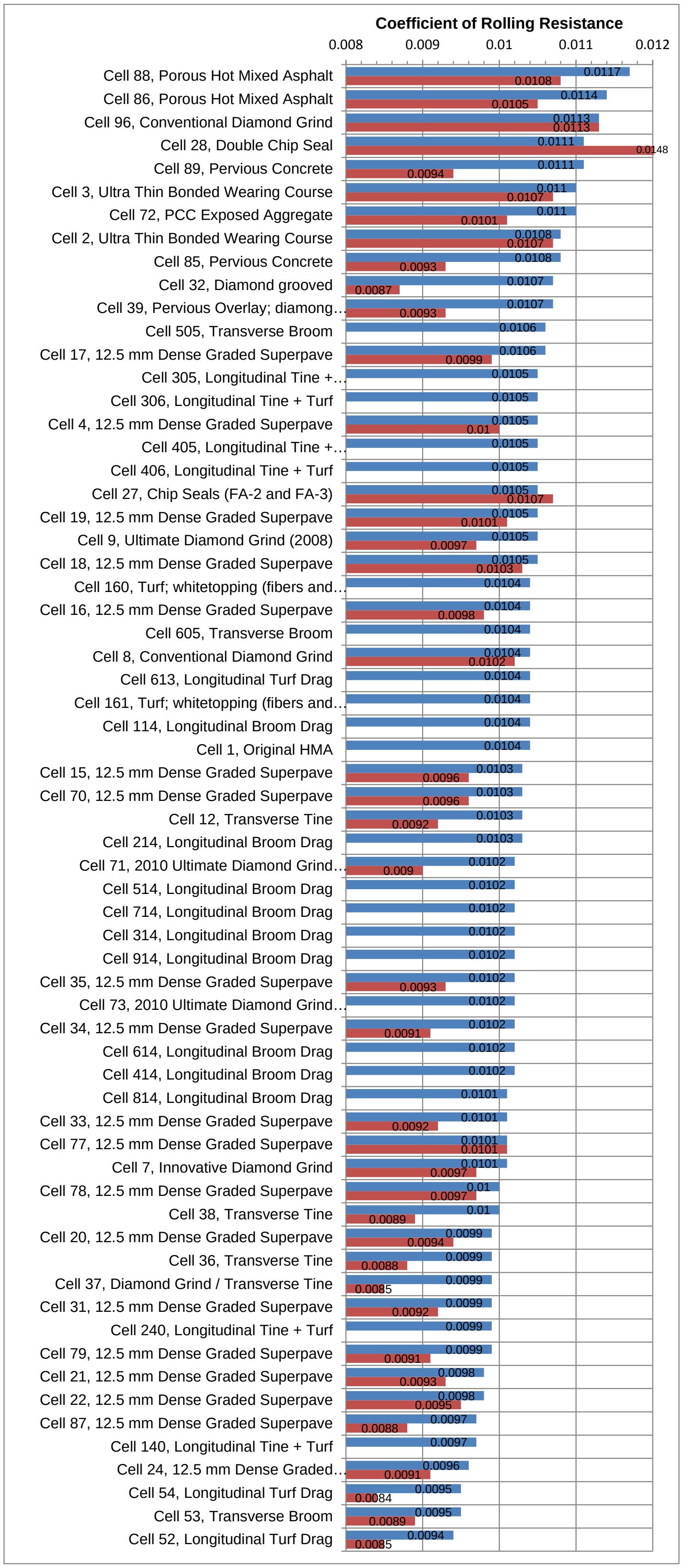

Figure 11. Surface ranking based on averaged CRR, 2014 and 2011 measurements.

Chapter 4. INFLUENCE OF ROLLING RESISTANCE ON ENERGY CONSUMPTION

Resistive Forces

Generally, several resistive forces act or may act on a moving car. These are shown in Figure 12. Some of the forces act on the vehicle all the time (rolling resistance, drag) while others may not be present under certain driving conditions (inertia forces, up/downhill force, tow force).

Rolling Resistance Force

Tire rolling resistance (F_R) is the force resisting the motion of the tire when it rolls on a road surface. It is mainly caused by non-elastic effects in the tire and the slippage between the tire tread and the pavement, which leads to dissipation of energy. Contrary to early cross-ply tires, rolling resistance of modern radial tires is not very much dependent on the speed, therefore for basic modeling used in this project it is assumed that rolling resistance is constant within low and moderate speeds, and given by Equation 3.

$$F_R = C_{RR} \cdot W \tag{3}$$

Where:

F_R = Force of rolling resistance, N,
CRR = Rolling resistance coefficient, and
W = Weight of the vehicle, N.

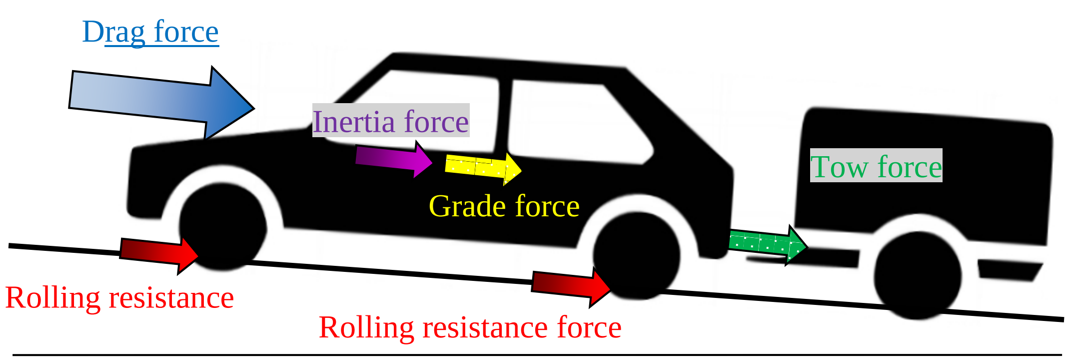

Figure 12. Resistive forces acting on moving car.

Drag Force

Vehicle drag resistance (F_D) is the aerodynamic force that opposes vehicle's motion through the air. Drag force is dependent on the relative speed of the air flowing around the vehicle, the vehicle cross-section, drag coefficient and air density. The value of the drag force is computed by the Equation 4.

$$F_D = c_X \cdot A \cdot \rho \cdot \frac{V^2}{2} \tag{4}$$

Where:

F_D = Drag force, N,
c_x = Drag coefficient,
A = Cross-sectional area, m^2,
ρ = Density of the air, kg/m^3, and
V = Speed of the vehicle relative to the air, m/s.

Inertia Force

The force of inertia (F_I) is the property common to all bodies that remain in their state, either at rest or in motion, unless some external cause is introduced to make them alter this state *(2)*. Inertia forces act on vehicles when they increase speed (accelerate) or decrease speed (decelerate). Inertia force always opposes the change of the speed, so acts as a resistive force for an accelerating vehicle and as a tractive force for a decelerating vehicle. The value of the inertia force is computed by Equation 5.

$$F_I = (m + m_r) \cdot a \qquad (5)$$

Where:

F_I = Inertia force, N,
m = Mass of the vehicle, kg,
m_r = Equivalent mass of the rotating components, kg, and
a = Acceleration, m/s^2.

Grade Force

The grade (also called slope) of a road refers to the inclination of the surface to the horizontal in longitudinal direction. Slope is often calculated as a fraction "rise over run" in which run is the horizontal distance and rise is the vertical distance. The value of grade force (F_G) is given by the Equation 6.

$$F_G = W \cdot \sin(\alpha) \qquad (6)$$

Where:

F_G = Grade force, N,
W = Weight of the vehicle, N, and
a = Angle of the slope, deg.

Tow Force

Tow force exists only when the vehicle tows another vehicle, usually trailer or semitrailer. Tow force is equal to the sum of all forces acting on the towed vehicle.

Test Cycle

It is relatively simple to evaluate energy consumption during driving on highways and freeways where cars travel with fairly steady speed. However, in order to evaluate energy consumption during driving in urban areas it is necessary to use certain driving cycles that simulate typical urban traffic conditions. The authors decided that the cycle used in the EPA Federal Test

Procedure (US FTP 75) fits calculations of energy consumption of light vehicles the best. The European Driving Cycle was also considered but it was judged to be less representative and less useful for evaluation of rolling resistance influence on fuel consumption. The speed profile of the US FTP 75 driving cycle is shown in Figure 13. The most important parameters of this cycle include:

- Distance traveled: 17.77 km (11.04 miles),
- Duration: 1874 sec, and
- Average speed: 34.1 km/h (21.2 mph).

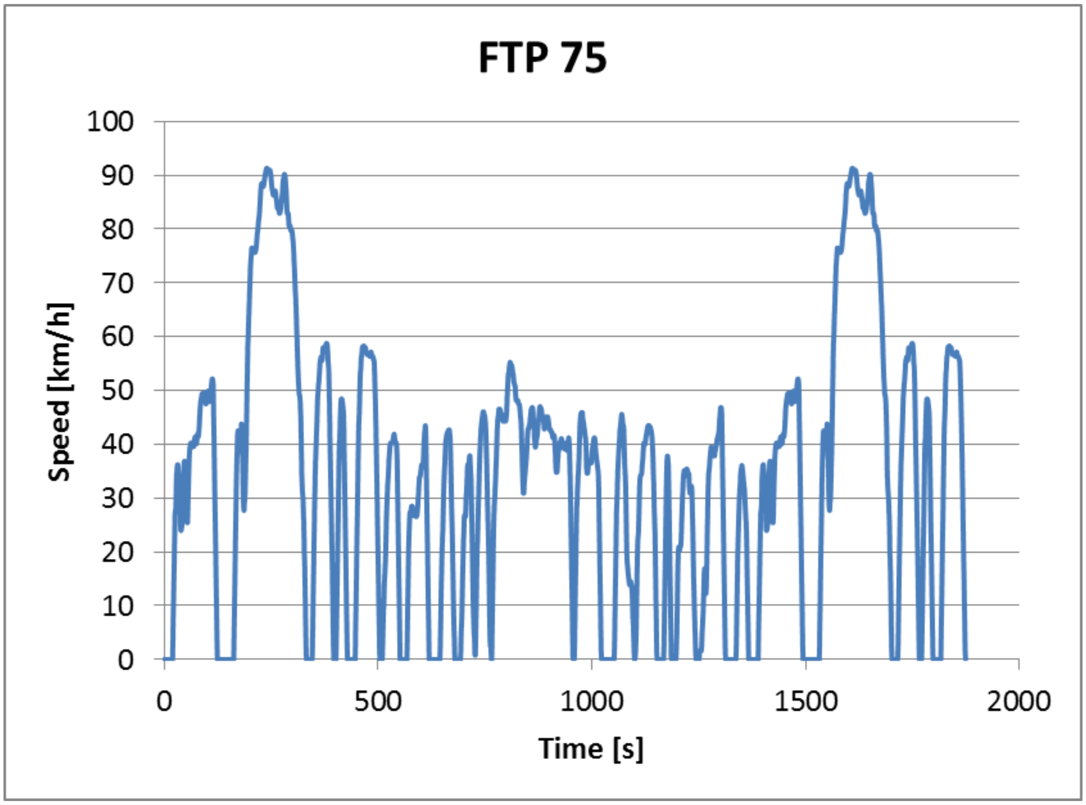

Figure 13. Speed profile of the US FTP 75 Driving Cycle.

Simulation Model

There are several simulation models used for estimation of energy consumption of light and heavy vehicles. They are usually very complicated and based on numerous input data that can be difficult to obtain. In the case of simulations performed within the project it is not necessary to use very elaborate models as the goal is not to predict absolute energy consumption values but to evaluate relative changes of energy consumption attributable to rolling resistance changes. Due to this simplification it is not necessary to investigate in detail the particularities of engine and power train efficiency. It is assumed that differences in engine load due to different tire rolling resistance are not large enough to result in different efficiency of the engine and power train.

The model used for evaluation is based on Equations 7 and 8.

$$P = (F_R + F_D + F_I + F_G) \cdot V + P_0 \quad (7)$$

$$E = P \cdot t \quad (8)$$

Where:

P	=	Power, W,
F_R	=	Rolling resistance force, N,
F_D	=	Drag force, N,
F_I	=	Inertia force, N,
F_G	=	Grade force, N,
V	=	Speed of the vehicle, m/s
E	=	Energy, J, and
P_0	=	During idling P_0= P_i , during normal driving P_0=P_e (power necessary to rotate unloaded engine), W.

The basic power necessary to drive a vehicle is calculated according to Equation 7. If the simulation is performed for a conventional vehicle (diesel or gasoline engine) the model evaluates when engine braking is present. Most vehicles are constructed in such a way that during engine braking fuel consumption is reduced to zero and this behavior is modeled in the algorithm. The algorithm also checks if the speed of vehicle is below 2 m/s and if so the virtual "idling power" value is used (Pi). In the case of electric and hybrid vehicles equipped with kinematic energy recovery systems (KERS) it is assumed that 50% of energy during "engine braking" is recovered. A schematic diagram of the algorithm is presented in Figure 14.

To simplify the calculations, energy is calculated according to Equation 8 with time interval of 1 sec and summed over the entire driving cycle. During idling, fuel consumption for most of conventional vehicles is at about 0.5-1.4 l of fuel per hour. The authors estimate that virtual "idling power" value (Pi) that represents the power necessary to idle the engine should be in the range of 0.4-1.3 kW for typical car engines. To rotate an unloaded engine at a certain rpm the virtual "rotation power" (Pe) is necessary. Estimations shows that depending on rotational speed the value of Pe is between 0.5-7.0 kW.

The model does not account for energy consumption of auxiliary systems like air conditioning, radio, lights, etc.

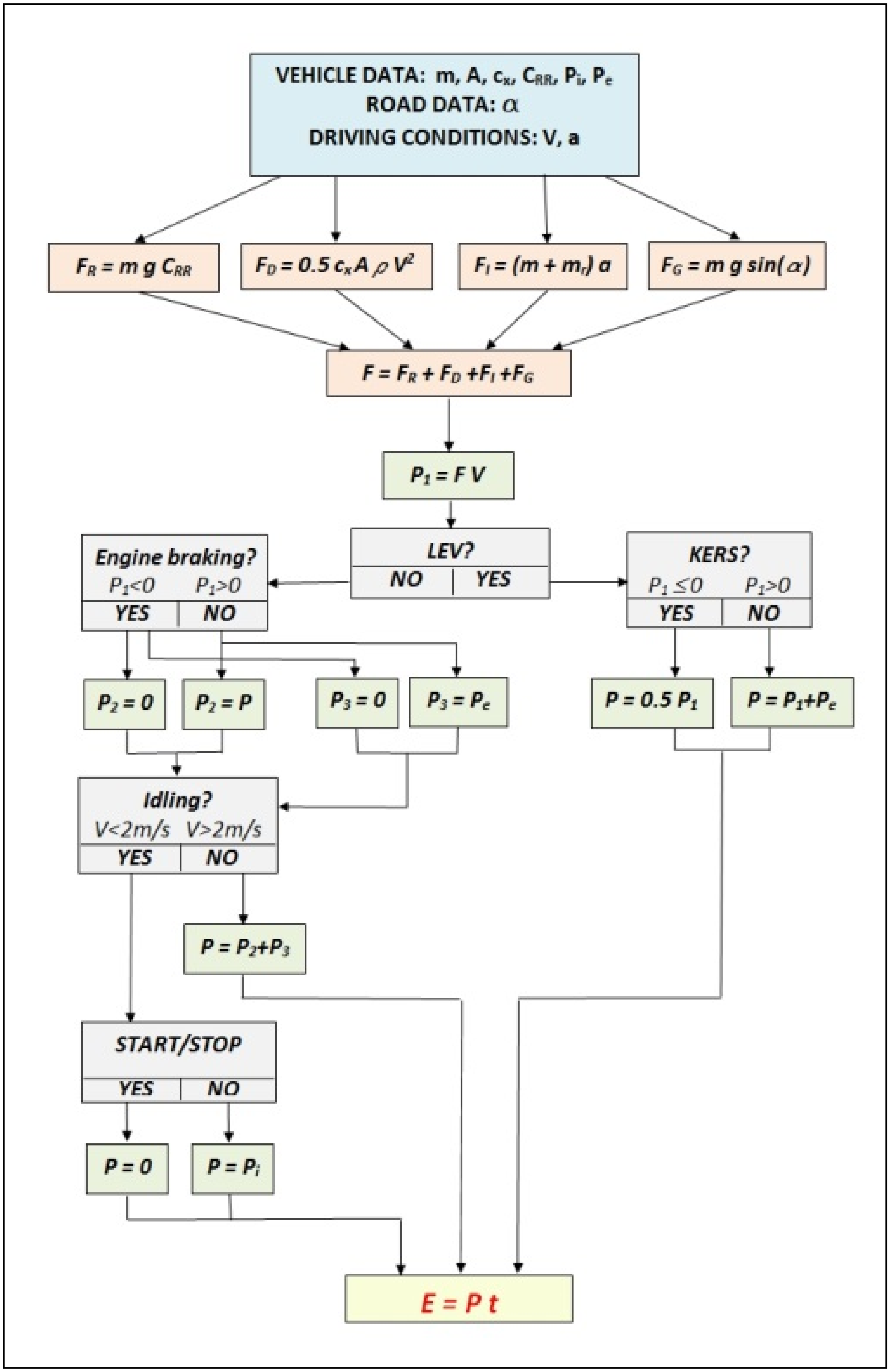

Figure 14. Algorithm of the energy consumption calculations.

Conventional Vehicles Used For Simulations

In order to simulate the influence of rolling resistance on overall energy consumption for conventional vehicles, six cars were selected.

- 2012 Jeep Liberty (Figure 15a)
- 2010 Subaru Outback Wagon (Figure 15b)
- 2009 Toyota Corolla (Figure 15c)
- 2009 Chevrolet Aveo (Figure 15d)
- 2009 GMC Sierra XFE (Figure 15e)
- 2010 Ford Mondeo Estate. (Figure 15f)

Technical data for these vehicles related to the calculations are presented in Table 3. The vehicles are also presented in Figure 15.

Table 3. Technical data of conventional vehicles used for simulation.

Manufacturer	**Model**	**Year**	c_x	**Frontal area, m²**	**Curb weight, kg**
Jeep	Liberty *(3)*	2012	0.394	2.81	1850
Subaru	Outback Wagon *(4)*	2010	0.37	2.55	1552
Toyota	Corolla *(5)*	2009	0.29	2.09	1350
Chevrolet	Aveo *(6)*	2009	0.32	2.14	1200
GMC	Sierra XFE *(7)*	2009	0.412	3.19	2300
Ford	Mondeo Estate *(8)*	2010	0.31	2.33	1615

Simulation Results

Energy consumption simulations were performed for constant speeds of 30, 50, 70, 90, 110, 130 and 150 km/h and for urban driving cycle FTP 75 described above. Calculations were performed for rolling resistance coefficients from 0.005 to 0.015 in increments of 0.001. A rolling resistance coefficient of 0.01 was considered as reference. The energy consumption calculated according to the algorithm presented in Figure 14 does not account for efficiency of the engine and power train but it may be assumed that the efficiency will not change considerably for small and moderate differences in engine load due to changes in rolling resistance. Energy consumption for each rolling resistance coefficient was related to the energy consumption for the same driving conditions but calculated for a reference rolling resistance coefficient of 0.01. The resulting factor is called in this report "Relative Change of Energy Consumption" and designated R_E *(9)*. Since this is a relative change in energy (or fuel) consumption, the actual fuel consumption is not estimated, and the factors included in traditional fuel consumption models such as HDM-4*(10)* are not required.

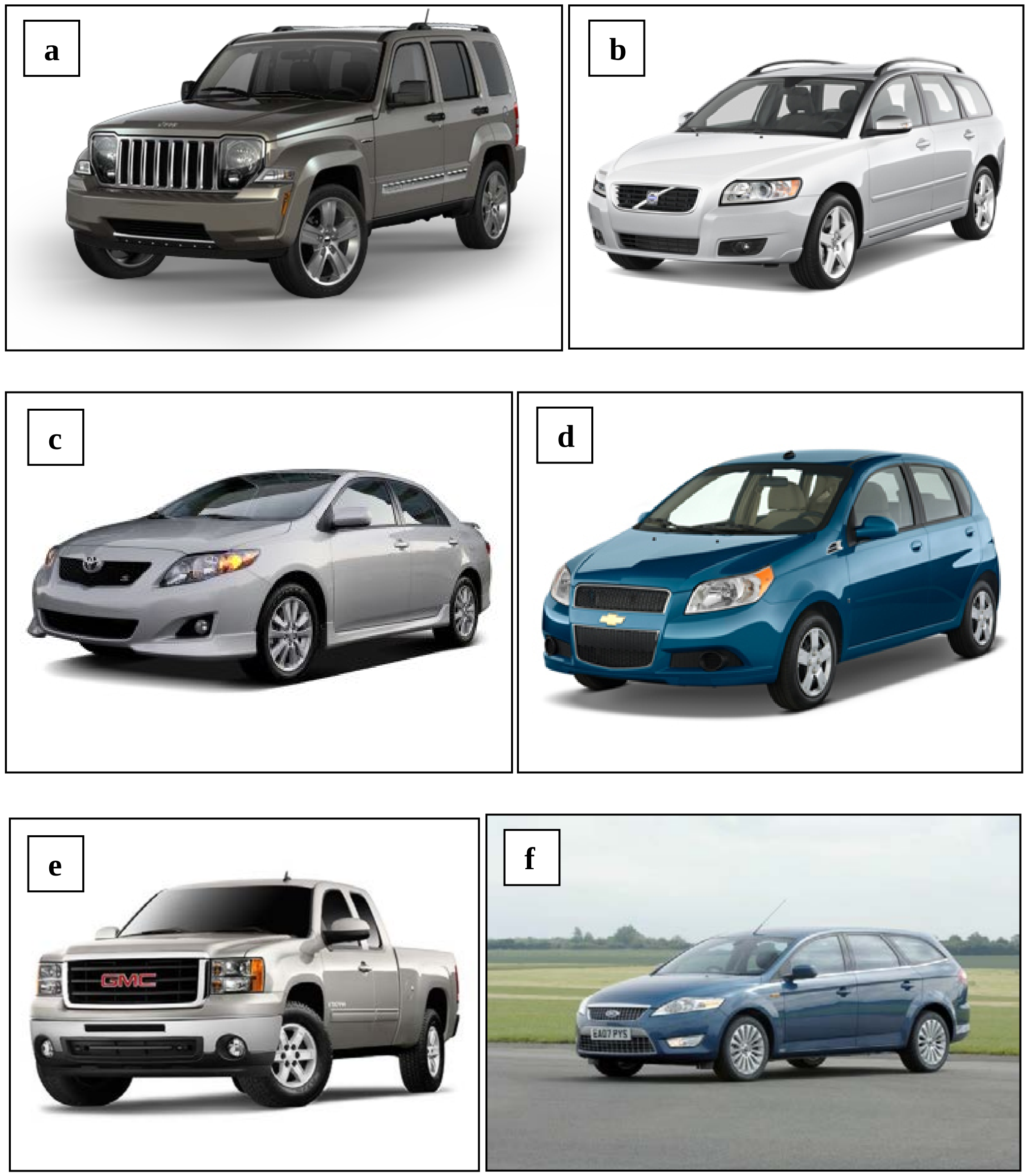

Figure 15. Conventional cars used for simulation.

Detailed analyses of the results show that the Relative Change of Energy Consumption is very similar for all investigated vehicles within a vehicle class (conventional and hybrid) so in order to simplify the presentation of results the characteristics were averaged. The results for conventional cars are presented in Table 4 and Figure 16.

The comparison of results obtained for different types of vehicles shows that there are no significant differences in sensitivity of energy consumption to changes in rolling resistance. This is easy to understand as both conventional and low emission (electric and hybrid) cars have similar weight, frontal area and drag coefficients. Tire rolling resistance is a major resistive force for slow, constant speed driving, thus R_E exhibits the highest values for slow speeds. As indicated in Table 4 and Figure 16, at 30 km/h the decrease of the rolling resistance coefficient from 0.01 to 0.005 may lead to a 23% decrease of energy consumption. For high speeds, the influence is less pronounced and a similar decrease of rolling resistance coefficient would result in only an 8% decrease of energy consumption for a speed of 150 km/h.

Table 4. Relative Changes of Energy Consumption averaged for six conventional vehicles.

CRR	Constant speed driving 30 km/h	50 km/h	70 km/h	90 km/h	110 km/h	130 km/h	150 km/h	Urban FTP-75
0.005	0.77	0.78	0.81	0.85	0.88	0.90	0.92	0.89
0.006	0.81	0.82	0.85	0.88	0.90	0.92	0.94	0.91
0.007	0.86	0.87	0.89	0.91	0.93	0.94	0.95	0.93
0.008	0.91	0.91	0.92	0.94	0.95	0.96	0.97	0.96
0.009	0.95	0.96	0.96	0.97	0.98	0.98	0.98	0.98
0.010	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
0.011	1.05	1.04	1.04	1.03	1.02	1.02	1.02	1.02
0.012	1.09	1.09	1.08	1.06	1.05	1.04	1.03	1.04
0.013	1.14	1.13	1.11	1.09	1.07	1.06	1.05	1.07
0.014	1.19	1.18	1.15	1.12	1.10	1.08	1.06	1.09
0.015	1.23	1.22	1.19	1.15	1.12	1.10	1.08	1.11

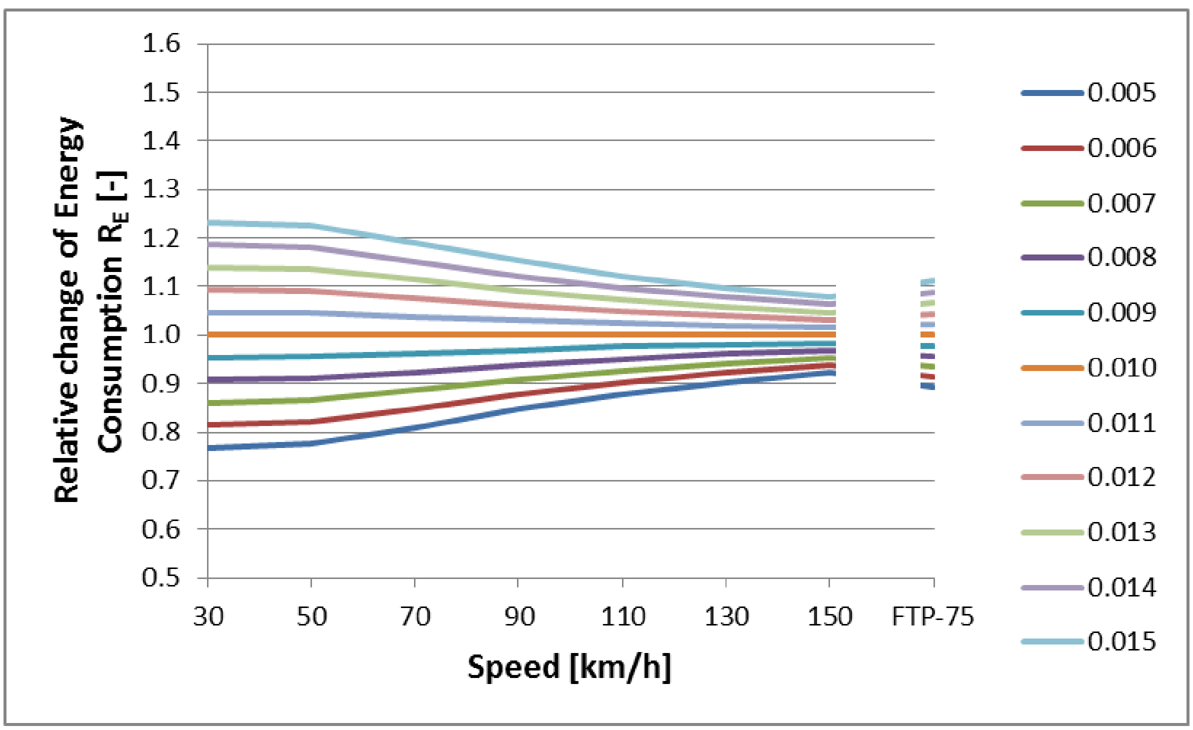

Figure 16. Relative Changes of Energy Consumption averaged for six conventional cars.

During urban driving the average speed is not high (34 km/h), but a lot of energy is consumed to accelerate vehicles. In conventional cars most of the energy during braking is lost. Also in low-emission vehicles this energy is not fully preserved by energy recovery systems. During urban driving R_E for conventional vehicles is on the same level as for constant driving with a constant speed of 110 km/h. For urban driving a decrease of the rolling resistance coefficient from 0.01 to 0.005 would lead to an 11% decrease of energy consumption for conventional vehicles.

In order to better describe the influence of rolling resistance on overall energy consumption the authors introduced "Rolling Resistance Impact Factor" (IFRR). This factor shows how much the energy consumption is influenced by a change in rolling resistance coefficient. For example, IFRR = 0.3 means that decrease of energy consumption will equal 30% of the decrease of rolling resistance. If the rolling resistance coefficient is reduced from 0.01 to 0.008 the energy consumption will be reduced by: (0.01-0.008)*0.3*100%, or 6%. Impact Factors for conventional vehicles are presented in Table 5.

Table 5. Relative Changes of Energy Consumption averaged for six conventional vehicles.

Vehicle	**Constant speed driving**							**Urban FTP-75**
	30 km/h	**50 km/h**	**70 km/h**	**90 km/h**	**110 km/h**	**130 km/h**	**150 km/h**	
Conventional	0.46	0.45	0.38	0.31	0.24	0.19	0.16	0.22

Road Surface Influence on Energy Consumption

Rolling Resistance Impact Factors were applied to results of rolling resistance measurements performed at MnROAD. Figure 17 presents results for the simulated influence of different pavements on energy consumption for constant driving speeds of 70 and 110 km/h (43 and 68 mph), respectively. Results are related to pavements that exhibit CRR_t = 0.01. In the case of measurements performed with test tires SRTT, MCPR and AAV4 and averaged for speeds 50 and 80 km/h the 12.5 mm Dense Graded SuperPave may be considered as a reference surface (CRR_t=0.01).

Results of rolling resistance measurements performed on Mainline and Low Volume Road at the MnROAD Facility indicate that in relation to Dense Graded SuperPave energy consumption on various pavements may be higher by 3.8% at 110 km/h and 6.1 % at 70 km/h, or lower by 1.4% or 2.3% respectively.

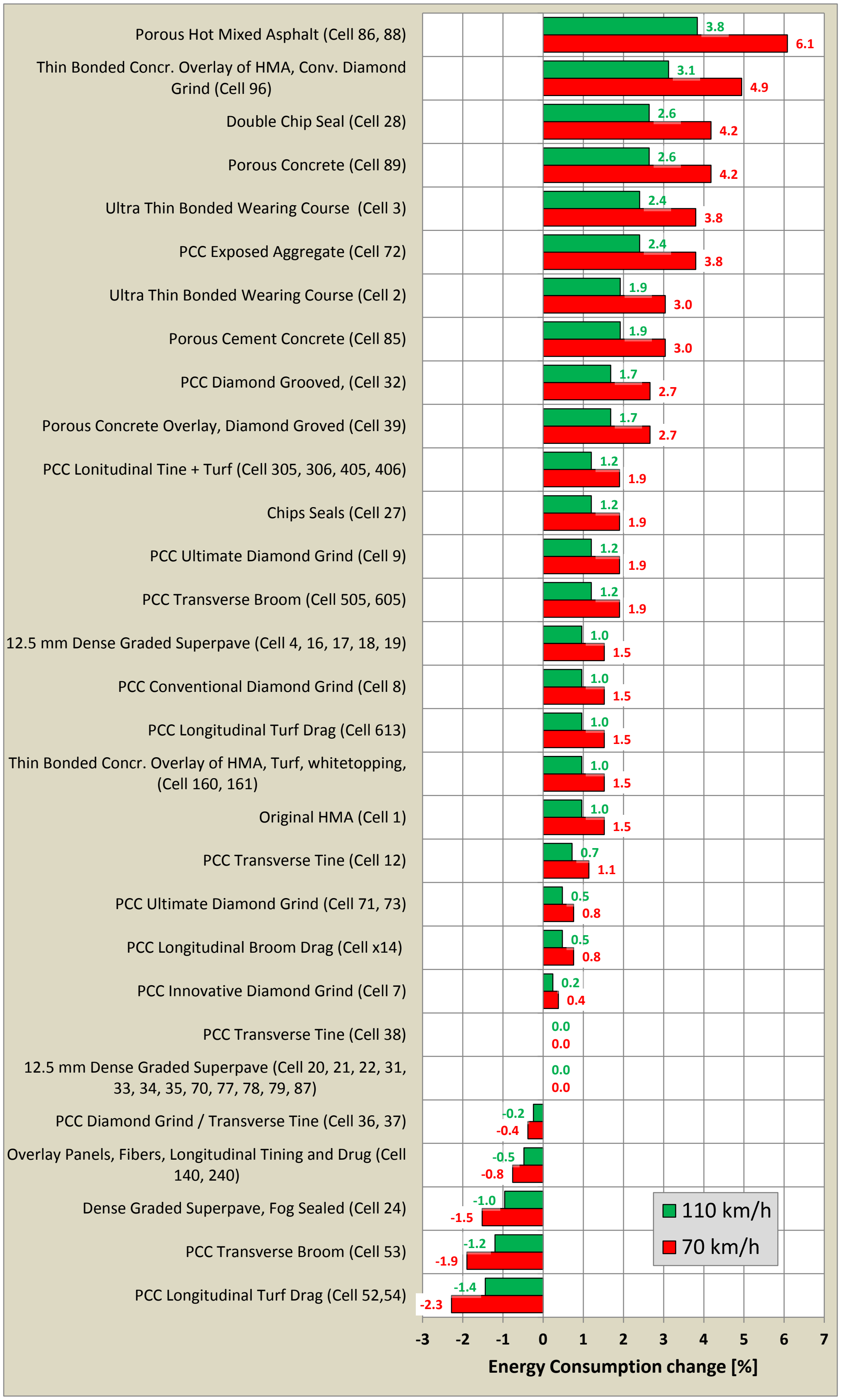

Figure 17. Road pavement influence on energy consumption of passenger cars.

Chapter 5. CONCLUSIONS

This project presented the rolling resistance testing program conducted by researchers at the Technical University of Gdańsk, Poland, using the rolling resistance measurement trailer R^2 Mk. 2 on the many pavement surfaces at the MnROAD research facility. The coefficients of rolling resistance were computed for each surface, as were estimates of energy consumption relative to a standard pavement surface. This second round of testing followed up a first round, which was conducted in September 2011. Based on the testing and the results of the data analysis, the following conclusions can be made.

- In general, pavement surfaces with higher rolling resistance coefficients are those with greater surface texture such as porous materials, conventional diamond grinding, and exposed aggregate. This finding is supported by the analysis conducted in the report on the first round of rolling resistance measurements *(1)*.
- The lower resistance surfaces tend to be bituminous pavements with dense graded aggregates, and concrete pavements with broom or turf drag surfaces.
- There is little difference in rolling resistance coefficients at speeds of 50 and 70 km/h, but at 110 km/h the coefficients increased significantly on all surfaces tested (the MnROAD mainline cells).
- As speed increases, the relative effect on energy consumption diminishes, as other impacts such as wind resistance are much more prominent.
- Using the 12.5 mm Dense Graded bituminous surface and a transverse-tined concrete surface as standards, the analysis estimated up to a 2.3% *decrease* in energy consumption and up to a 6.1% *increase* in energy consumption attributable to the various pavement surfaces. Similar to another conclusion mentioned above, the porous surfaces had the highest increase in predicted energy consumption, while the PCC broom and turf drag surfaces were predicted to have the highest decrease in consumption.

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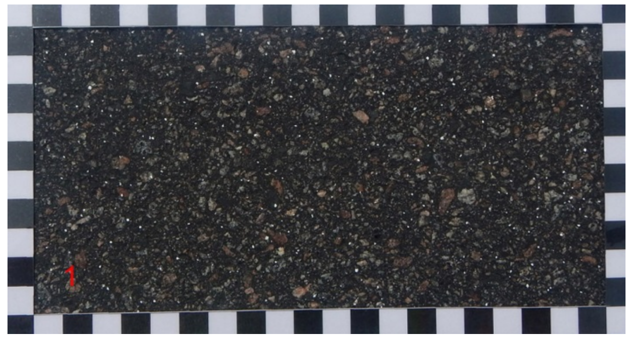
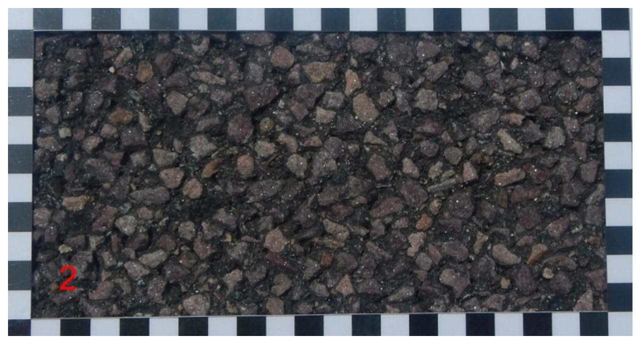
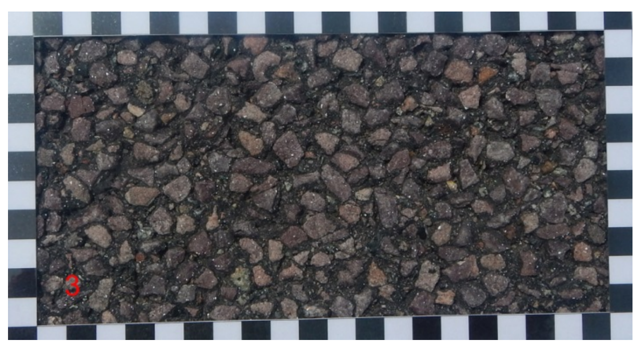
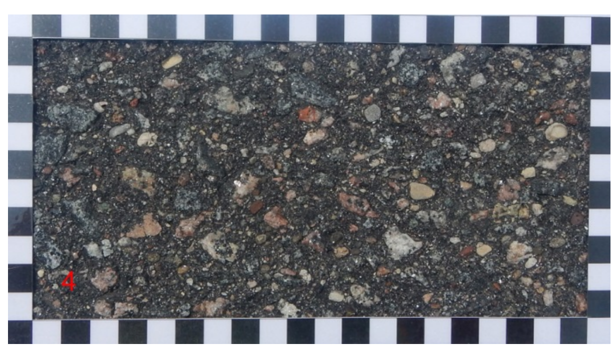
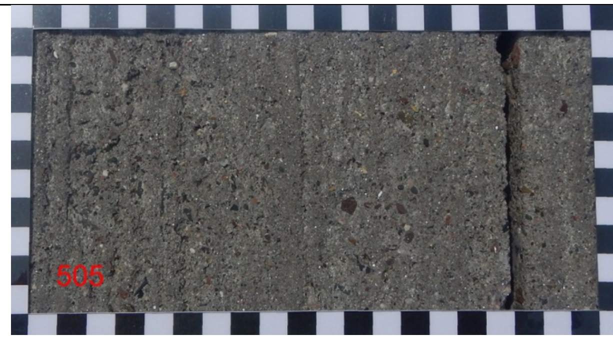
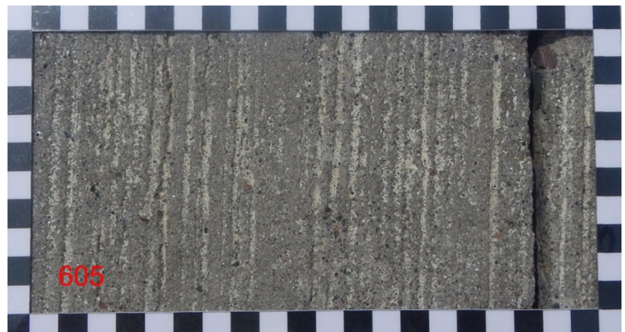
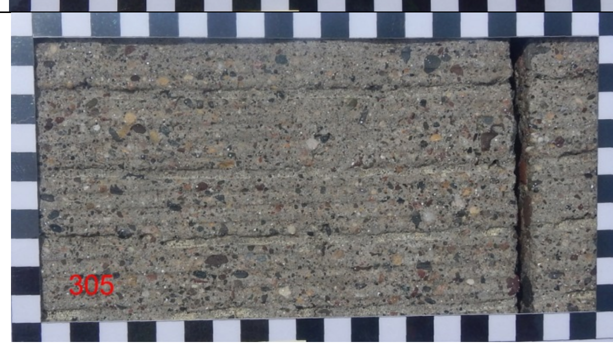
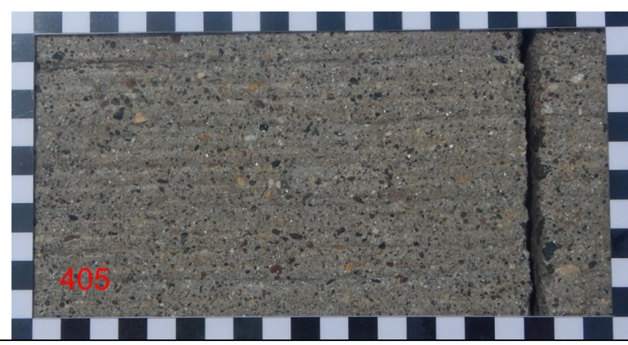
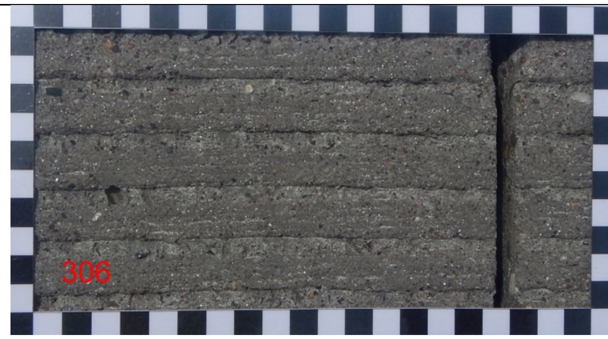
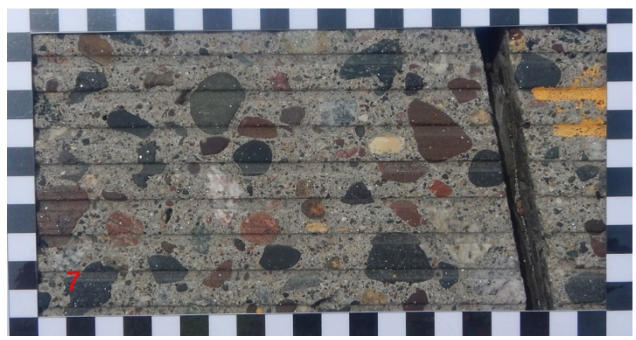
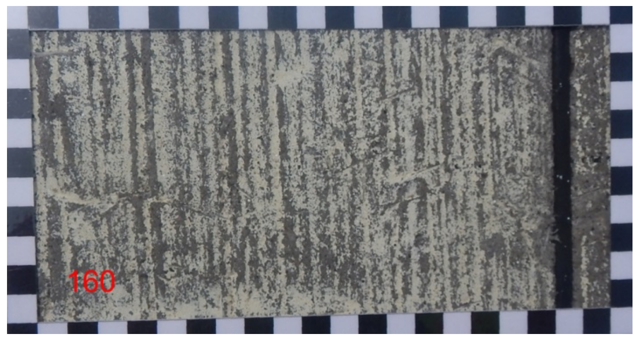
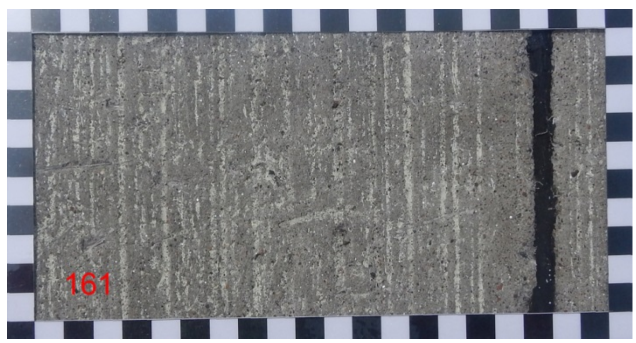
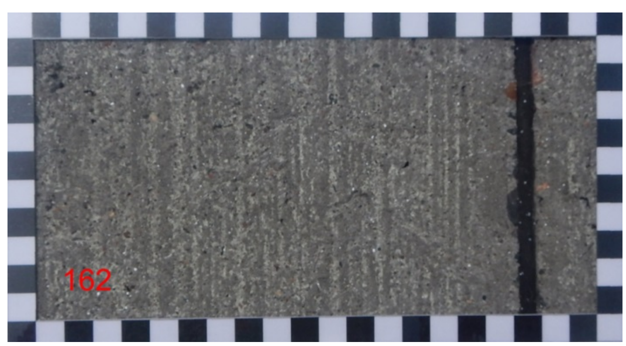
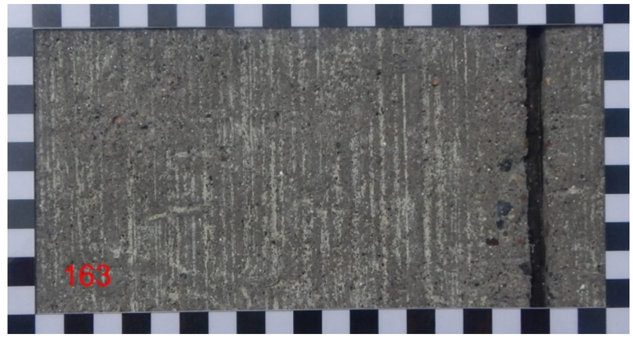
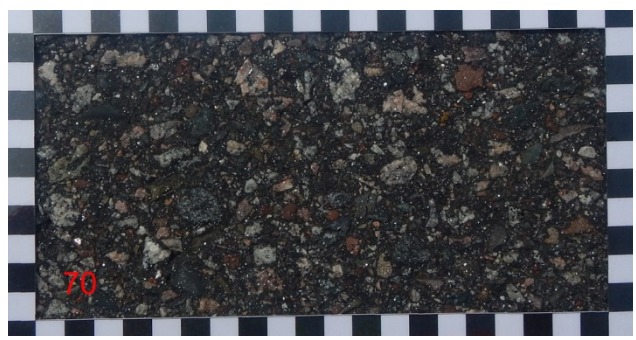
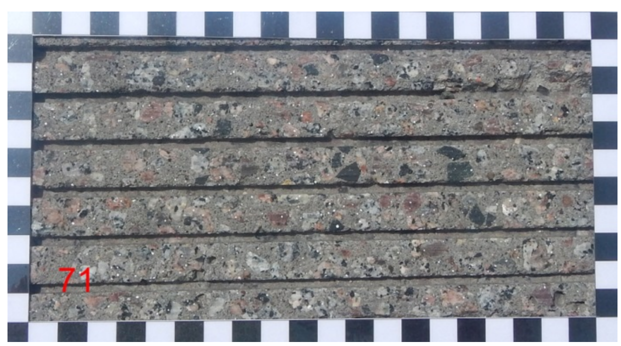
APPENDIX A. SUMMARY OF PAVEMENT SURFACE TYPES AT MnROAD

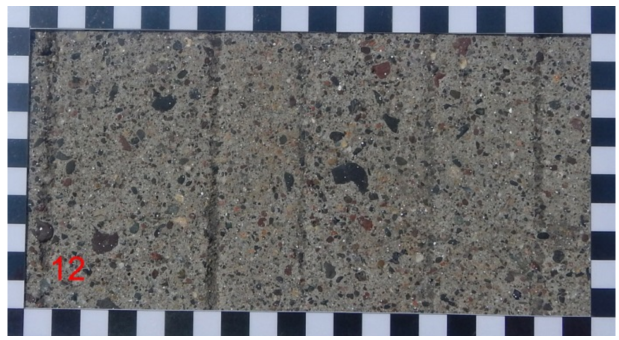
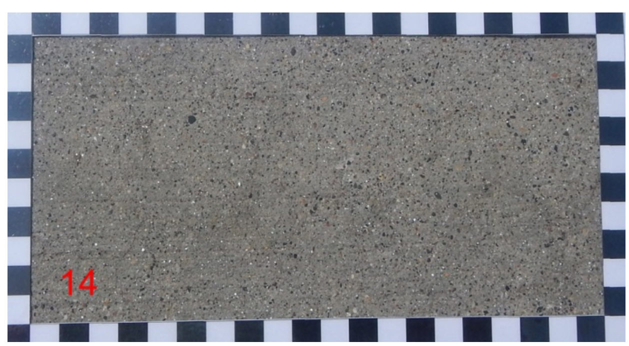
Cell	SubCell	Experiment	Surface Type	Picture
1			Original HMA	
2		SemMaterials FDR Study	Ultra Thin Bonded Wearing Course	
3		SemMaterials FDR Study	Ultra Thin Bonded Wearing Course	
4		SemMaterials FDR Study	12.5 mm Dense Graded SuperPave	

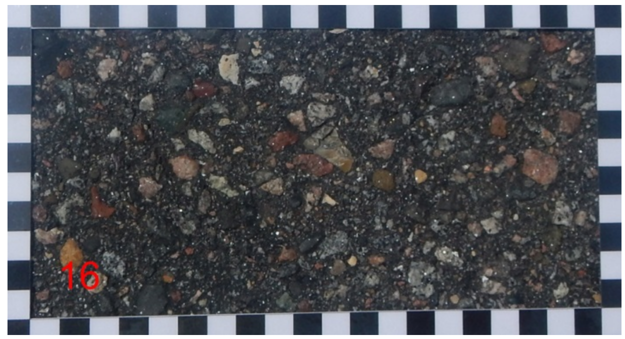
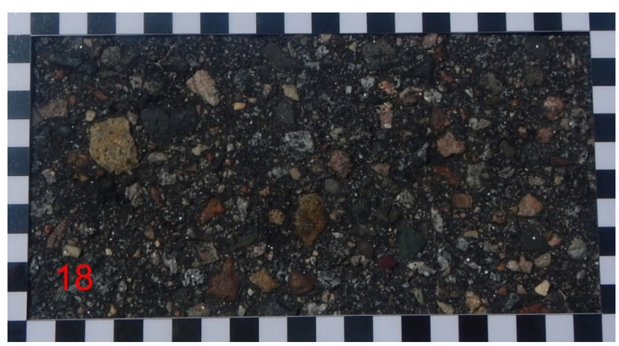
5	505 605		Transverse Broom		
	305 405		Longitudinal Tine + Conventional Grind		

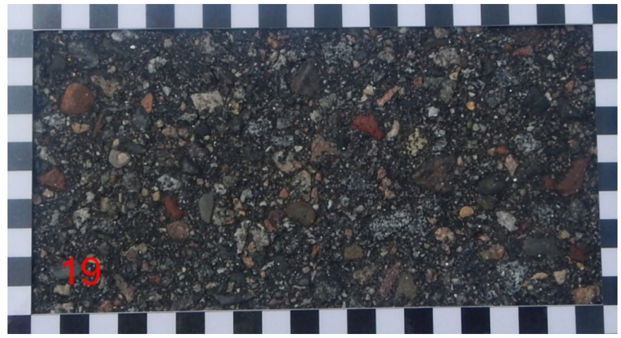
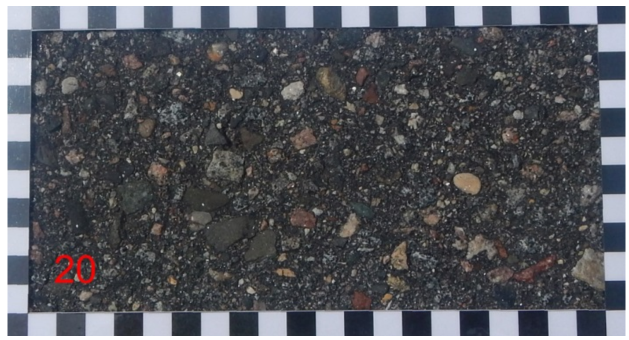
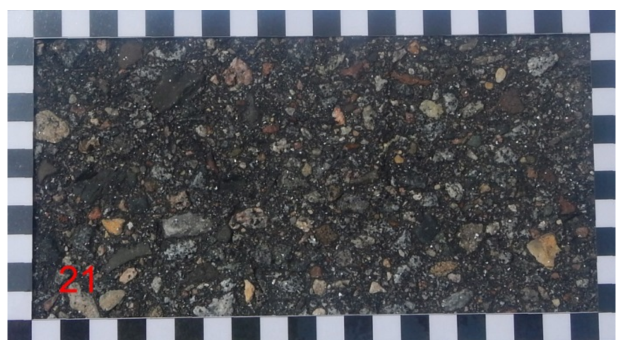
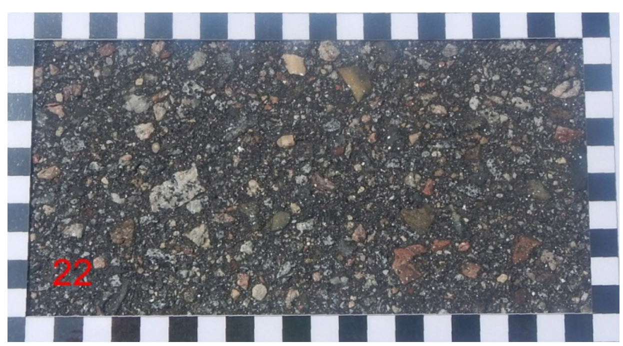
6	306 406		Longitudinal Tine + Turf	 
7		5 year design PCC – Widened lane – PASB – longer panel	Innovative Diamond Grind	
8		5 year design PCC – Widened lane – PASB – Supplemental Steel	Conventional Diamond Grind	

9		5 year design PCC – Widened lane – PASB	Ultimate Diamond Grind (2008)	
160		Thin Bonded Concrete Overlay of HMA – 5 inch – sealed	Turf; whitetopping (fibers and transverse drag)	
161		Thin Bonded Concrete Overlay of HMA – 5 inch – unsealed	Turf; whitetopping (fibers and transverse drag)	
162		Thin Bonded Concrete Overlay of HMA – 4 inch – sealed	Turf; whitetopping (fibers and transverse drag)	

163		Thin Bonded Concrete Overlay of HMA – 4 inch – unsealed	Turf; whitetopping (fibers and transverse drag)	
96		Thin Bonded Concrete Overlay of HMA – 5 by 6 panels	Conventional Diamond Grind	
70		SHRP II Composite Pavement Study – DL Doweled, PL Not Doweled	12.5 mm Dense Graded SuperPave	
71		SHRP II Composite Pavement Study – Diamond Grind Surface	2010 Ultimate Diamond Grind (Driving) Conventional Diamond Grind (Passing)	

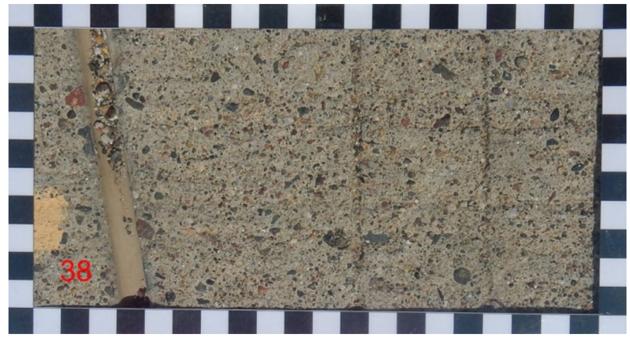
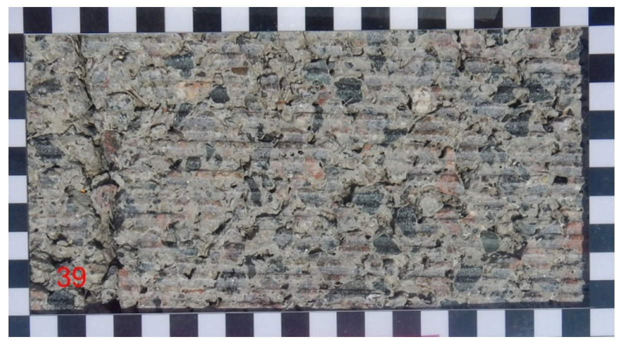
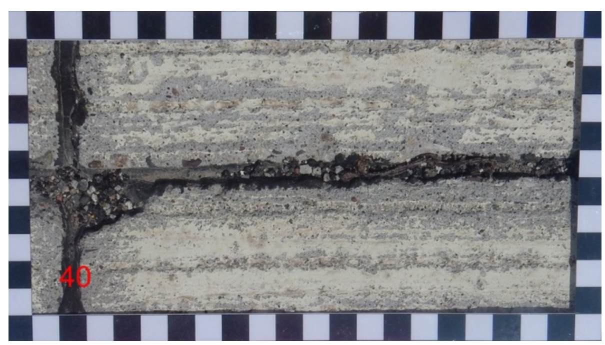
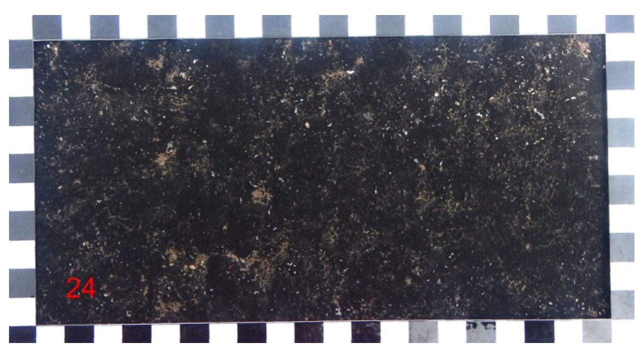
72		SHRP II Composite Pavement Study – EAC Surface	Exposed Aggregate	
12		10 year design PCC – Drained base	Transverse Tine	
13	513 413 313 213 113	PCC Thickness Optimization – 5 inch – Flat Plate Dowels – 12 and 15 foot panel lengths	Longitudinal Turf Drag	
14	914 814 714 614 514 414 314 214 114		Longitudinal Broom Drag	

15		Warm Mix Asphalt Overlay	12.5 mm Dense Graded SuperPave	
16		Recycled Unbound Base Study, Warm Mix Asphalt Surface	12.5 mm Dense Graded SuperPave	
17		Recycled Unbound Base Study, Warm Mix Asphalt Surface	12.5 mm Dense Graded SuperPave	
18		Recycled Unbound Base Study, Warm Mix Asphalt Surface	12.5 mm Dense Graded SuperPave	

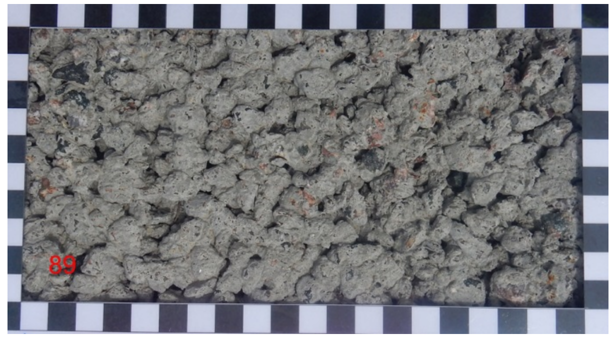
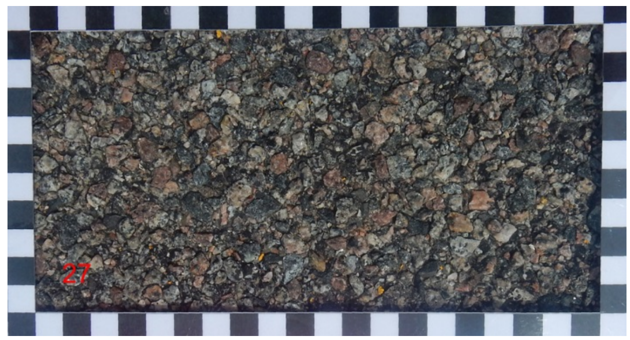
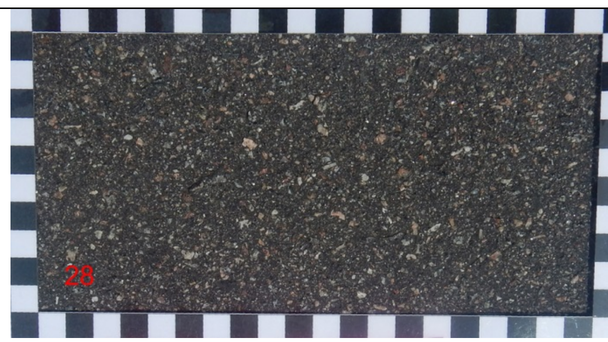
19		Recycled Unbound Base Study, Warm Mix Asphalt Surface	12.5 mm Dense Graded SuperPave	
20		Low Temperature Cracking, RAP Study	12.5 mm Dense Graded SuperPave	
21		Low Temperature Cracking, RAP Study	12.5 mm Dense Graded SuperPave	
22		Low Temperature Cracking, RAP Study	12.5 mm Dense Graded SuperPave	

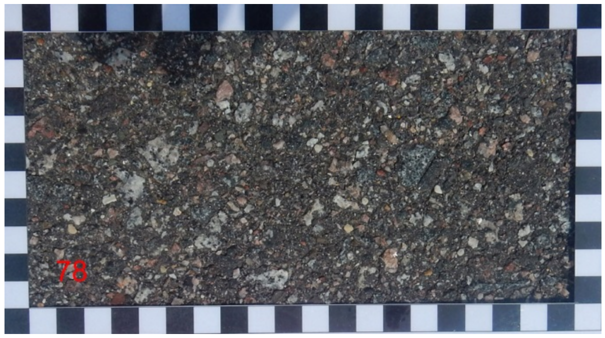
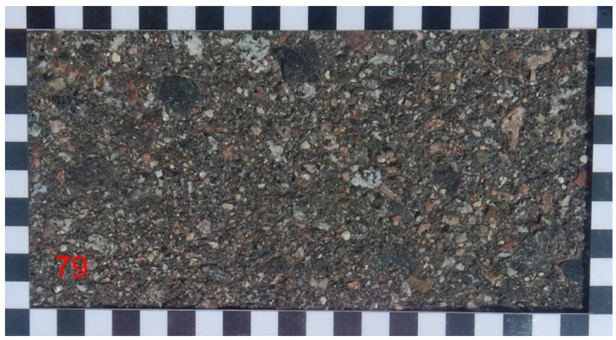
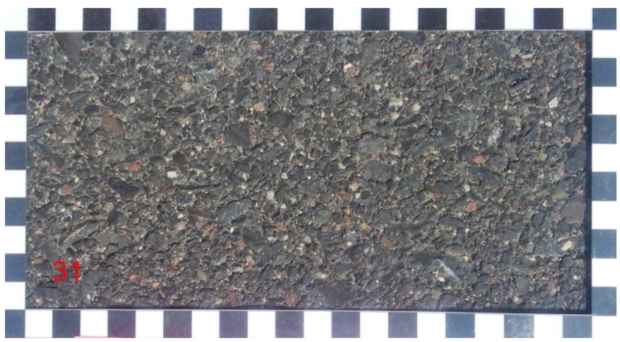
33		Polyphosphoric Acid Study	12.5 mm Dense Graded SuperPave	
34		Polyphosphoric Acid Study	12.5 mm Dense Graded SuperPave	
35		Polyphosphoric Acid Study	12.5 mm Dense Graded SuperPave	
36		LVR design PCC – SUBGRADE R70 subgrade – doweled	Transverse Tine	

37		LVR design PCC – SUBGRADE R70 subgrade –undoweled	Conventional Diamond Grind (TS3) Innovative Diamond Grind (TS 1 and 2) 2010 Diamond Grind (TS 5) Transverse Tine (TS 4 and Inside)	   

38		LVR design PCC – Standard base – doweled	Transverse Tine	
39		Porous Concrete Overlay Experiment	Pervious Overlay; diamond grooved	
40	140/240	LVR design PCC – 7-5.5-7 inch Trapezoidal – undoweled	Overlay 6x6 foot panels; fibers, longitudinal tining and drag	
24		Aging Study, WMA Control	12.5 mm Dense Graded SuperPave, Fog seals each year in 100-ft sections	

85		Pervious Concrete Experiment – Low Volume Road – Sand subgrade	Pervious Concrete	
86		Porous HMA Study	Porous Hot Mixed Asphalt	
87		Porous Pavement Study – Control Section	12.5 mm Dense Graded SuperPave	
88		Porous HMA Study	Porous Hot Mixed Asphalt	

89		Pervious Concrete Experiment – Low Volume Road – Clay subgrade	Pervious Concrete	
27		Geocomposite Capillary Barrier Drain	Chip Seals (FA-2 and FA-3)	
28		Stabilized Full Depth Reclamation	Double Chip Seal	

77		Fly Ash Study, Polyphosphoric Acid Study	12.5 mm Dense Graded SuperPave	
78		Fly Ash Study, Polyphosphoric Acid Study	12.5 mm Dense Graded SuperPave	
79		Fly Ash Study, Polyphosphoric Acid Study	12.5 mm Dense Graded SuperPave	
31		2004 LVR Taconite SuperPave	12.5 mm Dense Graded SuperPave	

32		LVR design PCC – Thin Slab	Diamond grooved	
52		5 year design PCC – Load testing – FRP dowels	Longitudinal Turf Drag	
53		60-year PCC	Transverse Broom	
54		PCC mix experiment – Mesabi Select aggregates	Longitudinal Turf Drag	

APPENDIX B. SUMMARY OF ROLLING RESISTANCE RESULTS

Table B-1. Coefficients of Rolling Resistance for tire SRTT on Mainline.

Tire – SRTT; Position – Right Wheel Track									
	Speed 50 km/h			Speed 80 km/h			Speed 110 km/h		
CELL	CRR	Air temp. [C]	CRR_t	CRR	Air temp. [C]	CRR_t	CRR	Air temp. [C]	CRR_t
1	0.0086	21.2	**0.0083**	0.0082	16.8	**0.0077**	0.0094	23.5	**0.0093**
2	0.0089	21.5	**0.0087**	0.0089	16.6	**0.0083**	0.0097	23.7	**0.0096**
3	0.0087	21.5	**0.0085**	0.0089	16.6	**0.0083**	0.0094	23.8	**0.0093**
4	0.0089	21.3	**0.0086**	0.0087	16.7	**0.0082**	0.0096	23.8	**0.0095**
505	0.0082	21.2	**0.0079**	0.0082	16.7	**0.0077**	0.0089	23.8	**0.0088**
605	0.0082	21.1	**0.0080**	0.0082	16.7	**0.0076**	0.0087	23.9	**0.0086**
305	0.0082	21.1	**0.0079**	0.0083	16.7	**0.0078**	0.0086	23.8	**0.0086**
405	0.0082	21.0	**0.0079**	0.0085	16.7	**0.0080**	0.0095	23.8	**0.0094**
306	0.0083	21.0	**0.0081**	0.0087	16.7	**0.0081**	0.0095	23.8	**0.0094**
406	0.0080	21.0	**0.0078**	0.0087	16.7	**0.0081**	0.0094	23.8	**0.0093**
7	0.0077	21.1	**0.0075**	0.0085	16.7	**0.0079**	0.0089	23.8	**0.0089**
8	0.0080	21.2	**0.0078**	0.0085	16.7	**0.0079**	0.0091	23.7	**0.0090**
9	0.0084	21.2	**0.0081**	0.0086	16.7	**0.0081**	0.0097	23.7	**0.0096**
160	0.0082	21.2	**0.0079**	0.0086	16.7	**0.0081**	0.0092	23.8	**0.0091**
161	0.0080	21.3	**0.0078**	0.0086	16.7	**0.0080**	0.0091	23.8	**0.0090**
96	0.0082	21.2	**0.0079**	0.0085	16.7	**0.0080**	0.0096	23.8	**0.0095**
70	0.0080	21.2	**0.0078**	0.0086	16.7	**0.0080**	0.0093	23.8	**0.0092**
71	0.0079	21.3	**0.0077**	0.0087	16.7	**0.0081**	0.0090	23.7	**0.0089**
73	0.0079	21.3	**0.0077**	0.0086	16.8	**0.0081**	0.0088	23.6	**0.0087**
72	0.0083	21.4	**0.0081**	0.0090	16.8	**0.0085**	0.0089	23.7	**0.0088**
12	0.0080	21.4	**0.0077**	0.0085	16.8	**0.0080**	0.0090	23.6	**0.0089**
613	0.0081	21.5	**0.0079**	0.0089	16.8	**0.0084**	0.0089	23.6	**0.0088**
114	0.0080	21.5	**0.0078**	0.0087	16.8	**0.0081**	0.0089	23.5	**0.0088**
214	0.0076	21.6	**0.0073**	0.0086	16.8	**0.0080**	0.0093	23.5	**0.0092**
314	0.0078	21.6	**0.0076**	0.0087	16.8	**0.0082**	0.0089	23.5	**0.0088**
414	0.0076	21.6	**0.0074**	0.0084	16.8	**0.0079**	0.0088	23.5	**0.0087**
514	0.0075	21.6	**0.0073**	0.0086	16.8	**0.0080**	0.0089	23.5	**0.0088**
614	0.0077	21.7	**0.0075**	0.0086	16.8	**0.0080**	0.0089	23.4	**0.0088**
714	0.0081	21.7	**0.0079**	0.0082	16.8	**0.0076**	0.0090	23.4	**0.0089**
814	0.0081	21.7	**0.0079**	0.0082	16.8	**0.0076**	0.0092	23.4	**0.0091**
914	0.0080	21.7	**0.0078**	0.0087	16.8	**0.0081**	0.0099	23.4	**0.0097**
15	0.0085	21.7	**0.0082**	0.0093	16.7	**0.0087**	0.0100	23.4	**0.0098**
16	0.0083	21.9	**0.0081**	0.0092	16.7	**0.0086**	0.0098	23.4	**0.0097**
17	0.0084	22.1	**0.0082**	0.0094	16.6	**0.0088**	0.0101	23.4	**0.0100**
18	0.0086	22.0	**0.0084**	0.0096	16.5	**0.0090**	0.0101	23.4	**0.0100**
19	0.0085	22.0	**0.0083**	0.0094	16.5	**0.0088**	0.0099	23.5	**0.0098**
20	0.0080	22.0	**0.0078**	0.0090	16.4	**0.0084**	0.0094	23.7	**0.0093**
21	0.0079	21.9	**0.0077**	0.0091	16.3	**0.0085**	0.0093	23.7	**0.0092**
22	0.0077	21.8	**0.0075**	0.0090	16.0	**0.0083**	0.0090	23.8	**0.0089**
23	0.0086	21.2	**0.0083**	0.0082	16.8	**0.0077**	0.0094	23.5	**0.0093**

Table B-1 continued. Coefficients of Rolling Resistance for tire SRTT on Mainline.

Tire – SRTT; Position – Between Wheel Track									
	Speed 50 km/h			Speed 80 km/h			Speed 110 km/h		
CELL	CRR	Air temp. [C]	CRR_t	CRR	Air temp. [C]	CRR_t	CRR	Air temp. [C]	CRR_t
1	0.0083	21.1	**0.0081**	0.0087	16.7	**0.0081**	0.0101	23.0	**0.0100**
2	0.0086	21.5	**0.0083**	0.0092	16.8	**0.0086**	0.0102	23.2	**0.0101**
3	0.0087	21.7	**0.0085**	0.0091	16.9	**0.0085**	0.0106	23.3	**0.0104**
4	0.0084	21.8	**0.0082**	0.0087	16.9	**0.0081**	0.0097	23.3	**0.0096**
505	0.0087	21.7	**0.0085**	0.0088	16.9	**0.0083**	0.0099	23.4	**0.0098**
605	0.0084	21.7	**0.0082**	0.0087	16.9	**0.0081**	0.0096	23.5	**0.0095**
305	0.0084	21.7	**0.0082**	0.0090	16.9	**0.0084**	0.0097	23.5	**0.0096**
405	0.0084	21.7	**0.0082**	0.0089	16.9	**0.0083**	0.0097	23.6	**0.0095**
306	0.0085	21.6	**0.0083**	0.0089	16.9	**0.0083**	0.0097	23.6	**0.0096**
406	0.0084	21.6	**0.0082**	0.0089	16.9	**0.0083**	0.0099	23.6	**0.0098**
7	0.0079	21.5	**0.0077**	0.0085	16.8	**0.0079**	0.0093	23.5	**0.0092**
8	0.0083	21.5	**0.0081**	0.0086	16.8	**0.0081**	0.0097	23.3	**0.0095**
9	0.0084	21.5	**0.0082**	0.0092	16.8	**0.0086**	0.0098	23.3	**0.0097**
160	0.0084	21.6	**0.0081**	0.0088	16.8	**0.0082**	0.0097	23.4	**0.0095**
161	0.0086	21.6	**0.0084**	0.0086	16.8	**0.0080**	0.0096	23.4	**0.0095**
96	0.0092	21.6	**0.0090**	0.0091	16.9	**0.0085**	0.0100	23.4	**0.0099**
70	0.0083	21.7	**0.0081**	0.0085	16.9	**0.0080**	0.0096	23.5	**0.0095**
71	0.0083	21.8	**0.0081**	0.0086	16.9	**0.0080**	0.0095	23.6	**0.0094**
73	0.0081	21.8	**0.0079**	0.0088	16.9	**0.0083**	0.0096	23.6	**0.0095**
72	0.0088	21.8	**0.0086**	0.0093	16.9	**0.0087**	0.0102	23.7	**0.0101**
12	0.0082	21.9	**0.0080**	0.0086	16.9	**0.0081**	0.0096	23.8	**0.0095**
613	0.0082	22.1	**0.0080**	0.0088	16.9	**0.0082**	0.0096	23.9	**0.0095**
114	0.0081	22.2	**0.0080**	0.0087	16.9	**0.0081**	0.0097	23.9	**0.0096**
214	0.0080	22.2	**0.0079**	0.0088	16.9	**0.0082**	0.0096	23.9	**0.0095**
314	0.0080	22.2	**0.0078**	0.0086	16.9	**0.0081**	0.0096	24.0	**0.0095**
414	0.0080	22.2	**0.0078**	0.0084	16.9	**0.0078**	0.0097	24.0	**0.0096**
514	0.0083	22.2	**0.0081**	0.0083	16.9	**0.0078**	0.0096	24.0	**0.0095**
614	0.0080	22.2	**0.0079**	0.0086	16.9	**0.0080**	0.0095	24.0	**0.0095**
714	0.0083	22.1	**0.0081**	0.0086	16.9	**0.0080**	0.0096	24.0	**0.0095**
814	0.0083	22.1	**0.0081**	0.0086	16.9	**0.0081**	0.0096	24.0	**0.0095**
914	0.0081	22.1	**0.0079**	0.0089	16.9	**0.0083**	0.0097	24.0	**0.0096**
15	0.0081	22.0	**0.0079**	0.0089	16.8	**0.0083**	0.0101	24.0	**0.0100**
16	0.0082	21.9	**0.0080**	0.0089	16.7	**0.0083**	0.0103	24.1	**0.0103**
17	0.0085	21.9	**0.0083**	0.0090	16.7	**0.0084**	0.0104	24.2	**0.0103**
18	0.0083	21.9	**0.0081**	0.0091	16.7	**0.0085**	0.0104	24.1	**0.0104**
19	0.0083	21.9	**0.0081**	0.0088	16.6	**0.0082**	0.0103	24.1	**0.0102**
20	0.0077	22.0	**0.0075**	0.0083	16.5	**0.0077**	0.0098	24.1	**0.0097**
21	0.0076	22.0	**0.0074**	0.0083	16.4	**0.0077**	0.0096	24.2	**0.0095**
22	0.0079	22.0	**0.0077**	0.0082	16.1	**0.0076**	0.0093	24.1	**0.0093**
23	0.0083	21.1	**0.0081**	0.0087	16.7	**0.0081**	0.0101	23.0	**0.0100**

Table B-1 continued. Coefficients of Rolling Resistance for tire SRTT on Mainline.

Tire – SRTT; Position – Left Wheel Track									
	Speed 50 km/h			Speed 80 km/h			Speed 110 km/h		
CELL	CRR	Air temp. [C]	CRR_t	CRR	Air temp. [C]	CRR_t	CRR	Air temp. [C]	CRR_t
1	0.0085	21.0	**0.0083**	0.0084	16.8	**0.0079**	0.0096	23.1	**0.0095**
2	0.0091	21.0	**0.0088**	0.0089	16.9	**0.0084**	0.0103	23.2	**0.0101**
3	0.0091	21.3	**0.0088**	0.0090	16.9	**0.0084**	0.0102	23.3	**0.0100**
4	0.0091	21.6	**0.0089**	0.0087	17.0	**0.0082**	0.0104	23.4	**0.0102**
505	0.0082	21.8	**0.0080**	0.0081	17.0	**0.0076**	0.0094	23.5	**0.0093**
605	0.0077	21.9	**0.0075**	0.0079	17.0	**0.0074**	0.0094	23.6	**0.0093**
305	0.0081	22.0	**0.0079**	0.0083	17.0	**0.0078**	0.0094	23.6	**0.0093**
405	0.0081	22.1	**0.0079**	0.0077	17.0	**0.0072**	0.0095	23.7	**0.0094**
306	0.0081	22.1	**0.0079**	0.0080	17.0	**0.0074**	0.0096	23.8	**0.0095**
406	0.0082	22.1	**0.0080**	0.0079	17.0	**0.0074**	0.0094	23.9	**0.0093**
7	0.0076	22.0	**0.0074**	0.0074	17.0	**0.0070**	0.0090	23.9	**0.0089**
8	0.0078	21.8	**0.0076**	0.0079	17.0	**0.0074**	0.0095	24.0	**0.0094**
9	0.0085	21.7	**0.0082**	0.0082	17.0	**0.0077**	0.0100	24.1	**0.0099**
160	0.0078	21.7	**0.0076**	0.0080	17.0	**0.0075**	0.0095	24.1	**0.0094**
161	0.0077	21.8	**0.0075**	0.0077	17.0	**0.0073**	0.0093	24.1	**0.0093**
96	0.0078	21.8	**0.0076**	0.0083	17.0	**0.0077**	0.0093	24.1	**0.0092**
70	0.0078	21.8	**0.0076**	0.0079	17.0	**0.0074**	0.0095	24.0	**0.0094**
71	0.0075	21.9	**0.0073**	0.0080	17.0	**0.0075**	0.0093	24.0	**0.0092**
73	0.0076	22.0	**0.0074**	0.0082	17.0	**0.0077**	0.0094	23.9	**0.0093**
72	0.0080	22.0	**0.0078**	0.0085	17.0	**0.0080**	0.0096	23.9	**0.0095**
12	0.0074	22.1	**0.0073**	0.0077	17.0	**0.0072**	0.0092	23.8	**0.0091**
613	0.0077	22.2	**0.0075**	0.0082	17.0	**0.0077**	0.0092	23.8	**0.0092**
114	0.0076	22.3	**0.0074**	0.0081	17.0	**0.0076**	0.0092	23.8	**0.0091**
214	0.0071	22.3	**0.0070**	0.0081	17.1	**0.0076**	0.0091	23.8	**0.0090**
314	0.0073	22.3	**0.0071**	0.0078	17.1	**0.0073**	0.0092	23.8	**0.0091**
414	0.0072	22.3	**0.0071**	0.0077	17.1	**0.0072**	0.0092	23.8	**0.0091**
514	0.0074	22.3	**0.0072**	0.0075	17.1	**0.0070**	0.0091	23.8	**0.0090**
614	0.0072	22.2	**0.0071**	0.0074	17.1	**0.0070**	0.0090	23.8	**0.0089**
714	0.0072	22.2	**0.0071**	0.0075	17.1	**0.0070**	0.0089	23.8	**0.0088**
814	0.0072	22.2	**0.0071**	0.0074	17.1	**0.0069**	0.0089	23.8	**0.0088**
914	0.0073	22.2	**0.0071**	0.0076	17.1	**0.0071**	0.0093	23.8	**0.0092**
15	0.0081	22.2	**0.0080**	0.0087	17.0	**0.0081**	0.0099	23.7	**0.0098**
16	0.0081	22.3	**0.0079**	0.0086	17.0	**0.0080**	0.0099	23.8	**0.0098**
17	0.0082	22.3	**0.0080**	0.0085	16.9	**0.0079**	0.0100	23.9	**0.0099**
18	0.0081	22.4	**0.0079**	0.0087	16.9	**0.0081**	0.0099	23.9	**0.0098**
19	0.0080	22.4	**0.0079**	0.0086	16.8	**0.0080**	0.0101	23.9	**0.0100**
20	0.0079	22.3	**0.0077**	0.0085	16.7	**0.0079**	0.0096	24.0	**0.0095**
21	0.0077	22.0	**0.0075**	0.0084	16.5	**0.0078**	0.0096	24.1	**0.0096**
22	0.0076	21.9	**0.0074**	0.0083	16.3	**0.0078**	0.0095	24.1	**0.0095**
23	0.0085	21.0	**0.0083**	0.0084	16.8	**0.0079**	0.0096	23.1	**0.0095**

Table B-2. Coefficients of Rolling Resistance for tire SRTT on Low Volume Road.

Tire – SRTT; Position – Between Wheel Track										
	Speed 50 km/h					Speed 70 km/h				
	CRR inner	CRR outer	Temperature [°C]	CRR_t inner	CRR_t outer	CRR inner	CRR outer	Temperature [°C]	CRR_t inner	CRR_t outer
33	0.0075	0.0078	16.2	**0.0070**	**0.0073**	0.0084	0.0076	16.1	**0.0078**	**0.0071**
34	0.0076	0.0076	16.2	**0.0071**	**0.0071**	0.0087	0.0078	16.2	**0.0081**	**0.0072**
35	0.0077	0.0077	16.3	**0.0071**	**0.0071**	0.0089	0.0078	16.1	**0.0083**	**0.0072**
36	0.0073	0.0078	16.2	**0.0068**	**0.0073**	0.0085	0.0079	16.2	**0.0079**	**0.0073**
37	0.0073	0.0082	16.2	**0.0068**	**0.0076**	0.0085	0.0079	16.2	**0.0079**	**0.0073**
38	0.0078	0.0076	16.1	**0.0072**	**0.0070**	0.0087	0.0076	16.2	**0.0081**	**0.0071**
39	0.0089	0.0086	16.0	**0.0083**	**0.0080**	0.0101	0.0087	16.2	**0.0094**	**0.0081**
140	0.0084	0.0079	15.9	**0.0078**	**0.0073**	0.0093	0.0074	16.1	**0.0086**	**0.0069**
240	0.0087	0.0078	15.8	**0.0080**	**0.0072**	0.0094	0.0075	16.0	**0.0087**	**0.0070**
54	0.0075	0.0079	15.9	**0.0069**	**0.0073**	0.0084	0.0075	15.9	**0.0078**	**0.0069**
53	0.0078	0.0078	15.9	**0.0072**	**0.0073**	0.0083	0.0075	15.9	**0.0077**	**0.0070**
52	0.0076	0.0076	15.9	**0.0071**	**0.0071**	0.0081	0.0074	16.0	**0.0075**	**0.0068**
32	0.0092	0.0092	16.0	**0.0085**	**0.0085**	0.0097	0.0090	16.0	**0.0090**	**0.0083**
31	0.0076	0.0078	16.0	**0.0070**	**0.0072**	0.0086	0.0076	16.1	**0.0079**	**0.0070**
79	0.0076	0.0082	16.1	**0.0070**	**0.0076**	0.0087	0.0078	16.1	**0.0081**	**0.0072**
78	0.0072	0.0082	16.0	**0.0067**	**0.0076**	0.0082	0.0086	16.1	**0.0077**	**0.0080**
77	0.0077	0.0085	16.0	**0.0072**	**0.0079**	0.0092	0.0086	16.1	**0.0085**	**0.0080**
28	0.0085	0.0101	15.9	**0.0079**	**0.0093**	0.0083	0.0104	16.1	**0.0077**	**0.0097**
27	0.0083	0.0087	16.0	**0.0077**	**0.0081**	0.0083	0.0090	16.1	**0.0077**	**0.0083**
89	0.0104	0.0094	16.0	**0.0096**	**0.0087**	0.0100	0.0093	16.1	**0.0093**	**0.0087**
88	0.0101	0.0099	16.0	**0.0094**	**0.0092**	0.0101	0.0100	16.1	**0.0094**	**0.0093**
87	0.0083	0.0070	16.1	**0.0077**	**0.0065**	0.0089	0.0077	16.1	**0.0083**	**0.0071**
86	0.0095	0.0098	16.1	**0.0089**	**0.0091**	0.0100	0.0098	16.1	**0.0093**	**0.0091**
85	0.0097	0.0087	16.1	**0.0090**	**0.0081**	0.0102	0.0092	16.0	**0.0095**	**0.0085**
24	0.0076	0.0072	16.0	**0.0071**	**0.0066**	0.0083	0.0084	16.0	**0.0077**	**0.0078**

Table B-2 continued. Coefficients of Rolling Resistance for tire SRTT on Low Volume Road.

Tire – SRTT; Position – Left Wheel Track										
	Speed 50 km/h					Speed 70 km/h				
	CRR inner	CRR outer	Temperature [°C]	CRR_t inner	CRR_t outer	CRR inner	CRR outer	Temperature [°C]	CRR_t inner	CRR_t outer
33	0.0080	0.0081	15.5	**0.0074**	**0.0075**	0.0089	0.0084	16.1	**0.0082**	**0.0078**
34	0.0081	0.0081	15.7	**0.0075**	**0.0075**	0.0090	0.0084	16.2	**0.0083**	**0.0078**
35	0.0083	0.0083	15.7	**0.0077**	**0.0077**	0.0089	0.0084	16.2	**0.0083**	**0.0078**
36	0.0081	0.0080	15.7	**0.0075**	**0.0074**	0.0085	0.0076	16.2	**0.0079**	**0.0071**
37	0.0078	0.0089	15.8	**0.0072**	**0.0082**	0.0084	0.0076	16.2	**0.0078**	**0.0070**
38	0.0081	0.0070	15.8	**0.0075**	**0.0065**	0.0087	0.0071	16.2	**0.0081**	**0.0066**
39	0.0095	0.0087	15.7	**0.0088**	**0.0081**	0.0102	0.0091	16.1	**0.0095**	**0.0084**
140	0.0086	0.0073	15.6	**0.0079**	**0.0067**	0.0091	0.0076	16.1	**0.0084**	**0.0070**
240	0.0087	0.0074	15.5	**0.0080**	**0.0068**	0.0092	0.0076	16.0	**0.0086**	**0.0070**
54	0.0079	0.0069	15.6	**0.0073**	**0.0064**	0.0086	0.0075	15.9	**0.0080**	**0.0069**
53	0.0077	0.0071	15.6	**0.0071**	**0.0065**	0.0080	0.0075	16.0	**0.0074**	**0.0069**
52	0.0077	0.0068	15.7	**0.0071**	**0.0063**	0.0082	0.0075	16.0	**0.0076**	**0.0069**
32	0.0086	0.0080	15.7	**0.0080**	**0.0074**	0.0090	0.0081	16.0	**0.0084**	**0.0075**
31	0.0082	0.0072	15.8	**0.0076**	**0.0067**	0.0085	0.0076	16.1	**0.0079**	**0.0070**
79	0.0079	0.0074	15.9	**0.0073**	**0.0068**	0.0075	0.0081	16.1	**0.0069**	**0.0076**
78	0.0078	0.0073	15.9	**0.0073**	**0.0067**	0.0075	0.0082	16.1	**0.0070**	**0.0076**
77	0.0078	0.0073	15.9	**0.0072**	**0.0068**	0.0077	0.0086	16.1	**0.0072**	**0.0080**
28	0.0074	0.0091	15.7	**0.0068**	**0.0084**	0.0076	0.0101	16.1	**0.0070**	**0.0093**
27	0.0082	0.0089	15.7	**0.0076**	**0.0083**	0.0090	0.0107	16.1	**0.0084**	**0.0100**
89	0.0094	0.0087	15.7	**0.0087**	**0.0081**	0.0093	0.0101	16.1	**0.0086**	**0.0094**
88	0.0104	0.0084	15.7	**0.0097**	**0.0078**	0.0106	0.0098	16.1	**0.0099**	**0.0091**
87	0.0091	0.0071	15.8	**0.0085**	**0.0066**	0.0095	0.0077	16.1	**0.0088**	**0.0072**
86	0.0097	0.0090	15.8	**0.0090**	**0.0084**	0.0106	0.0093	16.1	**0.0098**	**0.0087**
85	0.0095	0.0080	15.7	**0.0088**	**0.0074**	0.0100	0.0088	16.1	**0.0093**	**0.0082**
24	0.0083	0.0066	15.7	**0.0077**	**0.0061**	0.0087	0.0078	16.0	**0.0080**	**0.0073**

Table B-3. Coefficients of Rolling Resistance for tire AAV4 on Mainline.

Tire – AAV4; Position – Right Wheel Track									
	Speed 50 km/h			Speed 80 km/h			Speed 110 km/h		
CELL	CRR	Air temp. [C]	CRR_t	CRR	Air temp. [C]	CRR_t	CRR	Air temp. [C]	CRR_t
1	0.0127	20.8	**0.0123**	0.0123	22.1	**0.0120**	0.0132	22.3	**0.0129**
2	0.0130	20.8	**0.0126**	0.0128	22.1	**0.0125**	0.0140	22.4	**0.0137**
3	0.0129	21.2	**0.0125**	0.0126	22.1	**0.0123**	0.0139	22.5	**0.0136**
4	0.0131	21.2	**0.0127**	0.0128	22.1	**0.0125**	0.0142	22.6	**0.0139**
505	0.0126	21.2	**0.0122**	0.0122	22.1	**0.0119**	0.0136	22.7	**0.0134**
605	0.0123	21.2	**0.0119**	0.0121	22.1	**0.0118**	0.0133	22.7	**0.0130**
305	0.0124	21.3	**0.0120**	0.0120	22.1	**0.0118**	0.0133	22.7	**0.0131**
405	0.0125	21.3	**0.0121**	0.0122	22.2	**0.0120**	0.0139	22.7	**0.0137**
306	0.0121	21.3	**0.0117**	0.0125	22.2	**0.0122**	0.0135	22.7	**0.0132**
406	0.0120	21.2	**0.0116**	0.0123	22.2	**0.0120**	0.0133	22.6	**0.0130**
7	0.0116	21.1	**0.0112**	0.0120	22.2	**0.0118**	0.0130	22.6	**0.0127**
8	0.0118	21.0	**0.0114**	0.0119	22.2	**0.0117**	0.0131	22.6	**0.0128**
9	0.0120	21.1	**0.0116**	0.0120	22.3	**0.0118**	0.0132	22.6	**0.0130**
160	0.0118	21.1	**0.0115**	0.0122	22.3	**0.0120**	0.0133	22.6	**0.0130**
161	0.0117	21.1	**0.0114**	0.0121	22.3	**0.0118**	0.0133	22.6	**0.0130**
96	0.0121	21.1	**0.0117**	0.0124	22.2	**0.0121**	0.0135	22.6	**0.0132**
70	0.0117	21.1	**0.0113**	0.0120	22.2	**0.0117**	0.0131	22.6	**0.0129**
71	0.0116	21.1	**0.0112**	0.0119	22.3	**0.0116**	0.0130	22.6	**0.0127**
73	0.0117	21.2	**0.0113**	0.0118	22.3	**0.0115**	0.0130	22.6	**0.0128**
72	0.0120	21.3	**0.0116**	0.0122	22.4	**0.0120**	0.0134	22.6	**0.0131**
12	0.0119	21.2	**0.0115**	0.0119	22.4	**0.0116**	0.0130	22.6	**0.0128**
613	0.0120	21.1	**0.0116**	0.0122	22.3	**0.0119**	0.0132	22.7	**0.0129**
114	0.0119	21.1	**0.0115**	0.0122	22.2	**0.0120**	0.0133	22.7	**0.0130**
214	0.0118	21.1	**0.0114**	0.0121	22.2	**0.0118**	0.0132	22.7	**0.0130**
314	0.0116	21.1	**0.0113**	0.0119	22.2	**0.0116**	0.0131	22.7	**0.0129**
414	0.0116	21.2	**0.0112**	0.0119	22.2	**0.0117**	0.0132	22.7	**0.0130**
514	0.0118	21.2	**0.0114**	0.0120	22.2	**0.0117**	0.0133	22.7	**0.0130**
614	0.0116	21.2	**0.0113**	0.0118	22.2	**0.0116**	0.0133	22.7	**0.0130**
714	0.0116	21.2	**0.0113**	0.0119	22.2	**0.0116**	0.0134	22.6	**0.0132**
814	0.0118	21.2	**0.0114**	0.0119	22.2	**0.0117**	0.0135	22.6	**0.0133**
914	0.0120	21.2	**0.0116**	0.0120	22.2	**0.0117**	0.0136	22.6	**0.0133**
15	0.0121	21.2	**0.0118**	0.0121	22.1	**0.0118**	0.0136	22.6	**0.0133**
16	0.0122	21.4	**0.0118**	0.0121	22.0	**0.0119**	0.0137	22.5	**0.0135**
17	0.0122	21.6	**0.0119**	0.0123	21.9	**0.0120**	0.0139	22.4	**0.0136**
18	0.0124	21.8	**0.0120**	0.0124	21.9	**0.0121**	0.0140	22.4	**0.0137**
19	0.0125	21.8	**0.0121**	0.0121	21.8	**0.0118**	0.0140	22.2	**0.0137**
20	0.0120	21.8	**0.0117**	0.0120	21.7	**0.0116**	0.0137	22.0	**0.0133**
21	0.0120	21.6	**0.0116**	0.0119	21.5	**0.0116**	0.0135	21.8	**0.0132**
22	0.0121	21.5	**0.0118**	0.0119	21.3	**0.0116**	0.0135	21.5	**0.0131**
23	0.0127	20.8	**0.0123**	0.0123	22.1	**0.0120**	0.0132	22.3	**0.0129**

Table B-3 continued. Coefficients of Rolling Resistance for tire AAV4 on Mainline.

Tire – AAV4; Position – Between Wheel Track									
	Speed 50 km/h			Speed 80 km/h			Speed 110 km/h		
CELL	CRR	Air temp. [C]	CRR_t	CRR	Air temp. [C]	CRR_t	CRR	Air temp. [C]	CRR_t
1	0.0120	21.1	**0.0116**	0.0124	22.6	**0.0122**	0.0139	22.6	**0.0136**
2	0.0122	21.0	**0.0118**	0.0129	22.6	**0.0127**	0.0143	22.8	**0.0140**
3	0.0125	20.9	**0.0121**	0.0132	22.6	**0.0129**	0.0142	23.0	**0.0140**
4	0.0121	20.7	**0.0117**	0.0127	22.6	**0.0124**	0.0140	23.2	**0.0138**
505	0.0121	20.8	**0.0117**	0.0128	22.5	**0.0125**	0.0139	23.2	**0.0138**
605	0.0119	20.8	**0.0115**	0.0125	22.6	**0.0123**	0.0138	23.2	**0.0136**
305	0.0120	20.8	**0.0116**	0.0127	22.6	**0.0124**	0.0139	23.2	**0.0137**
405	0.0120	20.9	**0.0116**	0.0126	22.6	**0.0124**	0.0139	23.2	**0.0137**
306	0.0123	20.9	**0.0119**	0.0124	22.6	**0.0122**	0.0140	23.2	**0.0138**
406	0.0122	20.9	**0.0118**	0.0125	22.6	**0.0122**	0.0139	23.2	**0.0137**
7	0.0117	21.0	**0.0113**	0.0121	22.6	**0.0119**	0.0136	23.2	**0.0134**
8	0.0120	21.0	**0.0116**	0.0122	22.7	**0.0120**	0.0139	23.3	**0.0137**
9	0.0116	20.8	**0.0113**	0.0123	22.7	**0.0121**	0.0138	23.3	**0.0136**
160	0.0123	20.8	**0.0119**	0.0123	22.8	**0.0121**	0.0139	23.2	**0.0137**
161	0.0120	20.8	**0.0116**	0.0121	22.7	**0.0119**	0.0138	23.2	**0.0136**
96	0.0134	20.9	**0.0129**	0.0134	22.8	**0.0131**	0.0142	23.2	**0.0140**
70	0.0121	21.0	**0.0117**	0.0121	22.8	**0.0119**	0.0138	23.1	**0.0136**
71	0.0119	21.0	**0.0115**	0.0121	22.8	**0.0119**	0.0138	23.1	**0.0136**
73	0.0118	20.9	**0.0114**	0.0117	22.8	**0.0115**	0.0137	23.1	**0.0135**
72	0.0124	20.8	**0.0120**	0.0126	22.9	**0.0123**	0.0142	23.2	**0.0140**
12	0.0119	20.8	**0.0115**	0.0121	22.9	**0.0119**	0.0138	23.2	**0.0136**
613	0.0120	20.7	**0.0116**	0.0121	22.9	**0.0119**	0.0138	23.3	**0.0136**
114	0.0121	20.7	**0.0117**	0.0122	23.0	**0.0120**	0.0142	23.4	**0.0140**
214	0.0120	20.7	**0.0116**	0.0122	23.0	**0.0120**	0.0141	23.4	**0.0140**
314	0.0119	20.7	**0.0115**	0.0119	23.0	**0.0118**	0.0137	23.4	**0.0136**
414	0.0119	20.6	**0.0115**	0.0119	23.0	**0.0117**	0.0137	23.4	**0.0135**
514	0.0120	20.6	**0.0116**	0.0119	23.0	**0.0118**	0.0137	23.4	**0.0135**
614	0.0118	20.6	**0.0113**	0.0119	23.0	**0.0117**	0.0135	23.3	**0.0133**
714	0.0114	20.5	**0.0110**	0.0119	23.0	**0.0117**	0.0135	23.3	**0.0133**
814	0.0110	20.5	**0.0106**	0.0118	23.0	**0.0117**	0.0136	23.3	**0.0134**
914	0.0115	20.5	**0.0111**	0.0120	22.9	**0.0118**	0.0137	23.3	**0.0136**
15	0.0118	20.4	**0.0113**	0.0122	22.9	**0.0120**	0.0140	23.3	**0.0138**
16	0.0117	20.4	**0.0113**	0.0124	22.8	**0.0121**	0.0140	23.2	**0.0138**
17	0.0122	20.6	**0.0118**	0.0125	22.7	**0.0123**	0.0142	23.2	**0.0140**
18	0.0120	20.6	**0.0115**	0.0124	22.6	**0.0122**	0.0142	23.1	**0.0140**
19	0.0121	20.7	**0.0117**	0.0126	22.4	**0.0123**	0.0142	23.0	**0.0139**
20	0.0116	20.7	**0.0112**	0.0123	22.2	**0.0120**	0.0138	22.8	**0.0136**
21	0.0116	20.8	**0.0112**	0.0120	21.9	**0.0117**	0.0138	22.6	**0.0136**
22	0.0113	20.5	**0.0109**	0.0120	21.5	**0.0116**	0.0138	22.3	**0.0135**
23	0.0120	21.1	**0.0116**	0.0124	22.6	**0.0122**	0.0139	22.6	**0.0136**

Table B-3 continued. Coefficients of Rolling Resistance for tire AAV4 on Mainline.

Tire – AAV4; Position – Left Wheel Track									
	Speed 50 km/h			Speed 80 km/h			Speed 110 km/h		
CELL	CRR	Air temp. [C]	CRR_t	CRR	Air temp. [C]	CRR_t	CRR	Air temp. [C]	CRR_t
1	0.0121	20.8	**0.0117**	0.0116	21.8	**0.0113**	0.0132	22.7	**0.0129**
2	0.0125	21.0	**0.0121**	0.0123	21.9	**0.0120**	0.0135	22.7	**0.0133**
3	0.0125	21.0	**0.0121**	0.0122	22.0	**0.0120**	0.0135	22.9	**0.0132**
4	0.0125	21.3	**0.0121**	0.0122	22.2	**0.0119**	0.0136	23.0	**0.0134**
505	0.0117	21.4	**0.0113**	0.0116	22.2	**0.0114**	0.0131	23.1	**0.0129**
605	0.0113	21.4	**0.0109**	0.0113	22.2	**0.0110**	0.0129	23.1	**0.0127**
305	0.0115	21.4	**0.0112**	0.0116	22.3	**0.0113**	0.0134	23.1	**0.0132**
405	0.0114	21.3	**0.0110**	0.0116	22.3	**0.0113**	0.0133	23.1	**0.0131**
306	0.0114	21.3	**0.0110**	0.0118	22.3	**0.0116**	0.0131	23.2	**0.0129**
406	0.0114	21.2	**0.0110**	0.0118	22.3	**0.0115**	0.0132	23.2	**0.0130**
7	0.0108	21.1	**0.0105**	0.0114	22.3	**0.0112**	0.0128	23.2	**0.0126**
8	0.0112	21.1	**0.0109**	0.0117	22.3	**0.0114**	0.0132	23.2	**0.0130**
9	0.0116	20.9	**0.0112**	0.0118	22.3	**0.0115**	0.0132	23.3	**0.0130**
160	0.0115	20.6	**0.0111**	0.0118	22.3	**0.0116**	0.0132	23.2	**0.0130**
161	0.0113	20.5	**0.0109**	0.0117	22.3	**0.0114**	0.0131	23.2	**0.0129**
96	0.0117	20.6	**0.0113**	0.0118	22.2	**0.0116**	0.0131	23.2	**0.0129**
70	0.0115	20.6	**0.0111**	0.0118	22.2	**0.0115**	0.0131	23.2	**0.0129**
71	0.0112	20.5	**0.0108**	0.0117	22.2	**0.0115**	0.0131	23.2	**0.0129**
73	0.0112	20.6	**0.0108**	0.0116	22.2	**0.0114**	0.0127	23.1	**0.0125**
72	0.0116	20.6	**0.0112**	0.0121	22.3	**0.0118**	0.0133	23.1	**0.0131**
12	0.0112	20.7	**0.0108**	0.0117	22.3	**0.0115**	0.0131	23.2	**0.0129**
613	0.0113	20.6	**0.0109**	0.0120	22.2	**0.0117**	0.0133	23.2	**0.0132**
114	0.0113	20.7	**0.0109**	0.0118	22.2	**0.0116**	0.0131	23.3	**0.0129**
214	0.0113	20.7	**0.0109**	0.0118	22.2	**0.0115**	0.0130	23.2	**0.0129**
314	0.0113	20.7	**0.0109**	0.0118	22.2	**0.0115**	0.0131	23.2	**0.0129**
414	0.0111	20.7	**0.0108**	0.0117	22.2	**0.0115**	0.0130	23.2	**0.0128**
514	0.0112	20.7	**0.0108**	0.0117	22.2	**0.0115**	0.0129	23.2	**0.0128**
614	0.0110	20.7	**0.0106**	0.0116	22.2	**0.0114**	0.0129	23.2	**0.0128**
714	0.0111	20.7	**0.0107**	0.0117	22.2	**0.0114**	0.0130	23.2	**0.0128**
814	0.0110	20.7	**0.0106**	0.0117	22.2	**0.0115**	0.0130	23.2	**0.0128**
914	0.0111	20.7	**0.0107**	0.0118	22.2	**0.0115**	0.0130	23.2	**0.0128**
15	0.0115	20.7	**0.0111**	0.0121	22.2	**0.0118**	0.0134	23.2	**0.0132**
16	0.0117	20.6	**0.0112**	0.0124	22.1	**0.0121**	0.0136	23.1	**0.0134**
17	0.0116	20.4	**0.0112**	0.0122	22.1	**0.0119**	0.0135	23.1	**0.0133**
18	0.0118	20.3	**0.0114**	0.0125	22.0	**0.0122**	0.0137	23.1	**0.0135**
19	0.0118	20.2	**0.0113**	0.0124	21.9	**0.0121**	0.0136	23.0	**0.0134**
20	0.0116	20.3	**0.0111**	0.0121	21.7	**0.0118**	0.0134	22.9	**0.0131**
21	0.0114	20.2	**0.0109**	0.0121	21.5	**0.0118**	0.0134	22.7	**0.0131**
22	0.0114	20.2	**0.0110**	0.0119	21.2	**0.0115**	0.0133	22.5	**0.0131**
23	0.0121	20.8	**0.0117**	0.0116	21.8	**0.0113**	0.0132	22.7	**0.0129**

Table B-4. Coefficients of Rolling Resistance for tire AAV4 on Low Volume Road.

Tire – AAV4; Position – Between Wheel Track										
	Speed 50 km/h					Speed 70 km/h				
	CRR inner	CRR outer	Temperature [°C]	CRR_t inner	CRR_t outer	CRR inner	CRR outer	Temperature [°C]	CRR_t inner	CRR_t outer
33	0.0118	0.0122	19.8	**0.0113**	**0.0117**	0.0119	0.0126	20.1	**0.0114**	**0.0121**
34	0.0118	0.0122	19.9	**0.0113**	**0.0117**	0.0121	0.0126	20.2	**0.0116**	**0.0121**
35	0.0119	0.0124	20.1	**0.0114**	**0.0119**	0.0120	0.0127	20.2	**0.0116**	**0.0123**
36	0.0115	0.0121	20.0	**0.0110**	**0.0116**	0.0116	0.0122	20.2	**0.0112**	**0.0117**
37	0.0116	0.0121	20.0	**0.0111**	**0.0116**	0.0115	0.0121	20.2	**0.0110**	**0.0117**
38	0.0120	0.0124	19.9	**0.0115**	**0.0119**	0.0119	0.0122	20.2	**0.0114**	**0.0117**
39	0.0129	0.0121	19.8	**0.0123**	**0.0116**	0.0133	0.0116	20.2	**0.0128**	**0.0112**
140	0.0123	0.0114	19.7	**0.0118**	**0.0109**	0.0130	0.0108	20.1	**0.0125**	**0.0104**
240	0.0125	0.0116	19.6	**0.0120**	**0.0111**	0.0131	0.0111	20.1	**0.0126**	**0.0107**
54	0.0121	0.0114	19.7	**0.0116**	**0.0109**	0.0119	0.0111	20.0	**0.0114**	**0.0106**
53	0.0120	0.0115	19.7	**0.0115**	**0.0110**	0.0122	0.0111	20.1	**0.0117**	**0.0107**
52	0.0119	0.0114	19.7	**0.0114**	**0.0109**	0.0121	0.0110	20.1	**0.0116**	**0.0106**
32	0.0132	0.0125	19.7	**0.0126**	**0.0120**	0.0132	0.0122	20.2	**0.0127**	**0.0117**
31	0.0123	0.0118	19.7	**0.0118**	**0.0113**	0.0125	0.0114	20.3	**0.0120**	**0.0109**
79	0.0126	0.0121	19.7	**0.0121**	**0.0116**	0.0125	0.0119	20.4	**0.0121**	**0.0114**
78	0.0123	0.0122	19.8	**0.0117**	**0.0117**	0.0124	0.0116	20.4	**0.0119**	**0.0112**
77	0.0123	0.0124	19.9	**0.0118**	**0.0119**	0.0129	0.0119	20.4	**0.0124**	**0.0114**
28	0.0128	0.0136	19.8	**0.0123**	**0.0130**	0.0127	0.0136	20.4	**0.0123**	**0.0131**
27	0.0125	0.0122	19.8	**0.0120**	**0.0117**	0.0126	0.0124	20.4	**0.0122**	**0.0119**
89	0.0140	0.0130	19.8	**0.0134**	**0.0124**	0.0139	0.0123	20.4	**0.0134**	**0.0119**
88	0.0138	0.0132	19.8	**0.0133**	**0.0127**	0.0139	0.0129	20.4	**0.0133**	**0.0124**
87	0.0126	0.0106	19.8	**0.0121**	**0.0102**	0.0129	0.0109	20.3	**0.0125**	**0.0105**
86	0.0133	0.0127	19.7	**0.0127**	**0.0122**	0.0137	0.0122	20.3	**0.0132**	**0.0118**
85	0.0134	0.0120	19.6	**0.0129**	**0.0115**	0.0141	0.0117	20.2	**0.0136**	**0.0112**
24	0.0121	0.0109	19.6	**0.0116**	**0.0104**	0.0124	0.0108	20.1	**0.0120**	**0.0103**

Table B-4 continued. Coefficients of Rolling Resistance for tire AAV4 on Low Volume Road.

Tire – AAV4; Position – Left Wheel Track										
	Speed 50 km/h					Speed 70 km/h				
	CRR inner	CRR outer	Temperature [°C]	CRR_t inner	CRR_t outer	CRR inner	CRR outer	Temperature [°C]	CRR_t inner	CRR_t outer
33	0.0111	0.0124	20.0	**0.0107**	**0.0119**	0.0119	0.0122	20.1	**0.0114**	**0.0117**
34	0.0126	0.0125	19.9	**0.0121**	**0.0120**	0.0120	0.0123	20.2	**0.0115**	**0.0118**
35	0.0126	0.0126	19.8	**0.0121**	**0.0121**	0.0119	0.0124	20.2	**0.0115**	**0.0119**
36	0.0123	0.0123	19.6	**0.0118**	**0.0118**	0.0116	0.0118	20.1	**0.0111**	**0.0113**
37	0.0122	0.0126	19.8	**0.0117**	**0.0121**	0.0115	0.0118	20.1	**0.0111**	**0.0114**
38	0.0125	0.0114	19.8	**0.0120**	**0.0109**	0.0118	0.0116	20.1	**0.0113**	**0.0111**
39	0.0138	0.0129	19.7	**0.0132**	**0.0124**	0.0128	0.0128	20.0	**0.0123**	**0.0122**
140	0.0127	0.0118	19.6	**0.0122**	**0.0113**	0.0129	0.0117	19.9	**0.0123**	**0.0112**
240	0.0128	0.0119	19.5	**0.0123**	**0.0114**	0.0130	0.0117	19.8	**0.0124**	**0.0113**
54	0.0122	0.0119	19.6	**0.0117**	**0.0114**	0.0119	0.0114	20.0	**0.0115**	**0.0109**
53	0.0123	0.0118	19.7	**0.0118**	**0.0113**	0.0120	0.0121	20.0	**0.0116**	**0.0116**
52	0.0122	0.0116	19.7	**0.0117**	**0.0111**	0.0119	0.0118	20.1	**0.0114**	**0.0113**
32	0.0131	0.0125	19.7	**0.0126**	**0.0120**	0.0127	0.0127	20.1	**0.0122**	**0.0122**
31	0.0126	0.0122	19.7	**0.0121**	**0.0117**	0.0125	0.0121	20.2	**0.0120**	**0.0117**
79	0.0119	0.0124	19.7	**0.0114**	**0.0119**	0.0116	0.0125	20.2	**0.0112**	**0.0120**
78	0.0120	0.0122	19.8	**0.0115**	**0.0117**	0.0119	0.0126	20.3	**0.0114**	**0.0121**
77	0.0120	0.0126	19.8	**0.0115**	**0.0121**	0.0117	0.0128	20.3	**0.0112**	**0.0123**
28	0.0121	0.0137	19.8	**0.0116**	**0.0131**	0.0119	0.0141	20.3	**0.0115**	**0.0136**
27	0.0124	0.0135	19.8	**0.0119**	**0.0130**	0.0126	0.0141	20.3	**0.0122**	**0.0136**
89	0.0138	0.0120	19.8	**0.0132**	**0.0115**	0.0130	0.0125	20.2	**0.0125**	**0.0120**
88	0.0140	0.0117	19.8	**0.0134**	**0.0112**	0.0140	0.0125	20.1	**0.0135**	**0.0121**
87	0.0136	0.0103	19.8	**0.0130**	**0.0099**	0.0131	0.0106	20.1	**0.0125**	**0.0101**
86	0.0141	0.0117	19.8	**0.0135**	**0.0112**	0.0144	0.0116	20.1	**0.0138**	**0.0112**
85	0.0140	0.0112	19.7	**0.0134**	**0.0107**	0.0137	0.0109	20.0	**0.0131**	**0.0105**
24	0.0129	0.0100	19.5	**0.0123**	**0.0096**	0.0124	0.0103	19.9	**0.0119**	**0.0099**

Table B-5. Coefficients of Rolling Resistance for tire MCPR on Mainline.

Tire – MCPR; Position – Right Wheel Track									
	Speed 50 km/h			Speed 80 km/h			Speed 110 km/h		
CELL	CRR	Air temp. [C]	CRR_t	CRR	Air temp. [C]	CRR_t	CRR	Air temp. [C]	CRR_t
1	0.0117	18.9	**0.0111**	0.0118	19.1	**0.0113**	0.0127	20.2	**0.0122**
2	0.0125	19.0	**0.0119**	0.0124	19.3	**0.0119**	0.0140	20.5	**0.0135**
3	0.0125	18.9	**0.0119**	0.0124	19.3	**0.0118**	0.0138	20.6	**0.0133**
4	0.0125	18.8	**0.0119**	0.0125	19.2	**0.0119**	0.0138	20.8	**0.0133**
505	0.0114	18.8	**0.0108**	0.0114	19.2	**0.0108**	0.0128	20.9	**0.0124**
605	0.0112	18.8	**0.0106**	0.0111	19.2	**0.0106**	0.0126	20.9	**0.0121**
305	0.0113	18.8	**0.0107**	0.0113	19.2	**0.0108**	0.0127	20.9	**0.0123**
405	0.0114	18.8	**0.0108**	0.0113	19.2	**0.0108**	0.0129	21.0	**0.0125**
306	0.0115	18.8	**0.0110**	0.0120	19.2	**0.0115**	0.0128	21.0	**0.0124**
406	0.0115	18.8	**0.0110**	0.0122	19.2	**0.0116**	0.0126	21.0	**0.0122**
7	0.0111	18.9	**0.0105**	0.0117	19.2	**0.0111**	0.0121	21.0	**0.0118**
8	0.0111	19.0	**0.0106**	0.0117	19.1	**0.0111**	0.0124	21.1	**0.0120**
9	0.0116	19.1	**0.0110**	0.0124	19.0	**0.0118**	0.0128	21.1	**0.0124**
160	0.0113	19.1	**0.0108**	0.0118	19.0	**0.0113**	0.0123	21.1	**0.0119**
161	0.0112	19.1	**0.0106**	0.0120	19.0	**0.0114**	0.0124	21.1	**0.0120**
96	0.0117	19.0	**0.0111**	0.0122	19.0	**0.0116**	0.0125	21.1	**0.0121**
70	0.0114	19.0	**0.0108**	0.0121	19.0	**0.0115**	0.0125	21.1	**0.0121**
71	0.0113	19.0	**0.0108**	0.0117	19.0	**0.0111**	0.0121	21.1	**0.0118**
73	0.0116	19.0	**0.0110**	0.0119	19.0	**0.0114**	0.0124	21.1	**0.0120**
72	0.0117	19.1	**0.0111**	0.0122	19.0	**0.0116**	0.0127	21.1	**0.0123**
12	0.0112	19.1	**0.0107**	0.0116	19.0	**0.0111**	0.0122	21.2	**0.0118**
613	0.0114	19.1	**0.0109**	0.0117	19.0	**0.0112**	0.0123	21.2	**0.0119**
114	0.0112	19.2	**0.0107**	0.0118	19.0	**0.0112**	0.0127	21.2	**0.0123**
214	0.0110	19.3	**0.0105**	0.0117	19.0	**0.0111**	0.0126	21.2	**0.0122**
314	0.0111	19.3	**0.0106**	0.0114	19.0	**0.0108**	0.0123	21.2	**0.0119**
414	0.0111	19.3	**0.0106**	0.0115	18.9	**0.0110**	0.0119	21.2	**0.0116**
514	0.0111	19.3	**0.0106**	0.0116	18.9	**0.0110**	0.0118	21.2	**0.0115**
614	0.0108	19.3	**0.0103**	0.0113	18.9	**0.0107**	0.0121	21.2	**0.0117**
714	0.0110	19.3	**0.0105**	0.0112	18.9	**0.0107**	0.0127	21.1	**0.0123**
814	0.0110	19.3	**0.0105**	0.0113	18.9	**0.0107**	0.0127	21.1	**0.0123**
914	0.0111	19.3	**0.0106**	0.0116	18.9	**0.0110**	0.0121	21.1	**0.0118**
15	0.0114	19.3	**0.0109**	0.0121	18.9	**0.0115**	0.0128	21.1	**0.0124**
16	0.0115	19.4	**0.0110**	0.0120	19.0	**0.0115**	0.0128	21.1	**0.0124**
17	0.0117	19.5	**0.0112**	0.0123	19.0	**0.0117**	0.0132	21.1	**0.0127**
18	0.0117	19.3	**0.0112**	0.0124	19.1	**0.0118**	0.0137	21.2	**0.0133**
19	0.0118	19.1	**0.0113**	0.0123	19.0	**0.0117**	0.0133	21.2	**0.0129**
20	0.0113	18.8	**0.0107**	0.0120	18.9	**0.0114**	0.0131	21.1	**0.0127**
21	0.0112	18.6	**0.0106**	0.0117	18.8	**0.0112**	0.0130	20.9	**0.0126**
22	0.0110	18.5	**0.0104**	0.0121	18.5	**0.0115**	0.0129	20.7	**0.0125**
23	0.0117	18.9	**0.0111**	0.0118	19.1	**0.0113**	0.0127	20.2	**0.0122**

Table B-5 continued. Coefficients of Rolling Resistance for tire MCPR on Mainline.

Tire – MCPR; Position – Between Wheel Track									
	Speed 50 km/h			Speed 80 km/h			Speed 110 km/h		
CELL	CRR	Air temp. [C]	CRR_t	CRR	Air temp. [C]	CRR_t	CRR	Air temp. [C]	CRR_t
1	0.0116	19.0	**0.0110**	0.0117	18.8	**0.0111**	0.0127	23.0	**0.0125**
2	0.0119	19.2	**0.0113**	0.0127	19.0	**0.0121**	0.0134	23.1	**0.0132**
3	0.0124	19.2	**0.0118**	0.0128	19.0	**0.0122**	0.0134	23.1	**0.0132**
4	0.0117	18.9	**0.0111**	0.0121	19.0	**0.0115**	0.0125	23.0	**0.0123**
505	0.0116	18.9	**0.0110**	0.0120	19.0	**0.0115**	0.0127	23.0	**0.0125**
605	0.0114	18.9	**0.0109**	0.0119	19.1	**0.0113**	0.0127	23.0	**0.0124**
305	0.0117	18.9	**0.0111**	0.0122	19.1	**0.0116**	0.0125	22.9	**0.0123**
405	0.0117	18.9	**0.0112**	0.0120	19.1	**0.0114**	0.0125	22.9	**0.0123**
306	0.0119	18.9	**0.0113**	0.0118	19.1	**0.0113**	0.0125	22.9	**0.0123**
406	0.0118	18.9	**0.0112**	0.0118	19.1	**0.0113**	0.0126	22.9	**0.0124**
7	0.0112	18.9	**0.0107**	0.0115	19.2	**0.0109**	0.0121	22.9	**0.0119**
8	0.0118	18.8	**0.0112**	0.0119	19.3	**0.0114**	0.0126	22.9	**0.0124**
9	0.0118	18.7	**0.0112**	0.0121	19.3	**0.0115**	0.0127	22.9	**0.0125**
160	0.0116	18.7	**0.0110**	0.0118	19.3	**0.0113**	0.0129	23.0	**0.0126**
161	0.0115	18.7	**0.0109**	0.0120	19.2	**0.0114**	0.0130	22.8	**0.0128**
96	0.0124	18.8	**0.0118**	0.0134	19.2	**0.0128**	0.0140	22.8	**0.0138**
70	0.0118	18.9	**0.0112**	0.0118	19.2	**0.0112**	0.0124	22.7	**0.0122**
71	0.0115	18.8	**0.0110**	0.0116	19.2	**0.0111**	0.0125	22.7	**0.0123**
73	0.0114	18.8	**0.0108**	0.0116	19.2	**0.0111**	0.0124	22.7	**0.0122**
72	0.0126	18.7	**0.0119**	0.0127	19.2	**0.0121**	0.0134	22.8	**0.0131**
12	0.0116	18.7	**0.0110**	0.0117	19.3	**0.0112**	0.0126	22.9	**0.0123**
613	0.0117	18.8	**0.0111**	0.0119	19.4	**0.0114**	0.0126	22.9	**0.0124**
114	0.0118	18.8	**0.0112**	0.0119	19.4	**0.0113**	0.0127	22.9	**0.0124**
214	0.0114	18.8	**0.0109**	0.0117	19.4	**0.0112**	0.0127	22.9	**0.0125**
314	0.0115	18.8	**0.0110**	0.0117	19.4	**0.0112**	0.0124	22.9	**0.0122**
414	0.0114	18.8	**0.0109**	0.0116	19.4	**0.0111**	0.0125	22.8	**0.0123**
514	0.0115	18.9	**0.0109**	0.0117	19.4	**0.0111**	0.0126	22.8	**0.0124**
614	0.0113	18.9	**0.0107**	0.0118	19.4	**0.0113**	0.0126	22.8	**0.0124**
714	0.0112	18.9	**0.0107**	0.0123	19.4	**0.0117**	0.0125	22.8	**0.0123**
814	0.0112	18.9	**0.0106**	0.0123	19.4	**0.0118**	0.0126	22.8	**0.0124**
914	0.0112	18.9	**0.0107**	0.0120	19.4	**0.0115**	0.0129	22.8	**0.0127**
15	0.0115	19.1	**0.0110**	0.0121	19.5	**0.0115**	0.0131	22.8	**0.0129**
16	0.0117	19.4	**0.0112**	0.0123	19.4	**0.0117**	0.0131	22.8	**0.0129**
17	0.0117	19.4	**0.0112**	0.0121	19.3	**0.0116**	0.0134	22.8	**0.0132**
18	0.0114	19.2	**0.0109**	0.0123	19.2	**0.0118**	0.0136	22.8	**0.0133**
19	0.0115	18.9	**0.0109**	0.0123	19.1	**0.0117**	0.0135	22.8	**0.0132**
20	0.0107	19.0	**0.0102**	0.0117	19.0	**0.0111**	0.0129	22.6	**0.0126**
21	0.0106	19.1	**0.0101**	0.0115	18.8	**0.0110**	0.0130	22.3	**0.0128**
22	0.0106	19.0	**0.0101**	0.0115	18.5	**0.0109**	0.0129	21.8	**0.0125**
23	0.0116	19.0	**0.0110**	0.0117	18.8	**0.0111**	0.0127	23.0	**0.0125**

Table B-5 continued. Coefficients of Rolling Resistance for tire MCPR on Mainline.

Tire – MCPR; Position – Left Wheel Track									
	Speed 50 km/h			Speed 80 km/h			Speed 110 km/h		
CELL	CRR	Air temp. [C]	CRR_t	CRR	Air temp. [C]	CRR_t	CRR	Air temp. [C]	CRR_t
1	0.0115	18.5	**0.0109**	0.0120	18.7	**0.0114**	0.0127	23.3	**0.0125**
2	0.0126	18.7	**0.0120**	0.0125	19.1	**0.0120**	0.0138	23.5	**0.0136**
3	0.0125	18.7	**0.0119**	0.0124	19.4	**0.0118**	0.0137	23.7	**0.0136**
4	0.0125	18.7	**0.0119**	0.0124	19.6	**0.0118**	0.0137	23.8	**0.0135**
505	0.0114	18.8	**0.0108**	0.0122	19.8	**0.0117**	0.0129	23.8	**0.0127**
605	0.0108	18.8	**0.0103**	0.0118	19.9	**0.0113**	0.0124	23.7	**0.0123**
305	0.0112	18.7	**0.0106**	0.0118	19.9	**0.0114**	0.0126	23.7	**0.0125**
405	0.0111	18.7	**0.0106**	0.0117	20.0	**0.0112**	0.0126	23.7	**0.0125**
306	0.0112	18.7	**0.0106**	0.0114	20.0	**0.0110**	0.0127	23.7	**0.0125**
406	0.0111	18.7	**0.0105**	0.0115	19.9	**0.0110**	0.0127	23.6	**0.0126**
7	0.0106	18.8	**0.0101**	0.0113	19.9	**0.0108**	0.0122	23.5	**0.0121**
8	0.0110	18.9	**0.0105**	0.0114	19.9	**0.0109**	0.0125	23.4	**0.0123**
9	0.0114	19.1	**0.0109**	0.0112	19.9	**0.0107**	0.0130	23.4	**0.0129**
160	0.0112	19.1	**0.0107**	0.0110	20.0	**0.0106**	0.0125	23.4	**0.0123**
161	0.0111	19.1	**0.0106**	0.0111	20.0	**0.0107**	0.0124	23.4	**0.0122**
96	0.0116	19.0	**0.0110**	0.0117	20.0	**0.0112**	0.0126	23.4	**0.0124**
70	0.0114	18.9	**0.0108**	0.0116	20.0	**0.0111**	0.0127	23.4	**0.0125**
71	0.0113	18.8	**0.0107**	0.0116	20.1	**0.0111**	0.0126	23.4	**0.0124**
73	0.0111	18.7	**0.0105**	0.0115	20.2	**0.0111**	0.0127	23.4	**0.0125**
72	0.0117	18.7	**0.0111**	0.0120	20.2	**0.0116**	0.0131	23.4	**0.0130**
12	0.0110	18.9	**0.0105**	0.0114	20.3	**0.0109**	0.0123	23.6	**0.0122**
613	0.0113	18.9	**0.0107**	0.0115	20.3	**0.0110**	0.0126	23.7	**0.0125**
114	0.0110	19.0	**0.0104**	0.0116	20.3	**0.0111**	0.0125	23.7	**0.0123**
214	0.0107	19.0	**0.0101**	0.0115	20.3	**0.0111**	0.0124	23.7	**0.0122**
314	0.0108	19.0	**0.0103**	0.0114	20.3	**0.0110**	0.0123	23.7	**0.0122**
414	0.0107	19.0	**0.0102**	0.0113	20.2	**0.0109**	0.0123	23.7	**0.0122**
514	0.0108	19.0	**0.0103**	0.0113	20.2	**0.0109**	0.0123	23.7	**0.0121**
614	0.0107	19.0	**0.0102**	0.0110	20.1	**0.0106**	0.0122	23.7	**0.0121**
714	0.0108	19.1	**0.0103**	0.0107	20.1	**0.0103**	0.0123	23.7	**0.0122**
814	0.0108	19.1	**0.0103**	0.0110	20.1	**0.0106**	0.0123	23.7	**0.0122**
914	0.0108	19.1	**0.0103**	0.0112	20.1	**0.0107**	0.0124	23.7	**0.0123**
15	0.0115	19.2	**0.0110**	0.0115	20.1	**0.0110**	0.0131	23.6	**0.0130**
16	0.0118	19.3	**0.0113**	0.0117	20.1	**0.0112**	0.0134	23.6	**0.0132**
17	0.0118	19.3	**0.0112**	0.0112	20.1	**0.0108**	0.0134	23.5	**0.0132**
18	0.0120	19.2	**0.0114**	0.0115	20.1	**0.0111**	0.0136	23.4	**0.0134**
19	0.0119	18.9	**0.0113**	0.0123	20.1	**0.0118**	0.0134	23.2	**0.0132**
20	0.0112	18.7	**0.0107**	0.0121	20.1	**0.0116**	0.0131	22.9	**0.0129**
21	0.0112	18.6	**0.0106**	0.0121	20.1	**0.0116**	0.0132	22.7	**0.0129**
22	0.0110	18.6	**0.0104**	0.0114	20.2	**0.0109**	0.0133	22.4	**0.0130**
23	0.0115	18.5	**0.0109**	0.0120	18.7	**0.0114**	0.0127	23.3	**0.0125**

Table B-6. Coefficients of Rolling Resistance for tire MCPR on Low Volume Road.

Tire – MCPR; Position – Between Wheel Track										
	Speed 50 km/h					Speed 70 km/h				
	CRR inner	CRR outer	Temperature [°C]	CRR_t inner	CRR_t outer	CRR inner	CRR outer	Temperature [°C]	CRR_t inner	CRR_t outer
33	0.0106	0.0112	22.1	**0.0104**	**0.0109**	0.0118	0.0121	21.5	**0.0114**	**0.0117**
34	0.0108	0.0113	22.1	**0.0106**	**0.0110**	0.0120	0.0121	21.5	**0.0117**	**0.0118**
35	0.0110	0.0111	22.1	**0.0107**	**0.0109**	0.0121	0.0121	21.5	**0.0117**	**0.0117**
36	0.0102	0.0108	22.2	**0.0100**	**0.0106**	0.0115	0.0114	21.6	**0.0112**	**0.0111**
37	0.0103	0.0107	22.1	**0.0101**	**0.0104**	0.0114	0.0114	21.5	**0.0111**	**0.0110**
38	0.0107	0.0112	21.9	**0.0105**	**0.0109**	0.0118	0.0117	21.4	**0.0115**	**0.0113**
39	0.0120	0.0127	21.8	**0.0117**	**0.0124**	0.0130	0.0131	21.2	**0.0126**	**0.0127**
140	0.0109	0.0115	21.7	**0.0106**	**0.0112**	0.0119	0.0120	21.1	**0.0116**	**0.0116**
240	0.0113	0.0116	21.6	**0.0110**	**0.0113**	0.0122	0.0123	21.1	**0.0118**	**0.0119**
54	0.0104	0.0106	22.0	**0.0101**	**0.0103**	0.0108	0.0109	21.5	**0.0105**	**0.0106**
53	0.0103	0.0105	22.1	**0.0101**	**0.0102**	0.0113	0.0109	21.6	**0.0109**	**0.0106**
52	0.0104	0.0104	22.2	**0.0102**	**0.0102**	0.0111	0.0109	21.7	**0.0108**	**0.0106**
32	0.0122	0.0119	22.3	**0.0120**	**0.0116**	0.0128	0.0121	21.8	**0.0125**	**0.0118**
31	0.0110	0.0116	22.3	**0.0108**	**0.0114**	0.0121	0.0117	21.8	**0.0117**	**0.0114**
79	0.0110	0.0112	22.3	**0.0107**	**0.0110**	0.0120	0.0105	21.8	**0.0117**	**0.0103**
78	0.0107	0.0113	22.3	**0.0105**	**0.0110**	0.0117	0.0109	21.9	**0.0114**	**0.0106**
77	0.0110	0.0110	22.3	**0.0107**	**0.0108**	0.0126	0.0109	21.9	**0.0123**	**0.0106**
28	0.0117	0.0111	22.3	**0.0115**	**0.0108**	0.0123	0.0110	21.9	**0.0120**	**0.0107**
27	0.0112	0.0116	22.1	**0.0110**	**0.0113**	0.0121	0.0120	21.9	**0.0118**	**0.0117**
89	0.0131	0.0127	22.0	**0.0128**	**0.0124**	0.0137	0.0126	21.8	**0.0134**	**0.0123**
88	0.0130	0.0135	22.1	**0.0127**	**0.0132**	0.0136	0.0139	21.7	**0.0133**	**0.0135**
87	0.0111	0.0122	22.1	**0.0109**	**0.0119**	0.0124	0.0124	21.6	**0.0121**	**0.0121**
86	0.0130	0.0132	22.1	**0.0127**	**0.0129**	0.0133	0.0139	21.6	**0.0129**	**0.0135**
85	0.0127	0.0129	22.1	**0.0124**	**0.0126**	0.0136	0.0131	21.5	**0.0133**	**0.0127**
24	0.0105	0.0112	22.1	**0.0102**	**0.0109**	0.0112	0.0116	21.4	**0.0109**	**0.0113**

Table B-6 continued. Coefficients of Rolling Resistance for tire MCPR on Low Volume Road.

Tire – MCPR; Position – Left Wheel Track										
	Speed 50 km/h					Speed 70 km/h				
	CRR inner	CRR outer	Temperature [°C]	CRR_t inner	CRR_t outer	CRR inner	CRR outer	Temperature [°C]	CRR_t inner	CRR_t outer
33	0.0106	0.0113	21.5	**0.0103**	**0.0109**	0.0114	0.0108	22.0	**0.0112**	**0.0105**
34	0.0106	0.0113	21.6	**0.0103**	**0.0110**	0.0115	0.0110	22.1	**0.0112**	**0.0108**
35	0.0109	0.0113	21.4	**0.0105**	**0.0110**	0.0115	0.0111	22.1	**0.0113**	**0.0108**
36	0.0104	0.0111	21.5	**0.0101**	**0.0108**	0.0106	0.0102	22.0	**0.0103**	**0.0099**
37	0.0103	0.0112	21.5	**0.0100**	**0.0109**	0.0103	0.0101	22.1	**0.0101**	**0.0098**
38	0.0103	0.0099	21.4	**0.0100**	**0.0097**	0.0102	0.0098	22.0	**0.0100**	**0.0095**
39	0.0116	0.0117	21.2	**0.0113**	**0.0114**	0.0113	0.0117	22.0	**0.0110**	**0.0114**
140	0.0106	0.0103	21.0	**0.0102**	**0.0100**	0.0103	0.0102	21.9	**0.0100**	**0.0099**
240	0.0109	0.0105	21.0	**0.0105**	**0.0101**	0.0102	0.0103	21.9	**0.0100**	**0.0100**
54	0.0104	0.0099	21.0	**0.0101**	**0.0095**	0.0103	0.0098	21.7	**0.0101**	**0.0095**
53	0.0106	0.0103	21.0	**0.0102**	**0.0100**	0.0106	0.0106	21.8	**0.0103**	**0.0103**
52	0.0104	0.0099	21.0	**0.0100**	**0.0096**	0.0103	0.0103	21.9	**0.0101**	**0.0101**
32	0.0118	0.0110	21.0	**0.0114**	**0.0106**	0.0121	0.0111	22.1	**0.0118**	**0.0109**
31	0.0109	0.0105	21.1	**0.0105**	**0.0102**	0.0107	0.0106	22.2	**0.0105**	**0.0104**
79	0.0110	0.0104	21.2	**0.0107**	**0.0101**	0.0110	0.0114	22.4	**0.0108**	**0.0112**
78	0.0114	0.0107	21.2	**0.0110**	**0.0104**	0.0116	0.0112	22.6	**0.0113**	**0.0109**
77	0.0115	0.0108	21.2	**0.0112**	**0.0105**	0.0117	0.0116	22.6	**0.0115**	**0.0114**
28	0.0130	0.0127	21.3	**0.0127**	**0.0123**	0.0143	0.0135	22.5	**0.0140**	**0.0133**
27	0.0112	0.0128	21.4	**0.0109**	**0.0124**	0.0127	0.0136	22.5	**0.0124**	**0.0133**
89	0.0118	0.0124	21.6	**0.0115**	**0.0120**	0.0127	0.0129	22.5	**0.0124**	**0.0126**
88	0.0126	0.0122	21.7	**0.0122**	**0.0119**	0.0133	0.0133	22.5	**0.0130**	**0.0130**
87	0.0097	0.0106	21.7	**0.0094**	**0.0104**	0.0107	0.0105	22.5	**0.0104**	**0.0103**
86	0.0123	0.0122	21.7	**0.0120**	**0.0118**	0.0129	0.0119	22.4	**0.0126**	**0.0117**
85	0.0113	0.0113	21.6	**0.0110**	**0.0110**	0.0123	0.0113	22.4	**0.0120**	**0.0110**
24	0.0097	0.0099	21.5	**0.0094**	**0.0096**	0.0108	0.0098	22.3	**0.0106**	**0.0096**