Ontario's Transportation Technology Transfer Digest
MINISTRY OF TRANSPORTATION
Road Talk
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Quantm Route Selection: No Stone Left Unturned

The Ministry of Transportation's (MTO) pilot of the Quantm route optimisation system on Highway 129 in north-eastern Ontario last year has shown that it is possible to optimise land route selection effectively under ecological, geographical, societal and economical constraints with technological aid. Road planning typically involves hand-drawn routes on topographical maps. An engineer's ability and experience is depended upon to produce the most favourable course through terrain, but this process is often slow and tedious.

MTO tested Quantm, a model-based optimisation tool which generates potential route options by integrating the selection criteria arising from various road planning requirements. Options are narrowed as more criteria are defined. Quantm searches for low-cost routes that best satisfy the selection criteria.

The system was developed by Australian government agency CSIRO for road and railway route selection. Quantm was primarily used for railway route optimization, but has since been updated to allow geographic information systems (GIS) & Computer-aided design (CAD) maps to be read by the optimization engine. The increased flexibility is more practical for non-railway route optimization projects.

The program collects the digital terrain data into a database and analyzes the data through its custom Digital Elevation Model (DEM). Front-end software is installed onto a user's computer and the data is loaded both onto the software and Quantm's optimisation engine. The optimisation engine carries out encrypted data transmissions between the user's computer by way of the Internet. This arrangement eliminates the cost of setting up the IT infrastructure required to support the optimisation engine.

Northeast Region's Highway 129, 20 km long project was the first project in Ontario to use Quantm in a route planning procedure. The isolated location and the geographical limitations offered a good platform in which to test the software. Abrupt rock faces and the Mississagi River increased the levels of complexity in planning for a 20 km corridor realignment through the Algoma region. The hilly terrain made manual collection of data problematic as the area is difficult to access. One objective was to balance public concerns with the preservation of the scenic view of the river, which was an attraction to tourists passing by the area. MTO turned to Quantm and its unique capacities to render route options with a limited amount of information to locate a route that would strike the ideal balance between feasibility and environmental considerations.

> *"The program [allows] us to ensure that no stone was left unturned in the examination of new route options."*

Optimisation was carried out in two parts: one for corridors and one for routes. First, alternative corridors were generated and feedback sought at a Public Information Centre (PIC). Then, the team used Quantm's optimisation engine to generate a more meticulous combing for route options, along with more reliable cost measurements. The results were presented at a second PIC. Finally, the preliminary design was completed using traditional CAD methods.

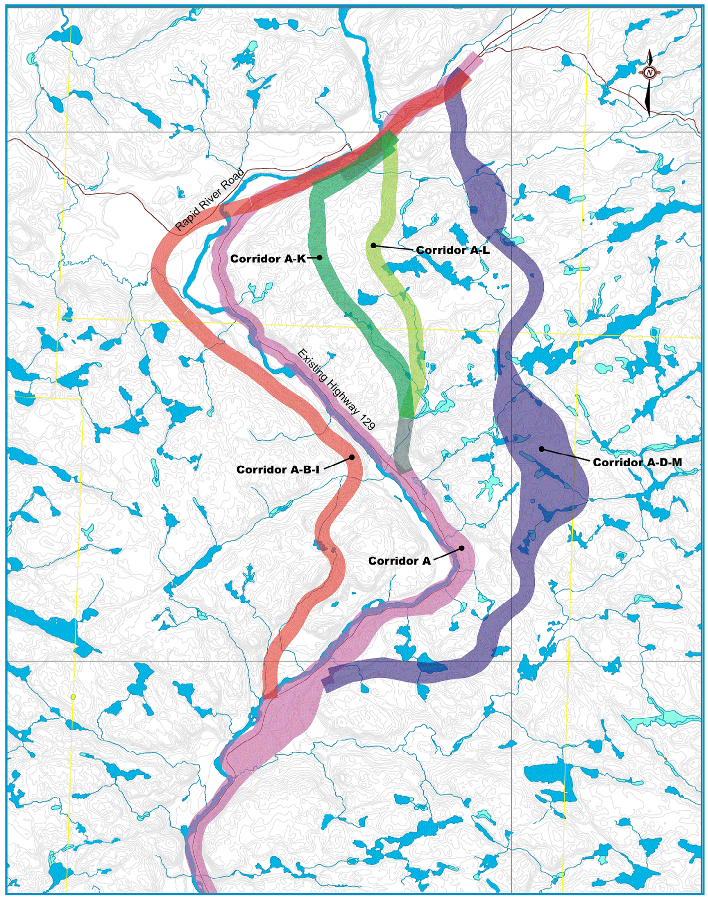

Figure 1: Possible corridors generated by the optimization engine.

The Quantm software successfully complemented the project's planning process. Overall, Quantm's most effective feature in this application was that it enabled MTO to explore route corridors under numerous parameters and the benefits of each alternative.

"The program allowed us to ensure that no stone was left unturned in the examination of new route options," said Ron Turcotte, project engineer of the Highway 129 project. •

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Water Blasting Trial Demonstration on a Stone Mastic Asphalt Surface Course

Stone Mastic Asphalt (SMA), a rut resistant and durable asphalt surface course mix, was adopted by MTO in 2000 as a premium asphalt pavement surface. SMA has since been used in Ontario on major highways with vehicle loads exceeding three million Equivalent Single Axle Loadings per year. Under these loads, its advantages include; good durability over time, increased service life, and reduced noise, an important design consideration in an urban freeway environment.

The essential features of the mix are its gap graded coarse aggregate skeleton and mastic composition. SMA's resistance to rut deformation stems from the coarse aggregate skeleton that provides more stone-on-stone contact than conventional dense graded asphalt mixes. The mastic characteristics of SMA incorporate a higher asphalt cement content, which improves binder durability, and a small quantity of cellulose or mineral fibres to help prevent drainage of bitumen during hauling and placement of the mix.

While the properties of SMA are excellent, MTO has experienced early age, lower skid resistance that improves with time and with traffic. This problem has also been reported in the U.S.A, Europe and Australia. The initial friction value is being influenced by the high asphalt mortar content and thick asphalt film which masks the micro-texture of protruding aggregates on the pavement surface.

MTO has been investigating methods to improve the initial friction of SMA. A joint MTO/Industry Task Group has been focusing on SMA mix design, construction, and treatment to determine potential solutions. The group, which includes representatives from the ministry, Ontario Hot Mix Producers Association, AECON, Lafarge, DBA Engineering, and Miller Paving, has researched various re-texturization technologies that could be used to specifically address the early life skid resistance of SMA including:sand grit application, diamond grinding, shot blasting, and water blasting of a new SMA surface.

Water blasting for the friction treatment trial was selected because it is less aggressive, more economical, faster, and more aesthetically pleasing than the others. MTO partnered with Hi-Lite Canada, a Canadian company based in Kingston, Ontario to water blast 2.3 kilometres of new SMA in the eastbound lanes of Highway 401 in Oshawa from east of Park Road to Bloor Street in October of 2008.

For result comparisons, a pre-water blast friction survey at the posted speed of 100 km/h (FN 100) was performed in September, before the trial. MTO performed follow-up friction surveys of the water blasted SMA immediately after the trial and again in April, 2009. The friction survey data revealed that water blasting substantially increased the friction value by about 20% in all 3 lanes tested. The April 2009 friction survey data confirmed that these improved friction values were maintained. Further friction surveying will be performed in fall 2009 and annually thereafter to continue assessing the longevity of the water blasting treatment on SMA.

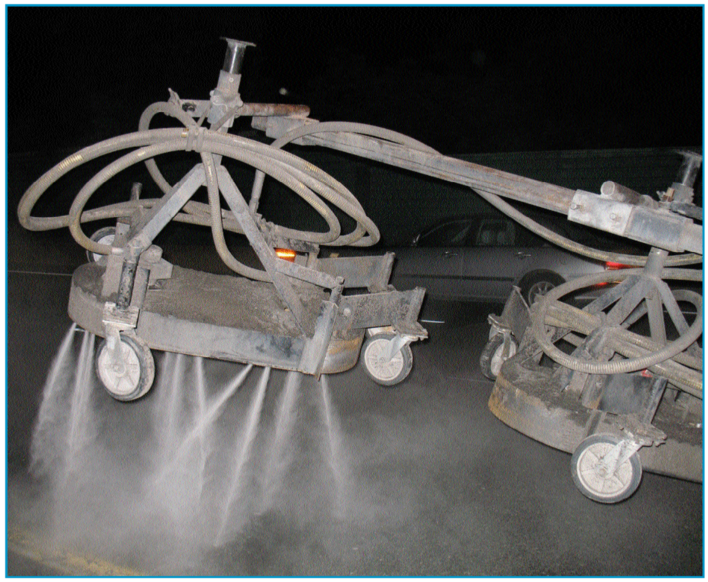

Figure 1: Close-up view of the water jets.

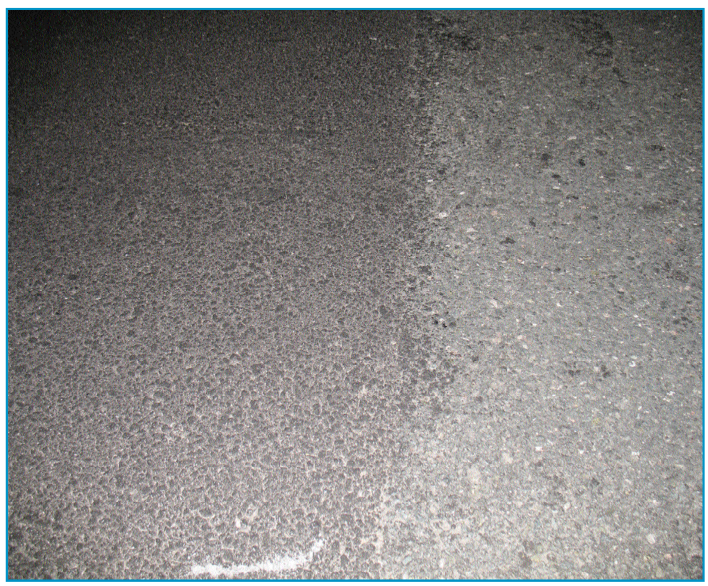

Figure 2: Close-up view before (left) and after (right) water blasting. Note the excess asphalt film thickness on the pavement surface has been removed.

The Task Group has concluded that the water blasting trial was successful and had no negative affect on the integrity or aesthetics of the pavement surface. The operation works well under >

Water Blasting Trial Demonstration on a Stone Mastic Asphalt Surface Course, *continued*

simple freeway lane closures and is faster and considerably less expensive when compared to other re-texturization methods. Upon completion of this trial, the pavement surface was power broomed to remove a minor amount of asphalt material remaining from the treatment and is recommended for future work of this nature.

Water blasting requires a large water source. On this trial, 47,000 litres of hydrant water was used; 180 litres blasted 40 metres per minute at 4.5 litres per metre. Hi-Lite Canada was able to work within the lane closure and traffic protection requirements and was able to administer the treatment at night to reduce traffic disruption.

Initial findings indicate that water blasting appears to be an efficient, and cost effective method to significantly improve early life skid resistance of SMA. A longitudinal friction survey on the same trial stretch will provide an assessment of the sustainability and long term reliability of this treatment. •

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Sustainable Asphalt Pavements

Over the years, MTO has developed several "green" initiatives to reduce its ecological footprint and promote more environmentally friendly methods of highway maintenance and repair. Examples include: in-place recycling of existing roadway materials, full-scale in-place pavement recycling, and incorporation of alternative recycled materials into the roadway.

Since 1989, MTO has used Cold In-place Recycling (CIR) as an alternative to traditional road maintenance treatments. CIR works by recycling the original hot mix already in place, grinding up the existing pavement, adding a small amount of emulsion and placing the mix back on the road. As a result, CIR saves on asphalt cement, aggregates, trucking, and conserves energy. By reusing existing materials, and because the process does not require heat, CIR uses 80% less energy and generates significantly less greenhouse gases than conventional hot mix asphalt.

One of the challenges of CIR is that the construction season is relatively short, as the method requires warm, dry weather in order for the emulsion to set. Ontario's climate provides only a small window of ideal conditions. As a result, MTO has been specifying a new technology which uses expanded asphalt instead of emulsion. This new method, called Cold In-place Recycling with Expanded Asphalt Mix (CIREAM), adds expanded asphalt to the milled pavement rather than emulsion. CIREAM is less dependent on hot, dry weather than CIR and allows for a longer construction period.

An MTO case study has shown that the use of either CIR or CIREAM in place of conventional road paving techniques reduces greenhouse gas emissions dramatically. The case study compared in-place recycling to traditional mill and overlay treatments. CO-2, NOx, SO2 were reduced by 52%, 54% and 61% respectively. Overall, CIR and CIREAM emits approximately 50% less greenhouse gases per two-lane kilometre. In-place recycling also consumes 62% less aggregates. Additionally, the methods have been shown to be more economical, reducing costs by 40-50% in comparison to the mill and overlay treatments. Where mill and overlay techniques only serve to temporarily suppress cracks within a damaged pavement, CIR/CIREAM mitigates cracks from reflecting to the surface.


Figure 1: CIR operation in action


Figure 2: CIR construction train and equipment

In addition to in-place pavement recycling, MTO has been using other innovative strategies of reusing industrial by-products in the pavement structure. Fly ash, silica fume and fine-powdered furnace slag have been incorporated into concrete mixes in place of Portland cement since the 1980s; reclaimed concrete and asphalt pavement, crushed glass, ceramics, and blast furnace slag have been used in granular bases and sub-bases; and roof shingles may now partially substitute for asphalt cement and aggregates in hot mix asphalt. Even with these substitutions, pavements constructed from the greener mixtures are expected to have the same lifespan and quality of conventional paving. >

Sustainable Pavements, continued

Other pavement greening initiatives include:

- Long-life/perpetual pavements - thicker asphalt pavements designed with a rich bottom layer to reduce fatigue cracking, with no major reconstruction required over a 50 year period.
- Warm mix asphalt - mixed and placed at lower temperatures than conventional hot mix, reducing plant GHG and particulate emissions by 35%-60%.
- Quiet pavements – to address noise concerns in sensitive areas.
- Pervious pavements – to reduce runoff and promote groundwater recharge (considered a storm water management best practice).
- Low VOC pavement markings – to reduce GHG emissions.

MTO will continue to refine its green approach through the integration of an environmental component into Life Cycle Costing models. MTO is also developing a "green rating system" that will promote the design, and construction of greener pavements. The rating system will be based on the innovative sustainable pavement technologies and resource usage. MTO recognizes the importance of environmental stewardship and will continue to pursue greener initiatives for environmental conservation. ●

For related articles, please see the Winter 2006 issue of Road Talk.

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Moving Towards Pavement Sustainability:

CPATT/MTO Sustainable Pavement Workshop

The Ministry of Transportation (MTO) is aiming to be a North American leader in adopting a more environmentally friendly approach to pavements. Over the years, the ministry has been working steadily to create more sustainable pavements through in-place recycling, recycling of industrial by-products, warm asphalt mixes, pervious pavements, and perpetual pavements.

The Ministry has also been promoting pavement sustainability and putting it into practice through various incentives, such as: developing a green component to incorporate into Life Cycle Costing Analysis (LCCA), investing in "green" Research and Development (R&D) innovations, providing education and knowledge for the industry, and setting clear expectations for quantities of recyclable material, emissions and energy reductions.

In December 2008, MTO and the University of Waterloo (Center for Pavement and Transportation Technology - CPATT) hosted a half-day Sustainable Pavement Workshop funded by the Ministry's Highway Infrastructure Innovation Funding Program. The primary objective of the workshop was to bring together a small group of stakeholders to brainstorm how sustainability can be incorporated into pavement engineering and management. The goal was to identify a list of promising innovations and how they can be realistically evaluated and incorporated into pavement engineering practice.

A total of 44 individuals, including MTO staff and the University of Waterloo, consultants, contractors, material suppliers participated in the workshop and were pre-assigned into six groups based on their expertise. Each of the six groups (Concrete Materials, Asphalt Materials, Design Processes, New Construction / Reconstruction, Preservation Strategies, and Rehabilitation) tackled issues relating to pavement materials, design, tools and processes, which resulted in the examination of the following ideas:

- More Research & Development, Education and Training
- More Long Life Pavements
- Reduction in Greenhouse Gas (GHG) emissions
- Life cycle costing analyses
- Energy savings
- Testing and monitoring of materials and performance
- Greater use of recycling and in-place recycling
- Overcoming resistance to change
- Allowing innovation in specifications

Susan Tighe presenting at the CPATT/MTO Sustainable Pavements workshop in December 2008.

This workshop fostered an opportunity for the participants to understand the need for quantifying pavement sustainability. While there is currently no officially established mechanism to quantify the impact of environmentally friendly materials, procedures and designs, the workshop was fruitful in beginning to formally evaluate the incorporation of sustainability into the pavement design and management process.

The LCCA incentives, R&D innovations, education and recycling expectations being practiced are intended to further quantify pavement sustainability. MTO's next step is to incorporate these concepts into the pavement design and management stages. Another task would be to review and modify existing specifications to encourage greater use of recycled materials in pavement design and construction.

Watch future issues of Road Talk for articles featuring pavement design and specification updates. •

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