Ontario's Transportation Technology Transfer Digest
MINISTRY OF TRANSPORTATION
Road Talk

Article 1 • Summer 2010 • www.mto.gov.on.ca/english/transtek/roadtalk

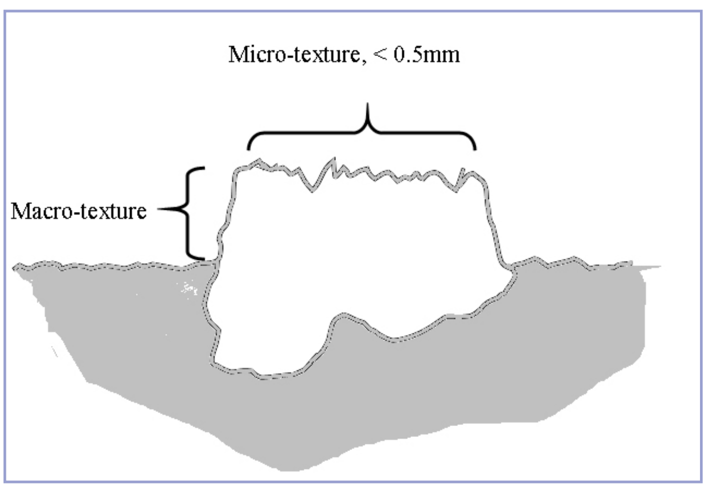
Get a Grip!

Improving pavement friction and aggregate skid resistance on Ontario Highways

One of the many ways the Ministry of Transportation (MTO) enhances highway safety is through continually researching and testing pavements to ensure those with the appropriate frictional properties are used on Ontario's highway network. MTO has a strong history of laboratory and field testing of aggregate skid resistance and pavement friction, work that is led by the ministry's Materials Engineering and Research Office (MERO).

Pavement friction, or how the pavement surface interacts with rolling vehicles, is related to many factors including pavement age, amount of traffic, design, construction of the mix, time of year and skid resistance of the aggregates used. Two main properties of the aggregate in a pavement include microtexture and macrotexture.

- Microtexture is the fine scale texture of individual aggregate particles. It is the "sandpaper-like feel" needed to penetrate the thin surface water film that develops when it's raining. It is mainly dependent on the physical nature of the aggregate (grain size, porosity) and composition (mineralogy).
- Macrotexture is the projection of wear-resistant coarse aggregates above the pavement surface. It is a function of the size, shape, spacing and arrangement/distribution of coarse aggregate particles in the mix and compaction method. Good macrotexture is maintained by aggregates composed of relatively hard, well bonded minerals. Macrotexture is related to the ability of the pavement to drain surface water.



Micro and Macro-texture of an aggregate particle in the pavement surface

An ASTM E-274 Brake Force trailer unit connected to a standard MTO fleet truck.

Microtexture and macrotexture are evaluated in the MERO laboratories using the Polished Stone Value Test and Aggregate Abrasion Value Test. However, only the aggregates are tested in the laboratory, not the specific asphalt mix. To address the limitations of laboratory testing, MERO uses a locked wheel friction tester, an ASTM E-274 Brake Force Trailer, to measure pavement friction in the field. This weighted trailer unit is connected to a standard fleet truck. Water is sprayed in front of a locked wheel as the trailer is pulled along the pavement section at the posted speed. The trailer provides a friction reading of the pavement surface which represents the horizontal force that is applied to the test tire divided by the dynamic vertical load.

In addition to using information from MERO's locked wheel friction tester, site specific information is analyzed, such as:

- Friction demand (vehicle operating speeds, conditions likely to cause driver surprise, sudden changes in micro-climate and the extremes of vehicle handling, i.e. steep slopes or curves);
- Traffic volume, collision history, conflict analysis, roadside forgiveness
- Pavement age and condition; and
- How friction changes with time. >

Improving pavement friction and aggregate skid resistance on Ontario Highways, *continued*

Improvements to pavement friction have included hot mix asphalt resurfacing with superior skid resistant aggregates as well as microsurfacing, seal coats, shotblasting, and micro milling.

MERO staff and their regional counterparts were recently involved in the testing of carbonate aggregates, historically used on eastern Ontario roads due to their abundance. Carbonate aggregates are composed of softer materials that tend to abrade or polish quickly under traffic, snow plough blades and winter sands. This leads to reduced frictional properties of hot mix asphalt pavements during the normal part of their life cycle.

MTO's Eastern Region has also performed a trial of *High Pressure Water Blasting* on a section of surface treated highway. Similar improvements are being performed by other regions throughout the province. •

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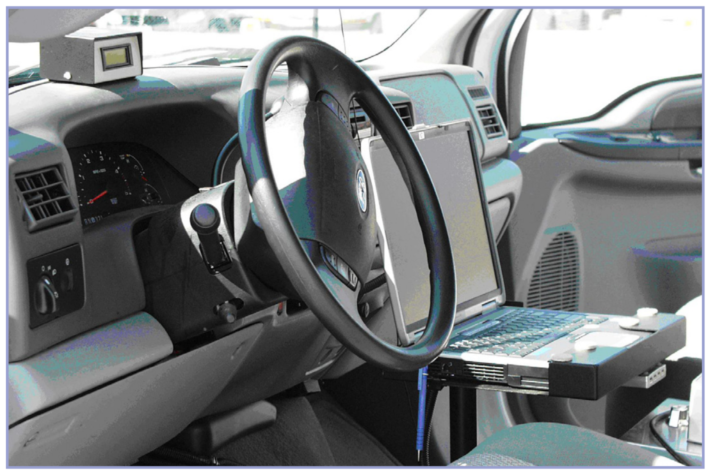
Demonstrating controlled friction on a simulated wet highway surface



Laptop computer used by operator to ensure ASTM E274 data collection procedures are followed

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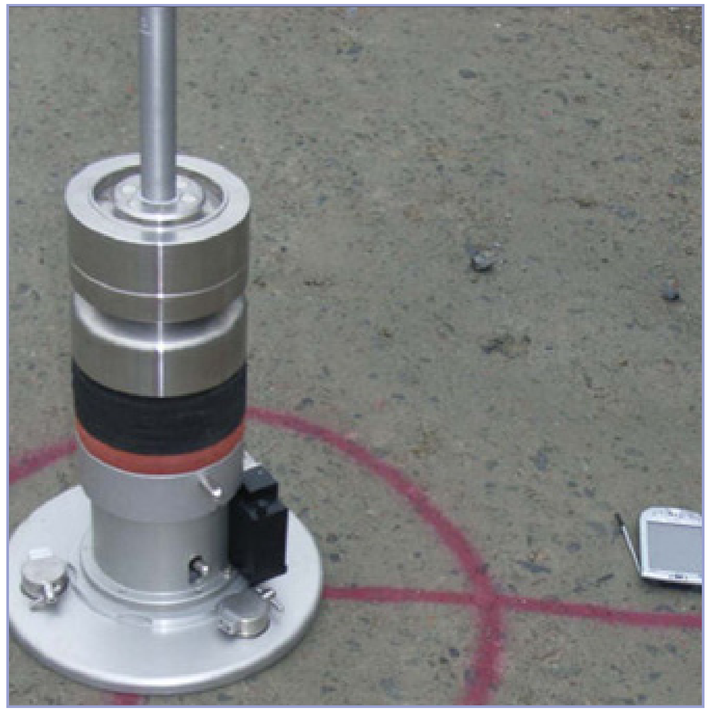
Protecting our Highways with Seasonal Load Restrictions

Multi-day frost predictions will help to set and lift roadway load restrictions



A Light Weight Deflectometer (LWD) used to measure pavement strength. This device is a portable version of a truck-mounted falling weight deflectometer, and is designed for use on surface treated and gravel roadways. Surface deflection is measured and recorded on a hand-held PDA for analysis.

The Ministry of Transportation (MTO) is testing a predictive and objective frost-depth forecast model in an effort to mitigate the economic impacts of load restrictions to the commercial transportation industry and to protect pavement from excessive damage. Once data has been validated and results confirmed, these multi-day frost predictions will support ministry decisions to set and lift roadway load restrictions using objective measurements.

The development of a new online notification system will provide advance information to the transportation industry of load limits during frost and thaw periods that will help the industry plan and reduce their economic impacts.

Seasonal Load Restrictions are placed on designated low volume highways in northern Ontario during spring thaw periods, when the roads are most susceptible to damage due to cyclic freeze and thaw conditions. During this phase, the carrying capacity and pavement strength of the roadway is dramatically reduced, and significant damage may occur as a result of even a small number of heavy vehicles travelling on these highways.

Enforcing load restrictions during the spring thaw period is a cost effective method of maximizing pavement service life while mitigating the economic impacts to the transportation industry, particularly those involved in the transportation of raw forest products.

During the winter months, the strength of the pavement structure increases as does its carrying capacity as a result of frost development. Commercial vehicles using these designated roads are permitted to increase payloads by 10%, as a Winter Weight Premium.

It is important that the ministry maintain a balance between protecting its road system while minimizing impacts to industry, by setting and lifting these restrictions as accurately as possible.

Traditionally, load restrictions are set on a calendar schedule and are modified by local staff, based on visual assessments of soil moisture conditions and observed surface deterioration. Restrictions must be posted five days in advance of their effect, which requires a conservative assessment that may restrict commercial traffic more than is necessary according to the physical conditions of the roadway.

Seasonal Load Restrictions have been implemented by many road authorities in Canada and the United States, and many use frost depth monitoring for decision making processes. These agencies typically use models that provide only current conditions, and cannot generate multi-day frost predictions required to adequately provide advance notification to industry as required in Ontario.

Through the Maintenance Technology Project, the ministry is working to develop a predictive and more objective model that would aid road managers in setting and lifting seasonal load restrictions. In 2005, instrumentation to measure subsurface temperature, soil moisture and pressure conditions was installed at seven frost susceptible locations. Pavement conditions were monitored at three of these sites using falling-weight >

A Load Restriction sign as found on Northern Ontario highways during spring thaw conditions.

Multi-day frost predictions will help to set and lift roadway load restrictions, *continued*

deflectometers at regular intervals throughout the freeze and thaw periods. These are non-destructive testing devices that calculate the strength and stiffness of pavement material by measuring surface response under the impact of a weight dropped from a preset height. This data was used by the University of Waterloo to develop a preliminary frost-thaw index model which is calculated using air temperatures combined with site specific surface temperatures.

Additional pavement strength tests were conducted using light weight deflectometers in 2008 and 2009 by Lakehead University, in order to calibrate Waterloo's frost-thaw index model to the specific pavement conditions at the seven test sites. This information was used to develop a frost-depth forecast, which is currently available on the ministry's Road Weather Information System (RWIS), as a prototype system to assist road mangers with load restriction decision-making. Subsurface and air temperatures combined with soil moisture data are used to present a graphical three-day thaw depth forecast for each of the test sites.

Over the course of the next two years, Lakehead University will test and calibrate the thaw index model, validating it against the actual dates when restrictions are set or removed, using conventional methods. It will also be tested against archived pavement conditions from the RWIS database to find cast restriction dates to further refine the model.

Once tested and validated, this system could be used to predict frost and thaw depths at other sites with similar weather and pavement conditions. If shown to produce optimal load restriction dates based on actual pavement conditions, then the next phase of this project will be to implement a map-based decision support system on the ministry's RWIS site that would provide five-day pavement thaw forecasts for improved decision making. •

A screenshot of MTO's Road Weather Information System (RWIS) available online.

The frost depth forecast (FX) is derived from a model that is currently undergoing validation. It is presented for demonstration purposes only.

Soil Temperature

° C < -10 | -10 < -4 | -4 < -1 | -1 < 1 | >= 1 | FX < 0 | FX > 0

Depth	11/18/09 18:07	11/19/09 00:05	11/19/09 06:07	11/19/09 12:05	11/19/09 18:06	11/20/09 00:05	11/20/09 06:06	12/06/09 00:10	01/01/10 06:07	01/04/10 06:05
5 cm	2.1	-0.5	-1.5	0	2.5	-0.7	-2.5	-11.2	-21.9	-25.7
15 cm	3.5	1.1	0.5	0.2	3.2	1.4	0.5	-7	-17.1	-22.1
30 cm	2.6	2.6	2.1	1.8	2.3	2.6	2.1	-2.7	-11.9	-17.4
45 cm	3	3.3	3.1	2.9	2.8	3.1	3	-0.4	-9.2	-14.5
60 cm	3.8	3.9	3.9	3.8	3.6	3.7	3.8	0.7	-7	-11.6
75 cm	4.9	4.8	4.8	4.8	4.7	4.7	4.7	2	-4.6	-8.2
90 cm	5.5	5.5	5.4	5.4	5.3	5.3	5.3	2.7	-3.1	-5.7
105 cm	6.2	6.1	6.1	6	6	6	5.9	3.5	-1.8	-3.7
135 cm	13.6	13.6	13.5	13.5	13.4	13.4	13.4	11.5	7.5	7.1
165 cm	8.3	8.2	8.2	8.2	8.1	8.1	8.1	6	1.9	1.6
195 cm	8.9	8.9	8.9	8.8	8.8	8.8	8.8	6.9	3.1	2.9
200 cm	9	9	9	8.9	8.9	8.9	8.9	7	3.2	2.9
200 cm	8.9	8.9	8.9	8.8	8.8	8.8	8.8	6.9	3.1	2.8

Soil Moisture

< .20 | .20 < .80 | .80 - 1.00

Depth	2010-05-24 11:13:07	2010-05-24 23:11:11	2010-05-25 11:11:00	2010-05-26 00:56:16	2010-05-26 11:10:09	2010-05-26 11:10:11	2010-05-27 00:55:13	2010-05-27 11:11:00	2010-05-27 23:11:00	2010-05-28 12:51:05
150 cm	0.157	0.173	0.159	0.153	0.151	0.151	0.148	0.147	0.145	0.166
450 cm	0.159	0.171	0.172	0.171	0.169	0.169	0.167	0.165	0.164	0.162
1000 cm	0.175	0.183	0.203	0.203	0.2	0.2	0.197	0.194	0.191	0.189

Prototype system on MTO's RWIS site used to predict thaw conditions at project test sites

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