GROUND-BREAKING ENGINEERING CHEMISTRY RESEARCH AT QUEEN'S UNIVERSITY PUTS A FLAWLESS STRETCH OF CANADIAN HIGHWAY WITHIN OUR REACH.

RIBBON ROADS

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Those of you who have travelled Ontario's highways may have unknowingly contributed to cutting-edge research on asphalt materials.

Over 15 years of studies conducted at Queen's University involve a remarkably successful partnership between government, industry,and academia. The Ministry of Transportation of Ontario (MTO) has commissioned over 30 pavement trial sections that test a variety of straight and modified asphalt cements from nearly every Canadian supplier. Trials on Highway 17 near Petawawa, Highway 655 near Timmins, Highway 417 near Ottawa, and Highway 427 just west of Toronto have provided new and valuable insights into this darkest of substances—asphalt cement.

Although our understanding of asphalt has greatly increased over the past 15 years, Canada's roads have not improved. Asphalt cement from modern oil refineries often fails to meet road construction specifications and has to be modified to increase performance in extreme temperatures. Experience shows that, depending on what type of chemical or polymeric modification is applied, materials perform very differently—from extremely poor to exceedingly well—even when these materials achieve the same ranking under currently accepted grading systems.

To increase the grade of inferior asphalt, companies employ catalytic air blowing (oxidation) techniques or acids (polyphosphoric acid) and bases (sodium hydroxide and tall oils) to gel the material. Modifying asphalt with polymers using styrene-butadiene type elastomers and plastomers is less popular since it typically costs more to produce the same grade of asphalt than air blowing, acids, or bases. Our research, however, suggests that the latter method produces higher quality, longer-lasting asphalt. Current asphalt cement standards and testing procedures are not making the grade when it comes to selecting the best quality asphalt for Ontario's highways.

Asphalt cement makes up only about five percent by weight of asphalt, with the rest of the material being composed of aggregate and sand. However, the importance of this critical asphalt "glue" cannot be overstated because it is responsible for over 90 percent of the long-term durability of flexible pavements. Asphalt cement is modified to increase high temperature deformation (rutting) resistance and improve the ability of the material to flow at low temperatures.

Queen's University research has revealed that the use of catalytic oxidation, acids, and other chemical agents leads to an increased tendency for the asphalt cement to gradually gel at low temperatures. This leads to reduced stress relaxation, increased thermal stresses and, unfortunately, increased levels of cracking distress. Current specification tests don't account for this gradual loss in performance, which leads to many inferior materials being applied to Canadian highways.

The photograph (above) shows a stretch of Highway 138 near Cornwall. This 17 km stretch of road required almost 66 km of crack sealing material a mere six years after construction. It continues to crack unabatedly. Analysis of the recovered material suggests it was made with a polyphosphoric, acid-modified asphalt cement. The adjacent contract, made with polymer-modified asphalt cement, has provided smooth driving conditions for over eight years, in spite of bearing up a slightly larger volume of traffic. Another example of superior performance can be found on Highway 28 near Burleigh Falls, which has been virtually crack-free throughout its entire length for more than 15 years after construction.

The good news is that with new test methods developed at Queen's, user agencies such as MTO can finally specify superior performing asphalt cements in their contracts and thereby control road quality much more accurately than in the past. Furthermore, companies like Imperial Oil, who supported this research with significant financial and in-kind contributions, can see their superior-quality asphalt cements recognized and gain a competitive advantage in the approximately 1.5 million tonne per year Ontario asphalt cement market. The ultimate beneficiaries of this work, however, are Ontario's motorists. Once these specifications are fully implemented, they can expect to see significant quality improvements and fewer repair costs for Ontario's provincial highways.

Simon A. M. Hesp has been investigating the failure mechanisms of asphalt cements and pavements for nearly 15 years as a faculty member in the department of chemistry at Queen's University. His research has won awards in Canada and the U.S. and has received generous support from government and industry.